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SATURN I WORKSHOP

The National Aeronautics and Space Administration proposes to place its embryonic space station -- the Saturn I Workshop -- into orbit in 1971 to gain a better understanding of the requirements for a premanent man-made island in space.

The Workshop project calls for changing a spent Saturn S-IVB propulsion stage into a living area after it has propelled itself into space. In this project, the S-IVB stage's liquid hydrogen tank will be first modified on the ground to allow astronauts to change the tank area into living and working quarters in space. The tank's 10,000-cubic-foot interior is many times larger than any spacecraft flown to date.

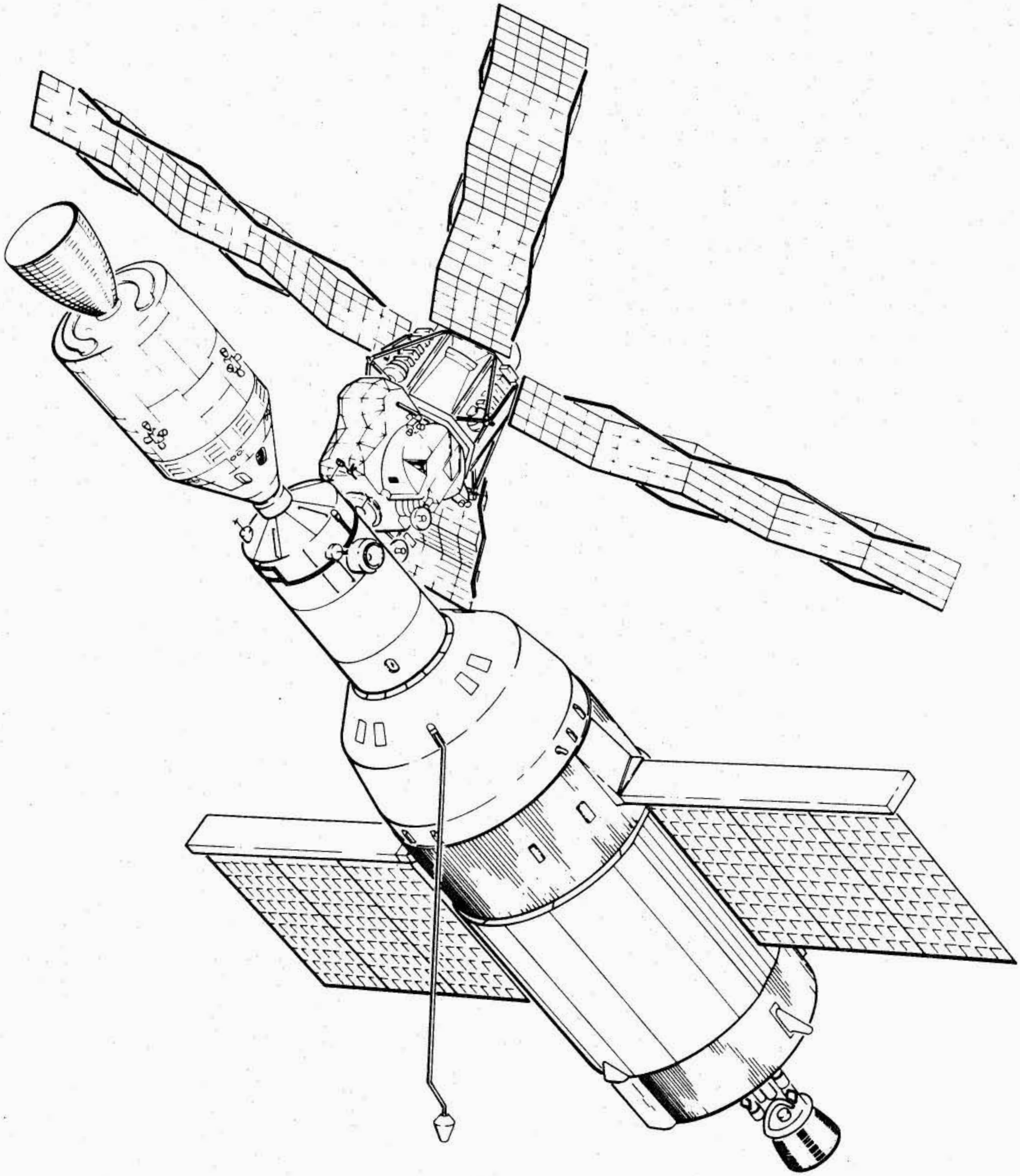
The first Workshop mission will last 28 days, two weeks longer than the 14-day Gemini 7 mission, the longest manned flight to date. NASA will launch the Workshop as the first of its Apollo Applications Program missions. Saturn IB launch vehicles will loft the Workshop and later a manned Apollo spacecraft. AAP launch vehicles will become available when they are not needed for the mainstream Apollo lunar landing effort.

