Exploring Saturn

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Topfoto

You're a long way from home. You've been asleep for 7 years during a journey with your sister, Cassini. *Now you have woken and you are alone, falling to a strange moon called Titan. You face a 2½ hour descent through cold orange smog. When you hit the surface below you'll either sink in a curious sea or be smashed by solid ground. Either way, your batteries will soon fail and all your systems will shut down for ever. It's tough being a robot space probe called* Huygens.

Huygens and *Cassini* are two spacecraft on a mission to explore Saturn and its moons. *Huygens* is planned to fall onto Titan, one of Saturn's moons. While it falls, it will gather all sorts of information. It is equipped with cameras of different sorts, chemical sensors and temperature sensors. *Huygens* has radio transmitters to send the information back up to *Cassini* which will remain in orbit round Saturn. *Cassini* will transmit the information back to Earth, and we'll find out much more about Titan.

Box 1 *Cassini-Huygens* science milestones

26 October 2004	Flyby of Titan
13 December	Flyby of Titan
15 December	Flyby of Dione
25 December	Release of *Huygens* probe
1 January 2005	Orbiter flyby of Iapetus
14 January	Descent of *Huygens* probe to surface of Titan
15 February	Flyby of Titan
17 February	Flyby of Enceladus
9 March	Flyby of Enceladus

Further flybys of Titan on: 31 March, 16 April, 22 August, 7 September, 28 October and 26 December 2005.

The rings of Saturn

The *Cassini-Huygens* mission is named after two scientists, one Italian and one Dutch, who worked more than 300 years ago. With their telescopes, a brand new technology of the time, they were able to see more than others had seen before.

Above: *An artist's impression of* Cassini-Huygens *orbiting Saturn*

Each instrument on *Cassini-Huygens* is managed by a principal investigator. Two of these are from the UK: Dr Michele Dougherty from Imperial College London and Professor John Zarnecki of the Open University. Watch out for them on television!

GCSE key words
Gravity
Orbits
Satellites
Sensing

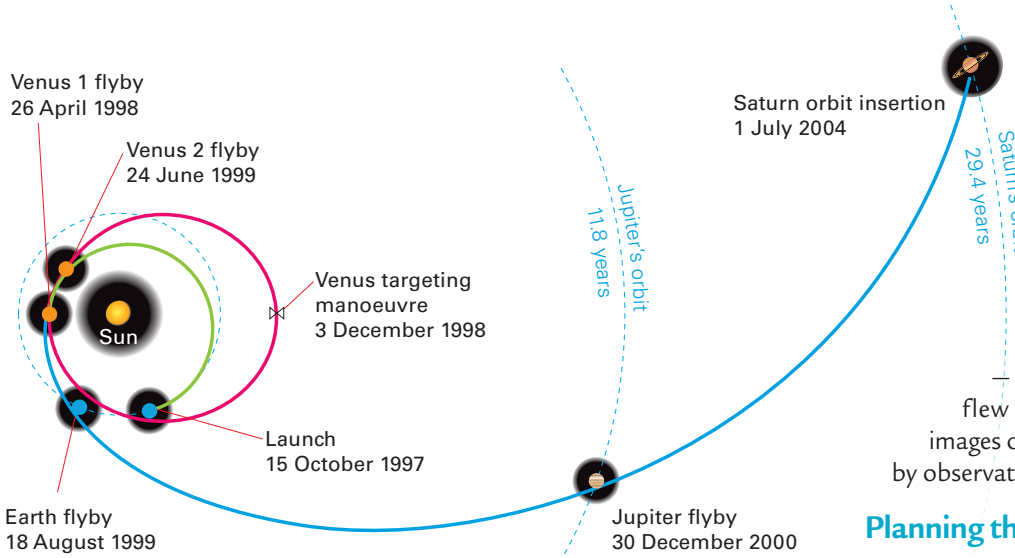


Figure 1
The journey to Saturn

In the 1650s Christiaan Huygens made his own telescope specially for the study of Saturn. He suggested that the shapes others had already seen around Saturn were a solid ring. He even found a moon of Saturn, which we call Titan. Giovanni Cassini discovered two more moons in the 1670s — Iapetus and Rhea. A few years later he found a dark line dividing the ring into two halves — inner and outer. We call it the Cassini division.

