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Earth is a small globe in a very large universe. It is inhabited by creatures who are curious about that universe. Men who want to see for themselves what the universe is all about.

In the United States, the National Aeronautics and Space Administration – NASA – is charged with organizing our space program in that search for knowledge.

NASA is a mere stripling – it celebrated its fifteenth anniversary on October 1, 1973 – but in the few years of its existence its capability has grown from the launching of a tiny 30-pound satellite to the orbiting of the huge, 100-ton Skylab. NASA has sent men safely to the Moon; it has begun to uncover the secrets of the Sun; it is probing the working of the galaxies and the universe itself. It is bringing mankind closer together through instant world-wide communications. It is providing man the means for overcoming environmental degradation and for unlocking Earth's resources.

NASA is made up of people – people who want to know, people who have the means for finding out, and people who put the knowledge to work in further exploration. The most important product of NASA is knowledge. All that NASA learns is relayed to the public of this and other countries. The guidelines for its activities were laid down in the Space Act of 1958 which created NASA. Its job is to "explore the phenomena of atmosphere and space for peaceful purposes for the benefit of all mankind. "

The first A in NASA stands for Aeronautics, the science of flight through the atmosphere. In 1917, just 14 years after the Wright brothers flew their first airplane, the National Advisory Committee for Aeronautics – NASA's predecessor – was organized. It concentrated on investigating the why and how of flight, studying the forces of life, thrust, drag, and gravity. NASA is still doing so.

The airplane wing, or airfoil, creates lift. It is curved on the top so that as the airplane moves, the air passing over the wing moves faster than the air passing under; thus the air on top has a lower pressure, and the wing rises. But the classic airfoil also produces drag, or resistance. Drag action starts at about midpoint in the air's flow over the wing. NASA is testing a new airfoil shape, called the supercritical airfoil. This shape moves the drag from the center of the airfoil to the rear. This delays the build-up of drag. Less fuel is needed to overcome the drag. The result is an airplane with higher speed and greater range using less fuel.

Our skies are crowded, and the roads around airports are even busier. Building more airports will not relieve this congestion, but the vertical or short take-off and landing craft – called VTOL or STOL craft – may provide a solution. NASA is studying a number of designs for such craft. A V/STOL can land and take off in a very small area – rather like a helicopter – but once altitude is reached, it moves forward like a regular airplane. Most airplane journeys are made over short distances. V/STOLs will be able to handle short-distance traffic from city centers, leaving the big airports for long-distance traffic.

Airline passengers are not the only people who benefit from NASA's aeronautical research. Work in quiet engines, for example, will benefit both commercial and general aviation and give some peace and quiet to those people who live near airports. There are more than 50 times as many general aviation airplanes – small, light weight airplanes – flying as there are airliners. NASA is investigating a number of measures to make flying of one's own plane, whether for business or fun, safer.

Beyond Earth's atmosphere, is the infinity of space. Unseen forces act on objects in space. Three centuries ago, Sir Isaac Newton explained some of these forces in his Law of Universal Gravitation. He said that all bodies attract all other bodies. The strength of the attraction, or pull, depends on the mass of each body and the distance between them. An apple falls because Earth exerts a stronger attraction on the apple than the apple exerts on Earth. That attraction – called gravity – is the one big factor man must learn to use in exploring space.

How do we overcome Earth's gravity? The answer is velocity (speed) produced by a rocket. According to Newton's Third Law of Motion, "for every action there is an equal and opposite reaction." In a rocket, the action is the escape of exhaust from the nozzle at the rear. The reaction is the movement of the rocket in the opposite direction from the exhaust flow. The exhaust does not push against anything; the rush of the exhaust itself is the push, or thrust. That is why a rocket can work in space where there is no atmosphere. A rocket doesn't need an atmosphere to push against. Nor does it need to take oxygen from an atmosphere to burn fuel. A rocket carries its own oxygen supply with it. The fuel and oxidizer are called propellants.

A rocket's job is to give speed and direction to a satellite. The rocket is long and slender, streamlined to cut cleanly through Earth's atmosphere. As the propellants are burned, the total weight of the rocket decreases and it moves faster and faster. It accelerates away from Earth, overcoming the force of gravity, until the propellants are used up or the engines turned off.

