National Aeronautics and Space Administration


# Advanced Air Vehicles Program

Jimmy Kenyon
Director, Advanced Air Vehicles Program

February 2022

# NASA Aeronautics – Vision for Aviation in the 21st Century


ARMD continues to evolve and execute the Aeronautics Strategy *https://www.nasa.gov/aeroresearch/strategy*

6 Strategic Thrusts

- Safe, Efficient Growth in Global Operations
- Innovation in Commercial Supersonic Aircraft
- Ultra-Efficient Subsonic Transports
- Safe, Quiet, and Affordable Vertical Lift Air Vehicles
- In-Time System-Wide Safety Assurance
- Assured Autonomy for Aviation Transformation

U.S. leadership for a new era of flight



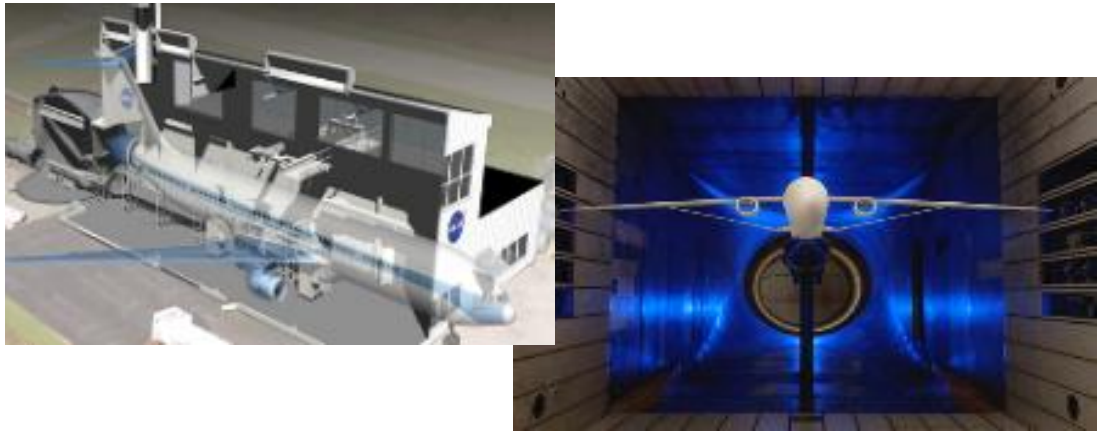




Four Transformations for Sustainability, Greater Mobility, and Economic Growth

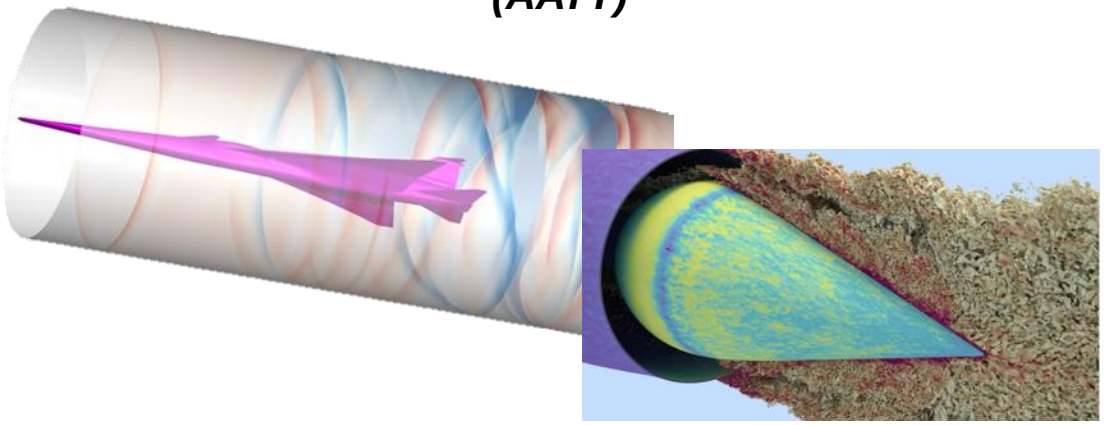
# Advanced Air Vehicles Program

***Cutting-edge research that will generate innovative concepts, technologies, capabilities & knowledge to enable revolutionary advances for a wide range of air vehicles***

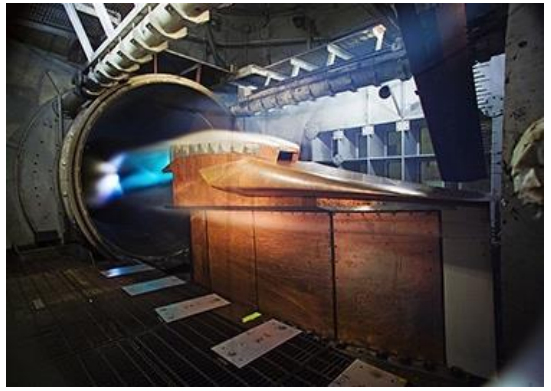


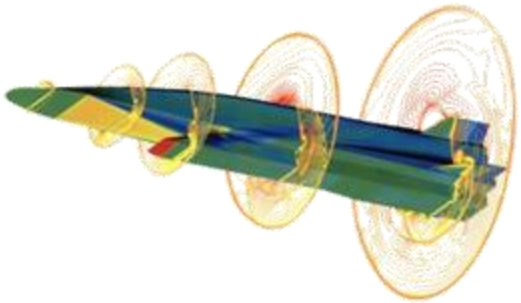
***Advanced Air Transport Technology (AATT)***

