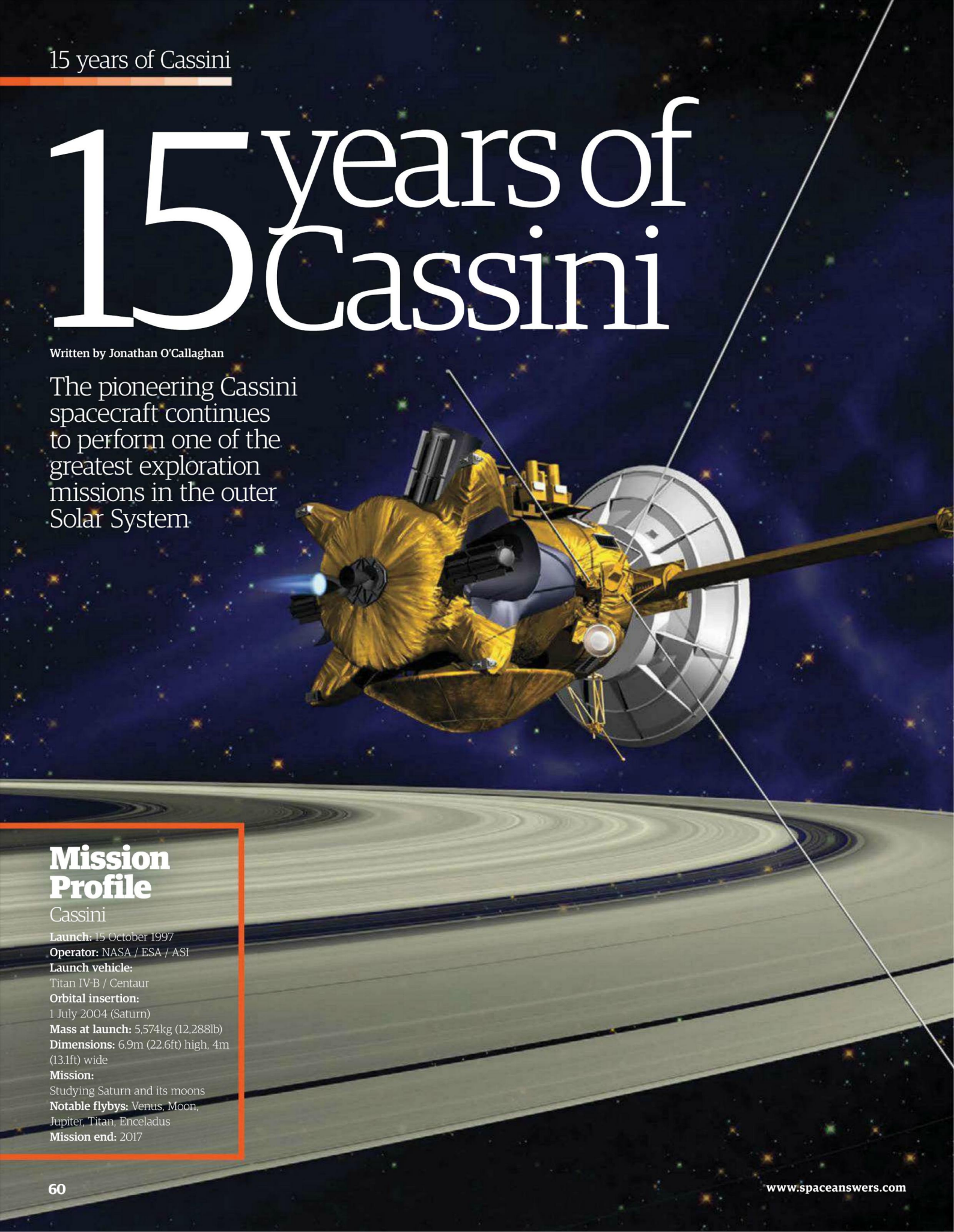
15 years of Cassini

Written by Jonathan O'Callaghan

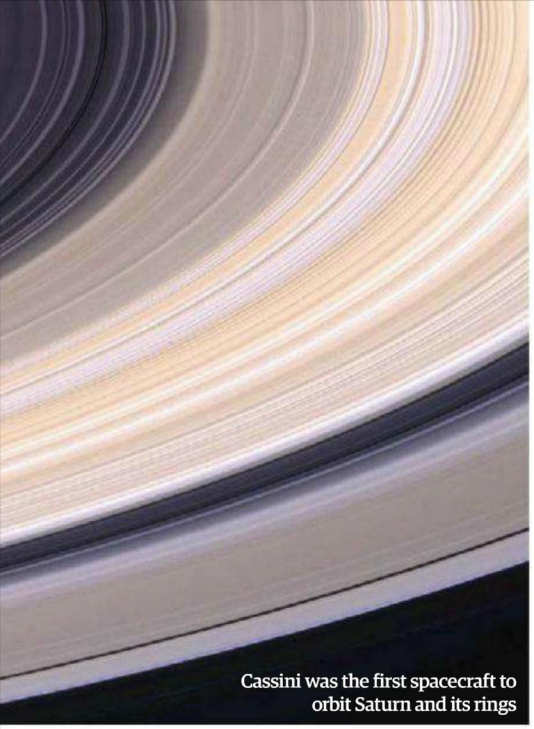
The pioneering Cassini spacecraft continues to perform one of the greatest exploration missions in the outer Solar System



Mission Profile

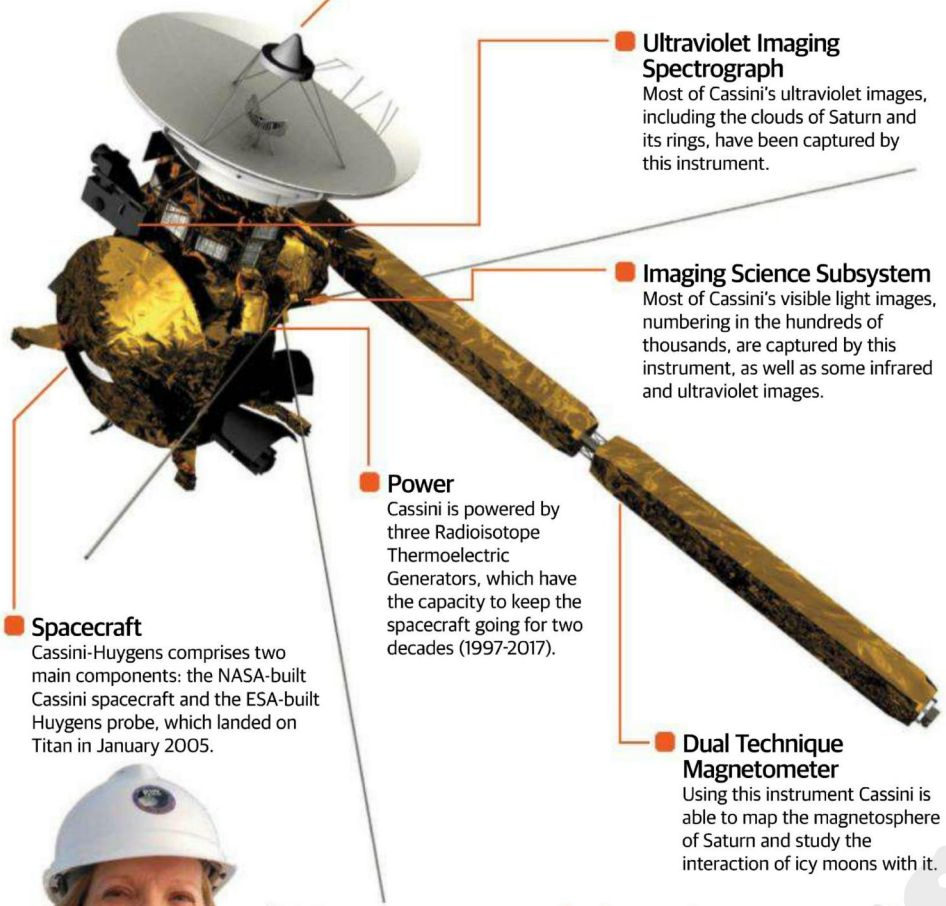
Cassini

Launch: 15 October 1997
Operator: NASA / ESA / ASI
Launch vehicle: Titan IV-B / Centaur
Orbital insertion: 1 July 2004 (Saturn)
Mass at launch: 5,574kg (12,288lb)
Dimensions: 6.9m (22.6ft) high, 4m (13.1ft) wide
Mission: Studying Saturn and its moons
Notable flybys: Venus, Moon, Jupiter, Titan, Enceladus
Mission end: 2017



Cassini was the first spacecraft to orbit Saturn and its rings

Inside the spacecraft



Communication
Cassini communicates with Earth by using its high-gain antenna. Its two low-gain antennas can also be used in emergency situations.

