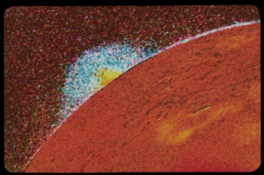
JPL CLOSEUP

JPL CLOSEUP

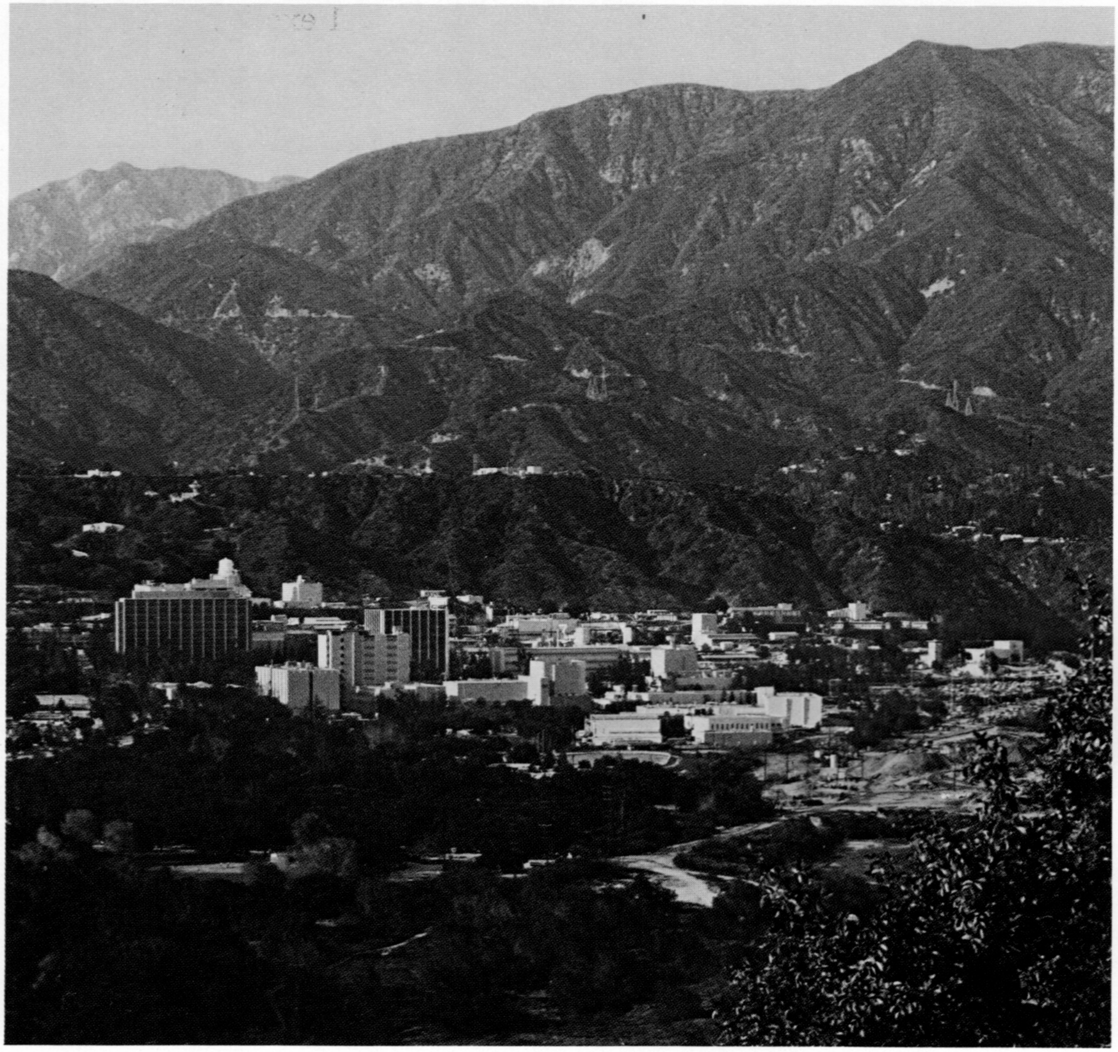
The American space age began on January 31, 1958, with the launch of the Jet Propulsion Laboratory's Explorer 1 – the first U.S. satellite and the discoverer of the Van Allen radiation belts that surround Earth. Dr. Werner von Braun's U.S. Army team provided the Jupiter C rocket that carried the 14-kilogram (31-pound) satellite into orbit.

The choice of JPL to conduct the nation's first space venture was based on the Laboratory's expertise in rocket propulsion research, which began with the late Theodore von Kármán and several graduate students of the California Institute of Technology in the mid-1930s. In the creekbed of the Arroyo Seco in the desolate foothills north of Pasadena, von Kármán and his students did what one member of the group has described as "rather odd experiments" in rocketry. Almost every rocket that flies today shares the common heritage of that pioneering research. And that desolate spot in the foothills of the San Gabriel Mountains is now the site of JPL, which covers 175 acres and employs more than 4,000 people.

Early research at JPL led to the further development of solid- and liquid-fueled rockets. The first application came in 1940 with JATO (jet-assisted takeoff) for aircraft. In later years, JPL developed the Corporal and Sergeant missile systems for the Army. JPL was transferred from Army jurisdiction to the National Aeronautics and Space Administration on December 3, 1958, two months after the civilian agency was created. Under a new NASA–Caltech contract, JPL was given its first assignments to lead the nation's exploration of deep space.

For NASA, JPL led the nation's unmanned missions to the Moon and planets, opening the new frontier of our solar system. Among JPL's achievements are the Ranger and Surveyor lunar projects, the Mariner missions to Mars, Venus, and Mercury, the Viking mission to Mars, and most recently the exploration of Jupiter and Saturn by Voyagers 1 and 2.

Current JPL studies of Earth and its environment include the Solar Mesosphere Explorer, which is examining concentrations of ozone and other chemicals in Earth's atmosphere. JPL scientists are also using the new space shuttle capability to carry experiments into Earth orbit. The success-



ful Shuttle Imaging Radar-A (SIR-A) and Shuttle Multispectral Infrared Radiometer (SMIRR), geologic and resource mapping instruments, were part of the first shuttle scientific payload and helped prove the usefulness of the orbiter as a vehicle for science experiments.

Other shuttle experiments are being built or are in development by JPL:

☆ The Shuttle Imaging Radar-B (SIR-B) will use the imaging radar and electronics of its predecessor (SIR-A), combined with sophisticated digital data recording and processing systems, on a shuttle flight in 1984.

☆ The Active Cavity Radiometer (ACR), a Spacelab 1 experiment, will precisely measure the total energy output of the Sun and help determine the effects of its energy variations on Earth's climate.

☆ The Superfluid Helium experiment on Spacelab 2 will study thermal fluctuations and distributions in superfluid helium at zero gravity. Superfluid helium is used extensively as a cryogen, or refrigerant, for cooling experimental, computer, and detector apparatus. Results will aid in developing future systems that use superfluid helium as a cryogen.

☆ Atmospheric Trace Molecule Spectroscopy (ATMOS) will determine the concentration, flow, and decay patterns of chemicals in the stratosphere, at an altitude of 20 to 80 kilometers (12 to 50 miles).

☆ The Drop-Dynamic Module will be used as a frame in which to position and photographically study the formation and behavior of drops of liquid in zero gravity.

In deep space, Voyager 2 presses toward Uranus while Voyager 1 searches for the boundary of the solar system. Viking Lander 1 continues to study the surface of Mars.

Tracking and communications for these planetary spacecraft are provided by JPL's Deep Space Network, which also tracks Pioneers 10 and 11 and the joint West German–U.S. Helios Project spacecraft, now studying interplanetary space near the Sun.

