EPSC Abstracts
Vol. 9, EPSC2014-437-1, 2014
European Planetary Science Congress 2014

Scientific Rationale and Concepts for an In Situ Saturn Probe

O. Mousis (1,2), D. Atkinson (3,4), S. Atreya (5), A. Coustenis (6), L. N. Fletcher (7), D. Gautier (6), T. Guillot (8), R. Hueso (9), J.-P. Lebreton (6,10), J. I. Lunine (1), B. Marty (11), K. Reh (4), E. Venkatapathy (12), J. H. Waite (13), P. Wurz (14), and the ESA-M4 Saturn Probe team.

(1) Center for Radiophysics and Space Research, Cornell University, USA (olivier.mousis@obs-besancon.fr) (2) Laboratoire UTINAM, UMR 6213 CNRS, Université de Franche Comté, Besançon, France (3) Department of Electrical and Computer Engineering, University of Idaho, USA, (4) Jet Propulsion Laboratory, California Institute of Technology, USA, (5) Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, USA (6) LESIA, Observatoire de Paris, CNRS, UPMC, Univ. Paris-Diderot, France, (7) Atmospheric, Oceanic & Planetary Physics, Department of Physics, University of Oxford, Clarendon Laboratory, UK, (8) Observatoire de la Côte d'Azur, France, (9) Universidad del País Vasco, Bilbao, Spain, Unidad Asociada Grupo Ciencias Planetarias UPV/EHU-IAA (CSIC), Bilbao, Spain, (10) LPC2E, CNRS-Université d'Orléans, 45071 Orléans Cedex 2, France, (11) CRPG-CNRS, Nancy-Université, 54501 Vandoeuvre-les-Nancy, France, (12) Bldg 229, Rm 110, NASA ARC, Moffett Field, CA 94035, (13) Southwest Research Institute, San Antonio, TX 78228, USA, (14) University of Bern, 3012 Bern, Switzerland.

Abstract

We summarize the science case for *in situ* measurements at Saturn and discuss the possible mission concepts that would be consistent with the constraints of ESA M-class missions.

1. Introduction

Remote sensing observations meet some limitations when used to study the bulk atmospheric composition of the giant planets of our solar system. A remarkable example of the unicity of *in situ* probe measurements is illustrated by the exploration of Jupiter, where key measurements such as noble gases abundances and the precise measurement of the helium mixing ratio have only been made available through *in situ* measurements by the Galileo probe. 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. This mission would greatly benefit from strong international collaborations. We intend to propose such a mission in response to the upcoming ESA M4 call.

2. 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.

3. 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.

4. 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.

5. Payload

To match the measurement requirements (see Table 1 and [1] for details), 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.

Table 1: Measurement requirements

Instrument	Measurement
Mass spectrometer	Elemental and chemical composition
	Isotopic composition
	High molecular mass organics
Helium abundance detector	Accurate He/H_2 ratio
Atmospheric Structure Instrument	Pressure, temperature, density, molecular weight profile
Doppler Wind Experiment	Measure winds, speed and direction
Nephelometer	Cloud structure
	Solid/liquid particles
Net-flux radiometer	Thermal/solar energy

References

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