REPORT NO. CASD-NAS-75-054
CONTRACT NAS 8-31368

(NASA-CR-144123) DEFINITION OF LIFE SCIENCES LABORATORIES FOR SHUTTLE/SPACELAB. VOLUME 5: LIFE SCIENCES LABORATORY SYSTEM REQUIREMENTS DATA BOOK. BOOK 1: SYSTEM REQUIREMENTS. BOOK 2: APPENDICES (General G3/51

N76-15767

Unclas
07422

DEFINITION OF LIFE SCIENCES LABORATORIES FOR SHUTTLE/SPACELAB

VOLUME V • LIFE SCIENCES LABORATORY SYSTEM REQUIREMENTS DATA BOOK

BOOK 1 • SYSTEM REQUIREMENTS
BOOK 2 • APPENDICES

GENERAL DYNAMICS
Convair Division

REPORT NO. CASD-NAS-75-054

DEFINITION OF LIFE SCIENCES LABORATORIES FOR SHUTTLE/SPACELAB

VOLUME V • LIFE SCIENCES LABORATORY SYSTEM REQUIREMENTS DATA BOOK

December 1975

Submitted to
National Aeronautics and Space Administration
GEORGE C. MARSHALL SPACE FLIGHT CENTER
Huntsville, Alabama

Prepared Under
Contract NAS 8-31368

Prepared by
GENERAL DYNAMICS CONVAIR DIVISION
P.O. Box 80847
San Diego, California 92138

MAJOR ACRONYMS AND ABBREVIATIONS

ARC	Ames Research Center
BEST	Bioexperiment Support & Transfer
CER	Cost Estimating Relationship
CDMS	Command and Data Management Subsystem
CIS	Central Integration Site
COL	Carry-On Laboratory
CORE	Common Operational Research Equipment
CRT	Cathode Ray Tube
CVT	Concept Verification Test
EC/LSS	Environmental Control/Life Support Subsystem
ECS	Environmental Control System
EDC	Experiment Development Center
EI	Equipment Item
ESA	European Space Agency
G&A	General & Administrative
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
HQTRS	Headquarters (NASA)
IMBLMS	Integrated Medical & Behavioral Laboratory Measurement System
JSC	Johnson Space Center
K	One Thousand (e.g., $K or Kbits)
KSC	Kennedy Space Center
LSPS	Life Support & Protective Systems
M	One Million
ML	Mini-Lab
MSFC	Marshall Space Flight Center
MSI	Man Systems Integration
MSOB	Manned Space Operation Building
NR	Non-Recurring
OPF	Orbiter Processing Facility
PCR	Payload Changeout Room
POC	Payload Operations Center
RAM	Research and Application Module
RAU	Remote Acquisition Unit
R-O	Recurring Operations (Cost)
R-P	Recurring Production (Cost)
S/L or SL	Spacelab
SRT	Supporting Research & Technology
SPDA	STS Payload Data & Analysis
STDN	Space Tracking & Data Network
STS	Space Transportation System
TDRS	Tracking and Data Relay Satellite
WBS	Work Breakdown Structure

BOOK 1 • SYSTEM REQUIREMENTS

1.0 INTRODUCTION

This document and updated versions of it are primarily intended to define the system requirements of the Life Science laboratories through various mission phases. Secondarily it can be used to acquaint the engineer, scientist, and program planner with the selected laboratory capabilities and limitations.

The system requirements of three selected Life Science laboratory concepts are defined for the mission phases of pre-launch, launch, on orbit, descent, and post landing.

2.0 LIFE SCIENCE LABORATORY CONCEPTS

The objective of having a family of Life Science laboratory concepts is to provide for program planning flexibility. This flexibility satisfies the science requirements as well as programmatic considerations.

The system requirements defined in this databook are based upon three classes of laboratories.

1. Carry-On Laboratories (COL) - These laboratories are the smallest being considered and generally weigh less than 25 Kg. They have minimum interface requirements and can be installed in the Orbiter crew compartment. They are normally considered for flights of opportunity of seven days or less.

2. Mini-Lab - These laboratories are intermediate in size and generally weigh less than 500 Kg. They are contained in one to several Spacelab equipment racks and have significant interfaces with the power, ECS, and CDMS. They are used on shared missions with durations from 7 to 30 days.

3. Dedicated Laboratories - These laboratories are the largest being considered and may weigh as much as 2500 Kg. As the name implies these laboratories are dedicated only to Life Sciences research. They have extensive interfaces with the Spacelab subsystems. They may use as many as three discipline specialist on missions from 7 to 30 days.

The individual laboratory concepts defined during the phase A study are defined below. The system requirements are presented for one lab from each of the three classes. The selected laboratories for detail system requirement definition are: COL-2A, ML-1A and MOD-IA.

Lab Concept	Designation	Research Emphasis
Carry-On	COL-2A	Biomedicine
Carry-On	COL-3A	Biomedicine
Mini-Lab	ML-1A	Biomedicine (1st US/ESA Mission)
Mini-Lab	ML-2A	Biomedicine/Biology
Mini-Lab	ML-3A	Biomedicine
Mini-Lab	ML-4A	Life Support/Protective Systems
Mini-Lab	ML-5A	Man-Systems Integration
Mini-Lab	ML-2B	Biomedicine/Biology
Mini-Lab	ML-2C	Biomedicine/Biology
Mini-Lab	ML-2D	Biology
Dedicated Lab	MOD-IA	Biomedicine/Biology

Table 2-1. Life Science Laboratory Equipment Inventory

E.I. No.	Equipment Item Name	Unit Weight kg	Unit Power w	Unit Volume dm^3
1	ACCELEROMETER	0.1	0	0.03
1A	ACCELEROMETER COUPLER	0.05	1	0.01
3E	AIRLOCK	SHUTTLE		
6	AIR PARTICLE SAMPLER	2.7	50	0.85
6A	AIRFLOW WORK SURFACE	5	75	6
7	AUTOANALYZER (GEMSAEC)	26	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	12.7	100	57
11	ANALYZER, GENL. SPECTROPHOT.	30	240	90
14	ANESTHETIZER, INVERT.	0.2	0	1
14B	ANTENNAS, ASSORTED	0.1	0	0.03
15	ANTHROPOMETRIC GRID	1.8	0	2.9
15A	ATMOS. SAMPLING SYSTEM	10	20	28
15D	AUDIO STEREO HEADSET	0.7	0	5.7
16E	AUDIOMETER	4.5	25	4.3
16L	BADGES, RADIATION	0.2	0	0.1
16F	BALLISTOCARDIOGRAM COUPLER	0.1	1	1
18C	CUSTOM BITE BOARDS	0.25	0	0.03
19D	BODY MASS MEAS. DEVICE	36.5	15	675
25	CAGE, INVERTEBRATES	0.3	0	0.2
25F	COLONY CHAMBER, SEALABLE	0.2	0	0.1
26A	CAGE, METABOLIC, C/T	0.8	5	0.9
26E	CAGE, METABOLIC, PLANT	7	30	74.6
28	CAGE, METABOLIC, RATS	8	20	28.3
29	CAGE, PLANT	4.5	0	56.6
30A	CAGE, RAT, HAMSTER, STANDARD	2.3	9	11
31	CALCULATOR, POCKET	0.47	0	0.4
32	CAMERA, CINE	5	15	5
32A	CAMERA CONTROLLER	13.6	100	28.3
33	CAMERA, POLAROID	3.3	0	5.6
36	CAMERA, 35 MM AND STROBE	2	0	2
37	CAMERA, VIDEO, B/W	4.4	15	3
38	CAMERA, VIDEO, COLOR	7.7	69	6.2
38B	CAMERA MOUNTS	3	0	3
38D	CAMERA TIMER, VIDEO	4	10	3
38F	CARDIOPULMONARY ANALYZER	90.7	200	172
40A	CENTRIFUGE, BLD SMPL PROCESSOR	12.7	100	25
43A	CENTRIFUGE, BIORESEARCH	250	354	6800
44	CHEMICALS	0.5	0	1.0
44A	CHEMICALS, RADIOISOT. TRACERS	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	4.0	0	14.1
46	CLEANER, VACUUM	2.3	100	10
50	CLINOSTAT (FOR PLANTS)	3	10	20
50A	CLINOSTAT (FOR C/T)	2	10	4
50B	COMPACTOR, SOLIDS	18	100	113
51	COMPUTER, DIGITAL	SPACELAB		
51D	CONTROL CONSOLE, EXPERIMENTER	22.7	100	113.3
51F	COOLANT LOOP, LIQUID	30	50	25
54	COUNTER, COLONY, MANUAL	1.5	50	1.5
55A	CREW MOBILITY AIDS	SPACELAB		

Table 2-1. Life Sciences Laboratory Equipment Inventory, Contd

E.I. No.	Equipment Item Name	Unit Weight kg	Unit Power w	Unit Volume dm^3
55B	CREW RESTRAINTS	SPACELAB		
55C	CREW WORK STATION	SPACELAB		
56A	DATA MGMT SYST BUSES	SPACELAB		
58A	DMS CONTROL AND DISPLAY STA.	SPACELAB		
58B	DMS REMOTE ACQUISITION UNIT	SPACELAB		
63B	DISPLAY KEYBOARD, PORTABLE	13.6	60	42.5
63C	DISPLAY, NUMERIC	2	2	4
64	ECG COUPLER	0.2	2	0.5
65	EEG COUPLER	0.2	2	0.5
65B	ELECTROPHYS. BACKPACK	0.3	0	0.25
65C	ELECTROPHYS. RECEIVER	2.7	25	5.0
66	EMG COUPLER	0.2	2	0.5
69A	ELECTROMETER	3.7	3	7.3
70	ELECTROPHORESIS APPARATUS	9.1	85	25.5
70C	EQUIPMENT RESTRAINT DEVICE	0.5	0	1
70E	EXERCISE EQUIP., PHYSIOL.	96	16	992
75C	FILM, CINE	0.54	0	0.54
75F	FILM, POLAROID	0.16	0	0.15
76C	FILM, 35 MM	0.13	0	0.05
76J	FLOWMETERS	0.5	1	0.5
76L	FIBROMETER, BLOOD CLOT	4.5	40	19.6
77B	FREEZER, CRYOGENIC	21.6	10	74.1
80	FREEZER, GENERAL	15	200	61.4
81	FREEZER, LOW TEMP.	8	10	30.5
85	FRIG. (REFRIGERATOR)	18	50	120
87	GAS ANALYZER, INFRARED	11.3	50	42.6
91	GAS ANALYZER, MASS SPEC.	25	50	20
95	GAS ANALYZER, RH	5.2	6	13
95A	GAS SUPPLIES	5.75	0	18
96	GLOVE BOX, PORTABLE	4.5	0	25
96C	GLOVE BOX LINERS	0.5	0	1
97C	HANDWIPES, BETADYNE	0.3	0	0.3
98A	HOLDING UNIT, CELLS/TISSUES	23	30	188
98C	HOLD. UNIT, INVERTEBRATES	23	50	188
99	HOLDING UNIT, COMMON	20.4	50	188
101	HOLDING UNIT, PLANT	25	500	188
101B	HOLDING UNIT, MONKEY POD	53	100	425
101C	HOLDING UNIT, PRIMATE	113	100	340
103	HOLDING UNIT, SM. VERT.	13.6	0	188
103B	INCUBATOR	5	5	8
105	KIT, CHEMICAL	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	5	0	9
106A	KIT, CLEANUP	1.5	0	4
108	KIT, HISTOLOGY	1	0	1
109	KIT, LINEAR MEAS.	1	0	1
110	KIT, MICROBIOLOGY	2	0	3
110C	KIT, HUMAN PHYSIOLOGY	3	0	8
111	KIT, PLANT MANAGEMENT	1	0	1
113	KIT, GENERAL TOOL	SPACELAB		

Table 2-1. Life Sciences Laboratory Equipment Inventory, Contd

E.I. No.	Equipment Item Name	Unit Weight kg	Unit Power w	Unit Volume dm³
113A	KIT, INVERT. MANAGEMENT	1	0	2
114A	KIT, DISSECTION	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	3	0	6
114E	LAMP, PORTABLE HI INT. PHOTO	6.3	150	6
114G	LIQUID STOR. AND DISPENS. SYS.	13	0	18
115F	LSS TEST CONSOLE	15	0	560
116	LOG BOOKS	0.5	0	0.4
117	LOWER BODY NEG. PRESS. DEVICE	78.7	26	2375
118	LYOPHILIZER	23	300	143
118I	MANIFOLD, VACUUM	9.1	0	28.3
119	MSI TASK SIMULATOR	22.7	5	200
121	MASS MEAS. DEVICE, MACRO	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	12	15	25
122A	MASS, TEST, VARIABLE SIZE	0	0	0
124	MEDIA, PREPARED	0.45	0	0.5
126	MICROSCOPE, COMPOUND	11	15	27.4
126A	MICROSCOPE, DISSECTING	9	100	28
126C	MONITOR, VIDEO	SPACELAB		
126I	MOBILITY UNIT, PROT. CORRIDOR	22.7	0	56.6
126J	MICR. ACCESS. KIT, COMPND	10	15	25
131D	MOTORIZED PLANT GROWTH MONITOR	0.5	5	0.6
131E	NON-VISUAL DIRECTION INDICATOR	4.1	0	2.8
131H	OPTISCAN - FIELD AND FIXED	2.3	5	8.5
131J	ORB. FROG OTOL. EXPER. PACKAGE	45	20	80
132	OSCILLOSCOPE AND CAMERA	11.7	75	28.9
133	OTOLITH TEST GOGGLES	0.2	0	2.8
134B	PAPER, RECORDING	0.6	0	1.2
138	PH METER	1.8	20	5.2
138B	PHOTOCELL COUPLER	0.2	2	0.5
138E	PHYSIOL. MULTICHAN. SENS SYS.	0.2	0	1.4
139	PLETHYSMOGRAPH, LIMB	2.4	5	6
140	PHONOVIBRACARDIOGRAM COUPLER	0.2	1	0.3
141A	PLUMBING	20	2	15
142	PORTABLE LSS	30.4	0	79
142B	POWER COND. EQUIP.	SPACELAB		
143C	PRESSURE COUPLER	0.2	2	0.5
144	PSYCHOMOTOR PERFORM. CONSOLE	8.2	15	10.5
144B	PSYCHOGALVANOMETER, GSR	0.5	1	0.3
144C	RADIATION DETECTOR, DOSIM.	0.3	0	0.5
147	RADIATION COUNTER	15	50	20
149G	RAD. SOURCE, SHIELDED	65	5	28.3
150A	RECORDER, STRIP CHART	11.8	0	16.9
150B	RECEIVER, BIOTELEMETRY	0.5	10	1
153	RECORDER, VOICE	1	0	1
153A	ROTATING LITTER CHAIR/CONSOLE	100.2	127	239
153B	SENSORS, ASSORTED	0.5	0	0.3
156	SIGNAL CONDITIONERS (COUPLERS)	0.2	2	0.5

Table 2-1. Life Sciences Laboratory Equipment Inventory, Contd

E.I. No.	Equipment Item Name	Unit Weight kg	Unit Power w	Unit Volume dm^3
156F	SONOCARDIOGRAM	19	32	59
157	SOUND LEVEL METER	13.6	0	33.4
158C	SPACESUIT TEST CONSOLE	35	50	50
159	STAINING SYSTEM	2.2	0	3.5
162	STERILIZER, AUTOCLAVE	11	300	34.7
165	STERILIZER, TOOL	1	110	1
167B	STORAGE, GENERAL	SPACELAB		
167C	STORAGE, FILM	SPACELAB		
172	SPACESUIT	56.3	1	198.2
174	TANK, VERTEBRATE WATER	8.5	5	28.3
175	TANK, PLANT/INVERT. WATER	1.7	0	3
176	TAPE, VIDEO	SPACELAB		
176H	TASKBOARD, FORCE/TORQUE	22.7	5	56.6
178B	THERMOCOUPLE INDICATOR	6	8	9.4
179	TEMPERATURE BLOCK	4.5	200	1.7
179A	THERMOCOUPLES	0.5	0	0.3
179D	THERMOMETER, ELECTRONIC	5.4	14	8.7
180	TIMER, EVENT	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	0.2	1	0.4
181E	TRASH CAN	SPACELAB		
182E	URINE VOLUME MEAS. SYST.	SHUTTLE		
182J	VCG COUPLER	0.2	2	0.5
182K	VISION TESTER	22.7	100	113.3
182P	VENTILATION UNIT, VERT.	19	40	32.7
182R	VERTEBRATE ECS	58	320	121
182T	VIDEO TAPE RECORDER	SPACELAB		
185	MULTIMETER	2	0	2.4
187A	WASTE STORAGE DEVICE	SPACELAB		
187C	WOODLAND WANDERER	10	15	12.9
188	WORK AND SURGICAL BENCH	136	1000	420

Lab Concept	Designation	Research Emphasis
Dedicated Lab	MOD-IIA	Biomedicine/Biology/ Adv. Technology
Dedicated Lab	MOD-IIIA	Biomedicine/Biology/ Adv. Tech. & Centrifuge
Dedicated Lab	MOD-IIB	Biology/Biomedicine
Dedicated Lab	MOD-IIC	Biology/Biomedicine
Dedicated Lab	MOD-IIIB	Biology-Centrifuge/Biomedicine

Those concepts with multiple research emphasis, i.e., Biomedicine/Biology can accomplish either or both areas in a single mission. The actual emphasis will depend upon the experiment or research protocol for the specific mission. The 16 laboratory concepts presented have been scheduled into mission models that will be used for NASA planning. The inherent flexibility of the multi laboratory concept permits the development of new mission model combinations to meet various NASA programmatic requirements.

The common operational research equipment (CORE) inventory for all the above laboratory concepts is summarized in Table 2-1. Each selected laboratory equipment complement is presented in detail in the subsequent design portions of this document. In addition to the CORE certain equipment items will be added to the laboratory complement as PI supplied. These are experiment specific items that would be developed independently by the PI and are not definable at this time. An allocation in weight, power, and storage volume must be provided in each mini and dedicated laboratory for these PI supplied items.

2.1 CARRY-ON LAB 2A (COL-2A)

2.1.1 System Requirements Summary

The functional, operational, performance and design characteristics of the COL-2A during the various mission phases are summarized in Table 2-2. The details of these laboratory characteristics are presented in the following subparagraphs of this section.

2.1.2 Functional Requirements

This Carry-On Lab performs body fluid composition and electrolyte functions research by sampling, fractionating, preserving and returning for ground analysis, human blood samples.

2.1.3 Operational Requirements

The freezer (EI81) is operational from the time cryogenic coolant is loaded aboard at prelaunch until sample removal post-landing. This requirement implies power availability during ascent/descent, on-orbit and certain ground phases.

Table 2-2. System Requirements Summary (COL-2A)

LABORATORY CHARACTERISTICS	SYSTEM REQUIREMENTS BY MISSION PHASE				
	PRE-LAUNCH	LAUNCH	ON-ORBIT	DESCENT	POST LANDING
FUNCTIONAL (What does it do?)	Freezer operation required or pre-chill freezer module	Same as pre-launch	Biomedicine research. Cardiovascular	Support and maintain frozen samples	Same as descent
OPERATIONAL (What are requirements to assure an effective and safe payload?)	No significant interaction	No significant interaction	Access required by crew during first day in orbit. Blood samples taken.	No significant interaction	Remove freezer and samples
PERFORMANCE (What are reqmts. for power, data, ECS and environmentals?)	Interface with power subsystem for blood centrifuge	Withstand 3g acceleration power needed during launch $\approx$10 Watts	Power: Avg. 10.42W Peak 110W Heat rejection equiv. to above power. No data mgt. required	Maintain cryogenics to freezer Power -10 W	Maintain freezer temperature -70°C
DESIGN (What are requirements for equipment, configurations, and sizes?)	Install in orbiter crew compartment stowage racks. Vent $\approx$0.5 kg LN_2 per day	Design for 3g acceleration Vent $\approx$ 0.5 kg LN_2/day	Weight 25.2 Kg Volume 58.4 dm^3 Vent $\approx$ 0.5 kg LN_2/day	Stow & restrain equipment for reentry Vent $\approx$0.5 kg LN_2/day	Design for easy removal of freezer and samples Vent $\approx$ 0.5 kg LN_2/day

Table 2-3. Power Requirement Summary (COL-2A)

LAB CODE: COL 2A		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
40A Cent. - Blood Sample	100	.10	.42	100	10	0	0
81 Freezer (-70°C)	10	24	10	10	240	10	10
	110		10.42	110	250	10	10

Table 2-4. Equipment List

PAYLOAD BLOOD SAMPLING CARRY-ON

NO. COL-2A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
40A	Centrifuge, Blood Sample Processor	1	12.7	100	25
81	Freezer, Low Temp	1	8	10	30.5
106	Kit, Hematology & Urology	1	0.2	0	0.5
116	Log Books	1	0.5	0	0.4
--	LN_2 (for EI 81)	1	3.8	0	2
	TOTAL WEIGHT		25.2		

Crew requirements are minimal. Crewman, trained in drawing blood from fellow subjects, would suffice. Operating the blood sample centrifuge (EI 40A) and recording and labelling samples are easily trainable. Total operating time for this payload is estimated to be 0.5 hr during the first day and essentially zero thereafter.

2.1.4 Performance Requirements

This section deals with the power data, and environmental control factors associated with the carry-on payload.

2.1.4.1 Power and Energy Requirements

The power demands for this COL are attributed to two items; the centrifuge for blood processing, and the controls for the cryogenics used to maintain the desired freezer temperature. This power must be made available in the general stowage area of the crew compartment.

The average power consumption is 10.42 watts during the first day and 10 watts until unloading after landing. The peak power is 110 watts and occurs for about 3 minutes during the first day of the mission. Total energy required is about 240 watt-hours per day. Table 2-3 summarizes all the specifics of the power requirements.

2.1.4.2 Data Requirements

There is no CDMS interface support required for this payload. Data requirements are minimal and consist primarily of labelling samples and log book entries.

2.1.4.3 Environment Control Requirements

The heat rejection is equivalent to the electrical energy usage. The level is relatively low and will be rejected to the air in the crew compartment of the orbiter.

2.1.5 Design Requirements

The equipment list for the COL-2A is shown in Table 2-4.

The interface requirements include the power connection, and the venting provisions of the liquid nitrogen from the dewar to the freezer and then the crew compartment.

2.2 Mini-Lab 1A (ML-1A)

2.2.1 System Requirements Summary

The functional, operational, performance and design characteristics of the ML-1A during the various mission phases are summarized in Table 2-5. The details of the laboratory characteristics are presented in the following subparagraphs of this section.

Table 2-5. System Requirement Summary (ML-1A)

LABORATORY CHARACTERISTICS	SYSTEM REQUIREMENTS BY MISSION PHASE				
	PRE-LAUNCH	LAUNCH	ON-ORBIT	DESCENT	POST LANDING
FUNCTIONAL (WHAT DOES IT DO?)	SUPPORT ORGANISMS OFO PACKAGE WITH POWER DATA & ENVIRONMENT. CAN BE LOADED 9 DAYS PRIOR TO LAUNCH. FREEZER OPERATION OR PRE-CHILL PRIOR TO LAUNCH.	SUPPORT ORGANISM OFO PACKAGE WITH POWER, DATA & ENVIRONMENT.	BIOMEDICAL RESEARCH IN THE AREAS OF : 1) VESTIBULAR, 2) CARDIOVASCULAR 3) BIOCHEMICAL REACTIONS TO STRESS, 4) CELLULAR PHYSIOLOGY	SUPPORT ORGANISM OFO PACKAGE - MAINTAIN FROZEN SAMPLES	SAME AS DESCENT
OPERATIONAL (WHAT ARE REQUIREMENTS TO ASSURE AN EFFECTIVE AND SAFE PAYLOAD?)	ORGANISM LOADING ON PAD DESIRABLE - ACCESS REQ'D. ON PAD TO MONITOR AND CHECKOUT ORGANISMS ON A SCHEDULED BASIS. COORDINATE WITH OTHER SHARING DISCIPLINES.	NO SIGNIFICANT INTERACTION.	NEED A MULTI-DISCIPLINE SPECIALIST FOR ≈2 HRS/DAY. NEED LABORATORY (ML-1A) STATUS DISPLAYS, I.E., ENVIRONMENTAL CONDITIONS.	NO SIGNIFICANT INTERACTION.	REMOVE FREEZER AND SAMPLES. REMOVE OFO PACKAGE & WOODLAWN WANDERER.
PERFORMANCE (WHAT ARE REQUIREMENTS FOR POWER, DATA, ECS AND ENVIRONMENTAL?)	POWER - 65W CONTINUOUS 200W - 8 HOURS/DAY FOR FREEZER EI 80 DATA - 106 KBPS FOR 30 MIN EVERY HOUR ECS - PROVIDE HEAT REJECTION FOR ABOVE POWER CONSUMPTION. ENVIRONMENTALS - NO ESTABLISHED REQMTS.	*POWER REQUIRED 65W FOR OFO PACKAGES, FREEZER & WOODLAWN WANDERER. DATA 106KBPS CONTINUOUSLY. ECS - REJECT HEAT FOR ABOVE POWER. ENVIRONMENTALS - NONE SPACELAB + OFO PACKAGE PROVIDES ADEQUATE ACOUSTIC ATTENUATION. WITHSTAND LAUNCH LOAD OF 3 g ACCELER.	POWER ON DUTY AVG. - 225W ON DUTY PEAK - 621W OFF DUTY AVG.- 194W OFF DUTY PEAK-327W DATA BUS RATE 106 KBPS ECS - REJECT HEAT FOR ABOVE POWER, PROVIDE HABITABLE ENVIRONMENT FOR MULTI-DISCIPLINE SPECIALIST. ENVIRONMENTALS - REQMTS TO BE DEFINED.	*POWER REQUIRE 65W (SEE LAUNCH FOR DETAILS) DATA - BUS RATE 106 KBPS ECS - REJECT HEAT FOR ABOVE POWER ENVIRONMENTALS- RQMTS. TO BE DEFINED.	MAINTAIN HABITABLE ENVIRONMENT FOR ORGANISMS. MAINTAIN FREEZER TEMPERATURE (-70°C)
DESIGN (WHAT ARE REQUIREMENTS FOR EQUIP., CONFIGURATIONS & SIZES?)	INSTALL EQPT. IN 1-1/3 SPACELAB RACKS + FLOOR MOUNTED RLC (.30 x .70 x .80 m) VENT ≈ .5 Kg LN_2/Day (FREEZER EI 81)	DESIGN FOR 3g ACCELERATIONS. VENT ≈ .5 Kg LN_2/DAY	WEIGHT COMMON EQPT. -347 Kg TOTAL MINI-LAB: 497 Kg VOLUME 1-1/2 STANDARD SPACELAB RACKS EXPENDABLES ≈ .5 Kg LN_2/DAY (FREEZER EI 81) FLOOR MOUNTING PROVISIONS REQUIRED FOR THE ROTATING LITTER CHAIR DURING OPERATION.	STOW AND RESTRAIN EQUIPMENT FOR REENTRY. VENT ≈ .5 Kg LN_2/DAY	DESIGN FOR EASY REMOVAL OF ORGANISM PKGS. AND FREEZER. VENT ≈ .5 K. LN_2/DAY

*NO ASCENT/DESCENT POWER TO FIRST US/ESA PAYLOAD - BATTERY PENALTY USED 10 Kg/KW-HR)

2.2.2 Functional Requirements

The functional characteristics during the non orbit phases of the mission are basically those which support the organisms and the freezer requirements.

During orbit the functional capability reflects the science requirements. This laboratory stresses biomedical research as defined in Table 2-6.

TABLE 2-6

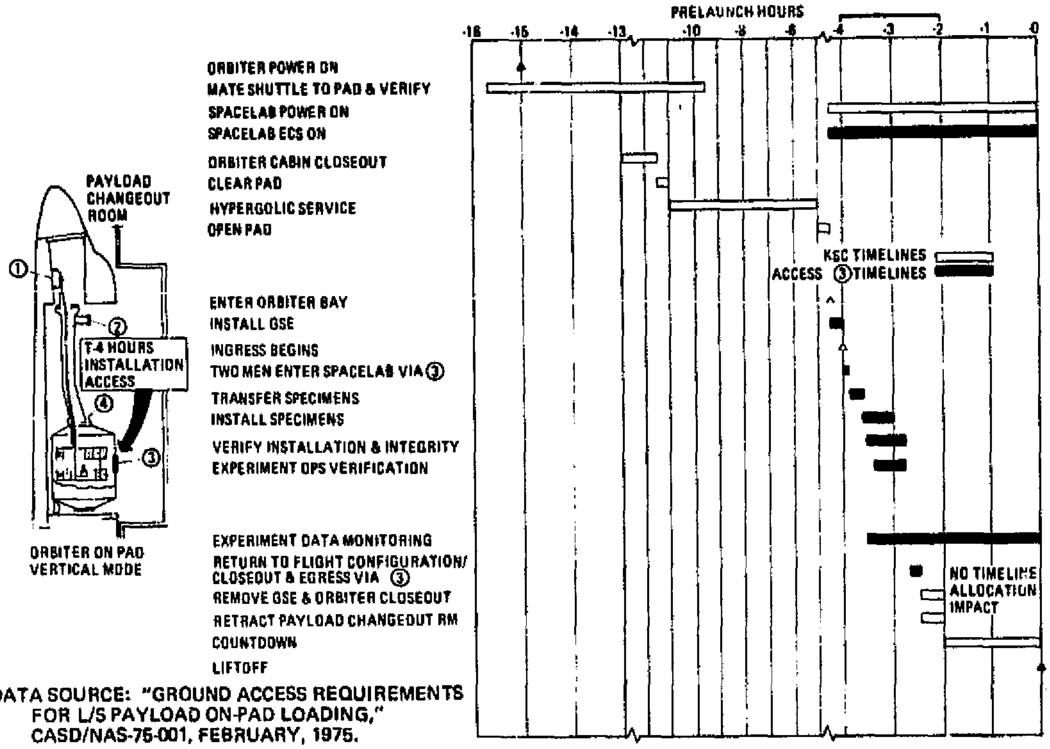
Research Requirements	Specific Capability
Biomedicine	
Vestibular	Mechanical & neural responses of otolith organs to zero-g.
	Role of visual cues to space nausea.
	Role of altered body fluid volume, pressure & distribution to space nausea.
Cardiovascular	Gauer-Henry reflex.
	ECG, VCG, Pulse
	Anthropomorphic measurements of fluid shifts.
	Altered vascular flow, volume & pressure relationships.
Biochemical Reactions	Measure stress hormone, enzyme, fluid/electrolye & fluid volume changes.
Cellular Physiology	Single-cell type culture responses to zero-g — bone marrow.

2.2.3 Operational Requirements

The most significant operational requirement other than the need for a multi-discipline specialist for about 2 hours a day is the organism loading, access, and retrieval operations.

Ideally the principle investigators (PIs) desire on pad organism loading as late as possible in the launch countdown. Figure 2-1 presents the time lines associated with the presently recommended approach to all Life Science laboratory on-pad access requirements. This access is also the desired approach for ML-1A, however, there may be severe restrictions to on-pad access during the 1st US/ESA mission. This may require that the organisms be loaded in the Spacelab as much as nine days in advance of the launch. This early loading would require periodic monitoring and checking by ground personnel prior to launch.

The removal of organisms after landing is required within two hours. Several options have been investigated and are shown in Figure 2-2. Option 1 requires the ground crew to enter the Orbiter/Spacelab at the planned crew exchange at landing + 30



DATA SOURCE: "GROUND ACCESS REQUIREMENTS FOR L/S PAYLOAD ON-PAD LOADING," CASD/NAS-75-001, FEBRUARY, 1975.

Figure 2-1. Life Science Payload Specimen Insertion On-Pad Access

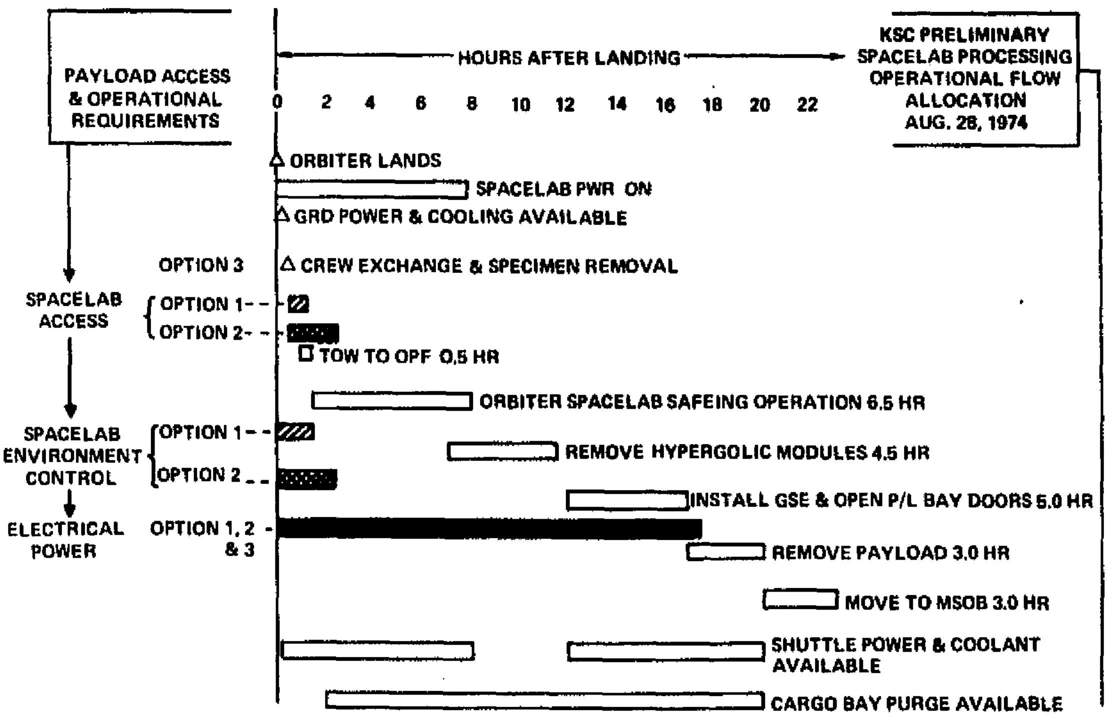


Figure 2-2. Postlanding Schedule — Spacelab

minutes and remove the organisms. Option 2 is the same as Option 1 except that instead of removing the organisms they are examined on board and data taken on the parameters of interest. Option 3 requires that the organisms be removed from the Spacelab prior to descent and stowed in the orbiter cabin and off loaded at the crew exchange. Presently Option 3 is recommended for mini-labs with small organism populations. Option 1 is recommended for the dedicated labs with larger organism populations.

2.2.4 Performance Requirements

This section deals basically with the power, data, environmental control and environmental factors associated with the payload. Because this is a mini-lab payload it represents only a portion of the total performance requirements of the Spacelab. The other sharing payload requirements must also be considered.

2.2.4.1 Power and Energy Requirements

Varying quantities of power are needed in all mission phases, i.e., prelaunch, launch, orbit descent and post landing. The most impacting are those requirements during prelaunch, launch, descent and post landing. The on-orbit requirements do not appear to result in any problems.

Table 2-7 summarizes the power requirements associated with all power consuming equipment items within the laboratory. The duty time for each equipment item is based upon an estimate of the nominal usage of the equipment item during the seven-day mission. The peak power is determined by combining those items that could be used simultaneously with the items that are nominally on 24 hours a day. The ascent and descent power requirements were minimized by allocating power only to those items required to maintain the organisms environment and the specimen freezer temperature. The total energy consumption of this laboratory is about 5 kW-hrs a day. This is about ten percent of that available to all the payloads.

2.2.4.2 Data Requirements

The data requirements cover all mission phases except the post landing. These data requirements will need either the Spacelab CDMS or separate recorders or both to be operational at various times during the non-orbit mission phases.

The data sources and requirements are shown in Table 2-8 for the on-orbit operations. The OFO experiment packages (131J) produce the highest data rates and the largest data amounts. Downlinking of this stream in real time is assumed, although recording and subsequent near real time transmission is acceptable.

A black and white video camera is also a part of this payload. Use and transmission to ground is assumed to be 0.25 hours/day.

Table 2-7. Power Requirement Summary (ML-1A)

LAB CODE: ML-1A		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
6A Airflow, Work Surface	75	.2	1.25		15	0	0
7A Auto. Poten. Elec. Analy.	100	1	8.33		100	0	0
37 Camera, Video B/W	15	.5	.63	15	7.5	0	0
40A Cent. Blood Sample	100	.2	1.67		20	0	0
51F Coolant Loop, Liquid	50	24	50	50	1200	0	0
63C Display Numeric	2	8	1.33	2	16	0	0
80 Freezer	200	8	66.67	200	1600	0	0
81 Freezer (Low Temp.)	10	24	10	10	240	10	10
114E Lamp. Port. Hi Int. Photo.	150	.5	6.25	150	75	0	0
126 Microscope	15	.5	.63		7.5	0	0
126J Microscope Ass. Kit	15	.5	.63		7.5	0	0
131J OFO Exp. Pack (2)	40	24	40	40	960	40	40
132 Oscilloscope	75	1	6.25		75	0	0
153A RLC/Console	127	.4	4.23	127	50.8	0	0
156 Signal Conditioners (6)	12	24	12	12	288	0	0
187A Woodlawn Wander	15	24	15	15	360	15	15
TOTALS	1001		224.87	621	5022.3	65	65

Off Duty Power = $\frac{5022.3-224.87 \times 12}{12} = 193.7$

Estimated Crew Involvement
≈2 man-hrs/day during a 12-hour period

Table 2-8. Data Sources and Requirements (ML-1A)

PAYLOAD FIRST US/ESA SPACELAB MISSION
NO. M-L 1A

EI	NAME	MEASUREMENT DESCRIPTION	FREQ OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
7A	Auto. Potent. Elect. Anal.	Measure pH, pCO_2, pO_2, K, Ca, Na, Cl, glucose	2/day	0.5 hr	Negl.	5 K			x			Conversion to conc. values. Downlink.	
80,81	Freezers	Monitor temperatures	Once/10 min.	-	Negl.	3 K			x	x	x	Out-of-tolerance determination.	
131J	OFO Experiment Packages	8 Otolith signals 4 ECG signals Housekeeping	1/day	24 hr.	100 K	8640 M	x	x	x	x	x	Transmission to ground. Real-time or near real-time.	Otolith channels sampled at 2000 samples/sec; ECG at 500 sps.
153A	Rotating Litter Chair	EOG/EMG, Controls	2/mission	0.5 hr	6.5 K	11.7 M			x			Transmission to ground.	
				Max. Rate	106 KBPS	8650 M							

2.2.4.3 Environmental Control Requirements

The environmental control is associated with 1) the rejection of heat equivalent to the power usage during all mission phases and 2) provisions for a habitable environment for in flight or ground crew members.

The on orbit heat rejection of 225 watts is rejected to the racks (96 W), the cabin air (12 W), and the experiment heat exchanger (117 W).

2.2.4.4 Environmental Factor Requirements

The environmental factors include such items as acoustics, vibration, shock, cleanliness, contamination, electrical, magnetic, and radiation. Except in a preliminary nature, these have not been established. The Spacelab environmental factors have been partially defined, however, the user requirements in terms of tolerance limits, have not.

2.2.5 Design Requirements

The laboratory is composed of 27 equipment items which are contained in 1-1/3 Spacelab racks plus a floor mounting for the rotating litter chair. Table 2-9 is the complete list of equipment along with estimates of the quantities, weight, power and volume. In addition to the common equipment which weighs 347 kg additional equipment consisting of racks, RAU's, power switch panels, converters, computer, interface hardware, and PI specific equipment brings the total weight to 497 kg.

The overall design must be compatible with the maximum launch acceleration of 3 g's. The freezer venting of approximately 0.5 kg/day must be considered in the pressurization and venting provisions of the Spacelab. The preliminary layout of the equipment within the racks is shown in Figure 2-3. The identification numbers on the layout indicate the equipment item numbers as presented in Table 2-9.

2.3 Dedicated Laboratory IA (MOD-IA)

2.3.1 System Requirements Summary

The functional, operational, performance, and design characteristics of the MOD-IA dedicated lab during the various mission phases are summarized in Table 2-10. The details of these laboratory characteristics are presented in the following sub paragraphs of this section.

2.3.2 Functional Requirements

The functional characteristics during the non-orbit phases of the mission are basically those which support the organisms holding units with power, data management and environmental control. The man surrogate testing requires that the organisms be exposed to the same environment as the crew. The Spacelab therefore must have a habitable environment during the non-orbit phases when the organisms are on-board.

Table 2-9. Equipment List (ML-1A)

PAYLOAD FIRST US/ESA SPACELAB MISSION

NO. M-L 1A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
6A	Airflow Work Surface	1	5	75	6
7A	Auto. Poten. Elec. Analyzer	1	12.7	100	57
31	Calculator, Pocket	1	0.47	0	0.4
36	Camera, 35 mm & Strobe	1	2	0	2
37	Camera, Video, B/W	1	4.4	15	3
40A	Centrifuge, Blood Sample	1	12.7	100	25
51F	Coolant Loop, Liquid	1	30	50	25
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
76C	Film, 35 mm	3	0.13	0	0.05
80	Freezer	1	15	200	61.4
81	Freezer, Low Temp.	1	8	10	30.5
106	Kit, Hematology & Urology	1	5	0	9
106A	Kit, Cleanup	1	1.5	0	4
110	Kit, Microbiology	1	2	0	3
110C	Kit, Human Physiology	1	3	0	8
114E	Lamp, Portable Hi Int. Photo	1	6.3	150	6
116	Log Books	1	0.5	0	0.4
126	Microscope, Compound	1	11	15	27.4
126J	Microscope Accessory Kit, Compd.	1	10	15	25
131J	OFO Experiment Packages	2	45	20	80
132	Oscilloscope & Camera	1	11.7	75	28.9
153	Recorder, Voice	1	1	0	1
153A	Rotating Litter Chair/Console	1	100.2	127	239
156	Signal Conditioners (Couplers)	6	0.2	2	0.5
182E	Urine Volume Measurement System		In Orbiter		
187C	Woodlawn Wanderer	1	10	15	12.9
	TOTAL WEIGHT		347		

Figure 2-3. First US/ESA Mission M-L 1A

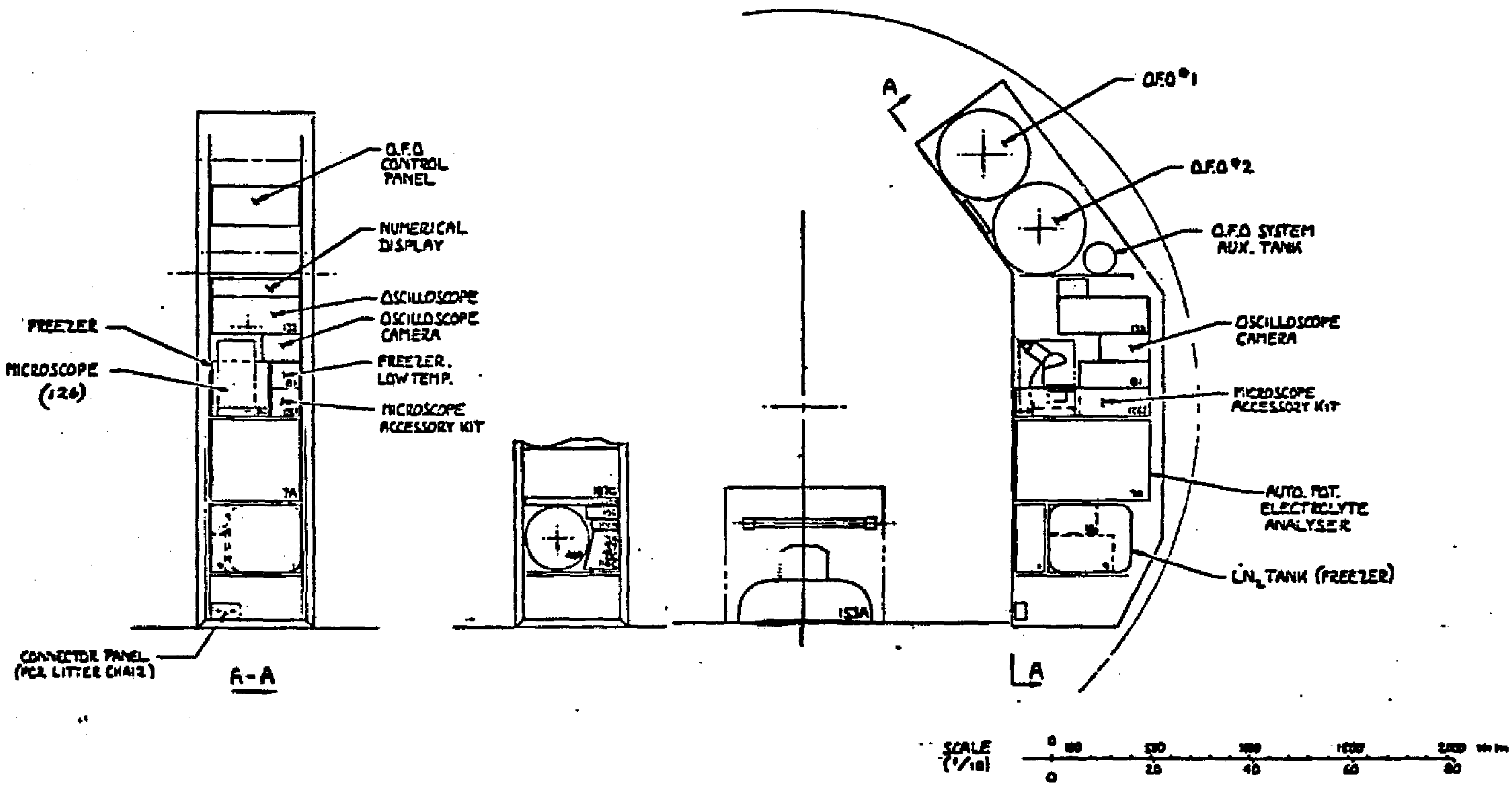


Table 2-10. System Requirement Summary (MOD-IA)

LABORATORY CHARACTERISTICS	SYSTEM REQUIREMENTS BY MISSION PHASE				
	PRE-LAUNCH	LAUNCH	ON-ORBIT	DESCENT	POST LANDING
FUNCTIONAL (WHAT DOES IT DO?)	SUPPORT ORGANISM HOLDING UNITS WITH POWER, DATA AND ENVIRONMENTAL REQUIREMENTS. FREEZER OPERATION OR PRE-CHILL PRIOR TO LAUNCH EIs 77B & 81	SAME AS PRE-LAUNCH	BIOMEDICAL RESEARCH IN VESTIBULAR, MUSCULOSKETAL PULMONARY, HEMATOLOGY, MICROBIOLOGY CREW PERFORMANCE ON MAN. MAN SURROGATE EXPERIMENTING WITH PRIMATES, SMALL VERTEBRATES AND CELLS AND TISSUES.	SUPPORT ORGANISMS HOLDING UNITS WITH POWER. MAINTAIN STATUS OF FROZEN SAMPLES	SAME AS DESCENT.
OPERATIONAL (WHAT ARE REQUIREMENTS TO ASSURE EFFECTIVE AND SAFE PAYLOAD?)	ORGANISM LOADING ON PAD REQUIRED, ACCESS REQUIRED ON PAD TO MONITOR AND CHECKOUT ORGANISMS ON A SCHEDULED BASIS. CERTAIN BIOLOGICALS TO BE LOADED INTO COLD STORAGE FREEZER OR REFRIGERATOR.	NO SIGNIFICANT INTERACTION DEFINED. ENVIRONMENTAL FACTORS., I.E., ACOUSTICS VIBRATION, EMI, ETC., NEED TO BE SPECIFIED BY SCIENTISTS.	REQUIRES 3 PAYLOAD SPECIALISTS WORKING A 12-HOUR DAY. ENVIRONMENT REQUIRED TO SUPPORT SPECIALIST. STATUS DISPLAY AND WARNINGS REQUIRED OF SPACELAB CONDITIONS AND ENVIRONMENT.	NO SIGNIFICANT INTERACTION DEFINED. ENVIRONMENTAL FACTORS TBD.	REMOVE ORGANISMS. REMOVE FREEZER AND SAMPLES. PROVIDE A BIOEXPERIMENTAL SUPPORT & TRANSFER UNIT.
PERFORMANCE (WHAT ARE REQUIREMENTS FOR POWER, DATA, ECS AND ENVIRONMENTALS?)	POWER - 412W TO SUPPORT HOLDING UNITS, FREEZERS AND COUPLERS + SPACELAB LIGHTING DATA - ≈30 KBPS FOR 30 MINUTES EVERY HOUR ECS - PROVIDE HEAT REJECTION FOR ABOVE POWER + 179W METABOLIC. VENTILATION FOR ORGANISMS AND GROUND CREW DURING LOADING. ENVIRONMENTALS - NO ESTABLISHED REQUIREMENTS.	POWER - 412W REQUIRED FOR ITEMS LISTED IN PRE-LAUNCH STATE. DATA - ≈30 KBPS CONTINUOUSLY ECS - REJECT HEAT FROM ABOVE POWER PLUS 179W METABOLIC HEAT. ENVIRONMENTALS - NONE DEFINED EXCEPT 120db ACOUSTIC LEVEL. WITHSTAND LAUNCH LOADS OF 3G ACCELERATION.	POWER ON DUTY AVG. -1370W ON DUTY PEAK -3210W OFF DUTY AVG. -672W OFF DUTY PEAK -838W DATA BUS RATE 70 KBPS ECS REJECT HEAT FOR ABOVE POWER LEVELS + 179 W METABOLIC EQUIVALENT. HUMIDITY CONTROL CAPACITY TO BE DETERMINED. ENVIRONMENTALS - REQUIREMENTS TO BE DEFINED.	POWER 472 W REQUIRED. FOR ITEMS LISTED IN PRE-LAUNCH STATE. DATA - ≈ 30 KBPS CONTINUOUSLY ECS - REJECT HEAT FROM ABOVE POWER PLUS 179W METABOLIC LOAD. ENVIRONMENTALS - REQUIREMENTS TO BE DETERMINED.	MAINTAIN A HABITABLE ENVIRONMENT FOR ORGANISMS. MAINTAIN FREEZER TEMPERATURES - 70°C POWER - 412W DATA - ≈ 30KBPS FOR 30 MINUTES EVERY HOUR.
DESIGN (WHAT ARE REQUIREMENTS FOR EQUIPMENT CONFIGURATION AND SIZES?)	INSTALL EQUIPMENT IN 16 SPACELAB RACKS - FLOOR MOUNT ROTATING LITTER CHAIR, WORK & SURGICAL BENCH, & EXERCISE EQUIPMENT VENT ≈.5 kg LN_2/DAY FREEZERS 77B & 81	DESIGN FOR 3G ACCELERATIONS. VENT ≈.5 kg LN_2/DAY	WEIGHT COMMON EQUIPMENT - 1904 kg TOTAL PAYLOAD 3315 kg VOLUME 16 SPACELAB STANDARD RACKS + FLOOR MOUNTING FOR ROTATING LITTER CHAIR, WORK & SURGICAL BENCH, AND EXERCISE EQUIPMENT EXPENDABLES ≈.5 kg LN_2/DAY FREEZERS 77B & 81	STOW AND RESTRAIN EQUIPMENT FOR REENTRY. VENT ≈.5 kg LN_2/DAY	DESIGN FOR EASY REMOVAL OF ORGANISM HOLDING UNITS AND FREEZERS VENT ≈.5 kg LN_2/DAY

During orbit the functional capability reflects the science requirements. The MOD IA lab is a 7-day, biomedical emphasis mission. Man-related studies will be undertaken from two distinct, though related, orientations:

1. As a human organism requiring scientific investigation and measurement:

   To understand the mechanisms of man's responses to space flight and his capability to adapt to the space environment. Special emphasis will be placed on those organ systems which have been found from previous flights to be influenced by gravity, e.g., cardiovascular, vestibular, and musculo-skeletal systems. Biological periodicities will be examined within the limits of mission profiles.

   Animal models will provide information concerning basic mechanisms not easily determined in man. Such animal models would provide information in areas where measurements have not been developed for use in humans or would carry a significant hazard if utilized in man.

2. As an important (human) element of a flight system whose total performance capability is reflected in the performance level of that (human) system, and whose safety is of primary concern in any manned system:

   To acquire, analyze, and interject data relevant to the problems of human performance, capability and behavior in space. This includes both group and individual behavior, attitudes, motivational levels, anxieties, etc.

   To establish operator capabilities and requirements as they impact total system performance and crew safety.

   To collect high fidelity, high quality data on the new population of space flight participants in order to substantiate and improve on the original medical selection criteria for Shuttle passengers and crews.

The specific research capability of the laboratory is summarized in Table 2-11.

TABLE 2-11

Research Requirements	Specific Capability
Vestibular	Investigate role of visual cues in space nausea. Repeat of Skylab M131 experiment. Rotating Litter Chair. Role of altered body fluid volume, pressure and distribution to space nausea. Urine sample collection and analysis.

TABLE 2-11 (Continued)

Research Requirements	Specific Capability
Cardiovascular	Altered vascular flow, volume & pressure relationships in zero-g. LBNP, VCG. Demonstrate presence or absence of Gauer-Henry reflex. Early mission urine/blood sample collection and analysis. APE, Freezers. Regulation responses to exercise in zero-g.
Pulmonary	Altered pumonary volume/flow/relationships in zero-g.
Musculoskeletal	Exercise effect upon musculoskeletal derangement. Diet and pharmacological control of musculoskeletal derangement.
Hematology	Collect, prepare & preserve blood samples. Determine red cell mass, recitulocyte counts, pCO_2, pO_2, pH, enzymes, proteins, etc.
Microbiology	Effects of space environment upon host defense mechanisms. Microbial sampling, culturing, staining, examination.
Crew Performance in Space	Time and motion studies, training tasks. Time relate performance measures with daily activity schedules, sleep patterns, environmental conditions and biomedical measurements.
Effects of Training upon Crew Efficiency	Correlate crew performance efficiency measurements with same tasks conducted in ground based simulators or prior missions.

2.3.3 Operational Requirements

The most significant operational requirement is the need for three payload specialists on duty 12 hours a day during on-orbit operations.

The requirement for organism loading, prelaunch access, and post launch retrieval have a significant effect upon the ground operations.

Ideally the PIs desire on-pad organism loading as late as possible in the launch countdown, Figure 2-1 (previously presented in paragraph 2.2.3) presents the time lines associated with the presently recommended approach to all Life Science on-pad access requirements.

The removal of organisms after landing is required within two hours. Several options have been investigated and are shown in Figure 2-2 (previously presented in paragraph 2.2.3). Option 1 requires the ground crew to enter the Orbiter/Spacelab at the planned crew exchange at landing + 30 minutes and remove the organisms. Option 2 is the same as Option 1 except that instead of removing the organisms they are examined on board and data taken on the parameters of interest. Option 3 requires that the organisms be removed from the Spacelab prior to descent and stowed in the Orbiter cabin and off loaded at the crew exchange.

Option 1 is recommended for the dedicated labs, and Mod-IA specifically because of the relatively large organism populations.

2.3.4 Performance Requirements

This section deals basically with the power, data, environmental control and environmental factors associated with the payload.

2.3.4.1 Power and Energy Requirements

Varying quantities of power are needed in all mission phases. The most impacting are the 412 watts during the pre orbit phases and the 472 watts during the post orbit phase. The on-orbit average requirement of 1570 watts does not appear to result in any significant problems.

Table 2-12 summarizes the power requirements associated with all power consuming equipment items within the laboratory. The duty time for each equipment item is based upon an estimate of the nominal usage of the equipment item during the seven day mission. The peak power of 3210 watts was determined by combining those items that could be used simultaneously with the items that are normally on 24 hours a day. The ascent and descent power requirements were minimized by allocating power only to those items required to maintain and monitor the organisms and to maintain the proper specimen freezer temperature. The total energy consumption of this laboratory is 26.9 kW-hrs a day which is about 50% of the maximum available to the payload.

