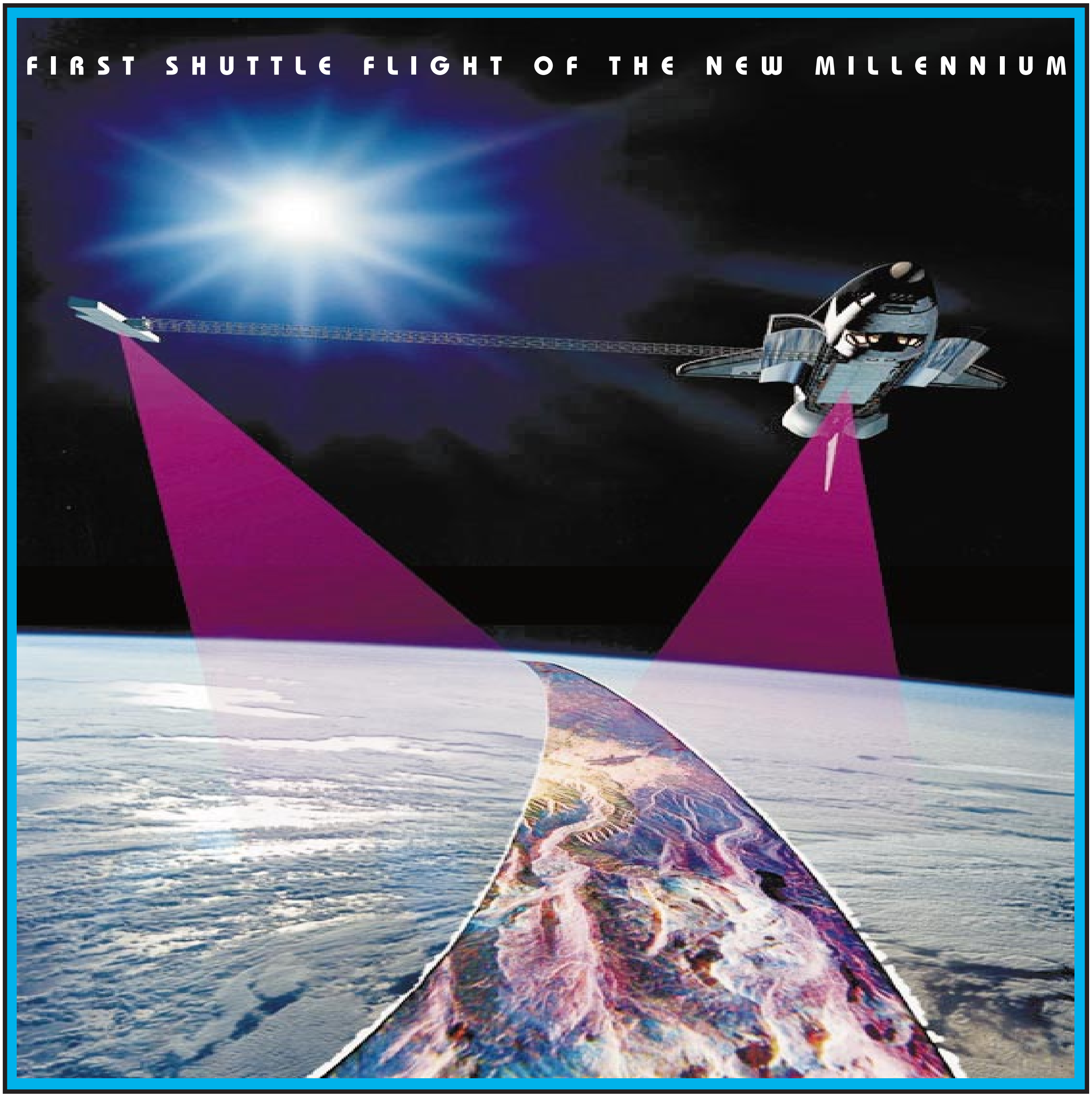
SHUTTLE RADAR TOPOGRAPHY MISSION



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NASA

USA
United Space Alliance

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Updated January 20, 2000

STS-99 Table of Contents

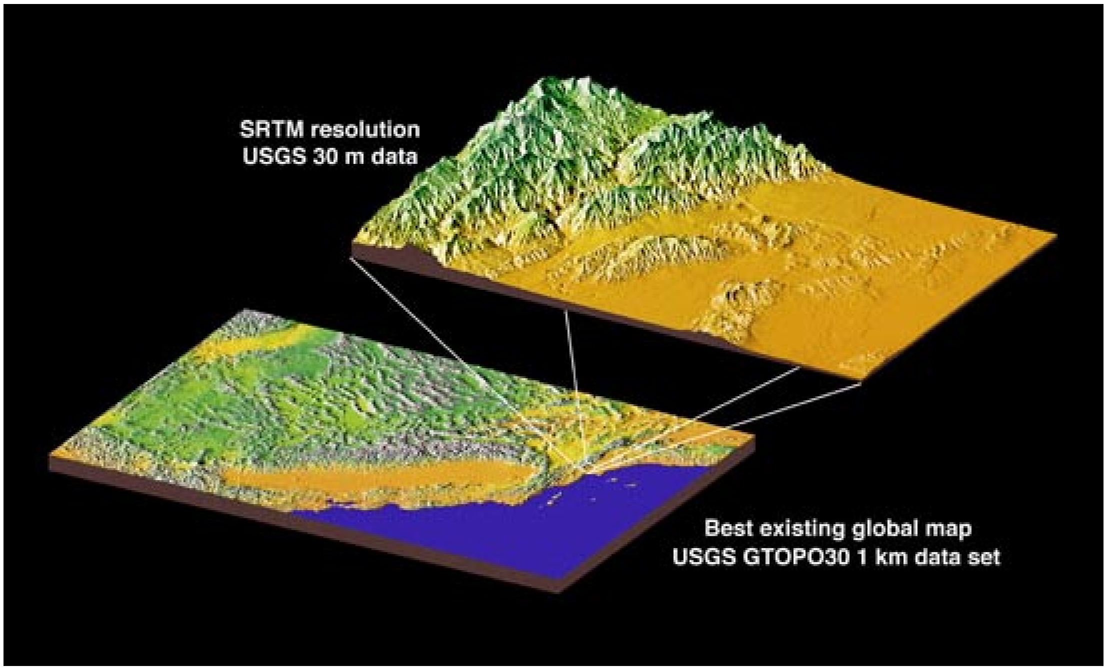
Endeavour OV105

Launch: Monday, January 31, 2000

Mission Objectives

The primary objective of the Shuttle Radar Topography Mission is to acquire a high-resolution topographic map of the Earth's land mass (between 60°N and 56°S) and to test new technologies for deployment of large rigid structures and measurement of their distortions to extremely high precision.

The Shuttle Radar Topography Mission represents a breakthrough in the science of remote-sensing and will produce topographic maps of Earth 30 times as precise as the best global maps in use today. The information will be used to attempt to produce one of the most comprehensive and accurate maps of Earth ever assembled.



A Comparison of Resolution Data

Data Statistics

Planned Data Takes	**Approximately 1,000 (every time Endeavour is over land)**
Data Acquisition	more than 80 hours
Data recording rate	180 Mbits/sec for C-band, 90 Mbits/sec for X-band
Total Raw Radar Data	9.8 Terabytes (15,000 CDs)
Data Tapes	**300 high-density tapes (each tape records 30 min. of C-band, or** or 60 min. of X-band data)

In addition, this mission offers a number of applications for data products and science, including: geology, geophysics, earthquake research, volcano monitoring; hydrologic modeling; ecology; co-registration and terrain correction of remotely-acquired image data; atmospheric modeling; flood inundation modeling; urban planning; natural hazard consequence assessments; fire spread models; and transportation/infrastructure planning.

Civilian Applications

Enhanced ground collision avoidance systems for aircraft; civil engineering, land use planning, and disaster recovery efforts; and line-of-sight determination for communications, e.g., cellular telephones.

Military Applications

Flight simulators; logistical planning, air traffic management; missile and weapons guidance systems; and battlefield management, tactics.

Crew

Commander:	Kevin R. Kregel
Pilot:	Dom L. Gorie
Mission Specialist 1:	Gerhard P.J. Thiele
Mission Specialist 2:	Janet L. Kavandi
Mission Specialist 3:	Janice Voss
Mission Specialist 4:	Mamoru Mohri

Launch

Orbiter:	Endeavour OV105
Launch Site:	
Launch Window:	2 hours, 02 minutes
Altitude:	126 nautical miles
Inclination:	57 degrees
Duration:	11 Days 4 Hrs. 5 Min.

Vehicle Data

Shuttle Liftoff Weight:	4,520,415 lbs.
Orbiter/Payload Liftoff Weight:	256,560 lbs.
Orbiter/Payload Landing Weight:	225,669 lbs.

Payload Weights

SRTM 14.5 tons

Software Version: OI-27

Space Shuttle Main Engines

SSME 1: 2052 **SSME 2:** 2044 **SSME 3:** 2047

External Tank: ET-92 (Super Light Weight Tank)

SRB Set: BI-100/RSRM-71

Landing

Landing Date:	02/11/00
Landing Time:	4:55 PM (eastern time)
Primary Landing Site:	KSC Shuttle Landing Facility

Payloads

Cargo Bay

Payload Overview, Applications, and Benefits

SRTM Hardware--the Mast

SRTM Hardware--the Antenna

Data Recording, Processing, and Products

In-Cabin

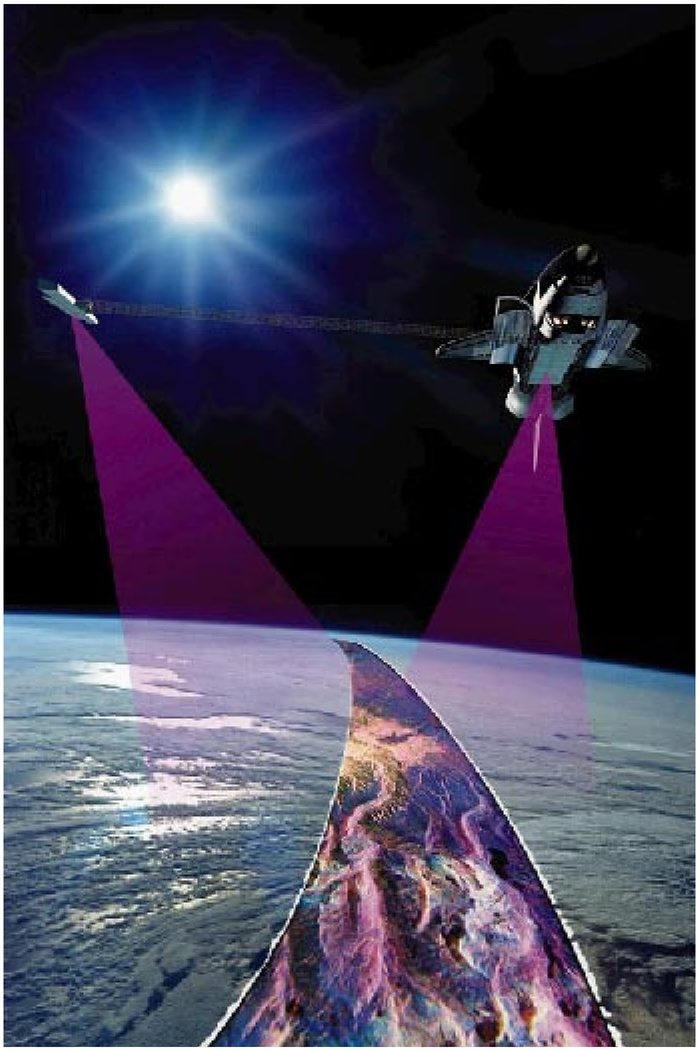
EarthKAM

Mission Overview

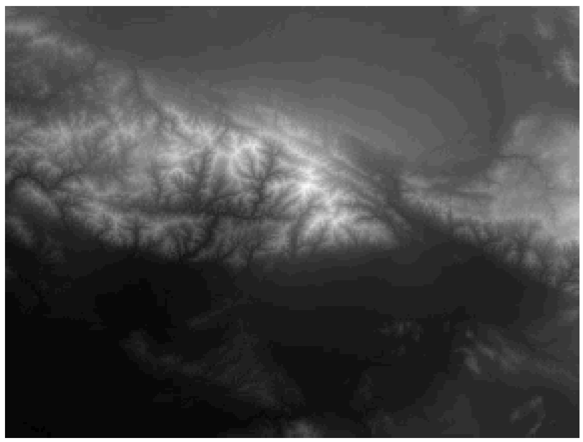
An innovative imaging radar, the first to map the Earth in three dimensions, is the primary payload onboard STS-99, the first Shuttle flight of the new century.

