more

Further Information

If you would like to know more about Saturn and the Cassini-Huygens mission, the following resources may help.

World Wide Web sites

The UK Cassini-Huygens mission home page
www.ssd.rl.ac.uk/news/cassini/

The Cassini-Huygens mission home page
www.jpl.nasa.gov/cassini

NASA home page
www.nasa.gov/

Books

Patrick Moore
Philip's Atlas of the Universe
G. Philip 1994

David Levy
Stars and Planets
Macdonald 1996

Nicholas Booth
Exploring the Solar System: new views of the solar system
G. Philip 1995

Seymour Simon
Saturn
A&C Black 1991

CD-ROMs

Nine Worlds, Palladium Interactive/Omnimedia 1997

The Universe Beyond, Mindscape 1997

Red Shift 2, Maris 1995

PPARC also publishes information on a variety of topics related to physics and astronomy, to help increase public awareness of the UK's achievements in science and technology. Find out more by visiting the PPARC World Wide Web site:
www.pparc.ac.uk

Particle Physics and Astronomy Research Council

The Cassini-Huygens mission is a good example of the many world-class achievements made by physicists and astronomers in the UK. The Particle Physics and Astronomy Research Council (PPARC) is the UK Government-funded body that exists to support research in basic science:

- **Particle Physics**
- **Astronomy**
- **Space Science**

This support is provided by funding UK researchers and by ensuring that they have access to world-class facilities in the UK and overseas. The Council pays the UK's subscription to the science programmes of the European Laboratory for Particle Physics (CERN) and the European Space Agency (ESA).

PPARC recognises the importance of its science in assisting wealth creation; in post-graduate training; and in motivating young people towards an interest and career in science generally.

