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A SPACE STATION OVERVIEW

BY

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WASHINGTON, D.C.

BRIEFING TO

EUROPEAN SPACE RESEARCH ORGANIZATION

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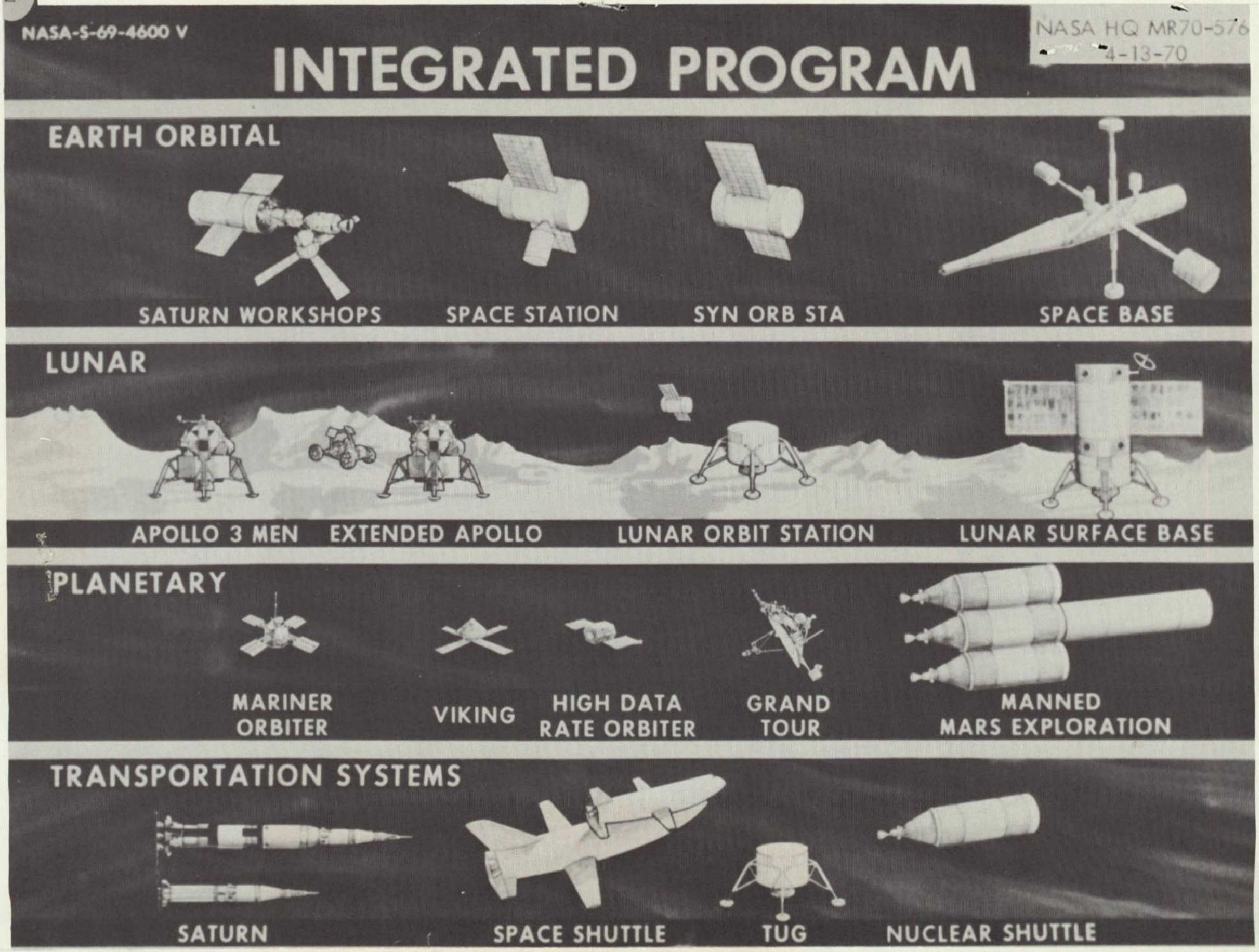
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NASA HQ MR70-576
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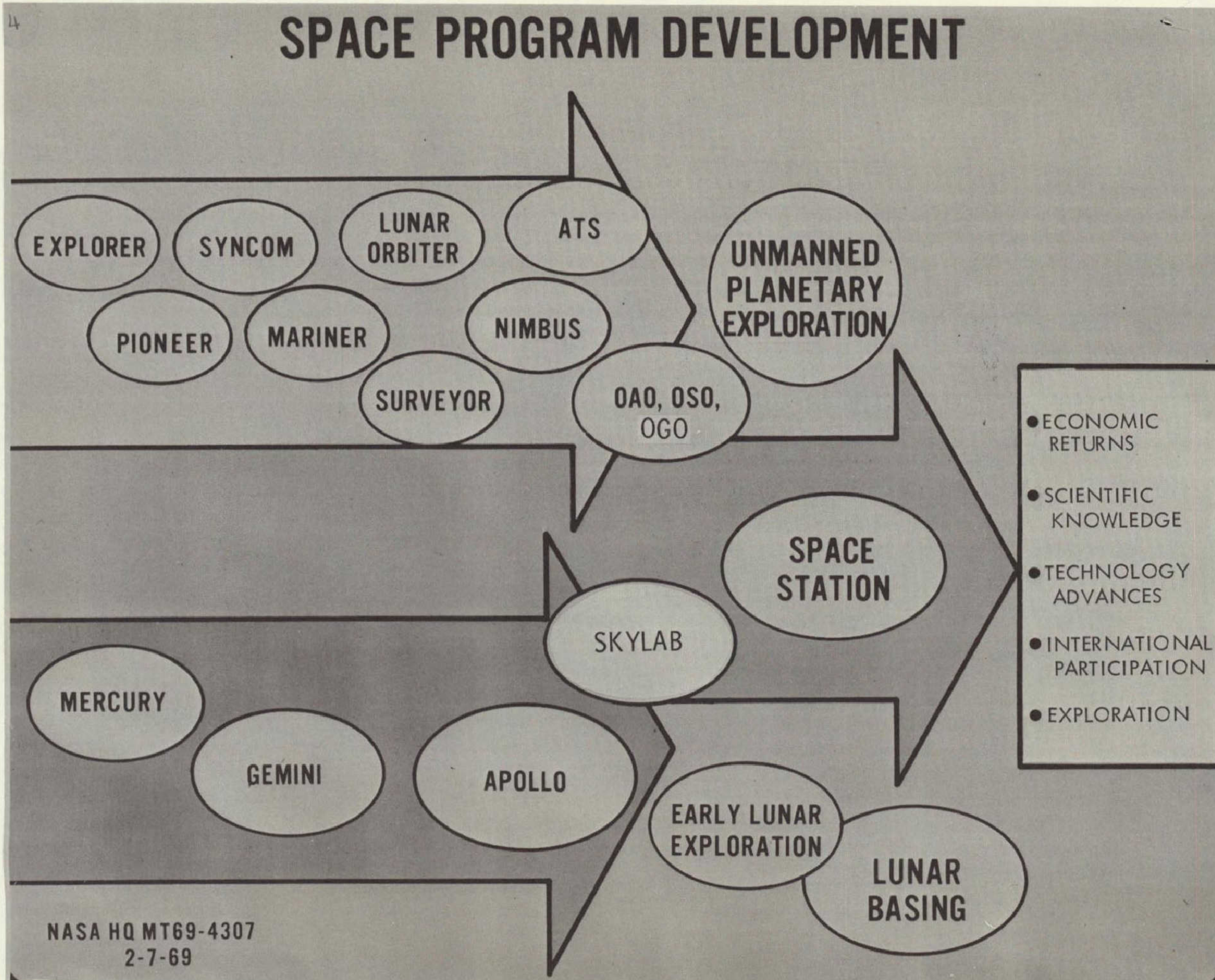
INTEGRATED PROGRAM
EARTH ORBITAL
SATURN WORKSHOPS
SPACE STATION
SYN ORB STA
SPACE BASE
LUNAR
APOLLO 3 MEN
EXTENDED APOLLO
LUNAR ORBIT STATION
LUNAR SURFACE BASE
PLANETARY
MARINER ORBITER
VIKING
HIGH DATA RATE ORBITER
GRAND TOUR
MANNED MARS EXPLORATION
TRANSPORTATION SYSTEMS
SATURN
SPACE SHUTTLE
TUG
NUCLEAR SHUTTLE

INTEGRATED PLAN

An overall plan for space exploration & utilization has been established. This plan is flexible. No specific time schedule is placed on the longer term elements. The plan does involve establishment of permanent bases - first in earth orbit then extending out into deeper space with a system of reusable transportation systems for logistic support. Usually the larger manned systems are preceded by smaller unmanned systems. But ultimately the features of both are incorporated in the future space activities.


SPACE PROGRAM DEVELOPMENT
EXPLORER
SYNCOM
LUNAR ORBITER
ATS
PIONEER
MARINER
NIMBUS
SURVEYOR
OAO, OSO, OGO
UNMANNED PLANETARY EXPLORATION
SPACE STATION
SKYLAB
MERCURY
GEMINI
APOLLO
EARLY LUNAR EXPLORATION
LUNAR BASING
• ECONOMIC RETURNS
• SCIENTIFIC KNOWLEDGE
• TECHNOLOGY ADVANCES
• INTERNATIONAL PARTICIPATION
• EXPLORATION
NASA HQ MT69-4307
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PROGRESS TO THE SPACE STATION

The ability to initiate a Space Station concept is largely based on the capabilities and experience obtained from over a decade of space flight. This experience encompasses both manned and unmanned programs and is intended to take advantage of both. The Space Station will blend both together as we move into the next decade.

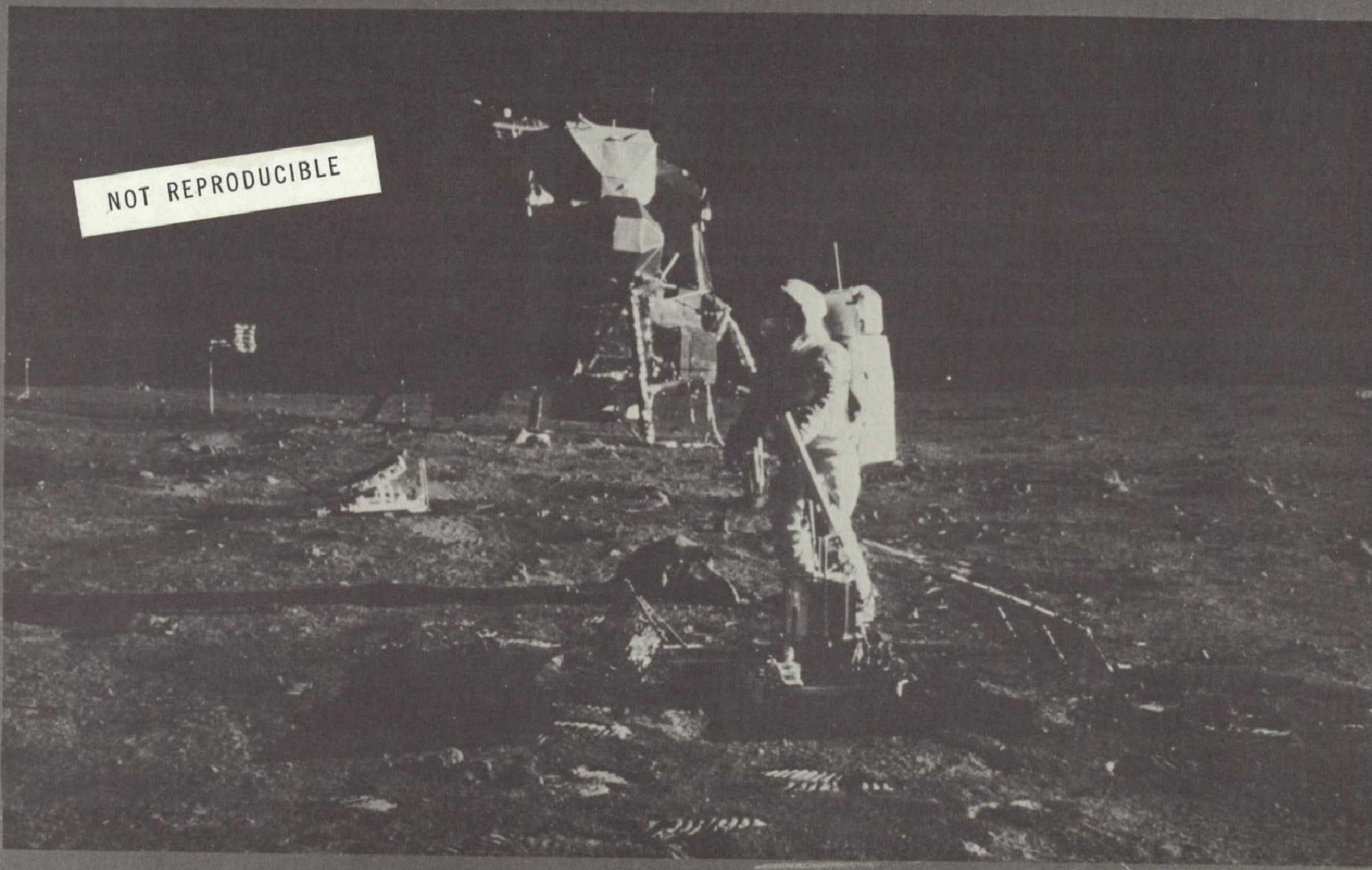
In addition, the Skylab Program, largely drawing on Apollo developments, will provide experience with an experimental Space Station. Initial flights will take place in the early 1970's.

GEMINI EARTH VIEW

GEMINI EARTH VIEW

An example of experience in orbital experiment activities is provided by this photograph obtained during the flight of Gemini XI. This photograph is of the Indian subcontinent and shows a large "U-shaped" cloud line formed as a result of the subsiding air in the sea-breeze circulation around India. Photographs of this kind serve to stimulate interest in obtaining meteorological and earth survey information from space. More than 40 different experiments were conducted during the Gemini flight program.

