STS-114 Discovery
Space Shuttle
Return to Flight

Information Kit
On 26 July 2005 the Space Shuttle will return to service when STS-114 Discovery is placed into orbit from Launch Pad 39B at NASA's Kennedy Space Center on flight LF1 to the International Space Station. This mission will be the first Shuttle flight following the STS-107 Columbia accident on 1 February 2003.

The Shuttle acts as an important element for assembly and servicing of the International Space Station in which Europe is one of the co-operating partners together with the United States, Russia, Japan and Canada. It has brought many of the current ISS elements to the Station and will in the future bring many of the modules needed to extend the ISS research capabilities and bring the assembly to completion. This includes transport of the core European elements developed under ESA contracts by European Industry such as the Columbus Laboratory, the European built Nodes 2 and 3 and the Cupola observation window.

As part of the STS-114 mission, the seven-person crew will deliver several tonnes of supplies to the ISS for use by the current Expedition 11 Crew Sergei Krikalev and John Phillips. The pressurised cargo will be transported in Discovery's cargo bay by one of the European-built Multi-Purpose Logistics Modules or MPLMs called ‘Raffaelo’. Once at the Station the MPLM will be attached to the Unity Node of the ISS.

While the Shuttle has been out of service, the role of ISS reboost and supply ship has been carried out primarily by the Russian Progress spacecraft. With the continuation of ISS assembly, this will lead to increased research capabilities and the need for increased crew sizes. This will in turn lead to the increased cargo delivery needs. In order to meet this demand for supplies and contribute towards ISS running costs, Europe's Automated Transfer Vehicle or ATV will come into service from 2006 onwards. The ATV will complement the Shuttle and Progress by becoming an ISS supply spacecraft capable of
Progress M1-11 during docking with the International Space Station on 31 January 2004 (Image: NASA)

delivering 7.7 tonnes of cargo to the ISS, removing waste from the Station and reboosting the Station to a higher orbit to account for atmospheric drag.

Graphic representation of ATV during docking with the ISS (Image: ESA/D.Ducros)

The Shuttle also acts as an important vehicle for bringing crews to and from the International Space Station either Expedition crews, crews carrying out ISS assembly missions or astronauts on scientific missions. Since February 2003 the role of crew exchange on the ISS has been carried out by the Russian Soyuz spacecraft. The Shuttle has also carried many astronauts into orbit on non-ISS research missions such as those utilising the European-developed Spacelab.


The following Shuttle flights will also include ESA astronauts Thomas Reiter, as the first European on a long-term ISS mission, being launched on the STS-121 Shuttle flight in September 2005 and Christer Fuglesang on the STS-116 ISS assembly mission in 2006.
ESA astronaut Thomas Reiter from Germany will become the first European astronaut to serve a long-term mission on the ISS after launch of the STS-121 Shuttle flight in September 2005 (Image: ESA)

While it has been out of service many improvements have been made to Shuttle systems and procedures. This includes many of the recommendations that were made in the report of the Columbia Accident Investigation Board in 2003. New designs to the external fuel tank will reduce the risk of debris damaging the Shuttle’s thermal protection system, which initiated the Columbia accident in 2003.

New techniques will also be used to confirm the health of the Shuttle and its heat shield during launch and while in space. This includes the use of a 30-metre long robotic arm tipped with sensor equipment to inspect critical heat shield areas on the wings and nose and the evaluation of data sent to the ground from 176 sensors located in the wing panels, and the Shuttle performing a backflip on approach to the Space Station in order to produce still images of its underside heat shield.

Three spacewalks will take place during the mission. These will involve the demonstration of techniques for repairing Shuttle heat shield materials as well as replacing one of the Station’s control gyroscopes, used for Station orientation, restore power to another gyroscope and install a work platform for future in-orbit construction. As part of the mission Discovery will be used to reboost the Space Station to a higher orbit.
Mission Key Reference Data

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<tr>
<td>Orbiter</td>
<td>Discovery</td>
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<tr>
<td>Launch Site</td>
<td>Launch Complex 39B, Kennedy Space Center, Florida</td>
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<td>Landing Site</td>
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Multi-Purpose Logistics Module (MPLM)

The MPLM is one of Europe's major hardware contributions to the ISS programme. The MPLMs are pressurised cargo containers that travel in the Shuttle's cargo bay. Once at the ISS the MPLM is removed from the Shuttle's cargo bay and docked to the Station to allow the astronauts to work inside, transferring scientific payloads and other supplies between the MPLM and the Station's other research and living areas. Each MPLM is a cylinder 6.5 m long and 4.5 m in diameter, with conical endcaps that house docking mechanisms and hatches. Each MPLM can accommodate 16 standard payload racks, five of which can be refrigerator/freezers. Each one can carry over nine tonnes of cargo to upload to the ISS and has a service life of 25 return trips to space.

