Skylab

Program Objectives

Skylab is an experimental space station program of the National Aeronautics and Space Administration, designed to expand our knowledge of manned earth orbital operations and to accomplish carefully selected scientific, technological, and medical investigations. It has as its goal the accomplishment of four basic objectives.

Scientific Investigations in Earth Orbit These investigations are designed to take advantage of space operations to learn more about the universe, the space environment, and the phenomena that exist in the solar system and how they influence the environment of man on earth.

Applications in Earth Orbit Applications experiments include the development and evaluation of efficient techniques using man for sensor operation, discrimination, data selection and evaluation, manned control, maintenance and repair, assembly and setup, and mobility involved in various operations. These experiments include studies in meteorology, earth resources, and communications. The proper relationship between manned and unmanned applications operations will be determined.

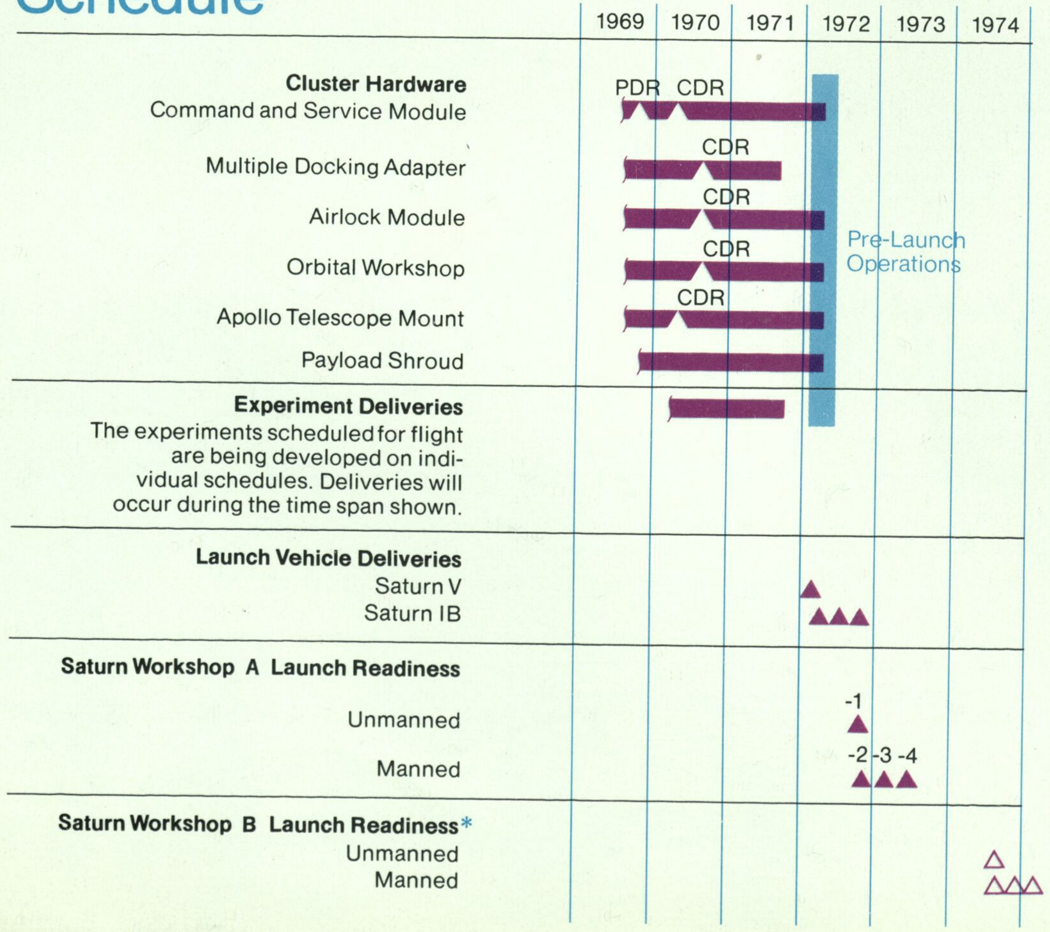
Long-Duration Space Flights of Men and Systems Skylab will employ the unique capabilities of man as a participant in space flight activities. Techniques are being developed for measuring the life of systems and subsystems of space vehicles. Man's psychological responses and aptitudes in space will be evaluated. Man's postmission adaptation to the terrestrial environment will be analyzed as a function of progressively longer missions. The need for artificial gravity will be determined, as well as the increments by which mission duration can be increased.

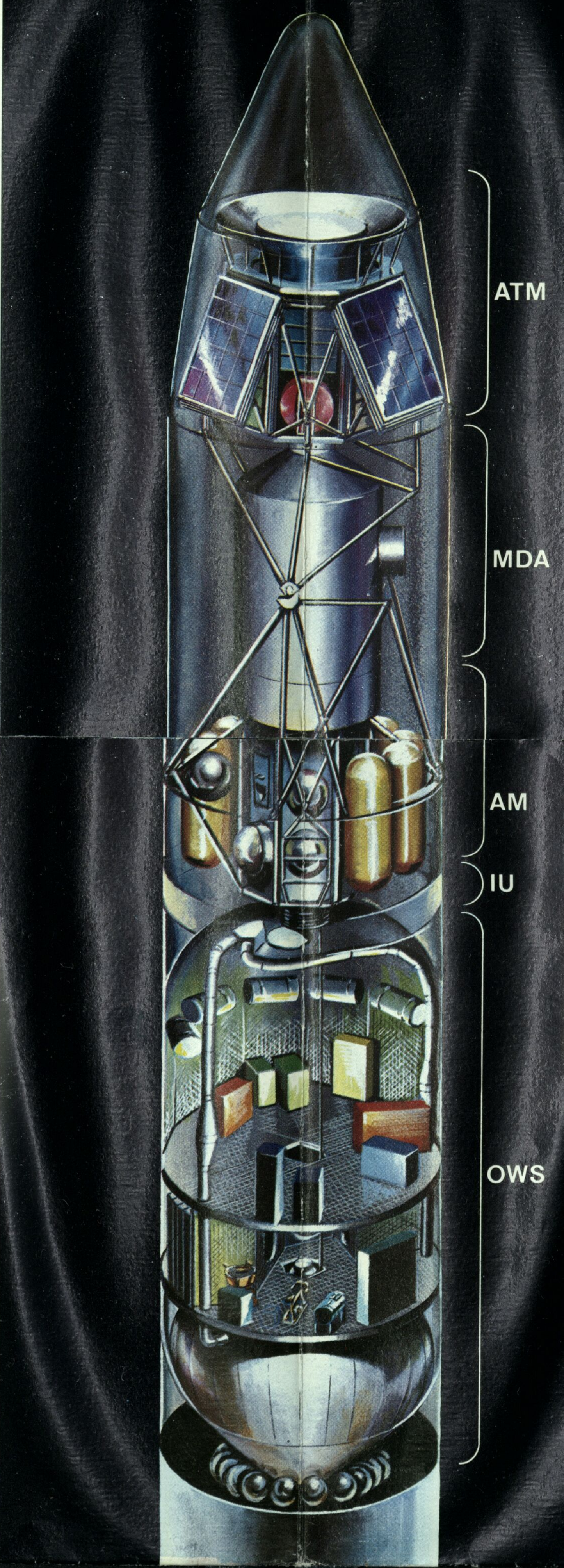
Effective and Economical Development of Future Space Programs The mission will give man the capability to operate in space for increasingly longer periods of time. The technology developed will provide the basis for the design and development of future long-duration space stations. In addition, manned operational requirements for future extended lunar operations and planetary exploration operations will be further defined.