Newton's First Law of Motion says that the rocket, once above the atmosphere, will keep moving forever in the direction it is going unless some force acts on it. Another force does act – Earth's gravity. The satellite is released from the rocket nose cone and is caught in an orbit, balanced between its velocity pulling it away from Earth, and gravity pulling it toward Earth. This combination of forces (gravity and velocity) is like a tug-of-war contest in which both sides have exactly equal strength. A satellite going 17,500 miles an hour parallel to the Earth's surface will settle in a near-circular orbit about 100 miles up. It will circle the Earth every 87 minutes.

A satellite is in a very useful orbit when it is about 22,300 miles from Earth moving eastward over the equator. That orbit is called a geosynchronous or 24-hour orbit. A satellite at that altitude moves at a speed – about 7,000 miles an hour – which keeps the satellite stationed over the same spot on Earth. The satellite's orbit is synchronized to Earth's 24-hour rotation.

Most orbits are not circular but elliptical, or oval. Earth itself is not perfectly spherical. It is pear-shaped, slightly broader through the Southern Hemisphere than through the Northern. And Earth does indeed have four corners, but you can't visit them because they are gravitational corners – placed where Earth's structure is denser and exerts a stronger gravitational pull.

An elliptical orbit has a far point, the apogee, and a near point, the perigee. The Apollo spacecraft's path to the Moon was actually part of a huge elliptical orbit with a perigee of about 100 miles and an apogee beyond the Moon. The Saturn V rocket had propelled the Apollo craft to about 24,200 miles an hour when the third stage dropped away and Apollo was on its way to the Moon. Even then, Earth tried to maintain its hold. Gravity made the craft go slower and slower, until, about 200,000 miles a way, it was moving only 2,000 miles an hour. But then a new pull started, that of the Moon's gravity. Apollo started moving faster again. The Moon's gravity added so much speed to Apollo that the craft had to be slowed with retrorockets in order to enter lunar orbit.

NASA has several different launch vehicles in its inventory. The little Scout can send a 400-pound payload into a 100-mile orbit. The biggest, the Saturn V, is capable of sending a payload of more than 90,000 pounds to the Moon. All these launch vehicles use chemical propellants, either liquid or solid. Most are liquid because solids are impractical to turn off or re-ignite. The propellants are the reason rockets are so big. Most of their size is just fuel tank. But there's no point in hauling an empty tank around after the propellants are used. So rockets have several stages that drop off after use. When the first stage of Saturn V drops off into the ocean after 2 1/2 minutes of burning, the rockets loses more than 300,000 pounds of useless weight. The second stage is then more efficient.

Rockets do more than life satellites off Earth. Small rockets, or gas jets called thrusters, are attached to satellites and spacecraft for use in changing their orbits or orientation in space.

Satellites – once in orbit – have jobs to do. There are many investigations that satellites can do in space better than researchers can do on Earth. Earth is surrounded by a thick blanket of atmosphere. The mixture of gases (called air or atmosphere) that gives us life gets in the way of studying the universe. Some of the radiation given off by the Sun, for example, never reaches Earth because it is absorbed or reflected by the atmosphere.

Even a great deal of visible light from the Sun and other stars is lost in the atmosphere. A Large Space Telescope (LST) is being designed to be put into orbit by the 1980's. It will be an optical telescope, 120 inches in diameter, that can collect 100 times more light than the biggest telescope now available on Earth – all because it will be above the atmosphere.

I said optical telescope. Optical means it collects visible light – light we can see. Light can be thought of as moving in waves, the length of which varies. Red light has a long wavelength. Violet, at the other end of the visible spectrum, has a shorter wavelength.

Visible light is just one form of radiation. There are also many invisible radiations which we cannot see, but which we can detect and measure.

At the short end of the wavelength, or electromagnetic, spectrum are cosmic rays, gamma rays, and X-rays. They are emitted by natural objects in space. Some satellites, such as the Orbiting Astronomical Observatory, are measuring those rays. Ultraviolet rays, which are just shorter than visible light, are the rays that tan you. "Black light" is a form of ultraviolet radiation.

The waves longer than visible light are extremely useful to the space program. Infrared waves are just a little longer than the red waves of visible light. Infrared radiation comes from two different sources. One is sunlight. Infrared from the Sun is absorbed and reradiated by all objects. It can be photographed like visible light, but the colors that show up are not the colors we are used to seeing. The other source of infrared radiation is any object itself. All matter emits heat infrared, also called thermal infrared, as a result of molecular motion. This radiation can be detected at night in the absence of sunlight.