Three of these Multi-Purpose Logistics Modules, Leonardo, Raffaello and Donatello, have been developed for NASA by the Italian Space Agency (ASI). Prime contractor Alenia Spazio in Turin is also developing two ISS Nodes for the European Space Agency. Leonardo was the first MPLM to visit the station with STS-102 in March 2001 and has made two subsequent flights. The first of these was on STS-105 in August 2001 on which was the first ESA and European experiment facility for the ISS, the Advanced Protein Crystallisation Facility. The second flight was on STS-111 in June 2002 on which was the ESA-developed Microgravity Science Glovebox, which was the first European rack facility to be launched to the ISS and was developed to perform a wide variety of materials, combustion, fluids and biotechnology experiments in weightlessness.

Raffaello, which will be used for the STS-114 mission first travelled to the ISS in April 2001 on the STS-100 mission, which included the first European astronaut to go on mission to the ISS, Umberto Guidoni. Raffaello has made one additional flight (STS-108).

In some ways, the MPLM is a descendant of Spacelab, which flew aboard the Shuttle between 1983 and 1996, though the MPLMs take advantage of improved technology, particularly in welding. It also shares some basic systems with Europe's forthcoming Columbus laboratory, which will be permanently attached to the ISS. Their structures are similar - although Columbus has a "skin" twice as thick as the MPLM - and both Columbus and the MPLM make use of ESA's ECLSS: the Environmental Control and Life Support Sub-system. The ECLSS provides a comfortable working environment for the astronauts as its main functions include distribution of fresh air throughout the MPLM, temperature monitoring, pressure control, fire detection and suppression, and support to contamination monitoring.
Pulmonary Function System (PFS)

Breath analysis has been an important medical and research tool for many years. However, it previously depended on a device called a mass spectrometer, which is highly sensitive but requires highly skilled operators and is difficult to calibrate accurately. The Pulmonary Function System or PFS uses an entirely different approach called photoacoustics.

The device will analyse exhaled gas from astronauts’ lungs and provide near-instant data on the state of crew health. It will also have important medical uses here on Earth. The method depends on the fact that different gases absorb infrared energy at different and very precise wavelengths. Analysing the samples after exposure to an infrared source will provide an accurate measure of how much of a given gas is present in the samples.

Six different gases can be measured simultaneously, with several measurements being made within a single breath. This will provide a lot of information about the subject’s lung function, blood flow and entire cardiovascular system.

The PFS is a collaboration between ESA and NASA in the field of respiratory physiology instrumentation. This will be accommodated in the NASA Human Research Facility located in the US Destiny Laboratory on the ISS. The PFS consists of four separate components, two developed by ESA: The Pulmonary Function Module (PFM) and the Photoacoustic Analyser Module (PAM); and two developed by NASA: the Gas Delivery System and the Gas Analyser System for Metabolic Analysis Physiology. These four elements can be combined in two different configurations to provide a variety of different measurements.

The PFM/PAM Unit consists of the Respiratory Valve Unit, with associated flow-meters, rebreathing bag, etc., and an electronics unit. The electronics unit is accommodated in a standard ISS drawer in the Human Research Facility rack, though there is a mode of operation in which this drawer is removed from the Human Research Facility rack and operated externally.

PFS is the first flight hardware developed by the Microgravity Facilities for Columbus Programme as part of the European Physiology Modules project, originally planned for launch in the Columbus Laboratory. The hardware was developed for ESA by the Danish company Innovision.

