Title:

ReMoVE – Rendezvous Modelling Visiting and Enhancing

Abstract:

The ReMoVE (Rendezvous Modelling Visiting and Enhancing) project addresses the problem of removing from space the large faulty satellites that are polluting strategical terrestrial orbits. The increasing number of inactive spacecraft orbiting around Earth, in fact, affects the probability of satellite explosions and collisions, which foster the growth of debris belts, a phenomenon known as Kessler syndrome. Currently this trend is becoming even more critical, given the recent boost of mega constellations projects in Low Earth Orbit (LEO) to provide broadband internet services. Among the several proposed and actuated policies to deal with the mitigation of the growth of the debris population, the scientific community has recognised active debris removal (ADR) as a key activity to be performed. In this context, ReMoVE investigates to which extend a small, agile, and modular satellite platform can be used to rendezvous a passive Target (i.e., an inactive satellite) and to join it, to restore its capability to perform orbital manoeuvres. The game-changing approach of ReMoVE is embedded in the Enhancing concept: by exploiting recent knowledge and technology advances, the ReMoVE platform acts as a smart and independent additive sub-system, whose contribution is to allow the Target to recover the capability to perform de-orbiting manoeuvres. The greatest challenge entailed in this concept is dealing with an unknown uncooperative Target, demanding the development of a robust and advanced autonomous spaceborne Relative Guidance Navigation and Control (RGNC) system.

The ReMoVE project develops through three main research areas, which embody the turning points to assess the practicability of the ReMoVE concept. The first one addresses the rendezvous to a passive Target to approach a noncooperative target object. Here, the focus is on the dynamics and control algorithms to reach the mating conditions in a safe and delta-v efficient fashion. Accordingly, the following steps are considered: 1. Building convenient mathematical tools to treat the specific problem of the (continuously controlled) close-range rendezvous. 2. Identifying operational feasible (natural and controlled) relative orbits that could be used as starting conditions for the final approach to the Target. 3. Developing guidance and control algorithms able to support the design of relative trajectories deriving from forced motion actions, as required within the final approach or during synchronisation phases and the design of rendezvous trajectories subject to the typical constraints (e.g., safety and visibility) that occur in the close-range region. The second research area addresses the estimation of the 6 Degrees-of-Freedom (DOF) - i.e., translational and rotational - relative motion in the vicinity of the Target. Here, the focus is on the RGNC system architecture, algorithm development and implementation to deliver an accurate and robust relative navigation solution. Accordingly, the following steps are considered: 1. Analysis of the available sensors to provide observations of the Target in the close-range region to identify the key features and quantitative parameters that convey their performance. 2. Identification of the convenient parametrisation of the 6 DoF relative dynamics to support the development of the algorithms in a compact and efficient fashion. 3. Development of the algorithms of the relative navigation filter to estimate the full 6 DoF motion as well as the main parameters of the Target that characterise its rotational motion. Lastly, the RGNC analysis performed within the first two research areas are conveyed into the system design of the ReMoVE platform. Here, the focus is on the study of the platform configuration to embark all

required devices and to guarantee their efficient double-use. Accordingly, the following steps are considered: 1. Definition of the main requirements to the key subsystems posed by an ADR mission towards a noncooperative Target. 2. Development of the Concept of Operations (ConOps) foreseen for the space mission carried out by the ReMoVE platform. 3. Design of the platform configuration to satisfy requirements and the RGNC analysis carried out within the project.

Overall, the ReMoVE mission - intended as an ADR mission based on the use of the ReMoVE platform - introduces a new perspective in the architecture of removal missions. De facto, the ReMoVE satellite can be seen as an intelligent, autonomous, de-orbiting kit capable to reach by its own the target, to join it, and to “enhance” it. Accordingly, this mission philosophy differs from the classical de-orbiting kits attached to the target by a servicer satellite and differs from the standard approach of using a chaser satellite to capture a target object. ReMoVE could be seen as on-orbit-servicing applied to a debris removal mission and insights on its possible use to set up a multi-player and distributed ADR service for the LEO region are discussed.

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