NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION

STS-34

PRESS KIT
OCTOBER 1989

PROJECT GALILEO

STS-34 INSIGNIA

S89-29077 -- The triangular shape of the STS-34 crew insignia represents forward motion and the entering into new frontiers of science, engineering and technology. The Galileo spacecraft overlaying the orbiter symbolizes the joining together of both manned and unmanned space programs in order to maximize the capabilities of each. The crew members, who designed the insignia, use a sunrise stretching across Earth's horizon to depict expansion of our knowledge of the solar system and other worlds, leading to a better understanding of our own planet. In the distance, Jupiter, a unique world with many unknowns, awaits the arrival of Galileo to help unlock its secrets. Meanwhile, the space shuttle remains in Earth orbit, continuing to explore the near-Earth environment.

The NASA insignia design for space shuttle flights is reserved for use by the astronauts and for other official use as the NASA Administrator may authorize. Public availability has been approved only in the form of illustrations by the various news media. When and if there is any change in this policy, which we do not anticipate, it will be publicly announced.

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PUBLIC AFFAIRS CONTACTS

Sarah Keegan/Barbara Selby
Office of Space Flight
NASA Headquarters, Washington, D.C.
(Phone: 202/453-8536)

Charles Redmond/Paula Cleggett-Haleim
Office of Space Science and Applications
NASA Headquarters, Washington, D.C.
(Phone: 202/453-1548)

Jim Ball
Office of Commercial Programs
NASA Headquarters, Washington, D.C.
(Phone: 202/453-2927)

Lisa Malone
Kennedy Space Center, Fla.
(Phone: 407/867-2468)

Kyle Herring
Johnson Space Center, Houston, Texas
(Phone: 713/483-5111)

Jerry Berg
Marshall Space Flight Center, Huntsville, Ala.
(Phone: 205/544-0034)

Mack Herring
Stennis Space Center, Bay St. Louis, Miss.
(Phone: 601/688-3341)

Nancy Lovato
Ames-Dryden Flight Research Facility, Edwards, Calif.
(Phone: 805/258-8381)

Robert J. MacMillin
Jet Propulsion Laboratory, Pasadena, Calif.
(Phone: 818/354-5011)

Jim Elliott
Goddard Space Flight Center, Greenbelt, Md.
(Phone: 301/286-6256)

Peter W. Waller
Ames Research Center, Mountain View, Calif.
(Phone: 415/694-5091)

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RELEASE: 89-151 **October 1989**

SHUTTLE ATLANTIS TO DEPLOY GALILEO PROBE TOWARD JUPITER

Space Shuttle mission STS-34 will deploy the Galileo planetary exploration spacecraft into low-Earth orbit starting Galileo on its journey to explore Jupiter. Galileo will be the second planetary probe deployed from the Shuttle this year following Atlantis' successful launch of Magellan toward Venus exploration in May.

Following deployment about 6 hours after launch, Galileo will be propelled on a trajectory, known as Venus-Earth-Earth Gravity Assist (VEEGA) by an Air Force-developed, inertial upper stage (IUS). Galileo's trajectory will swing around Venus, the sun and Earth before Galileo makes it's way toward Jupiter.

Flying the VEEGA track, Galileo will arrive at Venus in February 1990. During the flyby, Galileo will make measurements to determine the presence of lightning on Venus and take time-lapse photography of Venus' cloud circulation patterns. Accelerated by Venus' gravity, the spacecraft will head back to Earth.

Enroute, Galileo will activate onboard remote-sensing equipment to gather near-infrared data on the composition and characteristics of the far side of Earth's moon. Galileo also will map the hydrogen distribution of the Earth's atmosphere.

Acquiring additional energy from the Earth's gravitational forces, Galileo will travel on a 2-year journey around the sun spending 10 months inside an asteroid belt. On Oct. 29, 1991, Galileo will pass within 600 miles of the asteroid Gaspra.

On the second Earth flyby in December 1992, Galileo will photograph the north pole of the moon in an effort to determine if ice exists. Outbound, Galileo will activate the time-lapse photography system to produce a "movie" of the moon orbiting Earth.

Racing toward Jupiter, Galileo will make a second trek through the asteroid belt passing within 600 miles of asteroid Ida on Aug. 29, 1993. Science data gathered from both asteroid encounters will focus on surface geology and composition.

Five months prior to the Dec. 7, 1995, arrival at Jupiter, Galileo's atmospheric probe, encased in an oval heat shield, will spin away from the orbiter at a rate of 5 revolutions per minute (rpm) and follow a ballistic trajectory aimed at a spot 6 degrees north of Jupiter's equator. The probe will enter Jupiter's atmosphere at a shallow angle to avoid burning up like a meteor or ricocheting off the atmosphere back into space.

At approximately Mach 1 speed, the probe's pilot parachute will deploy, removing the deceleration module aft cover. Deployment of the main parachute will follow, pulling the descent module out of the aeroshell to expose the instrument-sensing elements. During the 75-minute descent into the Jovian atmosphere, the probe will use the orbiter to transmit data back to Earth. After 75 minutes, the probe will be crushed under the heavy atmospheric pressure.

The Galileo orbiter will continue its primary mission, orbiting around Jupiter and four of its satellites, returning science data for the next 22 months.

Galileo's scientific goals include the study of the chemical composition, state and dynamics of the Jovian atmosphere and satellites, and the investigation of the structure and physical dynamics of the powerful Jovian magnetosphere.

Overall responsibility for management of the project, including orbiter development, resides at NASA's Jet Propulsion Laboratory, Pasadena, Calif. The NASA Ames Research Center, Mountain View, Calif., manages the probe system. JPL built the 2,500-lb. spacecraft and Hughes Aircraft Co. built the 740-lb. probe.

Modifications made to Galileo since flight postponement in 1986 include the addition of sunshields to the base and top of the antenna, new thermal control surfaces, blankets and heaters. Because of the extended length of the mission, the electrical circuitry of the thermoelectric generator has been revised to reduce power demand throughout the mission to assure adequate power supply for mission completion.

Joining Galileo in the payload bay of Atlantis will be the Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument. The SSBUV is designed to provide calibration of backscatter ultraviolet instruments currently being flown on free-flying satellites. SSBUV's primary objective is to check the calibration of the ozone sounders on satellites to verify the accuracy of the data set of atmospheric ozone and solar irradiance data.

The SSBUV is contained in two Get Away Special canisters in the payload bay and weighs about 1219 lbs . One canister contains the SSBUV spectrometer and five supporting optical sensors. The second canister houses data, command and power systems. An interconnecting cable provides the communication link between the two canisters.

Atlantis also will carry several secondary payloads involving radiation measurements, polymer morphology, lightning research, microgravity effects on plants and a student experiment on ice crystal growth in space.

Commander of the 31st Shuttle mission is Donald E. Williams, Captain, USN. Michael J. McCulley, Commander, USN, is Pilot. Williams flew as Pilot of mission STS 51-D in April 1985. McCulley will be making his first Shuttle flight.

Mission Specialists are Shannon W. Lucid, Ph.D.; Franklin R. Chang-Diaz, Ph.D.; and Ellen S. Baker, M.D. Lucid previously flew as a Mission Specialist on STS 51-G in June 1985. Chang-Diaz flew as a Mission Specialist on STS 61-C in January 1986. Baker is making her first Shuttle flight.

Liftoff of the fifth flight of orbiter Atlantis is scheduled for 1:29 p.m. EDT on Oct. 12 from Kennedy Space Center, Fla., launch pad 39-B, into a 160-nautical-mile, 34.3-degree orbit. Nominal mission duration is 5 days, 2 hours, 45 minutes. Deorbit is planned on orbit 81, with landing scheduled for 4:14 p.m. EDT on Oct. 17 at Edwards Air Force Base, Calif.

Liftoff on Oct. 12 could occur during a 10-minute period. The launch window grows each day reaching a maximum of 47 minutes on Nov. 2. The window then decreases each day through the remainder of the launch opportunity which ends Nov. 21. The window is dictated by the need for a daylight landing opportunity at the trans-Atlantic landing abort sites and the performance constraint of Galileo's inertial upper stage.

After landing at Edwards AFB, Atlantis will be towed to the NASA Ames-Dryden Flight Research Facility, hoisted atop the Shuttle Carrier Aircraft and ferried back to the Kennedy Space Center to begin processing for its next flight.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

GENERAL INFORMATION

NASA Select Television Transmission

NASA Select television is available on Satcom F-2R, Transponder 13, C-band located at 72 degrees west longitude, frequency 3960.0 MHz, vertical polarization, audio monaural 6.8 MHz.

The schedule for TV transmissions from the orbiter and for the change-of-shift briefings from Johnson Space Center, Houston, will be available during the mission at Kennedy Space Center, Fla.; Marshall Space Flight Center, Huntsville, Ala.; Johnson Space Center; and NASA Headquarters, Washington, D.C. The schedule will be updated daily to reflect changes dictated by mission operations.

TV schedules also may be obtained by calling COMSTOR, 713/483-5817. COMSTOR is a computer data base service requiring the use of a telephone modem. Voice updates of the TV schedule may be obtained by dialing 202/755-1788. This service is updated daily at noon EDT.

Special Note to Broadcasters

In the 5 workdays before launch, short sound bites of astronaut interviews with the STS-34 crew will be available to broadcasters by calling 202/755-1788 between 8 a.m. and noon EDT.

Status Reports

Status reports on countdown and mission progress, on-orbit activities and landing operations will be produced by the appropriate NASA news center.

Briefings

An STS-34 mission press briefing schedule will be issued prior to launch. During the mission, flight control personnel will be on 8-hour shifts. Change-of-shift briefings by the off-going flight director will occur at approximately 8-hour intervals.

STS-34 QUICK LOOK

Launch Date:	Oct. 12, 1989
Launch Site:	Kennedy Space Center, FL, Pad 39B
Launch Window:	1:29 p.m. - 1:39 p.m. EDT
Orbiter:	Atlantis (OV-104)
Orbit:	160 nm
Inclination:	34.30 degrees
Duration:	5 flight days
Landing Date:	October 17, 1989
Landing Time:	4:14 p.m. EDT
Primary Landing Site:	Edwards AFB, CA
Abort Landing Sites:	Return to Launch Site - Kennedy Space Center Transoceanic Abort Landing - Ben Guerir, Morocco Abort Once Around - Edwards AFB, CA
Crew:	Donald E. Williams, Commander Michael J. McCulley, Pilot Shannon W. Lucid, Mission Specialist Ellen S. Baker, Mission Specialist Franklin R. Chang-Diaz, Mission Specialist
Cargo Bay Payloads:	Galileo spacecraft to Jupiter Shuttle Solar Backscatter Ultraviolet (SSBUV)
Middeck Payloads:	Growth Hormone Concentration & Distribution in Plants (GHCD) Mesoscale Lightning Experiment (MLR) Polymer Morphology (PM) Sensor Technology Experiment (STEX)

LAUNCH PREPARATIONS, COUNTDOWN AND LIFTOFF

Processing activities began on Atlantis for the STS-34 mission on May 16 when Atlantis was towed to Orbiter Processing Facility (OPF) bay 2 after arrival from NASA's Ames-Dryden Flight Research Facility in California. STS-30 post-flight deconfiguration and inspections were conducted in the processing hangar.

As planned, the three main engines were removed the last week of May and taken to the main engine shop in the Vehicle Assembly Building (VAB) for the replacement of several components including the high pressure oxidizer turbopumps. The engines were reinstalled the first week of July, while the ship was in the OPF. Engine 2027 is installed in the number one position, engine 2030 is in the number two position and engine 2029 is in the number three position.

The right hand Orbital Maneuvering System (OMS) pod was removed in mid-June for repairs. A propellant tank needed for Atlantis' pod was scheduled for delivery too late to support integrated testing. As a result, Discovery's right pod was installed on Atlantis about 2 weeks later. The left OMS pod was removed July 9 and reinstalled 2 1/2 weeks later. Both pods had dynatubes and helium isolation valve repairs in the Hypergolic Maintenance Facility.

About 34 modifications have been implemented since the STS-30 mission. One significant modification is a cooling system for the radioisotope thermoelectric generators (RTG). The RTG fuel is plutonium dioxide which generates heat as a result of its normal decay. The heat is converted to energy and used to provide electrical power for the Galileo spacecraft. A mixture of alcohol and water flows in the special cooling system to lower the RTG case temperature and maintain a desired temperature to the payload instrumentation in the vicinity of the RTGs. These cooling lines are mounted on the port side of the orbiter from the aft compartment to a control panel in bay 4.

Another modification, called "flutter buffet," features special instrumentation on the vertical tail and right and left outboard elevons. Ten accelerometers were added to the vertical tail and one on each of the elevons. These instruments are designed to measure in-flight loads on the orbiter's structure. Atlantis is the only vehicle that will be equipped with this instrumentation.

Improved controllers for the water spray boilers and auxiliary power units were installed. Other improvements were made to the orbiter's structure and thermal protection system, mechanical systems, propulsion system and avionics system.

Stacking of solid rocket motor (SRM) segments for flight began with the left aft booster on Mobile Launcher Platform 1 in the VAB on June 15. Booster stacking operations were completed by July 22 and the external tank was mated to the two boosters on July 30.

Flight crew members performed the Crew Equipment Interface Test on July 29 to become familiar with Atlantis' crew compartment, vehicle configuration and equipment associated with the mission.

The Galileo probe arrived at the Spacecraft Assembly and Encapsulation Facility (SAEF) 2 on April 17 and the spacecraft arrived on May 16. While at SAEF-2, the spacecraft and probe were joined and tested together to verify critical connections. Galileo was delivered to the Vertical Processing Facility (VPF) on Aug. 1. The Inertial Upper Stage (IUS) was delivered to the VPF on July 30. The Galileo/IUS were joined together on Aug. 3 and all integrated testing was performed during the second week of August.

The Shuttle Solar Backscatter Ultraviolet (SSBUV) experiment, contained in two Get Away Special (GAS) canisters, was mounted on a special GAS beam in Atlantis' payload bay on July 24. Interface verification tests were performed the next day.

Atlantis was transferred from the OPF to the VAB on Aug. 21, where it was mated to the external tank and SRBs. A Shuttle Interface Test was conducted in the VAB to check the mechanical and electrical connections between the various elements of the Shuttle vehicle and onboard flight systems.

The assembled Space Shuttle vehicle was rolled out of the VAB aboard its mobile launcher platform for the 4.2 mile trip to Launch Pad 39-B on Aug. 29. Galileo and its IUS upper stage were transferred from the VPF to Launch Pad 39-B on Aug. 25. The payload was installed in Atlantis' payload bay on Aug. 30.

The payload interface verification test was planned for Sept. 7 to verify connections between the Shuttle and the payload. An end-to-end test was planned for Sept. 8 to verify communications between the spacecraft and ground controllers. Testing of the IUS was planned about 2 weeks prior to launch in parallel with Shuttle launch preparations.

A Countdown Demonstration Test, a dress rehearsal for the STS-34 flight crew and KSC launch team, is designed as a practice countdown for the launch. At press time, it was planned for Sept. 14 and 15.