EARLY APOLLO SCIENTIFIC EXPERIMENT PACKAGE (EASEP) DEPLOYED AT TRANQUILITY BASE



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NASA HQ MA70-5059
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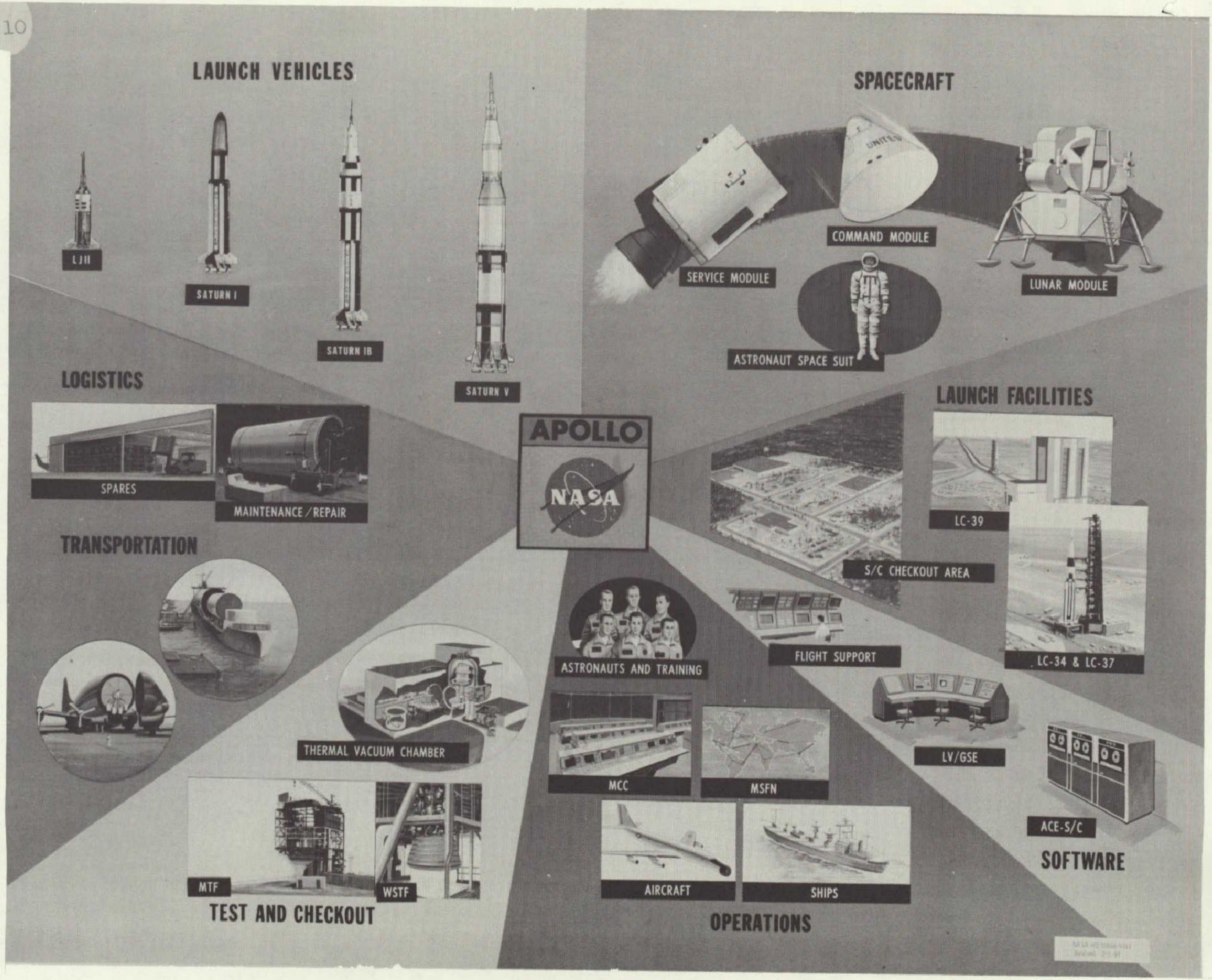
APOLLO LUNAR SCENE

As shown by this photograph, the arena for our scientific investigations in space has been extended to another celestial body -- the moon. The photograph shows one of the Apollo 11 astronauts deploying scientific instrumentation on the lunar surface. This equipment included a seismometer, a laser retro-reflector and a solar wind composition experiment. A more extensive lunar science program has been accomplished on Apollo 12 and will be further increased on future Apollo flights.



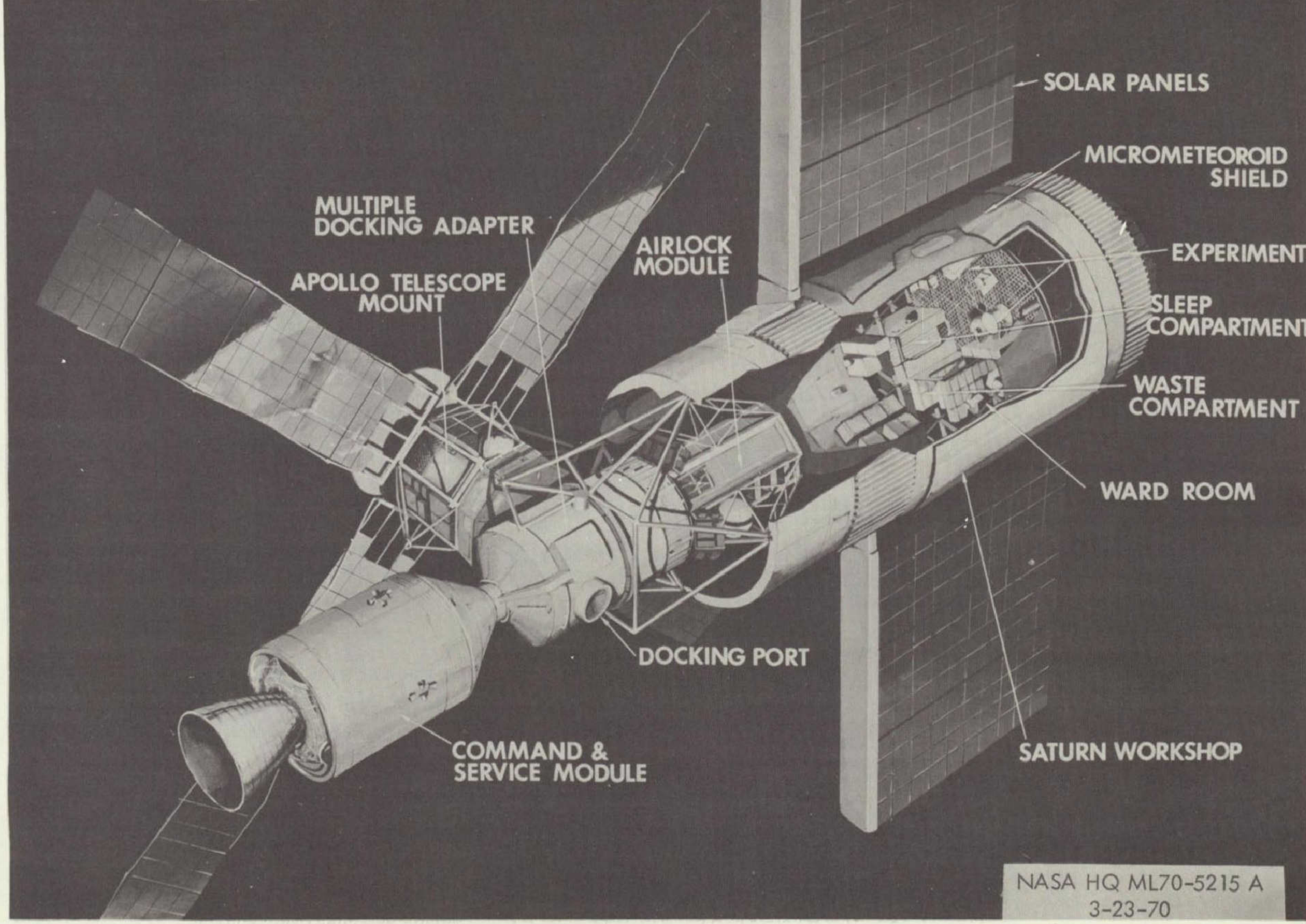
LAUNCH VEHICLES
LJII
SATURN I
SATURN IB
SATURN V
SPACECRAFT
COMMAND MODULE
SERVICE MODULE
LUNAR MODULE
ASTRONAUT SPACE SUIT
LOGISTICS
SPARES
MAINTENANCE / REPAIR
APOLLO
NASA
LAUNCH FACILITIES
LC-39
S/C CHECKOUT AREA
LC-34 & LC-37
TRANSPORTATION
ASTRONAUTS AND TRAINING
FLIGHT SUPPORT
THERMAL VACUUM CHAMBER
LV/GSE
MCC
MSFN
ACE-S/C
SOFTWARE
AIRCRAFT
SHIPS
MTF
WSTF
TEST AND CHECKOUT
OPERATIONS

APOLLO CAPABILITY

Although the Apollo Program is oriented towards lunar exploration, the capabilities developed in Apollo provide the basis for the next steps in all areas of our space endeavors. This capability includes, but involves much more than, the launch vehicle and spacecraft. Highly sophisticated missions have required the development of large facilities for manufacture, testing, checkout and launch. Large ground and flight support complexes including computers, complex computer programs, transportation and ground support equipment and highly trained ground personnel were developed for mission tracking and control. Techniques for mission simulation, crew training, flight operations and recovery were also implemented.

All of this capability is now in place and producing a continuing flow of launches in our Apollo flight program.

SKYLAB PROGRAM CLUSTER CONFIGURATION



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SKYLAB CONFIGURATION

Skylab involves modest modifications to Apollo flight hardware to provide a major experimental capability in earth orbit. A workshop is outfitted within the third stage structure of the Saturn V launch vehicle to provide a large habitation and work area for three astronauts.

The Skylab will be launched from Cape Kennedy, Florida in the early 1970's. A Saturn V will be used to launch the Workshop, Airlock, Multiple Docking Adapter, and Apollo Telescope Mount. A Saturn IB will send the first 3-man crew to the Skylab within 48 hours. The Skylab will be flown in a near-circular orbit of 235 n.mi. with a nominal orbit inclination of 50°. The Skylab will be oriented to a solar inertial (sun pointing) attitude mode. The interior of the Skylab will be pressurized to 5 psia with an oxygen (32%)-nitrogen (68%) atmosphere. The first crew will return to earth after 28 days. During the next seven months, two more 3-man crews will visit the Skylab for durations of 56 days each. During these entire periods, a large number of experiment activities will be carried out.

This figure indicates the location of each major component of the Skylab in the orbital configuration with solar panels extended.

SKYLAB
BASIC OBJECTIVES

- SCIENTIFIC INVESTIGATIONS IN EARTH ORBIT
  - SOLAR ASTRONOMY
  - EARTH OBSERVATIONS
  - STELLAR ASTRONOMY
- APPLICATIONS IN EARTH ORBIT
  - METEOROLOGY
  - EARTH RESOURCES
  - COMMUNICATIONS
- LONG DURATION SPACE FLIGHTS OF MEN AND SYSTEMS
  - UNIQUE CAPABILITIES OF MAN
  - HABITABILITY
  - BIOMEDICAL/BEHAVIORAL
  - SYSTEMS DEVELOPMENT
- EFFECTIVE AND ECONOMICAL APPROACH TO THE DEVELOPMENT OF A BASIS FOR POTENTIAL FUTURE SPACE PROGRAMS

NASA HQ ML68-6015
REV. 2-9-70

SKYLAB OBJECTIVES

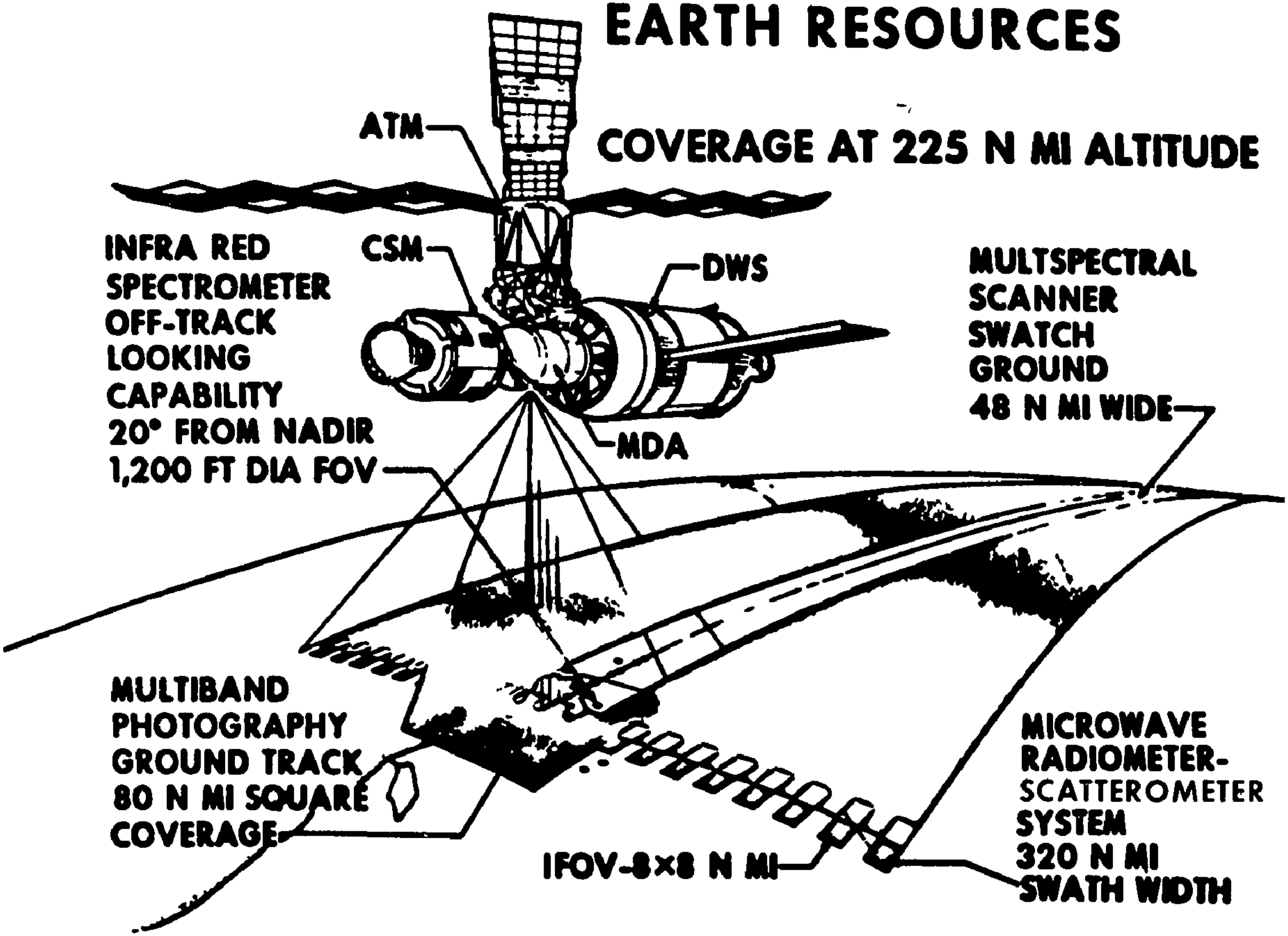
The basic objectives of Skylab are:

<u>Science</u>: These investigations are designed to learn more about the universe, the space environment, and the phenomena that exist in our solar system and how they influence the environment of man on earth.

<u>Applications in Earth Orbit</u>: These experiments include studies in meteorology, earth surveys and communications. They also include evaluation of techniques for using man during sensor operation, data selection, maintenance and repair and assembly.

<u>Long Duration</u>: Skylab will evaluate the life of space vehicle systems and subsystems and the capability of man to adapt to the space environment.

<u>Future Space Programs</u>: The results of the investigations described above will be directly applied to the planning of future activities such as the long duration Space Station.


EARTH RESOURCES
COVERAGE AT 225 N MI ALTITUDE
ATM
CSM
DWS
MDA
INFRA RED SPECTROMETER OFF-TRACK LOOKING CAPABILITY 20° FROM NADIR 1,200 FT DIA FOV
MULTSPECTRAL SCANNER SWATCH GROUND 48 N MI WIDE
MULTIBAND PHOTOGRAPHY GROUND TRACK 80 N MI SQUARE COVERAGE
IFOV-8×8 N MI
MICROWAVE RADIOMETER-SCATTEROMETER SYSTEM 320 N MI SWATH WIDTH

SKYLAB EARTH SURVEY OPERATIONS

This figure illustrates the earth survey operations to be conducted by the Skylab crew. The earth resources experiments are designed to support the development of earth sensor and applications technology. They will determine the extent to which multiband photography may be applied to secure data from selected earth sites. These experiments will be conducted during a total of 45 orbits. Typical investigations are crop and forest survey, land use pattern, coastal hurricane damage, air-sea interaction, mineral identification (infrared) and fish location (infrared).

