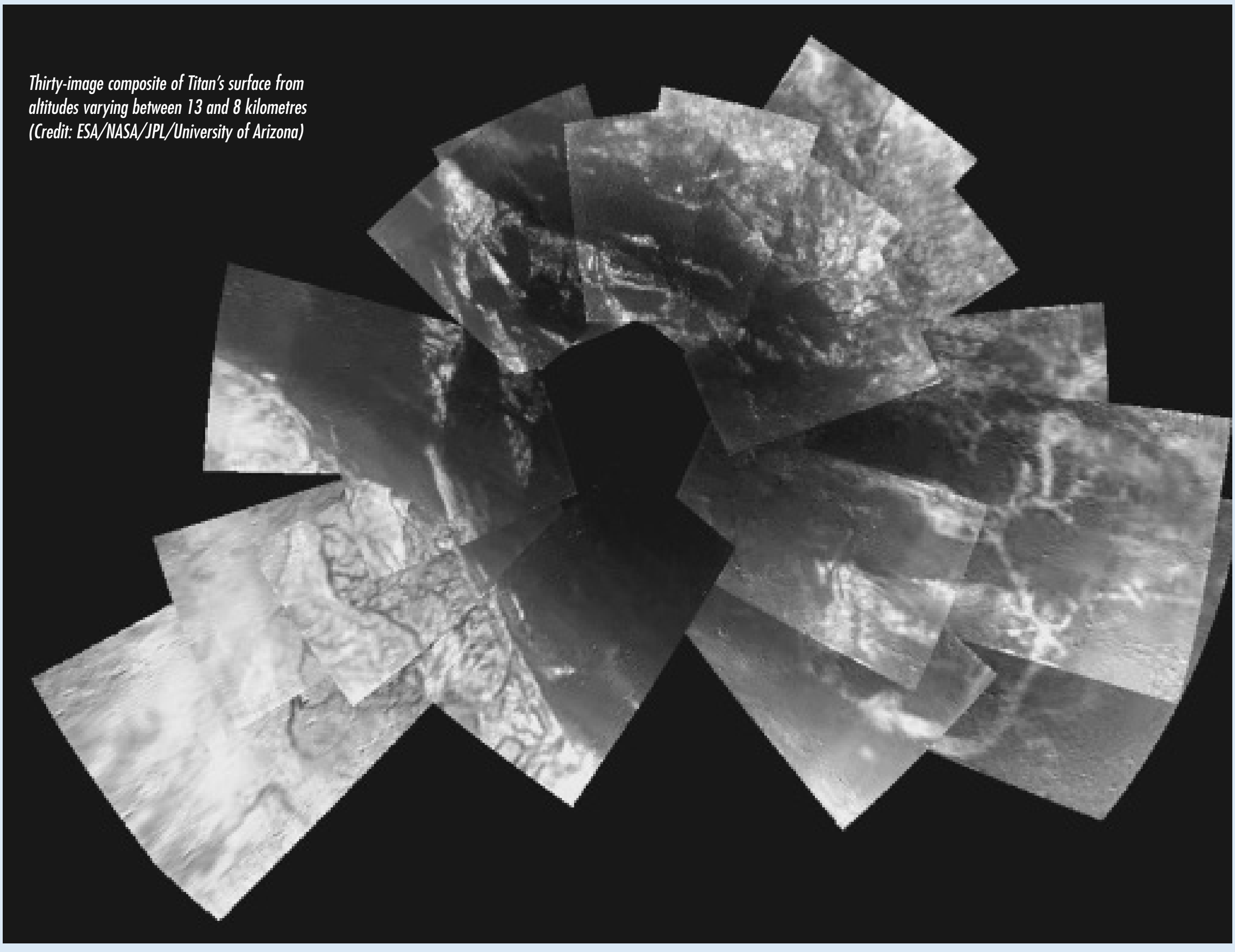
Europe Arrives at the New Frontier

– The Huygens Landing on Titan

On 14 January 2005, after a marathon seven-year journey through the Solar System aboard the Cassini spacecraft, ESA's Huygens probe successfully descended through the atmosphere of Titan, Saturn's largest moon, and landed safely on its surface. It was mankind's first successful attempt to land a probe on another world in the outer Solar System.

Following its release from the Cassini mothership on 25 December, Huygens reached Titan's outer atmosphere after 20 days and a 4 million kilometre cruise. The probe started its descent through Titan's hazy cloud layers from an altitude of about 1270 km at 09:06 UTC. During the following three minutes, Huygens had to decelerate from 18 000 to 1400 km per hour.

A sequence of parachutes then slowed it to less than 300 km per hour. At a height of about 160 km, the probe's scientific instruments were exposed to Titan's atmosphere for the first time and Huygens started to transmit its radio signal to Cassini at 09:12 UTC (spacecraft event time). The Huygens radio signals also arrived on Earth, but 67 min later as a faint tone that was detectable by large radio telescopes. At about 120 km altitude, the main parachute was jettisoned and replaced by a smaller one to complete the descent. The Huygens radio signal was detected on Earth at about 11:20 CET by the 110-m Robert Byrd Green Bank Telescope in West Virginia. About 2 hours later, the probe's signal was picked-up by telescopes in Australia, which indicated that Huygens had landed and continued to transmit after landing. Cassini listened to Huygens for 4h 36 min and then transmitted the Huygens data to Earth via NASA's Deep Space Network once the Huygens mission was over. The first scientific data arrived at ESA's European Space Operations Centre (ESOC) in Darmstadt, Germany at 17:19 CET, having also taken 67 min to travel across space. An hour later, the data indicated that Huygens had landed safely at 12:39 CET and had transmitted data for 72 min from Titan's surface.



