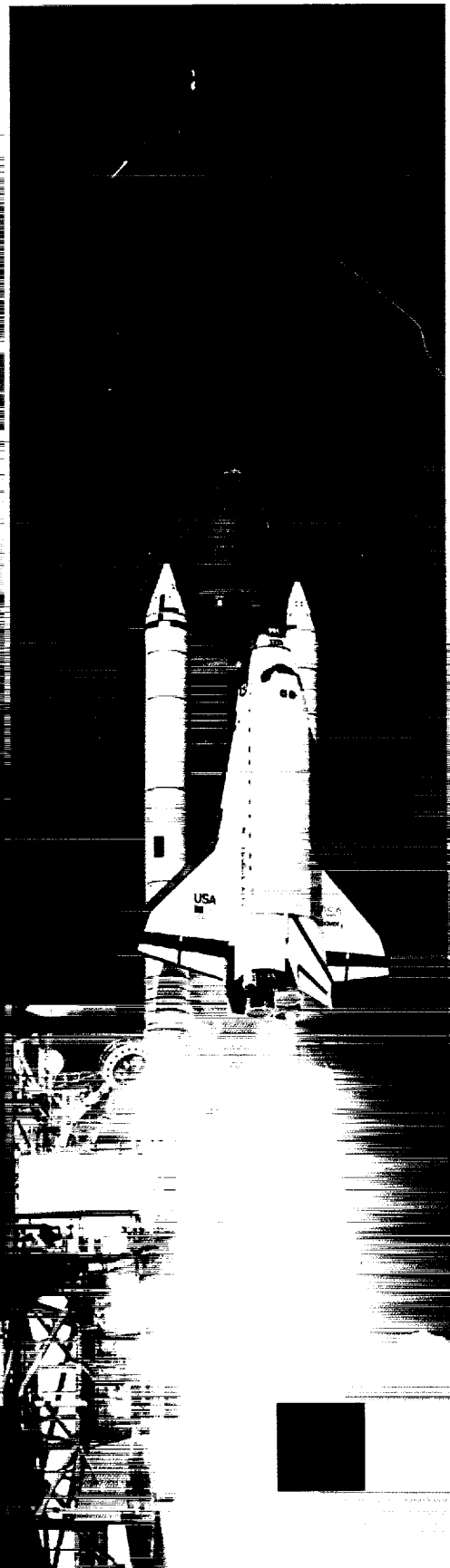
NASA-EP-269

On the Wings of a Dream

THE SPACE SHUTTLE



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National Aeronautics and Space Administration

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On the Cover:
Space Shuttle *Discovery* takes off on misson 51-C from Launch Pad 39-A at the Kennedy Space Center in Florida. Crew members are Ken Mattingly (commander), Loren Shriver (pilot), Ellison Onizuka and Jim Buchli (mission specialists), and Gary Payton (payload specialist).

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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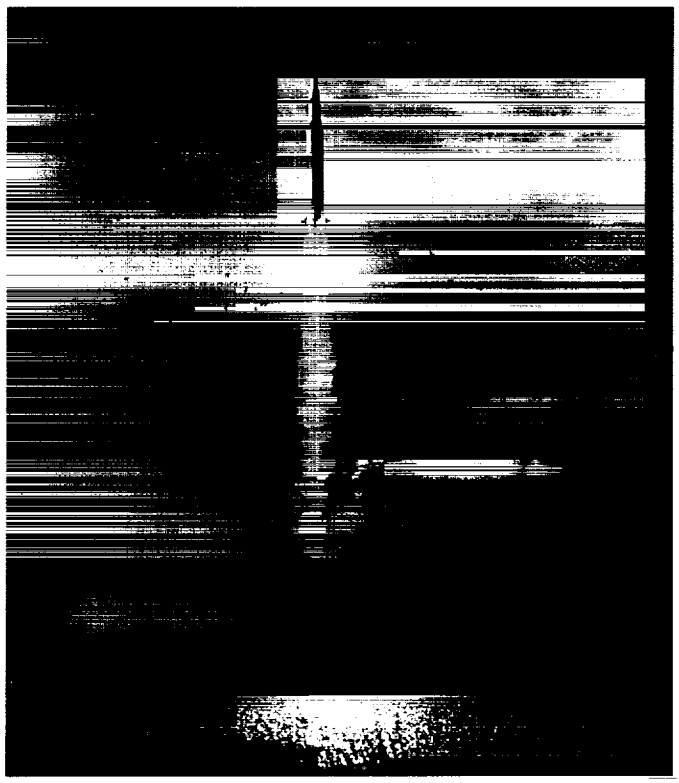


Liftoff of the Saturn V launch vehicle carrying the Apollo 8 crew around the Moon, December 21, 1968

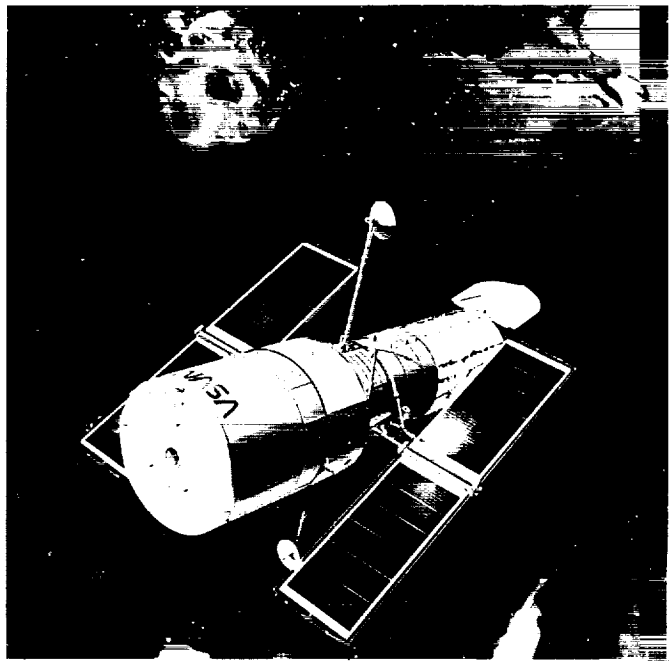
In 1958, Congress created the National Aeronautics and Space Administration (NASA), an independent agency of the federal government "devoted to the exploration of space for peaceful purposes for the benefit of all mankind."

NASA's story is one of learning. It is a story of progress from wind-tunnel models to research aircraft, from sounding rockets to the Saturn V, from small satellites to complex spacecraft. It is the story of humans traveling to the Moon and working in low-Earth orbit. Space probes have extended our vision to the outer planets, and scientific satellites have introduced us to Earth's neighborhood and to mysteries at the edge of the universe.

NASA, a network of many installations across the United States, is headquartered in Washington, D.C. Each NASA Center has specific responsibilities for one or more of NASA's programs, such as aeronautics, scientific and Earth resources satellites, manned spaceflight, and propulsion. If you are traveling in Alabama, California, Florida, Maryland, Mississippi, Ohio, Texas, or Virginia, you may have an opportunity to see some of NASA's work. Most of the installations have a Visitors Information Center with exhibits that tell you about the facility and its programs, and some information centers also have tours for visitors.

When you learn about NASA, you learn a lot about aviation and space. You also learn a lot about science and history and literature. For instance, you will notice that NASA spacecraft have different kinds of names. Some names come from myths and legends, some are based on descriptions of their missions. The Space Shuttle orbiters were named after sea vessels used in research and exploration, and others—like Space Station *Freedom*—grow out of a formal naming process within NASA. Each name and each project can lead to an exciting investigation—research, experiments—along with dreams for the future.

NASA has a number of educational programs for you and your teachers, for both classroom groups and individual students. If you would like to know more about them, ask your teacher to contact the Educational Affairs Division, Code XEE, NASA, Washington, DC 20546.



Artist's concept of the Hubble Space Telescope in Earth orbit

THE SPACE TRANSPORTATION SYSTEM

The United States has been sending astronauts into space since 1961. Until 1981, the National Aeronautics and Space Administration (NASA) manned programs—Mercury, Gemini, Apollo, and Skylab—used launch vehicles and spacecraft that went up only once. As the United States made progress in its space program, it was decided that a spacecraft and launch vehicle that could be put up into space more than one time was desirable. They were supposed to lower the cost of space flight and make space flight increasingly routine.

NASA was given the responsibility for developing this new transportation system. The Space Transportation System is NASA's name for the overall program producing the Space Shuttle.

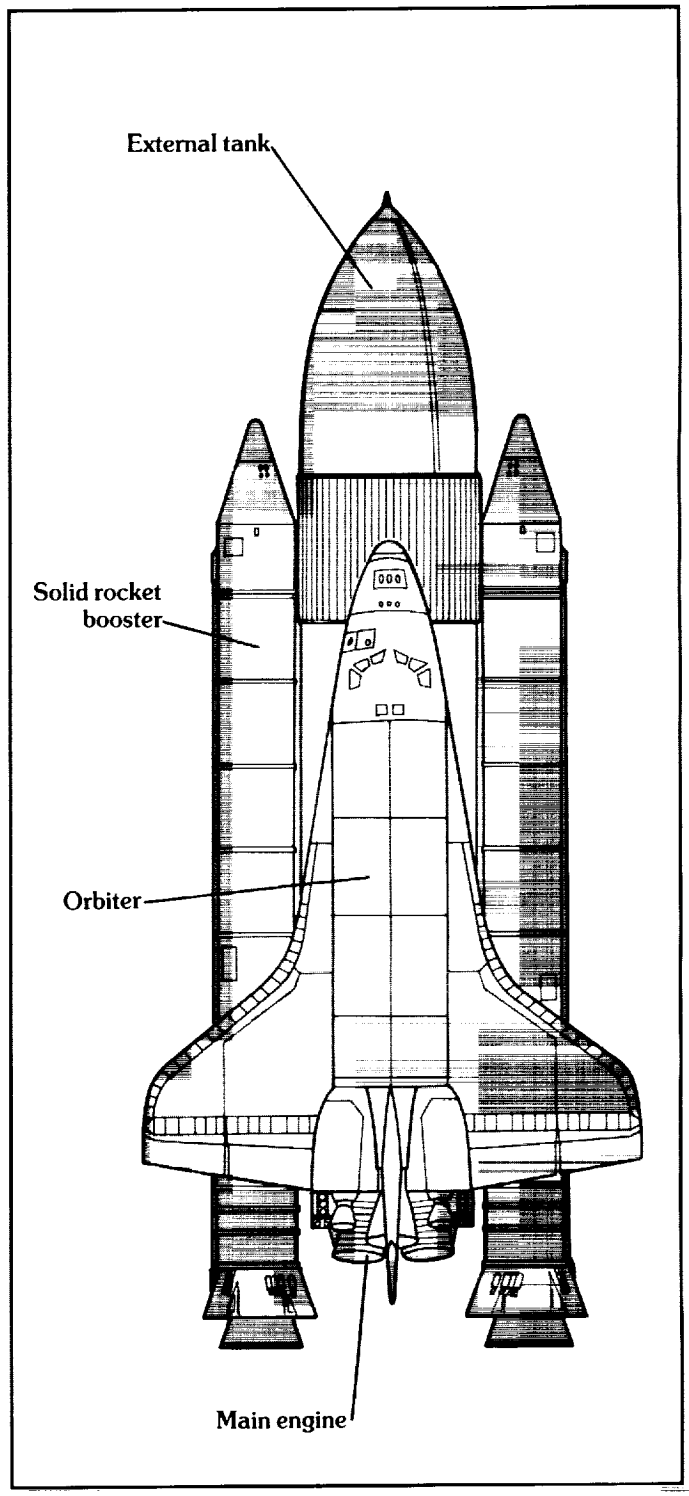
The Space Shuttle is a remarkable flying machine. It takes off like a rocket. In earth orbit it maneuvers like a spacecraft. It lands like a glider.

The main purpose of the Space Shuttle is to deliver payloads to Earth orbit over and over again. The astronauts aboard the Shuttle are able to deploy, repair, and retrieve satellites. They also can study Earth from space.

The Space Shuttle system consists of four primary parts. They are the orbiter, two solid rocket boosters, and an external fuel tank. NASA plans to reuse both the solid rocket boosters and the orbiter.

The orbiter is the main part of the Shuttle system. It carries the crew and payload to orbit and returns the astronauts and some of the payloads to Earth. NASA expects to reuse the orbiter more than 100 times. Five orbiters have been built to date: the *Enterprise, Columbia, Challenger, Discovery,* and *Atlantis.*

On April 12, 1981, the first Space Shuttle lifted off from Launch Complex 39, Pad A, at the Kennedy Space Center (KSC) in Cape Canaveral, Florida. After a two-day test flight, it landed at Edwards Air Force Base in California.



