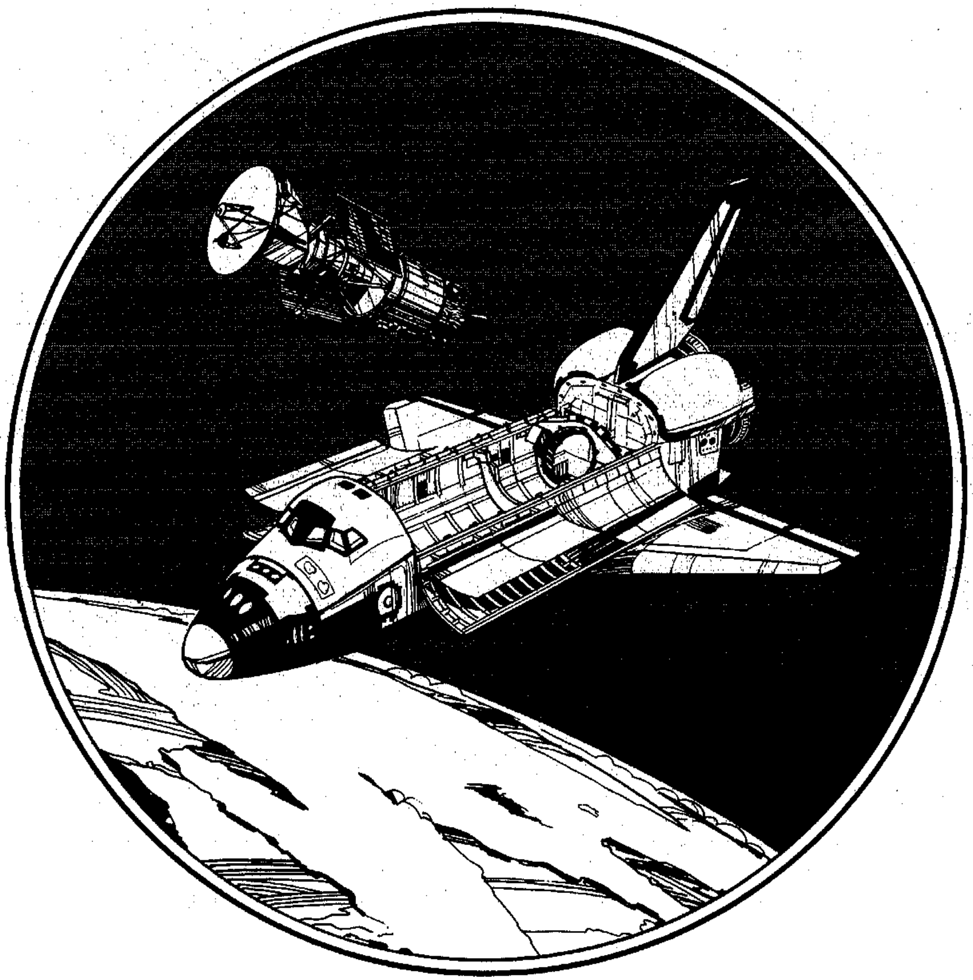

STS-30 PRESS INFORMATION

April 1989

Rockwell International
Space Transportation Systems Division
Office of Media Relations

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CONTENTS

MISSION OVERVIEW

This is the fourth flight of Atlantis and the 29th in the space transportation system program.

The flight crew for the STS-30 mission consists of commander David M. Walker; pilot Ronald J. Grabe; and mission specialists Norman E. Thagard, Mary L. Cleave and Mark C. Lee.

The primary objective of this four-day mission is to deploy the Magellan spacecraft mated with an inertial upper stage. After deployment of the Magellan spacecraft with its IUS from Atlantis' payload bay, the IUS will provide the necessary velocity to place Magellan in a transfer orbit from Earth to Venus.

Deployment of the Magellan spacecraft and IUS from Atlantis' payload bay is scheduled for the fifth orbit at a mission elapsed time of six hours and 18 minutes. Backup deployment opportunities are available on orbits 6, 7 and 16 with a contingency capability on orbit 17.

The first-stage of the IUS solid rocket motor will be ignited on orbit 6A (ascending node) for transfer orbit insertion approximately 60 minutes after the IUS and Magellan spacecraft are deployed. (Each orbit starts when the orbiter has crossed the equator on its ascending node.) IUS second-stage SRM ignition will occur approximately two minutes after IUS first-stage cutoff. Upon the completion of the two IUS thrusting periods, the Magellan spacecraft and IUS are separated and the Magellan spacecraft will intercept a hyperbolic Earth escape vector, leading to an arrival at Venus approximately 480 days later.

Two other payloads will be carried aboard Atlantis in this mission. One, the Fluids Experiment Apparatus, is located in the middeck of Atlantis' crew compartment. The other experiment is the Mesoscale Lightning Experiment, which uses an onboard cargo bay TV camera and 35mm cameras.

The Air Force Maui Optical Site Calibration Test experiment allows ground-based electro-optical sensors on Maui, Hawaii, to collect imagery and signature data of Atlantis' reaction control system plumes during cooperative overflights. This experiment was also accomplished during the STS-29 mission.

STS-30 MISSION STATISTICS

Launch: Launch window duration increases from a minimum of 23 minutes to a maximum of two hours over the launch period duration from April 28, 1989, through May 28, 1989.

4/28/89 2:24 p.m. EDT
1:24 p.m. CDT
11:24 a.m. PDT

Mission Duration: 96 hours (four days), 57 minutes

Landing: Nominal end of mission is on orbit 65.

5/2/89 3:21 p.m. EDT
2:21 p.m. CDT
12:21 p.m. PDT

Inclination: 28.85 degrees

Ascent: The ascent profile for this mission uses an OMS-1 and OMS-2 thrusting period after main engine cutoff.

Altitude: 85 by 4 nautical miles (97 by 4.6 statute miles), then to 51 by 161 nautical miles (58 by 185 statute miles), then to 160 by 161 nautical miles (184 by 185 statute miles) then to 160 by 177 nautical miles (184 by 203 statute miles)

Space Shuttle Main Engine Thrust Level in Ascent: 104 percent

Total Lift-off Weight: Approximately 4,536,344 pounds

Orbiter Weight, Including Cargo at Lift-off: Approximately 212,922 pounds

Payload Weight Up: Approximately 47,909 pounds

Payload Weight Down: Approximately 7,701 pounds

Orbiter Weight at Landing: Approximately 192,317 pounds

Payloads: Magellan/IUS-2, FEA, MLE and AMOS

Flight Crew Members:
- Commander: David M. Walker, second space shuttle flight
- Pilot: Ronald J. Grabe, second space shuttle flight
- Mission Specialist 1: Mark C. Lee, first space shuttle flight
- Mission Specialist 2: Norman E. Thagard, third space shuttle flight
- Mission Specialist 3: Mary L. Cleave, second space shuttle flight

Ascent Seating:
- Flight deck front left seat, commander David Walker
- Flight deck front right seat, pilot Ronald Grabe
- Flight deck aft center seat, MS-2 Norman Thagard
- Flight deck aft right seat, MS-1 Mark Lee
- Middeck, MS-3 Mary Cleave

Entry Seating:
Flight deck aft right seat, MS-3 Mary Cleave. Middeck, MS-1 Mark Lee.

Extravehicular Activity Crew Members, If Required:
Extravehicular activity astronaut 1 would be Norman Thagard and EV-2 would be Mark Lee.

Angle of Attack, Entry: 40 degrees.

Entry: Automatic mode will be used until subsonic; then control stick steering will be used.

Runway: Nominal end-of-mission landing will be on dry lake bed Runway 17 at Edwards Air Force Base, California.

Notes: The remote manipulator system is not installed in Atlantis' payload bay for this flight. The galley is installed in the middeck of Atlantis for this flight.

MISSION OBJECTIVES

- Deployment of Magellan spacecraft with IUS
- Secondary payloads
  - FEA
  - MLE
  - AMOS

DEVELOPMENT TEST OBJECTIVES

- Vibration and acoustic evaluation in payload bay
- Pogo stability, space shuttle main engine and orbiter structure
- Ascent debris
- Nose wheel steering
- Camcorder demonstration
- 10.2-psi cabin operations checkout, demonstration of LES hardware in preparation for STS-31 mission (Hubble Space Telescope)
- TDRS-to-TDRS handover
- Ku-band antenna friction test due to redesign and rerouting of cabling
- HUD backup to COAS for IMU aligns
- Text and graphics system continuation tests
- Payload and general-support computer evaluation
- Crosswind landing evaluation

DETAILED SUPPLEMENTARY OBJECTIVES

- In-flight salivary pharmacokinetics of scopolamine and dextroamphetamine
- Non-invasive estimation of central venous pressure during spaceflight
- In-flight holter monitoring (treadmill)
- Pre- and postflight cardiovascular assessment
- Influence of baroreflex function
- Documentary television
- Documentary motion picture photography
- Documentary still photography

Notes:

- Text and Graphics System. TAGS is the primary of text uplink and can only uplink images using Ku-band. TAGS consists of a facsimile scanner on the ground that sends text and graphics through the Ku-band communications system to the text and graphics hard copier in the orbiter. The hard copier is installed on a dual cold plate in avionics bay 3 of the crew compartment middeck and provides an on-orbit capability to transmit text material, maps, schematics, maneuver pads, general messages, crew procedures, trajectory and photographs to the orbiter through the two-way Ku-band link using the TDRS system. It is a high-resolution facsimile system that scans text or graphics and converts the analog scan data into serial digital data. Transmission time for an 8.5- by 11-inch page can vary from approximately one minute to 16 minutes, depending on the hard-copy resolution desired.

The text and graphics hard copier operates by mechanically feeding paper over a fiber-optic cathode-ray tube and then through a heater-developer. The paper then is cut and stored in a tray accessible to the flight crew. A maximum of 200 8.5- by 11-inch sheets are stored. The status of the hard copier is indicated by front panel lights and downlink telemetry.

The hard copier can be powered from the ground or by the crew.

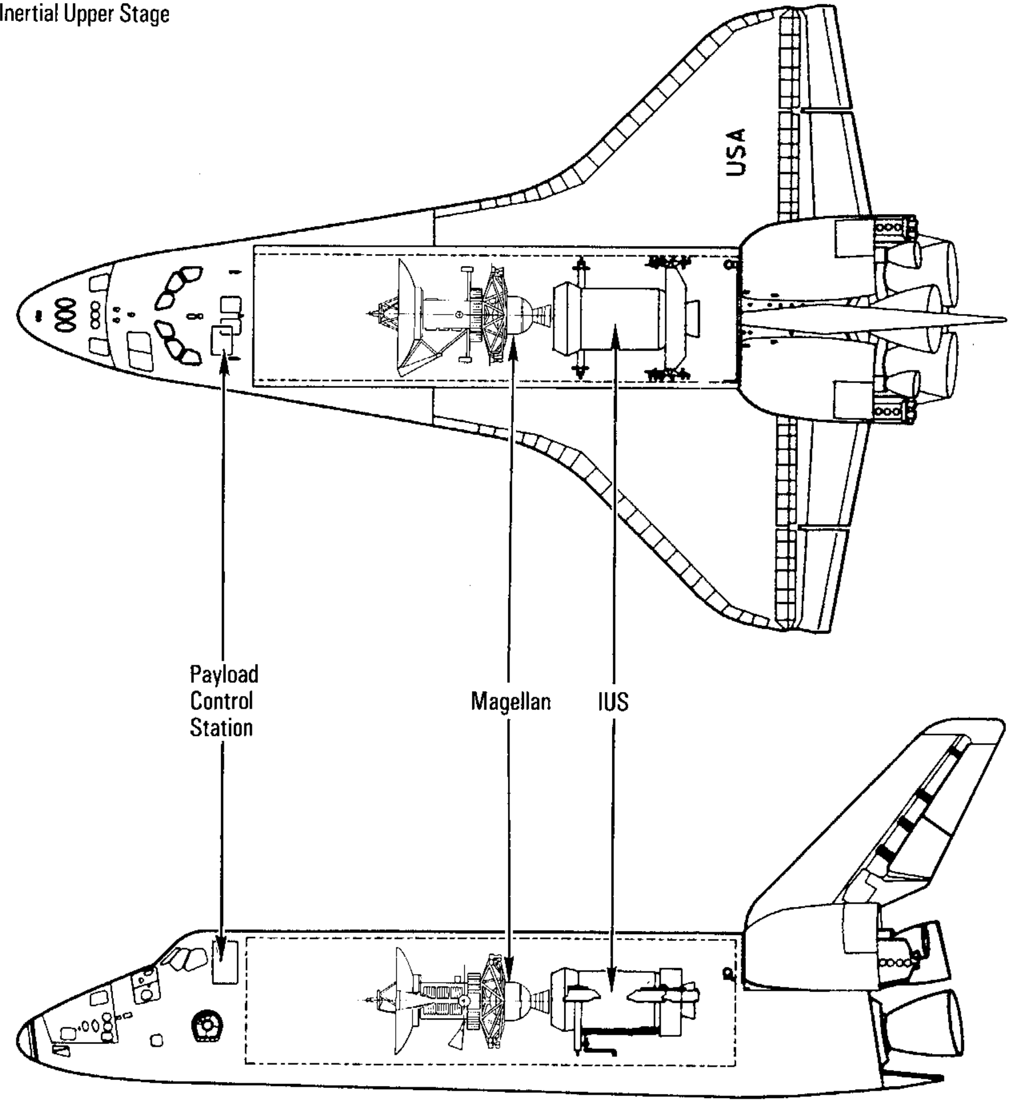
Uplink operations are controlled by the Mission Control Center in Houston. Mission Control powers up the hard copier and then sends the message. In the onboard system, light-sensitive paper is exposed, cut and developed. The message is then sent to the paper tray, where it is retrieved by the flight crew.

- Teleprinter. The teleprinter will provide a backup on-orbit capability to receive and reproduce text-only data, such as procedures, weather reports and crew activity plan updates or changes, from the Mission Control Center in Houston. The teleprinter uses S-band and is not dependent on TDRS Ku-band. It is a modified teletype machine located in a locker in the crew compartment middeck.

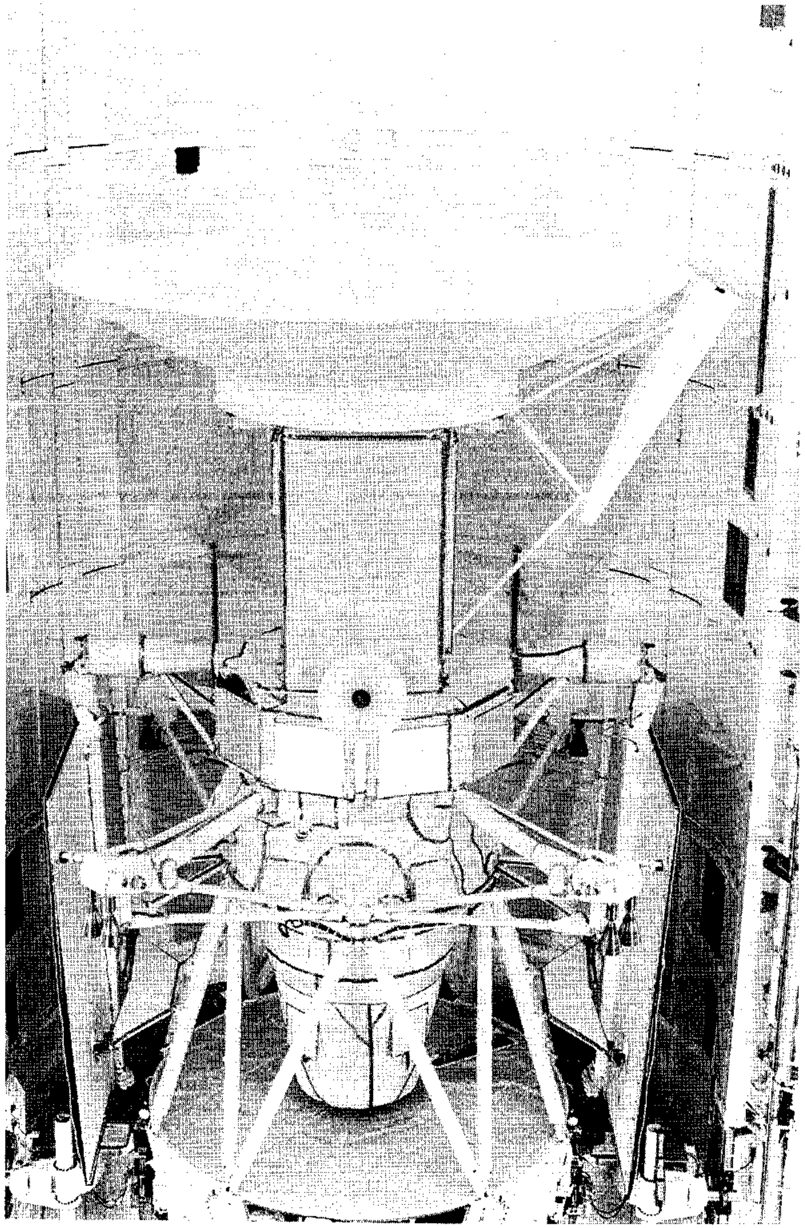
The teleprinter uplink requires one to 2.5 minutes per message, depending on the number of lines (up to 66). When the ground has sent a message, a *msg rcv* yellow light on the teleprinter is illuminated to indicate a message is waiting to be removed.

STS-30 PAYLOAD CONFIGURATION

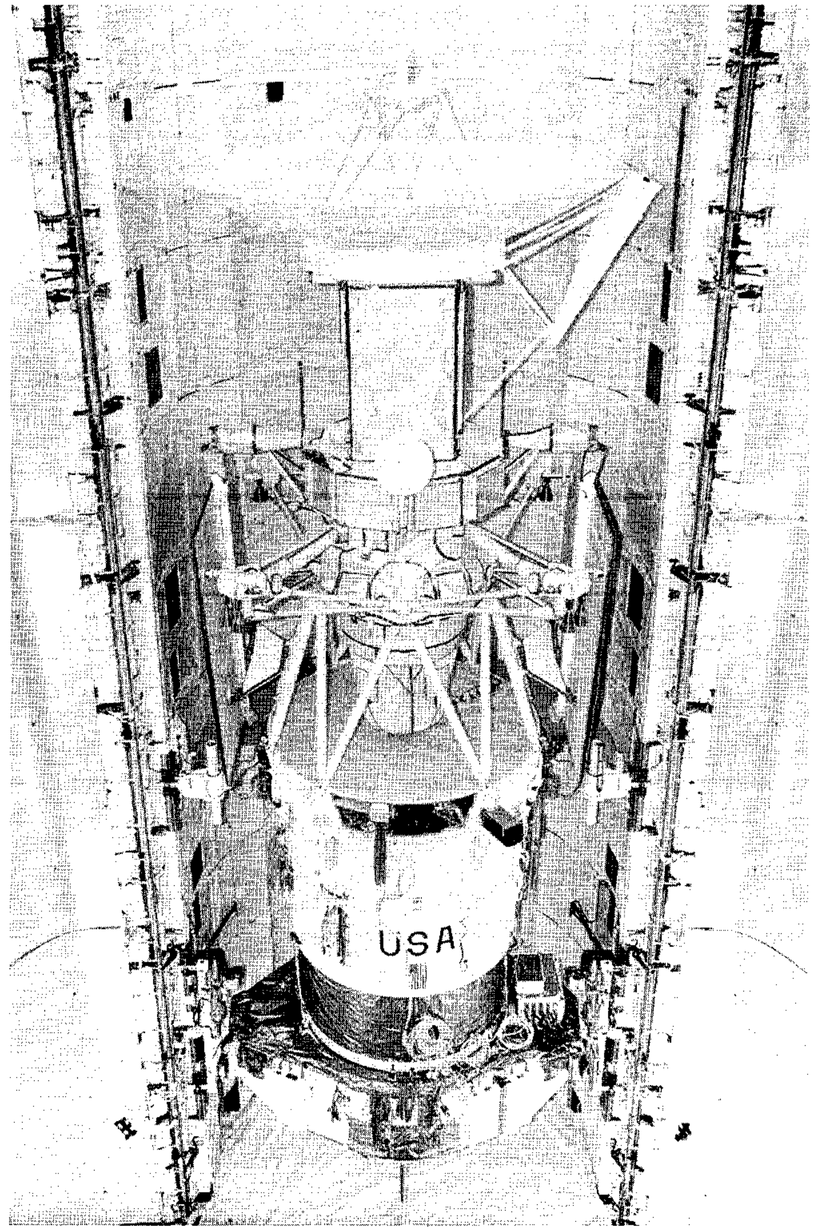
IUS — Inertial Upper Stage



Side View—Orbiter Payload Locations



Magellan Spacecraft in Atlantis' Payload Bay



Magellan Spacecraft With Inertial Upper Stage in Atlantis' Payload Bay

INERTIAL UPPER STAGE

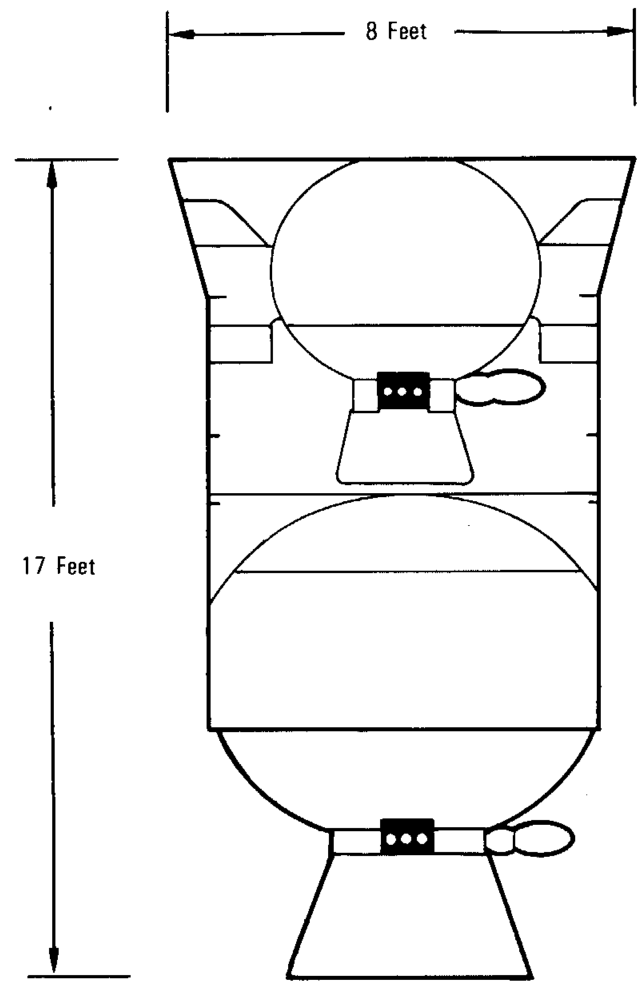
The inertial upper stage is used with the space shuttle to transport NASA's Tracking and Data Relay satellites to geosynchronous orbit, 22,300 statute miles from Earth. The IUS was also selected by NASA for the Magellan, Galileo and Ulysses planetary missions.

The IUS was originally designed as a temporary stand-in for a reusable space tug and was called the interim upper stage. Its name was changed to inertial upper stage (signifying the satellite's guidance technique) when it was realized that the IUS would be needed through the mid-1990s.

The IUS was developed and built under contract to the Air Force Systems Command's Space Division. The Space Division is executive agent for all Department of Defense activities pertaining to the space shuttle system and provides the IUS to NASA for space shuttle use. In August 1976, after 2.5 years of competition, Boeing Aerospace Company, Seattle, Wash., was selected to begin preliminary design of the IUS.

The IUS is a two-stage vehicle weighing approximately 32,500 pounds. Each stage is a solid rocket motor. This design was selected over those with liquid-fueled engines because of its relative simplicity, high reliability, low cost and safety.

The IUS is 17 feet long and 9.5 feet in diameter. It consists of an aft skirt, an aft stage SRM with 21,400 pounds of propellant generating 45,600 pounds of thrust, an interstage, a forward stage SRM with 6,000 pounds of propellant generating 18,500 pounds of thrust and using an extendable exit cone, and an equipment support section. The equipment support section contains the avionics that provide guidance, navigation, telemetry, command and data management, reaction control and electrical power. All mission-critical components of the avionics system and thrust vector actuators, reaction control thrusters, motor igniter and pyrotechnic stage separation equipment are redundant to ensure better than 98-percent reliability.



Inertial Upper Stage

FLIGHT SEQUENCE

After the orbiter's payload bay doors are opened in Earth orbit, the orbiter maintains a preselected attitude to fulfill payload thermal requirements and constraints except during those operations that require special attitudes (e.g., orbiter inertial measurement unit alignments, RF communications and deployment operations).

On-orbit predeployment checkout is followed by an IUS command link check and spacecraft RF command check, if required. The state vector is uplinked to the orbiter for trim maneuvers the orbiter performs. The state vector is transferred to the IUS.

The forward airborne support equipment payload retention latch actuator is released, and the aft frame ASE electromechanical tilt actuator tilts the IUS and spacecraft combination to 29 degrees. This extends the spacecraft into space just outside the orbiter payload bay, which allows direct communication with Earth during systems checkout. The orbiter is then maneuvered to the deployment attitude. If a problem develops within the spacecraft or IUS, they can be restowed.

Before deployment, the flight crew switches the spacecraft's electrical power source from orbiter power to IUS internal power. Verification that the spacecraft is on IUS internal power and that all IUS and spacecraft predeployment operations have been successfully completed is ascertained by evaluating data contained in the IUS and spacecraft telemetry. IUS telemetry data are evaluated by the IUS Mission Control Center at Sunnyvale, Calif., and the spacecraft data by the spacecraft control center. Analysis of the telemetry results in a go/no-go decision for IUS and spacecraft deployment from the orbiter.

When the orbiter flight crew is given a go decision, the orbiter flight crew activates the ordnance that separates the IUS and spacecraft's umbilical cables. The flight crew then commands the electromechanical tilt actuator to raise the tilt table to a 52-degree deployment position. The orbiter's reaction control system thrusters are inhibited, and the Super*zip ordnance separation device physically separates the IUS and spacecraft combination from the tilt table. Compressed springs provide the force to jettison the IUS and spacecraft from the orbiter payload bay at approximately 0.4 foot per second. The IUS and spacecraft are deployed in the shadow of the orbiter or in Earth eclipse. The tilt table is lowered to minus 6 degrees after deployment. Approximately 19 minutes after deployment, the orbiter's orbital maneuvering system engines are ignited to separate the orbiter from the IUS and spacecraft.