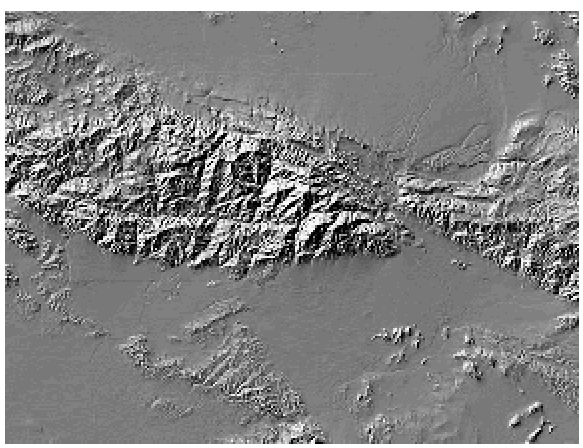
Known as the Shuttle Radar Topography Mission, this radar system represents a breakthrough in the science of remote-sensing and will produce topographic maps of Earth 30 times as precise as the best global maps in use today. The information has the potential to produce one of the most comprehensive and accurate maps of Earth ever assembled.

Scheduled for launch no earlier than January 31 from the Kennedy Space Center, the Space Shuttle Endeavour will carry the radar into space for an 11-day mission to learn more about the planet's changing landscapes, its environmental health, and many ecosystems.



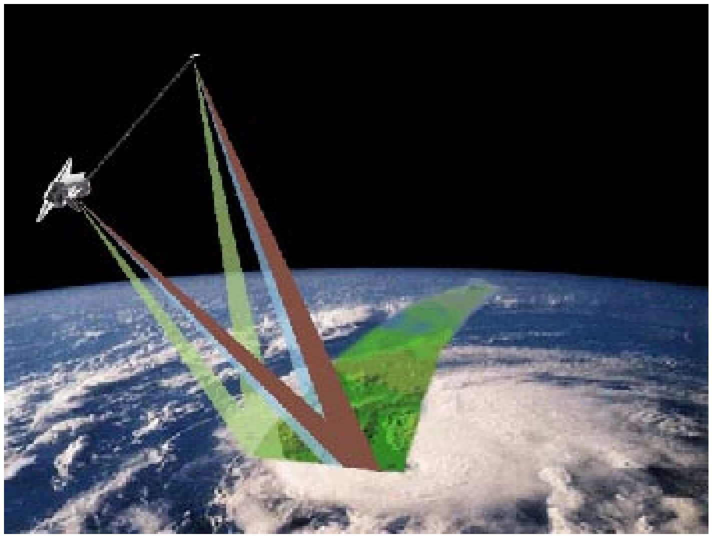
The imaging radar will be able to capture landscapes that have been sculpted through the millennia, with the passage of ice ages and periods of warmer weather. This new imaging system will orbit at 145 miles (233 kilometers) above Earth, with two radar antennas mounted in the Shuttle payload bay and two extended on a 200-foot-long (60-meter) mast. The radar will image vast, barren deserts, frozen tundra, and deep valleys carved by glaciers, such as those found in Alaska, the Andes, and Himalaya mountains. The vestiges of ancient human settlements, such as the Eighth Century Khmer civilization of Angkor, Cambodia, and the habitats of endangered species, such as the mountain gorillas of Central Asia, will be mapped.





The 13-ton radar system will be able to collect highly accurate, high-resolution images of Earth's crust between 60 degrees north latitude and 56 degrees south latitude. The regions to be mapped are home to about 95 percent of the world's population and will be captured with an accuracy of better than 100 feet (30 meters).

The genesis of the Shuttle Radar Topography Mission lies in NASA's 1994 flights of the Spaceborne Imaging Radar C/X-band Radar on STS-59 and STS-68. Several modifications have been made to the radar systems, which give the mission new capabilities compared with its predecessors. The cornerstone of innovation is the addition of a C-band and an X-band antenna at the end of a deployable mast, which will be the longest rigid structure ever flown in space. This will be the first time that a dual-antenna imaging radar is flown, allowing scientists to use a technique called interferometry--which is akin to combining stereo images--to map terrain elevation in a single pass.



By using interferometry to combine two images electronically, researchers will be able to generate computer versions of topographic maps, called digital elevation models. With the exception of weather satellite measurements, this topographic information will be the most universally useful data set about the Earth ever produced.

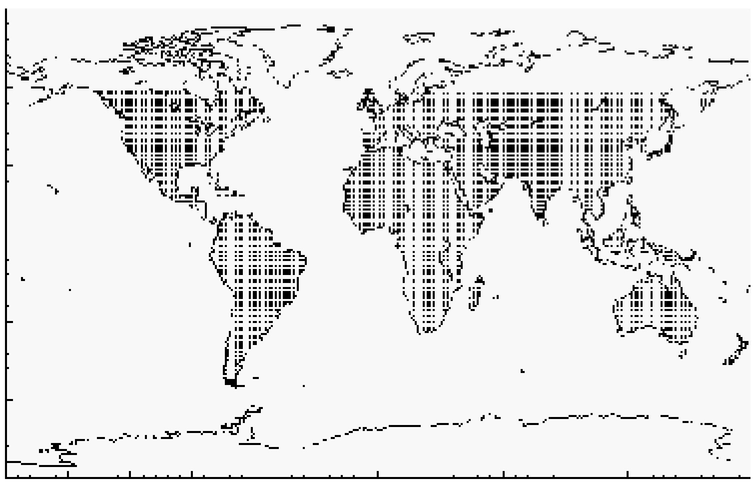
The mission is a partnership between NASA and the National Imagery and Mapping Agency, in which the agencies are jointly seeking information with valuable research and operational uses. The Shuttle Radar Topography Mission will provide important information for NASA's Earth Science Enterprise, which is dedicated to understanding the total Earth system and the effects of human activity on the global environment.

In addition to NASA and the National Imagery and Mapping Agency (NIMA), the Shuttle Radar Topography Mission is a collaboration of the German Aerospace Center (Deutsches Zentrum fur Luft- und Raumfart) and the Italian Space Agency, which provided the experimental X-SAR radar system. The two agencies are providing science teams for the mission. The Jet Propulsion Laboratory is managing the project for NASA's Earth Sciences program in Washington, D.C.

Background

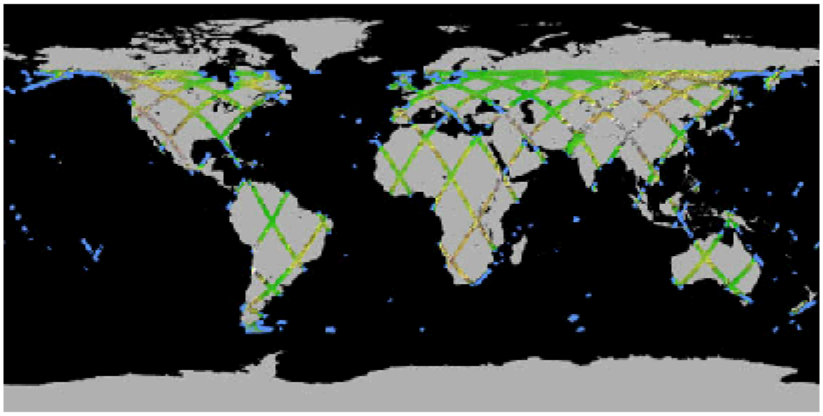
The Shuttle Radar Topography Mission (SRTM) provides a platform for mapping vast areas of the Earth in the relatively short time of a Shuttle flight. In addition, the processing of SRTM data will be almost completely automatic, allowing nearly 1 trillion measurements of the Earth's topography to be integrated into a consistent, high-resolution map.

Surprisingly, our home planet isn't mapped as well as one might think. A few countries, such as the U.S., much of Europe, Australia, and New Zealand, have digital maps at the 30 m (100 foot) resolution level, but the vast majority of our planet lacks maps at that resolution, and many lack reliable maps altogether. The main reason for this is that much of the globe, the equatorial regions in particular, are cloud-covered much of the time. Thus, optical cameras on satellites or aircraft can't image the areas. SRTM radar, with its long wavelength, will penetrate clouds as well as providing its own illumination, making it independent of daylight.


The land area to be mapped by SRTM

In the past decade, numerous imaging radar satellites have been lofted to orbit by the European Space Agency, Japan, and Canada. These radar systems have been demonstrated to have the capability to produce digital topographic data in many situations. However, none of these satellites was designed for the production of digital topographic maps, so they lack some important features of SRTM. The most important feature they lack is a second antenna. While it is possible to obtain the second radar image on a subsequent orbit using a single radar system, it is difficult to measure the separation between the two passes to the required millimeter accuracy. If enough control points can be measured in each scene so that the elevation is known for those points, it is possible to solve for the unknown radar positions. Since SRTM will measure the separation and orientation of its two antennas to a high precision, it needs few control points to make its maps.

SRTM is the culmination of a broad arc of technological innovation. Starting with the first civilian spaceborne imaging radar, Seasat, in 1978, it was discovered that meaningful radar images of the land could be obtained from space. Subsequent tests using the Shuttle proved the worth of that platform for improving the technology. The third Shuttle Imaging Radar, SIR-C, tested two critical technologies required for the development of SRTM: active, phased array antennas and ScanSAR. The active antenna was required for its ability to steer to any angle through electronic manipulation of the radar beam. No moving parts were required. ScanSAR was derived from that capability. The radar beam is literally scanned back and forth across as the Shuttle orbits, painting out a much wider swath than was possible in ordinary operation. Thus, the earlier swath of 50 km was increased to 225 km. It turns out that 225 km is just enough for an 11-day Shuttle mission to literally "cover the Earth" by painting one swath at a time.



Updated: 01/18/2000

Crew Profile Menu

Commander: Kevin R. Kregel

Making his fourth flight into space, Kregel has overall responsibility for the success and safe conduct of the STS-99 mission.

Kregel will lead the Red team shift, with his crewmates divided into two three-person teams working 12-hour shifts to conduct round-the-clock science activities. Kregel also is in charge of the operation of an HDTV camera during the flight and the EarthKam payload.

Kregel previously flew as pilot on STS-70 and STS-78 and commanded the STS-87 mission.

Ascent Seating: Flight Deck - Port Forward
Entry Seating: Flight Deck - Port Forward

Pilot: Dom L. Gorie

Gorie (Commander, USN) will lead the Blue team shift during STS-99 on this, his second flight into space.

A veteran of the STS-91 mission, Gorie will operate an HDTV camera and the EarthKam payload during the flight and will oversee orbiter operations during his 12-hour shift on the flight deck. Gorie would also serve as an intravehicular crew member, or choreographer, in the event a contingency spacewalk is required.

Ascent Seating: Flight Deck - Starboard Forward
Entry Seating: Flight Deck - Starboard Forward

Mission Specialist 1: Gerhard P.J. Thiele

In his first flight into space, European Space Agency astronaut Gerhard Thiele will work on the Red team shift, responsible for SRTM operations, including the deployment and retraction of the 200-foot high boom from Endeavour's cargo bay upon which one of the flight's radar systems is mounted.

Thiele would also be one of two spacewalking crew members along with Janet Kavandi, in the event a contingency spacewalk is required during the flight.

Ascent Seating: Flight Deck - Starboard Aft
Entry Seating: Mid Deck - Starboard

Mission Specialist 2: Janet L. Kavandi

In her second flight into space, Kavandi will be the flight engineer during Endeavour's launch and landing phases, sitting behind Kregel and Gorie on the flight deck.

She will work on the Red team shift, responsible for SRTM

spacewalk along with Thiele if a contingency arose during the mission.

Ascent Seating: Flight Deck - Center Aft
Entry Seating: Flight Deck - Center Aft

Mission Specialist 3: Janice Voss

Voss will work on the Blue team shift during STS-99 and, as Payload Commander, has the overall responsibility for the operation of the SRTM systems during the flight.

Voss is making her fifth trip into space, having previously flown on STS-57, STS-63, STS-83 and STS-94.