Looking at front view of the Space Shuttle, NASA's Space Transportation System

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THE ENTERPRISE

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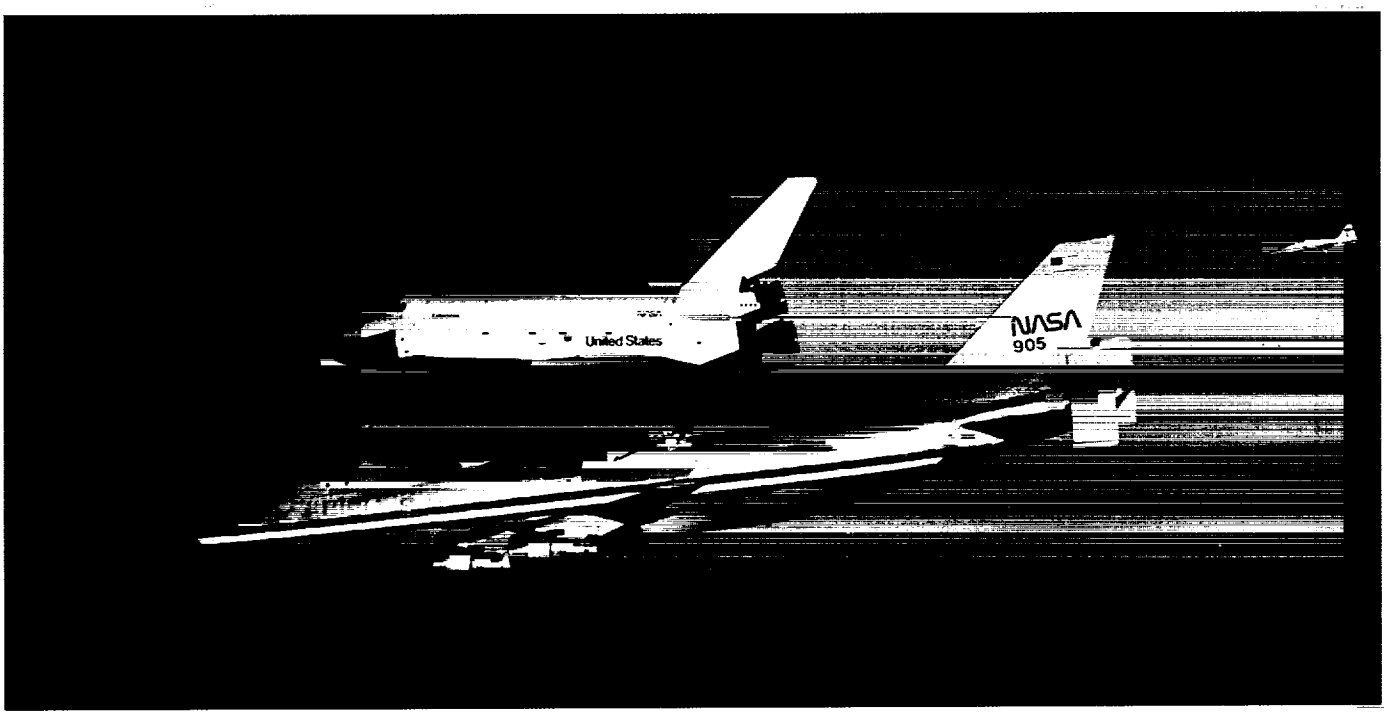

In the Approach and Landing Test Program, the *Enterprise* is released from its piggyback position atop NASA's modified 747 to test how well the spacecraft can glide to a runway landing after leaving orbit and returning to Earth.

By 1985, all of the orbiters except for the *Enterprise* had made flights into space. *Enterprise*, the first orbiter built, was never intended to go into space. Instead it was designed as a test vehicle to be flown in the atmosphere only, and was built to be identical to the future four orbiters in shape and weight.

Enterprise was first used in the Approach and Landing Test (ALT) Program. NASA modified a Boeing 747 aircraft so that it could ferry *Enterprise* on its back, and then also be used later to transport the other Shuttles from various parts of the United States to KSC.

The ALT program involved a total of 14 flights. Five flights were made with an unmanned *Enterprise* attached to the top of the 747. Two pilots then flew inside of *Enterprise* when it was still attached to the 747. Some of the Shuttle's flight systems were tested at this time. During the last test flights, *Enterprise* was released from the 747 at an altitude of approximately 7.2 kilometers (24,000 feet), and the pilots onboard glided *Enterprise* to an unpowered landing.

All of these tests were made at Edwards Air Force Base in California. The purpose was to study the flight characteristics of the orbiter in the atmosphere. The airframe and the mechanical and electrical parts of the orbiter were evaluated. The ALT test also helped train controllers and ground crews.

Enterprise was also used for a series of vibration tests at NASA's Marshall Space Flight Center in Huntsville, Alabama. At KSC, *Enterprise* was used to test the Shuttle mobile launch system. *Enterprise* was then used in similar fit checks at the new Shuttle Launch Complex at Vandenburg Air Force Base, California.

NASA gave the Space Shuttle orbiter *Enterprise* to the National Air and Space Museum on November 19, 1985. The *Enterprise* is now located at the Dulles International Airport near Washington, D.C. Some day soon NASM hopes to build a new museum where the *Enterprise* and other large aircraft will be exhibited.

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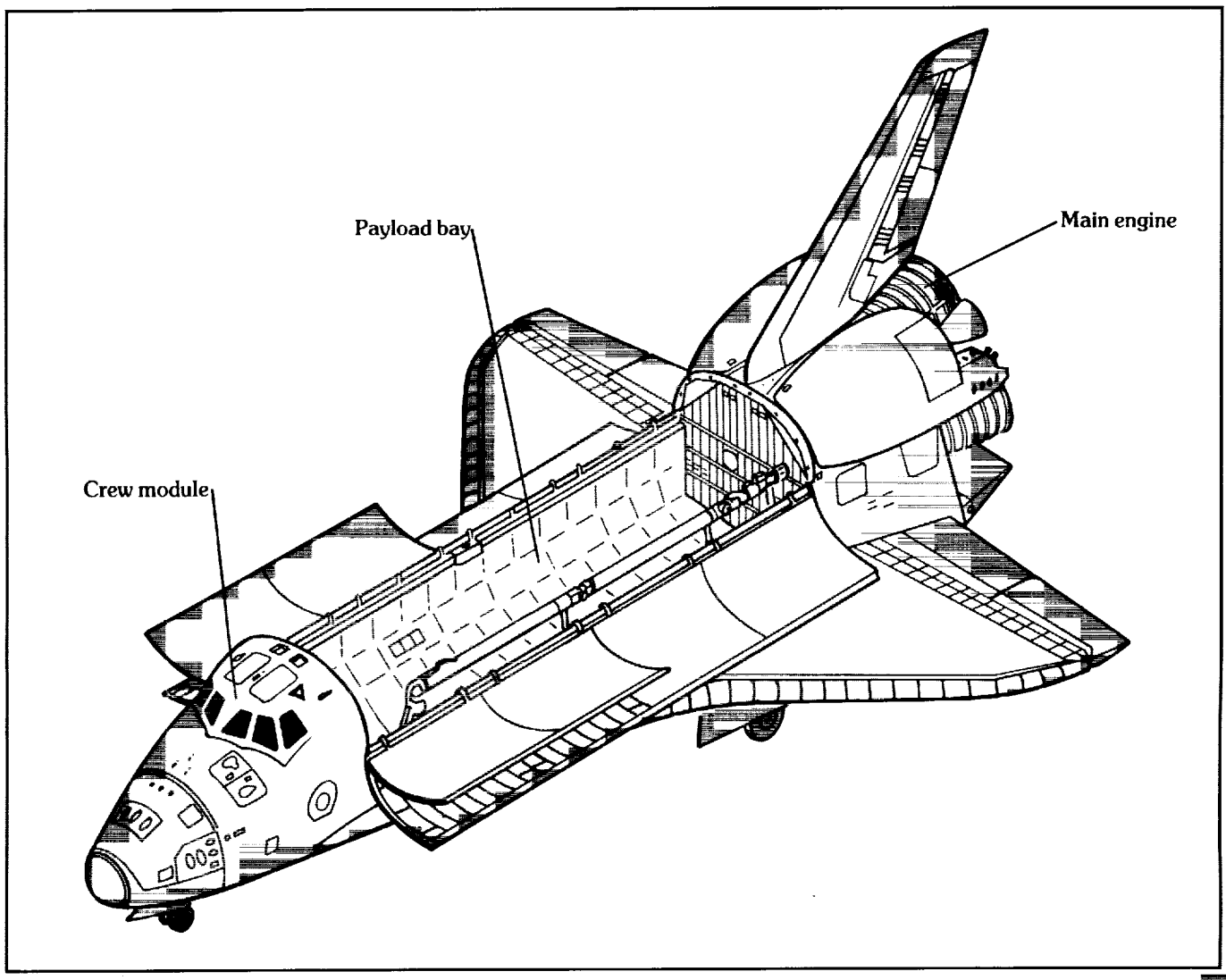
THE SHUTTLE ORBITER



The Shuttle's payload bay opened up

The orbiter is big! It is 37 meters long (122 feet). From wing tip to wing tip it spans 24 meters (78 feet). From the ground to the top of the vertical stabilizer, or tail, it stands 17 meters (57 feet) high. The orbiter is about the size of a DC-9 airplane.

The orbiter is divided into three main parts. The forward part is called the **crew module**. It is where the crew members stay while in space. The middle of the orbiter is called the **payload bay**. This is where the payloads are stored that are being hauled into space. A payload can be a satellite to be deployed or instruments to view the Earth. The back of the orbiter is where the Shuttle's three **main engines** are located.

The crew module is a three-section, pressurized working, living, and storage compartment. It is in this forward part of the Shuttle that the cockpit, living quarters and experiment operator's stations are located. This area of the Shuttle is divided into three levels: **flight deck, mid-deck,** and **lower deck**.

The flight deck is where the commander and pilot fly the Shuttle. The crew can see beautiful

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views of Earth from the flight deck through any of the six windshields, two overhead windows, or two rear-viewing payload bay windows.

The crew members must be well trained, since there are 2,020 separate displays and controls on the flight deck for use during flight. The payload satellites and instruments in the payload bay are operated from the back part of the flight deck.

The mid-deck is the crew's home in space. It is on the mid-deck where they prepare meals, use the bathroom, and clean up. Sleeping quarters are also on the mid-deck. Lockers are available on the mid-deck for storage of small equipment and clothing.

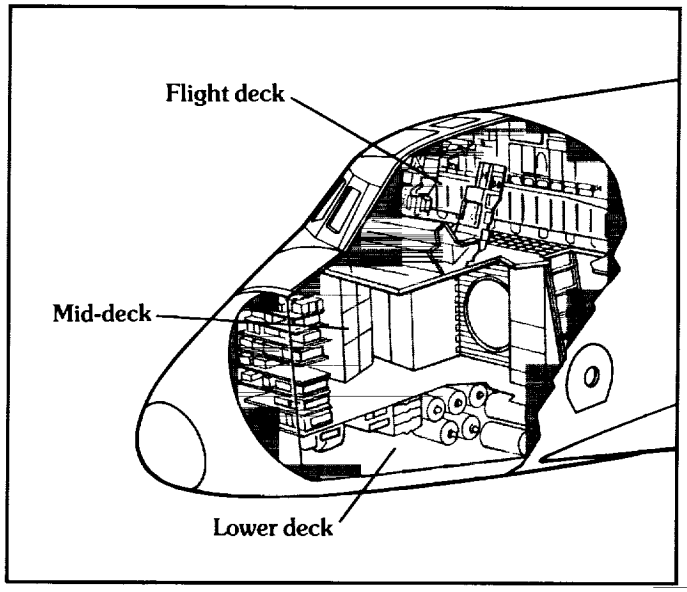
The crew members enter the left side of the orbiter through a 1-meter (40-inch) circular hatch. Once in orbit, the astronauts work in space by going through the airlock on the mid-deck. There is a ladder on the mid-deck to get to the flight deck, but no one needs to use the ladder in space, because you can float to the flight deck.

The lower deck is called the **equipment bay**. You get to the equipment bay through removable floor panels. Various parts of the environmental control equipment are stored here. Wet trash is also stored here.

The payload bay in the middle of the orbiter is 18.3 meters (60 feet) long and 4.6 meters (15 feet) wide. You could easily fit a school bus into the payload bay for a trip to space. The orbiter can transport up to 29,500 kilograms (65,000 pounds) of payload into orbit. It can bring back payloads weighing up to 14,500 kilograms (32,000 pounds).

Once in orbit, the two payload bay doors must be opened. Each door contains four radiator panels that expel the orbiter's excess heat into space. If the heat is not removed, the equipment in the orbiter becomes too hot and the mission would have to be cut short. A **remote manipulator system** (RMS) arm is often included in the payload bay. You can use the arm to lift objects in and out of the payload bay. Before returning to Earth, the payload bay doors must be closed.

The rear of the orbiter contains the Shuttle main engines, body flap, and vertical stabilizer. The three main engines are fixed together to get the Shuttle into orbit. The body flap is used during reentry into Earth's atmosphere to help protect the engines from the extreme heat of reentry. Wings located in the middle of the orbiter are used when the orbiter is returning from space and traveling through the atmosphere. The vertical stabilizer consists of a structural fin, which acts as a rudder and speed brake. This rudder can be used to steer the orbiter in a right or left direction in its flight through the atmosphere. During landing the rudder can split in half to help slow down the orbiter.



The crew module

Electrical power for the Shuttle is produced by three fuel cells in the orbiter. The fuel cells use hydrogen and oxygen to generate electricity. All three fuel cells are used during peak energy power conditions. Only two fuel cells are used during minimum power conditions. The fuel cells can produce 15 to 20 kilowatts of power. Drinking water is an important by-product of fuel cell operation.

