NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION STS-43

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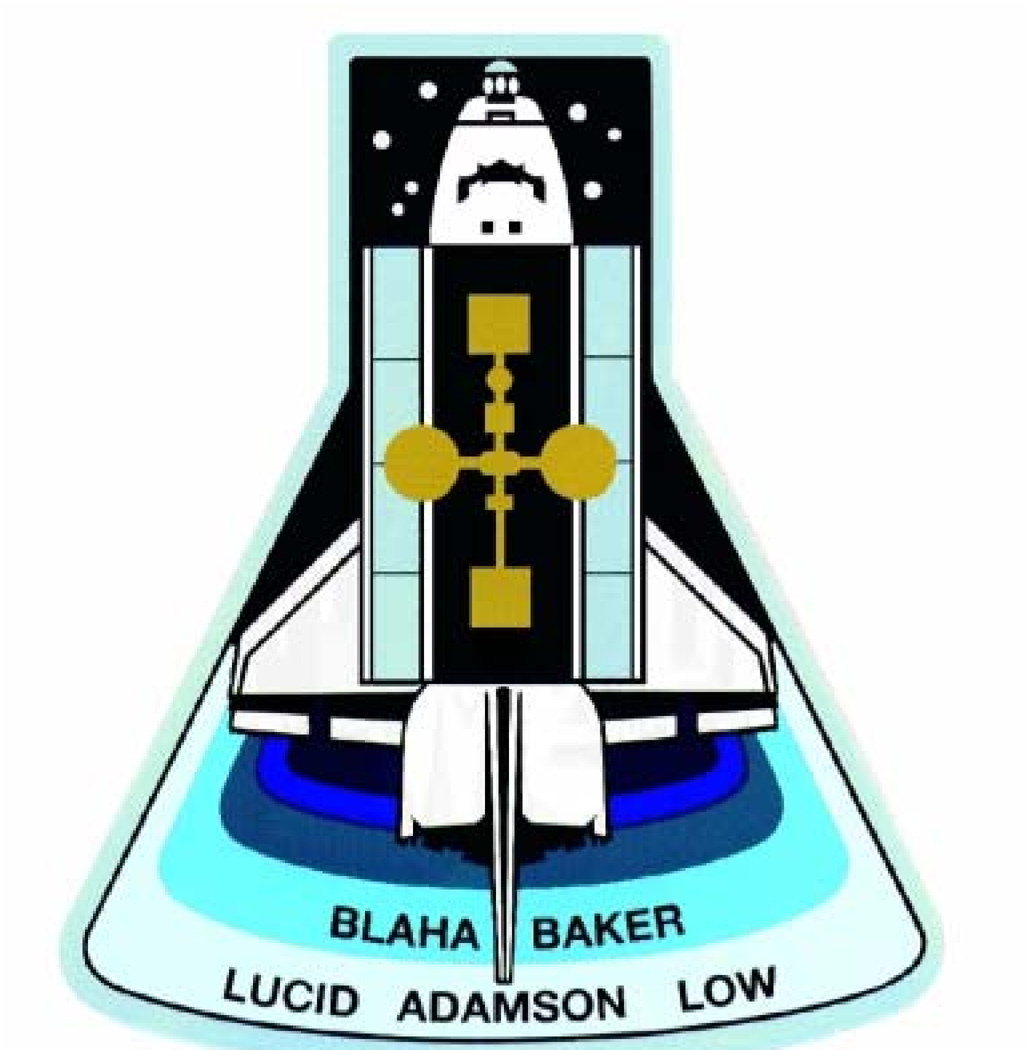
JULY 1991



TRACKING AND DATA RELAY SATELLITE -E (TDRS-E)

STS-43 INSIGNIA

STS043-S-001 -- *Designed by the astronauts assigned to fly on the mission, the STS-43 insignia portrays the evolution and continuity of the U.S. space program by highlighting thirty years of American manned spaceflight experience, from Mercury to the space shuttle. The emergence of the shuttle Atlantis from the outlined configuration of the Mercury space capsule commemorates this special relationship. The energy and momentum of launch are conveyed by the gradations of blue which mark the shuttle's ascent from Earth to space. Once in Earth orbit, Atlantis' cargo bay opens to reveal the Tracking and Data Relay Satellite (TDRS) which appears in gold emphasis against the white wings of Atlantis and the stark blackness of space. A primary mission objective, the Tracking and Data Relay Satellite System (TDRSS) will enable almost continuous communication from Earth to space for future space shuttle missions. The stars on the insignia are arranged to suggest this mission's numerical designation, with four stars left of Atlantis and three to the right.*

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

Mark Hess/Jim Cast/Ed Campion
Office of Space Flight
NASA Headquarters, Washington, DC
(Phone: 202/453-8536)

Duane Brown
Office of Space Operations
NASA Headquarters, Washington, DC
(Phone: 202/453-8956)

Barbara Selby
Office of Commercial Programs
NASA Headquarters, Washington, DC
(Phone: 703/557-5609)

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

Mike Simmons
Marshall Space Flight Center, Huntsville, AL
(Phone: 205/544-6537)

James Hartsfield
Johnson Space Center, Houston, TX
(Phone: 713/483-5111)

Jessie Katz
Goddard Space Flight Center, Greenbelt, MD
(Phone: 301/286-5566)

Myron Webb
Stennis Space Center, MS
(Phone: 601/688-3341)

Nancy Lovato
Ames-Dryden Flight Research Facility, Edwards, CA
(Phone: 805/258-3448)

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ATLANTIS TO BOOST FOURTH NASA TRACKING SATELLITE

Atlantis will put NASA's fourth Tracking and Data Relay Satellite (TDRS-E) into orbit on Space Shuttle mission STS-43 to update the satellite tracking network, resulting in two operating satellites plus a complement of two spares in the space network.

TDRS-E, to be deployed from Atlantis about 6 hours after launch, will be boosted to a geosynchronous orbit by an attached upper stage where TDRS-E will be positioned to remain stationary 22,400 miles above the Pacific Ocean southwest of Hawaii.

The Tracking and Data Relay Satellite System, in operation since the eighth Space Shuttle flight, provides almost uninterrupted communications with Earth-orbiting shuttles and satellites and has replaced the intermittent coverage provided by globe-encircling ground tracking stations used during the early space program. A reduced string of ground stations remains in operation, however, for radar tracking and backup communications.

Atlantis, making its ninth flight and the 42nd Space Shuttle mission, is scheduled for a 10:53 a.m. EDT launch July 23 from Kennedy Space Center's Launch Pad 39-A. On board Atlantis, planned to land about 9:30 a.m. EDT Aug. 1 at either Kennedy Space Center, FL, or Dryden Flight Research Facility, Edwards, Calif., will be Commander John Blaha, Pilot Mike Baker and mission specialists Shannon Lucid, G. David Low and James C. Adamson.

Along with the TDRS-E/IUS in Atlantis' cargo bay for STS-43 will be the Shuttle Solar Backscatter Ultraviolet instrument used to aid in calibrating ultraviolet satellites already in orbit that assist in measuring the Earth's ozone layer, among other functions; the Space Station Heat Pipe Advanced Radiator Element-II, a reflight of an earlier Shuttle experiment that tests a natural process incorporating no moving parts that may be used to cool Space Station Freedom; and the Optical Communications Through the Shuttle Window experiment that uses fiber optics for communications onboard the Shuttle.

In Atlantis' middeck will be the Auroral Photography Experiment-B , an Air Force-sponsored experiment to study the Earth's auroras, more commonly known as the Northern and Southern Lights; the BioServe-Instrumentation Technology Associates Materials Dispersion Apparatus, an experiment in growing large protein crystals in weightlessness; the Investigations into Polymer Membrane Processing experiment, a test of manufacturing polymers in orbit; the Protein Crystal Growth-III experiment, a device used to grow crystals in micro- gravity; the Space Acceleration Measurement System, a device used to measure accelerations and disturbances to weightlessness during Atlantis' stay in orbit; the Solid Surface Combustion Experiment, a test of the way materials burn in weightlessness; and the Tank Pressure Control Experiment, a check of innovative methods for controlling the amount of pressure inside high-pressure tanks.

