Backgrounder

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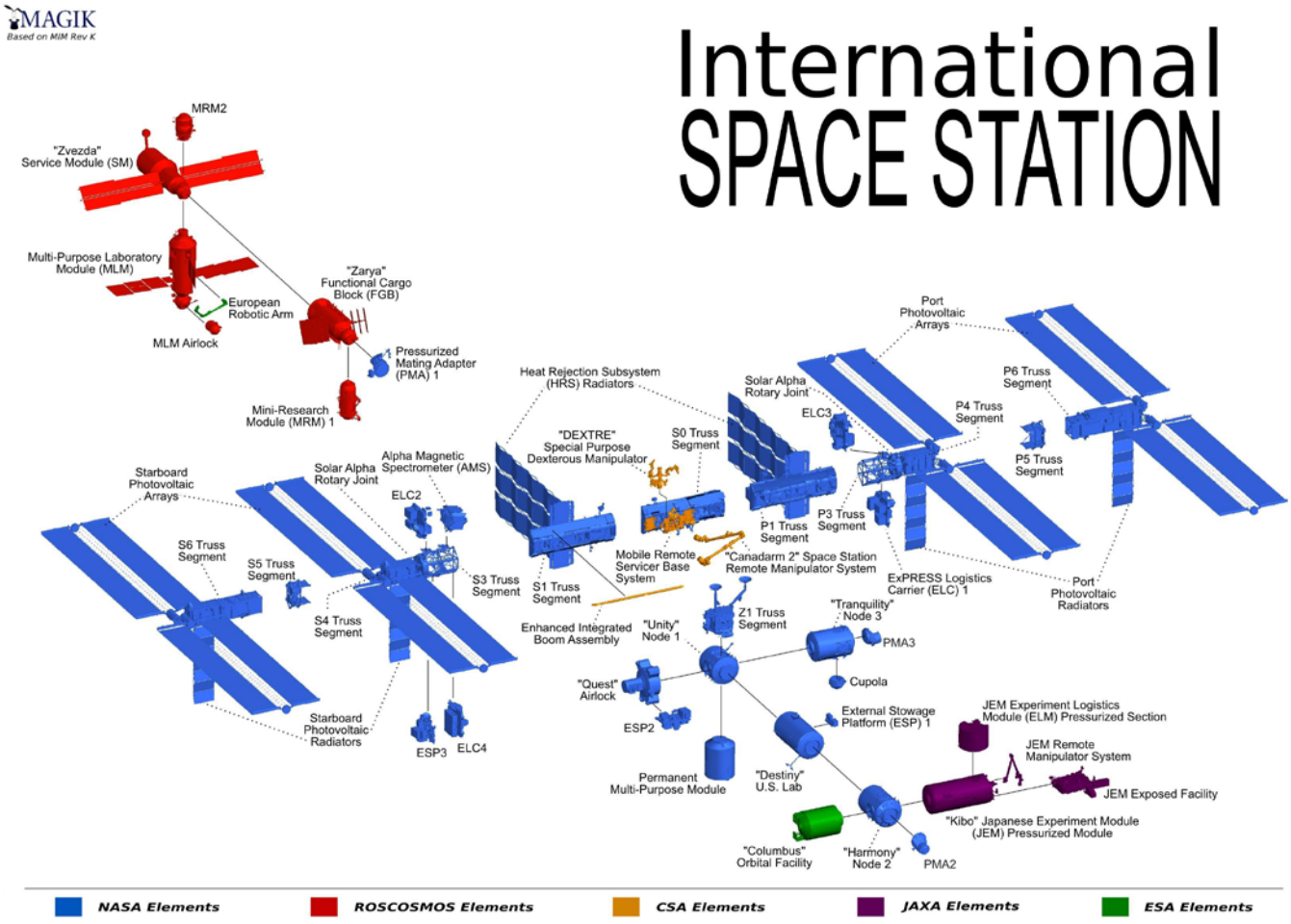
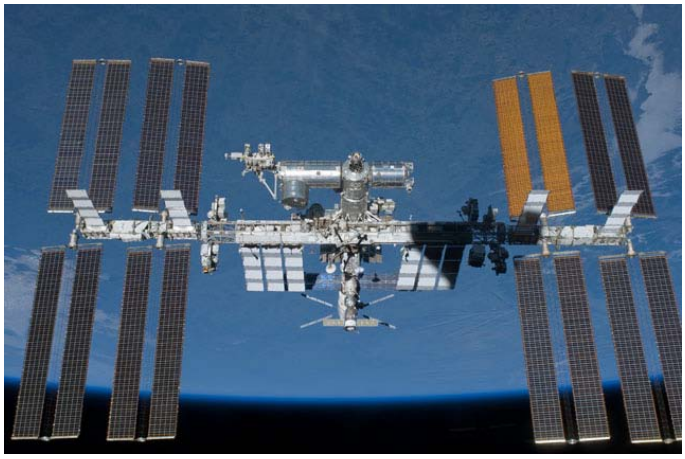