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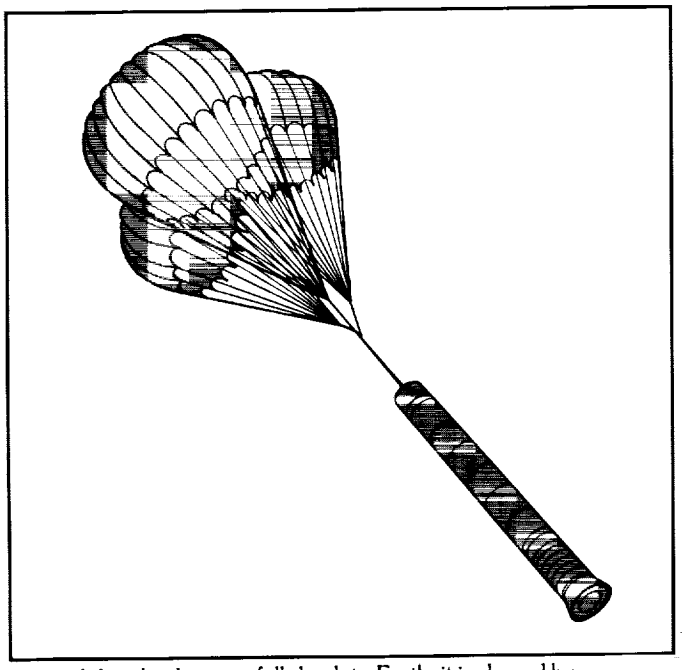
SOLID ROCKET BOOSTERS



As a solid rocket booster falls back to Earth, it is slowed by three large parachutes. Because boosters are used many times, they must not fall too fast or they will be damaged when they hit the ocean.

It takes a lot of energy to launch a spacecraft into orbit. The Shuttle uses its main engines and two **solid rocket boosters** (SRBs) to provide the thrust needed to get to space. Thrust, often stated in pounds, is the force produced by the rockets. One pound of thrust is equal to 22 horsepower.

One SRB is attached to each side of the external fuel tank. Each one is a solid fuel rocket. (Firework rockets launched on the Fourth of July are also solid fuel rockets.) SRB fuel is a mixture of aluminum and several other materials that help it burn. Each SRB produces 11.8 million neutrons (2.65 million pounds) of thrust. Each is 45.5 meters (149 feet) tall and 3.6 meters (12 feet) wide. At launch an SRB weighs 590,000 kilograms (1.3 million pounds).

The SRBs are fired only after the Shuttle's main engines have started. They burn for about the first two minutes of the flight. By the time the SRBs have used all of their fuel, the Shuttle has gained 45 kilometers (28 miles) in altitude.

At this time the SRBs separate from the Shuttle. They still have enough forward motion to carry them up for another 70 seconds. At the end of this time the SRBs have reached an altitude of 66 kilometers (41 miles). They then begin their fall into the Atlantic Ocean. During the fastest part of their fall, the SRBs travel nearly 4,600 kilometers (2,900 miles) per hour.

It takes almost five minutes from the time the SRBs separate from the Shuttle for them to land in the ocean. Three large parachutes slow the SRBs during their fall to Earth. They hit the water at a speed of 96 kilometers (60 miles) per hour, landing about 279 kilometers (169 miles) from the launch site. Because the SRBs are to be reused, they are recovered by two sea tugs. They are then returned to KSC, where they are cleaned up and refueled for another flight.

The Shuttle made 24 successful flights. Then, on January 28, 1986, during the 25th Shuttle flight, a seal on the right SRB ruptured and led to the tragic destruction of the orbiter *Challenger*. All seven crew members were killed. NASA and its contractors have redesigned the seals, called O-rings, used between the segments of the solid rocket boosters so that no hot gas can now escape. This new design will make the Shuttle a safer spacecraft system for future space travelers like yourself.

Recovery ships retrieve the Shuttle's solid rocket boosters after they have exhausted their fuel and fallen back to Earth. They will be hauled back to shore for reuse on another Shuttle flight.

THE EXTERNAL TANK

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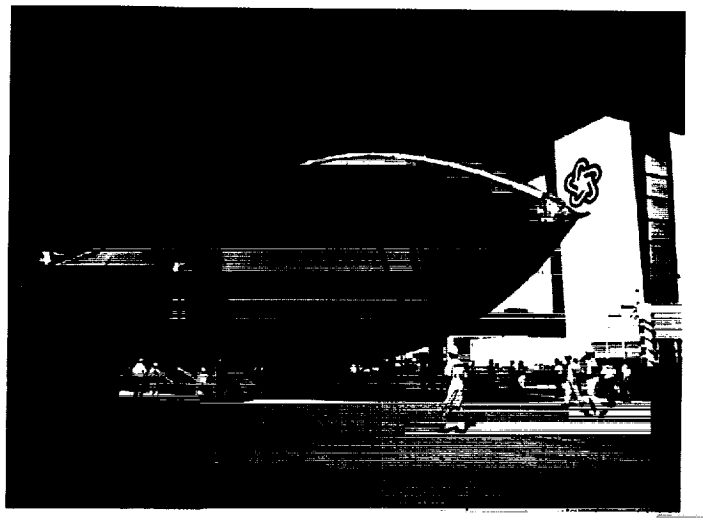
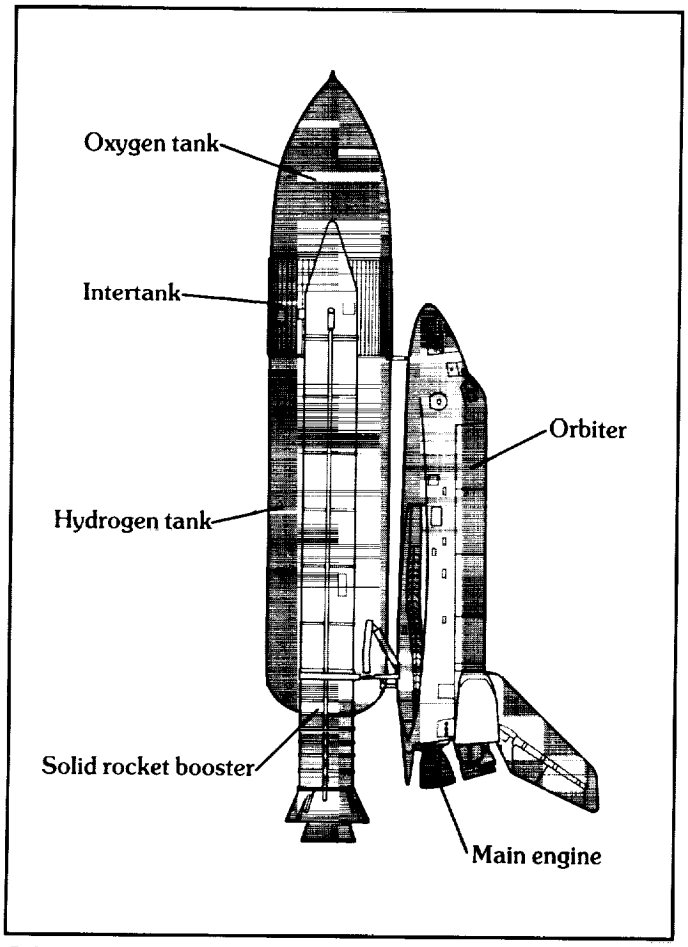
The Shuttle's three main engines are fueled by an external tank, really a huge gas tank. The tank has three main parts. The top part stores the oxygen, and the bottom part, the hydrogen. In between is a section that connects the two tanks with all sorts of plumbing-like equipment. The outside of the external tank is covered with a material that protects it from the heat of launch and early flight. The forward part of the tank curves to a point to reduce aerodynamic drag. Its tip serves as a lightning rod for the Shuttle once it has cleared the launch tower.

The external tank contains the liquid fuels that the Shuttle's main engines use during the first eight and one-half minutes of flight. The tank is the only major part of the Shuttle that is not reused. It is 47 meters (154 feet) long and 9 meters (29 feet) wide.



The external fuel tank is carried to the Vehicle Assembly Building in the background, where it will be joined to the two solid rocket boosters and the orbiter.



Side view of the Space Shuttle

It weighs about 35,000 kilograms (78,000 pounds) when empty. Full, the tank weighs 755,787 kilograms (1,667,667 pounds).

The Shuttle's three main engines burn large quantities of liquid oxygen and liquid hydrogen. In fact, when completely fueled, the Shuttle contains 541,000 liters (143,000 gallons) of liquid oxygen and 1.45 million liters (383,000 gallons) of liquid hydrogen. These fuels have to be stored in the tank at very cold temperatures. Liquid oxygen's storage temperature is -183 degrees Celsius (-297 degrees Fahrenheit), while hydrogen is -253 degrees Celsius (-423 degrees Fahrenheit). The Fahrenheit temperature scale is the temperature scale that is used in your home.

At launch the Shuttle uses about 63,600 liters (16,800 gallons) of liquid oxygen and almost 170,000 liters (45,000 gallons) of liquid hydrogen each minute. By burning these liquid fuels, each main engine can produce up to 1.7 million neutrons (375,000 pounds) of thrust. By the time the main engines shut down, the Shuttle has gained 112 kilometers (70 miles) in altitude.

The external tank is released from the Shuttle 10 to 15 seconds after the Shuttle's main engines shut down. Once released, it begins to tumble. It reenters Earth's atmosphere and breaks up. Pieces of the tank land in the Indian Ocean 58 minutes later.

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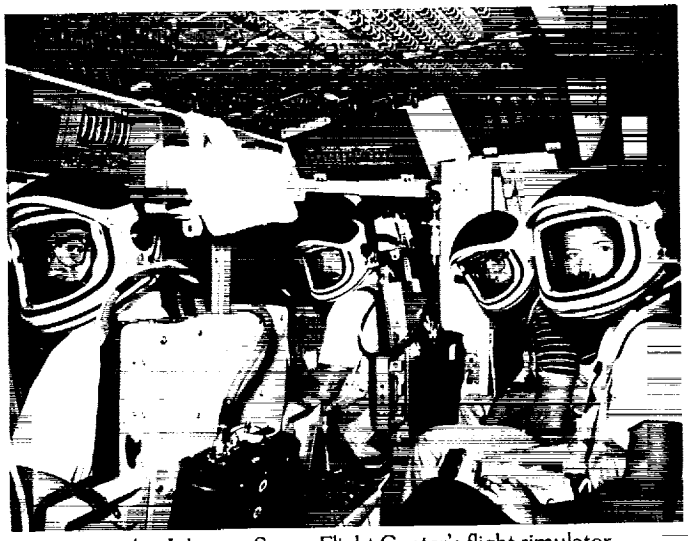
ASTRONAUT TRAINING



Training at the Johnson Space Flight Center's flight simulator for mission STS-7 are astronauts (left to right) Robert Crippen, Frederick Hauck, John Fabian, and Sally Ride.

As a member of a flight crew, you would have lots of jobs to do aboard the Shuttle. You would be put in charge of some aspect of the flight. As **commander**, for example, you would fly the Shuttle and be in charge of the mission. If assigned to be the **pilot**, you would assist the commander with flying the spacecraft. As a **mission specialist**, you would be in charge of the experiments and payloads being carried aboard the Shuttle. The commander, pilot, and mission specialists work for NASA. Most Shuttle astronauts plan on going into space several times during their NASA careers.

From time to time, a scientist, engineer, or physician who does not work for NASA will take a flight into space to oversee an experiment. These individuals are called **payload specialists**. They conduct experiments or observe the deployment of a payload for their sponsor. They will probably travel to space only once or, at most, just a few times.

You must receive training before you can go into space. It is not unusual to begin training several years before flight time. Your job aboard the orbiter determines the type of training you would receive.

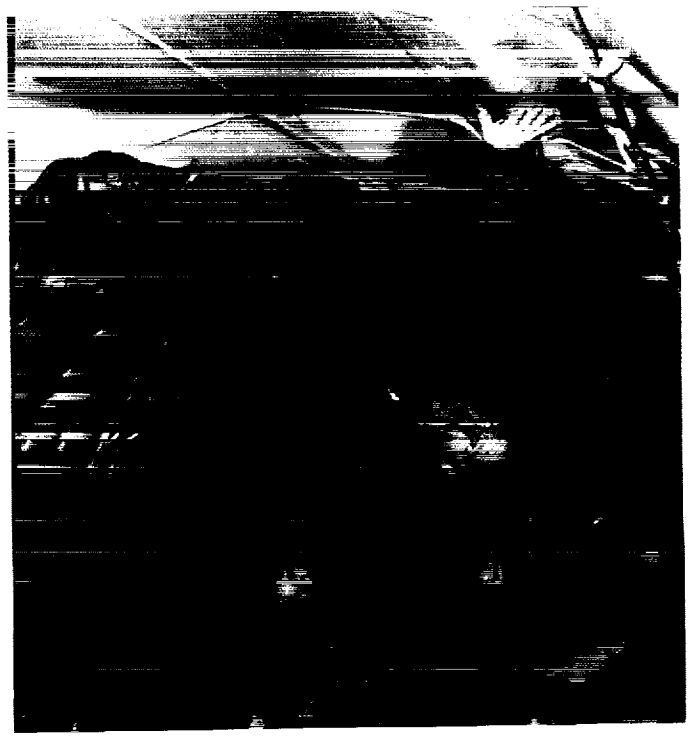
You would probably train in the various flight simulators at NASA's Johnson Space Center in Houston, Texas. You experience zero gravity by flying in a special NASA aircraft called KC-135. During parts of the flight, you will briefly float in free fall around the inside of the aircraft.

