NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION STS-35

PRESS KIT DECEMBER 1990

(Revised from September, 1990)
(Revised From May, 1990)

ASTRO-1 MISSION

STS-35 INSIGNIA

STS035-S-001 -- Designed by the crewmembers, the STS-35 insignia symbolizes the space shuttle flying above Earth's atmosphere to better study the many celestial objects of the universe, represented by the constellation Orion. The primary payload of STS-35 is ASTRO-1, a group of ultraviolet telescopes and the Broad-Band X ray Telescope.

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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RELEASE 90-63

COLUMBIA TO FLY ASTRONOMY MISSION

Highlighting mission STS-35, the 38th flight of the Space Shuttle and 10th mission of orbiter Columbia, will be around-the-clock observations by the seven-member crew using the ultraviolet astronomy observatory (Astro) and the Broad Band X-Ray Telescope (BBXRT). Both instruments are located in Columbia's payload bay and will be operated during 12-hour shifts by the crew.

Above Earth's atmospheric interference, Astro-1 will observe and measure ultraviolet radiation from celestial objects. Astro-1 is the first in a series of missions that will make precise measurements of objects such as planets, stars and galaxies in relatively small fields of view.

Liftoff of the 10th flight of Columbia is scheduled for the week of Dec. 2, 1990 from launch pad 39B at the Kennedy Space Center, FL. Columbia will be placed into a 218 statute (190 nautical) mile circular orbit, inclined 28.5 degrees to the equator. Nominal mission duration is expected to be 9 days 21 hours 57 minutes. Landing will take place at Edwards Air Force Base, Calif.

Astro-1 uses a Spacelab pallet system with an instrument pointing system and a cruciform structure for bearing the three ultraviolet instruments mounted in parallel configuration. The three instruments are the Hopkins Ultraviolet Telescope (HUT), the Wisconsin Ultraviolet Photo-polarimeter Experiment (WUPPE) and the Ultraviolet Imaging Telescope (UIT). The star tracker, which supports the instrument pointing system, also is mounted on the cruciform.

HUT will study faint astronomical objects such as quasars, active galactic nuclei and supernova remnants in the little-explored ultraviolet range below 1200 Angstroms. It consists of a mirror that focuses on an aperture of a prime focus spectrograph. Observations of the outer planets of the solar system will be made to investigate aurorae and gain insight into the interaction of each planet's magnetosphere with the solar wind.

WUPPE will measure the polarization of ultraviolet light from celestial objects such as hot stars, galactic nuclei and quasars. It uses two-mirror telescope optics in conjunction with a spectropolarimeter. This instrument will measure the polarization by splitting a beam of light into two mutually-perpendicular planes of polarization, passing the beams through a spectrometer and focusing the beams on two separate array detectors.

UIT consists of a telescope and two image intensifiers with 70 mm film transports (1000 frames each). It will acquire images of faint objects in broad ultraviolet bands in the wavelength range of 1200 to 3200 Angstroms. This experiment also will investigate the present stellar content and history of star formation in galaxies, the nature of spiral structure and non-thermal sources in galaxies.

Also in the payload bay is the Broad Band X-Ray Telescope which has two co-aligned imaging telescopes with cryogenically cooled lithium- drifted silicon detectors at each focus. Accurate pointing of the instrument is achieved by a two-axis pointing system (TAPS).

BBXRT will study various targets, including active galaxies, clusters of galaxies, supernova remnants and stars. BBXRT will directly measure the amount of energy in electron volts of each X-ray detected.

Astro observations will begin about 23 hours after Columbia has completed its maneuvering burn to circularize its orbit at 190 nautical miles. BBXRT will be activated approximately 13 hours after orbital insertion. Astro will be deactivated 12 hours before deorbit and BBXRT deactivation will be 4 hours before the deorbit burn.

Columbia's middeck will carry the Shuttle Amateur Radio Experiment (SAREX) to communicate with amateur radio stations within line-of-sight of the orbiter in voice mode or data mode. This experiment has previously flown on STS-9 and STS-51F. Also on this mission, Columbia will function as the subject for ground sensor operations as part of the Air Force Maui Optical Site (AMOS) calibration test.

Commander of the seven-member crew is Vance Brand. Pilot is Guy Gardner. STS-35 is Brand's fourth trip to space. He previously flew on the Apollo-Soyuz Test Project mission in 1975. He also commanded Shuttle missions STS-5 in November 1982 and STS-41B in February 1984. Gardner previously piloted STS-27 in December 1988.

Mission Specialists are Mike Lounge, Jeffrey Hoffman and Robert Parker. Lounge previously flew on STS-51I in August 1985 and STS-26 in September 1988. Hoffman flew as a Mission Specialist on STS-51D in April 1985. Parker's previous spaceflight experience was STS-9 in November 1983.

Payload Specialists Ronald Parise and Samuel Durrance round out the STS-35 crew. Both are making their first space flights.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

SUMMARY OF MAJOR ACTIVITIES

Flight Day 1
Ascent
Post-insertion
Unstow Cabin
Astro/BBXRT Activation
SAREX Setup
DSO

Flight Day 2
Astro/BBXRT Observations
SAREX

Flight Day 3
Astro/BBXRT Observations
SAREX

Flight Day 4
AMOS
Astro/BBXRT observations
SAREX

Flight Day 5
AMOS
Astro/BBXRT Observations
SAREX
Space Classroom

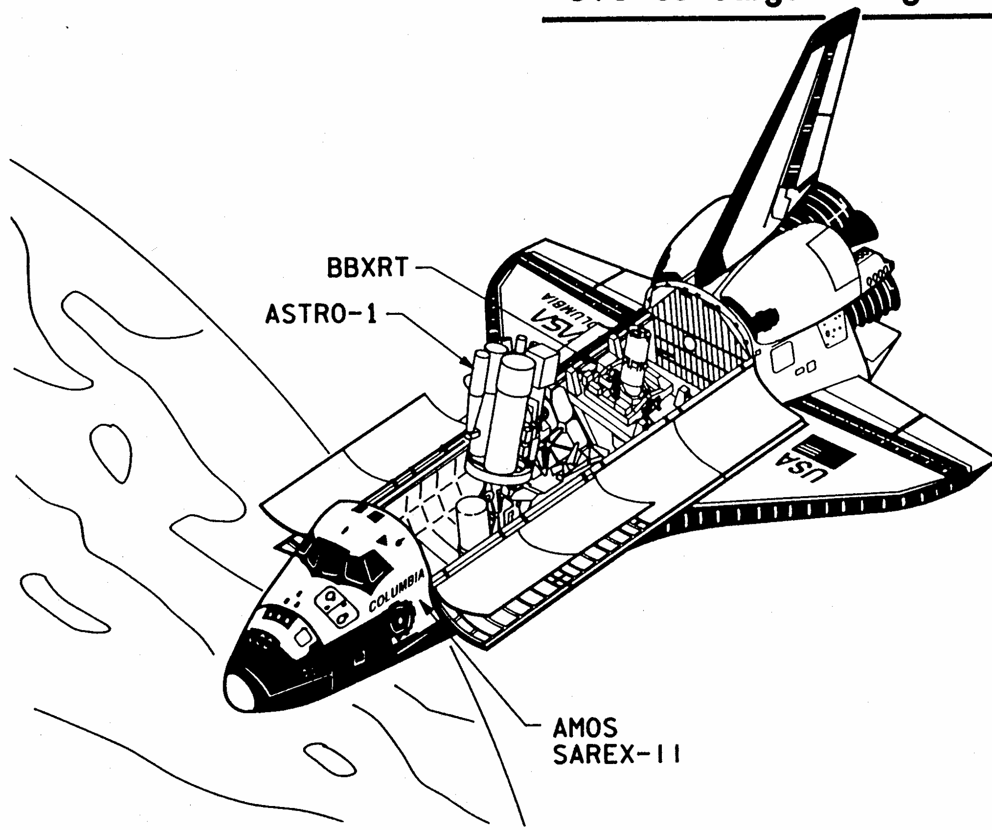
Flight Day 6
Astro/BBXRT Observations
SAREX

Flight Day 7
Astro/BBXRT Observations
RCS Hotfire

Flight Day 8
Astro/BBXRT Observations
SAREX
DTO
FCS checkout

Flight Day 9
Astro/BBXRT Observations
SAREX
SAREX stow
Astro/BBXRT deactivation
Cabin stow
Deorbit burn
Landing at Edwards AFB

Space Shuttle Program
STS-35 Cargo Configuration



STS-35 QUICK LOOK

Launch Date:	December 2, 1990
Launch Window:	1:24 a.m. - 3:54 a.m. EST
Launch Site:	Kennedy Space Center, FL
Launch Complex	39B
Orbiter:	Columbia (OV-102)
Altitude:	218 statute miles (190 nm)
Inclination:	28.45
Duration:	9 days, 21 hours, 57 minutes
Landing Date/Time:	Dec. 11, 1990, 8:21 p.m. PST
Primary Landing Site:	Edwards Air Force Base, CA
Abort Landing Sites:	Return to Launch Site -- Kennedy Space Center, FL Trans-Atlantic Abort -- Banjul, The Gambia Abort Once Around -- Edwards AFB, CA
Crew:	Vance D. Brand - Commander - Red/Blue Team Guy S. Gardner - Pilot - Red Team Jeffrey A. Hoffman - Mission Specialist 1/EV1 - Blue Team John M. "Mike" Lounge - Mission Specialist 2/EV2 - Blue Team Robert A. R. Parker - Mission Specialist 3 - Red Team Samuel T. Durrance - Payload Specialist 1 - Blue Team Ronald A. Parise - Payload Specialist 2 - Red Team Red Team shift is approximately 10:30 p.m. -- 10:30 a.m. EST Blue Team shift is approximately 10:30 a.m. -- 10:30 p.m. EST
Cargo Bay Payloads:	Ultraviolet Astronomy Telescope (Astro) Broad Band X-Ray Telescope (BBXRT)
Middeck Payloads:	Air Force Maui Optical Site (AMOS) Shuttle Amateur Radio Experiment (SAREX)

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, FL; Marshall Space Flight Center, Huntsville, Ala.; Johnson Space Center; Goddard Space Flight Center, Greenbelt, MD and NASA Headquarters, Washington, DC. 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.

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-35 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-35 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	162	0.14	613
End Roll Maneuver	00/00:00:16	340	0.30	2,505
SSME Throttle Down to 70%	00/00:00:26	608	0.54	6,759
Max. Dyn. Pressure (Max Q)	00/00:00:54	1,229	1.17	28,976
SSME Throttle Up to 104%	00/00:01:03	1,473	1.46	39,394
SRB Staging	00/00:02:05	4,203	3.87	150,267
Negative Return	00/00:03:58	6,940	7.58	309,526
Main Engine Cutoff (MECO)	00/00:08:31	24,439	22.99	360,922
Zero Thrust	00/00:08:37	24,556	22.73	363,937
ET Separation	00/00:08:49			
OMS 2 Burn	00/00:40:22			
Landing	09/21:57			

Apogee, Perigee at MECO: 185 x 33
Apogee, Perigee post-OMS 2: 190 x 190

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, CA; White Sands Space Harbor (Northrup Strip), NM; or the Shuttle Landing Facility (SLF) at Kennedy Space Center, FL.

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

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

STS-35 contingency landing sites are Edwards AFB, White Sands, Kennedy Space Center, Banjul and Ben Guerir, Moron.

PAYLOAD AND VEHICLE WEIGHTS

	Pounds
Orbiter Columbia empty	158,905
Ultraviolet Astronomy Telescope (Astro) (IPS, igloo and 2 pallets)	17,276
Astro Support Equipment (middeck equipment)	404
Broad Band X-Ray Telescope ((BBXRT) (including TAPS and support equipment)	8,650
Detailed Test Objectives (DTO)	274
Shuttle Amateur Radio Experiment (SAREX)	61
Total vehicle at SRB ignition	4,523,199
Orbiter and cargo at main engine cutoff	267,513
Orbiter landing weight	225,886

STS-35 PRELAUNCH PROCESSING

Columbia's first launch attempt on May 29 was scrubbed because of higher than allowable concentrations of hydrogen near the 17-inch disconnect and in the aft compartment. Since that time, there have been several launch attempts and two tanking tests.

After the first tanking test on June 6, officials decided to replace the 17-inch disconnect assemblies on both the orbiter and its external tank. Columbia was rolled back to the Vehicle Assembly Building June 11, demated from the external tank and transferred to the Orbiter Processing Facility. A new disconnect from the shuttle Endeavour was installed on Columbia and the orbiter and tank were remated.

