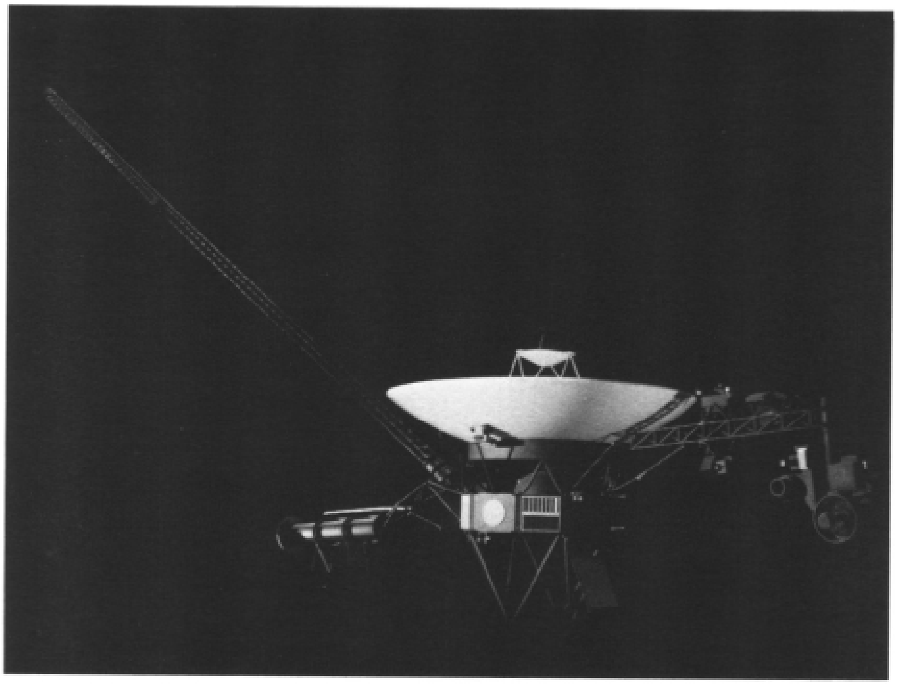


THE VOYAGER 1 AND VOYAGER 2 SPACECRAFT

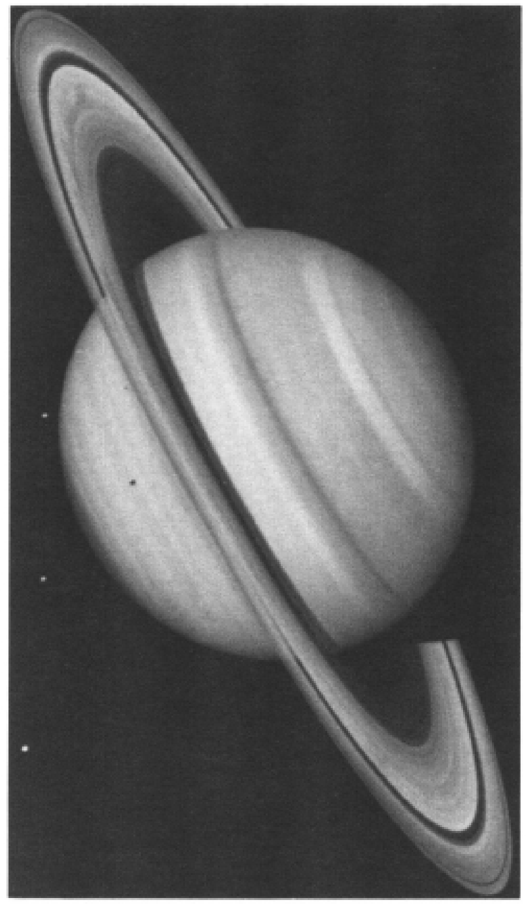
INTERNATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK

DESIGNATED NOVEMBER 12, 1993

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY

The Voyager 1 and 2 spacecraft represent the 40th International Historic Mechanical Engineering Landmark to be so designated by the American Society of Mechanical Engineers (ASME). Since the ASME Historic Mechanical Engineering Recognition Program began in 1971, 160 Historic Mechanical Engineering landmarks, 6 Mechanical Engineering Heritage sites and 4 Mechanical Engineering Heritage collections have been recognized. Each reflects its influence on society, either in its immediate locale or nationwide — or around the world.