Flight missions currently in development at JPL include:

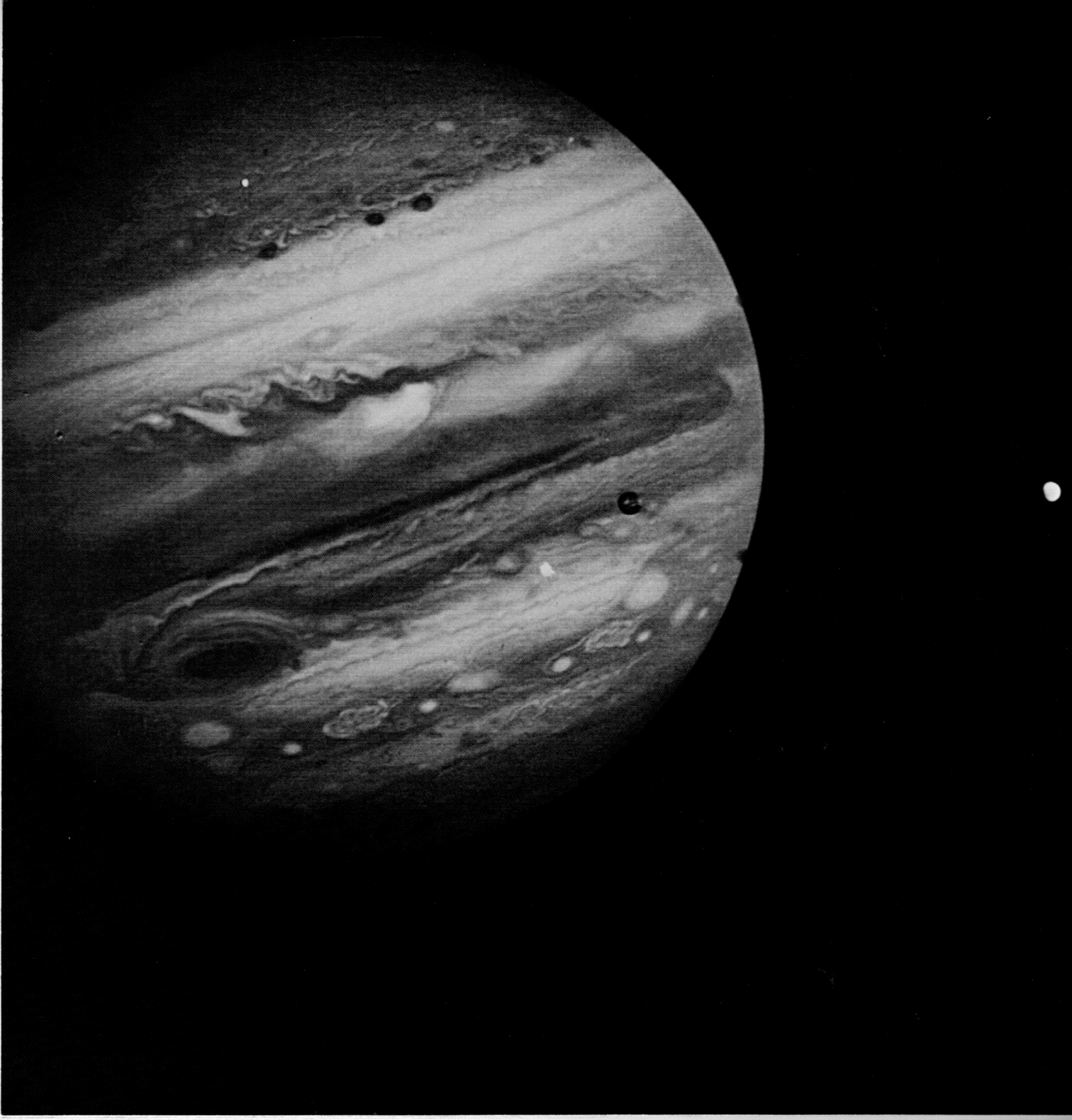
☆ Project Galileo – scheduled to be launched in 1986, it will place a spacecraft in orbit around Jupiter and send an instrument-laden probe into its atmosphere.

☆ The Infrared Astronomical Satellite (IRAS)– scheduled to be launched in late 1982, it will map the sky in wavelengths invisible to the human eye.

Space exploration at JPL is coupled with research and development across a broad spectrum of scientific and engineering disciplines.

Applying technological advances to solving problems on Earth is a dedicated effort at JPL. More than 100 tasks are being pursued in medical science, pollution, sewage disposal, transportation, and energy.

Other JPL installations include an astronomical observatory at Table Mountain, California, a rocket test station at Edwards Air Force Base, California, and a launch operations site at Kennedy Space Center, Florida.



As seen by Voyager 1, Jupiter makes an overwhelming backdrop for its volcanically active moon Io. One of Io's volcanoes (right), photographed by Voyager 1, spews sulfurous debris into space.

VOYAGER

The two Voyager spacecraft, launched in the summer of 1977, have performed unprecedented studies of Jupiter and Saturn. Equipped with television cameras and a variety of other scientific instruments, the Voyagers, in their brief encounters, sent back more information about Jupiter and Saturn than had been previously obtained in the history of science.

Now Voyager 1 is headed out of the solar system, its primary mission completed. Voyager 2's task continues, through a Uranus encounter in January 1986 and a final planetary encounter with Neptune in August 1989.

The Voyagers discovered that Jupiter possesses a ring and that Saturn is encircled by more than a thousand. Auroras were found in the atmospheres of both giant planets. The hottest spot known to exist near a planet was found in a region within Saturn's magnetosphere, where a torus of positively charged hydrogen and oxygen atoms reaches temperatures of 400 to 500 million degrees Kelvin (720 to 900 million degrees Fahrenheit).

The Voyagers found three new satellites around Jupiter, and at least seven more around Saturn.

Nine active volcanoes were discovered on Jupiter's moon Io, the most geophysically active body known in the solar system. Voyager 1's close study of Titan showed that the moon's dense atmosphere is mostly nitrogen. Methane and hydrocarbon constituents contribute to the production of the hydrogen cyanide and complex organic molecules that form Titan's deep smog layer. Titan's frigid temperature of 95 degrees Kelvin (-288 degrees Fahrenheit) may permit the formation of methane ice clouds in the lower atmosphere and liquid-methane oceans on its surface.

When Voyager 2 encounters Uranus in January 1986, it will study the gaseous planet's atmosphere, ring system, and five known satellites.

Voyager 2's trajectory at Uranus has been designed so that the spacecraft will go on to encounter distant Neptune in August 1989. Neptune's satellite Triton, which may resemble Titan, will be studied from a distance of less than 4,000 kilometers (2,500 miles) – the closest approach to any body during the Voyager mission.

The Voyagers are each equipped with an antenna that can be precisely pointed to send a tight radio beam to the huge, ultrasensitive receivers of JPL's Deep Space Network stations in California, Spain, and Australia.

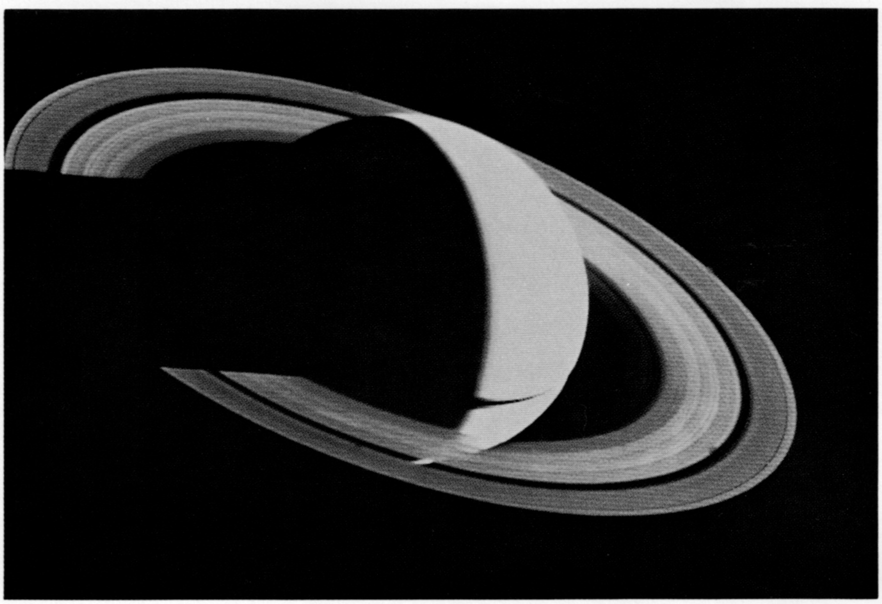
The vast distance between Earth and Uranus will make the one-way communications time with Voyager 2 two hours and 45 minutes. At Neptune, it will take more than four hours for Voyager's radio signal to reach Earth.