***Revolutionary Vertical Lift Technology (RVLT)***



***Commercial Supersonics Technology (CST)***

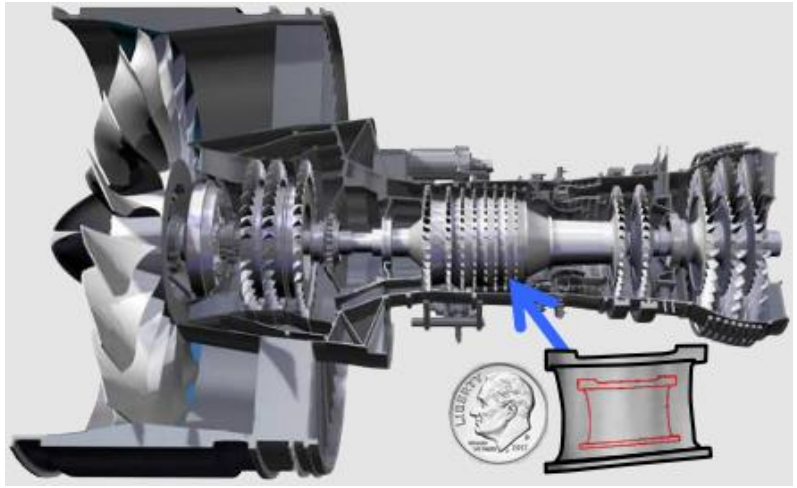




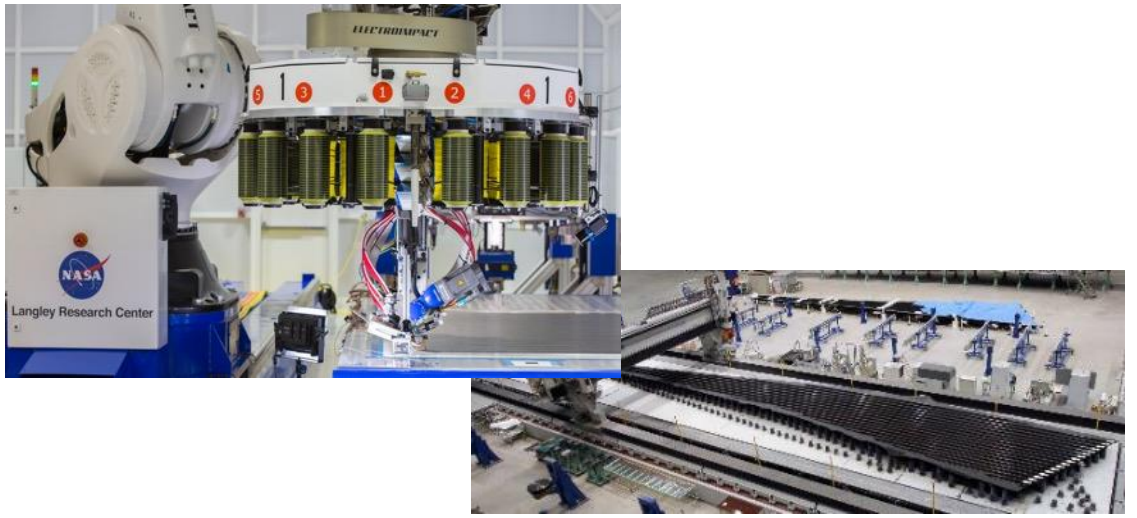
***Hypersonic Technology (HT)***

# Advanced Air Vehicles Program

***Accelerating development and demonstration of key technologies***

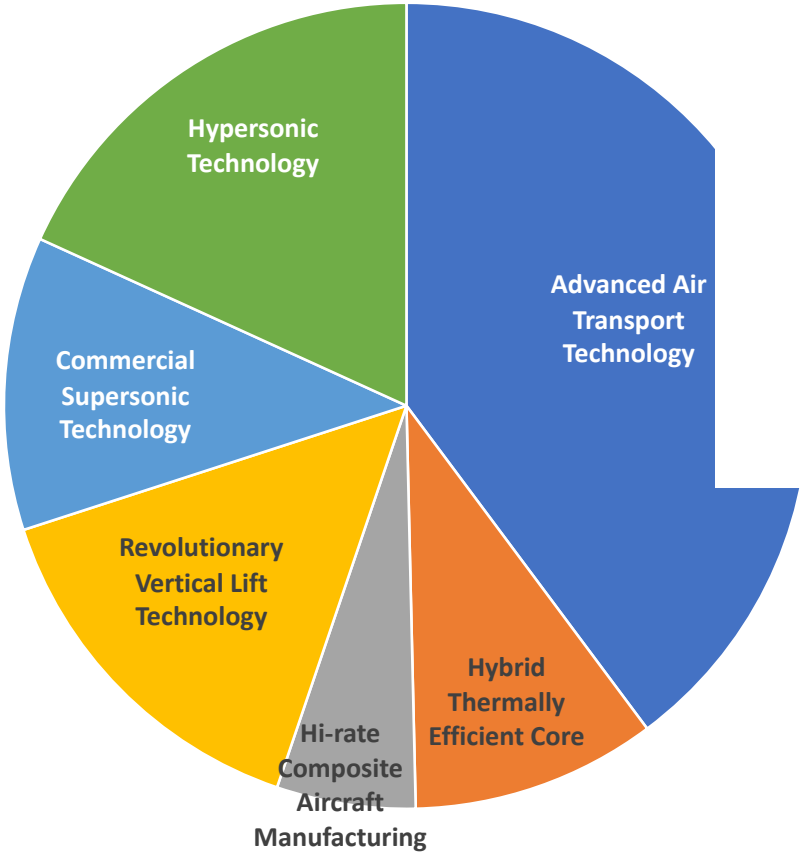


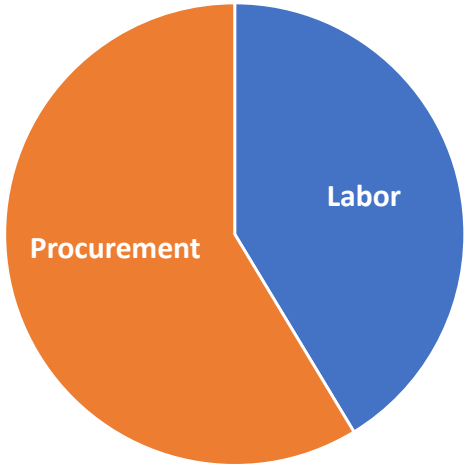
**Hybrid Thermally Efficient Core (HyTEC)**