One of the unique STS-34 processing milestones planned was a simulation exercise for the installation of the RTGs. Simulated RTGs were to be used in the 2-day event scheduled within the first week after Atlantis arrives at the launch pad. The test is designed to give workers experience for the installation of the RTGs, a first in the Shuttle program. In addition, access requirements will be identified and procedures will be verified.

Another test scheduled at the pad is installation of the flight RTGs and an associated test and checkout of the RTG cooling system planned for the third week of September. This test will verify the total RTG cooling system and connections. The RTGs will be removed at the completion of the 3-day cooling system test and returned to the RTG facility. The two flight RTGs will be reinstalled on the spacecraft 6 days before launch. The flight RTGs were not required for the RTG cooling system test.

Launch preparations scheduled the last 2 weeks prior to launch countdown include final vehicle ordnance activities, such as power-on stray-voltage checks and resistance checks of firing circuits; loading the fuel cell storage tanks; pressurizing the hypergolic propellant tanks aboard the vehicle; final payload closeouts; and a final functional check of the range safety and SRB ignition, safe and arm devices.

The launch countdown is scheduled to pick up at the T-minus 43-hour mark, leading up to the STS-34 launch. Atlantis' fifth launch will be conducted by a joint NASA/industry team from Firing Room 1 in the Launch Control Center.

MAJOR COUNTDOWN MILESTONES

T-43 Hours	Power up Space Shuttle vehicle.
T-34 Hours	Begin orbiter and ground support equipment closeouts for launch.
T-30 Hours	Activate orbiter's navigation aids.
T-27 Hours (holding)	Enter first built-in hold for 8 hours.
T-27 Hours (counting)	Begin preparations for loading fuel cell storage tanks with liquid oxygen and liquid hydrogen reactants.
T-25 Hours	Load orbiter's fuel cell tanks with liquid oxygen.
T-22 Hours, 30 minutes	Load orbiter's fuel cell tanks with liquid hydrogen.
T-22 Hours	Perform interface check between Houston Mission Control and Merritt Island Launch Area (MILA) tracking station.
T-20 Hours	Activate and warm up inertial measurement units (IMU).
T-19 Hours (holding)	Enter 8-hour built-in hold. Activate orbiter communications system.
T-19 hours (counting)	Resume countdown. Continue preparations to load external tank, orbiter closeouts and preparations to move the Rotating Service Structure (RSS).
T-11 Hours (holding)	Start 14-hour, 40 minute built-in hold orbiter flight and middecks.
T-11 Hours (counting)	Retract RSS from vehicle to launch position.
T-9 Hours	Activate orbiter's fuel cells.
T-8 Hours	Configure Mission Control communications for launch. Start clearing blast danger area.
T-6 Hours, 30 minutes	Perform Eastern Test Range open loop command test.
T-6 Hours (holding)	Enter 1-hour built-in hold. Receive management "go" for tanking.
T-6 Hours (counting)	Start external tank chilldown and propellant loading.
T-5 Hours	Start IMU pre-flight calibration.
T-4 Hours	Perform MILA antenna alignment.
T-3 Hours (holding)	2-hour built-in hold begins. Loading of external tank is complete and in a stable replenish mode. Ice team goes to pad for inspections. Closeout crew goes to white room to begin preparing oriter’s cabin for f light crew’s entry. Wake flight crew (launch minus 4 hours 55 minutes).

MAJOR COUNTDOWN MILESTONES

T-3 Hours (counting)	Resume countdown.
T-2 Hours, 55 minutes	Flight crew departs O&C Building for Launch Pad 39-B (Launch minus 3 hours,15 minutes).
T-2 Hours, 30 minutes	Crew enters orbiter vehicle (Launch minus 2 Hours, 50 minutes).
T-60 minutes	Start pre-flight alignment of IMUs.
T-20 minutes (holding)	10-minute built-in hold begins.
T-20 minutes(counting)	Configure orbiter computers for launch.
T-10 minutes	White room closeout crew cleared through launch danger are a roadblocks.
T-9 minutes (holding)	40-minute built-in hold begins. Perform status check and receive Launch Director and Mission Management Team “go.”
T-9 minutes (counting)	Start ground launch sequencer.
T-7 minutes, 30 seconds	Retract orbiter access arm.
T-5 minutes	Pilot starts auxiliary power units. Arm range safety, solid rocket booster (SRB) ignition systems.
T-3 minutes, 30 seconds	Orbiter goes on internal power.
T-2 minutes, 55 seconds	Pressurize liquid oxygen tank for flight and retract gaseous oxygen vent hood.
T-1 minute, 57 seconds	Pressurize liquid hydrogen tank.
T-31 seconds	"Go" from ground computer for orbiter computers to start the automatic launch sequence.
T-28 seconds	Start SRB hydraulic power units.
T-21 seconds	Start SRB gimbal profile test.
T-6.6 seconds	Main engine start.
T-3 seconds	Main engines at 90 percent thrust.
T-0	SRB ignition, holddown post release and liftoff.
T+7 seconds	Shuttle clears launch tower and control switches to JSC.

Note: This countdown timeline may be adjusted in real time as necessary.

TRAJECTORY SEQUENCE OF EVENTS

Event	MET (d/h:m:s)	Relative Velocity (fps)	Mach	Altitude (ft)
Launch	00/00:00:00			
Begin Roll Maneuver	00/00:00:09	165	0.15	627
End Roll Maneuver	00/00:00:17	374	0.33	2,898
SSME Throttle Down to 65%	00/00:00:34	833	0.75	11,854
Max. Dyn. Pressure (Max Q)	00/00:00:52	1,260	1.2	28,037
SSME Throttle Up to 104%	00/00:01:01	1,499	1.49	38,681
SRB Staging	00/00:02:04	4,316	3.91	153,873
Negative Return	00/00:03:54	6,975	7.48	317,096
Main Engine Cutoff (MECO)	00/00:08:27	24,580	22.41	366,474
Zero Thrust	00/00:08:33	24,596	22.17	368,460
ET Separation	00/00:08:45			
OMS 2 Burn	00/00:39:48			
Galileo/IUS Deploy (orbit 5)	00/06:21:36			
Deorbit Burn (orbit 81)	05/01:45:00			
Landing (orbit 82)	05/02:45:00			

Apogee, Perigee at MECO: 157 x 39 nm
Apogee, Perigee post-OMS 2: 161 x 161 nm
Apogee, Perigee post deploy: 177 x 161 nm

SPACE SHUTTLE ABORT MODES

Space Shuttle launch abort philosophy aims toward safe and intact recovery of the flight crew, orbiter and its payload. Abort modes include:

- Abort-To-Orbit (ATO) -- Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical mile orbit with orbital maneuvering system engines.

- Abort-Once-Around (AOA) -- Earlier main engine shutdown with the capability to allow one orbit around before landing at Edwards Air Force Base, Calif.; White Sands Space Harbor (Northrup Strip), N.M.; or the Shuttle Landing Facility (SLF) at Kennedy Space Center (KSC), Fla.

- Trans-Atlantic Abort Landing (TAL) -- Loss of two main engines midway through powered flight would force a landing at Ben Guerir, Morocco; Moron, Spain; or Banjul, The Gambia.

- Return-To-Launch-Site (RTLS) -- Early shutdown of one or more engines and without enough energy to reach Ben Guerir, would result in a pitch around and thrust back toward KSC until within gliding distance of the SLF.

STS-34 contingency landing sites are Edwards AFB, White Sands, KSC, Ben Guerir, Moron and Banjul.

SUMMARY OF MAJOR ACTIVITIES

Flight Day 1
Ascent
Post-insertion checkout
Pre-deploy checkout
Galileo/Inertial Upper Stage (IUS) deploy
Detailed Secondary Objective (DSO)
Polymer Morphology (PM)
Sensor Technology Experiment (STEX) activation

Flight Day 2
Galileo/IUS backup deploy opportunity
DSO
IMAX
PM
Shuttle Solar Backscatter Ultraviolet (SSBUV) activation
Shuttle Student Involvement Program (SSIP)
Landing preparations

Flight Day 3
DSO
IMAX
Mesoscale Lightning Experiment (MLE)
PM

Flight Day 4
DSO
IMAX
MLE
PM
SSBUV deactivation

Flight Day 5
DTO/DSO
GHCD operations
PM
STEX deactivation
FCS checkout
Cabin stow

Flight Day 6
PM stow
Deorbit preparation
Deorbit burn
Landing at Edwards AFB

LANDING AND POST LANDING OPERATIONS

Kennedy Space Center, Fla., is responsible for ground operations of the orbiter once it has rolled to a stop on the runway at Edwards Air Force Base, Calif. Those operations include preparing the Shuttle for the return trip to Kennedy.

After landing, the flight crew aboard Atlantis begins "safing" vehicle systems. Immediately after wheel stop, specially garbed technicians will first determine that any residual hazardous vapors are below significant levels for other safing operations to proceed.

A mobile white room is moved into place around the crew hatch once it is verified that there are no concentrations of toxic gases around the forward part of the vehicle. The flight crew is expected to leave Atlantis about 45 to 50 minutes after landing. As the crew exits, technicians enter the orbiter to complete the vehicle safing activity.

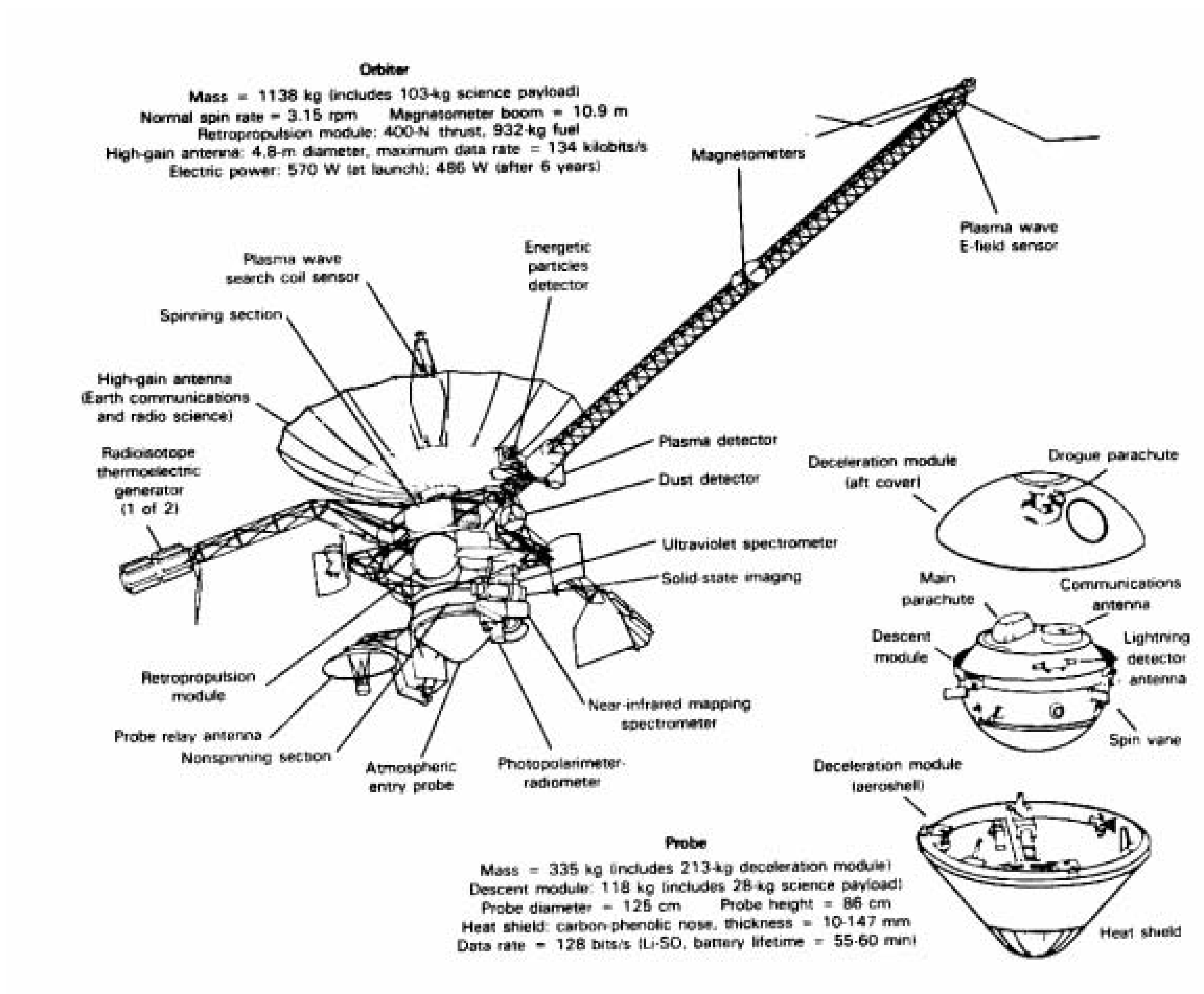
Once the initial aft safety assessment is made, access vehicles are positioned around the rear of the orbiter so that lines from the ground purge and cooling vehicles can be connected to the umbilical panels on the aft end of Atlantis.

Freon line connections are completed and coolant begins circulating through the umbilicals to aid in heat rejection and protect the orbiter's electronic equipment. Other lines provide cooled, humidified air to the payload bay and other cavities to remove any residual fumes and provide a safe environment inside Atlantis.

A tow tractor will be connected to Atlantis and the vehicle will be pulled off the runway at Edwards and positioned inside the Mate/Demate Device (MDD) at nearby Ames-Dryden Flight Research Facility. After the Shuttle has been jacked and leveled, residual fuel cell cryogenics are drained and unused pyrotechnic devices are disconnected prior to returning the orbiter to Kennedy.

The aerodynamic tail cone is installed over the three main engines, and the orbiter is bolted on top of the 747 Shuttle Carrier Aircraft for the ferry flight back to Florida. Pending completion of planned work and favorable weather conditions, the 747 would depart California about 6 days after landing for the cross-country ferry flight back to Florida. A refueling stop is necessary to complete the journey.

Once back at Kennedy, Atlantis will be pulled inside the hangar-like facility for post-flight inspections and in-flight anomaly troubleshooting. These operations are conducted in parallel with the start of routine systems reverification to prepare Atlantis for its next mission.


Orbiter
Mass = 1138 kg (includes 103-kg science payload)
Normal spin rate = 3.15 rpm Magnetometer boom = 10.9 m
Retropropulsion module: 400-N thrust, 932-kg fuel
High-gain antenna: 4.8-m diameter, maximum data rate = 134 kilobits/s
Electric power: 570 W (at launch); 486 W (after 6 years)
Magnetometers
Plasma wave E-field sensor
Plasma wave search coil sensor
Energetic particles detector
Spinning section
High-gain antenna (Earth communications and radio science)
Radioisotope thermoelectric generator (1 of 2)
Plasma detector
Dust detector
Ultraviolet spectrometer
Solid-state imaging
Retropropulsion module
Probe relay antenna
Nonspinning section
Atmospheric entry probe
Photopolarimeter-radiometer
Near-infrared mapping spectrometer
Deceleration module (aft cover)
Drogue parachute
Main parachute
Communications antenna
Descent module
Lightning detector antenna
Spin vane
Deceleration module (aeroshell)
Heat shield
Probe
Mass = 335 kg (includes 213-kg deceleration module)
Descent module: 118 kg (includes 28-kg science payload)
Probe diameter = 126 cm Probe height = 86 cm
Heat shield: carbon-phenolic nose, thickness = 10-147 mm
Data rate = 128 bits/s (Li-SO, battery lifetime = 55-60 min)

GALILEO

Galileo is a NASA spacecraft mission to Jupiter to study the planet's atmosphere, satellites and surrounding magnetosphere. It was named for the Italian renaissance scientist who discovered Jupiter's major moons by using the first astronomical telescope.