SKYLAB FLIGHT ASSIGNED EXPERIMENTS

MEDICAL

M071 MINERAL BALANCE
M072 BONE DENSITOMETRY
M073 BIOASSAY OF BODY FLUIDS
M074 SPECIMEN MASS MEASUREMENT
M091 LBNP (PRE- & POSTFLIGHT)
M092 INFLIGHT LBNP
M093 VECTORCARDIOGRAM
M111 CYTOGENETIC STUDIES OF BLOOD
M112 MAN'S IMMUNITY-IN VITRO ASPECTS
M113 BLOOD VOLUME AND RED CELL LIFE SPAN
M114 RED BLOOD CELL METABOLISM
M131 HUMAN VESTIBULAR FUNCTION
M151 TIME AND MOTION STUDY
M171 METABOLIC ACTIVITY
M172 BODY MASS MEASUREMENT
ESS EXPERIMENT SUPPORT SYSTEM

TECHNOLOGY

T003 INFLIGHT AEROSOL ANALYSIS
T013 CREW-VEHICLE DISTURBANCE
T018 PRECISION OPTICAL TRACKING
T020 FOOT CONTROLLED MANEUVER UNIT
T025 CORONAGRAPH CONTAMINATION MEAS.
T027 ATM CONTAMINATION MEASUREMENT
T029 PILOT DESCRIBING FUNCTION (B)

DOD (TECHNOLOGY)

D008 RADIATION IN SPACECRAFT
D021 EXPANDABLE AIRLOCK TECHNOLOGY
D024 THERMAL CONTROL COATINGS

SCIENTIFIC

S009 NUCLEAR EMULSION
S015 ZERO G SINGLE HUMAN CELLS
S019 UV STELLAR ASTRONOMY
S020 UV/X-RAY SOLAR PHOTOGRAPHY
S061 POTATO RESPIRATION
S063 UV AIRGLOW HORIZON PHOTOGRAPHY
S071 CIRCADIAN RHYTHM-POCKET MICE
S072 CIRCADIAN RHYTHM-VINEGAR FLY
S073 GEGENSCHEIN/ZODIACAL LIGHT
S149 PARTICLE COLLECTION
S150 GALACTIC X-RAY MAPPING (B)

S190 MULTISPECTRAL PHOTOGRAPHIC FACILITY
S191 INFRARED SPECTROMETER
S192 10-BAND MULTISPECTRAL SCANNER
S193 MICROWAVE SCATT., ALT., AND RAD.

S052 WHITE LIGHT CORONAGRAPH
S054 X-RAY SPECTROGRAPHIC TELESCOPE
S055 UV SPECTROMETERS (A INSTRUMENT MOD.)
S056 DUAL X RAY TELESCOPE
S082 UV SPECTROGRAPH/HELIOGRAPH

ENGINEERING

M402 ORBITAL WORKSHOP
M415 THERMAL CONTROL COATINGS
M479 ZERO G FLAMMABILITY
M487 HABITABILITY/CREW QUARTERS
M507 GRAVITY SUBSTITUTE WORKBENCH
M508 EVA HARDWARE EVALUATION
M509 ASTRONAUT MANEUVERING EQUIPMENT
M512 MATERIALS PROCESSING IN SPACE

NASA HQ ML70-5149
REV. 3-25-70

SKYLAB ASSIGNED EXPERIMENTS

This figure identifies each specific experiment presently planned for Skylab. The list is arranged in appropriate technical disciplines. Each experiment is expected to provide man with information and experience not possible to obtain from the surface of the earth. Heretofore, manned space flight programs have emphasized development of hardware and related systems to accomplish basic goals such as rendezvous and docking in space, landing on another celestial body, etc. Skylab is predominantly dedicated to the conduct of scientific, technological and applications experiments.

Solar Astronomy - The Apollo Telescope Mount instruments will investigate the sun's corona, solar flare phenomenon and other dynamic processes occurring on the sun.

Earth Resources - These experiments will enable the crews to gather valuable data about the earth and to obtain experience with earth sensors.

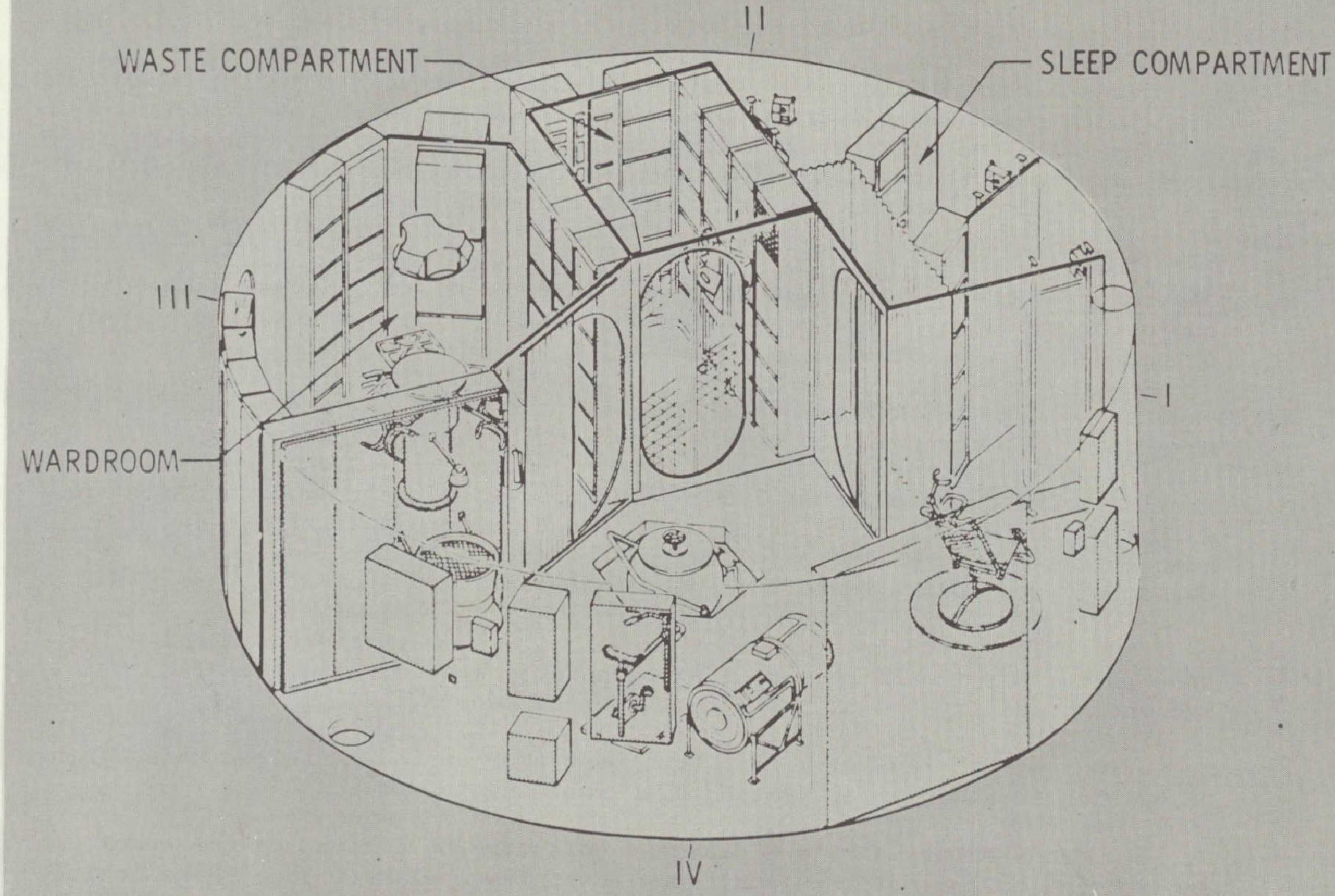
Biomedical - These experiments will determine the effect of long duration space flight on the crew. Major areas of interest include nutritional and musculoskeletal function; cardiovascular function; hematology, neurophysiology, pulmonary function; and metabolism.

Science - The scientific experiments on Skylab will investigate the areas of geophysics, physics of the upper atmosphere, galactic and intergalactic astronomy, and physics of the interplanetary médium.

Crew Operations - The crews will test equipment such as the Astronaut Maneuvering Unit which is aimed at augmenting crew mobility in space.

Technology - These experiments are designed to study the effects of the space environment on various technical and industrial applications. These include the manufacture and retrieval of valuable products such as large crystals for use on earth.

ORBITAL WORKSHOP
CREWS QUARTERS INSTALLATIONS



NASA HQ ML70-5170
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SKYLAB CREW QUARTERS

The Crew Quarters area of the Skylab is shown here. It contains the necessary crew provisions, living quarters, and food preparation and waste management facilities to support a crew of 3 men for up to 2 months. This area will also be used to conduct many medical experiments designed to monitor the basic physical and psychological status of the crew. Sophisticated instruments will provide a large and valuable addition to the medical data that has already been gathered in previous manned flight programs.

DESIRED SYSTEM CHARACTERISTICS

- **ROUTINE PRODUCTIVE OPERATIONS**
  - SUFFICIENTLY LARGE CREW FOR MULTIPLE RESEARCH AND APPLICATION TASKS
  - "GENERAL PURPOSE" LABORATORY.
  - FREQUENT AND CONVENIENT RESUPPLY.
  - ABILITY TO MODIFY AND REPAIR EQUIPMENT ONBOARD
- **LOW OPERATING COSTS**
  - VERY LONG USEFUL LIFE WITH MAINTENANCE AND RESUPPLY
  - LESS DEPENDENCE ON GROUND OPERATIONAL SUPPORT.
  - REUSABLE SPACE TRANSPORTATION SYSTEM (SHUTTLE).
- **PROGRAM FLEXIBILITY**
  - MODULAR REPLACEMENT AND GROWTH.
  - COMPATIBILITY WITH HIGH ENERGY MISSIONS.
  - DECOUPLING OF EXPERIMENT/PAYLOADS PROGRAM.
  - USE OF BOTH DOCKED AND FREE-FLYING EXPERIMENT MODULES.
- **CREW EFFICIENCY AND SAFETY**
  - GOOD ARCHITECTURE, FOOD, HYGIENE FACILITIES, ATMOSPHERE.
  - PROGRESS TOWARD ARTIFICIAL GRAVITY.
  - HIGHLY AUTOMATED HOUSEKEEPING.
  - ONBOARD FAULT ISOLATION, DAMAGE CONTROL, REFUGE AND MEDICAL HELP.

NASA HQ MF70-6066
5-25-70

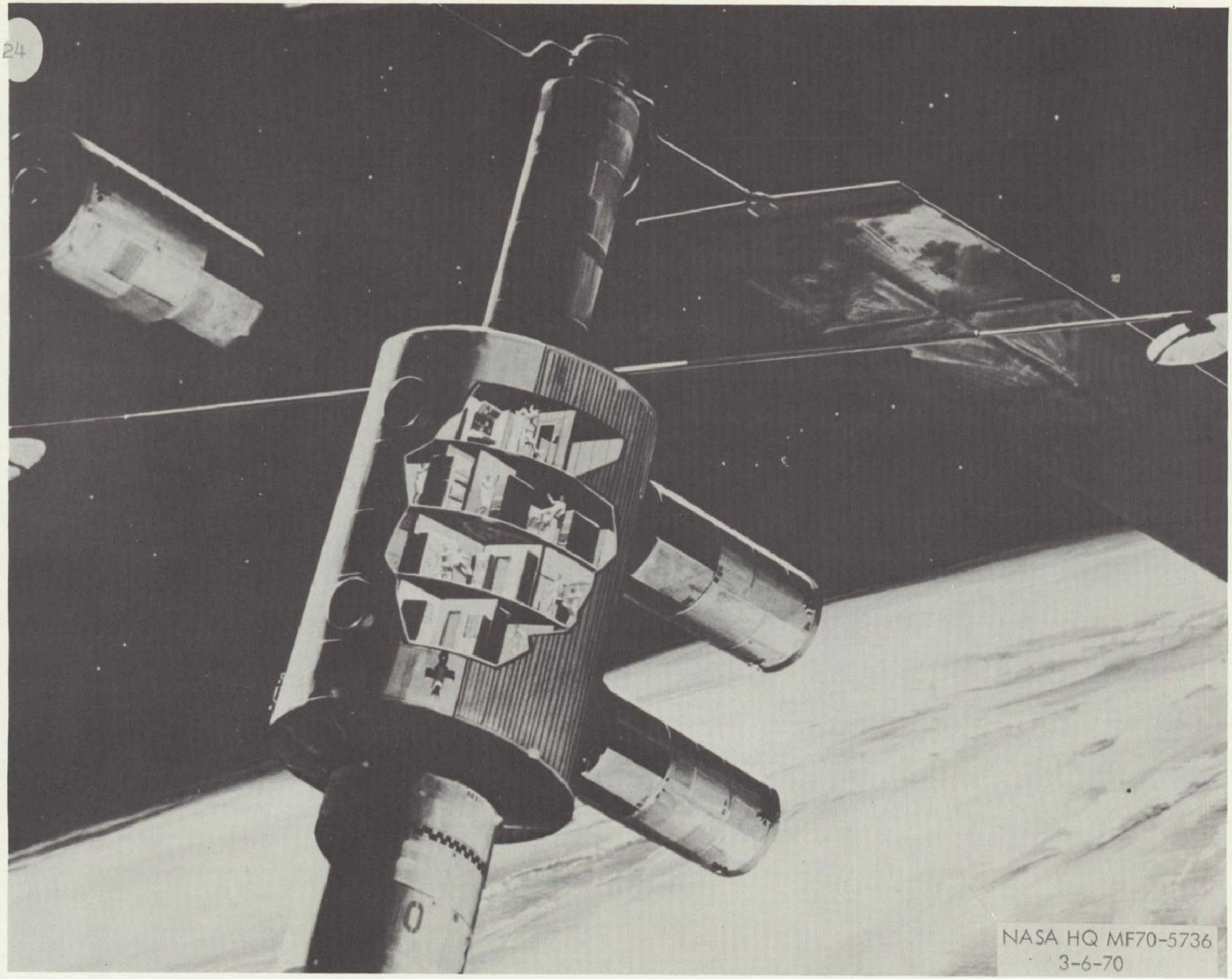
DESIRED SYSTEM CHARACTERISTICS

The Space Station will provide a centralized facility in orbit for research, applications, and space operations. The facility will have a crew large enough to permit a high degree of specialization. The crew will include experimenter/astronauts qualified in a research discipline but with minimum spacecraft systems training. A general purpose laboratory with commonly used instrumentation, photographic processing and automatic data processing will be available onboard.

The Space Station will be designed for a very long life over which to amortize the substantial investment. Onboard maintenance and economical resupply using the Shuttle will make this possible. As a further means of minimizing operating costs the Space Station will have capability onboard for fault isolation, and navigation; therefore, it will be unnecessary to man ground stations and control centers to the extent used for Apollo.

The Space Station will be designed like a ground-based laboratory facility for modification and growth. Research and development equipment not available or even conceived at the time the station is launched will be delivered by the Shuttle and installed in one of the integral laboratory areas. Alternatively, the new research equipment may be installed in an additional module which will be docked to the Space Station or may fly near by and be controlled from the station.

The Space Station will provide an efficient, comfortable and safe place for the crew to live and work. Routine functions will be automated so that the crew can use their skills productively.



NASA HQ MF70-5736
3-6-70

SPACE STATION

The current concepts for Space Station provide living quarters for a 12-man crew, supplies for six months, 25 Kw of power, a sea level atmosphere, and general purpose laboratory facilities. The core module of Space Station is 10 meters in diameter and approximately 15 meters long. Four full decks are arranged perpendicular to the cylinder axis with unpressurized volume for storage of consumables at both ends. Multiple docking ports for experiment modules and cargo modules will be provided.