Launch Readiness and Delivery Schedule

PDR: Preliminary Design Review
CDR: Critical Design Review

*Preliminary planning has been accomplished for an as yet unapproved second Saturn workshop. Potential launch readiness dates are shown for general information only.





Cluster System

The Skylab Program orbital cluster consists of a Saturn Workshop (SWS) with an Apollo Command and Service Module (CSM) docked to it. The SWS is composed of an S-IVB stage modified into an Orbital Workshop (OWS), an Airlock Module (AM), a Multiple Docking Adapter (MDA), a Saturn V Instrument Unit (IU), an Apollo Telescope Mount (ATM), and an ATM deployment assembly. The SWS assembly is launched by a two-stage Saturn V.

Saturn Workshop (SWS) Launch Configuration

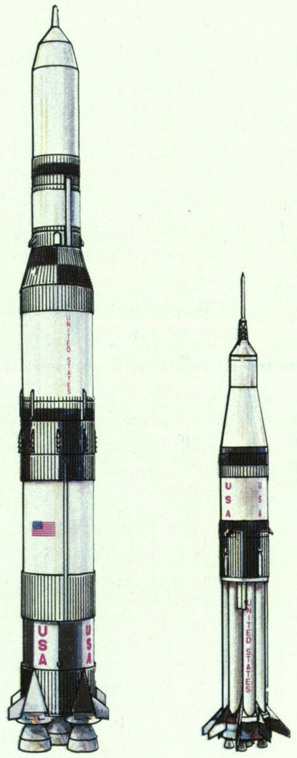
Apollo Telescope Mount (ATM) The Apollo Telescope Mount is the first use of manned scientific telescopes in space. The ATM is a solar observatory with the capability to observe, monitor, and record the structure and behavior of the sun particularly during periods of solar flare activity. The system is designed to provide attitude control and experiment-pointing for the entire cluster. Power is provided via a solar array and battery system. There is provision for retrieval and installation of the film used for the ATM by astronaut extravehicular activity (EVA). The ATM is supported by the ATM deployment assembly, which is shown here in the stowed position for the launch phase. The assembly contains a mechanism for on-orbit deployment of the ATM to a position 90° from the longitudinal axis of the cluster.

Multiple Docking Adapter (MDA) The Multiple Docking Adapter provides the docking interface for the Command and Service Module to the SWS. It has two docking ports; an axial port for normal CSM docking and a radial for contingency use. The MDA is pressurized and contains the ATM control and display console. There is also provision for internal storage of hardware and experiments that are launched and operated in the MDA.

Airlock Module (AM) The Airlock Module provides a pressurized passageway between the MDA and the OWS. It contains an airlock to enable astronaut EVA and is also the supply, distribution, and control center for cluster atmosphere and thermal control. In addition, it contains the equipment for electric power control and distribution to the OWS, MDA, and AM. The AM also provides support for cluster communications and data handling including delayed-time voice communciations with the ground. Other functions include thermal control of the ATM control and display console and support for selected experiments.

Instrument Unit (IU) The Saturn V Instrument Unit is used only during launch and the first 7½ hours of orbital operations. The IU provides guidance and sequencing functions to deploy the ATM and the OWS and ATM solar arrays and guidance, navigation, and control. It also provides a digital command system and telemetry link between the SWS and the ground.

Orbital Workshop (OWS) The Orbital Workshop is a modified S-IVB Stage which is suitable for long-duration manned habitation in orbit. It contains the necessary crew provisions, living quarters, and food-preparation and waste-management facilities to support a crew of three men for three periods of up to 56 days each. Certain experiments and the necessary support facilities for their operation are installed in the OWS. It contains the propulsive cold gas thruster attitude control system (TACS), which receives attitude control commands from either the IU or ATM electronics. The OWS has a solar array power source and provisions for routing power to the AM. It also is capable of unmanned on-orbit storage, reactivation, and reuse.



Launch Vehicles

Saturn V The Saturn V launch vehicle used to place the SWS in orbit consists of two stages, the S-IC and the S-II. Total weight of the Saturn V and the SWS at liftoff is approximately 6,222,000 lb. The height of the launch vehicle and SWS on the launch pad is 333.7 ft. The Saturn V payload capability into a 235-nmi circular orbit inclined at 50° is approximately 200,000 lb.

Saturn IB The Command and Service Module will be launched for docking with the SWS by a Saturn IB launch vehicle. The vehicle consists of two stages, the S-IB and the S-IVB. The Saturn IB and the CSM have a combined weight at liftoff of approximately 1,295,600 lb. Height is 223.4 ft. The Saturn IB payload capability into an 81x120-nmi orbit inclined at 50°, excluding payload penalty for launch window requirements, is approximately 40,000 lb.