Infrared Astronomical Satellite

The Infrared Astronomical Satellite (IRAS) is an international project of the United States, the Netherlands, and the United Kingdom.

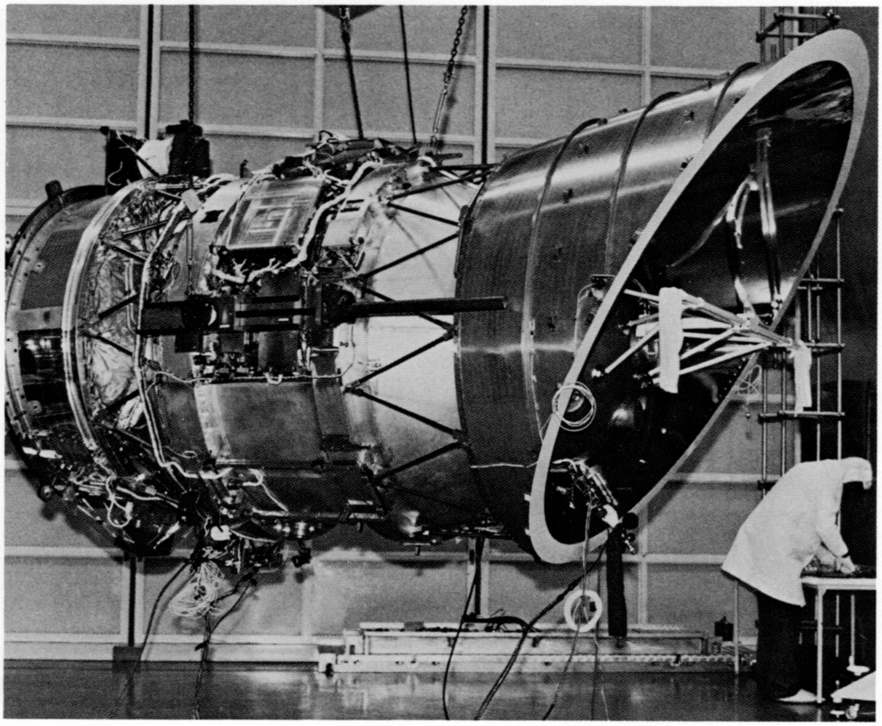
Most infrared radiation is blocked by Earth's atmosphere, limiting the observation of infrared sources. IRAS will extend our vision of astronomical events to such a distance that scientists will be able to study the birth and death of stars toward the edge of the universe.

IRAS will be launched from the Western Test Range at Vandenberg Air Force Base in California.



Voyager 1 took this last look at Saturn before the spacecraft began its journey out of the solar system. Voyager 2 will fly by Uranus in January 1986.

The Infrared Astronomical Satellite (IRAS), a joint project of the United States, the Netherlands, and the United Kingdom, will provide the data for mapping as many as one million new celestial infrared sources in the universe.



The IRAS spacecraft was built in the Netherlands. The large telescope, with an aperture of 57 centimeters (22 inches), was developed by NASA's Ames Research Center. The spacecraft and telescope were mated and tested at JPL.

JPL and The Netherlands Agency for Aerospace manage the project and will design and operate the scientific analysis facility, which will produce an infrared sky map and catalog containing as many as one million infrared sources.

Once IRAS is in a near-polar orbit 900 kilometers (560 miles) above Earth's surface, the satellite will be tracked and controlled from a ground station in Chilton, England.

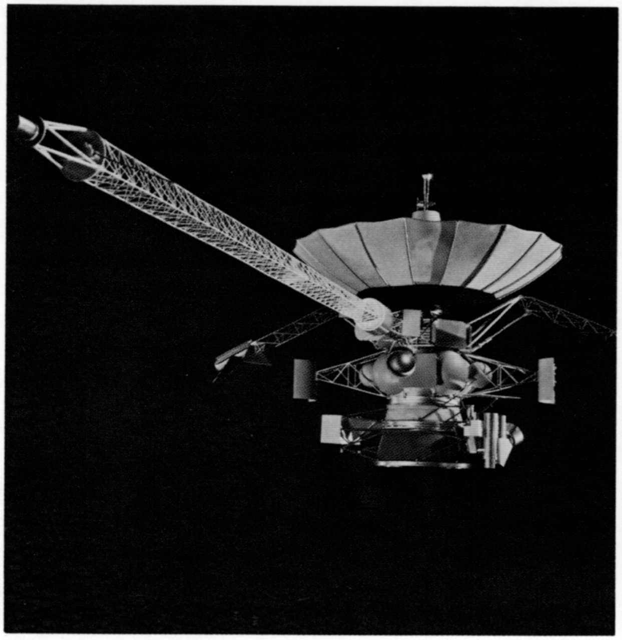
GALILEO

A mission to orbit Jupiter and send an instrumented probe into its atmosphere is under development.

The mission, called Galileo, was assigned to JPL by NASA's Office of Space Science and Applications. The Galileo orbiter was designed and is being built by JPL. NASA's Ames Research Center is developing the probe.

Scientists have called the Jovian system a "miniature solar system" because of the similarities between the planet and its satellites and the Sun and its planets.

Galileo is scheduled to be launched from a space shuttle in May 1986 and to arrive at Jupiter in September 1988. The probe will be jettisoned toward Jupiter and, supported



Galileo, a mission to Jupiter, will send an orbiter to study the giant planet's four largest moons in detail. The spacecraft will release a probe into Jupiter's clouds to study the planet's atmosphere.

This partially frost-covered Martian terrain, as seen by Viking Orbiter 2, creates strange patterns that mask topography in the polar region. The Thomas A. Mutch Memorial Station, Viking Lander 1, continues to study the surface and atmosphere of Mars.

by a parachute, will descend into the giant planet's turbulent atmosphere. It will transmit data to the orbiter from beneath Jupiter's cloud tops until increasing heat and pressure destroy the probe.

Meanwhile, using the gravity of each moon to bend its trajectory, the orbiter will swing repeatedly around the Galilean satellites – Io, Europa, Callisto, and Ganymede – making detailed studies of their varied surfaces.

