Cassini-Huygens in the European context

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Abstract

When it was selected, the Huygens probe was only the second planetary mission of ESA after the Giotto mission to Halley's comet. It has been a key element of stability for the Cassini mission, which was threatened with cancellation at several occasions. It has been a technological challenge to develop.

The Huygens probe was selected in competition as a medium mission of the Horizon 2000 programme. It is unlikely that it will have a successor in the present budgetary context of ESA's science programme. It is also unlikely that it would be selected today in the framework of a programme for the exploration of the Solar System openly dedicated to the Moon and to Mars. Will Huygens be the only attempt of Europe ever to adopt bold goals and explore the Solar System beyond the orbit of Mars? The paper will also discuss this aspect of the Cassini-Huygens mission.

1 Two contradictory historical decisions

The decision of the SPC in 1992, to include in ESA's science programme the then called 'Titan Probe' in the framework of a cooperative venture with NASA, must be seen in the context of planetary exploration within ESA's activities some 22 years after the historical decision of ESRO's LPAC.

In 1970, ESA did not exist yet. Its ancestor, ESRO, was governed by the LPAC, or Launch Programme Advisory Committee, the equivalent of the Space Science Advisory Committee that presently advises the Director General of ESA on space science matters. At their long term planning meeting in 1970, the LPAC decided not to plan any planetary missions because they were considered at that time as too expensive and beyond the financial capabilities of ESRO. Cooperation with NASA or the USSR was the only option for Europe to participate in the exploration of the Solar System. Consequently, several of the European space research groups developed very friendly and fruitful relationships with the Jet Propulsion Laboratory in the USA and with the Institute of Cosmic Research (IKI) in Moscow. In this way, Europe could be involved in missions launched to the Moon, Mars, Venus and the outer planets, but only at the level of scientific payload elements.

The first change from that policy was the proposal of the ESA Science Director, Ernst Trendelenburg, followed by the positive decision of ESA's

SPC in 1980, to launch a fast fly-by mission to Halley's comet on the occasion of its return to the vicinity of the Sun in March 1986. Giotto (the name given to that mission) was the first purely European mission to explore the Solar System with its own launcher: Ariane 1, launched on July 2nd 1985. It fully accomplished its mission and took the first close-up image of Halley's comet nucleus (Figure 1). The 1970 LPAC decision could thereby be considered as definitely abandoned!

Figure 1: First high resolution image of a comet nucleus, obtained during the close distance (600 km) fly-by of Comet Halley by ESA's Giotto spacecraft on 13 March 1986 (ESA)

2 Horizon 2000

Soon after, the science directorate of ESA established the Horizon 2000 long-term plan which identified the exploration of the Solar System as a possible orientation of ESA's science programme, building on the Giotto experience, through the introduction of a 'Comet Nucleus Sample Return Mission' (CNSR) – which later was renamed Rosetta – as one of the four cornerstones of the plan (Figure 5).

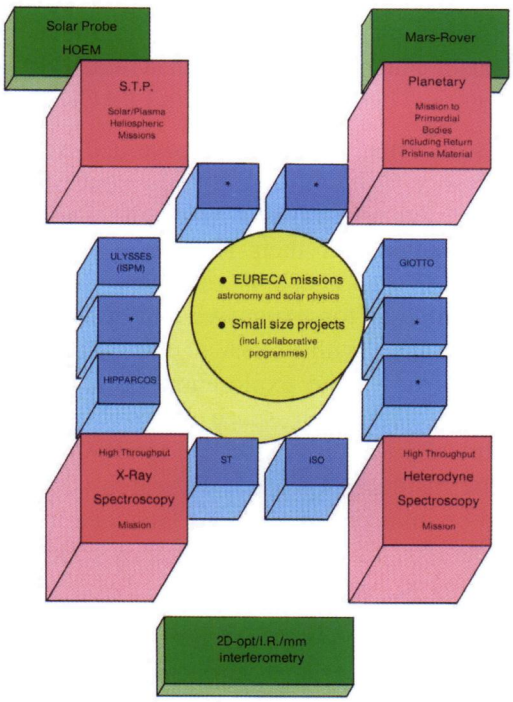

Figure 2: Conceptual design of the Horizon 2000 long term plan issued in 1984

Although not identified in the Horizon 2000 plan as a new strategic orientation of ESA's space science programme, Planetary Exploration then became possible through the CNSR cornerstone. In addition, Horizon 2000 offered the possibility of introducing at any stage in the selection process, medium-size or 'blue' missions, so-called because they were represented as blue boxes in the original diagram of the plan, whose cost would not be larger than half the value of the yearly budget.