The IUS and spacecraft are now controlled by computers on board the IUS. Approximately 10 minutes after the IUS and spacecraft are ejected from the orbiter, the IUS onboard computers send out discrete signals that are used by the IUS or spacecraft to begin mission sequence events. All subsequent operations are sequenced by the IUS computer from transfer orbit injection through spacecraft separation and IUS deactivation. Following RCS activation, the IUS maneuvers to the required thermal attitude and performs any required spacecraft thermal control maneuver.

Approximately 45 minutes after IUS and spacecraft ejection from the orbiter, the SRM-1 ordnance inhibits are removed. At this time, the bottom of the orbiter is oriented toward the IUS and spacecraft to protect the orbiter windows from the IUS SRM-1 plume. The IUS then recomputes SRM-1 ignition time and maneuvers to the proper attitude for the SRM-1 thrusting period. When the transfer orbit or planetary trajectory injection opportunity is reached, the IUS computer enables and applies ordnance power, arms the safe and arm devices and ignites the first-stage SRM. The IUS second-stage SRM is ignited approximately two minutes after SRM first-stage cutoff to provide sufficient thrust for the predetermined contribution of thrust for planetary trajectory for planetary missions.

The IUS then supports spacecraft separation and performs a final collision and contamination avoidance maneuver before deactivating its subsystems.

Boeing's propulsion team member, Chemical Systems Division of United Technologies, designed and tests the two solid rocket motors. Supporting Boeing in the avionics area are TRW, Cubic and the Hamilton Standard Division of United Technologies. TRW and Cubic provide IUS telemetry, tracking and command subsystem hardware. Hamilton Standard provides guidance system hardware support. Delco, under subcontract to Hamilton Standard, provides the avionics computer.

In addition to the actual flight vehicles, Boeing is responsible for the development of ground support equipment and software for the checkout and handling of the IUS vehicles from factory to launch pad.

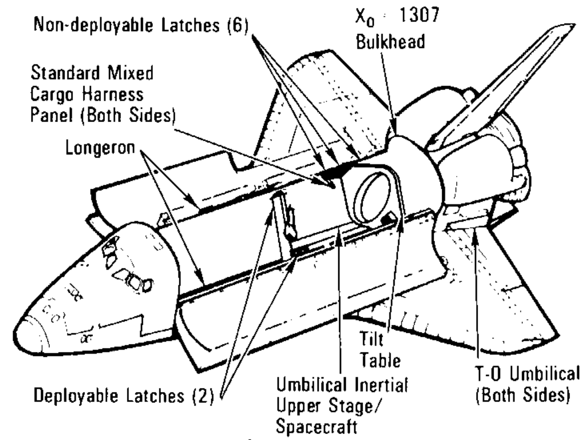
Boeing also integrates the IUS with various satellites and joins the satellite with the IUS, checks out the configuration and supports launch and mission control operations for both the Air Force and NASA. Boeing also develops airborne support equipment to support the IUS in the space shuttle and monitors it while it is in the orbiter payload bay.

The IUS, without the two SRMs, is fabricated and tested at the Boeing Space Center, Kent, Wash. SRMs are shipped directly from Chemical Systems Division in California to the eastern launch site at Cape Canaveral, Fla. Similarly, the Boeing-manufactured IUS subsystems are shipped from Washington to the eastern launch site. IUS/SRM buildup is done in the Solid Motor Assembly Building and the IUS and spacecraft are mated in the Vertical Processing Facility at the Kennedy Space Center. The combined IUS and spacecraft payload is installed in the orbiter at the launch pad. Boeing is building 22 IUS vehicles under its contract with the Air Force.

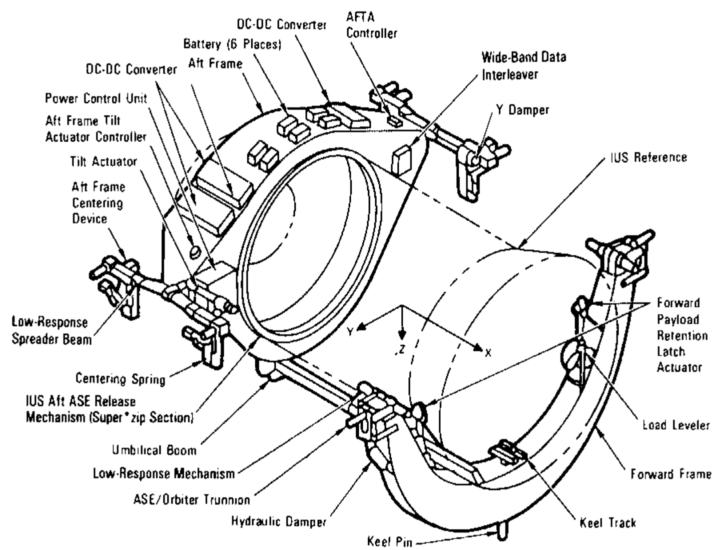
AIRBORNE SUPPORT EQUIPMENT

The IUS ASE is the mechanical, avionics and structural equipment located in the orbiter. The ASE supports and provides services to the IUS and the spacecraft in the orbiter payload bay and positions the IUS/spacecraft in an elevated position for final checkout before deployment from the orbiter.

The IUS ASE consists of the structure, batteries, electronics and cabling to support the IUS and spacecraft combination. These ASE subsystems enable the deployment of the combined vehicle and provide or distribute and control electrical power to the IUS and spacecraft and provide communication paths between the IUS, spacecraft and the orbiter.



Inertial Upper Stage Airborne Support Equipment



Inertial Upper Stage Airborne Support Equipment

The ASE incorporates a low-response spreader beam and torsion bar mechanism that reduces spacecraft dynamic loads to less than one-third what they would be without this system. In addition, the forward ASE frame includes a hydraulic load leveler system to provide balanced loading at the forward trunnion fittings.

The ASE data subsystem allows data and commands to be transferred between the IUS and spacecraft and the appropriate orbiter interface. Telemetry data include spacecraft data received over dedicated circuits via the IUS and spacecraft telemetry streams. An interleaved stream is provided to the orbiter to transmit to the ground or transfer to ground support equipment.

The structural interfaces in the orbiter payload bay consist of six standard non-deployable attach fittings on each longeron that mate with the ASE aft and forward support frame trunnions and two payload retention latch actuators at the forward ASE support frame. The IUS has a self-contained, spring-actuated deployment system that imparts a velocity to the IUS at release from the raised deployment attitude. Ducting from the orbiter purge system interfaces with the IUS at the forward ASE.

IUS STRUCTURE

The IUS structure is capable of transmitting all of the loads generated internally and also those generated by the cantilevered spacecraft during orbiter operations and IUS free flight. In addition, the structure supports all of the equipment and solid rocket motors within the IUS and provides the mechanisms for IUS stage separation. The major structural assemblies of the two-stage IUS are the equipment support section, interstage and aft skirt. The basic structure is aluminum skin-stringer construction with six longerons and ring frames.

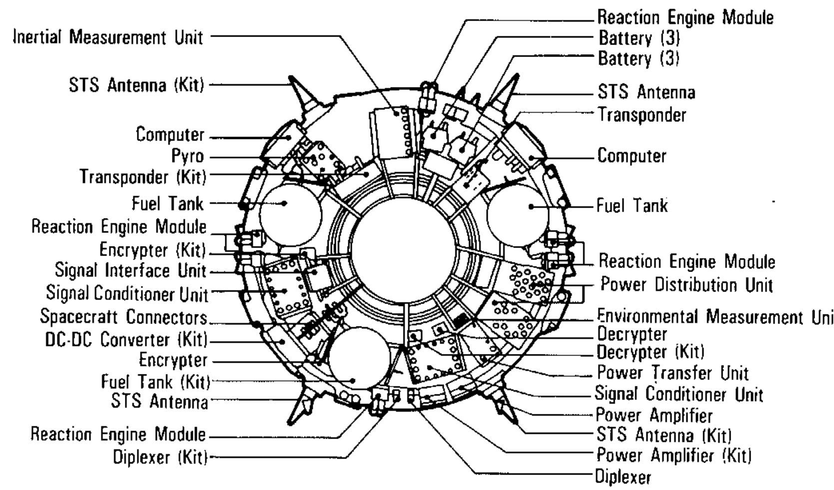
EQUIPMENT SUPPORT SECTION

The ESS houses the majority of the IUS avionics and control subsystems. The top of the ESS contains the 10-foot-diameter interface mounting ring and electrical interface connector segment for mating and integrating the spacecraft with the IUS. Thermal isolation is provided by a multilayer insulation blanket across the interface between the IUS and spacecraft. All line replaceable units mounted in the ESS can be removed and replaced via access doors even when the IUS is mated with the spacecraft.

IUS AVIONICS SUBSYSTEM

The avionics subsystem consists of the telemetry, tracking and command; guidance and navigation; data management; thrust vector control; and electrical power subsystems. This includes all of the electronic and electrical hardware used to perform all computations, signal conditioning, data processing and software formatting associated with navigation, guidance, control, data management and redundancy management. The IUS avionics subsystem also provides the communications between the orbiter and ground stations and electrical power distribution.

Data management performs the computation, data processing and signal conditioning associated with guidance, navigation and control; safing and arming and ignition of the IUS two-stage solid rocket motors and electroexplosive devices; command decod-



Inertial Upper Stage Equipment Support Section ing and telemetry formatting; and redundancy management and issues spacecraft discretes. The data management subsystem consists of two computers, two signal conditioner units and a signal interface unit.

Modular general-purpose computers use operational flight software to perform in-flight calculations and to initiate the vehicle thrust and attitude control functions necessary to guide the IUS and spacecraft through a flight path determined on board to a final orbit or planned trajectory. A stored program, including data known as the onboard digital data load, is loaded into the IUS flight computer memory from magnetic tape through the memory load unit during prelaunch operations. Memory capacity is 65,536 (64K) 16-bit words.

The SCU provides the interface for commands and measurements between the IUS avionics computers and the IUS pyrotechnics, power, reaction control system, thrust vector control, TT&C and the spacecraft. The SCU consists of two channels of signal conditioning and distribution for command and measurement functions. The two channels are designated A and B. Channel B is redundant to channel A for each measurement and command function.

The signal interface unit performs buffering, switching, formatting and filtering of TT&C interface signals.

Communications and power control equipment is mounted at the orbiter aft flight deck payload station and operated in flight by the orbiter flight crew mission specialists. Electrical power and signal interfaces to the orbiter are located at the IUS equipment connectors. Cabling to the orbiter equipment is provided by the orbiter. In addition, the IUS provides dedicated hardwires from the spacecraft through the IUS to an orbiter multiplexer/demultiplexer for subsequent display on the orbiter cathode-ray tube of parameters requiring observation and correction by the orbiter flight crew. This capability is provided until IUS ASE umbilical separation.

To support spacecraft checkout or other IUS-initiated functions, the IUS can issue a maximum of eight discretes. These discretes may be initiated either manually by the orbiter flight crew before the IUS is deployed from the orbiter or automatically by the IUS mission-sequencing flight software after deployment. The discrete commands are generated in the IUS computer either as an event-scheduling function (part of normal onboard automatic sequencing) or a command-processing function initiated from an uplink command from the orbiter or Air Force Consolidated Satellite Test Center to alter the onboard event-sequencing function and permit the discrete commands to be issued at any time in the mission.

During the ascent phase of the mission, the spacecraft's telemetry is interleaved with IUS telemetry, and ascent data are provided to ground stations in real time via orbiter downlink. Telemetry transmission on the IUS RF link begins after the IUS and spacecraft are tilted for deployment from the orbiter. Spacecraft data may be transmitted directly to the ground when the spacecraft is in the orbiter payload bay with the payload bay doors open or during IUS and spacecraft free flight.

IUS guidance and navigation consist of strapped-down redundant inertial measurement units. The redundant IMUs consist of five rate-integrating gyros, five accelerometers and associated electronics. The IUS inertial guidance and navigation subsystem provides measurements of angular rates, linear accelerations and other sensor data to data management for appropriate processing by software resident in the computers. The electronics provides conditioned power, digital control, thermal control, synchronization and the necessary computer interfaces for the inertial sensors. The electronics are configured to provide three fully independent channels of data to the computers. Two channels each support two sets of sensors and the third channel supports one set. Data from all five gyro and accelerometer sets are sent simultaneously to both computers.

The guidance and navigation subsystem is calibrated and aligned on the launch pad. The navigation function is initialized at lift-off, and data from the redundant IMUs are integrated in the navigation software to determine the current state vector. Before vehicle deployment, an attitude update maneuver may be performed by the orbiter.

If for any reason the computer is powered down before deployment, the navigation function is reinitialized by transferring orbiter position, velocity and attitude data to the IUS vehicle. Attitude updates are then performed as described above.

The IUS vehicle uses an explicit guidance algorithm (gamma guidance) to generate thrust steering commands, SRM ignition time and RCS vernier thrust cutoff time. Before each SRM ignition and each RCS vernier, the vehicle is oriented to a thrust attitude based on nominal performance of the remaining propulsion stages. During SRM burn, the current state vector determined from the navigation function is compared to the desired state vector, and the commanded attitude is adjusted to compensate for the buildup of position and velocity errors caused by off-nominal SRM performance (thrust, specific impulse).

Vernier thrust compensates for velocity errors resulting from SRM impulse and cutoff time dispersions. Residual position errors from the SRM thrusting and position errors introduced by impulse and cutoff time dispersions are also removed by the RCS.

Attitude control in response to guidance commands is provided by thrust vector control during powered flight and by reaction control thrusters during coast. Measured attitude from the guidance and navigation subsystem is compared with guidance commands to generate error signals. During solid motor thrusting, these error signals drive the motor nozzle actuator electronics in the TVC subsystem. The resulting nozzle deflections produce the desired attitude control torques in pitch and yaw. Roll control is maintained by the RCS roll-axis thrusters. During coast flight, the error signals are processed in the computer to generate RCS thruster commands to maintain vehicle attitude or to maneuver the vehicle. For attitude maneuvers, quarternion rotations are used.

TVC provides the interface between IUS guidance and navigation and the SRM gimbaled nozzle to accomplish powered-flight attitude control. Two complete electrically redundant channels minimize single-point failure. The TVC subsystem consists of two controllers, two actuators and four potentiometers for each IUS SRM. Power is supplied through the SCU to the TVC controller that controls the actuators. The controller receives analog pitch and yaw commands that are proportioned to the desired nozzle angle and converts them to pulsewidth-modulated voltages to power the actuator motors. The motor drives a ball screw that extends or retracts the actuator to position the SRM nozzle. Potentiometers provide servoloop closure and position instrumentation. A staging command from the SCU allows switching of the controller outputs from IUS first-stage actuators to the IUS second-stage actuators.

The IUS's electrical power subsystem consists of avionics batteries, IUS power distribution units, power transfer unit, utility batteries, pyrotechnic switching unit, IUS wiring harness and umbilical, and staging connectors. The IUS avionics subsystem distributes electrical power to the IUS and spacecraft interface connector for all mission phases from prelaunch to spacecraft separation. The IUS system distributes orbiter power to the spacecraft during ascent and on-orbit phases. ASE batteries supply power to the spacecraft if orbiter power is interrupted. Dedicated IUS and spacecraft batteries ensure uninterrupted power to the spacecraft after deployment from the orbiter. The IUS will also accomplish an automatic power-down if high-temperature limits are experienced before the orbiter payload bay doors are opened. Dual buses ensure that no single power system failure can disable both A and B channels of avionics. For the IUS two-stage vehicle, four batteries (three avionics and one spacecraft) are carried in the IUS first stage. Five batteries (two avionics, two utility and one spacecraft) supply power to the IUS second stage after staging. The IUS battery complement can be changed to adapt to mission-unique requirements and to provide special spacecraft requirements. Redundant IUS switches transfer the power input among spacecraft, ground support equipment, ASE and IUS battery sources.

Stage 1 to stage 2 IUS separation is accomplished via redundant low-shock ordnance devices that minimize the shock environment on the spacecraft. The IUS provides and distributes ordnance power to the IUS/spacecraft interface for firing spacecraft ordnance devices in two groups of eight initiators: a prime group and a backup group. Four separation switches, or breakwires, provided by the spacecraft are monitored by the IUS telemetry system to verify spacecraft separation.

IUS SOLID ROCKET MOTORS

The two-stage IUS vehicle incorporates a large SRM and a small SRM. These motors employ movable nozzles for thrust vector control. The nozzles are positioned by redundant electromechanical actuators, permitting up to 4 degrees of steering on the large motor and 7 degrees on the small motor. Kevlar filament-wound cases provide high strength at minimum weight. The large motor's 145-second thrusting period is the longest ever developed for space. Variations in user mission requirements are met by tailored propellant off-loading or on-loading. The small motor can be flown either with or without its extendable exit cone, which provides an increase of 14.5 seconds in the delivered specific impulse of the small motor.

IUS REACTION CONTROL SYSTEM

The IUS RCS is a hydrazine monopropellant positive-expulsion system that controls the attitude of the IUS and spacecraft during IUS coast periods, roll during SRM thrustings and delta velocity impulses for accurate orbit injection. Valves and thrusters are redundant, which permits continued operation with a minimum of one failure.

The IUS baseline includes two RCS tanks with a capacity of 120 pounds of hydrazine each. Production options are available to add a third tank or remove one tank if required. To avoid spacecraft contamination, the IUS has no forward-facing thrusters. The system is also used to provide the velocities for spacing between multiple spacecraft deployments and for a collision/contamination avoidance maneuver after spacecraft separation.

The RCS is a sealed system that is serviced before spacecraft mating. Propellant is isolated in the tanks with pyrotechnic squib-operated valves that are not activated until 10 minutes after IUS deployment from the orbiter. The tank and manifold safety factors are such that no safety constraints are imposed on operations in the vicinity of the serviced tanks.

IUS-TO-SPACECRAFT INTERFACES

The spacecraft is attached to the IUS at a maximum of eight attachment points. They provide substantial load-carrying capability while minimizing thermal transfer across the interface.

Power and data transmission to the spacecraft are provided by several IUS interface connectors. Access to these connectors can be provided on the spacecraft side of the interface plane or through the access door on the IUS equipment bay.

The IUS provides a multilayer insulation blanket of aluminized Kapton with polyester net spacers and an aluminized beta cloth outer layer across the IUS and spacecraft interface. All IUS thermal blankets are vented toward and into the IUS cavity. All gases within the IUS cavity are vented to the orbiter payload bay. There is no gas flow between the spacecraft and the IUS. The thermal blankets are grounded to the IUS structure to prevent electrostatic charge buildup.

MAGELLAN SPACECRAFT

MISSION GOALS

Magellan is a project designed to send a spacecraft containing a synthetic aperture radar system to map the surface of Venus. Radar is used to map Venus because the cloud cover of the planet obscures direct vision of the surface. SAR penetrates the clouds to obtain swaths of high-resolution images of the planet's surface.

SAR was first used by NASA on the Seasat oceanographer satellite in 1978. Shuttle imaging radar-A flew in the space shuttle Columbia's payload bay during the STS-2 mission in November 1981 and SIR-B flew in the space shuttle Challenger's payload bay during the STS-41G mission in October 1984. Aerial tests of SIR over the cloud-covered rain forests of Guatemala produced images that revealed agricultural canals dug by the Mayan civilization.

Seasat, SIR-A and B were managed by the Jet Propulsion Laboratory, Pasadena, Calif., for NASA's Office of Space and Terrestrial Applications. The Magellan project is also managed by JPL for NASA's Office of Space Science and Applications.

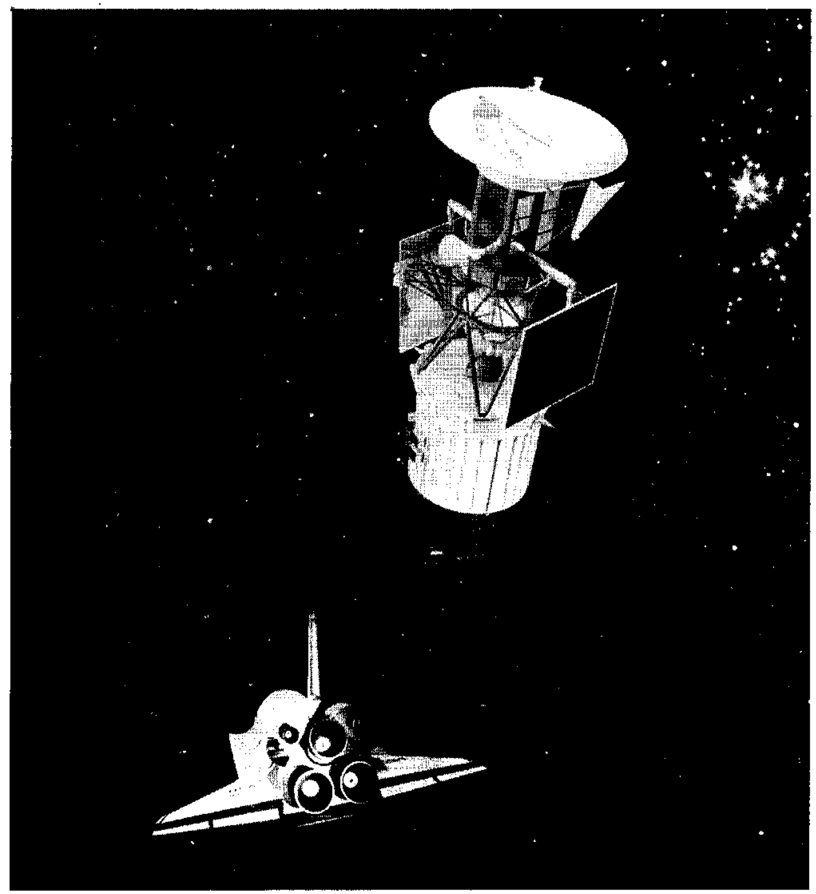
The prime contractor for the Magellan spacecraft is Martin Marietta Corporation. The prime contractor for the radar system aboard the Magellan spacecraft is Hughes Aircraft Company.

The spacecraft is based on existing hardware designs and incorporates a considerable amount of spare hardware from earlier projects. Its high-gain antenna is a 12-foot-diameter antenna from Voyager and is used for both radar mapping and data communications back to Earth. The primary structure and the small thrusters are also Voyager spares. Its command data system, attitude control computer and power-distribution units are spare parts from the Galileo project. Its medium-gain antenna is from the Mariner 9 project.

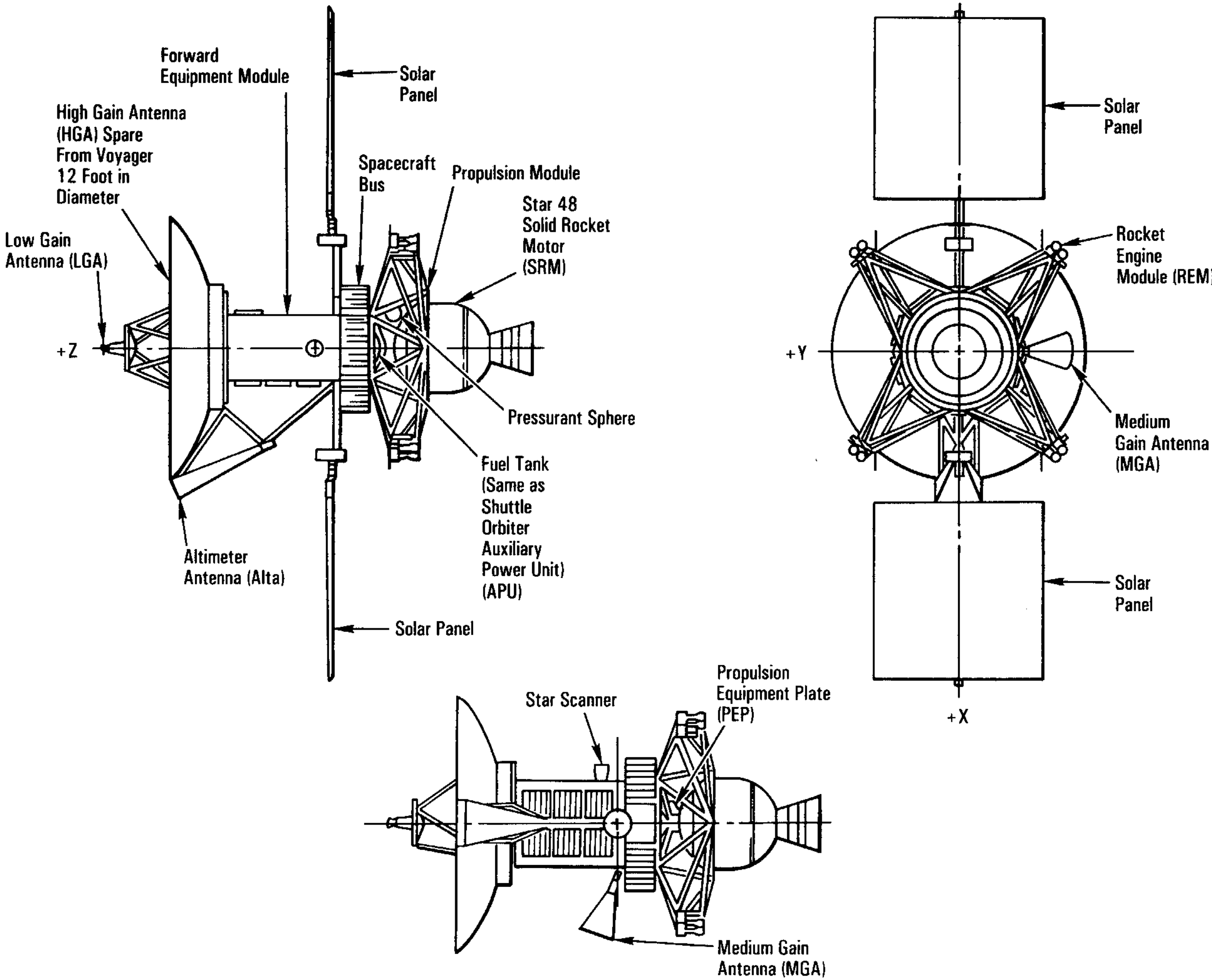
The launch vehicle for the Magellan spacecraft is the Atlantis orbiter combined with the IUS two-stage SRM attached to the Magellan spacecraft. The IUS replaces the canceled Centaur upper-stage vehicle.

