16th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 16th IAA SYMPOSIUM ON SPACE DEBRIS (IP)

Author: Mr. Kunal Jain
Indian Institute of Technology Kharagpur, India, kjkunal7996@gmail.com

Mr. Aditya R
U R RAO SATELLITE CENTRE (URSC), India, adityar@isac.gov.in

ACTIVE SPACE DEBRIS REMOVAL USING TETHER-NET CONNECTED TO SPACECRAFT IN FORMATION FLIGHT

Abstract

The growth of space debris, which has jeopardized the operation of spacecraft in the low earth orbit, calls upon the need for Active Debris Removal (ADR) missions and technology. This paper discusses an approach for containing space debris using large tether-nets connected to multiple spacecraft flying in formation. This approach provides an advantage in maneuvering of the tether-net in space during the initial deployment phase as well as during folding in the capture phase. The proposed method simulates a tether-net held together by a formation of four chaser spacecraft tracking a derelict object of assumed spherical geometry moving in a different orbit. The paper has been divided into different sections, each describing different stages in the ADR mission, including deployment of the tether-net in space, relative orbit dynamics for keeping the spacecraft in formation to maintain the required tether-net shape, rendezvous with the debris object, contact dynamics for debris capture and the de-orbiting phase to bring the debris to a sufficiently lower orbit where atmospheric drag is significant enough to de-orbit it. The focus is on the design of the relative dynamics and control system for the spacecraft formation during these phases. A lumped parameter approach is used to model the dynamics of the tether-net and the tether-net to spacecraft connectivity. A feedback linearization, based on the Hill-Clohessy-Wiltshire (HCW) equations which approximate the relative dynamics of two objects in close orbits, is used to model a proportional-derivative (PD) controller for generating the control commands for the spacecraft. This continuous control command is fed to a Pulse Width and Pulse Frequency modulator (PWPFM) to model the actuator logic for the on/off thrusters during the entire mission. Attitude control is formulated using a PD controller modeled using quaternion dynamics of the spacecraft and the generated torque commands are fed through an actuator saturation. Simulation results for each stage are presented and discussed in detail.