If you are to work outside the orbiter in space, you would train in a large tank of water. The underwater world is very much like the world of space, and the astronauts practice their assignments over and over again wearing their spacesuits in this huge tank. The commander and pilot also use a Shuttle training aircraft to practice Shuttle approach and landing procedures.

Classroom instruction is another important part of training. During your studies, you learn all about the Shuttle. You also learn about guidance, navigation, the effects of microgravity on your body, and many other related subjects.

If you are to be a payload specialist, most of your training would concern the payload you are to operate. The company or organization that is sending you up would coordinate most of your training.

Before you go into space, you would most cer-



Astronaut Rick Hauck trains for zero gravity aboard the KC-135. This airplane flies to a great altitude, then dives so that training astronauts may experience weightlessness.

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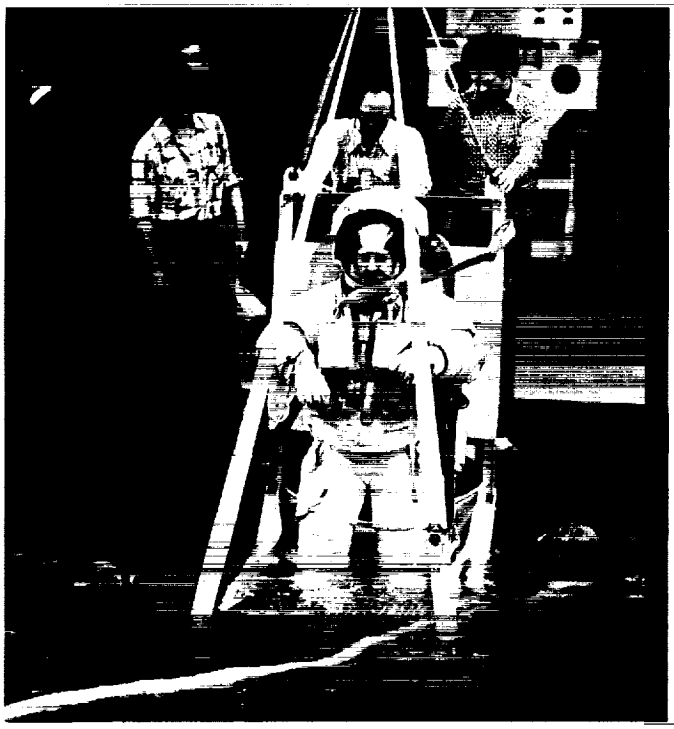

To train for work outside the Shuttle in space, Astronaut Richard Truly practices in the Weightless Environment Training Facility at the Johnson Space Center. This huge swimming pool is used because the underwater world and the world of space are much alike. Astronauts master all EVA activities here before going into space.

tainly also need to know about crew operations, housekeeping, and Shuttle emergency procedures. It is also every astronaut's responsibility to keep himself or herself in excellent physical condition.

Once assigned to a flight crew, you would train with the other crew members to prepare for the flight. As training progresses, the crew and the flight controllers practice an entire mission in a joint training exercise that proves everything is go for the real flight.

GETTING TO SPACE

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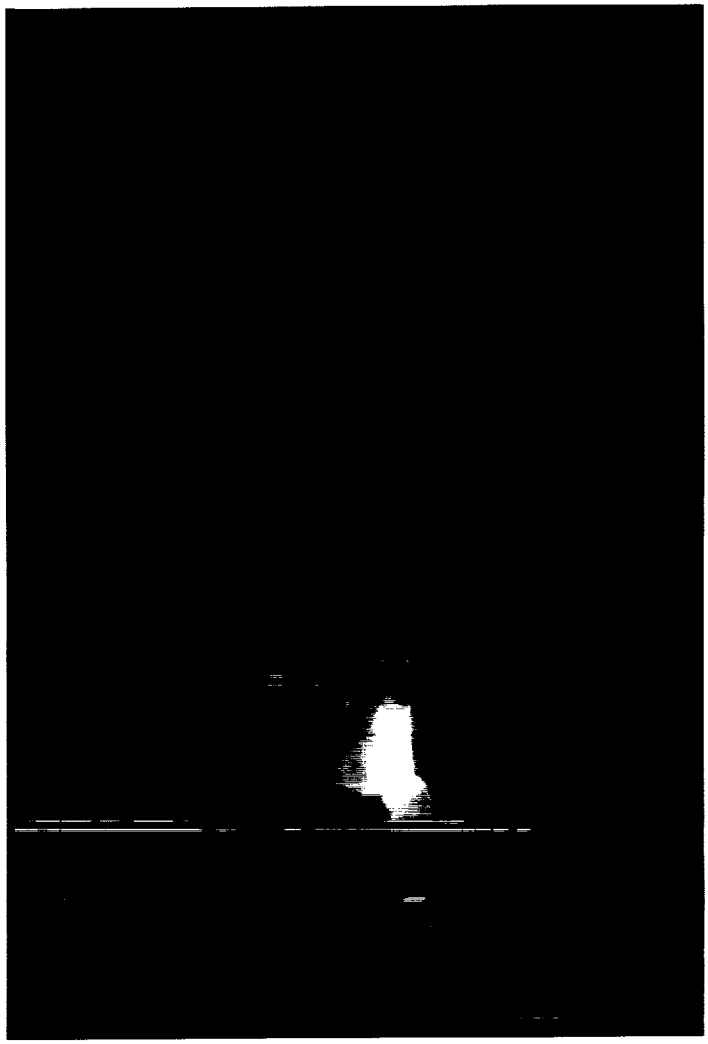

Columbia rises off Launch Pad 39-A for its second mission. This STS-2 mission carried astronauts Joe Engle and Richard Truly along with a payload of scientific experiments.

Imagine you are a highly trained specialist on your first Shuttle flight. As a Shuttle crew member you leave the astronaut quarters for the Shuttle about two hours before liftoff. You enter the orbiter through the 1-meter (40-inch) diameter circular hatch located on the left side of the mid-deck.

The commander, pilot, mission specialist, and one payload specialist sit on the flight deck. Seats for three other crew members are located on the mid-deck. After the crew is seated, you all strap yourselves in. You are now on your back in a reclining seat awaiting launch. Your heartbeat speeds up; the adventure is about to begin!

The last 30 minutes before launch is a busy time. Everything must be checked out. The five computers on board are helping the crew to check all parts of the orbiter, external tank, and solid rocket boosters. Each of the computers can make nearly 325,000 operations each second. The crew will depend on the computers throughout the whole mission.

The final few seconds before liftoff look like this:

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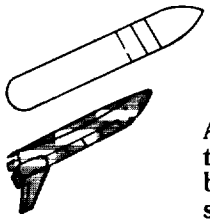
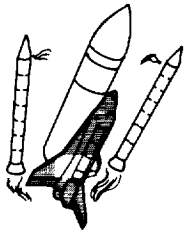


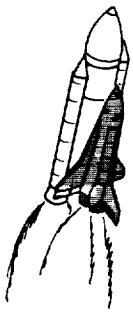
About eight and one-half minutes into the flight, the main engines cut off. The big tank is released about 10 to 15 seconds later. It breaks up and falls into the Indian Ocean.

About six and one-half minutes into flight, the Shuttle begins a long, shallow dive to prepare for external tank separation. The Shuttle is now at 128 kilometers (80 miles) in altitude. At the end of the dive, the orbiter will be 115 kilometers (72 miles) above Earth. All aboard the orbiter will feel three Gs of acceleration. (The pull of gravity is measured in Gs.)



About two minutes later, the Orbital Maneuvering System (OMS), the smaller engines inside that allow the orbiter to move about in orbit, fire. This OMS burn will continue for nearly two minutes. At the end of the burn, the orbiter will be in an elliptical orbit around Earth.

About two minutes into flight, the solid rocket boosters burn out. The orbiter is now about 45 kilometers (28 miles) in altitude. The SRBs separate seven seconds later and begin to fall into the Atlantic Ocean.



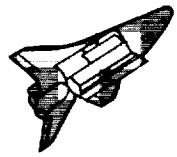
The Shuttle vibrates and shakes, and the crew can hear lots of metallic bangs and clanks.

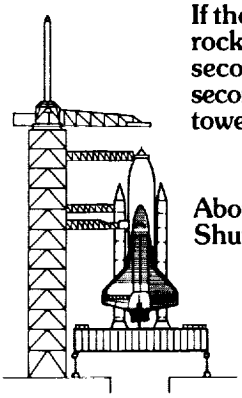
Approximately 45 minutes after launch, the OMS engines fire again to place the orbiter in a nearly circular orbit about 320 kilometers (200 miles) above Earth.

IMAGINE! YOU ARE NOW IN ORBIT!

About 70 seconds into flight, the orbiter reaches maximum dynamic pressure.

THE CREW IS ON ITS WAY!





If they are working properly, the solid rocket boosters fire about one-third of a second before liftoff. Three and one-half seconds later, the orbiter clears the launch tower.

About six seconds before liftoff, the three Shuttle main engines start.

Once in orbit, it is important to open the payload bay doors to get rid of the orbiter's excess heat.

It's time now to stow the crew seats and get to work. But in addition to working, Shuttle astronauts must know how to accomplish all the everyday tasks of life. Because you may wish to join a Shuttle crew some year in the future, let's look at life on board an orbiting Shuttle spacecraft.

ORBITING IN THE WORLD OF WEIGHTLESSNESS

Your Shuttle launch into space will be from Kennedy Space Center in Florida, which borders on the Atlantic Ocean. Because the Shuttle will launch over the Atlantic, nearby communities are in no danger from a possible accident.

Your path around and above Earth is called an **Earth orbit**. For the Shuttle to orbit Earth, it must travel at nearly 8 kilometers (5 miles) per second. The velocity needed to orbit Earth decreases the farther you get from Earth. This is because the pull of Earth's gravity decreases as you move away from our planet.

For an altitude above Earth of	Velocity required is
160 km (100 mi)	7.76 km (4.85 mi) a second
320 km (200 mi)	7.66 km (4.79 mi) a second
35,680 km (22,300 mi)	2.86 km (1.79 mi) a second

The farther you travel from Earth, the longer it takes to complete one orbit:

For 160 meters (100 miles), it takes 88 minutes.
For 320 meters (200 miles), it takes 91 minutes.
For 33,450 meters (22,300 miles), it takes 24 hours.

From an altitude of 480 kilometers (300 miles), you can see the entire United States from coast to coast. At this altitude it will take you about 12 minutes to cross the United States in the orbiter. Some types of orbits that you should be familiar with are circular, geosynchronous, elliptical, and polar.

A circular orbit is one in which your distance above the surface of Earth remains constant.

A geosynchronous orbit is one in which a spacecraft orbits 35,680 kilometers (22,300 miles) above the equator in a circular orbit. From Earth, the spacecraft seems to remain fixed in the sky, because the spacecraft goes around Earth in the same amount of time as Earth turns on its axis.

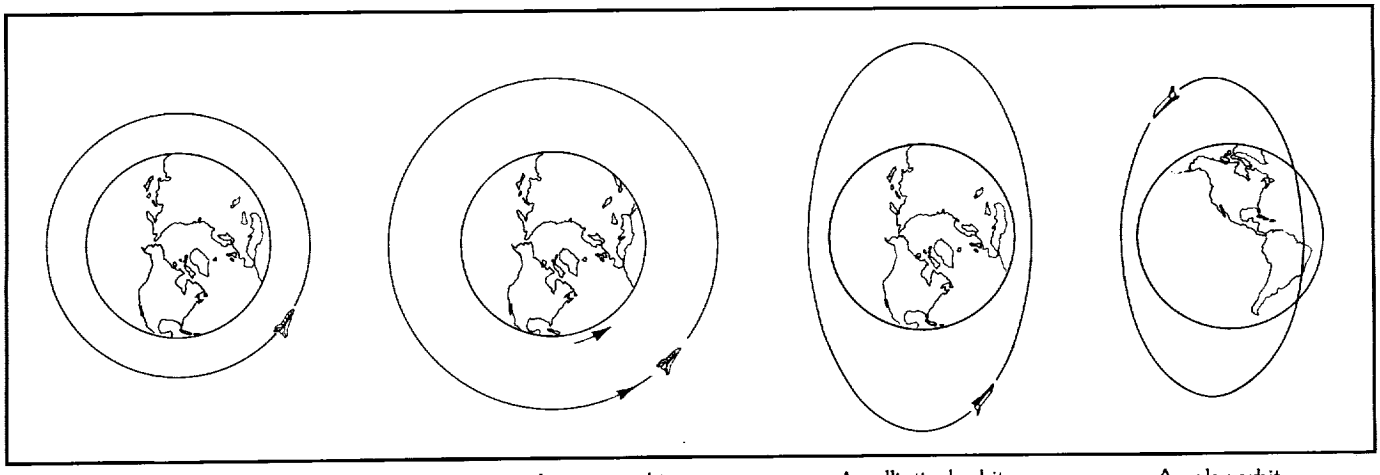
In an **elliptical orbit** your distance above Earth's surface is not constant. When you are at **perigee**, you are at the closest point in your orbit above the Earth's surface. At **apogee** you are at the most distant point in your orbit.