Radio and TV waves, which are longer than infrared, are used for communicating with spacecraft, just as they are used on Earth for radio and television communications. All the instruments aboard a satellite convert their readings into signals that are sent to Earth as radio waves. Thus scientists on Earth can monitor everything happening aboard the craft.

The very first American satellite detected a ring of trapped radiation around the Earth. The Geiger counter on board which discovered the belts was suggested by Dr. James Van Allen, so the radiation belts are named for him. Before the astronauts were sent to the Moon, we had to analyze the Van Allen belts very carefully to know just what kind of protection the men and sensitive equipment would need for passing safely through.

The radiation in the belts comes from the solar wind, a stream of charged particles given off by the outer region of the Sun. This wind increases its intensity during storms on the Sun, and the interaction of the wind with Earth's magnetic field probably causes the beautiful Aurora's at the Earth's poles. But it also interferes with radio communication and can damage spacecraft. So scientists want to learn all they can about that furnace – the Sun – that powers the solar system. We already use Solar Energy to make electricity for spacecraft, and we want to use it as an energy source on Earth. The Sun is vital to everyone, so many of the solar investigations are international in scope. For example, the French have an experiment aboard Skylab; German Helios probes will be sent almost to the Sun by NASA during the next few years.

Low-frequency waves, such as AM radio waves, bounce off that layer of atmosphere called the ionosphere, so they can be picked up by receivers below the horizon from the transmitter. But high-frequency waves, such as TV and FM, don't bounce. They must be received in line-of-sight (above the horizon) from the transmitter. It is impossible to place re-transmitting stations across the oceans, and it is expensive to lay cables under the sea. But a satellite in orbit can receive a high-frequency signal from Earth in regular line-of-sight fashion, amplify it, and retransmit it to another station on Earth – like two sides of a gigantic triangle. Three satellites in geosynchronous orbit can be used to transmit signals to any point on earth.

In mid-1962, a not-very-good TV picture was transmitted across the Atlantic Ocean by Telstar Satellite. Today, communications satellites are a common part of our lives. A transatlantic telephone call costs less than half what it used to. We can watch important news events as they happen, even from the other side of Earth.

The International Telecommunications Satellite Consortium (INTELSAT) consists of 83 nations, including the People's Republic of China. It operates a world-wide network of communications satellites carrying telephone, telex, telegraph, and television traffic. Its American representative is the publicly owned Communications Satellite Corporation, which hires NASA to launch the satellites it builds.

During the years since INTELSAT came into being, NASA has continued to provide a research and development role in communication satellites. That role will end, however, with the launch of the ATS-F in 1974; NASA's work in communications satellites will all have been turned over to private and non-governmental organizations.

Applications Technology Satellites – ATS satellites – have been test-beds for various communications and meteorological purposes. One purpose has been to investigate the potential of satellite use in air and ocean navigation, when airplanes and ships are far from land. Along this line, ATS-F will be used to test air traffic control via satellite.

The major function of ATS-F, however, is testing of direct broadcasting to inexpensive ground receivers in widely spread and remote communities. Other communications satellites have broadcast relatively weak signals that had to be picked up by special huge antennas. Direct broadcast technology will be used over North America by the Department of Health, Education, and Welfare, which will broadcast specially designed programs to the Appalachian and Rocky Mountain states and Alaska, where the population is spread out and difficult to reach. In Alaska, it will also be used for consultation between doctors. Later, the orbit will be changed so that the satellite will be available for India, a nation too vast to use regular radio communications. India will use the satellite as a social service system, broadcasting education programs, health and hygiene information into distant villages in several languages at once. Unlike previous communications satellites, ATS-F will have a broadcast antenna so big that signals can be received by small ground stations. Some of those ground stations will be powered by men pedaling bicycles to drive generators – the old and new working together.

In 1959, the Explorer VI satellite took the first crude, TV-like pictures of the clouds over Earth. Weather does not, of course, just consist of clouds. But clouds and their growth and movement indicate changing weather. Today, more than 50 nations receive cloud-cover pictures on inexpensive receivers that pick up automatic picture transmission (APT) signals from weather satellites. U.S. weather satellites, called ITOS for Improved TIROS Operational Satellite, are now fully operational and are under the control of the National Oceanic and Atmospheric Administration.

We can now receive routine three-day weather forecasts because we have a world view of weather. But more dramatically, weather satellites provide warning of dangerous weather. In 1969, Hurricane Camille rushed toward the Gulf Coast. The National Weather Service was able to get warnings out to people in the storm's path early enough to save thousands of lives.

