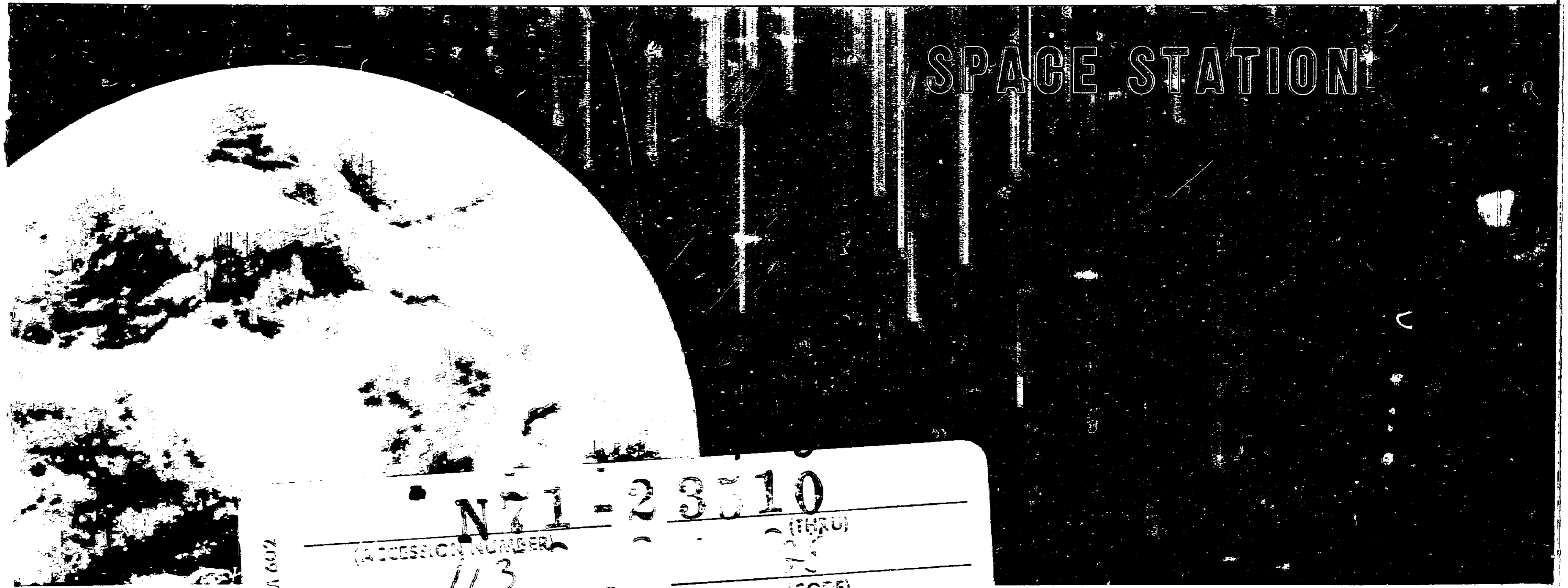
JUNE 1970

MDC G0583



DEVELOPMENT AND USE OF A 12-MAN SPACE STATION

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

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DEVELOPMENT AND USE OF A 12-MAN SPACE STATION

JUNE 1970 | MDC G0583

Briefing to the European Space Research Organization on Space Station Plans and Programs
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SPEAKER
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MCDONNELL DOUGLAS CORPORATION

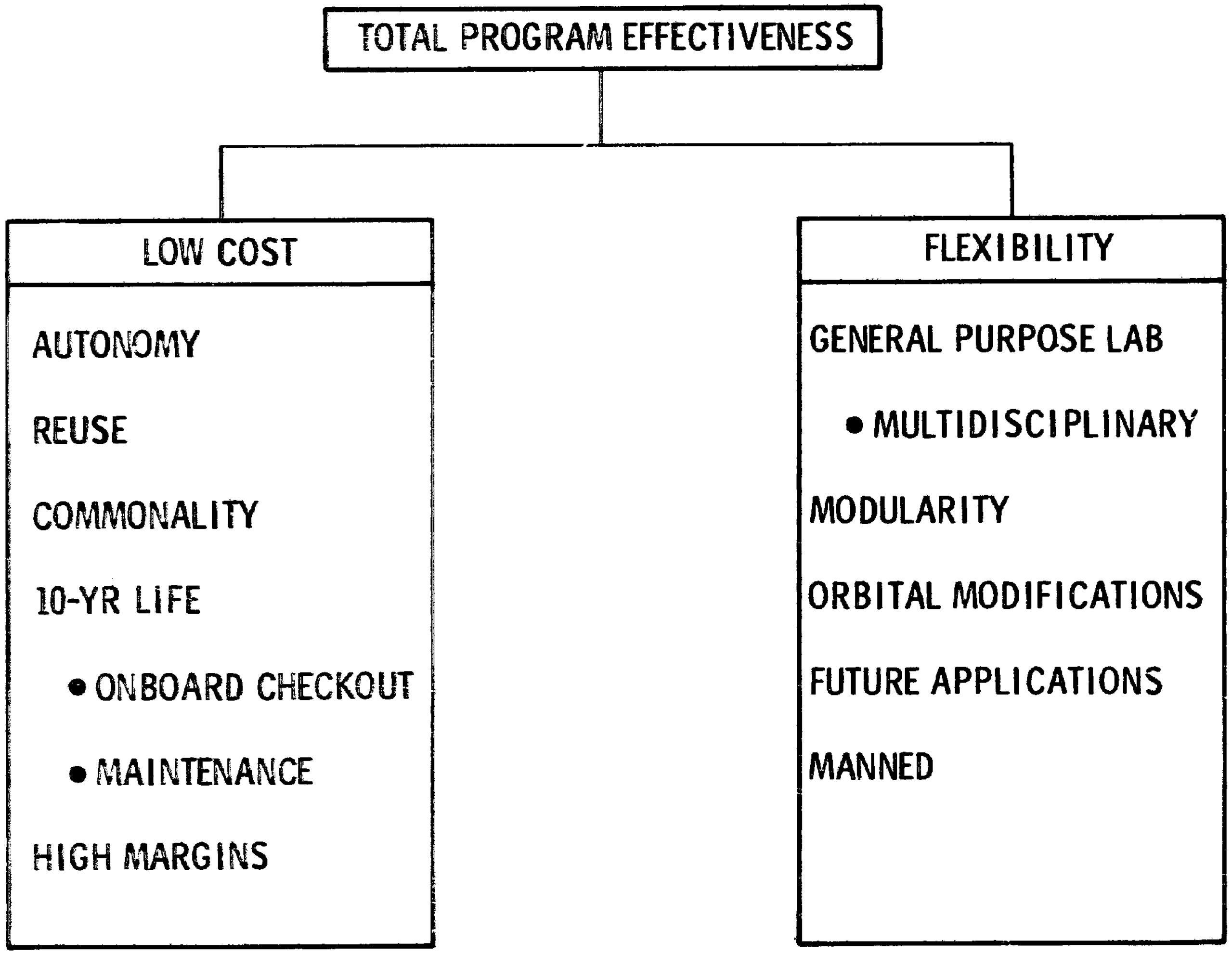
SPACE STATION PROGRAM

- OBJECTIVES AND SKYLAB CONTRIBUTIONS
- SPACE STATION CONCEPT
- EXPERIMENT CAPABILITY
- OPERATIONS

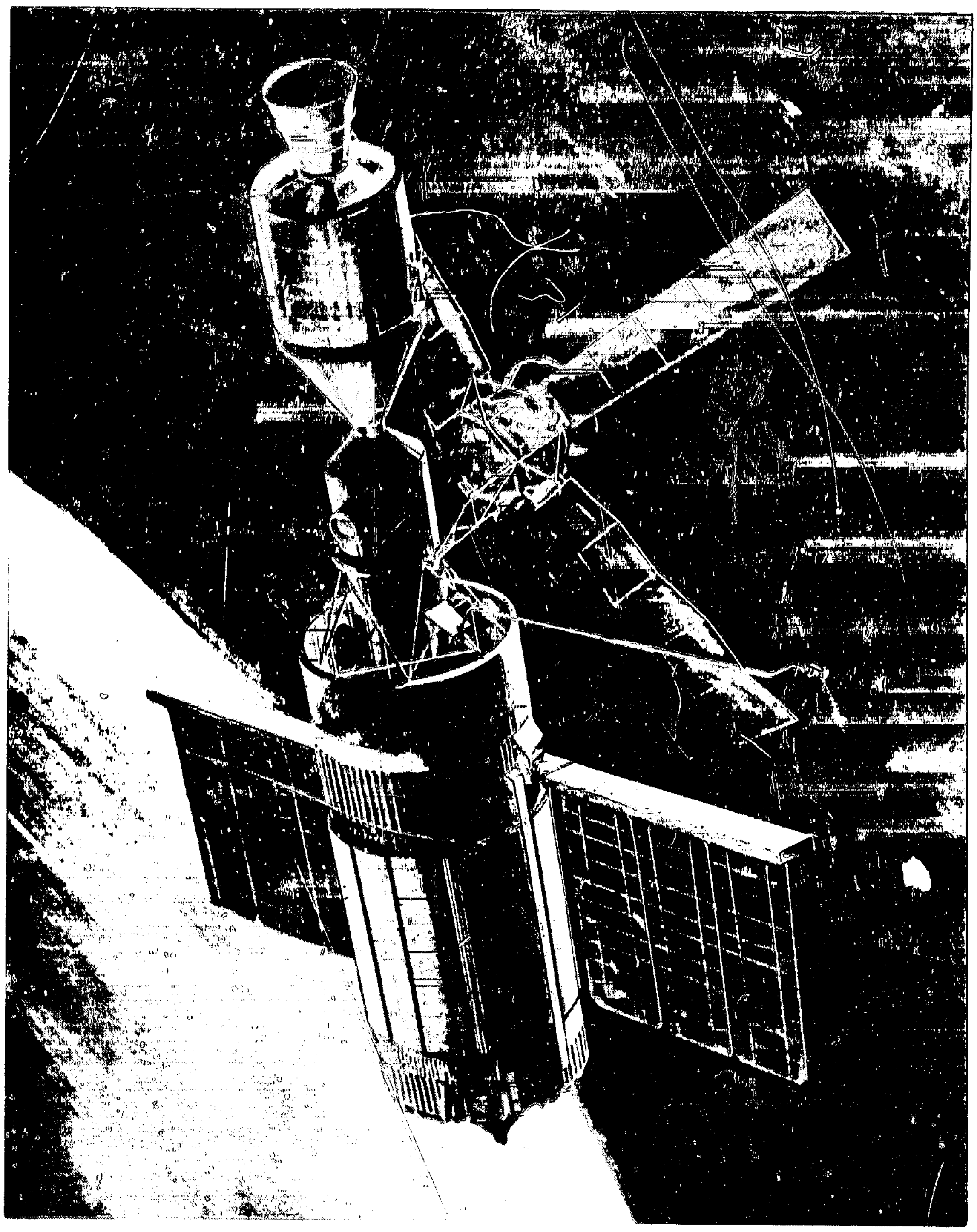
Low cost and flexibility are essential to total program effectiveness. Low cost is achievable by making maximum use of known technology in the design of the Space Station and in the structure of the program itself. A shift from ground-support operations to on-orbit autonomy and inherent long system life are the most influential low-cost factors. Flexibility must also be an inherent characteristic of the Space Station Program. Flexibility to respond to the dynamic nature of the experiment program to be accomplished is achieved through a general-purpose facility relatively insensitive to variations in flight objectives, program funding, and requirements for future missions.

12291

SPACE STATION PROGRAM OBJECTIVES



The Skylab Program scheduled for orbit operations in 1972-73 offers the Space Station Program a unique opportunity to obtain invaluable data on the performance of man and equipment in the Space Station environment for extended durations. The Skylab contains many systems that are prototypes of those to be used on the Space Station; although the requirements on these systems are not as severe, experience in the operation, maintenance, and habitability of the facility will significantly extend our knowledge and, thus, our confidence in the Space Station Program.



The manned space flight areas to be investigated on Skylab will cover almost all the general fields of interest for the Space Station Program. Also, flight-crew biomedical and performance data previously gathered on Gemini and Apollo can now be compared to similar data obtained in an environment free of the constraints associated with restricted mobility.

12314

SKYLAB CONTRIBUTION TO SPACE STATION DEVELOPMENT

- SKYLAB PROGRAM PROVIDES EXPERIMENTAL SPACE STATION FOR DEVELOPING TECHNICAL MATURITY IN THE FIELDS OF:

  BIOMEDICINE

  HABITABILITY

  TECHNOLOGY

  EXPERIMENTS

  OPERATIONS

- RESULTS ACHIEVED WILL RANGE FROM ADVANCED DATA GATHERING TO FLIGHT QUALIFICATION.

The Skylab mission doubles the exposure time of man's previous experience in the space environment. Extensive measurements and testing will form the basis for predicting the health and behavior of the flight crew for the Space Station mission. Equally important will be an assessment of prototypes of Space Station living facilities and of techniques and procedures for zero-gravity operations.

SKYLAB CONTRIBUTION TO SPACE STATION DEVELOPMENT (CONT)

BIOMEDICAL

- EXTEND MAN'S EXPOSURE TIME TO SPACE ENVIRONMENT – 30-56 DAYS
- EXTENSIVE MEDICAL DATA FROM IN SITU AND PROVOCATIVE TESTING
- TOTAL METABOLIC ANALYSIS IN CLOSED ENVIRONMENT
- MICROBIOLOGICAL EFFECTS AND CONTROL FOR EXTENDED AND MULTIPLE CREW HABITATION
- OVERALL MISSION EFFECTS ON CREW HEALTH AND WELL BEING

HABITABILITY

- UTILITY ANALYSIS OF LARGE CREW QUARTERS AND WORK AREAS
- EVOLUTION FROM COCKPIT TO SPACE SHIP ACCOMMODATIONS
- FOOD MANAGEMENT, NORMAL "EARTH" FOOD ACCOMMODATION
- HYGIENE AND SLEEP ACCOMMODATIONS
- MOBILITY, RESTRAINT, AND CARGO-TRANSFER TECHNIQUES

Prototype system designs will be evaluated to increase our confidence in Space Station technology. Many experiments to be performed on Skylab are precursors to those envisioned for the Space Station. The experience of the crew in operating and maintaining the Skylab will also be directly applicable.

SKYLAB CONTRIBUTION TO SPACE STATION DEVELOPMENT (CONT)

TECHNOLOGY

- METEOROID PROTECTION
- LARGE SOLAR ARRAYS
- PASSIVE THERMAL CONTROL (INSULATION, SURFACE COATING)
- FORCED-AIR ENVIRONMENTAL CONTROL IN ZERO GRAVITY
- ATTITUDE CONTROL WITH LARGE CONTROL-MOMENT GYROS

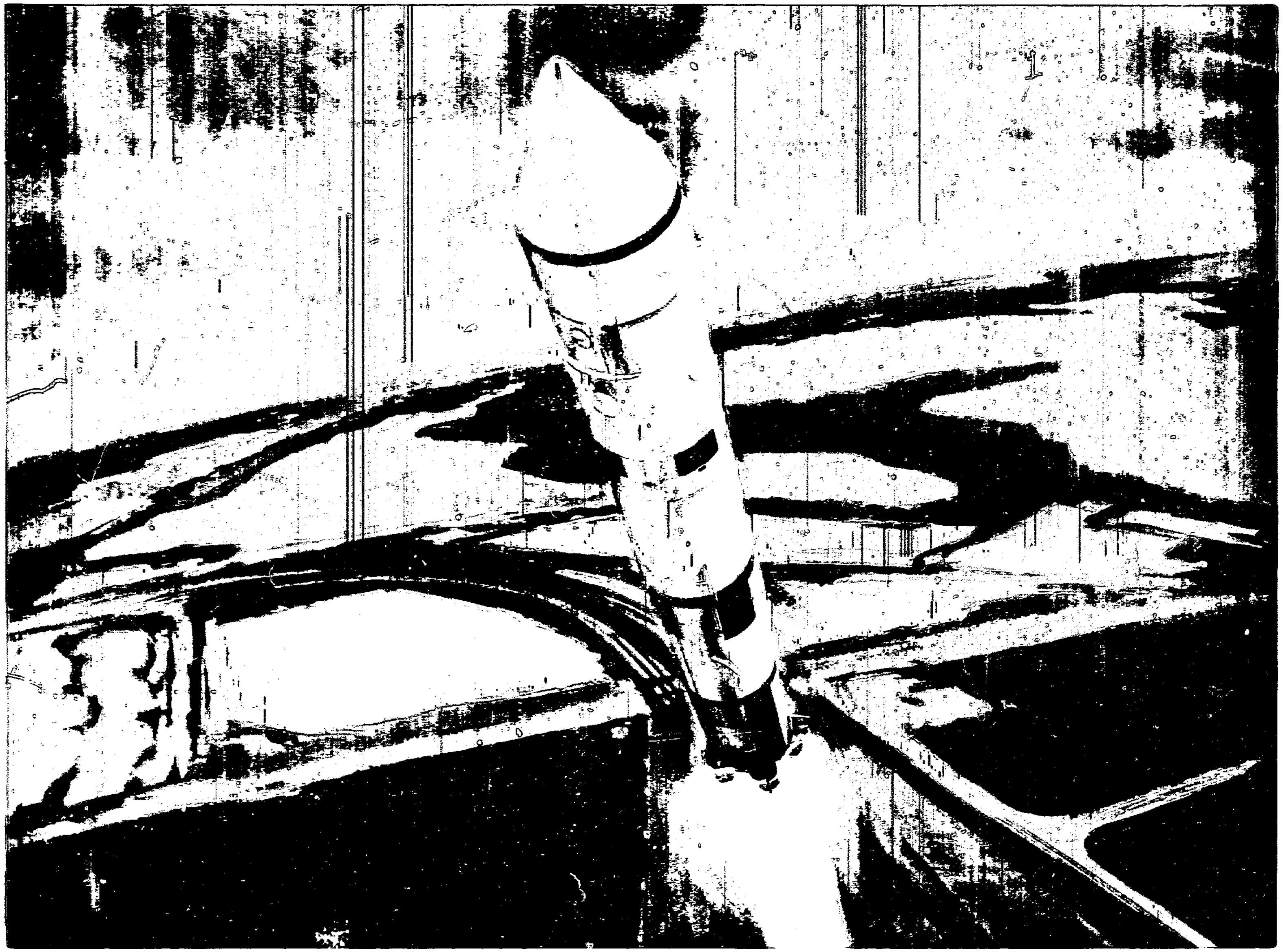
EXPERIMENTS

- SOLAR ASTRONOMY
- EXTRAVEHICULAR SPACE MANEUVERING UNITS
- PRECURSOR EXPERIMENTS IN REMOTE EARTH SENSING, SPACE MANUFACTURING

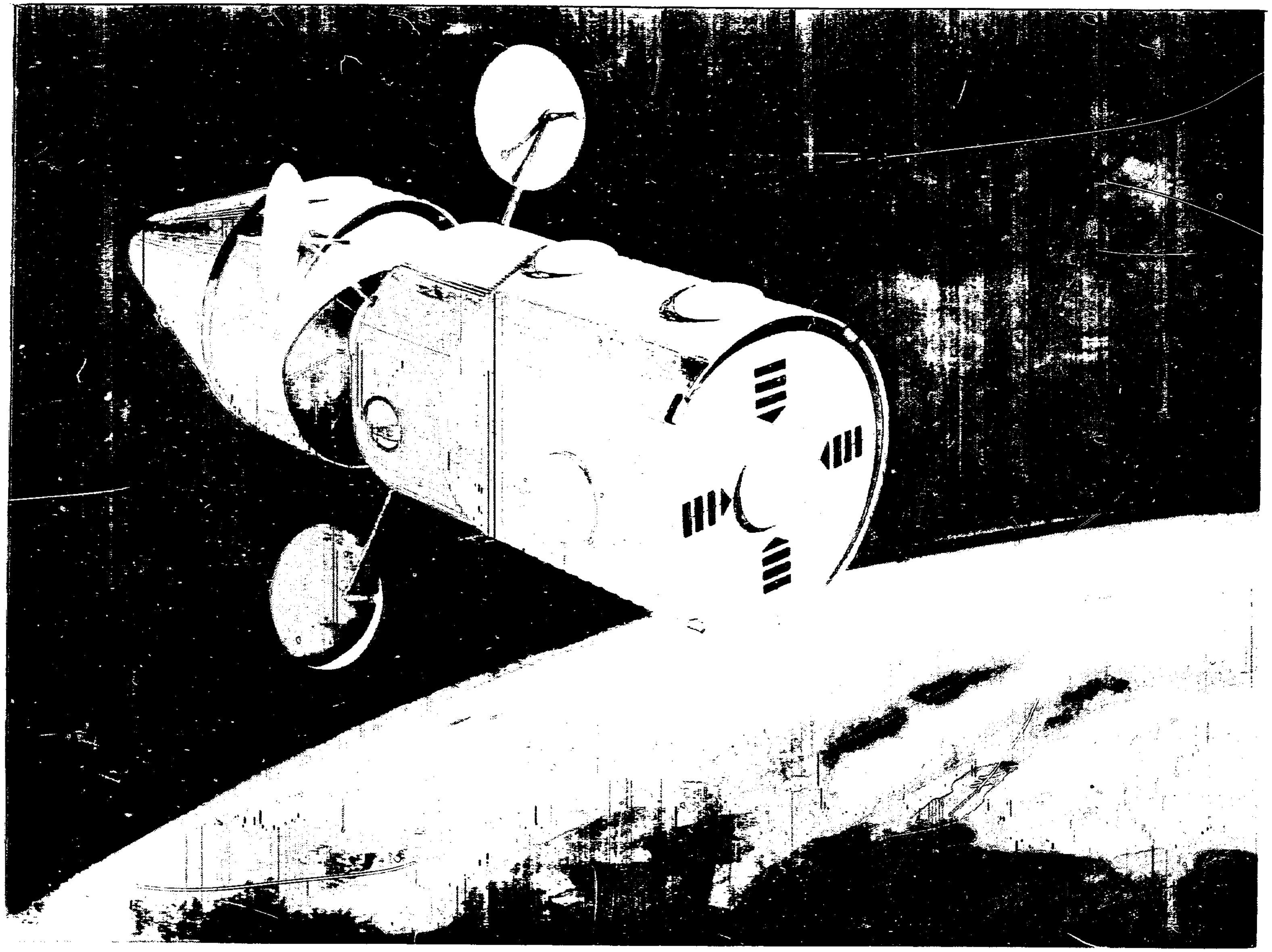
OPERATIONS:

- SPARES LOGISTICS AND RESUPPLY
- CREW UTILIZATION/SKILLS IDENTIFICATION FOR MULTIPLE EXPERIMENT PROGRAM
- DATA COLLECTION AND DISSEMINATION

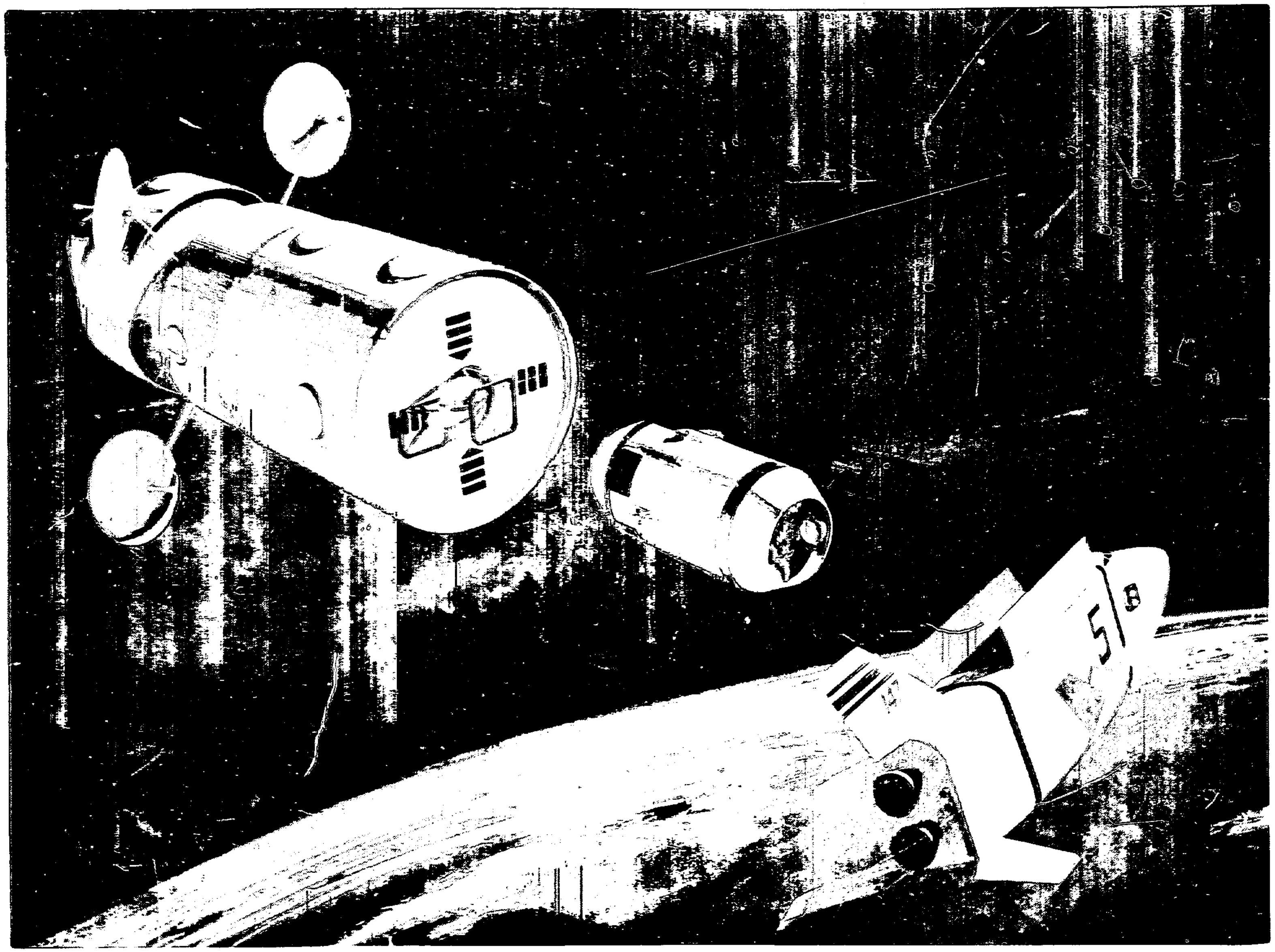
The Space Station will be launched unmanned from the Kennedy Space Center using the first two stages of the Saturn V launch vehicle, designated the INT-21.



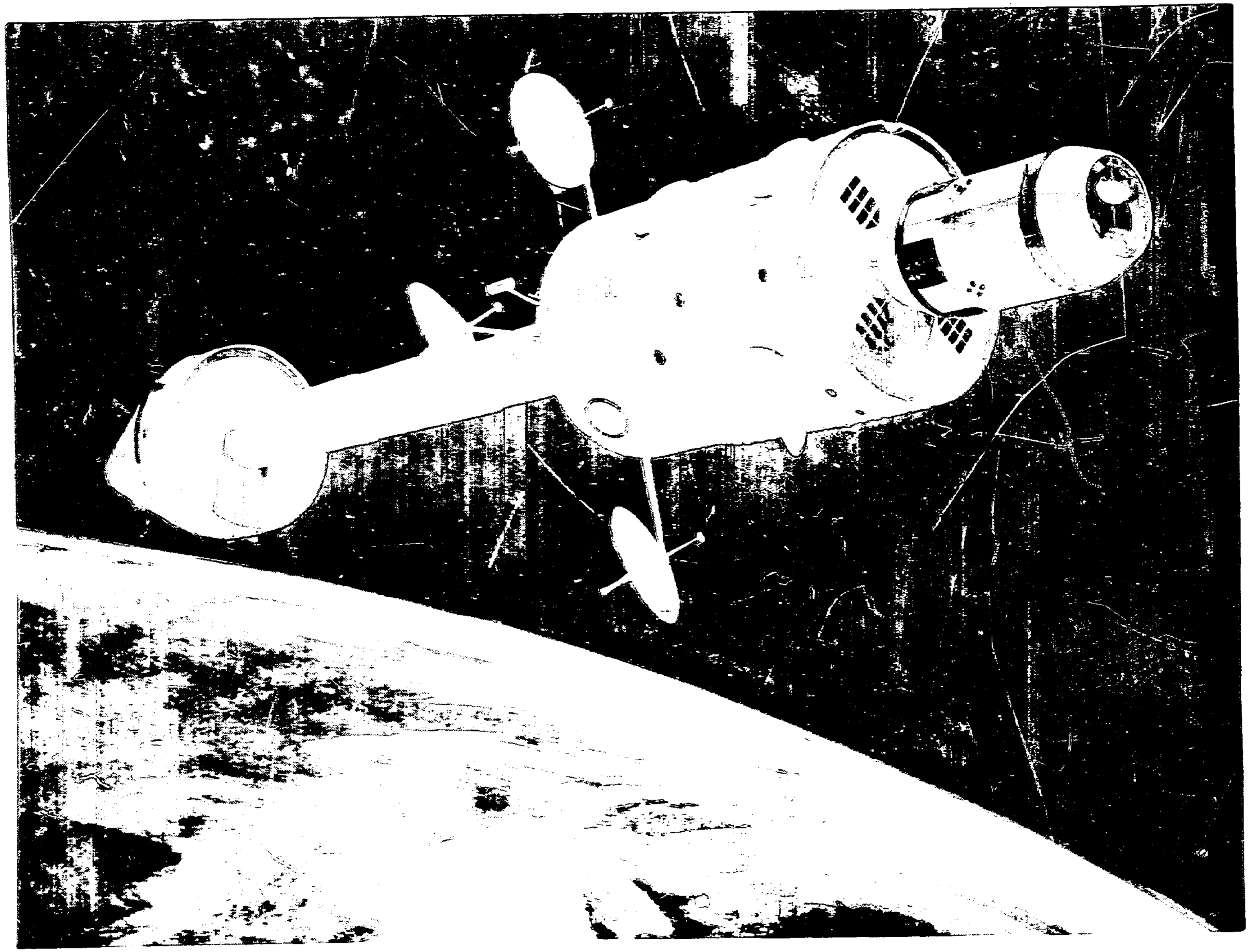
The launch vehicle places the Space Station into a 456-kilometer circular orbit at an inclination of 55 degrees. The S-II second stage is separated and deorbited into a preselected deep-ocean area. The critical systems - communications, life support, etc. - are activated and the readiness of the Space Station for manned occupancy is verified prior to committing the launch of the logistics system that will carry the Space Station crew.



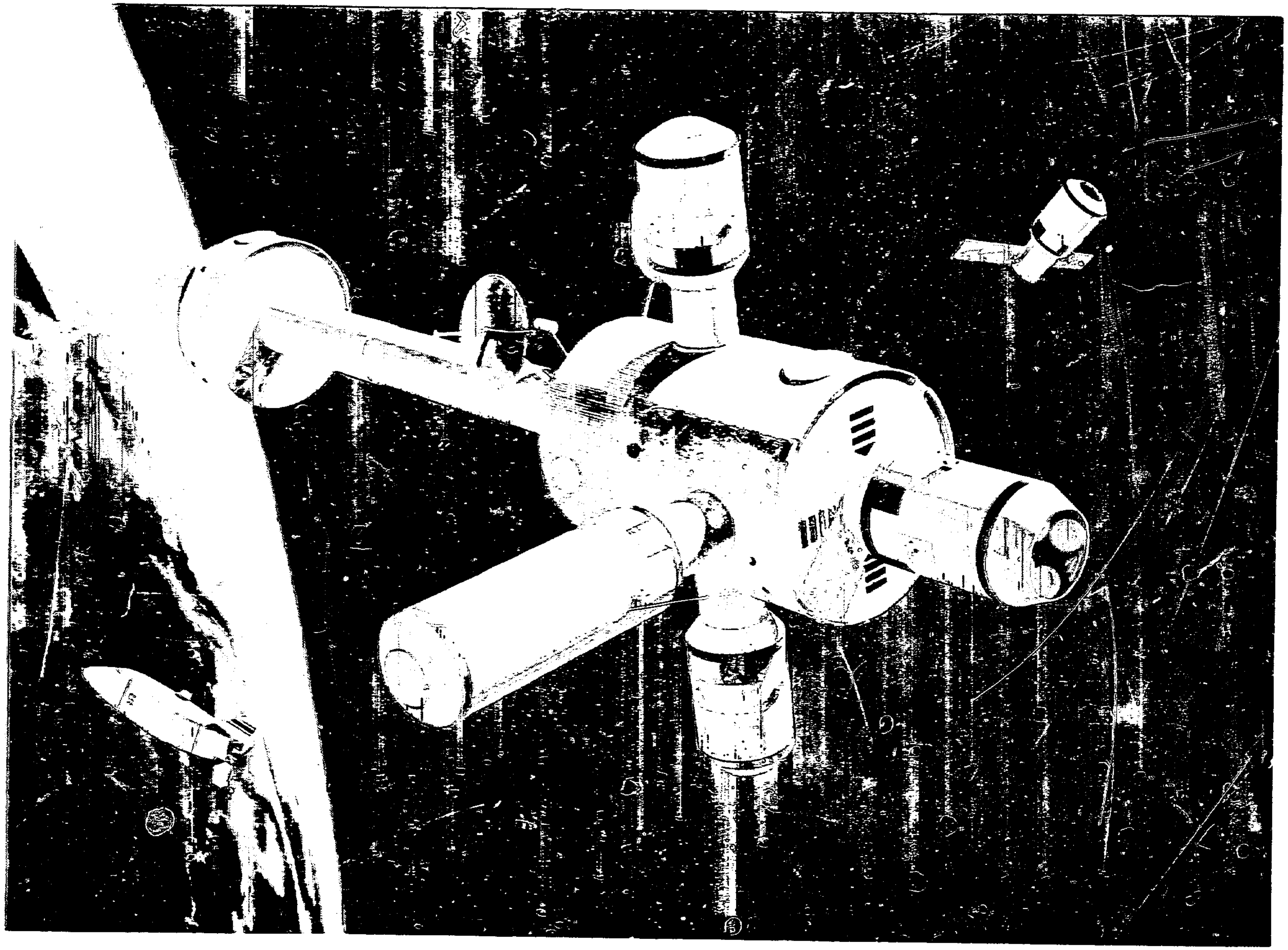
The logistics system, which consists of the logistics spacecraft (or orbiter) and the crew/cargo module, is launched 24 hours after the launch of the Space Station. After rendezvous some 8 hours later, the crew/cargo module separates from the logistics spacecraft and propels itself toward a docking maneuver with the Space Station. After docking, the crew enters the station, activates the remaining systems, and advises the orbiter that station operations can begin. Approximately 25 hours after initial manning, the orbiter begins its return flight to Earth.



During the first month, the crew activates all systems and readies the station for artificial-gravity test operations. The artificial-gravity module is deployed on a telescoping spoke. The combined mass of the artificial-gravity module and the station is spun about its center of gravity; the resulting centrifugal force produces a simulated gravity environment. The purpose of this operation is to explore the potential benefits and problems associated with artificial gravity.



When the artificial-gravity operations are completed, the logistics system begins delivery of additional experiments contained in modules; typically the Space Station may have three or four modules attached to it while three or four other modules are flying free around it. Logistics appointments become regular (nominally, every 90 days) and the experiment program is in full swing.



Among the major programmatic and design requirements that strongly influence the synthesis of the Space Station, these have the most significant impact. The selected launch vehicle permits a diameter of 9.2 meters, which allows a minimum-length station with maximum payload potential. Achievement of a 10-year life demands sophisticated techniques for onboard checkout, fault isolation, repair, and, if necessary, system replacement.

20603

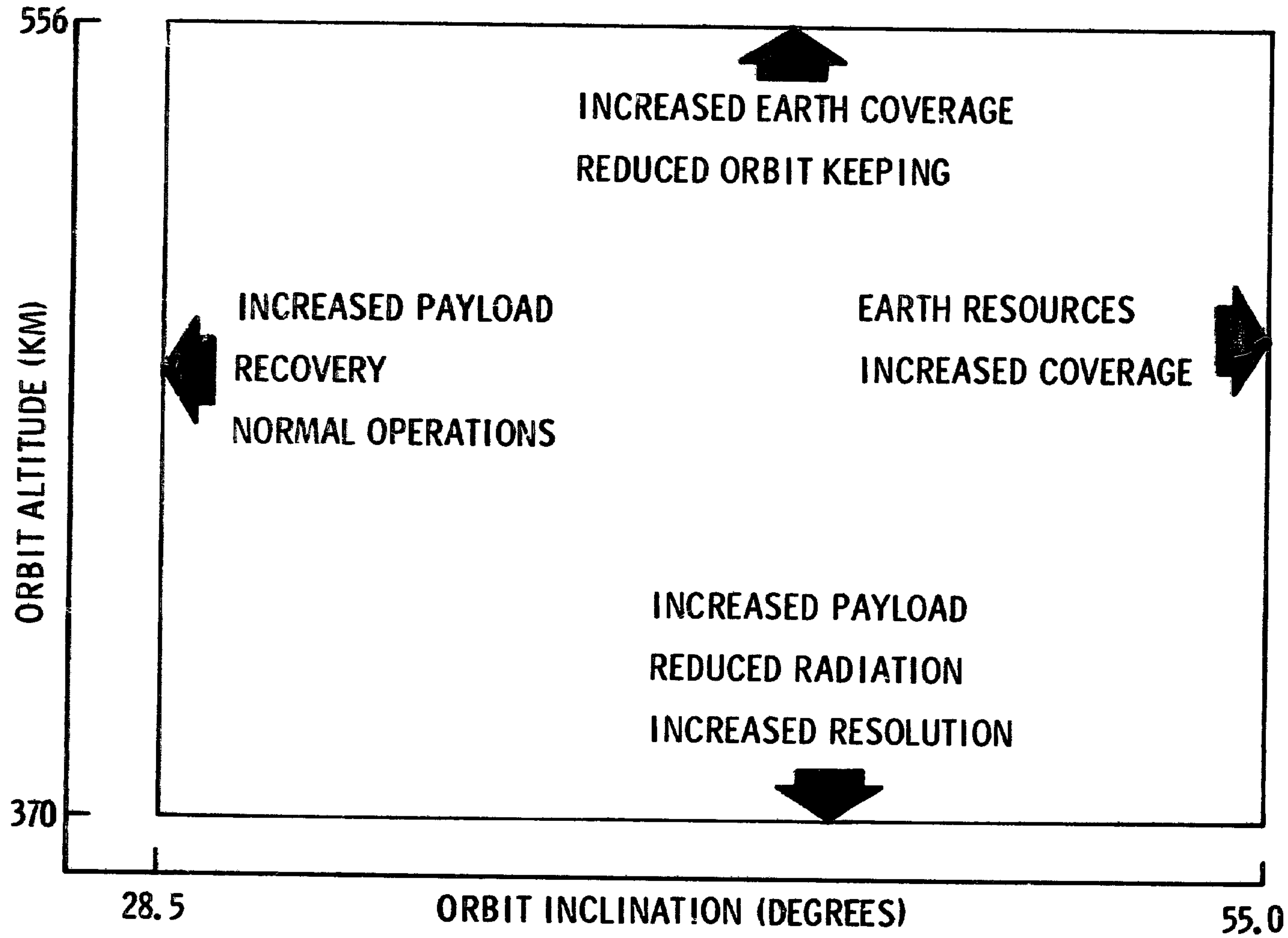
SPACE STATION GUIDELINES

- 1977 LAUNCH
- INT-21 (SATURN V) LAUNCH FROM KENNEDY SPACE CENTER
- 55 DEGREE INCLINATION
- 12-MAN CREW
- 10-YEAR OPERATIONAL LIFE
- 90-DAY RESUPPLY FREQUENCY
- 180-DAY CAPABILITY WITHOUT RESUPPLY
- MAXIMUM ONBOARD AUTONOMY
- ACCOMMODATION FOR ALL CANDIDATE EXPERIMENTS
- CAPABILITY FOR ARTIFICIAL-GRAVITY EXPERIMENTS

The Space Station is designed to operate in an orbit bounded by the indicated altitudes and inclinations. The nominal orbit is 456 kilometers at an inclination of 55 degrees. In addition, without provisions for artificial gravity, the Space Station can be placed into a 370-kilometer polar or sun-synchronous orbit, should the demands of the international research facility so dictate.

