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ANNEX A

SCIENCE AND TECHNOLOGY OBJECTIVES

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TECHNOLOGY TRANSITION

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AVIATION (Section D)

III.D.01—Rotorcraft Pilot's Associate (RPA) ATD. By FY99, develop and demonstrate through simulation and flight test a cooperative man–machine system that synergistically integrates revolutionary mission equipment package technologies, high-speed data fusion processing, cognitive decision aiding knowledge-based systems, and an advanced pilotage sensor and display to achieve maximum mission effectiveness and survivability of our combat helicopter forces. The product will contribute greatly to the pilot's ability to "see and comprehend the battlefield" in all conditions; rapidly collect, synthesize, and disseminate battlefield information; and take immediate and effective actions. Measures of performance beyond a Comanche-like baseline during day/night, clear, and adverse weather battlefield conditions include reduction in mission losses by 30–60 percent, increased targets destroyed by 50–150 percent, and a reduction in mission timelines by 20–30 percent. Milestones include system preliminary design 3Q95, software build #1 4Q95, simulation evaluation 2Q97, and flight test 3Q98.

Supports: RAH–66 Comanche, AH–64 Enhanced Apache, and system upgrades; Quiet Night; Early Entry Lethality and Survivability (EELS), Depth and Simultaneous Attack (D&SA), Mounted Battlespace (MBS), DBS, Battle Command (BC), and Combat Service Support (CSS) Battle Labs; and dual-use potential for general and commercial aviation, law enforcement, mass transit, etc.

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III.D.03—Advanced Rotorcraft Transmission II (ART II). Demonstrate a "quantum leap" in transmission system technology through the integration of emerging technologies in materials, structures, mechanical components, dynamics, acoustics, lubrication, and manufacturing processes. ART II will use advanced component technologies such as split-torque transmission design, improved gear tooth geometry, low-volume lube systems, and corrosion resistant housing materials, which have been developed under ART I, industry independent research and development (IR&D), or research, development, test, and evaluation (RDT&E) 6.2 programs, and integrate them into a full-scale demonstration of critical transmission subsystems. Candidate subsystems include lube system and accessory drives, input module, tail rotor drive system, or main gear box. Technologies will be demonstrated through detail design (by FY98), fabrication (by FY99), and subsystem performance, endurance, and noise testing (by FY00). The specific technology objectives to be demonstrated under ART II by FY00 will be 25 percent weight reduction, 10-decibel (dB) noise reduction, increase in mean time between repairs to 12,000 hours, and improved producibility. In terms of warfighting capabilities and payoffs, ART II technology will provide 15 percent increase in range or 25 percent increase in payload from an AH–64 baseline, significantly improved readiness, and improvements in maneuverability and agility and operations and support (O&S) cost reduction.

Supports: Joint Transport Rotorcraft (JTR); AH–64 Enhanced Apache; RAH–66 Comanche; system upgrades for naval aircraft (common light vertical system replacement); EELS, D&SA, MBS, and CSS Battle Labs; and dual-use potential for both general and commercial aviation.

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III.D.04—Helicopter Active Control Technology (HACT). By FY02, demonstrate a 50 percent reduction in the probability of degraded handling qualities due to flight control system failures, a 60 percent improvement in weapons pointing accuracy, a 50 percent increase in agility and maneuverability, and a 30 percent reduction in flight control system flight test development time. HACT will demonstrate integrated, state-of-the-art rotorcraft flight control technologies with exploitation of advanced fixed-wing hardware components and architectures. The objective is to demonstrate through simulation and flight test second-generation rotorcraft digital fly-by-wire/light control systems with fault-tolerant architectures, including carefree maneuvering, task-compliant control laws, and integrated fire/fuel/flight control capabilities, designed with robust control law design methods. The program will overcome technical barriers such as the lack of knowledge of optimal rotorcraft response types; inadequate techniques for sensing the onset of envelope limits, cueing the pilot, or limiting pilot inputs; inadequate air vehicle math modeling for high-bandwidth flight control; inadequate flight control system design, optimization, and validation techniques; and lack of knowledge in the optimum functional integration of flight control, weapon systems, and pilot interface. Program milestones are: FY99—complete hardware and software preliminary design; FY00—fabricate hardware and perform software validation and verification and hardware-in-the-loop (HITL) simulation; and FY02—integrate flight control system with flight test vehicle. Payoffs of the HACT program will include capability improvements in all-weather/night mission performance, flight safety, and development time/cost that contribute to a 4 percent reduction in RDT&E costs, a 65 percent increase in maneuverability and agility, and a 20 percent reduction in major accident rate.

Supports: JTR, RAH–66 Comanche, AH–64 Apache, and DoD rotorcraft system upgrades.

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III.D.09—Future Missile Technology Integration (FMTI). By FY98, demonstrate lightweight, fire-and-forget, air-to-air, multirole missile technology in support of **GTG** missions. Missile system must include the integration of common guidance and control (G&C), propulsion, airframe and warhead technologies capable of performing in high clutter/obscurants, day/night adverse weather environments, and under countermeasure (CM) conditions. Missile system performance (i.e., range, speed, lethality) must exceed current baseline systems.

Supports: Bradley, Follow-On-To-TOW(FOTT), Hellfire III, HWMMV, RAH–66 Comanche, and AH–64 Enhanced Apache.

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III.D.12—Advanced Helicopter Pilotage Phase I/II. Develop and demonstrate advanced night vision pilotage technology and revolutionary helmet-mounted display (HMDs) technology for night/adverse weather helicopter pilotage. By FY95, develop image intensified (I^2) sensor and fast (60 hertz (Hz)) focal plane array (FPA) for wide filed-of-view (FOV) forward-looking infrared (FLIR). By FY96, conduct flight demonstration and evaluation of sensor technology for wide FOV FLIR and I^2. By FY98, demonstrate ultra-wide FOV (40–80 degrees) night pilotage system—HMDs and dual-spectrum (IR and I^2) sensors in a single turret—to provide a significant reduction in pilot cognitive and physical work load.

Supports: MBS, D&SA, BC, and EELS Battle Labs; RAH–66 Comanche; Enhanced Apache; Special Operations Aircraft; and RPA ATD.

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III.D.13—Multispectral Countermeasures (MSCM) ATD. This project will demonstrate advances in laser technology, energy transmission, and jamming techniques for an all laser solution to infrared countermeasures (IRCM) and as a preplanned product improvement (P3I) to the Advanced Threat Infrared Countermeasure (ATIRCM) System/Common Missile Warning System (CMWS). These improvements will provide the capability to counter both present and future multicolor imaging FPA and nonimaging missile seekers. A tunable multiline laser with a fiber-optic transmission line and advanced detection and jamming algorithms will be live-fire tested using the ATIRCM testbed. The goal is a 4x reduction in laser jam head volume, 35 pounds in weight reduction, greater than 2x reduction in ATIRCM/CMWS power consumption, and a 6x improvement in jam-to-signal ratio. By FY97, complete module testing and evaluation of competitive solid state mid-IR laser technologies, initiate jamming algorithm enhancements, and fiber-optic coupling design. By FY98, integrate laser, fiber-optic coupler, tracker, and advanced jammer algorithms, and conduct distributed interactive simulation (DIS) using the Communications–Electronics Command (CECOM) Survivability Integration Laboratory (SIL) and the Fort Rucker cockpit testbed. By FY99, conduct live-fire cable car test and captive seeker tests to demonstrate a CM capability against advanced imaging IR missiles and other secondary threats to rotary-wing aircraft. Demonstrate antitank guided missile (ATGM) HTI to ground vehicles.

Supports: Air Maneuver, MBS, D&SA, and BC Battle Labs; PM–AEC Tri-Service ATIRCM/CMWS; PM–GSI Ground Combat Vehicle Multispectral Imagery (MSI) Warning and IRCM; and the proposed Integrated Situational Awareness and Countermeasures (ISACM) ATD.

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III.D.14—Air/Land Enhanced Reconnaissance and Targeting (ALERT) ATD. ALERT will demonstrate on-the-move (OTM), automatic aided target acquisition and enhanced identification via the use of a second-generation FLIR/multifunction laser sensor suite for application to future aviation assets, which do not have radar, and secondarily to ground assets. ALERT will leverage ongoing Air Force and Defense Advanced Research Proejcts Agency (DARPA) developments for search OTM automatic target recognition (ATR), including the use of temporal FLIR processing for moving target indicator (MTI). This approach will also enable application of the ATR capability to all weapons systems with integrated FLIR/laser sensors. The demonstration will be a real-time, fully operational flying testbed emulation of all modes of the basic RAH–66 target acquisition system. By FY98, collect OTM data for use in constructive and virtual simulation. By FY99, demonstrate baseline OTM performance using second-generation FLIR and standard rangefinding mode. By FY00, integrate laser range mapping capability to demonstrate OTM aided target acquisition with acceptable false alarms as a lower cost alternative to FLIR/radar fusion. By FY01, integrate laser profiling capability to demonstrate automatic acquisition and identification.

Supports: MBS, D&SA, BC, and EELS Battle Labs; RAH–66 Comanche; and AH–64C/D Apache.

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III.D.15—Low-Cost Precision Kill (LCPK) 2.75-Inch Guided Rocket. By the end of FY98, develop and demonstrate through HWIL simulation and captive field test using best available seeker/sensors, inertial instrumentation, controller characterizations, and launch platform integration technologies a low-cost, accurate (1-meter (m) Concept Experimentation Program (CEP)) G&C package concept for the 2.75-inch rocket that provides a standoff range, surgical strike capability against specified nontank point targets. This capability will provide for a high, single-shot probability of hit against long-range targets, exceeding the current unguided 2.75-inch rocket baseline by 1 or 2 orders of magnitude, thereby reducing the cost/kill, minimizing collateral damage, and greatly increasing the number of stowed kills. Fratricide will be reduced to a minimum by use of guidance techniques allowing post-launch adjustment of the rocket's point of impact. Low cost will be achieved by the combination of proven techniques with innovative sensor and control mechanizations and manufacturing processes to support a two-thirds reduction in manufacturing costs compared to current guided missiles.

Supports: EELS, D&SA, and CSS Battle Labs; Hydra–70 Improvement; Apache; Kiowa Warrior; Avenger; Bradley; SOF; and Rapid Force Projection Initiative (RFPI) ACTD.

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III.D.16—Rotary-Wing Structures Technology (RWST). By FY01, fabricate and demonstrate advanced lightweight, tailorable structures and ballistically tolerant airframe configurations that incorporate state of the art computer design / analysis techniques, improved test methods, and affordable fabrication processes. The technology objectives are to increase structural efficiency by 15%, improve structural loads prediction accuracy to 75% and reduce costs by 25% without adversely impacting airframe signature. By FY98, develop and demonstrate manufacturing process feedback algorithms to actively control the cure state of composite resins to reduce problems with porosity, degree of cure, and fiber volume fraction. By FY99, demonstrate fully composite primary structural joints to reduce the manufacturing labor for large composite components and increase the structural efficiency, and provide validated strength and fatigue life methodologies for rotorcraft composite structures. By FY00, demonstrate adaptive, out-of-autoclave tooling with preferential heating to optimize the cure cycle of cocured composite elements of highly variable thickness. Exploit emerging technologies in nondestructive inspection , miniature sensors for manufacturing process control, and modeling / virtual prototyping for reducing development time and cost.

Demonstrate by FY01, advanced airframe sections which are tailored for structural efficiency, affordable producibility, and field supportability. These goals support the systems payoffs of 55% increase in range or 36% increase in payload, 20% increase in reliability, 10% improvement in maintainability, 6% reduction in RDT&E costs, 15% reduction in procurement costs, and 5% reduction in O&S costs for utility type rotorcraft.

Supports: Primary emphasis provides technology options to the UH–60, AH–64, Improved Cargo Helicopter (ICH), RAH–66 & SOA upgrades, future air vehicles (Joint Transport Rotorcraft (JTR)), collaborative technology; and the Battle Lab FOCs (EEL, CSS, DSA, DBS and MTD). Contributes to RWV TDA objectives, goals, and payoffs.

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III.D.17—Advanced Rotorcraft Aeromechanics Technologies (ARCAT). By FY00, conduct research and development to achieve technical objectives by increasing maximum blade loading 8%, increasing rotor aerodynamic efficiency 3%, reducing aerodynamic adverse forces by 5%, reducing aircraft loads and vibration loads by 20%, reducing acoustic radiation by 4db, increasing inherent rotor lag damping 33%, and increasing rotorcraft aeromechanics predictive effectiveness to 65%. Results will be achieved by addressing technical barriers of airfoil stall, high unsteady airloads, blade-vortex interaction, highly interacting aerodynamics phenomena, complex aeroelastic and structural dynamics characteristics, and limited analytical prediction methods and design tools. Concepts include application of on-blade active control to increase rotor performance and aerodynamic efficiency, reduce BVI noise, blade loads and vehicle vibration at the source; optimizing the configuration geometry of the rotor blade and introducing advanced airfoil concepts to increase aerodynamic efficiency, and maximum blade loading; and vigorously integrating and validating advanced analytical tools such as CFD, finite element structural models, and advanced computational solution techniques to effectively advance rotorcraft aeromechanics technology. By FY97, exploit concepts for smart materials active on-blade aerodynamic controls. By FY98, simulate high-lift, low-energy, periodic-blowing airfoil design; evaluate practical Navier–Stokes CFD solver for rotorcraft interaction aerodynamics; and demonstrate model-scale, on-blade active control rotor concepts for reduced vibration and noise. By FY99, demonstrate integrated CFD / finite-element structures rotorcraft modeling. By FY00, demonstrate concepts towards elimination of conventional rotor lag dampers through the application of smart structures. Achievement of aeromechanics technology objectives will contribute to rotorcraft system payoffs in range, payload, cruise speed, maneuverability / agility, reliability, maintainability, and reduced RDT&E, procurement, and O&S costs.

Supports: RAH–66, AH–64, and Fielded System Upgrades, Next Generation Cargo Vehicles (Joint Transport Rotorcraft), collaborative technologies, and Battle Lab FOCs for EELS, CSS, D&SA, DBS and MTD Battle Labs. Contributes to RWV TDA objectives, goals, and payoffs.

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III.D.18—Subsystem Technology for Affordability and Supportability (STAS). Demonstrate subsystems technologies directly affecting the affordability and supportability of Army Aviation. Addresses technical barriers associated with advanced, digitized maintenance concepts, and real-time, on-board integrated diagnostics. The effort supports the advanced maintenance concept of "Digitized Aviation Logistics" to automate maintenance and move toward an integrated, digitized, maintenance information network. The expected benefits from this STO are reductions in Mean Time to Repair (MTTR), No Evidence of Failure (NEOF) removals, and spare parts consumption, resulting in overall reductions in system life cycle cost and enhanced mission effectiveness. Pursuits include on-board as well as ground-based hardware and software concepts designed to assist the maintainer in diagnosing system faults and recording and analyzing maintenance data and information. On-aircraft technologies will include advanced diagnostic sensors, signal processing algorithms, high-density storage, and intelligent decision aids. Ship-side diagnostic and maintenance actions will integrate laptop and body-worn electronic aids, advanced displays, knowledge-based software systems, personal viewing devices, voice recognition technologies, and telemaintenance network. By FY98, demonstrate seeded fault validation testing. By FY99, demonstrate Fuzzy Logic Fault Isolation technique aid. By FY00, demonstrate dynamic component fault detectors and virtual maintenance tool. Supports reduced MTTR across all systems by 15%, contributing directly to the rotary wing vehicle TDA goal of 25% reduction in maintenance costs per flight hour and payoffs of 10% improvement in maintainability, 20% increase in reliability, and 5% reduction in O&S costs.

Supports: AH–64, UH–60, RAH–66 upgrades; ICH and JTR developments; other service and civil rotorcraft fleet.

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III.D.19—Subsystem Technology for Infrared Reduction (STIRR). The focus of this STO is on the development, integration, and demonstration of improved Rotary Wing Vehicle (RWV) survivability through total aircraft thermal signature management. Technology objectives aimed at selectively reducing and balancing both the thermal emissions and engine / plume contributors to total aircraft IR signature are key components of this STO. Advances in infrared technologies that include the development of partial and full imaging capabilities on near-term threat missile systems, coupled with the proliferation of older yet still lethal surface-to-air missile systems have resulted in the need for a better equipped, lower IR signature aircraft. Concurrent with the increasingly lethal battlefield, today's fleet aircraft are assuming additional responsibilities that often result in additional on-board "heat-producing" equipment and greater engine power requirements.

Several technology initiatives have been identified as priorities based on current and expected future infrared advancements. By FY99, achieve development and measurement of advanced, multispectral (visual-through-far-IR) airframe coatings that are compatible with radar absorbing materials/structures, develop state-of-the-art, low-cost, lightweight thermal insulating materials,and conduct efforts to cool helicopter engine/plume. By FY00, advanced engine suppression concepts will be fabricated and demonstrated on both a subscale and full-scale level. Balanced thermal signature reduction will be achieved and demonstrated on an RWV by FY01. A goal of 35% reduction in aircraft IR signature is attainable and anticipated, which will support an RWV payoff of 40% increase in the probability of survival.

Supports: AH–64, UH–60, RAH–66 upgrades, ICH and JTR developments as well as other service aircraft.

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III.D.20p—Third-Generation Advanced Rotor Demonstration (3rd GARD). By FY04, develop and demonstrate the next generation rotor system to exploit the full potential of advanced blade configurations and active control systems. 3rd GARD will advance rotor concepts beyond current performance limits through high lift airfoils / devices, tailored planforms and tip shapes, elastic / dynamic tailoring, active on-blade control methods, and signature reduction techniques. These efforts will achieve technical objectives of increasing maximum blade loading 16%, increasing rotor aerodynamic efficiency 6%, reducing aircraft loads and vibration loads by 40%, and reducing acoustic radiation by 7db. By FY01, conduct advanced active control rotor design. By FY02, initiate test article fabrication. By FY03, complete test article structural tests, and initiate wind tunnel testing. By FY04, complete ground testing, and initiate flight test evaluation of technology. These goals contribute to the RWV TDA system level payoffs of 91% increase in range or 66% increase in payload, 6% increase in cruise speed, 65% increase in maneuverability / agility, 20% increase in reliability, and 21% reduction in O&S costs for attack rotorcraft.

Supports: RAH–66, AH–64, and Fielded System Upgrades, Next Generation Cargo Vehicles (Joint Transport Rotorcraft), collaborative technologies, and Battle Lab FOCs for EELS, CSS, D&SA, DBS and MTD Battle Labs. Contributes to RWV TDA objective, goals and payoffs.

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III.D.21p—Full-Spectrum Threat Protection (FSTP). By FY05, demonstrate on a fielded AH–64 Apache helicopter the synergistic benefits that can be obtained by integrating state-of-the-art technologies related to advanced active electronic warfare and decoy CM, advanced passive signature reduction technology and advanced air crew situational awareness and tactics. FSTP will capitalize on existing and in-process technical developments while identifying and pursuing advanced technologies necessary to support areas where advanced threat development is expected to surpass current capabilities. The primary challenge of this STO is to integrate active and passive CM that can produce a mission effective, survivable rotary wing vehicle that is both supportable and affordable. By FY02, select state-of-the art active/passive CM, aircrew situational awareness concepts and develop preliminary system design. By FY03, perform hardware fabrication and initial software development. By FY04, perform hot bench integration and subsystem flight test. By FY05, perform system flight test and simulation validation demo. FSTP will integrate passive features such as radar absorbing airframe and rotor structures, advance canopy and sensor window treatments, innovative IR suppressors, multispectral paints and coatings, lightweight insulative materials, and low glint canopy coatings along with the Advanced Threat Radar Jammer (ATRJ) and the Advanced Threat Infrared Countermeasure (ATIRCM) systems. These technologies will support achievement of the rotary wing 2005 TDA technology goals of a 40% reduction in radar cross section signature, a 50% reduction in infrared signature, and a 55% reduction in the visual/electro-optical signature. In turn, these will contribute to the system payoff of 60% increase in probability of survival. A 50% increase in active aircraft survivability equipment effectivenesss will also be achieved.

Supports: UH–60, AH–64, Improved Cargo Helicopter, and future Comanche upgrades and future systems, e.g., Joint Transport Rotorcraft (JTR). Supports MTD, DSA, EEL, CSS, and BC Battle Labs, and contributes to the RWV TDA objectives, goals and payoffs.

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III.D.22p—On-Board Integrated Diagnostic System (OBIDS). By FY04, demonstrate advanced diagnostics and prognostics on an operational helicopter with a high level of on-board systems integration to interface with the maintenance infrastructure. This program will highlight cost benefits and safety improvements. Systems assessments will include operational issues, training requirements and return on investment as well as expected maintainability and availability improvements. By FY00, initiate development contract. By FY01, complete preliminary and critical design reviews. By FY02, conduct aircraft modifications. By FY03, conduct safety of flight reviews, flight tests, and extended user operations. By FY04, reconfigure aircraft and issue final report. Key technologies will include failure detection, fault isolation and trending, performance and life use monitoring, condition based maintenance and prognostic methods. Related DoD initiatives include AI software, acoustic sensing, electronic devices and human–system interface. The improved diagnostics will affect No Evidence of Failure (NEOF) removals, false removals, flight mission aborts, flight safety, maintenance downtime, and availability. Logistics will be affected through spare management, engine R&R rates, soft Time Between Overhaul (TBO)/part life extension, and early corrosion and fatigue detection. A combination of DoD S&T, IR&D and commercial (NDI) technologies and products will be integrated for this technology demonstration.

Supports reduced maintenance logistics requirements by 15% or greater, contributing directly to Rotary Wing Vehicle TDA goal of 50% reduction in maintenance costs/flight-hour and payoffs of 20% improvements in maintainability, 45% increase in reliability, and 10% reduction in O&S costs.

Supports: AH–64, UH–60, RAH–66 upgrades; ICH and JTR developments; other service and civil rotorcraft fleet.

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III.D.23p—Hellfire III. By FY01 demonstrate an improved Hellfire missile, that remains compatible with current and future hellfire launchers, at a possible reduction in weight or cost. The Hellfire III missile must maintain laser-like precision strike capability while combining millimeter wave-like fire and forget capability at 8 km and in adverse weather/obscurants. The technology demonstration will utilize enhancements in propulsion, warhead, and aerodynamic technologies to allow missions to be performed at extended ranges (12 km), at reduced times of flight, and on a greater variety of target sets. These improvements to the Hellfire missile system will not adversely affect the operational effectiveness of the transit platform.

Supports: Hellfire III.

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III.D.24p—Low-Cost Precision Kill (LCPK). By 2001 develop and demonstrate innovative strapdown (nongimballed) seekers, miniature inertial devices, control systems, microprocessor and integration technologies to produce a low cost, accurate (1m CEP) G&C retrofit package for the 2.75 inch Hydra–70 rocket. This will provide a standoff range (>6 km) capability against specified nontank targets. In addition, a high single shot probability of hit (Phit >0.7) against the long range target will be achieved, exceeding the current unguided 2.75 inch rocket baseline by 1 to 2 orders of magnitude, and providing a 4 to 1 increase in stowed kills at 1/3 the cost per kill compared to current guided missiles. This will be accomplished through a set of 6.2 funded programs and 6.3 funded demonstrations to overcome barriers such as providing a low cost, produceable strapdown mechanism for precision guidance; considerations for guidance package retrofit to current 2.75 inch Hydra–70 rockets; and standoff range target acquisition and engagement techniques to address current free-rocket launch and flight dispersions.

Supports: Army Aviation, Apache AH–64.

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III.D.25—Automatic Target Recognition (ATR) for Weapons. Conventional weapon systems are looking to extend their range through various technology approaches to facilitate a more favorable loss—exchange ratio on the battlefield. The ATR for weapons effort will provide for effective weapon engagement against a widely dispersed threat within the context of the digital battlefield and demonstrate extended range capabilities for LOAL which will play a crucial role in future soldier/weapon platform survivability. ATR has the potential to provide the soldier with a weapon that has true LOAL fire and forget capability at extended ranges with the added benefits of reacquisition of targets after loss of lock, friendly avoidance, and optimum aim point selection for increased warhead effectiveness. Effort includes Tri-service and industry assessments to determine the optimum approach for the Army. By FY98, define concept approach and collect data on various sensors under consideration. By FY99, exchange and assess Army, Air Force and Navy approaches, develop additional hardware and algorithms as required. By FY00, tower test and captive carry demonstrations of hardware/algorithms in realistic battlefield environments to include smoke and countermeasures. By FY01, use collected data in flight simulations and performance assessments for applicability to relevant weapon systems.

Supports: Hellfire III, BAT P3I, MSTAR, EFOG–M, UAV, and extended range fire and forget which demands LOAL, UGV, Avenger, FOTT P^3I, Javelin, Stinger, FMTI.

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III.D.26—Airborne Manned/Unmanned System Technology (AMUST). Program Description: AMUST will evaluate the cooperative teaming of a manned helicopter with an Unmanned Aerial Vehicle (UAV) and the resulting gains in operational payoffs available to the Maneuver Commander in support of Vision XXI and the Army After Next Concepts. The effort completes the Air Maneuver Battlelab's Concept Experimentation Program for Manned and Unmanned Aerial Platform Operations on the Digitized Battlefield and will investigate a range of cost effective options for both ground and airborne control of the UAV, as well as sensor information availability as a function of mission scenarios and areas of operation (deep, close, urban), timelines, flight path G&C, airspace management, information fusion (onboard/offboard sensor data), spectrum management, and automation needs. AMUST will determine technical barriers associated with control of the UAV and sensors in the high workload environment of a manned helicopter and define the critical technologies for optimum manned/unmanned systems integration. AMUST will provide a 50% increase in survivability of the manned system, a 50% increase in aircraft lethality, and a real-time hunter-to-shooter capability. By FY98, determine AMUST scenario requirements, identify AMUST critical technologies and perform constructive simulations in an interactive environment. By FY99, continue technology investigations/optimizations and virtual simulations in an interactive environment. AMUST technology will have applications to the teaming of ground manned systems and Unmanned Ground Vehicles (UGVs) as well as ground manned systems with UAVs.

Supports: AH–64, RAH–66 upgrades; UAV Joint Program Office (JPO) developments; Air Maneuver Battle Lab Concept Experimentation Program (CEP); Depth and Simultaneous Attack (DSA), Mounted Maneuver Battlespace, Early Entry Lethality and Survivability, and Maneuver Support Battle Labs and other Services.

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III.D.27p—Low-Cost Aviator's Imaging Multispectral Modular Sensors. By FY02, develop and demonstrate multispectral pilotage sensors that leverage state-of-the-art technologies for sensors and displays, including FLIR, Image Intensifier, Obstacle Detection sensors, and wide field-of-view (40° x 90°) optics. The program will develop a core suite of modules with high resolution performance and low-light level capabilities required for pilotage sensors to achieve HTI across the aviation fleet to include Attack, Reconnaissance, utility, and cargo aircraft. The approach will improve aviators Safety-of-Flight, situational awareness, and pilotage capabilities under night battlefield, adverse weather, and MOUT conditions.

Supports: Attack, Reconnaissance, Utility/Cargo aircraft, Air Warrior, Mounted Battlespace.

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III.D.28—Integrated Sensors and Targeting. Integrated Sensors and Targeting will demonstrate enhanced hostile situation awareness, target acquisition, precision threat geolocation, and combat ID assist using information derived from Army aircraft and ground vehicle radio frequency (RF), missile, and laser warning sensors. To accomplish this objective, the AN/ALQ–211, AN/ALQ–212, and AVR–2A threat warning sensors will be upgraded to provide a 10X improvement in target acquisition and geolocation to an accuracy of 100 meters at 10 kilometers. Fusion of preflight and real time C^3I links with onboard emitter fingerprinting will provide enhanced combat ID assist for weapons release at maximum ranges. Real time bidirectional C^3I feeds to the digitized battlefield will provide ground commanders and vehicles with targeting feeds from Longbow Apache equipped with the AN/ALQ–211. Off axis laser detection will provide ability to locate and destroy laser designators. By FY99, demonstrate integration of digital and hardware-in-the-loop (HITL) models into the CECOM Survivability Integration Lab (SIL)/Digital Integration Laboratory (DIL). FY00, conduct real time DIS experiments with Fort Rucker's Cockpit simulator, Ft. Knox's Mounted Test Bed, and Ft. Sill's Targeting Test Bed that focus in on real time adjustments for operations OTM. FY01 conduct real time interactive Air/Ground cockpit digital modeling and simulation, hardware in the loop SIL testing. FY02 flight and ground vehicle testing, final report, transition to PM–AEC's Future Technology Program plus Common Air/Ground Electronic Combat Suite Demo. Note: This program has been staffed, with the support of the PM–AEC, by OSD as part of a cooperative EW Project Arrangement with the government of Australia.

Supports: PM–AECs Future Technologies Upgrade program for the AN/ALQ–211, AN/ALQ–212 and AVR–2A, PEO–IEW family of Shortstop, Common Air/Ground Electronic Combat Suite Demo. Air Maneuver Battle Lab, Dismounted Battlespace, Mounted Battlespace, Depth & Simultaneous Attack, Battle Command, Full Spectrum Protection ATD, PM–GSI GVC and ADS programs.

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III.D.29—Integrated Countermeasures. Integrated CM will demonstrate new multispectral radio frequency (RF), infrared (IR) and electro-optics (EO) CM techniques and device upgrades that will provide Army aviation and ground vehicles with full dimensional protection to enable dominate maneuver on the battlefield. The AN/ALQ–211 and AN/ALQ–212 PM–AEC systems will be upgraded with advanced jamming modulators and algorithms to provide a family of configurable air and ground vehicle CM modules. This program will provide CM that provide greater than a 99% probability of survival per mission to multisensor IR/EO/RF and laser homing missiles, ATGMs and top attack smart munitions. This program will demonstrate a 50% reduction in installed sensor and A-kit weight and a 200% increase in MTBF, a fiber optic remoted low cross section RF antennas/transmitters. By FY99, demonstrate integration of digital and hardware-in-the-loop (HITL) jamming effectivity models of advanced imaging IR SAMs and double digit RF SAM system, under development by MSIC, into the CECOM Survivability Integration Lab (SIL)/Digital Integration Laboratory (DIL). FY00, DSI integration of AATD's signature models into both CECOM's, Fort Rucker's Cockpit simulator, and Ft. Knox's Mounted Test Bed. FY01 conduct real time interactive Air/Ground cockpit digital modeling and simulation, hardware in the loop SIL testing. FY02 flight and ground vehicle testing, final report, transition to PM–AEC's AN/ALQ–211 and AN/ALQ–212 EMD update program plus Common Air/Ground Electronic Combat Suite Demo.

Supports: PM–AEC's Future Technologies Upgrade program for the AN/ALQ–211, AN/ALQ–212, and AVR–2A, PEO–IEW family of Shortstop, Common Air/Ground Electronic Combat Suite Demo. Air Maneuver Battle Lab, Dismounted Battlespace, Mounted Battlespace, Depth & Simultaneous Attack, Battle Command, Full Spectrum Protection TD, PM–GSI GVC and ADS programs.

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COMMAND, CONTROL, COMMUNICATIONS, AND COMPUTERS (Section E)

III.E.01—Joint Speakeasy—Multiband Multimode Radio (MBMMR). Joint Service R&D program to develop the architecture and technology for the objective MBMMR of the future, meeting the requirements of the Army MNS for the Future Digital Radio (FDR). The Phase I SPEAKeasy Advanced Development Models (ADM's) proved the feasibility of a programmable MBMMR. Phase 2 of the SPEAKeasy program, initiated in June 1995, will develop the final MBMMR "open system architecture" and ADM's providing a software re-reprogrammable, simultaneous 4-channel, multiband, multiwaveform capability. The reprogrammability will allow rapid change-over of waveforms, frequency bands (2-2000 MHz), internetworking protocols (cross-channel), voice/data modes, and INFOSEC algorithms (4-channel). In FY97, two Model–1 ADMs will be fabricated and demonstrated during the Task Force XXI AWE. In FY98, three Model–2 ADMs will be fabricated and integrated into an Army Command and Control Vehicle (C^2V) for participation in a C^2V communications field demonstration. Six full capability ADMs will be delivered in FY99 for demonstration in the DBC/RAP ATD. Waveforms to be implemented include SINCGARS SIP, EPLRS VHSIC, UHF SATCOM DAMA, Packet Data Waveform, HaveQuick I/II, LPI, T1, GPS, cellular phone, and HF SSB, AME, ALE, serial modem, and hopping antijam. The Near Term Digital Radio (NTDR) waveform will be implemented when available. 4-channel internetworking will also provide compatibility with TMG and INC. The "open system architecture" will be industry releasable, modular by function, and facilitate a large reduction in future ILS life cycle costs. In order to facilitate easy insertion of the SPEAKeasy MBMMR into current communications, the Model–2 and Model–3 ADM physical form-factors shall conform to the present vehicular SINCGARS SIP volume and mounting footprint. Results of this effort will transition to PEO–C^3S in the FY99/00 time frame.

Supports: All emerging C^3 architectures for "Digitizing the Battlefield," DBC/RAP ATD, Future Digital Radio.

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III.E.06—Battlespace Command and Control (BC^2) ATD. The STO objectives are to demonstrate, through simulation and experimentation with the user, a Command and Control & Battlefield Visualization (BV) Commander/Staff Workstation to support Consistent Battlespace Understanding; Forecasting, Planning and Resource Allocation; and Integrated Force Management for the Commander and Staff. The BC^2–ATD will develop and model the architectural basis for information transfer to/from higher/lower echelons including interfaces to Joint and Coalition forces to support worldwide, split-based military operations. BC^2 ATD will utilize the concepts and results of Staff XXI simulations (Prairie Warrior, etc.) to establish and refine systems requirements for C^2 and information visualization and its supporting systems architecture. Alternative technology based solutions will be evaluated through modeling and simulation. BC^2 uses knowledge based technologies (advanced decision aids, 3D visualization, distributed and shared databases, etc.) to provide faster, more accurate, and more tailorable battlespace information for commanders to assess combat situations. The objectives are to provide software applications on ABCS Systems (MCS/FBCB^2), and Systems/Operational Architectures which will reduce reaction/decision times, reduce the time from mission to order preparation, and increase the number of combat options evaluated. Demonstrations focus on multiechelon (Battalion through Division) Commander's and Staff's C^2/BV needs within a command post environment (BCV, C^{2}V, TOCs, etc.) as defined by Battlelabs (BCBL, MMBL, and DBBL). BC^2 will conduct prototype demonstrations, integrated into the system architecture of the various host experiments. By FY98, BC^2 will demonstrate an initial C^2/BV product containing database and decision aids. In addition, BC^2 will provide C^2/BV applications to the Rapid Terrain Visualization ACTD. In FY99, BC^2 will demonstrate prototype Commander's/Staff's visualization, planning and rehearsal aids within a command post environment. In FY00, BC^2 will demonstrate an enhanced version of the Commander's/Staff's C^2/BV Software Tool Set resident on COTS hardware, which will utilize advanced decision aids, battlefield visualization products, and advanced database technologies showing interoperability with allied assets.

Supports: Digitized Battlefield, ABCS, Force XXI, Intel XXI, Battlefield Visualization, Div XXI, Staff XXI, BCV/C^{2}V, Rapid Terrain Visualization ACTD, Battlefield Awareness Data Dissemination ACTD.

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III.E.07—Battlefield Combat Identification (BCID) ATD. This ATD is aimed at solving the combat identification (ID) problem underscored by the lessons learned from Operation Desert Storm. The effort will build upon the Battlefield Combat Identification System (BCIS), which is a millimeter wave question and answer, target ID system developed for ground vehicle platforms. This ATD forms the technical foundation for the FY96 start Combat Identification ACTD, which will demonstrate an integrated ground-to-ground and air-to-ground combat ID capability. An enhanced version of BCIS with digital datalink for improved situational awareness and various air-to-ground concepts including direct sensing Target ID, Don't Shoot Me Net and Situational Awareness Through Sight approaches will be investigated and selected concepts will be demonstrated in the Force XXI Brigade exercise in FY97 and in other field exercises to support a milestone decision in FY98. Probability of correct ID of 99% to 1.5X the effective range of the weapon, and position location accuracy of 100 meters or better will be demonstrated. In FY98, the ATD will demonstrate through sight concepts that integrate enhanced friendly and hostile ID. Additionally, concepts for lightweight combat identification of and for the dismounted soldier will be investigated for different mission areas in BLWEs during FY95–98. Laser ,radio frequency and thermal based solutions for the soldier-to-soldier and potentially vehicle interoperable application will be demonstrated in both a standalone version and as an integrated function in the Land Warrior equipment suite to support a milestone decision in FY97.

Supports: BCIS, Land Warrior, Protecting the Force, Digitizing the Battlefield, Winning the Information War.

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III.E.08—Aviation Integration Into the Digitized Battlefield. Develop pilotage algorithms and platform integration concepts for application onboard Army aircraft to enable avionics integration into the digitized battlefield. Develop a software algorithm that derives flight path guidance information from digitized topographic and threat data, precision navigation data, near field sensed obstacle and wire data, and aircraft survivability equipment data. Provide highly accurate robust worldwide positioning through GPS enhancements, advanced navigation sensors, and digital databases using advanced algorithms and integration concepts. Stringent performance levels are required to support precision navigation for advanced flight path guidance and situation awareness. Maximum utility of current GPS systems while conducting nap-of-the-earth flight and precision approach/landing will be investigated. Precision Navigation, integrated with a high integrity digital terrain database, provides the capability required to navigate in the digitized battlefield. By FY96, demonstrate flight path guidance based on digitized C^2 information and realtime updates from onboard sensors. By FY97, demonstrate improved GPS vulnerability reduction methods such as satellite selection algorithms for NOE and Low Level operations, robust integrated navigation concepts, and improved signal acquisition technology. By FY98, demonstrate platform positioning accurate to 1–3 meters to enhance situation awareness, in all environments (ECM, NOE). These errors include registration errors between the mapping database and GPS positioning.

Supports: Digitization of the Battlefield, Battlespace C^2, NAV WARFARE ACTD, Precision Strike, RPA, Comanche, PEO Aviation, PEO CCS PEO IEW, PM AEC, PM GPS, PM ATC, Advanced Capabilities and System Upgrades for Soldier, Ground and Air Vehicles, Comanche.

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III.E.09—Digital Battlefield Communications ATD. This ATD will exploit emerging commercial communications technologies to support multimedia communications in a highly mobile dynamic battlefield environment. It will supplement and in some cases replace, "legacy" military communications systems, which are unable to keep pace with the rapidly increasing demand for communications bandwidth and global coverage in support of Digitized Battlefield and split-based operations. It will evolve an integrated communication infrastructure that utilizes commercial protocols and standards to achieve global interoperability. In FY95 NDI wideband data radios were evaluated and procured for testing in TFXXI. In FY96 commercial ATM technology was integrated into tactical communications networks to provide "bandwidth on demand" to support multimedia information requirements. BCBL(G) will be supported in the DBC ATM experimentation through DS–3 connection to other service labs from FY96–99. In FY96 and 97 this program demonstrated Direct Broadcast Satellite technology in support of JWID 96 and TFXXI AWE FY97. In FY97 Multi-Level Security requirements were addressed by the insertion of TEED hardware into TFXXI. Wideband HF technology will be evaluated, tested in the CECOM DIL and inserted into the tactical internet. Leveraging from supporting 6.2 technology base programs, low profile SATCOM antenna technology products for both military (UHF, SHF) and commercial (C, Ku, X) SATCOM OTM from tactical vehicles, will be demonstrated in FY96 and 97. By FY99, an integrated phased array antenna will be demonstrated for the RAP. Work will continue on a full sized phased array antenna to address multibeam satellite and terrestrial high data rate communications OTM throughout FY99. Commercial terrestrial PCS will be demonstrated in FY97 and 98, respectively, to exploit commercial CDMA technology for WIN POC access. In order to extend ATM services to forward tactical units, a Radio Access Point (RAP) will be prototyped and tested in FY98. The RAP utilizes a high capacity OTM trunk radio to feed a variety of mobile subscriber services. By FY98, both manned and unmanned aerial platforms will be fitted with wideband relay packages to support OTM tactical operations, supporting bandwidths of up to 15 Mbps. This effort will be coordinated with, and executed in conjunction with DARO. Applicable products found to be acceptable through our commercial communications technology laboratory (C^2TL) program, and evaluated jointly with TRADOC battle labs, will be inserted into the DBC program. This ATD will conclude in FY99 with the insertion of appropriate technology products in JWID 99 in support of high capacity digitized communications and split-based operations.

Supports: PM JTACS Tactical Multinet Gateway, ISYSCON, Task Force XXI, Future Digital Radio (FDR), CGS ATD (Advanced Antenna Technology), PROTEUS, JADE, JWID 94, DIV XXI, Corps XXI0.

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III.E.10—Range Extension. The primary objective is to develop a Super High Frequency (SHF) tactical, UAV based surrogate satellite capability by integrating several technologies in a range extension testbed and leveraging the UAV airborne communications relay digitital battlefield communications ATD development. It will identify and develop key technologies required for airborne applications of a suite of communications packages, designing and integrating specific systems, and conducting system tests and demonstrations. This will be used to demonstrate intra-theatre communications range extension up to 400 miles (Range heavily dependent on terrain factors and look angle) at a variety of data rates. Major technology areas to be addressed are: airborne payload (including antennas) designs, ground terminal adaptations, interoperability/compatibility and simulation. These technologies will be used to supplement current (and programmed) SATCOM resources providing the flexibility to support a broad range of general and mission specific applications. SATCOM terminals will be augmented and enhanced to provide the capability of communicating via satellite and/or airborne platforms. Additionally, the utility of SATCOM terminals will be extended by improvements to reduce size and weight, increasing throughput and mobility and implementing emerging techniques such as DAMA. System design will be supported by enhancing CECOM's in-house satellite link analysis (SATLAB) capability and a Communications Range Extension Testbed will be developed to provide an adaptable testing environment. Major milestones include development of the Range Extension Test Bed in FY96, demonstration of the SHF Airborne Relay UAV based Surrogate Satellite System in FY97, development of an on-board switching capability and implementation of an airborne battlefield paging system by FY99.

Supports: Army C^4 Modernization, Digital Battlefield Communications, JPO UAV TIER II Program, DARPA ACN Program, Joint Precision Strike (JPS).

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III.E.11—Army Communications Integration and Cosite Mitigation. The objective of this STO is to reduce the size, weight, and cosite interference problems that occur when multiple radios in either the same or dissimilar frequency bands are integrated within a mobile communications command post platform. Solutions derived from this STO will be applicable to Army platforms within the Rapid Force Projection Initiative Light Digital Tactical Operations Center (RFPI LD TOC) and other Army platforms including the Command and Control Vehicle (C^2V), the Battle Command Vehicle (BCV), the Common Ground Station (CGS), and future systems utilizing the multiband/waveform Future Digital Radio (FDR). Technology from the current SPEAKeasy Multiband Multimode Radio (MBMMR) development effort and Antennas Across the Communications Spectrum (A^2CS) STO will be coupled with new CICM STO efforts to address the size/weight problem of multiple radio systems within the continuous frequency band from 2 MHz to 2 GHz, and the cosite interference problem in the VHF and UHF bands. New CICM STO efforts include the development of a VHF/UHF 6-port multiplexer utilizing cosite mitigation technology, a wideband (2 MHz to 2 GHz) linear power amplifier and enhancements internal to the Future Digital Radio (FDR) MBMMR to improve cosite performance. An initial demonstration will be conducted with SPEAKeasy ADM and the VHF/UHF 6-port multiplexer as part of the LD TOC exercise beginning July FY98. Wideband and multiband antennas developed under the A^2CS STO will also be utilized within the exercise. Development of the wideband power amplifier and MBMMR cosite enhancements will be completed in FY00. Additionally, a multiband communications system will be integrated within a typical Army SICPS shelter mounted on a HMMWV and tests will be performed to evaluate the resultant performance and enhancements. This testbed shall be exercised throughout the FY99–FY01 period, for evaluation of the individually developed items. A final field demonstration and evaluation of all the developed items, plus the MBMMR/FDR and A^2CS STO, will be performed in late FY01 Products will also be integrated into the Battlespace Command Platform for complete platform integration. These efforts are considered a natural extension of the size reduction and waveform reconfigurability goals of the Joint SPEAKeasy Multiband Multimode Radio (MBMMR) program.

Supports: All mobile multiband communications systems, e.g., C^2V, BCV, CGS, RAP, FDR, LD TOC, etc., and feeds the new Battlespace Command Platforms STO.

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III.E.12p—Universal Transaction Services. The goal is to provide seamless connectivity and integration across communications media resulting in the commander having the ability to exchange and understand information unimpeded by differences in connectivity, processing, or systems interface characteristics. Provides the ability to move information from wherever it exists, in whatever form it exists to wherever it is needed in whatever form it is needed. In particular, the following attributes should be able to be developed and demonstrated. (1) Automated interfaces for determining the necessary translations that need to be applied at network nodes where interfaces occur between systems of differing characteristics. (2) Techniques for enhancing the commercially available signal conditioning and for introducing automated brokering of user preferences (profiles) and network characteristics to determine the appropriate type of conditioning. (3) Provision of dynamic profiles and adaptive conditioning in gateways to the tactical extension networks. (4) Automatic, adaptive addressing to allow connections to be made to users completely independent of any knowledge of his location. In FY00, initiate development of automated interfaces and translators. In FY01, develop techniques for enhancing commercial signal conditioning. In FY02, demonstrate adaptive conditioning in gateways to the tactical extension networks. In FY03, demonstrate adaptive addressing to allow connections to users completely independent of knowledge of his location.

Supports: All tactical communications and the tactical internet.

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INTELLIGENCE AND ELECTRONIC WARFARE (Section F)

III.F.04—Orion. By FY98, demonstrate the operational effectiveness of a wide bandwidth SIGINT Electronic Support (ES) package on a Short-range UAV platform operating in conjunction with a ground-based IEW Common Sensor (IEWCS) that receives the UAV ES detected signals and performs the intercept/processing tasks to locate high value targets. Thus by virtue of the UAV platform, the IEWCS capabilities are vastly increased by allowing penetration of the enemy's communications space to detect even low signal levels from directional systems such as multichannel and down-hill comms. Line-of-sight restrictions, mobility restrictions, sensor placement problems and interference problems from our own close-in relatively high power signals are eliminated and by being in the threat's communications space the CEP for target location improves significantly with advanced algorithms.

Supports: UAV–Short Range, UAV–JPO, IEWCS, CGS, GRCS, BCBL(H), BCBL(G), EELS BL, D&SA, MBS BL.

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III.F.05—Tactical Intelligence Data Fusion. Develop and integrate enhanced MI collection and asset management tools, terrain reasoning tools, multiple source correlation and fusion tools, enhanced information dissemination tools and techniques, and Battle Damage Assessment (BDA) tools and techniques. Use simulation to evaluate using non conventional sources to gather intelligence. Demonstrate by FY96 enhanced multimedia database interface/sharing techniques to support information dissemination. Demonstrate by FY97 enhanced IEW asset management and Intelligence Preparation of the Battlefield (IPB) tools and techniques. Demonstrate by FY98 multiple source fusion using terrain reasoning tool and techniques, and Moving Target Indicator (MTI) automatic tracking. Demonstrate in FY99 advanced airborne planning algorithms and effectiveness tools utilizing IEWCS and integrate in IEWCS multisensor tasking and reporting tools using database to database interfaces. Evaluate the use of information from Airborne Survivability Equipment to enhance intelligence. In FY00, integrate SIGINT/MTI sensor cross-cueing and situation displays with previously developed FY98 techniques into IEWCS and ASAS.

Supports: ASAS, IEWCS, CGS, BCBL(H), DSABL.

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III.F.06—Multimission/Common Module Unmanned Aerial Vehicle Sensors. Multimission/common modular sensor suite for UAV applications will demonstrate an affordable family of rapidly interchangeable EO/IR multispectral and lightweight MTI Radar/ SAR payloads for future tactical or short range UAVs. These common modular payloads will be form/fit/interface compatible and share common electronics, datalink, and data compression. The radar payload will build upon successes in the current low-cost radar development program. The EO payload will leverage results of the ASSI program. The sensors will connect to Army TOCs via DARO's Low Cost Common Datalink (LCCDL). The LCCDL is currently used to deliver IMINT that is processed by DARPA's Semiautomated Image Processing (SAIP) capability. These advanced sensor payloads will provide enhanced reconnaissance, surveillance, battle damage assessment, and targeting for non-line-of-sight weapons. By FY97, mission requirements, payload constraints and common modular interfaces will be determined. By FY98, candidate sensors and signal processor selected and development initiated. By FY99, complete sensor development and payload integration, and initiate captive flight tests. By FY00, complete performance testing and operational demonstration in support of early entry, deep attack, mine detection and non-line-of-sight masked targeting mission scenarios.

Supports: , Tactical UAV, UAV JPO, DARO, DARPA.

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III.F.07—Digital Communications Electronic Attack (Classified). Provide the capability to intercept and bring under electronic attack advanced communications signals being used by adversarial command and control networks on the digital battlefield. Through electronic attack strategies demonstrated with prototype hardware and software, these digital communication signals will be disrupted, denied, and/or modified to render the communications system ineffective and unreliable to the threat command and control function. By FY97, demonstrate electronic attack against the digital formats being implemented in commercial communications systems, data transmission systems implemented by a variety of modern technologies, and wide bandwidth communications. In FY99, demonstrate the ability to disrupt other commercial communication networks. These communications systems in use today are being further technologically developed and are recognized as threat capabilities that will have to be faced in future conflicts. These Electronic Attack capabilities developed in parallel with advanced receiver technology upgrades for the IEWCS will provide the commander the ability to dominate the control the modern digital communications spectrum. It will enable the force to wage aggressive offensive information warfare. These efforts will be coupled with Battle Lab experiments and AWE opportunities.

Supports: IEWCS, ORION, ACS, BCBL(H), BCBL(G), BCBL(L), EELS BL.

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III.F.08—Rapid Terrain Visualization (RTV) ACTD. The objective of the Rapid Terrain Visualization (RTV) Advanced Concept Technology Demonstration (ACTD) is to integrate and demonstrate capabilities to rapidly collect and process: 1) high resolution digital terrain elevation data needed to accurately represent the 3D battlefield; 2) basic feature data such as roads, rivers and vegetation required for military planning and analysis; and 3) corresponding high resolution imagery for photo-realism. These products provide the foundation to support a wide range of Army operations, including rapid response and force projection. The Army Training and Doctrine Command has identified an operational requirement to generate and deliver these digital terrain products more rapidly: data coverage for a 20x20 km-square area within 18 hours, 90x90 km-square area within 72 hours, and 300x300 km-square area within 12 days. The Department of Defense (DoD) does not currently have the ability to rapidly collect and exploit these critical digital topographic products. The RTV ACTD will demonstrate an infrastructure to collect, develop, and provide digital topographic data more rapidly to support military operations anywhere in the world; specifically, the ACTD will demonstrate these capabilities for a 90 km x 90 km area within 72 hours. An operational testbed will be established with the XVIII Corps at Ft. Bragg, North Carolina, to demonstrate these capabilities in Army Advanced Warfighting Exercises. Specific capabilities with significant military value to other Army and Joint units can be provided to those units for additional evaluations. Leave-behind capabilities will be provided to the XVIII Corps beginning in FY 99 and supported through FY01.

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III.F.09—Tactical Command and Control (C^2) Protect ATD. The Tactical C^2 Protect ATD will demonstrate the ability to protect the Army's tactical information systems, components and data from modern network attacks. This ATD will leverage existing commercial off the shelf, and Department of Defense programs that target network security technology. The approach will be to develop tactical network protection and assessment capabilities, then use the assessment techniques against the protection mechanisms to determine the effectiveness of both. The knowledge gained developing assessment capabilities will also provide effective C^2 attack techniques against threat Integrated Battlefield Area Communications Systems (IBACS). The seamless security architecture developed will be an integrated solution which provides advanced network access control, intrusion detection, and response mechanisms within tactical communications networks. Advanced RF and wire based C^2 Attack techniques will be employed to demonstrate the effectiveness of protective mechanisms implemented as part of the ATD. By FY98, a security architecture for the Army's TI will be developed as a recommendation for the 1st Digitized Division. The initial assessment capabilities will be developed and evaluated in the DIL. By FY99, the existing security architecture will be evaluated using the assessment capability developed. By FY00, the security architecture will be extended to include MSE. A field test/demonstration will be conducted for RF attack against threat information systems. By FY01, the improved protect and assessment capabilities will be evaluated against each other. By FY02, the security architecture will be revised and extended down to include SUO. An integrated capability for launching RF and wire based attacks of threat tactical systems will be demonstrated, and tactics, techniques and procedures shall be developed for field IEW systems.

Supports: PROTECT: Tactical Internet, MSE, BCBL(L), BCBL(G), PEO C^3S.

ATTACK: Intercept, location, and electronic attack of modern digital C^2 systems, BCBL(L), BCBL(H), PEO IEW.

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III.F.10p—Modern Command and Control (C^2) Attack. By FY03, provide the Joint Warfighter with the capability to selectively influence an adversary's use of, or confidence in, information, processes, and systems through the use of offensive deceptive IW to manipulate the information or information sources which support them. By FY04, provide the capability to selectively destroy an adversary's information, information processes, and systems through the application of offensive weapons that destroy the information or the capability to use, transport, collect or access it.

Supports: IEWCS, BCBL(H), BCBL(L), BCBL(G), EELS BL, D&SA, MBS BL.

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III.F.11—Theater Precision Strike Operations (TPSO) ACTD. The TPSO ACTD will develop and demonstrate a significantly improved capability to synchronize, coordinate, deconflict, and employ the deep strike assets of the Joint Force Land Component Commander (JFLCC) with joint and coalition assets between the Forward Line of Own Troops (FLOT) and the Forward Boundary (FB). This effort will develop a theater Enhanced Deep Operations Coordination Center (EDOCC) with enhanced C^4I and strike planning processes to include Army Tactical Command and Control System (ATCCS) systems enhancements, Global Command and Control System (GCCS) integration, visualization tools, and connectivity with coalition forces. Using the capabilities within his DOCC, the JFLCC will be able to better use existing systems such as Multiple Launch Rocket System (MLRS), Army Tactical Missile System (TACMS), Predator, and Close Air Support and advanced systems such as Guided MLRS, MLRS Smart Tactical Rocket, Navy TACMS and powered submunitions. The ACTD will culminate in a FY01 OCONUS exercise in a Korean scenario that explores the transition from an unreinforced to a reinforced battle. New concepts demonstrated should allow the JFLCC to defeat 50% more threat targets in the first 24 hours than the current capability. Candidate residuals that will permit this improvement include networking US and ROK Firefinders, acoustic sensors, GCCS integration, ATCCS enhancements, and planning software.

Supports: CINCUNC/CFC, Depth and Simultaneous Attack Battle Lab.

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MOUNTED FORCES (Section G)

III.G.01—Composite Armored Vehicle (CAV) ATD. By FY98, demonstrate the feasibility of a composite structure and advanced armor solution for a 17–22 ton air-transportable vehicle weighing at least 33 percent less than an aluminum based structure and armor of equal protection level. In addition, demonstrate manufacturability, repairability, durability, and large section cutouts/joining of composites as well as integration of signature management. Assess affordability of composite structures for ground combat vehicle applications. By FY96, complete designs of an advanced composite structure with integrated signature management and advanced armor for application to all future lightweight ground combat vehicles. Complete fabrication and assembly of CAV composite hull structure in FY97. Full-up automotive subsystems to be outfitted, and CAV ATD delivered Feb 97. Durability/User evaluations 4Q97–4Q98.

Supports: FCS, FIV, FSV, Crusader, FSCS ATD.

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III.G.08—Target Acquisition ATD. Develop and demonstrate an extended range, multisensor target acquisition suite for combat and tactical vehicles. The multisensor suite will consist of a second generation thermal imaging sight with automated search and aided target recognition, a low cost MTI radar (growth to STI), and a multifunction laser. These enhanced target acquisition capabilities will be coupled with combat identification technologies to significantly improve the light armored combat vehicles' lethality and survivability. By FY97, demonstrate "target finder" capability—multifunction laser and auto target cuer—as a potential fast track acquisition upgrade for Abrams/Bradley and extended range cueing with a millimeter wave ground radar. These capabilities will extend identification range from 2100m to 3500m for exposed targets and from 1200m to 3000m for partially obscured targets. By FY98, demonstrate gimbal scan and automation to reduce search timelines by 60%–80% over manual search and streamline crew workload for future main battle tanks.

Supports: Abrams M1A2 SEP , Bradley upgrades, Advanced Tank Technologies ATD, AGS Upgrades, RFPI, FMBT, Future Scout Vehicle.

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III.G.10—Direct Fire Lethality ATD. This STO focuses on enhancing the hit and kill capability of the Abrams Tank against explosive reactive armor protected threats in both stationary and moving firing conditions. The STO consists of two major elements: an Advanced Kinetic Energy Cartridge, and Advanced Drives and Weapon Stabilization. In FY97, demonstrate 120mm KE novel penetrator to defeat the 2005 Explosive Reactive Armor (ERA) projected threat with an increase of 40% in lethality over the M829A2, and conclude and transition STAFF dual-liner design/test data to follow-on antiarmor programs; In FY98, demonstrate axial thruster function and feasibility to compensate a kinetic energy penetrator aerodynamic jump error, and conduct a hardstand dynamic demonstration of an Electric Direct Turret Azimuth Drive (gearless) technology. In FY99, complete design and initiate fabrication of the gun elevation drive and the optical fiber muzzle reference sensor. In FY00, demonstrate novel penetrator lethality up to 70% greater than the M829A2. In FY01, demonstrate radial thruster capability to correct for multiple jump errors in achieving 30–70% increase in system accuracy; conduct hardstand demonstration of gearless gun elevation drive and optical fiber muzzle reference sensor capability to continuously measure muzzle position. Also in FY01, conduct an integrated 120mm KE cartridge to defeat the 2005 ERA protected threat with up to 70% increase in lethality over the M829A2 and 30–70% increase in system accuracy under stationary conditions over the M829A2/M1A2, and demonstrate up to a 300% increase (at 3 km) in probability of hit over the M1A2 under dynamic scenarios using Gearless Turret/Gun Direct Drives, Modern Digital Servo Control, and optical fiber muzzle reference sensor. (Note: The Advanced KE Cartridge Program is a joint effort with PM–TMAS. The PM will provide $1.0M in FY98, $3.0M in FY99, and $2.0M in FY00 and FY01 to support novel penetrator development.)

Supports: All antiarmor weapon systems and weapon platforms: 120mm tank munitions (KE, CE), M1A1, M1A2, M1A2 SEP+, Future Combat System, etc. USAARMC & Mounted BL.

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III.G.11—Ground Propulsion and Mobility. By FY01, demonstrate the combined enhancements of semiactive suspension, band track, and electric drive on a Future Scout and Cavalry System (FSCS) weight class vehicle. Semiactive suspension will reduce the overall vehicle weight, decrease the "under armor" volume, and improve mobility by 30% over the M2. Band track will reduce acoustic and IR signatures (30–50%), decrease track weight 23% compared to M2, and increase soft-soil mobility. The electric drive program will drastically reduce acoustic and IR signatures and provide the power management scheme for other future electric devices (e.g., electric armament, sensors, active suspension). By FY98, demonstrate semiactive suspension on a Bradley weight class vehicle. By FY99, demonstrate band track on a 28 ton vehicle. This STO leverages DARPA's Electric Vehicle Power programs, and the Army will continue to contribute $1M per year in FY 98 and 99 to the DARPA programs.

Supports: FSCS, FIV, Bradley Fighting Vehicle, M113 FOV.

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III.G.12—Intravehicle Electronics Suite TD. By FY00, develop the crew interface and vehicle architecture for the Future Scout and Cavalry System (FSCS) ATD. This STO will demonstrate a 25% increase in overall crew efficiency, a 25% reduction in crew size, 25% increase in system performance, and reduce the cost ratio of electronics and software upgrades for system upgrades by 30%. Significant challenges to meeting crew efficiency goals include driving a vehicle without direct vision and using nonphysical interfaces, such as voice and audio in a combat vehicle. This program will demonstrate an open systems approach. By FY97, transition Crewman's Associate ATD (III.G.3) principles and interfaces to scout mission and simulate a conceptual FSCS crew station. By FY98, demonstrate and deliver FSCS conceptual crew station simulator to Ft. Knox, integrate voice recognition and 3D audio into FSCS crew stations, develop indirect vision and mobile crew station test bed, and demonstrate embedded map server, operating services application program interface (API) and the lethality software module. By FY99, demonstrate voice recognition and 3D audio working in mobile crew station test bed, and demonstrate off-road driving using indirect vision at 50% direct vision rate. By FY00, demonstrate off-road driving using indirect vision at direct vision rates, and demonstrate embedded training Vetronics System Integration Laboratory.

Supports: Army C^4I Technical Architecture, FSCS, Crusader, M1A2 and M2A3 upgrades, FCS, Open Systems Joint Task Force, Task Force XXI.

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III.G.13—Compact Kinetic-Energy Missile (CKEM) Technology. By FY99, develop and demonstrate technology for an insensitive, lightweight, miniature hypervelocity kinetic energy missile (35–40 kg), that is compatible with the LOSAT target acquisition and tracking system and could be compatible with the fire control system, for close combat and short range air defense missions. Demonstrate the missile KE Penetrator achieving M829A2 equivalent kinetic energy at 175 m and maintaining the energy to beyond 5 km, and achieving greater than 3 time the M829A2 penetrator energy at 450 m and maintaining it to 3.5 km. Demonstrate the missile delivering in excess of 30 MJ to the target at a range of less than 500 meters, as well as a range out to 4 km, and 25 MJ at 5 km. Leverage miniaturized G&C actuation technology, high-fidelity visual digital simulation, advanced composite motor and structure technology, fire control, insensitive nondetonable propulsion technology, and enhanced lethality characteristics from the LOSAT missile program and the Hypervelocity Missile Guidance STO. Demonstrate increased maneuverability against airborne targets at minimum range with continuous control actuation. Significantly increase missile platform adaptability to include future main battle tanks, helicopters, and multiple lightweight platforms that are strategically deployable. Demonstrate motor and propulsion concept by FY98, and conduct a flight test in FY98. Demonstration of this miniature hypervelocity missile concept will provide capability for a significant increase in lethality, survivability, and mobility of a dual role close combat and short range air defense hypervelocity guided KE weapon system.

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III.G.14—Future Scout and Cavalry System (FSCS) ATD. By FY02, demonstrate the operational potential of a lightweight scout vehicle integrating scout specific technologies with complementary advanced vehicle technologies. This effort will be a Fast Track, cooperative program with the United Kingdom. Using the Bradley M3A3 as a baseline, the FSCS ATD will increase vehicle and crew survivability by 20%, increase target detection rate by 600%, increase target recognition range by 35%, increase mobility by 15%, increase crew efficiency by 25%, reduce vehicle silhouette by 30%, and achieve transportability of 3 FSCS on a C–17 aircraft. By FY98, design advanced crew station(s). By FY99, build crew station simulators and initiate a vehicle-level Systems Integration Laboratory, and transfer program management to PEO GCSS. By FY00, develop detailed design and initiate subsystem fabrication. By FY01, complete subsystem fabrication and perform demonstrator fabrication and integration. By FY02, complete user experiments and validate improved battlefield performance. This integration effort potentially leverages technologies from the following STOs: Ground Propulsion and Mobility, Target Acquisition ATD, Multifunctional Sensor Suite ATD, Hunter Sensor Suite ATD, Combined Arms Command & Control ATD, Digital Battlefield Communications ATD, Hit Avoidance ATD, Crewman's Associate ATD, Intravehicle Electronics Suite TD, Composite Armored Vehicle ATD.

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III.G.15p—Full-Spectrum Active Protection (FSAP). By FY04, demonstrate a universal combat vehicle defensive system that can destroy or degrade chemical energy and kinetic energy antiarmor munitions prior to vehicle impact, thereby reducing the need for heavy ballistic armor. This system will defeat large top attack, hit to kill (Antitank Guided Missile), and tube launched KE/HEAT munitions. It will reduce the probability of kill to 0.2 with a system cost of no more than $185k per unit in production quantities. The FSAP program will exploit, adapt and develop technologies from SLID, NTAPS, Drozd, Arena, KEAPS, and other tri-service, industrial and foreign programs. FSAP will be integrated into the enhanced Commander's Decision Aid (CDA) for optimal utility. By FY01, evaluate and test Multiple EFP–CM and other counter-KE capable CM technology options. By FY02, determine optimal CM technology and sensor suite. By FY03, complete integration design and perform subsystem prototyping/testing. By FY04, complete testing and validate system performance.

Supports: Abrams, Bradley, FSCS, FIV, FCS, Crusader, Grizzly.

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III.G.16p—Mobility Demonstration for Future Combat System (FCS). This STO will demonstrate the technologies required to meet FCS mobility and power requirements. Emphasis is on developing and demonstrating an advanced propulsion system consisting of a high power density, low heat rejection, fuel efficient engine and a compact, high efficiency drive train. A fully active suspension and high speed track are also included in this STO. This effort is necessary because a new propulsion system with greater power density than is now achievable will be needed for FCS, regardless of the armament choice, to provide required power in a system that is substantially lighter, more agile and more fuel efficient than the Abrams tank. By FY04, the FCS high power density multicylinder diesel engine will be designed and fabricated.

Enough development testing and resultant improvements will have been made to demonstrate 80% full power, fuel consumption within 15% of target values, fluid temperatures within 40°F of target values, and heat rejection within 20% of target values. By FY05, a fully active electro-mechanical suspension system will be demonstrated on an FCS weight class vehicle. By FY06, an advanced high speed track meeting an FCS weight class vehicle will be demonstrated. Also by FY06, this STO will define the FCS propulsion system configuration and will be midway into the total FCS propulsion detailed design.

Supports: FCS, Crusader Upgrades, FIV.

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III.G.17p—Future Combat System (FCS) Integrated Demonstration. By FY06, demonstrate technical feasibility and operational potential of a lethal, survivable, deployable, multimission Abrams replacement vehicle. Using the M1A2 Abrams as a baseline, it will demonstrate 50% reduced crew workload, 40% reduced GVW, 20% increase in fuel economy, and a 40% increase in cross-country speed, and leap ahead lethality. Critical issues to be addressed are the acceptance of two crew vehicle operation, leap ahead mobility, non traditional survivability (replacing ballistic protection with signature management, CM, and active protection), and indefensible lethality (both direct and indirect fire). By FY03, complete studies and analyses, construct and evaluate virtual prototypes to support the demonstration and to validate user and technology requirements. By FY04, complete system design, and implement a System Integration Lab (SIL) test to validate electronics integration. Concurrently, demonstrate the vehicle and crew configuration in field experiments with surrogate technologies when necessary. By FY04, in the SIL, demonstrate power and energy management techniques and suspension control. By FY05, in the SIL, validate electrical and electronics integration of Full Scale Active Protection STO, FCS Mobility STO, FCS Advanced Electronics STO, and FCS Armament STO, and demonstrate 50% reduced crew workload. By FY06, integrate the technologies validated in the SIL in a Lightweight Chassis/Turret Structure STO test bed and demonstrate baseline. In FY07, technologies and designs evaluated in this TD will transition to the "FCS Integrated Demo II," a technology based program to integrate the actual technology products into a demonstrator vehicle.

Supports: FCS.

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III.G.18p—Advanced Electronics for Future Combat System (FCS). By FY04, develop an integrated ultra high power electronics package and crew station technologies for the Future Combat Systems (FCS) Integrated Technology Demonstrator (III.G.17p). Demonstrate a 50% increase in overall crew efficiency and a 50% reduction in crew size, a 30% reduction per source line of code, a 10x increase in FCS system performance per module and a 50% reduced cost ratio of electronics. This program will leverage crew station technologies, architecture developments and lessons learned from the Crewman's Associate ATD and Intravehicle Electronics Suite STOs (III.G.3 and III.G.12, respectively). Specific technologies to be integrated include: helmet-mounted displays, head trackers, panoramic displays, cognitive decision aids, load management algorithms, automated route planning, power management system (for electric drive, electric armament, etc.), an object oriented software backplane, a combat vehicle graphics tool kit able, and advanced electronics packaging. By FY01, initiate integration of advanced electronics plans for the FCS TD, and define software backplane architecture and graphics objects. By FY02, develop panoramic display and integrate it into mobile crew station test bed, conduct an FCS electronic power consumption analysis, upgrade VSIL to integrate high power components and thermal analysis and modeling tools, complete tradeoff investigation of electronics packaging technologies, and finalize approach. By FY03, demonstrate workload reductions using cognitive decision aids and load management algorithms, demonstrate SW backplane architecture and graphics objects in Vetronics Systems Integration Lab (VSIL). By FY04, develop automated route planning as a driver/commander aid and test in mobile crew station test bed, validate FCS electronic integration via warfighter experiments, and demonstrate electronics packaging technologies and final power management approach in VSIL.

Supports: Army C^4I Technical Architecture, FCS.

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III.G.19p—Future Infantry Vehicle (FIV) TD. By FY06, demonstrate Bradley replacement vehicle with increased survivability, lethality, strategic and tactical mobility, and effectiveness. Increase survivability by 33–50% using a combination of improved armor protection, CM, full spectrum active protection, and signature management. Increase onboard training and battle rehearsal by 100%. Accommodate full squad of 9 soldiers versus 7 in Bradley (with full Land Warrior gear). Improve mobility by 50%. Improve lethality through the integration of an advanced medium caliber weapon, fire and forget FOTT (P3I) missile system and the addition of nonlethal devices. By FY01, begin preliminary designs based on the Virtual Prototyping results. By FY02, the contractor, in conjunction with TARDEC, will initiate a vehicle-level Systems Integration Lab (SIL) to integrate key FIV technologies. By FY03, complete fabrication and perform demonstration of hardware and software Soldier–Machine Interface, and perform subsystem demonstration of Hardware and Software in the SIL. By FY06, perform technology demonstrations and User Experiments.

Supports: FIV.

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III.G.20—Extended-Range Munition. By FY02, this STO will demonstrate a 120mm Abrams tank main armament precision munition and associated fire control, including target handoff from a remote sensor to defeat targets at ranges in excess of 8 Km. The munition will defeat point targets at extended ranges (up to 3x range increase over M829A2). ERM will expand the Abram's Tank battlespace by engaging high value targets in both line-of-sight (LOS) and non-LOS (NLOS) modes. In FY98, a performance specification will be completed and baseline designs will be initiated. In FY99, the design will be finalized and component hardware fabrication will be initiated. In FY00, under simulated and live-fire conditions, subsystem demonstrations of critical components will be conducted, the concept design will be refined, and fire control system definition/design will be initiated. In FY01, from a hardstand, the capability of hitting stationary and moving targets at medium ranges will be demostrated, defeat of advanced threat armors and active protection systems in simulated and/or subsystem live-fire conditions will be demonstrated, and modification of an Abrams tank fire control system will be completed. In FY02, full-range capability to hit stationary and moving targets in live-fire demonstrations with a modified Abrams Tank will be demonstrated.

Supports: Abrams Tank, FCS.

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III.G.21p—Lightweight Chassis/Turret Structures. This STO will demonstrate minimum weight structural designs with structural efficiencies exceeding 80% to achieve the FCS 40 ton GVW, which is required so that two FCS can be transported by C–5 aircraft. It will also feature modular (removable) armor for +/- 15 ton deployable weight and to facilitate armor upgrades. The technical approach is to apply advanced materials to maximize structural performance, and to optimize different vehicle zones for unique design conditions. The goal for FY00 is to establish the number and boundary of vehicle zones, define their unique design conditions, establish "as-deployed" and "maximum mission" protection levels. By FY01, evaluate alternative armor integration approaches and basic design concept alternatives for integrity and durability for each zone. By FY02, complete zone designs and the hybrid integrated vehicle design and perform component level structural tests. By FY03, complete panel ballistic tests. By FY04, provide "User preferred" hull and turret to FCS for the ATD and one ballistic structure for firing.

Supports: FCS, FIV.

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III.G.22p—Future Combat System (FCS) Armament TD. By FY04, demonstrate an integrated armament system for FCS with over 100% increase in lethality (over the M829A2), 100% increase in stationary accuracy compared to M829A2/M1A2 at 3km (stationary), and over 500% increase in accuracy under moving conditions. The FCS Armament will meet the lethality requirements needed by the FCS. In FY00, investigate armament components including gun, ammunition, fire control, and ammunition handling technologies to develop a lightweight and low impulse gun armament system; develop system concept design using Pro-Engineering CAD. In FY01, finalize concept design and fabricate components including advanced gun, fire control, autoloader, and ammunitions with novel warheads. In FY02, conduct gun/ammunition functionality tests via simulations and actual firings. In FY03, demonstrate compact autoloader functionality tests in a simulated dynamic vehicle condition and initiate integration of the autoloader-to-gun system. In FY04, conduct an integrated gun/ammunition/autoloader/fire control FCS Armament system demonstration via simulations in a systems integration laboratory (SIL) and on a surrogate platform; and transition all hardware to TARDEC FCS integrated TD.

Supports: Future Combat System, USAARMC.

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III.G.24p—Advanced Light Armaments for Combat Vehicles (ALACV). By FY03, this STO will demonstrate 25/35mm ammunition with 75% or greater improvement in lethality compared to conventional point detonating munitions and 20–40% improvement compared to existing KE & bursting munitions. The ALACV will develop two types of munitions (antipersonnel and antiarmor) to meet the Future Scout and Cavalry System (FSCS) and the Future Infantry Vehicle (FIV) lethality requirements. In FY01, investigate novel lethal mechanisms, novel penetrators, advanced fuzes and advanced propellants; finalize optimized munition warhead designs. Conventional and cased telescoped munition configurations are candidates. In FY02, fabricate ammunition components and conduct components tests; conduct performance simulation based on demonstrated hardware performance. In FY03, conduct live fire testing of both types of munitions, and transition designs to FSCS EMD and/or FIV ATD.

Supports: Bradley, Future Scout and Cavalry System and the Future Infantry Vehicle.

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CLOSE COMBAT LIGHT (Section H)

III.H.03—Enhanced Fiber-Optic Guided Missile (EFOGM) ATD. By FY00, demonstrate, through a virtual prototype, flight test, and integrated demonstration, an Enhanced Fiber Optic Guided Missile (EFOGM) as the primary "Killer" within the "Hunter-Standoff Killer" concept of the Rapid Force Projection Initiative (RFPI) demonstration. The EFOG–M system is a multipurpose, precision kill weapon system. The primary mission of the EFOG–M is to enable a gunner in defilade to engage and defeat threat armored combat vehicles, other high value ground targets, and hovering or moving rotary wing aircraft that may be masked from line-of-sight direct fire weapon systems. EFOG–M is a day, night, and adverse weather capable system that allows the maneuver commander to extend his battle space beyond his line-of-sight to ranges up to 15 kilometers. The EFOG–M program will produce a total of 300 missiles and 16 ground stations for use in demonstrations and as residual hardware for extended user evaluation. The program will emphasize missile unit cost/affordability and the integrated process and product development process.

Supports: RFPI, ACTD/AWE.

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III.H.04—Precision-Guided Mortar Munition (PGMM) ATD. In FY99, this STO will demonstrate a capability to defeat a point target, autonomously or in a laser designated mode, in excess of 12 km, with a 120mm mortar munition. In FY01, this STO will demonstrate the viability of a GPS/INS sensor/seeker guidance package incorporated into the PGMM to achieve accuracy requirements. In FY98, conduct a seeker CFT with a tactical processor and an extended range firing test to verify 12 km range capability. Also in FY98, initiate laser designated firing tests and demonstrate an integrated man portable fire control system. In FY99, complete laser designated firing test, demonstrate PGMM firing tests and investigate GPS/INS technologies for improved performance at extended ranges in MOUT operations. In FY00, develop an integrated GPS/INS PGMM and conduct a MOUT operational experiment. In FY01, perform a comprehensive Hardware-in-the-loop (HWIL) test and simulations to validate hardware performance.

Supports: Rapid Force Projection Initiative ACTD. 120mm Battalion Mortar System ROC approved on 2 Mar 96. Dismounted BLs.

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III.H.05—Rapid Force Projection Initiative (RFPI) Command and Control (C^2). RFPI C^2 integrates technologies into a demonstration of capabilities required for a light insertion force that is air-deployable and first-to-fight in a forward or remote area. Increased lethality in a light force is supported by information distribution, that is optimized for speed and robustness, with non-line-of-sight weapon platforms. Firing loop performance from target acquisition to weapons firing is a critical item. Early threat warning, decisions, assessment, and resource management are critical C^2 related functions to be demonstrated for timely control and sustainment of light force capabilities. A limited TOC capability provides central focus for these functions. A robust network, with a high degree of connectivity, allows the commander to adapt the task force structure to concentrate sensors and firepower quickly as needed. RFPI C^2 will be consistent with the Army's technical C^2 architecture. Several demonstrations are planned for FY96–97. Final demonstration (RFPI ACTD) is 2QFY98.

Supports: RFPI ACTD and CAC^2 ATD.

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III.H.08—Aerial Scout Sensors Integration (ASSI). By FY98, evaluate and demonstrate sensor technology applicable to the family of UAVs with particular emphasis on the Light Force early entry mission. The program will demonstrate and recommend the proper mix of sensor technology for the RFPI application and for potential upgrades to the Tactical UAV. ASSI will demonstrate accurate, timely, and easily-usable "see over the hill" reconnaissance, surveillance, target acquisition, and battle damage assessment information from airborne scout platforms to augment the capabilities of ground-based scouts. A variety of sensors (FLIR, TV, Wide-Area Sensors, MTI Radar) will be demonstrated on one or more manned surrogate airframes. As appropriate to the individual sensor under demonstration, real-time digital datalinks, advanced data compression techniques, and workstation techniques will be explored or demonstrated.

Supports: Mounted Battlespace, Depth & Simultaneous Attack, Battle Command, Early Lethality & Survivability, RFPI Umbrella Program, Tactical/Maneuver/Pointer UAVs, and Precision Strike Korea.

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III.H.11—155-mm Automated Howitzer. By FY98, this STO will demonstrate an automated, digital, fire control system for a 155mm towed artillery system for the Light Forces. The goal of the 155 AH prototype will be to demonstrate advanced fire control, gun emplacement and lay automation (25% faster compare to current M198 fire mission). In FY97, fabricate advanced fire control for M198 howitzer. In FY98, participate in and provide equipment (8 systems plus 2 spares) for RFPI ACTD, and provide technical support for residual hardware in the field in FY99 & FY00.

Supports: Rapid Force Projection Initiative ACTD, Army/USMC Lightweight Howitzer program, Depth and Simultaneous Attack (D&SA) battle lab.

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III.H.12—Precision Offset, High-Glide Aerial Delivery of Munitions and Equipment. Demonstrate revolutionary technologies for the reliable precision guided delivery of combat essential munitions/sensors and equipment using high glide wing technology and incorporating a low cost, modular GPS G&C system. This technology will provide a 6:1 or better glide ratio. By the end of FY96, develop a modular GPS guidance package and demonstrate precision high glide capability of a 500 pound payload using semirigid wing technology. By the end of FY99, demonstrate precision high glide of a 2,000 pound. payload, with a goal of a 5,000 pound payload, using an advanced guidance package and high glide wing. An optional glide augmentation system will also be demonstrated. High glide technology will significantly enhance the military aerial delivery capability through substantially higher glide ratios than are possible with ram air parachutes and will directly benefit the initial deployment of Early Entry Forces.

Supports: Advanced Development–RA02/63804/D266–Airdrop; Engineering Development–RA02/64804/D279–Airdrop; MS Battle Lab, Quartermaster and Infantry Schools.

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III.H.13—Rapid Force Projection Initiative (RFPI) ACTD. The RFPI Program will demonstrate the combat worth of a new Army operational concept pairing forward sensors ("hunters") with an array of standoff weapons ("killers"). The RFPI Technology Program will provide unique items to facilitate integration of systems that are not currently in production, by utilizing commercial-off-the-shelf items. By FY98, provide simulation analysis activities to support developmental requirements as well as changes and upgrades of tactics, techniques, and procedures and demonstrate in a large scale field experiment. By FY99, through the use of the thirteen participating Advanced Technology Demonstrations/Technology Demonstrations, address the optimum operational capability requirements of the Early Entry Forces.

Supports: Battle Command, Depth and Simultaneous Attack, Dismounted Battle Space, Early Entry Lethality, and Survivability Battle Labs.

STO Manager	TSO	TRADOC POC
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III.H.14—Counteractive Protection Systems (CAPS). Overall objective: Develop and demonstrate technologies that can be applied to antitank guided weapons (ATGW) for improving their effectiveness against threat armor equipped with active protection systems (APS). Current technology development is concentrated in the following three areas: a. RF Countermeasure (RFCM) technology for Jamming or deceiving APS sensors used for detection, acquisition, and tracking; b. long standoff warheads for shooting from beyond the range of APS fragment producing countermunitions; c. ballistic hardening of ATGW to reduce vulnerability to fragment impact. RFCMs: MICOM RDEC is developing concepts for deceiving and jamming APS sensors. By end of FY97, a digital model of an APS radar will be completed, passive and active RFCM breadboards will be designed and fabricated, and a test radar will be designed and fabricated. By FY98, bench test and evaluate RFCM breadboards. By FY99, demonstrate prototypes of selected RFCM concepts. Warhead CM: MICOM RDEC, ARDEC, and ARL–WTD are currently working together in developing CAPS LSW technology for ATGW. The ultimate objective of these efforts is to demonstrate the target defeat of Turret Front armor with LSW fired from outside the range of threat APS. In FY96, MICOM will complete an investigation of jet particle dispersion at 10m standoff. In FY97, MICOM will test and evaluate current LSW at 6 & 10 m. In FY96, ARL will refine a current Mo Steady-State-Jet design, test it, and design a 2 stage warhead. In FY97, build and test 2-stage warhead to investigate sequenced jets and design multistage warhead. In FY98, build and test multistage warhead and evaluate alternative liner material. In FY96, ARDEC will demonstrate an LSW at 30 CD. In FY97, 45 CD. In FY98, 60 CD.

Supports: Dismounted Battle Space, Early Entry Lethality and Survivability Battle Labs; PEO Tactical Missiles, CCAWS AMS–H, Javelin, BAT.

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III.H.15—Multifunction Staring Sensor Suite (MFS^3) ATD. Demonstrate a modular, reconfigurable Multifunction Staring Sensor Suite (MFS^3) that integrates multiple advanced sensor components, including staring infrared arrays, multifunction laser, and acoustic arrays. The MFS3 will provide ground vehicles, amphibious assault vehicles, and surface ships with a compact, affordable sensor suite for low signature ground vehicle detection, long range noncooperative target recognition , mortar/sniper fire location, and air defense against low signature UAVs and long range helicopters. By FY98, conduct an early demonstration and evaluation of a mild wave infrared (MWIR) sensor with ultra narrow field of view to provide baseline performance data for the future scout and cavalry, complete sensor component risk reduction, and develop reconfigurable sensor backplane that fully integrates aperture, power, and signal processing requirements for multiple platform applications. By FY99, complete design of medium format staring array capable of being reconfigured for either visible through 5 micron or 8–12 micron operation. By FY00, integrate staring FLIR, multifunction laser, and acoustic cueing components and processing with common backplane, and demonstrate the capability for automated surface-to-surface, surface-to-air, and air-to-ground search, acquisition, and noncooperative identification. By FY01, integrate weapons/fire location processing and demonstrate capability to detect and accurately locate hostile mortar/sniper fire.

Supports: Future Scout Vehicle, Bradley Stinger Fighting Vehicle–Enhanced, Advanced Amphibious Assault Vehicle.

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III.H.16p—Airborne Insertion for Operations in Urban Terrain. Develop and demonstrate advanced airborne insertion technologies providing ultra-high altitude insertion of individuals and small units with the ability to accurately reach drop zones from increased standoff distances during night and limited visibility conditions. These technologies will enhance the covert mobility of early entry forces in urban terrain areas and greatly improve lethality and survivability. Technology breakthroughs will include personnel parachutes with high glide capabilities based on 3D nonlinear modeling, personnel miniaturized GPS/INS airborne navigation capabilities, improved high altitude life support technologies, and the application of innovative materials for enhanced reliability, maintainability and safety. By FY02, define accurate characterizations of decelerator aero-coefficients/performance and demonstrate 50% increase in airborne insertion offset distance. By the end of FY04, demonstrate enhanced integrated high altitude life support and airborne personnel navigation capabilities.

Supports: Advanced Development RA02/63804/D266, Airdrop; Engineering Development RA02/64804/D279; Airdrop; DBS Battle Lab, Quartermaster School.

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III.H.17—120-mm Extended-Range Mortar Cartridge. The STO will develop an extended range DPICM mortar cartridge having 50% greater range and 80% greater effectiveness than the current M934/120mm mortar system. Range extension is provided by a high performance, lightweight composite rocket motor. In FY98, establish a baseline design configuration; complete interior and exterior ballistic analyses and complete design of heavy weight test rocket motor and test fixtures. In FY99, fabricate light weight composite rocket motor test hardware/test fixtures; and initiate interior ballistic testing. In FY00, complete rocket motor static testing; update interior and exterior ballistic models. In FY01, conduct a full-up flight test demonstration.

Supports: Family of all 120mm Mortar Munitions, Dismounted Space BL.

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III.H.18—Line-of-Sight Antitank (LOSAT) ACTD. The LOSAT ACTD will demonstrate increased lethality against current and future threat armor and active protection systems and hardened high value targets, including bunkers and reinforced urban structures. The ACTD will assess survivability of the HMMWV based system and develop a concept of operations (CONOPS) for survivability through deception. The ACTD will also demonstrate enhanced deployability/mobility with the ability to fire upon landing. LOSAT operates as a kinetic kill mechanism and will demonstrate operation in day/night and adverse weather conditions. By FY98, provide simulation analysis activities to support developmental requirements. By FY02, provide system test results and participate in Battle Lab Warfare Experiments that will demonstrate deployability, survivability, and lethality. By FY03, hardware residuals will include as deliverables 13 Fire Units and 178 missiles.

Supports: Battle Command, Depth and Simultaneous Attack, Dismounted Battle Space, Early Entry Lethality, and Survivability Battle Labs.

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SOLDIER (Section I)

III.I.01—Objective Individual Combat Weapon (OICW) ATD. Demonstrate technologies for a revolutionary new small arms weapon system with dual lethality modes (5.56mm Kinetic Energy and 20mm Air Bursting Munition) yielding dramatically improved hit probability and terminal effects. Specific goals include demonstration of brassboard exhibiting hit probability greater than 0.5 out to 500 meters and 0.3 to 0.5 out to 1,000 meters in 1996. Effectiveness against personnel and light armor targets, given a hit, will be greater than those of the M433 High explosive Dual Purpose cartridge fire from the M203 Grenade Launcher and the M855 cartridge fire from the M16A2 rifle. By FY98, hardware build for six complete weapon systems and associated ammunition. By FY99, demonstrate a 0.5 probability of incapacitation to 300 meters (point target) and a 0.2 probability of incapacitation to 300 meters (defilade target).

Supports: Joint Service Small Arms Master Plan (JSSAMP), Land Warrior, MOUT ACTD. Replacement for selected M16A2, MWS, M4 and M203. Transitions to PM Small Arms in FY00.

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III.I.03—Rapid Deployment Food Service for Force Projection. By the end of FY96, demonstrate equipment components of a modular field food service system based on advances in diesel combustion and heat transfer technologies. By the end of FY98, demonstrate integral power generation, advanced insulative materials, and non/low powered regenerative refrigeration. By the end of FY99, fully integrate these technologies for the demonstration of a highly mobile, rapidly deployable, field feeding system that is more reliable (50% increase in MTBF), more efficient (50% decrease in fuel), that can be operational in minutes instead of hours, and that expands the range of tactical situations (by 40 percent) in which hot meals can be prepared and delivered.

Supports: Joint Service Food Program; Advanced Development–RJS2/63747/D610–FoodAdv. Dev.; Engineering Development–RJS2/64713/D548–Military Subsistence Systems; Army Field Feeding Equipment 2000 (MNS), Quartermaster School and Medical Department.

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III.I.04—Force XXI Land Warrior (FXXILW). By FY99, perform an Early User Test (EUT) to validate the improvements of advanced component technologies for the Land Warrior (LW) system with a squad's worth of upgraded LW systems. The FXXILW will demonstrate the improved individual and small unit operational effectiveness afforded by the modular integration of advanced components onto the Land Warrior platform. Technologies will be developed and demonstrated to include the development of a technology transition plan for each of the following: lighter weight helmet materials and designs (0.5 pound weight reduction), modeling and simulation, enhanced weapon and sensor interfaces (100% improvement in reliability), Integrated Sight (4 pound weight savings and 25% cost reduction compared to existing LW components), enhanced navigation, packet relay protocols for soldier radios, system voice control, combat ID functions, low power helmet mounted display upgrades (1 watt power savings), and head orientation sensor (decrease target acquisition time by 50%). In addition to these technologies, other technologies from the MOUT ACTD or Small Unit Operations programs, as coordinated with those programs, will be integrated onto the LW platform to support FY99 demonstrations. By FY00 a revolutionary technology path leading to a future warrior system architecture keyed toward four key systems drivers: weight reduction, power minimization, life cycle cost reduction, and system fightability.

Supports: Land Warrior, PM–Soldier, U.S. Marine Corps, DARPA and SOCOM, Engineering Development: RJS1/64713/D667–Enhanced Land Warrior, DBS and BC Battle Labs.

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III.I.06—Batteries for the Individual Soldier. Reduce the physical burden on the soldier and reduce O&S costs by using lighter weight primary (30 percent more energy, 1996) and rechargeable (50 Percent more energy, 1998) batteries. The deliverable will be achieved through a combination of new primary-battery chemistries (sulfuryl chloride or zinc-air), improved rechargeable-battery chemistries (nickel metal hydride or lithium-ion). The primary "pouch" batteries delivered in 1996 will be used in the FY96 21CLW Soldier System demo, and will be the pilot model of batteries required for the FY98 field demo.

Supports: CECOM, PEO–COMM, SORDAC, PM–SINCGARS, PM–SOLDIER, and NRDEC. 21st Century Land Warrior, Intelligent Minefield, and Remote Entry ATDs, Dismounted Battlespace Battle Lab, CSS Battle Lab.

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III.I.08—Military Operations in Urban Terrain (MOUT) ACTD. By the end of FY00, demonstrate a full spectrum, robust MOUT operational capability for small units that seamlessly integrates and aggregates the technologies of participating ATDs, TDs and other technology developments in the areas of MOUT C^4I, Survivability, Engagement, and Modeling & Simulation (M&S). Robust communications for MOUT will be pursued through contract options with DARPA's Small Unit Operations Program. Joint field exercises will be conducted with participation by dismounted soldiers, Special Operations Forces, and the Marine Corps. Demonstrations will include tactically realistic scenarios that will test individual and small unit performance in stressful MOUT environments to assess the operational interoperability of the MOUT system-of-systems. M&S will be used to facilitate mission planning and rehearsal, and augment quantification of performance enhancements. Minimum goals include: 50% increase in situational awareness at all levels and 20% increase in force survivability. Through FY01 and FY02, provide follow-on technical support to MOUT ACTD residuals. This STO is an integrated component of the MOUT ACTD.

Supports: Upgrades to Land Warrior; DBS Battle Lab, Infantry School and Battle Command (Leavenworth) Battle Lab.

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III.I.09p—Future Warrior Technologies. By the end of FY05, demonstrate the integration of and supportability of technology insertions into the Land Warrior, Air Warrior, and Mounted Warrior systems. The technology insertions will further enhance the various platforms in the areas of improved miniaturization, improved power management, improved C^4I integration, low observables, improved mobility and improved vision systems. Another focus of this demonstration will be the applicability of current technologies to various systems in order to reduce unit costs and increase producibility. The target goal of 20% reduction in unit production cost, while providing the increased capabilities, will be assessed during this demonstration. The concept of cost as an independent variable will be used to meet this objective. By the end of FY03, the highest payoff technologies will be validated through modeling and simulation and virtual prototyping. Early designs for the various warrior systems will be produced using virtual prototyping techniques. All systems will be designed for maximum commonality to reduce the overall logistics burden and unit costs. The program will exploit emerging commercial technology trends to ensure the final products, the upgraded warrior systems, are technologically superior to that of any potential adversary.

Supports: Upgrades to Land Warrior.

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COMBAT HEALTH SUPPORT (Section J)

III.J.01—**Shigella** ***Vaccines.*** By FY96, determine molecular features required for protective immunity against *Shigella* species. By FY97, select the best methodology for vaccine development. By FY97, transition to advanced development a candidate *Shigella sonnei* vaccine to protect 80 percent of immunized troops from dysentery caused by *Shigella sonnei.* By FY99, transition to advanced development a candidate *Shigella flexneri* vaccine to protect 80 percent of immunized troops from dysentery caused by *Shegilla flexneri* in deployed forces worldwide.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

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III.J.02—Vaccines for the Prevention of Malaria. By FY00, transition to advanced development a vaccine process to prevent P. falciparum infection in 80 percent of immunized personnel. By FY02, transition to advanced development a vaccine to prevent P. vivax infection in 80 percent of immunized personnel. By FY96, transition to advanced development a candidate blood stage Plasmodium falciparum vaccine to reduce incidence of severe clinical malaria by 70 percent. By FY97, transition a vaccine to prevent P. falciparum infection in 70 percent of immunized troops. By FY98, transition to advanced development a candidate blood stage Plasmodium vivax vaccine to protect 70 percent of immunized troops from vivax malaria.

Supports: Army Modernization Plan, Medical Annex O–Project, Sustain and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

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III.J.04—Antiparasitic Drug Program. By FY98, transition to advanced development antiparasitic drugs capable of preventing or treating malaria or leishmaniasis. Candidates include arteether (parenteral treatment of severe drug resistant malaria), FY96; topical paromomycin / gentamicin (cutaneous leishmaniasis treatment), FY96; Floxacrine analog (malaria treatment), FY98; antovoquone–proquanil (malaria prophylaxis), FY97; artelinic acid (malaria prophylaxis), FY01.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

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III.J.05—Dengue Virus Vaccines. By FY99, select the best methodology for vaccine development. By FY 1, transition to advanced development a candidate polyvalent dengue virus vaccine to protect 8 percent of immunized troops from dengue fever caused by dengue virus types 1, 2, 3, and 4.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

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III.J.07—Minimizing Blood Loss and Optimizing Fluid Resuscitation. Provide information and transition to development products to enhance capabilities for control of and resuscitation from hemorrhage. By FY96, complete evaluation of commercially available local hemostatic agents to assess potential for field use in controlling bleeding; determine whether nondevelopmental item investment strategy is appropriate or if additional research and development are needed. By FY96, transition to development a field intraosseous infusion device. By FY96, transition to development an improved thawed or fresh blood preservative. By FY97, transition to development a field-portable fluid infusion-warming device suitable for battlefield use. By FY98, define mechanisms of toxicity of blood substitutes and complete evaluation of status of commercial blood substitute development to define future research and development needs. By FY00, define optimum perfusion pressures for hemorrhaging individuals.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force—Far Forward Surgical Care. Products include an advanced resuscitation solution, oxygen-carrying blood substitute, advanced physiologic sensors, more wound dressings, advanced physiologic sensors, novel wound dressings, and intraosseous infusion device. Food and Drug Administration regulatory requirements.

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III.J.08—Treatments to Prevent Secondary Damage After Hemmorhage or Major Injury. Transition to development or operational use the materiel and information required to reduce complications and death resulting from massive blood loss or major injuries, including measures to minimize irreversible damage during potentially prolonged evacuation. By FY96, transition a pharmacologic intervention capable of blocking the early steps in development of brain and / or spinal cord injury that occur secondarily to trauma, reducing irreversible damage by at least 20 percent. By FY98, transition a pharmacologic intervention that will reduce ischemia / reperfusion injury by 20 percent under conditions in which definitive treatment is delayed by up to 24 hours. By FY00, transition an intervention that will prevent or reduce by 35 percent trauma induced immunosuppression and related sepsis.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force-Far Forward Surgical Care. Products include a therapeutic antibody for the treatment of sepsis and a recombinant delta opioid (DADLE) for use in the delay or prevention of multiple organ failure. Food and Drug Administration regulatory requirements.

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III.J.14—Nutritional Strategies. Identify and demonstrate nutritional strategies to maintain health and enhance soldier performance. Assess efficacy of selected nutrients, food components, and feeding strategies in enhancing physical and mental performance and promoting nutritional health of soldiers during sustained and continuous operations at all climatic extremes. By FY95, determine efficacy of modified garrison dining facility menus and nutritional health and fitness education materials in promoting the consumption of a healthy diet. By FY97, complete animal and human laboratory studies of selected performance-enhancing nutrients and food components (i.e., carbohydrate beverages, caffeine, tyrosine). By FY98, in collaboration with the Natick Research, Development and Engineering Center, conduct an initial field demonstration of performance-enhancing ration components.

Supports: Guidelines for development of performance optimizing rations; Army Modernization Plan, Medical Annex O-Project, Sustain, and Protect the Force—prevent environmental injury and degradation of soldier performance; DoD Executive Agent for Nutrition.

STO Manager	**TSO**	**TRADOC POC**
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***III.J.18—Medical Countermeasures for* Yersinia pestis.** Develop medical CM against the biological threat of *Yersinia pestis*, the causative agent of plague. By FY95, complete an assessment of the efficacy of the Cutter vaccine against an aerosol challenge of *Yersinia pestis*. By FY98, transition to development a vaccine that will protect 80 percent of immunized personnel against an aerosol challenge of *Yersinia pestis* and will induce minimum reactogenicity in soldiers when immunized.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

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III.J.19—Medical Countermeasures for Encephalitis Viruses. Develop medical CM against the biological warfare threat of the encephalitis viruses, a group of viruses that cause disorientation, convulsions, paralysis, and death. Vaccines will protect 80 percent of the immunized population against an aerosol exposure of the virus and will induce minimum reactogenicity in soldiers when immunized. By FY96, transition to development an improved vaccine effective against Venezuelan equine encephalomyelitis (VEE) virus stereotypes 1 A/B/C. By FY98, construct analogous vaccines for Eastern equine encephalitis (EEE) and Western equine encephalitis (WEE). By FY00, develop a multivalent VEE vaccine that includes serotypes 1E and III.

Supports: Army Modernization Plan Objectives, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

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III.J.20—Medical Countermeasures for Brucellosis. Develop medical countermeasures against the biological warfare threat of Brucella, the causative agent of brucellosis, a systemic bacterial disease characterized by fever, weakness, depression, and generalized aching. By FY97, demonstrate the feasibility of producing a vaccine against brucellosis using one species as the model approach (milestone 0). By FY99, transition to advanced development a vaccine that will protect 80 percent of immunized personnel against an aerosol challenge of any species of Brucella and will induce minimum reactogenicity in soldiers when immunized (milestone 1).

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

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III.J.23—Medical Countermeasures for Ricin. Develop medical CM against the biological warfare threat of ricin toxin. By FY97, conduct a Milestone 0 transition of a second generation vaccine. By FY99, transition to advanced development a second generation vaccine that will protect 90 percent of the immunized population against an aerosol challenge and will induce minimum reactogenicity in soldiers when immunized (Milestone 1).

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

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III.J.24—Medical Countermeasures for Staphylococcal Enterotoxin B (SEB). Develop medical CM against the biological warfare threat of SEB toxin. By FY96, transition to advanced development a vaccine that will prevent 80 percent of the immunized animals from death against a lethal aerosol challenge of SEB (milestone 1 transition). By FY96, demonstrate the feasibility of producing a secondary generation vaccine that will protect 90 percent of the immunized animals against both a lethal and incapacitating aerosol challenge of SEB (Milestone 0 transition). By FY00, transition to advanced development the second generation vaccine (Milestone 1 transition).

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

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III.J.25—Medical Countermeasures for Botulinum Toxin. Develop medical CM against the biological warfare threat of botulinum toxin. By FY97 transition to advanced development a recombinant vaccine that will protect 80 percent of immunized personnel against an aerosol challenge, provide protection against all serotypes, and induce minimum reactogenecity in immunized soldiers (milestone 1).

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

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III.J.26—Reactive Topical Skin Protectant/Decontaminant. By FY95, demonstrate proof of principle of the reactive topical skin protectant concept. By FY97, demonstrate efficacy of a reactive topical skin protectant. Demonstrate by FY99, safety and efficacy sufficient for a Milestone O transition of a reactive component for a topical skin protectant that will provide protection against penetration and will detoxify both vesicant and nerve chemical warfare agents.

Supports: Development of Food and Drug Administration-licensed reactive skin protectant; Program Manager–Soldier; Draft MNS (11 Sep 92); Operational and Organizational Plans (Feb 95, Aug 85, Dec 86, May 87, Aug 90); Joint Service Agreement (14 Dec 93) – Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

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III.J.27—Medical Countermeasures Against Vesicant Agents. By FY96, exploit pathophysiology database and new technologies for prophylaxis, pretreatment, and antidote strategies that will provide significant protection against vesicant injury. By FY97, demonstrate efficacy of a vesicant CM. Demonstrate by FY00, safety and efficacy of a candidate medical CM sufficient for a Milestone 0 transition.

Supports: Development of Food and Drug Administration-licensed protectants, pretreatments, and therapies for vesicant agents; Program Manager–Soldier; Operational and Organizational Plans (Mar 87); Draft MNS (11 Sep 92); Joint Service Agreement (14 Dec 93) - Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

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III.J.29—Advanced Anticonvulsant. By FY97, demonstrate safety and efficacy sufficient for a Milestone 0 transition of an advanced anticonvulsant adjunct or component for the soldier/buddy-use nerve agent antidote. Advanced anticonvulsant will overcome deficiencies of current anticonvulsant, Convulsant Antidote for Nerve Agent (CANA), i.e., will be more effective in stopping ongoing convulsive seizures, preventing their recurrence, and protecting against nerve-agent-induced, seizure-related brain damage. It will also demonstrate less abuse potential than CANA. Achieve Milestone 1 transition by FY99.

Supports: Development of Food and Drug Administration-licensed anticonvulsant for nerve agent therapy; Program Manager–Soldier; Operational and Organizational Plans (Mar 87); Draft MNS (11 Sep 92); Joint Service Agreement (14 Dec 93) - Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

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III.J.30—Chemical Agent Prophylaxes. By FY97, demonstrate the feasibility of a reactive/catalytic scavenger pretreatment effective against chemical agents. By FY99, demonstrate safety and efficacy sufficient for a Milestone 0 transition of a reactive/catalytic scavenger pretreatment that reduces chemical agent toxicity without operationally significant physiological or psychological side effects.

Supports: Development of Food and Drug Administration-licensed reactive/catalytic protectants for nerve agents; Program Manager–Soldier; Operational and Organizational Plans (Nov 86); Draft MNS (11 Sep 92); Joint Service Agreement (14 Dec 93) - Protect, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

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III.J.31—Computer-Aided Diagnosis and Treatment. This concept seeks to integrate all of the various individual soldier medically oriented advanced technology and route the data gathering, calculation, decision making and communication through the Soldier Individual Computer common to all 21st Century Land Warriors. This STO supports development of communication-enabled advanced technologies (both sensor and microprocessing) to support triage, diagnosis, treatment, casualty monitoring, and patient status awareness during enroute care. This research and development provides a seamless connection between local casualty assessment and treatment and telemedicine efforts to build an electronic medical record or mentor deployed health care providers. The approach is to develop medical overlays to tactical computing/communicating capability already under development, in order to assess performance without injury, and to compare data postinjury to preinjury "control" data for individualized injury severity assessment. Research efforts will develop a variety of noninvasive vital sign sensor (most utilizing infrared or near infrared technologies to determine deep tissue microvascular blood flow, tissue oxygenation, lactate and CO^2 build-up and tissue. Additional efforts will develop interfaces and controllers between these sensors and the Soldier Individual Computer. Finally, R&D efforts will focus on the development of medical decision assist algorithms that will aid the combat medic in diagnosing and selecting appropriate treatments. Such algorithms will be capable of updating every minute to provide assessment of treatment effectiveness or continued medical threat. By FY98, transition to advanced validation studies of noninvasive vital sign sensors for combat trauma diagnostics and monitoring; by FY 00 transition vital sign sensor interface to Soldier Individual Computer (21CLW); by FY00, transition to advanced development a candidate medical decision assist algorithm;

Supports: Early Entry, Dismounted, Mounted, Battle Command and Combat Service Support Battle Labs. Supports Army Modernization Plan objectives "Project and Sustain the Force."

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III.J.32—Biological Warfare Agent Confirmation Diagnostic Kit. Develop the capability to confirm the initial field diagnosis obtained with the forward deployable diagnostic kit. These tests will differ from forward deployed tests by being more specific and more sensitive and by using independent biological markers. By FY98, transition to development confirmation techniques for all biological warfare (BW) agents in the theater of operations.

Supports: DEPSECDEF guidance (26 Aug 91); Joint Requirements Oversight Council guidance (31 Aug 92); Combat Service Support and Dismounted Battle Labs.

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III.J.33—Filoviridae. Develop medical CM against the biological warfare (BW) threat of Filoviridae, which includes Marburg virus and Ebola virus. By FY 01, transition to advanced development a bivalent vaccine effective against Marburg and Ebola viruses.

Supports: Army Modernization Plan Objectives, Medical Annex O, Project, Sustain, and Protect the force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight council (31 Aug 92).

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III.J.34—Medical Countermeasures for Variola. Develop medical CM against the biological warfare threat of variola, the causative agent of smallpox. By FY97, confirm the use of an animal model for the purpose of demonstrating the efficacy of the current licensed vaccine against aerosol-delivered variola. By FY98, perform relevant preclinical testing of new cell culture-derived vaccinia vaccine directed towards variola. By FY99, develop rapid and highly specific diagnostic devices for clinical specimens. By FY00, explore the feasibility of using human monoclonal antibodies to replace vaccinia immune globulin (VIG). By FY01, screen and identify effective antiviral drugs for post-exposure treatment. Note: None of the studies conducted at USAMRIID will utilize variola itself, instead the studies will employ the use of an appropriate orthopox virus substitute.

Supports: Army Modernization Plan Objectives, Medical Annex O—Project, Sustain, and Protect the force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight council (31 Aug 92).

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III.J.35—Multiagent Vaccines for Biological Threat Agents. Description: Develop vaccine candidates that will concurrently provide protective immune response against a range of biological threat agents. Identify technologies that would permit multiple immunogens or nucleic acid based vaccine candidates to be combined in a single preparation with the endpoint of simultaneously immunizing recipients against multiple biological warfare threats. Demonstrate by FY 00 the feasibility of these approaches in appropriate animal models. Transition to advanced development (Milestone 1), by FY 02, a vaccine that protects 90 percent or more of immunized animals from death or incapacitation by specific agents, as appropriate, following exposure to aerosol delivery of agents at equivalent doses to those anticipated under operational settings.

Supports: Army Modernization Plan Objectives, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exporation, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

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III.J.36—Common Diagnostic Systems for Biological Threats and Endemic Infectious Disease. Develop diagnostic assays and reagents that will provide rapid laboratory diagnosis for a broad array of biological threats and infectious diseases, using common diagnostic technologies. Identify technologies that allow for forward and confirmatory laboratory diagnosis regardless of the etiological agent. By FY98, demonstrate the feasibility of common diagnostic systems for biological threats and infectious diseases. Identify genetic and immunological targets for emerging diagnostic systems technology for biological threats and infectious diseases. By FY02, transition to advanced development common diagnostic systems for biological threats and infectious diseases.

Supports: DEPSECDEF guidance (26 Aug 91); Joint Requirements Oversight Council guidance (31 Aug 92); Combat Service Support and Dismounted Battle Labs.

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III.J.37p—Novel Antiparasitic Drug Development. Provide development of novel compounds and transition to advanced development drugs capable of preventing or treating emerging drug resistant strains of parasitic diseases including malaria and leishmaniasis. This will result in sustained readiness by reducing loss of manpower due to illness caused by malaria and other diseases. Technical barriers include a continuing effort to keep up with multi-drug resistant malaria, determining mechanisms of drug-resistance and development of new animal and in vitro models. By FY03, identify new classes of compounds for the prevention and treatment of malaria. This will include testing to determine whether 80% of a population will be protected by pyridine methanol.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

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NUCLEAR, BIOLOGICAL, AND CHEMICAL (Section K)

III.K.03—Integrated Biodetection ATD. This ATD will demonstrate two technologies. The first will provide a pre-exposure warning for a biological attack. The second technology will provide an order-of-magnitude increased sensitivity to agents while adding a first time virus identification capability that significantly reduced logistics. These logistical improvements include automated versus manual operation, 5x size/weight reduction, reduced storage requirements, and reduced consumables. By FY97, demonstrate a remote biological aerosol warning capability using micro ultraviolet laser based particle counting technology. This technology will provide pre-exposure versus post-exposure warning of biological agent attacks for protection of personnel and high value battlespace assets. Also by FY98, demonstrate a point bio sensor capability that will incorporate an automated DNA diagnostic technology that identifies biological agents with the highest known degree of relability and sensitivity. By FY99, products will be demonstrated separately and as an integrated force protection suite in a future Battle Lab Warfighting Experiment.

Supports: Joint Biological Point Detection System (JBPDS) and Joint Biological Remote Early Warning Systems.

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III.K.04—Millimeter-Wave (MMW) Screening. By FY98, demonstrate the capability of obscurant materials to block or defeat enemy RSTA assets in the millimeter wave region of the electromagnetic spectrum. Exit criteria will include defeat of actual or simulated threat radar, reduction of logistics burden via RAM improvements and reduction of environmental impact due to degradability of the materials.

Supports: This technology supports the Multispectral Expendable Obscurant Generating System and the XM56 MMW Module P3I.

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III.K.07—Millimeter-Wave (MMW) Material and Dissemination Technology. The thrust of this STO is to use novel material technology to reduce the cost and logistics of the millimeter wave (MMW) obscurant smoke by evaluating both the dissemination and the obscurant material. By FY98, evaluate, design and fabricate a new cutter for dissemination of MMW obscurant smoke that could increase the mission turnover time from once every 30 minutes to once every 300 minutes. This novel dissemination would decrease manintenance and cost by at least 80% while maintaining battle tempo. By FY99, evaluate and select an MMW obscurant that will reduce cost by one order of magnitude while meeting current performance and environmental requirements. Also by FY99, evaluate the feasibility of eliminating the cutter, based on the new MMW obscurant material. By FY00, downselect and demonstrate the approach (new MMW material—new cutter versus new MMW material—no cutter) with a reduction in cost and logistics impact of 90% over present systems.

Supports: M56 Large Area Smoke Generator-Motorized and M58 Large Area Smoke Generator-Mechanized.

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AIR AND MISSILE DEFENSE (Section L)

III.L.01—Guidance Integrated Fuzing. The potential exists for the use of Guidance Integrated Fuzing to increase the probability of kill for missile and air defense systems. By FY97, collect non-far-field target signatures from millimeter wave, monopulse instrumentation radar. Generate high fidelity target models to support highly accurate seeker based fuzing simulations to validate robust fuzing algorithms. By FY99, demonstrate algorithms that can use guidance information from RF and imaging IR seekers, autopilots, and/or auto pilot instruments to direct and fuze aimable warheads to maximize damage to ballistic missiles, cruise missiles, unmanned air vehicles, and aircraft targets. Guidance Integrated Fuzing could double missile system lethality and decrease costs over conventional fuzing configurations by 25%–50%.

Supports: PEO–MD, PAC–3, Corps SAM, and FAADS PM/STINGER.

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III.L.05—2.75-Inch Antiair TD. Develop and demonstrate adapting an imaging IR seeker for a small-diameter-missile airframe. By the end of FY97 conduct captive carry testing of form factored seekers with breadboard electronics. By the end of FY99, develop form factored electronics packages, conduct ground test, develop signal processing algorithms with IR counter-countermeasures (CCM), and develop hardware-in-the-loop simulations.

Supports: EELS, Mounted and Dismounted Battlespace Battle Labs, GRAM and ATAM Project Offices.

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ENGINEER AND MINE WARFARE (Section M)

III.M.08—Vehicular-Mounted Mine Detector ATD. By FY98, demonstrate down and forward looking sensor technologies, including ground penetrating radar and infrared for use on a vehicle mounted system to detect metallic and nonmetallic AT mines. Detection performance improvement of 100 percent is expected when compared to the current metallic mine detector. Additionally, detection speed enhancements of up to 2500 percent (5 mph vs 0.2 mph). Standoff detection distances of 30 to 75 feet, an automatic mine recognition/marking system, and teleoperation will be demonstrated.

Supports: Mounted Battlespace, Early Entry Lethality and Survivability, Combat Service Support, Dismounted Battlespace, Ground Standoff Mine Detection System.

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III.M.09—Mine Hunter/Killer (MH/K) ATD. Mine Hunter/Killer will demonstrate an integrated system concept for autonomous detection and destruction of mines at maneuver speeds. By FY96, demonstrate an infrared detection scheme on a combat vehicle and transition to Vehicle Mounted Mine Detector ATD. By FY97, test and evaluate explosive neutralization technologies and select a baseline concept for Mine Hunter/Killer demonstration. By FY98, complete design of explosive neutralizer. By FY99, complete enhancements to detection sensors and integrate these pieces into a single system for static testing. By FY00 integrate Mine Hunter/Killer system onto a surrogate tactical platform and demonstrate the ability to detect and kill mines at a standoff range. This integration can provide a 10-fold increase in neutralization range (5 meters to 50 meters) and a two-fold increase in breaching speed (5 mph to 10 mph). This system will be capable of detecting unexploded ordnance (UXO's) as well as mines.

Supports: Joint Countermine ACTD, Hit Avoidance, FCS.

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III.M.10—Advanced Mine Detection Sensors. By FY97, evaluate underpinning enhancements to forward looking radar and integrate this technology fusion into a single system for static testing against antitank and antipersonnel mines with a 98% probability of detection and with a false alarm rate of less than <0.2 per meter of forward progress. By FY98, demonstrate potential payoffs for increased standoff detection in all weather conditions using advanced FLIR and SLR technologies. By FY99, investigate acoustic and seismic technologies as additional means of enhancing the performance of ground based detection systems. BY FY00, demonstrate multisensor ability to detect mines remotely at speeds of 5–20 km/hr. By FY01, integrate these technologies onto a surrogate ground-based platformand conduct advanced mine detection demonstration.

Supports: Early Entry/Lethality and Survivability, Mounted and Dismounted Battlespace Battle Labs Combat Service Support.

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III.M.11—Lightweight, Airborne Multispectral Countermine Detection System. Lightweight, Airborne Multispectral Minefield Detection Sensors will develop innovative concepts and technology to provide tactical and short range UAVs with the capability for standoff minefield and limited nuisance mine detection. This effort will investigate a variety of new component and focal plane array technologies such as 3–5um staring FPA's, multi/hyperspectral techniques, passive polarization, active sources and electronic stabilization. By FY99, complete study efforts and initiate critical component development. By FY00, complete development of sensors, mine detection algorithm and processor modifications. By FY01, complete integration on a tactical UAV and conduct a demonstration of the system.

Supports: Mounted and Dismounted Battlespace.

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III.M.12p—Standoff Scatterable Minefield Detection. This technology will provide BDE and below maneuver units an indigenous, rapidly transportable, sensor suite to provide real-time impact and launch locations of scattermine, chemical agent, and other artillery, rocket, and mortar delivered munitions. This technology will be capable of responding to cues from other sensors and handoff hostile weapons location data for counter battery missions. This research will explore the capability of the future Scout Multispectral Staring Sensor Suite (MFS^3) and the mm wave ground radar (MGR). The operational concept is to use the MFS^3 to scan the horizon continuously to acquire projectile tracks from volley fire events. Following initial detection, the MSF^3 will hand off tracking to the mm wave radar to determine range, trajectory and predict impact location and/or firing battery location. By FY00, collect live fire data and initiate investigation of sensors to validate detection and tracking capability. By FY01, initiate signal processing and ATR algorithms to predict munitions impact areas and battery position. By FY02, evaluate the detection and impact area prediction capabilities.

Supports: Mounted Battlespace Battlelab, Dismounted Battlespace Battlelab.

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III.M.14—Area Denial Systems (ADS). By FY01, this STO will demonstrate the capability of self-contained, semiautonomous, long standoff munitions that can defend an area by defeating, disrupting, and delaying vehicles that enter its battlespace. The ADS concept expands on the capabilities demonstrated under the Intelligent Minefield STO (III.M.07), which concluded in FY97, by extending the effective range from 100 meters to 1000 meters (100x increase in area coverage), and enhancing the operational utility through improved system employment and recovery. ADS will enhance other weapon systems in a manner similar to that achieved by land mines today, but without the post war civilian mine threat and the demining problem. In FY98, available sensor and communication technologies will be evaluated, tradeoffs including CM resistance will be defined, and a baseline design for hand-emplaced ADS will be developed. In FY99, alternative deterrent concepts will be evaluated. In FY00, prototype deterrent modules will be built and tested, and robotic platforms and alternative delivery and recovery methods will be investigated. In FY01, an integrated demonstration of hand emplaced sensors and deterrent modules will be conducted.

Supports: Replacement for conventional mines.

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III.M.15—Logistics-Over-the-Shore (LOTS). The two primary objectives of this effort are to demonstrate 1) a full-scale prototype version of the Rapidly Installed Breakwater system for application in Logistics Over the Shore (LOTS) and Joint Logistics Over the Shore (JLOTS) operations and 2) construction materials and techniques to provide roadway linkages to the inland infrastructure from LOTS/JLOTS sites. Present LOTS operations are limited to wave conditions in the mid-range of seastate 2. Based on consideration of global wave climates, CINCs require that LOTS operations be able to continue through seastate 3. There is also a significant need to minimize construction time and materials in moving personnel and equipment from the beach to the inland transportation infrastructure. The objective of this technology demonstration is to demonstrate at full scale the technology for enhanced LOTS operations, including (1) seastate 3 operability to greatly increase LOTS throughput and (2) significant reduction in time and materials required to link the beach to the inland transportation network. By the end of FY00, complete engineering design for full-scale breakwater(s) based on detailed engineering analyses, laboratory and 1/4-scale field tests, and acquisition of the capability to rapidly stabilize beach sands with minimum logistic burdens and reduced engineer equipment. By the end of FY02: demonstrate rapidly installed breakwaters for reduction of wave conditions in sea states up to the lower end of sea state 4 by 50%, and demonstrate improved techniques to rapidly stabilize soft soils for roads and material storage areas associated with LOTS operations.

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FIRE SUPPORT (Section N)

III.N.11—Guided Multiple Launch Rocket (MLRS) System ATD. By the end of FY98, demonstrate a low cost G&C package for the MLRS rocket. At extended ranges, large quantities of baseline rockets are required to defeat the target. With the addition of a guidance system, an improved delivery accuracy will be achieved. The number of rockets required to defeat the target will be reduced to one-sixth the current quantity at maximum ranges. The goal of the program is to conduct test flights in FY97–FY98. Technologies that will be integrated include a low cost inertial measurement unit, GPS receivers and antennas, and a canard or ring thruster control package, all of which must be housed in the forward section of the MLRS rocket.

Supports: MLRS Family of Munitions and RFPI ACTD, technology options for Joint Directed Attack Munition, Precision Strike—Korea.

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III.N.15—Multimode Airframe Technology (MAT):LONGFOG. By the end of FY97, demonstrate through sled testing a functioning multimode airframe that includes an integrated turbine engine, GPS/INS, ground station computer, and fiber optic datalink. By the end of FY98, demonstrate technologies through modeling, simulation, and flight testing, that will provide a 40 km day/night, multiple and high value time sensitive point target strike capability while inflicting minimum collateral damage. The technologies will provide a flexible airframe and subsystems to support missile systems that can select priority targets after launch, conduct limited man-in-the-loop BDA, and provide target area reconnaissance in addition to target attack by means of variable cruise velocity over areas of interest. These capabilities will be achieved by means of integrated GPS and inertial navigation, variable throttle air-breathing propulsion, composite material airframe providing low IR signature and low RCS, variable geometry wings for multiple speed regimes, imaging IR seeker, and other appropriate technologies.

Supports: RFPI, JPSD Precision/Rapid Counter MRL ACTDs.

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III.N.17—Ducted Rocket Engine. By FY98, develop and demonstrate a ducted rocket engine for a medium surface-to-air missile to significantly increase the intercept envelope against aircraft, cruise missiles, and tactical ballistic missiles when compared to surface-to-air missiles using current solid rocket propulsion technology. Component technology development will focus on the design and testing of a minimum signature, insensitive munitions, compatible booster, supersonic air inlets, and solid fuel gas generator that provides for high impulse, minimum signature ramburner operation. In FY96, complete heavyweight integration and initiate flightweight propulsion system development. In FY97, complete flightweight development and conduct ground testing. In FY98, complete ground testing and data reduction.

Supports: Battle Command, Depth and Simultaneous Attack, and Early Entry Lethality, and Survivability Battle Labs.

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III.N.18—Auto-Registration System. By FY98, this STO will demonstrate an 155mm Auto-Registration System (ARS) Projectile with a 140 CEP accuracy goal at 35 km. In FY97, fabrication and testing of subsystems for a P/Y Code GPS ARS. In FY98, conduct system demonstration including Standard Fuze GPS Translators and a Real Time Ground Receiver integrated with the ARL automated fire control system for towed howitzers. The demonstration will take place at YPG and Ft. Sill where a comparison between predicted fire accuracy and auto-registration correction accuracy will be shown. Auto-registration will utilize technology leverage from the Navy competent munitions program. Also, in FY98 complete engineering study to adapt a low cost GPS/INS guidance package (currently being developed by Navy with $26M leverage) for PGMM application.

Supports: PGMM ATD, Indirect Precision Fire Warfighting Experiment; Cost effective, enhanced accuracy for the entire stockpile of artillery ammunition, ORD currently in draft, Depth & Simultaneous Attack Battle Lab.

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III.N.19—Advanced SADARM Sensor. By FY01, this STO will demonstrate the application of a common aperature LADAR/IR transducer to enhance the current smart submunition (SADARM) sensor suite for use in gun launch environments. The sensor suite will improve CM performance and provide target classification capability with specific performance goals to include probability of detection (Pd) >.90, probability of classification (Pc) >.75, and 20 times increase in footprint compared to basic SADARM. The enhanced sensor suite performance will greatly reduce cost per kill for basic SADARM. In FY98, conduct analysis of SADARM BLOCK II sensor requirements in extended range 155mm and MSTAR, and fabricate LADAR/IR prototype hardware for preliminary sensor suite evaluation. In FY99, fabricate test hardware for sensor CFT data gathering and for G-hardening experiments; perform CFT data gathering. In FY00, conduct system tradeoff studies on alternate Block II sensor designs, perform sensor suite packaging analyses, finalize sensor detailed design, and begin fabication of sensor hardware. In FY01, conduct tactical sensor CFT, conduct sensor components G-hardening testing.

Supports: SADARM Munitions, MSTAR, Sensor Fuze Munitions.

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III.N.21—Future Direct Support Weapon. The objective of this STO is to demonstrate the viability of a 5,000 pound towed howitzer. The first phase of the program will involve a demonstration of a 6,750 pound towed howitzer. The second phase will involve a demonstration of a 5,700 pound towed howitzer, with a decision to go forward with the program to develop a 5,000 pound towed howitzer to begin in FY02. This effort will leverage the technology from current congressionally funded Electro-Rheological (ER) fluid research, which includes fluid characterization, software control methodology, materials and structures modeling, power supply design, 155mm soft recoil test bed fabrication, subscale laboratory test apparatus, and accuracy and effectiveness studies of 155mm vs. 105mm. In FY98, perform direct support (DS) weapon interior ballistics modeling, initiate virtual prototype and modeling of soft recoil testbed (6,750 pound), perform materials investigations, and develop an Army-wide database of ER fluids. In FY99, conduct a live fire of an existing (hard stand) soft recoil mechanism, design/fabricate a DS weapon cannon, modify a 155mm soft recoil testbed for DS, and develop concepts for a 5,700 pound ER fluid controlled soft recoil weapon. In FY00, initiate firing program for 6,750 pound testbed, verify modeling and simulation of 6,750 pound testbed, and initiate virtual prototype and modeling of 5,700 pound testbed. In FY01, execute limited user evaluation of 6,750 pound testbed, fabricate 5,700 pound testbed, and execute live fire evaluation; and validate virtual simulations.

Supports: 155mm towed howitzer for the light forces.

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III.N.22—Multiple Launch Rocket System (MLRS) Smart Tactical Rocket (MSTAR). MLRS Smart Tactical Rocket (MSTAR) will demonstrate the feasibility of deploying smart submunitions from one MLRS rocket. This technology will provide the ability to deliver smart submunitions to the target area while being a transparent MLRS Family of Munitions (MFOM) user. Logistic support, resupply, maintenance, required number of firing platforms (launchers), and other support equipment will be reduced by the relationship of the number of submunitions expected to be housed and dispensed by the rocket. Stowed kills will be increased due to the ability of the submunitions to attack multiple targets. Proof of an integrated design concept will be demonstrated through subsystem engineering hardware testing and verified by system level simulations. Results must ensure a relatively benign dispensing environment with a high probability of placing the submunitions in a posture to counter the posed threat and account for the required search characteristics of the various smart submunition candidates. Studies will be accomplished utilizing 6-degrees of freedom (DOF) simulations to evaluate aerodynamic characteristics, dispersion patterns, and dispersion accuracy, and to provide inputs into the submunition flight and terminal phase simulations

Supports: Multiple Launch Rocket System (MLRS).

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LOGISTICS (Section O)

III.O.05—Reforming Diesel to Refuel Soldiers (ReformD). Develop technology to catalytically reform diesel fuel into a versatile gaseous fuel that can be cleanly and reliably burned in high efficiency gas fired kitchen equipment and that can be safely dispensed in cartridges (bottled) to power soldier individual equipment for heating, cooling, illumination, and electric power generation devices. Specifically, by the end of FY98, demonstrate a diesel fuel reformer with an ability to convert diesel fuel into gaseous fuels (H2 and C1 to C^4) at a rate of 3 gallons per hour, and a yield of 70% High Heat Value. By the end of FY99, demonstrate a yield of 90%. By the end of FY01, integrate the reformer in a field kitchen with gas appliances that will enable the preparation of high quality meals and that will provide a convenient source for refilling gas cartridges. Demonstrate a soldier refueling concept whereby the field kitchen is a logistical supply point that fuels both individual soldiers and their equipment.

Supports: Joint Service Food Program; Advanced Development– RJS2/63747/D610– Food Advanced Development; Engineering Development RJS2/64713/D548–Military Subsistence Systems; Army Field Feeding Equipment 2000 (MNS); Quartermaster School.

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III.O.09—Lines of Communication (LOC) Construction Materials and Methods. Provide the capability for rapid construction and repair of the in-theater transportation and facilities infrastructure to sustain a deployed force with limited engineer resources. By the end of FY95, develop methods for rapid stabilization of loose dry soils in arid regions to provide operating surfaces (paved or unpaved) for contingency military operations. By the end of FY97, provide the technologies required to reduce current equipment and materials to construct operating surfaces in soft soils and environments by 25 percent and construction time by 35 percent. By the end of FY98, develop models, methods and technology required to construct and maintain operating surfaces in cold and transitional environments using limited material and equipment resources.

Supports: Design criteria, materials specifications, and construction guidance for the criteria update cycle of TM 5–430–001/2 "Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations," and TM 5–402–001/2 "Army Facilities Component System."

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III.O.14p—5-Kilowatt Advanced Lightweight Portable Power System (ALPPS). Demonstrate an efficient, portable engine-driven generator set operable on multiple fuels for tactically mobile use. The design shall be based on the integration of commercially available engines and state of the art alternator and power electronic technologies. The goal is to enhance electrical generation, storage, and conditioning capabilities required to support TOCs, communication/weapons systems, and sensors of the 21st Century Battlefield. By FY01, demonstrate a signature-suppressed, multifuel burning, electronically controlled/conditioned generator set that is capable of producing 5000 watts of continuous power at 60 Hz in all extreme, hostile environments. The target weight for this system is 350 pounds (dry weight). The basic design of this lightweight power system shall support implementation of and increase the Army's ability to achieve its power OTM and RFPIs.

Supports: 5 kW, 60 Hz Power Requirements for Signal Corps, Tactical Force Support, Battlefield Training Support.

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III.O.15p—Silent Energy Source for Tactical Applications (SIESTA). Demonstrate silent, lightweight liquid fueled fuel cell power sources in the 50–150 watt range for various soldier applications. These power sources will offer lighter, more energetic power sources than are currently available and would extend mission time, reduce weight and decrease the logistic burden associated with batteries. This effort is essential to leverage the efforts at DARPA, ARL and JPL. By FY00, using the best available methanol/air Proton Exchange Membrane (PEM) Fuel Cell Technology demonstrate a fuel cell power source providing 2000 watt-hours per Kg of fuel. By FY02, using the best available liquid fueled PEM technology demonstrate a 150 watt/5000 watt-hour fuel cell power source weighing less than 5 Kg.

Supports: Power Requirements for DBBL, SOF, CSS, Marine Corps/NSA, Soldier System, Sensors, Battery Charging.

