A Versatile Vehicle

The Space Shuttle Program is making the Vision for Space Exploration a reality. The first true aerospace vehicle, the Space Shuttle takes off like a rocket. The winged orbiter then maneuvers around the Earth, like a spaceship, and lands on a runway, like an airplane. The Space Shuttle is designed to carry large and heavy payloads into space, as well as ferry residents to the International Space Station. But unlike earlier manned spacecraft that were good for only one flight, the Space Shuttle and Solid Rocket Boosters can be used again and again.

In the early stages, the Space Shuttle also could repair or reboost satellites stranded in useless orbits. It retrieved a free-flying payload, remained in orbit almost six years before it was recovered and returned to Earth, where it yielded a wealth of new data on the space environment.

In addition, again unlike prior manned spacecraft, the techniques used in the Mercury, Gemini and Apollo human missions to Venus or the Galileo mission to Jupiter, the Shuttle astronauts, repaired and then reboosted to its proper orbit to begin operation. A station at the rear, overlooking the payload bay, was introduced, using small quantities of alumina fiber. Fibrous Insulation Blankets, made of silica felt held together by a polymer binder, were introduced, using small quantities of alumina fiber. Fibrous Insulation Blankets, made of silica felt held together by a polymer binder, were introduced.

A Unique Vehicle

The ability of the Shuttle to land on a runway, unlike the expensive parachute descent and recovery techniques used in the Mercury, Gemini and Apollo human space flight programs, saves time and money. In addition, again unlike prior manned spacecraft, the most expensive Shuttle components can be refurbished and reused for another launch. The complex and expensive orbiter returns to Earth and is processed for the next flight. The Solid Rocket Boosters, engine nozzles and parachutes were expensed on each flight. The high cargo capacity and main component reusability of the Shuttle make it unique among launch vehicles.

The orbiter is the only part of the Space Shuttle that has a name in addition to a part number. The first orbiter built was the Enterprise, which was designed for flight tests in the atmosphere rather than operations in space. It is now at the Smithsonian Museum at Dulles Airport outside Washington, D.C. Five operational orbiters were built (in order): Columbia (OV-101), which was lost in an accident Feb. 1, 2003; Challenger (OV-099), which was lost in an accident Jan. 28, 1986; Discovery (OV-103); Atlantis (OV-104); and Endeavour (OV-105).

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Just after sundown, Space Shuttle Endeavour ap- proached and mated with Runway 33 to complete the STS-99 mission, launching the Shuttle Radar Topography spacecraft.

Long-Duration Exposure Facility

A typical Shuttle crew includes a commander and pilot, mission specialists and occasionally payload specialists. They may be added to the Shuttle crews if activities involved are that have unique requirements.

Typical Shuttle Mission

The rotation of the Earth has a significant effect on the payload capabilities of the Space Shuttle. A due east launch from the Kennedy Space Center in Florida uses the Earth’s rotation as a launch assist, since the ground is turning to the east at that point at a speed of 915 miles (1,473 kilometers) per hour.

Orbiter Insulation

A Special silica-based insulation in the form of tiles and blankets serves as the primary heat shield for the orbiter. This material sheds heat so readily that one side can be held in bare hands while the opposite side is red-hot. These lightweight tiles are made to survive temperatures of up to 2,500 degrees Fahrenheit (1,371 degrees Celsius). Previous crewed spacecraft have used ablative systems, which produced a small plume of gas and/or liquid that carried off heat from the surface – during the fiery entry into Earth’s atmosphere.

The orbiter’s heat shield is made of a combination of graphite/phenolic foam and ceramic materials. The graphite/phenolic foam helps to reduce the amount of fuel required for flight with three main engines, each producing 394,260 pounds (1,754 million newtons) of thrust when operating at 104 percent at liftof (at sea level). This figure is derived from flight experience and is 2.5 percent better than the required design minimum. The engines burn for more than eight minutes, while together drawing 64,000 gallons (242,240 liters) of propellants each minute when at full power.

Before flight, the orbiter is mated to a huge external tank, containing 5 million gallons (18,648 liters) of liquid oxygen and 384,071 gallons (1,450,000 liters) of liquid hydrogen. The tank feeds these propellants to the main engines of the orbiter throughout the ascent into orbit, and the tank is then discarded.

Most of the Shuttle’s power at liftoff is provided by the External Tank, which contains liquid hydrogen and liquid oxygen. Each of the two main engines fires at 104 percent, total thrust of the Space Shuttle at liftoff is 6.999 million pounds (31.131 million newtons) of thrust before gradually declining for the remainder of a two-week mission.

In-orbit maneuvering capability is provided by two smaller Orbital Maneuvering System engines located on the orbiter. They burn nitrogen tetroxide as the oxidizer and monomethylhydrazine as the fuel, from on-board tanks carried in two pods at the upper rear.

