German Aerospace Center

Milestones in space: Five years ago the European Huygens space probe landed on Saturn's moon Titan

09 June 2011

Results of the current Cassini-Huygens mission are documented in two books – DLR scientists map the icy moons and describe their geology

Five years ago, on 14 January 2005, the Huygens probe floated through the atmosphere of Saturn's moon Titan suspended on parachutes and, two-and-a-half hours later, landed gently on the surface, which is at a temperature of minus 180 degrees Celsius. From there, it transmitted several hours of measurement data to the Cassini mother probe. Two new books, in which scientists from the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) have had significant involvement, bring together the results of the Huygens landing and the first four years of the Cassini spacecraft in orbit around Saturn.

The volumes 'Saturn from Cassini-Huygens', edited by Michele Dougherty, Larry Esposito and Stamatios M. Krimigis and published by Springer Dordrecht Verlag (Heidelberg, London, New York, 2009), and 'Titan from Cassini-Huygens', edited by Robert Brown, Jean-Pierre Lebreton and Hunter Waite and published by Springer Dordrecht Verlag (Heidelberg, London, New York, 2010), set the standard for Saturn research in the coming decade.

The bold manoeuvre of the Huygens probe was also the first landing of a space probe on a body in the outer Solar System. It took almost 90 minutes for radio signals to travel the 1.4 billion kilometres back to Earth. When the measurements from the experiments, the pictures of the probe’s descent and, finally, of the surroundings of the landing site arrived in Darmstadt, there was no end to the celebrations. In amazement, the scientists and over a hundred media representatives looked at the branching system of valleys through which ice-cold liquid hydrocarbons must have flowed. Blocks of ice, rounded by a flowing medium, lay in front of the probe. "The Huygens landing represented an exceptional success for European space exploration, and, above all, planetary research," Prof. Ralf Jaumann, from the DLR Institute of Planetary Research in Berlin, recalls.

Cassini-Huygens – journey to the alien, icy place that is the outer Solar System

"Since its arrival at Saturn in mid-2004, Cassini-Huygens has probably been the most exciting project in current planetary research – the mission, with its twelve experiments, keeps us in a constant state of excitement," Prof. Jaumann reports. "This mission has given us a much more precise picture of this alien region of giant gaseous planets in the outer Solar System – and their icy moons. Many things are new and unfamiliar, but the basic geological processes are similar to those on Earth - even if the ingredients are exotic," the planetary geologist and Cassini expert explains. Since 4 July 2004, Cassini has orbited Saturn more than 120 times. Another close Titan flyby, at a distance of 955 kilometres, occurred on 12 January 2010.

Other than Earth, Titan is the only body in the Solar System that has liquids on its surface. Its thick nitrogen atmosphere hides 'lakes' of liquid hydrocarbons such as methane and ethane. These hydrocarbons circulate like water on Earth in a cycle of evaporation, rain and drainage systems. DLR researchers recently demonstrated for the first time that a very large lake in Titan's north polar region is filled with liquid hydrocarbons.

Two books combine the collected knowledge into a new picture of the Saturn system

The Cassini probe and the landing of the Huygens atmospheric capsule on Titan are the basic elements of the joint American and European Cassini-Huygens mission. Both space probes

have literally redrawn the picture of this mysterious moon. The book 'Titan from Cassini-Huygens' presents for the first time an overall picture of Titan using the knowledge acquired from the Huygens landing and the Cassini flybys.

'Saturn from Cassini-Huygens' was published in parallel, drawing together on 805 pages the results of the Cassini orbiter's journey around Saturn, its rings and the other icy moons. More than 250 scientists from the USA, Europe and many other countries are directly involved with Cassini and Huygens. Now, these scientists have published for the first time all the results obtained since the arrival of the two probes.

DLR scientists were responsible for describing the geology of the icy moons – with the emphasis on Titan – as well as mapping the nine large icy moons. "Precise maps of all these bodies are one of the most important requirements for finding the answers to scientific questions," Prof. Jaumann explains. "Researchers can use them to investigate the scope of ice volcanism on mysterious Enceladus, how the strange light-dark division on the surface of Iapetus might be explained, why this moon has an up to 20-kilometre high mountain range along its equator, what causes the peculiar cracks on Tethys, Dione and Rhea, or how the 'lakes' on Titan are geographically distributed – to name but a few of the innumerable exciting topics."

Ali Baba: DLR cartographers use names from 'Arabian Nights' for new structures

The atlases for the large icy moons are being created under the direction of DLR physicist Dr Thomas Roatsch, using the images from the Cassini camera system. "We are constantly improving the maps of the moons," Dr Roatsch explains, "because the long duration of the mission means that there are repeated close flybys. These regularly give us new, detailed image data."

More precise pictures and maps reveal new surface phenomena. In planetary cartography, these are assigned names in accordance with specific rules made by the International Astronomical Union (IAU). "For Enceladus, characters and places from Arabian Nights were chosen for this purpose," Roatsch explains. So there is one map for the area of the northern polar region, for example, which is called Sindbad following DLR proposals and there are regions with the names Shahrazad (Scheherazade) and Ali Baba.