Ascent Seating: Mid Deck - Port
Entry Seating: Mid Deck - Port

Mission Specialist 4: Mamoru Mohri

NASDA astronaut Mohri is making his second flight into space,

Mohri will join Voss for responsibility of the SRTM payload during the Blue team shift and would serve as an intravehicular crew

contingency spacewalk was required. Mohri will also operate an

secondary experiments.

Ascent Seating: Mid Deck - Starboard
Entry Seating: Flight Deck - Starboard Aft

Flight Day Summary

DATE TIME (EST)	DAY	MET	EVENT
01/31/00 12:47:00 PM	0	000/00:00:00	Launch Time
01/31/00 1:24:00 PM	0	000/00:37:00	OMS-2
01/31/00 5:12:00 PM	0	000/04:25:00	Orb Adj.
01/31/00 6:07:00 PM	0	000/05:20:00	Mast Deploy
02/01/00 1:16:00 AM	1	000/12:29:00	Trim 1
02/02/00 2:09:00 AM	2	001/13:22:00	Trim 2
02/03/00 2:12:00 AM	3	002/13:25:00	Trim 3
02/04/00 1:41:00 AM	4	003/12:54:00	Trim 4
02/05/00 3:31:00 AM	5	004/14:44:00	Trim 5
02/06/00 1:14:00 AM	6	005/12:27:00	Trim 6
02/07/00 3:03:00 AM	7	006/14:16:00	Trim 7
02/08/00 2:15:00 AM	8	007/13:28:00	Trim 8
02/09/00 1:04:00 AM	9	008/12:17:00	Trim 9
02/10/00 4:52:00 PM	11	010/04:05:00	Landing
02/10/00 10:47:00 PM	10	010/10:00:00	Mast Retract (subject to change)
02/11/00 4:55:00 PM	11	011/04:08:00	Deorbit

Updated: 01/20/2000

Science and Technology Applications

Secondary Objective

Science and Technology Applications

Just within the past decade, Earth scientists have developed sophisticated computer models that integrate their observations of the planet's surface, allowing them a greater understanding of natural systems and a more reliable method for predicting changes in the atmosphere, land, and sea that are brought on by natural events and human-induced activities.

Topographic data are critical to the accuracy of these computer models. That is because Earth's shape determines the flow of air, water, and ice, and the geography of all life, including people. Topographic data also give scientists clues about the underlying structure of the Earth, including its tectonic activity.

The data will have a variety of uses in scientific disciplines ranging from hydrology, geology, and archaeology to ecology and studies of urban development and its impact on the environment.

Hydrology concentrates on the storage, distribution, and movement of water as rain and snow, in streams and rivers, within the soil as ground water, and as glaciers and ice caps. Scientists have developed models for the Earth's water cycle, and topography plays a key role in determining the

Threats to water resources from groundwater pollution or climate change can be evaluated using these models. Flood predictions are another important product of accurate hydrological models. The Shuttle Radar Topography Mission will give scientists globally consistent topographic data for these models, allowing them to better understand natural resources in abundance and scarcity throughout the world.

SRTM Partners and Imaging Radar History at NASA and JPL

Secondary Objective

The History of Imaging Radar at NASA and JPL

NASA and JPL's orbital radar program began with the Seasat synthetic aperture radar in 1978. Seasat was a single-frequency, L-band (wavelength of 24 cm or 9-1/2 inches), single polarization, fixed look-angle radar designed for ocean studies.

The first of the Shuttle Imaging Radars, called SIR-A, flew on the second Space Shuttle flight in 1981 and was also an L-band radar with a fixed look-angle. The second of that series, SIR-B, which flew on the Space Shuttle in 1984, used an L-band, single polarization radar with an adjustable look angle. The third mission, SIR-C/X-SAR, provided increased capability over Seasat, SIR-A, and SIR-B by being able to acquire images at three microwave wavelengths: L-band with quadruple polarization; C-band (6 centimeters or 2.4 inches) quadruple polarization; and X-band (3 centimeters or 1.2 inches)with a single polarization. SIR-C/X-SAR also had a variable look angle and could image at incidence angles between 20 and 65 degrees. SIR-C/X-SAR flew onboard the Shuttle in April and October of

Typical image sizes for SIR-C data products were 50 by 100 kilometers (30 by 60 miles), with resolution of between 10 and 25 meters (33 and 82.5 feet).

Parallel to the development of spaceborne imaging radars, JPL has built and operated a series of airborne imaging radar systems. The laboratory currently maintains and operates an airborne SAR system, known as AIRSAR/TOPSAR, which flies on a NASA DC-8 jet. This system collects radar images at three radar wavelengths: C-band, L- band, and P-band (68 cm or 27 in.). It also collects interferometric radar data at C-band and L-band with pairs of antennas mounted on the fuselage.

NASA's Office of Earth Sciences also is studying designs for future imaging radar missions that would be less expensive to fly and provide detailed coverage of regions that have not yet been imaged. Potential missions might include mapping freezing and thawing transition zones in polar regions, monitoring changes in the Earth's crust on a scale of millimeters, mapping topography areas that are prone to earthquakes and volcanic activity, and mapping vegetation cover to assess the rate of recovery from such stresses as deforestation, biomass burning, and other human activities and natural phenomena.

The National Imagery and Mapping Agency (NIMA)

The National Imagery and Mapping Agency (NIMA)is a member of the intelligence community and is a Department of Defense combat support agency. NIMA was created in 1996 to accelerate the fusion of geospatial information and imagery intelligence and to meet growing customer needs for a common, digital view of the mission space. NIMA is committed to delivering the imagery and geospatial information that gives national policymakers and military users information superiority in a rapidly changing global environment.

With its headquarters in Bethesda, Md., NIMA operates major facilities in St. Louis, Mo., Washington, D.C., and Reston, Va., and services a wide array of customers throughout the world. Professionals in disciplines such as cartography, imagery analysis, the physical sciences, geodesy, and photogrammetry make up NIMA's combined military and civilian work force.

Mission

NIMA's mission is to provide timely, relevant, and accurate imagery, imagery intelligence, and geospatial information in support of U.S. national security objectives.

Mapping in Three Dimensions

Presently, the U.S. has a better global topographic map of Venus than it does of the Earth's surface. However, the SRTM mission will improve our ability to produce topographic information by collecting high-resolution elevation data over most of the Earth's land surface. To process the data, NIMA uses Digital Terrain Elevation Data (DTED®), a process of evenly spaced points on the Earth's surface whose elevations have been recorded. These elevation data will provide an estimate of surface height every 30 meters, a density three times greater than the currently available height map.

Digital Terrain Elevation Data (DTED)

DTED is used by NIMA's military and civilian customers for a wide range of uses. Recently, NIMA provided the National Transportation Safety Board DTED converge to complete a video reconstruction of a major aviation accident. By providing a third dimension to normally flat map depiction, the DTED enabled investigators to view the terrain as the pilot saw it before the accident.

After Hurricane Mitch, NIMA provided DTED to the U.S. Geological Survey in support of a White House-sponsored Central American Reconstruction Task Force. To aid in recovery operations and infrastructure reconstruction, DTED was used to show terrain elevation in the affected countries before and after the hurricane. Back home, DTED has been combined with satellite imagery to generate a variety of commercial remote sensing data and products through NASA's Global LandSat Mapping Project.

The terrain data from SRTM is likely to spawn many uses for geospatial information that will save lives and enhance economic development around the world. SRTM data also can be used for hydrological studies that analyze ground water flow, optimizing the locations for cellular phone towers;

earthquake and glacier activity monitoring; and terrain modeling around airports to provide for safer approach routes.

Military uses of DTED include scene visualization, command-and-control, navigation and targeting. When draped over imagery in terrain modeling systems, DTED is used to produce simulated "fly throughs" that facilitate planning and enable aircrews to rehearse a mission before flying it. DTED also has been used to generate realistic radar and cockpit views in flight training simulators.

The Army uses DTED to determine field of view from different advance points, develop lines of sight, and identify minimum heights to keep a target in sight. The Army also uses DTED to determine the slope of terrain for off-the-road mobility and in dam analyses. Terrain analysts can measure the capacity of a dam with DTED and predict the impact of flooding, including the velocity of released water.

Products are currently produced with DTED on the Army's Combat Terrain Information System (CTIS). As the Army moves toward "dominant battle space awareness" under Joint Vision 2010, DTED will become a fundamental component of this vision.

DLR
(Deutsches Zentrum fuer Luft- und Raumfahrt, German Aerospace Center)

Germany's contribution to this spectacular international concerted effort is the X-band radar interferometer with DLR as the project lead and responsible for system engineering, mission operation, calibration, data processing, archiving, distribution, and data utilization. Dornier Satellitensysteme, together with the Italian Space Agency (ASI), is responsible for the development of the X-SAR flight instrument. X-SAR operates within the X-band of the electromagnetic spectrum at a wavelength of 3.1 cm, equivalent to a frequency of 9.6 Gigahertz.

DLR's Institute of Radio Frequency Technology was able to draw on its long experience with imaging synthetic aperture radar systems. Idea and conception for the construction of the X-SAR system originated at this institute. Several teams have participated in its realization. The scientific and technological supervision, as well as calibration and mission control, are with Institute of Radio Frequency Technology. The German X-SAR captures 50-kilometer swaths of the Earth's surface, mapping 40 percent of all orbits at a significantly high resolution.

DLR's German Space Operation Center (GSOC) in Oberpfaffenhofen is involved in mission planning, operational system design and in the mission itself. Each minute of the precious remote sensing time is planned years in advance. During the mission, the team will work in NASA's mission and

According to the open policy on Earth observation data, which is one of the main goals of DLR, X-SAR data will not be classified but will be made available to the general public. DLR's German Remote Sensing Data Center

(DFD), also located in Oberpfaffenhofen, will process the data acquired in the course of the mission and take care of the distribution. Users are from many disciplines. Hydrologists can exactly determine area of river flooding, geologists make out small changes in earthquake zones and around volcanoes, ecologists receive precise information in the extent and condition of vegetation, and climatologists are able to improve their forecast models. Also telecommunication, agriculture, air traffic, and marine navigation experts can profit from the SRTM information.

Dornier Satellitensysteme GmbH plays a leading role in the area of Earth observation in Europe. The company is a main industrial contractor for the radar satellites ERS-1 and ERS-2 and heads the environmental mission Envistal-1. For many years DSS has successfully participated in the development of Earth observation devices. One focus was on high-resolution SAR instruments. Dornier Satellitensysteme also offers geo-information products through its own service.

Payloads

Payload Overview, Applications, and Benefits

Payload Bay

14.5 tons lbs.

Prime:

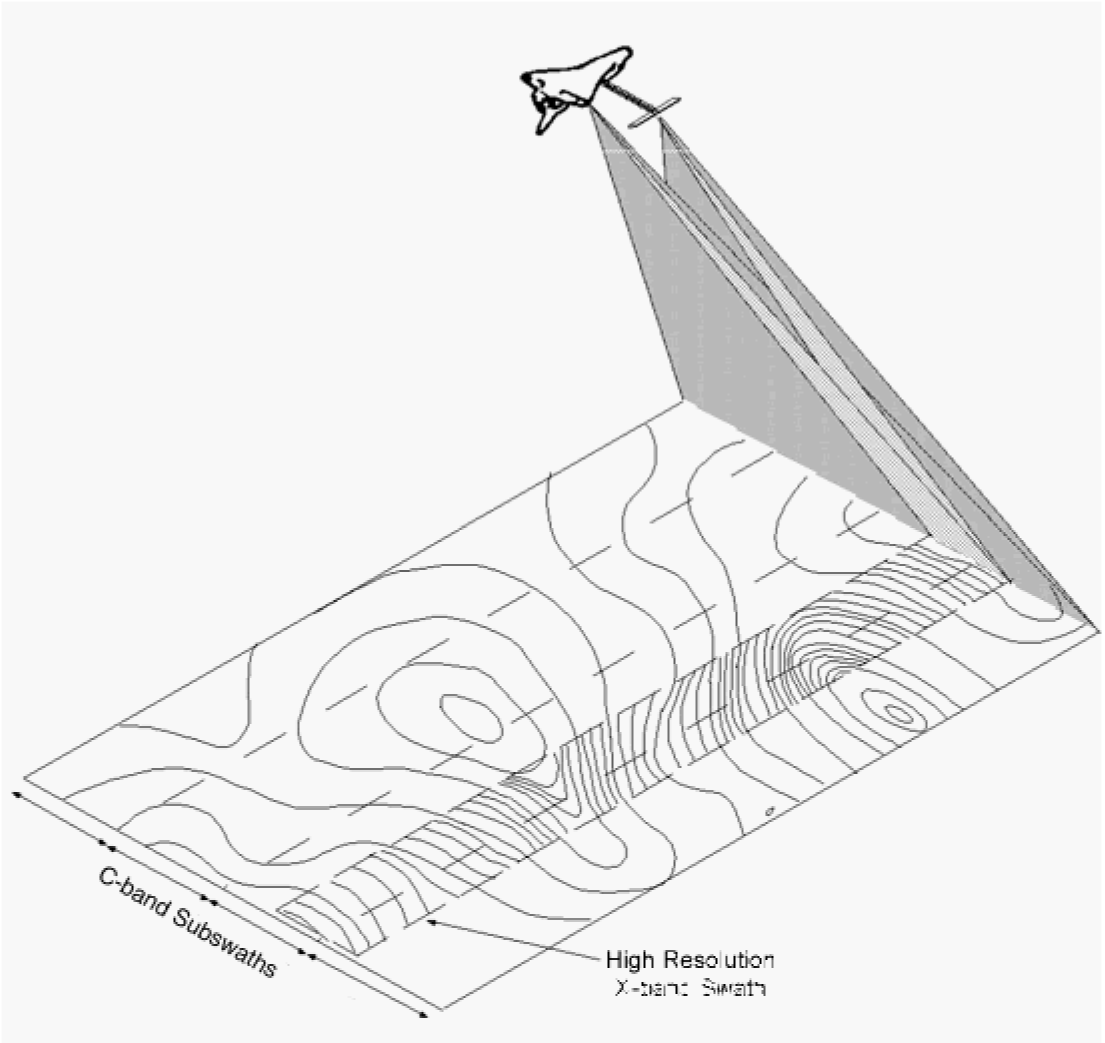
Backup:

Overview

On-Orbit Check-Out (OOCO) will take up the first 14-16 hours of the mission. During this time, the radar will be powered up, the mast will be deployed, the antennas will be aligned, and the first data will be acquired and analyzed on the ground. The major milestones, in Mission Elapsed Time (MET) are:

MET	EVENT
0:00	Launch
1:30	Payload Bay doors open
2:00 - 3:00	(AODA), and recorders
5:30	Mast deploy
7:00	AODA confirms mast deploy
8:00	Flip outboard antennas
8:30	First possible radar data
9:00	Pulse tests of mast resonant frequencies
10:00	Milkstool unstow and cold-gas enable
11:00	Radar data acquired
12:00	Radar data analyzed
14:00 - 15:00	
16:00	End OOCO, start of mapping

Creating 3-D images of the Earth's surface will require the first on-orbit use of single-pass interferometry, which means these topographic snapshots will take just one pass by the Shuttle, using the dual antennas. The Shuttle Radar Topography Mission will attempt to make close to 1 trillion measurements during the 11-day mission.



A reflection of the C-band and X-band Swaths

The power required to operate the Shuttle Radar Topography Mission and its associated equipment will push the edge of the Shuttle's generating capability. The payload will need 900 kilowatt-hours, enough to power a typical home for 2-3 months.

All data will be recorded onboard the Shuttle using payload high-rate tape recorders. Data will be recorded at a rate of 180 megabits per second for the C-band radar and 90 megabits per second for the X-band radar. The total data expected to be recorded are nearly 10 terabytes, enough to fill 15,000 compact disks. The data will be recorded on 300 high-density tapes.

Verifying that the data are properly recorded will be a challenge in itself, as data will be generated at a rate of four times the speed at which it can be downlinked from the Shuttle to the ground. Some data will be played back from the tape recorders at 1/4 speed and downlinked to the ground using the Shuttle Ku-band link to NASA's Tracking and Data Relay System satellites.

History/Background

What Is Imaging Radar?

Since radars provide their own illumination, they can image regions of the world at any time of the day or night. Also, because the radar wavelengths are much longer than those of visible or infrared light, synthetic aperture radar imaging also can "see" through cloudy and dusty conditions that would blind visible and infrared instruments.

An imaging radar works very much like a flash camera. A flash camera sends out a pulse of light--the "flash"--and records on film the light that is reflected back at it through the camera lens. Instead of a camera lens and film, a radar uses an antenna and digital computer tapes to record the reflected pulses of radar "light" that comprise its images. In a radar image, one can see only the light that was reflected back toward the radar antenna.

A typical radar (an acronym for radio detection and ranging) measures the strength and round-trip time of the microwave signals that are emitted by a radar antenna and reflected off a distant surface or object. The radar antenna alternately transmits and receives pulses at particular microwave wavelengths (in the range of 1 centimeter to 1 meter, which corresponds to a frequency range of about 300 MHz to 30 GHz). For an imaging radar system, about 1500 high-power pulses per second are transmitted toward the target or imaging area, with each pulse having a pulse duration, called a pulse width, of typically 10-50 microseconds.

At the Earth's surface, the energy in the radar pulse is scattered in all directions, with some reflected back toward the antenna. This so-called "backscatter" returns to the radar as a weaker radar echo and is received by the antenna. These echoes are converted to digital data and passed to a data recorder for later processing and display as an image.

Radar transmits a pulse and measures reflected echo or backscatter.
In the case of imaging radar, the radar moves along a flight path, and the area illuminated by the radar is moved along the surface in a swath, building the image as it moves along building up a radar image using the motion of the platform.

The length of the radar antenna determines the resolution in the azimuth direction of the image, or along the track of the swath that is being taken. The longer the antenna, the finer the resolution will be in this dimension.

Synthetic aperture radar refers to a technique used to synthesize a very long antenna by combining echoes received by the radar as it moves along its flight track. "Aperture" refers to the radar antenna. A "synthetic" aperture is constructed by moving a real aperture or antenna through a series of positions along the flight track.

How Are Radar Images Produced?

Radar images are composed of many dots, or picture elements. Each pixel, or picture element, in the radar image represents the radar backscatter, or the radar pulses that are reflected back from a surface. Darker areas in the image represent low backscatter, brighter areas represent high backscatter. Bright features mean that a large fraction of the radar energy was reflected back to the radar, while dark features imply that very little energy was reflected. Backscatter for an area at a particular wavelength will vary for a variety of conditions, such as the size of the objects being imaged in the desired mapping area, the moisture content of the area, the polarization of the pulses, and the observation angles. Backscatter will also differ when different wavelengths are used.

The rule of thumb in radar imaging is that the brighter the backscatter on the image, the rougher the surface that is being imaged. Flat surfaces that reflect little or no microwave energy back toward the radar always will appear dark in radar images. Vegetation is usually moderately rough on the scale of most radar wavelengths and appears as gray or light gray in a radar image. Surfaces inclined toward the radar will have a stronger backscatter than surfaces which slope away from the radar.

Some areas not illuminated by the radar, like the back slope of mountains, are in shadow and will appear dark. When city streets or buildings are lined up in such a way that the incoming radar pulses are able to bounce off the streets and then bounce again off the buildings--called a double-bounce--and directly back toward the radar, they will appear very bright, or white, in the radar images. Roads and freeways are flat surfaces, so they appear dark. On the other hand, buildings, which do not line up so that the radar pulses are reflected straight back, will appear light gray, like very rough surfaces.

Imaging Different Types of Surfaces With Radar

Backscatter is also sensitive to a mapping area's electrical properties, including water content. Wetter objects will appear bright, and drier objects will appear dark. The exception is a smooth body of water, which will act as a flat surface and reflect incoming pulses away from a mapping area. These bodies will appear dark.

Different observation angles will affect backscatter. The angle of the track will affect backscatter from very linear features, such as urban areas, fences, rows of crops, and fault lines. The angle of the radar wave hitting Earth's surface, called the incidence angle, also will cause a variation in the backscatter. Small incidence angles, which are nearly perpendicular to the surface, will result in high backscatter, whereas the backscatter will decrease with increasing incidence angles.

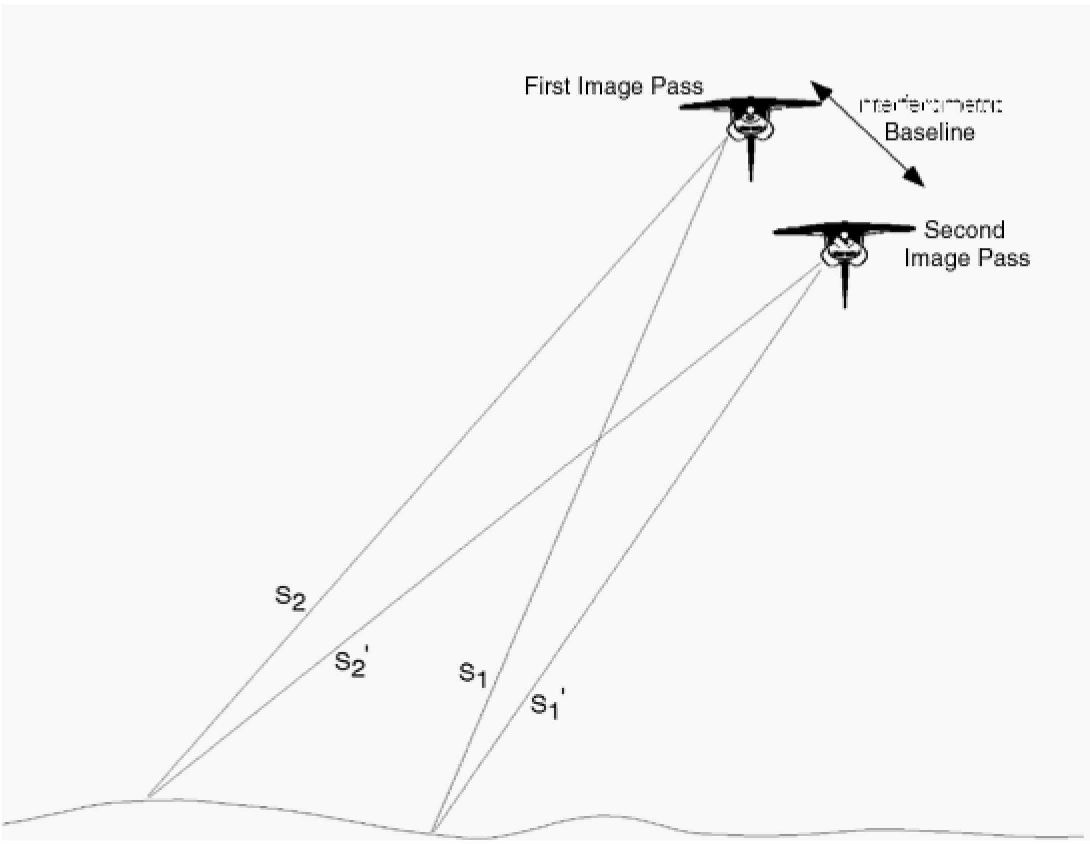
Radar backscatter is a function of the incidence angle.

What Is Radar Interferometry?

Radar interferometry is the study of interference patterns created by combining two sets of radar signals. There are several ways to explain how interferometry works. The following are two ways to explain radar interferometry.

Ripples in Still Water

If one imagines a person standing with both arms extended to his or her side, holding a pebble in each hand, then dropping the pebbles into a puddle of water, two rippling, concentric circles would emanate from the splash of the pebbles in the water. As the two waves travel outward, they will eventually hit each other and cause interference patterns. These interference patterns, where the two sets of waves meet, are the pulses that are measured by an interferometer. The dual measurements will allow scientists to build a single, three-dimensional image.



SIR-C Multiple-Pass Radar Interferometry

When two radar data sets are combined, the first product to be created is called an interferogram, which is also called a "fringe map." A fringe map looks similar to the ripples in a puddle of water. The main antenna located in the Space Shuttle payload bay will illuminate a portion of the surface of the Earth as it passes over, transmitting a radar wave, much like the ripples in a puddle of water that has been disturbed. When the radar wave hits the surface of the Earth, it will be scattered in various directions. These scattered waves will be collected by the two Shuttle Radar Topography Mission antennas. Using the information about the distance between the two antennas and the differences in the reflected radar wave signals, scientists will be able to obtain very accurate measurements of the heights of land surfaces.

Holograms

SRTM is basically producing a hologram of the surface of the Earth. Holograms are usually produced by shining a laser beam onto an object and recording the patterns resulting from the reflected light interfering with a reference laser beam. The result is a 3-D representation of the object on film. It turns out that radars are just like lasers, except they operate in the long wavelength microwave part of the spectrum.