Following great interest shown by NASA, ESA was offered an earlier flight opportunity to launch the PFS as part of the second NASA Human Research Facility to be installed on the ISS.
Eileen Collins is the Commander of STS-114 and was the first woman to command the Space Shuttle. She has previously flown on three Shuttle missions (STS-63, STS-84 and STS-93) and, as Commander, has overall responsibility for the on-orbit execution of the mission, Orbiter systems operations, and flight operations including landing the Orbiter.

Jim Kelly is the pilot on STS-114. This is his second Shuttle mission having been the pilot on STS-102 mission. He will be responsible for systems operations and assisting in the rendezvous for docking to the Station. He is also a robotic arm operator for the Shuttle and ISS.

Soichi Noguchi is Mission Specialist 1 representing the Japan Aerospace Exploration Agency (JAXA). Noguchi will lead and perform three EVAs, or spacewalks, during the mission together with astronaut Stephen Robinson.

Stephen Robinson is Mission Specialist 2. This is his third spaceflight having previously flown on STS-85 and STS-95. On STS-114 he will serve as the Flight Engineer.

Andrew Thomas is Mission Specialist 3. Prior to this mission he flew on STS-77, STS-89 and STS-102. He will be the lead Shuttle robotics officer for the inspection of the Orbiter's thermal protection system using a new robotic arm extension outfitted with sensors and cameras.

Wendy Lawrence is Mission Specialist 4. Her spaceflight experience includes serving on the STS-67, STS-86 and STS-91 missions. She will lead the transfer of supplies from the Shuttle's cargo module to the Station. She will also perform ISS robotics.

Charles Camarda is Mission Specialist 5. His duties include Shuttle robotics, assisting in the external inspection of the Orbiter's thermal protection system, photography and television support, and computer operations.
Not only does the return of the Shuttle to flight pre-empt the renewed construction of the International Space Station, it also pre-empts the first long-duration flight of a European astronaut to the ISS since construction started in 1998. Following the STS-114 Return to Flight mission, the next flight of Shuttle (STS-121) in September 2005 will include ESA astronaut Thomas Reiter from Germany, who will become a member of the ISS Expedition 12 Crew. He will remain on the ISS for six months before returning in 2006 with a Soyuz TMA spacecraft that will be based at the ISS. During his time on the ISS he will carry out relevant ISS tasks as well as an ESA experimental programme.

Reiter previously served 179 days (3 September 1995 until 29 February 1996) on the ESA-Russian Euromir 95 mission to the Mir Space Station performing some 40 European scientific experiments and performing two spacewalks (EVAs) to install and later retrieve cassettes of the European Space Exposure Facility experiments (ESEF).

ESA astronaut Christer Fuglesang from Sweden will follow Thomas Reiter into orbit on Shuttle in 2006 when he becomes part of the STS-116 crew to carry out an ISS assembly mission during which he will undertake three spacewalks.

The flights of ESA astronauts Reiter and Fuglesang come in a long tradition of European astronauts who have flown on the Shuttle since ESA astronaut Ulf Merbold from Germany became the first European astronaut to fly on Shuttle in 1983.

Ulf Merbold became the first European to undertake a mission on the Space Shuttle (STS-9) on the 10-day Spacelab-1 mission between 28 November 1983 and 8 December 1983. Not only was this the first spaceflight of an ESA astronaut, it was the first flight of the European-built Spacelab and the first flight of a non-American on the Shuttle.

Spacelab was the first purpose-built space laboratory developed by Europe under a cooperation agreement with NASA. It was a modular research laboratory that would fit inside the Shuttle's cargo bay and built by a consortium of European companies. During the Spacelab-1 mission over 70 scientific experiments were conducted in a variety of fields including Astronomy, Solar Physics, Space Plasma Physics, Earth Observation, Material Science, Technology and Life Sciences. Working in two teams of three, the crew worked 12-hour shifts, allowing for 24-hour operations.

Not only have Spacelab experiments made a major contribution to space science research, but also the knowledge and expertise gained by both ESA and NASA during the Spacelab missions has made a significant contribution to today’s International Space Station programme.