26


3-METER STELLAR ASTRONOMY MODULE
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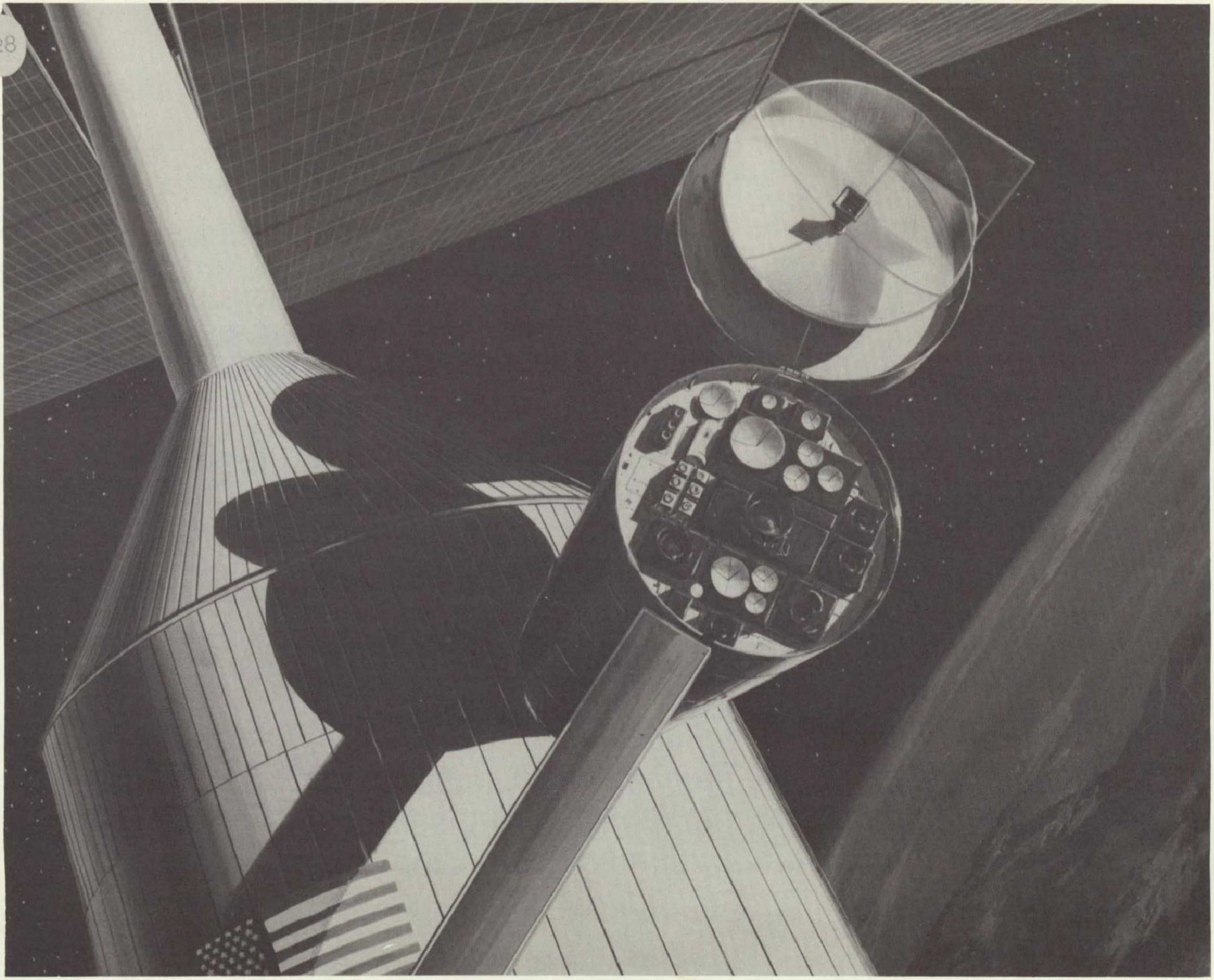
NASA HQ MF70-5135
1-23-70

SCIENCE

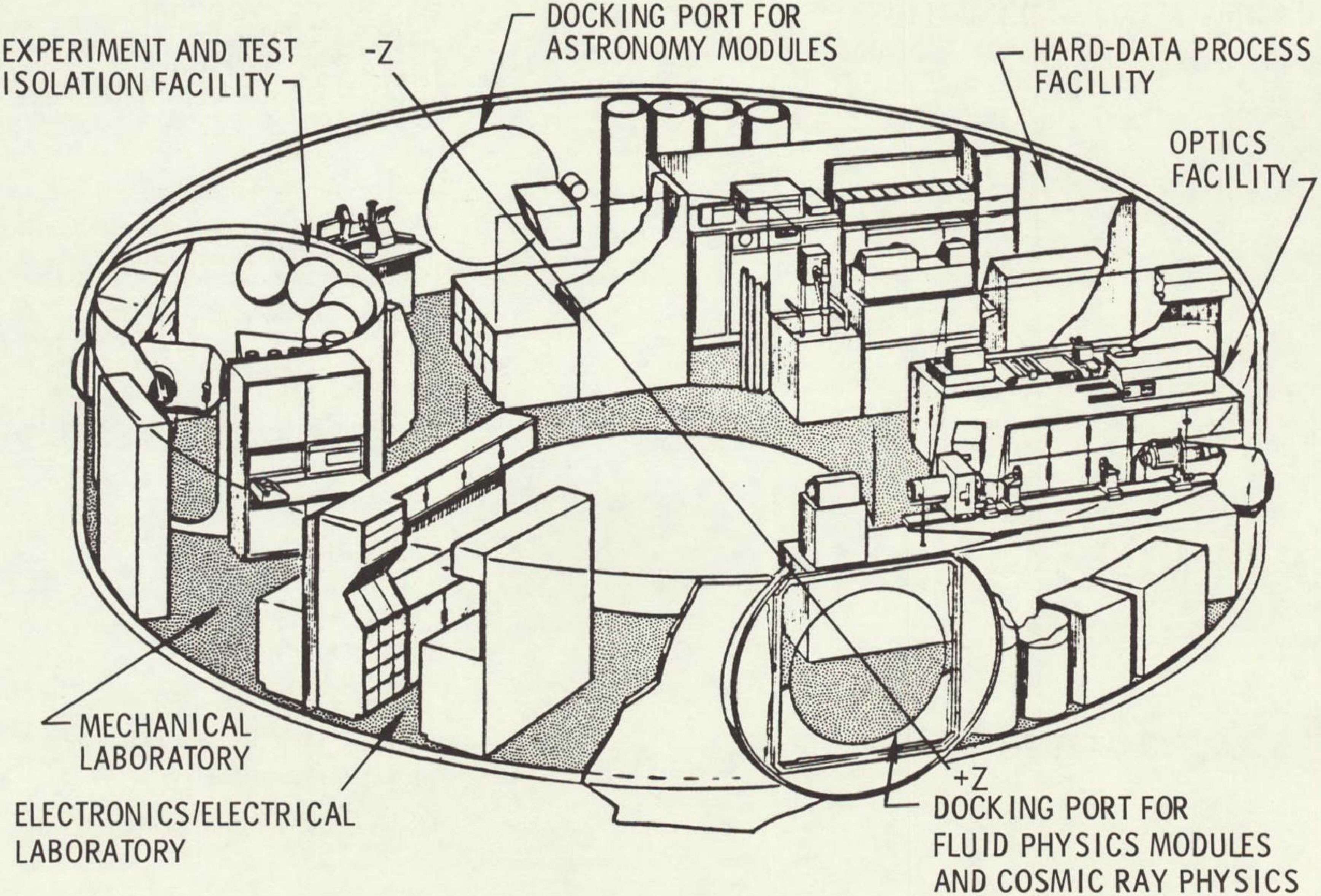
ASTRONOMY	OBSERVATIONS IN RADIO, IR, VISIBLE, UV, X-RAY AND GAMMA-RAY SPECTRUMS
SPACE PHYSICS	COSMIC RAY AND PLASMA PHYSICS INVESTIGATIONS
SPACE BIOLOGY	LOW GRAVITY AND CIRCADIAN RHYTHM EFFECTS
SPACE MEDICINE	BIOMEDICAL AND BEHAVIORAL EFFECTS



APPLICATIONS

	EXPLORATORY STUDIES SENSOR DEVELOPMENT OPERATIONAL TECHNIQUES
EARTH SURVEYS	AGRICULTURE & FORESTRY HYDROLOGY CARTOGRAPHY GEOLOGY OCEANOGRAPHY
METEOROLOGY	LONG RANGE WEATHER PREDICTION STORM SURVEILLANCE
SAFETY SERVICES	POLLUTION NAVIGATION & TRAFFIC CONTROL SEARCH & RESCUE NATURAL DISASTERS
COMMUNICATIONS	INFORMATION RELAY DIRECT BROADCAST

GENERAL PURPOSE LABORATORY-DECK 4



TECHNOLOGY

MATERIALS AND COATINGS	MATERIALS EXPOSURE LUBRICANT TESTS OPTICAL SURFACE DEGRADATION
SPACE STRUCTURES	DEPLOYMENT TESTS ASSEMBLE OF LARGE STRUCTURES ATTACHMENT TECHNIQUES
FLUID SYSTEMS	HEAT PIPE OPERATIONS FLUID TRANSFER AND STORAGE WASTE PROCESSING METHODS
SPACE MANUFACTURING	NEW COMPOSITES METAL FORMS THIN FILMS LARGE CRYSTALS
ENVIRONMENT DEFINITION	RADIATION FIELD METEORITE STUDIES CONTAMINATION SURVEYS

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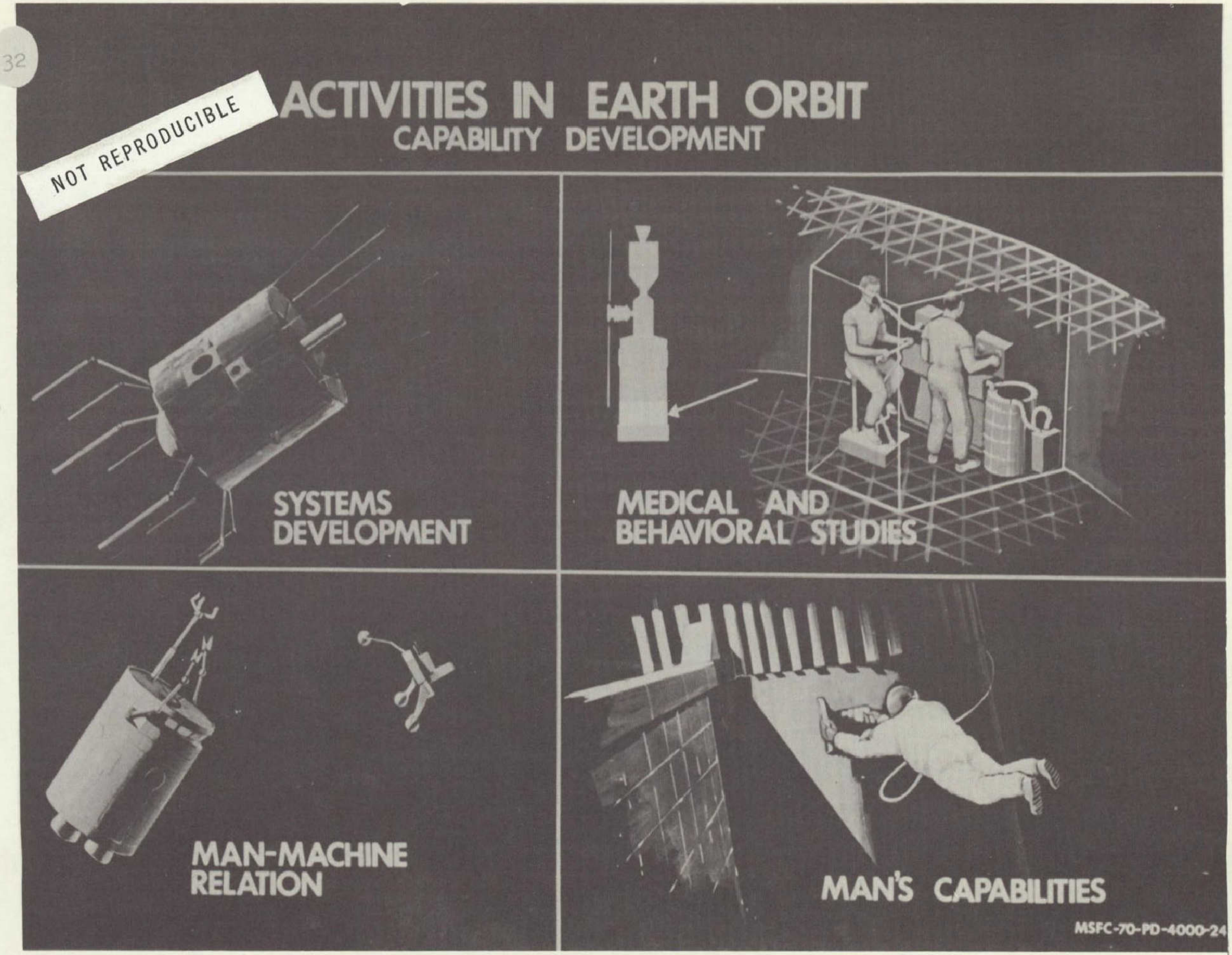
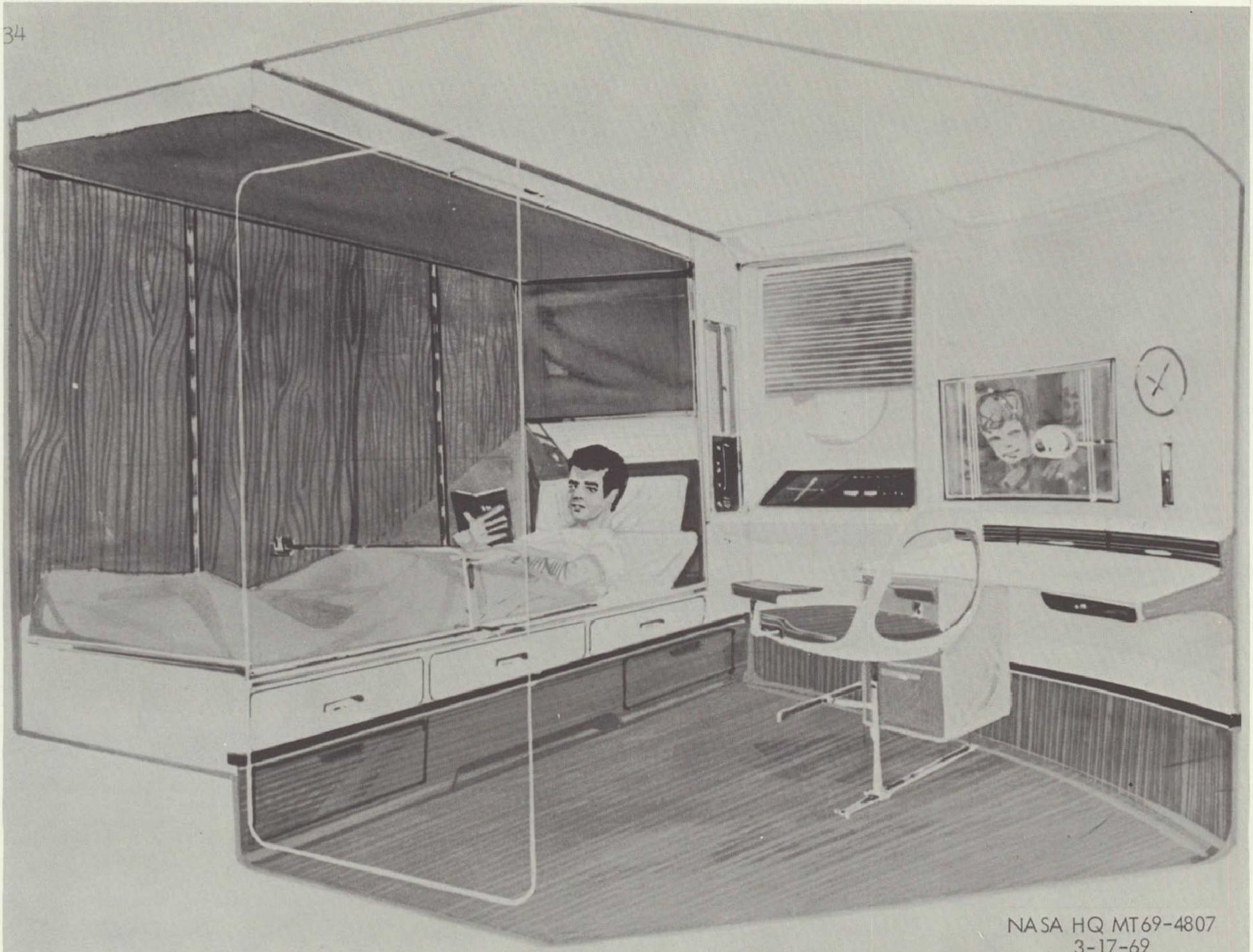