Columbia was rolled out to Pad 39-A on Aug. 9 for launch.

The countdown began and launch was postponed on Aug. 30 to allow the replacement of an electronic box for the Broad Band X-Ray Telescope. Launch was scrubbed on Sept. 5 because of higher than allowable concentrations of hydrogen in the aft compartment.

Another attempted launch occurred on Sept. 17, but again hydrogen was detected in the aft compartment.

A board was appointed to find the cause of the leak. At the board's direction, several main propulsion system seals were replaced, many leak tests using gaseous helium were performed and various joints were retorqued. In addition, the team completed a thorough analysis of data collected from the tanking tests and reviewed all work performed on the orbiter's propulsion system since Columbia's last flight.

The STS-35 vehicle was moved from Pad 39-A to 39-B on Oct. 8, following the successful launch of Discovery on Mission STS-41. The next day, Columbia was transferred back to the Vehicle Assembly Building because adverse weather prevented productive work in the aft compartment. On Oct. 14, the vehicle was rolled out to Pad 39-B, and specially outfitted for the successful tanking test conducted Oct. 30.

The successful tanking test paved the way for routine launch preparations leading up to Columbia's planned liftoff.

THE ASTRO-1 MISSION

Since the earliest days of astronomy, humankind has used the light from the stars to test their understanding of the universe. Now, an array of telescopes to be flown on the first Spacelab mission since 1985, will extend scientists' vision beyond the visible light to view some of the most energetic events in the universe.

Astro-1 is the first Spacelab mission devoted to a single scientific discipline -- astrophysics. The observatory will operate from within the cargo bay of Space Shuttle Columbia on the STS-35 mission. Together, four telescopes will dissect ultraviolet light and X-rays from stars and galaxies, revealing the secrets of processes that emitted the radiation from thousands to even billions of years ago. Wherever it points, Astro promises to reveal an array of information.

The Astro-1 Spacelab project is managed by NASA's Marshall Space Flight Center, Huntsville, Ala.

Seeing the Universe

Astronomy from the ground always has been hampered by the Earth's atmosphere. Even visible light is distorted and blurred by the motion of air masses, and visible light is just a small part of the radiation that virtually all objects in the sky emit. Other forms of radiation -- like cooler, low-energy infrared light and hotter, high-energy ultraviolet light and X-rays -- are largely absorbed by the atmosphere and never reach the ground.

Seeing celestial objects in visible light alone is like looking at a painting in only one color. To appreciate fully the meaning of the painting, viewers must see it in all of its colors.

The Astro-1 telescopes were constructed to add some of these "colors" to scientists' view of stars and galaxies. The telescopes' perch above the veil of Earth's atmosphere in Columbia's cargo bay will allow scientists to view radiation that is invisible on the ground.

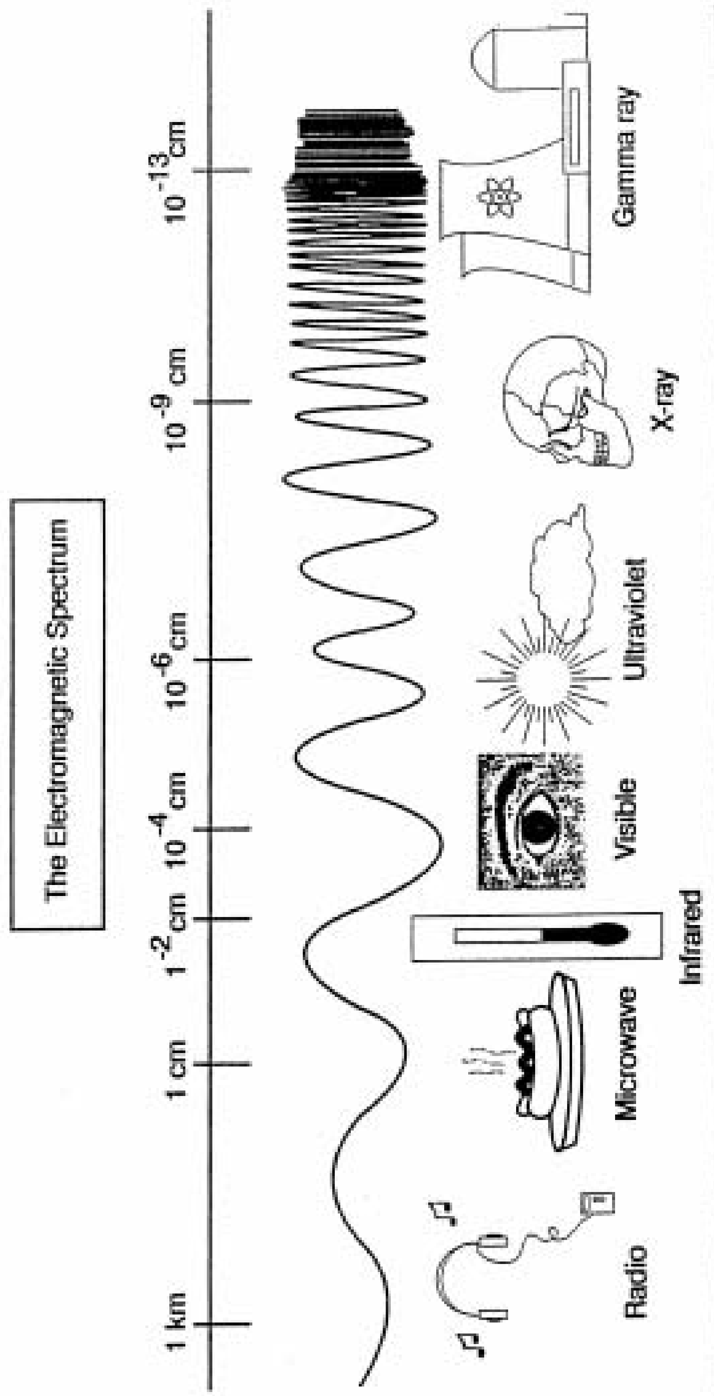
Three of Astro-1's telescopes will operate in the ultraviolet portion of the spectrum and one in the X-ray portion. One will take photographs; two will analyze the chemical composition, density and temperature of objects with a spectrograph; and the other will study the relative brightness and polarization (the study of light wavelength orientation) of celestial objects. Some sources will be among the faintest known, as faint as the glow of sunlight reflected back from interplanetary dust.

By studying ultraviolet and X-rays, astronomers can see emissions from extremely hot gases, intense magnetic fields and other high-energy phenomena that are much fainter in visible and infrared light or in radio waves -- and which are crucial to a deeper understanding of the universe.

Several space telescopes -- notably the Orbiting Astronomical Observatory-3 (Copernicus) launched in 1972, the International Ultraviolet Explorer launched in 1978 and the second High Energy Astronomy Observatory launched in 1979 -- opened the window in these exciting parts of the spectrum. The combined observations by Astro, the Hubble Space Telescope and ground-based observatories will provide astronomers with a more comprehensive view of the cosmos than ever before.

What Astro-1 Will "See"

The universe viewed by Astro will look strikingly different from the familiar night sky. Most stars will fade from view, too cool to emit significant ultraviolet radiation or X-rays. Yet, very young massive stars, very old stars, glowing nebulae, active galaxies and quasars will gleam brightly.


The Electromagnetic Spectrum
1 km
1 cm
1 -2cm
10 -4cm
10 -6cm
10 -9 cm
10 -13cm
Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma ray

Astro will make observations in this solar system. Astro will examine the chemistry of planetary atmospheres and the interactions of their magnetic fields. The Astro observatory will study comets as they interact with light and particles from the sun to produce bright, streaming tails.

Stars

Astro will peer far beyond this solar system to study many types of stars. The sun is only one of an estimated several hundred billion stars in the galaxy. Stars like the sun are the most common type: fiery spheres of gas, about 1 million times larger in volume than Earth, with nuclear furnaces that reach temperatures of millions of degrees.

Today, current evidence indicates that the sun is a stable, middle- aged star, but some 5 billion years hence it will swell and swallow the inner planets including Earth. As a red giant, it may eject a shell of dust and gas, a planetary nebula. As the sun fades, it will collapse to an object no bigger than Earth, a dense, hot ember, a white dwarf. Astronomers predict that most stars may end their lives as white dwarfs, so it is important to study these stellar remains. White dwarfs emit most of their radiation in the ultraviolet, and one of Astro-1's main goals is to locate and examine white dwarfs in detail.

Supernova

Astro-1 instruments will locate hot, massive stars of all ages so that astronomers can study all phases of stellar evolution. Stars with 10 to 100 times more mass than the sun burn hydrogen rapidly until their cores collapse and they explode as supernovas, among the most powerful events in the universe. These stars are initially are very hot and emit mostly ultraviolet radiation.

Astro will view the recent explosion, Supernova 1987A, which spewed stellar debris into space. Supernovas forge new elements, most of which are swept away in expanding shells of gas and debris heated by the shock waves from the blast. Astro-1 will look for supernova remnants which remain visible for thousands of years after a stellar death. Astro-1's ultraviolet and X-ray telescopes will provide information on element abundances, the physical conditions in the expanding gas and the structure of the interstellar medium.

Neutron Stars, Pulsars, Black Holes

After a supernova explosion, the stellar core sometimes collapses into a neutron star, the densest and tiniest of known stars, with mass comparable to the sun compacted into an area the size of a large city. Matter can become so dense that a sugar cube of neutron star material would weigh 100 million tons.

Sometimes neutron stars are pulsars that emit beacons of radiation and appear to blink on and off as many as hundreds of times per second because they spin so rapidly. Scientists have theorized that some stars may collapse so far that they become black holes, objects so dense and gravitationally strong that neither matter nor light escape. Astro will look for the ultraviolet radiation and X-rays thought to be produced when hot, whirling matter is drawn into a black hole.

Star Systems

Few stars live in isolation; most are found in pairs or groups. Some stellar companions orbit each other and often pass so close that mass is transferred from one star to the other, producing large amounts of ultraviolet and X-ray radiation which Astro-1's four telescopes are designed to study. These binary star systems may consist of various combinations of objects including white dwarfs, neutron stars, and black holes.

Star Clusters

Stars may congregate in star clusters with anywhere from a few to millions of members. Often, there are so many stars in the core of a cluster, it is impossible to distinguish the visible light from individual stars. Because they shine brightly in the ultraviolet, Astro-1 can isolate the hot stars within clusters.

The clusters are excellent laboratories for studying stellar evolution because the stars residing there formed from the same material at nearly the same time. However, within a single cluster, stars of different masses evolve at different rates.

Stellar evolution can be studied by looking at clusters of different ages. Each cluster of a given age provides a snapshot of what is happening as a function of stellar mass. By examining young clusters (less than 1 million years old) and comparing them to old clusters (1 billion years old), scientists can piece together what happens over a long time.

Interstellar Medium

The space between stars is filled with dust and gas, some of which will condense to become future stars and planets. This interstellar medium is composed chiefly of hydrogen with traces of heavier elements and has a typical density of one atom per thimbleful of space. Astro-1 will be able to measure the properties of this material more accurately by studying how it affects the light from distant stars. For the most part, the interstellar medium is relatively cool, but it includes pockets of hot matter as well. Dense clouds of dust that surround stars and scatter and reflect light are called reflection nebulae. These are often illuminated by hot, young stars in stellar nurseries hidden within the clouds. Ultraviolet observations will reveal the features of stars hidden by the dust as well as the size and composition of the dust grains.

Other Galaxies

Beyond the Milky Way are at least a hundred billion more galaxies, many with hundreds of billions of stars. They contain most of the visible matter in the universe and are often found in clusters of galaxies that have tens to thousands of members. X-ray and ultraviolet emission will allow scientists to study the hottest, most active regions of these galaxies as well as the intergalactic medium, the hot gas between the galaxies in a cluster.

Galaxies have a variety of shapes and sizes: gigantic spirals like the Milky Way, egg-shaped elliptical and irregular shapes with no preferred form. Astro will survey the different types of galaxies and study their evolution. The nearby galaxies will appear as they were millions of years ago, and Astro will see the most distant ones as they were billions of years ago. By comparing these galaxies, scientists can trace the history of the universe.

Quasars

Some galaxies are in the process of violent change. Such active galaxies have central regions (nuclei) that emit huge amounts of energy; their ultraviolet and X-ray emission may help us identify their source of power. Astro-1's ultraviolet and X-ray telescopes will detect quasars, very distant compact objects that radiate more energy than 100 normal galaxies.