This mission will be the first to make direct measurements from an instrumented probe within Jupiter's atmosphere and the first to conduct long-term observations of the planet and its magnetosphere and satellites from orbit around Jupiter. It will be the first orbiter and atmospheric probe for any of the outer planets. On the way to Jupiter, Galileo also will observe Venus, the Earth-moon system, one or two asteroids and various phenomena in interplanetary space.

Galileo will be boosted into low-Earth orbit by the Shuttle Atlantis and then boosted out of Earth orbit by a solid rocket Inertial Upper Stage. The spacecraft will fly past Venus and twice by the Earth, using gravity assists from the planets to pick up enough speed to reach Jupiter. Travel time from launch to Jupiter is a little more than 6 years.

In December 1995, the Galileo atmospheric probe will conduct a brief, direct examination of Jupiter's atmosphere, while the larger part of the craft, the orbiter, begins a 22-month, 10-orbit tour of major satellites and the magnetosphere, including long-term observations of Jupiter throughout this phase.

The 2-ton Galileo orbiter spacecraft carries 9 scientific instruments. There are another six experiments on the 750-pound probe. The spacecraft radio link to Earth serves as an additional instrument for scientific measurements. The probe's scientific data will be relayed to Earth by the orbiter during the 75-minute period while the probe is descending into Jupiter's atmosphere. Galileo will communicate with its controllers and scientists through NASA's Deep Space Network, using tracking stations in California, Spain and Australia.

GALILEO MISSION EVENTS

(Note: for both asteroids, closes in mid-October)	Oct. 12 to Nov. 21, 1989
Venus flyby (9,300 mi)	Feb. 9, 1990*
Venus data playback	Oct. 1990
Earth 1 flyby (about 600 mi)	Dec. 8, 1990*
Asteroid Gaspra flyby (600 mi)	Oct. 29, 1991*
Earth 2 flyby (200 mi)	Dec. 8, 1992*
Asteroid Ida flyby (600 mi)	Aug. 28, 1993*
Probe release	July 1995
(includes Io flyby, probe entry and relay, Jupiter orbit insertion)	Dec. 7, 1995
Orbital tour of Galilean satellites	Dec '95-Oct '97

*Exact dates may vary according to actual launch date

EARTH TO JUPITER

Galileo will make three planetary encounters in the course of its gravity-assisted flight to Jupiter. These provide opportunities for scientific observation and measurement of Venus and the Earth-moon system. The mission also has a chance to fly close to one or two asteroids, bodies which have never been observed close up, and obtain data on other phenomena of interplanetary space.

Scientists are currently studying how to use the Galileo scientific instruments and the limited ability to collect, store and transmit data during the early phase of flight to make the best use of these opportunities. Instruments designed to observe Jupiter's atmosphere from afar can improve our knowledge of the atmosphere of Venus and sensors designed for the study of Jupiter's moons can add to our information about our own moon.

VENUS

The Galileo spacecraft will approach Venus early in 1990 from the night side and pass across the sunlit hemisphere, allowing observation of the clouds and atmosphere. Both infrared and ultraviolet spectral observations are planned, as well as several camera images and other remote measurements. The search for deep cloud patterns and for lightning storms will be limited by the fact that all the Venus data must be tape-recorded on the spacecraft for playback 8 months later.

The spacecraft was originally designed to operate between Earth and Jupiter, where sunlight is 25 times weaker than at Earth and temperatures are much lower. The VEEGA mission will expose the spacecraft to a hotter environment from Earth to Venus and back. Spacecraft engineers devised a set of sunshades to protect the craft. For this system to work, the front end of the spacecraft must be aimed precisely at the Sun, with the main antenna furled for protection from the Sun's rays until after the first Earth flyby in December 1990. This precludes the use of the Galileo high-gain antenna and therefore, scientists must wait until the spacecraft is close to Earth to receive the recorded Venus data, transmitted through a low-gain antenna.

FIRST EARTH PASS

Approaching Earth for the first time about 14 months after launch, the Galileo spacecraft will observe, from a distance, the nightside of Earth and parts of both the sunlit and unlit sides of the moon. After passing Earth, Galileo will observe Earth's sunlit side. At this short range, scientific data are transmitted at the high rate using only the spacecraft's low-gain antennas. The high-gain antenna is to be unfurled like an umbrella, and its high-power transmitter turned on and checked out, about 5 months after the first Earth encounter.

FIRST ASTEROID

Nine months after the Earth passage and still in an elliptical solar orbit, Galileo will enter the asteroid belt, and two months later, will have its first asteroid encounter. Gaspra is believed to be a fairly representative main-belt asteroid, about 10 miles across and probably similar in composition to stony meteorites.

The spacecraft will pass within about 600 miles at a relative speed of about 18,000 miles per hour. It will collect several pictures of Gaspra and make spectral measurements to indicate its composition and physical properties.

SECOND EARTH PASS

Thirteen months after the Gaspra encounter, the spacecraft will have completed its 2-year elliptical orbit around the Sun and will arrive back at Earth. It will need a much larger ellipse (with a 6-year period) to reach as far as Jupiter. The second flyby of Earth will pump the orbit up to that size, acting as a natural apogee kick motor for the Galileo spacecraft.

Passing about 185 miles above the surface, near the altitude at which it had been deployed from the Space Shuttle almost three years earlier, Galileo will use Earth's gravitation to change the spacecraft's flight direction and pick up about 8,000 miles per hour in speed.

Each gravity-assist flyby requires about three rocket-thrusting sessions, using Galileo's onboard retropropulsion module, to fine-tune the flight path. The asteroid encounters require similar maneuvers to obtain the best observing conditions.

Passing the Earth for the last time, the spacecraft's scientific equipment will make thorough observations of the planet, both for comparison with Venus and Jupiter and to aid in Earth studies. If all goes well, there is a good chance that Galileo will enable scientists to record the motion of the moon about the Earth while the Earth itself rotates.

SECOND ASTEROID

Nine months after the final Earth flyby, Galileo may have a second asteroid-observing opportunity. Ida is about 20 miles across. Like Gaspra, Ida is believed to represent the majority of main-belt asteroids in composition, though there are believed to be differences between the two. Relative velocity for this flyby will be nearly 28,000 miles per hour, with a planned closest approach of about 600 miles.

APPROACHING JUPITER

Some 2 years after leaving Earth for the third time and 5 months before reaching Jupiter, Galileo's probe must separate from the orbiter. The spacecraft turns to aim the probe precisely for its entry point in the Jupiter atmosphere, spins up to 10 revolutions per minute and releases the spin-stabilized probe. Then the Galileo orbiter maneuvers again to aim for its own Jupiter encounter and resumes its scientific measurements of the interplanetary environment underway since the launch more than 5 years before.

While the probe is still approaching Jupiter, the orbiter will have its first two satellite encounters. After passing within 20,000 miles of Europa, it will fly about 600 miles above Io's volcano-torn surface, twenty times closer than the closest flyby altitude of Voyager in 1979.

AT JUPITER

The Probe at Jupiter

The probe mission has four phases: launch, cruise, coast and entry-descent. During launch and cruise, the probe will be carried by the orbiter and serviced by a common umbilical. The probe will be dormant during cruise except for annual checkouts of spacecraft systems and instruments. During this period, the orbiter will provide the probe with electric power, commands, data transmission and some thermal control.

Six hours before entering the atmosphere, the probe will be shooting through space at about 40,000 mph. At this time, its command unit signals "wake up" and instruments begin collecting data on lightning, radio emissions and energetic particles.

A few hours later, the probe will slam into Jupiter's atmosphere at 115,000 mph, fast enough to jet from Los Angeles to New York in 90 seconds. Deceleration to about Mach 1 -- the speed of sound -- should take just a few minutes. At maximum deceleration as the craft slows from 115,000 mph to 100 mph, it will be hurtling against a force 350 times Earth's gravity. The incandescent shock wave ahead of the probe will be as bright as the sun and reach searing temperatures of up to 28,000 degrees Fahrenheit. After the aerodynamic braking has slowed the probe, it will drop its heat shields and deploy its parachute. This will allow the probe to float down about 125 miles through the clouds, passing from a pressure of 1/10th that on Earth's surface to about 25 Earth atmospheres.

About 4 minutes after probe entry into Jupiter's atmosphere, a pilot chute deploys and explosive nuts shoot off the top section of the probe's protective shell. As the cover whips away, it pulls out and opens the main parachute attached to the inner capsule. What remains of the probe's outer shell, with its massive heat shield, falls away as the parachute slows the instrument module.

From there on, suspended from the main parachute, the probe's capsule with its activated instruments floats downward toward the bright clouds below.

The probe will pass through the white cirrus clouds of ammonia crystals - the highest cloud deck. Beneath this ammonia layer probably lie reddish-brown clouds of ammonium hydrosulfides. Once past this layer, the probe is expected to reach thick water clouds. This lowest cloud layer may act as a buffer between the uniformly mixed regions below and the turbulent swirl of gases above.

Jupiter's atmosphere is primarily hydrogen and helium. For most of its descent through Jupiter's three main cloud layers, the probe will be immersed in gases at or below room temperature. However, it may encounter hurricane winds up to 200 mph and lightning and heavy rain at the base of the water clouds believed to exist on the planet. Eventually, the probe will sink below these clouds, where rising pressure and temperature will destroy it. The probe's active life in Jupiter's atmosphere is expected to be about 75 minutes in length. The probe batteries are not expected to last beyond this point, and the relaying orbiter will move out of reach.

To understand this huge gas planet, scientists must find out about its chemical components and the dynamics of its atmosphere. So far, scientific data are limited to a two-dimensional view (pictures of the planet's cloud tops) of a three-dimensional process (Jupiter's weather). But to explore such phenomena as the planet's incredible coloring, the Great Red Spot and the swirling shapes and high-speed motion of its topmost clouds, scientists must penetrate Jupiter's visible surface and investigate the atmosphere concealed in the deep-lying layers below.

A set of six scientific instruments on the probe will measure, among other things, the radiation field near Jupiter, the temperature, pressure, density and composition of the planet's atmosphere from its first faint outer traces to the hot, murky hydrogen atmosphere 100 miles below the cloud tops. All of the information will be gathered during the probe's descent on an 8-foot parachute. Probe data will be sent to the Galileo Orbiter 133,000 miles overhead then relayed across the half billion miles to Deep Space Network stations on Earth.

To return its science, the probe relay radio aboard the orbiter must automatically acquire the probe signal below within 50 seconds, with a success probability of 99.5 percent. It must reacquire the signal immediately should it become lost.

To survive the heat and pressure of entry, the probe spacecraft is composed of two separate units: an inner capsule containing the scientific instruments, encased in a virtually impenetrable outer shell. The probe weighs 750 pounds. The outer shell is almost all heat shield material.

The Orbiter at Jupiter

After releasing the probe, the orbiter will use its main engine to go into orbit around Jupiter. This orbit, the first of 10 planned, will have a period of about 8 months. A close flyby of Ganymede in July 1996 will shorten the orbit, and each time the Galileo orbiter returns to the inner zone of satellites, it will make a gravity-assist close pass over one or another of the satellites, changing Galileo's orbit while making close observations. These satellite encounters will be at altitudes as close as 125 miles above their surfaces. Throughout the 22-month orbital phase, Galileo will continue observing the planet and the satellites and continue gathering data on the magnetospheric environment.

SPACECRAFT SCIENTIFIC ACTIVITIES

Galileo's scientific experiments will be carried out by more than 100 scientists from six nations. Except for the radio science investigation, these are supported by dedicated instruments on the Galileo orbiter and probe. NASA has appointed 15 interdisciplinary scientists whose studies include data from more than one Galileo instrument.

The instruments aboard the probe will measure the temperatures and pressure of Jupiter's atmosphere at varying altitudes and determine its chemical composition including major and minor constituents (such as hydrogen, helium, ammonia, methane, and water) and the ratio of hydrogen to helium. Jupiter is thought to have a bulk composition similar to that of the primitive solar nebula from which it was formed. Precise determination of the ratio of hydrogen to helium would provide an important factual check of the Big Bang theory of the genesis of the universe.

Other probe experiments will determine the location and structure of Jupiter's clouds, the existence and nature of its lightning, and the amount of heat radiating from the planet compared to the heat absorbed from sunlight.

In addition, measurements will be made of Jupiter's numerous radio emissions and of the high-energy particles trapped in the planet's innermost magnetic field. These measurements for Galileo will be made within a distance of 26,000 miles from Jupiter's cloud tops, far closer than the previous closest approach to Jupiter by Pioneer 11. The probe also will determine vertical wind shears using Doppler radio measurements made of probe motions from the radio receiver aboard the orbiter.

Jupiter appears to radiate about twice as much energy as it receives from the sun and the resulting convection currents from Jupiter's internal heat source towards its cooler polar regions could explain some of the planet's unusual weather patterns.

Jupiter is over 11 times the diameter of Earth and spins about two and one-half times faster -- a Jovian day is only 10 hours long. A point on the equator of Jupiter's visible surface races along at 28,000 mph. This rapid spin may account for many of the bizarre circulation patterns observed on the planet.

Spacecraft Scientific Activities

The Galileo mission and systems were designed to investigate three broad aspects of the Jupiter system: the planet's atmosphere, the satellites and the magnetosphere. The spacecraft is in three segments to focus on these areas: the atmospheric probe; a non-spinning section of the orbiter carrying cameras and other remote sensors; and the spinning main section of the orbiter spacecraft which includes the propulsion module, the communications antennas, main computers and most support systems as well as the fields and particles instruments, which sense and measure the environment directly as the spacecraft flies through it.

Probe Scientific Activities

The probe will enter the atmosphere about 6 degrees north of the equator. The probe weighs just under 750 pounds and includes a deceleration module to slow and protect the descent module, which carries out the scientific mission.

The deceleration module consists of an aeroshell and an aft cover designed to block the heat generated by slowing from the probe's arrival speed of about 115,000 miles per hour to subsonic speed in less than 2 minutes. After the covers are released, the descent module deploys its 8-foot parachute and its instruments, the control and data system, and the radio-relay transmitter go to work.

Operating at 128 bits per second, the dual L-band transmitters send nearly identical streams of scientific data to the orbiter. The probe's relay radio aboard the orbiter will have two redundant receivers that process probe science data, plus radio science and engineering data for transmission to the orbiter communications system. Minimum received signal strength is 31 dbm. The receivers also measure signal strength and Doppler shift as part of the experiments for measuring wind speeds and atmospheric absorption of radio signals.