Debate over the nature of the rings went on for 300 years. Some people believed the rings were solid, others that they were made up of fragments. There was no way of knowing which was true. In the middle of the nineteenth century the great Scottish mathematical physicist, James Clerk Maxwell, did some complex maths which suggested that solid rings could not exist. They'd break up into fragments under the effects of gravity and their own motion. But it wasn't until the space missions of the late twentieth century — *Pioneer 11*, *Voyager 1* and *Voyager 2* — flew close to Saturn and radioed back images of the rings that the debate was resolved by observation. The rings are made of fragments.

Below: *An artist's impression of the* Huygens *probe landing on Titan. It's purpose is to investigate the atmosphere and it may not survive the landing*


ESA/SPL

Planning the mission

The *Pioneer* and *Voyager* missions provided some answers, but there are still a lot of questions. Is the weather on Saturn like the weather on Earth? What is Saturn like under its outer layers of clouds? How does the planet's magnetism affect its atmosphere? Why are the rings so complicated? Why and how do they change? Are the chemicals in Titan's atmosphere like the chemicals of life on Earth? Does Titan have solid continents and liquid seas? What are Saturn's other moons made of apart from ice? Questions, questions.

The *Cassini-Huygens* mission has been planned to provide some answers. It's a truly international project — a collaboration between European and American scientists who will share their work and their ideas for years to come. They decided to send a two-part spacecraft. At the end of 2004 *Huygens* will separate from *Cassini*, and begin its tumble to Titan, arriving in January 2005. For 4 more years the *Cassini* orbiter will stay in orbit round Saturn.

The journey to Saturn

When we look at it from Earth, Saturn is just a bright dot in the sky. How do you launch a spacecraft and get it to arrive at that dot? With careful planning!

Box 2 Unknown Titan

We already know that Titan's atmosphere is mostly nitrogen, just like the Earth's. And the Hubble Space Telescope detected infrared radiation from Titan's surface. The radiation was patchy, so the surface could be patchy. Perhaps some is solid and some is liquid.

The temperature on Titan is about 180°C below the freezing point of water. Any water there will be frozen. But there seem to be ever-changing clouds of methane. It is possible that beneath the clouds and haze there are lakes of ethane. The chemistry of these clouds and lakes could be complicated enough to form some of the chemical building blocks of life — the things that we are all made of. *Cassini* and *Huygens* will find out more.

Box 3 Unknown Saturn

Saturn is a ball of gas, mostly hydrogen and helium with traces of water, methane and ammonia, becoming denser towards its centre. It probably has a deep rocky core surrounded by a layer of liquid metallic hydrogen. There are other uncertainties, like the cause of the colours in the planet's clouds.

Saturn's magnetic field is not understood very well either. The *Cassini* orbiter will study the field, to find out more so that we can compare it with Earth's magnetism. The gravity of the moons pulls on the fragments of the rings. Some of the moons even seem to 'shepherd' fragments to create patterns in the rings. *Cassini* will provide information to help us understand whether the rings themselves were once a moon that shattered into fragments long, long before there were people to look at the planet and wonder.

The *Cassini-Huygens* mission was launched in 1997, and went into orbit round Saturn in July 2004. It didn't just have to escape from the Earth's gravity, but had a long, long trek away from the Sun. All that time, the Sun's gravity was pulling it towards the centre of the solar system.