Beyond the Spacelab missions, European astronauts have carried out a wealth of research and gained a wealth of experience aboard Shuttle in the past 20 years. Following the flight of Patrick Baudry on the Spartan-1 mission for CNES in 1985, there was a gap of seven years until the flight of ESA and Europe’s most experienced astronaut to have flown on the Space Shuttle, Claude Nicollier having flown on Shuttle on four separate occasions.
Nicollier’s first flight was on STS-46 in 1992 together with Italian Space Agency astronaut Franco Malerba. This mission deployed the European Retrievable Carrier (EURECA) and the Tethered Satellite System (TSS-1). Nicollier’s second mission was on the first Hubble Space telescope servicing mission, STS-61 in December 1993. During the 11-day flight, the Hubble Space telescope was captured and restored to full capacity through a record of five spacewalks by four astronauts. His third flight was on STS-75 Columbia (22 February to 9 March 1996) together with ESA astronaut Maurizio Cheli and Italian Space Agency astronaut Umberto Guidoni. This mission was a 15-day flight, with principal payloads being the refight of the Tethered Satellite System (TSS) and the third flight of the United States Microgravity Payload (USMP-3).

The TSS experiment produced a wealth of new information on the electrodynamics of tethers and plasma physics before the tether broke at 19.7 km, just shy of the 20.7 km goal. Scientists on the ground were able to devise a programme of research making the most of the satellite’s free flight while the astronauts’ work centered on research related to the USMP-3 Microgravity investigations.

In December 1999 Nicollier was part of the STS-103 mission together with ESA astronaut Jean-François Clervoy who was on his third flight on the Shuttle. This was the third Hubble Space telescope mission. During this eight day mission, Nicollier carried out his first spacewalk or EVA, of 8 hours 10 minutes duration to install a new computer and one of three fine guidance sensors. He is the first European to obtain EVA experience on a Shuttle flight.

Between the third and fourth flights of Nicollier, four European astronauts undertook missions on the Shuttle. Jean-François Clervoy was on the 6th Shuttle flight to Mir in May 1997 and Jean-Loup Chrétien (CNES) on the 7th Shuttle/Mir flight (25 September 97 – 6 October 1997). Pedro Duque flew as Mission Specialist on the Space Shuttle Discovery, STS-95 mission (29 October to 7 November 1998). This nine-day mission was dedicated to research in weightlessness and the study of the Sun. Michel Tognini, currently Head of ESA’s European Astronaut Centre, flew on the STS-93 mission, which took place from 22-27 July 1999. During this mission his primary task was to assist in the deployment of the Chandra X-Ray Observatory, and to conduct a spacewalk if needed.
needed. The Chandra X-Ray Observatory is designed to conduct comprehensive studies of the universe, and the telescope will enable scientists to study exotic phenomena such as exploding stars, quasars, and black holes.

From 19 April to 1 May 2001, Umberto Guidoni participated in the Space Shuttle’s STS-100 mission, being the first European on board the International Space Station. On that flight, the Space Shuttle delivered elements and equipment required for the ongoing assembly of the International Space Station. In particular, it carried the Multi-Purpose Logistics Module (called Raffaello), provided by the Italian Space Agency and loaded with laboratory outfitting equipment, as well as the Space Station Remote Manipulator System (SSRMS), the Canadian robotic arm that will be used extensively to assemble the Space Station.

With the passing of the millennium, Gerhard Thiele became the first European astronaut to fly on Shuttle. From 11-22 February 2000, Thiele participated as mission specialist in the STS-99 Mission. The Shuttle Radar Topography Mission (SRTM) was dedicated to the first, three-dimensional, digital mapping of the Earth surface on a nearly global scale. He was 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 was mounted. Thiele was also one of two spacewalking crew members, in the event contingency spacewalk would have been required during the flight.