Probe electronics are powered by long-life, high-discharge-rate 34-volt lithium batteries, which remain dormant for more than 5 years during the journey to Jupiter. The batteries have an estimated capacity of about 18 amp-hours on arrival at Jupiter.

Orbiter Scientific Activities

The orbiter, in addition to delivering the probe to Jupiter and relaying probe data to Earth, will support all the scientific investigations of Venus, the Earth and moon, asteroids and the interplanetary medium, Jupiter's satellites and magnetosphere, and observation of the giant planet itself.

The orbiter weighs about 5,200 pounds including about 2,400 pounds of rocket propellant to be expended in some 30 relatively small maneuvers during the long gravity-assisted flight to Jupiter, the large thrust maneuver which puts the craft into its Jupiter orbit, and the 30 or so trim maneuvers planned for the satellite tour phase.

The retropropulsion module consists of 12 10-newton thrusters, a single 400-newton engine, and the fuel, oxidizer, and pressurizing-gas tanks, tubing, valves and control equipment. (A thrust of 10 newtons would support a weight of about 2.2 pounds at Earth's surface). The propulsion system was developed and built by Messerschmitt-Bolkow-Blohm and provided by the Federal Republic of Germany.

The orbiter's maximum communications rate is 134 kilobits per second (the equivalent of about one black-and-white image per minute); there are other data rates, down to 10 bits per second, for transmitting engineering data under poor conditions. The spacecraft transmitters operate at S-band and X-band (2295 and 8415 megahertz) frequencies between Earth and on L-band between the probe.

The high-gain antenna is a 16-foot umbrella-like reflector unfurled after the first Earth flyby. Two low-gain antennas (one pointed forward and one aft, both mounted on the spinning section) are provided to support communications during the Earth-Venus-Earth leg of the flight and whenever the main antenna is not deployed and pointed at Earth. The despun section of the orbiter carries a radio relay antenna for receiving the probe's data transmissions.

Electrical power is provided to Galileo's equipment by two radioisotope thermoelectric generators. Heat produced by natural radioactive decay of plutonium 238 dioxide is converted to approximately 500 watts of electricity (570 watts at launch, 480 at the end of the mission) to operate the orbiter equipment for its 8-year active period. This is the same type of power source used by the Voyager and Pioneer Jupiter spacecraft in their long outer-planet missions, by the Viking lander spacecraft on Mars and the lunar scientific packages left on the Moon.

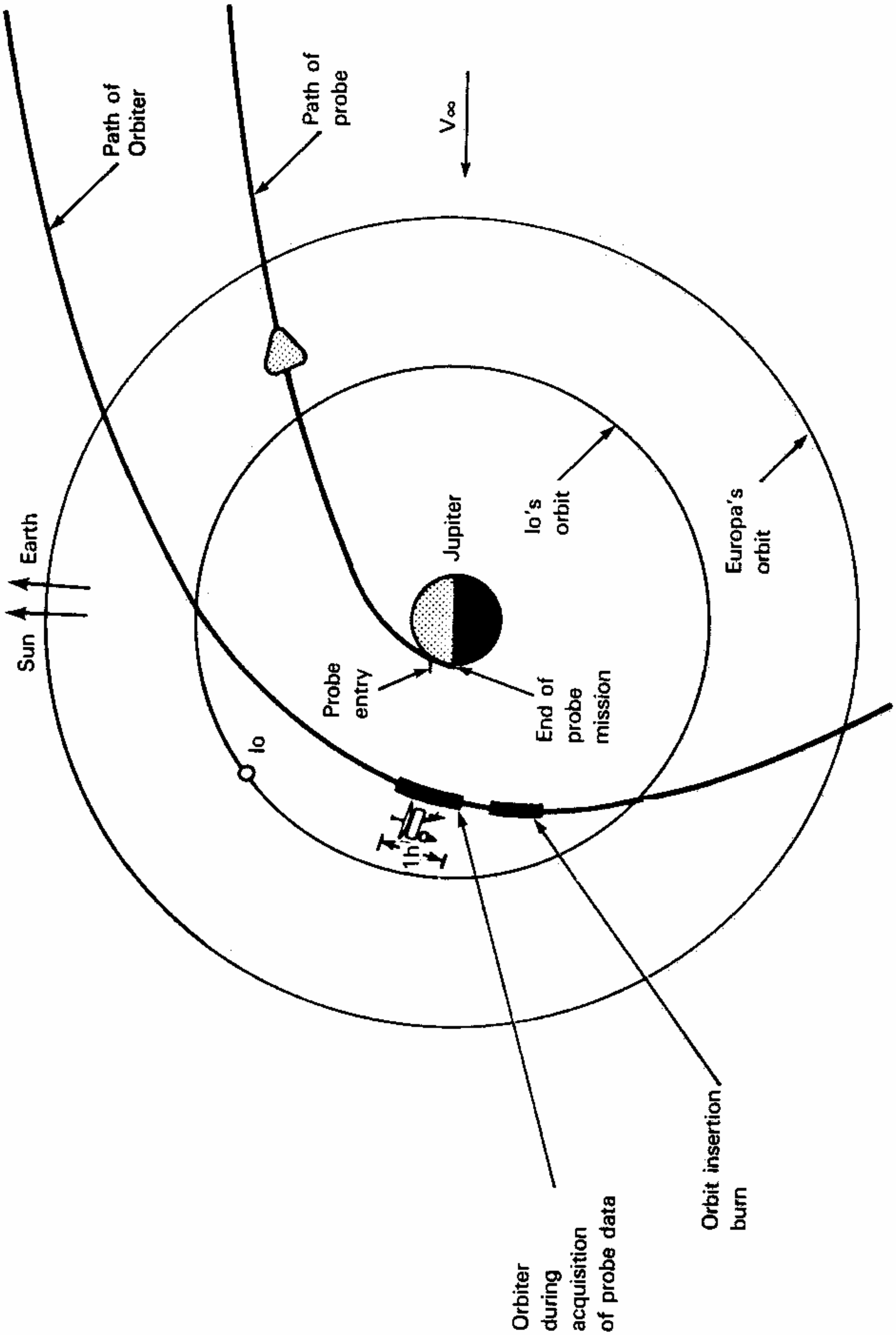
Most spacecraft are stabilized in flight either by spinning around a major axis or by maintaining a fixed orientation in space, referenced to the sun and another star. Galileo represents a hybrid of these techniques, with a spinning section rotating ordinarily at 3 rpm and a "despun" section which is counter-rotated to provide a fixed orientation for cameras and other remote sensors.

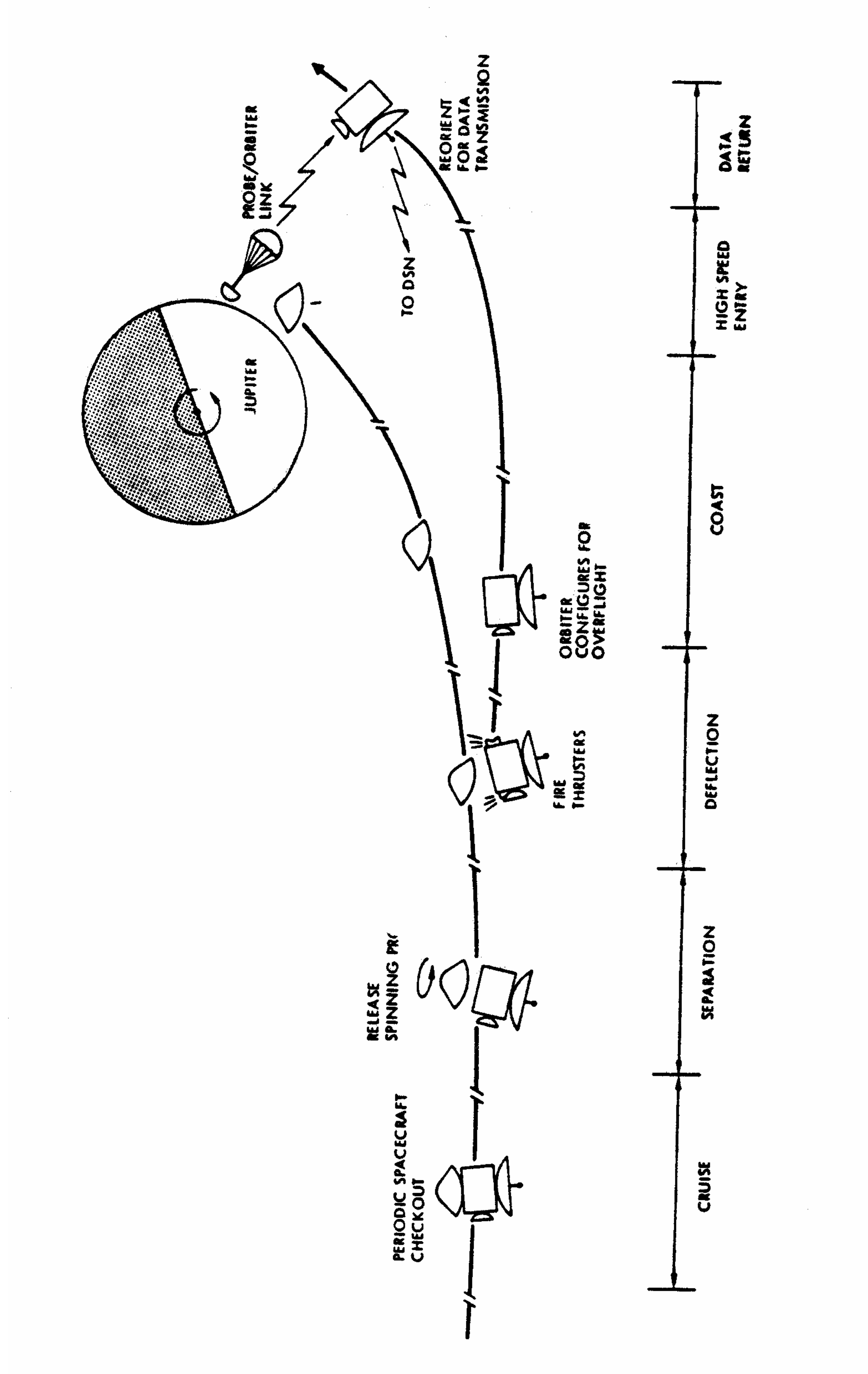
Instruments that measure fields and particles, together with the main antenna, the power supply, the propulsion module, most of the computers and control electronics, are mounted on the spinning section. The instruments include magnetometer sensors mounted on a 36-foot boom to escape interference from the spacecraft; a plasma instrument detecting low-energy charged particles and a plasma-wave detector to study waves generated in planetary magnetospheres and by lightning discharges; a high-energy particle detector; and a detector of cosmic and Jovian dust.

The despun section carries instruments and other equipment whose operation depends on a fixed orientation in space. The instruments include the camera system; the near-infrared mapping spectrometer to make multispectral images for atmosphere and surface chemical analysis; the ultraviolet spectrometer to study gases and ionized gases; and the photopolarimeter radiometer to measure radiant and reflected energy. The camera system is expected to obtain images of Jupiter's satellites at resolutions from 20 to 1,000 times better than Voyager's best.

This section also carries a dish antenna to track the probe in Jupiter's atmosphere and pick up its signals for relay to Earth. The probe is carried on the despun section, and before it is released, the whole spacecraft is spun up briefly to 10 rpm in order to spin-stabilize the probe.

The Galileo spacecraft will carry out its complex operations, including maneuvers, scientific observations and communications, in response to stored sequences which are interpreted and executed by various on-board computers. These sequences are sent up to the orbiter periodically through the Deep Space Network in the form of command loads.


Path of Orbiter
Path of probe
V∞
Sun
Earth
Jupiter
Io's orbit
Europa's orbit
Probe entry
End of probe mission
Io
1h
Orbiter during acquisition of probe data
Orbit insertion burn


PERIODIC SPACECRAFT CHECKOUT
RELEASE SPINNING PR
FIRE THRUSTERS
ORBITER CONFIGURES FOR OVERFLIGHT
JUPITER
PROBE/ORBITER LINK
TO DSN
REORIENT FOR DATA TRANSMISSION
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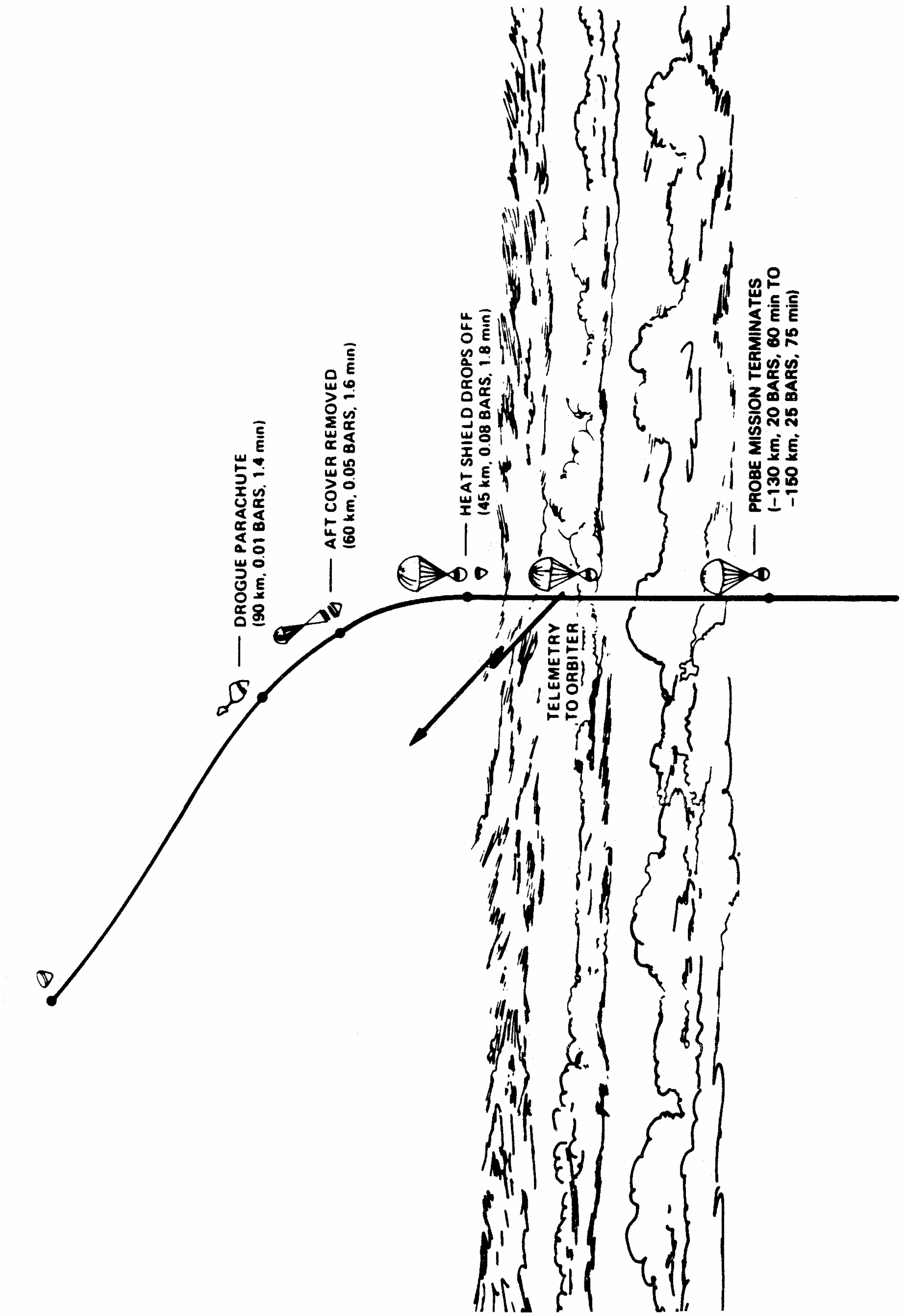
DEFLECTION
COAST
HIGH SPEED ENTRY
DATA RETURN


DROGUE PARACHUTE
(90 km, 0.01 BARS, 1.4 min)
AFT COVER REMOVED
(60 km, 0.05 BARS, 1.6 min)
HEAT SHIELD DROPS OFF
(45 km, 0.08 BARS, 1.8 min)
TELEMETRY
TO ORBITER
PROBE MISSION TERMINATES
(~130 km, 20 BARS, 60 min TO
~150 km, 25 BARS, 75 min)

GROUND SYSTEMS

Galileo communicates with Earth via NASA's Deep Space Network (DSN), which has a complex of large antennas with receivers and transmitters located in the California desert, another in Australia and a third in Spain, linked to a network control center at NASA's Jet Propulsion Laboratory in Pasadena, Calif. The spacecraft receives commands, sends science and engineering data, and is tracked by Doppler and ranging measurements through this network.