**High-rate Composite Aircraft Manufacturing (HiCAM)**

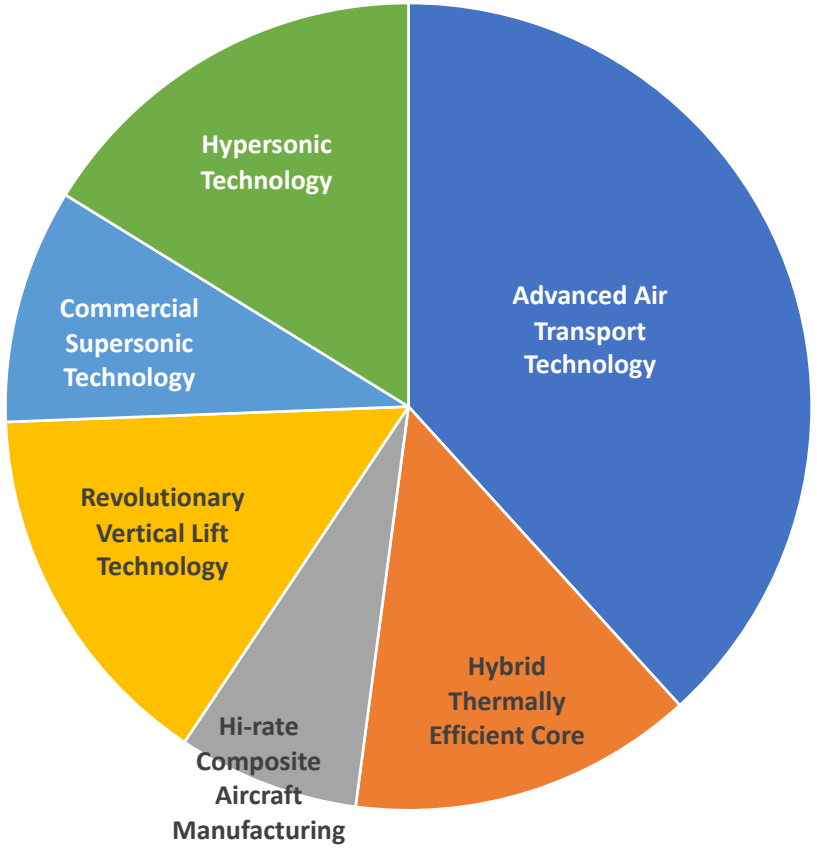
# AAVP FY22 Budget Request Breakout by Project




FY21
$211M

FY22
$244M



# FY22-23 AAVP Technical Priorities

- Complete computational tool and hardware preparations for X-59 acoustic validation testing and continue development of community response test plans, incorporating feedback from both national and international subject matter experts
- Establish and implement the MBSA&E initiative to digitally integrate all SFNP Project elements demonstrating overall benefits and insight into technology tradeoffs
- Execute AATT with a focus on contributions to SFNP including successful completion of major TTBW and EAP component tests
- Execute Phase 1 of HyTEC to advance critical technologies (including recent high-blend SAF combustor technologies) needed for integration into TRL 6 capstone demonstration in Phase 2
- Complete HiCAM formulation, enter implementation, and execute technology screenings to position HiCAM to downselect concepts for capstone manufacturing demonstration and structural test
- Establish and implement a long-term, zero-emissions strategy in partnership with TACP and launch advanced concept studies with industry
- Maintain priority & focus on AAM vehicle safety and noise through successful execution of current TCs and establishment of critical additional TCs in handling/ride qualities and crashworthiness
- Develop and implement a commercial high-speed strategy that addresses key barriers in commercial high-speed flight while continuing to support DOD partnerships and needs