00596

SPACE STATION ORBIT SELECTION CONSIDERATIONS

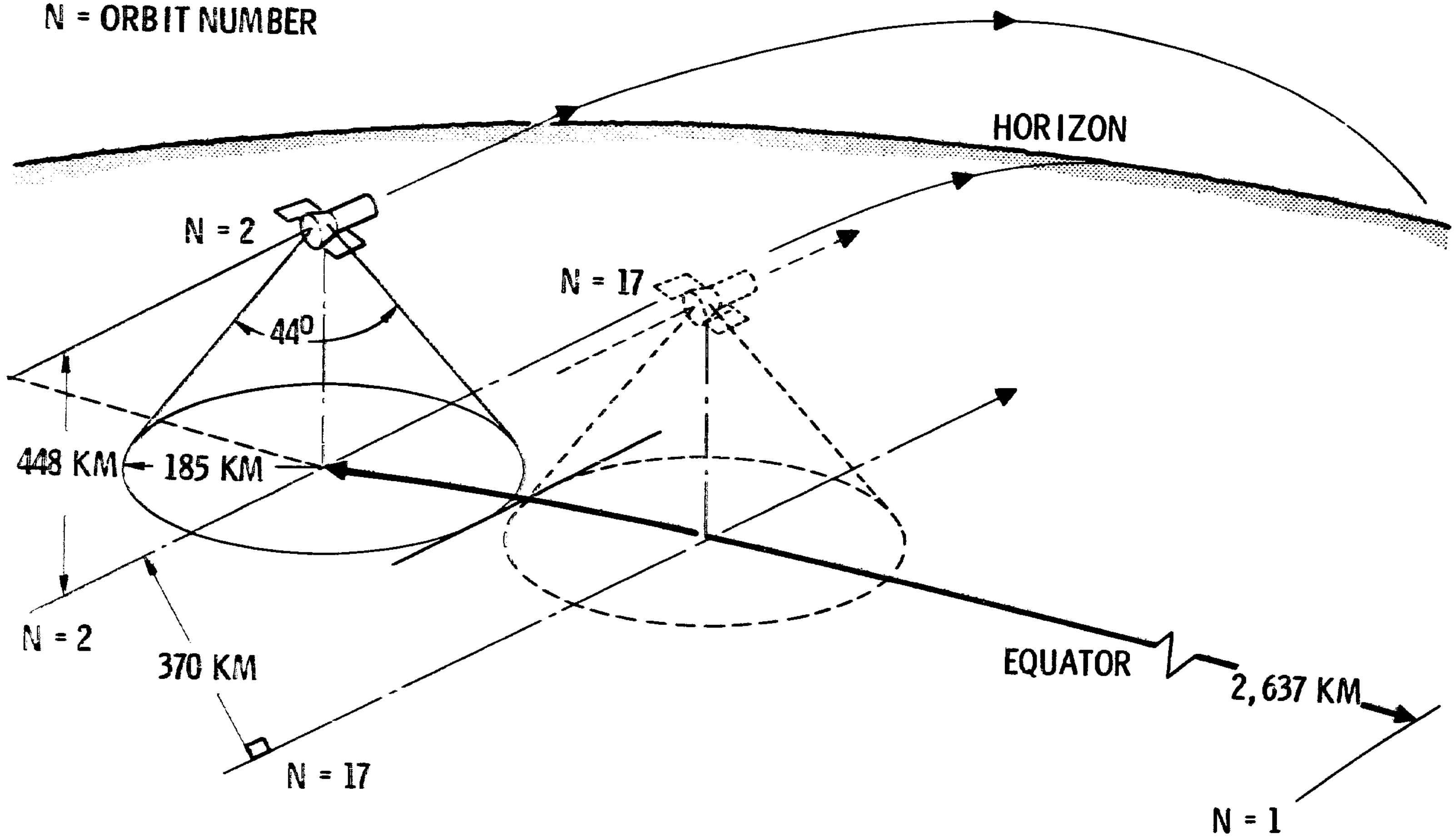


The nominal Space Station orbit of 456 kilometers provides Earth coverage in a minimum amount of time by progressively passing over all the surface area within the 0±55-degree band. This general requirement is obtained from a careful examination of potential Earth resources experiments which clearly indicate a preference for a progressive ground trace. Consideration is also given to total system payload performance and to launch vehic and logistics system payload capability; conveniently this capability is insensitive within a wide altitude band. With a field-of-view angle of 44 degrees, the Earth coverage is a band some 370 kilometers wide. Each orbit trace is about 2, 637 kilometers apart; some 15 orbits later, the traces touch each other.

00658

EARTH COVERAGE PROFILE
SPACE STATION

456 KM ALTITUDE (448 KM AT EQUATOR)
55 DEG INCLINATION
N = ORBIT NUMBER

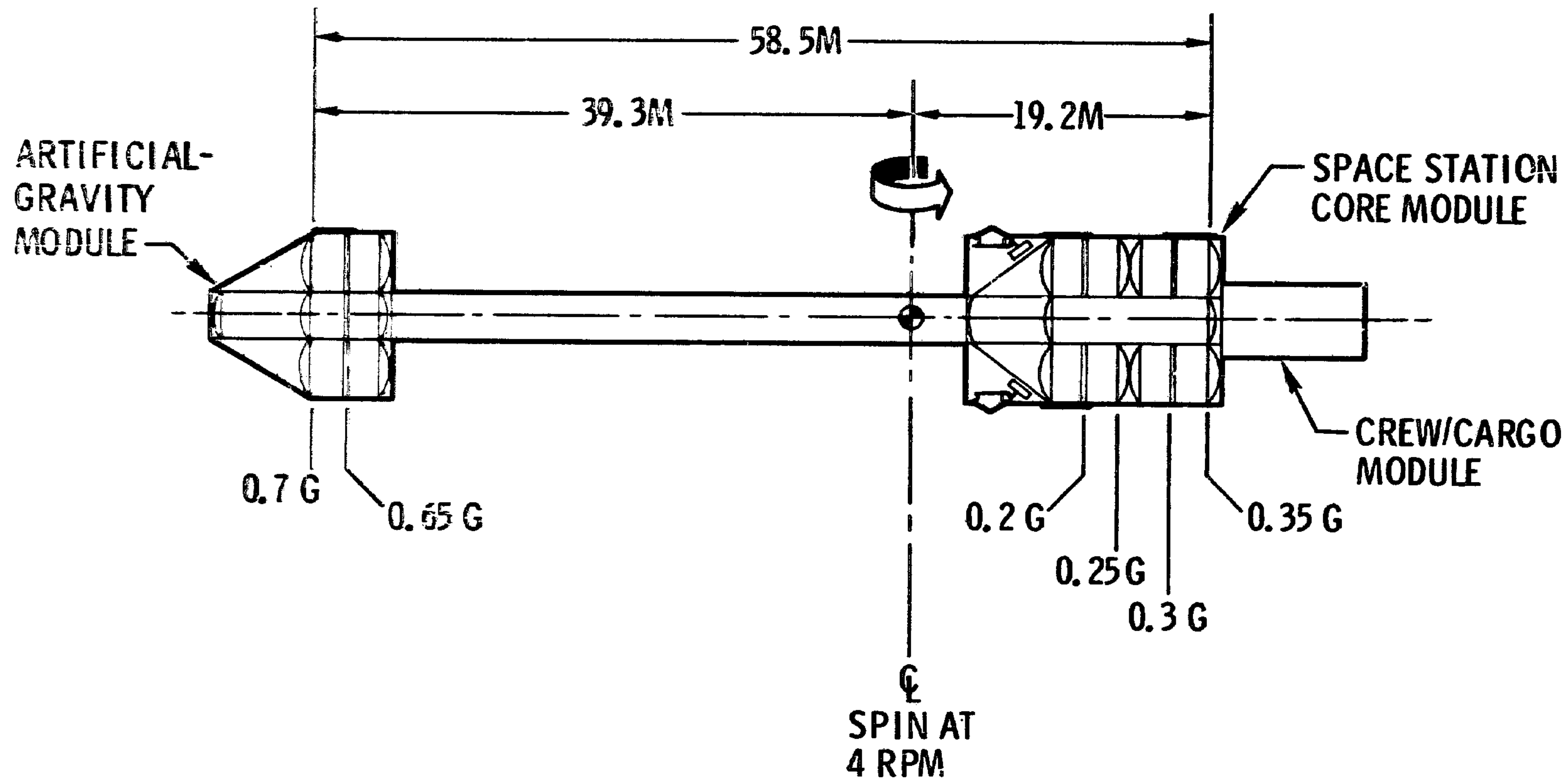


The Space Station is shown in a cutaway perspective. Equipment and activities are depicted as they would look upon completion of the outfitting of the station. The telescoping spoke is abbreviated for the purpose of this illustration.

During the 30-day artificial-gravity experiment, half the crew (six men) occupies the deployed artificial-gravity module. The men will live in the same environment as those remaining in the core module except that their effective gravity level will be higher (0.7 g) than it is in the core module. Some of the crew will inhabit a zero-gravity cab located at the center of rotation; there they will duplicate certain tasks being performed in artificial gravity so that the effects of the two environments can be compared. Of major interest is an evaluation of the effects of going from a zero-gravity environment to an artificial-gravity environment. The Space Station can repeat the artificial-gravity test as required; about five repetitions are assumed for design purposes.

20606

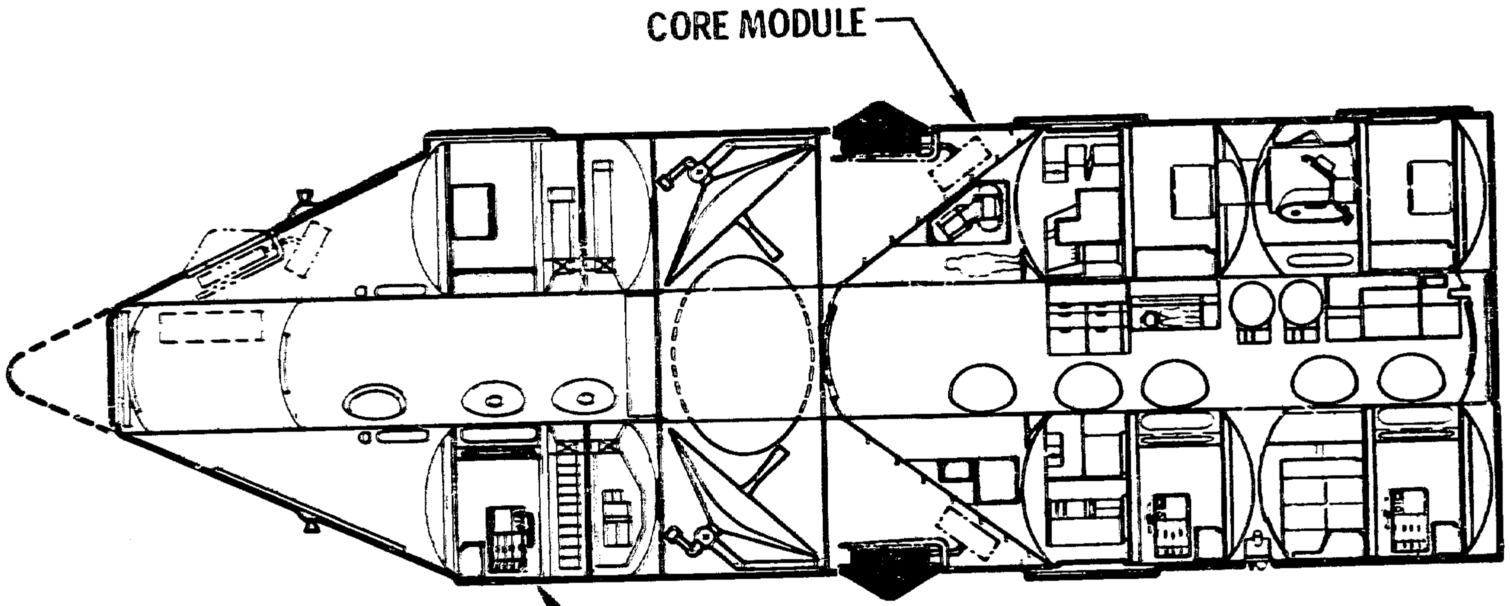
ARTIFICIAL GRAVITY TEST CONFIGURATION



The Space Station is 9.2 meters in diameter and about 34 meters long. It consists of a core module some 15 meters long and an artificial-gravity module. Further modular division is visible in that the core module contains two separate modules, each consisting of two decks; a third two-deck module comprises the habitable portion of the artificial-gravity module.

11908

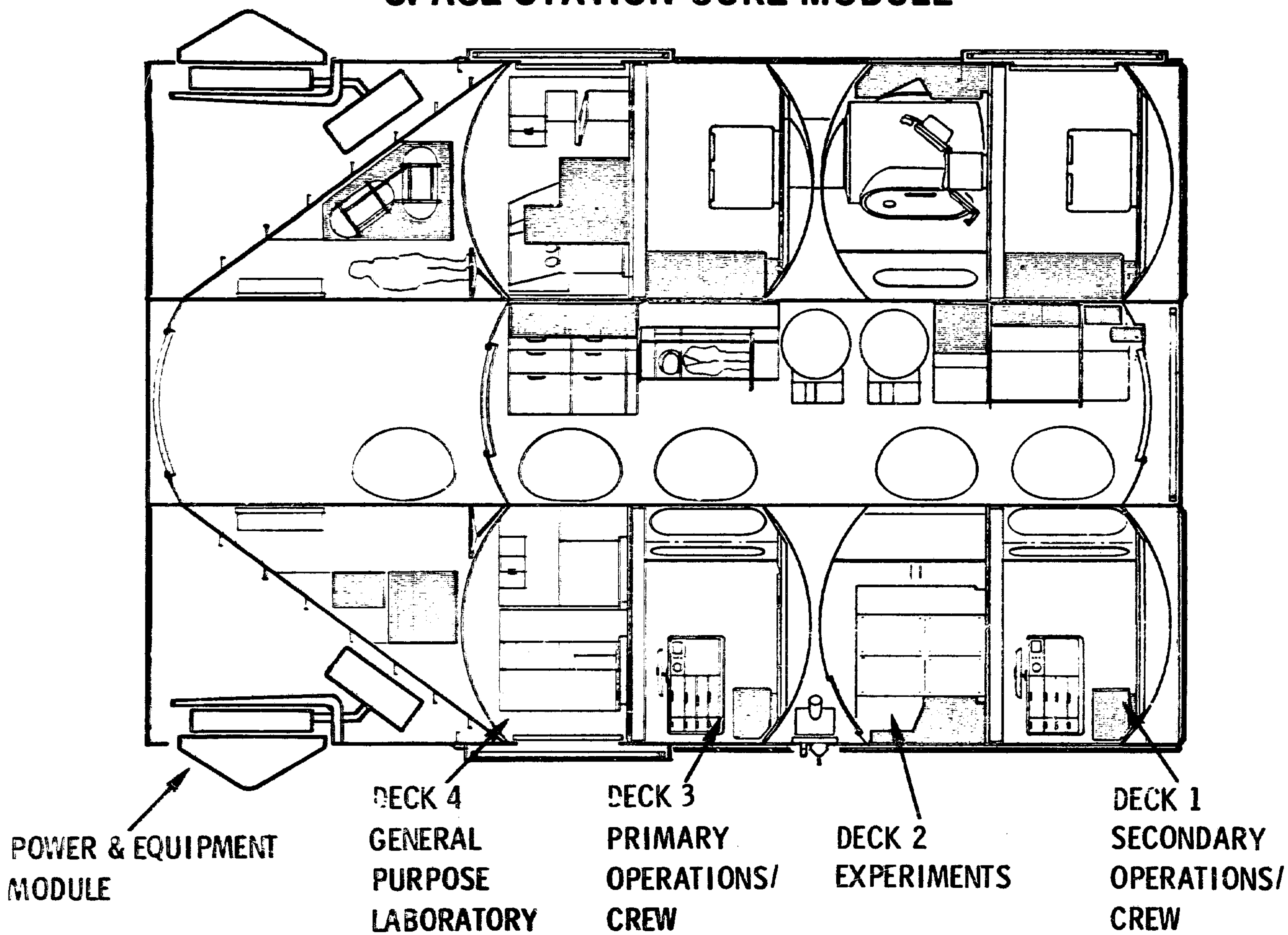
SPACE STATION CONFIGURATION AT LAUNCH



The core module contains three pressurized compartments; the compartment formed by Decks 1 and 2, the compartment formed by Decks 3 and 4, and the central tunnel. This feature ensures that a habitable environment will be available should pressure be terminated in either of the two primary compartments. The tunnel serves as the primary traffic route for men and equipment between decks. The forward end of the core module contains the isotope/Brayton electrical power system in an unpressurized environment and a storage compartment, which may be pressurized for access.

11089

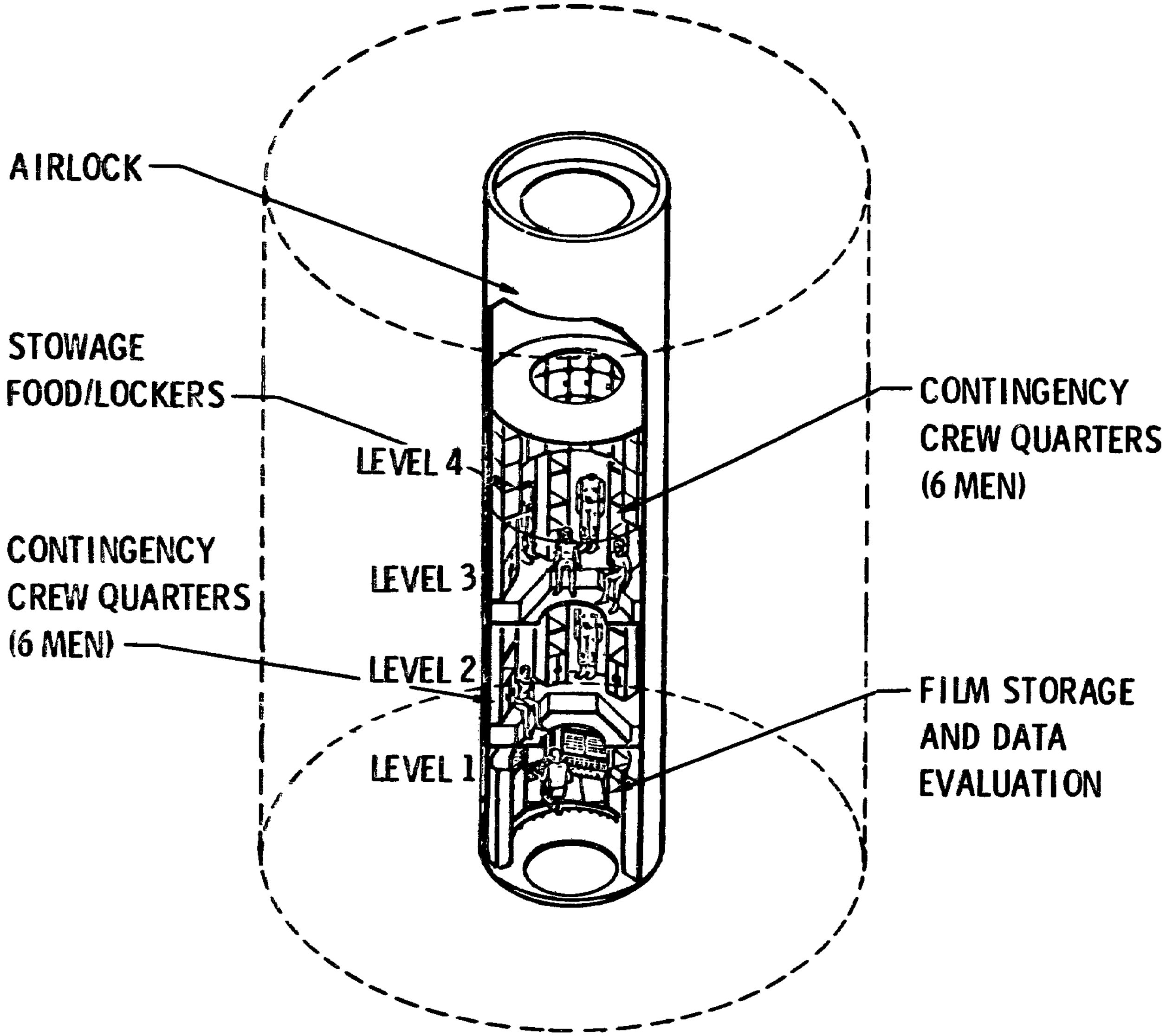
SPACE STATION CORE MODULE



The core module tunnel has many functions other than that of being the main traffic artery. Contingency provisions are available should habitation of this compartment be required.

TUNNEL

12297



Structural optimization combined with a thorough use analysis has produced the tunnel design whose features are presented here.

10022A

TUNNEL CHARACTERISTICS

PRIMARY REQUIREMENTS

- PROVIDE STRUCTURAL EFFICIENCY
- PROVIDE MAIN ARTERY FOR CREW AND CARGO TRAFFIC BETWEEN SEPARATE COMPARTMENTS
- PROVIDE A RADIATION SHELTER DURING SOLAR FLARE OR OTHER EMERGENCY

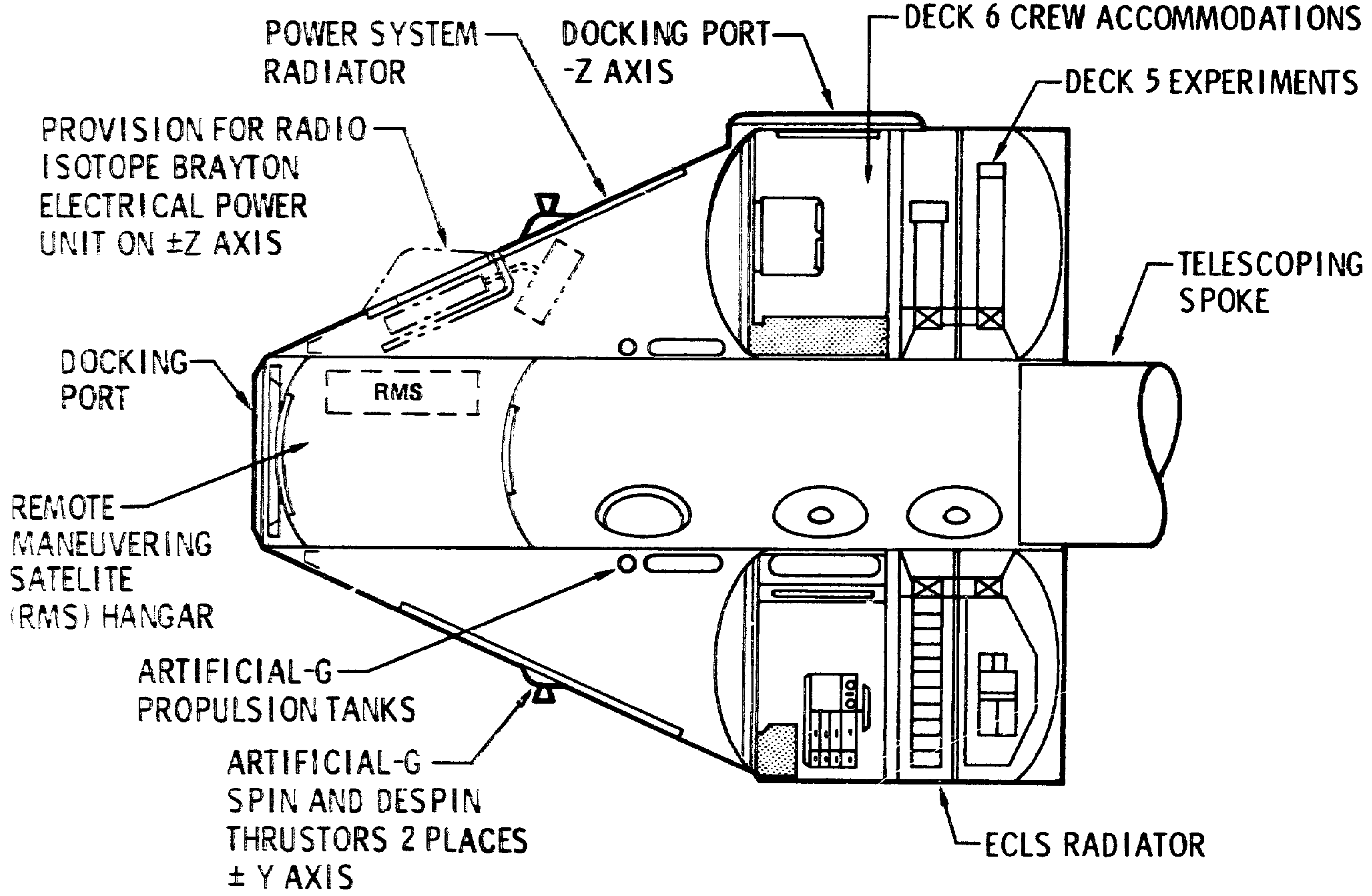
FEATURES

- 3 METERS DIAMETER
- 1.5 METERS DIAMETER OPENINGS AT ENDS AND TO EACH DECK
- CONVENIENT STORAGE VOLUME, I.E. FOOD, PRESSURE SUITS
- RADIATION PROTECTION FOR FILM STORAGE
- THROUGH PASSAGE FOR CONDUIT, PIPING, AND DUCTING
- CONNECTED TO ENVIRONMENTAL CONTROL SYSTEM OF EITHER OR BOTH COMPARTMENTS
- REVERSE PRESSURE CAPABILITY

Similar to the forward half of the core module, the artificial-gravity module contains a two-deck module and a conical section containing a propulsion system to provide the spin necessary for artificial-gravity operation. This conical section also has provisions to increase the electrical power capability of the Space Station through the later addition of one or more isotope/Brayton units. Initially, Deck 6 is configured as a crew and operations facility for the artificial-gravity experiment. When the equipment used in the crew and operations facility is stowed, the volume can be converted to accommodate additional research facilities. If the need arises to accommodate a larger crew (up to 18 men), this deck can be reconverted to a crew facility. Two centrifuges occupy Deck 5.