Ultraviolet Imaging Spectrograph
Most of Cassini's ultraviolet images, including the clouds of Saturn and its rings, have been captured by this instrument.

Imaging Science Subsystem
Most of Cassini's visible light images, numbering in the hundreds of thousands, are captured by this instrument, as well as some infrared and ultraviolet images.

Power
Cassini is powered by three Radioisotope Thermoelectric Generators, which have the capacity to keep the spacecraft going for two decades (1997-2017).

Spacecraft
Cassini-Huygens comprises two main components: the NASA-built Cassini spacecraft and the ESA-built Huygens probe, which landed on Titan in January 2005.

Dual Technique Magnetometer
Using this instrument Cassini is able to map the magnetosphere of Saturn and study the interaction of icy moons with it.

Our knowledge of Saturn's system today is far greater than it has ever been. We know that the planet itself has some extreme weather at its poles, we know how fast it rotates, and we know the characteristics of its atmosphere. We also know a lot about its moons, from the wet and wonderful world of Titan to the mysterious Iapetus with its giant equatorial ridge. However, were it not for the Cassini-Huygens mission, much of our knowledge of the Saturnian system would remain hidden away.

Launched 15 years ago on 15 October 1997, the Cassini-Huygens spacecraft (to use its full name, although only the Cassini orbiter is still operative) has greatly increased our understanding of Saturn, and in some parts Jupiter, and its surrounding moons. It was, and is, a mission jointly operated by NASA, the ESA and ASI (Italian Space Agency) to further our understanding of Saturn and its surrounding system like never before. While its seven-year journey to the second-largest planet in our Solar System included flybys of Venus, the Moon and Jupiter, the crux of its mission has focused around Saturn, and after becoming the first spacecraft to orbit the planet in 2004 it continues to operate nominally, constantly returning new data and images.

The mission itself has been a resounding success and highlights the benefits of an international endeavour to explore space. "Cassini is one of the greatest unmanned missions ever," NASA JPL's Cassini project scientist Dr Linda Spilker told **All About Space**. "Cassini's discoveries have implications not only for the Saturn system, but by extension for the other outer planets, and their icy moons and rings, as well as exoplanets orbiting other stars."

Indeed, findings by the Cassini orbiter have significantly helped to increase our understanding of water formation on many other celestial bodies and, as Dr Spilker says, the importance of finding ice on other worlds. "Cassini's discoveries have expanded the envelope of potentially habitable zones in our Solar System with the discovery of a liquid water reservoir on Enceladus, and a liquid water ocean under Titan's icy crust."

Of all the observations Cassini has made in its mission so far, Dr Spilker highlights the discovery of jets of water and icy particles on Enceladus as one of the most significant. "This unexpected discovery completely changed our thinking about activity on small bodies, as Enceladus is only 500 kilometres [310 miles] in diameter. A heat source and compounds that include carbon, hydrogen, oxygen and nitrogen in the liquid water reservoir underneath Enceladus's south pole provide a potentially habitable environment far from the Sun."

"No spacecraft has increased our understanding of the Solar System like Cassini has"

Dr Linda Spilker, NASA JPL's Cassini project scientist

In addition, the study of the Earth-like surface of Titan proved to be of huge significance, providing scientists with a look into an alien world that had many similarities to our own, and one that was the subject of the only ever landing in the outer Solar System. "The Huygens probe unveiled the surface of Titan for the first time," said Dr Spilker. "It revealed river channels and methane outgassing from the surface. Further Cassini explorations revealed north polar lakes, dunes, clouds and rainstorms on Titan." These continued observations brought about the realisation that methane on Titan plays the same role that water plays on Earth, adding to its Earth-like qualities. The likelihood of a liquid water ocean beneath its icy crust only heightened the intrigue, and has made Titan the predominant subject of Cassini's remaining five years of its mission.

