A New Algorithm to Compute the SRP Force and Torque on Generic Spacecraft

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The proper estimation of the force and torque exerted by the Solar Radiation Pressure on a spacecraft is key for the safety of the spacecraft operations. On the one hand, the estimation of the acceleration produced by the SRP is essential for the accurate navigation of the spacecraft. On the other hand, the torque exerted by the SRP is one of the main drivers for the angular momentum management strategy in missions with reaction wheels.

The computation of the SRP force and torque deals necessarily with the problem of determining the visible parts of the spacecraft as seen from the Sun and the shadows the different elements cast on one another. This problem, usually called “visibility problem”, can be tackled in many different ways, usually yielding very different performances, and is the reason for the existence of different SRP computation methods. The solution to the visibility problem can also have other potential applications in spacecraft operations, like the estimation of the force and torque produced by aerodynamic drag.

The selection of the method is important since it can have a clear impact in the ground operations. Experience with missions like Rosetta has shown that the performance of the SRP force and torque computation method can be the driver for long term reaction wheel level predictions or for spacecraft attitude dynamics simulations.

The purpose of this paper is to make a high level review of the existing methods to solve the aforementioned problem. In that frame, a specific algorithm based on Binary Space Partitioning trees [1] and polygon Boolean operations [2] that has been developed at ESOC will be presented in detail. The new algorithm is generic and can be configured for any reasonable spacecraft geometry, taking into account articulated units. The algorithm will be compared to the former operational software for interplanetary missions, based on ray tracing techniques, not only in terms of performance but also flexibility, robustness, complexity and maintainability. The data for this comparison will be drawn from the ExoMars-16 and Bepi-Colombo missions, for which the new algorithm is already in use as part of the Flight Dynamics system. These two missions present two extreme cases of geometrical complexity, Exomars-16 having a rather simple geometrical configuration and Bepi-Colombo lying at the opposite end. Taking both missions as comparison examples will therefore allow to test the behaviour of the different algorithms for different conditions of the underlying geometrical complexity.

References

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