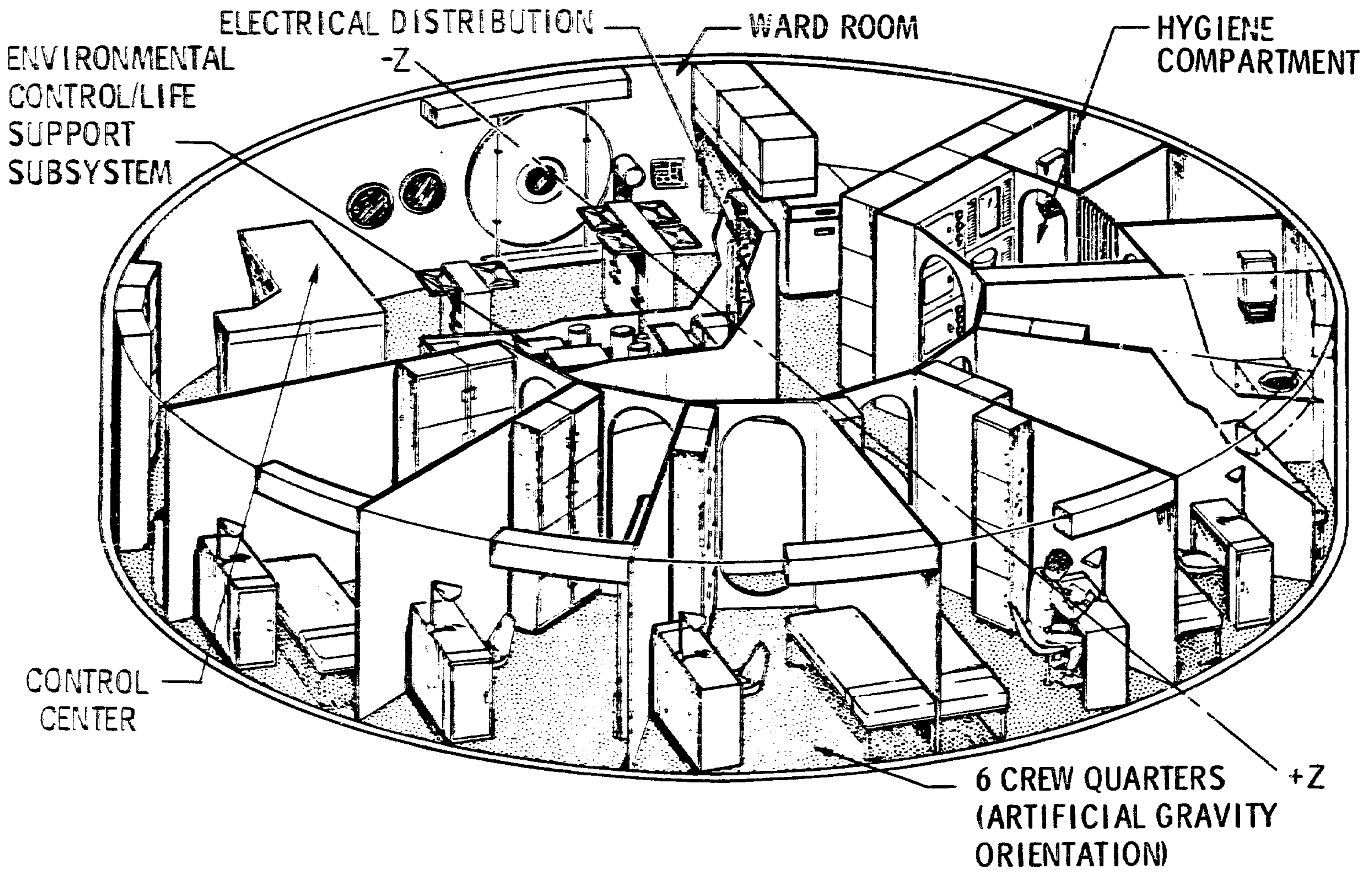
12292

ARTIFICIAL GRAVITY MODULE



One deck in each of the three modules is configured to support the crew. Facilities on each deck are sized to provide private quarters and eating and hygiene facilities for six men. However, the life support system will accommodate the entire crew of 12 on any deck. The layout shown is for the artificial-gravity module.

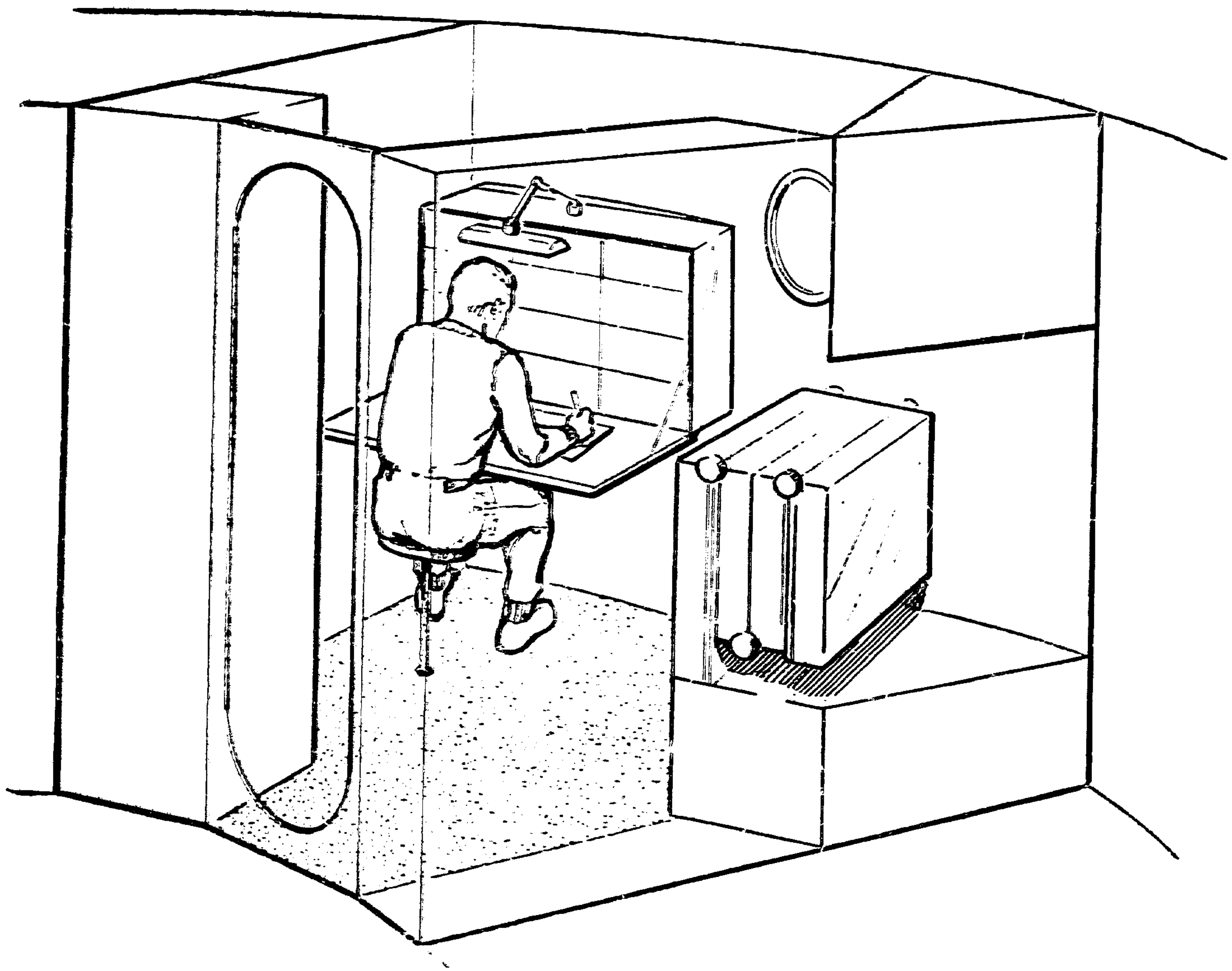
CREW FACILITIES AND OPERATIONS (DECKS 1, 3, AND 6)



Each crewman is provided private quarters of about 4.6 square meters for sleeping and for storage of personal items. These quarters can be used as an office or for relaxation, recreation, study, and meditation. A lightweight bed is correctly aligned for sleeping during the spinning artificial-gravity test. The illustration depicts a bunk and desk arrangement that permits the better space utilization possible in the zero-gravity mode.

10617

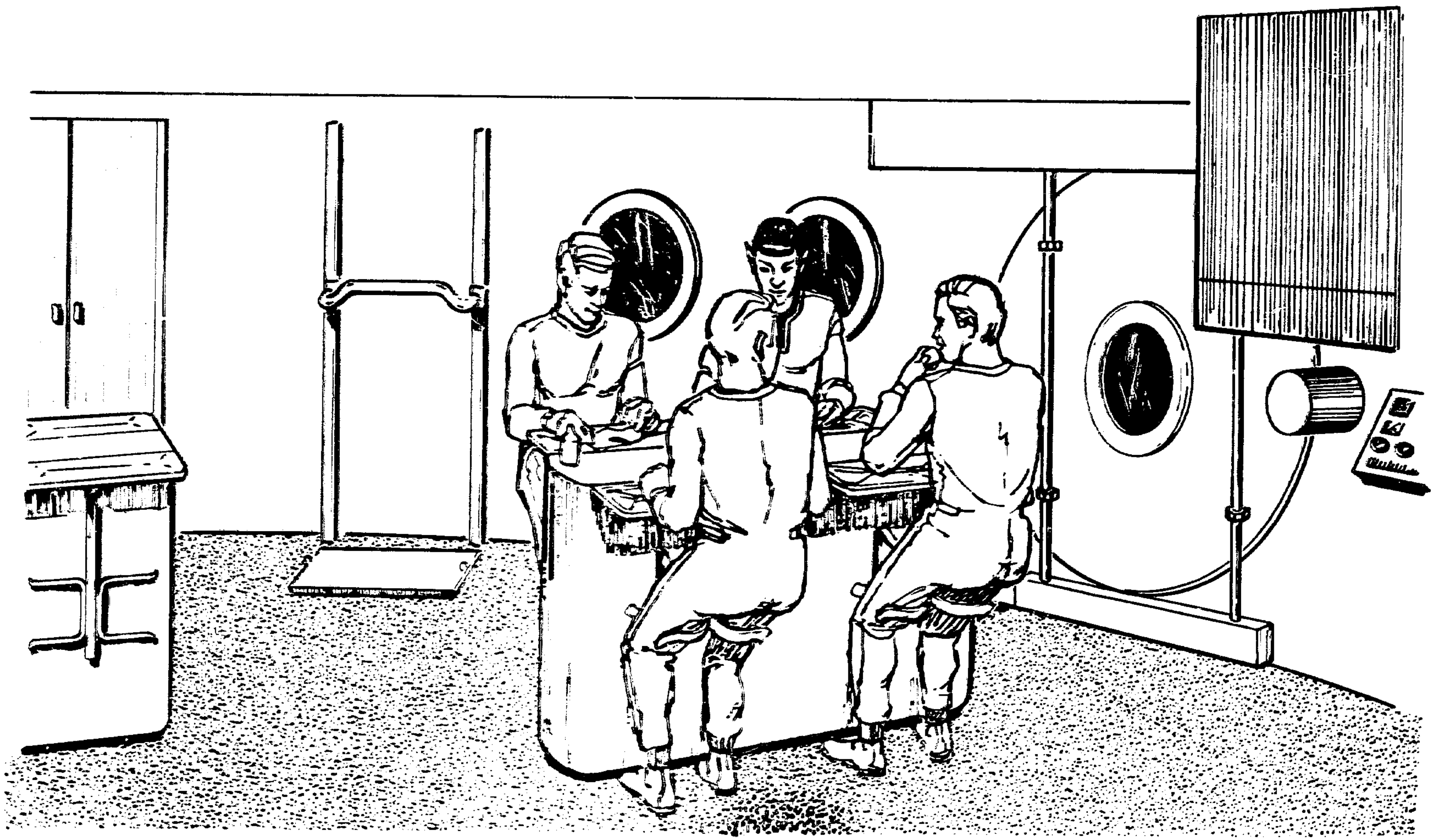
PRIVATE CREW QUARTERS



The wardroom is truly a multi-purpose room. Space is provided for portable eating tables, and the room may quickly and easily be converted into an exercise area, recreation room, meeting room, or theater.

12280

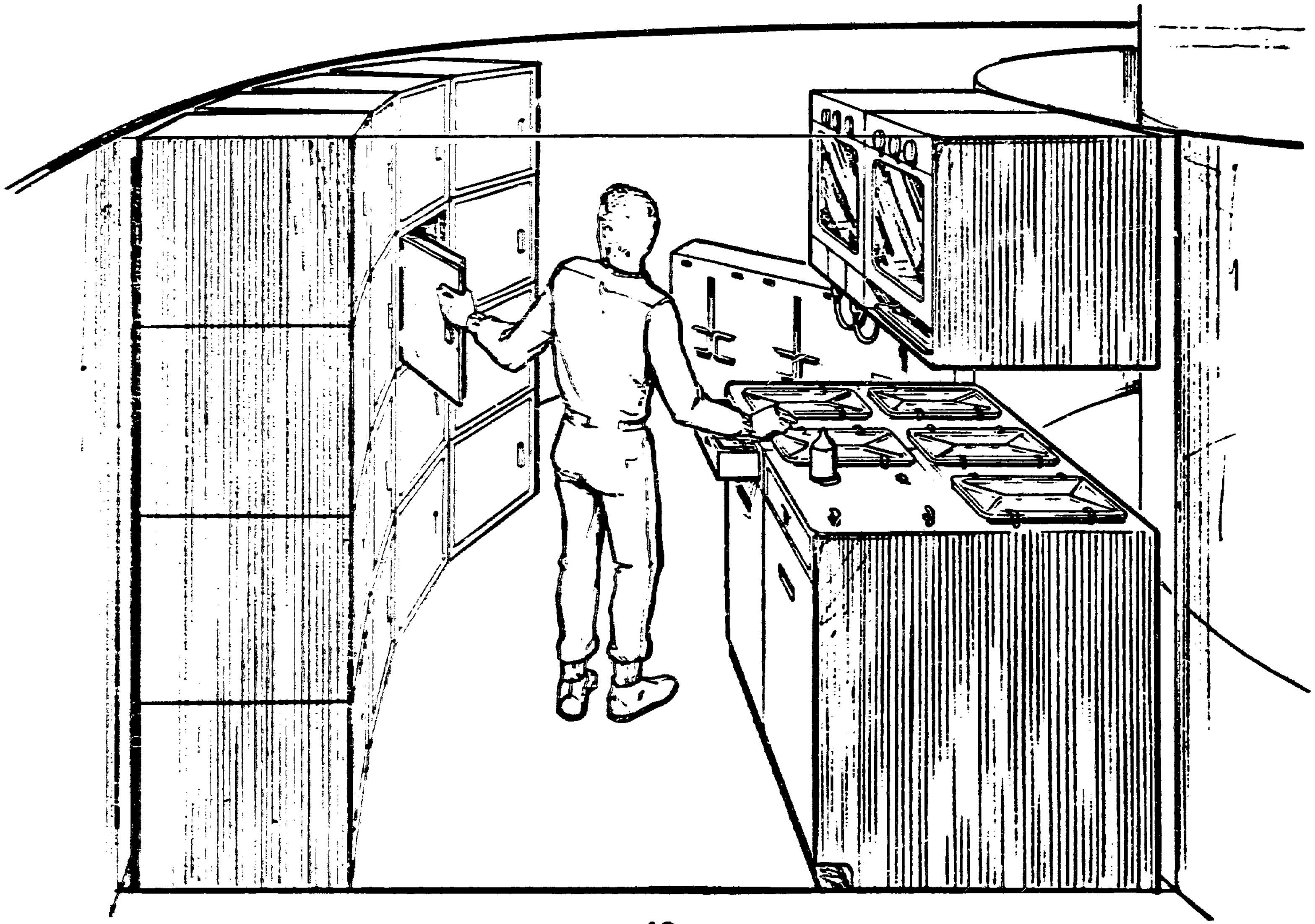
WARDROOM



The galley provides all the equipment necessary for food preparation. Food-storage lockers contain sufficient supplies for 90 days, the logistics resupply interval. The diet is selected for maximum palatability, with various degrees of wet and even fresh foods. Each crewman can serve himself or prepare food trays for his colleagues.

10628

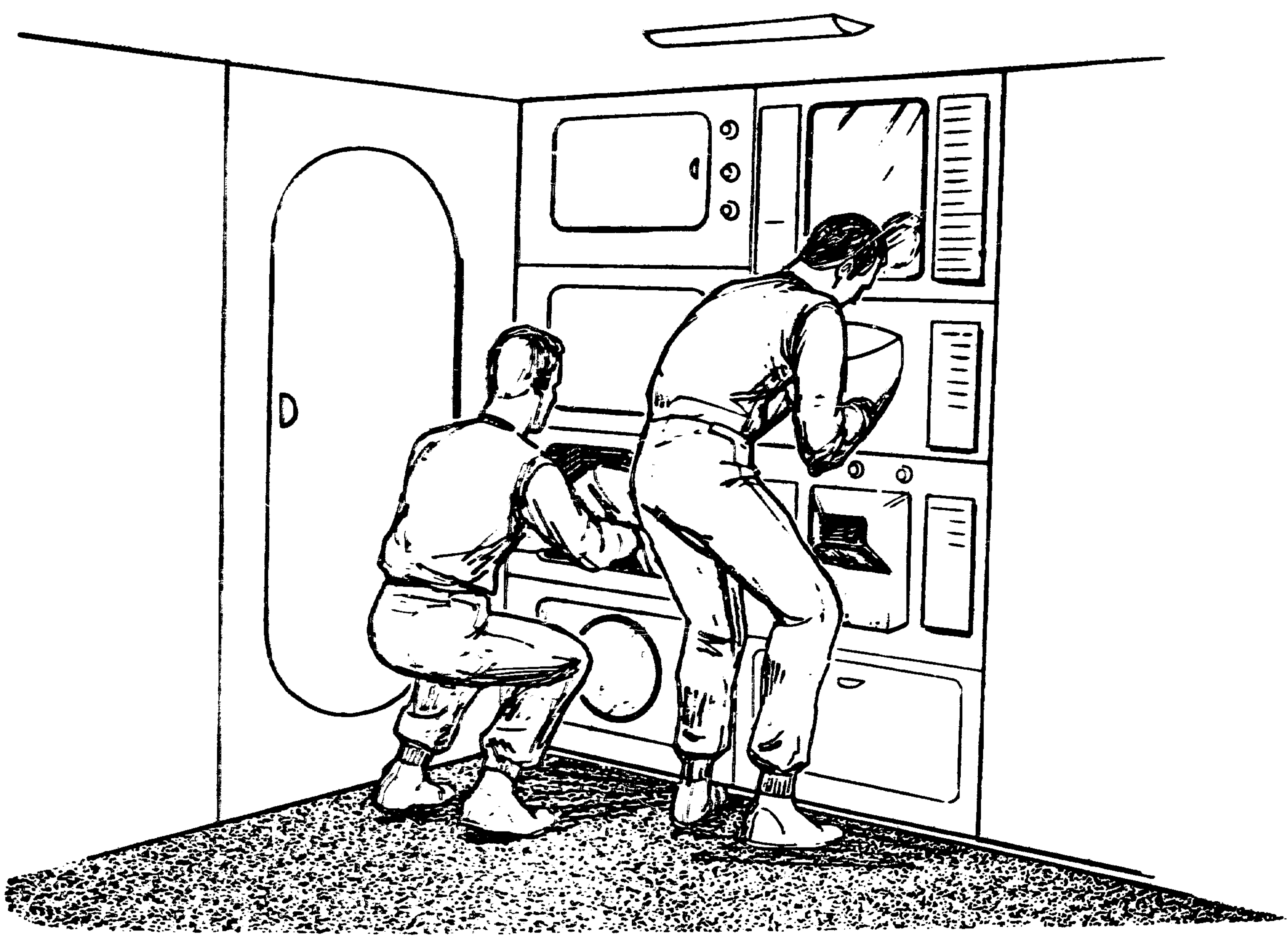
GALLEY



On each crew/operations deck is a hygiene facility containing the necessary equipment for personal cleanliness. The waste management facility contains a toilet, two urinals, and two hand-washing units. There is also a shower. A laundry unit provides for the reuse of clothing.