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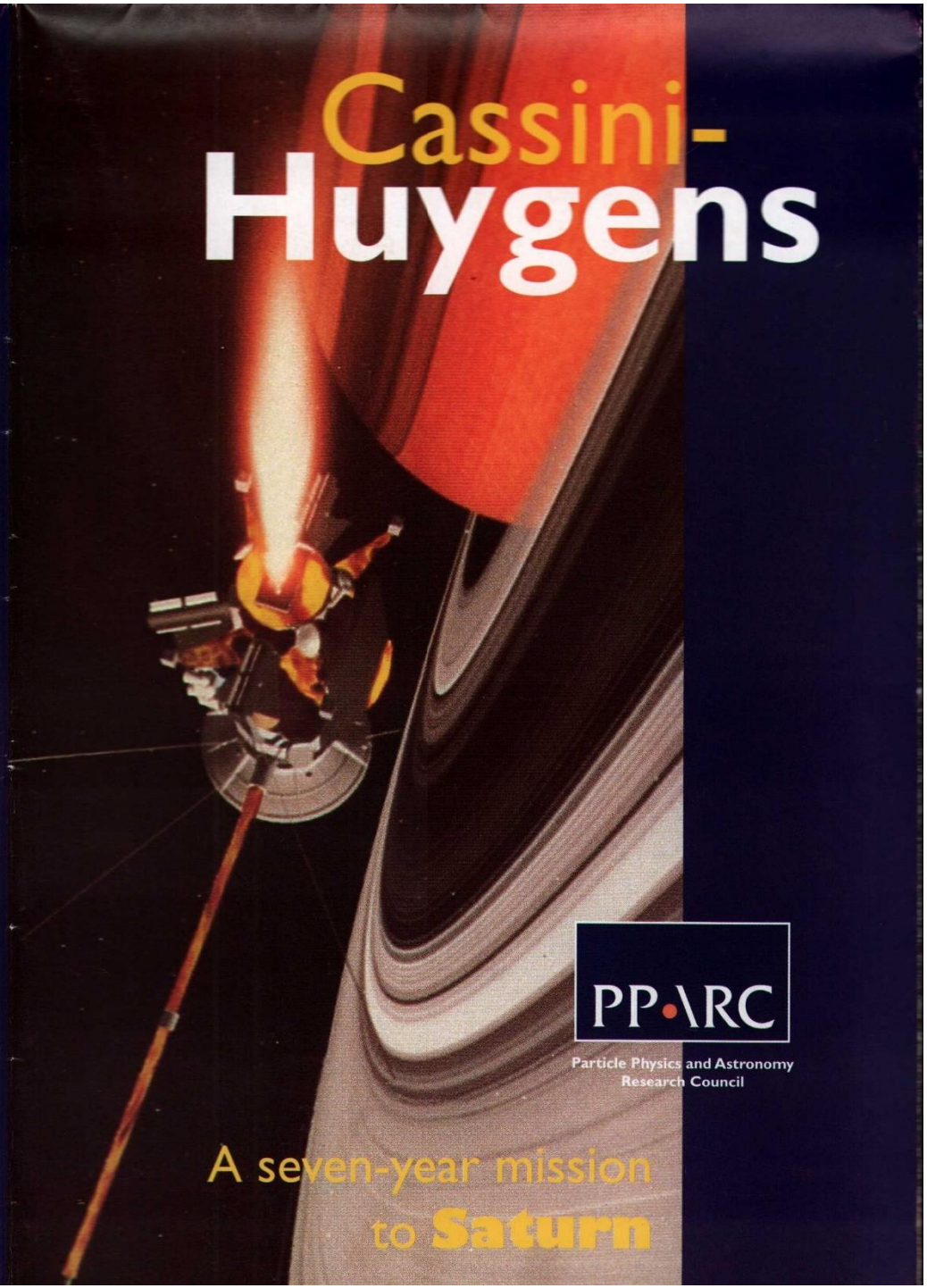
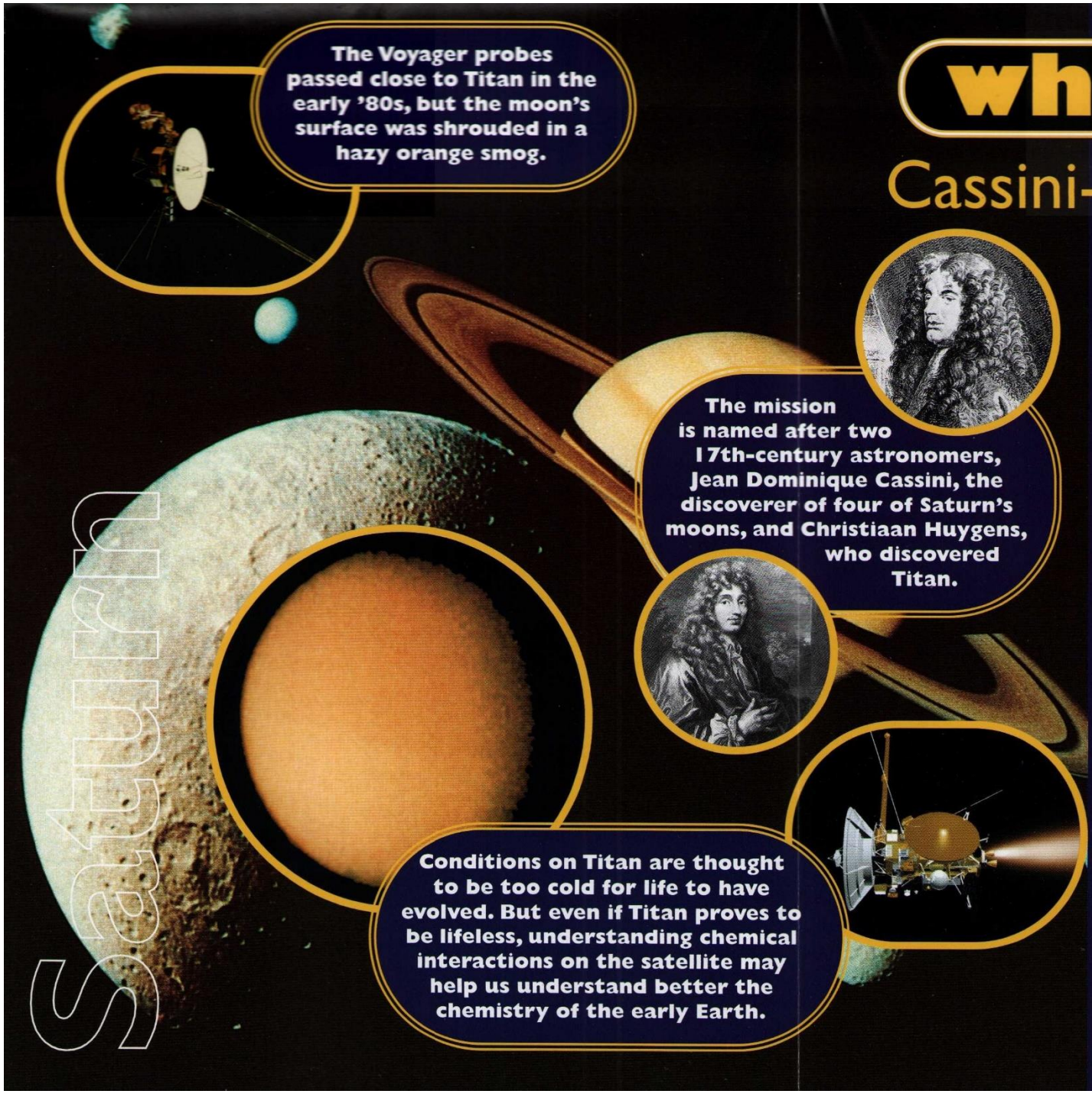
Cassini-Huygens



PPARC

Particle Physics and Astronomy Research Council

A seven-year mission to **Saturn**



what is Cassini-Huygens?