If you fly around the Earth in a **polar orbit**, you pass over Earth near the north and south poles.

How far the orbiter passes north or south of the equator depends on your launch angle. A due east launch from KSC would put you in an orbit inclined 28.5 degrees to the equator.

Because the crew must make sure that the solid rocket boosters and external tank will not hit land upon reentry, there is a limit to how far north or south you can launch. From KSC, launch to the north is limited to the southeast portion of Newfoundland; launch to the south is limited to the Bahama Islands. Because of these restrictions, the farthest north or south that the orbiter can travel from a launch at KSC is 57 degrees above or below the equator.

Before you even enter the orbiter, however, you will have to put on your space suit. First you get into a cooling and ventilation garment that looks like long underwear with plastic tubing sewn in. Water will flow through the tubing to keep you



A circular orbit — A geosynchronous orbit — An elliptical orbit — A polar orbit

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Objects not held down float around inside the cabin because, with the Shuttle in orbit, its forward motion exactly counter balances the downward pull of Earth's gravity. Weightlessness occurs because of this state of free fall.

cool. The open fabric weave also permits ventilation to the body.

The Shuttle suit itself comes in two parts. First you put on the trouser assembly. Then you are ready to put on the upper part of the suit. At this time you connect the cooling and ventilation garment to the portable life support system. This system, which you carry into the orbiter, provides oxygen and suit pressurization until you are in orbit. It also cools and circulates the water used in the cooling and ventilation garment.

If you are orbiting Earth in the Shuttle orbiter, you are really just falling around Earth. You are in a continuous free fall, similar to diving off a diving board. When you are falling, you are in a weightless condition. Sometimes this is referred to as zero gravity, or zero G.

You will find the world of weightlessness a lot of fun. One of the first things that you will notice, of course, is how things float around, including you! Your arms float away from your body and you are slightly bent at the waist, with your knees flexed and your toes pointing a bit.

You will have to learn to push yourself gently toward something to hold onto. Jobs that are simple on Earth usually take longer and require more energy in space. This is because it is difficult to remain in one spot, and you must keep track of your tools, which can easily float away.

You will also notice some physical changes to your body. Body fluids will shift from your lower body to your upper body. Because of the fluid shifts in your body, you will notice that you do not get thirsty. Your face will become puffy and you may get the sniffles. At the same time your legs will get thinner. You may find yourself not functioning at 100 percent capacity during the first three days in orbit. You will probably grow a few centimeters (an inch or so) in height. But don't worry. You will return to normal on your return to Earth.

A seemingly weightless astronaut, Dale Gardner, floats along with other items inside the Shuttle cabin.

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EATING IN SPACE

The Shuttle dinner plate is an aluminum tray that can fasten to crew member's leg or to a wall. The tray holds several food packages in place so that astronauts can dine on more than one item at the same time.

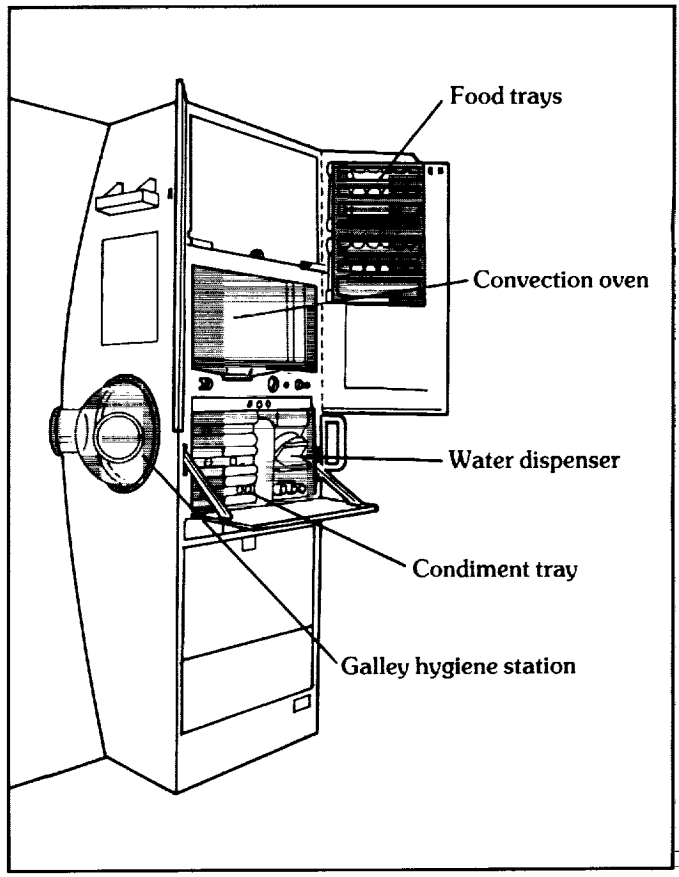
Mealtime gives crew members a chance to relax and visit. Three one-hour meal periods are scheduled each day for eating and cleanup. The crew usually eats on the mid-deck.

The Shuttle dinner plate is a lot different from the one you use on Earth. Each item of food is packaged separately. The food package is somewhat rigid, and the base can serve as a bowl. The top of the package is covered by a see-through lid. These packages are placed in an aluminum tray. During the meal, the tray can be strapped to your leg or to a wall. The tray prevents the food packages from floating away during the meal.

Eating from your tray aboard the orbiter is almost like eating at home. Eating utensils include a knife, fork, and spoon. You must, however, drink your beverages with a straw. Scissors are used to cut open some of the food packages. After the meal, the utensils and tray are cleaned with wet wipes. Utensils, tray, and trash must be stowed before returning to work.

Everyone takes turns preparing meals. There is no kitchen on the orbiter. Instead, the meals are prepared at the galley installed on the mid-deck. The galley has hot and cold water, an oven for warming some of the food packages, and a place to stow the meal trays.

The galley also contains packages of catsup, mustard, mayonnaise, taco sauce, and hot pepper sauce. Salt and pepper are also available. In space you do



The all-in-one galley aboard the orbiter

not use a salt or pepper shaker. Dropper bottles of liquid salt and pepper are used instead. Your sense of taste may diminish. Most astronauts have reported that beverages often taste sweeter to them in space than they did on Earth.

At the top of the galley is a pantry. The food in the pantry is most often used for snacks and beverages between meals. Food for each day is stored in a food locker. Each food package is identified by a colored dot. Each crew member is assigned a different colored dot for the mission.

Some fresh foods are taken into space. These include such items as bread, fruit, and carrot and celery sticks. They must be eaten during the first few days in orbit, because they will not stay fresh.

There is no refrigerator or freezer on the orbiter. All food, therefore, must be precooked or processed so that it does not require refrigeration. The food packages are either ready to eat or can be prepared simply by adding water or by heating.

Some of the foods are freeze-dried. This means that the water was removed from the food before launch. During the flight, water is added back to the food just before it is eaten.

The weight of the food and the food packages for one day is almost three and-a-half pounds and will give you about 2,800 calories of food each day.

Food preparations start 30 to 60 minutes before mealtime. The meal packages are taken from the food locker. Water is added according to directions. Foods to be heated are placed in the oven. Finally each crew member's food packages are placed in his or her tray.

It's time to eat.

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Astronaut Joe Allen, on STS-5, forces orange drink out of a beverage container through the straw. Liquids form spherical shapes if they are allowed to float freely in space.

YOUR BATHROOM IN SPACE

Mission specialist Richard Mullane shaves in preparation for postflight press conference.

It is as important to keep clean in space as it is on Earth. On the orbiter you clean up at what is known as the **personal hygiene station**, which is on the mid-deck near the hatch where the crew enters the orbiter. It has a light, mirror, and a handwashing enclosure.

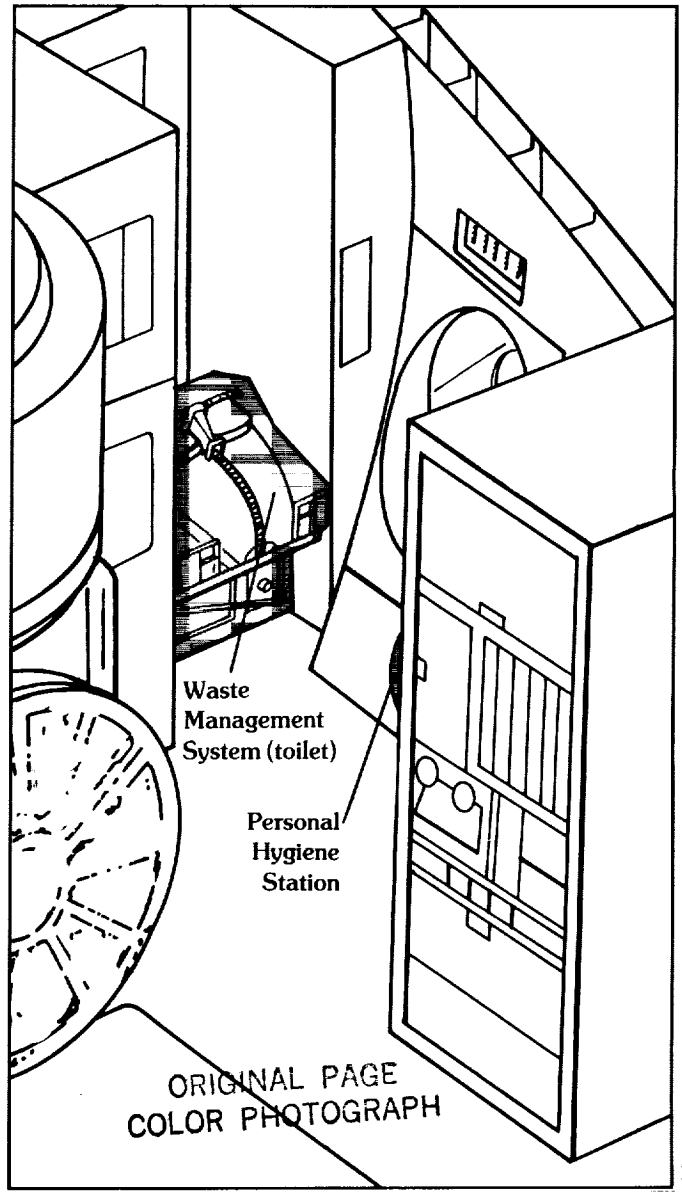
In the weightless world of space, water forms droplets and floats around. It does not go down a drain as it does on Earth. For this reason, you must take sponge baths in space. You must also use the handwashing enclosure when cleaning your hands. For the seven-day stay in space, you will get seven washcloths and three towels.

Each crew member has a personal hygiene kit. A kit might include a razor and shaving cream (for men only), stick deodorant, nail clippers, comb and brush, dental floss, toothbrush, toothpaste, and soap.

After brushing your teeth, you must either swallow your toothpaste or spit it into a towel. Remember, there is no sink. If you have long hair, do not be surprised if it points in every direction or floats about.

There are privacy curtains you can close while using the hygiene station or the **waste collection system** (WCS), a fancy way of describing the orbiter's toilet. It is located in a closet on the other side of the hatch from the hygiene station. It looks similar to the ones back on Earth. However, it does not use water. Instead, airstreams draw waste matter away. Another difference is that there are separate waste collection systems for liquid and solid wastes.

The toilet is used in the same manner as the one onboard a jet airliner. In space, however, you must use a seat belt to hold yourself on to the seat. There are also handholds as well as foot restraints for your use.



View of the orbiter's bathroom

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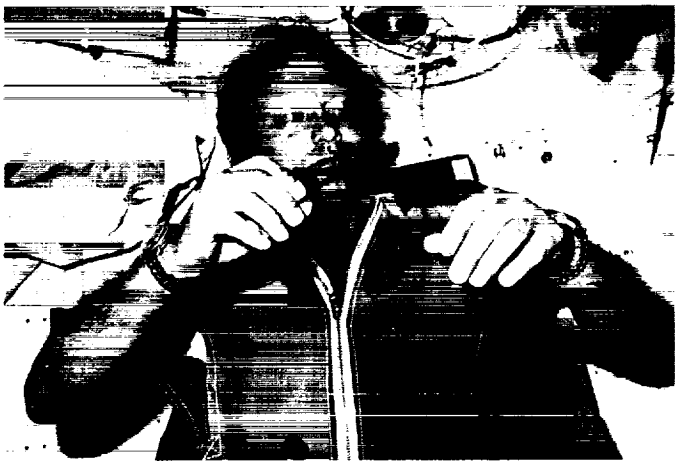
SLEEPING IN SPACE



The sleeping station is in the mid-deck. Astronaut Norman E. Thagard sleeps while his arms float outward and away from him. In space, anything not held down, including arms, floats.

After a long day working on Shuttle, all crew members look forward to a good night's sleep. On most flights, the entire crew goes to bed at the same time. However, during Spacelab missions, some of the crew will stay up to operate the lab.

If you participate in a Shuttle mission some day, do not expect to get much sleep during your first night in space. The excitement of the launch and your first day in orbit will probably keep you awake. By the second or third night, however, you'll sleep normally.