2.3.4.2 Data Requirements

The data requirements cover all mission phases. The pre launch and post landing requirements are for about 30 KBPS for 30 minutes out of each hour. During ascent or descent the rate remains at 30 KBPS however it is continuous. The rate increases to 70.1 kbps during the on orbit phase of the mission. The non-orbit mission phase will require either the Spacelab CDMS or separate recorders or both to be operational to properly monitor the data sources.

Table 2-12. Power and Energy Requirement Summary

LAB CODE: MOD 1A			ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power		Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
1A	Accelerometer Coupler (3)	3	24	3	3	72		
6	Air Particle Sampler	50	.4	1.76		20		
6A	Airflow Work Surface	75	.5	3.12		37.5		
7	Autoanalyzer	200	1.0	16.66	200	200		
7A	Auto Potentiometer Elec. Analysis	100	1.0	8.34		100		
16F	Ballistocardiogram Coupler	1	1.0	.08		1		
19D	Body Mass Measuring Device	15	.2	.26		3		
30A	Cage, Rat (16)	144	12	144	144	1726		
31	Calculator, Pocket	5	1.0	.42		5		
32	Camera, Cine	13	.5	.54		6.5		
32A	Camera, Controller	100	12	100	100	1200		
37	Camera, Video B/W	15	12	15	15	180		
38	Camera, Video, Color	69	.5	2.88	69	34.5		
38D	Camera Timer, Video	10	.5	.42	10	5		
38F	Cardiopulmonary Analyzer	200	1.0	16.66		200		
40A	Centrifuge, Blood Sample Processor	100	.4	3.34		40		
48	Cleaner, Vacuum	100	.4	3.34		40		
50A	Clinostat C/T	10	24	10	10	240		
50B	Compactor (Solids)	100	.05	.42		5		
51F	Coolant Loop, Liquid	50	24	50	50	1200		
54	Colony Counter (Manual)	50	.5	2.08		25		
63B	Display Keyboard Portable	60	1.0	5.0		60		
63C	Display, Numeric (2)	4	12	4.0	4	48		
64	ECG Coupler (12)	24	24	24	24	576	12	12
65	EEG Coupler (4)	8	24	8	8	192	4	4
65C	Electrophys. Receiver	5	1.0	.42		5		
66	EMG Coupler (6)	12	24	12	12	288	6	6
70E	Exercise Equip., Physiol.	18	4	6		72		
76J	Flowmeter, Gas (4)	16	.5	.66		8		
77B	Freezer, Cryo	10	24	10	10	240	10	10
80	Freezer, General	200	8	66.67	200	1600		
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator	50	8	16.67	50	400		
91	Gas Analyzer, Mass Spec. (2)	50	12	100	100	1200	50	50

Table 2-12. Power and Energy Requirement Summay, Contd

LAB CODE: MOD 1A (Cont'd) Equipment Items Using Power	Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
93 Gas Analyzer, RH	6	24	6	6	144		
98A Holding Unit C&T (2)	60	24	60	60	1440		60
101C Holding Unit - Primate (4)	400/120	12/12	400	400	6240	120	120
103B Incubator	5	24	5	5	120		
114E Lamp, Portable Hi. Int. Photo.	150	.5	6.16	150	75		
117 LBNP	26	.4	.86		10.4		
121 Mass Meas. Device (Macro)	15	.3	.38		4.5		
122 Mass Meas. Device (Micro)	15	.3	.38		4.5		
126 Microscope, Comp.	15	.5	.62		7.5		
126A Microscope, Dissecting	100	1.0	8.34	100	100		
126J Microscope, Access. Kit	15	.5	.62		7.5		
132 Oscilloscope	75	1.0	6.26		75		
138 PH Meter	20	.3	.50		6		
138B Photocell Coupler (12)	24	24	24	24	576		
139 Plethysmograph, Limb	5	.5	.20		2.5		
143G Pressure Coupler (4)	8	24	8	8	192		
147 Radiation Count - Biochemical	90	.5	3.76		45		
150B Receiver, Biotelemetry	10	24	10	10	240		
153A Rotating Litter Chair/Console	127	.4	4.24		50.8		
156 Signal Conditioners (12)	24	24	24	24	576		
156F Sonocardiogram	12	1.0	1.0		12		
162 Sterilizer, Autoclave	300	1.5	37.5		450		
165 Sterilizer, Tool	110	.4	3.66		44		
179 Temperature Block	200	1.5	25	200	300		
179D Thermometer (Electronic)	14	.2	.24		2.8		
181D Transducer, Pressure (4)	4	24	4	4	96		
182J Vectocardiogram Coupler	2	1.0	.16		2		
182P Ventilation Unit - Vertical (5)	200	24	200	200	4800	200	200
188 Work and Surgical Bench	1000	1.0	83.34	1000	1000		
TOTALS	4909		1569.96	3210	26907	412	472

On Duty is considered 12 hours.

Off Duty Average Power = $\frac{26,907 - 1569.96 \times 12}{12}$ = 671.29

The data sources are summarized in Table 2-13 during the on-orbit phase of the mission. The major contribution comes from various physiological measurements such as ECG, EEG, EMG, EOG, & VCG. Downlinking of this data stream in real time is assumed although recording and subsequent near real time transmission is acceptable.

The MOD-IA laboratory is equipped with two black and white and one color video camera. Transmission of video signals to ground is assumed to be 4.0 hours a day.

2.3.4.3 Environmental Control Requirements

The environmental control system (ECS) requirements are associated with all mission phases. The ECS requirements include heat loads related to the power consumption and the metabolic loads of the experiment organisms. The metabolic ECS loads include elements of heat, humidity, oxygen, and CO_2 control.

The metabolic loads of the MOD-IA laboratory imposed upon the Spacelab environmental control system are summarized in Table 2-14.

TABLE 2-14

MOD IA - METABOLIC LOADS
(4 Primates & 16 Rats)

Humidity Production grams/day	Oxygen* Consumption grams/day	CO_2* Production grams/day	Cabin Air Interchange dm^3/min
2928	1932	2262	2120

During the prelaunch and launch phase of the mission 320 watts of heat from the holding units (EI 101C) and the ventilation units (EI 182P) along with 179 watts from the metabolic load is rejected to the cabin air. The descent phase is the same except for an additional 60 watts fro'n the holding unit (EI 98A).

The other heat loads during these non orbit phases of the mission amount to 92 watts and are rejected to the avionics heat exchanger. In addition to the above heat and metabolic loads provisions must be available to support the ground crew during pre launch and post landing operations.

During the on-orbit phase the heat loads are as shown in Table 2-15. The loads are indicated for the three available coolant loops. All heat loads are within the present Spacelab capability. The other ECS loads involving humidity, O_2 and CO_2 control require off-design performance studies of the Spacelab system to determine compatibility.

*EI 182P provides this capability

Table 2-13. Data Sources and Requirements (MOD-IA)

PAYLOAD DEDICATED LAB - BIOMEDICAL EMPHASIS
NO. MOD IA

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
64/65/66	ECG, EEG, EMG Couplers	Conditions electrophysiological signals from organisms or man.	16 chls - 24/day 6 chls - 4/day	10 min. 0.5 hr	700 @ 16 chls 3500 @ 6 chls 25.2 K	161M 151M 312 M	x	x	x	x	x	Downlinking, waveform analysis, data compression and display.	Assume 6 high rate, 16 low rate chls.
156/138B/143G/1A	Signal Conditioners, Assorted Couplers	Miscellaneous physical and biophysical measurements. Pressure, temps., flows, etc.	Once/min., 24 hrs/day	--	3	252K	x	x	x	x	x	Downlink, out-of-tolerance determination, display.	Assume 35 chls.
77B/80/81/83/103B	Freezers/Refrig.	Monitor temperatures	Once/10 min.	--	Negl.	15K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls/EI.
7	Autoanalyzer	Measures approximately 12 constituents of blood serum.	2/day	0.5	100	360K			x			Conversion to conc. values. Downlink.	
7A	Auto. Poten. Elec. Anal.	Measure 8 properties of blood serum and/or urine.	2/day	0.5	Negl.	5K			x			Conversion to conc. values. Downlink.	
91	Mass Spectrometer(2)	Measure mass no. and peaks of trace contaminants and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Downlink. Possibly some on-board analysis.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
65C	Electrophysiology Receiver	Monitors electrophysiological signals from subject.	1/day	1 hr	14 K	44.5M			x			Downlink, waveform analysis and display.	
153A	Rotating Litter Chair	EOG/EMG	2/mission	0.5 hr	6.5 K	11.7M			x			Downlink.	
18C	Exercise Eqmt/Phy.	Monitor ergometer speed, output. Treadmill speed. Assume 4 chls.	2/day	1 hr	5 @ 4 chls	144K			x			Downlink, on board display & control.	Assume 4 chls, 1 sample/sec.
38F	Cardiopulmonary Analyze	Measure 6 gases used in breath-by-breath respiratory analysis.	2/day	0.5 hr	500 @ 6 chls	10.8M			x			Conversion to conc. values. Downlink.	
117/139/31	LBNP, Limb Plethysmographs	Monitor pressures, temps., and Plethys. chls.	1/day	1 hr	35	126K			x			On-board control of expmt. Downlink.	Assume 6 chls. Sample 1/sec.

Table 2-13. Data Sources and Requirements (MOD-IA), Contd

PAYLOAD DEDICATED LAB - BIOMEDICAL EMPHASIS (Cont'd)
NO. MOD IA

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
182J	VCG Coupler	Converts VCG signals	2/day	1 hr	21K	151M			x			Downlink. On-board waveform analysis.	
182P	Ventilation Unit, Vertebrates	Monitor flow, pressures, etc. Est. 6 sensors.	Once/min.	--	Negl.	43K	x	x	x	x	x	Out-of-tolerance determination.	
98A	Holding Unit, C&T	Monitor Temp.	Once/min.	--	Negl.	7K			x	x	x	Out-of-tolerance determination.	
50A	Clinostat, C&T	Monitor motor current	Once/min.	--	Negl.	7K			x			Out-of-tolerance determination.	

TABLE 2-15

MOD-1A THERMAL LOADS

Avionics Heat Exchanger watts	Experiment Heat Exchanger watts	Condensing Heat Exchanger watts
562	200	808 + 179*

*Metabolic load - 4 primates, 16 rats

2.3.4.4 Environmental Factor Requirements

The environmental factors include such items as acoustics, vibration, shock, cleanliness, contamination, electrical, magnetic and radiation. Except in a preliminary nature these have not been established. The launch environment for acoustics has been set at 120 db. The Spacelab environmental factors have been partially defined, however, the user requirements in terms of tolerance limits have not.

2.3.5 Design Requirements

The MOD-IA has 118 equipment items which is about 77% of the CORE inventory. This equipment inventory is contained in 16 Spacelab racks. Floor mounting is required for several equipment items namely the exercise equipment (EI 70C), rotating litter chair (EI 153A) and the work and surgical bench (EI 188). Table 2-16 is the complete list of equipment along with estimates of the quantities, weight, power, and volume. In addition to the common equipment which weighs 1904 Kg additional equipment consisting of racks, RAUs, power, switch panels, converters, computer, interface hardware, and PI specific equipment brings the total weight to 3315 Kg.

The overall design must be compatible with the maximum launch acceleration of 3 gs. The freezer venting of approximately .5 Kg/day must be considered in the pressurization and venting provisions of the Spacelab. The preliminary layout of the equipment within the racks is shown in Figure 2-4. Identification numbers in the layout indicate the equipment item numbers as presented in Table 2-16.

Table 2-16. Equipment List (MOD-1A)

	Q	Weight (kg)	Power (watts)	Unit Volume (dm^3)
1 ACCELEROMETER	3	0.1	0	0.03
1A ACCELEROMETER COUPLER	3	0.05	1	0.01
6 AIR PARTICLE SAMPLER	1	2.7	50	0.55
6A AIRFLOW WORK SURFACE	1	5	75	6
7 AUTOANALYZER (GEMSAEC)	1	26	200	40
7A AUTO POTENTIO. ELEC. ANAL.	1	12.7	100	57
14B ANTENNAS,ASSORTED	1	0.1	0	0.03
15A ATMOS. SAMPLING SYSTEM	1	10	20	28
16B AUDIOMETER	1	4.5	25	4.3
16D BADGES, RADIATION	2	0.2	0	0.1
16E BALLISTOCARDIOGRAM COUPLER	1	0.1	1	1
18D CUSTOM BITE BOARDS	1	0.23	0	0.03
19D BODY MASS MEAS. DEVICE	1	36.5	15	675
25B COLONY CHAMBER, SEALABLE	20	0.2	0	0.1
30A CAGE, RAT, HAMSTER, STANDARD	16	2.3	9	11
31 CALCULATOR, POCKET	1	0.47	0	0.4
32 CAMERA, CINE	1	5	13	5
32A CAMERA CONTROLLER	1	13.6	100	28.3
33 CAMERA, POLAROID	1	3.3	0	5.6
36 CAMERA, 35 MM AND STROBE	1	2	0	2
37 CAMERA, VIDEO, B/W	2	4.4	15	3
38 CAMERA, VIDEO, COLOR	1	7.7	69	6.2
38A CAMERA MOUNTS	1	3	0	3
38D CAMERA TIMER, VIDEO	1	4	10	3
38E CARDIOPULMONARY ANALYZER	1	90.7	200	172
40A CENTRIFUGE, BLD SMPL PROCESSOR	1	12.7	100	25
44 CHEMICALS	1	0.5	0	1.0
44A CHEMICALS, RADIOISOT. TRACERS	1	0.3	0	0.5
45 CHEMICAL STORAGE CABINET	1	4.0	0	14.1
49 CLEANER, VACUUM	1	2.3	104	10
50A CLINOSTAT (FOR C/T)	1	2	10	4
50B COMPACTOR, SOLIDS	1	18	100	113
51D CONTROL CONSOLE, EXPERIMENTER	1	22.7	100	113.3
51E COOLANT LOOP, LIQUID	1	30	50	25
54 COUNTER, COLONY, MANUAL	1	1.5	50	1.5
63B DISPLAY KEYBOARD, PORTABLE	1	13.6	60	42.5
63C DISPLAY, NUMERIC	2	2	2	4
64 ECG COUPLER	12	0.2	2	0.5
65 EEG COUPLER	4	0.2	2	0.5
65B ELECTROPHYS. BACKPACK	1	0.3	0	0.23
65C ELECTROPHYS. RECEIVER	1	2.7	25	5.0
66 EMG COUPLER	6	0.2	2	0.5
70C EQUIPMENT RESTRAINT DEVICE	1	0.5	0	1
70E EXERCISE EQUIP., PHYSIOL.	1	96	18	992
75C FILM, CINE	4	0.54	0	0.54
75E FILM, POLAROID	5	0.16	0	0.13
76C FILM, 35 MM	10	0.13	0	0.05
76J FLOWMETERS	4	0.5	1	0.5
77B FREEZER, CRYOGENIC	1	21.6	10	74.1
80 FREEZER, GENERAL	1	15	200	61.4
81 FREEZER, LOW TEMP.	1	8	10	30.5
83 FRIG. (REFRIGERATOR)	1	18	50	127
91 GAS ANALYZER, MASS SPEC.	2	25	50	20
93 GAS ANALYZER, PH	1	5.2	6	13
93A GAS SUPPLIES	6	5.75	0	18
96 GLOVE BOX, PORTABLE	1	4.5	0	25
96C GLOVE BOX LINERS	10	0.5	0	1
97C HANDWIPES, BETADYNE	10	0.3	0	0.3
98A HOLDING UNIT, CELLS/TISSUES	2	23	30	188
101C HOLDING UNIT, PRIMATE	4	113	100	340

Table 2-16. Equipment List (MOD-1A), Contd

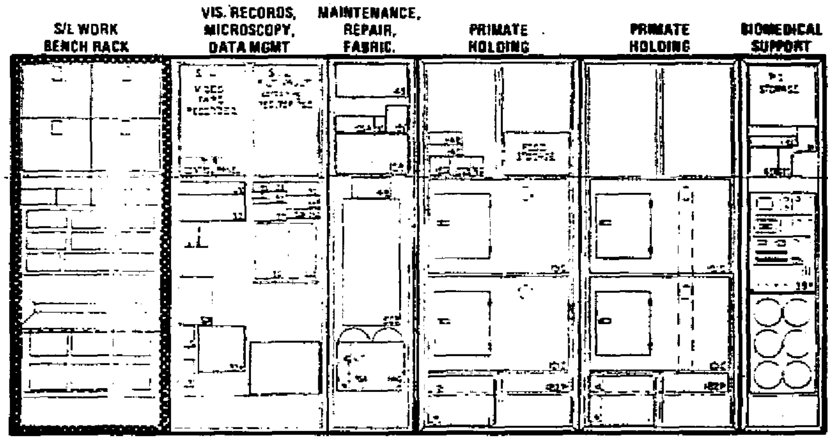
		Q	Weight (kg)	Power (watts)	Unit Volume (dm^3)
103	HOLDING UNIT, SM. VERT.	2	13.6	0	188
103B	INCUBATOR	1	5	5	8
105	KIT, CHEMICAL	1	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	1	5	0	9
106A	KIT, CLEANUP	1	1.5	0	4
108	KIT, HISTOLOGY	1	1	0	1
109	KIT, LINEAR MEAS.	1	1	0	1
110	KIT, MICROBIOLOGY	1	2	0	3
110C	KIT, HUMAN PHYSIOLOGY	1	3	0	8
114A	KIT, DISSECTION	1	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	1	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	1	3	0	6
114E	LAMP, PORTABLE HI INT. PHOTO	1	6.3	150	6
114G	LIQUID STOR. AND DISPENS. SYS.	1	13	0	18
116	LOG BOOKS	3	0.5	0	0.4
117	LOWER BODY NEG. PRESS. DEVICE	1	78.7	26	2373
118T	MANIFOLD, VACUUM	1	9.1	0	26.3
121	MASS MEAS. DEVICE, MACRO	1	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	1	12	15	25
124	MEDIA, PREPARED	2	0.45	0	0.5
126	MICROSCOPE, COMPOUND	1	11	15	27.4
126A	MICROSCOPE, DISSECTING	1	9	100	28
126J	MICR. ACCESS. KIT, COMPND	1	10	15	25
131E	NON-VISUAL DIRECTION INDICATOR	1	4.1	0	2.8
132	OSCILLOSCOPE AND CAMERA	1	11.7	75	28.9
133	OTOLITH TEST GOGGLES	1	0.2	0	2.8
134B	PAPER, RECORDING	1	3.6	0	1.2
138	PH METER	1	1.8	20	5.2
138B	PHOTOCELL COUPLER	12	0.2	2	0.5
138E	PHYSIOL. MULTICHAN. SENS SYS.	1	0.2	0	1.4
139	PLETHYSMOGRAPH, LIMB	1	2.4	5	6
140	PHONOVIBRACARDIOGRAPH COUPLER	1	0.2	1	0.3
141A	PLUMBING	1	20	2	15
143G	PRESSURE COUPLER	4	0.2	2	0.5
144C	RADIATION DETECTOR, DOSIM.	1	0.3	0	0.5
147	RADIATION COUNTER	1	15	50	20
150A	RECORDER, STRIP CHART	1	11.8	0	16.9
150B	RECEIVER, BIOTELEMETRY	1	0.5	10	1
153	RECORDER, VOICE	1	1	0	1
153A	ROTATING LITTER CHAIR/CONSOLE	1	100.2	127	239
153B	SENSORS, ASSORTED	1	0.5	0	0.3
156	SIGNAL CONDITIONERS (COUPLERS)	12	0.2	2	0.5
156E	SONOCARDIOGRAM	1	19	32	59
157	SOUND LEVEL METER	1	13.6	0	33.4
159	STAINING SYSTEM	1	2.2	0	3.5
162	STERILIZER, AUTOCLAVE	1	11	300	34.7
165	STERILIZER, TOOL	1	1	110	1
174	TANK, VERTEBRATE WATER	5	8.5	5	28.3
176B	THERMOCOUPLE INDICATOR	1	6	8	9.4
179	TEMPERATURE BLOCK	1	4.5	200	1.7
179A	THERMOCOUPLES	1	0.5	0	0.3
179B	THERMOMETER, ELECTRONIC	1	5.4	14	8.7
180	TIMER, EVENT	2	0.2	0	0.2
181B	TRANSDUCER, PRESSURE	4	0.2	1	0.4
182J	VCG COUPLER	1	0.2	2	0.5
182E	VENTILATION UNIT, VERT.	5	19	40	32.7
165	MULTIMETER	1	2	0	2.4
188	WORK AND SURGICAL BENCH	1	136	1000	423

RESEARCH CAPABILITY

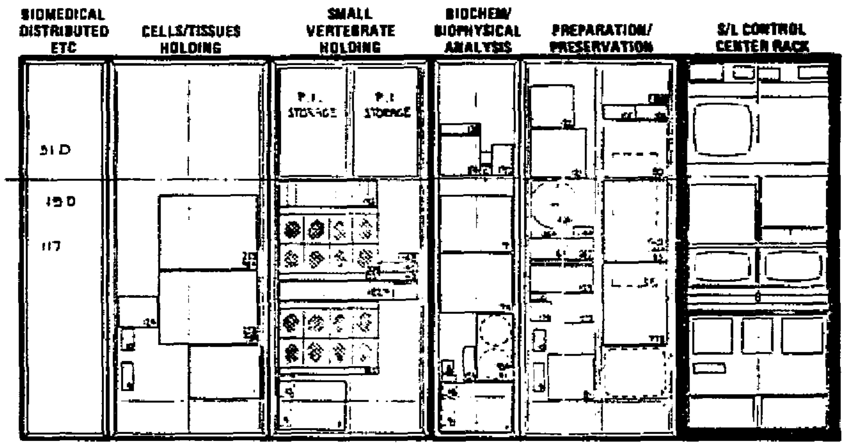
- BIOMEDICINE (MAN) - CARDIOVASCULAR, VESTIBULAR, MUSCULOSKELETAL, ETC
- BIOLOGY HOLDING UNITS - 4 PRIMATES, 2 SM. VERTS, 2 CELLS/TISSUES
- INFLIGHT ANALYSIS - BLOOD, URINE CHEMISTRIES, SURGERY, MICROSCOPIC, PHOTOGRAPHIC
- RETURN FOR GROUND ANALYSIS — FREEZERS, FRIG.; HISTOLOGY, DISSECTION, MICROBIOLOGY, HEMATOLOGY KITS

CHARACTERISTICS

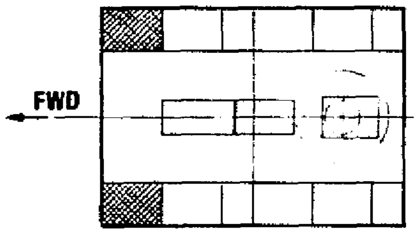
COMMON EQMT WEIGHT - 1904 KG
TOTAL P/L WEIGHT - 3314 KG
AVERAGE POWER - 1500 WATTS
USES ENTIRE S/L LONG MODULE



STARBOARD VIEW



PORT VIEW



09105CVF3662

Figure 2-4. Dedicated Laboratory Layout, MOD 1A – Biomedical Emphasis Lab

BOOK 2 • APPENDICES

BOOK 2

APPENDICES

APPENDIX A

LIFE SCIENCES RESEARCH REQUIREMENTS

APPENDIX A

LIFE SCIENCES RESEARCH REQUIREMENTS

The tabular information presented in this appendix is the condensation of data from various input data sources, pertinent information from past studies, and summaries of life sciences research objectives. All these data were used to support the evaluation and recommendation of life sciences research requirements discussed in Volume II, Section 2. The data are organized as follows:

TIME-PHASED LIFE SCIENCES RESEARCH FOR CONSIDERATION ON US/ESA FIRST SPACELAB MISSION

Preliminary Integrated Life Sciences Payloads for Shuttle/Spacelab through 1985, Prepared for Dr. Winter, 7 February 1975	Scientific Uses of the Space Shuttle, Space Science Board National Research Council, National Academy of Sciences, Washington, D.C., 1974
EFFECTS OF SPACE FLIGHT ON MAN Evaluation of the Gauer-Henry reflex in large mammals Animal studies of shifts in body fluid & blood distribution Human input/output water balance studies with respect to cardiovascular performance Anthropometric measures of cardiovascular fluid shifts Testing of inflight space nausea countermeasures Evaluate pre- and post-flight "space nausea" screening tests to determine predictive value Hormonal & electrolyte assays to measure mineral & fluid balance Follow-up studies in Skylab renal function observations Studies on bone marrow suppression in weightlessness Evaluate the effectiveness of types of exercise maintaining cardiovascular and muscular tone Invasive animals studies to measure factors controlling postflight cardiac output	BIOMEDICINE Cardiovascular System (Expts in both animals and humans needed) - Exercise effect on cardiovascular regulatory responses - Study of body fluid compartment volumes - Study possible atrophy of cardiac & other muscles Respiration - Study pulmonary vascular resistance Kidney & Metabolism - Aldosterone secretion - Body electrolytes - Body fluid compartment volume measurement - Bone formation in zero-g (bone repair in animals) Hematology - Red blood cell mass measurement - Bone marrow functional response to zero-g Neurology - Study vestibular functions in man & animals - Neurophysiological dysfunction (righting reflexes - cardiovascular)
BIOLOGY (Designated as "Research" in above source) Small vertebrate studies on the relationships of endocrine control of mammalian physiology Animal studies on the mechanisms involved in space nausea and vestibular adaptation to zero-g	BIOLOGY Physiological effects of zero-g on small mammals

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

Life Sciences Payload Schedule, R. Dunning, OMSF/MMS	The Proceedings of the Skylab Life Sciences Symposium, August 27-29, 1974, Vol. II, Report No. TM X-58154, JSC-09275, NASA-JSC. Comments from: "Skylab: A Beginning", Lawrence F. Dietlein, M.D., NASA/JSC
MEDICINE __Sept. 1980__ - US/ESRO Life Sciences Lab. First major Life Sciences Laboratory to be flown in Shuttle. Research capitalizes on preliminary experiments flown earlier. Major upgrading: Inclusion of man-surrogates for research in depth. Possible inclusion of fundamental biological research. Major Research Areas: vestibular function, cardiovascular function, hematopoetic function (bone marrow study). Additional Areas: urine volume measurement & preservation methods.	BIOMEDICINE (CANDIDATE FUTURE STUDIES) __Cardiovascular System__ - In-depth, noninvasive cardiovascular dynamics monitoring - Invasive pressure/volume/flow changes in early flight (animal) - Demonstrate presence or absence of Gauer-Henry reflex - Total body exercise regimen to maintain integrity of antigravity as well as major muscle groups - Assess role of venous (capacitance) vessels in observed deconditioning process - Assess role of fatigue __Musculoskeletal System__ - Absolute catabolic in-flight changes (bone, muscles) in animals - Countermeasure evaluation: Dietary Physical ? Hormonal __Fluid/Electrolytes__ - Demonstrate Gauer-Henry reflex - Renal hemodynamics in zero-g - Renal response to water/salt loads, dehydration in zero-g - Humoral interactions involved in above __Vestibular System__ - Role of altered cues: visual, kinesthetic, other sensory - Effect of overhydration, dehydration and increased venous pressure on motion sickness threshold - Predictive test for zero-g space sickness susceptibility (? parabolic flights) - Basic studies regarding etiology - Role of one-g training in prevention - Improved medications for prevention/control

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

TIME-PHASED LIFE SCIENCES RESEARCH
FOR CONSIDERATION ON CARRY-ON LABORATORIES/MINI LABORATORIES

Preliminary Integrated Life Sciences Payloads for Shuttle/Spacelab through 1985, Prepared for Dr. Winter, 7 February 1975	Scientific Uses of the Space Shuttle, Space Science Board, National Research Council, National Academy of Sciences, Washington, D.C., 1974
EFFECTS OF SPACE FLIGHT ON MAN Measurement of cardiopulmonary functions during spaceflight, using the cardiopulmonary analyzer Anthropometric measures of cardiovascular fluid shifts Evaluation of new techniques to study cardiovascular fluid shifts Evaluate pre and postflight "space nausea" screening devices to determine predictive value Test in-flight "space nausea" countermeasures Perform hormonal and electrolyte assays to measure mineral and fluid balance Study of microbial aerosol propagation in space	BIOMEDICINE Cardiovascular System (Expts in both animals & humans needed) - Peripheral blood flow (LBNP) - Exercise effect on cardiovascular regulatory responses - Study of body fluid compartment volumes - Study possible atrophy of cardiac & other muscles Respiration - Study mechanical function of lungs in zero-g - Study pulmonary vascular resistance Kidney & Metabolism - Aldosterone, insulin, & growth hormone secretion - Body electrolytes & fluid compartment volume measurement - Bone formation in zero-g (bone repair in animals) - Effect of zero-g on basal metabolic rate Hematology - Red blood cell mass measurement - Bone marrow functional response to zero-g - Blood granulocytic response to inflammatory stimuli Neurology - Study vestibular functions in man & animals - Neurophysiological dysfunction (righting reflexes - cardiovascular) Microbiology - Study of cellular immunity functions relative to host resistance (specific immune response monitoring & record of host infections)
BIOLOGY (Designated as "Research" in above source) Cardiovascular studies of output; the role of venous vessels in deconditioning; heart contractility; Gauer-Henry reflex Metabolic studies of fluid & mineral balance; total body composition; changes in bones, muscles & heart; metabolic energy expenditure shifts. Fluid/electrolyte studies of renal function Hematological studies of immune response, marrow changes, red cell mass loss. (Through utilization of a self-contained animal holding facility (Monkey-Pod))	BIOLOGY Animal Biology - Physiological effects of zero-g on small mammals
MAN/SYSTEMS INTEGRATION Evaluation of Advanced Design Concepts Evaluation of advanced crew restraint conce, ·s Simulation & training optimization studies for man-machine tasks Experiment Support Equipment Design Evaluations Flight test of man-machine interface design criteria developed from Skylab results. Assessment of the safety, efficiency, & effectiveness of laboratory techniques and procedures	MAN/SYSTEMS INTEGRATION Measure decrements in performance Study interpersonal reaction patterns Mental alertness and performance & sleep pattern relations

Test Subjects: Humans, Non-Human Primates

Test Subjects: Humans, Non-Human [illegible] ··ll Mammals

Life Sciences Payload Schedule
R. Dunning, OMSF/MMS

MEDICINE

CY - 1980 (Early) - Life Sciences C_1 Mini Laboratory. Small (22.9 kg) laboratory assembled from Skylab & IMBLMS equipment plus a major chemical analysis unit now under development.
Vestibular Function: Man only
Electrolyte & Body Fluid Distribution Test: Man only

Oct. 1980 - Life Sciences C_3 Mini Laboratory. Small laboratory (22.7 kg) as described above (C_1).
Electrolyte & body fluid distribution, cardiovascular function, and vestibular function: man only

March 1981 - Medical Carry-on Category B Experiments Lab. Small (42.3 kg) modular lab assembled from Skylab and IMBLMS equipment items.
Follow up results from US/ESRO Life Sciences Lab & Life Sciences Dedicated Lab
Vestibular function, electrolyte & body fluid distribution, and cardiovascular function: man only

Aug. 1981 - Medical Carry-on Category B Experiments Lab. Small (42.3) kg modular lab assembled from Skylab & IMBLMS equipment items.
Follow up results from US/ESRO Life Sciences Lab & Life Sciences Dedicated Lab
Vestibular function, electrolyte & body fluid distribution, and cardiovascular function: man only

Feb. 1982 - Medical Category B Carry-on Experiment Lab. Small (42.3 kg) modular lab assembled from Skylab & IMBLMS equipment items.
Follow up results from US/ESRO Life Sciences Lab & Life Sciences Dedicated Lab
Vestibular function, electrolyte & body fluid distribution, and cardiovascular function: man only

Aug. 1982 - Life Sciences Category A Medical/Biological Carry-on Experiments Lab. Medium size laboratory module cluster (201 kg, 1.44m^3) capable of accomplishing a wide range of medical research areas of interest to moderate depth in a series of flights.
Test Specimen: Man

BIOLOGY

Aug. 1982 - Life Sciences Category A Medical/Biological Carry-on Experiments Lab. Medium size laboratory module cluster (201 kg) 1.44m^3) capable of accomplishing a wide range of biological research areas of interest to moderate depth in a series of flights.
Test Specimens: Small vertebrates, cells & tissues

MAN/SYSTEMS INTEGRATION

Feb. 1983 - Life Sciences Category A Man-System Integration Carry-on Experiment Lab. Medium size laboratory module cluster (87.7 kg, 0.85m^3) capable of accomplishing all priority research areas of interest in MSI to moderate depth over a series of flights.

LIFE SUPPORT/PROTECTIVE SYSTEMS

Aug. 1983 - Life Sciences Category A Life Support & Protective Systems Carry-on Exp. Lab. Medium size laboratory module cluster (198 kg, 1.09m^3) capable of accomplishing a wide variety of Life Support and Protective Systems tests of prototype and flight hardware components and subsystems as well as scientific and engineering principles.

Test Subjects: Humans, Small Vertebrates, Cells & Tissues

The Proceedings of the Skylab Life Sciences Symposium, August 27-29, 1974, Vol. II, Report No. TM X-58154, JSC-09275, NASA-JSC. Comments from: "Skylab: A Beginning" Lawrence F. Dietlein, M.D., NASA/JSC

BIOMEDICINE (CANDIDATE FUTURE STUDIES)

Cardiovascular System
- In-depth, noninvasive cardiovascular dynamics monitoring
- Invasive pressure/volume/flow changes in early flight (animal)
- Demonstrate presence or absence of Gauer-Henry reflex
- Total body exercise regimen to maintain integrity of antigravity as well as major muscle groups
- Assess role of venous (capacitance) vessels in observed deconditioning process
- Assess role of fatigue

Musculoskeletal System
- Absolute catabolic in-flight changes (bone, muscles) in animals
- Countermeasure evaluation:
  - Dietary
  - Physical
  - ? Hormonal

Fluid/Electrolytes
- Demonstrate Gauer-Henry reflex
- Renal hemodynamics in zero-g
- Renal response to water/salt loads, dehydration in zero-g
- Humoral interactions involved in above

Vestibular System
- Role of altered cues: visual, kinesthetic, other sensory
- Effect of overhydration, dehydration and increased venous pressure on motion sickness threshold
- Predictive test for zero-g space sickness susceptibility (? parabolic flights)
- Basic studies regarding etiology
- Role of one-g training in prevention
- Improved medications for prevention/control

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

TIME-PHASED LIFE SCIENCES RESEARCH FOR CONSIDERATION ON 7-DAY DEDICATED LABORATORY

PRELIMINARY INTEGRATED LIFE SCIENCES PAYLOADS FOR SHUTTLE/SPACELAB THROUGH 1985, PREPARED FOR DR. WINTER, 7 FEBRUARY 1975	SCIENTIFIC USES OF THE SPACE SHUTTLE, SPACE SCIENCE BOARD, NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF SCIENCES, WASHINGTON, D.C., 1974
EFFECTS OF SPACE FLIGHT ON MAN Evaluation of the Gauer-Henry reflex in large mammals Animal studies of shifts in body fluid & blood distribution Human input/output water balance studies with respect to cardiovascular performance Anthropometric measures of cardiovascular fluid shifts Testing of inflight space nausea countermeasures Evaluate pre- and post-flight "space nausea" screening tests to determine predictive value Hormonal & electrolyte assays to measure mineral & fluid balance Follow-up studies in Skylab renal function observations Studies on bone marrow suppression in weightlessness Evaluate the effectiveness of types of exercise maintaining cardiovascular and muscular tone Invasive animals studies to measure factors controlling postflight cardiac output	**BIOMEDICINE** Cardiovascular System Experiments in both animals & humans needed: - Peripheral blood flow (LBNP) - Exercise effect on cardiovascular regulatory responses - Study of body fluid compartment volumes - Study possible atrophy of cardiac & other muscles Respiration - Study mechanical function of lungs in zero-g - Study pulmonary vascular resistance - Study lung resistance to infection (ciliary transport, lymphatic drainage, phagocytic function) Kidney & Metabolism Aldosterone secretion Body electrolytes Insulin secretion Growth hormone secretion Body fluid compartment volume measurement Bone formation in zero-g (bone repair in animals) Effect of zero-g on basal metabolic rate Hematology Red blood cell mass measurement Bone marrow functional response to zero-g Blood granulocytic response to inflammatory stimuli Neurology Study vestibular functions in man & animals Neurophysiological dysfunction (righting reflexes - cardiovascular) Nervous system development in animals in zero-g (demonstrate dysfunction in 1-g) Microbiology Study of cellular immunity functions relative to host resistance (specific immune response monitoring & record of host infections)
BIOLOGY Research* Small vertebrate studies on the relationships of endocrine control of mammalian physiology Animal studies on the mechanisms involved in space nausea and vestibular adaptation to zero-g *Designated as "Research" in above source.	**BIOLOGY** Physiological effects of zero-g on small mammals Behavioral patterns in zero-g Cellular and intracellular movement in zero-g Plant growth and development
MAN/SYSTEMS INTEGRATION Evaluation of Advanced Design Concepts Flight test of planetary sample return handling procedures Test of teleoperator performance in simulated payload maintenance and servicing tasks Simulation and training optimization studies for advanced man-machine tasks Experiment Support Equipment Design Evaluations Flight test of man-machine interface design criteria developed from Skylab results	**MAN/SYSTEMS INTEGRATION** Measure decrements in performance Study interpersonal reaction patterns Mental alertness and performance and sleep pattern relations Man/machine integration testing of teleoperator-remote manipulator system
LIFE SUPPORT/PROTECTIVE SYSTEMS Evaluation of Advanced Design Concepts Evaluation of gravity-influenced phenomena in regenerative life support systems Flight evaluation of advanced EVA life support and crew transportation concepts.	**LIFE SUPPORT TECHNOLOGY** Component testing

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues, Plants

LIFE SCIENCES PAYLOAD SCHEDULE, R. DUNNING, OMSF/MMS

MEDICINE

Dec. 1980 - Life Sciences Dedicated Laboratory, Mod I (Medical Emphasis Mission)
Medicine: All Research Areas of Interest (RAI)

July 1981 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Medicine: All Research Areas of Interest (RAI)

Jan. 1982 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Medicine: All Research Areas of Interest (RAI)

BIOLOGY

Dec. 1980 - Life Sciences Dedicated Laboratory, Mod I (Medical Emphasis Mission)
Biology: Primates, Small Vertebrates, and Cells & Tissues - All Research Areas of Interest (RAI)

July 1981 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Biology: Primates, Small Vertebrates, Cells & Tissues, Plants, Invertebrates: All RAI

Jan. 1982 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Biology: Primates, Small Vertebrates, Cells & Tissues, Plants, Invertebrates: All RAI

MAN/SYSTEMS INTEGRATION

Dec. 1980 - Life Sciences Dedicated Laboratory, Mod I (Medical Emphasis Mission)
Behavior: All RAI

July 1981 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Behavior: All RAI

Jan. 1982 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Behavior: All RAI

LIFE SUPPORT/PROTECTIVE SYSTEMS

July 1981 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Life Support & Protective Systems: All RAI

Jan. 1982 - Life Sciences Dedicated Lab, Mod II (Biology and Advanced Technology Mission)
Life Support & Protective Systems: All RAI

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues, Plants, Invertebrates

The Proceedings of the Skylab Life Sciences Symposium, August 27-29, 1974, Vol. II, Report No. TM X-58154, JSC-09275, NASA-JSC. Comments from: "Skylab: A Beginning" Lawrence F. Dietlein, M.D., NASA/JSC

BIOMEDICINE (CANDIDATE FUTURE STUDIES)

Cardiovascular System
- In-depth, noninvasive cardiovascular dynamics monitoring
- Invasive pressure/volume/flow changes in early flight (animal)
- Demonstrate presence or absence of Gauer-Henry reflex
- Total body exercise regimen to maintain integrity of antigravity as well as major muscle groups
- Assess role of venous (capacitance) vessels in observed deconditioning process
- Assess role of fatigue

Musculoskeletal System
- Absolute catabolic in-flight changes (bone, muscles) in animals
- Countermeasure evaluation:
  - Dietary
  - Physical
  - ? Hormonal

Fluid/Electrolytes
- Demonstrate Gauer-Henry reflex
- Renal hemodynamics in zero-g
- Renal response to water/salt loads, dehydration in zero-g
- Humoral interactions involved in above

Vestibular System
- Role of altered cues: visual, kinesthetic, other sensory
- Effect of overhydration, dehydration and increased venous pressure on motion sickness threshold
- Predictive test for zero-g space sickness susceptibility (? parabolic flights)
- Basic studies regarding etiology
- Role of one-g training in prevention
- Improved medications for prevention/control

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

TIME-PHASED LIFE SCIENCES RESEARCH FOR CONSIDERATION ON 30-DAY DEDICATED LABORATORY

Preliminary Integrated Life Sciences Payloads for Shuttle/Spacelab through 1985, Prepared for Dr. Winter, 7 February 1975	Scientific Uses of the Space Shuttle, Space Science Board, National Research Council, National Academy of Sciences, Washington, D.C., 1974
EFFECTS OF SPACE FLIGHT ON MAN Small mammal experiments to measure the absolute relationship between length of exposure to weightlessness and fluid volume shifts Small mammal studies on zero-g related musculoskeletal changes Small mammal studies on Erythropoiesis Effects of reduced gravity on calcium loss from bones Monitoring of input/output water balance to study cardiovascular fluid shifts Evaluation of in-flight space sickness countermeasures In-flight hormonal and electrolyte assays to measure mineral and fluid balance Follow-up studies on Skylab renal function observations Human & animal studies on bone marrow suppression Evaluate effectiveness of types of exercise in maintaining cardiovascular & muscular tone Evaluation of countermeasures for losses of minerals during spaceflight Evaluation of crew selection criteria (refractory to catabolic influences of spaceflight) for prolonged missions	BIOMEDICINE Cardiovascular System (Expts in both animals & humans needed) - Peripheral blood flow (LBNP) - Exercise effect on cardiovascular regulatory responses - Study of body fluid compartment volumes - Study possible atrophy of cardiac & other muscles Respiration - Study mechanical function of lungs in zero-g - Study pulmonary vascular resistance - Study lung resistance to infection (ciliary transport, lymphatic drainage, phagocytic function) Kidney & Metabolism - Aldosterone, insulin, & growth hormone secretion - Body electrolytes & fluid compartment volume measurement - Bone formation in zero-g (bone repair in animals) - Effect of zero-g on basal metabolic rate Hematology - Red blood cell mass measurement - Bone marrow functional response to zero-g - Blood granulocytic response to inflammatory stimuli Neurology - Study vestibular functions in man & animals - Neurophysiological dysfunction (righting reflexes - cardiovascular) - Nervous system development in animals in zero-g (demonstrate dysfunction in 1-g) Microbiology - Study of cellular immunity functions relative to host resistance (specific immune response monitoring & record of host infections) Radiobiology - Study biological effects of HZE-particle for proof-of-principle) - Study molecular basis of zero-g perturbation of cell division (in vivo & in vitro cell labeling)
BIOLOGY (Designated as "Research" in above source) Animal studies on effects of weightlessness on aging Small vertebrate & invertebrate studies of cellular division & differentiation during spaceflight Evaluation of biological rhythms during spaceflight Small vertebrate studies of the cellular mechanisms controlling behavior Study of mechanisms controlling geotrophic responses in plants Evaluate effects of weightlessness on plant growth, development, maturation, reproduction & productivity Human & animal studies on mechanisms involved in space nausea & vestibular adaptation to zero-g Study of effects of reduced gravity on vertebrate reproductive processes, embryogenesis, parturition, growth, development, maturation, nutrition & longevity Measure effects of reduced gravity on a broad range of animal behavior involving sensory, neuromuscular, and neurological performance Studies of the closed system ecology of higher plants	BIOLOGY Cellular & Molecular Biology - Studies of the kinetics of cell growth & cell division in: plant & animal tissue cultures, bone marrow in vivo, skin in vivo, intestinal epithelium in vivo, repair rate of damaged skin & injured bone marrow, embryonic development - Genetic studies: cell division, chromosome replication - Cellular & intracellular movement in zero-g Animal Biology - Physiological effects of zero-g on small mammals - Morphogenic characteristics of simple metazoans - protozoa - diatoms - Small mammal post-natal growth & development in zero-g: cardiac deconditioning, mineral metabolism, musculoskeletal development - Effects of fractional g (variable centrifuge) - Behavioral patterns in zero-g - Circadian rhythms Plant Biology - Plant Growth & Development: Arabidopsis, carrots, tobacco, sunflower-tissue cultures - Geotropism of stem & root tissue (perform on ground in clinostat - to mimic weightlessness & verify in zero-g on variable centrifuge
MAN/SYSTEMS INTEGRATION Evaluation of Advanced Design Concepts Evaluation of teleoperator systems (free-flying) in deploying, retrieving, & servicing satellites remote from the shuttle Testing of maintenance & repair techniques and tools Simulation & training optimization studies for man-machine tasks Experiment Support Equipment Design Evaluations Flight test of man-machine interface design criteria developed from Skylab results Assessment of the safety, efficiency, & effectiveness of laboratory techniques & procedures In situ measurement of EVA performance capabilities, validation of man-machine task allocation rules, & verification of EVA support hardware (tools, restraints, lights, etc.) acceptability	MAN/SYSTEMS INTEGRATION Measure decrements in performance Study interpersonal reaction patterns Mental alertness and performance & sleep pattern relations Man/machine integration testing of teleoperator-remote manipulator system
LIFE SUPPORT/PROTECTIVE SYSTEMS Evaluation of Advanced Design Concepts Evaluation of time-dependent, gravity-influenced phenomena in regenerative life support systems Experiment Support Equipment Design Evaluations Evaluation of time-dependent, gravity-influenced processes & components in Life Sciences support equipment	LIFE SUPPORT TECHNOLOGY *Component testing*

Test Subjects: Humans, Non-Human Primates, Small Mammals, Vertebrates, Invertebrates, Cells & Tissues, Plants

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues, Plants

Life Sciences Payload Schedule, R. [illegible], OMSF/MMS	The Proceedings of the Skylab Life Sciences Symposium, August 27-29, 1974, Vol. II, Report No. TM X-58154, JSC-09275, NASA-JSC. Comments from: "Skylab: A Beginning" Lawrence F. Dietlein, M.D., NASA/JSC
MEDICINE July 1982 - Life Sciences 30-Day Dedicated Lab, Mod II (Biology/ Advanced Technology Mission) Medicine: All Research Areas of Interest (RAI) Jan. 1983 - Life Sciences Dedicated Lab, Mod II (Biology/ Advanced Technology Mission) Medicine: All RAI July 1983 - Life Sciences Dedicated Lab, Mod III (Biology/Technology Emphasis Mission)* Medicine: All RAI *First flight of Life Sciences Research Centrifuge	BIOMEDICINE (CANDIDATE FUTURE STUDIES) Cardiovascular System - In-depth, noninvasive cardiovascular dynamics monitoring - Invasive pressure/volume/flow changes in early flight (animal) - Demonstrate presence or absence of Gauer-Henry reflex - Total body exercise regimen to maintain integrity of antigravity as well as major muscle groups - Assess role of venous (capacitance) vessels in observed deconditioning process - Assess role of fatigue Musculoskeletal System - Absolute catabolic in-flight changes (bone, muscles) in animals - Countermeasure evaluation: Dietary Physical ? Hormonal Fluid/Electrolytes - Demonstrate Gauer-Henry reflex - Renal hemodynamics in zero-g - Renal response to water/salt loads, dehydration in zero-g - Humoral interactions involved in above Hematologic System - Ground-based marrow-suppression factors - Validate Skylab results on longer Earth-orbital flights Vestibular System - Role of altered cues: visual, kinesthetic, other sensory - Effect of overhydration, dehydration and increased venous pressure on motion sickness threshold - Predictive test for zero-g space sickness susceptibility (? parabolic flights) - Basic studies regarding etiology - Role of one-g training in prevention - Improved medications for prevention/control
BIOLOGY July 1982 - Life Sciences 30-Day Dedicated Lab, Mod II (Biology/Advanced Technology Mission) Biology: All RAI Jan. 1983 - Life Sciences Dedicated Lab, Mod II (Biology/Advanced Technology Mission) Biology: All RAI July 1983 - Life Sciences Dedicated Lab, Mod III (Biology/Technology Emphasis Mission)* Biology: [illegible] *First [illegible] Sciences Research Centrifuge	
MAN/SYSTEMS INTEGRATION July 1982 - Life Sciences 30-Day Dedicated Lab, Mod II (Biology/Advanced Technology Mission) Behavior: All RAI Jan. 1983 - Life Sciences Dedicated Lab, Mod II (Biology/Advanced Technology Mission) Behavior: All RAI July 1983 - Life Sciences Dedicated Lab, Mod III (Biology/Technology Emphasis Mission)* Behavior: All RAI *First Flight of Life Sciences Research Centrifuge	
LIFE SUPPORT/PROTECTIVE SYSTEMS July 1982 - Life Sciences 30-Day Dedicated Lab, Mod II (Biology/Advanced Technology Mission) Life Support & Protective Systems: All RAI Jan. 1983 - Life Sciences Dedicated Lab, Mod II (Biology/Advanced Technology Mission) Life Support & Protective Systems: All RAI July 1983 - Life Sciences Dedicated Lab, Mod III (Biology/Technology Emphasis Mission)* Life Support & Protective Systems: All RAI *First Flight of Life Sciences Research Centrifuge	

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues, Plants, Invertebrates

Test Subjects: Humans, Non-Human Primates, Small Mammals, Cells & Tissues

Baseline Life Sciences Research Requirements for Spacelab, Extracted From NASA/ MSFC Report NAS8-30288, August 1974.

(General Dynamics Convair Report No. CASD-NAS-74-046).

Research Area Priorities for Biomedical and Biomedical Surrogate Missions

RESEARCH AREAS	PAYLOAD INTEGRATION TEAM-AUG. 72	STEERING COMMITTEE-JULY 72	HDQTS., JULY 1973	ARC, SEPT. 1973	SKYLAB	*VERTEBRATE	*CELLS & TISSUES
CARDIAC FUNCTION	1	1	2	1	TO BE DETERMINED	CARDIAC FUNCTION	BIOCHEMICAL PROPERTIES
PULMONARY FUNCTION	2	2	3	2		PULMONARY FUNCTION	BIOPHYSICAL PROPERTIES
HEMODYNAMICS	3	3	4	3		HEMODYNAMICS	RADIATION EFFECTS
BLOOD MORPHOLOGY						BLOOD MORPHOLOGY	MORPHOLOGY
ELECTROLYTES						ELECTROLYTES	
ENZYMES (HI)						ENZYMES	
ENDOCRINES						ENDOCRINES	
GASES						GASES	
ORGANISMS						ORGANISMS	
IMMUNOGLOBINS (PRIORITY)						IMMUNOGLOBINS	
PROTEINS						PROTEINS	
CHEMISTRIES						CHEMISTRIES	
G.I. FUNCTIONS	4	6	–	5		G.I. FUNCTIONS	
EXCRETORY FUNCTIONS (LO)	5	7	4	4		EXCRETORY FUNCTIONS	
METABOLIC STUDIES	6	5	4	6		METABOLIC STUDIES	
MICROBIOLOGY STUDIES	6	-	5	6		MICROBIOLOGY STUDIES	
NEUROLOGICAL FUNCTIONS	7	8	1	7		NEUROLOGICAL FUNCTIONS	
VESTIBULAR FUNCTIONS	7	4	6	6		VESTIBULAR FUNCTIONS	

*PARALLEL BIOMEDICAL RESEARCH OBJECTIVES TO STUDY BASIC MECHANISMS OF MAN'S ADAPTATION TO THE SPACE ENVIRONMENT.