Cassini Saturn mission remains in 'equinox phase' until September - multi-year extension envisaged

Currently 61 moons of Saturn are known. Most of these moons are blocks of ice just a few kilometres across, but Titan, with a diameter of 5,150 kilometres, is the second largest satellite in the Solar System after Jupiter's moon Ganymede, and the only one with a dense atmosphere. It is, therefore, one of the most interesting objects in planetary research.

Cassini-Huygens is a joint project of NASA, the European Space Agency (ESA) and the Italian space agency ASI. The Jet Propulsion Laboratory (JPL) in Pasadena (California) is carrying out the mission for the NASA Science Directorate. The Cassini orbiter was designed, developed and built at JPL.

In Germany, DLR, the Max Planck Society (Max-Planck-Gesellschaft; MPG), several universities and the German aerospace industry are scientifically involved in this mission. The main German contribution to the experiments on the Cassini orbiter consists of the provision of the cosmic dust analyser to investigate minute particles in space. The dust analyser investigates electrical charge, speed, course, mass and chemical composition. The mechanical components of the instrument were manufactured at DLR in Berlin under the direction of Dr Franz Lura.

Germany's financial contribution to the mission is about 120 million Euro. In this context, the DLR Space Agency has continuously supported the German contributions with funds from the federal government. The mission was extended for the first time in mid-2008 and christened 'Cassini Equinox Mission' because of the period on Saturn when day and night are equally long; it will officially end in September 2010. Further extensions of the mission are in prospect - until 2017 - and are being intensively prepared by NASA and the scientists involved.

On 14 January 2005 the Huygens atmospheric capsule landed on Saturn's moon Titan

One of the most exciting experiments in researching the Solar System with robotic space probes took place on 14 January 2005, when the European measurement capsule Huygens made a two-and-a-half hour flight through Titan's atmosphere and subsequently landed on the icy surface of the moon. The picture is an artist's impression of the landing site. A mechanism ejected Huygens from the NASA Saturn orbiter Cassini on 24 December 2004. Huygens started a three-week 'ballistic' – that is, not using a propulsion system – descent towards Titan. When Huygens got to the outer reaches of the dense nitrogen atmosphere, the atmosphere of the moon slowed down the probe. In the course of this deceleration, the protective shield of the capsule was heated to 1,500 degrees Celsius. One hundred and eighty kilometres above the surface, the first, two-and-a-half-metre diameter parachute pulled off the heat shield as planned. Immediately afterwards, a second parachute, with a diameter of more than eight metres, opened so that Huygens' fall was further slowed and the capsule – now a plaything of Titan's winds – floated through the atmosphere. The probe collected and analysed its first samples of the atmosphere and started acquiring images. The second parachute was released at a height of 125 kilometres. A third parachute allowed the probe to float downwards through the clouds. On 14 January 2005 at 12:38 Central European Time, Huygens landed on the surface of Titan, which is at a temperature of minus 180 degree Celsius. The measurement data and images from the landing site were first transmitted to Cassini and from there to Earth. Rounded ice blocks are visible which were presumably ground down by a flowing medium. After a few hours, the radio signals from a scientifically and technically magnificent mission ceased as expected.

Credit: ESA.

The 16 largest moons of Saturn shown to scale

The four largest gaseous planets Jupiter, Saturn, Uranus and Neptune are frequently described as 'miniature solar systems' because numerous moons of various sizes and characters orbit them. Currently, the largest number of satellites can be founded around Saturn – in 2009 the International Astronomical Union (IAU) counted 61 moons. Although most of the moons only have diameters of a few kilometres, with Titan, Saturn is orbited by the second largest moon in the Solar System at a distance of something over 1.2 million kilometres. Its diameter of 5,150 kilometres is significantly greater than that of the Earth's moon (3,476 kilometres). As a result of its size and mass, Titan is able to retain a dense atmosphere of nitrogen and gases such as methane and ethane. It displays some similarities with the early atmosphere of the Earth. This made Titan one of the most interesting objects in planetary research and the destination of the European Huygens atmospheric and landing capsule, which landed on Titan on 14 January 2005. Only at wavelengths close to infrared (such as in this image) or when flying over its surface can coarse structures be identified on cold moon, whose surface is at a temperature of minus 180 degrees Celsius. Saturn's large moons also include Rhea, Iapetus, Dione, Tethys, Enceladus, Mimas, Hyperion and Phoebe. The DLR Institute of Planetary Research in Berlin is creating the up-to-date atlases and maps of these moons as part of the Cassini project. The smaller moons shown here – Janus, Epimetheus, Prometheus, Pandora, Atlas, Helene and Telesto – were imaged as part of the Cassini mission during non-targeted flybys, sometimes at great distances. All of them are located in gaps between Saturn's rings or slightly outside them.

Credit: NASA/JPL/Space Science Institute.