Although two Shuttle missions have landed at the Kennedy Space Center's Shuttle Landing Facility since the return to flight following the Challenger accident, both were diverted to Kennedy due to bad weather at Edwards Air Force Base, Calif., STS-43 is the first mission since the return to flight to have Kennedy as a planned landing site, dependent on weather.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

MEDIA SERVICES

NASA Select Television Transmission

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

The schedule for television 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; and NASA Headquarters, Washington, D.C. The television schedule will be updated to reflect changes dictated by mission operations.

Television 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. A voice update of the television schedule may be obtained by dialing 202/755-1788. This service is updated daily at noon ET.

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

A mission press briefing schedule will be issued prior to launch. During the mission, change-of-shift briefings by the off-going flight director will occur at approximately 8-hour intervals.

STS-43 QUICK LOOK

Launch Date:	July 23, 1991
Launch Site:	Kennedy Space Center, FL, Pad 39A
Launch Window:	10:53 a.m.-3:12 p.m. EDT
Orbiter:	Atlantis (OV-104)
Orbit:	160 x 160 nautical miles, 28.45 degrees inclination
Landing Date:	Aug. 1, 1991
Landing Time:	Approximately 9:30 a.m. EDT
Primary Landing Sites:	Kennedy Space Center, FL; Edwards Air Force Base, CA
Abort Landing Sites:	Return to Launch Site - Kennedy Space Center, FL Transoceanic Abort Landing - Banjul, The Gambia Alternate - Ben Guerir, Morocco Abort Once Around - Edwards Air Force Base, CA
Crew:	John E. Blaha, Commander Michael A. Baker, Pilot Shannon W. Lucid, Mission Specialist 1 G. David Low, Mission Specialist 2 James C. Adamson, Mission Specialist 3
Cargo Bay Payloads:	TDRS-E/IUS (Tracking and Data Relay Satellite-E/Inertial Upper Stage) SHARE-II (Space Station Heat Pipe Advanced Radiator Element-II) SSBUV (Shuttle Solar Backscatter Ultraviolet Experiment) OCTW (Optical Communications Through the Shuttle Window)
Middeck Payloads:	AMOS (Air Force Maui Optical System) APE-B (Auroral Photography Experiment-B) BIMDA (BioServe-Instrumentation Technology Associates Materials Dispersion Apparatus) IPMP (Investigations into Polymer Membrane Processing) PCG-III (Protein Crystal Growth-III) SAMS (Space Acceleration Measurement System) SSCE (Solid Surface Combustion Experiment) TPCE (Tank Pressure Control Experiment)

SUMMARY OF MAJOR ACTIVITIES

Flight Day 1
Ascent; OMS 2
TDRS-E/IUS deploy
Tank Pressure Control Experiment
Protein Crystal Growth activation

Flight Day 2
SSBUV activation/Earth views
Remote Manipulator System checkout
SHARE-II; BIMDA sample activation
Ames Research Center operations

Flight Day 3
SSBUV Earth views
Tank Pressure Control Experiment deactivation
Medical DSOs

Flight Day 4
SSBUV Solar views; OCTW activation; SHARE-II

Flight Day 5
SSBUV Earth/Solar views; OCTW operations
Remote Manipulator System powerdown
SSBUV deactivation

Flight Day 6
SHARE-II; DSOs
Investigations into Polymer Membrane Processing
Solid Surface Combustion Experiment
Auroral Photography Experiment-B

Flight Day 7
SHARE-II operations; Medical DSOs

Flight Day 8
Auroral Photography Experiment-B
Medical DSOs; Air Force Maui Optical System operations

Flight Day 9
Flight Control System checkout
Reaction Control System hot-fire
Cabin stow

Flight Day 10
Deorbit preparation
Deorbit burn
Landing

VEHICLE AND PAYLOAD WEIGHTS

	Pounds
Orbiter (Atlantis), empty, and 3 SSMEs	171,748
TDRS-E/IUS	37,640
TDRS-E Airborne Support Equipment	5,611
IUS Support Equipment	192
Space Shuttle Backscatter Ultraviolet	1,183
Space Station Heat Pipe Advanced Radiator Element-II	859
Optical Communication Through Shuttle Window	22
Protein Crystal Growth-III	63
Solid Surface Combustion Experiment	138
Space Acceleration Measurement System	102
Investigations into Polymer Membrane Processing	17
Tank Pressure Control Experiment	203
Detailed Supplementary Objectives (DSOs)	235
Auroral Photography Experiment-B	40
BioServe-ITA Materials Dispersion Apparatus	72
Detailed Test Objectives	67
Total Vehicle at SRB Ignition	4,526,488
Orbiter Landing Weight	196,735

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 either Edwards Air Force Base, Calif.; the Shuttle Landing Facility (SLF) at Kennedy Space Center, FL; or White Sands Space Harbor (Northrup Strip), NM.

- Transatlantic Abort Landing (TAL) -- Loss of one or more main engines midway through powered flight would force a landing at either Banjul, The Gambia, or Ben Guerir, Morocco.

- 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-43 contingency landing sites are Edwards AFB, Kennedy Space Center, White Sands, Banjul and Ben Guerir.

STS-43 TRAJECTORY SEQUENCE OF EVENTS

Event	MET (d/h:m:s)	Relative Velocity (fps)	Mach	Altitude (ft)
Launch	00/00:00:00			
Begin Roll Maneuver	00/00:00:10	188	0.16	797
End Roll Maneuver	00/00:00:15	324	0.29	2,254
SSME Throttle Down to 87%	00/00:00:26	619	0.55	6,917
Max. Dyn. Pressure (Max Q)	00/00:00:52	1,231	1.19	27,991
SSME Throttle Down to 67%	00/00:00:53	1,251	1.21	28,988
SSME Throttle Up to 104%	00/00:01:02	1,498	1.54	39,730
SRB Staging	00/00:02:05	4,249	4.07	155,183
Main Engine Cutoff (MECO)	00/00:08:39	24,512	22.75	363,521
Zero Thrust	00/00:08:39	24,509	N/A	363,809
ET Separation	00/00:08:52			
OMS-2 Burn	00/00:39:57			
TDRS-E/IUS Deploy	00/06:13:00			
OMS-3 Burn (TDRS-E/IUS Sep)	00/06:28:00			
Deorbit Burn (orbit 142)	08/21:45:00			
Landing (orbit 143)	08/22:45:00			

Apogee, Perigee at MECO: 157 x 35 nautical miles
Apogee, Perigee post-OMS 2: 160 x 159 nautical miles
Apogee, Perigee post-Sep 1: 177 x 161 nautical miles

STS-43 PRELAUNCH PROCESSING

Processing the orbiter Atlantis for the STS-43 mission at Kennedy Space Center (KSC) began April 19, following its last mission - STS-37/Gamma Ray Observatory.

Originally, Atlantis was scheduled for a 65 day flow in the Orbiter Processing Facility (OPF), but the relatively small number of problems encountered allowed technicians to complete major tasks sooner and shorten the schedule. The 59 day processing of Atlantis is the quickest turn around accomplished since return to flight.

Space Shuttle main engine locations for this flight are as follows: engine 2024 is in the No. 1 position, engine 2012 is in the No. 2 position and engine 2028 is in the No. 3 position. These engines were installed in May.

The Crew Equipment Interface Test with the STS-43 flight crew was conducted on June 8th in the Orbiter Processing Facility (OPF). This test provided an opportunity for the crew to become familiar with the configuration of the orbiter and anything that is unique to the STS-43 mission.

