Cassini-Huygens spacecraft begins systematic exploration of Saturn system

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The successful passage of the Cassini-Huygens spacecraft through Saturn's rings June 30-July 1 sets the stage for an unprecedented four-year exploration of the second largest planet in the solar system and its complex system of 31 moons, powerful magnetic field and unique rings. On July 22, NASA released the first glorious full-color image of the rings, taken as the spacecraft approached them from below in late June (see http://photojournal.jpl.nasa.gov/jpegMod/PIA05421_modest.jpg).

The Cassini-Huygens is the latest of the great unmanned planetary missions launched by NASA—and likely to be the last, given the priorities set by the Clinton and now the Bush administration, cutting spending and opting for a supposedly "faster, better, cheaper" approach, scaling back the size and scientific ambitions of space probes.

The spacecraft was launched on October 15, 1997, from Cape Canaveral, as a joint mission between NASA, the European Space Agency (ESA) and the Italian Space Agency.

Cassini is the main spacecraft, 22 feet high and 13 feet wide, weighing six tons. Its purpose is to explore the Saturn system, using 12 different instruments to measure the characteristics of the planet, its dozens of moons and its rings.

Huygens is a smaller landing vehicle, equipped with six instruments devised for a close-up inspection of Saturn's largest moon, Titan, the only satellite in the solar system with its own atmosphere. Huygens will separate from Cassini on Christmas Day and rendezvous with Titan in early January 2005, making the first-ever landing on a moon of one of the four giant outer planets. The lander will not survive long on the surface of Titan, which is believed to consist of frozen rock partially covered by lakes of ethane, at temperatures approaching minus 300 degrees Fahrenheit.

The $3.3 billion mission represents the most complex and far-reaching effort at international collaboration in space. NASA built the main Cassini spacecraft and ESA the Huygens lander. The 18 instruments—spectrometers, particle collectors and imaging systems using electromagnetic frequencies ranging from ultraviolent to microwave—were built by 17 different countries. The Italian Space Agency built the high-gain antenna and other radio components that play the critical role in transmitting data across the nearly 1 billion miles to Earth.

The two spacecraft are named after scientists who played key roles in the understanding of the Saturn system, which was originally discovered by Galileo. Christiaan Huygens, the great Dutch astronomer who discovered Titan, suggested the existence of rings around the planet, to explain its fuzzy and changing image in the rudimentary telescopes of the seventeenth century. Jean-Dominique Cassini, a French-Italian astronomer, subsequently confirmed the existence of the rings.

Three previous spacecraft—Pioneer 11, Voyager 1 and Voyager 2—have passed through the Saturn system and collected data that constitutes the bulk of what is now known about the planet. Cassini is the first spacecraft to go into orbit around the giant planet, making possible an enormous advance in scientific understanding, not only of the planet itself, but of the whole class of giant gas planets that have many of the characteristics of stars, though much smaller. (Saturn, like many of the gas giants, radiates more energy than it absorbs.)

Getting Cassini to Saturn was a complex and challenging operation. The nearly seven-year trip began with the spacecraft taking a path toward rather than away from the Sun, and using the gravitational pull of several of the planets to bend its trajectory and boost its speed to the point that it could reach the ringed planet.

Cassini's path took it from Earth to Venus, twice using the gravity of Venus to increase its speed, then using the gravity of Earth to accelerate it toward Jupiter, and finally using the gravity of Jupiter to propel it toward Saturn. After a voyage of 2.2 billion miles, Cassini entered the Saturn system traveling at a speed of more than 49,000 miles per hour. The trip has taken so long that 13 additional moons of Saturn have been discovered between the time Cassini blasted off and the time it was in a position to explore the Saturn system.

Cassini's main engines were silent for nearly four years, since the last course correction. They were test-fired on June 6 as the spacecraft moved in to photograph Saturn's most distant moon, Phoebe. A rock 137 miles across, Phoebe is believed to have originated in the Kuiper Belt, on the edge of the solar system, rather than condensing from the disk of hot gas from which Saturn and its other moons were formed. Phoebe is four times as far from Saturn as any other moon, and it has a retrograde orbit, meaning that it moves in the opposite direction

from Saturn's own rotation and the orbit of the other moons.

