Ensuring the sustainable future use of space: a new tool for tracking environment health and mission impact

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Space is no longer the “next frontier”, at least in what regards the orbital regions around Earth. Technological advancements and the associated cost reductions have spurred the commercial, scientific, and even educational use of Earth satellites, for a myriad of applications like telecommunications, navigation, Earth observation, SAR support, and many others. But, as the use of space-based assets becomes commonplace, also the issue of capacity allocation grows more pressing. This is a common challenge to any activity involving limited resources, but one that has so far received relatively little attention in space (aside from the GEO protected region). To ensure the future sustainable use of space, policies for the responsible use and allocation of orbital space as a resource must be put into place, supported by accurate and actionable data.

To meet this goal, it is fundamental to track the health of the environment and the impact from current and proposed missions in a holistic way. And even more important, relevant, and clear quantitative metrics must be defined to support both policy making and individual mission design and approval. These are some of the objectives of the THEMIS software tool being developed by Politecnico di Milano and Deimos UK, within a project funded by the European Space Agency. The aim is to assess the impact of a space mission on the space environment to measure the overall Space capacity, and the contribution of each mission to it. As scientific developments, the project has devised a probabilistic continuum approach for describing the evolution in space and time of the density of debris fragments resulting from explosions and collisions in space. This approach is applied on a grid on potential initial conditions to compute the effect that a mission, in case of breakup, has on the active spacecraft population. This is a computationally heavy procedure that is periodically repeated to account for the evolution of the space environment and new missions, so particular attention is put to the performance of the mathematical models. The THEMIS tool allows for the computation of the quantitative space debris index of a mission described in mission phases, represented by a set of orbital elements, cross sectional area, mass and operational considerations such as collision avoidance manoeuvre efficacy and post mission disposal reliability. On the other hand, because the ultimate goal is for THEMIS to be used by satellite operators and other space actors when planning missions, it is important to pay attention to user experience and tool accessibility. The mission can be inputted to the tool through a web user interface that allows describing different mission architectures such as constellations, launcher and spacecraft and single spacecraft missions. The output of the analysis, given in terms of space debris index per phase, per spacecraft, per end-of-life disposal options can be aggregated into a single mission score to allow the integration in life cycle assessment studies. As part of the ESA project, the DISCOS database is also expanded to be save the results of each analysis for future re-evaluation of the missions and for comparison with other missions. In this way, a comprehensive tool will be available for debris experts and spacecraft operators to easily evaluate the environmental impact of the mission.

In this talk we will present the overall capabilities of THEMIS and current development status, paying particular attention to the mathematical models for the efficient propagation of the debris clouds and the subsequent computation of the effect maps.