Basic Science Research Area for Vertebrate, Cell and Tissue, Plant and Invertebrate Missions

VERTEBRATES	CELLS & TISSUES	PLANTS	INVERTEBRATES
GROWTH	GROWTH	GROWTH	GROWTH
DEVELOPMENT	DEVELOPMENT	DEVELOPMENT	DEVELOPMENT
REPRODUCTION	METABOLIC STUDIES	METABOLIC STUDIES	METABOLIC STUDIES
EMBRYOGENESIS	HOST-PARASITE RELATIONS	BIOCHEMICAL PROPERTIES	BIOCHEMICAL PROPERTIES
SENESCENCE & AGING	GENETICS	MORPHOLOGY	MORPHOLOGY
GENETICS	RADIATION/HZE PARTICLE EFFECTS	EMBRYOGENESIS	EMBRYOGENESIS
RADIATION/HZE PARTICLE EFFECTS		HOST-PARASITE RELATIONS	RADIATION/HZE PARTICLE EFFECTS
		GENETICS	
		RADIATION/HZE PARTICLE EFFECTS	

Representative Plant Research Functions List

GROWTH & DEVELOPMENT

GROWTH RATE
SEEDING CELL ORGANIZATION
ROOT DEVELOPMENT
FLOWER SYMMETRY
LEAF SYMMETRY
POLLEN MATURATION
GERMINATION TIME
GEOTROPISM/PHOTOTROPISM
SEED MORPHOGENESIS
CYTOLOGIC STAINING
STOMAL OPENING

PHYSIOLOGY

CHLOROPLAST METABOLISM
PHOTOSYNTHETIC ACTIVITY
VIRAL IDENTIFICATION
FUNGAL IDENTIFICATION

COMMON OPERATIONS

SPECIMEN STATUS OBSERVATION
AIR SAMPLING
MICROSCOPY
MASS MEASUREMENTS
BIOSAMPLING
OXYGEN MONITORING
CO_2 MONITORING
WATER VAPOR MONITORING
RADIATION MONITORING

BIOCHEMISTRY

TOTAL NITROGEN
CARBOHYDRATE CONTENT
WATER-MINERAL TRANSPORT
PLANT HORMONE ASSAY
  PHYCOCYANIN
  PROTOPORPHYRINE
PLANT ENZYME ASSAY
  INVERTASE ACTIVITY
  GEHYDROGENASE ACT.
  PEROXIDASE
PLANT LIPIDS
AMINO ACID ASSAY
ISOTOPIC UPTAKE (C, Ca, N, P)
STARCH GRANULE ASSAY
ALKALOID SYNTHESIS
CARBON DIOXIDE EVOLUTION
OXYGEN UPDATE

Initial List of Equipment Items for Biomedical and Biological Areas

EQUIPMENT ITEMS	USING F.P.E.'S				
	BIO-MEDICINE	SMALL VERTE-BRATES	CELLS & TISSUES	PLANTS	INVERTE-BRATES
SPECIMEN ACQUISITION					
AIR PARTICLE SAMPLER	X	X	X	X	X
ALCOHOL SWABS	X	X	X	X	X
ANESTHETIZER, INVERTEBRATE					X
BIOBACKPACK, MICRO		X			
BLADES, SURGICAL (25 PK)	X	X	X	X	X
CHLORAL HYDRATE		X			
CUFF, BLOOD PRESSURE	X				
ELECTRODES, EEG, EKG, DISPOSABLE	X	X			
FLOWMETER, DOPPLER, BLOOD	X	X			
FORCEPS, GILBERT		X	X	X	X
FORCEP, NEEDLE, METZENBAUM		X	X		X
FORCEPS, SPLINTER	X	X	X	X	X
FORCEPS, TISSUE (RATTOOTH), MICHEL		X	X	X	X
HARNESS, ELECTROPHYSIOLOGY	X				
HARNESS, ELECTROPHYSIOLOGY, MICRO		X			
KNIFE HOLDER, BARD PARKER		X	X	X	X
LANCETS (25/KIT)	X	X			
LOOP, INOCULATING	X	X	X	X	X
MEDIA, BLOOD AGAR, PLATED	X	X	X		X
MEDIA, EMB AGAR, PLATED	X	X	X		X
MEDIA, FLUID, EXP. SPECIFIC	X	X	X	X	X
MEDIA, PHENYLETHYL ALCOHOL AGAR	X	X	X		X
MEDIA, SOLID, EXP. SPECIFIC			X	X	
MEDIA, TSA AGAR, PLATED	X	X	X		X
MICROSURGERY SET		X	X	X	X
NEEDLE, INOCULATING	X	X	X	X	X
NEEDLES, VACUTAINER, 21 GA., 26 GA.	X	X			
NEMBUTAL		X			
ORGANISM TRANSFER/RESTRAINT CAPSULE		X			
PIPETTES, OXFORD SAMPLER	X	X	X	X	X
RESPIROMETER, STRAIN GAGE	X	X			
RETRACTOR, WEITLANER		X			X
SCISSORS, BABY OPERATING		X	X	X	X
SCISSORS, MAYO-NOBEL, DISSECTION		X	X	X	X
SCISSORS, OPERATING		X		X	
SPIROMETER MOUTHPIECES	X				
SYRINGES, 1 CC (20/KIT)	X	X	X	X	X
SYRINGE, BLOOD COLLECTING (EA)	X	X			
SYRINGE, VACUTAINER, PED SIZE (25/KIT)	X	X			
THERMISTOR, DEEP BODY TEMP.	X	X			X
XDCR, VENOUS PRESSURE, IMPLANTABLE		X			
ZERO G RESTRAINING DEVICE, EQUIPMENT	X	X	X	X	X
SPECIMEN PREPARATION					
ANIMAL DISSECTION BOARD, UNIVERSAL		X			
CENTRIFUGE, MICROCHEMICAL/HCT	X	X	X		X
COUNTER, DIFFERENTIAL		X	X		X
COUNTER, TALLY	X	X	X	X	X
COUPLER, DOPPLER FLWMTR.	X	X			
COUPLER, EEG	X	X			
COUPLER, EMG	X	X			
COUPLER, PRESSURE XDCR	X	X			X
COUPLER, STRAIN GAGE	X	X			X
COUPLER, THERMISTOR	X	X			X
COUPLER, VECTORCARDIOGRAM	X	X			
COVER SLIP (COUNTING CMBR)	X	X	X	X	X
CRITOSEAL	X	X	X		X
DISSECTION BOARD CLIPS (PACKAGE)		X			
GAUZE, 2x2, SPONGES (200)	X	X	X		X
GLOVE BOX		X	X	X	X
HOMOGENIZER, .2 TO 50 ML		X	X	X	X
LYOPHILIZER, SPACE VACUUM (MANIFOLD)		X	X	X	X
MICROSCOPE, DISSECTING		X	X	X	X
NEEDLES, ASSORTED SIZES	X	X	X	X	X
NEEDLES, SUTURE, ASSORTED SIZES		X			
ORGANISM/SPECIMEN MASS MEAS. DEVICE		X		X	X
PIPETTES, OXFORD SAMPLER	X	X	X	X	X
RADIOBIOLOGICALS, INJECTABLE	X	X		X	X
SAMPLE PROCESSOR, AUTOMATIC, BLOOD	X	X			

Initial List of Equipment Items for Biomedical and Biological Areas, Cont'd

EQUIPMENT ITEMS	USING F.P.E.'S				
	BIO-MEDICINE	SMALL VERTE-BRATES	CELLS & TISSUES	PLANTS	INVERTE-BRATES
SPECIMEN PREPARATION (CONT'D)					
SLIDES, MICROSCOPE	X	X	X	X	X
SLIDE STAINER, AUTOMATIC	X	X	X	X	X
SQUIBBS (PLANT GROWTH ARRESTER) (25/PK)				X	
SQUIBB FIRING MECHANISM				X	
STAINS, ASSORTED, HISTOLOGICAL		X	X	X	X
SUTURE MATERIAL, MONOFILAMENT		X			
SWABS, COTTON (4/TUBE)	X	X	X	X	X
TEMPERATURE BLOCK 56 DEG.C	X	X	X		X
TIMER, INTERVAL	X	X	X	X	X
TUBES, MICROHCT, HEPARINIZED	X	X	X		X
TUBES, MICROHCT, PLAIN	X	X	X		X
WRIGHT BUFFER	X	X	X		X
WRIGHT STAIN	X	X	X		X
SPECIMEN STORAGE					
BAGS, PLASTIC, SEALABLE, LARGE	X	X	X	X	X
BAGS, PLASTIC, SEALABLE, SMALL	X	X	X	X	X
DRY STORAGE CONTAINER (ROOM TEMP)	X	X	X	X	X
FIXATIVE, ETHANOL		X	X		X
FIXATIVE, FORMALIN		X	X		X
FIXATIVE, TISSUE, EXPERIMENT SPECIFIC	X	X	X	X	X
FIXATIVE, ZENKERS SOLUTION	X	X	X		X
FREEZER, CRYOGENIC (LN2) (OPTIONAL)	X	X	X	X	X
FREEZER, LOW TEMPERATURE -80C	X	X	X	X	X
FREEZER UNIT -10C	X	X	X	X	X
INCUBATOR, (MINI)	X	X	X	X	X
REFRIGERATOR	X	X	X	X	X
SPECIMEN VIALS	X	X	X	X	X
DATA ACQUISITION/STORAGE					
ADAPTER, MICROSCOPE-CAMERA	X	X	X	X	X
CAMERA, 35 MM	X	X	X	X	X
CAMERA, POLOROID	X	X	X	X	X
CAMERA, VIDEO, COLOR	X	X	X	X	X
CAMERA, VIDEOTAPE	X	X	X	X	X
LOG BOOKS	X	X	X	X	X
TAPE, MAGNETIC, INSTRUMENTATION	X	X	X	X	X
TAPE RECORDER		X	X	X	X
ON BOARD SPECIAL ANALYSIS, REQ'D EQUIP.					
ANALYZER, BLOOD GAS, PH, PCO2, PO2	X	X			
COUNTER, COLONY, MANUAL				X	X
DISPLAY, CRT, ELECTROPHYSIOL.	X	X			X
ELECTROCARDIOGRAPH	X	X			
LABSTIX (GLU,ALB,BLOOD,PH,KETONE)	X	X			
HEMACYTOMETER	X	X	X		X
HEMOGLOBINOMETER	X	X			
METABOLIC GAS ANALYZER, CELLULAR			X	X	
METABOLIC GAS ANALYZER, PULMONARY	X	X			
MICROSCOPE, COMPD	X	X	X	X	X
SPIROMETER (PART OF METAB. ANALYZER)	X				
PH METER, CELLS/TISSUES MEDIA			X	X	
MAINTENANCE/CLEANUP					
DISINFECTING SWABS (PREPACKED TOWELS)	X	X	X	X	X
LINERS, DISSECTING BOARD (50/PKG)		X			X
LINERS, GLOVE BOX (50/PKG)		X	X	X	X
PORTABLE AIRFLOW WORK SURFACE	X	X	X	X	X
STERILIZER, TOOL (BACTECINERATOR)	X	X	X	X	X
TOWELS, DRY, DISPOSABLE	X	X	X	X	X
TOWELS, PREMOISTENED, ZEPHIRAN CL	X	X	X	X	X
VACUUM CLEANER (PART OF ECS AIR RETURN)		X	X	X	X
WASTE STORAGE CONTAINER	X	X	X	X	X
ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEM					
ECS PACKAGE					
AIR CIRCULATOR (BLOWER SYSTEM)		X	X	X	X
COOLER, FLUID LOOP		X	X	X	X
FILTER, ACTIVATED CHARCOAL		X	X	X	X
FILTER UNIT, HEPA		X	X	X	X
HEATER, FLUID LOOP		X	X	X	X
OXYGEN MANIFOLD AND METERING SYSTEM	X	X	X	X	X
OXYGEN SUPPLY, PRESSURIZED CYLINDERS	X	X	X	X	X
THERMOCOUPLES	X	X	X	X	X
HOLDING UNIT MODULE					
ANIMAL WATERING DEVICE		X			
CAGE, SMALL VERTEBRATES		X			
CLINOSTAT				X	
COMMON CAGE MODULE		X	X	X	X
FEEDER, VERTEBRATE		X			
GAS MONITOR (CO2,O2)		X	X	X	X
HOLDING CHAMBER, CELLS/TISSUES			X		
HOLDING CHAMBER, INVERTEBRATES			X		X
LIOH CARTRIDGES		X			X
PLANT WATERING SYSTEM, AUTO				X	
MEDIA, TISSUE CULTURE			X		
WASTE MANAGEMENT SYSTEM, VERTEBRATES		X			

Initial List of Equipment Items for Candidate in MSI Experiments

REQUIRED EQUIPMENT ITEMS (E.I.'S)	EXPERIMENTS 1 Effects of Space Flight Environment on Sensory Processes	2 Effects of Space Flight Environment on Psychomotor Functions	3 Cargo Handling Capabilities	4 Assembly, Deployment, Maintenance & Repair Capabilities	5 Attached Teleoperator Manual Controllability	6 Free-Flying Teleoperator Remote Controllability	7 Effects of Space Flight Environment on Individual & Group Dynamics	8 Locomotion & Restraint Capabilities	9 Effectiveness of End Effector Designs	10 Off-Duty Activity & Facilities	11 Evaluation of Miniature Accelerometers—to Assess Effects of Stress & Fatigue	12 Urine & Feces Collection, Measurement & Sampling Systems	13 Inflight Determination of Bone Mineral Content	14 Compact Respiratory Measurement System	15 Automated Clinical Chemical Analyzer	16 System to Preserve Biological Materials	17 Medical Aspirator	18 Intravenous Fluid Administration Device	19 Blood Cell Counter
Accelerometer			x		x	x					x								
Accelerometer Coupler			x		x	x					x								
Accommodation Range Tester	x						x												
Airlock, EVA															x	x		x	x
Anomalascope	x						x												
Audio Stereo Headset	x						x												
Audio Tone Source, Portable	x						x												
Audiometer	x						x												
Bags, Plastic, Permeable															x	x		x	x
Bench, Laminar Flow			x	x															
Biobackpack, Micro	x	x	x	x	x	x	x	x		x	x								
Camera, Cine			x	x	x	x	x	x	x	x									
Camera, Still			x	x	x	x	x	x	x	x									
Camera, Video B&W		x	x	x	x	x	x	x	x	x						x	x	x	
Camera, Video Color			x	x	x	x	x	x	x	x									
Camera Controller			x	x			x	x		x						x	x	x	
Computer, Digital	x	x	x	x	x	x	x	x	x	x	x					x	x	x	
Console, Behavioral Measurements	x	x					x			x									
Converter, A-D	x	x	x	x	x	x	x	x		x	x								
Crew Mobility Aids			x	x				x		x									
Crew Restraints		x	x	x			x	x		x	x	x	x	x	x		x	x	
Data Control Unit, TV		x	x	x			x			x									
Data Management System, Plotter & Control Module	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x
Display/Keyboard, Portable			x	x	x	x	x									x			
Dynamometer, Grip		x					x												
ECG Coupler	x	x	x	x	x	x	x	x		x	x								
EEG Coupler	x	x					x			x	x								
Electrophysiology Console	x	x	x	x	x	x	x	x		x	x								
Electrophysiology Display	x	x	x	x	x	x	x	x		x	x								
Electrophysiology Monitor	x	x	x	x	x	x	x	x		x	x								
Electrophysiology Receiver	x	x	x	x	x	x	x	x		x	x								
Filters, Video			x	x			x	x		x						x	x	x	
Flicker Fusion Apparatus	x						x												
Gas Supply, Assorted															x	x		x	x
Generator Signal											x								
Harness, Small Wire	x	x	x	x	x	x	x	x		x	x								
Kit, Behavioral Measurements I	x	x					x			x									
Kit, Behavioral Measurements II	x	x					x			x									
Limb Board, Motor or Manual	x						x												
Log Books							x									x	x	x	
Manipulator, Remote					x	x			x										
Meters, Assorted	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x
Microphone	x	x					x			x									
Mirror, Revolving	x						x												
Mirror Mount - Commutator			x	x			x	x		x						x	x	x	
Monitor, Video			x	x	x	x	x	x	x	x									
Orthorater	x						x												
Oscillator, VDC	x	x	x	x	x	x	x	x		x	x								
Oscilloscope											x								
Paper, Recording	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x
Patchboard System	x	x	x	x	x	x	x	x		x	x								
Pegboard, Purdue		x					x												
Pegboard, Santa Ana		x					x												
Perceptual Motor Perf. Tester		x					x												
Position Estimation Control		x					x												
Power Supply			x	x	x	x	x	x	x	x						x	x	x	
Psychomotor Performance Console		x					x												
Psychomotor Rotating Disks		x					x												
Radiation Waste System															x	x		x	x
Receiver, EKG	x	x	x	x	x	x	x	x		x	x								
Recorder, Tape, Voice	x	x					x			x									
Room, Private							x			x									
Sensors, Assorted	x	x	x	x	x				x	x	x								
Signal Conditioners	x	x	x	x	x	x	x		x	x	x								
Sound Level Meter	x	x					x			x									
Steadiness Tremor Apparatus		x					x												
Sterilizer, Autoclave															x	x		x	x
Storage, General	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x
Tape, Video			x	x			x	x		x						x	x	x	
Target, Landolt Ring App.	x						x												
Taskboard, Force/Torque		x					x												
Taskboard, Manl./Gross C.		x					x												
Taskboard, Position Repro.		x					x												
Taskboard, Resp. Orientation		x					x												
Taskboard, Visual React. Time		x					x												
Timer, Event		x	x	x			x												
Timer, Integral Equip.			x	x															
Vision Tester	x						x												
Vision Tester, Howard Dolman	x						x												
Vision Tester, Amer. Optical	x						x												
Experiment Specific Equipment		x			x	x	x		x		x	x	x	x	x	x			x

Initial List of Equipment Items for the LSPS Experiment Categories

EQUIPMENT ITEMS	EXPERIMENT CATEGORIES											
	1	2	3	4	5	6	7	8	9	10	11	12
	Water Recovery	Waste Management	Protective Clothing & Suits	CO_2 Collection	Cooling Systems	Atmosphere Supply	Atmosphere Control	Trace Contam. Control	EVA Suit Biopack	Food & Feeding	O_2 Regeneration	Whole Body Shower
Air Lock - EVA			x						x			
Analyzer, Atomic Absorption Spectrophotometer								x		x		
Analyzer, Infrared Absorption	x		x	x								
Analyzer, General Spectrophotometer	x	x		x		x	x	x		x	x	
Analyzer, Micro-organism, Automatic I.D.	x	x										
Analyzer, Conductivity	x											
Atmospheric Sampling Manifold System				x		x	x	x			x	
Badges, Radiation, Standard Film								x				
Bags, Permeable Plastic		x										x
Bicycle Ergometer			x						x			
Bottles, Cells and Tissues	x	x			x							x
Camera, Cine												x
Camera, Still												x
Camera, Video, Black and White												x
Camera, Video, Color	x	x	x						x			x
Chemicals				x				x			x	
Compactor, Solids		x								x		
Computer, Digital	x	x	x	x	x	x	x	x	x		x	x
Cooler, Thermoelectric			x					x	x			x
Counter, Colony, Manual	x											
Crew Mobility Aids			x						x			x
Crew Restraints			x						x			x
Data Management Buses	x			x	x	x	x	x			x	
Data Management Plotter/Printer	x	x		x	x	x	x	x			x	x
Data Management Control Station	x		x	x	x	x	x	x	x		x	x
Data Management Remote Instrumentation Modules	x			x	x	x	x	x			x	
Data Management Wide Band & TV Unit	x			x	x	x	x	x			x	
Developer, Film								x				
Display - Keyboard				x	x	x	x	x			x	x
Electrometer				x		x	x	x			x	
Feeder, Liquid, Automatic	x	x										x
Flowmeters	x	x	x			x	x		x	x		x
Flowmeter Couplers	x	x	x			x	x		x	x		x
Filters, Chemical	x	x		x							x	x
Frig. (Refrigerator)	x	x								x		x
Gas Analyzer, CO_2		x		x		x	x	x			x	
Gas Analyzer, Gas Chromatograph	x	x	x	x		x	x	x	x	x	x	
Gas Analyzer, Mass Spectrometer, Research		x		x		x	x	x		x	x	
Gas Analyzer, Mass Spectrometer, Special	x	x		x		x	x	x			x	
Gas Analyzer, O_2			x					x	x			
Gas Analyzer, Relative Humidity				x				x			x	
Gas Supply	x	x		x		x	x	x		x	x	x
Gas Metering & Calibration Unit				x		x	x	x			x	
Holding Unit, Cells/Tissues	x	x										x
Indicator, Atmospheric O_2								x				
Ionization Detector, Flame	x	x		x		x	x	x		x	x	
Kit, Chemical	x	x	x	x		x	x		x	x	x	x
Kit, Clean-up	x	x	x	x	x	x	x	x	x	x	x	x
Kit, Microbiology	x	x	x						x			x
Kit, General Tool	x	x		x	x	x	x	x		x	x	x
Leak Detector		x	x			x	x	x	x			
Manifold, Vacuum	x	x		x							x	x
Maintenance Task Simulator			x						x			
Mass Measurement Device, Macro	x	x				x	x			x		x
Mass Measurement Device, Micro	x											
Media, Dehydrated	x	x										x
Media, Prepared										x		
Motors	x	x		x	x	x	x	x		x	x	x
Microscope, Compound	x	x	x						x			x
Monitor, Video												x
Paper, Recording	x	x		x	x	x	x	x			x	x
pH Meter	x									x		x
Portable Life Support System			x						x			
Power Supply												x
Pressure Suit Connector			x						x			
Pressure Suit Manipulation Aids			x						x			
Radiation Detector, Dosimeter								x				
Radiation Detector, General								x				
Radiation Waste System		x										x
Recorder, Multichannel Biomedical	x	x		x	x	x	x	x			x	x
Sensors	x	x		x	x	x	x	x		x	x	x
Shroud, Environmental		x				x	x	x				
Signal Conditioners	x	x	x	x	x	x	x	x	x	x	x	x
Sterilizer, Autoclave		x										x
Storage, General	x			x	x	x	x	x			x	x
Storage, Film								x				
Stove	x											
Temperature Sensors, Body										x		
Temperature Sensors, Infrared			x					x	x	x		
Thermocouples			x					x	x			x
Thermometers										x		
Transducer, Plethysmograph	x	x		x	x	x	x	x			x	x
Trash Can		x								x		
Valves	x	x		x	x	x	x	x			x	x
Voltmeter				x		x	x	x			x	

TYPICAL SPACELAB EXPERIMENT REQUIREMENTS

Prepared by NASA Ames Research Center

July 1975

BASELINE MINILAB PACKAGE FOR HUMAN VESTIBULAR EXPERIMENTS

OTOLITH FUNCTION EXPERIMENTS

I. Vestibulo-Spinal Reflex — Examination of otolith-originating reflex during OG habituation by measuring EMG response in gastrocnemios muscle resulting from unexpected acceleration in head to foot detection.

II. Linear Acceleration Threshold — Examination of sensitivity changes in otolith input channels during habituation to OG.

III. H-Reflex — Examination of otolith modulation of motoneuron excitability during habituation to OG and in response to sinusoidal head to foot acceleration.

VISUAL/VESTIBULAR EXPERIMENTS

IV. Visual Accommodation — Determine status of otolith system by monitoring changes in visual accommodation during habituation to OG (otolith-accommodation reflex).

V. Tilt Illusion — Examine effects of habituation to OG on illusions of tilt produced by random pattern rotating in frontal plane (illusion normally constrained by IG otolith input).

VI. Linear Vection Threshold — Examine sensitivity to illusion of linear acceleration in X, Y, and Z directions produced by moving visual stimulation of peripheral visual fields during OG.

BASELINE MINILAB PACKAGE FOR HUMAN VESTIBULAR EXPERIMENTS — 7-DAY & 30-DAY

Function	Otolith Function Experiments			Visual/Vestibular Experiments		
	I. Vestibulo-Spinal Reflex	II. Linear Acceleration Threshold	III. H-Reflex	IV. Visual Accommodation	V. Tilt Illusion	VI. Linear Vection Threshold
1a. Otolith Stimulation — Linear Acceleration in X		X				
1b. Otolith Stimulation — Linear Acceleration in Y		X				
1c. Otolith Stimulation — Linear Acceleration in Z	X	X	X			
2a. Visual Stimulation — Axially Rotating Display					X	
2b. Visual Stimulation — Peripheral Linearly Moving Display						X
3. H-Reflex Stimulation			X			
4a. Response Measurement — Visual Accommodation				X		
4b. Response Measurement — EMG	X		X			
4c. Response Measurement - Subjective		X			X	X
5. Data Handling	X	X	X	X	X	X
6. Experiment Sequencing and Control	X	X	X	X	X	X
7. Space Sickness Episode Documentation	X	X	X	X	X	X

BASELINE MINILAB PACKAGE FOR HUMAN VESTIBULAR EXPERIMENTS

Equipment

Function	A. Linear acceleration sled as per ERNO	B. Linear acceleration sled with chair tilted for acceleration head to foot	C. Large frontal display field with random pattern rotating around subjects line of sight	D. Viewing box with random figure display moving in X, Y, or Z direction presented to peripheral visual fields	E. Electric stimulator (Grass S-4)	F. Surface stimulating electrodes	G. Hartinger coincidence refractometer	H. EMG electrodes	I. Response lever (analog signal)	J. Signal conditioners	K. Analog time recorder (76 nan.)	L. Voice recorder	M. Log book	N. Preliminary data analysis logic	O. Chart recorder — 2 + Chan.	P. Digital result display	Q. On-line control logic for stimuli	R. Control logic for sequencing	S. Space sickness questionnaire	T. Fixed chair with bite board (may be linear acceleration chair in fixed mode)	U. Helmet with blindfold and/or tri-axial accelerometers
1a. Otolith Stimulation — Linear Acceleration in X	X																				
1b. Otolith Stimulation — Linear Acceleration in Y	X																				
1c. Otolith Stimulation — Linear Acceleration in Z		X																			
2a. Visual Stimulation — Axially Rotating Display			X																		
2b. Visual Stimulation — Peripheral Linearly Moving Display				X																	
3. H-Reflex Stimulation					X	X															
4a. Response Measurement — Visual Accommodation							X														
4b. Response Measurement — EMGe								X													
4c. Response Measurement — Subjective									X												
5. Data Handling										X	X	X	X	X	X	X					
6. Experiment Sequencing and Control																	X	X			
7. Space Sickness Episode Documentation																			X	X	
8. Other																					X

MINIMAL EXPERIMENT PACKAGE FOR A RESTRAINED PRIMATE

Essential Apparatus and Procedures

X — Required

O — Desirable

Essential Apparatus and Procedures	Typical Spacelab Experiments										
	Cardiovascular	Blood Distribution	Enzyme Changes	Biorhythms	Metabolic Balance	Bone Metabolism	Gastrointestinal	Vestibular Function	Phanocolobial	Organs and Vessels Contour	
Monkey Pod and ECS	X	X	X	X	X	X	X	X	X	X	
Analog Recording	X	X		X	O		X	X	X		
Food & Water Intake		X	X		X	X			O		
Urine Sample			X	O	X	X	X		O		
Urine Volume	X	X	X	O	X	X			X		
EKG	X			X					X		
EOG								X			
Mass Spectrometer					X						
Fecal Collection					X	X	X				
Body Temperature				X	X						
EEG				X				X			
Blood Samples	X		X	O		O			X		
LBNP	X										
Biotelemetry	X	X		X			X	X			
X-Ray, T.V., and Digital Recorders							O			X	
"Minimum" Exposure - 2 Days	X	X	X				X			X	
5 Days								X	X		
10 Days				X	X						
20 Days						X					

VESTIBULAR SENSITIVITY

Functions	Monkey Pod	ECS/Monitor Record	Biotelemetry, Heart	Video, X-Ray	LBNP/Control	Spec. Prep. & Preservation	Mass Spec./Flow	CRT	Analog Record	Digital Record	Microspheres	EKG	ECG	EEG	Venous Catheter	Urine Collection	Fecal Collection	Micro-Elect. Implant	Linear Accel. Track	Threshold Response Lever	Doppler Flowmeter	Echocardiograph	Temperature Implant	Food & Water Management
Retrained Primate	X	X																	X	X				
Ambient Recording	X									X														
Food & Water Intake	X									X														X
Fecal Collection																								
Urine, Rate, Vol., Sample																								
Respiratory Gas Analysis																								
Blood Samples																								
Intravenous Injection																								
Heart Rate																								
Blood Pressure																								
Cardiac Output																								
Cardiovascular Challenge																								
Body Temperature																								
Gastrointestinal Activity																								
Acceleration Threshold																			X	X				
Otolith Activity	X							X		X			X	X				X	X					
Blood Flow Distribution																								
Heart Size																								
Chyme Distribution																								
Food Label																								
Blood Flow Rates																								
Response Lever	X							X		X										X				

CARDIOVASCULAR

Functions	Monkey Pod	ECS/Monitor Record	Biotelemetry, Heart	Video, X-Ray	LBNP/Control	Spec. Prep. & Preservation	Mass Spec./Flow	CRT	Analog Record	Digital R. ord	Microspheres	EKG	ECG	EOG	EEG	Venous Catheter	Urine Collection	Fecal Collection	Micro-Elect. Implant	Linear Accel. Track	Threshold Response Lever	Doppler Flowmeter	Echocardiograph	Temperature Implant	Food & Water Management
Retrained Primate	X		X																						X
Ambient Recording	X	X																							
Food & Water Intake	X	X																							X
Fecal Collection						X																			
Urine, Rate, Vol., Sample	X	X																							
Respiratory Gas Analysis						X																			
Blood Samples																									
Intravenous Injection	X										X														
Heart Rate	X	X						X	X			X													
Blood Pressure	X	X																						X	
Cardiac Output																							X		
Cardiovascular Challenge		X						X																	
Body Temperature								X																	
Gastrointestinal Activity																									
Alteration Threshold																									
Otolith Activity																									
Blood Flow Distribution											X					X	X					X	X		
Heart Size		X	X						X																
Chyme Distribution																									
Food Label																									
Blood Flow Rates																						X			
Response Lever																									

CARDIOVASCULAR

Functions	Pod Shielding	Heart Implant	Echocardiograph	Urine Catheter/Ext.	Indwelling Venous Catheter	Lower Pod Δp and Pump	Blood Preparation	
Blood Pressure		X						
Monkey Pod and ECS	X							
Analog Recording		X	X					
Food and Water Intake								
Urine Sampling								
Urine Volume								
EKS		X		X				
EOG								
Mass Spectrometry								
Fecal Collection								
Body Temperature								
EEG								
Blood Samples					X		X	
LBNP						X		
Biotelemetry		X						
X-Ray/T.V. Digital								
Cardiac Output			X					

MINIMAL EXPERIMENT PACKAGE CONCEPT FOR SMALL ANIMAL RESEARCH

X — Required

O — Desirable

Animal Holding Equipment \ Typical Spacelab Experiments	Bone Metabolism	Bone Parameters	Hormonal Studies	Hemolysis & RBC Life Span	Cell-Mediated Immunity	Drosophila Aging	Eye Ultrastructure	Cardiac Norepinephrine	Endocrine Glands	Gastric Ulceration	Liver Regeneration	Metabolic Rate & Deep Body Temp.	Birth & Postnatal Survival	Muscle Atrophy
Animal Cage	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ECS	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Urine Elimination		X		X	X		X		X	X				
Urine Collection	X		X					X			X	X		
Fecal Elimination		X		X	X		X		X	X				
Fecal Collection	X	X						X			X	X		
Urine-Fecal Separation	X		X									X		
Volume/Amt. Measurement	X		X					X			X	X		
Food & Water Intake	X		X	X							X	X	X	
Respiration Collection			X								X	X		
Urine/Fecal Preservation	X		X					X			X	X		
Drug or Microbe Injection		X			X						X			X
Radioisotope Present	X			X							X	?		
Radioisotope Counting				X							X	?		
T. V. Monitor			X			X						X	X	X
Body Temperature											?	X	X	
Biotelemetry		!									?	X	X	X
Photography	X	X	X			X				X		?	X	X
Mass Determination	X	X	X			?		X	X	X	X	X	X	X
Activity	O		O						O	O	O	X	X	X
Analog Recording	X		O	X				X	O	O	X	X	X	X
Control Centrifugation	O	O	O	O	O	O		O	O	O	O	O	X	O

MINIMAL EXPERIMENT PACKAGE CONCEPT FOR SMALL ANIMAL RESEARCH

X — Required

O — Desirable

Typical Spacelab Experiments

Function	Bone Metabolism	Bone Parameters	Hormonal Studies	Hemolysis & RBC Life Span	Cell-Mediated Immunity	Drosophila Aging	Eye Ultrastructure	Cardiac Norepinephrine	Endocrine Glands	Gastric Ulceration	Liver Regeneration	Metabolic Rate & Deep Body Temp.	Birth & Postnatal Survival	Muscle Atrophy
1. Animal Holding & ECS	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. Food & Water Intake	X								X		X	X	X	
3. Biological Samples	X	X	X	X	X		X	X	X	X	X	X	X	X
4. Remote Monitoring	O		X			X		O	O	O		X	X	X
5. Surgery	X	X	X				X	X	X	X	X		?	X
6. Sample Processing														
6a. Chemical	O		X	X				X	X		X	?		O
6b. Histological		O	O		X	?	X	X	X	X	X		O	X
6c. Microbiol. /Culture					X									
6d. "Fixing" (Freezer, Chem., Fixative)	X	X	X	X		?	X	X	X	X	X	X	X	X
7. Radioisotope Drug Study	X	X		X	X						X	?		X
8. Control Animal Centrifugation	O	O	O	O	O	O		O	O	O	O	O	O	O
9. "Minimum" Effective Exposure- 7da	X	X	X	X	X	X	X	X	X	X		X		X
14da	X	X	X	X	X			X	X	X	X	X	X	X
30da													X	

MINIMAL EXPERIMENT PACKAGE CONCEPT FOR SMALL ANIMAL RESEARCH CONCEPT

X — Required

O — Desirable

Typical Spacelab Experiments

Biological Samples	Bone Metabolism	Bone Parameters	Hormonal Studies	Hemolysis & RBC Life Span	Cell-Mediated Immunity	Drosophila Aging	Eye Ultrastructure	Cardiac Norepinephrine	Endocrine Glands	Gastric Ulceration	Liver Regeneration	Metabolic Rate & Deep Body Temp.	Birth & Postnatal Survival	Muscle Atrophy
Respiration Samples				X							X			
Urine Sample	X		X					X			X	X		
Fecal Sample	X		X					X			X	X		
Freezer Preservation	X							X			X	X		
Chemical Preservation			X					X						
Blood Sample			X		X			X			?	?		
Centrifugation			X		X			X			?	?		
Refrig/Freezer			X					X			?	?		
Tissue Samples (Surgery)	X	X	X			X	X	X	X	X	X	?	X	X
Fixation		X	X				X	X	X	X	X	?	X	X
Sectioning		X	X				X	X	X	X	X		X	X
Embedding		X	X				X		X	X	X		X	X
Histology		X	X		X		X		X	X	X		X	X
Homogenization	O		X					X	X		X	?		X
Chemical Determination	O		X					X	X		X			X
Refrig-Freezer	X	X	X					X	X		X	X		X
Microbiol. Culture				X										
Tissue Culture				X										
Mass Determination	X	X	X				X	X	X	X	X	X	X	X
X-Ray or Bone Densitometry	X	X												
Electron Microscope		O	O				O	O	O	O	O		O	O
Photography		X			O	X	X	X		X	X	?	X	X
Isotope Counting	O		X	X	X						X			
Mass Spectrometer	?										X	X		
Spectroscopy	O		X					X			X	X		

Life Sciences Research Requirements

The following tables represent a condensation of information given in the input data relative to establishing the research requirements for a life sciences space program. The tables are organized into the four main categories: Biomedicine, Biology, Life Support/Protective Systems and Man Systems Integration. These are further subdivided into functional areas and specific research topics. Specific research functions and/or measurements are described. Finally, descriptive data used to establish the priority determinations, in most cases excerpted from the data sources, are presented. The superscript numeral following each entry refers to a citation given in the following table of references.

1. Scientific Uses of the Space Shuttle, National Academy of Sciences, Space Science Board, National Research Council, Washington, D. C., 1974.

   31 - p.173, 46 - p. 158, 47 - p. 158, 48 - p. 158, 49 - p. 168.

2. Physiology in the Space Environment: Volume I - Circulation, National Academy of Sciences, Space Science Board, National Research Council, Washington, D. C., 1968.

   10 - p. 7.

3. HZE - Particle Effects in Manned Spaceflight, National Academy of Sciences, Space Science Board, National Research Council, Washington, D. C., 1973.

   37 - p. 7.

4. Aviation, Space and Environmental Medicine, April 1975.

   36 - p. 466.

5. Skylab Medical Experiments Altitude Test (SMEAT), NASA TMX-58115, NASA-Johnson Space Center, Houston, Texas, October 1973.

   35 - "Foreword".

6. The Proceedings of the Skylab Life Sciences Symposium, August 27-29, 1974, Vols. I & II, NASA TMX-58154, JSC-09275, NASA-Johnson Space Center, Houston, Texas, November 1974.

   2 - p. 592, 3 - p. 629, 4 - p. 804, 5 - p. 26, 6 - p. 68, 7 - p. 403, 8 - p. 545, 9 - p. 619, 11 -p. 813, 12-p. 841, 13-p. 370, 14-p. 854, 15-p. 813, 16-p. 841, 17 - p. 802, 18 - p. 856, 19 - p. 634, 20 - p. 637, 21 - p. 436, 22 - p. 387, 23 - p. 450, 24 - p. 347, 25 - p. 66, 26 - p. 126, 27 - p. 855, 28 - p. 812, 29 - p. 495, 30 - p. 541, 32 - p. 853, 33 - p. 341, 34 - p. 339, 39 - p. 18 40 - p. 430, 41 - p. 430, 42 - p. 139, 43 - p. 141.

7. Infectious Disease in Manned Spaceflight - Probabilities and Countermeasures, National Academy of Sciences, Space Science Board, National Research Council, Washington, D. C., 1970.

44 - p. 7, 45 - p. 8.

8. The Biosatellite: Results of the Experiment, NASA-TT-F-15863, Technical Translation of Article in Pravda, No. 60, 1 March 1974, NASA, Washington, D. C., July 1974.

50 - p. 5.

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
Cardiovascular System		
Altered vascular flow, volume & pressure relationships in zero-gravity.	Pulmonary capillary blood volume Pulmonary capillary blood flow Venous capacitance Venous compliance Arterial flow in limbs Body fluid component volumes - total body water volume - extracellular volume - plasma volume Renal blood flow	Space flight furnishes an environment for cardiovascular study which can be produced in no other way. It is difficult to imagine that increased understanding of cardiovascular function and control mechanisms, as they are altered in weightlessness, will not in the future become relevant to the cardiovascular problems that face us on earth.[1] Skylab studies have clearly shown that changes in fluid volume distribution during the first few hours of flight creates profound alterations in cardiovascular functions which in turn, impair orthostatic mechanisms to a marked degree as early as four or five days after entering the weightless environment.[2] It should be noted in all crewmen there was an increase in compliance that required <u>10 days or more</u> to reach a maximum.[3]
Demonstrate presence or absence of Gauer-Henry-Reflex.	Intrathoracic blood volume ADH Renin Angiotensin Aldosterone Catecholamines Water excretion Sodium excretion Plasma volume	The Gauer-Henry reflex has yet to be demonstrated. This will not be easy to demonstrate in man, since the critical time-period to be investigated is thought to coincide with the early operationally exacting first day of the mission.[4] The first two to three days of each mission were spent in the activation of the orbital workshop.[5]
Cardiovascular regulatory responses to exercise in zero gravity. (Man)	Electrocardiogram/vectorcardiogram - pulse rate and rhythm - cardiac axis Echocardiogram - stroke volume - cardiac output - cardiac compliance Systolic blood pressure Diastolic blood pressure - pulse pressure - mean arterial pressure Calibrated exercise level	The increased quantity and quality of exercise available to the crew was important in maintaining crew health of Skylab 4.[6] Future research efforts should focus on optimum methods of exercise with respect to crew time and crew acceptance, interrelationship of musculoskeletal fitness with cardiovascular fitness, and design of practical, efficient, total body exercisers.[7]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
Cardiovascular System (Cont'd)		
Invasive studies on non-human primates.		
- Altered vascular flow volume and pressure relationship in zero-gravity	Intracranial pressure Brain blood flow Intracardiac catheterization Coronary flow Animal maintenance Animal restraints Electrocardiogram/ vectorcardiogram	Changed relationships in the anatomical distribution of blood volume and extravascular fluids, altered patterns of blood flow, and reduced total circulating blood volume induced by the weightless environment are offered as partial explanations for the changes in cardiovascular responses to lower body negative pressure.[8] These findings have, in a predictable fashion, opened new questions which will direct future ground-based and in flight researches - particularly in the area of cardiovascular electro-hemodynamic studies for the Shuttle era.[9]
- Demonstrate absence or presence of myocardial degeneration resulting from zero-g exposure	Histological preparation (post-mission)	
Pulmonary System		
Altered pulmonary volume/flow relationships in zero-g	VC Vital capacity FVC Forced vital capacity FEV-1 Forced expiratory volume - one second CV Closing volume MEFR Maximum expiratory flow rate MMRF Maximum midexpiratory flow rate TLC Total lung capacity RV Residual volume Pulmonary capillary blood volume Pulmonary capillary blood flow	The effects of gravity are so profound in altering the distribution of blood and gas within the lungs that many problems in basic pulmonary physiology can be studied more effectively under weightlessness than in a normal gravitational field. One of the dividends of space flight will be the opportunity to carry out experiments on the lungs that are impossible on Earth.[10] No untoward physiological responses have been noted that would preclude longer duration space flights, but more research is required in order to understand the mechanisms involved in the observed responses.[11]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
<u>Musculoskeletal System</u> Derangement basis and countermeasures in zero-gravity - exercise effect upon musculoskeletal derangement	Calibrated exercise level O_2 consumption CO_2 production M[illegible]e volume Body temperature ECG/VCG Systolic blood pressure Diastolic blood pressure Muscle strength Muscle mass Muscle reflexes Muscle potential *Bone mineral measurement *One-g readaptation time Anthropometric measurements *Post-mission	...bone loss definitely occurs under zero-g conditions. It is certain that this loss continues for at least sixty days, and it is almost certain that it continues for as long as 84 days. There has been no evidence that this phenomenon shows the type of adaptation to zero-g which has been exhibited in the other systems which have been the subject of this symposium.[12] Finally, these observations may have significance for Earth medicine. In reminding us of the deleterious effects of disuse on bone mass, they reemphasize the importance of direct physical longitudinal stress (weight bearing) to the integrity of bone. In research on osteoporosis, greater attention than heretofore might be given to this factor for the possible value of <u>increased</u> weight-bearing stress as a deterrent <u>to</u> or even as aid to correction <u>of</u> this extremely prevalent bone disorder.[13] It would seem advisable in any case to search for means by which an astronaut in space might not only maintain his leg muscle mass, but also exercise his postural equilibrium systems.[14]
- diet and pharmacological control of musculoskeletal derangement	Food/fluid input records Continuous 24-hr urine collection Total fecal collection Vomitus collection Storage of urine, feces, vomitus for analysis of: - urine & fecal calcium - " " phosphate - " " nitrogen - " " magnesium - " " potassium - " " sodium - urine-hydroxyproline - anthropometric measurements Premedication Plasma thyroxin level	Daily in-flight personal exercise regimens coupled with appropriate dietary intake and programed adequate sleep, work and recreation periods essential for maintaining crew health and well-being.[15] ...the continued high values for urine calcium through the entire length of the Skylab 4 study gives us no reason to believe that any kind of adaptation occurred during the 84 days of that mission.[16]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
Musculoskeletal System (Cont'd)		
Invasive studies on animals		
- absolute catabolic effects of zero-g on the musculoskeletal system	Restrained experimental animals Unrestrained control animals Animal maintenance Physiological monitoring (implanted) Food/fluid intake measurements Urine & fecal collection & storage Blood sample collection & storage Histological preparations of: - muscle tissue - bone - bone marrow	Clearly, man is not vegetating in space, but is actually doing his utmost to maintain a high level of physical fitness and performance. Thus the absolute detrimental effects of null gravity will, in most cases, have to be determined in subhuman surrogates.[17]
Basis and Control of Biochemical Reactions to Stresses in Space Environment Fluid & electrolyte balance Calcium regulation Adrenal function Food utilization	Time related record of crew nutrition and exposure to stress and exercise. Radionuclide body compartment studies: - total body water - extracellular volume - plasma volume Obtain fractionated urine samples and plasma and serum samples for on-board and/or delayed analysis.	However, taking an overview of the program as a whole, two outstanding features have emerged. First, Man can adapt to, and live in, the zero-gravity space environment for extended periods of time. But second, and therefore above all, none of the measured changes so far seen in missions extending up to 84 days have proved irreversible after return to Earth.[18] Venous compliance changes were demonstrated which, with blood volume changes, should provide an initial and primary point of departure for investigation of the complete response to lower body negative pressure. Time course of the compliance changes should be considered by mission planners. Shuttle reentry, for example, will fall within the zone of increased sensitivity to orthostatic stress.[19] By the time of the earliest in-flight measurement on mission day 3, all crewmen had lost more than two liters of extravascular fluid from the calf and thigh. The puffy faces, the "bird legs" effect, the engorgement of upper body veins, and the reduced volume of lower body veins were all documented with photographs.[20]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
Basis and Control of Biochemical Reactions to Stresses in Space Environment (Cont'd)	Urine Analyses: Volume Sodium Potassium Chloride Osmolality Calcium Phosphate-(PO_4) Magnesium Creatinine Antidiuretic hormone Aldosterone Cortisol Epinephrine Norepinephrine Total 17-Hydroxycorticosteroids Total 17-Ketosteroids Uric Acid	Significant increases in urinary antidiuretic hormone occurred early in-flight in all men. Due to inability to refrigerate the urine sample obtained on the first day in-flight, it could not be analyzed for this hormone.[21] Urine analyses from Skylab missions.[40]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
<u>Basis and Control of Biochemical Reactions to Stresses in Space Environment</u> (Cont'd)	<u>Plasma & Serum Analyses:</u>	
	Sodium*	
	Potassium*	
	Calcium*	
	Magnesium	
	Chloride*	
	Phorphorus*	It is concluded that mineral losses do occur from the bones of the lower extremities during missions of up to 84 days and that in general, they follow the loss patterns of the bedrested situation. The levels of loss observed in the Skylab crews have been of no clinical concern but it was fortuitous that all of the Skylab 4 crewmen had high prediction terms.[22]
	Osmolality*	
	Carbon dioxide	
	Cholesterol	
	Triglycerides	Plasma analyses from Skylab missions.[41]
	Adrenocorticotrophic hormone*	
	Cortisol*	
	Angiotensin I*	
	Aldosterone*	
	Insulin*	The in-flight decreases observed in both glucose and insulin have also been observed in bedrest, although it did not become significant until 56 days in bedrest, while the decrease became significant at 38 days in space.[23]
	Blood urea nitrogen	
	Uric acid	
	Creatinine*	
	Total protein	
	Alkaline phosphatase	
	Serum glutamic oxaloacetic transaminase (aspartate aminotransferase)	
	Creatine phosphokinase	
	Lactic dehydrogenase	
	Glucose*	
	Total bilirubin	
	Growth hormone	
	Thyroxine	
	Thyroid stimulating hormone	
	Testosterone	
	Parathormone*	
	Calcitonin	
	Vitamin D	

*Determined during flight

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
<u>Vestibular System</u>		It appears that a relatively modest amount of crew time may have been lost due to motion sickness on Skylab missions 3 and 4 but that each crew's performance was never substantially impaired for more than one day.[24]
Study the mechanical and neural responses of the otolith organs to stimuli in the space environment.	Apply calibrated stimulus to otoliths: - linear acceleration - angular acceleration Record ocular reflex motions Measure ocular muscle potentials	In Skylab 4 the Scientist Pilot did not experience motion sickness. The Commander had minimal malaise for three days. The Pilot had significant nausea with vomiting for one day and then malaise for two more days.[25] Under operational conditions seven of the nine crewmen experienced motion sickness, five of the seven while in orbit. The administration of antimotion sickness drugs made it difficult or impossible accurately to determine the level of susceptibility at all times. The Skylab 2 crewmen did not experience clear-cut symptoms aloft and only the Scientist Pilot experienced seasickness;
Investigate role of visual cues in space nausea.	Repeat Skylab M131 experiment with eyes open. Relate crew/spacelab orientation to signs and symptoms of spatial disorientation.	indeed, the Commander and Pilot did not take drugs, yet remained symptom free throughout the mission. Among the Skylab 3 crew the Pilot experienced motion sickness shortly after transition into orbit, the earliest diagnosis on record. The two remaining crewmen first experienced motion sickness shortly after entering the workshop. For a period of three days symptoms were controlled by drugs and by restricting activity. Recovery was complete by mission day seven. The Skylab 4 crewmen were scheduled to take antimotion sickness medication but only the Scientist Pilot avoided symptoms.[26]
Pharmacological prevention and treatment of space nausea.	Relate pharmacological administration to signs and symptoms of space nausea.	First, with the background supplied by M-131, advisably carried out in Skylab without vision, it would be of great interest to employ the same methodology to further explore the role of vision.[27]
Role of altered body fluid volume, pressure and distribution to space nausea.	Body fluid compartment volumes: - total body water - extracellular volume - plasma volume Venous capacitance Systolic blood pressure Diastolic blood pressure Anthropometric measurements Time-related signs and symptoms of space nausea.	
Invasive studies on animals.	Animal subject with implanted sensors and stimulation devices.	Among these findings, the occurrence of motion (space) sickness symptoms during the first few days of space flight is of paramount operational importance for the forthcoming Shuttle flights.[28]
Study mechanical and neural responses of the vestibular system to stimuli in the space environment	Apply calibrated stimulus to vestibular organs: - linear acceleration - angular acceleration - electrical stimulation - pressure stimulation Record ocular reflexes, righting reflexes & muscle potentials. Record signs & symptoms of space nausea.	

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
<u>Hematology</u>		
Man	Collect, prepare & preserve blood samples Measure red blood cell mass Obtain reticulocyte counts Measure blood O_2 tension Measure blood granulocytic response to inflammatory stimuli	Analyses of data from the red cell mass determinations indicate that the red cell mass drops occurred in the first 30 days of flight and that a gradual recovery of the red cell mass deficits began approximately 60 days after launch.[29] The loss of circulating red cells was also maximal at 20 to 40 days and decreased after that time. However, the recovery of red cell mass was independent of weightlessness or normal gravity after the initial insult.[30]
Invasive studies on animals	Collect, prepare, & preserve blood samples Measure red blood cell mass Obtain reticulocyte counts Perform bone marrow biopsies Measure total blood volume Measure blood O_2 tension Provide animal maintenance Provide animal physiological monitoring Provide erythropoietic stimulus: - acute blood loss - tissue hypoxia	

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
Microbiology		
Effects of space environment upon host defense mechanisms		
- Man	Alteration in normal bacterial microflora: - nasal sampling - skin sampling - air sampling - spacelab surface swabs Microbial mutation	These data show that, while gross contamination of the Skylab environment was demonstrated and there were several in-flight disease events (presumably of microbial origin), such events were not shown to be limiting hazards for long-term space flight.[42] The question of in-flight autoinfection remains unanswered because none of the in-flight disease events were evaluated microbiologically.[43]
- Animals	Experimentally induced infection (non-pathogenic strain for man) Maintenance of animals Microbial mutation Measure specific immune response: - macrophage activity - lymphocytic response - thymus gland response - immune globulin synthesis Blood sample collection and preservation Incubate microbial cultures	Examination of the effects of the spaceflight environment on latent and slow virus infections experimentally induced in animals.[44] Studies, both animal and human, of the effects of isolation on susceptibility to infection, particularly as related to the re-entry problem and microbial shock.[45]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOMEDICINE		
<u>Crew Performance in Space</u>	Conduct time and motion studies on a non-interference basis with scheduled, repetitive mission or training tasks and observe and record: - work space layout and lighting - crew restraints - equipment operation task efficiency - experimental task efficiency - task related movements of the subject - interpersonal reactions Time relate performance measures with daily activity schedules, sleep patterns, environmental conditions and biomedical measurements	A second feature bearing directly on the Shuttle program is the protracted period of space sickness malaise and loss of appetite encountered by a sizeable proportion of Skylab astronauts. Bearing in mind the short duration of the average Shuttle mission, it seems inevitable that effectively novice personnel engaged in research or other activities will be penalised by reducing work potential unless some form of successful preconditioning regimen is discovered.[32] It was found that on only two of the total of nine full or partial activation days was the crew work output significantly reduced. On the day of lowest efficiency, mission day 2 of the Skylab 3 mission, it appears that the crewmen were working at approximately 75 percent of their "normal" efficiency and may have lost approximately 7 man-hours of work. Overall, a nearly constant level of work was achieved on these activation days. However, as crew proficiency improved later in the missions, the daily crew work output in these same categories increased from approximately a 26 man-hour/day to at least a 34 man-hour/day.[33] Behavioral performance continued to improve from beginning to end of all Skylab missions.[34]
<u>Effects of Training Upon Space Crew Efficiency</u>	Correlate crew performance efficiency measurements in Spacelab missions with performance efficiency measured on the same task(s) when conducted previously in ground-based simulators or Spacelab flight training activities.	The Skylab Medical Experiments Altitude Test (SMEAT) was an integral part of the Skylab Program. SMEAT served both to gather vital baseline biomedical data and to resolve many of the equipment and procedural problems which otherwise might have impaired Skylab.[35]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOLOGY		
Cellular & Molecular Biology		
Density dependent growth and development processes	Cell turnover times Wound repair rates Cellular movement Intracellular movement Membrane electrolyte transport Maintain tissue cultures - bone marrow - intestinal epithelium - embryonic tissues	While certain of the projected experiments in the life sciences can be accomplished within the span of 7-day missions, others, such as those concerned with embryonic and fetal development, wound healing, and other aspects of cellular proliferation (e.g., marrow, skin, and gut), will require the full capability of the 30-day mission.[31]
Genetic alterations in zero-g	Cell division Mitotic abnormalities Chromosome aberrations Histological preparations Specimen preservation Monitor environment	
Higher Vertebrate Biology (non-human primates)	Described under biomedical requirements.	Enables invasive studies and critical control of experimental parameters of basic importance to understanding of human responses to space stresses. The non-human primates, due to anatomical, physiological, and biochemical characteristics of man, can provide research data transferable to man.
Lower Vertebrate Biology (rats, guinea pigs, frogs) -Basic mechanisms of physiological adaptation, growth, development and reproduction in zero g.	Maintenance of instrumented animals Animal restraints Metabolic monitoring - food/fluid intake - urine, feces, blood collection - circadian cycles Physiological monitoring - cardiorespiratory - vestibular adaptation to calibrated stimulation - behavior patterns Histological preparations - bone marrow erythropoieses - wound healing - genetic changes	30-day exposures of small mammals to zero-g effects should provide important information regarding basic factors which also affect man. Changes in activity of enzymes in heart, skeletal muscle, endocrine glands, and changes in bone marrow hematopoieses have been demonstrated in rats exposed to 22 days of zero g.

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOLOGY		
<u>Lower Vertebrate Biology</u> (rats, guinea pigs, frogs) Cont'd		
	Surgery, biopsy, autopsy - organ development - reversible/irreversible deconditioning Radioisotope injection Litter rearing Development stages Animal morphology Mass measurement Effects of fractional g Environmental monitoring - atmosphere/contaminants - acceleration - noise - radiation	Statistical numbers of experimental subjects can be maintained in space with less weight, volume, and power penalties than encountered for large primates.
<u>Invertebrates</u> (insects, spiders, nematodes)		
Basic mechanisms of physiological adaptation, growth, development & reproduction in zero g	Specimen maintenance through entire life cycles Monitor behavior patterns Monitor activity cycles Monitor reproduction Monitor growth rate Monitor development stages Monitor morphology Histological preparations for: - organ development - genetic changes - structural changes Specimen fixing & preservation for: - chemical changes Environmental monitoring - atmosphere/contaminants - airborne particulates - temperature/humidity	Enable complete life cycle studies which could provide important basic understanding of effects of prolonged zero g exposures on genetic, growth, development and reproduction factors.

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOLOGY		
<u>Invertebrates</u> (insects, spiders, nematodes, cont'd)	Environmental monitoring (cont'd) - noise - acceleration - radiation	
<u>Plant Biology</u>		
Basic mechanisms of growth, development, and reproduction in zero g	Specimen maintenance through several entire life cycles. Monitor: - geotropism - growth rate - morphology - photosynthetic activity - circadian cycles - productivity - life cycles Histological preparations for: - genetic changes - cellular replication - structural changes Specimen fixing & preservation for: - enzyme activity - chemical changes Mass measurement Effects of fractional g Environmental monitoring: - atmosphere - temperature - acceleration - radiation	Equal attention should be directed toward growth and development of plant cells in 0 g For example, does the absence of gravity influence the morphogenesis of plant cells and affect chromosome replication to alter the mechanism of cell division?[46] ...the obvious question, derived from extrapolation of the possible effects of weightlessness on chromosome replications, is whether plants can grow and develop normally in long-duration spaceflight. For example, can a microalgae population continue in a normal fashion after several generations at 0 g? Such information would be essential if one were to propose plant systems as secondary life-support systems in long-duration spaceflights.[47] Long-duration growth and development experiments might also provide important evidence for the possible evolutionary mechanisms of terrestrial plants.[48] Thus, among the fungi raised under conditions of weightlessness there was much poorer development of the supporting tissues, while the pedicel supporting the spore was much thicker and in area the fungus exceeds that of the "terrestrial variety".[50]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
BIOLOGY		
Radiobiology		...one of the most neglected problems in biology -- the vulnerability of themammalian tissues to cosmic ray particles.[36]
Biological effects of HZE particle irradiation	HZE particle detector Maintenance of: - small animals - plants - tissue cultures (described under vertebrates, invertebrates & plant biology) Histological preparations for: - genetic changes - structural changes - organ development Environmental monitoring: - atmosphere - radiation - temperature/humidity - acceleration	Enables study of molecular basis of zero-g effects upon cell division. Missions in low-inclination ($\leq 30°$) near-earth orbits do not present an HZE-particle hazard. Therefore, the urgency of securing the needed data depends on the schedule for long-duration (≥ 2 year) flights outside the earth's magnetosphere or in earth orbits inclined more than about 30° to the equator.[37] Ground-based studies with accelerator-produced heavy ions are thus the first requirement. NASA has the operational problem of assessing the potential hazard of HZE particles to man during long-duration space missions and should therefore take full advantage of the ground-based facilities that are becoming available. Flight studies can then be designed for proof-of-principle.[38] All Shuttle flights should contain dosimetric devices and materials positioned to accumulate data on the flux and energy of the several radiations in space and the shielding effect of spacecraft components on their intensity and scattering.[49]

LIFE SCIENCES SPACE RESEARCH REQUIREMENT

RESEARCH DISCIPLINE	FUNCTIONS/MEASUREMENTS REQUIRED	PRIORITY DETERMINANTS
LIFE SUPPORT & PROTECTIVE SYSTEMS		
<u>Life Support Hardware Testing in Zero G</u> e.g., Condensers Vapor Cycle Units Sterilizers CO_2 Reduction Biopacks Pressure Suits	Analyze gas mixtures Fluid sample transfer Vacuum supply management Fluid supply management Electrical power measurements Coolant supply management Low temperature specimen storage Isolation of process loops from cabin atmosphere Pressure suit testing	Determine the feasibility of using vapor compression refrigeration systems in the space environment. Develop advanced LSS hardware for water reclamation, waste management, atmospheric conditioning and purification, oxygen regeneration, feeding, and personal hygiene. Develop pressure suits and biopacks for more efficient EVA activity. Develop efficient air sterilization methods.
<u>Effects of Space Inertial Forces on Gravity Sensitive Processes</u> • Mixed Phase Fluid Flow • Liquid/Gas/Solid Phase Separation and/or Mixing Characteristics • Heat Transfer Characteristics	Measure: - fluid temperature - fluid pressure - fluid flow - fluid quality - fluid energy rates - color motion pictures of phase mixing - g level	Determine gravity influences on flow regimes and flow regimes influences on pressure drop, thereby providing a basis for engineering optimization of fluid systems for space applications. Develop design parameters for minimum energy separation over spectrum of liquid/gas ratios from near zero to near infinity. Develop design parameters for minimum energy phase mixing. Determine single phase and phase change heat transfer parameters.
MAN-SYSTEM INTEGRATION		
<u>Man-Machine Testing of Advanced Designs</u>	Provide crew inputs to operate, service and control hardware test items in zero g. Validate crew task time allocations. Validate hardware performance in zero g. Establish workspace/restraint requirement.	Skylab medical experiment equipment functioned without problems throughout the three flights. Medical data of high quality were obtained for all experiments.[39] Evaluation of teleoperator systems (free-flying) in deploying, retrieving, & servicing satellites remote from the shuttle.