Phillipe Perrin is currently the last European astronaut to have flown on Shuttle. He served as a mission specialist on STS-111 (5-19 June 2002) onboard Space Shuttle Endeavour. The 14-day STS-111 mission exchanged the ISS Expedition Crew and delivered a Canadian-built mobile base system for the Station’s robotic arm. During the Mission Perrin carried out three successful spacewalks. On the first two Extravehicular activities, he helped to install the mobile base system and on the third, he performed a late-notice repair of the Station’s robotic arm by replacing one of its joints. He spent a total of about 19 hours outside the station. During that mission, he was also arm operator and berthed the MPLM back into the orbiter payload bay towards the end of the mission.
On April 12, 1981, Shuttle operations commenced with the launch of Columbia on the STS-1 mission. NASA’s fleet of orbiters has comprised five ships to date: Challenger, Columbia, Discovery, Atlantis and Endeavour. Discovery, which is the chosen orbiter for the STS-114 mission has undertaken 30 missions since its first flight in August 1984 including deployment of the Hubble Space telescope in 1990 (STS-31), the STS-42 Spacelab IML-1 mission with ESA astronaut Ulf Merbold, in 1992, the third Hubble Space Telescope servicing mission (STS-103) in 1999 with ESA astronauts Claude Nicollier and Jean-Francois Clervoy, and transport of the ISS Z1 truss element (STS-92) and the European-built Multi-Purpose Logistics Module ‘Leonardo’ (STS-102 and STS-105) to the ISS.

Atlantis was first launched in October 1985 and has undertaken 26 missions, which include deployment of ESA’s European Retreivable Carrier (EURECA) and operation of the Tethered Satellite System on the STS-46 mission in 1992 with ESA astronaut Claude Nicollier and Italian Space Agency astronaut Franco Malerba, and transported the US Destiny laboratory, the Quest Airlock and two truss elements to the ISS on four separate missions (STS-98, STS-104, STS-110 and STS-112).

Endeavour was the fifth orbiter constructed, undertaking its first mission in 1992. Highlights of its 19 missions to date include the STS-88 mission, which transported the Unity Node as the second ISS module into orbit in December 1998, the Shuttle Radar Topography Mission (STS-99) in February 2000 with ESA astronaut Gerhard Thiele, the STS-100 mission in 2001, which brought Umberto Guidoni as the first European astronaut on mission to the ISS, and the STS-111 ISS assembly mission with ESA astronaut Philippe Perrin in June 2002.

Challenger was lost on launch in January 1986 on its tenth mission and Columbia was lost prior to landing on its 28th mission in February 2003.

The Space Shuttle or Space Transportation system (STS) consists of three major component parts: The orbiter, which most people refer to as the Space Shuttle, the external tank, which holds the orbiter's propellant and the solid rocket boosters which provide the most lift during the first two minutes of flight. Together they have a length of 56 metres and weigh more than 2,000 tonnes at lift-off. The Space Shuttle has a lift-off thrust of over 3,240 tonnes and is capable of carrying a cargo of just over 28 tonnes into orbit. A normal mission lasts between 5 and 16 days. Since 1981 more than 600 astronauts have flown on Shuttle and it has put more than 1.36 million kilograms into orbit. Since the Columbia accident in February 2003 there have been improvements made to all elements of the Shuttle.
The Orbiter
The 37-metre long orbiter is the element of the Space Shuttle system which contains the crew and returns the crew to earth at the end of their orbital mission. It also contains relevant equipment and supplies, either for use by the Shuttle crew on a non-ISS Shuttle mission, or additionally by the ISS Expedition Crew when on an ISS mission. To protect the orbiter from the up to 1600 °C temperatures during re-entry, all surfaces are covered with thermally protective materials. The main types of thermal materials used are Reinforced Carbon-Carbon (RCC), low- and high-temperature reusable surface insulation tiles, felt reusable surface insulation blankets and fibrous insulation blankets. RCC is used amongst other places on the wing leading edges where improvements have been made to prevent heat flow getting inside the wing structure.

The forward fuselage contains the 65.8 m³ crew station module. This pressurised three-section compartment contains areas for working, living and stowage. It consists of the flight deck, the middeck/equipment bay and an airlock. Four crew members seats are on the flight deck. On the forward flight deck there are more than 2000 displays and controls with the commander's seat positioned on the left and the pilot's seat on the right. The middeck contains the three other crew seats together with provisions and stowage facilities, four crew sleep stations the waste management system, the personal hygiene station and the work/dining table. Outside the aft bulkhead of the crew module in the payload bay, a docking
module and a transfer tunnel with an adapter can be fitted to allow crew and equipment transfer for docking, Spacelab and extravehicular operations.

