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NASA's Orbiter Fleet

Columbia, Discovery, Atlantis, Endeavour

Columbia

The first of NASA's orbiter fleet, Columbia (OV-102) was delivered to Kennedy Space Center in March 1979. Columbia initiated the Space Shuttle flight program April 12, 1981, when it lifted off Pad A in the Launch Complex 39 area at KSC. It proved the operational concept of a winged, reusable spaceship by successfully completing the Orbital Flight Test Program, missions STS-1 to STS-4.

Other achievements for Columbia have included the recovery of the Long Duration Exposure Facility (LDEF) satellite from orbit during mission STS-32 in January 1990; the Spacelab Life Sciences missions STS-40 – the first manned Spacelab mission totally dedicated to human medical research — in June 1991 and STS-78 in June 1996; the Neurolab mission STS-90 in April 1998; and Chandra X-ray Observatory mission STS-93 in July 1999.

The orbiter Discovery touches down Aug. 22, 2001, at KSC's Shuttle Landing Facility to conclude the 12-day STS-105 mission to the International Space Station. The mission was Discovery's 30th flight.





In the Vehicle Assembly Building, the orbiter Atlantis is lowered into position for mating to its external tank/solid rocket booster stack for launch on mission STS-104 July 12, 2001.

Columbia is named after a Boston-based sloop that operated out of Boston in 1792 and explored the mouth of the Columbia River on the West Coast of North America. The same ship was the first American vessel to circumnavigate the globe. The first U.S. Navy ship to circle the globe was named Columbia. And the command module for the Apollo 11 lunar mission was also named Columbia.

Discovery

Discovery (OV-103), the third of NASA's fleet of reusable, winged spaceships, arrived at Kennedy Space Center in November 1983. It was launched on its first mission, flight 41-D, on Aug. 30, 1984. It carried aloft three communications satellites for deployment by its astronaut crew.

Other Discovery milestones include the deployment of the Hubble Space Telescope on mission STS-31 in April 1990 as well as the first Hubble Servicing mission STS-82 in February 1997; the launching of the Ulysses spacecraft to explore the Sun's polar regions on mission STS-41 in October 1990; the de-

ployment of the Upper Atmosphere Research Satellite (UARS) in September 1991; and the second flight to the International Space Station on mission STS-96 in May 1999.

Discovery is named for two famous sailing ships: one sailed by Henry Hudson in 1610-11 to explore Hudson Bay in Canada as well as search for a north-west passage between the Atlantic and Pacific Oceans, and the other by James Cook in the 1770s on voyages in the South Pacific during which he discovered the Hawaiian Islands. The British Royal Geographical Society used two ships named Discovery: one to explore the North Pole in 1875 and one to explore the Antarctic in 1904.

Atlantis

Atlantis (OV-104) was delivered to Kennedy Space Center in April 1985. It lifted off on its maiden voyage on Oct. 3, 1985, on mission 51-J, the second dedicated Department of Defense flight. Later missions included the launch of the Galileo interplanetary probe to Jupiter on STS-34 in October 1989, and launch of the Gamma Ray Observatory (GRO) on STS-37 in April 1991. Others were STS-71 and STS-74, the first and second MIR dockings; and five SPACEHAB missions from March 1996 through September 1997.

Atlantis is named after a two-masted, 460-ton ketch that was operated for the Woods Hole Oceanographic Institute from 1930 to 1966. The ketch was the first U.S. vessel to be used for oceanographic research..

Endeavour

Authorization to construct the fifth Space Shuttle orbiter as a replacement for Challenger, lost in a 1986 accident, was granted by Congress on Aug. 1, 1987. Endeavour (OV-105) first arrived at KSC's Shuttle Landing Facility May 7, 1991, atop NASA's new Shuttle Carrier Aircraft (NASA 911). The space agency's newest orbiter began flight operations in 1992. Significant missions included the first SPACEHAB mission, STS-47, in June 1993; the first manned flight to the International Space Station, STS-88, in December 1998, carrying the Unity connecting module; and the Shuttle Radar Topography mission, STS-99, in February 2000.

Endeavour is named after the first ship commanded by 18th century British explorer James Cook. On its maiden voyage in 1788, Cook sailed into the South Pacific and around Tahiti to observe the passage of Venus between the Earth and the Sun. During another leg of the journey, Cook discovered New Zealand, surveyed Australia and navigated the Great Barrier Reef. A national competition in public schools produced the name of this fourth orbiter.

When built, Endeavour featured new hardware designed to improve and expand orbiter capabilities. Most of this equipment was later incorporated into the



Columbia returns March 6, 2001, from a 17-month-long modification and refurbishment process as part of a routine maintenance plan. Columbia was the first of NASA's orbiter fleet, delivered to Kennedy Space Center in March 1979. It was the first to launch, on April 12, 1981, completing mission STS-1.

other three orbiters during out-of-service major inspection and modification programs. The upgrades include:

- a 40-foot-diameter drag chute that reduces the orbiter's rollout distance by 1,000 to 2,000 feet.
- plumbing and electrical connections needed for Extended Duration Orbiter (EDO) modifications to allow up to 28-day missions.
- updated avionics systems that include advanced general purpose computers, improved inertial measurement units and tactical air navigation systems, enhanced master events controllers and multiplexer-demultiplexers, a solid-state star tracker and improved nose wheel steering mechanisms.
- an improved version of the Auxiliary Power Units (APUs) that provide power to operate the Shuttle's hydraulic systems.