Weather satellites carry both regular TV cameras and infrared cameras. The infrared cameras are able to photograph the high, wispy cirrus clouds which are almost invisible in regular reflected light. Weather satellites have generally been placed in orbits from 100 to 1,000 miles high. A picture of the whole Earth's weather requires the carefully piecing together of many satellite photographs. Soon Synchronous Meteorological Satellites will be placed in a 24-hour orbit and will provide a constant picture of the whole Earth, both day and night.

Some satellites are looking at the invisible atmosphere itself. Knowledge of the interaction of space phenomena with our atmosphere is important to understanding Earth. Nimbus probes of atmospheric temperature give airplanes warning of high-altitude winds. Several Atmosphere Explorer satellites investigate ion distribution in the atmosphere, seasonal changes in its layers, the air's photochemical processes, and the physics of the ionosphere. The British Ariel satellite, first satellite to be built by a nation other than the US or USSR, was an ionospheric satellite. So too is the Canadian Alouette, which is still operating after eleven years in orbit.

Dr. James Fletcher, NASA's Administrator, has reminded us that Earth is finite, "… and we have to do all we can to take care of it, to make it the best home we possibly can."

The Earth Resources Technology Satellite (ERTS) is opening a whole new era of learning about Earth, what we are doing to it, and how we can best use the resources we have. This program is getting right to the heart of what NASA is all about – "the peaceful exploration of space for the benefit of all mankind."

ERTS is a test platform for remote sensing, the study of the characteristics of things without touching them. Our eyes are remote sensors. The remote sensors aboard ERTS are cameras and scanners sensitive to both visible and infrared radiations. Every object reflects these radiations in a special way. That special way is called the object's spectral signature and is as individual as a fingerprint. The colors in this infrared photo are false colors selected by scientists to show intensity of radiation.

Many nations are testing the reliability of interpreting photographs taken at different visible and infrared wavelengths, or combinations of them. They want to know that they can look at the photos and positively identify, for example, a corn field from a wheat field, a diseased crop from a healthy one, polluted water from clean water, mixed forest from single species forest, residential from industrial areas, and even smoke from fire.

ERTS is providing the information that will allow us to develop a new kind of map of Earth. This map will show details far beyond the standard topographic or political information.

One section of the map, for example, will show not just boundaries of fields but the crops that are planted there, allowing our food supply to be inventoried. Photos taken after the basic map is made may reveal that there has not been enough rain to keep the soil at the right moisture level. Agriculturists will be able to forecast each season's food.

In other places, the photo map may reveal that good land is being lost to housing developments, while poor soil is left unused. Such discoveries, and the knowledge of how to use them, are part of the growing business of land management. For more than three centuries, the land has taken care of us. Now we must take care of the land, and this new remote-sensing technology is available for the work.

Places where petroleum might be found have been seen in ERTS photos where men on the ground had never detected the surface formations typical of oil-bearing rock. The Surgeon General's office of HEW is looking into ERTS photos for detecting newly cleared land. Such land is often the breeding ground for malaria, a disease that is still a problem in many places.

The oceans, too, are part of the new map. Infrared photos show the sea as black. But the water acquires meaningful color in photos of areas with much algae or plankton. Fish feed in such places, so fishermen know where to go for a good catch. New oil spills show up clearly because oil's spectral signature is different from water's. The spills can be cleaned up before they do much harm to ocean life.

So ERTS information has very practical applications. It is being used every day to discover what damage man is doing to his home and, hopefully, how it can be repaired.

But why can't this all be done from the ground or with aerial photography? Basically, it comes down to three familiar things – time, people, and money. Think of the number of people who have explored the backlands of South America, and still it is not well mapped. One series of ERTS photos revealed 36 freshwater lakes in South America that had never been discovered.

Each time an airplane goes up to photograph an area, it costs a great sum of money. But ERTS is already in orbit. Each time its photos are used, the cost of building and launching it are spread out more and more. It checks the same area every 18 days, gaining more information in that time than an aircraft could in 20 years. And because satellite photos show large areas, the entire US can be pictured with only 500 photos versus 500,000 from a high-altitude airplane.

ERTS is not just a satellite – it is part of an information system. About 150 electronic monitoring platforms have been put in remote places. They measure phenomena indicating probable volcanic activity, snow depth on mountains, soil moisture, wind, temperature, and the like. These measurements are relayed automatically to ERTS, which acts as a communications satellite in sending the data to scientists on Earth. They can then relate the data to ERTS photos.