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III.O.19—Munitions Survivability. This STO develops explosive propagation mitigation technologies to ensure the survivability of munitions at ports, air heads, and munitions storage areas. In FY97, investigate the use of microencapsulated fire retardant materials, thermal coated weaves, and low thermal conducting materials to protect vulnerable munition stacks from fire threats. Investigate microstructural shock absorbing materials, structural foams, gel-forming polymers, and kevlar spiral weaves as lightweight high performance materials to mitigate explosive propagation. Initiate laboratory testing of materials. Initiate development of heat transport computer codes and hydrocode models for treating shocks, rapid compression, and penetration in porous materials. In FY98, perform scaled experiments to calibrate computational models and define geometries necessary to prevent fire propagation and achieve optimum shock attenuating performance. In FY99, complete development of sympathetic detonation computational models. Conduct full scale experiments to verify models and demonstrate lightweight, high performance materials and designs optimized to prevent fire propagation and mitigate explosive propagation. These technologies will limit ammo loss to only 1% from a Scud missile direct hit. Ammo storage area footprint will be reduced by 60% while providing a 50% weight and construction time/labor decrease compared to current geosynthetic reinforced systems.

Supports: CSS and EELS Battle Labs.

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III.O.20—Advanced Parachute and Soft Landing Technologies. Demonstrate technologies to provide an improved cargo airdrop capability. Utilizing novel design techniques, by the end of FY97, demonstrate a small (personnel size) parachute and by the end of FY00, a full size cargo parachute that achieves a 20% reduction in weight, bulk and manufacturing costs (compared to fielded parachutes) while providing equivalent flight performance. By the end of FY98, demonstrate a parachute retraction system using clustered parachutes that provides a less than 10 ft/sec soft landing capability. This capability will allow for airdrop of critical items (such as robotics) too fragile for airdrop with conventional systems. By the end of FY00, demonstrate a less than 10 G (gravitational force) soft landing airbag system that provides an all weather, rapid roll-on/roll-off airdrop capability for the future Army.

Supports: Advanced Development–RA02/63804/D266–Airdrop; Engineering Development–RA02/64804/D279–Airdrop; Quartermaster and Engineer Schools and Maneuver Support Battle Lab.

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TRAINING (Section P)

III.P.03—Joint Training Readiness. By FY01, develop and demonstrate, in support of ground combat, new training and performance assessment methods that use synthetic distributed environments most effectively for Army, multiservice, and joint units. Included are metrics for how well forces communicate, coordinate, and synchronize resources and firepower. Leveraging other service and OSD funding, methods will be developed for units to achieve training readiness in 30% less time, more precisely measure readiness, and show a 50% increase in the number of warfighting tasks performed effectively during exercises. Demonstrations will use the Fire Support mission (air, ground, sea and C^4I). In FY97, provide distributed training methods for planning and executing the fire support mission from Brigade through Corps JTF. In FY98 define alternative methods for measuring complex organizational performance; develop and test metrics to represent Joint Mission Essential Tasks (JMET). In FY99, develop and test methods for planning and conducting systematic, vertical (multisite, multiservice, multichelon) After-Action Reviews. In FY00, provide methods for linking performance of brigade and above units to estimates of training effectiveness and readiness.

Supports: III Corps; TRADOC; CAC; Joint Warfighting Center; OUSD(R).

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SPACE (Section Q)

III.Q.02—Theater Laser Communications. Develop and demonstrate critical technologies required for a theater laser communications network. This activity will transition technologies developed under BMDO, OGAs, and industry to meet tactical Army applications. Technologies provide a high bandwidth data rate (overhead and ground) sensor capability while reducing size, weight, power, and cost. Potential applications are directed to airborne reconnaissance missions using a layered architecture involving satellites, manned and unmanned aircraft, aerostatic vehicles, and portable/fixed ground terminals. In FY96, a study was conducted to assess the viability of laser communication technology for space-to-ground applications. The study revealed that a layered architecture consisting of satellite-to-air-to-ground platforms provided high link availability through most weather conditions, especially for those missions with increased response time requirements. In FY97; 1) conduct an air-to-ground proof of concept demonstration using the Airborne Surveillance Testbed and existing BMDO lasercom terminals to transmit high bandwidth data (1.2 gbps), and 2) design and obtain necessary hardware to begin development of a portable demonstration ground terminal. In FY98, demonstrate the space-to-ground link using BMDO satellite (STRV–2) platform and a portable ground terminal. In FY99,demonstrate a joint satellite-to-air-to-ground technology and transition to Force XXI Battle Command Brigade and Below Tactical Internet; integrate into Space and Missile Defense Battle Lab and Battle Command Battle Lab for evaluation and requirement generation.

Supports: Battle Command Battle Lab and Space and Missile Defense Battle Lab.

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III.Q.03—Laser Boresight Calibration. The laser calibrator will provide a known ground registration point for space based sensors resulting in an improved impact area and launch point prediction for Theater Ballistic Missiles (TBM). It will reduce command and control time lines and improve the overall responsiveness of Joint Precision Strike and Theater Missile Defense forces. This capability will be integrated into the Joint Tactical Ground Station (JTAGS) P31. By FY97 demonstrate improved near real time determination of TBM launch point and trajectory parameters by using a compact, in-theater, tunable laser calibration system for space based Defense Support Program satellite sensors. The improved line-of-sight target accuracy will result in higher quality missile warning, alerting, and cueing information. The theater ballistic missile search box to detect launch systems is significantly reduced. This capability will be extensively field tested with the theater warfighter in FY96–97 and will be transitioned to JTAGS P31 in FY98.

Supports: Joint Precision Strike ATD, Theater Missile Defense AWE, Depth and Simultaneous Attack Battlelab, Dismounted Battle Space Battlelab, Mounted Battlespace Battlelab, PM–JTAGS, PM–Army Tactical Missiles, CINCSPACE.

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III.Q.04—Battlefield Ordnance Awareness (BOA). Battlefield Ordnance Awareness (BOA). Objective is to demonstrate a near real time ordnance reporting system using on board processing with space sensors. This technology will provide near real time battlefield visualization of friendly and enemy ordnance fires, and cruise missile launches. It addresses the need to target ordnance delivery for counterfire purposes, a major battlefield deficiency. While systems exist to locate and tract vehicle traffic and radio frequency transmitters for intelligence preparation of the battlefield, no system currently exists that reports type, time and sightings of either red or blue ordnance. The BOA capability will identify the ordnance by type and provide position information for counter fire opportunities, as well as Battle Damage Assessment, blue forces ordnance inventory, information for dispatch of logistical and medical support, and search and rescue. It also has the potential to type classify launch systems using the time domain intensity information in specific spectral bands. Advanced processor technology will be used with state of the art staring focal plane arrays to provide critical information to battlefield commanders. By FY97, acquire ordnance data by type and develop algorithms for near real time processing. By FY98, demonstrate near real-time processing of the ordnance data. In FY99, develop a space qualifiable BOA sensor design with state of the art near real time, onboard processing. Integrate BOA sensor and NRT processor by FY00. In FY01, qualify the BOA sensor and demonstrate airborne ordnance collection. Demonstrate NRT Airborne ordnance reporting by the end of FY02. Transition to the Defense Airborne Reconnaissance Office (DARO) and Army PEO–Field Artillery Systems.

Supports: USCENTCOM, USEUCOM, Depth and Simultaneous Attack Battle Lab, Intel Center, and PEO Field Artillery Systems.

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III.Q.05—Overhead Sensor Technology for Battlefield Characterization. Develop and demonstrate advanced overhead sensor technologies for wide area battlefield force detection, discrimination, and target identification in near real time and reduce platform data communications downlink and ground processing Army requirements. Technologies focus on passive optical sensor using spectral, polarimetric, and on focal plane array (FPA) requirements. Initial sensor is baselined for UAV testing and applications. Final sensor configuration will be integrated onto the USAF Mighty–Sat platform to be manifested in DoD Tri-Service Space Test Program. This provides opportunities for the Army to define operational and technical requirements for next generation optical space sensors and associated ground processing capabilities in support of the Army warfighting goals. Sensor bands in the 0.4–2.5, 3–5, and 8–12 micron regions with hyperspectral output will be investigated. Specific technologies exploited include approaches to improve area coverage, on FPA signal processing techniques to exploit spectral/polarimetric signatures to achieve high performance autocueing, hyperspectral, spatial and temporal signature processing, and wide field of view imagery. These sensor technologies will provide wide area coverage of the battlefield, robust detection and targeting data while remaining within current Army C^4I data rates. By FY99 baseline sensor packaging and configuration for UAV and space application and initial demonstration of on-FPA processing of spectral data. By FY00 demonstrate a hyperspectral sensor with smart focal plane processing in the 1–2.5, 3–5, and 8–12 micron wavebands, and improved cueing and clutter rejection via polarization and on FPA processing using ground test. Analyze and incorporate appropriate Warfighter hyperspectral technologies. By FY01 demonstrate on chip neomorphic processing, hyperspectral spatial and temporal signature processing with sensor using airborne testing. By FY02 field test an integrated sensor on a high altitude UAV and measure performance against stated objectives. In FY03 begin integration of advanced space sensor technologies into USAF Mighty–Sat platform for subsequent launch and demonstration in the DoD Tri-Service Space Test Program.

Supports: USASMDC/NVESD/USAF Phillips Lab Project, Force XXI, Army After Next, Space and Missile Defense Battle Lab, Battle Command Battle Lab, Depth and Simultaneous Attack Battle Lab, CCAWS

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TECHNOLOGY DEVELOPMENT

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AEROSPACE PROPULSION AND POWER (Section C)

IV.C.01—Integrated High-Performance Turbine Engine Technology (IHPTET). IHPTET is a three-phased tri-Service/DARPA/NASA effort to double U.S. turbine engine performance capability by 2003. Develop a tri-Service Joint Turbine Advanced Gas Generator (JTAGG) program to demonstrate performance goals consistent with the IHPTET initiative for the turboshaft/turboprop class of engines. Demonstrate, by FY94, a 25 percent reduction in specific fuel consumption (SFC) and 60 percent increase in power-to-weight ratio over current modern production engines via Joint Turbine Advanced Gas Generator—I (JTAGG–1) demonstration. By FY98, demonstrate JTAGG II improvements of 30 percent reduction in SFC and 80 percent increase in power-to-weight ratio, and 20 percent reduction in production and maintenance costs. Develop for future demonstration gas turbine engine technology to effectively double the propulsion system capability for turboshaft engines through a 40 percent reduction of SFC, 120 percent increase in power-to-weight ratio, and 35 percent reduction in production and maintenance costs. Demonstrate emerging technologies related to IHPTET goals in areas of structures, controls, aerodynamics, advanced materials, and accessories which provide reduced vulnerability, improved reliability and maintainability, and high levels of readiness and mission success.

Supports: Precision Strike, Advanced Land Combat, Technology for Affordability, RAH–66 Comanche, AH–64 Apache Improvement, Joint Transport Rotorcraft (JTR), and system upgrades, AM, MS,EELS, D&SA, MBS, and CSS Battle Labs. Dual use potential.

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IV.C.05—Integrated High-Performance Turbine Engine Technology (IHPTET) Joint Turbine. Program Description: IHPTET is a three-phased tri-Service/DARPA/NASA effort to double U.S. turbine engine performance capability by 2003. Develop a tri-Service Joint Turbine Advanced Gas Generator (JTAGG) to demonstrate performance goals consistent with the IHPTET initiative for the turboshaft/turboprop class of engines. Initiate the third phase of the JTAGG program. By FY00 complete testing of JTAGG III technologies. By FY03 effectively double the propulsion system capability through demonstration of a 40% reduction in specific fuel consumption, a 120% increase in SHP/wt ratio, and a 35% reduction in production & maintenance costs. Demonstrate emerging technologies related to IHPTET goals in the areas of structures, controls, aerodynamics, advanced materials and accessories which provide reduced vulnerability, improved reliability and maintainability, and high levels of readiness and mission success.

Supports: Precision Strike, Advanced Land Combat, Technology for Affordability, RAH–66 Comanche; AH–64 Apache improvement, JTR, and system upgrades, AM, MS, EELS, D&SA, MBS, and CSS Battle Labs. Dual-use potential.

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AIR VEHICLE (Section D)

IV.D.03—Structural Crash Dynamics Modeling and Simulation. Develop modeling and simulation tools that will enhance the potential for credibly developing and demonstrating compliance of aircraft systems with required crashworthiness design criteria. Additionally, the modeling and simulation codes will also be used in assessing crash impact conditions for Class A mishaps of current fielded aircraft through damage assessment. By FY98, develop modeling and simulation family of codes that can be used to optimize design for rotorcraft crashworthiness from system concept exploration/preliminary design stage through the air vehicle's life cycle. The effort will include accurate modeling of the performance of composite structures and energy absorption components such as landing gear, seat attenuators, and cockpit airbags during the dynamics of a crash. By FY99, the prediction codes will be demonstrated and validated through laboratory component and full-scale testing.

Supports: RAH–66 Comanche, Joint Transport Rotorcraft (JTR), System Upgrades, future advanced concepts, dual use potential, EELS, CSS, and MTD Battle Labs.

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INDIVIDUAL SURVIVABILITY AND SUSTAINABILITY (Section F)

IV.F.01—Small Arms Protection for the Individual Combatant. Develop armor material system to minimize penalties associated with small arms protective body armor (e.g., excess weight, thickness, and cost; rigidity of materials; manufacturing methodology). By the end of FY96, determine viability of "flexible" ballistic protective vest for small arms protection. By the end of FY98, demonstrate advanced material system for protection against combined fragmentation and small arms threats (known ball threats up to and including 0.30 caliber), to be measured by a 20–30 percent reduction in areal density (weight for given area) over current small arms protection without significantly increasing other penalties.

Supports: Force XXI Land Warrior, Military Operations in Urban Terrain ACTD, Department of Justice, Advanced Development–RJS1/63747/D669–Clothing and Equipment, Engineering Development–RJS1/64713/DL40–Clothing and Equipment. DBS Battle Lab, Infantry and Transportation Corps Schools.

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IV.F.02—Thermal Signature Reduction for the Individual Combatant. By the end of FY97, demonstrate textile materials that reduce the contrast between the soldier's thermal signature and the background by 30 percent, without significant degradation of the current level of visible or near-infrared camouflage protection. By the end of FY99, demonstrate combat uniform systems that reduce the soldier's thermal signature by 50% from background levels, providing multispectral camouflage protection to the Dismounted Land Warrior. The technical challenge entails integrating signature reducing materials/ technologies into a textile substrate while maintaining basic fabric characteristics (durability, flexibility, breathability, etc.) and other soldier's operational capabilities.

Supports: Force XXI Land Warrior, Military Operations in Urban Terrain ACTD, Advanced Development–RJS1/63747/D669–Clothing and Equipment, Engineering Development–RJS1/64713/DL40–Clothing and Equipment; DBS Battle Lab and Infantry School.

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IV.F.03—Agent Impermeable Membranes for Lightweight Chemical Protection. By the end of FY96, demonstrate the technical feasibility of eliminating/reducing carbon in the chemical protective ensemble through the use of advanced semipermeable membrane technology. The resulting advanced material system will be 20 percent lighter in weight than the standard FY96 battledress overgarment material system, allow selective permeation of moisture while preventing passage of common vesicant agent, provide protection against penetration by toxic agents in aerosolized form, and provide at least the current level of protection against other toxic vapors and liquids. By the end of FY98, demonstrate via Dismounted Battlespace Battle Lab warfighting experiment and JSLIST P3I, the efficacy and durability of novel, lightweight chemical protective garments and clothing systems utilizing these agent impermeable membranes.

Supports: Force XXI Land Warrior, Advanced Development–RJS1/63747/D669–Clothing and Equipment, Engineering Development–RJS1/64713/DL40–Clothing and Equipment; DBS Battle Lab.

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IV.F.05—Improved Water Purification. By the end of FY96, investigate emerging technologies such as aerogels, reverse osmosis membranes made from polyimides (as opposed to polyamide) and polyphosphazenes, and polyphosphazene coatings. Compare to other technologies such as mosaic membranes and polymeric microgels, and select those for further investigation. By the end of FY97, optimize the properties of the selected technologies to meet or exceed the performance of existing reverse osmosis membranes. Ultimately, the goal is to prove the feasibility of a new technology with a 300% increase in operating and storage life, a 50% increase in water flux, and tolerance to 5 ppm of chlorine, temperatures up to 165 degrees F, and pH from 5.0 to 9.5 when compared to conventional reverse osmosis membranes. The new technology will be applicable to military water treatment equipment ranging from individual purifiers to division and corps level units, and to municipal desalting plants. By the end of FY98, demonstrate an innovative water purification technology for providing drinking water to troops in the field.

Supports: Future and advanced water purification systems, and possibly wastewater treatment systems, commercial water treatment systems (dual-use, technology transfer), and Combat Service Support Battle Lab.

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IV.F.06—Multifunctional Fabric System. The objective of this effort is to enhance the flame and thermal protection levels of combat uniforms without compromising other protective characteristics. The technical challenge entails the integration of low-cost flame/thermal protection into other multiple threat systems to include capabilities such as electrostatic, environmental, chemical, and signature reduction. Potential technologies for use in the system are polyphenolic material coatings, microencapsulation of flame suppressants and electrospun fibers. By the end of FY99, demonstrate combined protection with a new or improved material such as a modified aramid, flame retardant fiber blends and novel experimental fibers. By the end of FY01, demonstrate combined protection using novel fibers and fabric treatments resulting in a fabric system, with a 50% decrease in the cost of existing flame protective systems, that will provide an increase in overall soldier survivability.

Supports: Upgrades to Land Warrior, Air Warrior, Mounted Warrior and MOUT; Transportation Corps, Quartermaster and Engineering Schools.

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IV.F.07—Biomimetic Materials for Soldier Protection. By the end of FY98, demonstrate a ten-fold increase in expression level of spider-silk-like polymer (100 mg/liter as compared to current 10 mg/liter levels). At that time a production partner from industry will have been engaged and a database of the ballistic protective performance of silk yarns and fibers will have been established. By the end of FY99, incorporate second generation spider-silk-based fibers with improved ballistic protective properties and producibility into fabrics providing a 20% reduction in weight in comparison with present materials of equal ballistic strength. The significant technical barriers include expression of the proteins at high levels and defining the proper genetic modifications to simultaneously improve mechanical properties and processability.

Supports: Joint service program with the Air Force, Wright Patterson AFB; Ballistic Protective Armor and Equipment; DBS Battle Lab and Transportation Corps School.

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IV.F.10—Advanced Personnel Airdrop Technologies. Demonstrate technologies to provide improved performance characteristics and enhanced safety of existing personnel parachute capabilities. Utilizing advanced airfoil and parachute designs, by the end of FY98, demonstrate a gliding personnel parachute with a 20% increase in maximum jump altitude and a 25% increase in glide ratio, when compared to the current Army state-of-the-art MC–4 parachute. By the end of FY00, demonstrate a soft landing capability that augments personnel parachute performance and will reduce system descent rates to values below 16 ft/sec, utilizing "pneumatic muscle" technologies.

Supports: Advanced Development–RAO2/63804/D266–Airdrop; Engineering Development RAO2/64804/D279–Airdrop; DBS Battle Lab.

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IV.F.11—Ballistic Protection for Improved Individual Survivability. Develop and insert advances in materials technology that will increase the protection and performance of armor systems for the individual warfighter. Specifically, by the end of FY99, integrate and transition improved technologies (at least 20% reduced weight for small arms protection) to development and/or as technology insertions to modify existing individual protective systems. By the end of FY00, demonstrate/insert protective materials technology that will provide a reduction in casualties at 35% less system weight than the 1996 individual countermine protective systems. By the end of FY01, develop enhanced assessment criteria, to include behind armor effects, for ballistic impact on personnel armor systems. By the end of FY03, demonstrate an improved material system prototype (over FY99 insertions) for second generation multiple ballistic threat protection with a 25% decrease in weight (or an increase in protection or a combination, depending on user input). Technologies with potential to satisfy this STO include advances in polymeric materials through modification of existing fibers (copolymerization of aramid, PBO), bioengineered protein-based fibers, and the synthesis of new polymers. Improved rigid materials are anticipated through DARPA, and Army programs. These could include low cost, high performance boron carbide, new metal alloys, metal matrix composites and potentially other new ceramics/composites.

Supports: Transportation Corps, Military Police and Engineer Schools; DBS Battle Lab, Department of Justice, Advanced Development RJS1/63747/D669–Clothing and Equipment, Engineering Development RJS1/64713/DL40–Clothing and Equipment.

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COMMAND, CONTROL, AND COMMUNICATIONS (Section G)

IV.G.01—Integrated Photonic Subsystems. Integrated Photonic subsystems will be developed by FY97 for application to optical control of single beam phased array antennas and fiber optic point-to-point links, local area networks, and antenna remoting systems. By FY99, subsystems will be developed for optical control of multibeam phased array antennas. These subsystems will reduce size, cost and power consumption while increasing the performance of high speed fiber optic systems. Fiber optic phased array control systems, which can be scaleable to any desired frequency, will enable communications OTM by utilizing multiple beams with acquisition and tracking capability. Demonstration of the photonically controlled single panel phased array antenna will be conducted during FY99. Demonstration of a photonically controlled multi panel phased array antenna will be conducted during FY00.

Supports: Local Area Communications, Mobile Communications, Satellite Communications, Radio Access Point Antenna.

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IV.G.02—Protocol Specifications for Digital Communication on the Battlefield. Through research in executable protocol specifications, create methods for implementing specifications in the IEEE/ANSI/DoD/FIPS approved hardware description language, known as VHSIC Hardware Description Language (VHDL). Research and test various narrow band (e.g., Mobile Subscriber Equipment) and broadband ISDN (e.g., Asynchronous Transfer Mode (ATM)) switches. The implementation will be an unambiguous, validatable, and simulation capable description of the interface, which can be tested as software. Once described in the hardware description language, the specification can be used to automatically generate hardware using commercially available CAD tools. The resulting hardware is guaranteed to comply with the original specifications because it was derived from the description language. The procedure will be verified using existing military and commercial standards. By FY95 complete a model to describe the All Digital Tactical-to-Strategic Gateway, MIL–STD–188–105. By FY96 further demonstrate the hardware description model by testing the newly emerging ATM standard in conjunction with DISA. By FY97 demonstrate the capability of VHDL to generate hardware by creating hardware implementation. By FY98 demonstrate interoperability of dissimilar COTS/GOTS ATM equipment on the battlefield.

Supports: CAC^2 ATD, Digitization of the Battlefield.

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IV.G.05—Networking and Protocols. Program will integrate and evaluate emerging commercial high speed network technology and protocols (e.g., Sonet, ATM) for performance and for achieving seamless communications with tactical and commercial systems. Commercial network management products will be analyzed and enhanced to ensure compatibility with military-specific requirements and Army legacy communications systems. Will participate in various commercial/academic forums to influence emerging protocols/products for dual use capabilities. Tactical multinet gateways will be evolved by modification and enhancement of commercial-off-the-shelf (COTS) router products to allow ATM and Non-ATM based networks to communicate. Hierarchical video routing to allow the network to automatically route a limited picture of the battlefield (i.e., still frame, slow scan) to users with limited bandwidth while at the same time allowing users with higher available bandwidth to receive a higher class of service (i.e., real-time video). Long term focus will address dynamic and fault tolerant protocol functionality to provide enhanced network survivability and greater capability for communication OTM. Dynamic network reconfiguration without user intervention will be demonstrated. By FY96, establish prototype broadcast ATM capability and monitoring and control functions for mobile networks. By FY97, demonstrate hierarchical video routing between ATM and IP multicast networks, and integrate broadcast protocol with the radio access point. By FY98, demonstrate protocol enhancements for large networks, across services and across media. For FY00, demonstrate dynamic network survivability through protocol adaptation to external environment (e.g. weather, threat, network congestion) and evolve protocols to accommodate next-generation communications architecture.

Supports: Winning the Information War, Digitizing the Battlefield, Battlespace Command & Control, Digital Battlefield Communications, JTF Communications Planning & Management System (JCPMS), ISYSCON.

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IV.G.06—Battle Planning. The Battle Planning effort will develop, integrate and demonstrate emerging technologies to significantly enhance battlespace visualization and enable collaborative planning, rehearsal, execution and monitoring (including real-time intelligence/operations) on the digital battlefield. The focus is on the commander's interface to the battlespace and the embedded software "tools" that will allow the commander and his staff to collaborate electronically in a rapid and effective manner. This STO is leveraging basic research being performed at Army Research Laboratories (ARL) in the area of real time three dimensional (3D) graphical representations, and advanced techniques for image utilization and management (to include zoom in/out, perspective from any viewpoint, and overlays of actual imagery, modeled objects or symbols). Expert systems and natural speech recognition algorithms will aid the commander and staff in rapidly generating and evaluating courses of action. These integrated capabilities will enable the commander to quickly grasp the situation and react to the dynamically changing battlespace. By FY97 demonstrate real-time collaborative planning between the commander and his intelligence and operations staff elements. By FY98, demonstrate capability to perform planning and real time rehearsal, demonstrate speaker independent, continuous speech recognition and exploit direct broadcast satellite (DBS) imagery and terrain data distribution. By FY00, demonstrate a fully integrated capability to allow the commander and staff to perform "end-to-end" collaboration to include: split based operations, course of action evaluation aids, "hands-off" user interface using "natural language" speech input and real-time 3D depiction of the battlefield.

Supports: Battle Command & Mounted Battlespace Battle Labs, Force XXI and follow-on Division and Corps AWE's, XVIII Airborne Corps AWEs, Battlespace Command & Control ATD , Rapid Terrain Visualization ACTD, Consistent Battlespace Understanding (IST IS.01), Forecasting, Planning & Resource Allocation (IST IS.02), and Integrated Force Management (IST IS.01)

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IV.G.07—Antennas for Communications Across the Spectrum. The objective of this STO is to develop, leverage and apply emerging antenna technology to reduce the number of antennas, reduce the visual signature (conformal), reduce the cosite and control problems and increase efficiencies and radiation patterns in the ranges of 2MHz to 2GHz. A second goal is to provide OTM SATCOM antenna capabilities in the Triband (e, x, Ku) and EHF bands. Five technologies will be explored to address different applications. For SPEAKeasy applications wideband technology will be exploited. For air and ground vehicles Structurally Embedded Reconfigurable Antenna Technology (SERAT) and structure tuned antenna techniques will be used. SHF and EHF low profile, self steering, OTM antenna technology will be applied to the SATCOM applications. The initial thrust will be to address the broadband requirements for SPEAKeasy. Following this, the effort will be expanded to pursue the remaining efforts concurrently. By FY98, a wideband SPEAKeasy antenna will be demonstrated. A UHF Conformal antenna (SERAT) will also be demonstrated in FY98 on a Blackhawk, followed by a demonstration on a selected ground platform in FY99. A structured tuned VHF antenna will be fabricated and demonstrated in FY99 on a ground vehicle. A Triband (c, x, Ku) OTM self steering SATCOM antenna capability will be demonstrated in FY00. In FY01, an OTM self steering EHF SATCOM antenna capability will be demonstrated.

Supports: SPEAKeasy, Future Digital Radio, Tactical Airborne and Ground vehicles, Direct Broadcast Satellite, DSCS, and MILSTAR.

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IV.G.08—Advanced Command, Control, and Communications (C^3) Modeling and Simulation. Objective is to provide modeling and simulation (M&S) that accurately represent dissemination, processing and transmission of information generated and collected on the battlefield. Approach includes developing systems performance models (SPMs) to support the introduction of evolving battlefield visualization, command and control (C^2) and high-speed information transport technologies, including asynchronous transfer mode (ATM) switching, personal communications systems (PCS), High-Capacity Trunk Radio (HCTR), and Radio Access Point (RAP); supporting the development of integrated secure, survivable and adaptive C^3 networks using Distributed Interactive Simulations and comply with the High Level Architecture (HLA) by developing a Common Modeling Environment (CME) capable of supporting all M&S domains. By FY98, provide integrated division/corps SPM, which includes all Army Battle Command System (ABCS) and Battlefield Information Transmission System (BITS) elements. By FY99, provide virtual communications systems models and DIS/HLA interfaces for ABCS to support man-in-the-loop evaluation and training for Force XXI. By FY00, transition existing virtual and systems performance models to CME to facilitate model enhancements for Force XXI acquisition/fielding and to realize cost/benefit ratio improvements in use of M&S. By FY01, complete transition to CME and demonstrate next-generation simulation aids for initialization, management and data reduction that will reduce time required to set up, execute and analyze results of simulations and user-interface technology that supports use by the Warfighter for mission planning/training. S&TCD Funded, C^2SID Executed.

Supports: Digital Battlefield Communications (DBC) and Battlespace Command and Control (BC^2) ATD programs, Battlefield Information Transmission System (BITS), and the Warfighters Information Network (WIN).

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IV.G.09—Personal Communications System for the Soldier. The objective of this STO is to develop the next generation Land Warrior Radio Technology by adapting commercial cellular PCS (CDMA and WB–CDMA) technology to support the needs of the dismounted soldier. A second goal is to satisfy the Joint Service requirements for dismounted Warfighter communications. The technical objectives will be executed in close cooperation with the DARPA Small Unit Operations (SUO) and Global Mobile Information Systems (GloMo) Programs. This technology offers significant advantages in Multipath performance (MOUT application) and Anti Jam/Low Probability of Detection protection. This effort will emphasize the elimination of fixed cellular infrastructure requirements on which the other PCS initiatives are based. This STO will build on technical and operational experience acquired with CDMA and W–CDMA technology in various frequency bands acquired during our activities in support of the DARPA Commercial Communications Technology Testbed (C^2T2) and GloMo programs, Digital Battlefield Communications ATD, and the USMC Hunter Warrior and Sea Dragon exercises. This STO will develop peer-to-peer and multihop packet relaying protocols on portable computer host, leading to a demonstration of a noncellular PCS handset exploiting commercial chipsets and ASICS used in CDMA and W–CDMA systems. In FY97, the RF multipath environment for dismounted soldiers moving in urban terrain and or other constrained terrains will be characterized. By FY98, host computer interface will be defined to enable rapid protocol development for implementation on portable (handheld) computer environments (e.g., PDA). In FY99 and FY00, peer-to-peer and multihop packet relaying will be demonstrated with commercial CDMA and W–CDMA handsets adapted for use without reliance on cellular land network infrastructure.. In FY99 and FY00, Fortezza COMSEC developed under the CONDOR and MISSI programs will be demonstrated in the DARPA SUO Program and MOUT ACTD. The final year's demo in FY01 will demonstrate a technology upgrade for the Land Warrior soldier platform. Benefits of CDMA and W–CDMA technology for tactical applications will be evaluated and demonstrated throughout the program.

Supports: Military Operations in Urban Terrain (MOUT), ARPA Small Unit Operation, Land Warrior Soldier Program, USMC Urban Warrior.

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IV.G.10—Advanced Battlefield Processing Technology. The objective of this effort is to develop an extensible, scaleable and adaptable software infrastructure to enhance the command and control decision making. This research effort focuses on significantly improving the information access and operator focus of attention so that significant battlefield events are rapidly perceived and readily understood by the commanders and staff with minimal interaction. By FY98, demonstrate software subsystems to enhance battlefield visualization fidelity / responsiveness. By FY99, demonstrate software subsystems to integrate battlefield environment models with high resolution terrain. By FY00, demonstrate software subsystems to enhance synchronized operations through focus of attention and seamless information access. By FY01, demonstrate software subsystems to evaluate hands-free multimodal human computer interaction (natural language, eye-tracking and gestures). This suite of tools will enhance battlefield visualization capabilities of C^2 systems by improving scalability from the TOC to the Platform level and extensibility across the maneuver and Intel BFA's.

Supports: Rapid Terrain Visualization ACTD, Battle Command and Control (BC^2) ATD, CERDEC

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COMPUTING AND SOFTWARE (Section H)

IV.H.01—Rapid Prototyping for a System Evolution Record. The objective of this STO is to develop a System Evolution Record (SER), using the Computer-Aided Prototyping System (CAPS) Rapid Prototyping Environment, which will provide a "cradle to grave" repository for all artifacts and information produced during software evolution. The SER will be modeled using CAPS, then each part of the software development process will be modeled in the same way to allow integration over the SER. In FY96, the modeling of the System Evolution Record will be completed, and the first attempts will be made to integrate the Evolvable Legacy Systems process developed at the MICOM Life Cycle Software Engineering Center (LCSEC). In FY97, the Cleanroom Software Engineering Process from the TACOM–Picatinny LCSEC will be integrated into the SER, and graphical analysis techniques will be analyzed to accelerate air worthiness reviews of flight control software. In FY98, a Requirements Validation tool being developed at ATCOM's LCSEC will be integrated into the SER. In FY99, the Domain Analysis and Software Reuse process develop at CECOM's LCSEC will be integrated into the SER. This project will improve the way we evolve Army software systems, providing the commander with the enhanced ability to see, hear, know, communicate, kill the enemy, and protect his/her own soldiers.

Supports: AMC Life Cycle Software Engineering Centers (ATCOM, MICOM, CECOM, TACOM, and VASTC ATD), DISC 4, Battle Command Battle Lab, CSS Battle Lab, DSA Battle Lab.

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CONVENTIONAL WEAPONS (Section I)

IV.I.03—Insensitive Munitions (IM) Minimum Smoke Propellants. Develop propulsion systems composed of energetic materials and inert components for current and future Army tactical missile systems that meet the policy of the Joint Services Requirement for Insensitive Munitions (JSRIM). By the end of FY96, load IM motor cases with minimum signature solid propellant and complete IM testing. By FY97, identify MS formulations with and survivable inert case concepts. By FY99, demonstrate the integration of an MS propellant and response-mitigating inert components in a tactical scale motor.

Supports: Mounted Battlespace Battle Lab, Dismounted Battlespace Battle Lab, Hellfire, JAVELIN and LOSAT, system upgrades and advanced concepts.

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IV.I.05—Objective Crew Served Weapon (OCSW). Develop and demonstrate an ultralight, two-man portable, crew served weapon system yielding improved suppression and incapacitation probabilities out to 2,000 meters against protected personnel, and having a high potential to damage light and lightly armored vehicles, water craft, and slow moving aircraft out to 2,000 meters. In FY97, demonstrate penetration capability of 2-inch (51mm) Rolled Homogeneous Armor (RHA) (threshold), or 2-inch (51mm) High Hardness Armor (HHA) (goal). In FY98, demonstrate high probability of suppression and incapacitation out to 2,000 meters against protected personnel targets with the following threshold/goals: Weapon < 38/25 lb; Ground Mount < 12/9 lb; Ammunition < 0.40/0.30 lb; Fire Control < 7/4 lb (est.). In FY99, integrate OICW variant fire control system into OCSW system (leverage OICW ATD; STO III.I.1). In FY00, conduct technical, safety and troop tests to demonstrate operational utility and technological maturity.

Supports: Replacement for selected 40mm MK19 GMG and Cal. .50, M2 HMG; primary/secondary armament for vehicle applications (i.e. CRUSADER, FSCS, FIV); Transitions to PM–Small Arms funded 6.4 program.

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IV.I.07—Flexible Sustainer for Multimission Weapons. This flexible sustainer will demonstrate two approaches, one a low thrust, controllable, bipropellant gel propulsion system, and a pintle controlled solid propulsion, both tightly integrated with the weapon system guidance and sensor to achieve dramatic gains in system performance. Approaches are dependent upon determination of optimum velocity required for range and target. By FY98, design the layout for the workhorse component demonstration. Select the baseline propellant. By FY99, demonstrate propulsion system performance in workhorse hardware, and develop advanced propellant. By FY00, downselect to a single approach, complete characterization of advanced propellant, and finalize design of flightweight component hardware. By FY01, complete flightweight component development and demonstrate high performance in a sustain engine. This flexible sustain technology will provide short time-to-target for close range, a doubling of the maximum range within the existing missile package, and high engagement velocities for improving terminal performance, particularly at the long ranges.

Supports: Follow-On-To-TOW (FOTT), Hellfire III, Stinger Block II.

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IV.I.08—Seeker Dome for Hypervelocity Air And Missile Defense. The Operational Requirements Document for the STINGER Guided Missile System, dated 17, Jan 1996, establishes a requirement to counter/engage a new generation threat that may be hypervelocity. This effort will develop a seeker dome for a 2.75 inch diameter missile that is capable of operating in and withstanding hypervelocity flight conditions. The concept is the P^3I growth of the existing STINGER system through the adaption of the planned Block II seeker to a hypervelocity motor. Development of a dome for this seeker is one of the critical technologies that must be addressed before this seeker can be implemented in a functional system. For this proposed effort, current state of the art seeker dome technologies will be identified and applied to development of a dome for the STINGER system. Current IR dome materials such as Sapphire and Spinel provide the thermal and thermal shock resistance required to perform in low altitude hypervelocity environments. In this program, the best dome design (i.e., material and configuration) will be developed and tested. The development of a dome attachment scheme to the missile airframe (which is a critical aspect of the design) will be included in this effort as well as system simulation studies to assess extended range capabilities. These simulation studies will include evaluating dome shapes as well as alternate motor designs. Testing of the dome will consist of subjecting the seeker system (dome along with an IR sensor) to a hyperthermal environment to assess its survival and operation. At the end of FY98 trade studies and preliminary concept will be complete. By the end of FY99, preliminary design, design evaluation, and laboratory testing will be complete. This STO will culminate in FY00 with the completion of the final design, fabrication of seeker domes and the testing of these domes in a hypervelocity environment to assess performance.

Supports: STINGER Weapons System, Cruise Missile Defense, AVENGER Weapon System, Bradley Linebacker.

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IV.I.09—Warheads for Armor Defeat. By FY98, this STO will demonstrate a single multimode warhead to defeat both lightly and heavily armored targets. In FY96, develop and demonstrate a wide area shaped charge penetrator warhead to provide a 400% increase in lethal area against lightly armored target. In FY97, conduct evaluation of more lethal main charge warhead for heavy armor defeat utilizing more powerful explosive and advanced liner material. In FY98, demonstrate warhead design that has selective mode to defeat either a heavy armored target (15–20% increase in performance compared to Javelin) or a lightly armored target (400% increase in lethal area compared to standard Shaped Charge).

Supports: Javelin, Hellfire, BAT, etc. Dismounted Battlespace BL.

STO Manager	TSO	TRADOC POC
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IV.I.10—Polynitrocubane Explosives. By FY99, this STO will demonstrate a more powerful explosive using polynitrocubane to increase energy performance by up to 25% compared to current fielded explosives. In FY96, initiate the synthesis of a more powerful polynitrocubane explosive. In FY97, scale up the polynitrocubane explosive to pound level. In FY98, scale up the polynitrocubane explosive to pilot plant quantity and initiate formulation study for antiarmor warhead (Shaped Charge or Explosively Formed Penetrator) loading. In FY99, conduct static warhead test using the polynitrocubane explosive to show increase in energy performance by up to 25% and with comparable sensitivity to LX–14.

Supports: BAT, AIS, Mounted & Dismounted Battlespace Battle Labs.

STO Manager	TSO	TRADOC POC
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IV.I.11—High-Energy/High-Performance Propellant Formulations for Tank Guns. By FY98, this STO will demonstrate a high performance propellant with a 10–20% increase in impetus values over JA2 propellants yielding a 5–10% increase in muzzle velocities over the M829A2. In FY96, initiate small scale evaluation of the high energy gun propellant composition. In FY97, scale up pilot plant processing technology and perform preliminary gun firings. In FY98, conduct final evaluation and demonstrate high performance propellant in live firing to increase impetus values by 10–20% over JA2 and muzzle velocities by 5–10% over M829A2 to enhance lethality.

Supports: All Tank Munitions, Mounted Battlespace battle lab.

STO Manager	TSO	TRADOC POC
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IV.I.13—Electrothermal-Chemical (ETC) and Electromagnetic (EM) Armaments for Direct Fire. Demonstrate leap ahead technology to defeat future threat targets such as explosive reactive armor and active protection systems using EM (2015) and ETC (nom. 2002) armaments in mobile, armored vehicles. EM gun technology is high risk, but has potential for tunable lethality for defeating a spectrum of future threats. ETC technology offers potential for achieving demonstrated 140-mm performance from a 120-mm cannon. ETC is high risk as an M1A2 SEP candidate, but is a risk mitigator for FCS, since power requirements are much lower than for EM. Crucial to the success of EM armaments is the development of compact pulsed power rotating machinery (compulsators, CPAs) and integrated launch packages (ILPs). Structural mechanics analysis methods for compact CPAs and ILPs will be developed. The understanding of EM launch package accuracy and rail interaction will be advanced. ETC combustion control will be modeled and tested. By FY97, complete and test the subscale pulsed power compulsator (CPA), perform structural mechanics analysis of ILP candidate, and develop ETC concepts for feasibility tests. By FY98, test subscale compulsator at full design limits, fire base-pushed novel penetrator ILP, and demonstrate 14 MJ ETC launch from 120mm, M256 cannon. By FY99, demonstrate 3 J/g in a pulsed power CPA system mated to an EM gun, ILPs at 7MJ:2.5 km/s, launch energy velocity, with less than 50% parasitic mass and no accuracy barriers, and from a 120-mm XM291 ETC gun system, obtain 16–17MJ, i.e., equivalent performance to that demoed in a 140-mm conventional gun. EM offers potential for hypervelocity launch with increased and flexible lethality, increased hit probability, reduced firing signature, propellant elimination, and synergism with an all-electric vehicle system. Benefits of ETC propulsion include significant muzzle energy increases at an order of magnitude less pulsed power than for EM guns by enabling advanced charge designs, and improved combustion control with potential for increased accuracy.

Supports: TRADOC, PM–TMAS, ARDEC, TARDEC, PEO–ASM.

STO Manager	TSO	TRADOC POC
Edward M. Schmidt ARL–WMRD (410) 278–3786 DSN: 298–3786	Catherine Kominos SARD–TP (703) 697–3558 DSN: 227–3558	Martin Bosemer Mounted Battlespace BL (502) 624–2045 DSN: 464–2045

IV.I.14—Target Destruct TD. The Target Destruct TD will demonstrate, via modeling and both surrogate and actual threat target testing the most promising advanced lethal mechanisms launched at ordnance and "super ordnance" velocities at extended range with up to 100% increase in lethality over the current equivalent caliber of ammunitions. The results will lead to a more efficient defeat of threat target arrays for the Future Combat System (FCS), Abrams tank, Future Scouts and Cavalry System (FSCS), Bradley, and Future Infantry Vehicle (FIV), Lethal mechanisms considered include a variety of novel penetrators (including hypervelocity-type), novel warheads, and "blunt trauma" projectiles. In FY98, novel penetrator warhead concepts capable of defeating threat target arrays (frontal top attack and counter APS) associated with the FCS. Abrams Tank will be defined, simulation completed to determine best technical approaches, and fabrication of demonstration hardware initiated. In FY99, initiate demonstrations of novel penetrator defeat FCS and Abrams threat targets, demonstrate and characterize, in live-fire testing, "blunt trauma" projectile lethal effects, and complete novel penetrator concept design and selection of the best technical approaches for defeat of the Bradley, FSCS, and FIV threat target arrays. In FY00, complete demonstrations of heavy threat target defeat, demonstrate novel penetrator defeat of heavy and light armored threat, and conduct overall assessment of all lethal mechanisms against future target arrays.

Supports: All antiarmor weapon systems and weapon platforms: 120mm Tank Ammunition (KE, CE, Smart Munitions, M1A1, M1A2, M1A2 SEP, M1A2 SEP–, Future Combat System, KE/CE Missiles, Bradley Future Scout and Cavalry System, Future Infantry Vehicle, Advanced Assault Amphibian, USAARMC, USAIS, USMC.

STO Manager	TSO	TRADOC POC
Anthony Sebasto ARDEC (201) 724–6192 DSN: 880–6192	John Appel SARDA–TT (703) 697–8432 DSN: 227–8432	A. Winkenhofer USAARMC (502) 624–8064 DSN: 464–8064

IV.I.15—Advanced Solid Propulsion Technology. Demonstrate advanced solid propellant technology to increase muzzle energy by 25%. The increased muzzle energy and lethality resulting from this advanced propellant technology will provide a same number of stowed kills in a smaller volume. By FY99, investigate RDX based advanced propellants. By FY00, manufacture and test CL20-based advanced propellants. By FY01, demonstrate propulsion performance increase of 25% in scaled and large-caliber guns. This STO is being conducted with ARDEC.

Supports: PM–Crusader, PM–Paladin, PM–TMAS, PM–Bradley, Future Infantry Fighting Vehicle, Future Scout Vehicle, Future Combat System.

STO Manager	TSO	TRADOC POC
T.C. Minor ARL–WMRD (410) 278–6189 DSN: 298–61989	Catherine Kominos SARD–TP (703) 697–3558 DSN: 227–3558	Charles Campbell MBS BL (502) 624–1963 DSN: 464–1963

IV.I.16—High Quantities Antimaterial Submunition (HI–QUAMS). The High Quantities Antimaterial Submunition (HI–QUAMS) effort is in support of a TRADOC Futures Division identified need for a 5–10x improvement in stowed kills for MLRS / ATACMS when attacking lightly armored, highly-valued targets. To improve stowed kills, more submunitions need to be dispensed and must be more effective. To store more submunitions in the MLRS the submunitions must be smaller and to be more effective they require accurate identification of targets in and out of clutter. HI QUAMS will demonstrate ladar seeker miniaturization technology necessary for future Army powered submunitions. The submunitions performance requirements dictate the need for ladar seekers and constrain the seeker diameter to about 3 ½ inches. Current sister service ladar technology programs are addressing size reduction (5–6 inches in diameter) efforts for current technologies to bombs and cruise missile applications. Advanced state of art fiber optic lasers, no moving parts scanners, and integrated detector electronics are expected to provide a miniaturization pathway supporting Army requirements. At the conclusion of FY98, two phase-one SBIRs ('A high speed, precise, "no moving parts," scanner for use in a compact eye safe ladar and Multiple Channel GHz Sample Rate Pulse Capture Module Development with Integrated InGaAs Detector Array) will be completed that support the final seeker design concept, simulation to verify seeker performance characteristics will be completed, and the detailed seeker design will begin. At the conclusion of FY99, the detailed design of the seeker will be completed and integration and testing will start. At the conclusion of FY00, the final integration and testing of the seeker will be completed and a functional ladar brassboard incorporating the components necessary to fit into a 3-inch diameter will be demonstrated.

Supports: Force XX1, US Army Field Artillery and School (USAFACS), and D&SA Battle Lab, MLRS, ATACMS.

STO Manager	**TSO**	**TRADOC POC**
Joseph Grobmyer MICOM RDEC (205) 876–1094 DSN: 746–1094	Irena Szkrybalo SARD–TT (703) 697–8432 DSN: 227–8432	Randy Shorr D&SA Battle Lab DSN: 639–2936

IV.I.17—Armament Decision Aids. By FY00, this STO will demonstrate decision aids software for an advanced self-propelled howitzer to reduce fire mission response time by 50% compared to current methods while operating with a maneuver force. In FY97, investigate armament decision aids using techniques that may include rule-based reasoning, fuzzy logic, Bayesian networks, artificial neural nets, or a combination of the four, and interface requirements for fire support elements in a maneuver environment. In FY98, conduct object oriented analysis of advanced reasoning and artificial intelligent techniques implemented in a set of software components for use by fire support elements capable of operating with a maneuver force. In FY99, integrate software components with existing platform vetronics. The components will be designed with the ability to be configured in a distributed (inter-netted) as well as a standalone environment. In FY00, demonstrate software components that reason based on digital terrain data, with a 50% reduction in time required to respond, emplace, fire, and conduct survivability moves while operating with a maneuver force, as compared to current methods.

Supports: STO III.G.12 Crusader, Paladin P^3I.

STO Manager	TSO	TRADOC POC
Victor Yarosh ARDEC (201) 724–3524 DSN: 880–3524	John Appel SARDA-TT (703) 697–8432 DSN: 227–8432	(TBD)

ELECTRON DEVICES (Section J)

IV.J.03—Army Automatic Target Recognition (ATR) Evaluation. This program provides the baseline technical/operational evaluation of algorithms developed by industry/academia/government against established datasets to ensure the functional performance of ATRs meets established requirements in accordance with previously established evaluation technology and associated metrics. By FY96, 1) establish a beta site for RASSP and initiate architectural assessments of ATRs operating in tanks and ground stations, and 2) define open system processing architecture based on commercial and MIL–STD practices, and assess 2nd Gen FLIR algorithms to cue operators to targets. By FY97, extend algorithm assessment to millimeter wave radar and demonstrate rapid prototyping of processor modules utilizing computer-aided design techniques and commercial/DARPA developed tool sets to reduce the development time by 30% and reduce module cost by a factor of 10. By FY98, implement critical target acquisition algorithms at the module level. By FY99, extend algorithm assessment to multisensor fusion and integrate and demonstrate advanced ATR algorithms integrated with a multimodule processor and smart focal plane array.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality & Survivability, Target Acquisition ATD, Aerial Scout Sensors Integration TD.

STO Manager	TSO	TRADOC POC
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CERDEC/NVESD	SARD–TT	MBS BL
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DSN: 654–1745	DSN: 227–8432	DSN: 464–1963

IV.J.04—Soldier Individual Power Source. By FY96, using the best available hydrogen–air Proton Exchange Membrane (PEM) Fuel Cell technology: (1) Demonstrate a fuel cell powered battery charger that can provide 1200 watt-hour of charging per Kg of fuel. (2) Evaluate pressurized hydrogen/oxygen PEM fuel cell systems and determine whether further development of such systems will be advantageous over the more near-term hydrogen/air systems. Demonstrate a 50 watt/200 watt-hour fuel cell power supply weighing 2 Kg and characterize a unit capable of 500 watt-hours. By FY98, using best available hydrogen/air, hydrogen/oxygen or liquid fueled PEM fuel cell technology, demonstrate a 50 watt/200 watt-hour fuel cell power supply that weighs less than 1 Kg and 150 watt/600 watt-hour unit weighing less than 2.5 Kg.

Supports: Generation II Soldier, 21 CLW, DBBL, SOF.

STO Manager	TSO	TRADOC POC
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DSN: 654–2637	DSN: 227–8432	DSN: 835–6391

IV.J.06—Ferroelectric Phase Shifter Materials. The cost of phased array antenna is predominantly dependent on the cost of its microwave phase shifter. This STO will develop the processing methodology to produce a microwave phase shifter from a low-cost, low-power dissipation, voltage driven ferroelectric composite ceramic and thereby reduce the cost of a phase shifter element from $5000 to $200. By FY96, demonstrate thick-film low-low phase shifter material for use at 15GHz. By FY97, demonstrate a thick film phase shifter material for use at 25GHz. By FY98, demonstrate a thick film, low cost phase shifter material in phased array antenna operating at 35GHz. The product of this STO will be a prototype replacement for the "ferrite phase shifter element" designed in mid to higher communication frequencies for the "geodesic cone antenna component" in the following systems: Ground Based Common Sensor; Air Reconnaissance Low, Aerial Common Sensor, Advanced Quickfix; Guardrail.

Supports: Technology for Affordability, PEO–IEW, Battle Command Battle Lab.

STO Manager	TSO	TRADOC POC
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IV.J.07—High-Energy, Cost-Effective Primary and Rechargeable Batteries. Modify cost-effective commercial technologies so that they can be used for both training and combat. By FY99 produce a low-cost, pseudo-rechargeable, environmentally benign battery (less than $0.05/Wh) for use in training and low-rate applications, with the possibility of recharging these for limited numbers of cycles before discarding. By FY00, provide prototypes for field trials of long cycle life rechargeable batteries, used for both training and Special Operations missions, having an energy content 20% greater than the existing nickel-metal hydride battery. The goals will be to reduce manufacturing cost, while maximizing performance and safety. By FY01, demonstrate proof-of-principle prototypes of the most cost effective, safe high performance primary battery with greater than 300 Wh/kg.

Supports: PEO–C^{3}S, SOCOM, PM–TRCS, PM–SOLDIER, SSCOM, Land Warrior, Air Warrior, Dismounted Battlespace Battle Lab, Task Force XXI.

STO Manager	TSO	TRADOC POC
Robert Hamlen CERDEC (908) 427–2084 DSN: 987–2084	Rob Saunders SARD–TT (703) 697–8432 DSN: 227–8432	Herbert Russakoff CSS Battle Lab (804) 734–0599 DSN: 687–0599

ELECTRONIC WARFARE/DIRECTED-ENERGY WEAPONS (Section K)

IV.K.02—Noncommunications Electronic Support Measures(ESM)/Electronic Countermeasures (ECM) Techniques. Development of the advanced techniques to intercept, identify and geolocate modern, low probability-of-intercept signals. These developments will allow for the location and subsequent deception/jamming/spoofing of threat emitters and electronic surveillance equipment on the battlefield. By FY95, demonstrate an advanced ESM receiver with increased sensitivity and multiple IF receivers to provide more accurate pulse descriptions. By FY96, develop coordinated roadmap for navigational/radar/ELINT deception. By FY98, demonstrate advanced radar system simulator to support PM battlefield deception. By FY99, demonstrate ESM capability against impulse radars.

Supports: IEWCS, AQF, BCBL(H), BCBL(L), BCBL(G), EELS BL.

STO Manager	TSO	TRADOC POC
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IV.K.05—Advanced Electro-Optic/Infrared Countermeasures. Advanced EO/IR CM will develop multifunction CM to protect Army aircraft and ground vehicles from advanced EO/IR surface to air missiles (SAMs), Antitank Guided Missiles (ATGMs) and smart munitions. Technology development will focus on key components and missile algorithms, jamming sources, optics, pointing/tracking devices, missile plume and laser sensors and include advanced jamming techniques against passive homing, command to line of sight and beamrider SAM and ATGM missiles. Particular emphasis will be on horizontal technology integration of ATIRCM architecture infused with low cost and adapted NDI components for ground vehicle protection. By FY96, demonstrate beam coupler for multiband ATIRCM laser and advanced jamming techniques for transition to the MSCM demonstration. By FY97, define optical breaklock criteria for short pulse laser based jamming techniques for use on MSCM/ATIRCM. By FY98, develop and test detection and CM against advanced imaging missiles directed at low flying aircraft and ground vehicles; and assess/develop EO/IR ATCM detection algorithms for transition to PM–GSI's Ground Vehicle missile warning program.

Supports: TRI-Service ATIRCM/CMWS, Suite of Integrated ASE, Hit Avoidance ATD, Armored Systems Modernization, Ground Combat Vehicle Missile Warning and IRCM, Air Maneuver Battle Lab, Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Upgrades to FSV.

STO Manager	TSO	TRADOC POC
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IV.K.06—Advanced Radio Frequency Countermeasures. By FY95, demonstrate jamming techniques against multispectral top attack smart munitions. By FY96, demonstrate an ECM modulator with the capability to jam monopulse millimeter wave. By FY97, demonstrate a fully interactive survivability simulation between CECOM SIL/DIL, Fort Rucker Aviation Test Bed, and the CECOM mobile ASE Test Bed over DSI for CM and Situational Awareness (SA) to provide over a 200% increase in survivability. Initiate bi-service exploitation and development of phased array model for digital ECM modeling. Integrate advanced fuze simulator into the SIL and conduct jamming simulations. Conduct ECM trials vs an I Ban SAM tracking radar. FY98, integration of Longbow simulator into SIL over DSI to demonstrate multifunctional of advanced EW sensors to provide over 200% increase in targeting and combat ID assist with links to ground vehicles. Demonstrate high accuracy LO RF direction finding, targeting assist for Comanche and over 200% increase in CM effectiveness against monopulse phased array SAM radar through the use of digital models. By FY99, SIL/DIL demo 200% increase in SA, CM and CID assist for Longbow and ground vehicles, a 40% A-kit weight reduction using fiber remoting of antennas, a 200% increase in emitter geolocation for SA and targeting and initiate advanced CM vs bistatic, impulse and low probability of intercept radars.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth & Simultaneous Attack, Battle Command, Early Entry Lethality & Survivability, RPA ATD, Hit Avoidance ATD, Proposed Integrated Situational Awareness and Countermeasures ATD, PM–AEC Suite of Integrated RF Countermeasures, AN/ALQ–211, PEO–211, PEO–IEW VLQ–9,10,10 & PLQ–7.

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IV.K.07—Low-Cost Electro-Optic/Infrared Countermeasures. Low Cost EO/IR CM will develop active/passive devices to protect aircraft and ground vehicles with conventional and suppressed signatures from EO/IR guided threats. Countermeasures to IR missiles is the number one DoD EW priority. IR Imaging missiles plus multispectral IR/EO/RF seekers that are being fielded must be countered. Technology development will focus on key components such as, sources, optics, pointing/tracking devices, missile plume and laser sensors and advanced jamming techniques against passive homing, command to line of sight, beamrider missiles and missile detection algorithms. Emphasis will be on horizontal technology integration of EW architecture infused with low cost and adapted NDI technologies for air and ground vehicle protection. By FY00, demo advanced on board laser based jamming techniques used in conjunction with offboard devices against advanced and imaging EO/IR SAM and ATGM threats. By FY00, demo advanced on board laser based jamming techniques used in conjunction with offboard devices against advanced and imaging EO/IR SAM and ATGM threats. By FY01, demo jamming techniques vs. advanced laser beam rider threats. By FY02, develop nonmechanical multiband beam steering for laser based jamming sources. Demo jamming effects against advanced multiband IR/EO missiles capable of attacking suppressed signature air and ground platforms. By FY03, demonstrate jamming source capable of defeating multispectral IR/EO/UV missile seekers.

Supports: Common Air/Ground Electronic Combat Suite Demo, Air Maneuver Battle Lab, Mounted Battlespace, Depth & Simultaneous Attack, Battle Command, Tri-Service ATIRCM/Common Missile Warning System AN/ALQ–212, FSV updates and the proposed Full Spectrum Threat Protection ATD.

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IV.K.08—Three-Dimensional Dynamic Multispectral Synthetic Scene Visualization. This effort will build upon two previous STO accomplishments by demonstrating dynamic 3D multispectral (IR plus passive and active MMW) terrestrial backgrounds for synthetic environments by merging weather, modeled multispectral sensor performance, and terrain data. By FY98, develop and improve visualization capabilities with the addition of dual-band IR and image intensifier capability, including the effects of meteorological conditions. By FY99, apply physics-based models to simulation applications, including visualization capabilities in support of weapon selection. By FY00, Extend physics-based models and visualization capability to passive and active MMW. By FY01, integrate mode derived IR and MMW sensor performance overlays into 3D visualization. By FY02, implement 3D dynamic multispectral synthetic scene visualization into force-on-force simulation.

STO Manager	TSO	TRADOC POC
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IV.K.09—Advanced Electronic Warfare Sensors. This project will develop multispectral missile, laser and radar warning sensors with precision angle of arrival, primarily to control and direct CM, but with added capability for enhanced situational awareness, target cueing, and combat ID assist. The multispectral sensor in a single head will reduce weight, maintenance, and spare logistics. Emphasis will be on horizontal technology integration of EW sensors infused with low cost and adapted NDI technologies for air and ground vehicle threat detection. The developed sensor technology, which will be P3I for the AN/ALQ–211 & ALQ–212, will provide expanded capability against multispectral and updated RF, IR, EO and laser air defense and ground threat weapons. FY99, initiate development of multioctave antennas for multispectral SAMs, top attack munitions and antiaircraft mines. FY00 conduct field testing of antennas and ECM, transition to ISAT, and initiate development of common air/ground vehicle sensor and CM modules. FY01, continue development of common air/ground sensors/CM against phased-array and UWB radars with advanced ECCM modes. FY02, field test common air/ground sensors/CM against phased array and UWB radars and transition to Common Air Ground Electronic Combat Suite (CAGES) demonstration program. FY03, conduct tests of CM to multispectral SAMs, antiair mines, UWB radars and advanced multispectral top attack munitions.

Supports: Proposed Integrated Situational Awareness and Countermeasures (ISACM) ATD,PM–AEC Suite of Integrated RF Countermeasures, AN/ALQ–211, PEO–IEW family of Shortstop VLQ–9, VLQ–10, VLQ–11, and PLQ–7. Dismounted Battlespace, Mounted Battlespace, Depth & Simultaneous Attack, Battle Command, Early Entry Lethality & Survivability, and the proposed Full Spectrum Protection ATD.

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CIVIL ENGINEERING AND ENVIRONMENTAL QUALITY (Section L)

IV.L.01—Installation Restoration. Provide cheaper and more effective technologies for cleanup of soil, sediment, groundwater, and surface water contaminated with hazardous and toxic wastes from past military activities. Provide technologies to reduce explosives-contaminated site remediation costs by 50% using biological degradation as an alternative to incineration by the end of FY95. By the end of FY96, provide technologies to reduce the costs of decontaminating organics-contaminated soil and ground water by 30% using innovative chemical, biological, and physical processes. By the end of FY97, provide technologies to reduce the cost of remediating heavy metals-contaminated soils by enhanced physical separation processes. By the end of FY98, develop concept guidance on the implementation of in situ biological processes for remediation of explosives contaminated soils.

Supports: Tri-Service Environmental Quality Strategic Action Plan.

STO Manager	TSO	TRADOC POC
Dr. J. Keeley USAEWES (601) 634–3477	Donald Artis SARD–TR (703) 697–3558 DSN: 227–3558	Bill Adams

IV.L.04—Sustainable Military Use and Stewardship of Army Lands. The goal is to improve military access to and stewardship of training/testing lands through improved knowledge bases and predictive tools that integrate multiple landscape factors into decision aids for military land use planning and management. By the end of FY00, develop measures to match land use with environmental conditions affecting land capacity. By FY01, provide simulation tools for erosion management and land rehabilitation options to restore/maintain lands for sustained use. By the end of FY01, provide better understanding of cause–effect relationships and models to simulate mission impacts on key protected species. By the end of FY02, provide a military land management decision support capability integrating erosion, land use and rehabilitation, and species impact models with land capacity.

Benefits include improved training realism and safety, reduced maintenance costs for equipment and land, increased flexibility in land use, up to 50% reduced constraints on access to land (at present, approximately 2 million acres are constrained), and reduced fines due to environmental compliance.

Supports: National Environmental Policy Act, Endangered Species Act, Historic Preservation Act, Clean Water Act, Clean Air Act, and FOC EN97–027

This proposed STO has been endorsed by Larry Chenkin, ATSC, (757) 878–3090.

STO Manager	TSO	TRADOC POC
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IV.L.05—Munitions Production Compliance Technology. The goal is to develop industrial installation compliance technologies to enable the Army industrial facilities to maintain production capability while achieving a 20% to 30% reduction in compliance costs under existing and projected effluent limitations. By the end of FY99, complete bench scale studies of energetic degradation under sulfate reducing conditions.

By FY00, reductive electrochemical processes for treating energetic (propellants, explosives, and pyrotechnics) waste streams contaminated with nitro-aromatics, nitramine or nitrate esters that will meet discharge permit limits with a lower cost and greater operational flexibility than conventional technology. By the end of FY01, sequential bioreactor technology for treatment of energetic contaminated industrial facility waste to substantially reduce the capital and operating costs of Army industrial facilities. Current treatment/disposal costs range from $200 to $300 per ton, the goal is a 20% reduction in treatment costs. One installation, alone, can generate in excess of 4,500 tons of energetic contaminated waste per year.

The benefit of this technology is compliance with existing and evolving environmental regulations allowing production unencumbered by environmental concerns.

Supports: AMC manufacture of ammunition for Tri-Services and FOC – EN97–027

This proposed STO has been endorsed by the Assistant Chief of Staff for Installation Management. ACSIM POC is Kathleen O'Halloran (703–693–0549)

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IV.L.07p—Environmental Cleanup. Provide cheaper and more effective technologies for site assessment and treatment of soils and groundwater contaminated with explosives and energetics (TNT, HMX, and RDX) and heavy metals (lead). By end of FY99, construct explosives/energetics exposure and effects models for use during site environmental risk assessments, reducing cleanup design costs by 20% by cutting risk analysis time in half (reduce from years to months). By the end of FY01, develop in-situ heavy metals extraction for lead, allowing reduced treatment costs from the previous $100–300/ton of soil to $50–150/ton and allowing treatment below existing structures, which is currently not possible. Also by the end of FY01, develop in-situ biotreatment processes for TNT, reducing costs from $100–500/cu.yd. in FY98 to $25–75/cu.yd. By the end of FY01, develop fate and transport risk assessment models and simulations for explosives and energetics that provide rapid contaminant fate predictions, improved risk assessment, and reduced design costs, allowing all risk assessment to be completed onsite. By end of FY02, develop advanced groundwater remediation technologies for TNT, providing increased treatment efficacy and flexibility with overall cost reduction from $1–5/kgal in FY95 to $0.10–2.00/kgal. By end of FY02, develop advanced visualization supporting onsite assessment during all cleanup phases, providing a 50% reduction in time (reduce from months to weeks) for data analysis and treatment selection.

Supports: DoD Reliance Defense Technology Area Plan and the Tri-Service Environmental Quality Strategic Action Plan.

This is a STO (Proposed). This Proposed STO has been endorsed by the Army Chief of Staff for Installation Management (ACSIM POC is Kathleen O'Halloran 703–693–0549).

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IV.L.08—Airfields and Pavements to Support Force Protection. The objective is to, by the end of FY02, provide improved pavement criteria for design/repair/material systems that will result in reduced DoD pavement construction costs (approximately $72M/yr in FY95 dollars), increased pavement reliability (approximately 20 percent) and reduced pavement construction effort (approximately 1 0 percent) in the Theater of Operation (TO). The criteria will consist of material specifications, construction practices, and pavement system design and evaluation models. This is a critical requirement for force strategic deployment from the Continental United States (CONUS) and operational employment in the TO. By the end of FY98, provide criteria for reliable airfields and pavements to support current generation military aircraft and vehicles through the use of local materials (which may be of inferior quality) and pavement binder modifications. This will extend the functional life of a pavement by one year ($250,000 life-cycle savings based on a 10,000 ft long runway). This objective will require new technologies for nonlinear visco-elastic and visco-plastic materials behavior affecting airfield and pavement performance. By the end of FY99, provide criteria for construction/design/repair systems to decrease construction effort by 10 percent for expedient surfaces in TO for military aircraft and vehicles. By the end of FY02, provide criteria for reliable airfields and pavements to support multiple passes of proposed future generation aircraft and military vehicles. Design, construction, and rehabilitation of Army and Air Force airfields is an Army Corps of Engineers responsibility under Project Reliance. This effort supports DTO MP.17.11.

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IV.L.09—Force Protection on the Battlefield. By the end of FY02, provide ballistic and low-signature protection for base clusters in tactical assembly areas by reducing target acquisition distances and increasing survivability from battlefield weapon threats by 3 0 percent. The objective is to develop concepts and criteria for protecting and concealing deploying forces from conventional weapons threats using indigenous or predesigned state-of-the-art materials. Provides a) integrated multispectral camouflage with lightweight construction materials for protective systems, b) validated protective concepts and structural safety assessment procedures, and c) rapid measures to protect critical assets in forward supply points and tactical assembly areas. Force protection will be provided against conventional munitions in operations short of war to high-level conflicts through development of capabilities that do not presently exist. By the end of FY99, provide sprayable multispectral tonedown agents for large area signature reduction. By the end of FY01, provide expedient protective concepts for key assets in forward logistics supply points, develop assessment procedures for the evaluation of the structural safety and protection provided by bunkers and fighting emplacements, and provide designs for fixed/long-dwell facility decoys.

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IV.L.10—Lines of Communication (LOC) Assessment and Repair. The objective is to develop, by the end of FY02, the technologies required for: assessment of in-theater road networks; assessment, classification, and rehabilitation of in-theater bridges; use of low quality or local materials for in-theater construction to increase road construction productivity per engineer battalion by 15 0 man-hours per day. The capabilities provided by these technologies are critical to successful execution of the strategic, operational, and tactical engineering mobility missions required to support Force XXI force projection. By the end of FY99, develop an analytical system for automated load classification of bridges (onsite and remote) reducing assessment time from 3 hrs to 0.5 hr per bridge. By the end of FY00, provide materials and techniques to maintain and repair in-theater operating surfaces while increasing productivity by 150 man-hours per battalion per day.

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IV.L.11—Force Protection Against Terrorist Threats. By the end of FY02, develop procedures to assess the vulnerability of structures that house military forces and methods to mitigate terrorist weapon effects and retrofit vulnerable building components to reduce required blast standoff distances by 40%. The goal is to provide the technology for assessing the risk and protecting the force from the effects of terrorist weapons, including small arms, rockets, mortars, and vehicle bombs. Included will be: (a) analytic software for calculating blast loads on structures, incorporating shielding effects of blast walls and other buildings; (b) methods for predicting damage to structures and building components and the associated hazard to personnel; and (c) effective techniques for retrofitting windows, doors, walls, and roofs. By the end of FY99, develop methods to use high-performance materials to increase the penetration resistance of structural components. By the end of FY01, develop techniques for retrofitting existing structures and mitigating the effects of terrorist impact/fragmentation weapons and vehicle bombs.

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BATTLESPACE ENVIRONMENTS (Section M)

IV.M.01—Target Area Meteorology. Exploit data from all available sources on the battlefield to include meteorological satellites, and through mesoscale modeling, fuse these data with digital terrain data to produce 4D weather forecast information at temporal and spatial resolutions adequate to characterize target area meteorology. By FY95, develop an automated 12-hour forecasting capability to support Joint and Combined Operations and generation of target area decision aids. By FY96, exploit satellite and ground-based remote sensors such as wind radars, lidars, and radiometers to characterize the atmosphere and analyze available upper air met data to produce a "best met" for any user within the battlefield area. Leverage advances in tactical observing, computer architecture, artificial intelligence, and numerical methods to extend forecast capability to 24 hours by FY97, and 48 hours by FY99. Develop met software for automatic fire control procedures by FY98 and integrate with the ballistic module in the artillery fire control center by FY99.

Supports: PM EW / RSTA, PM AF, CERDEC development of Target Area Meteorological Sensor System (TAMSS), PEO CCS—Project Director (PD) IMETS, Joint Precision Strike ATD.

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IV.M.04—Weather Effects and Battlescale Forecasts for Combat Simulation and Training. Integrate improved battlescale forecasting, real-time weather and environmental effects models to provide common, unified weather effects, features and representations for: Force XXI Advanced Warfighting Experiments (AWE); the Intelligence Electronic Warfare (IEW) Technology Investment Strategy; TRADOC combat models and Distributed Simulations such as the Synthetic Theater of War (STOW) Campaign Plan, and for Brigade Task Force XXI mission rehearsal. In FY97, within the IEW Common Operating Environment (COE) extend the Battlescale Forecast Model to provide weather forecast data for Distributed Interactive Simulation (DIS). By FY98, implement advanced algorithms for acoustic-propagation, illumination and visibility, terrain-coupled transport/diffusion and EO propagation effects at multiple levels of fidelity for environmental representations, Integrated Weather Effects Decision Aids (IWEDA) and battlefield visualization tools to support simulations and Division XXI mission planning. By FY99, incorporate an Improved Battlescale Forecast Model for forecast representations of clouds, fog, severe weather (rain) and improved battlefield aerosol diffusion at tactical scales. By FY00, assess improvements provided by shared battlescale weather forecasts, distributed weather processing for M&S and physics-based atmospheric feature and effects models. By FY01 demonstrate interoperability of verified/validated Unified Battlescale Weather and Battlescale Atmospheric Effects Models as a real-time Own the Weather capability for FORCE XXI situation awareness, mission planning and training.

Supports: Brigade XXI and Division XXI AWE's, IEW Technology Investment Strategy, and Synthetic Theater of War (STOW) Campaign Plan.

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IV.M.05—Weather Impacts and Decision Aids (WIDA) for Mission Rehearsal, Training, and Battle. Improve battlefield Weather Impacts and Decision Aids (WIDA) so that current forecast weather and predicted impacts on systems and operations produced by the fielded IMETS are also usable in mission rehearsal, training and combat simulations and so that we "train as we fight." Quantify weather impacts to improve current qualitative "red-yellow-green" stoplight outputs from integrated Weather Effects Decision Aids (IWEDA), developed under STO IV.M.3 for the fielded Integrated Meteorological System (IMETS) and the Army Battle Command System (ABCS) Battlefield Automated Systems (BAS). Weather effects decision aids are included under the Defense Technology Area Plan (DTAP) SE35, Combat Weather Support. In FY98, extend IWEDA rule-based warnings and qualitative weather impacts by upgrading its artificial intelligence techniques to incorporate quantitative atmospheric effects and system performance. By FY99, incorporate quantified impacts of acoustics, illumination, propagation, smoke obscuration, terrain-coupled wind transport, and weather forecasts. By FY00, extend weather-impact models and decision aids to produce quantitative, four-dimensional (4D) weather impacts incorporating improved battlescale forecasts and atmospheric effects on weapons systems and operations. By FY01, upgrade models for characteristics and weather impacts on threat platforms and weapons. By FY02, integrate improvements back into IMETS to upgrade tactical Army Battle Command System weather-impact and decision aids.

Demonstrate during Division Task Force XXI Advanced Warfighting Experiment (AWE) in FY98, Corps Task Force XXI and follow-on AWE's, incorporating Battlescale Weather forecasts and effects for consistent play of real-time Own the Weather capability for Force XXI situation awareness, mission planning, and combat training.

Supports: PEO C^{3}S, ABCS, TFXXI, IEW Technology Investment Strategy, Synthetic Theater of War (STOW) Campaign Plan.

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IV.M.06—Advanced Geospatial Management for Information Integration and Dissemination (AGMIID). AGMIID will develop and demonstrate an automated capability for geospatial data management, based upon feature/attribute linking, supporting the dissemination and integration of geospatial data and information at distributed user locations. AGMIID will demonstrate management technology of increasingly complex (point, line and area) features and functionality over the period of the program. FY98 will initiate the standards process defining link structure for all feature types and complete development of point datalinking. FY99 will see the completion of the standards and definition process, initiate linear feature management development and demonstrate the management, dissemination, and integration of point data and information. FY00 will see the initiation of areal feature management, completion of the linear feature management and development effort and demonstrate the management, dissemination and integration of point/linear data and information. In FY01, demonstrate and test the management, dissemination and integration of point, linear and areal data and information.

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IV.M.07—Rapid Mapping Technology. Develop software and integrate into an automated terrain information system the capability to rapidly extract and properly attribute geospatial information of importance to Army and DoD customers from multisources with various resolutions, densities, and formats. By FY98, incorporate/test techniques for processing Synthetic Aperture Radar (SAR)/Inferometric Synthetic Aperture Radar (IFSAR) feature data into the Digital Stereo Photogrammetric Workstation (DSPW). By FY99, incorporate/test initial spectral imagery and SAR automated feature extraction capabilities. By FY00, incorporate automated feature extraction techniques from spectral, SAR and electro-optical sources into the DSPW software. By FY01, incorporate/test initial automated feature attribution capability based on terrain reasoning software and demonstrate the ability to manage, disseminate and integrate point, line and aerial data under operational conditions. By FY02, incorporate initial terrain reasoning capability and demonstrate initial automated feature extraction and attribution capability on the DSPW.

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HUMAN SYSTEMS INTERFACE (Section N)

IV.N.04—Performance-Based Metrics for the Digitized Battlefield. This STO develops standardized, field-operational measurement scales for use by the Battle Labs, Army Digitization Office, and Army Research & Engineering Centers (RDECs) in defining and evaluating integrated soldier-information system performance on the digitized battlefield. These measurement scales will directly support the U.S. Army's Rolling Baseline assessment of digital information system technology during Advanced Technology Demonstrations, Advanced Warfighting Experiments, and related Force XXI field activities. The resulting metrics will provide both technology developers and field users with a common, standard framework for specifying performance requirements and assessing the contribution of digital information system technology across a variety of battlefield settings (e.g., brigade TOC staff, tank crew, individual dismounted soldier). To achieve this goal, the behavior-based measurement scales will (1) reflect important dimensions of the information processing and decision making tasks performed by soldiers, crews, and staffs; (2) correlate with success in satisfying TRADOC Operational Capability Requirements (OCRs) related to the soldier-information interface; (3) be sensitive to the introduction of new technology, doctrine, procedures, organization, and training; and (4) be observable and measurable in a field setting. Develop and test an initial set of behavioral performance markers addressing tank crew and Command and Control Vehicle (C^2V) operator performance as well as digital communications initiatives for dismounted operations in Warrior Focus (Nov. 95). These behavioral performance markers will be refined and further tested during FY96 in Warrior Focus, Army Logistics ACTD, or other major AWE. A draft Army-standard set of soldier-information system performance metrics for common use by ARL will be developed and refined during FY97, and demonstrated in the context of Prairie Warrior 97 and Division 97. Standards for Army Materiel Acquisition will be developed in FY98.

Supports: Warrior Focus, Army Logistics ACTD, ADO, Battle Command Battle Lab, Mounted Battlespace Battle Lab, Dismounted Battlespace Battle Lab.

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IV.N.05—Cognitive Engineering of the Digital Battlefield. Battle command operations at Bde and above are increasingly being characterized by component capabilities that focus on the cognitive aspects of a distributed decision making process. The STO effort responds through a focused research program aimed at better understanding these cognitive processes as they are shaped by time, stress, team structure, level of staff training and experience, and the introduction of digitization technology. Through experimentation and constructive exercises, the STO develops a set of predictive models and performance metrics for assessing TOC design tradeoffs among information display and decision support technology, team structure, skill and experience level, and cognitive workload (FY99–00). The models focus on commander's intent and maintenance of a relevant common picture, addressing battle staff performance from both a data-driven perspective and a concept-driven perspective. The models and metrics are refined to address both changing Op Tempo and asymmetric engagements (FY01–02). Research findings are used to refine a series of battle staff training approaches that address a broad range of staff officer cognitive skills and functions (FY99–02). Finally, research findings are integrated into a cognitive architecture for the battlefield—a functional roadmap for guiding R&D investments in information technology and staff officer training, Battle Lab experiment planning, and force development planning under Army After Next (FY01–02). The STO provides a formal mechanism for linking cognitive research activities in USARL and USARI and coordinating these programs with related activities in USASC, CGSC, USAARL, BCBL, and AMBL.

Note: A requested plus-up of $1.8M/year would provide contractor cognitive-decision making research personnel onsite at several battlelabs for C^2 experimentation design and data collection and analysis.

Supports: AAN, Division XXI AWE, Battlespace Command and Control ATD, Rapid Terrain Visualization ACTD, CERDEC

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PERSONNEL PERFORMANCE AND TRAINING (Section O)

IV.O.02—Combined Arms Training Strategy for Aviation. By FY98, develop training technologies based upon empirical data that support the development of a combined arms training strategy for aviation. A methodology will be developed and demonstrated that makes the most effective use of simulators, training devices, and live exercises for initial flight skills through unit combat tasks. In FY97, develop and demonstrate a methodology for rapid evaluation and thorough assessment of on-hand and proposed devices for unit training. Minimum fidelity requirements will be established for critical aircrew skills training and for utilization of, and upgrades to, existing simulators. In FY98, a rationale will be determined for the expanded use of simulators in IERW (Initial Entry Rotary Wing) training to achieve an effective mix of simulator and aircraft training.

Supports: U.S. Army Aviation Center (USAAVNC); STRICOM; PM CATT (AVCATT); TSMS for Longbow, Comanche, Kiowa Warrior.

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IV.O.06—Force XXI Training Strategies. By FY01 develop and demonstrate new training and evaluation technologies that prepare operators and commanders to take maximum advantage of evolving digitized C^3 systems. This training research will incorporate the use of virtual, constructive, and live simulations to demonstrate and evaluate selected prototype training techniques. By FY98 evaluate prototype staff training packages that use advanced digital technology. By FY99 evaluate training and performance assessment tools developed for the digitized battlefield. The training techniques and strategies will be demonstrated and evaluated in Advanced Warfighting Experiments (AWEs).

Supports: TRADOC, USAARMC&S, MBBL, III Corps.

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MATERIALS, PROCESSES, AND STRUCTURES (Section P)

IV.P.03—Cannon Wear and Erosion. The STO consists of two objectives. In FY98, the STO will develop an advanced rotating band and obturator for extended range 52+ caliber artillery munitions. Then in FY01, the STO will demonstrate the viability of wear & erosion resistant coatings that are applicable to both medium and large caliber gun barrels to improve gun barrel life by 10 fold compared to current equivalent gun barrels when used with advanced/higher energy propellants/munitions. In FY98, establish new rotating band design and improved obturator for XM982 & future extended range munitions that will meet the future muzzle velocity requirements (>1000mps); initiate development of tank gun barrel coating and coating process. In FY99, determine coatings candidates and fabricate coating coupons for testing. In FY00, conduct and evaluate coating coupon testing. In FY01, apply and test coating on subcaliber barrel.

Supports: 25mm, 120mm & 155mm Ammunition and Cannon Systems.

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IV.P.04—Ultra-Light Ballistically-Resistant Materials. Demonstrate ultra lightweight ballistically resistant materials that could be incorporated into small arms protective gear and have aerial densities of less than 5 pounds per square foot. The understanding of the materials dynamic properties, chemistry, and microstructure and their interrelationships will be advanced and implemented into the development/design of new materials weighing 40% less than current materials. Both quantitative and qualitative ballistic performance of candidate armor materials and select combinations will be studied. By FY96, determine the baseline dynamic response of lightweight ceramic and polymeric composite materials. By FY97, correlate the relevant materials dynamic properties and response to improvements in ballistic resistance. By FY98, provide guidelines through modeling and simulation codes for enhancing material performance. By FY99, demonstrate ballistic performance and dynamic response of optimal ultra lightweight armor materials. Analysis and data will be transitioned to the Soldier System Command (NRDEC) for applications into personnel armor for soldier protection.

Supports: Personnel protection for infantry and Special Operations forces, Protect the Force, Force XXI Land Warrior ATD–Follow on Program, Dismounted Battlespace Battle Lab.

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IV.P.05—Transparent Ceramics for Armor Applications. Develop and demonstrate transparent armor that meets or exceeds the ballistic performance of existing glass / polymer, with a 30% reduction in weight and thickness, while increasing the in-line transmission in the visible and near IR regions. It will also exhibit superior abrasion resistance, strength, and high temperature properties. By FY97 a ballistic database will be generated for candidate materials for threat levels ranging from fragment threats through 12.7mm Armor Piercing (AP). By FY98 optimized test transparent armor will be developed using the data generated during FY97. By FY99 a prototype component will be designed and fabricated for installation in an existing end item.

Supports: Personnel protection for infantry and Special Operations Forces, Protect the Force, Armored Vehicles, Force XXI Land Warrior Follow on Program, NRDEC, Soldier System Command, TACOM, and Dual Use (Law Enforcement), Dismounted Battlespace Battlelab.

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IV.P.06p—Advanced Materials for Lightweight Combat System Protection. Develop lightweight armor materials for combat systems protection with a resulting 30% reduction in weight by the year 2004. Knowledge gained from STO IV.P.04 of dynamic materials properties, microstructural and physical–chemical changes under impact, and penetration mechanics of ultra-lightweight armor materials will be applied to four classes of materials supporting new armor: (1) functional gradient materials, (2) high modules polymer fibers, (3) improved sintering processed B C/SiC, and (4) ultra-fine grain ceramic matrix composite materials. By FY00, complete feasibility study of fabrication technologies for four classes of materials. By FY01, develop fabrication procedures for four classes of materials. By FY02, initiate fabrication and characterization of selected materials including ballistic performance of the four classes of materials. By FY03, complete characterization of materials and develop guidelines for optimizing fabrication processes. By FY04, scale up fabrication processes for production and determine optimal applications.

Supports: Protect the Force, Dominate Maneuver, Future Armored Combat Vehicles.

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MEDICAL AND BIOMEDICAL SCIENCE AND TECHNOLOGY (Section Q)

IV.Q.02—Field Wake/Rest Discipline in Sustained and Continuous Operations. The physical and cognitive demands of operational missions interact with limited and fragmented opportunities for rest and sleep. The concept of water discipline emerged from an understanding that there is no alternative to adequate water intake for optimal performance; the same concept holds true for sleep discipline. Systematic sleep and rest, consistent with the demands of the OPTEMPO, must be provided to maintain performance quality and sustainability. This research will develop and demonstrate effective means for counteracting the effects of inadequate restorative sleep and rest on military performance. By FY98, develop and validate animal and human laboratory models and test methods to identify and screen the safety and efficacy of sleep and vigilance enhancing compounds in a military setting. By FY98, incorporate human laboratory database derived models of the effects of sleep deprivation on performance in Louisiana Maneuvers Continuous Operations simulations. By FY99, develop a continuous operations simulation to demonstrate and refine the Sleep-Induction/Rapid Reawakening and stimulant components of the Sleep Management System (SMS). By FY99, develop and demonstrate a rapid, reliable, and inexpensive means for assessing a soldier's level of mental fatigue and alertness, transitioning to development the wrist-worn sleep/activity monitor with integrated microprocessor system.

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IV.Q.03—Performance Limits Models. Warfighting thermal performance status is characterized in this STO using multidimensional advances employing USARIEM's state-of-the-art thermal models and mannequin systems, which make available quantitative assessment of heat and vapor transfer properties of clothing and individual protective systems. The information offered by such efforts generate a complete set of tools for implementing physiological thermal predictive control strategies useful over wide thermal and high terrestrial environments. The specific goals are to: (1) biophysically quantify, on both healthy and physically stressed soldiers, the impact of protective clothing and other systems such as handwear, footwear, and high technology fiber material needed for operations in harsh environments; (2) develop and validate operational and thermoregulatory models to predict performance using integrated schemes employing new concepts and materials such as microclimate cooling, enhanced chemical protective clothing and cold weather clothing systems; and (3) exploit the broad spatial coverage of weather satellite data resources to provide environmental inputs to thermal strain prediction models and incorporate recent advances in satellite data collection and image processing technologies needed for the Warfighter. By FY96, develop and validate a microclimate cooling model for concept support of the 21st Century Land Warrior, and develop and validate models to predict performance degradation and injury due to cold-air exposure. By FY97, develop a statistical model of rifle marksmanship as affected by environmental (heat and cold) and operational stressors (fatigue and food / water deprivation). By FY 98, complete the integration of real-time satellite-derived weather data into thermal strain decision aids for battlefield commanders.

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IV.Q.09—Biomechanics for Improved Footwear. By the end of FY97, develop a prototype combat boot embodying materials, design, construction fabrication techniques, and other features to enhance the biomechanical efficiency of the wearer. By the end of FY99, demonstrate a 10–15 percent reduction in the probability of occurrence of stress-related, lower extremity disorders among ground troops wearing the new combat boots.

Supports: U.S. Marine Corps, Advanced Development–RJS1 / 63747 / D669–Clothing and Equipment, Engineering Development–RJS1 / 64713 / DL40–Clothing and Equipment; DBS Battle Lab.

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IV.Q.11—Helicopter Crewmember Sustainment and Performance. By FY97, reduce performance decrements by 25 percent in aircrews following deployment across time zones and during night operations by demonstrating the efficacy of melatonin in operational units and by developing a software package to optimize crew rest strategies. By FY98, identify CM to optimize aircrew endurance and protection during sustained rotary-wing flight operations, including criteria for better helmet design to prevent fatigue from head-supported mass, hearing augmentation to overcome cockpit noise, criteria for the Aircrew Uniform Integrated Battlefield (AUIB) to prevent dehydration and heat stress, and determination of criteria for seats that prevent back pain and are crashworthy in vertical descents. By FY98, complete implementation of findings from the Aviator Epidemiological Data Registry (AEDR) to optimize medical screening and retention criteria for Army aviators. FY99, reduce low visibility accidents by as much as 50 percent with CM to Army-unique spatial disorientation problems encountered during night and reduced visibility flight.

Supports: Medical CM to aviator fatigue performance degradation; Program Apache, Program Manager Comanche, Program Manager Aviation Life Support Equipment, Aviation Center and School; Conduct Precision Strikes: enhance soldier imaging capabilities without spatial disorientation.

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IV.Q.12—Warfighter Readiness and Sustainability Assessment. Warfighter Physiological Status Monitoring. Commanders are concerned with detailed intelligence on enemy forces and are usually well informed of the status of their own materiel; however, they lack tools to access basic information on the physiological readiness of their own soldiers. In the fog of war, it is especially difficult to rapidly assess available human assets. A family of physiological sensors will be developed into a research tool kit needed to gather useful data on soldier status. These data, organized and reduced through a system of knowledge management, will be used to iteratively refine predictive models, and to guide the development of a wear-and-forget, soldier-acceptable Warfighter Status Monitor (WSM). Information commanders want to have about predicted and current status of soldiers will be provided. The communication and computation platform for the WSM will be the DARPA-developed Personnel Status Monitor (PSM), or its equivalent. All systems will be coordinated with soldier systems command to assure compatibility with 21st Century Land Warrior and follow-on programs. By FY98, a miniaturized accelerometry system will provide a personal assessment of cumulative sleep deficit and predicted level of psychophysiological performance. By FY 98, the MERCURY model system of environmental hazards will be complete, predicting soldier performance in specific real-time locations. By FY99, a sensor suite consisting of technologies such as accelerometry, ausculation, spectroscopy, electrical impedance, and force and temperature sensing technologies will be connected through a wireless body local area network (LAN) system, with remote passive data interrogation capabilities. By FY01, a knowledge management system will be developed to reduce information obtained through the WSM system and predictive performance and health risk models to provide essential information that commanders want to have. By FY03, enabling technologies will provided additional sensors for special environments, such as bioelectronic toxic hazard sensors, to detect imminent physiological threats in the immediate environment, as well as minute embedded sensors that will bring automation and reliability to physiological sensing.

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IV.Q.13—Prevention of Heat Injuries. Assurance of U.S. Army capability to operate in hot environments lies at the heart of the Force Projection concept now guiding strategic planning. This program establishes the scientific foundation for Army doctrinal development governing operations in thermal extremes and identifies and refines effective strategies to sustain health and performance following rapid deployment to environmentally challenging operational settings. This research will demonstrate the efficacy of strategies to sustain and enhance performance and to prevent and treat thermal illnesses. By FY98, develop and implement new cellular, organ, and animal models to assess mechanisms of thermal injury. By FY98, determine if antilipopolysaccharide is a key protective factor that explains the lower susceptibility of female, compared to male, Marine recruits to exertional heat illness. By FY99, develop acclimatization strategies using heat shock protein–70 as a biomarker of heat tolerance to improve immediate heat tolerance and accelerate heat acclimation. Determine effect of estrogen supplementation on heat acclimatization in servicewomen. By FY00, develop strategies for 21CLW ATD to modify skim blood flow to maximize the effectiveness of microclimate cooling and heating. By FY01, determine the feasibility of immunoprophylaxis in preventing thermal injury.

Supports: Supports medical CM to environmental threats, PM soldier, and AR 40–10. Supports the Army Modernization Plan objectives to Project, Sustain and Protect the Force – prevent and minimize environmental injury.

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IV.Q.14—Optimization of Physical Performance. This research will lead to the optimization of training programs to reduce injury of physically mismatched individuals to military tasks and to maximize physical readiness through nonmateriel ("skin-in") solution. By FY98, establish a database of energy requirements and activity patterns for men and women in a variety of military jobs to predict and plan for voluntary energy requirements. Demonstrate a reduction in training injuries through improved physical training programs during basic training.. Develop physical training strategies and alternatives to prevent stress fractures in susceptible individuals. By FY99, establish medical criteria to optimize efficiency and ensure safety of individual soldier equipment (combat boots, body armor, load carriage systems) for use by the equipment developers. Develop state-of-the-art scientifically based training programs to improve performance of elite units, for special occupational requirements, and to increase opportunities for all soldiers in jobs with specific physical standards. By FY00, identify biochemical mechanisms and functional consequences of the effects of sudden increases in physical training volume and prolonged physical exertion (overtraining) for soldiers. Identify high-risk-for-injury groups using existing outcome data. By FY01 develop strategies involving antioxidants, ergogenic aids, and physical training techniques to counter reductions in physical capacity produced by overtraining. By FY02, develop strategies including training and other fitness and nutrition habits to optimize bone mineral accretion in young women to reduce stress fracture, and later osteoporosis.

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IV.Q.15—Laser Bioeffects and Treatment. No single factor is more certain to compromise soldier effectiveness than the knowledge of battlefield threats against which there are no proven medical CM. No organ is more vulnerable to the directed energy of laser than the unprotected eye, and blindness, temporary or permanent, can occur in an instant and without warning. Medical research has demonstrated that not all forms of laser energy are equally harmful to the eye; thus, system developers can be guided away from harmful frequency/power mixes by medical exposure standards based on new research, which do not needlessly deny developers options to raise power levels or exploit frequencies that pose less threat. Understanding of the bioeffects must be translated into effective field treatment interventions. By FY97, demonstrate efficacy of early phase antiinflammatory therapy in nonhuman primate model for treatment of laser retinal trauma, and identify other early phase treatment candidates. By FY97, determine hazards of fast optical switch for tank sights and establish analytical methods for prediction of the degree of ocular protection. By FY97, refine eye tracker model to simulate laser injury and correlate performance with human laser accident case results. By FY98, resolve discrepancies in bioeffects database for subnanosecond exposures and update hazards assessment and exposure limits based on operational performance criteria. By FY98, determine bioeffects of broadband diodes used in advanced military display systems. By FY98, develop high resolution ophthalmoscopic imaging technology for use in telemedical assessment of laser eye injuries, and provide laser injury database for inclusion in smart far-forward medical information systems. By FY98, establish performance-based models characterizing levels of visual impairment pertinent to battlefield laser injury. By FY99, develop and test field therapy kits for laser retinal injury. By FY99, develop in vivo photoreceptor imaging in primate models to enhance assessment of laser retinal injury and repair mechanisms. By FY00, refine operational exposure limits. By FY02, refine methodologies to assess and treat laser retinal injuries. By FY02, convolve high resolution retinal imaging technology with photoreceptor transplant technology to evaluate autologous photoreceptor transplant methodology. By FY02, begin evaluation of electronic retinal implants for treatment of laser scotoma.

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IV.Q.16p—Deployable Exposure Assessment System for Environmental Contaminants. This research is being conducted to protect soldiers deploying into environments contaminated with industrial and agricultural chemical wastes that pose either short-term threats to military performance or long-term threats to health such as may have been encountered from chemical mixture exposures during the Persian Gulf War. By FY98, demonstrate application of alternate toxicity test system (nonmammalian bioassay) to rapidly screen water supplies for toxicants such as disinfectant byproducts. By FY99, demonstrate the feasibility of near-real-time biological sentinel technologies for onsite assessment of health hazards from environmental contaminants, including heavy metals, industrial solvents, arsenicals, and cyanide. Validate a comprehensive neurobehavioral toxicity test battery that will be used to identify molecular endpoints associated with performance deficits and neurological pathology from exposure to complex chemical mixtures. By FY00, develop protocols and procedures for simple, nonmechanical exposure and hazard assessment of selected environmental contaminants in air, water, and soil. Identify key bimolecular markers of neurobehavioral toxicity and develop prototype physiologically based model (pharmacodynamic) of bimolecular events leading to performance deficits. By FY02, develop prototype neuromolecular toxicity assessment system that models (pharmacokinetic and pharmacodynamic) outcomes of environmental toxicants on the central nervous system.

Supports: 21st Century Land Warrior; Warfighter Personal Status Monitoring technologies and ensembles; Chemical/Biological threat agent detection systems.

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SENSORS (Section R)

IV.R.02—Photonic Signal Processing Technology. By FY96, demonstrate broad bandwidth, wide dynamic range (20–30 dB) two-dimensional (2D) devices and processors with appropriate algorithms for detection and identification of signals. By FY98 demonstrate a photonic processor with appropriate algorithms for detection and identification of signals. By FY99, demonstrate a 2D optical processor capable of running real time signal and image processing algorithms on data from imaging sensors such as Synthetic Aperture Radar (SAR) or Electro-optical (EO) images that requires significantly less power than conventional digital processors.

Supports: ATR and SAR applications; Electronic Support Measures testbed.

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IV.R.06—Real Aperture Target Discrimination. Develop innovative technologies to detect, discriminate and classify stationary targets with a real beam radar. In FY95, completed conversion of primary clutter database to match Longbow resolution. In FY96, completed real beam radar algorithm training in geographically and seasonally diverse environments. By FY98, develop and demonstrate target/clutter discrimination techniques and algorithms that increase probability of target detection in these diverse environments. Provide quantitative assessment using a Longbow equivalent dataset as to the improvement of the existing capability. The algorithm suite will be capable of autonomous adaptation to various clutter backgrounds. Performance capabilities will be demonstrated using a Longbow equivalent dataset. By FY99, develop more effective classification of tactical vehicles using a two-fold approach: (1) Improve underlying fidelity of target signatures using super-resolution techniques and (2) apply data compression technique such as a wavelet-based approach to vehicle template storage for efficiently cataloging additional signatures.

Supports: Apache Longbow, Comanche, Mounted Battle Space Battle Lab, Target Acquisition ATD.

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IV.R.07—Acoustic Tracking and Identification on the Battlefield. Demonstrate the ability to detect, track, and identify targets from their acoustic signatures in the battlefield environment. This program will develop basic tools for acoustic algorithm development and evaluation and demonstrate real time tracking and identification of vehicles. In FY95, a testbed will be delivered to evaluate algorithms and a consolidated database of acoustic signatures will be created. In FY97, a laboratory capability to quickly analyze acoustic data and facilitate generation of acoustic algorithms will be delivered and real time tracking and identification of targets will be demonstrated. In FY98, the real time tracking and identification will be expanded to include a broader base of targets. In FY99, the capability to track large numbers of targets as a group will be demonstrated.

Supports: RFPI, including Remote Sentry, Intelligent Minefield, Scout Sensor Suite; DIA, including Unattended Measurement And Signature INTelligent (MASINT) sensors.

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IV.R.08—Battlefield Acoustic Sensors. By FY00, this STO will demonstrate an environmental sensor to be used as a decision tool to optimize the deployment of acoustic sensors in various propagation conditions. In FY97, initiate the development of acoustic sensor modeling tools to be used to simulate and predict acoustic sensor performance in various propagation environments, engagement scenarios, and translate user requirements to acoustic sensor design parameters. In FY98, verify performance of acoustic sensor model against target acoustic signatures in specific propagation environments, and initiate development of sensor emplacement algorithms based on environmental sensor measurement data. In FY99, develop prototype environmental characterization, propagation prediction, and artificial intelligence rule-based sensor deployment algorithms, and initiate integration of environmental sensors (e.g. temperature and wind) with an acoustic sensor package. In FY00 demonstrate capability of environmental sensors integrated with an acoustic sensor as a decision tool to assist battlefield commanders for optimal deployment of acoustic sensor systems in various propagation conditions and engagement scenarios.

Supports: WAM PIP, IMF, RFPI ACTD, Hunter Sensor ATD, Transitions to WAM PIP and IMF.

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IV.R.12—Monolithic Integrated Devices for Multidomain Sensors. The Scientific and Technology Objective is to develop an enabling technology for future infrared sensor upgrades beyond 2nd generation FLIR. These upgrades include active/passive interrogation, multispectral detection, and increased local processing in a single FLIR unit. The enabling technology will be demonstrated by the growth of electro-optic devices directly on silicon. The specific objectives are: In FY96, demonstrate a significant reduction in defect density for growth of CdZnTe and GaAs on silicon (to around 105/cm2) utilizing a recently developed molecular beam epitaxy (MBE) growth technique already demonstrated for CdTe on GaAs. In FY97, demonstrate bulk quality CdZnTe grown on silicon and fabricate a test HgCdTe array on silicon in FY98. In FY99, demonstrate high quality electro-optic devices monolithically integrated with silicon electronic devices.

Supports: Future battlespace visualization involving Army thermal imaging systems in tanks, helicopters, missiles, and autonomous scout vehicles, Mounted Battlespace Battle Lab.

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IV.R.13—Advanced Focal Plane Array (FPA) Technology. This STO builds on the Smart FPA STO IV.R.01 to develop and mature components for a more advanced generation of IR imaging sensors that take advantage of advanced large staring focal plane arrays that allow smart temporal and multispectral signal processing. Technology will be developed to provide affordable TV quality imagers in the 3–5mm and 8–12mm bands, including practical nonuniformity correction. By FY97, provide an evaluation of the practicality and affordability of large single spectrum staring/scanning arrays along with validated staring array performance models and complete evaluations and tradeoffs between the 3–5 and 8–12 micron spectral bands to support design of the Multifunction Staring Sensor Suite. By FY99, demonstrate multispectral sensing and partition smart functions between on- and off-focal plane processing. By FY00, integrate multispectral smart sensing with staring FPAs for enhanced soldier vision. By FY01, demonstrate large focal plane, hyperspectral smart sensing with feedback control from weapon system processor to optimize automated target acquisition. These objectives are obtained by integrating multispectral/hyperspectral FPAs with smart read-out-integrated-circuits (ROICs), innovative micro-optics and adaptive micro/nano electronics into tactical dewars.

Supports: Mounted Battlespace, Dismounted Battlespace, Depth & Simultaneous Attack, Early Entry Lethality, Battle Command, Force XXI.

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IV.R.14—Multiwavelength, Multifunction Laser. Develop and demonstrate high efficiency, compact, laser diode pumped, wavelength diverse laser source in the 0.26–12 micron spectral region for multi-functional applications. By FY96, develop moderate (up to 1 KHz) repetition rate laser module with multiple mode operation. By FY97, demonstrate modules in lab with multiple wavelength outputs from 0.26–12 microns for CM (mid IR, far IR), obstacle avoidance, biological agent detection, range-finding, enhanced target recognition, and laser radar for integration with vehicle target acquisition sensors. By FY99, complete development of multiwavelength multifunction modules and demonstrate commonality approach to multifunction and multiapplication laser source.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth & Simultaneous Attack, Battle Command, Early Entry Lethality & Survivability

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IV.R.15—Solid-State Near-Infrared Sensors. Develop a low cost, lightweight, low light level, exclusively solid state sensor with smart readout chip to provide a digital output and become an integral part of the future Digital Battlefield. This technology will rovide affordable, high resolution sensors for reflected light in the 0.4–1.8 micron wavelength region for systems supporting airborne, combat vehicle, and light infantry missions. This sensor technology will be immune to bright light "flashouts" and require no vacuum tube technology. These sensors will have high resolution and sensitivity to detect sniper fire, detect targets through conventional camouflage, detect laser rangefinders/designators, and detect stressed vegetation. By FY99, develop a low cost solid state near IR camera that demonstrates comparable sensitivity to present 12 tubes and can be transitioned as an HTI for all future vision devices. By FY00, develop a large format near IR solid state focal plane array that can be used for sniper scope applications and pick out targets in camouflage at long ranges. By FY01, demonstrate a near IR sensor for lightweight goggle applications.

Supports: Objective Sniper Weapon, OICW/OCSW Upgrades, Future Multispectral Goggles, Future Driving Devices, Special Operations

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IV.R.16—Advanced Signature Management and Deception. Demonstrate technologies that enable development of signature management (SMS) and deception systems that deny acquisition of friendly force assets from threat sensors. Demonstrations will be supported by signature characterization, modeling and simulation conducted under the Integrated Sensor Modeling and Simulation effort. These SMS/deception systems provide mobile and semimobile assets with low cost, low operational burden survivability upgrades addressing detection avoidance in global battlefield conditions. By FY99, develop reactive IR suppressive coatings/appliqués/structures to reduce vehicle and solar loading signatures over an extended period of a diurnal cycle and in varying backgrounds. Complete feasibility study for battlefield deception technologies. By FY00, develop a hybrid SMS to reduce the detection range of tactical, mine warfare, and fire support vehicles by 50% and an ULCANS screen that significantly reduces the signature of general purpose platforms in a desert/urban environment. By FY01, demonstrate synergistic coupling of physical and virtual decoys with passive and active signature management to improve survivability of combat and combat support units. By FY02, develop a multispectral SMS and deception system, operating in the radar, infrared, and visual spectrums, for tactical, mine warfare, fire support, and combat vehicles.

Supports: ULCANS P3I, Multispectral Camouflage System, Light/Medium Tactical Vehicles, LRAS3, Abrams, Bradley, Crusader, Ground Based Sensor, THAAD, Aviation Systems, BIDS, SICIPS.

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IV.R.17—Integrated Sensor Modeling and Simulation. Advance the state-of-the-art in synergistic modeling and prototyping capabilities to permit end-to-end predictive modeling and hardware trade-offs for performance evaluation of new technologies in a virtual environment. Implementation will be supported by development of high resolution, 3-dimensional target, background, and clutter object databases that scale from dismounted infantry to airborne applications. Features will also include realistic portrayal of advanced sensors such as 3rd generation FLIRs, acoustics and radars, aided, automatic and fused sensor usage, low observable signature management techniques, and mine targets. Linked or inserted into operational simulations, this technology will allow warfighters to test new capabilities, develop tactics and techniques, evaluate operational effectiveness, plan missions and train in parallel with the hardware development process. By FY99, develop real-time multispectral (0.4 to 14 microns) capability for insertion into wargame simulations. By FY00, develop and integrate SAR and MMW capability for insertion into wargame simulations. By FY01, validate multispectral portrayal for search and target acquisition simulations and implementation for driving and pilotage simulations.

Supports: Multifunction Staring Sensor Suite, Masked Targeting, Mine Hunter/Killer, Battlefield Visualization ACTD, MOUT ACTD, CATT, COFT, AGTS, FMBT, FIV, FSV.

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IV.R.18—Micro-Eyesafe Solid-State Laser Sources. Low cost, lightweight lasers will benefit the warfighter for multiple applications, including micro rangefinders, combat ID systems, training, and target pointers for individual soldiers as well as compact devices for IRCM and munitions. The development of "micro," low cost laser devices will complement the larger multifunction lasers (STO IV.R.14) under development for mounted applications. Recent improvements in nonlinear materials and laser diodes have made it feasible to develop microlaser devices that can produce wavelengths from the UV to the far infrared to meet the requirements for precision weapons, lightweight mid IR/far IR sources for IRCM, and Laser Radar for munitions. Examples of lasers to be developed are high peak power, eyesafe, laser diodes; micro diode pumped lasers shifted with PPLN OPOs and far IR semiconductor laser sources. By FY00, demonstrate candidate low cost laser devices and characterize performance. By FY01, develop candidate devices in ultra compact form for applications. By FY02, demonstrate sensors and systems based on the laser devices and evaluate performance.

Supports: Dismounted Battlespace, Mounted Battlespace, PM–AEC, PM–EW/RSTA.

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IV.R.19—Automatic Target Recognition (ATR) for Multiple Electro-Optic/Infrared Sensors (MEIRS). The goal of this effort is to design a multisensor target recognition capability that will increase the operational performance of existing passive electro-optic/infrared (EO/IR) target acquisition systems by combining imagery from multiple EO/IR sensors. Work will be completed in conjunction with Multiple Domain Smart Sensor (MDSS) program to perform sensor tradeoff studies to predict ATR system performance. Specific performance goals include enhanced probability of detection and identification (Pd = 90%; PI =90% on a 6 target class), reduced false alarm rates (0.2 FA per square degree), greater target standoff range (>4 km) and extend battlefield conditions (Concealment, Camouflage, and Deception, heavy clutter, obscuration). By FY98 complete FLIR single band and LADAR single sensor tradeoff study and initiate multisensor ATR algorithm design. By FY99 complete multisensor algorithm design and multisensor algorithm implementation. By FY00, complete, test, and evaluate ATR algorithms for delivery to NVESD. This effort will benefit the Army by providing predictions of ATR performance as a function of sensor parameters, thereby fostering better design of systems.

Supports: Multifunction Staring Sensor Suite ATD, MRDEC, NVESD

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IV.R.20—Low-Cost Electronically Scanned Antennas (ESAs). The goal of this effort is to develop and demonstrate a set of cost effective technologies for ESAs that can be used for multiple Army platforms and applications. An advantage of ESA technology in a cost effective package is the ability to control an aperture beam quickly. This will enable multimode operations where radar surveillance, target acquisition, fire control, combat identification, ELINT, and communications are performed within one integrated system. By FY98 demonstrate a Ku band Rotman lens with Vivaldi notch aperture and single beam switching matrix for technical performance. By FY99, characterize Ka band Rotman lens with a 34 element linear horn array for <3 degree azimuth beam width. By FY00, evaluate and select a switch technology for multibeam generation capability. A crossbar switch will be built. By FY01 demonstrate low cost, crossbar beam switching architectures (e.g., Microelectromechanical Switches (MEMs)) for multibeam demonstration with Ku band Rotman lens. The uniqueness for this development effort is to have Simultaneous Multimode and enhanced radar system performance with increased lethality and survivability of Army assets.

Supports: MTI Ground Radar (MGR), UAV Radar, LONGBOW, CERDEC.

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IV.R.21—Hybrid Optical Processing for Imagery Analysis. This effort will explore technologies for enhancing onboard processing capabilities of missiles and UAVs, allowing improvements in precision and range without operator intervention. The Hybrid Optical Processor demonstration will focus on the implementation of a near-real-time processor for both Synthetic Aperture Radar (SAR) and Multi-spectral/Hyperspectral Imagery (MSI/HSI). By FY99, modify existing hardware and software for operation in both spectral and spatial modes. By FY00, evaluate and select "smart" filter methodologies and identify the issues in both real and synthetic imagery utilized in filter calculations. Incorporate enhancements into an optical processor system for testing. By FY01, test and demonstrate the ability to process SAR with 1–20% improvement in target detection and false alarm rates while improving MSI/HIS processing rates an order of magnitude.

Supports: Enhanced Tactical Radar Correlator (ETRAC), UAV.

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GROUND VEHICLES (Section S)

IV.S.01—Advanced Protection and Protection Design Technology. In FY94, completed and documented the Protection Areal density design methodology for hard-faced armors to achieve 25 percent reduction in amount of testing required to define a minimum weight armor design. [TACOM] In FY94, conducted a feasibility demonstration of an armor technology achieving weight savings by using electromagnetic defeat mechanisms. [TACOM funded, ARL (WTD) execution] In FY95, demonstrated an armor for medium weight combat vehicles that defeats the medium caliber KE threat. In FY96, enhanced this armor to include CE threats. In FY96, demonstrated an armor to defeat future top attack threats. In FY97, select technology options for future frontal armor demonstration, and develop framework for armor virtual prototyping system. In FY98, demonstrate sensor configurations for smart frontal armor components, and implement fracture mechanics models in armor development codes. By FY99, demonstrate armor penetration modeling capability including 3D effects, material strength, and fracture mechanics that will provide 25 percent reduction in test costs for design of armors against CE jets, and heavy metal KE penetrators. [TACOM funded, ARL (WTD) execution, DARPA technology contribution]. By FY99, demonstrate a frontal armor system capable of defeating all tank gun launched threats at 65 percent of the weight of current Abrams armor. [TACOM funded, ARL (WTD, MD) technology execution, TACOM integration analysis]

Supports: Crusader, FCS, Abrams and Bradley Upgrades.

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IV.S.04—Inertial Reticle Technology (IRT). By FY98, demonstrate an inertial reticle fire control system (IRT) that can be used for the control of weapon systems on a variety of platforms: HMMWV, AGS, BFV, helicopters and unmanned ground vehicles. The primary focus will be the development of a semiautomated weapon station including (IRT) fire control system and operator control unit integrated with a semiautomatic weapon on a simple pan and tilt platform. This program uses sensor technology to create a virtually stabilized weapon platform that permits automatic tracking of targets, improves weapon control and reduces crew exposure to hostile environments. Intermediate developmental steps include incorporation of the (IRT) into a semiautonomous weapons station on a manned platform during FY96, subsequent integration of target tracking, image stabilization and target cueing in FY97, and culminating in integration and demonstration on a variety of platforms in FY98. Application of the (IRT) fire control system to direct fire weapons will improve their accuracy when fired OTM to the level of that while stationary. The (IRT) fire control system will improve Army warfighting capabilities through increased weapons lethality and improved crew survivability.

Supports: ARDEC, TARDEC, CERDEC, Dismounted Battlespace Battle Lab, Mounted Battlespace Battle Lab.

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IV.S.05—Virtual Prototyping Integrated Infrastructure. By FY99, demonstrate a reduction of the time and cost of combat vehicle development versus traditional physical development methods by a minimum of 30%. Integrate mobility survivability, electronics, command & control, lethality and manufacturing models and simulations into a seamless architecture. Provide for user and designer virtual interaction with vehicle designs and representations. By FY96, design the information kernel and functional area. By FY97, incorporate detailed design and implementation of the information kernel and selected functional interfaces. By FY99, complete evaluation of the time and cost, testing, and major design efficiency improvements.

Supports: FSCS, FCS, FIV, Crusader, Abrams & Bradley upgrades and tactical vehicle fleet improvements, TRADOC ICTs.

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IV.S.06—Detection Avoidance for Future Scout and Cavalry System (FSCS) ATD. By FY00, demonstrate integrated survivability components with reduced signature for the Future Scout and Cavalry System (FSCS) ATD. Ballistic, electronic warfare, and active protection components will be signature managed utilizing technologies from current vehicle and material development programs. Original protection levels will be maintained or improved by exploiting synergistic design techniques. By FY97, complete an initial study to determine the optimized suite for FSCS ATD and demonstrate signature suppressed grills with a goal of 50% signature reduction. By FY98, optimize warning receiver components to reduce signature by 25% and improve ballistic performance by 25%. By FY99 demonstrate side ballistic panels with a goal of 50% reduction in detectability that would be applicable to the FSCS ATD. By FY00 demonstrate side ballistic panels with a goal of 75% in detectability and 25% reduction in aerial density that would be applicable to the FSCS ATD.

Supports: FSCS, FIV.

STO Manager	TSO	TRADOC POC
David Thomas TARDEC (810) 574–8911 DSN: 786–8911	John Appel SARDA–TT (703) 697–8432 DSN: 227–8432	MAJ Paul Begeman Armor Center, DFD (502) 624–8994 DSN: 464–8994

IV.S.07—Laser Protection for Ground Vehicle Vision Systems. By mid FY99 demonstrate retrofittable wide angle optical viewing system design that can incorporate limiting of dispersive materials. These new optical systems could replace the current vision blocks and periscopes found in ground vehicles and allow the soldier to view the battlefield while protected from eye damaging laser energy, including frequency agile laser weapons.

Supports: Abrams, M113, and Bradley Upgrades, Crusader, FCS, FIV, FSCS ATD, Land Warrior.

STO Manager	TSO	TRADOC POC
Templeton Pease TARDEC/NRDEC (810) 574–5325 DSN: 786–5325/256–5546	John Appel SARDA–TT (703) 697–8432 DSN: 227–8432	Martin Bosemer Armor Center, DFD (502) 624–2045 DSN: 464–2045

IV.S.08—Tank Mobility Technology. By FY03, demonstrate critical track and suspension technologies for a lighter, more agile main battle tank or tank replacement. Track improvements will include nitrile rubber pads and an actively controlled track tension system. Nitrile rubber will increase track pad life from 1000 to 3,000 miles and increase fuel economy and track bushing life. These mobility advances will enhance system survivability, reliability, and operational effectiveness. This effort also includes the early technology development of an FCS propulsion system. In addition to conceptual analysis, work will focus on high power density, low heat rejection single cylinder diesel engine technology. This STO will also support electric drive development for an FCS size vehicle through the development by Army Research Laboratory (ARL) of high temperature SiC gate drivers and power devices. By FY01, demonstrate SiC based inverters operating at 400°C using existing engine oil (200°C) as a cooling fluid. This technology is critical to achieving acceptable power densities in electric drives. By FY98, determine active suspension requirements. By FY99 demonstrate track tensioner. By FY00, demonstrate nitrile track. By FY01, complete single unit active suspension lab testing.

Supports: FCS.

STO Manager	TSO	TRADOC POC
Dan Herrera TARDEC (810)574-6411 DSN: 786-6411	John Appel SARDA-TT (703) 697-8432 DSN: 227-8432	MAJ Monroe Harden Armor Center DFD (502)624-4412 DSN: 464-4412

IV.S.09—Combat Vehicle Concepts and Analysis. By FY02, develop vehicle concepts for the Army's next generation of combat and combat support vehicles. Refine User requirements through the Integrated Concept Team (ICT) process. Develop the vehicle alternatives for the formal Analysis of Alternatives (AOA) for Milestone I decisions. Provide technologists with vehicle based technology and component guidance for weight, volume, and electrical interfaces. By FY98, develop Future Scout & Combat System (FSCS) vehicle concepts with 25% increased crew efficiency, 20% reduced vehicle silhouette, 10% increase in mobility, 20% increase in vehicle and crew survivability, and 500% increase in target detection rate. By FY99, determine optimal Future Combat System (FCS) lethality option that will increase range by 50% with Pk/s of 1 and 80% increased loss exchange ratio. By FY99, develop Future Infantry Vehicle (FIV) concepts that will: increase capacity to carry squad (from 7 to 9 soldiers, with full Land Warrior Gear), decrease vehicle crew size by 33%, increase survivability by 33%, and improve mobility by 50%. By FY00, transfer FIV designs and analyses to the FIV AOA and FIV virtual prototypes. By FY01, develop Future Combat System requirements with 33% reduced gross vehicle weight and 25% reduced crew workload. By FY02, establish and address emerging vehicle requirements and the needs of future ICTs for the Army After Next.

Supports: Integrated Concept Teams (ICTs), AOAs (formerly COEA), Mission Need Statements (MNS) and Operational Requirements Documents (ORD) for future combat vehicles (FSCS, FIV, FCS, Scorpion, FC^2V) and upgrades (Bradley and Abrams).

STO Manager	TSO	TRADOC POC
Roger Halle TARDEC (810) 574-5287 DSN: 786-5287	John Appel SARDA-TT (703) 697-8432 DSN: 227-8432	Winkenhofer Smith Armor Center/Infantry Center, DCD (502) 624-8064 DSN: 464-8064/835-1915

IV.S.10—Future Light Vehicle Ballistic Protection Technology. Demonstrate new armor systems designed to provide vehicles in the 18–40 ton range protection against the future medium caliber cannon threat and also against light and medium shaped charge threats, top attack weapons, and mines. The armor systems will be compatible with advanced structural technology likely to be used in future light vehicles, will utilize advanced defeat mechanisms such as electrodynamics, and will be designed to avoid adverse impacts on mission equipment and other survivability measures, such as signature suppression. The technology will also apply to nonfrontal protection of future heavy systems, and provide collateral benefits to protection of tactical vehicles. The demonstration will include base structure protection and add-on appliqués for additional protection. By the FY98, assess technology approaches (i.e., passive, reactive, and electromagnetic). By the FY99, identify most promising concepts for electrodynamic defeat of the light vehicle threat. By the FY 00, demonstrate armors for medium caliber KE threats with 50% greater space efficiency than the FY96 state of the art. By the FY01, demonstrate armor systems with 30% improvement in weight efficiency over the FY96 state of the art.

Supports: Future Scout and Cavalry System; Future Infantry Vehicle; Future Combat System; P3I for M113, M2/M3, Crusader, Grizzly.

STO Manager	TSO	TRADOC POC
Thompson Morrison TARDEC/ARL-WMRD (810)574-5780 DSN: 786-5780/298-6800	John Appel SARDA-TT (703) 697-8432 DSN: 227-8432	Bosemer LTC Smith Armor Center/Infantry Center (502) 624-2045 DSN: 464-2045/835-1915

INFRASTRUCTURE

(Vol. I, Ch. VI)

DISTRIBUTED INTERACTIVE SIMULATION (Section C)

VI.C.16—Soldier System Modeling (SSM). Develop an automated environment to enhance analytic capabilities and promote rigorous soldier system cost/benefit analyses to quantify and evaluate equipment, operational policy, and training within a system context. By FY95, SSM will integrate models and data into a framework to facilitate multiple analytic functions with completion of the first generation system software for use in 21 CLW analyses. By FY96, provide modeling, simulation and analysis supporting 21CLW field demonstration to quantify and maximize the viability/capability of proposed systems. By FY97, integrate into the Computer Man Wound Ballistic Vulnerability Model the methodologies to assess vulnerability across the full range of MOSs. Conduct analyses to define optimal survivability, mobility and lethality concepts. By FY99, provide a distributed interactive simulation (DIS) compliant methodology to assess the results of the soldier system demonstrations and to provide a basis for future COEAs.

Supports: Force XXI Land Warrior; DBS Battle Lab and Infantry School.

STO Manager	TSO	TRADOC POC
John O'Keefe	Bill Brower	Chris Kearns
NRDEC	SARDA-TT	DBL
(508) 233-4881	(703) 697-8432	(706) 545-6391
DSN: 256-4881	DSN: 227-8432	DSN: 835-6391

VI.C.19—Individual Combat Simulation in the Synthetic Environment. This program provides and demonstrates technologies for creating multisensory, real-time simulation that immerses the individual and allows for interaction in three-dimensional geographical space. A multisite, distributed laboratory will be established that incorporates concepts and principles consistent with the evolving DoD M&S High Level Architecture (HLA). The cost effectiveness of networked virtual reality devices to immerse the individual into the synthetic environment will be determined. By FY96, the requirements for a mobility platform for an individual combatant simulator will be established, based upon empirical research using the Individual Soldier Mobility Simulator (ISMS). Software to interface the ISMS to synthetic environments will be developed. Studies will be conducted and guidelines will be published for use by metabolic platform developers. By FY97, the program will demonstrate an initial capability to provide individual combatant mobility and interaction in the synthetic environment. By FY98, the program will provide a demonstrated capability to fully immerse the live combatant in the synthetic environment, to include control of semiautomated forces through voice and gesture recognition.

Supports: Force XXI Land Warrior Program, STOW, Combined Arms Tactical Trainers (CATT) Program, MOUT ACTD, Small Unit Operations (SUO).

STO Manager	TSO	TRADOC POC
Gene Wiehagen STRICOM (407) 384–3930 DSN: 970–3930	Robert Rohde SARD–TR (703) 697–8432 DSN: 227–8432	Diane Schuetze Battle Lab Integration and Technology Directorate (804) 727–3712 DSN: 680–3712

VI.C.20—Computer Generated Forces (CGF). Demonstrate intelligent computer generated force simulation technologies for battalion, division, corps, echelon above corps and joint level forces. Determine the critical behaviors and essential characteristics that must be exhibited for each force level. Define the methodology and computational approach for full level force representation, with the capability to be reconfigurable to varying battlefield behavior. In FY97, improve tools for ModSAF (ground), continue ModSAF/CGF VV&A, and improve behavioral algorithms. In FY98, develop and demonstrate Intelligent Interactive Adversary, deliver improved DI Saf Baseline, and deliver ModSAF CGF Voice I/O. In FY99, deliver ModSAF/CGF 3D interface, improve C^4 simulation for varying echelons, develop and demonstrate realistic intelligence simulation. FY00 and FY01, improve intelligence models; improve CGF Voice I/O, improve behavioral algorithms.

Supports: ModSAF, PM DIS, PM CATT, Force XXI, STOW, Battlespace Command and Control ATD.

STO Manager	TSO	TRADOC POC
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VI.C.21—Intervehicle Embedded Simulation Technology. By FY00, develop and demonstrate in-vehicle Advanced Distributed Simulation (ADS) capability employing common reusable simulation components, interfaces, tutoring systems, take home packages, and scenarios. This effort will determine the specific Embedded Training (ET) architecture and common hardware and software components required for individuals and crews to maintain system proficiency while in-vehicle and on-station. It will enable units to conduct collective training, exercises, or mission rehearsals autonomously or when networked with other "live" or "virtual" simulations. The effort will also assess which tasks and skills are appropriate and affordable candidates for embedding and how this capability may augment the simulations systems in the existing training device simulation/simulator (TDSS) hierarchy. A standard ET simulation architecture using common components will permit development of a consistent synthetic battlefield representation for use in all ET systems and improve interoperability and affordability among future systems.

By FY97, establish ET testbed that uses existing virtual simulations and live systems (BFV) to prototype and assess ET architecture and common components. With TRADOC, initiate studies and analysis to determine hierarchy of embedded training capability. With TARDEC, assess databus loading, timing, sizing, RAM, and related impacts of ET to Intravehicle Electronics Suite. Initiate experiments and assess approaches to enable "direct-fire" or "line-of-sight" interactions between live and virtual systems. Assess commercial image generator technology to determine feasibility of displaying virtual targets on vehicle systems. With CECOM continue development of live to virtual linkage of C^4I systems. By 98, develop and prototype ET modular hardware and software common components. Prototype Virtual–Live interactive system. Link STRICOM ET Test bed with TACOM VETRONICS Systems Integration Laboratory (VSIL) and CECOM Digital Integrated Lab (DIL). By FY99, tailor and integrate standard ET common components to Future Scout and Cavalry System (FSCS) ATD program. With TRADOC initiate development of prototype training scenarios and databases. By FY00, support TARDEC with in-vehicle DIS experiments using Intravehicle Electronics Suite.

Supports: Future Scout and Cavalry System (FSCS) ATD, Future Combat System (FSC), M1A2 and M2A3 Upgrades, CRUSADER, Digitization of the Battlefield, TASK Force XXT, Open Systems Task Force, and Army Technical Architecture.

STO Manager	**TSO**	**TRADOC POC**
Gene Wiehagen	Robert Rohde	MAJ Sean Mahan
STRICOM	SARD–TR	BCTD
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ANNEX B

ADVANCED TECHNOLOGY DEMONSTRATIONS

IEW&S
PROGRAM EXECUTIVE OFFICE

Battlefield Combat Identification (BCID) ATD

Objective: Improve Combat Effectiveness and Substantially Reduce Fratricide

- Demonstrate a Fully Digitized SA/Target ID Capability at Platform Level Within a Digitized Task Force (Enhanced BCIS)
- Demonstrate Multiple System Concepts for Rotary Wing and Fixed Wing to Ground Combat ID
- Establish Technical Baseline for Joint Service ACTD for Integrated Ground-to-Ground and Air-to-Ground Combat ID
- Demonstrate Lightweight, Vehicle Interoperable Combat ID Concepts for Dismounted Soldier Application Including Functional Integration Into Land Warrior System
- Demonstrate Advanced Concepts for a Fully Digitized Friend and Foe, Target ID/Target Acquisition/SA Capability

Justification:

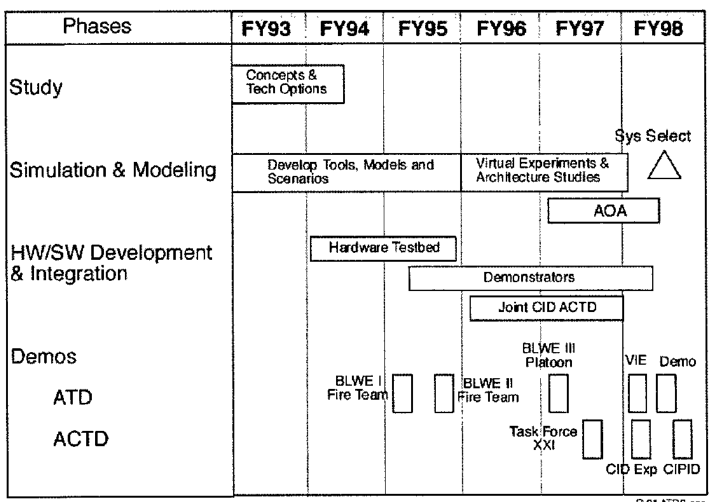
- Battlefield Combat ID ORD
- Combat ID For Dismounted Soldier ORD

Proponents:

- MBBL, DBBL

Acquisition:
PEO IEW&S (PMCI)

Schedule and Funding



Approach

Ground-to-Ground

- Enhanced BCIS
- SA Through Sight
- DDL (+)
- Laser/RF

Air-to-Ground

- BCIS Pod
- SINCGARS SIP(+)
- SIP(+) FO/FAC
- MK XII/GPS

Dismounted Soldier

- Interoperable Laser/RF
- Functional Integration into Land Warrior Suite

Modeling & Simulation

- Virtual Integrated Experiment
- Architecture Study

Applications:

- All US, NATO and Potential Coalition Combat, Combat Support and Combat Service Support System

IEW&S
PROGRAM EXECUTIVE OFFICE

Battlefield Combat Identification (BCID) ATD Exit Criteria

Operational Capability	Current Baseline	ATD Minimum	ATD Goal	Achievements to Date
Target ID (Friend) PID ID Range ID Time	Combat ID Panels (Limited by Weather and Man-in-Loop Performance)	Improved BCIS 98% 5.5 km <1 sec	Improved BCIS 99% 5.5 km <1 sec	Improved BCIS 99% >5.5 km <1 sec
Rotary Wing-to-Ground PID ID Range ID Time	(No Cooperative ID Capability)	90% 8 km <4 sec	99% 8 km <1 sec	SINCGARS SIP(+) >88% >12 km 2.3 sec
Fixed Wing-to-Ground PID ID Range ID Time	(No Cooperative Capability)	TBD (ACTD) TBD (ACTD) TBD (ACTD)	TBD (ACTD) TBD (ACTD) TBD (ACTD)	Enhanced FAC & SADL Concept Demonstrated
Dismounted Soldier PID ID Range ID Time Weight	Visual and Budd Lights (Limited by Weather and Man-in-loop Performance)	95% 1.1 km <1 sec <4 lbs	99% 1.1 km <1 sec <2 lbs	Laser/RF, Embedded IR 93% @ 1 km >1.1 km <1 sec 4 lbs
Target ID (Foe & Neutral) Gouund-to-Ground	1st Gen FLIR (Manual Operation)	Leverage Non-Cooperative Sensors - IDS - PLAID	Leverage Non-Cooperative Sensors - 2nd Gen FLIR - IDS - PLAID	BCIS/IDS Virtual Simulation Completed
Situational Awareness Ground-to-Ground Position Accuracy	~500 Meters	100 Meters	50 Meters	BS IS DDL (12 sec GPS Position Updates Demonstrated to 1.2 km)

Rotorcraft Pilot's Associate ATD

Objectives:

Develop a cooperative interdependent man/machine system that uses and understands the volume and quality of internal and external information available to achieve maximum effectiveness and survivability for our combat helicopter forces.