APPENDIX B

RESEARCH CAPABILITY OF DEFINED PAYLOADS

APPENDIX B

RESEARCH CAPABILITY OF DEFINED PAYLOADS

The research capability for each of the 16 candidate payloads defined in this study is shown in the following pages. There are two tables for each payload. The first indicates the main research requirements, the specific capability, and the major equipment used. The second, and immediately following table, is the total common equipment listing for the payload. The following table indicates the complement of payloads and their order.

Type	Designation	Research Emphasis
Carry-On	Col-2A	Biomedicine - Blood Sampling
	Col-3A	Biomedicine - Urine, Electrolytes
Mini-Lab	ML-1A (first S/L mission)	Biomedicine - OFO, Vestibular, Urine, Single Cell Studies
	ML-2A	Biomedicine/Biology - Small Vertebrates
	ML-3A	Biomedicine - Man
	ML-4A	Life Support/Protective Systems
	ML-5A	Man Systems Integration
	ML-2B	Biomedicine/Biology - Primates
	ML-2C	Biomedicine/Biology - Small Vertebrates/ Cells & Tissues
	ML-2D	Biology - Small Verts., Plants, C&T, Invertebrates
Dedicated	MOD IA	Biomedicine - Man, Vertebrates, Cells & Tissues
	MOD IIA	Biomedicine/Biology/Adv. Technology
	MOD IIIA	Biomedicine/Biology/Adv. Technology - Centrifuge
	MOD IIB	Biology/Biomedicine
	MOD IIC	Biology/Biomedicine
	MOD IIIB	Biology/Biomedicine - Centrifuge

BLOOD SAMPLING CARRY-ON LAB

COL-2A

Research Requirements	Specific Capability	Major Eqmt. Centrif., Blood Proc.	Major Eqmt. Freezer (-70°C)	Major Eqmt. Hematology Kit
Biomedicine Cardiovascular Gauer-Henry reflex Biochemical response to stress	Obtain first-day on-orbit biochemical measurements defining enzyme/endocrine concentrations relating to plasma volume regulation (ADH, aldosterone, renin, angiotensin). Method — draw blood, prepare, freeze, return for ground analysis.	x	x	x

Note: If simultaneous blood and urine samples are required for correlative studies, this payload can be combined with COL-3A. However, 23 kg limit is exceeded.

PAYLOAD BLOOD SAMPLING CARRY-ON
NO. COL-2A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
40A	Centrifuge, Blood Sample Processor	1	12.7	100	25
81	Freezer, Low Temp	1	8	10	30.5
106	Kit, Hematology & Urology	1	0.2	0	0.5
116	Log Books	1	0.5	0	0.4
--	LN_2 (for EI 81)	1	3.8	0	2
	TOTAL WEIGHT		25.2		

URINE SAMPLING CARRY-ON LAB

COL-3A

Research Requirements	Specific Capability	Major Eqpt. Freezer (-70°C)	Major Eqpt. Urology Kit	Major Eqpt. Anthr. Tapes
<u>Biomedicine</u> Cardiovascular Body fluid/electrolytes and renal function adaptations to weight-lessness	Obtain first-day, fractionated urine samples, 24 hour urine volumes, prepare, freeze & store for general analysis.	x	x	x
	Perform anthropomorphic measurements to define body fluid shifts in zero-g.			x
	Delayed body fluid compartment changes, pre- & post-flt.			
	Assumes use of urine Volume Measurement System in Shuttle Orbiter.			

Note: If simultaneous blood and urine samples are required for correlative studies, this payload can be combined with COL-2A. However, 23 kg limit is exceeded.

PAYLOAD URINE SAMPLING CARRY-ON
NO. COL-3A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
44A	Chemicals, Radioisotope Tracers	1	0.3	0	0.5
81	Freezer, Low Temp	1	8	10	30.5
106	Kit, Hematology & Urology	1	5	0	9
110C	Kit, Human Physiology	1	3	0	8
116	Log Book	1	0.5	0	0.4
	TOTAL WEIGHT		16.8		

US/ESA FIRST SPACELAB MISSION
ML-1A

Research Requirements	Specific Capability	Major Equipment: OFO Packages (2)	Rotating Litter Chair	Hem./Urology Kits	Freezers	Centrifuge Proc.	Human Phys. Kit	Auto. Poten. Elec. Anal.	Woodlawn Wanderer
Biomedicine									
Vestibular	Mechanical & neural responses of otolith organs to zero-g.	x							
	Role of visual cues to space nausea.		x						
	Role of altered body fluid volume, pressure & distribution to space nausea.			x	x	x			
Cardiovascular	Gauer-Henry reflex.			x	x	x			
	ECG, VCG						x		
	Anthropomorphic measurements of fluid shifts.						x		
	Altered vascular flow, volume & pressure relationships.			x	x		x		
Biochemical Reactions	Measure stress hormone, enzyme, fluid/electrolye & fluid volume changes.							x	
Cellular Physiology	Single-cell type culture responses to zero-g — bone marrow.								x

PAYLOAD FIRST US/ESA SPACELAB MISSION
NO. M-L 1A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
6A	Airflow Work Surface	1	5	75	6
7A	Auto. Poten. Elec. Analyzer	1	12.7	100	57
31	Calculator, Pocket	1	0.47	0	0.4
36	Camera, 35 mm & Strobe	1	2	0	2
37	Camera, Video, B/W	1	4.4	15	3
40A	Centrifuge, Blood Sample	1	12.7	100	25
51F	Coolant Loop, Liquid	1	30	50	25
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
76C	Film, 35 mm	3	0.13	0	0.05
80	Freezer	1	15	200	61.4
81	Freezer, Low Temp.	1	8	10	30.5
106	Kit, Hematology & Urology	1	5	0	9
106A	Kit, Cleanup	1	1.5	0	4
110	Kit, Microbiology	1	2	0	3
110C	Kit, Human Physiology	1	3	0	8
114E	Lamp, Portable Hi Int. Photo	1	6.3	150	6
116	Log Books	1	0.5	0	0.4
126	Microscope, Compound	1	11	15	27.4
126J	Microscope Accessory Kit, Compd.	1	10	15	25
131J	OFO Experiment Packages	2	45	20	80
132	Oscilloscope & Camera	1	11.7	75	28.9
153	Recorder, Voice	1	1	0	1
153A	Rotating Litter Chair/Console	1	100.2	127	239
156	Signal Conditioners (Couplers)	6	0.2	2	0.5
182E	Urine Volume Measurement System		In Orbiter		
187C	Woodlawn Wanderer	1	10	15	12.9
	TOTAL WEIGHT		347		

BIOMEDICINE/BIOLOGY MINI-LAB — SMALL VERTEBRATES

M-L 2A

Research Requirements	Specific Capability	Major Equipment: Small Vert. Cages (16)	Freezers	Mass Spectrometer	Auto. Poten. El. Anal.	Centrifuge, Blood	Hem./Urol. Kits	Vert. Phys. Kit	Rcdg. System	Histology Kit
Biomedicine										
Cardiovascular	Altered vascular flow/volume/pressure relationships. Internal blood flows, pressures; urine & blood collection, freeze & store; food & fluid intake, biochem. analysis.	x	x			x	x	x		
	ECG/pulse, Doppler flowmeter.							x	x	
	Demonstrate myocardial degeneration resulting from zero-g.							x		x
Musculoskeletal	Absolute catabolic effects of zero-g. Food & fluid intake; histological preparations of bone, bone marrow, muscle.							x		x
Hematology	Invasive studies — measure total blood volume, red blood cell mass, blood O_2 tension; obtain reticulocyte counts; collect, prepare & store blood samples.		x		x		x	x		
Biochemical Reactions	Fluid & electrolyte balance, Ca regulation, adrenal function. Urine collection, preservation & analysis. On-board & ground analysis.		x		x		x			
Pulmonary	Respiratory gas analysis	x		x						

PAYLOAD BIOMEDICINE/BIOLOGY - SMALL VERTEBRATES MINI-LAB
NO. M-L 2A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
6	Air Particle Sampler	1	2.7	50	0.85
6A	Airflow Work Surface	1	5	75	6
7A	Auto. Poten. Electrolyte Anal.	1	12.7	100	57
30A	Cage, Rat, Hamster, Std.	16	2.3	9	11
36	Camera, 35 mm & Strobe	1	2	0	2
38	Camera, Video, Color	1	7.7	69	6.2
40A	Centrifuge, Blood Sample Proc.	1	12.7	100	25
44A	Chemicals, Radioisotope Tracers	1	0.3	0	0.5
48	Cleaner, Vacuum	1	2.3	100	10
51F	Coolant Loop, Liquid	1	30	50	25
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
76C	Film, 35 mm	5	0.13	0	0.05
80	Freezer, General	1	15	200	61.4
81	Freezer, Low Temp.	1	8	10	30.5
83	Frig. (Refrigerator)	1	18	50	120
91	Gas Analyzer, Mass Spec.	1	25	50	20
96	Glove Box, Portable	1	4.5	0	25
96C	Glove Box Liners	10	0.5	0	1
103	Holding Unit, Small Vert.	2	13.6	0	188
103B	Incubator	1	5	5	8
106	Kit, Hematology & Urology	1	5	0	9
106A	Kit, Cleanup	1	1.5	0	4
108	Kit, Histology	1	1	0	1
110	Kit, Microbiology	1	2	0	3
110C	Kit, Human Physiology	1	3	0	8
114A	Kit, Dissection	1	1	0	2
114B	Kit, Vertebrate Mgmt.	1	3	0	6
114C	Kit, Vertebrate Physiology	1	3	0	6
114E	Lamp, Portable Hi Int. Photo	1	6.3	150	6
116	Log Books	2	0.5	0	0.4
126	Microscope, Compd.	1	11	15	27.4
126A	Microscope, Dissecting	1	9	100	28
126J	Microscope Access. Kit, Compound	1	10	15	25
132	Oscilloscope & Camera	1	11.7	75	28.9
153	Recorder, Voice	1	1	0	1
156	Signal Conditioners (Couplers)	12	0.2	2	0.5

PAYLOAD BIOMEDICINE/BIOLOGY - SMALL VERTEBRATES MINI-LAB (Cont'd)
NO. M-L 2A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
165	Sterilizer, Tool	1	1	110	1
174	Tank, Vertebrate Water	1	8.5	5	28.3
180	Timer, Event	1	0.2	0	0.2
182P	Ventilation Unit, Vert.	1	19	40	32.7
188	Work & Surgical Bench	1	136	1000	420
	TOTAL WEIGHT		460		

Research Requirements	Specific Capability	Major Equipment: Auto. Poten. El. Analyzer	Centrifuge, Bl. Proc.	Freezer	Hemat./Urol. Kit	Human Phys. Kit	Cardiopul. Analyzer	Exer. Physiol. Eqmt.
<u>Biomedicine - Man</u> Cardiovascular	Altered vascular flow/volume/pressure relationships. Internal blood flows, pressures, Doppler Flowmeter; urine & blood collection, freeze & store; food & fluid intake, biochemical analysis.	x	x	x	x	x		
	ECG, VCG pressures, pulse; Use of echocardiogram for determinations of stroke volume, cardiac output, cardiac compliance.					x		
	Body fluid compartment studies — total body water volume, plasma volume, renal blood flow.					x		
Vestibular	Role of altered body fluid volume, pressure and distribution to space nausea.					x		
	Pharmacological prevention and treatment of space nausea.					x		
Biochemical Reactions	Fluid & electrolyte balance, Ca regulation, adrenal function. Urine collection, preservation & analysis. On-board & ground analysis.	x		x	x	x		
Hematology	Collect, prepare & preserve blood samples. Measure red cell mass (Cr^{51}), plasma volume (I^{125}), blood granulocyte response to inflammatory stimuli.	x	x	x	x	x		
Musculoskeletal	Exercise effect upon musculoskeleta disarrangement. Calibrated exercise level, respiratory parameters, ECG/VCG, pressures, muscle mass, strength, reflexes.					x	x	x
Pulmonary	Altered pulmonary volume/flow relationships in zero-g — Measurements of respiratory gas partial pressures, flows. Derived quantitites - VC, FVC, TLC, RV, pulmonary capillary blood flow/volume.						x	

PAYLOAD BIOMEDICINE MINI-LAB
NO. M-L 3A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
6A	Airflow Work Surface	1	5	75	6
7A	Auto. Poten. Electro. Analyzer	1	12.7	100	57
36	Camera, 35 mm & Strobe	1	2	0	2
37	Camera, Video B/W	1	4.4	15	3
38F	Cardiopulmonary Anal.	1	90.7	200	172
40A	Centrifuge, Blood Sample Processor	1	12.7	100	25
44A	Chemicals, Radioisotope Tracers	1	0.3	0	0.5
51F	Coolant Loop, Liquid	1	30	50	25
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
70E	Exercise Eqmt., Physio.	1	96	18	992
76C	Film, 35 mm	3	0.13	0	0.05
80	Freezer, General	1	15	200	61.4
81	Freezer, Low Temp.	1	8	10	30.5
83	Frig. (Refrigerator)	1	18	50	120
106	Kit, Hematology & Urology	1	5	0	9
110C	Kit, Human Physiology	1	3	0	8
114E	Lamp, Portable Hi Int. Photo	1	6.3	150	6
116	Log Books	3	0.5	0	0.4
132	Oscilloscope & Camera	1	11.7	75	28.9
153	Recorder, Voice	1	1	0	1
156	Signal Conditioners (Couplers)	6	0.2	2	0.5
180	Timer, Event	1	0.2	0	0.2
182J	Vectorcardiogram Coupler	1	0.2	2	0.5
	TOTAL WEIGHT		328		

LIFE SUPPORT/PROTECTIVE SYSTEMS MINI-LAB
M-L 4A

Research Requirements	Specific Capability	LSS Test Console	Liquid Supplies/Handling	Gas Supplies/Handling	Mass Spectrometer	Recording Equipment
		Major Eqpt.				
Life Support/Protective Systems	Life support hardware testing in zero g Provide gas, liquid, electrical, thermal requirements. Analyze gas mixtures, temperatures, flows, voltages, powers, etc. Record data.	x	x	x	x	x
	Gravity-sensitive processes study Study fundamental fluid dynamic and thermodynamic phenomena. Interface with experimental apparatus. Measure physical parameters. Record data.	x	x	x	x	x

C-2

PAYLOAD LIFE SUPPORT/PROTECTIVE SYSTEMS MINI-LAB
NO. M-L 4A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
31	Calculator, Pocket	1	0.47	0	0.4
32	Camera, Cine	1	5	13	5
36	Camera, 35 mm & Strobe	1	2	0	2
37	Camera, Video B/W	1	4.4	15	3
48	Cleaner, Vacuum	1	2.3	100	10
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
75C	Film, Cine	8	0.54	0	0.54
76C	Film, 35 mm	3	0.13	0	0.05
76J	Flowmeters	4	0.5	1	0.5
83	Frig. (Refrigerator)	1	18	50	120
87	Gas Analyzer, Infrared	1	11.3	50	42.6
91	Gas Analyzer, Mass Spec.	1	25	50	20
93A	Gas Supplies	2	5.75	0	18
105	Kit, Chemical	1	1.5	0	5
106A	Kit, Cleanup	1	1.5	0	4
114E	Lamp, Portable Hi Int. Photo	1	6.3	150	6
114G	Liquid Storage & Disp. Sys.	1	13	0	18
115F	LSS Test Console	1	15	0	560
116	Log Books	1	0.5	0	0.4
118I	Manifold, Vacuum	1	9.1	0	28.3
122	Mass Meas. Device, Micro	1	12	15	25
134B	Paper, Recording	3	0.6	0	1.2
141A	Plumbing	1	20	2	15
150A	Recorder, Strip Chart	1	11.8	0	16.9
153	Recorder, Voice	1	1	0	1
180	Timer, Event	1	0.2	0	0.2
185	Multimeter	1	2	0	2.4
	TOTAL WEIGHT		135		

MAN-SYSTEMS INTEGRATION MINI-LAB
M-L 5A

Research Requirements	Specific Capability	Major Eqmt. Cameras	Major Eqmt. Voice Recorders	Major Eqmt. Log Books
Man-Systems Integration	Audio-visual measurements Cargo-handling studies; assembly, deployment, maintenance and repair studies; group dynamics studies; & locomotion, restraint and time/motion studies.	x	x	x

PAYLOAD MAN-SYSTEMS INTEGRATION MINI-LAB
NO. M-L 5A

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
36	Camera, 35 mm & Strobe	1	2	0	2
38	Camera, Video, Color	1	7.7	69	6.2
38B	Camera Mounts	1	3	0	3
38D	Camera Timer, Video	1	4	10	3
70C	Equipment Restraint Device	1	0.5	0	1
76C	Film, 35 mm	2	0.13	0	0.05
114E	Lamp, Portable Photo Hi Intensity	1	6.3	150	6
116	Log Books	1	0.5	0	0.4
153	Recorder, Voice	1	1	0	1
180	Timer, Event	1	0.2	0	0.2
	TOTAL WEIGHT		25.5		

BIOMEDICINE/BIOLOGY MINI-LAB – PRIMATES

M-L 2B

Research Requirements	Specific Capability	Primate Cages (2)	Metabolic Units	Freezers	Mass Spectrometer	Auto. Poten. El. Anal.	Centrifuge, Blood	Hem./Urol. Kit	Vert. Phys. Kit	Rcdg. System
Biomedicine										
Cardiovascular	Altered vascular flow/volume/pressure relationships. Internal blood flows, pressures; urine & blood collection, freeze & store; food & fluid intake, biochem. analysis.	x	x	x			x	x	x	
	ECG/VCG/pulse, Doppler flowmeter.								x	x
Vestibular	Invasive studies on animals.									
	Implanted sensors/stimulation devices.	x	x							
	Calibrated stimuli to vestibular organs, record ocular reflexes, signs & symptoms, EOG									x
Pulmonary	Respiratory gas analysis, O_2 uptake, CO_2 discharge using metabolic unit.	x	x		x					
Biochemical Reactions	Fluid & electrolyte balance, Ca regulation, adrenal func. Blood & urine collection, preservation and analysis. On-board & ground analysis.		x	x		x	x	x		

PAYLOAD BIOMEDICINE/BIOLOGY - PRIMATES MINI-LAB
NO. M-L 2B

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
6	Air Particle Sampler	1	2.7	50	0.85
6A	Airflow, Work Surface	1	5	75	6
7A	Auto. Poten. Electrolyte Anal.	1	12.7	100	57
36	Camera, 35 mm & Strobe	1	2	0	2.0
38	Camera, Video, Color	1	7.7	69	6.2
40A	Centrifuge, Blood Sample Proc.	1	12.7	100	25
44A	Chemicals, Radioisotope Tracers	1	0.3	0	0.5
48	Cleaner, Vacuum	1	2.3	100	10
51F	Coolant Loop, Liquid	1	30	50	25
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
76C	Film, 35 mm	5	0.13	0	0.05
80	Freezer, General	1	15	200	61.4
81	Freezer, Low Temp.	1	8	10	30.5
83	Frig. (Refrigerator)	1	18	50	120
91	Gas Analyzer, Mass Spec.	1	25	50	20
101B	Holding Unit, Monkey Pod	2	53	100	425
103B	Incubator	1	5	5	8
106	Kit, Hematology & Urology	1	5	0	9
106A	Kit, Cleanup	1	1.5	0	4
110	Kit, Microbiology	1	2	0	3
110C	Kit, Human Physiology	1	3	0	8
114B	Kit, Vertebrate Mgmt.	1	3	0	6
114C	Kit, Vertebrate Physiology	1	3	0	6
114E	Lamp, Portable Hi Int. Photo	1	6.3	150	6
116	Log Books	2	0.5	0	0.4
126	Microscope, Compd.	1	11	15	27.4
126J	Microscope Access Kit, Compd.	1	10	15	25
132	Oscilloscope & Camera	1	11.7	75	23.9
138E	Physiol. Multichannel Sens. Sys.	1	0.2	0	1.4
150B	Receiver	1	0.5	10	1
153	Recorder, Voice	1	1	0	1
156	Signal Conditioners	6	0.2	2	0.5
165	Sterilizer, Tool	1	1	110	1
174	Tank, Vertebrate Water	1	8.5	5	28.3
180	Timer, Event	1	0.2	0	0.2
182P	Ventilation Unit, Vert.	2	19	40	32.7

TOTAL WEIGHT: 364

BIOMEDICINE/BIOLOGY MINI-LAB — SMALL VERTEBRATES/CELLS & TISSUES
M-L 2C

Research Requirements	Specific Capability	Major Equipment: Small Vert. Cages (16)	Freezers	Mass Spec.	Auto. Poten. Analyzer	Centrif., Blood	Hematology/Urology Kit	Vert. Phys. Kit	Recording System	Histology Kit	C&T Holding Unit
Biomedicine											
Cardiovascular	Altered vascular flow/volume/pressure relationships. Internal blood flows, pressures; urine & blood collection, freeze & store; food & fluid intake, biochemical analysis.	x	x			x	x	x			
	ECG/pulse, Doppler flowmeter.							x	x		
	Demonstrate myocardial degeneration resulting from zero-g.							x		x	
Musculoskeletal	Absolute catabolic effects of zero-g. Food & fluid intake; histological preparations of bone, bone marrow, muscle.							x		x	
Hematology	Invasive studies — measure total blood volume, red blood cell mass, blood O_2 tension; obtain reticulocyte counts; collect, prepare & store blood samples.		x		x		x	x			
Biochemical Reactions	Fluid & electrolyte balance, Ca regulation, adrenal function. Urine collection, preservation & analysis. On-board & ground analysis.		x		x		x				
Pulmonary	Respiratory gas analysis.	x		x							
Microbiology	Experimentally induced infection, measure specific immune response, incubate microbial cultures.	x									x
Biology											
Cellular & Molecular	Density dependent growth & development processes. Cell turnover rates, wound repair. Tissue cultures of bone marrow, intestinal epithelium, embryonic tissues.										x

PAYLOAD NO. BIOMEDICINE/BIOLOGY-SMALL VERTEBRATES/CELLS & TISSUES MINI-LAB M-L 2C

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
6	Air Particle Sampler	1	2.7	50	0.85
6A	Airflow Work Surface	1	5	75	6
7A	Auto. Poten. Electrolyte Anal.	1	12.7	100	57
25B	Colony Chamber, Sealable	10	0.2	0	0.1
30A	Cage, Rat, Hamster, Std.	16	2.3	9	11
36	Camera, 35 mm & Strobe	1	2	0	2.0
38	Camera, Video, Color	1	7.7	69	6.2
40A	Centrifuge, Blood Sample Proc.	1	12.7	100	25
44A	Chemical, Radioisotope Tracers	1	0.3	0	0.5
48	Cleaner, Vacuum	1	2.3	100	10
50A	Clinostat, C/T	1	2	10	4
51F	Coolant Loop, Liquid	1	30	50	25
54	Counter, Colony, Manual	1	1.5	50	1.5
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
76C	Film, 35 mm	5	0.13	0	0.5
80	Freezer, General	1	15	200	61.4
81	Freezer, Low Temp.	1	8	10	30.5
83	Frig. (Refrigerator)	1	18	50	120
91	Gas Analyzer, Mass Spec.	1	25	50	20
96	Glove Box, Portable	1	4.5	0	25
96C	Glove Box Liners	10	0.5	0	1
98A	Holding Unit, C/T	1	23	30	188
103	Holding Unit, Small Vert.	2	13.6	0	188
103B	Incubator	1	5	5	8
106	Kit, Hematology & Urology	1	5	0	9
106A	Kit, Cleanup	1	1.5	0	4
108	Kit, Histology	1	1	0	1
110	Kit, Microbiology	1	2	0	3
110C	Kit, Human Physiology	1	3	0	8
114A	Kit, Dissection	1	1	0	2
114B	Kit, Vertebrate Mgmt.	1	3	0	6
114C	Kit, Vertebrate Physiology	1	3	0	6
114E	Lamp, Portable Hi Int. Photo	1	6.3	150	6
116	Log Books	2	0.5	0	0.4
124	Media, Prepared	1	0.45	0	0.5
126	Microscope, Compd.	1	11	15	27.4

PAYLOAD BIOMEDICINE/BIOLOGY-SMALL VERTEBRATES/CELLS & TISSUES MINI-LAB
NO. M-L 2C (Cont'd)

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
126A	Microscope, Dissecting	1	9	100	28
126J	Microscope Access. Kit, Compound	1	10	15	25
132	Oscilloscope & Camera	1	11.7	75	28.9
138	pH Meter	1	1.8	20	5.2
153	Recorder, Voice	1	1	0	1
156	Signal Conditioners (Couplers)	12	0.2	2	0.5
165	Sterilizer, Tool	1	1	110	1
174	Tank, Vertebrate Water	1	8.5	5	28.3
180	Timer, Event	1	0.2	0	0.2
182P	Ventilation Unit, Vert.	1	19	40	32.7
187C	Woodlawn Wanderer	1	10	15	12.9
188	Work & Surgical Bench	1	136	1000	420
	TOTAL WEIGHT	=	500		

BIOLOGY MINI-LAB
M-L 2D

Research Requirements	Specific Capability	Major Equipment: Sm. Vert. Holding Unit	Plant Holding Unit	Invertebrate Holding Unit	Cells/Tissues H.U.	Freezers	Mass Spectrometer	Work & Surg. Bench	Microscopy	Kits - Histology, Hem., & Urology, etc.
Lower Vertebrate Biology (Rats, guinea pigs, frogs, etc.)	Maintenance of instrumented animals, metabolic monitoring, physiological monitoring.	x					x			
	Histological preparation, incubation, examination					x			x	x
Basic mechanism of physiological adaptation, growth, development, reproduction in zero-g	Surgery, biopsy, autopsy							x		x
Plant Biology	Specimen maintenance through entire life cycles.		x							
Basic mechanisms of growth, development and reproduction in zero-g	Monitor geotropism, growth rate, morphology, circadian cycles, etc.		x						x	
	Histological preparations - genetic changes, replication					x			x	x
	Environmental monitoring						x			
Invertebrate Biology	Specimen maintenance through entire life cycles.			x						
(Insects, spiders, nematodes)	Monitor behavior patterns, activity cycles, morphology.			x					x	x
Basic mechanisms of growth, development and reproduction in zero-g	Histological prep. for genetic changes, organ development, structural changes - Fix & preserve.					x			x	x
	Environmental monitoring.									
Cellular & Molecular Biology	Specimen and culture maintenance, environment control/monitoring.				x					
Density dependent growth and development processes	Cell turnover times, wound repair rates, electrolyte transport.								x	x
	Histological preparations.					x			x	x
Genetic alterations in zero-g	Cell division, meiotic abnormalities, chromosome aberrations.				x				x	x

PAYLOAD BIOLOGY MINI-LAB
NO. M-L 2D

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
6	Air Particle Sampler	1	2.7	50	0.85
6A	Airflow Work Surface	1	5	75	6
7A	Auto. Poten. Electrolyte Anal.	1	12.7	100	57
14	Anesthetizer, Invert.	1	0.2	0	1
25	Cage, Invertebrates	20	0.3	0	0.2
25B	Colony Chamber, Sealable	10	0.2	0	0.1
29	Cage, Plant	1	4.5	0	56.6
30A	Cage, Rat, Hamster, Std.	15	2.3	9	11
36	Camera, 35 mm & Strobe	1	2	0	2.0
38	Camera, Video, Color	1	7.7	69	6.2
40A	Centrifuge, Blood Sample Proc.	1	12.7	100	25
44A	Chemical, Radioisotope Tracers	1	0.3	0	0.5
48	Cleaner, Vacuum	1	2.3	100	10
50A	Clinostat, C/T	1	2	10	4
51F	Coolant Loop, Liquid	1	30	50	25
54	Counter, Colony Manual	1	1.5	50	1.5
63C	Display, Numeric	1	2	2	4
70C	Equipment Restraint Device	1	0.5	0	1
76C	Film, 35 mm	5	0.13	0	0.05
80	Freezer, General	1	15	200	61.4
81	Freezer, Low Temp.	1	8	10	30.5
83	Frig. (Refrigerator)	1	18	50	120
91	Gas Analyzer, Mass Spec.	1	25	50	20
93	Gas Analyzer, RH	1	5.2	6	13
96	Glove Box, Portable	1	4.5	0	25
96C	Glove Box, Liners	15	0.5	0	1
98A	Holding Unit, C/T	1	23	30	188
98C	Holding Unit, Invertebrates	1	23	50	188
101	Holding Unit, Plant	1	25	500	188
103	Holding Unit, Small Vert.	2	13.6	0	188
103B	Incubator	1	5	5	8
106	Kit, Hematology & Urology	1	5	0	9
106A	Kit, Cleanup	1	1.5	0	4
108	Kit, Histology	1	1	0	1
110	Kit, Microbiology	1	2	0	3
111	Kit, Plant Mgmt.	1	1	0	1
113A	Kit, Invert. Mgmt.	1	1	0	2

PAYLOAD BIOLOGY MINI-LAB
NO. M-L 2D

EI#	EI NAME	Q	UNIT WEIGHT kg	UNIT POWER w	UNIT VOLUME dm^3
114A	Kit, Dissection	1	1	0	2
114B	Kit, Vertebrate Mgmt.	1	3	0	6
114C	Kit, Vertebrate Physiology	1	3	0	6
114E	Lamp, Portable Hi Int.	1	6.3	150	6
116	Log Books	2	0.5	0	0.4
124	Media, Prepared	2	0.45	0	0.5
126	Microscope, Compd.	1	11	15	27.4
126A	Microscope, Dissecting	1	9	100	28
126J	Microscope Access. Kit, Compound	1	10	15	25
132	Oscilloscope & Camera	1	11.7	75	28.9
138	pH Meter	1	1.8	20	5.2
153	Recorder, Voice	1	1	0	1
156	Signal Conditioners (Couplers)	12	0.2	2	0.5
165	Sterilizer, Tool	1	1	110	1
174	Tank, Vertebrate Water	1	8.5	5	28.3
175	Tank, Plant/Invert. Water	2	1.7	0	3
180	Timer, Event	1	0.2	0	0.2
182P	Ventilation Unit, Vert.	1	19	40	32.7
187C	Woodlawn Wanderer	1	10	15	12.9
188	Work & Surgical Bench	1	136	1000	420

TOTAL WEIGHT 556

SUMMARY TABLE

DEDICATED LABORATORY VS. RESEARCH CAPABILITY

TIME-PHASED RESEARCH REQUIREMENTS	DEDICATED LABS					
	IA	IIA	IIIA	IIB	IIC	IIIB
BIOMEDICINE - MAN						
Vestibular	x	x	x			
Cardiovascular	x	x	x	x	x	x
Pulmonary	x	x	x			
Biochemical Reactions	x	x	x			
Musculoskeletal	x	x	x	x	x	x
Hematology	x	x	x			
Psychomotor Perf.	x	x	x			
BIOMEDICINE - ANIMALS						
Vestibular	x	x	x	x	x	x
Cardiovascular	x	x	x	x	x	x
Pulmonary	x	x	x	x	x	x
Biochemical	x	x	x	x	x	x
Musculoskeletal	x	x	x	x	x	x
Hematology	x	x	x	x	x	x
BIOLOGY						
Higher Vertebrates	4*	52	2	2	2	
Lower Vertebrates	16*	16	32	16	16	32
Cellular & Molecular	x	x	x	x		
Invertebrate		x	x	x		
Plant		x	x	x		
Radiobiology		x	x	x		
Microbiology		x	x	x		
MAN-SYSTEMS INTEGRATION						
MSI Testing		x	x			
LIFE SUPPORT/PROTECTIVE SYSTEMS						
Life Support Hardware Test		x	x			
Zero-g Effects		x	x			

*Indicates number of animals aboard.

DEDICATED LABORATORY MOD IA
SCIENCE RATIONALE & RESEARCH CAPABILITY

SCIENCE RATIONALE

Dedicated Lab MOD IA is a 7-day, biomedical emphasis mission for the Shuttle/ Spacelab. Man-related studies will be undertaken from two distinct, though related, orientations:

A. As a human organism requiring scientific investigation and measurement:

To understand the mechanisms of man's responses to space flight and his capability to adapt to the space environment. Special emphasis will be placed on those organ systems which have been found from previous flights to be influenced by gravity, e.g., cardiovascular, vestibular, and musculo-skeletal systems. Biological periodicities will be examined within the limits of mission profiles.

Animal models will provide information concerning basic mechanisms not easily determined in man. Such animal models would provide information in areas where measurements have not been developed for use in humans or would carry a significant hazard if utilized in man.

B. As an important (human) element of a flight system whose total performance capability is reflected in the performance level of that (human) system, and whose safety is of primary concern in any manned system:

To acquire, analyze, and interject data relevant to the problems of human performance, capability and behavior in space. This includes both group and individual behavior, attitudes, motivational levels, anxieties, etc.

To establish operator capabilities and requirements as they impact total system performance and crew safety.

To collect high fidelity, high quality data on the new population of space flight participants in order to substantiate and improve on the original medical selection criteria for Shuttle passengers and crews.

RESEARCH CAPABILITY SYNOPSIS - Area/Functions/Measurements/Major Equipment

A. BIOMEDICAL - Man

1. Vestibular

Investigate role of visual cues in space nausea. Repeat of Skylab M131 experiment. Rotating Litter Chair.
Role of altered body fluid volume, pressure and distribution to space nausea. Urine sample collection and analysis.

2. Cardiovascular

Altered vascular flow, volume & pressure relationships in zero-g. LBNP, VCG.
Demonstrate presence or absence of Gauer-Henry reflex. Early mission urine/blood sample collection and analysis. APE, Freezers.
Regulation responses to exercise in zero-g. VCG, Human Phys. Kit, Exercise Eqmt.

3. Pulmonary

Altered pulmonary volume/flow/relationships in zero-g. Cardiopulmonay Analyzer, Exercise Eqmt.

4. Musculoskeletal

Exercise effect upon musculoskeletal derangement. Exercise physiology equipment, human physiology kit, ECG/VCG.
Diet and pharmacological control of musculoskeletal derangement. Food/fluid input records, feces/urine/vomitus collection/storage.

5. Hematology

Collect, prepare & preserve blood samples. Determine red cell mass, recitulocyte counts, pCO_2, pO_2, pH, enzymes, proteins, etc.

6. Microbiology

Effects of space environment upon host defense mechanisms. Microbial sampling, culturing, staining, examination. Incubator, staining system, microscopy.

7. Crew Performance in Space

Time and motion studies, training tasks. Time relate performance measures with daily activity schedules, sleep patterns, environmental conditions and biomedical measurements.

8. Effects of Training Upon Crew Efficiency

Correlate crew performance efficiency measurements with same tasks conducted in ground based simulators or prior missions.

B. BIOMEDICAL - Man Surrogate

To permit detailed invasive and statistical studies in the biomedical areas mentioned above, this laboratory contains the holding facilities, support equipment and monitoring instrumentation for the following populations:

Primates	- 4 Holding units (1 primate each)
Small vertebrates	- 2 Holding units (16 rats, hamsters, etc.)
Cells/Tissues	- 2 Holding units

C. SUPPORTIVE SERVICES

Microscopy - Compound microscope for dark field, bright field, phase contrast. Dissecting microscope. Microscope accessory kit includes polarizing equipment, filters, photographic and video attachments.

Photography - Cine film, 35 mm, polaroid.

Visual Records - Strip chart recorder (2-channel), digital display, oscilloscope, CRT/camera.

Preservation - Cryogenic freezer (quick-freeze), -70° & -20°C freezers, 4°C refrigerator.

Mass Measurement - Human mass device, macro mass measurement device (5 g to 2 kg) and micro mass measurement device (1 mg to 5 g).

PAYLOAD NO. MOD IA

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
103	HOLDING UNIT, SM. VERT.	2	13.6	0	188
107B	INCUBATOR	1	5	5	8
105	KIT, CHEMICAL	1	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	1	5	0	5
106A	KIT, CLEANUP	1	1.5	0	4
108	KIT, HISTOLOGY	1	1	0	1
109	KIT, LINEAR MEAS.	1	1	0	1
110	KIT, MICROBIOLOGY	1	2	0	3
110C	KIT, HUMAN PHYSIOLOGY	1	3	0	8
114A	KIT, DISSECTION	1	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	1	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	1	3	0	6
114E	LAMP, PORTABLE HI INT. PHOTO	1	6.3	150	6
114G	LIQUID STOR. AND DISPENS. SYS.	1	13	0	18
116	LOG BOOKS	3	5.5	0	0.4
117	LOWER BODY NEG. PRESS. DEVICE	1	78.7	26	2373
118T	MANIFOLD, VACUUM	1	9.1	0	25.3
121	MASS MEAS. DEVICE, MACRO	1	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	1	12	15	25
124	MEDIA, PREPARED	2	0.45	0	0.5
126	MICROSCOPE, COMPOUND	1	11	15	27.4
126A	MICROSCOPE, DISSECTING	1	9	100	29
126J	MICR. ACCESS. KIT, COMPND	1	10	15	25
131F	NON-VISUAL DIRECTION INDICATOR	1	4.1	0	2.8
132	OSCILLOSCOPE AND CAMERA	1	11.7	75	28.9
133	OTOLITH TEST GOGGLES	1	0.2	0	2.8
134B	PAPER, RECORDING	1	0.6	0	1.2
136	PH METER	1	1.6	20	5.2
136B	PHOTOCELL COUPLER	12	0.2	2	0.5
136F	PHYSIOL. MULTICHAN. SENS SYS.	1	0.2	0	1.4
139	PLETHYSMOGRAPH, LIMB	1	2.4	5	6
140	PHONOVIBRACARDIOGRAPH COUPLER	1	0.2	1	0.3
141A	PLUMBING	1	20	2	15
143G	PRESSURE COUPLER	4	0.2	2	0.5
144C	RADIATION DETECTOR, DOSIM.	1	0.3	0	0.5
147	RADIATION COUNTER	1	15	50	20
151A	RECORDER, STRIP CHART	1	11.5	0	16.9
150B	RECEIVER, BIOTELEMETRY	1	0.5	10	1
153	RECORDER, VOICE	1	1	0	1
153A	ROTATING LITTER CHAIR/CONSOLE	1	100.2	127	239
153B	SENSORS, ASSORTED	1	0.5	0	0.3
156	SIGNAL CONDITIONERS (COUPLERS)	12	0.2	2	0.5
156F	SONOCARDIOGRAPH	1	19	32	59
157	SOUND LEVEL METER	1	13.6	0	33.4
159	STAINING SYSTEM	1	2.2	0	3.5
162	STERILIZER, AUTOCLAVE	1	11	300	34.7
165	STERILIZER, TOOL	1	1	110	1
174	TANK, VERTEBRATE WATER	5	8.5	5	28.3
176B	THERMOCOUPLE INDICATOR	1	8	8	9.4
175	TEMPERATURE BLOCK	1	4.5	200	1.7
179A	THERMOCOUPLES	1	0.5	0	0.3
179D	THERMOMETER, ELECTRONIC	1	5.4	14	6.7
180	TIMER, EVENT	2	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	4	0.2	1	0.4
182I	VCG COUPLER	1	0.2	2	0.5
182F	VENTILATION UNIT, VERT.	5	19	40	32.7
185	MULTIMETER	1	2	0	2.4
188	WORK AND SURGICAL BENCH	1	136	1000	420

PAYLOAD NO. MOD IA

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
1	ACCELEROMETER	3	0.1	0	0.03
1A	ACCELEROMETER COUPLER	3	0.05	1	0.01
6	AIR PARTICLE SAMPLER	1	2.7	50	0.95
6A	AIRFLOW WORK SURFACE	1	5	75	6
7	AUTOANALYZER (GEMSAEC)	1	25	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	1	12.7	100	57
14D	ANTENNAS, ASSORTED	1	0.1	0	0.03
15A	ATMOS. SAMPLING SYSTEM	1	10	20	28
15B	AUDIOMETER	1	4.5	25	4.3
15D	BADGES, RADIATION	2	0.2	0	0.1
16E	BALLISTOCARDIOGRAM COUPLER	1	0.1	1	1
18D	CUSTOM BITE BOARDS	1	0.23	0	0.03
19D	BODY MASS MEAS. DEVICE	1	36.5	15	675
25B	COLONY CHAMBER, SEALABLE	20	0.2	0	0.1
30A	CAGE, RAT, HAMSTER, STANDARD	16	2.3	9	11
31	CALCULATOR, POCKET	1	0.47	0	0.4
32	CAMERA, CINE	1	5	13	5
32A	CAMERA CONTROLLER	1	13.6	100	28.3
33	CAMERA, POLAROID	1	3.3	0	5.6
34	CAMERA, 35 MM AND STROBE	1	2	0	2
37	CAMERA, VIDEO, B/W	2	4.4	15	3
38	CAMERA, VIDEO, COLOR	1	7.7	69	6.2
38A	CAMERA MOUNTS	1	3	0	3
38D	CAMERA TIMER, VIDEO	1	4	10	3
38E	CARDIOPULMONARY ANALYZER	1	90.7	200	172
40A	CENTRIFUGE, BLD SMPL PROCESSOR	1	12.7	100	25
44	CHEMICALS	1	0.5	0	1.0
44A	CHEMICALS, RADIOISOT. TRACERS	1	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	1	4.0	0	14.1
49	CLEANER, VACUUM	1	2.3	100	10
50A	CLINOSTAT (FOR C/T)	1	2	10	4
50B	COMPACTOR, SOLIDS	1	18	100	113
51D	CONTROL CONSOLE, EXPERIMENTER	1	22.7	100	113.3
51E	COOLANT LOOP, LIQUID	1	30	50	25
54	COUNTER, COLONY, MANUAL	1	1.5	50	1.5
63B	DISPLAY KEYBOARD, PORTABLE	1	13.6	60	42.5
63C	DISPLAY, NUMERIC	2	2	2	4
64	ECG COUPLER	12	0.2	2	0.5
65	EEG COUPLER	4	0.2	2	0.5
65B	ELECTROPHYS. BACKPACK	1	0.3	0	0.23
65C	ELECTROPHYS. RECEIVER	1	2.7	25	5.0
66	EMG COUPLER	6	0.2	2	0.5
70C	EQUIPMENT RESTRAINT DEVICE	1	0.5	0	1
70E	EXERCISE EQUIP., PHYSIOL.	1	96	14	992
75C	FILM, CINE	4	0.54	0	0.54
75E	FILM, POLAROID	5	0.16	0	0.13
76C	FILM, 35 MM	10	0.13	0	0.05
76J	FLOWMETERS	4	0.5	1	0.5
77A	FREEZER, CRYOGENIC	1	21.6	10	74.1
80	FREEZER, GENERAL	1	15	200	61.4
81	FREEZER, LOW TEMP.	1	8	10	30.5
83	FRIG. (REFRIGERATOR)	1	18	50	123
91	GAS ANALYZER, MASS SPEC.	2	25	50	20
93	GAS ANALYZER, PH	1	5.2	6	13
93A	GAS SUPPLIES	6	5.75	0	18
96	GLOVE BOX, PORTABLE	1	4.5	0	25
96C	GLOVE BOX LINERS	10	0.5	0	1
97C	HANDWIPES, BETADYNE	10	0.3	0	0.3
98A	HOLDING UNIT, CELLS/TISSUES	2	23	30	188
101C	HOLDING UNIT, PRIMATE	4	113	100	343

DEDICATED LABORATORY MOD IIA
SCIENCE RATIONALE & RESEARCH CAPABILITY

SCIENCE RATIONALE

Dedicated Lab MOD IIA is a 7-day biomedical/biology/advanced technology emphasis mission for Shuttle/Spacelab.

A. Man-related studies will be undertaken from two distinct, though related, orientations:

1. As a human organism requiring scientific investigation and measurement:

   To understand the mechanisms of man's responses to space flight and his capability to adapt to the space environment. Special emphasis will be placed on those organ systems which have been found from previous flights to be influenced by gravity, e.g., cardiovascular, vestibular, and musculo-skeletal systems. Biological periodicities will be examined within the limits of mission profiles. Animal models will provide information concerning basic mechanisms not easily determined in man. Such animal models would provide information in areas where measurements have not been developed for use in humans or would carry a significant hazard if utilized in man.

2. As an important (human element of a flight system whose total performance capability is reflected in the performance level of that (human) system, and whose safety is of primary concern in any manned system:

   To acquire, analyze, and interject data relevant to the problems of human performance, capability and behavior in space. This includes both group and individual behavior, attitudes, motivational levels, anxieties, etc.

   To establish operator capabilities and requirements as they impact total system performance and crew safety.

   To collect high fidelity, high quality data on the new population of space flight participants in order to substantiate and improve on the original medical selection criteria for Shuttle passengers and crews.

B. Although animals, as biological species, will be used as models for man-related studies, the term Space Biology encompasses research on a wide variety of biological materials ranging from cells to complex multi-cellular animals. Major objectives of the Space Biology program are:

To advance our knowledge of the role of gravity in the life processes and the capability of terrestrial organisms to adapt to gravitational changes.

To understand the basic nature of biological rhythms in terrestrial organisms and their influence on life processes.

To determine and assess the biological implications of galactic cosmic HZE particles for developing realistic radiation exposure guidelines and providing protective and/or preventive measures against particle radiation hazards for long duration space missions.

To determine the potential applications and to develop the techniques to utilize new advances in biological theories and space technology gained from research in the unique environment of space for space exploration and for the benefit of mankind. This includes cross-utilization of information between scientific disciplines, especially by means of flight experiments of mutual interest and/or applicability to different disciplines.

To assess the possible synergistic effects of gravity, magnetism and radiation on life-s origin and evolutionary processes.

C. Advanced technology research goals and objectives to be accomplished include but are not limited to:

Continuing advanced technology research on life support, protective systems, and work aids to provide as near an Earth atmospheric environment for man as possible; to provide him with protection from hazards of the space environment, optimize his ability to work in space and to maintain his health. Special emphasis will be placed on areas such as:

Development of regenerative life support systems including bioregenerative systems and new principles of membrane transport and related phenomena, development of advanced protective devices for manned space flight.

Measurement of man's performance in EVA, evaluation and validation of principles of system design and man-machine integration.

Demonstration and flight evaluation of teleoperator technology; e.g., visual environment sensors and displays, man-machine capabilities and acquisition of an experience and engineering data base.

RESEARCH CAPABILITY SYNOPSIS - Area/Functions/Measurements/Major Equipment

A. **BIOMEDICAL** - Man

1. Vestibular

Investigate role of visual cues in space nausea. Repeat of Skylab M131 experiment. Rotating Litter Chair.
Role of altered body fluid volume, pressure and distribution to space nausea. Urine sample collection and analysis.

2. Cardiovascular

Altered vascular flow, volume and pressure relationships in zero-g. LBNP, VCG.
Demonstrate presence or absence of Gauer-Henry reflex. Early mission urine/blood sample collection and analysis. APE, Freezers.
Regulator responses to exercise in zero-g. VCG, Human Phys. Kit, Exercise Eqmt.

3. Pulmonary

Altered pulmonary volume/flow/relationships in zero-g. Cardiopulmonary Analyzer, Exercise Eqmt.

4. Musculoskeletal

Exercise effect upon musculoskeletal derangement. Exercise physiology equipment, human physiology kit, ECG/VCG.
Diet and pharmacological control of musculoskeletal derangement. Food/fluid input records, feces/urine/vomitus collection/storage.

5. Hematology

Collect, prepare and preserve blood samples. Determine red cell mass, reticulocyte counts, pCO_2, pO_2, pH, enzymes, proteins, etc.

6. Microbiology

Effects of space environment upon host defense mechanisms. Microbial sampling, culturing, staining, examination. Incubator, staining system, microscopy.

7. Crew Performance in Space

Time and motion studies, training tasks. Time-relate performance measures with daily activity schedules, sleep patterns, environmental conditions and biomedical measurements.

8. Effects of Training Upon Crew Efficiency

Correlate crew performance efficiency measurements with same tasks conducted in ground based simulators or prior missions.

B. BIOMEDICAL - Man-Surrogate

To permit detailed invasive and statistical studies in the biomedical areas mentioned above. This laboratory contains the holding facilities, support equipment and monitoring instrumentation for the following populations:

Primates	- 5 Holding units (1 primate each)
Small vertebrates	- 2 Holding units (16 rats, hamsters, etc.)
Cells/Tissues	- 2 Holding units

C. SPACE BIOLOGY

The holding units mentioned in "B" above, besides supporting man-surrogate research, will support space biology research. Additional holding units are:

Plants	- 2 Holding units
Invertebrates	- 2 Holding units

1. Cellular & Molecular Biology

Density dependent growth/development processes. Wound repair rates, membrain electrolyte transport.
Generic alterations in zero-g. Cell metosis, chromosome aberrations, cell divisions.

2. Lower Vertebrate Biology

Basic mechanisms of physiological adaptation, growth, development and reproduction in zero-g. Circadian rhythm studies. Metabolic monitoring, physiological monitoring, histological preparations, surgery, environmental monitoring.

3. **Higher Vertebrate Biology**

Invasive studies of the physiological systems as described under "A" above.

4. Invertebrate Biology

Basic mechanisms of physiological adaptation, growth, development & reproduction in zero-g. Complete life cycle studies. Monitor behavior patterns, activity cycles, growth rates, morphology. Histological preparations.

5. Plant Biology

Study basic mechanisms of growth, development and reproduction in zero-g. Geotropism, morphology, photosynthetic activity, productivity.

6. Radiobiology

Biological effects of HZE particle irradiation. HZE particle detection. Exposure of small animals, plants, tissue cultures to HZE radiation.

D. <u>ADVANCED TECHNOLOGY</u>

1. Life Support Hardware Testing in Zero G

Test condensers, vapor cycle units, sterilizers, CO_2 reduction units, biopacks, pressure suits.
Life Support Test Console.

2. Effects of Space Inertial Forces on Gravity Sensitive Processes

Examine mixed phased flows, mixing, heat transfer characteristics.
Use PI developed hardware test apparatus.

3. Man-Machine Testing of Advanced Designs

Measure man's performance in EVA, systems design, etc. Use psychomotor performance console, Spacelab CRT/keyboard, etc.
Evaluate Teleoperator technology.

E. SUPPORTIVE SERVICES

Microscopy - Compound microscope for dark field, brightfield, phase contrast. Dissecting microscope. Microscope accessory kit includes polarizing equipment, filters, photographic and video attachments.

Photography - Cine film, 35 mm, polaroid.

Visual Records - Strip chart recorder (2-channel), digital display oscilloscope, CRT/camera.

Preservation - Cryogenic freezer (quick-freezer), -70° & -20°C freezers, 4°C refrigerator.

Mass Measurement - Human mass device, macro mass measurement device (5 g to 2 kg) and micro mass measurement device (1 mg to 5 g).