Dr. George E. Mueller, associate administrator for Manned Space Flight, said the Workshop "will provide us with a major step toward an understanding of the requirements for a space station."

Mueller said that the early development of long-duration flight capability is clearly one of the most important areas to be stressed, since it is a key requirement for most of the possible significant advances in manned flight. Apollo Applications flights of several months will represent a significant increase in the nation's operational capabilities in space and will provide opportunities for important scientific and technological experimentation. An extended flight experiment is also necessary to provide a basis for future decisions on manned programs, including permanent manned facilities in space or manned flights to the planets.

Economy will be achieved in the Apollo Applications Program through the full use and modification of Apollo spacecraft and Saturn launch vehicles. Until the Workshop idea was developed, a spent stage in orbit was considered useless. The S-IVB spent stage is now considered a flexible and economical resource, capable of fulfilling several manned space program requirements at a relatively low cost.

The major pieces of new equipment being developed for the Workshop project are an airlock and a multiple docking adapter. The airlock, being built for the Marshall Space Flight Center by the McDonnell Douglas Astronautics Co., will allow astronauts to move from their spacecraft to the S-IVB stage without depressurizing either unit. The docking adapter attached to the airlock provides a way of joining several different payloads. The Marshall Center is designing and manufacturing the multiple docking adapter.



AAP CLUSTER -- The Saturn I Workshop is at bottom. Extending from the airlock (opposite the engine end) is the multiple docking adapter, to which are docked an Apollo command/service module and an Apollo Telescope Mount.

The Workshop project will demonstrate the effects of long-duration flights on on man and his equipment, and will confirm and refine the hardware and techniques needed for orbital assembly. These objectives will be achieved by the crew doing extensive engineering, scientific and biomedical experiments during the flight.

A follow-on space station project, called the Saturn V Workshop, also is under study. The same Saturn S-IVB stage, in this application a Saturn V third stage, will be completely outfitted on the ground and "dry launched." NASA has included plans for such a follow-on study in its fiscal year 1969 budget request.

AAP MISSION SEQUENCE

Five Saturn IB launch vehicles will be used to loft the space agency's first AAP payloads. The clustering concept will be used to join the payloads in orbit. The first two-stage Saturn IB vehicle will launch the Workshop. The unmanned vehicle, consisting of the spent S-IVB stage, airlock and multiple docking adapter, will be placed in a 250-statute-mile circular orbit from Launch Complex 37B at the Kennedy Space Center, Fla.

A day later, a manned Apollo spacecraft will be launched by another Saturn IB from Launch Complex 34 at the Kennedy Center. The manned Apollo spacecraft will transfer to the orbit of the Workshop.

The three-man Apollo crew will rendezvous with the Workshop and dock at one of the ports on the docking adapter, and the astronauts will outfit the hydrogen tank area for their 28 days in space. Near the end of the stay, the men will prepare the Workshop for space storage, then return to earth in their Apollo spacecraft.

About four months later another crew of three astronauts will return to the Workshop and operate experiments for up to 56 additional days.

The fourth Apollo Applications Program flight will be made another five to six months later. The payload will be a manned Apollo spacecraft launched by another Saturn IB vehicle. An unmanned Apollo Telescope Mount will follow. The two will rendezvous in orbit and move to the Workshop's orbit. After the second rendezvous, one crewman will remotely control the ATM to a position for docking with the adapter's side port.