- Revolutionary MEP Technologies
- High Speed Data Fusion Processing
- Cognitive Decision–Aiding Expert Systems

Justification:

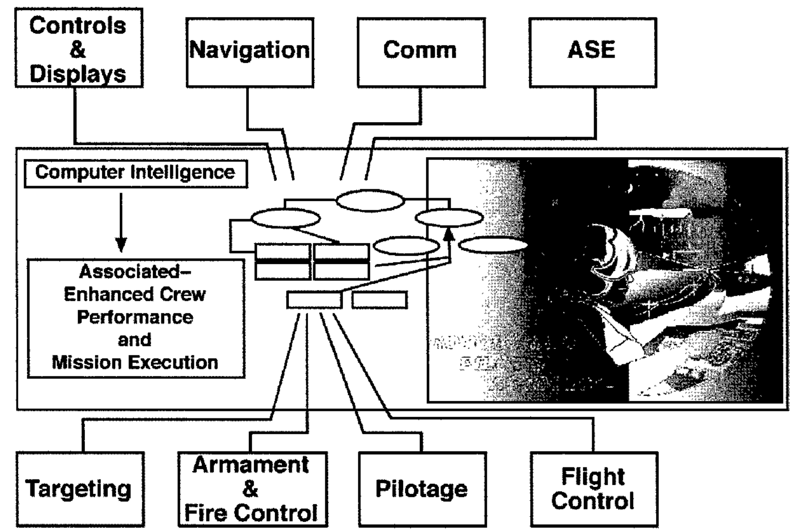
- Reduction in Mission Losses 30% – 60%
- Increase in Targets Destroyed 50% – 150%
- Reduction in Mission Timelines 20% – 30%

Battle Labs:

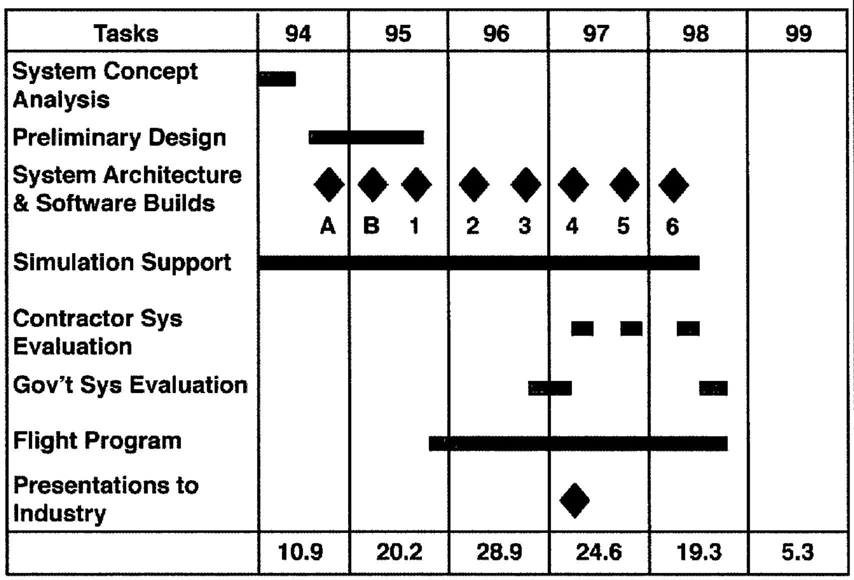
- Air Maneuver
- Mounted Maneuver

PEO:

- Aviation



Program Schedule



Approach:

Structure an interative development process which gathers knowledge and uses: rapid prototyping to develop CDAS software; simulation to evaluate system performance; the knowledge from the evaluation feeds the next iteration.

FY 94–96

- Design & Develop CDA & Integrate Software
- Conduct Initial Combined Arms Simulation

FY 97–98

- Complete CDA Development and Integration
- Conduct virtual and constructive simulation & flight test evals

FY 99:

- Complete data analysis and report.

Applications:

RAH–66 Comanche, AH–64 Apache improvements, OH–58D AHIP, SOA, A2C2S, AMPS, Improved Cargo Helicopter.

Rotorcraft Pilot's Associate ATD Exit Criteria

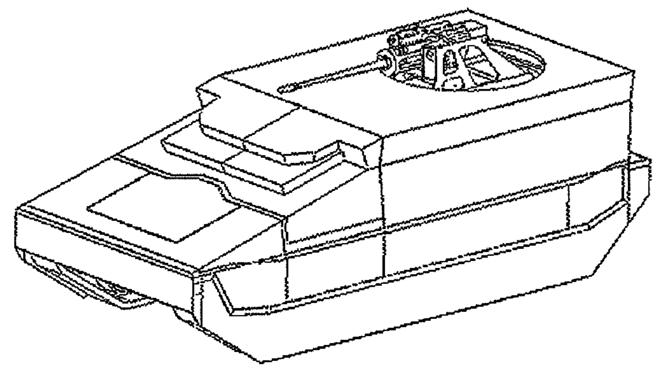
Operational Capability	Comanche–Like Baseline	Exit Criteria	ATD Goal
System Level:			
Reduction in Mission Losses	1	30%	60%
Increased Targets Destroyed	1	50%	150%
Reduction in Mission Timelines	1	20%	30%
Subsystem Level:			
Decrease in Time Exposed to Threat	1	15%	30%
Reduction in Blue Losses during Engagement	1	30%	80%
Improvement in On–Board Sensors	1	50%	100%
Increase INTEL for Threat Location	1	50%	100%
Improvement in Target Acquisition	1	30%	100%
Improvement in Missile/Gun Capability	1	30%	50%
Improvement in Loss Exchange Ratio	1	30%	100%
Reduction in Mission Replanning Time	1	20%	50%
Decreased Flight Time to Accomplish Mission	1	12%	30%
Improvement in Obstacle/Terrain Detection	1	70%	90%

Composite Armored Vehicle (CAV) ATD

OBJECTIVE:
- DEMONSTRATE TECHNICAL FEASIBILITY, OPERATIONAL POTENTIAL AND COST EFFECTIVENESS OF COMPOSITE MATERIALS FOR COMBAT VEHICLE STRUCTURES
  - VALIDATE DESIGN, MODELS AND SIMULATIONS
  - DEFINE COMPOSITE MATERIALS DESIGN BASELINES AND GUIDELINES FOR FUTURE LIGHTWEIGHT COMBAT SYSTEMS

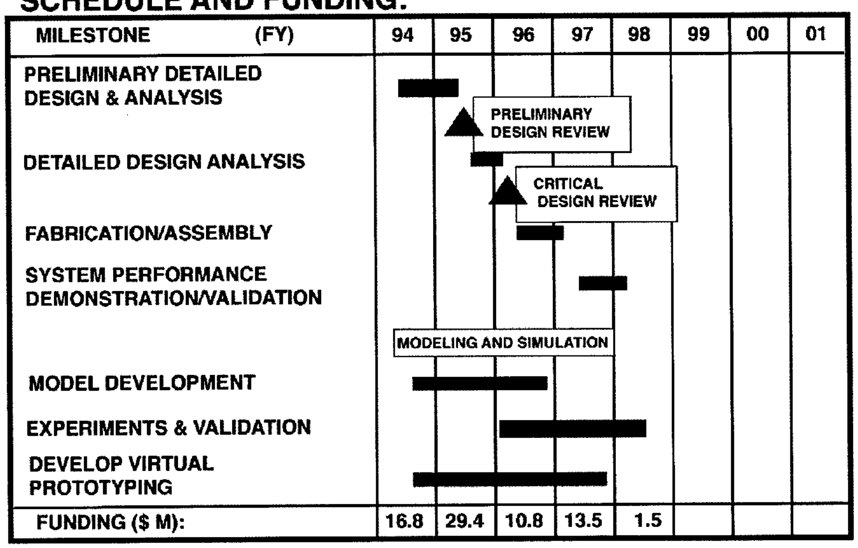
JUSTIFICATION:
- STRATEGIC DEPLOYABILITY IS DRIVEN BY VEHICLE SIZE & WEIGHT
  - MINIMUM 33% STRUCTURE AND ARMOR WEIGHT REDUCTION
- DEMONSTRATES COMPOSITE MATERIALS APPLICABILITY TO GROUND COMBAT VEHICLES
- DEMONSTRATES INTEGRATION OF STRUCTURE, ARMOR & SIGNATURE MATERIALS

BATTLELAB SUPPORT:	BATTLELAB EXPERIMENT:	PEO:
DISMOUNTED BATTLESPACE MOUNTED BATTLESPACE	MOUNTED BATTLESPACE	GCSS



LIGHTWEIGHT STRUCTURE/ARMOR
ENHANCED SURVIVABILITY
STRATEGIC DEPLOYABILITY
IMPROVED PRODUCIBILITY

SCHEDULE AND FUNDING:



APPROACH:
- ANALYZE AND OPTIMIZE COMPOSITE STRUCTURE DESIGNS BY MODELING & SIMULATION
- CONDUCT BALLISTIC AND STRUCTURAL TESTING ON COMPONENTS AND COUPONS
  - VALIDATE MATERIAL DESIGN LIMITS
- FABRICATE A DEMONSTRATOR AND STRUCTURAL TEST HULL
- DEMONSTRATE PERFORMANCE
  - MEASURE 105mm GUN FIRING LOADS ON HULL STRUCTURE
  - 6K MILE ENDURANCE TEST W/25mm CANNON
  - DEPLOYMENT DEMONSTRATION
  - REPAIR DEMONSTRATION
- VALIDATE MODELS/SIMULATIONS
- TRANSITION DESIGN TOOLS & DOCUMENTATION
- DEMO CHASSIS AVAILABLE FOR FOLLOW-ON USER EXPERIMENTS

APPLICATIONS:
- FUTURE COMBAT VEHICLES:
  - FUTURE SCOUT AND CALVARY SYSTEM ATD
  - FUTURE INFANTRY VEHICLE
- FUTURE COMBAT SYSTEM
  - CRUSADER
- PREPLANNED PRODUCT IMPROVEMENTS (COMPONENTS)

Composite Armored Vehicle (CAV) ATD Exit Criteria

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END ATD		ACHIEVED
		MINIMUM	MAXIMUM	
LIGHTWEIGHT	MONOLITHIC ALUMINUM (22 TON WEIGHT CLASS)	33% WEIGHT SAVINGS (STRUCTURE / ARMOR)	>33% WEIGHT SAVINGS (STRUCTURE / ARMOR)	MET@35%
DEPLOYABLE	C130/C141 TRANSPORTABLE	C130/C141 TRANSPORTABILITY	C130/C141 TRANSPORTABILITY	MET
SURVIVABLE	CAMOUFLAGE	CLASSIFIED	CLASSIFIED	Exceeded in both Thermal IR & mmW
AFFORDABILITY	METAL STRUCTURE/ ARMOR (MSA) COST	1.4 MSA COST	1.0 MSA COST	1.9 MSA COST

Enhanced Fiber Optic Guided Missile (EFOGM) ATD

Team EFOGM

Objective

- Demonstrate EFOGM Multi-purpose, Precision Kill
  - -- Day / Night / Adverse Weather
  - -- Extend Maneuver Commander Battlespace
- Engage and Defeat
  - -- Armored Combat Vehicles
  - -- Hovering or Moving Rotary Wing Aircraft
  - -- Other High Value Ground Targets, Even in Urban Terrain

Battlelabs

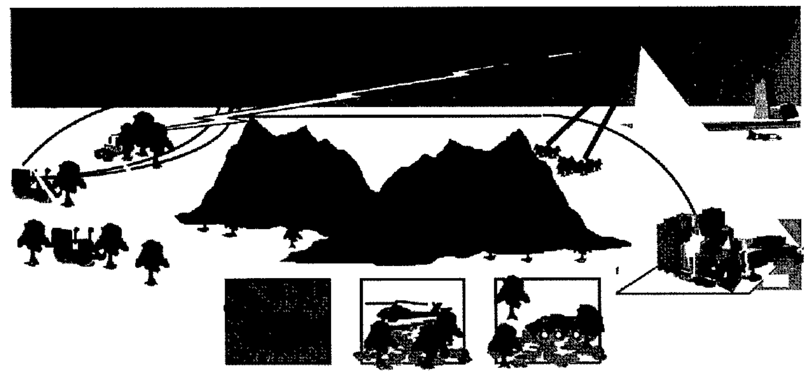
- Dismounted Battlespace Battlelab
- Early Entry Lethality and Survivability Battlelab

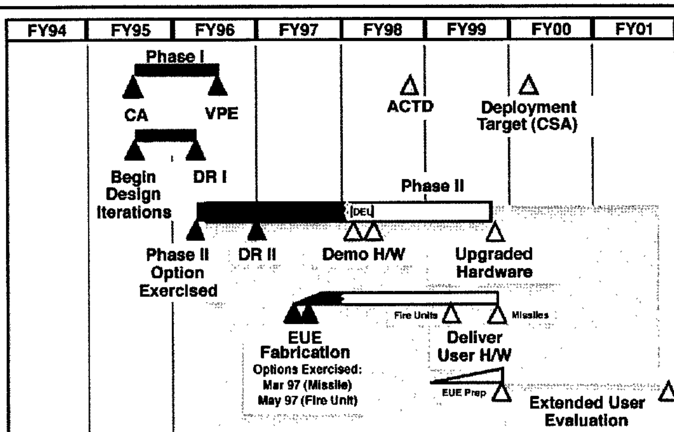
Description

- Day / Night / Adverse Weather Capability
- 15 Km Range
- Non-ballistic Trajectory
- Positive Visual ID Eliminates Fratricide
- IMU Navigation
- Army Command & Control Interface
- Embedded Training
- Man in the Loop

Command Element

- AMCOM DSA





FY 99 BES	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01
- RDTE	40.4	55.3	35.3	31.4	36.6	14.9	3.8	0.0
- Proc	0.0	0.0	0.0	0.0	13.3	0.0 *	0.0	0.0

* PBD 104 Adds $13.0M Procurement

Approach

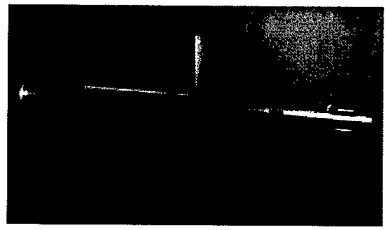
- Contract Awarded 16 May 95
- Basic Contract for Virtual Prototype
- Phased Options
  - -- Prototype Hardware / Software
  - -- Demonstrations Support
  - -- User Test Support
- Integrated Product Development (IPD)
- No Planned Production

Applications

- RFPI Demo in FY98
- Extended User Evaluation (FY99 - FY01)

Enhanced Fiber Optic Guided Missile (EFOGM) ATD

Launcher, Guided Missile, Vehicle Mounted: XM44



Guided Missile, Surface Attack - YMGM-157B

PRIME CONTRACTOR:

RAYTHEON COMPANY

SYSTEM DESCRIPTION:

- Mission:
  - -- Non-Line of Sight anti-armor / high value targets and anti-helicopter
  - -- Reconnaissance
  - -- Pinpoint destruction of hard targets
- System Characteristics:
  - -- Day / Night / Adverse Weather
  - -- Range: 15 Km
  - -- Payload: 8 fiber optic guided missiles per fire unit
- Special Features:
  - -- Missile
    - --- IR seeker
    - --- Non-ballistic trajectory
    - --- Positive visual ID alleviates IFF casualty risks
    - --- Inertial navigation
  - -- Fire Unit
    - --- Heavy HMMWV
    - --- C4I Compatible
    - --- Embedded Training
    - --- Gunner in the loop

PROGRAM PHASES:

- ATD Program
  - -- Phase I
    - --- Basic Contract 3QFY95 thru 3QFY96
    - --- Virtual Prototype Experiment (VPE)
    - --- Operational Concept Validation (OCV) with Battlelabs
    - -- 2 Stationary Simulators
    - -- 1 Mobile Simulator
  - -- Phase II
    - --- RFPI ACTD Demonstration
    - --- Conduct Missile Firings with Soldiers
    - --- 12 Fire Units, 2 Platoon Leader Vehicles, 108 Missiles
  - -- Extended User Evaluation
    - --- 1EFOGM Company Set, consisting of 12 fire units, 3 platoon leader vehicles, and 192 missiles, provided to Alpha Company, 511th Parachute Infantry Regiment, XVIII Airborne Corps

REQUIREMENT:

Fire Unit/Platoon Leader Vehicle

- Heavy HMMWV Chassis And Manrated
- 6 Or More Hot Launch Missiles
- Man-In-The-Loop
  - -- Gunner's Display (Missile Control)
  - -- Embedded Training
  - -- Automated Mission Planning
- Army Command & Control Interface
- System Test - BIT / BITE
- Sling Load / Air Drop (Added By CSA Decision, Dec 96)

Missile

- Day / Night / Adverse Weather Seeker
- 1 To 15 Km Range (.62 To 9.3 Miles)
- In-Flight Intelligence
- Anti-Armor / Anti-Helicopter Capability
- IMU Navigation
- Fiber Optic Datalink
- 2 Missile In Flight
- Manrated
- 100 M/S Cruise (225 MPH)
- Dual Field of View
- Nominal Altitude 350 Meters (1148 Feet)

EFOGM ATD Exit Criteria

PROJECT AND SUSTAIN FORCE

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
TACTICAL DEPLOYMENT	NONE	AIR TRANSPORTABLE BY C130 AIRCRAFT	SLING TRANSPORTABLE BY CH-47D HELICOPTER IN A MARCH ORDER CONFIGURATION SLING TRANSPORTABLE BY UH-60 HELICOPTER (2 LIFTS)
SYSTEM DEPLOYMENT	NONE	EMPLACEMENT _*_ MIN CUE / ALERT TO LAUNCH _*_ MIN	EMPLACEMENT _*_ MIN STANDBY TO OPERATE MODE _*_ MIN CUE ALERT TO LAUNCH _*_ MIN

*(CLASSIFIED NUMBERS IN JUN 93 DRAFT ORD)

EFOGM ATD Exit Criteria

PROJECT AND SUSTAIN FORCE (CONTINUED)

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
SYSTEM DEPLOYMENT (CONT'D)	NONE		HASTY MARCH ORDER * ___ MIN AIR DROPPABLE USING LOW VELOCITY, LOW ALTITUDE AIRDROP PROCEDURES
SYSTEM MISSILE LOAD	NONE	READY TO FIRE MISSILES 6 msls	READY TO FIRE MISSILES > 6 msls
SYSTEM MISSILE RELOAD	NONE	BENIGN CONDITIONS 15 MIN	BENIGN CONDITIONS < 15 MIN
	NONE	NBC, NIGHT AND / OR ADVERSE WEATHER 20-30 MIN	NBC, NIGHT AND / OR ADVERSE WEATHER < 20 MIN

*(CLASSIFIED NUMBERS IN JUN 93 DRAFT ORD)
ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

EFOGM ATD Exit Criteria

PROJECT AND SUSTAIN FORCE (CONCLUDED)

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
SYSTEM RESPONSE TIME FOR MISSILE LAUNCH	NONE	LAUNCH TWO MISSILES WITHIN .5 MINUTES	LAUNCH THREE MISSILES WITHIN .5 MINUTES
		CAPABLE OF AT LEAST TWO MISSILES IN FLIGHT AT ONE TIME	MORE THAN TWO MISSILES IN FLIGHT AT ONE TIME
RAM	NONE	FU MTBOMA = 120 HRS	FU MTBOMA > 120 HRS
			FU MAINTAINABILITY: MAINTENANCE RATIO ≤ 0.18 MMHS PER SYSTEM OH FU AVAILABILITY ≥ 0.90 MISSILE RELIABILITY ≥ 0.89
MISSILE RANGE	NONE	MINIMUM 1000M MAXIMUM 15Km	MINIMUM < 1000M MAXIMUM > 15Km

ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

EFOGM ATD Exit Criteria

PROTECT THE FORCE

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
PROTECT THE FORCE	NONE	FOR LIGHT SYSTEM MOUNTED ON HEAVY HMMWV PROTECTION TO CREW & VEHICLE NOT LESS THAN PROVIDED BY HOST VEHICLE	PROVIDE BALLISTIC PROTECTION / SURVIVABILITY FOR CREW & VEHICLE AGAINST NON-NUCLEAR INDIRECT ARTILLERY ABOVE THAT OF HOST VEHICLE
MISSION PLANNING AID	PAPER MAPS	AUTOMATED MISSION PLANNING TO INCLUDE MISSILE FLIGHT TO TARGET AREA	------
POSITIVE IDENTIFICATION	LINE OF SIGHT	GUNNER RECOGNITION W/O DIVERTING MISSILE; OBTAIN IN-FLIGHT INTELLIGENCE	POSITIVE ID

ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

EFOGM ATD Exit Criteria

WIN INFORMATION WAR

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
SYSTEM LOCATION	NONE	AUTOMATIC AZIMUTH ORIENTATION & POSITION/LOCATION DEVICE INTEGRATED INTO FIRE CONTROL SYSTEM	-----
		BACKUP GPS RECEIVER	-----
MISSILE SEEKER IMAGERY EXPLOITATION	NONE	SYSTEM CAPABLE OF RECORDING MISSILE SEEKER VIDEO	-----
		PLT LDR CAPABILITY TO OBSERVE ANY OF PLT GUNNER's VIDEOs SELECTIVELY REAL TIME	-----

ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

EFOGM ATD Exit Criteria

WIN INFORMATION WAR (CONCLUDED)

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
MISSILE SEEKER IMAGERY EXPLOITATION (CONT'D)	NONE	PLT LDR CAPABILITY TO PASSIVELY TRANSMIT SAME VIDEO TO OTHER GUNNERS IN PLT	PLT LDR CAPABILITY TO TRANSMIT NEAR REAL TIME SEEKER DATA IMAGES (FREEZE FRAME) W/6 DIGIT GRID COORDINATES, TO COMPANY CDR / HIGHER ECHELON
		CAPABILITY TO AUTOMATICALLY RECEIVE TARGET INFORMATION THROUGH BRIGADE-LEVEL C2 SYSTEMS IN USE AT THE TIME OF THE DEMONSTRATION	-----

ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

EFOGM ATD Exit Criteria

CONDUCT PRECISION STRIKE

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
OPERABILITY	NONE	DNAW	-----
COUNTERMEASURE SUSCEPTABILITY	NONE	PERFORMANCE DURING AND AFTER EXPOSURE TO BATTLEFIELD ENVIRONMENTS	EXCEED PERFORMANCE DURING AND AFTER EXPOSURE TO BATTLEFIELD ENVIRONMENTS
GUNNER CONTROL OF IN-FLIGHT MISSILES	NONE	GUNNER CAPABILITY OF MAKING MANUAL IN-FLIGHT CORRECTIONS TO SINGLE LAUNCHED MISSILES AND FOR SUBSEQUENT MISSILES IN THE TARGET AREA IN ALL MULTIPLE MISSILE ENGAGEMENTS	-----

ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

EFOGM ATD Exit Criteria

CONDUCT PRECISION STRIKE (CONCLUDED)

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD	
		MINIMUM	MAXIMUM
GUNNER CONTROL OF IN-FLIGHT MISSILES (CONT'D)	NONE	GUNNER CAPABILITY TO MANUALLY SWITCH TO NEXT MISSILE IN-FLIGHT SEEKER AFTER INITIAL MISSILE LOCK-ON IN MULTIPLE MISSILE ENGAGEMENTS	-----
RECEIVE / PROVIDE UPDATED TARGET INFO TO MISSILE	NONE	PERIODIC UPDATE OF MISSILE WITH CURRENT TARGET LOCATION AS PROVIDED BY C2 SYSTEM	RECEIVE UPDATED TARGET INFO & PROVIDE TO MISSILE

ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

EFOGM ATD Exit Criteria

DOMINATE THE MANEUVER BATTLE

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END OF ATD MINIMUM	END OF ATD MAXIMUM
WARHEAD LETHALITY	NONE	DEFEAT EXISTING THREAT TANKS DEFEAT HELICOPTERS	DEFEAT PROJECTED THREAT TANKS THROUGH THE YEAR 2005
ENGAGE TARGETS NOT IN LINE OF SIGHT	NONE	ENGAGE TARGETS NOT IN LINE OF SIGHT	-----

ITALICS REPRESENT CAPABILITY TO BE DEMONSTRATED AT END OF PHASE I

Precision-Guided Mortar Munition ATD

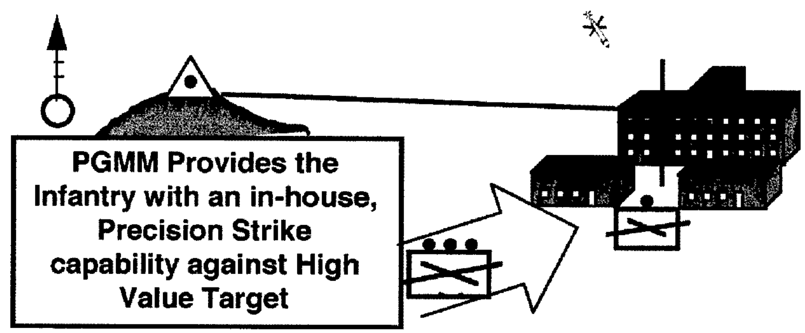
OBJECTIVE:

- Demonstrate Precision Guided Mortar Concept
- Demonstrate Feasibility of Integrated Man Portable Fire Control

JUSTIFICATION:

- Expand Capability Of Mortars (12KM) with Increased Ph and Pk Against High Value Targets
- Point Target Capabilities at Extended Ranges
- Improved Accuracy Provides Means to Redefine Close Fight
- Man-in-the-Loop Operation
- Rapid, Accurate Fire Missions (2.5 Minutes, 3 Mils)

PM: PM-MORTARS ***BATTLE LAB:*** DBBL



PROGRAM SCHEDULE

MILESTONES (FY)	95	96	97	98	99	00	01
PGMM ATD							
Advanced Concept Demo							
Initiate GPS/INS							
Demonstrate GPS/INS							
($M)							
63004/D43A	5.6	9.3	6.7	4.2	1.9		
Proposed 63004/D43A						2.5	1.5

APPROACH:

- Select ATD Technical Approach (FY95)
- Demonstrate Extended Range Feasibility (FY96)
- Demonstrate Target Detection Capability (FY97)
- Initiate Laser Detection Demonstration and Feasibility (FY98)
- Complete Laser and Autonomous Demonstrations and Initiate GPS/INS Feasibility (FY99)
- Conduct GPS MOUT Operational Experiment (FY00)
- Perform Comprehensive GPS HWIL Evaluation (FY01)

APPLICATIONS:

- Integral Part Of Rapid Force Projection Initiative (RFPI)
- Top Attack Surgical Kill Capability for US Infantry Against High Value Targets

Precision-Guided Mortar Munition ATD Exit Criteria

	Baseline	Threshold	Goal
120mm Range (km)	7.2	12.0	15.0
120mm Targets	N/A	High Value Targets	High Value Targets
120mm Weight (lbs)	50.0	40.0	35.0
FC Time To Fire (min)	4.0	2.5	0.5
FC Accuracy (mil)	5.0	3.0	1.0
FC Weight (lbs)	N/A	30.0	15.0
Accuracy Requirements			
- 12 km	* 359 m CEP	** 118 m CEP	
- 15 km	* 636 m CEP		** 118 m CEP
Auton. Precision Strike			** < 2 m CEP

*Accuracy with Current Gyros **Improved Accuracy with GPS/INS

Digital Battlefield Communications (DBC) ATD

Tactical Communications for the Warrior

OBJECTIVE

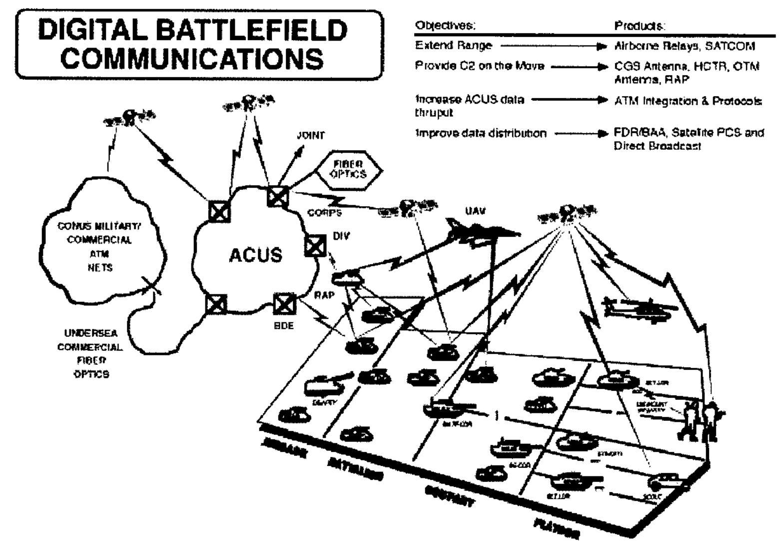
DEMONSTRATE A SECURE, ROBUST, SEAMLESS, DIGITAL, MULTIMEDIA, INFORMATION TRANSPORT CAPABILITY FOR THE ARMY TACTICAL USER THAT IS COMPLIANT WITH AND EXPLOITS EMERGING COMMERCIAL STANDARDS AND THE DISN ARCHITECTURE

JUSTIFICATION

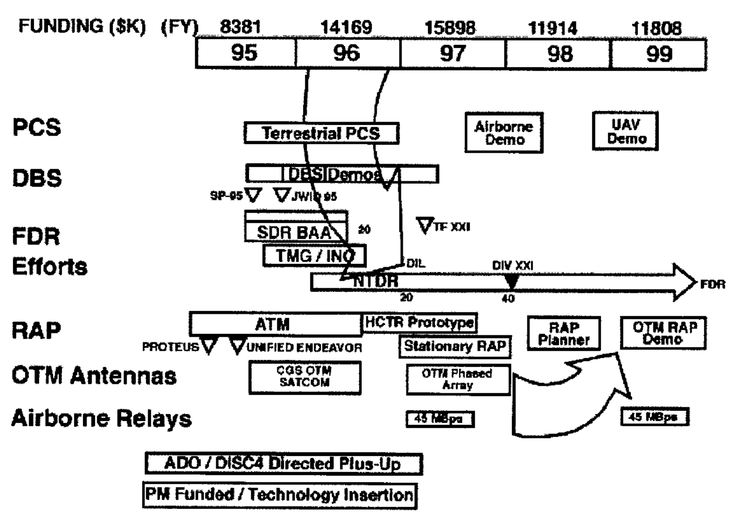
- SATISFIES "INFORMATION PULL" REQUIRED BY THE WARFIGHTER OF THE NEXT DECADE
- RESOLVES CURRENT COMMUNICATION DEFICIENCIES OF LIMITED BANDWIDTHS, MOBILITY, RANGE AND INTEROPERABILITY
- PROVIDES ACCESS WHENEVER, AND WHEREVER, NEEDED TO LARGE VOLUMES OF IMAGERY, INTELLIGENCE AND LOGISTICS DATA NECESSARY TO SUPPORT SPLIT BASED OPERATIONS

BATTLE LAB:
- BATTLE COMMAND

PEO:
- C3S



DBC / BITS Product Evolution



APPROACH:

- DEVELOP & INTEGRATE A SERIES OF TECHNOLOGIES TO SUPPORT THE DIGITIZED BATTLEFIELD
  - WIDEBAND MOBILE DIGITAL RADIOS
  - WIDEBAND OTM HIGH CAPACITY TRUNK RADIOS (HCTR)
  - MOBILE COMMUNICATIONS (CNR, SATCOM)
  - AIRBORNE RELAYS (UAV)
  - NEW SERVICES (DBS, SATPCS, PCS)
- ALLOW EVOLUTIONARY GROWTH FROM TODAYS'S SYSTEMS TO SUPPORT INTERFACE TO COMMERCIAL ATM INFRASTRUCTURE/GLOBAL COMM/DISN
- ESTABLISH JOINT TEST BED EXPERIMENTS WITH BCBL(G) AND OTHER SERVICE LABS
  - SUPPORT ADO CAMPAIGN PLAN BY INJECTING TECHNOLOGY INTO TF, DIV, CORPS XXI
  - INCREMENTAL PRODUCT INSERTION INTO BATTLE LABS/AWEs
- MODELING AND SIMULATION TO DEFINE AND EVALUATE ALTERNATIVE CONCEPTS
- UTILIZE CAC2 AND BC2 AS FEEDER APPLICATIONS

APPLICATIONS:

- FORCE XXI BITS
- ARMY COMMUNICATIONS AT ALL ECHELONS

Digital Battlefield Communications (DBC) ATD Exit Criteria

Digital Battlefield Communications Advanced Technology Demonstration Exit Criteria

3 April, 1997 update

Technology	Current Capability	Minimum Exit Criteria	Goal Exit Criteria
RAP Phased Array Antenna	S/C - Band, low data rate, static operation, one transmit beam, three receive beams, half duplex	X - Band, Static, two beam full duplex operation @ 15MBps with Airborne relay and fixed sites	X - Band, On-The -Move (OTM),two beam full duplex operation @ 15MBps with Airborne relay and fixed sites
Airborne Relay	UHF SATCOM surrogate satellite	DS-3 (45 Mbpsfull duplex link) radio/antenna system payload for UAV serving static users (e.g., RAP)	DS-3 (45MBps full duplex link) radio/antenna system payload for UAV serving OTM users (e.g. RAP)
RAP	None	Integration of mobile subscriber, radios, trunk radios, associated antennas, and switching equipment capable of full duplex linkto wide area ATM network via airborne relay at halt operation	Integration of mobile subscriber, radios, trunk radios, associated antennas, and switching equipment capable of full duplex linkto wide area ATM network via airborne relay OTM.
ATM Access	None	Demo operational network with 6 ATM enabled ACUS nodes; use permanent virtual circuits for ATM switching; transmit MSE voice integrated with multimedia over ATM; Operate ATM with Channel BER of 10–4	Demo operational network with 8 ATM enabled ACUS nodes; use switched virtual circuits, transparent call establishment (10 calls simultaneously established); Demo 10 on demand 4 way VTCs; Use adaptive FEC with varying BERs in external FEC unit

Digital Battlefield Communications (DBC) ATD Exit Criteria

Technology	Current Capability	Minimum Exit Criteria	Goal Exit Criteria
PCS	MSRT/Radio Access Unit in MSE	Integration of commercial PCS (IS-95) Cellular Capability Into WIN POCs Standalone operation (place calls within a cell without the backbone present) Man Portable user terminal less than 2 pounds Tactical Base Station supports 30 simultaneous calls with tactical antenna heights Calls into/across WIN POCs	Type 1 security integrated into user terminal Demonstrate Hand-off and Roaming between base stations Calls into/across WIN POCs
Direct Broadcast	None	Demo Multiple Channel Broadcast (push) of secured/ unsecured digital data up to 23 Mbps including video, MCS & ASAS and JSTARS to multiple receive sites with VCR size receive sets and 1.2 m quick deployable antennas. Demo in-theater user reachback (pull) via Surrogate Digital Radio and Trojan spirit to uplink info source	Same as minimum with the ultimate goal of evolving into an element of the Warrior Multicast Service, providing the Warfigher with worldwide information and multimedia exchange while on the move.

Digital Battlefield Communications (DBC) ATD Exit Criteria

ADDITIONAL DBC PRODUCTS

Technology	Current Capability	Minimum Exit Criteria	Goal Exit Criteria
High Capacity Trunk Radio	None	DS-3 (Fixed Bandwidth of 45 MB/s) operation transferring full duplex ATM data cells in a stationary mode of operation External Forward Error Correction (FEC)	DS-3 (Fixed Bandwidth of 45 MB/s) operation transferring full duplex ATM data cells while operating on-the-move (one end stationary). External Forward Error Correction (FEC)
HCTR (-)	2 Mbps MSE Line of Sight links AN/GRC-222 @ 40Km	10Mbps replacement for MSE AN/GRC-222 Line of Sight links @ 40Km	10Mbps replacement for MSE AN/GRC-222 Line of Sight links @ 40Km
Wideband HF Radio	Narrowband HF, 2400 Baud data rate. No access to Tactical Internet	Narrowband HF, @ 4800 Bps. Tactical Internet Access COTS Wideband HF	Wideband HF @ 19200 Bps Tactical Internet Access
Surrogate Digital Radio	EPLRS 56 Kbps of network throughput Dynamic Multihop Relay Tactical Internet	Data hauler for Tactical Internet ABCS traffic 180 Kbps throughput per net Dynamic Internet routing Dynamic multihop relay	Same as minimum with the ultimate goal of providing a seamless network with connectivity transparent to the user.

Guided MLRS ATD

OBJECTIVE:

DEMONSTRATE 2 MIL DELIVERY ACCURACY USING INERTIAL GUIDANCES & 10 METER CEP DELIVERY ACCURACY USING GPS-AIDED INERTIAL GUIDANCE

DEMONSTRATE A GUIDANCE AND CONTROL PACKAGE WITH A PROJECT COST OF LESS THAN $14,000

JUSTIFICATION:

THE EXTENDED RANGE MLRS ROCKET IS IN DEVELOPMENT

IMPROVEMENTS IN DELIVERY ACCURACY WILL REDUCE:
- THE NUMBER OF ROCKETS REQUIRED TO DEFEAT THE TARGET BY AS MUCH AS SIX-FOLD AT MAX RANGES
- THE REQUIRED NUMBER OF LAUNCHERS PER FIREMISSION
- THE LOGISTICS BURDEN
- FIREMISSION DURATION AND COLLATERAL DAMAGE/FRATRICIDE

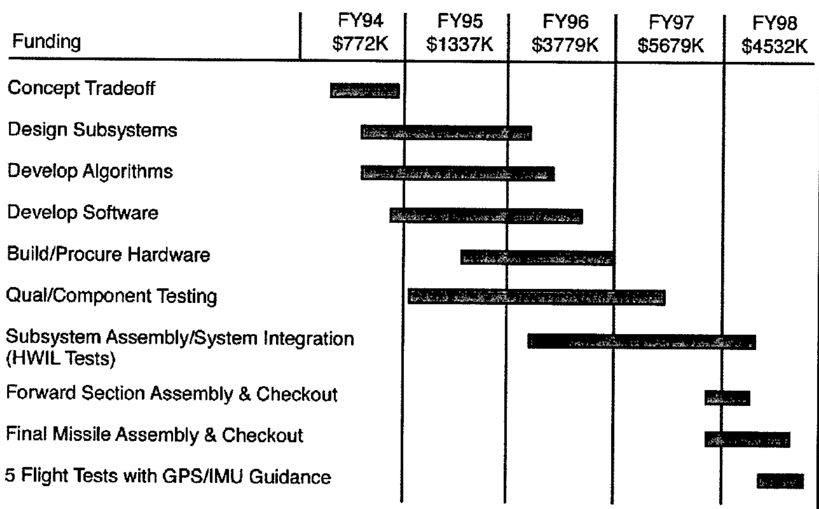
TRADOC INTERFACE:

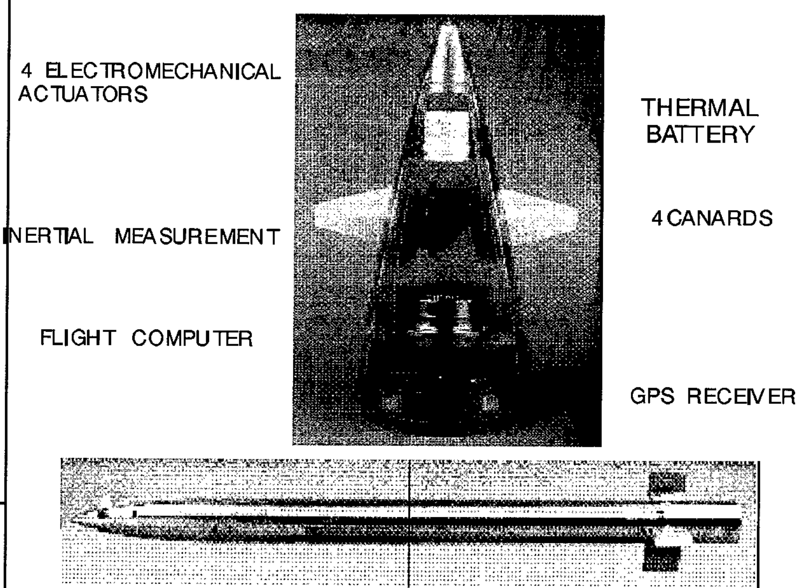
TRADOC SYSTEM MANAGER FOR ROCKETS & MISSILES DEPTH & SIMULTANEOUS ATTACK BATTLE LAB

PEO INTERFACE:

PEO TACTICAL MISSILES - MLRS PROJECT OFFICE

SCHEDULE & FUNDING:





APPROACH:

INTEGRATE A GUIDANCE & CONTROL PACKAGE INTO THE NOISE OF THE CURRENT EXTENDED RANGE ROCKET

DESIGN A PACKAGE WHICH IS INDEPENDENT OF ROCKET PAYLOAD

DEMONSTRATE A PACKAGE BASED ON A LOW-COST INERTIAL MEASUREMENT UNIT AND CANARDS WHICH MEETS USER REQUIREMENT FOR BOMBLET WARHEAD

INTEGRATE GPS INTO THE GUIDANCE & CONTROL PACKAGE TO EXCEED USER REQUIREMENT AND POSTURE FOR FUTURE MUNITIONS (UNITARY WARHEAD)

APPLICATIONS:

GUIDED MLRS EMD AND PRODUCTION

M270 & HIGH MOBILITY ARTILLERY ROCKET SYSTEM (HIMARS) LAUNCHERS

MRLS SMART TACTICAL ROCKET (MSTAR)

MLRS WITH MINE OR EARTH PENETRATOR/UNITARY WARHEAD

Guided MLRS ATD Exit Criteria

Demonstrate a low cost guidance and control package for the MLRS rocket. At extended ranges, large quantities of baseline rockets are required to defeat the target. With the addition of a guidance system, an improved delivery accuracy will be achieved. The number of rockets required to defeat the target will be reduced to one-sixth the current quantity at maximum ranges. The program will conduct test flights in FY98. Technologies that will be integrated include low cost inertial measurement units, GPS receivers and antennas, and a canard control package, all of which must be housed in the forward section of the MLRS rocket.

Supports: MLRS Family of Munitions, Rapid Force Projection Initiative (RFPI) ACTD, MLRS Smart Tactical Rocket, Precision MLRS (unitary warhead concept), High Mobility Artillery Rocket System (HIMARS)

FUNDING

PE	PROJ	FY95	FY96	FY97	FY98	FY99	FY00	FY01
63313	D380	1365	3779	5679	4532	0	0	0

STO Manager:
Allan E. Gamble
MICOM RDEC
205-876-2511
DSN: 746-2511

TSO:
Irena Szkrybalo
703-697-8434
DSN: 227-8434

TRADOC POC:
Pat McCartney
Depth & Sim Attack Battle Lab
405-442-5028
DSN: 639-5028

GMLRS ATD Exit Criteria

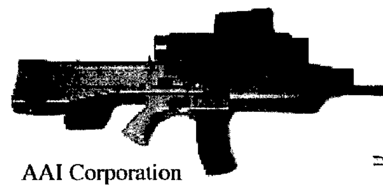
	Current Baseline	ATD Threshold	ATD Goal
Cost of G&C Modifications	$0	$30,000	$14,000
Delivery Accuracy w/o GPS	Confidential	4-mil	2-mil
Delivery Accuracy w GPS	Confidential	30m CEP	10m CEP
Shelf Life (years)	15	15	15
Maintenance Requirement	none	none	none
Reliability	0.97	0.70	0.91

Objective Individual Combat Weapon (OICW) ATD

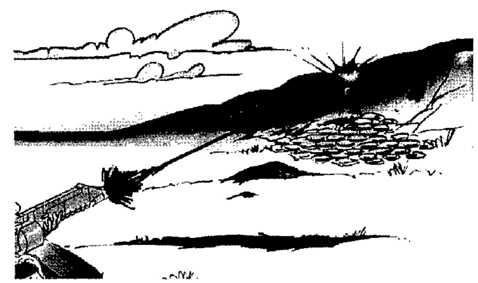
OBJECTIVE:
Demonstrate OICW Operational Utility, Versatility,Technological Maturity & Lethality Through Scenario Driven Troop Testing, Simulation, and Land Warrior Soldier System Interfacing.

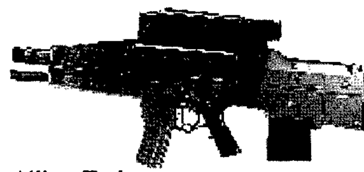
JUSTIFICATION:
- Probability of Incapacitation: >0.5 to 300m (Point Target)
  >0.2 to 300m (Defilade Target)
- Decisively Violent and Suppressive Target Effects
- New Ability to Defeat Defilade Targets; Increased Range
- Army & Joint Service Small Arms Master Plans - Potential Replacement: M16A2 Rifle Family & M203 Grenade Launcher
- MNS; ACAT III; MS Decision Authority-AMC Commander
- DTO WE16; STO III.I.1/ATD; Joint Service Program

BATTLE LAB: DBS ***PM:*** PMSA Linkage



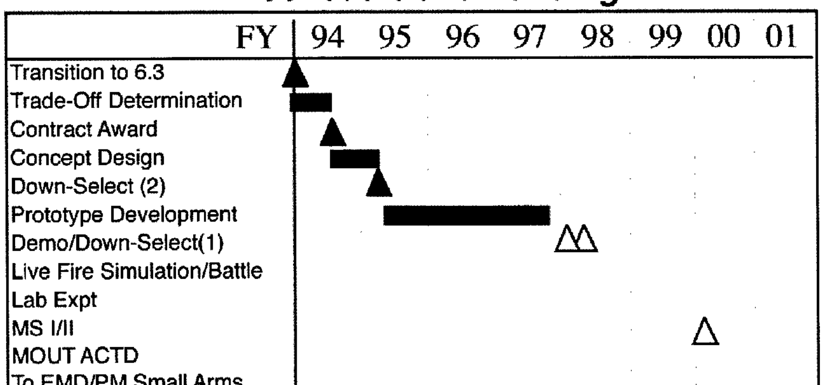
AAI Corporation





Alliant Techsystems

Schedule and Funding



($K)	94	95	96	97	98	99	00	01
PE/Proj: 62623A/AH21		2431	620					
PE/Proj: 63607A/D627	1895	4041	3700	4500	3352	5010		
USMC PE633640			500	800	1200	600		
Congressional Plus-Up		1786	250	3000	(5500)			

APPROACH:
- DOD Technology Assessment/R&D Plan Formulation
- Integrated Product & Process Development (IPPD)
- Design & Demonstrate Integrated OICW Systems:
  - Air Bursting Warheads, Lethal Mechanisms
  - Modular Optoelectronic Fire Control
  - Operational Utility & Technological Maturity
- Simulation: Constructive/Virtual/Live Fire
- Interface With FORCE XXI Land Warrior & MOUT ACTD
- By-pass DEM/VAL, Transition Directly Into EMD

APPLICATIONS:
- Objective Family of Small Arms (OFSA)
- Land Warrior & FORCE XXI

POC: Mr. Matthew T. Zimmerman, OICW ATD Program Manager, DSN 880-7993; <zimmerman@pica.army.mil>

OICW ATD Exit Criteria

Metric	M16/ M203/TWS	OICW ATD Threshold	Contractor Threshold	Contractor FUE Goal
Probability of Incapacitation	**<15% @ 300M**	50% @ 300M	50-70% @ 300M	40-50% @500M
Transmit TOF Signal To Fuze	N/A	Single Shot	Semi-Auto	Semi-Auto
System Weight: Loaded:	>16.5 lbs	<18	< 18	<14
System Cost	$28+K	$15.0 K	<$10-11K	
Ammunition Cost	$14 (M433)	$30	<19-$25	

Target Acquisition ATD

OBJECTIVE

- DEMONSTRATE AUTOMATED WIDE AREA SEARCH, ACQUISITION, IDENTIFICATION AND PRIORITIZATION WITH AUTOMATED CUEING/TRACKING/HAND-OFF AT EXTENDED RANGES TO ALLOW REDUCED CREW WORKLOAD/TIMELINES, IN SUPPORT OF LETHAL, DEPLOYABLE COMBAT VEHICLES WITH FEWER CREW MEMBERS

JUSTIFICATION

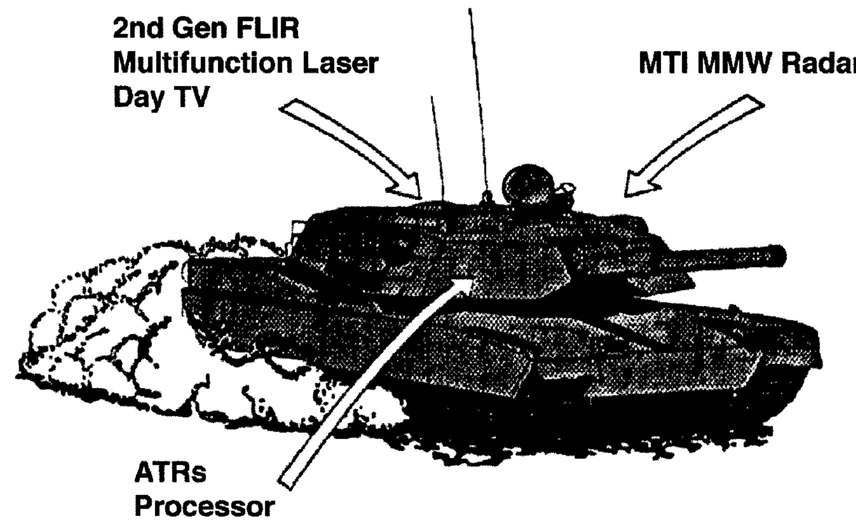
- ADDRESSES KEY USER REQUIREMENTS FOR FUTURE COMBAT VEHICLES AND COMBAT VEHICLES UPGRADES
  - LETHALITY (RAPID DETECTION & LONG RANGE ID)
    - DEGRADED CONDITION FIRE CONTROL
  - DEPLOYABILITY - LIGHTER VEHICLE, REDUCED CREW
  - SURVIVABILITY - SEE FIRST, SHOOT FIRST

BATTLELAB

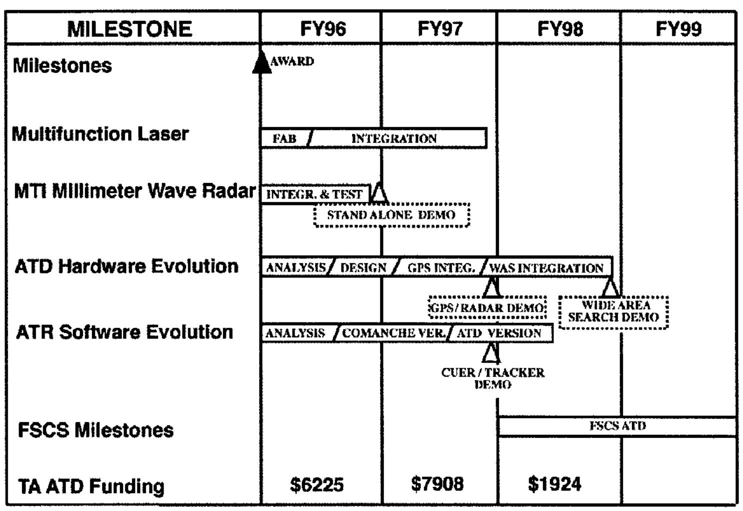
- MOUNTED BATTLESPACE

PEO

- IEW (SENSORS) (PM NVEO)
- GCSS (INTEGRATION)



SCHEDULE



APPROACH

- THE TARGET ACQUISITION ATD MTI RADAR AND THE GIMBAL SCAN SECOND GENERATION FLIR WILL PERFORM TARGET DETECTION, THEN HAND-OFF TARGET POSITIONS TO THE FLIR SENSOR/MULTI-FUNCTION LASER SENSOR (FUTURE STI RADAR SENSOR) FOR AIDED TARGET IDENTIFICATION
- INTEGRATE A MULTI-FUNCTION LASER, SECOND GENERATION FLIR SENSOR SUITE, AND A HIGH DENSITY PROCESSOR COUPLED WITH MODIFIED ATR ALGORITHMS AS A 'B" KIT INTO A SURROGATE CHASSIS FOR OPERATIONAL DEMONSTRATION.
- PROVIDE MTI MMW RADAR (STI GROWTH POTENTIAL) FOR TARGET ACQUISITION, TRACKING, & CUEING ENHANCEMENT IN DEGRADED CONDITIONS
- INTEGRATE AND DEMONSTRATE WIDE AREA SEARCH AND SENSOR FUSION OF THE FLIR AND MFLS TO DECREASE OPERATOR TIMELINES.
- INCORPORATE IPPD APPROACH TO ADDRESS PRODUCIBILITY AND AFFORDABILITY RISKS AND USE STATISTICAL METRICS TO ESTIMATE AND MANAGE ATD SIGMA
- EMPLOY FLIR/LASER SENSOR FUSION, DESIGN FOR GROWTH TO FULL SENSOR FUSION (STI RADAR)
- TECHNOLOGY FEED TO THE MBBL SPONSORED ACT II LATARS PROGRAM

APPLICATIONS

- POTENTIAL UPGRADES (ABRAMS, BRADLEY, LRAS3)
- TECH TRANSFER TO FSCS / FIV

Target Acquisition ATD Exit Criteria

OPERATIONAL CAPABILITY	GEN II FLIR (BASELINE - NO AUTOMATION)	END ATD SENSOR SUITE	
		MINIMUM	GOAL
• TARGET DETECTION			
• MOVING/STAT	1.0 good 0.5 bad	1.2 good 0.6 bad	1.5 good 1.2 bad
• HULL DOWN	0.6 good 0.4 bad	0.6 good 0.4 bad	0.7 good 0.5 bad
• IDENTIFY TARGET			
• MOVING/STAT	0.5 good 0.3 bad	0.8 good 0.6 bad	1.0 good 0.7 bad
• HULL DOWN	0.3 good 0.2 bad	0.7good 0.5 bad	0.9 good 0.6 bad
• TIME TO DETECT	90 sec	15-20 sec	10-15 sec
FALSE ALARM RATE	N/A	1.0 X / deg^2 *	0.16 X / deg^2 *

NOTE: ALL RANGE CRITERIA ARE NORMALIZED
* INDICATES MSAT-AIR ATD BASED VALUES

Direct Fire Lethality ATD

OBJECTIVE:

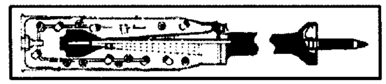
- Provide advanced frontal armor defeat capability against post 2005 ERA protected threats at extended ranges
- Provide dramatic increase in system accuracy (P(h)) at 3km under stationary and moving conditions
- Reduce O&S Costs

JUSTIFICATION:

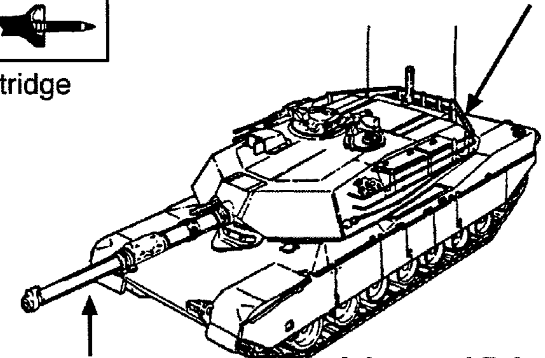
- 2005 ERA projected threat protection levels
- User desire to expand lethal battlespace
- Large system errors degradation of P(h)at extended ranges
- DoD cost reduction philosophy

BATTLELAB:	*PEO:*
MBBL	GCSS

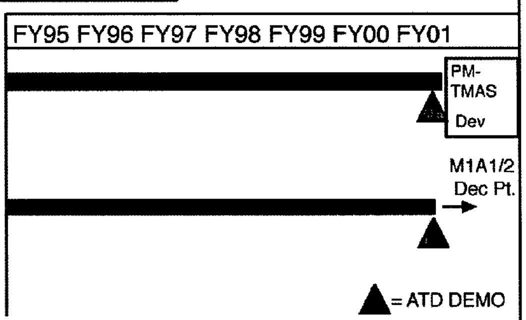
Munition



Advanced KE Cartridge



SCHEDULE and FUNDING



Funding ($M)	FY95	FY96	FY97	FY98	FY99	FY00	FY01
6.2 ARDEC		3.7	4.0	3.3	1.5		
ARL		.3	.3	.3			
6.3 ARDEC		2.1	3.8	4.6	12.2	12.7	10.5
PM-TMAS				1.0	3.0	2.0	2.0

APPROACH

- Integrate novel KE penetrators, MEMS accelerometer with thruster mechanisms to efficiently defeat ERA protection and increase stationary probability of hit
- Integrate & demo on an M1A1 distributed direct (gearless) drive, Optical Fiber Muzzle Reference Sensor, & modern digital servo control technologies to stabilize system at the muzzle and increase accuracy under moving conditions
- Conduct integrated performance demonstration via Simulation & Modeling

APPLICATION

- Future Combat Vehicles
  - M1A2 SEP, SEP+, M1A1D, FCS, FSCS, FIV
- Future aviation platforms
  - Apache Upgrade/Comanche
- Preplanned Product Improvements

Direct Fire Lethality ATD Exit Criteria

OPERATIONAL CAPABILITY	BASELINE	THRESHOLD	OBJECTIVE
Advanced KE Cartridge:			
Armor Penetration (against ERA 3 protected threat)	M829A2/M256	≥40% @ 3Km	≥70% @ 3Km
System Accuracy (S-S)	M829A1/M256	≥30% @ 3Km	≥70% @ 3Km
Affordability (UPC)	M829A2	< (Baseline + 30%)	<(Baseline + 20%)
Structural Integrity	M829A2	10 Shots at Gun PIMP	
Target Impact Dispersion (mils) at 1, 2, 3km & -25F, +70F, & +120F	M829A2	1.33H x 1.33V (Normalized)	1.0H x 1.0V (Normalized)
Function: Demo (@2Km) critical axial/radial offsets established through armor tests and Pk analysis	N/A	80%	100%
Advanced Drives & Weapon Stab:			
Affordability: O&S Cost	M1A1(FY95 Historical data = $3000/vehicle/yr	≤$700/vehicle/yr	≤$200/vehicle/yr
Probability of Hit (moving vs. stationary) (moving vs moving)	M1A2 M1A2	≥100% @ 3Km ≥ 50% @ 3Km	>200% @3Km ≥100% @3Km
Gearless Drive Integration (Based on Abrams tank feasibility design)	M1A1/A2	No major mods to turret/chassis	No major Mods to turret/chassis
Power Requirements	M1A1/A2	APU only (silent watch) or prime power only	

Integrated Biodetection ATD

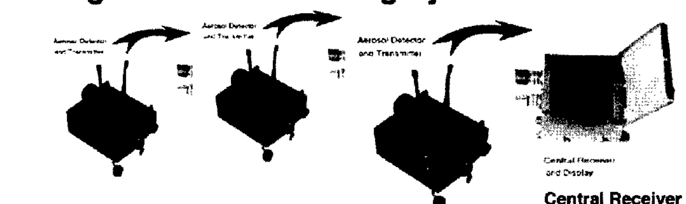
OBJECTIVES:
- Demonstrate the ability of state-of-the-art biological agent detection and identification technologies to provide pre-exposure warning of biological agent attacks
- Demonstrate an enhanced identification device with improved sensitivity, selectivity and extended range of threat agents for the Joint Biological Point Detection System (JBPDS)
- Demonstrate a real-time remote biological aerosol detection system for early warning of an immediate hazard. Supports Joint Biological Remote Early Warning System (JBREWS) ACTD

JUSTIFICATION:
- Provides increased decision cycle for commanders
- Enhances overall force mobility and survivability
- Critical for early masking, "all clear" signal and early treatment

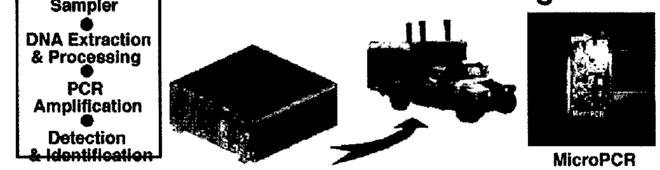
BATTLELAB:
Maneuver Support Battlelab

PEO:
JPO-Bio Defense

Biological Aerosol Warning System



Automated DNA Diagnostic



SCHEDULE AND FUNDING:

MILESTONES		FY96	FY97	FY98	FY99
6.2 Supporting Technologies					
Fab/demo Automatic DNA Diagnostic					
Pathogen Testing					
Fab/demo Bioaerosol Warning System					
Integration					
BLWE Planning					
BLWE					
FUNDING ($K)	63384/DE83	3714			
	63384/CB3		7231	7071	6107

APPROACH :
- Develop and demonstrate real-time detection and early warning/alert of immediate bio-hazard using existing military communications system
- Develop and demonstrate Automatic DNA Diagnostics using evolving gene probe technology to uniquely identify threats
- Conduct battlefield simulation and agent simulant outdoor field trials to assess effectiveness of technologies
- Conduct developer/user field demo to simulate, validate operation under CB mission conditions

APPLICATIONS:
- JBREWS ACTD
- JBPDS

Integrated Biodetection ATD Exit Criteria

Operational Capability	Current Capability	Developmental (FY98)	End ATD Goals (FY98)
Point Biosensors:			
Bacteria identification	2 agents (1)	5-agents (2)	All threats
Automated virus ID	None	None	All threats
Identification sensitivity	25 ACPLA	15 ACPLA	1 ACPLA
Selectivity	Antibody-based	Antibody-based	DNA-based
Identification times	30 Minutes	20 Minutes	20 Minutes
Operator interface	Manual	Semi-automatic	Automatic
Logistics burden	Multiple reagents	Multiple reagents	Single-step assays
Reagent storage	Basic	Basic	Hot, basic, cold
Pre-Exposure Warning	Low probability	Same	High probability
Detection of Missile, Bomblet, covert release over corps area	Post-exposure warning	Same	Pre-exposure warning
Upwind alert to attacked area	Generic (aerosol)	Same	Specific (bioaerosol)
Aerosol type	Line source	Same	Line, point sources
Threat source	Helicopter	Same	Ground unit
Platform	Voice transmission	Digitized transmission	Digitized transmission
Battlefield integration			

(1) Plus two toxins; (2) Plus three toxins;

ACPLA - Agent Containing Particles per Liter of Air

Vehicular Mounted Mine Detector ATD

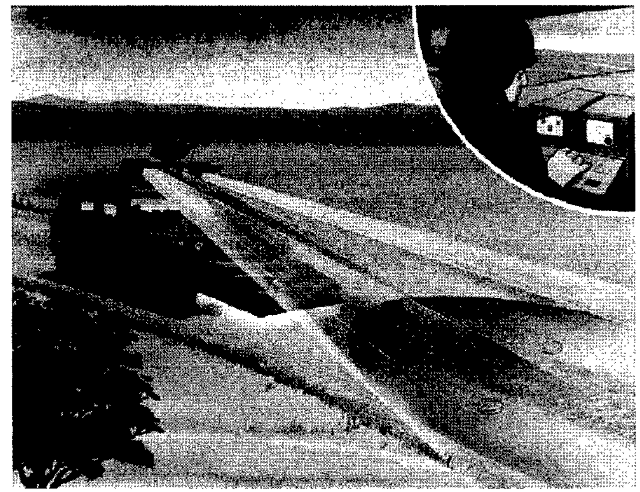
Objective:
- To Evaluate and Demonstrate the Capability to Detect Metallic and Non-Metallic Anti-tank Mines On/Off Roads at Moderate Speeds.

Justification:
- To Maintain LOC/MSR Free of Mines
- To Improve Survivability by Avoiding Main Source of Vehicular Losses in Most Confilcts (including OOTW)
-

Battle Lab:
- Mounted Battlespace
- Dismounted Battlespace
- Maneuver Support

PEO:
- ASM (PM-MCD)

DTAP -DTO WE.02



MILESTONES	FY94	FY95	FY96	FY97	FY98
6.2 Exploratory Development					
Sensor Testbed Fabrication					
Sensor Arid Field Testing					
Sensor Temperature Field Testing					
Data Analysis/ATD Sys. Spec					
System Fabrication					
Arid Field Demos					◇
Temerate Field Demo					◇
Transition/Milestone II (EMD)					◇
Funding 63606/(D608)		5.6	4.5	8.3	3.0

Approach:
- Demonstrator Development
  - Develop Two Multi-sensor Suite Approaches
  - Electromagnetic Induction
  - Down & Forward Looking Ground Penetrating Radars
  - Forward Looking IR
  - Sensor Fusion/ATR
- ATD Phase
  - Test in Arid & Temperature Realistic Terrains & Clutter
  - Test in Operational Scenarios
  - Test Best Sensors or Combinations
  - Teleoperation

Applications:
- Joint Countermine ACTD
- Countermine Lightfighter Battle Lab Experiments

Vehicular Mounted Mine Detector ATD Exit Criteria

CURRENT ARMY VEHICULAR CAPABILITY DOES NOT EXIST

	OFF ROAD	ON ROAD
OPERATIONAL CHARACTERISTIC	MIN. (GOAL)	MIN. (GOAL)
DETECTION SPEED (km/H)	2 (3)	3.6 (5)
PROBABILITY OF DETECTION (%)		
AT SURFACE	92 (98)	95 (99)
AT BURIED	90 (95)	92 (95)
MAXIMUM FALSE ALARM RATE (PER METER OF FORWARD PROGRESS)	0.25 (0.15)	0.06 (0.04)
SYSTEM POWER REQUIREMENT (kw)	5 (3.5)	5 (3.5)
PER UNIT PRODUCTION COST ($K)	250	250

NOTE: AT (ANTITANK) MINE TO INCLUDE METALLIC AND NON METALLIC

Multispectral Countermeasures ATD

Objective:

- This program will develop and test advancements in laser technology, energy transmission, and jamming techniques for an all-laser solution to IRCM, and as P3I to the ATIRCM/CMWS program. These improvements will provide the capability of countering both present and future multi-color imaging Focal Plane Array and non-imaging missile seekers.

Justification:

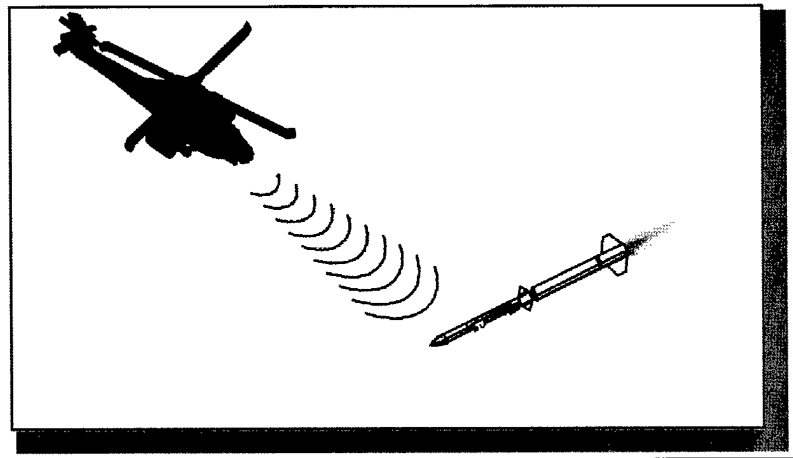
- AV97-007 Survivability
- AV97-017 Live, Virtual and Constructive Simulation Technologies
- MMB97-008 Survivability

Battle Lab:
- Air Maneuver

PEO:
- Aviation
- ASM

Schedule & Funding:

MILESTONE	FY96	FY97	FY98	FY99
• Supporting IRCM Effects Test & Simulation				
• Contract Award				
• Investigate Fiber Optic Cable Options				
• Characterize DARPA Laser				
• Multiline OPSL Laser Design				
• Evaluate IRCM techniques with Laser				
• Integrate with ATIRCM				
• Lab Test				
• Live Fire Test				
• Final Report				
Funding PE 63270/DK16 ($K)		3,712	5,299	7,000



Approach:

- Utilize ATIRCM/Tri-Service Common Missile Warning System (CMWS) Sensors and Processor as Core System Hardware
- Upgrade Jamming Capability With Multi-Line Laser
- Demonstrate and implement advancements in Fiber Optics for transmission of Laser energy to Jam Head
- Leverage Tri-Service Development of Advanced IRCM techniques
- Leverage Air Force laser program
- Utilize surrogate generic imaging missile hardware for evaluation of jamming techniques
- Conduct Captive Seeker & Live Fire Cable Car Test Versus Imaging SAMS

Applications:

- Tri-Service ATIRCM/CMWS Improvements
- Integrated Suite of ASE
- All Army/Navy/Air Force/SOCOM/VIP Aircraft

Multispectral Countermeasures ATD Exit Criteria

Operational Capability	ATIRCM	ATD Minimum	ATD Goal
• Effectiveness			
– Non-Imaging	90 % (Lamp/Laser)	95 %	99 %
– Imaging	N/A	90 % (Laser Only)	99 % (Laser Only)
• J/S Ratio	500 / 1	2,000 / 1	3,000 / 1
• System Weight	125 lbs.	100 lbs.	90 lbs.
• Prime Power	2.4 kW	1.2 kW	1 kW
• Jam Head Size (NAVY ATD)	13.5" h x 8.0" dia.		4.2" h x 8.6" dia. (6 sided pyramid)

NVESD

Air/Land Enhanced Reconnaissance and Targeting ATD

Objective:

- Demonstrate On-the-Move Wide Area Search, Target Detection and Identification in an Automated FLIR/ Laser Target Acquisition Suite
- Justification:
- Improved Target Acquisition
- Real-Time Location and Identification of Targets
- Enhanced Capabilities to Stop Modernized Threat Forces
- Improved Sensors

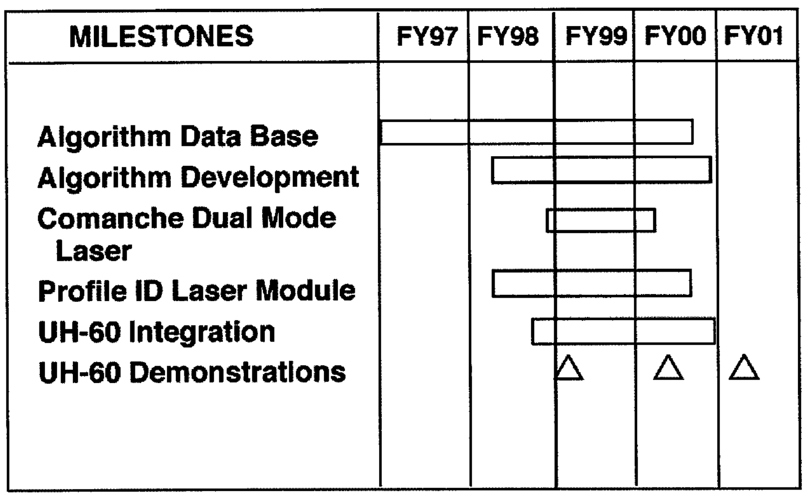
Battle Lab:

- Air Maneuver Battle Lab
- Mounted Battle Lab
- D&SA Battle Lab

PEO:

- Aviation

Schedule & Funding



Approach:

- Demonstrate Advanced Targeting for Rotary Wing Strike Aircraft
  - 2nd Gen FLIR/Multifunction Laser Sensor Suite
  - EO MTI/USAF Fractil Algorithms
  - Neural Net Processing
  - Data/Image Compression and Transmission of Targeting Reports and Imagery
- Applications:
  - RAH-66 Comanche
  - AH-64C Apache
  - OH-58D Kiowa Warrior
  - Future Scout Combat System

NVESD

Exit Criteria

Normalized to current field performance

Operational Capability	Current Baseline FLIR Performance	Minimum Exit Criteria	*Goal Exit Criteria
On The Move Detection	1x Pd	1.35x Pd	1.6x Pd
On The Move Recognition	1x% Pr	1.2x% Pr	1.4x% Pr
On The Move Identification	N/A	1.1x% Pi	1.35x% Pi
False Alarms with Clutter Levels	1y/Km^2 - Low N/A - High	.1y/Km^2 - Low .2y/Km^2 - High	.01y/Km^2 - Low .05y/Km^2 - High
Acquisition Range	1z- 2z Km	2z-3z Km	3z - 4z Km
Forward Velocity and Scan Size	k Knots d Degrees	k Knots 5d Degrees	k Knots 7d Degrees

Performance is for 2.3 x 2.3 Meter Target with .6 degree C temperature contrast at the sensor.

* Goal is to achieve static performance or better while on-the-move.

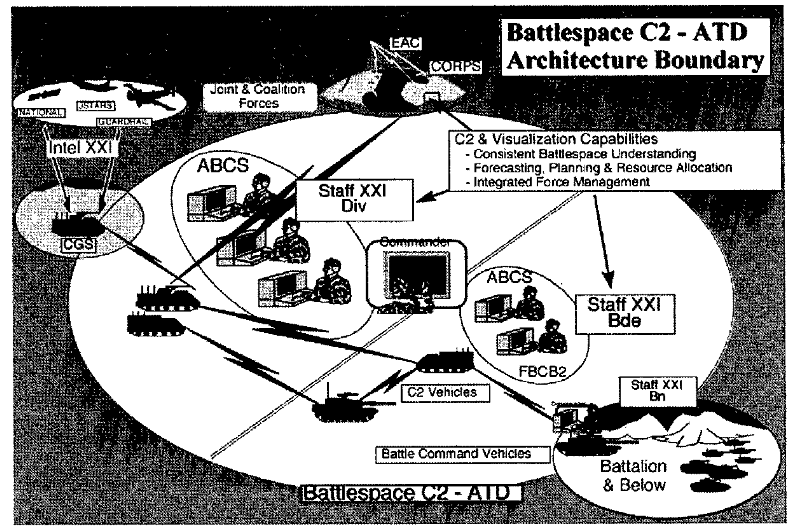
Battlespace Command and Control ATD

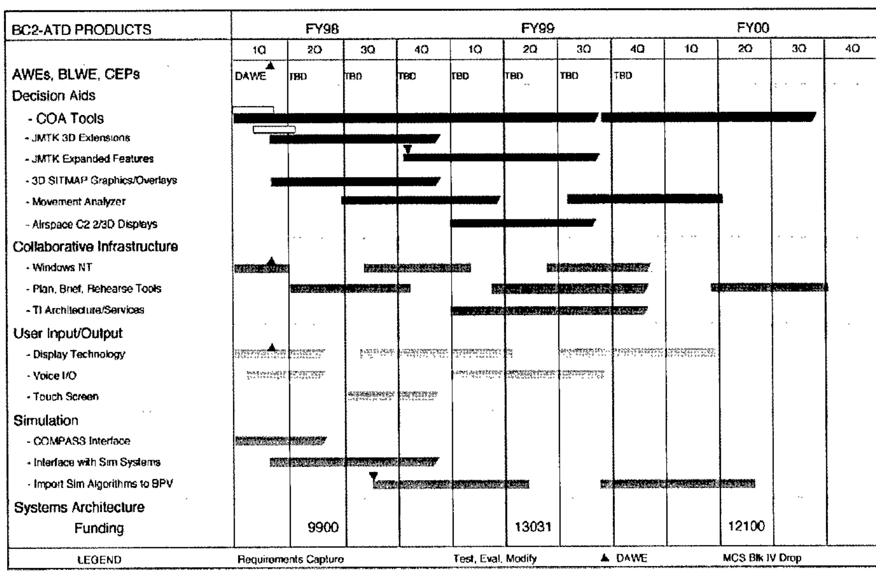
Objective - Develop, evolve, demonstrate advanced information technologies that significantly enhance the Commander/Staff's decision making abilities, by providing:
Visualization tools which support/enhance information assimilation and cognitive reasoning
- Automated capability to collaboratively select/analyze courses of action, develop plans and perform rehearsals
- Tools to monitor, control, coordinate dynamic combat activities

Justification - Rapid and accurate assessment of combat situations, mission planning, and replanning are essential to success in the future battlefields.

Battlelabs:
BCBL(L, G, H), MMBL

PEO: C3S -
PMs - ATCCS, FBCB2





Approach

Identify detailed C2 and Visualization requirements (User Lead)

Develop/Evolve software prototype solutions and architecture definition

Examine/analyze prototypes, products, architectures and alternative solutions using enhanced M&S tools

Evaluate Products in tactical environment (BLWEs, SIMEX's, CEPs, AWEs)

Demonstration solution sets at selected AWEs

Hand over incremental product modules to PEO ATCCS and other ABCS PMs

Battlespace Command and Control ATD Exit Criteria

CRITERIA	BASELINE	MINIMUM	GOAL
• REDUCE REACTION / DECISION TIME *[Deliberate]**	BDE = 12/24 Hrs DIV = 24/36 Hrs	Factor of 2	Factor of 4
• REDUCE MISSION TO ORDER PREPARATION TIMES *[Deliberate]**	BDE = 12/24 Hrs DIV = 24/36 Hrs	Factor of 2	Factor of 4
• INCREASE THE NUMBER OF COMBAT OPTIONS EVALUATED *[per unit time]**		Factor of 1.5	Factor of 2

* *Dependent on: Echelon being evaluated (BN, BDE, or DIV) & SCENARIO (dictates where in Military Decision Making Continuum - DELIBERATE, COMBAT, or QUICK)*

Command & Control / Battlefield Visualization Software Modules/ Utilities developed will impact:

- Plan Development
- Information Availability/Accuracy
- Plan Evaluation
- Force Synchronization
- Intelligence Collection Focus

- Collaborative Work Environment
- Mission Rehearsal
- Situation Awareness
- Commanders' Perception of Situation
- % Planning Time @ Each Echelon

Future Scout and Cavalry System (FSCS) ATD

OBJECTIVE:

- DEMONSTRATE TECHNICAL FEASIBILITY, OPERATIONAL POTENTIAL OF A SCOUT BY INTEGRATING SCOUT SPECIFIC TECHNOLOGIES WITH ADVANCED VEHICLE TECHNOLOGIES.

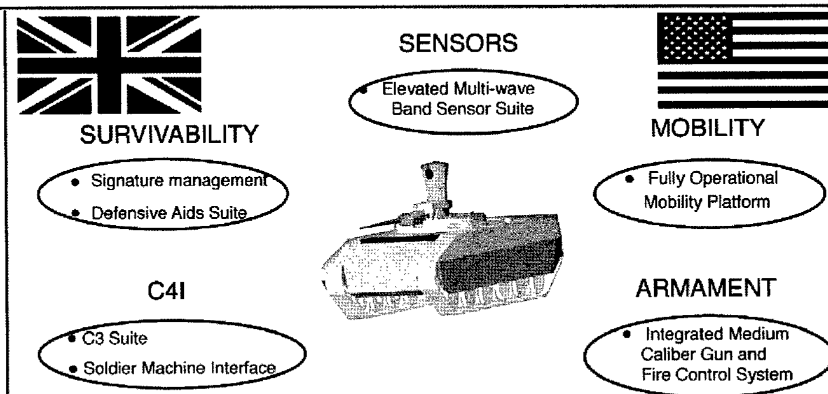
JUSTIFICATION:

- FSCS MISSION NEED STATEMENT APPROVED 21 APR 97
- FSCS INTEGRATED CONCEPT TEAM
- FSCS/TRACER DRAFT COMBINED OPERATIONAL REQUIREMENTS DOCUMENT
- FSCS/TRACER STATEMENT OF INTENT
- FSCS/TRACER DRAFT MEMORANDUM OF UNDERSTANDING BETWEEN US/UK
- FSCS/TRACER DRAFT TECHNICAL REQUIREMENTS SPECIFICATION
- ADDRESSES 10 INTEGRATED FUTURE OPERATIONAL REQUIREMENTS (FOCs)

USER SUPPORT:
ARMOR CENTER DFD
MOUNTED MANEUVER BATTLELAB

USER EXPERIMENT:
JOINT US/UK

PEO:
GCSS



SCHEDULE AND FUNDING:

MILESTONE (FY)	97	98	99	00	01
DESIGN/BUILD CREW STATION SIMULATORS					
COMPETITIVELY AWARD THE ATD CONTRACTS					
DEVELOP REQUIREMENTS/DESIGN FSCS ATD					
FABRICATE FSCS ATD					
DEMONSTRATE FSCS ATD					
DEVELOP FSCS VIRTUAL PROTOTYPE					
DEMONSTRATE KEY FSCS HARDWARE COMPONENTS IN SIL					
OTHER TECH BASE PROGRAMS					
FUNDING ($M):	0.8	7.5	26.3	56.7	63.0

APPROACH:

- COOPERATIVE PROGRAM WITH UK
- USE VIRTUAL PROTOTYPING TO EVALUATE DIFFERENT CONFIGURATIONS TO DETERMINE THE OPTIMAL COMBINATION OF SURVIVABILITY, MOBILITY, TARGET ACQUISITION, LETHALITY, & DEPLOYABILITY TECHNOLOGIES SUCH AS:
  - SCOUT SENSOR SUITE
  - ADVANCED CMD & CONTROL
  - ADVANCED CREW STATION
  - ADVANCED SURV SYSTEMS
  - ADV MOBILITY COMPONENTS
  - ADV LTWT STRUCTURAL MATERIALS & ARMORS
  - MEDIUM CALIBER WEAPON/SURROGATE
- DEMONSTRATE SCOUT VEHICLE HARDWARE AND SOFTWARE SOLDIER MACHINE INTERFACE IN DISTRIBUTIVE INTERACTIVE SIMULATION (DIS) ENVIRONMENT
- DEMONSTRATE HARDWARE/SOFTWARE IN SYSTEM INTEGRATION LAB (SIL)
- FINALIZE SCOUT DESIGN AND BUILD DEMO VEHICLE PLATFORM
- PROVIDE DEMO VEHICLE PLATFORM TO USER FOR EVALUATION
- LEVERAGE DARPA'S HYBRID ELECTRIC POWER PROGRAM
- PERFORMANCE BASED SPECIFICATION FOR ATD AND EMD

APPLICATIONS:

- TRANSITION TO EMD FOR NEXT GENERATION FSCS
- UPGRADES TO EXISTING SCOUT VEHICLE PLATFORMS
- FUTURE INFANTRY VEHICLE

Future Scout and Cavalry System (FSCS) ATD Exit Criteria

Enhancement	Baseline	Required	Goal
1. Reduced Signature.	*	30%	50%
2. Decreased Target Detection Time.	90 sec**	20 sec	10 sec
3. Increased Target Identification Range.	2nd Gen FLIR	50%	275%
4. Increased Deployability.		3 on a C-17	1 on a C130

* Based on test results with/without application
** Manual system with man in the loop

Mine Hunter/Killer ATD

Objective:

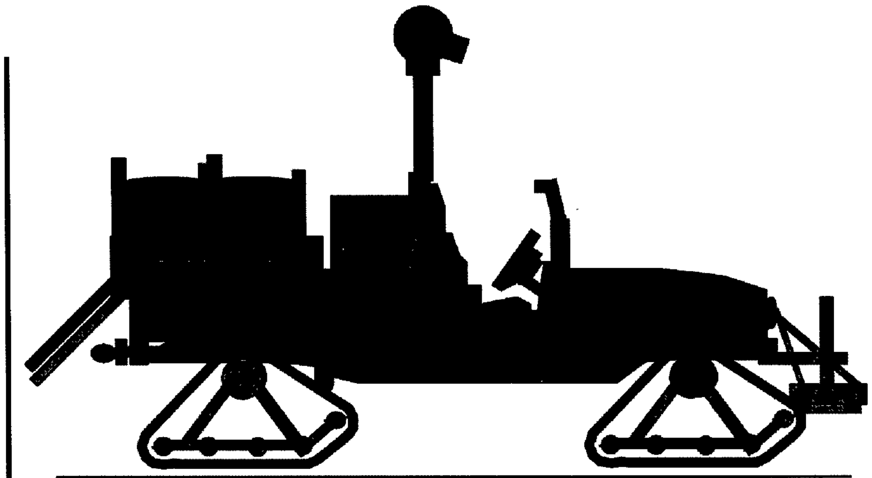
- Develop an integrated system for the semi-autonomous detection and neutralization of anti-tank mines from a single tactical military vehicle at the fastest operational tempo possible
- Justification (Future Operational Capabilities):
- AR 97-009 Mounted Standoff Minefield Detection and Neutralization
- EN 97-009 Operate Freely in a Mine/UXO Threat Environment
- TR 97-041 Operations in a UXO/Mine Threat Environment

Battle Lab:

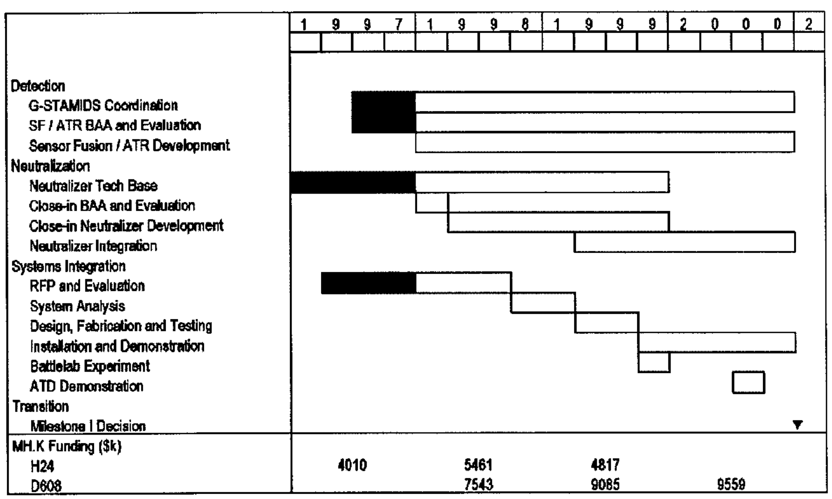
- Maneuver Support, Mounted, Dismounted

PEO:

- GCSS



Schedule :



Approach:

- Leverage downward looking mine detection from the Ground - Standoff Mine Detection System (G-STAMIDS) Program and cooperatively develop forward looking mine detection, sensor fusion and automatic target recognition technologies
- Develop close-in neutralizers for individual buried and surface laid anti-tank mines and investigate standoff alternatives
- Combine detection and neutralization technologies onto an existing military vehicle with desired mobility and compatibility with Army standard tele-remote system
- Integrate existing lane proofing and marking systems

Applications:

- Mine Clearing Operations on and off route, in Major/Lesser Regional Conflicts (MRC/LRC) and Stability and Support Operations (S&SO)

Mine Hunter/Killer ATD Exit Criteria

Operational Capability	Current Vehicle Mounted Capability		MH/K Minimum Capability		MH/K Goal Capability	
	On-Route	Off-Route	On-Route	Off-Route	On-Route	Off-Route
Mine Detection	None		AT	AT	All	All
Detection Standoff			1 m	1 m	30 m	30 m
Probability of Detect (buried)			0.92	0.92	0.97	0.97
False Alarm Rate (FA/sqm)			0.04	0.16	0.03	0.1
Mine Neutralization			AT	AT	All	All
Neutralization Standoff			1 m	1 m	15 m	15 m
Neutralization Time Per Target			< 60 sec	< 60 sec	< 15 sec	< 15 sec
Probability of Neutralization			0.9	0.9	0.99	0.99
Rate of Advance			0.20 km/h	0.05 km/h	1.00 km/h	0.25 km/h

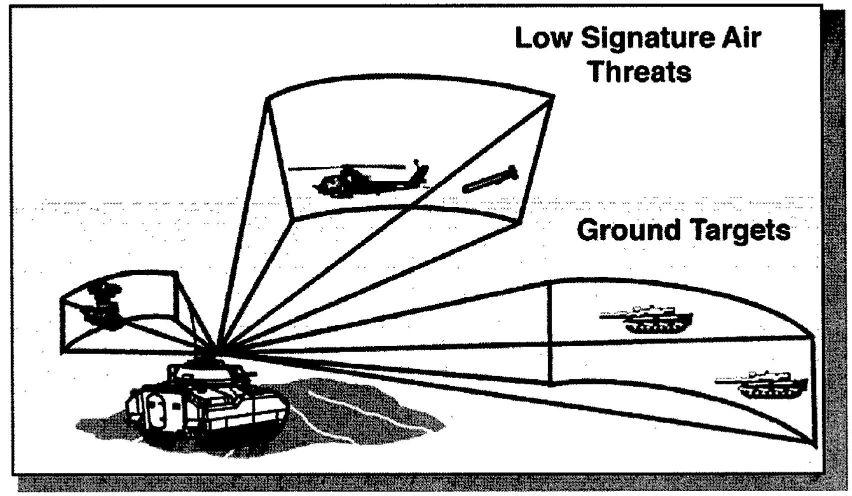
Multifunction Staring Sensor Suite ATD

Objective:

- Demonstrate a Compact, Affordable, Multifunction - Mortar/Sniper Location, Low Signature Air/Ground Detection, Target ID - Staring Sensor Suite for Future Scout Cavalry System EMD and other Ground Vehicle Applications
- Justification:
- TR97-021 Provides Capability to Detect & Identify Active & Passive Targets in All Battlefield Conditions Throughout the Extended, 360 Degree, 3- Dimensional Battlespace
- AR97-004 Improves Capability to Detect & Identify Low Signature Targets Despite the Most Cluttered Battlefield or Sophisticated Foreign Camouflage System
- IN97-660 Provides Overmatching Range Multi-Spectral Target Acquisition and Identification Capability for Infantry Platforms

Battlelab:
- Mounted Maneuver Battlespace
- Dismounted Battlespace

PEO:
- ASM
- IEW



Schedule and Funding:

MILESTONES	FY97	FY98	FY99	FY00	FY01
System Modeling and Simulation					
UNFOV Demonstration					
Component Modeling and System					
Modular Backplane					
Staring FLIR					
Laser/Acoustics					
Sensor Integration					
Mortar/Sniper Fire Location S/W Integration					
Demonstration					
FUNDING: DK70 - $35.2M		6.3	9.7	9.6	9.6

Approach:
- Confirm Sensitivity/Resolution Goals with Modeling, Simulation, and Early Field Tests
- Conduct Early Demonstration of Long Range ID with Ultra-Narrow FOV
- Establish Interfaces with FSCS Baseline
- Develop Modular Sensor Backplane to Accommodate Multiple Sensor Interfaces
- Demonstrate Reconfigurable Sensor with ATR in an Operational Environment
  - –Staring FLIR operating in NIR/MWIR or LWIR Spectrums
  - –Multifunction Laser
  - –Acoustic Cueing Sensors

Application:
- Future Scout Cavalry System (FSCS)
- Future Infantry Vehicle (FIV)
- Future Combat System (FCS)
- Amphibious Assault Vehicles
- Surface Ships

Multifunction Staring Sensor Suite ATD Exit Criteria

OPERATIONAL CAPABILITY	Baseline LRAS3 FLIR	ATD Minimum	ATD Goal
MANUAL			
Ground Target ID (Pid=0.90), ***Manual***			
Tank Target NFOV (1.5°) Ultra-NFOV (0.5°)	1.0 X N/A	1.3 X 2.1 X	1.4 X 2.6 X
Target Detection (Pd=0.70), ***Manual***			
Helo NFOV (1.5°) UAV NFOV (1.5°)	2.7 X* 6.4 X*	3.1 X 7.0 X	3.8 X 8.9 X
AIDED			
Ground Target Det/Recg (Pd/r=0.50), ***Aided***			
Tank Target, NFOV (1.5°), ***MFS3 Stationary***	N/A	2.1 X	2.6 X
Tank Target, NFOV (1.5°), ***MFS3 On-The-Move*** (25 km/hr on Secondary Road)	N/A	1.6 X	2.1 X
Time to Detect (seconds)	N/A	1.5 Y (Initial) / 0.6 Y (Update)	1.0 Y (Initial) / 0.4 Y (Update)
False Alarm Rate	N/A	1.0 Z / FOR	1.0 Z / FOR
Field of Regard (FOR)	None	180° x 9°	360° x 9°

* Capability, No Requirement

Tactical Command and Control Protect ATD

Objective:

- Identify, develop, integrate and demonstrate C^2 protect operational capabilities for deployed information systems (Tactical Internet) and components.
- Develop and leverage HW & SW assessment tools, methods and techniques to identify and quantify the vulnerabilities of the Tactical Internet
- Develop, integrate and demonstrate C^2 Attack operational capabilities against threat tactical information systems and components

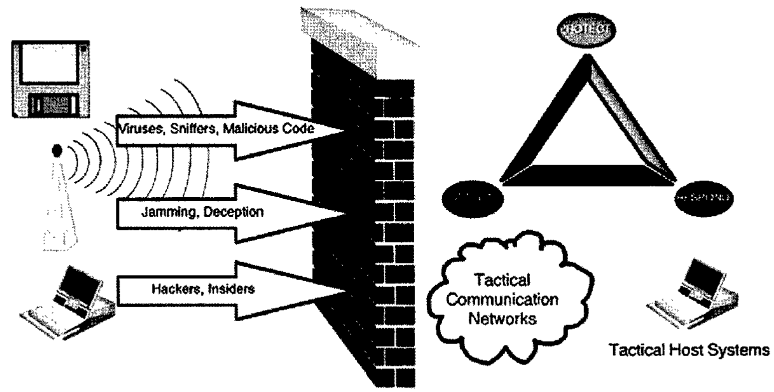
Justification:

- Information Networks are increasingly vulnerable to attack, both unsophisticated hacker and determined foe.

Battlelabs:
BCBL (L), (G), (H)

PEO:
C3S, IEW, STAMIS

Concept:



Schedule/Funding: $K

		STO	ATD				
		FY97	FY98	FY99	FY00	FY01	FY02
Protect	A779	500K	250K	0	0	0	0
	A906	244K	250K	0	0	0	0
	AH92	256K	500K	500K	357K	368K	504K
	D247	700K	0	0	2,990K	2,973K	3,592K
	DK15	0	300K	700K	2,000K	2,000K	0
	A140	0	250K	250K	250K	250K	0
Protect Totals		1,700K	1,550K	1,450K	5,597K	5,591K	4,096K
Attack	DK15	0	100K	400K	2,300K	2,100K	1,200K

Phase I
- TI and MSE Vulnerability Analysis
- Security Solution Investigation
- System Integration
- TI Security Recommendation for TI Force XXI

Phase II Tactical Vulnerability Development
- Initial Assessment Test Cycle
- Security Solution Development
- System Integration
- MSE/ABCS Recommendation
- RF Attack
- Field Demonstration

Phase III
- Advanced Assessment Test Cycle
- Security Solution Development
- System Integration
- SUO to Strategic Seamless Recommendation
- Integrated RF/Network Attack
- Field Demonstration

Approach:

- Assess vulnerabilities of Tactical Internet components and networks through modeling, simulation, and experimentation.
- Develop and leverage IO Protect and Attack methodologies, HW/SW tools, ongoing IW programs and STO developments to identify and quantify vulnerabilities of the Tactical Internet in support of C^2 Protect efforts.
- Conduct risk assessment to prioritize vulnerabilities.
- Engineer, integrate, and validate HW/SW security solutions to the Tactical Internet which address exploitable vulnerabilities.
- Modify and improve current assessment capabilities to target tactical systems and networks.
- Conduct new vulnerability analysis to determine effectiveness of security improvements and assessment capabilities.
- Repeat risk assessment, security solution and assessment improvement, and vulnerability analysis process.
- Provide recommendations to PEO C^3S and PEO IEW.
- Leverage information from interactive testing of protection systems for IO Attack application.
- Demonstrate and Identify engineering strategies for developing unified IW Attack systems

Tactical Command and Control Protect ATD

Technology	Current Capability	Minimum Exit Criteria	Goal Exit Criteria
Intrusion Detection	None	Detection of existing attack signatures 75% of the time. Detection of SA anomalous behavior 75% of the time.	Increase minimum criteria to 90% of the time. Detection of BC anomalous behavoir 75% of the time. Detection of emerging attack signatures 75% of the time.
Network Access Control	Weak Passwords TRANSEC Link Encryption	Generation of random alpha numeric passwords, resistant to basic dictionary attacks 95% of the time. Prevention of unauthorized access to the TI from external network connection 80% of the time.	Increase minimum criteria to 99% of the time. Increase minimum criteria to 99% of the time.
Code Modification	None	Detect unauthorized modification of system software 95% of the time.	Increase minimum criteria to 99% of the time.
Security Tool Integration	NA	Adds <10% additional overhead to existing TI performance.	Lower minimum criteria to <5%.

Tactical Command and Control Protect ATD

Operational Capability	Current Capability	Minimum	Goal
• Capability against tactical systems (OSI model)	Layer Model	Layer Model	Layer Model
• Degradation of Threat System Performance	• R & D	• High Value Targets (HVT)	• HVT
Decrease Detectability	• Detectable	• Less than ____ Detectable	• Less than ____ Detectable
Locate and Identify C2 Nodes	• Limited LOS	Same as Goal	Extended LOS
• Attack C2 Nodes	• Signal Type	• Signal Type	• Signal Type

Multimission/Common Module UAV Sensors ATD

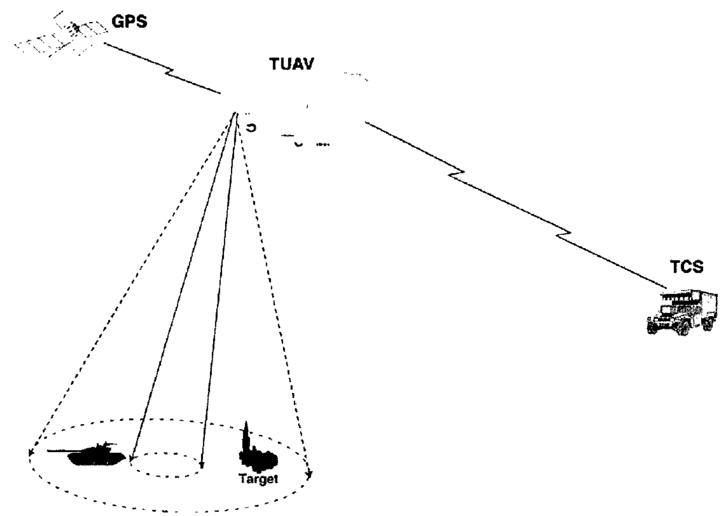
OBJECTIVE:

- Develop and demonstrate an adverse weather, low cost, lightweight modular sensor payloads for integration on Tactical UAVs.
- Demonstrate enhanced reconnaissance, surveillance, battle damage assessment, and targeting of moving and stationary non-line of sight weapons.
- The common modular approach will operate with DARO's Tactical Common Data Link (TCDL) to deliver IMINT products to Army TOC.

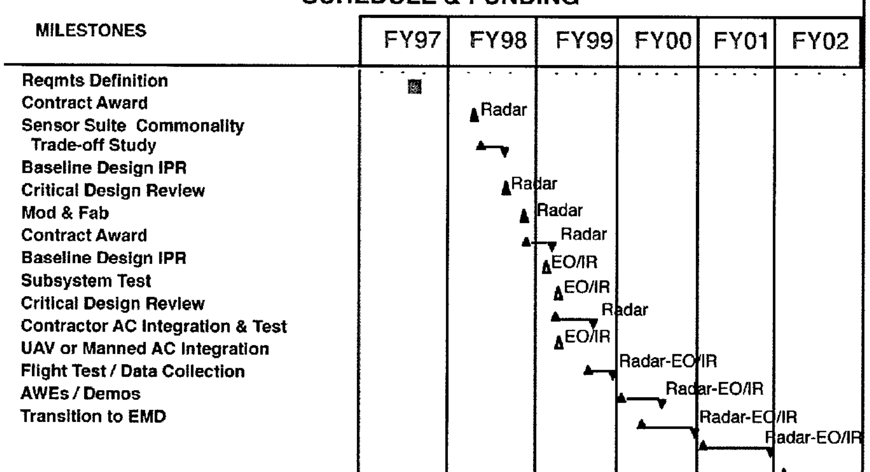
JUSTIFICATION:

- TR 97-021 Real Time Target Acquisition, Identification and Dissemination: Platform and sensor suite that is capable of detecting, locating, and identifying high-priority enemy threats, both stationary and moving, at various battlefield depths under adverse weather conditions.

Battlelab:	PEO:
• BC BL	• IEW
• D&SA BL	• JPO UAV



SCHEDULE & FUNDING



Funding ($k)		FY97	FY98	FY99	FY00	FY01	FY02
D243		~~939~~	~~3863~~	~~5762~~	~~6686~~	~~2398~~	
	SAR/MTI	939	3423	4162	4160	2398	
	FOPEN	0	440	1600	2526	2040	
DK86	EO/IR			3204	4890		

Approach:

- Assess Technology Status Versus Multiple Mission Requirements in Support of Deep Attack Forces .
- Develop lightweight SAR/MTI radar, improved EO/IR sensors
- Develop Enhanced Sensor Correlation Algorithms to Improve Target Detection & Recognition Performance.
- Integrate Sensors into Tactical UAV and Evaluate in rapid counter strike scenarios.
- Leverage DARPA's FOPEN for integration and field evaluation data.

Application:

- Tactical UAV
- Stand-Off Mine Detection
- Aerial Common Sensor

Multimission/Common Module UAV Sensors ATD Exit Criteria

- **Approved Exit Criteria**

OPERATIONAL CAPABILITY	BASELINE	ATD MINIMUM	ATD GOALS
E.O. Payload	FLIR/TV	FLIR/LS/TV	FLIR/LS/TV/Laser
- FPA Technology	PtSI	InSb	High Res InSb
- Range (90%)	2.0km	4.0km	6.0km
- Target Location Accuracy	N/A	80m	50m
- Spectral Modes	N/A	none	Multi-spectral
Radar Payload	N/A	SAR/MTI	SAR/MTI
- Range (SAR / MTI)	N/A	3-7km / none	3-10km / 3-14km
- Resolution (SAR)	N/A	0.3 / 1.0m spot	0.3 / 1.0m strip
- P_d / P_{fa} (MTI)	N/A	N/A	0.75 / 2 per min
- Target Location Accuracy (SAR/MTI)	N/A	75m / none	50m / 100m
Weather Conditions	Day/Night	Day/Night/Adverse	Day/Night/Adverse
Weight:			
- SAR / MTI	N/A	80 lbs	60 lbs
- EO/IR	35 lbs	50 lbs	35 lbs

Multimission/Common Module UAV Sensors ATD Exit Criteria

- **Approved Exit Criteria**

OPERATIONAL CAPABILITY	BASELINE	ATD MINIMUM	ATD GOALS
Area Coverage Rate			
- SAR : spot	N/A	100 spots/hr	225 spots/hr
- MTI	N/A	N/A	1200 km^2/hr
- FLIR: stare (90% Pd/Pr)	12 km^2/hr	86 km^2/hr	173 km^2/hr
spot (0.3m/1.0m)	N/A	(120 / 450) spots/hr	(240 / 900) spots/hr
strip	N/A	300 km^2/hr	400 km^2/hr
Payload Cost:			
- SAR / MTI	N/A	$475K	$350K
- FLIR	$120K	$180K	$120K
Payload Exchange Time			
- Radar/FLIR	N/A	60 min	30 min

ANNEX C

INTERACTION WITH TRADOC

CONTENTS

ANNEX C

INTERACTION WITH TRADOC

A. INTRODUCTION

Battle laboratories were created in response to the factors and implications of a changing world, strategy, budgetary reality, and a need for a new way of doing business. Battle laboratories have quickly demonstrated their values as places where new concepts and technologies can be investigated for their implications on the battlefield in the areas where warfighting appears to be changing most dramatically.

Following are the future operational capabilities (FOCs) developed by the Training and Doctrine Command (TRADOC) combat developers. The combat development community included participants from all TRADOC schools, battle laboratories, the Army Materiel Command, Army Corps of Engineers, and the TRADOC Deputy Chief of Staff, Training and Space Operations. Identified in this annex are the TRADOC integrated FOCs, branch FOCs, and branch-specific FOCs.

This annex describes the FOC requirements generated by the Army's combat developers and their identifiers.

FOCs are statements of operational capabilities required by the Army to develop the warfighting concepts (TRADOC Pamphlet (T.P.) 525 series) approved by commander, TRADOC. FOCs address specific warfighting capabilities not functions or operations. They describe those capabilities in operational terms and what must be done—not how to do it. The FOCs provide a standalone description of the capability. FOCs are enduring, they apply to tomorrow's Army, but may be equally relevant to today's or yesterday's Army.

FOCs do not describe a deficiency or shortcoming. They do not provide or identify a system specification, specific technology, organization, or timeframe and they do not encompass an entire branch or functional concept. FOCs do not use relational or comparative words or phrases.

Applications include:

- FOCs articulate required and desired capabilities that form the basis for determining warfighting requirements in doctrine, training, leader development, organizations, materiel, and soldier support systems. FOCs will form the basis for conducting experimentation to define and refine requirements. FOCs state desired capabilities across the full dimension of operations.

- FOCs are used to focus organizational and functional structure changes through the force design update process as the Army changes its organization to meet national military strategy guidance.

- FOCs are employed in the TRADOC science and technology (S&T) reviews as the yardstick for assessing the relevance of individual science and technology efforts. FOCs guide the Army's S&T investment.

- Materiel developers and industry use FOCs as a reference to guide independent research and development (R&D) and to facilitate horizontal technology integration.
- Perceptions of shortfalls derived from S&T reviews generate dialogue with the materiel developers to confirm or resolve the perceived shortfalls. Confirmed shortfalls are to be considered in budgetary, planning, and programming reviews by the materiel developer. Shortfalls that exceed Army resource capabilities can be identified to industry to permit discretionary industry investments in needed areas.
- FOCs are used within the *Army Science and Technology Master Plan* (ASTMP) process to provide a warfighting focus to technology-based funding.
- FOCs are employed in the Army Science and Technology Objectives (STOs) process as the measure of warfighting merit. Candidate efforts selected as Army STOs within this process are published in the ASTMP as the most important S&T objectives for the Army R&D community. The STO review provides the basis for the construct of Advanced Technology Demonstrations (ATDs). Army STOs receive senior Army leadership oversight and have priority for resourcing.
- ATDs address selected high priority FOCs and demonstrate a capability that does not currently exist. ATDs are resource intensive and provide the medium to conduct troop interaction with mature technologies. The ATD demonstration plan is jointly developed between TRADOC and the materiel developer with exit criteria established to execute the ATD. ATD management plans are briefed to a council of colonels and approved at the Army Science and Technology Workgroup.
- FOCs are used as a yardstick to assess the relevance of Advanced Concepts and Technology II (ACT II) broad agency announcement (BAA) topics and industry proposals to address these topics. The government determines which proposals will be funded. The government determines whether the technology offers a useful capability and, if so, how best to exploit it.
- All warfighting requirements must have linkage through an FOC to an approved branch, operational, or functional concept supporting the overarching concept and the TRADOC commander's vision.
- FOCs may be updated at anytime given identification of new needs or opportunities for new capabilities.
- At a minimum, T.P. 525–66 will be reviewed, updated, and published annually.
- The elements to be reviewed and considered for updating the FOCs include:
  - TRADOC approved concepts
  - Operational lessons learned, including Center for Army Lessons Learned documents
  - Commander in Chief integrated priority lists
  - Opportunities from technology. TRADOC proponents will accrue awareness of opportunities from interaction with the S&T community throughout the year. The intent of TRADOC proponents' interaction with technology should focus on understanding the potential battlefield capability benefits. In many cases, it will be the TRADOC proponent personnel's operational knowledge of warfighting that may see applications otherwise unforeseen by the materiel developers.

  - It is incumbent upon both the combat developer and materiel developer personnel to generate ideas of potential capability from the nexus of technology opportunity and warfighting operational concepts.

The following annual FOC review cycle is recommended:

- *Year Round*—Combat developers accumulate inputs for FOC updates from sources listed above.
- *Summer/Fall*—Conduct internal FOC review.
- *November*—Combat developers publish draft update of FOCs and submit to Battle Laboratory Integration, Technology, and Concepts Directorate (BLITCD). BLITCD will disseminate draft FOCs to the other combat and materiel developers to solicit comments and additional information. Combat developers will review the draft FOC submissions for validity, overlap, duplication, omission, and potential for integration.
- *December*—Combat developers publish revised updated FOCs, incorporating appropriate field input.
- *December*—Headquarters (HQ) TRADOC, BLITCD conduct FOC integration workshop to exchange information and consolidate similar FOCs as may be appropriate.
- *January*—HQ TRADOC task TRADOC schools and battle laboratories to review FOCs for commandant concurrence/comments.
- *February*—HQ TRADOC BLITCD consolidate input from the combat developers.
- *March*—HQ TRADOC submit final draft FOCs to the commanding general of TRADOC for approval.
- *May*—Approved T.P. 525–66, FOCs published, distributed, and submitted as input to ASTMP.
- *January–May*—Application of FOCs to TRADOC S&T review, Army STO review process, ACT II BAAs, concept experimentation program, and battle laboratories interactions with industry.

The combat developers will prepare FOCs for submission and inclusion in T.P. 525–66. FOCs will be formatted as outlined below. The four components of an FOC are identifier, title, description, and reference:

- *Identifier*—All FOCs will use an identifier that will consist of the combat developer's designator, a two-digit year of development and the three-digit sequential numeric capability designator, (i.e. Battle Command (Gordon)—BCG 97–001).
- *Title*—The title of the FOC will describe a prevailing capability (e.g., missile warning, medical evacuation, logistics survivability) required to implement the warfighting concept from which it was derived.
- *Description*—The description will state a required capability in operational terms (capability to . . .). The FOC will state what capability is needed, why the capability is needed, and the benefits expected from achieving this capability. The FOC will be a prevailing operational capability. Prevailing operational capabilities are those relevant capabilities that have endured over time and will still be relevant in the foreseeable future (e.g., logistics support battlefield visualization, direct/indirect fires, battlefield communications). The FOC will not identify a solution to the desired capability.

- *Reference*—The combat developer will reference the concept document (525 series) from which the FOC is derived. This will identify the linkage between the FOC and the specific concept or draft concept (for initial FOC preparation) it was written to support.

B. INTEGRATED FUTURE OPERATIONAL CAPABILITIES

The TRADOC integrated FOC are those FOCs that apply to more than one TRADOC proponent. They are integrated to provide the materiel developer with a sense of what common capabilities are needed across the force as a whole. The FOCs will be reviewed and updated annually.

1. Command and Control

TR 97–001, Command and Control (C^2). Capability for commanders to have the freedom of moving around the battlespace to locations where they can best influence the battle at the critical time and place. Capability to link all battlespace elements from the individual soldier through the national command authority in real time. Capability to electronically partition data and hand off relevant data to the appropriate user. Capability to continuously plan, communicate intent, issue orders, monitor, and coordinate operations, including joint and coalition operations. Capability must support battle command functions wherever the commander is located. Capability must be small, lightweight, transportable, multimedia capable, and facilitate rapid movement and emplacement. Capability must be mobile and transportable yet ensure that designs and human engineering are adequate to house and support battle command personnel and systems for continuous operations (i.e., adequate space, power, internal communications).

Branch FOCs: AD 97–004; AR 97–006, AR 97–007, AR 97–014; AV 97–011, AV 97–012; BCL 97–002, BCL 97–004, BCL 97–005, BCL 97–006, BCL 97–008; CM 97–001, CM 97–004, CM 97–008; EEL 97–024 EEL 97–025; EN 97–005, EN 97–006; FA 97–006, FA 97–009, FA 97–010, FA 97–013, FA 97–015, FA 97–024, FA 97–035, FA 97–036; DSA 97–007, DSA 97–016, DSA 97–017, DSA 97–022, DSA 97–025, DSA 97–027; IN 97–500, IN 97–510, IN 97–520, IN 97–530; MD 97–002; MI 97–005; MMB 97–017; MSB 97–003; MP 97–003; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–006, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–019, SP 97–020.

References: T.P. 525–5; T.P. 525–70; T.P. 525–75; TRADOC Black Book No. 4.

TR 97–002, Situational Awareness. Capability to create an accurate and high-fidelity, all-weather, common collaborative real-time picture of the battlespace to include weather, terrain, environment, and friendly/enemy/neutral/noncombatant situational and status information. The common picture must be continuous and selectable from the common air, stationary, or on-the-move (OTM) ground platforms, air defense, naval, space, and wargaming sources depending on the needs of the viewer. The common picture provides understanding of available information in terms of the battlespace—width, depth, height, position, time, terrain, materiel, weather, obstacles and barriers, early warning of nuclear, biological, and chemical (NBC)/theater ballistic missile hazards, electromagnetic, and human. The relevant common picture must be scaleable to appropriate levels of command, tailorable by function and personal preference, and based on variable user defined parameters. To effectively use the common picture at various echelons, there must be a capability to electronically partition data and to hand off relevant data to the appropriate user. The common picture must be based on standardized decision-oriented graphics. These standardized graphics must be shared with and include joint and coalition forces, and must be portrayed over a common, relevant, tailored, and accurate terrain picture. Achievement of this capability is key to battlefield visualization by conveying to the warfighter an immediate understanding of the operational impact of the current and projected situation and provide predictive information, impacting enhanced survivability, facilitating synchronization of fires, maneuver, and logistics/personnel supportability and accountability in order to achieve maneuver dominance and influence battle tempo.

Branch FOCs: AD 97–004; AR 97–006; AV 97–002, AV 97–004, AV 97–011, AV 97–012; BCL 97–004; CH 97–008; CM 97–001, CM 97–002, CM 97–008, CM 97–009; DBS 97–065; DSA 97–004, DSA 97–005, DSA 97–006, DSA 97–007, DSA 97–008, DSA 97–009, DSA 97–010, DSA 97–011, DSA 97–012, DSA 97–013, DSA 97–014, DSA 97–015, DSA 97–016, DSA 97–020, DSA 97–021, DSA 97–022, DSA 97–025; EN 97–003, EN 97–004, EN 97–006, EN 97–007, EN 97–009, EN 97–011; EEL 97–011; FA 97–005, FA 97–006, FA 97–007, FA 97–008, FA 97–009, FA 97–010, FA 97–013, FA 97–020, FA 97–022, FA 97–023, FA 97–024, FA 97–035, FA 97–036; IS 97–001, IS 97–002, IS 97–003; MD 97–001, MD 97–002, MD 97–005; MMB 97–018, MMB 97–019; BCL 97–001; MI 97–005, 6; MMB 97–012, MMB 97–017; MSB 97–003, MSB 97–004, MSB 97–007; MP 97–006, MP 97–007; MSB 97–012, MSB 97–014; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–006, SP 97–007, SP 97–009, SP 97–011, SP 97–012, SP 97–013, SP 97–015, SP 97–016, SP 97–017, SP 97–020.

References: T.P. 525–5; T.P. 525–70; T.P. 525–71: T.P. 525–75; TRADOC Black Book No. 4.

TR 97–003, Mission Planning and Rehearsal. Capability of the warfighter to conduct rapid mission planning, preparation, and execution. Decision making and operations planning requires knowledge based capabilities and decision aids to improve quality and reduce decision making time. Decision making must take advantage of real-time information available on seamless information networks to plan and rehearse operations. Embedded training and simulation tools must be incorporated into decision support software for training, mission rehearsal, and other tasks that are critical either because of the complexity of the task or the time sensitivity of the results. Capability must operate OTM and under all conditions. Decision aids are required to facilitate in-depth, timely analysis of information, forecasting, and support "wargaming" efforts.

Branch FOCs: AD 97–005; AR 97–013; AV 97–003; BCL 97–001, BCL 97–003, BCL 97–010, BCL 97–016, BCL 97–017, BCL 97–019, BCL 97–020; CH 97–011; CM 97–001, CM 97–008; DSA 97–001, DSA 97–002, DSA 97–007, DSA 97–013, DSA 97–014, DSA 97–022, DSA 97–027; EEL 97–021, EEL 97–022; EN 97–003, EN 97–004, EN 97–005, EN 97–006, EN 97–007, EN 97–008, EN 97–009, EN 97–010, EN 97–011, EN 97–016, EN 97–017, EN 97–018, EN 97–030; FA 97–007, FA 97–008, FA 97–009, FA 97–015, FA 97–023, FA 97–035, FA 97–036; IN 97–520, IN 97–700; MSB 97–003, MSB 97–007, MSB 97–012, MSB 97–014; MI 97–001, MI 97–002; MP 97–003, OD 97–003; MMB 97–018, MMB 97–20; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–007, SP 97–010, SP 97–011, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–020; TRD 96–002, TRD 96–004, TRD 96–005, TRD 96–006, TRD 96–012.

References: T.P. 525–5; T.P. 525–60; T.P. 525–70, T.P. 525–75; TRADOC Black Book No. 4.

TR 97–004, Tactical Operation Center (TOC) Command Post (CP). TOC and CP facilitate the commander and his staffs with capabilities to maintain situational awareness and to control/dominate the battlespace/mission tempo. Provides deployable, transportable, modular, reconfigurable, highly survivable, and highly mobile CPs that function equally well when stationary, en route, or OTM, in all environments to include battlefield clutter. Must support simultaneous operation of diverse information systems and be quickly reconfigurable to support various combinations of automated systems and staff functions, to include mission planning, rehearsal, and execution, ensuring maximized signature reduction. Facilitates real-time, robust, long-range, seamless connectivity to all space, air, ground, surface, and submersible information systems and subsystems as applicable to mission requirements. Provides commander and staff with the ability to perform C^2 from remote sites.

Branch FOCs: AD 97–006; AR 97–007; AV 97–011; BCL 97–010, BCG 97–001, BCG 97–004, BCG 97–005; CM 97–001; CM 97–004, CM 97–008; DBS 97–050, DBS 97–053; DSA 97–015, DSA 97–019, DSA 97–027; EEL 97–017, EEL 97–021, EEL 97–022, EEL 97–024; FA 97–009, FA 97–012, FA 97–014, FA 97–022, FA 97–025, FA 97–036; MI 97–005, MI 97–006, MI 97–007, MI 97–008; MMB 97–017; SP 97–001, SP 97–002, SP 97–005, SP 97–009, SP 97–010, SP 97–011, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–018, SP 97–020.

Reference: T.P. 525–75.

TR 97–005, Airspace Management. Capability to effectively manage, in real time, multiple users of airspace thus minimizing conflicts and maximizing the overall successful mission accomplishment rate. This requires close integration between C^2, Army Airspace C^2, Army aviation, air defense, artillery, military intelligence, aeromedical support, special operations, airborne and infantry operations, mounted ground operations, sister service and coalition members operations, and possibly civilian airspace management agencies. Also requires communication and automation capability that is compatible with these organizations and that is compliant with the Army Battle Command System/ Common Operating Environment equipment and with required standards. The system must be capable of rapid deployment, must be operational while mobile, and must maintain flexibility in response to an ever-changing operational situation. The system must have a real-time air picture and real-time communications with all airspace-user elements. The system must be able to electronically translate raw airspace data into a useable three-dimensional (3D) fused real-time airspace picture and direct two-way interface into the Contingency Theater Automated Planning System for Army airspace users requiring near-real-time deconfliction or situational awareness of air assets. In addition to analog and digital communication, the system should support an automated capability to collect, display, and disseminate airspace control measures to all airspace users. Data communication must interface with and facilitate sensor to shooter linkage systems for air defense and field artillery platforms. The airspace management system must comply with Federal Aviation Administration requirements for peacetime United States operations, and be compatible with all other airspace C^2 systems, including existing joint, multinational and host nation airspace management requirements during joint or coalition exercises outside the United States.

Branch FOCs: AD 97–004, AD 97–006; AV 97–001, AV 97–003, AV 97–012; DSA 97–015; FA 97–010; MD 97–001.

References: T.P. 525–5; T.P. 525–72; TRADOC Black Book No. 4.

TR 97–006, Combat Identification. Capability to detect, discriminate, identify through active, noncooperative methods, and prioritize both ground and aerial platforms at ranges in excess of the threat's detection and weapon systems effective ranges and inside the threat's detection and response time. The capability must be effective day or night in adverse weather, in cluttered background environments, and in the presence of threat countermeasures. The capability must provide real time, accurate target location information.

Branch FOCs: AD 97–006; AR 97–004, AR 97–010; AV 97–005; DSA 97–005, DSA 97–010, DSA 97–011, DSA 97–021, DSA 97–024, DSA 97–025, DSA 97–028; FA 97–004, FA 97–013; MI 97–003; MP 97–006; MMB 97–015; SP 97–001, SP 97–002, SP 97–003, SP 97–009, SP 97–010, SP 97–011, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–020.

References: T.P. 525–5; T.P. 525–75.

2. Communication

TR 97–007, Battlefield Information Passage. Capability for a highly employable seamless, secure, global information architecture that is dynamic, self-organizing, self-healing, which is modular, and is reconfigurable for use by airborne, light, and heavy forces. This architecture will provide a capability for total, uninterrupted, interoperable data networking of secure and nonsecure data, voice, imagery, and video transfer in real time, near-real time, and non-real time between government, nongovernment, and military health services systems assets agencies; combined arms; tactical and strategic forces; and joint, combined, and coalition forces throughout the battlespace from the National Command Authority to operator level. Included are information transfer over all phases (alert to redeploy), ranges (contingency operations to high intensity conflict), and levels (tactical, operational, and strategic) of operations with acceptable levels of throughput, capacity, information quality, grade of service, security, and precedence in austere environments with minimum sustainment requirements. Also included is the ability to track data lineage, and synchronize data updates from multiple sources. The architecture will be compatible with the joint technical architecture and common operating environment.

Branch FOCs: AD 97–004, AD 97–006, AD 97–011; AR 97–001, AR 97–003, AR 97–004, AR 97–006, AR 97–007, AR 97–010, AR 97–012; AV 97–001, AV 97–003, AV 97–011, AV 97–012; BCG 97–001, BCG 97–002, BCG 97–003, BCG 97–005, BCG 97–006, BCG 97–007; BCL 97–002, BCL 97–004, BCL 97–005, BCL 97–007; CH 97–001, CH 97–002, CH 97–004, CH 97–005, CH 97–008, CH 97–011; CS 97–004; CM 97–001, CM 97–002, CM 97–008, CM 97–009; DSA 97–07, DSA 97–008, DSA 97–012, DSA 97–014, DSA 97–016, DSA 97–017, DSA 97–021, DSA 97–025; EEL 97–011, EEL 97–017, EEL 97–024 EEL 97–025; EN 97–002, EN 97–005, EN 97–007, EN 97–011, EN 97–018; FA 97–005, FA 97–006, FA 97–007, FA 97–008, FA 97–009, FA 97–010, FA 97–011, FA 97–012, FA 97–013, FA 97–015, FA 97–019, FA 97–021, FA 97–022, FA 97–023, FA 97–024, FA 97–025, FA 97–026, FA 97–029, FA 97–030, FA 97–035, FA 97–036; FI 97–001, FI 97–002, FI 97–003, FI 97–004, FI 97–005, FI 97–006, FI 97–007, FI 97–008; IS 97–001, IS 97–002, IS 97–004, IS 97–005; MD 97–001, MD 97–002, MD 97–003, MD 97–005, MD 97–006, MD 97–008; MI 97–005; MMB 97–017, MMB 97–018, MMB 97–019; MP 97–003, MP 97–004; MSB 97–003; SP 97–001.

References: T.P. 525–71; T.P. 525–75.

TR 97–008, Power Projection and Sustaining Base Operations. Capability to support future operations with selected elements that have not deployed from homestation, or operate strictly out of a rear base or sanctuary areas. Capability to support split-based/force projection operations that must be deployable, robust, assured, and provide a seamless state-of-the-art command, control, communications, computers, and intelligence (C^4I) across the operational continuum (including joint and combined forces) on a continuous basis. Capability to transfer information within the architecture without requiring specific knowledge of the mechanism or platform characteristics that make up the automatic systems and communications. For example, the warfighter will have the capability to use the same telephone and computer in garrison and in any tactical environment. Capability to provide standardized access for deployed forces to strategic infrastructure services such as the distributed interactive simulation network, NIPRNET, and SIPRNET.

Branch FOCs: AD 97–004; BCG 97–001, BCG 97–006; BCL 97–009; CH 97–011; CM 97–004; CS 97–004; DSA 97–008, DSA 97–016; EEL 97–014, EEL 97–017; EN 97–002, EN 97–005; FA 97–011, FA 97–019, FA 97–021, FA 97–025, FA 97–026; FI 97–001, FI 97–002, FI 97–007, FI 97–008; IS 97–001, IS 97–002, IS 97–003, IS 97–004, IS 97–005; MD 97–002; MP 97–004; SP 97–001, SP 97–002, SP 97–003,

SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–011, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–018, SP 97–019.

Reference: Terrain Visualization Master Plan.

TR 97–009, Communications Transport Systems. Capability for a combination of communications transport systems that provide high capacity and throughput to efficiently and effectively support simultaneous real-time voice, data, imagery, video transfer, video conference, and personal communication services at all levels of security. These systems must be integrated into the global, seamless communications architecture.

Branch FOCs: AR 97–004, AR 97–006, AR 97–007, AR 97–012, AR 97–013, AR 97–014; AV 97–001, AV 97–011, AV 97–012; BCG 97–001, BCG 97–002, BCG 97–005, BCG 97–007; CH 97–001, CH 97–003, CH 97–008; CM 97–001, CM 97–002, CM 97–008, CM 97–009; CS 97–004; DSA 97–007, DSA 97–008, DSA 97–012, DSA 97–014, DSA 97–016, DSA 97–017, DSA 97–021, DSA 97–025; EEL 97–024, EEL 97–025; EN 97–002, EN 97– 005; FA 97–023, FA 97–024, FA 97–029, FA 97–030, FA 97–036; FI 97–001, FI 97–002, FI 97–004, FI 97–007, FI 97–008; IS 97–001, IS 97–002, IS 97–003, IS 97–004, IS 97–005; MD 97–001, MD 97–002, MD 97–003, MD 97–005, MD 97–006, MD 97–008; MI 97–005; MMB 97–017; MI 97–015; MP 97–004; SP 97–001, SP 97–005, SP 97–006, SP 97–007, SP 97–009, SP 97–010, SP 97–012, SP 97–017, SP 97–019.

References: FM 100–6; T.P. 525–75, paragraphs 3–3d and 4–5d.

TR 97–010, Tactical Communications. Capability to extend simultaneous data, voice, image, and video transfer systems to the soldier/platform with acceptable levels of throughput, range, capacity, information quality, grade of service, security, and precedence in real or near real time. These systems will be multichanneled and will be interoperable with joint, combined, and coalition forces and provide a broad array and distribution in austere environments. Also required is a capability to provide uninterruptible, continual, real time sensor to shooter communication.

Branch FOCs: AD 97–004, AD 97–006; AR 97–001, AR 97–002, AR 97–003, AR 97–004, AR 97–006, AR 97–07, AR 97–012, AR 97–013, AR 97–014; AV 97–001, AV 97–011, AV 97–012; BCG 97–001, BCG 97–002, BCG 97–005, BCG 97–007; BCL 97–002, BCL 97–007; CH 97–008; CM 97–001, CM 97–002, CM 97–008, CM 97–009; CS 97–004; DSA 97–007, DSA 97–008, DSA 97–012, DSA 97–014, DSA 97–016, DSA 97–017, DSA 97–021, DSA 97–025; EEL 97–023, EEL 97–024, EEL 97–025; EN 97–002, EN 97–005; FA 97–005, FA 97–006, FA 97–007, FA 97–008, FA 97–009, FA 97–010, FA 97–012, FA 97–013, FA 97–015, FA 97–019, FA 97–022, FA 97–023, FA 97–024, FA 97–025, FA 97–035, FA 97–036; FI 97–001, FI 97–002, FI 97–008; IS97–001, IS 97–002, IS 97–003, IS 97–004, IS 97–005; MD 97–002; MI 97–005; MMB 97–017; MP 97–004; MSB 97–003; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–011, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–018.

References: FM 100–6, T.P. 525–75.

TR 97–011, Information Services. Capability for seamless global information services that include data warehousing, televideoconferencing, multilevel security, and seamless messaging. Capability to verify data integrity, verify/authenticate the originator of a transaction, provide proof of participation of both sender and receiver of a transaction, ensure the availability of services to authorized users, and provide an optional data encryption capability.

Branch FOCs: AR 97–002, AR 97–003, AR 97–007; AV 97–001, AV 97–011, AV 97–012; BCG 97–001; BCL 97–013; CH 97–002, CH 97–005; CM 97–001, CM 97–002, CM 97–008, CM 97–009; CS 97–004;

DSA 97–007, DSA 97–008, DSA 97–012, DSA 97–014; EN 97–002, EN 97–005; FA 97–005, FA 97–022, FA 97–023, FA 97–024, FA 97–036; FI 97–004, FI 97–008; IS 97–001, IS 97–002, IS 97–003, IS 97–004, IS 97–005; MD 97–002; MI 97–004, MI 97–005; MP 97–003; SP 97–006, SP 97–008, SP 97–009.