The nominal launch period for the Magellan spacecraft will open on April 28, 1989, and will close on May 23, 1989. Launch of Atlantis with its primary payload of the Magellan spacecraft and IUS will be from Launch Complex 39-B. Atlantis will carry the combined primary payload into a 160-nautical-mile (184-statute-mile) circular Earth orbit.

The nominal deployment of the Magellan spacecraft and IUS from Atlantis' payload bay is scheduled on orbit 5 at a mission

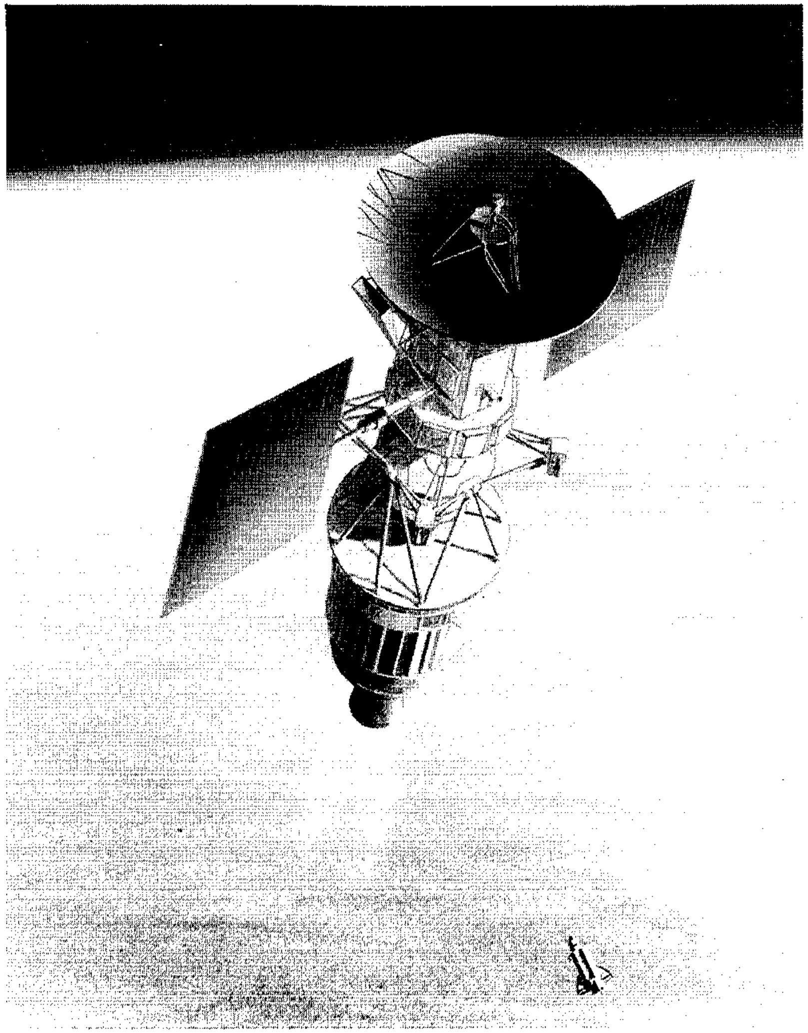


IUS/Magellan Spacecraft Deployment From Atlantis



Major Components of the Magellan Spacecraft elapsed time of six hours and 18 minutes. Backup deployment opportunities are available on orbits 6, 7 and 16 with a contingency capability on orbit 17.

After deployment of the Magellan spacecraft and IUS from Atlantis, ignition of the IUS first-stage SRM will occur at approxi-



Magellan Cruise Configuration

mately seven hours and 13 minutes MET. Ignition of the IUS second-stage SRM will occur at approximately seven hours and 18 minutes MET. Upon the completion of these two thrusting periods, the Magellan spacecraft will be injected into orbit and will intercept a hyperbolic Earth escape vector on its way to Venus. At approximately seven hours and 39 minutes MET, the IUS will separate from the Magellan spacecraft. Near-Earth coverage of the IUS/Magellan spacecraft separation event will be provided by both deep-space network and non-DSN ground stations.

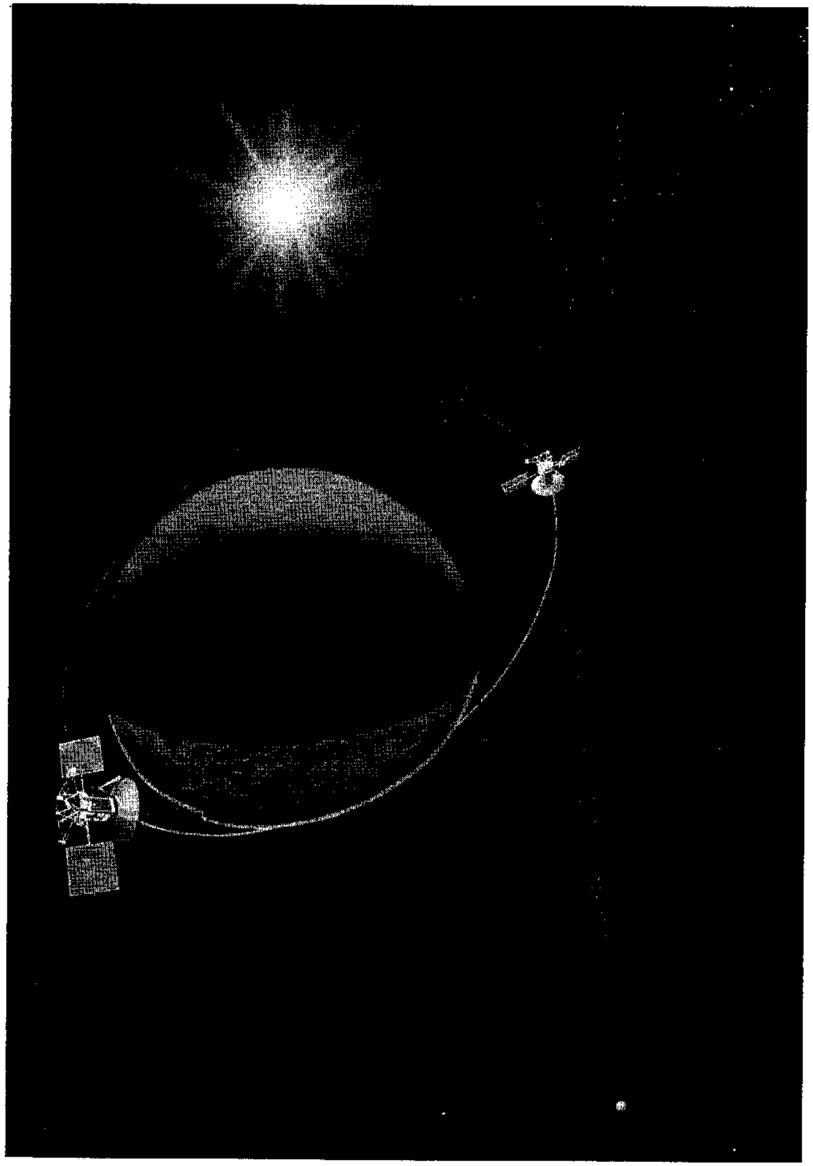
After leaving the gravitational influence of Earth, the spacecraft will cruise to Venus for 15 months. The spacecraft will orbit the Sun approximately 1.6 times before encountering Venus.

During the voyage, no scientific experiments are planned; however, there are periodic checks and calibrations of the gyros, antennas, clock and spacecraft mass properties. Selected collection periods of very long baseline interferometry data are also scheduled to refine knowledge of the orbit along with three trajectory correction maneuvers. The first maneuver, injection plus 15 days, will correct for errors from the injection thrust maneuver. The second maneuver, injection plus 360 days, will further refine the transfer orbit. The final TCM, 17 days before Venus orbit insertion, will ensure correct arrival conditions and will mark the end of the cruise phase. The spacecraft's arrival time is selected to maximize simultaneous coverage of pre-VOI thrusting period activities by the Goldstone and Madrid DSN stations. The actual VOI thrusting period will occur behind Venus as seen from Earth.

The Star 48 SRM and onboard hydrazine on the Magellan spacecraft will provide the required thrust to insert the spacecraft into orbit when it arrives at Venus on August 10, 1990. A nominal orbit trim maneuver provides for adjustment to three orbit parameters. OTM-1, near apoapsis, primarily corrects for periapsis altitude and latitude. OTM-2, near periapsis, corrects for orbit period and inclination.

The orbit will be inclined 86 degrees to the Venus equator to ensure the coverage of the north pole. The spacecraft will be placed in an elliptical orbit around Venus of 134 nautical miles

(155 statute miles) and 4,335 nautical miles (4,989 statute miles). The spacecraft will complete one orbit every three hours and nine



Magellan in Elliptical Orbit Around Venus

minutes. The spacecraft will orbit Venus for 243 Earth days, one Venus day, on its primary mission. During that time, it will map from 70 to 90 percent of Venus' surface.

When the spacecraft orbit is close to Venus, SAR will image a swath between 9 and 15 nautical miles (10 and 17 statute miles), beginning at or near the north pole and continuing into the southern hemisphere. Subsequent swaths will slightly overlap and, during its primary mission, the spacecraft will map most of the planet.

When the spacecraft moves into the part of its elliptical orbit farthest from Venus, the spacecraft high-gain antenna will be turned towards Earth and will send the data collected during the imaging to Earth. The spacecraft will also locate certain stars in the sky during this time to make sure its attitude is correct and then the vehicle will continue its orbit for another imaging swath. These swaths will be used to put together mosaics of Venus that will be made into maps of the planet. If a further mission cycle of the spacecraft is approved, the spacecraft will map areas previously missed and will perform gravity experiments.

SAR sends out millions of radio energy pulses each second at an angle across its target swath. The signals bounce off the target and are detected by the spacecraft's high-gain antenna. Part of the SAR is its altimeter, which sends radio signals straight down and receives them back to determine the altitude of features. A separate, smaller antenna, attached to the high-gain antenna, is used for this function.

SAR also measures the time the signal takes to make the round trip between the antenna and the ground. It also measures the Doppler shift, a measurement of relative motion that is akin to a change in pitch, as the radar and the target pass each other. With these data, it forms a two-dimensional image of the surface characteristics.

Between the pulses sent out by SAR, the spacecraft antenna is passive and, in that mode, reads the brightness, or thermal wavelengths, emanating from the surface. From that study, called radiometry, scientists can infer the composition of the surface material.

Gravity measurements are made by radio. Radio telescopes on Earth will measure the Doppler changes that occur when the spacecraft speeds up or slows down while passing over certain features. This study will help determine the interior composition of Venus.

While different in many ways, Venus and Earth do share some similarities. Earth is 6,887 nautical miles (7,926 statute miles) in diameter, while Venus is 6,534 nautical miles (7,520 statute miles) in diameter. Earth's density is 5.52 grams per cubic centimeter, while Venus' density is 5.24 grams per cubic centimeter. Earth is 80,770,511 nautical miles (92,957,200 statute miles) from the Sun, and Venus is 58,390,080 nautical miles (67,200,000 statute miles) from the Sun.

Despite the similarities, the differences are striking. Mariner 2, the first U.S. mission to another planet, passed Venus in December 1962 and found, along with subsequent missions, that the temperature of Venus is about 470°C (about 900°F) and the atmospheric pressure at the surface is 90 times greater than Earth's. In addition to the searing heat and crushing pressure, Venus has an atmosphere almost devoid of water. Its atmosphere is 97-percent carbon dioxide and its upper clouds contain sulfuric acid. Venus has no moons and no magnetic field has been detected. Venus rotates on its axis in a retrograde direction, which is opposite that of Earth and most of the other planets. Its rotation is once in 243 Earth days.

Scientists know that Earth and Venus accreted from the solar nebula about the same time, 4.6 billion years ago; and there are some indications that they may have been more similar in times past. Both planets are volcanic. Earth is still very much so, and it is not known for sure if Venus still has active volcanoes. However, radar scans from Earth and altimeter measurements by spacecraft have turned up a great mountain that may be the largest volcano in the solar system. In addition, radar scans show large land masses on Venus that rise above the lowlands. One such mass, called Ishtar Terra, is about the size of Australia. Another large high-altitude area is called Aphrodite.

Venus is the victim of a runaway greenhouse effect. The heat from the Sun is captured in the carbon dioxide atmosphere and is not radiated back into space. On Earth, much of the heat from the Sun is bounced back into space through the atmosphere of nitrogen and oxygen. The atmosphere reaches a state of temperature equilibrium when a certain amount of heat is absorbed.

Scientists know there is no water on Venus now, but it is not known if water has ever existed there. Magellan will search for signs that Venus once may have had oceans similar to, but smaller than, Earth's. If Venus did once have seas, their ancient shorelines would probably still be detectable in the radar images.

Scientists are looking to Magellan to answer some long-standing questions about our sister planet. They want to know what caused the greenhouse effect on Venus and if Venus was ever like Earth. On Earth, continents ride on great plates moving above the mantle. That movement is called tectonism. One of the unanswered questions is whether or not Venus has tectonic plates.

SPACECRAFT SYSTEMS

The high-gain antenna is used for either the SAR or for transmitting data to Earth. During the data acquisition (mapping) portion of an orbit, the spacecraft is oriented with the antenna toward Venus and the data are stored on tape recorders. When the antenna is oriented toward Earth, SAR data are played back to Earth.

The electrical power subsystem includes the single-degree-of-freedom Sun-tracking solar panels, rechargeable nickel-cadmium storage batteries and suitable control and distribution equipment. The solar panel area is 15 square feet.

The attitude control subsystem uses periodic Sun and star calibrations to update gyro references. Spacecraft torquing is done by means of three orthogonal reaction wheels with momentum unloading by means of hydrazine jets. The spacecraft is three axes stabilized. Pointing accuracy is 0.13 degree per axis in Venus orbit.

The propulsion subsystem includes the Star 48B SRM and a pressurized monopropellant system. Together, these two systems provide approximately 8,858 feet per second of velocity change to the spacecraft at VOI. Current plans call for the rocket casing to be jettisoned after the first OTM. The monopropellant system consists of 59 pounds of hydrazine and thrusters with thrust levels from 4 to 1,977 pounds. The thrusters are also used for TCMs during the Earth-to-Venus cruise phase of the mission and for trims after VOI for orbit mapping.

The telecommunications subsystem provides S- and X-band uplink and S- and K-band downlink. Commands are normally uplinked on S-band at 62.5 bits per second. Real-time engineering data are normally downlinked continuously on S-band at 1,200 bits per second. The X-band downlink allows stored radar and engineering data to be sent to Earth at 268.8 kilobits per second from Venus orbit. The telecommunications subsystem uses one low-gain antenna for uplink, a medium-gain antenna for uplink and downlink, and the high-gain antenna for uplink and downlink.

In addition to command and telemetry, the telecommunications subsystem also provides phase-coherent frequency transponding. Two-way Doppler S- and X-band uplink and S- and X-band downlink are used for navigation. X-band uplink and downlink are used for the gravity experiment and navigation, but with no redundancy.

The command and data handling subsystem directs activities for command and control, data acquisition and formatting and storage. The repetitive nature of command sequencing for each orbit permits up to four days of commands to be stored in the spacecraft. During mapping activities, engineering data at 1,200 bits per second are formatted with SAR data for a total recording rate of 806.4 kilobits per second. These data are stored on tape recorders with a combined capacity of 3.6×10^9 bits. The command and data handling subsystem also provides for data formatting, emergency telemetry and command, spacecraft timing and other functions.

Mosaic imaging of the SAR, radiometry and altimeter data functions are performed by the image data processing subsystem at JPL.

MESOCALE LIGHTNING EXPERIMENT

The Mesoscale Lightning Experiment objectives are to observe and record the visual characteristics of large-scale lightning as seen from space during nighttime using onboard payload bay TV cameras and 35mm cameras in order to develop a better understanding of this type of lightning

The payload bay TV cameras provide camera orientation data so that the locations and dimensions of observed lightning discharges can be readily determined from the video images.

The scientific objectives include the measurement of the horizontal dimensions of the cloud top optical emissions produced by lightning, the study of lightning activity in the intertropical convergence zone and over the oceans (data-sparse regions), the search for time-correlated lightning discharges, the correlation of video images with flash locations obtained from ground-based lightning detection systems and the simulation of global sampling strategies.

Targets of opportunities for storms observed to be producing lightning include storms directly under Atlantis' ground track, over land or water and oblique from Atlantis' ground track but near a ground-based lightning detection network (Marshall Space Flight Center, Kennedy Space Center, etc).

It is anticipated the MLE will be replaced with specialized instrumentation designed to provide quantitative lightning measurements.

AIR FORCE MAUI OPTICAL SITE CALIBRATION TEST

This experiment is a continuation of tests from the STS-29 mission that allows ground-based electro-optical sensors located on Mt. Haleakala, Maui, Hawaii, to collect imagery and signature data of Atlantis during cooperative overflights. The scientific observations made of Atlantis while it performs reaction control system thruster firings, water dumps or payload bay light activation are used to support the calibration of the AMOS sensors and the validation of spacecraft contamination models. The AMOS tests have no payload-unique flight hardware and only require that Atlantis be in predefined attitude operations and lighting conditions.

The AMOS facility was developed by Air Force Systems Command through its Rome Air Development Center at Griffiss Air Force Base, N.Y. It is administered and operated by the AVCO Everett Research Laboratory in Maui. The principal investigators for the AMOS tests on the space shuttle are from AFSC's Air Force Geophysics Laboratory, Hanscom Air Force Base, Mass., and AVCO.

Flight planning and mission support activities for the AMOS test opportunities are provided by a detachment of AFSC's Space Division at NASA's Johnson Space Center in Houston. Flight operations are conducted at NASA's Mission Control Center in coordination with the AMOS facilities located in Hawaii.

ON-ORBIT DEVELOPMENT TEST OBJECTIVES

KU-BAND ANTENNA FRICTION

The purpose of this DTO is to provide Ku-band antenna gimbal friction data after eight radar high speed scans.

HUD BACKUP TO COAS

This DTO will verify the suitability of the HUD as a star sighting device for IMU alignments.

TEXT AND GRAPHICS SYSTEM TEST (TAGS)

This DTO is designed to provide a significant confidence test and evaluation of TAGS under zero g and to generate data for comparison with data from 1g test conditions. Approximately 400 images will be sent.

PAYLOAD AND GENERAL SUPPORT COMPUTER EVALUATION

The payload and general support computer is a portable computer that provides a common crew interface for a variety of STS payloads. The PGSC will also be used to functionally replace the Shuttle portable onboard computer. The PGSC is a GRID CASE 1530 portable lap top computer. The purpose of this DTO is to evaluate the unique hardware aspects of the GRID CASE 1530, interactions with the middeck payloads, the crew functional interfaces.

TDRS TO TDRS HANDOVER DEMONSTRATION

The DTO will perform demonstrations of S-band and Ku-band TDRS to TDRS handover capability. Ku-band handovers will involve Ku-band Return link only.

8MM CAMCORDER DEMONSTRATION

The DTO will perform documentary cabin and exterior television. The equipment will be evaluated as a possible future enhancement to orbiter cabin television equipment.

OTHER

A helmet retention assembly and launch escape suit helmet prebreath rehearsal will be performed. During the prebreath, the cabin will be depressed to 10.2 psia according to the normal EVA prep protocol. The cabin will be repressed to 14.7 psia after approximately 24 hours. The test will determine helmet flowrates and suitability of the hardware to support EVA preparations.

IN-FLIGHT SALIVARY PHARMACOKINETICS OF SCOPOLAMINE AND DEXTROAMPHETAMINE

The purpose of this DSO is to investigate the pharamacokinetics of anti-motion sickness agents during space flight and predict the resultant therapeutic consequences. The crew member will take the drug after an eight-hour fast and take salivary samples at required intervals during the flight day.

NON-INVASIVE ESTIMATION OF CENTRAL VENOUS PRESSURE DURING SPACE FLIGHT

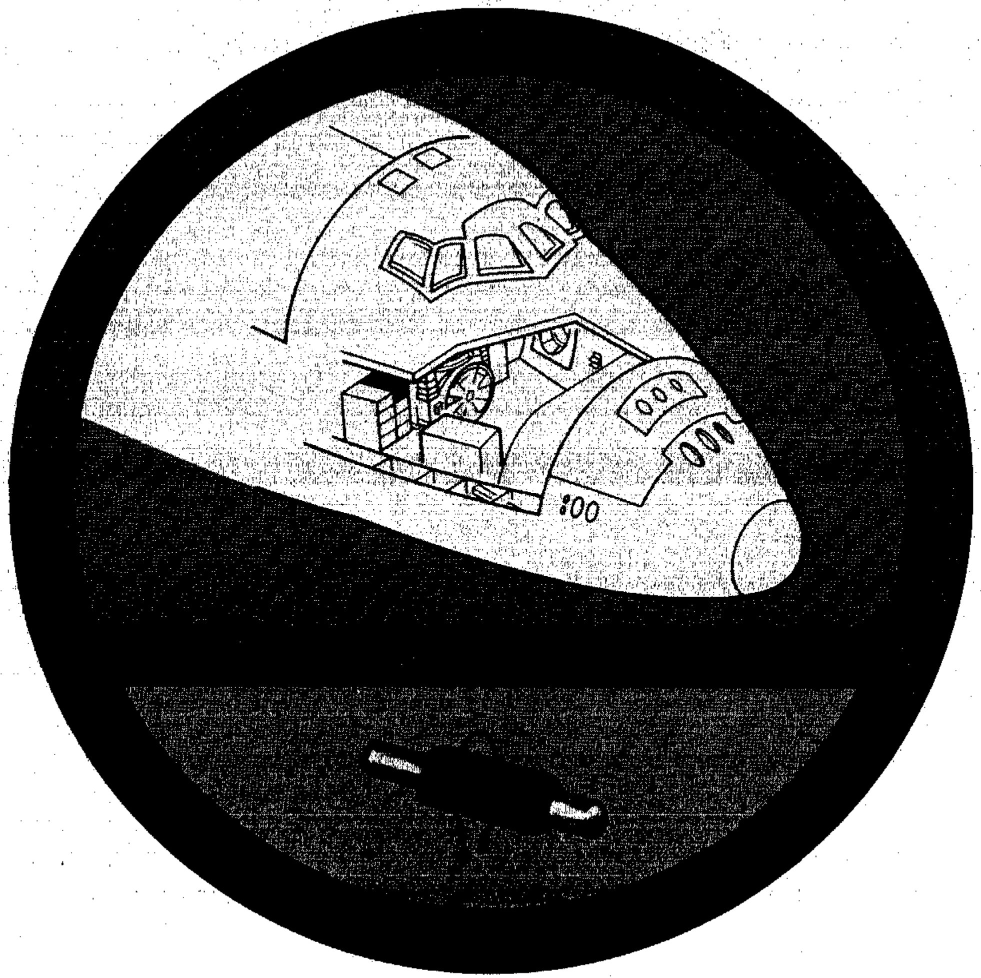
The objective of this investigation is to measure physiological adaptations to the headward fluid shift seen in microgravity. The non-invasive technique of determining central venous pressure uses a mouthpiece instrument utilizing Doppler flowmetry. The specified crew member will take measurements as early as possible on flight day 1 and before and after sleeping as time permits during the remainder of the flight.

IN-FLIGHT HOLTER MONITORING

The objective of this investigation is to document the frequency of cardiac rhythm abnormalities during space flight without the complicating factors of the extravehicular activity environment. It will record the electrocardiogram for at least 24 hours, including periods at rest, during treadmill exercise and after exercise.

PREFLIGHT ADAPTATION TRAINING

The purpose of this DSO is to obtain reactions to the stimulus rearrangement produced by a prototype trainer before and immediately following orbital flight. The bulk of this DSO is done on the ground. In flight, the crew members are asked to document (via cassette tape recorder) perceived self-motion and surround motion accompanying slow head motions during reentry and descent.



STS-30

PRESS INFORMATION

April 1989

Rockwell International

Space Transportation
Systems Division

Office of Media Relations

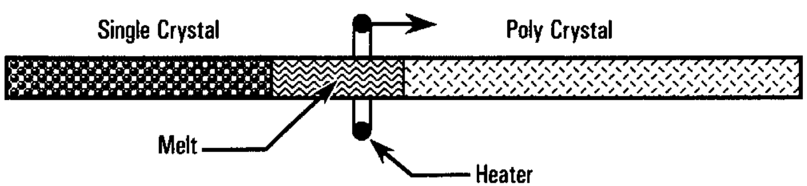
PUB 3546-V-1 REV 4-89

FLOATING ZONE CRYSTAL GROWTH AND PURIFICATION

Rockwell International, through its Space Transportation Systems Division in Downey, Calif., is engaged in a Joint Endeavor Agreement (JEA) with NASA's Office of Commercial Programs in the field of floating zone crystal growth and purification research. The agreement, signed on March 17, 1987, provides for microgravity experiments to be performed in the company's microgravity laboratory, the Fluids Experiment Apparatus (FEA), on two space shuttle missions.

Rockwell's Space Transportation Systems Division has the responsibility for developing the FEA hardware and for integrating the experiment payload. Rockwell's Science Center in Thousand Oaks, Calif., has the responsibility for developing the materials science experiments and for analyzing the results. The Indium Corporation of America of Utica, N.Y., is collaborating with the Science Center in the development and analysis of the experiments and is providing the indium sample materials to be processed on the FEA-2 mission. NASA will provide space shuttle flight services under the JEA.

The floating zone process involves a cylindrical sample encircled by an annular heater which melts a portion of the sample material, illustrated below, followed by translation of the heater along the sample. As the heater moves, more and more of the polycrystalline material in front of it melts. The molten material behind the heater cools and resolidifies into a single crystal. The presence of a "seed" crystal at the initial solidification interface will establish the crystallographic lattice structure and orientation of the single crystal that results. Impurities in the polycrystalline material will tend to stay in the melt as it passes along the sample and will be deposited at the end when the heater is turned off and the melt finally solidifies.



Floating Zone Process Schematic

On the ground, under the influence of gravity, the length of the melt depends on the density and surface tension of the material being processed. Many industrially important materials cannot be successfully processed on Earth because of their properties, but in the microgravity environment of space the length of the melt is only limited to the circumference of the sample and is independent of its material properties.