10624

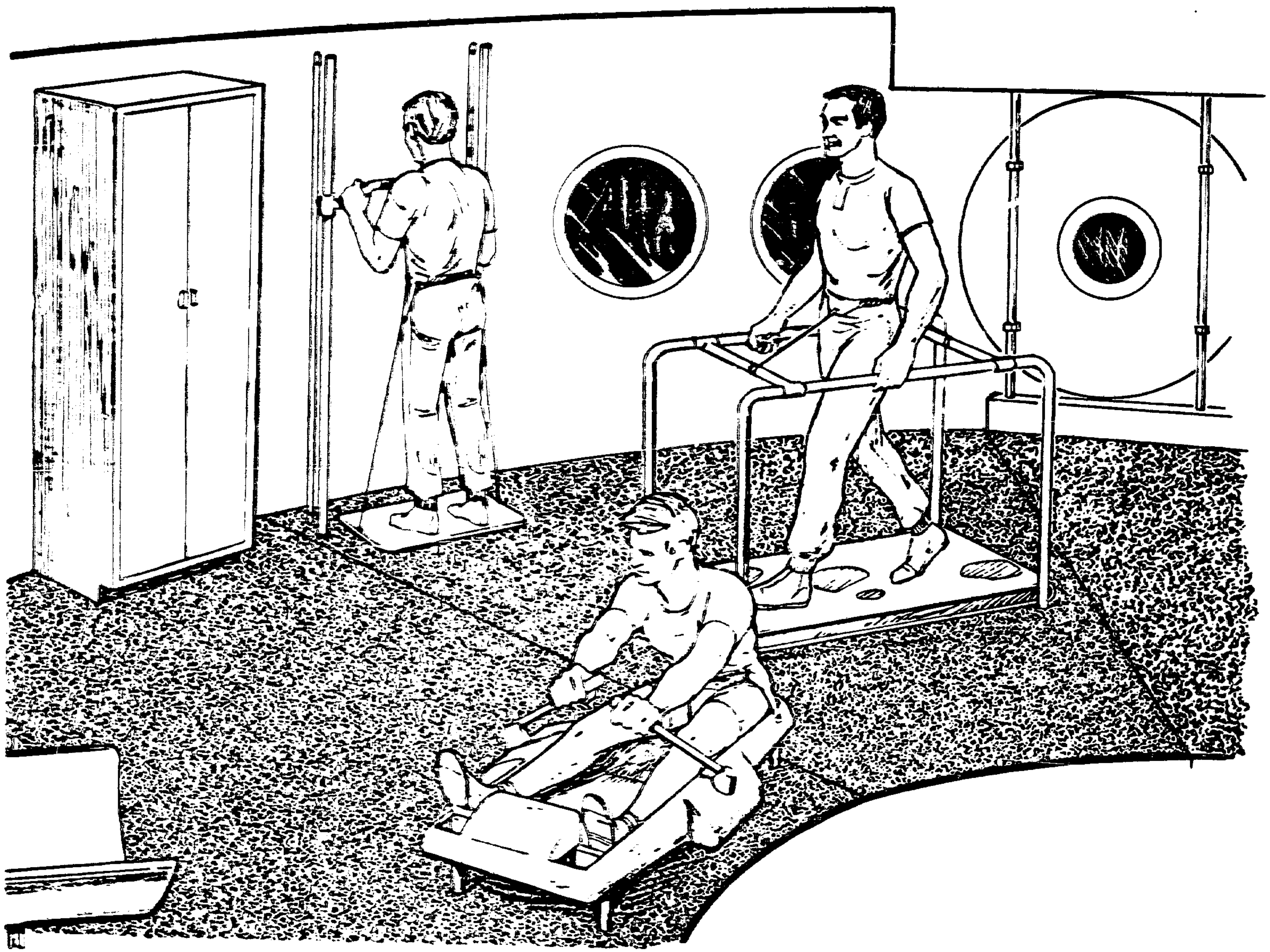
HYGIENE FACILITY



The exercise facility depicts one use of the multi-purpose wardroom. A whole-body exerciser, rowing unit, and jogging unit are among the equipment provided.

EXERCISE FACILITY

10985



The subsystems are the heart of the Space Station as the engine is the heart of the automobile. Collectively they provide all the services to sustain life within the station and for the conduct of the research program. A comparison between subsystems selected for Skylab and for the Space Station points out the advancement as well as the commonality in technology between the two programs. The trend is to provide more resources with finer capabilities and to minimize dependence on ground support.

12290

SPACE STATION SUBSYSTEMS

SUBSYSTEM	SKYLAB	SPACE STATION
ELECTRICAL POWER		
USABLE POWER	7 KWe	25 KWe
SYSTEM TYPE	SOLAR ARRAY/BATTERY	ISOTOPE/BRAYTON
ENVIRONMENTAL CONTROL/ LIFE SUPPORT		
ATMOSPHERE	0.35 KG/CM^2; O_2-N_2	1.03 KG/CM^2; O_2-N_2
H_2O CIRCUIT	OPEN	CLOSED
O_2 CIRCUIT	OPEN	PARTIALLY CLOSED
STABILIZATION AND CONTROL		
CONTROL ACTUATION	CONTROL MOMENT GYROS	CONTROL MOMENT GYROS
ORBIT MAINTENANCE	NONE	RESISTOJET (LOW THRUST)
DISTURBANCES/MANEUVERS	COLD GAS	MONOPROPELLANT - HIGH THRUST

Flexibility and autonomy are the key features of the electronic subsystems. Features such as a capability for continuous communication through synchronous data-relay satellites give the experimenter maximum flexibility by enabling him to discuss his activities with his colleagues on Earth.

12296

SPACE STATION SUBSYSTEMS (CONT)

SUBSYSTEM	SKYLAB	SPACE STATION
COMMUNICATIONS		
GROUND CONTACT	INTERMITTENT	CONTINUOUS
DATA RELAY SATELLITES	NONE	3-SYNCHRONOUS ORBIT
GROUND STATIONS	MANNED SPACEFLIGHT NETWORK (~12)	TWO
GUIDANCE / NAVIGATION		
TYPE	GROUND TRACKING / ONBOARD DISPLAY	AUTONOMOUS
SENSORS	NONE	STELLAR INERTIAL AND LANDMARK TRACKING
DATA MANAGEMENT		
SUBSYSTEM CONTROL	MANUAL / GROUND	MANUAL-COMPUTER / AUTONOMOUS
DATA DISTRIBUTION	MULTIPLE WIRES	DATA BUS
CHECKOUT	GROUND	ONBOARD
RELIABILITY / MAINTENANCE	REDUNDANCY / MINIMUM MAINTENANCE	REDUNDANCY / REPLACEMENT / REPAIR

A good example of the complex analyses required to select and design the Space Station subsystems is the selection of the design point for the isotope/Brayton power system. Along with operational complexity, safety, and many other considerations is the critical parameter of launch weight. All the elements and their effect on radiator-area requirements (hence vehicle length), operating temperature, and the separation distance of the radiation source from the crew are critical and must be considered.

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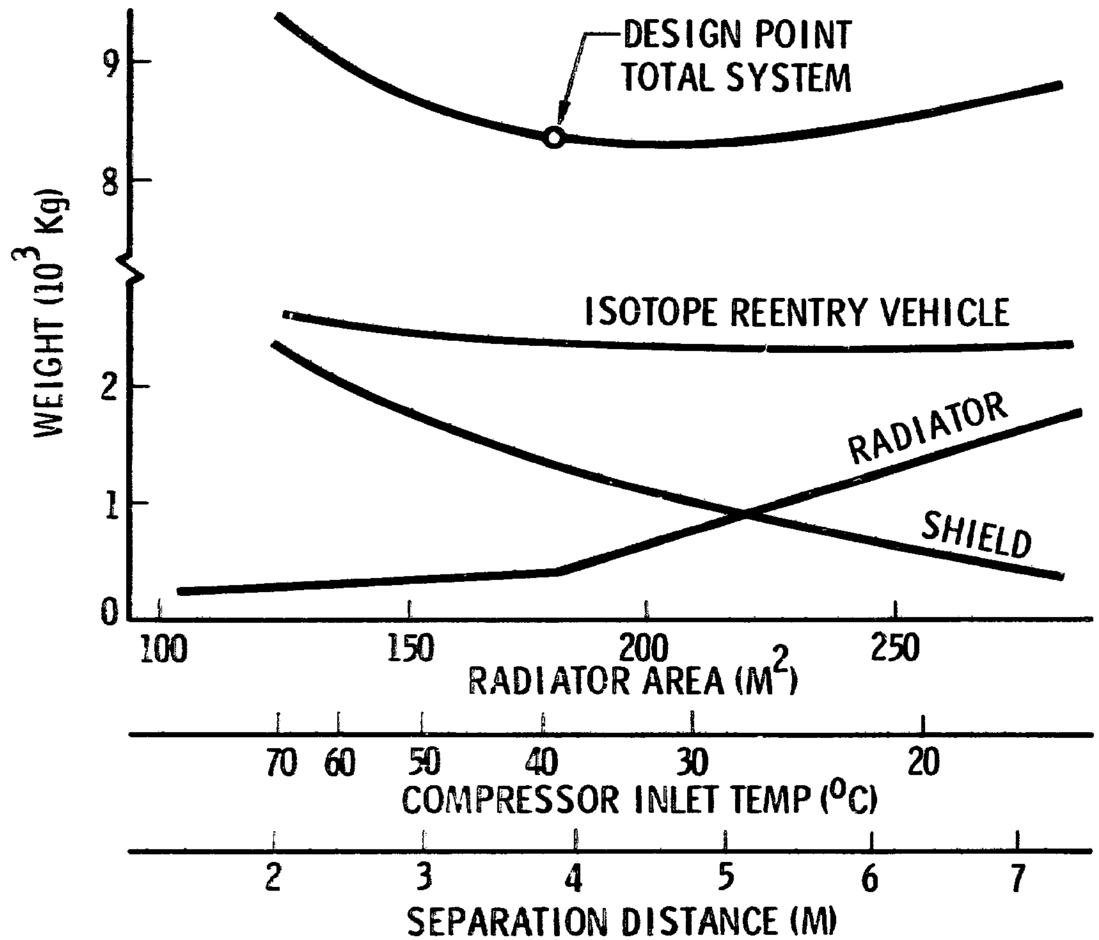
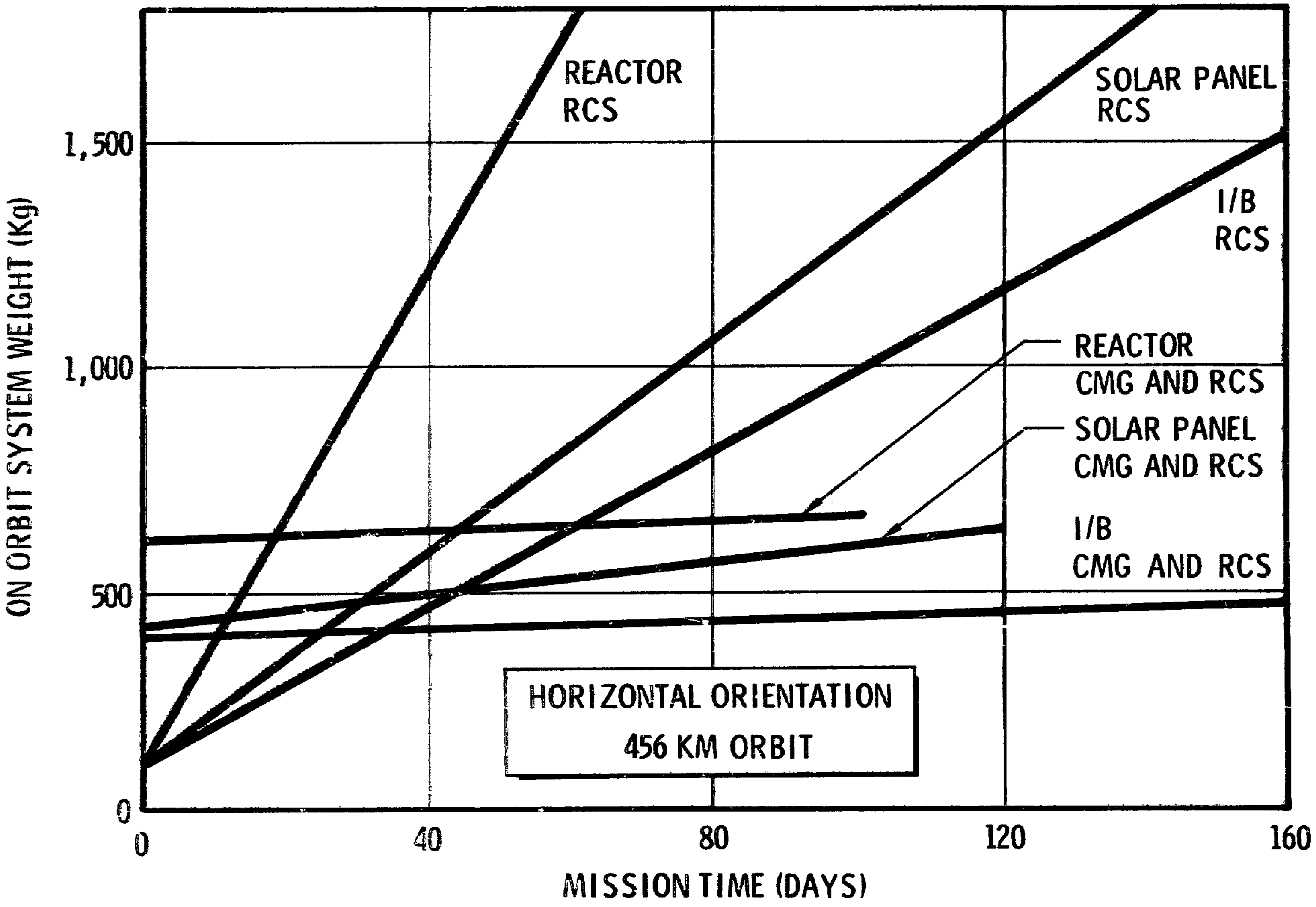
RADIOISOTOPE BRAYTON INTEGRATION OPTIMIZATION



Another example illustrates that there may be several acceptable technical solutions to satisfying a set of requirements. Depicted are system weight variations with mission duration along with the influence factors of the power system, which has a substantial influence on the vehicle configuration.

CONTROL ACTUATION TRADE



Design of any one subsystem (environment control, life support, propulsion) can involve consideration of the functions and capabilities of other subsystems. For example, oxygen for breathing is provided in the form of H_2O, which is electrolyzed into O_2 and H_2. The CO_2 in the atmosphere is combined with the H_2 to produce H_2O and waste products, which in turn are used as a propulsive fuel. The optimization considers all demands for water and concludes that by selecting the proper food diet (degree of water content) all requirements can be met.

LIFE SUPPORT/PROPULSION OPTIMIZATION

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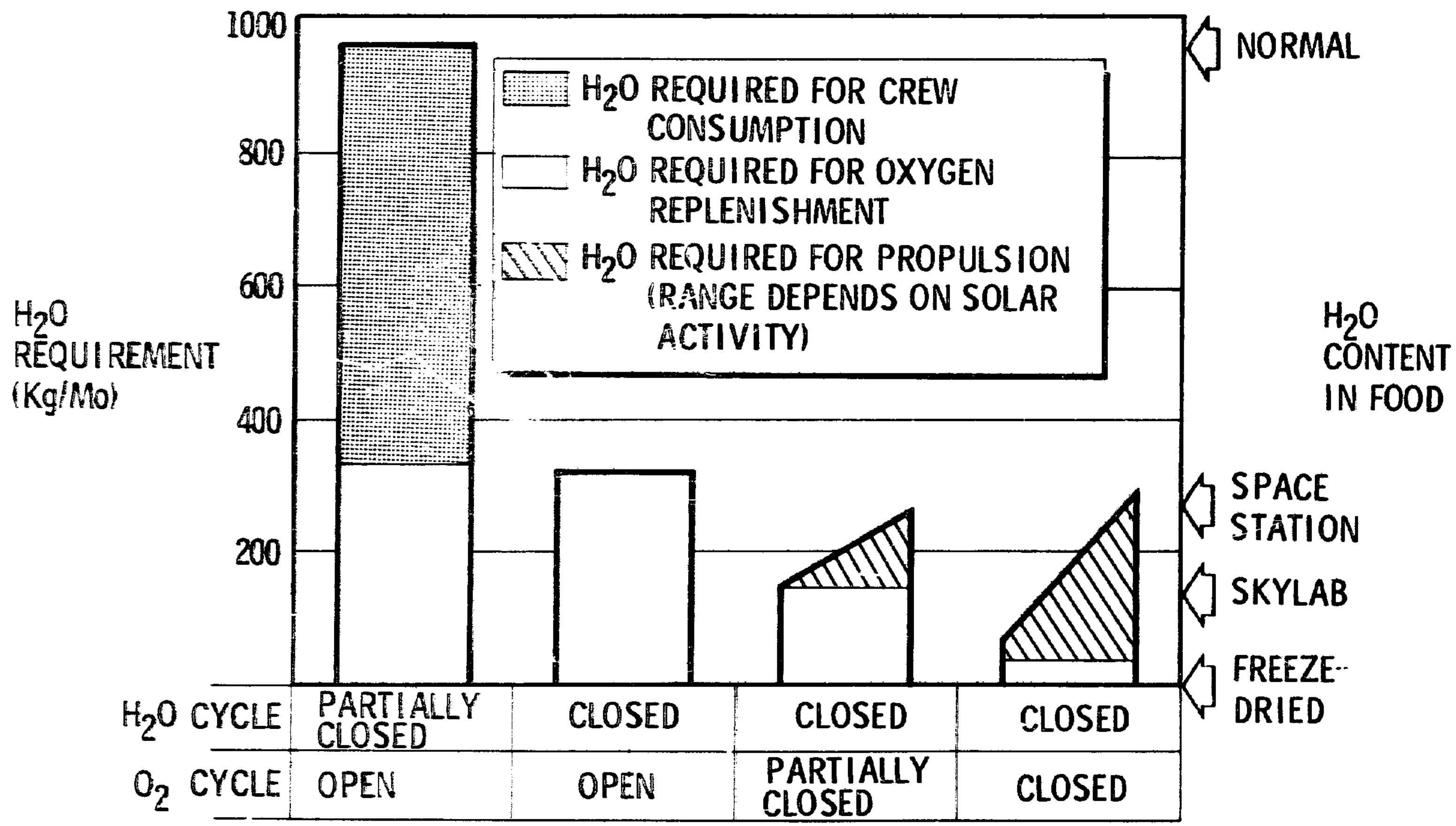
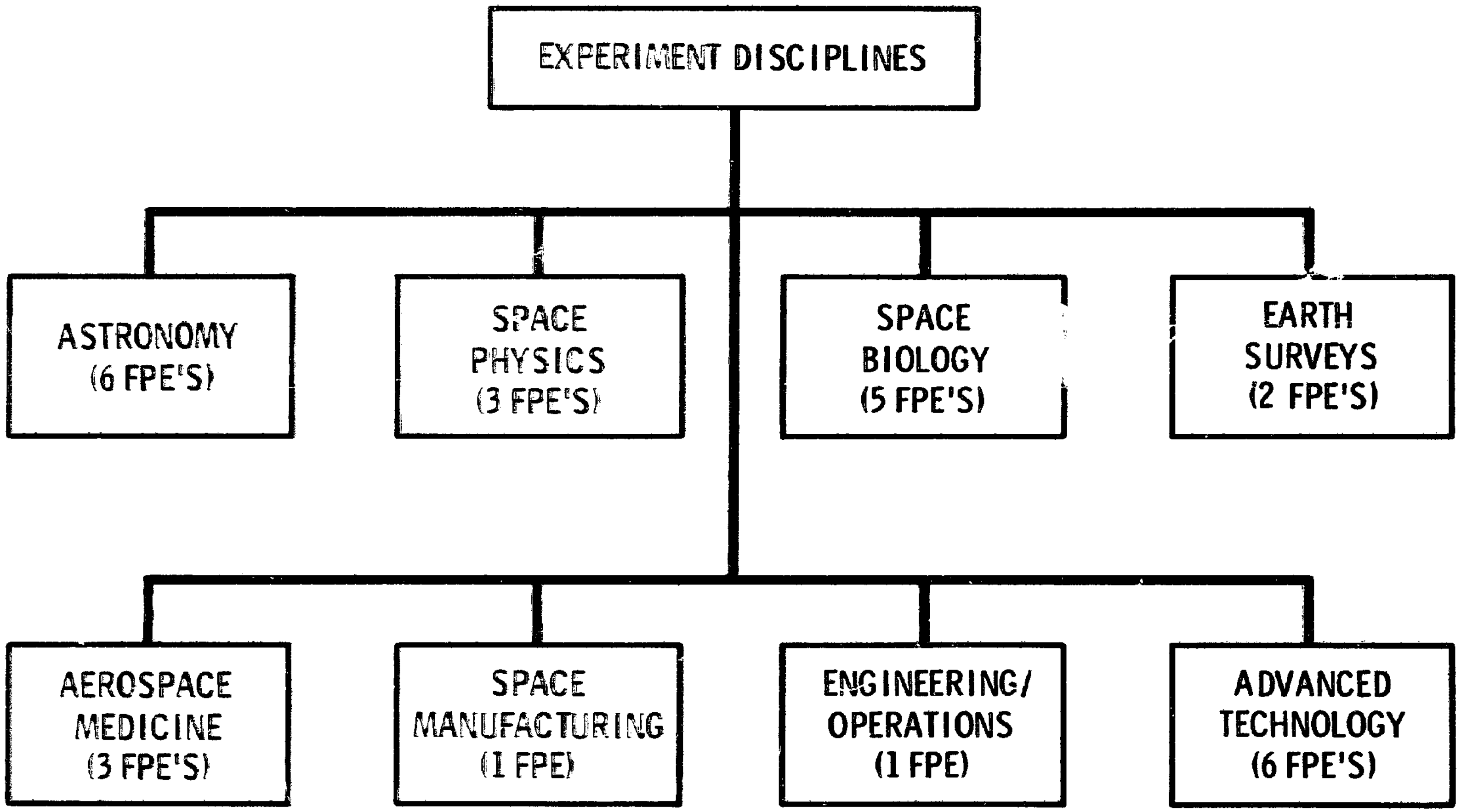


The Space Station is designed to be a research facility to accommodate all experiment disciplines. To derive a set of requirements for vehicle design, NASA provided detailed examples of orbital experiments arranged according to functional program elements (FPE's). If properly designed to accommodate these FPE's, the character of the Space Station will be relatively insensitive to restructuring or reordering of individual experiments. This approach led to the concept of a general-purpose laboratory.