Reference: T.P. 525–75.

TR 97–012, Information Systems. Capability to supply the warfighter with key decision making information in a time sensitive manner, real- or near-real time. This capability involves acquiring, integrating, and synchronizing information from vertical and horizontal C^2 systems; sensor systems; and battlefield functional area systems. This encompasses strategic, operational, tactical, and joint operations. The resulting "system-of-systems" provides the warfighter with a force multiplier in battle command, common picture, target acquisition, lethality / survivability, logistics, operations planning, and joint interoperability. The information systems must be scaleable, and the platforms capable of hosting multiple information system applications. The information systems must be compatible with the Defense Information Infrastructure Common Operating Environment.

Branch FOCs: AD 97–004, AD 97–011; AR 97–001, AR 97–002, AR 97–003, AR 97–004, AR 97–006, AR 97–007, AR 97–012, AR 97–013, AR 97–014; AV 97–001, AV 97–011, AV 97–012; BCL 97–001, BCL 97–002, BCL 97–005; CH 97–001, CH 97–002, CH 97–004; CM 97–001, CM 97–002, CM 97–008, CM 97–009; CS 97–004; DSA 97–007, DSA 97–008, DSA 97–012, DSA 97–014, DSA 97–016, DSA 97–017, DSA 97–021, DSA 97–025; EEL 97–023, EEL 97–024, EEL 97–025; EN 97–002, EN 97–003, EN 97–005, EN 97–006, EN 97–007, EN 97–008, EN 97–010, EN 97–011, EN 97–018, EN 97–030; FA 97–005, FA 97–022, FA 97–023, FA 97–024, FA 97–036; FI 97–001, FI 97–002, FI 97–004, FI 97–008; IS 97–001, IS 97–002, IS 97–003, IS 97–004, IS 97–005; MD 97–002; MI 97–005; MP 97–004; MSB 97–014; SP 97–001, SP 97–002, SP 97–003, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–011, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017.

Reference: T.P. 525–75.

TR 97–013, Network Management. Capability to maximize the availability of communication networks and data distribution systems to all echelons. This includes the following management functions: (1) network planning and engineering, which includes the automated and interactive placement of network resources against subscriber requirements, terrain conditions, tactical restrictions, and communications security requirements; (2) battlefield spectrum management, which includes the ability to perform frequency assignments that eliminate adverse collateral effects of cosite and adjacent frequency, and maximizes spectral efficiency and the effective utilization and allocation of bandwidth including bandwidth on demand when appropriate; (3) wide area network management, which is a capability to monitor and maintain communication services including fault, performance, and near real time reconfiguration management; and (4) communications security.

Branch FOCs: AR 97–001, AR 97–002, AR 97–003, AR 97–004, AR 97–006, AR 97–007, AR 97–012, AR 97–013, AR 97–014; AV 97–001, AV 97–011, AV 97–012; BCG 97–003; CS 97–004; DSA 97–008, DSA 97–012, DSA 97–016, DSA 97–017; FA 97–006, FA 97–013, FA 97–025, FA 97–036; FI 97–001, FI 97–002, FI 97–005, FI 97–006, FI 97–007; IS 97–001, IS 97–002, IS 97–003, IS 97–004, IS 97–005; MD 97–002; MI 97–005; MP 97–003, MP 97–004; SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–012, SP 97–017, SP 97–018, SP 97–019.

Reference: T.P. 525–75.

TR 97–014, Hands-Free Equipment Operation. Capability to operate and control equipment hands-free while stationary or OTM. This capability must exist in noisy, unstable, and stressful conditions. These capabilities are required to facilitate operation by minimizing operator interface requirements.

Branch FOCs: AD 97–005; AV 97–002, AV 97–004, AV 97–009, AV 97–011; BCG 97–04; BCL 97–003; CH 97–001; DSA 97–022; EEL 97–024; EN 97–009, EN 97–018; FA 97–012.

3. Information Management

TR 97–015, Common Terrain Portrayal. Capability allowing commanders to rapidly and accurately visualize friendly and enemy battlespace conditions and situations, command directives, and other essential information in continuous real- or near-real-time displays, and provide a common background for simulations, training, mission planning, rehearsals, and commander's decision aids. The capability includes the ability to conduct rapid assessments of accessible terrain, line of sight relationships, trafficability, and obstacle planning. The capability provides information as scaleable integrated digital projections, or tactical decision aid products. This capability, when integrated with weather, position location, environmental and situational updates, provides a common portrayal of the physical characteristics of the battlespace. This capability is an essential element of battlefield visualization and the portrayal of synthetic scenes and dynamic environmental effects in simulations.

Branch FOCs: AR 97–006; AR 97–002, AR 97–013, AR 97–014; AV 97–011; CM 97–001, CM 97–002, CM 97–008, CM 97–009; DBS 97–033; DSA 97–006, DSA 97–020; EEL 97–021, EEL 97–022; EN 97–03, EN 97–030; FA 97–005, FA 97–006, FA 97–023; MI 97–006; MP 97–007; MMB 97–018; MSB 97–007; SP 97–001, SP 97–002, SP 97–004, SP 97–007, SP 97–009, SP 97–010, SP 97–014, SP 97–015, SP 97–016, SP 97–017.

References: T.P. 525–5; T.P. 525–41; T.P. 525–75; *Joint Vision 2010.*

TR 97–016, Information Analysis. The Army requires the capability for common systems at all echelons to provide rapid analysis, processing, collaboration, understanding, and throughput of information from all sources (air, ground, sea, space) within compressed decision timelines. Fusion and aggregation must occur between bottom-up and top-down feeds. Information must be rapidly retrievable or accessible in an internet, nonhierarchical environment at all echelons by appropriate users requesting the data. High capacity data storage and data retrieval are required to facilitate seamless, real-time information exchange across joint, national, coalition forces, and intra-/intervehicular/platform exchange. Require means to tailor information (mission, enemy, troops, terrain, and time) to meet individual needs. Ability to process OTM is required thus mandating reduced processor size and weight. Processing capability must be accurate, timely, and enhance operator efficiency. Capability to work at various classification levels (multilevel security) is required. Achieving this capability will permit the processing environment to rapidly and dynamically assimilate information to satisfy multiple battlefield functions.

Branch FOCs: AD 97–004; AR 97–001, AR 97–003, AR 97–004, AR 97–006, AR 97–007, AR 97–010, AR 97–011, AR 97–014; AV 97–004, AV 97–012; BCG 97–008; BCL 97–003, BCL 97–004, BCL 97–010; CM 97–001, CM 97–004, CM 97–007, CM 97–008; DSA 97–013, DSA 97–014, DSA 97–020, DSA 97–007, DSA 97–008, DSA 97–012, DSA 97–016, DSA 97–022, DSA 97–025; EN 97–004, EN 97–006, EN 97–007, EN 97–008, EN 97–010, EN 97–018; FA 97–006, FA 97–007, FA 97–009, FA 97–010, FA 97–013, FA 97–022, FA 97–023, FA 97–035, FA 97–036; MI 97–002, MI 97–004; OD 97–003, OD 97–014; MMB 97–002, MMB 97–017, MMB 97–018, MMB 97–019; MSB 97–007, MSB 97–012; MP 97–004; SP 97–001, SP 97–002,

SP 97–003, SP 97–004, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–020; TRD 96–003.

References: T.P. 525–5; T.P. 525–41; T.P. 525–63; T.P. 525–70, p. 5; T.P. 525–72; T.P. 525–75; T.P. 525–200–5; TRADOC Black Book No. 4; *Joint Vision 2010*, p.13; Joint Concept for NBC Defense, A1 paragraph A6; Ordnance Corps Vision, paragraphs 3–2f, 3–2d, and 3–2e.

TR 97–017, Information Display. The Army requires a family of displays to access information easily from any location in the battlespace. Display requirements include an integrated family of displays that covers various needs from large screen displays in a homestation, rear area, or CP environment; mobile displays that can be accessed en route or in moving ground and aerial vehicles; and personal displays used by the individual soldier such as a heads up capability. Each of these display applications must be adapted to specific information needs and resolution requirements. All displays must be capable of realistic 3D portrayal and evolve to incorporation of holograms and full sensory virtual reality presentation. Displays must be fully reconfigurable to suit situational needs and personal preferences without disrupting the underlying information sources. Interactive tools must be incorporated in the display capability. The display hardware and software must be user friendly and minimize operator training requirements. Because the systems will be employed in stressful physical and mental environments, multiple layers of menus should be avoided. Achieving this capability facilitates access to tailored battlefield information from any location either static or OTM.

Branch FOCs: AD 97–004, AD 97–013; AR 97–001, AR 97–002, AR 97–003, AR 97–004, AR 97–006, AR 97–007, AR 97–010, AR 97–011, AR 97–013, AR 97–014; AV 97–002, AV 97–011, AV 97–012; CH 97–003; CM 97–001, CM 97–008; EN 97–003, EN 97–005, EN 97–006, EN 97–007, EN 97–030; MI 97–001, MI 97–005, MI 97–007; MP 97–003; SC 97–006; SP 97–011; BCL 97–001, BCL 97–003, BCL 97–005, BCL 97–008; DSA 97–006, DSA 97–007, DSA 97–008, DSA 97–012, DSA 97–013, DSA 97–014, DSA 97–015, DSA 97–016, DSA 97–020, DSA 97–022, DSA 97–025, DSA 97–027, DSA 97–028; MMB 97–018, MMB 97–019; MSB 97–007; TRD 97–003, TRD 97–008; FA 97–005, FA 97–006, FA 97–007, FA 97–008, FA 97–012, FA 97–013, FA 97–015, FA 97–022, FA 97–023, FA 97–024, FA 97–031, FA 97–035, FA 97–036.

References: FM 100–13; T.P. 525–3; T.P. 525–5; T.P. 525–41; T.P. 525–60; T.P. 525–63; T.P. 525–70; T.P. 525–72; T.P. 525–75; T.P. 525–200–5; TRADOC Black Book No. 4; *Joint Vision 2010.*

TR 97–018, Relevant Information and Intelligence. Establish linked processes to collect, process, and provide critical information and intelligence, that supports battlefield visualization, decision making and information operations—both offensive and defensive. Identify commanders critical information and priority intelligence requirements to support decisions. Develop essential elements of friendly information and requirements for non-military information. Assess friendly IO/C^4I/C^2 warfare (C^2W) capabilities and vulnerabilities. Assess adversary IO/C^4I/C^2W capabilities and vulnerabilities.

Branch FOCs: AD 97–004; AR 97–001, AR 97–003, AR 97–004, AR 97–006, AR 97–007, AR 97–014; AV 97–004, AV 97–012; CM 97–001, CM 97–008; EN 97–007, EN 97–008; FA 97–006, FA 97–007, FA 97–010, FA 97–013, FA 97–022, FA 97–023, FA 97–035, FA 97–036; MI 97–002, MI 97–004; OD 97–003, OD 97–014; BCG 97–008; BCL 97–003, BCL 97–004, BCL 97–010; DSA 97–007, DSA 97–008, DSA 97–012, DSA 97–016, DSA 97–022, DSA 97–025; MMB 97–002, MMB 97–017, MMB 97–018; MSB 97–012; TRD 96–003.

References: T.P. 525–5; T.P. 525–7; T.P. 525–20; T.P. 525–21(R); T.P. 525–41; T.P. 525–55; T.P. 525–60; T.P. 525–69; T.P. 525–70; T.P. 525–71; T.P. 525–72; T.P. 525–75; T.P. 525–100–1; T.P. 525–200–1.

TR 97–019, Command and Control Warfare. The Army requires the ability to conduct combined, joint, and coalition operations that enhance and protect the commanders decision cycle and execution while negatively impacting an opponent's ability to operate and make decisions. Information dominance must be achieved through the effective use of intelligence, C^2, C^2W operations, and supported by available friendly information systems. Information operations must be conducted across the full range of military operations in all battlespace conditions. Information operations encompass the need to *protect* information, *attack* information nodes, and *exploit* information sources.

Branch FOCs: AD 97–006, AD 97–008; AR 97–003, AR 97–006, AR 97–007; BCL 97–012, BCL 97–013, BCL 97–014, BCL 97–015; BCG 97–008; CM 97–007; DSA 97–030; EEL 97–007, EEL 97–009, EEL 97–010; EN 97–010, EN 97–011, EN 97–012, EN 97–013, EN 97–014, EN 97–026; FA 97–027; MI 97–003 MI 97–008, MI 97–009; MSB 97–002, MSB 97–005, MSB 97–008, MSB 97–009, MSB 97–014; MD 97–002; MP 97–003, MP 97–004; SP 97–001, SP 97–003, SP 97–004, SP 97–007, SP 97–009, SP 97–010, SP 97–012, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–018, SP 97–020.

Information Protection—Information protection requires the capability to reduce the adversary's ability to attack friendly information systems and reduce friendly vulnerability to counter information gathering operations. C^4I systems must survive to operate in all weather conditions, on dirty battlefields, and despite enemy disruption efforts. The protection capability must provide warning of unauthorized penetration and monitoring; facilities protection; a capability to recover from loss of processing capability or loss of data; computer virus detection, protection, and source identification; and multilevel security and controls to disguise active signatures and prevent pattern detection. Decoys must simulate sight, sound, thermal, image, and electronic signatures of friendly high-payoff C^2 nodes. The capabilities supporting the protection of C^2 and decision making information will also be available to protect non-C^2 information systems.

Information Attack—Information attack requires the capability to destroy, disrupt, deny, deceive, degrade, target, destroy, or neutralize adversary information networks and C^2 systems. Options may vary from surgical jamming of the frequency spectrum to intrusion into C^2 systems to manipulate data. To effectively conduct information attack, a thorough understanding of the adversary's decision making and C^2 process is required. Information attack systems must be multifunction and modular and capable of defeating optics, electro-optics and night vision devices; jamming the entire frequency spectrum; electronic intrusion and data manipulation without alerting operators of computer compromise; electronic deception; computer attack; and the use of precision munitions to seek out and destroy high-payoff information systems engaged in collection, processing, dissemination, or display of information. Information attack impedes the adversary's decision making process and potentially lengthens friendly decision making timelines and windows of opportunity.

Information Exploitation—Information exploitation requires integrated ground, airborne, and space-based multidiscipline collection systems that support situation development. Capability requires the collection of information from an adversary's information age systems such as digital and LPI communications. Tools must exist to allow for analysis of an adversary's C^2 system. Distributed all-source analysis and dissemination systems are required to facilitate seamless access to intelligence information at all echelons.

References: T.P. 525–5; T.P. 525–75.

TR 97–020, Information Collection, Dissemination, and Analysis. The Army requires collection capability that enables warfighters to see and understand the 360-degree, 3D battlespace with the timeliness necessary to shape the battlespace. The collection capability must be an integrated effort between ground, airborne, spacebased, manned or unmanned, organic, nonmilitary intelligence, joint, national, or multinational assets. Sensors must be able to detect, identify, and locate and confirm active and passive targets that are underground, above ground, waterborne, airborne, or in space to support targeting, situation awareness, or force protection requirements. To support targeting requirements sensors must be capable of collecting air and missile threats, supporting counter-drug activity, supporting the employment of smart munitions, detecting enemy emitters, detecting missile launchers, detecting chemical and biological (CB) facilities, detecting ICBMs/SLBMs, detecting logistics forces, and discerning and attacking targets through the employment of a smart/brilliant munitions. To support situation awareness requirements sensors must be capable of detecting "modern" communications signals and nontraditional electromagnetic signals, friendly and enemy data, terrain data, weather data, soil conditions, climatic information, NBC contamination (including physical state and density data), toxic industrial chemicals, natural and manmade obstacles, obscurants (including wavelength and density), battle damage assessment and the presence of mines; collecting information from adversarial data stores and map adversarial C^2 nodes; providing reconnaissance, surveillance, early warning, and indications and warning; and supporting counter-drug activities, police intelligence operations, identification friend or foe (IFF), and drop-zone intelligence.

To support force protection requirements sensors must be capable of detecting intrusions in support of area security, supporting airspace deconfliction and IFF, and supporting survivability through the detection of laser employment, muzzle flash, use of millimeter-wave or acoustics and radar warning. Information must be collected for all levels of operations regardless of natural or manmade environmental conditions (weather, terrain, obscurants, electronic warfare, cluttered conditions, day/night, etc.). Collection systems must be modular and tailorable with multifunction capabilities and extended ranges. Collectors must be full spectrum, capable of covering wide areas, multidimensional, and extremely accurate to enable precision operations and strike. Sensors must operate autonomously in semiautomatic and manual modes, function within short detection timelines, be capable of remote operation, operate in a real-time/seamless environment, perform dedicated long-dwell missions, discriminate between conventional and weapons of mass destruction munitions, handle mass attacks, automatically identify targets, employ sensor-to-shooter linkages, operate in both point and area modes, be easily reprogrammable and employ modular plug-in capabilities. Capability is needed to enable a critical, timely, and near-instantaneous dissemination with associated mixed, netted, distributed, and nondedicated systems from foxhole to national command authority to ensure relevant information is passed to the en route commander.

Branch FOCs: AD 97–004, AD 97–006, AD 97–007, AD 97–011; AR 97–002, AR 97–003, AR 97–004, AR 97–009, AR 97–010, AR 97–011; AV 97–005, AV 97–007; BCG 97–005, BCG 97–007, BCG 97–008; BCL 97–006, BCL 97–007; CH 97–011; CM 97–002, CM 97–009; DBS 97–013, DBS 97–014; DSA 97–002, DSA 97–003, DSA 97–005, DSA 97–008, DSA 97–009, DSA 97–010, DSA 97–011, DSA 97–012, DSA 97–013, DSA 97–014, DSA 97–017, DSA 97–018, DSA 97–021, DSA 97–025, DSA 97–028; EN 97–004, EN 97–005, EN 97–006, EN 97–007, EN 97–009, EN 97–011, EN 97–021; EEL 97–005, EEL 97–007, EEL 97–012, EEL 97–013, EEL 97–015; FA 97–002, FA 97–003, FA 97–007, FA 97–008, FA 97–010, FA 97–013, FA 97–022, FA 97–024, FA 97–029; IN 97–600, IN 97–620, IN 97–621, IN 97–622, IN 97–630, IN 97–640, IN 97–650, IN 97–670; MI 97–003, MI 97–008; MMB 97–001, MMB 97–002, MMB 97–007, MMB 97–008, MMB 97–009, MMB 97–010, MMB 97–011, MMB 97–012, MMB 97–013, MMB 97–015, MMB 97–019, MMB 97–020; MSB 97–003, MSB 97–007, MSB 97–012, MSB 97–014; MP 97–010, MP 97–011; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–009, SP 97–010, SP 97–011, SP 97–012, SP 97–014, SP 97–015, SP 97–016, SP 97–020.

References: T.P. 525–3; T.P. 525–5, p. 2–7, paragraphs 2–2.h.1 and 2–2.h.2, p. 2–9, paragraph 2–3b(2), p. 3–2.b.(7), p. 3–2.b.(7)(c), p. 3–2.d.(6), p. 3–6, paragraph 3–2.a.(4), p. 6, paragraph 3–2, p. 3–7, paragraph 3–2.a.(10), p. 3–8, paragraphs 3–2.b.(2), 3–3b(1), 3–3b(6), 3–2.b(7)(a), 3–2.b(7)(c), 3–2.d(6), and 4–1e(2)(f), p. 3–9, paragraph 3–2.b, p. 3–10, paragraphs 3–2.b.(7) and 3–2(c), p. 3–11, paragraph 3–2.c.2, p. 3–20, paragraphs 2–3.b.1, 3–3.c.4, and 4–1.b.3, p. 4–7, paragraph 4–1.e.(2), p. 4–8, paragraphs 4–1c and 4–1e; T.P. 525–60; T.P. 525–63; T.P. 525–70, p. 4, paragraph 3–3.a, p. 5, paragraphs 3–3 and 3.3.b.3, p. 5–6, paragraphs 3–3.a.4 and 3–3.b; T.P. 525–75, paragraphs 3–3b, 3–3f, 4–5b, and 4–5f; T.P. 525–200–2 p. 5, paragraph 3–3.b, p. 6, paragraph A–5.a.(6), p. 5, paragraph 3–3.b, p. 6, paragraph A–5.a.(4), p. 7, paragraphs A–5.a.(11) and A–5.c; T.P. 525–200–3, T.P. 525–200–5, p. 6, paragraphs 3–7b and 3–7a, p. 8, paragraph 4–4d; TRADOC Black Book No. 4.

TR 97–021, Real-Time Target Acquisition, Identification, and Dissemination. The Army requires the capability to conduct continuous, responsive, proactive, real-time ground, air and space-based target acquisition from a moving or stationary platform. Capability to detect, locate, track, identify and classify active and passive targets in all weather, all terrain and all environments at extended ranges throughout the extended, 360-degree, 3D battlespace. Capability to defeat emerging threat protective systems. Capability to precisely conduct automatic target recognition, battle damage assessment, and moving target indication with zero target location error. Capability to disseminate targeting information throughout the force with a netted, distributed, nondedicated, integrated, seamless communications network. Capability must be compatible with fratricide prevention measures, operated beyond threat's ability to detect and inside threat's detection and response times.

Branch FOCs: AD 97–006; AR 97–004; AV 97–005; DSA 97–009, DSA 97–010, DSA 97–011, DSA 97–014, DSA 97–016, DSA 97–017, DSA 97–021, DSA 97–025, DSA 97–028, DSA 97–030; EEL 97–005, EEL 97–012; FA 97–001, FA 97–002, FA 97–007, FA 97–008, FA 97–013, FA 97–020, FA 97–024, FA 97–029, FA 97–035, FA 97–036; IN 97–660.

References: T.P. 525–5; TRADOC Black Book No. 4.

4. Mobility/Countermobility

TR–022, Mobility—Combat Mounted. Capability of combat forces to dominate maneuver and use position advantage to deliver fires in order to destroy the enemy's will to fight. This includes speed, acceleration, in-stride obstacle mitigation, firing OTM, gaining position advantage against the threat, real time dissemination of battlefield information and situational awareness, and NBC detection and mitigation on a stabilized platform in all battlespace environments to include battlefield clutter. Must be capable of extended operations with decreased logistics and must provide commonality and equality in both speed and maneuverability for all ground and aerial maneuver vehicles supporting the force. Must be capable of meeting load bearing requirements for mission accomplishment.

Branch FOCs: AD 97–002; AV 97–002, AV 97–008, AV 97–009; AR 97–002, AR 97–012; BCL 97–001; CM 97–001, CM 97–002, CM 97–004, CM 97–005, CM 97–008, CM 97–009; DSA 97–007, DSA 97–008, DSA 97–015, DSA 97–019, DSA 97–020, DSA 97–021, DSA 97–025, DSA 97–027; EN 97–003, EN 97–007, EN 97–008, EN 97–009, EN 97–018; FA 97–011, FA 97–021, FA 97–025, FA 97–026; IN 97–300; MMB 97–003, MMB 97–004; MSB 97–001, MSB 97–005, MSB 97–006; MP 97–001, MP 97–005, MP 97–007, MP 97–008, MP 97–013; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–020.

Reference: Operational Concept for Maneuver Engineering.

TR 97–023, Mobility—Combat Dismounted. Forces operating in dismounted battlespace require the capability for rapid, agile maneuver in close terrain, vehicular restrictive terrain, and during airborne, air assault, and waterborne operations. Human capability enhancements of load bearing capabilities and nutritional/medical enhancements of human performance will make dismounted soldiers capable of extended activity in all physical environments and climates, to include night and obscured environments.

Branch FOCs: CM 97–003; DBS 97–030, DBS 97–031, DBS 97–033, DBS 97–034; EEL 97–017; EN 97–007, EN 97–008, EN 97–009, EN 97–018; IN 97–310, IN 97–320, IN 97–321, IN 97–330; MD 97–003; MSB 97–001, MSB 97–006, MSB 97–008; MP 97–005, MP 97–013.

References: T.P. 525–200–3; Operational Concept for Maneuver Engineering.

TR 97–024, Combat Support/Combat Service Support Mobility. Capability to effectively and efficiently move resources in a timely manner and keep pace with the supported force. Will provide maneuverability and agility, survivability, flexibility, timeliness, and safety in daylight, darkness, collision avoidance, and obscured vision conditions during all phases of movement.

Branch FOCs: AD 97–002; AV 97–008, AV 97–009, AV 97–010; CM 97–013, CM 97–016; DSA 97–019; EN 97–09, EN 97–15, EN 97–16, EN 97–17, EN 97–18, EN 97–19, EN 97–20; FA 97–011, FA 97–O21, FA 97–030; MD 97–003, MD 97–005, MD 97–006; MP 97–005; MSB 97–008; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–020; TC 97–003.

References: T.P. 525–5; T.P. 525–200–3; T.P. 525–70; T.P. 525–75; T.P. 525–78; T.P. 525–200–2; TRADOC Black Book No. 4; *Joint Vision 2010.*

TR 97–025, Countermobility. Capability for commanders to restrict the mobility of the threat, to control battle tempo, and to seize and maintain maneuver dominance. Capabilities include area denial, disrupting, turning, fixing or blocking enemy movement at the appropriate times and places of need. The capability also covers rapid, effective accurate delivery and emplacement of battlefield obstacles through use of direct/indirect, air/ground operations. Obstacles may consist of lethal or nonlethal means of delaying and neutralizing enemy formations before they can be brought to bear. Other capabilities include planning, creating, and emplacing manmade obstacles and exploiting natural obstacles while simultaneously assuring our own freedom to maneuver.

Branch FOCs: BCL 97–003; CM 97–007, CM 97–010, CM 97–011; EN 97–010, EN 97–011; FA 97–028, FA 97–033; IN 97–180; MMB 97–007; MSB 97–013, MSB 97–014; SP 97–001, SP 97–002, SP 97–003, SP 97–006, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–020.

References: T.P. 525–5; TRADOC Black Book No. 4; *Joint Vision 2010*; Mission Need Statement for Tactical Liquid Explosives.

TR 97–026, Deployability. Capability to rapidly deploy, employ, and redeploy while keeping pace with future technological advances in air, land, sea, and space delivery capabilities in support of strategic operational and tactical power projection and prepositioned operations. Capability to be deployable with minimal preparation, operate in and from unimproved areas (at sea this includes operating in seastate 3), and conduct en route operations. Capability to be rapidly operational with minimal support upon arrival with emphasis on reception, staging, onward movement, and integration to the tactical assembly area.

Branch FOCs: AD 97–001; AR 97–002; AV 97–008; BCL 97–001; CH 97–009; CM 97–012; CS 97–002, CS 97–004; DSA 97–018; EEL 97–002, EEL 97–003, EEL 97–018; EN 97–004, EN 97–006, EN 97–007, EN 97–009, EN 97–014, EN 97–016, EN 97–017, EN 97–018, EN 97–020, EN 97–021, EN 97–029; FA 97–014, FA 97–016, FA 97–021, FA 97–026; IN 97–301; MD 97–002, MD 97–006, MD 97–008;

MP 97–016; FI 97–001, FI 97–004, FI 97–005, FI 97–006, FI 97–008; MSB 97–001; QM 97–001, QM 97–002, QM 97–003, QM 97–004, QM 97–005, QM 97–006, QM 97–009, QM 97–011; SP 97–001, SP 97–002, SP 97–003, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–019, SP 97–020.

References: T.P. 525–5; T.P. 525–60; T.P. 525–100–1; T.P. 525–200–2; T.P. 525–200–5; T.P. 525–200–6; TRADOC Black Book; CASCOM Pub—Vision of Combined Arms Support.

TR 97–027, Navigation. Forces require navigation capabilities that produce automated and on-demand, real-time, on-board, all-weather position location that locates terrain features and elements of friendly units, while they are stationary and OTM. Capability will provide an autonavigation feature linked to terrain products and operational plans. Navigation information will be an integrated part of situational awareness. Capability includes aerial, ground, and water surface navigation and movement masked by terrain.

Branch FOCs: AD 97–004; AR 97–002, AR 97–003, AR 97–004, AR 97–006, AR 97–007; AV 97–002; CM 97–014; DBS 97–032; DSA 97–006; EEL 97–002; EN 97–004, EN 97–007, EN 97–011; FA 97–005, FA 97–012; IN 97–320; MMB 97–003; MSB 97–014; MP 97–006; SP 97–001, SP 97–002, SP 97–006, SP 97–007, SP 97–009, SP 97–010, SP 97–012, SP 97–014, SP 97–017.

References: FM 100–13; T.P. 525–5; TRADOC Black Book No. 4.

TR 97–028, Unmanned Terrain Domination. Capability of land forces to dominate an area of operations through the effects of mass (the necessary concentration of combat power at the decisive time and place) without the need to fully commit troops. Includes the autonomous unmanned capability to achieve total situational awareness (on the ground or in the air), evaluate data received, develop courses of action consistent with the commander's intent, and employ combat power (lethal and non-lethal "smart" munitions) to achieve the commander's objectives. This "economy of force" means will control terrain, reduce the risk to soldiers in certain areas, and complement and maintain maneuver dominance at the strategic, operational, and tactical levels. Additionally, this capability will substantially enhance peacemaking and peacekeeping operations.

Branch FOCs: AD 97–002, AD 97–007, AD 97–009; AV 97–002; DSA 97–001, DSA 97–002, DSA 97–006, DSA 97–007, DSA 97–009, DSA 97–010, DSA 97–011, DSA 97–012, DSA 97–013, DSA 97–014, DSA 97–015, DSA 97–017, DSA 97–021, DSA 97–024, DSA 97–025; EEL 97–01, EEL 97–04, EEL 97–05, EEL 97–06, EEL 97–07, EEL 97–13; EN 97–04, EN 97–10, EN 97–11; FA 97–001, FA 97–013; MI 97–001, MI 97–003, MI 97–008; MMB 97–001, MMB 97–002, MMB 97–012; MSB 97–002, MSB 97–014.

References: T.P. 525–5, paragraphs 3–2b and 4–9; T.P. 525–75; TRADOC Black Book No. 4, p. 16, 23, 24; *Joint Vision 2010* (p. 13, 18); Mission Need Statement for Teleoperated Munitions; Mission Need Statement for Nonlethal Mines and Munitions; Mission Need Statement for Unmanned Terrain Domination Capabilities.

5. Sustainment

TR 97–029, Sustainment. Capability to provide flexible, tailorable, modular, seamless, anticipatory systems, processes, and services to deliver combat and combat service support in all operations. Capability for early entry and follow-on forces to plan for and exploit host nation/or nearby nation support. Capability to provision and provide other support required to maintain personnel and equipment during prolong operations or combat until successful accomplishment or revision of the mission.

Branch FOCs: AD 97–010; AR 97–002, AR 97–008, AR 97–012; AV 97–009, AV 97–010; BCL 97–003, BCL 97–009; CS 97–001; CH 97–002, CH 97–006, CH 97–007; CM 97–005, CM 97–013; CS 97–003, CS 97–004; DSA 97–018; EEL 97–016; EN 97–014, EN 97–015, EN 97–019, EN 97–020, EN 97–023; FA 97–016, FA 97–030, FA 97–031; FI 97–003, FI 97–004, FI 97–005, FI 97–006, FI 97–008; IS 97–001; MD 97–001, MD 97–002, MD 97–003, MD 97–004, MD 97–005, MD 97–006, MD 97–007, MD 97–008, MD 97–009, MD 97–010, MD 97–011, MD 97–012; MP 97–015, MP 97–016; MSB 97–004; OD 97–001, OD 97–003, OD 97–004, OD 97–005, OD 97–006, OD 97–007, OD 97–008, OD 97–014, OD 97–016, OD 97–017; QM 97–001, QM 97–002, QM 97–003, QM 97–004, QM 97–005, QM 97–006, QM 97–007, QM 97–008, QM 97–009, QM 97–011; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–019, SP 97–020; TC 97–001, TC 97–002.

References: T.P. 525–5; T.P. 525–60; T.P. 525–63; T.P. 525–200–2; T.P. 525–200–5; T.P. 525–200–6; TRADOC Black Book No. 3; TRADOC Black Book No. 4; *Joint Vision 2010*; Mission Need Statement for ICS3; U.S. Army Transportation Corps Strategic Vision; Ordnance Corps Vision; Battery Modernization Strategy; Army Strategic Logistics Plan. CASCOM Pub—Vision of Combined Arms Support.

TR 97–030, Sustainment Maintenance. Capability to support the combat readiness and effectiveness of the Army in the field. Will provide anticipatory, real-time, and remote diagnostics and prognostics to provide efficient battle damage assessment and repair. The following areas of maintenance concern will employ and be dependent on developed capabilities in this area: maintenance aids, contact maintenance, recovery maintenance data, tools, operator maintenance, operator decontamination, host-nation support, and operations in all environments (NBC) during all operations.

Branch FOCs: AD 97–010; AR 97–002, AR 97–008, AR 97–012; AV 97–009, AV 97–010; BCL 97–003, BCL 97–009; CM 97–004, CM 97–005; CS 97–001, CS 97–003, CS 97–004; DSA 97–018; EN 97–014, EN 97–015, EN 97–019, EN 97–020, EN 97–30; FA 97–016, FA 97–030, FA 97–031; FI 97–003, FI 97–004, FI 97–005, FI 97–006, FI 97–008; IS 97–001; MD 97–001, MD 97–002, MD 97–003, MD 97–004, MD 97–005, MD 97–006, MD 97–007, MD 97–008, MD 97–009, MD 97–010, MD 97–011, MD 97–012; MP 97–015, MP 97–016; OD 97–001, OD 97–003, OD 97–004, OD 97–005, OD 97–006, OD 97–007, OD 97–008, OD 97–014, OD 97–016, OD 97–017; QM 97–001, QM 97–002, QM 97–003, QM 97–004, QM 97–005, QM 97–006, QM 97–007, QM 97–008, QM 97–009, QM 97–011; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–019, SP 97–020; TC 97–001, TC 97–002.

References: T.P. 525–5; T.P. 525–60; T.P. 525–63; T.P. 525–200–2; T.P. 525–200–5; T.P. 525–200–6; TRADOC Black Book No. 3; TRADOC Black Book No. 4; *Joint Vision 2010*; Mission Need Statement for ICS3; U.S. Army Transportation Corps Strategic Vision; Ordnance Corps Vision; Battery Modernization Strategy; Army Strategic Logistics Plan; CASCOM Pub—Vision of Combined Arms Support.

TR 97–031, Sustainment Services. Capability to execute and manage all personnel-related matters and contribute to the morale and welfare of the soldier in the field by providing the most benefit to the maximum number of personnel. Will provide near real time strength accounting, replacement operations, religious support/pastoral care operations, medical support operations, casualty reporting, finance services, postal services, morale support activities, and legal services. These services share equal importance with the requirement for availability of materiel on the battlefield.

Branch FOCs: AD 97–010; AR 97–002, AR 97–008, AR 97–012; AV 97–009, AV 97–010; BCL 97–003, BCL 97–009; CH 97–011; CM 97–005; CS 97–001, CS 97–003, CS 97–004; DSA 97–018; EN 97–014, EN 97–015, EN 97–019, EN 97–020; FA 97–016, FA 97–030, FA 97–031; FI 97–003, FI 97–004, FI 97–005, FI 97–006, FI 97–008; IS 97–001; MD 97–001, MD 97–003, MD 97–004, MD 97–005, MD 97–006,

MD 97–007, MD 97–008, MD 97–009, MD 97–010, MD 97–011, MD 97–012; MP 97–015, MP 97–016; OD 97–001, OD 97–003, OD 97–004, OD 97–005, OD 97–006, OD 97–007, OD 97–008, OD 97–014, OD 97–016, OD 97–017; QM 97–001, QM 97–002, QM 97–003, QM 97–004, QM 97–005, QM 97–006, QM 97–007, QM 97–008, QM 97–009, QM 97–011; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97019, SP 97–020; TC 97–001, TC 97–002.

References: T.P. 525–5; T.P. 525–60; . T.P. 525–63; T.P. 525–200–2; T.P. 525–200–5; T.P. 525–200–6; TRADOC Black Book No. 3; TRADOC Black Book No. 4; *Joint Vision 2010*; Mission Need Statement for ICS3; U.S. Army Transportation Corps Strategic Vision; Ordnance Corps Vision; Battery Modernization Strategy; Army Strategic Logistics Plan; CASCOM Pub—Vision of Combined Arms Support.

TR 97–032, Sustainment Logistics Support. Capability to provide responsive, flexible, and precise field services support to soldiers during any environmental or tactical situation. Will be able to perform graves registration, airdrop, fuel dispensing, water production and delivery, food preparation, clothing exchange and bath, laundry, light textile and clothing renovation, unit reconstitution, decontamination, and salvage. Will provide less continuous support with a smaller logistics footprint, decreasing the vulnerability of the Army's logistics lines of communication.

Branch FOCs: AD 97–010; AR 97–002, AR 97–008, AR 97–012; AV 97–009, AV 97–010; BCL 97–003, BCL 97–009; CH 97–003; CM 97–004, CM 97–005; CS 97–001, CS 97–003, CS 97–004; DSA 97–018; EEL 97–016; EN 97–004, EN 97–008, EN 97–010, EN 97–018, EN 97–014, EN 97–015, EN 97–019, EN 97–020; FA 97–016, FA 97–030, FA 97–031; FI 97–003, FI 97–004, FI 97–005, FI 97–006, FI 97–008; IS 97–001; MD 97–001, MD 97–003, MD 97–004, MD 97–005, MD 97–006, MD 97–007, MD 97–008, MD 97–009, MD 97–010, MD 97–011, MD 97–012; MP 97–015, MP 97–016; MSB 97–012; OD 97–001, OD 97–003, OD 97–004, OD 97–005, OD 97–006, OD 97–007, OD 97–008, OD 97–014, OD 97–016, OD 97–017; QM 97–001, QM 97–002, QM 97–003, QM 97–004, QM 97–005, QM 97–006, QM 97–007, QM 97–008, QM 97–009, QM 97–011; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97019, SP 97–020; TC 97–001, TC 97–002.

References: T.P. 525–5; T.P. 525–60; T.P. 525–63; T.P. 525–200–2; T.P. 525–200–4; T.P. 525–200–5; TRADOC Black Book No. 3; TRADOC Black Book No. 4; *Joint Vision 2010*; Mission Need Statement for ICS3; U.S. Army Transportation Corps Strategic Vision; Ordnance Corps Vision; Battery Modernization Strategy; Army Strategic Logistics Plan; CASCOM Pub—Vision of Combined Arms Support.

TR 97–033, Sustainment Transportation. Capability to move personnel, equipment, materiel, and supplies to sustain operations and move the forces which execute those operations. Will provide for all elements of moving forces and their logistics requirements to the locations required by operations. Will encompass the load-carrying capacity of mode operators, terminal operations, and movement control. Materiel must be transferred from one mode of transportation to another at sea ports of debarkation, rail and air-heads, inland waterways, and truck terminals. Air and sea ports of debarkation must be cleared expeditiously to make way for follow-on cargo. Sustaining supplies and replacement personnel will flow over the same routes required by maneuver units and will compete for limited main supply routes in the theater.

Branch FOCs: AD 97–010; AR 97–002, AR 97–008, AR 97–012; AV 97–009, AV 97–010; BCL 97–003, BCL 97–009; CH 97–009; CM 97–004, CM 97–005; CS 97–001, CS 97–003, CS 97–004; DSA 97–018; EEL 97–016; EN 97–014, EN 97–015, EN 97–019, EN 97–020; FA 97–014, FA 97–016, FA 97–021, FA 97–026, FA 97–030, FA 97–031; FI 97–003, FI 97–004, FI 97–005, FI 97–006, FI 97–008; IS 97–001; MD 97–001, MD 97–002, MD 97–003, MD 97–004, MD 97–005, 97–006, MD 97–007, MD 97–008,

MD 97–009, MD 97–010, MD 97–011, MD 97–012; MP 97–015, MP 97–016; OD 97–001, OD 97–003, OD 97–004, OD 97–005, OD 97–006, OD 97–007, OD 97–008, OD 97–014, OD 97–016, OD 97–017; QM 97–001, QM 97–002, QM 97–003, QM 97–004, QM 97–005, QM 97–006, QM 97–007, QM 97–008, QM 97–009, QM 97–011; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–012, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97019, SP 97–020; TC 97–001, TC 97–002.

References: T.P. 525–5; T.P. 525–60; T.P. 525–63; T.P. 525–200–2; T.P. 525–200–5; T.P. 525–200–6; TRADOC Black Book No. 3; TRADOC Black Book No. 4; *Joint Vision 2010*; Mission Need Statement for ICS3; U.S. Army Transportation Corps Strategic Vision; Ordnance Corps Vision; Battery Modernization Strategy; Army Strategic Logistics Plan; CASCOM Pub—Vision of Combined Arms Support.

TR 97–034, Enemy Prisoner of War/Civilian Internee (EPW/CI) Operations. Capability to conduct EPW and CI evacuation, medical support, accountability, and sustainability operations. EPW accountability is mandated by the Geneva Convention Agreements and by International Committee of the Red Cross rules. Military police units conducting internment or resettlement operations require the capability to rapidly recall and forward personnel data to facilitate accountability. This capability should be compatible with emerging information exchange and processing systems and would capture and report costs associated with EPW and CI pay. Capability to translate (to and from) is required to expedite the information gathering process, including human intelligence collection, translation, and document exploitation and interrogation capability. The capability for quick access to EPW/CI information enables the timely availability of comprehensive information and identification of EPW/CI within compounds, during transit, turnover to a third party, and during repatriation. Military Police require the capability to execute the expeditious evacuation of EPW/CI to retain freedom of maneuver for combat forces and control of personnel within compounds. This can only be attained through early planning and prioritization of sustainment resources on the battlefield.

Branch FOCs: CH 97–004; CS 97–004; FI 97–003; IS 97–001, IS 97–002, IS 97–003, IS 97–004, IS 97–005; MD 97–001, MD 97–002, MD 97–003, MD 97–004, MD 97–005, MD 97–006, MD 97–010, MD 97–011; MI 97–003; MP 97–009; MSB 97–0010.

Reference: T.P. 525–75.

TR 97–035, Power Source and Accessories. Capability to provide a small, lightweight, long-lasting, high-energy density, maintenance-free, low-signature, high-quality power source for electronics communications, weapons, individual soldiers, vehicles, air and water craft, and medical equipment, which will be cost effective, operate in any environment, and will be environmentally safe. For the individual soldier the objective capability will be a universal power source that provides simultaneous power to any/all soldier carried systems/subsystems without degradation.

Branch FOCs: AR 97–007, AR 97–008; CH 97–006; CS 97–001; MI 97–010; MMB 97–006; SP 97–012, SP 97–017, SP 97–019.

Reference: Battery Modernization Strategy.

TR 97–036, Nonprimary Power Sources Combat Vehicles/Support Systems. Capability to provide a small, lightweight, and low-signature nonprimary power sources for combat vehicles or support systems. This will allow the operation of combat vehicle electro-optics communications, weapons, life support, and protection or survivability devices or accessories while the primary vehicle power source is shut down.

Branch FOCs: AR 97–008; CH 97–007; FA 97–018; MMB 97–006.

Reference: T.P. 525–5.

TR 97–037, Combat Vehicle Propulsion. Capability to provide high power and fuel efficient propulsion for combat vehicles. Capability must be small, lightweight, reliable, maintainable, safe, low signature, multifuel capable and environmentally safe. Capability to provide energy on demand for propulsion, life support and weapon system functions.

Branch FOCs: AR 97–005; AV 97–009; FA 97–017; DSA 97–019; MMB 97–004.

Reference: T.P. 525–5.

TR 97–038, Casualty Care, Patient Treatment, and Area Support. The Army requires the capability for level I and II medical treatment and area support. Rapid casualty location and application of improved treatment modules will provide focus toward reducing the historically recalcitrant killed-in-action (KIA) rate. The capability requires improved methods of physiological resuscitation, improved diagnostic and treatment capabilities at both unit- and area-level treatment facilities. All health care providers will require advance trauma management training and sustainment training and organizations must provide communications between providers and mentors to optimize reductions in the KIA rate. Medical personnel require the ability to treat patients under all conditions and require night vision capability. Combat health support providers require the ability to initiate and continue casualty treatment under NBC conditions. The combat medic will require improved ability to function while in individual protective gear. All forward deployed medical modules will require collective medical protection to ensure continued patient care under NBC conditions. NBC casualties will require improved methods of rapid decontamination and emergency treatment followed by protection and continued medical management to ensure survival. Digitized patient records, beginning prior to deployment and continuing throughout casualty management are required to ensure seamless medical treatment. Automated read/write devices and database software for medical status, patient tracking, and reconstitution are required for use before, during, and after operations to ensure soldier readiness for combat and to allow timely transmission of location and status to health providers, commanders, and family members. Capability to track casualty emergency ministrations and pastoral care information to data collection points for use by casualty assistance offices and notification of next of kin. Capability would provide notification officers and accompanying chaplains with vital battlefield pastoral care information.

Branch FOCs: CH 97–002; CM 97–004, CM 97–006; MD 97–003.

Reference: T.P. 525–50; T.P. 525–78, paragraph 3–3c; T.P. 525–200–5.

TR 97–039, Lines of Communications (LOCs) Maintenance and Repair. Capability to assess, repair, and maintain LOCs in a vast spectrum of environments. Includes repair, refurbishment, or construction of ports, airfields, roads, bridges, and other transportation conduits. This includes preparation and installation activities for logistics over the shore (LOTS) operations.

Branch FOCs: EN 97–004, EN 97–005, EN 97–006, EN 97–007, EN 97–008, EN 97–009, EN 97–012, EN 97–015, EN 97–016, EN 97–017, EN 97–018, EN 97–019, EN 97–020, EN 97–021, EN 97–022.

References: T.P. 525–5; TRADOC Black Book No. 4.

6. Lethality

TR 97–040, Firepower Lethality. Capability to provide responsive overmatching lethal combat power against current and future threats throughout the battlespace. Capability should be impervious to countermeasures and all environmental conditions to include battlefield clutter. Capability should include overmatching range, probability of hit and kill, and accuracy that minimize resources expended, maximize effects, and minimize collateral damage.

Branch FOCs: AD 97–003, AD 97–009, AD 97–012; AR 97–001; AV 97–006; DBS 97–10, DBS 97–011, DBS 97–012, DBS 97–013, DBS 97–014, DBS 97–015, DBS 97–016, DBS 97–017, DBS 97–018, DBS 97–61; DSA 97–001, DSA 97–002, DSA 97–003, DSA 97–014, DSA 97–023, DSA 97–024, DSA 97–026, DSA 97–028; EEL 97–001, EEL 97–004; EN 97–010, EN 97–011; FA 97–001, FA 97–002, FA 97–017, FA 97–020, FA 97–021, FA 97–026, FA 97–029, FA 97–032; IN 97–100, IN 97–110, IN 97–111, IN 97–112, IN 97–119, IN 97–120, IN 97–130, IN 97–140, IN 97–150, IN 97–160; MI 97–008; MMB 97–001; MP 97–002; MSB 97–002, MSB 97–014; SP 97–001, SP 97–002, SP 97–003, SP 97–006, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–012, SP 97–014, SP 97–015, SP 97–016, SP 97–020; TC 97–001.

Reference: T.P. 525–200–5.

TR 97–041, Operations in an Unexploded Ordnance (UXO)/Mine Threat Environment. Capability of land forces to safely conduct in-stride breaching and assure tempo of operations when facing mines and UXO threats. The capability must support rapid and accurate remote standoff surveillance, reconnaissance, detection and location of mines, UXO components, materials, and neutralize or destroy identified devices. Capability must limit munitions and submunitions dud rates to eliminate UXO hazards. Capability must relay tactical data through strategic systems during employment of contingency forces. Capability must meet joint countermine and Army criteria and must support battlefield dominance while minimizing any decrease of operational tempo.

Branch FOCs: AR 97–009; DSA 97–006; EEL 97–007; EN 97–002; FA 97–034; OD 97–009, OD 97–013; MMB 97–005; MSB 97–006.

References: T.P. 525–5, p. 3–9; *Joint Vision 2010* p.13, 20–21, 22–24, 25.

TR 97–042, Firepower Nonlethal. Capability to safely engage or control personnel and degrade or immobilize equipment using nonlethal means throughout the battlespace during combat or stability and support operations.

Branch FOCs: CM 97–007, CM 97–011; IN 97–400, IN 97–410, IN 97–420, IN 97–430; MP 97–014; FA 97–033; EN 97–010, EN 97–011; SP 97–012, SP 97–020; EEL 97–006; DBS 97–040, DBS 97–041, DBS 97–042, DBS 97–043; MMB 97–005, MMB 97–016; MSB 97–013, MSB 97–014; SP 97–001, SP 97–002, SP 97–003, SP 97–006, SP 97–007, SP 97–009, SP 97–010, SP 97–011, SP 97–013, SP 97–014, SP 97–015, SP 97–016, SP 97–020.

Reference: T.P. 525–73.

7. Survivability

TR 97–043, Survivability—Materiel. Capability to survive against the full spectrum of battlespace threats (directed-energy weapons, NBC weapons, thermal and ballistic weapons, corrosives, environmental effects). Integration of an optimized suite of detection, warning, hit, penetration, and kill avoidance measures is necessary to achieve this. Capability of surviving against threats attacking at any aspect around, above, or below the system. Sensor, information systems, and countermeasure combinations providing this capability must be able to operate autonomously, while retaining semiautomatic and manual modes. Optimization of the suite requires the proper combination of signature management, sensors, countermeasures, such as smoke/active protection/obscurants, and armors, all developed and integrated as part of the system's basic design, to reduce cost, maximize effectiveness, and minimize system-level burdens. Capability required to protect facilities, information systems, and equipment by minimizing risks associated with acts of terrorism and sabotage, including sympathetic detonations of ammunition stores, terrorist attacks, or direct and indirect fires. This includes the capability to rapidly construct and repair fortifications, protective shelters/positions, forward operating bases, landing strips and pads, and combat roads and trails. Capability to enhance aircraft and aircrew survival. Capability to survive through the use of active and passive defense measures.

Branch FOCs: AD 97–008, AD 97–009; AR 97–003, AR 97–015; AV 97–007; CM 97–004, CM 97–007; DSA 97–003, DSA 97–004, DSA 97–028, DSA 97–030; EEL 97–007, EEL 97–008, EEL 97–009, EEL 97–010; EN 97–005, EN 97–006, EN 97–009, EN 97–012, EN 97–013; FA 97–003, FA 97–004, FA 97–011, FA 97–034; FI 97–008; IN 97–230; MI 97–003, MI 97–004, MI 97–007; MMB 97–008, MMB 97–013, MMB 97–014; MP 97–001, MP 97–010; OD 97–017; MSB 97–003, MSB 97–004, MSB 97–006, MSB 97–008; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–005, SP 97–006, SP 97–007, SP 97–008, SP 97–009, SP 97–010, SP 97–012, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–019, SP 97–020.

References: T.P. 525–5; T.P. 525–60; T.P. 525–63; T.P. 525–75, paragraphs 3–3b, 3–3c, 4–5c, 3–3e, and 4–5e; T.P. 525–200–2; T.P. 525–200–5; TRADOC Black Book No. 4; *Joint Vision 2010*; Ordnance Corps Vision; Maneuver Support Enduring Battlefield Function.

TR 97–044, Survivability—Personnel. Army forces operating throughout the battlefield will be highly survivable. This survivability will be achieved through the integration of overmatching lethality, situational awareness, state-of-the-art sensors and countermeasures, a full complement of directed energy, ballistic, NBC, endemic disease, thermal, and environmental protections. Army forces will derive their survivability from the amalgamation of the individual soldier and combat vehicle survivability (including crash-worthiness to protect crew members and passengers from injury during accidents), its redundant force structure and the density of distribution of its combat power within the battlespace. Personnel survivability is comprised of both active and passive survivability capabilities.

Branch FOCs: AD 97–008; AR 97–012; AV 97–007; CM 97–003, CM 97–004, CM 97–006, CM 97–007; EEL 97–008; EN 97–009, EN 97–012, EN 97–013; FA 97–003; FI 97–008; IN 97–200, IN 97–210, IN 97–220; MD 97–001, MD 97–003, MD 97–004, MD 97–005, MD 97–006, MD 97–007, MD 97–008, MD 97–009, MD 97–010, MD 97–011, MD 97–012,; MP 97–001, MP 97–010; MMB 97–014; MSB 97–003; MSB 97–004, MSB 97–006, MSB 97–008; SP 97–001, SP 97–002, SP 97–003, SP 97–004, SP 97–009, SP 97–010, SP 97–011, SP 97–012, SP 97–014, SP 97–015, SP 97–016, SP 97–017, SP 97–020.

Active Capabilities—Army forces will have active capabilities to ensure overmatching survivability, including soldier-to-soldier/vehicle-to-vehicle/soldier-to-vehicle combat identification, combat life saving, battle injury treatment and prevention, nonbattle casualty prevention and treatment, physiological monitoring and battle stress, and selected nonbattle injuries prediction. Vehicle capabilities will include maneuverability, low observability, and active protection. When forces are operating independently, in war or sustainment and support operations, it will be augmented with veterinary services.

Passive Capabilities—Soldiers require passive capabilities to ensure overmatching survivability, including timely intelligence, and low observability, lightweight protection from ballistic, directed-energy (to include agile vision protection throughout the electromagnetic spectrum), tactical and industrial chemicals, and environmental stresses, and medical protection from disease.

References: T.P. 525–5; T.P. 525–63.

TR 97–045, Camouflage, Concealment, and Deception. Capability to reduce the probability of being detected, acquired, ranged, engaged, and hit by the threat. This capability is needed to protect the force and reduce or eliminate visual, electromagnetic, acoustic, infrared, and radar signatures. Capability to mask friendly intentions, protect forces, shape the battlespace, and conduct decisive operations by reducing or eliminating operational signatures and employing decoys.

Branch FOCs: AD 97–008; AR 97–002, AR 97–003; AV 97–007; CM 97–007; DBS 97–024; DSA 97–030, DSA 97–004; EEL 97–009; EN 97–13; FA 97–003, FA 97–018, FA 97–029; MI 97–009; MP 97–001, MSB 97–008, MSB 97–009; MMB 97–009; SP 97–012; IN 97–210, IN 97–240.

References: T.P. 525–200–3; T.P. 525–5; T.P. 525–75; paragraphs 3–3g and 4–5g; T.P. 525–200–2; Black Book No. 4; CAC&FLW Pam 525–05; Mission Need Statements for Multispectral Camouflage.

TR 97–046, Battlefield Obscuration. Capability to selectively deny enemy observation, target acquisition, sensing, and signaling capability through the use of visible and invisible obscurants.

Branch FOCs: AR 97–002, AR 97–003; CM 97–007; EEL 97–010; FA 97–003, MMB 97–010, MMB 97–011; MP 97–001; MSB 97–005.

References: T.P. 525–5, T.P. 525–3.

8. Training

TR 97–047, Leader and Commander Training. Capability to train leaders and commanders to be versatile and adaptive to varied mission requirements. Future commanders and their staffs will face a technologically advanced, information-rich, operationally diverse, and fast paced battle staff environment. Trainers must fully understand the impacts of this environment on leaders and commanders. Training systems must provide capabilities needed to:

- Develop and exercise cognitive skills and knowledge to enable them to handle the ambiguity of combat with confidence, and adjust and adapt in real time to quickly changing task demands, operational situations, and conditions.
- Train leaders and commanders to make optimal use of battle staffs as problem solving resources through improved teamwork and collaboration. Commanders must have training and team building strategies at their disposal to use in team integration. Training developers need a thorough understanding of the factors influencing effective teams in order to design training and training support products that promote effective teamwork. Both must understand the factors influencing high and low performing teams and how these factors may vary with different missions and mission conditions. Commanders must also be able to choose soldiers for units, task forces, special team assignments, and duty assignments based on a soldier's proven performance and training on mission-relevant skills and tasks.
- Provide leaders and commanders ample opportunities, both at homestation and during deployment, to gain essential experience in battle command decision making through training. This must occur through training/mission rehearsal in simulators (e.g., individual battle staff trainers, incorporation of battle staff decision processes into battle simulations) or other training media that are reconfigurable to match training scenarios to battlefield function or operational mission.
- Train leaders and commanders in the interpersonal skills needed to work effectively with diverse groups of people. Future leaders must be able to shape units into cohesive teams, work effectively with joint, coalition and interagency personnel, and nongovernmental organizations and private volunteer organizations and the media, and serve as effective intermediaries between the Army and U.S. and foreign civilians.
- Train leaders and commanders to comprehend the organization, structure, capabilities, and limitations of Force XXI C^4I architectures (organic and split-based).

- Train leaders and commanders to either exploit or react to the influence of the media on operations. Commanders need to be schooled on the capabilities of the media in all its forms—electronic, written, and audio. Commanders must be constantly aware of the changing global information environment, its effect on the opinions, attitudes, and beliefs held by the American public, political leaders, soldiers and their families, allies, adversaries; and other important audiences, and the impact of these opinions, attitudes, and beliefs on the Army and its operations.

- Train leaders and commanders to serve as the Army's basic environmental stewards and to take a professional and personal responsibility for understanding and supporting the Army's environmental program. In order to develop effective training for commanders and leaders, training developers need information that describes the situations leaders will encounter during specific types of operations and while rapidly transitioning from one type of operation to another. Essentially, the Army needs the capability to model leadership requirements in future operations. Once trainers identify the most essential leadership capabilities for the future, they must be able to determine the best mix of training strategies and tools to train and assess competencies throughout leaders' careers.

Branch FOCs: AR 97–013; BCL 97–016, BCL 97–017, BCL 97–020; CH 97–011; DSA 97–029; EN 97–006, EN 97–027; FI 97–007; MI 97–011; MMB 97–020; MP 97–012; SP 97–005, SP 97–18; TRD 97–002, TRD 97– 005; TRD 97–017.

References: T.P. 525–5; T.P. 525–75.

TR 97–048, Performance Support Systems. Capability to provide soldiers enhanced performance support on the job to enable them to adapt effectively to quickly changing missions and equipment technologies, and adapt to a wider array of tasks and responsibilities. Advanced performance support capabilities will blur the lines between training and operational tools. Many performance support technologies will be deployed during conflict to help soldiers sustain their skills and do their jobs on the battlefield. The following types of capabilities are needed:

- Learning/job-aid environments that, for example, put the digitized expertise of senior officers and noncommissioned officers (NCOs) on a soldier's desktop.

- Smart tutors and embedded diagnostics systems that assist soldiers in diagnosis and repairs, as well as other types of problem solving and decision making.

- Guided, goal-oriented simulations that enable soldiers to interact with and get advice from computerized experts while working through situations they encounter on the job.

- Decision aids that support mission planning, preparation, and execution. Soldiers will need the capability to move around freely to perform their duties while interacting with performance support systems via visual and auditory or other hands-free, user-friendly interfaces. Systems will need to be embedded within equipment or organic TOE assets. Selected systems will need to be man portable. Training and materiel developers need the capability to identify those tasks and conditions where development of performance support systems will have the most payoff for the Army. Information regarding the perceived performance support needs of soldiers and officers in TOE units is needed to assist training developers in identifying requirements.

Branch FOCs: AD 97–005; AV 97–003, AV 97–014; BCL 97–003; EN 97–006, EN 97–011; FA 97–015; IS 97–003; MI 97–011; MMB 97–020; MP 97–012; SP 97–005, SP 97–18; TRD 97–003.

References: T.P. 525–5; T.P. 525–60, paragraph 3.2.e.2; T.P. 525–70; T.P. 525–75; T.P. 525–200–4; T.P. 525–200–5.

TR 97–049, Battle Staff Training and Support. Capability of battle command support teams (BCST) to support the commander in controlling current operations and adjusting plans for future operations. The staff must be an extension of the commander. The staff must provide the critical information necessary for the commander to make informed, timely decisions to best effect the action/mission requirements. Skilled staffs work within the commander's intent to direct and control units and allocate the means to support that intent. They assist the commander in anticipating the outcome of the current operation and developing the concept for the follow-on mission. They understand, and can apply, a common doctrine. The battle staff must also understand what information the commander deems important for making decisions and provide it in an accurate and timely manner. It is the product of staff work that serves the needs of the commander. Battle staffs must be organized to ensure the command process is sustained during any absence of the commander. Underlying this capability is the requirement to recruit, develop, and retain quality people. Recruiting programs must be developed and employed to determine early the capabilities and potential of commanders and staffs. Training programs must be developed and harness new technologies to improve the comprehension and retention of key leadership and staff skills. BCSTs are desirable to reduce strategic lift requirements, present smaller targets enhance mobility, and reduce sustainment requirements. In order that BCSTs be reduced in size, but still perform the same functions, technologies must be applied that will reduce the workload on soldiers. Enabling technologies include decision support software and planning aids, user-friendly systems that optimize work performance, systems that automate staff functions, allow workload sharing, and predict high workload periods and miniaturized hardware. Deployed BCSTs may also be made smaller through the use of virtual staffs. Using advanced command, control, and communications (C^3) systems, small BCSTs could be linked to larger staffs in the rear, in a sanctuary, or even the continental United States (CONUS). Using a shared, relevant common picture, rearward staffs could provide timely and accurate planning, operational, and administrative support to the forward located BCST. Other actions required to make BCSTs smaller are more efficient and effective man–machine information interface, reorganization of staff structure around information flows that reduce fragments, stovepipes, and handoffs. Staffs should be internetted, and at least partially nonhierarchical, to conduct cross-BOS processes.

Branch FOCs: AR 97–013; BCL 97–010, BCL 97–016; CM 97–001, CM 97–008; FA 97–015; FI 97–009; SP 97–005, SP 97–018, SP 97–020; TRD 97–004.

Reference: T.P. 525–5.

TR 97–050, Joint, Combined, and Interagency Training. Capability to conduct training and mission rehearsals for joint, combined, or interagency operations. Army units need the capability to reconfigure virtual, constructive, and live simulations to train/mission rehearse joint, combined, and interagency operations. Commanders and individual battle staff members must be able to practice problem solving and decision making skills in mission relevant, joint, combined, and interagency scenarios prior to their participation in exercises or use on the battlefield. They must understand the differences in the Army's tactical decision making process and the joint deliberate and crisis action planning process. Soldiers need the ability to train-up rapidly on a variety of potential topics, including foreign cultures and foreign language skills, and the doctrine and standing operating procedures or terminology used by other services, coalition forces, or agencies. Units need the capability to link up via distance learning technologies with joint, combined, and interagency personnel for common training/ mission rehearsal. Other services resources must be integrated into battalion- and brigade-level simulations to train other service's combat capabilities on a regular basis. Commanders also need capability to bring together Army units, including Reserve Components, with joint, combined, and interagency forces for training/mission rehearsal through linkage of synthetic distributed environments, including common, datalinked terrain databases.

Branch FOCs: AR 97–013; BCL 97–018; CH 97–011; EEL 97–021, EEL 97–022; EN 97–003, EN 97–005, EN 97–006, EN 97–009, EN 97–030; FA 97–024; FI 97–009; MI 97–011; MP 97–015; SP 97–005, SP 97–018, SP 97–020; TRD 97–007.

References: T.P. 525–5; T.P. 525–75.

TR 97–051, Training Infrastructure. Capability to deliver required training, throughout a soldier's career, how, when, and where it will be most training and cost effective. Soldiers must be able to learn and practice the basic job-oriented physical and mental skills and gain required knowledge at their primary duty station, receive advanced individual training at homestation distributed training centers, and learn and practice hands-on skills on the job. Only the most difficult hands-on skills and selected courses taught using small group instruction will require training onsite at the school. To achieve maximum effectiveness and efficiency, training must be self-paced and individualized to a soldier's needs. Soldiers must have easy access to individualized sustainment training and Army training doctrine at homestation and post-mobilization. The training infrastructure must be designed to fully support this evolution to phased-in, individualized, distributed "soldier-oriented" training. Training developers at the schools must be linked to unit commanders in order for them to do integrated and coordinated training development, delivery, and testing. Training developer-unit linkages, as well as training developer-unit-combat training center (CTC) linkages, will also enable school and unit training developers to receive timely feedback on new and emerging training requirements as well as feedback on soldier performance. Training developers at both unit and school sites must have ready access to easy-to-use training authoring tools and training doctrine. Authoring tools must be capable of quickly building training programs with minimal input from a unit or school developer. Linkages between the services' training developers and training development systems will support identification of tasks for which common training can be developed. Linkages between the services' televideotraining and Internet-based training systems will support joint training delivery. Training infrastructure must also be capable of:

- Developing and delivering training/mission rehearsals, on demand, to meet contingency mission requirements. Training developers need capability to develop new or reconfigure existing training for a variety of media on short notice. Units must be capable of rapid planning, desktop/online development, and delivery of training /mission rehearsals for contingency missions. Training developers and units must also be able to rapidly develop performance evaluation tools tailored to present level of unit performance and requirements of the immediate mission.
- Providing commanders knowledge and decision aids necessary to select best mix of training and performance support option from the suite of available alternatives (e.g., live, virtual, and constructive simulations or a combination thereof, individual and collective training support packages, paper-based training/job aids, training devices and simulations, distance learning products, field exercises, electronic performance support systems, embedded training). Commanders must have capability to factor need for multiservice, multinational, and interagency training into equation for determining best training mix. Commanders also must be able to

select from a suite of individual and collective performance evaluations to build an overall evaluation strategy that provides them essential feedback on unit readiness for the immediate mission.

- Providing training developers / unit commanders ability to employ valid performance enhancing techniques appropriately to optimize soldier performance.
- Providing soldiers the means to identify training and skill requirements for various unit and duty assignments. Soldiers also must be able to assess their status relative to these skill requirements and to other soldiers, for purposes of self-development.

Branch FOCs: AR 97–013; DBS 97–070; FA 97–037; IN 97–990; MI 97–011; MP 97–012; SP 97–005, SP 97–018, SP 97–020; TRD 97–001, TRD 97–006, TRD 97–011, TRD 97–010, TRD 97–018.

References: T.P. 525–5; T.P. 525–75, paragraph 4–2(a–f); T.P. 525–200–3.

TR 97–052, Training Aids, Devices, Simulators, and Simulations (TADSS) Fidelity Requirements. Capability to employ the minimum essential level of fidelity in TADSS to support attaining and sustaining individual and collective warfighting skills. Commanders need capability to conduct and assess training and rehearsals, using a variety of tools, appropriate for the training audience and the commander's training objectives. The Army and joint forces must determine how much fidelity is required for a given simulation, how to maximize training transfer from the simulated to real world, and how best to balance TADSS fidelity requirements with fiscal constraints (i.e., increased fidelity = increased program costs). The Army must develop and institutionalize design principles, protocols, and common operating environments for TADSS.

Branch FOCs: AR 97–013; AV 97–014; BCL 97–003; EN 97–003, EN 97–030; SP 97–005, SP 97–018, SP 97–020; TRD 97–012.

Reference: T.P. 525–5.

TR 97–053, Embedded Training and Soldier–Machine Interface. Capability to design training systems into or add training systems to operational systems to enable soldiers to train using organic equipment while in the field or at homestation. The objective embedded training system(s) will provide the cues necessary to train individual and collective skills; allow the system to participate in force-on-force exercises through embedded tactical engagement simulation and instrumentation; and interoperate with Army Battle Command System (ABCS) platforms and CTC instrumentation systems. Near-term requirements include integrating embedded training functions within current warfighting systems. Capability to provide soldiers with new equipment systems designed to optimize human performance. Soldiers must be able to use new equipment systems quickly, easily, and effectively with only the minimum essential new equipment training, sustainment training, experience using the equipment, or performance support systems. Capability must extend to operation of equipment under high workload and high stress conditions (i.e., noise, motion, sustained operations), when performance problems often occur. Training and performance support systems must also be human-engineered for ease of use by soldiers.

Branch FOCs: AD 97–005; AR 97–013, AR 97–016; AV 97–015; CM 97–001, CM 97–008; DBS 97–099; EN 97–003, EN 97–006, EN 97–030; FA 97–015; SP 97–005, SP 97–018, SP 97–020; TRD 97–013, TRD 97–008.

References: T.P. 525–5; T.P. 525–60; T.P. 525–70.

TR 97–054, Virtual Reality. Capability to use advanced simulation as a means of providing cost-effective, safe, realistic, versatile, and accessible training to achieve proficiency in critical combat skills. Numerous factors influence the requirement for this capability, including:

- Environmental constraints on training.
- Reduced range and exercise areas.
- Training safety concerns, pressure to trim OPTEMPO and ammunition budgets.
- The need to rehearse missions on the terrain and under the conditions that simulate the next deployment as closely as possible.
- The need for training to be versatile enough to change in response to quickly changing individual and collective task performance requirements.

When highly realistic training is needed to produce adequate training transfer, but field training or on-the-job training is not feasible, trainers need the capability to provide training with the required level of realism through other means. Similarly, when field training or on-the-job training can not adequately replicate the operational environment/situation soldiers are facing, trainers must have a viable alternative for provision of truly realistic training/mission rehearsal. Realistic, advanced simulation capabilities are also critical to train/mission rehearse tasks that require multiple repetitions to achieve proficiency when repetitions would not otherwise be possible. The capability to provide highly realistic training through means other than on-the-job or field training is needed in numerous areas of individual and collective skills training, including training for dismounted soldiers, maintenance training, training of equipment operation, battle staff, and small group leader training. Trainers must be capable of easily reconfiguring advanced simulations to meet training/mission rehearsal requirements of the immediate contingency. Capability to train/mission rehearse tasks realistically within advanced simulation also requires realistically simulated friendly and opposing forces.

Branch FOCs: AR 97–013, AR 97–016; AV 97–016; CH 97–003, CH 97–010; CM 97–001, CM 97–008; DSA 97–029; EN 97–003, EN 97–030; FA 97–015, FA 97–037; MI 97–011; MMB 97–020; SP 97–005, SP 97–018, SP 97–020; TRD 97–014.

References: T.P. 525–5; T.P. 525–75, paragraph 4–2 (a–f).

TR 97–055, Live, Virtual, and Constructive Simulation Technologies. Capability to provide commanders homestation and deployable training systems providing targetry, tactical engagement simulation, and training, analysis, and feedback capabilities, similar to those provided at the Army's CTCs. These systems must interoperate with CTC instrumentation systems, virtual and constructive simulation systems, and ABCS systems. Tactical engagement simulation and future CTC instrumentation systems must leverage current capabilities provided by Multiple Integrated Laser Engagement System (MILES), SAWE–RF, and MILES II; and incorporate current and future systems that must be represented in the live simulation environment (i.e., embedded training systems, electronic warfare systems, future weapons systems, and future munitions).

Branch FOCs: AR 97–013, AR 97–016; AV 97–017; CH 97–010; DSA 97–029; EN 97–003, EN 97–030; FA 97–015; MMB 97–020; SP 97–005, SP 97–018, SP 97–020; TRD 97–015.

Reference: T.P. 525–5; TRADOC Black Book No. 4, pp. 9–24.

TR 97–056, Synthetic Environment. Capability to provide training, at different levels (i.e., platoon through brigade) at different geographic locations using different simulation systems on an interactive basis. Future simulation systems, instrumentation systems, and ABCS platforms must be developed that operate (and interoperate) using common terrain, weather, and object databases; accurately represent atmospheric effects; and provide visual displays that are consistent with user requirements at all levels.

Branch FOCs: AR 97–013, AR 97–016; AV 97–018; DSA 97–029; EN 97–003, EN 97–030; MI 97–011; MMB 97–020; SP 97–005, SP 97–018, SP 97–020; TRD 97–016.

References: T.P. 525–5; 525–70; T.P. 525–75, paragraph 4–2(a–f); Black Book No. 4.

TR 97–057, Modeling and Simulation. Capability to model/simulate existing and future Army and joint forces organizations, doctrinal concepts, training systems and approaches, weapons systems, and other entities for use in training, training development, mission planning and rehearsal, combat development, materiel development, and experiments.

Branch FOCs: AD 97–013; AR 97–013, AR 97–016; AV 97–013; CM 97–001, CM 97–008; EEL 97–021; EN 97–003, EN 97–030; FA 97–015, MMB 97–018, MMB 97–020; SP 97–005, SP 97–018, SP 97–020; TRD 97–015, TRD 97–019.

References: T.P. 525–5; T.P. 525–60; T.P. 525–70; T.P. 525–200–2; TRADOC Black Book No. 4.

C. BRANCH/FUNCTIONAL UNIQUE FUTURE OPERATIONAL CAPABILITIES

Branch/functional unique FOCs are those FOC submissions that offer unique capabilities for a particular TRADOC proponent. The TRADOC proponent is responsible for ensuring the FOC is reviewed and updated annually.

1. Chaplain School

CH 97–011, Religious Support Projection. Capability to project religious support (e.g., rites, sacraments, emergency ministrations, worship, counseling, education) to soldiers positioned outside physical contact with religious support elements on a dispersed battlefield. This capability is critical to religious support for independent company-size (or smaller) units conducting split-based operations, or attached to multinational forces devoid of religious support.

Reference: T.P. 525–78.

2. Chemical School

CM 97–010, Advanced Flame and Incendiaries. The capability to employ target degrading, obscuring, and defeating advanced incendiary materials/effects throughout the battlefield. Must provide electro-optical (multispectral) obscuration and cause dissipation or attenuate other battlefield obscurants. Must be accurately deployable in a soldier—carried, mounted, dismounted, projectable or space-based configuration. Must be safely transportable and employable by a minimum of non-specialized soldiers. Must provide training munitions or simulations techniques.

References: T.P. 525–3, p. 16, paragraph 4g(4), p. 20, paragraph 4h(2)(h)(4); T.P. 525–5, p. 3–12, paragraph 3–2d; p. 3–18, paragraphs 3–3b(1)(a) and 3–3b(1)(c).

3. Combat Service Support Battle Laboratory

CSS 97–002, Containerization and Packaging. Capability to optimize package and container load configurations to cover the spectrum of distribution platforms in CONUS and in theater. Will provide cargo adaptable packaging that is recoverable, recyclable, light weight, needing little to no dunnage, and capable of being decontaminated, electronically tracked during employment and monitored for integrity and effects of adverse environmental conditions (e.g., temperature, moisture, shock).

Reference: T.P. 525–100–1, p. 11, paragraph XX.

4. Early Entry Lethality and Survivability Battle Laboratory

EEL 97–018, Rapid Insertion of Army Equipment and Aviation. Capability to self-deploy or preposition army aviation assets for rapid insertion during force projection operations.

References: T.P. 525–66; T.P. 525–200–2.

5. Engineer School

EN 97–001, Develop Digital Terrain Data. Capability to acquire, analyze, develop, update, and validate digital terrain data that provides a basic foundation for the common knowledge of the battlespace, which is scaleable, tailorable, timely, and relevant to the situation. This capability includes the ability to enrich terrain data with higher resolution feature and elevation data, from information collected throughout the battlespace by a wide variety of sensors and units.

References: T.P. 525–41, paragraphs 1–3b and 2–5; TRADOC Black Book No. 4, p. 20–25; *Joint Vision 2010*, p. 13.

EN 97–002, Common Terrain Database Management. Capability to collect, catalog, warehouse, transform, update, and distribute in real- or near-real time large quantities of digital terrain data to provide the most up-to-date information to all users. This should include procedures for tracking data lineage, synchronizing data updates from various sources, and verifying the accuracy of data updates. It also includes the ability to share data horizontally and vertically on the battlefield, and exchange data updates between terrain data producers in CONUS or the theater and the terrain data managers/users.

References: T.P. 525–41, paragraphs 1–3b, 2–4, and 2–5; TRADOC Black Book No. 4, p. 20–25; *Joint Vision 2010*, p. 13.

EN 97–014, Provide, Repair, and Maintain Logistics Facilities. Capability to procure, construct, repair, and maintain logistics facilities for supply, maintenance, and ammunition storage. This capability includes repair of damages by hostile fire and damage remediation.

References: FM 5–104, p. 78–84; TRADOC Black Book No. 4, p. 25; *Joint Vision 2010*, p. 24.

EN 97–015, Procurement and Production of Construction Materials. Capability to rapidly obtain a supply of suitable construction materials as a basis for constructing, maintaining, or repairing facilities in the theater of operations. This capability includes obtaining materiel through the standard military supply system, procurement from local manufacturers or producers, and extracting local natural resources or local military processing. Local extraction requires the ability to excavate, load, and transport natural raw materials from borrow pits; establish quarries to recover rock by drilling and blasting; or conduct logging operations. Local processing of materials requires the ability to crush, screen, and wash rock to specific size and gradation needed for asphalt and concrete; mix and transport asphalt; and produce, mix, and transport concrete.

References: FM 5–104, p. 7–14; *Joint Vision 2010*, p. 24.

EN 97–026, Fire Protection. Capability to provide rapid firefighting and emergency rescue to high-risk supply facilities, forward area rearm and refuel points, and Army aviation facilities, and provide knowledge and expertise in fire prevention.

EN 97–028, Engineering Support to Nonmilitary Operation. Capability to provide engineering services to humanitarian operations, relief to natural or manmade disasters, and support to civil authorities. Includes counter-drug operations and post-conflict remediation.

References: TRADOC Black Book No. 4, p. 16; Joint Pub. 4–04.

6. Finance

FI 97–001, Military Pay. Capability to quickly establish a client/server automation system in finance units at echelons detachment and above. System will need to provide the capability to locally produce leave and earning statements, and query and update military pay records for all services. It will also be compatible with automated identification technology (MARC and others). The future system will be integrated with Adjutant General School (personnel) databases. It will allow for split-based operations (Split Operations) resulting in the smallest possible PSS footprint on the battlefield.

Reference: T.P. 525–200–6, p. 6 paragraph 3–3c.(2), p.7, paragraph 3–3c.(3).

FI 97–002, Civilian Pay. Capability to quickly establish a client/server automation system in finance units at echelons detachment and above. System will need to provide the capability to query and update DoD civilian employee pay records. The future system will be compatible with automated identification technology and will support all future Defense Finance and Accounting Service (DFAS) developed software. This system promotes split operations by limiting the need to deploy DFAS assets.

Reference: T.P. 525–200–6, p. 6, paragraph 3–3a.

FI 97–005, Travel Support. Capability to quickly establish an automation system capable of standalone or client/server operations at echelons battalion and above. The system will allow deployed personnel to provide travel support to service members and civilians. It must have the capability to process travel advances made during noncombatant evacuation operations. This includes instances when the State Department issues noncombatant evacuation orders for U.S. citizens in the host nation or target country. The system must be capable of recording all travel settlements, and advances and travel. The future system must also capture all cost associated with authorized travel and update appropriate resource management and pay databases via digital communications.

FI 97–006, Disbursing. Capability to quickly establish an automation system capable of standalone or client/server operations at echelons detachment and above. The system would track all disbursements (cash, check, foreign currency, or EFT) and collections. The future system must be compatible with automated identification technology and be fully integrated with pay and RM systems.

FI 97–007, Accounting. Capability to quickly establish a network of accounting computers using wireless communications technologies at echelons above battalion. The system will capture the use of all appropriated and nonappropriated funds. The timely accurate accounting data provided by this system will help commanders meet their responsibility for stewardship of public resources. This data will help ensure rapid and accurate reimbursement of OMA funds used to finance deployments. This system will be fully integrated with DFAS and supports split operations.

7. Medical

MD 97–001, Patient Evacuation. Required capability of the Army Medical Department (AMMED) is to provide a seamless air and ground medical evacuation system throughout the operational spectrum. The system must have the capability to provide continuous support in all environmental conditions, communicate with supporting and supported units, maintain situational awareness on the future digitized battlefield, be modular in design, and possess the capability to provide state-of-the-art medical care compatible with the medical structure on the battlefield. Medical evacuation provides a means of reducing morbidity and mortality through timely movement of casualties under continuous medical supervision and care. Furthermore, the system must allow for coordination, integration, and be compatible with joint and combined forces. Medical evacuation must be capable of operating in an NBC contaminated environment.

Aeromedical Evacuation—The changing nature of modern warfare demands that medical evacuation platforms have communication, navigation, and situational awareness capabilities compatible with the forces they support. It also demands the medical capability to provide treatment and sustain casualties during evacuation over greater distances. Future aeromedical evacuation platforms must have the capability to visually acquire patients at night or during periods of degraded visibility, and positively identify casualty and casualty pickup points, as well as maintain threat avoidance. As future options force the Army to leave large hospitals in the rear and push resuscitative surgery forward, aeromedical evacuation aircraft must be capable of providing enhanced en route medical care and monitoring capabilities. Medical evacuation aircraft must possess the capability to effectively operate on the future digitized battlefield.

Ground Evacuation—Capabilities required in the future ground medical evacuation platforms include expansion of treatment space for the medical attendant to provide en route care, ability to keep pace with the supported force, accessible storage of medical equipment, and improved medical capabilities of the vehicle. Those capabilities include an on board oxygen production unit, a medical suction system, improved litter configuration, and provisions for a medical mentoring system. Capabilities required in the treatment role include providing adequate space and equipment configuration for a trauma treatment team to provide care to combat casualties inside of the vehicle under the protection of armor.

References: T.P. 525–50, paragraphs 2–3d(1), 3–1, and 3–3b.

MD 97–004, Combat Health Support in a Nuclear, Biological, and Chemical Environment. Capability required to perform medical support operations in NBC environments. Medical doctrine needs to incorporate the full range of NBC threat, from peacetime regulatory limits to all out war. NBC environments seriously degrade the ability to triage, diagnose, and treat casualties while in protective posture. Each NBC hazard presents unique, well-documented injuries, but when used in combination or combined with conventional insults or disease nonbattle injuries, the injuring effects are not fully understood.

References: FM 3–5, Chapter 9; FM 8–10–7; T.P. 525–50, paragraph 2–2d; Medical Readiness Strategic Plan–2001, Chapter 12.

MD 97–005, Far-Forward Surgical Support. Capability to provide forward deployed emergency resuscitative surgery across the range of military operations, to include NBC environments. Capability to project surgery forward increases as a result of the extended battlefield. Capability to provide urgent resuscitative surgery for casualties who require surgical stabilization prior to further evacuation.

Capability to provide improved shelter systems that allow for both tactical and strategic deployability, quick set-up, and a rapid-response surgical capability under environmentally controlled conditions.

Reference: T.P. 525–50, paragraph 3–3c.

MD 97–006, Hospitalization. Capability to provide full hospital care across the range of military operations, to include NBC environments. Hospital personnel must provide definitive care for return to duty or stabilizing care for evacuation out of theater to an increasingly diverse population of deployed personnel from all the uniformed and government services. In addition, combat hospitals must care for refugees and displaced civilians as the result of combat, civil strife, or natural disasters. Required capabilities include inpatient care, outpatient care, and consultant services in the medical, surgical, obstetrical, gynecological, pediatric, geriatric, and NBC arenas. Combat hospitals must organize as effectively augmented, fully functional modules to rapidly deploy and operate forward, independently of the main hospital unit.

Clinical systems such as cardiac resuscitation, ventilation management, intravenous fluid administration and surgery, and anesthesia equipment must all possess the capability to keep pace with deployability requirements as well as the ever increasing disease and injury spectrums found in the area of operation. Integral to clinical systems are the skills of the hospital staff themselves. Senior medical leadership must possess the capability of staffing combat hospitals with personnel who demonstrate the unique skills needed for the particular type of mission. Future capabilities of all hospital personnel must include keeping pace with changing mission requirements, functioning in an NBC environment, and caring for decontaminated NBC casualties.

Reference: T.P. 525–50, paragraph 3–3c.

MD 97–007, Preventive Medicine. Capability to improve soldier sustainability through the prevention of endemic diseases; injury from radiation environmental, occupational, and CB warfare agent hazards; or from combat stresses. It must be capable of deploying a modular support package to provide comprehensive support, adaptable to a full range of military operations. Will provide rapid and comprehensive environmental and occupational monitoring to assess acute and chronic health risks encountered during military operations. Will provide versatile, mobile, and enhanced disease vector control support to reduce vector-borne diseases in a theater of operations. Must be capable of integrating disease surveillance from the forward line of troops to CONUS.

References: T.P. 525–5, paragraph 2–1a(8); T.P. 525–50, paragraph 2–2d.

MD 97–008, Combat Health Logistics Systems (CHLS) and Blood Management. Capability to support force projection Army in multiple locations through split-based operations. The CHLS must be modular in design and anticipatory to provide the necessary flexibility and mobility. Division-level class VIII support includes receipt, storage, processing, disposal, and distribution of medical materiel; unit-level medical maintenance; receipt of type O red blood cells; and single optical fabrication and repair. Corps and echelons above corps support includes receipt, storage, processing, contracting, disposal, and distribution of medical materiel, unit and direct support/general support level medical maintenance; blood distribution and the limited capability to collect blood; single and multivision optical fabrication and repair; medical gas distribution; and the building of medical assemblages/resupply packages. The CHLS must centrally manage critical class VIII items, patient movement items, blood products, medical maintenance, and class VIII contracting. It must be capable of coordinating logistics and transportation support with nonmedical logistics organizations for all medical logistics activities within an area of operations. It must be able to support reception operations for prepositioned afloat medical materiel at ports of debarkation. The CHLS must employ state-of-the-art standardized medical logistics information management and communication systems to facilitate total asset and in-transit visibility, automated transmission of optical fabrication requests, management of blood and blood products, management of medical equipment readiness, and management of captured enemy medical materiel and equipment. These systems must be compatible with and connected to all services to accomplish the single integrated medical logistics management mission of the AMMED.

Reference: T.P. 525–50, paragraph 3–3d(1–3).

MD 97–009, Combat Stress Control (CSC). Capability to deploy small stress control (mental health) teams routinely to all battalion and company-sized units, at all echelons, across the continuum of operations from combat to unit field training, garrison, and unit family support. Corps-level CSC units' teams will augment officer/NCO teams organic to forward support and area support medical companies. All these teams provide ongoing command consultation, education, stress monitoring, unit surveys, critical event debriefings, reconstitution support, DoD-mandated medical and stress surveillance, and other unit-level interventions. They will help the command sustain operation performance of crucial weapons and logistics systems, and prevent stress-induced error, disability, and misconduct (primary prevention). Stress control teams will be linked with a Human Dimension Team (organic to Corps Medical Command) to magnify preventive capability. The same stress control teams have the capability for task organization to provide restoration treatment near stress casualties' units for quick return to duty (second prevention), and echelon reconditioning treatment to maximize return to duty and prevent chronic disability (tertiary prevention).

References: T.P. 525–50, paragraph 3–3h and Annex I.

MD 97–010, Medical Laboratory Support. Medical laboratories must be modular in design to provide the necessary flexibility and tailorability to support split-based operations and deployment as functional emulative increments. The medical laboratory system must provide a seamless continuum of functional capability across the entire range of military operations with the level of capabilities and sophistication increasing with each successively higher echelon of care. Far-forward medical laboratory support at the division requires limited, rapid laboratory procedures to support patient stabilization, resuscitation, and advanced trauma management of combat casualties. Additional blood gas and chemistry capabilities are needed to augment basic manual laboratory procedures currently performed by laboratory personnel assigned to divisional/nondivisional medical companies. Equipment and rapid diagnostic tests are needed to provide point-of-care laboratory support for blood gas, basic hematology, and limited urinalysis testing at division-level forward surgical teams. These laboratory procedures will be performed by nonlaboratory personnel assigned to the forward surgical team and will require remote monitoring by qualified laboratory personnel. Additional anatomic pathology and clinical reference laboratory capabilities can be added to a corps or echelons above corps hospital with the attachment of a theater level pathology augmentation team. Medical equipment sets for the pathology augmentation team must be developed to support the additional capabilities for anatomic pathology and more definitive chemistry and microbiology procedures. Independent of the corps and echelons above corps hospital laboratories, the Area Medical Laboratory is a theater-level unit that will focus on the assessment and field confirmation of health threats to forces in the area of operation posed by endemic diseases, occupational and environmental health hazards, radiation hazards, and CB warfare agents. It must have equipment that is state of the art and readily upgradeable to keep abreast of new and emerging technologies that arise in the R&D community. A specialized biocontainment shelter system must be developed for the Area Medical Laboratory to provide a safe, environmentally-controlled working environment for the handling and analysis of highly infectious pathogens and hazardous materials.

Reference: T.P. 525–50, paragraph 3–3j.

MD 97–011, Dental Service. Capability to provide emergency, preventive, general, and specialty dental care throughout the full range of military operations. Capability to insure the highest level of soldier oral health prior to deployment. This requires the ability to provide dental care on a sustained basis for all of America's Army. America's Army is composed of the Active Army, the National Guard, and the Reserve Component. Capability of providing far forward dental services to small and forward deployed troop concentrations. This far forward care will result in the early treatment of dental emergencies, the immediate return of the soldier to duty, and minimal evacuations of dental emergencies to the rear. These teams will augment and reconstitute division dental assets as necessary. Capability to amplify and augment medical assets during combat and mass casualty situations. This includes, but is not limited to, Advanced Trauma Management, augmentation of anesthesia teams, wound closure, and first aid. This alternative wartime capability will reduce battlefield morbidity and mortality.

References: T.P. 525–5, paragraphs 1–2a(2), 1–2b(3)(b), 1–2d, 1–2e, 1–3, 1–3a, 1–3b, 2–6, 2–3b(2), 3–1a, 3–1a(2), 3–1a(3)(5), 3–1b, 3–2a(1), 3–2a(5), 3–2e, 4–1c, 4–1d, and Figures 1–2 and 2–4,line 1; T.P. 525–50, paragraphs 2–3a, 2–3d(2), 2–3e, 3–1, 3–2c, 3–2e, and 3–3a(2).

MD 97–012, Veterinary Services. Capability to deploy personnel/teams to provide theater-level veterinary services and support. Support includes health and treatment of government animals; food hygiene, safety, and quality assurance for subsistence at the point of origin and for DoD operational rations; inspections of commercial food, water, and ice establishments; and surveillance for NBC contaminated subsistence. These teams must have the capability to task organize and deploy modules for short duration in support of civil operations.

References: T.P. 525–5, paragraphs 1–3, 1–3b, 3–2a(5), and 4–4; T.P. 525–50, paragraph 2–3c(1)(2).

8. Ordnance School

OD 97–016, Tool Improvement. Capability to repair Army equipment using fewer, improved, multipurpose hand tools, and portable test equipment. Will provide test equipment and tools that are multicapable, portable, multisystem, possess an open architecture to facilitate upgrades, and incorporation of new technology.

Reference: T.P. 525–200–6.

9. Quartermaster School

QM 97–010, Mortuary Affairs. Capability to provide rapid identification and evacuation of human remains. Will provide rapid automated identification, location, and evacuation of human remains.

Reference: T.P. 525–200–6, paragraph 4–6a.

10. Space

SP 97–021, Space Control. An offensive and defensive capability is required to allow U.S. forces to gain and maintain control of activities conducted in space. This capability is designed to prevent an enemy force from gaining an advantage from space systems and space capabilities, and protect U.S. forces' ability to conduct military operations. Capabilities to conduct surveillance and protect U.S.

space systems are required. Measures to deceive, disrupt, degrade, or destroy threat space systems, segments, or infrastructure are required to support force projection operations. Depending on operational considerations, nonlethal means of denying threat satellites may be required for certain orbits or portions of orbits, and to minimize generation of space debris. The ability to achieve and maintain space control is required from both terrestrial and space locations. A U.S. infrastructure providing support for space control operations is a required capability.

Reference: T.P. 525–60, Chapter 3.

D. ABBREVIATIONS

3D	three dimensional
ABCS	Army Battle Command System
ACT II	Advanced Concepts and Technology II
AD	Air Defense School
AMMED	Army Medical Department
AR	Armor School
ASTMP	*Army Science and Technology Master Plan*
ATD	Advanced Technology Demonstration
AV	Aviation School
BAA	broad agency announcement
BCG	Battle Command (Gordon) Battle Laboratory
BCL	Battle Command (Leavenworth) Battle Laboratory
BCST	battle command support team
BLITCD	Battle Laboratory Integration, Technology, and Concepts Directorate
C^2	command and control
C^2W	command and control warfare
C^3	command, control, and communications
C^4I	command, control, communications, computers, and intelligence
CB	chemical and biological
CH	Chaplain School
CHLS	Combat Health Logistics Systems
CI	Civilian Internee
CM	Chemical School
CONUS	continental United States
CP	Command Post
CSC	Combat Stress Control
CTC	combat training center
DBS	Dismounted Battlespace Battle Laboratory
DFAS	Defense Finance and Accounting Service
DSA	Depth and Simultaneous Attack Battle Laboratory
EELS	Early Entry, Lethality, and Survivability Battle Laboratory
EN	Engineer School

EPW	Enemy Prisoner of War
ET	Embedded Training
FA	Field Artillery School
FI	Finance School
FOC	Future Operational Capability
HQ	Headquarters
IFF	identification friend or foe
IN	Infantry School
KIA	killed-in-action
LOC	lines of communication
MD	Medical Department
MI	Military Intelligence School
MILES	Multiple Integrated Laser Engagement System
MMB	Mounted Maneuver Battle Laboratory
MP	Military Police School
MSB	Maneuver Support Battle Laboratory
NBC	nuclear, biological, and chemical
NCO	noncommissioned officer
OD	Ordnance Corps School
OTM	on the move
QM	Quartermaster School
R&D	research and development
S&T	science and technology
SC	Signal Corps School
SP	Space Operations
STO	Science and Technology Objective
TADSS	training aids, devices, simulators, and simulations
TC	Transportation Corps School
TOC	Tactical Operation Center
T.P.	TRADOC pamphlet
TR	TRADOC
TRADOC	Training and Doctrine Command
TRD	training research and development
UXO	unexploded ordnance

ANNEX D

SPACE AND MISSILE DEFENSE TECHNOLOGIES

CONTENTS

ANNEX D

SPACE AND MISSILE DEFENSE TECHNOLOGIES

A. PURPOSE

This annex describes space and missile technology developments that support the needs that are documented in *Joint Vision 2010, Army Vision 2010, U.S. Space Command Vision for 2020,* and insights emerging from the *Army After Next* (AAN) process. It provides a technology development roadmap to meet the evolving needs for joint operations of the warfighter out to 2015. It also provides an overview of the Program Executive Office—Air Missile Defense (PEO–AMD) system elements and the associated technology programs that address the needs of the system elements. The objective is to provide the Army position for missile defense and space technology, needs, and requirements.

The near-term technologies support ongoing programs that typically provide a risk mitigation alternative to the program managers and cover up to 5 years. Mid-term technologies addressing preplanned product improvement (P^3I) and next-generation efforts to counter known threats are also included under the near-term technologies. Far-term technologies are initiatives that typically address future operational capabilities (FOCs) and projected/evolving threats and focus on the efforts with payoffs 5 years and beyond.

B. INTRODUCTION

On October 1, 1997, the Army Space and Strategic Defense Command (SSDC) was reorganized to become the Space and Missile Defense Command (SMDC). The reorganization recognizes the command's expanding role in Army space and missile defense areas and better postures the Army to meet space and missile defense needs for *Joint Vision 2010, Army Vision 2010,* and *U.S. Space Command Vision 2020,* as well as insights emerging from the *Army After Next* process. A memorandum of agreement (MOA) between the Army's Training and Doctrine Command (TRADOC) and SMDC was signed in February 1997. This MOA established SMDC as the Army's specified proponent for space and national missile defense (NMD) issues and the lead for integration of TRADOC theater missile defense (TMD) issues; identified SMDC as the Army lead for the generation and definition of space and national defense requirements, and authorized SMDC to establish a space and missile defense battle laboratory to develop warfighting concepts, focus military science and technology (S&T) research, and conduct warfighting experiments. The SMDC has a unique role as technology developer and integrator, combat developer, materiel developer, tester, evaluator, and operational commander.

In response to the expanded role of the command, SMDC has outlined four goals of the reorganized command. These goals encompass the major themes for Army space and missile defense modernization. Progress towards the goals will enable the joint and army visions of warfighting in the 21st century. The goals are:

- Robust space integration into full-spectrum land force operations
- Global, multielement missile defense

- Progressive space and missile defense technology for land forces
- Anticipatory space partnerships.

Missile Defense and Space Technology Center (MDSTC), Huntsville, Alabama. The MDSTC is the nation's hub of Army missile defense technology excellence. In addition to advancing missile defense technologies in support of organizations such as the Ballistic Missile Defense Organization (BMDO), it places renewed emphasis on space technology development. The MDSTC enables FOCs in space and missile defense and will continue to develop opportunities for international cooperation as well as partnerships with academia, industry, and other government organizations.

Space and Missile Defense Battle Laboratory (SMDBL), Huntsville, Alabama. The SMDBL will conduct warfighting experiments, develop and use space missile defense modeling and simulation (M&S) tools, support Army and other major exercise and training activities, and conduct studies and analyses on issues relevant to the battle laboratory. This effort is the heart of the Army space and missile defense requirements determination process. Progressive and iterative mixtures of constructive, virtual, and live simulations will be used, incorporating soldiers and units. The warfighting insights developed from this process will serve as way points to plot the Army's future space and missile defense course.

The SMDBL synthetic battlefield environment (SBE) will support space and missile defense live-virtual-constructive experiments in the domains of advanced concepts and requirements (ACRs); training, exercises, and military operations (TEMO); and research, development, and acquisition (RDA). The SBE architecture will be holistic, allowing operators, combat and materiel developers, technology developers, and testers to examine doctrine, training, leader development, organization, materiel, and soldiers (DTLOMS) requirements in a virtual environment.

The SMDBL will work in close coordination with the TRADOC Analysis Center, Operational Test and Evaluation Command (OPTEC), the S&T community, the joint test community, TRADOC battle laboratories, and battle laboratories of other services.

Army Space Command (ARSPACE), Colorado Springs, Colorado. The ARSPACE will conduct space and missile defense operations supporting U.S. Space Command and other joint forces and commands. ARSPACE will represent the Army in the space planning and requirements system process. In addition, ARSPACE will coordinate plans for Army national missile defense, including plans for fielding and operating a national missile defense battalion. ARSPACE will maintain contact with other joint space and missile defense users to determine needs and demonstrate capabilities such as the joint in-theater injection (JITI) capability. Army space support teams will remain the Army's primary interface with the warfighter in the field. These teams will be enhanced with increasingly capable space applications developed through the SMDBL and the Space Technology Directorate (STD).

Army Space Program Office (ASPO), Fairfax, Virginia. The ASPO will provide national intelligence to the warfighter. In addition to the well-established tactical exploitation of national capabilities (TENCAP) program, SMDC will apply ASPO's TENCAP to other operational capabilities involving space and missile defense. ASPO, working in coordination with SMDBL, STD, and ARSPACE, will place emphasis on integrating space capabilities, evolving into the overall space materiel developer for the command. Initiatives such as Eagle Vision II will leverage commercial space applications for commanders in the field.

Force Development and Integration Center (FDIC), Arlington, Virginia. The FDIC's mission is to develop, coordinate, and prioritize Army actions associated with space and missile defense combat and materiel development. The FDIC will integrate and synchronize space and missile defense

DTLOMS solutions across the Army and, as appropriate, among joint warfighters. The FDIC will determine requirements to integrate solutions horizontally and vertically. To coordinate externally, SMDC will exchange liaison officers with appropriate organizations. In some cases, this liaison is already in place (TRADOC and U.S. Space Command, for example). Identifying additional liaison requirements is a priority.

Space Technology Directorate (STD), Huntsville, Alabama. The STD, organized within MDSTC, will identify space technologies and applications developed by the Army and other agencies. The STD will develop a long-range space research and development program. This program will focus Army space technology on space future warfighting concepts and space operational capabilities. It will review space technology initiatives in cooperation with the SMDBL experimentation program. The STD will emphasize horizontal technology integration and search for opportunities to leverage the technology developed outside of the Army in organizations such as BMDO, Defense Advanced Research Projects Agency (DARPA), other services, and other military and commercial technology developers.

Space and Missile Defense Acquisition Center, Huntsville, Alabama. The Space and Missile Defense Acquisition Center centralizes materiel development, testing, and evaluation. The center will develop, field, and sustain low-density space and missile defense systems for the warfighter. Initially, the center will include the National Missile Defense (Ground) Project Office, ASPO, Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) Project Office, and Targets Program Office, in addition to U.S. Army Kwajalein Atoll (USAKA) and High Energy Laser Systems Test Facility (HELSTF). The center will develop working relationships with organizations such as the Test and Evaluation Command (TECOM), OPTEC, and Communications–Electronics Command (CECOM).

U.S. Army Kwajalein Atoll (USAKA) and Kwajalein Missile Range (KMR), Republic of the Marshall Islands. The USAKA/KMR is a world-class space surveillance and missile defense test facility that provides a vital role in the research, development, test, and evaluation (RDT&E) of America's defense and space programs. The Kiernan Reentry Measurement System (KREMS) radar complex will continue to support U.S. Space Command operations, and USAKA/KMR will proactively develop additional test support initiatives. In supporting the U.S. Space Command and the Army space mission, KMR will conduct space-object identification and provide orbital information on new foreign launches.

High Energy Laser Systems Test Facility (HELSTF), White Sands Missile Range (WSMR), New Mexico. The HELSTF operates the nation's most powerful laser (mid-infrared (IR) advanced chemical laser) in support of Army and DoD laser RDT&E. It also provides test support to DoD NASA, industry, universities, and foreign governments under appropriate user agreements. The HELSTF will be a major contributor to the command's international and commercial partnership initiatives. HELSTF's capabilities will support active defense against aerospace targets, as well as initiatives such as space control and applying force into and from space.

C. REQUIREMENTS

1. Technology Drivers (Threat Summary)

This section briefly describes the missile- and space-based threats to the United States and its allies projected for the periods 1998–03 and 2004–15. Theater ballistic missiles (TBMs) are discussed first, followed by the strategic threat to the United States, cruise missiles, and, finally, space systems. Each of these sections addresses threat trends that will likely drive U.S. technology development.

a. Overview

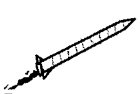
Proliferation. There continues to be a trend away from manned weapon platforms toward unmanned weapon systems (TBMs, cruise missiles, etc.) with longer range standoff capabilities. Factors motivating this trend include economics, availability, regional power struggles, and lessons from the Gulf War. (Reference 1)

Technology Trends. As a result of the increase in "dual-use" computer, electronics, and materials technologies, we anticipate technological improvements in virtually every type of weapon system. The use of global positioning systems (GPSs) for cruise missile accuracy improvements is a good example of the employment of dual-use technology to improve an existing weapon system. (References 22, 23)

Weapons of Mass Destruction (WMD). At least 20 countries have, or may be developing, nuclear, biological, and chemical (NBC) weapons and the ballistic missile systems needed to deliver them. Ten countries are reportedly pursuing biological weapons research, and at least as many are reported to be interested in developing nuclear weapons. The incorporation of these WMD munitions on various weapon platforms presents enormous challenges to defensive weapon systems designers. (References 2–4)

b. Theater Ballistic Missile Threat Overview

TBMs include ballistic missiles with ranges of less than 5,500 kilometers (km). They are surface launched, fly a ballistic trajectory that may include aimpoint corrections, and can carry conventional or WMD warheads. TBMs are typically transported and launched from a transporter-erector launcher (TEL), which provides both mobility and concealment. The threat from TBMs is real and growing. The proliferation of ballistic missile-delivered WMD is an issue directly confronting the strategic interests of the U.S. and its traditional allies. Long-range artillery rockets are included with TBMs since their size, trajectory, warheads, and target set are similar. TBM performance trends are summarized in Figure D–1. (References 1, 6)

	98 99 00 01 02 03	04 05 06 07 08 09 10	11 12 13 14 15
 TBM	• Varied trajectories • 30–1,200 km range • 35–50 m CEP • Highly survivable TELs • Limited launch indicators	• 10–2,000 km range • Expanded use of WMD • Wider proliferation • Growing use of solid propellants	• 3–5,000 km range • Improved C^3I • Specialized payloads • Low RCS
 Rocket	• 30–70 km range • 12 rockets/1.6 s firing rate • Limited launch indicators	• 30–70 km range • 12 rockets/1.6 s firing rate • Limited launch indicators	• Smart submunitions

Source: Air and Missile Defense Master Plan

Figure D–1. TBM Performance Trends

c. Strategic Threat Overview

The strategic threats to the U.S. include intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and long-range cruise missiles armed with WMD. The only current ICBM and SLBM threats to the U.S. are Russia and China. Russia possesses over 6,500 warheads mounted on 1,300 ICBMs and SLBMs. Under the provisions of the START I treaty, they must draw down inventories to less than 4,900 warheads by the year 2002, and they appear to be on schedule. If START II is ratified by the Duma, a further reduction to 3,500 warheads should occur. While China is both improving performance and the quantity of the weapons in its strategic force, Russia is the only current strategic-range cruise missile threat. The strategic threat performance summary is shown in Figure D–2. (References 1–3, 5, 7)

	97 98 99 00 01	02 03 04 05 06 07 08	09 10 11 12 13 14 15
ICBM	• Penetration aids • Mobile basing • Increased accuracy • MIRVs	• Improved reliability • Improved penaids • Tailored trajectories • Increased accuracy	• Possible proliferation
SLBM	• MIRVs	• More sophisticated payload/guidance system • Improved reliability • Increased range	• Improved penaids

Figure D–2. Strategic Threat Performance Summary

d. Cruise Missile Threat Overview

Cruise missiles are receiving increased attention as a weapon that U.S. and allied forces are likely to encounter in various situations around the world. Cruise missiles are not a new threat. They were used extensively in World War II (the German V–1), the Falklands War EXOCET, and most recently by the U.S. in the Persian Gulf War. While the majority of the current threat is designed for the antiship mission, this trend is expected to change to an emphasis on land attack cruise missiles (LACMs) in the near future. A further complication is their similarity to unmanned aerial vehicles (UAVs), which are being used more and more primarily for nonlethal missions around the world. Systems that possess antiradiation homing (ARH) capabilities are a particular concern to defensive systems. LACM and UAV performance trends are shown in Figure D–3. (References 1, 4, 5, 9–16, 20)

e. Space System Threat Overview

Virtually all countries now have some degree of access to space system resources, either by developing their own space system resources, or by purchasing, leasing, renting, or timesharing available space system assets from one of the space developer nations or consortiums. Space systems are primarily utilized for two major purposes: observation and communications, with research coming up a distant third. The two primary functions serve as major force multipliers when considered in a military perspective. The space threat to the U.S. involves any trends that increase a foreign capability to perform these functions or to impair the U.S. capability, resulting in a reduction in the degree of our infor-

	98 99 00 01 02 03	04 05 06 07 08 09	10 11 12 13 14 15
 LACM	• Low-altitude (to 50 m AGL) • All aspect flight profile • 30–3,000 km range • CEP of 2–3 m • Land attack versus individual tank	• Improved guidance/ propulsion • Altitude down to 30 m AGL • CEP of 1 m • Dual mode seekers	• Very Low RCS • Greater accuracy • Smart munitions
 UAV	• Real-/near-real time recon • Decoy capabilities • Antiradar	• More sophisticated payload/guidance system • Night and multimission systems • RCS down to 0.01 m–sq	• Longer ranges • Smaller RCS/airframes • Laser designators/ rangefinders

Source: Air and Missile Defense Master Plan

Figure D–3. LACM and UAV Performance Trends

mation superiority. The importance of this superiority was illustrated by the fact that the denial of access to space-based information by Iraq was considered a major factor in the overall campaign success of Operation Desert Storm. Threat trends involving employment of space systems and antisatellite (ASAT) threats to U.S. space assets are summarized below in Figure D–4. (References 1, 5, 8, 17–19, 21)

	98 99 00 01 02 03	04 05 06 07 08 09 10 11 12 13 14 15
Satellite	• Communications • Imaging products • Scientific • On-orbit delivery • Indigenous	• Proliferation • Tape drop • NRT downlink
ASAT	• Co-orbital system • Nuclear direct ascent	• Conv direct ascent • HEL • Space mine

Source: Air and Missile Defense Master Plan

Figure D–4. Space System Performance Trends

2. Linkage of Technology to Future Operational Capabilities

FOCs provide fundamental guidance for S&T work based on warfighting requirements. Throughout this document every opportunity will be made to link technology to the fundamental needs of the warfighter as expressed in the FOCs. It is important to understand what constitutes warfighting requirements: it is a change to any of the current DTLOMS systems needed to achieve a desired future operational capability. Consulting a number of different areas—including concept development, S&T research, warfighting experimentation, and the existence of urgent and immediate operational needs—will now derive the new requirements. The requirements are determined throughout the Army but documented and defended primarily at TRADOC schools and Battle Labs. A crosswalk of FOCs to SMDC technologies is provided in Table D–1.

Table D–1. FOC/Technology Crosswalk

Technology Area	Future Operational Capabilities (May 1997)	
	Kinetic Energy Weapon Technology	
Hit-to-Kill Miniature Interceptor	TR97–040 Firepower Lethality AD97–003 Munitions	DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Exoatmospheric Interceptor Technology	TR97–040 Firepower Lethality	
Pilot Line Experiment Technology	AR97–001 Mounted Firepower AV97–006 Weapons Suite	DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Focal Plane Array Technology	AR97–001 Mounted Firepower AV97–006 Weapons Suite DSA 97–002 Smart & Brilliant Munitions for Deep Attack	DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Advanced Discriminating LADAR	AR97–001 Mounted Firepower AV97–006 Weapons Suite	DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Signal/Data Processor	AD97–006 Classification, Discrim, ID, & Correlation of Information AR97–001 Mounted Firepower AR97–004 Mounted Target Acquisition & ID AV97–006 Weapons Suite	DSA 97–002 Smart & Brilliant Munitions for Deep Attack DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Algorithm Development	AD97–006 Classification, Discrimination, ID, & Correlation of Information AR97–001 Mounted Firepower AR97–004 Mounted Target Acquisition & ID AV97–006 Weapons Suite	DSA 97–002 Smart & Brilliant Munitions for Deep Attack DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Inertial Measurement Unit	DSA97–003 TMD	DSA97–028 Missile Defense of the U.S.
Control System	AD97–002 Mobility	
Booster Development	AD97–002 Mobility AD97–012 Counter Aerial & Space-Based RISTA DSA97–001 Extended Ranges of Deep Attack Systems	DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Power Development	DSA97–003 TMD	DSA97–028 Missile Defense of the U.S.
Warhead Development	AD97–002 Mobility AD97–003 Munitions AV97–006 Weapons Suite DSA97–001 Extended Ranges of Deep Attack Systems	DSA 97–002 Smart & Brilliant Munitions for Deep Attack DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Endoatmospheric Interceptor Technology	AD97–012 Counter Aerial & Space-Based RISTA Platforms	DSA97–003 TMD DSA97–028 Missile Defense of the U.S.
Millimeter-Wave Component	AV97–006 Weapons Suite DSA97–003 TMD	DSA97–028 Missile Defense of the U.S.
Window Technology Development	DSA97–003 TMD	DSA97–028 Missile Defense of the U.S.
Composite Airframe & Structure	AD97–002 Mobility AD97–003 Munitions AD97–012 Counter Aerial & Space-Based RISTA Platforms AV97–006 Weapons Suite	DSA97–001 Extended Ranges of Deep Attack Systems DSA97–019 Enhanced Mobility for TMD & Precision Strike Attack Systems DSA97–003 TMD DSA97–028 Missile Defense of the U.S.

Table D–1. FOC/Technology Crosswalk (continued)

Technology Area	Future Operational Capabilities (May 1997)	
Poly Acrylonitrile Fiber	DSA97–003 TMD	DSA97–028 Missile Defense of the U.S.
SHORAD With Optimized Radar Distribution	TR97–040 Firepower Lethality AD97–002 Mobility AD97–003 Munitions AV97–006 Weapons Suite DSA97–001 Extended Ranges of Deep Attack Systems	DSA 97–002 Smart & Brilliant Munitions for Deep Attack DSA97–003 TMD DSA97–018 Rapidly Deployable Attack Systems
Sensors Technology		
CO_2 LADAR Development Programs	TR97–002 Situational Awareness AR97–004 Mounted Target Acquisition & ID AR97–009 Mtd Standoff Minefield AV97–006 Weapons Suite AV97–007 Survivability	DSA97–003 TMD DSA97–021 Sensors DSA97–024 Sensor to Shooter Linkages EEL97–026 Space-Based Early Warning
Advanced Radar Technology Program	TR97–002 Situational Awareness TR97–006 Combat ID AV97–011 Aviation Battle Command DSA97–003 TMD DSA97–004 Survivability of Deep Attack Systems	DSA97–010 Day/Night, All-Weather Sensors DSA97–011 Rapid ID & Location of Passive Targets DSA97–021 Sensors DSA97–028 Missile Defense of the U.S.
Focal Plan Array Processing & Packaging Development	AR97–001 Mounted Firepower AR97–004 Mounted Target Acquisition & ID AV97–006 Weapons Suite DSA97–003 TMD DSA97–010 Day/Night, All-Weather Sensors	DSA97–011 Rapid ID & Location of Passive Targets DSA97–021 Sensors DSA97–028 Missile Defense of the U.S. EEL 97–026 Space-Based Early Warning
Multimission Sensor Suite	TR97–002 Situational Awareness TR97–006 Combat ID TR97–020 Information Collection, Dissemination, & Analysis TR97–021 Real-Time Target Acquisition, ID, & Dissemination AD97–006 Classification, Discrimination, ID, & Correlation of Information AD97–007 Sensors	AR97–006 Situational Awareness DSA97–003 TMD DSA97–010 Day/Night, All-Weather Sensors DSA97–011 Rapid ID & Location of Passive Targets DSA97–021 Sensors DSA97–028 Missile Defense of the U.S. EEL 97–026 Space-Based Early Warning
Phenomenology		
Phenomenology Analysis & Algorithm Development Program	AD97–006 Classification, Discrimination, ID, & Correlation of Information DSA97–003 TMD	DSA97–004 Survivability of Deep Attack Systems
Phenomenology Experiments Program	AD97–006 Classification, Discrimination, ID, & Correlation of Information DSA97–003 TMD	DSA97–004 Survivability of Deep Attack Systems
BM/C^4I		
Integrated Operational Airspace Management System (IOAMS)	TR97–001 Command & Control TR97–002 Situational Awareness TR97–005 Airspace Management AD97–002 Mobility AR97–007 C&C On the Move	AV97–006 Weapons Suite BCG97–001 Battlefield Information Passage BCL97–013 Information Protection AV97–011 Aviation Battle Command DSA97–017 Terrain Independent Communications & Information Distribution

Table D–1. FOC/Technology Crosswalk (continued)

Technology Area	Future Operational Capabilities (May 1997)	
Free Space Laser Communications	TR97–007 Battlefield Info Passage SP97–001 Space Sensors Linked with Terrestrial Systems SP97–102 Survivable Systems with Low Probability of Intercept/Detection SP97–011 Real-Time Dissemination Systems	SP97–012 Survivable Systems with Low Probability of Intercept/Detection AD97–004 Fused & Correlated Situational Awareness BCG97–008 Information Protection
BM/C^{3}I Technology	TR97–XX Command & Control (ALL) TR97–XX Information Management (ALL) AD97–004 Fused & Correlated Situational Awareness AD97–005 Decision Support Software & Tactical Planning Aids SP97–001 Space Sensors Linked with Terrestrial Systems SP97–003 NBC Threats & TM Attack Warning SP97–009 Real-Time Dissemination Systems	SP97–020 Missile Defense BCG98–001 Battlefield Information Passage BCL97–003 Decision Planning Support AD97–005 Decision Support Software & Tactical Planning Aids AD97–006 Classification, Discrimination, ID, & Correlation of Information AR97–007 C&C On the Move AV97–003 Mission Planning & Rehearsal AV97–012 Airspace Management
Survivability and Lethality		
Survivability	TR97–043 Survivability—Materiel AD97–008 Air Defense Systems Survivability AV97–007 Survivability	DSA97–003 Theater Missile Defense DSA97–004 Survivability Of Deep Attack Systems SP97–020 Missile Defense
Lethality	TR97–040 Firepower Lethality AR97–001 Mounted Firepower AV97–006 Weapons Suite	BCL97–012 Information Attack DSA97–003 TMD SP97–020 Missile Defense
Modeling and Simulation		
Modeling & Simulation	TR97–003 Mission Planning & Rehearsal TR97–047 Leader & Commander TR97–054 Virtual TR97–055 Live, Virtual, & Constructive Simulation Technologies TR97–057 Modeling & Simulation	AD97–013 Live Virtual Battlefield Description AV97–013 Systematic Upgrade of Constructive Combat Development Models AV97–016 Virtual Reality; Interactive Training Capabilities in Synthetic Environment Systems
Targets, Test, and Evaluation		
Future Test Target Requirements	TR97–040 Firepower Lethality AD97–002 Mobility AD97–003 Munitions	DSA97–028 Missile Defense of the U.S. SP97–020 Missile Defense
Directed-Energy Weapons Technology		
Solid-State Laser Technology	TR97–040 Firepower Lethality SP97–020 Missile Defense SP97–021 Space Control BCL97–012 Information Attack	DSA97–003 TMD DSA97–026 Alternative Attack Systems DSA97–028 Missile Defense of the U.S.
Hydrogen Fluoride Overtone Technology	AR97–004 Mounted Target Acquisition & ID BCL97–012 Information Attack DSA97–003 TMD	DSA97–026 Alternative Attack Systems DSA97–028 Missile Defense of the U.S. DSA97–030 Counter RISTA
Materials and Components Technology		
Microelectronics/Optics Program	SP97–006 Robust Architecture to Overcome Degradation Factors SP97–020 Missile Defense AD97–013 Live Virtual Battlefield Description AR97–001 Mounted Firepower AV97–006 Weapons Suite	DSA97–002 Smart & Brilliant Munitions for Deep Attack DSA97–003 TMD DSA97–004 Survivability of Deep Attack Systems DSA97–028 Missile Defense of the U.S.

Table D–1. FOC/Technology Crosswalk (continued)

Technology Area	Future Operational Capabilities (May 1997)	
Innovative Radar Components Research	TR97–002 Situation Awareness TR97–005 Airspace Management TR97–006 Combat ID AD97–007 Sensors AD97–011 Early Warning DSA97–003 TMD DSA97–004 Survivability of Deep Attack Systems	DSA97–010 Day/Night, All-Weather Sensors DSA97–011 Rapid ID & Location of Passive Targets DSA97–021 Sensors DSA97–028 Missile Defense of the U.S. DP97–002 Sensors to Detect Passive & Active Targets SP97–020 Missile Defense
Operations Research and Systems Analysis		
TEL Hunter/Killer	TR97–040 Firepower Lethality AD97–002 Mobility AR97–004 Mounted Target Acquisition & ID AV97–006 Weapons Suite DSA97–001 Extended Ranges of Deep Attack Systems	DSA97–002 Smart & Brilliant Munitions for Deep Attack DSA97–010 Day/Night, All-Weather, All Terrain Sensors DSA97–025 Sensor to Shooter Linkages
Advanced Technology Demonstrations		
JLENS Program	TR97–002 Situation Awareness TR97–006 Combat ID TR97–020 Information Collection, Dissemination, & Analysis TR97–021 Real-Time Target Acquisition, ID, & Dissemination AD97–007 Sensors AD97–011 Early Warning AR97–006 Situation Awareness	AV97–006 Weapons Suite DSA97–003 TMD DSA97–004 Survivability of Deep Attack Systems DSA97–011 Rapid Location & ID of Passive Targets DSA97–021 Sensors DSA97–024 Beyond the Visual Range ID DSA97–28 Missile Defense of the U.S.
Kinetic Energy Antisatellite Program	TR97–040 Firepower Lethality AD97–008 Air Defense Systems Survivability AD97–012 Counter Aerial & Space-Based RISTA Platforms	BCL97–012 Information Attack DSA97–030 Counter RISTA SP97–021 Space Control
Advanced Concept Technology Demonstrations		
Tactical High Energy Laser (THEL)	TR97–040 Firepower Lethality AD97–002 Mobility AD97–012 Counter Aerial & Space-Based RISTA Platforms AR97–001 Mounted Firepower BCL97–012 Information Attack DSA97–018 Rapidly Deployable Attack Systems	DSA97–019 Enhanced Mobility for TMD & Precision Strike Attack Systems DSA97–026 Alternative Attack Systems DSA97–028 Missile Defense of the U.S. DSA97–030 Counter RISTA SP97–021 Space Control
Science and Technology Objectives		
Laser Communications	TR97–001 Command & Control TR97–007 Battlefield Information AD97–007 Sensors AV97–006 Weapons Suite AV97–011 Aviation Battle Command	DSA97–003 TMD DSA97–010 Day/Night, All-Weather SP97–001 Space Sensors Linked with Terrestrial Systems SP97–009 Real-Time Dissemination Systems

Table D–1. FOC/Technology Crosswalk (continued)

Technology Area	Future Operational Capabilities (May 1997)	
Laser Boresight (LLYNX–EYE)	TR97–002 Situational Awareness TR97–006 Combat ID TR97–020 Information Collection AD97–004 Fused & Correlated Situational Awareness AD97–006 Classification, Discrimination, ID, & Correlation of Information AR97–004 Mounted Target Acquisition & ID AR97–006 MF Situation Awareness AV97–006 Weapons Suite	AV97–011 Aviation Battle Command DSA97–008 Real-Time Seamless National Targeting Dissemination DSA97–010 Day/Night, All-Weather, All-Terrain Sensors DSA97–011 Rapid Location & ID of Passive Targets DSA97–014 Information Fusion Technology Supporting Precision Strikes DSA97–025 Sensor to Shooter Linkages
Battlefield Ordnance Awareness	TR97–002 Situational Awareness TR97–006 Combat ID TR97–020 Information Collection AD97–007 Sensors AD97–011 Early Warning AR97–009 Mtd Standoff Minefield Detection & Neutralization AV97–006 Weapons Suite	DSA97–004 Survivability of Deep Attack Systems DSA97–011 Rapid Location & ID of Passive Targets DSA97–023 Low-Altitude, Low-Observable Threat DSA97–024 Beyond the Visual Range ID DSA97–025 Sensor to Shooter Linkages
Overhead Passive Sensor Technology for Battlefield Awareness	TR97–002 Situational Awareness TR97–006 Combat ID TR97–020 Information Collection, Dissemination, & Analysis TR97–021 Real-Time Target Acquisition, ID, & Dissemination AD97–006 Classification, Discrimination, ID, & Correlation of Information AD97–007 Sensors AR97–006 Situational Awareness	DSA97–003 TMD DSA97–010 Day/Night, All-Weather Sensors DSA97–011 Rapid ID & Location of Passive Targets DSA97–021 Sensors DSA97–025 Sensor to Shooter Linkages SP97–002 Sensors to Detect Passive & Active Targets SP97–009 Real-Time Dissemination Systems

3. Relationship to *Joint Vision 2010*

The technology under development and for future development by SMDC and MDSTC must support the *Joint Vision 2010*. *Joint Vision 2010* applies new operational concepts as a mechanism to achieve military success across a range of operations. It recognizes that changes in how information is used and disseminated, as well as changes in technology, potential adversaries, and capabilities, will dramatically impact how well armed forces can perform their duties in 2010. This annex focuses on contributions to *Joint Vision 2010* and the vision's four key operational concepts, as described briefly below.

Dominate maneuver concerns the application of information, engagement, and mobility capabilities to position and employ widely dispersed joint air, land, sea, and space forces to accomplish assigned operational tasks (supporting technology efforts include battle management/command control, communications, and intelligence (BM/C^3I), IOAMS, laser satellite communications, etc.).

Precision engagement concerns enhanced joint operations that ensure greater commonality between service precision engagement capabilities and provide future joint force commanders with a wide array of accurate and flexible response options. Technology programs supporting precision engagement include Advanced Radar Technology Program, multimission sensor suite (MMSS), forward acoustical sensor and digital relay (FASDR), CO_2 laser detection and ranging (LADAR), LLYNX–EYE, BM/C^3I, hit-to-kill (HTK) miniature interceptor, tactical high-energy laser (THEL), free electron laser (FEL), algorithm development, etc.

Full-dimensional protection concerns control of the battlespace to ensure forces can maintain freedom of action during deployment, maneuver, and engagement, while providing multilayered defenses (Exoatmospheric/Endoatmospheric Interceptor Technology Programs, THEL, short-range air defense (SHORAD) with optimized radar distribution (SWORD), etc.) for forces and facilities.

Focused logistics concerns the fusion of information, logistics, and transportation technologies to provide rapid crisis response; track and shift assets even while en route; and deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical level. BM/C^3I, laser satellite communications, free space laser communications (LASERCOM), etc., are technology programs and will support focused logistics.

4. Relationship to *Army Vision 2010*

Missile and space defense capabilities are an important part of *Army Vision 2010*. They enable a full spectrum of operations by contributing to force projection and force sustainment. They will also assist in providing information dominance and shaping of the battlespace through contributions of advanced technology and rapid prototyping of systems available to the soldier in near-real time such as was demonstrated during Desert Storm. Army missile and space defense contributions to *Army Vision 2010* include sensor fusion, NMD, situational understanding, total asset visibility, assured space access, precision navigation, precision targeting, global missile warning, near-real-time weather, global communications, sensor-to-shooter links, and multielement joint TMD.

D. TECHNOLOGY DEVELOPMENT PROGRAMS

1. Introduction

The section addresses the technology to support the requirements of the Army, BMDO, and PEO–AMD, in order to meet future potential threats and to avoid technological surprise. Table D–2 provides a summary of potential missile and space defense technology applications for the PEO–AMD.

Table D–2. PEO–AMD/SMDC Technology Matrix

Far-Term Technology Area/ Program Title	Near-Term Technology Title	THAAD	PATRIOT	CORPS SAM/ MEADS	JTAGS	NMD	ARROW
Kinetic Energy Weapons Tech							
Low-Cost Cruise Missile Interceptor		A	A	A		A	
HTK Miniature Interceptor	Miniature Interceptor Technology	P		A			
Exoatmospheric Interceptor Technology							
Pilot Line Experiment Technology	Pilot Line Experiment Technology	A		A		P	
FPA Technology		A		A		A	
Advanced Discriminating LADAR		A		A		A	
Signal/Data Processor		A		A		A	

Table D–2. PEO–AMD/SMDC Technology Matrix (continued)

Far-Term Technology Area/ Program Title	Near-Term Technology Title	THAAD	PATRIOT	CORPS SAM/ MEADS	JTAGS	NMD	ARROW
Algorithm Development		A		A		A	
Inertial Measurement Unit	Interferometric Fiber Optic Gyroscope		P	A		P	A
	Resonant Fiber Optic Gyroscope	P				P	
Control System		A		A			
Booster Development	Gel Propulsion	A	A	A		P	
Divert and Attitude Control System	Maneuvering System	A	A	A		P	
Power Development	Improved Therm Batteries for Missile	A	P	A		P	A
Warhead Development							
Other Interceptor Effort							
Endoatmospheric Interceptor Technology	Jet Inter/Reaction Control	P					
Millimeter-Wave Component			A	A			A
Radome			A	A			A
Antenna		A	A	A			A
Transmitter							
Window Technology Development		A		A			A
Composite Airframe and Structure		A		A		A	
Poly Acrylonitrile Fiber		A		A			
SHORAD With Optimized Radar Distribution							
Sensors Technology							
CO_2 LADAR Development Programs							
Advanced Radar Technology Program	Advanced Radar Comp Technology	P	A	A		P	
	Range Doppler Imager	P		A		A	
	Innovative Radar Component Res	P		A		A	
	Significant Increase in Transmitter Duty Cycle		P	A			
	Semiactive Antenna		P	A			

Table D–2. PEO–AMD/SMDC Technology Matrix (continued)

Far-Term Technology Area/ Program Title	Near-Term Technology Title	THAAD	PATRIOT	CORPS SAM/ MEADS	JTAGS	NMD	ARROW
	A/D Converter and Corresponding Signal Processor Throughput		P	A			
	Solid-State Transmitter		P	A			
	Radar Signature System		P	A			
FPA Processing and Packaging Development	Mosaic Array Data Compression and Processing Module	A		A		P	
Multimission Sensor Suite		A					
Forward Acoustical Sensor and Digital Relay			A	A			
Space Technology							
	Kill Assessment Technology	P		A		P	
	Optical Data Analysis	P		A		P	
	Optical Signatures Code	P		A		P	
Phenomenology Experiments Program		S		S		S	
BM/C^{4}I							
Integrated Operational Airspace Management System							
Free Space Laser Communications							
	Satellite Communication on the Battlefield	A	P	A			
	Satellite Transmission of Recorded Battlefield Data	A	P	A			
BM/C^{3}I		S	S	S		S	
Survivability and Lethality							
Survivability		S	S	S		S	
	TMD Survivability Program	P		A		A	
	Counter antiradiation missile		P	A			
Lethality		S	S	S		S	

Table D–2. PEO–AMD/SMDC Technology Matrix (continued)

Far-Term Technology Area/ Program Title	Near-Term Technology Title	THAAD	PATRIOT	CORPS SAM/ MEADS	JTAGS	NMD	ARROW
Modeling and Simulation							
Advanced Research Center		S	S	S		S	
Simulation Center		S	S	S		S	
Simulation and Modeling Testbed		S	S	S		S	
Targets, Test, and Evaluation							
Future Test Requirements		S	S	S		S	
Directed-Energy Weapons							
Solid-State Laser Technology Program							
Hydrogen Fluoride Overtone Technology							
Materials and Components							
Microelectronics/Optics	Hardened Ada Signal Processor	A		A		P	
Innovative Radar Components Research	Innovative Radar Comp Research	A		A		P	
Operations Res and Systems Analysis							
Transporter, Erector, Launcher Hunter/Killer							
Cruise Missile Defense Expert System		S	S	S		S	
Advanced Technology Demonstrations							
JLENS Program							
Missile Alert Broadcast System		S	S	S	S	S	
Kinetic Energy Antisatellite Program							
Advanced Concept Technology Demonstrations							
Tactical High Energy Laser							
Science and Technology Objectives							
Laser Satellite Communications							
LLYNX–EYE					A		
Battlefield Ordnance Awareness							
Overhead Passive Sensor Technology for Battlefield Awareness							

P = Planned for Insertion A = Applicable Technology S = Supporting Technology

2. Current Level of Technology Maturity

a. Transitioning and Maturing Technologies

The need for integrated technology development, experiment and demonstration to meet future needs, along with the M&S needed to underpin technology development and provide user interface, is a must for maturing and transitioning technology. An approach that provides for the development of potential technology capabilities that can be "bundled" and transitioned through Advanced Technology Demonstrations (ATDs) and Advanced Concepts Technology Demonstrations (ACTDs) is depicted in Figure D–5.