PAYLOAD NO. MOD IIA

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
1	ACCELEROMETER	1	0.1	0	0.03
1A	ACCELEROMETER COUPLER	1	0.05	1	0.01
6	AIR PARTICLE SAMPLER	1	2.7	50	0.35
6A	AIRFLOW WORK SURFACE	1	5	75	6
7	AUTOANALYZER (GEMSAEC)	1	26	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	1	12.7	100	57
14	ANESTHETIZER, INVERT.	1	0.2	0	1
14B	ANTENNAS,ASSORTED	1	0.1	0	0.03
15	ANTHROPOMETRIC GRID	1	1.8	0	2.9
15A	ATMOS. SAMPLING SYSTEM	1	10	20	26
15D	AUDIO STEREO HEADSET	1	0.7	0	5.7
16B	AUDIOMETER	1	4.5	25	4.3
16D	BADGES, RADIATION	2	0.2	0	0.1
16F	BALLISTOCARDIOGRAM COUPLER	1	0.1	1	1
18D	CUSTOM BITE BOARDS	1	0.23	0	0.93
19B	BODY MASS MEAS. DEVICE	1	36.5	15	675
25	CAGE, INVERTEBRATES	40	0.3	0	0.2
25B	COLONY CHAMBER, SEALABLE	20	0.2	0	0.1
26B	CAGE, METABOLIC, PLANT	2	7	30	74.6
29	CAGE, PLANT	2	4.5	0	56.6
30A	CAGE, RAT, HAMSTER, STANDARD	16	2.3	9	11
31	CALCULATOR, POCKET	1	0.47	0	0.4
32	CAMERA, CINE	1	5	13	5
32A	CAMERA CONTROLLER	1	13.6	100	28.3
33	CAMERA, POLAROID	1	3.3	0	5.6
36	CAMERA, 35 MM AND STROBE	1	2	0	2
37	CAMERA, VIDEO, B/W	2	4.4	15	3
38	CAMERA, VIDEO, COLOR	1	7.7	55	6.2
38B	CAMERA MOUNTS	1	3	0	3
38D	CAMERA TIMER, VIDEO	1	4	10	3
38F	CARDIOPULMONARY ANALYZER	1	90.7	200	172
40A	CENTRIFUGE, BLD SMPL PROCESSOR	1	12.7	100	25
44	CHEMICALS	2	0.5	0	1.0
44A	CHEMICALS, RADIOISOT. TRACERS	2	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	1	4.0	0	14.1
48	CLEANER, VACUUM	1	2.3	100	13
50	CLINOSTAT (FOR PLANTS)	1	3	10	20
50A	CLINOSTAT (FOR C/T)	1	2	10	4
50B	COMPACTOR, SOLIDS	1	18	100	113
51D	CONTROL CONSOLE, EXPERIMENTER	1	22.7	100	113.3
51F	COOLANT LOOP, LIQUID	1	30	50	25
54	COUNTER, COLONY, MANUAL	1	1.5	50	1.5
63B	DISPLAY KEYBOARD, PORTABLE	1	13.6	60	42.5
63C	DISPLAY, NUMERIC	2	2	2	4
64	ECG COUPLER	16	0.2	2	0.5
65	EEG COUPLER	6	0.2	2	0.5
65B	ELECTROPHYS. BACKPACK	1	0.3	0	0.23
65C	ELECTROPHYS. RECEIVER	1	2.7	25	5.0
66	EMG COUPLER	8	0.2	2	0.5
70	ELECTROPHORESIS APPARATUS	1	9.1	85	25.5
72C	EQUIPMENT RESTRAINT DEVICE	1	0.5	0	1
72F	EXERCISE EQUIP., PHYSIOL.	1	96	18	992
75C	FILM, CINE	4	0.54	0	0.54
75F	FILM, POLAROID	5	0.16	0	0.13
76C	FILM, 35 MM	10	0.13	0	0.35
76J	FLOWMETERS	5	0.5	1	0.5
77B	FREEZER, CRYOGENIC	1	21.6	10	74.1
80	FREEZER, GENERAL	2	15	200	61.4
81	FREEZER, LOW TEMP.	1	8	10	30.5
83	FRIG. (REFRIGERATOR)	2	18	50	120

PAYLOAD NO. MOD IIA

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
83	GAS ANALYZER, INFRARED	1	11.3	50	42.6
91	GAS ANALYZER, MASS SPEC.	2	25	50	20
92	GAS ANALYZER, PH	1	5.2	6	13
92A	GAS SUPPLIES	6	5.75	0	18
96	GLOVE BOX, PORTABLE	1	4.5	0	25
96C	GLOVE BOX LINERS	20	0.5	0	1
97C	HANDWIPES, BETADYNE	20	0.3	0	0.3
98A	HOLDING UNIT, CELLS/TISSUES	2	23	30	188
98C	HOLD. UNIT, INVERTEBRATES	2	23	50	189
101	HOLDING UNIT, PLANT	2	25	500	189
101C	HOLDING UNIT, PRIMATE	5	113	100	340
103	HOLDING UNIT, SM. VERT.	2	13.6	0	188
103F	INCUBATOR	1	5	5	8
105	KIT, CHEMICAL	1	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	1	5	0	9
106A	KIT, CLEANUP	1	1.5	0	4
108	KIT, HISTOLOGY	1	1	0	1
109	KIT, LINEAR MEAS.	1	1	0	1
110	KIT, MICROBIOLOGY	1	2	0	3
110C	KIT, HUMAN PHYSIOLOGY	1	3	0	8
111	KIT, PLANT MANAGEMENT	1	1	0	1
113A	KIT, INVERT. MANAGEMENT	1	1	0	2
114A	KIT, DISSECTION	1	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	1	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	1	3	0	6
114F	LAMP, PORTABLE HT INT. PHOTO	1	6.3	150	6
114G	LIQUID STOR. AND DISPENS. SYS.	2	13	0	18
115F	LSS TEST CONSOLE	1	15	0	560
116	LOG BOOKS	3	0.5	0	0.4
117	LOWER BODY NEG. PRESS. DEVICE	1	78.7	26	2373
118T	MANIFOLD, VACUUM	1	9.1	0	28.3
119	MSI TASK SIMULATOR	1	22.7	5	200
121	MASS MEAS. DEVICE, MACRO	1	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	1	12	15	25
122A	MASS, TEST, VARIABLE SIZE	1	6	0	0
124	MEDIA, PREPARED	2	0.45	0	0.5
126	MICROSCOPE, COMPOUND	1	11	15	27.4
126A	MICROSCOPE, DISSECTING	1	9	10	28
126T	MOBILITY UNIT, PROT. CORRIDOR	1	22.7	0	56.6
126J	MICR. ACCESS. KIT, COMPND	1	10	15	25
131D	MOTORIZED PLANT GROWTH MONITOR	2	0.5	5	0.6
131F	NON-VISUAL DIRECTION INDICATOR	1	4.1	0	2.8
131H	OPTISCAN - FIELD AND FIXED	1	2.3	5	8.5
132	OSCILLOSCOPE AND CAMERA	1	11.7	75	23.9
133	OTOLITH TEST GOGGLES	1	0.2	0	2.8
134B	PAPER, RECORDING	1	0.6	0	1.2
135	PH METER	1	1.8	20	5.2
135B	PHOTOCELL COUPLER	12	0.2	2	0.5
135F	PHYSIOL. MULTICHAN. SENS SYS.	1	0.2	0	1.4
139	PLETHYSMOGRAPH, LIMB	1	2.4	5	6
140	PHONOVIBRACARDIOGRAPH COUPLER	1	0.2	1	0.3
141A	PLUMBING	1	20	2	15
143G	PRESSURE COUPLER	4	0.2	2	0.5
144	PSYCHOMOTOR PERFORM. CONSOLE	1	8.2	15	10.3
144C	RADIATION DETECTOR, DOSIM.	1	0.3	0	0.5
147	RADIATION COUNTER	1	15	50	20
150A	RECORDER, STRIP CHART	1	11.5	0	16.9
150C	RECEIVER, BIOTELEMETRY	1	0.5	10	1
153	RECORDER, VOICE	1	1	0	1
153A	ROTATING LITTER CHAIR/CONSOLE	1	100.2	127	239
153B	SENSORS, ASSORTED	1	0.5	0	0.3

PAYLOAD NO. **MOD IIA**

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
156	SIGNAL CONDITIONERS (COUPLERS)	16	0.2	2	0.5
156E	SONOCARDIOGRAM	1	19	32	59
157	SOUND LEVEL METER	1	13.5	0	33.4
158C	SPACESUIT TEST CONSOLE	1	75	50	50
159	STAINING SYSTEM	1	2.2	0	3.5
162	STERILIZER, AUTOCLAVE	1	11	300	34.7
165	STERILIZER, TOOL	1	1	110	1
172	SPACESUIT	1	36.3	1	198.2
174	TANK, VERTEBRATE WATER	6	8.5	5	28.3
175	TANK, PLANT/INVERT. WATER	2	1.7	0	3
176H	TASKBOARD, FORCE/TORQUE	1	22.7	5	56.6
176B	THERMOCOUPLE INDICATOR	1	6	8	9.4
179	TEMPERATURE BLOCK	1	4.5	200	1.7
179A	THERMOCOUPLES	1	0.5	0	0.3
179D	THERMOMETER, ELECTRONIC	1	5.4	14	8.7
180	TIMER, EVENT	2	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	4	0.2	1	0.4
182I	VCG COUPLER	1	0.2	2	0.5
182K	VISION TESTER	1	22.7	100	113.3
182P	VENTILATION UNIT, VERT.	6	19	40	32.7
185	MULTIMETER	1	2	0	2.4
185	WORK AND SURGICAL BENCH	1	136	1000	420

DEDICATED LABORATORY MOD IIIA
SCIENCE RATIONALE & RESEARCH CAPABILITY

SCIENCE RATIONALE

Dedicated Lab MOD IIIA is a 30-day biomedical/biology/advanced technology emphasis mission for Shuttle/Spacelab.

A. Man-related studies will be undertaken from two distinct, though related, orientations:

1. As a human organism requiring scientific investigation and measurement:

   To understand the mechanisms of man's responses to space flight and his capability to adapt to the space environment. Special emphasis will be placed on those organ systems which have been found from previous flights to be influenced by gravity, e.g., cardiovascular, vestibular, and musculo-skeletal systems. Biological periodicities will be examined within the limits of mission profiles. Animal models will provide information concerning basic mechanisms not easily determined in man. Such animal models would provide information in areas where measurements have not been developed for use in humans or would carry a significant hazard if utilized in man.

2. As an important (human element of a flight system whose total performance capability is reflected in the performance level of that (human) system, and whose safety is of primary concern in any manned system:

   To acquire, analyze, and interject data relevant to the problems of human performance, capability and behavior in space. This includes both group and individual behavior, attitudes, motivational levels, anxieties, etc.

   To establish operator capabilities and requirements as they impact total system performance and crew safety.

   To collect high fidelity, high quality data on the new population of space flight participants in order to substantiate and improve on the original medical selection criteria for Shuttle passengers and crews.

B. Although animals, as biological species, will be used as models for man-related studies, the term Space Biology encompasses research on a wide variety of biological materials ranging from cells to complex multi-cellular animals. Major objectives of the Space Biology program are:

To advance our knowledge of the role of gravity in the life processes and the capability of terrestrial organisms to adapt to gravitational changes.

To understand the basic nature of biological rhythms in terrestrial organisms and their influence on life processes.

To determine and assess the biological implications of galactic cosmic HZE particles for developing realistic radiation exposure guidelines and providing protective and/or preventive measures against particle radiation hazards for long duration space missions.

To determine the potential applications and to develop the techniques to utilize new advances in biological theories and space technology gained from research in the unique environment of space for space exploration and for the benefit of mankind. This includes cross-utilization of information between scientific disciplines, especially by means of flight experiments of mutual interest and/or applicability to different disciplines.

To assess the possible synergistic effects of gravity, magnetism and radiation on life-s origin and evolutionary processes.

C. Advanced technology research goals and objectives to be accomplished include but are not limited to:

Continuing advanced technology research on life support, protective systems, and work aids to provide as near an Earth atmospheric environment for man as possible; to provide him with protection from hazards of the space environment, optimize his ability to work in space and to maintain his health. Special emphasis will be placed on areas such as:

Development of regenerative life support systems including bioregenerative systems and new principles of membrane transport and related phenomena, development of advanced protective devices for manned space flight.

Measurement of man's performance in EVA, evaluation and validation of principles of system design and man-machine integration.

Demonstration and flight evaluation of teleoperator technology; e.g., visual environment sensors and displays, man-machine capabilities and acquisition of an experience and engineering data base.

RESEARCH CAPABILITY SYNOPSIS - Area/Functions/Measurements/Major Equipment

A. BIOMEDICAL - Man

1. Vestibular

Investigate role of visual cues in space nausea. Repeat of Skylab M131 experiment. Rotating Litter Chair.
Role of altered body fluid volume, pressure and distribution to space nausea. Urine sample collection and analysis.

2. Cardiovascular

Altered vascular flow, volume and pressure relationships in zero-g. LBNP, VCG.
Demonstrate presence or absence of Gauer-Henry reflex. Early mission urine/blood sample collection and analysis. APE, Freezers.
Regulator responses to exercise in zero-g. VCG, Human Phys. Kit, Exercise Eqmt.

3. Pulmonary

Altered pulmonary volume/flow/relationships in zero-g. Cardiopulmonary Analyzer, Exercise Eqmt.

4. Musculoskeletal

Exercise effect upon musculoskeletal derangement. Exercise physiology equipment, human physiology kit, ECG/VCG.
Diet and pharmacological control of musculoskeletal derangement. Food/fluid input records, feces/urine/vomitus collection/storage.

5. Hematology

Collect, prepare and preserve blood samples. Determine red cell mass, reticulocyte counts, pCO_2, pO_2, pH, enzymes, proteins, etc.

6. Microbiology

Effects of space environment upon host defense mechanisms. Microbial sampling, culturing, staining, examination. Incubator, staining system, microscopy.

7. Crew Performance in Space

Time and motion studies, training tasks. Time-relate performance measures with daily activity schedules, sleep patterns, environmental conditions and biomedical measurements.

8. Effects of Training Upon Crew Efficiency

Correlate crew performance efficiency measurements with same tasks conducted in ground based simulators or prior missions.

B. BIOMEDICAL - Man-Surrogate

To permit detailed invasive and statistical studies in the biomedical areas mentioned above. This laboratory contains the holding facilities, support equipment and monitoring instrumentation for the following populations:

Primates	- 2 Holding units (1 primate each)
Small vertebrates	- 2 Holding units (16 rats, hamsters, etc.)
Cells/Tissues	- 2 Holding units

C. SPACE BIOLOGY

The holding units mentioned in "B" above, besides supporting man-surrogate research, will support space biology research. Additional holding units are:

Plants	- 2 Holding units
Invertebrates	- 2 Holding units

1. Cellular & Molecular Biology

Density dependent growth/development processes. Wound repair rates, membrain electrolyte transport.
Generic alterations in zero-g. Cell metosis, chromosome aberrations, cell divisions.

2. Lower Vertebrate Biology

Basic mechanisms of physiological adaptation, growth, development and reproduction in zero-g. Circadian rhythm studies. Metabolic monitoring, physiological monitoring, histological preparations, surgery, environmental monitoring.

3. Higher Vertebrate Biology

Invasive studies of the physiological systems as described under "A" above.

4. Invertebrate Biology

Basic mechanisms of physiological adaptation, growth, development & reproduction in zero-g. Complete life cycle studies. Monitor behavior patterns, activity cycles, growth rates, morphology. Histological preparations.

5. Plant Biology

Study basic mechanisms of growth, development and reproduction in zero-g. Geotropism, morphology, photosynthetic activity, productivity.

6. Radiobiology

Biological effects of HZE particle irradiation. HZE particle detection. Exposure of small animals, plants, tissue cultures to HZE radiation.

7. Bioresearch Centrifuge

A 3.88 m diameter centrifuge permits 1-g control organisms on-board to compare with zero-g test organism. Capability of 16 small animal holding units.

D. ADVANCED TECHNOLOGY

1. Life Support Hardware Testing in Zero G

Test condensers, vapor cycle units, sterilizers, CO_2 reduction units, biopacks, pressure suits.
Life Support Test Console.

2. Effects of Space Inertial Forces on Gravity Sensitive Processes

Examine mixed phased flows, mixing, heat transfer characteristics. Use PI developed hardware test apparatus.

3. Man-Machine Testing of Advanced Designs

Measure man's performance in EVA, systems design, etc. Use psychomotor performance console, Spacelab CRT/keyboard, etc.
Evaluate Teleoperator technology.

E. SUPPORTIVE SERVICES

Microscopy - Compound microscope for dark field, brightfield, phase contrast. Dissecting microscope. Microscope accessory kit includes polarizing equipment, filters, photographic and video attachments.

Photography - Cine film, 35 mm, polaroid.

Visual Records - Strip chart recorder (2-channel), digital display oscilloscope, CRT/camera.

Preservation - Cryogenic freezer (quick-freezer), -70° & -20°C freezers, 4°C refrigerator.

Mass Measurement - Human mass device, macro mass measurement device (5 g to 2 kg) and micro mass measurement device (1 mg to 5 g).

PAYLOAD NO. MOD IIIA

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
1	ACCELEROMETER	6	0.1	0	0.03
1A	ACCELEROMETER COUPLER	6	0.05	1	0.01
6	AIR PARTICLE SAMPLER	1	2.7	50	0.65
6A	AIRFLOW WORK SURFACE	1	5	75	6
7	AUTOANALYZER (GEMSAEC)	1	26	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	1	12.7	100	57
11	ANALYZER, GENL. SPECTROPHOT.	1	30	240	90
14	ANESTHETIZER, INVERT.	3	0.2	0	1
14D	ANTENNAS, ASSORTED	1	0.1	0	0.03
15	ANTHROPOMETRIC GRID	1	1.8	0	2.3
15A	ATMOS. SAMPLING SYSTEM	1	10	20	25
15B	AUDIO STEREO HEADSET	1	0.7	0	5.7
16B	AUDIOMETER	1	4.5	25	4.3
16D	BADGES, RADIATION	5	0.2	0	0.1
16E	BALLISTOCARDIOGRAM COUPLER	1	0.1	1	1
18D	CUSTOM WIRE BOARDS	1	0.23	0	0.03
19D	BODY MASS MEAS. DEVICE	1	36.5	15	675
25	CAGE, INVERTEBRATES	40	0.3	0	0.2
25B	COLONY CHAMBER, SEALABLE	20	0.2	0	0.1
26A	CAGE, METABOLIC, C/T	1	0.8	5	0.9
26B	CAGE, METABOLIC, PLANT	2	7	30	74.6
28	CAGE, METABOLIC, RATS	1	8	20	28.3
29	CAGE, PLANT	2	4.5	0	56.6
30A	CAGE, RAT, HAMSTER, STANDARD	15	2.3	0	11
31	CALCULATOR, POCKET	1	0.47	0	0.4
32	CAMERA, CINE	1	5	13	5
32A	CAMERA CONTROLLER	1	13.6	100	28.3
33	CAMERA, POLAROID	1	3.3	0	5.5
36	CAMERA, 35 MM AND STROBE	1	2	0	2
37	CAMERA, VIDEO, B/W	3	4.4	15	3
38	CAMERA, VIDEO, COLOR	1	7.7	59	6.2
38B	CAMERA MOUNTS	1	3	0	3
38D	CAMERA TIMER, VIDEO	1	4	10	3
39E	CARDIOPULMONARY ANALYZER	1	90.7	200	172
40A	CENTRIFUGE, BLD SMPL PROCESSOR	1	12.7	100	25
43A	CENTRIFUGE, BIORESEARCH	1	250	354	6300
44	CHEMICALS	2	0.5	0	1.2
44A	CHEMICALS, RADIOISOT. TRACERS	2	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	3	4.0	0	14.1
48	CLEANER, VACUUM	1	2.3	100	10
50	CLINOSTAT (FOR PLANTS)	1	3	10	20
50A	CLINOSTAT (FOR C/T)	1	2	10	4
50B	COMPACTOR, SOLIDS	1	18	100	113
51D	CONTROL CONSOLE, EXPERIMENTER	1	22.7	100	113.3
51E	COOLANT LOOP, LIQUID	1	30	50	25
54	COUNTER, COLONY, MANUAL	1	1.5	50	1.5
63B	DISPLAY KEYBOARD, PORTABLE	1	13.6	60	42.5
63D	DISPLAY, NUMERIC	3	2	2	4
64	ECG COUPLER	24	0.2	2	0.5
65	EEG COUPLER	8	0.2	2	0.5
68B	ELECTROPHYS. BACKPACK	1	0.3	0	0.33
68D	ELECTROPHYS. RECEIVER	1	2.7	25	5.0
66	EMG COUPLER	10	0.2	2	0.5
69A	ELECTROMETER	1	3.7	3	7.3
70	ELECTROPHORESIS APPARATUS	1	9.1	85	25.5
70D	EQUIPMENT RESTRAINT DEVICE	1	0.5	0	1
70E	EXERCISE EQUIP., PHYSIOL.	1	96	[illegible]	992
75D	FILM, CINE	12	0.54	0	0.54
75E	FILM, POLAROID	15	0.16	0	0.13
76D	FILM, 35 MM	30	0.13	0	0.05

PAYLOAD NO. MOD IIIA

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
75J	FLOWMETERS	6	0.5	1	0.5
76L	FIBROMETER, BLOOD CLOT	1	4.5	40	19.6
77A	FREEZER, CRYOGENIC	2	21.5	10	74.1
80	FREEZER, GENERAL	2	15	200	61.4
81	FREEZER, LOW TEMP.	2	8	10	30.5
83	FRIG. (REFRIGERATOR)	2	18	50	120
87	GAS ANALYZER, INFRARED	1	11.3	50	42.6
91	GAS ANALYZER, MASS SPEC.	2	25	50	20
93	GAS ANALYZER, PH	1	5.2	6	13
93A	GAS SUPPLIES	6	5.75	0	18
96	GLOVE BOX, PORTABLE	1	4.5	0	25
96C	GLOVE BOX LINERS	60	0.5	0	1
97C	HANDWIPES, BETADYNE	50	0.3	0	0.3
98A	HOLDING UNIT, CELLS/TISSUES	2	23	30	138
98C	HOLD. UNIT, INVERTEBRATES	2	23	50	188
101	HOLDING UNIT, PLANT	2	25	500	188
101B	HOLDING UNIT, MONKEY POD	1	53	100	425
101C	HOLDING UNIT, PRIMATE	1	113	100	340
103	HOLDING UNIT, SM. VERT.	2	13.6	0	188
103B	INCUBATOR	1	5	5	8
105	KIT, CHEMICAL	2	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	3	5	0	9
106A	KIT, CLEANUP	3	1.5	0	4
108	KIT, HISTOLOGY	3	1	0	1
109	KIT, LINEAR MEAS.	1	1	0	1
110	KIT, MICROBIOLOGY	3	2	0	3
110C	KIT, HUMAN PHYSIOLOGY	1	3	0	8
111	KIT, PLANT MANAGEMENT	2	1	0	1
113A	KIT, INVERT. MANAGEMENT	1	1	0	2
114A	KIT, DISSECTION	1	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	1	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	1	3	0	6
114E	LAMP, PORTABLE HI INT. PHOTO	1	6.3	150	6
114G	LIQUID STOR. AND DISPENS. SYS.	3	13	0	18
115E	LSS TEST CONSOLE	1	15	0	560
116	LOG BOOKS	10	0.5	0	0.4
117	LOWER BODY NEG. PRESS. DEVICE	1	78.7	26	2373
118	LYOPHILIZER	1	23	300	143
118T	MANIFOLD, VACUUM	1	9.1	0	28.3
119	MSI TASK SIMULATOR	1	22.7	5	200
121	MASS MEAS. DEVICE, MACRO	1	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	1	12	15	25
123A	MASS, TEST, VARIABLE SIZE	1	0	0	0
124	MEDIA, PREPARED	4	0.45	0	0.5
126	MICROSCOPE, COMPOUND	1	11	15	27.4
126A	MICROSCOPE, DISSECTING	1	9	100	28
126I	MOBILITY UNIT, PROT. CORRIDOR	1	22.7	0	56.6
126J	MICR. ACCESS. KIT, COMPND	1	10	15	25
131D	MOTORIZED PLANT GROWTH MONITOR	2	0.5	5	0.6
131F	NON-VISUAL DIRECTION INDICATOR	1	4.1	0	2.8
131H	OPTISCAN - FIELD AND FIXED	1	2.3	5	8.5
132	OSCILLOSCOPE AND CAMERA	1	11.7	75	26.9
133	OTOLITH TEST GOGGLES	1	0.2	0	2.8
134B	PAPER, RECORDING	3	0.5	0	1.2
135	PH METER	1	1.5	20	5.2
136B	PHOTOCELL COUPLER	12	0.2	2	0.5
138F	PHYSIOL. MULTICHAN. SENS SYS.	1	0.2	0	1.4
139	PLETHYSMOGRAPH, LIMB	1	2.4	5	6
140	PHONOVIBRACARDIOGRAM COUPLER	1	0.2	1	0.3
141A	PLUMBING	1	20	2	15
142	PORTABLE LSS	1	30.4	0	79

PAYLOAD NO. MOD IIIA

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
143G	PRESSURE COUPLER	4	0.2	2	0.5
144	PSYCHOMOTOR PERFORM. CONSOLE	1	0.2	15	13.3
144B	PSYCHOGALVANOMETER, GSR	1	0.5	1	0.3
144C	RADIATION DETECTOR, DOSIM.	1	0.3	0	0.5
147	RADIATION COUNTER	1	15	50	20
149G	RAD. SOURCE, SHIELDED	1	65	5	28.3
150A	RECORDER, STRIP CHART	1	11.8	0	16.9
150B	RECEIVER, BIOTELEMETRY	1	0.5	10	1
153	RECORDER, VOICE	1	1	0	1
153A	ROTATING LITTER CHAIR/CONSOLE	1	100.2	127	239
153B	SENSORS, ASSORTED	1	0.5	0	0.3
156	SIGNAL CONDITIONERS (COUPLERS)	24	0.2	2	0.5
156F	SONOCARDIOGRAM	1	19	32	59
157	SOUND LEVEL METER	1	13.6	0	33.4
158C	SPACESUIT TEST CONSOLE	1	35	50	50
159	STAINING SYSTEM	3	2.2	0	3.5
162	STERILIZER, AUTOCLAVE	1	11	300	34.7
165	STERILIZER, TOOL	1	1	110	1
172	SPACESUIT	1	35.3	1	198.2
174	TANK, VERTEBRATE WATER	3	8.5	5	28.3
175	TANK, PLANT/INVERT. WATER	6	1.7	0	3
176H	TASKBOARD, FORCE/TORQUE	1	22.7	5	56.6
178B	THERMOCOUPLE INDICATOR	1	6	8	9.4
179	TEMPERATURE BLOCK	1	4.5	200	1.7
179A	THERMOCOUPLES	2	0.5	0	0.3
179B	THERMOMETER, ELECTRONIC	1	5.4	14	8.7
180	TIMER, EVENT	2	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	4	0.2	1	0.4
182J	VCG COUPLER	1	0.2	2	0.5
182K	VISION TESTER	1	22.7	100	113.3
182P	VENTILATION UNIT, VERT.	3	19	40	32.7
185	MULTIMETER	1	2	0	2.4
188	WORK AND SURGICAL BENCH	1	135	1000	420

DEDICATED LABORATORY MOD IIB
SCIENCE RATIONALE & RESEARCH CAPABILITY

SCIENCE RATIONALE

Dedicated Lab MOD IIB is a 7-day space biology emphasis mission for Shuttle/ Spacelab. Research will be performed to advance our knowledge of the role of gravity, magnetism and radiation in the life processes of a wide variety of biological material ranging from cells to multicellular animals.

Major objectives of the research are:

To advance our knowledge of the role of gravity in the life processes and the capability of terrestrial organisms to adapt to gravitational changes.

To understand the basic nature of biological rhythms in terrestrial organisms and their influence on life processes.

To determine and assess the biological implications of galactic cosmic HZE particles for developing realistic radiation exposure guidelines and providing protective and/or preventive measures against particle radiation hazards for long duration space missions.

To determine the potential applications and to develop the techniques to utilize new advances in biological theories and space technology gained from research in the unique environment of space for space exploration and for the benefit of mankind. This includes cross-utilization of information between scientific disciplines, especially by means of flight experiments of mutual interest and/or applicability to different disciplines.

To assess the possible synergistic effects of gravity, magnetism and radiation on life's origin and evolutionary processes.

<u>RESEARCH CAPABILITY SYNOPSIS</u> - Area/Functions/Measurements/Major Equipment

A. SPACE BIOLOGY

To permit detailed invasive and statistical studies in the various biological areas of interest, this laboratory contains the holding facilities support equipment and monitoring instrumentation for the following populations:

Primates	- 2 Holding units (1 primate each)
Small Vertebrates	- 2 Holding units (16 rats, hamsters, fowl, etc.)
Plants	- 2 Holding units

Invertebrates	- 2 Holding units
Cells/Tissues	- 2 Holding units

1. Cellular & Molecular Biology

   Density dependent growth/development processes. Wound repair rates, membrane electrolyte transport.
   Genetic alterations in zero-g. Cell mutosis, chromosome aberrations, cell divisions.

2. Lower Vertebrate Biology

   Basic mechanisms of physiological adaptation, growth, development and reproduction in zero-g. Circadian rhythm studies. Metabolic monitoring, physiological monitoring, histological preparations, surgery, environmental monitoring.

3. Higher Vertebrate Biology

   Invasive studies in altered vascular flow volume and pressure relationships, absence or presence of myocardial degeneration, absolute catabolic effects of zero-g on musculoskeletal system, mechanical and neural responses of the vestibular system to space environment stimuli and hematological collect, preservation and analysis.
   Use of work and surgery bench.

4. Invertebrate Biology

   Basic mechanisms of physiological adaptation, growth, development and reproduction in zero-g. Complete life cycle studies. Monitor behavior patterns, activity cycles, growth rates, morphology. Histological preparations.

5. Plant Biology

   Study basic mechanisms of growth, development and reproduction in zero-g. Geotropism, morphology, photosynthetic activity, productivity.

6. Radiobiology

   Biological effects of HZE particle irradiation. HZE particle detection. Exposure of small animals, plants, tissue cultures to HZE radiation.

B. SUPPORTIVE SERVICES

Microscopy - Compound microscope for dark field, bright field, phase contrast. Dissecting microscope. Microscope accessory kit includes polarizing equipment, filters, photographic and video attachments.

Photography - Cine film, 35 mm, polaroid.

Visual Records - Strip chart recorder (2-channel), digital display oscilloscope, CRT/camera.

Preservation - Cryogenic freezer (quick-freezer), -70° & -20°C freezers, 4°C refrigerator.

Mass Measurement - Macro mass measurement device (5 g to 2 kg) and micro mass measurement device (1 mg to 5 g).

PAYLOAD NO. MOD IIB

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
1	ACCELEROMETER	[illegible]	0.1	0	0.03
1A	ACCELEROMETER COUPLER	[illegible]	0.05	1	0.01
6	AIR PARTICLE SAMPLER	1	2.7	50	0.65
61	AIRFLOW WORK SURFACE	1	5	75	6
7	AUTOANALYZER (GEMSAEC)	1	26	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	1	12.7	100	57
14	ANESTHETIZER, INVERT.	1	[illegible]	0	1
14B	ANTENNAS, ASSORTED	1	[illegible]	0	0.03
15A	ATMOS. SAMPLING SYSTEM	1	10	20	26
16D	BADGES, RADIATION	2	0.2	0	0.1
25	CAGE, INVERTEBRATES	40	0.3	0	0.2
25B	COLONY CHAMBER, SEALABLE	20	0.2	0	0.1
26B	CAGE, METABOLIC, PLANT	2	7	30	74.6
28	CAGE, METABOLIC, RATS	1	8	20	28.3
29	CAGE, PLANT	2	4.5	0	56.6
30A	CAGE, RAT, HAMSTER, STANDARD	16	2.3	9	11
31	CALCULATOR, POCKET	1	0.47	0	0.4
32	CAMERA, CINE	1	5	13	5
32A	CAMERA CONTROLLER	1	13.6	100	28.3
33	CAMERA, POLAROID	1	3.3	0	5.6
36	CAMERA, 35 MM AND STROBE	1	2	0	2
37	CAMERA, VIDEO, B/W	2	4.4	15	3
38	CAMERA, VIDEO, COLOR	1	7.7	69	6.2
38B	CAMERA MOUNTS	1	3	0	3
38D	CAMERA TIMER, VIDEO	1	4	10	3
40A	CENTRIFUGE, BLD SMPL PROCESSOR	1	12.7	100	25
44	CHEMICALS	1	0.5	0	1.0
44A	CHEMICALS, RADIOISOT. TRACERS	1	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	1	4.0	0	14.1
46	CLEANER, VACUUM	1	2.3	100	10
50	CLINOSTAT (FOR PLANTS)	1	3	10	20
50A	CLINOSTAT (FOR C/T)	1	2	10	4
51F	COOLANT LOOP, LIQUID	1	30	50	25
54	COUNTER, COLONY, MANUAL	1	1.5	50	1.5
67B	DISPLAY KEYBOARD, PORTABLE	1	13.5	50	42.5
67C	DISPLAY, NUMERIC	2	2	2	4
64	ECG COUPLER	12	0.2	2	0.5
65	EEG COUPLER	4	0.2	2	0.5
66	EMG COUPLER	6	0.2	2	0.5
70C	EQUIPMENT RESTRAINT DEVICE	1	0.5	0	1
72F	EXERCISE EQUIP., PHYSIOL.	1	96	10	592
75C	FILM, CINE	4	0.54	0	0.54
75F	FILM, POLAROID	5	0.15	0	0.13
76C	FILM, 35 MM	10	0.13	0	0.05
76J	FLOWMETERS	4	0.5	1	0.5
77B	FREEZER, CRYOGENIC	1	21.6	10	74.1
80	FREEZER, GENERAL	1	15	200	61.4
81	FREEZER, LOW TEMP.	1	8	10	30.5
83	FRIG. (REFRIGERATOR)	1	18	50	120
91	GAS ANALYZER, MASS SPEC.	2	25	50	20
93	GAS ANALYZER, PH	1	5.2	5	13
93A	GAS SUPPLIES	6	5.75	0	18
96	GLOVE BOX, PORTABLE	1	4.5	0	25
96C	GLOVE BOX LINERS	20	0.5	0	1
97C	HANDWIPES, BETADYNE	20	0.3	0	0.3
98A	HOLDING UNIT, CELLS/TISSUES	2	23	30	158
98C	HOLD. UNIT, INVERTEBRATES	2	23	50	138
101	HOLDING UNIT, PLANT	2	25	500	183
101C	HOLDING UNIT, PRIMATE	2	113	100	343
103	HOLDING UNIT, SM. VERT.	2	13.6	0	183

PAYLOAD NO. MOD IIB

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
103B	INCUBATOR	1	5	5	8
105	KIT, CHEMICAL	1	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	1	5	0	9
106A	KIT, CLEANUP	1	1.5	0	4
108	KIT, HISTOLOGY	1	1	0	1
109	KIT, LINEAR MEAS.	1	1	0	1
110	KIT, MICROBIOLOGY	1	2	0	3
111	KIT, PLANT MANAGEMENT	1	1	0	1
113A	KIT, INVERT. MANAGEMENT	1	1	0	2
114A	KIT, DISSECTION	1	1	0	2
114D	KIT, VERTEBRATE MANAGEMENT	1	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	1	3	0	6
114E	LAMP, PORTABLE HI INT. PHOTO	1	6.3	150	6
114G	LIQUID STOR. AND DISPENS. SYS.	2	13	0	18
116	LOG BOOKS	3	0.5	0	0.4
119T	MANIFOLD, VACUUM	1	9.1	0	28.3
121	MASS MEAS. DEVICE, MACRO	1	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	1	12	15	25
124	MEDIA, PREPARED	2	0.45	0	0.5
126	MICROSCOPE, COMPOUND	1	11	15	27.4
126A	MICROSCOPE, DISSECTING	1	9	100	28
126B	MICR. ACCESS. KIT, COMPND	1	10	15	25
131D	MOTORIZED PLANT GROWTH MONITOR	2	0.5	5	0.6
132	OSCILLOSCOPE AND CAMERA	1	11.7	75	28.9
134B	PAPER, RECORDING	1	0.6	0	1.2
138	PH METER	1	1.8	20	5.2
138B	PHOTOCELL COUPLER	12	0.2	2	0.5
136E	PHYSIOL. MULTICHAN. SENS SYS.	1	0.2	0	1.4
141A	PLUMBING	1	20	2	15
143G	PRESSURE COUPLER	4	0.2	2	0.5
144C	RADIATION DETECTOR, DOSIM.	1	0.3	0	0.5
150A	RECORDER, STRIP CHART	1	11.8	0	16.9
150B	RECEIVER, BIOTELEMETRY	1	0.5	10	1
153	RECORDER, VOICE	1	1	0	1
153D	SENSORS, ASSORTED	1	0.5	0	0.3
156	SIGNAL CONDITIONERS (COUPLERS)	12	0.2	2	0.5
157	SOUND LEVEL METER	1	13.6	0	33.4
159	STAINING SYSTEM	1	2.2	0	3.5
162	STERILIZER, AUTOCLAVE	1	11	300	34.7
165	STERILIZER, TOOL	1	1	110	1
174	TANK, VERTEBRATE WATER	3	8.5	5	25.3
175	TANK, PLANT/INVERT. WATER	3	1.7	0	3
176B	THERMOCOUPLE INDICATOR	1	6	3	9.4
178	TEMPERATURE BLOCK	1	4.5	200	1.7
179A	THERMOCOUPLES	1	0.5	0	0.3
179D	THERMOMETER, ELECTRONIC	1	5.4	14	8.7
180	TIMER, EVENT	2	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	4	0.2	1	0.4
182J	VCG COUPLER	1	0.2	2	0.5
182E	VENTILATION UNIT, VERT.	2	19	40	32.7
182B	VERTEBRATE ECS	1	38	320	121
185	MULTIMETER	1	2	0	2.4
188	WORK AND SURGICAL BENCH	1	136	1000	420

DEDICATED LABORATORY MOD IIC
SCIENCE RATIONALE & RESEARCH CAPABILITY

SCIENCE RATIONALE

Dedicated Lab MOD IIC is a 30-day space biology emphasis mission for Shuttle/Spacelab. Research will be performed to advance our knowledge of the role of gravity, magnetism and radiation in the life processes of a wide variety of biological material ranging from cells to multicellular animals.

Major objectives of the research are:

To advance our knowledge of the role of gravity in the life processes and the capability of terrestrial organisms to adapt to gravitational changes.

To understand the basic nature of biological rhythms in terrestrial organisms and their influence on life processes.

To determine and assess the biological implications of galactic cosmic HZE particles for developing realistic radiation exposure guidelines and providing protective and/or preventive measures against particle radiation hazards for long duration space missions.

To determine the potential applications and to develop the techniques to utilize new advances in biological theories and space technology gained from research in the unique environment of space for space exploration and for the benefit of mankind. This includes cross-utilization of information between scientific disciplines, especially by means of flight experiments of mutual interest and/or applicability to different disciplines.

To assess the possible synergistic effects of gravity, magnetism and radiation on life's origin and evolutionary processes.

RESEARCH CAPABILITY SYNOPSIS - Area/Functions/Measurements/Major Equipment

A. SPACE BIOLOGY

To permit detailed invasive and statistical studies in the various biological areas of interest, this laboratory contains the holding facilities support equipment and monitoring instrumentation for the following populations:

Primates	- 2 Holding units (1 primate each)
Small Vertebrates	- 2 Holding units (16 rats, hamsters, fowl, etc.)

1. Cellular & Molecular Biology

Density dependent growth/development processes. Wound repair rates, membrane electrolyte transport.
Genetic alterations in zero-g. Cell mutosis, chromosome aberrations, cell divisions.

2. Lower Vertebrate Biology

Basic mechanisms of physiological adaptation, growth, development and reproduction in zero-g. Circadian rhythm studies. Metabolic monitoring, physiological monitoring, histological preparations, surgery, environmental monitoring.

3. Higher Vertebrate Biology

Invasive studies in altered vascular flow volume and pressure relationships, absence or presence of myocardial degeneration, absolute catabolic effects of zero-g on musculoskeletal system, mechanical and neural responses of the vestibular system to space environment stimuli and hematological collect, preservation and analysis.
Use of work and surgery bench.

4. Radiobiology

Biological effects of HZE particle irradiation. HZE particle detection. Exposure of small animals to HZE radiation.

B. SUPPORTIVE SERVICES

Microscopy - Compound microscope for dark field, bright field, phase contrast. Dissecting microscope. Microscope accessory kit includes polarizing equipment, filters, photographic and video attachments.

Photography - Cine film, 35 mm, polaroid.

Visual Records - Strip chart recorder (2-channel), digital display oscilloscope, CRT/camera.

Preservation - Cryogenic freezer (quick-freezer), -70° & -20°C freezers, 4°C refrigerator.

Mass Measurement - Macro mass measurement device (5 g to 2 kg) and micro mass measurement device (1 mg to 5 g).

PAYLOAD NO. MOD IIC

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
1	ACCELEROMETER	3	0.1	0	0.03
1A	ACCELEROMETER COUPLER	3	0.05	1	0.11
6	AIR PARTICLE SAMPLER	1	2.7	50	0.85
6A	AIRFLOW WORK SURFACE	1	5	75	6
7	AUTOANALYZER (GEMSAEC)	1	25	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	1	12.7	100	57
14B	ANTENNAS,ASSORTED	1	0.1	0	0.03
15A	ATMOS. SAMPLING SYSTEM	1	10	20	28
16D	BADGES, RADIATION	5	0.2	0	0.1
30A	CAGE, RAT, HAMSTER, STANDARD	15	2.3	9	11
31	CALCULATOR, POCKET	1	0.47	0	0.4
32	CAMERA, CINE	1	5	13	5
32A	CAMERA CONTROLLER	1	13.6	100	28.3
33	CAMERA, POLAROID	1	3.3	0	5.6
36	CAMERA, 35 MM AND STROBE	1	2	0	2
37	CAMERA, VIDEO, B/W	2	4.4	15	3
38	CAMERA, VIDEO, COLOR	1	7.7	69	6.2
38B	CAMERA MOUNTS	1	3	0	3
38D	CAMERA TIMER, VIDEO	1	4	10	3
40A	CENTRIFUGE, BLD SMPL PROCESSOR	1	12.7	100	25
44	CHEMICALS	1	0.5	0	1.0
44A	CHEMICALS, RADIOISOT. TRACERS	1	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	1	4.0	0	14.1
46	CLEANER, VACUUM	1	2.3	100	10
51E	COOLANT LOOP, LIQUID	1	30	50	25
54	COUNTER, COLONY, MANUAL	1	1.5	50	1.5
63B	DISPLAY KEYBOARD, PORTABLE	1	13.6	50	42.5
63C	DISPLAY, NUMERIC	1	2	2	4
64	ECG COUPLER	12	0.2	2	0.5
65	EEG COUPLER	4	0.2	2	0.5
66	EMG COUPLER	6	0.2	2	0.5
70C	EQUIPMENT RESTRAINT DEVICE	1	0.5	0	1
70E	EXERCISE EQUIP., PHYSIOL.	1	96	18	992
75C	FILM, CINE	12	0.54	0	0.54
75E	FILM, POLAROID	15	0.15	0	0.13
76C	FILM, 35 MM	20	0.13	0	0.05
76I	FLOWMETERS	4	0.5	1	0.5
77B	FREEZER, CRYOGENIC	1	21.6	10	74.1
80	FREEZER, GENERAL	2	15	200	61.4
81	FREEZER, LOW TEMP.	1	8	10	30.5
83	FRIG. (REFRIGERATOR)	2	18	50	120
91	GAS ANALYZER, MASS SPEC.	2	25	50	20
93	GAS ANALYZER, RH	1	5.2	6	13
93A	GAS SUPPLIES	6	5.75	0	18
96	GLOVE BOX, PORTABLE	1	4.5	0	25
96C	GLOVE BOX LINERS	20	0.5	0	1
97C	HANDWIPES, BETADYNE	20	0.3	0	0.3
101B	HOLDING UNIT, MONKEY POD	1	53	100	425
101C	HOLDING UNIT, PRIMATE	1	113	100	340
103	HOLDING UNIT, SM. VERT.	2	13.6	0	188
105	KIT, CHEMICAL	2	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	2	5	0	9
106A	KIT, CLEANUP	1	1.5	0	4
108	KIT, HISTOLOGY	2	1	0	1
109	KIT, LINEAR MEAS.	1	1	0	1
110	KIT, MICROBIOLOGY	2	2	0	3
114A	KIT, DISSECTION	1	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	1	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	1	3	0	6
114E	LAMP, PORTABLE HI INT. PHOTO	1	6.3	150	6

PAYLOAD NO. MOD IIC

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
1145	LIQUID STOR. AND DISPENS. SYS.	2	13	0	18
116	LOG BOOKS	5	0.5	0	0.4
117T	MANIFOLD, VACUUM	1	9.1	0	28.3
121	MASS MEAS. DEVICE, MACRO	1	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	1	12	15	25
126	MICROSCOPE, COMPOUND	1	11	15	27.4
126A	MICROSCOPE, DISSECTING	1	9	100	28
126I	MICR. ACCESS. KIT, COMPND	1	10	15	25
132	OSCILLOSCOPE AND CAMERA	1	11.7	75	28.9
134B	PAPER, RECORDING	3	0.5	0	1.2
135	PH METER	1	1.8	20	5.2
136B	PHOTOCELL COUPLER	12	0.2	2	0.5
138E	PHYSIOL. MULTICHAN. SENS SYS.	1	0.2	0	1.4
141A	PLUMBING	1	20	2	15
143G	PRESSURE COUPLER	4	0.2	2	0.5
144C	RADIATION DETECTOR, DOSIM.	1	0.3	0	0.5
150A	RECORDER, STRIP CHART	1	11.8	0	16.9
150B	RECEIVER, BIOTELEMETRY	1	0.5	10	1
153	RECORDER, VOICE	1	1	0	1
157B	SENSORS, ASSORTED	1	0.5	0	0.3
156	SIGNAL CONDITIONERS (COUPLERS)	16	0.2	2	0.5
157	SOUND LEVEL METER	1	13.6	0	33.4
159	STAINING SYSTEM	2	2.2	0	3.5
165	STERILIZER, TOOL	1	1	110	1
174	TANK, VERTEBRATE WATER	3	8.5	5	28.3
178B	THERMOCOUPLE INDICATOR	1	6	8	9.4
179	TEMPERATURE BLOCK	1	4.5	200	1.7
179A	THERMOCOUPLES	1	0.5	0	0.3
179D	THERMOMETER, ELECTRONIC	1	5.4	14	8.7
180	TIMER, EVENT	2	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	4	0.2	1	0.4
182A	VCG COUPLER	1	0.2	2	0.5
182B	VENTILATION UNIT, VERT.	2	19	40	32.7
182C	VERTEBRATE ECS	1	38	320	121
185	MULTIMETER	1	2	0	2.4
188	WORK AND SURGICAL BENCH	1	136	1000	420

DEDICATED LABORATORY MOD IIIB
SCIENCE RATIONALE & RESEARCH CAPABILITY

SCIENCE RATIONALE

Dedicated Lab MOD IIIB is a 30-day space biology emphasis mission for Shuttle/Spacelab. Research will be performed to advance our knowledge of the chronic effects of gravity, magnetism and radiation in the life processes of multicellular animals. A Bioresearch Centrifuge in the laboratory permits 1-g control organisms to be studied along with their zero-g counterparts.

Major objectives of the research are:

To advance our knowledge of the role of gravity in the life processes and the capability of terrestrial organisms to adapt to gravitational changes.

To understand the basic nature of biological rhythms in terrestrial organisms and their influence on life processes.

To determine and assess the biological implications of galactic cosmic HZE particles for developing realistic radiation exposure guidelines and providing protective and/or preventive measures against particle radiation hazards for long duration space missions.

To determine the potential applications and to develop the techniques to utilize new advances in biological theories and space technology gained from research in the unique environment of space for space exploration and for the benefit of mankind. This includes cross-utilization of information between scientific disciplines, especially by means of flight experiments of mutual interest and/or applicability to different disciplines.

To assess the possible synergistic effects of gravity, magnetism and radiation on life's origin and evolutionary processes.

RESEARCH CAPABILITY SYNOPSIS - Area/Functions/Measurements/Major Equipment

A. SPACE BIOLOGY

To permit detailed invasive and statistical studies in the various biological areas of interest, this laboratory contains the holding facilities, support equipment and monitoring instrumentation for the following populations:

Small Vertebrates - 2 holding units (16 rats, hamsters, fowl, etc.) in laboratory; 16 holding stations in Centrifuge.

1. Small Vertebrate Biology

Invasive studies in altered vascular flow volume and pressure relationships, absence or presence of myocardial degeneration, absolute catabolic effects of zero-g on musculoskeletal system, mechanical and neural responses of the vestibular system to space environment stimuli and hematological collect, preservation and analysis.

Basic mechanisms of physiological adaptation, growth, development and reproduction in zero-g. Circadian rhythm studies. Metabolic monitoring, physiological monitoring, histological preparations, surgery, environmental monitoring.

2. Bioresearch Centrifuge

A 3.88 m diameter centrifuge permits 1-g control organisms on-board to compare with zero-g test organisms. Capability of 16 small animal holding units.

B. SUPPORTIVE SERVICES

Microscopy - Compound microscope for dark field, bright field, phase contrast. Dissecting microscope. Microscope accessory kit includes polarizing equipment, filters, photographic and video attachments.

Photography - Cine film, 35 mm, polaroid.

Visual Records - Strip chart recorder (2-channel), digital display oscilloscope, CRT/camera.

Preservation - Cryogenic freezer (quick-freeze), -70° & -20°C freezers, 4°C refrigerator.

Mass Measurement - Macro mass measurement device (5 g to 2 kg) and micro mass measurement device (1 mg to 5 g).

PAYLOAD NO. MOD IIIB

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
1	ACCELEROMETER	6	0.1	0	0.03
1A	ACCELEROMETER COUPLER	6	0.05	1	0.01
6	AIR PARTICLE SAMPLER	1	2.7	50	0.85
6A	AIRFLOW WORK SURFACE	1	5	75	6
7	AUTOANALYZER (GEMSAEC)	1	26	200	40
7A	AUTO POTENTIO. ELEC. ANAL.	1	12.7	100	57
143	ANTENNAS,ASSORTED	1	0.1	0	0.03
15A	ATMOS. SAMPLING SYSTEM	1	10	20	28
15D	BADGES, RADIATION	5	0.2	0	0.1
28	CAGE, METABOLIC, RATS	1	8	20	23.7
28A	CAGE, RAT, HAMSTER, STANDARD	16	2.3	9	11
31	CALCULATOR, POCKET	1	0.47	0	0.4
32	CAMERA, CINE	1	5	13	5
32A	CAMERA CONTROLLER	1	13.6	100	28.3
33	CAMERA, POLAROID	1	3.3	0	5.6
34	CAMERA, 35 MM AND STROBE	1	2	0	2
35	CAMERA, VIDEO, B/W	2	4.4	15	3
36	CAMERA, VIDEO, COLOR	1	7.7	69	6.2
36B	CAMERA MOUNTS	1	3	0	3
36D	CAMERA TIMER, VIDEO	1	4	10	3
40A	CENTRIFUGE, BLD SMPL PROCESSOR	1	12.7	100	25
43A	CENTRIFUGE, BIORESEARCH	1	250	354	6800
44	CHEMICALS	1	0.5	0	1.0
44A	CHEMICALS, RADIOISOT. TRACERS	1	0.3	0	0.5
45	CHEMICAL STORAGE CABINET	1	4.0	0	14.1
46	CLEANER, VACUUM	1	2.3	100	10
51F	COOLANT LOOP, LIQUID	1	30	50	25
54	COUNTER, COLONY, MANUAL	1	1.5	50	1.5
63B	DISPLAY KEYBOARD, PORTABLE	1	13.5	50	42.5
63C	DISPLAY, NUMERIC	1	2	2	4
64	ECG COUPLER	16	0.2	2	0.5
65	EEG COUPLER	8	0.2	2	0.5
66	EMG COUPLER	5	0.2	2	0.5
70C	EQUIPMENT RESTRAINT DEVICE	1	0.5	0	1
70F	EXERCISE EQUIP., PHYSIOL.	1	96	18	992
75C	FILM, CINE	12	0.54	0	0.54
75E	FILM, POLAROID	15	0.16	0	0.13
76C	FILM, 35 MM	20	0.13	0	0.05
76J	FLOWMETERS	5	0.5	1	0.5
77B	FREEZER, CRYOGENIC	2	21.6	10	74.1
80	FREEZER, GENERAL	2	15	200	61.4
81	FREEZER, LOW TEMP.	1	8	10	30.5
83	FRIG. (REFRIGERATOR)	2	18	50	120
91	GAS ANALYZER, MASS SPEC.	2	25	50	20
93	GAS ANALYZER, PH	1	5.2	6	13
93A	GAS SUPPLIES	6	5.75	0	18
96	GLOVE BOX, PORTABLE	1	4.5	0	25
96C	GLOVE BOX LINERS	20	0.5	0	1
97G	HANDWIPES, BETADYNE	20	0.3	0	0.3
103	HOLDING UNIT, SM. VERT.	2	13.6	0	188
105	KIT, CHEMICAL	2	1.5	0	5
106	KIT, HEMATOLOGY AND UROLOGY	2	5	0	9
106A	KIT, CLEANUP	3	1.5	0	4
108	KIT, HISTOLOGY	2	1	0	1
109	KIT, LINEAR MEAS.	1	1	0	1
110	KIT, MICROBIOLOGY	2	2	0	3
114A	KIT, DISSECTION	1	1	0	2
114B	KIT, VERTEBRATE MANAGEMENT	1	3	0	6
114C	KIT, VERTEBRATE PHYSIOLOGY	1	3	0	6
114F	LAMP, PORTABLE HI INT. PHOTO	1	6.3	150	6

PAYLOAD NO. MOD IIIB

EI	Name	Q	Unit Wt. kg	Unit Pwr. w	Unit Vol. dm^3
114G	LIQUID STOR. AND DISPENS. SYS.	3	13	0	18
116	LOG BOOKS	5	0.5	0	0.4
118I	MANIFOLD, VACUUM	1	9.1	0	26.3
121	MASS MEAS. DEVICE, MACRO	1	11.8	15	32.8
122	MASS MEAS. DEVICE, MICRO	1	12	15	25
126	MICROSCOPE, COMPOUND	1	11	15	27.4
126A	MICROSCOPE, DISSECTING	1	9	100	29
126J	MICR. ACCESS. KIT, COMPND	1	10	15	25
132	OSCILLOSCOPE AND CAMERA	1	11.7	75	28.9
134D	PAPER, RECORDING	3	0.6	0	1.2
136	PH METER	1	1.8	20	5.2
138B	PHOTOCELL COUPLER	12	0.2	2	0.5
138F	PHYSIOL. MULTICHAN. SENS SYS.	1	0.2	0	1.4
141A	PLUMBING	1	20	2	15
143G	PRESSURE COUPLER	4	0.2	2	0.5
144C	RADIATION DETECTOR, DOSIM.	1	0.3	0	0.5
150A	RECORDER, STRIP CHART	1	11.8	0	16.9
150B	RECEIVER, BIOTELEMETRY	1	0.5	10	1
153	RECORDER, VOICE	1	1	0	1
153B	SENSORS, ASSORTED	1	0.5	0	0.3
156	SIGNAL CONDITIONERS (COUPLERS)	16	0.2	2	0.5
157	SOUND LEVEL METER	1	13.6	0	33.4
159	STAINING SYSTEM	2	2.2	0	3.5
165	STERILIZER, TOOL	1	1	110	1
174	TANK, VERTEBRATE WATER	2	8.5	5	28.3
175B	THERMOCOUPLE INDICATOR	1	6	5	9.4
179	TEMPERATURE BLOCK	1	4.5	200	1.7
179A	THERMOCOUPLES	1	0.5	0	0.3
179D	THERMOMETER, ELECTRONIC	1	5.4	14	6.7
180	TIMER, EVENT	2	0.2	0	0.2
181D	TRANSDUCER, PRESSURE	4	0.2	1	0.4
182J	VCG COUPLER	1	0.2	2	0.5
182P	VERTEBRATE ECS	1	38	320	121
185	MULTIMETER	1	2	0	2.4
188	WORK AND SURGICAL BENCH	1	136	1000	420

APPENDIX C

LABORATORY AND BIORESEARCH CENTRIFUGE LAYOUT DRAWINGS

APPENDIX C

LABORATORY AND BIORESEARCH CENTRIFUGE LAYOUT DRAWINGS

This appendix contains the major drawings produced in the study. They are presented in the following order:

Laboratory

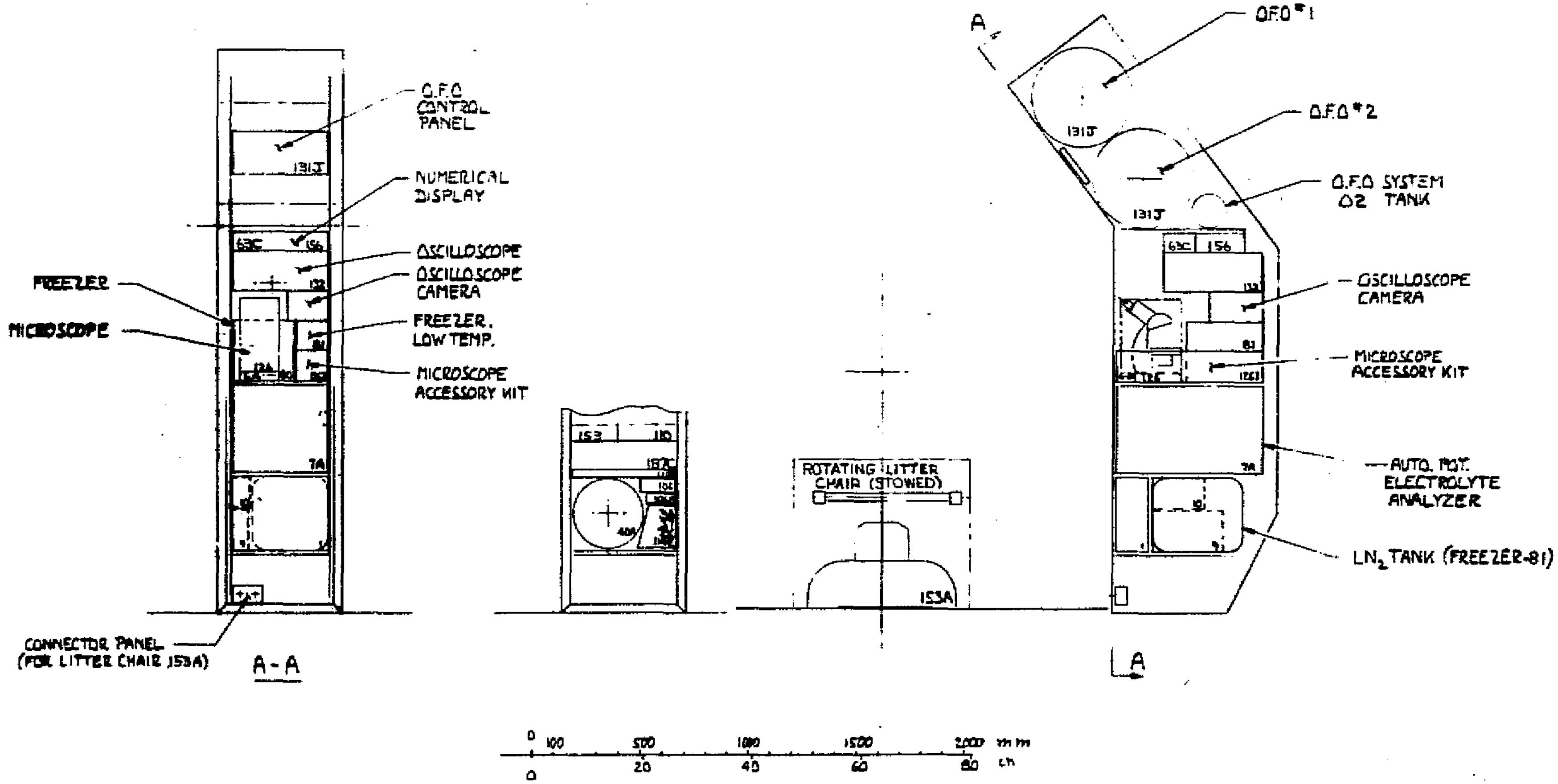
Mini-lab ML-1A
Mini-lab ML-2A
Mini-lab ML-3A
Mini-lab ML-4A
Mini-lab ML-5A
Mini-lab ML-2B
Mini-lab ML-2C
Mini-lab ML-2D
Dedicated MOD IA
Dedicated MOD IIA
Dedicated MOD IIIA
Dedicated MOD IIB
Dedicated MOD IIC
Dedicated MOD IIIB

Bioresearch Centrifuge

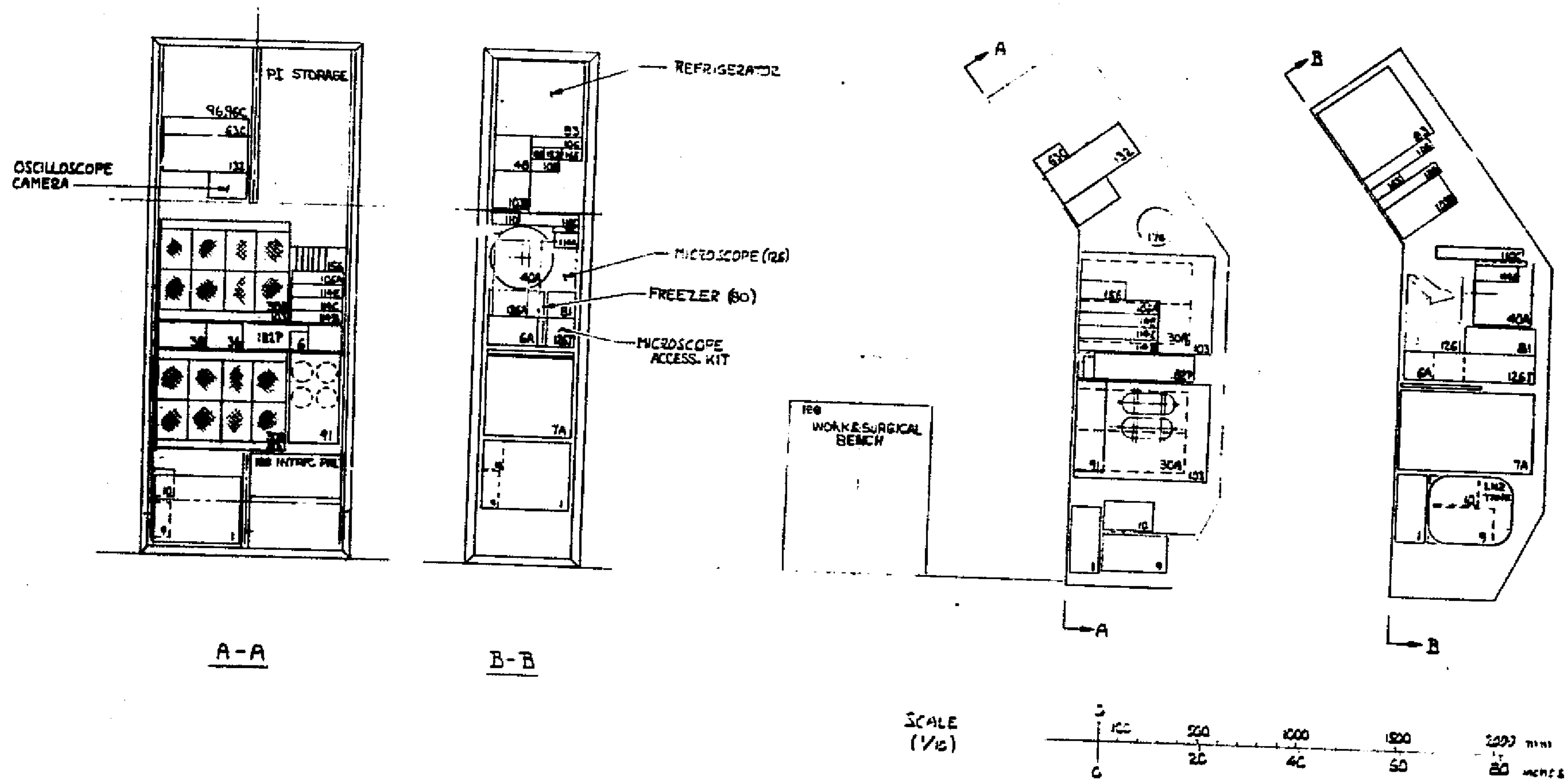
Accommodation Concept A
Accommodation Concept B
Accommodation Concept C
Accommodation Concept D
Accommodation Concept E
Accommodation Concept F
Detail Design A
Detail Design B
Detail Design D

The numbers given in the laboratory drawings refer to the equipment item (EI) number. The identification and characteristics of each EI are found in the respective laboratory equipment listing in Appendix B. The units labeled "1," "9," and "10," however, are Spacelab hardware — electrical power switch panel, dc-converter and remote acquisition unit (RAU), respectively.