Materials of industrial interest include selenium, indium antimonide, cadmium telluride, gallium arsenide and silicon. Potential applications for these materials include advanced electronic, electro-optical, and optical devices and high-purity feedstock.

The FEA-2 experiments involve four samples (plus one spare) of indium, with a melting point of 156 degrees Celsius. Indium, because of its relatively low melting point, is an excellent material with which to begin this research. High-purity indium is also required as an element of several industrially important compounds. The samples will each be 1 centimeter in diameter and 19 centimeters long. The sample seeding, heater translation rates and process durations are given in the following table.

Experiment Samples and Parameters

Sample	Seeded	Heater Rate (centimeters/hour)	Duration (hours)
1	No	0	2
2	Yes	1.25	16
3	No	1.25	16
4	Yes	0.62	16

FEA-2 EXPERIMENT PLAN

On orbit, at a mission elapsed time of 7.6 hours, the flight crew will prepare the FEA by unstowing and connecting its computer and camera. The four experiment samples will be sequentially installed in the FEA at mission elapsed times of 21.5, 30.2, 51.8, and 73.6 hours and processed according to their unique requirements. The experiment parameters (heater power and translation rate) will be controlled by the operator through the FEA control panel. Sample behavior (primarily melt zone length) will be observed by the operator and recorded by the FEA camera. Experiment data (heater power, translation rate and position; experiment time; and various experiment and FEA temperatures) will be formatted, displayed to the operator and recorded by the computer. The operator will record the mission elapsed time at the start of each experiment and significant orbiter maneuvers that occur during FEA operations.

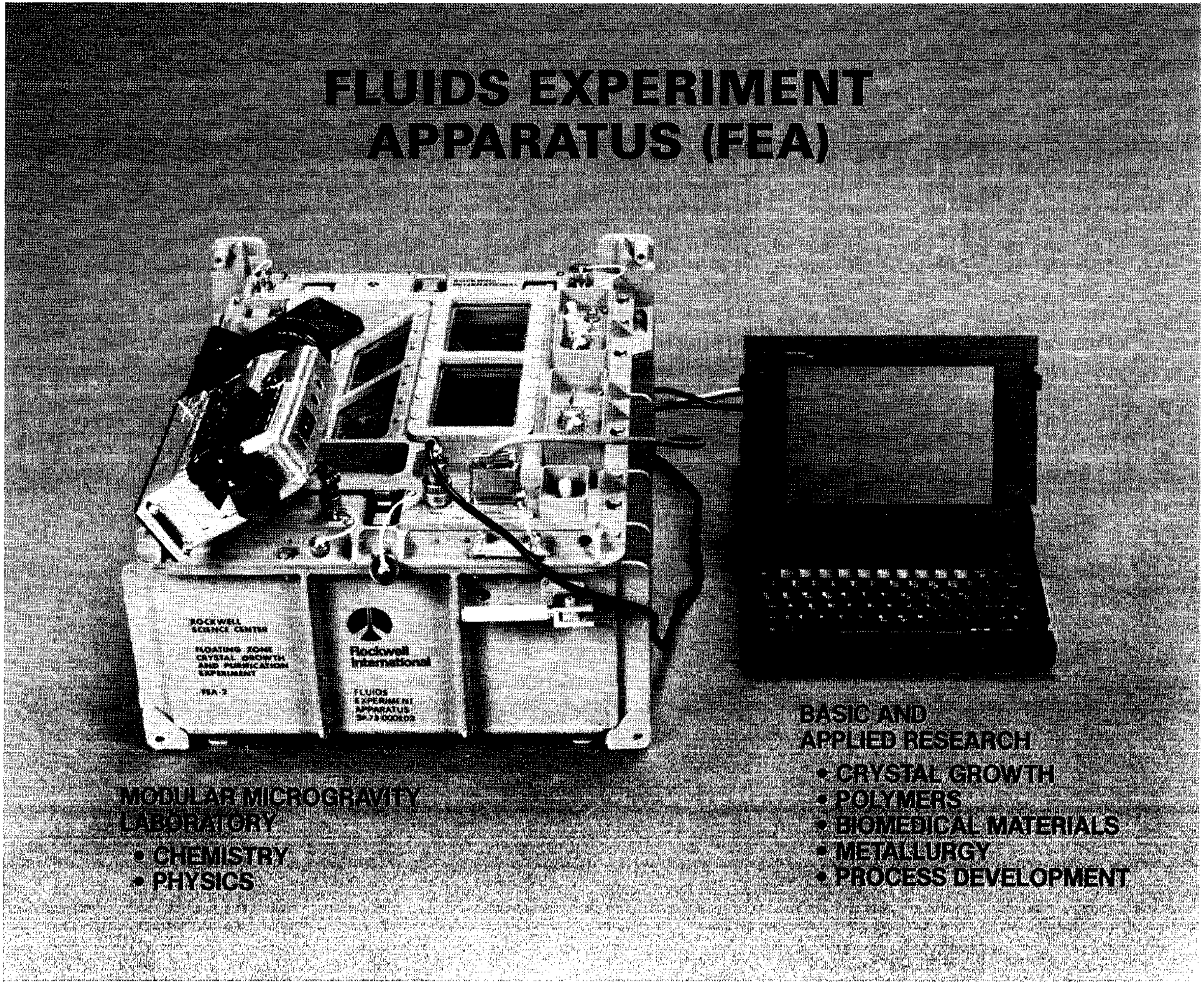
In general, the experiment process involves installing a sample in the FEA, positioning the heater at a predesignated point along the sample, turning on the heater to melt a length of sample (approximately twice the diameter), starting the heater translation at a fixed rate (for the last three samples only), and maintaining a constant melt zone length by controlling the heater power. When the heater reaches the end of the sample, it is turned off (allowing the sample to completely solidify), and the heater's translation is reversed until it reaches the starting end of the sample. The sample, camera film and computer disk with the experiment data can then be changed and the next experiment started.

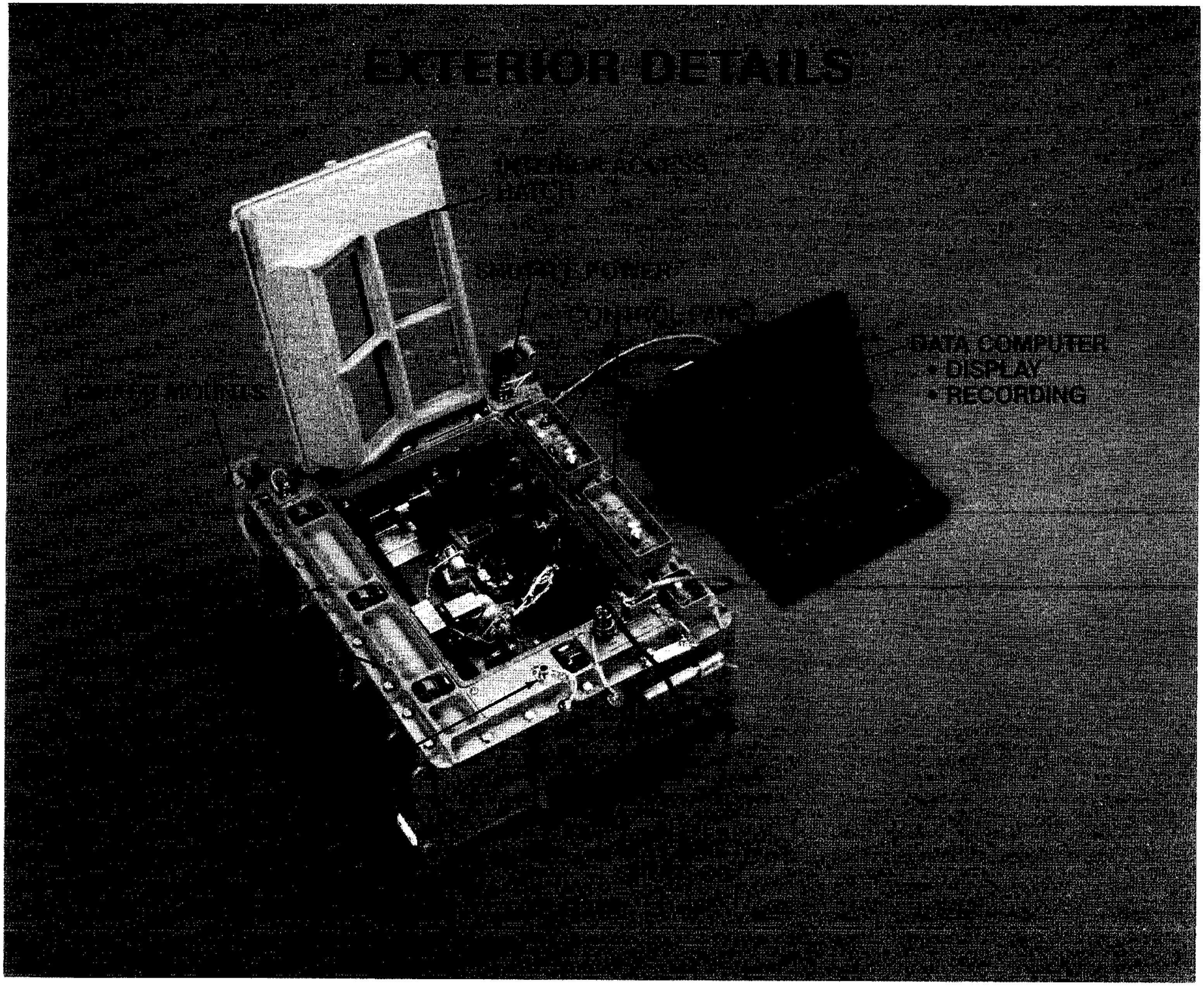
FLUIDS EXPERIMENT APPARATUS (FEA)

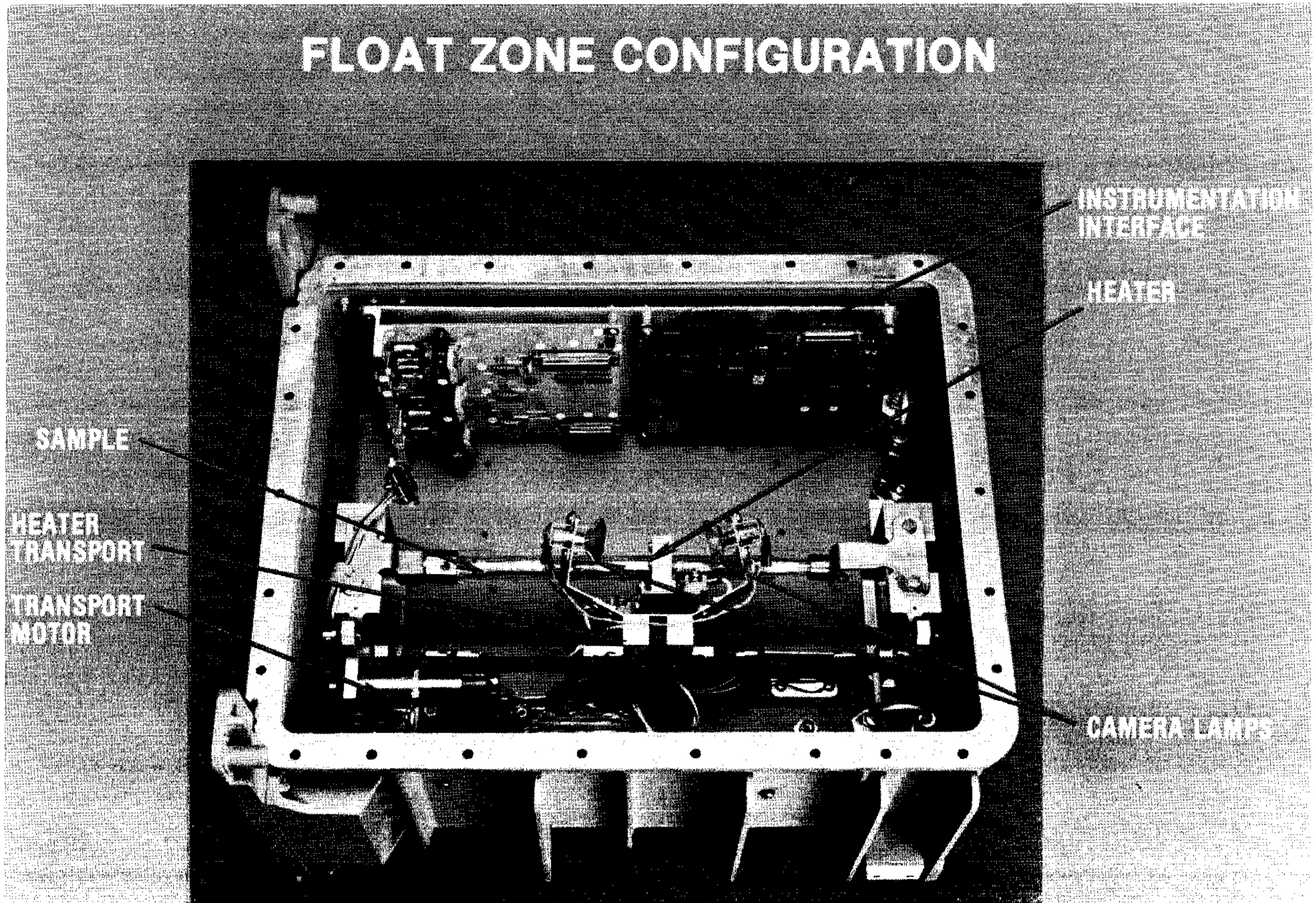
The FEA, a multipurpose experiment support system developed by the Space Transportation Systems Division of Rockwell International, is designed to perform materials-processing research in the microgravity environment of space. Its design and operational characteristics are based on actual industrial requirements and have been thoroughly coordinated with industrial scientists, NASA materials-processing specialists and space shuttle operations personnel. Convenient, low-cost access to space for basic and applied research in a variety of product and process technologies is provided by the FEA.

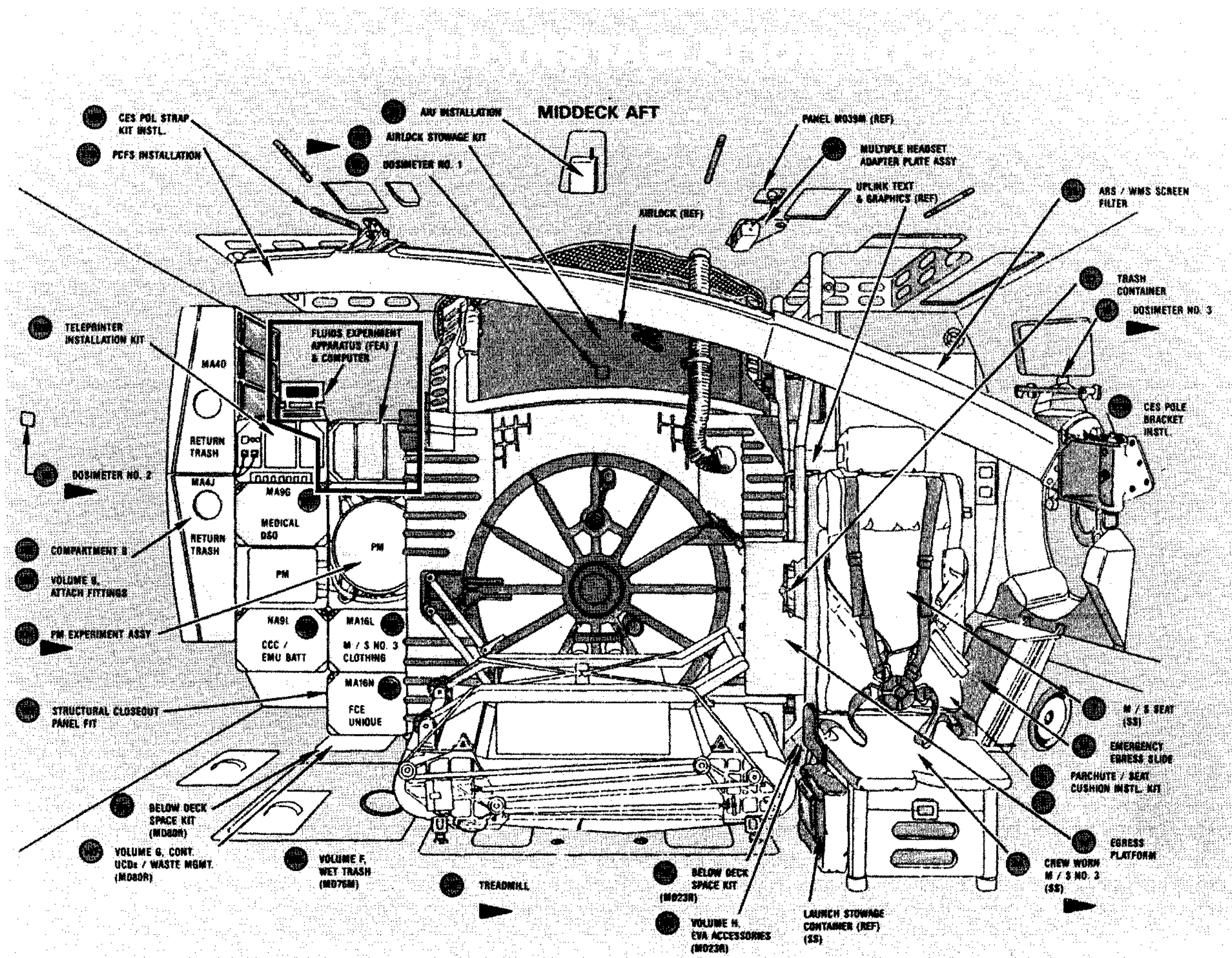
The FEA is a modular microgravity chemistry and physics laboratory for use on the space shuttle that supports materials-processing research in crystal growth, general liquid chemistry, fluid physics and thermodynamics. It has the functional capability to heat, cool, mix, stir or centrifuge gaseous, liquid or solid experiment samples. Samples can be processed in a variety of containers or in a semicontainerless floating zone mode. Multiple samples can be installed, removed or exchanged during a mission through a 14.1- by 10-inch door in the FEA's cover. Instrumentation can measure a sample's temperature, pressure, viscosity, etc. A video, super-8-millimeter movie or still camera can be used to record sample behavior. Experiment data can be displayed and recorded by using a portable computer that can also control the experiments.

The interior dimensions of the FEA are approximately 18.6 by 14.5 by 7.4 inches, and it can accommodate approximately 26 pounds of experiment-unique hardware and subsystems. It mounts in place of a standard stowage locker in the middeck of the shuttle crew compartment, where it is operated by the flight crew. This installation and means of operation permit the FEA to be flown on most space shuttle missions. Its modular design permits the FEA to be easily configured for almost any experiment. Configurations can even be changed in orbit, permitting experiments of different types to be performed on a shuttle mission. Optional subsystems can include a custom furnace and oven, special sample containers, low-temperature air heaters, a specimen centrifuge, special instrumentation and others specified by the user. Up to 100 watts of 120-volt, 400-hertz power is available from the shuttle orbiter for FEA experiments.


FLUIDS EXPERIMENT
APPARATUS (FEA)
Rockwell International
MODULAR MICROGRAVITY
LABORATORY
• CHEMISTRY
• PHYSICS
BASIC AND
APPLIED RESEARCH
• CRYSTAL GROWTH
• POLYMERS
• BIOMEDICAL MATERIALS
• METALLURGY
• PROCESS DEVELOPMENT


EXTERIOR DETAILS
DATA COMPUTER
• DISPLAY
• RECORDING


FLOAT ZONE CONFIGURATION
INSTRUMENTATION INTERFACE
HEATER
SAMPLE
HEATER TRANSPORT
TRANSPORT MOTOR
CAMERA LAMPS



MIDDECK AFT
CES POL STRAP KIT INSTL.
PCFS INSTALLATION
AIU INSTALLATION
AIRLOCK STOWAGE KIT
DOSIMETER NO. 1
AIRLOCK (REF)
PANEL MO39M (REF)
MULTIPLE HEADSET ADAPTER PLATE ASSY
UPLINK TEXT & GRAPHICS (REF)
ARS / WMS SCREEN FILTER
TRASH CONTAINER
DOSIMETER NO. 3
CES POLE BRACKET INSTL.
TELEPRINTER INSTALLATION KIT
FLUIDS EXPERIMENT APPARATUS (FEA) & COMPUTER
MA4O
RETURN TRASH
DOSIMETER NO. 2
MA4J
MA9G
MEDICAL DSO
COMPARTMENT 8
RETURN TRASH
PM
VOLUME 6, ATTACH FITTINGS
PM EXPERIMENT ASSY
MA9L
CCC / EMU BATT
MA16L
M / S NO. 3 CLOTHING
MA16N
FCE UNIQUE
STRUCTURAL CLOSEOUT PANEL FIT
BELOW DECK SPACE KIT (MD80R)
VOLUME G, CONT. UCDs / WASTE MGMT. (MD80R)
VOLUME F, WET TRASH (MD76M)
TREADMILL
BELOW DECK SPACE KIT (MD23R)
VOLUME H, EVA ACCESSORIES (MD23R)
LAUNCH STOWAGE CONTAINER (REF) (SS)
M / S SEAT (SS)
EMERGENCY EGRESS SLIDE
PARCHUTE / SEAT CUSHION INSTL. KIT
EGRESS PLATFORM
CREW WORN M / S NO. 3 (SS)

KEY PERSONNEL

At Rockwell's Space Transportation Systems Division, microgravity projects are the responsibility of Michael J. Martin, joint endeavor manager for the floating zone crystal growth and purification research project. He is working to provide space laboratory equipment and integration engineering services to meet scientific and commercial requirements in microgravity research. Mr. Martin was the project engineer for the highly successful FEA-1 mission, which flew on STS-14 (41-D) in September of 1984. He has been involved in numerous microgravity studies, including the identification of products that could be manufactured in space by Rockwell International. Mr. Martin is a member of the American Institute of Aeronautics and Astronautics and a past member of the institute's space processing technical committee.

Mr. Martin has more than 10 years of experience in the design and analysis of electro-optical systems and components. During that time, he specialized in optical design and the attenuation of stray radiation. He has worked for Rockwell International for 18 years, including 3-1/2 years at Electronics Operations in Anaheim, Calif. He graduated in 1969 from the University of California at Irvine, where he majored in engineering.

Dr. M. David Lind of Rockwell International's Science Center is the principal investigator for the experiments to be performed under the Rockwell-NASA JEA. Dr. Lind was the science advisor for the FEA-1 mission and the principal coinvestigator for crystal growth experiments on the Apollo-Soyuz Test Project, the Space Processing Applications Rocket Project, the Long-Duration Exposure Facility and the Eureca satellite. Dr. Lind's principal research interests are in crystal growth and X-ray crystallography; he has more than 30 publications in these fields. Dr. Lind received his BS from Otterbein College in 1957 and his PhD in physical chemistry from Cornell University in 1962. After 1-1/2 years of postdoctoral work at Cornell University, he was employed at the Union Oil Company Research Center from 1963 to 1966 and has been with Rockwell International since 1966. He is a member of the American Physical Society, American Crystallographic Association, American Association for Crystal Growth and Sigma Xi.

Michael F. McNamara, manager of Chemical Process Engineering at the Indium Corporation of America, is the coinvestigator for the experiments on the FEA-2 mission. Mr. McNamara is responsible for designing and improving chemical processes relating to indium metal purification and fabrication and all chemical operations involved in the production and application of indium chemicals.

Mr. McNamara graduated from Mohawk Valley Community college in 1981 with an AS degree in engineering and science. He is currently pursuing a BS degree in materials engineering at Syracuse University. He is a member of the American Society of Metals, the American Crystal Growers Society and the International Society for Hybrid Microelectronics.

Max Vallejo joined Rockwell in 1987 and is currently the project engineer for the FEA-2 mission. He is responsible for configuring the FEA hardware for the mission and mission integration engineering. Mr. Vallejo has 30 years of engineering experience in the design of mechanical, electrical, thermal, fluid and pneumatic systems. He has directed engineering and other technical disciplines during system concept, analysis, and development phases. Mr. Vallejo has extensive board and CAD/CAM layout experience and has conducted classes in mechanical devices, hydraulics and design. He received a BSME from West Coast University in 1963.

For further information, contact:

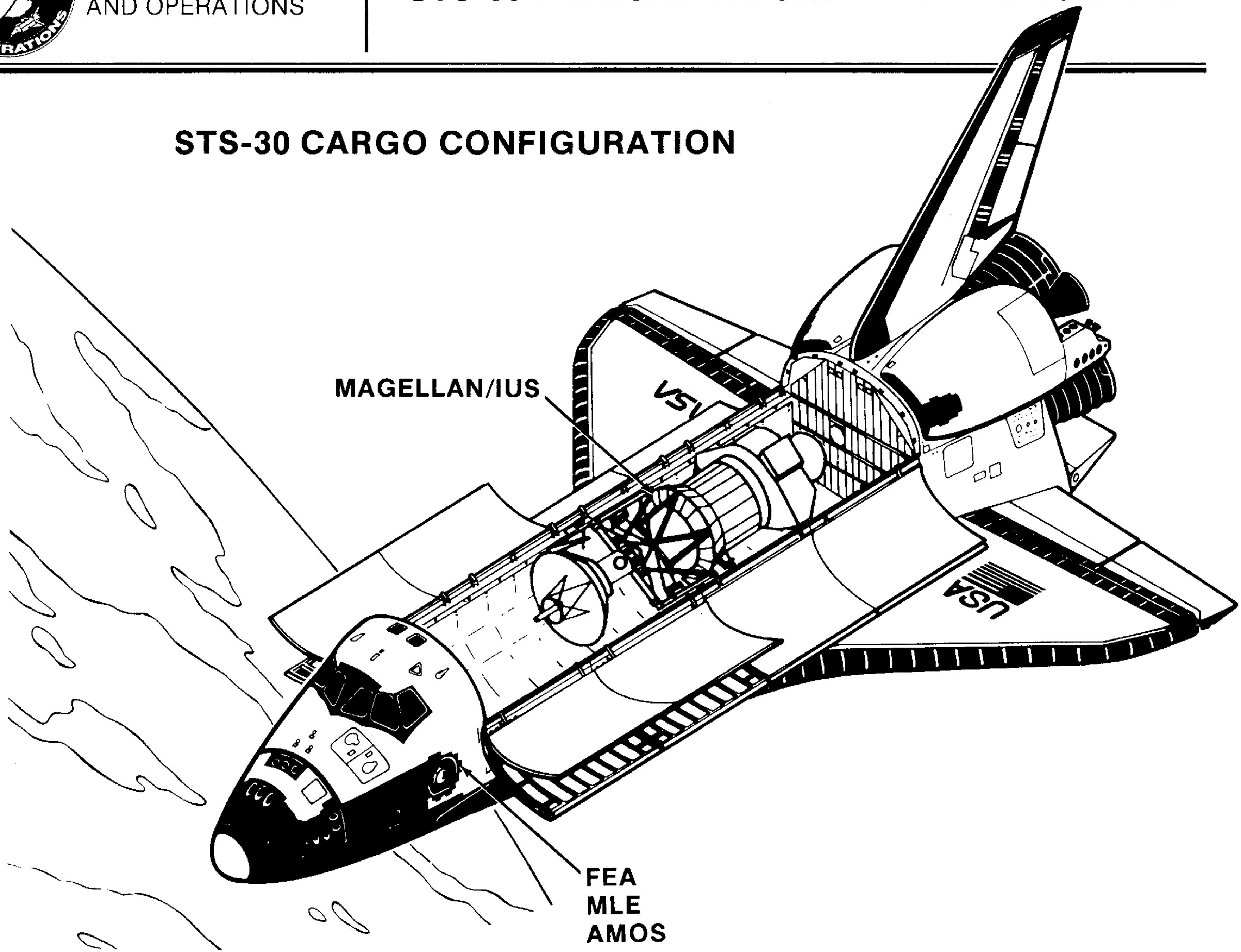
W.F. (Bill) Green
Media Relations
(213) 922-2066

STS-30
PAYLOAD INFORMATION DOCUMENT

PURPOSE

TO SUMMARIZE THE DESCRIPTIONS, PURPOSES, OPERATIONS, AND FLIGHT HISTORIES OF STS-30 PAYLOADS.