Your schedule will allow you up to eight hours of sleep a night. Forty-five minutes are included to get ready for bed. Another forty-five minutes are allowed for you to get dressed and cleaned up in the morning.

During each 90-minute orbit, the sun rises and sets two times. For this reason, the fluorescent lights are left on all the time. Because the orbiter is never completely dark, the orbiter is equipped with window shades and sleep masks to keep the light out of your eyes while you are sleeping. Ear plugs are also available to reduce the noise of the orbiter.

If everyone does go to bed at the same time, at least one person has to wear a communications carrier to hear the ground calls. If an emergency were to occur during the night, you would hear the caution-and-warning alarms go off.

Because you float in orbit, you do not need a bed. Some crew members have slept in the commander and pilot's seats on the flight deck. Most often the crew members use sleeping bags called **sleep restraints**. You would probably want to tie your sleep restraint to something so that you do not float around during the night. If you do not tuck your arms into the sleep restraint, they tend to float out in front of you. There is no up or down so you can sleep in any direction. You must stow your personal belongings, or they will drift off during the night.

Because there is no up or down in the near weightless environment of orbit, astronauts can sleep in any orientation they choose. Ear plugs and eyeshades are available to block noise and light.

DRESSING FOR SPACE

Dressing for space flight in the orbiter is not easy even though in the Earth-like pressure and temperature inside the orbiter, astronauts do not need to wear spacesuits. Instead, they wear very comfortable clothes. However, if you're not careful while dressing, you can start spinning.

All of the clothing, except for the underwear, is designed for use by both sexes. Crew members do not change their entire wardrobe each day. They only change their underwear daily. Socks and shirts are changed every three days. Trousers are good for seven days. Only one jacket is issued for the flight.

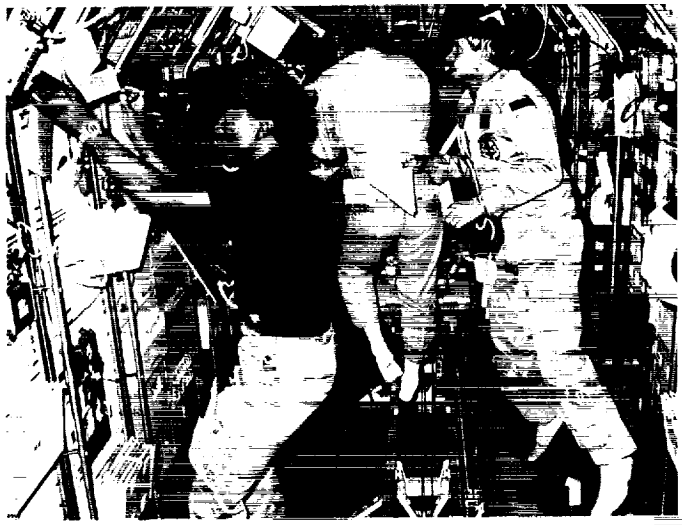
Both the jacket and trousers are cobalt blue in color. Cotton knit shirts are navy blue, with short sleeves. The jacket and trousers have many pockets for carrying personal items such as pens, pencils, and scissors. The pockets do not have buttons. Instead, they close with either zippers or Velcro.

Putting on your trousers in space will be a lot different than on Earth. You pick up both your feet, bend both of your knees toward your stomach, hold the trousers out from your body, and push your feet down both legs at once!

Clothing and many other small items used during the flight are stored in lockers with insertable trays. Almost all of the lockers are on the mid-deck. Each tray is packed so that no item covers another unless the items are alike. Inside dimensions of the trays are 20 x 43 x 5 centimeters (10 x 17 x 20 inches). The contents of each locker is listed on the door. Each locker can hold up to 27 kilograms (60 pounds).

Clothing for Shuttle astronauts is casual and includes shorts, soft slippers, and socks. All clothing is designed to be worn by both sexes.

A medical kit is stored aboard the mid-deck of the orbiter. It contains bandages as well as medicines such as pills and ointments. The crew has access to a doctor at any time by using the communications network to Earth. On several flights, astronauts have reported mild headaches. Doctors had them take aspirin from the medical kit. Equipment is also on board to treat very sick or injured crew members until they can return to Earth.



The flight suit has many pockets and compartments to hold pens, equipment, and personal belongings. Pockets are secured with zippers or Velcro.

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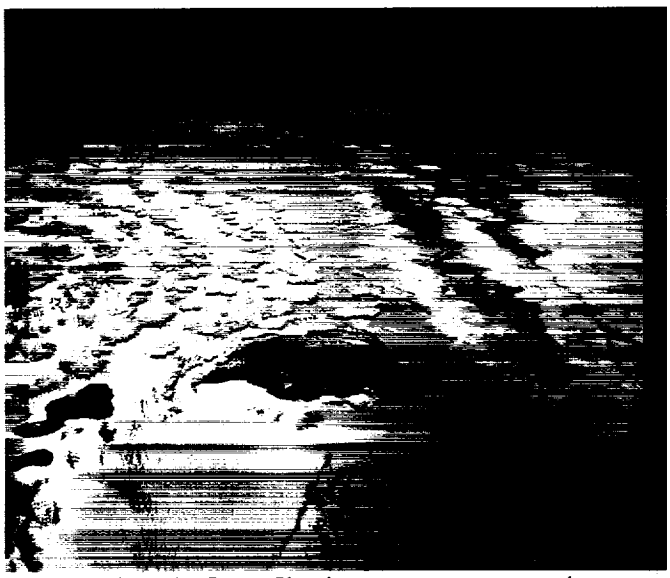
SEEING, HEARING, AND EXERCISING IN SPACE



Earth seen from the Space Shuttle is an overpowering sight. White cloud tops swirl above the blues of water and the reds, greens, yellows, and browns of land formation.

You might be wondering how well you can see in space. After all, the fluid shifts in your body might change the shape of your eyes and require eyeglasses. Rest assured. If you do not wear glasses on Earth, you will not need them in space.

You will be able to see stars out of the orbiter's windows. Because you are looking at them from above the Earth's atmosphere, the stars do not twinkle, and surprisingly, may appear a bit smaller to you than if you were seeing them from Earth.

Earth looks majestic from space. You will see it painted with all sorts of beautiful colors. The various blues of the oceans and the greens and browns of the mountains are spectacular. You can see weather formations and possibly forest fires. You can see the contrails of airplanes and the wakes of ships as well. Lightning in thunderstorms is exciting to watch. You will have to be careful not to spend all your time watching these marvels of nature.

You may have no problem seeing, but what about hearing? You will be able to hear well in the orbiter. Because of fluid shifts, however, you will probably talk with more of a nasal twang. Other people will say you sound different.

Being in space is also like having to stay in bed for a long time on Earth. Therefore, to prevent your heart from weakening, you must exercise each day that you are in space. Exercising in space is a lot different than exercising on Earth. In orbit it is easy to do one-hand push-ups, or lift 459.6 kilograms (1,000 pounds). Exercising in space requires special equipment. You must use the exercise treadmill made from a piece of teflon. After you attach the treadmill to a floor or wall, you must put on a special belt and shoulder harness. The belt and shoulder harness will hold you down so that you can run in place on the treadmill. The tension in the harness can be adjusted to make you work harder.

For missions less than seven days long, you should exercise 15 minutes each day. For longer missions, you should exercise 30 minutes a day.

Daily exercise is important to keep fit. Joe Engle works out on a treadmill designed with a restraining belt for exercising in space.

WORKING INSIDE THE ORBITER

Housekeeping is essential in space, and includes emptying the trash. Jack Lousma, STS-3 crew commander, is shown here with almost a week's trash in the mid-deck area aboard *Columbia*.

During a Shuttle mission, you would have tasks to do during all your waking hours. You would spend some of your time keeping the orbiter clean and in operational condition. Everyone helps with such housekeeping chores.

During the flight, the crew takes turns running the vacuum cleaner to clean the orbiter and the various air filters. The trash will need to be emptied. The equipment in the galley and waste management areas will need to be wiped down. One important job is changing the carbon dioxide absorbers, which filter the carbon dioxide from the recirculated air to keep the air fresh.

Most of your working time would be devoted to conducting experiments. For some of the experiments the only thing that the crew has to do is turn the experiments on and off. Some experiments will be done on the mid-deck, others in the payload bay.

Crew members must also deploy satellites into space from the orbiter. These payloads have been placed in the payload bay by ground crews before the flight. The crew members responsible for these payloads will work from the back portion of the flight deck. Here they have all the necessary controls. You can see a payload in the payload bay through one of four windows or by watching the television screen. The commander or pilot can also fly the orbiter from the back part of the orbiter. From here the orbiter can be pointed in the proper direction for a special payload operation.

To operate some of the payloads, you might have to use the **remote manipulator system** (RMS). The RMS is a mechanical arm 15 meters (50 feet) long contributed to the Shuttle program by Canada. It can move objects in and out of the payload bay. The RMS is operated from the back part of the flight deck.

On Spacelab I, payload specialist Ulf Merbold conducts an experiment using the laboratory's gradient heating facility.

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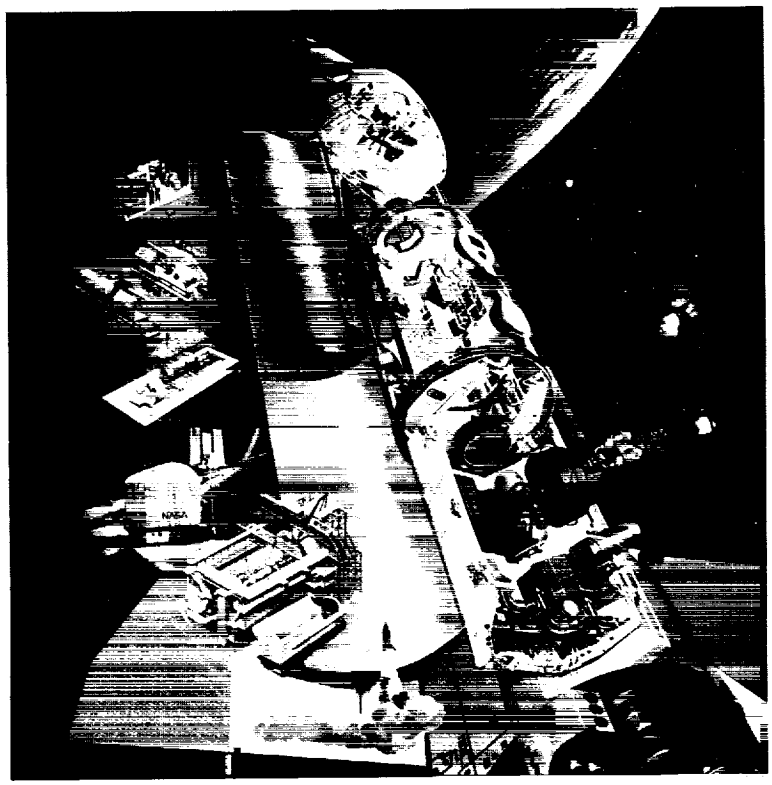
SPACELAB



Spacelab is a scientific laboratory that rides inside the Shuttle cargo bay. Here Spacelab scientists perform experiments that rely on the weightless environment of orbit. Such experiments might be making extremely pure medicines, growing nearly perfect crystals, or mixing materials that are unmixable under the pressure of gravity of Earth.

Some Shuttle flights will include a laboratory called Spacelab in the payload bay. Spacelab is a joint venture of the European Space Agency (ESA) and NASA. ESA built the Spacelab, and NASA launches and operates it. Spacelab will be used by many payload specialists from the United States and European nations.

Spacelab is made up of pressurized modules as well as unpressurized pallets. The pressurized modules have the same temperature and air pressure as the orbiter. You can work in your shirtsleeves in the pressurized module. The long module is 7 meters (23 feet) long and 4 meters (13 feet) wide. The pallets are platforms which experiments and instruments can be attached. You must don your spacesuit to work with anything on the pallet.

The parts of Spacelab can be arranged in several different ways. Three basic arrangements are used. They are module-only, module-plus-pallet, and pallet-only.

You cannot enter Spacelab until you are in orbit. To do so, you go through a tunnel from the airlock. Spacelab will be available 24 hours a day to study all sorts of things. You can photograph the sun and distant stars with different kinds of telescopes. You can make measurements of Earth's atmosphere and pollution conditions or study Earth's surface by doing remote sensing of Earth's resources. You can plot the weather on a worldwide scale. You can make pure metals and alloys or study living organisms.

One of the great things about Spacelab is that experimenters on the ground can work with the crew as they perform experiments in space.

WORKING OUTSIDE THE ORBITER

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Before going on an EVA, an astronaut must don a space suit in an airlock inside the Shuttle. Bruce McCandless prepares for his spacewalk on STS-41-B.

Your Shuttle crew might have jobs to do outside the orbiter as well as inside. You might have to retrieve a satellite near the orbiter and bring it to the payload bay for return to Earth, or repair it and return it to orbit. This type of work is called **extravehicular activity** (EVA).

Outside the orbiter is space—a very harsh world in which to work. You no longer have the orbiter to protect you from its dangers.