Quasars may be the nuclei of ancient active galaxies. Strong X-ray and ultraviolet radiation arising in the central cores of these powerful objects may help scientists discover what these objects really are.

This overview is the known universe today, but many of these ideas are only predictions based on theory and a few observations. Scientists still lack the definitive observations needed to confirm or refute many of these theories. Scientists do not know the exact size of the universe or its age. Scientists have never definitely seen a black hole, and they continue to question the nature of quasars.

To understand these mysteries, scientists need to see the universe in all its splendor. Astro is part of NASA's strategy to study the universe across the electromagnetic spectrum, in all wavelengths.

THE ASTRO-1 OBSERVATORY

The Astro-1 observatory is a compliment of four telescopes. Though each instrument is uniquely designed to address specific questions in ultraviolet and X-ray astronomy, when used in concert, the capability of each is enhanced. The synergistic use of Astro-1's instruments for joint observations serves to make Astro-1 an exceptionally powerful facility. The Astro-1 observatory has three ultraviolet-sensitive instruments:

- **Hopkins Ultraviolet Telescope (HUT)** uses a spectrograph to examine faint astronomical objects such as quasars, active galactic nuclei and normal galaxies in the far ultraviolet.

- **Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE)** will study the ultraviolet polarization of hot stars, galactic nuclei and quasars.

- **Ultraviolet Imaging Telescope (UIT)** will take wide-field-of-view photographs of objects such as hot stars and galaxies in broad ultraviolet wavelength bands.

These instruments working together will make 200 to 300 observations during the STS-35 mission. The Astro ultraviolet telescopes are mounted on a common pointing system in the cargo bay of the Space Shuttle. The grouped telescopes will be pointed in the same direction at the same time, so simultaneous photographs, spectra and polarization studies will be available for each object observed. The telescopes will be operated by Columbia's crew.

A fourth Astro instrument, the Broad Band X-Ray Telescope (BBXRT), will view high-energy objects such as active galaxies, quasars and supernovas. This telescope is mounted on a separate pointing system secured by a support structure in the cargo bay.

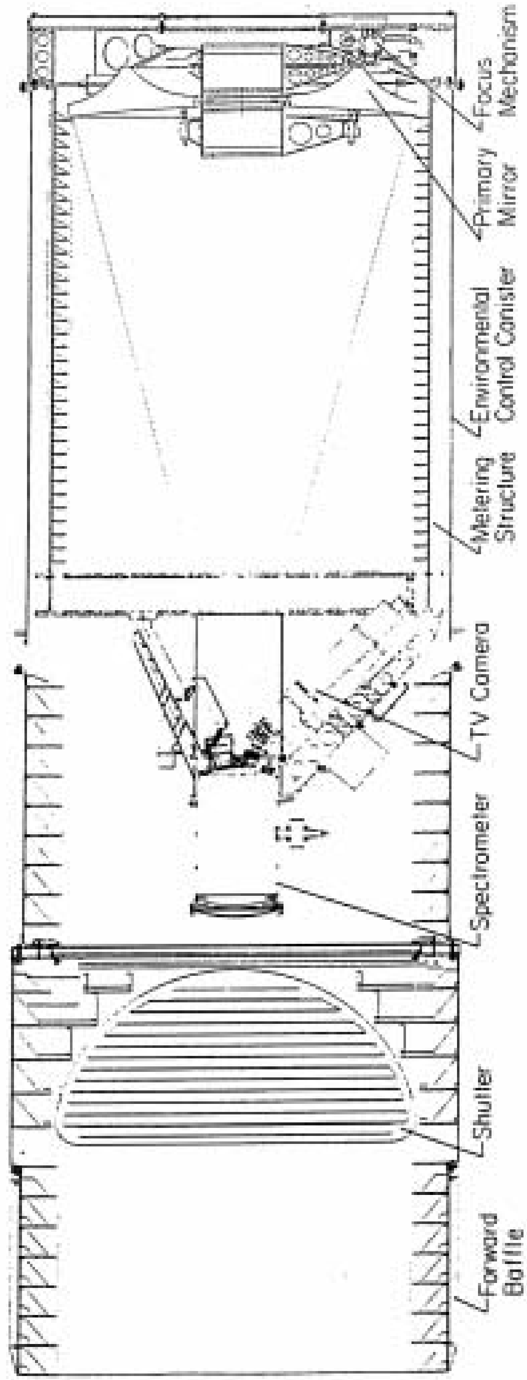
For joint observations, BBXRT can be aligned with the ultraviolet telescopes to see the same objects, but it also can be pointed independently to view other X-ray sources. BBXRT will be operated remotely by ground controllers. Since the ultraviolet telescopes and the X-ray telescope are mounted on different support structures, they can be reflown together or separately.

The Hopkins Ultraviolet Telescope

The Hopkins Ultraviolet Telescope is the first major telescope capable of studying far ultraviolet (FUV) and extreme ultraviolet (EUV) radiation from a wide variety of objects in space. HUT's observations will provide new information on the evolution of galaxies and quasars, the physical properties of extremely hot stars and the characteristics of accretion disks (hot, swirling matter transferred from one star to another) around white dwarfs, neutron stars and black holes.

HUT will make the first observations of a wide variety of astronomical objects in the far ultraviolet region below 1,200 Angstroms (A) and will pioneer the detailed study of stars in the extreme ultraviolet band. Ultraviolet radiation at wavelengths shorter than 912 A is absorbed by hydrogen, the most abundant element in the universe. HUT will allow astronomers, in some instances along unobserved lines of sight, to see beyond this cutoff, called the Lyman limit, because the radiation from the most distant and rapidly receding objects, such as very bright quasars, is shifted toward longer wavelengths.

HUT COMPONENTS



HUT was designed and built by the Center for Astrophysical Sciences and the Applied Physics Laboratory of The Johns Hopkins University in Baltimore, MD. Its 36-inch mirror is coated with the rare element iridium, a member of the platinum family, capable of reflecting far and extreme ultraviolet light. The mirror, located at the aft end of the telescope, focuses incoming light from a celestial source back to a spectrograph mounted behind the telescope.

A grating within the spectrograph separates the light, like a rainbow, into its component wavelengths. The strengths of those wavelengths tell scientists how much of certain elements are present. The ratio of the spectral lines reveal a source's temperature and density. The shape of the spectrum shows the physical processes occurring in a source.

The spectrograph is equipped with a variety of light-admitting slits or apertures. The science team will use different apertures to accomplish different goals in their observation. The longest slit has a field of view of 2 arc minutes, about 1/15th the apparent diameter of the moon. HUT is fitted with an electronic detector system. Its data recordings are processed by an onboard computer system and relayed to the ground for later analysis.

Johns Hopkins scientists conceived HUT to take ultraviolet astronomy beyond the brief studies previously conducted with rocket- borne telescopes. A typical rocket flight might gather 300 seconds of data on a single object. HUT will collect more than 300,000 seconds of data on nearly 200 objects during the Astro-1 mission, ranging from objects in the solar system to quasars billions of light-years distant.

HUT Vital Statistics

Sponsoring Institution:	The Johns Hopkins University, Baltimore, MD
Principal Investigator:	Dr. Arthur F. Davidsen
Telescope Optics:	36 in. aperture, f/2 focal ratio, iridium-coated paraboloid mirror
Instrument:	Prime Focus Rowland Circle Spectrograph with microchannel plate intensifier and electronic diode array detector
Field of View of Guide TV:	10 arc minutes
Spectral Resolution:	3.0 A
Wavelength Range:	850 A to 1,850 A (First Order); 425 A to 925 A (Second Order)
Weight:	1,736 lb.
Size:	44 inches in diameter ; 12.4 ft. in length

Wisconsin Ultraviolet Photo-Polarimeter Experiment

Any star, except for our sun, is so distant that it appears as only a point of light and surface details cannot be seen. If the light from objects is polarized, it can tell scientists something about the source's geometry, the physical conditions at the source and the reflecting properties of tiny particles in the interstellar medium along the radiation's path.

The Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE), developed by the Space Astronomy Lab at the University of Wisconsin- Madison, is designed to measure polarization and intensity of ultraviolet radiation from celestial objects. WUPPE is a 20-inch telescope with a 5.5-arc-minute field of view.

WUPPE is fitted with a spectropolarimeter, an instrument that records both the spectrum and the polarization of the ultraviolet light gathered by the telescope. Light will pass through sophisticated filters, akin to Polaroid sunglasses, before reaching the detector. Measurements then will be transmitted electronically to the ground.

Photometry is the measurement of the intensity (brightness) of the light, while polarization is the measurement of the orientation (direction) of the oscillating light wave. Usually waves of light move randomly -- up, down, back, forward and diagonally. When light is polarized, all the waves oscillate in a single plane. Light that is scattered, like sunlight reflecting off water, is often polarized. Astro-1 astronomers expect to learn about ultraviolet light that is scattered by dust strewn among stars and galaxies. They also can learn about the geometry of stars and other objects by studying their polarization. To date, virtually no observations of polarization of astronomical sources in the ultraviolet have been carried out. WUPPE measures the polarization by splitting a beam of radiation into two perpendicular planes of polarization, passing the beams through a spectrometer and focusing the beams on two separate array detectors.

In the ultraviolet spectrum, both photometry and polarization are extremely difficult measurements to achieve with the high degree of precision required for astronomical studies. To develop an instrument that could make these delicate measurements required an unusually innovative and advanced technical effort. Thus, the WUPPE investigation is a pioneering foray with a new technique.

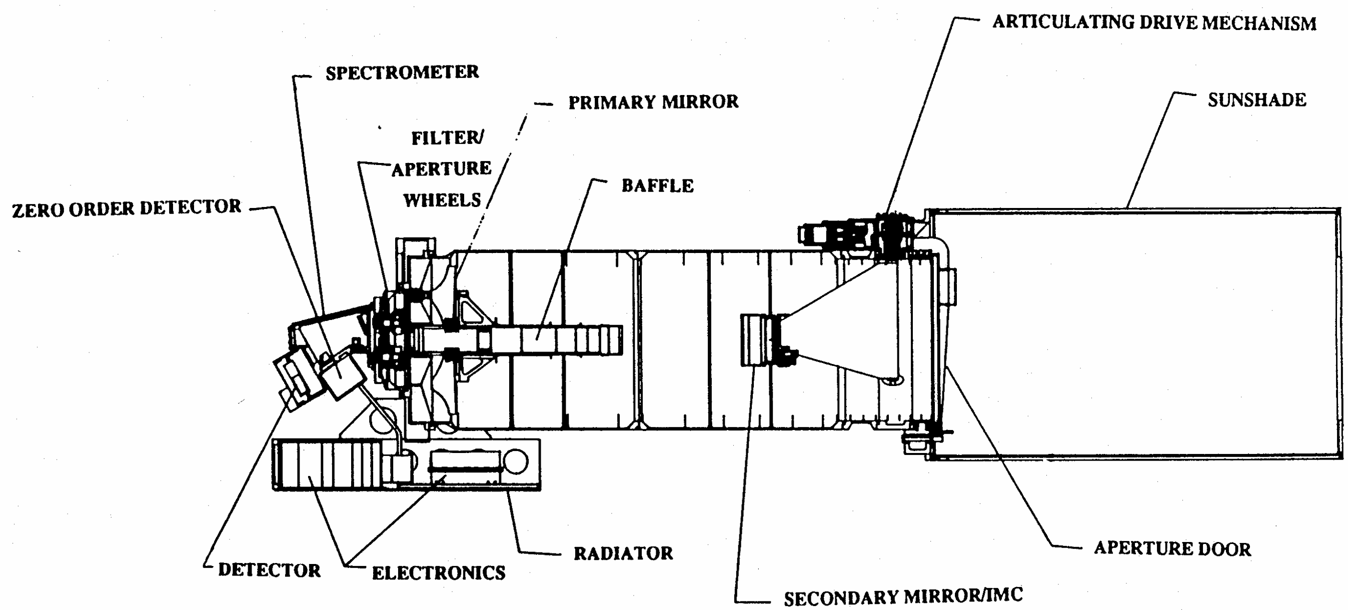
The targets of WUPPE investigations are primarily in the Milky Way galaxy and beyond, for which comparative data exist in other wavelengths. Like the Hopkins Ultraviolet Telescope, WUPPE also makes spectroscopic observations of hot stars, galactic nuclei and quasars. Operating at ultraviolet wavelengths that are mostly longer than those observed by HUT (but with some useful overlap), WUPPE provides chemical composition and physical information on celestial targets that give off a significant amount of radiation in the 1,400 to 3,200 A range.

