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Author: Mr. David Hubert
Università di Pisa, Italy

Mr. Fabrizio Tracchegiani
University of Pisa, Italy
Mr. Emanuele Luzzati
Università di Pisa, Italy
Mr. Alessandro Billi
University of Pisa, Italy
Mr. Oscar Eduardo Cepeda Caliman
Università di Pisa, Italy
Mr. Osama Eldeeb
University of Pisa, Italy
Mr. Francesco Pasquale Foti
Università di Pisa (Unipi), Italy
Mr. Francesco Paolo Salzo
University of Pisa, Italy
Prof. Salvo Marcuccio
Università di Pisa, Italy

CERES LANDER EXPLORATION AND SAMPLE RETURN MISSION

Abstract

Laying the groundwork for future exploration and scientific inquiry into the nature and origins of our solar system, the Dawn mission studied the dwarf planet Ceres and discovered a frozen world with bright concentrations of salts and minerals, and the presence of organic molecules in several locations on the surface. With its closest approach to Earth of 1.6 AU, Ceres is a prime candidate for in-situ robotic exploration beyond Mars, hosting potentially liquid water, cryovolcanism, and the building blocks for life. This paper discusses a mission proposal for the collection of samples from the surface of the dwarf planet Ceres and their subsequent return to Earth for laboratory analysis. A full Pre-Phase A study was conducted to define in-depth the mission concepts and objectives, assess the feasibility of such a mission, and develop a preliminary program proposal. Eighteen potential mission architectures were analyzed, giving way to a mission design consisting of four main phases: an outbound trajectory of a main spacecraft carrying a lander, via Mars flyby to Ceres orbit and rendezvous; a surface exploration mission involving multiple hops of the sample-collecting lander, focused on salt-brine faculae of Occator crater and locations containing high concentrations of organics; sample return capsule launch from the surface with in-orbit docking to the main spacecraft; and the return to Earth with the ejection of the sample return capsule for re-entry and collection. This 11.5-year mission will utilize proven as well as new technologies, relying upon a pair of 240 mN gridded ion thrusters for the interplanetary trajectory, and the green propellant LMP-103s for powering the unique, controlled hops of the lander to multiple locations across the low-gravity environment of Ceres. Small, state-of-the-art sensors and instruments have been carefully chosen to maximize the scientific performance of the mission while keeping the mass at a minimum. Cost, performance, and risk assessments throughout multiple in-depth mock customer reviews showed

the sample-return mission to be feasible for a limited mass of samples, provided that the timeline for mission development is properly coordinated with Ceres transfer windows. The complete mission proposal, including scientific goals and measurement instrumentation, preliminary spacecraft design, trajectory and mission design, results of the pre-Phase A feasibility assessment, program proposal, and mission concept review are all presented.