In space, the side of your body facing the sun could reach temperatures of up to 121 degrees Celsius (250 degrees Fahrenheit) if not protected. At the same time, your shady side could be a chilling -101 degrees Celsius (-150 degrees Fahrenheit). You would have no air to breathe. In the vacuum of space, your blood would boil and turn to gas. You must guard against harmful ultraviolet radiation from the sun. A micrometeroid might hit you. You can see, of course, why you would wear a spacesuit to work in space. The Shuttle spacesuit and the back part that provides life support is properly referred to as the **extravehicular mobility unit** (EMU).

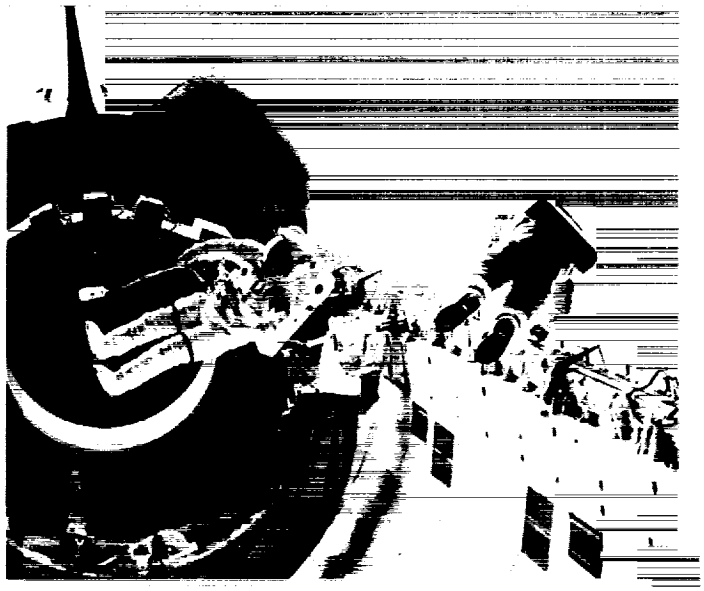
About three hours before your scheduled EVA, you would begin breathing pure oxygen. You do this to remove the nitrogen from your blood so that you will not get the bends. The bends is a condition where gas bubbles collect in your joints and blood. It can kill you.

About 30 minutes prior to EVA, you would enter the Shuttle in airlock. The airlock is located on the mid-deck. It is 1.6 meters (63 inches) wide and 2.1 meters (83 inches) tall and has two pressure-sealing hatches. The spacesuits are stowed here.

Now you are ready to don your suit once more. This time you strap the portable life support system on you back so you hands are free to work in space.

Now you must check out your suit by closing the hatch to the mid-deck and removing the air from the airlock. If the suit checks out, you can open the outer hatch and enter the payload bay to begin your walk in space. The display unit will tell you the status of your oxygen supply and suit pressure, as well as the time elapsed since your EVA began.

Some EVAs may require the use of the **manned maneuvering unit** (MMU). The MMU allows astronauts to jet from the orbiter to a nearby satellite. Nitrogen gas is used to propel the MMU. With the



Outside the Shuttle, astronauts work in protective space suits. Here, F. Story Musgrave (left) and Donald H. Peterson (right) work in the cargo bay, their movement restricted by tethers.

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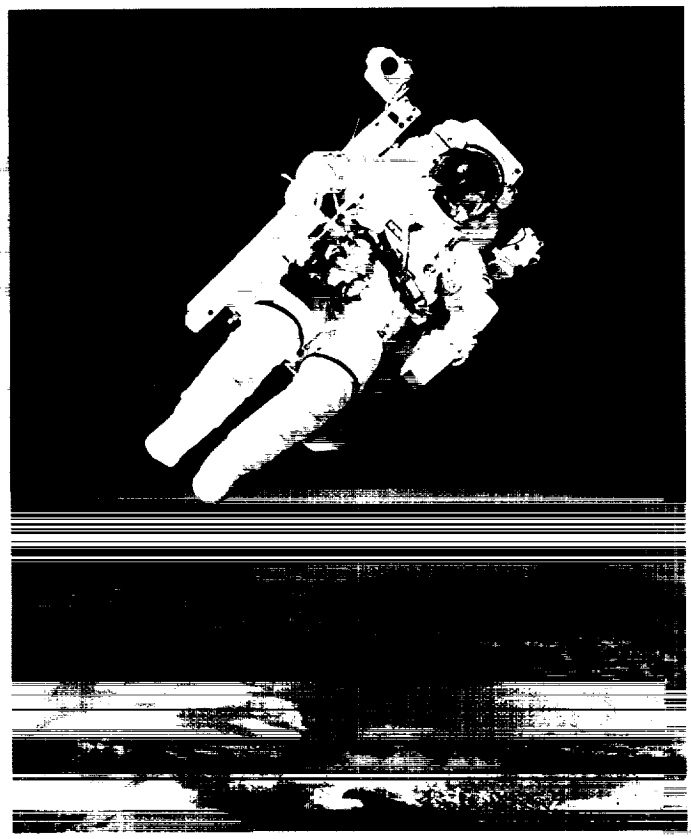
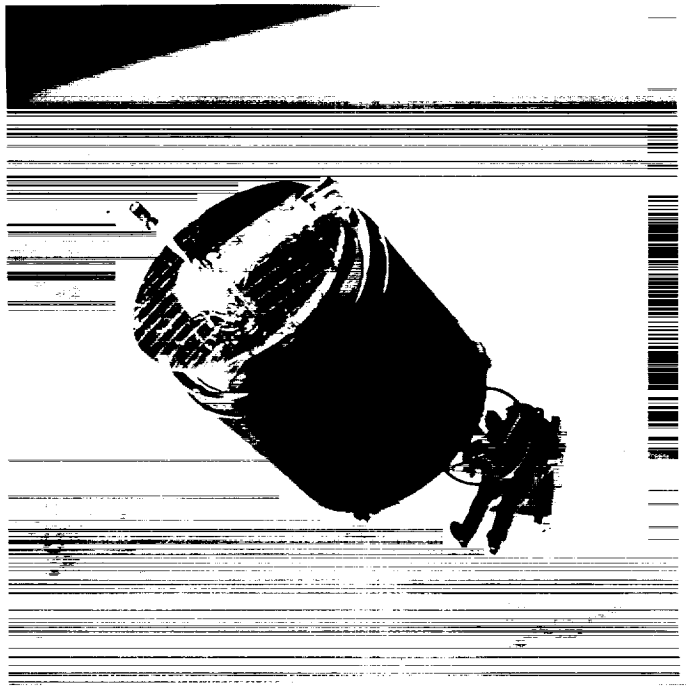
MMU, the operator can turn in any direction.

You would have enough oxygen to work outside of the orbiter for at least 7 hours and 18 minutes. Most tasks are accomplished in much less time. Once you have finished your EVA, you reenter the orbiter through the outer hatch. After closing the outer hatch, you can repressurize the airlock and remove your spacesuit.

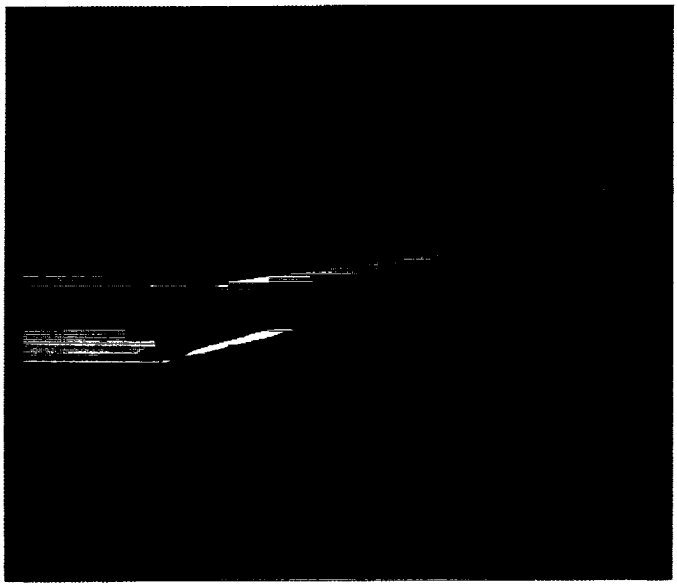


The MMU gives an astronaut freedom to explore areas outside the cargo bay. Bruce McCandless flies his MMU untethered and in complete control of his movements.



Wearing an MMU, Dale Gardner propels himself to the nearby Westar IV satellite, which needs repair. The satellite will be retrieved, placed in the cargo bay, and returned to Earth, where it will be fixed.

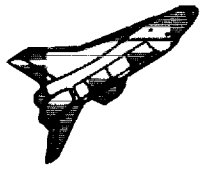
RETURNING TO EARTH



Columbia returns home after its first flight. The landing is nearly perfect as commander Thomas Mattingly and pilot Henry Hartsfield set down at Edwards Air Force Base in California.

After a typical mission of seven days, the crew will have finished all its tasks. If you were on board, you would take one last look at beautiful Earth from space. It's time now to get ready for your trip home. About two hours before landing, you will return to your seat.

Once the payload bay doors are closed and locked, the orbiter is turned to point tail first in its orbit. The **reaction control system** (RCS) engines are used to do this. These engines are located at three places on the orbiter. One set is at the front between the nose and the flight deck. The other two sets are on the orbital maneuvering pods. The RCS engines can make the orbiter turn in any direction in space; these turns are called **pitch**, **roll**, and **yaw** maneuvers.



About 60 minutes before landing, the OMS engines fire for two to three minutes. This burn slows the orbiter down about 320 kilometers (200 miles) per hour. Using the RCS, the orbiter turns once again so that its nose is pointing forward.

Twenty-three minutes to touchdown, your speed is 24,000 kilometers (15,000 miles) per hour. The elevons can now also control the pitch motion of the orbiter.

It is almost 30 minutes to landing. You are now about 122 kilometers (76 miles) in altitude and traveling 27,360 kilometers (17,100 miles) per hour. The orbiter has a thermal protection system that withstands the high temperature conditions in space and the searing heat of reentry. The system consists of two types of heat tiles that provide special insulation. In just five minutes, you will be 94 kilometers (59 miles) above the Earth and traveling at a speed of 26,720 kilometers (16,700 miles) per hour. At this time a communications blackout begins. The blackout is caused by ionizing particles surrounding the orbiter as the heat tiles reflect the heat upon reentering the atmosphere. Once the orbiter is within the atmosphere, the elevons on the wings can control the roll motion of the orbiter.

You begin your reentry with the orbiter's nose pointing up at an angle between 28 and 38 degrees. With just a little over 30 minutes to landing, you inflate your anti-G suit. This suit prevents you from fainting during reentry. Remember, at liftoff you were lying on your back. During reentry you are sitting upright in your seat. If you do not use your anti-G suit, blood would drain from your head to the lower part of your body when you leave the weightlessness of space, and you would black out.

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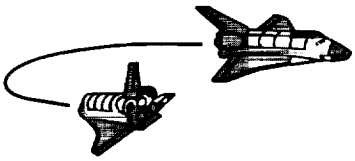
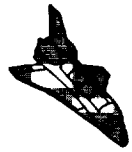
It is now 12 minutes to touchdown. The orbiter leaves the communications blackout. You are now 54 kilometers (34 miles) above Earth and traveling 13,240 kilometers (8,275 miles) per hour. The second S-turn is made. Another S-turn will be made at seven minutes before landing.

At 16 minutes to landing, the orbiter makes its first S-turn. S-turns reduce lift and slow down the orbiter.



It is now 20 minutes to touchdown. You are 80 kilometers (50 miles) above Earth. The outside of the orbiter is now as hot as it will ever be. The nose and leading edges of the wings are nearly 1,300 degrees Celsius (2,300 degrees Fahrenheit).

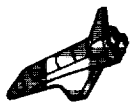
With six minutes to go, you are traveling at 3.3 times the speed of sound. The orbiter has dropped to 27 kilometers (17 miles) in altitude. In 30 seconds the orbiter will make another S-turn. The orbiter continues to slow down. You are now traveling at 2.5 times the speed of sound at 26 kilometers (16 miles) above the surface of the Earth.

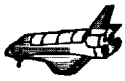


The orbiter moves at the speed of sound at three minutes before landing. You are now at nearly 15.2 kilometers (9.5 miles) in altitude. By using the rudder on the tail, the pilot can steer the orbiter in a right or left direction.

During the last two minutes of flight, a special landing system will help guide the orbiter to the runway. Thirty seconds to go. The orbiter has slowed to 560 kilometers (350 miles) per hour and is 600 meters (2,000 feet) above the ground. The orbiter's nose is pulled up so that the glide angle will be one and one-half degrees. The landing gear is released 14 seconds before touchdown. The orbiter's speed is now 530 kilometers (330 miles) per hour. The orbiter is now only 27 meters (90 feet) up.

At touchdown you are traveling 344 kilometers (215 miles) per hour. The commander or pilot use the speed brake and wheel brakes to slow the orbiter. The orbiter lands on a long runway. It is 4,500 meters (15,000 feet) long and 90 meters (300 feet) wide.