ENGINEERING/OPERATIONS

MAINTENANCE, REPAIR & SERVICING	- EXPERIMENT MODULES - UNMANNED SATELLITES - SPACE TUG - ORBIT TO ORBIT SHUTTLE - TANK FARM
ASSEMBLY & CHECKOUT	- UNMANNED PROBES - PROPULSION MODULES - PAYLOAD MODULES
ADVANCED SYSTEM TESTS	- POWER GENERATION - ENVIRONMENTAL CONTROL - ADVANCED COMPONENTS - LAZER COMMUNICATION
CONTROL CENTER	- FREE FLYING MODULES - REMOTE EXPERIMENTS - RENDEZVOUS AND DEPARTURE



NASA HQ MT69-4807
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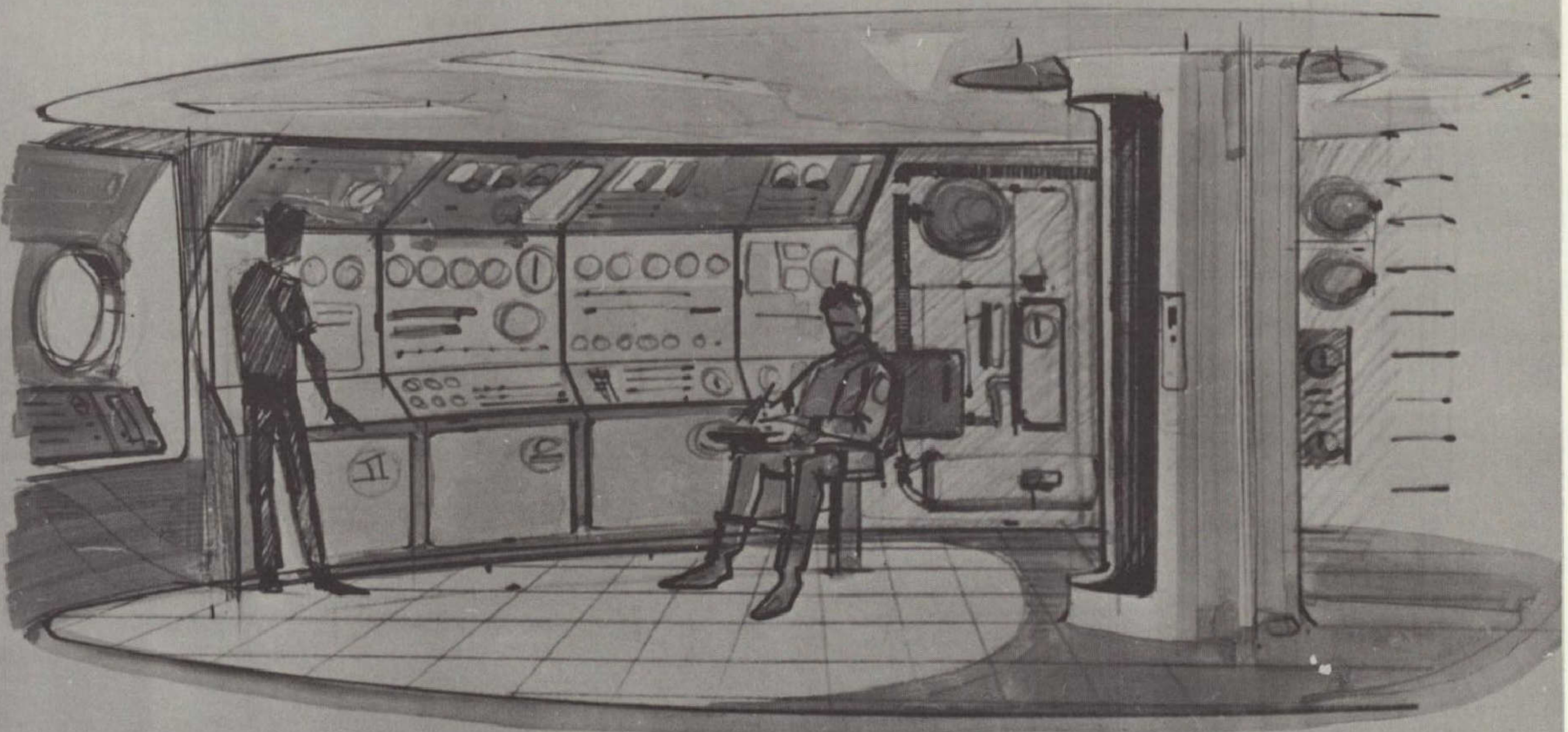
SPACE STATION LIVING QUARTERS

This picture illustrates a typical living quarters layout for the Space Station.

A primary concern of the Space Station design teams has been to provide the crew with comfortable, safe and convenient accommodations in which to live for the three to six month tours of duty. These accommodations will include good food, adequate personal hygiene facilities, and quarters designed to meet the needs of the crew member for a private area in which to work and relax.

The design shown assumes artificial gravity. Zero "g" accommodations would differ in certain parameters, principally the location and number of restraint devices. Common to either would be comfort and convenience features.

SPACE STATION CONTROL ROOM



NASA HQ MT69-4802
1-22-70

CONTROL ROOM

For station operations, current concepts include onboard monitoring and command consoles for subsystem checkout, status and fault isolation, for experiment observation, for remote control of detached modules, for data processing and communications, for logistcs vehicle rendezvous and docking, and for emergencies. Many of these functions will be combined into one or two central locations similar to the control room shown in the artist's drawing.

OPPORTUNITIES FOR PARTICIPATION

FACILITY IN DEVELOPMENT

- o PLANNING THE FACILITY
- o FORMULATING USER PROGRAM
- o OUT FITTING MODULES
- o SUPPLYING MODULES
- o DEVELOPING SUB-SYSTEM
- o DEVELOPING MANAGEMENT ARRANGEMENTS

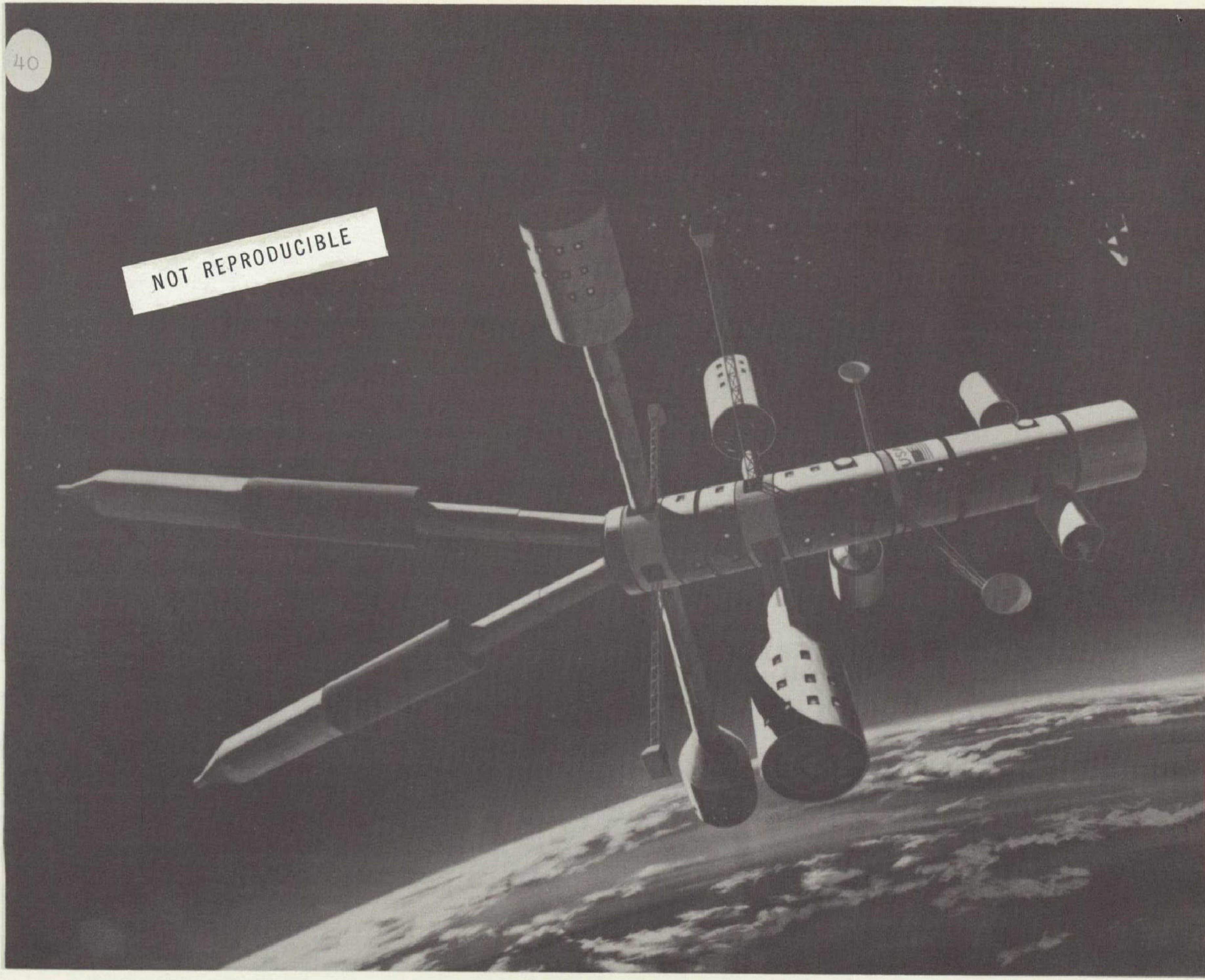
FACILITY IN OPERATION

- o PARTICIPATING IN USER PANELS
- o DEVELOPING AND SUPPLYING EXPERIMENTS
- o DEVELOPING AND SUPPLYING EXPERIMENT MODULES
- o MANNING GROUND STATION
- o SELECTING ACTIVITIES
- o PROVIDING EXPERIMENTER/ASTRONAUTS
- o EVALUATING RESULTS

OPPORTUNITIES FOR PARTICIPATION

The accompanying chart lists a number of areas in the Space Station Program where users and contributors from outside the NASA will be able to participate. At this time we envision that there will be many opportunities for individuals and organizations to become involved.

While the details of such participation, particularly on an international scale, have not been completely defined, activities in the months ahead will be devoted to that objective.



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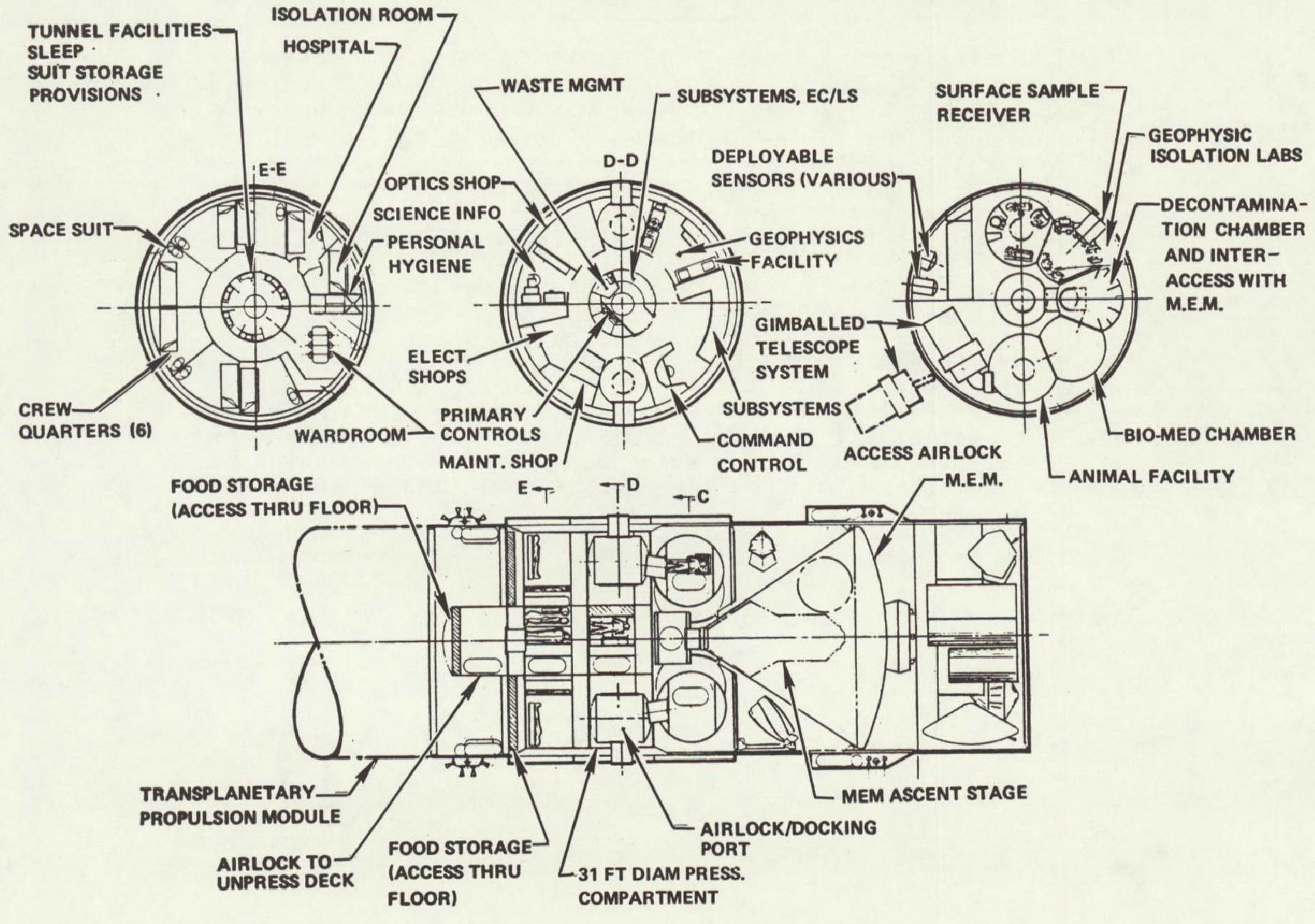
SPACE BASE

Looking to the future, we expect that larger Space Stations will prove to be desirable. When a crew on the odrer of 50 men and women can be accommodated, a community of disciplinary specialists will be available. There will be less need for the current type of astronaut training and physical conditioning. Permanent special purpose laboratory and observatory facilities can be operated adjacent to one another simultaneously.

The Space Base concept shown has rotating arms to provide artificial gravity in selected modules. Although the long term physiological effects of zero gravity have not been resolved, the primary reason for artificial gravity is for the comfort and convenience of the crew in cooking, dining, washing, waste management and certain types of work activities. Laboratories and observatories will be located principally in the non-rotating hub to obtain near zero gravity conditions. The Space Station core module is being designed so that it could grow into a Space Base at a later date.