THREE OF SATURN'S MOONS — TETHYS, DIONE AND RHEA (TOP TO BOTTOM) — ARE VISIBLE IN THIS PHOTOGRAPH FROM VOYAGER 2. TETHYS' SHADOW APPEARS ON SATURN'S CLOUDS.

The twin spacecraft Voyager 1 and Voyager 2 were launched separately by the National Aeronautics and Space Administration (NASA) in the summer of 1977 from Cape Canaveral, Florida. As originally designed, the Voyagers were to conduct close-up studies of Jupiter and Saturn, Saturn's rings and the larger moons of the two planets.

To accomplish their two-planet mission, the spacecraft were built to last 5 years. But as the mission went on, and with the successful achievement of all its objectives, the additional flybys of the two outermost giant planets, Uranus and Neptune, proved possible — and irresistible — to mission scientists and engineers at the Voyagers' home at the California Institute of Technology's Jet Propulsion Laboratory (JPL) in Pasadena, California.

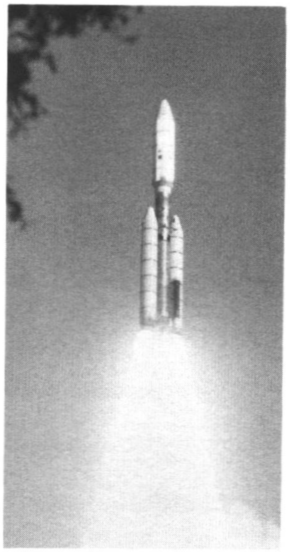
As the spacecraft flew across the solar system, remote-control reprogramming was used to endow the Voyagers with greater capabilities than they possessed when they left Earth. Their two-planet mission became a four-planet mission. Their 5-year lifetimes were stretched to 15 years and more.

Eventually, between them, Voyagers 1 and 2 would explore all the giant outer planets of our solar system, 48 of their moons and the unique systems of rings and magnetic fields those planets possess.

Had the Voyager mission ended after the Jupiter and Saturn flybys, it still would have provided the material to rewrite astronomy textbooks. But having doubled their already ambitious itineraries, the Voyagers returned to Earth information over the years that has revolutionized the science of planetary astronomy, helping to resolve key questions while raising intriguing new ones about the origin and evolution of the planets in our solar system.

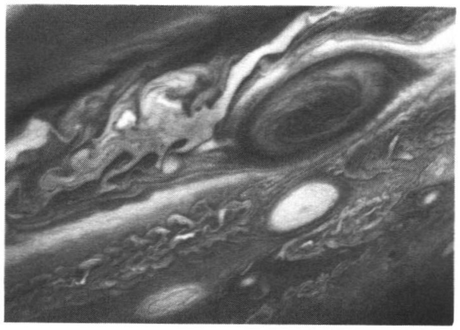
Voyager 1 is now leaving the solar system, rising above the ecliptic plane at an angle of about 35 degrees and at a speed of about 520 million kilometers a year. Voyager 2 is also headed out of the solar system, diving below the ecliptic plane at an angle of about 48 degrees and at a speed of about 470 million kilometers a year.

Both spacecraft will continue to observe ultraviolet sources among the stars, and the fields and particles instruments aboard the Voyagers are studying the boundary between the Sun's influence and interstellar space. The Voyagers are expected to return valuable data for decades. Communications will be maintained until the Voyagers' nuclear-power sources can no longer supply enough electrical energy to power critical subsystems.



ABOVE: IN SUMMER 1977, A VOYAGER LEAVES EARTH ATOP ITS TITAN/CENTAUR EXPENDABLE LAUNCH VEHICLE.