And so we come to man – who wants to go into space to see for himself.

Because man is a creature of Earth, he must take a bit of Earth into space with him in order to survive the hostile environment. Man needs oxygen to inhale and a way to get rid of the carbon dioxide he exhales. He needs food and water to keep his body functioning. His body requires a certain pressure on it that resembles the pressure that Earth's atmosphere exerts. These bits of Earth are called life support.

NASA has sent man into space in an orderly, step-by-step fashion. The little Mercury capsule first carried astronaut Alan Shepard in a simple, suborbital trajectory in 1961. The trip lasted only 15 minutes, but we learned that man's body was very adaptable. He could stand forces several times Earth's gravity (one G) during launch, then function quite well in the quick change to no gravity at all, or weightlessness. We learned that he could reenter the atmosphere safely, and be recovered at sea. Within only three weeks of the first Mercury flight, President Kennedy declared a Moon landing within the sixties to be a national goal.

Four Mercury flights were orbital, the last making 22 orbits of Earth – almost a day and a half. Two years after that, the Gemini flights were ready to go, carrying two men (Gemini means twins) for up to 14 days at a time.

Gemini was both the workshop for preparing to fly to the Moon and the beginning of scientific experimentation by men in space. The astronauts and ground controllers learned to rendezvous two craft far out in space. The learned to dock, or link two craft together. They left the craft and learned to maneuver in the weightlessness of orbit that can't really be duplicated on Earth. They began to photograph Earth and the Sun.

As with all astronauts, their body functions were continually monitored. Physicians on Earth watched their respiration, blood flow, food intake and waste output, and even brain activity during sleep. Medical science has always concentrated on sick people. Now, for the first time, we are acquiring basic data on supremely healthy people working under varying conditions.

The instruments used in studying the astronauts have been of great benefit to medical science. For example, a urinalysis for identifying bacterial infection used to take up to four days. Now it can be done automatically in minutes, allowing physicians to start appropriate treatment immediately. The micrometeoroid counter you saw led to a device for detecting the very slight muscular tremors that are early signs of some serious diseases.

By 1968, everything was ready for a flight to the Moon. The huge Saturn V launch vehicle and the complex, three-part Apollo craft had been tested and re-tested. Improved spacesuits were designed that would protect the men from the heat and cold of the airless Moon. Ranger probes had photographed the Moon, and Surveyor probes had taken pictures, tested the soil, and found that it was firm. Men would not sink into the Moon dust, as some scientists had predicted. Lunar Orbiter satellites had photographed the lunar surface so thoroughly that landing sites could be selected. A tracking and communications network covered the world so that the astronauts would be out of contact only when the command module was behind the Moon.

Nine trips were made to the Moon. Twelve men walked on the Moon and rode a Moon buggy on its surface. Millions of people on Earth watched the men work in a strange environment and return home safely.

Collecting a pile of Moon rocks was not the goal for going to the Moon. Of those rocks brought back, only part have been studied; the rest are in storage for future generations to investigate using techniques perhaps not even dreamed of now. The goal is knowledge – knowledge of a heavenly body that plays a tremendously important role in Earthly life, knowledge that men can make a giant step into the universe, knowledge that can be useful at home.

The spacecraft and launch vehicles that took men to the Moon became local transportation for taking them to Skylab, the observatory in the sky. Skylab was launched as the third stage of a Saturn V. The first crew went up a week later in a Saturn IB and carried out the first major repair job in space by fixing the solar cell panels and meteoroid shield that were damaged during launch. They stayed 28 days, which is twice 14 days, the longest previous flight, done in Gemini. These numbers give doctors easy figures to work with in calculating biomedical data. The second and third crews will stay (are staying) 59 days.

Skylab is about the size of a small house, complete with kitchen, bedroom, recreation and exercise space, and even a bathroom. The men live in lightweight, disposable overalls and comfortable boots that latch to the grid-like walls when they decide where they want up or down to be. They eat canned foods that are heated in special magnetic trays. They sleep in sleeping bags. They have books, music tapes, games, and exercise gear for recreation.

The exercise gear, however, is not just for fun. Skylab missions are important tests to see just how well man's body will adapt to spacecraft living for long, deep-space journeys in the future. We must know if man's body – which evolved under one G pressure – will comfortably adapt to long periods of weightlessness. Seventeen different biomedical experiments are being conducted, including mineral and hormone balance in blood, equilibrium tests, blood flow, and heart activity.

