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SATURN I WORKSHOP

The National Aeronautics and Space Administration proposes to place its embryonic space station -- the Saturn I orbital workshop -- into orbit in 1970 to gain a better understanding of the requirements for a permanent man-made island in space.

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

The first orbital workshop mission will be 28 days, two weeks longer than the 14 day Gemini 7 mission which is the longest manned flight to date.

NASA will launch the orbital workshop as the first of its Apollo Applications missions. Saturn IB launch vehicles will loft the workshop and subsequent manned Apollo spacecraft. AAP launch vehicles will become available when they are not needed for the mainstream Apollo lunar landing effort.

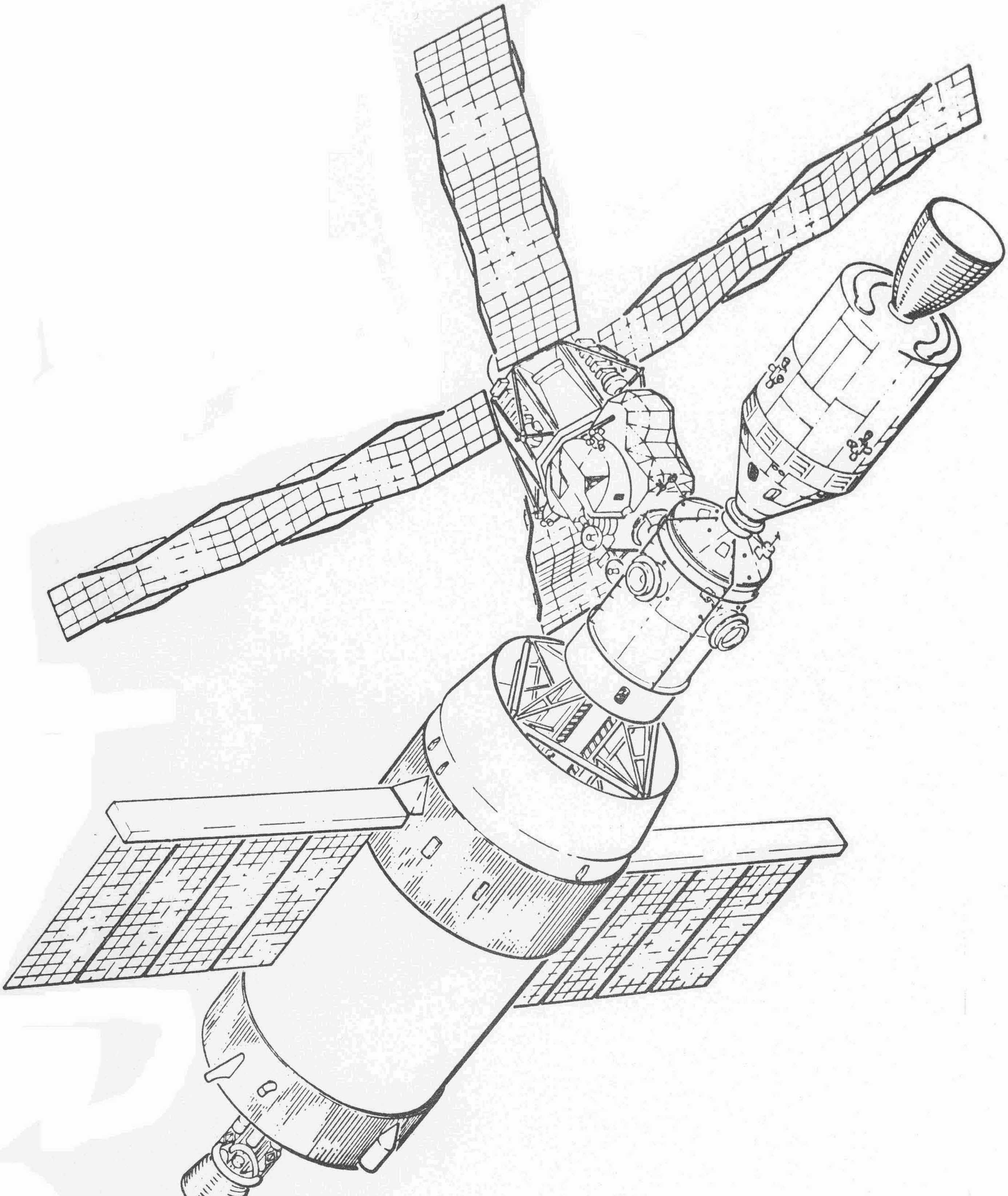
Dr. George E. Mueller, associate administrator for Manned Space Flight, said the orbital workshop "will provide us with a major step towards an understanding of the requirements for a space station."