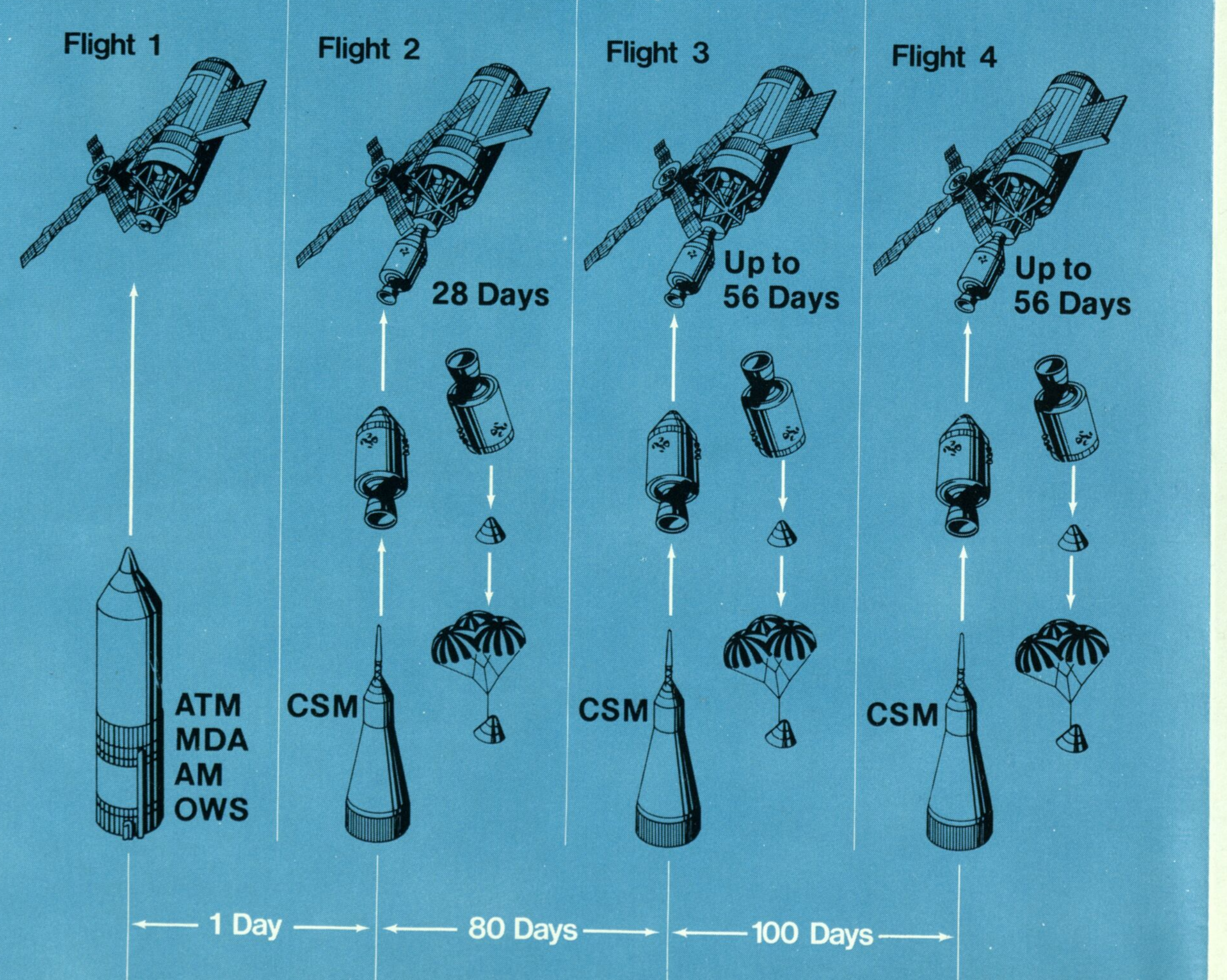
Mission Profile

Flight 1 The Skylab Mission will begin with the launch of the unmanned SWS from Kennedy Space Center's Launch Complex 39. The SWS will be inserted into a near-circular orbit of about 235 nmi, with a nominal orbit inclination of 50°. Within the 7½-hr lifetime of the IU, the SWS will be oriented to a solar-inertial (sun-pointing) attitude mode, and the workshop solar array will be deployed. The ATM will be rotated 90° from the launch position, and the ATM solar arrays will be deployed. The ATM pointing control system will be activated to maintain the solar-inertial attitude. The interior of the SWS will be pressurized to 5 psia with an oxygen-nitrogen mixture, making it ready to accept docking of the CSM and entry of the flight crew. The SWS atmosphere will be 3.7 psia oxygen and 1.3 psia nitrogen.

Flight 2 will be launched from KSC Launch Complex 39 approximately one day after Flight 1 using a Saturn IB launch vehicle. A CSM with a three-man crew will be inserted into an interim orbit of 81x120 nmi. The CSM will rendezvous with the SWS, using the service propulsion system to boost it to the required 235-nmi orbit, and will dock to the axial port of the MDA, thus completing the cluster. The crew will enter and complete activation of the SWS for habitation. The CSM will be powered down to the maximum extent, with only essential elements of the communications, instrumentation, and thermal control systems operating. For the remainder of the Flight 2 Mission, the experiment program will be conducted, placing emphasis on the medical experiments and evaluation of the habitability systems. The ATM experiments will be activated and their operation will be verified. The SWS will be prepared for orbital storage by the crew before their return. Nominally, the CSM will deorbit on the 28th manned mission day, and splashdown is planned in the West Atlantic recovery area.

Flight 3 involves the launch of a second crew on a Saturn IB approximately 80 days after the launch of Flight 2. The orbit-insertion, rendezvous, and docking procedures will be the same as those for Flight 2. The mission will be similar to Missions 1 and 2, except that it will be open-ended up to 56 days duration. In addition, more emphasis will be placed on the solar astronomy experiments. Assuming nominal mission duration and deorbit, recovery is planned in the mid-Pacific recovery area.

Flight 4 will be launched approximately 100 days after the launch of Flight 3. Its payload is the third CSM and crew. This mission will complete the planned experiment objectives, and will provide additional statistical data on the space crew's adaptability and performance over the planned 56-day mission. Recovery will be in the mid-Pacific.



Key Mission Events

Day	Flights 1 and 2
−1	Flight 1 Launch and Orbital Activation—The SWS will be inserted into the operational orbit and activated for crew entry and habitation
1	Flight 2 Launch, Rendezvous, Docking, and Cluster Activation—The first CSM will be launched and docked to the SWS. The crew enters and completes cluster activation
2 thru 15	Mission Experiment Operations
16	EVA for Experiments D021, Expandable Airlock and D024, Thermal Control Coatings
17 thru 25	Mission Experiment Operations
26	EVA for ATM Film Retrieval
27 and 28	SWS Deactivation of Experiments and Preparation of SWS for 1½-Month, Nonoperational, Unmanned Storage Period
28	CSM Separation, Deorbit, and Return to Earth—Experiment data return: film, specimens, and records limited to approximately 1000 lb and 23 cu ft of space in the Command Module

Flight 3

1	Flight 3 Launch, Rendezvous, Docking, and Cluster Activation—Identical to Flight 2
2	Mission Experiment Operations
3	EVA for ATM Film Loading
4 thru 24	Mission Experiment Operations
25	EVA for ATM Film Retrieval and Reloading
26 thru 52	Mission Experiment Operations
53	EVA for ATM Film Retrieval and Experiments D021 and D024
54 thru 55	SWS Deactivation—Identical to Flights 1 and 2
56	CSM Separation, Deorbit and Return to Earth