The TDRS-E spacecraft arrived at Kennedy Space Center from Los Angeles aboard an Air Force C-5 transport plane on March 5, 1991. It was taken to the Vertical Processing Facility (VPF) for processing. The Inertial Upper Stage was delivered from Cape Canaveral Air Force Station to the VPF on April 26. TDRS-E was mated to IUS-15 on May 8. The two primary integrated tests were successfully completed. The Interface Verification (IVT) Test, which checks electrical connections between the two flight elements, was finished on May 22. The End-to-End (ETE) communications test, verifying all communications paths with the payload, was complete on June 7.

IUS/TDRS was transported to Pad 39-A and placed in the payload changeout room on June 17. The cargo was scheduled for installation into the payload bay of Atlantis June 26. The IVT and End-to-End tests were scheduled to be repeated, with the Space Shuttle Atlantis also participating, in late June and early July. The Inertial Upper Stage was scheduled to conduct its final principal test, an IUS Simulated Countdown, in mid-July. The payload bay doors are scheduled for closure 2 days before flight.

Booster stacking operations for STS-43 began on April 29. Stacking of all booster segments was completed by May 31st. The external tank was mated to the boosters on June 3 and Atlantis was transferred to the Vehicle Assembly Building on June 19 where it was mated to the external tank and solid rocket boosters. The STS-43 vehicle was rolled out to Launch Pad 39-A on June 25. A launch countdown dress rehearsal was scheduled for July 3 at KSC.

A standard 43-hour launch countdown is scheduled to begin 3 days prior to launch. During the countdown, the orbiter's onboard fuel and oxidizer storage tanks will be loaded and all orbiter systems will be prepared for flight.

About 9 hours before launch, the external tank will be filled with its flight load of a half million gallons of liquid oxygen and liquid hydrogen propellants. About 2 and one-half hours before liftoff, the flight crew will begin taking their assigned seats in the crew cabin.

For the first time since return to flight, there will be two primary landing sites. Under newly established guidelines, KSC will be considered on equal status with Dryden Flight Research Facility (DFRF) in support of Shuttle landing. After reviewing data on various factors that affect landing such as tire performance, braking performance, runway condition, weather forecasting, mission duration, orbiter weight and use of a drag chute, officials concluded that the program was ready to use the Kennedy Space Center as a nominal end of mission landing site. Specific landing criteria based on the factors mentioned above will determine whether the Shuttle lands at KSC or DFRF.

TRACKING AND DATA RELAY SATELLITE SYSTEM

The Tracking and Data Relay Satellite (TDRS)-E is the fifth in a series of communications spacecraft planned for the Tracking and Data Relay Satellite System (TDRSS). TDRS-A, now in orbit and known as TDRS-1, was deployed from the Space Shuttle Challenger on April 5, 1983 on STS-6. TDRS-B was destroyed during the Challenger accident in January 1986. TDRS-C, known as TDRS-3 in orbit, was launched from Discovery on Sept. 29, 1988 on STS-26. TDRS-D, known as TDRS-4 in orbit, was launched from Discovery on March 13, 1989 on STS-29.

Currently, TDRS-4 is located at 41 degrees West longitude, over the Atlantic Ocean off Brazil, TDRS-3 is located at 174 degrees west longitude, and TDRS-1 is located at 171 degrees west longitude. Both TDRS-3 and TDRS-1 are over the Pacific, east of the Gilbert Islands and South of Hawaii. TDRS-4 also is known as TDRS-East and the combination of TDRS-1 and TDRS-4 provide the TDRS western satellite capability.

The satellite communications system was initiated following studies in the early 1970s which showed that a system of telecommunication satellites operated from a single ground station could better support the Space Shuttle and scientific application mission requirements planned for the Nation's space program than a world-wide network of ground stations. In addition, the system was seen as a means of halting the spiraling costs of upgrading and operating a network of tracking and communications ground stations located around the world.

Upon reaching geosynchronous orbit, the deployment of TDRS antennas and appendages is started. The deployment sequence is:

1. Deploy solar arrays.
2. Deploy space-ground link boom.
3. Deploy C-band boom.
4. Separation of IUS and TDRS.
5. Release single access booms.
6. Position single access antennas.
7. Open single access antennas.

During steps five, six and seven, Earth acquisition is taking place concurrently.

The TDRS is three-axis stabilized with the multiple access body fixed antennas pointing constantly at the Earth while the solar arrays track the sun.

Communication System

The TDRSs do not process user traffic in either direction. Rather, they operate as "bent pipe" repeaters, relaying signals and data between the user spacecraft and the ground terminal and vice versa without processing.

The operational TDRSS is equipped to support up to 24 user spacecraft, including the Space Shuttle, simultaneously. It will provide two types of service: (1) multiple access which can relay data from as many as 20 low data rate (100 bits per second to 50 kilobits per second) user satellites simultaneously and (2) single access which will provide two high data rate channels (to 300 megabits per second) from both the East and West locations.

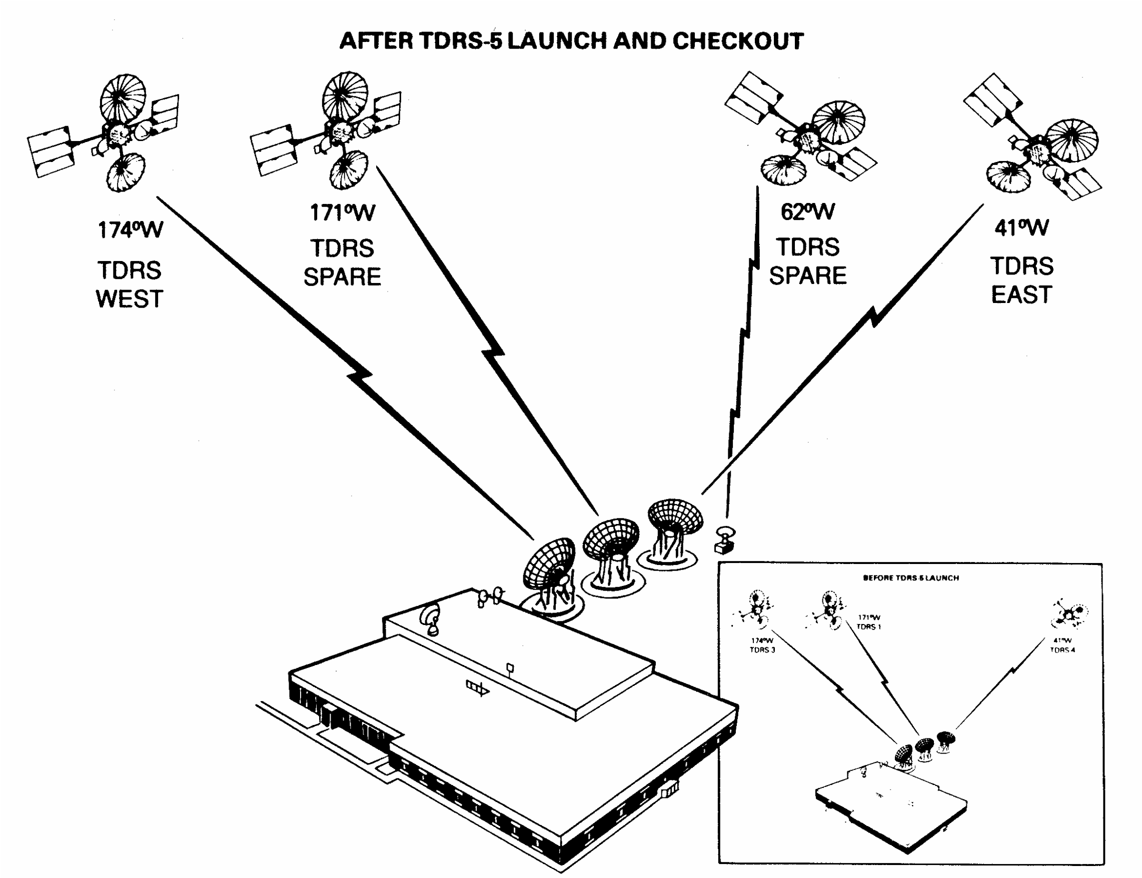
The TDRSS ground terminal is located at White Sands, NM. It provides a location with a clear line-of-sight to the TDRSs and a place where rain conditions have limited interference with the availability of the Ku-band uplink and downlink channels. The White Sands Ground Terminal (WSGT) is operated for NASA by Contel Federal Systems, Atlanta, Ga., under a contract expiring in 1995.