Benefits

Science and Technology Applications

Geomorphology is the study of Earth's landscapes. These geologic formations are all around us, standing as huge mountain ranges, carved deep into the Earth to form valleys, and stretching flat across thousands of miles of land to create plains.

Plate boundaries cut through continents and oceans and are concealed by them. However, titanic geological events along these boundaries offer clues to their locations. Where plates converge, mountains and volcanoes are often found. Where they pull apart, oceans are born. Wherever they grind against each other, they are jostled by frequent earthquakes.

Digital topographic data of mountain ranges, which will be available for the first time with the retrieval of Shuttle Radar Topography Mission data, will allow geologists to test new models of how mountains form and determine the relative strength of the forces that uplift and crumple mountains and the erosive forces which polish and reshape them.

Lower resolution digital topographic data, available only in the last few years, have yielded some surprising results. It seems that landslides in mountainous areas are responsible for far more of the erosion than previously thought, causing revision of many basic ideas of mountain development. Even more surprising, models based on new digital data have shown that erosion of deep valleys into mountain ranges actually causes the adjacent peaks to rise in elevation due to the buoyant force of the underlying mantle.

As with most disciplines, archaeology has become more interdisciplinary, using cutting-edge technological tools in parallel with detailed field work. Increasingly, archaeologists are studying sites and human activity within their regional context to determine how the sites relate to each other and

This more regional view helps answer questions such as why cities and towns were built in particular locations and how the patterns of settlement relate to natural resources in the area. To do this, it is important to look at why events occurred when they did and how those events might have changed over time. Scientists are intensely interested in examining the interactions of people with the land they inhabited and exploited over time in an effort to explain the changes that occurred in both human societies and in the natural environment.

The Shuttle Radar Topography Mission will provide archaeologists with a topographic view of both ancient sites and the current landscape, which they can use to help determine the boundaries of original sites. They also will be able to learn how and where these sites fit into the regional landscape, as well as probable migration routes through topographic barriers such as mountain ranges.

Shuttle radar data also will enable them to compare large-scale ancient settlement patterns and their distribution around the world. Since many archaeologists working in remote parts of the world rely on outdated maps or no maps at all to conduct these studies, the Shuttle Radar Topography Mission's highly precise 3-D data will provide many with their first comprehensive tools.

Ecology concentrates on the interrelationship of living things and their environment. As civilization and technology advance, people have learned to modify the environment. Human activity has had enormous repercussions, changing ecosystems and depleting natural resources. People use vast amounts of energy and produce massive amounts of waste and exhaust. It is critical that scientists understand the impact humanity is having on planet Earth and that better tools be developed to accurately measure changes in world climate, temperatures, habitats,and species.

Global climate change is another large-scale event occurring in the atmosphere, brought about by the increase of so-called "greenhouse gases" such as carbon dioxide. Like glass in a greenhouse, these gases admit the sun's light but tend to reflect the heat that is radiated from the ground below back down to the ground, trapping heat in Earth's atmosphere.

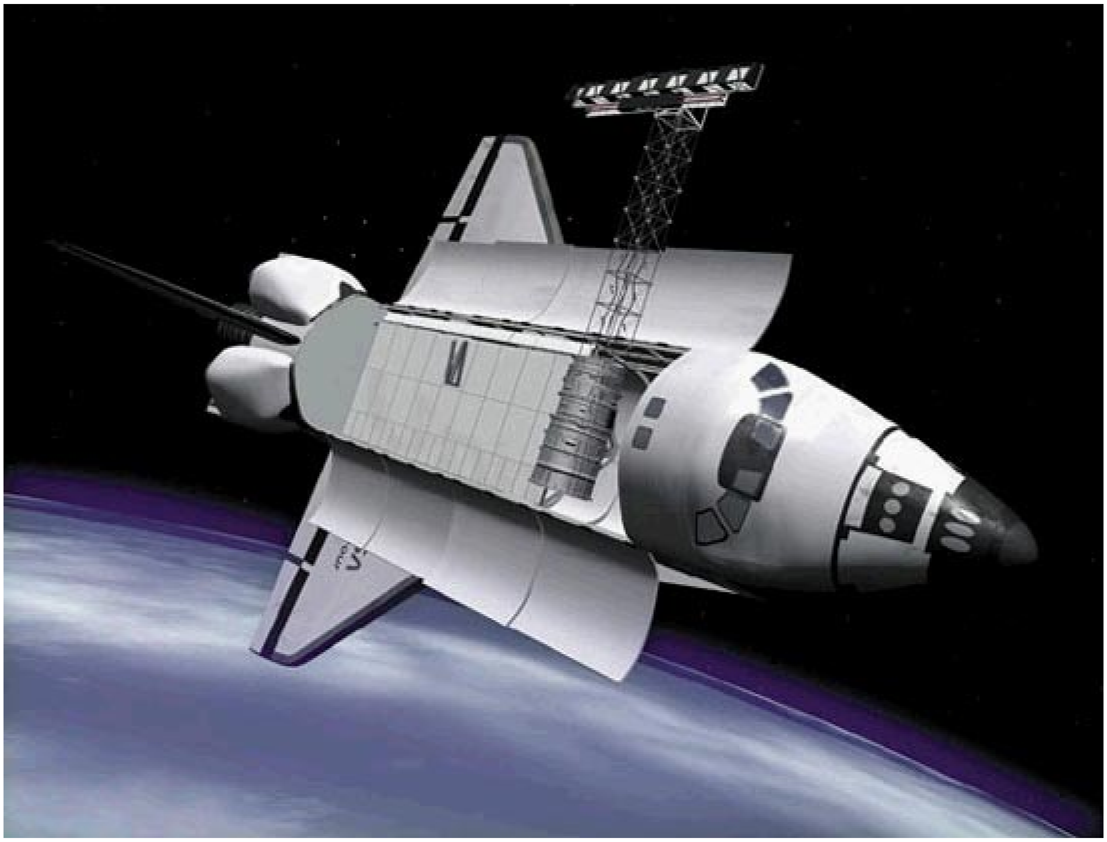
Scientists continue to work on computer models of climate change to determine how much of an increase in greenhouse gases is occurring in Earth's atmosphere. Shuttle Radar Topography Mission data will allow them to develop more accurate models of the global circulation of the atmosphere.

Mapping of the world's rainforests is an essential ingredient in global protection of Earth in the next century. Another avenue of investigation during the Shuttle Radar Topography Mission will focus on radar-imaging of fragile habitats, such as Earth's tropical forests, to assess vegetation types and determine terrain characteristics. Terrain data that will be collected during the Shuttle Radar Topography Mission will provide near-global-scale coverage of these ecosystems at a much higher resolution and allow scientists to study tropical rainforests in more detail. Combined with data from other remote sensing satellites, three-dimensional data of landforms, waterways, and other types of vegetation will contribute to their

Communities nestled near the bases of active volcanoes or on earthquake faults will be of interest to volcanologists and seismologists as well.

Scientists can use three-dimensional topographic maps to study the potential of natural hazards. In addition to volcanic eruptions and earthquakes, regions prone to severe flooding by major rivers will be of interest.

Radar imaging will be used as a tool for city planners, land management, and resource conservation, efforts which require highly detailed topographic maps for monitoring land use patterns. Spaceborne radar imaging systems can clearly detect the variety of landscapes in an area, as well as the density of urban development. Examples of previous land management surveys included imaging of major world cities, such as Los Angeles, New York, and Washington, D.C.



Commercial Applications

Some of the commercial products that will be possible using Shuttle Radar Topography Mission data will benefit the transportation industry, as well as the communications and information technologies markets. In telecommunications, wireless service providers and operators will be particularly interested in this digital elevation data. Topographic data can be used for building better transceiver stations and identifying the best geographic locations for cellular telephone towers.

Companies conducting geological and mineral exploration, as well as hydrological and meteorological services, including risk assessment, also will be interested in the data. Providers of satellite data, tourist and leisure maps, and virtual reality software also will reap the benefits of these data, which can be integrated into an absolute geographic grid system that will make all data products uniform and consistent. In fact, just about any industry that requires accurate digital elevation data stands to benefit from this mission.

Terrain height data also may be a valuable addition to current aircraft navigational tools to assist pilots in takeoffs, landings, and pinpointing their locations during flight. Ground collision avoidance systems will become far more accurate with new measurements and topographic maps of Earth's terrain derived from the Shuttle Radar Topography Mission. Flight simulators for crew training will have realistic backgrounds and, by adding information from inflight global positioning system receivers, will become state-of-the-art reference systems, giving pilots a set of "virtual eyes" for use in bad weather or at night.

Automobile navigation displays and digital road maps also will benefit from terrain information provided by the Shuttle Radar Topography Mission. Here terrain height is required, combined with accurate data about the horizon. The newly acquired data will be made available to commercial users and tailored to their specific needs.

Defense Applications

The National Imagery and Mapping Agency (NIMA) plans to use the digital global terrain elevation maps for planning, rehearsal, modeling, and simulation for military and civilian uses. Successful completion of the SRTM data set will provide NIMA with coverage of most of Earth's populated land areas, with three times better resolution than previously available.

Additional information about Defense Department applications is available from NIMA, a partner in the Shuttle Radar Topography Mission.

Updated: 01/18/2000

Payloads

SRTM Hardware--the Antenna

Payload Bay

Prime:

Backup:

Overview

The Outboard Antenna Structure

The outboard antenna structure is connected to the end of the mast. It contains a C-band and an X-band antenna, two global positioning system antennas, light emitting diode targets, and a corner-cube reflector. The two outboard antennas can only receive radar signals. Transmitting of radar signals will be done only by the main antenna.

The C-band and X-band antennas on the outboard antenna structure receive radar signals reflected from the ground. The signals are passed down cables to the Shuttle for recording along with the signals from the main antennas.

Global Positioning System antennas will be used to gather accurate information on the position of the Space Shuttle. Meanwhile, light emitting diode (LED) targets will be used by a target tracker on the Attitude and Orbit Determination Avionics (AODA), mounted on the main antenna, to measure the position of the outboard antenna relative to the main antenna. A corner-cube reflector will be used by the electronic distance measurement unit on AODA to measure the length of the mast to within three millimeters (1/8 inch).

Updated: 01/18/2000

Payloads

SRTM Hardware--the Mast

Payload Bay

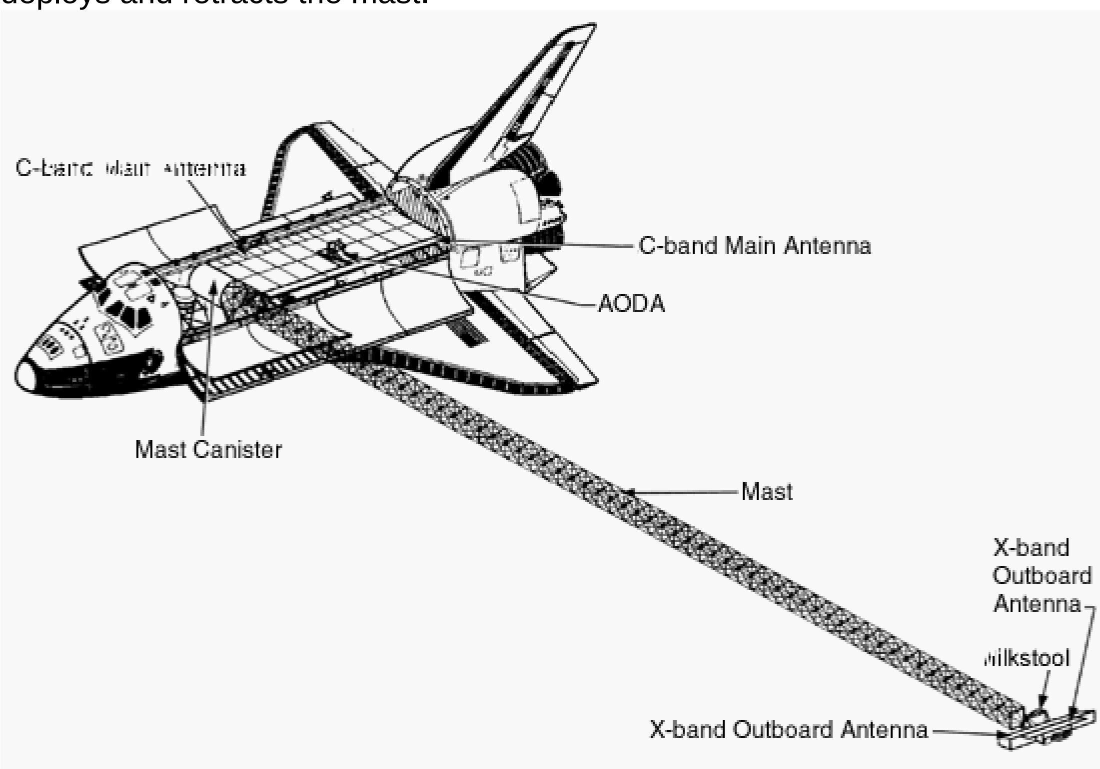
Prime:

Backup:

Overview

The Mast

Made of carbon fiber reinforced plastic (CFRP), stainless steel, alpha titanium, and Invar, the mast is a truss structure that consists of 87 cube-shaped sections called bays. Unique latches on the diagonal members of the truss allow the mechanism to deploy bay-by-bay out of the mast canister to a length of 60 meters (200 feet), about the length of five school buses. The canister houses the mast during launch and landing and also deploys and retracts the mast.