12319

EXPERIMENTS



NOTE:
138 RESEARCH CLUSTERS DESIGNATED; DISTRIBUTION INCLUDES ALL DISCIPLINES

The terminology used to describe functional and objective-oriented subdivisions of the eight experiment disciplines is specified.

EXPERIMENT GROUPING DEFINITIONS

FUNCTIONAL PROGRAM ELEMENT (FPE):

(1) INDIVIDUAL EXPERIMENTS THAT ARE MUTUALLY SUPPORTIVE OF A PARTICULAR AREA OF RESEARCH OR INVESTIGATIONS

(2) EXPERIMENTS THAT IMPOSE SIMILAR AND RELATED DEMANDS ON THE SPACE STATION SUPPORT SYSTEMS

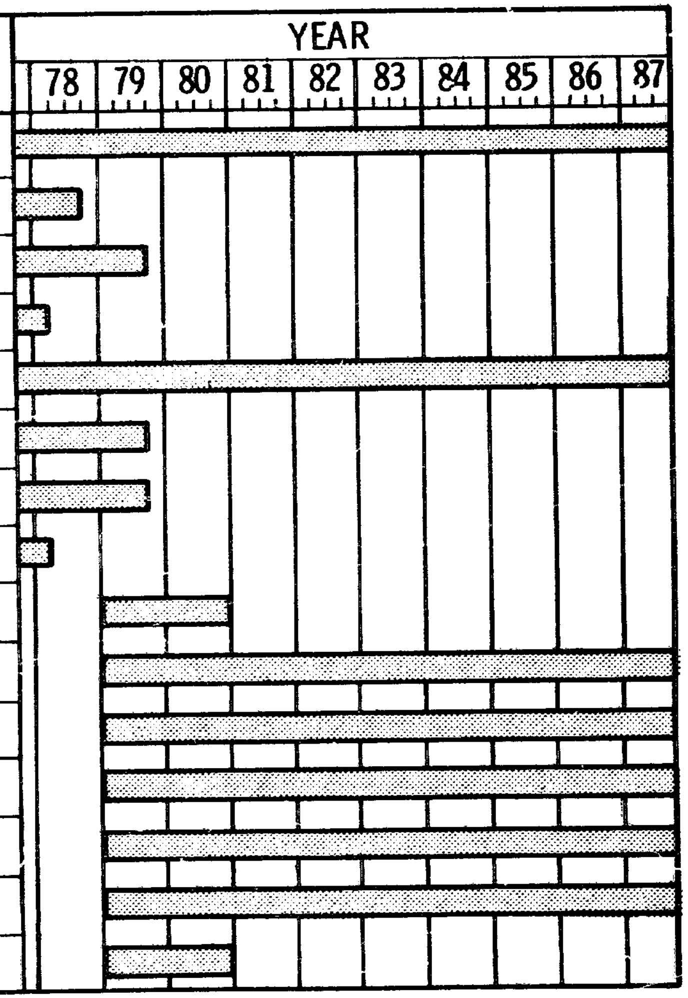
RESEARCH CLUSTER:

A GROUPING OF RELATED CRITICAL ISSUES (KEY QUESTIONS) WITHIN A DISCIPLINE, WITH SIMILAR OPERATIONAL AND OBSERVATIONAL SPECIFICATIONS

In order to size certain systems, such as data management, logistics, or docking, it is necessary to derive typical experiment flight plans which depict potential utilizations of the research facility. From an analysis of these plans, we can derive typical data rates and the nominal and maximum number of experiment modules that may be docked to the Space Station at a given time.

TYPICAL EXPERIMENT FLIGHT PLAN

FPE	TITLE	MODE OF ACCOMM
13A	BIOMEDICAL	I
24 E AND F	MAINTENANCE AND LOGISTIC	I
24G	OCCUPANCY AND SPACE LIVING	I
6	SPACE PHYSICS AIRLOCK	I
14	MAN-SYSTEM INTEGRATION	I
17	CONTAMINATION	I
18	EXPOSURE	I
22	COMPONENT TEST	I
4	UV STELLAR ASTRONOMY	AM
11	EARTH SURVEYS	AM
3	SOLAR ASTRONOMY	FF
9A	SMALL VERTEBRATES	I
25	MICROBIOLOGY	I
26	INVERTEBRATES	I
27	PHYSICS AND CHEMISTRY LAB	I

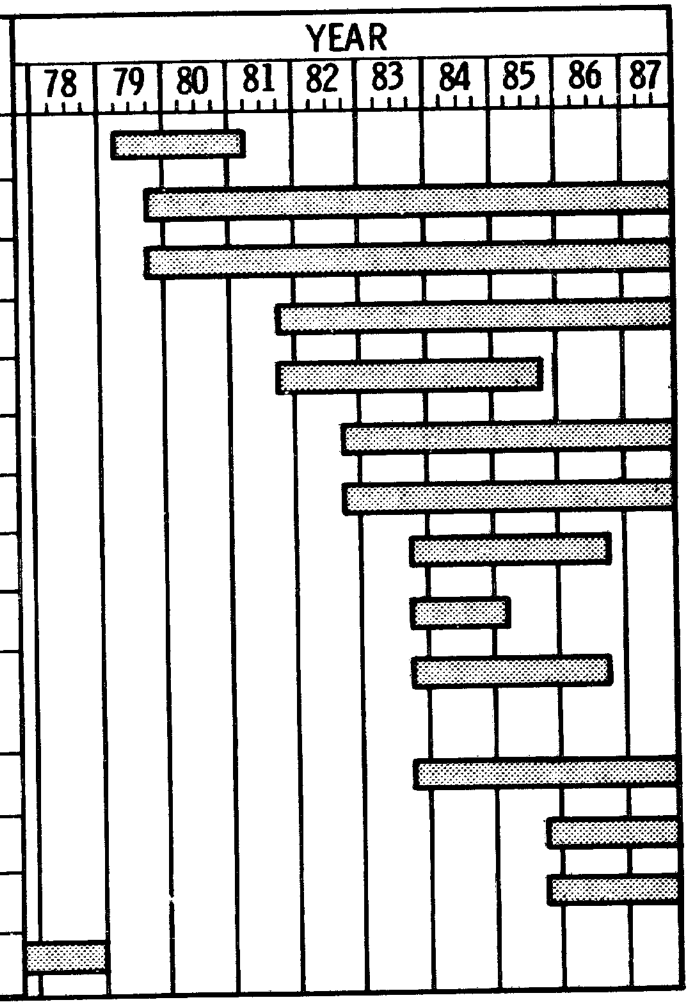


LEGEND
I = INTEGRAL
AM = ATTACHED MODULE
FF = FREE FLYING MODULE
RMS = REMOTE MANEUVERING SATELLITE

The integral experiments scheduled for the later years are delivered by the logistics system and installed in the Space Station, replacing other experiments whose objectives have been satisfied.

TYPICAL EXPERIMENT FLIGHT PLAN (CONT)

FPE	TITLE	MODE OF ACCOMM
5	HIGH ENERGY STELLAR	FF
10	PLANT SPECIMENS	I
2	STELLAR ASTRONOMY	FF
13B	BIOMEDICAL CENTRIFUGE	AM
20	FLUID PHYSICS	AM
9B	SMALL VERTEBRATES CENTRIFUGE	AM
21	IR STELLAR SURVEY	AM
12	SUBSATELLITE	RMS
7A AND B	PLASMA WAKE AND CYCLOTRON	I
7C, D AND E	WAVE PARTICLE, ELECTRON ACCEL. & PLASMA JET ENGINE	I
1	X-RAY TELESCOPE	FF
16	MATERIALS SCIENCE	I
8	COSMIC RAY PHYSICS	FF
	ARTIFICIAL GRAVITY	



LEGEND I = INTEGRAL FF = FREE FLYING MODULE
AM = ATTACHED MODULE RMS = REMOTE MANEUVERING SATELLITE

Extensive capability is provided to conduct research activities. More than two-thirds of the station contains general-purpose and experiment facilities. Adding to this the facilities to house the researchers, there is virtually nothing left that is not directly related to conducting the experiment program.

20579 A

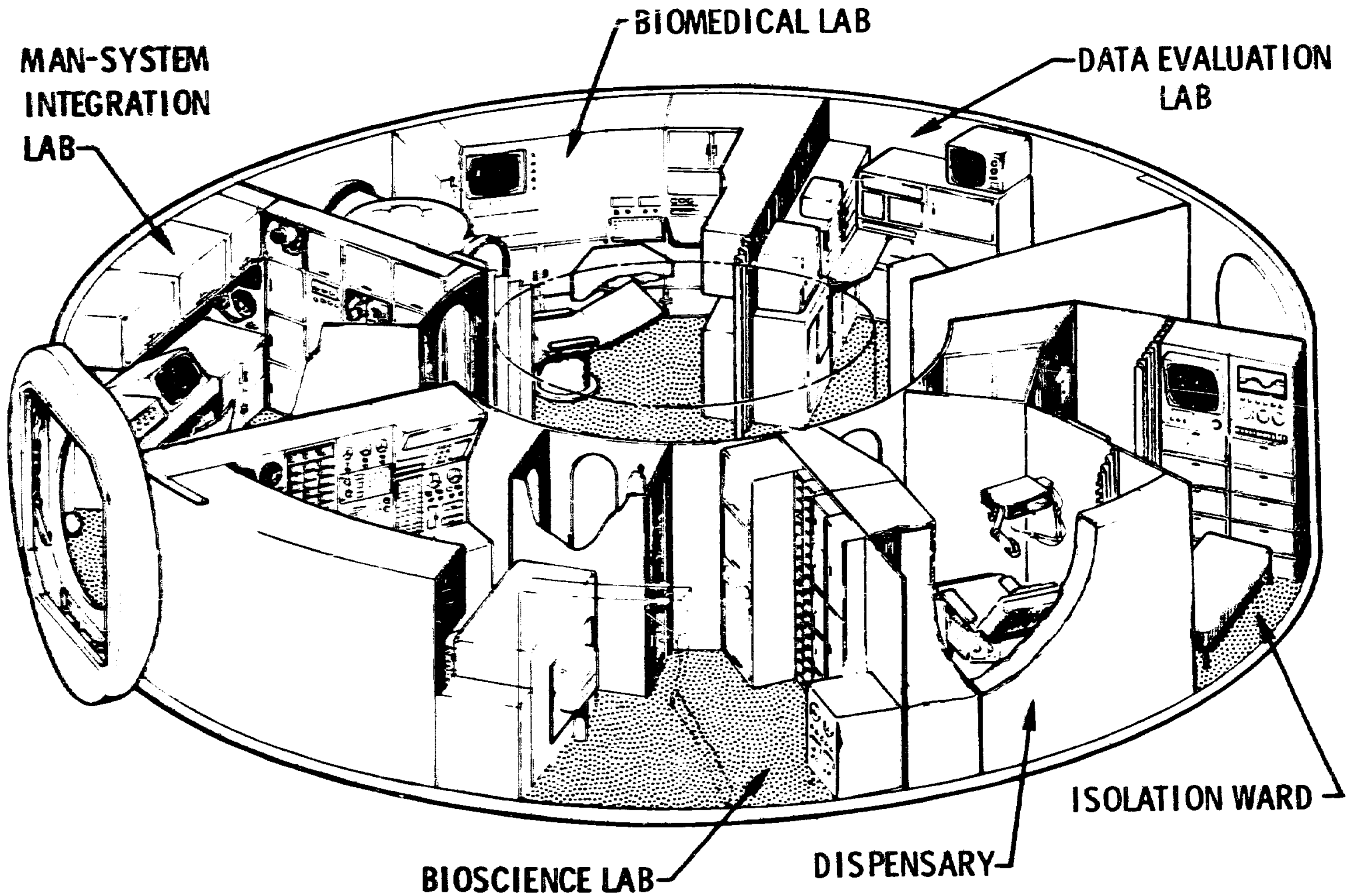
LABORATORY CHARACTERISTICS AND CAPABILITY SUMMARY

GENERAL PURPOSE LABORATORY	• 4 DECKS
POWER FOR EXPERIMENTS	• 8.5 KWe AVERAGE; 20 KWe PEAK INITIALLY; 16 KWe AVERAGE AND 30 KWe PEAK WITH THIRD ISOTOPE POWER UNIT
EXPERIMENT CHECKOUT	• CHECKOUT AND FAULT ISOLATION CAPABILITY
POINTING AND STABILIZATION	• ALL ATTITUDE CAPABILITY (MANEUVER)
	• 0.1 DEGREE AND 0.005 DEGREE/SECOND HOLD
	• INERTIAL AND EARTH CENTERED ATTITUDE AND RATE DATA SUPPLIED TO EXPERIMENT
DATA MANAGEMENT	• 9,070 Kg PER YEAR FILM AND TAPE
	• QUICK LOOK CAPABILITY ONBOARD
	• 10^{12} BITS PER DAY RELAY SATELLITE THROUGHPUT AS REQUIRED
	• TWO-WAY TV
GRAVITY	• LESS THAN 1×10^{-4} G

Deck 2 is dedicated to experiment activities associated with the study of various life forms in zero gravity. Man, animals, plants, microorganisms are all subjects for analysis. Considerations of equipment and facility commonality result in locating the dispensary and isolation ward adjacent to these laboratories.

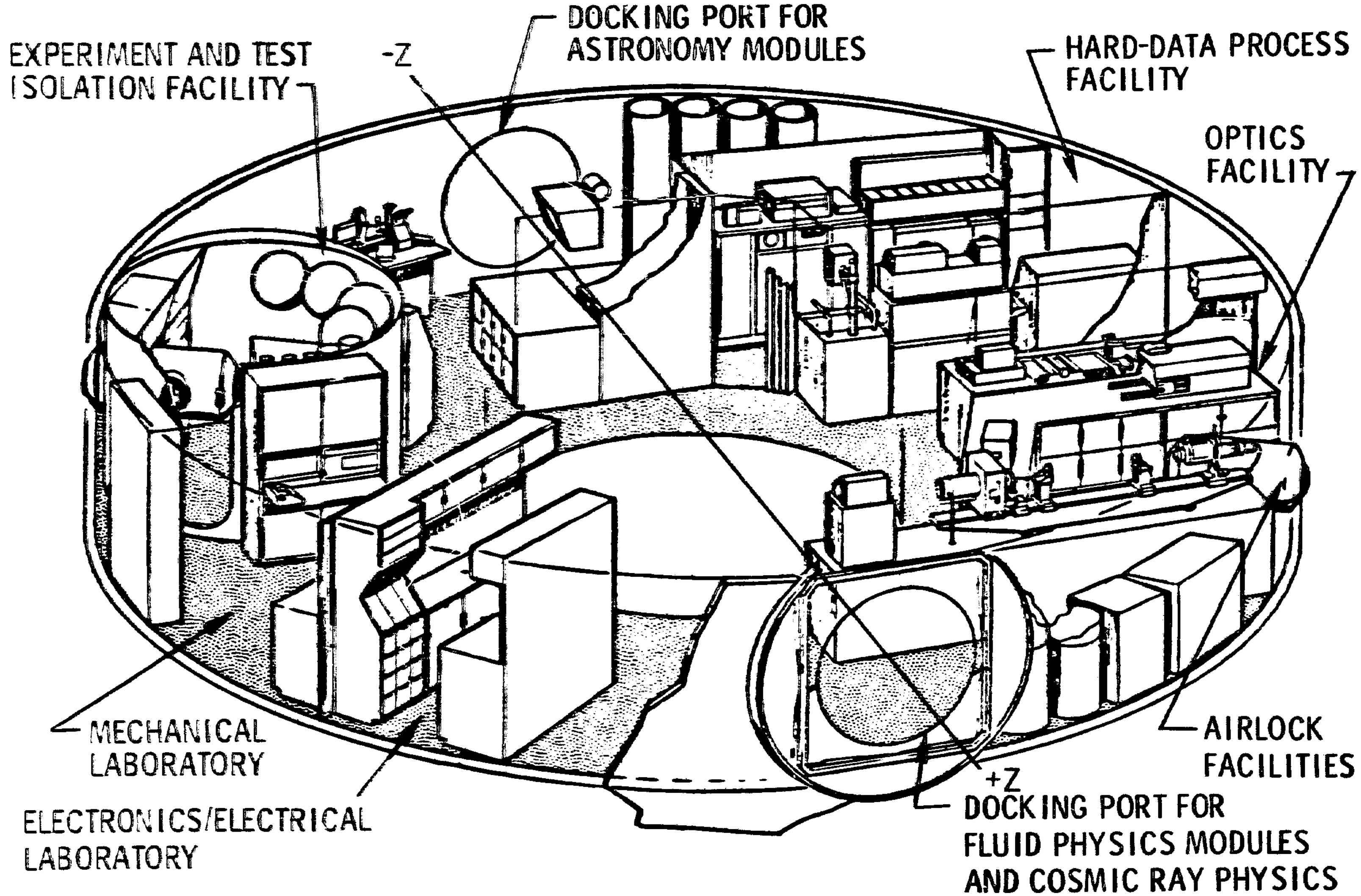
12073

EXPERIMENTS - (DECK 2)



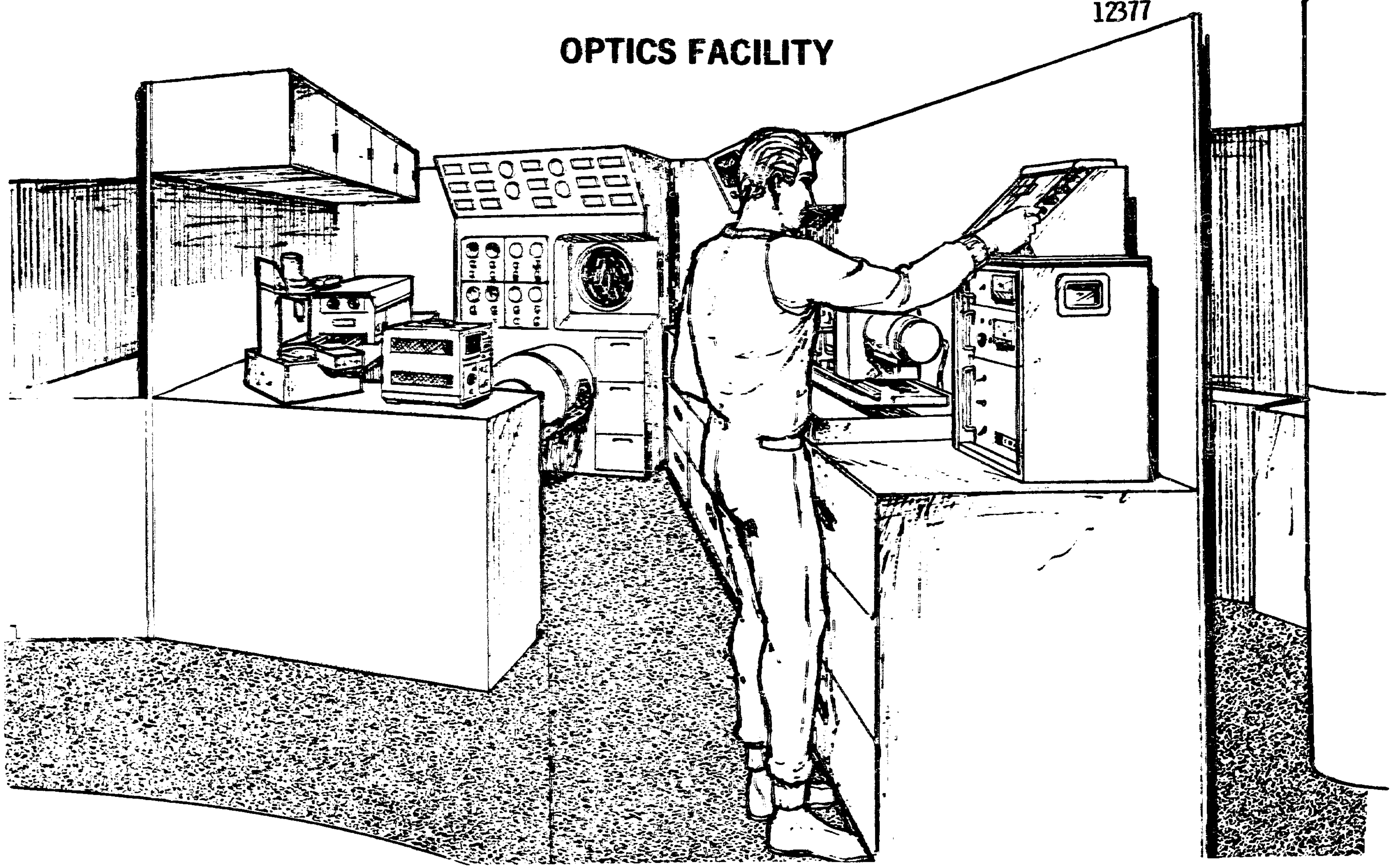
The general-purpose laboratory consists of those facilities required to support all experiments and the Space Station subsystems. Docking provisions for modules that most frequently require laboratory support are located on this level.

