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A robust mission concept for a low-cost Ceres Plume Sample Return

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Abstract

The recent discovery of ejecta from dwarf planet Ceres by scientists [1] using ESA's Herschel telescope provides for a golden opportunity for a low cost sample return mission for very high value science return. NASA's mission Dawn will arrive at Ceres in 2015 and pave the way for future missions to Ceres. Thales Alenia Space presents here an original short-duration low-cost mission concept that provides for two low altitude fly-by's of Ceres and returns samples from the plumes to the Earth. Mission parameters are discussed and preliminary assessed in view of maximizing mission success.

1. Introduction

The main reason for the high cost of planetary missions is due to the large spacecraft size induced by the delta-V needed for orbiting the targets: this impacts the spacecraft cost itself, the launch cost and, when lengthy cruise times are needed to get gravity assists on the way, the operations cost. Bringing a lander on a planetary surface, even with mild gravity like Ceres, and getting it back to Earth is very costly in terms of cumulated delta-V and snowball effect on launched configuration. In the case of Ceres, the samples can come to the spacecraft [1]. Not having to break and to adjust the spacecraft speed to the one of the target is especially valuable when devising a low cost mission.

The recent discovery of sources of water vapour from dwarf planet Ceres by scientist using ESA's Herschel telescope [1] provides for a golden opportunity for a low cost sample return mission for very high value science return. NASA's mission Dawn will arrive at Ceres in 2015 and obtain, in addition to science from orbit, key inputs for future missions to Ceres, such as spin parameters, gravitational field, more accurate localization of the ejecta sources.

2. Mission concept

Thales Alenia Space presents an original short mission concept that provides for two low altitude fly-by's of Ceres close to its perihelion, when the ejecta have been detected by Herschel. The double fly-by strategy offers the possibility either to get samples from the two plume-ejecting sites if both fly-by's succeed, or a back-up sample collection in case the first fly-by could not fly through dense enough areas of the plume.

3. Mission design challenges and mission parameters adjustment

We discuss the navigation challenges for the first fly-by, the impact on the trajectory and how the altitude and location of the second one can be further adjusted so as to maximize mission success probability. The relative speed has to remain reasonable in order to preserve the plume samples by limiting impact speed on the collector. The sensitivity to the time-lapse in between the two fly-by's is also addressed by studying how the mission orbital parameters can be set to provide for enough time for adjustment while neither letting natural time variation displace the plume density maxima or decrease their intensity nor amplifying navigation errors. The Earth return commands too to set the orbit around the Sun properly so as to minimize the need for deep space maneuvers.

4. Spacecraft design challenges

We discuss the challenges specific to spacecraft design, in particular navigation technologies, sample collection, and Planetary Protection design constraints. The forward and backward contamination requirements, pending COSPAR categorization, will lead to specific provisions in the design to cover failure cases during Ceres fly-by, Earth return final phase for the entire spacecraft and Earth atmosphere re-entry for the capsule.

5. Summary and Conclusions

A preliminary sizing of the spacecraft is presented along with the main budgets and mission duration assessment.

References

[1] Küppers M. et al, Localized sources of water vapour on the dwarf planet (1) Ceres, Nature, 505 525-527 January 2014 doi: 10.1038/nature12918