He said the early development of long duration flight capability is clearly one of the most important areas to be pressed forward, since it is a key requirement for most of the possible significant advances in manned flight. Apollo Applications flights of several months duration 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 duration flight experiment is also necessary to provide a sound basis for those future decisions on manned programs of the greatest interest and potential. These include permanent manned facilities in space or manned flights to the planets.

Maximum economy will be achieved in the Apollo Applications effort through the full use and modification of Apollo spacecraft and Saturn launch vehicles.

Until the orbital workshop idea developed, a spent stage in orbit was considered to be useless. Today, based on detailed studies, the S-IVB spent stage is considered to be a flexible and economical resource, capable of fulfilling a variety of manned space program requirements at relatively low cost.

The major pieces of new equipment being developed for the workshop experiment are an airlock and multiple docking adapter. The airlock, being built for the Manned Spacecraft Center by McDonnell Douglas Corp., will allow astronauts to move from their spacecraft to the S-IVB stage without depressurizing either. The docking adapter attached to the airlock provides a means of joining together up to five payloads. The NASA-Marshall Space Flight Center is designing and manufacturing the multiple docking adapter.



AAP CLUSTER -- In this sketch the Saturn I orbital workshop is at bottom. Extending from the airlock (opposite the engine end) is the multiple docking adapter, to which is docked an Apollo command/ service module and Apollo telescope mount.

The space agency will demonstrate with this project 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 performing 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's third stage, would be completely outfitted on the ground and be "dry launched." NASA has included plans for such a follow-on effort in its fiscal year 1969 budget request.

AAP MISSION SEQUENCE

Four 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. Clustering the smaller payloads in orbit will provide greater capability to carry out planned long term experiments.

The first two-stage Saturn IB vehicle will launch the orbital workshop. The unmanned vehicle, consisting of the spent S-IVB stage, airlock and multiple docking adapter will be placed in a 260 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 orbiting workshop.

The three-man Apollo crew will rendezvous with the workshop and dock at one of the ports on the multiple docking adapter. The astronauts will insure the tanks are vented and will outfit the hydrogen tank for their 28 days in space.

Near the end of the stay, the astronauts will prepare the workshop for space storage and return to earth in their Apollo spacecraft.

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

The fourth Apollo Applications flight is to be about five to six months later. This will be an unmanned Apollo Telescope Mount, launched by another Saturn IB vehicle. A manned Apollo spacecraft will precede the ATM flight. The manned craft will rendezvous and dock with the Apollo Telescope Mount and then rendezvous and dock with the workshop.