Flight 4

1	Flight 4 Launch, Rendezvous, Docking and Cluster Activation—Identical to Flight 2
2 thru 4	Mission Experiment Operations
5	EVA for ATM Film Loading
6 thru 30	Mission Experiment Operations
31	EVA for ATM Film Retrieval
32 thru 53	Mission Experiment Operations
54 and 55	SWS Deactivation—Final deactivation of SWS systems
56	CSM Separation, Deorbit and Return to Earth

Data current to 1 June, 1970

General Cluster Data

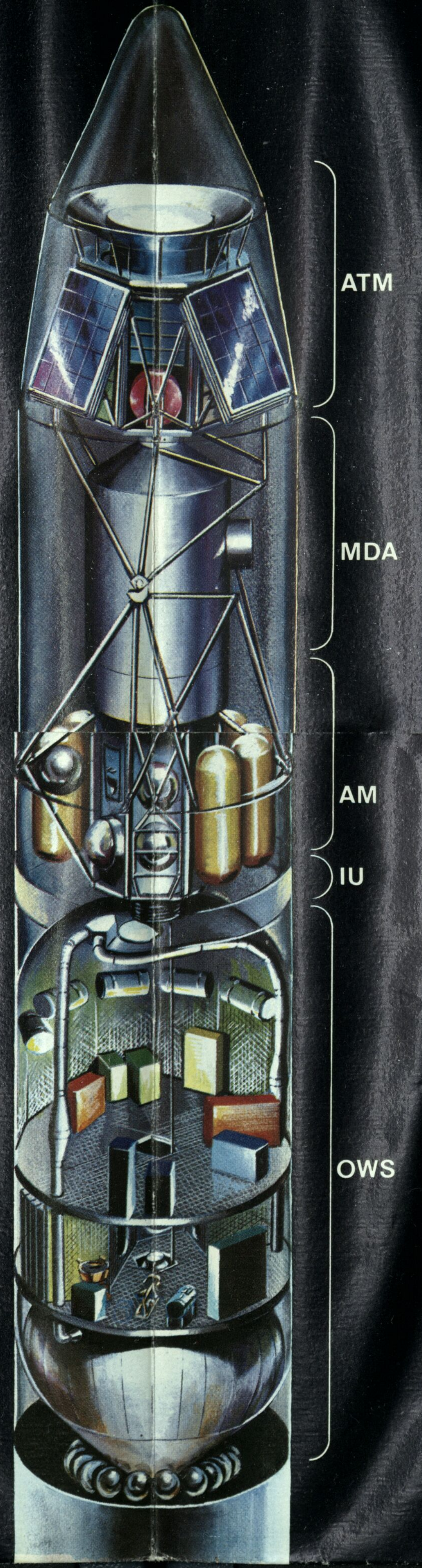
	Length (ft)	Diameter (ft)	Control Weight (lb)	Conditioned Work Volume (cu ft)
CSM (CM)	11.5	13.0	31,000	366
(SM)	24.4	13.0		
MDA	17.4	10.0	12,000	1,140
ATM	14.7	11.3	22,200	
AM (STS)	3.9	10.0	49,000 ●	613
(Tunnel)	13.7	5.5		
IU	3.0	21.6	4,600	
OWS	48.1	21.6	62,500	10,644

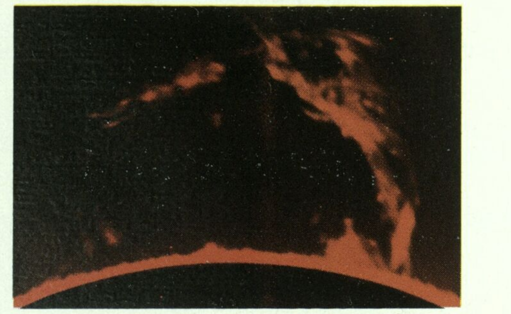
Total Cluster Weight 181,300 lb ●
Total Cluster Length 118.5 ft
Total Conditioned Work Volume 12,763 cu ft

● Includes ATM Deployment Truss
● Excludes Payload Shroud (27,000 lb)

Command and Service Module

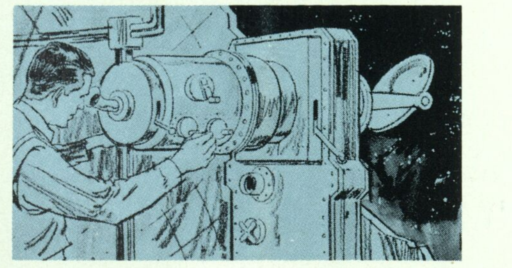
An Apollo Command and Service Module, modified to provide an on-orbit life of 56 days while docked to the SWS, is the logistics vehicle for the Skylab Program. The CSM and its three-man crew will be launched by a Saturn IB launch vehicle. The CSM also provides stowage and resupply of selected experiments. It has the propulsive capability for damping any transient cluster motions induced during its docking to the SWS. The Command Module will also function as the return carrier for experiment data obtained during the cluster missions.





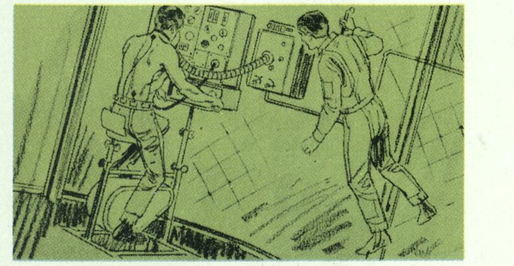
Solar Astronomy

Solar astronomy scientific experiments comprise the payload for the ATM. These instruments are the largest, most complex ever designed for performing solar research from an orbiting spacecraft. Special emphasis is placed on observations that are invisible to astronomers on the ground because of absorption in the earth's atmosphere. These experiments will provide additional solar data that will complement current information as portrayed by this solar flare. Solar photographs used in this brochure are courtesy of Mount Wilson and Palomar.



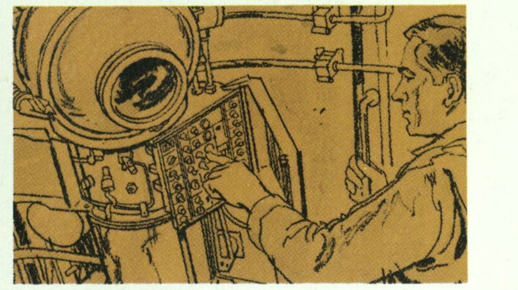
Science

Science experiments are designed to study the discipline areas of geophysics, physics of the upper atmosphere, physics of the interplanetary medium, solar studies supplementing ATM, and both galactic and intergalactic astronomy. Portrayed is experiment S019 which will be used to perform a partial survey of Milky Way star fields, designed to obtain UV spectra.