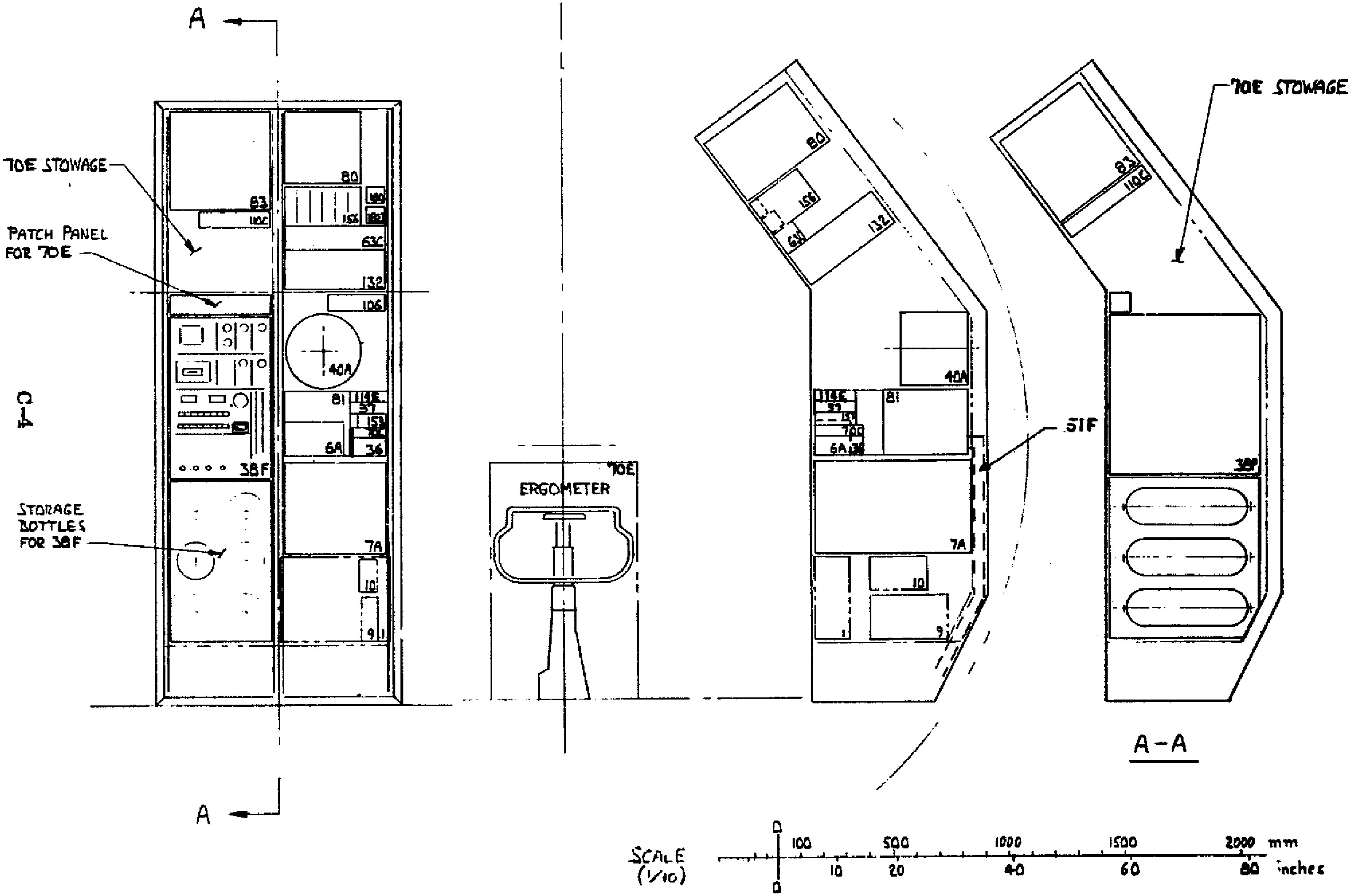
MINI-LAB ML-1A



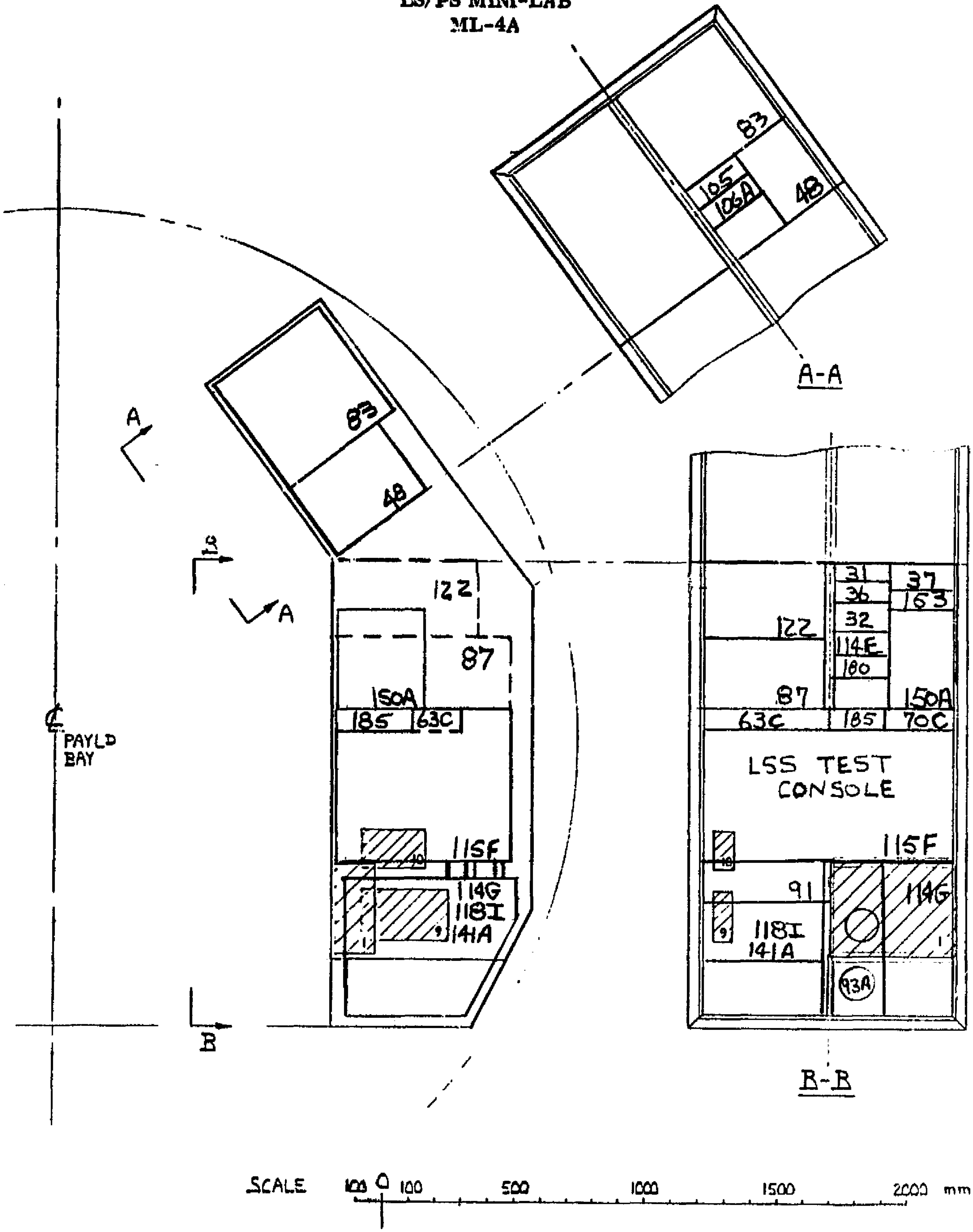
MINI-LAB ML-2A



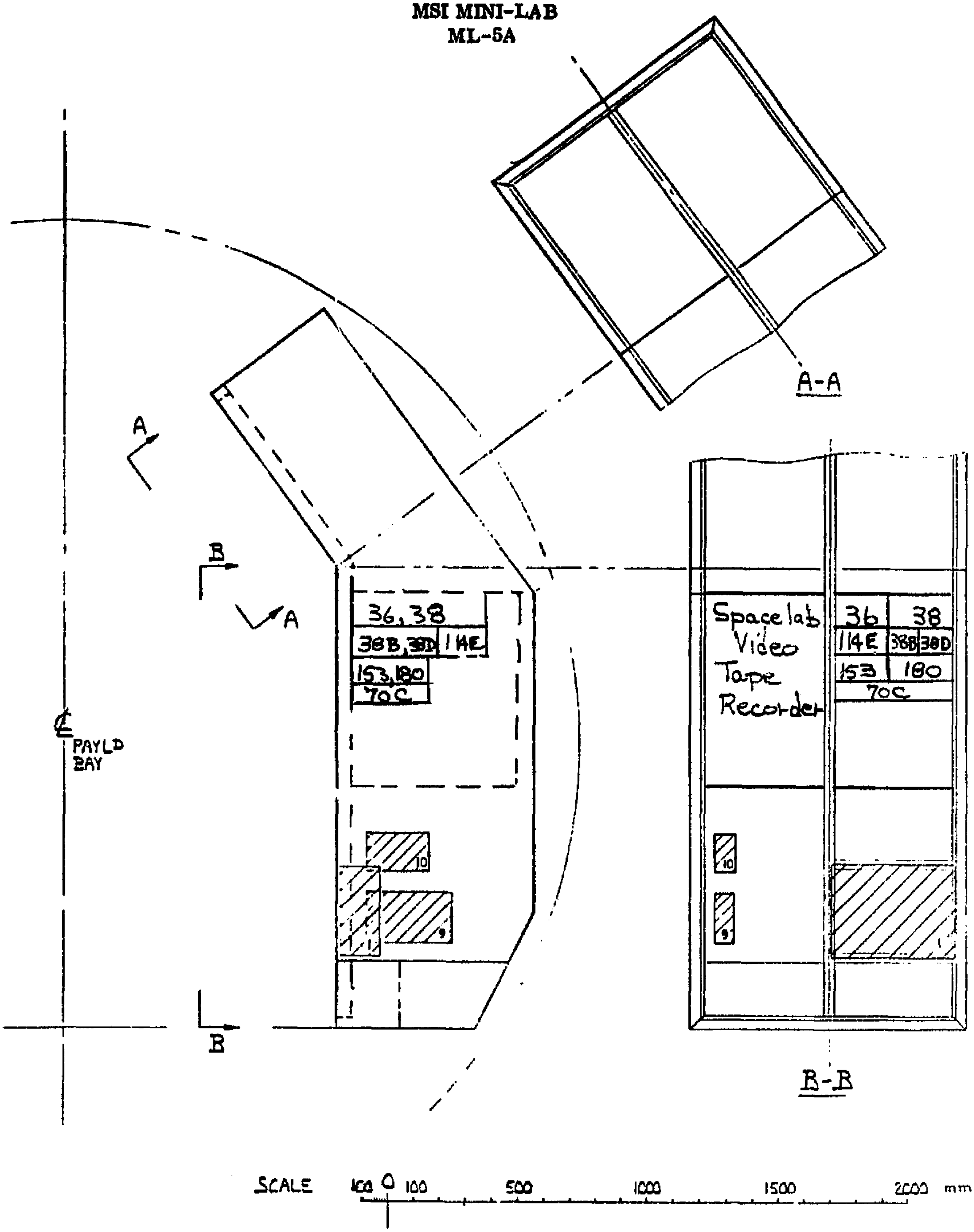
MINI-LAB ML-3A



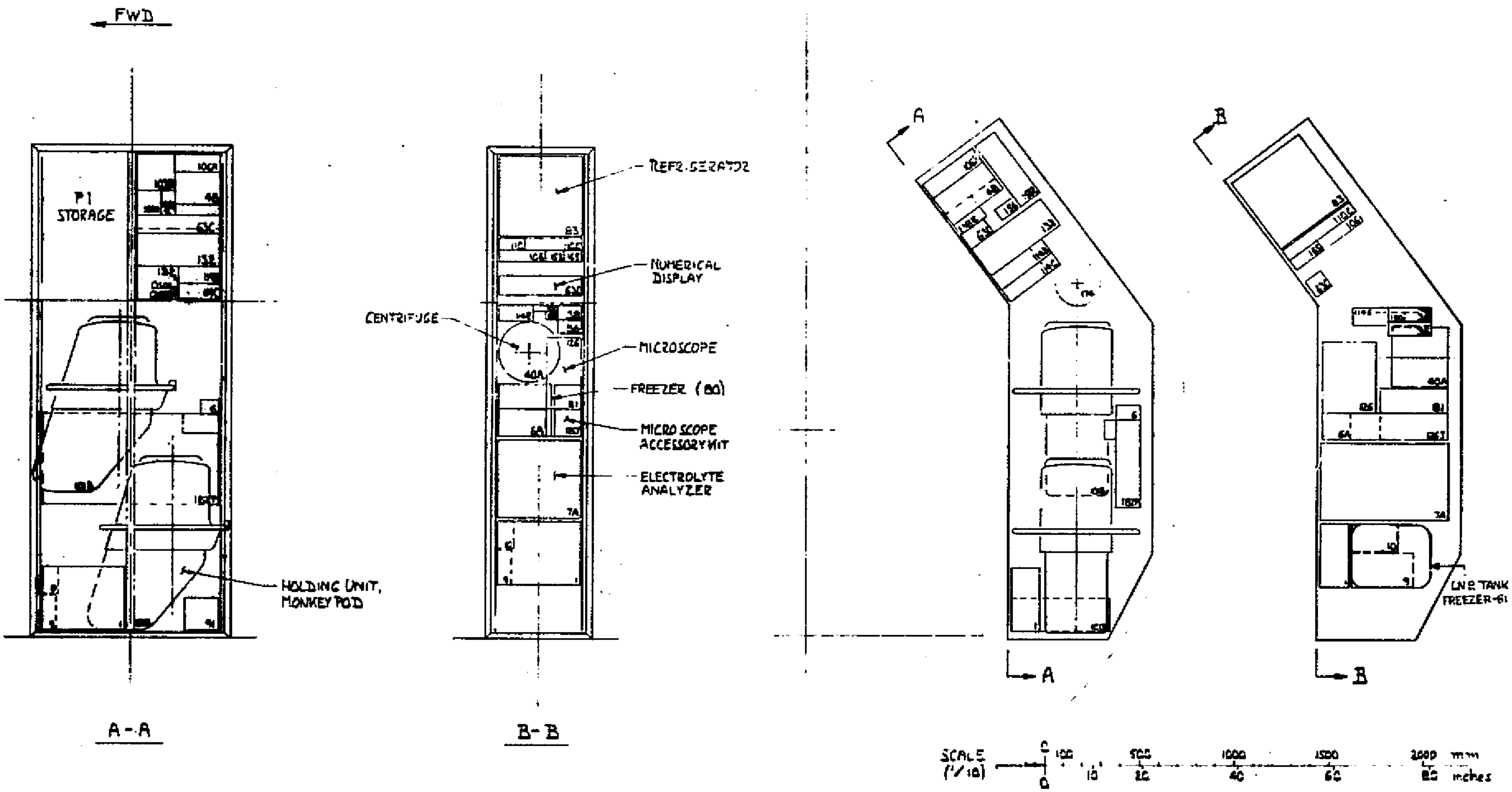
LS/PS MINI-LAB
ML-4A



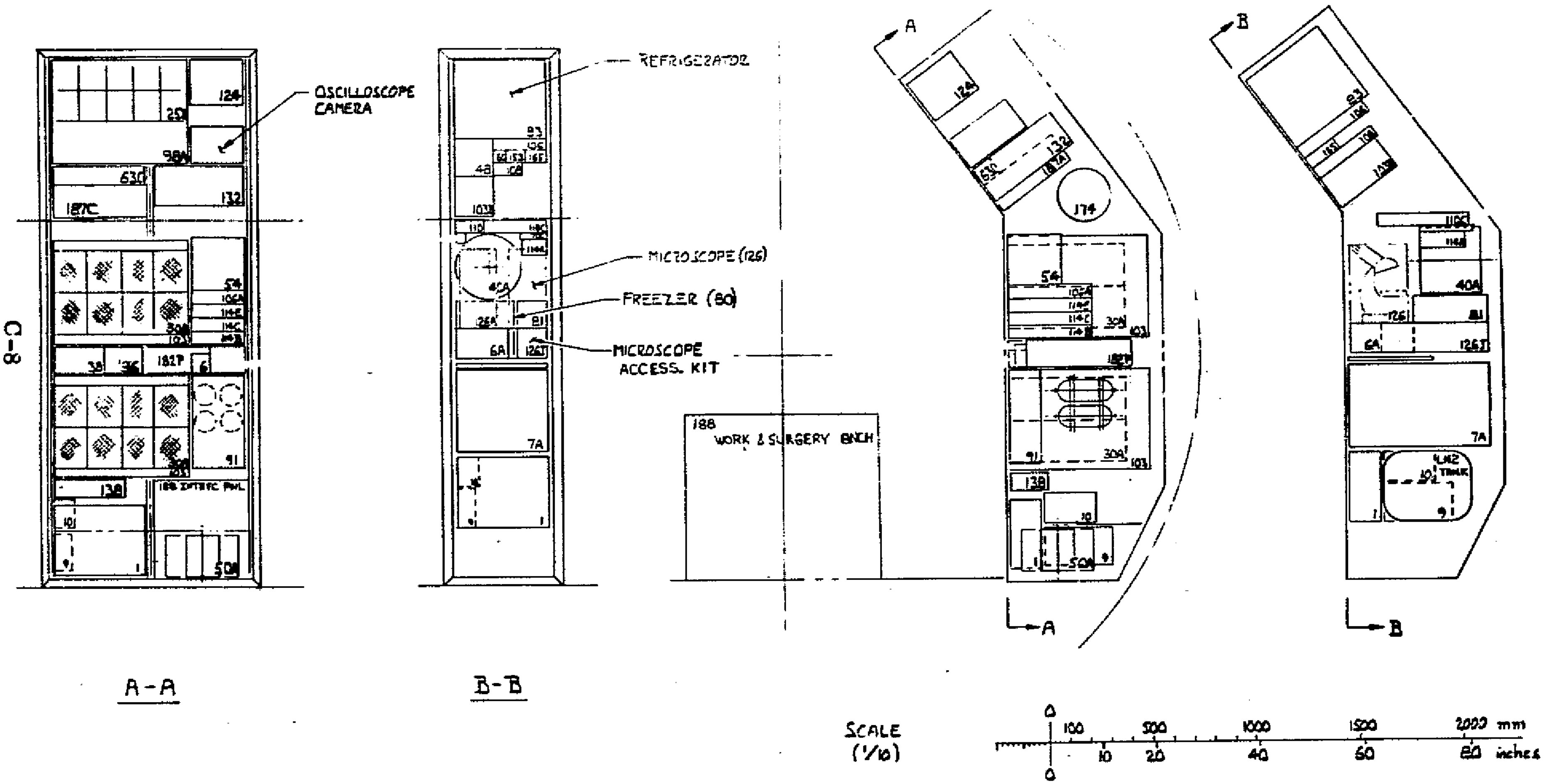
MSI MINI-LAB
ML-5A



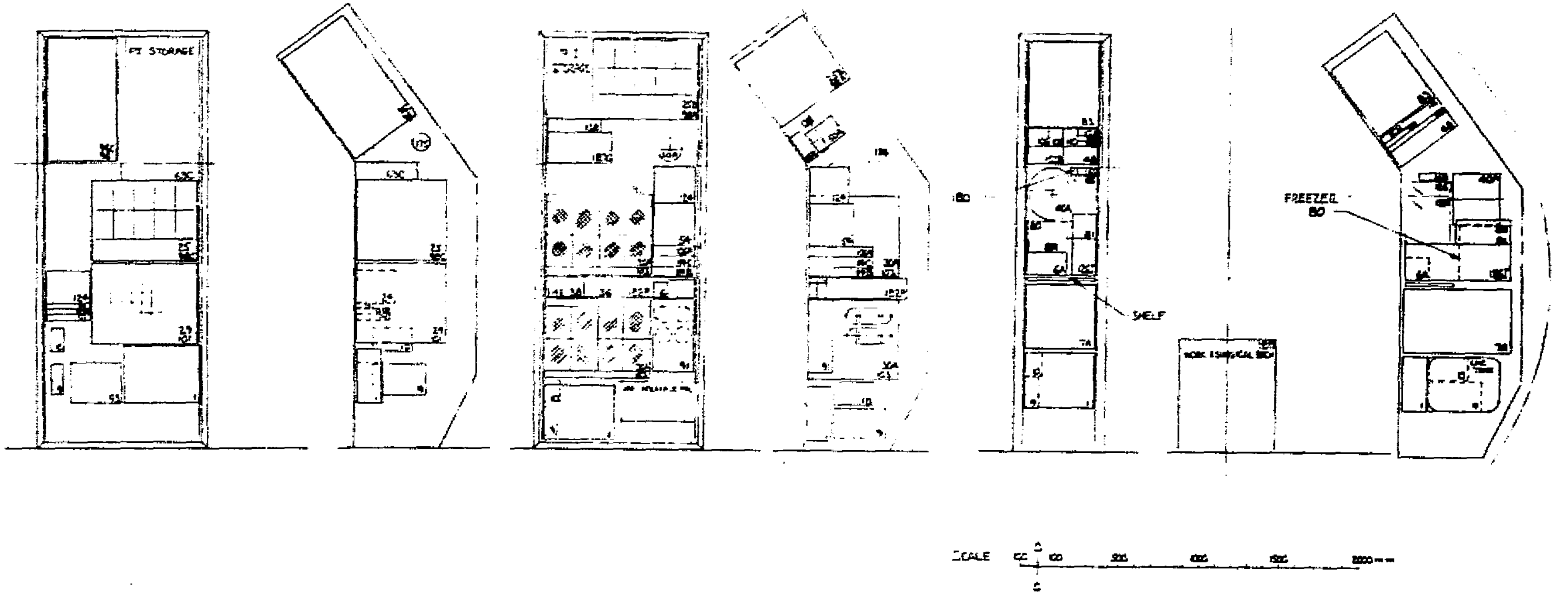
MINI-LAB ML-2B



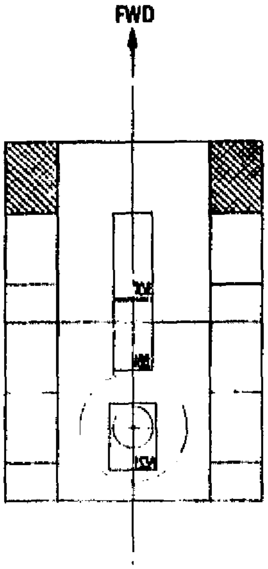
MINI-LAB ML-2C

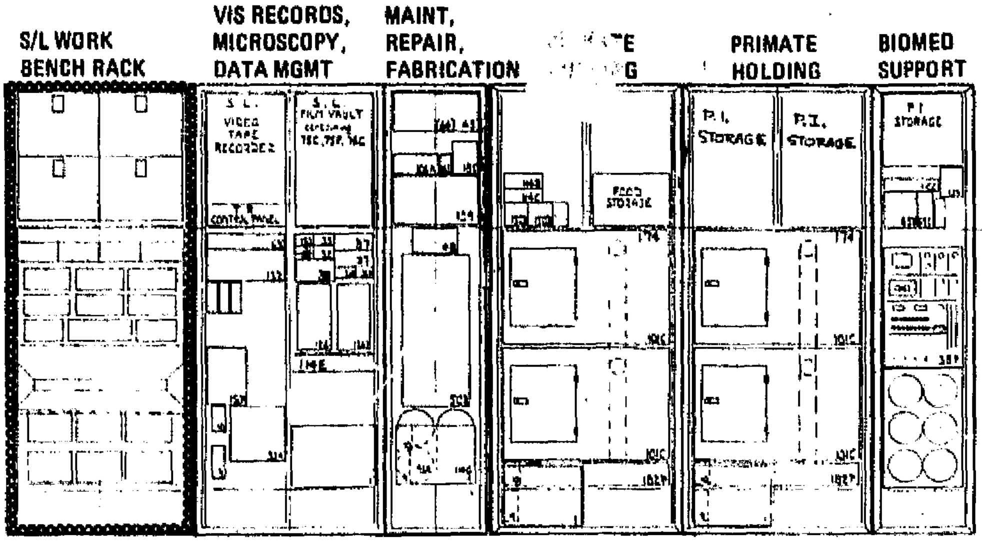


BIOLOGY MINI-LAB ML-2D

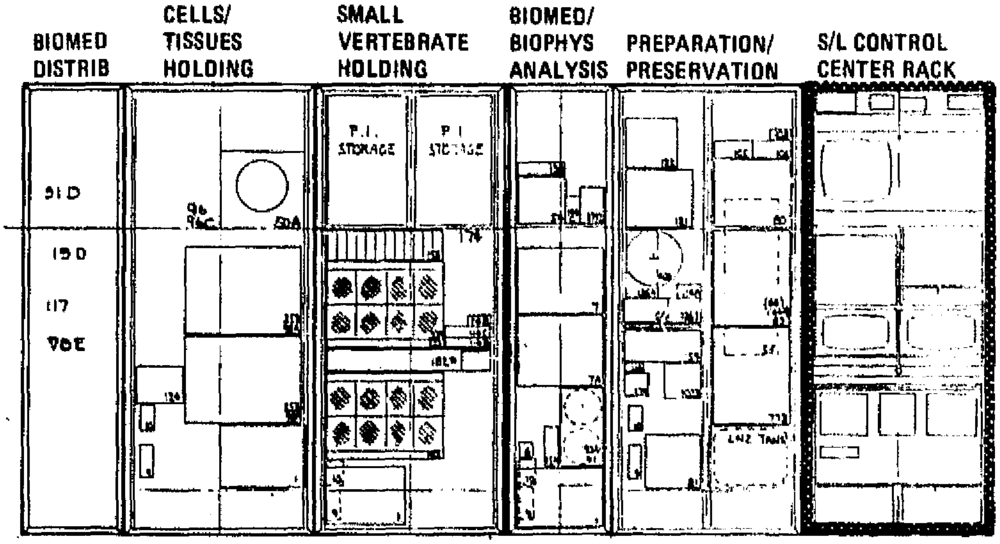


DEDICATED MOD I A



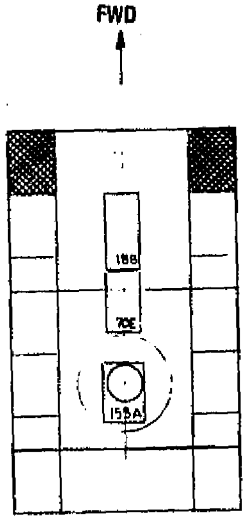


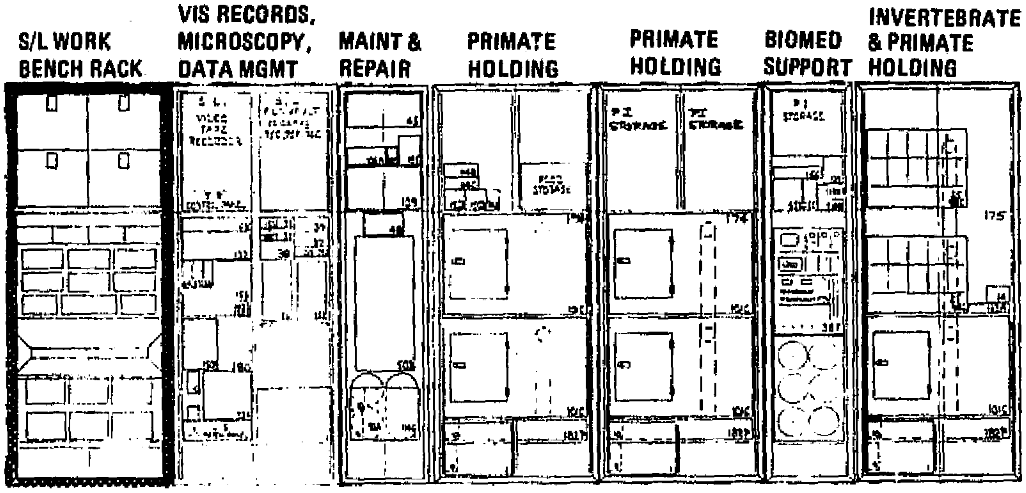
STARBOARD VIEW



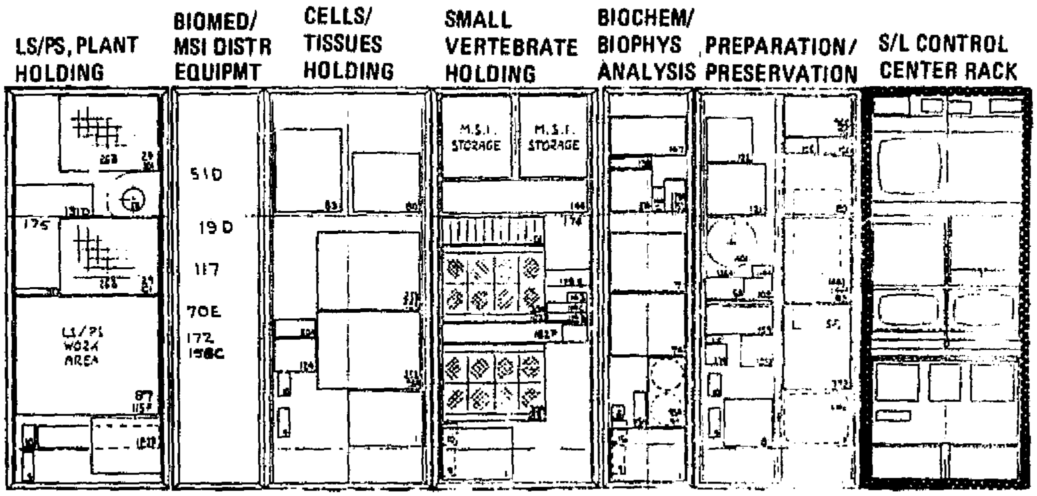
PORT VIEW

DEDICATED MOD II A



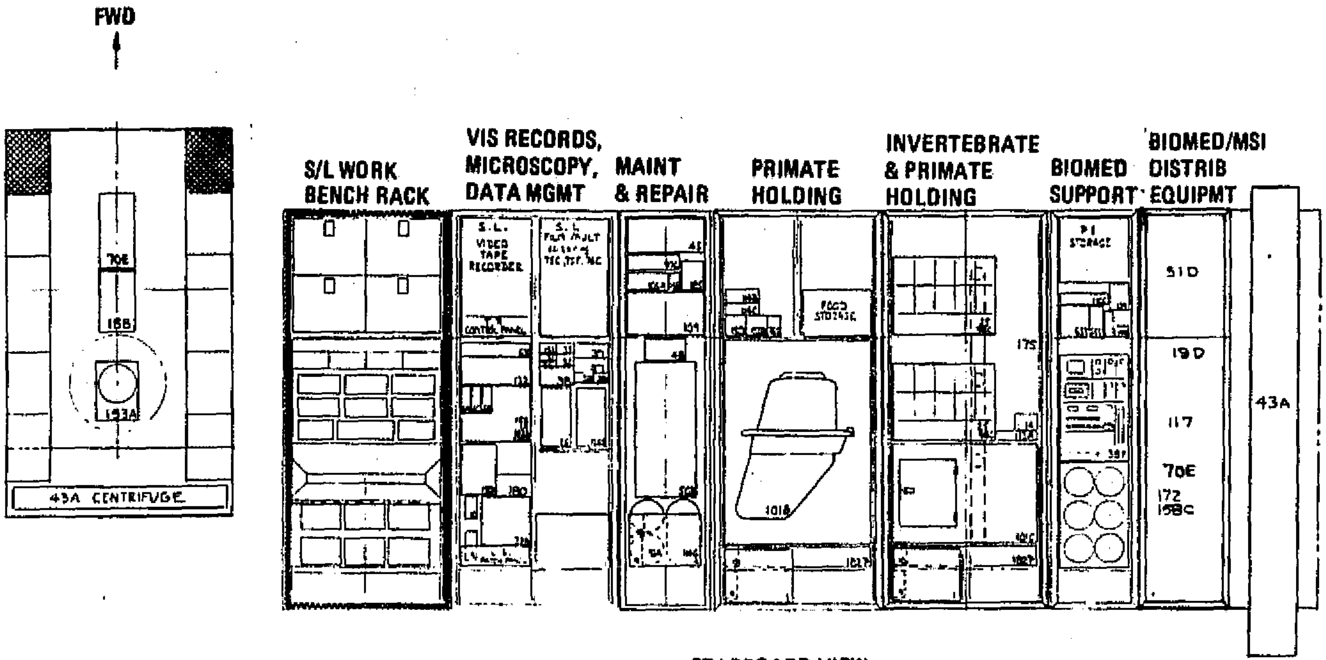


STARBOARD VIEW

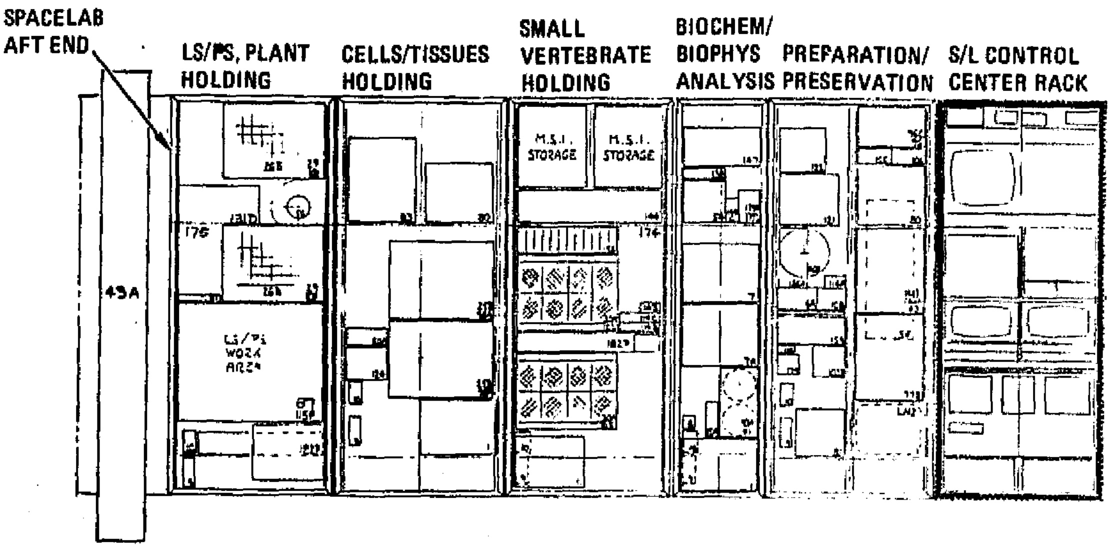


PORT VIEW

DEDICATED MOD III A



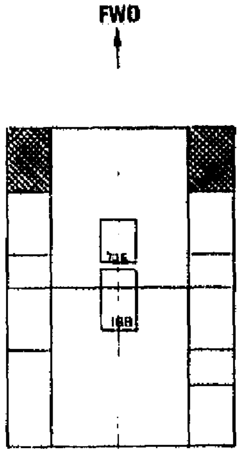
STARBOARD VIEW

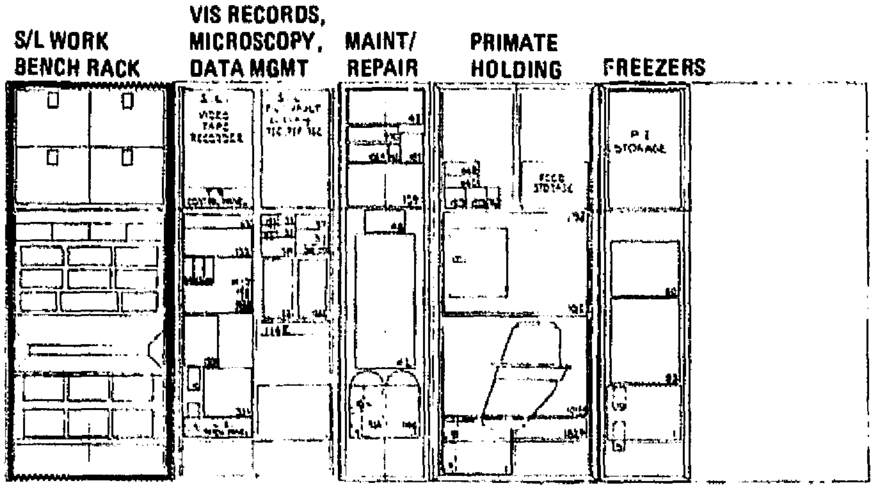


PORT VIEW

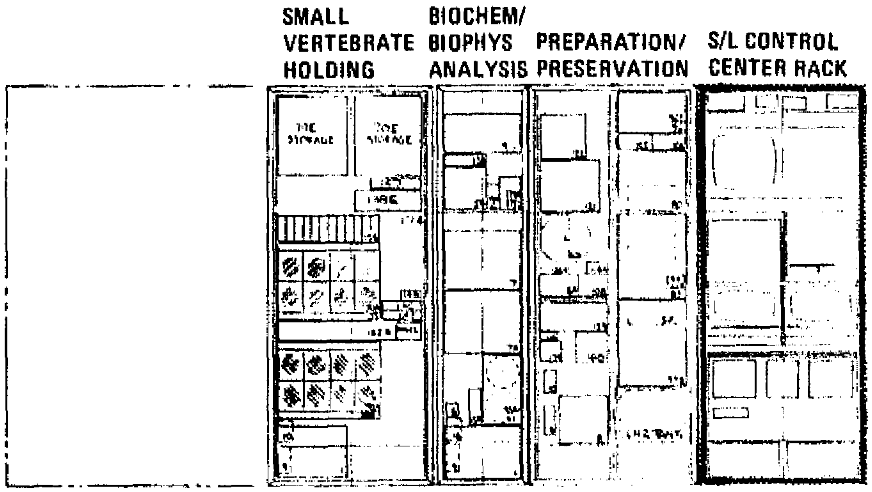
DEDICATED MOD II B

DEDICATED MOD II C



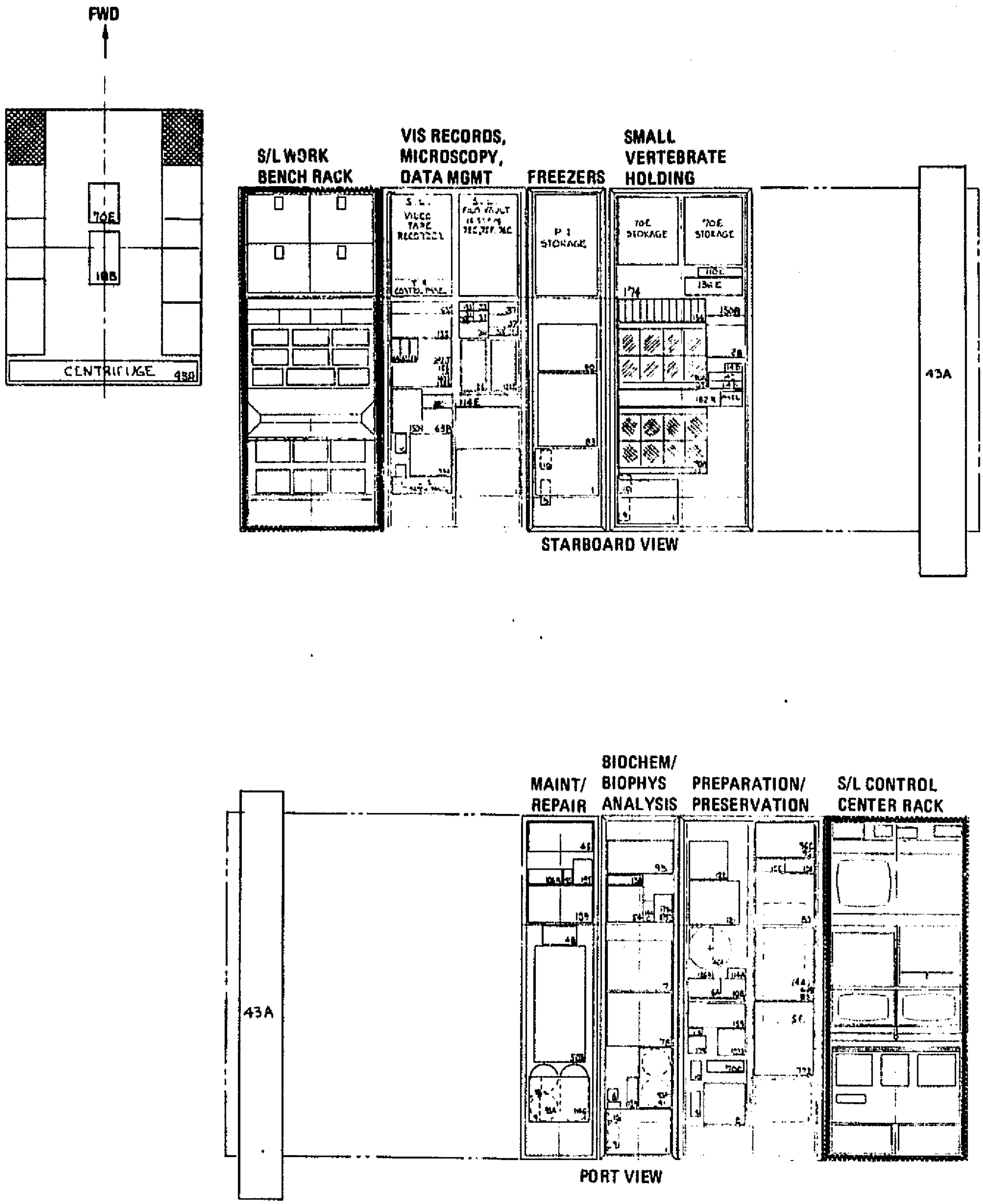


STARBOARD VIEW

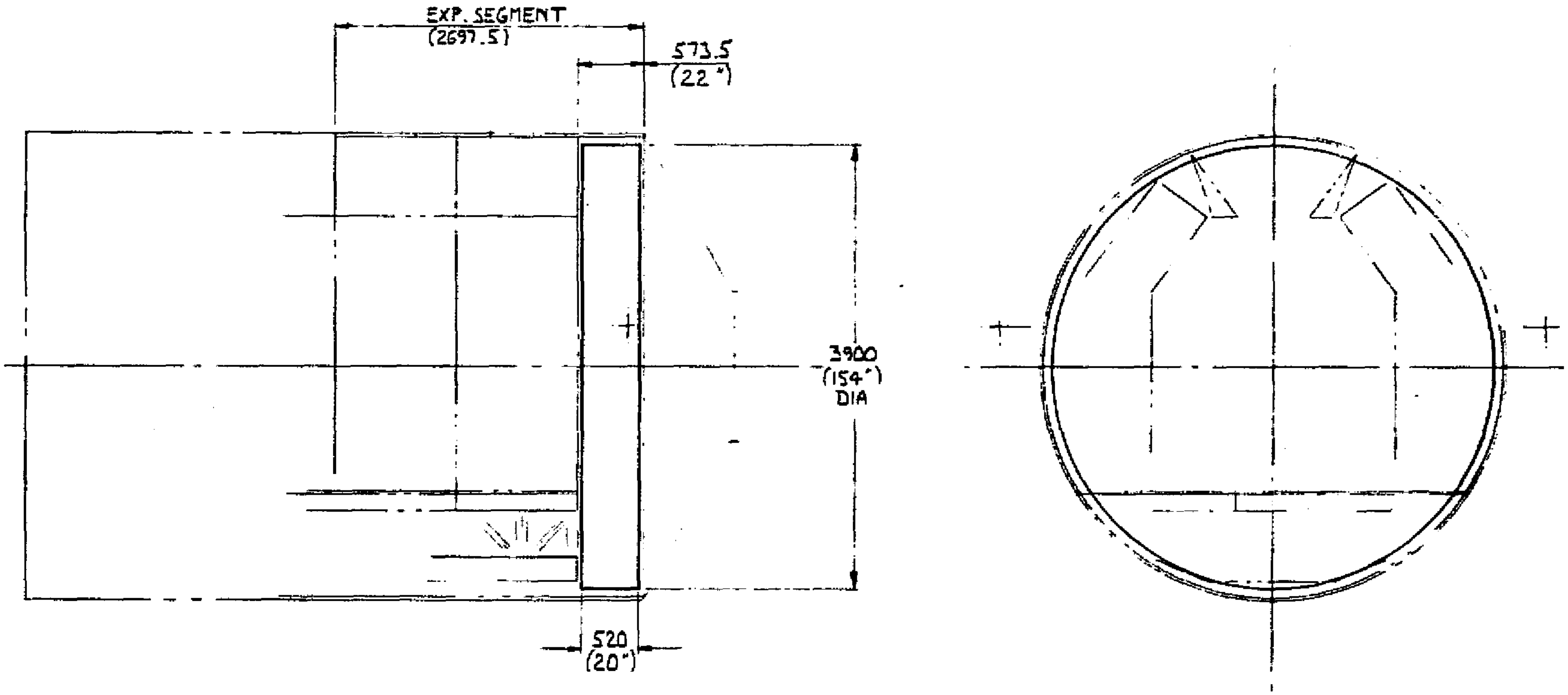


PORT VIEW

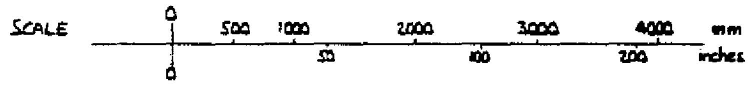
DEDICATED MOD III B



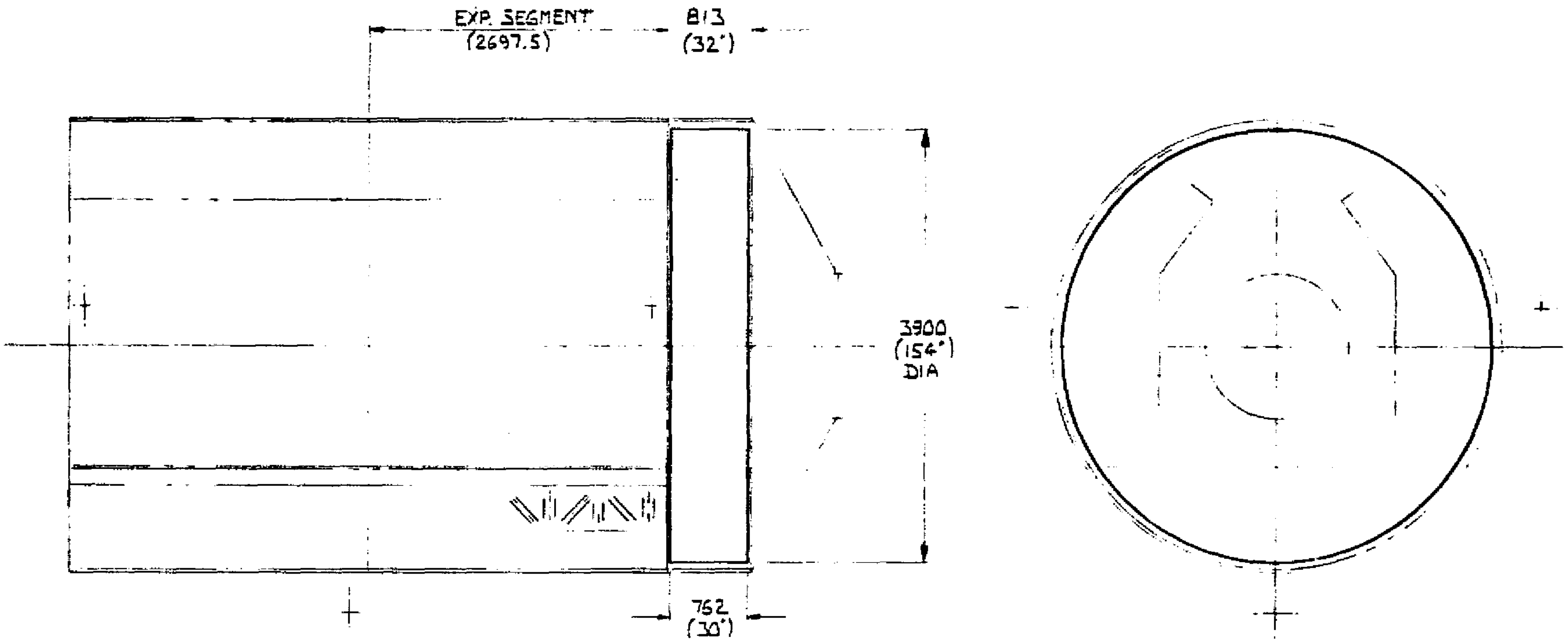
BIORESEARCH CENTRIFUGE ACCOMMODATION CONCEPT A



- 154" CENTRIFUGE ACCOMMODATED WITHIN AFT BAY OF EXISTING EXP. SEGMENT AXIAL LENGTH RESTICTED TO APPROX. 20"
- WITHIN THIS 20" SECTION ALL RACKS, FLOOR BEAMS AND CEILING STRUCT. ARE REMOVED. ALL SYSTEMS ARE RE-ROUTED OR RELOCATED.
- LOSS OF RACK SPACE 10%
  LOSS OF CREW SPACE 10%
  LAB. MODULE MODIFICATION 5%