The Skylab astronauts are not just guinea pigs, of course. They have important scientific work to do.

1973 was the Year of the Sun. Eight instruments for studying the Sun are part of the Apollo Telescope Mount on Skylab. The first crew took thousands of photographs of the Sun, including many of a solar flare, those mysterious and powerful explosions of the solar corona. Other instruments measure X-ray, ultraviolet, and electron emissions.

The Skylab astronauts also investigate Earth. Skylab serves as a manned Earth Resources Technology Satellite. The data from the remote sensors aboard are used in conjunction with ERTS data. Skylab, however, has an advantage over an unmanned ERTS satellite. The astronauts can select sites to be studied and delay their work if weather conditions are not right.

In addition to all of this, the Skylab astronauts are experimenting with using weightlessness in manufacturing – a preview of factories in space. Some molten metal mixtures tend to separate in Earth gravity. Perhaps they will mix and harden evenly in weightlessness. Pure crystals that won't grown more than an inch on Earth might reach six inches if grown in space.

Skylab is just that – a laboratory in the sky, a place to study ways to extend our understanding of our environment and to enlarge our useful environment.

When the crippled Apollo XIII spacecraft reentered Earth's atmosphere, the Soviets cut off all radio transmissions on the frequencies used by Apollo. They had ships and planes ready to help in recovery if necessary. In 1975, that international cooperative spirit will extend into space. Soviet and American astronauts will meet in space, docking their Apollo and Soyuz spacecraft with a specially designed module. We will each be able to rescue the other in the event of space emergencies.

In the Apollo journey's to the Moon, only the tiny conical top of the whole Saturn/Apollo stack returned to Earth – a section 10 1/2 feet high from a total original height of 363 feet.

This is very wasteful. So NASA is building a Space Shuttle that can be used again and again.

The Shuttle will consist of an airplane-like craft, called the orbiter, which will life off from Earth attached to a huge tank of liquid propellant and two solid-propellant booster engines. The two engines will drop off at about 25 miles altitude, be recovered from the ocean, and used again. The orbiter's own three engines, taking liquid propellant from the tank, will send the craft to a higher altitude where the tank will be jettisoned. The orbiter will then continue on to orbit at an altitude of about 115 miles.

The orbiter is about 124 feet long, the size of a DC-9 airliner. It will carry a crew of four for up to 30 days. It will have a cargo compartment about 60 feet long and 15 feet wide. In other words, it's a space truck. It can carry several satellites, which will go into orbit when dumped overboard from the cargo bay.

The bay can be converted to carry people. Space scientists will be able for the first time to go with their satellites. They, or the crew, will be able to repair satellites right in space. If the repairs are too extensive to carry out in orbit, a satellite can be retrieved from orbit, packed into the cargo bay, and be brought home.

Probably one of the first payloads to get a lift from the Shuttle will be the Large Space Telescope. Another will be the manned Sortie Laboratory, or Spacelab, planned by the multi-nation European Space Research Organization.

Some research programs may call for altitude higher than 115 miles, so NASA is planning a Space Tug. It will be a rocket vehicle that can be carried into orbit by the Shuttle. It will then propel a satellite or probe to the desired altitude and travel back to the Shuttle, which then returns to Earth.

That "return to Earth" sounds so simple, but it is a problem that NASA has studied for many years. An Apollo craft coming back from the Moon reentered the atmosphere at 25,000 miles an hour. The temperature on the side hitting the atmosphere reached 4,500 degrees Fahrenheit. But that same atmosphere did the important job of slowing the craft for a safe splashdown. The temperature problem is met by coating the reentry surface of spacecraft with an ablative material. This material vaporizes and carries the heat away in the vapor. The X-15 rocket plane was very important in testing ablative materials.

The blunt end of Apollo is like a lifting body. It is similar to an airplane wing in that it gets its lift from the way air travels over it. The astronauts control the angle at which the bottom hits the atmosphere. If they roll it one way, they decelerate rapidly. To ease the deceleration forces, they angle the craft differently, acquiring lift and slowing descent. They control the two forces of deceleration and life mile by mile until they are slowed to only 325 miles an hour and the parachutes can go into action. NASA has flown a number of craft specially built to test the lifting-body principle. It will be put into operation in the Space Shuttle.

