Scientific rationale and concepts for an in situ Saturn probe

Conference or Workshop Item

SCIENTIFIC RATIONALE AND CONCEPTS FOR AN IN SITU SATURN PROBE. O. Mousis[1], A. Coustenis[2], J.-P. Lebreton[2,3], D. H. Atkinson[4,5], J. I. Lunine[6], K. Reh[5], L. Fletcher[7], A. Simon-Miller[8], S. Atreya[9], W. Brinckerhoff[8], T. Cavalié[10], A. Colaprete[11], D. Gautier[1], T. Guillot[12], R. Hueso[13], P. Mahaffy[8], B. Marty[14], A. D. Morse[14], J. Sims[5], T. Spilker[15], L. Spilker[5], C. Webster[5], J. H. Waite[16], P. Wurz[17], [1]UTINAM, Université de Franche-Comté, Observ. Besançon, France (olivier.mousis@obs-besancon.fr), [2]LESIA, Observatoire de Paris, CNRS, UPMC, Univ. Paris-Diderot, 5, place Jules Janssen, F-92195 Meudon Cedex, France, [3]LPC2E, CNRS-Université d'Orléans, 45071 Orléans Cedex 2, France, [4]University of Idaho, Moscow ID 83844-1023, USA, [5]NASA Jet Propulsion Lab / California Institute of Technology, Pasadena, CA 91109, USA, [6]Cornell University, Ithaca, NY 14853, USA, [7]AOPS, University of Oxford, Oxford OX1 3PU, UK, [8]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA, [9]University of Michigan, Ann Arbor, MI 48109-2143, USA, [10]Max-Planck-IfS, 37191 Katlenburg-Lindau, Germany, [11]NASA Ames Research Center, Mountain View, USA, [12]Observatoire de la Côte d'Azur, France,[13]Universidad del País Vasco, Bilbao, Spain, Unidad Asociada Grupo Ciencias Planetarias UPV/EHU-IAA (CSIC), Bilbao, Spain, [14]CRPG-CNRS, Nancy-Université, 54501 Vandoeuvre-ls-Nancy, France, [15]The Open University, Milton Keynes MK7 6AA, UK, [16]Solar System Science & Exploration, Monrovia, USA, [17]SwRI, San Antonio, TX 78228, USA, [18]University of Bern, 3012 Bern, Switzerland.

Introduction: *In situ* exploration of Saturn's atmosphere would bring insights in two broad themes: the formation history of our Solar System and the processes at play in planetary atmospheres. Here we summarize the science case for *in situ* measurements at Saturn (see also [1] for details) and discuss the possible mission concepts that would be consistent with the constraints of ESA M-class missions.

Solar System formation: To understand the formation of giant planets and the origin of our Solar System, statistical data obtained from the observation of exoplanetary systems must be supplemented by direct measurements of the composition of the planets in our Solar System. A giant planet's bulk composition depends on the timing and location of planet formation, subsequent migration and the delivery mechanisms for the heavier elements. By measuring a giant planet's chemical inventory, and contrasting these with measurements of (i) other giant planets, (ii) primitive materials found in small bodies, and (iii) the composition of our parent star and the local interstellar medium, much can be revealed about the conditions at work during the formation of our planetary system.

Planetary Atmospheric Processes: Saturn's complex and cloud-dominated weather-layer is our principle gateway to the processes at work within the deep interior of this giant planet. *In situ* studies provide access to atmospheric regions that are beyond the reach of remote sensing, enabling us to study the dynamical, chemical and aerosol-forming processes at work from the thermosphere to the troposphere below the cloud decks.

Mission concepts : Different mission architectures are envisaged, all based on an entry probe that would descend through Saturn's stratosphere and troposphere under parachute down to a minimum of 10 bars [1]. Future studies will focus on the trade-offs between science return and the added design complexity of a probe that could operate at pressures greater than 10 bars. Three possible mission configurations are currently under study (with different risk/cost trades):

• *Configuration 1*: Probe + Carrier. After probe delivery, the carrier would follow its path and be destroyed during atmospheric entry, but could perform pre-entry science. The carrier would not be used as a radio relay, but the probe would transmit its data to the ground system via a direct-to-Earth (DTE) RF link;

• *Configuration 2*: Probe + Carrier/Relay. The probe would detach from the carrier several months prior to probe entry. The carrier trajectory would be designed to enable probe data relay during over-flight as well as performing approach and flyby science;

• *Configuration 3*: Probe + Orbiter (similar to the Galileo Orbiter/Probe). As for Configuration 2, but after probe relay during over-flight, the orbiter would transition to a Saturn orbit and continue to perform orbital science.

In all three configurations, the carrier/orbiter would be equipped with a combination of solar panels, secondary batteries and possibly a set of primary batteries for phases that require a high power demand, for example during the probe entry phase.

Payload: To match the measurement requirements, a model payload could include a mass spectrometer, a tunable laser system, a helium abundance detector, an atmospheric structure instrument, accelerometers, temperature sensors, pressure profile, Doppler wind and nephelometer instruments, etc.

Such a mission would greatly benefit from strong international collaborations.

References [1] Mousis, O., et al. 2014, "Scientific Rationale of Saturn's in situ exploration", submitted to *Plan. Space Sci.* (and references therein).