Description & Purpose

The International Space Station (ISS) is the largest, most complex international scientific and engineering space project in history and our largest endeavor into space to date. Completed in 2011, the ISS is larger than an American football field including the end zones. The ISS serves as a test bed for building and maintaining large structures in space, for conducting science and technology research leading to discoveries that will benefit us here on Earth, and as a test bed for developments in future human space exploration. The 15 countries who have come together to build the ISS are: Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, Russia, United Kingdom and United States. Today, five space agencies operate the ISS.

In March 2010, the National Aeronautics Association recognized the ISS with the 2009 Collier Trophy "for the design, development and assembly of the world's largest spacecraft, an orbiting laboratory that promises new discoveries for mankind and sets new standards for international cooperation in space."

Also in March 2010, the ISS received the prestigious Aviation Week 2010 Laureate Award for Space for its major completion with the addition of the last major modules and the expansion of the crew to six in 2009. In its award write-up, Aviation Week stated that "the ISS is arguably the signature engineering achievement of the last 60 years. By working together, partner agencies demonstrated that the station is as much an achievement in foreign relations as it is in aerospace engineering."



The ISS is truly an undertaking in a class by itself. It shatters the mold as an engineering, scientific, management and diplomatic achievement. It has been staffed continuously since November 2, 2000, in support of assembly and science research activities that include several hundred experiments on topics ranging from human physiology to physical science.

The ISS plays a critical role in support of the nation’s space exploration aspirations and supports a variety of pure and applied research for the United States and its international partners. The ISS provides a unique, continuously operating capability to develop medical countermeasures for long-term human space travel, to develop and test technologies and engineering solutions in support of exploration, and to provide ongoing practical experience in living and working in space. Boeing works with NASA and industry to optimize science and research on the orbital outpost.

The U.S. segment interfaces with all the ISS international partner elements. It encompasses the truss segments, including the four solar arrays and several pressurized modules, which consist of:

- Unity and Harmony, connecting nodes 1 and 2
- the Destiny laboratory module
- the Quest airlock
- pressurized mating adapters
- the Zarya storage module, built in cooperation with the Russian Federal Space Agency

Additionally, thousands of components comprise the segment's core systems for thermal control, environmental control, guidance and navigation, communication and tracking, electrical power distribution, command and control, structure and mechanisms, and robotics. Boeing is supporting a variety of capability enhancements that will enable

use of the ISS to be extended to 2028. Those enhancements include a new communications system for visiting spacecraft, a new NASA docking system, lithium-ion batteries for the solar arrays, improved life support systems, software and avionics upgrades. In addition, Boeing supports processing of the laboratory experiment racks to facilitate experiments in space.

Customer(s): NASA is the principle customer for the International Space Station.

General Characteristics

ISS at Completion

Length (pressurized section):	167 feet (51.0 m)
Total Length:	192 feet (58.5 m)
Total Height:	100 feet (30.5 m)
Solar Array Wingspan (tip to tip):	239 feet (72.8 m)
Integrated Truss Length:	357 feet (109 m)
***Mass (weight):**	919,964 lbs
Operating Altitude:	220 nmi average (407 km)
Inclination:	51.6 degrees to the equator
Atmosphere Inside:	14.7 psi (101.36 kilopascals)
***Pressurized Volume:**	34,700 cubic feet (habitable volume of 14,400 cu. ft.)
Computers to control ISS:	52
Robotic Arms:	55-foot robot arm assembly that can lift 220,000 pounds and is used for assembly of main ISS elements. European Robotic arm: 30-foot robotic arm based on the Russian laboratory and used to move external experiments; Japanese robotic arm: 30-foot robotic arm based on Kibo and used to move and deploy experiments on the Japanese External Facility.
Power Generation:	84 to 120 kilowatts (usable power)
Maximum Crew Size:	Six

* assumes two Soyuz vehicles are docked to station.