Cassini-Huygens is a space mission that will travel more than 3 billion kilometres to study Saturn and the planet's main moon, Titan, which boasts organic chemistry that may hold clues to how life formed on the primitive Earth. The mission will also investigate Saturn's rings and its magnetosphere – the space around Saturn affected by its magnetic field – as well as the planet's smaller icy moons.

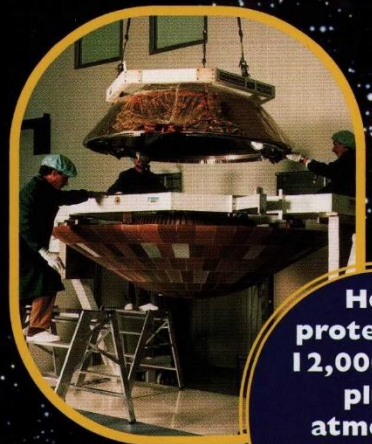
The spacecraft sets out in 1997 and will arrive at Saturn in 2004, when the project will split into two. The Huygens probe will land on Titan's surface while the Cassini orbiter will start to study Saturn's system.

Cassini-Huygens is one of the heaviest spacecraft ever to be sent on an interplanetary mission. It weighs about 5,650 kilograms and will be launched from Cape Canaveral by the most powerful American rocket, a Titan IV/Centaur. This piggy-back operation would be the equivalent of a small car being carried by a bus.

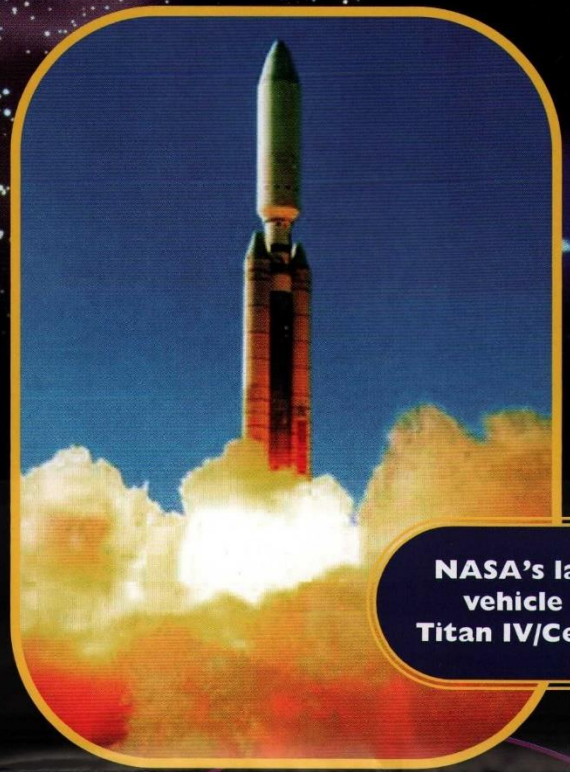
This is not the first mission to investigate Saturn. In the 1970s and '80s the Pioneer 11, Voyager I and II spacecraft passed close enough to take photos of Titan. But it was difficult for scientists to see the surface clearly because it was shrouded in a hazy orange fog. What fascinates scientists about this 'fog' in Titan's atmosphere is that it is filled with complex organic molecules, similar to the atmosphere of the primordial Earth.

Astronomers are not only interested in Titan's atmosphere: they hope the Huygens probe will tell them if the surface of Titan is made of liquid methane or solid rock. If it is methane, they want to know where it comes from: it could be a huge ocean or springs beneath the moon's surface.