Thirty-image composite of Titan's surface from altitudes varying between 13 and 8 kilometres (Credit: ESA/NASA/JPL/University of Arizona)

The Descent

Huygens was expected to provide the first direct and detailed sampling of Titan's atmospheric chemistry and the first photographs of its hidden surface, and to supply a detailed 'weather report'. One of the main reasons for sending Huygens to Titan was that its nitrogen atmosphere, rich in methane, and its surface may contain many chemicals of the kind that existed on the young Earth. Combined with the Cassini observations, Huygens could therefore deliver an unprecedented view of Saturn's mysterious moon.

The view from thirteen kilometres high

The picture on the previous page is a composite of 30 images taken by Huygens from an altitude varying from 13 kilometres down to 8 kilometres as the probe was descending towards its landing site. At that stage of its descent, Huygens was dropping almost vertically at a speed of about 5 metres per second and drifting horizontally at about 1.5 metres per second, just a leisurely walking pace. The composite image covers an area extending out about 30 kilometres around the probe.

The final descent and the landing site

As soon as Huygens had touched down on Titan's surface, some 15 scientists in the Descent Trajectory Working Group were hard at work to determine the location of the landing site. Apart from being needed to understand where exactly the probe had landed and to provide a reference trajectory to analyse and interpret the Huygens data set, having such a profile available for a probe entering the atmosphere of another Solar System body is extremely important for future space missions.

"This is a great achievement for Europe and its US partners in this ambitious international endeavour to explore the Saturnian system," said Jean-Jacques Dordain, ESA's Director General. *"The teamwork in Europe and the USA, between scientists, industry and agencies has been extraordinary and has set the foundation for this enormous success".*

"Titan was always the target in the Saturn system where the need for 'ground truth' from a probe was critical. It is a fascinating world and we are now eagerly awaiting the scientific results," said Professor David Southwood, Director of ESA's Scientific Programme.

"The Huygens scientists are all delighted. This was worth the long wait," said Dr Jean-Pierre Lebreton, ESA Huygens Mission Manager and Project Scientist.

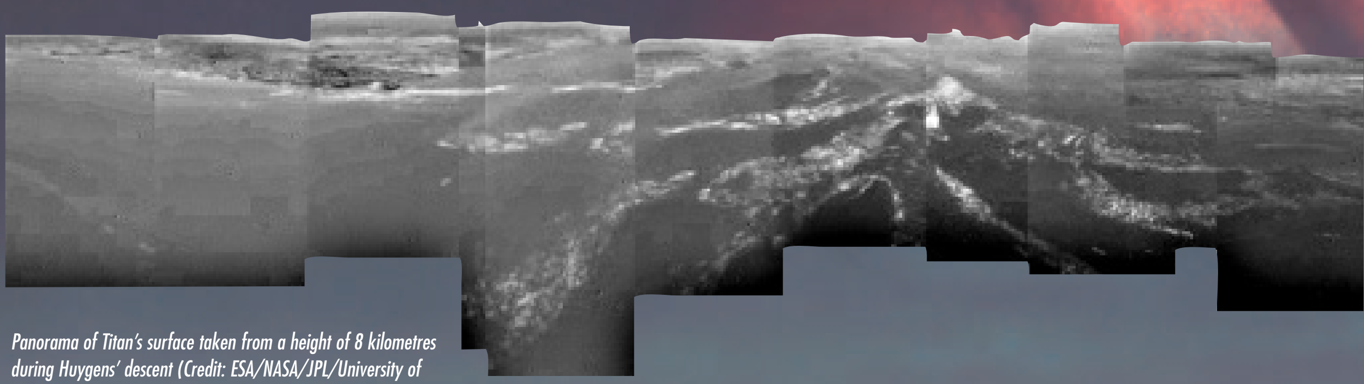
"Descending through Titan was a once-in-a-lifetime opportunity and today's achievement proves that our partnership with ESA was an excellent one," said Alphonso Diaz, NASA Associate Administrator of Science.

"The ride was bumpier than we thought it would be," said Martin Tomasko, Principal Investigator for the Descent Imager/Spectral Radiometer (DISR), the instrument that provided Huygens' stunning, images among other data. The probe rocked more than expected in the upper atmosphere. During its descent through high-altitude haze, it tilted at least 10 to 20 degrees, while once below the haze layer it was more stable, tilting less than 3 degrees. The Huygens scientists are investigating the probe's atmospheric environment during its descent in order to explain the bumpy ride.