SRTM as Deployed From Endeavour's Payload Bay

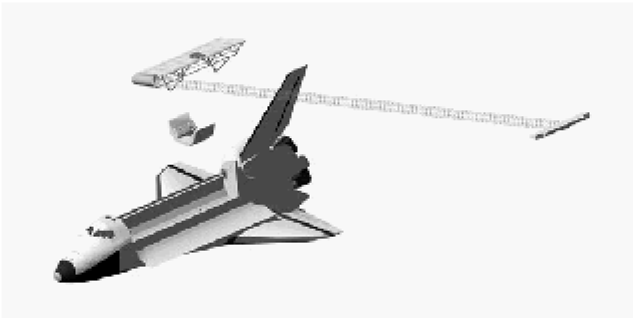
The mast will be deployed and retracted by a motor-driven nut within the mast canister. This nut will pull the mast from its stowed configuration and allow it to unfold like an accordion. An astronaut inside the Space Shuttle will initiate the mast deployment, which will take about 20 minutes. The mast also may be deployed manually during an EVA using a hand-held motor if necessary.

The mast technology enables the SRTM system to perform at the high precision necessary to achieve the desired mapping resolution. The mast supports a 360-kilogram (792-pound) antenna structure at its tip and carries 200 kilograms (440 pounds) of stranded copper, coaxial, fiber optic cables, and thruster gas lines along its length.

The Shuttle Radar Topography Mission Mast

Mast Length	60 m 200 feet
Nominal Mast Diameter	1.12 m 44 1/8 in
Nominal Bay Width at Longerons	79.25 cm 31 1/4 in
Nominal Bay Length	69.75 cm 27 1/2 in
Number of Bays	87
Stowed Height/Bay	1.59 cm 5/8 in
Total Stowed Height	128 cm 54 in

The Main Antenna



The main antenna is connected to a pallet that in turn is bolted into the payload bay of the Space Shuttle. The system consists of two antennas and the avionics that compute the position of the antenna.

Each antenna is made up of special panels that can transmit and receive radar signals. One antenna is the C-band antenna and can transmit and receive radar wavelengths that are 2.25 inches or 5.6 centimeters long. The second antenna is the X-band antenna. This antenna can transmit and receive radar wavelengths that are 1.2 inches or 3 centimeters long. Both wavelengths were used in the Spaceborne Imaging Radar C-band/X-SAR missions in 1994 for a variety of environmental studies. The L-band antenna, also used during SIR-C/X-SAR, has been removed to save weight.

History/Background

Attitude and Orbit Determination Avionics

In order to map the Earth's topography, SRTM researchers will need to do two basic things:

1) Measure the distance from the Shuttle to some common reference, such as sea-level

2) Measure the distance from the Shuttle to the surface feature over which it is flying

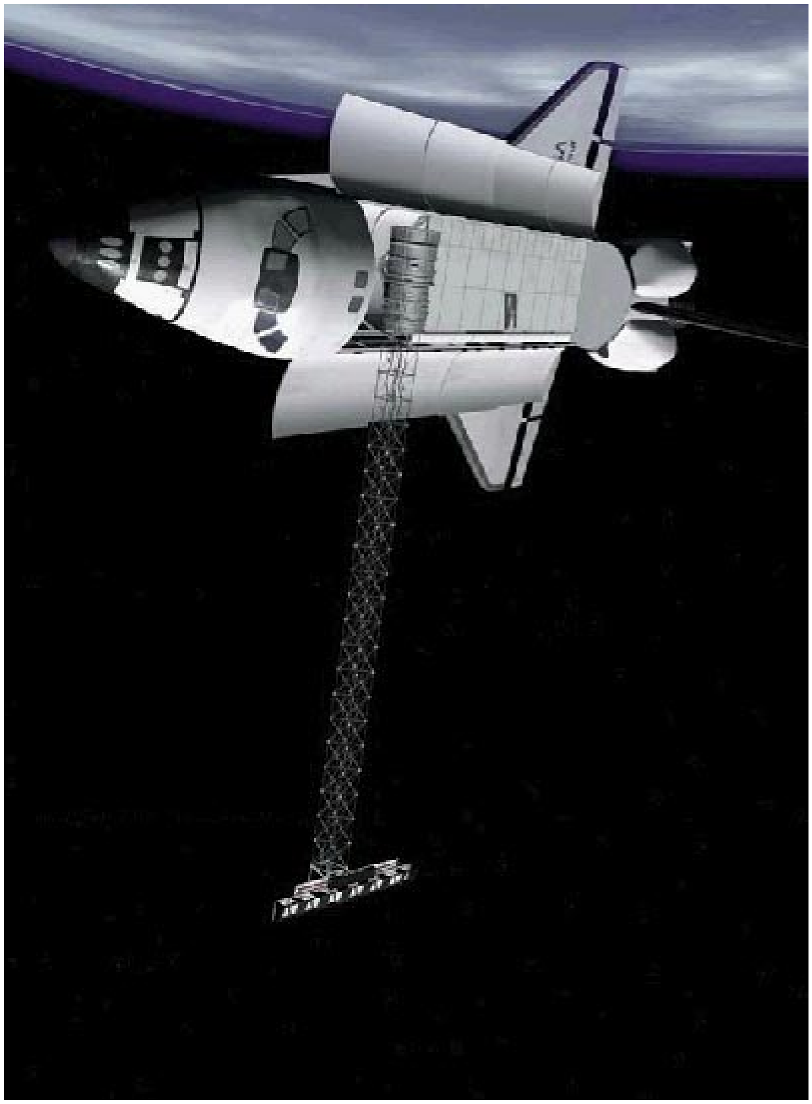
For example, if the Shuttle's height above sea level is known and its respective height above a mountain, then researchers can subtract to get the height of the mountain above sea level.

For the first part, researchers need to know the Shuttle's height above sea level at all times. NASA will need to constantly measure the Shuttle position to an accuracy of 1 meter (about 3 feet).

For the second part of the formula, SRTM is using radar interferometry to measure the height of the Shuttle above the Earth's surface. One of the biggest challenges in making interferometry work is knowing the length and orientation of the mast at all times. Changes in its length and orientation can have a profound effect on the final height accuracy. Suppose the mast tip moves around by only 2 cm (a bit less than 1 inch) with respect to the Shuttle (this is something that is expected to happen during the mission, due to the astronauts moving around and Shuttle thrusters firing). That doesn't sound like much, but if not taken into account, it would result in a height error at the Earth's surface of 120 meters (almost 400 ft).

Researchers also expect changes in mast length of about 1 cm (about a half-inch) which if not detected would result in additional errors. Therefore, SRTM team members will need to constantly monitor the mast orientation and length. Part of this is measuring where the mast tip is relative to the Shuttle to better than 1 mm (about 4/100th of an inch). The other part is knowing how the Shuttle is oriented relative to the Earth to about 1 arcsec. An arcsecond is the angular size of a dime seen from a distance of 2 miles.

To keep track of the Shuttle's position, NASA will make use of the Global Positioning System (GPS). Mission managers do this by combining measurements taken by some specially designed GPS receivers being flown on the Shuttle with measurements taken by an international network of GPS ground receivers.



To measure the mast length and orientation, team members will use a variety of optical sensors. A target tracker will be used to follow a set of Light Emitting Diode (LED) targets which can be seen on the outboard radar antenna once the mast is fully deployed.

The target tracker also is used to monitor the antenna alignment. There are laptop computers on the Shuttle which display the antenna alignment (kind of a cross-hairs with a dot, representing the alignment error). The crew will use these displays to guide adjustment of some motors at the mast tip (the "milkstool") to remove any alignment errors so the radar can operate properly.

To get the most accurate measure of the mast length, SRTM managers will use a set of rangefinders, called Electronic Distance Measurement (EDM) units. To save time and money, the SRTM team decided to buy commercial surveying instruments and modify them for use in space. The rangefinders work by bouncing a beam of light off a special corner-cube reflector on the outboard antenna and measuring the time to determine the distance.

To measure the orientation of the Shuttle with respect to the Earth, mission managers will use one of the most precise star tracker and gyroscope packages ever built. The star tracker looks at the sky and compares what it sees with a star catalogue in its memory to get the attitude of the Shuttle.

Updated: 01/18/2000

Payloads

Data Recording, Processing, and Products

Payload Bay

Prime:

Backup:

Overview

Data Recording

Once SRTM payload managers receive the radar echoes from both antennas, they will route the data through the Digital Data Handling System (DDHS). That system puts the different channels together and then sends the data to the Recorder Interface Controller (RIC), a laptop in the flight deck of the Shuttle. The laptop decides which of three Payload High-Rate Recorders (PHRR) will get the data. The crew will monitor this and will change tapes as they become full. SRTM will record to about 300 tapes during the mission, which adds up to about 10 terabytes of data. Mission managers also will send a small amount of data to the ground during the flight in order to monitor the instrument.

Data Processing and Products

When the high-speed digital tapes on board the Shuttle record the echoes collected by the SRTM interferometer, it is only the beginning of the mission. The worlds of microwave optics, orbital mechanics, signal processing, and computer processing and networking merge in a sophisticated and intensive effort to map the Earth's topography with record accuracy in record time.

A synthetic aperture radar is much like a camera without a lens, transcribing enough information from the signal echoes to allow the raw data to be focused into an image. The SRTM interferometer has two sets of these radar "cameras," one antenna in the Shuttle bay, the other at the end of the mast. The radars alternately look at four different subswaths in order to build up the wide swath necessary to map the world. The task of generating digital topography from the recorded data requires powerful computers to focus the eight data sets into images, two for each of four subswaths. The echoes in each subswath are not continuous because the radar can collect only two subswaths at a time, so mini-images are formed individually for each small segment of data. Then for each subswath, the two small image pieces are combined to form the "interferogram" which encodes the information about topography. These miniature topographic images then must be carefully pieced together for each subswath to form a larger interferogram.

Topographic information in the interferogram needs further deciphering to be useful, however. The interferometer produces what are in essence topographic contours of equal height, but at this point the elevation value for any contour is unknown, as is the height difference between any two contours. This is where the measurements made by the Attitude and Orbit Determination Avionics (AODA) becomes useful. Accurate knowledge of the mast length and orientation is used to solve for the height of each contour. In addition, data collected over the ocean are used to reference all elevations to sea level.

These operations must be repeated for each subswath for the length of each data-take. An SRTM data-take extends from the time just before landfall until just after the swath leaves land for every continent and every island.

These data are still not a map, as they are still in distorted radar coordinates, so each subswath must be "ortho-rectified" to map coordinates. With hundreds of data takes processed to ortho-rectified intermediate products, the effort shifts from interferometry to mosaicking. Specifically, the subswaths and data takes must be "sewn" together to form a continent, with all the seams well-formed and continuous across boundaries. If all goes according to plan, the subswaths will lay down perfectly on top of each other. If there are some small uncertainties in the geometry of the interferometer, a little assistance to the mosaicking may be needed. This is accomplished by measuring how well the subswaths match each other where they overlap and by comparing them to known points on the ground. Once these measurements are made, they are used to adjust all subswaths in three dimensions to the best, smoothest mosaic.

After the mosaic is produced, the product must be checked. At least six stages of quality checks are performed on the subswaths as they proceed through the processing, so the mosaicked data are expected to be of high quality. Nonetheless, a last test of the accuracy of the product is made and the results recorded in map form.

