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Bachelor / Master Thesis

Collision risk assessment of different debris avoidance measures of large objects

With the significant rise in the number of orbital rocket launches by annually about 15% or more within the next decades (not including space tourism), the risk of collisions with uncontrolled space objects in certain orbits increases. Possible solutions include removing existing objects and modifying future missions. Large space structures like orbital rocket stages make up half of debris-generating objects, making them focus of current research. The common measure to reach faster de-orbiting of orbital stages is an active de-orbit burn, which requires additional fuel mass. Passive systems such as drag sails are also conceivable, although orbital stages often deorbit passively within a few days, not least because of their large cross-sectional area. Current research in the field of aerodynamics in Very Low Earth Orbits is interesting for these objects, as attitude control of the upper stage could be utilized for accelerated aerodynamic de-orbit maneuvers. However, any increase in cross-sectional area also increases the risk of collision.

As part of a final thesis, the relationship between accelerated de-orbit and increased collision risk with increased cross-sectional area is to be characterized. In addition, the use of a deployable drag surface is to be considered as an extreme case. The risk is calculated using the cumulative collision probability, with object fluxes over altitude as input. Further environmental conditions due to atmospheric fluctuations will also be included. The results may provide a “sweet spot” of cumulative collision probability versus de-orbit acceleration. For orbit propagation for different geometries under different environmental conditions, ESA tools such as MASTER and DRAMA. The student will conduct literature research and is provided with geometry and mass properties of different orbital stages.

Task description of the Bachelor thesis work:

- Literature research on space debris models, collision risks determination
- Familiarization with ESA tools MASTER, DRAMA
- Definition of test cases (initial altitudes, geometry and mass)
- Determination of cumulated collision risk using MASTER and DRAMA
- Documentation

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