At JPL, about 275 scientists, engineers and technicians, will be supporting the mission at launch, increasing to nearly 400 for Jupiter operations including support from the German retropropulsion team at their control center in the FGR. Their responsibilities include spacecraft command, interpreting engineering and scientific data from Galileo to understand its performance, and analyzing navigation data from the DSN. The controllers use a set of complex computer programs to help them control the spacecraft and interpret the data.

Because the time delay in radio signals from Earth to Jupiter and back is more than an hour, the Galileo spacecraft was designed to operate from programs sent to it in advance and stored in spacecraft memory. A single master sequence program can cover 4 weeks of quiet operations between planetary and satellite encounters. During busy Jupiter operations, one program covers only a few days. Actual spacecraft tasks are carried out by several subsystems and scientific instruments, many of which work from their own computers controlled by the main sequence.

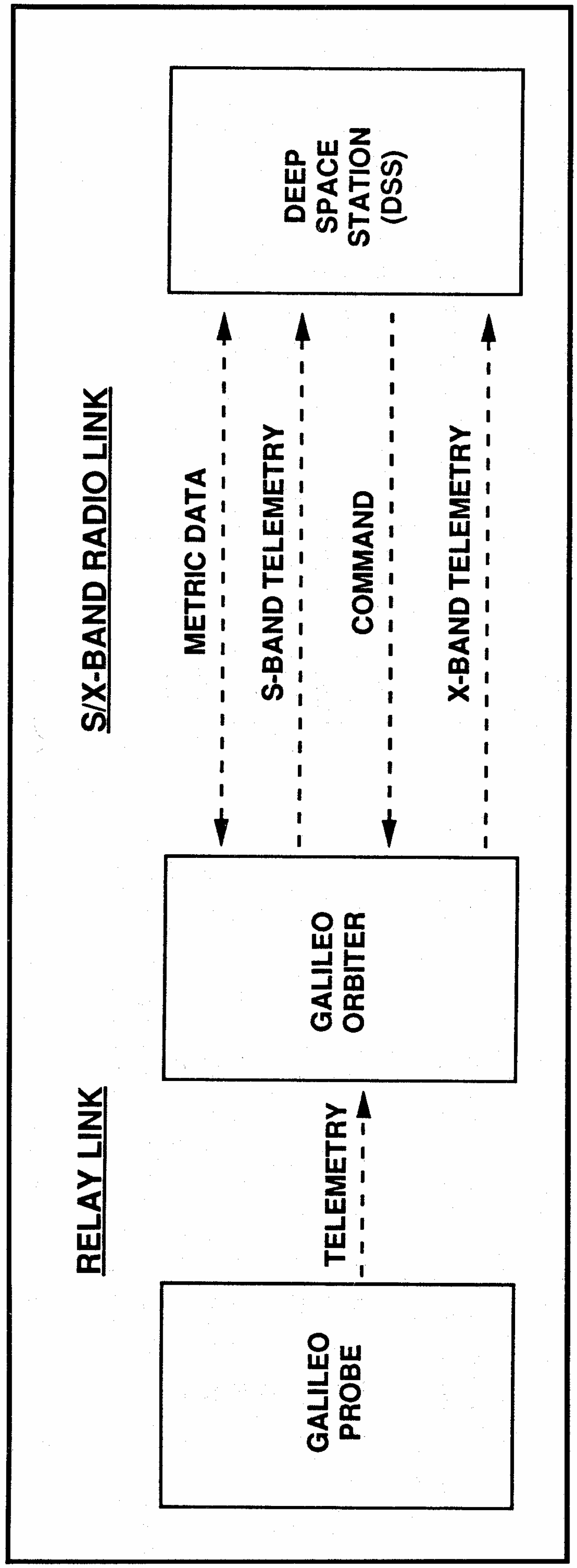
Designing these sequences is a complex process balancing the desire to make certain scientific observations with the need to safeguard the spacecraft and mission. The sequence design process itself is supported by software programs, for example, which display to the scientist maps of the instrument coverage on the surface of an approaching satellite for a given spacecraft orientation and trajectory. Notwithstanding these aids, a typical 3-day satellite encounter may take efforts spread over many months to design, check and recheck. The controllers also use software designed to check the command sequence further against flight rules and constraints.

The spacecraft regularly reports its status and health through an extensive set of engineering measurements. Interpreting these data into trends and averting or working around equipment failures is a major task for the mission operations team. Conclusions from this activity become an important input, along with scientific plans, to the sequence design process. This too is supported by computer programs written and used in the mission support area.

Navigation is the process of estimating, from radio range and Doppler measurements, the position and velocity of the spacecraft to predict its flight path and design course-correcting maneuvers. These calculations must be done with computer support. The Galileo mission, with its complex gravity-assist flight to Jupiter and 10 gravity-assist satellite encounters in the Jovian system, is extremely dependent on consistently accurate navigation.

In addition to the programs that directly operate the spacecraft and are periodically transmitted to it, the mission operations team uses software amounting to 650,000 lines of programming code in the sequence design process; 1,615,000 lines in the telemetry interpretation; and 550,000 lines of code in navigation. These must all be written, checked, tested, used in mission simulations and, in many cases, revised before the mission can begin.

Science investigators are located at JPL or other university laboratories and linked by computers. From any of these locations, the scientists can be involved in developing the sequences affecting their experiments and, in some cases, in helping to change preplanned sequences to follow up on unexpected discoveries with second looks and confirming observations.


RELAY LINK
S/X-BAND RADIO LINK
GALILEO PROBE
TELEMETRY
GALILEO ORBITER
METRIC DATA
S-BAND TELEMETRY
COMMAND
X-BAND TELEMETRY
DEEP SPACE STATION (DSS)

SPACECRAFT CHARACTERISTICS

	Orbiter	Probe
Mass, lbs.	5,242	744
Propellant, lbs	2,400	none
Height (in-flight)	15 feet	34 inches
Inflight span (w/o boom)	30 feet	
Instrument payload	10 instruments	6 instruments
Payload mass, lbs	260	66
Electric power, watts	570-480 (RTGs)	730 (Lithium-sulfur battery)

JUPITER'S SYSTEM

Jupiter is the largest and fastest-spinning planet in the solar system. Its radius is more than 11 times Earth's, and its mass is 318 times that of our planet. Named for the chief of the Roman gods, Jupiter contains more mass than all the other planets combined. It is made mostly of light elements, principally hydrogen and helium. Its atmosphere and clouds are deep and dense, and a significant amount of energy is emitted from its interior.

The earliest Earth-based telescopic observations showed bands and spots in Jupiter's atmosphere. One storm system, the Red Spot, has been seen to persist over three centuries.

Atmospheric forms and dynamics were observed in increasing detail with the Pioneer and Voyager flyby spacecraft, and Earth-based infrared astronomers have recently studied the nature and vertical dynamics of deeper clouds.

Sixteen satellites are known. The four largest, discovered by the Italian scientist Galileo Galilei in 1610, are the size of small planets. The innermost of these, Io, has active sulfurous volcanoes, discovered by Voyager 1 and further observed by Voyager 2 and Earth-based infrared astronomy. Io and Europa are about the size and density of Earth's moon (3 to 4 times the density of water) and probably rocky inside. Ganymede and Callisto, further out from Jupiter, are the size of Mercury but less than twice as dense as water. Their cratered surfaces look icy in Voyager images, and they may be composed partly of ice or water.

Of the other satellites, eight (probably captured asteroids) orbit irregularly far from the planet, and four (three discovered by the Voyager mission in 1979) are close to the planet. Voyager also discovered a thin ring system at Jupiter in 1979.

Jupiter has the strongest planetary magnetic field known. The resulting magnetosphere is a huge teardrop-shaped, plasma-filled cavity in the solar wind pointing away from the sun. Jupiter's magnetosphere is the largest single entity in our solar system, measuring more than 14 times the diameter of the sun. The inner part of the magnetic field is doughnut- shaped, but farther out it flattens into a disk. The magnetic poles are offset and tilted relative to Jupiter's axis of rotation, so the field appears to wobble with Jupiter's rotation (just under 10 hours), sweeping up and down across the inner satellites and making waves throughout the magnetosphere.

WHY JUPITER INVESTIGATIONS ARE IMPORTANT

With a thin skin of turbulent winds and brilliant, swift-moving clouds, the huge sphere of Jupiter is a vast sea of liquid hydrogen and helium. Jupiter's composition (about 88 percent hydrogen and 11 percent helium with small amounts of methane, ammonia and water) is thought to resemble the makeup of the solar nebula, the cloud of gas and dust from which the sun and planets formed. Scientists believe Jupiter holds important clues to conditions in the early solar system and the process of planet formation.

Jupiter may also provide insights into the formation of the universe itself. Since it resembles the interstellar gas and dust that are thought to have been created in the "Big Bang," studies of Jupiter may help scientists calibrate models of the beginning of the universe.

Though starlike in composition, Jupiter is too small to generate temperatures high enough to ignite nuclear fusion, the process that powers the stars. Some scientists believe that the sun and Jupiter began as unequal partners in a binary star system. (If a double star system had developed, it is unlikely life could have arisen in the solar system.) While in a sense a "failed star," Jupiter is almost as large as a planet can be. If it contained more mass, it would not have grown larger, but would have shrunk from compression by its own gravity. If it were 100 times more massive, thermonuclear reactions would ignite, and Jupiter would be a star.

For a brief period after its formation, Jupiter was much hotter, more luminous, and about 10 times larger than it is now, scientists believe. Soon after accretion (the condensation of a gas and dust cloud into a planet), its brightness dropped from about one percent of the Sun's to about one billionth -- a decline of ten million times.

In its present state Jupiter emits about twice as much heat as it receives from the Sun. The loss of this heat -- residual energy left over from the compressive heat of accretion -- means that Jupiter is cooling and losing energy at a tremendously rapid rate. Temperatures in Jupiter's core, which were about 90,000 degrees Fahrenheit in the planet's hot, early phase, are now about 54,000 degrees Fahrenheit, 100 times hotter than any terrestrial surface, but 500 times cooler than the temperature at the center of the sun. Temperatures on Jupiter now range from 54,000 degrees Fahrenheit at the core to minus 248 degrees Fahrenheit at the top of the cloud banks.

Mainly uniform in composition, Jupiter's structure is determined by gradations in temperature and pressure. Deep in Jupiter's interior there is thought to be a small rocky core, comprising about four percent of the planet's mass. This "small" core (about the size of 10 Earths) is surrounded by a 25,000-mile-thick layer of liquid metallic hydrogen. (Metallic hydrogen is liquid, but sufficiently compressed to behave as metal.) Motions of this liquid "metal" are the source of the planet's enormous magnetic field. This field is created by the same dynamo effect found in the metallic cores of Earth and other planets.

At the outer limit of the metallic hydrogen layer, pressures equal three million times that of Earth's atmosphere and the temperature has cooled to 19,000 degrees Fahrenheit.

Surrounding the central metallic hydrogen region is an outer shell of "liquid" molecular hydrogen. Huge pressures compress Jupiter's gaseous hydrogen until, at this level, it behaves like a liquid. The liquid hydrogen layer extends upward for about 15,000 miles. Then it gradually becomes gaseous. This transition region between liquid and gas marks, in a sense, where the solid and liquid planet ends and its atmosphere begins.

From here, Jupiter's atmosphere extends up for 600 more miles, but only in the top 50 miles are found the brilliant bands of clouds for which Jupiter is known. The tops of these bands are colored bright yellow, red and orange from traces of phosphorous and sulfur. Five or six of these bands, counterflowing east and west, encircle the planet in each hemisphere. At one point near Jupiter's equator, east winds of 220 mph blow right next to west winds of 110 mph. At boundaries of these bands, rapid changes in wind speed and direction create large areas of turbulence and shear. These are the same forces that create tornados here on Earth. On Jupiter, these "baroclinic instabilities" are major phenomena, creating chaotic, swirling winds and spiral features such as White Ovals.

The brightest cloud banks, known as zones, are believed to be higher, cooler areas where gases are ascending. The darker bands, called belts, are thought to be warmer, cloudier regions of descent.

The top cloud layer consists of white cirrus clouds of ammonia crystals, at a pressure six-tenths that of Earth's atmosphere at sea level (.6 bar). Beneath this layer, at a pressure of about two Earth atmospheres (2 bars) and a temperature of near minus 160 degrees Fahrenheit, a reddish-brown cloud of ammonium hydrosulfide is predicted.

At a pressure of about 6 bars, there are believed to be clouds of water and ice. However, recent Earth-based spectroscopic studies suggest that there may be less water on Jupiter than expected. While scientists previously believed Jupiter and the sun would have similar proportions of water, recent work indicates there may be 100 times less water on Jupiter than if it had a solar mixture of elements. If this is the case, there may be only a thin layer of water-ice at the 6 bar level.
However, Jupiter's cloud structure, except for the highest layer of ammonia crystals, remains uncertain. The height of the lower clouds is still theoretical -- clouds are predicted to lie at the temperature levels where their assumed constituents are expected to condense. The Galileo probe will make the first direct observations of Jupiter's lower atmosphere and clouds, providing crucial information.

The forces driving Jupiter's fast-moving winds are not well understood yet. The classical explanation holds that strong currents are created by convection of heat from Jupiter's hot interior to the cooler polar regions, much as winds and ocean currents are driven on Earth, from equator to poles. But temperature differences do not fully explain wind velocities that can reach 265 mph. An alternative theory is that pressure differences, due to changes in the thermodynamic state of hydrogen at high and low temperatures, set up the wind jets.