# FY22-23 AAVP Organizational Priorities

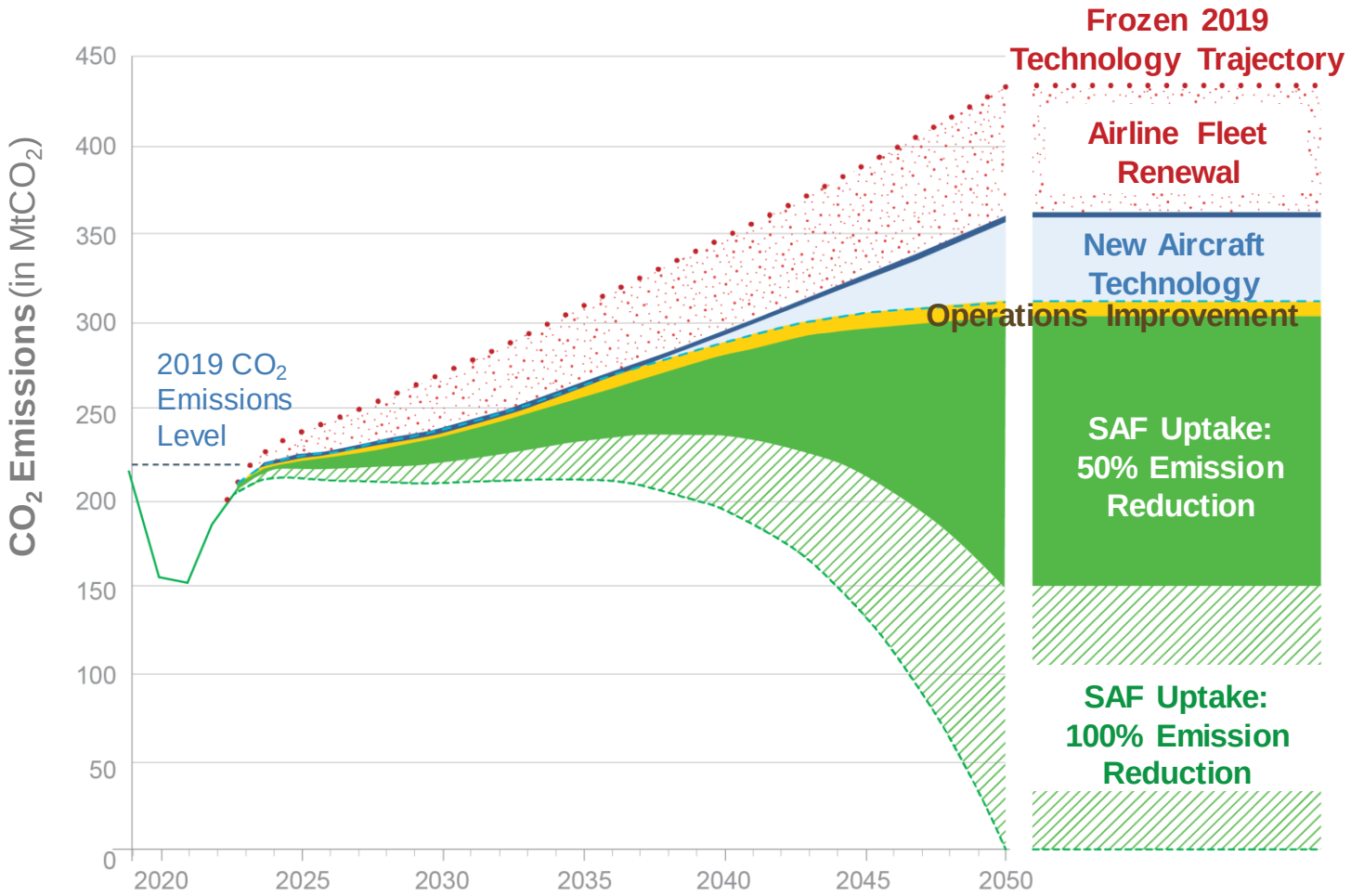
- Work with Center Aeronautics Research Directors to develop and implement a strategy to ensure availability and efficacy of critical research capabilities by balancing resource requirements with research priorities
- Hire Integration Manager, establish Technical Advisor rotational assignment, and ensure AAVP organization is positioned to meet all Program and Project commitments
- Remain cognizant of managing workloads and expectations for the program team, including PMs and DPMs, within a hybrid work environment to help ensure healthy work-life balance and sustainable productivity considering the diverse and individual needs of team members
- Support and strengthen Agency/ARMD internal and external partnerships to ensure alignment and coordination of efforts—to leverage all efforts and avoid duplication, to deliver AAVP product into Missions, and to maximize return on investments

# Global Context for Sustainable Aviation

## U.S. Government Aviation Climate Action Plan

To address the U.S. economy-wide goal of net-zero greenhouse gas emissions by 2050, the U.S. aviation sector is pursuing a basket of measures

U.S. Government goal and plan consistent with ICAO (global Nations) and with ATAG (global industry) goals and directions

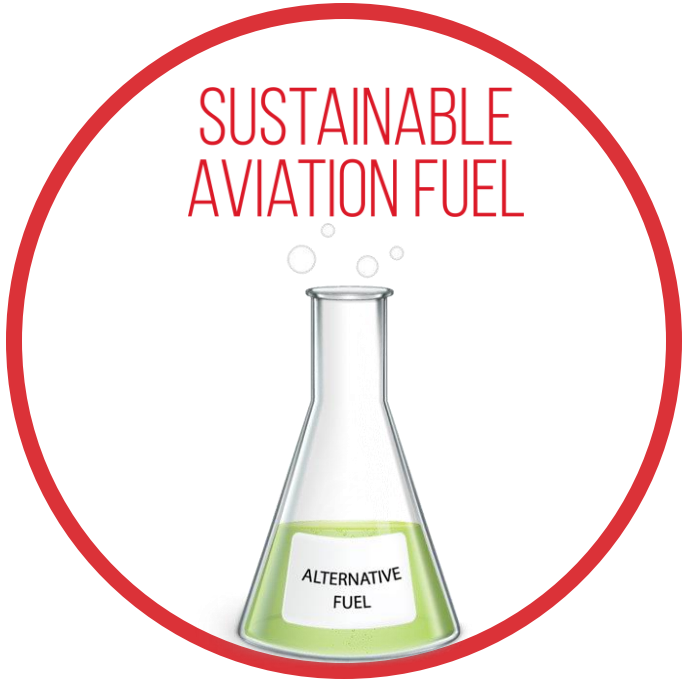



More than 97% of U.S. aviation $CO_2$ emissions is from the combustion of jet fuel. 80% of domestic aviation emissions and 94% of international aviation emissions come from en-route operations above 10k ft.

# Aviation Pillars for a Sustainable Future

**Global Aviation Industry GOAL: net-zero carbon emissions by 2050**

NASA = Primary Role

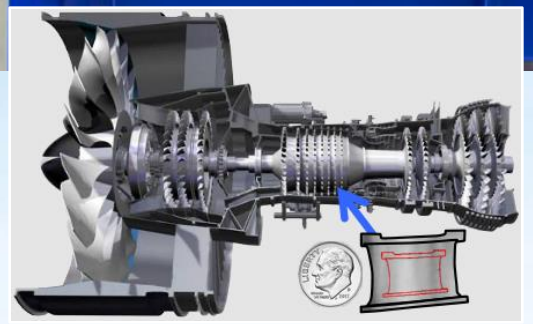



NASA = Supporting Role


NASA = Primary Role

Ensure U.S. industry is the first to establish the new "S Curve" for the next 50 years of transports