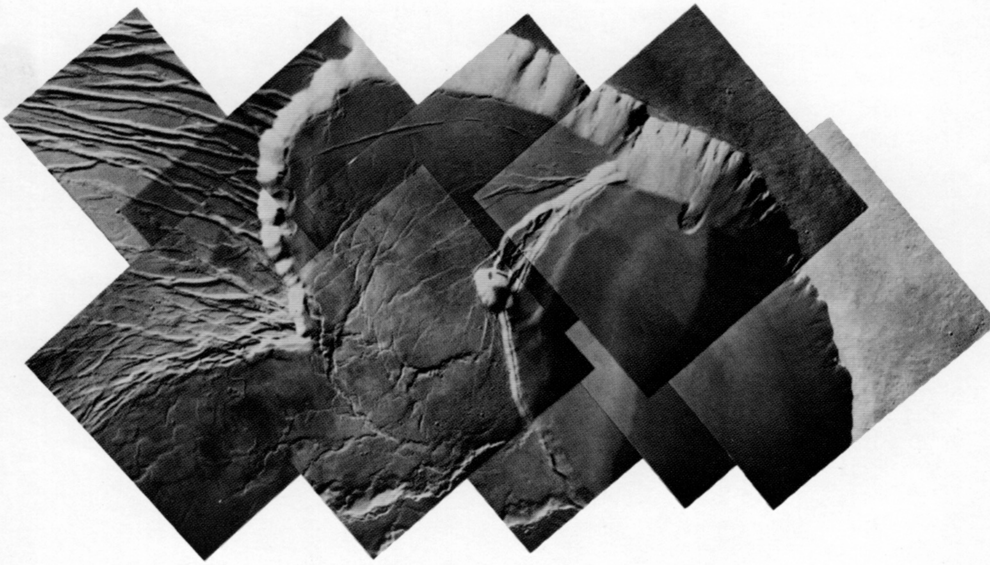
A variety of scientific instruments will fly aboard the orbiter, including a new imaging system that uses a charge-coupled device (CCD) rather than the vidicon tubes flown on earlier Voyager, Viking, and Mariner spacecraft. The CCD imaging system provides a much greater spectral response than vidicon cameras. It is expected that Galileo images will resolve features as small as 20 meters (66 feet).

VIKING

Two Viking landers descended to the surface of Mars in the summer of 1976, after an 11-month cruise aboard their orbiter spacecraft. The successful landings on the Red Planet brought us the first pictures from its surface. A prime objective of the mission was to search for microscopic life on Mars in our first serious attempt to find life beyond Earth.

The Vikings performed 13 detailed and sensitive experiments from orbit and from the surface, including analysis of the planet's atmosphere during descent. Thus far, the Viking spacecraft have sent more than 57,000 pictures to Earth, of which about 4,600 were taken by the landers and the rest by the orbiters.

The Viking primary mission ended in November 1976 when Mars was eclipsed by the Sun as viewed from Earth. When the planet



The largest volcano known in the solar system, Olympus Mons, dominates this mosaic of photographs taken by Viking Orbiter 1 in 1980.

reemerged, the Viking team began an extended mission that continued through August 1980. One of the landers is still in operation. The Thomas A. Mutch Memorial Station (Viking Lander 1) continues monitoring Martian weather and surface changes, returning imaging and other data weekly through the Deep Space Network.

Scientists have now had their first long-term look at the weather on Mars. In addition, they have tested the Martian soil for chemical makeup, organic compounds, and microbial life. A seismometer listened for Marsquakes, and a soil sampler dug trenches and shook bits of soil out of its sieved collector head to study the soil's physical and magnetic properties.

From orbit, Viking measured water vapor in the Martian atmosphere and made more than a hundred million remote measurements of the temperature of the surface, the clouds, and the polar caps. Two high-resolution cameras visually documented the varied geology and meteorology of the Red Planet.

The Viking mission has found no clear evidence of the presence of living microorganisms in the soil near the landing sites, though the question of life on Mars still remains open.

Elements and isotopes in the atmosphere indicate that a much denser atmosphere – one with abundant water – existed in the past.

The surface is a type of iron-rich clay containing a highly oxidizing substance that releases oxygen when wetted. There is evidence that subsurface water in the form of permafrost covers much if not all of the planet.

NASA's Langley Research Center had overall management responsibility for the Viking primary mission; JPL was responsible for building and flying the orbiters, and for operating the Mission Control and Computing Center and the Deep Space Network tracking stations. Full Viking management responsibility was transferred from the Langley Research Center to JPL in April 1978.

SOLAR MESOSPHERE EXPLORER

Ozone serves as a protective filter against the Sun's ultraviolet rays. Scientists believe that pollutants, especially fluorocarbons, may deplete the concentration of ozone in the upper atmosphere to a dangerously low level.

JPL's Solar Mesosphere Explorer (SME) satellite is examining the amount and distribution of ozone in the mesosphere–which extends from 50 to 85 kilometers (30 to 50 miles) in altitude–and is studying the interaction between ozone and sunlight. Five scientific instruments monitor ozone and other atmospheric constituents.

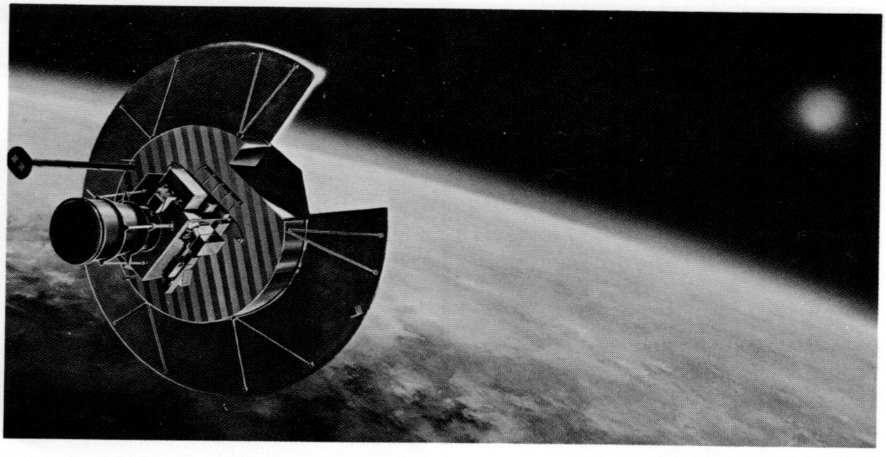
In its first year of operation SME found that the loss of ozone in the mesosphere slowed during a mesospheric cooling trend in early 1982. The results indicate a strong relationship between the loss of mesospheric ozone and upper atmospheric temperatures.

Ozone is produced in the upper atmosphere through the interaction of sunlight and oxygen molecules. SME's findings show there may also be a relationship between atmospheric temperature and the production of ozone.

SME was also called upon to perform unanticipated studies of dust and gas shot into the upper atmosphere by the volcano El Chichon in spring 1982. SME scientists at the University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) in Boulder tracked the volcanic debris as it encircled the globe, forming a ring just above the equator. SME will continue to study the cloud's movement, the distribution and density of particles within it, and its interaction with sunlight.

Launched in October 1981, SME is expected to study the upper atmosphere for at least a half dozen years, since it operates without

Ozone and its interaction with sunlight is under study by the Solar Mesosphere Explorer. Data from the satellite is received directly by its science users at the University of Colorado's Laboratory for Atmospheric and Space Physics, in Boulder.



consumable fuels – it produces electricity from its solar cells and uses that electricity and Earth's magnetic field to change its attitude.

Science data from the SME is received directly by its science users at LASP in Colorado. LASP, which developed the five science instruments, also commands the satellite. JPL manages the project for NASA's Office of Space Science and Applications.

Wide-Field/Planetary Camera

NASA's Space Telescope, which will bring the most distant reaches of the universe seven times closer into view, will carry five science instruments, including the Wide-Field/Planetary Camera, designed and being built by JPL and Caltech.

The Space Telescope is scheduled to be launched from a NASA space shuttle in January 1985.

Objects to be studied by the telescope and camera range from asteroids, comets, and planets in our solar system to nearby stars and, beyond those, to galaxies and quasars at the edge of the universe. The camera system, in conjunction with the telescope, will detect objects 100 times fainter than those visible from Earth-based telescopes, with about 10 times greater resolution.

The Wide-Field/Planetary Camera consists of two camera systems of different focal lengths (with four individual cameras in each system), sharing the same housing and electronics. The wide-field camera will be used to gain a wide perspective on the sky, while the planetary camera will make high-resolution studies of individual objects, including planets, galaxies, and stellar objects. The planetary camera's high-resolution capability would allow the instrument to resolve an object the size of a baseball from a distance of 200 miles.