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Columbia, the first on-line orbiter to undergo the first scheduled inspection and retrofit program, was transported Aug. 10, 1991, after its completion of mission STS-40, to prime Shuttle contractor Rockwell International's Palmdale, Calif., assembly plant, where the work was performed. The oldest orbiter in the fleet underwent approximately 50 modifications, including the addition of carbon brakes, drag chute, improved nose wheel steering, removal of development flight instrumentation and an enhancement of its thermal protection system. The orbiter returned to KSC Feb. 9, 1992 to begin processing for mission STS-50 in June

of that year. Columbia was sent to Palmdale in 1999 for a second round of upgrades, returning to KSC in 2001.

The orbiters' EDO changes allow them to support up to a 16-day mission. The upgrades that make a longer stay in space possible include the EDO pallet, which holds a set of liquid hydrogen and liquid oxygen tanks to provide additional fuel for the orbiter's electrical power generation system; a regenerating system for removing carbon dioxide from the crew cabin atmosphere; two additional nitrogen tanks for cabin air; an improved waste collection system; and additional middeck lockers for storage.

Return to Flight Orbiter Modifications

Many other modifications were made to the orbiter fleet before Discovery's Return to Flight mission, STS-26, in September 1988, including improvements to the main engines, thermal protection system and propellant supply systems, and installation of a new crew escape system.

Main engine modifications included changes to the high-pressure turbo machinery, hydraulic actuators and main combustion chamber.

Some of the tiles that make up the orbiter thermal protection system were replaced to make the system lighter, stronger and more durable. Also, a reinforced carbon-carbon panel was added to the orbiter chin between the nose cap and the nose wheel well door to provide improved insulation against the searing heat experienced during reentry into the Earth's atmosphere.

Improvements to the orbiter propellant supply system included a redesigned 17-inch quick disconnect valve between the orbiter and the external tank. Additional modifications were made to the propellant systems of the orbiter reaction control system, orbital maneuvering system and the auxiliary power units.

A new crew escape system was added that allows the Space Shuttle crew to bail out if the orbiter has to make an emergency return descent and a safe runway cannot be reached. This system consists of an escape pole that can be extended from the opened crew hatch. The crew would then fasten a lanyard hook assembly that is a part of the pole to their parachute harnesses. Once attached to this hook, the crew would slide down the deployed pole, away from the orbiter. Once free of the pole, they would parachute to safety.

Two more recent upgrades on the orbiters are installation of the "glass cockpit" and improved Space Shuttle main engines.

Both Columbia and Atlantis have received the new full-color, flat, 11-panel Multifunction Electronic Display Subsystem. The new system improves crew/orbiter interaction with easy-to-read, graphic portrayals of key flight indicators like attitude, altitude and speed.

The most recent improvement to the Space Shuttle's propulsion system is the Block II Main Engine configuration that includes a new Pratt & Whitney high-pressure fuel turbopump. The new turbopump made its debut flight on Atlantis in July 2001 on mission STS-104. The Block II configuration results in a more reliable and safer engine due to increased pump robustness.

The primary modifications to the engine are the elimination of welds by implementing a casting process for the housing, an integral shaft/disk with thin wall blades and ceramic bearings. The unique casting makes the pump stronger and will increase the number of flights between major overhauls.

Other significant improvements in the Shuttle's main engine's are the high-pressure liquid oxygen turbopump, the two-duct power-head, the large throat main combustion chamber and the single-coil heat exchanger.

Future modifications include an Advanced Health Management System that will monitor main engine performance from start to cut-off, and an Advanced Thrust Vector Control System that will provide an updated steering source for the solid rocket boosters.

Final Preparations for Flight

After completing a space mission, the orbiter is returned to KSC to undergo preparations for its next flight in a sophisticated aircraft-like hangar called the Orbiter Processing Facility (OPF). Here, the vehicle is

safed, residual propellants and other fluids are drained, and returning horizontal and middeck payloads are removed.

Any problems that may have occurred with orbiter systems and equipment on the previous mission are checked out and corrected. Equipment is repaired or replaced and extensively tested. Any modifications to the orbiter that are required for the next mission are also made in the OPF.

Orbiter refurbishment operations and processing for the next mission also begin in the OPF. Large horizontal payloads, such as the Multi-Purpose Logistic Modules, are installed in the orbiter cargo bay. Vertical payloads, such as components for the Space Station, are installed at the launch pad.

Following extensive testing and verification of all electrical and mechanical interfaces, the orbiter is transferred to the nearby Vehicle Assembly Building where it is mated to the external tank and attached solid rocket boosters atop the Mobile Launcher Platform (MLP). Then, the assembled Space Shuttle vehicle on the MLP is carried to the launch pad by a large tracked vehicle called the crawler-transporter.

At the launch pad, final preflight and interface checks of the orbiter, its payloads and associated ground support equipment are conducted. After a positive Flight Readiness Review, the decision to launch is made and the final countdown begins.

Specifications

Space Shuttle

- Height: 184.2 feet
- Gross liftoff weight: 4,500,000 pounds
- Total liftoff thrust: 7,145,000 pounds

Orbiter

- Length: 122.17 feet
- Wingspan: 78.06 feet
- Landing Weight: 242,000 pounds
(109,771 kilograms)
- Main Engines: (3) 375,000 pounds of thrust
each at sea level
- Cargo Bay: length - 60 feet
diameter - 15 feet

Solid Rocket Boosters (2)

- Length: 149.16 feet.
- Diameter: 12.17 feet.
- Liftoff Weight (each): 1,300,000 pounds.
- Recovery Weight (each): 192,000 pounds
thrust; 3,060,000 pounds at sea level.

External Tank

- Length: 153.8 feet.
- Diameter: 27.6 feet.
- Weight: 58,500 pounds
- Fueled at Liftoff: 1,648,000 pounds

Propellants

- Liquid Oxygen: 141,750 gallons (1,350,000 pounds)
- Liquid Hydrogen: 384,071 gallons (227,800 pounds)