"In the next five years Cassini will continue to follow seasonal change in the Saturn system, as well as follow up on new discoveries and continue to make additional discoveries," said Dr Spilker. "As the seasons change on Titan will the northern lakes begin to evaporate or remain unchanged? Will more storms develop in Titan's north polar region? Will a polar hood now form at Titan's south pole as winter approaches?" These are just some of the questions that the Cassini team hope their incredible spacecraft will answer before its mission ends in 2017.

However, even Cassini's finale will be magnificent, much like the rest of the mission. Dr Spilker told

us what would make its final moments so exciting: "Cassini will dive between the innermost D ring and the top of Saturn's atmosphere for a series of 22 orbits. It will map Saturn's magnetic and gravity fields to a much higher order than was possible from more distant orbits. The magnetic field data may reveal the internal rotation rate of Saturn for the first time, something we do not yet know. We will also measure the mass of the rings for the first time, key to understanding their age and origin. This end of mission is planned so Cassini will not inadvertently impact either Titan or Enceladus."

Cassini's end in 2017 will bring with it a situation where, for the first time since the arrival of the Galileo spacecraft at Jupiter in 1995, the outer Solar System will be devoid of any spacecraft. The next – the ESA's JUICE mission – is not scheduled to arrive at Jupiter until 2030, while there are no plans in advanced development to send another vehicle to Saturn. It's a situation that Dr Spilker regrets, especially with regards to encouraging younger generations to become involved in what is no doubt one of the most interesting and important areas of space exploration.

"The lack of an outer planet mission until JUICE's arrival in 2030 is very unfortunate for planetary science," said Dr Spilker. "In particular, the current young generation of outer planet scientists will not have any new data after Cassini and JUNO [NASA's Jupiter orbiter, which is due to arrive on a one-year mission in 2016]."

Whatever does, eventually, come after Cassini will have an extremely hard act to follow. 15 years and counting, no spacecraft has increased our understanding of the Solar System, particularly Saturn and its surrounding system, like Cassini has, and it still has five more years to blow our minds again with new discoveries and observations. While we've taken a look here at the highlights of its groundbreaking mission so far, its continuing work will help us unearth many more secrets of the Solar System and beyond. ●

On its journey to Saturn, Cassini required a number of GAMs (gravity assist manoeuvres) and flybys

A journey of discovery

1. 26 April 1998: Manoeuvres
Cassini's first flyby was of Venus in April 1998, and it performed a second one on 24 June 1999. It flew by Earth on 18 August 1999, taking calibration photos of the Moon in the process.

2. 30 December 2000: Jupiter flyby
Cassini's flyby of Jupiter lasted several months, during which it took about 26,000 images and made extensive studies of the planet.

3. 2004: New moons
As Cassini approached Saturn in 2004 it began to discover a number of new moons. These included two within Saturn's ring system: Daphnis and Pan.

4. 1 July 2004: Saturn orbit
After a series of complex manoeuvres, it was confirmed that Cassini had entered orbit around Saturn, the first spacecraft ever to do so.

5. 2 July 2004: Titan flyby
Cassini made its first flyby of Saturn's largest moon, Titan. On 25 December it released the Huygens probe, which landed on Titan in 2005.

6. 2005: Enceladus flyby
In 2005, Cassini performed two flybys of Saturn's moon Enceladus, and observed water ice geysers erupting from the south pole. This has been one of Cassini's major finds.

7. May 2005: Saturn's rings
Cassini measured the size of particles in Saturn's rings by positioning the rings between itself and Earth and transmitting radio signals through them.

8. 21 July 2006: Lakes of Titan
Radar images revealed what seemed to be lakes of liquid methane and ethane on Titan, the first time surface liquids had ever been found off Earth.

9. November 2006: Saturn hurricane
A storm 8,000km (5,000 miles) across was found by Cassini at Saturn's south pole, with winds approaching 560km/h (350mph).

10. 10 September 2007: Iapetus flyby
Flying just 1,600km (1,000 miles) above its surface, Cassini imaged the strange two-toned moon of Iapetus and its giant equatorial ridge.

11. 2008: Equinox mission
Cassini's mission was extended, named the Cassini Equinox Mission, and it began by observing the ejected plumes of cryovolcanoes on Enceladus.

