

## Huygens Science and Instrumentation: Lessons Learned For The Future *In Situ* Exploration of Titan

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### Abstract

The international *Cassini-Huygens* mission to Saturn was jointly developed by NASA, The European Space Agency (ESA), and the Italian Space Agency (ASI). It took more than 6 years to develop the international collaboration that needed to be put in place before the development proper could start in the early 90's. Then, after more than 7 years of development, the *Cassini-Huygens* spacecraft, consisting of the NASA-provided Saturn Orbiter and the ESA-provided Huygens Titan Atmospheric Probe was launched on 15 October 1997 by a Titan IVB Centaur rocket from Cape Canaveral Air Force Station in Florida. The 5.6 t spacecraft was too heavy to be injected into a direct trajectory to Saturn, so the interplanetary voyage of about 6.7 years included gravity-assist manoeuvres at Venus, Earth and Jupiter.

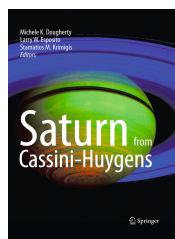
*Cassini-Huygens* went into orbit around Saturn on 1<sup>st</sup> July 2004. Then, the 4-year orbital tour of Saturn started. At the end of the third revolution around Saturn, on 25<sup>th</sup> December 2004, the Orbiter released the Huygens Probe on its ballistic trajectory to Titan. The Probe entry into Titan's atmosphere took place on 14th January 2005. It descended under parachute in the atmosphere, landed safely and continued functioning on the surface for several hours. The Huygens probe operating sequence was executed nominally, and the six onboard instruments performed very well. It transmitted its data to the Orbiter on two quasi-redundant channels. Due to a mis-configuration, the receiver of one channel could not decode the data. However, the Huygens carrier radio signal for that channel was detected on Earth by a prearranged network of radio telescopes, allowing precise Doppler tracking of the Probe carrier signal and VLBI tracking of Huygens descent. The quality of the returned data was excellent and exceeded *a priori* expectations. Following the completion of the Probe mission, the Orbiter continued, and still continues today, its exploration of the Saturnian system.

This paper gives an overview of the Huygens probe mission and it illustrates how the *in situ* Huygens measurements, the Orbiter *in situ* observations of the upper atmosphere and its remote observations of the stratosphere, troposphere and its surface are complementary and synergistic. Lessons learned from the Huygens mission are discussed in the context of the preparation of the future *in situ* exploration of Titan by probes, landers and balloons.

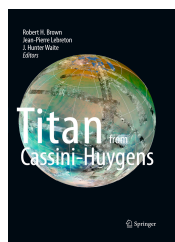
### Acknowledgements

It is a great pleasure to acknowledge all the Cassini-Huygens teams for the work done during almost 30 years (so far, still counting), which represents the duration of a revolution of Saturn around the Sun !. The spirit of the international collaboration on Cassini-Huygens will hopefully inspire future generations of deep solar system explorers.

### References



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