Boeing's Role

NASA selected Boeing as prime contractor for the ISS on Aug. 17, 1993, and the original cost-plus-award-fee contract began on Jan. 13, 1995. In this role, Boeing has been responsible for the design, development, integration, testing and delivering – and now sustains the U.S.-built elements.

On Oct. 1, 2010, Boeing began work under a five-year, $1.24 billion contract extension to continue engineering support of the ISS through Sept. 30, 2015. Boeing is responsible for maintaining the station at peak performance levels so the full value of the unique research laboratory is available to NASA, its international partners, other U.S. government agencies and private companies. This action extends the space station's Vehicle Sustaining Engineering Contract, which was originally awarded in January 1995 and most recently extended in 2008. The extension brings the total

contract value through the end of fiscal year 2015 to $16.2 billion. In addition to the sustaining support, Boeing receives additional contract funding to perform various modifications and upgrades to station subsystems, such as a new NASA Docking System for visiting spacecraft and Lithium ion replacement batteries for the solar arrays.

The overwhelming success of the ISS program and its on-orbit performance have substantiated Boeing's core competency as a large-scale system integrator. The complex integration effort includes hardware and software from 16 countries, 37 states and more than 10,000 first-to-fourth tier suppliers, often with first-time integration occurring on orbit.

Boeing integrates ISS elements provided by the international partners. International partner components include: a Canadian-built 55-foot-long robotic arm and mobile servicing system used for assembly and maintenance tasks on the space station; a pressurized European laboratory called *Columbus* and logistics transport vehicles; a Japanese laboratory called *Kibo*, with an attached exposed exterior platform for experiments, as well as logistics transport vehicles; and two Russian research modules, an early living quarters called the *Zvezda Service Module* with its own life support and habitation systems, logistics transport vehicles and *Soyuz* spacecraft for crew return and transfer. Boeing is looking at the integration of future expandable and inflatable habitats on the station in the future.

Boeing also prepares every U.S. component for space flight at the Space Station Processing Facility at Kennedy Space Center, Fla. Boeing employees in Houston, TX, Huntsville, Ala., Huntington Beach, Calif. and Kennedy Space Center, Fla., work with NASA on the ISS program.

On March 5, 2010, Boeing officially turned over the U.S. on-orbit segment of the ISS to NASA with the signing of government form DD-250 at the conclusion of an Acceptance Review Board meeting in Houston.

Often referred to as "handing over the keys," the DD-250 document is equivalent to a final bill of sale that formally transfers ownership. Through the review board, NASA and Boeing verified the delivery, assembly, integration and activation of all hardware and software required by contract.

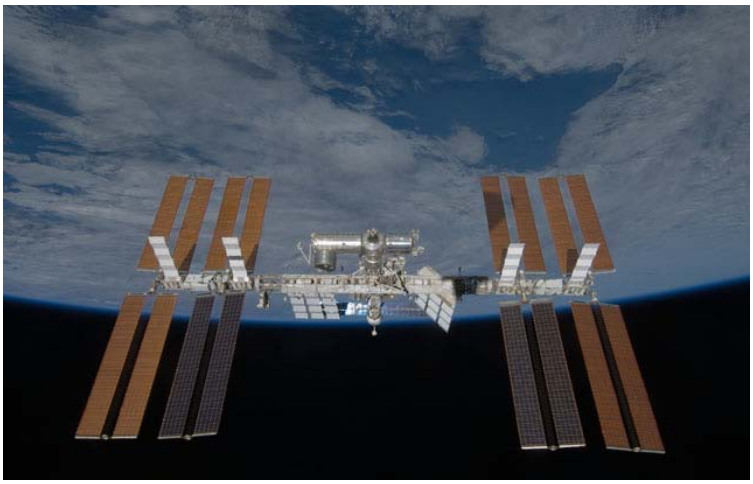
The S6 Truss Segment is loaded into the into the payload canister at the Space Station Processing Facility at NASA's Kennedy Space Center before being transferred to Launch Pad 39A for mission STS-119.