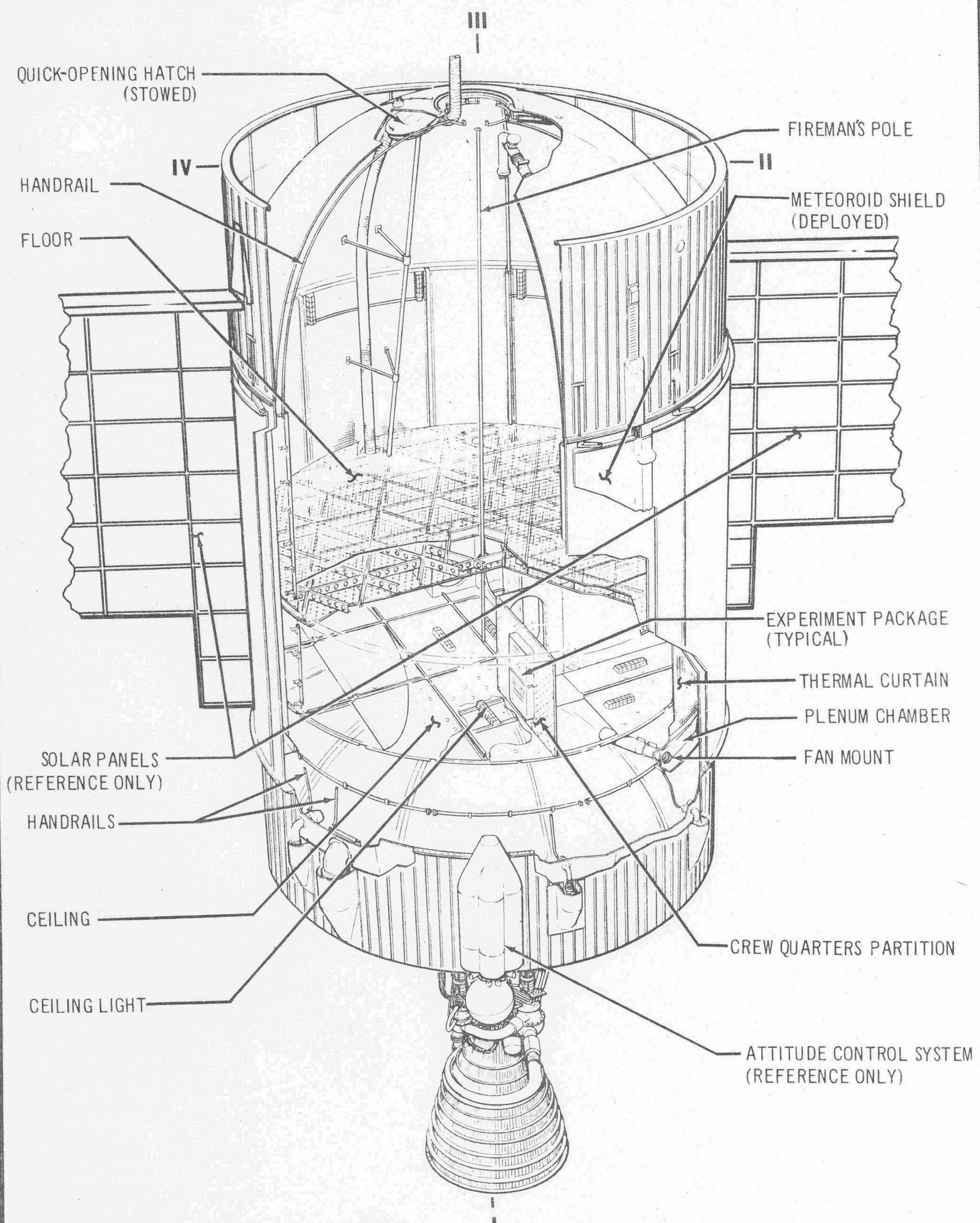
This time, the three astronauts are expected to stay in space for some 56 days. These astronauts will operate the ATM solar experiments to provide scientific information on the sun's activity.

Once again the men will prepare the workshop for an inactive period and will then return to earth with the film used to record solar data.

SATURN I WORKSHOP DESCRIPTION

A flight Saturn S-IVB stage, with some modification, will be used for the orbital workshop.

Along with the S-IVB stage, major equipment being developed for the workshop are an airlock, a multiple docking adapter and solar array. The airlock will be mounted on the forward end of the stage at the lunar module attach points. The multiple docking adapter will be rigidly mounted at the forward end of the airlock.



SATURN I WORKSHOP

Two solar arrays will be mounted to the stage's outside wall.

S-IVB STAGE

Once the liquid oxygen-liquid hydrogen propelled stage has achieved orbit, the tanks will be automatically vented to expell the residual fuels as part of the preparation of making it habitable. The pre-installed workshop equipment will not interfer with the liquid hydrogen flow during the powered portion of the flight.

Upper stages for later Saturn IB flights -- 209 through 212 -- are receiving basic modifications so any of these vehicles could be used for the workshop role. These basic changes include the drilling of some 100 holes throughout the stage to be used as attach points for the floor, partitions and experiment racks.

McDonnell Douglas Corp., prime S-IVB stage contractor, has a contract for the workshop role.

The stage selected for the workshop mission will have a great deal of 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 along 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 aspects of the workshop, will be located in the aft end of the liquid hydrogen tank. The common floor separates the crew quarters section of the tank 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 adjacent to the liquid oxygen tank-hydrogen tank common bulkhead will serve as a reference surface for the astronauts and will reflect light in the area. Ceiling beams also serve as handrail supports.

Waste management and food management compartments will be sealed to control the movement or odors and particles. These areas will be sealed with aluminum sheet and will have folding "telephone-booth" type doors.

Designers have provided relatively large crew quarters. The food and waste management areas each have 30 square feet of floor area. One sleep compartment is 67 square feet and 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 on the workshop. The internal pressure will be maintained at 5-6 pounds per square inch.

Fans will circulate the workshop atmosphere to keep the temperature constant. 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.

Electrical power distribution system will be pre-installed and will connect the workshop living and working areas with power sources in airlock and the solar cell assemblies. Lights will be installed by the astronauts and may be moved about for lighting control.

