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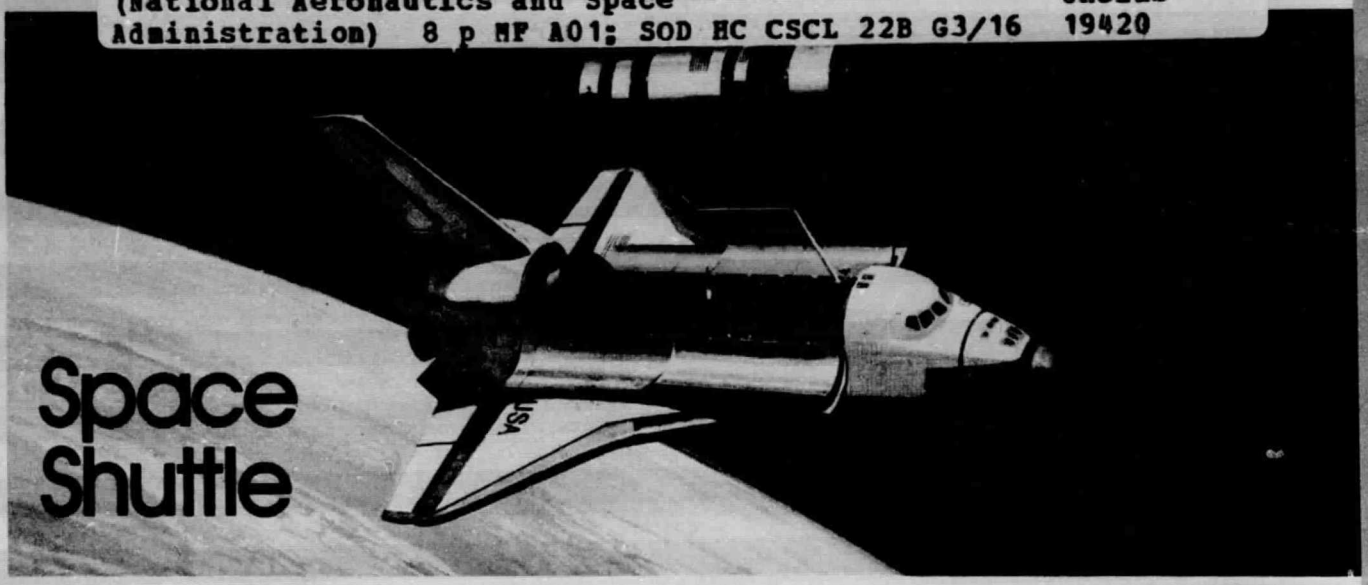


An unmanned spacecraft with attached Interim upper stage (IUS) has been transferred to orbit from the open cargo bay of the Shuttle by the orbiter's arm-like remote manipulator (artist's concept). The IUS will propel unmanned spacecraft from Earth orbit into interplanetary trajectories or to higher Earth orbits than the Shuttle can reach.

The beginning of frequent scheduled flights by NASA's Space Shuttle, to and from Earth orbit in the 1980's, will mark the coming of age in space. The Shuttle will turn formidable and costly space missions into routine, economical operations generating maximum benefits for people everywhere. Moreover, the Shuttle will open space to men and women of all nations who are reasonably healthy and have important work to do in space.

A Versatile Vehicle

The Space Shuttle is a true aerospace vehicle. It takes off like a rocket, maneuvers in Earth orbit like a spacecraft, and lands like an airplane.