Biomedical

The biomedical experiments are planned to determine the effect of long-duration space flight on the crew. Major areas of interest are nutritional and musculoskeletal function; cardiovascular function; hematology and immunology; neurophysiology; pulmonary function; and metabolism. Man's metabolic effectiveness in space will be evaluated by experiment M171 to determine long-duration mission requirements for logistics resupply, environmental control, and task planning.



Technology

The technology experiments are designed to make use of the space environment to study its effect on various scientific phenomena and industrial arts. The knowledge gained through these experiments will be applied to future applications of the space environment for the manufacture and retrieval of valuable products for use on earth. The M512 experiment, shown here, is designed to study molten metal phenomena in the space environment.

Earth Resources

Earth resources experiments are designed to support the development of sensor and applications technology required for the design of operational spacecraft systems. These systems form an integral part of an earth resources development program. The approved Skylab earth resources experiments include a multispectral photographic facility, an infrared spectrometer, a 10-band multispectral scanner, and a microwave radiometer-scatterometer. These experiments will be used to determine the extent to which earth resources data can be secured from selected earth sites.

Crew Operations

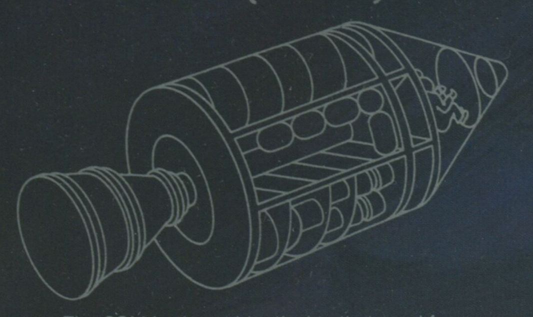
These experiments are designed to evaluate and demonstrate engineering developments and hardware aimed at facilitating the functioning of the crew in the space environment. Experiment M509, the Astronaut Maneuvering Unit, will be used to obtain data on mechanical and human factors problems encountered by man using maneuvering devices.

Experiments

Number	Title	Agency	Investigator	Flights 2	3	4
S052	White-Light Coronagraph	MSFC	Dr. Gordon Newkirk, High Altitude Observatory, Boulder	X	X	X
S054	X-Ray Spectrographic Telescope	MSFC	Dr. M. Zombeck, American Science & Engineering, Cambridge, Mass.	X	X	X
S055A	UV Scanning Polychromator Spectroheliometer	MSFC	Dr. Edward Reeves, Harvard College Observatory	X	X	X
S056	Dual X-Ray Telescope	MSFC	Mr. James Milligan, MSFC	X	X	X
S082A	Extreme UV Coronal Spectroheliograph	MSFC	Mr. J. D. Purcell, Naval Research Laboratory, Washington, D.C.	X	X	X
S082B	Extreme UV Spectrograph	MSFC	Mr. J. D. Purcell, Naval Research Laboratory, Washington, D.C.	X	X	X
S009	Nuclear Emulsion	MSFC	Dr. M. M. Shapiro, USN Research Lab.	X		
S019	UV Stellar Astronomy	MSC	Dr. K. G. Henize & Dr. James Wray, Northwestern University	X	X	
S020	X-Ray UV Solar Photography	MSC	Dr. R. Tousey, USN Research Lab.	X		
S061	Potato Respiration	MSC	Dr. B. W. Pince, Space Defense Corp.			X
S063	UV Airglow Horizon Photography	MSC	Dr. D. Packer, USN Research Lab.		X	
S073	Gegenschein Zodiacal Light	MSFC	Dr. J. Weinberg, Dudley Obs.		X	
S149	Particle Collection	MSC	Dr. C. L. Hemmenway, Dudley Obs.	X	X	
S150	Galactic X-Ray Mapping	MSFC	Dr. W. Kraushaar, Univ. of Wisconsin		X	
S190	Multispectral Photographic Facility	MSC	Mr. A. L. Grandfield, MSC	X	X	X
S191	Infrared Spectrometer	MSC	Dr. T. Barnett, MSC	X	X	X
S192	Ten-Band Multispectral Scanner	MSC	Dr. C. L. Korb, MSC	X	X	X
S193	Microwave Scatterometer	MSC	Mr. D. Evans, MSC	X	X	X
D008	Radiation in Spacecraft	AF MSC	Capt. M. F. Schneider, USAF	X		
D021	Expandable Airlock Technology	AF MSFC	Mr. F. W. Forbes, USAF, WPAFB	X	X	
D024	Thermal Control Coatings	AF MSFC	Mr. Carl Boebel, USAF, WPAFB	X	X	
M512	Material Processing in Space	MSFC	Mr. P. G. Parks, MSFC	X		
S015	Effects of Zero g on Human Cells	MSC	Dr. P. O. Montgomery, Dallas County Hospital	X		
S071	Circadian Rhythm, Pocket Mice	ARC	Dr. C. S. Pittendrigh, Princeton University		X	
S072	Circadian Rhythm, Vinegar Gnat	ARC	Dr. C. S. Pittendrigh, Princeton University		X	
T013	Crew Vehicle Disturbances	LaRC	Mr. B. A. Conway, LaRC		X	
T018	Precision Optical Tracking	MSFC	Mr. John Gould, MSFC	X	X	X
T025	Coronagraph Contamination Measurement	MSC	Dr. G. P. Bonner, MSC		X	
T027	Contamination Measurement	MSFC	Dr. J. Muscari, Martin Marietta Corp.	X		
M479	Zero-g Flammability	MSFC	Mr. Howard Kimzey, MSC		X	
M507	Gravity Substitute Workbench	MSFC	Mr. J. Rendall, MSFC	X		
M508	EVA and IVA Hardware Evaluation	MSC	Mr. John Jackson, MSC	X	X	
M509	Astronaut Maneuvering Equipment	MSC	Maj. C. E. Whitsett, USAF		X	
T020	Foot-Controlled Maneuvering Unit	LaRC	Mr. D. E. Hewes, LaRC		X	
M071	Mineral Balance	MSC	Dr. G. D. Whedon, National Institute of Health	X	X	X
M072	Bone Densitometry	MSC	Dr. Pauline Mack, Texas Womens' University	X	X	X
M073	Bioassay of Body Fluids	MSC	Dr. C. Leach, MSC	X	X	X
M074	Specimen Mass Measurement	MSC	Col. John Ord, USAF, Brooks AFB	X	X	X
M091	Lower Body Negative Pressure	MSC	Col. John Ord, USAF, Brooks AFB	X	X	X
M092	Inflight Lower Body Negative Pressure	MSC	Dr. R. J. Johnson, M.D., MSC	X	X	X
M093	Vectorcardiogram	MSC	Capt. Newton W. Allebach, USN Bureau of Medicine & Surgery	X	X	X
M111	Cytogenetic Studies of Blood	MSC	Dr. M. Shaw, Univ. of Texas Medical Center	X	X	X
M112	Man's Immunity in Vitro Aspects	MSC	Dr. Stephen Ritzman, Shriners' Burns Institute	X	X	X
M113	Blood Volume & Red Cell Life Span	MSC	Dr. Phillip Johnson, Baylor Univ.	X	X	X
M114	Red Blood Cell Metabolism	MSC	Mr. Charles Mengel Univ. of Missouri	X	X	X
M131	Human Vestibular Function	MSC	Dr. Ashton Graybiel, M.D. Naval Aviation Medical Institute	X	X	
M151	Time and Motion Study	MSC	Dr. J. F. Kubis, Fordham Univ.	X	X	X
M171	Metabolic Activity	MSC	Mr. Edward Michel, MSC	X	X	X
M172	Body Mass Measurement	MSC	Col. John Ord, USAF, Brooks AFB	X	X	X
M415	Thermal Control Coatings	MSFC	Mr. E. C. McKannon, MSFC	X		
T003	Inflight Aerosol Analysis	ERC	Dr. W. Leavitt, ERC	X	X	X