STS-30 CARGO CONFIGURATION



STS-30 MANIFEST

- PAYLOAD BAY PAYLOAD
  - MAGELLAN (MGN)/INERTIAL UPPER STAGE (IUS)
- MIDDECK PAYLOADS
  - FLUIDS EXPERIMENT APPARATUS (FEA)
  - MESOSCALE LIGHTNING EXPERIMENT (MLE)
  - AIR FORCE MAUI OPTICAL SITE CALIBRATION TEST (AMOS)

PAYLOAD BAY PAYLOAD

MAGELLAN/INERTIAL UPPER STAGE (MGN/IUS)

• DESCRIPTION

AN UNMANNED, THREE-AXIS ATTITUDE-CONTROLLED EXPLORATION SPACECRAFT MATED TO THE IUS AND COMPRISING PROPULSION, INSTRUMENTATION, ELECTRICAL POWER, AND TELECOMMUNICATION EQUIPMENT REQUIRED TO ACHIEVE ORBIT OF VENUS AND MAP ITS SURFACE. MAGELLAN SPACECRAFT ACTUAL WT.: 7,383 LB. IUS ACTUAL WT.: 38,416 LB. TOTAL ACTUAL WT.: 45,799 LB.

• PURPOSE

TO ACQUIRE TECTONIC/GEOLOGIC HISTORICAL, GEOPHYSICAL, AND SMALL-SCALE SURFACE PHYSICAL DATA ABOUT VENUS FOR DISSEMINATION TO THE PUBLIC AND TO THE SCIENTIFIC COMMUNITY. CUSTOMER: JET PROPULSION LABORATORY.

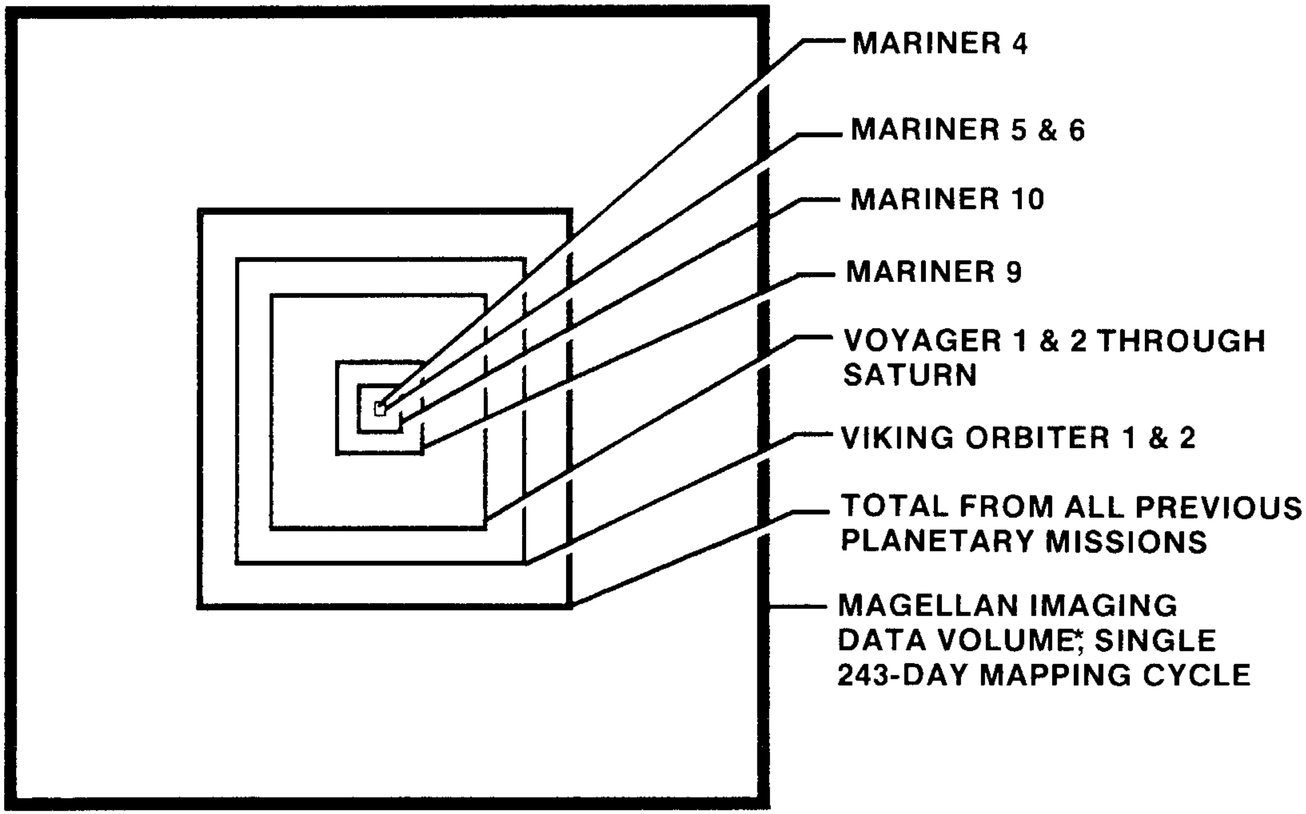
MAGELLAN (CONT)

- **OPERATION**

ONE HOUR AFTER DEPLOYMENT FROM THE PAYLOAD BAY, THE IUS PLACES MAGELLAN ON A TRAJECTORY TO VENUS WITH BURNS OF ITS TWO SOLID ROCKET MOTORS. THE COAST TIME BETWEEN IUS FIRST AND SECOND STAGE BURNS IS 2.5 MINUTES. THE CRUISE TO VENUS LASTS APPROXIMATELY 15 MONTHS. UPON APPROACH TO VENUS, THE SPACECRAFT'S STAR 48B SOLID ROCKET MOTOR INSERTS IT INTO AN ELLIPTICAL 3.1-HOUR ORBIT. A 14-DAY TEST AND CALIBRATION PERIOD FOLLOWS. THEN, USING SYNTHETIC APERTURE RADAR (SAR), MAGELLAN PRODUCES CONTIGUOUS IMAGES OF 70-90% OF VENUS'S SURFACE. MAGELLAN ALSO MEASURES SURFACE BRIGHTNESS TEMPERATURES OF >70% OF THE SURFACE, PRODUCES TOPOGRAPHIC AND RADAR-SCATTERING CHARACTERISTICS MAPS, AND, WHEN POSSIBLE, PRODUCES GRAVITY MAPS, ALL OVER A PERIOD OF 243 DAYS. ON ORDER FROM GROUND CONTROL, MAGELLAN MAY UNDERTAKE AN EXTENDED MISSION BEYOND THE NOMINAL ONE STATED ABOVE.

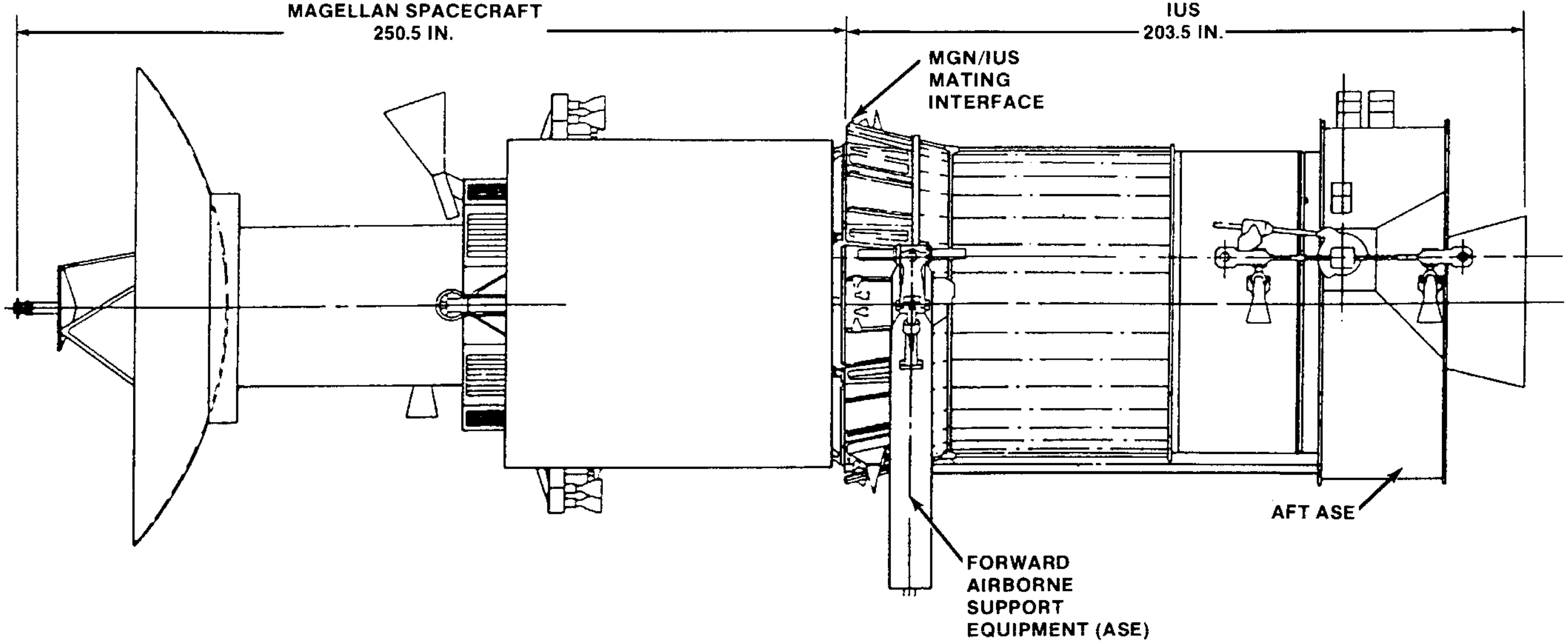
- **NO PREVIOUS FLIGHTS**

MAGELLAN'S CONTRIBUTION INCREASES U.S. PLANETARY IMAGING DATA VOLUME 400%

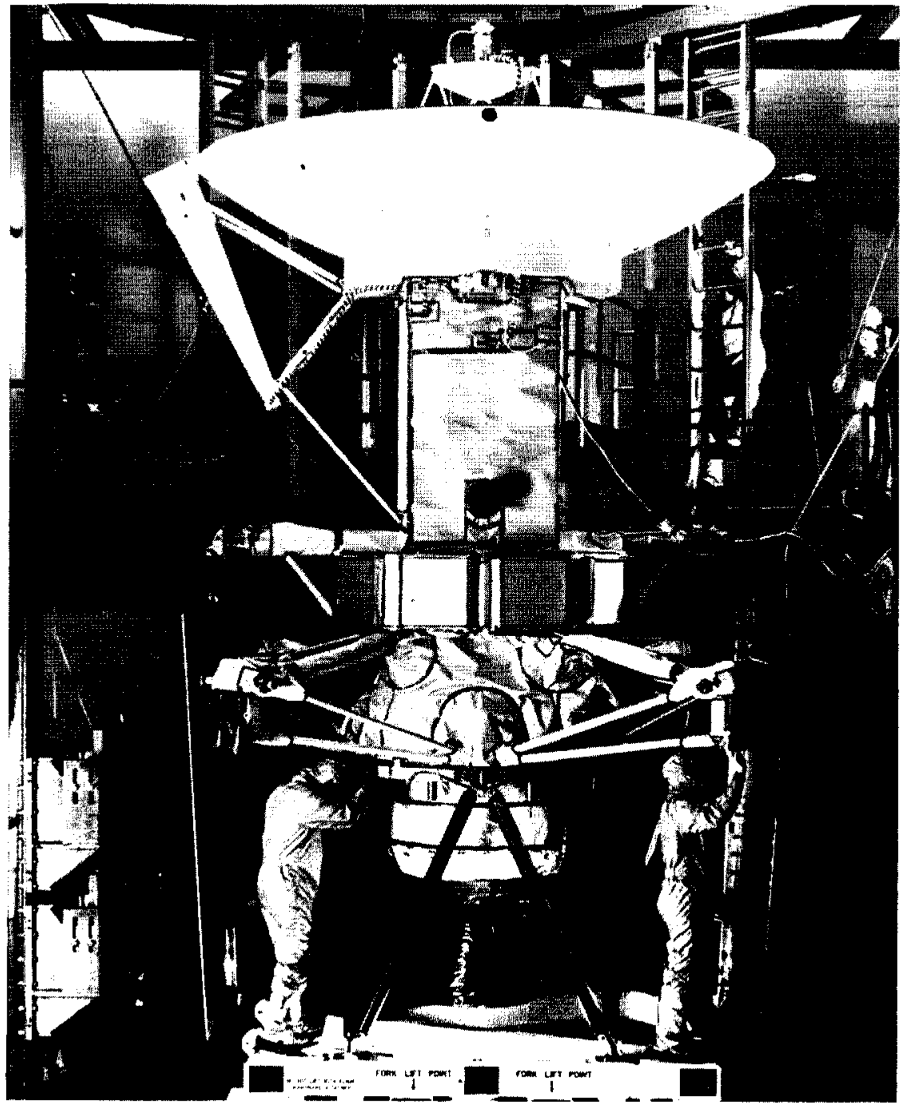


*VOLUME OF DATA IS EXPRESSED IN TWO-DIMENSIONAL SPACE.

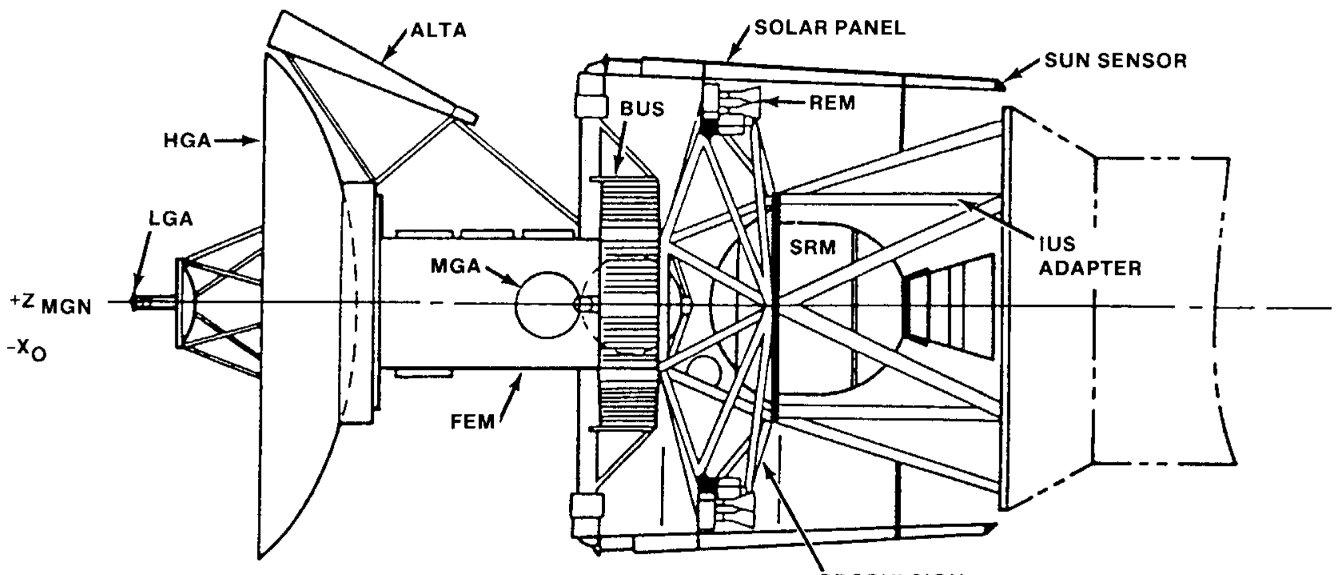
MGN SPACECRAFT/IUS CONFIGURATION



MAGELLAN



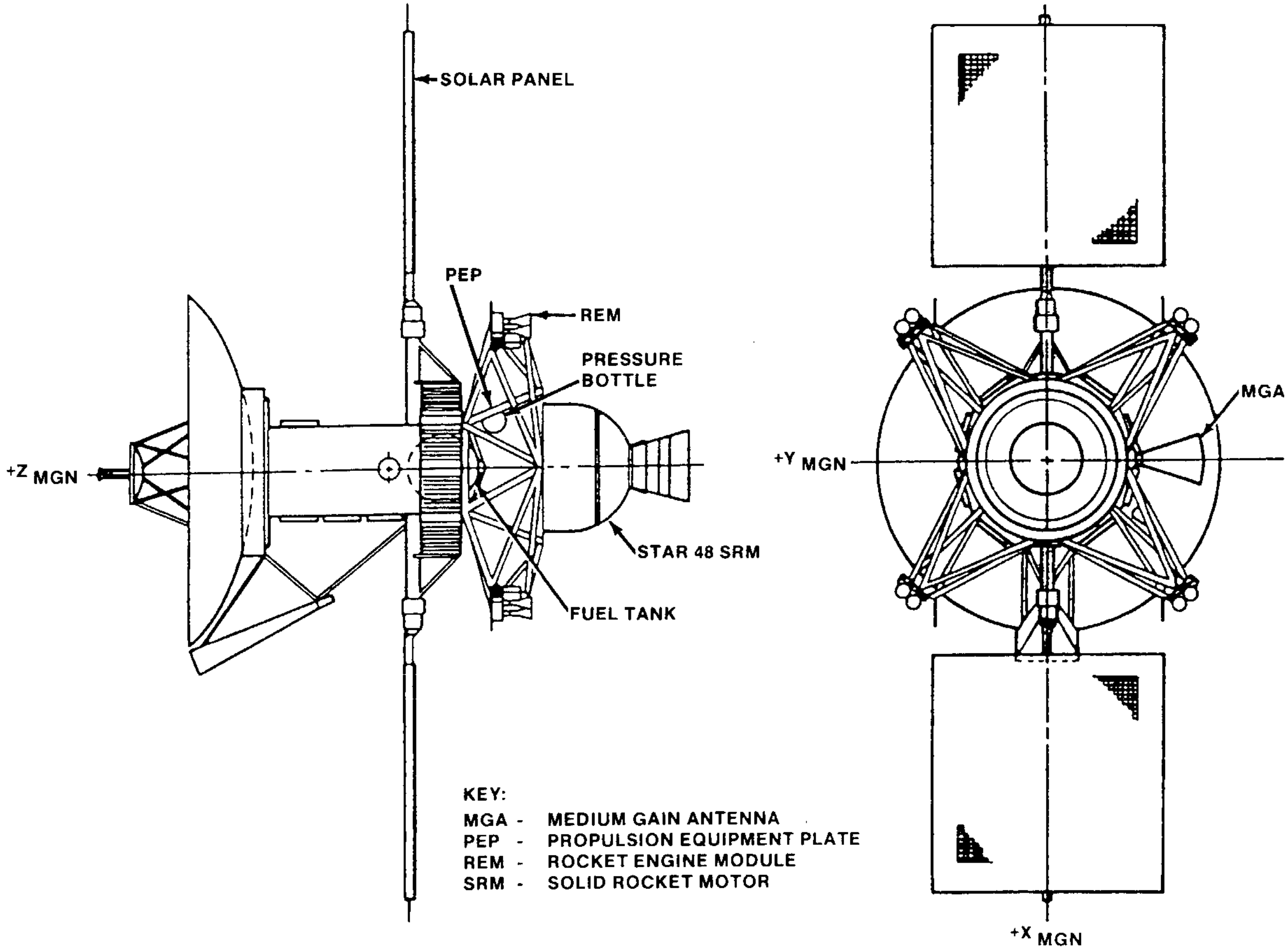
MGN CONFIGURATION FOR LAUNCH



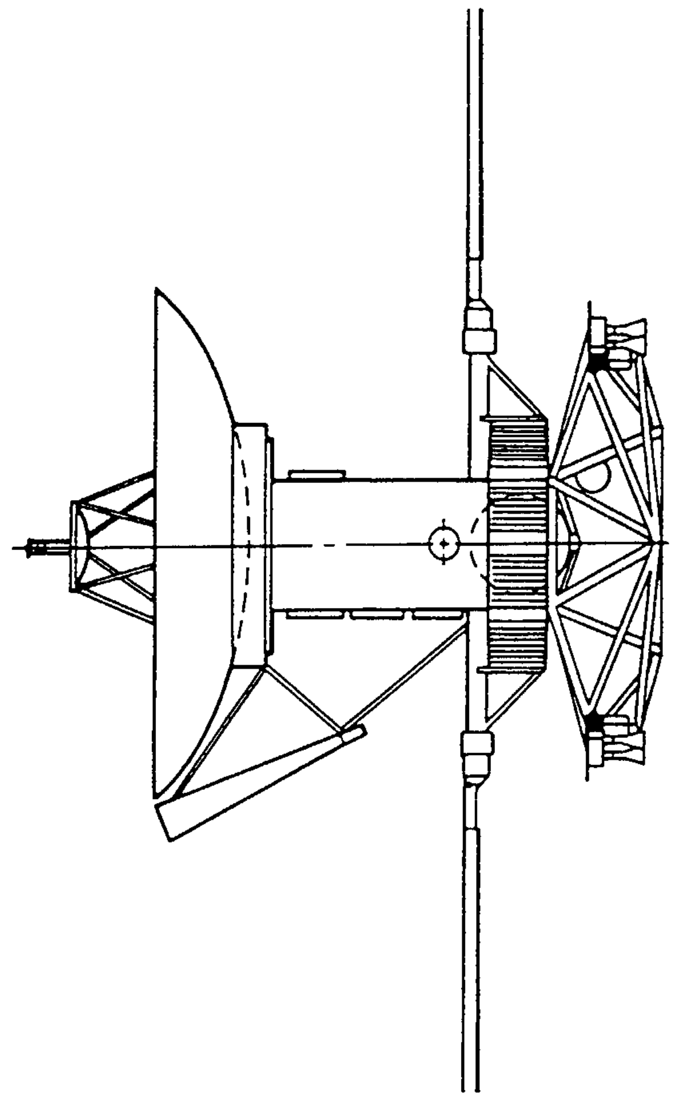
KEY:

ALTA - ALTIMETER ANTENNA
FEM - FORWARD EQUIPMENT MODULE
HGA - HIGH GAIN ANTENNA
LGA - LOW GAIN ANTENNA
MGA - MEDIUM GAIN ANTENNA
REM - ROCKET ENGINE MODULE
SRM - SOLID ROCKET MOTOR

MGN CONFIGURATION FOR CRUISE TO VENUS

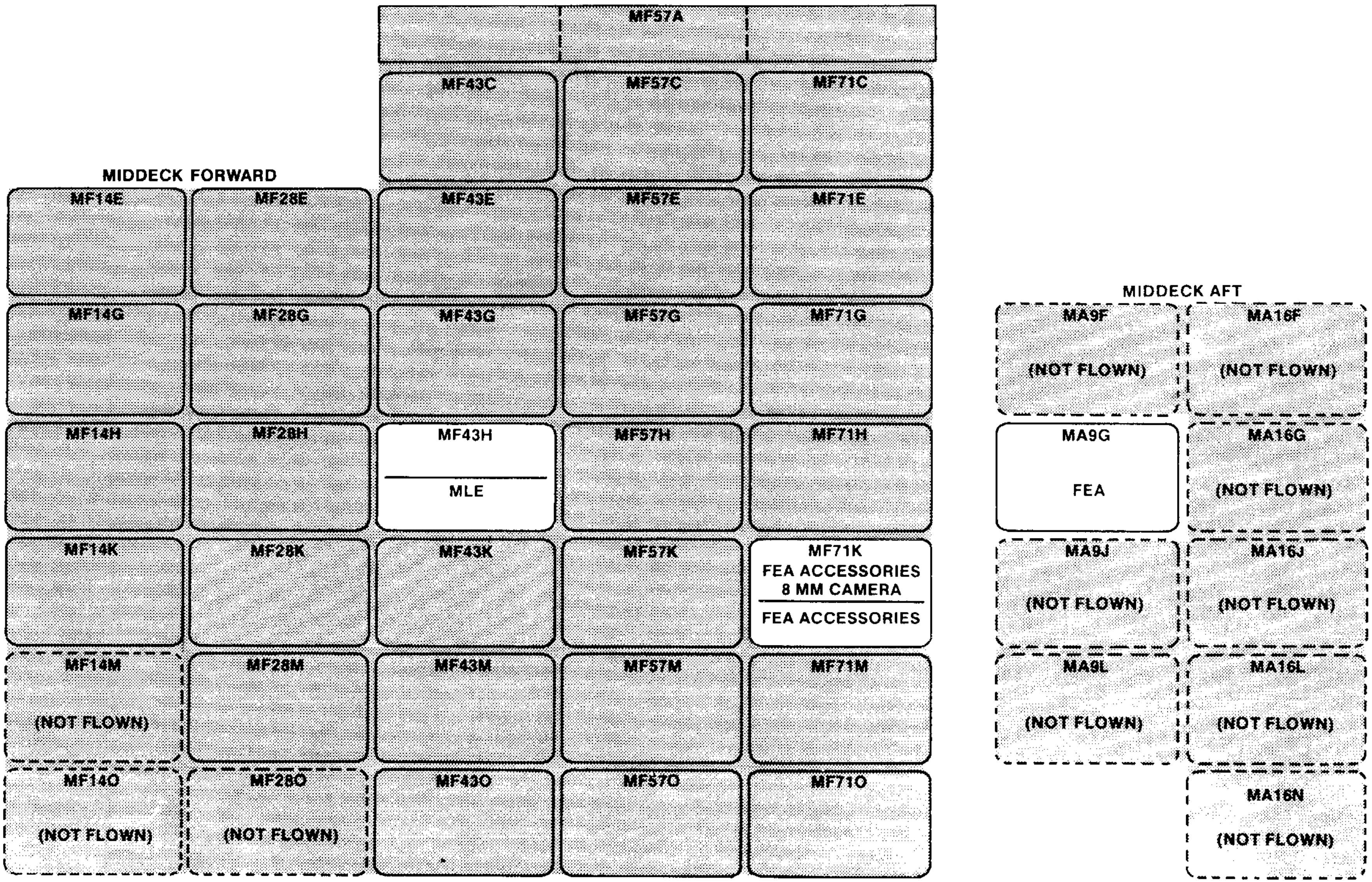


MGN CONFIGURATION FOR MAPPING



MIDDECK PAYLOADS

MODIFIED MODULAR LOCKER LAYOUT, STS-30 (MIDDECK PAYLOADS)



FLUIDS EXPERIMENT APPARATUS (FEA)

- **DESCRIPTION**

A CRYSTAL GROWTH SYSTEM USING THE MICROGRAVITY OF SPACE FLIGHT TO ENHANCE THE EFFECTS OF FLOATING ZONE MATERIALS PROCESSING. FLOATING ZONE PROCESSING IS THE TECHNIQUE OF GROWING CRYSTALS FROM A MELTED ZONE HELD IN PLACE BY SURFACE TENSION. THE FEA COMPRISES A MATERIALS PROCESSING CONTAINER, FIVE PYREX SAMPLE AMPOULES CONTAINING INDIUM, AND A HEATER TRANSPORT DEVICE FOR CONTROLLED MELTING AND RECRYSTALLIZING OF THE SAMPLES. THE FEA CONTAINER (21 X 18 X 11 INCHES) REPLACES A STANDARD ORBITER MIDDECK LOCKER. FEA CONTROL WT.: 69 LB. TOTAL CONTROL WT.: 116 LB.