There will also be a caution and warning system in the workshop. The system has sensors and indicator/controller panel to alert the astronauts of hazardous conditions.

A "fireman's" pole will extend from the quick-opening hatch vertically 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 and equipment 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 multiple docking adapter will be performed.

The meteoroid shield will decrease the probability of hazardous penetration of the workshop by meteoroids. The shield will be installed as a kit with minimum stage modifications.

The shield is an 0.025 inch aluminum sheet which is held against the stage's liquid hydrogen tank during launch. Once in space it is deployed by swinglinks driven by torsion springs. It is held five inches from the tank wall in orbit.

AIRLOCK

The airlock is made up 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, as are most of the airlock controls.

The 65 inch diameter tunnel assembly includes two internal bulkheads with hatches and a flexible pressure-tight assembly which is connected to the liquid hydrogen tank of the S-IVB stage. The tunnel permits intravehicular transfer of crew members within the pressurized environment of the orbital assembly. The airlock compartment contains a Gemini hatch in the tunnel wall. This compartment provides the crew access to space without requiring depressurization of the entire cluster and is sized to permit occupancy by two crew members in pressurized suits with portable life support systems.

MULTIPLE DOCKING ADAPTER

The multiple docking adapter is a cylindrical pressure vessel which is structurally attached to the airlock by a structural transistion section.

The MDA is 17 feet two inches long and 12 feet in diameter at its widest point. The forward end tapers and includes an axial docking port. Four additional docking ports are spaced at 90 degree intervals, radial to the cylindrical section. Three of the radial ports and the axial port are configured for command/service module docking. The other radial port will be configured for lunar module/Apollo telescope mount docking.

Four windows are located 90 degrees apart on the conical section. A grid floor, normal to the longitudinal axis, is located approximately 23 inches below the radial docking port centerlines. Four flat grid walls, parallel to the longitudinal axis, are mounted between the structural transition section and grid floor. Hinging will permit access to the backsides of the walls, adjacent to the cylindrical structural shell so that experiments and equipment may be mounted on both sides of these walls.

Mounting provision for experiments to be conducted in the MDA as well as for experiments and equipment to be moved to the Saturn I workshop are provided. There is about 1,500 cubic feet of area available for use as a storage area for experiments, equipment and supplies during launch and while in orbit.

SOLAR ARRAY

The solar array will provide electric power for the workshop while the fuel cells in the command and service modules will handle the CSM power requirements The systems are, however, cross linked for flexibility in handling peak loads as well as for countering failure situations. For the eight-week 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 in order to reduce cryogenic loading requirements.

ORBITAL WORKSHOP EXPERIMENTS

There are about 50 candidate experiments being considered for the first five Apollo Applications flights. A majority of the experiments will be on the first orbital workshop. These experiments are categorized into several areas: 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 has the overall experiment management chore.

The candidate experiments include:

Scientific experiments

SO27	Galactic x-ray mapping
SO61	Potato respiration
SO65	Multi-band terrain photography
SO69	X-ray astronomy
SO73	Gegenschein flash zodiacal light

Technological experiments

T003	Inflight nephelometer
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
M423	Hydrostatic gas bearing
M439	Star horizon automatic tracking
M469	ST-124 guidance system removal
M479	Zero gravity flammability
M487	Habitability/crew quarters
M489	Heat exchanger service
M492	Tube joining assemblies
M493	Electron beam welding
M508	EVA hardware evaluation
M509	Astronaut maneuvering equipment

Medical experiments

M070	Nutriona and musculo skeletal function
M071	Mineral balance
M072	Bone desitometry
M073	Bioassay of body fluids
M074	Small mass measurement
M090	Cardiovascular function
M091	LBNP (lower body negative pressure) (pre and post flight)
M092	LBNP (lower body negative pressure) (inflight)

M093 Vectorcardiogram

M094 Antideconditioning garment

M130 Neurophysiology

M131 Human vestibular function

M150 Behavioral effects

M151 Time and motion study

M170 Pulmonary function and energy metabolism

M171 Metabolic activity

M172 Body mass measurement

ORBITAL WORKSHOP PASSIVATION AND ACTIVATION

The S-IVB stage arrives in orbit with some residual propellants, an active range safety system and with other potential hazards to astronaut safety. These systems must be put in a safe condition before the astronauts can begin outfitting the stage.