PLANETARY MISSION MODULE

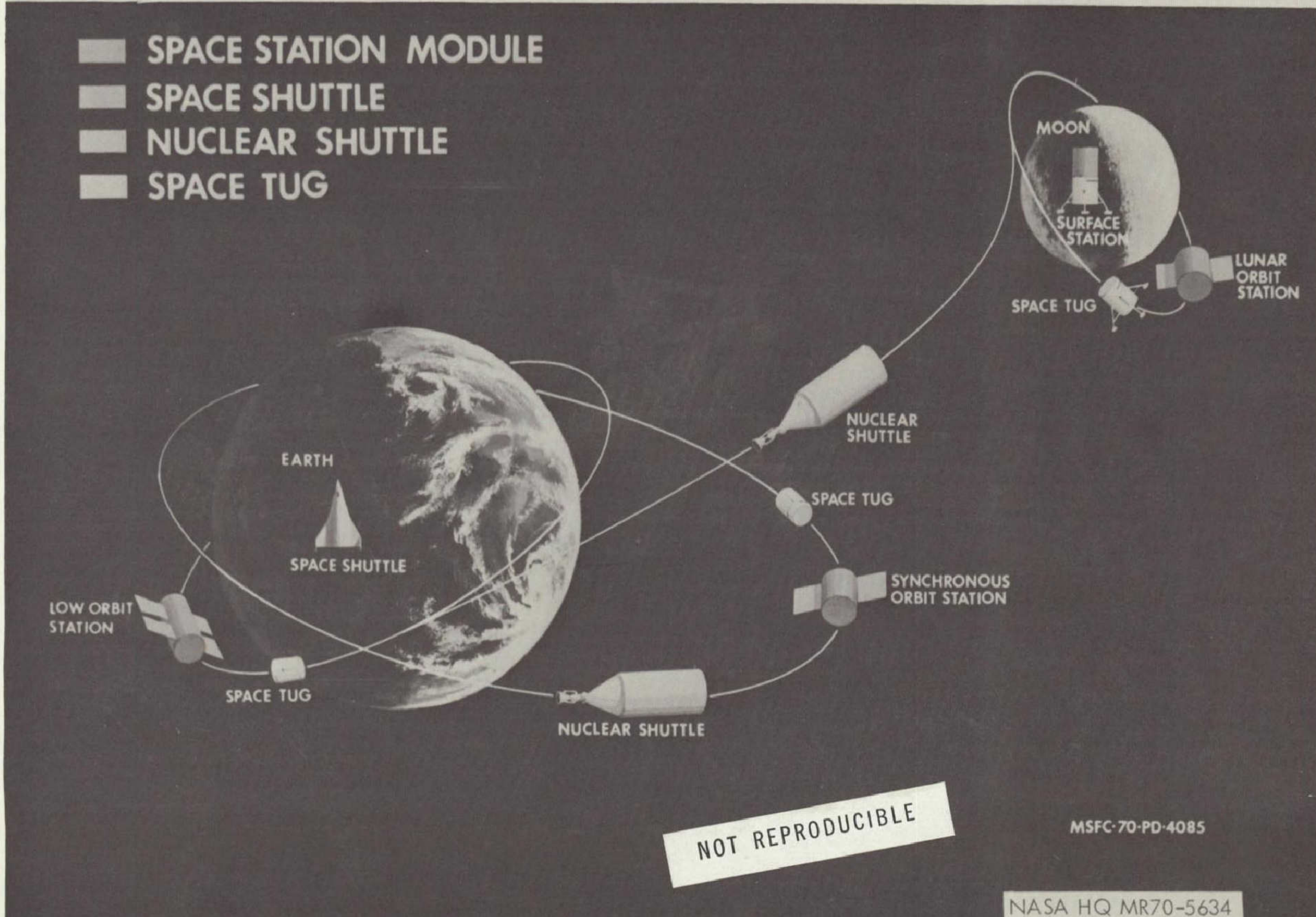


PLANETARY MISSION MODULE

NASA has a long range goal of eventually sending men to explore the planet Mars. To assure that the developments undertaken as part of the Space Station program contribute to this long term goal without undue increase in program cost or complexity, an assessment is underway to determine where common or near common requirements exist and may be met by a single module segment. The planetary vehicle concepts involve the use of two nuclear shuttles for Earth departure and a third nuclear shuttle to accompany the planetary spacecraft for use in braking into Mars orbit, in Mars orbit departure and in braking into a highly elliptic Earth orbit.

Although complete spacecraft concepts with Mars excursion modules and probes have been developed the principal effort is being devoted to the so-called mission module, which houses the living quarters, command and control, and laboratories. The mission module concept shown is very similar to two decks of Space Station and utilizes an isotope Brayton power generation system. The concept has a centrally located radiation shelter. Substantial commonality could exist between the postulated planetary mission and the Earth orbital mission, particularly in habitability and long life system approaches.

SPACE TRANSPORTATION



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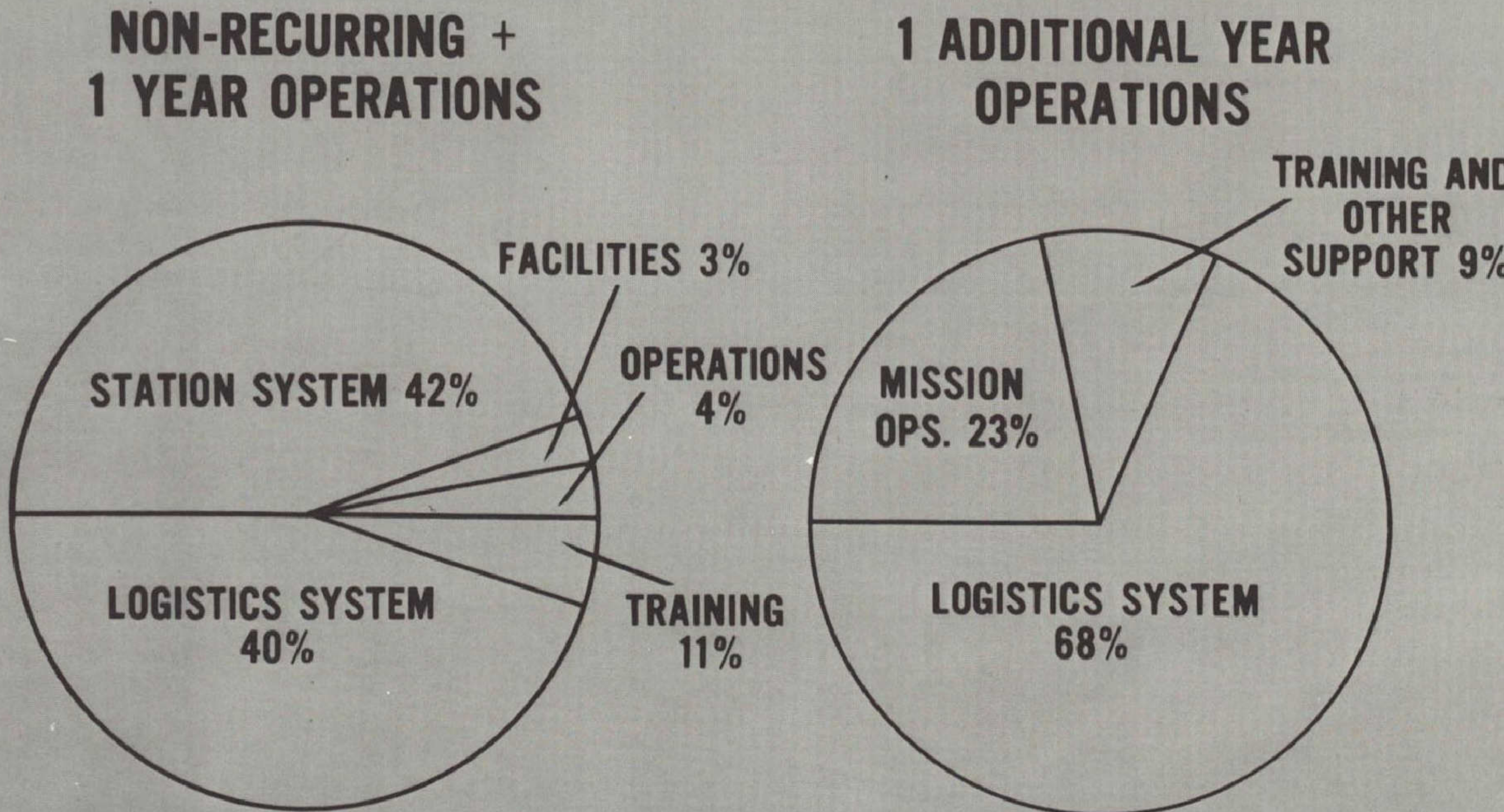
3-27-70

SPACE TRANSPORTATION

This illustration includes the major elements of the space transportation system as it is now envisioned. A key feature of this system is that all of its elements, the Space Tug, the Earth Orbit Shuttle, and the Nuclear Shuttle will all be designed for a maximum degree of mutual operational compatibility. For example, the Earth Orbit Shuttle will be able to deliver the Space Tug to earth orbit and then service it. The EOS will also carry liquid hydrogen propellants, payloads, and other operational logistics for the nuclear shuttle. The Nuclear Shuttle will be able to transport the Space Tug into deep space for operations there. The Space Tug, properly configured, will be able to assist in the assembly and later maintenance of the Nuclear Shuttle.

All of these elements will make it possible to assemble and operate a space station in low or synchronous earth orbit, lunar orbit, or as planetary mission modules. As the space exploration moves into the future development of the Space Base, manned planetary expeditions and beyond, the space transportation system as pictured here will be a key to the feasibility of such undertakings.

ECONOMIC SIGNIFICANCE OF LOGISTICS TO SPACE STATION PROGRAM



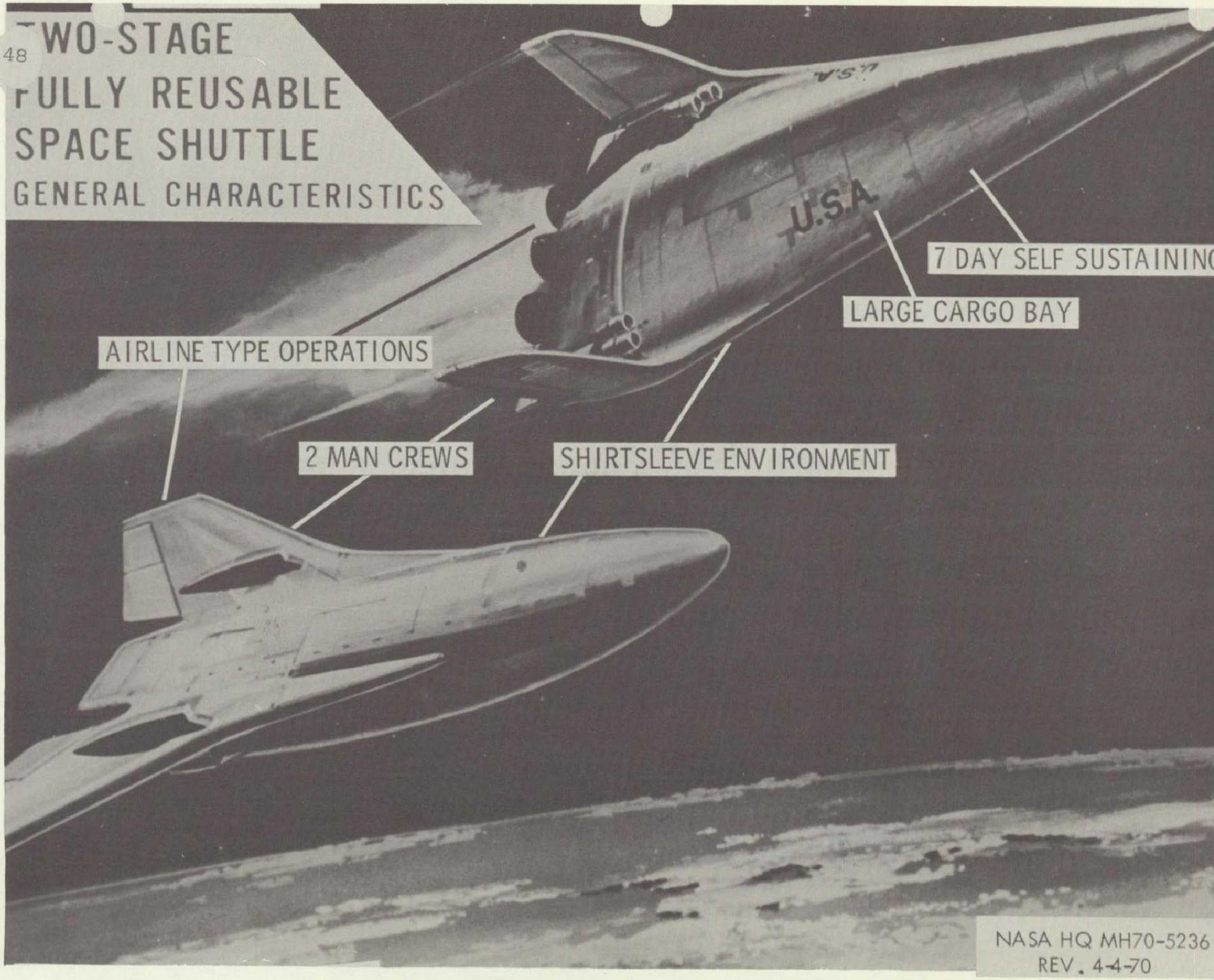
NASA HQ MT68-7234
11-21-68

ECONOMIC SIGNIFICANCE OF LOGISTICS TO SPACE STATION PROGRAM

Logistics systems for personnel rotation, expendables resupply, and experiments and experiment module delivery represent a major share of the space station flight program costs.

A recent NASA study indicates that in the second year of the operational phase of the space station program nearly 70 percent of the costs are consumed by the logistics part of the operation.

The viability and success of long duration space station flight programs are critically dependent on the availability of a cost effective and versatile round-trip transportation system.


TWO-STAGE
FULLY REUSABLE
SPACE SHUTTLE
GENERAL CHARACTERISTICS
U.S.A.
7 DAY SELF SUSTAINING
LARGE CARGO BAY
AIRLINE TYPE OPERATIONS
2 MAN CREWS
SHIRTSLEEVE ENVIRONMENT
NASA HQ MH70-5236
REV. 4-4-70

TWO-STAGE FULLY REUSABLE SPACE SHUTTLE

General Characteristics

The following are a few of the characteristics of the concepts we are pursuing in present Space Shuttle studies:

Vertical take-off, horizontal landing

Payload of 25-50,000 pounds into low earth orbit and return

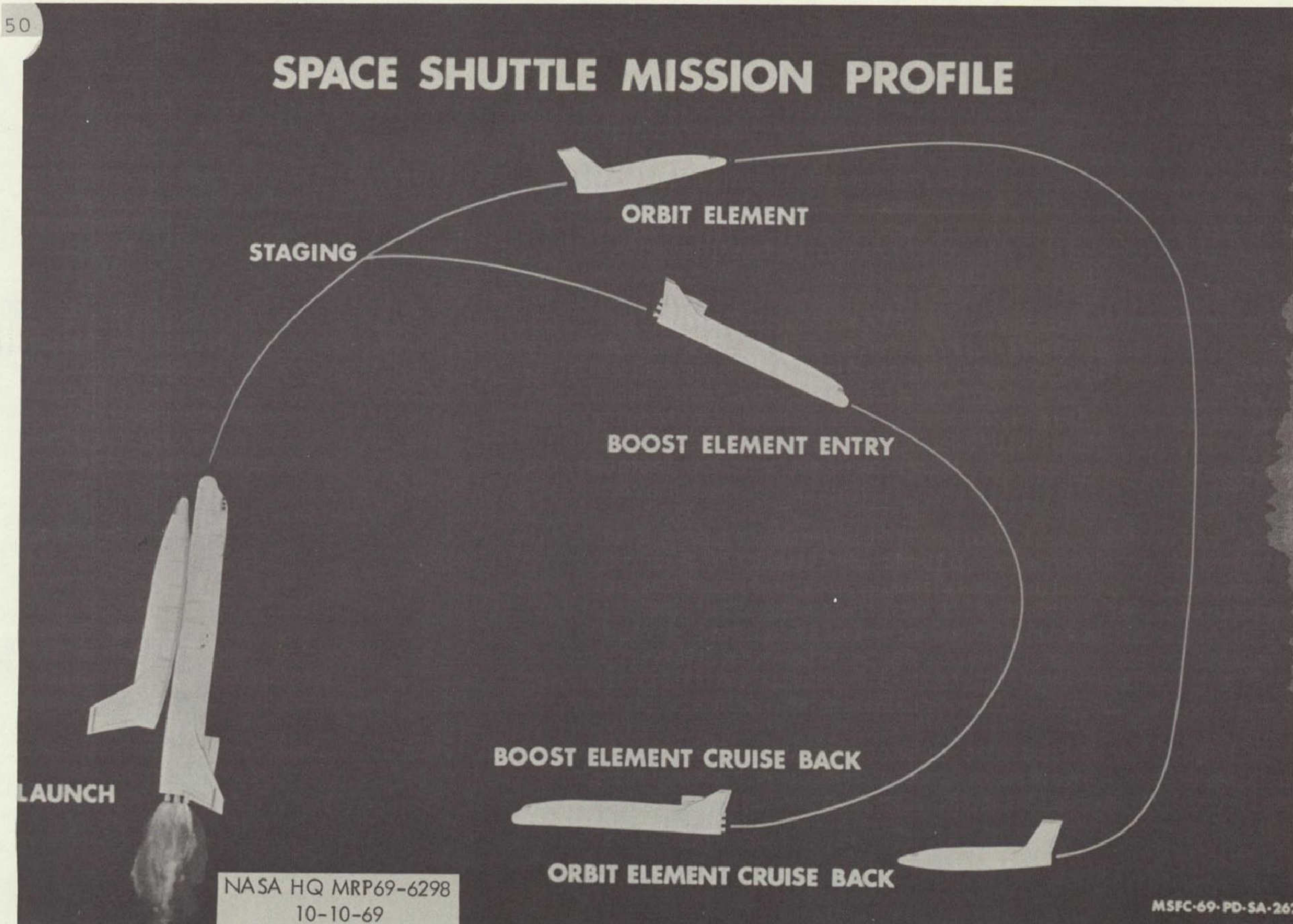
Takeoff weight approximately 3.5 million pounds with payload and fully fueled