Co-located at White Sands is the NASA Ground Terminal (NGT), which is operated for NASA by Bendix Field Engineering and provides the interface between WSGT and other primary network elements located at NASA's Goddard Space Flight Center, Greenbelt, Md.

Those facilities at Goddard include the Network Control Center (NCC), which provides system scheduling and is the focal point for NASA communications and the WSGT and TDRSS users; the Flight Dynamics Facility (FDF), which provides the network with antenna pointing information for user spacecraft and the TDRSs; and the NASA Communications Network (NASCOM), which provides the common carrier interface through Earth terminals at Goddard, White Sands and the Johnson Space Center in Houston.

The Network Control Center console operators monitor the network's performance, schedule emergency interfaces, isolate faults in the system, account for system use, test the system and conduct simulations. The user services available from the Space Network are provided through NASCOM, a global system which provides operational communications support to all NASA projects.

NASCOM offers voice, data and teletype links with the Space Network, the Ground Spaceflight Tracking and Data Network (GSTDN) and the user spacecraft control centers.



TDRS COMPONENTS

The TDRSs are composed of three distinct modules: a spacecraft module, a payload module and an antenna module. The modular design reduces the cost of individual design and construction efforts that, in turn, lower the cost of each satellite.

The spacecraft module, housing the subsystems that operate the satellite, is located in the lower hexagon of the spacecraft. The attitude control subsystem stabilizes the satellite to provide accurate antenna pointing and proper orientation of the solar panels to the sun. The electrical power subsystems consists of two solar panels that provide power of approximately 1,700 watts. The thermal control subsystem consists of surface coatings and controlled electric heaters.

The payload module is composed of the electronic equipment required to provide communications between the user spacecraft and the ground. The receivers and transmitters for single access services are mounted in compartments on the back of the single-access antennas.

The antenna module is composed of seven antenna systems: two single-access, the multiple access array and space-to-ground link and the S-band omni for satellite health and housekeeping. Commercial K-band and C-band antennas round out the complement.

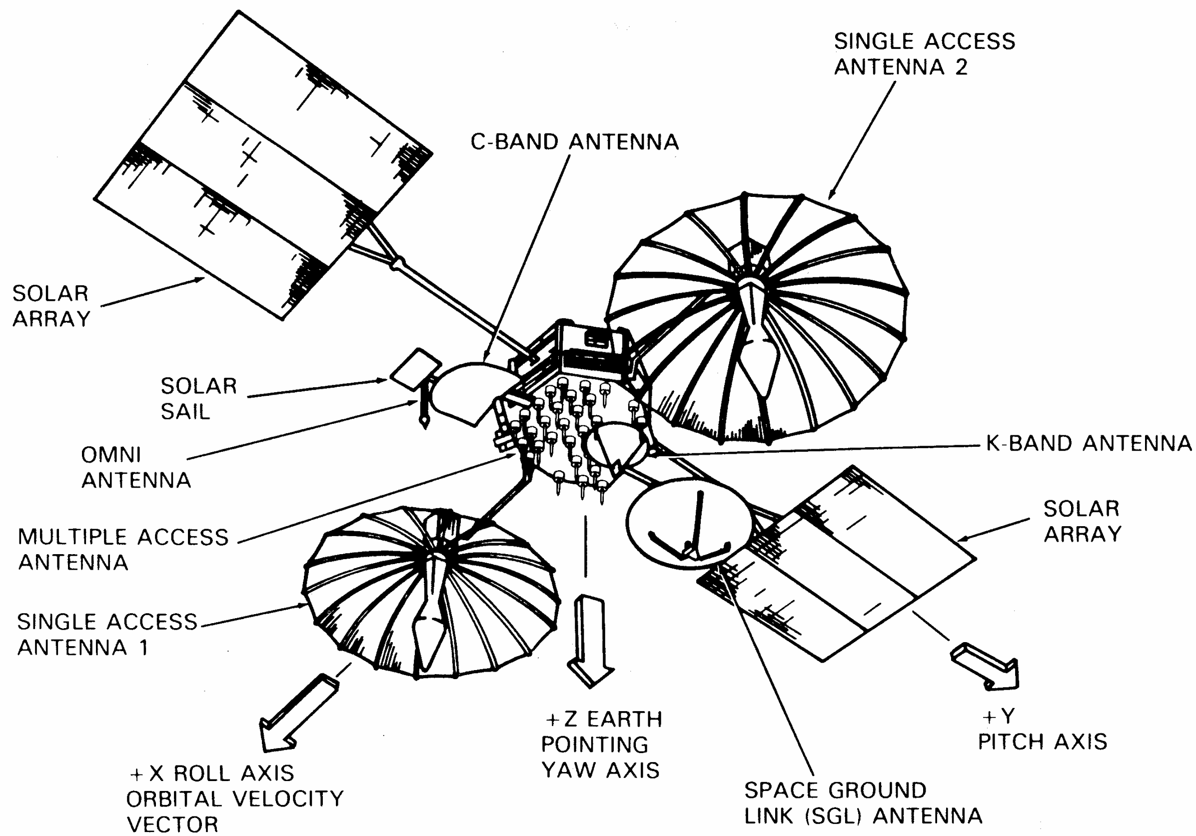
For single-access service, the TDRSs have dual-feed S-band, Ku-band parabolic (umbrella-like) antennas. These antennas are free to be positioned in two axes directing the radio beam to orbiting user spacecraft below.

These antennas are used only to relay communications to and from user spacecraft. The high data rates provided by these antennas is available to users on a time-shared basis. Each antenna is capable of supporting two user spacecraft services simultaneously -- one at S-band and one at Ku-band -- provided both users are within the beam width of the antenna.

The multiple access antenna array is hard-mounted in one position on the surface of the antenna module facing the Earth. Another antenna, a 6.5 foot (2-meter) parabolic reflector, provides the prime link for relaying transmissions to and from the ground terminal at Ku-band.

Project Support

TRW Space and Technology Group, Redondo Beach, Calif., is the prime spacecraft contractor. Ground operations at the White Sands complex are conducted by Contel Federal Systems and Bendix Field Engineering.



TDRS SPACECRAFT ON-ORBIT CONFIGURATION

INERTIAL UPPER STAGE (IUS)

Background

The IUS was developed and built under contract to the Air Force Systems Command's Space Division. The Space Division is executive agent for all Department of Defense activities pertaining to the Space Shuttle system and provides the IUS to NASA for Space Shuttle use. After 2-1/2 years of competition, Boeing Aerospace Company, Seattle, was selected in August 1976 to begin preliminary design of the IUS.

Specifications

IUS-15, the vehicle to be used on mission STS-43, is a two-stage rocket weighing approximately 32,500 pounds. Each stage has a solid rocket motor, preferred over liquid-fueled engines for their relative simplicity, high reliability, low cost and safety.

The IUS is 5.18 meters (17 feet) long and 2.8 meters (9.25 feet) in diameter. It consists of an aft skirt; an aft stage solid rocket motor containing 21,400 pounds of propellant generating approximately 42,000 pounds of thrust; an interstage; a forward stage solid rocket motor with 6,000 pounds of propellant generating approximately 18,000 pounds of thrust; and an equipment support section.

The equipment support section 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.

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 TDRS-E in the orbiter payload bay and elevates the IUS/TDRS for final checkout and deployment from the orbiter.

The IUS ASE consists of the structure, aft tilt frame actuator, batteries, electronics and cabling to support the IUS/TDRS combination. These ASE subsystems enable the deployment of the combined vehicle; provide, distribute and/or control electrical power to the IUS and satellite; and serve as communication conduits between the IUS and/or satellite and the orbiter.