The 18-metre long, 5-metre wide mid fuselage is the location of the payload bay and payload bay doors. It is in this cargo area that the European Columbus Laboratory will be carried to the ISS and in which the MPLM’s are carried as pressurised cargo containers for resupplying the ISS. The payload bay is the location of the Shuttle’s Remote Manipulator System or robotic arm which is controlled from the flight deck. This allows payloads to be deployed out of the payload bay or payloads to be grappled and secured in the payload bay for return to Earth.

The 5.5 metre long aft fuselage consists of the left and right orbital maneuvering systems, Space Shuttle main engines, body flap, vertical tail and orbiter/external tank rear attachments. The orbiter has a wingspan of 24 metres and, on the runway, a height of 17 metres. It has an in-orbit altitude of between 185 and 643 kilometres, with a velocity of 28,000 km/h. The orbiter’s engines exert a thrust of over 170 tonnes at sea level.

**External Tank**

The External Tank is the fuel tank for the orbiter. It contains the propellants used by the Space Shuttle main engines. It has been redesigned in the past two years to eliminate the possibility of foam coming off during launch which could potentially damage the Shuttle. When it’s empty the External Tank weighs more than 35 tonnes and can carry almost 720 tonnes of propellant, more than 616 tonnes of liquid oxygen and nearly 103 tonnes of liquid hydrogen.

The External Tank is 47 metres long and acts as the “backbone” of the Shuttle during the launch, providing structural support for attachment with the solid rocket boosters and orbiter. The tank is the only component of the Space Shuttle that is not reused. Approximately 8.5 minutes into the flight, with its propellant used, the tank is jettisoned at an altitude of approximately 110 kilometres above the Earth. The now nearly empty tank separates and falls in a preplanned trajectory with the majority of it disintegrating in the atmosphere and the rest falling into the ocean.

The three main components of the External Tank are an oxygen tank holding a volume of more than 540,000 litres of liquid oxygen, located in the forward position, an aft-positioned hydrogen tank holding more than 1,450,000 litres of liquid hydrogen and a collar-like intertank, which connects the two propellant tanks, houses instrumentation and processing equipment, and provides the attachment structure for the forward end of the solid rocket boosters.
The hydrogen tank is 2.5 times larger than the oxygen tank but weighs only one-third as much when filled to capacity. The reason for the difference in weight is that liquid oxygen is 16 times heavier than liquid hydrogen.

The aluminium skin of the External Tank is covered with a thermal protection system that is a 2.5-centimetres thick coating of polyisocyanurate foam. The purpose of the thermal protection system is to maintain the propellants at an acceptable temperature, to protect the skin surface from aerodynamic heat and to minimize ice formation.

The External Tank includes a propellant feed system to duct the propellants to the orbiter engines, a pressurisation and vent system to regulate the tank pressure, an environmental conditioning system to regulate the temperature and render the atmosphere in the intertank area inert, and an electrical system to distribute power and instrumentation signals and provide lightning protection.

The tank's propellants are fed to the orbiter through a 43-centimeter diameter connection that branches inside the orbiter to feed each main engine.

**Solid Rocket Boosters**

The two Solid Rocket Boosters (SRBs) operate in parallel with the main engines for the first two minutes of flight to provide the additional thrust needed for the orbiter to escape the gravitational pull of the Earth. Each booster is over 45 metres long and weighs about 590 tonnes at lift-off. At an altitude of approximately 45 km, the boosters separate from the orbiter/external tank, descend on parachutes, and land in the Atlantic Ocean where they are recovered and thereafter refurbished for reuse. The boosters also assist in guiding the entire vehicle during initial ascent. Thrust of both boosters is equal to 2,400 tonnes.

In addition to the solid rocket motor, the booster contains the structural, thrust vector control, separation, recovery, and electrical and instrumentation subsystems.

The solid rocket motor is composed of a segmented motor case loaded with solid propellants, an ignition system, a movable nozzle and the necessary instrumentation and integration hardware. Each solid rocket motor contains more than 450 tonnes of propellant, which requires an extensive mixing and casting operation. The solid fuel is actually powdered aluminium, mixed with oxygen provided by a chemical called ammonium perchlorate.