GENERAL PURPOSE LABORATORY - (DECK 4)



The optics facility contains optical calibration, test, and fabrication equipment. This equipment will be suitable for support of a wide range of experiment and operational gear: cameras, telescopes, IR imagers, photo-recorders, sun sensors, horizon sensors, star trackers, navigation equipment, rendezvous equipment, and any other equipment that requires precise optical alignment and calibration. The optics shop is arranged so that a long optical throw is available for calibration of long-focal-length equipment.

OPTICS FACILITY



10194

OPTICS FACILITY ASSEMBLY DATA

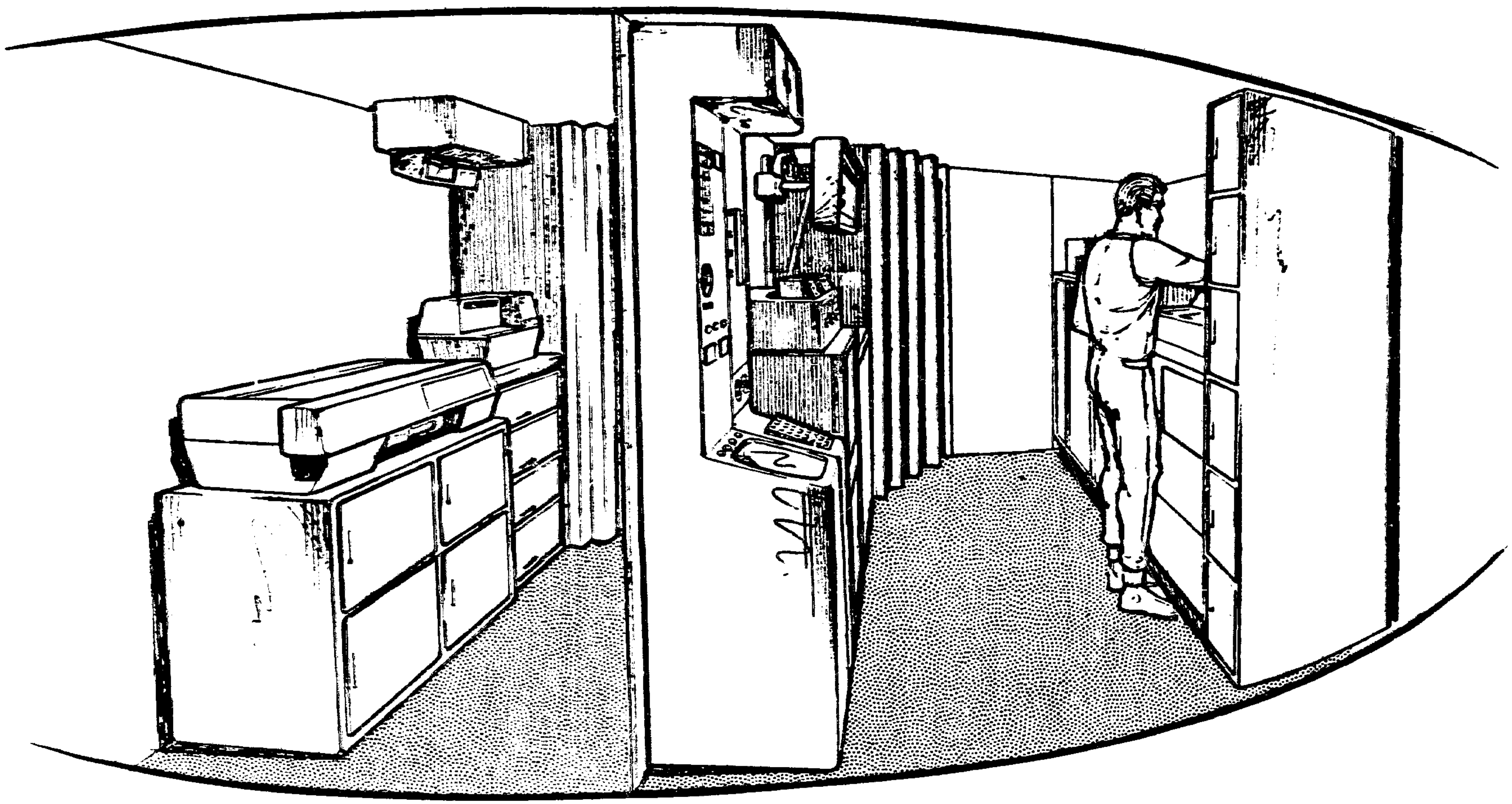
- OPTICAL BENCH

  MODULATION TRANSFER FUNCTION TESTER SYSTEM

- ONBOARD CHECKOUT SYSTEM INTERFACE
- CONTROL CONSOLE AND VENTILATION SYSTEM
- POWER CENTER AND EQUIPMENT STORAGE
- AIRLOCK
- VIEWING WINDOW
- OPTICAL AND CALIBRATION ACCESSORY STORAGE
- DENSITOMETER
- OPTICAL REPAIR AND TEST BENCH, LIGHT DUTY
- OPTICAL BENCH SUPPORT TABLE
- MISCELLANEOUS STORAGE

The hard-data processing facility contains all the equipment necessary to develop film, produce microfilm, calibrate developed film data, and do basic-analysis test strips.

HARD DATA PROCESSING FACILITY



10208

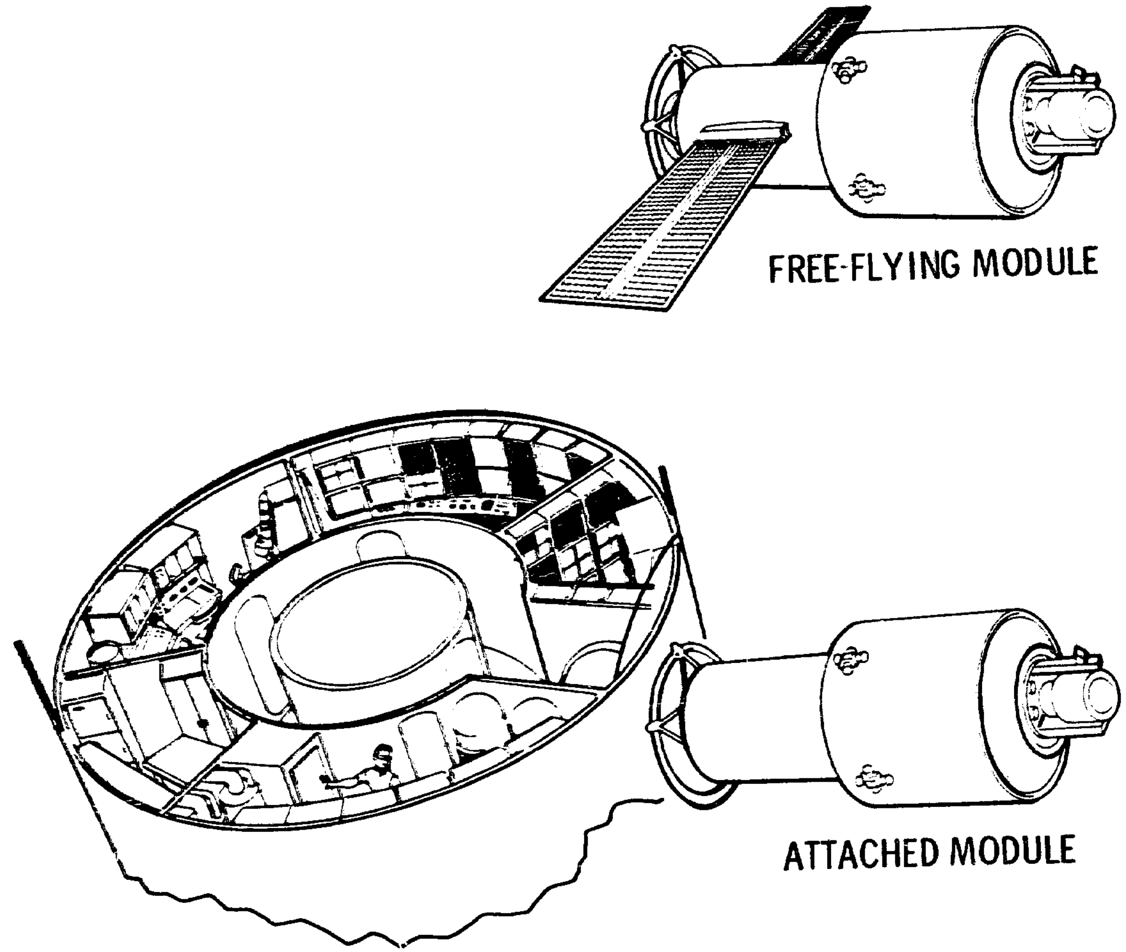
HARD DATA PROCESSING FACILITY ASSEMBLY DATA SHEET

- FILM PROCESSOR, HIGH RESOLUTION
- FILM PROCESSOR, COLOR
- FILM PROCESSOR, BLACK AND WHITE RAPID
- MICRO FILMER
- PHOTO PLATE PROCESSOR
- FILM LIGHT TABLE
- VIDEO REPEATER
- OPERATIONS CONSOLE
- DENSITOMETER
- SPECTROMETER
- X-RAY DEVELOPING FACILITY
- FILM PROCESSOR DRY OR SEMI-DRY
- ROLL FILM AND PLATE STORAGE
- FILM STORAGE, STANDARD

Experiments may be accommodated either within the Space Station or in attached or free-flying modules that use services provided by the Space Station. Internal experiments are either launched with the Space Station or brought up later by the logistics system, transferred aboard, and installed; all attached and free-flying modules are delivered to orbit by the logistics system.

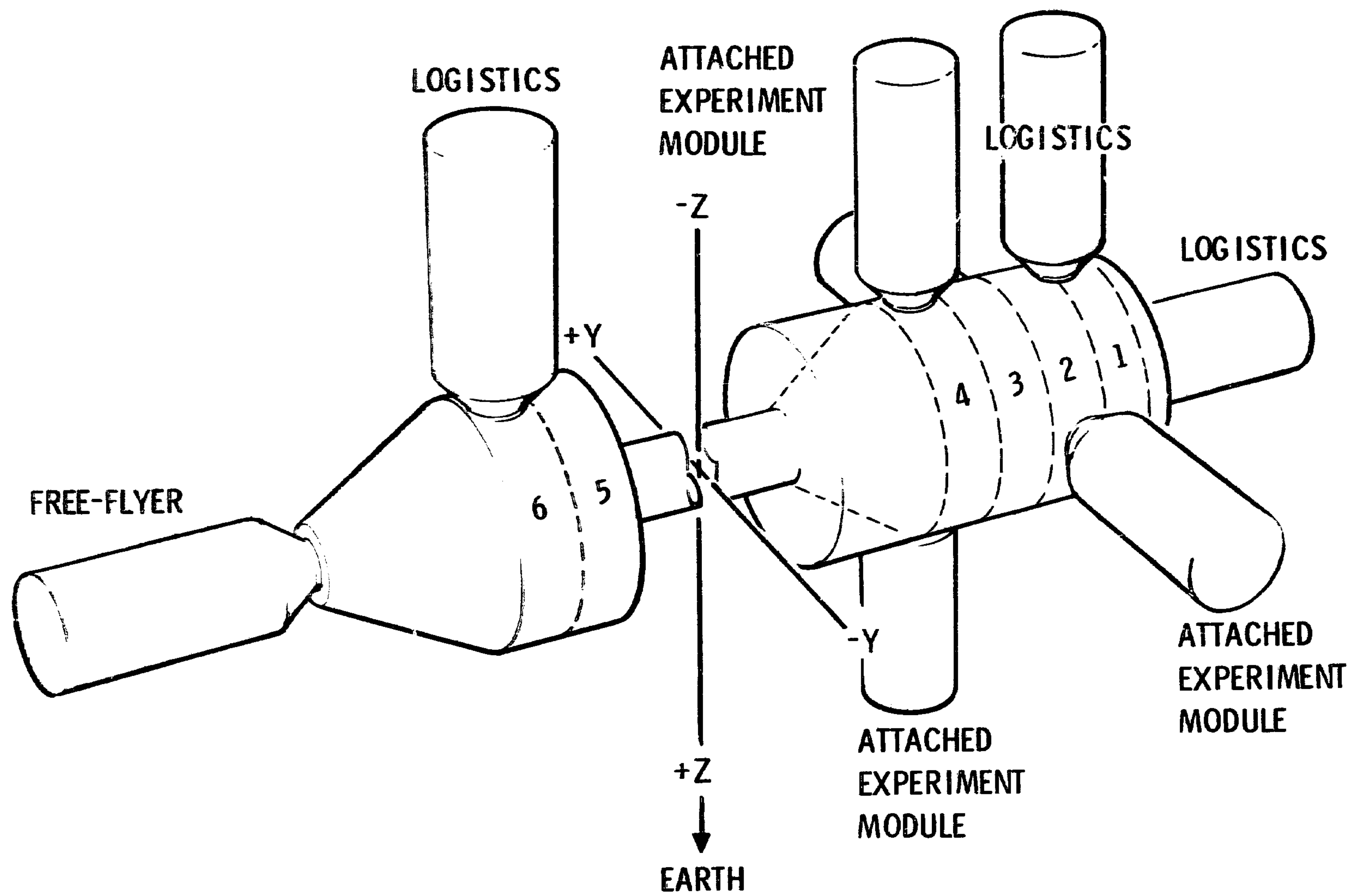
20318

MODULE AND GENERAL PURPOSE LABORATORY DESIGN



The Space Station contains a total of eight docking ports; these ports are of universal design to accommodate either crew/cargo modules or attached or free-flying experiment modules. Normally, logistics modules will dock on the artificial gravity module and the aft end of the core module. The free-flying experiment modules will share the forward docking port, while all attached modules dock to the core module.

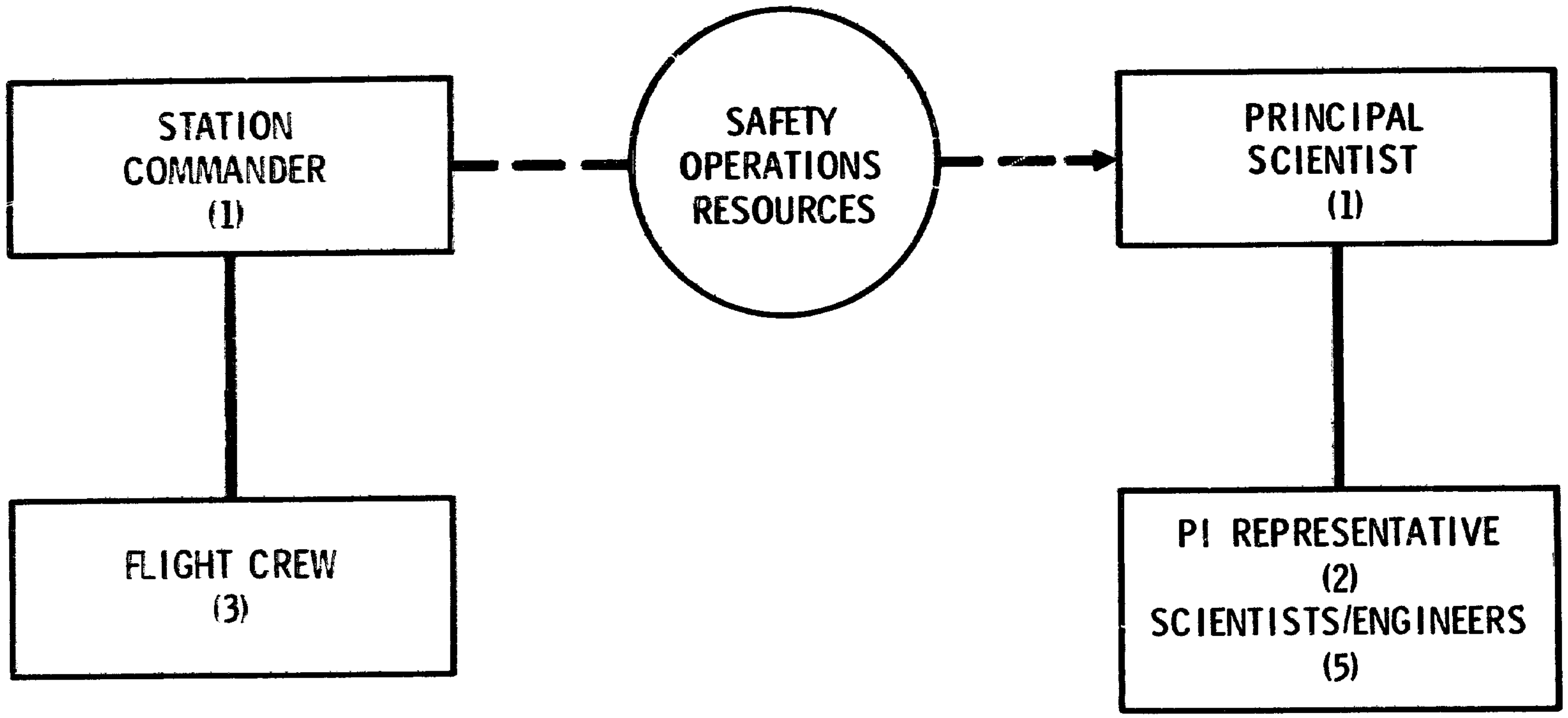
SPACE STATION WITH ATTACHED MODULES



The Space Station is designed to be operated normally by a two-man flight crew and never to require more than three men for its operation. Thus, assuming a two-shift operation, the 12-man crew can include eight experimenters. It is envisioned that the research crew will be represented by a principal scientist who will provide the main interface with the flight-crew commander. The crew commander has overall responsibility for the safety of the entire complement in orbit.

12321

SPACE STATION OPERATIONS



Crew functions are divided between the two crew elements according to areas of responsibility. The flight crew controls, maintains, and manages the station operations, while the experiment crew performs similar functions on all experiment equipment including the attached and free-flying modules.