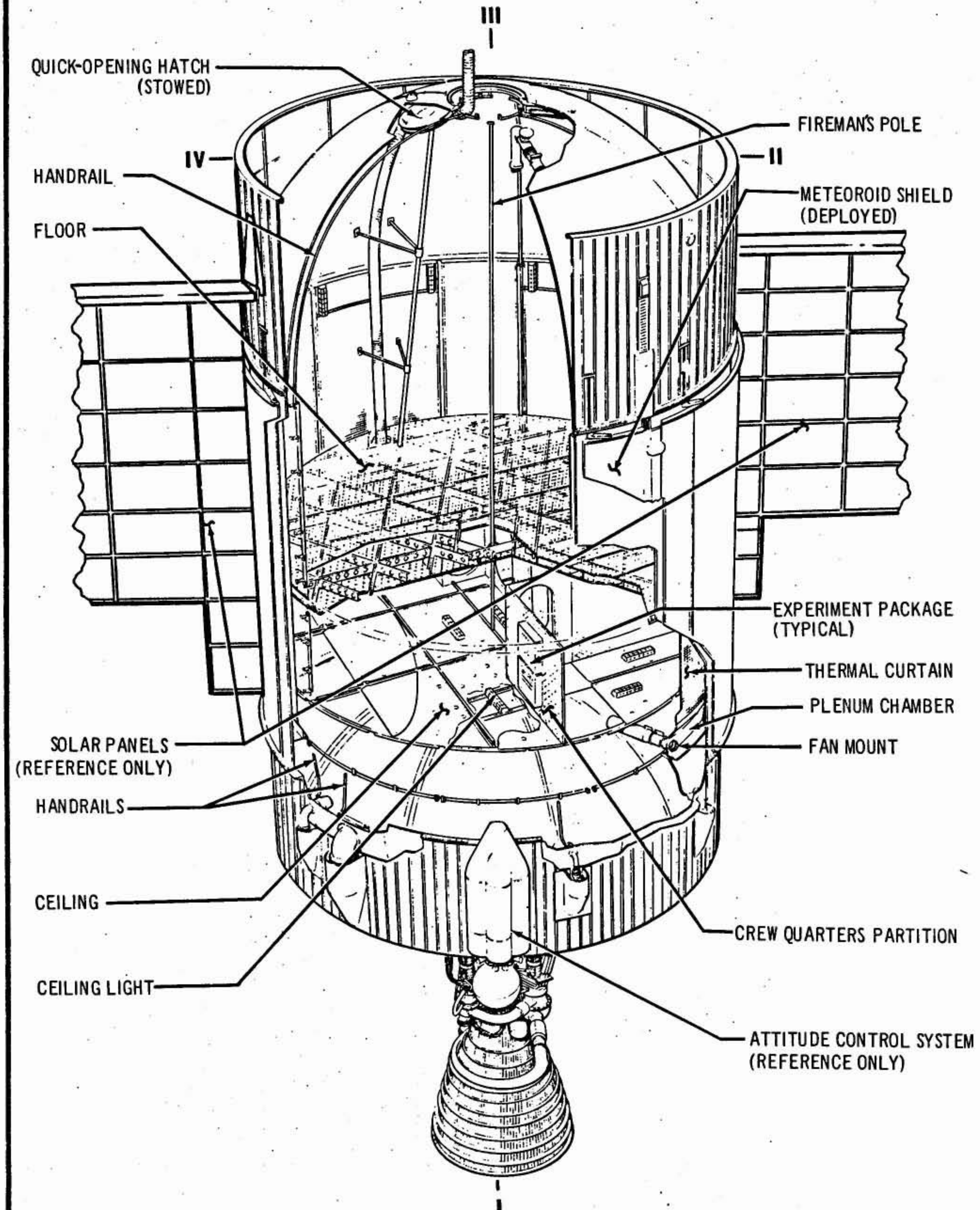
On this mission, the astronauts are expected to stay in space for up to 56 days, operating the ATM solar experiments to provide scientific information on the sun's activity. Once again the men will prepare the Workshop for an inactive period, then return to earth with experiment data and the film used to record solar observations.

SATURN I WORKSHOP

A flight Saturn S-IVB stage, with some modification, will be used for the Workshop. Major equipment being developed with the S-IVB stage includes an airlock, a docking adapter and a solar array. The airlock will be mounted on the forward end of the stage at the lunar module attach points. The docking adapter will be rigidly mounted at the forward end of the airlock. Two solar arrays will be mounted to the S-IVB stage's outside wall.