Two-man crew

Payload volume of about 10,000 cubic feet for cargo, supplies, fuel or passengers

Environment more like an airplane than a present spacecraft

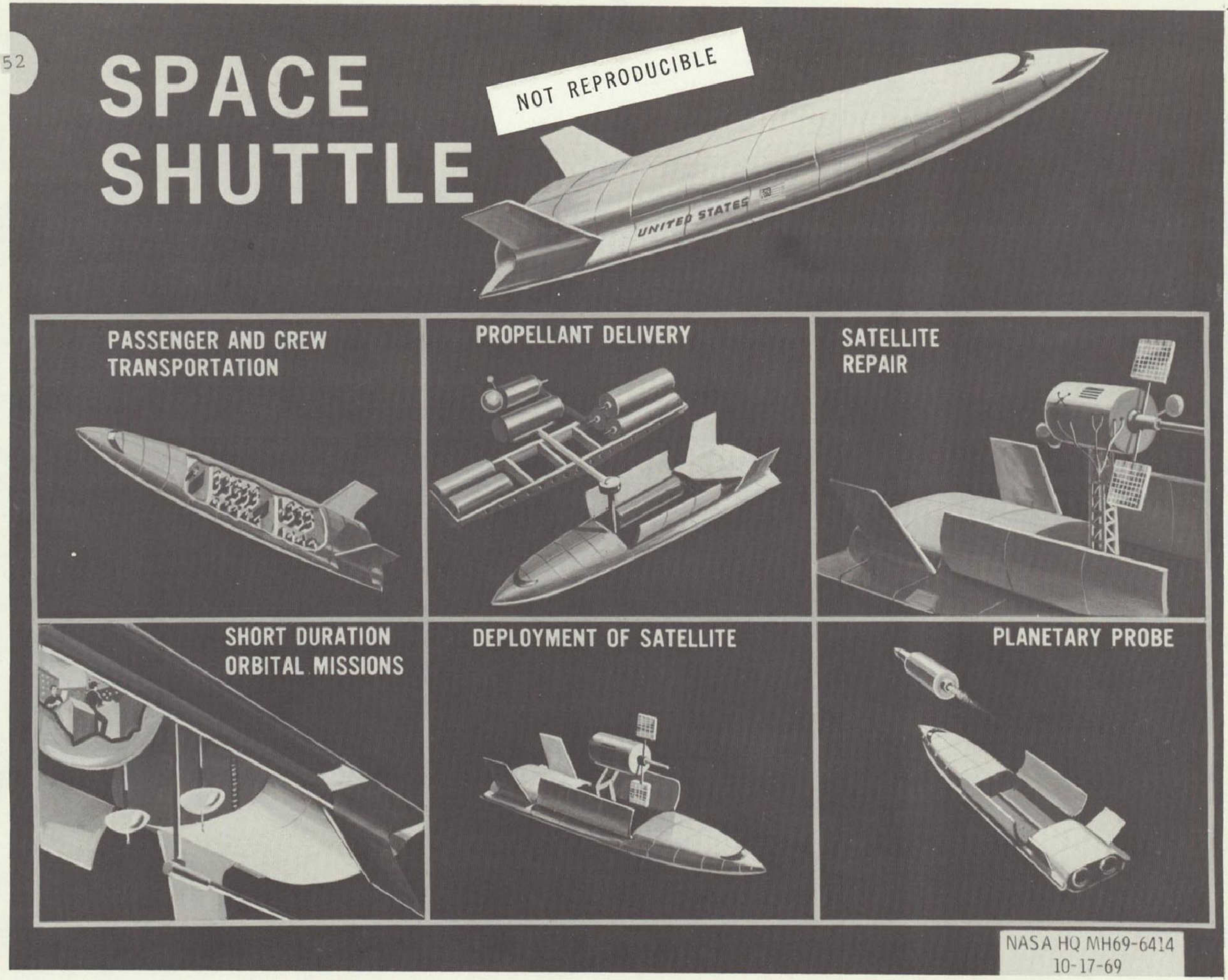
Minimum refurbishment and quick turnaround time prior to next flight


SPACE SHUTTLE MISSION PROFILE
ORBIT ELEMENT
STAGING
BOOST ELEMENT ENTRY
LAUNCH
BOOST ELEMENT CRUISE BACK
ORBIT ELEMENT CRUISE BACK
NASA HQ MRP69-6298
10-10-69
MSFC-69-PD-SA-262

SPACE SHUTTLE MISSION PROFILE

This chart shows how the space shuttle mission operation is conducted. We are proceeding with the definition of a two-stage vehicle. The first stage of this vehicle would launch vertically and bring the vehicle quickly to a velocity of about 7,000 miles an hour and an altitude on the order of 40 miles. The booster is separated at this point, returns to earth and is refurbished for another flight.

The orbiter element continues on to perform its mission. It may remain in orbit for as much as a week. On its return the orbiter is highly stressed by temperature and heat loads; thus it will require a much more sophisticated design than the booster. The aerodynamic shape of the orbiter permits it to return to earth horizontally and make a normal airport landing.


SPACE
SHUTTLE
NOT REPRODUCIBLE
UNITED STATES
PASSENGER AND CREW TRANSPORTATION
PROPELLANT DELIVERY
SATELLITE REPAIR
SHORT DURATION ORBITAL MISSIONS
DEPLOYMENT OF SATELLITE
PLANETARY PROBE
NASA HQ MH69-6414
10-17-69

SPACE SHUTTLE

The shuttle will be capable of accomplishing a wide variety of missions of major interest to our future space endeavors. This chart shows a few of them. It will be an efficient means of providing a space station with logistics support--passengers, crew, propellants and other consumables, and whatever is needed to repair and maintain satellites and space equipment. The space shuttle itself could conduct short duration orbital missions for special purposes such as rescue. It could deploy satellites. It might provide some or all of the delta velocity needed for the launch of a planetary probe. In the case of very complex and costly scientific equipment, the space shuttle provides the possibility of returning them to earth for updating or repair of equipment, leading to further reduction in costs.

VALUES OF THE EARTH-TO-ORBIT SPACE SHUTTLE

1. COST REDUCTION
2. MARRIAGE OF MANNED AND UNMANNED PROGRAMS
3. REDUCES INVENTORY OF ROCKET AND SPACECRAFT MODELS
4. SPACE RESCUE
5. AS INTEGRAL ELEMENT OF OTHER SPACE PROGRAMS
6. INTERNATIONAL PARTICIPATION AND COOPERATION
7. SPACE FLIGHT FOR NON-ASTRONAUT PASSENGERS
8. AS A STIMULUS TO AVIATION

NASA HQ MC70-5733
4-6-70

VALUES OF THE EARTH-TO-ORBIT SPACE SHUTTLE

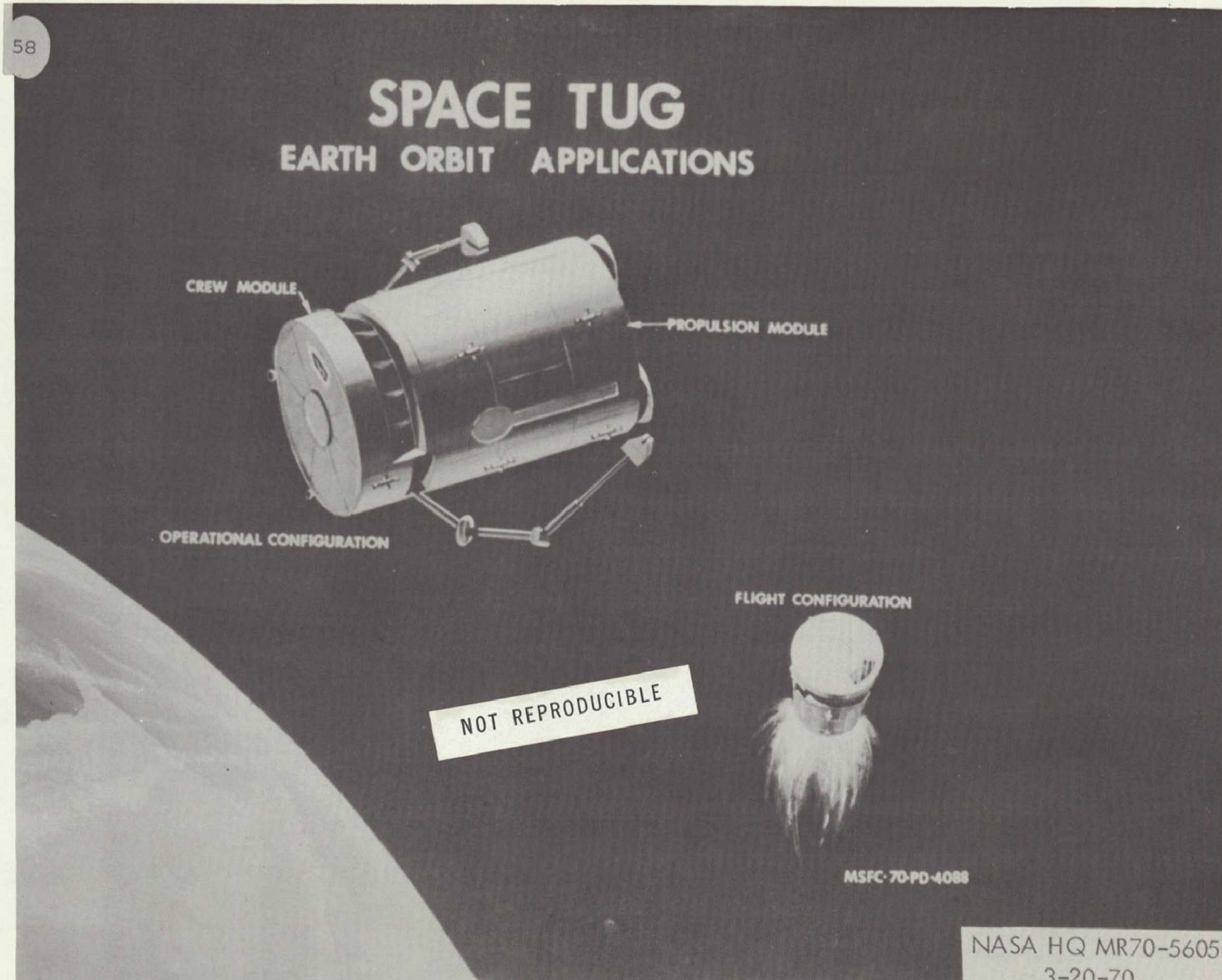
1. A low cost and versatile round-trip system
2. Adaptable to both manned and unmanned programs
3. Reduces inventory of launch vehicles
4. Provides rescue from earth orbit
5. An integral element of other space programs
6. Provides excellent opportunity for international participation
7. Compatible with non-astronaut passengers
8. Provides a stimulus to aeronautics

POTENTIAL SPACE TUG OPERATIONAL REQUIREMENTS

MISSION AREA	OPERATIONS
EARTH ORBIT	o SPACE BASE AND SPACE STATION SUPPORT ACTIVITIES - TRANSFER PAYLOADS FROM EOS AND NUCLEAR SHUTTLE - ORBIT KEEPING - SPACE BASE ASSEMBLY AND MAINTENANCE SUPPORT o ORBITAL SERVICE STATION - PROPELLANTS, HANGAR, C/O AND MAINTENANCE, ASSEMBLY o SATELLITE PLACEMENT AND RETRIEVAL (LOW TO HIGH ENERGY ORBITS) o IN SITU SATELLITE SERVICING AND INSPECTION o SATELLITE AND UNMANNED INTERPLANETARY SPACECRAFT LAUNCH o CREW SHUTTLE TO HIGH ENERGY ORBITS AND CREW RESCUE
LUNAR	o LUNAR ORBIT TO SURFACE TO ORBIT CREW TRANSFER o DELIVERY OF LUNAR SURFACE PAYLOADS o RESCUE o EARTH ORBIT TO LUNAR ORBIT (SMALL PAYLOADS)
PLANETARY	o MIDCOURSE CORRECTION MANEUVERS o RESCUE (DUAL SPACECRAFT MODE, EARTH RETURN) o PLANETARY ESCAPE AND EARTH CAPTURE MANEUVERS (LOW ENERGY MISSIONS) o MARS PROPULSIVE LANDER

SPACE TUG OPERATIONAL REQUIREMENTS

The adjacent table lists a variety of potential missions in which the Space Station would be used. As may be noted, the largest number of these applications at this juncture is in Earth orbit. This reflects the predominance of that mission area in the immediate future. For other mission areas such as lunar and planetary, the space tug will be transported by a nuclear shuttle to the appropriate region. It may be seen, also, that the lunar and planetary mission areas include propulsive soft lander requirements on the tug. The landing requirement highlights another of the alternative mission configurations that are included in the Space Tug concept.