Experiment Definition by Location

Command and Service Module (CSM)



The CSM is almost identical to that used for Apollo. Modifications have been made to accommodate the long-duration Skylab Mission, and the capability of having the CSM semidormant while docked to the cluster.

Environmental Control System The active/passive thermal control uses glycol coolant radiators, water evaporators, and local electric heaters. A self-contained 5-psia, oxygen atmosphere system is provided for undocked operations.

Electric Power Two fuel cells (2850 w), entry and postlanding batteries (120 amp-hr), descent batteries (1500 amp-hr), and pyrotechnic batteries (80 amp-hr) provide basic power. When docked to the cluster, operating power (1100 w) is received from the cluster.

Data and Communications A unified S-band system for tracking, voice, TV, data, and commands, and a VHF system available for ranging and backup voice communications are provided.

Propulsion and Attitude Control The attitude control system uses hypergolic storable propellants with thrusters of 93 lb thrust each. The main propulsion system, with one hypergolic engine of 20,000 lb thrust, provides for large maneuvers when undocked.

Crew Provisions Food, water, and other commodities are included for support of astronauts when the CSM is not docked to cluster.

Experiments

M071 Mineral Balance Precisely measure the input and output of calcium and nitrogen by the astronaut to quantify rates of gain or loss (also conducted in the OWS).

M073 Bioassay of Body Fluids Evaluate plasma and urine samples taken during flight to assess the metabolic changes in man as a result of space flight.

D008 Radiation in Spacecraft Measure and record the absorbed radiation inside the spacecraft to assure astronaut awareness of any dangerous increase in radiation levels.

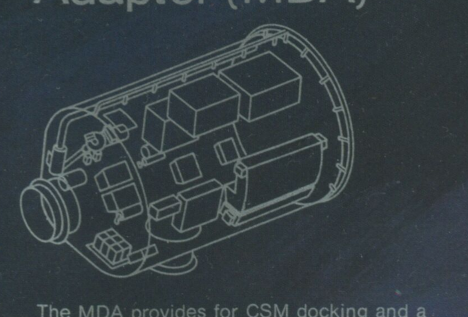
S015 Effects of Zero g on Single Human Cells Study the influence of zero g on living human cells and determine if the absence of gravity has a significant effect on their metabolism.

S071 Circadian Rhythm-Pocket Mice Determine the effects on the physical functions of pocket mice when removed from gravity and the geophysical 24-hr period.

S072 Circadian Rhythm-Vinegar Gnat Determine the effects on the physical functions of vinegar gnats when removed from gravity and the geophysical 24-hr period.

S061 Potato Respiration Determine whether removal from the earth's rhythmic geophysical environment will affect a well-known biorhythm.

Multiple Docking Adapter (MDA)



The MDA provides for CSM docking and a crew working area for control of the ATM and Earth Resources Experiments (EREP).

Environment Control Provided by the AM.

Other Provisions The ATM and EREP control and display consoles and the Thruster Altitude Control System (TACS) are housed in the MDA. An optically correct window is provided for EREP photography, plus storage vaults for ATM and EREP film.

Experiments

S009 Nuclear Emulsion Investigate physical and chemical characteristics of cosmic radiation incident on the earth's atmosphere.

M479 Zero g Flammability Determine the effects of zero gravity on the flammability of non-metallic materials in a spacecraft.

M512 Materials Processing in Space Determine molten-metal flow characteristics under zero gravity and space vacuum conditions.

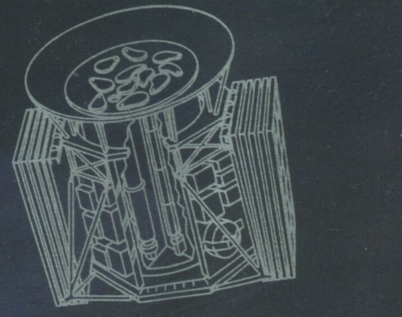
S190 Multispectral Photographic Facility Obtain multispectral photographs of the earth's surface using a six-camera array with synchronized shutters.

S191 Infrared Spectrometer Manually acquire and track ground truth sites to obtain spectrometer data to evaluate earth resources sensing from orbital altitudes in the visible to infrared spectral regions.

S192 Ten-Band Multispectral Scanner Secure quantitative radiance values simultaneously in ten spectral bands, from visible to infrared, using imagery scanning with automated data processing techniques.

S193 Microwave Scatterometer, Altimeter, Radiometer Obtain active and passive microwave data from space for application to earth resources disciplines.

Apollo Telescope Mount (ATM)



The ATM provides a mounting structure, electric power, fine pointing system, and environmental control for the six solar experiments. The control console for experiment operation is mounted in the MDA.

Environmental Control The active/passive thermal system, using coolant radiators and local electric heaters, controls the temperatures of ATM hardware and precision cameras. Contamination of the ATM canister (containing the experiments) is controlled with an inert-gas system during launch operations.

Electric Power Four solar array wings (1200 sq ft total) provide 10.5 kw (at 55°C) recharge capability from solar energy to the 18 ATM Ni-Cd batteries, with individual battery charger/regulator units. The average output capability of the ATM system is approximately 3700 w each orbit.

Data and Communications A self-contained VHF data system provides for both real- and delayed-time transmissions through redundant antennas on the ATM structure. A UHF system will be used for ground commands.

Crew Working Area Two EVA astronaut stations are provided for film removal/replacement, and are reached via the AM EVA hatch.

