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Author: Dr. Marco Sabatini
Sapienza University of Rome, Italy, marco.sabatini@uniroma1.it

Dr. Paolo Iannelli
Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), France, paolo.iannelli2@isae-supaero.fr
Prof. Paolo Gasbarri
University of Rome "La Sapienza", Italy, paolo.gasbarri@uniroma1.it
Prof. Giovanni B. Palmerini
Sapienza University of Rome, Italy, giovanni.palmerini@uniroma1.it
Dr. Federica Angeletti
University of Rome "La Sapienza", Italy, federica.angeletti@uniroma1.it
Dr. Finn Ankersen
ESA - European Space Agency, The Netherlands, ankersen.finn@ieee.org

SCALING, MANUFACTURING AND OPERATIONS OF A FREE-FLOATING PLATFORM FOR THE ON-GROUND TESTING OF ROBUST COLLOCATED CONTROL FOR A LARGE FLEXIBLE SATELLITE

Abstract

Agile maneuvers of satellites equipped with very large and flexible structures (such as solar panels or antennas) are a challenging task due to the impact of elastic dynamics on the attitude motion, resulting in reduced pointing accuracy and dimensional stability of the payload. In this paper, the problem is addressed by developing a collocated control utilizing actuators for both the elastic (distributed piezoelectric devices) and the attitude (ON-OFF thrusters) dynamics. The project employs the mu-synthesis approach to develop a robust control system. In the initial phase of the project, the algorithm was extensively verified using a high-fidelity numerical model of a spacecraft equipped with two very-low frequency flexible solar panels and a payload consisting of two long booms and a transversal antenna's reflector. The second phase of the project, which is the primary focus of this paper, deals with experimental verification of the control architecture concept. To achieve this, a scaling procedure using the dynamic analogy approach is implemented to obtain the design parameters of a free-floating platform equipped with elastic appendages, ensuring that the resulting elastic multibody system has a similar dynamic behavior as the full-scale satellite. The test rig has been realized and equipped with thrusters and piezo-electric linear and patch actuators, along with relevant sensors (IMU and piezo-electric sensors) which were accurately characterized for testing the algorithm's performance in a laboratory environment. The ACAC (Active Collocated Attitude Control) system's performance is compared to traditional benchmark PID controllers. Experiments show that it is possible to tune the gains so that classic control systems can perform maneuvers that do not excite the elastic dynamics, but with a resulting very slow attitude motion. Conversely, it is possible to tune the gains so that very fast slew maneuvers are achievable, but it may cause significant disturbance to the elastic dynamics, which could ultimately result in mission failure. The proposed collocated control architecture, developed in the frame of an ESA project, is instead able to perform fast maneuvers with very limited elastic oscillations; the pointing requirements are fulfilled even in presence of uncertainties on inertia and elastic parameters, thus verifying the robustness properties. Therefore, despite its higher complexity level due to the presence of active elastic control devices, the ACAC rep-

resents an interesting and viable choice for the attitude control of large and flexible satellites with strict agility and pointing requirements.