IAF SPACE PROPULSION SYMPOSIUM (C4)
Disruptive Propulsion Concepts for Enabling New Missions (9)

Author: Dr. Alice Brunello
CISAS "G. Colombo" - University of Padova, Italy, alice.brunello.3@studenti.unipd.it

Dr. Gabriel Borderes-Motta
Swedish Institute of Space Physics, Sweden, gabriel.borderes.motta@irf.se
Ms. Sadaf Shahsavani
Universidad Carlos III de Madrid, Spain, sshahsav@pa.uc3m.es
Dr. Andrea Valmorbida
University of Padova - DII/CISAS, Italy, andrea.valmorbida@unipd.it
Dr. Gonzalo Sánchez-Arriaga
Universidad Carlos III de Madrid, Spain, gonsanch@ing.uc3m.es
Prof. Enrico C. Lorenzini
Università degli Studi di Padova, Italy, enrico.lorenzini@unipd.it

OPTIMAL DESIGN AND CURRENT CONTROL STRATEGIES OF AN ELECTRODYNAMIC TAPE FOR ISS STATION-KEEPING

Abstract

Every year, the International Space Station (ISS) uses tons of fuel to keep its operational altitude with a cost of billions of dollars over a decade of operation [L. Johnson and M. Herrmann, 1999]. Propellant-less propulsion technologies would be desirable for limiting the expenditures for propellant mass and ground operation.

Previous works demonstrated that outfitting ISS with an Electrodynamic Tether (EDT) is a promising propellant-less option for its station-keeping. Johnson et al. in 1996 demonstrated that an EDT with a 10-km-long bare tether and an input power between 5 and 10 kW, can overcome the altitude loss due to the atmospheric aerodynamic drag on the ISS with a savings of almost 90% of the operational cost. In 2000, Estes et al. and Vas et al., considering a 7 to 10 km long bare tether that did not violate the microgravity requirements of the ISS and fed by a power supply of 5-10 kW, concluded that the EDT could reduce the propellant usage by 80% over a period of 10 years. In 2004, Strashinsky studied an insulated EDT in tandem with electro-rockets acting on the ISS for station-keeping and the analysis revealed that, in 10 years, an EDT with an electrical propulsion system could save up to 5 times the required cargo weight compared with electrical propulsion alone and up to 20 times when compared to chemical propulsion. The application of Low Work function Tethers for the ISS was also investigated [Sanchez-Arriaga et Sanmartin, 2019].

This work presents an analysis of the performances of a tape-like and bare EDT equipped with an electron emitter to perform ISS station-keeping. Based on a recent design algorithm for EDTs in the active mode [Shahsavani et Al., 2023], the optimal dimensions of the tether were found. The performance of the EDT was studied through numerical simulation. By modulating the input power that feeds the EDT system, the tether current is controlled and can be adjusted to compensate the aerodynamic drag. A comparison with previous analysis, based on round EDTs, is performed. A rough estimation of the reduction of the power that would be required from the ISS by using a bare-photovoltaic EDT is presented. The study shows that the use of EDTs can yield important mission benefits, and make the ISS independent on resupply while producing cost savings.