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SPACECRAFT REFLECTANCE EXPERIMENTAL FACILITY FOR SPACE TRAFFIC MANAGEMENT AND BRIGHTNESS ESTIMATION: LESSONS LEARNED FROM HELIOS AT S5LAB

Abstract

The rising number of launches and the growing interest in mega-constellation and large swarms of spacecraft is raising concerns over the impact of such large clusters of in-orbit objects on the astronomical community. In particular, while the brightness of the external surfaces is not usually constrained by requirements during the satellite development, very bright objects with low values of magnitude can significantly impact on ground-based astronomical observatories, diminishing the importance and the achievements of their scientific activities. Furthermore, the attitude of extinct or malfunctioning objects can be coarsely derived by photometry when observing the reflected light from an object, satellite or space debris. In this case, the luminosity trend over time during multiple observations is observed and analyzed to retrieve the rotational rate (in general, through Fast Fourier Transform), but the accuracy of such determination is impacted by many unknown factors, including the degradation of the external surfaces and the usual axial-symmetry of the launched bodies. Such technique is paramount for Space Traffic Management tasks, such as re-entry prediction with drag estimation, and for future active debris removal. In the future, pre-launch photometry characterization of sub-units and entire spacecraft should be performed in order to assess the impact of the launched satellites on astronomic observation, i.e. by determining its brightness in operational scenarios, and to derive an accurate reflectance model in case on-ground photometry-based attitude prediction is necessary. The Sapienza S5Lab research team has developed a testing facility able to experimentally derive the brightness and reflectance model of in-orbit objects and smaller scale models which is acting with a small-power Sun simulator, radiometric probes and a robotic arm. The facility, named HELIOS and built in Winter 2022-2023, is under qualification. The validation process for laboratory testing includes evaluation of theoretical and graphical rendering-based models, actual testing for nano-satellite models and smaller-scale optical models of larger satellite platforms and verification of photometry data with in-orbit objects through the network of telescopes managed by the same research group. This paper will deal with the description of the development, evaluation and validation tasks for the HELIOS testing facility at Sapienza University of Rome. After an introduction over the impact of low-magnitude objects on astronomical observations and on the importance of photometry data on inactive spacecraft attitude determination, the facility validation and on-going testing campaigns will be described, together with future plans and perspectives.