This entire process is carried out for all the continents covered by SRTM. A powerful computerized production system has been developed to transform the basic radar and ancillary measurements acquired by SRTM to these digital topographic maps and other derived products. The system brings together all data elements in a processing environment that will deliver the world's topography in less than two years. To accomplish this feat, the production system comprises numerous computer subsystems linked together on a high-speed network at JPL. The system pushes several terabytes of raw data through in two years, with intermediate storage of upwards of 100 terabytes.

First, special-purpose hardware decodes the raw data. A workstation then conditions the data to a usable form. A suite of parallel processing computers performs the radar interferometry processing and mosaicking. A robotic tape storage device automatically retrieves the data tape needed for processing at each step. The final verified product is delivered to the customer electronically, continent by continent.

Payloads

EarthKAM

In-Cabin

Prime: Kevin Kregel
Backup: Dom Gorie

Overview

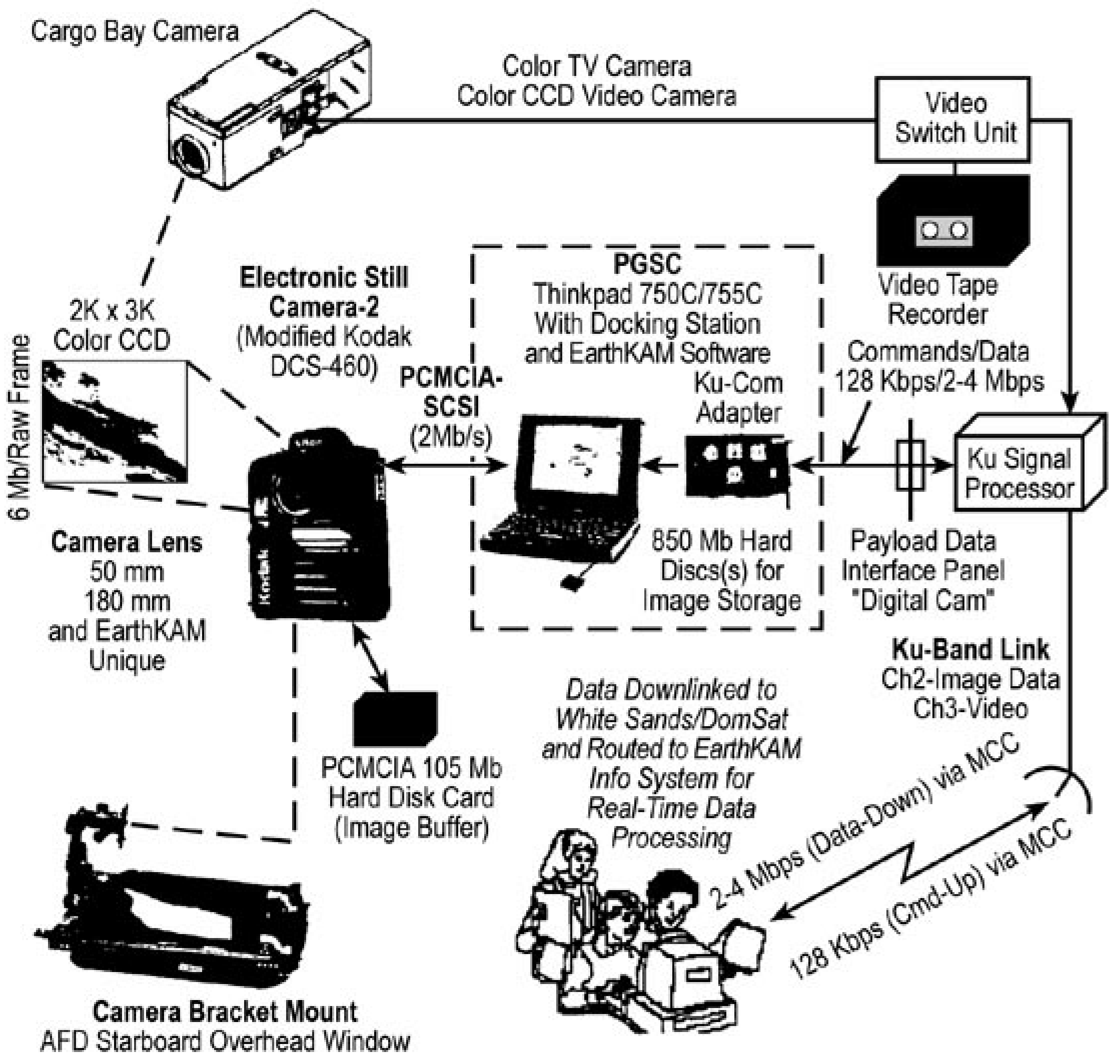
EarthKAM is a NASA-sponsored program that enables middle school students to take photographs of the Earth from a camera aboard the Space Shuttle. During missions, students work collectively and use interactive web pages to target images and investigate the Earth from the unique perspective of space.

An electronic still camera (ESC) bracket-mounted to the overhead starboard window of the orbiter aft flight deck will face the nadir to observe various student-selected sites on Earth. Other than equipment setup, initial camera pointing, and possible camera lens changes, no crew intervention is required for nominal operations.

The University of California at San Diego houses the EarthKAM Mission Operations Center (MOC). Most participating schools (or group of schools) establish a Student Mission Operation Center (SMOC) whose computers are connected to the Internet for a number of purposes:

· To communicate with other SMOC teams and EarthKAM personnel

· To track the Shuttle's orbit
· To select and submit target requests



How EarthKam Works

Before the mission, students select a topic of interest, such as human settlement patterns, mountain ranges, or agricultural patterns. Then they define investigations that will be supported by the EarthKAM images.

During the mission, each SMOC submits a number of photo requests through specialized EarthKAM web pages. The requests are processed and uplinked to the EarthKAM ESC aboard the Shuttle.

After the ESC takes the pictures, digital images are sent back to Earth and posted on the data system for the students to use in their investigations. For their final reports, students use these new images along with other relevant images from the full EarthKAM image set. Scientists and educators review the original proposal and the final report to provide feedback to the students.

The EarthKAM program also is preparing to mount a camera aboard the International Space Station.

History/Background

During the first four missions of EarthKAM, students took more than 2,000 high-resolution digital images of the Earth. These photographs included the Himalayas, clouds over the Pacific, volcanoes, and recent forest fires in Indonesia.

Benefits

Students use the EarthKAM images in classroom projects to learn about Earth science, geography, mathematics, and space science. They also develop skills in investigation and image analysis, as well as learning how to use the Internet.

Updated: 01/18/2000

DTO/DSO/RMEs

Heat Exchange Unit Evaluation

DTO 686

Prime:

Backup:

Overview

The purpose of this DTO is to test the effectiveness of a portable heat exchange unit that uses the vacuum of space to chill nearby items by controlling the vaporization rate of water. The objectives of the DTO are to demonstrate the technology in microgravity, identify potential shuttle applications, and measure the chilling capacity of the unit.

This commercial portable heat exchanger uses water as the refrigerant. It chills items by evaporating water in the reduced-pressure environment created by the vacuum of space. The unit, which is smaller than a beverage can (a cylinder 1.75 inches in diameter and 5 inches long), has the potential for extensive chilling capacity from two abundant resources aboard the Shuttle, water and vacuum. The heat exchanger has a unique internal feature that controls the water vaporization rate while maximizing heat exchange during the process. Since chilling occurs on the outer surface of the unit, items to be chilled (such as beverages or ice cream) are simply exposed to this outer surface.

The exchange unit, which is designed to connect to the orbiter waste control system vacuum port (TP126) or the wastewater overboard dump system, is equipped with quick disconnects that interface with the overboard dump system. The system performed well in demonstrations on Earth; theoretically, it should perform just as well in microgravity.

History/Background

This DTO has flown once before on STS-96.

DTO/DSO/RMEs

Urine Collection Device

DTO 690

In-Cabin

Prime: **Principal Investigator:** Jennifer D. Villarreal
Backup:

Overview

Five crew members will participate in this DTO, which has five objectives:

1. Evaluate the fit of several sizes/types of manual urine collection devices (UCDs) and their adapters (anatomical interface) in microgravity.
2. Evaluate the ability of the adapter and valve design to accommodate urine flow with minimal leakage.
3. Evaluate hygienic aspects of the UCD design, e.g., its ability to minimize residual urine in or around the adapter that could potentially disperse into the cabin. This UCD feature will also make scientific measurements of total

4. Evaluate user-friendliness of urine collection operations.
5. Evaluate techniques for returning urine to the waste collection system (lower priority).

There are two primary benefits of an improved design for manual urine collection devices. The UCD will be used as a backup to the current waste collection system (WCS). Normally, if the WCS fails, the crew uses diapers and must cut the mission short. But with the backup UCD, this will not be necessary.

Secondly, the ability of current UCDs to collect urine from females is a serious disadvantage in scientific studies that include female subjects. With the small number of subjects participating in microgravity experiments, loss of all female subjects in studies requiring urine collection is unacceptable to the scientific community. Although this study aims to optimize UCD designs for both sexes, the highest priority is to find an acceptable female adapter,

Male subjects have also had problems with the existing UCDs: leakage, fit, and urine remaining in the dead volume. Therefore, a secondary objective of this study is to design and evaluate upgrades for the male interface. The final designs will be flown on all missions that require urine collection samples, either as the primary method of collection or as a backup to an automated system proposed for space station.

History/Background

This is the third flight of DTO 690. Its last flight was STS-96.

Updated: 01/18/2000

DTO/DSO/RMEs

Single-String Global Positioning System, With PGSC and GPS

DTO 700-14

In-Cabin

Prime: Kevin Kregel

Principal Investigator: Ray Nuss, Wayne Hensley, Michael Sarafin

Backup: Dom Gorie

Overview

This DTO demonstrates the performance and operation of the Global Positioning System (GPS) during orbiter ascent, on-orbit, entry, and landing phases. A modified military GPS receiver-processor and the existing orbiter GPS antennas will be used, and GPS data will be downlinked during all mission phases. A payload and general support computer (PGSC) hard drive may be used (optional) to record GPS data during ascent, entry, and/or extended orbital phases.

The single-string GPS supports operational use of GPS as a Shuttle navigation aid. This flight test of the single-string GPS configuration--basically an extension of an earlier GPS development flight test--entails the following:

· GPS receiver output data will be downlinked through the flight forward 2 (FF2) multiplexer/demultiplexer (MDM) and operational forward 2 (OF2)

· A PGSC may be connected to the receiver's RS-422 instrumentation port to collect data during ascent, entry, and/or orbital phases (optional).

· The crew may be requested to perform various activities, such as exercising certain GPS SOP and navigation commands and/or cycling power to the GPS receiver. Requirements for this option are defined specifically for each mission to achieve the following objectives whenever feasible: (a) incorporate GPS to NAV in OPS 201 (PASS), (b) incorporate GPS to NAV in OPS 301 (PASS and BFS), and (c) perform GPS receiver commands (via crew keyboard item entries) during OPS 201.

History/Background

DTO 700-14 has previously flown on nine Shuttle missions. It last flew on STS-96.

DTO/DSO/RMEs

High-Definition Television (HDTV) Camcorder Demonstration

DTO 700-17A

Prime: Kevin Kregel

Principal Investigator: Toshibumi Sakata, Earth Science and Technology Organization (ESTO); Toshihiro Ogawa, NASDA, Earth Observation Research Center (EORC); Yoshifumi Yasuoka, University of Tokyo, Institute of Industry Sciences (IIS); Shoji Matsubara, NASDA; Akitoshi Yokota, NA

Backup: Dom Gorie

Overview

Specific objectives for STS-99 are listed in order of priority:

Required:

· Earth observation consisting of forest areas, dry land, mountain areas, and urban areas
· Atmospheric observation consisting of lightning and aurora
· Educational objectives

Desired:

HDTV coverage of SRTM targets

This system will provide NASA source material from Shuttle for the initial U.S. HDTV broadcast. It represents the first step in NASA's transitional process toward HDTV flight video systems and the new U.S. standard. The DTO task of flying an HDTV camcorder is the minimal method to begin meeting the requirements for HDTV implementation on the Shuttle.

History/Background

The U.S. television standard is in transition from the current analog National Television Systems Committee (NTSC) format to the digital Advanced Television Systems Committee (ATSC) format adopted by the Federal Communications Commission (FCC). In order for NASA to provide source material that supports these new standards, the current Shuttle video system must be upgraded. The NASA administrator and Headquarters Code M have established requirements and applications for this new capability and have called for the Shuttle and Station programs to make provisions that support it. A minimal hardware upgrade of existing Shuttle resources is the first step toward this objective of giving the Shuttle program some digital television capability.