In response to a call for ideas for new missions released by ESA in 1982, a group of European and US scientists (Table 1) proposed adding a Titan Probe as an element of the US Cassini mission (Figure 3).

M. Allison	Goddard Institute for Space Studies, New York, (USA)
S. Bauer	Karl Franzens Universitat, Graz, (A)
M. Blanc	Centre de Recherches en Physique de l'Environnement, St. Maur, (F)
S. Calcutt	Department of Atmospheric Physics, Oxford, (UK)
J. Cuzzi	NASA Ames Research Center, Moffett Field, (USA)
M. Fulchignoni	Istituto Astrofisica Spaziale, Rome, (I)
D. Gautier	Observatoire de Paris, Meudon, (F)
D. Hunten	University of Arizona, Tucson, (USA)
W. Ip	MPI für Aeronomie, Katlenburg-Lindau, (D)
T. Johnson	Jet Propulsion Laboratory, Pasadena, (USA)
H. Masursky	US Geological Survey, Flagstaff, (USA)
T. Owen	State University of New York, Stony Brook, (USA)
R. Samuelson	NASA Goddard Space Flight Center, Greenbelt, (USA)
F. Scarf	TRW, Redondo Beach, (USA)
E. Sittler	NASA Goddard Space Flight Center, Greenbelt (USA)

Table 1: List of the European and US investigators at the origin of the Titan probe proposal

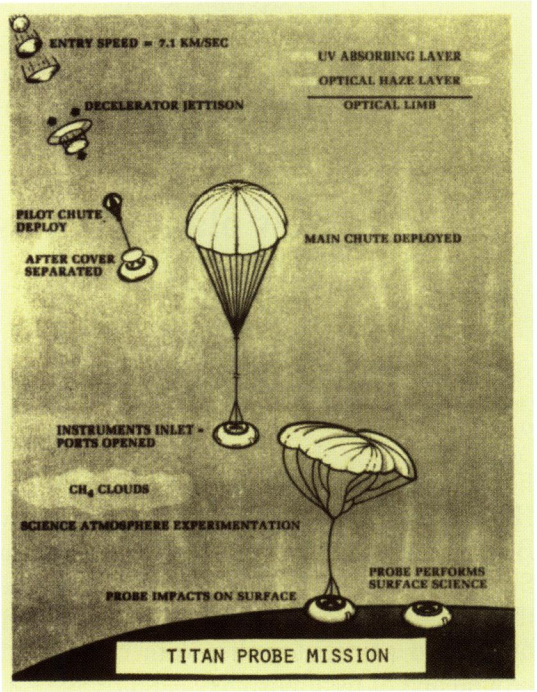

Figure 3: Original concept of the Titan probe proposed by European scientists as a complement to NASA's Cassini mission

Following a normal cycle of selection, through the Solar System Working Group, ESA undertook a feasibility study in 1984-1985, followed by the selection for Phase A in 1986. The Titan Probe was eventually selected by ESA's SPC in Nov. 1998 as the first 'blue' mission of Horizon 2000, against

four other missions: VESTA, LYMAN, QUASAT, and GRASP. The minutes of the meeting recall how the mission was renamed Huygens:

> "At the end of the SPC meeting the Director of the Science Programme reminded delegations that the Saturn moon Titan had been discovered in 1655 by the Dutch astronomer Huygens. In response to the Swiss request, he therefore proposed that the European contribution to the American Cassini project henceforth be known as 'Huygens'. The Netherlands Delegation very much appreciated this proposal to pay homage to a Dutch astronomer. The Chairman of the SSAC (Prof. Balsiger, Switzerland), speaking on behalf of the scientific community, happily accepted the proposal to call the next European mission 'Huygens'."

