FUTURE EXPLORATION OF ENCELADUS AND SATURN'S ICY MOONS. J. I. Lunine[1], G. Tobie[2], G. Mitri[2], F. Tosi[3] and A. Coustenis[4], [1]Dept. of Astronomy, Cornell Univ., Ithaca, NY,14853, [2] Laboratoire de Planétologie et Géodynamique de Nantes, Université de Nantes, Nantes, France, [3]INAF-IAPS, Istituto di Astrofisica e Planetologia Spaziali, Area di Ricerca di Tor Vergata, Via del Fosso del Cavaliere, 100, I-00133 Rome, Italy, [4]LESIA, Observatoire de Paris, CNRS, UPMC Univ Paris 06, Univ. Paris-Diderot, Meudon 92195, France.

Introduction: The final flythrough of the plume of Enceladus by the Cassini Orbiter on October 21, 2015 marked the end of Cassini's *in situ* investigations of this remarkable small moon of Saturn. Over a decade of flybys and seven flythroughs of the plume, Cassini has determined that Enceladus has a global ocean [1,2], organics [3], salty water [4], and a possible hydrothermal system at the ocean's base [5]. This makes Enceladus a key target for future exploration.

Near-term exploration proposals: A proposal in 2011 from the Jet Propulsion Laboratory with international collaborations to fly a Discovery-class Saturn orbiter repeatedly past Enceladus and Titan, called Journey to Enceladus and Titan (JET), would have carried a Rosetta-spare mass spectrometer, a near-infrared mapping spectrometer, and conducted experiments in gravity mapping of the two bodies [6]. The intent was to provide an astrobiological assessment of both Saturn moons, together with Titan mapping and geophysical objectives. The spacecraft power supply was the Advanced Sterling Radioisotopic Generators, or ASRG's, then under development but with a currently uncertain future. The proposal was not selected.

In 2015 a revised JPL Discovery proposal, again with international collaboration, refocused the objectives on those that could be accomplished entirely with mass spectrometry. This concept, called Enceladus Life Finder (ELF), was to fly a solar-powered spacecraft into Saturn orbit and to make multiple deep flythroughs of the Enceladus plume [7]. The payload consisted of one mass spectrometer to study the gaseous species in the plume, while a second would analyze ice grains features, both with an exceptional mass range, sensitivity and substantial resolution improvement over Cassini. In addition to assessing the habitability of the ocean by determining key parameters such as redox state, pH and temperature of the ocean, ELF would conduct three tests looking for biological activity in the ocean. The mission was not selected for Phase A in the 2015 Discovery round.

A sample return concept involving a flythrough of the plume and capture of material for return to the Earth has been developed at JPL; called Life Investigation for Enceladus (LIFE) the mission would also sample and analyze the plume in situ [8]. The concept was too ambitious for Discovery but potentially might be a New Frontiers-class mission. The TSSM mission to Titan and Enceladus was studied by ESA and NASA as a flagship and large (L-)class mission in 2008-2009, but was not selected [9].

Parallel efforts in Europe to continue the exploration of Enceladus led to a mission proposal for an L-class mission in 2013 [10] and several M-class concepts possibly in conjunction with Titan exploration. In 2016, the 'Explorer of Enceladus and Titan' (E^2T) mission was proposed in response to the M5 ESA call to assess the evolution and habitability of these Saturnian icy moons using a solar electric powered spacecraft in orbit around Saturn, performing multiple flythroughs of Enceladus' plume. The E^2T mission payload consists of two time-of-flight mass spectrometers and a high resolution IR Camera.

Roadmap: The plethora of mission concepts for future exploration of Enceladus and the interest by NASA and ESA in the "Ocean Worlds" (planetary bodies with water or other-type oceans), requires a strategy to be developed against which proposals can be fielded. One such strategy has recently been published [11]. It features a roadmap that progresses from plume flythrough missions, to plume sample return, and on to more ambitious missions that might land near fractures or even attempt to enter the ocean. Progression to more ambitious missions depends on the results of their predecessors. With current launch vehicles, a possible Enceladus plume flythrough mission that might be completed and approved through a New Frontiers' opportunity in 2016/2017 would not arrive until after 2030. This makes the search for life in the Saturn system a multi-generational effort.

Other icy moons of Saturn: The entire Saturn satellite system exhibits a diversity of processes and properties unrivalled by the other giant planets. While proposals for future missions have focused on Titan and Enceladus, it is tempting to speculate that a mission to one or both of these bodies would also carry out investigations of some of the other moons.

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