BELOW: VOYAGER 2 REVEALS JUPITER'S ATMOSPHERE OF VIOLENT STORMS AND SWIRLING EDDIES, INCLUDING THE GREAT RED SPOT AT UPPER RIGHT.

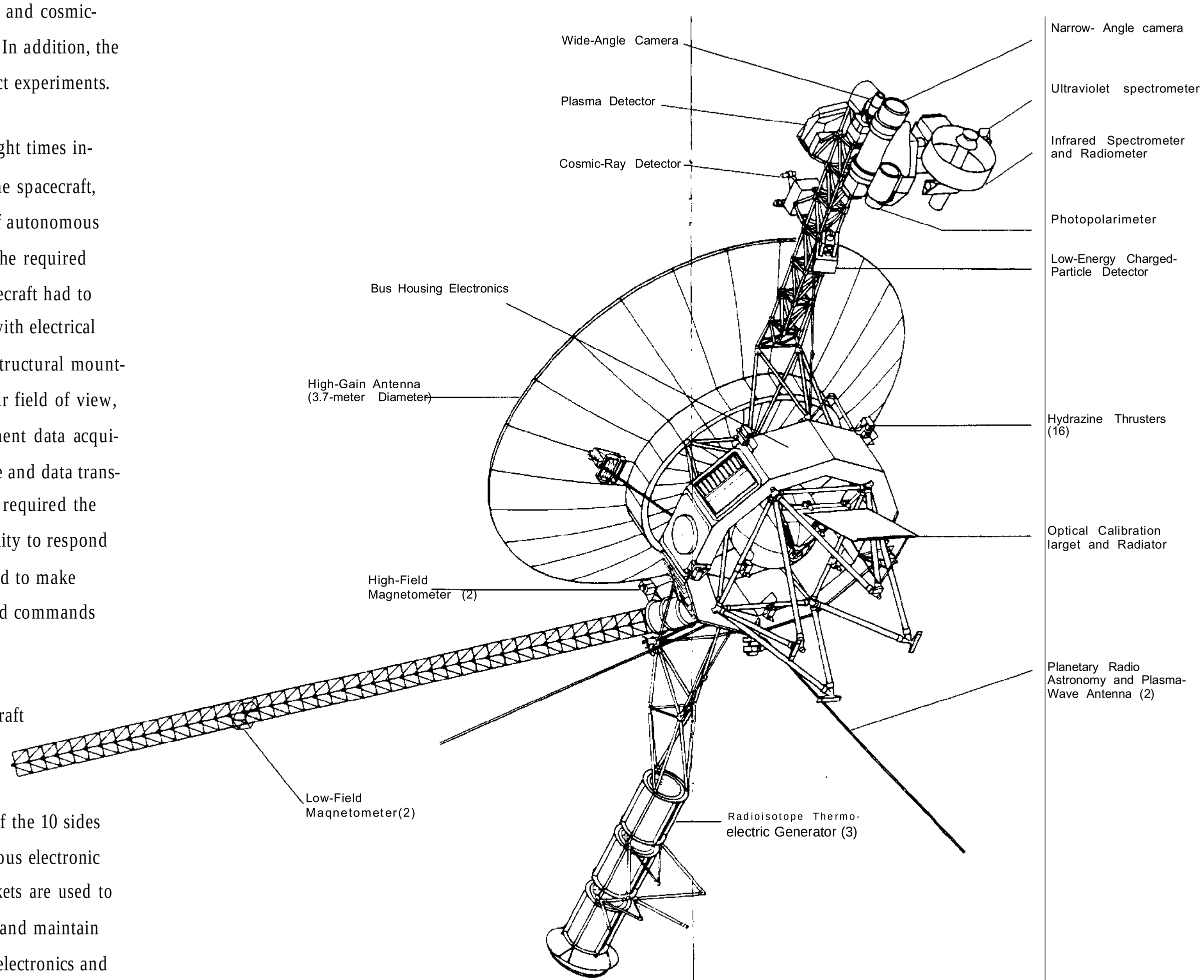


THE VOYAGER SPACECRAFT

Voyagers 1 and 2 are identical spacecraft. Each is equipped with instruments to conduct 10 different experiments. The instruments include television cameras, infrared and ultraviolet sensors, magnetometers, plasma detectors and cosmic-ray and charged–particle sensors. In addition, the spacecraft radio is used to conduct experiments.