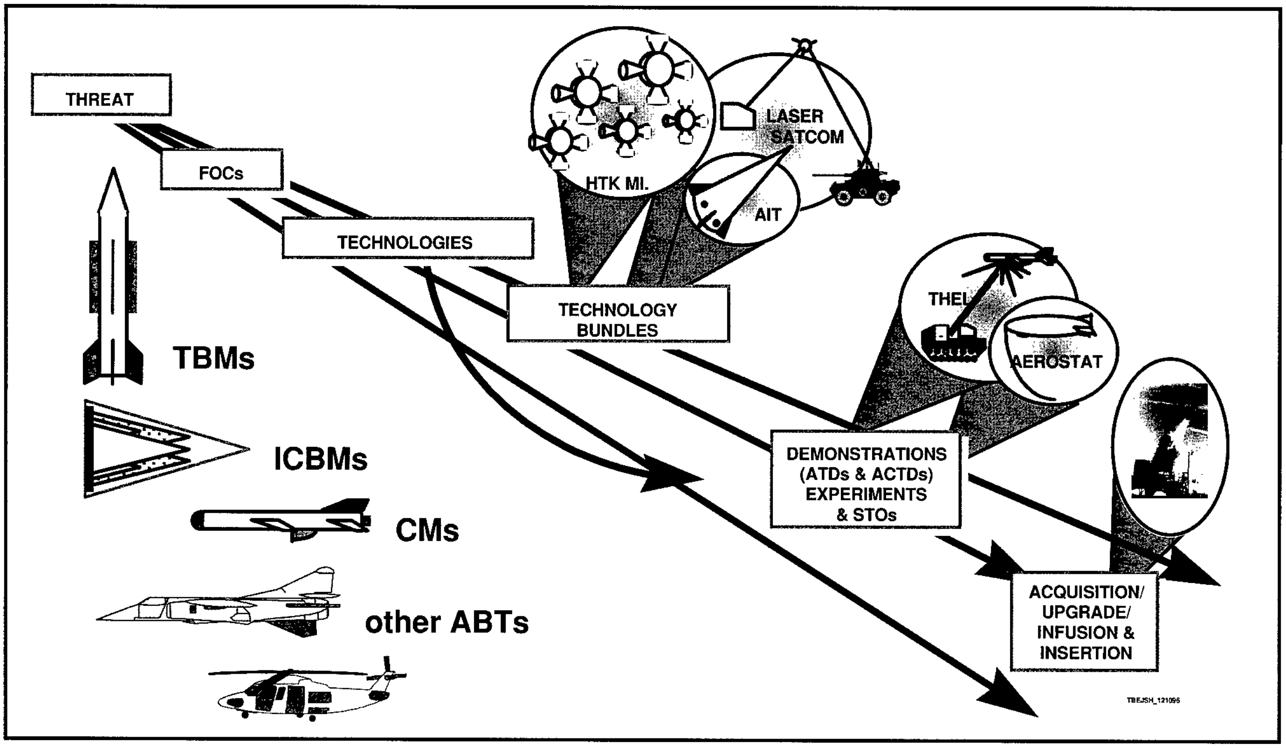


Figure D–5. Development and Transition of Technology

Five "bundled" technology programs with high payoff potential that address expected needs in the near and mid term are discussed below. Most are applicable to both the TMD and NMD mission areas. They leverage existing service core competencies and expertise and will require a minimum learning curve or infrastructure investment. When these five technology areas are developed concurrently, capability demonstrations will yield multiple options that can be integrated into existing weapon programs to enable them to meet evolving threats, or rapidly develop and field complementary systems. The five technology areas also offer excellent capability transition across the services by addressing the need for protection against early release of submunitions and low cross-section missiles and by reducing the size, weight, and cost components while increasing performance and efficiency. These five technology areas are summarized as follows:

- *Atmospheric Interceptor Technology (AIT).* This program focuses on advanced lightweight technologies for hypersonic HTK intercept and advanced propulsion systems and propellants for higher velocity and safe storage and handling.

- *Counter Early-Release Submunitions Technology (CET).* This program focuses on technology for miniature, lightweight HTK warheads, reactive materials for warheads and other advanced kill mechanisms, and lethality technology focused on defeating early-release chemical and biological (CB) submunitions.
- *Exoatmospheric Interceptor Technology (EIT).* This program focuses on fire-and-forget smart interceptor technology for exoatmospheric interceptors with onboard discrimination capability, radiation-hardened advanced electronics, high-performance boosters, and sensor fusion algorithms. This program supports NMD and Navy upper tier programs with follow-on technology insertion for future needs.
- *Advanced Radar Technology (ART).* This program focuses on technology for higher power and efficiency X- band solid-state transmit / receive (T / R) modules, more stable and efficient power conditioning, multifunction waveform processing, and dual-band technology for future radar applications. Effort will provide warfighter with improved target detection, discrimination, kill assessment, and data for precision tracking and engagement with flexible reengagement capabilities.
- *Information Processing/Communications Technology (IPCT).* This program focuses on technology for advanced satellite to interceptor communications for over-the-horizon (OTH) cueing of interceptors in flight, advanced image processing for the Space and Missile Tracking System (SMTS), and sensor data fusion for advanced BM / C^3.

3. Technology Programs

A technology taxonomy has been developed to define the core technology capabilities in SMDC. Part of the command's missions and goals is tied directly to the development of advanced technology, as well as the support of the FOCs of the warfighter and the demonstration of "bundled" technology capabilities to defeat the projected threats discussed in subsection C. These technologies have been broken into eleven technology areas and subareas, which are discussed below.

a. Kinetic Energy Weapons Technology

Hit-to-Kill (HTK) Miniature Interceptor. The advanced submunitions (AS) threat has received significant attention recently in the defense community as a potentially effective countermeasure to those TMD systems currently in development, such as theater high-altitude area defense (THAAD) and Navy upper tier. The AS countermeasure appears to be easy to implement (BMDO SM–2 experiment) and could be a validated threat by the year 2002. The submunitions could be either conventional, chemical, or biological. The HTK miniature interceptor is a multiple-kill vehicle concept intended to counter this threat. It is based on advanced component technologies under development with BMDO funding, which are integrated into extremely small kill vehicles, thereby allowing many to be carried aboard a single interceptor. The HTK miniature interceptor concept would be designed to be compatible with the baseline TMD concept of operation using the same radar, booster, launcher, and BM / C^3. However, the conventional kill-payload would be replaced with a cluster of HTK miniature interceptors. A small fraction of the conventional interceptors in each fire unit would be replaced with interceptors filled with HTK miniature interceptor kill vehicles. The threat would be detected and tracked as in the conventional TMD scenarios. The TMD radar would determine the composition of the threat payload and, when needed, an interceptor with a cluster of HTK miniature interceptor projectiles would engage the submunitions in an exoatmospheric environment.

The current state of the technology and the technical innovations needed by the year 2002 and year 2015 is shown in Table D–3.

Table D–3. Hit-to-Kill Miniature Interceptor Technology Plan

System Element	Current	By 2002	By 2015	Innovations Needed
Propulsion & Steering	Impulsive diverters under development	>5 g	>40g	More maneuverable, responsive, and robust divert systems, miniature, low cost
Sensor	Single color passive sensor under development	Single color	Multicolor, multimode IR and RF with decoy resistance	Miniature, low cost, high resolution, low loss optics, shock resistant
Tracking	Star tracking experiment planned	Passive	Active/passive	High power laser diode, small and low cost
Terminal Guidance	Reticle based guidance under development	Reticle/proportional	FPA/advanced guidance (endoatmospheric)	Higher accuracy guidance algorithms and high data rate processors.
Integrated Kill Vehicle/Dispenser	No work to date	Transition to materiel developer	System fielded	Lightweight, spin rate control, dispenser induced pointing error

Exoatmospheric Interceptor Technology (EIT). The EIT program will provide the only exoatmospheric interceptor technology testbed program for the development of fire-and-forget smart interceptors. This program will develop and integrate active and passive sensors, data fusion, lightweight avionics, high-sensitivity low background focal plane arrays (FPAs) with high-speed hardened electronics, high acceleration and divert propulsion, and sophisticated onboard target track and discrimination capability. The testbed will serve to demonstrate the technology goals without development of new interceptor kill vehicles (KVs).

The EIT program includes coordinating and maintaining a complementary interceptor technology base for relevant components and subsystems, correlating its core technologies to ongoing ATDs, ACTDs, and acquisition programs. It also includes working through BMDO to coordinate the users and acquisition programs to identify, develop, and mature the technologies further.

Fire-and-forget smart interceptors directly support the *Joint Vision 2010* of precision engagement, dominant maneuver, and full-dimensional protection. The testbed demonstrations of fire-and-forget exointerceptor target kills will be performed against responsive threat complexes. A series of end-to-end, 6-degree-of-freedom (DOF), hardware-in-the-loop (HWIL) simulations, ground, and flight tests will be performed with the integrated KVs. After successful demonstration of the integrated KV capability, the technology will be available for transitioning to the appropriate interceptor ACTD or acquisition programs. [POC: Robert Franklin, (205) 955–5817, e-mail: franklinb@smdc.army.mil]

These technologies will enhance existing interceptor capabilities and add new ones such as advanced inertial measurement units (IMUs) and batteries enabling longer flyout times. Advanced LADARs, FPAs, algorithms, and signal/data (S/D) processors will enable longer acquisition ranges and better discrimination. Advanced divert and attitude control system (DACS) will enable a much greater divert capability. The current technology capabilities, projected capabilities for 2009 and 2015, and innovations needed to achieve these capabilities are listed in Table D–4.

Endoatmospheric Interceptor Technologies. The objective of AIT is to develop and demonstrate advanced lightweight technologies for hypersonic HTK intercept of threat missiles within the atmosphere and integrate these technologies into a small (130 cm^3), lightweight (50 kg) KV. High velocity intercepts are essential to maintain sufficient battle space, lethality, and coverage/footprint performance. However, such conditions provide severe aero-optic, aerodynamic, aerothermal, and structural requirements. Jet interaction (JI) testing is providing insights into JI sensitivities to design

Table D–4. Exoatmospheric Interceptor Technology Plan

Component	Today	2009	2015	Innovations Needed
IMU	0.4-kg IFOG with 4-deg/hr bias stability, 10-mg acceleration sensitivity	0.5-kg RFOG with 0.01 deg/hr bias stability, 100-µG acceleration sensitivity	0.4 kg RFOG with 0.001 deg/hr bias stability, 50-µG acceleration sensitivity	Low loss optical connectors, low loss fibers, improved laser source, solid-state accelerometers, improved power management technology
LADAR	No interceptor LADAR available	5-kg, 300-km range, solid state	4-kg, 500-km range, solid state	Improved laser transmitters and receivers improved power management technology
FPA	256^2 MCT, non-rad hard on FPA readout electronics	512^2, rad hard, multiwave band on FPA processing electronics	1024^2, rad hard, tunable waveband, high temperature on FPA processing electronics	Improved materials and processing techniques improved manufacturing techniques
Algorithms	Basic discrimination algorithms	Onboard active/passive discrimination, control system algorithms for maneuvering threats	Algorithms promoting autonomous launch-and-forget operation	Improved S/D processors
S/D Processors		Level–2 hardened, 10^{12} IPS, 10^{12} OPS	Level–2 hardened, 10^{14} IPS, 10^{14} OPS	Improved power management technology; improved chipset design and parallel processing technologies
DACS	Army LEAP DACS subsystem	200-km divert capability, solid propellant, start/stop capability	400-km divert capability, solid propellant, start/stop capability	Higher Isp propellants, faster response, high temperature hot gas valves, high temperature nozzles
Boosters	Not available	Booster with composite motorcase, thrust vector control	Advanced composite integrated stage booster, thrust vector control	Higher Isp propellants, faster response, high temperature injector valves, higher strength fibers
Warheads	Conventional warhead, directionally fragmented	Explosive reactant, counter early-release submunitions (CERS) warhead	Directed energy warhead	CERS and directed-energy design and development
Control Systems	Not available	Advanced actuator control system	Adaptive learning control system for maneuvering threats	Fast response controllers; innovative learning algorithms
Structures	THAAD	Composite airframe with integrated plumbing, wiring, and DACS	Composite advanced materials airframe with integrated plumbing, wiring, and DACS	Advanced materials; improved manufacturing techniques
Power	PAC–3/THAAD/ASAT batteries	Long life (60 min), high current density, lightweight	Long life (120 min), high current density, lightweight	Improved materials, packaging, thermal management

parameters, data to develop engineering models, and computational fluid dynamics (CFD) validation data. AIT provides significant technology advancements in the seeker, cooled window/forebody, and high performance solid DACS. AIT has a variety of multiservice applications of risk reduction opportunities and performance enhancements (P^3I). [POC: Mike Cantrell, (205) 955–5968, e-mail: cantrellm@smdc.army.mil]

The current technology capabilities, projected capabilities for 2009 and 1015, and innovations needed to achieve these capabilities are listed in Table D–5.

Table D–5. Endoatmospheric Interceptor Technology Plan

Component	Today	2009	2015	Innovations Needed
Polyacrylonitrile (PAN) Fiber	Conventional Japanese fibers, 55 msi modulus, 650 ksi tensile strength	Advanced composite fiber, 90 msi modulus, 800 ksi tensile strength	Advanced composite fiber, 100 msi modulus, 1000 ksi tensile strength	Research, improved materials development
Control Systems	None available	Advanced actuator control system	Adaptive learning control system for maneuvering threats	Fast response controllers; innovative learning algorithms
Structures	THAAD	Composite airframe with integrated plumbing, wiring, and DACS	Composite advanced materials airframe with integrated plumbing, wiring, and DACS	Advanced materials; improved manufacturing techniques
MMW Radomes	PAC–3	Dual mode RF/IR radome	Dual mode RF/IR, actively cooled, high strength/erosion resistance	Advanced materials development; improved manufacturing and characterization techniques
MMW Transmitters	PAC–3/THAAD	200–300 W average, 4.5 kg, 150 $inch^2$	200–300 W average, 3.5 kg, 125 $inch^2$	Improved components, power generation and management techniques
MMW Antennas	PAC–3/THAAD	Active conformal array	Active conformal array, dual-mode antenna/aperture	Improved manufacturing
Algorithms	Basic discrimination algorithms	Onboard active/passive discrimination, control system algorithms for maneuvering threats	Algorithms promoting autonomous launch and forget operation	Improved S/D processors
IMUS	Army LEAP IMU, 0.4-kg IFOG with 4-deg/hr bias stability, 10-μG acceleration sensitivity	0.5-kg RFOG with 0.01-deg/hr bias stability, 100-μG acceleration sensitivity, high bandwidth (5x existing)	Chip gyroscopes and accelerometers 0.01-deg/hr bias stability, 100-μG acceleration sensitivity, high bandwidth (5x existing)	Low loss fibers; low loss optical connectors Improved laser source; improved micromechanical fabrication techniques Solid-state accelerometers Improved power management technology
Power	PAC–3/THAAD	High current density, lightweight	High current density, lightweight	Improved materials, packaging, thermal management

Short-Range Air Defense (SHORAD) With Optimized Radar Distribution (SWORD). The SWORD advanced technology program will provide the Army with mobile, all-weather, close-in defense against cruise missiles and short-range ballistic missiles (SRBMs). Also, this system has capability against short-range rockets, air-to-ground missiles, and UAVs. This program will leverage an interferometric radar and gigahertz (GHz) signal/data fusion technologies, utilize existing infrastructure, and achieve point and area defense performance exceeding existing fielded capabilities.

The SWORD concept was conceived from a BMDO initiative for NMD point defense. An interferometric fire control radar capable of command guiding an HTK interceptor to impact a strategic ballistic missile warhead out to a range of 25 km was initiated in early 1991. A 10-meter (m) baseline X-band interferometric fire control radar and radio frequency (RF) transceiver was developed and demonstrated to perform this mission. This technology has demonstrated eight microradian angular accuracy at a 25-km range. A tactical version of this system can be deployed on wheeled or tracked vehicles operating with a 2–3-m baseline interferometric fire control radar. Specific advantages of SWORD include radar classification of hostile targets at ranges to perform intercepts at 10 km with optimized fusing, aimpoint, flight path, and divert firing techniques; providing 360-degree search/track, on-the-move (OTM) capability at 20 km; tracking 80 simultaneous targets; and controlling up to 5 intercepts every second. The estimated production cost goal of the missile is less than $15,000 and $8 million for the interferometric fire control radar. [POC: Ron Smith, (205) 955–1182, e-mail: smithr@smdc.army.mil]

b. Sensors Technology

CO_2 LADAR Development Programs. SMDC is developing two CO_2 laser sensor systems that differ in their measurement energy, pulse repetition rates, compactness, and applications. The two technologies are the field LADAR (FL) and the multiple-folded laser (MFL). The FL is more advanced in its development and is bigger in mass (180 X), volume (1400 X), measurement energy (40 X), and transmitter power (10 X) than the MFL, as suggested by the data in Table D–6. Research goals for both devices are targeted at reducing mass and volume, demonstrating functionality for multiple applications, and developing high speed signal processors for their different waveforms. Due to the compactness of the MFL, example candidate roles include being a seeker for a discriminating interceptor or a precision surveillance sensor on a lightweight UAV. The high energy measurement capability of the FL makes it a candidate for hosting on a satellite or a manned aircraft.

The CO_2 laser radar offers several payoffs for space and missile defense applications, including:

- Remote sensing for detection and identification of chemical warfare agents
- Missile, aircraft, or satellite hosting for missile defense sensing
- Multifunction sensing of missiles in boost, midcourse, or terminal phases of flight
- Cruise missile detection and track in clutter
- Range-Doppler imaging for highly effective discrimination of advanced threats
- Precision track, precision launch point estimates (LPEs), and precision impact point prediction
- Precision guidance for HTK intercepts
- Imaging for precision HTK aimpoint selection
- Stealth target sensing

Table D–6. CO_2 LADAR Development Technology Plan

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
Compact, LightWeight Coherent CO_2 (MFL)					
Wide bandwidth waveform for imaging	340 MHz	750 MHz	—	—	Efficient A/O Modulators
Transmitter power (issue—long range measurements)	100 watts	150 watts	250 watts	350 watts	Small RF power supplies
Frequency Stability	100 kHz	2 kHz	—	—	Stable materials
Range-Doppler Images					
• Range Resolution	45 cm	20 cm	20 cm	—	—
• Doppler Resolution	50 cm/s	2 cm/s	1 cm/s	—	—
Laser Radar Sensor					
• Weight	15 kg	5 kg	—	—	Lightweight materials
• Volume	8 liter	4 liter	—	—	Waste heat removal
Beam Director					
• Lightweight, Low Volume	20 kg	4 kg, 3 liter	2 kg, 2 liter	1 kg, 1 liter	Lightweight materials
• Agile, Fast Retargeting	10 targets/s	100 targets/s	500 targets/s	1000 target/s	—
Signal Processor					
• Lightweight, Low Volume	5 kg, 2 liter	0.5 kg, 0.4 liter	0.2 kg, 0.2 liter	0.1 kg, .05 liter	Electronic packaging
• Agile, Fast Retargeting	—	—	5 GFLOPS	20 GFLOPS	—
Field LADAR					
Wide Bandwidth waveform for Imaging 1 GHz	complete 1997				
Transmitter					
• Power	1,110 W fixed site	800 W (fielded system)	—	—	Discharge loading
• Weight/Energy	200 lb/joule	50 lb/joule	—	—	Optical materials
Frequency Stability (improve velocity measurements)	60 kHz	4 kHz	—	—	Atomic flash molecular stabilization
Range Doppler Images					
• Range Resolution	20 cm	20cm	—	—	Currently available
• Velocity Resolution	37 cm/s	10 cm/s	2 cm/s	—	Discharge stability & algorithms
Laser Radar Sensor					
• Weight	6,000 lb	1,000 lb	—	—	Packaging
• Volume	400 cubic feet	200 cubic feet	—	—	—
Optics/Beam Director					
• Weight	2000 lb	500 lb	—	—	Materials
• Volume	130 cubic feet	25 cubic feet	—	—	Packaging
Advanced Detector Array Concepts	2×2	8×8	64×64	—	Materials processing

Table D–6. CO_2 LADAR Development Technology Plan (continued)

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
Reduce Signal Processing Size and Weight					
• Weight	200 lbs	100 lbs	50 lbs	—	Large-scale integration
• Volume	15 cubic feet	7.5 cubic feet	3.75 cubic feet	—	
Signal Processing Speed Increase	—	+16 Xs	+16 Xs	—	Reconfigurable hardware
• Clock Rate	200 MHz	500 MHz	1 GHz	—	Semiconductor technology
• Bus Speed	20 MB/s	500 MB/s	1 GB/s	—	Semiconductor technology
• Throughput	1.2 GFLOPS	5 GFLOPS	20 GFLOPS	—	Parallel architecture
Predicable A/D Converters for Wide Bandwidth and High Speed	—	8–10 effec bits	10–12 effec bits	—	Semiconductor device technology
• Module	500 M/s	1 G/s	4 G/s	—	
• Subsystems	2 G/s	20 G/s	40 G/s	—	
Airborne/Helicopter System Design/Build	—	LIDAR available 2001	—	—	Algorithm & software
Extend Wavelength Agile Operation	LWIR	—	Double CO_2	Solid-state MWIR	Improve crystal technology
CO_2 LADAR/LIDAR Hybrid Air Mobile Package	—	—	LWIR/MWIR LADAR/LIDAR	Solid-state LWIR/MWIR LADAR/LIDAR	Improve high-power solid-state laser & crystals
Clandestine Chemical Processing to Detect Solvents	—	LIDAR available 2001	—	—	Algorithms & software

- Counterelectronic warfare
- Accurate miss distance and kill assessment measurements.

The CO_2 LADAR technology development program is shown in Table D–6.

Advanced Radar Technology Program. This program is developing advanced radar sensors for surveillance, interceptor seekers, and space sensor missions. These sensor outputs will be data fused with other active/passive sensor outputs that are remotely or collocated on the same platform to form improved target detection, discrimination, and kill assessment. Development of advanced radar technologies will achieve more efficient, more rapidly deployable sensor systems for detection of missile threats (SRBM, cruise, aircraft, UAV), and they will provide data for precision, accurate engagement with flexible reengagement capabilities.

The technologies in Table D–7 will provide precision tracking for engagement by joint forces of hostile targets, timely and accurate data for responsive command and control (C^2), accurate assessment of results, and flexible reengagement capabilities. They will also develop high performance analog-to-digital (A/D) converters, nonvolatile memories, and component testing of both government-developed and commercial off-the-shelf (COTS) microelectronics.

Table D–7. Advanced Radar Technology Plan

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
High-Power, High-Efficiency, Solid-State Transmit/Receive Modules					
• Producibility/Cost	>$1,000 ea	<$1,000 ea	<$500 ea	<$300 ea	New semiconductor material
• Increase Module Power	20 W	>25 W	>30 W	>40 W	
• Increase Module Efficiency	18%	>30%	>40%	>50%	
Wide Bandwidth RF for Threat Identification and Active Imaging	~ 1 GHz	>1 GHz	>2 GHz	>4 GHz	Advanced A/D converters
Complex RF Waveforms for Feature Extraction & Imaging and ECCM	~ 1 GHz	>1 GHz	>2 GHz	>4 GHz	Capability & terahertz electronics
Adaptable Beamforming (ADBF)	<100 MHz	>1 GHz	>2 GHz	>4 GHz	True time delay
Advanced Signal Processing	<1 GHz	>1GHz	>2 GHz	>4 GHz	Advanced analog components & digital components

Focal Plane Array (FPA) Processing and Packaging Technology Development Program. The objective of this effort is to develop the architecture and components of FPA signal processing for near- to mid-term IR/visible mosaic sensors, and to transition these technologies to U.S. sensor systems. Beginning in FY91, this technology effort has significantly advanced FPA signal processing and packaging by reducing the size, weight, and power needed for these processing functions. The program was initiated to develop circuitry and packaging technology to process and manage the data from very large sensors, particularly in the presence of transient effects induced by nuclear radiation environments. This development created a "library" of very lower power, on focal plane image data processing circuits that significantly improved data transmission from the focal plane of high-resolution sensors. The digital interface reduces assembly and test costs and results in lower equipment maintenance cost. The focal plane packaging technology allows the stacking and interconnecting of multiple integrated circuits.

A high-density, multilayered, cryogenic packaging technology supports on focal plane signal processing for applications that range from very large field-of-view (FOV) satellite sensors to space, power, and heat dissipation constrained vehicle interior and man-portable applications. A basic application of the technology incorporates A/D conversion on the focal plane of both strategic and tactical IR sensors to modularize the hardware and reduce cost and complexity. The digital interface reduces assembly and test costs and results in lower equipment maintenance cost. The focal plane packaging technology allows the stacking and interconnecting of multiple integrated circuits. The low thermal mass of the very thin signal processing circuits permits focal plane signal processing for sensor applications that require rapid cool down. The package is designed to operate at temperatures as low as 10K (see Table D–8).

Multimission Sensor Suite (MMSS). The proposed MMSS is a small, lightweight sensor system for surveillance and tracking of TBMs during boost phase and early mid-course flight, and for cruise missiles throughout their entire flight trajectory. The MMSS will employ two passive IR sensors (one for surveillance and one for tracking), X-band radar, and laser ranger in a suite onboard a UAV operating at an altitude around 65,000 feet for periods greater than 24 hours. The technological innovations required to develop the MMSS will lead to improvements in power generation technology, thermal battery technology, electronic component technology, and electric power distribution technology,

Table D–8. Focal Plane Array Processing and Packaging Technology Plan

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
IR FPAs With Integrated (on FPA) Signal Processing Electronics for Fast Frame Rate Seeker	100 Hz, 128 × 128	10 k Hz, 1024 × 1024	1 MHz	1 GHz	Materials research
Reduce Electronics Size and Weight By Factor of	8 Xs	20 Xs	40 Xs	100 Xs	Packaging technologies
Volt Logic	3.3 volt	1/2 volt	0.01	0.01	Materials & processes
High Operational Temperature IR FPAs	100K	100°K, Δ 0.01°C	Δ 0.001 °C	Two color	Materials research
IR FPAs for Long-Range Launch-and-Forget Operation	Two color, mid wave	KM, two color	Three-color IR	—	Materials & processes
IR Device With Electronics	256 × 256, 180 mAmps	512 × 512, 140 mAmps	1024 × 1024, 120 mAmps, intelligent processing	Grow focal plane with electronics all-in-one monolithic unit	Materials & etching technology

which will benefit both government and civilian users. The proposed X-band radar component of the sensor suite will provide the Army with a highly portable system with performance characteristics comparable to THAAD—Ground-Based Radar.

Desired performance can be achieved with existing technology but with an unacceptable weight penalty. Existing capabilities and the technological innovations and improvements needed to retain desired performance while achieving the required reduction in weight for each system element by 2015 are described in Table D–9.

c. Space Technology

Space capabilities are critical enablers to achieving information dominance and to ensuring full spectrum dominance across all levels of conflicts. The space S&T challenge is to determine how to exploit, leverage, and integrate horizontally military, civil, and commercial space technologies and capabilities into the current force, programmed force (Army XXI), and the potential force (*Army After Next*). Space technology will accelerate essential and leap-ahead capabilities required for full-spectrum dominance.

As the Army proponent for space, SMDC is evolving to meet space needs that are documented in the *Joint Vision 2010, Army Vision 2010, U.S. Space Command Vision for 2020,* and insights emerging from the *Army After Next* process. It has a vision to provide the warfighter with space products that will allow land force dominance in the 21st century. The SMDC is developing technologies in areas such as communications, position/navigation, intelligence, surveillance, target acquisition, mapping, weather, and missile warning that support these visions and support the Army's goal of developing space products that get the right information to the warfighter at the right time.

The Army has specific goals to support the above visions regarding space and include robust space integration into full-spectrum land force operations, progressive space and missile defense technology for the warfighter, and anticipatory space partnerships.

Table D–9. Multimission Sensor Suite Technology Plan

System Element	Current	By 2015	Innovations Needed
Passive IR Sensors • One Surveillance • One Tracking	Mass at 200 kg 3-faced (120°) wide FOV (13° elevation, 360° azimuth)	Mass at 80 kg Retain performance capability	Lightweight gimbals (reduce weight of control mechanism by 50%)
Laser Ranger	Mass at 100 kg Can range: • TBMs to 500 km CMs to 200 km	Mass at 30 kg Retain performance capability	CO_2 MFL (240-W unit weighing 14 kg, 10-fold weight loss)
X-Band Radar	Mass at 27000 kg Performance on par with THAAD–: • Detect/track TBMs 300 to 600 km • Detect CM 200 km • Track CM 100 km	Mass at 3020 kg Retain performance capability	Fuel cell & power generation technology • Electronic components (reduce weight by 40%) • High capacity/ high power density fuel cell • Develop HTS YBCO wire to lower generator weight by a factor of 4 Antennae array packaging/cooling technology & low temperature transistor technology (reduce antennae weight by 15%) Tile technologies for T/R modules (reduce antennae weight by additional 25%) HTSC technology for power distribution (cut heat dissipation in half) Local oscillator technologies (lower power & cooling requirements by 25%)

Robust Space Integration Into Full-Spectrum Land Force Operations. As the varied demands on land forces increase, we must integrate space into the full spectrum of these operations, from peacetime, domestic operations to large-scale force projection operations when overseas interests are at risk. To support these operations, data collected by or transmitted through space systems must be developed into information. Then it must be integrated into decision-making processes and systems. Army space capabilities must be integrated into joint and Army architectures. This goal encompasses DTLOMS solutions to warfighting requirements. Our integration of space work will also ensure that space capabilities are tailored to support land force missions, as well as those of all joint warfighters. This goal includes considerations such as system design, space and missile defense architectures, data selection and definition, and tasking procedures. Joint space doctrine, tactics, techniques, and procedures must reflect land force needs. The Army will work to shape systems design so that land force requirements are given high priority.

Progressive Space and Missile Defense Technology for the Warfighter. It is critical for the Army to emphasize progressive technology development. These efforts will anticipate challenges stemming from the mixture of commercial, international, and multiagency operations in space. The Army will also participate in developing technologies for our nation's joint space and missile defense architectures. Priorities will be to ensure the protection of friendly space capabilities, the control of space, and application of force from and into space.

The Army's focus for technology development in modernizing its space assets is to exploit space for the tactical commander. Therefore, space technology development is focused on providing the warfighter such capabilities as:

- Sensors that are multifunctional and leverage commercial technology
- Processors that serve to decrease the decision cycle, provide processing in-theater with rapid access to stored data, and provide automatic target recognition and advanced decision aids
- Assured access to medium and high data rate satellite communications
- Multiband terminals
- Space control efforts that deny enemy information capabilities and protect space assets.

Anticipatory Space Partnerships. Global partnerships augment military space capabilities through the leveraging of civil, commercial, and international space systems. The Army must foresee the challenges inherent in a global operating medium. In support of U.S. Space Command, the Army will explore their implications for land forces. Of particular interest will be international alliances, mixed commercial and military space use, military capabilities onboard commercial satellites, ground station requirements, policies and treaties, partnerships with national agencies, and affordable, responsive launch capabilities. Future conflict will be nonlinear and complex, as will operations in space. There will be challenging combinations of combatant and noncombatant systems. Army partnerships will anticipate these challenges and prepare us for this evolution.

Refer to Volume I, Chapter III, Section Q of the *Army Science and Technology Master Plan* (ASTMP) for more details on space technology. Also, Refer to Volume I, subsection III–Q.4 for details of ongoing technology development programs in the space exploitation area.

d. Phenomenology

Phenomenology Analysis and Algorithm Development Program. Currently, a broad-based discrimination effort is being pursued in the SMDC Sensor Analysis Division. The Radar and Real-Time Discrimination (RRTD) program develops solutions for critical ballistic missile defense (BMD) functions such as bulk filtering, discrimination, handover, aimpoint selection, and kill assessment. The Lexington Discrimination System (LDS) real-time testbed, a part of the RRTD program, is a tool that uses archived field measurements to determine performance characteristics of algorithms developed to address the above issues. Conceived as a radar live-time imaging effort in 1985, the effort currently provides algorithms to many of the core elements, including THAAD, NMD, and Navy Theater Wide. The LDS is currently being expanded to include seeker hardware and a radar simulator to exercise HWIL simulations. The Optical Discrimination Analysis (ODA) program, RRTD's sister program, is composed of an integrated team whose mission is to increase the effectiveness of BMD with cost-effective solutions to key issues through improved interceptor algorithms (sensor-to-sensor handover, discrimination, aimpoint selection, data fusion) and focused optical data analysis. The Optical Signatures Code (OSC) program, is composed of a team whose mission is to use real field data to validate models of optical signatures to enable TMD and NMD systems to test their algorithms. The Kill Assessment Program is composed of a team whose mission is to use field data to validate models that are able to determine if a hit was made and whether or not the target was killed. Another program called the Missile Defense Data Center is used to store the data collected and make it readily accessible to the TMD, NMD, and technology programs for evaluation and development of algorithms.

Measurement-based threat characterization (MBTC) provides ultra-wideband radar cross section (RCS) models for each component of a ballistic missile complex. The collection of broadcasts from remote assets or other sensors obtain the measurements on which the models are based. Ultra-wideband processing, a technique recently used at Lincoln Laboratory for interpolating radar signals between data bands, is used to isolate individual scattering centers. Electromagnetic scattering codes are then used to predict the RCS, and this is used to evaluate BMD fire control algorithms on testbeds such as the LDS. MBTC will be applied to the large existing threat database for NMD and to the TMD database currently being obtained.

Kill assessment technology provides algorithms to determine whether or not the engaged target was a warhead and, if so, whether it was fully destroyed. If not, then a subsequent engagement may be required to adapt to "surprises" occurring during the initial engagement. Kill assessment technology, currently under development at Lincoln Laboratory for TMD, and HTK interceptors will be extended to include NMD conditions and fragmenting warhead interceptors.

Battlefield adaptation technology provides algorithm designs that can adapt to any "surprises" occurring during the engagement. These adaptations may occur in real time, within hours after the engagement or within days at a mission analysis center outside the theater of engagement. During engagement, truth measurements made by defense sensors can be used to modify a priori threat models, adapt fire control algorithms using flexible decision thresholds, and minimize errors. During the past year, Lincoln Laboratory has been examining possible approaches to develop technology that could be used with the core systems to permit them to adapt to surprises that occur during engagements.

Currently, these programs are developing algorithms in the areas of bulk filtering, discrimination, handover, aimpoint selection, and kill assessment utilizing the LDS and ODA facilities. Work is progressing in concert with existing THAAD and NMD efforts (see Table D–10).

Table D–10. Phenomenology Analysis and Algorithm Development Program Technology Plan

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
Measurement-Based Threat Characterization	Concept only	Initial model complete & data stream fed to LDS	Models of a variety of target types utilized by LDS	All known targets modeled statistical eval in variety of scenarios performed on LDS	Faster processors
MBTC bandwidth expansion by factor of:	2.5x	5x	7x	10x	Adequate field database
Kill Assessment	No effort	Initial NMD algos derived from TMD	NMD mission data utilized to test algos	100% NMD kill assessment probability for known threat	Adequate field database
Hit assessment time:	<1 s	<0.5 s	<25 s	<0.1 s	
Battlefield Learning—reset thresholds in surprises in:	Days	6 hours	1 hour	Minutes or real time	Faster processors Fast, reliable battlefield communications

Phenomenology Experiments Program with a Fly Along Sensor Package (FASP). The FASP is a self-contained sensor package that may be carried onboard a launch vehicle and deployed to view the booster and deployed targets at a very close range. An altitude control system maintains the pointing of the system as well as governing its translational velocity away from the launch vehicle. The FASP's velocity is selected by the experiment planner to provide the desired relative range history for viewing the target complex. On the Theater Missile Defense Critical Measurements Program (TCMP), the program developing FASP, a beacon system is used to maintain pointing at the reentry vehicle throughout the flight. Sensor imagery is telemetered to ground stations beginning at FASP deployment. The first generation FASP was successfully flown on three TCMP Campaign 2 (TCMP–2) launches conducted in FY96 and FY97. The FASP contained an IF and a visible sensor. Because of the proximity to the target at which data collection begins, FASP data is particularly valuable for seeker applications or other uses requiring resolved target data.

The current FASP has a visible television camera and a medium-wavelength IR camera. A two-color capability is being developed for the FY99 timeline, allowing participation in TCMP–3 flights scheduled for FY00. Also the current data rate of 10 hertz (Hz) will be increased to support TCMP–3. For future TCMP campaigns and for other TMD and NMD experiments, the capability of the FASP will be incrementally upgraded to two-color long wavelength IR and increased data rates (see Table D–11).

Table D–11. Phenomenology Experiments Technology Plan

System Element	Current	By 2000	By 2002	By 2007	Innovations Needed
TCMP for THAAD and Navy Air Defense for TMD Measurements Discrimination/Aimpoint Selection/Hit Assessment	1-color FASP	2-color FASP with downlink capabilities	2-color FASP with higher downlink capability	SWIR, LWIR, & super-high-speed data rate	Sensor development and packaging data link improvements

e. Battle Management/Command, Control, Communication, Computers, and Information

Integrated Operational Airspace Management System (IOAMS). The IOAMS will consist of a family of closely linked modular software to:

- Maintain four-dimensional (4D) portrayal of all friendly air assets in the area of operation.
- Identify the airspace in which it is optimum to conduct intercepts or not suitable for an intercept due to the adverse impact on ground assets if the threat is carrying a NBC warhead.
- Predict the probable routes of air threats.
- Predict the impact of NBC effects on land assets, automated to maintain air deconfliction.
- Provide the commander with alternate courses of action (such as which asset to engage the incoming air threat), and the communication links and integrating software to manage the airspace.

The software would have to run in real time and, in some of the modeling, run ahead of and faster than real time.

The technology developments needed to achieve IOAMS system performance goals by the year 2012 are presented in Table D–12.

Free Space Laser Communications (LASERCOM). Free Space LASERCOM is a line-of-sight (LOS), high data rate, antijam, low-probability of intercept, communications technology being developed and demonstrated for use between satellites and among TMD and NMD communications networks on the ground and in the air. As BMDO's principal agent for developing this technology, SMDC continues to pursue development of four major LASERCOM systems. The technology in its current configuration (Mark–1) uses laser diodes for transmission, tracking, and alignment; low noise avalanche photodiodes for collecting data transmissions, and charge-coupled device (CCD) arrays for tracking and alignment. Future advanced technology development will address high bandwidth potential (≥10 gigabits per second (Gbps)) and other issues such as improving laser output power and maximizing link availability.

Current and projected performance of LASERCOM systems for different types of links along with innovations needed to obtain projected performance are described in Table D–13.

Table D–12. Integrated Operational Airspace Management System Technology Plan

System Element	Current	By 2003	By 2009	By 2012	Innovations Needed
IOAMS Technology	Some rudimentary software that portrays in 2D some aspects of IOAMS	Proof-of-principle system	Unintegrated modules (robust standalone modules)	Real-time operation airspace management, mission rehearsal and execution	Continuous weapon system (include missile, UAVs, etc.) IFF, sensor infusion software, common sense computer, mega-intercept calculator with METT–T and threat generator, air defense employment strategies calculator, and 4D air deconfliction tool
Cognitive Technology	Flat computer screen	4D computer screen with additional sensory capability	Holographic projections	Walkthrough virtual airspace environment	4D cognitive human display, 2D to 3D to 4D software conversion, battlefield human auditory, olfaction, and optical presentation
Knowledge Technology	Human decision making with information aids from the computer	Expert system	Artificial intelligence system	Human decision emulator	Knowledge ghosts, knowledge software, and smart databases

Table D–13. Free Space Laser Communications Technology Plan

System Element	Current	By 2015	Innovations Needed
Satellite–Satellite	Max range: 2,500 km Max data rate: 1.2 Gbps Altitude: exoatmospheric weight, power, cost	Max range: 2,500 km Max data rate: 12.0 Gbps size, weight, power, cost	• Increased miniaturization of electronics • Ultra-stable laser sources weight, power, and cost? • Increased single mode laser power • High bandwidth, high current laser drivers • Wide FOV acquisition & tracking • Novel beam steering • High bandwidth receiver • Increased detector sensitivity • Spatially incoherent transmitter arrays
Satellite–Surface	Range: 800–1,800 km Data rate: 155 Mbps to 1.2 Gbps Altitude: low-earth orbit		• Software/hardware for atmospheric scintillation mitigation • Extremely high rated (10 Gbps) direct modulation detector systems • Eye safety
Aircraft–Aircraft	Range: 50–500 km Max data rate: 1.2 Gbps Altitude: 40,000 feet		
Aircraft–Surface	Range: 11–14 miles Data rate: 1.2 Gbps Altitude: 30,000 feet		
Surface–Surface	Stationary • Range: 150 km • Data rate: 1.2 Gbps Binocular • Max range: 2,500 km • Max data rate: 1.2 Gbps		

Battle Management/Command, Control, Communications, and Intelligence (BM/C^{3}I) Technology. The BM/C^{3}I program will directly address the technology challenges associated with future missile defense BM/C^{3}I needs. Communications topics addressed include both transmitter and receiver technology developments and will build on the satellite LASERCOM program that is developing high data rate laser communication systems for antijam, low-probability-of-intercept voice and datalinks between satellites and missile defense surveillance platforms. New developments should increase data rates beyond the 1.2 Gbps that has been demonstrated. In addition, advanced distributed processing is being addressed by merging research in optical multiprocessor interconnects and optimistic computing techniques to provide low-cost, distributed adaptive supercomputer capability for a variety of applications that include real-time conflict resolution, faster than real-time mission planning, and synthetic environments for training and exercises.

COTS processor chips are expanding speed capability at a rate of double per 18-month period. By 2015, conventional electronics will have lost the capability to provide adaptive interconnects for closely coupled, distributed processing systems. Although architectures and algorithms have been adapted to compensate for disparity in performance between processor and interconnect, such techniques are unlikely to satisfy next-generation radar teraflop system requirements. Current SMDC research activity addresses distributed low-cost COTS workstation "ShuffleNet" implementation of the Jet Propulsion Laboratory's (JPL) bit-per-wavelength technology. The effort centers on microsecond processor-to-network transfer and photonic space–time deflection routing architecture, which provide near-speed-of-light transfer between processors with time reconstruction of packets received. By 2015, the JPL effort will address expanding current four-wavelength wave division multiplexing technology to provide hundreds of kilometers separation between processing elements at terabit per second rates (see Table D–14).

f. Survivability and Lethality

Survivability. Space and BMD systems must operate and survive in a reasonable set of hostile environments created by enemy actions before or during operation, including battlefield collateral environments produced by friend or foe and natural hostile environments. The Weapons Directorate Survivability Division serves as the focal point for both system survivability and survivability technology development for SMDC.

Survivability technology is needed to achieve a cost-effective solution set to a diverse hostile environment set. Survivability technology is tasked to support missile defense elements throughout the life cycle by development of analysis and simulation tools, including upgrades and maintenance of validated models, hardware test facilities, and hardware prototypes; hardware and software hardening options to a specific set of hostile environments; independent assessment programs for integrated electromagnetic environmental effects; countermeasures for special weapon technologies; and threat sensing/deception hardening options.

The NMD survivability technology program will develop and demonstrate technologies to ensure that strategic BMD systems can perform their mission in all expected natural and hostile environments. The NMD survivability technology program is primarily funded via the NMD program offices and is intended to be funded by BMDO.

The TMD survivability technology program will develop and demonstrate technologies to ensure that theater BMD systems can perform their mission in all expected natural and hostile environments. The TMD survivability technology program is primarily funded via TMD program offices and BMDO.

Table D–14. BM/C³I Technology Plan

System Element	Current	By 2003	By 2015	Innovations Needed
Distributed Computing	1000 s WS latency to network GB/s data rate <100 km platform separation Limited scalability Log N relationship between number of nodes and speedup Networks possess limited robustness and fault tolerance GFLOP parallel/distributed Processing speeds	Handoff to NMD program manager	0.5 μs WS latency to network Terabit/s data rate 1000s of km platform separation Unlimited scalability Linear relationship between number of nodes and speedup Extremely robust and fault tolerant networks TFLOPs parallel/distributed processing speeds	Higher BW optical links Homogeneous optical network technology combining freespace and fiber Advanced distributed computing architectures New computing paradigms (e.g. optimistic processing)
Advanced Interaction Technologies	Limited virtual reality modeling; information overlay Limited speech/text recognition and natural language processing		Total immersion Information overlay Multiuser, multidomain Fully interactive, multinatural language based systems	Adaptable anchor desks Display technology (human factors) 3D virtual worlds Machine-based speech/text recognition Content-based retrieval Interactive dialog systems Natural language processing
Decision Aids	Primitive intelligent agents Neural networks/expert systems		Autonomous agents dynamically making and acting on decisions Just-in-time and just-adequate data processing presentation	Network of intelligent agents that can operate in uncertain, dynamic environments Enhanced information processing infrastructure Smart knowledge/databases

The survivability technology program also provides support to Army BMD systems and products (see PEO–AMD technology requirements), and direct support is provided to JLENS, Army Hellfire and Longbow missile systems, Army Research Laboratory, Defense Special Weapons Agency, and Simulation, Training, and Instrumentation Command.

The Survivability Division has developed core capabilities in the full spectrum of damage mechanisms. These damage mechanisms include nuclear weapons effects, NBC, conventional blast and fragmentary effects, directed-energy weapons (DEWs) effects, electromagnetic pulse, and electromagnetic environmental effects (E^3). In addition the threats posed by reconnaissance, surveillance, and target acquisition (RSTA) sensors and precision guided munitions sensors are being met by camouflage, concealment, and deception (CCD) as well as low-observable technologies.

Simulations and Models—System simulations, environment models, effects models, and mitigation schema (including algorithms for testbeds and software for radar and optical sensors) are maintained and distributed. The Army Multiple Engagement Model is a many-on-many simulation that includes nuclear and RF environments/effects on all elements of Army NMD and TMD systems. High-Synthetic Scene Generation Model, total radiation environment model, blast, dust, and thermal model, electromagnetic pulse estimator, kinetic impact debris distribution (KIDD), electronic data guidelines for element survivability, wideband measurement error model, nuclear environment effects on deterministic sensor signal [processor], AVATAR, sensor simulation, particulate emissions and response levels for sensors, and VHDL's Accelerated Simulation Technology (USAF project) are the major environments and effects models supported and maintained by SMDC. The SBE will be the major simulation that will allow the use of these models to play in the high-level architecture and distributed interactive simulation (DIS) activities.

Facilities—The antiradiation missile countermeasures evaluator (ACE) is an HWIL testbed that can emulate a radar waveform and be directly injected into an antiradiation missile (ARM) seeker. The Portable Optical Radiation Testbed for Sensors (PORTS) is a test chamber for active emulation of infrared seekers and sensors while being irradiated. The ACE and PORTS are unique DoD facilities. Nuclear test cassettes are available for active emulation of filters, lenses, and mirrors while being irradiated. CCD and conventional weapon countermeasure devices are available for demonstration and exercises.

Documentation—The Weapon Effects Library and Analysis Center serves as a depository of codes and simulations and the Air and Missile Defense Survivability Technology Information Center is a classified library service containing 20 years of survivability databases and reports.

Future Capabilities—Major initiatives are: (1) a virtual prototyping capability to represent survivability issues in support of BMD and Army space acquisition, development and training; (2) an HWIL environmental modifier capability to corrupt reconstituted RF data from original radar digital data (this capability will be ideal for investigations of mitigation techniques for electronic countermeasures, propagation of RF signals in a nuclear weapon environment, and weather effects on RF propagation); and (3) a new technology for remote detection of fissile material.

Lethality. Lethality is the bottom line in the development and acquisition of missile defense kinetic energy weapon (KEW)/DEW systems that must provide protection from conventional, chemical, biological, and nuclear threats. Laboratory testing and first-principles physics simulations (hydrocodes) are used to develop lethality information/criteria for the KEW/DEW systems in the concept definition phase, and evaluate phenomenologies and new technologies that can be incorporated during the design and development phases. High-fidelity field tests and lethality instrumentation on board flight targets are used to evaluate the lethality of systems in acquisition and satisfy Title X Live Fire Test and Evaluation (LFT&E) requirements prior to Milestone III. The lethality program consists of participation in the LFT&E process and working closely with other Army organizations and the Office of the Secretary of Defense to identify lethality issues and contribute to the development of test and evaluation master plans and live-fire strategies. The parametric endoatmospheric/exoatmospheric lethality simulation (PEELS) and the post engagement ground effects model (PEGEM) are lethality simulations under the lethality program to support missile defense acquisition activities. These simulations, which are used throughout the BMD community, are configuration controlled and distributed by the Lethality Division, and they undergo rigorous accreditation prior to being used in the missile defense acquisition process.

The PEELS and PEGEM developed by the lethality group enables lethality simulations to support defense acquisition activities.

g. Targets, Test, and Evaluation

Future Test Target Requirements. BMD weapon and sensor program definition and risk reduction programs emerging from advanced technology efforts indicate a need for test targets that are fully threat-representative from prelaunch operations to impact. For example, there has been no requirement to replicate threat signatures and performance during the boost phase. The arrival of ground, airborne, and space-based DEWs and offensive BMD systems will require targets with credible threat signatures and threat-traceable structures to evaluate system element performance for target acquisition, tracking, and kill assessment. Furthermore, these systems will probably require engagement geometries unachievable at existing ranges because of range safety and environmental constraints. The use of mobile sea or air based launch platforms will expand the Targets, Test, and Evaluation (TT&E) Directorate's ability to satisfy projected TBM and directed-energy (DE) test requirements. Improved guidance algorithms, coupled with variable thrust or throttleable propulsion systems, will permit missions from range extension areas that were previously prohibited because the expended booster footprint was outside the range boundaries.

Table D–15 shows the SMDC TT&E Directorate current and projected technology capabilities required to satisfy projected target requirements by 2015.

h. Directed-Energy Weapons Technology

Solid-State Laser (SSL) Technology Program. The SSL program will be conducted in three phases. In phase one—Disk Amplifier Optimization and Brassboard Construction—the goals are to integrate, test, and verify near-optimum disk amplifier technology. Edge cladding tests of amplifier disks will be conducted to minimize power loss due to amplified spontaneous emission. These tests will be done in a cost-effective manner by using flashlamp/disk amplifier technology. In phase two—High Average Power Upgrade with Static Lethality Testing—the disk amplifiers developed, integrated, and tested with flashlamps will be upgraded to the 100-kilowatt level by replacing the flashlamps with high-density diode packages. Lethality testing on static coupons and devices will be performed. This will allow for testing of propagation assessments, pulsed laser-target energy coupling coefficients, and beam quality assessments. In phase three, the laser will be upgraded to the 300-kilowatt level, an accurate beam director will be manufactured, and the system will be integrated. Long range, full power propagation and dynamic testing will be conducted against flying targets. Achievements made for SSLs have been primarily made through the Department of Energy's Laser Fusion program. The SSL program will leverage this multibillion-dollar investment by making the steps necessary to produce militarily applicable laser devices. [POC: Dr. Randy Buff, (205) 955–1911, e-mail: buffr@smdc.army.mil]

The SSL would be developed for future laser weapon systems (see Table D–16).

Table D–15. SMDC Targets, Test, and Evaluation Technology Plan

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
Launch Systems	Fixed launch sites using 30+ year old decommissioned boosters & guidance systems Flight termination, tracking, & instrumentation systems tailored to range capabilities	Mobile launch platforms Universal flight termination system (FTS)/safety system GPS navigation & tracking High accuracy single stage for range extension safety	Full range independent systems Improved telemetry (TLM)/instrumentation Modified fielded system variant	Environmentally friendly propellants Theater-strategic target synergy Multiple/salvo/rapid fire capability	Sea & air launch platforms Safe, nontoxic solid, & liquid propellants Lightweight, highly-reliable, low-cost, solid-state GPS navigation systems for missile guidance & range safety tracking Standardization of FTS & range safety systems Full modular TLM & instrumentation Improved guidance algorithms Variable thrust or throttleable propulsion systems
Cost Reduction	$10–15 million per launch Mission-unique hardware & software Trajectories & intercept conditions constrained by range safety Nonrecoverable/nonreusable	Recoverable or reusable target systems or elements	Virtual range	≤$5 million per launch Wooden round	Reliable, low-cost booster, guidance, instrumentation, & payload interface systems Validated multisensor data fusion algorithms supports virtual range Range data fusion Mid-air recovery of targets, instrumentation, & guidance systems
Emerging User Requirements	KE KV with RF and IR seekers Exoatmospheric and endoatmospheric intercept targets	DE targets DE scoring Vector miss distance scoring	Space targets Soft kill scoring	Stealth technology Full trajectory targets	Plume modeling Reliable, low-cost, liquid propellant systems emulating threat booster signatures DE scoring devices that do not affect RF & IR signatures Soft kill scoring devices Radar absorbing materials (RAM) and IR masking materials Emulate launch site signatures or emissions

Table D–15. SMDC Targets, Test, and Evaluation Technology Plan (continued)

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
Target Identification/Threat Replication	Baseline target set Single-type threat replication targets Unitary & bulk chemical RVs	Plume models Sled–flight test correlation Range data fusion Reliable foreign materiel acquisition (FMA) performance MRV to replace Pershing Submunition dispensing RV	Jamming decoys Maneuvering decoys Precision behavior of associated objects	Tunable materials—active RCS/IR Tunable materials—passive (RCS/IR)	Modular target to replicate multiple threat characteristics RAM & IR masking materials Enhanced threat characteristic modeling Validated multisensor data fusion algorithms Plume modeling Miniaturized, hardened beacons & instrumentation for submunition recovery & post flight lethality assessment Reliable, low-cost guidance & instrumentation for FMAs to improve test reliability without changing performance/signature characteristics

Table D–16. Directed-Energy Technology Plan

Component	Today	2009	2015	Innovations Needed
Solid State Laser	No potential weapons grade solid state laser at present	500 kW	1 MW	Diode cooling techniques Supply power generation
SSL Component Disk Amplifier	Glass doped	Segmented GGG:Nd	Single crystal GGG:Nd	Large crystal growth capability
SSL High Power Diodes	10 diodes/cm, $20/W	$3/W	30 diodes/cm, <$1/W	Cooled area emitters
Power Generation/Storage	1 kW/Kg	2 kW/Kg	4 kW/Kg	Turbine power without gearbox Batteries/flywheel
Mirrors and Optics (Beam Director)	MIRACL, THEL	Less expensive mirrors	Inexpensive atmospheric compensation	Lightweight mirrors
Tracking and Pointing	μrad class accuracy	<μrad class accuracy	<<μrad class accuracy	Accurate, lightweight, fast steering mirrors
Chemical laser	MIRACL (>1 MW) and THEL	500 kW, transportable	1 MW, mobile	Reduction in size Increase efficiency
Nozzles		Erosion resistant nozzles		Advanced materials

Hydrogen Fluoride Overtone Technology (Chemical Laser Nozzle Development). This effort is creating a new generation of hydrogen fluoride/deuterium fluoride/hydrogen fluoride overtone laser nozzle technology. The objectives of the Overtone Technology Development Program are to improve laser power density, improve laser specific power, increase mode width, improve thermal management, and simplify manufacturing of components. This program will demonstrate scalability in intermediate laser module size through the Overtone Research Advanced Chemical Laser, demonstrate a high power hydrogen fluoride overtone device that can operate in the hydrogen fluoride fundamental and deuterium fluoride bands, and demonstrate uncooled resonator optics at each level. [POC: John Wachs, (205) 955–1494, e-mail: wachsj@smdc.army.mil]

Nozzle development will enable more efficiency and reliability of future chemical laser weapon systems (see Table D–16).

i. Materials and Components Technology

Microelectronics/Optics Program. SMDC microelectronics uses a farsighted technology approach in the ever-changing world of the electronics semiconductor industry. Rapid change in this industry requires continuous evaluation of the technologies. In planning for electronic technologies that will operate in future DoD systems, system operational requirements and goals are continually monitored, taking into account the stages of system development that include conceptual design, demonstration devices, testing, initial device manufacture, and full-up production. The system applications for the electronics technology include satellites, tactical and strategic missile systems, and land-based systems that have past, present, or future requirements for operation in extreme environments.

Generally, there is a need to have microelectronics for advanced system capabilities that survive and operate in multienvironments and dynamic mechanical influences, such as cryogenic and high temperature, and that also have the possibility of being impacted by natural radiation and weapon-enhanced space radiation. Tasks associated with these efforts include evaluation, characterization, design, simulation, testing ,or prototyping of advanced concepts for microelectronics components (see Table D–17).

Table D–17. Microelectronics Technology Plan

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
Radiation Hardened Static Random Access Memory					Materials & processing
• Density (bits)	1 M	>4 M	>64 M	>64 M	
• Power Volts (v)	3.3/5.0	3.3/1.8	1.8/0.0	0.9	
• Access Time (nanoseconds)	25	<15	<10	<5	
Rad Hard High Performance Data Processors					Materials & processing
• Bits/Word	32	32	64	>64	
• Clock Rate (MHz)	20	200	400	600	
Rad Hard High Performance Digital Signal Processors					Materials & processing
• Bits/Word (data)	32	32	64	>64	
• MIPS	20	40	80	>80	
• MFLOPS	40	80	160	>160	
Radiation Hardened High Density Gate Arrays					Materials & processing
• Gate Length (μm)	0.5/0.65	0.25/0.35	0.25/0.18	0.18/0.12	
• Power (v)	3.3/5.0	3.3/1.8	1.8/0.9	0.9	
• Number of Gates (thousands)	400	1,000	6,000	7,500	
• Metallization (number of levels)	2–3	3–4	5–6	6–7	

Table D–17. Microelectronics Technology Plan (continued)

System Element	Current	By 2003	By 2009	By 2015	Innovations Needed
Rad Hard Field Programmable Gate Arrays					Materials & processing
• Number of Gates (thousands)	20	50	500	1,000	
• Programming Voltage(v)	5.0	2.5	1.5	1.5	
• Technology (Note 1)	SONOS	GMR/SONOS	GMR/SONOS	GMR/SONOS	
Rad Hard Nonvolatile Memory					Materials & processing
• Technology (Note 1)	MR/SONOS	GMR/SONOS/ FE	GMR/SONOS/ FE	GMR/SONOS/ FE	
• Density (bits)	256 K	1 M	4 M	64 M	
Rad Hard Analog to Digital Converters					Materials & processing
• Resolution (bits)	12	14	16	18	
• Power Dissipation (mW/MS)	10–15	10	<10	<10	
• Sample Rate [MSPS)	20–60	40–100	100–250	250–500	
Diamond Thin-Film-Based Electronics					Materials & processing
• Gate Dielectric Thickness (anstroms)	2,000	1,000	250	150	
• Device Types	Discretes	Power FET	Power IC	VLSI ICs	
Silicon Carbide (High Temperature) Electronics					
• Integration Level	SSI	MSI	LSI	VLSI	
• Technology	Discretes	CMOS	CMOS	CMOS	
Packaging					Materials & processing
• Type (Note 2)	QFP/BGA/ MCM	BGA/CSP/ MCM	CSP/MCM	CSP/MCM	
• I/O Count (QFP/GBA/CSP)	400	600	750	1,000	
• RH Digital EDA	1 foundry	>1 Foundry	>1 foundry	>1 foundry	
• RH Linear EDA	1 foundry	>1 Foundry	>1 foundry	>1 foundry	
• RH Mixed Signal	—	1 foundry	>1 foundry	>1 foundry	
Test					Materials & processing
• RH Technologies	Notes 3 & 4	Notes 3 & 4	Notes 3 & 4	Notes 3 & 4	
• COTS Technology	Notes 3 & 4	Notes 3 & 4	Notes 3 & 4	Notes 3 & 4	
Hardened IR Optical Components					Materials & processing
• Long Wave IR Filters					
• Cryogenic Operating Temperature		< 10°K			

Notes:

1 MR = Magnetoresistive; GMR = Giant Magnetoresistive; SONOS = Silicon Oxide Nitride Semiconductor; FE = Ferroelectric

2 QFP = Quad Flat Pack; BGA = Ball Grid Array; CSP = Chip Scale Package

3 Requires x-ray, gamma ray (Co^{60}), proton, neutron, and particle beam to determine sensitivity to permanent and transient radiation effects

4 Temperature range: Elevated temperature > 125°C < 350°C; MIL temperature –55°C to 125°C; Cryogenic 77K to 10K

Innovative Radar Components Research. The Advanced Technology Directorate has identified a radar technology vision for future radar systems. An "active radiator" concept is being explored that will replace the basic T/R module and provide significant improvements in radar system sensitivity, prime power requirements, weight, and volume. The Advanced Technology Directorate is pursuing a program to develop this "active radiator" technology as the next fundamental phased array building block for future solid-state radars. This program is expected to require 2 to 3 years for proof of principle, followed by another 3 years required for technology transfer to industry. A more advanced version of this concept will possibly support monolithic super elements by 2015.

This active radiator concept replaces T/R modules as we know them and requires an entire new suite of component technologies. Innovative limited technology, bidirectional amplifier architectures, radiators, material growths, and manufacturing approaches are required. One of the greatest benefits of this approach is the near elimination of front-end losses that directly improve erp and noise temperature. These improvements directly increase system sensitivity, reduce prime power, weight, and volume. Space fed arrays suddenly become more attractive, as well as provide the opportunity to exploit plasma-grating beamformers. Active radiator technology defines a new architecture for all 2015 phase array radars (see Table D–18).

Table D–18. Innovative Radar Components Research Through 2015

Domain	Parameter	Current Typical Performance	Advanced Components (2002)	Monolithic Super Element (2015)
Power Amp MMIC	Po (Class AB)	5 W Typ GaAs	3–9 dB Improvement GaN (20 W Nominal)	
	Efficiency	20%	>40%	
Circulator	Loss	0.5 dB	<0.1 dB	0 dB
	Isolation	40 dB	60 dB	—
	% Bandwidth	25	>80	>80
Limiter	Loss	0.5 dB	<0.1 dB	<0.1 dB
	Protection	100 W	10 kW	10 kW
	% Bandwidth	20	>80	>80
Optical TDU	Linearity	8° rms	1° rms	—
	Loss	10–15 dB (PS)	0 dB	—
	% Bandwidth	20	>90	—
Power AMP/LNA	Path Loss to free space	1.5–3 dB	0.4–1 dB	<0.1 dB
Total Performance	Nominal Loss	2 dB	0.45 dB	0.1 dB
	Po	3.5 W	18 W	19.5 W
	Efficiency (Overall)	14%	36%	~40%
	Noise Figure	Fmin + 2 dB	Fmin + 0.45 dB	~Fmin
	Cost Ratio	1X	0.3X	0.05X

j. Modeling and Simulations

The SMDC supports the M&S arena through its advanced research center (ARC) and simulation center (SC), both located in Huntsville, Alabama. The ARC is a self-contained, fully integrated testbed research center for missile defense technologies M&S (see Figure D–6). The ARC provides systems M&S analysis and engineering services required to support the design, development, and test of defense system components to support all missile defense programs. The ARC supports experimenta-

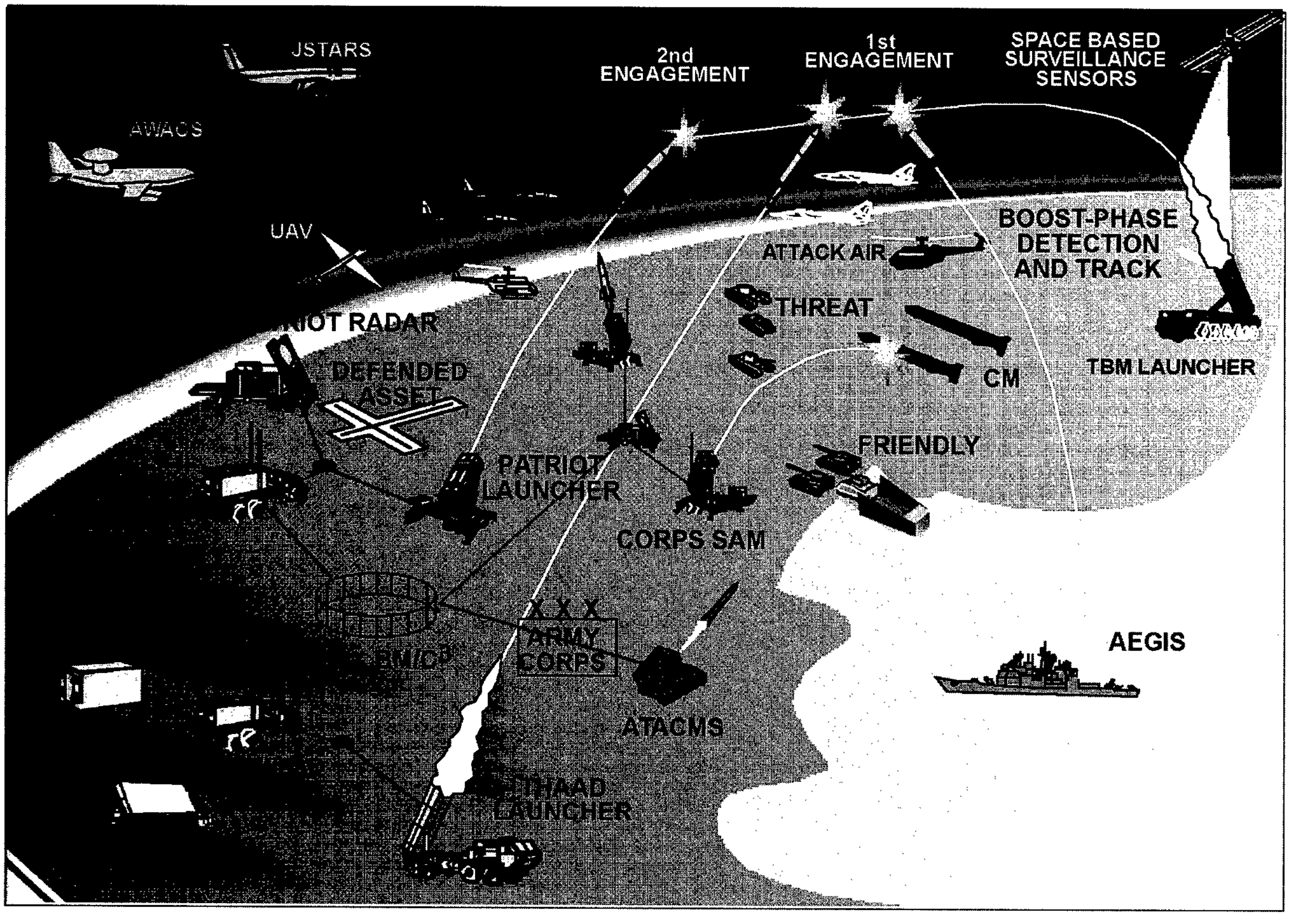


Figure D–6. Synthetic Battlefield Environment

tion and evaluation of advanced distributed software technologies, advanced real-time algorithm technologies, advanced M&S technologies, advanced visualization technologies, and advanced network technologies. The ARC integrates virtual, live, and constructive simulations to achieve operational objectives. The SC serves as the primary SMDC command asset for high performance scientific and engineering computational support.

Advanced Research Center (ARC). The ARC serves both as a principal computational resource center for developing and integrating complex PEO–AMD simulations and testbeds, and as a command asset of the SMDC for space and missile defense research and technology (see Figure D–7). The ARC has purchased the latest high performance computing equipment and it is expected to be fully operational before the beginning of FY98. The computational facilities of the ARC are maintained and improved routinely in order to host complex models and simulations. Models and simulations are improved to respond to the current and future threats; simultaneously, faster computer processes and increased memory requirements are met by capital investments in new equipment.

The ARC supports the ground based elements for TMD and NMD, with system development, integration, evaluation, operations, and test activities for missile defense program acquisition and technology. Testbeds included in the ARC are the Extended Air Defense Testbed (EADTB), Ground-Based Radar Test Facility (GBRTF), MDDC, integrated system test capability, TMD System Exerciser (TMD–SE), THAAD Verification and Validation System (TVVS), ACE, and others that support space

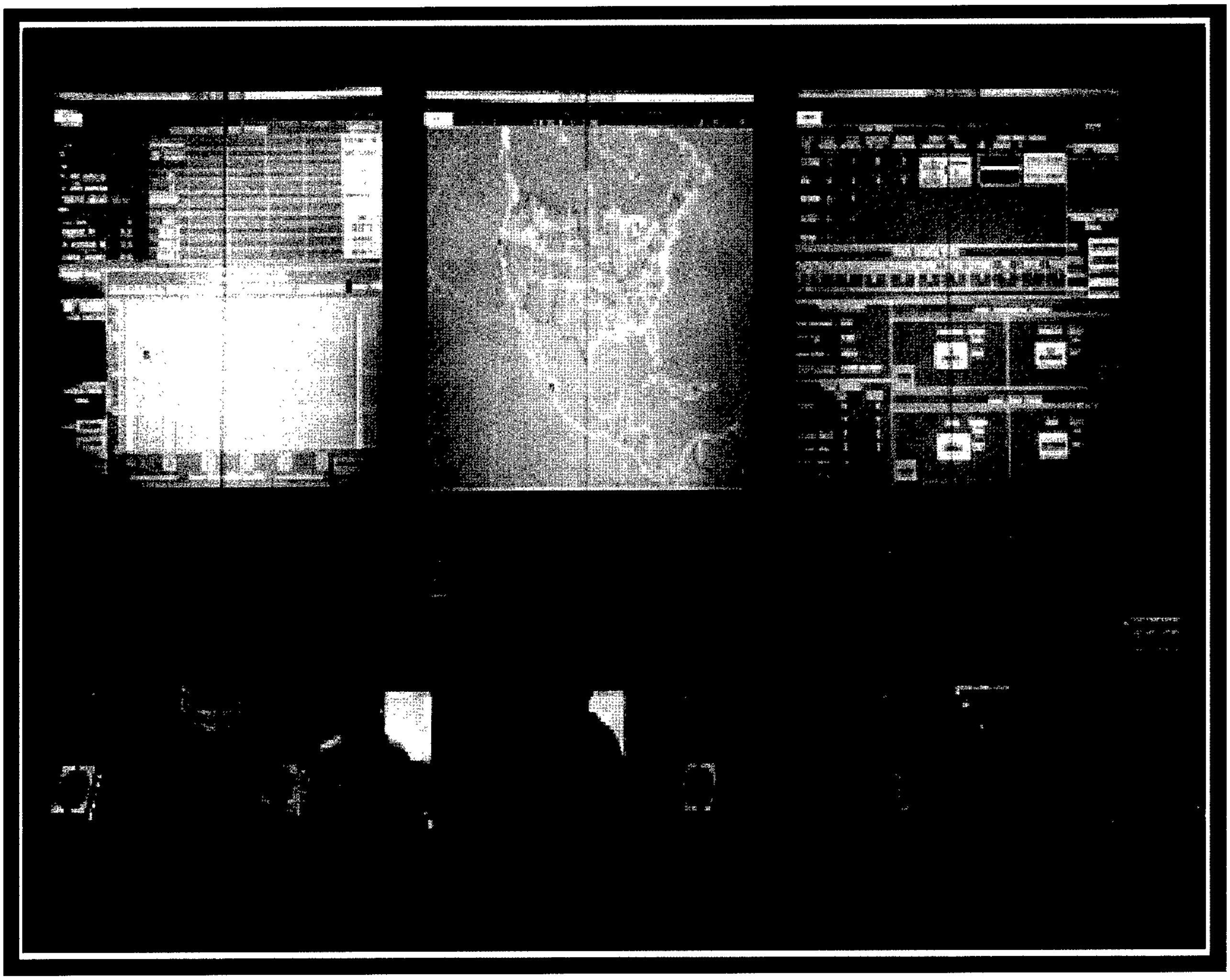


Figure D–7. Advanced Research Center

and missile defense programs. The ARC has the capability to conduct testbed intraactions among a variety of army elements; the same capability can be utilized among intraservice elements as required.

The ARC provides a treaty-compliant computational resource environment for the integration, evaluation, and demonstration of evolutionary NMD and BMD systems and their associated responses to designated threats. The environment includes effectiveness studies of alternative solutions, analysis of integrated element interfaces and interactions, technology insertion, reuse, and comprehensive tests in simulated realistic environments. The ARC:

- Hosts and executes theater and strategic simulations of missile defense architectures.
- Hosts end-to-end missile defense simulations in a networked environment, including HWIL live exercises.
- Supports Army and other DoD-sponsored military, joint service, agency, and multinational experiments and exercises.
- Provides efficient hardware and software development environments for theater and strategic defense components simulations and models.

- Provides a distributed access system to all authorized DoD customers.
- Functions as a repository for validation and configuration control DoD models and simulations.
- Organizes and processes missile defense data collected in domestic and other tests.

The ARC maintains a state-of-the-art testbed support environment through:

- An integration of advanced testbed technology including computing hardware, display media, local and long haul networks, distributed testbed control, and testbed tools (e.g., techniques for test, evaluation, simulation, modeling, instrumentation, data collection, and data reduction).
- A comprehensive life-cycle software engineering environment supporting the design, development, test, verification, and validation of real-time embedded software systems.
- Analysis of algorithms, models, simulations, and simulation frameworks that support the development, integration, evaluation, and demonstration of an evolutionary BMD.

Simulation Center (SC). The SC serves as the primary SMDC asset for high performance scientific and engineering computational support. On site, the SC maintains large scale Cray and Silicon Graphics Incorporated (SGI) supercomputer class systems in addition to Digital Alpha processors along with Sun and SGI workstations. The SC also serves as the SMDC connection point to the Defense Research and Engineering Network (DREN) and was recently designated by the High Performance Computing Management Office (HPCMO) as a distributed center. Through the DREN, the SC user community can access extensive computational resources, specifically the HPCMO major shared resource centers and other distributed centers. By providing these resources, the SC is an effective environment in which engineers and scientists can produce the models and run the simulations necessary for the development of modern defensive weapons systems.

The SC responds to future threats through a strong CFD capability to analyze both foreign threats and friendly defensive systems. The extensive use of CFD software to model the interactions between airborne vehicles and their environments has been a major thrust in recent years. The SC supports this effort by providing the appropriate compute resources and many of the software tools used by engineers and scientist to simulate and analyze these interactions.

The SC also provides user-required COTS products, such as NASTRAN and PATRAN, which are used for the modeling, simulation, and display of structural elements under load. In addition, government-developed codes are hosted on SC systems. The extended air defense simulation, for example, is used extensively by many SC users. The SC also serves as the host site for the airborne sensor testbed (AST) program's data reduction and analysis and the Huntsville Infrared Sensor Integration System efforts. The SC maintains a secure and reliable operating environment to support missions by analysis, archival resources, and distribution of data gathered during AST and other flights.

Modeling and Simulation Testbed Environments. Several permanent, maintained, and improved models and simulations reside on the ARC/SC testbeds and infrastructure, while numerous other testbed models and simulations have been run as one-time customer events. The permanent models and simulations are described as follows:

- *THAAD Ground-Based Radar Test Facility (GBRTF).* The THAAD GBRTF, comprised of actual GBR tactical signal and data processing hardware, is designed to support a variety of activities. The primary functions of the GBRTF include performance evaluations such as detailed mission plans and tests, database development, and data analysis with sometime supportive elements surveillance testbed, MDDC, EADTB, and ACE. For premission data, the ARC simulates test cases for the development of key database files used as real-time mission scenarios; post-mission data are transferred and archived at the ARC for detailed data analysis. Communication links connect GBR's prime contractor's facility with the ARC facility to allow for GBRTF HWIL signal and data processor evaluations and analyses, and connect among the ARC, WSMR, and USAKA support integration and test of GBR during live-fire exercises.

- *TMD, THAAD Verification and Validation System (TVVS).* The TVVS, a mobile testbed, is a comprehensive tool set to ensure software requirement adherence through the use of manual documentation, automated databases, static and dynamic code analysis tools, software-in-the-loop dynamic testing tools, concurrent tests to validate software in real-time, and flight test data replay. The ARC has two specialty features: (1) mobile van with capability for the THAAD mobile testbed to park, connect, and conduct integration tests, and (2) fiber optic data connections, power, and security to support the mobile van hookup. The TVVS integrated with the GBRTF will perform independent verification and validation (IV&V) of the BM/C^3I and GBR subsystems and validate GBR to BM/C^3I software interfaces prior to each scheduled THAAD flight test.
- *TMD Phased-Array Track to Intercept of Target (PATRIOT) Advanced Capability 3 (PAC–3).* The PAC–3 testbed is designed to support the database development for PAC–3 flight tests and demonstration and validation (DEM/VAL) flight test processes. A 6-DOF PAC–3 missile simulation, resident at the ARC, has been developed for IV&V of the missile design. Communication links among the ARC, defense contractors, Army Missile Command (MICOM), and WSMR support mission flight tests and data transfers. The KEW Digital Emulation Center and EADTB facilities are used in the system analysis and evaluation of the PAC–3 system.
- *EADTB.* The EADTB, a theater-level, end-to-end, high-fidelity TMD simulation, provides its users with a software architecture that provides friendly experimental setup, experiment execution, and results analysis with varying degrees of model fidelity. The EADTB and facilities have the capability to accommodate local, remote, and NATO/foreign EADTB users. Communication links connect EADTB to other TMD testbeds to support TMD system evaluations and analyses.
- *TMD—System Exerciser (TMD–SE).* The TMD–SE testbed supports simulation and HWIL development and various ground-based/TMD system element tests. The TMD–SE integrates functional processors and operations and supports HWIL integration, communications, and system performance measurements and predictions. It also provides communication links with other government agencies and contractors to support TMD–SE joint experiments.
- *ARM Countermeasure Evaluation (ACE).* ACE is a high fidelity HWIL testbed built to develop and test ARM countermeasure techniques in a laboratory-based test environment built for low-cost, quick-turnaround investigations. The objective of ACE is to provide a national resource for counterarm technology evaluations to include multiple applications of GBR and other radar that interface to GBRTF and other simulations in a modular structure to facilitate growth and enhancements. ACE has a secure, internal ARC connectivity to other collocated radar and technology testbeds.

k. Operations Research and Systems Analysis

Transporter Erector Launcher (TEL) Hunter/Killer (THK). The proposed THK uses modified Army tactical missile system (ATACMS) units with existing Defense Support Program (DSP) satellites (calibrated by LLYNX–EYE), improved airborne synthetic aperture radar (ASAR), and the Joint Tactical Ground Station (JTAGS) to locate, track, and destroy TELs. ATACMS missiles would be modified to receive and use in-flight target updates (IFTUs) to reduce target location error (TLE). The operational concept works as follows:

- An enemy TBM is detected at launch by a DSP satellite.
- DSP satellites, in conjunction with JTAGS, locate the TEL that launched the missile.
- JTAGS cues ATACMS to launch a missile to destroy the enemy TEL.
- JTAGS cues an ASAR to track the TEL.
- The ASAR provides IFTUs to the ATACMS via a BM/C^{4}I) network.
- With reduced TLE, the ATACMS missile maneuvers and engages the TEL.

Existing ATACMS missiles are incapable of receiving IFTUs. The proposed THK system reduces the TLE of ATACMS by enabling its missiles to receive IFTUs based on information obtained by ASAR. The technology developments needed to achieve system performance goals by the year 2000 are presented in Table D–19.

Table D–19. THK Technology Plan

System Element	Capability Today	Capability in 2000	Innovation Needed to Achieve Capability in 2000
ATACMS Missile Modification	ATACMS cannot accept IFTU	ATACMS capable of receiving IFTU, reducing target location error	Modify existing G&C software and hardware Design & install IFTU receiver with antenna Develop BM/C^{4}I to enable IFTU communications
Airborne SAR	Limited range, unacceptable data processing time required	Increase range, reduce processing time	Work with existing technology in near term, in far term leverage off technical developments in proposed MMSS
DSP Launch Point Error (LPE)	DSP LPE is capable of supporting strategic ballistic missile warning (ICBM) but not TBM attack operations	DSP & JTAGS support TBM attack operations with improved TBM LPE determinations using LLYNX–EYE laser calibration system	Develop the LLYNX–EYE laser calibration system to increase the probability of killing TELs
BM/C^{4}I	None capable of supporting THK	BM/C^{4}I capable of supporting THK	Develop procedures, software, & hardware to minimize processing, analysis, & transmission of BM/C^{4}I between the elements that make up the THK system

Cruise Missile Defense Expert System (CMDES). The proposed CMDES will use expert system technology (EST) to increase the warfighter's ability to define optimized emplacement and operation of cruise missile defense (CMD) to increase the lethality and the battlespace of existing or planned Army air defense systems and the survivability of friendly forces and critical assets. An expert system (ES) is a computer program designed to emulate the capabilities of a human expert in a specific knowledge domain. Procedural rules are used to evaluate data and reach conclusions about the meaning of the data or the actions that should be taken as a result of these conclusions. When properly implemented, expert systems can equal or better the performance of human experts with the advantage that they will consistently provide decision support under conditions of stress, lack of sleep, absences, or death of the human commander expert.

Although the CMDES is tailored to CMD, this tool will provide a working model and a mature software shell from which ES tools can be developed to support other military applications such as intelligence preparation of the battlefield and civilian applications where volumes of data and human expertise must be called upon to make decisions in a timely and effective manner. Little progress has been made in the application of this technology to aid military commanders. The capability to understand, integrate, and to draw advanced information from large technical CMD databases and from diverse scientists and make well founded decisions from the database does not exist. The two-phase program to develop this capability in the form of an expert system (CMDES) for CMD is outline in Table D–20.

Table D–20. Program To Develop CMDES

Program Phase	Current	Steps Involved in Phase	Demonstration/End Product
Phase I—CMD Concept Evaluation and Design Tool	A large database of information exists but utilization of the data requires a large staff of human analysts. A comparable ES does not exist at this time.	• Investigate expert system shells tools that would be used to build the CMDES • Acquire the tool shell. • Prepare CM information • Acquire knowledge & rules form human experts • Conclude Phase I by coding the knowledge & rules, testing the EST prototype, & using the tool to interrogate CMD knowledge.	A prototype of the tool will exist that will enable developers to better understand & analyze CMD while learning to use EST. Demonstration in 2000. Field in 2002.
Phase II—CMD Operational Planning, Training, and Operations		Build proof of principle ES decision tool to improve planning, training, & execution by decision makers in using CMD to counter a threat.	A more mature proof of principle tool will facilitate commander's decision making & automated capabilities for rapid identification of the correct weapon asset to engage targets. The tool effort will supply decision support to enhance BM/C^{4}I capabilities for CMD. Demonstration in 2008. Field in 2012.

Missile and Space Defense Operations Research and Systems Analysis (ORSA). This program has a broad base of expertise and is currently involved in addressing a broad range of issues. This program is currently performing system effectiveness analysis of joint CMD architectures. Various levels of force structure are being explored and operational issues such as doctrine and tactics are being addressed. In addition, advanced technologies are being assessed to determine the contribution to this mission area. This program is also supporting several space-related advanced concepts by assessing the value added of the concept to the battlefield. These advanced concepts provide capabilities such as increased situational awareness and decreased error in estimating ballistic missile launch point.

To address and resolve complex missile and space defense issues, ORSA analyst and engineers use sophisticated analysis tools and advanced distributed simulations. The simulation tools are very versatile and can be modified to represent any changes in the threat. ORSA analyst and engineers use engineering analysis tools, models, simulations, simulators, and advanced distributed simulation capabilities to provide an integrated analysis of NMD and all four pillars to TMD. Examples of these capabilities are:

- *TMD Operational Analysis.* This includes looking at current or near-term systems and assessing systems effectiveness based on changes to doctrine, tactics, techniques, and procedures (i.e., changing firing doctrine based on threat, changing the way data is shared, how engagements are controlled).
- *TMD and NMD System Effectiveness Analysis.* Includes evaluating different architectures, joint scenarios, etc. to determine current capability, effectiveness of total fighting force against current and future threats, value added of individual systems to specific theaters, etc.
- *Advanced Concepts Analysis.* Involves assessing the effectiveness of advanced concepts and determining value added to the warfighter. An example is evaluating the value added of a long range interceptor and overhead sensor for performing wide area CMD.
- *Distributed Interactive Simulation.* Involves performing an analysis of systems using high fidelity simulations and simulators to model specific systems and connecting through DIS to evaluate effectiveness of total fighting force in a scenario.

4. Demonstration Programs

a. Science and Technology Objectives

The following technology programs are Science and Technology Objectives managed by the SMDC MDSTC that support the space technology arena.

Laser Communications. LASERCOM is an LOS, high data rate, antijam, low-probability-of-intercept, lightweight, communications technology being developed and demonstrated for use between satellites and among TMD and NMD communications networks both on the ground and in the air. As the Army's designated manager for this STO, the STD in coordination with DoD and other government agencies continues to evaluate the potential of this high-data-rate wireless communication system to meet Force XXI warfighter requirements. The current program focus is on the ability to use a layered architecture consisting of a network of satellite-to-air-to-ground sensor platforms. The technology uses laser diodes for transmission, tracking, and alignment; low noise avalanche photodiodes for collecting data transmissions; and CCD arrays for tracking and alignment. Future advanced technology development will address high bandwidth potential (≥ 10 Gbps) and other issues such as improving laser output power and maximizing link availability.

LASERCOM is particularly suited for those situations that require secure, high traffic, long range applications. Those applications include space-to-space, space-to-air, space-to-ground, air-to-air, air-to-ground, and ground-to-ground communications. Shorter range, low traffic links would rely on the use of RF communications.

LASERCOM's advantages over RF can be primarily attributed to its capability to produce a highly focused beam of energy, enabling more signals to reach the receiver for a given amount of transmitted power. Current and projected performance of LASERCOM systems for different types of links, along with innovations needed to obtain projected performance, are described in Table D–21.

Table D–21. Laser Communications Technology Plan

System Element	Current	By 1999	Innovation Needed
Satellite–Satellite	Max range: 2,500 km Max data rate: 1.2 Gbps Altitude: exoatmospheric weight, power, cost	Max range: 2,500 km Max data rate: 12.0 Gbps size, weight, power, cost	Increased miniaturization of electronics Ultra-stable laser sources weight, power, & cost Increased single mode laser power High bandwidth, high current laser drivers Wide FOV acquisition & tracking Novel beam steering High bandwidth receiver Increased detector sensitivity Spatially incoherent transmitter arrays
Satellite–Ground	Range: 800–1,800 km Data rate: 155 Mbps to 1.2 Gbps Altitude: LEO		Software/hardware for atmospheric scintillation mitigation Extremely high rated (10 Gbps) direct modulation detector systems Eye safety
Aircraft–Aircraft	Range: 50–500 km Max data rate: 1.2 Gbps Altitude: 40,000 feet		
Aircraft–Ground	Range: 11–14 miles Data Rate: 1.2 Gbps Altitude: 30,000 feet		
Ground–Ground	Stationary/Fixed • Range: 150 km • Data rate: 1.2 Gbps Binocular • Max range: 5 km • Max data rate: 100Kbps Eye Safe	Portable ground terminal • Range: 25 km • Data rate: 1.2 Gbps	

LLYNX–EYE (Laser Boresight). LLYNX–EYE is a laser system that is being designed to reduce the TLE of Defense Satellite Program (DSP) satellites and other defense satellites. LLYNX–EYE will operate in conjunction with JTAGS or with satellite control network stations. The LLYNX–EYE consists of an erbium yttrium aluminum garnet (Er: YAG) solid-state laser and automated laser pointing and alignment controls to permit remote use by JTAGS or satellite control operator personnel. It will provide a laser beacon to the DSP from a known location so that any error in DSP pointing accuracy may be reduced or removed. LLYNX–EYE must operate in a near autonomous mode to minimize impacts on operator personnel strength. This laser calibrator can support DSP, space-based infrared system (SBIRS), and other satellite programs. Improved GPS/IMU may be used in aircraft, UAVs, and missile systems. Improvements in pumping and cooling of Er: YAG solid-state laser has broad application to government and civilian user market.

Existing DSP satellites do not provide LPEs with sufficient accuracy for optimal TMD. LLYNX–EYE can improve the sensor pointing accuracy of existing DSP assets by improving satellite calibration. The technology developments needed to achieve performance goals by the year 2000 are presented in Table D–22.

Table D–22. LLYNX–EYE Technology Plan

System Element	By 2000	Innovations Needed
Er:YAG Solid-State Laser	Develop software/hardware to compensate for scintillation observed as random noise by satellite operators which limits DSP satellite accuracy	Atmospheric scintillation compensation
	Improve power output by 25% Reduce laser weight by 75%	Improved laser pumping & cooling
	Develop gimbaled mirror system to enable single laser to point to & calibrate multiple satellites to reduce hardware fielding requirements by 75%	Laser optics & pointing
Automated Satellite Location	Reduce existing GPS/IMU size, weight & power needs to enable fielding of suitcase sized LLYNX–EYE hardware with the ground location and celestial pointing accuracy's required by LLYNX–EYE	Compact GPS/IMU that performs as well as existing units onboard aircraft
	Use current state of the art hardware & software to develop controller to interface JTAGs with LLYNX–EYE to allow automated calibration of satellites	LLYNX–EYE controller
	Develop LLYNX–JTAGs intercommunications using standard telephone or radio communication links	LLYNX–JTAGs intercommunications

Battlefield Ordnance Awareness (BOA). The BOA program focuses on providing the warfighter near-real-time identification and location of battlefield ordnance events. These events include artillery fire, rocket launches, and explosions. The BOA will utilize a multitiered sensor system to achieve the sensitivity, accuracy, and area coverage objectives. Space-based sensors will provide broad area coverage, while airborne elements will provide accurate position information and will be more sensitive to lower signature events (see Figure D–8).

BOA will increase the control of battlefield information by providing the warfighter with near-real-time reporting of ordnance events (within < 30 seconds), identifying both location (within <100m) and type of ordnance. Shooters will have targeting data on enemy artillery and missile launch sites within 10 seconds with a direct link and with a position error of less than 50 meters using UAV stationed sensors. Early warning of enemy missile launches (within 30 seconds of burnout) and impact point predictions accurate to within 3kilometers will be provided by space-based sensors. BOA will also provide battle damage assessment to the battlefield commander.

While systems exist to locate and track vehicle traffic and radio frequency transmitters for intelligence preparation of the battlefield, no system currently exists that reports type, time, and sightings of either red or blue ordnance. The BOA capability will identify the ordnances by type and provide position information for counterfire opportunities, as well as battle damage assessment, blue forces ordnance inventory, information for dispatch of logistical and medical support, and search and rescue. It also has the potential to type and classify launch systems using time domain intensity information in specific spectral bands. Advanced processor technology will be used with state-of-the-art staring focal plane arrays to provide this critical information to battlefield commanders (see Table D–23).

Overhead Passive Sensor Technology for Battlefield Awareness. This program is developing a passive optical sensor for overhead platforms that uses hyperspectral, polarimetric, and on-FPA processing to support battlefield awareness with wide area, near-real-time target detection, discrimination, identification, and location. This sensor will be able to detect camouflaged and concealed threats, such as tactical vehicles and aircraft, with target location accuracies that are comparable to those obtained from airborne synthetic aperture radar. The program will use sensor and processing technologies to reduce requirements on communication links and ground processing while providing near-real-time targeting data to support the warfighter.

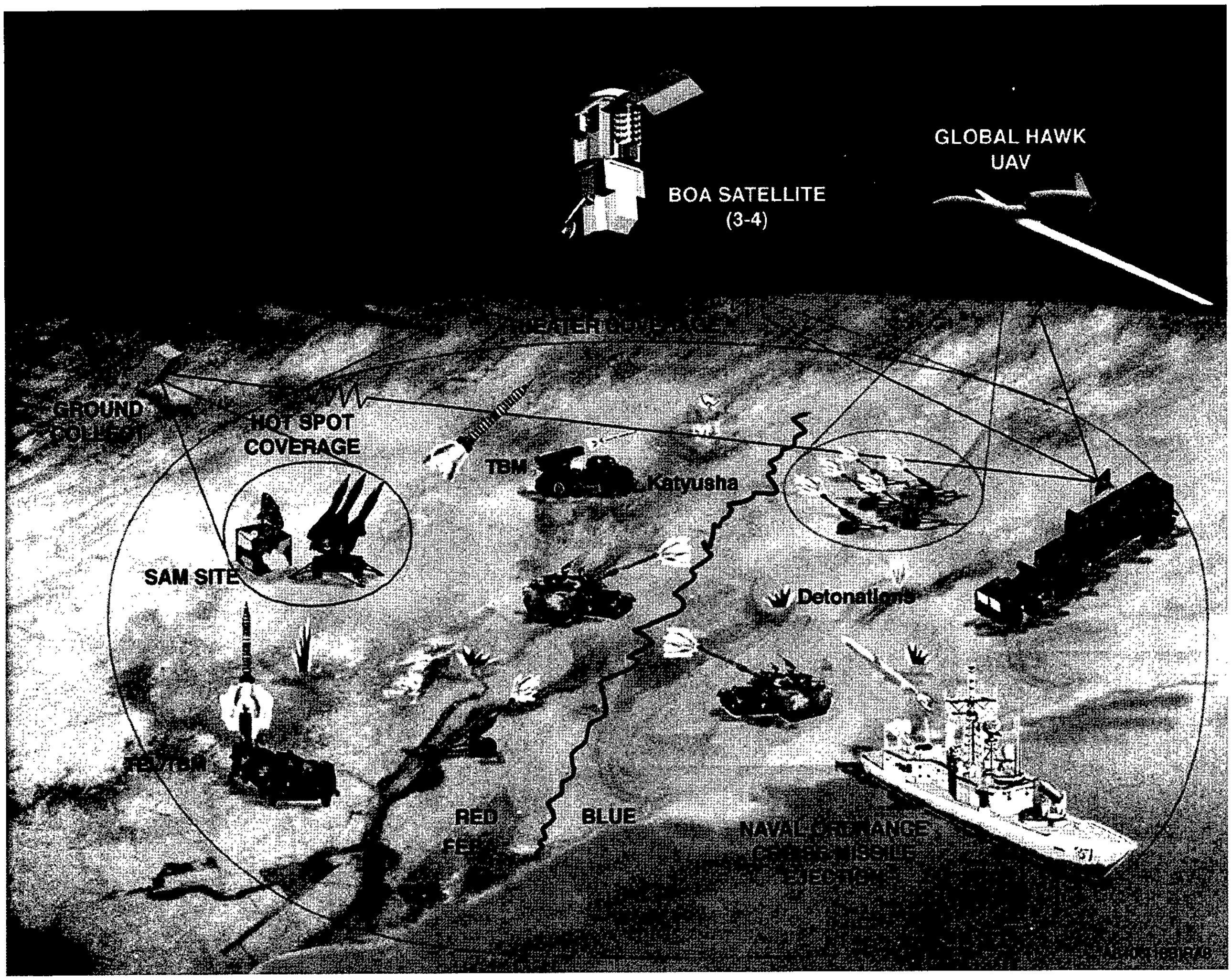


Figure D–8. Battlefield Ordnance Awareness

Table D–23. Battlefield Ordnance Awareness Technology Plan

System Element	Current	By 2002	Innovation Needed
Sensor	Laboratory sensor Poor geolocation	Ruggedized sensor Few meter geolocation	Improved sensitivity and processing rate with on-FPA processing Added GPS and star tracker
Processor	Ground processing in minutes	Near-real-time onboard processing	Fast algorithms for reduced processing time
Ordnance Data	Some ordnance data (intensity/time)	Complete red/blue ordnance database	No technology innovations. Targets of opportunity required

This sensor provides a significant advancement over current sensors in detecting, discriminating, identifying, and locating masked or concealed targets as well as low signature targets such as cruise missiles. By providing this new battlefield information in near-real-time, this program responds to the need for better situation awareness, while at the same time significantly reducing the communication bandwidth requirements with on-focal plane processing.

The timely information provided by this sensor system will support a wide range of programs such as TMD, ATACMS, forward area air defense system, combat close assault weapon system, and line-of-sight antitank and the battle laboratories including Early Entry Lethality and Survivability, Depth and Simultaneous Attack, Maneuver Support, Dismounted Battlespace, Space and Missile Defense, and Battle Command. The sensor and processing capabilities being developed under this program will have utility for many other programs that need fast, wide area detection of hard-to-locate targets such as reconnaissance, intelligence, and terrain analysis. These markets include military, government, and civilian areas.

Specific technologies that will be exploited include approaches to improve passive spatial resolution; signal processing techniques to exploit temporal signatures; polarimetry to achieve high performance autocueing; hyperspectral, spatial, and temporal signature processing; on-chip FPA motion detection; wide FOV, high resolution imagery; and opponent color vision analog focal plane processing. These sensor technologies will provide wide area coverage of the battlefield, robust detection, and targeting data while remaining within current Army C^4I data rates. Current and projected performance of the overhead sensor technology, along with innovations needed to obtain projected performance, are described in Table D–24.

Table D–24. Overhead Sensor Technology Plan

System Element	Current	By 2002	Innovation Needed
Adaptive Spectral	Mechanical selection of spectral content	Extend AOTF technology to MWIR (2.6–3.5 μ m)	Tuneable filter for discrete waveband selection
Polarimetry	Cannot detect zero targets	Detection of zero targets	Near-real-time algorithm development and processing
On-FPA Processing	Typical transmission rates without on-FPA processing = 1,000 Mbps	Typical transmission rates with on-FPA processing = 100 Mbps	FPAs with integrated processing electronics

b. Advanced Concept Technology Demonstrations

Tactical High-Energy Laser (THEL). The THEL weapon system concept is a mobile, high-energy laser weapon that uses proven laser beam generation technologies, proven beam pointing technologies, and existing sensors and communications networks to provide a bold new active defense capability in counterair missions against current threats that are proliferating throughout the world. The THEL can be integrated into the short- to medium-range air defense architecture to provide an innovative solution not offered by other systems or technologies for the acquisition and close-in engagement problems associated with these types of threats, thereby significantly enhancing the defense coverage to combat forces and theater-level assets (see Figure D–9). The THEL low-cost-per-kill (a few thousand dollars or less per kill) will also provide a very cost-effective defense against low cost air threats.

Approximately 21 months is required to design and build the system, followed by 12–18 months of field testing at the HELSTF and in Israel. This program will deliver a THEL demonstrator with limited operational capability to defend against short-range rockets. [POC: Dick Bradshaw, (205) 955–3643, e-mail: bradshawd@smdc.army.mil]

THEL protects the force theater level assets against multiple, low signature, maneuvering, low-cost threats. It also provides low-cost-per-kill, rapid-fire engagement on late detection threats, compact and transportable, common C^3I utilization, and multimission capability.

Figure D–9. Tactical High Energy Laser

c. Other Demonstrations

Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) Program. The Army tasked the SMDC to set up a joint service project office to develop DoD's first priority element for defense against land attack cruise missiles. The JLENS Project Management Office for Cruise Missile Defense was set up in February 1996 by SMDC MDSTC to develop a JLENS that could provide both surveillance and fire control for defense systems such as the Army's PAC–3 and the Navy's SM–2 missile that can shoot down cruise missiles. Its mission is to provide OTH surveillance and precision tracking data to enhance battlespace against land attack cruise missiles, and to provide battlefield visualization of both air and ground targets in support of the battlefield.

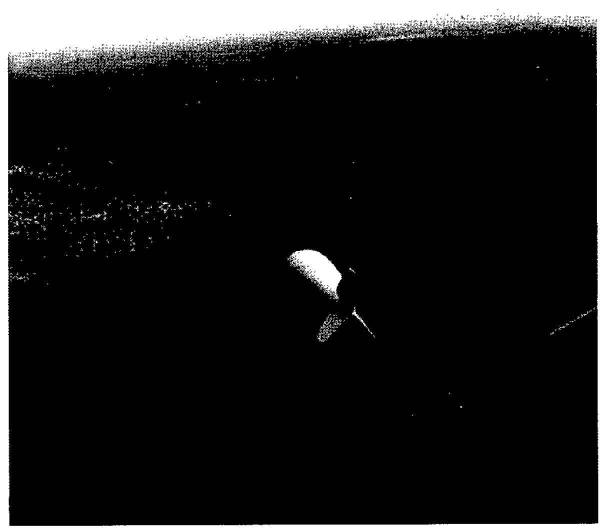


Figure D–10. JLENS

JLENS is a large, unpowered elevated sensor moored to the ground by a long cable (see Figure D–10). From its position above the battlefield, the elevated sensors will allow incoming cruise missiles to be detected, tracked, and engaged by surface-based air defense systems even before the targets can be seen by the systems. The elevated sensors have several characteristics, which may make them especially suited to CMD. They are less expensive to buy and operate than comparable fixed-wing aircraft. This makes them the most affordable alternative for achieving a near-term CMD. The elevated sensors can stay aloft up to 30 days at a time providing 24-hour per day coverage over extended areas.

The internal pressure of JLENS is about the same as the exterior pressure. This makes them extremely difficult to shoot down. These elevated sensors can absorb lots of punctures before they lose altitude. When they do, they come down so slowly that they can be reeled in, repaired easily, and sent right back up. In the long term, JLENS would complement fixed-wing aircraft performing a similar mission, and this will provide the U.S. more robust and flexible CMDs. Mooring systems for large JLENSs covering major portions of a theater of operations would probably be relatively permanent. For short or medium range surveillance and fire control, JLENSs would be smaller and the mooring systems could be transportable or ground-mobile. Currently, the program plans to issue multiple concept definition contracts and then downselect to a single contractor for development. In parallel to the concept studies, an Army JLENS testbed has been established at Fort Bliss, Texas, using off-the-shelf equipment.

Kinetic Energy Antisatellite (ASAT) Program. The most important application of a U.S. ASAT capability would be to ensure that hostile satellites are not used against U.S. and allied forces to provide an enemy important information derived from space-based surveillance and targeting. A secondary application would be to deny an adversary the use of low earth-orbit satellites for any purpose including battlefield communications, terrain mapping, weather data collection, and any other purpose that may have military application.

The U.S. Army's kinetic energy antisatellite (KE ASAT) program will provide the United States with the capability to interdict hostile satellites, preventing enemy space-based surveillance and targeting of U.S. battlefield assets. The KE ASAT consists of missile and weapon control subsystems. The major components of the missile subsystem are the booster, kill vehicle, shroud, and launch support system. The weapon control subsystem is composed of a battery control center and a mission controls element, which performs readiness and engagement planning, command, and control.

To date, two KE ASAT prototype KVs have been integrated—one has been test fired, and two prototype weapon control systems (WCSs) have been built and successfully tested. Booster specifications have been developed and completed. All DEM/VAL phase exit criteria, as approved by the Defense Acquisition Board, have been met and demonstrated.

The plan is to complete demonstration testing of the KV by conducting a full-up, free flight hover test of the integrated vehicle. During the test, the KV vehicle will use its onboard seeker to acquire and track a simulated target while hovering using its onboard propulsion system. This test will demonstrate the closed loop capability of the kill vehicle to acquire, track, and guide on targets. Also, preparations for continued demonstration testing of the system will be initiated for two flight tests of the KV. The WCS will be updated and placed at ARSPACE for interface and testing in the existing Command in Chief, Space architecture.

Army Space Exploitation Demonstration Program (ASEDP). The Army's use of space-based capabilities and products continues to increase their value added to the warfighter. This has been proven again and again in actual conflict, peace related operations, and field exercises. The Army ASEDP was established in 1986 and became an SMDBL function in 1997 when the battle laboratory was activated. Through ASEDP, the SMDBL is working to keep the Army in the forefront of technology design and development to maintain a preeminent position in tactical space support to the warfighter.

It supports continued technology advancements, documents requirements, and subsequent materiel developments.

Past ASEDP successes include use of the small lightweight global positioning receiver in Operations Desert Shield and Desert Storm; the Gun Laying and Positioning System, which uses GPS to increase field artillery pointing accuracy; and the Tracking Command, Control, and Communications demonstration using GPS and commercial satellite communications to enhance logistics tracking capabilities.

Initiatives for FY98 include:

- Army Battle Command Systems enhancements
- Low-Earth Orbit Mobile Data Communications
- Global Broadcast Systems
- Meteorological Automated Sensor and Transceiver
- Direct Broadcast Communications
- Joint In-Theater Injection
- Deployable Weather Satellite Workstation
- Battlefield Ordnance Awareness
- Camouflage, Concealment, and Deception (CCD)
- Tactical Data Relay Systems
- Force Warning Systems
- Orbital Mapping Software
- GPS Mapping
- Eagle Vision II
- Bronco
- Project Antenna
- Multiple Path Beyond Line of Sight
- Clark and Lewis
- Hyperspectral Imagery.

Space support to the warfighter continues to be the ASEDP's driving force. As the Army space policy states: "Army access to space capabilities and products is essential to successful operations."

E. OPPORTUNITIES FOR TECHNOLOGY INFUSION

With the active participation of the SMDC, PEO–AMD is pursuing the identification and infusion of technologies that meet requirements of their core acquisition programs. Given their mission to develop, integrate, acquire, and field quality air and missile defense systems, the PEO–AMD is currently developing and testing core acquisition programs for TMD and NMD systems. The FY97 infusion efforts focused on the PATRIOT and THAAD programs; FY98 efforts are extended to include NMD. As other AMD programs proceed further in their life cycles, the technology infusion effort will be directed to them. Some of the specific technologies that are applicable to ARROW, PATRIOT, THAAD, and NMD may also be applicable to the other core acquisition programs such as CORPS surface-to-air missile (SAM)/Medium Extended Air Defense System (MEADS) and JTAGS.

The PEO–AMD also has the responsibility to carry out a coordinated program for the infusion of key technologies that are being developed under the guidance of BMDO. The development of technologies to support TMD and NMD systems is an ongoing and evolutionary process. This section is based on the core acquisition program requirements for the period FY99 through FY05 and provides a framework within which the technology developers and the PEO–AMD program/project/product offices can identify optimal decision points for infusing new technologies into the core acquisition programs and, when necessary, make program adjustments to maximize the effectiveness of limited funds.

1. Theater Missile Defense

a. PATRIOT Advanced Capability 3 (PAC–3)

PATRIOT is a long-range, mobile, field army and corps air defense system that uses guided missiles to engage and destroy multiple targets simultaneously at varying ranges. The design objective of the PATRIOT system was to provide a baseline system capable of modification to cope with the evolving threat. The PATRIOT missile system is modular in nature, characterized by high technology and intensive software enhancements. This approach minimizes technological risks and provides a means of enhancing system capability through planned upgrades of deployed systems. The PAC–3 growth program consists of radar and communication enhancements, software upgrades, and ground support improvements. The program upgrades are blocked into configuration groupings and procured with independent acquisition decision.

The PAC–3 missile provides essential increases in battlespace, accuracy, and kill potential required to counter the most stressing tactical missile and fixed wing threats of the future. The PAC–3 missile improves PATRIOT's capability to counter advanced high-speed TBM threats, and provides a design capability against low RCS (LRCS) air breathing threat (ABT) targets in all operational environments. The PAC–3 missile engages TBMs at higher altitude, thereby increasing the defended battlespace. The lethality enhancements for the PAC–3 missile accommodate the most stressful conditions specified in the Operational Requirements Document (ORD) and Systems Threat Assessment Report; specifically, high-speed TMBs and LRCS targets in clutter.

Improved Thermal Batteries for Missile Interceptors. The applicable ORD requirements addressed by an improved lithium thermal battery technology program are range at target intercept, interceptor missile shelf life, and capability of a thermal battery interchangeable with the shape, size, voltage/power, and weight constraints of current PAC–3 thermal batteries. Improvements will enhance mission performance for any missile interceptor utilizing thermal batteries.

The PAC–3 missile uses thermal batteries for its power requirements prior to and after launch. The goal of this program is to improve significantly the thermal batteries used by PAC–3, and any other missile interceptor requiring thermal batteries. This program will specifically focus on increasing the relatively short discharge life of thermal batteries, particularly for high voltage and high discharge applications. An additional objective is to achieve an increase in the discharge life by a factor of 4–5 while maintaining both an adequate cell voltage and a large discharge current density. This technology program for improved lithium batteries for the PAC–3 missile (and any other missile desiring this upgrade) will result in longer battery power duration. This longer thermal battery lifetime implies increased range that can be greater or equal to the missile kinematic capabilities. Technology insertion can be accomplished at any time during missile production or even afterwards. [POC: Alan Pope, PATRIOT, (205) 955–1990]

Interferometric Fiber Optic Gyroscope. The TMD missiles must provide navigation accuracy consistent with the seeker FOV, divert capabilities, target uncertainties, and in-flight guidance updates within the engagement battle space. In order for PAC–3, THAAD, and CORPS SAM/MEADS to meet individual operational requirements, a low-cost, lightweight, high reliability, small, high-performance gyroscope must be developed. The interferometric fiber optic gyroscope (IFOG) is one of the gyro developments with the potential to meet the requirements.

IFOG represents an improvement over the current ring laser gyroscope (RLG) in the following technical areas: (1) the IFOG provides increased accuracy over the RLG, (2) the IFOG is all solid state, and (3) the IFOG is smaller and lighter, occupying about one third the volume and requiring less power for guiding the rotating PAC–3 missile as it closes on the target. For the IFOG, light from an external solid-state laser device is split into two waves traveling clockwise and counterclockwise, each of which propagates around many turns of a fiber coil before being interfered. The output, based on the Sagnac effect, appears as a well-known two-beam interference pattern. The path length difference due to rotation results in an optical phase shift between two waves. The most probable infusion period for the technology would be 3QFY00. [POC: Jim Putman, PATRIOT, (205) 955–1997]

Miniaturized Seeker Receiver Circuitry (MMIC, HYBRID). There is an operational requirement to increase the seeker dynamic range and reduce its size, weight, and cost. There is a need for a technology development program that will produce seeker receiver circuitry that provide all of the receiving functions for a Ka-band radar seeker in a miniaturized package that minimizes size, weight, and volume, with increased performance and reliability. The combination of reduced packaging size coupled with increased reliability would result in lower life cycle costs for these seeker receiver circuits.

The proposed technology is the miniaturized seeker circuitry (monolithic microwave integrated circuit (MMIC) modules that provide all of the receiving functions for a Ka-band radar seeker. The program to develop these MMIC or HYBRID modules will require direct interaction between the seeker contractor and the module developers. The use of this technology would result in lower manufacturing costs, lower life-cycle costs, and higher reliability. The earliest possible infusion point would be 4QFY99. The most probable and latest possible infusion points would occur in 1QFY00. [POC: Jim Putman, PATRIOT, (205) 955–1997]

Uplink Downlink Antenna System. The PATRIOT ORD has requirements for positive control, electronic countermeasures (ECM), and range among other system features. There is a specific need for an improved uplink/downlink antenna system.

The need for an improved antenna design is driven by the solid-state power amplifier that the PAC–3 missile uses to maintain a lightweight design. A series of design studies were performed to determine the antenna gain required to provide sufficient effective radiated power for transmission of the downlink signal at long ranges in ECM environments. Various missile flyout trajectories were considered during these studies. As a result of the above indicated studies, a need exists for an antenna system with the following characteristics:

- C-band operation
- Low development and manufacturing complexity
- Low production cost
- High gain (long ranges in ECM environments)
- Wide FOV (0° to 132° in pitch; ± 45° yaw per quadrant)
- Missile skin conformance
- Low complexity beam directivity implementation
- Lightweight

- Small size
- Capability of being integrated into a baseline radio frequency datalink (RFDL).

The RFDL antenna system will transmit downlink and receive uplink digital serial messages to and from the ground based PATRIOT radar throughout the flight of the missile. The RFDL system provides alignment uplinks for aligning the missile IMU with the PATRIOT radar coordinate frame, missile status downlinks to the PATRIOT system, target data uplinks (i.e., position, velocity, acceleration), and engagement data downlinks (i.e., target information transmitted to ground radar during endgame). The technology infusion period ranges from 4QFY99 to 1QFY00. [POC: Jim Putman, PATRIOT, (205) 955–1997]

Miniaturized Uplink/Downlink Transceiver Circuitry (MMIC, HYBRID). The PATRIOT ORD requires positive control, operation in ECM, and long range communications. There is a need for replacement of the current RFDL components in the PAC–3 missile midsection assembly with a lightweight compact RFDL with improved producibility and reduced unit production costs.

The value-added by this technology is better producibility, lower cost, smaller size, lower weight, and greater flexibility of design during development. There should also be reductions in the operations and support costs from the above improvements. The RFDL in the PAC–3 missile midsection assembly provides two-way C-band communications between the PATRIOT ground radar and the PAC–3 missile. It is a solid-state device composed of two main parts: the target data uplink receiver and the missile downlink transmitter. The technology infusion period ranges from 4QFY99 to 1QFY00. [POC: Jim Putman, PATRIOT, (205) 955–1997]

Radio Frequency Target Discrimination and Recognition. The Patriot ORD states a requirement for onboard target acquisition, tracking, recognition, discrimination, and homing. Key technology issues related to targets, measurements, and algorithms for TBM defense include threat complex assessment, discrimination, interceptor guidance, and aimpoint selection.

This programs provides support to the PAC–3 Project Office in meeting these critical technology requirements. This program provides unique abilities in the areas of radar data analysis, real-time algorithm evaluation, real-time architecture evaluation, and real-time LDS testing using real and simulated radar data. This program and the LDS testbed will provide a source of real-time radar algorithms and architectures for handling diverse TBM threats. The technology infusion period ranges from 1QFY99 to 1QFY01. [POC: Doug Deaton, PATRIOT, (205) 955–1923]

Improvement to Target Identification and Discrimination Technology. The Patriot ORD states a requirements for the discrimination of TBMs from debris and penaids, the discrimination of TBMs from non-TBM targets, the classification of TBMs and non-TBM targets, and the identification and classification of ABT targets for friend versus foe.

The PATRIOT Program Office is currently involved in development of a Classification, Discrimination, and Identification Phase III (CDI–3) capability to be integrated into the PAC–3 system. The CDI–3 subsystem will provide the discrimination of TBM reentry vehicles (RVs) from debris and penaids. It will also allow for the growth of the CDI–3 capability to encompass the classification and identification of non-TBM targets and ABTs. The subsystem is centered around a wideband waveform generation, receiver, and signal processor subsystem. This technology effort involves the analysis and modeling of candidate TMD system characteristics, surveyance of pertinent target data set to be measured and modeled, measurement of aspect dependent target RCS/range profiles, and participation in the XPATCH Code Consortium chaired by the U.S. Air Force Wright Laboratories for the development of a detailed target range profile simulation. The technology infusion period ranges from 3QFY97 to 4QFY98. [POC: Mike Eison, PATRIOT, (205) 955–4120]

Analog-to-Digital Converter Technology and Corresponding Signal Processor Throughput and Dynamic Range. For the PATRIOT radar, advanced signal process technology is required to support dynamic ranges while maintaining the throughput, size, weight, and prime power requirements. Applicable advanced signal processing techniques, such as maximum entropy method (MEM), are required for incorporation into PATRIOT, along with a concept for their utilization, signal processor hardware concepts, and an assessment of their performance improvement over pulse Doppler for various environments.

The PAC–3 radar signal processors currently use 12-bit A/D converters for narrow band actions. For radar performance in clutter, more dynamic range is needed—up to 14–16 bits for wide band. system/transmitter intermediate frequency (S/T–IF) receiver subsystem changes would require the incorporation of 16 bit A/D converters into the PATRIOT S/T–IF receive subsystem, along with the incorporation of the advanced signal processor hardware and processor resident software. Included in the proposed architecture and design is the removal or disabling of the current digital signal processor and the replacement of their functions in the advanced signal processor. The CDI–3 receiver subsystem was designed for later incorporation of 12 bit A/D converters when available. The incorporation of the 14-bit converter will require some redesign of the receiver. The value added for PATRIOT is improved fire unit search, track, and CDI capabilities in low altitude, high clutter or extensive antitactical missile debris environments. The technology infusion period is from 1QFY02 to 4QFY03. [POC: Rodney Sams, PATRIOT, (205) 955–3166]

Satellite Communications on the Battlefield. The PAC–3 ORD states that PATRIOT must be capable of using organic or nonorganic single-channel and multichannel tactical satellite systems for extended range data and voice communications. Additionally, PAC–3 must accept and process told-in intelligence data and declare identification at sufficient ranges. Also, the PAC–3 Information Coordination Central (ICC) and the engagement control station (ECS)/fire unit (FU) must be capable of interfacing with and processing (in combination as external data transmission mediums) the Improved Army Tactical Area Communications System (IATACS), the Army Common User System (ACUS), the Army Data Distribution System (ADDS), the High Frequency Combat Net Radios (HFCNR), Army troposcatter transmission system, satellite communications, and commercial-leased communications circuits.

PATRIOT uses the Tactical Information Broadcast System to support this requirement. No other satellite programs exist as part of the PAC–3 program. Currently there is a Commanders Tactical Terminal–Hybrid Receiver (CTT–HR) installed in the Battalion Tactical Operations Center (BTOC). The CTT–HR is a satellite receiver that received told-in intelligence data from a theater intelligence system. This information is sent to the BTOC communications processor where it is translated into PATRIOT's data protocol, and then transferred from the BTOC to the ICC. Once in ICC, it is fused in the expanded weapons control computer with data provided by the battalion's internal radars to provide enhanced classification and identification of potential targets. The information is then displayed to the operators in both the ICC and BTOC. A key goal of this technology program is to be able to extend PATRIOT's defended area by extending PATRIOT's communications range. Satellite technology could allow a PATRIOT battalion to be deployed over a larger area and provide coverage to more assets on the theater commander's priority list. The technology infusion period is from 2QFY00 to 4QFY03. [POC: Gerald Skidmore, PATRIOT, (205) 955–3869]

Solid-State Transmitter. There is an operational need to improve missile seeker acquisition and tracking in a cluttered environment, reduce power and size, and improve its overall reliability. Performance improvements such as in solid-state transmitter will provide increased capabilities to PAC–3 and CORPS SAM/MEADS.

Solid-state transmitters offer a number of potential advantages for active radar seekers. The more significant advantages include low voltage operation, graceful degradation due to failures, and lower phase noise floor, approximately 15 decibel (dB) lower than current traveling wave tube transmitters. It also offers reduced phase noise and graceful degradation as components fail in millimeter wave radar seekers. These benefits should result in more reliable transmitter operation as well as improved seeker acquisition and track performance in severe clutter environments. Reliability has cost savings implications for the operations and support phase, and the improved performance has possible cost savings in reduction of requirements on other components or maybe even reduced deployment quantities. The technology infusion period is from 2QFY99 to 1QFY00. [POC: Jim Putman, PATRIOT, (205) 955–1997]

Radar Signature (Target Signature System). There is a need to optimize PATRIOT missile system's engagement capability by providing positive target identification. Other technology is required to provide protection for friendly fixed wing aircraft, identify non-TBMs by specific platform, and provide ARM countermeasure support via ARM carrier identification.

Aircraft, TBMs, and cruise missiles become more difficult to detect and track with conventional radar because of the reduced RCS. Improvements or other adjunct technologies are needed to supplement radar tracking of these targets in more stressing environments. The proposed technology effort should identify available technologies, such as electronic support measure or IR, that are applicable to this problem for the PATRIOT system. For example, IR technology may be available but may not support the longer ranges required. Concepts for implementing the selected technologies into PATRIOT should be developed, considering the need to minimize impact on force structure, and to quantify detection, tracking, and identification performance. This is a P^3I effort with an opportunity for insertion beyond PAC–3. [POC: Mike Eison, PATRIOT, (205) 955–4120]

Satellite Transmission of Recorded Battlefield Data. The PAC–3 ORD states a requirement for an in-theater capability of copying and validating software tapes, disks, or other such electronic or photonic storage media at each battalion. The originating source must be capable of copying data recording media and archiving selected portions in a master database and should have over-the-air transferring capability to other using locations. PATRIOT must be capable of using organic or nonorganic single channel and multichannel tactical satellite systems for extended range data and voice communications. The PAC–3 ICC and ECS–FU must be capable of interfacing with and processing in combination with the following external data transmission mediums: IATACS modified, ACUS, ADDS, HFCNR, Army troposcatter transmission system, satellite communications, and commercial-leased communication circuits.

PATRIOT needs a small organic satellite terminal such as the Lightweight Satellite Transceiver satellite terminal or the AN/USC–39 satellite terminal that would be dedicated to satellite communications. The terminal could be installed in the BTOC, which already receives the full tactical data stream from the ICC Expanded Weapons Control Computer and has the capability to record all data. This effort could reduce data transfer time during deployments to remote locations such as Southwest Asia or Korea. It could also translate into few interceptors required and significant cost savings. The technology infusion period is from 1QFY00 to 1QFY01. [POC: Gerald Skidmore, PATRIOT, (205) 955–3869]

b. Theater High Altitude Area Defense (THAAD)/Ground Based Radar (GBR)

THAAD comprises the upper tier of the Army's planned two-tiered BMD architecture. Its long-range intercept capability will make possible the protection of wide areas, dispersed assets, and population centers against TBM attacks. THAAD's high altitude intercepts will effectively defend against maneuvering RVs and greatly reduce the probability that debris and chemical or biological agents from a TBM warhead will reach the ground. Its HTK technology will provide high lethality against a broader range of threat missiles. The combination of higher altitude and longer range capability will provide multiple engagement (shoot-look-shoot) opportunities to kill incoming threat missiles. THAAD will be interoperable with both existing and future air defense systems and other external data sources. The THAAD missile, combined with the radar element, forms the THAAD system.

TMD Survivability Program. Technology Requirements Document (TRD) and ORD requirements state that TMD Systems, including THAAD, PATRIOT, and CORPS SAM/MEADS, are high-value assets and are required to have a high probability of survival on all TMD battlefield environments, including nuclear. The TMD systems are required to minimize the multispectral signatures and reduce the susceptibility to detection, recognition, and acquisition by RSTA systems.

The TMD Survivability (TMDS) program consists of eight interrelated tasks for TMD objective systems that require research and susceptibility assessment, exploitability evaluation, vulnerability assessment, solution development, and technology insertion. Those eight tasks are:

- Top/down survivability and demonstrations
- CCD technology engineering
- Nuclear and natural propagation effects analysis and countermeasures development
- E^3
- Antiradiation and cruise missile countermeasure evaluator (ACE) upgrades
- ARM and smart weapons countermeasures analysis
- Nuclear, natural, kinetic debris model development
- Conventional munitions countermeasures and tests.

This program will provide enhanced battlefield survivability of the TMD systems. The emphasis is on providing solutions that are low-cost, easy to integrate into the system, and available in the near term. The technology infusion period is from 1QFY98 to 4QFY02. [POC: Bob Balla, (205) 895–3308]

Optical Data Analysis. The THAAD requirements document requires target characterization for seeker onboard optical discrimination to identify, track and kill the target accurately. Optical data analysis (ODA) will provide the analysis, algorithm development and evaluation, and the tools and models necessary for development of seeker discrimination.

The ODA program is managed by the Sensors Analysis Division of the SMDC. The ODA program's focus is on data analysis, algorithm development and evaluation, defense sensor functional evaluation, and models and tools development. The key risk reduction goals for the ODA program are to provide ancillary sensor data analysis input to assist DEM/VAL test planning/evaluation, implement and evaluate algorithms as necessary to provide assessments of DEM/VAL success/issues, provide assessments of expected DEM/VAL target performance to assist pretest planning and post-test evaluation, and assist in the characterization of the THAAD system for user operational evaluation system capability and objective system requirements. The technology infusion period is from 1QFY98 to 4QFY99. [POC: Delois Ragland, THAAD, (205) 895–4058]

Kill Assessment Technology Program. The THAAD TRD places stringent discrimination, false alarm, and kill assessment performance requirements on the THAAD radar system. Critical kill assessment technology requirements include near-real-time algorithms for both unitary and separated warheads that can determine to what degree the target has been rendered nonlethal. Also required are near-real-time advanced algorithms to identify warhead and missile types. All of these technology products require thorough verification and validation testing on the Massachusetts Institute of Technology/Lincoln Laboratory LDS facilities.

A critical function required of the THAAD radar as part of the THAAD system is to perform near-real-time kill assessment of intercepts made during tactical ballistic missile engagements. The kill assessment technology is essential for implementing shoot-look-shoot capability for THAAD, as well as for supporting upper tier/lower tier proper cueing by BM/C^3I. Critical technology development requirements for THAAD radar kill assessment include near-real time algorithms for both attached (unitary) and separated warheads of threat missile systems. First, these algorithms must determine and quantify effectiveness (i.e., whether and to what degree an interceptor has rendered the target nonlethal), thus ensuring accurate further response cues. Second, they must accomplish near-real time identification of warhead types (i.e., high explosive, chemical, biological, nuclear).

This technology effort will pursue extensive data/measurements collection from major flight demonstrations plus ground based tests for a comprehensive database and a broad-based development, test, verification, and validation activity towards advanced kill assessment algorithms and architectures. Additionally, the kill assessment program will support DEM/VAL flight testing through timely post mission intercept assessment, radar data reduction and analysis, and algorithm evaluation, which should demonstrate an operational kill assessment capability for key TMD elements such as THAAD. The technology infusion period is from 1QFY98 to 2QFY06. [POC: Joe Roberts, THAAD, (205) 895–3211]

Real-Time Discrimination Technology (RTDT). The ORD and TRD impose stringent discrimination and false alarm requirements on the THAAD radar system demanding separation of RVs from tankage, RV associated objects, closely spaced objects, and decoys.

To support successful engagements of TBMs, critical technology requirements and issues for the THAAD radar include missile system typing, discrimination, wideband tracking, target object map handover to THAAD, support for THAAD seeker aimpoint selection, and support for upper tier handover to the lower tier.

These requirements are supported by the RTDT program, including the LDS real-time testbed. The program supports the development of missile system typing, discrimination, and tracking algorithms through field data reduction and analysis in conjunction with real time algorithm design, testing, and validation. The capabilities of LDS allow for detailed testing of multi sensor system functions (i.e., radar to interceptor handover and upper tier/lower tier handover and fusion) using both field measurements and simulated data as required. This program also supports PAC–3 requirements for onboard target acquisition, recognition, discrimination, and homing. The technology infusion period is from 1QFY98 through 1QFY05. [POC: Joe Roberts, THAAD, (205) 895–3211]

Advanced Radar Component Technology. THAAD has stringent discrimination and engagement assessment requirements that necessitate wide bandwidth and improved range and Doppler resolution. The system also has traffic handling and simultaneous attack requirements demanding high processing speeds and a large processing capacity. The radar system must be able to operate in a severe ECM environment, must not have interference by other friendly radar systems, must be able to survive ARM attacks, and must be off-road and cross-country mobile and C–141 transportable.

An increase in performance combined with a decrease in size/weight of advanced radar components developed by the proposed program contribute to electronic counter-countermeasures (ECCM), discrimination, kill assessment, and mobility/transportability requirements. The initial effort of this program is the development of a concept for utilizing components from the current waveform generator to provide real-time simulated digital beamforming at the subarray level for X-band radars. In addition, an advanced waveform generator will be built that is capable of both analog and digital beamforming at twice the instantaneous bandwidth of the current waveform generator in one-half volume. This combination addresses ECCM, discrimination, kill assessment, and mobility/transportability requirements. The wideband waveform generator will be a major contribution to the down range simulator used in HWIL testbed, where the capability to test signal processing of wideband arbitrary waveforms exists. The acousto-optic processor may be inserted as and adjunct to the THAAD signal processor to perform wideband arbitrary signal processing. [POC: Bob Balla, (205) 895–3308]

Miniature Interceptor Technology. There is a requirement for interceptors to meet future threats using significantly less onboard power consumption, reduced size and weight, and improved control during divert maneuvering. The miniature interceptors are small and light, require less power, and provide increased guidance, control, stability, and kill effectiveness. Defending against the advanced submunitions threat is one example of future threat requirements.