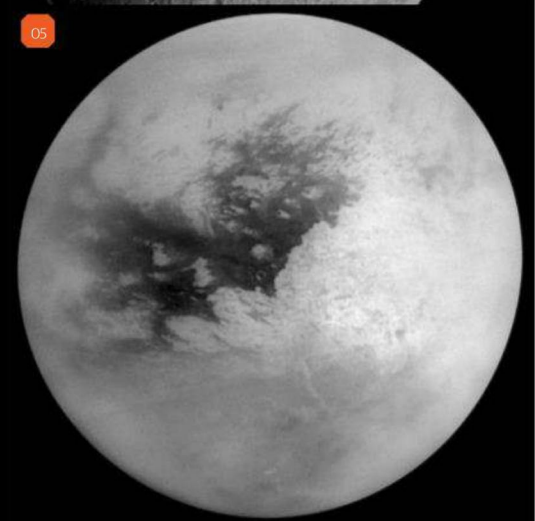
12. 2010: Solstice mission
Cassini's mission was again extended, this time named the Cassini Solstice Mission, until 2017. In late-2010, it observed Enceladus once more.

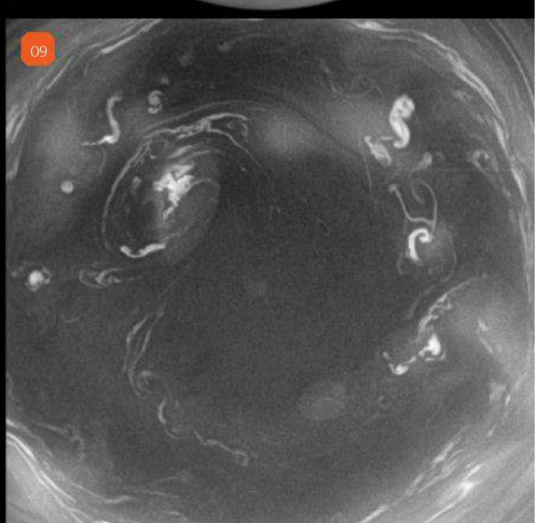
13. January 2011: Rhea flyby
Cassini flew within just 69km (43 miles) of the icy surface of Saturn's second-largest moon, Rhea.

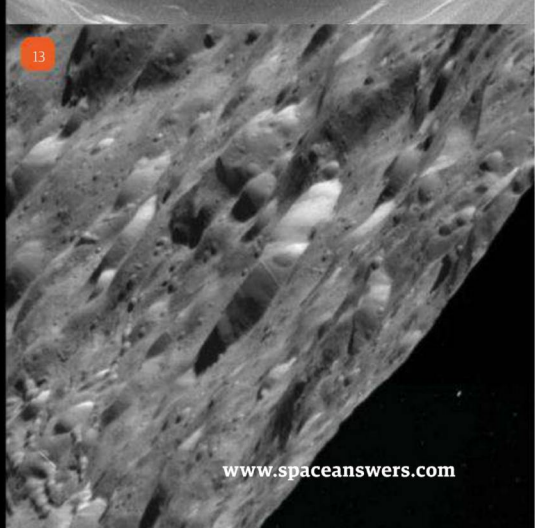
14. 2012-2015: Titan observations
Cassini will observe Titan for about four years, performing multiple flybys and imaging its surface in great detail, as well as observing other moons.

15. 2015-2016: Enceladus and Titan
In 2015, Cassini will perform flybys of Enceladus, Epimetheus, Prometheus (right in image, next to Mimas) and Aegaeon before returning to Titan.

16. 2017: Saturn impact
It has been decided to end the Cassini mission in 2017. To prevent it crashing on a nearby moon, it will be sent to burn up in Saturn's atmosphere.