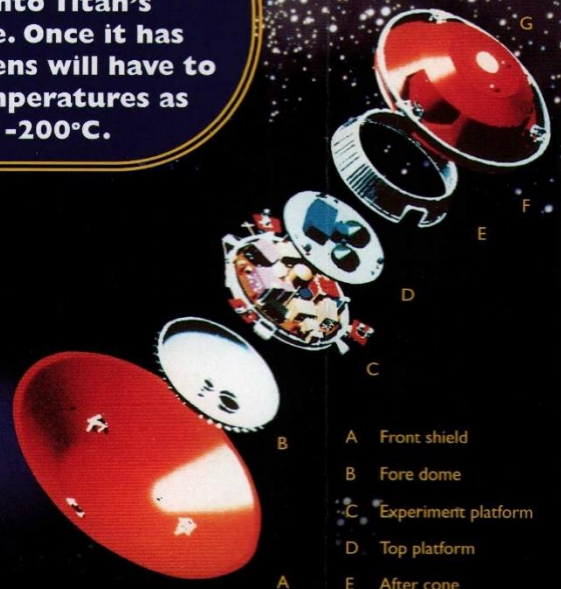
Scientists also want to know more about Saturn's rings, and the tiny moons embedded in the rings. The Cassini orbiter will be able to provide information about how the rings – and Saturn itself – were formed.



Heat-resistant tiles protect Huygens from the 12,000°C produced when it plunges into Titan's atmosphere. Once it has landed, Huygens will have to work in temperatures as low as -200°C.



NASA's launch vehicle is a Titan IV/Centaur.



A Front shield
B Fore dome
C Experiment platform
D Top platform
E After cone
F Back cover
G Spin/eject device

how will Cassini-Huygens get to Saturn?

Even the giant Titan IV/Centaur rocket, towering more than 40 m above the Cape Canaveral launch pad, will not be powerful enough to send Cassini-Huygens on a direct path to Saturn.

Though the rocket will give Cassini-Huygens a speed of 4 km per second, it would actually need to travel at 10 km per second to go directly to Saturn. But 4 km per second will take the craft to Venus, where, by a process called 'gravity assist', it can use that planet's gravitational pull to give it more speed. But even then, Cassini-Huygens will have to cross Venus's orbit again, and then also pass Earth and Jupiter before it finally has enough speed to reach Saturn.

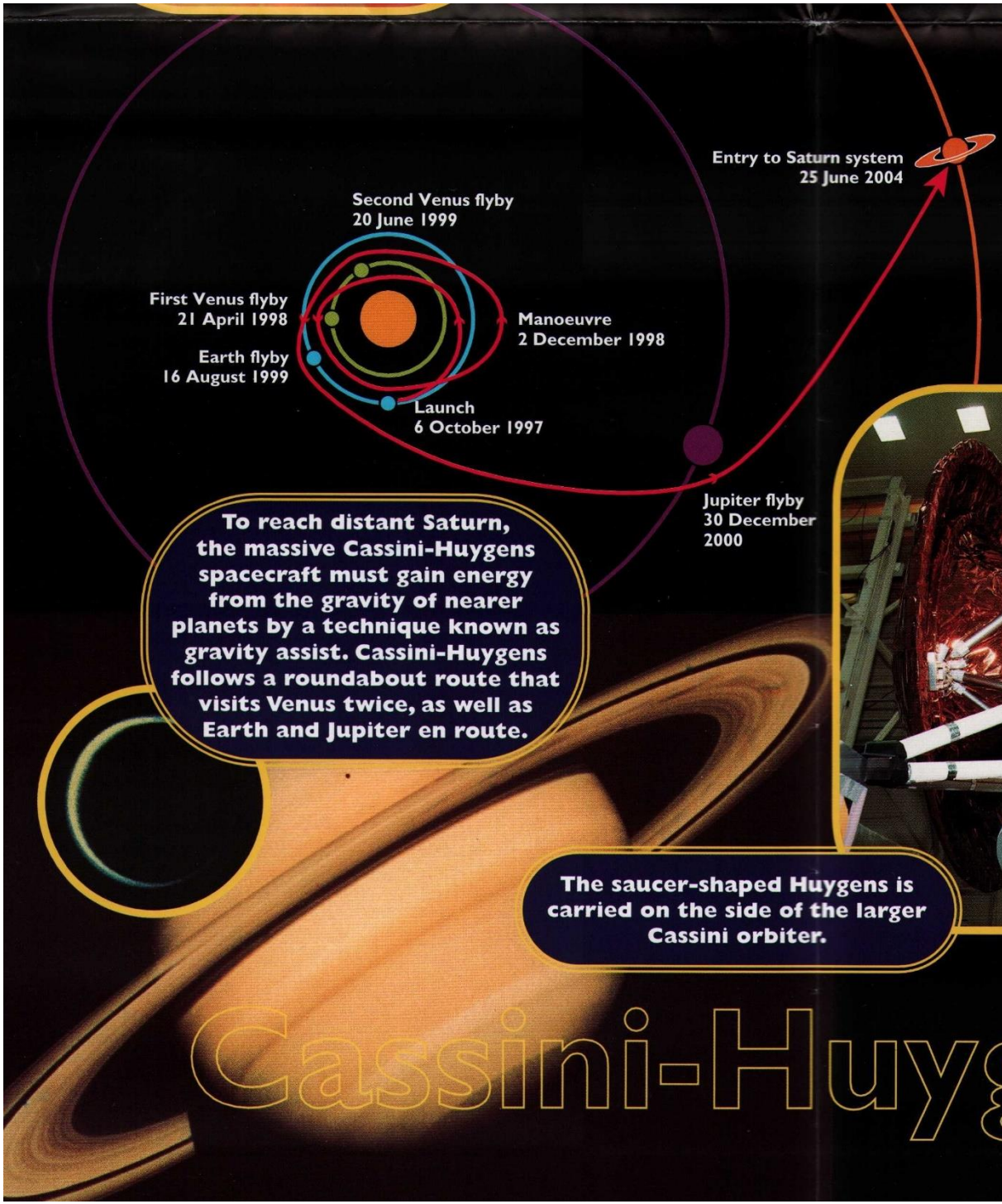
Just getting the spacecraft and the instruments to survive the vibrations at launch will be a major challenge. And because Cassini-Huygens has to take such a roundabout route to Saturn, it will be exposed to great changes in temperature. At Venus, the Sun's rays will be more than twice as strong as they are on Earth. Nearer Saturn, they will be about one-hundredth the strength.

