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# STUDY INTO IN-ORBIT SERVICING OF THE ROSETTA MISSION

**Abstract**

This paper presents results of a research project defined by the Luxembourg Space Agency in collaboration with and supported by the retired principal investigator of Rosetta. The research is undertaken by a group of researchers and students from the Interdisciplinary Centre for Security, Reliability and Trust of the University of Luxembourg. The project is based on the ESA's deep space mission, Rosetta, that was operational from 2004 until 2016 with the objective of studying comet 67P/Churyumov-Gerasimenko. The Rosetta spacecraft was composed of a comet orbiter and a lander, Philae.

The overall objective of this project is to identify how the Rosetta mission could benefit of on-orbit servicing from a technical, reliability or cost perspective. In order to achieve the objectives, a reverse engineering and redesign study of the Rosetta mission and spacecraft is performed. Specifically, the study considers a refueling scenario where a propellant depot is assumed to be operational in lunar Distant Retrograde Orbit (DRO).

The original Rosetta mission had a complex mission profile and performed several planetary fly-bys on its 10 plus years long journey to the comet. Thus, the study is driven by trajectory analysis where two primary mission phases are modelled. First mission phase addresses the trajectory from Earth to DRO (propellant depot) while the second phase addresses trajectory analysis from DRO to Comet 67P. The spacecraft system configuration and related subsystem changes associated with both these phases are then addressed following the trajectory analysis. In addition to the trajectory derived factors (delta-V, time-of-flight etc.), refuelling operations in DRO also affect how the spacecraft design changes.

The aim of first mission phase (Earth-DRO) is to minimize the launch mass for any configuration of the spacecraft. The second phase (DRO-Comet) presents a greater number of options where multiple trajectory scenarios are possible. The simplest scenario being a direct transfer trajectory from DRO to Comet while another scenario could be to perform a lunar fly-by on the way to the comet. Similarly, other planetary fly-bys are modelled. The objective of the second phase is to perform a trade-off of the viable interplanetary trajectories and select the combination that optimize the total launch mass and/or total time of flight.

This paper presents the resulting spacecraft and mission re-designand illustrates the refuelling operations at the propellant depot. A second paper focusses specifically on the trajectory analysis performed as part of this study.