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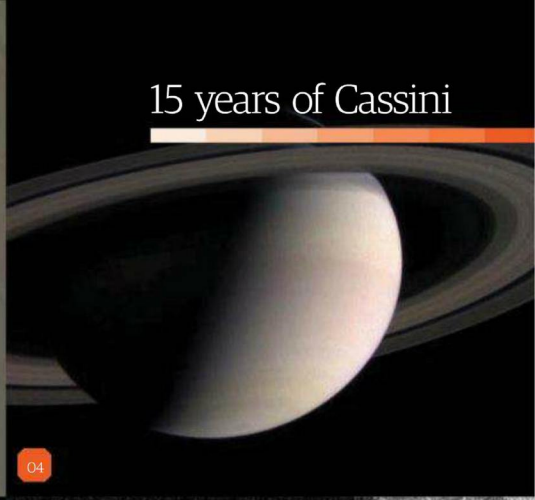
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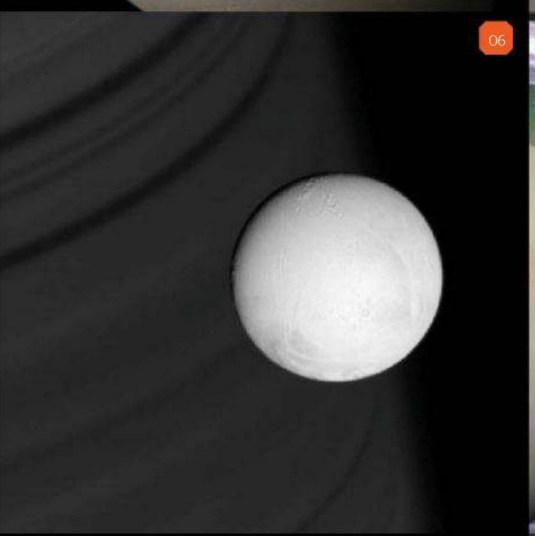
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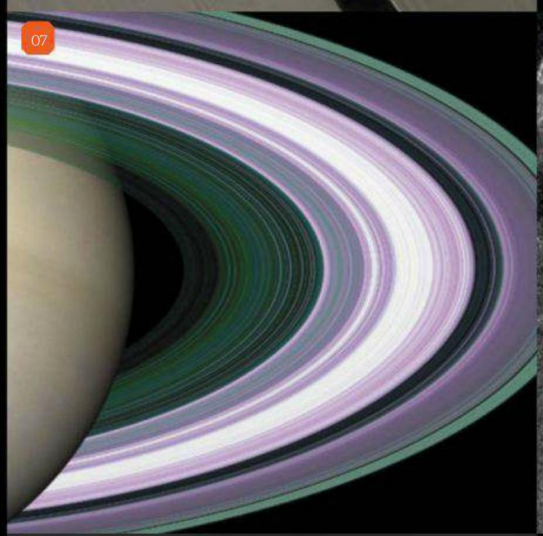
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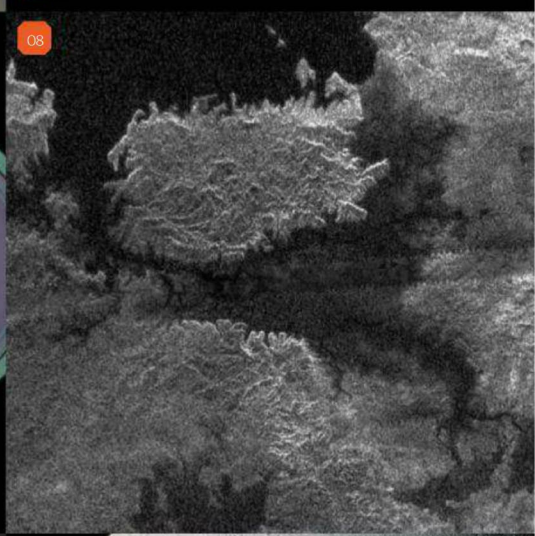
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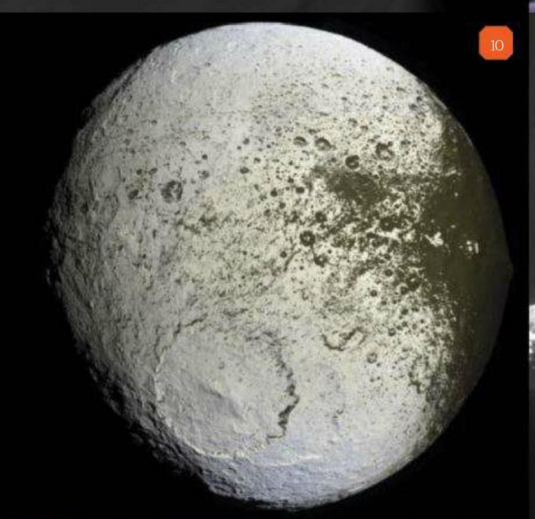
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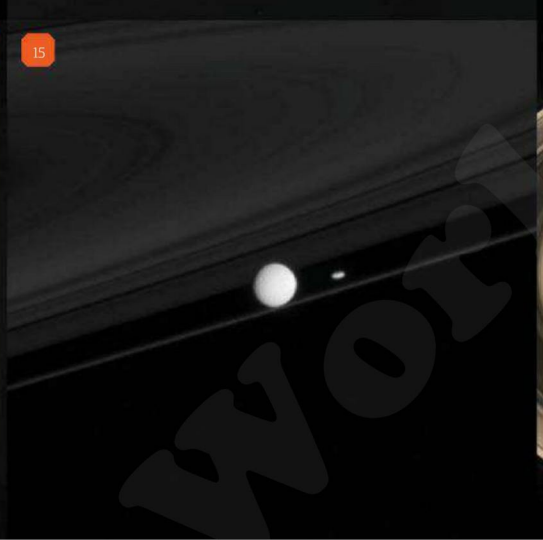
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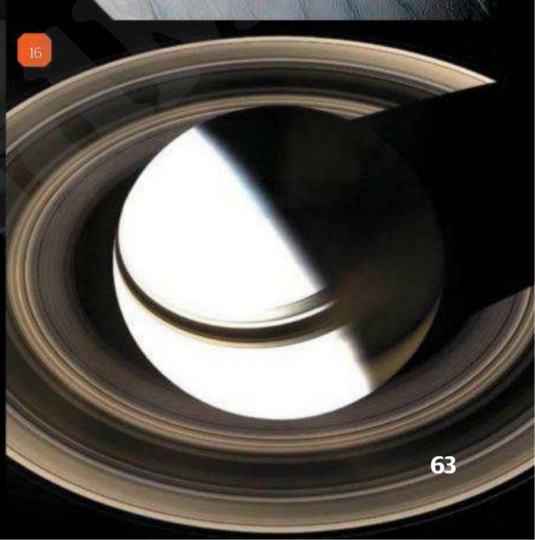
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The Huygens probe