Because of the long round–trip light times involved in communicating with the spacecraft, the Voyagers had to be capable of autonomous operation. In order to carry out the required scientific measurements, the spacecraft had to support the science instruments with electrical power, sequencing and control, structural mounting, controlled positioning of their field of view, environmental control, measurement data acquisition and processing, data storage and data transmission. Autonomous operations required the Voyagers to have an onboard ability to respond to a large number of problems and to make themselves safe until they received commands from the ground.

The basic structure of each spacecraft is a 10–sided bus that carries various engineering subsystems and scientific instruments. Each of the 10 sides of the bus houses one of the various electronic assemblies. Special insulating blankets are used to contain internally generated heat and maintain the temperature of the spacecraft electronics and science instruments. The Voyager spacecraft are



(Spacecraft Shown Without Thermal Blankets for Clarity)

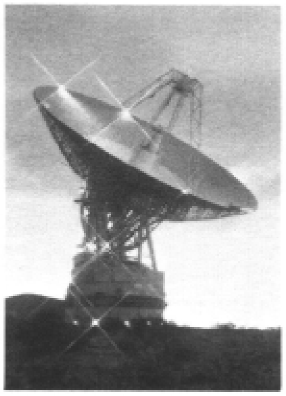
fully attitude-stabilized in three axes, using the Sun and a star (nominally Canopus) as the primary reference objects while maintaining communications with Earth.

The high-gain antenna is a fixed 3.7-meter dish that transmits and receives data in two frequency channels (X-band and S-band). The antenna was painted white to control its temperature while the spacecraft was in the near-Earth environment.

Each spacecraft contains three separate booms that extend from the main bus. These booms contain the radioisotope thermoelectric generators (RTGs), the magnetometers and the science platform. The magnetometer boom is located on the opposite side of the spacecraft from the remote-sensing instruments to prevent interference.

The RTGs are the Voyagers' power sources; they are required since the spacecraft travel too far from the Sun to use solar panels. The RTGs, also used on other deep space missions, convert the heat produced from the natural radioactive decay of plutonium into electricity to power the spacecraft instruments, computers, radio and other systems.

The Voyager spacecraft are controlled — and their data returned — through the Deep Space Network (DSN), a global spacecraft tracking system operated by JPL for NASA. DSN antenna complexes are located in California's Mojave Desert; near Madrid, Spain, and in Tidbinbilla, near Canberra, Australia.



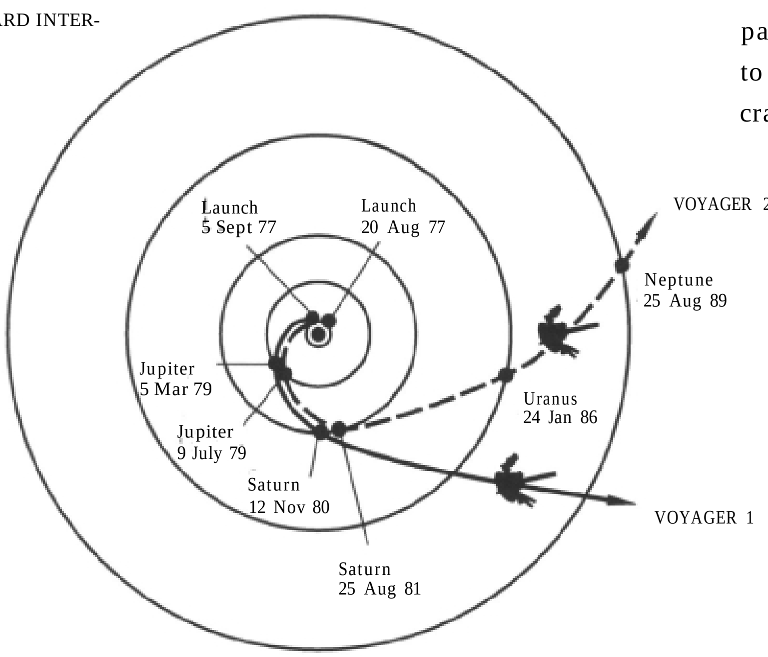
ABOVE: THIS DEEP SPACE NETWORK ANTENNAIN CALIFORNIA'S MOJAVE DESERT, SHOWN IN ITS 64-METER-DIAMETER CONFIGURATION, WAS EN-LARGED TO 70 METERS TO SUPPORT THE VOYAGER NEPTUNE ENCOUNTER.