Attitude Control and Pointing Primary cluster attitude control is maintained with the ATM control moment gyro (CMG) system and associated electronics. ATM experiment pointing is maintained to less than 2.5 arc sec in pitch and yaw, and within 10 arc minutes in roll.

Other Features A deployment mechanism rotates the ATM 90° from launch position to the operational mode. The truss transmits ATM loads through the fixed payload shroud. Key to operation of the ATM is the H-alpha No. 1 telescope camera which provides the astronaut with a pointing aid for collecting sun-film data for reference to ground observations. There is also an H-alpha No. 2 telescope that provides a tool for standard orbital patrol observations of the sun.

Experiments

S052 White-Light Coronagraph Use an externally occulted coronagraph to monitor, in the 4000 to 6000 angstrom (A) range, the brightness, form, and polarization of the solar corona from 1.5 to 6 solar radii.

S054 X-Ray Spectrographic Telescope Record spectra of solar flare X-ray emission in the 2 to 10 A wavelength range with a resolution of 0.5 A.

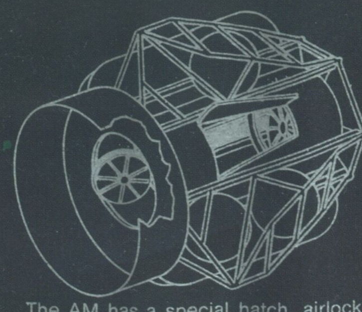
S055A UV Scanning Polychromator / Spectroheliometer Photoelectrically record high-resolution solar images in six spectral lines simultaneously.

S056 Dual X-Ray Telescope Obtain high-resolution (5 arc sec) photographs of the sun's coronal X-ray emission in the 3 to 60 A wavelength region.

S082A Extreme UV Coronal Spectroheliograph Obtain high-resolution (5 arc sec) spectroheliograms of the solar atmosphere in the 150 to 650 A wavelength range.

S082B Extreme UV Spectrograph Record spectra of the solar disk in the 900 to 3900 A wavelength region with a 0.08-to-0.16 A spectral resolution.

Airlock Module (AM)



The AM has a special hatch, airlock compartment, and services for supporting EVA from the cluster-conditioned area. It is used by crew members for going outside to replace/retrieve the ATM film. The AM also provides the main power distribution control and the atmosphere supply and conditioning equipment for the entire cluster.

Environment Control System An active/passive radiator thermal control system (16,000 Btu/hr heat rejection), EVA umbilical provisions, and the cluster's 5-psia, nitrogen and oxygen atmosphere supply and air purification systems are provided in the AM.

Electric Power Eight rechargeable Ni-Cd batteries with individual charger/regulator units provide a total average output capability of 3830 w per orbit. The batteries are charged by the OWS solar array.

Data and Communication A VHF system for data and command, and also delayed-time (recorded) voice operates with redundant deployable antennas.

Experiments

D021 Expandable Airlock Technology Demonstrate the feasibility of employing expandable structures in an earth-orbital environment.

D024 Thermal Control Coatings Determine the effects of the near-earth environment on thermal control coatings to gain new insight into the mechanisms of degradation.

Orbital Workshop (OWS)

The OWS houses most of the cluster experiments, provides two solar array wings for power generation, and has complete crew quarters and commodities for sleeping, eating, and housekeeping, during all mission operations.

Environmental Control The two-gas (nitrogen, oxygen), 5-psia atmosphere and thermal control for the OWS are provided by the AM.

Electric Power Generation Two 23x30-ft solar array wings provide 1200 sq ft of solar-energy conversion area for charging (11.9 kw capability @ 55°C) the 8 AM batteries each orbit.

Attitude Control Six cold-gas thrusters are mounted in two areas (3 each) on the OWS aft end to control changes in attitude and supplement the CMG s as required. The electronics for these thrusters is located on the ATM, and the astronaut control panel is in the MDA.

Experiments

S019 UV Stellar Astronomy Perform a partial sky survey of Milky Way star fields to obtain UV spectra using a Ritchey-Chretien objective-prism spectrograph.

S020 UV Solar Photography Obtain X-ray/UV solar spectra by a grazing incidence spectrograph to support development of solar flare prediction techniques.

S063 UV Airglow Horizon Photography Secure photographs of the UV emission from the airglow layers of the upper atmosphere.

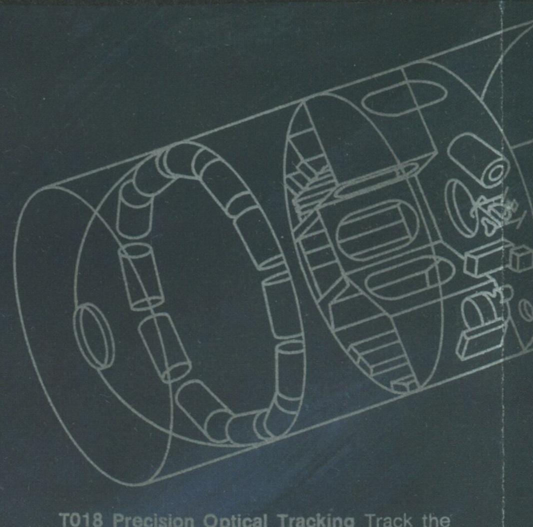
S073 Gegenschein Zodiacal Light Measure the intensity and polarization of the night sky light in the Zodiacal and Gegenschein region.

S149 Particle Collection Study flux, size, composition, and velocity of micrometeoroids in the near-earth environment.

S150 Galactic X-Ray Mapping Perform a high-sensitivity survey of a portion of the celestial sphere to determine galactic X-ray sources and to develop an understanding of the apparent phenomenon of X-ray background radiation (located in IU).

T003 Inflight Aerosol Analysis Determine the aerosol particle concentration and size distribution in the spacecraft atmosphere as a function of time.

T013 Crew Vehicle Disturbances Measure the effects of crew motion on the dynamics of their spacecraft and determine how these motions affect high-accuracy pointing experiments.



T018 Precision Optical Tracking Track the Saturn vehicle with a laser radar system during the early launch phase to determine liftoff motions (located on IU).

T020 Foot-Controlled Maneuvering Unit Determine the feasibility of the maneuvering unit for astronaut translation and rotational maneuvers in space.

T025 Coronagraph Contamination Measurement Monitor the presence of particulate matter in the near vicinity of the spacecraft and provide measurements of the solar f-corona.

T027 Contamination Measurement Measure the sky brightness background caused by solar illumination of contamination particles around a spacecraft and determine the effect of contamination on the optical properties of lenses and mirrors.

M074 Specimen Mass Measurement Demonstrate the feasibility of mass measurement without gravity to assess food intake, urinary output, and bone and muscle changes during flight.