Supplied by the European Space Agency (ESA), the Huygens probe provided us with our first chance to land on the surface of a world other than Venus, the Moon and Mars. It was an ambitious feat, aiming to traverse the somewhat unknown atmosphere of Titan before landing on the surface, be it water or solid rock. The probe could have landed on either, as little was known of this moon's surface.

The Huygens probe was attached to the Cassini orbiter for the majority of its seven-year trip to Saturn, during which it was dormant. Then, on Christmas Day 2004, the probe was released and sent on a collision course with Titan. It did not have its own propellant, so it was merely flung towards the moon by Cassini.

As the probe approached Titan, Cassini took images of its expected landing site and revealed that Huygens would be landing on what appeared to be a shoreline between rock and a possible liquid methane lake. The probe contained a number of scientific instruments including atmospheric sensors and a camera.

The probe used Cassini, at the time in the vicinity of Titan, as a relay between itself and Earth. Unfortunately, an operational commanding error meant that half of Huygens' data, including 350 images, were lost. However, from its descent it still managed to return incredible images of its journey all the way to the surface, which turned out to be partially solid rock similar in consistency to crème brûlée.

Huygens was a milestone in space exploration, one that has not and will not be repeated for many years.

Taken by Cassini, this image shows Titan's atmosphere

Landing on Titan

1. Atmosphere
On 14 January 2005, about four weeks after separating from Cassini, the Huygens probe first entered Titan's atmosphere.

2. Heatshield
The probe's heatshield bore the brunt of 14g of deceleration as Huygens slowed from 20,000 to 1,400km/h (12,500 to 870mph).

3. Parachute
About 160km (100 miles) above the surface of Titan a pilot parachute pulled off a cover that released the main parachute.

4. Jettisoned
Huygens' now-burnt heatshield was jettisoned, allowing the instruments on the probe to study the atmosphere and image the ground.

5. Images
As it descended, the probe's Descent Imager/Spectral Radiometer (DISR) took hundreds of photos of the ground.

6. Second parachute
110km (68 miles) above the surface, Huygens jettisoned its main parachute and used a smaller parachute to complete the two-and-a-half-hour descent.

7. Lamp
A few hundred metres above the ground, the DISR switched on a lamp that allowed the probe to illuminate the ground and examine surface material.

8. Landing
The probe landed at a 'leisurely' 5m (16ft) per second and returned images and data from the surface of a world in the outer Solar System for the first time.

> "It did not have its own propellant, so it was merely flung towards the moon by Cassini"