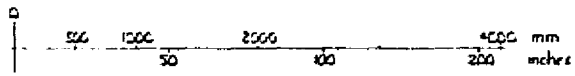


BIORESEARCH CENTRIFUGE ACCOMMODATION CONCEPT B

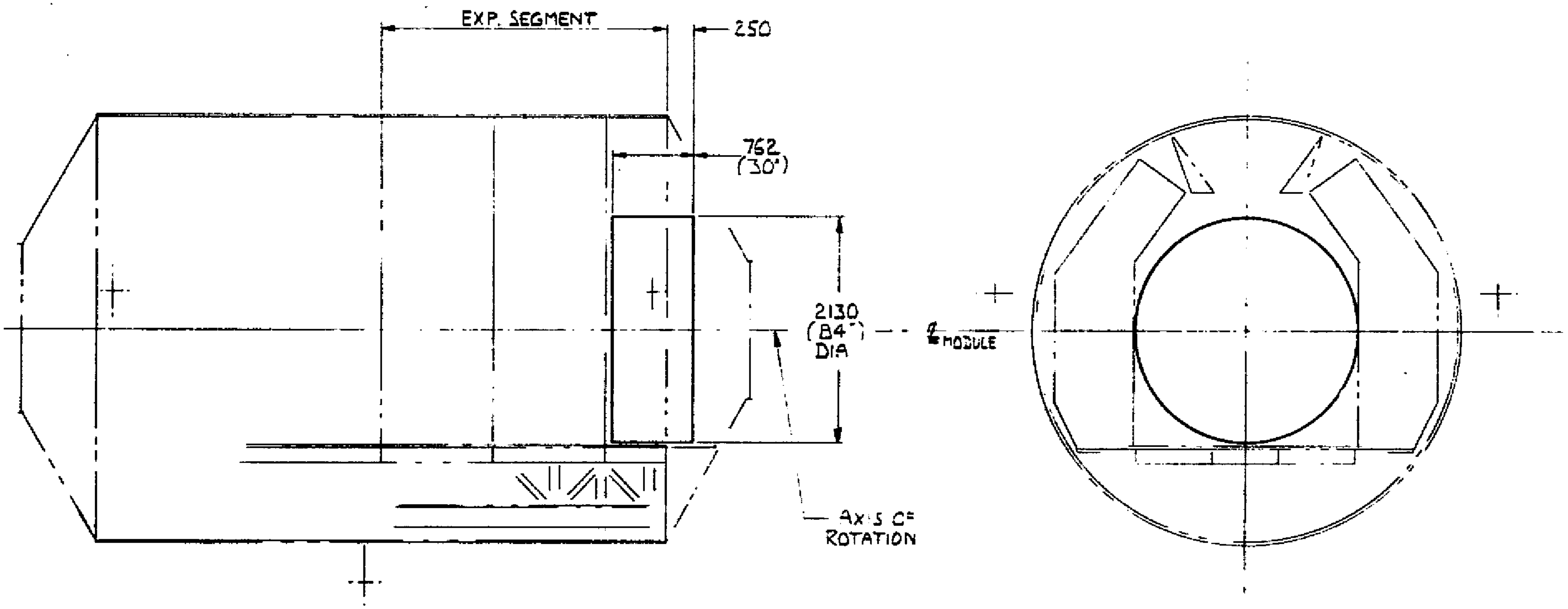


- 154" DIA CENTRIFUGE ACCOMMODATED IN 32" EXTENSION TO EXISTING EXP. SEGMENT
- SINGLE PIECE EXTENSION STRUCT. INCORPORATING END CONE, OR CYLINDRICAL EXTENSION STRUCT. PLUS EXISTING END CONE, THE LATTER RESULTING IN AN ADDITIONAL SEALED JOINT.
- NO IMPACT ON EXISTING EXP. SEGMENT STRUCTURE OR SYSTEMS.
- NO IMPACT ON EXISTING RACK CAPACITY OR CREW SPACE
- NEW STRUCT. DESIGN TASK 10 TO 15 %
  NEW STRUCT. FAB. TASK 5 TO 20 %

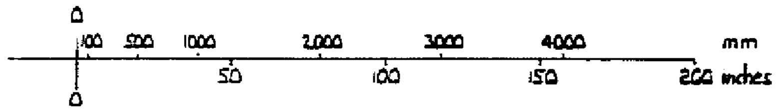
SCALE



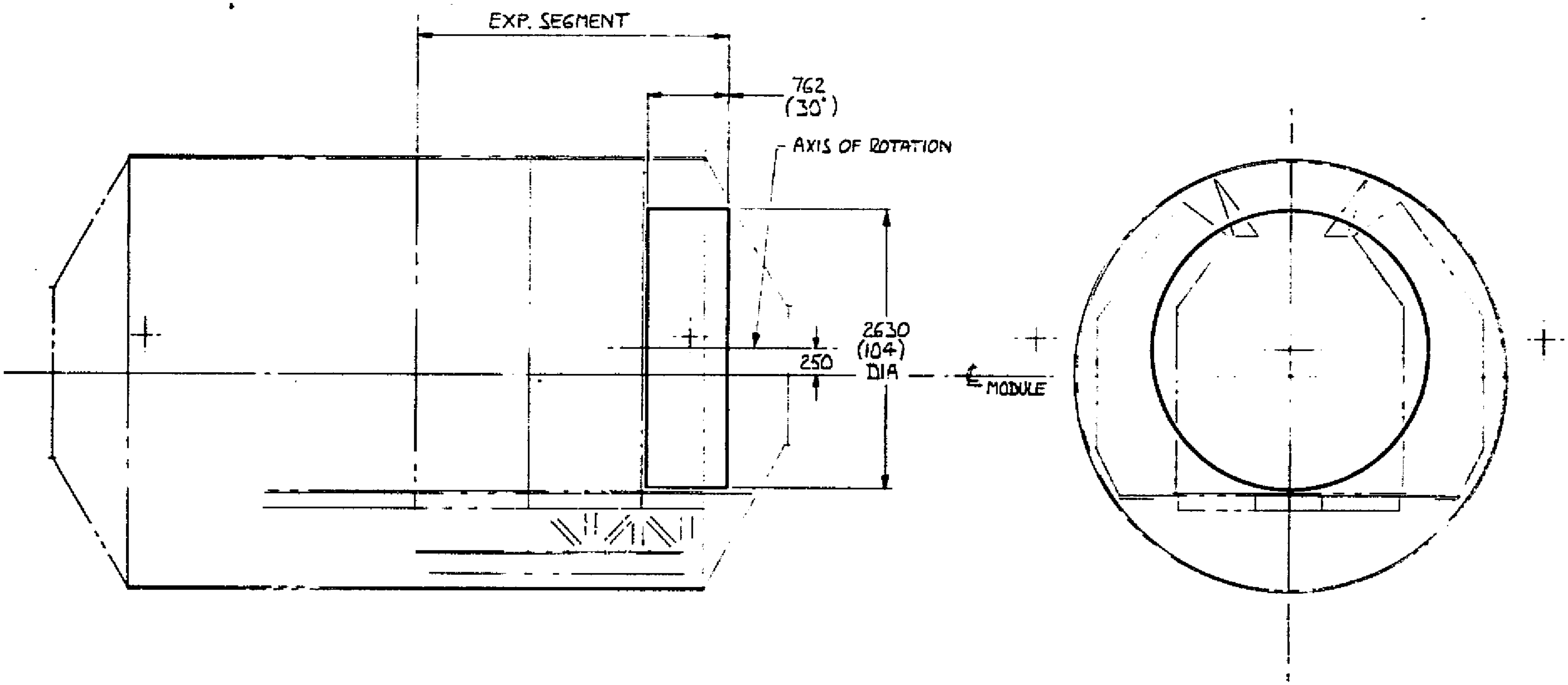
BIORESEARCH CENTRIFUGE ACCOMMODATION CONCEPT C



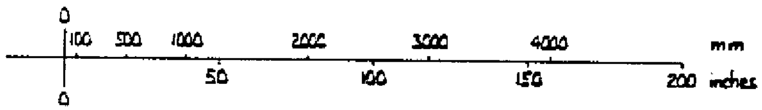
- 84" DIA CENTRIFUGE ACCOMMODATED WITHIN EXISTING EXP. SEGMENT
- NO IMPACT ON EXISTING EXP. SEGMENT STRUCTURE AND SYSTEMS
- NO LOSS OF RACK SPACE
- LOSS OF CREW SPACE - 12 %



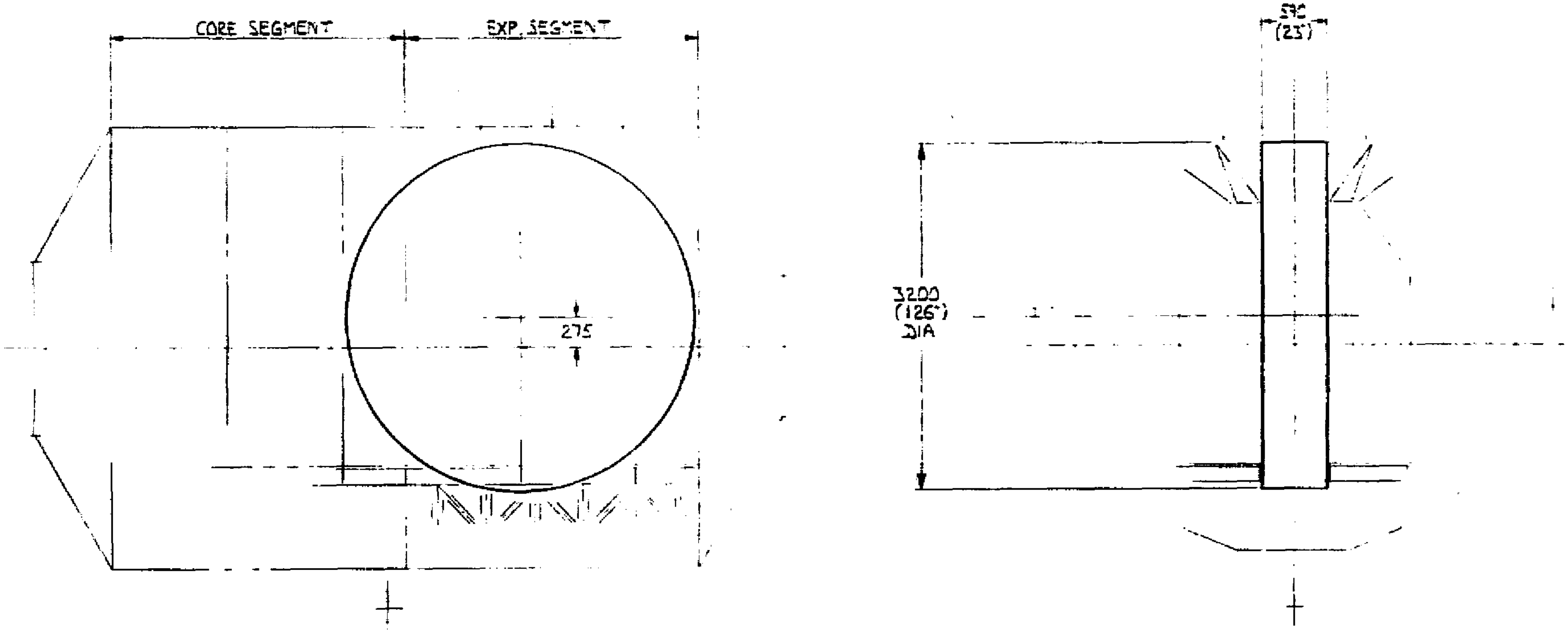
BIORESEARCH CENTRIFUGE ACCOMMODATION CONCEPT D



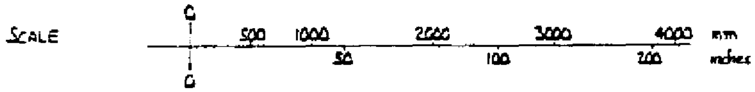
- 104" DIA CENTRIFUGE ACCOMMODATED WITHIN EXISTING EXP. SEGMENT
- CEILING STRUCT. MODIFIED TO CLEAR CENTRIFUGE, OTHERWISE NO IMPACT ON EXISTING EXP. SEGMENT STRUCTURE AND SYSTEMS.
- LOSS OF CREW SPACE – 13%
- LOSS OF RACK SPACE – 10%



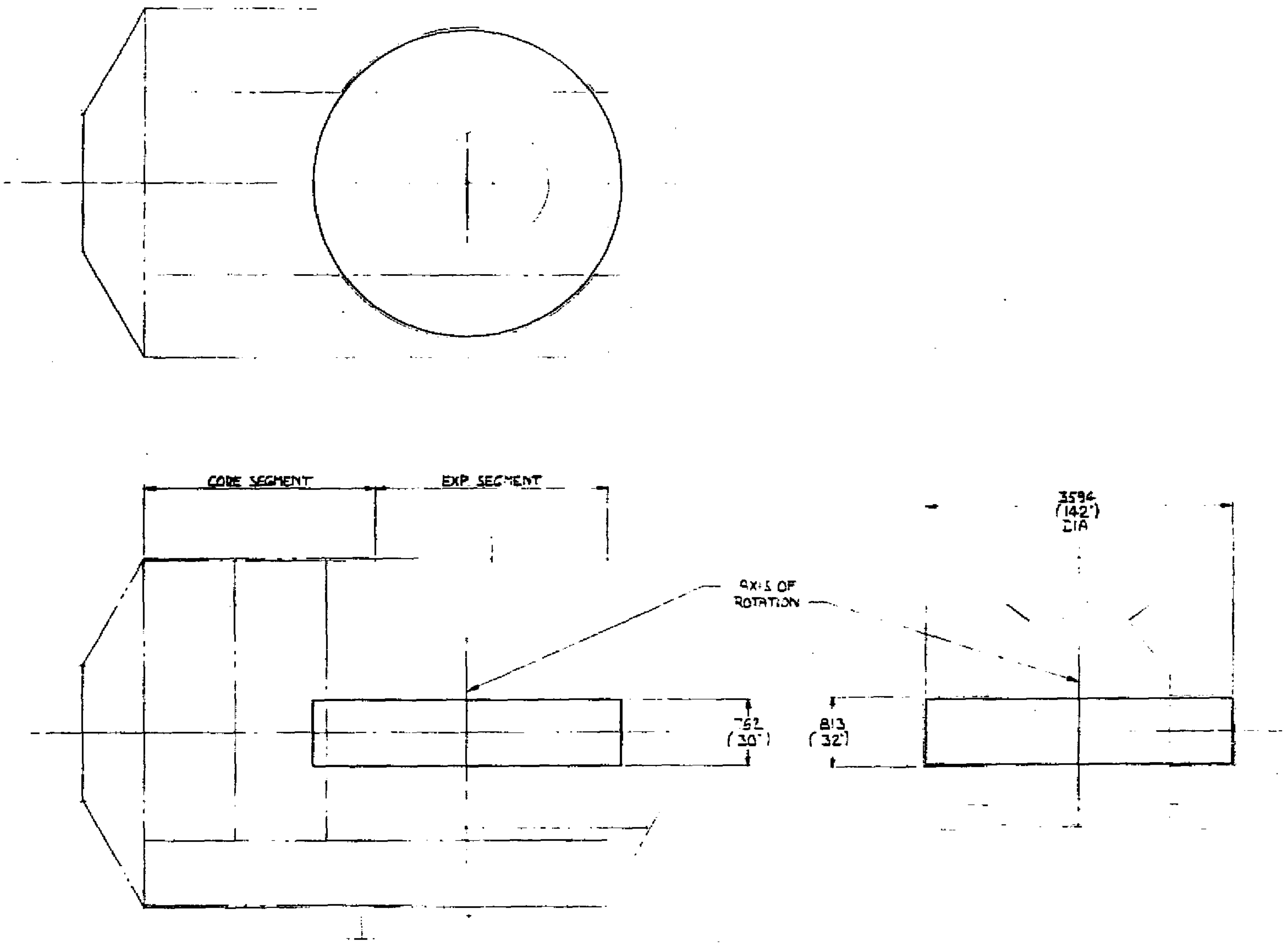
BIORESEARCH CENTRIFUGE ACCOMMODATION CONCEPT E



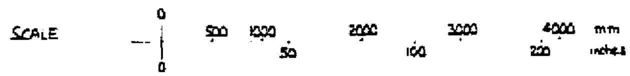
- 126" CENTRIFUGE ACCOMMODATED WITHIN EXISTING EXP. SEGMENT AXIAL LENGTH RESTRICTED TO APPROX. 23" BY INTERNAL STRUCTURE
- MINIMAL IMPACT ON STRUCTURE AND SYSTEMS
- NO IMPACT ON EXISTING RACK CAPACITY
- MAJOR CREW SPACE IMPEDIMENT



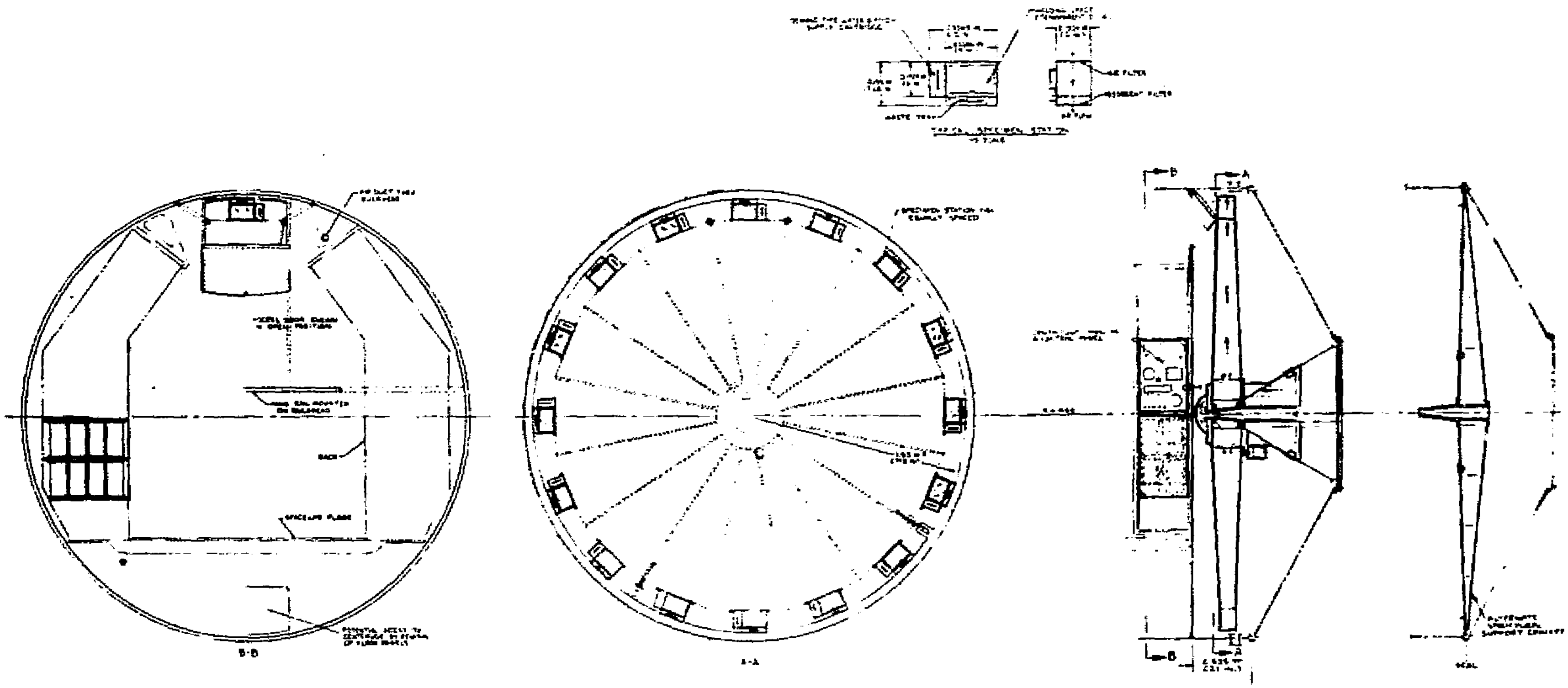
BIORESEARCH CENTRIFUGE ACCOMMODATION CONCEPT F



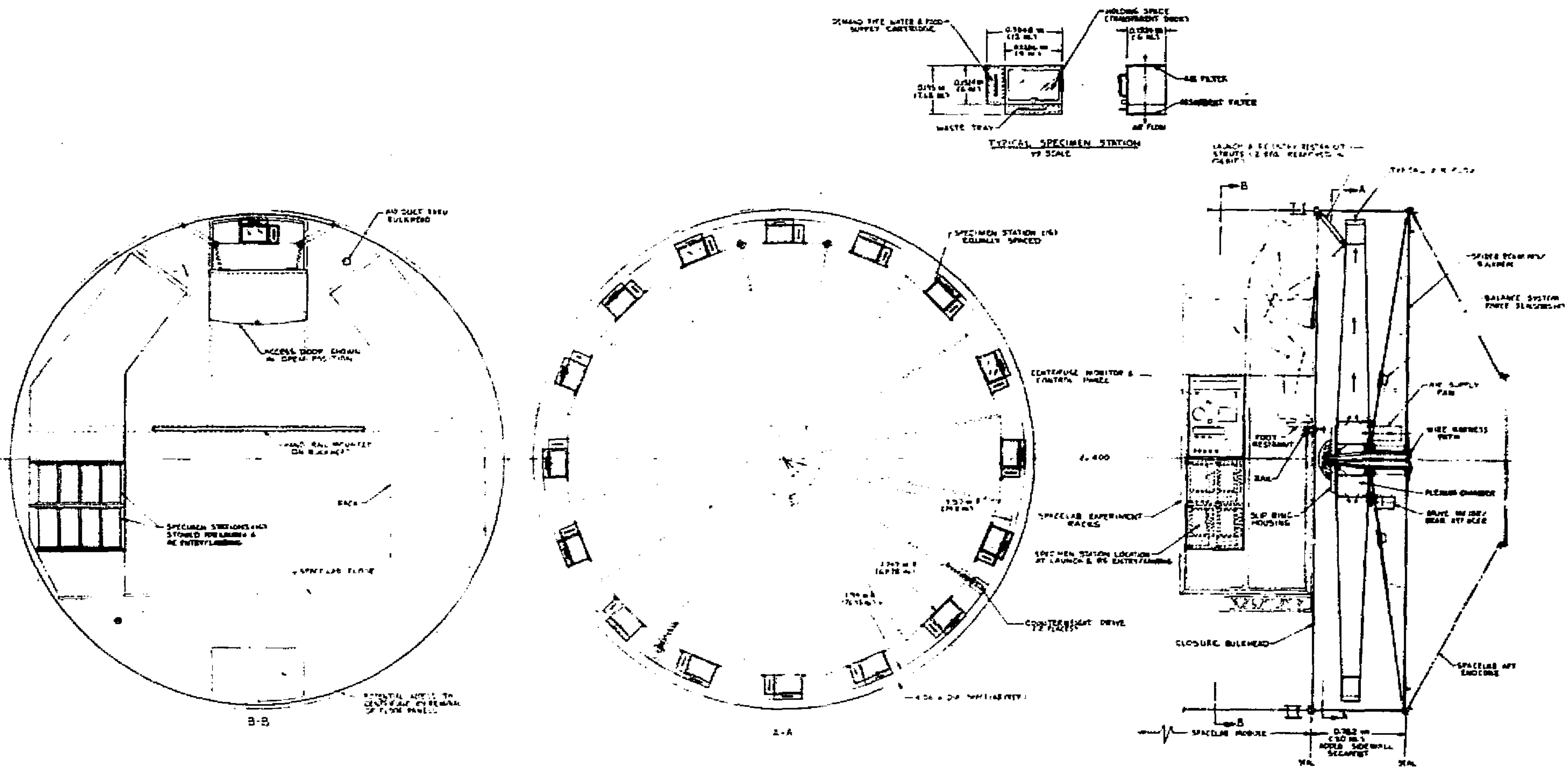
- 142" DIA CENTRIFUGE ACCOMMODATED WITHIN EXISTING EXP. SEGMENT
- FOUR DOUBLE AND FOUR SINGLE RACKS REDESIGNED TO CLEAR CENTRIFUGE ENVELOPE. LOSS OF RACK SPACE 15%
- NO IMPACT ON EXISTING EXP. SEGMENT STRUCTURE AND SYSTEMS
- MAJOR CREW SPACE IMPEDIMENT



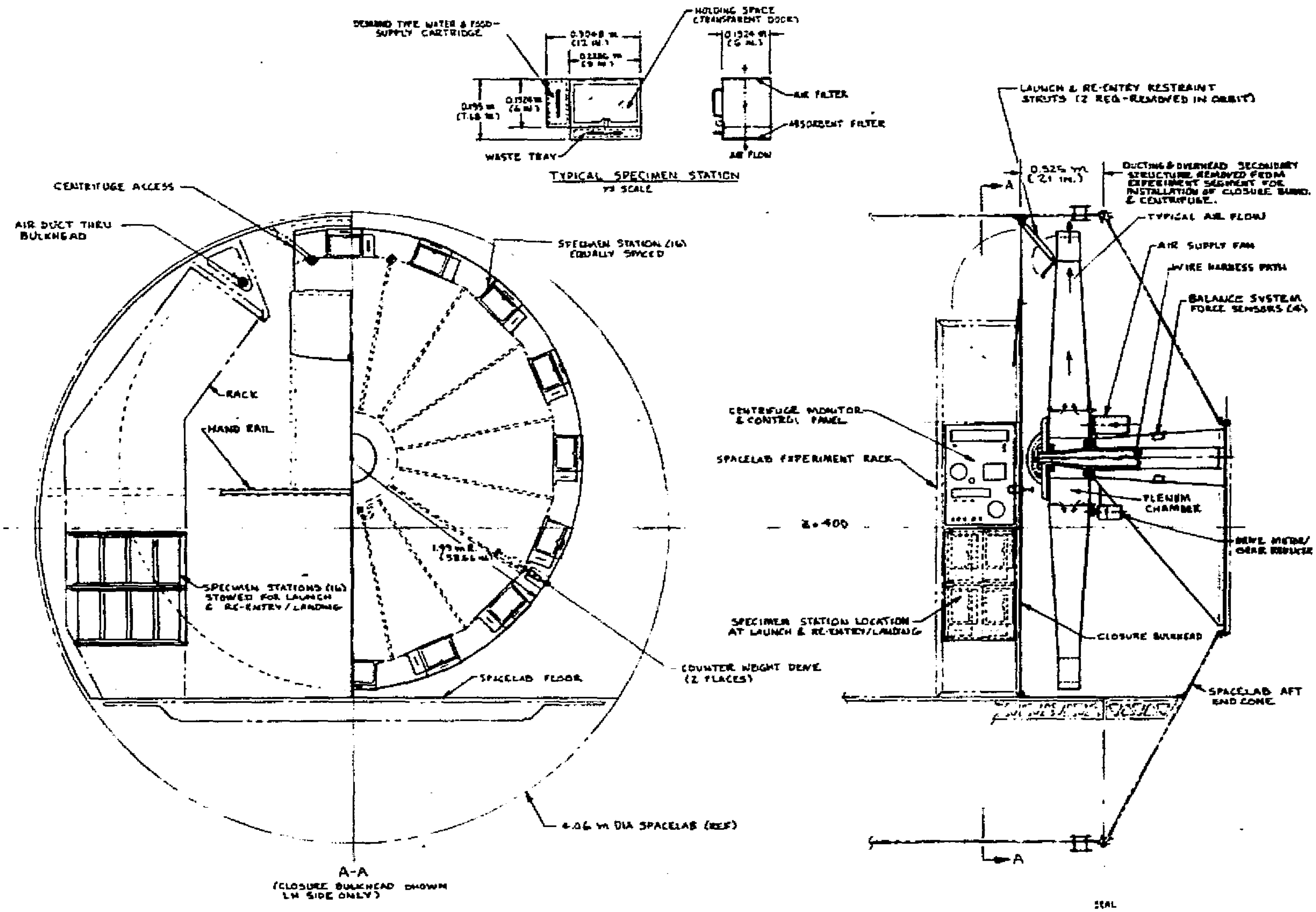
BIORESEARCH CENTRIFUGE DETAIL DESIGN A



BIORESEARCH CENTRIFUGE DETAIL DESIGN B



BIORESEARCH CENTRIFUGE DETAIL DESIGN D



APPENDIX D

LABORATORY POWER AND ENERGY REQUIREMENTS

APPENDIX D

LABORATORY POWER AND ENERGY REQUIREMENTS

The power and energy requirements for the 16 life sciences laboratory concepts are given in this appendix. The payloads are covered in the following order.

Type	Designation
Carry-On	Col-2A
	Col-3A
Mini-Lab	ML-1A (first Spacelab mission)
	ML-2A
	ML-3A
	ML-4A
	ML-5A
	ML-2B
	ML-2C
	ML-2D
Dedicated	MOD 1A
	MOD IIA
	MOD IIIA
	MOD IIB
	MOD IIC
	MOD IIIB

POWER AND ENERGY REQUIREMENT SUMMARY

LAB CODE: COL 2A		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
40A Cent. - Blood Sample	100	.10	.42	100	10	0	0
81 Freezer (-70°C)	10	24	10	10	240	10	10
	110		10.42	110	250	10	10

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: COL 3A

			ORBIT OPERATIONS					ASCENT	DESCENT
	Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day		Watts	Watts
81	Freezer (-20°C)	10	24	10	10	240		10	10

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-1A

Equipment Items Using Power	Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
6A Airflow, Work Surface	75	.2	1.25		15	0	0
7A Auto. Poten. Elec. Analy.	100	1	8.33		100	0	0
37 Camera, Video B/W	15	.5	.63	15	7.5	0	0
40A Cent. Blood Sample	100	.2	1.67		20	0	0
51F Coolant Loop, Liquid	50	24	50	50	1200	0	0
63C Display Numeric	2	8	1.33	2	16	0	0
80 Freezer	200	8	66.67	200	1600	0	0
81 Freezer (Low Temp.)	10	24	10	10	240	10	10
114E Lamp. Port. Hi Int. Photo.	150	.5	6.25	150	75	0	0
126 Microscope	15	.5	.63		7.5	0	0
126J Microscope Ass. Kit	15	.5	.63		7.5	0	0
131J OFO Exp. Pack (2)	40	24	40	40	960	40	40
132 Oscilloscope	75	1	6.25		75	0	0
153A RLC/Console	127	.4	4.23	127	50.8	0	0
156 Signal Conditioners (6)	12	24	12	12	288	0	0
187A Woodlawn Wander	15	24	15	15	360	15	15
TOTALS	1001		224.87	621	5022.3	65	65

Off Duty Power = $\frac{5022.3-224.87 \times 12}{12} = 193.7$

Estimated Crew Involvement
≈2 man-hrs/day during a 12-hour period

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-2A

			ORBIT OPERATIONS				ASCENT	DESCENT
	Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
6	Air Part. Sampler	50	.2	.83		10.0	0	0
6A	Work Surface, Air Flow	75	.2	1.25		15	0	0
7A	Auto. Poten. Elect. Anal.	100	1.0	8.33	100	100	0	0
30A	Cage - Rat (16)	144	12	144	144	1728	0	0
38	Camera, Video Color	69	.5	2.88	69	34.5	0	0
40A	Cent. Blood Samp.	100	.2	1.67		20	0	0
48	Vacuum Cleaner	100	.1	.83		10	0	0
51F	Coolant, Loop Liq.	50	24	50	50	1700	50	50
63C	Display, Numeric	2	12	2	2	24	0	0
80	Freezer, Gen.	200	8	66.67	200	1600	0	0
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator	50	8	16.67	50	400	0	0
91	Mass Spec.	50	1	4.17		30	0	0
103B	Incubator	5	24	5	5	120	0	0
114E	Lamp, Port. Hi Int.	150	.5	6.25	150	75	0	0
126	Microscope, Comp.	15	.5	.63		7.5	0	0
126A	Microscope, Dissect.	100	1.0	8.33	100	100	0	0
126J	Microscope, Acc. Kit	15	.5	.63		7.5	0	0
132	Oscilloscope	75	1.0	6.25		75	0	0
156	Signal Cond. (12)	24	24	24	24	576	0	0
165	Sterilizer Tool	110	.2	1.83		22	0	0
182P	Vent. Unit, Sm. Vert.	40	24	40	40	960	40	40
188	Work and Surgical Bench	1000	1	83.33	1000	1000	0	0
		2534		486.05	1944	8374.5	50	50

Off Duty Power - $\frac{8374.5 - 486.05 \times 12}{12} = 211.83$

Payload Spec. - 8 man/hrs/day available

On Duty - 12 hours

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-3A

	Equipment Items Using Power	Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
6A	Work Surface Air Flow	75	.2	1.25		15	0	0
7A	Auto. Pot. Elec. Analy.	100	1.0	8.33	100	100	0	0
37	Video, Camera B/W	15	.5	.63		7.5	0	0
38F	Cardiopul. Anal.	200	1	16.67	200	200	0	0
40A	Cent. Blood Sampler	100	.2	1.67	100	20	0	0
51F	Coolant, Loop Liq.	50	24	50	50	1200	0	0
63C	Display, Numeric	2	12	2.0	2	24	0	0
70E	Physio. Exer. Equiment	18	4	6	18	72	0	0
80	Freezer, Gen.	200	8	66.67	200	1600	0	0
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator	50	8	16.67	50	400	0	0
132	Oscilloscope	75	1.0	6.25		75	0	0
156	Signal Conditioners (6)	12	24	12.0	12	288	0	0
182	V.C.G. Coupler	2	4	.67		8	0	0
		859		198.81	742	4249.5	10	10

Off Duty Power $- \frac{4249.5 - 198.81 \times 12}{12} = 155.8$

Payload Specialist - 8 man/hrs/day available
On Duty 12 hours

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-4A

Equipment Items Using Power		Operating Power (Watts)	Orbit Operations: On Time Hrs/Day	Orbit Operations: Average On Duty Power	Orbit Operations: Peak Power Contribution	Orbit Operations: Energy Consumption Watt-hrs/Day	Ascent: Watts	Descent: Watts
32	Camera, Cine	13	.5	.54		6.5	0	0
37	Camera, Video B/W	15	.5	.63	15	7.5	0	0
48	Cleaner, Vacuum	100	.2	1.67	100	20.0	0	0
63C	Display, Numeric	2	8	1.33	2	16	0	0
76J	Flowmeter (4)	4	8	2.67	4	32		
83	Refrigerator	50	8	16.67	50	400	0	0
87	Gas Analyzer, Infra.	50	4	16.67	50	200	0	0
91	Mass Spectrometer	50	.5	2.0		25.0	0	0
114E	Lamp, Port. Photo	150	1	12.5	150	150	0	0
122	Mass Meas. Device	15	.2	.25		7.5	0	0
		449		54.93	371	864.5	0	0

Off Duty Power $= \dfrac{864.5 - 54.93 \times 12}{12} = 17.11$

Payload Spec. 8 man/hrs/day available
On Duty = 12 hours

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-5A

Equipment Items Using Power		Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
38	Camera, Video Color	69	2	11.5	69	138	0	0
38D	Camera, Video Timer	10	2	1.67	10	20	0	0
114E	Lamp, Portable Photo	150	2	25	150	300	0	0
		229		38.17	229	458		

Payload Spec. - 8 man/hrs/day available
On duty 12 hours

Off Duty Power - $\frac{458 - 38.17 \times 12}{12} = 0$

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-2B			ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power		Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
6	Air Part. Samp. Collector	50	.2	.83		10	0	0
6A	Work Surface, Air Flow	75	.2	1.25		15	0	0
7A	Auto. Poten. Elec. Anal.	100	1.0	8.33	100	100	0	0
38	Camera, Video Color	69	.5	2.88	69	34.5	0	0
40A	Cent. Blood Samp. Proc.	100	.2	1.67		20	0	0
48	Vacuum Cleaner	100	.1	.83		10	0	0
51F	Coolant Loop, Liq.	50		50	50	1200	0	0
63C	Display, Numeric	2	12	2	2	24	0	0
80	Freezer, Gen.	200	8	66.67	200	1600	0	0
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator	50	8	16.67	50	400	0	0
91	Mass Spectrometer	50	1.0	4.17	50	50	0	0
101B	Holding Unit, Monkey Pod (2)	200/60	12/12	200	200	3120	60	60
103B	Incubator	5	24	5	5	120	0	0
114E	Lamp, Port. Hi Int.	150	.5	6.25	150	75	0	0
126	Microscope, Compound	15	.5	.63		7.5	0	0
126J	Microscope, Acc. Kit	15	.5	.63		7.5	0	0
132	Oscilloscope	75	1.0	6.25		75	0	0
150B	Receiver	10	24	10	10	240	0	0
156	Signal Conditioners (6)	12	24	12	12	288	0	0
165	Sterilizer, Tool	110	.2	1.83		22	0	0
182P	Ventilation Unit (2)	80	24	80	80	1920	80	80
		1528		487.89	988	9578.5	150	150

Off Duty Power $- \dfrac{9578.5 - 487.89 \times 12}{12} = 310.3$

Payload Spec. - 8 man/hrs/day available
On Duty 12 hours

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-2C

			ORBIT OPERATIONS				ASCENT	DESCENT
	Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
6	Air Part. Sampler	50	.2	.83		10	0	0
6A	Work Surface Air Flow	75	.2	1.25		15	0	0
7A	Auto. Poten. Elec. Analy.	100	1.0	8.33	100	100	0	0
30A	Cage, Rat (16)	144	12	144	144	1728	0	0
38	Camera, Video Color	69	.5	2.88	69	34.5	0	0
40A	Cent. Blood Samp.	100	.2	1.67		20	0	0
48	Vacuum, Cleaner	100	.1	.83		10	0	0
50	Clinostat	10	24	10	10	240	0	0
51F	Coolant Loop, Liq.	50	24	50	50	1200	0	0
54	Colony Counter	50	.5	2.08		25	0	0
63C	Display, Numeric	2	12	2	2	24	0	0
80	Freezer, Gen.	200	8	66.67	200	1600	0	0
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator	50	8	16.67	50	400	0	0
91	Mass Spectrometer	50	1.0	4.17		50	0	0
98A	Holding Unit C/T	50	12	50	50	600	0	0
103B	Incubator 37°C	5	24	5	5	120	0	0
114E	Lamp, Port. Hi Int.	150	.5	6.25	150	75	0	0
126	Microscope Acc. Kit	15	.5	.63		7.5	0	0
126A	Microscope, Dissect.	100	1.0	8.33	100	100	0	0
126J	Microscope, Comp.	15	.5	.63		7.5	0	0
132	Oscilloscope	75	1.0	6.25		75	0	0
138	pH Meter	20	.1	.17		2	0	0
156	Signal Conditions (12)	24	24	24	24	576	0	0
165	Sterilizer, Tool	110	2	1.83		22	0	0
182P	Ventilation Unit, Sm. Vt.	40	24	40	40	960	40	40
187A	Woodlawn Wanderer	15	24	15	15	360	15	15
188	Work and Surgical Bench	1000	1	83.33	1000	1000	0	0
		2609		562.80	2019	9601.5	65	65

Off Duty Power = $\frac{9601.5 - 562.80 \times 12}{12} = 237.82$

Payload Spec. - 8 man/hrs/day availability
On Duty - 12 hours

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: ML-2D

	Equipment Items Using Power	Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
6	Air Part. Sampler	50	.2	.83		10	0	0
6A	Air Flow, Work Surface	75	.2	1.25		15	0	0
7A	Auto. Poten. Elec. Analy.	100	1.0	8.33	100	100	0	0
30A	Cage, Rat (16)	144	12	144	144	1728	0	0
38	Camera, Video Color	69	.5	2.88	69	34.5	0	0
40A	Cent. Blood Samp. Proc.	100	.2	1.67		20	0	0
48	Cleaner, Vacuum	100	.1	.83		10	0	0
50	Clinostat	10	24	10	10	240	0	0
51F	Coolant Loop, Liq.	50	24	50	50	1200	0	0
54	Colony Counter	50	.5	2.08		25	0	0
63C	Display, Numeric	2	12	2	2	24	0	0
80	Freezer, Gen.	200	8	66.67	200	1600	0	0
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator	50	8	16.67	50	400	0	0
91	Spectrometer, Mass	50	1.0	4.17		50	0	0
93	Gas Analyzer, H_2O Vapor	6	24	6	6	144	0	0
98A	Holding Unit C/T	50	12	50	50	600	0	0
98C	Holding Unit Invert.	50	12	50	50	600	0	0
101	Holding Unit, Plants	500	12	500	500	6000	187	187
103B	Incubator 37°C	5	24	5	5	120	0	0
114E	Lamp, Port., Hi Int.	150	.5	6.25	150	7.5	0	0
126	Microscope Acc. Kit.	15	.5	.63		7.5	0	0
126A	Microscope, Dissect.	100	1.0	8.33	100	100	0	0
126J	Microscope Comp.	15	.5	.63		7.5	0	0
132	Oscilloscope	75	1.0	6.25		75	0	0
138	pH Meter	20	.1	.17		2	0	0
156	Signal Conditions (12)	24	24	24	24	576	0	0
165	Sterilizer, Tool	110	.2	1.83		22	0	0
182P	Ventilation Unit, Vertical	40	24	40	40	960	40	40
187A	Woodland Wanderer	15	24	15	15	360	15	15
188	Work & Surgical Bench	1000	1	83.33	1000	1000	0	0
	TOTALS	3235		1118.80	2625	16345.5	252	252

Payload Specialist – 8 man/hrs/day available

On Duty – 12 hours

Off Duty Power = $\frac{16345.5 - 1118.80 \times 12}{12} = 243.33$

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD 1A			ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power		Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
1A	Accelerometer Coupler (3)	3	24	3	3	72		
6	Air Particle Sampler	50	.4	1.73		20		
6A	Airflow Work Surface	75	.5	3.12		37.5		
7	Autoanalyzer	200	1.0	16.66	200	200		
7A	Auto Potentiometer Elec. Analysis	100	1.0	8.34		100		
16F	Ballistocardiogram Coupler	1	1.0	.08		1		
19D	Body Mass Measuring Device	15	.2	.26		3		
30A	Cage, Rat (16)	144	12	144	144	1728		
31	Calculator, Pocket	5	1.0	.42		5		
32	Camera, Cine	13	.5	.54		6.5		
32A	Camera, Controller	100	12	100	100	1200		
37	Camera, Video B/W	15	12	15	15	180		
38	Camera, Video, Color	69	.5	2.88	69	34.5		
38D	Camera Timer, Video	10	.5	.42	10	5		
38F	Cardiopulmonary Analyzer	200	1.0	16.66		200		
40A	Centrifuge, Blood Sample Processor	100	.4	3.34		40		
48	Cleaner, Vacuum	100	.4	3.34		40		
50A	Clinostat C/T	10	24	10	10	240		
50B	Compactor (Solids)	100	.05	.42		5		
51F	Coolant Loop, Liquid	50	24	50	50	1200		
54	Colony Counter (Manual)	50	.5	2.08		25		
63B	Display Keyboard Portable	60	1.0	5.0		60		
63C	Display, Numeric (2)	4	12	4.0	4	48		
64	ECG Coupler (12)	24	24	24	24	576	12	12
65	EEG Coupler (4)	8	24	8	8	192	4	4
65C	Electrophys. Receiver	5	1.0	.42		5		
66	EMG Coupler (6)	12	24	12	12	288	6	6
70E	Exercise Equip., Physiol.	18	4	6		72		
76J	Flowmeter, Gas (4)	16	.5	.66		8		
77B	Freezer, Cryo	10	24	10	10	240	10	10
80	Freezer, General	200	8	66.67	200	1600		
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator	50	8	16.67	50	400		
91	Gas Analyzer, Mass Spec. (2)	50	12	100	100	1200	50	50

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD 1A (Cont'd)		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
93 Gas Analyzer, RH	6	24	6	6	144		
98A Holding Unit C&T (2)	60	24	60	60	1440		60
101C Holding Unit - Primate (4)	400/120	12/12	400	400	6240	120	120
103B Incubator	5	24	5	5	120		
114E Lamp, Portable Hi. Int. Photo.	150	.5	6.16	150	75		
117 LBNP	26	.4	.86		10.4		
121 Mass Meas. Device (Macro)	15	.3	.38		4.5		
122 Mass Meas. Device (Micro)	15	.3	.38		4.5		
126 Microscope, Comp.	15	.5	.62		7.5		
126A Microscope, Dissecting	100	1.0	8.34	100	100		
126J Microscope, Access. Kit	15	.5	.62		7.5		
132 Oscilloscope	75	1.0	6.26		75		
138 PH Meter	20	.3	.50		6		
138B Photocell Coupler (12)	24	24	24	24	576		
139 Plethysmograph, Limb	5	.5	.20		2.5		
143G Pressure Coupler (4)	8	24	8	8	192		
147 Radiation Count - Biochemical	90	.5	3.76		45		
150B Receiver, Biotelemetry	10	24	10	10	240		
153A Rotating Litter Chair/Console	127	.4	4.24		50.8		
156 Signal Conditioners (12)	24	24	24	24	576		
156F Sonocardiogram	12	1.0	1.0		12		
162 Sterilizer, Autoclave	300	1.5	37.5		450		
165 Sterilizer, Tool	110	.4	3.66		44		
179 Temperature Block	200	1.5	25	200	300		
179D Thermometer (Electronic)	14	.2	.24		2.8		
181D Transducer, Pressure (4)	4	24	4	4	96		
182J Vectocardiogram Coupler	2	1.0	.16		2		
182P Ventilation Unit - Vertical (5)	200	24	200	200	4800	200	200
188 Work and Surgical Bench	1000	1.0	83.34	1000	1000		
TOTALS	4909		1569.96	3210	26907	412	472

On Duty is considered 12 hours.

Off Duty Average Power = $\frac{26,907 - 1569.96 \times 12}{12} = 671.29$

D-13

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIA

	Equipment Items Using Power	Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
1A	Accelerometer Coupler (3)	3	24	3	3	72		
6	Air Particle Sampler	50	.4	1.76		20		
6A	Airflow Work Surface	75	.5	3.12		37.5		
7	Autoanalyzer	200	1.0	16.66	200	200		
7A	Auto Potentiometer Elec. Analysis	100	1.0	8.34		100		
16F	Ballistocardiogram Coupler	1	1.0	.08		1		
19D	Body Mass Measuring Device	15	.2	.26		3		
26B	Cage, Metabolic Pit. (2)	60	24	60	60	1440		60
30A	Cage, Rat (16)	144	12	144	144	1728		
31	Calculator, Pocket	5	1.0	.42		5		
32	Camera, Cine	13	.5	.54		6.5		
32A	Camera, Controller	100	12	100	100	1200		
37	Camera, Video B/W	15	12	15	15	180		
38	Camera, Video, Color	69	.5	2.88	69	34.5		
38D	Camera Timer, Video	10	.5	.42	10	5		
38F	Cardiopulmonary Analyzer	200	1.0	16.66		200		
40A	Centrifuge, Blood Sample Processor	100	.4	3.34		40		
48	Cleaner, Vacuum	100	.4	3.34		40		
50A	Clinostat C/T	10	24	10	10	240		
50	Clinostat Plants	10	24	10	10	240		
50B	Compactor (Solids)	100	.05	.42		5		
51F	Coolant Loop, Liquid	50	24	50	50	1200		
54	Colony Counter (Manual)	50	.5	2.08		25		
63B	Display Keyboard Portable	60	1.0	5.0		60		
63C	Display, Numeric (2)	4	12	4.0	4	48		
64	ECG Coupler (16)	32	24	32	32	768	12	12
65	EEG Coupler (6)	12	24	12	12	288	4	4
65C	Electrophys. Receiver	5	1.0	.42		5		
66	EMG Coupler (8)	16	24	16	16	384	6	6
70E	Exercise Equip., Physiol.	18	4	6		72		
76J	Flowmeter, Gas (6)	24	.5	1.0		12		
77B	Freezer, Cryo	10	24	10	10	240	10	10
80	Freezer, General (2)	400	8	133.33	400	3200		
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator (2)	100	8	33.33	100	800		

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIA (Cont'd)		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
91 Gas Analyzer, Mass Spec. (2)	100	12	100	100	360	50	50
93 Gas Analyzer, RH	6	24	6	6	144		
98A Holding Unit C&T (2)	60	24	60	60	1440		
98C Holding Unit Invt. (2)	100	12	100	100	1200		
101 Holding Unit Plt. (2)	1000	12	1000	1000	12000	374	374
101C Holding Unit - Primate (5)	500/150	12/12	500	500	7800	150	150
103B Incubator	5	24	5	5	120		
114E Lamp, Portable Hi. Int. Photo.	150	.5	6.16	150	75		
117 LBNP	26	.4	.86		10.4		
121 Mass Meas. Device (Macro)	15	.3	.38		4.5		
122 Mass Meas. Device (Micro)	15	.3	.38		4.5		
126 Microscope, Comp.	15	.5	.62		7.5		
126A Microscope, Dissecting	100	1.0	8.34	100	100		
126J Microscope, Access. Kit	15	.5	.62		7.5		
132 Oscilloscope	75	1.0	6.26		75		
138 PH Meter	20	.3	.50		6		
138B Photocell Coupler (12)	24	24	24	24	576		
139 Plethysmograph, Limb	5	.5	.20		2.5		
144 Psychomotor Per. Cons.	15	.5	1.25		7.5		
143G Pressure Coupler (4)	8	24	8	8	192		
147 Radiation Count.-Biochemical	90	.5	3.76		45		
150B Receiver, Biotelemetry	10	24	10	10	240		
153A Rotating Litter Chair/Console	127	.4	4.24		50.8		
156 Signal Conditioners (16)	32	24	32	32	768		
156F Sonocardiogram	12	1.0	1.0		12		
162 Sterilizer, Autoclave	300	1.5	37.5		450		
165 Sterilizer, Tool	110	.4	3.66		44		
179 Temperature Block	200	1.5	25	200	300		
179D Thermometer (Electronic)	14	.2	.24		2.8		
181D Transducer, Pressure (4)	4	24	4	4	96		
182J Vectocardiogram Coupler	2	1.0	.16		2		
182P Ventilation Unit - Vertical (6)	240	24	240	240	5760	240	240
188 Work and Surgical Bench	1000	1.0	83.34	1000	1000		
TOTALS	6566		2988.89	4794	4688.25	856	976

On Duty is considered 12 hours Off Duty Average Power $\frac{46882.5 - 2988.89 \times 12}{12} = 918$

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD III A			ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power		Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
1A	Accelerometer Coupler (3)	3	24	3	3	72		
6	Air Particle Sampler	50	.4	1.76		20		
6A	Airflow Work Surface	75	.5	3.12		37.5		
11	Analyzer, Gen. Spect'phot'r.	250	1	20.5	250	250		
7	Autoanalyzer	200	1.0	16.66	200	200		
7A	Auto Potentiometer Elec. Analysis	100	1.0	8.34		100		
16F	Ballistocardiogram Coupler	1	1.0	.03		1		
19D	Body Mass Measuring Device	15	.2	.26		3		
26A	Cage, Metabolic C/T	5	24	5	5	120		
26B	Cage, Metabolic Plt. (2)	60	24	60	60	1440		60
28	Cage, Metabolic Rat	20	24	20	20	480		20
30A	Cage, Rat (16)	144	12	144	144	1728		
31	Calculator, Pocket	5	1.0	.42		5		
32	Camera, Cine	13	.5	.54		6.5		
32A	Camera, Controller	100	12	100	100	1200		
37	Camera, Video B/W	15	12	15	15	180		
38	Camera, Video, Color	69	.5	2.88	69	34.5		
38D	Camera Timer, Video	10	.5	.42	10	5		
38F	Cardiopulmonary Analyzer	200	1.0	16.66		200		
40A	Centrifuge, Blood Sample Processor	100	.4	3.34		40		
43A	Centrifuge - Research △	354/210	12/12	354	354	6768		
48	Cleaner, Vacuum	100	.4	3.34		40		
50A	Clinostat C/T	10	24	10	10	240		
50	Clinostat Plants	10	24	10	10	240		
50B	Compactor (Solids)	100	.05	.42		5		
51F	Coolant Loop, Liquid	50	24	50	50	1200		
54	Colony Counter (Manual)	50	.5	2.08		25		
63B	Display Keyboard Portable	60	1.0	5.0		60		
63C	Display, Numeric (3)	6	12	6	6	72		
64	ECG Coupler (24)	48	24	48	48	1152	12	12
65	EEG Coupler (8)	16	24	16	16	384	4	4
66C	Electrophys. Receiver	5	1.0	.42		5		
66	EMG Coupler (10)	20	24	20	20	480	6	6
70E	Exercise Equip., Physiol.	18	4	6		72		
76J	Flowmeter, Gas (6)	24	.5	1.0		12		

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIIA (Cont'd)		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
77B Freezer, Cryo	10	24	10	10	240	10	10
80 Freezer, General (2)	400	8	133.33	400	3200		
81 Freezer, Low Temp. (2)	20	24	20	20	480	20	20
83 Refrigerator (2)	100	8	33.33	100	800		
87 Gas Analyzer, Infrared	50	.5	4.16		25		
91 Gas Analyzer, Mass Spec. (2)	100	12	100	100	1200	50	50
93 Gas Analyzer, RH	6	24	6	6	144		
98A Holding Unit C&T (2)	60	24	60	60	1440		60
98C Holding Unit, Invt. (2)	100	12	100	100	1200		
101 Holding Unit, Plt. (2)	1000	12	1000	1000	12000	374	374
101B Holding,Unit, Monkey Pod	100/30	12/12	100	100	1560	30	30
101C Holding Unit - Primate (1)	100/30	12/12	100	100	1560	30	30
103B Incubator	5	24	5	5	120		
114E Lamp, Portable Hi. Int. Photo.	150	.5	6.16	150	75		
117 LBNP	26	.4	.86		10.4		
121 Mass Meas. Device (Macro)	15	.3	.38		4.5		
122 Mass Meas. Device (Micro)	15	.3	.38		4.5		
126 Microscope, Comp.	15	.5	.62		7.5		
126A Microscope, Dissecting	100	1.0	8.34	100	100		
126J Microscope, Access. Kit	15	.5	.62		7.5		
132 Oscilloscope	75	1.0	6.26		75		
138 PH Meter	20	.3	.50		6		
138B Photocell Coupler (12)	24	24	24	24	576		
139 Plethysmograph, Limb	5	.5	.20		2.5		
143G Pressure Coupler (4)	8	24	8	8	192		
144 Psychomotor Per. Cons.	15	.5	1.25		7.5		
147 Radiation Count - Biochemical	90	.5	3.76		45		
150B Receiver, Biotelemetry	10	24	10		240		
153A Rotating Litter Chair/Console	127	.4	4.24		50.8		
156 Signal Conditioners (24)	48	24	48	48	1152		
156F Sonocardiogram	12	1.0	1.0		12		
162 Sterilizer, Autoclave	300	1.5	37.5		450		
165 Sterilizer, Tool	110	.4	3.66		44		
179 Temperature Block	200	1.5	25	200	300		
179D Thermometer (Electronic)	14	.2	.24		2.8		

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: IIIA (Cont'd)		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
181D Transducer, Pressure (4)	4	24	4	4	96		
182J Vectocardiogram Coupler	2	1.0	.16		2		
182P Ventilation Unit - Vertical (3)	120	24	120	120	2880	120	120
188 Work and Surgical Bench	1000	1.0	83.34	1000	1000		
TOTALS	6896		3034.55	5056	48189.5	656	696
On Duty is considered 12 hours.							
Off Duty Average Power = $\frac{48,189.5 - 3034.55 \times 12}{12} = 981.2$							
△ For 182R in Centrifuge 43A	320		320	320	3840		

POWER AND ENERGY REQUIREMENT SUMMARY. CONTD

LAB CODE: MOD IIB		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
1A Accelerometer Coupler (3)	3	24	3	3	72		
6 Air Particle Sampler	50	.4	1.76		20		
6A Airflow Work Surface	75	.5	3.12		37.5		
7 Autoanalyzer	200	1.0	16.66	200	200		
7A Auto Potentiometer Elec. Analysis	100	1.0	8.34		100		
16F Ballistocardiogram Coupler	1	1.0	.08		1		
19D Body Mass Measuring Device	15	.2	.26		3		
26B Cage, Metabolic Plt. (2)	60	24	60	60	1440		60
28 Cage, Metabolic Rat	20	24	20	20	480		20
30A Cage, Rat (16)	144	12	144	144	1728		
31 Calculator, Pocket	5	1.0	.42		5		
32 Camera, Cine	13	.5	.54		6.5		
32A Camera, Controller	100	12	100	100	1200		
37 Camera, Video B/W	15	12	15	15	180		
38 Camera, Video, Color	69	.5	2.88	69	34.5		
38D Camera Timer, Video	10	.5	.42	10	5		
38F Cardiopulmonary Analyzer	200	1.0	16.66		200		
40A Centrifuge, Blood Sample Processor	100	.4	3.34		40		
48 Cleaner, Vacuum	100	.4	3.34		40		
50A Clinostat C/T	10	24	10	10	240		
50 Clinostat Plants	10	24	10	10	240		
50B Compactor (Solids)	100	.05	.42		5		
51F Coolant Loop, Liquid	50	24	50	50	1200		
54 Colony Counter (Manual)	50	.5	2.08		25		
63B Display Keyboard Portable	60	1.0	5.0		60		
63C Display, Numeric (2)	4	12	4.0	4	48		
64 ECG Coupler (12)	24	24	24	24	576	12	12
65 EEG Coupler (4)	8	24	8	8	192	4	4
66 EMG Coupler (6)	12	24	12	12	288	6	6
70E Exercise Equip., Physiol.	18	4	6		72		
76J Flowmeter, Gas (4)	16	.5	.66		8		
77B Freezer, Cryo	10	24	10	10	240	10	10
80 Freezer, General	200	8	66.67	200	1600		
81 Freezer, Low Temp.	10	24	10	10	240	10	10
83 Refrigerator	50	8	16.67	50	400		

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIB (Cont'd)		ORBIT OPERATIONS				ASCENT	DESCENT
Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
91 Gas Analyzer, Mass Spec. (2)	100	12	100	100	1200	50	50
93 Gas Analyzer, RH	6	24	6	6	144		
98A Holding Unit C&T (2)	60	24	60	60	1440		60
98C Holding Unit Invt. (2)	100	12	100	100	1200		
101 Holding Unit Plt. (2)	1000	12	1000	1000	12000	374	374
101C Holding Unit - Primate (4)	200/60	12/12	200	200	3120	60	60
103B Incubator	5	24	5	5	120		
114E Lamp, Portable Hi. Int. Photo.	150	.5	6.16	150	75		
117 LBNP	26	.4	.86		10.4		
121 Mass Meas. Device (Macro)	15	.3	.38		4.5		
122 Mass. Meas. Device (Micro)	15	.3	.38		4.5		
126 Microscope, Comp.	15	.5	.62		7.5		
126A Microscope, Dissecting	100	1.0	8.34	100	100		
126J. Microscope, Access, Kit	15	.5	.62		7.5		
132 Oscilloscope	75	1.0	6.26		75		
138 PH Meter	20	.3	.50		6		
138B Photocell Coupler (12)	24	24	24	24	576		
139 Plethysmograph, Limb	5	.5	.20		2.5		
143G Pressure Coupler (4)	8	24	8	8	192		
150B Receiver, Biotelemetry	10	24	10	10	240		
156 Signal Conditioners (12)	24	24	24	24	576		
156F Sonocardiogram	12	1.0	1.0		12		
162 Sterilizer, Autoclave	300	1.5	37.5		450		
165 Sterilizer, Tool	110	.4	3.66		44		
179 Temperature Block	200	1.5	25	200	300		
179D Thermometer (Electronic)	14	.2	.24		2.8		
181D Transducer, Pressure (4)	4	24	4	4	96		
182J Vectocardiogram Coupler	2	1.0	.16		2		
182P Ventilation Unit - Vertical (2)	80	24	80	80	1920	80	80
182R Vertebrate ECS	320	24	320	320	7680	320	320
188 Work and Surgical Bench	1000	1.0	83.34	1000	1000		
TOTALS	5927		2751.54	4400	43834	926	1066

On Duty is considered 12 hours.

