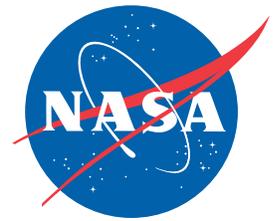


NASA Facts



National Aeronautics and
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A Big Boost for Cassini NASA Glenn Efforts Launch Cassini Toward Saturn

Liftoff! On Wednesday, October 15, 1997, at 4:43 a.m. EDT, a Titan IV-B launch vehicle with a Centaur high-energy upper stage lifted the Cassini spacecraft into Earth orbit and then sent it on the first leg of its 7-year journey to Saturn. Repeating the picture-perfect performance of so many other Centaur missions, the Titan IV-B inserted Cassini onto its trans-Venus trajectory with the expected high precision generally associated with America's most powerful upper stage. The NASA Glenn Research Center was responsible for providing this launch service in close cooperation with the U.S. Air Force (USAF), which manages the Titan IV-B program, and the NASA Jet Propulsion Laboratory, which manages the spacecraft and the overall Cassini mission.

Unlike the almost routine launches of communications satellites and the shuttles, this launch was complicated by (1) the great distance that Cassini will travel to reach Saturn (3.2 billion kilometers, or 2 billion miles), (2) the spacecraft's great complexity and size (as tall as a two-story building and heavier than a large African elephant), and (3) the special measures that were necessary to safeguard its interplanetary power source. To lift this heavy payload, the launch team used the Titan IV-B, the Nation's largest, most powerful, and newest heavy-lift expendable launch vehicle. This mammoth rocket is as



U.S. Air Force Titan IV-B33 launches the Cassini spacecraft on October 15, 1997.

tall as a 20-story building and, with the solid rocket boosters and fuel, weighs about 940,000 kilograms (2 million pounds).

This complex mission was taken on by a talented team of scientists, engineers, technicians, and other personnel from Cassini's government, international, and industry partners. NASA is ultimately responsible for Cassini's success, including the launch service. NASA Glenn was responsible for integrating the spacecraft with the launch vehicle and designing the mission-unique hardware and software modifications necessary for that integration. To support these tasks, Glenn contracted with the Lockheed Martin Corporation. Under a memorandum of agreement with NASA, the USAF procured the basic launch vehicle and launch

operations. They selected Lockheed Martin as the prime contractor for the Titan IV-B program and its Centaur upper stage.

Preparing for Launch

NASA Glenn's involvement began 8 years before the launch. In 1990, Glenn was involved in the jettison testing of the Titan IV payload fairing. This was a cooperative effort of the USAF, the Martin Marietta Company (now Lockheed Martin Corporation), and NASA. The Titan IV's 86-ft-tall, 16-ft-diameter fairing, the largest payload fairing ever tested in a vacuum chamber, had internal dimensions about the size of the space shuttle payload bay. To accommodate the fairing's great size, researchers conducted



Titan IV payload fairing in NASA Glenn's Space Power Facility, located at Plum Brook Station in Sandusky, Ohio.

the tests at NASA Glenn's Plum Brook Station in the Space Power Facility, the world's largest space environment simulation chamber.

Launching Cassini

Members of the NASA Glenn team monitored Cassini's flight from launch through the end of Centaur operations. After ignition, the three Titan IV stages burned; then the Centaur rocket separated from the booster vehicle and burned for about 2 minutes to "park" the spacecraft in orbit. After 20 minutes in orbit, the Centaur main engines fired for the last time, launched Cassini out of Earth orbit and onto its initial trajectory toward Venus, and performed contamination and collision avoidance maneuvers. With the launch and separation complete, Cassini began its 7-year trip to Saturn, the majority of which will be an unpowered coast through space.

But why did Cassini head toward Venus when Saturn is in the opposite direction? Cassini's trajectory planners designed a convoluted path because there is no launch vehicle powerful enough to send Cassini on a direct path to Saturn. Instead, they planned for Cassini to pick up acceleration from the gravity of nearby planets—making two "swingbys" of Venus and one each of Earth and Jupiter before turning toward Saturn. These "gravity assists" will lend energy to Cassini, greatly accelerating it.

When it finally reaches its destination in 2004, Cassini will go into orbit around Saturn to study its atmosphere, magnetic fields, rings, and icy moons. The Huygens probe, supplied by the European Space Agency (ESA), will scrutinize the clouds, atmosphere, and surface of Saturn's largest moon, Titan. Cassini is carrying state-of-the-art science and communication equipment, as well as an additional special payload—a compact disk with the digitized signatures of about a million school children.

Working Together

As they prepared for Cassini's launch, NASA Glenn and the USAF drew from their strong working relationship, closely coordinating the basic launch vehicle production, definition of launch support requirements, and verification that all mission requirements were met. Glenn participated in all Air Force vehicle production reviews and launch processing coordination meetings and reviews.

Glenn also participated in the actual launch operations, including the prelaunch countdown.