WUPPE Vital Statistics

Sponsoring Institution:	University of Wisconsin, Madison
Principal Investigator:	Dr. Arthur D. Code
Telescope Optics:	Cassegrain (two-mirror) system, f/10 focal ratio
Instrument:	Spectropolarimeter with dual electronic diode array detectors
Primary Mirror Size:	20 in. diameter; 279 sq.* in. area
Field of View:	3.3 x 4.4 arc minutes
Spectral Resolution:	6 Angstroms
Wavelength Range:	1,400 to 3,200 Angstroms
Magnitude Limit:	16
Weight:	981 lb.
Size:	28 inches in diameter, 12.4 ft. in length

* This and subsequent changes were made to avoid confusion since the computer that printed this press kit will not create exponents for cm2 or the circle over the A for Angstrom.

WUPPE COMPONENTS



The Ultraviolet Imaging Telescope

In the 20 years that astronomical observations have been made from space, no high-resolution ultraviolet photographs of objects other than the sun have been made. Nonetheless, the brief glimpses of the ultraviolet sky have led to important discoveries in spiral galaxies, globular clusters, white dwarf stars and other areas.

Deep, wide-field imaging is a primary means by which fundamentally new phenomena or important examples of known classes of astrophysical objects will be recognized in the ultraviolet. The Ultraviolet Imaging Telescope (UIT), developed at NASA's Goddard Space Flight Center in Greenbelt, MD, is the key instrument for these investigations.

UIT is a powerful combination of telescope, image intensifier and camera. It is a 15.2-inch Ritchey Chretien telescope with two selectable cameras mounted behind the primary mirror. Each camera has a six- position filter wheel, a two-stage magnetically focused image tube and a 70-mm film transport, fiber optically coupled to each image tube. One camera is designed to operate in the 1200 - 1700 Angstrom region and the other in the 1250-3200 Angstrom region.

Unlike data from the other Astro instruments, which will be electronically transmitted to the ground, UIT images will be recorded directly onto a very sensitive astronomical film for later development after Columbia lands. UIT has enough film to make 2,000 exposures. A series of 11 different filters allows specific regions of the ultraviolet spectrum to be isolated for energy-distribution studies. After development, each image frame will be electronically digitized to form 2,048 x 2,048 picture elements, or pixels, then analyzed further with computers.

UIT has a 15-inch diameter mirror with a 40-arc-minute field of view -- about 25 percent wider than the apparent diameter of the full moon. UIT has the largest field of view of any sensitive UV imaging instrument planned for flight in the 1990s. It will photograph nearby galaxies, large clusters of stars and distant clusters of galaxies.

A 30-minute exposure (the length of one orbital night) will record a blue star of 25th magnitude, a star about 100 million times fainter than the faintest star visible to the naked eye on a dark, clear night. Since UIT makes longer exposures than previous instruments, fainter objects will be visible in the images.

The instrument favors the detection of hot objects which emit most of their energy in the ultraviolet. Common examples span the evolutionary history of stars -- massive stars and stars in the final stages of stellar evolution (white dwarfs). Images of numerous relatively cool stars that do not radiate much in the ultraviolet are suppressed, and UV sources stand out clearly.

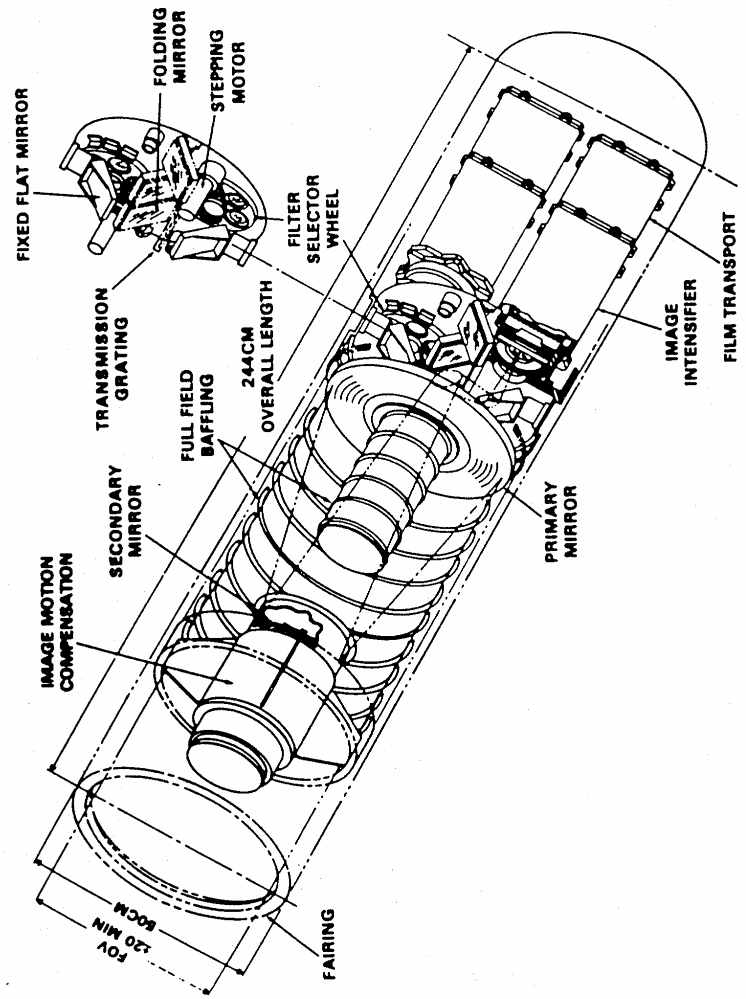
The UIT's field of view is wide enough to encompass entire galaxies, star clusters and distant clusters of galaxies. This deep survey mode will reveal many new, exciting objects to be studied further by NASA's Hubble Space Telescope. Although the Hubble Space Telescope will have a much higher magnification and record much fainter stars, the UIT will photograph much larger regions all at once. In addition, the UIT will suffer much less interference from visible light, since it is provided with "solar blind" detectors. For certain classes of targets, such as diffuse, ultraviolet-emitting or ultraviolet-scattering nebulae, UIT may be a more sensitive imager.

A wide selection of astronomical objects will be studied in this first deep survey of cosmic phenomena in the ultraviolet. The UIT is expected to target hot stars in globular clusters to help explain how stars evolve. Another experiment may help astronomers learn whether properties and distribution of interstellar dust are the same in all galaxies. High-priority objects are Supernova 1987A and vicinity, star clusters, planetary nebulae and supernova remnants, spiral and "normal" galaxies, the interstellar medium of other galaxies and clusters of galaxies.

UIT Vital Statistics

Sponsoring Institution:	NASA Goddard Space Flight Center (GSFC), Greenbelt, MD
Principal Investigator:	Theodore P. Stecher (NASA GSFC)
Telescope Optics:	Ritchey-Chretien (variation of Cassegrain two-mirror system with correction over wide field of view)
Aperture:	15 in.
Focal Ratio:	f/9
Field of View:	40 arc minutes
Angular Resolution:	2 arc seconds
Wavelength Range:	1,200 A to 3,200 A
Magnitude Limit:	25
Filters:	2 filter wheels, 6 filters each
Detectors:	Two image intensifiers with 70-mm film, 1,000 frames each; IIaO astronomical film
Exposure Time:	Up to 30 minutes
Weight:	1,043 lb.
Size:	32 inches in diameter; 12.4 ft. in length

UIT COMPONENTS



THE BROAD BAND X-RAY TELESCOPE

The Broad Band X-Ray Telescope (BBXRT) will provide astronomers with the first high-quality spectra of many of the X-ray sources discovered with the High Energy Astronomy Observatory 2, better known as the Einstein Observatory, launched in the late 1970s. BBXRT, developed at NASA's Goddard Space Flight Center in Greenbelt, MD, uses mirrors and advanced solid-state detectors as spectrometers to measure the energy of individual X-ray photons. These energies produce a spectrum that reveals the chemistry, structure and dynamics of a source.

BBXRT is actually two 8-inch telescopes each with a 17 arc-minute field of view (more than half the angular width of the moon). The two identical telescopes are used to focus X-rays onto solid-state spectrometers which measure photon energy in electron volts in the "soft" X-ray region, from 380 to 12,000 eV. The use of two telescopes doubles the number of photons that are detected and also provides redundancy in case of a failure.

X-ray telescopes are difficult to construct because X-ray photons are so energetic that they penetrate mirrors and are absorbed. A mirror surface reflects X-rays only if it is very smooth and the photons strike it at a very shallow angle. Because such small grazing angles are needed, the reflectors must be very long to intercept many of the incident X-rays. Since even shallower angles are required to detect higher-energy X-rays, telescopes effective at high energies need very large reflecting surfaces.

Traditionally, X-ray telescopes have used massive, finely polished reflectors that were expensive to construct and did not efficiently use the available aperture. The mirror technology developed for BBXRT consists of very thin pieces of gold-coated aluminum foil that require no polishing and can be nested very closely together to reflect a large fraction of the X-rays entering the telescope.

Because its reflecting surfaces can be made so easily, BBXRT can afford to have mirrors using the very shallow grazing angles necessary to reflect high-energy photons. In fact, BBXRT is one of the first telescopes to observe astronomical targets that emit X-rays above approximately 4,000 electron volts.

The telescope will provide information on the chemistry, temperature and structure of some of the most unusual and interesting objects in the universe. BBXRT can see fainter and more energetic objects than any yet studied. It will look for signs of heavy elements such as iron, oxygen, silicon and calcium. These elements usually are formed in exploding stars and during mysterious events occurring at the core of galaxies and other exotic objects.

BBXRT will be used to study a variety of sources, but a major goal is to increase our understanding of active galactic nuclei and quasars. Many astronomers believe that the two are very similar objects that contain an extremely luminous source at the nucleus of an otherwise relatively normal galaxy. The central source in quasars is so luminous that the host galaxy is difficult to detect. X-rays are expected to be emitted near the central engine of these objects, and astronomers will examine X-ray spectra and their variations to understand the phenomena at the heart of quasars.

Investigators are interested in clusters of galaxies, congregations of tens or thousands of galaxies grouped together within a few million light- years of each other. When viewed in visible light, emissions from individual galaxies are dominant, but X-rays are emitted primarily from hot gas between the galaxies.

In fact, theories and observations indicate that there should be about as much matter in the hot gas as in the galaxies, but all this material has not been seen yet. BBXRT observations will enable scientists to calculate the total mass of a cluster and deduce the amount of "dark" matter.

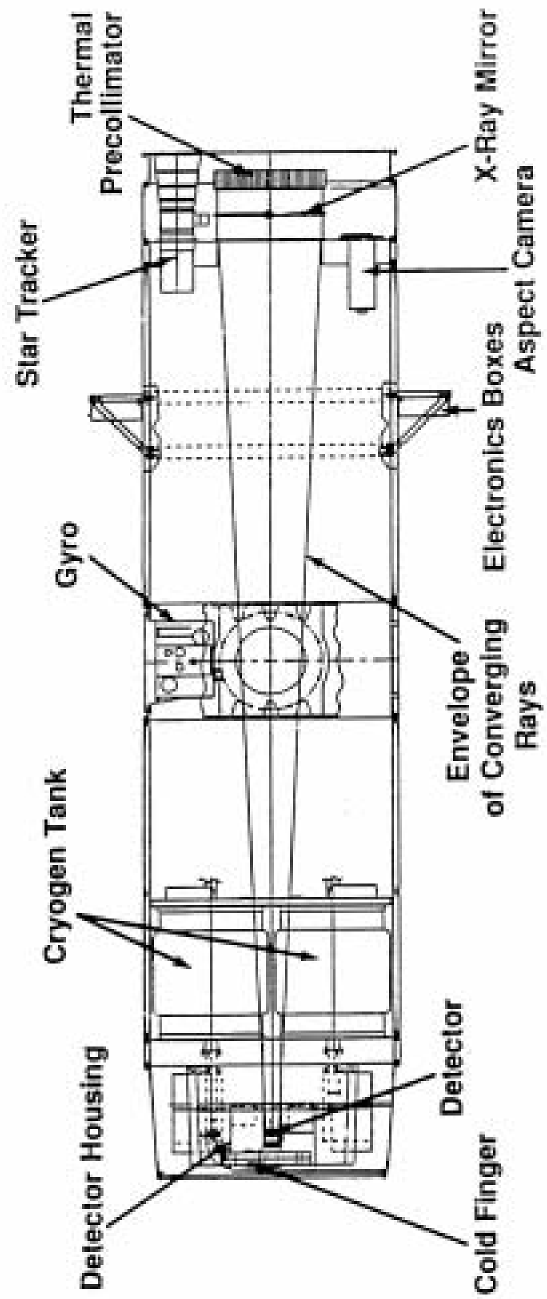
A star's death, a supernova, heats the region of the galaxy near the explosion so that it glows in X-rays. Scientists believe that heavy elements such as iron are manufactured and dispersed into the interstellar medium by supernovas. The blast or shock wave may produce energetic cosmic ray particles that travel on endless journeys throughout the universe and instigate the formation of new stars. BBXRT detects young supernova remnants (less than 10,000 years old) which are still relatively hot. Elements will be identified, and the shock wave's movement and structure will be examined.