ISS Background

Since 1998, 18 major U.S. ISS components have been assembled in space. The 18th and final major U.S. and Boeing-built element, the Starboard 6 Truss Segment, was delivered to the ISS in February 2009. The 357-foot long integrated truss structure and solar arrays, with an active area of 32,528 sq. ft., generate electrical power for the space station. The one-acre of solar panels provide 84 -120 kilowatts of power.

U.S. scientific research is conducted aboard the ISS in the Boeing-built U.S. laboratory called *Destiny*, which holds 13 telephone booth-sized racks for science experiments. The crews work with experiments across a wide variety of fields including human life sciences, physical sciences and Earth observation, as well as education and technology demonstrations. *Destiny* also houses one of the workstations for Canada's space station robotic arm. *Destiny* is joined by laboratory modules sponsored by the Japan Aerospace Exploration Agency, European Space Agency and Roskosmos. With its five laboratories, the ISS has more than enough room and electrical power to do all kinds of ground-breaking research. The space shuttle, *Soyuz* and *Progress* vehicles as well as transfer vehicles from Japan and the European Space Agency, transport experiments up and/or down between Earth and Low Earth Orbit, about 240 miles in altitude. In addition to the laboratory, the ISS has living quarters aboard the Russian-built *Zvezda Service Module*. The crews access the outside of the ISS during spacewalks from the U.S.-built Joint Airlock called *Quest*, and the Russian Docking Compartment and Airlock called *Pirs*.

The Boeing systems and software groups produced about 7.5 million lines of flight software code running on more than 50 computers which communicate via 100 data networks to transfer 400,000 signals (e.g. pressure, temperature measurements, valve positions, etc.) that are necessary to operate the ISS. The software helps drive the Russian and U.S. built Guidance, Navigation and Control System.



The S-6 truss segment, along with the final set of solar arrays, was delivered to the ISS in March of 2009 marking the U.S. core completion of the ISS. The ISS is shown here after the successful installation of the S-6 truss.

A six-person expedition crew typically stays four to six months aboard the ISS. If the crew needs to evacuate the station, they can return to Earth aboard two Russian *Soyuz* vehicles docked to the ISS. Additional crewmembers are transported to the ISS by the space shuttle and *Soyuz*. Crews aboard the ISS are assisted by mission control centers in Houston and Moscow and a payload control center in Huntsville, Ala. The ISS can be controlled from mission control centers in Houston or Moscow.

The ISS has proven to be an important platform for research in biology and biotechnology, Earth and space science, human physiology, physical science, technology development and education. In the six months between March and September 2010, the five partner space agencies provided 195 research opportunities on the orbiting outpost for 385 investigators from 29 countries. More than 30 million students have participated in human spaceflight through communications downlinks and interactive experiments with station astronauts. Increasing the station's use as a unique laboratory is of paramount importance to the international partners and Boeing.

History

NASA began the current plan to build a space station in 1984 (FY 1985). In 1988, the space station was named *Freedom* and Japan, Canada and nine European countries under the aegis of the European Space Agency (ESA) agreed to be partners in the space station program. Following a significant redesign in 1993, NASA announced that the *Freedom* program would now be a new program called the International Space Station, with Russia joining the partnership.

The ISS is planned to be operated at least through the end of 2020. Boeing has completed studies to ensure the ISS can be safely extended to 2028. Following the completion of the Space Shuttle Program, NASA plans to develop commercial crew vehicles to provide crew support beginning in 2015 or 2016 and will continue to rely upon Russian *Soyuz* spacecraft to bring crews back and forth from the ISS.

Assembly Sequence

Nov. 20, 1998 (Mission 1 A/R): The *Zarya Control Module* was launched atop a Russian Proton rocket. *Zarya* provides battery power and fuel storage.

Dec. 4, 1998 (Mission 2A): Space Shuttle *Endeavour* delivered the *Unity Node* with two pressurized mating adapters. The STS-88 crew captured *Zarya* and mated it with the *Unity Node*.