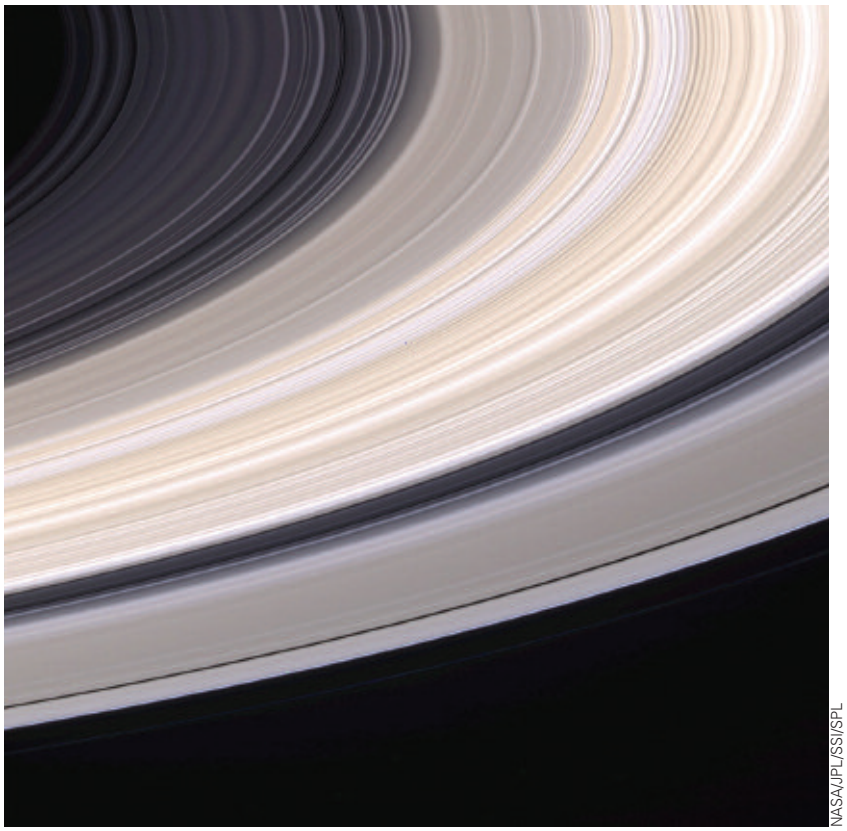
To give the spacecraft enough energy to overcome that inward pull, the planners decided to steal a little energy from the motions of other planets. So they sent it off in the 'wrong' direction — inwards through the solar system to the orbit of Venus. It flew past Venus and took energy from its motion, thanks to the gravitational pull of the planet. Then it did it again, faster than before. It came hurtling back towards the Earth, and in 1999 it flew past, taking a little energy from our orbital motion just as it had done from Venus.

Now it was going at a much higher speed than a launch rocket could ever have given it. And it flew onwards and outwards, but still not directly towards Saturn. It flew past Jupiter, and used the same energy-stealing trick once more, before heading out on the last part of its journey.

Cassini will orbit Saturn at a distance of about 1.5 million km, a similar distance to the radius of Titan's orbit, and well beyond the outer reaches of Saturn's rings.

Instruments and information

Some of the cameras on the two spacecraft can sense visible light, and some can sense other parts of the electromagnetic spectrum. *Cassini*'s imaging science subsystem, for example, has two digital cameras, one for wide-angle shots and one for details of small areas. But unlike your eyes, these cameras can also produce images from ultraviolet and infrared radiations. Meanwhile the composite infrared spectrometer detects infrared radiation emitted by Saturn's layers, rings and moons.



NASA/JPL/SSI/SPL

Above: *An image of Saturn's rings from the* Cassini *spacecraft, taken in June*

Box 4 Weblinks

The European Space Agency's website will give you up-to-date information on the progress of the mission: http://www.esa.int and click on the *Focus on…Cassini/Huygens* button once it is loaded.

SEDS is a student-run site; try searching it for images of Saturn and Titan — there are a lot! http://www.seds.org

A radar system will make maps of Titan as *Cassini* flies past, and other radio waves will travel through the atmosphere and the rings of Saturn to explore their structures. All the information will travel for more than an hour at the speed of light to sensitive radio antennae here on Earth.

Doing the science

More than 200 scientists around the world will work on the data that arrive at the radio antennae. They will be experts in different fields: atmospheric chemistry, weather systems, the unsolved questions of planetary magnetism, the complex dynamics of the motions of Saturn's many moons and the fragments of the rings. As they solve the riddles posed by the new information they will develop new ideas and new techniques. These will increase human understanding of our solar system, of the Earth and of ourselves.

David Brodie *has written many books and articles for school students.*