'Titan from Cassini Huygens' provides a first overall picture of the satellite

The Cassini probe, which has been orbiting Saturn since July 2004, and the landing of the Huygens atmospheric capsule on Titan are the basic elements of the joint American and European Cassini-Huygens mission. Both space probes have literally redrawn the picture of this mysterious moon. The book 'Titan from Cassini-Huygens' presents for the first time an overall picture of Titan using the knowledge acquired from the Huygens landing and the Cassini flybys. DLR planetary researcher Prof. Ralf Jaumann is the senior author of the chapter 'Geology and Surface Processes on Titan'.

Credit: Springer Science + Business Media.

DLR scientists are co-authors of the book 'Saturn from Cassini-Huygens'

The results of the Huygens landing and the first four years of the Cassini spacecraft in orbit around Saturn have now been compiled in two books in which scientists from the German Aerospace Center (DLR) have had significant involvement. The volume 'Saturn from Cassini-Huygens' was edited by Michele Dougherty, Larry Esposito and Stamatios M. Krimigis and published by Springer Dordrecht Verlag (Heidelberg, London, New York, 2009). The DLR planetary geologist Prof. Ralf Jaumann is the senior author of the chapter 'Icy Satellites: Geological Evolution and Surface Processes'. Together with DLR planetary researcher Dr Katrin Stephan, Prof. Jaumann was also involved in the chapter 'Cartographic Mapping of the Icy Satellites Using ISS and VIMS Data'. Over 805 pages, 'Saturn from Cassini-Huygens' describes the results of the Cassini orbiter regarding Saturn, its rings and the icy moons. More than 250 scientists from the USA, Europe and many other countries are directly involved with Cassini and Huygens.

Credit: Springer Science + Business Media.

Precise maps of Saturn's moons as the basis for scientific work

As is the case for geoscientists on Earth, it is of fundamental importance for planetary researchers to have precise maps of the areas they are investigating. The creation of global image mosaics and atlases of the icy moons is therefore an important long-term project of the Cassini mission. The Cassini team at the DLR Institute of Planetary Research in Berlin uses the images from the camera system on the Cassini space probe for this purpose. The system has collected image data from various distances during the numerous flybys of Saturn's large icy moons. The example shows a map sheet from the northern hemisphere of the icy moon Enceladus at a scale of 1:500,000; this means that one centimetre on the original map sheet (105 centimetres by 75 centimetres) corresponds to five kilometres (500,000 centimetres) in reality. This representation is referred to in cartography as the 'Lambert conformal conic projection'. Enceladus has a diameter of 504 kilometres and is of particular interest to planetary researchers because of its 'cryovolcanic' ice eruptions, which are ejected into space from the southern polar region. The map is called 'Shahrazad' (Scheherazade). DLR cartographers give all surface phenomena on Enceladus, such as craters, plains or fissures, names from the oriental tales of the Arabian Nights – following rules set by the International Astronomical Union (IAU). Shahrazad is the storyteller in these tales.

Credit: NASA/JPL/DLR/Space Science Institute.

Equal length of day and night on Saturn: the start of spring in the northern hemisphere

As with the Earth, the rotational axis of Saturn, the second largest planet in the Solar System, is inclined with respect to the plane of its path around the Sun. This means that in the almost 29 (Earth) years and 164 days that Saturn requires to orbit the Sun once, there are also seasons on this celestial body. For half a 'Saturn year' – that is, almost 15 Earth years – the southern hemisphere receives the greater amount of sunlight and for 15 years the northern hemisphere is more brightly illuminated. However, the quantity of the Sun's energy that the planet receives at a distance of something over 1.4 billion kilometres from the Sun is only one ninetieth of that received on Earth. In August 2009, Saturn passed through the vernal equinox – that is, for a virtual observer on the clouds of Saturn, the Sun appeared to cross the celestial equator. The southern summer has come to an end and after 11 August 2009, when day and night were of equal length – known as the equinox – spring started in the northern hemisphere. At the time of the equinoxes, the Sun shines precisely on the edge of Saturn's rings, which surround the planet at its equator. This rather rare astronomical event is something worth celebrating – not just for observers on Earth with their telescopes – because at that time the edge of the plane of the rings is seen as a small line. For the Saturn orbiter Cassini, too, the way that the light falls across the disc at a very shallow angle offers exceptional possibilities for observation, producing special scientific results regarding the structure and dynamics of the rings. At a distance from Saturn of approximately 847,000 kilometres and a viewing angle of 20 degrees above the surface of the rings, Cassini’s wide-angle camera acquired a sequence of 75 images one-and-a-half days after the equinox in 2009, producing this image mosaic of Saturn, its rings and some of its moons. The scale of the picture is 50 kilometres per pixel. The unusual lighting geometry means that the rings appear very dark. In contrast, the structures outside the plane of the rings

are unusually bright and throw long shadows across the rings. In addition, the shadows of Saturn's extensive rings appear at the equinox as a single, narrow band on the planet.

Credit: NASA/JPL/Space Science Institute.

Contact details for image and video enquiries as well as information regarding DLR's terms of use can be found on the DLR portal imprint.