Following the Columbia accident there have been redesigns of the bolt catchers which catch part of the bolts that hold the boosters to the external tank during booster separation and the booster separation motors which push the boosters away from the external tank during separation.
Space Shuttle Discovery will be launched from Launch Complex 39B of NASA’s Kennedy Space Center, Merritt Island in Florida, just north of Cape Canaveral. Launch pads 39A and B were originally constructed in the 1960’s for launching the Apollo missions and have been used to launch the Apollo, Skylab, Apollo-Soyuz and Space Shuttle missions.

The Space Shuttle is transported to the octagonal-shaped launch pad by a large tracked crawler. Each launch pad has a 106-metre tall Fixed Service Structure with three retractable swing arms and a Rotating Service Structure, which rotates around the orbiter. New coatings have been put on the service structures to deal with the critical debris issue.

The retractable swing arms of the Fixed Service Structure provide access to the Shuttle on the pad. The lowest arm provides access to the orbiter crew compartment and acts as an emergency escape route for the crew up to seven minutes, 24 seconds before launch. The middle arm is used amongst other things for attachment of umbilicals to the external tank to support tanking and launch. The highest arm contains a vent hood, which is used to prevent ice formation at the liquid oxygen vent system at the top of the external tank.

The 40-metre high Rotating Service Structure provides protected access to the Shuttle orbiter for installation and servicing of payloads at the launch pad, as well as servicing access to certain systems on the orbiter. It is retracted before launch.

There is a 3400 m³ tank for storing liquid oxygen at -183 ºC and a 3200 m³ tank for storing liquid hydrogen at -253 ºC. The launch pad contains a flame trench, which is 150 metres long, 13 metres deep and 18 metres wide.

STS-114 Discovery, as a majority of Shuttle orbiters, will land at the Kennedy Space Center on one of the largest runways in the world. The runway is located 3.2 km northwest of the Vehicle Assembly Building and is 4,572 meters long and 91.4 meters wide.

The facility includes a 150 x 168 meter parking apron and a 3.2 km tow-way connecting it with the Orbiter Processing Facility. Located adjacent to the parking apron is a Landing Aids Control Building (LACB) which supports landing operations and houses operations personnel. The Shuttle Landing Facility is equipped with a number of navigation and landing aids to assist Shuttle pilots in landing.

A Recovery Convoy Staging Area, located just east of the runway about midway along its length, houses trailers, mobile units and specially designed vehicles that are used to “safe” the orbiter immediately after landing for crew egress and transfer of the orbiter to the Orbiter Processing Facility.
ISS Intergovernmental Agreement

The International Space Station is a co-operative programme between United States, Russia, Canada, Japan and eleven Member States of the European Space Agency (Belgium, Denmark, France, Germany, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom).

It is governed by an international treaty, signed by these Member States on 29 January 1998, called the ISS Intergovernmental Agreement, which provides the framework for design, development, operation, and utilisation of a permanently inhabited civil Space Station for peaceful purposes.

Furthermore, bilateral Memoranda of Understanding exist between NASA and each of the four associated space agencies: The European Space Agency (ESA), Russian Federal Space Agency, (FKA or Roscosmos, formerly Rosaviakosmos), the Canadian Space Agency (CSA) and the Japanese Space Agency (JAXA, formerly NASDA), outlining relevant ISS responsibilities, obligations and rights between the agencies.

National jurisdiction of the International Partner States extends to the ISS elements in orbit. This applies to areas such as criminal matters, liability issues, and protection of intellectual property rights.

Utilisation rights are outlined in the Memoranda of Understanding. The European Space Agency allocation rights comprise 8.3% of the Space Station utilisation resources including, in particular, 8.3% of crew time, which represent approximately 13 hours per week. In compensation for the provision of the resources (energy, robotics, cooling, telecommunications, etc.) to the Columbus Laboratory by NASA and CSA, Europe provides 49% of the laboratory’s utilisation resources to NASA and 2% to the CSA.