This DTO has been flown once before on STS-93.

Updated: 01/18/2000

DTO/DSO/RMEs

Crosswind Landing Performance

DTO 805

Prime: Kevin Kregel
Backup: Dom Gorie

Overview

The purpose of this DTO of opportunity is to perform a manually controlled Shuttle landing in the presence of a 90-degree, 10- to 15-knot, steady-state crosswind.

History/Background

This DTO has been attempted 57 times. It was last manifested on STS-93.

Updated: 01/18/2000

DTO/DSO/RMEs

Effect of Space Flight on Bone, Muscle and Immune Function

DSO 206

Prime:

Principal Investigator: Hiroshi Ohshima, M.D., Ph.D., NASDA; Tetsuo Fukunaga, Ph.D., NASDA; Koh Mizuno, Ph.D., NASDA; Takashi Shigematsu, M.D., Ph.D.; Tatsunori Suemitsu, M.D., NASDA

Backup:

Overview

The primary objective of this study is to investigate the basic mechanism of how space flight affects the musculoskeletal system and immune function during long missions. These accumulated baseline data will be used to develop countermeasures for physiological changes in the musculoskeletal system and immune function during long space flights.

Successful completion of this investigation will contribute to a better understanding of the physiological adaptation of bone, muscle, and immune function in space flight. This information will be used to prevent progressive bone and muscle disease and immunological suppression. One crew member will participate in the study, which requires examination only before and after the flight.

Updated: 01/18/2000

DTO/DSO/RMEs

Monitoring Latent Virus Reactivation and Shedding in Astronauts

DSO 493

In-Cabin

Prime:

Principal Investigator: Duane L. Pierson, Ph.D.

Backup:

Overview

Six crew members will participate in this DSO, whose premise is that the incidence and duration of latent virus reactivation in saliva and urine will increase during space flight. The objective is to determine the frequency of induced reactivation of latent viruses, latent virus shedding, and clinical disease after exposure to the physical, physiological, and psychological stressors associated with space flight.

Space-flight-induced alterations in the immune response become increasingly important on long missions, particularly the potential for reactivation and dissemination (shedding) of latent viruses. An example of a latent virus is Herpes Simplex Type 1 (HSV-1), which infects 70 to 80 percent of all adults. It classically manifests with cold sores, pharyngitis, and tonsillitis and is usually acquired through contact with the saliva, skin, or mucous membranes of an infected individual. However, many recurrences are asymptomatic, resulting in shedding of the virus. Twenty subjects have been studied for Epstein-Barr virus. Three additional viruses will be examined in an expanded subject group.

Updated: 01/18/2000

DTO/DSO/RMEs

Individual Susceptibility to Post-Space-Flight Orthostatic Intolerance

DSO 496

Prime:

Principal Investigator: Janice M. Yelle, M.S.; Michael G. Ziegler, M.D.; Peggy A. Whitson, Ph.D.

Backup:

Overview

Researchers think that postflight orthostatic hypotension occurs in some, but not all, astronauts because of (1) preflight, gender-related differences in autonomic regulation of arterial pressure, and (2) space-flight-induced changes in autonomic function, which precipitate the condition in predisposed individuals. This DSO tests this hypothesis by examining preflight and postflight differences in susceptible and nonsusceptible astronauts.

Significant alteration of cardiovascular function after space flight is well documented. One of the most important changes negatively affecting flight operations and crew safety is the postflight loss of orthostatic tolerance. Symptoms include difficulty walking independently, lightheadedness or fainting, and impaired ability to climb out of the Shuttle after landing. Recent evidence indicates that postflight autonomic dysfunction contributes to orthostatic intolerance. Susceptibility to postflight orthostatic intolerance is highly individual. Some astronauts experience very little effect, others have severe symptoms, and women are more often affected than men.

The goal of the proposed studies is to clarify mechanisms responsible for these problems in order to customize countermeasures that prevent them. Three crew members will participate in this study, only before and after the flight.

Updated: 01/18/2000

DTO/DSO/RMEs

Space Flight and Immune Functions

DSO 498

Prime:

Principal Investigator: Duane L. Pierson, Ph.D.

Backup:

Overview

Scientists expect the essential functions of neutrophils, monocytes, and cytotoxic cells (lymphokine-activated and natural killer cells) to be altered during space flight. This DSO will let them know if they are right.

This project will characterize the effects of space flight on selected immune elements that are important in maintaining an effective defense against infectious agents. The roles of neutrophils, monocytes, and cytotoxic cells--all important elements of the immune response--have not been studied adequately in the U.S. space program. Therefore, these studies complement ongoing and previous investigations in space immunology. The specific objectives of the experiment will prove or disprove the hypothesis: (1) analyze the function of neutrophils and monocytes before and after space flight, and (2) assess cytotoxic cells and cytokine production before and after space flight.

As astronauts work and live in the relatively crowded, closed environment of spacecraft on longer and longer missions, the risk of infectious disease increases. The human immune system plays a pivotal role in preventing infectious illnesses, but the effects of space flight on the immune response are not fully understood. This DSO is designed to determine the functional status of important elements of the immune response during STS-99, which should provide valuable data for assessments of infectious disease risks on long-duration space missions. Understanding the clinically relevant changes, if any, will allow scientists to develop suitable countermeasures that minimize risk.

DTO/DSO/RMEs

Educational Activities, Objective 2

DSO 802

In-Cabin

Prime: Kevin Kregel
Backup: Dom Gorie

Overview

This DSO, which is tied to DTO 700-17A (use of HDTV to film NASA astronaut activities), will provide live TV downlink of the mission to classrooms in hopes of attracting students to careers in science, engineering, and mathematics. The addition of this DSO to a particular flight is coordinated through the JSC Educational Working Group (EWG).

The tasks required by this DSO support three distinct objectives:

1. Produce educational products, such as 20-minute video lessons, with scenes recorded both in space and on the ground. The on-orbit video should represent about one-third of the finished video product. This objective requires the videotaping of on-orbit educational activities performed by the flight crew as well as other educational activities deemed appropriate by the EWG and the flight crew.

2. Support the live TV downlink of educational activities performed by the flight crew explicitly for, or involving participation by, students and teachers. Typically, these downlinks are limited to one or two 30-minute live sessions.

3. Support the live or videotaped TV downlink of educational activities performed by the flight crew for a general audience. Typically, these activities are limited to 5 or 10 minutes per demonstration/narration to explain the science and/or principles of the experiments performed by the crew members. The number of events is mission dependent.

For STS-99, the crew will concentrate on Objective No. 2.

History/Background

This educational DSO supports the NASA administrator's educational initiative and complies with his direction to use live and recorded lessons from astronauts on Space Shuttle missions to meet the goals of NASA's educational programs.

NASA Television Transmission

NASA Television is available through the GE2 satellite system which is located on Transponder 9C, at 85 degrees west longitude, frequency 3880.0 MHz, audio 6.8 MHz.

The schedule for television transmissions from the orbiter and for mission briefings will be available during the mission at Kennedy Space Center, FL; Marshall Space Flight Center, Huntsville, AL; Dryden Flight Research Center, Edwards, CA; Johnson Space Center, Houston, TX; and NASA Headquarters, Washington, DC. The television schedule will be updated to reflect changes dictated by mission operations.

Status Reports

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

Briefings

A mission press briefing schedule will be issued before launch. During the mission, status briefings by a flight director or mission operations representative and when appropriate, representatives from the payload team, will occur at least once each day. The updated NASA television schedule will indicate when mission briefings are planned.

Internet Information

Information is available through several sources on the Internet. The primary source for mission information is the NASA Shuttle Web, part of the World Wide Web. This site contains information on the crew and its mission and will be updated regularly with status reports, photos and video clips throughout the flight. The NASA Shuttle Web's address is:

http://spaceflight.nasa.gov

General information on NASA and its programs is available through the NASA Home Page and the NASA Public Affairs Home Page:

http://www.nasa.gov

or

http://www.nasa.gov/newsinfo/index.html

Shuttle Pre-Launch Status Reports

http://www-pao.ksc.nasa.gov/kscpao/status/stsstat/current.htm

Information on other current NASA activities is available through the Today@NASA page:

http://www.nasa.gov/today/index.html

The NASA TV schedule is available from the NTV Home Page:

http://spaceflight.nasa.gov/realdata/nasatv/schedule.html

Resources for educators can be found at the following address:

http://education.nasa.gov

Access by Compuserve

Users with Compuserve accounts can access NASA press releases by typing "GO NASA" (no quotes) and making a selection from the categories offered.

Media Contacts

NASA PAO CONTACTS

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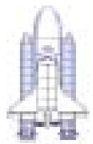
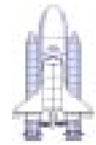
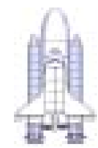
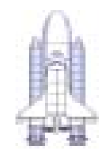
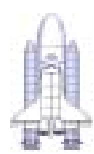
Updated: 01/19/2000

SHUTTLE FLIGHTS AS OF FEBRUARY 2000

96 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 71 SINCE RETURN TO FLIGHT

OV-102 **Columbia** **(26 flights)**	**OV-099** **Challenger** **(10 flights)**	**OV-103** **Discovery** **(27 flights)**	**OV-104** **Atlantis** **(20 flights)**	**OV-105** **Endeavour** **(13 flights)**
		STS-103 12/19/99 - 12/27/99		
STS-93 07/23/99 - 07/27/99		STS-96 05/27/99 - 06/06/99		
STS-90 04/17/98 - 05/03/98		STS-95 10/29/98 - 11/07/98		
STS-87 11/19/97 - 12/05/97		STS-91 06/02/09 - 06/12/98		
STS-94 07/01/97 - 07/17/97		STS-85 08/07/97 - 08/19/97		
STS-83 04/04/97 - 04/08/97		STS-82 02/11//97 - 02/21/97		
STS-80 11/19/96 - 12/07/96		STS-70 07/13/95 - 07/22/95		
STS-78 06/20/96 - 07/07/96		STS-63 02/03/95 - 02/11/95	STS-86 09/25/97 - 10/06/97	
STS-75 02/22/96 - 03/09/96		STS-64 09/09/94 - 09/20/94	STS-84 05/15/97 - 05/24/97	
STS-73 10/20/95 - 11/05/95		STS-60 02/03/94 - 02/11/94	STS-81 01/12/97 - 01/22/97	
STS-65 07/08/94 - 07/23/94		STS-51 09/12/93 - 09/22/93	STS-79 09/16/96 - 09/26/96	
STS-62 03/04/94 - 03/18/94		STS-56 04/08/83 - 04/17/93	STS-76 03/22/96 - 03/31/96	
STS-58 10/18/93 - 11/01/93		STS-53 12/02/92 - 12/09/92	STS-74 11/12/95 - 11/20/95	
STS-55 04/26/93 - 05/06/93		STS-42 01/22/92 - 01/30/92	STS-71 06/27/95 - 07/07/95	
STS-52 10/22/92 - 11/01/92		STS-48 09/12/91 - 09/18/91	STS-66 11/03/94 - 11/14/94	STS-88 12/04/98 - 12/15/98
STS-50 06/25/92 - 07/09/92		STS-39 04/28/91 - 05/06/91	STS-46 07/31/92 - 08/08/92	STS-89 01/22/98 - 01/31/98
STS-40 06/05/91 - 06/14/91		STS-41 10/06/90 - 10/10/90	STS-45 03/24/92 - 04/02/92	STS-77 05/19/96 - 05/29/96
STS-35 12/02/90 - 12/10/90	STS-51L 01/28/86	STS-31 04/24/90 - 04/29/90	STS-44 11/24/91 - 12/01/91	STS-72 01/11/96 - 11/20/96
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-43 08/02/91 - 08/11/91	STS-69 09/07/95 - 09/18/95
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-67 03/02/95 - 03/18/95
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-68 09/30/94 - 10/11/94
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-59 04/09/94 – 04/20/94
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-61 12/02/93 - 12/13/93
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-57 06/21/93 - 07/01/93
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-54 01/13/93 - 01/19/93
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-47 09/12/92 - 09/20/92
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	STS-49 05/07/92 - 05/16/92

Table prepared by Richard W. Orloff, 02/2001