Huygens Probe Experiments

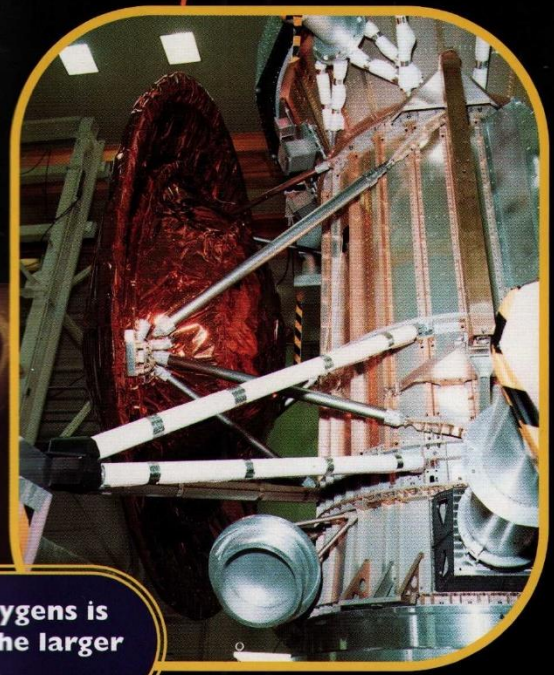
Upper side

Lower side

1 HASI (Huygens Atmospheric Structure Instrument)
2 GCMS (Gas Chromatograph and Mass Spectrometer)
3 ACP (Aerosol Collector Pyrolyser)
4 DISR (Descent Imager and Spectral Radiometer)
5 DWE (Doppler Wind Experiment)
6 SSP (Surface Science Package)



To reach distant Saturn, the massive Cassini-Huygens spacecraft must gain energy from the gravity of nearer planets by a technique known as gravity assist. Cassini-Huygens follows a roundabout route that visits Venus twice, as well as Earth and Jupiter en route.



The saucer-shaped Huygens is carried on the side of the larger Cassini orbiter.

Cassini-Huygens

Cassini Orbiter Experiments

ISS (Imaging Science Subsystem)
CR (Cassini Radar)
RSS (Radio Science Subsystem)
INMS (Ion and Neutral Mass Spectrometer)
VIMS (Visual and Infrared Mapping Spectrometer)
CIRS (Composite Infrared Spectrometer)
CDA (Cosmic Dust Analyser)
RPWS (Radio and Plasma Wave Science)
CAPS (Cassini Plasma Spectrometer)
UIS (Ultraviolet Imaging Spectrograph)
MII (Magnetospheric Imaging Instrument)
MAG (Dual Technique Magnetometer)

Cassini-Huygens has reflective thermal insulation to stop it overheating near the Sun. Its large radio antenna will also help by acting as a sunshade: during the first two years this will point at the Sun and will not be able to communicate with Earth. But as the spacecraft nears Saturn's orbit, sunlight is weak and arrays of solar panels would not provide sufficient electricity to run Cassini-Huygens. Instead, heat produced from the decay of small amounts of radioactive plutonium fuel will be used to generate electrical power.