Figure 4: The launch of Cassini and Huygens on board a US Titan rocket on 15 October 1997 (ESA)

At the completion of the selection process, the CNSR cornerstone and Huygens were the only planetary missions of Horizon 2000. Following the competitive selection of Aerospatiale as Prime Contractor in 1990, Phase B started in 1991. The launch (Figure 4) occurred on 15 October 1997 on board a US… Titan rocket!

What made it possible to include planetary missions in ESA's plan can be seen *a posteriori* as a combination of:

1) A decision to explore the small bodies of the Solar System (CNSR)
2) The possibility of developing a substantial element of a major planetary mission at a cost which was no more than half the yearly budget

3 New planetary missions

Amazingly, the costs of ESA's planetary missions are today much lower than those of astronomy missions, and consequently it has been possible to include several more in the programme, contrary to the strategic decision of ESRO's LPAC back in 1970.

For example, in 1994, the prolongation of the Horizon 2000 plan, called Horizon 2000-plus, incorporated a new planetary cornerstone: the BepiColombo mission to Mercury to be launched in 2012. In 1997, the Space Science Advisory Committee decided on the Mars Express mission that was launched in June 2003 and is presently providing stunning pictures of the red planet, together with exclusive results on the chemistry of its ground and of its atmosphere (Figure 5).

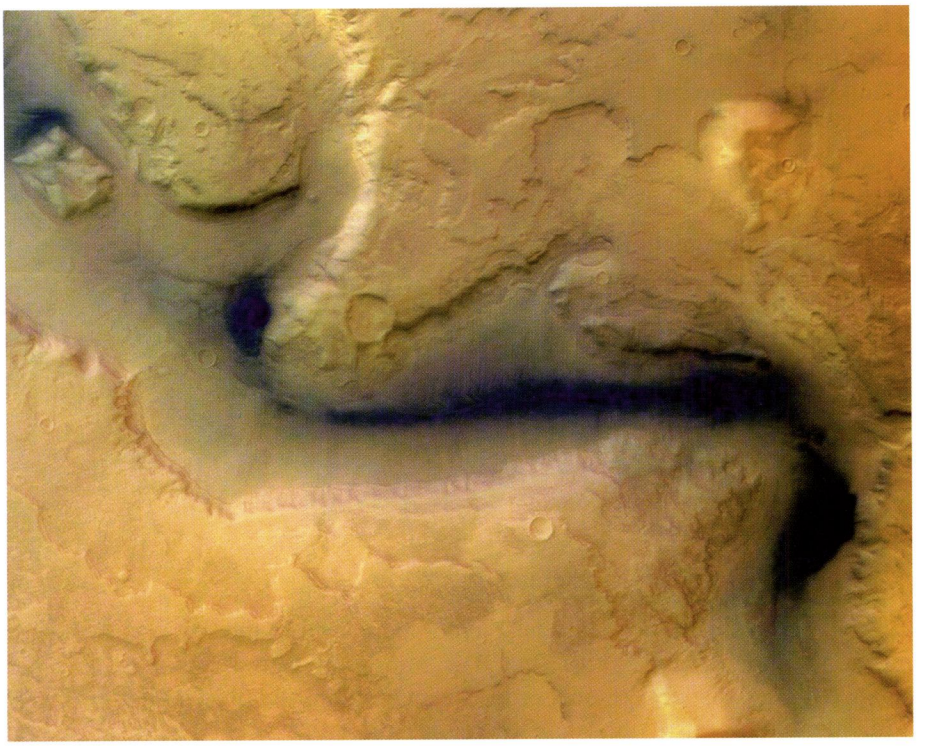

Figure 5: Stunning images of the red planet as observed from the High Resolution Stereoscopic Camera on board Mars Express (ESA)

Then came SMART-1, the cheapest ever of all planetary missions, designed to test solar electric propulsion, launched on 27 September 2003 as a piggy-back passenger on Ariane 5, and sent toward the Moon through a long series of orbit adjustments (Figure 7).