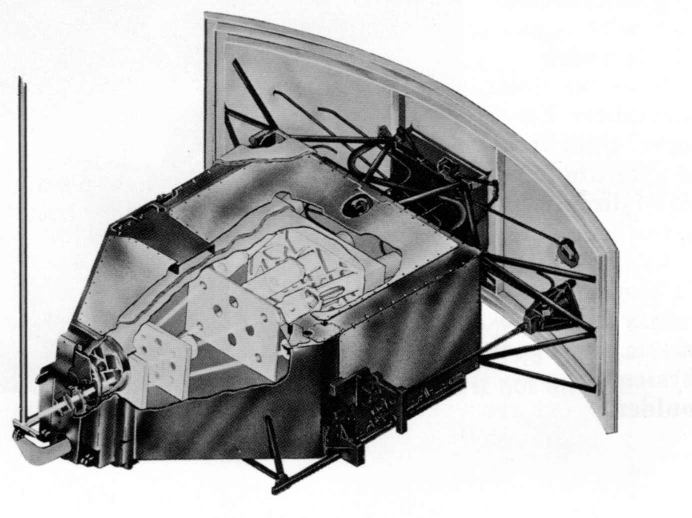
The instrument will perform:

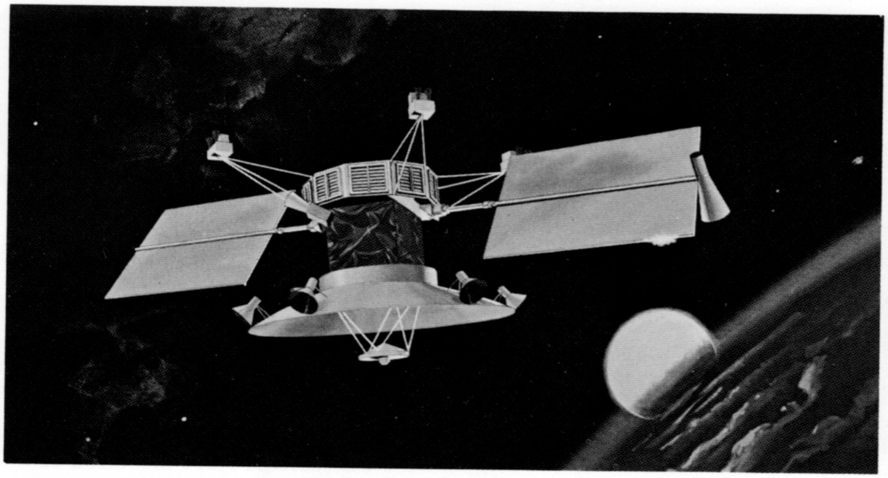
☆ High-resolution measurements of galactic centers.

☆ Searches for perturbations of nearby stars that would indicate the presence of planets the size of Jupiter in orbit around them.

☆ Studies of the dynamics of protostars and supernova remnants.

Photographs of stars and galaxies near the edge of the universe will be taken by the Wide-Field/Planetary Camera, which will be a part of NASA's Space Telescope. The telescope will be launched from a space shuttle in January 1985.





The Venus Mapper, carrying a radar system that produces photograph-like images, would orbit Venus, piercing through the clouds that curtain the planet's surface from view.

☆ Studies of cloud motions and atmospheric compositions of planets in our solar system.

☆ Surface-structure mapping of satellites, asteroids, and comets.

An image obtained by the camera system is recorded on four of eight charge-coupled devices (CCDs), solid-state arrays of silicon detectors similar to those used in the Galileo orbiter imaging system. Each CCD contains 800 by 800 picture elements. Transmitted back to Earth, the four images will be computer-processed and recombined in a mosaic – an analog to the scene observed by the cameras.

Venus Mapper

A proposed spacecraft that would see through the clouds of Venus and obtain detailed images of that planet's surface is being studied by JPL as a low-cost scientific mission for NASA.

The Venus Mapper would use the JPL-developed synthetic aperture radar (SAR) to pierce through the planet's thick cloud cover and reveal features as small as 300 meters (1,000 feet). In less than a year of orbiting Venus, the mapper would return detailed radar images of nearly 90 percent of the planet's surface.

The Venus Mapper would be partially assembled from spare parts from past and future JPL missions, including Viking, Voyager, and Galileo.

The thick, poisonous clouds of sulfuric acid and carbon dioxide that shield the surface of Venus from view are transparent to microwave radar, and the SAR system would produce photograph-like images of the surface. Recent studies have indicated that Venus, where the average surface temperature is 470 degrees Celsius (900 degrees Fahrenheit), may once have had oceans of water 30 or more percent the size of Earth's oceans.

Topographical evidence of evaporated ocean basins and river channels, if they once existed, would be revealed by the Venus Mapper.

INTERNATIONAL SOLAR POLAR MISSION – SOLAR INTERPLANETARY SATELLITE

NASA and the European Space Agency (ESA) are cooperating in a joint flight mission to explore the poles of the Sun and to investigate the energy and matter flowing into the solar system from those regions.

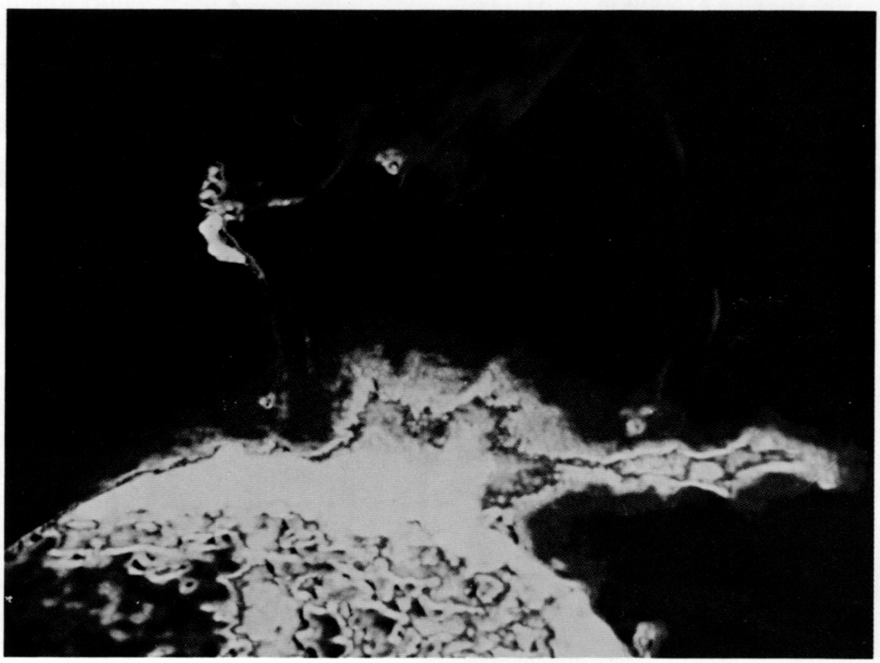
A spacecraft built by the ESA and carrying a payload of European and U.S. instruments will be launched in early 1985 from a space shuttle. The spacecraft will first fly to Jupiter, whose powerful gravity will boost it back over the Sun. Instruments on the spacecraft will study both the north and south polar regions as it orbits the Sun. At the same time, the spacecraft will measure galactic material entering the solar system from above and below the orbital planes of the planets. Neither the Sun nor interplanetary space has ever before been studied in these regions.

A second mission designed to complement the ISPM is under study at JPL. Called the Solar Interplanetary Satellite (SIS), this mission would send a spacecraft into orbit around the Sun, trailing Earth in its orbit by about 90 degrees. From this position, SIS would study solar events not observable from either Earth or the polar orbit of the ISPM spacecraft.