S-IVB STAGE

Once the liquid oxygen-liquid hydrogen propelled stage is in orbit, the tanks will be automatically vented to expel residual fuels and to make the stage habitable. The pre-installed Workshop equipment will not interfere with the liquid hydrogen flow during the powered part of the flight.



SATURN I WORKSHOP

Two S-IVB stages for later Saturn IB flights are receiving basic modifications so that either stage can be used as a Workshop. The changes include drilling about 200 holes throughout the stage as attach points for the floor, partitions and experiment racks. McDonnell Douglas Astronautics Co., prime S-IVB stage contractor, is making the modifications.

The stage selected for the Workshop mission will have much of its equipment installed before it leaves the launch pad. A quick-opening hatch replaces an existing manhole cover in the forward tank dome. The hatch is designed for easy, trouble-free and quick access to the tank.

An aluminum grid pattern floor will be placed in the lower section of the tank to divide it into two "stories." Partitions will be installed, with a fire retardant liner around the inside tank surface. Another feature will be a meteoroid shield on the outside of the stage.

Crew quarters, one of the more important parts of the Workshop, will be located in the aft end of the liquid hydrogen tank. The common floor will separate the crew quarters from a large laboratory area. Pre-installed partitions divide the crew quarters into sleep compartments, food and waste management compartments and a work area.

A cloth ceiling, installed next to the liquid oxygen tank-hydrogen tank common bulkhead, will be a reference surface for the astronauts and will reflect flight in the area. Ceiling beams will serve as handrail supports. Waste and food management compartments will be sealed with aluminum sheet and folding "telephone booth" style doors to control the movement of odors and particles.

The crew quarters are relatively large. The food and waste management areas each have 30 square feet of floor area. One sleep compartment is 67 square feet; the other is 70 square feet. The work compartment has 181 square feet of floor area.

A thermal control and ventilation system will give the astronauts a habitable environment with a temperature in the range of 60 to 90 degrees Fahrenheit. A two-gas (oxygen-nitrogen) environmental system will be used, with internal pressure kept at 5-6 pounds per square inch. Fans will circulate the Workshop atmosphere to keep a constant temperature. Special fan assemblies will be installed by the astronauts. This equipment and the other astronaut-installed gear will be stored during the launch in the multiple docking adapter.

An electrical power distribution system will be pre-installed to connect the Workshop living and working areas with power sources in the airlock and the solar cell assemblies. Lights will be installed by the astronauts and may be moved about for lighting control. There will be a caution and warning system in the Workshop with sensors and an indicator/controller panel to warn astronauts of hazardous conditions.

A "fireman's" pole will extend vertically from the quick-opening hatch through the crew quarters. Astronauts will use the pole to move through the center of the Workshop. An experiment transfer device will also be used with the fireman's pole to transfer experiment containers from the multiple docking adapter to the work area. The forward portion of the Workshop will be a work area where experiments brought from the adapter will be done.

The meteoroid shield will decrease the probatility of hazardous penetration of the Workshop by meteoroids. It will be installed as a kit with a few stage modifications. The shield is an 0.025-inch aluminum sheet, held against the stage's liquid hydrogen tank during launch. Once in space, it will be deployed by swinglinks powered by torsion springs. It is held five inches from the tank wall in orbit.

AIRLOCK

The airlock is made of a load-bearing truss framework and a central, compartmented tunnel assembly. The 16-foot, eight-inch-long airlock, including the structural transition section, is mounted at the forward end of the S-IVB stage within the instrument unit and the spacecraft lunar adapter structure. The structure is attached to the vehicle at the lunar module attach points in the spacecraft lunar module adapter. The forward end of the airlock is rigidly attached to the multiple docking adapter.

Four viewing ports, spaced approximately 90 degrees apart, are provided in the transition section at the forward end of the airlock module, as are most airlock controls. The 65-inch diameter tunnel assembly includes two internal bulkheads with hatches and a flexible pressure-tight assembly connected to the liquid hydrogen tank. The tunnel permits intra-vehicular transfer of crew members within the pressurized environment of the orbital assembly. The airlock compartment has a Gemini hatch in the tunnel wall. This compartment provides crew access to space without depressurization of the entire cluster, and is big enough to hold two crew members in pressurized suits with portable life support systems.