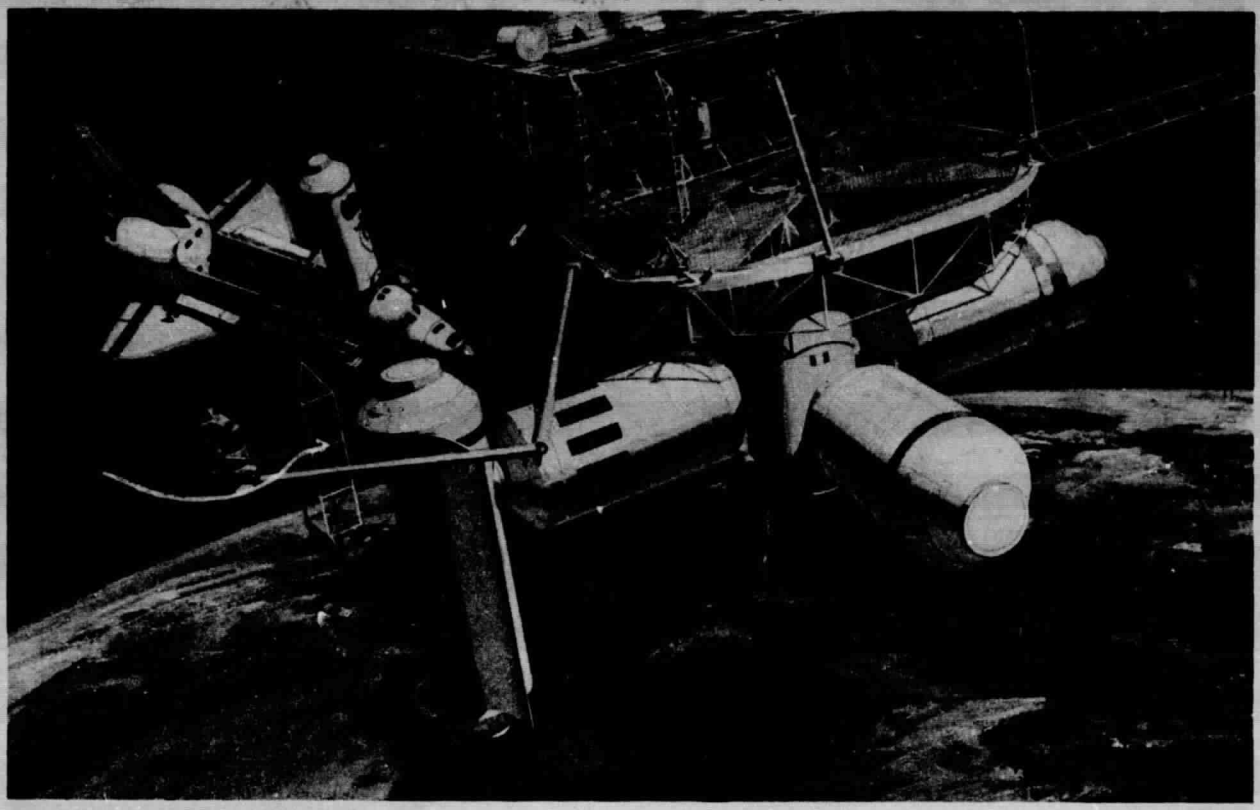
The Space Shuttle is designed to carry heavy loads into Earth orbit. Other launch vehicles have done this. But unlike the other launch vehicles which could be used just once, each Space Shuttle orbiter may be reused more than 100 times.

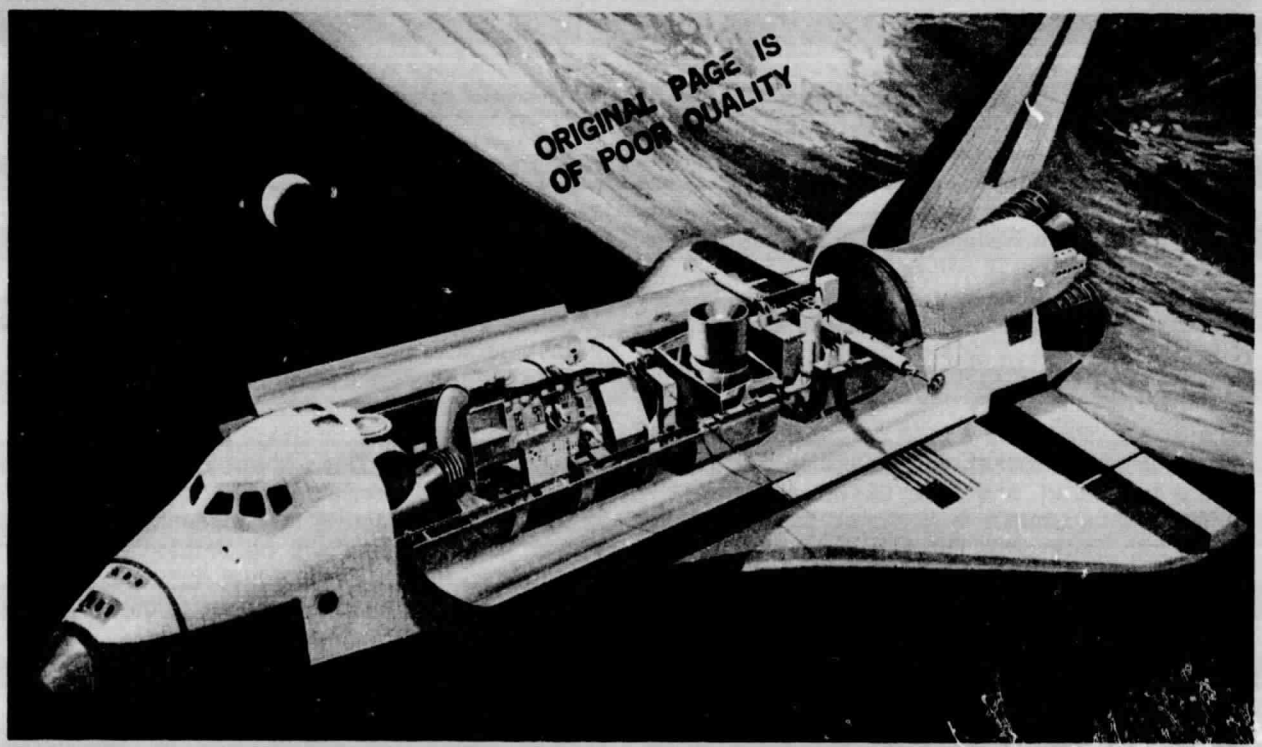
The Shuttle permits the check out and repair of unmanned satellites in orbit or their return to Earth for repairs that cannot be done in space. Thus, the Shuttle makes possible considerable savings in spacecraft costs. The types of satellites that the Shuttle can orbit and maintain include those involved in environmental protection, energy, weather forecasting, navigation, fishing, farming, mapping, oceanography, and many other fields useful to man.