EXTREME ULTRAVIOLET EXPLORER

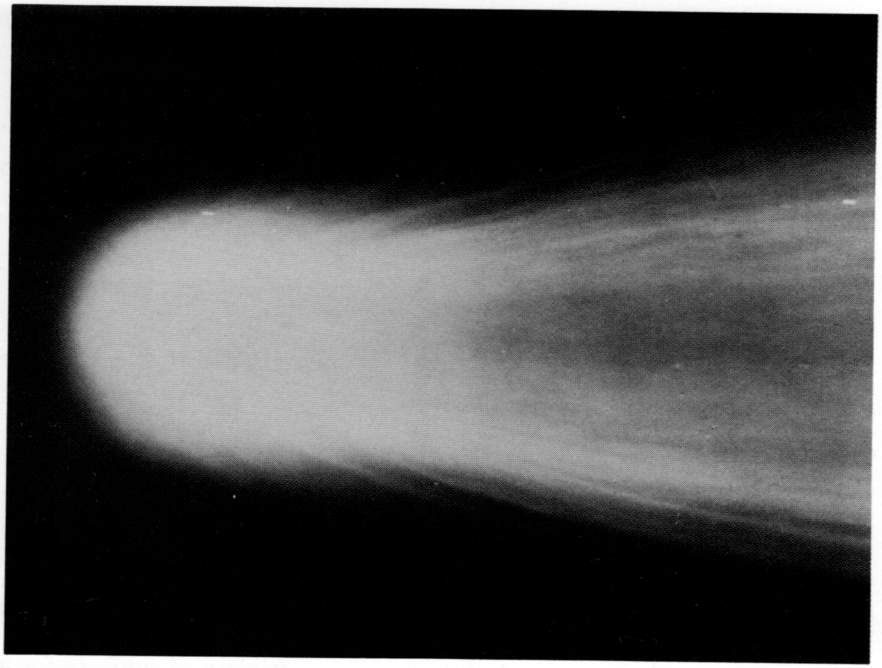
The Extreme Ultraviolet Explorer (EUVE) is a proposed satellite project intended to conduct an all-sky survey of objects radiating in extreme-ultraviolet wavelengths (100 to 1,000 angstroms).

Four telescopes would survey the sky, searching for and determining the positions of extreme-ultraviolet point sources. Diffuse



Closeup studies of the Sun would be performed by Starprobe. Another mission, the Solar Interplanetary Satellite, would study solar events not observable from Earth, providing measurements complementary to those of the International Solar Polar Mission.

Halley, the most famous of comets, was photographed during its last sweep past Earth in 1910. A worldwide network of amateur and professional astronomers will study the comet in depth when it passes again in 1986.



sources and the cosmic extreme-ultraviolet radiation would also be studied.

Starprobe

A heat- and radiation-resistant spacecraft that would perform a close-up examination of the Sun is under study as a possible future mission for NASA.

Starprobe would investigate the fields and particles environment around the Sun, study its magnetic field, and obtain high-resolution photographs of its surface with X-ray, ultraviolet, and visible-light telescopes.

In order to achieve the velocity necessary to reach the Sun, the spacecraft would first be launched toward Jupiter. Enough momentum would be gained in one swing around Jupiter to send the spacecraft back toward the Sun.

International Halley Watch

JPL and the University of Erlangen-Nürnberg in West Germany are the lead centers for the International Halley Watch (IHW), which is coordinating the observations of Halley's Comet by professional and amateur astronomers around the world.

When Halley circles the Sun and passes Earth in 1986, the comet will be observed from Earth, from Earth orbit, and by spacecraft from the Japanese, European, and joint French–Soviet space agencies.

The Space Telescope and various space shuttle payloads will make long-term observations of the comet. The IHW will work closely with these projects to insure that ground-based studies by amateurs and professionals are made concurrently. Data gathered through these methods will be compiled by the IHW and archived for study by researchers.

MARINER MARK II

The Mariner Mark II spacecraft is being designed to meet the goal of the next generation of NASA's exploratory deep-space missions–to study objects in the solar system at a fraction of the cost of the first wave of unmanned United States planetary probes and orbiters to Mars and the outer planets.

Design flexibility is central to the Mariner Mark II. It would be easily reconfigured to accomodate instrumentation for a variety of exploratory missions to planets, satellites, asteroids, and comets.

The benefits of reconfigurable spacecraft include reduced costs for redesigning, retesting, and qualifying for flight. Block buys of items that could be useful in several missions would be possible, and the same ground data system could be used with little modification from mission to mission.

A rendezvous with a comet is included among the missions for which the Mariner Mark II would be used. A long-term rendezvous would allow scientists to study a full range of cometary phenomena. A Mariner Mark II spacecraft could fly alongside a comet for a period of months. With small propulsion maneuvers, the spacecraft could move around the comet's nucleus and view it from different perspectives. Instruments on board the spacecraft could study the comet while its activity builds, peaks, and dies down as the comet nears the Sun and then retreats toward the outer solar system.

A rendezvous mission to one or more main-belt asteroids and flybys of several others are also under study. In addition, a sample of cometary material could be obtained by a spacecraft flying through a comet's tail. The collected gases and dust could then be returned to Earth.

Future planetary exploration will also focus on the outer planets–Saturn, Uranus, Neptune, and Pluto. The outer planets and their ring systems and satellites offer a wide variety of subjects for study.

Possible missions to be performed by Mariner Mark II spacecraft include voyages to Saturn and its moon Titan. A probe that would descend to Titan's surface could reveal details of its terrain and thick atmosphere.

The Shuttle Imaging Radar-A (SIR-A) revealed the Southern California coast despite cloud cover and darkness. An upgraded version of the system will fly again as SIR-B in 1984.

A mission under study at JPL would send to Saturn a Mariner Mark II spacecraft equipped with a probe that would be detached and would descend to the surface of Saturn's satellite Titan. The probe would return information on Titan's atmosphere and terrain.

Another mission under study would place a Mariner Mark II in orbit around Saturn to map Titan in infrared and radio wavelengths during repeated close flybys of that moon. Current studies favor a three-year mission with 22 Titan encounters and additional close encounters (less than 2,500 kilometers, or 1,550 miles) with the moons Dione, Rhea, Hyperion, and Iapetus.

SAMEX

Radar scientists are planning a shuttle experiment that would extend the capabilities of the synthetic aperture radar – the instrument used for Seasat and SIR-A imaging – to multispectral imaging. The proposed instrument, called the Shuttle Active Microwave Experiment (SAMEX), is being planned for possible flight in 1986 and would perform high-resolution and multispectral mapping of Earth.

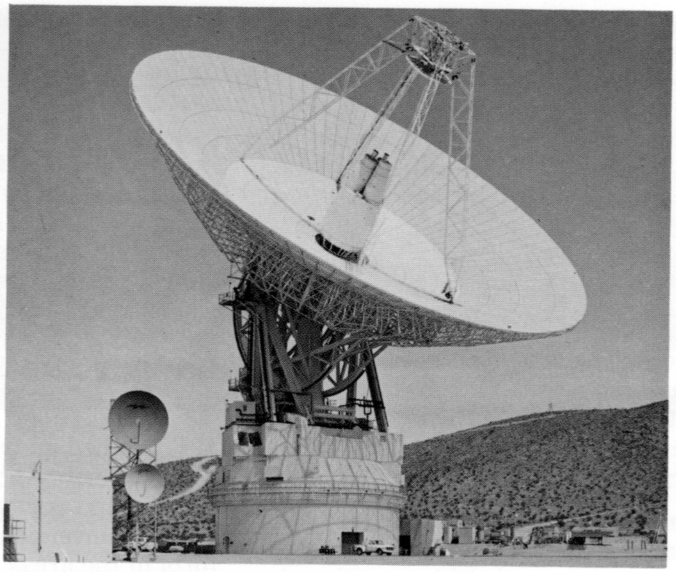
SHUTTLE IMAGING RADAR-A

JPL flew the Shuttle Imaging Radar-A (SIR-A) on the second flight of the space shuttle Columbia in November 1981. The instrument was part of the first shuttle scientific payload.

Images were acquired around the world with a total coverage of 10 million square kilometers (3.9 million square miles). Preliminary analysis of the data is providing additional information on surface and near-surface structure, which in some regions is not available in the most recent geologic maps.