IUS Structure

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

Equipment Support Section

The Equipment Support Section houses the majority of the avionics of the IUS. 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 multi-layer insulation blanket across the interface between the IUS and TDRS.

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 attitude 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, power transfer unit, utility batteries, pyrotechnic switching unit, IUS wiring harness and umbilical and staging connectors. The IUS avionics system distributes electrical power to the IUS/TDRS interface connector for all mission phases from prelaunch to spacecraft separation.

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 solid rocket motor 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 fuel carried. The IUS-15 first stage motor will carry 21,400 pounds of propellant; the second stage over 6,000 pounds.

Reaction Control System

The reaction control system controls the IUS/TDRS's attitude during coasting; roll control during SRM thrustings; and velocity impulses for accurate orbit injection. As a minimum, the IUS includes one reaction control fuel tank with a capacity of 120 pounds of hydrazine. Production options are available to add a second or third tank. IUS-15 will carry two tanks, each with 120 pounds of fuel. To avoid spacecraft contamination, the IUS has no forward facing thrusters. The reaction control system also is used to provide the velocities for spacing between several spacecraft deployments and for avoiding collision or contamination after the spacecraft separates.

IUS-to-Spacecraft Interfaces

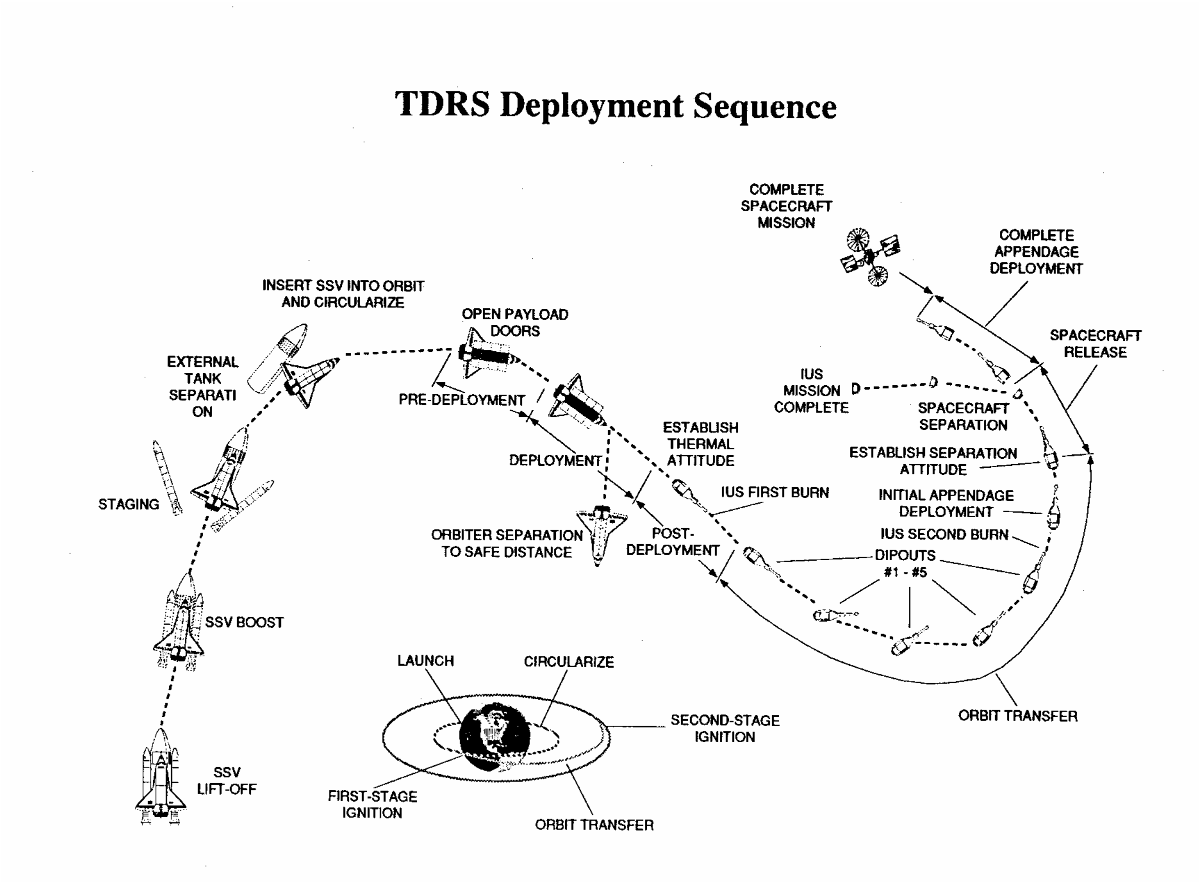
The TDRS spacecraft is physically attached to the IUS at eight attachment points, providing substantial load-carrying capability while minimizing the transfer of heat across the connecting points.

Power, command and data transmission between the two are provided by several IUS interface connectors. In addition, the IUS provides an insulation blanket comprised of multiple layers of double-aluminized Kapton and polyester net spacers across the IUS/TDRS interface. The outer layer of the blanket, facing the TDRS spacecraft, is a special Teflon-coated fabric called Beta cloth. The 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.

IUS/TDRS DEPLOYMENT AND 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 maneuver(s) are normally performed at this time.



Forward payload restraints are released and the aft frame of the airborne support equipment tilts the IUS/TDRS to 29 degrees. This extends the TDRS into space just outside the orbiter payload bay, allowing direct communication with Earth during systems checkout. The orbiter then is maneuvered to the deployment attitude. If a problem develops within the spacecraft or IUS, the IUS and its payload can be restowed.

Prior to deployment, the spacecraft electrical power source is 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 IUS/TDRS predeployment operations have been successfully completed, a GO/NO-GO decision for IUS/TDRS deployment is sent to the crew.

When the orbiter flight crew is given a GO decision, they activate the pyrotechnics that separate the IUS/TDRS umbilical cables. The crew then commands the electromechanical tilt actuator to raise the tilt table to a 58- degree deployment position. The orbiter's RCS thrusters are inhibited and an pyrotechnic separation device is initiated to physically separate the IUS/spacecraft combination from the tilt table. Compressed springs provide the force to jettison the IUS/TDRS from the orbiter payload bay at approximately 0.10 meters (4.2 inches) per second. The deployment normally is performed in the shadow of the orbiter or in Earth eclipse.

The tilt table then is lowered to minus 6 degrees after IUS and its spacecraft are deployed. A small orbiter maneuver is made to back away from the IUS/TDRS. Approximately 19 minutes after IUS/TDRS deployment, the orbiter's engines are ignited to move the orbiter away from the IUS/spacecraft.

At this point, the IUS/TDRS is controlled by the IUS onboard computers. Approximately 10 minutes after the IUS/TDRS is ejected from the orbiter, the IUS onboard computer sends signals used by the IUS and/or TDRS to begin mission sequence events. This signal also enables the reaction control system. All subsequent operations are sequenced by the IUS computer, from transfer orbit injection through spacecraft separation and IUS deactivation.

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

At approximately 45 minutes after ejection from the orbiter, the pyrotechnic inhibits for the first solid rocket motor are removed. The belly of the orbiter has been oriented towards the IUS/TDRS combination to protect the orbiter windows from the IUS's plume. The IUS recomputes 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 sends the signal to ignite the first stage motor. This is expected at approximately 60 minutes after deployment (L+7 hours, 13 minutes). After firing approximately 146 seconds and prior to reaching the apogee point of its trajectory, the IUS first stage expends its fuel. While coasting, the IUS performs any maneuvers needed by TDRS for thermal protection or communications. When this is completed, the IUS first stage and interstage separate from the IUS second stage.