Interplanetary spacecraft can be placed in Earth orbit by the Shuttle together with a rocket stage called the Interim Upper Stage (IUS) which is being developed by the Department of Defense. After the IUS and spacecraft are checked out, the IUS is ignited to accelerate the spacecraft into deep space. The IUS also will be employed to boost satellites to higher Earth orbits than the Shuttle's maximum altitude which is about 1,000 kilometers (approximately 600 miles).

Unmanned satellites such as the Space Telescope, which can multiply man's view of the Universe, and the Long Duration Exposure Facility (LDEF), which can demonstrate the effects on materials of long exposure to the space environment, can be placed in orbit, erected, and returned to Earth by the Space Shuttle. Also, Shuttle crews

Shuttle orbiter delivers module for assembly of space station (artist's concept).





Spacelab fills cargo bay of Shuttle orbiter (artist's concept). This Spacelab version, one of several, includes a pressurized laboratory where the payload specialists live and work and pallet sections where telescopes, sensors, and antennas are exposed to and have a comparatively unobstructed view of space. The pallet equipment is operated remotely from within the pressurized section. Tunnel and airlock connect the pressurized laboratory to the orbiter crew section.

can perform such services as replacing the Space Telescope's film packs and lenses.

The Space Telescope is being studied by the NASA Marshall Space Flight Center, Huntsville, Alabama, and the NASA Goddard Space Flight Center, Greenbelt, Maryland, while LDEF is a project of the NASA Langley Research Center, Hampton, Virginia.

The Shuttle orbiter is a manned spacecraft, but unlike manned spacecraft of the past, it touches down on a landing strip. Thus, the Shuttle eliminates the expensive recovery at sea which was necessary for Mercury, Gemini, Apollo, and Skylab.

The reusable Shuttle also has a short turnaround time. It can be refurbished and ready for another journey into space within two weeks after landing.

The Shuttle can quickly provide a vantage point in space for observation of interesting but transient astronomical events or of sudden weather, agricultural, or environmental crises on Earth. Information from Shuttle observations would contribute to sound decisions for dealing with such urgent matters.

The Shuttle will also be used to transport into space a complete scientific laboratory called Spacelab. Developed by the European Space Agency (ESA), Spacelab is adapted to operate in zero gravity (weightlessness). It provides conditions suitable for working, eating, and sleeping in ordinary clothing.

Spacelab provides facilities for as many as four laboratory specialists to conduct experiments in such fields as medicine, manufacturing, astronomy, and pharmaceuticals. Spacelab remains attached to the Shuttle orbiter throughout its mission. Upon return to Earth, Spacelab is removed from the orbiter and outfitted for its next assignment. It can be reused about 50 times.