BELOW: A HELIOCENTRIC VIEW OF THE VOYAGER TRAJECTORIES. THE SPACE-CRAFT ARE NOW ON A JOURNEY TOWARD INTER-STELLAR SPACE.

The Voyagers are continuing to return data about interplanetary space and some of our stellar neighbors near the edges of the Milky Way. As the spacecraft cruise gracefully through the solar wind, they are examining the space around them with instruments that study fields, particles and waves. In May 1993, scientists concluded that the plasma-wave experiment was picking up radio emissions that originate at the heliopause — the outer edge of our solar system.

The heliopause is the outermost boundary of the solar wind itself, where the interstellar medium restricts the outward flow of the solar wind and confines it within a magnetic bubble called the heliosphere. The solar wind is made up of electrically charged atomic particles composed primarily of ionized hydrogen that stream outward from the Sun.

Exactly where the heliopause is has been one of the great unanswered questions in space physics.



By studying the radio emissions, scientists now theorize the heliopause exists some 90 to 120 astronomical units (AU) from the Sun. (One AU is equal to about 150 million kilometers, or the distance from Earth to the Sun.)

The Voyagers have also become space-based ultraviolet observatories, with their unique locations in the universe lending astronomers the best vantage points they have ever had for looking at celestial objects that emit ultraviolet radiation.

The cameras on the spacecraft have been turned off; the ultraviolet instruments are the only functioning experiments on the scan platforms. Voyager scientists expect to continue to receive data from the ultraviolet spectrometers at least until the year 2000. By that time, there will not be enough electrical power for the heaters to keep the ultraviolet instruments warm enough to operate.

Yet there are several other fields and particles instruments that can continue to send back data as long as the spacecraft stay alive. These include the cosmic-ray subsystem, the low-energy charged-particle instrument, the magnetometer, the plasma subsystem, the plasma-wave subsystem and the planetary radio astronomy instrument. Barring catastrophe, JPL should be able to retrieve Voyager information for another 20 to 30 years.

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FURTHER INFORMATION

The National History and Heritage Committee is part of the ASME Council on Public Affairs and the ASME Board of Public Information. For further information, please contact the Public Information Department, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, (212) 705-7740.

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INTERNATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK

THE VOYAGER SPACECRAFT— INTERPLANETARY EXPLORERS, 1977

Voyagers 1 and 2 were launched in 1977 to meet a solar system alignment that occurs only once every 176 years. Both spacecraft sent back valuable pictures and information of Jupiter and Saturn and their satellites. Voyager 2 sailed on to explore Uranus and Neptune. Engineering subsystems provided power and stabilized the spacecraft. Onboard computers controlled flight and transmitted data to Earth independent of human control. These systems made the Voyagers the most intelligent spacecraft ever built. The Voyagers now are exploring near the edge of our solar system and will return useful data well into the 21st century.

The American Society of Mechanical Engineers — 1993

National Aeronautics and
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Jet Propulsion Laboratory
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Pasadena, California

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