

10 April 1969

Date ----- Doc. No. -----

Public Affairs Office
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

December 5, 1968
(Revised slightly
April 10, 1969)

Phone: 453-0034, 453-0035

111.4

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 permanent man-made island in space

The Workshop project calls for changing a spent Saturn S-IVB propulsion stage into living and working quarters after it has propelled itself into space. The stage's liquid hydrogen tank will be first modified on the ground and then astronauts will complete the conversion in space. (See page 4.) 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 longest manned flight to date. NASA will launch the Workshop as the first of its Apollo Applications Program, AAP, missions. Saturn IB launch vehicles will loft the Workshop and, a day or two later, a manned Apollo spacecraft. AAP launch vehicles have become available now that 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. AAP 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 (MDA). The airlock and the MDA 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 McDonnell Douglas Astronautics Co. is building the airlock; the Marshall Center is designing and manufacturing the multiple docking adapter.

The Workshop project will demonstrate the effects of long-duration flights 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.

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 240 statute mile circular orbit from Launch Complex 37B at the Kennedy Space Center, Florida.

A day or two 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 two to three months later another crew of three astronauts will return to the Workshop and operate experiments for up to 56 additional days.

The fourth AAP flight will be made another two or three months later. The payload will be a manned Apollo spacecraft launched by another Saturn IB vehicle. An unmanned Apollo Telescope Mount, ATM, will follow about three days later. The ATM will be remotely controlled to rendezvous with the Workshop. Crewmen in the CSM will then remotely control the ATM to dock with the MDA 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 in the command module with experiment data and the film used to record solar observations.

SATURN I WORKSHOP

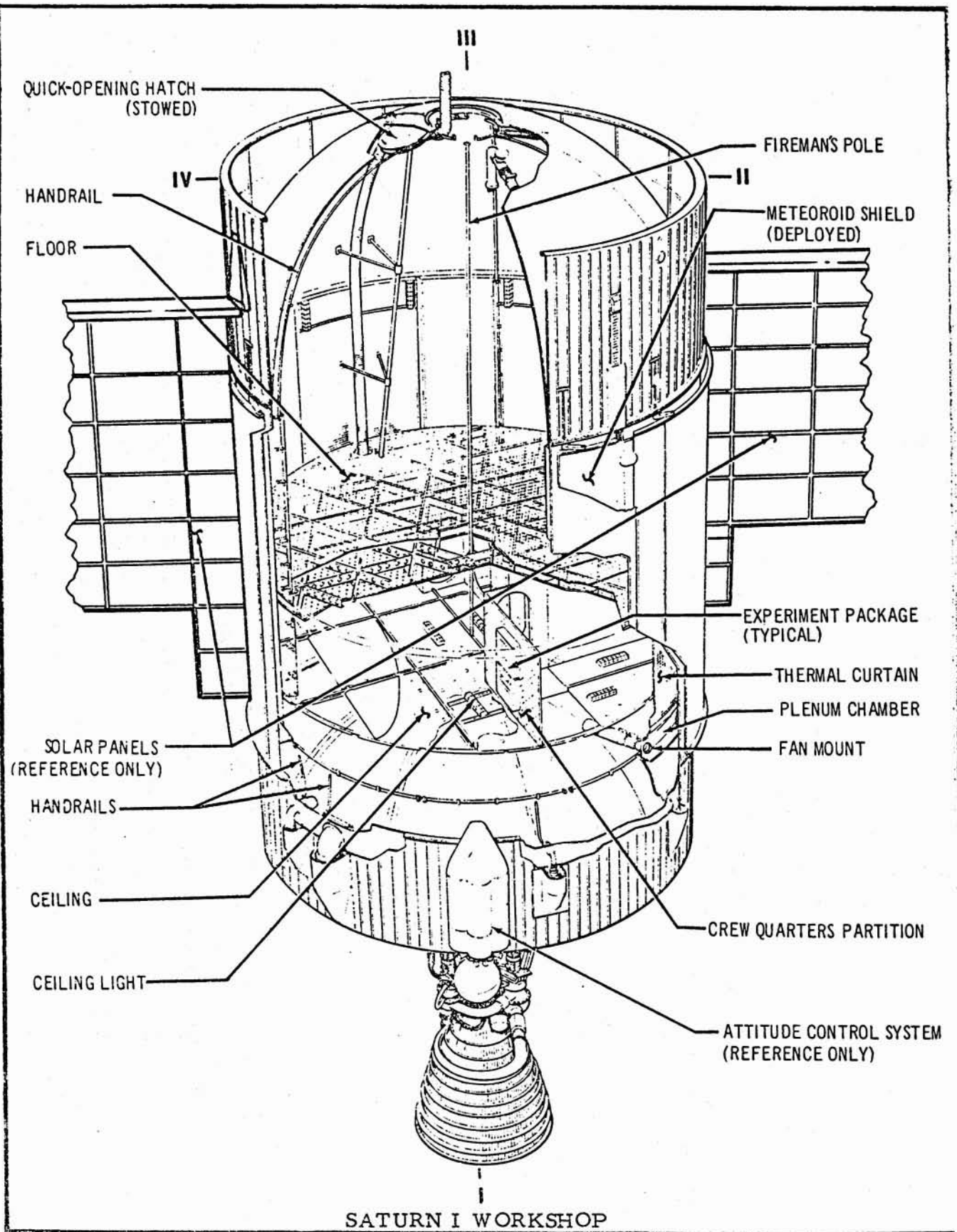
A flight Saturn S-IVB stage, with some modification, will be used for the Workshop. Major equipment being developed with the S-IVB stage includes an airlock, a docking adapter and a solar array. The airlock will be mounted on the forward end of the stage at the lunar module attach points. The docking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