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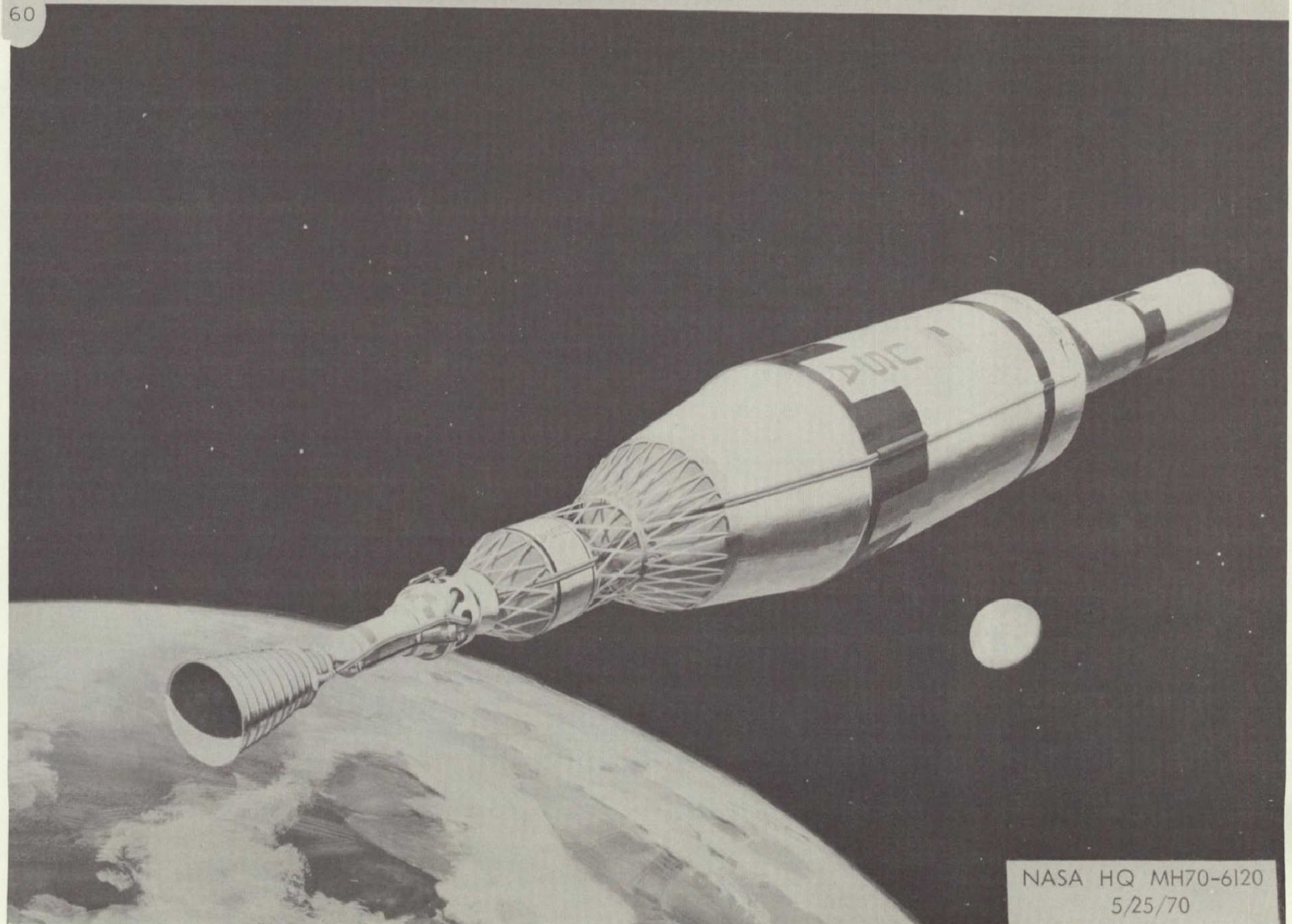
THE SPACE TUG

The Space Tug is envisioned as a key part of the space transportation system. The concept calls for a highly versatile, multi-application, manned or unmanned spacecraft. It will be made up of four basic modules (crew, propulsion, astrionics, and cargo) each of which may operate independently or with another element of the space transportation system. Essentially space based, the tug will be able to perform a wide variety of missions - placing or recovering unmanned spacecraft, moving cargo, adjusting spacecraft orbits and general support of the space station. The tug will be compatible with the nuclear shuttle for transport into deep space. The illustration is for a manned version of the tug. Unmanned operations would be possible by replacing the crew module with a payload or other module.

2

NUCLEAR SHUTTLE (33 FT DIA)

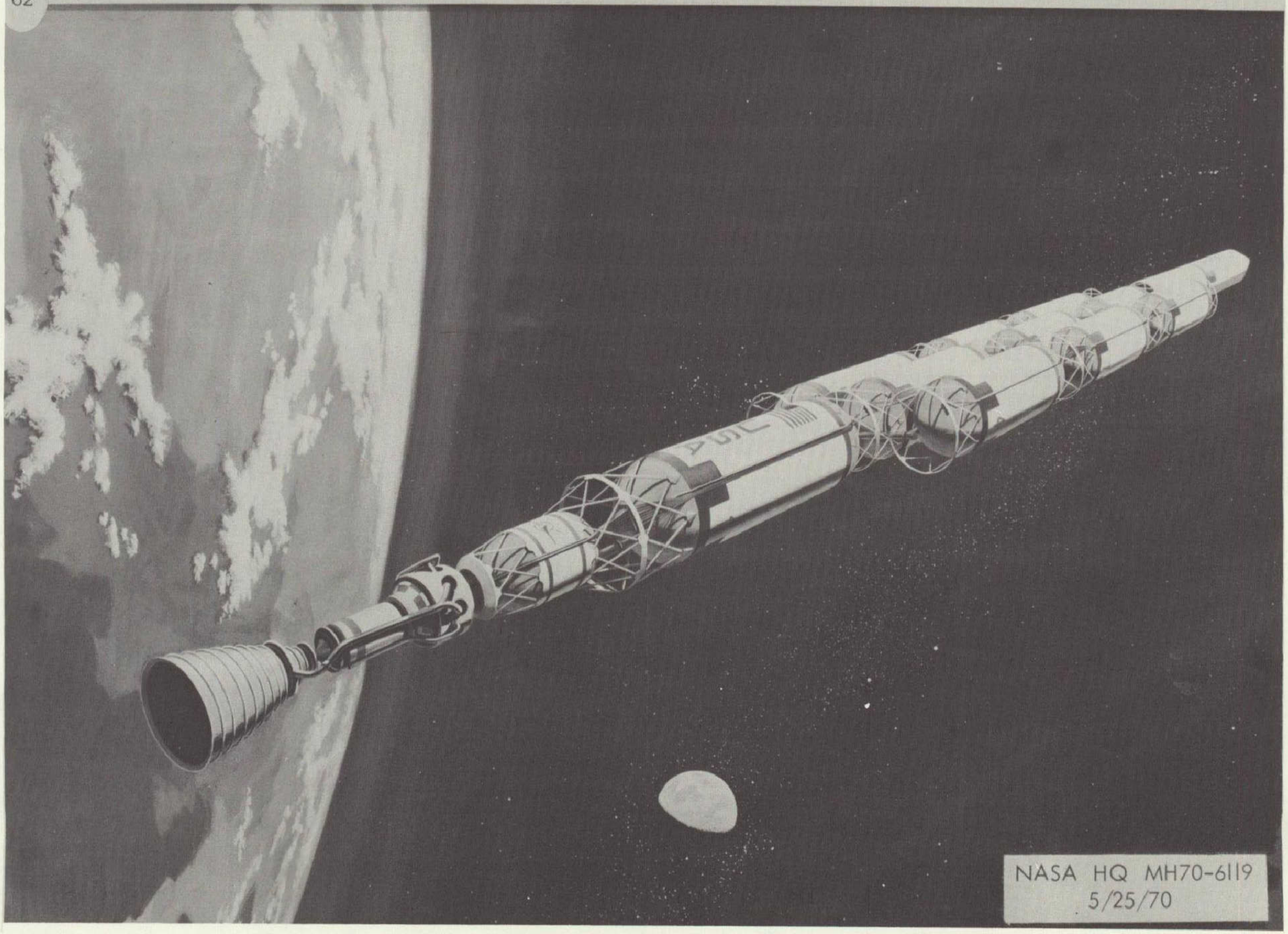


NASA HQ MH70-6120
5/25/70

NUCLEAR SHUTTLE

This illustration is an artist's concept of a single propellant tank Nuclear Shuttle. Such a vehicle is envisioned as being space-based and would be used to transport large payloads into lunar or geosynchronous orbits or deep space. In time it would provide propulsion for manned planetary expeditions. The liquid hydrogen fuel tank for this version of the Shuttle is about 10 meters in diameter, and has about 136,000 kilograms capacity. High performance insulation and low conductivity heat blocks will minimize boil-off for mission durations of months or years and meteoroid bumpers with the insulation will protect the tank from puncture. A single NERVA rocket engine makes up the propulsion system. Onboard, integrated avionics subsystems will accommodate the needs of the stage, engine and overall flight vehicle.

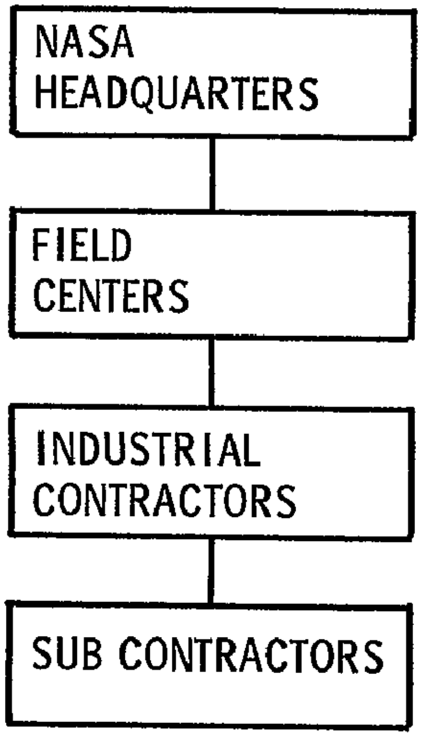
MODULAR NUCLEAR SHUTTLE



MODULAR NUCLEAR SHUTTLE

Pictured here is the artist's drawing of a variation of the Nuclear Shuttle concept. This is a modular vehicle, made up of fuel tank modules that would all be sized for compatibility with the Earth Orbit Shuttle. As contrasted to the 10 meter diameter vehicle shown before, this Shuttle would be assembled in its entirety in orbit. Fueling would be accomplished by replacing fuel tank modules. Weight inefficiencies due to the modular construction may be largely offset by reductions in shield weights required, cold gas residuals, and reduced meteoroid protection needs.

SPACE STATION DEVELOPMENT ORGANIZATION



PROGRAM INTEGRATION

PROJECT MANAGEMENT

PROJECT IMPLEMENTATION

SYSTEM ELEMENTS

SPACE STATION DEVELOPMENT ORGANIZATION

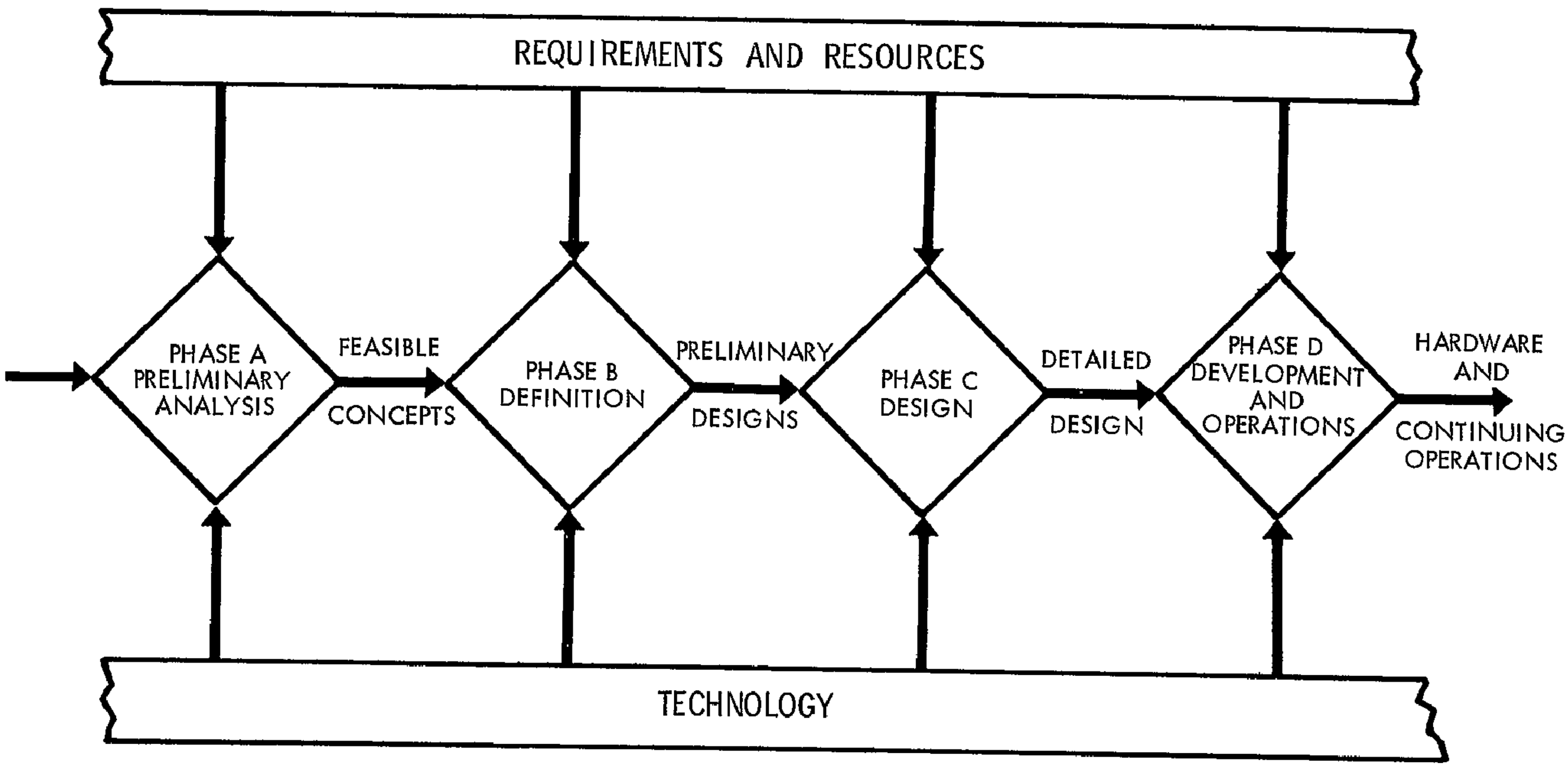
The adjacent chart is a sketch of the organizational structure that NASA envisions using in the Space Station development. The functions of each element are listed.

Program Integration, which is the responsibility of Headquarters, involves the bringing together of all elements and organizations of the program and arranging these into a plan that can be implemented by a Field Center. Direct management of the project is the responsibility of one or more Field Centers which, in certain instances (development of a nuclear power supply, for example), may not be within the NASA organization.

Industrial organizations and their subcontractors will be responsible for implementing the Space Station development in response to direction from the Field Centers.

User and contributor points of contact may be at any level of this organization, determined by the nature of the business to be conducted.

PHASED PROJECT PLANNING



PHASED PROJECT PLANNING

In phased project planning, a major decision is made at the beginning of each phase. At that time, assessment is made of the requirements for the project, the resources (funds, manpower, institutions, facilities) available, and the state of technology. These matters are also taken into account as necessary during each phase.

Phase A consists of feasibility analyses and studies to determine whether the proposed objective or mission is valid. Phase B comprises detailed studies and definition, comparative analyses and preliminary design directed toward a single approach from among the alternate approached selected in the first phase. Phase C involves the preparation of detailed design specifications, manufacturing, test and operations plans, and comprehensive program schedules and cost estimates. Phase D covers development, manufacture, test, checkout, operations and evaluation.

OPPORTUNITIES FOR PARTICIPATION

FACILITY IN DEVELOPMENT

- PLANNING THE FACILITY
- FORMULATING USER PROGRAM
- OUT FITTING MODULES
- SUPPLYING MODULES
- DEVELOPING SUB-SYSTEM
- DEVELOPING MANAGEMENT ARRANGEMENTS

FACILITY IN OPERATION

- PARTICIPATING IN USER PANELS
- DEVELOPING AND SUPPLYING EXPERIMENTS
- DEVELOPING AND SUPPLYING EXPERIMENT MODULES
- MANNING GROUND STATION
- SELECTING ACTIVITIES
- PROVIDING EXPERIMENTER/ASTRONAUTS
- EVALUATING RESULTS

OPPORTUNITIES FOR PARTICIPATION

To assure that the Space Station Program achieves a high level of use, a number of specific working arrangements between the users and contributors and the development program must be established.

Listed in the adjacent chart are a number of areas of participation in which we expect all potential users and contributors to be involved. This will apply to both the development phase of the facility and its operation.

The first area in which the facility users will be needed is in planning the facility. This will result in the most generally useful design. A second element in development is formulation of a user program that can be used to size the station. Next are suggested areas in which contributions to the facility operational capability may be made. This includes provision of developed hardware at a variety of system levels.

Key to all such participation is the opportunity to be a part of developing management arrangements.

In operation, the areas of participation are tailored more to using the station. Serving on panels that advise management on user considerations, supplying experiments and experiment modules, and providing or serving as experimenters in the facility are typical of the activities involved.

Active participation in development and operation of the station is fundamental to its success as a space research facility.

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