Independent verification and validation analyses are normally conducted for Titan IV missions to assure mission success. Coupled loads, spacecraft dynamic testing, software, vehicle guidance and control, mission design, separation dynamics, and flight performance must all be assessed. Although these analyses are normally performed by a subcontractor, NASA Glenn took advantage of the extensive experience and specialized expertise available at Glenn by performing these analyses for the Cassini mission as part of its integration responsibility. This role was particularly important because Cassini is the largest (5712 kilograms, or 12,593 pounds, including its fuel and the Huygens probe) and most complex (sensitive electronic equipment with over 14 km, or 8.7 miles, of cables) spacecraft ever launched on an interplanetary mission.

Deciding When to Launch

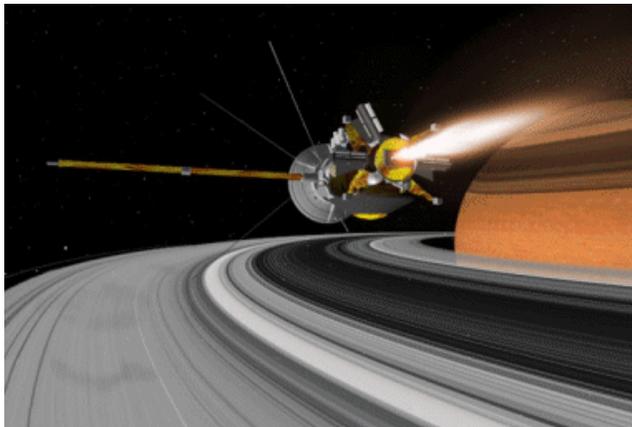
NASA Glenn also was involved in determining when to launch Cassini. Every planetary mission has an ideal launch day. However, there is never a guarantee that a launch will be able to take place on the ideal day because the weather may be poor or there may be a problem with the launch vehicle or spacecraft. To increase the chances of being able to launch, NASA scientists and contractors plan a launch period, or launch "window," for each mission. Most planetary spacecraft, like Cassini, are designed to be launched within a window of 30 days. For example, Cassini's launch window, from October 6 through November 4, 1997, was chosen to accommodate the launch vehicle's capabilities as well as mission performance and operational requirements. If the launch window had been extended to November 15, additional propellant would have been needed. Such an extension proved unnecessary when Cassini successfully began its trek to Saturn on October 15.

Traveling Waves to Better Science

Cassini's data would be useless without a way to send it to Earth, and Earth will be over a billion miles away. To reach across this great distance, Cassini needs a powerful radio link—one that can send more information home with less distortion and using less energy than previously possible. To meet these goals for Cassini and future

spacecraft, NASA Glenn's Communication Technology Division began exploring an advanced technology, a 32-gigahertz traveling wave tube (TWT) and its power supply, together called a traveling wave tube amplifier (TWTA). TWTA's are an advanced type of vacuum tube amplifier that offer lighter weight, higher reliability, and higher efficiency than solid-state amplifiers offer at high radiofrequency power levels (greater than 10 watts).

Although it proved too expensive to adapt Cassini's communication system to accommodate this 32-gigahertz TWTA, it was used for science experiments on Cassini and its power supply served as the technology prototype for the power supply for two 8.4-gigahertz TWTA's developed by the NASA Jet Propulsion Laboratory. These smaller TWTA's ultimately became Cassini's communication link, and Glenn provided technical support for this project. In addition, Glenn and JPL are planning a follow-on program that will use the results of experiments with Cassini's 8.4- and 32-gigahertz TWTA's to develop an improved 32-gigahertz TWTA for extraterrestrial communications from future spacecraft, making it even easier for these emissaries to call home.



Computer-rendered image of Cassini during its Saturn Orbit Insertion maneuver, just after its main engine has been fired.

To explore Saturn's atmosphere and help make measuring distances more accurate in space, researchers will use both the 8.4- and 32-gigahertz TWTA's in radio science and gravitational wave experiments conducted while Cassini is in orbit around Saturn. Cassini's radio science experiments, which will be conducted when the spacecraft is on the side of Saturn that faces away from Earth, will give researchers

clues to the composition and temperature of Saturn's atmosphere. The gravitational wave experiments will investigate how plasma affects distance measurements in space.

Astronomers use the length of time it takes radio waves to travel through space to estimate distances, but space plasma can alter the speed of these waves and make such data less accurate. Being able to compensate for changing wave speeds would make it possible for scientists to more accurately calculate the distances between planets, satellites, and other objects in space, possibly to within 1 foot. In addition, the masses of asteroids and moons could be more accurately determined, and space navigation would be much more precise. Gravitational wave experiments on Cassini will bring us closer to reaching these goals.

Making History Again

NASA Glenn was a logical choice for the Cassini launch because its experience with interplanetary launches goes back to the Rangers, Mariners, Surveyors, and Voyagers—the early days of space exploration. Since 1962, Glenn has been responsible for all intermediate and large class payload launches on expendable (unmanned) rockets by NASA—a total of 119 launches. Until the advent of the space shuttle program, this responsibility included all U.S. launches to the planets. Though NASA Glenn's management of interplanetary launches ended with Cassini, Glenn is proud of its historical role in planetary exploration and is proud to be a vital part of the Cassini mission.

For more information, visit Glenn's Cassini "launch site" on the World Wide Web:
<http://www.grc.nasa.gov/WWW/PAO/cassini.htm>

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