- **PURPOSE**

TO GROW LARGE CRYSTALS OF HIGH PURITY, HOMOGENEITY, AND STRUCTURAL PERFECTION FOR POTENTIAL COMMERCIAL APPLICATIONS. CUSTOMER: ROCKWELL INTERNATIONAL (DOWNEY).

FEA (CONT)

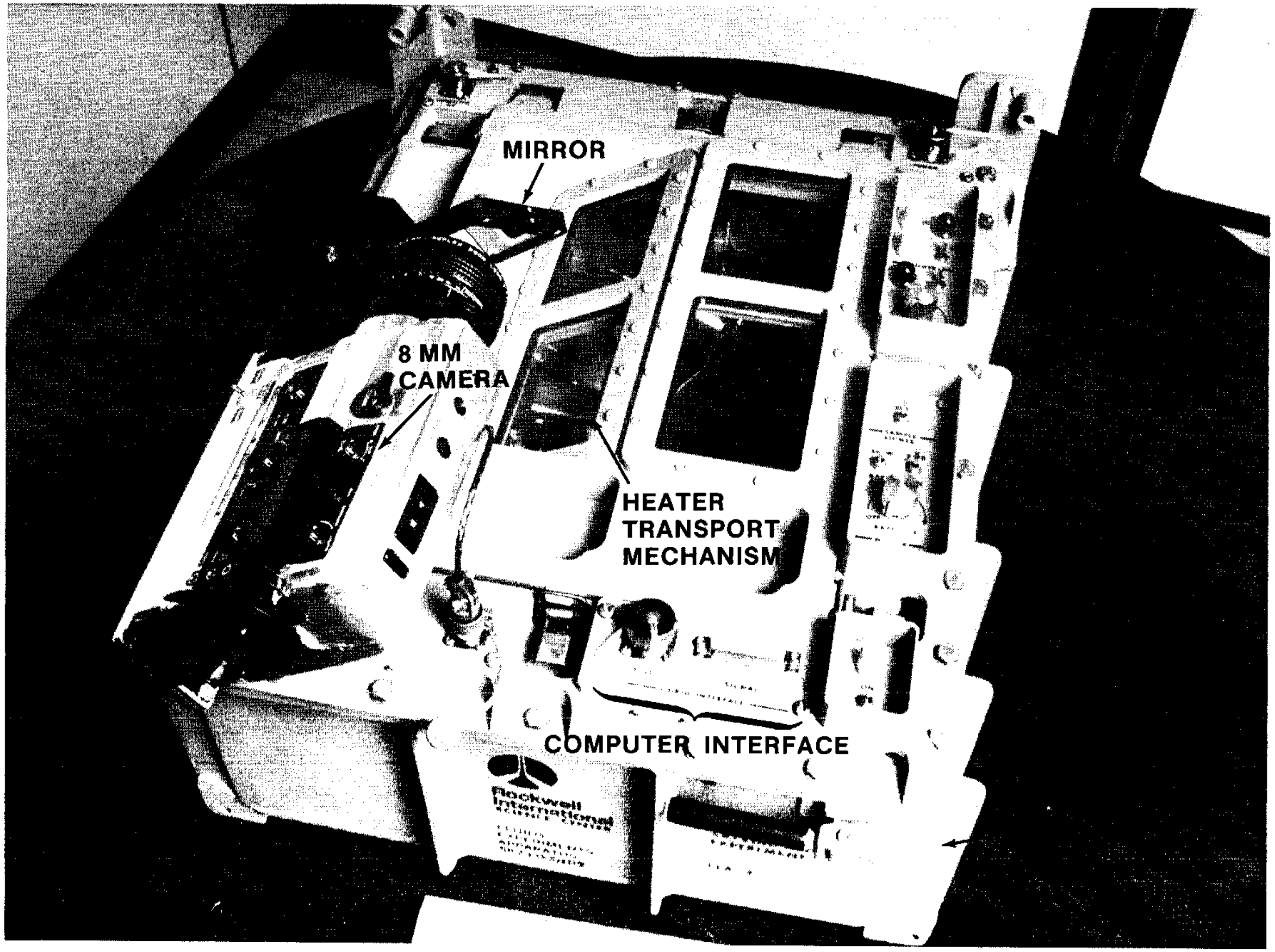
- ## OPERATION

FOR EACH SAMPLE THE CREW SETS THE HEATER FOR FLOAT ZONE SIZE AND TRANSLATION RATE AND PERIODICALLY COLLECTS 8MM PHOTOGRAPHY. AS THE HEATER MOVES ALONG THE AMPOULE, THE ZONE OF THE SOLID MATERIAL UNDER THE HEATER MELTS. WHEN THE HEATER TRANSLATES, THE MELTED MATERIAL COOLS AND FORMS A CONTINUOUS CRYSTAL INSIDE THE AMPOULE. THE FIRST TWO RUNS, TWO HOURS EACH, DEMONSTRATE MELTED ZONE STABILITY. THE LAST THREE RUNS, 16 HOURS EACH, ACTUALLY CREATE THE LARGE CRYSTALS.

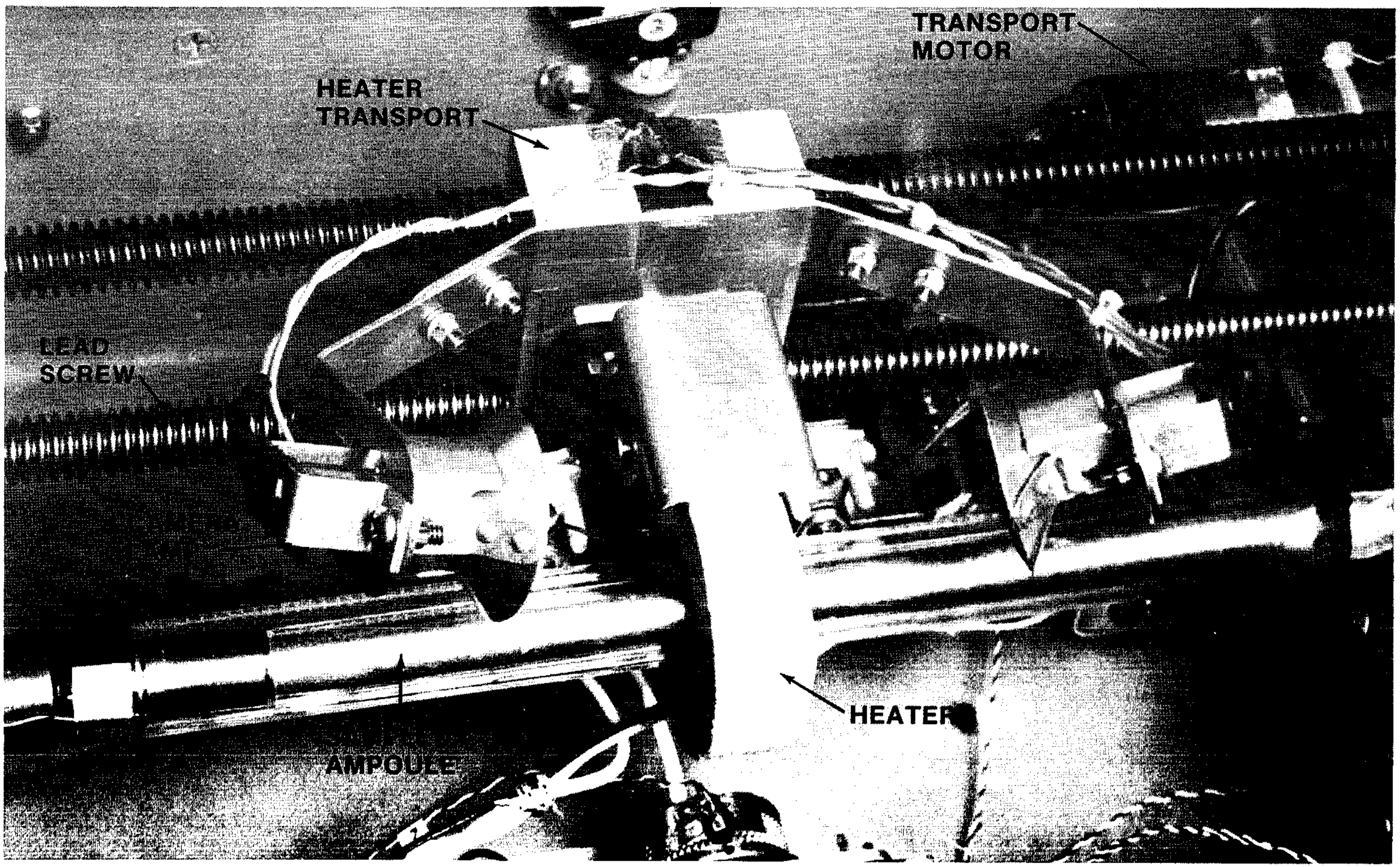
- ## PREVIOUS FLIGHT

STS 41-D (12)

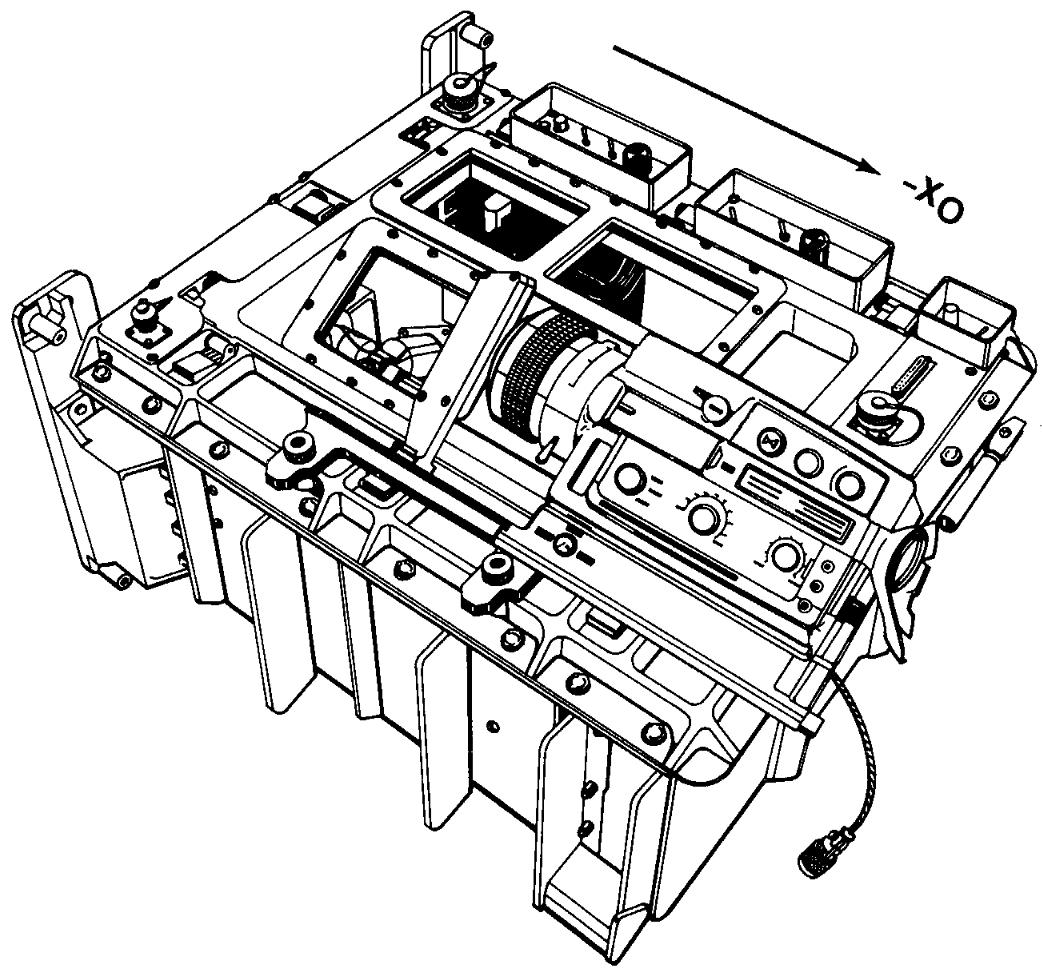
FLUIDS EXPERIMENT APPARATUS



FEA HEATER TRANSPORT DEVICE AT MIDPOINT OF SAMPLE AMPOULE



FEA VIEWED FROM STARBOARD MIDDECK



MESOSCALE LIGHTNING EXPERIMENT (MLE)

• DESCRIPTION

A SPECIAL APPLICATION OF THE STANDARD ORBITER PAYLOAD BAY REMOTELY CONTROLLED CLOSED-CIRCUIT TELEVISION CAMERA SYSTEM AND A DEDICATED STS STANDARD ORBITER 35 MM CAMERA BODY WITH 85 MM LENS. THE 35MM CAMERA BODY IS A MODIFIED NIKON F3 EQUIPPED WITH AN HR-MIN-SEC DATA BACK WHICH AUTOMATICALLY TAGS EACH FRAME WITH GREENWICH MEAN TIME (GMT) OF EXPOSURE. CAMERA, FILM, AND VIDEOCASSETTES TOTAL CONTROL WT.: 15 LB.

• PURPOSE

TO GAIN A BETTER UNDERSTANDING OF THE CHARACTERISTICS OF LARGE-SCALE LIGHTNING BY RECORDING IT FROM SPACE. CUSTOMER: MARSHALL SPACE FLIGHT CENTER.

MLE (CONT)

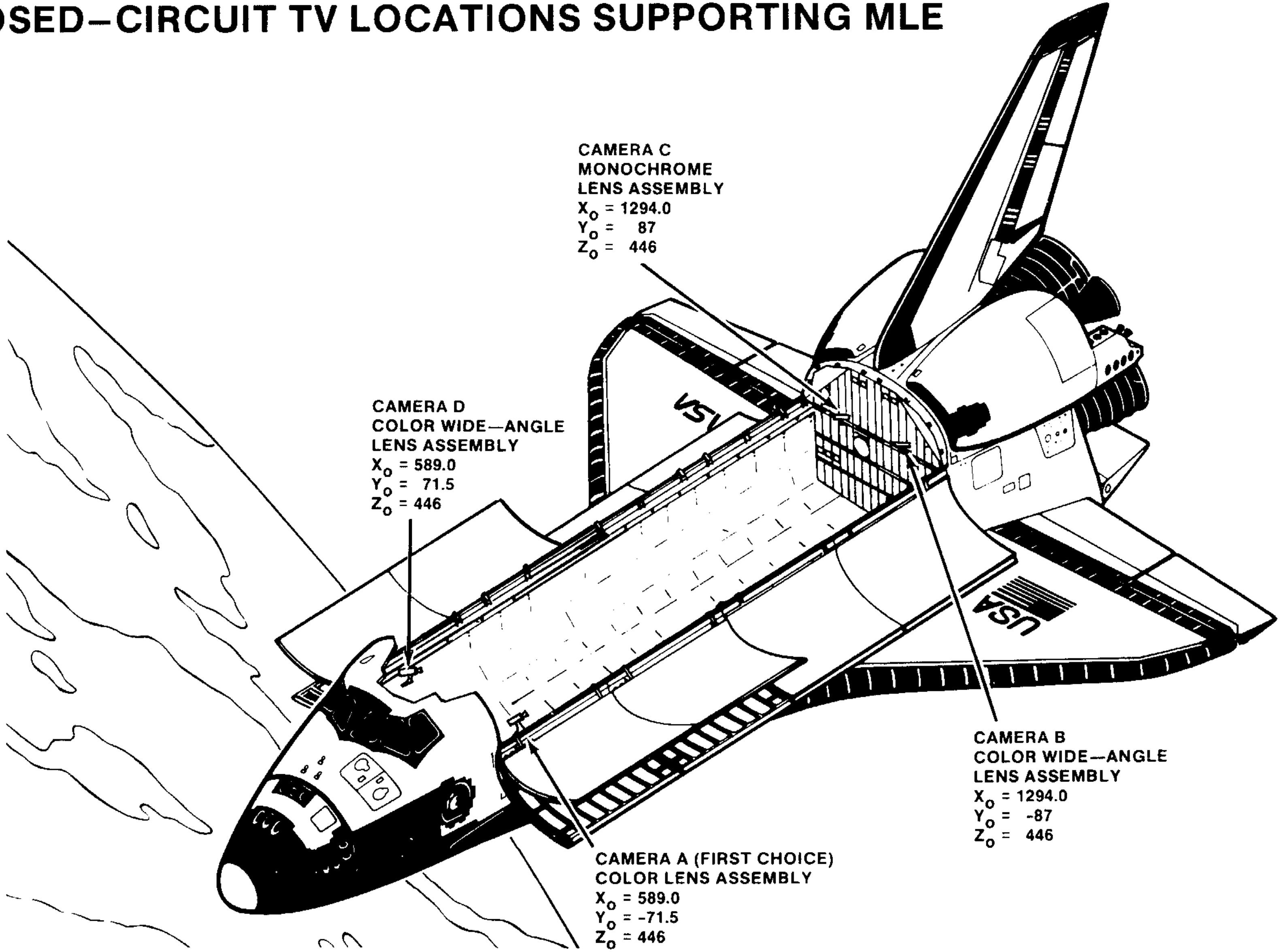
- **OPERATION**

THE CREW TRACKS AND COORDINATES 35MM AND CCTV RECORDING OF LIGHTNING ACTIVITY OVER A PLANNED TARGET AREA AND OVER SEVERAL TARGET-OF-OPPORTUNITY AREAS. CCTV CAMERA "A" IS THE CAMERA OF CHOICE.

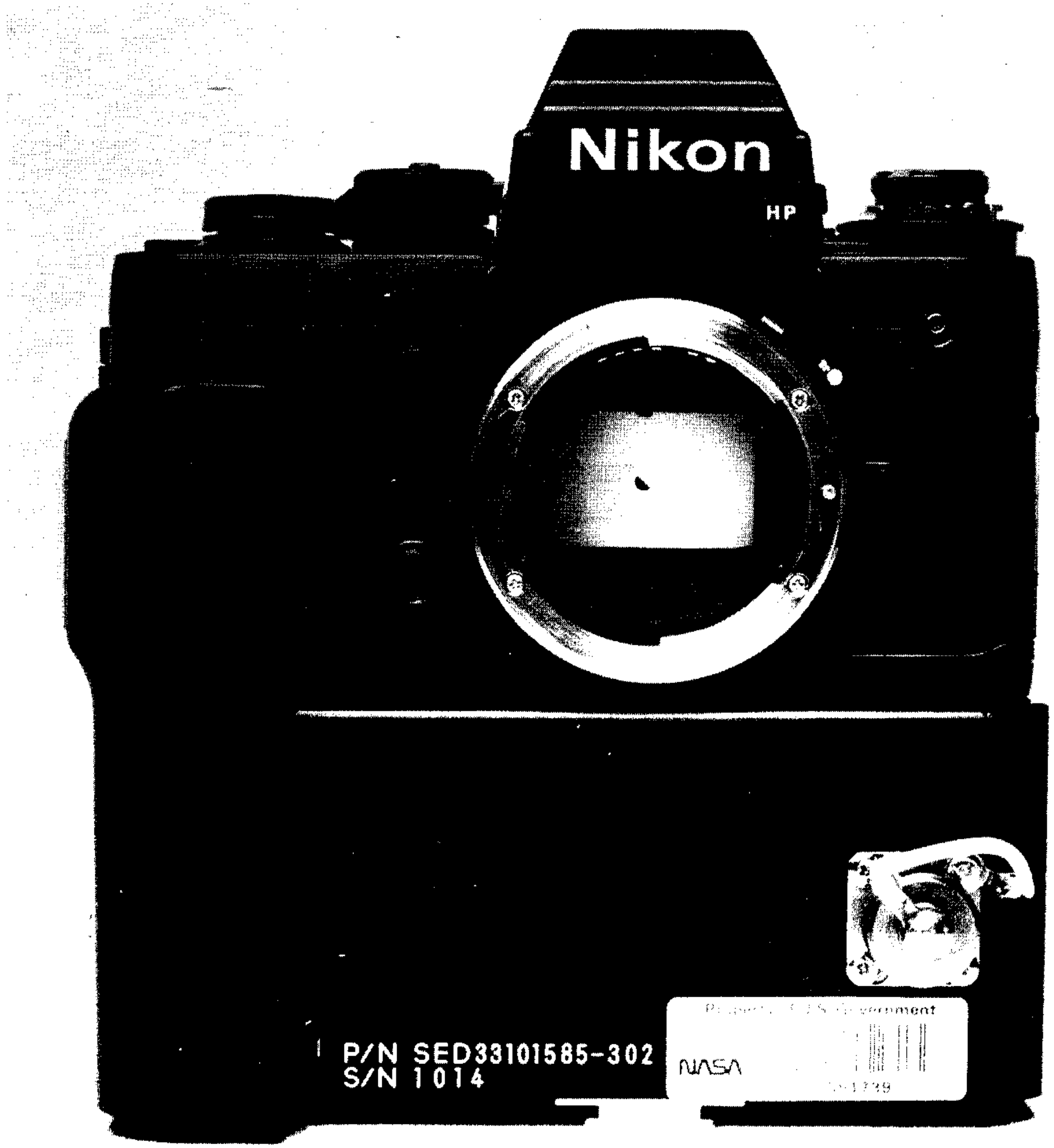
- **PREVIOUS FLIGHT**

STS-26

CLOSED–CIRCUIT TV LOCATIONS SUPPORTING MLE



MLE SUPPORT: 35MM CAMERA BODY FRONT



AIR FORCE MAUI OPTICAL SITE CALIBRATION TEST (AMOS)

- **DESCRIPTION**

  NO FLIGHT HARDWARE. ORBITER ACTS AS SUBJECT FOR GROUND SENSOR OPERATIONS.

- **PURPOSE**

  TO ALLOW GROUND-BASED ELECTRO-OPTICAL SENSORS TO COLLECT IMAGERY AND SIGNATURE DATA OF THE ORBITER UNDER CONTROLLED CONDITIONS, AND TO ALLOW THE STUDY OF PLUME PHENOMENA. CUSTOMER: USAF SPACE DIVISION.

AMOS (CONT)

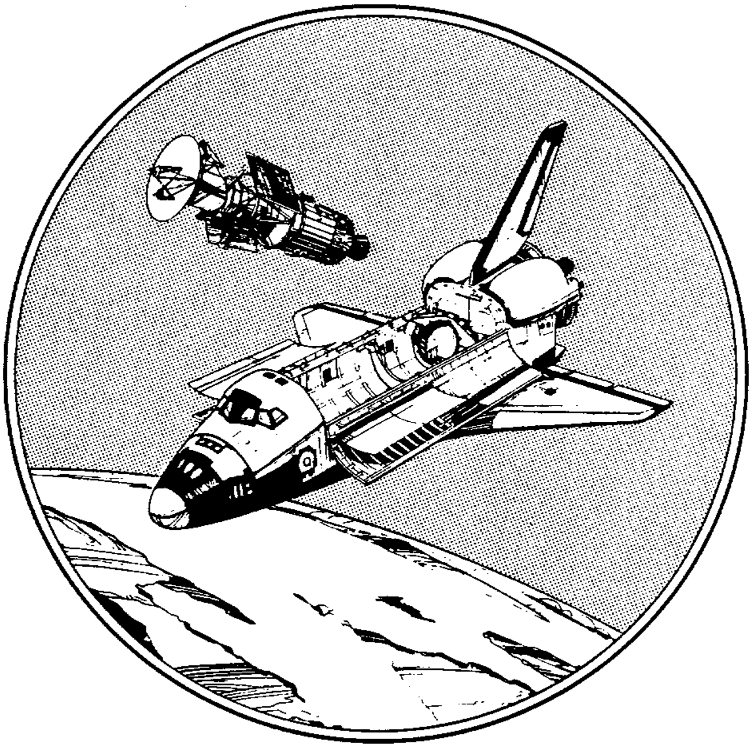
- **OPERATION:**

AS STS MISSION TIMELINE AND PROPELLANT BUDGET PERMIT, ORBITER AND CREW PARTICIPATE IN REACTION CONTROL SYSTEM (RCS) BURN TESTS, NOSE TRACKING TESTS, PITCH/YAW TESTS, PAYLOAD BAY LIGHTING TEST, AND WATER DUMPS DURING COOPERATIVE OVERFLIGHTS OF THE MAUI SITE.