May 27, 1999 (Mission 2A.1): STS-96 crew delivered and outfitted the ISS with logistics and supplies.

May 19, 2000 (Mission 2A.2a): The STS-101 crew readied the ISS for the arrival of the *Zvezda Service Module*.

July 12, 2000 (Mission 1R): The *Zvezda Service Module* launched atop a Russian Proton rocket and docked to the ISS two weeks later.

Sept. 8, 2000 (Mission 2A.2b): The STS-106 crew delivered supplies and performed maintenance on the ISS.

Oct. 11, 2000 (Mission 3A): Arriving aboard Space Shuttle *Discovery*, the STS-92 crew installed the Z1-Truss, a third pressurized mating adapter and a Ku-band antenna.

Nov. 2, 2000 (Mission 2R): The first crew to live and work aboard the ISS arrived in a Soyuz spacecraft.

Nov. 30, 2000 (Mission 4A): The STS-97 crew delivered and installed the P-6 truss which supports the first U.S. solar arrays.

Feb. 7, 2001 (Mission 5A): The STS-98 crew installed the Boeing-built *Destiny* Laboratory Module after removing it from Space Shuttle *Atlantis'* payload bay.

March 8, 2001 (Mission 5A.1): Space Shuttle *Discovery* resupplied the ISS with cargo from the Italian-built *Leonardo* Multi-Purpose Logistics Module (MPLM). The shuttle also arrived with the Expedition Two crew and returned the Expedition One crew home.

This panoramic scene of the International Space Station shows astronauts working on the Port 3/Port 4 truss, which was delivered during the STS-115 mission in September 2006.

April 19, 2001 (Mission 6A): Space Shuttle *Endeavour* delivered racks to the Destiny Laboratory with the *Raffaello* MPLM. Canadarm 2, the station's robotic arm, left the shuttle to its new home on the ISS.

July 12, 2001 (Mission 7A): The STS-104 crew used the Space Shuttle *Atlantis'* robotic arm to install the new Joint Airlock from which both Russian and American spacewalks take place.

Aug. 10, 2001 (Mission 7A.1): Space Shuttle *Discovery* transferred ISS crews bringing Expedition Three to their new home and taking home Expedition Two.

Sept. 14, 2001 (Mission 4R): A *Soyuz* rocket delivered a cargo crane and the Russian *Pirs* Docking Compartment for both a *Soyuz* docking port and Russian-based spacewalks.

Dec. 5, 2001 (Mission UF-1): Space Shuttle *Endeavour* delivered experiment racks inside the MPLM that were installed in the *Destiny* laboratory.

April 8, 2002 (Mission 8A): Space Shuttle *Atlantis* delivered the S0-Truss and the Mobile Transporter, which the STS-110 crew installed. The Mobile Transporter gives extra mobility to the Canadarm2.

June 5, 2002 (Mission UF-2): Space Shuttle *Endeavour*, with a Multi-Purpose Logistics Module, delivered more payload and experiment racks to the *Destiny* laboratory. The Mobile Base System was also installed completing the ISS Mobile Servicing System.

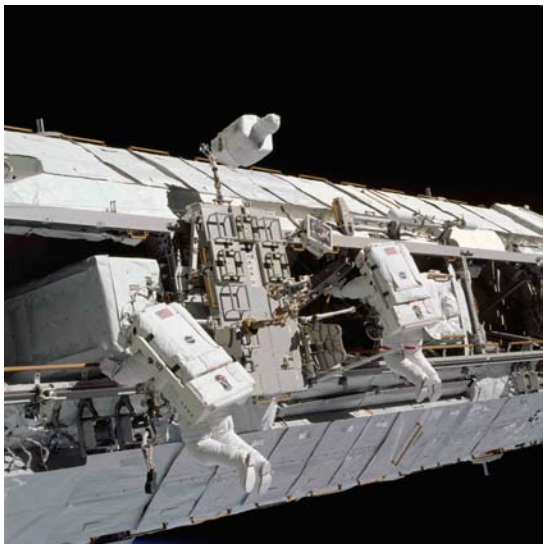
Oct. 7, 2002 (Mission 9A): Space Shuttle *Atlantis* delivered the first starboard truss segment, the S1 Truss, which the STS-112 crew installed.