Research goals in this area encompass the development of miniature interceptor components that will reduce size and weight, improve control, reduce onboard power consumption, increase accuracy of guidance and control, increase divert capability and increase reliability and ruggedness. The technology program will demonstrate a non-IMU spin stabilized homing projectile; will build a polarization sensitive sensor and measure polarization from strategic materials; and will fabricate and test a 9-centimeter path length ring laser gyroscope IMU (250 grams, 3.5 cubic inches). The goals include the concept that consists of simultaneous targeting and engagement of multiple objects (which would be encountered in an advanced submunitions threat) by spin-stabilized homing projectiles. Specific capabilities to be obtained from this technology effort include polarization technology that will provide discrimination capability, eliminate aim point ambiguity, identify and discriminate hard body from plume, and determine target orientation; a propulsion system that will provide 25 percent higher Isp (specific impulse) than the current THAAD propulsion system; IMUs that will be developed with milliwatt power consumption while reducing cost and size, and increasing accuracy; and HTK miniature interceptor properties that will be developed to enhance the THAAD kill mechanism. The technology infusion period is from 1QFY99 to 4QFY02. [POC: Peter Wright, THAAD, (205) 895–3720]

Optical Signatures Code (OSC). The THAAD TRD places a stringent requirement on optical discrimination. OSC provides a validated capability for simulation of infrared, visible, and ultraviolet (UV) signatures of missile targets applicable to both strategic and tactical missile defense scenarios. OSC is an analysis tool supporting mission planning, sensor and seeker design, data analysis, and threat missile signatures. A key goal of OSC is to provide credible optical signatures as required by BMDO programs. The OSC is considered the industry standard, a high fidelity signature simulation code to be used in ballistic missile scenarios. Current enhancements to the code capabilities include theater and cruise missile applications. Specifically, OSC contains improvements that allow it to provide accurate estimates of the aerothermal ascent and reentry heating of tactical and test targets. For the proposed effort, additional upgrades to the code are currently being designed to predict the behavior of a variety of threats more accurately.

Signature predictions from the OSC will be used by THAAD to predict target intensities. As the OSC is further refined to predict intensities of the full range of DEM/VAL, engineering manufacturing development (EMD) and objective system targets for the THAAD system, it will allow THAAD designers to tighten their requirements on seeker acquisition, resolution, optical discrimination, and endgame imaging performance. The code has been upgraded, both to predict behavior of targets with nonaxisymmetric shapes more accurately, and to provide capabilities for theater and cruise missile simulations. Other upgrades are needed to model complex targets with four conical sections, improve wake and debris models, and complete development of graphical user interfaces for PC Windows and workstations. The technology infusion period is from 1QFY98 through 1QFY05. [POC: Mike Butler, THAAD, (205) 895–4059]

Range Doppler Imager (RDI). The THAAD ORD requires that the radar design incorporate survivability features to permit operation in a severe ECM environment. The radar has stringent discrimination and engagement assessment requirements that necessitate wide bandwidth and improved range and Doppler resolution. The radar also has traffic handling and simultaneous attack requirements demanding high processing speeds and a large processing capacity. As the ECM environment becomes more severe, an advanced signal processor utilizing technology from the RDI may need to be incorporated into the THAAD radar.

The objective of the RDI development effort is to design, fabricate, test, and evaluate an advanced optical signal processing architecture. The proposed technology program provides instantaneous or real-time processing of wideband arbitrary waveforms. The technology developed in this program can be utilized in advanced acousto-optic signal processing hardware capable of real-time wideband signal processing of arbitrary signal modulations in dense target environments. Pseudorandom noise waveforms, which are difficult for ARMs to acquire and track, allow for a robust ECCM waveform suite to be developed for the THAAD radar. This additional waveform diversity capability enables the successful wideband tracking and accurate discrimination of targets in a severe ECM environment. The most probable technology infusion point is 3QFY99. A P^3I insertion is possible after 2QFY02. [POC: Bob Balla, (205) 895–3308]

Resonant Fiber Optic Gyroscope (RFOG). The TMD missiles must provide navigation accuracy consistent with the missile seeker FOV, missile divert capability, target state uncertainties, and in-flight guidance updates within the engagement battle space. In order for THAAD, PAC–3, and CORPS SAM to meet their individual operational requirements, a low-cost, lightweight, high reliability, small, high performance gyroscope must be developed. The RFOG is one of the gyroscope developments with the potential to meet all the requirements.

RFOG represents an improvement over both the current RLG and IFOG. The resonance approach yields more sharply defined resonance peaks providing increased accuracy compared to the IFOG and the RLG. The resonance technique also requires many less turns of fiber providing one half the volume requirement compared to the IFOG and one third the volume of the RLG. This accuracy is required for guiding the THAAD missile as it closes on the target. In addition, an all solid-state RFOG has no moving parts, requires low voltage and power, and can be packaged in smaller volumes than either the RLG or the IFOG. The RFOG-driven IMU is being developed to provide enhanced THAAD terminal guidance accuracy. It is a fit, form, and enhanced function replacement for the RLG-driven IMU but requires less weight, space, and input power. The technology infusion period is from 3QFY00 through 4QFY02. [POC: Ray Noblitt, THAAD, (205) 955–1857]

Jet Interaction/Jet Reaction (JI/JR) Phenomenology. The expanded high-speed, high-altitude engagement requirements in which current and planned interceptors such as THAAD are employed necessitate the understanding of JI/JR phenomena. The unexpected flow of Attitude Control System (ACS) reaction products during interceptor maneuvers has the potential of affecting the IR transmission capabilities of the optical sensor window that, in THAAD, is in close proximity to the ACS. Testing and analysis of the JI/JR processes throughout the battlespace cannot only help understand and mitigate potential engagement and detection limitations, but also aid in product improvements and future design efforts on new weapon systems.

The knowledge and insight gained through a comprehensive test program, coupled with CFD code and model development, would not only significantly reduce the design and performance risks associated with new weapons systems, but also add to the basic understanding of the physical interactions of active control systems in high-speed, high-altitude atmospheric conditions. This knowledge will impact both the capabilities of DACS and the efficient design of optical sensors located near the ACS. In addition, the test program will examine new material developments and other technologies needed to develop low cost, high performance solid DACS for use in future programs. The successful performance of this risk reduction program requires access to advanced test facilities and state of the art CFD codes and models. The ability to use test data collected both at modeled and actual flight conditions to normalize and validate computational techniques and models will support extending the ability to optimize missile design and capabilities. This program will lead to the understanding required to maximize the capabilities of modern interceptors while reducing the design, development, and test risks associated with the programs. The most probable technology infusion point is 2QFY03, with a possible P^3I insertion anytime afterwards. [POC: Dr. Don McClure, (205) 955–1952]

c. CORPS Surface-to-Air Missile/Medium Extended Air Defense System

The CORPS SAM will be a highly mobile, low-to-medium altitude air defense system, and will be a key element of the TMD in the PEO–AMD architecture. It will protect the maneuver forces with area and point defense capabilities against tactical ballistic missiles, air-to-surface missiles and ARMs; fixed and rotary wing aircraft; cruise missiles; and UAVs. CORPS SAM will be the implementation of the MEADS in the DoD infrastructure.

The system will consist of sensors, launcher, missile and Tactical Operations Center, and will be capable of standalone operational capability. However, as part of the PEO–AMD architecture, the system will be compatible/interoperable with other Army air defense systems (i.e., THAAD, PATRIOT, FAAD) and will interface with joint and allied sensors and BM/C^3I networks.

The MEADS is a trilateral U.S.–Germany–Italy cooperative development program, now entering the project definition–validation phase and continuing through FY98. Two international contractor teams will compete during this phase, with the ultimate selection of a single winner for the design and development phase occurring in early FY99. Because MEADS is in this competitive phase, technology infusion is not appropriate.

Furthermore, because the MEADS is an international cooperative program, all PEO–AMD communications concerning U.S. technology capabilities and MEADS technology requirements are to be directed to the CORPS SAM National Product Office (NPO). The CORPS SAM NPO point of contact (POC) will monitor technology developments for consideration by CORPS SAM/MEADS for further technology infusion opportunities.

d. ARROW

The ARROW Continuation Experiments is a follow-on to the ARROW Experiment Program. ARROW is a joint United States–Israel program to assist the Government of Israel to attain critical performance objectives and obtain the test information to enable a decision to enter into production and deployment of the ARROW-centered Israeli Missile Defense System. The U.S. benefits from test and technology products of the program. FY93 efforts focused on conducting lethality flight tests using the

ARROW I missile and completing the subsystem critical design reviews for the ARROW II tests, and the ARROW II system CDR. The initial ARROW II missile flight test was completed during the summer of 1995. The ARROW program will have five ARROW II system tests in FY98–99.

The ARROW Project Office has identified the technology programs suitable for application to ARROW II and possible for infusion within the current technology export restrictions. The ARROW Project Office will monitor future technology developments for consideration by ARROW for further technology infusion opportunities.

e. Joint Tactical Ground Station

The JTAGS is a transportable information processing system that can receive and process in-theater, direct downlinked data from DSP sensors and disseminate warning, alerting, and cueing information on TBMs and other tactical events of interest. JTAGS, an Acquisition Category III, nondevelopmental item program, is in the production phase. Five units were produced and fielded in 1997.

The current JTAGS P^3I program includes the following system enhancements:

- Phase I (FY97–99)
- Joint Tactical Information Distribution System Integration
- Sensor fusion
- Sensor calibration (beacon)
- Phase II (FY98–03)
- Four SBIRS integration.

A tri-service MOA signed by all service executives in September 1996 agreed to pursue use of the Army JTAGS as the SBIRS common mobile ground processor. While no technology programs have been identified for potential infusion into JTAGS, the JTAGS Program management Office POC will monitor future technology developments and changes to the JTAGS mission for further technology infusion opportunities.

2. National Missile Defense

NMD is a strategic endeavor of all U.S. armed services to provide protection for national assets against an attack by various third world countries with an emerging delivery means for WMDs. NMD has entered the first year of a 3-year development period that will culminate in a decision to deploy. With an affirmative decision in FY99, NMD will enter a 3-year development period. The NMD program will continue to DEM/VAL technologies for possible development and production, should the threat worsen.

a. Ground-Based Interceptor/Exoatmospheric Kill Vehicle

Pilotline Experiment Program. The NMD ground-based interceptor (GBI) ORD and segment specifications are now under revision. However, there will likely be tractability to the GBI–X TRD. According to the GBI–X TRD, the GBI element KV seeker will be capable of target selection by performing onboard discrimination in accordance with known target optical characteristics and exoatmospheric nonnuclear, HTK intercepts. The TRD has an implied requirement to incorporate margin in the operational seeker for any final threat variations, handover shortfalls, or more stressing environments.

The Pilotline Experiment Technology Program is an ongoing FPA technology program addressing a number of issues, including high-speed, on-chip readout electronics, radiation hardening, and on-chip hybrid FPA producibility, thereby demonstrating repeatable, reliable, and predictable performance with end-product deliveries. This program is developing critical component technology emphasizing NMD and TMD system applications, including CMD. Refer to subsection D.3a for more information. The most probable technology infusion point is 1QFY98, with the possibility of a P^3I insertion afterwards. [POC: Janet Fuqua, NMD–GBI, (205) 722–1965]

Improved Thermal Batteries for Missile Interceptors. The applicable ORD requirements to be addressed by an improved lithium thermal battery technology program are range at target intercept, interceptor missile shelf life, and similarity of the shape, size, voltage/power, and weight constraints of the NMD–GBI design. Improvements to thermal batteries will enhance mission performance for any missile interceptor utilizing thermal batteries. See subsection E.1a for more information on the program. The earliest and most probable technology infusion points are 4QFY99 and 3QFY00 respectively. There is a possibility for a P^3I insertion afterwards. [POC: Rick Bowen, NMD–GBI, (205) 722–1216]

Interferometric Fiber Optic Gyroscopes (IFOGs). The NMD–GBI must provide navigation accuracy consistent with the seeker FOV, divert capabilities, target uncertainties, and in-flight guidance updates within the engagement battle space. In order to meet operational requirements, a low-cost, lightweight, high-reliability, small, high-performance gyroscope must be developed. The IFOG is one of the gyroscope developments with the potential to meet the requirements. Refer to subsection E.1a for a description of the program. The earliest and most probable technology infusion points are 4QFY99 and 3QFY00 respectively. There is a possibility for a P^3I insertion afterwards. [POC: Rick Bowen, NMD–GBI, (205) 722–1216]

Resonant Fiber Optic Gyroscopes (RFOGs). Refer to subsection E.1b for a description of the program. The earliest and most probable technology infusion points are 4QFY99 and 3QFY00, respectively. There is a possibility for a P^3I insertion afterwards. [POC: Rick Bowen, NMD–GBI, (205) 722–1216]

Gel Propulsion. Gel propulsion technology is based on taking highly energetic, highly reactive, highly hazardous liquid hypergolic propellants and adding a gelling agent. This produces a gelled liquid propellant that retains its high energy characteristics but is much less hazardous. The total impulse of the gel propulsion unit meets or exceeds the solid rocket motor capabilities. The gel booster offers the option of improved performance in the same booster envelope. If preferred, the booster performance can be held equivalent to the baseline system, and the propulsion weight and volume can be reduced. The gel booster offers complete energy management flexibility and has an on-demand, on-off-on, adaptive thrust capability. The basic gel propulsion technology has been demonstrated in the THAAD gel DACS program. This program will package the components to NMD–GBI system requirements. The NMD–GBI design documents will be used to ensure that the gel booster is a form-fit-and-function equivalent of the baseline system. The gel booster development schedule will be tied directly to the NMD–GBI schedule. Environmental and system level tests will be conducted and a technical data package will be developed. The most probable technology infusion point is 3QFY00. [POC: Gene Lenning, (205) 722–1216]

b. Ground-Based Radar/Radar Technology Validation

Mosaic Array Data Compression and Processing (MADCAP) Module. There is a need for addition of transient filtering to improve the sensitivity of the GBI focal plane in a nuclear environment. The MADCAP technology will support this need. Refer to subsection D.3b for a description of the program. [POC: Dr. Virginia Kobler, NMD–PO, (205) 895–3836]

Discriminating Interceptor Technology Program (DITP). The DITP has the prime objective of demonstrating potential TMD and NMD interceptor seeker upgrades with a sensor data fusion capability.

It will demonstrate, for the first time, data fusion from miniaturized, colocated, dissimilar sensors on an interceptor platform. During scheduled test flights, DIPT will demonstrate interceptor-based discrimination against simulated targets. The key technologies being developed in this program are the discrimination algorithms, and the intelligent processing algorithms and methodology for fusing the data from the various sensors.

The schedule for DIPT calls for flight tests to begin near the end of FY 00. To support this schedule, the discrimination algorithms and intelligent processing algorithms will be delivered in initial form near the end of FY98. This will include the algorithms configured to run on a massively parallel computer similar to that which would fly on an interceptor and a fused sensor discrimination tool to test and evaluate the algorithms against threat scenarios using real and simulated data. These algorithms and the testbed for evaluation and testing will be updated throughout the life of the program. The technology infusion period is from 4QFY98 through 4QFY04. [POC: Earl Deason, NMD–PO, (205) 895–1425]

Optical Signatures Code (OSC). OSC is utilized in this effort to predict signature intensities for ballistic missiles, targets, decoys, penaids, and missile fragments. Refer to subsection E.1b for a description of the program. The technology infusion period is from 1QFY98 through 4QFY05. [POC: Dave Lacy, NMD–PO, (205) 895–3208]

Optical Data Analysis. The GBI Office requires target characterization for its integrated flight test (IFT) and the accurate evaluation of performance as well as the evaluation of sensor/seeker algorithms to identify, track and kill its target accurately.

The ODA program will provide the tools and models necessary for the characterization of target signatures and the accurate evaluation of algorithm performance. The ODA Program's focus is on data analysis, target modeling and signature generation, algorithm development and evaluation, defense sensor functional evaluation, and models and tools development.

The GBI Office's expectation is that work by the ODA program will mitigate risk to GBI during the flight test phase, result in the delivery of better algorithms for insertion during the GBI development process, result in a better understanding of performance characteristics, and provide the basis for better algorithms for technology insertion in the EMD phase of development. Refer to subsection E.1b for more information on the program. The technology infusion period is from 1QFY98 through 1QFY99. [POC: Dave Lacy, NMD–PO, (205) 895–3208]

Innovative Radar Components Research. The NMD GBR has stringent requirements that require high overall sensitivity. The active radiator will provide a sensitivity enhancement of up to 6 decibels at potentially less cost per element than a T/R module architecture.

An active radiator proof of principle will be demonstrated in FY98 using the FY98 proof of principle demonstration results as a foundation. The proposed FY98/99 tasks will (1) extend the level of active radiator component integration; (2) perform tradeoffs and develop and test signaling element control methodology; (3) perform tradeoffs and develop and test a power distribution network; and (4) perform a pilot build of about 64 elements. This program will provide invaluable technology that will improve overall system performance and requirements for subarray cooling, power delivery, beam steering control, etc. Refer to subsection D.3i for more information on the program. The earliest and most probable technology infusion points are 1QFY00 and 3QFY00 respectively. P^3I insertions are possible through 2010. [POC: Bill Dionne, (205) 722–1830]

F. ABBREVIATIONS

4D	four-dimensional
AAN	*Army After Next*
ABT	air breathing threat
ACE	antiradiation missile countermeasure evaluation
ACTD	Advanced Concept Technology Demonstration
ACS	attitude control system
ACUS	Army Common User System
A/D	analog-to-digital
ADBF	adaptable beamforning
ADDS	Army Data Distribution System
AIT	atmospheric interceptor technology
ARC/SC	advanced research center/simulation center
ARH	antiradiation homing
ARM	antiradiation missile
ARSPACE	Army Space Command
AS	advanced submunition
ASAR	airborne synthetic aperture radar
ADEDP	Army Space Exploitatin Demonstration Program
ASTMP	*Army Science and Technology Master Plan*
ASAT	antisatellite
ASPO	Army Space Program Office
AST	airborne sensor testbed
ATACMS	Army Tactical Missile System
ATD	Advanced Technology Demonstration
AWS	Arrow Weapon System
BAT	battlefield adaptation technology
BM/C^3I	battle management/command, control, communications, and intelligence
BM/C^4	battle management/command, control, communications, and computers
BM/C^4I	battle management/command, control, communications, computers, and intelligence
BMD	ballistic missile defense
BMDO	Ballistic Missile Defense Organization
BOA	battlefield ordnance awareness
BPI	boost phase intercept
BTOC	Battalion Tactical Operations Center
BTW	bit per wavelength
C2	command control
C^4I	command, control, communications, computers, and intelligence
CAD	chemically augmented device

CB	chemical and biological
CCD	charged-coupled device; camouflage, concealment, and deception
CDC	Center for Combat Development
CDI	classification, discrimination, and identification
CDI–3	Classification, Discrimination, and Identification Phase III
CDR	critical design review
CECOM	Communications–Electronics Command
CEP	circular error probable
CERS	counter early release submunitions
CET	counter early-release submunition technology
CFD	computational fluid dynamics
CINC	commander-in-chief
CM	cruise missile
CMD	cruise missile defense
CMDES	Cruise Missile Defense Expert System
CONUS	continental United States
CORPS SAM	Corps Surface-to-Air Missile
COTS	commercial off the shelf
CSO	closely spaced object
CTBW	chemical toxin biological warfare
CTPP	Consolidated Target Program Plan
CTT–HR	Commanders Tactical Terminal–Hybrid Receiver
CW	chemical warfare
D&D	design and development
DAB	Defense Acquisition Board
DACS	Divert and Attitude Control System
DARO	Defense Airborne Reconnaissance Office
DARPA	Defense Advanced Research Projects Agency
DART	data analysis reporting team
dB	decibel
DE	directed energy
DEM/VAL	demonstration/validation
DEW	directed-energy weapon
DIA	Defense Intelligence Agency
DIS	distributed interactive simulation
DITP	Discriminating Interceptor Technology Program
DMTB	digital messages transfer device
DNA	Defense Nuclear Agency
DOAMS	Distant Objective Attitude Measurement System
DoD	Department of Defense
DOF	degree of freedom

DREN	Defense Research and Engineering Network
DS	desert ship
DSI	defense simulation internet
DSP	defense support program; defense satellite program
DSWA	Defense Special Weapons Agency
DTLOMS	Doctrine, Training, Leader Development, Organization, Materiel, and Soldier
E^3	electromagnetic environmental effect
EAC	echelons above corps
EADSIM	extended air defense simulation
EADTB	extended air defense testbed
ECCM	electronic counter-countermeasures
ECM	electronic countermeasures
ECS	engagement control station
EEU	electronics equipment unit
EIT	exoatmospheric interceptor technology
EKV	exoatmospheric kill vehicle
EMC	electromagnetic compatibility
EMD	engineering manufacturing development
EMI	electromagnetic interference
EMP	electromagnetic pulse
EPLARS	Enhanced Position Location Reporting System
ERIS	exoatmospheric reentry vehicle interceptor subsystem
ES	expert system
ESD	electrostatic discharge
EST	expert system technology
FAAD	forward area air defense
FASDR	forward acoustical sensor and digital relay
FASP	fly along sensor package
FEL	free electron laser
FL	field LADAR
FLAGE	flexible lightweight agile guided experiment
FLTSAT	fleet satellite
FMA	foreign materiel acquisition
FME	foreign materiel exploitation
FOC	future operational capability
FOCPAT	fiber-optic controlled phased array technology
FOG	fiber-optic gyroscope
FOV	field of view
FPA	focal plane array
FSC	fire solution computer
FTS	flight termination system

GAO	Government Accounting Office
GBI	ground-based interceptor
GBR	ground-based radar
GBRTF	Ground-Based Radar Test Facility
GHz	gigahertz
GOI	Government of Israel
GPS	global positioning system
HALO	high-altitude observatory
HALO/IRIS	high-altitude observatory/infrared imaging system
HEDI	high endoatmospheric defense interceptor
HELSTF	High Energy laser Systems Test Facility
HERA	high explosive rocket assisted
HFCNR	High Frequency Combat Net Radios
HGV	hot gas valves
HMMWV	high mobility multipurpose wheeled vehicle
HOE	homing overlay experiment
HPC	high performance computing
HPCMO	High Performance Computing Management Office
HPM	high power microwave
HRR	high range resolution
HTI	horizontal technology integration
HTK	hit-to-kill
HVPS	high voltage power supply
HWIL	hardware in the loop
Hz	hertz
IATACS	Improved Army Tactical Area Communications System
ICBM	intercontinental ballistic missile
ICC	information coordination central
IFFN	identification friend, foe, or neutral
IFOG	interferometer fiber optic gyroscope
IFTU	in-flight target update
IHFR	improved high frequency radio
IMU	inertial measurement unit
IOAMS	Integrated Operational Airspace Management System
IOC	initial operational capability
IPB	intelligence preparation of the battlefield
IPCT	information processing/communications technology
IR	infrared
IRBM	intermediate range ballistic missile
IRIS	Infrared Instrumentation System
IRST	infrared search and track

ISO/OSI	International Standards Organization/Open Systems Interconnect
ITU/TSS	International Telegraphic Union Telecommunications Standard Sector
IV&V	independent verification and validation
JI	jet interdiction
JI/JR	jet interactional/jet reaction
JLENS	Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System
JPL	Jet Propulsion Laboratory
JRE	JTIDS range extension
JTAGS	Joint Tactical Ground Station
JTB	Joint Technology Board
KAT	kill assessment technology
KE ASAT	kinetic energy antisatellite
KEW	kinetic energy weapon
km	kilometers
KMR	Kwajalein Missile Range
KREMS	Kiernan Reentry Measurement System
KV	kill vehicle
KW	kilowatt
LACM	land attack cruise missile
LADAR	laser detection and ranging
LAN	local area network
LASERCOM	laser communications
LATS	longwave infrared advanced technology seeker
LDS	Lexington Discrimination Testbed
LEAP	lightweight exoatmospheric projection
LEO	low earth orbit
LFT&E	live fire test and evaluation
LIDAR	light detection and ranging
LOS	line of sight
LPE	launch point estimate; launch point error
LRCS	low radar cross section
LWIR	long wave infrared
m	meter
MADCAP	mosaic array data compression and processing
MB	megabyte
MBTC	measurement-based threat characterization
MCS	Maneuver Control System
MD	missile defense
MDBIC	Missile Defense Battle Integration Center
MDSTC	Missile Defense and Space Technology Center
MDTP	Missile Defense Technology Plan

MEADS	Medium Extended Air Defense System
METT–T	mission, enemy, troops, terrain, weather, and time available
MFL	multiple folded laser
MIRV	multiple independently targetable reentry vehicle
MIT LL	Massachusetts Institute of Technology/Lincoln Laboratory
MMIC	monolithic microwave integrated circuit
MMSS	multimission sensor suite
MMW	millimeter wave
MNS	mission needs statement
MOA	memorandum of agreement
MOTR	multiple object tracking radar
MS	milestone
MSE	mobile subscriber equipment
MSRT	mobile subscriber radio terminal
MTCR	missile technology control regime
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, and chemical
NC	node center
NDI	nondevelopmental item
NIE	national intelligence estimate
NMD	national missile defense
NPO	National Product Office
NT	near term
NTBN	National Testbed Network
NWE	nuclear weapons effect
ODA	optical data analysis; optical discrimination analysis
OGA	other government agency
OPTEC	Operational Test and Evaluation Command
ORD	operational requirements document
ORSA	operations research systems analysis
OSC	optical signatures code
OTH	over-the-horizon
OT&E	operational test and evaluation
P^3I	preplanned product improvement
PAC–3	PATRIOT Advanced Capability 3
PAN	polyacrylonitrile
PAT	process action team
PATRIOT	phased array track to intercept of target
PDR	preliminary design review
PEELS	parametric endoatmospheric/exoatmospheric lethality simulation
PEGEM	post engagement ground effects model

PEO–AMD	Program Executive Office—Air Missile Defense
PET	pilotline experiment technology
PM	program manager
PMA	program management agreement
PO	project office
POC	point of contact
POM	program objectives memorandum
PORTS	Portable Optical Radiation Testbed for Sensors
RAM	radar absorbing materials
RCS	radar cross section
RDA	research, development, and acquisition
RDI	range doppler imager
RDAOSP	range Doppler acousto-optic signal processor
RDEC	research, development, and engineering center
RDT&E	research, development, test, and evaluation
RF	radio frequency
RFI	radio frequency interference
RFOG	resonance fiber-optic gyroscope
RLG	ring laser gyroscope
RMDM	ring matrix diverter module
ROE	rules of engagement
ROW	rest of world
RRTD	radar and real-time discrimination
RSTA	reconnaissance, surveillance, and target acquisition
RTD	real-time discrimination
RTDT	real-time discrimination technology
RV	reentry vehicle
SA	systems analysis
SAM	surface-to-air missile
SBE	synthetic battlefield environment
SBIR	space-based infrared system
SBIR	spaced-based infrared
SC	simulation center
S/D	signal/data
SDCC	San Diego Convention Center
SDIO	Strategic Defense Initiative Organization
SEN	small extension node
SEO	survivability enhancement option
SGI	Silicon Graphics Incorporated
SHORAD	short-range air defense
SINGGARS	Single Channel Ground and Airborne Radio System

SLBD	sealite beam director
SLBM	submarine-launched ballistic missile
SLV	space launch vehicle
SMDC	Space and Missile Defense Command
SMTS	Space and Missile Tracking System
SRBM	short range ballistic missile
SSL	solid-state laser
S/T–IF	system/transmitter intermediate frequency
STD	Space Technology Directorate
STO	Science and Technology Objective
STORM	target for HERA
SWARM	target for miniature interceptor technology demonstration
SWIR	short wave infrared
SWORD	SHORAD with optimized radar distribution
T/R	transmit/receive
TACSAT	tactical satellite
TADIL	tactical digital information link
TBM	tactical ballistic missile; theater ballistic missile
TCMP	Theater Missile Defense Critical Measurements Program
TDMA	time difference of mean arrival; time division multiple access
TDS	top/down survivability
TECOM	Test and Evaluation Command
TEL	transporter-erector launcher
TEMO	training, exercise, and military operations
TENCAP	tactical exploitation of national capabilities program
teraflops	trillions of floating point operations per second
TFLOPS	trillions of floating point operations per second
TG	terminal guidance
THAAD	theater high-altitude area defense
THEL	tactical high-energy laser
THK	TEL Hunter/Killer
TID	technology infusion database
TIP	technology infusion plan
TLE	target location error
TLM	telemetry
TMD	theater missile defense
TMDS	theater missile defense survivability
TMD–SE	theater missile defense—system exerciser
TMP	technology master plan
TNSAT	TSD near-term technology infusion product team subtier
TPO	THAAD Project Office

TRADOC	Training and Doctrine Command
TRD	technology requirements document
TSD	tactical surveillance demonstration
TSDE	tactical surveillance demonstration enhancement
TT&E	targets, test, and evaluation
TVC	thrust vector control
TVVS	THAAD Verification and Validation System
UAH	University of Alabama in Huntsville
UAV	unmanned aerial vehicle
USADASCH	U.S. Army Air and Missile Defense School
USAKA	U.S. Army Kwajalein Atoll
USAMICOM	U.S. Army Missile Command
USASMDC	U.S. Army Space and Missile Defense Command
UV	ultraviolet
V&V	verification and validation
Vb_o	burnout velocity
VLSIC	very large scale integrated circuit
WAN	wide area network
WCS	weapon control subsystem
WFS	waveform simulator
WMD	weapons of mass destruction
WSMR	White Sands Missile Range
YAG	yttrium aluminum garnet

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ANNEX E

GLOBAL TECHNOLOGY CAPABILITIES AND TRENDS

CONTENTS

ANNEX E

GLOBAL TECHNOLOGY CAPABILITIES AND TRENDS

This annex to the *Army Science and Technology Master Plan* contains the International Armaments Strategy. The strategy is significantly expanded in this revision. In addition to an update of the opportunities identified for technologies identified in Volume I, Chapter IV of the ASTMP, this annex also addresses long-term trends in basic research areas (Chapter V).

The Deputy Under Secretary of the Army for International Affairs has identified this annex as one of the key guidance documents for planning and initiating international cooperative programs. This revision represents the next step in evolving to meet this requirement and reflects many of the changes suggested by the international points of contact whose names and organizations are cited throughout this annex. Their contributions, both to this revision and to long-range planning for future directions, are gratefully acknowledged.

This annex was prepared under the Army Research Laboratory contract to Orion Enterprises, Incorporated, which was responsible for integrating and presenting information gathered from various Army organizations involved. Special recognition is appropriate for the work of the Institute for Defense Analyses for its analysis and preparation of the new Section C, "International Research Capabilities and Long-Term Opportunities," covering basic research, to Mr. Larry Beck (Army Materiel Command) and Mr. Stephen Cohn (Army Research Laboratory).

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A. STRATEGIC OVERVIEW

1. Background

The Department of Defense (DoD) must operate and plan for a future characterized by rapid proliferation of technological threats, uncertainty in the world order, and strong domestic pressures for significant reductions in defense spending. Deep cuts in defense spending will almost certainly continue, not only for the United States, but for our allies also. The Army faces the daunting challenge of maintaining and modernizing forces that will ensure the dominance and security of U.S. ground forces in this environment. We will rely more heavily on cooperative action with our allies to meet this challenge. International armaments cooperation—consistent with the Army's technology leveraging strategy as described in Volume I, Chapter VII, "Technology Transfer"—has become an increasingly important part of our national strategy.

2. Vision

International military–industrial partnerships contribute to the warfighting capabilities of our soldiers and our allies by maintaining truly world-class technology and industrial bases built on a global-minded workforce and the best available industrial capabilities and services. As shown in Figure E–1, our International Armaments Cooperative Strategy (IACS) is a comprehensive effort to focus our diverse goals to:

- Maintain a global awareness of the best technological developments and to develop leveraging strategies while considering the potential contributions of industry, universities, other government agencies, and international sources.
- Arrange data and personnel exchanges and participate in international forums to optimize the benefit to the U.S. Army.
- Develop and represent in the *Army Science and Technology Master Plan* (ASTMP), senior-level guidance based on well-thought out leveraging strategies.

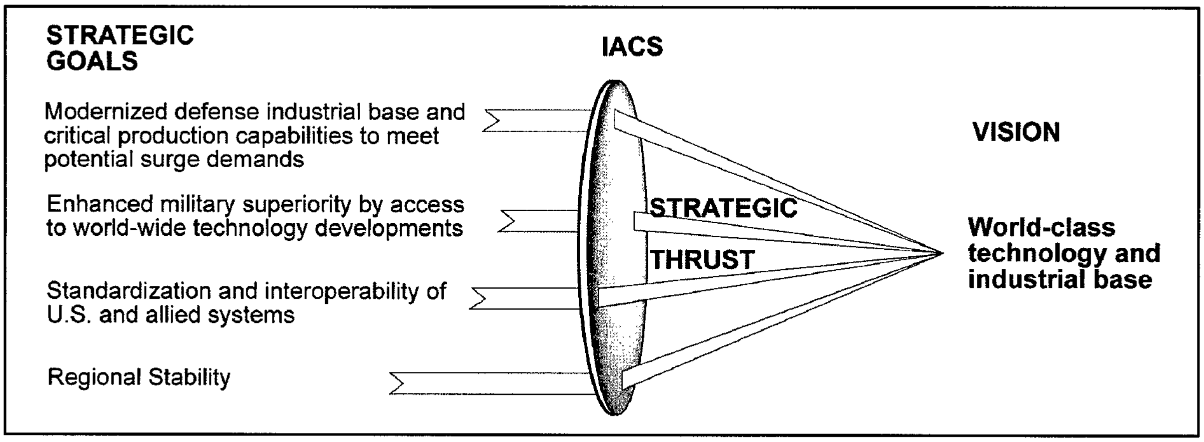

Figure E–1. The International Armaments Cooperative Strategy Focus

3. Role of Annex E in International Programs

Effective international cooperation demands both the development of sound long-term partnerships and the ability to respond opportunistically when the occasion arises. Annex E is designed to accomplish both these objectives. First, this annex provides insights into the broad capabilities of other countries that can be used to allocate resources to develop and cultivate cooperative programs with partners that are most likely to provide reliable long-term benefits. At the same time, identification of specific niches of excellence provides a basis for responding quickly to targets of opportunity.

As discussed in Volume I, Chapter VII, identification of an opportunity for partnering in this annex to the ASTMP establishes the existence of an acceptable technological quid pro quo. Within the guidelines of identified subtechnologies and countries, this annex provides an authoritative basis for initiation of international agreements, as shown in Figure E–2. However, the proponent organization must make the final determination that appropriate quid pro quo exists for concluding cooperative agreements. This annex offers a snapshot in time, and new and rapidly emerging development may not be reflected. As this document is publicly released, sensitive or classified information is not included. However, the annex includes global technology leveraging opportunities that are updated annually.

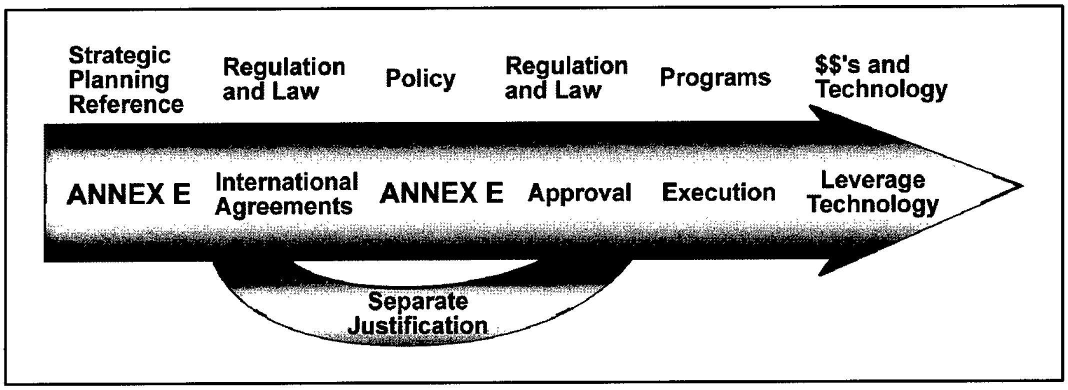

Figure E–2. Role of Annex E in International Programs

The *Army Plan* is the Army's capstone strategy planning document. This annex plays a supporting role in several of the *Army Plan's* mission areas. As a planning and reference tool, this annex provides senior Army management with a roadmap for initiating discussions with partnering countries on technology cooperation.

4. Country Capabilities and Trends Analysis

Understanding trends is key to an effective strategy, but technology is advancing rapidly, and some opportunities may be time sensitive. This annex contains a broad-based global technology and trends analysis by the Institute for Defense Analyses (IDA) and from within the Army's technology base. The criteria for determining county capabilities and associated trends were as follows:

- *Comparative demonstrated technical performance*—Countries were examined for materials, components, or systems produced indigenously, relative to best U.S. practice.
- *Indicators of recognized quality*—Does the country have significant market share in products based on this technology area and is it cited by others as authoritative?
- *Strength and balance of supporting infrastructure*—The number of research and development (R&D) organizations, diversity of participation (industry, academia, government) and the level of investment were considered.
- *Expert consensus*—U.S. Army subject matter experts made the final call in their areas of expertise.

Leadership in applied technology with identified military relevance is shared among relatively few countries—the United States and its NATO allies France, Germany, and the United Kingdom (U.K.); Japan, and to a lesser extent, the former Soviet Union (FSU) states of Russia and the Ukraine. Two other countries (Israel and Canada) are identified as having significant capabilities. As noted in Volume I, Chapter VII, the trend is toward the development of more advanced capabilities in a growing number of countries.

We can obtain a rough measure of how widespread technological capability is by looking at the number of countries identified as having a significant capability in the subareas of technology and research (identified in Volume I, Chapters IV and V). As a point of reference, the technology and research areas listed in Tables E–1 and E–2 have been cross-referenced to the areas in the *Defense Technology Area Plan* (DTAP) and the *Basic Research Plan* (BRP), respectively.

Table E–1. Summary of Technology Leveraging Opportunities

ASTMP TECHNOLOGY AREAS	Number of Subareas	Subareas With One or More Countries on Par	Subareas With One or More Countries at Leading Edge	Subareas With Three or More Countries at Leading Edge	DTAP TECHNOLOGY AREAS
Aerospace Power & Propulsion	3	3	2	0	Air Platforms
Air Vehicles	4	4	2	1	
Chemical and Biological Defense	7	7	3	1	Chemical/Biological Defense & Nuclear
Individual Survivability & Sustainability	2	2	2	1	Human Systems
Command, Control, & Communications	3	3	3	3	Information Systems Technology
Computing & Software	5	5	1	0	
Conventional Weapons	6	6	1	0	Weapons
Electron Devices	4	4	4	3	Sensors, Electronics & Battlespace Environment
Electronic Warfare/Directed Energy Weapons	2	2	0	0	Weapons
Civil Engineering & Environmental Quality	2	2	2	1	Materials/Processes
Battlespace Environments	5	5	2	0	Sensors, Electronics & Battlespace Environment
Human Systems Interface	4	4	4	2	Human Systems
Personnel Performance & Training	2	2	2	1	
Materials, Processes, & Structures	3	3	2	0	Materials/Processes
Medical & Biomedical Science & Technology	4	4	2	0	Biomedical
Sensors	5	5	2	0	Sensors, Electronics & Battlespace Environment
Ground Vehicles	5	5	4	1	Ground & Sea Vehicles
Manufacturing Science & Technology	2	2	2	0	Materials/Processes
Modeling & Simulation	4	4	4	4	Information Systems Technology

Table E–2. Summary of Basic Research Opportunities

ASTMP TECHNOLOGY AREAS	Number of Subareas	Subareas With One or More Countries on Par	Subareas With One or More Countries at Leading Edge	Subareas With Three or More Countries at Leading Edge	BRP TECHNOLOGY AREAS
Mathematical Sciences	5	4	3	1	Mathematics
Computer & Information Sciences	5	5	2	1	Computer Science
Physics	5	4	4	2	Physics
Chemistry	10	10	6	3	Chemistry
Materials Science	5	5	5	5	Materials Science
Electronics Research	5	5	4	2	Electronics
Mechanical Sciences	3	3	3	3	Mechanics
Atmospheric Sciences	2	2	1	0	Terrestrial Sciences; Atmospheric & Space Sciences
Terrestrial Sciences	2	2	1	0	Atmospheric & Space Sciences; Terrestrial Sciences
Medical Research	4	4	4	4	Biological Sciences
Biological Sciences	5	5	5	5	
Behavioral, Cognitive, & Neural Sciences	4	4	4	3	Cognitive & Neural Science

Table E–1 provides a summary of the number of technology subareas of interest where other countries are assessed to be on a par with the U.S. or at the leading edge of technology and capable of offering technology leveraging opportunities. At least one country was found to be on a par with the U.S. in all 72 subareas of technology identified in the Chapter IV roadmaps. Of these there were 44 subareas in which other countries were working at a level that could be considered as driving the state of the art, and 18 in which such capabilities are shared by three or more countries.

Table E–2 provides a similar summary for the subareas of basic research identified in Chapter V. The capabilities in basic research are indicators of future technological capabilities, and point to areas where the Army might seek to develop long-term cooperative relationships. There was at least one country assessed to be on a par with the U.S. in all but two of the 53 basic research subareas—discrete mathematics (such as computational fluid dynamics) where the U.S. has a lead based on a combination of historical access to superior computing capabilities, and in the area of image enhancement and analysis in physics. Even in these subareas, a number of countries are identified as having niche capabilities and having the potential to drive the state of the art in the future. Of the 53 subareas, there were 42 in which at least one country was assessed to be at the state of the art, and 29 subareas where three or more share a leading role.

The number and geographic distribution of countries having significant scientific and technological capabilities is large and can be expected to increase. In the global economy, reliable sources of electronics, computers, many types of sensors, and new materials are becoming more widely available as advances spread rapidly throughout global markets. Computers and electronics are simply commodities, basic tools for studying the scientific areas that these countries have chosen—the life sciences, biology, chemistry, and behavioral and medical sciences.

Tables E–3 and E–4, provide more detailed breakouts of specific technology and basic research areas wherein other countries are identified as having particularly strong capabilities. The capabilities highlighted correlate generally to the areas where countries are shown in the individual subsection tables as having world-class capabilities, and a level of activity that is expected to enhance or at least maintain their relative position.

5. The Future

While scientific and technological capabilities are important determiners of future capabilities, there are global economic forces at work that will also play an important role. These forces will inevitably change the distribution of wealth, and with that shift, the future potential for technological and scientific leadership. The dominance of the United States as the largest economy and market in the world is changing. There is an evolution towards at least three major economies and markets—Europe, Asia–Pacific, and North America. Each of these will have its leaders and as each market develops, other countries will emerge with increasing economic and technological strength.

Europe is currently dominated by the Western European nations, but Eastern Europe will play an increasingly important economic role. In the Asian–Pacific arena, Japan, and to a lesser extent, Korea, Singapore, Thailand, Malaysia, and Indonesia, currently hold sway, but already India and China are showing signs of great growth potential and no one doubts that they will soon be major players. In North and South America, the United States and to some extent Canada have been dominant. This situation is not likely to change soon, but eventually Mexico and Brazil will probably become more important players. These future shifts will have dramatic consequences that will help influence the future technological leadership of the world.

Table E–3. Highlighted Near/Mid-Term Opportunities

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Aerospace Propulsion & Power	Gas turbine engine High-performance transmission	High-temperature structures & lubricants Rotorcraft propulsion Bearingless rotor hub	High-temperature gas turbines & lubricants Rotorcraft propulsion Bearingless rotor hub Composite & high-strength alloy shafting				
Air Vehicles	Rotorcraft design Active harmonic control Composites Smart structures FADEC Rotor systems	Rotorcraft CFD Adaptive controls Fly-by-light Crash survivability C-C matrix ceramic Smart structures Subsystems	Rotorcraft Control theory Smart structures Fatigue Advanced cockpit systems	Ceramics Composite materials & structures		*Russia* Rotorcraft structures Titanium alloy & steel structures	
Chemical and Biological Defense	Propagation & EMP effects All aspects Chemical agent point sensors Individual protection Vehicle systems DIS	Propagation & EMP effects Blast & thermal CBW agent sensors Individual protection Vehicle systems Electronic decon DIS	Propagation & EMP effects Radiation, blast, & thermal protection Detection systems Individual & collective protection Decon	Detection systems Collective protection Decon		*Russia* EMP effects EME survivability BW detection sensors Individual & collective protection	*Canada* Detection systems *Israel* Individual & collective protection
Individual Survivability & Sustainability	Soldier systems (physiological & psychological)	Soldier systems (ballistic protection)	Soldier systems	Electric power for man-portable systems	*AU* Soldier systems (microclimate control)		*Canada* Soldier systems
Command, Control, & Communications	Battlefield interoperability Natural language processing Intelligent systems Mission planning	Battlefield interoperability Distributed real-time communications Switching systems Machine translation C^2 simulation Mission planning	Communication networks Battlefield & international interoperability Machine translation Natural language processing	Fuzzy logic High-speed communications High-speed switching & networks			*Netherlands* Natural language processing Knowledge base & database science
Computing & Software	MPP Optical switching Visually-coupled systems	Optical processing Tactical fiber-optic systems Visually-coupled systems	MPP ANNs Fiber-optic systems MPP & neural network software AI Visually-coupled systems	ANNs Optical switching & networks Visually-coupled interfaces			*Canada* Optical switching & networks Visually-coupled systems Large dataset representation

Table E–3. Highlighted Near/Mid-Term Opportunities (continued)

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Conventional Weapons	Overall strength ETC gun	Overall strength	Overall strength ETC gun Vehicle integration			*Russia* Overall strength	*Israel* ETC gun BMD missile *Italy* Mines/countermines
Electron Devices		IR FPAs MMIC components Compound semiconductors Batteries	MMIC components Compound semiconductors Small engines	All aspects MMIC Acoustic wave devices Compound semiconductors		*Russia* Molecular electronics Power switching Rechargeable batteries	
Electronic Warfare/Directed Energy Weapons	LELs	Laser materials	Laser materials	HELs & LELs		*Russia, Ukraine* HPMs *Russia* HELs	
Civil Engineering & Environmental Quality	Environmental protection Bioremediation Regulatory compliance Lightweight bridging Response of conventional structures to blast	Environmental protection Bioremediation Demil of energetic materials High-performance construction materials Survivable structures	Environmental protection Bioremediation Response of hardened structures to conventional weapons	Environmental protection Bioremediation			*Nordic Group* Environmental protection Bioremediation
Battlespace Environments	Overall capability	Overall capability Remote sensors IR FPAs	Overall capability	Remote sensing Robotics		*Russia* Weather prediction	*Israel* Atmospheric effects *Canada* 3D data display Atmospheric dispersion
Human Systems Interface	VRIs Soldier–system interface HPM Performance models	Displays Soldier–system interface Ergonomics Performance models	Soldier–system interface HPM Performance models	Displays VR Robotics			*Canada* VR displays
Personnel Performance & Training	Good overall capabilities Dynamic training & simulation	Good overall capabilities Dynamic training & simulation	Good overall capabilities		*Australia, New Zealand* Participate in TTCP		*Canada* Simulation & displays *Belgium* Computer-based selection tests

Table E–3. Highlighted Near/Mid-Term Opportunities (continued)

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Materials, Processes, & Structures	Metal alloys Composites Welding & joining Lightweight engineering structures Smart structures	Metal alloys Composites C-C ceramic part fabrication Smart structures Energy-absorbing structures	Metal alloys Composites Functional gradient coatings Engineering structures Smart structures	Ceramics Composites Polymer processing Lightweight structures			
Medical & Biomedical Science & Technology	Infectious diseases CBD Operational medicine Combat casualty care	Infectious diseases CBD Operational medicine Combat casualty care	Infectious diseases CBD Operational medicine Combat casualty care	Medical imaging Infectious diseases	*Singapore, China* Infectious diseases		
Sensors	Seismic sensors Acoustic sensors Signal processing Vehicle integration Combat ID	IR FPAs Laser sensors Multidomain sensors Signal processing Multisensor integration Combat ID	Combat ID Signal processing Vehicle integration	Electronic components Photonic devices Laser applications			*Israel* Acoustic sensors Target recognition Signal processing
Ground Vehicles	Good overall capabilities Gas turbines	Good overall capabilities Secondary batteries Multisensor integration	Good overall capabilities Structural design Vehicle survivability Autonomous control Diesel engines Integrated electronics	Ceramic engines Electric drive		*Russia* Electric drive Batteries Switches	*Israel* RPVs Teleoperation *Austria* Diesel engines *Switzerland* Armored vehicles *Italy, Sweden, Switzerland* Vehicle chassis & turret
Manufacturing Science & Technology	Bioprocess engineering CASE tools Industrial robotics	Bioprocess engineering CASE tools Industrial robotics	Bioprocess engineering CASE tools Industrial robotics	Fuzzy logic Bioprocess engineering Industrial robotics			*Israel, Nordic Group, Netherlands* Bioprocess engineering
Modeling & Simulation	DIS Dynamic training simulation M&S VR	DIS Dynamic training simulation M&S VRI	DIS Battle M&S M&S Simulation interfaces	VR Distributed industrial enterprises	*Australia, New Zealand* DIS		*Canada* VR 3D visualization

Note: The lack of an entry does not necessarily indicate the absence of cooperative opportunities. In some cases, work by a single researcher in a foreign university may prove important.

Table E–4. Highlighted Long-Term Opportunities

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Mathematical Sciences	Fluid dynamics Linear algebra	Levy processes Dynamic systems Boltzman's equations Control theory Computer vision Finite elements Nonsmooth optimization	Finite elements Interactive methods	General capabilities	*China* General Capabilities *India* Computational Mathematics Statistics	*Russia* Numerical methods	*Canada* Analytic geometry *Israel* Computational physics
Computer & Information Sciences	Database sciences Natural language processing	Natural language processing	Natural language processing	Software prototyping			*Netherlands, Sweden*
Physics	Optical switching Sensors Signature reduction Lasers	Optical switching Sensors Signature reduction Lasers	Submicron research Optical switching Sensors	Submicron research Optical switching Sensors Fiber-optic gyros Lasers		*Russia* Glonass Optical sensors NLOs	*Canada, Sweden, Israel*
Chemistry	Polymer composites Surface resistance to wear & corrosion CBD Soldier power Demil, restoration, & pollution prevention	CBD Soldier power	Polymer composites Surface resistance to wear & corrosion CBD Soldier power Explosives/propellants	Polymer composites Surface resistance to wear & corrosion Explosives/propellants CBD	*South Korea China* Surface resistance		*Israel, Sweden, Netherlands, Finland* CBD *Israel, Sweden, Canada* Explosives/propellants
Materials Science	Welding & joining Armor/antiarmor Coatings Ion implant	CMCs Armor	Ceramics Coatings	Composites Superconductors Coatings	*South Korea* Tungsten alloy penetrators	*Russia* Armor/antiarmor Superalloys *Ukraine* Welding & joining	*Israel* Armor Personnel armor Diamond deposition
Electronics Research	JESSI/MEDEA research C^3 Networking Switching	JESSI/MEDEA research Battlefield communications	JESSI/MEDEA research Networking Switching	Solid-state devices Networking Switching MMIC Low-power devices			
Mechanical Sciences	Smart/active structures Fluid dynamics Gas turbine engines Solid/liquid gun	Smart/active structures Fluid dynamics Gas turbine engines Solid gun	Smart/active structures Reciprocating engines Solid gun	Smart/active structures Fluid dynamics Reciprocating engines		*Russia, Ukraine* Naval gun propulsion Experimental/ theoretical fluid dynamics	*Italy* Smart/active structures *Canada* Fluid dynamics Solid gun Gas turbines

Table E–4. Highlighted Long-Term Opportunities (continued)

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Atmospheric Sciences	Atmospheric backscatter Global & regional weather prediction Cold weather prediction Low-level weather prediction	Atmospheric electricity–aircraft interactions IR physics of the atmosphere Low-level weather prediction	Atmospheric environmental prediction Low-level weather prediction	Ionosphere & troposphere interactions Tropical cyclones Urban pollution		*Russia* Solar flare prediction Atmosphere spectral transmissivity Low-level weather prediction	*Canada* Ice flow & weather prediction Atmospheric dispersion *Denmark* Polar cap & aerial ionosphere interactions *Netherlands* IR celestial background *Brazil* Weather & ionosphere experiments *Israel* LIDAR measurements
Terrestrial Sciences	Retrofit material systems Hydrology	Geotechnical materials Hydrology	Structural response	Basic research			*Israel* Stochastic hydrology *Canada* Hydrolgeology *Australia* Basic research
Medical Research	Infectious diseases Combat casualty care Operational medicine Biological defense	Infectious diseases Combat casualty care Operational medicine Biological defense	Infectious diseases Combat casualty care Operational medicine Biological defense	Infectious diseases Combat casualty care Operational medicine Biological defense	*China* Infectious diseases Combat casualty care	*Russia* Combat casualty care Biological defense	*Switzerland, Israel, Sweden, Netherlands* Infectious diseases Combat casualty care Operational medicine Biological defense
Biological Sciences	Combinatorial chemistry Genome project Receptor characterization NMR Microbial products for nutrition Bioremediation Nutritional additives Protein stabilizers PHB plasticizer Energy transduction Biomaterials for tensile strength	Genome project Receptor characterization Nutrient additives Bioremediation Stress resistance Protein stabilizers Energy transduction Biomaterials for tensile strength	Combinatorial chemistry Genome project Nutrient additives Bioremediation Protein stabilizers Energy transduction Biomaterials for tensile strength	Genome project Receptor characterization NMR Visual sensing Metabolic products Bioremediation Protein stabilizers Biomaterials for tensile strength	*Australia* Wide range of entries		*Israel, Netherlands, Switzerland* Wide range of entries

Table E–4. Highlighted Long-Term Opportunities (continued)

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Behavioral, Cognitive, & Neural Sciences	Cognitive/noncognitive Perceptual processes	Cognitive/noncognitive Perceptual processes	Cognitive/noncognitive Perceptual processes	Cognitive/noncognitive			*Netherlands* Perceptual processes *Israel, Sweden* Cognitive/noncognitive Perceptual processes Leadership

Note: The lack of an entry does not necessarily indicate the absence of cooperative opportunities. In some cases, work by a single researcher in a foreign university may prove important.

For the near term, the U.S. and our traditional allies will probably maintain a commanding dominance in the physical sciences and in electronics and computers (as we currently know them), and will perpetuate a worldwide abundance of devices, systems, and instruments, including sophisticated weapons. In other areas, however, an increasing number of countries will have world-class capabilities. In areas that do not require a large infrastructure investment, or a high level of education, many other countries can contribute effectively in the global market. Software, for instance, is an area in which good mathematical skills and education are the primary ingredients, especially since inexpensive, powerful computers are becoming so widely available. The life sciences, biology, chemistry, medicine, and behavioral science are other areas in which many countries have the requisite skills to compete effectively.

This document provides the necessary basis for building a strategic approach to international technological cooperation. With the growing emphasis on coalition warfare, it is important not only to leverage global technology, but to keep the channels of communication open and viable. Given the widespread and increasing opportunities for technology leveraging, coupled with the decreasing resources, it is important that the Army's approach to cooperation be both focused and productive.

6. Technology Assessments

Sections B and C contain specific technology assessments based on previously mentioned criteria. The numbers in the summary charts in this sections reflect a general assessment of country capabilities and their rate of advance relative to the field at large, as follows:

- ❶ The country is considered to have world-class capabilities in one or more key aspects of the subtechnology identified. Based on current and projected levels of research and expenditures, the level is likely to continue to define or remain near the global state of the art.
- ❷ The country is considered to have world-class capabilities in one or more key aspects of the subtechnology identified. Based on current and projected levels of research and expenditures, the level will no longer define the state of the art, although it should remain near world-class capabilities.
- ❸ The country presently has world-class capabilities; however, current research activities are unlikely to keep them at this level.
- ❹ The country is not yet considered to have world-class capability in this field. However, the country has promising capabilities or an accelerated, coordinated R&D effort under way in selected areas of technology that could contribute to making it among the world leaders or enable it to help define the global state of the art in the future.
- ❺ The country has capabilities in selected areas that are not considered world-class, nor is the country likely to achieve that level in the near future. The capabilities still could contribute beneficially to U.S. Army R&D activities.
- ❻ The country has capabilities that could contribute in the short term to U.S. Army R&D requirements, but are likely to be overcome or rendered irrelevant by future advances elsewhere.

To implement our international cooperative strategy effectively, we must be prepared to take advantage of existing capabilities and exchange mechanisms to access cutting-edge research and technology in other countries. At the same time, we need to improve our awareness of new opportunities and significant global technology trends. With the spread of the Internet and other modern communications links, there is unprecedented access to global data. The continuing evolution of new tools needed to collect, evaluate, and synthesize these data will continue to enhance the dynamic nature of global technology assessments.

B. NEAR- AND MID-TERM INTERNATIONAL COOPERATIVE OPPORTUNITIES

1. Opportunity Assessment Overview

This annex represents the latest step in an evolutionary process to identify, refine, and focus efforts to implement our international cooperative strategy. The process brings together a variety of technology and intelligence assessments to identify broad areas where the capabilities and trends in the state of the art among potential partners offer significant promise for contributing to U.S. Army objectives. Within these broad areas, there are designated technology area points of contact (POCs) for Volume I, Chapter IV, and highlighted specific needs to consider in the process of identifying existing or near-term pending agreements. The results of the process have been refined through several iterations of the ASTMP and this annex. The resulting collection of capabilities and mid-term opportunities described in the following subsections and summarized in Volume I, Chapter IV, illustrate the breadth and diversity of international cooperative opportunities for deployable advances within the next 2–6 years.

Our European allies, notably the United Kingdom, France, and Germany, are technologically advanced and we have longstanding exchange programs with them in most areas of military technology. There are niches of particular excellence and strong European community cooperative programs in information systems technology, semiconductor manufacture, materials, and manufacturing science and technology (S&T) that should increase the capabilities of our allies. Except for specific niches of excellence, these capabilities are more likely to parallel those of the United States and provide complementary opportunities as opposed to revolutionary breakthroughs. However, cooperation has other objectives and benefits in terms of effective cost and risk sharing and improved interoperability. Cooperative programs with countries having current excellence and an upward trend in development offer sound prospects for contributing to these objectives. Future interoperability objectives for coalition forces stress the ability to exchange information across allied forces seamlessly to support preemptive planning and mission rehearsal, integrated force management, and effective employment of precision forces. This, in turn, will provide an impetus for international development of standards and models to support battlespace digitization and Army Digitization Office objectives.

In a few instances, most notably within the FSU, the opportunities identified may prove somewhat perishable as technologies advance and economic conditions erode the base of support for research. Such time-sensitive opportunities may be found in piezoelectric crystal growth, certain aspects of gas turbine engines and ramjet propulsion, and pulsed power. Other areas of strong capability, less time-sensitive, may be found in mathematical science where Russia and the other countries of the FSU have been traditionally strong.

Japan offers the widest range of technological capabilities. The Ministry of International Trade and Industry (MITI) oversees and coordinates a wide range of R&D in electronics, structural materials including ceramics, and manufacturing S&T. Applications of these technologies to military uses are not widely advertised, but there is clear evidence of growing capability and activity in this direction.

The Army has initiated several programs with Japan, for example, in ramjet propulsion and in applications of fuzzy logic to helicopter flight control. The Japanese technological capabilities offer numerous other opportunities. However, indications are that patience and a concerted long-term commitment are necessary prerequisites to successful negotiation of cooperative agreements with Japan.

Those countries that we think of as traditionally strong in technology are rapidly being joined by other countries as global dissemination and internationalization of high-technology industries increases. Countries such as Israel and Korea have growing capabilities in a wide range of military–industrial technologies, including microelectronics and electronic systems, aerospace, ground vehicles, and sensors (primarily Israel) that already offer selected cooperative opportunities. India has a broad base of expertise for software development capable of supporting advances in a number of technology areas. Singapore, under the auspices of the National University, has launched a strong and diversified world-class program in biotechnology. Malaysia and Indonesia (in large part based on technology transfer from European aerospace firms), are developing a helicopter and small air transport design and manufacturing base. In the future, other niches of capability, backed by solid basic industrial infrastructures, are likely to develop in these and other countries, particularly in biotechnology and environmental sciences, which are becoming pervasive worldwide areas of R&D.

The following subsections provide a brief overview of the international state-of-the-art and key technological capabilities that have the potential to contribute to objectives and milestones identified in each of the 19 areas of technology addressed in Volume I, Chapter IV. Within each technology, we also identify one or more near-term opportunities to address specific needs. Each specific opportunity includes a brief description and justification highlighting potential benefits of the international effort envisioned. Benefits are defined in terms of the potential to address specific ASTMP or DoD technology milestones and objectives. Appropriate Army Material Command (AMC) and international POCs or project officers for each of the technologies and agreements cited are also provided.

2. Aerospace Propulsion and Power

Aerospace propulsion and power focuses on technologies that will result in aircraft and missile propulsion systems and components, including prime power transmission, that are more compact, lighter weight, higher horsepower, more fuel efficient, and lower cost than those currently available. Advances in this area are needed to support Army objectives for improved rotorcraft and transport performance, and for other services, attack and fighter aircraft and unmanned air vehicles (UAVs).

Technology subareas include rotorcraft propulsion (encompassing small gas turbine engines and rotorcraft drive systems) and fuels and lubricants. Table E–5 and the following paragraphs summarize key capabilities and trends in each technology subarea.

Table E–5. International Research Capabilities—Aerospace Propulsion and Power

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Small Turbine Engines	❷	❶ High-temperature structures ❷ Rotorcraft propulsion	❷ High-temperature gas turbines; rotorcraft propulsion	❺ Ceramics		*Russia* ❸ Wind tunnel test facilities	*Israel, Canada* ❺ Small gas turbines
Rotorcraft Power Transfer Systems	❷ High-performance transmission	❶ Bearingless rotor hub	❶ Bearingless rotor hub; composite & high-strength allow shafting				
Fuels & Lubricants		❷ High-temperature lubricants	❷ High-temperature lubricants				

Note: See page E–11 for explanation of key numerals.

a. Small Turbine Engines

The Army, other services, NASA, DARPA, and industry are working together to reduce specific fuel consumption by 40 percent and increase the power-to-weight ratio by 20 percent in engines by FY03. This will significantly improve Army rotorcraft range and payload characteristics. This technology will also be applicable to ground vehicles. Technical challenges in gas turbine engine technology include:

- High-temperature, lightweight materials, including metal matrix composites (MMCs) and ceramic matrix composites (CMCs)
- Efficient, highly loaded, wide-range compressors and turbines
- High-temperature, high-speed, high-pressure engine mechanical parts (e.g., bearings, seals, gears)
- Computationally efficient, experimentally validated advanced design codes.

The importance of gas turbine propulsion in civilian aircraft markets has led to the development of worldwide capabilities, with over 40 producers in 11 countries listed as suppliers in recent global surveys. Many other countries have technologies for repair and overhaul. Market figures indicate that the United States has continued to capture a growing share in a declining market, largely through exports. A growing number of companies look to international joint ventures as a strategy for remaining competitive in this market. International cooperative R&D in gas turbine technology may, in addition to providing access to state-of-the-art technology, provide access to an increasingly competitive international market.

France, Germany, and the U.K. are at or nearly at a par with the U.S. in many aspects. Key areas of capability with leveraging potential include materials and coatings, and related structures and aerodynamic design and modeling. Russia, Canada, Israel, and Japan have substantial infrastructures and niches of excellence (e.g., Japan, ceramics; Canada, small gas turboprops).

One area offering special opportunities relates to the French expertise in ceramic materials for gas turbine engines. Ceramic material technologies can provide significant enhancements over currently fielded systems. In particular, they offer lightweight, fuel efficient engines with greatly increased power-to-weight ratios, and are capable of operation at high temperatures. While the U.S, Germany, and Japan also are world leaders in ceramic technologies, France is a recognized leader in ceramic/carbon composites, which are most applicable to gas turbine engines. Existing agreements with France provide a potential vehicle for establishing a cooperative agreement in this area.

b. Rotorcraft Power Transfer Systems

Drive train and power transfer research is required to lower weight, volume, noise, and increase durability. Technical challenges in rotorcraft drive technology include:

- Lightweight, high-strength, tribologically robust gear materials
- Accurate dynamic noise and life prediction codes
- Minimum lubricant weight designs
- Efficient, lightweight, high-power density electric drive components.

The U.K. has strong capabilities in high-performance power transmission technologies. France has expertise in bearingless rotor hubs, as does Germany. Germany also has noteworthy capabilities in composite materials and high-strength alloy shafting.

c. Fuels and Lubricants

The Army's main interest in the fuels and lubricants subarea is the development and validation of new analytical technologies. Of particular interest are techniques for rapid assessment of petroleum quality using spectroscopic and chromatographic methods. New analytical methods will enable a significant reduction in operational requirements for petroleum testing in the field. This includes less manpower, reduced test time, and less test hardware. Technical challenges relate to compressing testing time, developing improved detection systems, correlating testing results, and developing computer-based expert systems.

In this subarea, France and Germany are the only countries noted as having special capabilities, both in the area of high-temperature lubricants.

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3. Air Vehicles

Rotorcraft are of particular interest to the Army. They are, and will remain, essential for a variety of critical scout, transport, and combat missions. The operational flexibility afforded by vertical takeoff and landing (VTOL) capabilities has created growing civil and military markets, particularly in third world nations. As a result, the helicopter industry has become highly internationalized and interdependent. In addition to the capabilities in the U.S.–Canadian industrial base, Germany, France, the United Kingdom, Russia, and Italy are all capable of designing and producing state-of-the-art military rotorcraft. Japan, Malaysia, India, and South Africa all have substantial capabilities for rotorcraft production. India and South Africa have indigenous military helicopter development programs. Other countries, notably Malaysia and China, have acquired modest capabilities (principally through licensing arrangements with other countries) in rotorcraft manufacturing to meet local market needs. These countries are not currently at a level that would contribute to significant advances in technology, but could develop niche capabilities in the future.

Competition for international military sales is intense and marketing rights and export prospects have affected a number of development decisions, particularly in international programs. Such market forces continue to push worldwide developments. Foreign capabilities may offer opportunities to reduce the cost of improving each of the key technology subareas: aeromechanics, flight control, structures (including survivability and as a major consideration signature reduction), and subsystems. Table E–6 and the following paragraphs summarize potential prospects.

Table E–6. International Research Capabilities—Air Vehicles

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Aeromechanics	❶ Rotorcraft design	❶ Rotorcraft; CFD	❶ Rotorcraft	❺ CFD; hypervelocity		*Russia* ❸ Wind tunnel test facilities	*Italy, Israel, Sweden* ❺ Aeromechanical design
Flight Control	❷ Active harmonic control	❶ Adaptive controls; fly-by-light	❶ Control theory				*Sweden* ❺ Adaptive controls
Structures	❶ Composites ❷ Smart structures	❶ Crash survivability; C-C matrix ceramic ❷ Smart structures	❶ Smart structures; fatigue	❶ Ceramics; composite materials & structures	*Malaysia, China* ❺ Rotorcraft	*Russia* ❷ Rotorcraft structures; Ti & steel alloy structures	*Canada* ❹ Fracture/ fatigue analysis *Italy* ❺ Rotorcraft structures
Subsystems	❶ FADEC; rotor systems	❷	❷ Advanced cockpit systems	❺ Avionics cockpit system	❺	❺	*Israel* ❺ Advanced cockpit systems

Note: See page E–11 for explanation of key numerals.

a. Aeromechanics

Aeromechanics technology includes multidisciplinary efforts in acoustics, aerodynamics, rotor loads, vibration, maneuverability, and aeroelastic stability. The goal is to improve the performance of rotorcraft while reducing noise, vibration, and stress loads inherent in helicopter operation. Major efforts involve refining analytical prediction methods and testing capabilities, and improving the versatility and efficiency of modeling advanced concepts. Another area of interest is attaining a smoother and quieter ride, which will improve performance and also enhance public acceptance. Technical challenges include the inability to accurately predict and control a number of factors:

- Stall and compressibility characteristics of airfoils
- Viscous and interactive aerodynamics and separated flow forces
- Rotor blade forces and loading limits
- Effects of rotor wake and blade response
- Aeroelastic rotor couplings to increase damping.

The proliferation of low-cost, high-performance computing (HPC) systems has lead to a growing worldwide interest in computational fluid dynamics (CFD) to address many of these issues.

Use of CFD for design of rotors and blades can enhance helicopter speed, maneuverability, and lift capabilities, while reducing acoustic signatures and structural vibration. While the United States is the world leader in CFD and related techniques, France, Germany, and Israel have complementary world-leading efforts to improve and develop analytical techniques and generate experimental databases that may contribute to ASTMP goals in this area. The U.K. has strong capabilities in rotor and overall rotorcraft design, and Italy and Sweden have noteworthy capabilities in aeromechanical design. In addition, Japan has special skills in CFD especially related to hypervelocity vehicles, and finally, Russia has special strengths in wind tunnel test facilities. Russia has also fielded some of the most capable military rotorcraft in terms of aerodynamic performance (speed and lift capability).

b. Flight Control

Flight control technology defines the aircraft's flying qualities and the pilot interface. Helicopters are inherently unstable, nonlinear, and highly cross-coupled. Advances in smaller, more powerful computers hold tremendous promise in this field, to allow realization of the full potential of the rotorcraft's performance envelope and maintenance of performance even in poor weather and at night. Integrating flight control with weapons control is of great interest, to permit improved pointing accuracy and the use of lower-cost unguided rockets as precision munitions. Other goals include improved external load handling at night, and increased exploitable agility and maneuverability. Technical challenges in flight control include:

- Knowledge of rotorcraft response and interactions with load suspension dynamics
- Sensing the onset of limits and cuing the pilot to fly safely at or near the envelope limits
- Air vehicle mathematical modeling for control system design, optimization, and validation
- Knowledge of optimum functional integration of flight controls, engine fuel control, weapons systems, and the pilot interface.

Foreign countries leading in flight control technology include the United Kingdom, France, and Germany. The U.K. has special capabilities in harmonic control for noise reduction. France has strong capabilities in adaptive controls and in fly-by-light technology. Germany has strengths in several areas that are of interest. One of the most important relates to ground-based and in-flight simulation studies on handling qualities. Specific areas of concern are the investigation of cross-coupling requirements, gust rejection for rate response systems, and the response time delay limits for high bandwidth response systems. Continuing work using Germany's in-flight simulator and correlated U.S. ground-based simulators has produced a viable database to build on, which could not be accomplished using U.S. assets alone. In the area of stability and control analysis, the U.S. predominantly uses a frequency domain method, whereas the Germans predominantly use a time-domain approach. Each technique has inherent advantages and disadvantages. A coordinated approach combining the strengths of both techniques yields the most promising path to success in detailing complete and accurate portrayal of flight control system design and performance parameters. This technology provides a critical link bridging theoretical design, prediction, simulation, and test analysis. In addition, Sweden has some ongoing efforts in adaptive controls that are of interest.

c. Structures

Science and technology related to structures aims at improving aircraft structural performance while reducing both acquisition and operating costs. Virtual prototyping to optimize structural design for efficiency and performance is of particular interest to remove a large portion of the risk involved in exploring new concepts and moving rapidly from concept to production. An integrated product and process development approach will be used. The reduction in dynamically loaded structural stress prediction inaccuracy is another area of great interest, as is reducing the production labor hours per pound for composite structures. Breakthroughs in these and other areas will lead to improvements in maintenance and production costs, as well as reducing the empty weight fraction of the airframe, while increasing durability, performance, and ride comfort. Technical challenges in structures include:

- Accurate methodologies for flight regime recognition algorithms
- Accurate algorithms for determining rotorcraft flight condition from state parameters in a dynamic environment

- Sensing and measuring rheological behavior of materials during cure
- Multidisciplinary design and production techniques to meet cost, weight, reliability, and performance requirements
- Advances in smart materials
- Modeling and analysis of rotating and fixed system structural loads and their interactions with the vehicle's aerodynamic environment.

Advanced composite structures and fly-by-wire/light are becoming common in international aircraft. Technologies for military systems reside primarily in the few countries that produce military helicopters. Predominant among these are France, Germany, the United Kingdom, and Italy. The United Kingdom has strong capabilities in composites and in smart structures. Crash survivability is an area of special interest. France has expertise and in general is on a par with the United States in this area. Survivability depends on a number of factors including equipment performance, which may be enhanced by more efficient design and testing of aircraft structures. Of particular interest is the testing of advanced structural concepts and manufacturing processes for composite and thermoplastic materials for primary helicopter airframe structures. In addition to the above countries, Canada has strong capabilities in fracture/fatigue analysis, and Russia in titanium and steel alloy structures. Finally, Japan has world-class expertise in ceramics and composite materials.

d. Subsystems

Rotary-wing vehicle subsystems encompass a broad range of S&T topics related to support, sustainment, and survivability of aircraft systems and their associated weaponry. Five key technology areas are of interest:

- Reduction of radar cross section (RCS)
- Reduction of infrared (IR) signature
- Reduction of visual and electro-optic (EO) signature
- Increased hardening to threats
- Increased probability of detecting incipient mechanical component failures.

Technical challenges relate to modeling and analytical predictions for components and materials used in signature reduction and hardening against threat, and developing rugged, cost-effective, nonintrusive monitoring techniques, sensors, algorithms, and methods.

Several countries have capabilities of interest in subsystems for rotorcraft. Germany, Japan, and Israel all have strong capabilities in advanced cockpit systems, but the German work on cockpit integration is of special interest. Germany is a recognized world leader in cognitive decision-aiding, knowledge-based systems and in high-speed data fusion. It is actively pursuing integration of these capabilities in vehicle driving systems that could be of significant value. The United Kingdom is doing significant work on full authority digital engine control (FADEC). In addition, Japan has strong capabilities in avionics, based upon its world-class electronics capability.

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4. Chemical and Biological Defense

Contamination avoidance is the highest priority of the DoD chemical and biological (CB) defense program. The program also includes force protection (individual and collective), medical, and decontamination. The past 2 years have been marked by growing interest and rapid advances in and proliferation of biosensing technology for environmental, industrial, and medical applications. For example, in recent years, Singapore has made a significant national investment in a world-class facility and may offer future capabilities in sensors and materials for personnel protection and decontamination.

While these technologies are dual use in nature, the growing threat of CB weapons of mass destruction (WMD) has focused continued attention on development of operational sensors to meet military requirements. Table E–7 indicates areas of capability and trends. The U.K., France, Germany, and Japan

Table E–7. International Research Capabilities—Chemical and Biological Defense

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Electromagnetic Environment Survivability	❷ Propagation & EMP effects	❷ Propagation & EMP effects	❷ Propagation & EMP effects			*Russia* ❷ EMP effects	*Israel* ❺ Propagation *Canada, India* ❺ High altitude electromagnetic pulse *India* ❺ Propagation
Radiation, Blast, & Thermal Protection	❷ All aspects	❷ Blast & thermal	❷ All aspects	❺ Transient radiation effects on electronics		*Russia* ❷	*Israel* ❺ All Aspects
Detection	❶ Chemical agent point sensors	❶ CBW agent point & remote sensing	❶ Detection systems	❶	*Singapore* ❹	*Russia* ❷ BW detection sensors	*Canada* ❶ Detection systems *Israel, Sweden, Netherlands, Switzerland, Czech Republic, Poland* ❺ Detection sensors
Individual Protection	❷	❷	❷	❺		*Russia* ❷	*Israel* ❷
Collective Protection	❷ Vehicle systems	❶ Vehicle systems	❷	❷		*Russia* ❷	*Israel* ❷
Decontamination		❶ Electronics decon	❷	❷			*Canada* ❹
Modeling & Simulation	❺ ❷ DIS	❺ ❷ DIS	❺	❺ Local meteorology	*China* ❺ Meteorology	❺ Meteorology transport effects	*Canada, Israel* ❺ *Denmark* ❻ Atmospheric transport effects

Note: See page E–11 for explanation of key numerals.

all have strong capabilities in sensors, with France having particular strengths in remote sensing. Germany and Israel have strengths in individual and collective protection, with Germany identified as particularly capable in collective protection for military vehicles.

Modeling and simulation (M&S) capabilities relate to and are parallel to capabilities in meteorology and prediction of atmospheric transport effects and sensor performance modeling. Remote and real-time point detection of CB agents are prominently identified in the *Joint Warfighting Science and Technology Plan* (JWSTP), as are models and simulations to support processing and dissemination of real-time warning and reporting data. The ASTMP Volume I, Chapter IV includes milestones for these and identifies additional requirements for individual and collective protection and decontamination. Table E–7 summarizes potential prospects.

Following are highlights in specific areas that offer potential opportunities for cooperative efforts to advance.

a. Electromagnetic Environment (EME) Survivability

Even civilian electronics are exposed to a wide range of electromagnetic (EM) interference and naturally occurring electromagnetic propulsion (EMP) effects. In addition, the phenomenology of propagation is fundamental to design of sensors and communications. Thus, capabilities and potential cooperative opportunities are indicated in countries that are traditional producers of military communications equipment. With regard to techniques for protecting military systems against EMP, the existing nuclear powers—the United States, United Kingdom, France, and Russia—have the most practical experience.

b. Radiation, Blast, and Thermal Protection

Most countries involved in development of military hardware require some capabilities for analysis and design of systems and structures to protect against radiation, blast, and thermal effects. In addition, civilian nuclear power systems and space systems must be designed and built to withstand a variety of radiation effects. With regard to techniques for protecting military systems against nuclear weapon effects, the existing nuclear powers—the United States, United Kingdom, France, and Russia—have the most practical experience.

c. Detection

Reliable detection of biological warfare (BW) agents is particularly difficult, due to the high background and diversity of naturally occurring organisms. Canada, the United Kingdom, and the United States participated in joint exercises (completed in 1995), that identified promising technologies. Other countries, including Israel, the Netherlands, Sweden, Switzerland, and Russia, have ongoing work in various methods of biodetection.

One method of point detection and identification of CB agents now under active investigation is mass spectrometry. The goal is to develop technologies that result in significant improvements to the CB agent detection/identification capability of fieldable mass spectrometers. This includes technological means to increase the sensitivity, speed of response, selectivity, and specificity. There is an existing agreement with Germany in this technology area that could potentially expedite implementation of a specific program agreement to leverage Germany's past developmental experience with the development, integration, and testing of mass spectrometers in such systems as the Fuchs NBCRS.

A 6.2 exploratory development program for a biological detector (BD) has been completed successfully in cooperation with the United Kingdom and Canada. A follow-on 6.3b development has been conducted with the U.K. and Canada. The focus of cooperative development has shifted from hardware elements to antibodies and reagents, with increased emphasis on joint test and evaluation (T&E). The results of this cooperative project are contributing to the upgrade of the interim U.S. Biological Integrated Detection System (BIDS). The Czech Republic has a capability in nerve agent detection and is in the process of developing a promising new detector. The Chemical and Biological Defense Command (CBDCOM) is discussing possible cooperation with it. Poland has developed a new protocol for detecting spores, using current BIDS equipment. This procedure is being integrated into U.S. doctrine.

The BD will be a component of the BIDS, providing an automatic detection and identification capability. The objective is to develop and field an automated antibody-based BD that will be incorporated into the detector suite of the BIDS. Cooperative efforts are focused on development of the agents at target concentrations, as well as the T&E of these antibodies in various prototype detection systems. There are existing agreements in this technology area with the United Kingdom and Canada that could potentially expedite implementation of a specific program agreement to address this opportunity.

Systems using remote detection offer obvious advantages over point source detectors, which must be in local contact with the CBW agent. The United States and France (with whom there is an existing agreement for work in this area) are world leaders in laser technology and in CBW-related technologies, and have exchanged much information in CBW research and testing. French R&D may contribute to development of standoff biological agent detection and identification capability using laser light scattering techniques.

d. Individual Protection

Virtually any country advanced enough to have concerns for medical isolation, personal protection, and industrial safety in hazardous CB environments will have some expertise in personal protection. However only a few countries—notably the United States, United Kingdom, Germany, France, Russia, and Israel—have extensive capabilities in meeting the requirements demanded for operational military use. (Military requirements are primarily distinguished by the need to sustain a level of operational effectiveness over an extended (many-hour) time period.) This places particular demands on support services and primary power for same. The United States and Canada have jointly developed a new vapor systems test for identifying leaks in the seals of individual protection equipment. Germany has a major mask effort under way, as does France. Israel has developed a number of "civilian" masks.

e. Collective Protection

Collective protection encompasses the need to protect both fixed and mobile assets from nuclear, biological, and chemical (NBC) weapons effects. Current collective protection filters for combat vehicles impose a significant logistic burden in their requirement for replacement after a finite number of attacks or after extended attack-free service. Technologies are under investigation to create filters that have a nearly indefinite service life and offer exceedingly broad spectrum protection. The primary candidate at the moment is pressure swing absorption technology.

The U.K. has been developing temperature swing adsorption for collective protection, which will likely go into the next-generation scout vehicle and may be part of a joint U.S.–U.K. program. The United States has pursued a research and exploratory development program to model the performance of such systems and to do some confirmatory testing. Germany initiated a companion program last year and had planned to begin to obtain test data but experienced nontechnical difficulties in the laboratory. Technical experts on both sides have met and data collection is scheduled to begin later in the year.

With regard to specific opportunities for cooperation, the U.S. has extensive experience with prototype systems that could reduce German development costs very significantly while still providing an extensive prototype database. German R&D may contribute additional experimental data for validation of the U.S. computational models, thereby reducing U.S. development costs while increasing reliability. There are existing agreements in this technology area with Germany that could potentially expedite implementation of a specific program agreement to address this opportunity.

f. Decontamination

In addition to operational battlefield decontamination, specific ASTMP NBC warfare (NBCW) objectives include the effective remediation of contaminated waste sites and the destruction (using environmentally safe practices) of chemical agents and energetic materials. Bioprocesses have the potential to meet these requirements.

Existing decontaminating liquids are caustic and logistically difficult to handle. Enzymes are being investigated for use as catalytic agents to neutralize chemical agents. While personnel protection is of primary importance, there is also a requirement to protect and decontaminate mission critical equipment. At present, there are no methods available for the decontamination of sensitive equipment such as avionics, electronics, detectors, computers, and communication equipment. In the late 1980s and early 1990s, the United States was pursuing the development of a system to satisfy this requirement. Germany (with whom there are existing agreements that could potentially expedite implementation of a specific program agreement to address this requirement) also was beginning a companion study. Both efforts were terminated because the technology used an ozone-depleting substance. Steeply declining defense budgets over the next few years and higher priorities forced the United States to all but abandon the search for a technical solution. Germany, however, continued to pursue the issue as part of the Haupt Entgiftungs Platz–90 (HEP–90) development and has exploratory development studies underway. Canada is also strong in the subarea of decontamination, having developed, in time for the Gulf War, the most effective universal Soman (nerve agent) antitoxin.

The CBD program is now managed as a fully integrated joint service program; this has resulted in the resurfacing of this requirement and work on decontamination needs is currently scheduled to begin again, albeit at modest levels, in FY97. This is reflected in the Defense Technology Objective (DTO) CB.09.12.D, "Decontamination for Global Reach." Ongoing German R&D may contribute to the development of equipment capable of decontaminating sensitive pieces of military hardware without damaging them irreversibly. Of the concepts currently being explored, one using new aqueous surfactant and decontaminant formulations appears to be the most promising.

Biotechnology also (specifically biodegradation/bioremediation) provides methods for decontamination of waste sites and the demilitarization of energetic materials. These processes are accomplished through the use of biological organisms including fungi, bacteria, and algae. Japan, the U.K., Germany (with whom there is an existing agreement that could potentially expedite implementation of a specific program agreement to address this opportunity), France, Israel, and the Nordic group (Norway, Sweden, and Denmark) have significant capabilities in segments of this area. France is particularly strong in developing bioprocessing techniques for disposing of energetic materials (explosives and propellants). Biotechnology is highly internationalized and strongly centralized within the European Community (EC). Because of the open nature of exchange in this area, agreements with one nation may serve as a vehicle for accessing EC technology at large.

g. Modeling and Simulation

Much of the capability needed for M&S of CB transport and dispersion modeling is common to civil weather forecasting and environmental pollution modeling. The U.K., France, Germany, Canada, and Israel all have or have had active programs that provide a potential basis for cooperation in M&S of atmospheric effects on agent dispersion. Other countries that have evidenced strong interest in fine-grain meteorological prediction include Japan, China, and Russia. Denmark has also typically had an effort, although it has not invested heavily in staying up to date.

Distributed interactive simulation (DIS) is one effort underway to develop training and materiel development simulation systems interconnected via a high-level architecture (HLA). Current efforts include the inclusion of chemical, biological, and smoke effects into the HLA, both for training in a CB environment and for materiel acquisition support. DIS has the potential to account for environmental and equipment effects; can operate in virtual, constructive, or live modes, and will use high-fidelity phenomenology and component models. Further, this will provide a value-added process for systems and materiel evaluations.

Japan has placed particular emphasis on the use of dynamic distributed simulations of large, complex, geographically dispersed industrial enterprises like electrical power systems. Similar technologies are being developed and implemented in Canada.

The United States has extensive expertise in the development of DIS networks. The (other) Technical Cooperation Program (TTCP) member countries could take advantage of this network and tie in at a much reduced cost. Further, by initiating HLA nodes reflecting their equipment, it would be possible to develop doctrine and training better suited to coalition forces. An existing agreement in this technological area with the United Kingdom, Canada, Australia, and New Zealand could potentially expedite implementation of a specific program agreement to address this.

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5. Individual Survivability and Sustainability

Survivability and sustainability of individual soldiers and small operational groups for the future battlefield and for operations other than war (OOTW) will require advances across a wide spectrum of capabilities. These include ballistic protection, CBW protection, signature reduction, as well as enhanced capabilities for delivering provisions and electrical power for the soldier system. The suite of underlying technologies is also diverse, ranging from textiles (a special case is biotechnologically derived materials such as spider silk or bioceramics for body armor) to advanced fuel cells and batteries. Requirements for electrical power for individual soldier equipment vary with primary (disposable) cells being of interest for battle, and rechargeable (such as nickel-metal hydride) having a key role in training, currently a major consumer of batteries.

Table E–8 summarizes key capabilities and trends in individual survivability and sustainability. The following paragraphs provide additional information for each technology subarea.

Table E–8. International Research Capabilities—Individual Survivability and Sustainability

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Individual Survivability	➊ Soldier systems (physiological & psychological)	➊ Soldier systems (ballistic protection)	➊ Soldier systems		*Australia* ➊ Soldier systems (microclimate control)		*Canada* ➊ Soldier systems
Sustainability		➍ Batteries for man-portable systems	➍ Fossil fuel-driven electrical power	➊ Electrical power for man-portable systems		*Russia* ➍ Batteries for man-portable systems	*Canada* ➍ Electrical power

Note: See page E–11 for explanation of key numerals.

a. Individual Survivability

Individual survivability includes all material and combat clothing systems for protection of the individual warfighter. Areas of particular interest are individual ballistic protection, countermeasures to sensors, laser eye protection, multifunction materials, and warrior performance and endurance enhancements. A number of technological advances address these concerns:

- Textile and composite materials for ballistic protection
- Percutaneous CB protection (e.g., selectively permeable membranes)
- Multifunction materials (environmental and flame/thermal protection)
- Laser eye protection materials and systems
- Microclimate conditioning for warrior performance enhancement
- Integration of soldier system modular components.

Cooperative opportunities in individual survivability relate primarily to improved soldier systems. The soldier system focuses on enhancing soldier capabilities in the five areas of lethality, command and control (C^2), survivability, sustainability, and mobility. This encompasses everything the soldier wears, carries, and consumes in a tactical environment. France has special expertise in ballistic protection for individual soldiers. The United Kingdom has strong capabilities in the physiological and psychological aspects of soldier systems. Germany and Canada both have strong capabilities in materials and soldier system integration. In addition, a niche capability in individual microclimate control has been identified in Australia.

b. Sustainability

Sustainability includes scientific and technological efforts to sustain and enhance warfighter performance and combat effectiveness. These range from nutritional performance enhancement, food preservation, food service equipment, energy technologies, and drinking water to precision cargo/ personnel airdrop and airbeam technologies for lightweight, rapid-setup shelters.

A key area for sustainability will continue to be man-portable electrical power. As the soldier relies increasingly on sophisticated electronic sensors, computers, and communications, there is a corresponding need for more efficient sources of portable electrical power. Japan is a world leader in secondary (rechargeable) batteries, fuel cells, and small gasoline engines. France and Russia also have significant capabilities in selected aspects of secondary batteries. Advanced lithium and nickel-metal-hydride batteries and fuel cells offer exceptional energy densities and longer operating life, which are key factors in man-portable weapons and sensors.

Canada also has recognized strengths in the subarea of sustainability as demonstrated by the FY96 approved foreign comparative testing (FCT) of a Canadian less-than-3-kilowatt generator, and Canadian multifuel burner. In addition, Canadian research in hydroxide fuel cells is strong. A Canadian firm is currently fielding a test fleet of hydrogen-oxide powered buses at Disneyland; the only waste product is water. Canadian companies are also working in other fuel cell concepts such as aluminum-oxide. A small Canadian company has, with the Special Operations Command (SOCM), further developed this cell for military use. Ongoing efforts with France offer special opportunities to accelerate the development of low-cost, long-life power sources based on these technologies. In addition, there is a great need for small, portable, high-efficiency power generation. Germany has world-leading capabilities in the specific area of miniature fossil fuel engines for portable electrical power.

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6. Command, Control, and Communications

Command, control, and communications (C^3) technology encompasses the capability to acquire, process, and disseminate information across force elements (including international coalition forces).

The capability must be reliable, provide secure multilevel access, and be protected from enemy attacks. This will require advances not only in computing hardware and software but in the interconnecting fabric of communications. As delineated in the JWSTP, the goal is seamless and effective integration of capabilities for planning and preemption, integrated force management, and effective employment of sensor-to-shooter system-of-systems. Table E–9 summarizes trends in capabilities to meet milestones in seamless communications, information distribution and management, and decision making addressed in Volume I, Chapter IV.

Table E–9. International Research Capabilities—Command, Control, and Communications

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Seamless Communications	❶ Battlefield interoperability	❶ Battlefield interoperability	❶ Communications networks; battlefield interoperability; international interoperability	❶ Fuzzy logic; high-speed communications	*Korea* ❺ System interoperability		*Canada* ❺ Tactical interoperability
Information Management & Distribution	❶ Natural language processing	❶ Real-time distributed communications; switching systems; machine translation; C^2 simulation	❶ Machine translation; natural language processing	❶ High-speed switching & networks	*Korea* ❺ Data fusion		*Canada* ❺ Advanced data display *Netherlands* ❶ Natural language processing; knowledge base/ database science
Decision Making	❶ Intelligent systems; mission planning	❶ Mission planning		❶ Fuzzy logic			*Israel* ❺ Battle management

Note: See page E–11 for explanation of key numerals.

As reflected in the Army command, control, communications, computers, and intelligence (C^4I) technical architecture and the interoperability objectives of the Army Digitization Office, digitization of the battlefield is expected to rely largely on the effective use of commercial-off-the-shelf (COTS) equipment. While this may provide many of the building blocks, integration and demonstration of the technology in the field remains a significant challenge. Widespread mass market availability of low-cost computers of unprecedented power and global connectivity over the Internet has led to rapid expansion and proliferation of information system technologies. Key areas where international developments are likely to provide continuing opportunities for cooperation include:

- High-speed digital switching and networking techniques supporting seamless communications and robust interoperable systems
- Machine translation software products and intelligent agents for data acquisition and retrieval
- Intelligent systems technologies for real-time decision support.

The following paragraphs describe opportunities that support DTOs for achieving information superiority and operational dominance in the battlespace of the future. The breadth, diversity, and number of the areas highlighted reflect the nature of the global information infrastructure. Areas where existing or near-term pending agreements offer significant opportunities for cooperation are noted.

a. Seamless Communication

Seamless communication means robust, survivable, multilevel secure communication systems that provide the warfighter access to mission-essential information over the entire operational continuum without requiring user intervention to achieve connectivity across heterogeneous networks.

Seamless communication includes the technologies associated with networks, network management, and advanced radio communication systems. The technical challenge is to provide local area networks and ground mobile radio networks that will survive the hostile and demanding environment of the modern battle and that are capable of being interfaced to fixed-backbone or space-based wide area networks.

France, Germany, and the U.K. are major players in all aspects of communication networks and in battlefield interoperability. Canada also has significant capabilities in tactical interoperability. The following programs are of particular interest for cooperative opportunities:

- *Battlespace Command and Control (BC^2)*—Seamless information transfer in C^2 to include collaborative planning, intelligence, logistics, and weather. France, Germany, and the United Kingdom all have significant capabilities and ongoing cooperative relationships with the United States to develop joint C^2 capabilities. There is a need to address and expand this effort to the Korean Peninsula to effect force compatibility with the Republic of Korea (ROK) forces where the U.S. Army has a large ongoing commitment.
- *Command Post Communications*—Broadband communication networks for corps, division, and brigade command posts. Germany is developing a wideband, wireless command post communication network that will be capable of providing voice, digital data, and video connectivity among the elements of a dispersed command post. This system is similar to that being investigated in the U.S. Army's Survivable Adaptive System (SAS) ATD. There is potential for data exchanges and an interoperability effort between these two programs. A key German technology includes ultrafast (40 gigahertz (GHz)) optical switching developed by the Heinrich Hertz Institute.
- *Battlefield Interoperability*—Implement, evaluate, and validate improved interoperability between the tactical (regiments, battalions, and companies) C^2 systems of different allied nations. One area of interest involves developing an intelligent translation gateway box that will receive variable message formats (VMFs) from a command post in English and convert them in real time to French common AdatP3 message format and vice versa. A similar effort with Germany is ongoing as a follow-on to a memorandum of understanding (MOU) related to the combat vehicle C^2 system.
- *International C^2 Systems Interoperability*—Part of the Army's strategy for international digitization is to establish a joint testbed facility to conduct R&D to demonstrate and evaluate interoperability and implement new procedures and functions required for a digitized battlefield. Initial efforts involve Germany but it is envisioned that this testbed will accommodate joint testing between U.S. and other multinational forces.
- *Tactical Level Allied/Coalition Force C^2 Simulation*—Providing a tactical level C^2 exercise for a U.S.–French allied task force utilizing DIS protocols in a Janus environment. This effort will begin to evolve a plausible doctrine, tactics, and training procedure with the concomitant military language, symbology, and rank structure, and provide the architecture for integration of military equipment and systems in order to form a unified C^2 structure where this is politically acceptable.

In addition to our traditional NATO allies, Japan also offers significant capabilities in networking and high-speed communications. Of particular interest is its world-class work on fuzzy logic. This area of technology is expected to play an important role in future automated and autonomous systems.

b. Information Management and Distribution

Information management and distribution provide the backbone infrastructure to allow near-perfect, real-time knowledge of the enemy and the ability to automatically disseminate that information to dispersed forces and command centers.

Technical challenges relate to heterogeneous distributed computing environments, distributed database management, multilevel information security, advanced human–computer interfaces (HCIs), and automated information distribution.

France, Germany, and the U.K. have significant capabilities in information management and distribution. In addition, Canada has strong capabilities in advanced data display. Another NATO country with noteworthy capabilities is the Netherlands, which has particular strengths in natural language processing as well as knowledge base and database science. South Korea and Canada have significant efforts ongoing relative to data fusion and the underlying technology applied to military intelligence. Cooperative efforts with these countries would be beneficial in applying state-of-the-art technologies to address the data fusion problem. The following are examples of potential cooperative opportunities:

Real-Time Distributed Artificial Intelligence (AI)-Based Data Fusion—Applications of distributed intelligent systems to real-time data fusion and combat battle management. The objective is to incorporate AI into large synthetic computing environments to handle networking and process management automatically and transparently for the network user. France has extensive experience and a sound information technology infrastructure combined with strong capabilities in battlefield communications.

Next-Generation Tactical Switches—To increase information flow to and from the land forces (Army) commander. Advanced asynchronous transfer mode (ATM) switching promises many advantages to the next-generation information infrastructure for commercial as well as military tactical and strategic applications. France has significant capabilities in this area of technology.

Machine Translation—For information exchange between U.S. and allied forces in combined operation. Military communications offer a promising area for implementation of machine translation because of the relatively limited and specialized military lexicon. Two areas are of special interest, one with Germany and one with France. The German Army has developed a prototype translation system consisting of a 16-channel recorder, a server, two workstations, and an electronic military lexicon. They are interested in further development of this capability in the areas of language and speaker identification. World-class research in machine translation is being done in Germany at Siemens and the University of Karlsruhe. A French–English interlingual-based machine translation system, capable of high-quality translation of complex sentences in the domain of military free text messages, is being developed under a 4-year effort between France and the United States. Using corpus material from the Communications–Electronics Command (CECOM) and STSIE DGA (formerly Research Institute for High-Energy Physics, Finland (SEFT)), the system will contain semantic lexicons of both French and English each having 1,000–3,000 root word form entries, graphical user interface tools, and wide coverage grammar parsers and generators. Finally, Japan offers world-class capabilities in high-speed switching and networks that could be a valuable contribution to this area.

c. Decision Making

Decision making or battle command remains a combination of art and science. The nonhierarchical dissemination of intelligence, targeting, and other data, facilitated by seamless communications and effective information management and distribution, will replace the current hierarchical command structure. Units, key decision makers, and commanders will be more independent and dispersed. Information will be voluminous, nonsynchronous, ambiguous, partial, and at times erroneous. To support this revolution in battle command, dispersed command units must be able to share a common, accurate picture of the battlespace. To take advantage of this information, a multilayered reasoning environment is required to aid the warfighter and commanders in making battlefield decisions.

Technical challenges include developing an environmental and force structure database and reasoning mechanisms that are scalable, dynamic, extensible, and robust. In addition, the system must be affordable and offer real-time response. The decision making and planning aspects require improved machine learning and reasoning paradigms coupled with intelligent agents or aids.

France and the United Kingdom have special capabilities in the area of fuzzy logic technology that offer opportunities for potential cooperative efforts.

Fuzzy Logic in Mission Planning and Decision Making—The French are doing world-class research on automated mission planning and decision making. Automated mission planning systems require evaluation of potential paths based on a perception of the current true situation. In virtually every case this is based on vague or uncertain data (e.g., data on enemy positions, weapon ranges, reaction time, efficiency). Conventional rule-based approaches do not work well with this type of data. Fuzzy logic approaches for data collection, aggregation, and potentially deaggregation are being integrated into an automated system to allow manipulation of vague data to increase realism of simulation and, ultimately, of decision making.

Intelligent Command Aids—The U.K. is investigating the potential payoff from incorporating fuzzy logic techniques into a large-scale battlefield decision making simulation. Intelligent command aids could be extremely important in simulation and computer-generated forces (CGFs). A common problem is the fact that it is far too expensive to have human controllers "command" the CGFs. Rather than using large rule-based systems to construct "command agents" that attempt to model individual decision making entities, fuzzy logic and fuzzy inference engines are an approach that can enhance current intelligent command aids and provide more realistic and effective simulations. The GeKnoFlexE system developed by the United Kingdom (Ft. Halstead) will be the testbed system. The current rule-based inference structure will be "fuzzified" by augmenting or replacing it with fuzzy rules and fuzzy inference mechanisms. Since the current system is nonfuzzy, direct comparisons of complexity, behavior, and other performance parameters will be possible.

Israel also has strong capabilities in automated battle management that could offer an important contribution to this effort.

In addition to the above, Japan has world-class capabilities in fuzzy logic. Most Japanese work is related to control of industrial processes or consumer products, however, it is also applicable to military decision making and mission planning.

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7. Computing and Software

While military applications will increasingly rely on COTS, there remain unique requirements for which technological advances in basic computing hardware and software will be required. These fall into the realm of so-called "grand challenge," which will require trillions of floating point operations per second (teraflops). Several approaches are being considered, each of which, if ultimately realized, is likely to offer certain inherent advantages for different applications. HPC and scalable parallel systems are of particular importance. Optical processing techniques combine elements of both and are being pursued as a means of increasing inherent parallelism and computational throughput. Software advances are seen as a way to allow aggregation of very large numbers of computing elements. Both of these approaches lend themselves to solutions to complex deterministic problems (i.e., problems for which a sequence of calculations to reach a specific solution can be defined). By contrast, neural networks provide a better way of attacking less determinate problems.

Table E–10 highlights significant capabilities and trends in key areas of computing and software. HPC is an area of international R&D. In addition to France, which is recognized as a world leader in photonics, Japan and Russia have had strong programs in optical computing. Germany has a growing interest and has strong capabilities in production of photodynamically active bacteriorhodopsin films that may be an enabling technology for future optical/molecular computers. Israel has a small but sound and growing EO infrastructure as well. The growth of the Internet and multimedia are producing growing demand for development and global implementation of very high-speed digital networks. Development of these is an international activity, with cooperation among major telecommunications firms. One example is the Japanese Real-World Computing (RWC) program, which includes a number of other countries as participants.

a. High-Performance Computing and Scalable Parallel Systems

The United States has dominated and is projected to continue to drive the state-of-the art in HPC; Japan has strong capabilities. However, Japan has dominated in areas of "traditional" supercomputing high-cost mainframes and vector processors

Table E–10. International Research Capabilities—Computing and Software

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
High-Performance Computing & Scalable Parallel Systems	❷ MPP	❷ Optical processing	❷ MPP; ANNs	❷ ANNs			
Networking	❷ Optical switching	❷ Tactical fiber optic systems	❷ Fiber optic systems	❷ Optical switching & networks			*Canada* ❷ Optical switching & networks *China, Israel* ❺ Fiber optics
Software Engineering	❷	❷	❷ MPP & ANN software				*India, Israel* ❹ CASE & applications
Artificial Intelligence	❷	❷	❷	❷		*Russia* ❺	❷ Many
Human–Computer Interface	❷ Visually-coupled systems	❷ Visually-coupled systems	❷ Visually-coupled systems	❷ Visually-coupled interfaces			*Canada* ❷ Visually-coupled systems; large dataset representation *Italy* ❹ Haptic/tactile sensors *Israel* ❹ Heads up display

Note: See page E–11 for explanation of key numerals.

The United States has pioneered a variety of technologies for scalable distributed processing based on U.S. microprocessor designs whose computational power continues to double approximately every 18 months. These configurations now dominate the market. Availability of affordable HPC capability has also led to a growing level of international interest and work in intelligent systems and human–composite interfaces.

Massively parallel processing (MPP) and neural network programming could be applied to numerous applications covered by ASTMP milestones and objectives. M&S are examples of applications requiring the computing speed and power offered by MPP techniques, while neural network programming may be more useful in the development of decision aids. Only a few countries have the supporting infrastructure necessary for major R&D in these technologies. World leaders include the United States, Japan, Germany (with whom an active Data Exchange Agreement (DEA) exists), and to a lesser extent the United Kingdom and France.

MPP and neural network programming are important aspects of the Army's electronic battlefield (EBF) concept. MPP will contribute significantly to simulation and virtual reality (VR) components of the EBF.

Military requirements for processing real-time signals and imagery data severely challenge existing computing capabilities. Optical processing offers potential advantages for these applications and is an important area of technology development where other nations have world-leading capabilities.

ASTMP goals include demonstration of a two-dimensional (2D) optical processor capable of running real-time automatic target recognition (ATR) and signal processing algorithms on data from imaging sensors such as the synthetic aperture radar (SAR) or EO systems. Near-term ASTMP milestones include the development of optical interconnections for computers; photonic and electronic devices integrated on the same chip; image-forming light modulators, and an order of magnitude improvement in spatial light modulation dynamic range.

Optical processing techniques are well suited for analysis of data generated by these high-volume throughput applications. The development of photonic devices necessary for optical computing are of significant interest to the U.S. Army and have numerous military applications. World leaders in photonics/EO include the United States and Japan, followed by France, the U.K., and Germany.

b. Networking

The network throughput demands of international telecommunications firms are primary drivers of the state of the art in most networking areas, including fiber optic communications and optical switching (including wave division multiplexing techniques). All of the major telecommunications-producing nations—the United States, United Kingdom, Japan, France, Germany, and Canada, followed closely by China and Israel, have good capabilities in fiber optic networks. The implementation of the 5–10 gigabits per second (Gbps) fiber optic cable that will link Europe and intermediate points in Africa and Asia with Japan will almost certainly speed proliferation of this technology. While Japan and selected regions of Europe may lead in deployment of high speed fiber-optic cables, implementation in other areas is limited primarily by economic considerations rather than technology. In the critical area of switching the United States, Canada, and the United Kingdom have the strongest technological positions, followed very closely by Germany and France.

c. Software Engineering

International software developments are enabled by widespread availability of very powerful microprocessor-based symmetrical multiprocessing systems. A number of countries, including Israel, India, and Russia, are actively engaged in commercial cooperative software developments.

In software one key to achieving our goals for M&S is the implementation of advanced algorithms, specifically for MPP. Currently only a few countries possess the supporting infrastructure necessary for major R&D in this area. World leaders include the United States, Japan, Germany (with whom there is an active agreement), the United Kingdom, and France.

d. Artificial Intelligence

AI (or machine intelligence or intelligent systems) is an area of worldwide research interest. One area that is particularly promising for international collaboration is artificial neural networks (ANNs); for example, the optical ANNs being pursued by Japan as part of the RWC initiative. Another area is the application of AI to so-called intelligent agents for collecting information and managing operations in a distributed battlefield command, control, communication computers, intelligence, and information system. For example, Australia has a particularly strong presence and activity on the Internet World Wide Web. Much of the work is theoretical in nature, and many of the problems are tractable with modest computing power, widely available in the commercial market. This active and effective research in AI can be found in most developed or developing countries. Much of this work is being driven by the Internet or by requirements for managing and administering extremely large, complex telecommunications systems. In addition to work in the United States, which is the world leader in this area, Japan's RWC initiative has a strong component of AI. Strong capabilities in intelligent agents also reside in the U.K. and Germany, followed closely by France. AI capabilities are found in many other countries.

e. Human–Computer Interface

One of the effects of increased computer hardware performance and communications bandwidth has been to spur rapid interest and growth in VR. While the U.S. holds or shares a lead in most areas of HCI research, the U.K. (which has an existing cooperative effort in helmet-mounted displays (HMDs) with the Air Force and NASA Ames), France (visually-coupled displays and digital scene generation), Canada (head-mounted stereo displays and large data set visualization), Germany (applications to robotics and teleoperations), and Japan (visually-coupled systems) have world-leading development efforts. Other countries have niches of capability, two notable examples being the strong capability in haptic devices at the University of Pisa in Italy, and Israel's work in heads-up displays.

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8. Conventional Weapons

The ASTMP Chapter IV includes milestones for extending the range and lethality of conventional artillery and antiarmor rounds. Conventional weapons objectives are directed towards a variety of technologies for increasing the lethality and mission effectiveness of guided and unguided weapons and mines. Russia, France, Germany, and the U.K. are major developers of conventional weapons, followed closely in capability by Italy, Sweden, and Israel. Japan, which is prohibited by its national legislation from exporting weapons, has significant indigenous capabilities as well as strong capabilities in certain lay component technologies such as gallium arsenide (GaAs) microwave components and neural net and fuzzy logic pattern recognition, and hypervelocity propulsion.

Armor and antiarmor technologies represent a special subset of operational capabilities toward which many of the subtechnology developments discussed below will be directed. Technologies of interest will include improved lethal mechanisms, advanced sensing techniques for optional delivery of the lethal mechanisms, and better methods of M&S of weapons effects and system vulnerabilities. Army objectives for improvements in tungsten alloy penetrators may be furthered by cooperation with other countries, including the U.K. and France. France has strong capabilities in explosives and propulsion systems, including air-breathing hypervelocity propulsion systems. Japan has also taken steps to improve its technological capabilities in aerospace materials and aerodynamic design for hypersonic propulsion systems. Both of these could contribute to development of long-range hypervelocity systems for the Army.

Opportunities are to be found in a variety of subareas identified in the ASTMP Volume I, Chapter IV, as illustrated in the Table E–11.

Table E–11. International Research Capabilities—Conventional Weapons

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Fuzing, Safing, & Arming	❷ Overall	❷ Overall	❷ Overall	❹ Components			*Italy* ❺
Guidance & Control	❷ Overall	❷ Overall	❷ Overall	❹ Components			*Israel, Sweden* ❺
Guns—Conventional & Electric	❶ ETC gun	❷ Overall	❶ ETC gun		*Australia, ROK* ❺ Rail guns	*Russia* ❺ Overall	*Israel* ❷ ETC gun
Mines & Countermines	❷ Overall	❷ Overall	❷ Overall			*Russia* ❷ Overall	*Italy, Canada* ❷
Warheads, Explosives, & Rocket/Missile Propulsion	❷ Overall	❷ Overall ❹ Hypervelocity propulsion	❷ Vehicle integration	❹ Hypervelocity propulsion		*Russia* ❷ Overall	*Israel* ❷ BMD missile *Sweden, Switzerland* ❺
Weapon Lethality & Vulnerability	❷	❷	❷				

Note: See page E–11 for explanation of key numerals.

The following examples illustrate international cooperative programs that might contribute to meeting Army objectives.

a. Safing, Arming, Fuzing, and Firing

Any country with an armaments industry can produce simple contact, time, and proximity sensing fuzes. Capabilities to contribute to advanced fuzing for programmable / smart ordnance and aimable warheads and look-down / shoot-down antiarmor weapons, are primarily in the United Kingdom and France, with possible niche capabilities residing in Germany, Italy, and Sweden.

As noted previously, while Japan is generally prohibited by its constitution from export sales of weapons, there are a number of specific areas where Japanese technology might enhance U.S. Army safing, arming, fuzing, and firing (SAFF) capabilities. These include optical and IR lasers and detectors, millimeter-wave (MMW) components, and ANN and fuzzy logic for use in target detection and aimpoint selection logic.

b. Guidance and Control

Germany, the United Kingdom, and France, have leading capabilities in terminal guidance and control. Germany was involved in the design of a MMW seeker for the advanced precision-guided munition (APGM) prior to that program's cancellation. Sweden (e.g., the Bofors BILL) and Israel (Arrow) both have demonstrated capabilities in terminal guidance and control.

c. Guns—Conventional and Electric

Advanced gun technology is an important component of the Army's R&D program. Weapons able to deliver effective payloads from longer range and with greater accuracy give a well-trained soldier a decisive advantage on the modern battlefield. Current propulsion technology is focused in three areas: advanced solid propellants, EMP (rail gun) and electrothermal chemical (ETC) propulsion.

The United States currently has an active EM launch technology development program in cooperation with a strong program in the United Kingdom. The United States leads in the difficult challenge of developing an electric power generation unit capable of producing the required pulsed power within the confinements of a vehicle. The Netherlands and Germany have small-scale research in this area. Korea is starting a development effort in this area but has yet to develop a significant capability. Several countries are working toward integrating electric power units into vehicles.

d. Mines and Countermines

Humanitarian concerns have led to increasing international pressures to outlaw land mines. At the same time, mines are seen by military forces worldwide as meeting critical mission needs. The growing global concern about increased proliferation of mines and countermine capabilities point to the need for international development and adoption of new design standards and mine clearing capabilities.

The technological solution—more intelligent mines and minefields—is of global interest. Opportunities for cooperation in intelligent mine / minefield technologies will be found in countries that couple historical capabilities in state-of-the-art land mines with strong capabilities in advanced sensors and electronics, such as the U.K. and France, followed closely by Italy and Germany. Canada is doing substantial work in the subarea of mines and countermines. There is currently an MOU between CECOM and its Canadian defense laboratories counterpart in staffing to expand cooperation. Russia has been a major operational user of land mines and should have substantial empirical experience from which to draw.

e. Warheads, Explosives, and Rocket/Missile Propulsion

A number of countries (including certain developing countries) have some capability of producing standard explosives such as TNT, RDX, nitroglycerin, ammonium perchlorate, metal fuels, hydrazine, and related compounds for military use. The U.S., France, the U.K., and Japan are the world leaders in formulation and production of advanced explosives and propellants.

Advances in hypersonic/hypervelocity (Mach 6–8), shortening engagement cycle times, and increasing system lethality threat handling capabilities will enhance close combat and short-range air defense missions. The development of hypervelocity vehicles depends greatly on advanced rocket propulsion techniques, as well as advances in airframe design and guidance and control. Advances in propulsion technology (specifically air-breathing propulsion) are necessary to support near-term objectives of U.S. Army missile development programs.

Japan, Germany, and France, followed closely by the U.K. and Russia, have significant experience in the design, manufacture, and testing of air-breathing rocket motors and components. Japan has initiated a broad-based initiative to develop materials and structural / aerodynamic design techniques for hypervelocity transport, the results of which could contribute to this effort. The focus of efforts is towards a multimission kinetic energy missile capable of being launched from multiple light platforms and hitting a target with 3–5 times the kinetic energy of tank cannons.

f. Weapon Lethality and Vulnerability

Two overarching security concerns effect cooperation in this area. The first is the potential compromise of U.S. intelligence collection sources and methods in programs dealing with lethality against specific foreign weapons. The second is operational security of information relating to vulnerabilities of U.S. weapons that might be exploited by a potential adversary to defeat or degrade U.S. systems. Within the limits imposed by these concerns, however, there may be opportunities for cooperative programs. In some cases, foreign participation may fill gaps in U.S. program capabilities. The U.K., France, and Germany all have strong programs in M&S of weapons effects as well as extensive empirical databases. These countries have capabilities in armored systems, with France having a particular niche capability in helicopter structural survivability.

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9. Electron Devices

Electronics plays a crucial role in battlefield supremacy, enabling or affecting virtually every aspect of warfighting. Electronic devices comprise four major subareas of technology: EO, MMW components, nanoelectronics, and portable power sources. These are the cutting-edge technologies that constitute the nerves and brains of the digitized battlefield. A superior and innovative program in electron device S&T is essential to the broad Army vision of decisive force multiplication with a minimum number of platforms and personnel, and avoidance of potentially disastrous technological surprise on the battlefield. Weapon systems that meet present and projected future requirements and that have affordable life-cycle costs will require exploitation of commercial electronics whenever possible, plus development of special technologies for Army systems having unique requirements or capabilities.

Table E–12 summarizes key foreign capabilities in each technology subarea, and the following paragraphs provide additional information on specific opportunities and strengths.

Table E–12. International Research Capabilities—Electron Devices

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Electro-Optics	❺ Photonics signal processing	❶ IR FPA	❹ Photonics signal processing	❶ All aspects			*Israel, Italy* ❺
Millimeter-Wave Components	❹ MMIC; GaAs	❶ MMIC; compound semiconductors	❶ MMIC; compound semiconductors	❶ MMIC; acoustic wave devices; compound semiconductors			*Israel* ❺
Nanoelectronics	❺ Microscopy; biotechnology	❺ Molecular chemistry; biotechnology	❹ Submicron devices	❶ All aspects		*Russia* ❷ Molecular electronics	
Portable Electrical Power	❺ Diesel engines	❶ Batteries	❶ Small engines	❶ All aspects		*Russia* ❷ Rechargeable batteries; power switching	*Switzerland, Israel* ❺ Batteries *Austria, Italy* ❺ Diesel engines

Note: See page E–11 for explanation of key numerals.

a. Electro-Optics

EO includes critical military components such as lasers, focal plane arrays (FPAs), detectors, and displays. These represent the technologies that enable smart and precise weapons to function so effectively. Areas of particular interest to the Army include high-resolution, full-color, HMDs, affordable multispectral FPAs, fiber optic distributed sensors, light detection and ranging (LIDARs), and optical countermeasures. Technical challenges relate to optical and EO materials science, optoelectronic integrated circuits (OEICs), and monolithic or hybrid integration of electronic and photonic devices.

The United States and Japan generally share a commanding world lead in most aspects of electronic and EO devices and packaging. Japan is particularly strong in displays, laser diodes, and low-power lasers, with outstanding capabilities in commercial applications of photonic technology.

France has a strong capability in photonics, especially in the areas of optical switching and IR FPAs. Of particular interest is the design, fabrication, and packaging of smart FPAs into a single (monolithic) structure, for which France has the requisite expertise and supporting infrastructure. French scientists are working with the Army at Fort Belvoir on the technical challenge of growing cadmium zinc telluride (CdZnTe) and mercury cadmium telluride (HgCdTe) on silicon (Si). This work could overcome a major barrier to implementing a monolithic smart FPA, and could lead to a whole new generation of high-density, 2D sensor arrays.

Germany and the U.K. also have significant capabilities in photonics, and especially photonic processing of signals and images. In addition, Israel and Italy have niche capabilities that could be important. Israel, in particular, has an extensive EO S&T infrastructure including academic and industrial centers of excellence (COEs).

b. Millimeter-Wave Components

MMW components operate in the spectral range between microwaves and IR but share many properties of microwave radio frequency (RF) devices and signals. Having a shorter wavelength than microwaves, MMW devices require smaller size antennas and other components and offer greater resolution than microwaves. They are finding increasing applications in sensors and communications where relatively short range and high definition are required. They are especially useful for short range high-definition mapping radar and target surveillance. MMW phased-array radar is of particular interest. Another key application is for secure, jamproof, affordable wireless communications that might be used for instance in combat identification systems. While some of the technologies developed for microwave components can be applied to MMW, there still remain challenges to designing affordable components especially for the higher frequency MMW regions (40 GHz and above).

The key technology involves monolithic microwave integrated circuits (MMICs) and the challenge is to design and develop more affordable, higher power, and more efficient MMW components. Future electronic systems demand increasingly smaller, faster, and cheaper microelectronic devices. Devices based on silicon technology have reached a point at which components cannot be manufactured in significantly smaller sizes. To meet these requirements, compound semiconductors, especially GaAs are necessary.

France, Germany, Japan, and the U.K. all have significant capabilities in MMIC technology and the compound semiconductor technology on which they are based. Israel also has niche capabilities in GaAs devices. Of particular interest, however, Germany has developed a specific niche in indium phosphide as an alternative to GaAs. The promise of indium compounds has yet to be realized in production devices and a breakthrough in this area would be significant. Another noteworthy area is Japan's expertise in acoustic wave devices, which are important components in many signal processing systems.

c. Nanoelectronics

Nanoelectronics or nanotechnology refers to devices having feature sizes in the nanometer range. In order to achieve the requisite packaging density for future microprocessors and other integrated circuits, the technology must advance well beyond the current submicron feature size limits into the nanometer range. Smaller, faster, cheaper electronic devices of the future require this technological breakthrough. In addition, microscale or nanoscale electromechanical components depend on this technology.

Technological goals include developing lithography and fabrication capabilities to produce integrated, nanometer feature size, ultradense circuits for revolutionary warfighting sensors and information systems capabilities. An overall major challenge is developing high-performance, very low-power electronic systems to substantially reduce battery requirements and the associated weight and size penalties. A major technical challenge is creating new widebandgap semiconductor devices for high-temperature electronics and for low-leakage, high-breakdown, highly linear power devices. Another challenge is achieving mixed-signal performance of nanoelectronics with on-chip MMW and EO components.

Japan has strong capabilities in all aspects of nanotechnology and Germany has noteworthy expertise in submicron device technology. Devices in the nanoworld are approaching the feature size scale of molecular chemistry and biotechnology. It is widely believed that true breakthroughs in nanotechnology are most likely to come from advances in these fields. France has strong capabilities in molecular chemistry that may be applied to nanoelectronics. Likewise, Russia has a strong background in molecular electronics. Germany has interesting capabilities in bio-optical thin-film materials that may be useful in many applications. In addition, due to advances in atomic force microscopy, the tools necessary to do world-class research are becoming more readily available. France and the U.K. have special capabilities in advanced microscopy and biotechnology that could prove important to nanoelectronics. An interesting twist in using biotechnology and molecular electronics is the possibility of self-assembling nanostructures that could greatly simplify the challenges to fabricating devices of this size.

Since the areas of molecular electronics and biotechnology do not demand the enormous infrastructure investments that are required to do world-class electronics R&D, this is an area where a number of smaller countries could play a key role. Unlike the field of advanced electronics, where the United States and Japan basically dominate, nanotechnology may open up the playing field to many more players.

d. Portable Electrical Power

One of the most pressing Army needs is for small lightweight electrical power for the individual soldier. As the era of the digital battlefield unfolds, there is an increasing need for smarter and more self-reliant individual soldiers and weapons. This places an increasing demand on the computing, communicating, and sensing capabilities of the individual soldier, who requires more compact yet more powerful electrical power sources. Some of the foreseeable power requirements include enhanced hearing, night vision devices, computers, voice/data communications, helmet displays, individual navigation, weapon rangefinders, and possibly individual climate control. All of these require electrical power. The most promising near-term technology is advanced batteries offering lighter weight, higher power, and longer life. Lithium primary and secondary batteries seem to offer the best hope for low-cost, lightweight batteries with sufficient energy density for soldier power.

Japan is a world leader in virtually all aspects of portable electrical power with strength in batteries, fuel cells, power control devices, and switching components. France has significant capabilities in lithium-ion, lithium polymer, nickel-metal-hydride batteries, and in small-lot production of high-reliability batteries. Russia has strong capabilities in very high energy density silver-zinc batteries and Israel has niche capabilities in lithium thionyl chloride batteries.

Another area of major interest in portable power is the need for primary and auxiliary power for vehicle-borne systems, remote facilities (manned and unmanned), and for various remote sensors. Technologies of interest include batteries, fuel cells, and rotating machines. High energy density is an important requirement, as is fuel selection to simplify logistics requirements. In many cases, low observability (acoustic, thermal, and EM) is a critical factor.

Germany and Japan both have exceptional capabilities in small fossil-fueled rotating engines for power generation. A German company (Deutz) has developed a very small one-cylinder diesel engine with potential for auxiliary power in tanks and other applications. Austria, Italy, and the U.K. also have good capabilities in high-power middle distillate (diesel) engines.

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10. Electronic Warfare/Directed Energy Weapons

Electronic warfare (EW) includes any military action involving the use of EM and directed-energy (DE) to control the EM spectrum or attack an enemy. There are three major categories of EW: electronic attack, electronic support, and electronic protection. Directed-energy weapons (DEWs) can be considered a special type of electronic attack that are handled as a separate category to distinguish them from more traditional EW techniques. Laser weapons, RF weapons, and particle beam weapons are the three main categories of DEW. As a practical matter, only lasers and RF weapons have advanced sufficiently to be of military value.

The major technology areas of Army interest are shown in Table E–13. As indicated in the table, design of EW and DEW systems often demands detailed support intelligence regarding the characteristics of the system being attacked. To the extent that this requires disclosure of threat intelligence, international cooperation is impeded. This is especially important in the traditional EW areas of jamming, electronic support, and electronic protection. There are, however, several areas of technology of

Table E–13. International Research Capabilities—Electronic Warfare and Directed Energy Weapons

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Electronic Attack	Research in these areas may require sharing of sensitive threat information & is handled on a case-by-case basis.						
Electronic Support							
Electronic Protection							
Radio Frequency Directed-Energy Weapons	❺ HPM	❺ HPM				*Russia, Ukraine* ❷ HPM	
Lasers Directed-Energy Weapons	❷ LELs	❷ Laser materials	❷ Laser materials	❷ HELs; LELs		*Russia* ❷ HELs ❺ LELs	

Note: See page E–11 for explanation of key numerals.

a more general dual-use nature, including high-power microwave (HPM) tubes and lasers in which there are significant foreign capabilities and opportunities. The following paragraphs provide additional information for each technology subarea.

a. Electronic Attack

Electronic attack involves the use of EM or DE to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability. Areas of interest include suppression of enemy air defense, fusion and data integration algorithms, communications countermeasures for UAVs, jamming of mobile and digital radio systems, and deception against advanced surveillance, acquisition, and fire control radars. Technical challenges include development of wide area distributed databases, advanced antennas, precision targeting in the low GHz range, and signal recognition, demodulation, and electronic countermeasures (ECM) waveforms against commercial grade high capacity cellular and satellite transceivers.

Research in this area may require sharing of sensitive threat information. Exchange of data on system characteristics, vulnerabilities, and weapon effectiveness are generally needed to develop effective requirements and system specifications for this type of EW. For this reason, all cooperative efforts involving electronic attack must be carefully handled on a case-by-case basis, and no technological areas of special interest are identified in this summary.

b. Electronic Support

Electronic support includes actions taken to search, intercept, identify, and locate sources of radiated EM energy for threat recognition in support of EW operations and other tactical actions, such as threat avoidance, homing, and targeting. Technologies to intercept, direction-find, and locate current and emerging hostile emitters are critical for targeting and tactical situation awareness. Next-generation electronic support measures (ESM) processors must offer improved emitter identification, deinterleaving techniques, direction-finding/geolocation algorithms, multipath suppression techniques, and increased capabilities in the super high frequency region. Continued development of correlation and templating, automated tracking, cross-queuing, and situation display tools are also important. Technical challenges include the integration of ceramic phase shifters into phased-array antennas, application specific integrated circuits for fast Fourier transform processing, and tools and techniques for tasking and reporting from multi-intelligence sensor platforms.

This too is an area that may require sharing of sensitive threat information, system characteristics, and vulnerabilities. All cooperative efforts involving electronic support must be handled on a case-by-case basis, and no technological areas of special interest are identified in this summary.

c. Electronic Protection

Electronic protection includes actions taken to protect personnel, facilities, or equipment against EW that might degrade, neutralize, or destroy combat capability. Sensor and countermeasure technologies are essential elements in the complex battle that pits defensive EW systems against the enemy's offensive systems. On the modern battlefield, this is an encounter in which a timespan of 1 or 2 seconds can mean the difference between winning or losing. Advanced technology is critical in providing the winning edge in performance. Technical goals include development of multifunction and multi-spectral IR countermeasures (IRCM), radar and laser warning, and real-time situational awareness. Technology challenges include development of uncooled, low false alarm rate detectors, multicolor IR FPAs, missile detection algorithms, and more efficient, low-cost, and temperature-stable IR/ultraviolet (UV) filters. Development of high-speed wideband digital receivers based on GaAs technologies will also play a key role in electronic protection, as will development of high-power ultra-wideband (UWB) jamming modulators and transmitters.

Again, this is an area that may require sharing of sensitive threat information, system characteristics, and vulnerabilities. All cooperative efforts involving electronic support must be handled on a case-by-case basis, and no technological areas of special interest are identified in this summary.

d. Radio Frequency Directed-Energy Weapons

High-power radio frequency (HPRF) DE systems can be categorized by frequency bandwidth or power level. Narrowband systems are commonly referred to as HPM, while the wideband are referred to as wideband or UWB. As DEWs, RF systems are intended to defeat, degrade, or destroy electronic equipment. The effects can range from temporary upsets in performance to permanent circuit deterioration to burnout or destruction. As modern weapons systems become more dependent on sophisticated electronics, they also become more vulnerable to DE RF radiation. One of the highest Army priorities is to assess potential vulnerabilities of U.S. systems to unintentional fratricide by our own emissions, as well as intentional irradiation by enemy systems. Hardening technology is being developed to protect against both of these threats. Particular areas of improvement include developing and testing HPM sources and interference modulation, hardening MMIC circuits against RF, and developing broadband, high-gain antennas. One promising technology is the use of silicon carbide for hardening devices. Technical challenges primarily relate to making the RF generators smaller, lighter, and more fuel efficient. In addition, modulators and antennas must also be improved.

Some of the required developments in RF weapons involve very sensitive areas as mentioned in the above sections. Certain areas, however, involve technology of a more general dual-use nature, which offer potential for cooperative development. France is a leading producer of HPM tubes. Significant RF source development efforts also exist in the United Kingdom. Several other countries have limited research efforts in this area: Germany, Switzerland, China, Japan, and to a lesser extent, Sweden, Israel, and Australia.

In addition, Russia and Ukraine both have significant capabilities in RF weapons. The FSU was considered the world leader in HPM at the time of its disintegration. The Russians have concentrated on development of HPRF generators such as various types of gyrotrons and klystron amplifiers.

e. Laser Directed-Energy Weapons

Compact, high-efficiency lasers are critical for EO countermeasures, IRCM, and DEW applications. As diode-pumped lasers, nonlinear frequency conversion, and laser designs have matured, it has become feasible to incorporate these devices into tactical vehicles and aircraft for self-protection and missile defense. The main challenge is to demonstrate the required power levels in a compact package and to develop the ability to scale the power level up to higher levels to meet future needs. Lightweight, wavelength-diverse diode pumped lasers for the mid-IR are currently being developed, as are sophisticated active tracker systems to provide precision pointing and atmospheric compensation. Remaining technical challenges relate to packaging of higher power devices and cost reduction of laser diode arrays. Compact solid-state lasers with sufficient power for standoff DEW applications represent a longer term challenge.

Semiconductor laser diodes are expected to have a major impact on future battlefield laser systems because of their compact size, ruggedness, and efficiency. Japan is the leading producer of laser diodes, especially low-to-medium power devices and diode arrays, which are beginning to appear in a number of industrial and medical lasers. The U.K., France, and Russia also have significant capabilities in most areas of laser technology. Russia has special capabilities in free electron laser (FEL) and other high-energy lasers (HELs).