The success of SIR-A led to the approval of the follow-on program (SIR-B), which will use a more sophisticated instrument, to be flown on a shuttle in 1984.

Huge dish antennas 64 meters (210 feet) in diameter dominate the sky at the DSN's three facilities in California, Spain, and Australia. The Network controls and communicates with U.S. and European spacecraft across the solar system.



Deep Space Network

The Deep Space Network (DSN) operates spacecraft communications facilities in California, Spain, and Australia. The Network's large, 64-meter (210-foot) dish antennas are located 120 degrees longitude apart to allow continuous communication with spacecraft exploring the solar system.

The DSN was developed and is operated by JPL for NASA's Office of Space Tracking and Data Systems. The Network maintains communications with a number of spacecraft, transmitting commands and receiving scientific and engineering data.

Voyagers 1 and 2, which encountered Jupiter and Saturn, are being tracked and commanded through the DSN, and meteorological and other scientific information is still being received from the remaining Viking 1 lander on Mars. Communications for the Galileo mission to Jupiter will be conducted through the DSN.

Pioneers 10 and 11 are managed by NASA's Ames Research Center, while JPL is responsible for navigating and communicating with the spacecraft. Both Pioneers began as missions to Jupiter, and Pioneer 11 went on to become the first spacecraft to pass Saturn. Both continue to return information on unexplored regions of deep space, and are expected to operate through the early 1990s.

Launched in the 1960s and also the responsibility of Ames, Pioneers 6 through 9 are still providing data on interplanetary space. Pioneer 12 continues to orbit and study Venus. All the Pioneers return their data through the DSN.

Helios, a joint NASA/West German mission that sent two spacecraft to explore the Sun in 1974 and 1976, is managed by the Goddard Space Flight Center (GSFC). One of the spacecraft continues to investigate the solar wind, the Sun's magnetic field, solar and galactic cosmic rays, electromagnetic waves, micrometeoroids, and zodiacal light.

The DSN will support the "Giotto" spacecraft of the European Space Agency (ESA) and Japan's "Planet A" and MS-T5 spacecraft. All three spacecraft are scheduled to intercept Comet Halley in 1986. The network will also support ESA's International Solar Polar Mission (ISPM) mission to the Sun in 1985.

A major effort is underway to consolidate the DSN with the ground stations of the GSFC Ground Spaceflight Tracking and Data Network. The combined networks will conduct communications with several Earth-orbiting satellites for which GSFC has been responsible in the past, while the DSN continues to track its own deep-space missions.

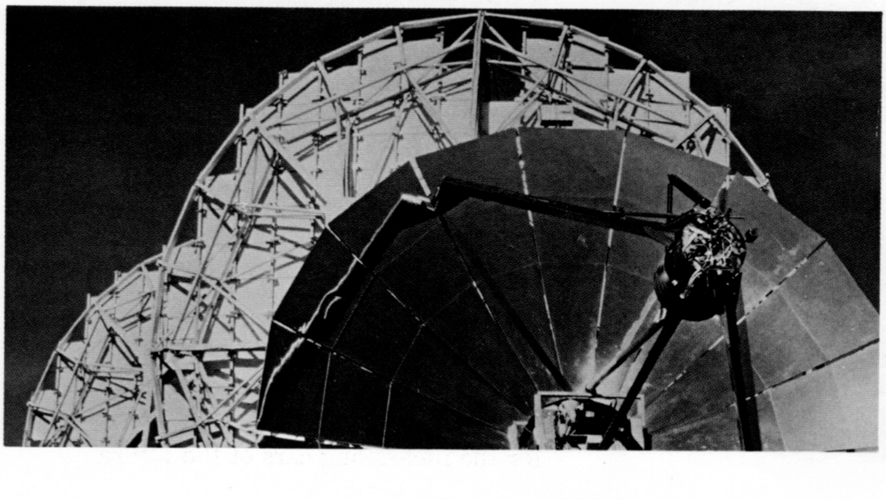
Radar astronomy experiments for studying the surfaces of planets, asteroids, and comets are conducted through DSN facilities at Goldstone. The Network also supports radio astronomy experiments involving pulsars and other compact radio sources.

The DSN is also responsible for the Operational Radio Interferometry Observing Network (ORION), which uses quasars and radio galaxies as precise reference points for detecting tectonic-plate motion. Ultra-precise atomic clocks time the arrival of energy from an extragalactic source at two antennas in different locations. The difference in the signal's arrival times at the mobile ORION antenna and at a stationary antenna is calculated, and the distance between the two is determined. If the antennas are located on either side of a fault, the ORION system can potentially detect plate movement by measuring changes in the distance between the two antennas as small as two centimeters per year.

Energy and Technology Applications

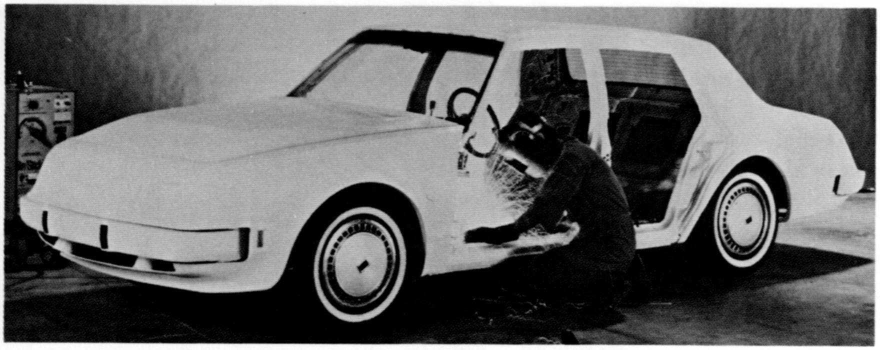
JPL has had a strong commitment to our nation's energy program for more than a decade, and is engaged in more than 100 energy-conversion tasks, including major efforts in the areas of coal, solar energy, and conservation.

JPL was selected by the Department of Energy (DOE) in 1978 as the lead center for photovoltaics development and application. (Photovoltaics are solid-state solar energy devices that directly convert sunlight to electricity.) Since then, the Flat-Plate Solar



Experimental engines atop mirrored dish collectors transform solar energy into electrical power. This represents one of JPL's many tasks in solar energy research for the Department of Energy.

The Hybrid Power Train Mule Vehicle is shown being fabricated. The hybrid power train is composed of an electric motor and a four-cylinder engine.



General Electric Corp., R&D

Array Project at the Laboratory has sponsored advances in photovoltaic technology that have lead to significant reductions in manufacturing costs.

As a result, photovoltaics systems are now economically practical for small-scale applications in remote areas, and the project is currently working with industry and universities to develop longer-term and larger-scale systems.

The solar-thermal approach to generating energy from the Sun is being researched at JPL's Edwards Test Station using parabolic reflectors that concentrate the Sun's heat to drive turbine/alternators that produce electricity. Power generated by these collectors is fed into the utility grid of the Southern California Edison Company. In addition, steam produced by the collectors has been used to make furfural, a fossil fuel substitute, from agricultural byproducts.

Southern California Edison and JPL are working together on another energy project. The Salton Sea in California is the proposed site of a solar-pond power plant that would supply 600 million watts of power to the utility company.

A solar pond absorbs heat but does not release it to the atmosphere, because a stable upper layer of low-salinity water guards dense, warm, saltier water below. Warm water from the pond is used to drive a turbine that, in turn, produces electricity.

In addition to solar energy, JPL is researching improved ways to mine and use coal as an energy source. U.S. coal reserves are among the largest in the world, and the Fossil Energy Program is using JPL systems-engineering experience to solve problems of coal recovery and handling and of synthetic-fuel production. Safer and more efficient coal-mining systems are being designed, as well as a method for removing sulfur pollutants from the fuel before burning it.