The Shuttle orbiter will be able to carry about 40,000 pounds back to Earth. It will reenter the atmosphere as a lifting body with the capability of maneuvering more than 1,000 miles left or right. When it reaches an altitude of 50,000 feet, it will descend like an aircraft. Its landing gear will open out and it will land on a regular runway. It will not have air-breathing engines, so it will land like a glider, using techniques tested by the X-15. The orbiter will be reused at least 100 times. This means the cost of launches will go down, and more nations will be able to join hands in space.

In exploring space, several large objects catch the eye. The Moon, of course, is first, but then come the planets that orbit the Sun in concert with Earth.

A Mariner probe passed mysterious Venus 109 days after launch in 1962. It and other probes discovered a surface temperature of more than 800 degrees Fahrenheit, and an atmosphere with a crushing pressure more than 100 times that of Earth. It is very unlikely that man will visit Venus any time soon.

Going outward in the solar system, we come to Mars, the planet that for centuries astronomers thought was populated by intelligent beings. Mariner probes have been looking at Mars since 1965. The most successful was Mariner 9, which, in one year of operation, photographed the entire surface after waiting several weeks for a global dust storm to subside on the red planet.

Astronomers had thought that Mars was rather dull, with no big features to catch the eye. But Mariner 9 revealed some features grander than anything on Earth. One volcano with a crater 40 miles across stands 15 miles above the plain. It and other volcanoes may still burn deep inside the planet. A canyon 20,000 feet deep knifes across the surface for 2,300 miles, almost as long as the United States is wide. Dust lies everywhere, in deep piles that move with the winds. Dust movement probably accounts for the shifting light and dark patches which scientists of old thought were seasonal changes in vegetation. The polar caps are mostly frozen carbon dioxide – dry ice – that vaporizes in summer.

There is no liquid water on Mars. There is little atmospheric pressure to hold it there. But that does not mean there never has been. Earth has gone through incredible changes in its long history. Perhaps Mars has, too – cataclysmic changes that made it lose its atmosphere. Mars may be currently in an ice-age-like period with spores of past life frozen into the surface. In 1976, Viking will land on the surface of Mars and look for such evidence.

In orbit around Mars, Viking will separate into two parts: an orbiting photographic and communications section and a lander. The lander will be sterilized before leaving Earth so it can't contaminate the Martian environment with matter from Earth. It will drop into the thin carbon dioxide atmosphere and slow to a gentle stop with the help of parachutes and a rocket system.

A sophisticated computer will control the landing. This computer must be independent of instructions from Earth because of one difficulty basic to exploring the solar system. Radio signals travel only at the speed of light – 186,000 miles per second. That sounds very fast, but it would take about 20 minutes for a radio signal to reach Mars and another 20 for the acknowledgement to return – too slow a process for dealing with the immediate requirements of a landing.

The lander will be able to operate for about 90 days. Its biological instruments will be looking for organic molecules in the soil. They will analyze the soil for its ability to support photosynthesis – a basic life process on Earth – and they will check for any signs that cellular respiration occurs. Other instruments will photograph the surface, check the composition and density of the atmosphere, and search for water vapor.

NASA is looking beyond Mars to Jupiter, the super-giant of our solar system. Between it and Mars is a belt of asteroids where so many tiny planets and rock fragments orbit that they haven't all been mapped or counted. The danger they present to spacecraft must be calculated. Pioneer 10, launched in 1972, passed safely through.

Jupiter has the kind of atmosphere which scientists think must have existed on Earth when life began. Pioneer will take a look at that atmosphere as it speeds by Jupiter in December 1973. Then it will swing toward Uranus, where we will lose radio contact.

Pioneer will carry on out into the Milky Way. Perhaps some day, far out in the universe, an intelligent life form will find Pioneer. A special plaque is attached to the craft. It tells, in symbols and binary numbers, where and when Pioneer was launched. It also shows by whom. Two figures are etched on the plaque – an Earth man and woman. The man's hand is raised in a gesture of good will.

When we first started exploring space, a new word was coined. The word is aerospace. It indicates that man is no longer Earth-bound, no longer a captive under an ocean of air. Instead, our new environment is one of both air and space, and it reaches to the edge of the universe. The changes in our lives wrought by the incredibly brief fifteen years of NASA's work in exploring this new environment have been greater than those of any fifteen years in history. And those changes are only beginning. America will continue to explore aerospace for the benefit of all mankind.