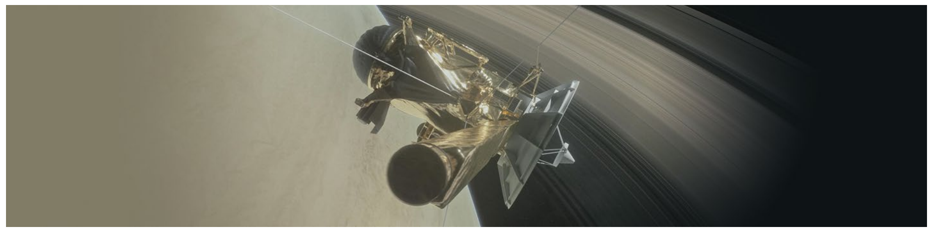
Cassini's swan song

The NASA/ESA/ASI Cassini–Huygens mission ends in a 'Grand Finale' this month, after 13 years in orbit around Saturn. The ESA and NASA JPL project scientists Nicolas Altobelli, Linda J. Spilker and Scott G. Edgington give an overview of the last moments of Cassini's operational lifetime.

Near Saturn's equator at local noon, 15 September 2017, 10:44 UTC: the most challenging and successful mission ever flown to Saturn and its moons is about to end. Acquiring and transmitting science measurements up until the very last moments, the Cassini spacecraft will dive into the atmosphere of Saturn and disintegrate as a fireball. This end of mission scenario, determined years ago, aims at disposing of the spacecraft without crashing on, and contaminating, one of Saturn's icy moons, where conditions suitable for life have been discovered.

Thirteen years after Saturn orbit insertion on 4 July 2004, the Cassini spacecraft has performed 295 orbits at varying inclinations, so as to provide the best vantage points from which to address the mission science objectives. The last 22 orbits of the mission, initiated on 23 April this year and called the Grand Finale, are an opportunity to make daring manoeuvres and trajectories bearing more risks, but also allowing a harvest of completely unprecedented scientific results in regions of the system never before explored. A last close flyby of Titan (nicknamed the farewell kiss) was performed on 22 April to modify Cassini's trajectory, providing the gravitational pull necessary to reduce the periapsis altitude to just 1.063 Saturn radii and cutting the orbital period to about a week. On this new trajectory, Cassini repeatedly crosses Saturn's ring plane through a 2,000-km-wide gap between the upper atmospheric layers of Saturn and the innermost D ring (pictured).



This artist's view shows the Cassini spacecraft diving through the gap between the upper atmosphere of Saturn and its rings, shielded by its High Gain Antenna.
Image credit: NASA/JPL-Caltech

The main science objectives of the Grand Finale include direct in situ sampling of the ring particle composition and of Saturn's exosphere and innermost radiation belts; probing the magnetic and gravity field in order to better understand the magnetic dynamo and interior structure of Saturn; measuring the relative abundance of various chemical compounds of Saturn's ionosphere; observing the upper atmosphere for molecules that escape the atmosphere itself and for water-based molecules originating from the rings; and constraining the total ring mass and observing its fine-scaled structures with the highest resolution possible.

The closest distance to Saturn, reached during each passage through the ring plane, ranges between 1,655 km and 3,910 km of Saturn's reference surface. The first few dives were performed with the High Gain Antenna (HGA) pointed forwards as a shielding measure. During later orbits where the protective measure is relaxed, the spacecraft is able to track Earth with its HGA, performing the radio science gravity experiment. These six passes probe the mass distribution within the interior of Saturn by very precisely measuring the gravitational pull experienced by the spacecraft. Two ESA deep space antennae are joining by the NASA Deep Space Network to provide the best signal-to-noise for those measurements. Unique inside-out views of the rings can also be acquired during such crossings, and instruments can examine the material populating the gap.

The 4.5 tonne spacecraft equipped with twelve instruments has revolutionized our view of Saturn's system, following the first glimpse provided by the Voyager flybys in the 1980s. The overall mission lifetime will have covered half of Saturn's seasonal cycle from northern winter to summer solstice, after two successive extensions of the nominal mission, called Equinox and Solstice. Monitoring the seasonal evolution of the different objects in Saturn's system has been key to many of Cassini's discoveries. Seasonal changes result in varying solar energy inputs that drive phenomena like the spokes in Saturn's rings, the changing weather patterns in Saturn's atmosphere like the giant storm of 2010, the change of Saturn's colour due to haze formation and Titan's methane cycle. The change in illumination conditions revealed the long-lived northern polar vortex with its exquisite details and the vertical structures in the rings, driven by gravitational perturbations of nearby moons, become visible only at equinox. The extended mission time was also crucial to track the evolution of small-scale dynamical features in the rings like the 'propellers', revealing that Saturn's rings may be the last place in the Solar System where accretion processes are still ongoing.

The Grand Finale may be the end of the mission, but Cassini's heritage is opening an area of advance for astrobiology, exposing the tantalizing prospect of habitability for life as we know it within oceans below the surfaces of icy moons, like Enceladus, around gas giant planets. As Cassini is plunging towards Saturn's atmosphere, the next missions to icy worlds are in the making: ESA's JUpiter ICy moons Explorer (JUICE) mission and NASA's Europa Clipper will explore the habitability of Jupiter's moons in detail. Both missions are heavily relying on Cassini–Huygens heritage at operational and scientific levels, of course. But they are also a human adventure to be lived by the next generation of planetary scientists who had the unique chance to grow up with Cassini–Huygens. ❒

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