A JPL study has shown that coal-powered locomotives could reduce the operations costs of the nation's railroads. According to the study, a coal-burning locomotive, replacing the diesel-electric models now in use, could be in operation by the 1990s.

In other areas of transportation, the Laboratory is conducting an Electric and Hybrid Vehicles Project and is a major development and test center for the nation's experimental electric-automobile program. JPL is developing electric-car technology and measuring the performance of experimental electric and hybrid (combination gasoline and electric) vehicles in its search for the fuel-saving cars of the future.

Potentials for rooftop solar applications are shown in this computer-generated map of the San Fernando Valley.

The Utility Systems Program at JPL seeks to develop new techniques for conserving and storing energy for our nation's existing utilities, since the growing use of photovoltaic, solar-thermal, and wind-turbine residential and community power systems will necessitate changes in the way the utilities operate.

The potential exists for millions of new small power sources, all of which must be integrated into existing utility grids. The Utility Systems Program has developed new computer simulation techniques and is working on new communication and control technologies that will allow small power sources to share the energy their systems produce.

Biomedical Technology

Biomedical research was one of the first nonspace endeavors at JPL. The Laboratory's experience in computers, image enhancement, and instrumentation continues to be applied to a variety of biomedical tasks.

In collaboration with the UCLA Department of Medicine, JPL is using computer image analysis to monitor minute changes in atherosclerotic disease over time. Using data from participants in a clinical study, small changes in the disease due to regimens of chemotherapy, diet, and exercise are being studied at a level of detail never before available.

An effort sponsored by the National Cancer Institute is also underway to produce an automated system for screening cells for cancer.

The Medical Ultrasound Program is developing instrumentation for pre- and post-flight cardiovascular examinations of astronauts and other space shuttle passengers. The ultrasound research uses recent technological advances in ultrasound physics, image processing, and clinical research to bring new ultrasound methods into practical use in both clinical environments and the space program.

A collaborative effort between JPL and the University of Southern California Cancer Research Center seeks to determine the consequences of the higher radiation doses typically received by shuttle passengers. Researchers on the project are using JPL's advanced electro-optical ion detector, attached to a mass spectrometer, to detect carcinogenic modification of the DNA of animals living in an irradiated atmosphere.

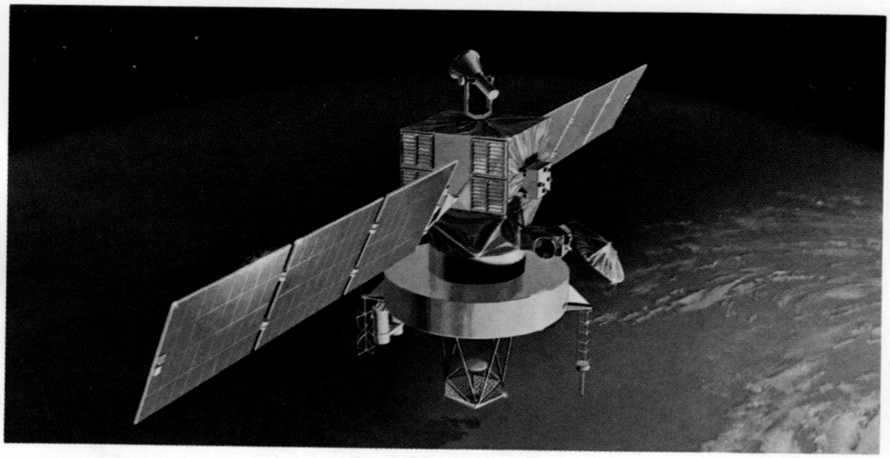
Ocean Studies

The Ocean Topography Experiment, called TOPEX, is a satellite mission under study at JPL. TOPEX would carry an altimeter to make detailed, global measurements of the topography, or height differences, of the ocean surface, which in turn would reveal the behavior of currents and other features of ocean circulation. The multiyear mission is being planned for the late 1980s.

Improved knowledge of the ocean's circulation would contribute to an understanding of the relationship between the atmosphere and ocean, and help determine how that circulation affects the ocean food chain, the movement of pollutants, and the operations of commercial and naval vessels.

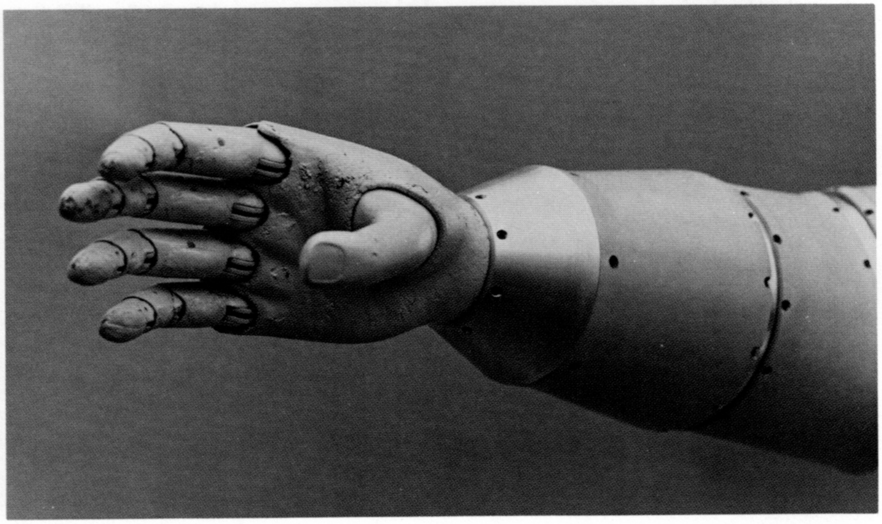
A submersible Advanced Oceanographic Technology Development Platform (AOTDP), designed for deploying and testing oceanographic instruments and sonars, was developed by JPL. The AOTDP is unique among oceanographic submersibles because of its computer systems, which were adapted from space technology. They enable scientific and engineering data to be processed in real time and stored on magnetic tape. Sonar images obtained by the AOTDP can be processed by JPL's Image Processing Laboratory.

Five major U.S. oceanographic institutions are now participants in JPL's Pilot Ocean Data System, an interconnected data management system for oceanographic information provided by JPL, Woods Hole Oceanographic Institution, Scripps Institution of Oceanography, Oregon State University, Florida State University, and the Naval Postgraduate School in Monterey, California.



TOPEX, an ocean topography experiment, would use a satellite altimeter to map the world's ocean circulation in detail.

Research for NASA and industry includes the development of a tactile sense as well as hand/eye coordination for robots and teleoperators.



DEPARTMENT OF DEFENSE

A variety of projects are underway at JPL for the U.S. Air Force, Army, and Navy and the Defense Advanced Research Projects Agency (DARPA).

Work continues on a new project for the Air Force Space Division to achieve, by the end of the decade, a high degree of defense-satellite autonomy and independence from ground stations.

Future efforts will include compilation of JPL's autonomous spacecraft design experience into a document for Air Force and industrial use. Design, development, and demonstration of a prototype fault-tolerant, computer-based spacecraft subsystem for defense satellites is also planned. Development and flight demonstration of the concept will be conducted over a five-year period.

ROBOTICS

The Laboratory's work in robotics, artificial intelligence, and teleoperators has expanded from developing experimental planetary rovers in the early 1970s to finding applications for automation and performing research on industrial robots that will operate both in space and on Earth.

Research has concentrated on improving robotic hand/eye systems, which will allow robots to work with moving objects. This technology, being developed for use in the space shuttle teleoperator arm, will permit remote manipulators to track and grasp objects, like satellites, moving past the spacecraft. JPL is developing voice-controlled television cameras that will be used by the astronaut/operator inside the shuttle to help guide the arm.

Also in development are proximity sensors that will enable a robot to "feel" the distance between its manipulator and the object it is aiming for. The Laboratory is designing manipulator force sensors that will allow robots to judge how much force is needed to perform any given task.

NASA

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