Jupiter's rapid rotation rate is thought to have effects on wind velocity and to produce some of Jupiter's bizarre circulation patterns, including many spiral features. These rotational effects are known as manifestations of the Coriolis force. Coriolis force is what determines the spin direction of weather systems. It basically means that on the surface of a sphere (a planet), a parcel of gas farther from the poles has a higher rotational velocity around the planet than a parcel closer to the poles. As gases then move north or south, interacting parcels with different velocities produce vortices (whirlpools). This may account for some of Jupiter's circular surface features.

Jupiter spins faster than any planet in the solar system. Though 11 times Earth's diameter, Jupiter spins more than twice as fast (once in 10 hours), giving gases on the surface extremely high rates of travel -- 22,000 mph at the equator, compared with 1000 mph for air at Earth's equator. Jupiter's rapid spin also causes this gas and liquid planet to flatten markedly at the poles and bulge at the equator.

Visible at the top of Jupiter's atmosphere are eye-catching features such as the famous Great Red Spot and the exotic White Ovals, Brown Barges and White Plumes. The Great Red Spot, which is 25,000 miles wide and large enough to swallow three Earths, is an enormous oval eddy of swirling gases. It is driven by two counter-flowing jet streams, which pass, one on each side of it, moving in opposite directions, each with speeds of 100-200 mph. The Great Red Spot was first discovered in 1664, by the British scientist Roger Hook, using Galileo's telescope. In the three centuries since, the huge vortex has remained constant in latitude in Jupiter's southern equatorial belt. Because of its stable position, astronomers once thought it might be a volcano.

Another past theory compared the Great Red Spot to a gigantic hurricane. However, the GRS rotates anti-cyclonically while hurricanes are cyclonic features (counterclockwise in the northern hemisphere, clockwise in the southern) -- and the dynamics of the Great Red Spot appear unrelated to moisture.

The Great Red Spot most closely resembles an enormous tornado, a huge vortex that sucks in smaller vortices. The Coriolis effect created by Jupiter's fast spin, appears to be the key to the dynamics that drive the spot.

The source of the Great Red Spot's color remains a mystery. Many scientists now believe it to be caused by phosphorus, but its spectral line does not quite match that of phosphorus. The GRS may be the largest in a whole array of spiral phenomena with similar dynamics. About a dozen white ovals, circulation patterns resembling the GRS, exist in the southern latitudes of Jupiter and appear to be driven by the same forces. Scientists do not know why these ovals are white.

Scientists believe the brown barges, which appear like dark patches on the planet, are holes in the upper clouds, through which the reddish-brown lower cloud layer may be glimpsed. The equatorial plumes, or white plumes, may be a type of wispy cirrus anvil cloud.

GALILEO MANAGEMENT

The Galileo Project is managed for NASA's Office of Space Science and Applications by the NASA Jet Propulsion Laboratory, Pasadena, Calif. This responsibility includes designing, building, testing, operating and tracking Galileo. NASA's Ames Research Center, Moffett Field, Calif. is responsible for the atmosphere probe, which was built by Hughes Aircraft Company, El Segundo, Calif.

The probe project and science teams will be stationed at Ames during pre-mission, mission operations, and data reduction periods. Team members will be at Jet Propulsion Laboratory for probe entry.

The Federal Republic of Germany has furnished the orbiter's retropropulsion module and is participating in the scientific investigations. The radioisotope thermoelectric generators were designed and built for the U.S. Department of Energy by the General Electric Company.

GALILEO ORBITER AND PROBE SCIENTIFIC INVESTIGATIONS

Listed by experiment/instrument and including the Principal Investigator and scientific objectives of that investigation:

PROBE

Atmospheric Structure	A. Seiff	NASA Ames Research Center	Temperature, pressure, density, molecular weight profiles
Neutral Mass Spectrometer	H. Neimann	NASA Goddard Space Flight Center	chemical composition
Helium Abundance	U. von Zahn	Bonn University, FRG	helium/hydrogen ratio
Nephelometer	B. Ragent	NASA Ames Research Center	clouds, solid/liquid particles
Net Flux Radiometer	L. Sromovsky	University of Wisconsin-Madison	thermal/solar energy profiles
Lightning/Energetic Particles	L. Lanzerotti	Bell Laboratories	detect lightning, measuring energetic particles

ORBITER (DESPUN PLATFORM

Solid-State Imaging Camera	M. Belton	National Optical Astronomy Observatories (team leader)	Galilean satellites at 1-km resolution or better
Near-Infrared Mapping Spectrometer	R. Carlson	NASA Jet Propulsion Laboratory	surface/atmospheric composition, thermal mapping
Ultraviolet Spectrometer	C. Hord	University of Colorado	atmospheric gases, aerosols
Photopolarimeter Radiometer	J. Hansen	Goddard Institute for Space Studies	atmospheric particles, thermal/reflected radiation

ORBITER (SPINNING SPACECRAFT SECTION)

Magnetometer; M. Kivelson. University of California at Los Angeles; strength and fluctuations of magnetic fluids

Energetic Particles; D. Williams, Johns Hopkins Applied Physics Laboratory; electrons, protons, heavy ions in magnetosphere and interplanetary space

Plasma; L. Frank, University of Iowa; composition, energy, distribution of magnetospheric ions

Plasma Wave; D. Gurnett, University of Iowa; electromagnetic waves and wave-particle interactions

Dust; E. Grun, Max Planck Institute; mass, velocity, charge of submicron particles

Radio Science - Celestial Mechanics; J. Anderson, NASA Jet Propulsion Laboratory (team leader); masses and motions of bodies from spacecraft tracking

Radio Science – Propagation; H. T. Howard, Stanford University; satellite radii, atmospheric structure both from radio propagation.

INTERDISCIPLINARY INVESTIGATIONS

F. P. Fanale	University of Hawaii
P. Gierasch	Cornell University
D. M. Hunten	University of Arizona
A. P. Ingersoll	California Institute of Technology
H. Masursky	U.S. Geological Survey
D. Morrison	Ames Research Center
M. McElroy	Harvard University
G. S. Orton	NASA Jet Propulsion Laboratory
T. Owen	State University of New York at Stony Brook
J. B. Pollack	NASA Ames Research Center
C. T. Russell	University of California at Los Angeles
C. Cagan	Cornell University
G. Schubert	University of California at Los Angeles
J. Van Allen	University of Iowa

STS-34 INERTIAL UPPER STAGE (IUS-19)

The Inertial Upper Stage (IUS) will again be used with the Space Shuttle, this time to transport NASA's Galileo spacecraft out of Earth's orbit to Jupiter, a 2.5-billion-mile journey.

The IUS has been used previously to place three Tracking and Data Relay Satellites in geostationary orbit as well as to inject the Magellan spacecraft into its interplanetary trajectory to Venus. In addition, the IUS has been selected by the agency for the Ulysses solar polar orbit mission.

After 2 1/2 years of competition, Boeing Aerospace Co., Seattle, was selected in August 1976 to begin preliminary design of the IUS. The IUS was developed and built under contract to the Air Force Systems Command's Space Systems Division. The Space Systems Division is executive agent for all Department of Defense activities pertaining to the Space Shuttle system. NASA, through the Marshall Space Flight Center, Huntsville, Ala., purchases the IUS through the Air Force and manages the integration activities of the upper stage to NASA spacecraft.

Specifications

IUS-19, to be used on mission STS-34, is a two-stage vehicle weighing approximately 32,500 lbs. Each stage has a solid rocket motor (SRM), preferred over liquid-fueled engines because of SRM's relative simplicity, high reliability, low cost and safety.

The IUS is 17 ft. long and 9.25 ft. in diameter. It consists of an aft skirt, an aft stage SRM generating approximately 42,000 lbs. of thrust, an interstage, a forward-stage SRM generating approximately 18,000 lbs. of thrust, and an equipment support section.

Airborne Support Equipment

The IUS Airborne Support Equipment (ASE) is the mechanical, avionics and structural equipment located in the orbiter. The ASE supports the IUS and the Galileo in the orbiter payload bay and elevates the combination for final checkout and deployment from the orbiter.

The IUS ASE consists of the structure, electromechanical mechanisms, batteries, electronics and cabling to support the Galileo/IUS. These ASE subsystems enable the deployment of the combined vehicle; provide, distribute and/or control electrical power to the IUS and spacecraft; provide plumbing to cool the radioisotope thermoelectric generator (RTG) aboard Galileo; and serve as communication paths between the IUS and/or spacecraft and the orbiter.

IUS Structure

The IUS structure is capable of supporting loads generated internally and also by the cantilevered spacecraft during orbiter operations and the IUS free flight. It is made of aluminum skin-stringer construction, with longerons and ring frames.

Equipment Support Section

The top of the equipment support section contains the spacecraft 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 Galileo.

The equipment support section also contains the avionics which provide guidance, navigation, control, telemetry, command and data management, reaction control and electrical power. All mission-critical components of the avionics system, along with thrust vector actuators, reaction control thrusters, motor igniter and pyrotechnic stage separation equipment are redundant to assure reliability of better than 98 percent.

IUS Avionics Subsystems

The avionics subsystems consist of the telemetry, tracking and command subsystems; guidance and navigation subsystem; data management; thrust vector control; and electrical power subsystems. These subsystems include all the electronic and electrical hardware used to perform all computations, signal conditioning, data processing and formatting associated with navigation, guidance, control, data and redundancy management. The IUS avionics subsystems also provide the equipment for communications between the orbiter and ground stations as well as electrical power distribution.

Attitude control in response to guidance commands is provided by thrust vectoring during powered flight and by reaction control thrusters while coasting. Attitude is compared with guidance commands to generate error signals. During solid motor firing, these commands gimbal the IUS's movable nozzle to provide the desired pitch and yaw control. The IUS's roll axis thrusters maintain roll control. While coasting, the error signals are processed in the computer to generate thruster commands to maintain the vehicle's altitude or to maneuver the vehicle.

The IUS electrical power subsystem consists of avionics batteries, IUS power distribution units, a power transfer unit, utility batteries, a pyrotechnic switching unit, an IUS wiring harness and umbilical and staging connectors. The IUS avionics system provides 5-volt electrical power to the Galileo/IUS interface connector for use by the spacecraft telemetry system.

IUS Solid Rocket Motors

The IUS two-stage vehicle uses a large solid rocket motor and a small solid rocket motor. These motors employ movable nozzles for thrust vector control. The nozzles provide up to 4 degrees of steering on the large motor and 7 degrees on the small motor. The large motor is the longest-thrusting duration SRM ever developed for space, with the capability to thrust as long as 150 seconds. Mission requirements and constraints (such as weight) can be met by tailoring the amount of propellant carried. The IUS-19 first-stage motor will carry 21,488 lb. of propellant; the second stage 6,067 lb.

Reaction Control System

The reaction control system controls the Galileo/IUS spacecraft attitude during coasting, roll control during SRM thrustings, velocity impulses for accurate orbit injection and the final collision-avoidance maneuver after separation from the Galileo spacecraft.

As a minimum, the IUS includes one reaction control fuel tank with a capacity of 120 lb. of hydrazine. Production options are available to add a second or third tank. However, IUS-19 will require only one tank.

IUS To Spacecraft Interfaces

Galileo is physically attached to the IUS at eight attachment points, providing substantial load-carrying capability while minimizing the transfer of heat across the connecting points. Power, command and data transmission between the two are provided by several IUS interface connectors. In addition, the IUS provides a multilayer insulation blanket of aluminized Kapton with polyester net spacers across the Galileo/IUS interface, along with an aluminized Beta cloth outer layer. All IUS thermal blankets are vented toward and into the IUS cavity, which in turn is 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.

Flight Sequence

After the orbiter payload bay doors are opened in orbit, the orbiter will maintain a preselected attitude to keep the payload within thermal requirements and constraints.

On-orbit predeployment checkout begins, followed by an IUS command link check and spacecraft communications command check. Orbiter trim maneuvers are normally performed at this time.

Forward payload restraints will be released and the aft frame of the airborne-support equipment will tilt the Galileo/IUS to 29 degrees. This will extend the payload into space just outside the orbiter payload bay, allowing direct communication with Earth during systems checkout. The orbiter then will be maneuvered to the deployment attitude. If a problem has developed within the spacecraft or IUS, the IUS and its payload can be restowed.

Prior to deployment, the spacecraft electrical power source will be switched from orbiter power to IUS internal power by the orbiter flight crew. After verifying that the spacecraft is on IUS internal power and that all Galileo/IUS predeployment operations have been successfully completed, a GO/NO-GO decision for deployment will be sent to the crew from ground support.

When the orbiter flight crew is given a "Go" decision, they will activate the ordnance that separates the spacecraft's umbilical cables. The crew then will command the electromechanical tilt actuator to raise the tilt table to a 58-degree deployment position. The orbiter's RCS thrusters will be inhibited and an ordnance-separation device initiated to physically separate the IUS/spacecraft combination from the tilt table.

Six hours, 20 minutes into the mission, compressed springs provide the force to jettison the IUS/Galileo from the orbiter payload bay at approximately 6 inches per second. The deployment is normally performed in the shadow of the orbiter or in Earth eclipse.

The tilt table then will be lowered to minus 6 degrees after IUS and its spacecraft are deployed. A small orbiter maneuver is made to back away from IUS/Galileo. Approximately 15 minutes after deployment, the orbiter's OMS engines will be ignited to move the orbiter away from its released payload.

After deployment, the IUS/Galileo is controlled by the IUS onboard computers. Approximately 10 minutes after IUS/Galileo deployment from the orbiter, the IUS onboard computer will send out signals used by the IUS and/or Galileo to begin mission sequence events. This signal will also enable the IUS reaction control system. All subsequent operations will be sequenced by the IUS computer, from transfer orbit injection through spacecraft separation and IUS deactivation.

After the RCS has been activated, the IUS will maneuver to the required thermal attitude and perform any required spacecraft thermal control maneuvers.

At approximately 45 minutes after deployment from the orbiter, the ordnance inhibits for the first SRM will be removed. The belly of the orbiter already will have been oriented towards the IUS/Galileo to protect orbiter windows from the IUS's plume. The IUS will recompute the first ignition time and maneuvers necessary to attain the proper attitude for the first thrusting period. When the proper transfer orbit opportunity is reached, the IUS computer will send the signal to ignite the first stage motor 60 minutes after deployment. After firing approximately 150 seconds, the IUS first stage will have expended its propellant and will be separated from the IUS second stage.

Approximately 140 seconds after first-stage burnout, the second- stage motor will be ignited, thrusting about 108 seconds. The IUS second stage then will separate and perform a final collision/contamination avoidance maneuver before deactivating.

SHUTTLE SOLAR BACKSCATTER ULTRAVIOLET INSTRUMENT

The Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument was developed by NASA to calibrate similar ozone measuring space-based instruments on the National Oceanic and Atmospheric Administration's TIROS satellites (NOAA-9 and -11).

The SSBUV will help scientists solve the problem of data reliability caused by calibration drift of solar backscatter ultraviolet (SBUV) instruments on orbiting spacecraft. The SSBUV uses the Space Shuttle's orbital flight path to assess instrument performance by directly comparing data from identical instruments aboard the TIROS spacecraft, as the Shuttle and the satellite pass over the same Earth location within a 1-hour window. These orbital coincidences can occur 17 times per day.