Approximately 6 hours, 12 minutes after deployment (at approximately L+12:30) the second stage motor ignites, thrusting about 108 seconds. After burn is complete, the IUS stabilizes the TDRS while the solar arrays and two antennas are deployed. The IUS second stage separates and performs a final collision/contamination avoidance maneuver before deactivating.

SPACEFLIGHT TRACKING AND DATA NETWORK

Although primary communications for most activities on STS-43 will be conducted through the orbiting Tracking and Data Relay Satellite (TDRS -1 and TDRS-4), NASA's Spaceflight Tracking and Data Relay Network (STDN)- controlled ground stations will play a key role in several mission activities. In addition, the stations along with the NASA Communications Network (NASCOM), at Goddard Space Flight Center, Greenbelt, Md., will serve as backups for communications with Space Shuttle Atlantis should a problem develop in the satellite communications.

Three of the 7 stations serve as the primary communications focal point during the launch and ascent phase of the Shuttle from Kennedy Space Center, FL. They are Merritt Island and Ponce de Leon in Florida and Bermuda down range from the launch site. For the first minute and 20 seconds, all voice, telemetry and other communications from the Shuttle are relayed to the mission managers at KSC and at Johnson Space Center , Houston, by way of the Merritt Island facility.

At 1 minute, 20 seconds, the communications are picked up from the Shuttle and relayed to KSC and JSC from the Ponce de Leon facility, 30 miles north of the launch pad. This facility provides the communications for 70 seconds or during a critical period when exhaust energy 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 and 30 seconds after launch when communications are "handed over" to Bermuda. Bermuda then provides the communications until 8 minutes and 45 seconds after liftoff when the TDRS-4 (EAST) satellite acquires the Shuttle.

SHUTTLE SOLAR BACKSCATTER ULTRAVIOLET (SSBUV)

The Shuttle Solar Backscatter Ultraviolet (SSBUV) instrument was developed by NASA's Goddard Space Flight Center to compare the observations of several ozone measuring instruments aboard the National Oceanic and Atmospheric Administration's NOAA-9 and NOAA-11 satellites and NASA's Nimbus-7 satellite. The SSBUV data is used to calibrate these instruments to ensure the most accurate readings possible for the detection of atmospheric ozone trends.

The SSBUV will help scientists solve the problem of data repeatability caused by the calibration drift of the Solar Backscatter Ultraviolet (SBUV) instruments on these satellites. The SSBUV uses the Space Shuttle's orbital flight path to assess instrument performance by directly comparing data from identical instruments aboard the NOAA spacecraft and Nimbus-7 as the Shuttle and satellite pass over the same Earth location within an hour. These orbital coincidences can occur 17 times a day.

The satellite-based SBUV instruments estimate the amount and height distribution of ozone in the upper atmosphere by measuring the 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 energy in the ultraviolet wavelengths, an ozone measurement can be derived by comparing the amount of incoming radiation to the amount backscattered by the atmosphere.

SSBUV's value lies in its ability to provide precisely calibrated, or verified, ozone measurements. The instrument is calibrated to a laboratory standard before flight, then is recalibrated during and after flight to ensure its accuracy. When SSBUV is on the ground, its transmission diffuser, which allows sunlight into the instrument, is calibrated separately at the National Institute of Standards and Technology. The rigorous calibration provides a highly reliable standard to which data from the SBUV instruments can be compared. The two previous SSBUV flights occurred on STS-34 in October 1989 and STS-41 in October 1990. Five more flights are manifested through 1996, beginning with STS-48 in April 1992. During that mission, SSBUV data will be used to calibrate measurements from the Upper Atmosphere Research Satellite, planned for launch this September. NASA's goal is to fly SSBUV missions approximately once a year between 1989 and 2000 to provide precise calibration measurements across a full 11-year solar cycle.

The SSBUV instruments and its dedicated electronics, power, data and command systems are mounted in the Shuttle's payload bay in two Get Away Special canisters that together weigh 1,200 pounds (545 kilograms). The instrument canister holds the SSBUV, its 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 in-flight calibration. The support canister contains the power system, data storage and command decoders. The dedicated power system can operate the SSBUV for approximately 40 hours.

Ernest Hilsenrath of GSFC is the principal investigator for SSBUV, which is managed by GSFC for NASA's Office of Space Science and Applications.

PROTEIN CRYSTAL GROWTH EXPERIMENT

The Protein Crystal Growth (PCG) payload aboard STS-43 is a continuing series of experiments leading toward major benefits in biomedical technology. The experiments on this Space Shuttle mission could improve pharmaceutical agents such as insulin for treatment of diabetes. Protein crystals like inorganic crystals such as quartz, are structured in a regular pattern. With a good crystal, roughly the size of a grain of table salt, scientists are able to study the protein's molecular architecture.

Determining a protein crystal's molecular shape is an essential step in several phases of medical research. Once the three-dimensional structure of a protein is known, it may be possible to design drugs that will either block or enhance the protein's normal function within the body or other organisms.

Though crystallographic techniques can be used to determine a protein's structure, this powerful technique has been limited by problems encountered in obtaining high-quality crystals well ordered and large enough to yield precise structural information.

Protein crystals grown in Earth-based laboratories are typically small and lacking in uniformity or "order." However, lack of size and order greatly hamper procedures used to deduce the actual structure of the molecules constituting the protein crystal. The problem with growing larger and highly ordered crystals on Earth is analogous to trying to make a geometric shape out of Styrofoam cups on a breezy day. The "breeze" is caused by gravity-driven forces of convection that thwart attempts to arrange the cups (molecules) in a neat and orderly fashion. The growth of relatively large and highly ordered protein crystals in the almost "breeze-less" environment of space facilitates and greatly reduces the time required for the analysis of protein structure.

During the STS-43 flight, experiments will be conducted using bovine insulin. Though there are four processes used to grow crystals on Earth -- vapor diffusion, liquid diffusion, dialysis and batch process -- only batch process will be used in this set of experiments. Shortly after achieving orbit, a crewmember will activate the experiment to grow insulin crystals by decreasing the experiment's temperature from 40 degrees C to 22 degrees C as was done on STS-37. The results of the STS-37 experiment indicate that the space-grown crystals are much larger than their Earth-grown counterparts.

Protein crystal growth experiments were first carried out by the investigating team during Spacelab 3 in April 1985. The experiments have flown a total of nine times. The STS-26, -29, -32 and -31 experiments were the first opportunities for scientific attempts to grow useful crystals at controlled temperatures by vapor diffusion in microgravity. The set of PCG experiments on STS-43 will use the batch process and fly in hardware configuration flown for the time on STS-37, the Protein Crystallization Facility, developed by the PCG investigators.

The PCG program is sponsored by NASA's Office of Commercial Programs, the Office of Space Science and Applications, with management provided through Marshall Space Flight Center, Huntsville, Ala. Richard E. Valentine is mission manager, Blair Herron is PCG experiment manager and Dr. Daniel Carter is project scientist for Marshall.

Dr. Charles E. Bugg, Director, Center for Macromolecular Crystallography (CMC), a NASA Center for the Commercial Development of Space located at the University of Alabama-Birmingham, is lead investigator for the PCG experiment. Dr. Lawrence J. DeLucas, Associate Director and Chief Scientist, and Dr. Marianna Long, Associate Director for Commercial Development, also are PCG investigators for CMC.

INVESTIGATIONS INTO POLYMER MEMBRANE PROCESSING

The Investigations into Polymer Membrane Processing (IPMP), a middeck payload, will make its third Space Shuttle flight for the Columbus, Ohio-based Battelle Advanced Materials Center, a NASA Center for the Commercial Development of Space (CCDS), sponsored in part by the Office of Commercial Programs.

The objective of the IPMP is to investigate the physical and chemical processes that occur during the formation of polymer membranes in microgravity such that the improved knowledge base can be applied to commercial membrane processing techniques. Supporting the overall program objective, the STS-43 mission will provide additional data on the polymer precipitation process.

Polymer membranes have been used by industry in separation processes for many years. Typical applications include enriching the oxygen content of air, desalination of water and kidney dialysis.