Off Duty Average Power = $\frac{43,834 - 2751.54 \times 12}{12} = 901.3$

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIC

	Equipment Items Using Power	Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
1A	Accelerometer Coupler (3)	3	24	3	3	72		
6	Air Particle Sampler	50	.4	1.76		20		
6A	Airflow Work Surface	75	.5	3.12		37.5		
7	Autoanalyzer (Minitized)	200	1.0	16.66	200	200		
7A	Auto Potentiometer Elec. Analysis	100	1.0	8.34		100		
16F	Ballistocardiogram Coupler	1	1.0	.08		1		
19D	Body Mass Measuring Device	15	.2	.26		3		
30A	Cage, Rat (16)	144	12	144	144	1728		
31	Calculator, Pocket	5	1.0	.42		5		
32	Camera, Cine	13	.5	.54		6.5		
32A	Camera, Controller	100	12	100	100	1200		
37	Camera, Video B/W	15	12	15	15	180		
38	Camera, Video, Color	69	.5	2.88	69	34.5		
38D	Camera Timer, Video	10	.5	.42	10	5		
38F	Cardiopulmonary Analyzer	200	1.0	16.66		200		
40A	Centrifuge, Blood Sample Processor	100	.4	3.34		40		
48	Cleaner, Vacuum	100	.4	3.34		40		
50B	Compactor (Solids)	100	.05	.42		5		
51F	Coolant Loop, Liquid	50	24	50	50	1200		
54	Colony Counter (Manual)	50	.5	2.08		25		
63B	Display Keyboard Portable	60	1.0	5.0		60		
63C	Display, Numeric (2)	2	12	2	2	24		
64	ECG Coupler (12)	24	24	24	24	576	12	12
65	EEG Coupler (4)	8	24	8	8	192	4	4
66	EMG Coupler (8)	12	24	12	12	288	6	6
70E	Exercise Equip., Physiol.	18	4	6		72		
76J	Flowmeter, Gas (4)	16	.5	.66		8		
77B	Freezer, Cryo	10	24	10	10	240	10	10
80	Freezer, General (2)	400	8	133.34	400	3200		
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator (2)	100	8	33.34	100	800		
91	Gas Analyzer, Mass Spec. (2)	100	12	100	100	1200	50	50
93	Gas Analyzer, RH	6	24	6	6	144		
101B	Holding Unit Monkey Pod	100/30	12/12	100	100	1560	30	30

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIC (Cont'd)			ORBIT OPERATIONS				ASCENT	DESCENT
	Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
101C	Holding Unit - Primate (2)	200/60	12/12	200	200	3120	60	60
114E	Lamp, Portable Hi. Int. Photo.	150	.5	6.16	150	75		
117	LBNP	26	.4	.86		10.4		
121	Mass Meas. Device (Macro)	15	.3	.38		4.5		
122	Mass Meas. Device (Micro)	15	.3	.38		4.5		
126	Microscope, Comp.	15	.5	.62		7.5		
126A	Microscope, Dissecting	100	1.0	8.34	100	100		
126J	Microscope, Access. Kit	15	.5	.62		7.5		
132	Oscilloscope	75	1.0	6.26		75		
138	PH Meter	20	.3	.50		6		
138B	Photocell Coupler (12)	24	24	24	24	576		
139	Plethysmograph, Limb	5	.5	.20		2.5		
143G	Pressure Coupler (4)	8	24	8	8	192		
150B	Receiver, Biotelemetry	10	24	10	10	240		
156	Signal Conditioners (16)	32	24	32	32	768		
156F	Sonocardiogram	12	1.0	1.0		12		
162	Sterilizer, Autoclave	300	1.5	37.5		450		
165	Sterilizer, Tool	110	.4	3.66		44		
179	Temperature Block	200	1.5	25	200	300		
179D	Thermometer (Portable)	14	.2	.24		2.8		
181D	Transducer, Pressure (4)	4	24	4	4	96		
182J	Vectocardiogram Coupler	2	1.0	.16		2		
182P	Ventilation Unit - Vertical (2)	80	24	80	80	1920	80	80
182R	Vertebrate ECS	320	24	320	320	7680	320	320
188	Work & Surgical Bench	1000	1.0	83.34	1000	1000		
	TOTALS	5018		1675.88	3491	30402	582	582

On Duty is considered 12 hours.

Off Duty Average Power = $\frac{30402 - 1675.88 \times 12}{12} = 857.6$

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIIB			ORBIT OPERATIONS				ASCENT	DESCENT
	Equipment Items Using Power	Operating Power (Watts)	On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	Watts	Watts
1A	Accelerometer Coupler (3)	3	24	3	3	72		
6	Air Particle Sampler	50	.4	1.76		20		
6A	Airflow Work Surface	75	.5	3.12		37.5		
7	Autoanalyzer	200	1.0	16.66	200	200		
7A	Auto Potentiometer Elec. Analysis	100	1.0	8.34		100		
16F	Ballistocardiogram Coupler	1	1.0	.08		1		
19D	Body Mass Measuring Device	15	.2	.26		3		
28	Cage, Metabolic Rats	20	24	24	20	480		
30A	Cage, Rat (16)	144	12	144	144	1728		
31	Calculator, Pocket	5	1.0	.42		5		
32	Camera, Cine	13	.5	.54		6.5		
32A	Camera, Controller	100	12	100	100	1200		
37	Camera, Video B/W	15	12	15	15	180		
38	Camera, Video, Color	69	.5	2.88	69	34.5		
38D	Camera Timer, Video	10	.5	.42	10	5		
38F	Cardiopulmonary Analyzer	200	1.0	16.66		200		
40A	Centrifuge, Blood Sample Processor	100	.4	3.34		40		
43A	Centrifuge L. S. Res.	354/210	1211.2	354	354	6768		
48	Cleaner, Vacuum	100	.4	3.34		40		
50B	Compactor (Solids)	100	.05	.42		5		
51F	Coolant Loop, Liquid	50	24	50	50	1200		
54	Colony Counter (Manual)	50	.5	2.08		25		
63B	Display Keyboard Portable	60	1.0	5.0		60		
63C	Display, Numeric (2)	2	12	2.0	2	24		
64	ECG Coupler (16)	32	24	32	32	768	12	12
65	EEG Coupler (8)	16	24	16	16	384	4	4
66	EMG Coupler (8)	16	24	16	16	384	6	6
70E	Exercise Equip., Physiol.	18	4	6		72		
76J	Flowmeter, Gas (6)	24	.5	1.0		12		
77B	Freezer, Cryo	10	24	10	10	240	10	10
80	Freezer, General (2)	400	8	133.34	400	3200		
81	Freezer, Low Temp.	10	24	10	10	240	10	10
83	Refrigerator (2)	100	8	33.34	100	800		
91	Gas Analyzer, Mass Spec. (2)	100	12	100	100	1200	50	50

POWER AND ENERGY REQUIREMENT SUMMARY, CONTD

LAB CODE: MOD IIIB (Cont'd)

	Equipment Items Using Power	Operating Power (Watts)	ORBIT OPERATIONS On Time Hrs/Day	Average On Duty Power	Peak Power Contribution	Energy Consumption Watt-hrs/Day	ASCENT Watts	DESCENT Watts
93	Gas Analyzer, RH	6	24	6	6	144		
114E	Lamp, Portable Hi. Int. Photo.	150	.5	6.16	150	75		
117	LBNP	26	.4	.86		10.4		
121	Mass Meas. Device (Macro)	15	.3	.38		4.5		
122	Mass Meas. Device (Micro)	15	.3	.38		4.5		
126	Microscope, Comp.	15	.5	.62		7.5		
126A	Microscope, Dissecting	100	1.0	8.34	100	100		
126J	Microscope, Access. Kit	15	.5	.62		7.5		
132	Oscilloscope	75	1.0	6.26		75		
138	PH Meter	20	.3	.50		6		
138B	Photocell Coupler (12)	24	24	24	24	576		
139	Plethsymograph, Limb	5	.5	.20		2.5		
143G	Pressure Coupler (4)	8	24	8	8	192		
150B	Receiver, Biotelemetry	10	24	10	10	240		
156	Signal Conditioners (12)	32	24	32	32	768		
156F	Sonocardiogram	12	1.0	1.0		12		
162	Sterilizer, Autoclave	300	1.5	37.5		450		
165	Sterilizer, Tool	110	.4	3.66		44		
179	Temperature Block	200	1.5	25	200	300		
179D	Thermometer (Electronic)	14	.2	.24		2.8		
181D	Transducer, Pressure (4)	4	24	4	4	96		
182J	Vectocardiogram Coupler	2	1.0	.16		2		
182R	Vertebrate ECS	320	24	320	320	7680	320	320
188	Work and Surgical Bench	1000	1.0	83.34	1000	1000		
	TOTALS	5040		1690.22	3505	31524	412	412
	On Duty is considered 12 hours.							
	Off Duty Average Power = $\frac{31,524 - 1690.22 \times 12}{12}$ = 936.78							
	For 182R in Centrifuge 43A	320		320	320	3840		

APPENDIX E

LABORATORY SAMPLED DATA REQUIREMENTS

APPENDIX E

LABORATORY SAMPLED DATA REQUIREMENTS

The sampled data requirements for the life sciences laboratory concepts are given in this appendix. Three of 16 payloads defined in the study, COL 2A, COL 3A and ML-5A have no sampled data requirements. Data for these are taken manually. The requirements for the other 13 payloads are covered in the following order.

Mini-Lab	ML-1A
	ML-2A
	ML-3A
	ML-4A
	ML-2B
	ML-2C
	ML-2D
Dedicated	MOD IA
	MOD IIA
	MOD IIIA
	MOD IIB
	MOD IIC
	MOD IIIB

PAYLOAD FIRST US/ESA SPACELAB MISSION
NO. M-L 1A

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
7A	Auto. Potent. Elect. Anal.	Measure pH, pCO_2, pO_2, K, Ca, Na, Cl, glucose	2/day	0.5 hr	Negl.	5 K			x			Conversion to conc. values. Downlink.	
80, 81	Freezers	Monitor temperatures	Once/10 min.	-	Negl.	3 K			x	x	x	Out-of-tolerance determination.	
131J	OFO Experiment Packages	8 Otolith signals 4 ECG signals Housekeeping	1/day	24 hr.	100 K	8640 M	x	x	x	x	x	Transmission to ground. Real-time or near real-time.	Otolith channels sampled at 2000 samples/sec; ECG at 500 sps.
153A	Rotating Litter Chair	EOG/EMG, Controls	2/mission	0.5 hr	6.5 K	11.7 M			x			Transmission to ground.	
				Max. Rate	106 KBPS	8650 M							

PAYLOAD NO. BIOMEDICINE/BIOLOGY MINI-LAB - SMALL VERTEBRATES
M-L 2A

SI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
7A	Auto. Potent. Elec. Anal.	Measure pH, pCO_2, pO_2, K, Ca, Na, Cl, glucose	2/day	0.5 hr	Negl.	5 K			x			Conversion to conc. values. Downlink.	
156	Signal Conditioners (12)	Monitor electrophysiological outputs such as ECG, EEG, etc.	24/day 6/day	10 min. 10 min.	3500/6 Chnl. 700/6 Chanl.	302.4 M 15.1 M 318 M	x	x	x	x	x	Transmission to ground. Possibly some waveform analysis/ compression.	6 channels - 500 samples/ sec. 6 channels - 100 samples/sec.
80/81/ 83	Freezers/Refrig.	Monitor temperatures	Once/10 min.	--	Negl.	9 K	x	x	x	x	x	Out-of-tolerance determination.	12 channels, 5 bit/chnl.
103B	Incubator	Monitor temperatures	Once/15 min.	--	Negl.	1.5 K			x			Out-of-tolerance determination.	
182P	Ventilation Unit, Vertebrates	Monitor flows, pressures, humidities, etc., 3 sensors.	Once/min.	--	Negl.	22 K	x	x	x	x	x	Out-of-tolerance determination.	
91	Mass Spectrometer	Monitor mass no. and peaks of trace contaminant and major atmospheric gases.	--	Continuous	600	52 M	x	x	x	x	x	Transmission to ground. Possibly some waveform analysis.	

PAYLOAD BIOMEDICINE - MAN
NO. M-L 3A

SI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
7A	Auto. Poten. Elec. Anal	Measure pH, pCO_2, pO_2, K, Ca, Na, Cl, glucose	2/day	0.5 hr.	Negl.	5K			x			Conversion to conc. values. Downlink.	
156	Signal Conditioners (6)	Monitor electrophysiological outputs such as ECG, EEG, etc.	3/day	1.0 hr	3500/3 Chnl. 700/3 Chnl.	113.4M 22.7M 136M			x			Downlink. Possible on-board waveform analysis/compression.	Includes VCG coupler.
80/81/83	Freezers/Refrig.	Monitor temperatures.	Once/10 min.	--	Negl.	9 K			x	x	x	Out-of-tolerance determination.	
38F	Cardiopulmonary Analyzer	Measure H_2O, N_2, $C^{18}O$, O_2, A, CO_2, N_2O gases on breath-by-breath basis.	2/day	0.5 hr	500/6 chnls	10.8M			x			Conversion to conc. values. Downlink.	
18C	Exercise Eqmt., Physiological	Monitor ergometer speed, output. Treadmill speed. Assume 4 chnls.	2/day	1.0 hr	5/4 chnls	144K			x			Downlink, onboard display and control.	Assume 4 chnls. 1 sample/sec.

PAYLOAD LIFE SUPPORT/PROTECTIVE SYSTEMS MINI-LAB
NO. M-L 4A

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	SUPPORT NEEDED: Ascent	SUPPORT NEEDED: On-orbit	SUPPORT NEEDED: Descent	SUPPORT NEEDED: Post-launch	PROCESSING REQUIRED	REMARKS
93A	Gas Supplies	Monitor pressures (3)	Once/min	--	Negl.	21.6K			x			Out-of-tolerance determination.	
87	Gas Analyzer, Infrared	Measures concentration of gas constituents.	--	Continuous	10	864K			x			Out-of-tolerance determination. Selected conc. display.	
91	Mass Spectrometer	Monitor mass no. and peaks of trace contaminant & major atmospheric gases.	--	Continuous	600	52M			x			Downlinking. Possibly some on-board analysis and display.	
83	Refrigerator	Monitor temperatures.	Once/10 min	--	Negl.	1.5K			x			Out-of-tolerance determination.	
115F	LSS Test Console	Monitor temps., pressures, flows, currents, etc. Assume 10 chls.	Once/10 sec	12 hrs-10 chls; 12 hrs-2 chls	5 1	216K 43K 259K			x			Out-of-tolerance determination. Downlink exp. data. Trend analysis.	

PAYLOAD BIOMEDICINE/BIOLOGY - PRIMATE MINI-LAB
NO. M-L 2B

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
7A	Auto. Poten. Elec. Anal	Measure pH, pCO_2, pO_2, K, Ca, Na, Cl, glucose	2/day	0.5 hr.	Negl.	5K			x			Conversion to conc. values. Downlink.	
156	Signal Conditioners (6)	Monitor electrophysiological outputs such as ECG, EEG, etc.	24/day 6/day	10 min. 10 min.	3500/3 Chnl. 700/3 Chnl.	151.2M 7.6M 159M	x	x	x	x	x	Transmission to ground. Possibly some waveform analysis/ compression.	3 - 500 samples/sec chls. 3 - 100 samples/ sec chls.
80/81	Freezers	Monitor temperatures.	Once/10 min.	--	Negl.	6K			x	x	x	Out-of-tolerance determination.	8 channels, 5 bit/chnl.
103B	Incubator	Monitor temperatures	Once/5 min.	--	Negl.	1.5K			x			Out-of-tolerance determination.	
91	Mass Spectrometer	Monitor mass no. and peak height of trace contaminant and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Transmission to ground. Possibly some waveform analysis.	
83	Refrigerator	Monitor temperatures	Once/10 min.	--	Negl.	3K	x	x	x	x	x	Out-of-tolerance determination.	
182P	Ventilation Unit, Vertebrates	Monitor flows, pressure, humidities, etc. Est. 6 sensors.	Once/min.	--	Negl.	43K	x	x	x	x	x	Out-of-tolerance determination.	

PAYLOAD NO. BIOMEDICINE/BIOLOGY MINI-LAB - SMALL VERTS./CELLS & TISSUES
M-L 2C

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
7A	Auto. Poten. Elec. Anal	Measure pH, pCO_2, pO_2, K, Ca, Na, Cl, glucose	2/day	0.5 hr.	Negl.	5K			x			Conversion to conc. values. Downlink.	
156	Signal Conditioners (12)	Monitor electrophysiological outputs such as ECG, EEG, etc.	24/day 6/day	10 min. 10 min.	3500/6 Chnl. 700/6 Chnl.	302.4M 15.1M 318 M	x	x	x	x	x	Transmission to ground. Possibly some waveform analysis/compression.	6 chnls - 500 samples/sec. 6 channels - 100 samples/sec.
80/81/83	Freezers/Refrig.	Monitor temperatures.	Once/10 min.	--	Negl.	9 K	x	x	x	x	x	Out-of-tolerance determination.	2 channels, 5 bit/chnl.
103B	Incubator	Monitor temperatures	Once/15 min.	--	Negl.	1.5K			x			Out-of-tolerance determination.	
182P	Ventilation Unit, Vertebrates	Monitor flows, pressures, humidities, etc., 3 sensors.	Once/min.	--	Negl.	22K	x	x	x	x	x	Out-of-tolerance determination.	
96A	Holding Unit, C&T	Monitor temp.	Once/min.	--	Negl.	7K			x	x	x	Out-of-tolerance determination.	
50A	Clinostat	Monitor motor current.	Once/min.	--	Negl.	7K			x			Out-of-tolerance determination.	
91	Mass Spectrometer	Monitor mass no. and peaks of trace contaminant and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Transmissions to ground. Possibly some onboard analysis.	

PAYLOAD NO. M-L 2D BIOLOGY MINI-LAB

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
7A	Auto. Poten. Elec. Anal	Measure pH, pCO_2, pO_2, K, Ca, Na, Cl, glucose	2/day	0.5 hr.	Negl.	5K			x			Conversion to conc. values. Downlink.	
156	Signal Conditioners (12)	Monitor electrophysiological outputs such as ECG, EEG, etc.	24/day 6/day	10 min. 10 min.	3500/6 Chnl. 700/6 Chnl.	302.4M 15.1M 318 M	x	x	x	x	x	Transmission to ground. Possibly some waveform analysis/ compression.	6 chnls - 500 samples/ sec. 6 channels - 100 samples/sec.
80/81/83	Freezers/Refrig.	Monitor temperatures.	Once/10 min.	--	Negl.	9 K	x	x	x	x	x	Out-of-tolerance determination.	2 channels, 5 bit/chnl.
103B	Incubator	Monitor temperatures	Once/15 min.	--	Negl.	1.5K			x			Out-of-tolerance determination.	
182P	Ventilation Unit, Vertebrates	Monitor flows, pressures, humidities, etc., 3 sensors.	Once/min.	--	Negl.	22K	x	x	x	x	x	Out-of-tolerance determination.	
98A	Holding Unit, C&T	Monitor temp.	Once/min.	--	Negl.	7K			x	x	x	Out-of-tolerance determination.	
50A	Clinostat	Monitor motor current.	Once/min.	--	Negl.	7K			x			Out-of-tolerance determination.	
91	Mass Spectrometer	Monitor mass no. and peaks of trace contaminant and major atmospheric gases.	--	Continuous	1200	104M	x	x	x	x	x	Transmission to ground. Possibly some onboard analysis.	
98C	Holding Unit, Inverts.	Monitor temp.	Once/min.	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
101	Holding Unit, Plants	Monitor temp., light current level	Once/min.	--	Negl.	14K	x	x	x	x	x	Out-of-tolerance determination.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	

PAYLOAD DEDICATED LAB – BIOMEDICAL EMPHASIS
NO. MOD IA

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
64/65/66	ECG, EEG, EMG Couplers	Conditions electrophysiological signals from organisms or man.	16 chls – 24/day 6 chls – 4/day	10 min. 0.5 hr	700 @ 16 chls 3500 @ 6 chls 25.2 K	161M 151M 312 M	x	x	x	x	x	Downlinking, waveform analysis, data compression and display.	Assume 6 high rate, 18 low rate chls.
156/138B/143G/1A	Signal Conditioners, Assorted Couplers	Miscellaneous physical and bio-physical measurements. Pressure, temps., flows, etc.	Once/min., 24 hrs/day	—	3	252K	x	x	x	x	x	Downlink, out-of-tolerance determination, display.	Assume 35 chls.
77B/80/81/83/103B	Freezers/Refrig.	Monitor temperatures	Once/10 min.	—	Negl.	15K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls/EI.
7	Autoanalyzer	Measures approximately 12 constituents of blood serum.	2/day	0.5	100	360K			x			Conversion to conc. values. Downlink.	
7A	Auto. Poten. Elec. Anal.	Measure 8 properties of blood serum and/or urine.	2/day	0.5	Negl.	5K			x			Conversion to conc. values. Downlink.	
91	Mass Spectrometer(2)	Measure mass no. and peaks of trace contaminants and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Downlink. Possibly some on-board analysis.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	—	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
65C	Electrophysiology Receiver	Monitors electrophysiological signals from subject.	1/day	1 hr	14 K	44.5M			x			Downlink, waveform analysis and display.	
153A	Rotating Litter Chair	EOG/EMG	2/mission	0.5 hr	6.5 K	11.7M			x			Downlink.	
18C	Exercise Eqmt/Phy.	Monitor ergometer speed, output. Treadmill speed. Assume 4 chls.	2/day	1 hr	5 @ 4 chls	144K			x			Downlink, on board display & control.	Assume 4 chls, 1 sample/sec.
38F	Cardiopulmonary Analyze	Measure 6 gases used in breath-by-breath respiratory analysis.	2/day	0.5 hr	500 @ 6 chls	10.8M			x			Conversion to conc. values. Downlink	
117/139/31	LBNP, Limb Plethysmographs	Monitor pressures, temps., and Plethys. chls.	1/day	1 hr	35	126K			x			On-board control of expmt. Downlink.	Assume 6 chls. Sample 1/sec.

PAYLOAD DEDICATED LAB - BIOMEDICAL EMPHASIS (Cont'd)
NO. MOD 1A

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
182J	VCG Coupler	Converts VCG signals	2/day	1 hr	21K	151M			x			Downlink. On-board waveform analysis.	
182P	Ventilation Unit, Vertebrates	Monitor flow, pressures, etc. Est. 6 sensors.	Once/min.	--	Negl.	43K	x	x	x	x	x	Out-of-tolerance determination.	
98A	Holding Unit, C&T	Monitor Temp.	Once/min.	--	Negl.	7K			x	x	x	Out-of-tolerance determination.	
50A	Clinostat, C&T	Monitor motor current	Once/min.	--	Negl.	7K			x			Out-of-tolerance determination.	

PAYLOAD DEDICATED LAB - BIOMEDICAL/BIOLOGY/ADVANCED TECHNOLOGY EMPHASIS
NO. MOD IIA

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF MEASMT.	DURATION OF MEASUREMENT	CONTINUOUS DATA RATE	DAILY TOTAL BITS	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
64/65/66	ECG, EEG, EMG Couplers	Conditions electrophysiological signals from organisms or man.	16 chls - 24/day 6 chls - 4/day	10 min. 0.5 hr	700 @ 16 chls 3500 @ 6 chls 25.2 K	161M 151M 312M	x	x	x	x	x	Downlinking, waveform analysis, data compression and display.	Assume 6 high rate, 16 low rate chls.
136/138B/143G/1A	Signal Conditioners, Assorted Couplers	Miscellaneous physical and bio-physical msmts, pressure, temps., flows, etc.	Once/min., 24 hrs/day	--	3	252K	x	x	x	x	x	Downlink, out-of-tolerance determination, display.	Assume 35 chls.
77B/80/81/83/103B	Freezers/Refrig.	Monitor temperatures	Once/10 min.	--	Negl.	15K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls/EI.
7	Autoanalyzer	Measures approximately 12 constituents of blood serum.	2/day	0.5	100	360K			x			Conversion to conc. values. Downlink.	
7A	Auto. Poten. Elec. Anal.	Measure 8 properties of blood serum and/or urine.	2/day	0.5	Negl.	5K			x			Conversion to conc. values. Downlink.	
91	Mass Spectrometer(2)	Measure mass no. and peaks of trace contaminants and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Downlink. Possibly some on-board analysis.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
65C	Electrophysiology Receiver	Monitors electrophysiological signals	1/day	1 hr	14K	44.5M			x			Downlink, waveform analysis and display.	
153A	Rotating Litter Chair	EOG/EMG	2/mission	0.5 hr	6.5 K	1.7M			x			Downlink.	
18C	Exercise Eqmt/Pkg	Monitor Ergometer speed output, Treadmill speed. Assume 4 chls.	2/day	1 hr	5 @ 4 chls	144K			x			Downlink, on board display & control.	Assume 4 chls, 1 sample/sec.
38F	Cardiopulmonary Analyzer	Measure 6 gases used in breath-by-breath respiratory analysis.	2/day	0.5 hr	500 @ 6 chls	10.8M			x			Conversion to conc. values. Downlink.	
117/139	LBNP, Limb Plethysmographs	Monitor pressures, temps., and plethys. chls.	1/day	1 hr	35	126K			x			On-board control of expmt. Downlink.	Assume 7 chls, sample/sec.

PAYLOAD DEDICATED LAB - BIOMEDICAL/BIOLOGY/ADVANCED TECHNOLOGY EMPHASIS (Cont'd)
NO. MOD IIA

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
182J	VCG Coupler	Converts VCG signals.	2/day	1 hr	21K	151M			x			Downlink. On-board waveform analysis.	
182P	Ventilation Unit, Verts.	Monitor flow, pressures, etc. Est. 6 sensors.	Once/min	--	Negl.	43K	x	x	x	x	x	Out-of-tolerance determination.	
98A	Holding Unit, Cells & Tissues	Monitor temp.	Once/min	--	Negl.	7K			x	x	x	Out-of-tolerance determination.	
50A	Clinostat, C&T	Monitor motor current	Once/min	--	Negl.	7K			x			Out-of-tolerance determination.	
101	Holding Unit, Plants	Monitor temps., light levels	Once/min	--	Negl.	28K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls.
50	Clinostat, Plant	Monitor motor current.	Once/min	--	Negl.	7K			x			Out-of-tolerance determination.	
98C	Holding Unit, Invert.	Monitor temps.	Once/min	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
116F	LSS Test Console	Monitor temps., pressures, flows, currents, etc. Assume 10 chls.	Once/10 sec.	12 hrs - 10 chls; 12 hrs - 2 chls	5 1	216K 43K 259K			x			Out-of-tolerance determination. Downlink exp. data. Trend analysis.	
144	Psychomotor Perf. Console	Monitor sensor outputs which measure various psychomotor tasks such as tracking steadiness, pattern recognition.	1/day	6 hr	20K	432K			x			Statistical analysis. Downlink.	

PAYLOAD DEDICATED LAB - BIOMEDICAL/BIOLOGY/ADVANCED TECH./BIOCENTRIFUGE EMPHASIS
NO. MOD IIIA

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
64/65/66	ECG, EEG, EMG Couplers	Conditions electrophysiological signals from organisms or man.	16 chls - 24/day 6 chls - 4/day	10 min. 0.5 hr	700 @ 16 chls 3500 @ 6 chls 25.2 K	161M 151M 312M	x	x	x	x	x	Downlinking, waveform analysis, data compression and display.	Assume 6 high rate, 16 low rate chls.
156/138B/143G/1A	Signal Conditioners, Assorted Couplers	Miscellaneous physical and bio-physical msmts, pressure, temp., flows, etc.	Once/min., 24 hrs/day	--	3	252K	x	x	x	x	x	Downlink, out-of-tolerance determination, display.	Assume 35 chls.
77B/80/81/83/103B	Freezers/Refrig.	Monitor temperatures	Once/10 min.	--	Negl.	15K	x	x	x	x	x	Out-of-tolerance determination.	Assume chls/EI.
7	Autoanalyzer	Measures approximately 12 constituents of blood serum.	2/day	0.5	100	360K			x			Conversion to conc. values. Downlink.	
7A	Auto. Poten. Elec. Anal.	Measure 8 properties of blood serum and/or urine.	2/day	0.5	Negl.	5K			x			Conversion to conc. values. Downlink.	
91	Mass Spectrometer(2)	Measure mass no. and peaks of trace contaminants and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Downlink. Possibly some on-board analysis.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
65C	Electrophysiology Receiver	Monitors electrophysiological signals	1/day	1 hr	14K	44.5M			x			Downlink, waveform analysis and display.	
153A	Rotating Litter Chair	EOG/EMG	2/mission	0.5 hr	6.5 K	1.7M			x			Downlink.	
18C	Exercise Eqmt/Pkg	Monitor Ergometer speed output, Treadmill speed. Assume 4 chls.	2/day	1 hr	5 @ 4 chls	144K			x			Downlink, on board display & control.	Assume 4 chls, 1 sample/sec.
38F	Cardiopulmonary Analyzer	Measure 6 gases used in breath-by-breath respiratory analysis.	2/day	0.5 hr	500 @ 6 chls	10.8M			x			Conversion to conc. values. Downlink.	
117/139	LBNP, Limb Plethysmographs	Monitor pressures, temps., and plethys. chls.	1/day	1 hr	35	126K			x			On-board control of expmt. Downlink.	Assume 7 chls, sample/sec.

PAYLOAD DEDICATED LAB - BIOMEDICAL/BIOLOGY/ADVANCED TECH./BIOCENTRIFUGE EMPHASIS (Cont'd)
NO. MOD IIIA

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
182J	VCG Coupler	Converts VCG signals.	2/day	1 hr	21K	151M			x			Downlink. On-board waveform analysis.	
182P	Ventilation Unit, Verts.	Monitor flow, pressures, etc. Est. 6 sensors.	Once/min	--	Negl.	43K	x	x	x	x	x	Out-of-tolerance determination.	
98A	Holding Unit, Cells & Tissues	Monitor temp.	Once/min	--	Negl.	7K			x	x	x	Out-of-tolerance determination.	
50A	Clinostat, C&T	Monitor motor current	Once/min	--	Negl.	7K			x			Out-of-tolerance determination	
101	Holding Unit, Plants	Monitor temps., light levels	Once/min	--	Negl.	28K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls.
50	Clinostat, Plant	Monitor motor current.	Once/min	--	Negl.	7K			x			Out-of-tolerance determination.	
98C	Holding Unit, Invert.	Monitor temps.	Once/min	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
115F	LSS Test Console	Monitor temps., pressures, flows, currents, etc. Assume 10 chls.	Once/10 sec.	12 hrs - 10 chls; 12 hrs - 2 chls	5 1	216K 43K 259K			x			Out-of-tolerance determination. Downlink exp. data. Trend analysis.	
144	Psychomotor Perf. Console	Monitor sensor outputs which measure various psychomotor tasks such as tracking steadiness, pattern recognition.	1/day	6 hr	20K	432K			x			Statistical analysis. Downlink.	
43A	Bioresearch Centrifuge	Monitor and control speed, motor current, temps., balancing, ECS, etc.	--	Continuous 24 hrs/day	10	864K			x			Downlink, on-board display, caution/warning.	Assume 10 chls.

PAYLOAD DEDICATED LAB - BIOLOGY EMPHASIS
NO. MOD IIB

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
64/65/66	ECG, EEG, EMG Couplers	Conditions electrophysiological signals from organisms	16 chls - 24/day 6 chls - 4/day	10 min. 0.5 hr	700 @ 16 chls 3500 @ 6 chls 25.2 K	161M 151M 312 M	x	x	x	x	x	Downlinking, waveform analysis, data compression and display.	Assume 6 high rate, 16 low rate chls.
156/138B/143G/1A	Signal Conditioners, Assorted Couplers	Miscellaneous physical and bio-physical msmts, pressure, temps., flows, etc.	Once/min., 24 hrs/day	--	3	252K	x	x	x	x	x	Downlink, out-of-tolerance determination, display.	Assume 35 chls.
77B/80/81/83/103B	Freezers/Refrig.	Monitor temperatures	Once/10 min.	--	Negl.	15K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls/EI.
7	Autoanalyzer	Measures approximately 12 constituents of blood serum.	2/day	0.5	100	360K			x			Conversion to conc. values. Downlink.	
7A	Auto. Poten. Elec. Anal.	Measure 8 properties of blood serum and/or urine.	2/day	0.5	Negl.	5K			x			Conversion to conc. values. Downlink.	
91	Mass Spectrometer(2)	Measure mass no. and peaks of trace contaminants and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Downlink. Possibly some on-board analysis.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
180	Exercise Eqmt./Phys.	Monitor Ergometer speed, output, treadmill speed. Assume 4 chls.	2/day	1 hr	5 @ 4 chls	144K			x			Downlink, on-board display and control.	Assume 4 chls, 1 sample/sec.
182P	Ventilation Unit, Verts.	Monitor flow, pressures, temps., etc. Est. 6 sensors.	Once/min	—	Negl.	43K	x	x	x	x	x	Out-of-tolerance determination.	
98A	Holding Unit, Cells & Tissues	Monitor temp.	Once/min	--	Negl.	7K			x	x	x	Out-of-tolerance determination.	
50A	Clinostat, C&T	Monitor Motor Current	Once/min	--	Negl.	7K			x			Out-of-tolerance determination.	
101	Holding Unit, Plants	Monitor temps., light levels.	Once/min	--	Negl.	28K	x	x	x	x	x	Out-of-tolerance determination.	

PAYLOAD NO. DEDICATED LAB - BIOLOGY EMPHASIS (Cont'd) MOD IIB

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
50	Clinostat, Plants	Monitor motor current	Once/min	--	Negl.	7K			x			Out-of-tolerance determination.	
98C	Holding Units, Invert.	Monitor temp.	Once/min	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	

PAYLOAD DEDICATED LAB - BIOLOGY EMPHASIS
NO. MOD IIC

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED: Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
64/65/66	ECG, EEG, EMG Couplers	Conditions electrophysiological signals from organisms	16 chls - 24/day 6 chls - 4/day	10 min. 0.5 hr	700 @ 16 chls 3500 @ 6 chls 25.2 K	161M 151M 312 M	x	x	x	x	x	Downlinking, waveform analysis, data compression and display.	Assume 6 high rate, 16 low rate chls.
156/138B/143G/1A	Signal Conditioners, Assorted Couplers	Miscellaneous physical and biophysical msmts, pressure, temps., flows, etc.	Once/min., 24 hrs/day	—	3	252K	x	x	x	x	x	Downlink, out-of-tolerance determination, display.	Assume 35 chls.
77B/80/81/83/103B	Freezers/Refrig.	Monitor temperatures	Once/10 min.	—	Negl.	15K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls/EI.
7	Autoanalyzer	Measures approximately 12 constituents of blood serum.	2/day	0.5	100	360K			x			Conversion to conc. values. Downlink.	
7A	Auto. Poten. Elec. Anal.	Measure 8 properties of blood serum and/or urine.	2/day	0.5	Negl.	5K			x			Conversion to conc. values. Downlink.	
91	Mass Spectrometer(2)	Measure mass no. and peaks of trace contaminants and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Downlink. Possibly some on-board analysis.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	—	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
180	Exercise Eqmt./Phys.	Monitor Ergometer speed, output, Treadmill speed. Assume 4 chls.	2/day	1 hr	5 @ 4 chls	144K			x			Downlink, on-board display and control.	Assume 4 chls, 1 sample/sec.
182P	Ventilation Unit, Vertebrates	Monitor flow, pressures, etc. Est. 12 sensors.	Once/min	—	Negl.	86K	x	x	x	x	x	Out-of-tolerance determination.	

PAYLOAD NO. DEDICATED LAB - BIOMEDICAL EMPHASIS MOD IIIB

EI	NAME	MEASUREMENT DESCRIPTION	FREQ. OF OPERATION	DURATION OF OPERATION	CONTINUOUS DATA RATE, bps	DAILY TOTAL, bits	SUPPORT NEEDED Pre-launch	Ascent	On-orbit	Descent	Post-launch	PROCESSING REQUIRED	REMARKS
64/65/66	ECG, EEG, EMG Couplers	Conditions electrophysiological signals from organisms	16 chls - 24/day 6 chls - 4/day	10 min. 0.5 hr	700 @ 16 chls 3500 @ [illegible] chls 25.2 K	161M 151M 312 M	x	x	x	x	x	Downlinking, waveform analysis, data compression and display.	Assume 6 high rate, 16 low rate chls.
156/138B/143G/1A	Signal Conditioners, Assorted Couplers	Miscellaneous physical and bio-physical msmts, pressure, temps., flows, etc.	Once/min., 24 hrs/day	--	3	252K	x	x	x	x	x	Downlink, out-of-tolerance determination, display.	Assume 35 chls.
77B/80/81/83/103B	Freezers/Refrig.	Monitor temperatures	Once/10 min.	--	Negl.	15K	x	x	x	x	x	Out-of-tolerance determination.	Assume 4 chls/EI.
7	Autoanalyzer	Measures approximately 12 constituents of blood serum.	2/day	0.5	100	360K			x			Conversion to conc. values. Downlink.	
7A	Auto. Poten. Elec. Anal.	Measure 8 properties of blood serum and/or urine.	2/day	0.5	Negl.	5K			x			Conversion to conc. values. Downlink.	
91	Mass Spectrometer(2)	Measure mass no. and peaks of trace contaminants and major atmospheric gases.	--	Continuous	600	52M	x	x	x	x	x	Downlink. Possibly some on-board analysis.	
93	Gas Analyzer, Water Vapor Specific	Measure resistivity of humidity sensors.	Once/min.	--	Negl.	7K	x	x	x	x	x	Out-of-tolerance determination.	
18C	Exercise Eqmt/Phys.	Monitor Ergometer speed, output, Treadmill speed. Assume 4 chls.	2/day	1 hr	5 @ 3 chls	144K			x			Downlink, on-board display and control.	Assume 4 chls, 1 sample/sec.
182P	Ventilation Unit, Vertebrates	Monitor flow, pressures, etc.	Once/min.	--	Negl.	86K	x	x	x	x	x	Out-of-tolerance determination.	
43A	Bioresearch Centrifuge	Monitor and control speed, motor current, temps., balancing, ECS, etc.	--	Continuous 24 hr/day	10	864K			x			Downlink. On-board display. Caution/warning.	Assume 10 chls.

APPENDIX F

EI GSE REQUIREMENTS

APPENDIX F

EI GSE REQUIREMENTS

The following tables identify the GSE requirements of the equipment items (EIs) of the life sciences common equipment inventory. The EI's are grouped according to equipment units (EU). Spacelab (SL) and principal investigator (PI) equipment is not evaluated.

EI GSE REQUIREMENTS

Equipment Item	SL & Pl Els	Special Handling and Transportation: Special Shipping Container	Special Handling and Transportation: Transportation	Special Handling and Transportation: Handling Equipment	Special Handling and Transportation: Other	Servicing Equipment: Pressurized Gas	Servicing Equipment: Liquids	Servicing Equipment: Other	Checkout and Maintenance: Monitor Equipment	Checkout and Maintenance: Checkout Equipment	Checkout and Maintenance: General Test Equipment	Checkout and Maintenance: Pwr/Environ/Stim. Simulator	Checkout and Maintenance: Special Maint. Aids/Tools	Checkout and Maintenance: General Tools	Checkout and Maintenance: Calibration/Checkout Gases	Checkout and Maintenance: Leak Test Equipment	Checkout and Maintenance: Other	Automatic Checkout	Auxiliary Equipment: Interface Equipment	Auxiliary Equipment: Other	Special GSE Equipment: Launch Operations	Special GSE Equipment: Mission Operations	Special GSE Equipment: Post Mission Operations	Special GSE Equipment: Maintenance & Refurbishment
EU 1 VISUAL RECORDS + MICROSCOPY																								
32 Camera, Cine											X		X	X										
32A Camera Controller											X			X										
33 Camera, Polaroid														X										
36 Camera, 35 MM + Strobe														X										
37 Camera, Video B/W										X	X			X										
38 Camera, Video, Color										X	X			X										
38B Camera Mounts														X										
38D Camera Timer, Video											X			X										
75C Film, Cine																								
75F Film, Polaroid																								
76C Film, 35 MM																								
114E Lamp, Portable Hi Int, Photo										X				X										
116 Log Books																								
126 Microscope, Compound										X				X										
126J Micr. Access. Kit, Compnd										X				X										
134B Paper, Recording																								
150 Recorder, Strip Chart											X			X										
EU 2 DATA MANAGEMENT																								
14B Antennas, Assorted											X			X										
31 Calculator, Pocket														X										
51 Computer, Digital	SL																							
56A Data Mgmt Syst Buses	SL																							
58A DMS Control + Display Station	SL																							
58B DMS Remote Acquisition Unit	SL																							
63B Display Keyboard, Portable											X			X										
63C Display, Numeric														X										
64 ECG Coupler												X		X										
65 EEG Coupler												X		X										
66 EMG Coupler												X		X										
128G Monitor, Video	SL											X		X										
132 Oscilloscope and Camera											X			X										
138B Photocell Coupler											X			X										
143G Pressure Coupler											X			X										
153 Recorder, Voice														X										
156 Signal Conditioners (Couplers)											X			X										
176 Tape, Video	SL																							
180 Timer, Event														X										
181D Transducer, Pressure											X			X										
182T Video Tape Recorder	SL																							
EU 3 LIFE SCI. EXPER. SUPPORT UNIT																								
1 Accelerometer										X	X			X										

EI GSE REQUIREMENTS

		Special Handling and Transportation				Servicing Equipment			Checkout and Maintenance									Automatic Checkout	Auxiliary Equipment		Special GSE Equipment			
Equipment Item	SL & PI Els	Special Shipping Container	Transportation	Handling Equipment	Other	Pressurized Gas	Liquids	Cryo	Monitor Equipment	Checkout Equipment	General Test Equipment	Pwr/Environ/Stim. Simulator	Special Maint. Aids/Tools	General Tools	Calibration/Checkout Gases	Leak Test Equipment	Other		Interface Equipment	Other	Launch Operations	Mission Operations	Post Mission Operations	Maintenance & Refurbishment
1A Accelerometer Coupler											X			X										
6A Airflow Work Surface											X			X										
51F Coolant Loop, Liquid							X				X			X		X								
55A Crew Mobility Aids	SL																							
55B Crew Restraints	SL																							
55C Crew Work Station	SL																							
70C Equipment Restraint																								
76J Flowmeter, Gas											X			X										
93A Gas Supplies																X								
114G Liquid Stor. + Disp. Sys.							X				X			X		X								
118I Manifold, Vacuum											X			X		X								
141A Plumbing							X							X		X								
142B Power Cond. Equip.	SL																							
178B Thermocouple Indicator										X	X			X										
187A Waste Storage Device	SL																							
<u>EU 4 PREPARATION + PRESERV. UNIT</u>																								
40A Centrifuge, Bld Smpl Processor											X			X										
44 Chemicals																								
44A Chemicals, Radioisot Tracers		X																						
70 Electrophoresis Apparatus	SL									X				X										
77B Freezer, Cryo.								X		X	X			X									X	
80 Freezer, Gen'l											X			X										
81 Freezer, Lo Temp								X		X	X			X										
83 Frig.										X	X			X										
96 Glove Box, Portable														X		X								
96C Glove Box Liners																								
103B Incubator											X			X										
105 Kit, Chemical														X										
106 Kit, Hematologh + Urology														X										
108 Kit, Histology														X										
110 Kit, Microbiology														X										
114A Kit, Dissection														X										
118 Lyophilizer	PI									X	X			X										
121 Mass Meas. Device (Macro)										X	X			X										
122 Mass Meas. Device (Micro)										X	X			X										
126A Microscope, Dissecting		X								X				X										
159 Staining Syst							X				X			X										
179 Temp. Block														X										
186 Work + Surgical Bench		X				X	X			X	X			X		X								
<u>EU 5 BIOCHEM. + BIOPHYS.ANAL. UNIT</u>																								
6 Air Particle Sample Collector											X			X										
7 Autoanalyzer (Gemsaec)										X	X			X										

EI GSE REQUIREMENTS

Equipment Item	SL & PI Els	Special Handling and Transportation				Servicing Equipment			Checkout and Maintenance										Auxiliary Equipment		Special GSE Equipment			
		Special Shipping Container	Transportation	Handling Equipment	Other	Pressurized Gas	Liquids	Other	Monitor Equipment	Checkout Equipment	General Test Equipment	Pwr/Environ/Stim. Simulator	Special Maint. Aids/Tools	General Tools	Calibration/Checkout Gases	Leak Test Equipment	Other	Automatic Checkout	Interface Equipment	Other	Launch Operations	Mission Operations	Post Mission Operations	Maintenance & Refurbishment
7A Auto Potentio. Elec. Anal.		TBD					X			X	X			X										
11 Analyzer, Genl. Spectrophot.		TBD		TBD						X	X			X	X									
15A Atmos. Sampling System											X			X		X								
54 Counter, Colony Manual														X										
76L Fibrometer, Blood Clot														X										
87 Gas Analyzer, Infrared										X	X			X	X									
91 Gas Analyzer, Mass Spec.											X			X	X									
93 Gas Analyzer, RH											X			X	X									
138 PH Meter											X			X										
157 Sound Level Meter														X										
179A Theromcouples	PI																							
179D Thermometer, Portable Elect.										X				X										
EU 6 MAINT. REPAIR + FAB. UNIT																								
48 Cleaner, Vacuum														X										
50B Compactor (Solids)														X										
69A Electrometer	PI																							
97C Handwipes, Betadyne (10 ea.)																								
106A Kit, Cleanup																								
109 Kit, Linear Meas.																								
113 Kit, General Tool	SL																							
153B Sensors, Assorted	PI																							
162 Sterilizer, Autoclave											X			X										
165 Sterilizer, Tool														X										
181G Trash Can	SL																							
185 Multimeter												X		X										
EU 7 ANCILLARY STORAGE UNIT																								
45 Chemical Storage Cabinet																								
167B Storage, Genl.	SL																							
167C Storage, Film	SL																							
EU 11 EVA CAPABILITY UNIT																								
3B Airlock	PI																							
158C Spacesuit Test Console	PI																							
172 Spacesuit	PI																							
EU 23 INTERNAL CENTRIFUGE UNIT																								
43A Centrifuge, Life Sc. Research		X	X	X						X	X			X							TBD	TBD	TBD	TBD
EU 26 RADIOBIOLOGY SUPPORT UNIT																								
16D Badges, Radiation (10 ea.)																								

EI GSE REQUIREMENTS

		Special Handling and Transportation				Servicing Equipment			Checkout and Maintenance										Auxiliary Equipment		Special GSE Equipment			
Equipment Item	SL & PI Els	Special Shipping Container	Transportation	Handling Equipment	Other	Pressurized G s	Liquids	Other	Monitor Equipment	Checkout Equipment	General Test Equipment	Pwr/Environ/ Stim. Simulator	Special Maint. Aids/Tools	General Tools	Calibration/ Checkout Gases	Leak Test Equipment	Other	Automatic Checkout	Interface Equipment	Other	Launch Operations	Mission Operations	Post Mission Operations	Maintenance & Refurbishment
144 C Radiation Detector, Dosir...										X	X													
147 Rad. Counter, Biochem. Sample										X	X			X										
149G Rad. Source, Shielded	PI																							
EU 12 BIOMED/BEHAV. RES. SUP. UNIT																								
16B Audiometer	PI																							
18D Custom Bite Boards	PI																							
51D Control Console, Experimenter	PI																							
65B Electrophys. Backpack											X	X		X										
65C Electrophys. Receiver											X			X										
131E Non-visual Direction Indicator	PI																							
133 Otolith Test Goggles	PI																							
144B Psychogalvanometer, GSR	PI																							
153A Rotating Litter Chair/Console				X		X					X			X		X								
EU 31 BIOMEDICAL RESEARCH SUP. UNIT																								
16F Ballistocardiogram Coupler	PI																							
18C Exercise, Physiol. Equip.		TBD		X						X	X			X										
19D Body Mass Meas. Device		TBD		TBD						X	X			X										
38F Cardiopulmonary Analyzer		X		X		X				X	X	X		X										
110C Kit, Human Physiology														X										
117 LBNP		X		X						X	X			X										
139 Plethysmograph, Limb											X			X										
140 Phonovibracardiogram Coupler	PI																							
156F Sono Cardiogram											X			X										
182E Urine Volume Meas. Systm.							X				X			X										
182J Vectorcard. Coupler											X			X										
EU 40 SMALL VERT. HOLDING UNIT																								
28 Cage, Total Metabolic, Rats											X	X		X		X								
30A Cage, Rat, Hampster, Std														X										
103 Hold. Unit, Sm. Vert.				TBD						X	X			X		X								
131J Orb. Frog Otol. Exper. Package	PI																							
EU 41 PRIMATE HOLDING UNIT																								
101B Holding Unit, Monkey Pod				TBD						X	X			X		X								
101C Holding Unit, Primate		X		X						X	X			X		X								
EU 42 VERT. RESEARCH SUPPORT UNIT																								
76G Physiol. Multichan. Sens Sys.	PI																							
114B Kit, Vertebrate Management														X										
114C Kit, Vertrabrate Physiology														X										

EI GSE REQUIREMENTS

Equipment Item	SL & PI Els	Special Handling and Transportation				Servicing Equipment			Checkout and Maintenance									Automatic Checkout	Auxiliary Equipment		Special GSE Equipment			
		Special Shipping Container	Transportation	Handling Equipment	Other	Pressurized Gas	Liquids	Other	Monitor Equipment	Checkout Equipment	General Test Equipment	Pwr/Environ/ Stim. Simulator	Special Maint. Aids/Tools	General Tools	Calibration/ Checkout Gases	Leak Test Equipment	Other		Interface Equipment	Other	Launch Operations	Mission Operations	Post Mission Operations	Maintenance & Refurbishment
150B Receiver										X	X			X										
174 Tank, Vertebrate Water				TBD		TBD	X			X	X			X		TBD								
182P Ventilation Unit, Vert.		Attached to H. U.			TBD					X	X			X		X								
182R Vertebrate ECS		X		X						X	X			X		X								
EU 50 PLANT HOLDING UNIT																								
26B Cage, Metabolic Plant											X			X										
29 Cage, Plant														X										
101 Holding Unit, Plant		TBD		TBD					X	X	X			X										
175 Tank, Plant/Invert. Water							X			X	X			X		TBD								
EU 51 PLANT RESEARCH SUPPORT UNIT																								
50 Clinostat											X			X										
111 Kit, Plant Management																								
131D Motorized Plant Growth Monitor	PI																							
EU 60 CELLS/TISSUES HOLDING UNIT																								
25B Colony Chamber, Sealable											X			X										
26A Cage, Metabolic, C/T											X			X										
98A Holding Unit, Incub., C/T		TBD		TBD						X	X			X										
187C Woodlawn Wanderer											X			X										
EU 61 CELLS/TISSUES RES. SUP. UNIT																								
50A Clinostat (for C/T)											X			X										
124 Media, Prepared																								
EU 70 INVERTEBRATE HOLDING UNIT																								
14 Anesthetizer, Invert.														X										
25 Cage, Invertebrates														X										
98C Hold. Unit, Invertebrates		TBD		TBD							X			X										
113A Kit, Invert. Management																								
EU 80 LSS TEST UNIT																								
115F LSS Test Console	PI	X		X		X	X			X	X			X		X								
142 Portable LSS	PI																							
EU 91 MSI MEASUREMENTS UNIT																								
15D Audio Stereo Headset	PI																							
119 MSI Task Simulator	PI																							
131H Optiscan - Field + Fixed	PI																							
144 Psychomotor Perform. Console										X	X			X										

EI GSE REQUIREMENTS

		Special Handling and Transportation				Servicing Equipment			Checkout and Maintenance										Auxiliary Equipment		Special GSE Equipment			
Equipment Item	SL & PI EIs	Special Shipping Container	Transportation	Handling Equipment	Other	Pressurized Gas	Liquids	Other	Monitor Equipment	Checkout Equipment	General Test Equipment	Pwr/Environ/ Stim. Simulator	Special Maint. Aids/Tools	General Tools	Calibration/ Checkout Gases	Leak Test Equipment	Other	Automatic Checkout	Interface Equipment	Other	Launch Operations	Mission Operations	Post Mission Operations	Maintenance & Refurbishment
176H Taskboard, Force/Torque	PI																							
182K Vision Tester	PI																							
EU 93 MOBILITY UNIT																								
15 Anthropometric Grid														X										
122A Mass, Test, Variable Size	PI																							
126I Mobility Unit, Prot. Corridor				X										X										