**Transonic Truss-Braced Wing**
**5-10% fuel burn benefit**

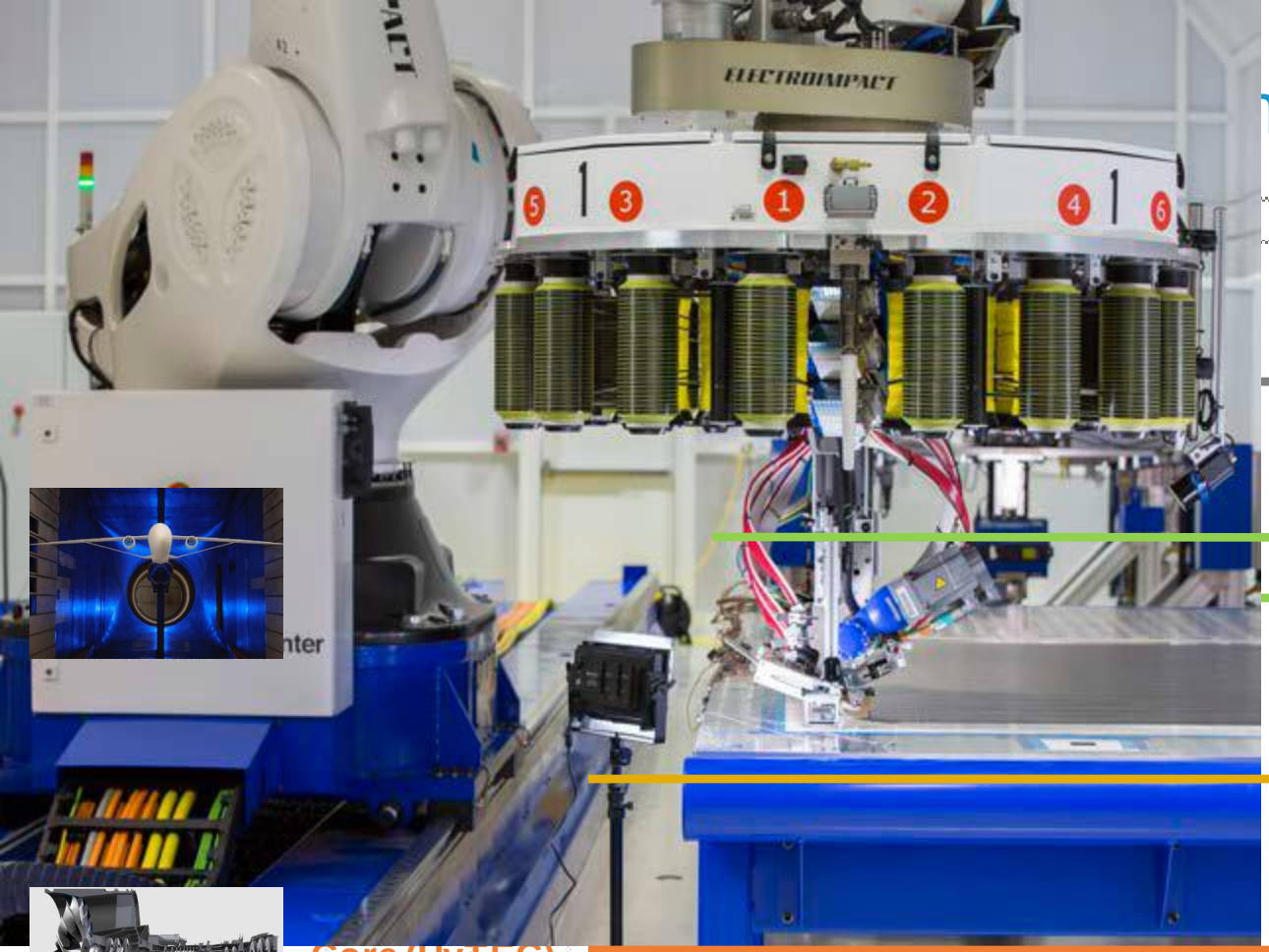


**Small Core Gas Turbine**
**5-10% fuel burn benefit**

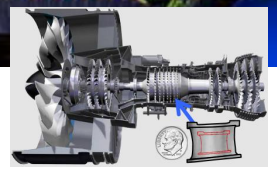
**Electrified Aircraft Propulsion**
**~5% fuel burn and maintenance benefit**

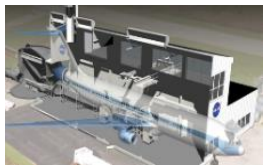
**High-Rate Composite Manufacturing**
**4x-6x manufacturing rate increase**

# nology Development







FY25 | FY26 | FY27 | FY28 | FY29

Technology Readiness Target

Flight Test

TC Completion

Mfg Demo & Structural Test

Core Demonstration & Test

Core (HyTEC)

Electrified Powertrain Flight Demonstration (EPFD) Flight Test

AATT - Electrified Aircraft Propulsion

TC Completion

Achieve TRL 6 in time for Industry Product Decision-Making

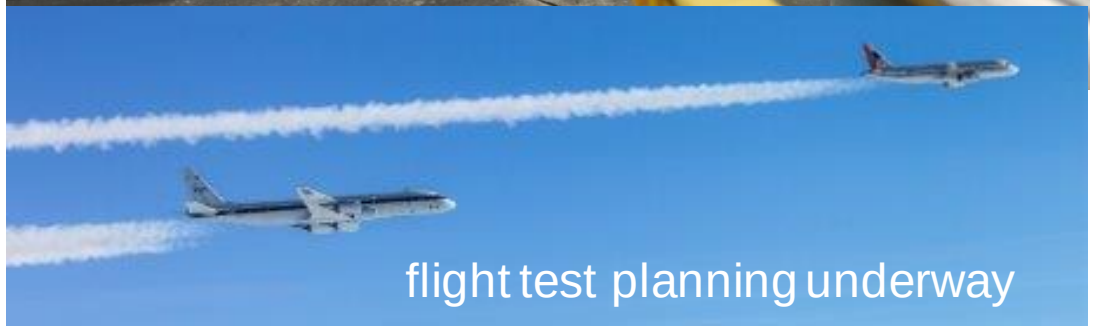
Leverage the Asset – Future Spirals

Planned

Notional

# Sustainable Aviation Fuels

Enable the use of 100% SAF and reduced climate impact


**Scope**

- Support adoption of high blend ratio sustainable aviation jet fuels

**Benefit**

- Reduced aviation environmental impact
- Reduced uncertainty for climate impact of aviation-induced cloudiness
- Improved efficiency/emissions with drop-in synthetic & biofuels