Polymer membranes frequently are made using a two-step process. A sample mixture of polymer and solvents is applied to a casting surface. The first step involves the evaporation of solvents from the mixture. In the second step, the remaining sample is immersed in a fluid (typically water) bath to precipitate the membrane from the solution and complete the process.

On the STS-43 mission, Commander John Blaha will operate the IPMP experiment. By turning the unit's valve to the first stop, the evaporation process is initiated. After a specified period consisting of several minutes, a quench procedure will be initiated. The quench consists of introducing a humid atmosphere which will allow the polymer membrane to precipitate out. The units are allowed to free float in the cabin for 10 minutes. Ground-based research indicates that the precipitation process should be complete after approximately 10 minutes, and the entire procedure is at that point effectively quenched. The two units are then restowed in the locker for the duration of the flight.

Following the flight, the samples will be retrieved and returned to Battelle for testing. Portions of the samples will be sent to the CCDS's industry partners for quantitative evaluation consisting of comparisons of the membranes' permeability and selectivity characteristics with those of laboratory-produced membranes.

Lisa A. McCauley, Associate Director of the Battelle CCDS, is program manager for IPMP. Dr. Vince McGinness of Battelle is principal investigator.

BIOSERVE ITA MATERIALS DISPERSION APPARATUS (BIMDA)

The BioServe/Instrumentation Technology Associates (ITA) Materials Dispersion Apparatus (BIMDA) payload has been jointly developed by BioServe Space Technologies, a NASA Center for Commercial Development of Space (CCDS) located at the University of Colorado, Boulder, and its industrial affiliate, Instrumentation Technology Associates, Inc. (ITA), Exton, Pa. Also collaborating in the BIMDA activity are researchers from NASA's Johnson Space Center, Houston, and Ames Research Center, Mountain View, CA.

Sponsored by NASA's Office of Commercial Programs, the objective of the BIMDA experiment is to obtain data on scientific methods and commercial potential of biomedical manufacturing processes and fluid science processing in the microgravity environment of space.

The BIMDA primary elements, developed by ITA with private sector funding, are the Materials Dispersion Apparatus (MDA) minilabs and their controller with a self-contained power supply and the Refrigerator/Incubator Module (R/IM) carrier which houses the entire BIMDA experiment hardware. The MDA minilab is a compact mixing device capable of mixing up to 100 separate samples of any two or three fluids using the liquid-to-liquid diffusion process. The MDA is capable of conducting biomedical, manufacturing processes and fluid sciences experiments.

The BIMDA-2 mission is essentially a reflight of the BIMDA-1 flown aboard STS-37 with repeats of some experiments and some additional new experiments. The four MDA units to be flown on STS-43 are expected to yield over 200 separate data points from experiments conducted in the science disciplines of protein crystal growth, zeolite crystal formation, collagen and virus assembly, interferon induction, seed germination, cell fixation and fluid sciences/diffusion experiments.

Another primary element of the BIMDA payload is the bioprocessing testbed, designed and developed by BioServe. The testbed contains the hardware for six bioprocessing modules and six cell syringes. The bioprocessing testbed elements will be used to mix cells with various activation fluids followed by extended periods of metabolic activity and subsequent sampling into a fixative solution. The bioprocessing module and cell experiments are to determine the response of live cells to various hormones and stimulating agents under microgravity conditions.

On this second and last of the planned flights of BIMDA aboard the Space Shuttle, 17 principal investigators will use the MDA to explore the commercial potential of 36 different experiments in the biomedical, manufacturing processes and fluid sciences fields.

Subsequent Shuttle flights of the MDA hardware by ITA will be on a commercial basis and will contribute to the commercial development of space infrastructure by providing generic materials processing in space hardware for users.

BIMDA Hardware

The BIMDA payload includes three elements of hardware: the MDA minilab units, cell syringes and bioprocessing modules (contained in a bioprocessing testbed). All are contained within a temperature-controlled environment provided by a R/IM in a Shuttle middeck locker position.

At the beginning of BIMDA activation, the testbed housing the cell syringes and bioprocessing modules will be removed from the R\IM and attached with Velcro to an available surface within the middeck. The testbed will remain outside the R/IM until BIMDA reconfiguration prior to reentry.

The MDA minilabs will remain in the thermally controlled environment of the R/IM during the entire flight. Each MDA minilab unit consists of a number of sample blocks having self-aligning reservoirs or reaction chambers in both top and bottom portions of the device. By sliding one block in relation to the other, the reservoirs align to allow diffusion to occur between fluid substances contain within each reservoir. The process of sliding the blocks can be repeated to achieve time-dependent dispersion (or mixing) of different substances. A prism window in each MDA unit allows the crew member to determine the alignment of the blocks on each unit.

The cell syringe apparatus consists of six two-chambered syringes containing biological cells, needle/valve adapters and sample vials. When the plunger is depressed, the payload is activated, thus the fluids in the two chambers are mixed and permitted to react. Periodic samples are taken during the flight, using the needle/valve adapters and sample vials.

The six bioprocessing module units each consist of three syringes connected via tubing and three-position valve. The direction of the valve controls the flow of biological cells/fluids between various syringes, allowing different types of mixing and sampling from one syringe to another. The valve apparatus provides options for variations in the mixing of fluids.

Lead investigators for the BIMDA payload are Dr. Marvin Luttges, Director of BioServe Space Technologies, and John M. Cassanto, President of ITA, whose company developed the MDA hardware with private sector funds as a commercial space venture.

AIR FORCE MAUI OPTICAL SYSTEM (AMOS)

The Air Force Maui Optical System (AMOS) is an electrical-optical facility located on the Hawaiian island of Maui. The facility tracks the orbiter as it flies over the area and records signatures from thruster firings, water dumps or the phenomena of Shuttle glow, a well-documented glowing effect around the Shuttle caused by the interaction of atomic oxygen with the spacecraft.

The information obtained is used to calibrate the infrared and optical sensors at the facility. No hardware onboard the Shuttle is needed for the system.

AURORAL PHOTOGRAPHY EXPERIMENT-B (APE-B)

The Auroral Photography Experiment-B (APE-B) is an Air Force-sponsored payload designed to study the aurora, or the Northern and Southern lights, and the phenomena of Shuttle glow, an illumination around the shuttle caused as the spacecraft encounters atomic oxygen in orbit.

APE-B hardware consists of a Nikon 35 mm camera, a 55 mm lens and several filters and adapters. The camera can be mounted in the aft flight deck window using a special camera mount, and shrouds are provided to block out light from the crew compartment during exposures. The photography will take place while Atlantis is in darkness, with crew cabin lights and cargo bay lights off.

SPACE ACCELERATION MEASUREMENT SYSTEM (SAMS)

The Space Acceleration Measurement System (SAMS) payload is sponsored by NASA and used to collect data on accelerations felt onboard the Shuttle while it is in orbit, measuring the amount of disturbance to the weightless environment onboard.

Located in the middeck, information from the sensors in the unit is stored on optical disks. The SAMS will be activated by the crew about two and a half hours after launch, and the optical disks will be changed periodically. Acceleration information will be recorded throughout the flight, and during specific events such as orbital maneuvering system and reaction control system engine firings.

STS-43 CREWMEMBERS

STS043-S-002 -- STS-43 official crew portrait shows astronauts standing in front of a landed space shuttle orbiter at sunset. Crewmembers, wearing launch and entry suits (LESs) and holding launch and entry helmets (LEHs), are (left to right) mission specialists Shannon W. Lucid, James C. Adamson, mission commander John E. Blaha, mission specialist G. David Low, and pilot Michael A. Baker. The portrait was created using a double exposure.

PHOTO CREDIT: NASA or National Aeronautics and Space Administration.

BIOGRAPHICAL DATA

JOHN E. BLAHA, 48, Col., USAF, will serve as Commander of STS-43 and will be making his third space flight. Blaha, from San Antonio, TX, was selected as an astronaut in May 1980.