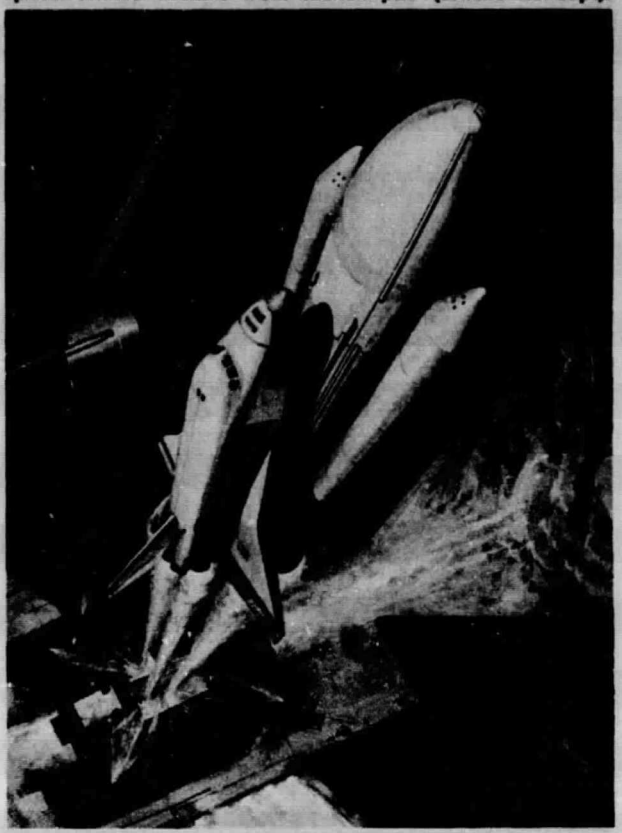
Spacelab personnel will be men and women of many nations who are experts in their fields and are in reasonably good health. They will require only a few weeks of space flight training.

The ESA member nations involved are Belgium, Denmark, France, Italy, Netherlands, Spain, Switzerland, United Kingdom, and the Federal Republic of Germany (West Germany). Austria is also participating in Spacelab. Spacelab is an example of international sharing of space costs and of worldwide interest in the Space Shuttle capabilities.

The Space Shuttle will bring within reach projects that not too long ago many considered impractical. The Shuttle could carry into orbit the "building blocks" for constructing large solar power stations that would convert the unlimited solar heat and sunlight of space into electricity for an energy hungry world. The components would be assembled by specialists whom the Shuttle would transport to, and support in, space.

The Shuttle could also carry into Earth orbit the

Space Shuttle rockets from launch pad (artist's concept).



Remote manipulator retrieves orbiting satellite which it will place in the orbiter's cargo bay for return to Earth (artist's concept). The manipulator system, which permits astronauts inside the orbiter to deploy or retrieve satellites, was developed by Canada at Canadian expense.

Space Telescope (artist's concept) will be placed and serviced in Earth orbit by Shuttle.

Booster rockets detach from Shuttle at about 43-kilometer (27-mile) altitude (artist's concept).

modular units for self-sustaining settlements. The inhabitants of the settlements could be employed in building and maintaining solar power stations and in manufacturing drugs, metals, glass for lenses, and electronics crystals. Manufacturing in weightless space can, among other things, reduce costs of certain drugs, create new alloys, produce drugs and lenses of unusual purity, and enable crystals to grow very large. Drugs, metals, glass, and crystals will be manufactured experimentally during Spacelab missions, long before establishment of a space settlement.

Principal Components of Shuttle

The Space Shuttle has three main units: the *orbiter,* the *external tank* and two solid rocket *boosters.* Each booster rocket has a sea-level thrust of 11.6 million newtons (2.6 million pounds).

The orbiter is the crew and payload carrying unit of the Shuttle system. It is 37 meters (122 feet) long, has a wingspan of 24 meters (78 feet) and weighs without fuel about 68,000 kilograms (150,-000 pounds). It is about the size and weight of a DC-9 commercial air transport.

The orbiter can transport a payload of 29,500 kilograms (65,000 pounds) into orbit. It carries its cargo in a cavernous payload bay 18.3 meters (60 feet) long and 4.6 meters (15 feet) in diameter. The bay is flexible enough to provide accommodations for unmanned spacecraft in a variety of shapes and for fully equipped scientific laboratories.