The Huygens probe is built like a clam, with a bivalve outer shell that will act as a thermal shield and as a brake when opened. As it descends to Titan, the temperature in front of the shield will rise to 12,000 degrees C. Engineers left a wide safety margin when they designed special insulating tiles for the shell, in case reactions with Titan's atmosphere make this temperature even higher.

The probe will have to withstand g-forces 16 times that of the earth's gravity. When it hits Titan, it will be travelling at about 25 km per hour – similar to the speed of a fridge falling off the roof of a house. But nobody knows if it will hit a hard surface or a sea of ethane and methane.

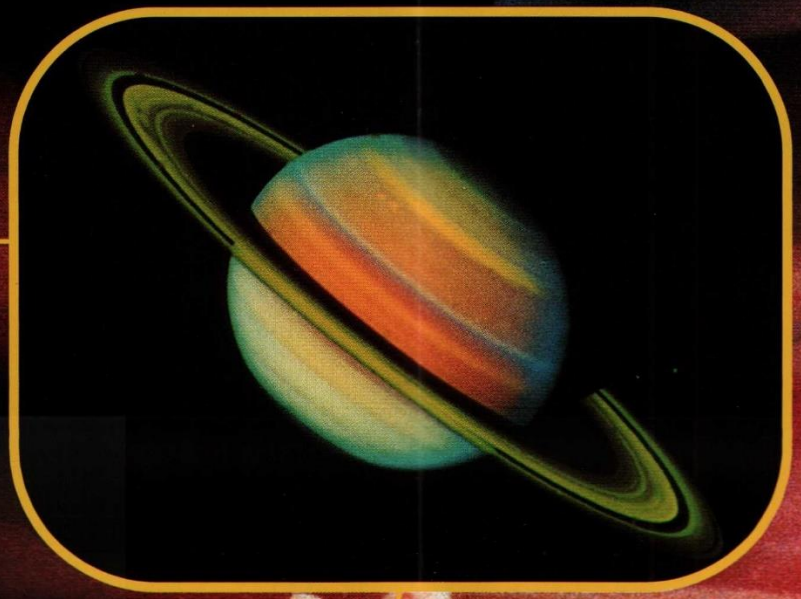
what will Cassini-Huygens do when it reaches Saturn?

If everything goes to plan, on 6 November 2004, the Cassini orbiter will release the still-dormant Huygens probe towards Titan. After a 22-day drop towards the moon, the probe will be powered up. Its sensors will come alive, in effect its 'brain' will be active.

As it enters Titan's atmosphere it will begin to slow down, but will still be travelling as fast as Concorde! A series of parachutes will help reduce the speed to that of a fast train. At 150 km above the surface of Titan, the front shell of the probe will be released, exposing the instruments to the atmosphere.

Some 50 km above the surface, the orange fog should have cleared enough for the cameras to get their first view of Titan, between the clouds.

What will they see? Possibly a landscape of icy plains, mountains and lakes of ethane. There may be an ocean of methane, possibly with coloured, organic ice floes. Or a dry landscape with geysers spouting methane, or volcanoes erupting ammonia and water.