BBXRT was not part of the originally selected ASTRO payload. It was added to the mission after the appearance of Supernova 1987A in February 1987, to obtain vital scientific information about the supernova. In addition, data gathered by BBXRT on other objects will enhance studies that would otherwise be limited to data gathered with the three ultraviolet telescopes.

BBXRT Vital Statistics

Sponsoring Institution:	NASA Goddard Space Flight Center, Greenbelt, MD
Principal Investigator:	Dr. Peter J. Serlemitsos
Telescope Optics:	Two co-aligned X-ray telescopes with cooled segmented lithium-drifted silicon solid-state detectors in the focal planes
Focal Length:	12.5 ft. each, detection area 0.16 in. diameter pixel
Focal Plane Scale:	0.9 arc minutes per mm
Field of View:	4.5 arc minutes (central element); 17 arc minutes (overall)
Energy Band:	0.3 to 12 keV
Effective Area:	765 cm2 at 1.5 keV, 300 cm2 at 7 keV
Energy Resolution:	0.09 keV at 1 keV, 0.15 keV at 6 keV
Weight:	1,500 lb. (680.4 kg)
Size:	40 inches in diameter; 166 inches in length

BBXRT COMPONENTS



ASTRO CARRIER SYSTEMS

The Astro observatory is made up of three co-aligned ultraviolet telescopes carried by Spacelab and one X-ray telescope mounted on the Two-Axis Pointing System (TAPS) and a special structure.

Each telescope was independently designed, but all work together as elements of a single observatory. The carriers provide stable platforms and pointing systems that allow the ultraviolet and X-ray telescopes to observe the same target. However, having two separate pointing systems gives investigators the flexibility to point the ultraviolet telescopes at one target while the X-ray telescope is aimed at another.

Spacelab

The three ultraviolet telescopes are supported by Spacelab hardware. Spacelab is a set of modular components developed by the European Space Agency and managed by the NASA Marshall Space Flight Center, Huntsville, Ala. For each Spacelab payload, specific standardized parts are combined to create a unique design. Elements are anchored within the cargo bay, transforming it into a short-term laboratory in space.

Spacelab elements used to support the Astro observatory include two pallets, a pressurized igloo to house subsystem equipment and the Instrument Pointing System. The pressurized Spacelab laboratory module will not be used for Astro. Rather, astronauts and payload specialists will operate the payload from the aft flight deck of the orbiter Columbia.

Pallets

The ultraviolet telescopes and the Instrument Pointing System are mounted on two Spacelab pallets -- large, uncovered, unpressurized platforms designed to support scientific instruments that require direct exposure to space.

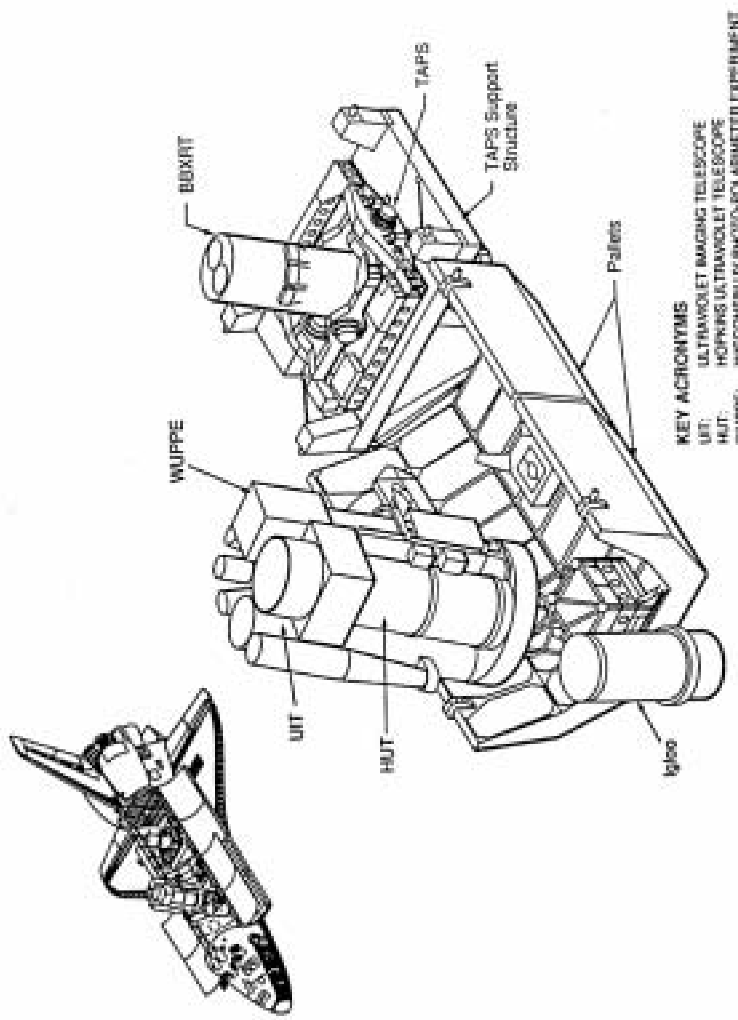
Each individual pallet is 10 feet long and 13 feet wide. The basic pallet structure is made up of five parallel U-shaped frames. Twenty-four inner and 24 outer panels, made of aluminum alloy honeycomb, cover the frame. The inner panels are equipped with threaded inserts so that payload and subsystem equipment can be attached. Twenty-four standard hard points, made of chromium-plated titanium casting, are provided for payloads which exceed acceptable loading of the inner pallets.

Pallets are more than a platform for mounting instrumentation. With an igloo attached, they also can cool equipment, provide electrical power and furnish connections for commanding and acquiring data from experiments. Cable ducts and cable support trays can be bolted to the forward and aft frame of each pallet to support and route electrical cables to and from the experiments and the subsystem equipment mounted on the pallet. The ducts are made of aluminum alloy sheet metal. In addition to basic utilities, some special accommodations are available for pallet-mounted experiments.

For Astro-1, two pallets are connected together to form a single rigid structure called a pallet train. Twelve joints are used to connect the two pallets.

Igloo

Normally Spacelab subsystem equipment is housed in the core segment of the pressurized laboratory module. However, in "pallet only" configurations such as Astro, the subsystems are located in a supply module called the igloo. It provides a pressurized compartment in which Spacelab subsystem equipment can be mounted in a dry-air environment at normal Earth atmospheric pressure, as required by their design. The subsystems provide such services as cooling, electrical power and connections for commanding and acquiring data from the instruments.


WUPPE
BBXRT
UIT
HUT
TAPS
TAPS Support Structure
Pallets
Igloo
KEY ACRONYMS
UIT: ULTRAVIOLET IMAGING TELESCOPE
HUT: HOPKINS ULTRAVIOLET TELESCOPE
WUPPE: WISCONSIN UV PHOTO-POLARIMETER EXPERIMENT
BBXRT: BROAD BAND X RAY TELESCOPE
TAPS: TWO-AXIS POINTING SYSTEM

The igloo is attached vertically to the forward end frame of the first pallet. Its outer dimensions are approximately 7.9 feet in height and 3.6 feet in diameter. The igloo is a closed cylindrical shell made of aluminum alloy and covered with multi-layer insulation. A removable cover allows full access to the interior.

The igloo consists of two parts. The primary structure -- an exterior canister -- is a cylindrical, locally stiffened shell made of forged aluminum alloy rings and closed at one end. The other end has a mounting flange for the cover. A seal is inserted when the two structures are joined together mechanically to form a pressure-tight assembly.

There are external fittings on the canister for fastening it to the pallet, handling and transportation on the ground, and thermal control insulation. Two feed-through plates accommodate utility lines and a pressure relief valve. Facilities on the inside of the canister are provided for mounting subsystem equipment and the interior igloo structure. The cover is also a cylindrical shell, made of welded aluminum alloy and closed at one end. The igloo has about 77.7 cubic feet of interior space for subsystems.

Subsystem equipment is mounted on an interior or secondary structure which also acts as a guide for the removal or replacement of the cover. The secondary structure is hinge-fastened to the primary structure, allowing access to the bottom of the secondary structure and to equipment mounted within the primary structure.

Instrument Pointing System

Telescopes such as those aboard Astro-1 must be pointed with very high accuracy and stability at the objects which they are to view. The Spacelab Instrument Pointing System provides precision pointing for a wide range of payloads, including large single instruments or clusters of instruments. The pointing mechanism can accommodate instruments weighing up to 15,432 pounds and can point them to within 2 arc seconds and hold them on target to within 1.2 arc seconds. The combined weight of the ultraviolet telescopes and the structure which holds them together is 9,131 pounds.

The Instrument Pointing System consists of a three-axis gimbal system mounted on a gimbal support structure connected to the pallet at one end and the aft end of the payload at the other, a payload clamping system for support of the mounted experiment during launch and landing and a control system based on the inertial reference of a three-axis gyro package and operated by a gimbal-mounted microcomputer.

Three bearing-drive units on the gimbal system allow the payload to be pointed on three axes: elevation (back and forth), cross-elevation (side to side) and azimuth (roll), allowing it to point in a 22-degree circle around a its straight-up position. The pointing system may be maneuvered at a rate of up to one degree per second, which is five times as fast as the Shuttle orbiter's maneuvering rate. The operating modes of the different scientific investigations vary considerably. Some require manual control capability, others slow scan mapping, still others high angular rates and accelerations. Performance in all these modes requires flexibility achieved with computer software.

The Instrument Pointing System is controlled through the Spacelab subsystem computer and a data-display unit and keyboard. It can be operated either automatically or by the Spacelab crew from the module (when used) and also from the payload station in the orbiter aft flight deck.

In addition to the drive units, Instrument Pointing System structural hardware includes a payload/gimbal separation mechanism, replaceable extension column, emergency jettisoning device, support structure and rails and a thermal control system. The gimbal structure itself is minimal, consisting only of a yoke and inner and outer gimbals to which the payload is attached by the payload-mounted integration ring.
An optical sensor package is used for attitude correction and also for configuring the instrument for solar, stellar or Earth viewing. The Astro-1 mission marks the first time the Instrument Pointing System has been used for stellar astronomy. Three star trackers locate guide stars. The boresite tracker is in the middle, and two other trackers are angled 12 degrees from each side of the boresite. By keeping stars of known locations centered in each tracker, a stable position can be maintained.
The three ultraviolet telescopes are mounted and precisely co- aligned on a common structure, called the cruciform, that is attached to the pointing system.

Image Motion Compensation System

An image motion compensation system was developed by the Marshall Space Flight Center to provide additional pointing stability for two of the ultraviolet instruments.

When the Shuttle thrusters fire to control orbiter attitude, there is a noticeable disturbance of the pointing system. The telescopes are also affected by crew motion in the orbiter. A gyro stabilizer senses the motion of the cruciform which could disrupt UIT and WUPPE pointing stability. It sends information to the image motion compensation electronics system where pointing commands are computed and sent to the telescopes' secondary mirrors which make automatic adjustments to improve stability to less than 1 arc second.

The Astro-1's star tracker, designed by the NASA Jet Propulsion Laboratory, Pasadena, Calif., fixes on bright stars with well-known and sends this information to the electronics system which corrects errors caused by gyro drift and sends new commands to the telescopes' mirrors. The mirrors automatically adjust to keep pointed at the target.