Prior to the Manned spacecraft docking to the spent stage, the range system will be deactivated by ground command. Venting of propellant residuals will be started by a preprogrammed, tape-operated sequencer in the instrument unit. Much of the propellants will be dumped through the J-2 engine. This exercise was conducted experimentally during the Apollo 5 mission January 22, 1968. It was successful in reducing the tank pressures and propellants. The liquid oxygen tank will be vented and then the hydrogen tank pressure will be relieved.

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

Three functions will be performed by the astronauts in the airlock after docking. These include checking the liquid hydrogen tank low pressure indicators, second, commanding liquid hydrogen tank non propulsive venting valve closed, and commanding the passivation of the stage helium control bottle.

After all the operational systems and equipment have been put in a safe condition, the astronauts will begin tasks required to make the liquid hydrogen tank a habitable workshop. Activation procedures are planned to provide maximum safety, economy of effort, minimum tools and minimum time for the astronauts.

As 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 prior to launch. These things must not compromise the S-IVB's primary function as a flight stage nor interfere with passivation. Provisions for monitoring conditions in the workshop shall be provided in the command module.

During the initial activation period, the astronauts work in the pressurized airlock and multiple docking adapter modules. They then pressurize the workshop. Once the tank is pressurized, the astronauts release the quick-opening hatch in the forward dome of the tank and a pressure-suited astronaut enters. He performs certain basic tasks such as installing redundant seals at all tank penetrations, installing fans at appropriate locations and attaching them up to the pre-installed wiring outlets, and otherwise making the workshop suitable for shirt sleeve operation.

The next step then is to transport to and assemble in the workshop the systems involved with food preparation, waste management, sleeping quarters, and finally, the various medical, scientific and technical experiments to be conducted in that area.

At the end of the stay, the crew will prepare the stage for space storage. The AAP plans call for the stage to be revisted and reactivated for 56 days and then for another 56 days in the solar observatory mission Later revisits may last from six months to one year.

ORBITAL WORKSHOP MANUFACTURE AND TESTING

Five versions of the workshop are now scheduled for assembly or modification.

The first workshop model is the engineering mockup built at the McDonnell Douglas Corp. facility at Huntington Beach, Calif. The mockup is presently at the Marshall Center and is being used in extensive design reviews.

Others are a neutral buoyancy test article for the Marshall Center, a neutral buoyancy trainer for the Manned Spacecraft Center, a flight trainer for astronauts at MSC and the flight version.

Many of the orbital workshop activation tasks have been performed in "neutral buoyancy" or water tank tests. In these tests, a pressure suited man has weights added to his suit so he neither rises or sinks. Thus "suspended" the man works in much the same environment as in weightlessness. Of course, the water pushing against him tends to hinder his movements but the underwater tests are called the best long term weightlessness simulation available on earth.

These underwater tests tell design engineers and human factors people how well their tools and equipment can be handled in space.

PROJECT MANAGEMENT

The organizations responsible for directing the orbital workshop project are the Office of Manned Space Flight within NASA Headquarters; the Apollo Applications Office within OMSF at Headquarters; and the OMSF Field Centers: Kennedy Space Center, Manned Spacecraft Center and the Marshall Space Flight Center.

At the Marshall Center, the Industrial Operations Apollo Applications Program Office is responsible for the overall management of the system design and payload integration for the mission module or orbital workshop, development of the mission module (workshop plus multiple docking adapter).

The Marshall Center's Propulsion and Vehicle Engineering Laboratory is the lead laboratory for this project and is the focal point for all the MSFC Research and Development Operations (R&DO) activities.

The Manned Spacecraft Center has management responsibility for the airlock module, command-service module, spacecraft/lunar module adapter and ground support equipment modifications in support of the above elements. The MSC director has delegated the operation of the project to the manager of Apollo Applications.

The Apollo Applications Office at Kennedy Space Center is established in the Plans, Programs and Resources Directorate. KSC is in charge of launch operations, including facility preparations.

Martin-Marietta Corp., Denver Division, has been selected by NASA to perform services in the Apollo Applications program. The 27-month contract calls for payload integration of experiments and experiments support equipment in space vehicles. The work will include mission analysis and systems engineering associated with Apollo Applications flights in addition to integration of experiments and support equipment.

The contractor will perform tasks for the three NASA manned space flight centers. Presently Martin Denver is doing work at the Marshall Center involving the Saturn I workshop and the Apollo Telescope Mount. Manned Spacecraft Center work will involve meteorological and earth resources payloads. Test integration planning in support for launch operations will be performed for the Kennedy Space Center.

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