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.



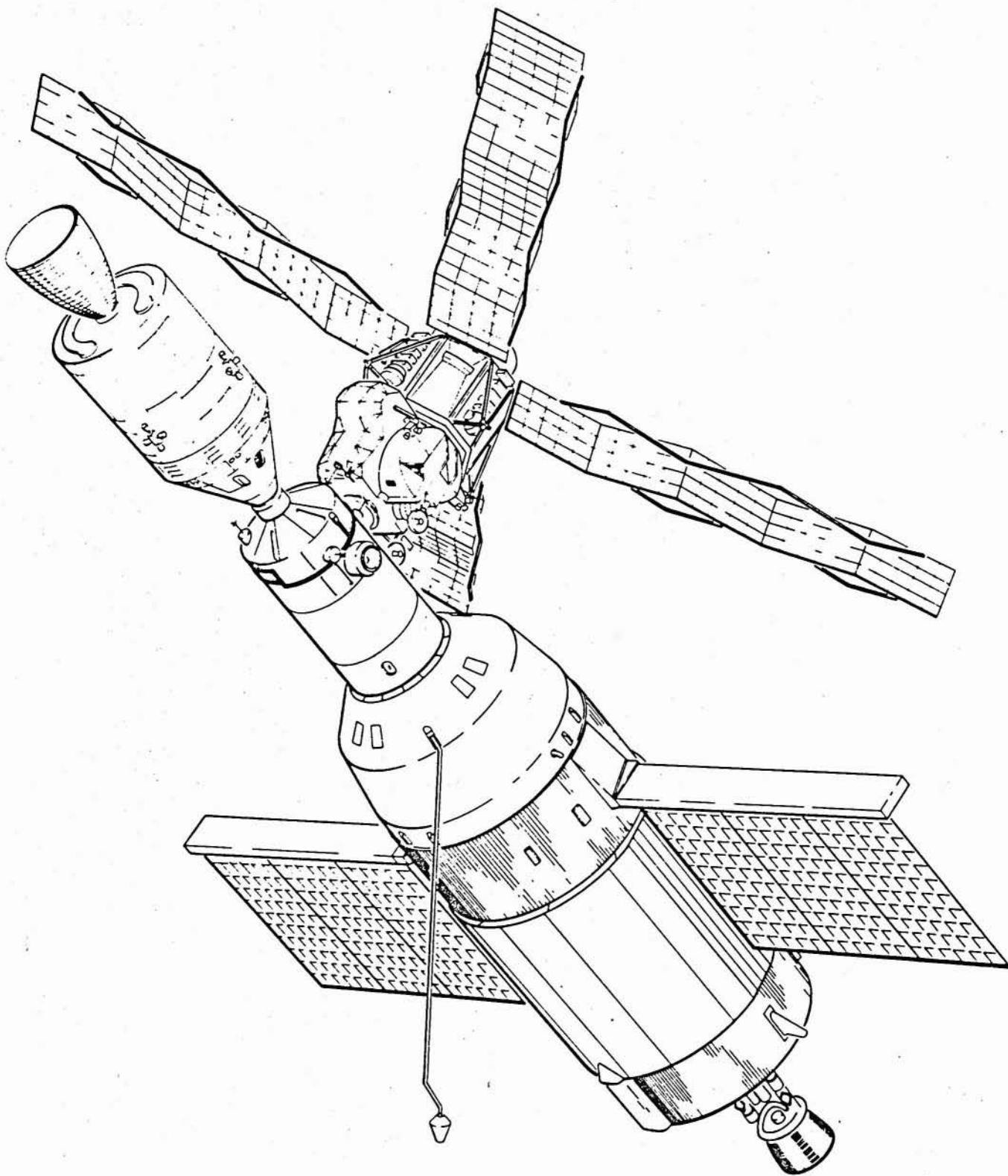
An aluminum grid pattern floor will be placed in the lower section of the tank to divide it into two "stories." Partitions will be installed, with a fire retardant liner around the inside tank surface. Another feature will be a meteoroid shield on the outside of the stage.