Diode-pumped solid-state lasers operating directly at visible wavelengths offer significant potential in optical countermeasure systems for the visible spectral region. They offer much higher efficiency than can be achieved by frequency shifting from existing lasers. The technical challenge is to develop improved materials (gain media). Two foreign groups are among the world leaders in the development of such materials: a research group at the Université de Lyon in France and a group at Universitat Hamburg in Germany. Both groups have the expertise and infrastructure to make valuable progress in the identification and development of the needed materials. Existing agreements with both countries offer potential vehicles to pursue cooperative efforts.

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11. Civil Engineering and Environmental Quality

This technology area focuses on critical environmental and civil engineering problems related to training, mobilizing, deploying, and employing a force at any location at any time. The goal is to provide an environmentally sustainable, military-unique infrastructure at the lowest possible life-cycle cost.

The problems of meeting national and international environmental standards and of engineering affordable and sustainable facilities and infrastructures in a climate of reduced funding are common to all of our potential partners. Remediation of environmental pollution and maintenance of infrastructure are areas of considerable importance to the civil sector as well, and most industrialized nations have active programs in techniques, materials, and in M&S to support requirements analysis and design.

Table E–14 and the following paragraphs summarize the significant environmental and civil engineering capabilities and opportunities.

Table E–14. International Research Capabilities—Civil Engineering and Environmental Quality

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Environmental Quality	➊ Environmental protection; bioremediation; regulatory compliance	➊ Environmental protection; bioremediation; demil of energetic materials	➊ Environmental protection; bioremediation	➊ Environmental protection; bioremediation			*Nordic Group, Israel* ➊ Environmental protection; bioremediation
Civil Engineering	➊ Lightweight bridging; response of conventional structures to blast	➋ Survivable structures; high-performance construction materials	➋ Response of hardened structures to conventional weapons				

Note: See page E–11 for explanation of key numerals.

a. Environmental Quality

Environmental quality subareas include cleanup of contaminated sites, compliance with all environmental laws, pollution prevention to minimize Army use and generation of wastes and to minimize adverse affects on the environment, and conservation of our natural and cultural resources. Technical challenges include a host of issues related to these areas. Items of current focus include developing technologies and applications such as:

- Supercritical water oxidation, cold plasma reaction, catalytic decomposition, biodegradation, sorption/concentration, separation, and conversion to reduce costs and increase efficacy of treatment and disposition
- Replacement materials for existing solvents, acids, bases, and oxidizers with more environmentally acceptable alternatives
- New sensors for contaminated site characterization, integration of site characterization, ground water modeling, rate and effects predictions, and management techniques.

Among notable highlights, the United Kingdom has been a leading force in the development of international standards for environmental management systems. Many of the current draft International Standardization Organization (ISO) standards are patterned after existing British standards. Japan, the U.K., Germany, France, Israel, and the Nordic Group all have significant efforts in bioremediation (the use of biological organisms or their products (enzymes) to breakdown or neutralize a wide range of contaminants). The French in particular have had a longstanding interest and strong effort in biodegradation and demilitarization of energetic materials. Internationally there is growing concern for clean up of organophosphate insecticide contaminated sites. An effective enzymatic treatment for this purpose might also be adopted for decontamination of nerve agents. We can anticipate that growing awareness of environmental effects as regional and global issues, and the emergence of international standards for their effective management will lead to opportunities for increased cooperation to improve pollution prevention, environmental protection, techniques for monitoring and compliance, and remediation, particularly with EC countries and Japan, which are moving rapidly towards adoption of the ISO 14000 standard.

b. Civil Engineering

Civil engineering subareas include conventional facilities, airfields and pavements, survivability and protective structures, and sustainment engineering. The primary thrust of technologies for conventional facilities is to revitalize and operate DoD's aging infrastructure at an affordable cost. In airfields and pavements, the major effort is to reduce life-cycle costs. Survivability and protective structures address reliable, affordable structural hardening, retrofit hardening, and camouflage, concealment, and deception (CC&D), to increase survivability and force protection from the foxhole to the deeply buried command structure against threats from conventional munitions, terrorist threats, and advanced precision penetrators. Sustainment engineering provides the civil engineering technologies required for successful execution of strategic, operational, and tactical force projection, employment, and sustainment.

Technical challenges in civil engineering cover a wide range of technologies and need. Developments of current interest include:

- Collaborative automated environment to optimize facility life-cycle costs
- Automated monitoring of facility components

- Rapidly installed breakwaters for logistics-over-the-shore operations
- Concrete admixtures, dynamic 3D models and viscoelastic material responses for airfields and pavements
- Construction during winter and thawing conditions
- Criteria, materials, and assessment techniques for constructible, survivability measures against a broad spectrum of increasingly lethal weapons and threats.

Foreign capabilities of most interest are in the areas of high performance construction materials (France), material systems and response of conventional structures to blasts (United Kingdom), and response of hardened structures to conventional weapons (Germany).

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12. Battlespace Environments

The battlespace environment technology area encompasses the study, characterization, prediction, and M&S of the terrestrial, ocean, lower atmosphere, and space/upper atmosphere environments to understand their impact on personnel, platforms, sensors, and systems. This will enable tactics and doctrine to exploit that understanding and to optimize new system designs. The technologies and capabilities addressed in this section are critical to realizing the Joint Chiefs of Staff's (JCS) long-term strategy for information superiority and dominant battlespace knowledge.

An understanding of battlefield environments and effects are essential in all aspects of a military system's life cycle, from M&S for design, through mission planning and rehearsal, to actual configuration and programming of sensors and weapons in execution. Here cooperative international programs are needed to ensure that coalition forces can interoperate effectively with a common and consistent understanding of the battlespace, and with an ability to receive and process environmental information required to execute the battle.

Table E–15 and the following paragraphs highlight capabilities and opportunities in this area. Five technology subareas of battlespace environment are highlighted: cold regions, topography, combat environment, battlescale meteorology, and atmospheric effects.

a. Cold Regions

Cold regions engineering focuses on minimizing or eliminating the dramatic effects of winter weather on operations conducted by the U.S. Army. To do this, effective decision-making tools, models, simulations, and mission planning/rehearsal factors are required that accurately predict the state of the ground, atmospheric conditions, and system performance in complex cold regions environments. The winter environment presents a severe challenge to the performance and operability of weapon systems, target identification and acquisition sensors, equipment, and personnel. This challenge is not confined only to the effects of temperature. It also included the detrimental effects of snow, ice, and the state of the ground whether frozen or thawing. Frozen and thawing soils greatly affect the projection and mobility of forces, mine clearing operations, and earth excavation required for force

Table E–15. International Research Capabilities—Battlespace Environments

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Cold Regions						*Russia* ❷	*Norway* ❷
Topography	❷	❷	❷	❷			❷
Combat Environment		❶ Remote sensing; IR FPA		❶ Remote sensing; robotics			
Battlescale Meteorology	❷ EC nations & Canada share overall capability in weather prediction			❷		*Russia* ❷ Weather prediction	❷ EC nations & Canada share overall capability in weather prediction
Atmospheric Effects	❷ EC nations have capabilities in various areas						*Israel* ❶ Atmospheric effects *Canada* ❶ 3D data display; atmospheric dispersion

Note: See page E–11 for explanation of key numerals.

projection and construction. Snow, ice, and frozen ground dramatically alter the propagation of acoustic and seismic energy and interfere with IR and MMW signatures. This greatly reduces the effectiveness of weapon systems and sensors. Icing conditions dramatically change fixed and rotary-winged aircraft performance, impact safe operation of equipment on roads, airfields, and bases, and impact the ability to communicate. Technical challenges relate to developing and validating models of these phenomena, and finding ways to enable operations to continue in spite of them. Norway and Russia provide significant foreign capabilities in cold regions technology.

b. Topography

Topographic research focuses on better understanding the terrain through improved data generation, analysis, and representation especially those exploiting sensor data. Efforts are needed to provide technology for rapid digital terrain data generation, terrain visualization, terrain analysis, data management, and realistic mission rehearsal and training.

Major technical challenges include:

- Identifying terrain features automatically
- Developing a total force positioning and navigational capability
- 3D dynamic multispectral scene visualization
- Generating terrain and weather environments in near-real time.

The ability of global satellite data, coupled with more powerful low-cost information systems to manage large quantities of data, has fostered growing international dissemination and standardization of topographical data. Technology for application of the data to military uses (real-time generation and prediction of terrain signatures from stored or measured geographic/topographic data; mission planning and targeting; etc.) will be found predominately in the U.K., France, and Germany. However, there is growing interest in development and use of geographic information systems for a wide range of civil and military applications. Significant niche capabilities may be found in Japan and elsewhere.

c. Combat Environment

This subarea provides high spatial and time resolution descriptions of the immediate environment of the combat warfighter, including both the measurement and modeling/prediction of that environment. Spatial scales range from several meters to several hundred meters and time scales from seconds to several hours.

Technical challenges relate to transport and diffusion of gases and particulate, atmospheric flow, measurement systems that resolve microscale dynamical structures, dynamic and optical characteristics of aerosols and instrumentation for their detection and analysis, and remote sensor concepts and software.

The above comments related to global satellite data apply equally here. Remote sensing capabilities of interest include the French expertise on advanced IR FPAs, and the Japanese strength in CC&Ds and IR sensors. Japan also has strengths in robotics that could be important.

d. Battlescale Meteorology

The objective of battlescale meteorology is to generate the best possible description of current or future states of the battle environment for military planning, tactical decision making, and training.

Technical challenges relate to developing better prediction models and parameterization methods for the physical processes and phenomena involved, assuring accurate state descriptions and data quality from various sensors and platforms, and developing the computational speed and memory capacity to resolve the mesoscale phenomena.

Most of our European allies and Canada have strong capabilities in weather monitoring and prediction. In addition, Russia has developed special expertise in weather prediction.

e. Atmospheric Effects

The objective of atmospheric effects is to provide both real-time assessments to operational forces and a simulation capability for planning and training. The weather always has a significant effect on battlefield operations, and accurate weather prediction is a major tactical advantage. Atmospheric modeling can forecast long-term weather, acoustic and EM propagation, smoke and obscurant effects, and CB agent dispersal.

Developing and validating models of various related phenomena is a major technical issue. Modeling EM, acoustic, and seismic effects; target detection and prediction effects as a function of atmospheric effects; developing environmental decision aids; and effects of obscurants on performance and prediction are all important technical challenges.

We observe growing international exchanges in weather prediction and in research related to predication of long-term environmental and climatic conditions. Specific expertise in short-term, high-resolution battlescale weather predictions, and in real-time prediction of atmospheric effects on battlefield sensors is primarily limited to the EC nations (notably Germany and the U.K.) and Canada. Israel also has specific capabilities that are of interest. In addition, within the U.S.–Canadian infrastructure, Canada has notable capabilities in weather prediction, and in techniques for visualization and presentation of large three dimensional data sets.

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13. Human Systems Interface

Human systems interface (HSI) technologies leverage and extend the capabilities of warfighters and maintainers to ensure that fielded systems will exploit the fullest potential of the warfighting team. The primary goal is to maximize information throughput from sensors, processors and displays to warfighters. HSI technologies are organized into four subareas: information management and display (IMD), performance aiding, system supportability, and design integration.

Most developed nations have significant research efforts in HSI. Interest in this area is driven by multiple requirements, including the need for improved presentation of information to match human cognition and improved representation of human performance to improve realism and fidelity of CGFs and "actors" in both simulations and operational systems. Important trends in foreign technology are summarized in Table E–16, and additional information on each technology subarea are discussed in the following paragraphs.

Table E–16. International Research Capabilities—Human Systems Interface

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Information Management & Display	❶ VRIs; soldier–system interface	❶ Display; soldier–system interface	❶ Soldier–system interface	❶ Displays; VR; robotics			*Israel* ❺ HMD *Canada* ❶ VR display
Performance Aiding	❶ HPM	❶ Ergonomics; performance modeling	❶ HPM				*Israel, Sweden, Netherlands* ❹ Human performance measures
System Supportability		❶ Ergonomics					
Design Integration	❶ Performance modeling	❶ Performance modeling	❶ Performance modeling	❹ Automated industry/enterprise design			

Note: See page E–11 for explanation of key numerals.

a. Information Management and Display

IMD develops methods and media to process and deliver task-critical information to individuals, teams, and organizations. Maximizing the flow of information depends on developing time-sensitive, supportable information handling and display components that serve as visual and auditory HSI for both weapons and support systems. Developing simulation interfaces is another area of keen interest. Simulations must be of sufficient fidelity to enhance mission planning and to permit diagnostic examination of emerging technologies and concepts. Model development is an important aspect of this work.

The major problem is that vast amounts of information, ranging from low to high degrees of certainty and veracity, threaten to overwhelm the human capacity to monitor, query, and act upon. Technical challenges include:

- Improve alerting, warning, situational awareness, and identification of friend or foe (IFF)
- Improve techniques for data fusion data using visual, auditory, and tactile displays
- Develop individual VR displays
- Improve voice recognition for computer control in the battlefield environment
- Improve communications links for teleoperation, communications, and display.

A number of foreign countries have significant capabilities in HSI technologies. The United States has ongoing efforts with France and Germany in soldier–system interfaces, especially related to teleoperations. The U.K. has noteworthy capabilities in soldier–system interfaces, and VR interfaces (VRIs), and Canada in VR and HMDs. Israel also has unique expertise in HMDs. Japan is a leader in displays, VR, and robotics, all of which are needed for teleoperations.

b. Performance Aiding

The goals of performance aiding technologies are to enable soldiers to operate well beyond normal mental, physical, and perceptual capabilities, and to enhance performance in stressful, hazardous, time-constrained, inhospitable, and remote environments. Areas of particular interest include computer-aided crisis management decision support, unmanned robotic vehicles, and mobile manipulator platform control. In addition, concepts for battlefield synchronization, on-the-move collaborative techniques, real-time decision making, and visualization for distributed problem solving are becoming increasingly important.

Technical challenges related to decision aiding and collaborative aiding include better understanding of the mechanisms of complex decision making and team collaboration, devising reliable diagnostic and performance measures, and developing models and methods to understand the internal and external motivating factors. Key elements are workload, uncertainty, coordination strategies, and real-time structural reconfiguration needs. Real-time, on-the-move C^2 is an essential element.

Physical and perceptual aiding, including teleoperations, faces difficult challenges in computer-assisted map storage, retrieval, and reading, as well as developing practical-sized designs for powered exoskeletal machines to be worn by soldiers and controlled by kinematic sensors. This would allow significantly increased capabilities for lifting, carrying, and mobility. Another important area related to teleoperation is providing stabilized systems that can operate in mixed-terrain without losing their balance. To aid in perception, technologies that provide textural, shape, color, and stereo effects for information presentation are needed.

The overall challenge in HSI is integrating the various aids into working systems and platforms.

Human performance modeling is a critical factor in meeting future Army requirements. Such modeling contributes to enhanced soldier–system battlefield performance through low-risk, quick-turnaround simulation, permitting rapid assessment of proposed systems concepts. Human performance modeling ranges from anthropometric models of impulse and acoustic detection by the human ear, through cognitive and physical workload assessment, up to decision making under stress. France is recognized as a key international source for cooperative research in these aspects of HSI. Negotiations are underway with France on auditory research and ergonomics issues. The U.K. and Germany also have very strong capabilities in human performance modleing, and to a lesser but still significant extent, Israel, Netherlands and Sweden all have capabilities.

c. System Supportability

System supportability includes improving affordability, availability, operability, maintainability, and logistical supply to reduce life-cycle support costs. The Army must be able to provide early estimates of manpower, personnel, and training (MPT) as well as associated human performance requirements and costs for HSI, so they can be fed into the acquisition and design process. The set of manpower and personnel integration (MANPRINT) methods and tools are key elements in this effort. The goal is to have validated techniques that are robust enough to permit quantitative tradeoff analyses among various MPT variables and design options. This will allow decision makers to examine variations in systems performance as a function of MPT investment.

The increasing complexity of weapon systems makes it increasingly difficult to support those systems with personnel who can effectively operate and maintain them. Research is needed to determine the limits of attention saturation, mental workload, and manpower utilization in order to balance soldier resources and requirements with emerging technologies. This is essential to maintaining full military readiness, availability, sustainability, and effectiveness.

No specific foreign capabilities have been identified in support of this subarea, however, the cooperative effort with France mentioned above, related to ergonomics is directly related. The French are sharing modern ergonomic performance measuring instrumentation and techniques while the U.S. is sharing its MANPRINT suite of soldier–system performance enhancement tools.

d. Design Integration

Developing and producing a fully integrated crew weapon or information system demands effective design tools, HSI models and databases, and performance metrics. Human–system performance and cost variables must be part of the design process. Technology capabilities are required in human performance assessment and modeling, tools for enhancing physical accommodation, methods for human error and reliability assessment, and tools for crew station design and testing. Major technical challenges include:

- Managing the magnitude of existing and emerging anthropometric and human–system accommodation databases
- Modeling and predicting complex human behavior
- Simulating and quantifying battlefield effects on human mobility, sustainability, and performance
- Integrating the diverse and fragmented technical disciplines required

- The lack of industry or government standards and methodologies for HSI and crew system integration
- Integrating human performance algorithms into semiautomated and fully automated forces simulation.

The MANPRINT efforts will play an important role in the design integration subarea. Foreign capabilities are similar to the IMD subarea described above. The U.K., France, and Germany offer the most capabilities in terms of performance modeling. Some of the world-class work that Japan is doing in automating industry and enterprise design may be applicable to the challenging aspects of integrating system-of-systems.

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14. Personnel Performance and Training

PPT efforts seek to maximize human military performance. There are two main subareas: (1) manpower and personnel, and (2) training. Investments in manpower and personnel address recruitment, selection, classification, and assignment of people to military jobs. The goal is to reduce attrition of high-quality personnel and support the development of managers and leaders. Investments in training technology improve the effectiveness of individual and collective training, enhance military training systems, and provide more cost-effective opportunities for skill practice and mission rehearsal. The overall objective is to develop soldiers and support personnel who are intelligent, physically fit, educated, highly motivated, and well trained.

Significant advances are being made in DIS and VR technologies that can have a major impact on this area of technology, especially in training. Table E–17 and the following paragraphs summarize foreign capabilities and opportunities in each technology subarea.

Table E–17. International Research Capabilities—Personnel Performance and Training

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Manpower & Personnel	❷ These nations have capabilities & are involved in cooperative programs				*Australia, New Zealand* ❷ Participate in TTCP in this area		*Belgium* ❷
Training	❶ Dynamic training & simulation	❶ Dynamic training & simulation		❹ Distributed training & simulation of complex enterprises			*Canada* ❶ Simulators & displays

Note: See page E–11 for explanation of key numerals.

a. Manpower and Personnel

Manpower and personnel technologies address three important topics:

- *Selection and Classification.* Dealing with aptitude testing and sophisticated assignment systems that reduce training time and increase quality of performance. Research areas include simulations of new selection and classification systems, methods to measure performance-related aptitudes, improved prediction of leadership and performance under stress, and improved temperament and psychomotor/spatial tests.
- *Human Resources Development.* Providing products and methods to improve leadership in complex and ambiguous situations, support efficient career development, and improve support for soldiers and their families. Research areas include leadership characteristics, unit cohesion, motivation, and career commitment. In addition, the current and long-term effects of combat, organizational and mission changes, and issues such as gender integration on career commitment and development are of keen interest.
- *Leader Development.* Focusing on understanding, evaluating, and determining the behaviors required for effective leadership. This is accomplished by collecting and analyzing descriptive, experiential, and empirical data tracking the careers of officer candidates and officers.

Major technical challenges in manpower and personnel include:

- Developing new selection techniques that cover a wider range of human abilities
- Relating aptitude test to performance on a simulated battlefield
- Developing techniques to more effectively adapt to organizational change
- Identifying characteristics of the most effective leaders
- Developing methods for assessing, developing, and retaining quality leaders.

Manpower and personnel issues are of concern to all countries wishing to field and maintain an effective military capability. International cooperation in manpower and personnel is taking place through a variety of mechanisms. The U.S., U.K., Canada, Australia, and New Zealand pursue collaborative research and actively exchange information of defense R&D projects through the Technical Cooperation Program (TTCP). Examples of collaborative manpower and personnel research include selection tests for tank gunners and effects of workload levels and stress on decision making. Collaborative research also occurs through the Defense Research Group (Panel 8, Human and Biomedical Sciences) of the NATO Armaments and Research Organization. For example, the U.S. is gaining valuable information regarding the fielding of computer-based selection tests in Germany and Belgium and on use of distance learning technologies in European countries.

b. Training

The requirement to execute increasingly complex dynamic mission objectives as part of a multinational coalition force is pushing us to devise new and innovative ways to train, perform mission planning, conduct rehearsals, and maintain critical skill levels while at home station, deployed for extended periods, and if feasible, en route to an operation. Our major allies are limited, as we are, by budgetary constraints, reduced access to training areas, environmental and safety concerns, and cost of munitions. This reality is pushing us toward an increased reliance on more robust, flexible simulation systems. While the current emphasis in training is in VR and synthetic environments, an effective training strategy should employ a complimentary mix of devices and simulation including: individual, crew, ranges and targets, maneuver, command and control, force-on-force engagement systems, and where feasible embedded training systems.

Live force-on-force tactical engagement simulation remains a key element of the training strategy for both us and our major allies, but the increased lethality and longer ranges of our weapon systems and improved C^4I systems are pushing the limits of our current laser engagement training systems and their corollary T&E instrumentation systems.

The information systems technologies used to improve our tactical situational awareness could be augmented with embedded simulation hardware and software to provide viable training anywhere, anytime. The Training and Doctrine Command's (TRADOC) stated, preferred method of training for the future is embedded training.

Soldiers need the ability to train up rapidly on the doctrine and standing operating procedures used by other services, coalition forces or agencies. Units need the capability to link up via distance learning technologies with joint, combined, and interagency personnel for common training/mission rehearsal. Commanders and staff must be able to practice and refine problem solving and decision-making skills in mission relevant, joint, combined, and interagency scenarios.

This training strategy provides a considerable technical challenge at a time of shrinking budgets and will require coordination and cooperation among our system program managers, simulation developers, laboratories, R&D centers, TRADOC, and cooperative R&D programs with other nations should be strongly encouraged.

Technical challenges involve new training and performance measurement technologies that will allow more effective training within tight budgetary constraints. New training strategies are needed that are specifically developed for DIS to take maximum advantage of its capabilities, recognize its limitations, and assess its effectiveness. Developing training strategies that provide an effective and affordable mix of live exercises and synthetic training is another challenging area. Finally, an emerging topic of importance is developing training strategies and performance evaluation to support the emerging digital battlefield technologies and the accompanying doctrinal changes.

A number of foreign countries have significant capabilities in training and simulation technology. Canada, France, Germany, the Netherlands, and the U.K. all have made valuable contributions and each represents considerable leveraging opportunities. Australia has hosted several international simulation conferences and symposia to expand their knowledge, increase their capability, and broaden their use of simulation. The U.K. has established an industrial advisory board to monitor simulation activities in the U.S. and advise on military use in their nation. The Germans are experimenting with injecting virtual targets into live sights that will be a key challenge for embedded training and live-to-virtual linkages. Canada's advanced displays systems would be useful for all types of simulations, and the U.K. and France's ability in human performance modeling and VR technology could enhance battlefield representations. The Netherlands has assumed a prominent role in Europe as a technical expert in the use of training simulation technology and have orchestrated several major demonstrations of advanced distributed simulation (ADS) technology in support of NATO vision and goals. Australia, Canada, New Zealand, the U.S., and the U.K. have established working groups in VR and distributed simulation under TTCP's Training Technology Panel HUM–2. NATO Army Armaments Land Group 8 is identifying standard agreements (STANAGs) for training interoperability among member nations, and NATO Research and Technology Panel Number 8 is investigating human factors issues in the use of VR for military purposes.

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15. Materials, Processes, and Structures

The Army's materials, processes, and structures program provides enabling technologies that are used to construct every physical system or device used by the Army. This program provides unique solutions and options that increase the level of performance and durability, and reduce the maintenance burden and life-cycle costs of all Army systems.

Advances in basic materials, materials processing, and structures are integral objectives of a number of opportunities discussed throughout the ASTMP and this annex, including materials for aeropropulsion, characterization of structures for rotorcraft, ballistic protection for soldier systems, materials and structures for hypervelocity missiles; and structures for ground vehicles. Table E–18 and the following paragraphs provide a summary of key capabilities and trends for each technology subarea.

Table E–18. International Research Capabilities—Materials, Processes, and Structures

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Materials	❷ Metal alloys; composites; polymers	❷ Metal alloys; composites; ceramics	❷ Metal alloys; composites; ceramics	❶ Ceramics; composites; polymers; ferrous allows	*China* ❺ Refractory & rare-earth materials & alloys	❹ Ti alloy	*Israel* ❺ Metal alloys; organic matrix composite
Processes	❶ Welding & joining	❷ C-C ceramic part fabrication	❷ Functional gradient coatings	❶ Polymer processing	*ROK* ❺ Tungsten processing *Australia* ❺ Composites		*Austria* ❺ Refracting metals
Structures	❷ Lightweight engineering structures; smart structures	❷ Energy-absorbing structures; smart structures	❷ Engineering structures; smart structures	❺ Structures; engineering structures		❺ Ti; structures; welding; ion-beam coating	

Note: See page E–11 for explanation of key numerals.

a. Materials

The materials subarea focuses on materials with superior properties required for use in structural, optical, armor and antiarmor, CB and laser protection, biomedical, and Army infrastructure applications. All classes of materials are included—metals, ceramics, polymers, composites, coatings, energetic, semiconductors, superconductors, and electromagnetically functional materials.

Technical challenges focus on extending the state-of-the-art knowledge of composition-microstructure-property relationships to allow modeling and prediction of material behavior involving very complex phenomena (e.g., ballistic penetration, long-term environmental exposure, chemical agent permeation). Specific areas of interest include:

- Models to predict static and dynamic behavior of fiber/matrix interphases
- Predictive models of environmental durability for monolithic and composite materials
- Models for the interactions of gases, vapors, and liquids with polymeric barriers
- Cost-efficient, lightweight transparent armors for personnel and sensor protection
- Tungsten and other heavy metal alloys/microstructures that will provide equal ballistic performance as depleted uranium
- Steels with high-strength, toughness, and ballistic properties that also are weldable and resistant to stress corrosion cracking
- Modeling/mitigation of micromechanical failure mechanisms in elastomeric materials
- Improved nonlinear and other optical materials for protection of soldier's vision, direct view optics, and sensors.

As the table illustrates, a number of countries have strong capabilities in advanced materials. The U.K., France, and Germany all have expertise in metal alloys and composite materials. Noteworthy here is the special capabilities that France is developing in carbon-carbon (C-C) and other ceramics and in the design of crash survivable structures as noted elsewhere in this annex. Japan is a world leader in "fine ceramics." Fine ceramics refers to high-purity ceramics with specific performance characteristics, as opposed to bulk ceramics as might be employed for ballistic protection. Russia has strong capabilities in bulk ceramics as well as in titanium and steel alloys. In addition, Israel has niche capabilities in metal alloys and in organic matrix composites.

b. Processes

Materials processing includes all technologies by which raw or precursor materials are transformed into useful materials or components with the requisite properties and at an acceptable cost for Army applications. This includes such technologies as casting, rolling, forging, sintering, polymerization, composite lay-up and curing, machining, and chemical vapor deposition. Coating processes are of special interest because they affect so many devices and components. Ion-beam-assisted deposition and pulsed laser deposition are two areas of keen interest. Improved process control techniques are also sought, especially related to resin transfer molded composites and Smartweave armor materials.

A major technical challenge involves integrating noncontact, real-time online sensing (especially at very high temperatures) with adaptive control technology. Specific challenges include:

- Knowledge-based models for thermal and thermomechanical processing

- Improved joining and repair of polymers, ceramics, and organic and inorganic matrix composites
- Development of process specific sensors and control systems
- Techniques to achieve near or actual net shape components of complex geometry and variable composition in more affordable materials/design systems.

Several foreign capabilities are of interest in the materials processing subarea. The United Kingdom has strengths in welding and joining. Germany has unique capabilities in explosively formed projectile (EFP) and other warhead metallurgy and processes for deposition of functionally gradient materials. Japan has been and is expected to continue to be a major developer and producer of fibers and matrix feedstock for advanced polymer composites that are essential for many advanced materials. Austria has also been identified as having tungsten processing research of interest and Australia as having research in composites.

France has special skills in high-density tungsten carbide ceramics that has potential for armor technologies. Russian capabilities in welding and ion-beam coating may also be of interest. The Army Research Laboratory (ARL) recently initiated development of a new class of high-density ceramics (defined as any ceramic whose density is greater than steel (7.85 gm/cc). While conventional ballistic ceramics offer excellent protection against conventional small arms threats, these low-density materials suffer damage accumulation effects and reduced effectiveness as the impact threat increases, particularly against modern, high-density eroding rod penetrators. High-density ceramics inherently offer greater space effectiveness (2–3 times more efficient than steel). Current efforts are trying to optimize these high-density ceramics for ballistic application.

Korea has a noteworthy program in tungsten penetrator technology that could be beneficial to the U.S. Advanced materials technology offers enhanced ballistics, increased range, and lethality for penetrators. Specific heat treatment processes for tungsten alloys have been developed by South Korea that offer the potential to enhance impact strength for penetrators. A near-term goal of the ASTMP is to increase the ballistic performance of tungsten to equal that of depleted uranium (as measured in depth of penetration). Korea's heat treatment process could increase the impact strength of tungsten to meet ASTMP milestones.

Finally, readers should refer to the discussion of biological sciences that addresses the rapidly growing field of bioprocessing, where researchers are looking to biomimetic materials (such as spider silk) to meet critical long-term requirements. In addition, worldwide interest is growing in the potential for bioprocessing to replace more costly or environmentally threatening chemical processes.

c. Structures

This subarea focuses on developing structural elements with a high level of structural integrity that are inspectable, analyzable, and can survive the harsh combat environment. To be cost effective the design must integrate advanced structural concepts that are compatible with mass production manufacturing technologies. The structures must also be designed to specific vibration and noise levels to maintain crew comfort and a low noise signature. Particular emphasis is on design tools, modeling, failure and fatigue, and life prediction analysis. In addition, developing nondestructive evaluation (NDE) techniques for identification and quantification of defects and anomalies in composite structures is very important.

A growing area of worldwide research interest is smart structures—instrumented structural designs that adapt to external conditions and stimuli to optimize performance. Closely related to this is the use of embedded sensors (usually based on fiber optics) for monitoring performance and structural conditions. The U.K., France, and Germany all have significant capabilities in this area and offer potential opportunities for cooperation.

The U.K. and Germany develop and market military systems for lightweight bridging and other civil engineering applications, and have sound capabilities in alloys and structural design for such systems. As mentioned earlier, France has special expertise in developing crash-survivable and energy-absorbing materials. Japan has a significant capability in structural design, and in practical engineering of crash-survivable vehicles and structures. Finally, Russia's expertise in titanium alloys may be applicable to some Army structural needs.

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16. Medical and Biomedical Science and Technology

Military medical and biomedical research is concerned with preserving and optimizing combatant's health and capabilities despite extraordinary battle, nonbattle, and disease threats. Individual service men and women are the most important and the most vulnerable components of military systems and mission capabilities. Disease and nonbattle injury typically far outweigh battle-related injuries as the greatest cause of military casualties. The current force structure is confronted with an expanded potential for large-scale regional conflicts, proliferation of WMD, and ready availability of advanced conventional weapons. These dangerous challenges are coupled with enduring threats of disease, harsh climates, and operational stress, often in third-world nations lacking any medical infrastructure.

There are five subareas of technology: infectious diseases, medical biological defense, medical chemical defense, Army operational medicine, and combat casualty care. Table E–19 and the following paragraphs summarize foreign capabilities and opportunities for each technical subarea.

For humanitarian reasons, much of the research and technology related to this area are shared widely. No one country has a commanding lead. However, virtually all developed countries (including U.K., France, and Germany) will have significant national research programs capable of contributing to U.S. Army requirements. The spread of AIDS and other virulent diseases such as Ebola and other filoviruses, and the emergence of a variety of antibiotic-resistant bacterial strains have spurred worldwide medical and biomedical research efforts. Many countries involved in medical and biomedical research are not specifically interested in military applications or biomedical defense per se, however, any breakthroughs in prevention and treatment of the more virulent diseases would be of great interest. Here opportunities for cooperation are driven by a variety of factors, including the geographical location of the occurrence of certain diseases (e.g., Kenya, Thailand), or COEs in specific research areas (e.g., virology in France).

Table E–19. International Research Capabilities—Medical and Biomedical Science and Technology

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Infectious Diseases of Military Importance	❷ Infectious diseases	❷ Infectious diseases	❷ Infectious diseases	❷	*Singapore, China* ❷ Infectious diseases	❺ Infectious diseases	*Israel, Kenya, Thailand, Switzerland, Sweden, Italy, Netherlands* ❹ Infectious diseases
Medical Biological Defense/ Medical Chemical Defense	❷ CBD	❷ CBD	❷ CBD	❺ Many countries involved in applicable biomedical defense research			*Canada, Austria* ❹ CBD *Israel, Sweden, Switzerland, Netherlands, Brazil, Poland, Australia* ❹ Chemical
Army Operational Medicine	❷ Broad cooperation sought in all aspects of military medicine & casualty care			❶ Medical imaging			❷ Broad cooperation sought in all aspects of military medicine & casualty care
Combat Casualty Care				❶ Medical imaging			

Note: See page E–11 for explanation of key numerals.

In addition to work directly on medical and biomedical areas, the growth and dissemination of basic biotechnology tools has led to rapid advances in capabilities in a number of foreign countries. These are discussed elsewhere in this annex.

Another area of medicine that is growing rapidly worldwide is the use of internetworking and high quality video to create geographically dispersed medical teams for diagnosis and treatment (including surgery). The underlying technologies are discussed elsewhere in this annex.

a. Infectious Diseases of Military Importance

This technology area seeks to protect soldiers from incapacitating infectious diseases by the development of vaccines and disease preventing drugs, and to return soldiers to duty by the discovery of effective drug treatments. Infectious diseases pose a significant threat to operational effectiveness and most Americans lack natural immunity to diseases that are endemic abroad.

Many diseases that were feared killers only a few years ago have been subdued largely through vaccination and public health advances. The focus of market-driven pharmaceutical development has been primarily on diseases important in the industrial world. Unfortunately, infections prominent in many strategically significant areas of the world do not receive attention comparable to the extent of the populations affected. This puts our soldiers at greater risk.

Technical challenges of current interest include:

- Develop rodent blood and tissue systems for growth of human malaria parasites
- Develop animal models for dysentery
- Detect and identify neutralizing antibodies produced in minuscule amounts
- Formulate vaccines to maximize the immune response
- Design drugs that will evade parasite defenses

- Grow hepatitis E virus and vivax malaria parasites in cell culture
- Develop vaccines effective against geographic variants of disease.

These and a number of other technical challenges in medical and biomedical science require the commitment of major research resources from around the world. This is a natural area in which to encourage international cooperation. In addition to the obvious cooperative work with our European allies, the infectious disease research program has international agreements for cooperative research to develop vaccines for the prevention of dysentery, malaria, and dengue fever.

Dysentery is caused by Shigella and leads to severe diarrhea. During Operation Desert Shield/ Storm, diarrheal disease became a major threat to U.S. forces—57 percent of troops had at least one episode and 20 percent reported they were temporarily incapacitated. The leading cause of lost duty time during Operation Rescue Hope was acute diarrhea.

Malaria has long been a serious problem for military forces, especially during combat. Malaria is the world's most common insect-borne parasitic disease. During Operation Desert Shield/Storm, troops in Southern Iraq became infected with vivax malaria. More recently, troops were infected with vivax or falciparum malaria while serving in Somalia for Operation Restore Hope. Treatment of this deadly disease is complicated by the increasing incidence of drug-resistant strains.

Dengue fever is the world's most common mosquito-borne viral disease. It was encountered during the Vietnam War, and more recently in Somalia. It poses a serious problem whenever military forces are deployed to the tropics.

Countries having significant capabilities and offering special opportunities to address infectious diseases not commonly found in the industrialized world include Israel, Kenya, Thailand, Singapore, and China.

b. Medical Biological Defense

The primary goal of medical biological defense is to ensure the sustained effectiveness of U.S. armed forces operating in a BW environment. Specifically, to prevent casualties by the use of medical countermeasures, to diagnose exposure to BW agents, to use chemotherapeutics and immunotherapeutics to prevent lethality, and maximize return to duty.

Major technical challenges relate to better understanding of the pathogenic mechanisms of a disease in hopes of developing new vaccines. Much of the testing must be done in model systems. Animal models do not currently exist for many of the BW agents. Specific technical challenges include:

- Developing appropriate animal models to test safety and efficacy
- Increase genetic and biological information for medical countermeasures against threat agents
- Exploit the human immune system to provide protection against threat agents
- Analyze new vaccine delivery systems and multiagent vaccines.

The Medical Biological Defense Research program includes an international agreement for cooperative research for the development of an improved vaccine for the prevention of botulinum poisoning and for the development of effective treatment drugs. Botulinum toxin, a recognized biological threat agent, is one of the deadliest neurotoxins known to man. The toxin prevents the release of acetylcholine and produces nerve cell dysfunction. The cause of death is usually respiratory paralysis, due to the blockage of transmitter release from the phrenic nerve to the diaphragm muscles. The Imperial College of Science and Technology, United Kingdom, is an international leader in the area of functional and structural analysis of botulinum toxin binding to cholinergic nerves.

c. Medical Chemical Defense

The mission of this program is to preserve combat effectiveness by timely provision of medical countermeasures in response to joint service chemical warfare (CW) defense requirements. The challenges are to maintain technological capability to meet present requirements and counter future threats, to provide individual level prevention and protection, and to provide medical management of chemical casualties.

A major technical challenge is developing pretreatment, protectant, or antidote that is both effective against CW agents and safe for human use. Specific challenges relate to developing models of efficacy and effects, developing pretreatment/antidotes with special characteristics (e.g., quick acting, long acting), generating immune response to small molecules, and developing various reactive/catalytic decontaminant and protectant compounds.

The Medical Chemical Defense Research Program involves cooperative efforts between the United Kingdom, Canada, Israel, Germany, and other nations in developing methods to protect the soldier from CW agents. These nations are using the latest medical information and techniques for these developments. Current efforts include research into pretreatments, antidotes, and medical therapies. X-ray crystallographic analytical techniques have been employed to elucidate the structure of acetylcholinesterase. This achievement supports mechanistic studies in understanding the actions of nerve agents as well as development of molecular approaches to a countermeasure. In addition, molecular biochemical techniques are being used to mutate genes to produce variants of human acetylcholinesterase and butylcholinesterase. This will improve understanding of nerve agent mechanisms of action and identification of prophylaxes for nerve agents.

d. Army Operational Medicine

The goals of this effort are to protect soldiers from environmental injury and materiel/system hazards, shape medically sound safety and design criteria for military systems, sustain individual and unit health under operational stress, especially sustained and continuous operations, and to quantify performance criteria and soldier effectiveness.

Technical challenges cover a wide range of effects and issues. These include sleep management, display design criteria, physical and psychological training strategies, tyrosine and caffeine interactions for increased alertness, and a variety of related phenomena.

This is an area in which broad cooperation is sought in all aspects of military medicine. The only technology specifically identified for potential cooperative efforts involves Japan's strong capability in medical imaging.

e. Combat Casualty Care

This program aims at saving lives far-forward in the combat arena. Major areas where improvement is needed include delivery of far-forward resuscitation, minimizing lost duty time from minor injuries, reducing unnecessary evacuations, and decreasing resupply requirements of all forward echelons of care.

Technical challenges include understanding and overcoming the toxicity of oxygen-carrying hemoglobin solutions, development of battery power and computing capability to allow computer-aided diagnostics, overcoming the problem of applying local hemostatic agents to the wet surfaces of a hemorrhaging wound, and miniaturizing all equipment necessary to induce suspended animation far-forward.

As indicated in the table, this also is an area in which broad cooperation is sought in all aspects of combat casualty care. The only technology specifically identified for potential cooperative efforts involves Japan's strong capability in medical imaging.

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17. Sensors

The topic of sensors encompasses a wide range of diverse physical phenomena and technology, including seismic/acoustic ground sensors and EM sensors in all regions of the spectrum from extremely low frequency magnetic anomaly detection to space-based UV and even shorter wave optical devices. As defined in the ASTMP, sensor technologies also include associated capabilities for acquiring and processing sensor data to derive useful information regarding operating environment and the location and identity and activities of friendly and adversary forces. Table E–20 below summarizes capabilities in areas of sensor technology identified in Volume I, Chapter IV of the ASTMP.

Table E–20. International Research Capabilities—Sensors

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Radar Sensors	❺	❹ Optical switching of microwave power	❺	❶ Electronic components			
Electro-Optic Sensors	❺ Optical processing	❶ IR FPA; laser sensors; multidomain sensors		❶ Photonic devices; laser applications			*Netherlands* ❺
Acoustic, Magnetic, & Seismic Sensors	❶ Acoustic sensors ❷ Seismic	❺ Seismic					*Israel* ❷ Acoustic sensors
Automatic Target Recognition Sensors	❷ Signal processing; combat ID	❷ Signal processing; combat ID	❷ Combat ID; signal processing	❹ Signal & image processing			*Israel* ❷ Target recognition; signal processing
Integrated Platform Electronics	❷ Vehicle integration	❷ Multisensor integration	❷ Vehicle integration				

Note: See page E–11 for explanation of key numerals.

a. Radar Sensors

Radar is the primary sensor for all-weather detection of air, ground, and subsurface targets. It includes wide area surveillance radars, tactical reconnaissance radars, and airborne and ground fire control radars. Areas of special interest involve the phenomenology of UWB SAR to enable detection and classification of stationary targets that are subsurface or concealed by foliage or camouflage.

Foliage penetration and ground penetration systems are the major goal. Major technical challenges include understanding wave propagation in background/clutter environments, development of high-power, low-frequency, and wideband system capability, and development of components and algorithms to support high-probability detection and classification with low false alarm rates. Specific technical issues relate to:

- Real beam search on-the-move targeting against stationary ground targets
- Buried target detection
- Enhanced spatial resolution
- MMW antennas and scanning.

Affordability is a major issue for all sensors because they are so prevalent on the battlefield.

The United States has traditionally enjoyed a strong lead in military radar systems, particularly in the area of electronically steerable phased array radars. The United Kingdom, France, and Germany, and to a lesser extent, Japan and Israel all have significant capabilities and niches of excellence. Noteworthy highlights include France's expertise in optical distribution and switching of microwave energy, and Japan's world leadership position in electronic components. MMIC components are especially important for MMW radars and the U.K., France, Germany, and Japan all have strong capabilities in this area of technology.

b. Electro-Optic Sensors

EO sensors provide passive/covert and active target acquisition (detection, classification, recognition, identification) of military targets and also allow military operations under all battlefield conditions. Platforms include combat personnel, ground combat and support vehicles, tactical rotary-wing aircraft, manned/unmanned reconnaissance aircraft, and ballistic missile defense (BMD)/theater missile defense.

Major technical challenges include:

- Growth and processing of thin-film materials for uncooled detectors
- Monolithic integration of detector, readout, and processing modules
- Material growth and processing for multicolor FPAs
- Fusion algorithms for multidomain sensors
- Performance against countermeasures
- Multidomain signature databases
- Diffractive optical element (DOE) design
- Integration of DOEs, detectors, and post-processing circuitry
- Affordable and effective laser hardening against multifunction, multiband lasers.

EO sensors are playing an increasingly important role in weapons systems of all kinds. The U.S. is certainly a leader in most areas, however, other countries have significant capabilities that could be beneficial.

France is recognized as a world leader in state-of-the-art IR FPAs. Their work on HgCdTe large-area staring arrays could be important for future multidomain smart sensors. ARL and scientists from

LETI (Grenoble, France) are cooperating to develop techniques to grow buffer layers on Si that would allow integration of the HgCdTe detectors and Si readout in much larger arrays. A new technique is being investigated that promises far lower defects for much larger arrays. France also has special capabilities in short wavelength (visible and UV) lasers that are very important for some optical countermeasures and standoff biological agent detection. Appropriate laser media are required to take full advantage of advances in laser diodes and diode pumping technologies. The Université de Lyon has special expertise in highly efficient laser emission and extensive knowledge of UV-emitting materials.

Japan is a world leader in all aspects of photonics and is strongly positioned in laser applications. Their CC&D technology dominates consumer electronics and may provide leveraging opportunities in the future for military applications. Germany has made significant progress in processing IR images and in multisensor integration. At the Fraunkofer Institute in Freiburg, considerable research efforts are conducted in quantum well and superlattice materials for detectors spanning the spectral region from UV to long-wave IR.

The U.K. has special expertise in optical processing, optical components, and optoelectronics. Photonic processors using this technology offer inherently high bandwidth, compactness, power efficiency, and immunity to EM interference. The noninterfering nature of light and its propagation characteristics lend themselves to future massively parallel, high-speed information processing. Finally, the Netherlands has special capabilities in third-generation image intensification that could be of value.

c. Acoustic, Magnetic, and Seismic Sensors

Acoustic, magnetic, and seismic sensors provide real-time tracking and target identification for a variety of battlefield ground and air targets. Advances in digital signal processing devices and algorithms have lead to significant improvements in acoustic sensors making them more feasible and affordable. Attended and unattended systems are of interest and find application against both continuous signals (such as engine noise) and impulsive signals (such as gun shots). Acoustic sensors involve the use of microphone arrays to detect, locate, track, and identify air and ground targets at tactical ranges. Target information from multiple acoustic sensor arrays is digitally transmitted to a remote central location for real-time battlefield monitoring. Enhanced hearing for individual soldiers is another important area and techniques to extend the soldier's long-range hearing and frequency response are being developed.

Technical challenges include:

- Advanced target identification algorithms
- Multitarget resolution
- Detection
- Platform and wind noise reduction techniques
- Compact array design for long-range hearing.

Most modern armies have some ongoing work in battlefield acoustic sensors, with no one country having a dominant capability. The U.K. and France offer strong capabilities related to seismic sensors and Israel provides unique opportunities in acoustic sensors. Current efforts in acoustics include adaptive beamforming algorithms, sound cancellation techniques, and neural network algorithms for target identification. Israel has been developing advanced helicopter detection, sniper, and mortar location systems based on acoustic sensing. The United States has been conducting joint exercises with the Israeli Army and future cooperation will provide potential solutions to acoustic propagation problems, long-range target detection algorithms, and detection in the presence of wind and platform noise.

d. Automatic Target Recognition Sensors

The goal of ATR is to provide sensors with the capability to recognize and identify targets under real-world battlefield conditions. ATR systems will allow weapons systems to automatically identify targets (and friendly forces), which will increase lethality, reduce the number of costly weapons used, and eliminate or reduce the cost and tragedy of losses from friendly fire. The technical challenge is to provide high identification rates with very few false alarms for a large number of target classes. Supporting technologies include processors, algorithms, and development tools, including M&S. Current efforts focus on single and multiple sensor ATR algorithm development.

Most countries have active development programs aimed at enhancing ATR capabilities. Underlying feature extraction and pattern recognition algorithms are common topics of academic research. Adaptation of these algorithms for effective military use demands access to specific target and threat characteristics, information that is closely held by all nations to protect sensitive collection methods and sources. Several areas are of special interest for possible cooperative efforts. Japan has done extensive work in visual systems for industrial robots and in Kanji character recognition. While not directed to military ends, the underlying techniques may be of interest. The U.K., France, and Germany all have strong capabilities in signal processing for ATR and combat ID, and are close enough allies to share some sensitive target/threat information. Germany has particular expertise in combat identification of friendly troops that is very important for reducing fratricide and improving situational awareness. The laser technology being pursued by Germany is of special interest. France has special expertise in ATR algorithms for use in multisensor (forward-looking IR, MMW, and possibly laser radar) systems that could be helpful in developing real-time multisensor techniques. In addition, Israel has strong capabilities in target characterization that could be applicable to a number of efforts, including signature measurements in radar/MMW, signature rendering in the visual and IR, and target acquisition modeling for imaging IR sensors. The United States has held a cooperative Signature Work Shop with Israel that covered a number of areas associated with ATR. This included topics on characterization of target/clutter, synthetic scene generation modeling, as well as target acquisition model enhancement, dynamic measurements using super high-resolution MMW, and model validation.

e. Integrated Platform Electronics

Integrated platform electronics (IPE) focuses on the integration technologies, disciplines, standards, tools, and components to physically and functionally integrate and fully exploit electronic systems on airborne, (helicopters, remotely piloted vehicle (RPV), and fixed wing), ground, and human platforms. IPE can result in dramatic cost and weight savings while providing full mission capability. The major technical challenge lies in determining an architecture that is sufficiently robust to readily accept technology commercial innovations. Improving reliability is always an important challenge that can lead to reduced logistics and deployment burdens while containing support costs. In addition, standardized image compression techniques and architectures are of current interest to permit transfer of images with sufficient clarity and update rates to support digitization of the battlefield.

Cooperation in this area leads not only to enhanced performance but also contributes to standardization and interoperability of coalition forces. As one would expect, those countries most advanced in development and production of advanced military vehicles offer the best potential for cooperative efforts. The U.K. and Germany have special capabilities in vehicle integration that is of interest and France has special expertise in multisensor integration that is relevant to IPE.

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18. Ground Vehicles

Ground vehicle technologies support the basic Army and Marine Corps land combat functions: shoot, move, communicate, survive, and sustain. This technology area is comprised of the following subareas: systems integration, vehicle chassis and turret, integrated survivability, mobility, *and* intra-vehicular electronics suite. Rapid deployment, manageable logistics, and compatibility with third-world infrastructures are current topics of major interest. Specific objectives include advances in diesel and gas turbine propulsion, better track and suspension to increase cross-country mobility, and improvements in survivability through improved ballistic protection and reduced observables (including use of active armor). Table E–21 and the following paragraphs summarize capabilities and opportunities in each technology subarea.

a. Systems Integration

Each ground vehicle consists of several subsystems (e.g., power and drive train, electronics, weapons, sensors), which must be integrated into a full-up, system-level technology demonstration. The primary process to evolve future vehicles is virtual prototyping. M&S will develop preliminary concepts, optimize design, reduce cost, and schedule maximize force effectiveness for ground vehicles. The goal is to develop lighter, more lethal, and survivable ground vehicles. Virtual concepts can be readily evaluated for mobility, agility, survivability, lethality and transportability, forming the basis for validation, verification, and accreditation. The major technical challenge is to provide the user with systems that can attain an effective balance between increased fighting capability, enhanced survivability, and improved deployability while meeting cost, manufacturing, and reliability/maintainability goals. Specific challenges relate to developing verifiable models in a usable time frame.

Table E–21. International Research Capabilities—Ground Vehicles

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Systems Integration	❷ EC nations have capabilities in various areas		❶ EC nations have capabilities in various areas	❺		❷	*Israel* ❶ RPVs; teleoperation *Switzerland* ❷ Armored vehicles
Vehicle Chassis & Turret	❷	❷	❶ Structure & design	❺	*China, ROK* ❺	❷	*Israel, Sweden, Switzerland, Italy* ❷
Integrated Survivability	❺	❺ Modular armor	❶ Vehicle survivability			*Russia* ❺ Bulk ceramics; active protection	*Israel, Sweden, South Africa* ❺
Mobility	❶ Gas turbine	❶ Secondary batteries	❶ Autonomous control; diesel engines electric drive	❶ Ceramic engine; electric drive		*Russia* ❷ Electric drive components; batteries; switches	*Austria* ❷ Diesel engines
Intravehicular Electronics Suite	❷	❷ Multisensor integration	❶ Integrated electronics & optronics				

Note: See page E–11 for explanation of key numerals.

The major players in ground vehicle systems integration and design are the U.K., France, Germany, Israel, Japan, and Russia, all of whom have a long history of developing and manufacturing military armored systems including main battle tanks. Switzerland also has a capability in armored vehicles that may be of interest and Israel has unique experience in the use of RPVs and UAVs that may contribute to advances in teleoperation of ground vehicles.

b. Vehicle Chassis and Turret

The use of composite and titanium-based materials will make future combat vehicles lighter, more easily deployed, versatile, and survivable. These technologies are key to optimizing and exploiting structural integrity, durability, ballistic protection, repairability, and signature reduction. Future vehicle chassis and turrets will be fabricated to integrate advanced designs using a combination of lightweight structures and modular armor packages.

Using composite materials or titanium as the primary structure in a combat vehicle is new and there are significant technical challenges. Issues related to composite materials include durability, producibility, and repairability. The primary issue for titanium is its high cost, which has so far kept it from being used on any U.S. combat vehicles.

The same countries mentioned under systems integration also have strong capabilities in vehicle chassis and turret technologies. Of these, Germany continues to be one of the few world leaders in combat vehicle R&D in all weight classes. They develop and field wheeled combat vehicles that meet or exceed tracked vehicle capabilities. Mercedes design and prototyping has provided the basis for a German–French cooperative effort in medium-weight armored vehicles GTK), and their main battle tank development and prototyping continues beyond Leopard 2 block improvements. In addition, the

EGS heavy combat vehicle technology demonstrator, developed by Krauss Maffei with firms such as Pietsch, Diehl, MTU, and a host of others incorporates state-of-the-art construction and materials fabrication technology with a focus on signature management.

c. Integrated Survivability

The goal of integrated survivability is to protect ground vehicles from a proliferation of advanced threats. Hit avoidance, detection avoidance, penetration avoidance, and damage reduction technologies are critical to achieving overall vehicle survivability. Hit avoidance technologies confuse or physically affect incoming threats. ECM and improved sensors are the key elements. Detection avoidance revolves around management of visual, thermal, radar, acoustic, seismic, and dust signatures. Armor is the major element in penetration avoidance, and damage reduction deals with firefighting agents and compartmentalization of ammunition and fuel. Advances in penetration avoidance center on producing efficient armors with reduced weight, space, and cost. The U.S. is currently the world leader, but other nations are improving rapidly. TTCP nations have strong armor programs. Sweden has a vigorous program following unusual research not found in NATO countries. Israel has strong capabilities, as evidenced by a indigenous development in the Merkava aimed at survivability. South Africa's Rooicat wheeled armored fighting vehicle incorporates a number of indigenously developed and integrated survivability features, including ballistic protection, obscurants, and collective CB protection.

The major technical challenge relates to the cost of the technologies required for survivability. In addition, many of the technologies have significant weight, volume, electrical power, and thermal loading requirements that make their insertion into fielded systems both costly and time consuming.

The U.S. is the world leader in most aspects of integrated survivability, but niche capabilities may be found in countries that develop and manufacture armored systems. Several German capabilities deserve special mention. These include strong capabilities in integrated CBD, and in the areas of indirect protection (detection and hit avoidance). The firm of Buck has conducted extensive research in multispectral obscurants. In direct protection, the German firm of Deisenroth continues to be a leader in composite armor for light, medium, and heavy vehicles, both as integrated and modular add-on packages. The German firm of Condat specializes in analytic and predictive modeling for armored systems vulnerability assessments. The FSU has been a world leader in active protection for the past 20 years. Finally, Russian developments in bulk ceramics have potential for ballistic protection.

d. Mobility

Mobility focuses on the "move" function of tracked and wheeled land combat vehicles. Mobility components include suspension, tracks, wheels, engine, transmission, and fuels and lubricants. Technologies of interest include active noise and vibration control to increase cross-country performance; quiet, lightweight band track; and advanced high-output diesel, turbine engines, and electric drives. Another major area of interest is providing increased electrical power in smaller, lighter packages. Electrical power is shared among propulsion, survivability, lethality, and auxiliary systems. Energy management is an important factor. Electric and hybrid drive systems are also being developed. Finally, to reduce operation and support costs, the number and types of fuels and lubricants must be reduced.

Technical challenges for electric drive include power, reducing cooling system size, and total volume. For advanced track systems, the major challenge is to extend the lightweight conventional track durability while reducing operational and support costs. For fuels and lubricants, the challenge is to define performance tradeoffs for a single engine/powertrain lubricant.

In addition to the U.S., Japan and Germany are the world leaders in automotive propulsion, both having significant capabilities in functionally gradient coatings, monolithic ceramics, and in engines and high-power sensor diesel engines. Germany is a world leader in air-cooled diesel engines. Much of this expertise is applicable to military vehicles.

Primary interest in electric drive is found in the major automobile producing and exporting countries (the U.S., Japan, and Germany) driven primarily by growing restrictions on exhaust emissions. Japan is the world leader in some aspects of electric drive technology. France has special capabilities in secondary batteries, such as lithium polymer, which are of great interest for military applications, due to their high energy and power density, long life cycle, and rapid charge/discharge abilities. They also are lightweight, compact, vibration resistant, and have no EM signature. Military applications include electric vehicle propulsion (15 kilowatt or more of power) and silent watch. The U.K., Japan, and Russia also have strong capabilities in lithium battery technology. Another foreign capability of great interest is Germany's experience in hybrid electric vehicles. The German firm of Magnet Motors has been working in this area for over 10 years and has attained the state of the art in multiple electric permanent magnet (MED) motors and generators, as well as magnet dynamic storage (MDS). Other German firms—Siemens, ABB, AEG, and Max Planck—are world leaders in microsystem technology as characterized by a combination of power semiconductors, which will make electric drives smaller, more robust, and more responsive. These technologies could play an important role in Tank–Automotive Research, Development, and Engineering Center's tank mobility technology. Also related to electric drive, Russia has special expertise in certain types of very high energy batteries and some silicon carbide switching devices.

Another technology area of interest for mobility in that of autonomous navigation and control of vehicles. Germany and the U.S. have a collaborative program entitled Next-Generation Autonomous Navigation System (AUTOVON). Participating research laboratories and their technological contributions to the project are as follows:

- *Universitat der Bundeswehr Munchen (UBM), Germany*—UBM will produce an advanced autonomous road navigation system with cost-effective collision avoidance technology. For a number of years, UBM has been a leader in the European Prometheus program oriented towards the development of commercial highway automation. As part of the Prometheus program, UBM has been developing a sophisticated highway lane following system using only normal video for sensor input.

- *Dornier GmbH, Germany*—Dornier will provide advanced off-road obstacle detection and avoidance capabilities using laser radar technology.

- *David Sarnoff Research Center (DSRC), Princeton, New Jersey*—DSRC will perform as technical lead in obstacle detection and recognition. DSRC's obstacle detection approach is entered on high definition, area-based recognition technology, which, together with UBM's research orientation on feature-based recognition, shows promise of complementary research products that, when combined, will offer significant obstacle detection potential. DSRC contributions will include a faster, low-cost, processing capability allowing faster autonomous speeds of operation.

- *National Institute of Standards and Technology, Gaithersburg, Maryland*—This institute will develop a common computer architecture base. The common computer architecture thrust could lead to a standard vehicle controller system supporting technology transfers in a wide range of future developments. ARL will support the institute with a sensor platform stabilization system and global positioning system (GPS)/inertial navigation system integration to enhance navigation system sensor performance.

The AUTOVON effort will accelerate progress in existing Army/DoD unmanned ground vehicle programs since German researchers hold the lead in the development and implementation of some of the key technologies.

e. Intravehicular Electronics Suite

The goal of this subarea is to develop a standardized framework within which to integrate digital technologies for embedded vehicular weapons systems. This is important for enabling current and future ground vehicles to maintain superior combat effectiveness in the digital battlefield. There are two aspects to this area: integration of the electronics into the vehicle, and natural and seamless interconnection of the crew with the electronics.

Technical challenges in intravehicular electronics suites include:

- Electronic integration techniques that are scalable to many platforms
- Advanced crew station design
- Real-time distribution of battlefield information within a vehicle
- Reduction of system development time and cost
- Reduction of system integration time and cost.

The only foreign work of note in this area is that done by the German firm Pietsch, which has conducted extensive future crew compartment studies, focusing on crew size reduction, human factors such as man–machine interface, endurance, and multiple taskings. Integration of technologies such as sensor suites, optronics, and robotics have been demonstrated and continue to be pursued. Existing U.S.–German agreements are ongoing in support of efforts in this area. Future studies are being planned/discussed on the following topics:

- Day and night observation equipment
- Sighting and fire control, including stabilized gun control systems
- Data processing equipment, sensors, and modes logic
- Radio and navigation equipment
- Test, display, and operating equipment
- Laser applications for battle tank fire control
- Laser application for artillery fire control.

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19. Manufacturing Science and Technology

Manufacturing S&T focuses on technologies that will enable the industrial base to produce reliable and affordable materials and products. It requires integration of all aspects of manufacturing from raw materials through design and integration of components, subsystems, and systems. Table E–22 summarizes capabilities in key technical subareas.

Table E–22. International Research Capabilities—Manufacturing Science and Technology

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Advanced Processing	❷ Bioprocess engineering	❷ Bioprocess engineering	❷ Bioprocess engineering	❶ Fuzzy logic for process control ❷ Bioprocess engineering			*Canada, Israel, Netherlands, Nordic Group* ❶ Bioprocess engineering
Manufacturing Engineering Support Tools	❷ Cooperative efforts—CASE tools; industrial robotics			❷ Industrial robotics			
Advanced Manufacturing Demonstrations	Advanced manufacturing demonstrations program-specific						

Note: See page E–11 for explanation of key numerals.

No specific opportunities are identified for this technology area; however, biotechnology applications can contribute to U.S. Army efforts. Large-scale production of biomaterials and products is necessary to capitalize on emerging biotechnology developments. The techniques for providing these large quantities of biomaterials (bioprocess engineering) are of significant interest to the U.S. Army, and include production of the material (including cell culture and fermentation), downstream product processing, and packaging. The United States is an overall world leader in this area, with several nations having significant capabilities including the United Kingdom, Japan, Germany, France, Canada, Israel, the Netherlands, and the Nordic Group.

In the future, international developments are likely to drive greater standardization in manufacturing engineering support tools, including CASE, virtual prototyping, and enterprise integration and control technologies. Already we are seeing rapid growth in technologies for distributed design and management of very complex enterprises in highly industrialized countries, notably Japan, the U.K., France, Germany, and throughout the EC. This trend will be further supported and enabled by the growth of the Internet and its underlying telecommunications infrastructure. Ultimately we can expect to see a seamless integration of distributed M&S with enterprise operation, which will further speed the international exchange of advanced manufacturing capabilities.

20. Modeling and Simulation

M&S objectives, as defined for this technology area, include development of a common technical framework for M&S; timely and authoritative representations of the natural environment, friendly and threat systems, and human behavior; and development of an M&S infrastructure to meet developer and end-user needs. These are critical for achieving the JCS vision for seamless integration of mission planning and rehearsal and effective execution required for dominant maneuver and the application of precision multinational coalition forces to overwhelming effect.

The Defense Modeling and Simulation Office (DMSO) is leading a DoD wide effort to establish a common technical framework to facilitate the interoperability of all types of models and simulations among themselves and with C^4I systems. This common technical framework includes the HLA, and represents the highest priority effort within the DoD modeling and simulation community. HLA was approved as the standard technical architecture for all DoD simulations in September 1996.

The primary mission of HLA is to define a consistent and common picture of the battlespace and will be crucial to effective employment and interoperability of multinational coalition forces. HLA will define an infrastructure for linking simulations of various types at multiple locations to create realistic, "virtual worlds" for the simulation of highly complex interactive events. These exercises are intended to support a mixture of virtual, live, and constructive simulation. HLA will identify the interface standards, information structures, information exchange mechanisms, and other data required to transform heterogeneous simulations into a cohesive seamless synthetic environment. These synthetic environments will support design and prototyping, education and training, T&E, emergency preparedness and contingency response, and readiness and warfighting. Further international cooperation will be essential.

M&S has four technology subareas: simulation interconnection, simulation information, simulation representation, and simulation interfaces. Table E–23 and the following paragraphs summarize capabilities and potential opportunities for each technical subarea.

a. Simulation Interconnection

This subarea is concerned with the development and instantiation throughout the international community of the overarching HLA. This requires the development of an advanced runtime infrastructure (time, data distribution, and large-scale federation management); development of automated tools to support federation development, including automation of the end-to-end process of identifying candidate simulations; development and test of prototype object model development software; investigation of innovative techniques for supporting scaleable executing systems using HLA; and development of an automated HLA compliance testing capability.

Table E–23. International Research Capabilities—Modeling and Simulation

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Simulation Interconnection	❶ NATO countries active in standardization of DIS			❶ Distributed industrial enterprises	*Australia, New Zealand* ❷ DIS		❶ NATO countries active in standardization of DIS
Simulation Information	❶ Dynamic training simulation	❶ Dynamic training simulation	❶ Battle M&S	❶ VR			*Canada, Netherlands* ❹ Battle M&S
Simulation Representation	❶ M&S	❶ M&S	❶ M&S	❹ Distributed enterprises			*Netherlands* ❹ M&S
Simulation Interfaces	❶ VR	❶ VR	❶	❶ VR			*Canada* ❶ VR 3D visualization

Note: See page E–11 for explanation of key numerals.

Technical challenges include establishing the architectural design, protocols and standards, and security mechanisms to facilitate the interoperability of simulations; developing the supporting infrastructure software to apply the architecture to simulation applications with the needed levels of performance; and extension of the architecture to provide time management, data distribution, and federation management services.

In addition to Canada, the United Kingdom, Australia, and New Zealand—all of whom participate with the U.S. in TTCP—France, Germany, and the Netherlands have strong capabilities in M&S, and in the underlying information systems technologies required to distribute and process the information. Japan has had an extensive program aimed at M&S and management of large, complex, distributed enterprises. Other capabilities, including those of Israel may also contribute.

b. Simulation Information

This subarea addresses modeling of mission space, mission tasks, strategy, tactics, intelligent systems emulating human decision making processes, and optimal resource utilization. To achieve this ability, it is necessary to develop simulations that provide consistent and reliable results through the development of common conceptual models of the mission space (CMMS) using authoritative representations. Common syntax and semantics must be developed to specify the warfighter mission (the entities, their actions and interactions) to the simulation developer, and to formulate and define standard data structures, dictionaries, and enumeration of complex M&S data (e.g., highly derived data, command hierarchies, artifacts of legacy systems). Areas of interest include the development of an M&S resource repository; and verification, validation, and accreditation/certification standards and guidelines.

Several factors are fostering rapid growth and internationalization of simulation information and representation. Coalition operations is a major theme in the use of military force. The threat to these forces, geographically dispersed and increasingly capable technologically, demands more effective transnational mission planning and rehearsal. The same requirements and capabilities are, to only a slightly lesser extent, reflected in the operations of large multinational companies. Worldwide availability of low-cost powerful information management systems are allowing exchange of data and promoting standardization of data and models for terrain, weather, and environmental effects. The resulting advances will contribute directly to improved interoperability of coalition forces.

The challenge to developing coherent, complete, and consistent CMMS is an extensive task. The span of military M&S covers a wide range of missions, from conventional to other-than-war missions and M&S applications, and from systems acquisition activities to mission planning and rehearsal. The distributed and interactive nature of advanced M&S capability and security concerns makes the standardization and ready availability of standardized data an extremely complex technical issue.

c. Simulation Representation

This subarea is concerned with technologies that will enable, within the time of operational decision cycles, the generation of realistic and high-fidelity synthetic representation of the prevailing physical environment, natural and manmade, the natural and humans operating in it, and their interactions with each other. These technologies will enable developers and users of M&S applications to represent the natural environment, the performance and capabilities of warfighting systems, and human behaviors (individual and group) in a manner that promotes cost effectiveness, ready access, interoperability, reuse, and confidence. This will enhance the realism of models and simulations used in military training, acquisition, and analysis by providing authoritative representation for (1) static and dynamic, natural and manmade environments, and related effects on human and system performance; (2) the performance and capabilities of warfighting systems and their effects on natural and manmade environments; and (3) human behavior (individual and group).

Technical challenges include rapid database generation and near-real-time interaction of consistent and correlated representations. The representation of human behavior must reflect the effects of the capabilities, limitations, and conditions that influence human behavior (e.g., morale, stress, fatigue). Another significant challenge will be to provide variable human behavior for friendly, enemy, and non-hostile forces—to include CGFs that exhibit platform-based behavioral modeling and command forces models through division level.

d. Simulation Interfaces

This subarea addresses interfaces required for seamless integration of models and simulations with "live" systems, which may consist of instrumented individuals or platforms used for training, testing, or other synthetic environment applications. Interactions with C^4I systems and simulations are a priority. Common operational planning and simulation tools and the development of a modular reconfigurable C^4I interface will focus on these interfaces. This critical capability will facilitate the use of M&S in providing mission rehearsal capability and could augment existing operational planning processes and systems. Technical challenges include:

- Modular interfaces that are responsive and easily reconfigurable for multiple similar but heterogeneous systems and compliant with Joint Technical Architecture (JTA) and the M&S common technical framework
- Accurate representation of live systems and individuals in a simulation
- Realistic representation of synthetic forces on tactical systems.

In the area of simulator interfaces, leading technologies are found primarily in those countries that have been traditionally strong in dynamic training and simulation—Canada (which is also developing significant capabilities in data visualization), the United Kingdom, France, and Germany, and in Japan, which is actively pursuing the development of VR for industrial applications, including visualization of complex systems and enterprises.

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C. INTERNATIONAL RESEARCH CAPABILITIES AND LONG-TERM OPPORTUNITIES

1. Overview

Access to international capabilities in basic research offers a potential vehicle for both near- and long-term return on investment. Within the overall Army S&T strategy, one key objective is to emphasize high leverage opportunities, fostering partnerships where we anticipate the best prospects for sustained excellence in technology development. This includes cooperation with both foreign government and industries, in order to access niches of technical excellence that can best be coupled to existing and future Army technology goals. The following pages provide a snapshot of international basic research capabilities and trends having potential to address one or more of the long-term research goals identified in Volume I, Chapter V of the ASTMP. Many of these areas overlap opportunities highlighted in the previous section, and indicate prospects for long-term partnerships and further cooperative advances. Others indicate areas where future opportunities may develop, either under an existing exchange or a new initiative.

The following discussion and trends charts portray very clearly the international scope of S&T. As might be expected, opportunities for cooperation in basic research are far more pervasive and widely dispersed than those for applied research in technology discussed in the previous section. Increased global accessibility of scientific information is such that no researcher is out of touch with his or her field. Collaborative research across international boundaries is commonplace.

Taken as a whole, the trends charts indicate a high and growing level of scientific research capabilities abroad in virtually every aspect identified as of importance to the U.S. Army. This suggests the importance of an international cooperative strategy that can effectively encompass both immediate opportunities and long-range cooperative partnerships.

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These offices are tasked with keeping abreast with important developments in S&T in their respective areas.

2. Mathematical Sciences

Table E–24 summarizes international research capabilities for the major subareas of mathematical science.

Basic research in applied analysis and physical mathematics directly contributes to the modeling, analysis, and control of complex phenomena and systems active within the Army. Applied mathematicians define practical boundaries, set the framework of analysis, and act as collaborators for scientists and engineers on many development projects. It is often the case that seemingly unrelated research will have effects on the development of critical technologies (e.g., the influence of advances in control theory on the development of nonskid brakes).

Many nations show significant capability in a number of areas identified as having potential impact on future Army technologies. This is consistent with the fact that many advanced applied mathematics research efforts involve only a small number of researchers and have minimal hardware requirements. Thus even nations without an extremely powerful industrial or research base can have a few specific points of excellence in mathematics.

Germany, France, and the United Kingdom are all considered to be on a par with the United States in a number of these areas of mathematics research. All of these countries are noted for developing partnerships between academic and industrial groups working on mathematical problems directly related to modeling and manufacturing issues. In general, Canada and Japan are also considered to be working at or near this high level. Both China and India exhibit strong potential research efforts, which are constantly improving and conceivably, will soon be world leading. The countries of the FSU show a declining capability, largely due to a lack of resources. For example, though many important numerical methods for modeling physical phenomena were developed in the Soviet Union in the 1950s and 1960s, current research is no longer considered world leading. Additionally, Ukraine is noted for a traditional weakness in more basic research and tends to be stronger in development areas. Many

Table E–24. International Research Capabilities—Mathematical Sciences

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Applied Analysis & Physical Mathematics	❶ Fluid dynamics	❷ Bolzman's equations; dynamic systems; computer vision	❷	❺	*China* ❹	*Russia* ❸ Numerical methods; mechanics	*Hungary* ❹ Real variables *Canada* ❺ Analytic geometry; fluid dynamics *Israel* ❺ Symplectic geometry; fluid dynamics
Computational Mathematics	❹ Linear algebra	❷ Finite elements; nonsmooth optimization	❶ Finite elements; interactive methods	❹	*India* ❶ *China* ❹	*Russia* ❻	*Israel* ❷ Computational physics
Discrete Mathematics	❹	❹ Computer algebra	❹	❹	*China* ❹	*Russia* ❸	*Canada* ❹ *Hungary* ❺ *Czech Republic* ❺ Computational geometry
Systems & Control	❹	❶ Control theory	❹	❹	*China* ❹	*Russia* ❻	*Canada* ❹
Probability & Statistics	❶	❶ Levy processes	❹	❶ Fuzzy logic	*India* ❶ *China* ❹	*Russia* ❻	*Canada* ❹ *Austria* ❺ Fuzzy logic

Note: See page E–11 for explanation of key numerals.

other small countries have very strong mathematical talent—Holland, Denmark, Hungary, Israel, Poland, Romania, Greece, Sweden, and Norway—and all could be considered for potential cooperative efforts in specific areas. In addition, there are also significant efforts under way in Asia and the Pacific Rim (especially Singapore and Malaysia) to develop mathematical research enterprises, but these are not yet of world-class stature.

a. Applied Analysis and Physical Mathematics

Research in applied analysis and physical mathematics contributes to the modeling of physical processes critical to the development of new technologies in a variety of fields including smart materials, flow control, electromechanics, and optics. For example, CFD studies in the U.K., Canada, and Israel can contribute significantly to missile, rotor, and explosive design.

b. Computational Mathematics and Discrete Mathematics

There are many examples of specific areas of computational mathematics and discrete mathematics that hold promise for military applications. Research in numerical methods and optimization is the basis for many advances in fluid dynamics, material behavior, and simulation of large mechanical and computational systems. Advanced work in finite element analysis in France and Germany can be applied to the problems of the design and function of complex mechanical structures. Also of interest are international research efforts in linear algebra (France) and computational geometry (Czechoslovakia) that are applicable to the development of new computer network hardware and software platforms.

c. Systems and Control

Systems and control theory work has also been used as the basis for the development of computer systems as well as applications in robotics. Research areas include work in control in the presence of uncertainties, robust and adaptive control for multivariable and nonlinear systems, and distributed communication and control. France is considered a world leader in control theory research. The United Kingdom, Germany, Japan, Canada, China, and Russia have significant capabilities in this area as well.

d. Probability and Statistics

Research in probability and statistics, especially stochastic analysis and statistical methods, is integral in the development of simulation methodologies, data analysis systems, and complex image analysis technology, including new approaches to computer vision for ATR. Fuzzy logic research in Japan is an example of international research that can significantly contribute to Army goals in these areas.

The following highlight a few selected examples of specific research facilities engaged in work in the mathematical sciences:

United Kingdom—The Basic Research Institute in the Mathematical Sciences (BRIMS), Bristol. BRIMS was set up by Hewlett–Packard in 1994 as part of an initiative to widen the corporate research base. BRIMS is an experiment in fostering basic research in an industrial setting. All scientific work undertaken at BRIMS is in the public domain. Main areas of research are dynamical systems, solitons, quantum chaology, quantum computation, probability, and information theory. Research into topological phase effects explores the nature of quantum eigenstates and geometric phase, and applications in a wide range of disciplines throughout physics, including atomic and molecular physics, condensed matter physics, optics, and classical dynamics. BRIMS shares a close relationship with the Isaac Newton Institute in Cambridge, England.

Germany—The Weierstrass Institute for Applied Analysis (WIAS). WIAS performs mathematical research projects in various fields of the applied sciences. These research projects include modeling in cooperation with researchers from the applied sciences, mathematical analysis of properties of these models, development of numerical algorithms and of software, and numerical simulation of processes in economy, and S&T. One program in control theory is concerned with the behavior of nonlinear dynamic systems. General approaches are developed for analysis and control of the longtime behavior of dynamical systems. These methods are applied to simulations and control of processes in chemical engineering, optoelectronics/nonlinear optics (NLOs), and problems in geophysics.

France—French National Institute for Research in Computer Science and Control (INRIA). INRIA is made up of five research units spread in various French regions and one service unit. The main activities of this government institute consist of basic research and realization of experimental systems in computer science, mathematics, and automatic control. INRIA has adopted five major strategic directions in its research activities. They are the control of distributed computer information, programming of parallel machines, development and maintenance of safe and reliable software, construction of systems integrating images and new forms of data, analysis, simulation, and control and optimization of systems.

Austria—Department of Medical Computer Science, University of Vienna. Research here focuses on the applications of fuzzy logic in the field of expert systems for internal medicine. Work has centered on the CADIAG project, which has already produced a number of advanced systems assisting the differential process of diagnostics through indicating all possible diseases, that might be the cause of a patient's pathological finding (with special emphasis on rare diseases), by offering further useful examination to confirm or to exclude gained diagnostic hypothesis, and by indicating patients' pathological findings not yet accounted for by expert system's proposed diagnoses. The system has a database of profiles and rules for diseases that can be easily integrated with an expert's definition and judgmental knowledge from experience to assist in medical care.

Russia—St. Petersburg Institute for Informatics and Automation, Russian Academy of Sciences (SPIIRAS). SPIIRAS conducts basic and applied research in the fields of computer science, computer systems, and automation of scientific research and manufacturing. One research thrust studies the automation and quality testing of models, algorithms, and programs. Problem of models qualimetry are formulated, and some results for solving a problem of adequacy of mathematical models, applied to problems of forecasting and optimization are developed. Technology, methods and tools for automation of complex systems modeling based on their representation visualization using language of algorithmic networks and cognitive graphics are developed. Algorithms for numerical solution of ordinary differential equations in a network structure are used to increase modeling accuracy. This work can be applied to the analysis and evaluation of complex systems, including computer networks, information processing systems, and telecommunication systems.

3. Computer and Information Sciences

Computers and information systems are pervasive in virtually all military systems and operations and are essential to maintaining the present leading position of U.S. military capabilities. Table E–25 summarizes international research capabilities for each major subarea.

Table E–25. International Research Capabilities—Computer and Information Sciences

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Theoretical Computer Science	❷	❷	❷	❷	*India* ❹	*Russia* ❸	*Sweden, Netherlands* ❷
Formal Methods for Software Engineering	❷	❷	❷	❷	*India* ❹	*Russia* ❸	*Sweden, Finland, Netherlands* ❷
Software Prototyping, Development, & Evolution	❷	❷	❷	❶	*India* ❹	*Russia* ❸	*Sweden, Hungary, Netherlands* ❷
Knowledge base & Database Sciences	❶	❹	❹	❹		*Russia* ❺	*Netherlands* ❶
Natural Language Processing	❶	❷	❶	❷		*Russia* ❺	*Netherlands, Sweden, Hungary* ❶

Note: See page E–11 for explanation of key numerals.

The computer and information sciences research area addresses fundamental issues in understanding, formalizing, acquiring, representing, manipulating, and using information. The advanced systems, including the software engineering environments and new computational architectures, facilitated by this research will often be interactive, adaptive, sometimes distributed or autonomous, and frequently characterized as intelligent.

a. Theoretical Computer Science

Theoretical computer science is directed at extending the state of the art of HPCs, an enabling technology for modern tactical and strategic warfare. Research in this area includes development of formal models underlying computing technology, optimization of input/output communication, and design of new computing architectures and parallel systems. Though the United States is the world leader in most aspects of theoretical computer science, many other nations show strong capabilities, including the U.K., Germany, Japan, Netherlands, France, Russia, and Sweden. India is beginning to develop a strong research base in these fields.

b. Software Engineering and Database Sciences

Formal methods of software engineering and knowledge-based database science are the software parallels to improving the computer hardware addressed in computer studies. U.S. software development has been a driving force in enhancing the overall tactical and strategic capabilities of the U.S. armed forces. The United States has been the world leader in computer science and most areas of software development. However, a number of countries have world-class capabilities in various aspects of the overall science. The U.K. is a leader in most areas, with extensive capabilities in knowledge-based database science. Japan has world-class capabilities in software prototyping, as well as being very active in most other areas. India is becoming strong in software prototyping, development, and evolution by virtue of knowledge transfer by U.S. companies employing Indian subsidiaries for software development. Other countries have niche capabilities (e.g., Sweden and Finland). Russia's previously strong capabilities in all areas of computer and information sciences are gradually declining due to budget constraints and aging hardware.

c. Natural Language Processing

Natural language processing has taken on an increased importance with the use of multinational/multilanguage forces in the field. The need for rapid communication between such forces is essential to the efficient and safe military cooperation between various national forces. Germany has numerous universities engaged in natural language processing, making it the most active country in the world outside the United States involved in this particular field. The U.K. also is a leader in most areas of natural language processing, with many universities having advanced research programs. Various universities in Sweden, in addition to the Royal Institute of Technology, have programs relating to natural language translation. France, Hungary, and the Netherlands are also quite advanced and have active programs in language processing.

The following highlights a few selected examples of specific facilities engaged in computer and information sciences research:

Germany–Hungary—Darmstadt University of Technology and Technical University of Budapest. This joint collaborative project combines the dialogue modeling paradigm with natural language generation and speech synthesis in an information retrieval system. This is implemented in SPEAK!, a prototype system that combines a knowledge-based dialogue manager with text generation and speech synthesis components in an integrated framework. It uses a speech synthesizer developed by the Speech Research Technology Laboratory of the Technical University of Budapest.

United Kingdom—Center for Speech Technology Research (CSTR), University of Edinburgh. CSTR does research in the areas of linguistics, speech synthesis, speaker verification, speech technology, speech signal processing, speech recognition, and phonetics. It has worked in areas such as speech synthesis, speech recognition, speaker identification and the characterization of vocal pathologies. Work in automatic speech recognition is concerned with building systems that can convert speech into words. Typically this involves performing signal processing on digitized speech and using sophisticated pattern analysis techniques to match the speech with previously trained models of sounds or words. Speech synthesis research is concerned with producing speech by machines. Often this takes the form of a text-to-speech system, whereby unrestricted text is transformed into speech.

Sweden—Department of Numerical Analysis and Computing Science (NADA), Royal Institute of Technology (KTH). NADA is responsible for the research at KTH and Stockholm University in computer science and numerical analysis. Research in computer science has been established in a number of groups. The Interaction and Presentation Laboratory was established as an interdisciplinary group of researchers and research students in computing science, linguistics, psychology, sociology, and design, with common interest in human–computer interaction. Another group focuses on studies of artificial neural systems. The scope of its research ranges from the design and evaluation of ANN algorithms to realistic modeling of biological neuronal networks.

Hungary—Technical University of Budapest. Computer science and engineering research is diffused over several departments including the Department of Automation where work is done in operating systems, databases, and computer architecture. Most of the research in this department is concentrated in areas related to control and computer engineering. Research in the Department of Mathematics and Computer Science is concentrated on the mathematical and statistical aspects of computation, including information theory and statistical image processing. In addition, the Department of Telecommunications has programs in performance modeling.

United Kingdom—Computer Laboratory, Cambridge University. Research in Great Britain in computer and network security is very broad, including cryptography, network protocols, computer artifact fingerprinting, communications reliability, computer fraud detection, computer security management, and computer privacy policy. The laboratory has a relatively large group exploring various issues associated with network and computer security. They have developed considerable insight into how to engineer secure computing systems, especially security protocols. The computer security group is currently working on techniques for altering smart cards used for electronic transactions. The laboratory's long-term research in network security protocols, cryptographic algorithms, and digital signatures contributes to the maturing of good engineering practices in the development of secure computing systems.

4. Physics

Basic research in physics broadly supports advanced technology developments by providing insight into the nature and interaction of energy and matter and contributing to technologies with a wide range of civil and military applications. Areas of interest to the Army include nanotechnology, photonics, and processes and technology related to obscured visibility, novel sensing, optical warfare and image analysis enhancement. For example, this research enables ongoing advancement in microminiaturization and optical subsystems. This also improves sensor capability and continues development of image analysis and target recognition systems. Table E–26 shows a wide range of countries possess capabilities in the subareas of physics.

Table E–26. International Research Capabilities—Physics

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Nanotechnology	❺ Microscopy	❺ Molecular chemistry	❶ Submicron research	❶			
Photonics	❶ Optoelectronics; signal processing ❷ Optical switching	❶ Optoelectronics; signal processing; optical computing ❷ Optical switching	❶ Optical switching; optoelectronics; signal processing	❶ Optical switching, optoelectronics; signal processing; optical computing		*Russia* ❷ Optical sensors ; optical computing	*Belgium, Canada, Sweden* ❺ Optical switching
Obscured Visibility/ Novel Sensing	❶ Sensors; signature reduction; lasers ❺ IR FPAs	❶ Signature reduction; lasers; IR FPAs ❷ Sensors	❹ Sensors; lasers	❶ Fiber-optic gyroscopes; sensors; lasers ❺ IR FPAs	*Korea* ❺ IR FPAs	*Russia* ❷ Glonass; signature reduction; lasers; IR FPAs	*Israel* ❺ Signature reduction; IR FPAs
Optical Warfare	❹ HELs; sensing of CB agents	❹ HELs; sensing of CB agents	❶ Sensing of CB agents ❹ HELs	❹ NLOs		*Russia* ❺ NLOs; HELs; sensing of CB agents	*Israel, Canada* ❹ Sensing of CB agents
Image Analysis Enhancement Technology	❹ Signal processing; software & modeling	❹ Signal processing; software & modeling	❹ Signal processing; software & modeling	❹ Signal processing; software & modeling			*Canada* ❹ Signal processing; software & modeling *Turkey* ❹ Tomographic imaging *Sweden* ❺ Software & modeling

Note: See page E–11 for explanation of key numerals.

a. Nanotechnology

The objective of nanotechnology programs is to develop the capability to manipulate atoms and molecules individually, to assemble small numbers of them into nanometer size devices, and to exploit the unique physical mechanisms that operate in these devices. Japanese and German research in submicron imaging and overall capabilities in nanotechnology offer great potential in producing smaller, faster, devices designed to consume less power.

b. Photonics

Photonics research seeks to develop optical subsystems for military applications such as information storage, displays, optical switching, signal processing, and optical interconnections of microelectronic systems. The U.K., France, Germany, and Japan have ongoing research in the various areas of photonics. Russia has a strong but declining capability in photonics research. Research in obscured visibility and novel sensing seeks to provide the Army the ability to operate on the ground in conditions of poor visibility, as well as providing significant control of physical signatures. The U.K., France, and Japan have significant capabilities in the related technology areas. Germany, Israel, Sweden, Canada, and Belgium have capabilities that also merit consideration.

c. Obscured Visibility/Novel Sensing and Optical Warfare

The Army's ability to operate under conditions of poor visibility is enhanced by improved sensing capabilities. Optical warfare research studies and develops optical sensors and sources, NLO processes, tunable sources, and materials with special reflective, absorptive, and polarization properties to perform specialized remote sensing missions. Japan has world-class capabilities in novel sensing. The U.K. and France also have capabilities and obscured visibility and novel sensing techniques. Both of these countries have advanced programs in the development of novel semiconductor materials and devices for use in IR FPAs, as do Japan and Israel. Russia has considerable capabilities in obscured visibility and novel sensing; however, funding difficulties point to a decreasing capability.

d. Image Analysis Enhancement Technology

The objectives of image analysis research are to develop the fundamental limits and theoretical underpinnings of object recognition and image analysis. These areas are of increasing importance, because of the increasing speed of modern weapons and the need for faster and more accurate IFF. It also applies to the development of novel technologies for mine detection, medical imaging, and geophysics. This is an area where a number of countries are developing broad capabilities, including the U.K., France, Germany, and Japan. Israel, Canada, Turkey, and Sweden have important niche capabilities.

The following highlight a few selected examples of specific facilities engaged in physics research:

United Kingdom—Next-Generation Laser Diodes Programme British Engineering and Physical Sciences Research Council (EPSRC). EPSRC has established the program to study six main areas of diode research. The areas are laser sources with enhanced functionality, new high-power technologies, beam quality and control, new wavelength ranges, high-speed and high-frequency laser diodes, and reduced threshold currents. This program is intended to bring industry and academia together in cooperative research. Participants represent the largest research organizations in the U.K., including the Optical Research Centre at Southampton University and the Scottish Collaborative Initiative in Optoelectronics Sciences.

Germany—Photonic Optical Interconnection Technology Project, Fraunhofer Institute for Applied Solid-State Physics. This project is focused on research related to the connection of optics to electronics. The project consists of five universities, four research institutions, and three cooperate partners. The project has been split into four groups: systems theory, passive optical components, detectors, and laser diodes. The goal is to incorporate optics into the interconnection of circuitry, rather than the more difficult "optical computer," which uses light solely.

Sweden—Department of Electronics, Royal Institute of Technology (KTH). Research in the Laboratory of Photonics and Microwave Engineering at KTH is aimed at fabricating a monolithic optical receiver and transmitter, including a PIN-diode and a front-end amplifier, and a laser diode or an external modulator with a driver, respectively. The electronics are based on heterojunction bipolar transistors (HBT). PIN-diodes with good sensitivity have been fabricated, using some layers of an HBT-structure. Other research efforts are attempting to improve these materials and structures to improve device performance and reliability.

Japan—Department of Physics, Kyoto University. The Quantum Optics Group engages in research that is leading to the development of working atom lasers. This work focuses on Bose–Einstein condensates of alkaline atoms and the study of its many body and optical properties. Additional work is being done into laser-matter interactions, including laser cooling and trapping of atoms and the nonlinear interaction between trapped cold atoms and short intense light pulses.

Europe—The European Industrial GaN Program. The European Commission has established an R&D program on Ga-Al-In-N for multicolor sources under the acronym RAINBOW. Two key products are being developed: (1) a high-brightness outdoor lighting as used in large outdoor displays, traffic signals, automobile lighting, etc., and (2) a high-density optical disk storage as used in multimedia environments. A consortium of European firms and universities (including Thomson CSF, Philips, University of Erlagen, and AIXTRON) is working to develop a complete Al-Ga-In-N materials base, leading to production technology of ultra-high-brightness light emitting diodes in various colors, and in the fabrication of nitride-based blue laser devices.

Turkey—Radio Physics and Antenna Laboratory, Space Technologies Department, Marmara Research Center. The laboratory conducts radio physics research in the microwave, millimeter, and quasi-optical regimes. Projects include studies of microwave imaging and devices, microwave applications of superconductivity, and SAR image compression. Advanced research is being done to develop a tomographic imaging system at the 8-millimeter waveband. This work will lead to the development of algorithms and devices used for the detection of buried objects, biomedical imaging, and the NDE of materials and structures.

5. Chemistry

This area includes research on CBD and on a number of advanced materials. Advanced materials provide the Army with capabilities for new and improved systems and devices. Performance, life-cycle cost, sustainability, maintainability, costs, availability, etc., are all strongly influenced by advances in materials. The Army is especially interested in NLO materials for laser protection, smart materials, structural polymer composites, ballistic protection polymer composites, fire retardants for vehicles, and surface resistance to corrosion and wear, among other topics. These are areas where special Army requirements place stringent demands on materials, and especially on materials chemistry. Table E–27 summarizes international research capabilities for each major program. The advanced materials research program has been listed by subarea.

a. Chemical and Biological Defense

A number of countries are active in materials R&D for CBD. The U.K. and Canada have world-class capability and have ongoing efforts to provide better defense against CB agents. They have been at the forefront of CBD for years and can be expected to continue to devote resources in this area. Israel, Sweden, Finland, France, Germany, the Czech Republic, Poland, China, the Netherlands, and Japan also have some capabilities. For the most part, efforts are more concentrated in the biological area where the need is greatest. Australia, Russia, and Ukraine also have significant programs in this area.

b. Advanced Materials Research

The processing of NLO materials area is of importance to the Army because they are required for wavelength conversion in some laser systems and in personnel eye protection. The materials must be very uniform, of very high purity, and the selection of useful materials currently is limited. The U.K., France, and Russia have strong efforts in preparation and characterization of NLO materials, and Japan and Israel have credible capabilities. Hungary and China are also working extensively in this area.

Smart materials are ones that can sustain sensory capabilities, actuator activity, and information processing as part of their basic microstructure. Design, synthesis, and processing of such materials is a chemical challenge, as it is done at the atomic/molecular level. Applications such as damage detection and control, vibration damping, and precision manipulation and control motivate the field. At the microstructural level, challenging areas of interest include phase transitions (e.g., shape memory

Table E–27. International Research Capabilities—Chemistry

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Chemical & Biological Defense	❶ Detection; protection; decon	❷ Detection; protection; decon	❷ Detection; protection; decon	❺ Detection; protection; decon	*China* ❷ Detection; protection; decon *Australia* ❹	*Russia, Ukraine* ❷ Detection; protection; decon	*Canada* ❶ CD/BD *Poland, Sweden, Czech Republic, Finland* ❺ CD/BD *Netherlands* ❺ BD *Israel* ❺ CD
NLO Materials for Laser Protection	❷	❷	❺	❺		*Russia* ❷	*Israel, Hungary* ❺
Smart Materials		❹	❹	❷	*South Korea* ❹	*Russia* ❺	*Israel, Netherlands, Switzerland* ❺
Polymer Composites (Structural)	❷	❷	❶	❶	*South Korea, China* ❹ *India* ❺	*Russia* ❺	*Canada* ❷ *Israel, Spain* ❹ *Sweden, Finland* ❺
Polymer Composites (Ballistic Protection)	❶	❺	❺	❺		*Russia* ❺	*Israel* ❷
Fire Retardants for Vehicles	❷	❷	❺				*Israel* ❷
Surface Resistance to Wear & Corrosion	❶	❷	❶	❶	*South Korea, China, India* ❶	*Russia, Ukraine* ❷	*Switzerland, Sweden* ❷ *Canada, Italy, Netherlands, Israel* ❹
Explosives & Propellants	❷	❺	❶	❶	*Singapore, South Korea* ❷	❷	*Sweden, Israel, Canada* ❶
Soldier Power	❶	❶	❶	❺		*Russia* ❺	*Israel, Canada* ❺
Demilitarization, Installation Restoration, & Pollution Prevention	❶	❷	❷	❺		❺	

Note: See page E–11 for explanation of key numerals.

alloys), layer-by-layer design of materials, materials with defect structures that can sustain sensing and responses, biocomposites, piezoelectric ceramics, multifunctional macromolecules, and others. This area offers large payoffs in areas such as delamination control of composite helicopter blades and increased battlefield survivability of materials via active damage control. World activity in smart materials continues to grow rapidly. Japan is a clear leader in some aspects. France, Germany, and South Korea have growing programs.

Thick-sectioned glass reinforced composites are of interest to the Army because they offer weight savings while providing other systems-useful, stringent characteristics with controlled costs. Thick-sectioned composites of this kind offer the Army much in structural integrity. Most overseas work in this area is now done in the commercial sector and is focused on manufacturing and processing issues. Major foreign capabilities in this area are rather widespread, including significant work in the U.K., France, Germany, and Japan.

Polymer matrix composites (PMCs) offer much to the Army for ballistic protection for personnel, equipment, emplacements, and vehicles. The challenges are to learn how to make very high quality material at a controlled, low cost and to understand and improve upon dynamic response for these materials. The U.K., France, Canada, Germany, and Japan all have broad capabilities and research in PMCs. Israel, Spain, and South Korea have important and growing capabilities.

Fire retarding materials for vehicles are of significance to the Army to protect personnel from conflagrations and to allow Army assets to return to operation as rapidly as possible. These materials are essential in order to enable Army systems to perform under battlefield conditions. This capability allows for sustainability of vehicles involved in force projection and advanced land combat. In addition to fire retardancy, these materials must be easily applied to vehicles and also not produce toxic products when experiencing high temperatures. The countries with strong capabilities in these areas are the U.K., France, and Israel.

Wear and corrosion cost the Army several billion dollars each year due to premature failures, excessive wear of systems and components, application and removal of protective coatings and paints, and the need to have high spares inventories to meet all of these challenges. Corrosion control and avoidance is a challenging scientific area, as is tribology (the study of surfaces in contact). Elements of materials science, chemistry, and mechanics enter into understanding these systems-defined problem areas. These areas are exceptionally important for maintainability and affordability, in terms of life-cycle costs for Army systems. Nearly all industrialized nations have programs of some extent in wear and corrosion. The strongest are in the U.K., Germany, Japan, France, Sweden, and Switzerland with niche capabilities existing elsewhere.

c. Explosives and Propellants

Basic research is often undertaken to solve problems of explosive and propellant effectiveness or to compile properties sufficient to improve detection or identification. Army applications include the basic outgassing chemistry for detection of mines and charges. Chemistry used to mimic vehicle IR signatures is applicable to decoy flares. Chemistry of propellant bonding provides insight into the life-cycle projections for Army missile systems. Germany, with a world-class tradition of expertise in chemistry, leads in most of these areas. Traditional leadership in the U.K. across broad chemistry areas is fertile for international interest. Japan's space interest promote expertise in missile propellants. Long-term military requirements underscore ongoing basic research in Israel, Singapore, and Korea. Research in the FSU suffers from lack of operating capital.

d. Soldier Power

Soldier power embraces a menu of appliances that provide the 21st century warrior with power sources and devices to enable advanced sensors, communications, and other man-portable weapons and devices. This suite of tools will enhance the soldier's situational awareness and provide a selection of force applications tailored to varying situations. Power sources of importance include electrolytes for fuel cells and batteries of advanced and environmentally friendly types. The U.K., Germany, and France are leaders in these technologies with Japan close behind. All of these countries have significant programs in the development of nickel metal hydride (Ni–M–H) and Li batteries. Russia, Canada, and Israel have significant capabilities as well.

e. Demilitarization, Installation Restoration, and Pollution Prevention

The U.S. has a strong lead in research related to demilitarization, installation restoration, and pollution prevention. Sensing pollution and destroying pollutants, and practices that prevent pollution, all lead to more efficient or more effective military operation. Of foreign countries, the U.K. has the strongest potential. France and Germany follow, but their potential for military applications is weaker due to budgetary constraints.

The following highlight a few selected examples of specific facilities engaged in chemistry research:

Finland—Technical Research Center of Finland (VTT) Chemical Technology. VTT is the largest institute of its type in Finland. It is headquartered in Helsinki, with a number of branch laboratories spread throughout the nation. VTT works with both industry and government, and focuses research in nine areas, including chemical technology, energy, and nuclear safety. VTT also is working with several American companies as well as NASA and the Department of Energy. VTT Chemical Technology has active programs in nonpolluting processes and waste reduction, polymer and fiber technology, catalyst research, atmospheric emission monitoring, and flywheels for automotive applications.

Germany—German Aerospace Research Institute (DLR). DLR is among the leaders of the world-class German efforts in the development of new fuel cell systems. Significant work is being done in development of synthesis and processing techniques for electrode structures in polymer electrolyte fuel cell (PEFC) systems. These cells can provide compact and efficient power systems for vehicles with low-toxic emission levels. Other projects include studies of new catalysis materials for the PEFC systems and oxide high-temperature fuel cells. DLR also participates extensively in cooperative R&D projects with German and international industry and government, including programs on PEFCs with Siemens; thermal plasma chemical vapor deposition with the University of Minnesota; and the study of electrochemical energy conversion and materials in fuel cells with the Lawrence Berkeley National Laboratory.

Switzerland—Smartec. Smartec is developing smart composite structures with embedded fiber optic sensors for quality control and health monitoring. Sensors can be used to detect failures, changes in length, and structural stability caused by temperature variation or during mission performance. Smartec has developed a fiber sensor system using mirrored fiber ends or reflector pairs for inline multiplexing. The technology is being used in laboratory optical tables, bridges, and tunnels. The firm is an outgrowth of work performed at the Swiss Federal Institute of Technology as part of the French Surveillance d'Ouverages par Fibres Optiques project.

Hungary—TTKL Research Laboratory for Crystal Physics. This laboratory specializes in the development of material preparation, purification, and crystal growth of optical single crystals. The laboratory grows crystals of LiNbO3 and various borates for NLO applications, $Li_2B_4O_7$ for surface acoustic wave applications, and photorefractive bismuth oxides. Research also includes studies on the growth, structure, and physical properties of the crystals. The laboratory helps organize the Oxide Crystal Network, which fosters the exchange of information, research samples, and expertise among academic and commercial centers in 30 institutions located in 20 European countries. One of these activities is the preparation of crystals, including choosing the composition, dopants, crystal growth methods, and thermal treatments. Another principal activity is the development of standard experimental characterization and less standard theoretical modeling methods.

6. Materials Science

Materials science provide the enabling technologies for fabrication of all physical devices and systems used by the Army. Advances in materials science, engineering, and technology make possible the solutions, options, and improvements for performance, durability, and life-cycle costs of all these systems. Table E–28 summarizes international research capabilities in each major subarea of materials science.

All industrialized and rapidly developing countries have materials-related activities and capabilities. Many nations now can produce materials for specific military usage, including materials engineered to defeat enemy threats and those which preserve the capability of high-performance systems in the field. Thus, Army capabilities can face challenges internationally. Also of importance for materials science and materials technology is that all industrialized nations continue to do advanced work across these fields, and rapidly developing nations are building strengths in materials fields as well.

Materials science provides the bases for materials with desired, high-level properties needed by the Army in structural armor, antiarmor, CB agent protection, laser protection, infrastructure applications, propulsion, and biomedical applications. All materials classes are included—metals, ceramics, polymers, composites, coatings, energetic solids, semiconductors, superconductors, magnetic, and other functional materials. Army research in materials includes vital areas such as synthesis of new materials, modifications of existing materials, and design of microstructures and composite architectures to meet property-specific performance needs. Also included are advanced characterization concepts and methods to specify and control microstructure, properties, and degradation events.

a. Manufacturing and Processing of Structural Materials

Processing of materials is a key part of this program. It spans the flow of precursor materials on through microstructural developments into useful materials or components at acceptable costs. Materials processing includes topics such as polymerization, composite layup, physical and chemical vapor deposition, and surface modifications, among others.

Many nations have significant capability in the manufacturing and processing of advanced materials of interest to the Army. The U.K., France, Germany, and Japan are all at or near the forefront of research into the processing of steels, titanium, aluminum, PMCs, MMCs, superalloys, intermetallics, and C-C composites. Expertise in these areas also resides in the FSU, particularly in Russia. Niche capabilities can be found in many countries, for example in Austria, Sweden, Canada, and South Africa for advanced steel research; and Israel and Italy for C-C composites, among others. Growing capabilities are developing in Asia and the Pacific Rim, particularly in China, India, and South Korea.

Table E–28. International Research Capabilities—Materials Science

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Manufacturing & Processing of Structural Materials	❶ Welding & joining ❷ Steel; Al; Ti; PMC; superalloys; intermetallics; C-C ❺ MMC	❶ CMC ❷ Steel; Al; Ti; PMC; superalloys; intermetallics; C-C ❺ MMC	❶ Ceramics ❷ Steel; Al; Ti; PMC; superalloys ❺ MMC; C-C	❶ Steel; MMC; PMC; C-C; CMC ❷ Al, Ti; superalloys; intermetallics	*China, South Korea* ❸ *India* ❹ Steel *China, India* ❹ Al, Ti *China, India* ❺ C-C	*Russia* ❷ Al; Ti ❸ Steel; superalloys ❺ PMC *Ukraine* ❷ Welding & joining	*Austria, Sweden, Israel, Canada, South Africa* ❷ Steel *Canada, Sweden, Spain, Israel* ❷ PMC *Sweden* ❺ Superalloys *Sweden, Canada* ❺ Intermetallics *Israel, Italy* ❺ C-C *Norway* ❺
Materials for Armor & Antiarmor	❹ Personnel armor ❷ Armor; antiarmor	❶ Personnel armor; tungsten-carbine armor ❷ Heavy armor; antiarmor	❷ Armor ❹ Antiarmor	❹ Armor, antiarmor ❺ Ceramic armor	*China* ❺ Armor; antiarmor *South Korea* ❹ Tungsten alloy penetrators; armor	*Russia, Ukraine* ❷ Armor; antiarmor	*Israel* ❶ Personnel *Israel, Sweden* ❶ Antiarmor *Israel* ❷ Armor *Slovakia* ❺ Armor
Processing of Functional Materials	❶ Electronic & electrical ❺ Optical & optoelectronic; magnetic	❷ Optical & optoelectronic ❹ Electronic & electrical ❺ Magnetic	❶ Electronic & electrical ❺ Optical & optoelectronic; magnetic	❶ Electronic & electrical; optical & optoelectronic; magnetic; superconductors	*Taiwan, South Korea* ❹ Electronic & electrical	*Russia* ❸ Electronic & electrical ❺ Magnetic ❻ Optical & optoelectronic; superconductors	*Netherlands, Israel, Italy* ❷ Optical & optoelectronic *Netherlands* ❷ Electronic & electrical; magnetic *Slovakia, Italy* ❻ Electronic & electrical
Engineering of Material Surfaces	❶ Coatings; ion implantation ❺ Machining, finishing, & polishing	❷ Ion implantation; machining, finishing, & polishing ❹ Coatings	❶ Coatings ❷ Ion implantation; machining, finishing, & polishing	❶ Coatings; machining, finishing, & polishing ❺ Ion implantation	*South Korea* ❹ Machining, finishing, & polishing; coatings *China* ❺ Machining, finishing, & polishing; coatings	*Russia, Ukraine* ❷ Coatings ❹ Machining, finishing, & polishing ❺ Diamond deposition	*Switzerland, Sweden* ❶ Coatings *Canada Italy, Netherlands* ❹ Coatings *Sweden, Italy* ❷ Machining, finishing, & polishing *Netherlands, Switzerland* ❺ Machining, finishing, & polishing *South Africa, Israel* ❺ Diamond deposition

Table E–28. International Research Capabilities—Materials Science (continued)

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Nondestructive Characterization of Components	❶ Metrology; NDE systems	❶ Metrology ❹ NDE systems	❶ Metrology ; NDE systems	❶ Automat. ❹ Metrology; NDE systems	South Korea ❹ Metrology; NDE systems *China* ❺ Metrology; NDE systems	*Russia* ❺ NDE systems	*Sweden, Switzerland* ❹ Metrology *Sweden, Italy, Switzerland* ❹ NDE systems

Note: See page E–11 for explanation of key numerals.

b. Materials for Armor and Antiarmor

There are many unique Army requirements that make stringent demands on materials. As a prime example, armor/antiarmor clearly is a high-priority area for the Army. Armor materials include those specifically designed to protect equipment and personnel from enemy threats. Antiarmor materials are used in the projectiles, penetrators, shaped-charge liners, etc., designed to defeat enemy armor. For armor, the U.K., France, Germany, Israel, and Russia are overall world leaders, along with the United States. For antiarmor projectile materials, the U.K., France, Israel, Sweden, and Russia have very significant and relevant dense alloy capabilities.

c. Processing of Functional Materials

Processing of functional materials is key to providing military advantage to materials that fulfill optical, magnetic, electrical, and electronic needs. Although many commercial applications exist for such materials, these are often at lower performance levels than those of the Army. Thus, understanding of the processing of functional materials allows their use in military systems with performance at the upper limits of their capabilities. These functional materials must be of the highest quality also because of their influence on sustainability and for operations of all types of Army platforms, vehicles, weapons systems, etc. Optical materials of interest include waveguides, lenses, mirrors, laser hosts, and sensor covers. For magnetic materials, the Army is concerned with data recording media, signature control, power supplies, and motor applications. Electrical materials needs focus on solenoids, minesweeping, and high field magnets. Since electronic materials are the key foundations of the Army's electronic systems, they are of interest for functions including logic, amplification, memory, display, delay, signal generation, sensing, and switching.

For processing of functional materials, the United States generally has the lead overall, but others (France, the United Kingdom, Germany, Japan, other European nations, and Russia) have strong capabilities that rival those of the United States. Japan is more advanced than the United States in some areas of electronic materials. The United Kingdom, Russia, Japan, Israel, Germany, and China are very active across several areas of optical materials. For magnetic materials, the United States is the leader overall, though Japan has some capabilities in all areas of magnetic materials as well. The United Kingdom is capable in high-permeability magnetic alloys. For magnetorestrictive alloys, Sweden and the United Kingdom have technologies comparable to that of the United States. Many other nations are active in selected areas of magnetic materials. For electrical materials, the United States has the lead in superconducting wire. Japan, Germany, Italy, and the United Kingdom have capabilities in wire processing as well. High-temperature superconducting materials work goes on all over the world, with the United States in the lead with prototype wire processing.

d. Engineering of Material Surfaces

Precise control, fabrication, and modification of materials' surfaces are areas with great impact on Army systems. The surface is the region where the component meets its operating environment, be it chemical, mechanical, thermal, EM, etc., in nature. It is the region within which failure usually originates during system performance or storage. Control, modification, tailoring, and precise definition (e.g., of dimensions, geometry, optical figure, flaw content) contribute very strongly to the costs and value added of Army materials. Thus, activity on machining, ion implantation, chemical vapor deposition and sputtering for coatings, and adhesion of protective layers, are fertile topics in engineering of surfaces for Army use.

Materials surface engineering capabilities are widely held across the world. For precision machining and polishing, Japan, Germany, France, and the U.K. are very strong, as are Switzerland and Sweden. For coatings of many types, France, Germany, the U.K., and Russia are among the leaders. Areas of strength exist abroad in ion implantation and thin-film diamond deposition.

e. Nondestructive Characterization of Components

NDE of components divides into a few focus areas. For quality of materials produced, France, Germany, the U.K., other European countries, and Japan have increased capabilities with NDE systems. In all aspects of metrology, Japan is excellent, as are the U.K., France, and Germany. Switzerland and Sweden also excel in selected areas. All of these nations are paying growing attention to automation in the use and interpretation of NDE both for product quality and process control.

The following highlight a few examples of specific research facilities engaged in work in materials science.

South Africa—Materials Science and Technology Division (MATTEK), CSIR. A government supported facility, the CSIR is Africa's largest scientific and technological R&D organization. CSIR's MATTEK has one of the broadest ranges of materials research activities in South Africa, including some programs with state-of-the-art facilities and world-class research. Selected programs in MATTEK include piezoelectric composites for underwater acoustics, medical diagnostics, and ultrasonic instrumentation, rapid prototyping, thermal spray coating, and polymer additives for a variety of applications, including corrosion resistance, antifogging agents, and lubricants.

Norway—The Foundation for Scientific and Industrial Research (SINTEF), Materials Technology Institute. SINTEF is Scandinavia's largest independent research organization. The institute has 200 staff members in two sites, in Oslo and Trondheim. Research areas include process metallurgy and ceramics, casting and metal forming, fracture mechanics and materials testing, and corrosion and surface technology. Significant research projects include studies into new technologies for rapid prototyping and ceramic materials for stronger porcelains, membranes for sensors and liquid-gas separation, and abrasion resistant tools and equipment. World-class work is being done in the area of silicon microelectromechanical system (MEMS) accelerometers by a spinoff company, SensoNor, a world leading supplier of MEMS technology to the automotive industry.

China—Chinese Academy of Sciences (CAS). CAS is one member of a collaborative group of research institutes that is working in the area of functional polymers. Other collaborating institutions include Tsinghua University, City University of Hong Kong, and the Institute of Photographic Chemistry of the CAS. These groups are actively working to develop organic materials for a variety of photonic and electronic applications. Though the level of work has yet to achieve world-class stature, the research equipment and funding are improving, and the scientists are of very high quality and training. Specific programs include development of polymer materials for nonlinear refractive indices, EO effects, and characterization of structural properties of novel polymer materials.

Japan—International Superconductivity Technology Center (ISTEC). ISTEC is a nonprofit foundation formed in 1988 to develop and exploit superconductivity technologies in government and industry. The foundation has over 100 industrial and government supporting member organizations and runs the Superconductivity Research Laboratory and its affiliated centers. ISTEC supported R&D of high-temperature superconductivity has given Japan a lead in the development of the basic science and applications of these materials and devices. ISTEC supported work has led to significant improvements in the growth of multilayer thin-film growth of high-temperature superconductors for electronic device applications, as well as the development of a number of thin-film devices (e.g., a Josephson Junction mixer for radio astronomy antenna).

7. Electronics Research

Basic research in electronics supports advanced technology development with many applications. Important examples include continued advancement in solid-state devices, telecommunications, microwave and MMW circuit integration, image analysis, and low-power electronics. Table E–29 shows that many countries host capabilities in these various areas that support military applications and a wide range of civil applications.

Table E–29. International Research Capabilities—Electronics Research

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Solid-State Devices & Components	❶ JESSI/MEDEA research	❶ JESSI/MEDEA research ❷ Photonics	❶ JESSI/MEDEA research; photonics	❶ All phases of solid-state devices			*Europe* ❹ JESSI/MEDEA research
Mobile, Wireless Tactical Communications Systems & Networks	❶ Telecommunications	❶ World leader in battlefield communications	❶ Telecommunications	❶ Telecommunications			*Canada, Belgium, Sweden, Italy* ❷ Telecommunications
Electromagnetics & Microwave/Millimeter-Wave Circuit Integration	❹ JESSI/MEDEA programs; microwave tubes; antennas	❹ JESSI/MEDEA programs; microwave tubes; antennas	❷ Antennas; MMIC ❹ JESSI/MEDEA programs; microwave tubes	❶ MMIC; acoustic wave devices; microwave tubes			*Canada* ❹ Microwave tubes; antennas
Image Analysis & Information Fusion	❷ Image analysis; target recognition; sensors	❶ Target recognition; sensors ❷ Image analysis	❷ Sensors ❸ Image analysis; target recognition	❶ Sensors ❷ Image analysis ❸ Target recognition		*Russia* ❻ 3rd-generation image intensifier tubes	*Sweden* ❷ Airborne radar *Italy* ❷ Sensors; target recognition; image analysis *Israel* ❺ Sensors; target recognition; image analysis
Minimum Energy, Low-Power Electronics, & Signal Processing	❹ JESSI/MEDEA programs; NLOs; antennas; low-power devices	❹ JESSI/MEDEA programs; NLOs; antennas; low-power devices	❹ JESSI/MEDEA programs; antennas; low-power devices	❶ MMIC; NLOs; low-power devices		*Russia* ❺ NLOs	*Europe* ❹ JESSI/MEDEA research

Note: See page E–11 for explanation of key numerals.

a. Solid-State Devices and Components

Research in solid-state devices concentrates on the development of novel, robust, reliable multifunctional ultrafast/ultradense electronic, photonic, and optoelectronic components and architectures. This includes the design of nanoscale and microscale devices based on new physical principles of operation leading to expanded functionality, greater packing density, and devices capable of operation at terahertz speeds. Basic research continues in an effort to develop new families of devices that operate at high speeds and at extremely low power levels. Japan and a number of European countries, through their JESSI/MEDEA program, are active in this area.

b. Mobile, Wireless Tactical Communications Systems and Networks

Battlefield communications continues to be an application of great interest, as the need for real-time battlefield information becomes more critical. A number of countries have developed extensive research capabilities in niche areas ranging from C^3 to networking, switching, and transmission. The United Kingdom, France, Japan, and Germany are world leaders in this area. Canada, Belgium, Sweden, and Italy have significant niche capabilities.

c. Electromagnetics and Microwave/Millimeter-Wave Circuit Integration

Microwave/MMW circuit integration helps to satisfy the need for improved communications, radar, and seeker systems. Other direct applications, including novel antenna arrays and optical control of circuits, support the "digitized" battlefield. Japan, with its research in MMIC devices and acoustic wave devices, is a leader in applicable areas. Again, European countries are involved through the JESSI/MEDEA consortium. Canada and Italy have significant niche capabilities.

d. Image Analysis and Information Fusion

Image analysis and target recognition are critical to maintaining superior U.S. forces. This involves the full energy spectrum: IR, visible, and radar. Research also addresses the fusion of the vast quantities of information on the digital battlefield generated by sensors that may be IR, visible, or radar. The United Kingdom, Japan, France, Germany, Russia, Sweden, Italy, and Israel are active in these areas.

e. Minimum Energy, Low-Power Electronics, and Signal Processing

Low-power electronics are critical for the lightweight prime power sources and man-portable systems of the near future. For these systems, it is necessary to develop a new generation of design rules for electronics that operate with minimum energy requirements and dissipate very low direct current power. This research will address highly efficient and low direct current power consumption digital and RF circuits and solid-state devices. Japan has extensive experience in this area and is considered a world leader. Several countries in Europe, including the U.K., France, and Germany, have developing capabilities.

The following highlight a few selected examples of specific facilities engaged in electronics research:

France—French–Japanese Integrated Micromecatronic Systems Laboratory. LIMMS was formed in 1995 by the (French) National Scientific Research Center and Tokyo University's Institute for Industrial Sciences. Researchers there have successfully combined silicon micromachining, integrated circuits, and microrobotic technologies, resulting in the completion of novel silicon microactuators. Further work has been done in pivoting-mirrors and evanescent-wave optical switchers, actuators that permit control of linear displacement in two dimensions, and pivot-mounted "patch" antennas. The overall goal of the laboratory is to advance current technology toward full autonomous microsystem capabilities.

England—The Terahertz Integrated Technology Initiative (TinTin). TinTin is a consortium of Bath, Nottingham, and Reading universities in the U.K., British Aerospace (BAe), the Max Plank Institute in

Stuttgart, Germany, and IBM in Zurich. Its research is focused on developing micromachined integrated terahertz systems, imaging array development, and the characterization of satellite components for various space organizations, including NASA. The overall task is directed at the development of terahertz (THz) waveguides and devices for operation in the 600 GHz to 1.6 THz range.

Switzerland—Swiss Electronics and Microelectronics Center (CSEM). CSEM specializes in developing low-consumption dedicated circuits. Recently, it has developed a high-speed, 8-bit reduced instruction set computer (RISC) microprocessor core. This new technology can perform 5,000 million instructions per second per watt (MIPS/W), or 40 times higher than current 8-bit complex instruction set computer processors. These cores, called CoolRISC, are as small as 0.4 mm^2 in 1-micron complementary metal oxide semiconductor (CMOS), so they are well suited for space limited, very-low-power consumption circuits. The CoolRISC has already led to development of an 8-bit microcontroller with 5,000 MIPS/W computing power at 10 hertz and under 3 volt.

Japan—Atmospheric Electromagnetic Wave Research Center, Kyoto University. This joint research team with Nissan Motor Corporation has been investigating the transmission of electric power by microwave. They have successfully lit a lamp using this technology. Additionally, Kyoto University and the Institute of Space and Astronautical Science were successful in flying a model airplane using microwave. Research is now under way into the possibility of recharging an electric car while in motion.

Norway—SensoNor. SensoNor is world leader in the development of silicon MEMS devices, including pressure transducers and accelerometers, for automotive, medical, and industrial applications. These devices have already been implemented in a number of systems, including automotive crash sensors for airbag deployment. Current research is aimed at improving the reliability and sensitivity of the sensors, and integrating multiple devices in a single MEMS system.

8. Mechanical Sciences

Table E–30 summarizes international research capabilities in each major subarea of mechanical sciences.

a. Structures and Dynamics

The area of structures and dynamics consists of structural dynamics and simulation and air vehicle dynamics. Within structural dynamics, priority research applies to ground vehicle and multibody dynamics, structural damping, and smart structures. The goal of significant vibration reduction in Army vehicles offers substantial increases in weapons platform stability, weapons system reliability, weapons lethality, and crew performance. Within air vehicle dynamics, priority research applies to integrated aeromechanics analysis, rotorcraft numerical analysis, helicopter blade loads and dynamics, and projectile elasticity. In solid mechanics, research areas are the mechanical behavior of materials, integrity and reliability of structures, and tribology. These contribute to damage tolerance, damage control, and life prediction, while tribology contributes to lubrication, dynamic friction, and low-heat rejection.

In the field of structures and dynamics, the U.K., Germany, Italy, France, and Japan all demonstrate world-class capabilities in smart/active structures and M&S development. India, South Korea, China, Brazil, Israel, South Africa, Poland, Russia, and Ukraine all demonstrate potential future capabilities in the same area. However, the potential of Russia and Ukraine appears to be dwindling because of lack of resources. The U.K. also demonstrates a world-class capability in structural acoustic research and development.

Table E–30. International Research Capabilities—Mechanical Sciences

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Structures & Dynamics	❶ Smart/active structures; structural acoustics; M&S	❶ Smart/active structures; M&S	❶ Smart/active structures; M&S	❶ Smart/active structures; M&S	*India, China, South Korea* ❹ Smart/active structures; M&S	*Russia, Ukraine* ❹ Smart/active structures; M&S	*Italy* ❶ Smart/active structures; M&S *Brazil, Israel, South Africa, Poland* ❹ Smart/active structures; M&S
Fluid Dynamics	❶ CFD; theoretical ❷ Experimental	❶ CFD; theoretical ❷ Experimental	❷ Experimental ❺ CFD; theoretical	❶ CFD; theoretical ❺ Experimental		*Russia, Ukraine* ❻ CFD ❸ Experimental; theoretical	*Canada* ❶ CFD *Australia* ❺ Experimental; theoretical
Combustion & Propulsion	❶ Small GT; reciprocating engines; solid/liquid gun	❶ Small GT; solid gun ❹ Reciprocating engines	❶ Reciprocating engines; solid gun ❹ Small GT	❶ Reciprocating engines ❹ Solid/liquid gun; small GT	*South Korea* ❹ Solid gun; reciprocating engine *South Korea, India* ❺ Solid gun	*Russia* ❶ Novel gun propulsion ❷ Small GT; reciprocating engine	*Canada, Australia* ❶ Solid gun; reciprocating engines; small GT

Note: See page E–11 for explanation of key numerals.

b. Fluid Dynamics

Basic research in fluid dynamics can directly contribute to advances in predicting the capabilities of maneuvering projectiles. Future advances would enhance the ability to predict the capabilities of smart munitions, integrated propulsion systems, flight dynamics, guidance and control, and structural dynamics within the Army. Fluid dynamics research priority areas are unsteady aerodynamics, aeroacoustics, and vortex dominated flows. Complementary research on CFD of multibody aerodynamics would provide a capability to predict and define submunition dispensing systems. Multidisciplinary research in this area will lead to hypervelocity launch technology as well as low speed military delivery systems.

A balanced world-class capability in the theoretical, experimental and CFD elements of fluid dynamics research is not resident in any single foreign country. There are a number of examples of world-class capability in specific areas of research that hold promise for military applications. CFD studies in the U.K., France, and Japan can contribute significantly to missile, rotor, and explosive design. France and Japan also excel in theoretical ability and Japan also exhibits excellent experimental ability. The U.K., France, and Germany are maintaining a mature experimental capability. Both Russia and Ukraine have had mature experimental and theoretical ability; however, they show a declining capability, largely due to a lack of resources.

c. Combustion and Propulsion

Combustion and propulsion research supports advanced technology development providing continued advancement in small gas turbine engine propulsion, reciprocating engine propulsion, and solid, liquid, and novel gun propulsion technology. The development of high-performance small gas turbine engines requires basic research in turbomachinery stall and surge, as well as advances in CFD simulation. These basic research areas directly contribute to highly loaded, efficient turbomachinery components. This type of research is necessary to meet the integrated high-performance turbine engine technology goals of a 120 percent increase in turboshaft power-to-weight ratio. Reciprocating engine technology research tends to move forward at a more evolutionary pace with advances in ultra-low heat rejection, enhanced air utilization, and cold start phenomena as priority areas. Solid gun propulsion technology requires research priority to be placed on ignition and combustion dynamics and high performance solid propellant charge concepts. Liquid gun propulsion requires priority research in atomization and spray combustion, ignition and combustion mechanisms, and combustion instability, hazards and vulnerability. Novel gun propulsion depends on ECT propulsion, active control mechanisms, and novel ignition mechanisms.

In the combustion and propulsion area, the U.K. and France both demonstrate world-class capabilities in small gas turbine engine development. Canada, Germany, and Japan approach this level of capability in limited areas, but show good potential over the next decade to make significant contributions to small gas turbine power-to-weight ratio improvement. Germany leads in reciprocating engine development technology with Japan also demonstrating world-class capability. Both countries particularly excel in the application of ceramic materials to low heat rejection technology. The U.K. also demonstrates excellent reciprocating engine development capability, with France, Canada, Australia, and South Korea exhibiting good future potential. Russia and Ukraine both have demonstrated mature capability in the past, however, limited resources reflect a declining future potential. Novel gun propulsion technology leadership is still maintained by Russia, however, its future growth potential may be muted. Liquid gun propulsion development technology is led by the U.K., with Japan showing significant potential. Solid gun propulsion development technology is resident in a number of countries, including the U.K., France, Germany, Canada, and Australia. Japan and South Africa both demonstrate significant future potential.

The following highlight a few selected examples of specific facilities engaged in mechanical sciences research:

Europe—Optical Sensing Technologies for Intelligent Composites (OSTIC). The European community organized the OSTIC project to explore the developing field of "smart technologies." The participants include Strathclyde University and AEA Harwell Co. in England, Italy's CIS and Allenia Corp., EDF in France, and Germany's MBB Corp. This research is focused on health monitoring by fiber optical embedding in composites, airplane maintenance surveillance systems, signal processing, and neural network processing and device technologies.

Germany—German Aerospace Research Establishment (DLR). The DLR constitutes seven research centers and 26 institutes. Its mission is to develop new technologies, perform scientific investigations, and test materials and equipment s in cooperation with numerous national and international industries and universities. Specific institutes include the Institute of Fluid Mechanics, the Institute of Structural Mechanics, and the Institute for Structures and Design. Its basic research focus is on aviation, space flight, and energy technology. Current research includes studies in structural control in relation to vibrational control for space structures, fixed-wing planes, and helicopters.

France—Aerospatiale Space and Defense. Aerospatiale has expertise in the field of computational fluid mechanics. In particular, it excels at numerical modeling of rarefied gases, modeling of moving bodies, and modeling of viscous reactive flows for complex geometries not in chemical or vibrational equilibrium. Aerospatiale is responsible for proposing and carrying out design analysis on such systems as launchers, missiles, satellites, and space capsules. Research projects are multidisciplinary and are typically about 10 years in duration.

Japan—Engineering Research Association for a Supersonic/Hypersonic Transport Propulsion System Project. The Japanese government's New Energy and Industrial Technology Development Organization established a project which has the goal of developing the technologies needed for the production of a supersonic commercial jetliner that has a low-noise propulsion system, good fuel consumption, low levels of exhaust emissions, and has the ability to reach speeds of Mach 5. Its research is focused on ramjets, high-performance turbojets, measurement and control systems, and ultra-high-temperature generators.

United Kingdom—Aerophysics, Defense Evaluation and Research Agency (DERA). Aerophysics is a part of the DERA Weapon Systems Sector. It executes a coordinated program of R&D in the areas of aerophysics and hypersonic flows. Within the section, an integrated group of experimental and computational scientists and engineers, with a wide variety of technical expertise and backgrounds, work closely together. Notable ongoing research is in the field of plasma aerodynamics. A joint U.K. DERA / Ministry of Defense (MoD) research initiative to examine FSU claims of significant drag reduction with applications to aircraft and missiles is currently under way.

9. Atmospheric Sciences

Much present and future basic research in the atmospheric sciences focuses on the atmospheric boundary layer where the Army operates at high time and spatial resolution. The proliferation of sensing satellites, ground weather collection sites, and advances in M&S have brought about a significant capability to predict local and regional weather. Much remains to be done to provide the needed lower atmospheric data to support the rapid increase of smart and brilliant weapons whose operation can be affected by weather phenomena. Work in propagation, remote sensing, and boundary layer meteorology will contribute significantly to understanding lower atmospheric phenomenology. Table E–31 shows most of the industrialized countries have capabilities in certain niches of these research areas.

a. Propagation and Remote Sensing

These research thrusts stress fundamental understanding of the atmospheric boundary layer and the processes of its interaction with the natural ground surface. These issues have direct bearing on CBD, atmospheric effects on weapon systems and operations, and predictability of atmospheric conditions. Remote sensing of wind fields enables detection of hazardous winds in aircraft landing zones, paradrop zones, and accidental release of hazardous gases or aerosols. Active and passive remote sensing research is essential to detection of objects in snow or on the ground, modeling and rapid detection of natural and manmade features, including camouflage, and MMW propagation at low grazing angles over and through a variety of vegetation.

The United States and Russia have been sharing space solar flare radiation data, which has aided in better prediction of communication and GPS navigation variances due to atmospheric scintillation in the equatorial and polar regions of the world. The flow of both weather data and research information to all members of the World Meteorological Organization is well established and for the foreseeable future this collaboration will continue. The U.K. and Germany have advanced programs in global and regional weather prediction. Japan has advanced work ongoing in ionosphere and troposphere interactions and predictions. France and Russia have wide technology coverage as well, with significant programs in atmospheric phenomenology. Canada, the Netherlands, Denmark, Brazil, Israel, and China have narrower coverage, but can still make substantial contributions in niche areas.