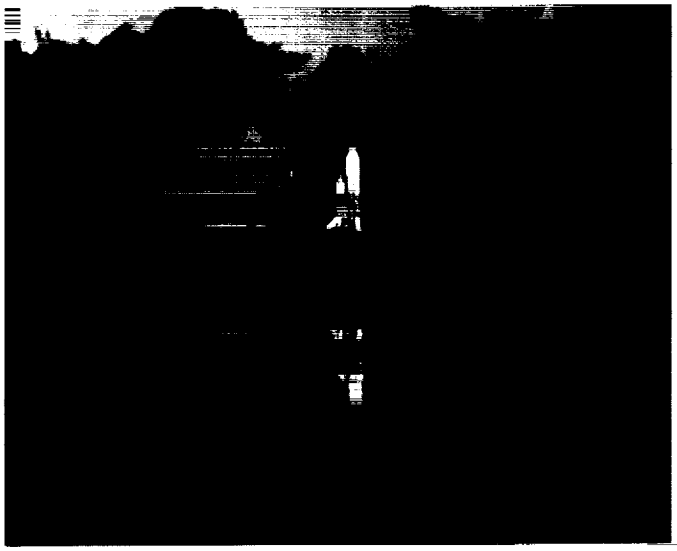


Welcome home! Before the crew can leave the orbiter, all of its systems must be turned off. At the same time, a ground crew arrives to hook up equipment to cool the orbiter. About 30 minutes after landing, you will be ready to leave.

A ground crew will take the orbiter to KSC's Orbiter Processing Facility.

CONGRATULATIONS ON COMPLETING A GOOD FLIGHT!

SHUTTLE FLIGHT FACTS



The first Space Shuttle, *Columbia*, majestically poised on Launch Pad 39-A on the evening before its first flight-readiness firing.

Between 1981 and 1986, the Shuttle was launched 25 times, with *Challenger* launched the most often. Together all four shuttles orbited Earth for a total of 152 days. They completed 2,435 orbits and traveled almost 96 million kilometers (60 million miles).

SHUTTLE	NUMBER OF LAUNCHES
Challenger	10
Columbia	7
Discovery	6
Atlantis	2
Total launches	25

During the 25 missions, the Shuttle launched 132 people into space, with 27 riding the Shuttle more than once. Both men and women have taken part in the flights. Some of the payload specialists have been from foreign countries, demonstrating NASA's cooperation with other countries. The twenty-fifth flight, STS 51-L, ended in tragedy, claiming the lives of all seven crew members.

A special commission appointed by the President investigated the accident. NASA then immediately set to work to design a safer solid rocket booster so that future Shuttle flights can be launched without similar malfunctions. It must always be remembered that space flight requires special training and will always be accompanied by some risks. But the risks are worth the accomplishments. This country will always need professionals who are ready to work in space.

The following table gives more information about the Shuttle flights. The first column gives the mission, name of the Shuttle used, and dates of the flight. Note that the first nine flights are listed STS-1, 2, through STS-9.

With the tenth flight that was launched, a new system is used to identify each mission. Note that the flight is listed as STS 41-B. The first number, *4*, refers to the fiscal year of the scheduled launch. The government's fiscal year is from October 1 through September of the next calendar year. So the launch was scheduled for sometime between October 1, 1983 and September 30, 1984. Indeed, actual launch date for STS 41-B was February 3, 1984.

The *1* tells you that the launch was made from the Kennedy Space Center. The *B* tells you that this was the second Shuttle flight scheduled during Fiscal Year 1984. (The first Shuttle scheduled for that fiscal year, STS-10, was cancelled.) Notice that the scheduled next flight is STS 41-C. The letters don't always run in order because launch dates sometimes are changed. The second column of numbers tells you how many crew members were onboard a flight.

The next three columns give you the length of the mission in days, hours, and minutes. The landing site appears next. The last column contains comments about the mission.

This is your introduction to the Shuttle flights. To find more information, you will have to visit the library.

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SHUTTLE SCHEDULE

Flight	No. in Crew	No. of Orbits	Length of Flight Days	Hours	Min	Landing Site	Comments
STS-1 *Columbia* 04/12/81 - 04/14/81	2	36	2	6	21	Edwards AFB, CA	First shuttle flight; first flight of *Columbia*
STS-2 *Columbia* 11/12/81 - 11/14/81	2	36	2	6	13	Edwards AFB, CA	First operation of RMS arm; first scientific payload (OSTA-1)
STS-3 *Columbia* 03/22/82 - 03/30/82	2	129	8	4	49	Northrop Strip U.S. Army White Sands Missile Range, NM	Landed one day late due to flooding at primary landing site
STS-4 *Columbia* 06/27/82 - 07/04/82	2	112	7	1	9	Edwards AFB, CA	First landing on concrete runway; final orbital test flight; first DOD payload
STS-5 *Columbia* 11/11/82 - 11/16/82	4	81	5	2	14	Edwards AFB, CA	First commercial satellite launches
STS-6 *Challenger* 04/04/83 - 04/09/83	4	80	5	0	24	Edwards AFB, CA	First flight of *Challenger;* launched new class of tracking satellite (TRDS-1)
STS-7 *Challenger* 06/18/83 - 06/24/83	5	98	6	2	24	Edwards AFB, CA	First American woman in space
STS-8 *Challenger* 08/30/83 - 09/05/83	5	98	6	1	9	Edwards AFB, CA	First black American in space; shuttle night-launch and landing
STS-9 *Columbia* 11/28/83 - 12/08/83	6	148	10	7	47	Edwards AFB, CA	First flight of Spacelab 1, two-shifts, round-the-clock science operations; West German payload specialist—first non-American crew member
STS-41-B *Challenger* 02/03/84 - 02/11/84	5	127	7	23	16	Kennedy Space Center, FL	First Kennedy Space Center landing; first use of MMU during EVA; two satellites deployed, failed to achieve orbit
STS-41-C *Challenger* 04/06/84 - 04/13/84	5	107	6	23	41	Edwards AFB, CA	Highest STS operating altitude to date, 498 km (301 mi); crew retrieved and repaired Solar Max satellite
STS-41-D *Discovery* 08/30/84 - 09/05/84	6	97	6	0	56	Edwards AFB, CA	First "frisbee" satellite deployment; first commercial payload specialist; first flight of *Discovery*
STS-41-G *Challenger* 10/05/84 - 10/13/84	7	133	8	5	24	Kennedy Space Center, FL	First American woman to perform EVA; first 7-person crew; first Canadian in space
STS-51-A *Discovery* 11/08/84 - 11/16/84	5	127	7	23	45	Kennedy Space Center, FL	Retrieved and returned disabled satellites from orbit
STS-51-C *Discovery* 1/24/85 - 1/27/85	5	48	3	1	33	Kennedy Space Center, FL	DOD mission
STS-51-D *Discovery* 04/12/85 - 04/19/85	7	108	6	23	55	Kennedy Space Center, FL	First nonspecialist passenger; "Toys in Space" mission
STS-51-B *Challenger* 04/29/85 - 05/06/85	7	110	7	0	9	Edwards AFB, CA	Carried two monkeys, 24 rats in Spacelab 3 flight
STS-51-G *Discovery* 06/17/85 - 06/24/85	7	112	7	1	39	Edwards AFB, CA	First French and Saudi Arabian crew members; first reuseable payload deployed (SPARTAN 1)
STS-51-F *Challenger* 07/29/85 - 08/06/85	7	126	7	22	45	Edwards AFB, CA	Spacelab 2 flight
STS-51-I *Discovery* 08/27/85 - 09/03/85	5	111	7	2	18	Edwards AFB, CA	Launched three satellites; captured, salvaged, repaired LEASAT-3
STS-51-J *Atlantis* 10/03/85 - 10/07/85	5	97	4	1	45	Edwards AFB, CA	First flight of *Atlantis;* DOD mission
STS-61-A *Challenger* 10/30/85 - 11/06/85	8	110	7	0	45	Edwards AFB, CA	First 8-person crew; first foreign-dedicated Spacelab mission
STS-61-B *Atlantis* 11/26/85 - 12/03/85	7	108	6	22	54	Edwards AFB, CA	EASE/ACCESS spacestation construction experiment performed; first Mexican in space
STS-61-C *Columbia* 01/12/86 - 01/18/86	7	96	6	2	4	Edwards AFB, CA	Landed at Edwards AFB after Kennedy Space Center weather wave-off
STS-51-L *Challenger* 01/28/86	7	0	0	0	0	N/A	Explosion 73 seconds after lift-off claims crew, including teacher-in-space
STS-26 *Discovery* 09/29/88 - 10/03/88	5	65	4	1	1	Edwards AFB, CA	The Journey Continues; deployed TDRS-C; two Shuttle Student Involvement Program (SSIP) experiments were tested

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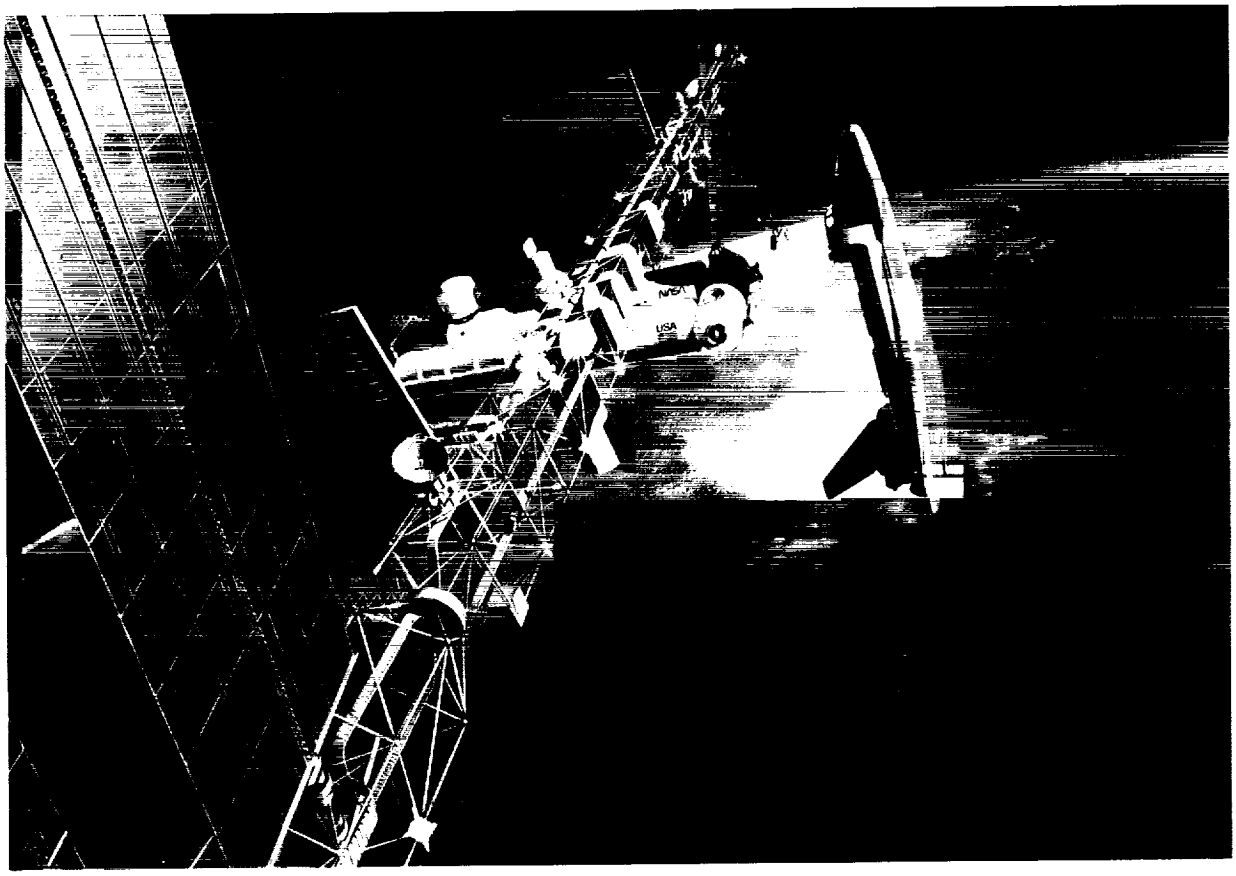
THE FUTURE IS YOURS



A Space Station now being developed, *Freedom*, will be a permanent community in space, where astronauts and scientists can live and work while orbiting Earth.

Exploration on Earth or in space involves risks, and there can be setbacks along the way. Nevertheless, humankind must keep the spirit of exploration alive whether exploring the oceans of Earth or the oceans of space. Our star sailors have to be brave and willing to accept the risks that accompany space exploration. And all of us must support them in their endeavors.

We will long remember the *Challenger* tragedy. These brave astronauts were willing to take on the dangers of space flight because they had a vision of the great possibilities that lay ahead. We must continue to expand that vision.

Space holds new challenges. In the not-too-distant future, we will have a Space Station in orbit. Crews of astronauts will circle Earth for up to ninety days in the Space Station. It is hoped that these astronauts will perform scientific experiments, produce new medicines, and even lay the base for space industries that need a microgravity environment for optimum success.

Perhaps we will return to the Moon to establish Moon settlements. Maybe the people living in the lunar settlements will be testing and advancing technology to carry us to the asteroids, to Mars, and beyond.

Perhaps you will be a member of the first crew to journey to Mars. The important thing for you to do now is study hard and dream dreams of tomorrow.

THE FUTURE BELONGS TO YOU!