The descent to Titan

Huygens probe

Altitude 270 km
Speed 18,000 km/h

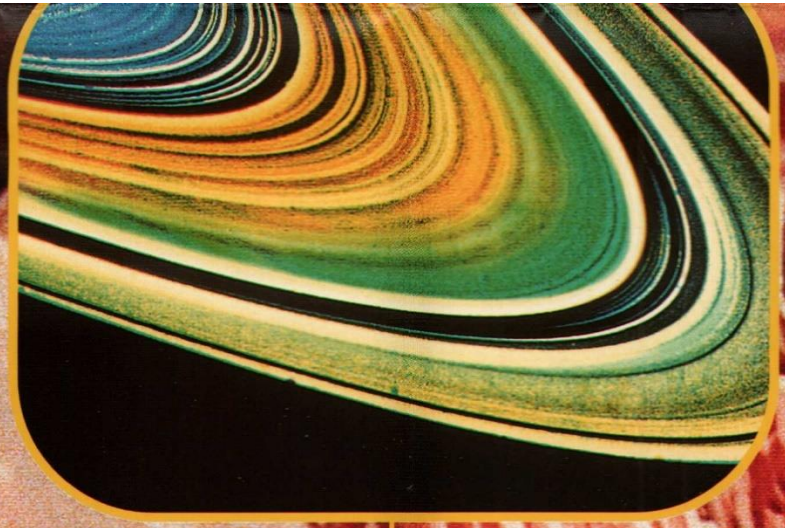
Pilot parachute

Altitude 180 km
Speed 1,400 km/h

Huygens' descent will be slowed to 25 km per hour by the final parachute. The probe is designed to survive impact at this speed. Once it has landed, there will be enough battery power for up to 30 minutes' data collection. The probe, which is designed to function in liquid as well as on land, will beam its findings to the Cassini orbiter to be stored and finally relayed to Earth.

It takes nearly an hour and a half for radio waves to get from Saturn to Earth. So by the time scientists in the UK get the first data, the instrument designed to investigate the surface of Titan will already have stopped working. This means that a mission that has taken six years to prepare for and travelled for seven years through space, will have collected just three hours of data on Titan's atmosphere and surface.

Though the story ends there for the Huygens probe, scientists will be working on the data for many years. Cassini has a much longer working life. The orbiter will tour Saturn's system for four years. During this phase of its mission, it will execute some three dozen close flybys of particular bodies of interest, including more than 30 encounters with Titan and at least four with selected icy satellites of greatest interest. Cassini's 12 instruments will measure magnetic fields, plasmas, dust particle densities, Saturn's weather and the geology of several of Saturn's moons.



Passing by the spectacular rings of Saturn, the orbiter will see fragments jostling together.