Shuttle crews experience a maximum gravity load of 1.4 g during launch and reentry, and 0.5 g during reentry. These accelerations are about one-third the levels of experienced on previous U.S. human spaceflights. Many other aspects of the Space Shuttle, such as a standard sea-level atmosphere, make spaceflight more comfortable for the astronaut.

Astronaut James F. Reilly, STS-104 mission specialist, looks over supplies in the Quest Module aboard the International Space Station (ISS). Reilly was one of two assigned spacewalkers on the STS-104 mission. The third extravehicular activity utilized the new airlock, marking its first usage.

Mission operations display and controls are on the right side of the cabin, and payload controls are on the left. The latter are sometimes operated by payload specialists, who are usually not career NASA astronauts. The living, eating and sleeping area for off-duty crew members, called the mid-deck, is located below the flight deck. It contains prepackaged food, a toilet, bunk beds and other amenities. For experiments the flight deck may also be stowed in mid-deck lockers.

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Improved Space Suit and Unique Rescue System for Spacewalkers

An improved space suit and an independent rescue unit were developed for the Shuttle by the Johnson Space Center in Houston. Johnson is responsible for mission planning and provides ground control and support during each flight. The space suit has been used when a crew member is working outside the pressurized crew cabin. Spacecab or SPACEHAB modules.

Unlike earlier suits, each of which was tailored to an astronaut’s specific measurements, the Shuttle-era space suits come in small, medium and large sizes, and can be adjusted to fit both men and women. A suit comes in two parts — upper torso and pant — and each part is pressure-sealed, unlike previous suits that were zipper-sealed at the waist. The material used for the elbow, knee and other joints is a fabric that allows easier movement, and costs and weighs less than the neoprene rubber joints of earlier units. Each suit has an integral Primary Life Support System, rather than the previously required set of connected tanks carried on astronauts’ backs.

A Simplified Aid For Extravehicular Activity Rescue (SAFER) was developed by Johnson for emergency situations. A scaled-down version of the Manned Maneuvering Unit (MMU) flown aboard Shuttle missions in 1984, the SAFER is designed for self-rescue use by a spacewalker in the event the Shuttle is unable or unavailable to retrieve a detached, drifting crew member. Examples of such times may include a mission where the Shuttle is docked to the International Space Station. The SAFER was first flown on STS-64 in September 1994.

International Space Station

The Space Shuttle has carried many of the components of the International Space Station into orbit for assembly in space, and has provided an initial base for assembly operations. Phase 1 of construction was completed in 2003. The installation of NASA’s Node 2 will signify the U.S. Core Complete stage of International Space Station assembly and increase the living and working space inside the station to approximately 14,000 cubic feet. Other U.S. elements installed include the Unity module, Destiny laboratory, Node 1 and port and starboard trusses, as well as the Quest Joint Airlock. The airlock is the primary path for International Space Station spacewalk entry and departure for U.S. spacesuits, which are known as Extravehicular Mobility Units, or EMUs. In addition, the Joint Airlock is designed to support the Russian Orlan spacesuit for spacewalks.

Elements of the Space Station provided by Russia include the Zvezda service module, Zarya control module, and the Pro docking port. At 298 feet (88.4 meters) long and 361 feet (110 meters) across, the finished Space Station will be the largest structure ever assembled in space. Its current weight is 40,649 pounds. The habitable volume is 15,000 cubic feet. Its height is 90 feet.

The Space Station also represents the largest cooperative scientific program in space history, and will include contributions from NASA, Japan, Canada, the member nations of the European Space Agency and Russia.

People operating inside the microgravity of a Space Station can create products difficult or impossible to make on Earth, such as regular and perfect forms of protein crystals. In addition, such a platform orbiting above the distorting atmosphere can provide astronomers and other scientists an excellent vantage point to study the composition and phenomena of our universe.

Spacecab and SPACEHAB: Science in Orbit

The Shuttle was used to carry a complete scientific laboratory into Earth orbit. Two configurations were used: the Spacelab, until 1993, and the SPACEHAB. The SPACEHAB modules were similar to small, well-equipped laboratories on Earth, but designed for zero-gravity operation.

Two complete SPACEHABs (plus instrument-carrying platforms exposed to space, called “pallets”) were built by the European Space Agency. The SPACEHAB modules were commercially developed by McDonnell Douglas Aerospace-Huntsville, under contract to SPACEHAB.

The module offered up to 61 standard lockers, such as those found in the orbiter mid-deck, and two single or double racks for experiments.

Other applications are the economical manufactur- ing in zero gravity of presently very expensive medical drugs, glass for lenses, electronic crystals of unrivaled purity and size, as well as various alloys, composites and metallic materials impossible to produce on Earth.

The Space Shuttle is overall the most capable vehicle built since the space program began. It is the major means of providing humanity with the limitless benefits available from space exploration and space utilization.

The Orbital Maneuvering System (OMS) engines then ignite – and then separates from the external tank. The latter breaks up as it re-enters the atmosphere over an uninhabited area of the Indian Ocean.

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