Broad Band X-ray Telescope and the Two-Axis Pointing System (TAPS)

Developed at the NASA Goddard Space Flight Center, these pointing systems were designed to be flown together on multiple missions. This payload will be anchored in a support structure placed just behind the ultraviolet telescopes in the Shuttle payload bay. BBXRT is attached directly to the TAPS inner gimbal frame.

The TAPS will move BBXRT in a forward/aft direction (pitch) relative to the cargo bay or from side to side (roll) relative to the cargo bay. A star tracker uses bright stars as a reference to position the TAPS for an observation, and gyros keep the TAPS on a target. As the gyros drift, the star tracker periodically recalculates and resets the TAPS position.

ASTRO OPERATIONS

Operation of the Astro-1 telescopes will be a cooperative effort between the science crew in orbit and their colleagues in a control facility at the Marshall Space Flight Center and a support control center at Goddard Space Flight Center. Though the crew and the instrument science teams will be separated by many miles, they will interact with one another to evaluate observations and solve problems in much the same way as they would when working side by side.

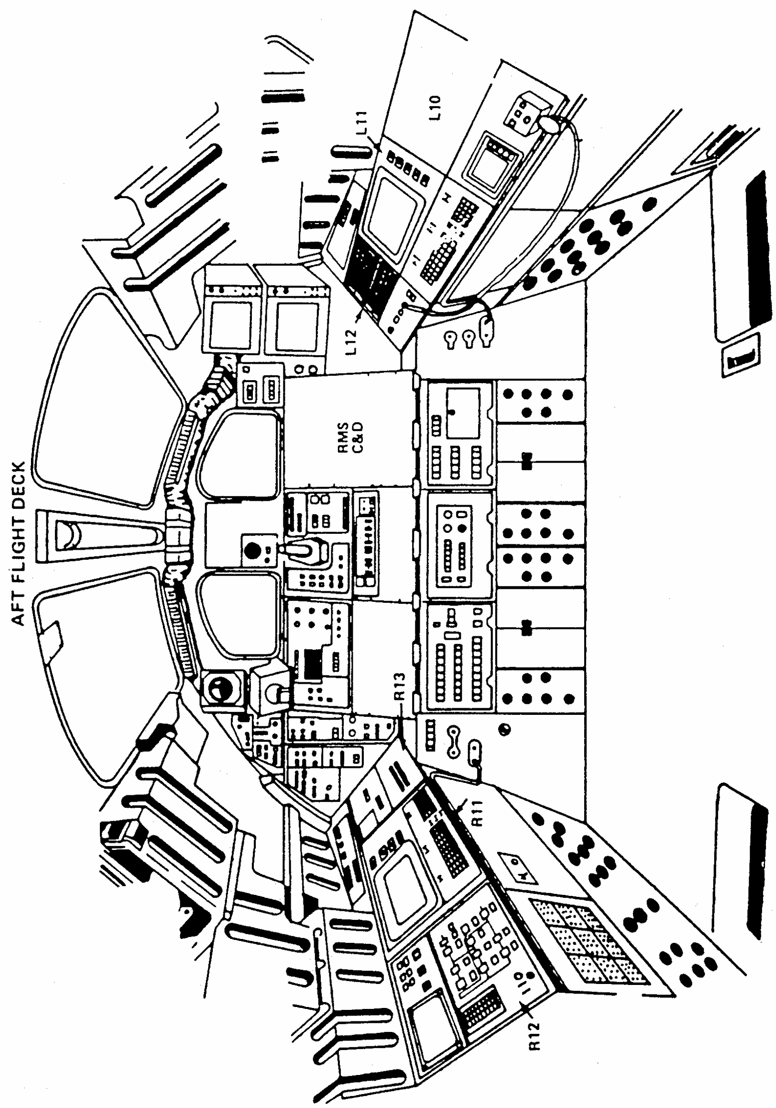
On-Orbit Science Crew Activities

The Astro science crew will operate the ultraviolet telescopes and Instrument Pointing System from the Shuttle orbiter's aft flight deck, located to the rear of the cockpit. Windows overlooking the cargo bay allow the payload specialist and mission specialist to keep an eye on the instruments as they command them into precise position. The aft flight deck is equipped with two Spacelab keyboard and display units, one for controlling the pointing system and the other for operating the scientific instruments. To aid in target identification, this work area also includes two closed-circuit television monitors. With the monitors, crew members will be able to see the star fields being viewed by HUT and WUPPE and monitor the data being transmitted from the instruments.

The Astro-1 crew will work around the clock to allow the maximum number of observations to be made during their mission. The STS-35 commander will have a flexible schedule, while two teams of crew members will work in 12-hour shifts. Each team consists of the pilot or flight mission specialist, a science mission specialist and a payload specialist. The crew and the ground controllers will follow an observation schedule detailed in a carefully planned timeline.

In a typical Astro-1 ultraviolet observation, the flight crew member on duty maneuvers the Shuttle to point the cargo bay in the general direction of the astronomical object to be observed. The mission specialist commands the pointing system to aim the telescopes toward the target. He also locks on to guide stars to help the pointing system remain stable despite orbiter thruster firings. The payload specialist sets up each instrument for the upcoming observation, identifies the celestial target on the guide television and provides any necessary pointing corrections for placing the object precisely in the telescope's field of view. He then starts the instrument observation sequences and monitors the data being recorded. Because the many observations planned create a heavy workload, the payload and mission specialists work together to perform these complicated operations and evaluate the quality of observations. Each observation will take between 10 minutes to a little over an hour.

The X-ray telescope requires little attention from the crew. A crew member will turn on the BBXRT and the TAPS at the beginning of operations and then turn them off when the operations conclude. The telescope is controlled from the ground. After the telescope is activated, researchers at Goddard can "talk" to the telescope via computer. Before science operations begin, stored commands are loaded into the BBXRT computer system. Then, when the astronauts position the Shuttle in the general direction of the source, the TAPS automatically points the BBXRT at the object. Since the Shuttle can be oriented in only one direction at a time, X-ray observations must be coordinated carefully with ultraviolet observations.


AFT FLIGHT DECK
L11
L10
L12
RMS
C&D
R13
R11
R12

ASTRO GROUND CONTROL

Astro-1 science operations will be directed from a new Spacelab Mission Operations Control facility at the Marshall Space Flight Center. BBXRT will be controlled by commands from a supporting payload operations control facility at Goddard.

Spacelab Mission Operations Control

Beginning with the Astro-1 flight, all Spacelab science activities will be controlled from Marshall's Spacelab Mission Operations Control Center. It will replace the payload operations control center at the Johnson Space Center from which previous Spacelab missions have been operated. The Spacelab Mission Operations Control team is under the overall direction of the mission manager.

The Spacelab Mission Operations Control team will support the science crew in much the same way that Houston Mission Control supports the flight crew. Teams of controllers and researchers at the Marshall facility will direct all NASA science operations, send commands directly to the spacecraft, receive and analyze data from experiments aboard the vehicle, adjust mission schedules to take advantage of unexpected science opportunities or unexpected results, and work with crew members to resolve problems with their experiments.

An air/ground communications channel, in addition to the one used by the Mission Control Center in Houston, will be dedicated to communications between the Alabama control facility and the science crew aboard the Space Shuttle. "Huntsville" will be the call sign from space that astronauts will use to address their control team at the Marshall facility.

The Spacelab Mission Operations Control facility is located on two floors of Building 4663 at the Marshall Space Flight Center. Most of the activity occurs in two work areas: the payload control area on the upper floor from which the overall payload is monitored and controlled; and the science operations area on the ground level, where scientists for the individual telescopes monitor their instruments and direct observations.

The payload control area is the hub of payload operations. Communication with the crew, on-orbit and ground computer systems monitoring, science activities, and even television camera operations are marshaled from work stations in the control room. Console operators in the area are referred to as the payload operations control center (POCC) cadre. The cadre is made up of three teams under the leadership of the payload operations director.

The operations control team is responsible for real-time payload control. They make sure that the pre-planned observation schedule is being followed and send commands to the instruments and instructions to the crew. Designated team members stay in voice contact with the on-board science crew via an air-to-ground communications loop.

The data management team ensures that the science data needed from the payload is scheduled and received properly. The responsibilities range from telling the on-board computer when to send down the information it has been storing to scheduling TV transmissions from orbit.

The payload activities planning team is in charge of replanning the payload crew activity schedule when anything from unexpected science opportunities to equipment problems requires a change. After a science operations planning group makes rescheduling decisions for upcoming shifts, the planning team determines the many adjustments that will allow those changes to be accomplished.

The POCC cadre also includes the mission scientist, who leads the science operations planning group and acts as a liaison between the cadre and the science investigator teams; the alternate payload specialist, a backup crew member who helps with air-to-ground communications and assists the mission scientist; and a public affairs commentator.

The science operations area on the ground floor of the Spacelab Mission Operations Control facility is staffed by teams of scientists and engineers who developed the Astro-1 telescopes. The principal investigators and support groups for the Hopkins Ultraviolet Telescope, the Ultraviolet Imaging Telescope and the Wisconsin Photo-Polarimeter Experiment, along with the Broad Band X-ray telescope representatives and a team monitoring the Marshall Space Flight Center's Image Motion Compensation System share a large room in the science operations area.

The teams monitor the data flowing back from each instrument, evaluate the instruments' performance, and assess and analyze the science information revealed by the data. It is possible for the principal investigator to talk directly with the crew member operating his instrument if circumstances demand personal interaction.

Engineers on the science teams provide inputs on instrument performance and if necessary recommend alternate methods to maintain optimal performance. Scientists in each group evaluate the quality of data given the scientific objectives. They also may do preliminary analysis of their data, though a complete study may take months or even years.

Space astronomy is a fluid process because observations sometimes produce unexpected results that demand more study than originally planned during the mission. In addition, hardware contingencies may demand that some activities be rescheduled. Any changes in the plan will affect the observations of all four science teams. Therefore, representatives from each team participate in the twice-daily, science- operations planning group meetings. The science objectives and viewpoints of the various teams are weighed; then the group agrees on changes to the original activity plan.

BBXRT Payload Operations Control Center

A special team located at a remote payload operations control center at the Goddard Space Flight Center will operate the Broad Band X- Ray Telescope and its Two-Axis Pointing System. However, some members of the BBXRT team will be stationed at the Marshall control center to participate in science planning, and all commands issued to the payload will be coordinated with the mission management team at Marshall. The two payload operations control centers will be linked via voice communication so that teams at both places can confer.

ASTRO-1 HISTORY

In February 1978, NASA issued an announcement of opportunity for instruments that could travel aboard the Space Shuttle and utilize the unique capabilities of Spacelab. Three telescopes -- HUT, UIT, and WUPPE -- evolved as a payload manifested as OSS-3 through 7, and these missions were assigned to the Goddard Space Flight Center. Because the Instrument Pointing System and other Spacelab facilities were needed for OSS-3, management was moved in 1982 to the Marshall Space Flight Center. The payload was renamed Astro.

The Wide Field Camera was added to the payload in 1984 to make detailed studies of Comet Halley, which was due to move through the inner solar system in the spring of 1986.

The instruments were constructed, and the observatory had completed Spacelab integration and testing by January 1986. Astro-1, consisting of HUT, UIT, WUPPE and the Wide Field Camera, was ready for orbiter installation when the Challenger accident occurred.

After the accident, the instruments were removed from Spacelab and stored. Periodic checks were made during storage. However, because of the long interval, the decision was made to examine and recertify all of the Astro instruments. As a part of this process, questions arose in the summer of 1987 about the quality certifications of the bolts used in the Astro-1 hardware. Support structures and instrument and electronics attachments were inspected for possible faulty bolts. A total of 298 bolts eventually were replaced.

HUT was kept at Kennedy Space Center, but its spectrograph was returned to The Johns Hopkins University in October 1988. Although protected from air and moisture by gaseous nitrogen, HUT's extremely sensitive ultraviolet detector had degraded with time. The detector was replaced but failed to pass an acceptance review, and a third detector was installed in January 1989. An aging television camera was replaced in May 1989.

WUPPE's precise instruments also required recalibration after their storage period. Rather than ship the large, sensitive telescope back to the University of Wisconsin where it was developed, astronomers there built a portable vertical calibration facility and delivered it to the Kennedy Space Center. Calibration was completed in April 1989.

WUPPE's power supplies for the spectrometer and for the zero order detector were returned to the University of Wisconsin, where they were modified to reduce output noise.

UIT also stayed at Kennedy, where the power supply for its image intensifier was replaced in August 1989.

