20th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 20th IAA SYMPOSIUM ON SPACE DEBRIS (IPB)

Author: Mr. Shun Isobe
Kyushu University, Japan

Dr. Yasuhiro Yoshimura
Kyushu University, Japan
Prof. Toshiya Hanada
Kyushu University, Japan
Mr. Yuki Itaya
Sky Perfect JSAT Corporation, Japan
Mr. Tadanori Fukushima
Sky Perfect JSAT Corporation, Japan

FORMATION KEEPING CONTROL FOR SIMULTANEOUS DEORBIT USING LASER ABLATION

Abstract

Numerous nonfunctional objects remain in near-Earth orbits, such as defunct satellites, rocket upper stages, and fragments from on-orbit collisions or breakups. To remediate the orbital environment, the annual active debris removal (ADR) of 5–10 from low-Earth orbit is required. Though several ADR methods such as electrodynamic tethers and robotic arms have been proposed and demonstrated, they need a direct-contact operation. Laser ablation is a vital technology for contactless ADR, where a service satellite with a laser system irradiates a target satellite to generate the ablation force for deorbiting. Thus, the removal satellite has a smaller risk of functional loss by accidental collisions. The deorbiting force decelerates the target, and the service satellite needs to maintain its relative position and keep irradiating. This simultaneous deorbit of service satellite and target makes the mission challenging because conventional formation flying missions assume that only a service satellite maneuvers. Thus, this paper derives the relative equations of motion when both service satellite and target have accelerations and then proposes the control law for the simultaneous deorbit. Furthermore, the proposed control law is extended to deorbit multi-target satellites by one service satellite. Multi-deorbit would be economy and more advantage than other ADR methods.

In this study, the service satellite's maneuver and target satellite's deorbit force are assumed to be low and continuous. Using Gauss' variational equations, the equations of relative motion between service satellite and target in powered flight are derived. On the basis of this equation, this paper proposes a control law for simultaneous deorbit. This control law contributes to practical operation and low collision risk during ablation. The laser ablation and service satellite's maneuver are assumed to operate exclusively. That is, the laser ablation and service satellite's maneuver do not operate simultaneously, but either one always operates, which enables long-time laser ablation, resulting in shorter deorbiting time. Numerical simulations are carried out for two test cases to verify the control law, involving the single-target and multi-target. The performance of the proposed control law in terms of accuracy and descent altitude is compared in the numerical simulations.