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 ceiling, installed next to the liquid oxygen tank-hydrogen tank common bulkhead, will be a reference surface for the astronauts and will reflect light in the area. Ceiling beams will serve as hand-rail 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



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.

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 into fixtures already installed, and portable lights may be used for additional 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 probability 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 feet, 8 inches long airlock, including the structural transition section, is mounted at the forward end of the S-IVB stage within the instrument unit and the payload shroud. The structure is attached to the vehicle at the lunar module attach points in the payload shroud. 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 cluster controls and displays. 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.

The airlock module is the nerve center of the Workshop cluster. It provides for the condition of the environmental gases; power control and distribution; real and delayed time instrumentation; data management; intercommunication system; ground network to cluster command system; and experiment installation provisions.

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 Apollo Telescope Mount docking; and a 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.

The main functions of the MDA are stowage of equipment that can't stand the liquid hydrogen environment and early operation of the medical experiments.

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 counter-ing 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.

AAP EXPERIMENTS

There are about 50 experiments being considered for the first five AAP flights. Most of them will be on the first Workshop and are divided into several groups: scientific, technological, applications, operational and medical.

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

S009	Nuclear emulsion
S018	Micrometeorite collection
S019	Ultra-violet stellar astronomy
S020	Ultra-violet/X-ray solar photography
S063	Ultra-violet airglow horizon photography
S073	Gegenschein flash/zodiacal light

Technological Experiments

T013	Crew-vehicle disturbances
D021	Expandable airlock technology

Technological Experiments cont'd:

D022 Expandable structures for recovery
T025 Coronagraph and contamination measurements
T027 ATM contamination measurement
M492 Tube joining assemblies
M493 Electron beam welding

Applications Experiments

S101 Multi-spectral terrain photography

Operations Experiments

D019 Suit donning and sleep evaluation
D020 Alternate restraints evaluation
T020 Jet shoes
M507 Gravity substitute workbench
M508 Extra-vehicular activity hardware evaluation
M509 Astronaut maneuvering equipment

Medical Experiments

M071 Mineral balance
M072 Bone densitometry
M073 Bioassay of body fluids
M074 Specimen mass measurement
M091 Lower body negative pressure (pre- and post-flight)

Medical Experiments cont'd:

M092	Cardiovascular function
M093	Vectorcardiogram
M111	Cytogenetic studies of blood (pre- and post-flight)
M113	Blood volume and red cell life span
M131	Human vestibular function
M132	Neurological experiment-EEG
M151	Time and motion study
M171	Metabolic activity
M172	Human mass measurement device
T003	In-flight nephelometer

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 (with suit unpressurized) 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 hardware includes a neutral buoyancy test

article at the Marshall 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 LM/Apollo Telescope Mount -- the modified lunar module ascent stage and the ATM experiments and supporting subsystems.

The Marshall Center has overall design responsibility for the Saturn I Workshop, the multiple docking adapter and the ATM. Management responsibility for the airlock module and the modified lunar module ascent

stage for the ATM was assigned 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 developments for 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.

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