Nov. 23, 2002 (Mission 11A): Space Shuttle *Endeavour* delivered the first port truss segment, the P1 Truss, which the STS-113 crew installed. The P6 solar arrays were deployed and its batteries were activated.

July 26, 2005 (Mission LF1): The Space Shuttle *Discovery's* Return to Flight mission carried supplies and equipment inside the *Raffaello* MPLM to the station. A faulty Control Moment Gyro was removed and replaced.

July 4, 2006 (Mission ULF1.1): The Space Shuttle *Discovery's* second Return to Flight mission delivered supplies and cargo and tested new equipment and safety procedures. The Mobile Transporter was repaired by replacing a power, data and video umbilical.

Sept. 9, 2006 (Mission 12A): Space Shuttle *Atlantis* delivered Port 3/Port 4 (P3/P4) to the ISS, the first new component to be delivered in almost four years. The new solar arrays on P4 were successfully deployed.



Dec. 9, 2006 (Mission 12A.1): Space Shuttle *Discovery* allowed continued construction of the outpost, adding the Port 5 spacer truss segment during the first of four spacewalks. The next two spacewalks rewired the ISS power system, preparing it to support the station's final configuration and the arrival of additional science modules.

June, 8, 2007 (Mission 13A): Space Shuttle *Atlantis* delivered and installed the Boeing-built 17.5 ton Starboard 3 and Starboard 4 truss segment to the starboard side of the integrated truss system of the orbital outpost. The truss,

part of the station's girder like backbone, is a mirror image of the Port 3 and Port 4 truss.

Aug. 8, 2007 (Mission 13A.1): Space Shuttle *Endeavour's* STS-118 mission was the 22nd shuttle flight to the ISS. It continued construction by delivering the Boeing-built third starboard truss segment. *Endeavour* made its 20th flight, the first since the STS-113 mission in November 2002. This was the first time the Boeing-designed Station Shuttle Power Transfer System was used, allowing the shuttle to remain docked to station for a longer period of time.

Oct. 23, 2007 (Mission 10A): Space Shuttle *Discovery* was the 23rd shuttle mission to the ISS and launched an Italian-built U.S. multi-port module. Also known as Node 2, *Harmony* is the first pressurized module added to the ISS since the Russian *Pirs* Docking Compartment was installed in September 2001. *Harmony* joined three other named U.S. modules on the station: the Boeing-built *Destiny* laboratory and the *Quest* airlock. Boeing provided a large number of *Harmony's* subsystem components, including lights, fans, power switches and converters, racks, air diffusers, smoke detectors, hatches and Common Berthing Mechanisms.

Feb. 7, 2008 (Mission 1E): Scientific research took on a new look aboard the ISS when Space Shuttle *Atlantis* launched on the STS 122 mission. The mission delivered the newest research module, the European Space Agency's *Columbus* laboratory*,* to the orbiting complex, expanding the ISS science capabilities.

March 11, 2008 (Mission 1J/A): The first pressurized component of the Japanese *Kibo* laboratory, a Canadian robotic device called Dextre and five spacewalks were major elements of *Endeavour's* STS-123 mission. *Endeavour's* 16-dayflight was the longest shuttle mission to the ISS.

May 31, 2008 (Mission 1J): STS-124, the 26th mission to the ISS, was the second of three flights that launched components to complete the *Kibo* laboratory. The mission included three spacewalks. The lab's logistics module, which was installed in a temporary location during STS-123, was attached to the new lab.

Nov. 14, 2008 (Mission ULF2): Endeavour, during its STS-126 mission, carried a reusable logistics module loaded with supplies and equipment, including additional crew quarters, additional exercise equipment, equipment for the regenerative life support system and spare hardware. In all, the *Leonardo* multipurpose logistics module delivered more than 1,000 items to the ISS - more than 400 provided by The Boeing Company.

March 15, 2009 (Mission 15A): Space Shuttle *Discovery* carried the fourth starboard truss segment (S6) along with the fourth set of solar arrays and batteries to the ISS. The installation signified U.S. core complete for the ISS.