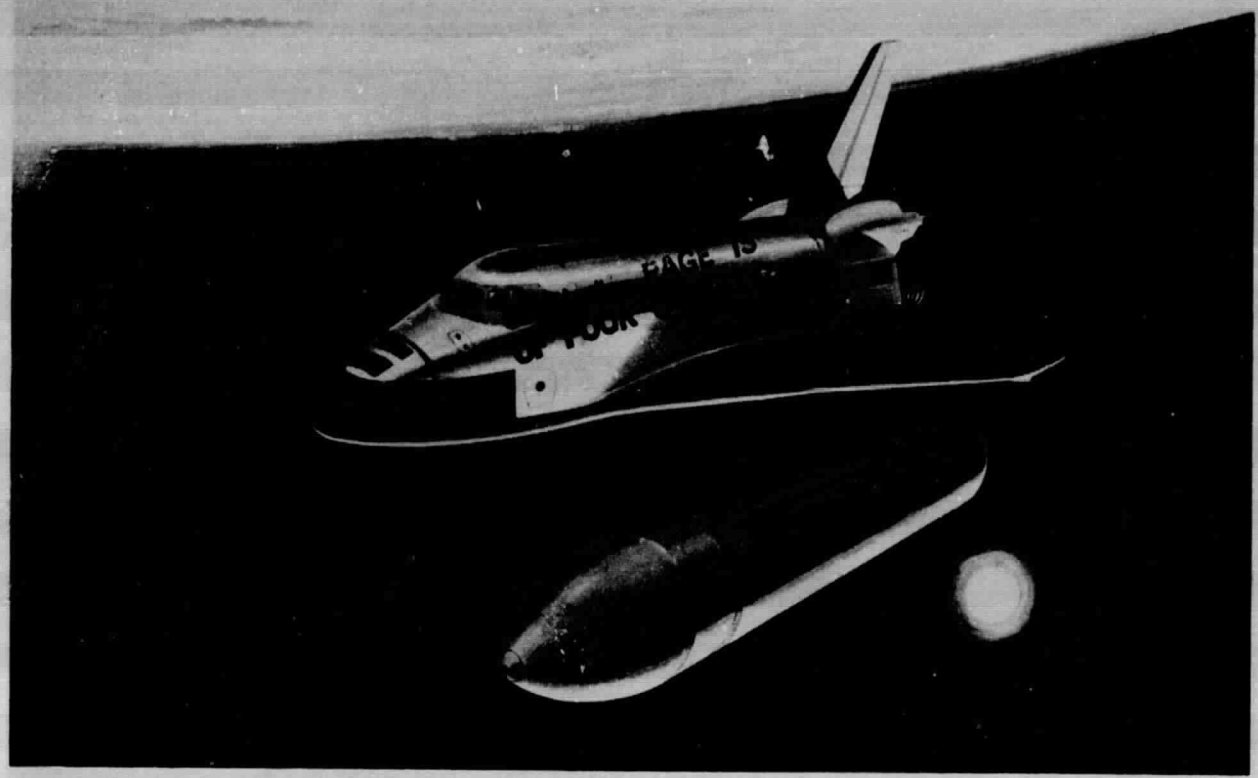
The orbiter's three main liquid rocket engines each have a thrust of 2.1 million newtons (470,000 pounds). They are fed propellants from the external tank which is 47 meters (154 feet) long and 8.7 meters 28.6 feet) in diameter. At liftoff, the tank holds 703,000 kilograms (1,550,000 pounds) of propellants, consisting of liquid hydrogen (fuel) and liquid oxygen (oxidizer). The hydrogen and oxygen are in separate pressurized compartments of the tank. The external tank is the only part of the Shuttle system that is not reusable.