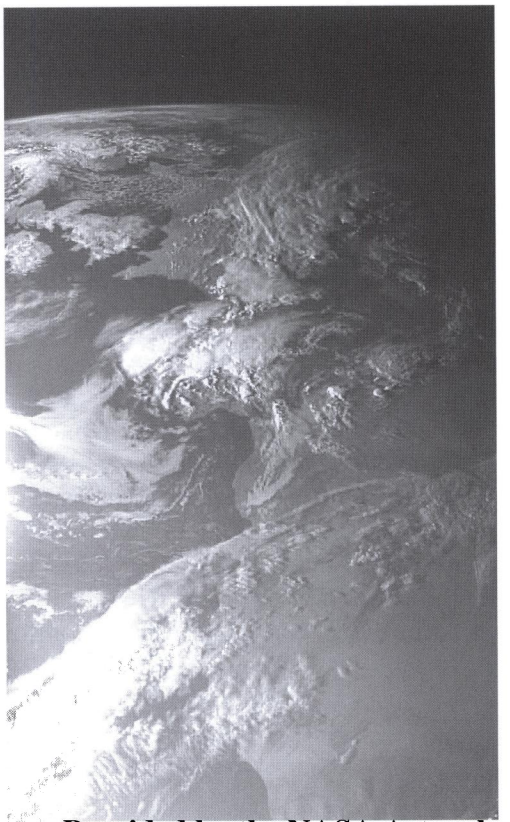

Figure 6: An image of the Earth obtained by the AMIE Camera on board the SMART-1 mission, on its way to the Moon. (ESA)

The Venus Express orbiter, to be launched in November 2005, follows the same trend. It makes use of the Mars Express bus and takes advantage of the much lower recurrent cost of its various subsystems, once more proving that the 1970 decision of ESRO is not valid anymore in a context where experience and knowledge have been gained and the intrinsic cost of hardware is, on average, relatively much cheaper than thirty years ago.

In the end, the outcome of ESA's plans for the exploration of the Solar System is not negligible, as can be judged from the following list:

- Giotto, 1986, 1992: 2 comets (Halley, 1986, Grigg-Skjellerup 1992)
- Mars Express, 2004: Mars
- Huygens, 2005: Titan
- Smart-1, 2005: the Moon
- Venus Express, 2006: Venus
- Rosetta, 2014: two asteroids and one comet
- BepiColombo 2015(?): Mercury

Of course this is a modest list as compared with the large number of missions launched by NASA, but it is important to remember that ESA's science budget is nearly one order of magnitude smaller than its NASA equivalent. It is also important to realise that for ESA to have built and launched these missions has given Europe a position of strength in negotiating future cooperative ventures. Through these missions, all of them in prominent positions, Europe through ESA has placed itself in the position of a key player in future programmes of planetary exploration. This does not mean that, based on this success, ESA adopts an arrogant attitude. It just means both that ESA has proven to be a reliable partner in international cooperation, and that it has acquired a degree of competence that permits it to be considered also as a responsible partner in the course of any future negotiation.

4 Cassini-Huygens: a unique example of international cooperation

Indeed, the Cassini-Huygens programme can be remembered in the future as a paradigm of international cooperation (see Table 2). Remembering the long series of ups and downs in the NASA programme, and the frequent threats of cancellation, and eventually the complete re-scoping of the mission at the beginning of the 1990s, it is clear that the existence of Huygens in the NASA programme saved Cassini from a fatal issue. Without Huygens, Cassini most likely would have been dropped by NASA, and it is thanks to the intervention of ESA and of its Member states that finally, in a few months, Cassini and Huygens will enter Saturn's rings and start exploring Titan and all the other moons of this entirely new world!