Main parachute and shield release

Altitude 165 km
Speed 290 km/h

Stabiliser parachute

Altitude 125 km
Speed 290 km/h

Hydrocarbon haze

Minimum atmospheric temperature -200°C

Altitude 40 km
Speed 46 km/h

Condensate haze

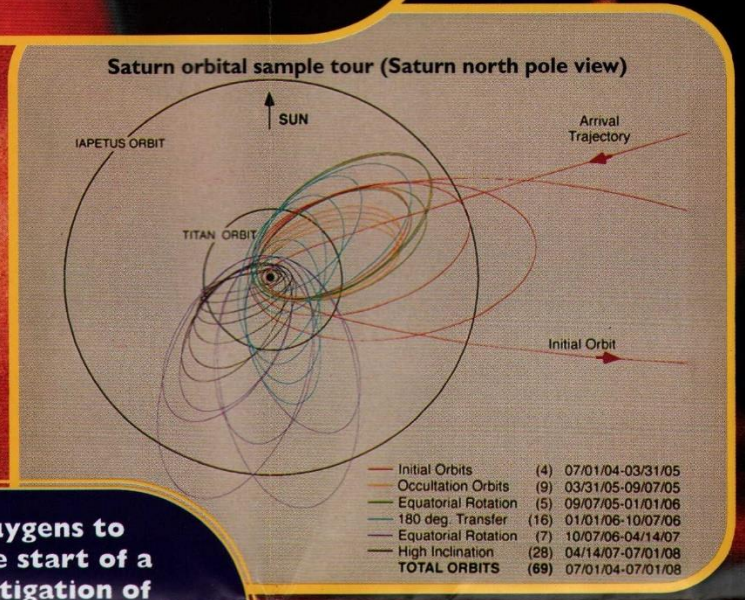
Methane/nitrogen clouds

Surface impact
Ambient temperature -180°C

teamwork

Casssini orbiter

Radio link

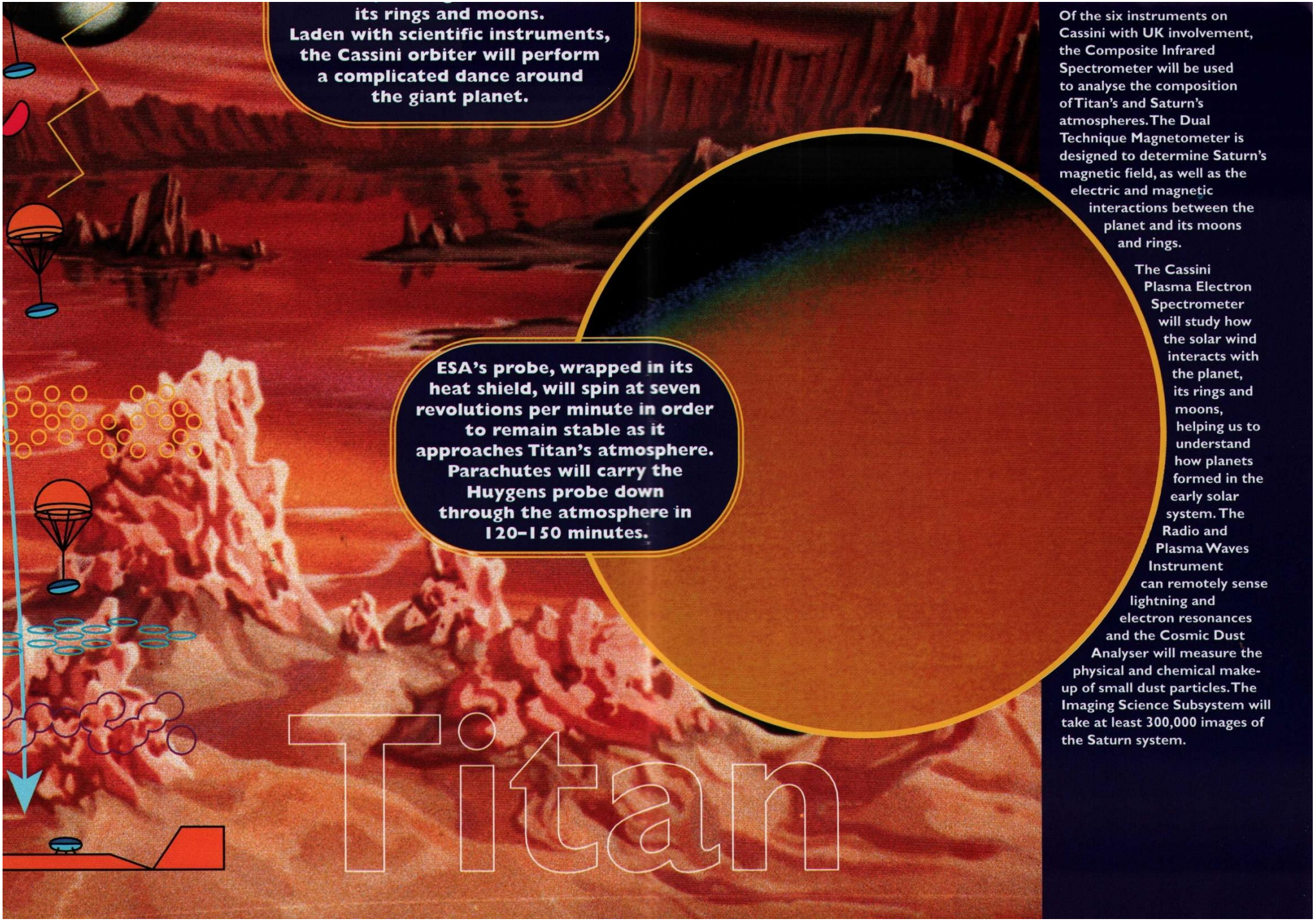


Delivering Huygens to Titan is just the start of a four-year investigation of Saturn, its magnetic field and

Such large space projects would be impossible if different countries did not co-operate closely with each other. Developing the Cassini-Huygens mission will cost over half a billion pounds, of which Britain's share will be about £40 million. The 18 instruments on board were designed and built by 27 teams, from 14 European countries and 32 states of the United States. In all, some 4,000 people were involved.

The European Space Agency has supplied the Huygens probe: UK industry helped develop the Huygens flight software, the descent system and the parachutes. British scientists have taken part in the development of eight of the 18 instruments on Cassini and Huygens.

UK scientists have led the development of the Surface Science Package, which will show how hard and flat the landing site is. If the landing is in an ocean, it will indicate how deep it is, and how dense the liquid is. This in turn will tell scientists if the ocean is as old as Titan or if it was formed later. British expertise also helped develop the Huygens Atmospheric Instrument, which will measure the temperature, pressure, density and electrical properties of the atmosphere.



Of the six instruments on Cassini with UK involvement, the Composite Infrared Spectrometer will be used to analyse the composition of Titan's and Saturn's atmospheres. The Dual Technique Magnetometer is designed to determine Saturn's magnetic field, as well as the electric and magnetic interactions between the planet and its moons and rings.

The Cassini Plasma Electron Spectrometer will study how the solar wind interacts with the planet, its rings and moons, helping us to understand how planets formed in the early solar system. The Radio and Plasma Waves Instrument can remotely sense lightning and electron resonances and the Cosmic Dust Analyser will measure the physical and chemical make-up of small dust particles. The Imaging Science Subsystem will take at least 300,000 images of the Saturn system.

Outer pages

Inner pages