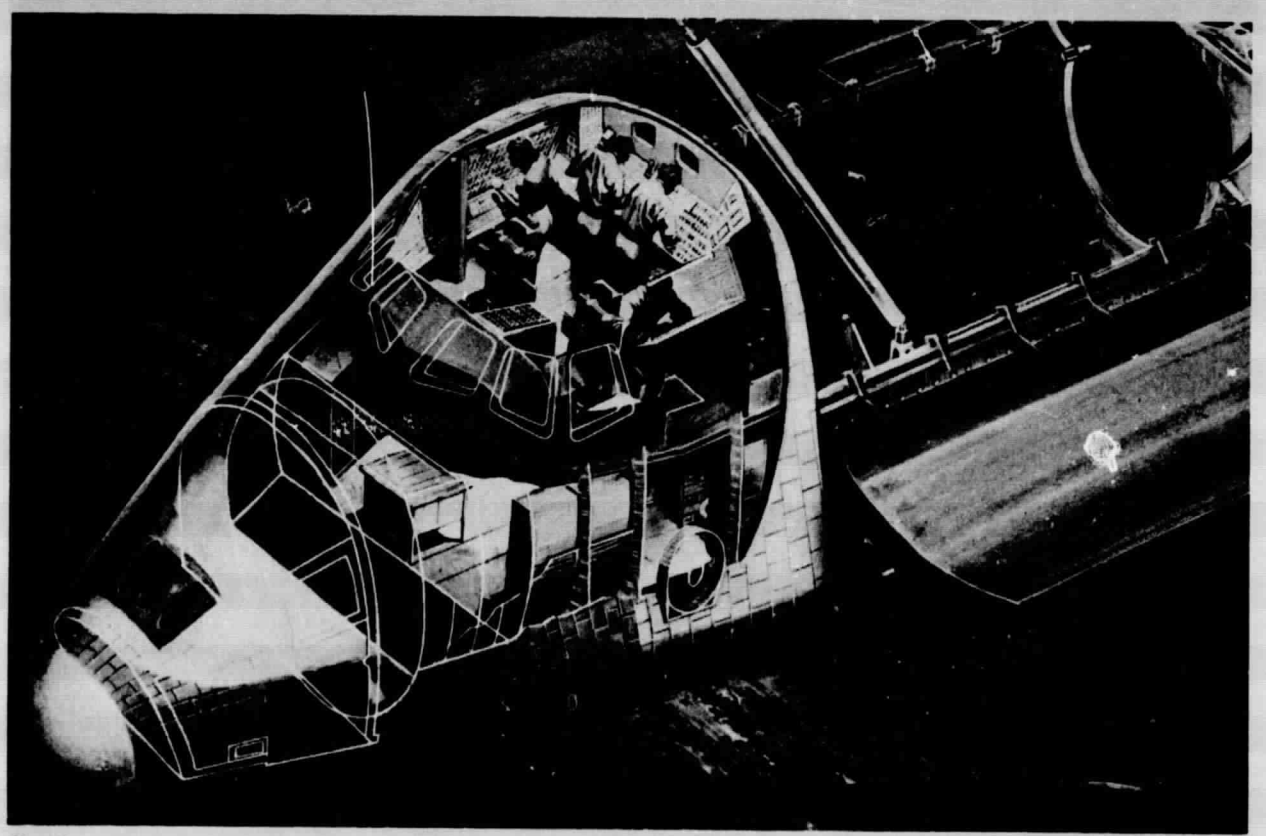
Typical Shuttle Mission

In a typical Shuttle mission, which could last from 7 to 30 days, the orbiter's main engines and the booster ignite simultaneously to rocket the Shuttle from the launch pad. Launches are from the John F. Kennedy Space Center in Florida for east-west orbits or from Vandenberg Air Force Base in California, for north-south orbits.

At a predetermined point, the two solid rocket boosters separate from the orbiter and parachute to the sea where they are recovered for reuse. The orbiter continues into space. It jettisons its external propellant tank just before orbiting. The external tank enters the atmosphere and breaks