The Cassini payload:	
• 12 instruments, all of them involving international teams	
• 2 European Principal Investigators:	
• Dual Technique Magnetometer	D. Southwood, UK
• Cosmic Dust Analyser	E. Gruen, Germany
The Huygens payload:	
• Huygens Atmospheric Structure Instrument	M. Fulchignoni, Italy
• Gas Chromatograph Mass Spectrometer	H.B. Niemann, USA
• Aerosol Collector and Pyrolyser	G. Israel, France
• Descent Imager/Spectral Radiometer	M.G. Tomasko, USA
• Doppler Wind Experiment	M.K. Bird, Germany
• Surface Science Package	J.C. Zarnecki, UK
Huygens Interdisciplinary Scientists:	D. Gautier, France J. Lunine, USA F. Raulin, France

Table 2: International team of Cassini and Huygens payloads

Conversely, the excellent relationships developed between ESA's DG and its Science Programme Directors on one side, and the Associate Administrators and Directors of JPL on the other side, without forgetting the exemplary cooperative spirit that the two project scientists, D. Matson and J-P. Lebreton developed, has given the project a unique tone of friendship, of understanding each other's problems, and of mutual respect – all ingredients of the best possible cooperative spirit.

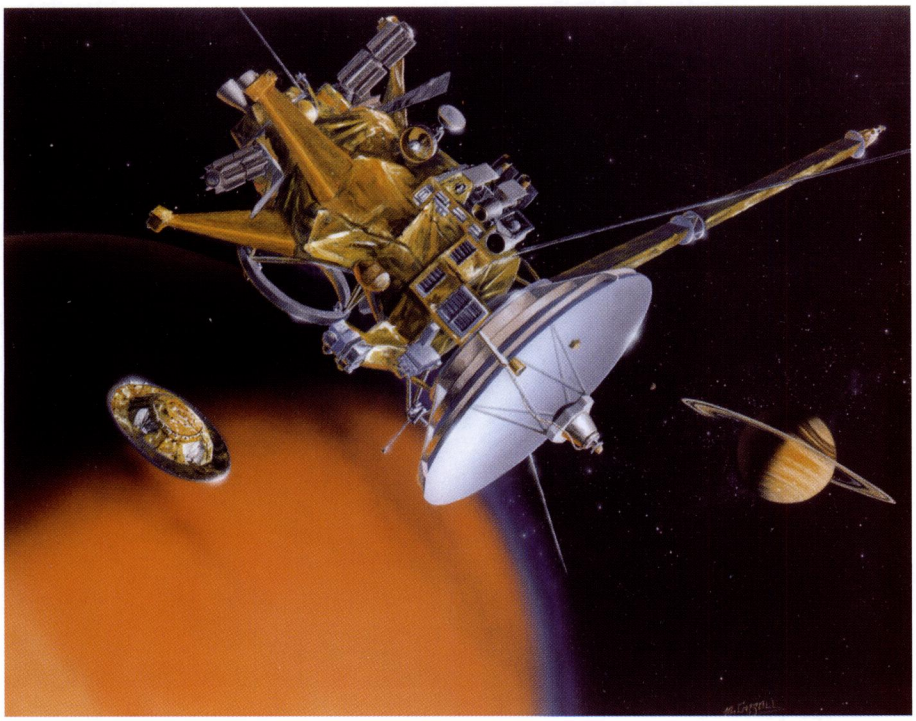

Figure 7: An artist's impression of the ESA/NASA Cassini-Huygens mission to Saturn and Titan

The Cassini-Huygens programme will remain in history not only as a spectacular success but also as a lesson learnt for the benefit of other projects. Let me just mention one example. When Dan Goldin, the NASA Administrator, imposed that the whole Cassini programme, including the

Huygens probe, be submitted to an independent review, the ESA project and I considered this as an unacceptable violation of the cooperative spirit. After some tense meetings, we eventually accepted the principle of that review, which was indeed independent and was led by Mr Kutler from MIT. The exemplary international spirit that had prevailed throughout the project continued during that review, out of which the ESA contribution came successfully. We were so impressed by the principle of the independent review and by the way it had been conducted that I demanded that a similar review be conducted for the Rosetta Lander (the review was chaired by Mr Kutler himself) and for Beagle2. However, reviews are essential but not sufficient. In spite of its thoroughness, the Huygens independent review did not identify the telecommunication problem that was discovered several years later once it was in orbit, and we all know the fate of Beagle2!