M092 Inflight Lower-Body Negative Pressure Record heart rate, blood pressure, and electrocardiogram data during flight with negative pressure on the lower body to evaluate space flight cardiovascular deconditioning.

M093 Vectorcardiogram Monitor electrical actions of the heart during space flight, using sensors and signal conditioners to obtain vectorcardiograms.

M131 Human Vestibular Function Evaluate the condition of the crew during flight to determine angular acceleration comfort zone and to identify vestibular changes.

M151 Time and Motion Study Use time and motion studies of standardized mechanical tasks to evaluate the relative consistency between ground-based and inflight astronaut performance.

M171 Metabolic Activity Evaluate man's metabolic effectiveness in space to determine long-duration mission requirements for logistics resupply, environmental control, and task planning.

M172 Body Mass Measurement Validate a mass measurement device large enough to contain a man and to provide data for bone and tissue studies.

M415 Thermal Control Coatings Determine degradation effects of prelaunch, launch, and space environments on the absorptivity, emissivity, and stability characteristics of various materials used for passive thermal control.

M507 Gravity Substitute Workbench Assess the use of aerodynamic and electrostatic force fields as an aid in the manipulation of loose objects in zero gravity.

M508 EVA and IVA Hardware Evaluation Evaluate man's capability to perform work under the conditions imposed by space flight and develop quantitiative design criteria applicable to future missions in space.

M509 Astronaut Maneuvering Equipment Obtain data on the mechanical and human-factor problems encountered by man using maneuvering devices.

PreFlight and PostFlight Only

M072 Bone Densitometry Make a densitometric comparison of preflight and postflight X-rays of selected bones of the body to evaluate bone demineralization under prolonged weightlessness.

M091 Lower-Body Negative Pressure Apply negative pressure to the lower half of the astronaut's body before and after flight to ascertain the cardiovascular function changes resulting from space flight.

M111 Cytogenetic Studies of Blood Determine the preflight and postflight chromosome aberration frequencies in the peripheral blood leukocytes of the crew.

M112 Man's Immunity— In Vitro Aspects Assay humoral and cellular immunity as reflected by the plasma concentrations of the major immunoglobulin classes, study the functions of blood lymphocytes, and assay selected coagulation factors.

M113 Blood Volume and Red Cell Life Span Document changes in red cell mass, red cell survival, and plasma volumes occurring as a result of space flight.

M114 Red Blood Metabolism Determine the effects of space flight on red cell metabolism and membrane integrity.

Painted especially for
Martin Marietta Corporation
by Charles Oren Bennett

Roles and Responsibilities

National Aeronautics and Space Administration

Office of Manned Space Flight–Washington, D.C. The Skylab Program Office is responsible for directing, integrating, and evaluating all phases of Skylab to ensure the success of each flight mission and the program as a whole. The organization provides for the execution of functional responsibilities in the areas of program integration and control, test, reliability, quality and safety, systems engineering, and operations. The directives of the OMSF Skylab Program Office are implemented by the office at each of the responsible NASA Centers.

Marshall Space Flight Center—Huntsville, Alabama MSFC has program management responsibility for:

- Developing all Saturn Workshop hardware elements including the Orbital Workshop, Airlock Module, Multiple Docking Adapter, and Apollo Telescope Mount;
- Developing assigned experiments and supporting hardware;
- Integrating assigned experiments and support systems into the Saturn Workshop flight hardware;
- Overall systems engineering and integration to assure the compatibility and integration of the complete mission hardware for each flight;
- Flight evaluation.

MSFC is also responsible for providing the Saturn IB and Saturn V launch vehicles and for making any required vehicle modifications.

Manned Spacecraft Center—Houston, Texas MSC has responsibility for:

- Development of the Modified Command and Service Modules for the program;
- Development of the Spacecraft Launch Adapter (SLA) for manned launches;
- Development of assigned experiments, crew systems, medical equipment, food, and other crew supporting hardware;
- Integrating experiments to be carried in the CSM and providing for stowage in the CSM of experiment data and hardware designated for return from orbit;
- Mission analysis, including mission requirements development, detailed mission flight planning and pre-flight preparations;
- Providing and training flight crews;
- Planning and executing mission control, flight operations, and recovery activity;
- Mission evaluation.

John F. Kennedy Space Center—Florida KSC has responsibility for:

- Providing launch facilities for Flights 1 through 4;
- Preparing checkout procedures and accomplishing the prelaunch checkout;
- Planning and executing launch operations.

Major Skylab Cluster and Vehicle Element Contractors

The Boeing Company Responsible for the production of the first stage of the Saturn V launch vehicle. This stage is produced by Boeing at the NASA Michoud Assembly Facility and at the Mississippi Test Facility located near New Orleans, Louisiana.

Chrysler Corporation Responsible for the production of the first stage of the Saturn IB launch vehicle. The production is also accomplished at the NASA Michoud Assembly Facility.

Martin Marietta Corporation Role includes cluster payload integration responsibilities involving systems engineering analysis and evaluation of the overall cluster plus module interface definition and evaluation. Crew related responsibilities are oriented toward the preflight support of crew operations, crew training, and real-time mission support for specified hardware.

Martin Marietta is responsible for Multiple Docking Adapter hardware modification, equipment installation, and checkout. Also, the development and production of the ATM Control and Display Console is performed by The Bendix Corporation under contract to Martin Marietta. Experiment management is another MMC role and involves the development and production of assigned experiments, including portions of M171, M509, S019, T020, and T027.

McDonnell Douglas Corporation Responsible for the design, development, fabrication, equipment installation, testing, and checkout of the Orbital Workshop and the Airlock Module. Included in these modules are the prime electrical and environmental control systems for the entire cluster. The McDonnell Douglas is responsible for providing habitable living quarters for the astronauts in the Orbital Workshop. This involves the interior arrangement and design of the living and work areas and responsibility for the sleeping, eating, and personal hygiene facilities. In addition, they have responsibility for the Payload Shroud and the Deployment Assembly for the Apollo Telescope Mount and the S-IVB stage for Saturn launch vehicles.

North American Rockwell Corporation Responsible for modifying the Apollo Command and Service Module to meet the requirements of the Skylab Program. These modifications are required to extend the life of the CSM to 56 days while docked to the SWS. Significant modifications will be made to the thermal control system, service propulsion system, cryogenic storage system, and electrical power system, including the addition of a descent battery pack. NAR has design, development, production, testing, and checkout responsibility for the basic Apollo CSM and the modifications required for Skylab. North American Rockwell also developed and produced the F-1 and J-2 engines that are used in the various stages of the Saturn V launch vehicle. NAR also has total development and manufacturing responsibility for the second stage of the Saturn V.

MARTIN MARIETTA
DENVER DIVISION