When NASA's Cassini spacecraft careens to its final destination, the upper atmosphere of Saturn, it will take with it a sizable chunk of University of Arizona space research history. After a journey of 4.9 billion miles, and one month shy of 20 years in space, the probe is programmed to end its voyage exploring the Saturnian system through a deliberate plunge into the second-largest planet of the solar system.
The spacecraft's fateful dive on Friday will be the final beat in the mission's Grand Finale — 22 weekly dives, begun in late April, through the gap between Saturn and its rings. According to NASA, no spacecraft has ever ventured so close to the planet before.

"Cassini-Huygens is a classic example of a 'flagship' mission, accomplishing tremendous science in many disciplines over many years," said Alfred McEwen, a UA professor of planetary sciences, on Monday as he prepared to leave for Pasadena, California. There, at NASA's Jet Propulsion Laboratory, he would attend the final moments of the mission, along with other UA planetary scientists who have participated in the project.

NASA chose to end the mission by safely disposing of the spacecraft, burning it up in Saturn's atmosphere rather than allowing it to run out of fuel and committing its fate to an aimless tumble and potential crash onto one of Saturn's moons. Mission scientists were especially concerned about contaminating Titan or Enceladus, the two Saturnian moons where life as we know it might be possible — a possibility discovered by Cassini's multiple flybys.

When it launched, Cassini-Huygens was the biggest, most complex interplanetary spacecraft ever flown. In 2004, it arrived in the Saturn system, carrying with it a robotic passenger in form of the Huygens probe, contributed to the mission by the European Space Agency, or ESA. On Jan. 14, 2005, Huygens would make history as the first — and, so far, only — humanmade object to touch down on a world in the outer solar system. Through the eyes of Huygens, an instrument built by UA scientists and engineers, people on Earth could watch as the probe hurtled through the opaque and hazy atmosphere enshrouding Titan.

The probe was equipped with an instrument called DISR, short for Descent Imager/Spectral Radiometer. Led by Martin Tomasko, a now-retired research professor at the Lunar and Planetary Laboratory, UA scientists joined their ESA colleagues in Germany to follow Huygens with six science experiments as it descended through Titan's thick atmosphere until it touched down on a virtually unseen surface. In addition to images taken with DISR, the lander recorded data that enabled LPL staff scientist Erich Karkoschka to gather surprising clues about Titan's surface many years after the event.

**Monitoring the Moon Titan**

During many flybys, Cassini monitored the dynamic Titan using its camera suite and an instrument called VIMS, a Visual and Infrared Mapping Spectrometer. Built at Jet Propulsion Laboratory under the leadership of Robert Brown, operations for VIMS moved to the UA when Brown assumed a position as professor at LPL. According to Brown, VIMS has been taking spectra over areas of Saturn, its rings and moons so scientists can discover what these objects are made of.

Those observations revealed details about the cycle of methane, which on Titan takes the role of water on Earth — forming clouds, raining down and forming lakes, as well as freezing into
ice. In all those observations, Cassini’s cameras played an important role, said McEwen, who is a team member of the craft’s imaging science subsystem. Those cameras, over the years of photographing Saturn, its rings and moons, created some of the most visually beautiful images of the solar system.

Cassini’s imaging team leader Carolyn Porco was appointed to the mission while on the faculty at LPL, where she had been working on NASA’s Voyager mission, and was a co-originator of the idea to use Voyager-1 to take portraits of the planets, including the famous Pale Blue Dot image of Earth.

Surface observations on Titan are planned at LPL, and then sent to the Cassini Imaging Central Laboratory for Operations, or CICLOPS, at the University of Colorado, Boulder, which Porco heads as director.

"From there, the necessary commands are sent to JPL and then to the spacecraft,” McEwen explains.

Another one of Saturn’s moons, ice-clad Enceladus, rose to stardom during several flybys over the course of the mission. Enceladus plows along the orbit of the E Ring, Saturn’s second-from-outermost ring, which reaches extremely far out into space, brushing up against the orbit of Titan.

“There was speculation that the moon had something to do with the E Ring,” McEwen says.

During multiple close flybys, Cassini used its full science payload to detect and analyze water-rich plumes erupting from the moon’s south pole far into space, a spectacular discovery that McEwen considers one of the highlights of the entire mission.

"We saw that these plumes are quite large and extensive,” he recalls. "Because we were able to measure their composition with Cassini’s instruments, we could show that (tiny particles from those eruptions) are the source of the E Ring."

**The Last Closest Approach**

Evidence for subsurface oceans of water were discovered by Cassini inside both Enceladus and Titan, making them prime targets for future NASA missions.

Cassini made its last closest approach to Titan on Sept. 11 at 12:04 p.m. PDT, at an altitude of 73,974 miles (119,049 kilometers) above the moon’s surface, causing the spacecraft to slingshot into its final approach to Saturn — but not before it would send final images from Titan to Earth, eagerly awaited by scientists, including McEwen.

"Previously, we saw thunderstorms in Titan’s southern hemisphere when it was summer there,” he says, "and because it’s now the northern summer solstice, we are hoping to see cloud activity and perhaps thunderstorms in the northern hemisphere."
Cassini will be doing science even after being gripped by Saturn's gravity, pulling it into destruction, by measuring the composition, temperature and other properties of Saturn's atmosphere.

"The spacecraft will be transmitting data until the very end, and we'll be there when it stops," McEwen says. "It won't go very deep, because it is not a probe designed to go deep, but still deeper than anything else."

When Cassini arrived at Saturn, where one "year" lasts 29.5 Earth years, the gas giant went through northern winter, and Cassini was there to witness the planet's change of seasons.

The end of the mission, McEwen says, is "not unexpected," adding that the plan to end with a solstice mission, followed by a plunge into Saturn, was put in place about seven years ago.

Still, "this mission has been going for so long, it's a little hard to believe that it's over," he says.

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