MULTIPLE DOCKING ADAPTER

The multiple docking adapter is a cylindrical pressure vessel attached structurally to the airlock by a transition section. It is 17 feet long and 10 feet in diameter. The forward end tapers to an axial docking port, and two other docking ports project from the side of the cylindrical section. The axial port is built for command and service module docking; one radial port is built for command and service module docking; one radial port is built for lunar module or Apollo Telescope Mount docking; and the second radial port will be a "back-up" port for the command/service module.

Two windows are located 180 degrees apart on the cylindrical section. One is directly above the lunar module/ATM port and will be used when crewmen remotely control the LM/ATM for docking. Experiments and equipment will be mounted on the cylindrical wall by attachments made to eight longitudinal stringers. There are about 1,500 cubic feet for storage during launch and for crew operations in orbit.

SOLAR ARRAY

The solar array will provide electric power for the Workshop while fuel cells in the command and service modules will handle CSM power needs. The systems are cross-linked for flexibility in handling peak loads and for countering failure situations. For the 56-day mission power will be supplied to the CSM from the Workshop solar arrays and the fuel cells will be operated at a low level, commensurate with water production requirements, to reduce cryogenic loading requirements.

SATURN WORKSHOP EXPERIMENTS

There are about 50 condidate experiments being considered for the first five Apollo Applications flights. Most of them will be on the first Workshop and are divided into several groups: biomedical, engineering, technological and scientific.

Three NASA Headquarters program offices -- Space Science and Applications, Advanced Research and Technology, and Manned Space Flight -- plus the Department of Defense, are contributing to the experiment pool. OMSF is responsible for overall experiment management. The candidate experiments include:

Scientific Experiments

S018	Micrometeorite collection
S019	Ultra-violet stellar astronomy
S020	Ultra-violet/X-ray solar photography
S027	Galactic X-ray mapping
S061	Potato respiration
S065	Multi-band terrain photography
S073	Gegenschein flash zodiacal light

Technological Experiments

T003	In-flight nephelometer
T004	Frog otolith function
T013	Crew vehicle disturbance
T017	Meteoroid impact and erosion
T018	Precision optical tracking
T020	Jet shoes

T021	Meteoroid velocity
T023	Surface absorbed materials
T025	Coronagraph and contamination measurements
T027	ATM contamination measurements

DOD Experiments

D008	Radiation in spacecraft
D017	Carbon dioxide reduction
D019	Suit donning and sleep station evaluation
D020	Alternate restraints evaluation
D021	Expandable airlock technology
D022	Expandable structures

Engineering Experiments

M402	Orbital Workshop
M415	Thermal control coatings
M439	Star horizon automatic tracking
M479	Zero gravity flammability
M487	Habitability/crew quarters
M489	Heat exchanger service
M492	Tube joining assemblies
M493	Electron beam welding
M508	Extra-vehicular activity hardware evaluation
M509	Astronaut maneuvering equipment

Medical Experiments

M071	Mineral balance
M072	Bone desitometry
M073	Bioassay of body fluids
M074	Small mass measurement
M091	LBNP (lower body negative pressure) (pre- and post-flight)
M092	LBNP (lower body negative pressure) (in-flight)
M093	Vectorcardiogram
M094	Anti-deconditioning garment
M131	Human vestibular function
M151	Time and motion study
M171	Metabolic activity
M172	Body mass measurement

WORKSHOP PASSIVATION AND ACTIVATION

The S-IVB stage will arrive in orbit with some residual propellants, an active range safety system and other potential hazards to astronaut safety. These systems must be made safe before astronauts can begin outfitting the stage for work and living.

Before the Apollo spacecraft docks with the spent stage, the range system will be deactivated by ground command. Propellant residual venting will be started by a pre-programmed, tape-operated sequencer in the instrument unit. Much of the propellant will be dumped through the J-2 engine (this experiment was conducted during the Apollo 5 mission January 22, 1968, and successfully reduced tank pressures and propellants). The liquid oxygen tank will be vented and the hydrogen tank pressure will be relieved.

Other venting processes begun by the instrument unit sequencer include venting the cold helium spheres, the J-2 engine start bottle and the J-2 engine control sphere.