Table E–31. International Research Capabilities—Atmospheric Sciences

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Propagation & Remote Sensing	❷ Atmospheric backscatter; global & regional weather prediction	❷ Atmospheric electricity–aircraft interactions; IR physics of the atmosphere	❷ Atmospheric environmental prediction	❷ Ionosphere & troposphere interactions & predictions	*China* ❺ Upper atmosphere testing	*Russia* ❷ Solar flare prediction; atmospheric spectral transmissivity	*Canada* ❷ Ice flow & weather prediction; tracer technology for atmospheric dispersion *Netherlands* ❷ IR celestial background *Denmark* ❷ Polar/cap & aerial ionosphere interactions *Brazil* ❷ Weather & ionosphere experiments *Israel* ❷ LIDAR measurements
Boundary Layer Meteorology	❷ Low-level weather prediction	❷	❷ Low-level weather prediction	❷ Tropical cyclone; urban pollution		*Russia* ❷ Low-level weather prediction	*Canada* ❶ Atmospheric dispersion technology *Israel* ❷ Low-level weather prediction *Denmark* ❷ Atmospheric turbulence *Italy, Poland* ❺ Atmospheric physics

Note: See page E–11 for explanation of key numerals.

b. Boundary Layer Meteorology

Boundary layer meteorology research improves characterization of boundary layer processes over land in weather prediction models. It also supports multiple functions of the Army's integrated meteorological system in intelligence preparation of the battlefield. Research in turbulent dispersion of aerosols and gases leads to a significantly improved dispersion model applicable to open detonation/open burning of munitions; improved prediction of transport and diffusion of NBC materials on short time and space scales, over varied terrain shapes and ground covers, and all times of day; and modeling effectiveness of smoke and other obscurants in realistic scenarios.

Many countries have focused their weather development programs on regional issues, such as Japan in pollution monitoring of tropical cyclones. Results of these efforts will have multiple applications across the full spectrum of weather modeling and prediction. The U.K., France, Israel, Germany, Japan, and Russia have strong technology coverage in low-level weather prediction. Canada has significant capability in the development of atmospheric dispersion technology, while Italy, Poland, and Denmark have niche capabilities in areas of atmospheric physics.

The following highlight a few selected examples of specific research facilities engaged in work in the atmospheric sciences:

United Kingdom—Center for Marine and Atmospheric Science (CMAS), University of Sunderland. CMAS is the U.K.'s newest center entirely focused on meteorological studies. Research is primarily done in the areas of cloud and aerosol physics. The center originated in the atmospheric physics program at the University of Manchester Institute of Science and Technology and continues to maintain close contact. It is composed of a rather small group of tightly focused researchers whose main focus is on the formation and evolution of marine aerosols. Additional research is done on aerosol impact on boundary layer optical propagation and climate.

United Kingdom—Department of Meteorology, University of Reading. The university houses the United Kingdom's largest academic meteorology program. The research program has two main thrusts, global scale atmospheric dynamics and synoptic and mesoscale meteorology, with smaller thrusts in radar meteorology, radiative transfer, tropical satellite data applications, atmospheric chemistry, and oceanography. Research in boundary layers and micrometeorology includes work on flow over hills and the development of new instruments that apply acoustic thermographic techniques to measure humidity. Other programs include atmospheric modeling, studies into the behavior of tropical cyclones, and cloud and precipitation research.

Italy—Institute of the Physics of the Atmosphere. The institute is CNR, Italy's largest institute devoted to atmospheric research. Work here is primarily involved in atmospheric research, with thrust areas including remote sensing, polar stratus, and atmospheric dynamics. Remote sensing studies include the use a spectrum of sensors from the visible through the RFs, including LIDAR and Italy's SODAR, to study the atmosphere, as well as satellite-based precipitation work. Work in atmospheric dynamics concentrates largely on modeling to study mesoscale regional dynamics.

Poland—Warsaw University of Technology, Institute of Environmental Engineering Systems, Meteorology and Air Pollution Division. Research focuses on boundary layer meteorology, numerical modeling of atmospheric processes, environmental aspects of energy production, and air pollution. Past projects include the development of a mesoscale dispersion modeling system for pollution and radioactive wastes, and the development of a short-range air pollution predicting system for small geographical areas. Current work includes developing techniques for wind energy assessment in regions of complex topography, work on an operational mesoscale weather prediction system, and tropospheric chemistry modeling.

10. Terrestrial Sciences

Basic research in terrestrial sciences studies terrain characteristics and processes, including topography, climatology, and hydrology. These critically affect all aspects of mission planning, logistics, unit effectiveness, and system performance. Knowledge of the topographic, geological, climatological, and hydrological character of the landscape are critical to mobility / countermobility, logistics, communications, survivability, and troop and weapons effectiveness. The digital battlefield also requires detailed and sophisticated information about topography as well as terrain and environmental features and conditions. Terrestrial sciences research in two broad areas is of particular importance to Army goals: solid earth sciences, and hydrodynamics and surficial processes. Table E–32 highlights international research capabilities in terrestrial sciences.

Table E-32. International Research Capabilities—Terrestrial Sciences

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Solid Earth Sciences	❶ Retrofit materials systems	❷ Geotechnical materials	❷ Structural response	❷	*China, India* ❺		*Australia* ❺ Geosciences *Sweden* ❺ Soil remediation *Canada* ❷ *Italy* ❺
Hydrodynamics & Surficial Processes	❶ Hydrology	❷ Hydrology	❺	❷	*India* ❹ *China* ❺	*Russia* ❺	*Israel* ❷ Stochastic hydrology *Canada* ❷ Hydrogeology *Australia* ❷ *Netherlands* ❹

Note: See page E–11 for explanation of key numerals.

a. Solid Earth Sciences

This field contributes to the characterization of the surface geometry and terrain features needed for enhanced planning and tactical decision making, as well as for designing equipment to the challenges of the natural environment. Research in topography and terrain seeks to develop new remote sensing data acquisition capabilities, data synthesis, and analysis techniques to develop topography and terrain database information. This work is supported by studies of the dynamic physical processes involved in the interactions between surface features and materials and the atmospheric boundary layer and weather systems, in order to produce highly sophisticated models of dynamic environmental effects on mission performance. Geotechnical engineering research focuses on the strength and behavior of natural materials under a variety of external forces, both natural and manmade. This includes studies of the properties of snow, ice, and frozen ground, as well as soil dynamics and structural mechanics.

International capabilities in areas related to Army goals include research on retrofit material systems in the U.K., geotechnical materials research in France, and precision experiments in structural response in Germany. Many other countries have significant capabilities in niche areas of solid earth sciences, including Australia, Japan, India, Canada, Italy, Sweden, and China.

b. Hydrodynamics and Surficial Processes

Basic research in hydrodynamics relates to the hydrologic cycle and focuses on hydrometeorology, rainfall/runoff dynamics, and fluvial hydraulics as well as the relationship between surface and groundwater hydrology. Research in surficial processes relates to the geomorphological character of the surficial environment, primarily the physical processes operating in arid/semiarid, tropical, and coastal environments. This work contributes to the ability to estimate hydrologic and physical response and, therefore, to the ability to accomplish specific activities within a range of expected environmental conditions. International capabilities in areas of research related to Army goals include studies of hydrogeology in Israel and Canada, and magnetohydrodynamics and hydrology work in France and the United Kingdom. Other countries with active basic research programs in this area include Japan, Australia, India, China, Russia, and the Netherlands.

The following highlight a few selected examples of specific facilities engaged in terrestrial sciences research:

United Kingdom—Department of Engineering Science, Oxford University. Research includes work in reinforced soil design aimed at calculations and design methods for practical application. These methods stem from the understanding of behavior developed through laboratory research and instrumented field experiments. These studies can contribute to selection of design safety parameters for reinforced soil, including the use of polymer reinforcement materials. Work has recently been focused on the use of reinforcement over poor ground for the construction of embankments and unpaved roads. New analyses have been developed for both cases, using plasticity theory for the embankment and a limit equilibrium analysis for unpaved roads.

Sweden—Department of Chemical Engineering and Technology, Royal Institute of Technology. Research in electrokinetic remediation attempts to develop new technologies for soil remediation. This process applies a low-level direct current to the polluted soil by electrodes placed in the ground to remove inorganic and organic contaminants from the soil by dissociation. This low-cost process can be used in a variety of soil types and is applicable equally to coarse- and fine-grained soils. The specific goal of the research effort is to study the transport and chemistry in the electrokinetic process and to improve the electrokinetic remediation technology.

Israel—Department of Fluid Mechanics and Heat Transfer, Tel Aviv University. Research includes work in theory of flow through porous media and groundwater hydrology. Other activities involve the modeling of water flow and contaminant transport in the upper soil layer and in aquifers. Subjects of environmental concern such as transport of radioactive waste in highly heterogeneous formations, motion of chemically reactive contaminants, and modeling of multiphase flows at field scale are planned for investigation in the coming years, as well as research on the impact of uncertainty on hydrological prediction.

Canada—National Hydrology Research Institute. Hydrologic model development and applications research concentrates on the hydrology of northern regions in both the arctic and subarctic regions of Canada. Current distributed hydrologic models are used to estimate components of the hydrologic cycle in two specific test regions. This approach utilizes detailed, satellite-derived land-cover information, along with physiographic and climate data. To advance this research, new modeling techniques that can be applied in distributed hydrologic models are being developed. Other research efforts include work to incorporate permafrost components in these models and characterization of snow cover distribution.

Russia—Hydrometeorological Centre of Russia. The main directions of research include studies of regional and mesoscale hydrometeorological processes; modeling of ocean processes, the study of ocean-atmosphere interaction and the interaction of atmosphere with hydrological processes over the land, and development of new methods for hydrometeorological forecasting within different time scales. One specific program involves mathematical modeling to develop systems of long-range forecasts of hydrological regime of large chains of reservoirs and methods of forecasting hazardous events on mountain rivers. This approach rationalizes calculations and long-range forecasts of freezing and break-up of rivers and reservoirs and discharge hydrographs of mountain rivers using precipitation and temperature data.

11. Medical Research

Basic research efforts in the medical sciences related to military missions address four areas: infectious diseases of military significance, combat casualty care, Army operational medicine, and medical CBD. The first relates to protection/prophylaxis of personnel deployed to a mission area from indigenous organisms or to biological agents; the second to care of personnel following acute injury; the third to enhancers/sustainers of performance in the field; the fourth to treatment and care of persons following exposure to biological agents. These areas of investigation are dual use and impact general health care delivery, although the military aspects often differ from civilian concerns in several critical instances. For example, deployed military personnel may be more susceptible than indigenous populations to infectious agents because of a lack of prior exposure. Also, developing novel means useful in delaying onset of clinical disease in the face of the physically and mentally demanding nature of combat is of critical importance, as incapacitating military forces for short periods may have profound effects on the outcome of operations. Table E–33 summarizes international capabilities in medical research.

a. Infectious Diseases of Military Significance

Basic research in infectious diseases of military significance concentrates on prevention, diagnosis, and treatment of infectious diseases affecting readiness and deployment.

The Human Genome project has identified those gene profiles that render specific populations more susceptible to disease than other populations. This project is a multinational effort spearheaded by the United States, EC, and Japan; the information is freely available on the Internet. Novel combinatorial chemistry strategies have allowed the synthesis of nonpeptide molecules that bind gene fragments, receptors, or cell proteins and thereby offer the potential of protection against threat agents. These same materials also may provide utility in multiarray sensors used for the detection of biological agents. Combinatorial chemistry strategies are being pursued in many developed nations through the pharmaceutical sector. Switzerland, Sweden, and Israel have expertise in these areas, as do the abovementioned nations.

b. Combat Casualty Care

The critical areas of care for combat casualties in the next decade include treatment for fluid loss and accompanying shock, management of impact injury on the nervous system including the spinal cord, increased susceptibility to infection at points of projectile entry because of stress related events, and prevention of biological agent dissemination by friendly forces exposed to agents. Biocompatible materials that bind oxygen and have utility as blood expanding agents are in development in the U.S., EC, and Japan. Cellular growth factors acting on neural tissues have been found to stimulate the repair of transected spinal cord and other central nervous system regions. Macromolecular growth factors, acting on tissues other than the nervous system, have been shown to enhance the rate of wound healing and to increase resistance to disease. This research is actively explored in the the United States, Canada, Germany, the U.K., France, Japan, Israel, Italy, and Sweden.

Table E–33. International Research Capabilities—Medical Research

<table>
<tr><th>Technology</th><th>United Kingdom</th><th>France</th><th>Germany</th><th>Japan</th><th>Asia/Pacific Rim</th><th>FSU</th><th>Other Countries</th></tr>
<tr><td>Infectious Diseases of Military Significance</td><td colspan="3">❶ Human genome & disease susceptibility
❶ Nonpeptic antivirals
❶ Rapid diagnosis
❶ Vaccines
❶ Delivery of vaccines post exposure</td><td>❶ Human genome & disease susceptibility
❶ Nonpeptic antivirals
❶ Rapid diagnosis
❶ Delivery of vaccines post exposure</td><td>China
❶ Nonpeptic antivirals
❶ Rapid diagnosis</td><td>❷ Human genome & disease susceptibility
❷ Nonpeptic antivirals
❷ Rapid diagnosis</td><td>Switzerland
❶ Human genome & disease susceptibility; vaccines
Switzerland, Sweden, Israel, Italy, Netherlands
❶ Nonpeptic antivirals
Switzerland, Sweden, Israel, Italy, Netherlands
❶ Rapid diagnosis
Switzerland, Sweden, Israel, Netherlands
❶ Delivery of vaccines post exposure</td></tr>
<tr><td>Combat Casualty Care</td><td colspan="3">❶ Manage acute trauma shock (blood loss, CNS change, & perfusion)
❶ Pharmacology of wound healing & CNS injury repair
❶ Containment of personnel & equipment after exposure (containment pods & telemedicare)</td><td>❶ Manage acute trauma shock (blood loss, CNS change, & perfusion)
❶ Pharmacology of wound healing & CNS injury repair</td><td>China
❶ Manage acute trauma shock (blood loss, CNS change, & perfusion)
❶ Pharmacology of wound healing & CNS injury repair</td><td></td><td>Switzerland, Italy, Sweden, Israel
❶ Manage acute trauma shock (blood loss, CNS change, & perfusion)
Switzerland, Italy, Sweden, Israel
❶ Pharmacology of wound healing & CNS injury repair
Italy, Sweden, Israel
❶ Containment of personnel & equipment after exposure (containment pods & telemedicare)</td></tr>
<tr><td>Army Operational Medicine</td><td>❶ Biomarkers for toxicant exposure (GST, P450, acute phase proteins)
❶ Nutrient additives
❶ Countermeasure to intense noise</td><td>❶ Biomarkers for toxicant exposure (GST, P450, acute phase proteins)
❶ Countermeasure to intense noise</td><td>❶ Biomarkers for toxicant exposure (GST, P450, acute phase proteins)
❶ Nutrient additives
❶ Countermeasure to intense noise</td><td>❶ Countermeasure to intense noise</td><td></td><td></td><td>Israel, Sweden
❶ Biomarkers for toxicant exposure (GST, P450, acute phase proteins)
Sweden
❶ Nutrient additives
Israel, Sweden
❶ Countermeasure to intense noise</td></tr>
<tr><td>Medical Chemical and Biological Defense</td><td colspan="4">❶ Immune response enhancers (interferor, interlukin)
❶ Intracellular transport molecules (M protein)
❶ Block viral docking & replication
❶ Enhance uptake of drups to cells (Botox)</td><td>Taiwan
❶ Enhance uptake of drups to cells (Botox)
China
❶ Immune response enhancers (interferor, interlukin)</td><td>❶ Immune response enhancers (interferor, interlukin)
Enhance uptake of drups to cells (Botox)</td><td>Sweden, Israel, Switzerland, Netherlands
❶ Immune response enhancers (interferor, interlukin)
❶ Intracellular transport molecules (M proteint)
❶ Block viral docking & replication
❶ Enhance uptake of drups to cells (Botox)</td></tr>
</table>

Note: See page E–11 for explanation of key numerals.

c. Army Operational Medicine

Basic research within the Army operational medicine research area provides a basic understanding of the pathophysiology of environmental and occupational threats affecting soldier health and performance. In addition to the risks to health and performance from operations in extreme climatic environments, and the rigors imposed by military operations in and of themselves (e.g., sleep deprivation, jet lag, stress), operation of Army systems may present additional health hazards (e.g., EM radiation, noise, vibration, blast, and toxic chemical by-products).

Biomarkers for toxicant exposure in humans and animals have been identified as materials that are body catalysts and enzymes that serve to detoxify chemicals. The absence of some of these normally occurring enzymes in specific persons has been shown to increase susceptibility to disease. It is now possible to screen blood and urine samples and determine the concentration of these biomarkers in selected persons. It is likely that biomarker profiles will have utility in selection of persons resistant to toxicants (for special operations) and for reviewing fitness for duty. The Human Genome project is likely to increase the number of biomolecules that can serve as biomarkers for exposure. The United States, Canada, EC, and Japan have expertise in this area.

d. Medical, Chemical and Biological Defense

Foreign efforts in medical chemical defense closely parallel those in medical biological defense. For the most part, countries that are engaged in one are also active in the other. The one exception for countries listed is the Netherlands. The Dutch effort in medical chemical defense is not as extensive as in medical biological defense. All countries listed have world leading capabilities and none is expected to pull ahead of the others.

Normally occurring biomolecules have now been identified that enhance or degrade the immune response of persons to infectious material or to toxins. These materials are called biological response modifiers (BRMs). Treatment with novel BRMs, of military forces who may have been exposed to pathogenic agents as a consequence of deployment or through biological agent attack, may enhance the survival or sustain the performance of the affected personnel. In the past few years, it has been shown that transport of infectious materials across cell membranes is a critical element in viral replication and maturation. Chemical treatment that interferes with the ability of a virus to bind to a target cell or with intracellular transport can impede viral multiplication and infectivity; such treatments may sustain performance of affected personnel for long periods after exposure to such agents. The United States, Japan, France, the U.K., Germany, Sweden, and the Netherlands are leaders in this area.

The following highlight a few selected examples of specific facilities engaged in medical research:

Russia—State Scientific and Technical Program. Organized through the Russian Academy of Medical Sciences, the program has developed of number of R&D projects unified in six thrust areas. These include development of medicinal substances to regulate immune processes, development of agents affecting hemostasis processes, computer designing of new medicinal substances, and pharmacokinetic and biopharmaceutical principles of improvement in medicinal preparations. The program oversees the collaboration of over 3,500 specialists and 75 organizations, including the Russian Academy of Sciences, Russian Academy of Medical Sciences, the Russian Federation (RF) Ministry of Health Care, and the medical industry. Recent research results include the development of a number of medicinal substances that regulate immune responses, including antitumoral agents, immunomodulating agents, and antiarrythmic preparations.

Japan—Chemical Research Center. The Cytoprotein Network project involves the codification of human proteins through the synthesis of full-length cDNA rather than fragments. This technique produces proteins both in vitro and in vivo directly from full-length cDNA clones and is thus able to rapidly identify a large number of proteins as well as the genes that are coded for them. The functions of some of these 10,000–20,000 intracellular proteins (cytoproteins) are known. Many of them have a maintenance function, whereas others are specific to certain cells. Research to better understand them, their movements (by tagging the proteins with fluorescent markers) and functions is concentrated into three areas. These include the cloning of full-length cDNAs, a search for novel sorting signal sequences, and in vitro translation of cDNAs to find receptors and their ligands.

France—National Health and Medical Research Institute (INSERM). INSERM was founded in 1964 as France's central agency for health research. It performs basic and applied research, technical development, and medical surveys. The primary objective of INSERM is to participate actively in biomedical research in order to increase knowledge of human health and thereby improve the diagnosis, therapy, and prevention of illness. Its supplementary missions include applications development, information exchange, research training, and international relations. INSERM participates in a number of European Science Foundation programs, including projects on environmental and health, the European Neuroscience Programme, molecular neurobiology of mental illness, and toxicology programs.

United Kingdom—Department of Medical Microbiology, University of London. Research in this department within St. Bartholomew's and the Royal London School of Medicine and Dentistry has thrusts in microbial pathogenicity, antibiotics, and molecular epidemiology. The microbial pathogenicity research group studies the molecular and genetic basis of microbial infection and attempts to apply this knowledge to clinical problems. Specific research focuses on the fundamental pathogenic properties of enteric pathogens. Within this area, individual projects focus on the genetic regulation of virulence, bacterial host cell interactions and the development of vaccines and vaccine delivery systems. Future goals include the exploitation of available genome sequence data from several bacterial pathogens with a view to the development of improved vaccines, diagnostic, epidemiological and therapeutic agents.

Japan—National Cancer Center. Located in Tokyo, Japan, this center is developing applications of VR technology in medicine. It specializes in medical imaging and development of enhanced VR tools for image-guided surgery. Research goals include improving patient amenity with VR and the development of new diagnosis methods for medical imaging using VR technology. These VR systems have several advantages for surgical applications, including ease of repetition of medical procedures, application of surgical experiences to develop models from individual patients' medical images, self-training on surgical procedure in real time, and objective evaluation by remote supervisors.

12. Biological Sciences

Basic research in the biological sciences contributes directly to a knowledge of food production in deployed areas, production of potable water, protection of military personnel from infectious agents in a deployed region, production of sensors for CB agents, reduction of signatures to increase stealth, and the production of materials useful in communications, sensing, and self-assembly. Biomaterials have the ability to self-assemble (phospholipids), transduce light and pressure to electrical signals, and encode large amounts of information in very small areas or volumes (the entire genetic information for a human resides in each cell nucleus that has a diameter of 5 micrometers or less).

Table E–34 summarizes international research capabilities in the technical areas of biological sciences. These include biochemistry, biophysics, and molecular biology, microbiology, physiology, and pharmacology, biodegradative processes, food science, and bioscience. Biochemistry, biophysics, and molecular biology examine the structural and functional properties of biopolymers (such as DNA and RNA) involved in information storage, the catalytic properties of proteins that function as enzymes, and the recognition properties of proteins that function as antibodies and receptors. Microbiology, physiology, and pharmacology areas concern the role of intact cells, cell membranes, and ion fluxes

Table E–34. International Research Capabilities—Biological Sciences

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Biochemistry, Biophysics, & Molecular Biology	❶ Combinatorial chemistry; Genome project; receptor characterization; NMR	❶ Genome project; receptor characterization	❶ Combinatorial chemistry; Genome project; receptor characterization	❶ Genome project; receptor characterization; NMR		*Russia* ❸ Transducer molecules; receptor characterization	*Netherlands* ❶ Transducer molecules; NMR *Israel* ❶ Receptor characterization *Australia, Israel* ❶ Combinatorial chemistry *China* ❹ Surface characterization *Korea, Brazil* ❹
Microbiology, Physiology, & Pharmacology	❶ Microbial products for nutrition; stress resistance	❶ Nutrient additives	❶ Sensing mechanisms; nutrient additives	❶ Visual sensing; metabolic products		*Russia* ❸ All areas	*PRC* ❹ Nutrient additives; biological response modifiers
Biodegradative Process	❶ Bioremediation	❶ Bioremediation	❶ Bioremediation; water purification	❶ Bioremediation		*Russia* ❷ All areas	*Israel* ❶ Bioremediation; water purification
Food Sciences	❶ Nutritional additives from microbiological products; protein stabilizers	❶ Nutritional additives from microbiological products; protein stabilizers	❶ Protein stabilizers; encapsulation; shelf life; IR irradiation	❶ Protein stabilizers		*Russia* ❷ All areas	*Netherlands, Switzerland* ❶ Protein stabilizers; encapsulation; sugar modification
Biosciences	❶ PHB plasticizer; energy transduction; biomaterials for tensile strength	❶ Energy transduction; biomaterials for tensile strength	❶ Energy transduction; biomaterials for tensile strength	❶ Biomaterials for tensile strength		*Russia* ❷ All areas	*Israel, Australia, Netherlands* ❶ Energy transduction; Biomaterials for tensile strength

Note: See page E–11 for explanation of key numerals.

across membranes in the operation of the intact organism. The biodegradative processes area addresses remediation of soil and water to produce a potable end product, and reduce signatures. Food science investigates mechanisms to increase shelf life of food and the nutritional quality of food. The bioscience area is concerned with the use of biopolymers as structural materials—ceramics, silks, signal transducers, etc.

a. Biochemistry, Biophysics, and Molecular Biology

The Human Genome project utilizes biochemistry (combinatorial chemistry), biophysics, and molecular biology to explore questions of intrinsic disease susceptibility in humans and crops. These technologies also reveal the nature of molecules that allow viruses to infect cells and allow cells to communicate with each other (i.e., receptors). Since the effect of toxins on cells is a result of their action on specific cell receptors, these technologies reveal how we can neutralize toxins. The Russians had developed expertise in the use of biological toxins to deliver molecules to specific cells. The Russian capability has decreased in many of these areas during the past 5 years, but still remains strong in targeted delivery (associated with MOD laboratories). The U.K., Canada, Japan, EC, Taiwan, Russia, Sweden, China, Korea, Brazil, and Israel have capabilities in these areas. A number of nations have strong programs in the characterization of biomolecules, for example surface characterization work in China, and nuclear magnetic resonance (NMR) studies in Japan, the Netherlands, and the U.K.

b. Microbiology, Physiology, and Pharmacology

Microbiology, physiology, and pharmacology are essential sciences in the production of fermented and processed foods (bread, yogurt, beer, and wine), of pharmaceuticals and human hormones (the latter using genetic engineering), and in evaluating human performance (neural function and vital signs). The U.K., Japan, Germany, France, and Russia have a long tradition of expertise in these areas. Hungary has an established capability in production of fermenters. China has a developing capability in nutrient additives and biological response modifiers.

c. Biodegradative Process

Remediation of soils and water using biological organisms to metabolize contaminants has been an area of extensive research in the past decade. The U.K., France, Germany, Netherlands, Sweden, Finland, Japan, Russia, and Israel have expertise in this area, with the U.K. and Israel particularly active in water purification.

d. Food Sciences

The preparation of nutritious, palatable foods with long shelf life and biodegradable containers is the focus of the fourth set of technologies. This includes research in nutrient additives, protein stabilizers, and sugar modification, as well as the synthesis of biopolymers for use as elastomers in food containers. Encapsulation and irradiation technologies have been used to increase shelf life and encapsulation also increases palatability. Most EC nations and Japan have advanced food technology programs. Strong capability in the use of biopolymers as packaging is primarily resides in the EC.

e. Biosciences

The use of biomaterials as structural elements or as models to construct nonbiological materials that function as biomimetics has grown along with the demand for miniaturization. Polyhydroxybutyrate and silks are two examples of biomaterials with good tensile properties. The U.K., France, Germany, Israel, the Netherlands, and Australia are developing advanced biomaterials for energy transduction applications. New materials emerging from nanotube technology, ceramics based on marine shell structures, and isolated bacterial rhodopsin (bR) have applications in signature reduction and information storage. Russia, in collaboration with the former Former East Germany (FDR), utilized bR to construct a read/write device called biochrome. The reduction in financial resources in the FSU has caused a decline in this capability. A biochrome material is currently available from Germany. The U.K., Japan, France, the Netherlands, and Israel also have strong capabilities in this area.

The following highlight a few selected examples of specific facilities engaged in biological sciences research:

United Kingdom—Biotechnology and Biological Sciences Research Council (BBSRC). BBSRC supports basic and applied research into the exploitation of biological systems and technologies for use in agriculture, bioprocessing, chemical, food, health care, pharmaceutical, and other biotechnology industries. It supports a number of international collaborative efforts, including the International Scientific Exchange Scheme for personal level collaboration, as well as broader memoranda of understanding with most western European nations and the U.S. Department of Agriculture. BBSRC also runs a number of world-class research institutes. Among these is the Roslin Institute in Edinburgh, which recently announced the cloning of a sheep, as well as the Oxford University Centre for Molecular Sciences, a leader in research in protein molecules.

Belgium—Flanders Interuniversity Institute for Biotechnology (VIB). VIB is a consortium of nine university research centers aimed at stimulating research and promoting implementation of its results. The initial program has been funded for 5 years at approximately 5 billion Belgian francs. A number of projects are also linked to industry (e.g., companies such as Plant Genetic Systems, Innogenetics, and Antwerp Bionic Systems). Areas of research interest include molecular biology, gene therapy, immunology, and neurogenetics.

Japan—Tsukuba Research Center. Located near Tokyo, Japan, the center is noted for expertise in NMR spectroscopy and molecular surface structure studies. One institute within the center, the National Institute of Bioscience and Human Technology, conducts leading and innovative research in the fields of bioscience and human technology. The institute now concentrates not only on basic researches on biological chemistry, physics, biophysics, biotechnology, human engineering, and surface chemistry, but also on development of advanced new technologies relating to energy, environmental, and medical applications.

Israel—Weizmann Institute. Located in Rehovet, Israel, the institute has expertise in sensor biopolymer components, thin films, and self-assembly of biomaterials. A major area of activity concerns the crystallography of macromolecules and macromolecular assemblies, including proteins, DNA, ribosomal particles, and their complexes. Dynamical aspects of protein structures and interactions in solutions are studied by NMR in peptides, small proteins, and antibody/antigen complexes. The molecular biological approach to structural biology is represented by research antibody/antigen interaction and chaperone activity. The adaptation of organisms to extreme environment and the mechanism of muscular contraction are being investigated by biophysical techniques.

Australia—Ship Structures and Materials Division (SSMD), Defence Science and Technology Organization. SSMD conducts research into the defensive and disarmament aspects of CW agents, including detection of chemical agents, protective clothing, respiratory protection, decontamination of personnel and equipment, and prophylaxis and therapy of poisoning. SSMD develops methods to detect trace levels of relevant chemical residues and conducts research on rapid screening methods required for the monitoring of chemical industry. SSMD's program in food science focuses on the determination of the energy and nutritional requirements of active military personnel, together with assessments of the nutritional values of feeding systems, and the effects of long-term storage on flavor, texture, and nutrients of food.

China—University of Science and Technology (USTC). USTC, located in Hefei, Anhui Province, is a leading center for biological research in Asia. The facility has world-class capabilities in synchrotron and laser chemistry programs for thin film studies of biological materials. Academician Zhu heads the laser program. There is also a very good research program in the analysis of protein structure by NMR.

13. Behavioral, Cognitive, and Neural Sciences

Table E–35 summarizes international research capabilities in the four areas recognized by the Army behavioral, cognitive, and neural sciences program: cognitive skills and abilities, perceptual processes, noncognitive skills and abilities, and leadership. Basic research in these areas contributes directly to the ability of a soldier to analyze and act on information presented on a video display terminal (multimodal display systems and iconography), training in virtual and constructed realities, and determining fitness for duty as well as when training goals have been achieved.

Table E–35. International Research Capabilities—Behavioral, Cognitive, and Neural Sciences

Technology	United Kingdom	France	Germany	Japan	Asia/Pacific Rim	FSU	Other Countries
Cognitive Skills & Abilities	❶ Distributed simulation & constructed reality (U.S. ADS system) ❶ Iconograph compatibility with human user ❶ Vital sign remote	❶ Distributed simulation & constructed reality (U.S. ADS system) ❶ Iconograph compatibility with human user	❶ Distributed simulation & constructed reality (U.S. ADS system) ❶ Iconograph compatibility with human user ❶ Vital sign remote	❶ Iconograph compatibility with human user	*Taiwan, Malaysia* ❶ Distributed simulation & constructed reality (U.S. ADS system) *South Korea, China* ❶ Iconograph compatibility with human user	❸ Distributed simulation & constructed reality (U.S. ADS system)	*Israel, Sweden, Netherlands, Canada* ❶ Distributed simulation & constructed reality (U.S. ADS system) ❶ Iconograph compatibility with human user
Perceptual Processes	❶ Multimodal data presentation (couple visual presentation on display panel with auditory display) ❶ Iconographic compatibility with human user				*South Korea, China* ❶ Iconographic compatibility with human user	❸ Multimodal data presentation (couple visual presentation on display panel with auditory display) ❸ Iconographic compatibility with human user	*Netherlands, Canada, Israel* ❶ Multimodal data presentation (couple visual presentation on display panel with auditory display)
Noncognitive Skills & Abilities	❶ Neurophysiological measures of human performance ❶ Pharmacological performance sustainers ❶ Stress reduction	❶ Neurophysiological measures of human performance ❶ Pharmacological performance sustainers ❶ Neuropsychological profile	❶ Neurophysiological measures of human performance ❶ Pharmacological performance sustainers ❶ Stress reduction	❶ Neurophysiological measures of human performance ❶ Pharmacological performance sustainers ❶ Neuropsychological profile	*South Korea, China, Taiwan* ❶ Neurophysiological measures of human performance ❶ Pharmacological performance sustainers ❶ Neuropsychological profile	❸ Pharmacological performance sustainers ❸ Stress reduction	*Israel, Sweden, Netherlands, Canada* ❶ Neurophysiological measures of human performance ❶ Pharmacological performance sustainers ❶ Neuropsychological profile
Leadership	❷		❶ Multinational force integration	❶			*Canada* ❷

Note: See page E–11 for explanation of key numerals.

a. Cognitive Skills and Abilities

The current era in C^2 systems is characterized by acquisition of such large amounts of data simultaneously that processing of the information is limited by perceptual processes of the human mind. To manage this reality, C^3 systems have made progress in iconographic representations and in multimodal data presentation by using auditory input to complement visual display systems. Color-coded icons can be used to present complex data in a relatively simple manner. Auditory cues improve the operator's attentiveness and response to changing incoming data. Nonetheless, as our ability to sense battlefield conditions improves through the use of multiarray sensors, the amount of information to be processed will increase dramatically. The task then is to present the large volume of data in a compressed and comprehensible manner.

Research in cognitive skills and abilities concerns data, models, and theories relating to how individuals acquire, process, store, and use information. Wide-ranging programs of basic research on skill acquisition, retention, and transfer are supported by most major universities and research institutions in northern Europe and Canada. In addition, other countries provide opportunities for collaboration on more narrowly defined topics within this area. An example is research in Israel concerning the identification and transfer of basic cognitive skills to military flight training. Another is research on learning and using information from prose text, being carried out in the Netherlands. Iconographic systems are under development in Canada, the EC, and Japan. The Netherlands, Israel, and some Pacific Rim nations also have efforts in this area. The advent of computer-generated auditory and visual data presentation modes led to advanced distributed simulation (ADS) techniques and programs. This allows multiforce operations to be imaged from distributed sites. Such technology facilitates training activities and integration of activities across the services. The software and hardware used in model systems are developed in Japan and the EC.

b. Perceptual Processes

Perceptual processes concern the reception and processing of sensory information. As true in the first research area, basic research on human perception is supported by most major universities and research institutions in northern Europe and Canada. Again, other countries also support perceptual processes on more specific topics within this area. Of particular interest to the Army is research in Israel on methods and technologies for enhancing human perception and attention in complex situations.

c. Noncognitive Skills and Abilities

Researchers in this area examine the debilitating effects of stress on human performance. The effects of physical and psychological fatigue on human performance have been examined in Canada and the U.K.. Another classic topic studied in Canada and northern Europe is the vigilance of attention and performance. Other related subjects include the effects of age on driving performance (the Netherlands) and the information processing in a space environment (Germany).

Unobtrusive measures of vital signs require miniaturized sensors (of blood pressure, respiration, electrical conductivity) and compact, lightweight relay systems. The United States, Japan, the EC (including the Netherlands), and Asia and the Pacific Rim (including Taiwan, South Korea, and Malaysia) have increasing capability in this area. Pharmacological performance sustainers (e.g., melatonin) are being explored for efficacy. Nations with extensive programs in the pharmaceutical area or in processed foods have capabilities here. These include the U.K., Japan, France, Switzerland, The Netherlands, Sweden, and Germany.

d. Leadership

Research in this area has not been as active as in previous decades. More than any of the other three areas, cultural differences among countries may limit collaborative research efforts to those countries that share our basic concepts. For instance, the highly individualistic and aggressive leadership style admired in the United States and other English-speaking countries may not be as relevant to other countries that do not share the same cultural background. An exception, however, is leadership research in Japan, which dates back to just after the end of World War II. For example, Japanese researchers have advanced the concept of performance–maintenance leadership, which has had a substantial impact on U.S. research.

The following highlight a few selected examples of specific research facilities engaged in work in the behavioral, cognitive, and neural sciences:

Israel—Department of Psychology, Hebrew University. The main areas of research include biopsychology, psychophysiology, cognitive psychology, and social psychology. Psychophysiology research includes work on orientation reactions and habituation processes, psychophysiological detection of information, and electrophysiological correlates of cognitive processes. Other work includes efforts to understand and develop methods and technologies for enhancing human perception in complex situations. An example is the research being done on attention and effort.

Canada—Human Performance Laboratory, York University. The laboratory is one of the seven research laboratories in the Institute for Space and Terrestrial Science. Research in the laboratory is concerned with the human visual, auditory, vestibular, and somatosensory systems, as well as with visual–vestibular relationships and sensory motor coordination. Empirical and computational research is conducted at a fundamental level and in relation to human performance in aviation and space. Research includes work on the effects of physical and psychological fatigue on human performance.

Netherlands—The Netherlands Organization for Applied Scientific Research–Human Factors Research Institute (TNO–HFRI). TNO–HFRI is a subdivision of TNO Defense Research specializing in knowledge on human factors and its application in the design of human work and of adequate technical aids. The primary mission is to develop and apply human factors research in a high-technology military environment and to promote efficient deployment of personnel and materials. Research thrusts include perception, information processing, skilled behavior, and the work environment. Specific work of interest includes studies on the effects of age on driving performance.

Japan—Department of Human Sciences, Kyushu University. Japanese research in leadership has a strong tradition, dating back to World War II. This work helps to identify the essentials of successful leadership performance and to develop effective training techniques for leadership skills. At Kyushu University, Misumi and his colleagues have developed a concept of performance–maintenance leadership, which has had a substantial impact on worldwide research in the field.

Germany—Unit of Applied Cognitive Research, University of Dresden. This department has active research programs on problems of information processing, including human–computer interaction, attention fixation, visualization of subjective attitudes toward complex scenery and pictures, level-of-processing effects in memory tasks, neuroinformatics, and joint attention effect in communication. The unit employs many experimental techniques, including measurement of eye movements with high-speed and head-free eyetrackers, gaze-dependent image processing and online control of experiments, and analysis of data using ANNs.

D. ABBREVIATIONS

2D	two dimensional
3D	three dimensional
AI	artifical intelligence
AMC	Army Materiel Command
ANN	artificial neural network

APGM	advanced precision-guided munition
ARL	Army Research Laboratory
ASTMP	*Army Science and Technology Master Plan*
ATM	asynchronous transfer mode
ATR	automatic target recognition
AUTOVON	Next-Generation Autonomous Navigation System
BC^2	battlespace command and control
BD	biological detector
BIDS	Biological Integrated Detection System
BMD	ballistic missile defense
BRP	*Basic Research Plan*
BW	biological warfare
C^2	command and control
C^3	command, control, and communications
C^4I	command, control, communications, computers, and intelligence
C^4I2	command, control, communications, computers, intelligence, and information
CASE	computer-aided software enginerering
CB	chemical and biological
CBD	chemical and biological defense
CBDCOM	Chemical and Biological Defense Command
CBW	chemical and biological warfare
C-C	carbon-carbon
CC&D	camouflage, concealment, and deception
CdZnTe	cadmium zine telluride
CECOM	Communications–Electronics Command
CFD	computational fluid dynamics
CGF	computer-generated forces
CMC	ceramic matrix composite
CMMS	conceptual model of the mission space
COE	center of excellence
COTS	commercial off the shelf
CW	chemical warfare
DARPA	Defense Advanced Research Projects Agency
DE	directed energy
DEA	Data Exchange Agreement
decon	decontamination
demil	demilitarization
DEW	directed-energy weapon
DIS	distributed interactive simulation
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense

DOE	diffractive optical element
DSRC	David Sarnoff Research Center
DTAP	*Defense Technology Area Plan*
DTO	Defense Technology Objective
EBF	electronic battlefield
ECM	electronic countermeasures
EFP	explosively-formed projectile
EM	electromagnetic
EME	electromagnetic environment
EMP	electromagnetic propulsion
EO	electro-optic, electro-optical, electro-optics
ESM	electronic support measure
ETC	electrothermal chemical
EW	electronic warfare
FADEC	full authority digital engine control
FCT	foreign comparative testing
FEL	free electron laser
FLIR	forward-looking infrared
FPA	focal plane array
FSU	former Soviet Union
FY	fiscal year
GaAs	gallium arsenide
GBps	gigabit per second
GHz	gigahertz
GPS	global positioning system
HCI	human–computer interface
HEP–90	Haupt Entgiftungs Platz–90
HgCdTe	mercury cadmium telluride
HLA	high-level architecture
HMD	helmet-mounted display
HPC	high-performance computing
HPM	high-power microwave
HPRF	high-power radio frequency
HSI	human–system interfare
IACS	International Armaments Cooperative Strategy
IDA	Institute for Defense Analyses
IF	infrared
IFF	identification friend or foe
IMD	information management and display
INS	inertial navigation system
IPE	integrated platform electronics

IR	infrared
IRCM	infrared countermeasures
ISO	International Standardization Organization
JCS	Joint Chiefs of Staff
JTA	Joint Technical Architecture
JWSTP	*Joint Warfighting Science and Technology Plan*
kW	kilowatt
LAN	local area network
LIDAR	light detection and ranging
M&S	modeling and simulation
MANPRINT	manpower and personnel integration
MDS	magnet dynamic storage
MED	multiple electric permanent magnet
MEMS	microelectromechanical systems
MITI	Ministry of International Trade and Industry
MMC	metal matrix composite
MMIC	monolithic microwave integrated circuit
MMW	millimeter-wave
MOU	memorandum of understanding
MPP	massively parallel processing
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, and chemical
NBCRS	Nuclear, Biological, Chemical Reconnaissance Systems
NBCW	nuclear, biological, and chemicl warfare
NDE	nondestructive evaluation
NIST	National Institute of Standards and Technology
NLO	nonlinear optics, nonlinear optical
NMR	nuclear molecular resonance
Nordic Group	Norway, Sweden, and Denmark
OEIC	optoelectronic integrated circuit
OOTW	operations other than war
PMC	polymer matrix composite
POC	point of contact
PPT	personnel performance and training
R&D	research and development
RCS	radar cross section
RF	radio frequency
ROK	Republic of Korea
RPV	remotely piloted vehicle
RWC	real-world computing

S&T	science and technology
SAFF	safing, arming, fuzing, and firing
SAR	synthetic aperture radar
SAS	Survivable Adaptive System
SEFT	Research Institute for High-Energy Physics, Finland
Si	silicon
SMART	sensor mounted as moving threat
SOCM	Special Operations Command
STANAG	standard agreement
T&E	test and evaluation
tera	10^{15}
teraflops	trillions of floating point operations per second (10^{15})
Ti	titanium
TMD	theater missile defense
TRADOC	Training and Doctrine Command
TTCP	The Technical Cooperation Program
UAV	unmanned aerial vehicle
UBM	Universitat der Bundeswehr Muchen, Germany
U.K.	United Kingdom
UV	ultraviolet
UWB	ultra wideband
U.S.	United States
USACE	United States Army Corps of Engineers
VMF	variable message format
VR	virtual reality
VRI	virtual reality interface
VTOL	vertical takeoff and landing
WMD	weapons of mass destruction

ANNEX F

U.S. SPECIAL OPERATIONS COMMAND TECHNOLOGY OVERVIEW

CONTENTS

ANNEX F

U.S. SPECIAL OPERATIONS COMMAND TECHNOLOGY OVERVIEW

A. INTRODUCTION

The United States Special Operations Command (SOCOM) was formally stood up as a unified command on 16 April 1987. It is one of nine unified commands reporting to the Secretary of Defense (SECDEF) through the Chairman, Joint Chiefs of Staff (CJCS). The primary mission of SOCOM is to provide combat-ready Special Operations Forces (SOF) in peacetime and in war for the theater combatant commanders, American ambassadors and their country's teams, and other government agencies. The Commander in Chief, United States Special Operations Command (USCINCSOC) carries out that primary responsibility by performing several supporting functions, which include developing and acquiring SOF-unique equipment, materiel, supplies, and services. Within SOCOM, the Special Operations Acquisition Executive (SOAE) is directly responsible for the Research, Development, and Acquisition (RD&A) of systems peculiar to Special Operations (SO). The SOAE manages this responsibility in two ways: (1) program execution within SOCOM for systems unique to SOF; or (2) working cooperatively with the services and Department of Defense (DoD) agencies such as the Defense Advanced Research Projects Agency (DARPA), with other government agencies such as the Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA), and with industry as well as academia.

In 1986, Title 10, U.S. Code (USC), Section 167, was signed, which provided SOCOM the responsibility to develop and acquire SO-peculiar equipment, materiel, supplies, and services. In 1988, the SECDEF granted SOCOM the opportunity to establish a contracting activity. In 1989, the acting SECDEF assigned Major Force Program 11 (MFP 11) Program Objective Memorandum (POM) and budget authority to SOCOM; and, in 1992, SOCOM appointed the SOAE to execute the command's acquisition objectives and strategies. However, because of the limited funding in MFP 11, congressional committees on appropriations directed that SOCOM work with all research activities to ensure that SO technology needs are considered in the development of their technology base programs. To this end, Congress reiterated that the unique missions of SOF require its capabilities be based on the leading edge of technology, and, therefore, expects these activities "to expend an appropriate amount of the technology base effort identifying and developing technologies that have Special Operations potential." While SOCOM has a Service-like responsibility for research, development, and acquisition, the command is a user rather than a developer of technology, and does not have a dedicated laboratory structure as do the military departments. SOCOM's technology strategy is to monitor emerging technology relevant to SOF needs, participate in selected programs that relate to SOF technology development objectives, and execute selected high-priority projects to exploit emerging technology for near-term SOF application. A key thrust of this strategy is to proceed urgently with the prevailing objective to "increase the capability of assigned forces through the fielding of SO-peculiar materiel meeting user requirements in the shortest possible time, i.e., aggressive use of prototyping." This strategy is summarized below in Figure F–1.

A key part of SOCOM's Technology Program strategy is the flexibility it uses in tailoring its programs to both accelerate the delivery of capabilities to the field and to reduce programmatic delays.

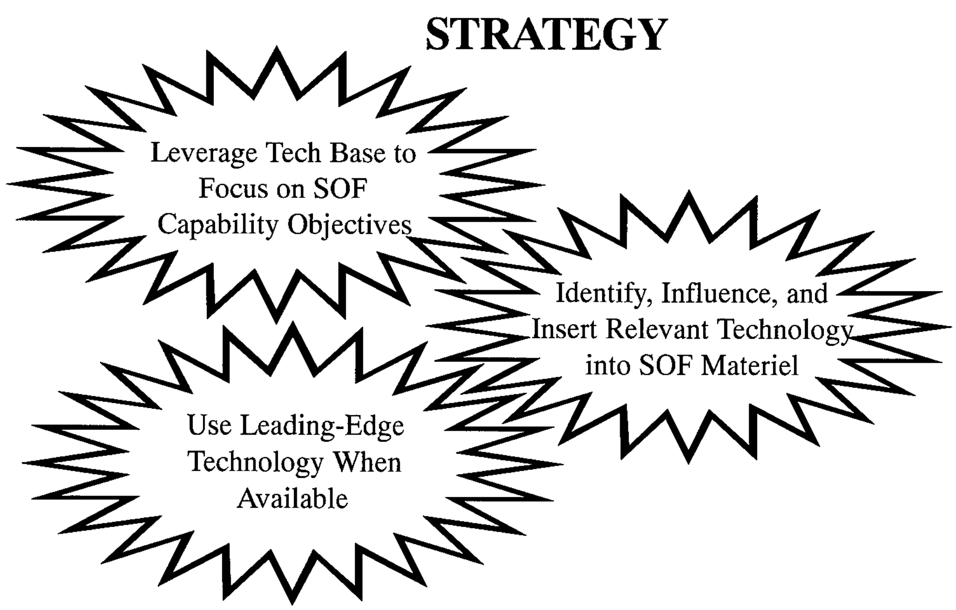


Figure F–1. SOCOM Technology Strategy

This tailoring concept, portrayed with the standard DoD development sequence, is shown in the following schematic (Figure F–2). SOCOM works in and around this core process, appropriately tailoring approaches for each unique situation. The result is a flexible process that can greatly accelerate the schedule and reduce the cost of development. The innovative use of tools, such as demonstrations and operational assessments in conjunction with direct jumps to fielding of prototypes and insertions into ongoing system productions, as well as the use of fewer decision levels in the acquisition process, provides great flexibility in the implementation of tailored technology development/transition programs.

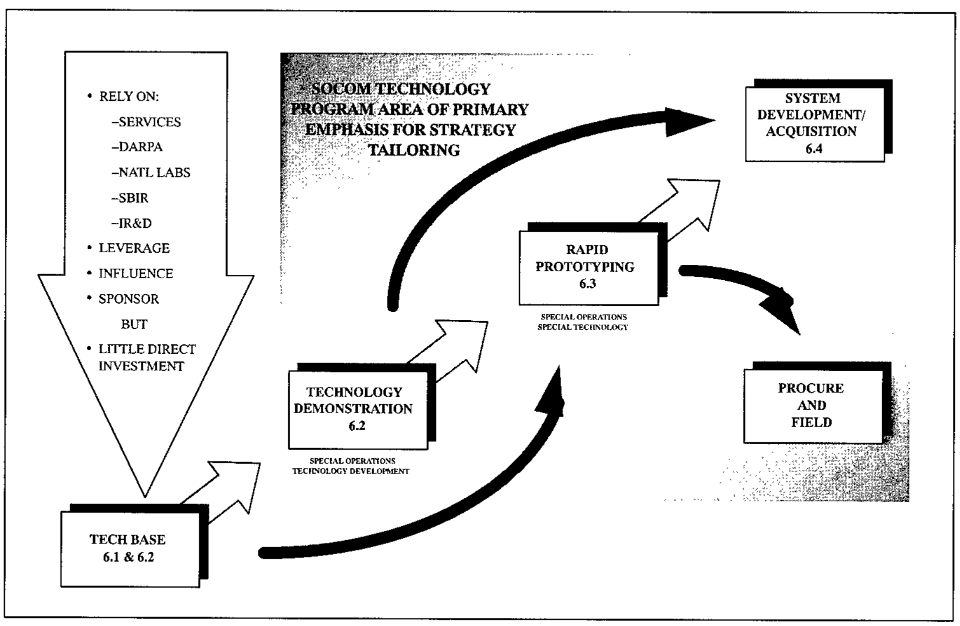


Figure F–2. Tailoring Technology Development Strategy

B. FUTURE VISION

To prepare SOF properly and ensure relevancy in a volatile and changing global environment, the USCINCSOC in 1997 established SOF's future vision in SOF VISION 2020. This vision outlines three parallel paths—professional development of its people, technological innovation, and proactive acquisition—to ensure that SOF continues to be the world's premier special operations force, *already there or first to deploy,* in the uncertain world of the future.

With regard to technological innovation, SOCOM will look to emerging, leading edge technologies in such areas as sensing and identification, biotechnology, miniaturization, signature reduction, secure communications, sensor/C^3 disruption, information protection, advanced weapons/munitions, stealth, human enhancements, microrobotics, computerized speech recognition, and interactive simulation, to increase the efficiency and effectiveness of its people and platforms. The command will continue to identify and pursue key technologies that have the potential to satisfy future SOF requirements, maintain its core competencies, and meet emerging SOF missions. SOCOM will continue to be a testbed for new technologies. SOF will expand its initiative of leveraging relevant technology projects within the DoD agencies, services, national laboratories, and industry, as well as develop closer working relationships with the key organizations that will drive technologies most relevant to SOF interests.

C. TECHNOLOGY PROGRAM

To execute the MFP 11 responsibilities for technology development, SOCOM has developed a Technology Development Program that comprises the following efforts, as well as the leveraging and influencing of technology thrusts ongoing in defense-related research programs. These efforts are entitled: Special Operations Technology Development (SOTD), which concentrates on exploratory development and technology studies; Special Operations Special Technology (SOST), which concentrates on advanced engineering development and rapid prototyping; SOF Biomedical Research and Development (BIOMED), which performs studies on basic exploratory medical technologies centering on physiologic, psychologic, and ergonomic factors to enhance the ability of SOF operators to better perform their missions; Small Business Innovative Research (SBIR); and Tactical Exploitation of National Capabilities (TENCAP), which explores the tactical use and interface with national systems/architectures.

The principal driver of SOCOM's Technology Development Program evolves around a list of prioritized Technology Development Objectives (TDOs). This prioritization reflects the SOF's command and field perspective of its operational deficiencies and future capability needs, which typically requires either a new technology application or an advanced technology demonstration. The TDOs are required by DoD Instruction 5000.2. They are developed jointly by the SOCOM staff and its four components, reviewed, and—if necessary—updated every two years in conjunction with the POM process, prior to official approval by USCINCSOC. These TDOs provide focus to the command—as well as to technologists, engineers, and industry representatives—on areas of technology that potentially can address SOF operational deficiencies and meet future requirements or operational capability objectives for SOCOM. They are used as the foundation for selecting SOCOM technology projects and to influence service/agency technology efforts. They also assist with resource allocation decisions to support technology-based projects and studies. In an abbreviated form these TDOs are denoted as follows:

1. Weapons of Mass Destruction
2. Individual Survivability

3. Sensors
4. Power Sources
5. Mobility Platforms
6. C^4I
7. Information Warfare
8. Countermine and Demining
9. Targeting and Tracking
10. Weapons and Munitions
11. Simulation and Training.

A wide and diverse set of concepts or systems is required to satisfy the deficiencies within each TDO. However, the following general characteristics, which are particularly important to SOF operators, pervade across multiple concept/system requirements: lightweight, small, rugged, minimal signature, lethal, survivable, maintainable, and affordable.

The following is a more complete description of each of the SOCOM TDOs, along with a narrative of the types of technologies that are important in reducing the SOF shortcomings in these combat and noncombat functional areas.

1. Weapons of Mass Destruction (WMD) Detection, Classification, Neutralization, and Protection Systems

Technologies that should have the potential to provide capabilities for rapidly detecting, precisely locating, and accurately classifying fixed and mobile WMD threats from standoff distances in both semi- and nonpermissive environments. Proposed technologies should demonstrate potential for use as either a man-portable or a SOF mobility platform (ground, air, maritime) mounted system useable in underground facilities. Technology must be compatible with SOF mission scenarios and be suitable for SOF tactical or clandestine environments. Technologies are needed to detect deep underground structures; and also to assist SOF in disabling or defeating systems in such facilities. Technologies should be able to detect U.S., foreign, and improvised Nuclear, Biological, and Chemical (NBC) agents currently available or projected for use on the battlefield or in an Operations Other Than War (OOTW) scenario. Technologies are desired to assess and analyze NBC weapons in order to cause yield reductions; to assist in disassembly; to perform advanced diagnosis; and to help neutralize, render safe, or otherwise destroy the weapon in a semi- or nonpermissive environment. Technologies are also desired to perform initial chemical agent analysis and identification in a remote and austere environment. Most individual and unit NBC detection and protection technologies are more service-like items and, although desired and utilized by SOF forces, they usually are not suitable for SOF-only missions. For example, SOF requires very lightweight, one-time-use but low-volume NBC protection.

2. Lightweight, Low-Volume Survival, Sustainment, and Personal Equipment

Technologies that, in both favorable and adverse environment and mission conditions, should have the potential to provide enhanced performance, sustainment, and protection of SOF personnel; and that will include endurance/fatigue reduction, mobility, active and passive camouflage, signature reduction, lethality, alertness, protection against ballistic, DEW, etc. Proposed technologies should be applicable to the full range of individual SOF equipment and systems, to include: C^4I equipment, rations, protective clothing, camouflage, signature reduction, laser and direct energy protection, body armor, sensors, maritime and diving equipment, individual water purification, etc. Camouflage/deception concepts should show adaptability to a variety of topographical and climatic backgrounds. Development of technologies and follow-on systems must not reduce durability, performance, or usability due to size and weight reduction; or adversely affect the individual's physical strength, flexibility, endurance, etc. Robotic technologies for ground and air platform applications will be of interest to reduce the burden of noncombat essential equipment. Such technologies should demonstrate improvements in operational capabilities utilizing current and future advances in miniaturization and weight reduction, fatigue reduction, biochemistry, nutrition, electronics, fabrics, textiles, hybrid materials, metallurgy, or the life sciences. Medical technologies to enhance the treatment and prevention of battle injuries and nonbattle casualties will also be of interest.

3. Advanced Vision Devices, Sensors, Fire Controls for SOF Weapons, and Human Sensory Enhancement and Performance Amplification Equipment

Technologies that should have the potential to enable the SOF operators, drivers, pilots, or crew members to significantly improve their ability to detect threats and avoid obstacles in both favorable and inclement weather and environment conditions. Technologies should improve the ability to detect, identify, track, and maintain surveillance of threats (weapons systems, personnel, installations, sensors, emitters, targets, etc.). Technology should be capable of multispectral detection (radar, thermal, infrared, acoustic, visual) and be adaptable to both man-portable and mobility platform uses. The technology should not detrimentally interfere with normal sensory functions of hearing, smell, or sight. Sensor technology should provide enhanced sensory capabilities in night, fog, precipitation, smoke, dust, etc. Technologies should also improve range, magnification, field of view, and resolution during periods of both good and limited visibility. Technologies should encourage the ability to increase information and intelligence awareness. Any such technology should demonstrate potential for integration into all applicable planned system acquisitions.

Proposed technologies should significantly increase the capability, speed, and accuracy of SOF operators to acquire and engage targets—in all environmental and visibility conditions—using current and proposed SOF individual, crew-served, and platform-mounted weapon systems. Technologies should demonstrate adaptability to man-portable systems with all-weather capabilities, reliability, sustainability, and maintainability in field conditions. Technologies must possess the ability to process a full ballistic solution in near-real-time; have variable power optic/sensors; and provide day, night, and limited visibility capabilities.

4. Lightweight, Low-Volume Power Supply, Storage, Management, and Generation Technologies

Technologies that should have the potential to provide SOF with improved power sources, power storage, power generation, or power management capabilities for C^4I systems, weapons, mobility platforms, and SOF equipment. Technologies should demonstrate significant improvements in power density, transportability (land, sea, and air), rechargeability, disposability, reliability, commonality, and size and weight characteristics. Substantially improved electrical generation storage and conditioning capabilities are required to enhance vehicle propulsion and support current and future weapons systems/concepts.

5. Enhanced SOF Mobility and Attack Platforms With Increased Speed and Range, Decreased Detectability, and True All-Weather Capabilities

Technologies that should have the potential to significantly reduce mobility mission area deficiencies that include: improving performance; lowering the probability of detection; improving the supportability of SOF air, land, and maritime mobility platforms; and reducing the logistics signatures of SOF mobility platforms. Technologies should address reductions in multispectral (radar, thermal, infrared, acoustic, visible) signatures while providing mobility platforms with increased maneuverability, speed, range, all-weather capability, threat avoidance, survivability and protection, transportability, reliability, maintainability, and durability. Technologies must show potential for application to future SOF mobility platforms or upgrades to current systems.

Resupply technologies should have the potential to enhance the capability to provide accurate and timely resupply to SOF operators in an unmarked, denied, tactical environment without causing undue loss or damage to items being resupplied. Enhanced resupply systems must have increased accuracy in all weather, have significant standoff range, and have a Low Probability of Detection (LPD). Systems may include unattended resupply vehicles, low platforms, and rigging gear. Proposed technologies should show significant improvements over current systems capabilities.

6. Improved Digital Transmission, Switching, Information Transfer Automation, and Human-to-Machine Interface Communications (C^4I) Technologies

Technologies that should have the potential to provide improvements in weight reduction, size, LPI/LPD, power consumption/management, over-the-horizon capabilities, transmission rates, processor throughput, programmability, modularity, multiband operations, simultaneous transmission/reception capabilities, real-time information, imagery/system/sensor fusion, spectral utilization, compatibility, seamless GPS integration, and miniaturized Automated Data Processing (ADP). Technologies must be suitable for application in extreme environments and be compatible with standardized open architectures and complementary technologies, such as integrated navigation, direction finding, security, Identification, Friend or Foe (IFF), automatic encryption/authentication, etc. New systems must comply with SOCOM's architectural tenets, which specify that systems must be seamless, robust, automated, use the full spectrum, and be standards compliant.

7. Automated Information Warfare (IW) Systems Enhancements To Influence and Protect Information Systems, Links and Nodes

Technologies that should have the potential to provide SOF advanced capabilities for deception, Electronic Warfare (EW), Psychological Operations (PSYOP), and speech technologies.

Technologies for deception and EW should enhance capabilities to disable, jam, spoof, or otherwise confuse enemy sensor and detection systems, including radars; thermal imageries and other optical-electronic systems; acoustic detectors; and seismic sensors and systems. Other areas for enhanced tactical deception include disruption, disablement, or reducing the efficiency of communication and command and control systems, which may have Radio Frequency (RF), laser, hard-wire, fiber-optic, or other links.

Advanced PSYOP technologies are also required to develop, produce and disseminate PSYOP products, including: radio (AM/FM/SW); television broadcasts; and printed material. Technology must support production, distribution, and dissemination of PSYOP products to, from, and within forward and remote locations. It also should include the integrated utilization of broadcasts or products using broadcast range extenders, aerial pamphlet disseminators, loudspeakers, high-capacity print facilities, translators, etc. Technologies should enable the development of new and advanced means of disseminating or projecting PSYOP messages to a target audience. Such technologies might include direct satellite broadcasting, UAV payloads, digital signal processing, voice synthesizing, laser video, acoustic generators, holograms, artificial intelligence applications, and attitudinal/behavior agents.

Applicable speech technologies should provide automated recognition and translation both from English to the target language and from the target language to English. Technology must have the potential to achieve real-time, voice-to-voice translation; speaker identification; be a small, lightweight package; interface with C^4I systems; and transcribe and translate text at a near-real-time rate.

8. Passive Shallow Water/Terrestrial Mine, Explosive, and Boobytrap Detection, Identification, and Neutralization Technologies

Technologies that should have the potential to provide passive, accurate, tactical detection and classification of surf zone, shallow water, and terrestrial mines, explosives, and boobytraps. Demonstrate or identify technologies that enhance the ability to destroy or disable mines and boobytraps on land and in shallow water without posing a threat to the individual operator. Technologies should be applicable to all ground and sea-bottom soil types, lead to increased detection capabilities, longer ranges, lower false alarm rates, and autonomous or standoff capabilities. Technologies should apply to magnetic, acoustic, command-detonated, and pressure mines, as well as to future mine and fusing/ detonation systems and must be transferable to man-portable, modular packages. Technologies should be applicable for land and water applications and be compatible with either timers, command detonation, or smart activation. Technologies and systems must apply to both SOF submissions: antimining and demining. Antimining is a combat mission where SOF identifies, marks, or neutralizes mines and boobytraps during, or just prior to, combat operations. Demining is a humanitarian assistance mission where SOF either trains the trainers in demining activities, or SOF trains and assists indigenous personnel to detect, mark, avoid, and neutralize mines and boobytraps in a permissive environment.

Attaching systems should demonstrate or identify technologies that provide SOF the capability to accomplish positive nonmagnetic adhesion in fresh and salt water; and on dirty, uneven, nonmetallic, and petroleum-coated surfaces. The adhesive needs to have comparable holding/bonding properties as current adhesives are used to bond explosives to dry, smooth, nonmetallic surfaces. The system must be user-friendly underwater. It must retain its holding abilities in the surf zone and on an ocean/ lake/river floor for an extended period of time and in extreme temperature ranges.

9. Clandestine Target Locating, Tracking, and Marking Technologies

Technologies that should have the potential to provide SOF an improved passive or semiactive method to mark both fixed and mobile targets for identification, tracking, targeting, and precision munitions guidance to include GPS integration. Marking methods must be undetectable by the enemy, but positively identified by both SOF and conventional airborne, waterborne, and ground/vehicular sensors and targeting systems, to include the AC–130 gunship. Technologies for IFF and Combat Identification (CID) must seamlessly interface and integrate with Service systems, plus allow SOF IFF to deep strike fire-and-forget conventional weapons. Marking methods should include a removal capability without special equipment.

10. Future Force Application Weapons and Munitions, Enhanced Explosives and Munitions, and Nonlethal Technologies

Technologies that should have the potential to provide the basis for advanced offensive and defensive weapons and weapons-related systems that demonstrate significant improvements in responsiveness, range, accuracy, reliability, and target effects. Systems are desired for fixed and rotary wing aircraft, small boats, and HMMWV-size vehicles. Defensive weapons are desired to counter IR, laser, TV, and other smart or seeker-head guided munitions. Demonstrate or identify technologies that provide miniature guided or precision projectiles with long-range, non-line-of-sight destructive capabilities. Technologies must destroy, disable, or render unusable fuel tanks, light armored vehicles, fortified positions, other soft military vehicles, and SO–critical military and industrial target nodes and systems. Technology should allow the operator to conduct firing operations with an LPD and from within enclosed areas.

Applicable technologies should have the potential to provide SOF operators a man-portable, reliable, long-range, accurate, signature-less, sustained rate of fire, day and night capable, tunable, or nonlethal weapons system. In the nonlethal role, the system should be man-portable and must be able to stun an opponent or temporarily incapacitate multiple targets in close proximity to the operator. Nonlethal technologies are needed for area applications (crowd control), for point applications (selected individuals in close proximity to noncombatants, prisoners, etc.), and for antimaterial applications.

In the lethal role, the weapon system must be able to be used in a medium-range (250 to 600 meters) sniper role to defeat key personnel and to disable soft targets, such as radars, C^2 vans, aircraft, sensors, POL containers, weapons systems, etc. An effective range up to 2,000 meters is the eventual goal. Demonstrate or identify technologies that provide increased lethality, enhanced flexibility, reduced weight and volume, increased accuracy and controllability, and improved safety of explosive charges and munitions. Technologies should demonstrate antimaterial capabilities for a wide range of target types for small and medium caliber SOF weapons systems—both handheld and platform mounted. Multipurpose, low-detectable munitions and explosives are preferred. Items must be certifiable as safe for use and transportability (land, sea, and air) by all Service or SOCOM safety review and certification boards.

11. Advanced Learning, Training, and Mission Planning/Rehearsal Technologies

Technologies that should have the potential to provide for fusion of diverse and multispectral data, application of artificial intelligence, effective use of constructive, virtual, and live simulations as the basis for future systems for enhanced Mission Planning, Analysis, Rehearsal, and Execution (MPARE); or provide integrated, insertable upgrades to current systems. Technologies should address the potential for networking and include realistic sight, sound, olfactory, and motion sensations. Technologies must have application to as many SOF mission areas, skills, environments, and component–unique requirements as is feasible. Improving rapid learning and retention techniques for foreign languages are also of interest.

This completes the description of the TDOs.

SOCOM's technology development programs are separate and independent from our specific acquisition programs and they provide a valuable process that links SO-peculiar requirements to new warfighting systems through emerging technology development. New capabilities enabled under the technology development programs can be transitioned to SOF operators through rapid or normal acquisition programs or inserted into existing systems through system upgrades or in conjunction with Preplanned Product Improvements (P^3Is). Table F–1 below summarizes the distribution of the SOCOM's FY98 Technology Development Program funding, which is managed by the Advanced Concepts and Engineering Division (SOAC–DT) of SOAC. This program, which totals approximately $16.4M, covers four of the five Technology Development Program efforts mentioned earlier in this annex; the fifth effort, TENCAP, is managed by the Program Executive Office for C^4I within SOAC.

Table F–1. SOCOM's Technology Development Program Funding Structure

Program Element	Line No.	Project Title	% Program Funding
1160401BB	S100	Special Operations Technology Development	25.3
1160402BB	S200	Special Operations Special Technology	48.8
1160407BB	S275	SOF Biomedical Research and Development	12.4
1160279BB	S050	Small Business Innovation Research	13.5

Note: Of SOCOM's total RDT&E budget for FY98, the above is the distribution of just the technology development funds, with the exception of TENCAP.

Some of the specific individual projects under the FY97 SOTD program are:

- Active Noise Cancellation
- Audio Deception Emitter
- Color Night Vision Fusion
- Enhanced Thermal Protection
- Head–Mounted Thermal Vision
- Maximum Efficiency Language Trainer
- Thermal Imaging Device
- Underwater Tactical Display.

Some of the specific individual projects under the FY97 SOST program are:

- Advanced Sniper Weapon Fire Control
- Aircraft Off/Onload System
- Clandestine Lighting System
- Communications Helmet
- Hasty Hide Shelter
- Intrusion Sensor System
- Low Observables, Covert Obstacle Avoidance Navigation System
- Nonlethal Submunition
- Quick Erect Antenna/Mast
- Remote Miniature Weather Station
- Sensor Hardening
- SOF Enhanced Weapons
- Very Slender Vessel
- Weapons Control System.

D. LEVERAGING THE ARMY TECHNOLOGY BASE

As part of its overall technology program strategy, SOCOM has initiated an effort to institutionalize a process that will strengthen the cooperation between the command and the Army R&D community in the pursuit of technologies of mutual value to both users. In 1997, this process was implemented by an assessment team made up of representatives from the SOCOM staff and its components. SOCOM's goal for the first year of execution is to review the technology projects (i.e., the Work Packages (WPs)) of four of the technology Directorates of the Army Research Laboratory (ARL) and one of the Army's Research, Development, and Engineering Centers (RDEC), and identify the WPs that are of high-to-considerable value to SOF in resolving materiel shortcomings. The Army Science Advisor to SOCOM has developed this process and the related assessment methodology, serves as the team leader for this effort, and has briefed the assessment results to the Army organization's senior staff for establishing future cooperative endeavors. The Army organizations whose WPs were reviewed and who received briefings on SOF's assessment of their value for improving future capabilities, are (in review order for this year):

- Sensors and Electron Devices Directorate (S&EDD), ARL
- Weapons and Materials Research Directorate (W&MRD), ARL
- Information Science and Technology Directorate (IS&TD), ARL
- Human Research and Engineering Directorate (HR&ED), ARL
- Natick Research, Development, and Engineering Center (NRDEC), Soldier System Command (SSCOM).

During 1998, SOCOM will expand this effort to several of the other Army Materiel Command's RDECs, as well as to the Army Research Institute.

In addition to presenting a prioritization of the WPs relevant to SOF needs in four categories ranging from Critical (Technologies to SOF) to Of Interest (to SOF), the briefings included: 1) a description of the methodology used in establishing the prioritization; 2) an identification of the Technology Development Objective(s) to which a majority of an organization's WPs were aligned; 3) the specific SOF capability that each of the higher-rated WPs will improve; and 4) technology projects that are currently not in the organization's technology base program but are in their area of technical expertise and are rated as being very important in resolving a SOF need. The Army WPs (identified in Table F–2) have been judged to be very important potentially for improving SOF future capabilities .

As a leveraging initiative, the SOF community will begin monitoring the progress of these technology developments; will suggest revisions to the technology project (in coordination with the responsible Army research organization) if necessary, to ensure it will directly resolve a SOF need; will consider a future possible transition to a SOF development program if the technology successfully reaches maturity; and may possibly commit manpower/equipment assets to operationally assess its capability when the technology successfully matures to the prototype stage. In these cases SOCOM will be identified as a proponent for these WPs. Therefore, SOCOM anticipates that the above technologies will remain as viable Army research projects, or at least as long as they continue to demonstrate expected progress.

Table F–2. Most Important Army Technologies for Resolving SOF Needs

Work Package Title/Number	Responsible R&D Organization
RF Imaging Technology/16MRM04	S&EDD (ARL)
Airdrop Systems Technology/AA	NRDEC
Biosensor Devices to Detect Biological/Chemical Warfare Agents/94MDB01	S&EDD (ARL)

Table F–2. Most Important Army Technologies for Resolving SOF Needs

Work Package Title/Number	Responsible R&D Organization
Inertial Reticle Technology/WCD2035*	W&MRD (ARL)
Weapons Technology for the Light Forces/WCD 211	W&MRD (ARL)
Protocol Specs for Digital Commo on the Battlefield/ISTDY1001*	IS&TD (ARL)
VR Research-Virtual Interface Technology/4221, 422INS	HR&ED (ARL)
Intelligent User Interfaces/4213NS, 4213*	HR&ED (ARL)
Countermeasures to Battlefield Sensors/AB	NRDEC
Ballistic Protection for Soldier Survivability/CC	NRDEC
Laser Eye Protection and Integrated Headgear/CA	NRDEC
Warrior Performance and Endurance Enhancement/AA	NRDEC
Future Warrior Technologies/STOp19*	NRDEC
Force XXI Land Warrior (S&T)/A*	NRDEC

*These WPs are part of a Science and Technology Objective (STO) Program.

NOTE: This assessment is based on a review of only five Army organization's technology projects.

Approximately 35 additional Army WPs were assessed to be of interest to the SOF community, and they have been passed on to the senior staff of the five Army organizations identified earlier. The SOF community judged these technologies to have potential impact on reducing conventional Army materiel shortcomings, which could also benefit SOF for Army-common developments and acquisition. In these cases, SOCOM will be identified as a supporter for these WPs.

The correlation of these projects assessed to be of most value to SOF, along with the Army research organizations responsible for their execution, the SOCOM technology requirements to which these technologies can potentially solve SOF shortcomings, and the Army Battle Lab whose future operational capabilities are most closely aligned to each of the SOF-proponent WPs, are depicted in Table F–3. This alignment should identify to each of the five Battle Labs (Battle Command (BC), Combat Service Support (CSS), Depth and Simultaneous Attack (D&SA). Dismounted Battle Space (DBS), and Mounted Battle Space (MBS)), the Army WPs most important to SOF. As a result, during the Battle Lab's annual review of the Army Materiel Command's (AMC's) technology projects in early 1998, they will be aware of these CINC-supported WPs and can factor this SOF input into their user assessment of AMC's Tech Base program.

Table F–3. Correlation of Select Army Technologies with SOCOM Requirements

Army Work Packages Important to SOF	Responsible Army R&D Organizations					Relevant SOCOM Technology Development Objectives											Army Battle Labs				
	HR&ED	IS&TD	S&EDD	W&MRD	NRDEC	WMD	Ind. Surv.	Sensors	Power	Mobility	C^4I	IW	Countermine	Target/Track	Weapons	Simulation and Training	BC	CSS	D&SA	DBS	MBS
RF Imaging			●					●		●											●
Airdrop Systems Technology					●					●								●			
Biosensor Devices for CBW Agents			●			●		○												●	
Inertial Reticle Technology				●											●					●	
Weapons Technology for Light Forces				●			○			○					●					●	
Protocol Specs for Digital Comm.		●									●						●				
VR Research—Virtual Interface	●															●	●			●	
Intelligent User Interfaces	●						●									●				●	
Countermeasures to Battlefield Sensors					●		●													●	
Ballistic Protection for Soldier Survivability					●		●													●	
Laser Eye Protection & Integrated Headgear					●		●													●	
Warrior Performance & Endurance Enhancement					●		●													●	
Future Warrior Technology					●		●	○			○									●	
Force XXI Land Warrior (S&T)					●		●	○			○									●	

● Most relevant TDO to the WP
○ Other TDOs benefiting by the WP

E. ABBREVIATIONS

ADP	automated data processing
AMC	Army Materiel Command
ARL	Army Research Laboratory

BC	battle command (a battle lab)
BIOMED	biomedical research and development
C^2	command and control
C^3	command, control, and communications
C^4I	command, control, communications, computers, and intelligence
CBW	chemical and biological warfare
CID	combat identification
CJCS	Chairman, Joint Chiefs of Staff
CSS	Combat Service Support (a battle lab)
DARPA	Defense Advanced Research Projects Agency
DBS	Dismounted Battle Space (a battle lab)
DEW	directed energy weapon
DoD	Department of Defense
DOE	Department of Energy
D&SA	Depth and Simultaneous Attack (a battle lab)
EW	electronic warfare
GPS	global positioning system
HMMWV	high-mobility, multi-purpose, wheeled vehicle
HR&ED	Human Research and Engineering Directorate
IFF	identification, friend or foe
IR	infrared
IS&TD	Information Science and Technology Directorate
IW	information warfare
LPD	low probability of detection
MFP 11	Major Force Program 11
MPARE	mission planning, analysis, rehearsal, and execution
MBS	Mounted Battle Space (a battle lab)
NASA	National Aeronautics and Space Administration
NBC	nuclear, biological, and chemical
NRDEC	Natick Research, Development, and Engineering Center
OOTW	operations other than war
P3Is	preplanned product improvements
POM	program objective memorandum
PSYOP	psychological operations
RD&A	research, development, and acquisition
RDEC	Research, Development, and Engineering Center
RF	radio frequency
SBIR	small business innovative research
SECDEF	Secretary of Defense
S&EDD	Sensors and Electron Devices Directorate
SO	special operations

SOAC	Special Operations Acquisition Center
SOAE	Special Operations Acquisition Executive
SOCOM	United States Special Operations Command
SOF	Special Operations Forces
SOST	special operations special technology
SOTD	special operations technology development
SSCOM	Soldier System Command
TENCAP	tactical exploitation of national capabilities
TDOs	technology development objectives
UAV	unmanned aerial vehicle
USC	United States Code
USCINCSOC	United States Commander in Chief, Special Operations Command
VR	virtual reality
WMD	weapons of mass destruction
W&MRD	Weapons and Materials Research Directorate
WPs	work packages

ANNEX G

LOGISTICS

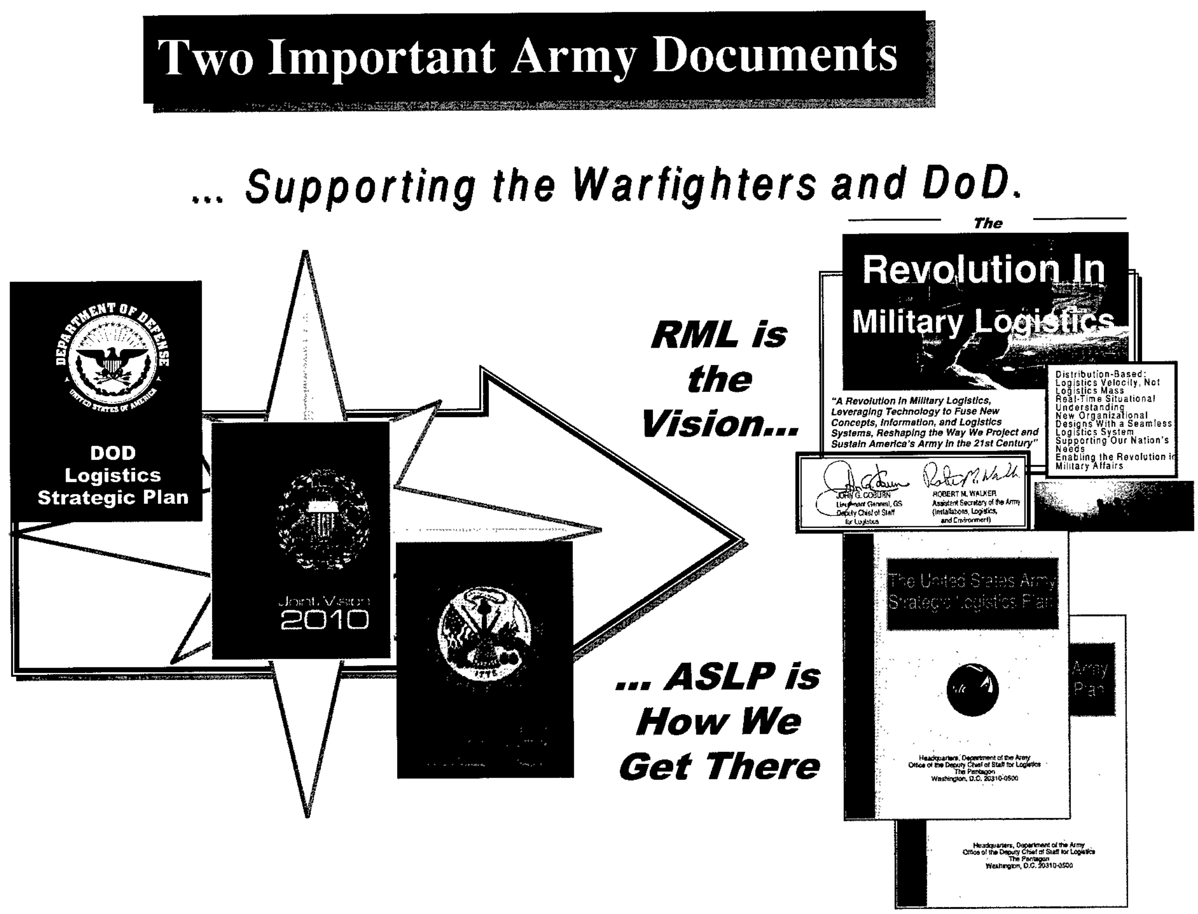
CONTENTS

ANNEX G

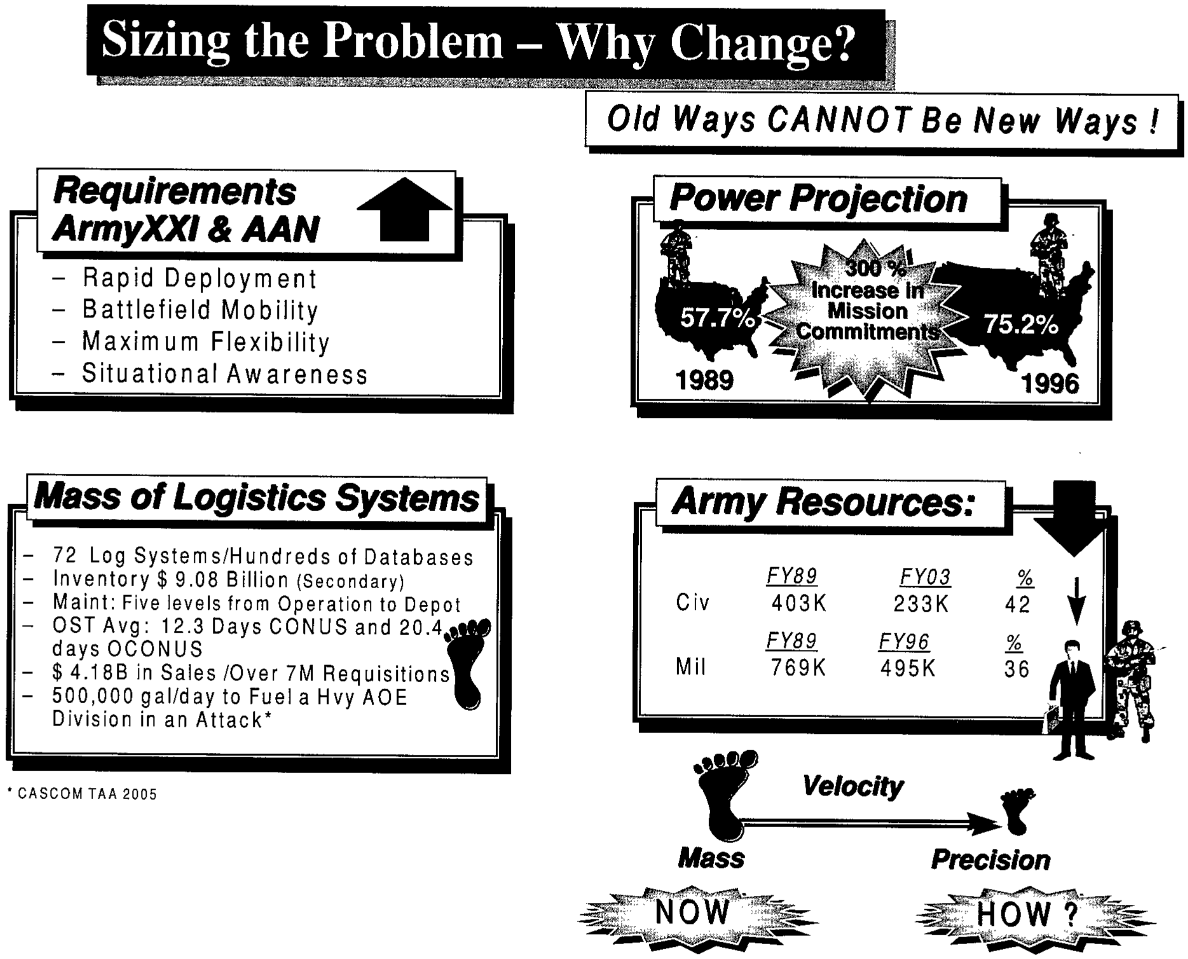
LOGISTICS

A. LOOKING TO THE FUTURE

The mobility, deployability, and sustainability essential to the Army of 2010, as well as the *Army After Next* (AAN) cannot be achieved without a revolutionary change in support concepts. The Army's *Revolution in Military Logistics* (RML) will be an integral part of the Revolution in Military Affairs (RMA). It is the document to transform logistics into a global, distribution-based logistics system that substitutes logistics velocity for logistics mass, taking maximum advantage of technological breakthroughs. The Army Strategic Logistics Plan (ASLP) is the Army's roadmap to achieve the RML vision. Technology will be leveraged to fuse new organizational constructs, concepts, transportation, information, and logistics systems, fundamentally reshaping the way forces are projected and sustained. Investment in technologies will reduce logistics' operational encumberments that directly impede the capability to support the warfighters' prosecution of the battle.

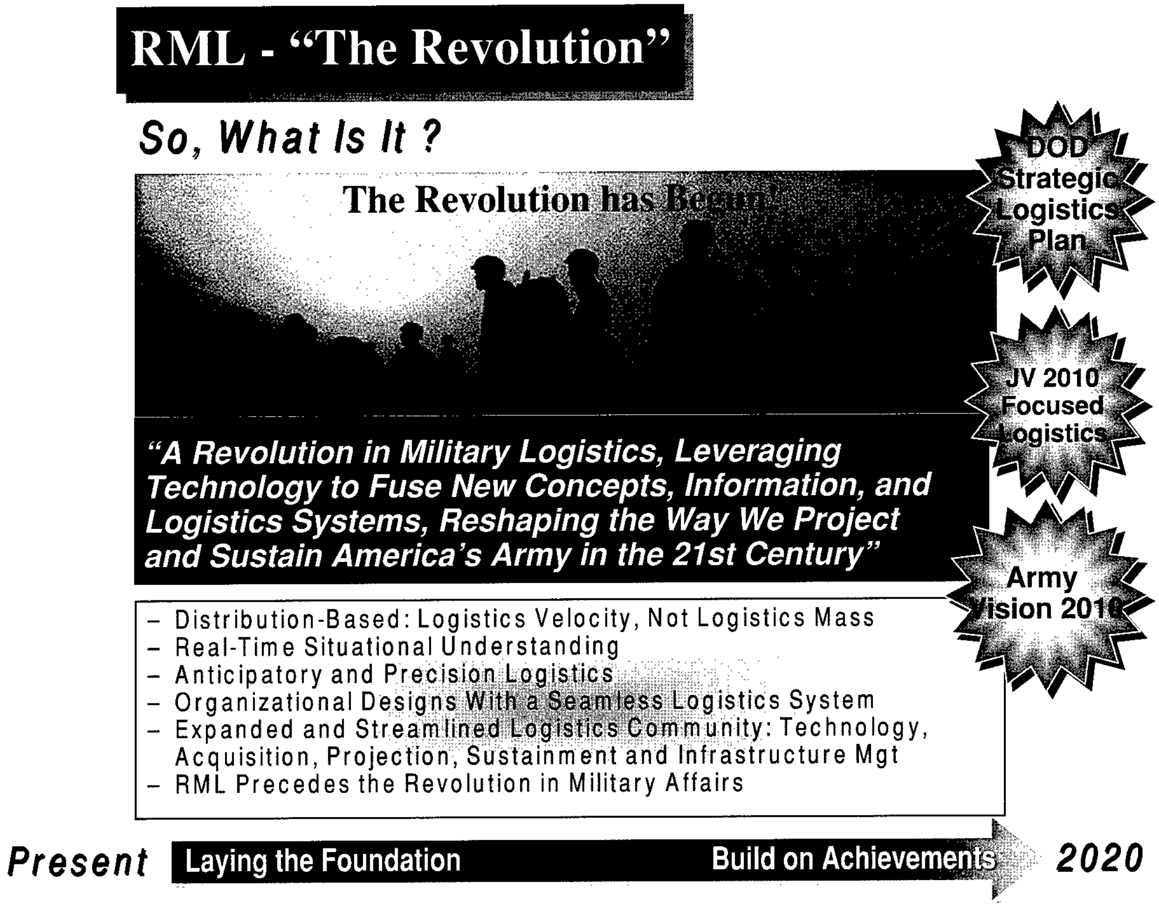


The revolution in logistics requires one to view logistics requirements in a new perspective. Gone are the days when brute force and the sheer mass of materiel and numbers of soldiers can be counted on to overcome any mobilization, deployment, sustainment, or maintenance situation. Not only has the U.S. Army undergone a 36 percent reduction in uniformed personnel and expects a 42 percent reduction by FY03 in civilian personnel, but other services have also undergone similar downsizing. These reductions have had a correspondingly direct impact on the numbers and types of combat equipment that can be used to mobilize, deploy, sustain, and maintain the Army. While the number and types of global missions that the Army is being tasked to support have grown by 300 percent, the basing of the Army's assets within the continental United States has grown from 58 percent to 75 percent. If we are to obtain an AAN that is a viable fighting force on the battlefield of the future, we must also obtain a commensurate logistics capability. With the realities of reduced personnel and other assets we must focus our logistics support.



B. REVOLUTION IN MILITARY LOGISTICS

The RML requires logistics to acquire a number of capabilities that it currently does not have. To achieve these capabilities requires research and development (R&D) of advanced technologies. Underlying a distribution based system, real-time situational understanding, anticipatory and precision logistics, seamless logistics system, and streamlined acquisition are a wide array of advanced technologies that must be researched, developed, applied, and acquired for there to be an RML and thus the attainment of Army XXI and the AAN.



C. RML TECHNOLOGY ENABLING AREAS

Technology areas that are key to making the vision of the RML a reality for Army XXI and the AAN include:

- Sensors
- Diagnostics/prognostics
- Source data automation
- Sentinel systems
- Intelligent networks
- Natural language processors
- Voice activated automation
- Advanced materials
- Robotics
- Smart/brilliant munitions
- Artificial intelligence

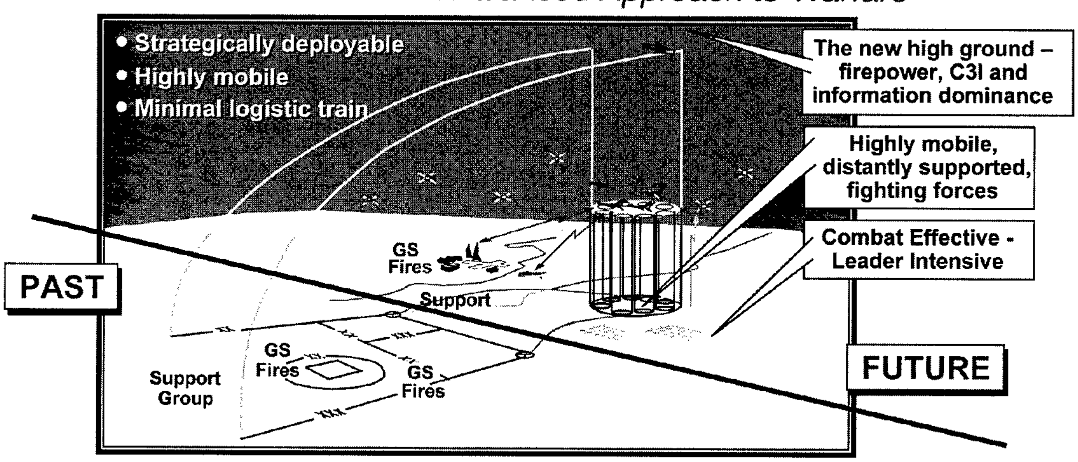
- Satellite communications
- Advanced manufacturing
- Space operations
- Biomimetics
- Nanotechnology
- Microminiaturization
- Fuels.

As evidenced by the current Army Science and Technology Management Information System (ASTMIS), the combat weapon systems that the logisticians sustain and maintain have been and will continue to be more and more technologically sophisticated. The warfighters are developing technologies for their combat equipment that will allow them to move about the battlefields of the future with near impunity; day, night, all weather, all terrain, against virtually any threat. For the logistician to be capable of sustaining and maintaining this combat force there must be similar battlefield mobility and situational awareness built into logistic's equipment and command and control systems. In the past this would have dictated increased numbers and types of test measurement diagnostic equipment (TMDE) to be developed, maintained, and deployed to support the weapon systems. The Army no longer has the logistics personnel available to conduct business as usual. A *Glimpse of the Future* tells us

RML / AAN - Glimpse of The Future

Operational Characteristics of AAN (20XX)

. . . A Balanced Approach to Warfare



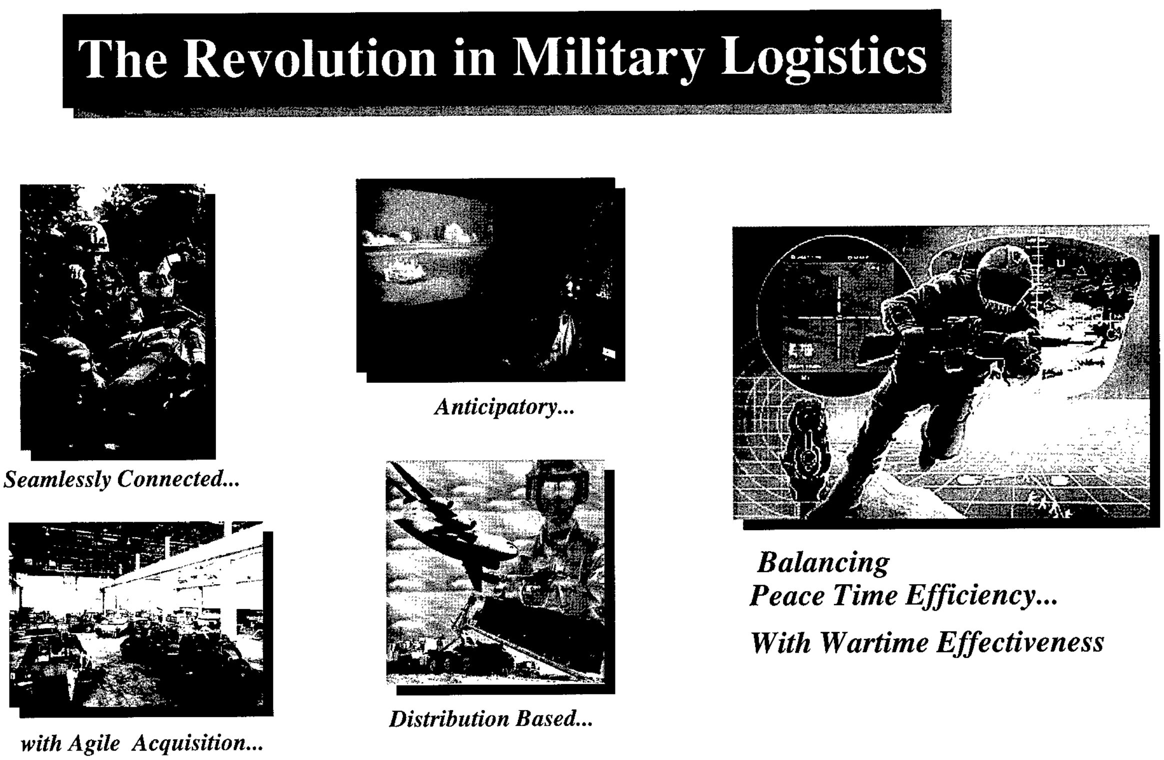
- ∗ Battle Force Units with combined air and ground capabilities
- ∗ All operating systems resident within battle force
- ∗ "Reach back" for combat functions (Fires, C^2, Logistics)
- ∗ Independent operations for 2 to 14 days without resupply / refuel
- ∗ Self-protection through movement, organic weapons, low-observables, and situational awareness

This Means:

Log Must Be Equally Mobile and Agile -- Predictive Not Reactive

that logisticians must have mobility and agility on the battlefield equal to that of the warfighter. Technologies must provide predictive capability to the logistician. This is the only way to relieve the reactive burden currently imposed upon the logistician.

There are technologies available and being developed that will allow the logisticians to change their business practices/processes to meet these current and warfighters' requirements for logistics support. The ability of the logistician to project and sustain the force is governed by the capability of the Army R&D community to research, develop, and apply advanced technologies to logistics' functions. The key criterion is to make the logistics functions seamlessly connected, anticipatory, and distribution based with an agile acquisition strategy. Battle forces are almost logistically self-reliant for 48–120 hours.



D. HORIZONTAL INTEGRATION OF R&D INITIATIVES

There are advanced technologies that provide significant value added when applied to logistics' functions. The Army's largeset career field, Logistics, Quartermaster, Transportation, Medical, and Ordnance, are dependent upon other functional areas for the funding of R&D initiatives that have application to logistics. Horizontal integration of these research initiatives and their resulting advanced technologies are essential to the modernization of logistics to fulfill the operational requirements of Army XXI and the AAN.

Logistics' Initiatives and their link to the DoD and Army visions are shown in Table G–1. This table also summarizes the operational capabilities/benefits for each of the initiatives. If we are to reduce demands upon the logistics system, an integrated effort is needed.

Table G–1. Technology Initiatives Supporting the Future Vision of Army Logistics

Initiative	Vision Supported: *Joint Vision 2010*	*Army Vision 2010*	RML	*Army After Next*	DoD Strategic Research Objectives	Benefit of Initiative
Project the Force						
Precision Offset Aerial Delivery	●		●		●	Provides reliable precision-guided delivery of combat essential munitions and equipment
Rapid Deployment Food Services	●	●	●			Provides a 50% increase in MTBF with a 50% decrease in fuel usage
Advanced Cargo Airdrop	●	●	●	●	●	Provides a 20% reduction in cost
Sustain the Force						
Joint Logistics	●		●			Provides rapid integration log data to meet Army and joint mission requirements
Mobility Enhancement Ration Components	●		●			Provides shelf stable, no-preparation rations compatible with existing ration systems
Electrical Power Generation	●		●	●	●	Provides light, highly mobile power sources capable of operating on multiple fuels
Munitions Survivability	●	●	●			Ensures the survivability of munitions at ports, airheads, and munitions storage areas
Reforming Diesel Fuel	●	●	●	●	●	Reduces field feeding costs
Improved Multipurpose Fluids	●	●	●	●	●	Reduce component failures by 25%
Emerging Petroleum Quality	●	●	●	●	●	Decrease manpower by 75% for petroleum laboratories
Other Initiatives						
Battlespace Command and Control	●	●	●	●	●	Provides EEI required for velocity management and battlefield distribution
Perform Enhancing Demonstrations	●	●	●			Enables personnel to perform at high levels of performance for extended time
Helicopter Active Control Technology			●			Enables advanced fault-tolerant systems to maintain reliability and simplify maintenance
Digital Battlefield Communications	●		●	●	●	Provides bandwidth on demand to support multimedia information requirements
Battlefield Combat Identification	●		●	●	●	Provides situational awareness to prevent fratricide—aids resupply and maintenance
Integrated High Performance Turbine Engine	●		●	●	●	25% reduction in fuel consumption and 60 percent increase in power-to-weight ratio
Future Scout and Cavalry System			●			Provides advanced lightweight materials and electric drive
Ground Propulsion and Mobility	●		●			Provides critical engine, electronic drive, track and suspension, and storage devices
Advanced Electronics Future Combat System	●		●	●	●	Advanced concepts to resupply power and distribution systems to be developed

Table G–1. Technology Initiatives Supporting the Future Vision of Army Logistics (continued)

Initiative	Vision Supported					Benefit of Initiative
	Joint Vision 2010	*Army Vision 2010*	RML	*Army After Next*	DoD Strategic Research Objectives	
Future Combat System Mobility	●		●			Provides an electric drive and power conditioning system; an active suspension system
Universal Transaction Communications	●		●	●	●	Information to flow—wherever it exists, in any form, to wherever it is needed in any form
Third-Generation Advanced Rotor Demonstration	●	●	●		●	Increases range 36% or payload 98%, reliability 45% and reduce O&S costs 10%
Advanced Rotorcraft Transmission II		●	●		●	Provides 25% weight reduction, increases MTBR, significantly reduces O&S costs
Rotor Wing Structures Technology		●	●			Increases reliability 20%, maintainability 10%, reduces O&S 5% (utility rotorcraft)
Advanced Rotorcraft Aerodynamics		●	●		●	Reduces MTBF, increases reliability and maintainability, and reduces O&S costs
Subsystem Technology Affordability and Support		●	●	●	●	Overcomes technical barriers associated with advanced digitized maintenance and real-time OBIDs
Intravehicle Electronics Suite	●	●	●		●	Validates real-time performance requirements Vetronics open systems architecture
Military Operations in Urban Terrain	●	●	●			"Open system" architecture facilitates large reduction in future ILS life-cycle costs
Joint Speakeasy	●	●	●		●	Flexible radio architecture, rapid waveform reprogrammability/reconfigurability
Range Extension	●	●	●		●	Technology supplement current (and programmed) SATCOM resources, all frequency bands
Machine Vis–Autonomous UGV	●	●	●		●	Provides capability to ensure resupply continues at the required level and timeliness
SATCOM Technology	●	●	●	●	●	Provides higher data rates, improvements in throughput, and reduced life-cycle costs
Rapid Terrain Visualization	●		●	●	●	Provides battlefield situational awareness required to plan and execute log missions

E. LOGISTICS REQUIREMENTS TO PROJECT AND SUSTAIN THE FORCE

The following force projection and force sustainment domains of the RML articulate capabilities required to project and sustain the force of the future. There may be specific, ongoing R&D initiatives relevant to logistics' requirements, but where no stated or apparent linkage to logistics has been identified in the areas listed below, "none" is listed. This does not mean that there is no requirement for R&D efforts needed to fulfill the stated capability. Quite the contrary—these are areas where there is a need for R&D to support required logistics capabilities. In those cases where there is already ongoing research in the relevant technologies but logistics has not been previously been identified as a requirer of the technology, this connection needs to be formally established. Situational awareness is a specific example of an area that has ongoing research and development but logistics has not been identified previously as an eventual user of the technology.

1. RML Domain—Force Projection

To project the force the logistics community needs:

- Key information technologies that rapidly and automatically identify and track assets.
- Access to and use of theater entry technologies such as battlefield visualization and situational awareness.
- Advanced thermo-reactive material for climatically controlled, unattended, tamper proof, "smart containers."
- Advanced materiel handling equipment
- Access to and use of theater command and control technologies.
- "Smart" delivery resupply systems for early entry and emergency resupply.
- Early entry soldier sustenance.

a. Key Information Technologies That Rapidly and Automatically Identify and Track Assets

None. While a movement tracking system has been partially acquired there remains a definite need for advanced identifying and tracking technologies.

b. Theater Entry Technologies

None. Virtually every other functional area in the Army has identified the requirement for battlefield visualization and situational awareness. It is at the core of logistics' requirements to enable us to provide the support capabilities required for Army XXI and AAN.

c. Advanced Thermoreactive Material for "Smart Containers"

None. Advanced thermoreactive material that adjusts its insulating properties based upon ambient climatic conditions, and smart systems technologies need to be integrated to provide shipping, storage, and distribution containers that dramatically unencumber the soldier.

d. Advanced Materiel Handling Equipment

None. With the force structure reductions, the Army no longer can manually handle materiel shipments. Advanced materiel handling equipment incorporating advanced sensors, AI, and robotics must be developed and acquired if Army XXI and the AAN are to be supplied and resupplied in a timely manner.

e. Theater Command and Control Technologies

None. There are a host of R&D initiatives ongoing in this area but few if any incorporate the needs of logistics. This is one of the reasons that the log community "survives" on what is appropriately referred to as the "sneaker net."

f. Smart Delivery Resupply Systems

See Volume I, Chapter III, Section O.

g. Early Entry Soldier Sustenance

See Volume I, Chapter III, Section O.

2. RML Domain—Force Sustainment

To sustain the force, the logistics community needs smart combat systems that have:

- Ultra-reliability built into them during manufacture.
- Built-in self-prognostics that predict potential failures automatically.
- Self-healing subsystems that provide the capability to delay repairs and continue to prosecute the battle.
- Smart materials that self-heal and change according to the demands of the battlefield.
- Alternative propulsion systems and fuels; significantly greater fuel efficiency.
- Biomimetic materials that provide order of magnitude increases in strength and are noncorrosive and nonerosive.
- Sensors and AI that will enable resupply and repair movements about the battlefield with a high degree of impunity.
- Battlefield situational awareness.
- Nanotechnology applied to battlefield manufacture of supplies as well as the maintenance and repair of combat equipment.
- Basic command and control capabilities.
- Information technologies that rapidly and automatically identify and track assets.
- Access to and use of theater command, control (C^2) and assessment/decision making technologies.
- Logistics survivability on the battlefield.

a. Ultra-Reliability Built In During Manufacture

Helicopter Active Control Technology (HACT) TD (98–02). The HACT TD will demonstrate advanced processing for fault-tolerant systems to maintain reliability while improving affordability and O&S costs and simplifying maintenance. It is discussed in detail in Volume I, Chapter III, Section D, "Aviation." *Supports:* Comanche, Apache, JTR, ICH, and the RML.

Advanced Rotorcraft Transmission (ART II) TD (97–00). The ART TD will provide increased MTBF drivetrain subsystems, and significantly improve readiness and O&S cost reduction. It is discussed in detail in Volume I, Chapter III, Section D, "Aviation." *Supports:* JTR, ICH, Apache, dual-use potential, and the RML.

Rotor-Wing Structures Technology (RWST) TD (97–01). RWST will fabricate and demonstrate advanced airframe sections by FY01 that are tailored for field supportability. System payoffs of 20 percent increase in reliability, 10 percent improvement in maintainability, and 5 percent reduction in O&S for utility type rotorcraft. The technology objectives include a 25 percent cost reduction. It is discussed in detail in Volume I, Chapter III, Section D, "Aviation." *Supports:* Battle Labs, JTR, ICH, UH–60 upgrades, collaborative technology, and the RML.

Advanced Rotorcraft Aeromechanics Technologies (ARCAT) (97–00). Reduced MTBFs will be the result of R&D conducted to achieve reduced aircraft loads and vibration loads. Achievement of aerodynamics technology objectives will contribute to rotorcraft system payoffs, reliability, maintainability, and reduced O&S costs. It is discussed in detail in Volume I, Chapter III, Section D, "Aviation." *Supports:* Battle Labs, Force XXI, and the RML.

Subsystems Technology for Affordability and Supportability (STAS) TD (97–00). This focuses on those subsystem technologies directly affecting the supportability of Army aviation. It addresses technical barriers associated with advanced, digitized maintenance concepts, and real-time, on-board integrated diagnostics. The expected benefits are reductions in MTTR, no evidence of failure removals, and spare parts consumption resulting in overall reductions in system life cycle cost and enhanced mission effectiveness. Supports reduced MTTR across all systems by 15 percent, 25 percent reduction in maintenance costs per flight hour and payoffs of 10 percent improvement in maintainability, 20 percent increase in reliability, and 5 percent reduction in O&S costs. It is discussed in detail in Volume I, Chapter III, Section D, "Aviation." *Supports:* Battle Labs, AH–64, UH–60, RAH–66 upgrades, ICH, JTR, other services, civil rotorcraft fleets, advanced prognostics, telemaintenance, and the RML.

Third-Generation Advanced Rotor Demonstration (3rd GARD) TD (01–04). This is to provide for system-level payoffs of a 45 percent increase in reliability and a 10 percent reduction in O&S costs for attack rotorcraft. It is discussed in detail in Volume I, Chapter III, Section D, "Aviation." *Supports:* Far-term Advanced Rotorcraft Concepts and the RML.

Advanced Electronics for Future Combat System (AEFCS) (00–04). This effort will upgrade the VOSA developed under Intravehicle Electronics Suite ATD to support high-power electronic devices. This technology, when applied, will dramatically change logistics sustainment policy, doctrine, and operations. Advanced concepts for resupply of power and distribution systems will be needed to support these high-power electronic devices on the battlefield of the future. It is discussed in detail in Volume I, Chapter III, Section G, "Mounted Forces." *Supports:* FCS, Abrams, CSS Battle Lab, and the RML.

Intravehicle Electronics Suite (IVES) TD (96–00). This TD will develop and demonstrate a ground vehicle integrated electronic architecture. These technologies, when applied, will change logistics sustainment policy, doctrine and concept of operations It is discussed in detail in Volume I, Chapter III, Section G, "Mounted Forces." *Supports:* FSCS ATD, Open Systems Joint Task Force, Army C^4I Technical Architecture, FCS, FIV, Abrams, Bradley, Crusader, and the RML.

b. Alternative Propulsion Systems and Fuels

Future Scout and Cavalry System (FSCS) ATD (98–01). This will fabricate and test a multifunction staring sensor suite, advanced lightweight structural materials and armors, electric drive, lightweight track, semiactive and fully active suspension, advanced crew stations, advanced C^2, and advanced survivability systems, all of which significantly impact logistics operations, training, and support concepts, policy and doctrine. It is discussed in detail in Volume I, Chapter III, Section G, "Mounted Forces." *Supports:* FSCS, FIV, FCS, alternative propulsion systems, and the RML.

Integrated High-Performance Turbine Engine Technology (IHPTET) Program [Joint Turbine Advanced Gas Generator (JTAGG)] Demonstration (91–03). Specific goals include a 25 percent reduction in fuel consumption. It is discussed in detail in Volume I, Chapter III, Section D, "Aviation." *Supports:* The RML, JTR, ICH, Apache, all rotorcraft, and dual-use potential.

Ground Propulsion and Mobility (97–01). This effort will demonstrate advanced electronic drive, track and suspension technologies. These technologies, when applied, will dramatically change logistics sustainment policy, doctrine and concept of operations. This is discussed in detail in Volume I, Chapter III, Section G, "Mounted Forces." *Supports:* FSCS ATD, FCS, FIV, Future Electrically Driven Vehicles, Future Medium Weight Combat Vehicles, Tactical Wheeled Vehicles, and the RML.

Future Combat System Mobility (FCSM) (02–06). This effort will demonstrate an advanced propulsion system that consists of a high power density, low heat rejection, engine (diesel or turbine); an electric drive and power conditioning system; an active suspension system; an automatic track tensioning system; and an advanced track. These technologies, when applied, will dramatically change logistics sustainment policy, doctrine and concept of operations It is discussed in detail in Volume I, Chapter III, Section G, "Mounted Forces." *Supports:* FCS, Abrams, Crusader, and the RML.

c. Biomimetic Materials

None. The Army laboratories have research ongoing in biomimetics. Spider silk research is one specific R&D initiative that is being funded. Outside the Army laboratories, but still within the federal system of laboratories, there is considerable biomimetic research ongoing. A recently opened molecular science laboratory dedicated to molecular nanoscience offers considerable confidence that the logisticians will be capable of molecular battlefield manufacturing and repair in support of the AAN.

d. Sensors and Artificial Intelligence

None. R&D is ongoing and extensive for the warfighters in this area. It is also needed for logistics' vehicles.

e. Battlefield Situational Awareness

None. R&D is ongoing and extensive for the warfighters in this area. It is also needed for logistics' functions.

f. Nanotechnology

None. The Army labs have research ongoing in nanotechnology. Outside the Army labs but still within the federal system of laboratories there is considerable nanotechnology research ongoing. A recently opened molecular science laboratory that is dedicated to molecular nanoscience offers considerable confidence that the logisticians will be capable of molecular battlefield manufacturing and repair in support of the AAN.

g. Information Technologies To Automatically Identify and Track Assets

Universal Transaction Communications/Services TD (96–03). This TD will allow information to flow in any form to wherever it is needed in whatever form it is needed, thus permitting unrestrained information flow between otherwise incompatible systems. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* All tactical communications and the tactical internet, Force XXI, and the RML.

h. Theater Command, Control and Assessment/Decision Making Technologies

Battlespace Command and Control (BC^2) ATD (97–03). This ATD will develop and demonstrate advanced decision aids, 3D visualization, distributed and shared databases, all capabilities required to ensure that logistics can meet the demands imposed by combat operations. The tri-service C^2 sources will provide essential elements of information required for the timely and survivable distribution of supplies, repair parts, and technicians to perform battlefield maintenance and repair. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* Force XXI, RTV ACTD, Velocity Management, Battlefield Distribution, and the RML.

Digital Battlefield Communications (DBC) ATD (95–99). This ATD will support digitized battlefield and split-based operations. It will provide bandwidth on demand to support multimedia information requirements. Digitized communications directly supports the rapid processing of logistics data critical to supporting battlefield commanders. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* All Transport Systems, Force XXI, Future Digital Radio (FDR), and the RML.

Rapid Terrain Visualization (RTV) ACTD (97–01). The goal of this ACTD is to demonstrate capabilities to collect source data and generate high resolution digital terrain databases quickly to support crisis response and force projection operations within the timelines required by the Joint Force Commander. Rapid knowledge of terrain characteristics helps logistics commanders provide battlefield support under all conditions. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers" and Section F, "Intelligence and Electronic Warfare." *Supports:* JSPD / RFPI, Force XXI, Vision 2010, Army Battle Command System (ABCS), Intel XXI, Division '98 AWE, the RML, Telemaintenance and Logistics C^2.

Military Operations in Urban Terrain (MOUT) C^4I TD (96–00). The "open system" architecture will facilitate a large reduction in future Integrated Logistics Support (ILS) life cycle costs. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* Force XXI Land Warrior and the RML.

Joint Speakeasy/Multiband Multimode Radio (MBMMR) TD (95–99). MBMMR will demonstrate a highly flexible radio architecture to support maintenance, interoperability, networking, traffic load, frequency assignment, and general modes of operation. The number of antennas required will be minimized. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* Future Digital Radio, Force XXI, and the RML.

Range Extension (RE) TD (97–99). This program will identify and develop key technologies required for airborne applications of a suite of communications packages, design and integrate specific systems, and conduct system tests and demonstrations of intratheater communications range extension at a variety of data rates. When applied these technologies will overcome current restrictions on maintenance communications requirements. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* JPO UAV TIER II Program, Goldenhawk, Joint Precision Strike, Automated Self-Prognosis Decision System, Telemaintenance, and the RML.

SATCOM TD (00–02). This technology effort will extend the applications and capabilities of SATCOM terminals by providing higher data rates, improvements in throughput, and reduced life-cycle costs. Overall improvements to systems and equipment will reduce size and increase mobility. When applied these technologies will overcome current restrictions on maintenance communications requirements It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* SATCOM upgrades and the RML.

i. Logistics Survivability on the Battlefield

Battlefield Combat Identification (BCID) ATD (93–98). The BCID addresses the mission need to develop effective and survivable ground-to-ground and air-to-ground combat identification capabilities to avoid engagement of friendly forces and noncombatants. This ATD will demonstrate target identification techniques together with situational awareness information, which will prevent fratricide during resupply and maintenance missions. It is discussed in detail in Volume I, Chapter III, Section F, " Intelligence and Electronic Warfare." *Supports:* Armored Vehicles, the Integrated C^3IEW System-of-Systems, Land Warrior, Battlespace C^2, Aviation platform upgrades, JPSD/RFPI, Force XXI, Logistics Survivability, and the RML.

Precision Navigation (PN) (94–98). This program provides accurate, robust, worldwide positioning that will allow resupply and maintenance/repair missions on the battlefield of the future. It is discussed in detail in Volume I, Chapter III, Section E, "Command, Control, Communications, and Computers." *Supports:* Digitization of the Battlefield, Navigation Warfare, Battlespace C^2, Precision Strike, RPA, Comanche, PEO Aviation, PEO C^3S, PEO IEW, PM AEC, PM GPS, PM ATC, systems upgrades Soldier System, Ground and Air Vehicles, and the RML.

Machine Vision for Autonomous Unmanned Ground Vehicle (MVAUGV) TD (96–99). Through this technology demonstration an autonomous navigation capability will be developed and demonstrated on a UGV that allows operation on or off roads, that can detect and circumnavigate obstacles, and that can autonomously replan its route. Resupply of the Army is essential to sustaining combat operations. This technology provides the capability to ensure that resupply operations continue at the required level and timeliness even with continued troop strength reductions. It is discussed in detail in Volume I, Chapter III, Section F, " Intelligence and Electronic Warfare." *Supports:* Joint UGV Project Office, Rapid Force Projection Initiative ACTD, Early Entry Lethality and Survivability, Dismounted Battlespace, Combat Service Support, and Depth and Simultaneous Attack Battle Labs, and the RML.

j. Soldier Sustainment

Performance Enhancing Demonstrations (95–98). Special supplemental components will supplement the Individual Combat Ration to heighten alertness, extend endurance, and reduce the effects of high altitude sickness. Sustaining our soldiers in all combat conditions is a key logistics mission. It is discussed in detail in Volume I, Chapter III, Section I, "Soldier." *Supports:* Army Field Feeding Future and the RML.

In March 1997, TRADOC hosted an AAN Technology Workshop with six panels, one of which focused on logistics efficiencies. The AAN Logistics Efficiencies Panel identified applications of advanced technology in power, distribution, soldier sustainment, system sustainment, ammunition, and C^4I. Its mission was to conduct broad studies of warfare to about the year 2025 to frame issues vital to the Army after about 2010 and to provide issues to the senior Army leadership for integration into TRADOC combat development programs. The objectives were to expand the AAN network of technologists across multiple disciplines and organizations, link technological *possibilities* to innovative operational capabilities, introduce the Integrated Idea Team Concept, identify enabling technologies that provide needed capabilities, integrate human and organizational issues, and answer these questions:

- How can the AAN project influence the science and technology process?
- How can science and technology influence AAN?

Technological issues identified by the AAN Logistics Efficiencies Panel include:

- Power and energy
  - Fossil fuel energy conversion is nearing the upper limits
  - AAN platforms, even at 15 tons, exceed current energy conversion capabilities for a ten-day operational mission
  - Significant RDT&E is required to obtain better energy conversion with new techniques, and reduce the weight of the AAN platform
  - Tactical energy distribution requires development
  - Alternate energy options (e.g., hydrogen, natural gas, methanol)
- System sustainment
  - "Ultra-reliability" as a major design priority: systems that never "break"
  - Predictive maintenance—systems that report on their condition: system health monitors, embedded sensors—nanoscience, and advanced prognostics
  - Self-repair—systems that fix themselves: smart structures—biomimetics (natural processes) and microengineered machines
  - Ease of repair—parts within 24 hours: telemaintenance and global distribution, design for discard—100 percent recoverability, and embedded training
- Command, control, communication, and automation
  - Fully automated, integrated operations/logistics C^2 capability: intelligent agents, and equally capable as combat platform and fielded concurrently
  - Automated logistics planning: interactive, predictive, and collaborative; and "sentinels"
  - Zero staging: AI-based and embedded simulation
  - Rapid supply: data mining, automatic requisition, automated contract negotiation, and EDI
  - Real-time situational awareness: object-based visualization, HCI, modeling, and simulation; real-time day/night, all-weather, all-terrain, all-threat knowledge; and real-time comprehensive knowledge of (1) location and combat status of friendly forces, (2) location, type, and timing of degrading and degraded ("broken") friendly assets, (3) disposition of threat forces ion relationship to degraded and degrading friendly assets, (4) location of natural and manmade obstacles to resupply/repair routes, (5) location and availability of supply/resupply assets to include repair parts, (6) location and availability transportation assets, and (7) current and predicted weather conditions
- Distribution
  - Information-based distribution, based on anticipated demand: embedded sensors and real-time total situational awareness (logistics, operations, supply chain)
  - Strategic maneuverability: "pipes" project logistics support fluidity, advanced airlift and fast sealift, single mobility platform (combat and combat support), and tactical sorter hub
  - 24-hour global delivery with 100 percent accuracy: precision (next generation) GPS air delivery

- Soldier sustainment
  - Agility, 90 percent lighter weight for combat load, uniform: advanced materials, multispectral protective fabrics; and combat power from external sources
  - Every soldier a "combat center": personal communications and POSNAV, heads-up displays with IFF, wearable computers/intelligent assistants, and "infallible" communications and support
  - Long term (2–4 weeks) self-sustainability: medical and nutrient patches, vehicles for medical evacuation owned by the medics, mission tailorable/sensory enhancing rations, physiological and mental status sensors, and next-generation water purification (e.g., polymers, UV)
  - Advanced soldier power sources (microturbines, fuel cells/batteries)
- Ammunition
  - Single round, single fuze: GPS—guided munitions, variable thrust, and lethality; and electronic fuze with built in IFF
  - "Safe" ammunition/environmentally green: insensitive munitions and energetic materials
  - Single propellant—run on what you shoot: hybrid electric weapons and energetic materials—liquid propellant hydrogen (multipurpose)
  - "Smart" lightweight packaging: embedded condition sensors and composites and plastics
  - "Soft kill" of equipment.

The AAN Logistics Efficiencies Panel has provided this framework of issues/requirements that need to be addressed in the S&T community for the Army to realize its Logistics capabilities required for Army XXI and the AAN.

The DoD S&T community has identified six Strategic Research Objectives (SROs) where the long-term potential exists for developing advanced technologies to meet requirements: nanotechnology, smart structures, intelligent systems, biomimetics, broadband communications, and compact power sources. These SROs are described below.

Nanotechnology. *Achieve dramatic, innovative enhancements in the properties and performance of structures, materials, and devices on the nanometer scale (i.e., tens of angstroms).* Fabrication of structures at the nanometer scale will enable manufacturing of more reliable, lower cost, higher performance and more flexible electronic, magnetic, optical, and mechanical devices. The potential exists for "battlefield manufacture" of materials required to prosecute a conflict.

Smart Structures. *Demonstrate advanced capabilities for modeling, predicting, controlling, and optimizing the dynamic response of complex, multielement, deformable structures used in land, sea, and air vehicles and systems.* Smart structures offer significant potential for expanding the effective operations envelope and improving critical operational characteristics for weapon systems. Logistics applications include a "self-healing" area for structural damage detection and mitigation systems.

Intelligent Systems. *Enable the deployment of advanced systems able to sense, analyze, learn, adapt, and function effectively in changing or hostile environments.* Intelligent systems typically consist of a dynamic network of agents interconnected via spatial and communications links that operate in uncertain and dynamically changing environments using decentralized or distributed input and under localized goals that may change over time. Intelligent systems must be capable of gathering relevant information about their environment, analyzing its significance in terms of assigned functions, and defining the most appropriate course of action consistent with programmed decision logic. Built-in, real-time, self-reporting prognostics for weapon systems is an application of this technology that will dramatically reduce logistic burdens, associated costs, and significantly improve the MTTR.

Biomimetics. *Enable the development of novel synthetic materials, processes, and sensors through advanced understanding and exploitation of design principles found in nature.* Materials and structures of intricate complexity that exhibit remarkable properties are found throughout the biological world. Many of these biological systems derive their functionality from fabrication through several levels of self-assembly involving molecular clusters organized into structures of different length scales. The result is an optimized architecture tailored for specific applications through molecular, nanoscale, microscale, and macroscale levels that is unobtainable through conventional, equilibrium-based, synthetic fabrication methods. The superior strengths and other properties such as noncorrosiveness and light weight of biomimetic materials lend themselves to solving and reducing numerous logistics burdens.

Broadband Communications. *Provide fundamental advances enabling the rapid and secure transmission of large quantities of multimedia information (speech, data, graphics, and video) from point-to-point, broadcast, and multicast over distributed networks for heterogeneous C^3I systems.* Research is needed to dramatically improve the throughput, survivability, and security of communication networks critical to logistics viability and the success of future Force XXI military operations.

Compact Power Sources. *Achieve significant improvements in the performance (power and energy density, operating temperature, reliability, and safety) of compact power sources through fundamental advances relevant to current technologies (e.g., batteries and fuel cells) and the identification and exploitation of new concepts.* Efficient, long-life, durable, and quiet compact power sources are a critical requirement for electronics, communications, heating and cooling, weapons, and propulsion systems.

Table G–2 portrays the value added for logistics from the application of the technologies represented in the six DoD SROs.

Table G–2. Logistics' Applications of DoD SRO Technologies

Nanotechnology	Smart Structures	Intelligent Systems	Biomimetics	Broadband Communications	Compact Power Sources
Changes concept of manufacturing—do anywhere	Vibration damping and reduction via embedded sensors	Execution of logistics system tasks without human intervention except when desired	Medical applications to include immediate repair of broken/crushed bones and combat injuries	Provide field users with flexible, mobile, and easily deployable communications conduits	Reduce fuel and power storage and distribution requirements significantly
Synthesis from local materials	Reduced maintenance requirement	Unmanned ground/air vehicles decrease force structure and improve system response time	Repairs to combat damaged equipment	Untether logistics processes from fixed wire sites	Increased operational capability of the soldier as a system
Sophisticated, extremely lightweight material	Reduced resupply and transportation requirements	Robots to handle materiel that is dangerous, heavy, or sensitive	Designer vaccines and drugs for quick return to healthy status	Increased data pass capability	Handle power requirement of dismounted soldier: heating and cooling; computer use; communications transmissions

Table G–2. Logistics' Applications of DoD SRO Technologies (continued)

Nanotechnology	Smart Structures	Intelligent Systems	Biomimetics	Broadband Communications	Compact Power Sources
Quantum computing at very high speed	Improved storage with ambient temperature control	Decision support system "brains" to monitor individual weapon systems and prevent failure	Lightweight structures and system components with ultra-reliability and virtually frictionless	Reduce frequency of data reporting	Reduced dependence on fossil fuels
Prophylactics and cures for chem/bio agents	Secure system containers for critical resources	Reduced logistics distribution requirements by accurately assessing potential component failures and using collective knowledge of entire weapon system	Impact resistant material that can be grown in combat area	Integrate weapon system sensors reporting prognostic information on a broad scale	Reduced resupply requirement for power sources
Ultra-strong fibers	Reduced damage to material by adjusting containers and structures for various shock and impact conditions	Improved logistics planning via multisensory perception development	Lightweight armor—reduced logistics footprint across the board	Evaluate the "health" of entire groups of common weapon systems individually and independently	Reduce environmental issues associated with battery disposal
Programmed ultra-reliability	Structures respond to external stimuli and adapt accordingly	Improved exoskeletons to reduce force structure for materials handling equipment—increased lift capability	High resolution sensors to detect imperfections and for troubleshooting	Improve timeliness of the logistics communications support structure	Required to develop containers with micro heat pumps and long term power capability for independent operations
Reduced logistics demand	Retain history of access and denials/automatic inventory	Reduced hazardous exposure during critical item operations or repair	Development of superconductor material could lead to propulsion without motors or gears as we know them		
Environmentally enhancing	Reduce logistics requirements for chem/bio defense		Noncorrosive and nonerosive		
	Immediate battle damage assessment and failure reporting				
	Improve fuel storage capability				

Table G–2. Logistics' Applications of DoD SRO Technologies (continued)

Nanotechnology	Smart Structures	Intelligent Systems	Biomimetics	Broadband Communications	Compact Power Sources
	Biomedical applications including "in vivo" sensing and control				
	Rapid nondestructive testing responses (less out of service time)				

This annex shows R&D initiatives that are ongoing in the Army laboratories that directly and significantly benefit Army logistics in its quest to fulfill its obligations to support Army XXI and AAN.

F. ABBREVIATIONS

3D	three dimensional
3rd GARD	third-generation advanced rotor demonstration
AAN	*Army After Next*
ABCS	Army battle command system
AEC	airborne electronic combat
AEFCS	advanced electronics for future combat system
AI	artificial intelligence
ARCAT	advanced rotorcraft aeromechanics technologies
ASLP	Army Strategic Logistics Plan
ASTMIS	Army Science and Technology Management Information System
ATD	advanced technology demonstration
BCID	battlefield combat identification
C^2	command and control
C^3I	command, control, communication, and intelligence
C^3IEW	command, control, communications, intelligence, and electronic warfare
C^4I	command, control, communications, computers, and intelligence
CONUS	continental United States
CSS	close combat support
DBC	digital battlefield communications
DoD	Department of Defense
EEI	essential elements of information
FCS	future scout and cavalry system
FCSM	future combat system mobility
FDR	future digital radio
GPS	global positioning system

HCI	hydrocyanic acid
ICH	improved cargo helicopter
IFF	identification friend or foe
IHPTET	integrated high-performance turbine engine technology
ILS	integrated logistics support
IVES	intravehicle electronic suite
JTAGG	joint turbine advanced gas generator
JTR	joint transport rotocraft
JV 2010	Joint Vision 2010
MBMMR	multiband multimode radio
MOUT	military operations in urban terrain
MTBF	mean time between failures
MTBR	mean time between replacements
MTTR	mean time to repair
MVAUGV	machine vision for autonomous unmanned ground vehicle
OCONUS	outside continental United States
O&S	operation and support
OBID	on-board integrated diagnostic system
PEO	Program Executive Office
PN	precision navigation
POS/NAV	position/navigation
R&D	research and development
RTV	rapid terrain visualization
RDT&E	research, development, test and evaluation
RE	range extension
RMA	*Revolution in Military Affairs*
RML	*Revolution in Military Logistics*
RPA	rotorcraft pilot's aircraft
RTV	rapid terrain visualization
RWST	rotor-wing structures technology
S&T	science and technology
SATCOM	satellite communications
SRO	strategic research objectives
STAS	subsystem technology for affordability and supportability
TMDE	test measurement diagnostic equipment
TRADOC	Training and Doctrine Command
UGV	unmanned ground vehicle
UV	ultraviolet