- **PREVIOUS FLIGHT**

STS-29

☆ U.S. GOVERNMENT PRINTING OFFICE: 1989—661-008/00130



STS-30

MISSION STATISTICS

PRELAUNCH COUNTDOWN TIMELINE

MISSION TIMELINE

April 1989

Rockwell International

Space Transportation
Systems Division

Office of Media Relations

CONTENTS

MISSION OVERVIEW

This is the fourth flight of Atlantis and the 29th in the space transportation system program.

The flight crew for the STS-30 mission consists of commander David M Walker; pilot Ronald J. Grabe; and mission specialists Norman E. Thagard, Mary L. Cleave and Mark C. Lee.

The primary objective of this four-day mission is to deploy the Magellan spacecraft mated with an inertial upper stage. After the deployment of the Magellan spacecraft with its IUS from Atlantis' payload bay, the IUS will provide the necessary velocity to place the Magellan in transfer orbit from earth to Venus.

Deployment of the Magellan spacecraft and its IUS from Atlantis' payload bay is scheduled for the fifth orbit at a mission elapsed time of six hours and 18 minutes. Backup deployment opportunities are available on orbits 6, 7 and 16, with a contingency capability on orbit 17.

The first stage of the IUS solid rocket motor will be ignited on orbit 6A (ascending node) for transfer orbit insertion approximately 60 minutes after the IUS and Magellan spacecraft are deployed. (Each orbit starts when the orbiter has crossed the equator on its ascending node.) IUS second-stage SRM ignition occurs approximately two minutes after IUS first-stage cutoff. Upon the completion of the two IUS thrusting periods, the Magellan spacecraft and IUS are separated and the Magellan spacecraft intercepts a hyperbolic earth escape vector, leading to an arrival at Venus approximately 480 days later.

Two other payloads will be carried aboard Atlantis in this mission. One is located in the middeck of Atlantis' crew compartment. This experiment is the Fluids Experiment Apparatus. The other experiment is the Mesoscale Lightning Experiment which uses an onboard cargo bay TV camera and 35mm cameras.

The Air Force Maui Optical Site Calibration Test experiment allows ground-based electro-optical sensors on Maui, Hawaii, to collect imagery and signature data of Atlantis' reaction control system plumes during cooperative overflights. This experiment was also accomplished during the STS-29 mission.

MISSION STATISTICS

Launch: Launch window duration increases from a minimum of 23 minutes to a maximum of two hours over the launch period duration from April 28, 1989 through May 28, 1989.

4/28/89 2:24 p.m. EDT
1:24 p.m. CDT
11:24 a.m. PDT

Mission Duration: 96 hours (four days), 57 minutes

Landing: Nominal end of mission is on orbit 65.

5/2/89 3:21 p.m. EDT
2:21 p.m. CDT
12:21 p.m. PDT

Inclination: 28.85 degrees

Ascent: The ascent profile for this mission utilizes an orbital manuevering system, OMS-1 and OMS-2 thrusting period after main engine cutoff.

Altitude: 85 by 4 nautical miles (97 by 4.6 statute miles), then 51 by 161 nautical miles (58 by 185 statute miles), then 160 by 161 nautical miles (184 by 185 statute miles), then 160 by 177 nautical miles (184 by 203 statute miles)

Space Shuttle Main Engine Thrust Level in Ascent: 104 percent

Total Lift-off Weight: Approximately 4,536,344 pounds

Orbiter Weight, Including Cargo at Lift-off: Approximately 212,922 pounds

Payload Weight Up: Approximately 47,909 pounds

Payload Weight Down: Approximately 7,701 pounds

Orbiter Weight at Landing: Approximately 192,317 pounds

Payloads: Magellan/IUS-2, FEA, MLE and AMOS

Flight Crew Members:
Commander: David M. Walker (second space shuttle flight)
Pilot: Ronald J. Grabe (second space shuttle flight)
Mission Specialist: Norman E. Thagard (third space shuttle flight)
Mission Specialist: Mary L. Cleave (second space shuttle flight)
Mission Specialist: Mark C. Lee (first space shuttle flight)

Ascent Seating:
Flight deck front left seat, commander David Walker
Flight deck front right seat, pilot Ronald Grabe
Flight deck aft center seat, MS-2, Norman Thagard
Flight deck aft right seat, MS-1, Mark Lee
Middeck, MS-3, Mary Cleave

Entry Seating:
Flight deck aft right seat, MS-3, Mary Cleave. Middeck, MS-1, Mark Lee.

Extravehicular Activity Crew Members, If Required:
Extravehicular 1 would be Norman Thagard and EV-2 would be Mark Lee.

Entry Angle of Attack: 40 degrees.

Entry: Automatic mode will be used until subsonic; then control stick steering will be used.

Runway: Nominal end-of-mission landing will be on dry lake bed Runway 17 at Edwards Air Force Base, California

Notes: The remote manipulator system is not installed in Atlantis' payload bay for this flight. The galley is installed in the middeck of Atlantis for this flight.

MISSION OBJECTIVES

- Deployment of Magellan spacecraft with IUS
- Secondary payloads
  - FEA
  - MLE
  - AMOS

DEVELOPMENT TEST OBJECTIVES

- Vibration and acoustic evaluation in payload bay
- Pogo stability, space shuttle main engine and orbiter structure
- Ascent debris
- Nose wheel steering
- Camcorder demonstration
- 10.2 psi cabin operations checkout, demonstration of LES hardware in preparation for STS-31 mission (Hubble Space Telescope)
- TDRS to TDRS handover
- Ku-band antenna friction test due to redesign and rerouting of cabling
- HUD backup to COAS for IMU aligns
- Text and graphics system continuation tests
- Payload and general support computer evaluation with FEA.
- Crosswind landing evaluation

- In-flight salivary pharmacokinetics of scopolamine and dextroamphetamine
- Noninvasive estimation of central venous pressure during spaceflight
- In flight holter monitoring (treadmill)
- Pre- and postflight cardiovascular assessment
- Influence of baroreflex function
- Documentary television
- Documentary motion picture photography
- Documentary still photography

Notes:

- The text and graphics system is the primary mode of text uplink and can only uplink images using Ku-band. TAGS consists of a facsimile scanner on the ground that sends text and graphics through the Ku-band communications system to the text and graphics hard copier in the orbiter. The hard copier is installed on a dual cold plate in avionics bay 3 of the crew compartment middeck and provides an on-orbit capability to transmit text material, maps, schematics, maneuver pads, general messages, crew procedures, trajectory and photographs to the orbiter through the two-way Ku-band link using the TDRS system. It is a high-resolution facsimile system that scans text or graphics and converts the analog scan data into serial digital data. Transmission time for an 8.5- by 11-inch page can vary from approximately one minute to 16 minutes, depending on the hardcopy resolution desired.

  The text and graphics hard copier operates by mechanically feeding paper over a fiber-optic cathode-ray tube and then through a heater-developer. The paper then is cut and stored in a tray accessible by the flight crew. A maximum of 200 8.5- by 11-inch sheets are stored. The status of the hard copier is indicated by front panel lights and downlink telemetry.

  The hard copier can be powered from the ground or by the crew.

  Uplink operations are controlled by the Mission Control Center in Houston. Mission Control powers up the hard copier and then sends the message. In the onboard system, light-sensitive paper is exposed, cut and developed. The message is then sent to the paper tray, where it is retrieved by the flight crew.

- The teleprinter will provide a backup on-orbit capability to receive and reproduce text-only data from the Mission Control Center in Houston. The TPR uses S-band and is not dependent on TDRS Ku-band. It is a modified teletype machine located in a locker in the crew compartment middeck.

  The teleprinter provides the capability to receive and reproduce text-only data, such as procedures, weather reports and crew activity plan updates or changes, aboard the orbiter from the Mission Control Center.

  The teleprinter uplink requires one to 2.5 minutes per message, depending on the number of lines (up to 66). When the ground has sent a message, a *msg rcv* yellow light on the teleprinter is illuminated to indicate a message is waiting to be removed.

STS-30 PRELAUNCH COUNTDOWN

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
06:00:00	Verification of the launch commit criteria is complete at this time. The liquid oxygen and liquid hydrogen systems chill-down commences in order to condition the ground line and valves as well as the external tank (ET) for cryo loading. Orbiter fuel cell power plant activation is performed.
05:50:00	The space shuttle main engine (SSME) liquid hydrogen chill-down sequence is initiated by the launch processing system (LPS). The liquid hydrogen recirculation valves are opened and start the liquid hydrogen recirculation pumps. As part of the chill-down sequence, the liquid hydrogen prevalves are closed and remain closed until T minus 9.5 seconds.
05:30:00	Liquid oxygen chill-down is complete. The liquid oxygen loading begins. The liquid oxygen loading starts with a "slow fill" in order to acclimate the ET. Slow fill continues until the tank is 2-percent full.
05:15:00	The liquid oxygen and liquid hydrogen slow fill is complete and the fast fill begins. The liquid oxygen and liquid hydrogen fast fill will continue until that tank is 98-percent full.
05:00:00	The calibration of the inertial measurement units (IMUs) starts. The three IMUs are used by the orbiter navigation systems to determine the position of the orbiter in flight.
04:30:00	The orbiter fuel cell power plant activation is complete.
04:00:00	The Merritt Island (MILA) antenna, which transmits and receives communications, telemetry and ranging information, alignment verification begins.
03:45:00	The liquid hydrogen fast fill to 98 percent is complete, and a slow topping-off process is begun and stabilized to 100 percent.
03:30:00	The liquid oxygen fast fill is complete to 98 percent.
03:20:00	The main propulsion system (MPS) helium tanks begin filling from 2,000 psi to their full pressure of 4,500 psi.
03:15:00	Liquid hydrogen stable replenishment begins and continues until just minutes prior to T minus zero.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
03:10:00	Liquid oxygen stable replenishment begins and continues until just minutes prior to T-0.
03:00:00	The MILA antenna alignment is completed.
03:00:00	The orbiter closeout crew goes to the launch pad and prepares the orbiter crew compartment for flight crew ingress.
03:00:00 Holding	Begin 2-hour planned hold. An inspection team examines the ET for ice or frost formation on the launch pad during this hold.
03:00:00 Counting	Two-hour planned hold ends.
02:30:00	Flight crew departs Operations and Checkout (O&C) Building for launch pad.
02:00:00	Checking of the launch commit criteria starts at this time.
02:00:00	The ground launch sequencer (GLS) software is initialized.
01:50:00	Flight crew orbiter and seat ingress occurs.
01:50:00	The solid rocket boosters' (SRBs') hydraulic pumping units' gas generator heaters are turned on and the SRBs' aft skirt gaseous nitrogen purge starts.
01:50:00	The SRB rate gyro assemblies (RGAs) are turned on. The RGAs are used by the orbiter's navigation system to determine rates of motion of the SRBs during first-stage flight.
01:35:00	The orbiter accelerometer assemblies (AAs) are powered up.
01:35:00	The orbiter reaction control system (RCS) control drivers are powered up.
01:35:00	Orbiter crew compartment cabin closeout is completed.
01:30:00	The flight crew starts the communications checks.
01:25:00	The SRB RGA torque test begins.
01:20:00	Orbiter side hatch is closed.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
01:10:00	Orbiter side hatch seal and cabin leak checks are performed.
01:10:00	IMU preflight align begins.
01:00:00	The orbiter RGAs and AAs are tested.
00:50:00	The flight crew starts the orbiter hydraulic auxiliary power units' (APUs') H_2O (water) boilers preactivation.
00:45:00	Cabin vent redundancy check is performed.
00:45:00	The GLS mainline activation is performed.
00:40:00	The eastern test range (ETR) shuttle range safety system (SRSS) terminal count closed-loop test is accomplished.
00:40:00	Cabin leak check is completed.
00:32:00	The backup flight control system (BFS) computer is configured.
00:30:00	The gaseous nitrogen system for the orbital maneuvering system (OMS) engines is pressurized for launch. Crew compartment vent valves are opened.
00:26:00	The ground pyro initiator controllers (PICs) are powered up. They are used to fire the SRB hold-down posts, liquid oxygen and liquid hydrogen tail service mast (TSM), and ET vent arm system pyros at lift-off and the SSME hydrogen gas burn system prior to SSME ignition.
00:25:00	Simultaneous air-to-ground voice communications are checked. Weather aircraft are launched.
00:22:00	The primary avionics software system (PASS) is transferred to the BFS computer in order for both systems to have the same data. In case of a PASS computer system failure, the BFS computer will take over control of the shuttle vehicle during flight.
00:21:00	The crew compartment cabin vent valves are closed.
00:20:00	A 10-minute planned hold starts.
Hold 10 Minutes	All computer programs in the firing room are verified to ensure that the proper programs are available for the final countdown. The test team is briefed on the recycle options in case of an unplanned hold.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
	The landing convoy status is again verified and the landing sites are verified ready for launch.
	The chase planes are manned.
	The IMU preflight alignment is verified complete.
	Preparations are made to transition the orbiter onboard computers to Major Mode (MM)-101 upon coming out of the hold. This configures the computer memory to a terminal countdown configuration.
00:20:00	The 10-minute hold ends.
Counting	Transition to MM-101. The PASS onboard computers are dumped and compared to verify the proper onboard computer configuration for launch.
00:19:00	The flight crew configures the backup computer to MM-101 and the test team verifies the BFS computer is tracking the PASS computer systems. The flight crew members configure their instruments for launch.
00:18:00	The Mission Control Center-Houston (MCC-H) now loads the onboard computers with the proper guidance parameters based on the prestated lift-off time.
00:16:00	The MPS helium system is reconfigured by the flight crew for launch.
00:15:00	The OMS/RCS crossfeed valves are configured for launch.
	The chase aircraft engines are started.
	All test support team members verify they are "go for launch."
00:12:00	Emergency aircraft and personnel are verified on station.
00:10:00	All orbiter aerosurfaces and actuators are verified to be in the proper configuration for hydraulic pressure application. The NASA test director gets a "go for launch" verification from the launch team.
00:09:00	A planned 10-minute hold starts.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
Hold 10 Minutes	NASA and contractor project managers will be formally polled by the deputy director of NASA, National Space Transportation System (NSTS) Operations, on the Space Shuttle Program Office communications loop during the T minus 9-minute hold. A positive "go for launch" statement will be required from each NASA and contractor project element prior to resuming the launch countdown. The loop will be recorded and maintained in the launch decision records.
	All test support team members verify that they are "go for launch."
	Final GLS configuration is complete.
00:09:00 Counting	The GLS auto sequence starts and the terminal countdown begins.
	The chase aircraft are launched.
	From this point the GLSs in the integration and backup consoles are the primary control until T-0 in conjunction with the onboard orbiter PASS redundant-set computers.
00:09:00	Operations recorders are on. MCC-H, Johnson Space Center, sends a command to turn these recorders on. They record shuttle system performance during ascent and are dumped to the ground once orbit is achieved.
00:08:00	Payload and stored prelaunch commands proceed.
00:07:30	The orbiter access arm (OAA) connecting the access tower and the orbiter side hatch is retracted. If an emergency arises requiring flight crew activation, the arm can be extended either manually or by GLS computer control in approximately 30 seconds or less.
00:05:00	Orbiter APUs start. The orbiter APUs provide pressure to the three orbiter hydraulic systems. These systems are used to move the SSME engine nozzles and aerosurfaces.
00:05:00	ET/SRB range safety system (RSS) is armed. At this point, the firing circuit for SRB ignition and destruct devices is mechanically enabled by a motor-driven switch called a safe and arm device (S&A).
00:04:30	As a preparation for engine start, the SSME main fuel valve heaters are turned off.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:04:00	The final helium purge sequence, purge sequence 4, on the SSMEs is started in preparation for engine start.
00:03:55	At this point, all of the elevons, body flap, speed brake and rudder are moved through a preprogrammed pattern. This is to ensure that they will be ready for use in flight.
00:03:30	Transfer to internal power is done. Up to this point, power to the space vehicle has been shared between ground power supplies and the onboard fuel cells.
	The ground power is disconnected and the vehicle goes on internal power at this time. It will remain on internal power through the rest of the mission.
00:03:30	The SSMEs' nozzles are moved (gimbaled) through a preprogrammed pattern to ensure that they will be ready for ascent flight control. At completion of the gimbal profile, the SSMEs' nozzles are in the start position.
00:02:55	ET liquid oxygen prepressurization is started. At this point, the liquid oxygen tank vent valve is closed and the ET liquid oxygen tank is pressurized to its flight pressure of 21 psi.
00:02:50	The gaseous oxygen arm is retracted. The cap that fits over the ET nose cone to prevent ice buildup on the oxygen vents is raised off the nose cone and retracted.
00:02:35	Up until this time, the fuel cell oxygen and hydrogen supplies have been adding to the onboard tanks so that a full load at lift-off is assured. This filling operation is terminated at this time.
00:01:57	Since the ET liquid hydrogen tank was filled, some of the liquid hydrogen has turned into gas. In order to keep pressure in the ET liquid hydrogen tank low, this gas was vented off and piped out to a flare stack and burned. In order to maintain flight level, liquid hydrogen was continuously added to the tank to replace the vented hydrogen. This operation terminates, the liquid hydrogen tank vent valve is closed, and the tank is brought up to a flight pressure of 44 psia at this time.
00:01:15	The sound suppression system will dump water onto the mobile launcher platform (MLP) at ignition in order to dampen vibration and noise in the space shuttle. The firing system for this dump, the sound suppression water power bus, is armed at this time.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:00:38	The onboard computers position the orbiter vent doors to allow payload bay venting upon lift-off and ascent in the payload bay at SSME ignition.
00:00:37	The gaseous oxygen ET arm retract is confirmed.
00:00:31	The GLS sends "go for redundant set launch sequence start." At this point, the four PASS computers take over main control of the terminal count. Only one further command is needed from the ground, "go for main engine start," at approximately T minus 9.7 seconds. The GLS in the integration console in the launch control center still continues to monitor several hundred launch commit criteria and can issue a cutoff if a discrepancy is observed. The GLS also sequences ground equipment and sends selected vehicle commands in the last 31 seconds.
00:00:28	Two hydraulic power units in each SRB are started by the GLS. These provide hydraulic power for SRB nozzle gimbaling for ascent first-stage flight control.
00:00:21	The SRB gimbal profile is complete. As soon as SRB hydraulic power is applied, the SRB engine nozzles are commanded through a preprogrammed pattern to assure that they will be ready for ascent flight control during first stage.
00:00:21	The liquid hydrogen high-point bleed valve is closed.
00:00:18	The onboard computers arm the explosive devices, the pyrotechnic initiator controllers, that will separate the T-0 umbilicals, the SRB hold-down posts, and SRB ignition, which is the final electrical connection between the ground and the shuttle vehicle.
00:00:16	The aft SRB multiplexer/demultiplexer (MDM) units are locked out. This is to protect against electrical interference during flight. The electronic lock requires an unlock command before it will accept any other command.
	The MPS helium fill is terminated. The MPS helium system flows to the pneumatic control system at each SSME inlet to control various essential functions. The GLS opens the prelift-off valves for the sound suppression water system in order to start water flow to the launch pad.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
00:00:15	If the SRB pyro initiator controller (PIC) voltage in the redundant-set launch sequencer (RSLS) is not within limits in 3 seconds, SSME start commands are not issued and the onboard computers proceed to a countdown hold.
00:00:10	SRB SRSS inhibits are removed. The SRB destruct system is now live.
	Launch processing system (LPS) issues a "go" for SSME start. This is the last required ground command. The ground computers inform the orbiter onboard computers that they have a "go" for SSME start. The GLS retains hold capability until just prior to SRB ignition.
00:00:09.7	Liquid hydrogen recirculation pumps are turned off. The recirculation pumps provide for flow of fuel through the SSMEs during the terminal count. These are supplied by ground power and are powered in preparation for SSME start.
00:00:09.7	In preparation for SSME ignition, flares are ignited under the SSMEs. This burns away any free gaseous hydrogen that may have collected under the SSMEs during prestart operations.
	The orbiter goes on internal cooling at this time; the ground coolant units remain powered on until lift-off as a contingency for an aborted launch. The orbiter will redistribute heat within the orbiter until approximately 125 seconds after lift-off, when the orbiter flash evaporators will be turned on.
00:00:09.5	The SSME engine chill-down sequence is complete and the onboard computers command the three MPS liquid hydrogen prevalves to open. (The MPS's three liquid oxygen prevalves were opened during ET tank loading to permit engine chill-down.) These valves allow liquid hydrogen and oxygen flow to the SSME turbopumps.
00:00:09.5	Command decoders are powered off. The command decoders are units that allow ground control of some onboard components. These units are not needed during flight.
00:00:06.6	The main fuel and oxidizer valves in each engine are commanded open by the onboard computers, permitting fuel and oxidizer flow into each SSME for SSME start.

T – (MINUS) HR:MIN:SEC	TERMINAL COUNTDOWN EVENT
	All three SSMEs are started at 120-millisecond intervals (SSME 3, 2, then 1) and throttle up to 100-percent thrust levels in 3 seconds under control of the SSME controller on each SSME.
00:00:04.6	All three SSMEs are verified to be at 100-percent thrust and the SSMEs are gimbaled to the lift-off position. If one or more of the three SSMEs do not reach 100-percent thrust at this time, all SSMEs are shut down, the SRBs are not ignited, and an RSLS pad abort occurs. The GLS RSLS will perform shuttle and ground systems safing.
	Vehicle bending loads caused by SSME thrust buildup are allowed to initialize before SRB ignition. The vehicle moves towards ET including ET approximately 25.5 inches.
00:00:00	The two SRBs are ignited under command of the four onboard PASS computers, the four hold-down explosive bolts on each SRB are initiated (each bolt is 28 inches long and 3.5 inches in diameter), and the two T-0 umbilicals on each side of the spacecraft are retracted. The onboard timers are started and the ground launch sequence is terminated. All three SSMEs are at 104-percent thrust. Boost guidance in attitude hold.
00:00	Lift-off.

STS-30 MISSION TIMELINE

DAY ZERO

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:00:06.8	Tower is cleared (SRBs above lightning rod tower).
0/00:00:08	120 degree roll maneuver positive roll (right-clockwise) is started. Pitch profile is heads down (astronauts) wings level.
0/00:00:20	Roll maneuver ends.
0/00:00:20	All three SSMEs throttle from 104 to 101 percent for maximum aerodynamic load (max q).
0/00:00:30	All three SSMEs throttle from 101 to 65 percent for max q.
0/00:00:56	All three SSMEs throttle to 104 percent.
0/00:01:09	Max q occurs.
0/00:02:05	SRBs separate.
	When chamber pressure (P_C) of the SRBs are less than 50 psi, automatic separation occurs with manual flight crew backup switch to the automatic function (does not bypass automatic circuitry). SRBs descend to approximately 15,400 feet, when the nose cap is jettisoned and drogue chute are deployed for initial deceleration. At approximately 6,600 feet, drogue chute is released and three main parachutes on each SRB provide final deceleration prior to splashdown in Atlantic Ocean, where they are recovered for reuse in another mission. Flight control system switchover from SRB to orbiter RGAs occurs.
0/00:03:58	Negative return. The vehicle is no longer capable of return to launch site (RTLS) abort to Kennedy Space Center runway.
0/00:07:14	Single engine to main engine cutoff (MECO).
0/00:07:34	All three SSMEs throttle from 104 percent for vehicle no greater than 3 g acceleration capability.
0/00:08:24	All three SSMEs throttle down to 65 percent for MECO.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:08:31	MECO, approximate velocity 25,871 feet per second (fps), 85 by 4 nautical miles (97 by 4.6 statute miles).
0/00:08:49	ET separation is automatic with flight crew manual backup switch to the automatic function (does not bypass automatic circuitry).
	First use of orbiter forward and aft Reaction Control System (RCS), which provides attitude hold and negative Z translation of 4 fps of the orbiter for separation of external tank from orbiter.
	External tank liquid oxygen valve opened at separation to induce a tumble to external tank for Indian Ocean impact area footprint.
	Orbiter external tank liquid oxygen/liquid hydrogen umbilical retraction.
	Negative Z translation complete.
0/00:10:31	OMS-1 thrusting period is 2 minutes 19 seconds in duration, 224.6 fps, 51 by 161 nautical miles (58 by 185 statute miles).
	In conjunction with this thrusting period, approximately 1,700 pounds of liquid hydrogen and 3,700 pounds of liquid oxygen are trapped in the main propulsion system (MPS) ducts and SSMEs, which result in an approximate 7-inch center of gravity shift in the orbiter, which sporadically vent on orbit affecting guidance and create contaminants for payload and in entry, liquid hydrogen could combine with atmospheric oxygen to form a potentially explosive mixture. As a result, the liquid oxygen is dumped out through the SSME's combustion chamber and the liquid hydrogen is dumped out through the right hand side T-O umbilical overboard fill and drain. This velocity was precomputed in conjunction with OMS-1.
	MPS dump terminates.
	Auxiliary power unit (APU) shuts down.
	Main propulsion vacuum inerting occurs.
	• Remaining residual propellants are vented to space vacuum, inerting the main propulsion system.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	• Orbiter/external tank umbilical doors close (one door for liquid hydrogen and one door for liquid oxygen) at bottom of aft fuselage, which seals the aft fuselage for entry heat loads.
	• Main propulsion system vacuum inerting terminates.
0/00:44:29	OMS-2 thrusting period is 2 minutes 3 seconds in duration, 195.1 fps, 161 by 160 nautical miles (185 by 184 statute miles).
0/00:53	MS seat egress occurs.
0/00:54	Commander and pilot configure general purpose computers (GPCs) for OPS-2.
0/00:57	MS configures middeck.
0/00:59	MS configures aft station.
0/01:08	Pilot activates payload bus.
0/01:10	Commander and pilot don and configure communications.
0/01:12	Pilot maneuvers to payload bay door opening attitude, negative Z local vertical biased negative Y velocity vector.
0/01:16	Orbit No.2 begins.
0/01:17	Commander activates radiators.
0/01:28	Pilot opens payload bay doors.
0/01:29	Commander loads payload data interleaver (PDI).
0/01:33	Pilot checks out cryo heaters, liquid oxygen tank 3 heaters A, B, (2) to AUTO and liquid hydrogen tank 3 heaters A, B, (2) to AUTO, panel R1.
0/01:35	Commander powers the star trackers (STs) ON.
0/01:36	MCC-H gives flight crew "go for orbit operations."
0/01:37	Commander and pilot egress seats.
0/01:38	Commander and pilot doff launch entry suits (LESs).