Astronauts will do three jobs in the airlock after docking: check the liquid hydrogen tank's low-pressure indicators, command the closing of the hydrogen tank's non-propulsive venting valve and command the venting of the stage's helium control bottle.

After the operational systems and equipment have been made safe, astronauts will begin making the hydrogen tank habitable. Activation procedures will provide safety, economy of effort, few tools and little time.

Most of the features required for habitability, such as flooring, mobility aids, thermal sleeves, fire retardative coating, various mounting and stowage provisions and protective padding, will be installed in the tank before launch. These things will neither compromise the S-IVB's primary function as a flight stage nor interfere with passivation. Provisions for monitoring conditions in the Workshop will be provided in the command module.

During the initial activation period, astronauts will work in the pressurized airlock and multiple docking adapter modules. They will then pressurize the Workshop and release the quick-opening hatch in the tank's forward dome. One pressure-suited astronaut will enter the tank and do basic tasks such as installing redundant seals at all tank penetrations, installing fans at appropriate locations and attaching them to pre-installed wiring outlets, and otherwise making the Workshop suitable for shirt-sleeve work.

The next job is to transport to, and assemble in, the Workshop the systems involved with food preparation, waste management, sleeping quarters and the several medical, scientific and technical experiments to be conducted.

At the end of the mission, the crew will prepare the stage for space storage. AAP plans call for the stage to be revisited and reactivated for 56 days and then for another 56 days in the solar observatory mission.

WORKSHOP MANUFACTURE AND TESTING

An engineering mockup of the Saturn I Workshop was built at the McDonnell Douglas Astronautics Co. facility at Huntington Beach, Calif. The mockup is now at the Marshall Center, being used in extensive design reviews and development tests such as lighting, ventilation, acoustics, and floor and wall layout. Other developmental units will be built. There is a neutral buoyancy test article at the Marshall Center, a neutral buoyancy trainer planned for the Manned Spacecraft Center, a flight trainer planned for MSC and the flight version of the Workshop.

Many of the Workshop's activation tasks have been done in "neutral buoyancy" or water tank tests. In the tests, a pressure-suited man has weights added to his suit so he neither rises nor sinks. Thus "suspended," the man works in an environment similar to weightless space. Water pushing against him tends to hinder his movements, but the underwater tests are considered the best long-term weightless simulation available for stationary operations. The tests show design and human factors engineers how well their tools and equipment can be handled in space.

PROJECT MANAGEMENT

The organizations responsible for directing the Workshop project are the Office of Manned Space Flight and its Apollo Applications Office at NASA Headquarters, and the OMSF field centers: Kennedy Space Center, Manned Spacecraft Center and Marshall Space Flight Center.

The Marshall Center's Apollo Applications Program Office has the management responsibility for the Saturn I Workshop, the airlock module, the multiple docking adapter and both elements of the Apollo Telescope Mount -- the modified lunar module ascent stage and the ATM rack.

The Marshall Center has had the overall design responsibility for the Saturn I Workshop, the multiple docking adapter and the ATM rack since the start of these projects. However, NASA reassigned management responsibility for the airlock module and the modified lunar module ascent stage for the ATM to the Marshall Center in September 1968. The Manned Spacecraft Center formerly managed these activities. The realignment was made to establish a satisfactory balance between Apollo Applications and Apollo programs and places AAP design integration responsibilities under a single NASA Center.

The management responsibilities encompass systems engineering and include development, test and integration efforts required to assure the compatibility, as an integrated system, of flight hardware elements and ground support equipment.

The Manned Spacecraft Center has management responsibility for the manned aspects of the Apollo Applications Program. Crew training and management of AAP medical and many other experiments are the responsibility of MSC. As in previous manned flight programs, MSC will have charge of mission planning and operations.

The Kennedy Space Center is in charge of launch operations, including preparation of launch facilities.

Martin-Marietta Corp., Denver Division, is responsible to NASA for systems engineering and integration work for the Apollo Applications Program. This work includes mission analysis and systems engineering of all Apollo Applications flights, in addition to the integration of experiments and support equipment.

The Marshall Center's Propulsion and Vehicle Engineering Laboratory is the lead laboratory for the project and is the focal point for all MSFC research and development activities.

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