The Cassini-Huygens mission

The story begins

The Cassini-Huygens space mission grew out of an action by a few planetary scientists in Europe to establish Europe firmly in robotic planetary exploration. A mission to orbit Saturn and drop a probe onto the moon, Titan, emerged as a favoured choice. The excitement of the NASA Voyager spacecraft images of Jupiter and Saturn had sparked an increasing sense of frustration that Europe was taking little part in exploring the outer planets. In the early 80s, a small group of European and American scientists was assembled under the auspices of the European Science Foundation and the US National Academy of Sciences to look at options for cooperation.

As the US was already committed to send an orbiter and descent probe to Jupiter, it was rapidly clear what the next grand challenge should be, an orbital tour of the Saturn system. As the US already planned a probe diving into the Jupiter atmosphere, it was decided that any Saturn programme should have a probe to descend on Titan, the only solar system moon with an atmosphere and one that even resembled that of the early Earth. The more radical conclusion was the recommendation that Europe should build the Titan probe. However, the Europeans in the group knew that a technological goal like landing a probe on the surface of a distant celestial body would be seen as the science community setting a grand joint challenge to European industry. This would help gain critical political support in Europe and, indeed, it did.

In 1989, both ESA and NASA selected the mission by their separate processes for joint development. It was agreed that Europe would take responsibility for the Titan lander and US would build the orbiter. However, the lander and orbiter would carry a mix of American and European instruments. As the mission started just as the Cold War was ending, Cassini-Huygens also had the distinction, particularly in Europe, of instrument teams involving scientists from former Iron Curtain countries.

The Cassini magnetometer

Imperial College was to win a 3-way competition against two US competitors to build the magnetometer for the orbiter spacecraft, now called Cassini.

In the early 80's, the new Space Physics group (from 1986, Space and Atmospheric Physics group) in the Physics Dept at Imperial College had taken a strategic decision to focus on magnetometry. Staff from the group had already been involved in ground (with British Geological Survey, BGS) and space magnetometery (HEOS 1 and 2 magnetometers and ISEE 1 and 2). Part of the rationale for the choice was that many spacecraft need to carry magnetometers for scientific or other reasons but the group were also aware that there were alternative applications of rugged magnetometers. For example, in the 70's BGS with whom Imperial cooperated, started providing a geomagnetic disturbance prediction service to a consortium of oil companies who were drilling in the first phase of exploitation of North Sea oil. An approach to offer a similar service to the national electrical power supplier at the time was rejected. Years later, Scottish Power was to discover that transformer failure was linked to geomagnetic activity levels.

When formed, the Imperial group was already involved in provision of magnetometers (in collaboration with NASA/JPL) for the Ulysses solar polar mission and (with UCLA) for the AMPTE-UKS spacecraft. Instrument development funds were started with research council support in parallel with the expansion of the European Space Agency space science programme (Horizon 2000). A division of Dowty Aerospace (subsequently, Ultra Electronics) became the industrial partner. Ultra specialised in provision of marine defence systems such as sonobuoys. Rugged magnetometers are also important in several aspects of marine defence; the instrument development for the space applications should have multiple potential uses in the defence market. Although some of the uses are classified, there is little doubt that the joint development magnetometer work for scientific goals raised our industrial partner's capacity to address their primary market.

The Huygens probe

As well as Imperial winning a place on the NASA orbiter spacecraft, a British team led by John Zarnecki of the Open University won a prime instrument position in the European lander payload to build the Huygens Surface Science Package, the lander now being named after the Dutch astronomer, Christian Huygens. As clouds and a photochemical haze always cover Titan, this presented an interesting challenge as the surface had never been seen and might be solid or liquid. The surface temperature of Titan is close to the triple point of methane. The team was faced with the prospect where Huygens might land where the surface has methane lakes and thus in liquid.

As ESA was to design, build, test deliver and operate the Huygens probe, British companies were expected to take a full part in its development and operation. In fact, UK industry won major parts in the programme. The Martin Baker company, the world's leading manufacturer of ejector seats, took responsibility for the entry, descent and landing sub-system. The parachutes to be used came from the Welsh company, Irvin. Logica (now CGI) developed the on-board software. Electronic parts procurement was done through IGG.

Once the mission was launched, the industrial team (under the French prime contractor, Aerospatiale, now part of Thales Alenia Space) was mainly British, a division of Martin-Baker had become Vorticity which had responsibility for the parachute behaviour and dynamics and stability of the whole descent while Logica (CGI) were responsible for on-board software. An idea of the engineering challenges both companies faced can be obtained from the article by the respective lead engineers, Steve Lingard and Pat Norris: https://www.ingenia.org.uk/Ingenia/Articles/7cf998f7-b886-42b7-8f1e-4596af1354e8.

On December 25 2004, Cassini released the Huygens probe. It would fly on its own for 3 weeks to land on Titan on January 15th 2005. There were panics and glitches but overall all went well. At the same time, there were magnificent surprises. As Huygens descended Cassini picked up its signals and relayed them to Earth for 1h 12m from Huygens on the surface. At that point it went over Huygens horizon. However, in a global effort, the radio astronomers of the world combined their telescopes to point to Titan and to pick up Huygens tiny (mobile phone scale) signal directly for 3h 14m.

On landing. We were looking at an entirely new world (hitherto hidden by thick cloud) and one with a pre-biotic atmosphere containing Nitrogen, Hydrogen and Carbon. The moon itself contains Oxygen. One day, say, as the Sun becomes a red giant and Titan is warmed, would life appear? The science team had always said that there might be a methane driven meteorology. River channels were seen on descent that must sometimes contain methane rivers. Indeed, although Huygens landed in what resembled a dry riverbed and gaseous methane was detected rising from the heating of the soil on landing. Subsequently, the Cassini orbiter, which flew past Titan 127 times, discovered there were methane lakes.

Vorticity was purchased by Airbus and Logica by CGI and has gone on to work for NASA in as well as ESA planetary exploration. Both companies participated in the Beagle2 UK Mars lander, the successful entry, descent and landing of which made UK only the third country to land on Mars. Sadly mechanical failure after landing appears to have precluded full mission success. The software for Huygens was written in the military Ada language. CGI UK continues to work in developing software for systems requiring high security and reliability. Most recently, they were responsible for developing critical secure elements of the of the EU Galileo navigation system. They can be expected to take a similar role in UK-alone GNSS currently in design phase.

The Cassini mission

The Cassini orbiter mission continued as a joint NASA-ESA scientific programme until 2017. The Saturn system with its rings and 62 moons in itself is a miniature solar system and, indeed, had much to teach us about the origin, dynamics and evolution of the solar system. Apart from the Huygens landing, the most important discovery of the mission was that the moon, Enceladus, had an internal ocean. The result came originally from measurements by the Imperial College magnetometer. Magnetic disturbances as Cassini flew by Enceladus suggested that Enceladus was emitting plumes of material. In subsequent passes, Cassini was retargeted and the spacecraft camera revealed images of geysers on the surface of the moon.

Partly because of the discovery of what might be a life-bearing environment in the Saturn system the Cassini spacecraft was deliberately sent to dive to destruction in the Saturn atmosphere 13 years after arriving in the Saturn system and nearly 20 years after launch. Some idea of the mission's reach into the public consciousness through all forms of media and social media coverage was the 2018 award of an Emmy for the Cassini "Grand Finale" coverage: https://www.nasa.gov/feature/jpl/and-the-emmy-goes-to-cassinis-grand-finale