Because Comet Halley was no longer in position for detailed observation, the Wide Field Camera was removed from the payload in the spring of 1987. In March of 1988, BBXRT was added to the Astro-1 payload. Originally proposed in response to the 1978 announcement of opportunity, BBXRT had been developed as one of three X-ray instruments in a payload designated OSS-2. This was renamed the Shuttle High-Energy Astrophysics Laboratory and proposed for flight in 1992. However, when Supernova 1987A occurred, BBXRT was completed ahead of schedule and added to the Astro-1 payload. The addition would allow study of the supernova and other objects in X-ray as well as ultraviolet wavelengths.

The completed payload was tested at 6-month intervals. Level IV testing, in which instruments and command software are operated apart from Spacelab pallets, was completed in August 1989. The three ultraviolet telescopes, the Instrument Pointing System and the igloo were integrated with the Spacelab pallets for Level III testing, which concluded in December 1989. The pallet-mounted ultraviolet telescopes and pointing system, as well as the BBXRT and its Two-Axis Pointing System, were moved to the Cargo Integration Test Equipment stand where testing was completed at the end of February 1990.

Astro-1 was installed in Columbia's payload bay March 20, 1990. Final integrated testing in the Orbiter Processing Facility between the orbiter, payload, mission centers and satellite relays was completed March 26-28. Payload pad activities included installation of Ultraviolet Imaging Telescope (UIT) film, removal of telescope covers, final pallet cleaning and BBXRT argon servicing.

SHUTTLE AMATEUR RADIO EXPERIMENT (SAREX)

Conducting short-wave radio transmissions between ground-based amateur radio operators and a Shuttle-based amateur radio operator is the basis for the Shuttle Amateur Radio Experiment (SAREX).

SAREX communicates with amateur stations in line-of-sight of the orbiter in one of four transmission modes: voice, slow scan television (SSTV), data or (uplink only) fast scan television (FSTV).

The voice mode is operated in the attended mode while SSTV, data or FSTV can be operated in either attended or unattended modes.

During the mission, SAREX will be operated by Payload Specialist Ron Parise, a licensed operator (WA4SIR), during periods when he is not scheduled for orbiter or other payload activities. At least four transmissions will be made to test each transmission mode.

The primary pair of frequencies intended for use during the mission is 145.55 MHz as the downlink from Columbia, with 144.95 MHz as the uplink. A spacing of 600 kHz was deliberately chosen for this primary pair to accommodate those whose split frequency capability is limited to the customary repeater offset.

SAREX crew-tended operating times will be dictated by the time of launch. As a secondary payload, SAREX will be operated by Parise during his pre- and post-sleep activities each day. This means that wherever the Shuttle is above Earth during those operating windows, amateur stations can communicate with Columbia. Currently, those windows provide coverage for Australia, Japan, South America and South Africa.

The continental United States has little or no coverage except through a network of ground stations in other parts of the world in conjunction with relay links back to the United States.

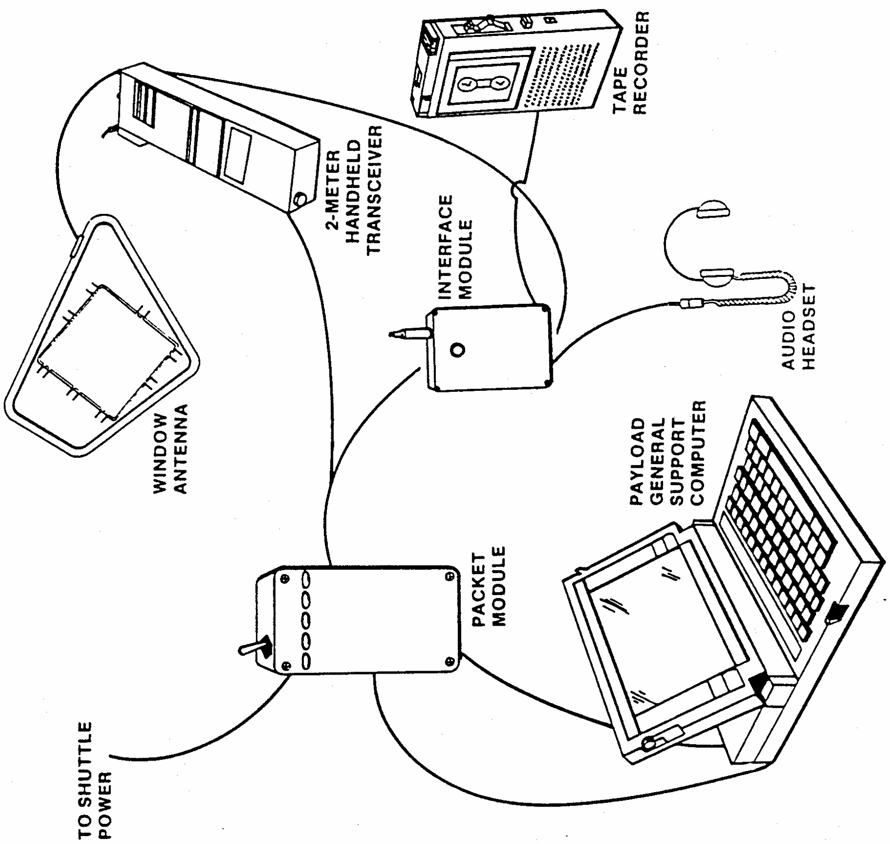
Another part of the SAREX is the "robot," providing an automated operation which can proceed with little human intervention. The robot will generally be activated during one of the crew-tended windows and deactivated during the next one. This gives approximately 12 hours on and 12 hours off for the robot, with the operational period chosen to cover all of the U.S. passes.

SAREX has previously flown on missions STS-9 and STS-51F in different configurations, including the following hardware: a low-power hand-held FM transceiver, a spare battery set, an interface (I/F) module, a headset assembly, an equipment assembly cabinet, a television camera and monitor, a payload general support computer (PGSC) and an antenna which will be mounted in a forward flight window with a fast scan television (FSTV) module added to the assembly.

Antenna location does not affect communications and therefore does not require a specific orbiter attitude for operations. The equipment is stowed in one middeck locker.

SAREX is a joint effort of NASA and the American Radio Relay League (ARRL)/Amateur Radio Satellite Corporation (AMSAT)

SAREX OPERATIONAL CONFIGURATION



STS-35 COLUMBIA SAREX FREQUENCIES

	Shuttle Transmit Frequency (MHz)	Accompanying Shuttle Receive Frequencies (MHz)
Group 1	145.55	144.95
	145.55	144.91
	145.55	144.97
Group 2	145.51	144.91
	145.51	144.93
	145.51	144.99
Group 3	145.59	144.99
	145.59	144.95
Group 4	145.55	144.95
	145.55	144.70
	145.55	144.75
	145.55	144.80
	145.55	144.85

Note: The 145.55/144.95 combination is in both Groups 1 and 4 because alternate uplink frequencies from Group 1 would be used over North and South America while those from Group 4 would be used generally in other parts of the world.

"SPACE CLASSROOM, ASSIGNMENT: THE STARS"

"Space Classroom" is a new NASA educational effort designed to involve students and teachers in the excitement of Space Shuttle science missions. This new program joins more than 160 other educational programs being conducted by NASA that use the agency's missions and unique facilities to help educators prepare students to meet the nation's growing need for a globally competitive work force of skilled scientists and engineers.

The first Space Classroom project, called Assignment: The Stars, will capitalize on the December 1990 flight of Astro-1, a Space Shuttle astronomy mission. It is designed to spark the interest of middle school students, encouraging them to pursue studies in mathematics, science and technology. It will offer educators an alternative approach to teaching their students about the electromagnetic spectrum -- a science concept that is required instruction in many classrooms in the United States.

Space Classroom, Assignment: The Stars, involves several educational elements: a lesson on the electromagnetic spectrum to be taught live by the Astro-1 crew from the cabin of the Space Shuttle Columbia during the flight; a supporting lesson to be taught from the Astro-1 control center in Huntsville, Ala.; an Astro-1 teachers guide; an Astro-1 slide presentation; a NASA educational satellite video conference next fall; and post-flight video products suitable for classroom use.

The major component of Assignment: The Stars will be a lesson taught by members of the Astro-1 science crew from the Space Shuttle as they orbit the Earth during the mission. This 15-20 minute presentation will focus on the electromagnetic spectrum and its relationship to the high-energy astronomy mission.

The crew presentation will be followed by demonstrations and discussions of the concepts introduced by the crew from a classroom in the Astro-1 control center at Marshall Space Flight Center.

The lesson will conclude with an opportunity for some students participating in the lesson from Marshall and students at Goddard Space Flight Center, Greenbelt, MD, to ask questions of the crew in orbit. Students at both centers will participate in additional workshops, tours and laboratory sessions.

The lesson by the crew, the follow-up lesson from the Astro-1 control center and the question-answer session will be carried live on NASA Select TV, Satcom satellite F2R, transponder 13, 3960 megahertz, 72 degrees West longitude. NASA Select will carry continuous programming of all mission events as well. The lesson is tentatively scheduled for the fifth day of the mission.

Beginning about 1 week before launch, Astro-1 Update, a recorded bulletin on the status of the Astro-1 mission and Space Classroom, will be available by dialing 205/544-8504.

In the fall of 1991, tapes of the lesson will available for a small fee from NASA CORE, Lorain County Joint Vocational School, 15181 Route 58 South, Oberlin, Ohio, 44074 (phone: 216/ 774-1051).

ORBITER EXPERIMENTS PROGRAM

The advent of operations of the Space Shuttle orbiter provided an opportunity for researchers to perform flight experiments on a full-scale, lifting vehicle during atmospheric entry. In 1976, to take advantage of this opportunity, NASA's Office of Aeronautics, Exploration and Technology instituted the Orbiter Experiments (OEX) Program.

Since the program's inception, 13 experiments have been developed for flight. Principal investigators for these experiments represent NASA's Langley and Ames Research Centers, Johnson Space Center and Goddard Space Flight Center.

Six OEX experiments will be flown on STS-35. Included among this group will be five experiments which were intended to operate together as a complementary set of entry research instrumentation. This flight marks the first time since the September 1988 return-to-flight that the Langley experiments will fly as a complementary set.

Shuttle Entry Air Data System (SEADS)

The SEADS nosecap on the orbiter Columbia contains 14 penetration assemblies, each containing a small hole through which the surface air pressure is sensed. Measurement of the pressure levels and distribution allows post-flight determination of vehicle attitude and atmospheric density during entry. SEADS, which has flown on three previous flights of Columbia, operates in an altitude range of 300,000 feet to landing. Paul M. Siemers III, Langley, is the principal investigator.

Shuttle Upper Atmosphere Mass Spectrometer (SUMS)

The SUMS experiment complements SEADS by enabling measurement of atmospheric density above 300,000 feet. SUMS samples air through a small hole on the lower surface of the vehicle just aft of the nosecap. It utilizes a mass spectrometer operating as a pressure sensing device to measure atmospheric density in the high altitude, rarefied flow regime where the pressure is too low for the use of ordinary pressure sensors. The mass spectrometer incorporated in the SUMS experiment was spare equipment originally developed for the Viking Mars Lander. This is the first opportunity for SUMS to fly since STS-61C in January 1986. Robert C. Blanchard and Roy J. Duckett, Langley, are co-principal investigators.

Both SEADS and SUMS provide entry atmospheric environmental (density) information. These data, when combined with vehicle motion data, allow determination of in-flight aerodynamic performance characteristics of the orbiter.

Aerodynamic Coefficient Identification Package (ACIP)

The ACIP instrumentation includes triaxial sets of linear accelerometers, angular accelerometers and angular rate gyros, which sense the orbiter's motions during flight. ACIP provides the vehicle motion data which is used in conjunction with the SEADS environmental information for determination of aerodynamic characteristics below about 300,000 feet altitude.

The ACIP has flown on all flights of Challenger and Columbia. David B. Kanipe, Johnson Space Center, is the ACIP principal investigator.

High Resolution Accelerometer Package (HiRAP)

This instrument is a triaxial, orthogonal set of highly sensitive accelerometers which sense vehicle motions during the high altitude portion (above 300,000 feet) of entry. This instrument provides the companion vehicle motion data to be used with the SUMS results. HiRAP has been flown on 11 previous missions of the orbiters Columbia and Challenger. Robert C. Blanchard, Langley, is the HiRAP principal investigator.

