SPACE DEBRIS SYMPOSIUM (A6)
Space Debris Removal Concepts (6)

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ACTIVE DEBRIS REMOVAL SPACE MISSION CONCEPTS BASED ON HYBRID PROPULSION

Abstract

During the last 40 years, the mass of the artificial objects in orbit increased quite steadily at the rate of about 145 metric tons annually, leading to a about 7000 metric tons. Most of the cross-sectional area and mass (97% in LEO) is concentrated in about 4500 intact abandoned objects plus a further 1000 operational spacecrafts. Analyses have shown that the most effective mitigation strategy should focus on the disposal of objects with larger cross-sectional area and mass from densely populated orbits. Recent NASA results have shown that worldwide adoption of mitigation measures in conjunction with active yearly removal of approximately 0.1% of the abandoned objects would stabilize the debris population. Targets would have typical masses between 500 and 1000 kg in the case of spacecraft, and of more than 1000 kg for rocket upper stages. In the case of Cosmos-3M 2nd stages, more than one object are located

nearly in the same orbital plane. This provides the opportunity of multi-removal missions, more suitable for yearly removal rate and cost reduction needs.

This paper identifies the requirements of two alternative space mission concepts for multiple active removal of large debris objects from LEO, as well as at investigating related technological and operational issues. The first concept relies on flying a multi-removal space platform carrying a number of Hybrid Engine Modules (HEMs) to dock with the pre-selected targets, according to a pre-fixed removal sequence. Each target is then de-orbited in a controlled way by firing the attached HEM package. Alternatively, the partial contribution of the atmospheric drag could be exploited to perform a cost-free altitude lowering. In this respect, the primary propulsion system of the multi-removal space platform could be used to leave the targeted debris into an orbit where the atmosphere effect is significant and a HEM could be attached on it for the atmospheric reentry. In such a way, thanks to the natural decay, the final burn for a controlled reentry will require less Delta-V. This second option introduces the question of in-orbit HEM aging, though a significant mass saving is expected, depending on mission details. With reference to the alternative mission concepts, particular attention will be given to multiple removal feasibility. These aspects will be investigated by using analytical models and numerical simulations. In addition, technological solutions relevant to mission and system aspects will be identified. Results will be used to compare the different mission concepts.