5 The visibility of Cassini-Huygens

The complete integration of the international teams in the project gives it a unique character and a high visibility. This is indeed a very media-friendly programme! At the beginning of next July, Cassini will enter its orbit around Saturn. It is already planned that all opportunities be seized to observe Titan in as much detail as possible in order to refine the targeting of Huygens. On December 25, Huygens will be released from Cassini, ending a more than seven-year love affair. On the following 14th January (Figure 8), Huygens will enter Titan's atmosphere, and 2.5 hours later it will attempt for the first time ever to land on the largest moon of the Solar System that Huygens – the scientist – discovered exactly 350 years before!

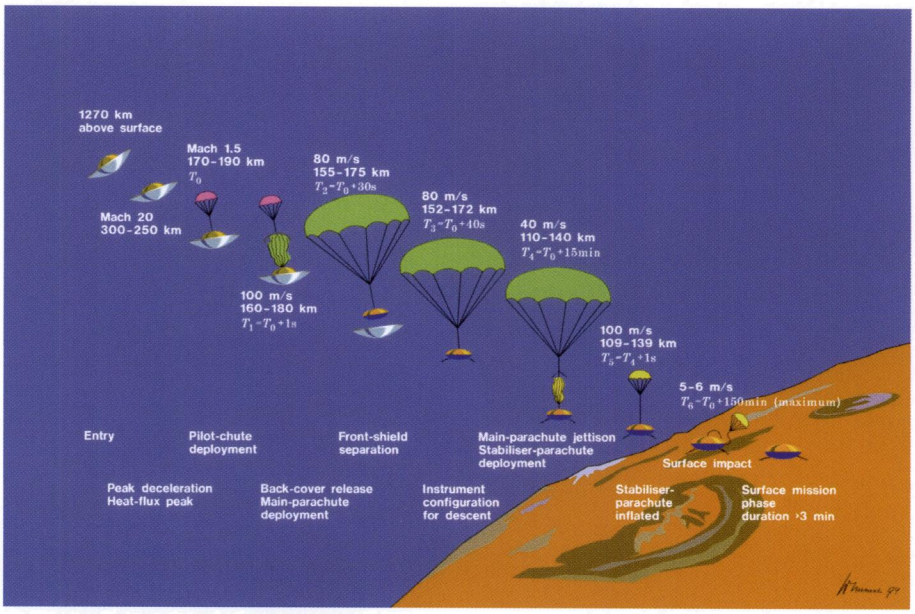

Figure 8: The descent of Huygens in the atmosphere of Titan on 15 January 2005

On board Huygens, just before launch, ESA attached a CD-ROM carrying several hundred testimonies from Europeans of all ages, and of citizens from all around the world: drawings, paintings, texts, poems, messages, etc. Several of these messages are of a high philosophical or artistic value. Several others are pure nonsense or of a much lower quality. No attempt was

made to filter these testimonies because it was felt that they constituted a 'snapshot' of the way of thinking and of the imagination of our civilisation of the mid-1990s, when the CD was recorded. It is to be hoped that it will not take another 350 years for us to get back to Titan and be able to recover the CD from the remains of the Huygens probe – unless somebody else (?) has already recovered this CD and attempted to decipher it!

6 Conclusion

The names of two of the most prestigious European astronomers have been given to one of the most prestigious international planetary missions ever undertaken. What can be done better after that? Unfortunately for ESA, it may well be that Huygens will remain as one isolated and unique attempt. Its budget is too small to envisage follow-on. It is also impossible to plan a mission to Saturn without nuclear power from radioisotope thermal generators (RTGs), therefore without cooperating with NASA. If, as one can hope, the mission is in the end crowned by a complete success, it is likely that NASA will plan new ventures to Saturn and to Titan, and ESA should soon be prepared to include the necessary flexibility in its programmes to respond to the challenge of going back to Titan and doing more and better than Huygens!

One wonders, however, whether Huygens (the mission) would have ever been selected in the framework of ESA's Aurora Exploration programme, with its pre-orientated emphasis on the Moon and on Mars. Back in 1984, the Horizon 2000 frame offered the opportunity to reverse the negative approach of ESRO with regards to planetary exploration. It is now time to prepare the proper planning frame to allow Europe to build on its previous experience and to take an active part in one of the most ambitious ventures of the new century, and return to the giant moon that Huygens (the scientist), with cleverness and sense of discovery, observed for the first time 350 years ago.