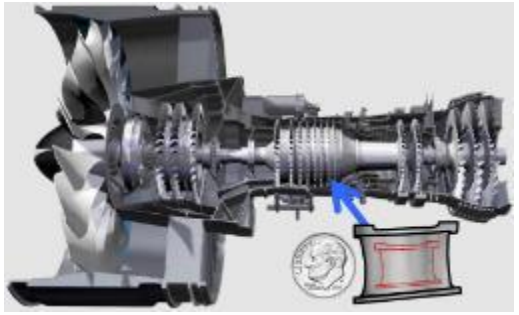
**Approach**

- Characterize high-blend sustainable aviation jet fuel emissions on ground and in flight
- Advance small core combustor design & operability for sustainable aviation fuels

# SFNP Status: Flurry of Coordinated Activity

Electrified Powertrain Flight Demos kicked off, SFD in formulation

TTBW low-speed high-lift testing completed in LaRC 14x22', high-speed buffet testing underway in ARC 11x11'



HyTEC Phase I work underway
HyTEC combustor awards pending

HiCAM approved for implementation


Coordinating efforts with FAA, other government agencies, industry, academia

# Sustainable Flight National Partnership Benefits

Small Core Gas Turbine for 5%-10% fuel burn benefit
(HyTEC Project)

Electrified Aircraft Propulsion for ~5% fuel burn and maintenance benefit
(EPFD & AATT Projects)

Sustainable Aviation Fuels for reduced lifecycle carbon emissions
(AATT Project)

Transonic Truss-Braced Wing for 5%-10% fuel burn benefit
(AATT Project)

High-Rate Composites for 4-6x manufacturing rate increase
(HiCAM Project)

Integrated Trajectory Optimization for 1%-2% reduction in fuel required and minimization of contrail formation
(ATM-X Project)

# Long-Term Transport Technology & Innovation

***Generational studies to inform future technology investments***


## Opportunities to Define Future Aviation Systems and Concepts

- Advanced Concept Studies for 2040+ EIS
- Net-Zero Emissions Concepts
- Promising Technology & Architectures
- Support Aviation Community with NASA-unique Contributions




INNOVATIONS FOR 2040s AND BEYOND

# High-Speed Commercial Flight

## Sustainable transformation of the speed of air travel

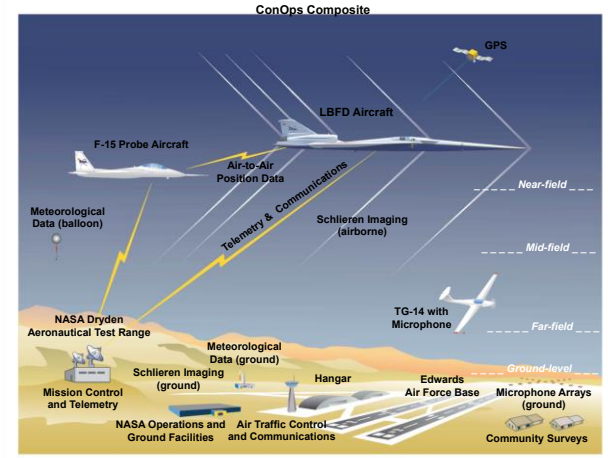

**Addressing the unique barriers to sustainable, environmentally responsible high-speed flight**

Generate key data to support development of en route certification standards based on acceptable sound levels