Shuttle Infrared Leeside Temperature Sensing (SILTS)

This experiment uses a scanning infrared radiometer located atop the vertical tail to collect infrared images of the orbiter's leeside (upper) surfaces during entry, for the purpose of measuring the temperature distribution and thereby the aerodynamic heating environment. On two previous missions, the experiment obtained images of the left wing. For STS-35, the experiment has been reconfigured to obtain images of the upper fuselage.

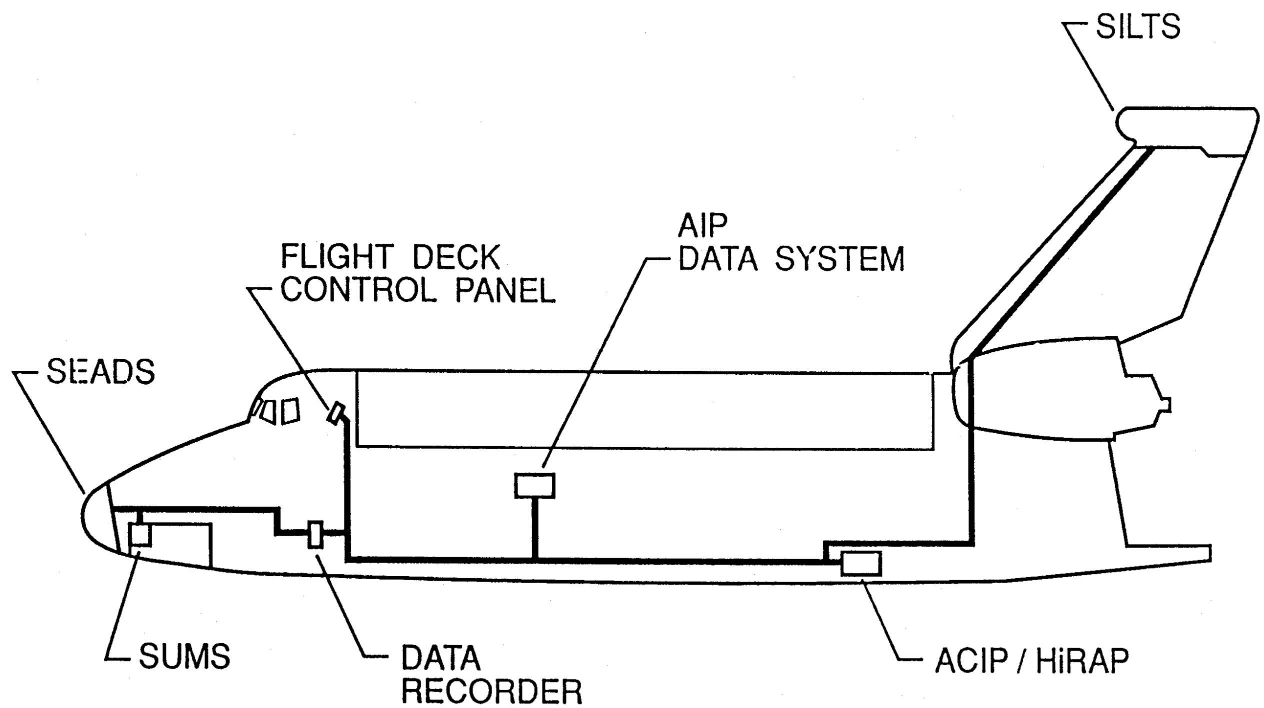
SILTS has flown on three Columbia flights. David A. Throckmorton and E. Vincent Zoby, Langley, are co-principal investigators.

Aerothermal Instrumentation Package (AIP)

The AIP comprises some 125 measurements of aerodynamic surface temperature and pressure at discrete locations on the upper surface of the orbiter's left wing and fuselage, and vertical tail. These sensors originally were part of the development flight instrumentation system which flew aboard Columbia during its Orbital Flight Test missions (STS-1 through 4). They have been reactivated through the use of an AIP-unique data handling system. Among other applications, the AIP data provide "ground-truth" information for the SILTS experiment.

The AIP has flown on two previous Columbia flights. David A. Throckmorton, Langley, is principal investigator.

ORBITER EXPERIMENTS PROGRAM CONFIGURATION FOR STS-35



STS-35 CREWMEMBERS

STS035-S-002 -- The five astronauts and two payload specialists assigned to NASA's STS-35 mission, scheduled aboard Columbia, Orbiter Vehicle (OV) 102, in the spring of this year, pose for their crew portrait. Astronaut Vance D. Brand, center front and holding STS-35 insignia, making his fourth flight in space and his third STS flight, will serve as mission commander. He is flanked on the front row by pilot Guy S. Gardner and mission specialist John M. Lounge. On the back row (left to right) are mission specialists Robert A.R. Parker, payload specialist Ronald A. Parise, mission specialist Jeffrey A. Hoffman, and payload specialist Samuel T. Durrance.

BIOGRAPHICAL DATA

VANCE D. BRAND, 58, will serve as Commander. Selected as an astronaut in 1966, he considers Longmont, CO, to be his hometown. STS-35 will be Brand's fourth space flight.

Brand was Apollo Command Module Pilot on the Apollo-Soyuz Test Project (ASTP) mission, launched on July 15, 1975. This flight resulted in the historic meeting in space between American astronauts and Soviet cosmonauts. The three-member U.S. crew spent 9 days in Earth orbit.

Brand's second flight was as Commander of STS-5 in November 1982, the first fully operational flight of the Shuttle Transportation System and first mission with a four person crew. Brand next commanded the 10th Space Shuttle mission aboard Challenger. STS-41B with its crew of five was launched Feb. 3, 1984.

Prior to joining NASA, Brand was a commissioned officer and naval aviator with the U.S. Marine Corps from 1953 to 1957. Following release from active duty, he continued in Marine Corps Reserve and Air National Guard jet fighter squadrons until 1964. Brand was employed as a civilian by the Lockheed Aircraft Corporation from 1960 to 1966. He was an experimental test pilot on Canadian and German F-104 programs and has logged 8,777 flying hours, which includes 7,312 hours in jets, 391 hours in helicopters, 531 hours in spacecraft and checkout in more than 30 types of military aircraft.

GUY S. GARDNER, 42, Col. USAF, will serve as Pilot. Selected as an astronaut in 1980, he considers Alexandria, VA, to be his hometown. STS-35 will be his second Shuttle flight.

Gardner was Pilot for STS-27, a 4-day flight of Atlantis launched Dec. 2, 1988. The mission carried a Department of Defense payload. The crew completed their mission with a lakebed landing at Edwards on Dec. 6. Gardner graduated from George Washington High School in Alexandria in 1965. He received a bachelor of science degree in engineering sciences, astronautics and mathematics from the USAF Academy in 1969 and a master of science degree in astronautics from Purdue University in 1970.

After completing pilot training, he flew 177 combat missions in Southeast Asia in 1972 while stationed at Udorn, Thailand. In 1973, he flew F-4's and in 1975 attended the USAF Test Pilot School at Edwards. In 1977-78 he was an instructor pilot at the USAF Test Pilot School. He has logged over 4,000 hours flying time and 105 hours in space.

JEFFREY A. HOFFMAN, 45, will serve as Mission Specialist 1 (MS1). Selected as an astronaut in 1978, he was born in Brooklyn, NY. STS-35 will be his second Shuttle flight.

Hoffman was a Mission Specialist aboard Discovery on STS-51D, which launched from the Kennedy Space Center in April 1985. On this mission, he made the first STS contingency spacewalk, in an attempted rescue of the malfunctioning Syncom IV-3 satellite.

Hoffman graduated from Scarsdale High School, Scarsdale, NY, and received a bachelor of arts degree in astronomy from Amherst College in 1966. He received a doctor of philosophy in astrophysics from Harvard University in 1971 and a masters degree in materials science from Rice University in 1988.

At NASA, Hoffman has worked as the astronaut office payload safety representative. He also has worked on extravehicular activity (EVA), including the development of a high-pressure space suit.

BIOGRAPHICAL DATA

JOHN M. "MIKE" LOUNGE, 43, will be Mission Specialist 2 (MS2). Selected as an astronaut in 1980, Lounge considers Burlington, CO,, to be his hometown. He will be making his third Shuttle flight.

Lounge was a mission specialist on STS-51I conducted in August 1985. During that mission his duties included deployment of the Australian AUSSAT communications satellite and operation of the remote manipulator system (RMS) arm. The crew deployed two other communications satellites and also performed a successful on-orbit rendezvous and repair of the ailing SYNCOM IV-3 satellite. His second flight was aboard Discovery on STS-26 in September 1988.

Lounge graduated from Burlington High School in 1964 and received a bachelor of science degree in physics and mathematics from the U.S. Naval Academy in 1969 and a master of science degree in astrogeophysics from the University of Colorado in 1970. At NASA, Lounge now serves as Chief of the Space Station Support Office which works with design and operation of the Freedom space station.

ROBERT ALAN RIDLEY PARKER, 53, will serve as Mission Specialist 3 (MS3). Selected as an astronaut in 1967, he grew up in Shrewsbury, Mass., and will be making his second Shuttle flight.

Parker was a member of the astronaut support crews for Apollo 15 and 17 missions. He served as a mission specialist on Columbia's sixth space flight, STS-9, in November 1983 which was the first Spacelab mission.

Parker attended primary and secondary schools in Shrewsbury, Mass.; received a bachelor of arts degree in astronomy and physics from Amherst College in 1958, and a doctorate in astronomy from the California Institute of Technology in 1962.

SAMUEL T. DURRANCE, 46, will serve as a Payload Specialist. Durrance is a research scientist in the Department of Physics and Astronomy at Johns Hopkins University, Baltimore, MD. He considers Tampa, FL, his hometown.

Durrance has made International Ultraviolet Explorer satellite observations of Venus, Mars, Jupiter, Saturn and Uranus. He helped develop special pointing techniques needed to observe solar system objects with that satellite. His main astronomical interests are in the origin and evolution of planets, both in this solar system and around other stars.

Durrance received a bachelor of science degree and a master of science degree in physics from California State University and a doctor of philosophy degree in astrogeophysics from the University of Colorado.

RONALD A. PARISE, 38, also will serve as a Payload Specialist. Parise is a senior scientist in the Space Observatories Department, Computer Science Corporation in Silver Spring, MD. He is a member of the research team for the Ultraviolet Imaging Telescope, one of the instruments scheduled for flight as part of the Astro payload. He is from Warren, Ohio.

Parise has participated in flight hardware development, electronic system design and mission planning activities for the Ultraviolet Imaging Telescope project. He is pursuing his astronomical research interests with the International Ultraviolet Explorer satellite under a NASA grant. Parise also will conduct the Shuttle Amateur Radio Experiment (SAREX) during the STS-35 mission.

He received a bachelor of science degree in physics, with minors in mathematics, astronomy and geology from Youngstown State University, Ohio, and a master of science degree and a doctor of philosophy degree in astronomy from the University of Florida.

STS-35 MISSION MANAGEMENT

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Brewster Shaw	Deputy Director, Space Shuttle (Operations)

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Bruce Thoman	BBXRT Operations Manager

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Franklin Brizzolara	Payload Integration Manager

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Robert Sturm	Astro-1 Launch Site Support Manager

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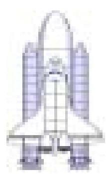
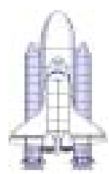
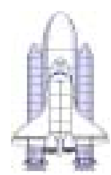
Jack Jones	Astro Mission Manager
Stuart Clifton	Assistant Mission Manager
Dr. Eugene Urban	Deputy Mission Scientist
Thomas Rankin	Payload Operations Director
Fred Applegate	Payload Operations Director
Steven Noneman	Payload Operations Director

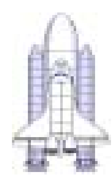
SHUTTLE FLIGHTS AS OF DECEMBER 1990

37 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 12 SINCE RETURN TO FLIGHT









		STS-41 10/06/90 - 10/10/90	
	STS-51L 01/28/86	STS-31 04/24/90 - 04/29/90	
STS-32 01/09/90 - 01/20/90	STS-61A 10/30/85 - 11/06/85	STS-33 11/22/89 - 11/27/89	
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-38 11/15/90 - 11/20/90
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-36 02/28/90 - 03/04/90
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-34 10/18/89 - 10/23/89
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 (9 flights)	**OV-099 Challenger (10 flights)**	**OV-103 Discovery (11 flights)**	**OV-104 Atlantis (7 flights)**