The SBUV measures the amount and height distribution of ozone in the upper atmosphere. It does this by measuring incident solar ultraviolet radiation and ultraviolet radiation backscattered from the Earth's atmosphere. The SBUV measures these parameters in 12 discrete wavelength channels in the ultraviolet. Because ozone absorbs in the ultraviolet, an ozone measurement can be derived from the ratio of backscatter radiation at different wavelengths, providing an index of the vertical distribution of ozone in the atmosphere.

Global concern over the depletion of the ozone layer has sparked increased emphasis on developing and improving ozone measurement methods and instruments. Accurate, reliable measurements from space are critical to the detection of ozone trends and for assessing the potential effects and development of corrective measures.

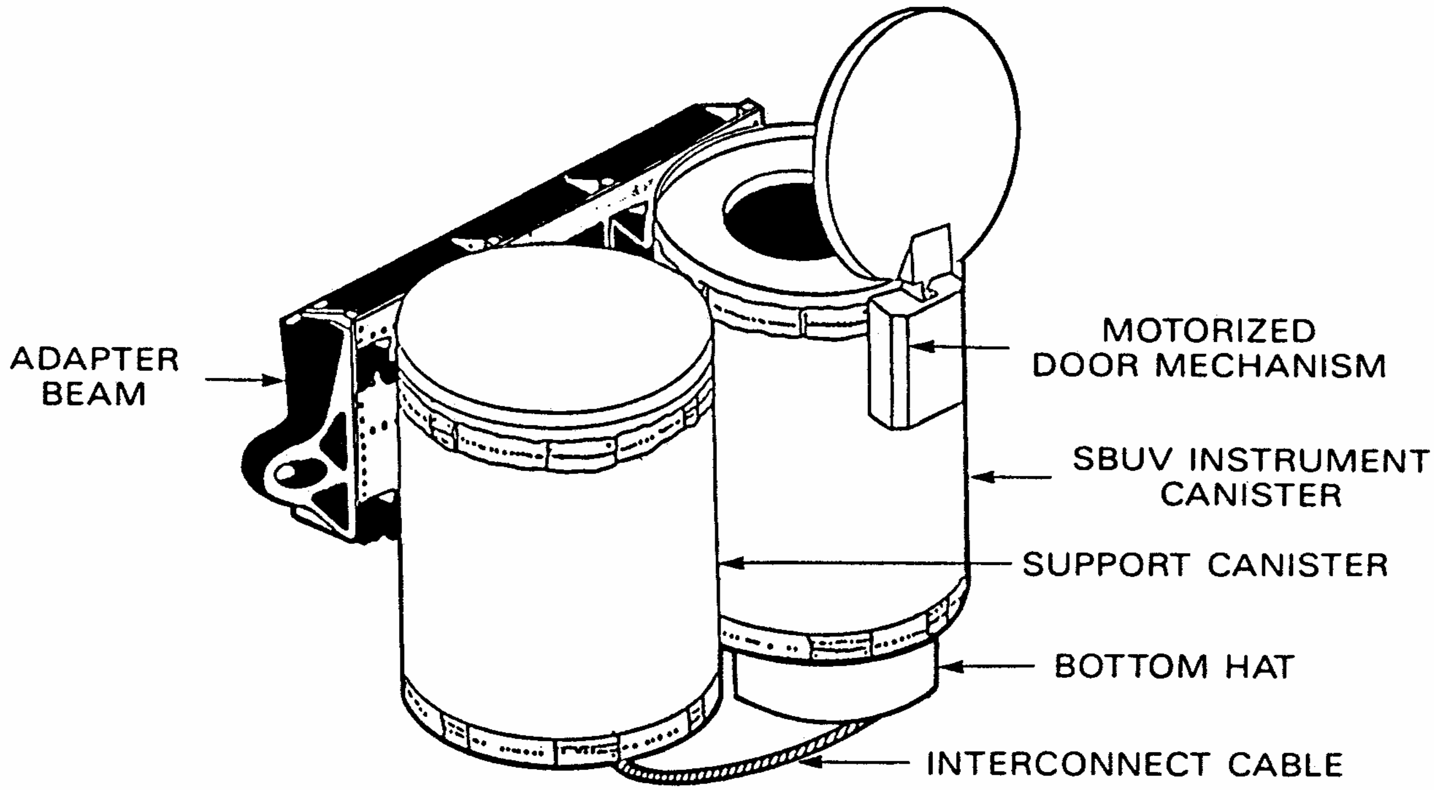
The SSBUV missions are so important to the support of Earth science that six additional missions have been added to the Shuttle manifest for calibrating ozone instruments on future TIROS satellites. In addition, the dates of the four previously manifested SSBUV flights have been accelerated.

The SSBUV instrument and its dedicated electronics, power, data and command systems are mounted in the Shuttle's payload bay in two Get Away Special canisters, an instrument canister and a support canister. Together, they weigh approximately 1200 lb. The instrument canister holds the SSBUV, its specially designed aspect sensors and in-flight calibration system. A motorized door assembly opens the canister to allow the SSBUV to view the sun and Earth and closes during the in-flight calibration sequence.

The support canister contains the power system, data storage and command decoders. The dedicated power system can operate the SSBUV for a total of approximately 40 hours.

The SSBUV is managed by NASA's Goddard Space Flight Center, Greenbelt, Md. Ernest Hilsenrath is the principal investigator.

SSBUV FLIGHT CONFIGURATION



GROWTH HORMONE CONCENTRATIONS AND DISTRIBUTION IN PLANTS

The Growth Hormone Concentration and Distribution in Plants (GHCD) experiment is designed to determine the effects of microgravity on the concentration, turnover properties, and behavior of the plant growth hormone, Auxin, in corn shoot tissue (Zea Mays).

Mounted in foam blocks inside two standard middeck lockers, the equipment consists of four plant canisters, two gaseous nitrogen freezers and two temperature recorders. Equipment for the experiment, excluding the lockers, weighs 97.5 pounds.

A total of 228 specimens (Zea Mays seeds) are "planted" in special filter, paper-Teflon tube holders no more than 56 hours prior to flight. The seeds remain in total darkness throughout the mission.

The GHCD experiment equipment and specimens will be prepared in a Payload Processing Facility at KSC and placed in the middeck lockers. The GHCD lockers will be installed in the orbiter middeck within the last 14 hours before launch.

No sooner than 72 hours after launch, mission specialist Ellen Baker will place two of the plant canisters into the gaseous nitrogen freezers to arrest the plant growth and preserve the specimens. The payload will be restowed in the lockers for the remainder of the mission.

After landing, the payload must be removed from the orbiter within 2 hours and will be returned to customer representatives at the landing site. The specimens will be examined post flight for microgravity effects.

The GHCD experiment is sponsored by NASA Headquarters, the Johnson Space Center and Michigan State University.

POLYMER MORPHOLOGY

The Polymer Morphology (PM) experiment is a 3M-developed organic materials processing experiment designed to explore the effects of microgravity on polymeric materials as they are processed in space.

Since melt processing is one of the more industrially significant methods for making products from polymers, it has been chosen for study in the PM experiment. Key aspects of melt processing include polymerization, crystallization and phase separation. Each aspect will be examined in the experiment. The polymeric systems for the first flight of PM include polyethylene, nylon-6 and polymer blends.

The apparatus for the experiment includes a Fournier transform infrared (FTIR) spectrometer, an automatic sample manipulating system and a process control and data acquisition computer known as the Generic Electronics Module (GEM). The experiment is contained in two separate, hermetically sealed containers that are mounted in the middeck of the orbiter. Each container includes an integral heat exchanger that transfers heat from the interior of the containers to the orbiter's environment. All sample materials are kept in triple containers for the safety of the astronauts.

The PM experiment weighs approximately 200 lb., occupies three standard middeck locker spaces (6 cubic ft., total) in the orbiter and requires 240 watts to operate.

Mission specialists Franklin R. Chang-Diaz and Shannon W. Lucid are responsible for the operation of the PM experiment on orbit. Their interface with the PM experiment is through a small, NASA-supplied laptop computer that is used as an input and output device for the main PM computer. This interface has been programmed by 3M engineers to manage and display the large quantity of data that is available to the crew. The astronauts will have an active role in the operation of the experiment.

In the PM experiment, infrared spectra (400 to 5000 cm-1) will be acquired from the FTIR by the GEM computer once every 3.2 seconds as the materials are processed on orbit. During the 100 hours of processing time, approximately 2 gigabytes of data will be collected. Post flight, 3M scientists will process the data to reveal the effects of microgravity on the samples processed in space.

The PM experiment is unique among material processing experiments in that measurements characterizing the effects of microgravity will be made in real time, as the materials are processed in space.

In most materials processing space experiments, the materials have been processed in space with little or no measurements made during on-orbit processing and the effects of microgravity determined post facto.

The samples of polymeric materials being studied in the PM experiment are thin films (25 microns or less) approximately 25 mm in diameter. The samples are mounted between two infrared transparent windows in a specially designed infrared cell that provides the capability of thermally processing the samples to 200 degrees Celsius with a high degree of thermal control. The samples are mounted on a carousel that allows them to be positioned, one at a time, in the infrared beam where spectra may be acquired. The GEM provides all carousel and sample cell control. The first flight of PM will contain 17 samples.

The PM experiment is being conducted by 3M's Space Research and Applications Laboratory. Dr. Earl L. Cook is 3M's Payload Representative and Mission Coordinator. Dr. Debra L. Wilfong is PM's Science Coordinator, and James E. Steffen is the Hardware Coordinator.

The PM experiment, a commercial development payload, is sponsored by NASA's Office of Commercial Programs. The PM experiment will be 3M's fifth space experiment and the first under the company's 10-year Joint Endeavor Agreement with NASA for 62 flight experiment opportunities. Previous 3M space experiments have studied organic crystal growth from solution (DMOS/1 on mission STS 51-A and DMOS/2 on STS 61-B) and organic thin film growth by physical vapor treatment (PVTOS/1 on STS 51-I and PVTOS/2 on mission STS-26).

STUDENT EXPERIMENT

Zero Gravity Growth of Ice Crystals From Supercooled Water
With Relation To Temperature (SE82-15)

This experiment, proposed by Tracy L. Peters, formerly of Ygnacio High School, Concord, Calif., will observe the geometric ice crystal shapes formed at supercooled temperatures, below 0 degrees Celsius, without the influence of gravity.

Liquid water has been discovered at temperatures far below water's freezing point. This phenomenon occurs because liquid water does not have a nucleus, or core, around which to form the crystal. When the ice freezes at supercold temperatures, the ice takes on many geometric shapes based on the hexagon. The shape of the crystal primarily depends on the supercooled temperature and saturation of water vapor. The shapes of crystals vary from simple plates to complex prismatic crystals.

Many scientists have tried to determine the relation between temperature and geometry, but gravity has deformed crystals, caused convection currents in temperature-controlled apparatus, and caused faults in the crystalline structure. These all affect crystal growth by either rapid fluctuations of temperature or gravitational influence of the crystal geometry.

The results of this experiment could aid in the design of radiator cooling and cryogenic systems and in the understanding of high-altitude meteorology and planetary ring structure theories.

Peters is now studying physics at the University of California at Berkeley. His teacher advisor is James R. Cobb, Ygnacio High School; his sponsor is Boeing Aerospace Corp., Seattle.

Peters also was honored as the first four-time NASA award winner at the International Science and Engineering Fair (ISEF), which recognizes student's creative scientific endeavors in aerospace research. At the 1982 ISEF, Peters was one of two recipients of the Glen T. Seaborg Nobel Prize Visit Award, an all-expense-paid visit to Stockholm to attend the Nobel Prize ceremonies, for his project "Penetration and Diffusion of Supersonic Fluid."

MESOSCALE LIGHTNING EXPERIMENT

The Space Shuttle will again carry the Mesoscale Lightning Experiment (MLE), designed to obtain nighttime images of lightning in order to better understand the global distribution of lightning, the interrelationships between lightning events in nearby storms, and relationships between lightning, convective storms and precipitation.

A better understanding of the relationships between lightning and thunderstorm characteristics can lead to the development of applications in severe storm warning and forecasting, and early warning systems for lightning threats to life and property.

In recent years, NASA has used both Space Shuttle missions and high-altitude U-2 aircraft to observe lightning from above convective storms. The objectives of these observations have been to determine some of the baseline design requirements for a satellite-borne optical lightning mapper sensor; study the overall optical and electrical characteristics of lightning as viewed from above the cloudtop; and investigate the relationship between storm electrical development and the structure, dynamics and evolution of thunderstorms and thunderstorm systems.

The MLE began as an experiment to demonstrate that meaningful, qualitative observations of lightning could be made from the Shuttle. Having accomplished this, the experiment is now focusing on quantitative measurements of lightning characteristics and observation simulations for future space-based lightning sensors.

Data from the MLE will provide information for the development of observation simulations for an upcoming polar platform and Space Station instrument, the Lightning Imaging Sensor (LIS). The lightning experiment also will be helpful for designing procedures for using the Lightning Mapper Sensor (LMS), planned for several geostationary platforms.

In this experiment, Atlantis' payload bay camera will be pointed directly below the orbiter to observe nighttime lightning in large, or mesoscale, storm systems to gather global estimates of lightning as observed from Shuttle altitudes. Scientists on the ground will analyze the imagery for the frequency of lightning flashes in active storm clouds within the camera's field of view, the length of lightning discharges, and cloud brightness when illuminated by the lightning discharge within the cloud.

If time permits during missions, astronauts also will use a handheld 35mm camera to photograph lightning activity in storm systems not directly below the Shuttle's orbital track.

Data from the MLE will be associated with ongoing observations of lightning made at several locations on the ground, including observations made at facilities at the Marshall Space Flight Center, Huntsville, Ala.; Kennedy Space Center, Fla.; and the NOAA Severe Storms Laboratory, Norman, Okla. Other ground-based lightning detection systems in Australia, South America and Africa will be integrated when possible.

The MLE is managed by the Marshall Space Flight Center. Otha H. Vaughan Jr., is coordinating the experiment. Dr. Hugh Christian is the project scientist, and Dr. James Arnold is the project manager.

IMAX

The IMAX project is a collaboration between NASA and the Smithsonian Institution's National Air and Space Museum to document significant space activities using the IMAX film medium. This system, developed by the IMAX Systems Corp., Toronto, Canada, uses specially designed 70mm film cameras and projectors to record and display very high definition large-screen color motion pictures.

IMAX cameras previously have flown on Space Shuttle missions 41-C, 41-D and 41-G to document crew operations in the payload bay and the orbiter's middeck and flight deck along with spectacular views of space and Earth.

Film from those missions form the basis for the IMAX production, "The Dream is Alive." On STS 61-B, an IMAX camera mounted in the payload bay recorded extravehicular activities in the EAS/ACCESS space construction demonstrations.

The IMAX camera, most recently carried aboard STS-29, will be used on this mission to cover the deployment of the Galileo spacecraft and to gather material on the use of observations of the Earth from space for future IMAX films.