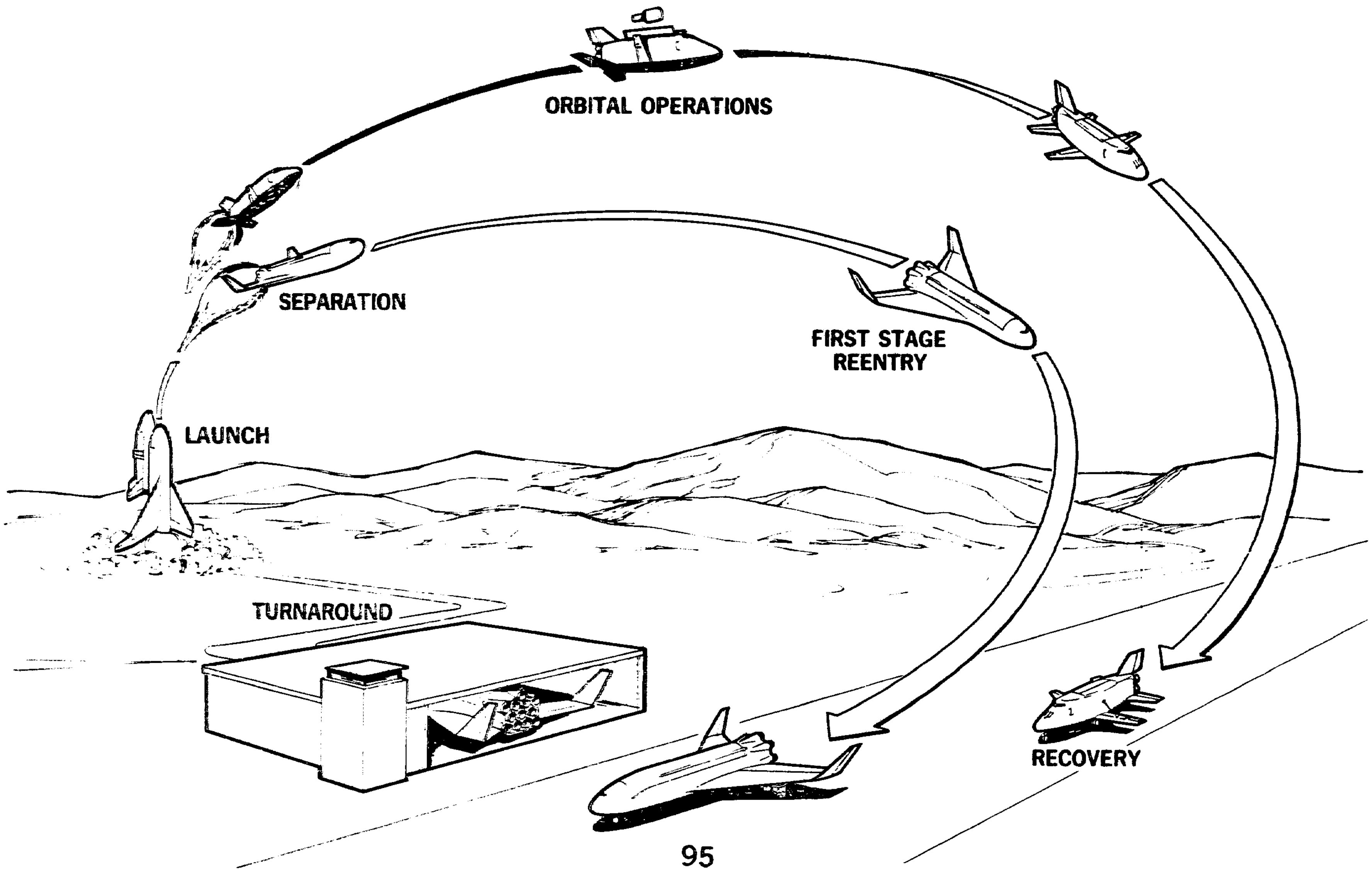
20724

SPACE STATION CREW OPERATIONS

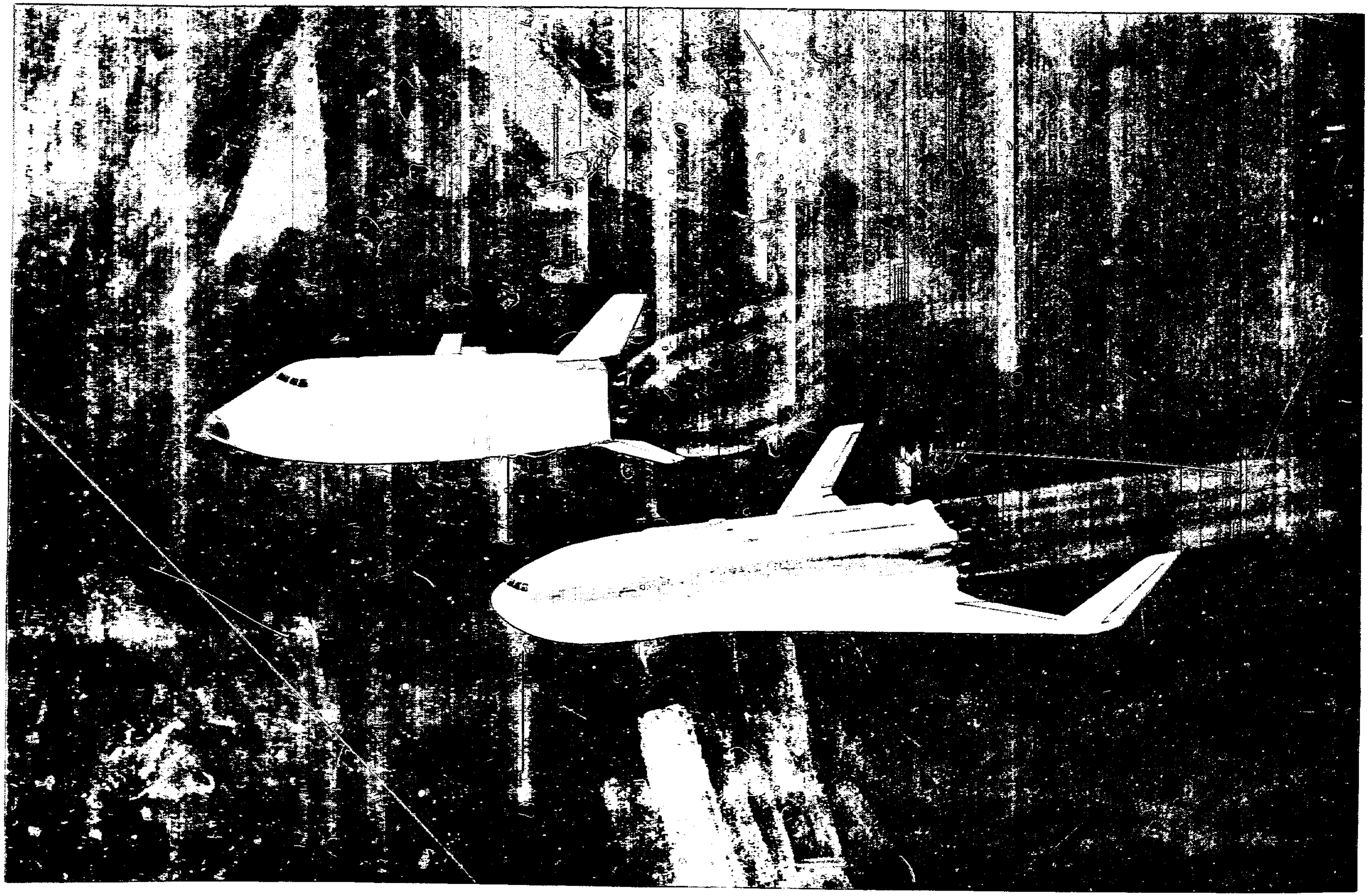
FLIGHT CREW FUNCTIONS	EXPERIMENT CREW FUNCTIONS
• SS FLIGHT MANAGEMENT	• SCHEDULING
• SS FLT OPERATIONS CONTROL	• CONDUCT
• SS SUBSYSTEM CHECKOUT	• INSTALLATION AND SETUP
• MAINTENANCE OPERATIONS	• SYSTEMS CHECKOUT
• COMMUNICATIONS CONTROL	• EXPERIMENT MAINTENANCE OPERATIONS
• DATA MANAGEMENT	• TEST ANALYSIS
• CARGO AND INVENTORY CONTROL	• EXPERIMENT MODULE OPERATION
• EXPERIMENT OPERATIONS SUPPORT	
• MEDICAL & DENTAL CARE	

Illustrated is the sequence of logistics operations performed by the Earth-to-orbit space shuttle.

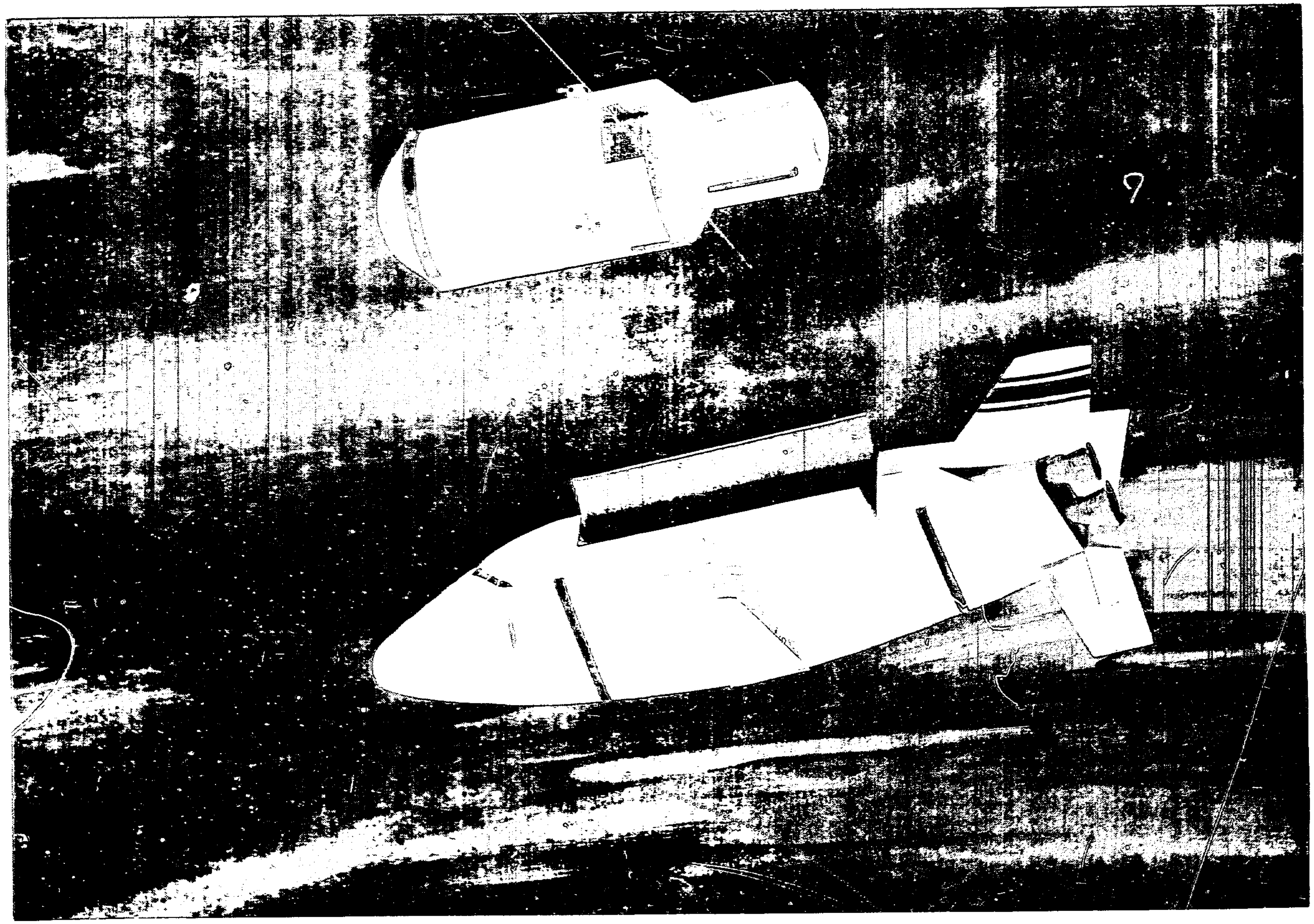
TYPICAL MISSION



The orbiter vehicle is seen separating from the booster stage, which now prepares to return to Earth.



A typical payload for the logistics system is an experiment module seen leaving the cargo bay. Its propulsion system has ignited as it makes its guided way to the station.

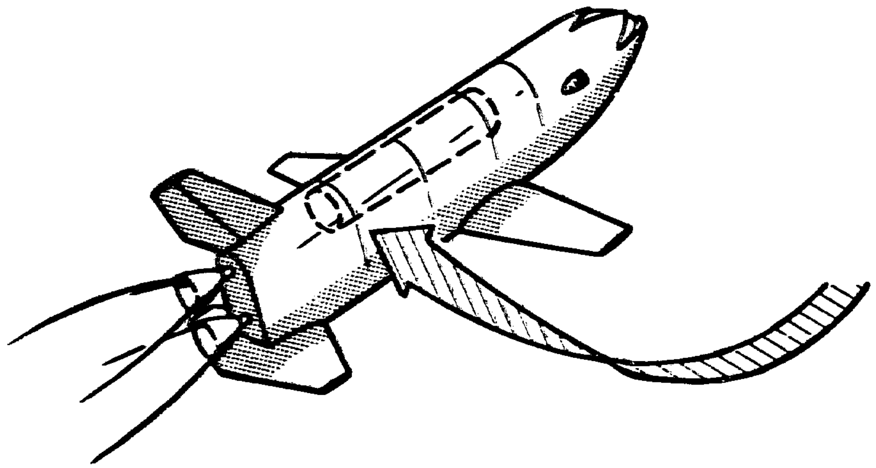


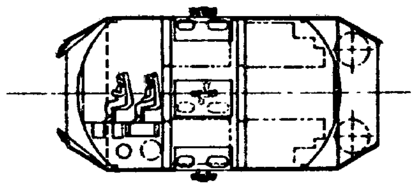
7

The logistics system delivers three types of payload modules to the Space Station. The payload capability to orbit is about 18, 000 kilograms and each module is carried within a cargo bay which is 18.3 meters long and 4.6 meters in diameter. In addition, special payload modules, such as a specially packaged power system unit, may also be carried.

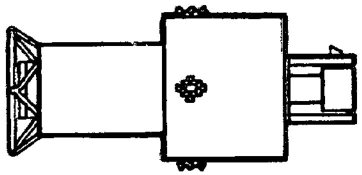
12294

LOGISTICS SYSTEM

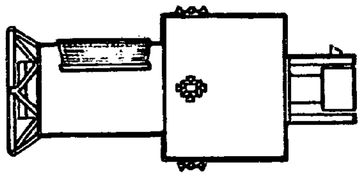




CREW/CARGO MODULE



ATTACHED EXPERIMENT MODULE

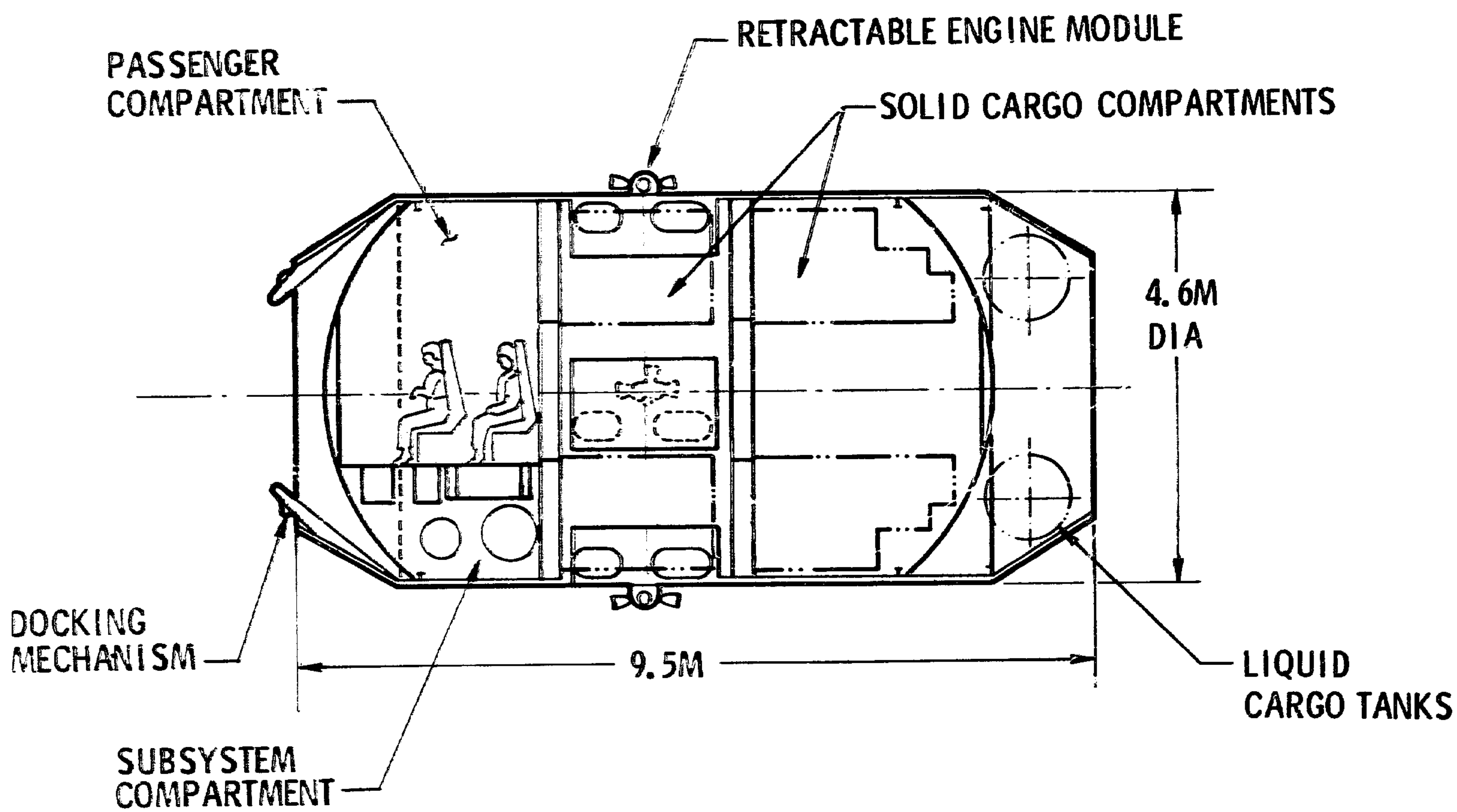


FREE-FLYING EXPERIMENT MODULE

The crew/cargo module delivered by the logistics system can carry a full replacement crew of 12 men and sufficient cargo to permit resupply every 90 days. The cargo consists of experiments, spare parts, and expendables such as propellant, food, clothing, and miscellaneous equipment.

00619

CREW/CARGO MODULE



GROSS WEIGHT = 18,000 KG

CARGO CAPACITY = 13,000 KG

In the analysis of station operations, many simulations are required in order to design the facilities and to determine crew skills required to perform the research program. One such analysis examined a 2-day period in the 10-year operations of the Space Station. Activities were defined and analyzed minute by minute. Illustrated are crew activities at a particular moment. Six crewmen are on duty and engaged in various work activities.

12325

TYPICAL SPACE STATION ACTIVITY TIMELINE
2030 HR (GMT), MARCH 26, 1985
ON-DUTY CREW

CREWMAN	LOCATION		ACTIVITY
	DECK LEVEL	FACILITY	
1. STATION COMMANDER	3	TUNNEL	CONDUCTING SAFETY CONFIGURATION CONTROL CHECK OF EVA SPACE SUITS
2. STATION ENGINEER	1	ENVIRONMENTAL CONTROL / LIFE SUPPORT SUBSYSTEM	OBTAINING H_2O SAMPLE FOR BACTERIA LEVEL TEST
3. PHYSICIAN	2	BIOMEDICAL LABORATORY - MICROBIOLOGY CONSOLE	ANALYZING BLOOD AND URINE SAMPLES
4. PSYCHOLOGIST	2	MAN / SYSTEM INTEGRATION AREA	ANALYZING DATA ON CREW SKILL RETENTION IN EXTENDED ZERO GRAVITY
5. ASTRONOMER / SYSTEMS ENGINEER	5	SECONDARY CONTROL CONSOLE	MONITORING DATA BEING GATHERED BY FREE-FLYING X-RAY TELESCOPE MODULE
6. GEOLOGIST / PHOTO-OPTICAL ENGINEER	2	WITHIN EARTH SURVEY ATTACHED MODULE	INSTALLING AND ALIGNING EARTH SENSORS PREVIOUSLY CALIBRATED IN GENERAL PURPOSE LABORATORY

Six crewmen are off duty, have just finished their late meal, and are engaged in various forms of relaxation and recreation prior to going to sleep.

12326

TYPICAL SPACE STATION ACTIVITY TIMELINE (CONT)
2030 HR (GMT), MARCH 26, 1985
OFF-DUTY CREW

CREWMAN	LOCATION		ACTIVITY
	DECK LEVEL	FACILITY	
7. OPERATIONS DIRECTOR	3	PERSONAL HYGIENE	WHOLE BODY CLEANSING - SHOWER
8. STATION CONTROLLER	3	WARDROOM	RECREATION - PARTICIPATING IN COMPETITIVE SIMULATED BICYCLE TIME - DISTANCE RACE
9. ASTRO-PHYSICIST	3	WARDROOM	SAME AS ABOVE
10. PHYSICIAN	3	PRIVATE QUARTERS	REST - VIEWING VIDEO TAPE TELEVISION PROGRAM BEFORE GOING TO SLEEP
11. BIOLOGIST	3	WARDROOM	RECREATION - COMPETING IN GAME OF COMPUTER FOOTBALL
12. ELECTRO-MECHANICAL ENGINEER	3	WARDROOM	SAME AS ABOVE

In summary, a Space Station design concept has been developed to provide a low-cost, flexible, international research facility. Its design is based on sound technology and can meet NASA's goals for launch in 1977.

12322

SUMMARY

- KNOWN TECHNOLOGY ADEQUATE FOR SPACE STATION
- SPACE STATION CAN GROW WITH THE EXPERIMENT PROGRAM
- MIX OF INTEGRAL AND MODULAR EXPERIMENT ACCOMMODATIONS INSURES PROGRAM FLEXIBILITY
- CONCEPT IS ADAPTABLE TO FUTURE APPLICATIONS

The usefulness of the Space Station core module as a building block for various future applications has also been investigated. In fact, these potential future requirements have influenced the selection and design of Space Station systems and operations.

SPACE STATION COMMON MODULE CONCEPT