According to Pasadena's Jet Propulsion Laboratory (JPL), which is managing the mission, Cassini added more knowledge about Phoebe than had been accumulated in the 100 years since the moon was discovered. A key measurement showed that Phoebe is lighter than rock but heavier than ice, similar to Neptune and its moon Triton. Its surface contains water ice, carbon dioxide and primitive organic chemicals, showing that the moon is an asteroid captured by Saturn's gravity, as once thought, because carbon dioxide is not found in the asteroid belt.

The test firing was in preparation for the successful Saturn Orbit Insertion, which took place June 30. On that day, the spacecraft made its passage through Saturn's rings, then fired its engines in reverse for 96 minutes, using up much of its fuel. This maneuver slowed it just enough—as it was accelerated by Saturn's enormous gravitational pull—to allow it to enter the planet's orbit, instead of flashing by and out into space like the three previous spacecraft to have visited Saturn.

The operation was extremely complicated. Eighty-five minutes before the engine firing, the spacecraft was rotated so that its antenna dish, normally pointed toward the Earth (i.e., behind it), would face forward towards the rings, serving as a sort of shield to catch particles of ice before they could hit and possibly damage the spacecraft body.

Instructions for this maneuver and the subsequent engine burn were uploaded into Cassini's memory last year, although final commands were being uploaded as late as three days before the orbit insertion. Because it takes an hour and 24 minutes for a radio signal from Earth to reach Cassini, everything had to be prepared in advance.

The result was success beyond even the most optimistic of expectations. The spacecraft reached Saturn's rings within seven miles of the position initially projected—an astonishingly precise result for a voyage of 2.2 billion miles. The rocket firing ended within one second of the projected time, and the resultant braking was so close to perfect that JPL could dispense with a secondary course correction maneuver that was allowed in the original mission planning.

Having settled into orbit around Saturn, Cassini then "went dark" for seven days, as it passed behind the Sun, as seen from Earth, and could not communicate. On July 12, it reemerged and began transmitting data again. The spacecraft has already made observations of five of Saturn's major moons: Titan, Rhea, Dione, Tethys and Iapetus.

Over the next four years, Cassini will orbit Saturn 76 times, and 52 of those passes will include close approaches to various moons, including Mimas, the moon closest to Saturn, and Enceladus, which is believed to possess liquid water under its surface.

The most important target is Titan, 3,200 miles in diameter, larger than Mercury, Pluto or the Earth's moon. Its atmosphere has high concentrations of organic molecules, and it is thought to resemble the chemical composition of the early years of the Earth itself, when life first developed. In addition to the Huygens landing, Cassini will approach within 600 miles of the surface of the planet on 45 separate passes, providing an unprecedented opportunity for scientific study. The first such fly-by will take place October 26.

On July 3, Cassini sent its first photos of Titan, taken from a distance of 600,000 miles (about twice the distance from the Earth to the Moon). These pictures were fuzzy because of the dense haze of the moon's atmosphere, but did not show the anticipated oceans of liquid methane or ethane. Instead, spectroscopic analysis showed large areas of nearly pure water ice, together with mixtures of ice and hydrocarbons.

The spacecraft will spend 15 hours a day using its instruments to carry out direct observations and saving the data on its recorder, whose capacity is about the same as a music CD. Then Cassini will transmit an average of 500 images back to Earth. This routine will continue for the next four years in a program that has already been worked out in detail, using the gravity of Saturn and Titan to bend its orbit as required.

The Cassini-Huygens mission is a triumph of organized, planned scientific endeavor. Initial preparations began 22 years ago, and many of its scientists have devoted their entire careers to the mission. At its peak, in 1995, two years before launch, 1,500 scientists and engineers at JPL worked on the mission either full-time or part-time.

A unique feature of the mission is a DVD imprinted with the digital representations of the actual written signatures of 616,400 people, as well as handprints and pawprints of people, dogs and cats from 81 countries. The disc is placed in an aluminum box to shield it from microscopic particles that the spacecraft has encountered throughout its journey, especially in the passage through Saturn's rings.