# Low Boom Flight Demonstration Mission

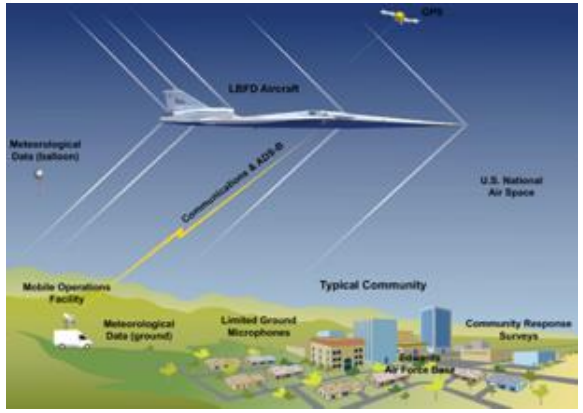
## Phase 1 – Aircraft Development

*FY18-23*




## Phase 2 – Acoustic Validation

*FY23-24*

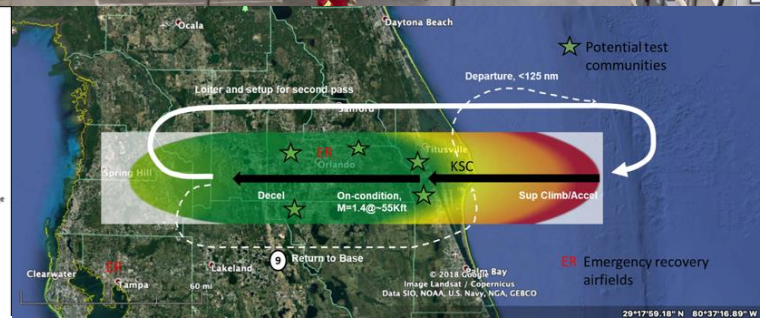



## Phase 3 – Community Response Testing

*FY24-27*

# LBFD Mission Status

Credits: Lockheed Martin


**Aircraft Development**

X-59 aircraft shipped to Fort Worth

Structures load testing underway

**Acoustic Measurement**

Ground Recording System being developed, phased delivery of 125+ units

Progress continues on airborne acoustic measurement systems

**Community Test Planning & Execution**

Test and survey plans in development

Airfield & community selection process ongoing

**International Standards Development**

Continued engagement with FAA, ICAO/CAEP & international research community

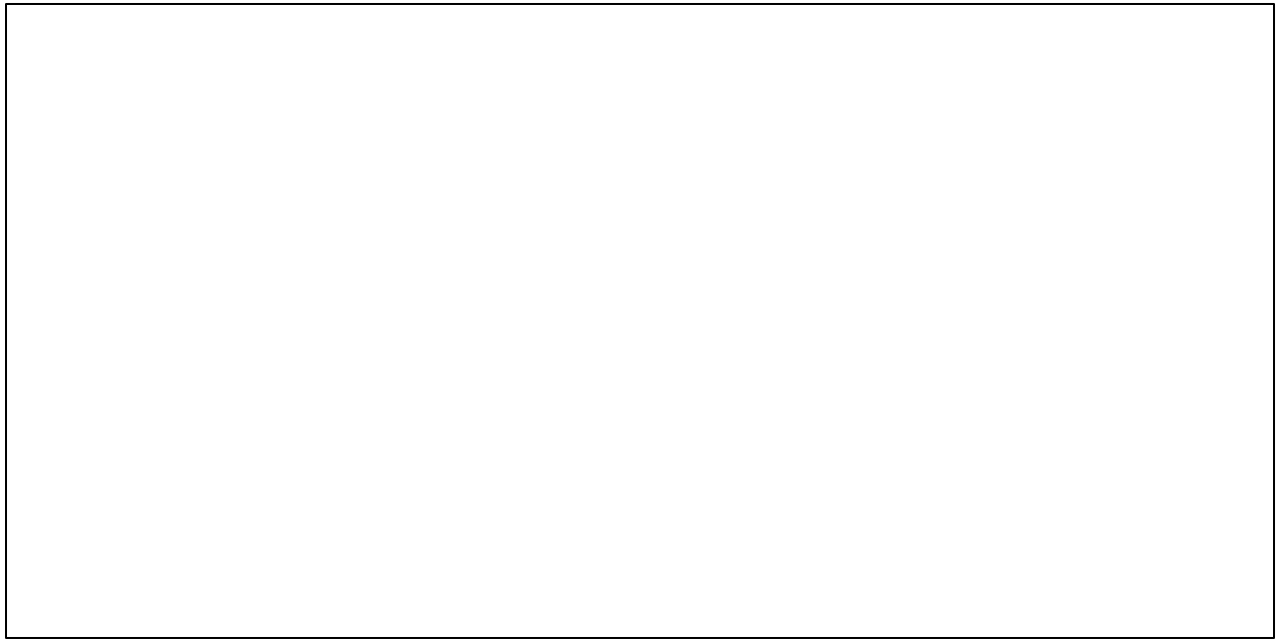
Third virtual international workshop in late 2022