AIR FORCE MAUI OPTICAL SITE CALIBRATION TEST

The Air Force Maui Optical Site (AMOS) tests allow ground-based electro-optical sensors located on Mt. Haleakala, Maui, Hawaii, to collect imagery and signature data of the orbiter during cooperative overflights. Scientific observations made of the orbiter while performing 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. AMOS tests have no payload-unique flight hardware and only require that the orbiter be in predefined attitude operations and lighting conditions.

The AMOS facility was developed by Air Force Systems Command (AFSC) through its Rome Air Development Center, Griffiss Air Force Base, N.Y., and is administered and operated by the AVCO Everett Research Laboratory, Maui. The principal investigator for the AMOS tests on the Space Shuttle is from AFSC's Air Force Geophysics Laboratory, Hanscom Air Force Base, Mass. A co-principal investigator is from AVCO.

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

SENSOR TECHNOLOGY EXPERIMENT

The Sensor Technology Experiment (STEX) is a radiation detection experiment designed to measure the natural radiation background. The STEX is a self-contained experiment with its own power, sensor, computer control and data storage. A calibration pack, composed of a small number of passive threshold reaction monitors, is attached to the outside of the STEX package.

Sponsored by the Strategic Defense Initiative Organization, the STEX package weighs approximately 50 pounds and is stowed in a standard middeck locker throughout the flight.

SPACEFLIGHT TRACKING AND DATA NETWORK

Primary communications for most activities on STS-34 will be conducted through the orbiting Tracking and Data Relay Satellite System (TDRSS), a constellation of three communications satellites in geosynchronous orbit 22,300 miles above the Earth. In addition, three NASA Spaceflight Tracking and Data Network (STDN) ground stations and the NASA Communications Network (NASCOM), both managed by Goddard Space Flight Center, Greenbelt, Md., will play key roles in the mission.

Three stations -- Merritt Island and Ponce de Leon, Florida and the Bermuda -- serve as the primary communications during the launch and ascent phases of the mission. For the first 80 seconds, all voice, telemetry and other communications from the Space Shuttle are relayed to the mission managers at Kennedy and Johnson Space Centers by way of the Merritt Island facility.

At 80 seconds, the communications are picked up from the Shuttle and relayed to the two NASA centers from the Ponce de Leon facility, 30 miles north of the launch pad. This facility provides the communications between the Shuttle and the centers for 70 seconds, or until 150 seconds into the mission. This is during a critical period when exhaust from the solid rocket motors "blocks out" the Merritt Island antennas.

The Merritt Island facility resumes communications to and from the Shuttle after those 70 seconds and maintains them until 6 minutes, 30 seconds after launch when communications are "switched over" to Bermuda. Bermuda then provides the communications until 11 minutes after liftoff when the TDRS-East satellite acquires the Shuttle. TDRS-West acquires the orbiter at launch plus 50 minutes.

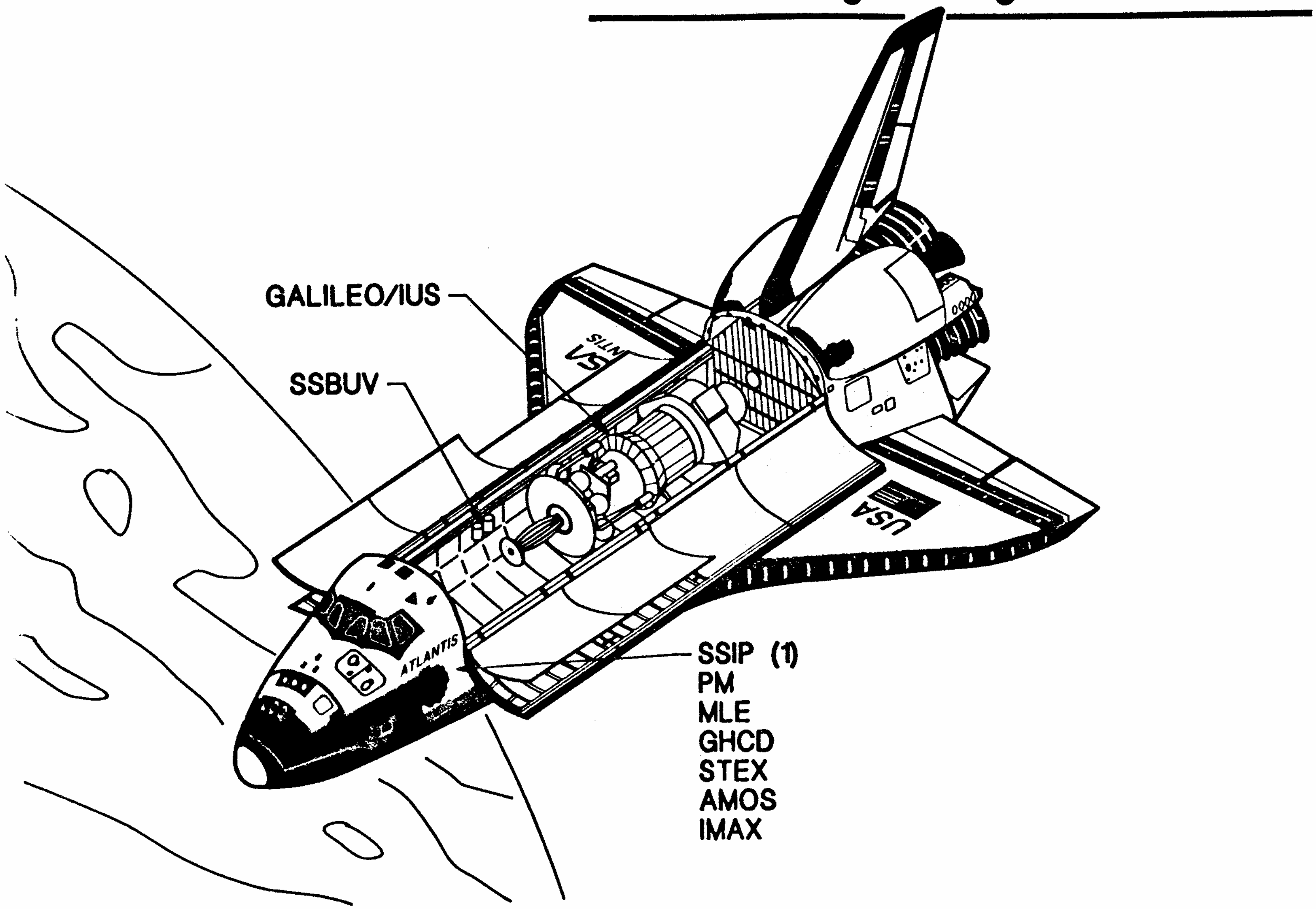
The TDRS-East and -West satellites will provide communications with the Shuttle during 85 percent or better of each orbit. The TDRS-West satellite will handle communications with the Shuttle during its descent and landing phases.

PAYLOAD AND VEHICLE WEIGHTS

	(Pounds)
Orbiter (Atlantis) Empty	172,018
Galileo/IUS (payload bay)	43,980
Galileo support hardware (middeck)	59
SSBUV (payload bay)	637
SSBUV support	578
DSO	49
DTO	170
GHCD	130
IMAX	269
MLE	15
PM	219
SSIP	70
STEX	52
Orbiter and Cargo at SRB Ignition	264,775
Total Vehicle at SRB Ignition	4,523,810
Orbiter Landing Weight	195,283

NASA
C907847C.ART;8

National STS Program
STS-34 Cargo Configuration



STS-34 CREWMEMBERS

S89-39803 -- *The STS-34 Atlantis, OV-104, official crew portrait includes mission commander Donald E. Williams, pilot Michael J. McCulley, mission specialists Shannon W. Lucid, Ellen S. Baker, and Franklin R. Chang-Diaz wearing red mission t-shirts. Seated (left to right) are Lucid, Chang-Diaz, and Baker with Williams (left) and McCulley standing. Crew insignia is displayed in the background.*

BIOGRAPHICAL DATA

DONALD E. WILLIAMS, 47, Capt., USN, will serve as commander. Selected as an astronaut in January 1978, he was born in Lafayette, Ind.

Williams was pilot for STS-51D, the fourth flight of Discovery, launched April 12, 1985. During the mission, the seven-member crew deployed the Anik-C communications satellite for Telesat of Canada and the Syncom IV-3 satellite for the U.S. Navy. A malfunction in the Syncom spacecraft resulted in the first unscheduled extravehicular, rendezvous and proximity operation for the Space Shuttle in an attempt to activate the satellite.

He graduated from Otterbein High School, Otterbein, Ind., in 1960 and received his B.S. degree in mechanical engineering from Purdue University in 1964. Williams completed his flight training at Pensacola, Fla., Meridian, Miss., and Kingsville, Texas, and earned his wings in 1966.

During the Vietnam Conflict, Williams completed 330 combat missions. He has logged more than 5,400 hours flying time, including 5,100 in jets, and 745 aircraft carrier landings.

MICHAEL J. MCCULLEY, 46, Cdr., USN, will be pilot on this flight. Born in San Diego, McCulley considers Livingston, Tenn., his hometown. He was selected as a NASA astronaut in 1984. He is making his first Space Shuttle flight.

McCulley graduated from Livingston Academy in 1961. He received B.S. and M.S. degrees in metallurgical engineering from Purdue University in 1970.

After graduating from high school, McCulley enlisted in the U.S. Navy and subsequently served on one diesel-powered and two nuclear-powered submarines. Following flight training, he served tours of duty in A-4 and A-65 aircraft and was selected to attend the Empire Test Pilots School in Great Britain. He served in a variety of test pilot billets at the Naval Air Test Center, Patuxent River, Md., before returning to sea duty on the USS Saratoga and USS Nimitz.

He has flown more than 50 types of aircraft, logging more than 4,760 hours, and has almost 400 carrier landings on six aircraft carriers.

SHANNON W. LUCID, 46, will serve as mission specialist (MS-1) on this, her second Shuttle flight. Born in Shanghai, China, she considers Bethany, Okla., her hometown. Lucid is a member of the astronaut class of 1978.

Lucid's first Shuttle mission was during STS 51-G, launched from the Kennedy Space Center on June 17, 1985. During that flight, the crew deployed communications satellites for Mexico, the Arab League and the United States.

Lucid graduated from Bethany High School in 1960. She then attended the University of Oklahoma where she received a B.S. degree in chemistry in 1963, an M.S. degree in biochemistry in 1970 and a Ph.D. in biochemistry in 1973.

Before joining NASA, Lucid held a variety of academic assignments such as teaching assistant at the University of Oklahoma's department of chemistry; senior laboratory technician at the Oklahoma Medical Research Foundation; chemist at Kerr-McGee in Oklahoma City; graduate assistant in the University of Oklahoma Health Science Center's department of biochemistry; and molecular biology and research associate with the Oklahoma Medical Research Foundation in Oklahoma City. Lucid also is a commercial, instrument and multi-engine rated pilot.

BIOGRAPHICAL DATA

FRANKLIN CHANG-DIAZ, 39, will serve as MS-2. Born in San Jose, Costa Rica, Chang-Diaz also will be making his second flight since being selected as an astronaut in 1980.

Chang-Diaz made his first flight aboard Columbia on mission STS 61-C, launched from KSC Jan. 12, 1986. During the 6-day flight he participated in the deployment of the SATCOM KU satellite, conducted experiments in astrophysics and operated the materials science laboratory, MSL-2.

Chang-Diaz graduated from Colegio De La Salle, San Jose, Costa Rica, in 1967, and from Hartford High School, Hartford, Conn., in 1969. He received a B.S. degree in mechanical engineering from the University of Connecticut in 1973 and a Ph.D. in applied plasma physics from the Massachusetts Institute of Technology in 1977.

While attending the University of Connecticut, Chang-Diaz also worked as a research assistant in the physics department and participated in the design and construction of high-energy atomic collision experiments. Upon entering graduate school at MIT, he became heavily involved in the United State's controlled fusion program and conducted intensive research in the design and operation of fusion reactors. In 1979, he developed a novel concept to guide and target fuel pellets in an inertial fusion reactor chamber. In 1983, he was appointed as visiting scientist with the MIT Plasma Fusion Center which he visits periodically to continue his research on advanced plasma rockets.

Chang-Diaz has logged more than 1,500 hours of flight time, including 1,300 hours in jet aircraft.

ELLEN S. BAKER, 36, will serve as MS-3. She will be making her first Shuttle flight. Baker was born in Fayetteville, N.C., and was selected as an astronaut in 1984.

Baker graduated from Bayside High School, New York, N.Y., in 1970. She received a B.A. degree in geology from the State University of New York at Buffalo in 1974, and an M.D. from Cornell University in 1978.

After medical school, Baker trained in internal medicine at the University of Texas Health Science Center in San Antonio, Texas. In 1981, she was certified by the American Board of Internal Medicine.

Baker joined NASA as a medical officer at the Johnson Space Center in 1981 after completing her residency. That same year, she graduated with honors from the Air Force Aerospace Medicine Primary Course at Brooks Air Force Base in San Antonio. Prior to her selection as an astronaut, she served as a physician in the Flight Medicine Clinic at JSC.

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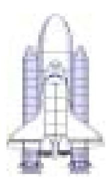
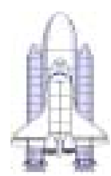
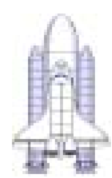
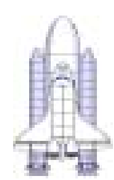
SHUTTLE FLIGHTS AS OF OCTOBER 1989

30 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 5 SINCE RETURN TO FLIGHT

	STS-51L 01/28/86		
	STS-61A 10/30/85 - 11/06/85		
STS-28 08/08/89 - 08/13/89	STS-51F 07/29/85 - 08/06/85	STS-29 03/13/89 - 03/18/89	
STS-61C 01/12/86 - 01/18/86	STS-51B 04/29/85 - 05/06/85	STS-26 09/29/88 - 10/03/88	
STS-9 11/28/83 - 12/08/83	STS-41G 10/05/84 - 10/13/84	STS-51-I 08/27/85 - 09/03/85	
STS-5 11/11/82 - 11/16/82	STS-41C 04/06/84 - 04/13/84	STS-51G 06/17/85 - 06/24/85	
STS-4 06/27/82 - 07/04/82	STS-41B 02/03/84 - 02/11/84	STS-51D 04/12/85 - 04/19/85	STS-30 05/04/89 - 05/08/89
STS-3 03/22/82 - 03/30/82	STS-8 08/30/83 - 09/05/83	STS-51C 01/24/85 - 01/27/85	STS-27 12/02/88 - 12/06/88
STS-2 11/12/81 - 11/14/81	STS-7 06/18/83 - 06/24/83	STS-51A 11/08/84 - 11/16/84	STS-61B 11/26/85 - 12/03/85
STS-1 04/12/81 - 04/14/81	STS-6 04/04/83 - 04/09/83	STS-41D 08/30/84 - 09/05/84	STS-51J 10/03/85 - 10/07/85
OV-102 Columbia (8 flights)	**OV-099 Challenger (10 flights)**	**OV-103 Discovery (8 flights)**	**OV-104 Atlantis (4 flights)**