Ten years at Saturn with the Cassini spacecraft

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Since its successful insertion into orbit around Saturn on July 1, 2004, the Cassini-Huygens spacecraft has proved to be one of the most fruitful scientific explorations ever conducted. For the past ten years, Cassini has provided extraordinary scientific data on Saturn's atmosphere and magnetic field, its complex ring system and its numerous moons, including the descent of the Huygens probe onto the surface of Saturn's largest satellite, Titan. To date, Cassini is the only man-made object to enter orbit around that planet.

Cassini has long outlived its mission specifications. When it first arrived at Saturn, it was only slated for a four-year mission. The extended mission has allowed for detailed characterizations of the moons Titan, Mimas, Hyperion, Iapetus, Enceladus and others, a study of the dynamics of Saturn's rings and a close-up look at part of Saturn's thirty-year seasonal cycle. Throughout this time, Cassini has remained more or less fully operational.

One of Cassini's first major activities was the dispatch of the Huygens probe to parachute through the atmosphere of Titan, which has an atmosphere of approximately Earth's pressure but at a much colder temperature. (See: Huygens probe lands on Titan: a scientific leap for mankind) Titan remains the most distant body on which mankind has landed. Huygens measured wind speeds during its descent while simultaneously detailing the composition of Titan's atmosphere and photographing its surface. The probe also provided further evidence of organic compounds, including amino acids, in the atmosphere.

The most significant puzzle in Titan’s atmosphere is the presence of considerable amounts of methane. The lifetime of methane subject to ultraviolet radiation from the Sun should only be a few tens of millions of years, much shorter than the age of the solar system. Thus, there must be a mechanism to replenish it. The measurement of amounts of specific isotopes of carbon, nitrogen, and the detection of considerably less argon than was expected have made it clear that the methane found on Titan was not simply collected during the formation of the moons of Saturn, but has undergone more complex processing, perhaps being formed through mineralogical reactions deep inside Titan.

Imaging of Titan has continued throughout the mission in a series of close passes, in which the gravity of Titan has been used to deflect Cassini into a series of different orbits about Saturn. Radar maps have produced a complete picture of Titan underneath its thick and mostly opaque atmosphere, showing a rich landscape of streams, rivers, and lakes.

The dynamics of Saturn's rings proved richer than expected. Complex sets of waves in the rings stimulated by the motion of shepherding moons have been mapped, and some ringlets have changed significantly in size and location over even the ten years of Cassini monitoring. The inner edge of the famous “Cassini division” has proven to be littered with large, mile-sized bodies. Earlier this year, a discovery of a new feature at the edge of Saturn's A ring suggests that a small icy moon may be in the process of birth from the aggregation of debris.

Saturn’s many satellites have been the source of a wealth of discoveries. Enceladus has been found to eject geyser-like plumes of water vapor. Cassini flew through one on a close encounter with the moon and measured the composition of the liquid, which includes water vapor, sodium chloride and ice crystals. The geysers imply the existence of a reservoir of liquid water under the moon's surface, making it a prime target for searches for extraterrestrial life within the solar system.

Another peculiar moon of Saturn is Iapetus. When it was first discovered in 1671 by Giovanni Cassini (the spacecraft's namesake), it would appear on the western side of Saturn, but not on the eastern side. It wasn't until three decades later that more advanced telescopes saw Iapetus on the eastern side and astronomers realized that the moon has a dark and light hemisphere. It is now known, with help from Cassini, that the bright side is covered mostly in ice while the darker side is largely primordial organic compounds. Cassini has shed light on many more mysteries of Saturn's moons, giving astrogeologists material for years of study.

Cassini also mapped Saturn's cloud system in fine detail. It was able to observe one of the rare storms seen roughly every 30 years and studied the evolution and dissipation of the storm in depth. The spacecraft also took pictures and a video of a hexagonally shaped feature at Saturn's South pole that was first imaged by the Voyager probes more than 30 years ago. The data showed the storm to be a long-lived feature of the planet.

The technological challenges of operating in the outer solar system are profound. At great distances from the Sun, spacecraft temperatures plunge to well below those encountered in ordinary engineering practice, solar panels fail to produce adequate power, spacecraft communications become more difficult as round trips for signals to reach Earth and return exceed two hours. At the same time, the scientific bounty to be won from potentially years of close proximity to a remote planet is enormous. As the technological challenges are solved for how to operate in orbit around a distant planet, more and more scientific instruments are developed to make use of those orbits in answering fundamental questions about the planets, their environment, and the solar system as a whole.

Cassini represents the last flowering of the resources available to the space race between the United States and the Soviet Union during the Cold War. NASA spending briefly in 1965 topped 5 percent of the federal budget. But following the initial Moon landings, there was a massive reduction in the resources available to NASA for deep-space exploration. NASA's budget has fallen to less than a tenth of what it was at its height, in percentage terms.

Astronomer Dan Weedman, director of the NASA astrophysics division during 1993-1995 when Cassini was given its final green light, spoke with the *World Socialist Web Site* about the shifts in US policy that led to such a decline.

“What has changed in 20 years is that neither Congress nor the administration now have any strong advocates for science for its own sake. As a result, the scientific community has limited access to budgetary decisions. Large scientific projects are increasingly dependent on the benefits that flow to specific constituencies.” This has caused the “flagship” class of NASA missions, those with budgets of at least $2 billion but promising great scientific returns, to fall by the wayside. Only two such missions, Cassini and the Mars rover Curiosity, have been launched in the last two decades.

Weedman discussed public interest in space exploration: “I don't think that most working people have been well educated regarding the accomplishments of these missions, but I do think that most are inspired by the existence of scientific discovery. I am often surprised by the level of interest. For example, my barber last month was asking about extrasolar planets! I think the level of mass interest is under-appreciated by the political system.

“I am amazed that so many brilliant young people still enter science, given the diminishing chances for obtaining a permanent job. I fear that in the US we will soon face what has already happened in the former Soviet Republics – young people simply give up on becoming scientists because their society gives no rewards to the pursuit of any knowledge which cannot be explicitly coupled to profits."