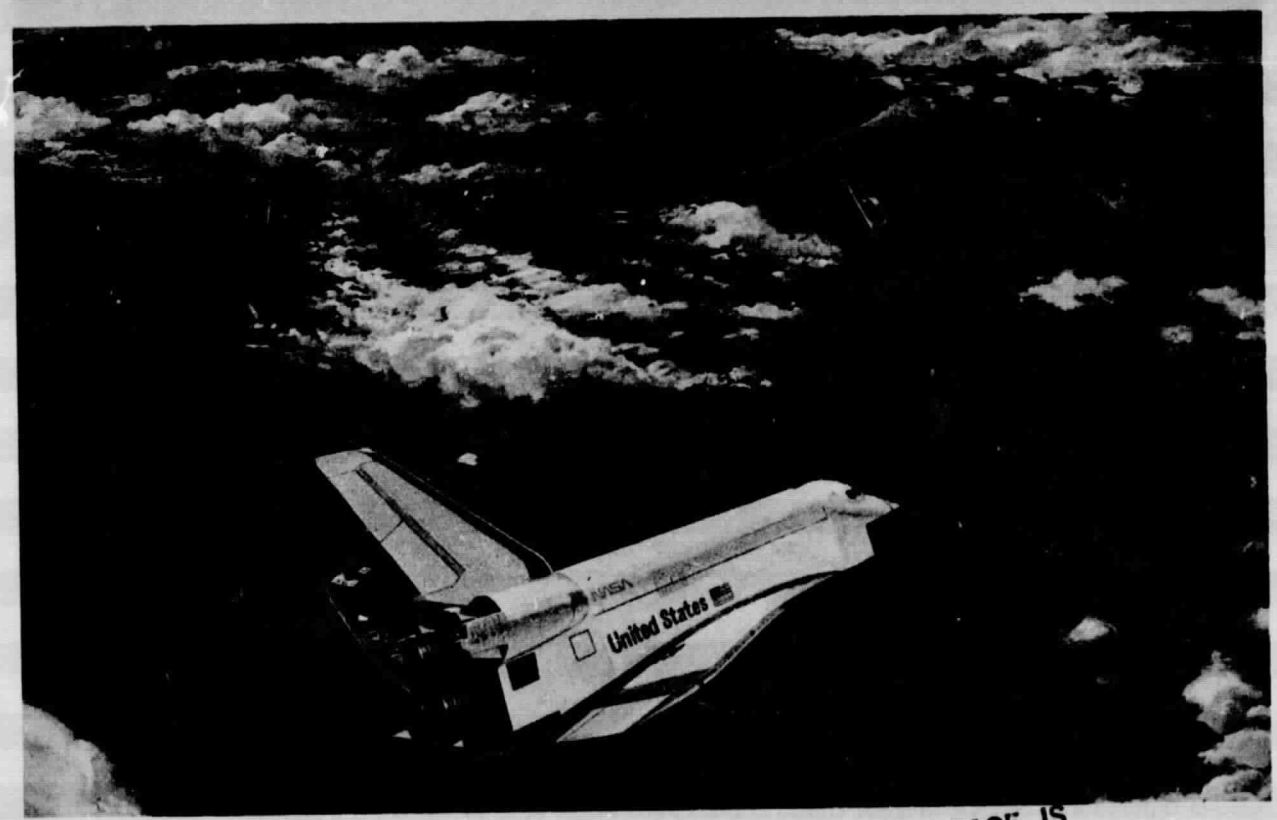
External (propellant) tank is jettisoned (artist's concept).





Shuttle astronauts at work within upper station of pressurized orbiter crew section (artist's concept).

Orbiter landing approach to John F. Kennedy Space Center, Florida (artist's concept). Runway is upper left.



Orbiter nears touchdown (artist's concept).

up over a remote ocean area.

In orbit, the orbiter uses its orbital maneuvering subsystem (OMS) to adjust its path, for rendezvous operations, and at the end of its mission, for slowing down so as to head back toward Earth. OMS propellants are monomethyl hydrazine as the fuel and nitrogen tetroxide as the oxidizer. They ignite

Improved Space Suit and Unique Rescue System Developed for Shuttle

An improved space suit and a rescue system have been developed for the Shuttle crew and passengers by the NASA Lyndon B. Johnson Space Center, Houston, Texas. The space suit is for use when working outside of the spacecraft's pressurized compartments. Unlike previous suits that were tailored to individual specifications, these suits come in small, medium, and large sizes and can be adjusted to fit both men and women. The space suit comes in two parts—upper torso and pants—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 suits. Each suit has an integral life support system rather than requiring separate life support tanks.

The rescue system is a 86.36-centimeter (34-inch) diameter plastic inflatable ball, inside of which is a life support and communications system. Since it is suitable for one person, it is called a *personal rescue enclosure.*

If a Shuttle orbiter should become disabled in space, the commander and payload specialists will get inside of a personal rescue enclosure; the pilot and mission specialist will don their space suits. The occupied personal rescue enclosures will be transferred to the rescue ship by (1) the on-board remote manipulator used to grip satellites or (2) a clothesline like rescue device or (3) being carried by the space suited personnel. Carrying people and personnel rescue enclosures on Earth would be difficult because of their weight, but in the weightlessness of space, this is no problem.

Shuttle space suit (right) and personal rescue enclosure (left).

Orbiter airstrip at Kennedy Space Center.

on contact and thus do not require ignition devices.

The orbiter does not necessarily follow a ballistic path to the ground as did its predecessor manned spacecraft. It has a crossrange capability (can maneuver to the right or left of its entry path) of about 2035 kilometers (1270 miles).

The orbiter touches down like an airplane on a runway at Kennedy Space Center or Vandenberg Air Force Base. Landing speed is about 335 kilometers (210 miles) per hour.

Crew

The Shuttle crew can include as many as seven people: the commander; the pilot; the mission specialist who is responsible for management of Shuttle equipment and resources supporting payloads during the flight; and one to four payload specialists who are in charge of specific payload equipment. The commander, pilot, and mission specialist are NASA astronauts and are assigned by NASA. Payload specialists conduct the experiments and may or may not be astronauts. They are nominated by the payload sponsor and certified for flight by NASA.