FIRST FLIGHT IN 2022

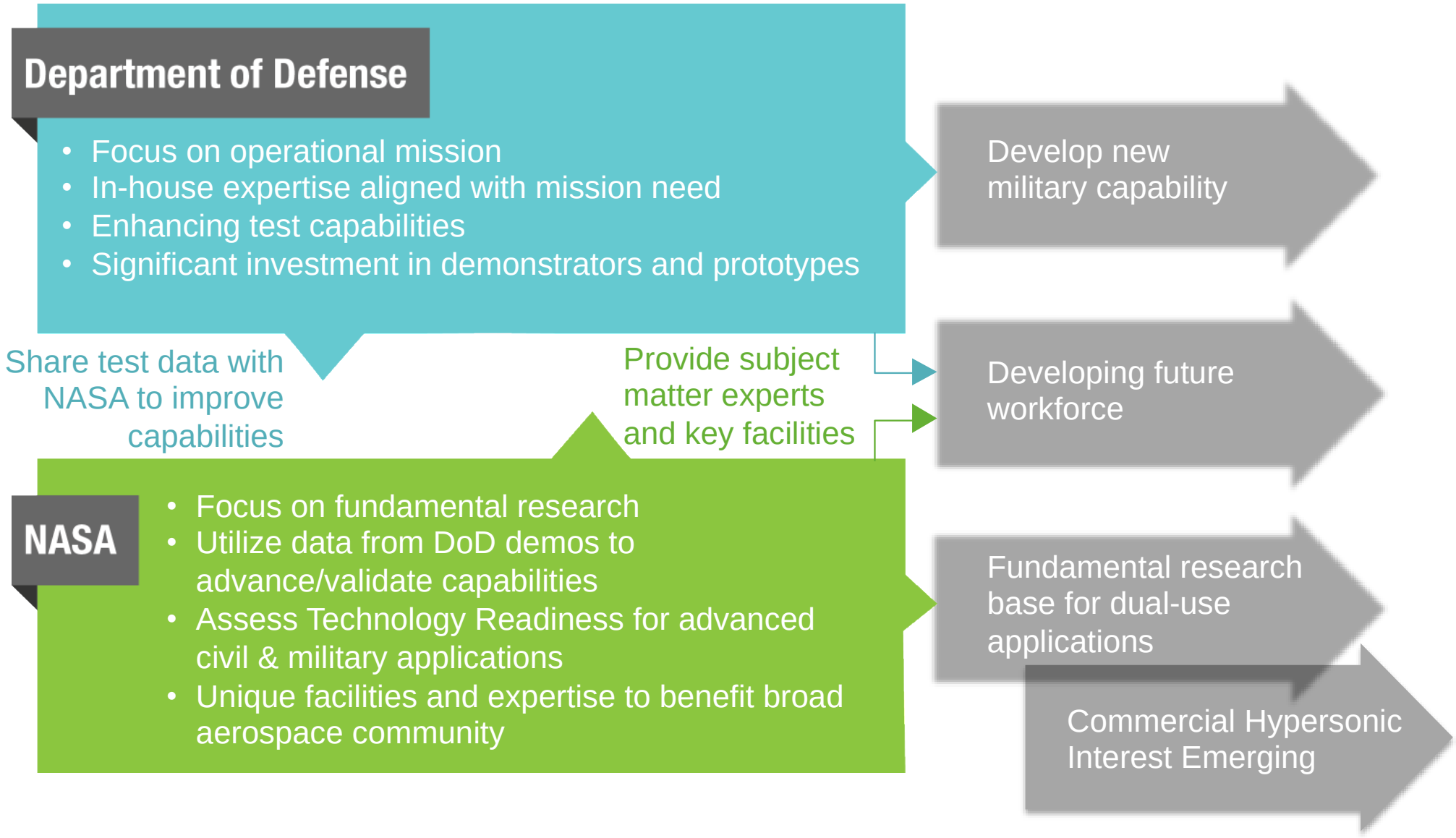
# Hypersonic Strategy Assessment

**Enabling routine, reusable, airbreathing hypersonic flight**

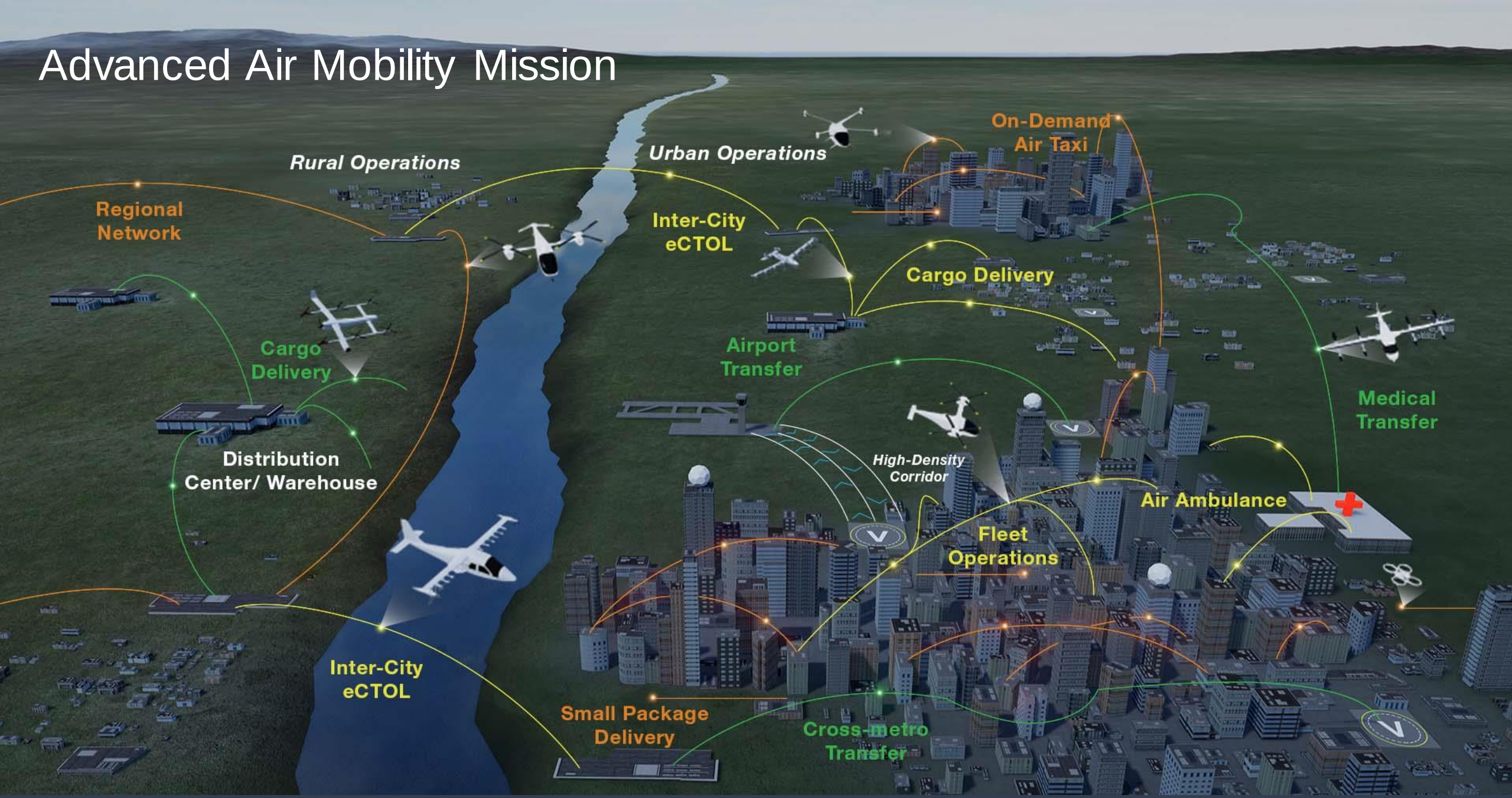
- Independent market studies indicate potential for a commercial high-speed market
- Hypersonic market barriers similar to supersonic, but solutions are different
- Additional market and technology studies kicking off
- Continuing development of critical technologies and capabilities



# NASA/DoD Partnership for Hypersonics



# Advanced Air Mobility Mission




***Safe, sustainable, affordable, and accessible aviation for transformational local and intraregional missions***

# AAM North Stars

**Noise**

**Airspace**

**Safety**

**Automation**



Image Credit: Daniel Mennerich

# AAM Current Status

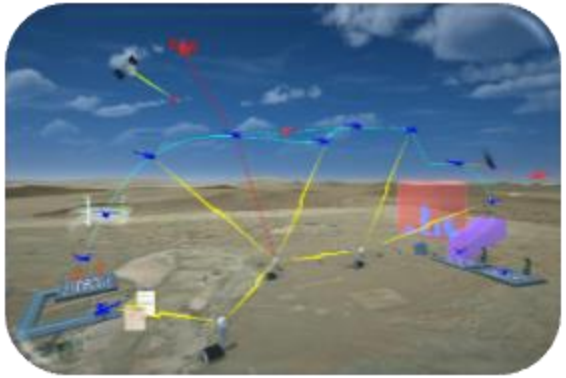
National Campaign Developmental Testing completed

*Flights with Joby enabled initial assessment and data collection of eVTOL performance characteristics and acoustics*


Credit: Joby Aviation

Finishing lab conversions in the Engine Research Building for high-reliability propulsion components

Moog Surefly noise measurements

Preparing for NC-1 flights coming up in 2022

# Challenges and Opportunities





NASA