Blaha graduated from Granby High School in Norfolk, VA, in 1960, received a bachelor of science in engineering science from the USAF Academy in 1965, and received a master of science in astronautical engineering from Purdue University in 1966.

He received his pilot wings at Williams Air Force Base, AZ, in 1967, and subsequently was assigned as an operational pilot completing 361 combat missions in Vietnam. He attended the USAF Aerospace Research Pilot School at Edwards Air Force Base, CA, in 1971, and following graduation, served as an F-104 instructor pilot. In 1973, he was assigned as a test pilot working with the Royal Air Force, Boscombe Down, United Kingdom. He then attended the USAF Air Command and Staff College and upon graduation was assigned to USAF Headquarters in the Pentagon.

Blaha was pilot on Shuttle mission STS-29, flown March 13-18, 1989, to deploy a Tracking and Data Relay Satellite. Blaha next flew in space as pilot on STS-33 from Nov. 22-27, 1989, a Department of Defense-dedicated mission. Blaha has logged a total of 239 hours in space.

MICHAEL A. BAKER, 37, Cmdr., USN, will serve as Pilot. Selected as an astronaut in 1985, Baker, from Lemoore, CA, will be making his first space flight.

Baker graduated from Lemoore Union High School in 1971 and received a bachelor of science degree in aerospace engineering from the University of Texas in 1975.

He earned his wings at NAS Chase Field, Beeville, TX, in 1977 and attended the USN Test Pilot School in 1981, becoming an instructor at the school after graduation.

After his selection as an astronaut, Baker was assigned as a member of the team pursuing redesign, modification and improvements to Shuttle landing and deceleration systems before the return to flight following the Challenger accident. Baker also has served as a CAPCOM in Mission Control for 11 Shuttle flights.

SHANNON W. LUCID, 48, Ph.D., will serve as Mission Specialist 1 (MS1). Selected as an astronaut in 1978, Lucid considers Bethany, OK, her hometown and will be making her third space flight.

Lucid graduated from Bethany High School in 1960; received a bachelor of science degree in chemistry from the University of Oklahoma in 1963; and received a master of science followed by a doctorate in biochemistry in 1970 and 1973, respectively, from the University of Oklahoma.

Lucid flew as a mission specialist on STS-51G, June 17-24,1985, on which the crew deployed three communications satellites and used the mechanical arm to deploy and retrieve an X-ray astronomy platform. She next flew on STS-34, Oct. 18-23, 1989, that deployed the Galileo planetary probe on its way to explore Jupiter and operated the Shuttle Solar Backscatter Ultraviolet instrument. Lucid has logged more than 290 hours in space.

BIOGRAPHICAL DATA

G. DAVID LOW, 35, will serve as Mission Specialist 2 (MS2). Selected as an astronaut in 1984, Low will be making his second space flight.

Low graduated from Langley High School, McLean, VA, in 1974; received a bachelor of science in physics-engineering from Washington and Lee University in 1978; a bachelor of science in mechanical engineering from Cornell University in 1980; and received a master of science in aeronautics and astronautics from Stanford University in 1983.

Low served as a mission specialist on STS-32, Jan. 9-20, 1990, a flight that retrieved the Long Duration Exposure Facility using the Shuttle's mechanical arm. Low has logged more than 261 hours in space.

JAMES C. ADAMSON, 45, Col., USA, will serve as Mission Specialist 3 (MS3). Selected as an astronaut in 1984, he will be making his second space flight and considers Monarch, MT, his hometown.

Adamson received a bachelor of science in engineering and was commissioned in the Army at West Point in 1969. In 1977, he received a master of science in aerospace engineering from Princeton University.

He completed undergraduate and graduate pilot training and paratrooper training in the Army and has served as a test pilot, logging over 3,000 hours in 30 different aircraft. Adamson worked for NASA in mission control, serving as a guidance, navigation and control officer prior to his selection as an astronaut. Adamson flew on STS-28, Aug. 8-13, 1989, a Department of Defense-dedicated mission. He has logged 121 hours in space.

STS-43 MISSION MANAGEMENT

NASA HEADQUARTERS, WASHINGTON, DC

Richard H. Truly	NASA Administrator
J. R. Thompson	Deputy Administrator
Dr. William Lenoir	Associate Administrator, Office of Space Flight
Robert L. Crippen	Director, Space Shuttle
Leonard S. Nicholson	Deputy Director, Space Shuttle (Program)
Brewster Shaw	Deputy Director, Space Shuttle (Operations)
Charles Force	Associate Administrator for Space Operations
Eugene Ferrick	Director, Space Network
David Harris	Manager, Space Network Operations
James Maley	Manager, Launch and Space Segment
Daniel Brandel	Manager, TDRSS Continuation
Raymond Newman	Manager, Ground Segment

KENNEDY SPACE CENTER, FL

Forest S. McCartney	Director
Jay Honeycutt	Director, Shuttle Management and Operations
Robert B. Sieck	Launch Director
John T. Conway	Director, Payload Management and Operations
P. Thomas Breakfield	Director, STS Payload Operations
Russell D. Lunnen Jr.	STS-43 Payload Manager

JOHNSON SPACE CENTER, HOUSTON, TX

Aaron Cohen	Director
Paul J. Weitz	Deputy Director
Daniel Germany	Manager, Orbiter and GFE Projects
Paul J. Weitz	Acting Director, Flight Crew Operations
Eugene F. Kranz	Director, Mission Operations
Henry O. Pohl	Director, Engineering
Charles S. Harlan	Director, Safety, Reliability and Quality Assurance

MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, AL

Thomas J. Lee	Director
Dr. J. Wayne Littles	Deputy Director
G. Porter Bridwell	Manager, Shuttle Projects Office
Dr. George F. McDonough	Director, Science and Engineering
Alexander A. McCool	Director, Safety and Mission Assurance
Victor Keith Henson	Manager, Solid Rocket Motor Project
Cary H. Rutland	Manager, Solid Rocket Booster Project
Jerry W. Smelser	Manager, Space Shuttle Main Engine Project
Gerald C. Ladner	Manager, External Tank Project

GODDARD SPACE FLIGHT CENTER, GREENBELT, MD

Dr. John M. Klineberg	Director
Dr. Dale W. Harris	Director, Flight Projects
Dale L. Fahnestock	Director, Mission Operations and Data Systems
Daniel A. Spintman	Chief, Networks Division
Vaughn E. Turner	Chief, Communications Division
Charles Vanek	Project Manager, Advanced TDRS Project
Thomas E. Williams	Deputy Project Manager, Advanced TDRS Project
Nicholas G. Chrissotimos	TDRS Manager
Gary A. Morse	Network Manager

STENNIS SPACE CENTER, BAY ST. LOUIS, MS

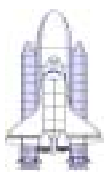
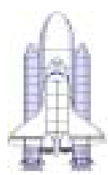
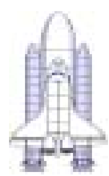
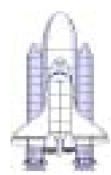
Roy S. Estess	Director
Gerald W. Smith	Deputy Director
J. Harry Guin	Director, Propulsion Test Operations

AMES-DRYDEN FLIGHT RESEARCH FACILITY, EDWARDS, CA

Kenneth J. Szalai	Director
T.G. Ayers	Deputy Director
James R. Phelps	Chief, Shuttle Support Office

SHUTTLE FLIGHTS AS OF JULY 1991

41 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 16 SINCE RETURN TO FLIGHT

		STS-39 04/28/91 - 05/06/91	
STS-40 06/05/91 - 06/14/91		STS-41 10/06/90 - 10/10/90	
STS-35 12/02/90 - 12/10/90	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-37 04/05/91 - 04/11/91
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 (11 flights)	**OV-099 Challenger (10 flights)**	**OV-103 Discovery (12 flights)**	**OV-104 Atlantis (8 flights)**