Shuttle Management Team

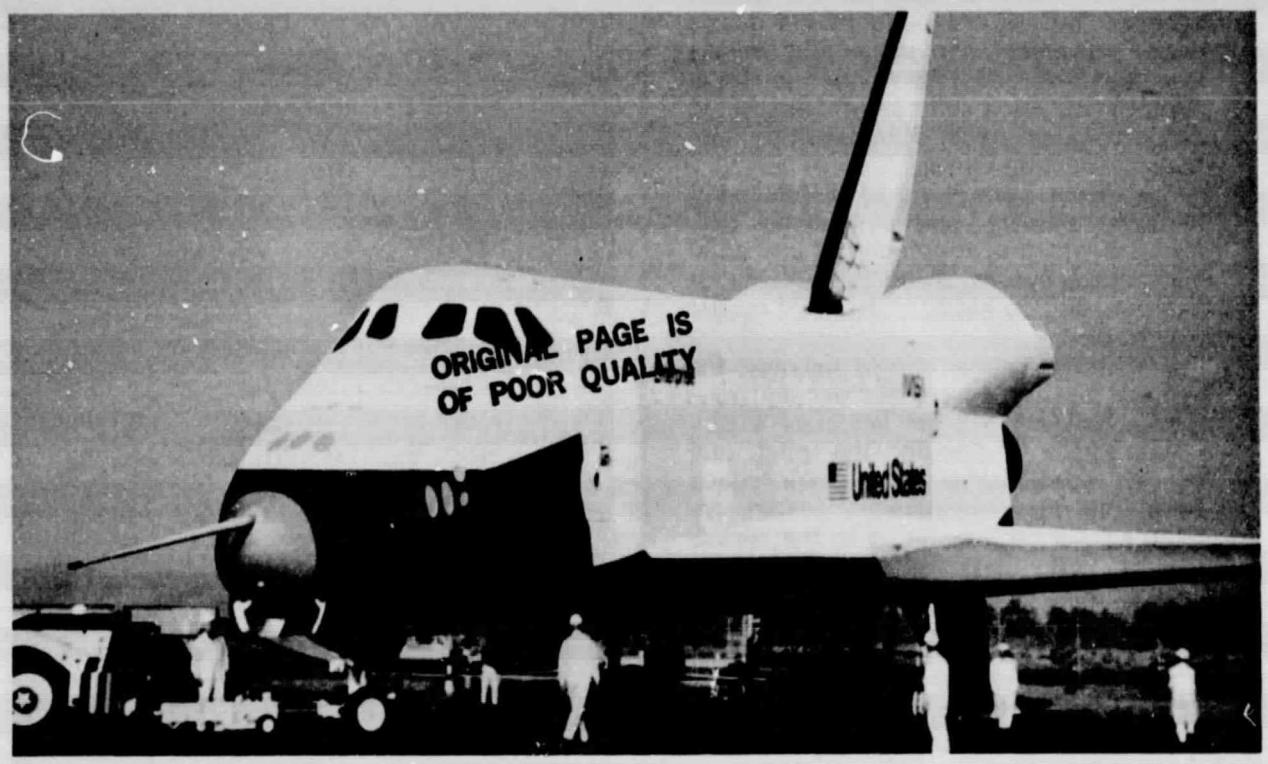
NASA's Lyndon B. Johnson Space Center, Houston, Texas, manages the Space Shuttle program and is also responsible for development, production, and delivery of the orbiter.

NASA's George C. Marshall Space Flight Center, Huntsville, Alabama, is responsible for the development, production, and delivery of the solid rocket boosters, the external propellant tank, and orbiter main engines. Test firings of Shuttle engines are carried out at NASA's National Space Technology Laboratories, Bay St. Louis, Mississippi.

NASA's John F. Kennedy Space Center in Florida is responsible for design and development of launch and recovery facilities and for operational missions requiring easterly launches.

Thousands of companies make up the Shuttle contractor team. They are located in nearly every state in the United States.

A special insulation, that sheds heat so readily that one side is cool enough to hold in bare hands while the other side is red hot, serves as the orbiter heat shield. The insulation is made to survive temperatures up to 1260 degrees Celsius (2300 degrees Fahrenheit) for 100 flights with little or no refurbishment. Previous manned spacecraft used heat shields that eroded considerably during the fiery entry into Earth's atmosphere.



Roll-out of first Shuttle orbiter, "Enterprise," at Rockwell International Space Division, Palmdale, California, September 17, 1976.

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