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:39	MS doff LESs.
0/01:50	Pilot activates AUTO fuel cell purge.
0/01:51	MS activates teleprinter, if flown.
0/01:52	Commander configures radiators for post payload bay door operations.
0/01:55	MS removes and stows seat.
0/01:56	Commander opens ST doors and performs self test.
0/01:57	Pilot closes MNB supply H_2O dump isolation circuit breaker, ML86, and activates supply H_2O dump isolation valve open (OP) on R12L.
0/02:00	Pilot activates APU steam vent heater boiler control power heater (3) to A, controller (3) power to ON.
0/02:05	MS engages IUS actuator.
0/02:10	Commander configures RCS vernier control.
0/02:12	Commander and pilot configure controls for on orbit and unstow and install heads-up display (HUD) covers.
0/02:21	Pilot enables hydraulic systems thermal conditioning.
0/02:22	Pilot positions cabin temperature controller to 1.
0/02:24	MS resets caution and warning (C/W) system.
0/02:26	MS unstows and installs treadmill in middeck.
0/02:27	Pilot switches APU fuel pump/valve cool from A-OFF to B-AUTO.
0/02:29	Pilot plots fuel cell performance.
	EZ ACTIVITIES FOR TODAY
	— Cryo heater oxygen tank sensor check
	— Pressure control system (PCS) configuration to system 1
	— Lamp and fire suppression test, 10 minutes

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	— Meal preparation
	— LES cleaning and drying, 25 minutes, one crew member
	— Central venous pressure, 5 minutes
0/02:30	Unstow cabin equipment.
0/02:31	Photo/TV are activated for satellite deploy.
0/02:45	IUS predeploy checkout occurs.
0/02:47	Orbit No. 3 begins.
0/03:01	Photo/TV cameras are assembled.
0/03:01	IUS direct check is performed.
0/03:11	Vehicle is maneuvered to IMU align attitude.
0/03:26	IMU is aligned with Star Tracker (ST).
0/03:31	AMU sequence is performed.
0/03:40	APU steam vent heater is deactivated; boiler power (3) are turned to OFF.
0/03:45	Photo/TV assembly is set up for satellite deploy scenes.
0/03:54	Vehicle is maneuvered to negative Z local vertical negative X velocity vector attitude.
0/04:00	AMU sequence is performed.
0/04:01	APU cool are turned to OFF; APU Fuel Pump/Valve Cool B are turned to OFF.
0/04:11	TAGS is activated.
0/04:17	Orbit No. 4 begins.
0/04:20	Checkout of aft station controller is performed.
0/04:20	Transfer of state vector (SV) through Hawaii for IUS predeploy checks.
0/04:30	Crew members mealtime.
0/05:30	Vehicle is maneuvered to IUS deploy attitude.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/05:30	IUS payload interleaver (PI) locks.
0/05:30	APU heater gas generator/fuel pump (3) is turned to AUTO.
0/05:40	Elevate IUS/Magellan tilt table to 29 degrees.
0/05:46	Photo/TV are activated for satellite deploy.
0/05:47	Orbit No. 5 begins.
0/05:48	IUS transfers to internal power.
0/05:51	Magellan batteries are brought on line.
0/05:55	Flight crew is informed to "go for deploy"; begin deploy countdown.
0/06:02	IUS umbilical is released.
0/06:03	IUS/Magellan tilt table is elevated to 52 degrees.
0/06:18	IUS/Magellan are deployed.
0/06:20	Vehicle is maneuvered to post deploy separation attitude.
0/06:25	IUS tilt table is lowered to minus 6 degrees.
0/06:28	Magellan solar arrays are deployed.
0/06:33	OMS separation thrusting period, 16 seconds in duration, 31 fps, 160 by 177 nmi (184 by 203 smi).
0/06:34	Vehicle is maneuvered to IUS viewing attitude.
0/06:50	Payload interleaver is OFF.
0/06:55	Vehicle is maneuvered to window protection attitude.
0/07:00	Postdeploy separation maneuver is performed.
0/07:00	Photo/TV activation satellite is deployed.
0/07:16	Close out IUS deploy and postdeploy operations.
0/07:18	Orbit No. 6 begins.
0/07:18	IUS solid rocket motor (SRM) 1 ignition.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/07:23	Configure DAP to A1/AUTO/VERNIER.
0/07:26	Payload and general support computer (PGSC) evaluation.
0/07:30	Load pulse code modulation master unit format.
0/07:30	Ku-band antenna is deployed.
0/07:30	Crew begins presleep activity.
0/07:35	Unstow FEA.
0/07:40	Ku-band antenna is activated for communications/ instrumentation.
0/07:58	Vehicle is maneuvered to IMU align attitude.
0/08:13	COAS power is OFF; mount COAS aft.
0/08:14	IMU is aligned with ST.
0/08:19	COAS is calibrated.
0/08:23	Vehicle is maneuvered to negative Z local vertical, positive X velocity vector attitude.
0/08:29	Paper is stacked in TAGS paper tray.
0/08:34	Crew empties TAGS paper tray.
0/08:39	COAS is power OFF; stow COAS.
0/08:48	Orbit No. 7 begins.
0/09:40	Flash evaporator controller primary A (B) is positioned to OFF.
0/10:19	Orbit No. 8 begins.
0/10:30	Crew begins 8-hour sleep period.
0/11:50	Orbit No. 9 begins.
0/13:20	Orbit No. 10 begins.
0/14:51	Orbit No. 11 begins.
0/16:22	Orbit No. 12 begins.
0/17:52	Orbit No. 13 begins.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/18:30	Crew ends 8-hour sleep period and begins postsleep activity.
	EZ ACTIVITIES FOR TODAY
	— Exercise, one hour (all).
	— Food preparation.
	— Salivary SCOP/DEX kinetics, 5 minutes (MS2).
	— Central venous pressure, 5 minutes (commander and pilot).
0/18:45	Paper is stacked in TAGS paper tray.
0/19:23	Orbit No. 14 begins.
0/19:35	Crew uses last TAGS message to sort crew messages from TAGS DTO pages.
0/19:45	Vehicle is maneuvered to IMU align attitude.
0/20:00	IMU is aligned with ST.
0/20:05	Vehicle is maneuvered to COAS calibration attitude.
0/20:20	HUD backup to COAS, data take 1.
0/20:45	Vehicle is maneuvered to TDRS attitude.
0/20:53	Orbit No. 15 begins.
0/21:05	Photo/TV are set up for FEA.
0/21:35	Photo/TV are activated for FEA.
0/21:35	FEA is activated, sample 1.
0/22:00	TDRS early S-band handover.
0/22:24	Orbit No. 16 begins.
0/22:50	VTR is set up for satellite deploy.
0/23:00	Monitor FEA.
0/23:20	VTR playback of satellite deploy.
0/23:55	Orbit No. 17 begins.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
DAY ONE	
1/00:00	TDRS early Ku-band handover.
1/00:00	FEA is terminated, sample 1.
1/00:10	Photo/TV are set up for Mesoscale Lightning Experiment (MLE).
1/00:15	Vehicle is maneuvered to negative Z local vertical, positive X velocity vector attitude.
1/00:45	Photo/TV are activated for MLE scenes.
1/01:05	FEA is reset.
1/01:25	Orbit No. 18 begins.
1/01:30	Crew mealtime.
1/01:50	FEA is activated, sample 2.
1/02:50	FEA is monitored.
1/02:56	Orbit No. 19 begins.
1/03:09	AMOS RCS thrusting period.
1/03:10	Change DAP B to B1.
1/04:25	FEA is terminated, sample 2.
1/04:25	Vehicle is maneuvered to TDRS attitude.
1/04:27	Orbit No. 20 begins.
1/04:30	PGSC temperature test is performed.
1/04:30	PGSC system disk test is performed.
1/04:45	TDRS early Ku-band handover.
1/05:25	Photo/TV are set up, 8mm camcorder demonstration.
1/05:30	FEA is reset.
1/05:55	Photo/TV are activated for 8mm camcorder scenes.
1/05:57	Orbit No. 21 begins.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/06:15	FEA is activated, sample 3.
1/06:25	Filter cleaning, scheduled inflight maintenance.
1/06:55	Maneuver vehicle to negative Z local vertical, positive X velocity vector attitude.
1/07:10	Paper stacking in TAGS paper tray.
1/07:28	Orbit No. 22 begins.
1/07:35	FEA status is checked.
1/07:58	AMOS RCS thrusting period.
1/08:05	Crew performs supply water dump.
1/08:05	Crew performs fuel cell purge.
1/08:05	Change DAP B to B5.
1/08:10	COAS OFF, mount COAS forward.
1/08:10	Vehicle is maneuvered to IMU align attitude.
1/08:15	FEA status is checked.
1/08:25	IMU is aligned using ST.
1/08:30	Vehicle is maneuvered to COAS calibration attitude.
1/08:30	Vehicle is maneuvered to negative Z local vertical, positive X velocity vector attitude.
1/08:35	Crew begins presleep activity.
1/08:55	FEA status is checked.
1/08:58	Orbit No. 23 begins.
1/09:15	COAS OFF, stow COAS.
1/10:00	Crew begins 8-hour sleep period.
1/10:29	Orbit No. 24 begins.
1/12:00	Orbit No. 25 begins.
1/13:30	Orbit No. 26 begins.
1/15:01	Orbit No. 27 begins.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/16:31	Orbit No. 28 begins.
1/18:00	Crew ends 8-hour sleep period and begins postsleep activity.
	EZ ACTIVITIES FOR TODAY
	— Exercise, one hour (all).
	— Food preparation, 30 minutes.
	— Reconfigure RCS regulator helium pressure A (3) to CLOSE, B (3) to GPC, 5 minutes.
	— Electrical power system (EPS) heater reconfiguration to B, 5 minutes.
	— Environmental control life support system (ECLSS) redundant component check out, 10 minutes.
	— Pressure control system (PCS) configuration from 1 to 2, 5 minutes (2 crew members).
	— Cabin temperature controller reconfiguration, pin cabin temperature controller actuator linkage to actuator 2, cabin temperature controller to 2, 5 minutes.
	— Humidity separator reconfiguration, humidity SEP B to OFF, A to ON.
	— Salivary SCOP/DEX kinetics DSO;5 minutes (MS2).
	— Central venous pressure DSO, 5 minutes (commander and pilot).
1/18:02	Orbit No. 29 begins.
1/18:45	Paper is stacked in TAGS paper tray.
1/19:33	Orbit No. 30 begins.
1/19:50	Crew purges fuel cells manually.
1/20:00	Vehicle is maneuvered to IMU align attitude.
1/20:05	Crew uses last TAGS message to sort crew messages from TAGS DTO pages.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
1/20:15	IMU is aligned with ST.
1/20:20	Vehicle is maneuvered to COAS calibration attitude.
1/20:40	HUD backup to COAS, data take 2.
1/20:55	Change DAP B to B1.
1/20:55	Vehicle is maneuvered to negative Z local vertical, positive X velocity vector attitude.
1/21:03	Orbit No. 31 begins.
1/21:20	Photo/TV are set up for MLE.
1/21:50	Photo/TV are activated for MLE scenes.
1/22:34	Orbit No. 32 begins.
1/22:45	FEA is terminated, sample 3.
1/23:10	EVA, aspirin protocol.

DAY TWO

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/00:05	Orbit No. 33 begins.
2/00:15	The crew perform helmet retention assembly (HRA) and LES helmet prebreathe rehearsal to determine helmet flowrates and suitability of hardware to support EVA operations.
2/00:30	Conduct PGSC DC power test.
2/01:00	Two crew members prepare for 10.2 psi cabin.
2/01:10	Two crew members depressurize cabin from 14.7 to 10.2 psi.
2/01:10	Conduct PGSC floppy disk boot test.
2/01:35	Orbit No. 34 begins.
2/01:46	AMOS RCS thrusting period.
2/01:50	Terminate HRA prebreathe.
2/01:50	10.2 psi cabin configuration.
2/02:00	Change DAP B to B1.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/02:00	Crew mealtime.
2/03:06	Orbit No. 35 begins.
2/03:10	FEA is reset.
2/03:25	Photo/TV are set up for FEA scenes.
2/03:55	Photo/TV are activated for FEA scenes.
2/03:55	FEA is activated, sample 4.
2/04:36	Orbit No. 36 begins.
2/05:30	FEA status is checked.
2/06:05	FEA status is checked.
2/06:10	Orbit No. 37 begins.
2/06:30	Crew begins presleep activity.
2/06:40	FEA status is checked.
2/06:55	Vehicle is manuvered to IMU align attitude.
2/07:15	IMU is aligned with ST.
2/07:15	Vehicle is maneuvered to negative Z local vertical, positive X velocity vector attitude.
2/07:15	Paper is stacked in TAGS paper tray.
2/07:38	Orbit No. 38 begins.
2/07:40	Crew empties TAGS paper tray.
2/09:08	Orbit No. 39 begins.
2/09:30	Crew begins 8-hour sleep period.
2/10:39	Orbit No. 40 begins.
2/12:09	Orbit No. 41 begins.
2/13:40	Orbit No. 42 begins.
2/15:11	Orbit No. 43 begins.
2/16:41	Orbit No. 44 begins.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/17:30	Crew ends 8-hour sleep period and begins postsleep activity.
	EZ ACTIVITIES FOR TODAY
	— Exercise, one hour (all).
	— Food preparation, 30 minutes.
	— Central venous pressure, DSO, 5 minutes. (commander and pilot)
2/18:12	Orbit No. 45 begins.
2/18:20	Paper is stacked in TAGS paper tray.
2/18:40	Vehicle is maneuvered to IMU align attitude.
2/18:50	IMU aligned with ST.
2/18:50	Crew uses last TAGS message to sort crew messages from TAGS DTO pages.
2/19:00	Vehicle is maneuvered to COAS calibration attitude.
2/19:15	HUD backup to COAS, data take 3.
2/19:20	Vehicle is maneuvered to COAS calibration attitude.
2/19:40	HUD backup to COAS.
2/19:40	Vehicle is maneuvered to TDRS attitude.
2/19:43	Orbit No. 46 begins.
2/20:15	Photo/TV are set up for crew conference.
2/20:25	FEA is terminated, sample 4.
2/20:40	Crew conference.
2/20:45	Photo/TV are activated for crew conference.
2/20:55	Vehicle is maneuvered to negative Z local vertical, positive X velocity vector attitude.
2/21:05	Treadmill stress test.
2/21:05	PGSC test is performed.
2/21:13	Orbit No. 47 begins.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
2/21:15	Ku-band antenna friction.
2/21:35	Photo/TV are set up for MLE.
2/22:35	Two crew members repressurize cabin from 10.2 to 14.7 psi.
2/22:44	Orbit No. 48 begins.
2/23:15	APU steam vent heater is activated, boiler controller/heater (3) to B and power (3) to ON.

DAY THREE

3/00:14	Orbit No. 49 begins.
3/00:15	Flight control system (FCS) check out performed by two crew members.
3/00:55	FEA is reset.
3/01:30	Crew mealtime.
3/01:35	FEA is activated, sample 5.
3/01:45	Orbit No. 50 begins.
3/01:55	Change DAP B to B1.
3/01:58	AMOS RCS thrusting period.
3/02:35	APU cool off, APU Fuel Pump/Valve Cool A to OFF, reconfigure APU heaters.
3/02:40	RCS hot fire test.
3/02:50	Configure DAP to A1/AUTO/Vernier.
3/03:00	Crew cabin configuration/stowage.
3/03:05	FEA status is checked.
3/03:16	Orbit No. 51 begins.
3/03:35	FEA status is checked.
3/04:05	FEA status is checked.
3/04:46	Orbit No. 52 begins.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/06:00	Crew begins presleep activity.
3/06:17	Orbit No. 53 begins.
3/06:40	Change DAP B to B1.
3/06:47	AMOS RCS thrusting period.
3/06:55	Crew performs supply water dump.
3/06:55	Crew performs fuel cell purge.
3/07:05	Vehicle is maneuvered to IMU align attitude.
3/07:10	Paper is stacked in TAGS paper tray.
3/07:20	IMU is aligned with ST.
3/07:20	Vehicle is maneuvered to negative Z local vertical, positive X velocity vector attitude.
3/07:35	Crew empties TAGS paper tray.
3/07:47	Orbit No. 54 begins.
3/09:00	Crew members begin 8-hour sleep period.
3/09:18	Orbit No. 55 begins.
3/10:49	Orbit No. 56 begins.
3/12:19	Orbit No. 57 begins.
3/13:50	Orbit No. 58 begins.
3/15:20	Orbit No. 59 begins.
3/16:51	Orbit No. 60 begins.
3/17:00	Crew ends 8-hour sleep period and begins postsleep activity.

EZ ACTIVITIES FOR TODAY

— Air samples.

— Fluid loading preparation, fill four drink containers with 8 ounces of H_2O each, per person.

— Central venous pressure DSO, 5 minutes (commander and pilot).

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/17:05	Paper is stacked in TAGS paper tray.
3/17:15	Crew uses last TAGS message to sort crew messages from TAGS DTO pages.
3/17:40	Vehicle is maneuvered to IMU align attitude.
3/18:00	IMU aligned with ST.
3/18:05	Vehicle is maneuvered to biased negative X solar inertial attitude.
3/18:10	FEA is terminated, sample 5.
3/18:22	Orbit No. 61 begins.
3/19:15	FEA is reset.
3/19:52	Orbiter No. 62 begins.
3/19:55	Set up cathode ray timer (CRT).
3/20:00	FEA is stowed.
3/20:00	Initiate coldsoak attitude.
3/20:10	Crew stows radiators, if required.
3/20:27	Crew configures data processing system (DPS) for deorbit preparation.
3/20:30	Mission Control Center (MCC) updates IMU pad, if required.
3/20:38	MCC, "Go for payload bay door closure."
3/20:39	Crew configures for payload bay door closure.
3/20:50	Crew stows Ku-band antenna, if required.
3/20:56	Vehicle is maneuvered to IMU align attitude.
3/21:03	DAP is set to B/AUTO/NORMAL.
3/21:04	Radiator is set to BYPASS and flash evaporator system (FES) is checked out.
3/21:10	IMU is aligned with ST.
3/21:15	Payload bay doors are closed.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
3/21:23	Orbit No. 63 begins.
3/21:25	Preliminary deorbit update/uplink.
3/21:34	Crew configures dedicated displays.
3/21:38	MCC, "Go for OPS 3."
3/21:41	Vehicle is maneuvered to deorbit burn attitude.
3/21:50	Crew configures DPS for entry.
3/22:00	All crew members verify entry switch list.
3/22:15	All crew members perform entry review.
3/22:30	Commander and pilot don LES clothing.
3/22:45	MS don LES clothing.
3/22:53	Orbit No. 64 begins.
3/22:55	Commander and pilot ingress seats.
3/23:08	Deorbit is updated.
3/23:09	OMS thrust vector control (TVC) gimbal check is performed.
3/23:11	APU prestart.
3/23:27	Vent doors are closed.
3/23:33	MCC, "Go for deorbit thrusting maneuver."
3/23:39	MS ingress seats.
3/23:39	Vehicle is maneuvered to deorbit thrusting attitude.
3/23:50	First APU is activated.
3/23:55	Deorbit thrusting period, 2 minutes 43 seconds in duration, 307 fps.

DAY FOUR

4/00:00:05	Post deorbit attitude maneuver is initiated.
4/00:05	Forward RCS dump is performed, if required.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/00:13:32	Crew starts two remaining APUs.
4/00:14	SSME hydraulic systems are repressurized.
4/00:24	Orbit No. 65 begins.
4/00:26:31	Vehicle achieves entry interface (EI) 400,000 feet altitude.
4/00:29:07	Vehicle enters S-band blackout through ground station.
4/00:31:18	RCS roll thrusters are deactivated automatically.
4/00:38:38	RCS pitch thrusters are deactivated automatically.
4/00:42:14	Vehicle performs first roll reversal.
4/00:43:52	Vehicle exits S-band blackout through ground station.
4/00:46:10	Vehicle performs second roll reversal.
4/00:49:20	Air data system (ADS) is deployed.
4/00:49:32	Vehicle performs third roll reversal.
4/00:50:47	ENTRY/terminal area energy management (TAEM) is achieved.
4/00:50:52	Vent doors open.
4/00:52:58	RCS yaw thrusters are deactivated automatically.
4/00:52:59	Vehicle is at 50,000 feet altitude.
4/00:55:48	TAEM-approach and landing (A/L) interface is achieved.
4/00:56:45	Landing gear deployment is initiated.
4/00:57:07	Vehicle has weight on main landing gear wheels.
4/00:57:16	Vehicle has weight on nose landing gear wheels.
4/00:57:23	Braking is initiated.
4/00:57:29	Nose wheel steering is initiated.
4/00:57:49	Wheels stop.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
4/01:03	Flight crew safes OMS/RCS.
4/01:06	Sniff checks are performed.
4/01:08	Aft vehicles are positioned.
4/01:18	Ground purge unit (transporter) is connected to right hand (starboard) T-0 orbiter umbilical and ground cooling unit (transporter) to left hand (port) T-0 orbiter umbilical.
4/01:18	Crew compartment side hatch access vehicle is positioned.
4/01:25	Orbiter crew egress/ingress side hatch is opened.
4/01:53	Orbiter flight crew and ground crew exchange.

GLOSSARY

AA	accelerometer assemblies
ADSF	automatic directional solidification furnace
A/L	approach and landing
AOA	abort once around
APU	auxiliary power unit
ARC	Aggregation of Red Blood Cells experiment
ARS	attitude reference system
ASE	airborne support equipment
CAP	crew activity plan
CAPS	crew altitude protection suit
CBSA	cargo bay stowage assembly
CCTV	closed circuit television
CDR	commander
CEC	control electronics container
CFES	continuous flow electrophoresis system
CIU	communications interface unit
CRT	cathode ray tube
CSS	control stick steering
DMOS	diffusive making of organic solutions
DPS	data processing system
EAFB	Edwards Air Force Base
EAC	experiment apparatus container
EEP	electronics equipment package
ELRAD	Earth Limb Radiance experiment
EMU	extravehicular mobility unit
EPS	electrical power system
ET	external tank
EV	extravehicular
EVA	extravehicular activity
FC	fuel cell
FES	flash evaporator system
FPS	feet per second
FSS	flight support structure
FSS	flight support system
GAS	getaway special
GEM	generic electronics module
GLS	ground launch sequencer
GPS	general-purpose computer
GSFC	Goddard Space Flight Center
HDRS	high data rate system
HGAS	high gain antenna system
HRM	handheld radiation meter
HUD	heads-up display
IEF	Isoelectric Focusing Experiment
IMU	Inertial measurement unit

IRCFE	Infrared Communications Flight Experiment
IUS	inertial upper stage
IV	intravehicular
JEA	joint endeavor agreement
JSC	Johnson Space Center
KBPS	kilobits per second
KSC	Kennedy Space Center
LDEF	long duration exposure facility
LEASAT	leased communication satellite
LES	launch entry suit
LPS	launch processing system
LRU	line replaceable unit
MC	midcourse correction maneuver
MCC-H	Mission Control Center—Houston
MDM	multiplexer/demultiplexer
MEB	main electronics box
MECO	main engine cutoff
MEM	Middeck electronics module
MET	mission elapsed time
MFR	manipulator foot restraint
MILA	Merritt Island
MLE	Meoscale Lightning Experiment
MLR	monodisperse latex reactor
MM	major mode
MMU	manned maneuvering unit
MPES	mission peculiar equipment support structure
MPS	main propulsion system
MS	mission specialist
MSFC	Marshall Space Flight Center
NC	normal corrective maneuver
NCC	normal corrective combination maneuver
NH	normal height adjust maneuver
NMI	nautical miles
NPC	normal plane change maneuver
NSR	normal slow rate maneuver
O&C	operations and checkout
OCP	Office of Commercial Programs
OEX-OASIS	Orbiter experiment, Autonomous Supporting Instrumentation System
OAST	Office of Aeronautics and Space Technology
OMS	Orbital maneuvering system
OSSA	Office of Space Sciences and Applications
OSTA	Office of Space and Terrestrial Applications
PALAPA	Indonesian communication satellite
PAM	payload assist module
PCM	payload control panel
PCS	pressure control system
PCG	protein crystal growth

PDI	payload data interleaver
PFR	portable foot restraint
PI	payload interrogator
PIC	pyro initiator controller
PL	payload
PLT	pilot
POCC	payload operations control center
PPE	Phase Partitioning Experiment
PRCS	primary reaction control system
PRM	pocket radiation meter
PS	payload specialist
PTI	preprogrammed test input
PVTOS	Physical Vapor Transport Organic Solids experiment
RAHF-VT	research animal holding facility-verification test
RCC	reinforced carbon-carbon
RCS	reaction control system
RGA	rate gyro assembly
RME	radiation monitoring equipment
RMS	remote manipulator system
RTLS	return to launch site
S&A	safe and arm
SESA	special equipment stowage assembly
SL	Spacelab
SM	statute miles
SMS	space motion sickness
SRB	solid rocket booster
SRSS	shuttle range safety system
SSIP	shuttle student involvement project
SSME	space shuttle main engine
STS	Space Transportation System
SYNCOM	synchronous communication satellite
TACAN	tactical air navigation
TAEM	terminal area energy management
TAL	transatlantic landing
TDRS	tracking data relay satellite
TDRSS	tracking and data relay satellite system
TI	thermal phase initiation
TIG	time of ignition
TLD	thermoluminescent dosimeter
TPAD	trunnion pin acquisition device
TPF	terminal phase final maneuver
TPI	terminal phase initiation maneuver
TPS	thermal protection system
TV	television
VCGS	vapor crystal growth system
VRCS	vernier reaction control system
VTR	video tape recorder
VWFC	very wide field camera
WCS	waste collection system