July 15, 2009 (Mission 2JA): Space Shuttle *Endeavour's* 16-day mission included five spacewalks and the installation of two platforms outside of the Japanese Kibo module - the Japan Aerospace Exploration Agency's (JAXA) Japanese Experiment Module

Exposed Facility and Experiment Logistics Module Exposed Section. The “porch” or “outdoor patio” platform was used to expose three experiments to space that were moved by Kibo’s robotic arm from the pallet to the platform.

August 28, 2009 (Mission 17A): Space Shuttle *Discovery’s* 13-day mission carried the *Leonardo* Multi-Purpose Logistics Module to supply two additional research racks and four system racks. The new research racks support continuing ISS research in fluid physics and materials sciences. A second treadmill (COLBERT) also was delivered. *Discovery* also carried a Boeing-provided ammonia tank assembly, which is part of the ISS’s cooling system.

November 16, 2009 (Mission ULF3): Space Shuttle *Atlantis* carried 14 tons of cargo to equip the ISS with its own home improvement store of sorts, stocked with spare parts for its electrical, plumbing, air conditioning, communications and robotics systems – only the shuttle can transport all that at once. A total of 15 spare parts (known as Orbital Replacement Units or ORUs) were taken up on this mission. Twelve of the 15 large spares were designed, built or provided by Boeing and all of the hardware was processed by Boeing’s Checkout, Assembly and Payload Processing Services team.

February 8, 2010 (Mission 20A): Space Shuttle *Endeavour* transported the *Tranquility* (Node 3) and Cupola modules to the ISS. *Tranquility* expands the volume for the station’s existing life support and environmental control systems. Thales Alenia Space (TASI) built the module, while Boeing teams provided many of the subsystem components essential to supporting life on the station. Boeing’s Huntsville team produced many of the vital components of *Tranquility* -- including hatches, berthing mechanisms, ammonia hoses, ventilation and thermal-coolant valves.

April 5, 2010 (Mission 19A): Space Shuttle *Discovery* transported the Leonardo Multipurpose Module and the Lightweight Multi-purpose Carrier (LMC). Four experiment racks were transported to the ISS, along with one systems rack, seven resupply stowage platforms and four resupply stowage racks. Boeing engineers in Huntsville, Ala., designed and built two of the four experiment racks – the Expedite the Processing of Experiments to Space Station (EXPRESS) Rack 7 and the Window Observational Research Facility (WORF). Besides spare parts on the LMC, the mission also delivered an Ammonia Tank Assembly (ATA) that Boeing refurbished at Kennedy Space Center. The ATA works in conjunction with the station’s External Active Thermal Control System to help cool the exterior and interior components of the ISS.

May 14, 2010 (Mission ULF4): Space Shuttle *Atlantis* carried critical spare parts to the ISS. Included in *Atlantis’* payload bay were six replacement batteries and a space to ground antennae and accompanying boom assembly all provided by Boeing. *Atlantis* also delivered a Russian Mini-Research Module 1 (MRM1) and spare parts for the Canadian Dextre robotic arm.

February 24, 2011 (Mission ULF5): During Space Shuttle *Discovery's* final spaceflight, crew members delivered important spare parts to the ISS, including the Permanent

Multipurpose Module (PMM), which was converted from the multi-purpose logistics module (MPLM) Leonardo. The PMM provides additional storage for the station crew, and experiments may be conducted inside it, such as fluid physics, materials science, biology and biotechnology. In addition, the Express Logistics Carrier-4 (ELC4) brought several elements – a heat rejection system radiator, flight support equipment and a mechanical system support component for a cargo carrier attached to the truss.

May 16, 2011 (ISS assembly flight ULF6): During Space Shuttle *Endeavour's* final flight, crew members installed the Alpha Magnetic Spectrometer and ExPRESS Logistics Carrier 3 to the ISS. This mission marked the final assembly mission for the ISS.

July 8, 2011 (ISS Assembly Flight ULF 7): During Space Shuttle Atlantis final mission, crew members delivered supplies, logistics and spare parts to the International Space Station. The mission also flew a system to investigate the potential for robotically refueling existing spacecraft and returned a failed ammonia pump module to help NASA better understand the failure mechanism and improve pump designs for future systems.

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