One important point is that ESA and the other Space Station International Partners can barter or sell their unused utilisation rights among themselves and to other non-participants to the Station’s programme.
ISS Current Configuration

- **Radiator for heat dispersion**
- **P1 Truss section** was launched to the ISS on 24 November 2002.
- **Central 50 Truss section** was launched on 8 April 2001.
- **Canadian 2** was an element taken to the ISS during STS-100.
- **Destiny** is the US laboratory. It was launched on 7 February 2001.
- **S1 Truss section** was launched on 9 October 2002.
- **Soyuz spacecraft**

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**ISS General Information**

- **Human Spaceflight**
- **Space Shuttle Return to Flight**

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**ISS Current Configuration** (Image: ESA/D Ducros)

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Directorate of Human Spaceflight, Microgravity and Exploration Programmes

www.esa.int/spacelife - e-mail: spacelife.info@esa.int - July 2005
ISS and Europe's Major Contributions

Columbus Laboratory

Columbus is ESA's Research laboratory. It provides space for research facilities in the fields of material science, fluid physics and life science. In addition, an external payload area can accommodate experiments and applications in the fields of space science, Earth observation, technology and innovative sciences from space. Columbus will be permanently stationed at the International Space Station attached to another European-built module, Node 2. It is planned for launch with Shuttle in October 2006.

Automated Transfer Vehicle (ATV)

The Automated Transfer Vehicle is Europe's unmanned supply vehicle for the ISS. It will take up to 9 tons of cargo to the ISS, boost the station to a higher orbiting altitude and remove up to 6.5 tons of waste from the station. It measures approximately 10 metres long by 4.5 metres in diameter, with solar arrays spanning more than 22 metres for generating its electrical power. Cargo transported will include pressurised cargo, water, air, nitrogen, oxygen and attitude control propellant. The first planned launch is in 2006.

Node 2 and Node 3

Nodes are pressurised modules that interconnect the research, habitation, control and docking modules of the ISS. The Nodes are used to...
control and distribute resources between the connected elements. The ISS will have three Nodes. Node 1, called Unity, was developed by NASA. It became the second module of the ISS in orbit after its launch in December 1998. Node 2 and 3 are developed under an ESA contract with European industry with Alenia Spazio as the prime contractor.

Node 2 will be the first European Node launched. It will act as a connection point for the European Columbus laboratory, the US Laboratory Destiny and the Japanese Laboratory Kibo. It also will be the attachment point for the Japanese HII Transfer Vehicle, carry a docking adapter for the US Space Shuttle, and act as an attachment point for the Multi-Purpose Logistics Module (MPLM). The MPLM is a pressurised cargo container, which travels in a space shuttle cargo bay. Node 2 also provides a working base point for the Space Station Remote Manipulator System, a Canadian robotic arm on the ISS called Canadarm 2.

Node 3 will be the second European node to arrive at the ISS and will be attached to the American-built Node 1, which was launched to the ISS in December 1998. The forward port of Node 3 will act as the connecting point for the European-built Cupola.

Ownership for Node 2 has been, and for Node 3 will be, transferred to NASA within the framework of a barter agreement between ESA and NASA.

**European Robotic Arm (ERA)**

The European Robotic arm or ERA is a robotic arm, which serves to install solar arrays on the Russian section of the ISS. It further acts as an inspection tool on the Russian segment of the ISS and can carry out additional assembly and replacement tasks on the external surface of the station such as on the Russian Research Module and Multipurpose Laboratory Module. The 11-metre long ERA also serves to support or transfer astronauts carrying out tasks on spacewalks. It has an extensive range, as it is able to walk around the Russian segment of the station and while in orbit is able to manipulate up to 8000kg of mass.

**Data Management System (DMS-R)**

Europe’s DMS-R Data Management System was the first piece of European hardware on the ISS in July 2000. It includes two fault-tolerant computers and two control posts. It is the ‘brain’ or control centre of the Russian Segment of the ISS and carries out a great degree of the vital and fundamental functions on the station including: guidance, navigation and control of the entire ISS; failure management and recovery; and control of additional ISS systems and subsystems.
The Cupola will become a panoramic control tower for the International Space Station (ISS), a dome-shaped module with windows through which operations on the outside of the Station can be observed and guided. It is a pressurised observation and work area that will accommodate command and control workstations and other hardware.

Through the Robotics Work Station, astronauts will be able to control the Space Station’s robotic arm, which helps with the attachment and assembly of the various Station elements.

However, the Cupola will operate as more than a workstation. With a clear view of Earth and celestial bodies, the Cupola will have scientific applications in the areas of Earth Observation and Space Science as well as holding psychological benefits for the crew.
Credits

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