The bumpy ride was not the only surprise during the descent. Scientists had theorised that the probe would drop out of the haze at between 70 and 50 kilometres altitude. In fact, Huygens began to emerge from the haze when only 30 kilometres above the surface.

When the probe landed, it was not with a thud or a splash, but a 'splat' – it had landed in Titanian 'mud'. *"I think the biggest surprise is that we survived landing and that we lasted so long,"* said DISR team member Charles See. *"There wasn't even a glitch at impact. That landing was a lot friendlier than we anticipated."*

When the mission was designed, it was decided that the DISR's 20-Watt landing lamp should turn on 700 metres above the surface and illuminate the landing site for as long as 15 minutes after touchdown. *"In fact, not only did the landing lamp turn on at exactly 700 metres, but also it was still shining more than an hour later, when Cassini moved beyond Titan's horizon for its ongoing exploratory tour of the giant moon and the Saturnian system,"* said Martin Tomasko.



Panorama of Titan's surface taken from a height of 8 kilometres during Huygens' descent (Credit: ESA/NASA/JPL/University of Arizona)

The first colour image of Titan's surface, with centimetre scales superimposed to characterise surface features (Credit: ESA/NASA/JPL/University of Arizona)

The First Scientific Results

More than 474 megabits of data were received in 3 hours 44 minutes from Huygens, including some 350 pictures collected during the descent and on the ground, which revealed a landscape apparently modelled by erosion, with drainage channels, shoreline-like features, and even pebble-shaped objects on the surface.

The atmosphere was probed and sampled for analysis at altitudes from 160 km to ground level, revealing a uniform mix of methane with nitrogen in the stratosphere. The methane concentration increased steadily in the troposphere and down to the surface. Clouds of methane were detected at about 20 km altitude, and methane or ethane fog near the surface. During the descent, sounds were recorded in order to detect possible distant thunder from lightning, providing an exciting acoustic backdrop to Huygens' descent.

As the probe touched down, its instruments provided a large amount of data on the texture of the surface, which resembles wet sand or clay with a thin solid crust, its composition, mainly a mix of dirty water ice and hydrocarbon ice, resulting in a darker 'soil' than expected. The temperature measured at ground level was about minus 180 degrees Celsius.

Spectacular images captured by the DISR reveal that Titan has extraordinarily Earth-like meteorology and geology. Images have shown a complex network of narrow drainage channels running from brighter highlands to lower, flatter, dark regions. These channels merge into river systems running into lakebeds featuring offshore 'islands' and 'shoals' remarkably similar to those on Earth.

"We now have the key to understanding what shapes Titan's landscape," said Dr Tomasko, adding: *"Geological evidence for precipitation, erosion, mechanical abrasion and other fluvial activity says that the physical processes shaping Titan are much the same as those shaping Earth."*

Data provided in part by the Gas Chromatograph and Mass Spectrometer (GCMS) and Surface Science Package (SSP) support Dr Tomasko's conclusions. Huygens' data show strong evidence for liquids flowing on Titan. However, the fluid involved is methane, a simple organic compound that can exist as a liquid or gas at Titan's very cold temperatures, rather than water as on Earth. Titan's rivers and lakes appear dry at the moment, but rain may have occurred not long ago.

Deceleration and penetration data provided by the SSP indicate that the material beneath the surface's crust has the consistency of loose sand, possibly the result of methane rain falling on the surface over eons, or the wicking of liquids from below towards the surface.

Heat generated by Huygens warmed the soil beneath the probe and both the GCMS and SSP instruments detected bursts of methane gas boiled out of surface material, reinforcing the evidence for methane's principal role in Titan's geology and meteorology.

In addition, DISR surface images show small rounded pebbles in a dry riverbed. Spectra measurements (colour) are consistent with a composition of dirty water ice rather than silicate rocks. However, these form a rock-like solid at Titan's temperatures.

Titan's soil appears to consist at least in part of precipitated deposits of the organic haze that shrouds the planet. This dark material settles out of the atmosphere. When washed off high elevations by methane rain, it concentrates at the bottom of the drainage channels and riverbeds contributing to the dark areas seen in DISR images.

Stunning new evidence based on finding atmospheric argon 40 strongly suggests that Titan has experienced volcanic activity generating not lava, as on Earth, but water ice and ammonia.

Thus, while many of Earth's familiar geophysical processes occur on Titan, the chemistry involved is quite different. Instead of liquid water, Titan has liquid methane. Instead of silicate rocks, Titan has frozen water ice. Instead of dirt, Titan has hydrocarbon particles settling out of the atmosphere, and instead of lava, Titanian volcanoes spew very cold ice. Titan is therefore an extraordinary world, having Earth-like geophysical processes operating on exotic materials in very alien conditions.

"This is only the beginning; these data will live for many years to come and they will keep the scientists very very busy", says Jean-Pierre Lebreton, ESA's Huygens Project Scientist and Mission Manager.

The Cassini-Huygens mission is a cooperative endeavour by NASA, ESA and ASI, the Italian space agency. The Jet Propulsion Laboratory (JPL), a division of the California Institute of Technology in Pasadena, designed, developed, assembled and is operating the Cassini orbiter, while ESA was responsible for the Huygens atmospheric probe.