DENSITY BASED APPROACH FOR COLLISION RISK COMPUTATION

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In February the satellite DMSP-F13 exploded in orbit producing 136 new trackable pieces of space debris. In the following days, ESA and then other operators have assessed how the explosion affects the risk for their spacecraft. These analyses, as well as the study of debris evolution in general, are usually performed considering only debris objects larger than 10 cm, whereas the contribution of small debris fragments is often neglected. However, small debris fragments are an important part of the debris population: any collision with objects larger than 1 mm may interfere with the spacecraft operation and a collision with objects larger than 1 cm may destroy a satellite. In the case of the satellite DMSP-F13, for example, the presence of 136 new catalogued objects suggests than more than 50 000 small fragments larger than 1 mm were created, if the explosion is modelled with the NASA breakup model.

The impact of a new fragmentation event considering also the presence of small fragments can be assessed by studying the produced fragment cloud in terms of its spatial density. A density based approach for small fragments collision risk computation (CiELO) was developed at the University of Southampton. This novel formulation of the problem allows representing the long-term evolution of a large number of fragments with an analytical model based on the continuity equation, with a limited computational effort compared to the standard approach of following each individual object.

Once the cloud density is known, the collision probability for a large number of fictitious targets with different altitude and inclination is computed. In this way, it is possible to build a collision map that clearly shows which are the most affected regions of space as a consequence of the breakup. Coupling this map with a database of spacecraft or space debris objects it is also possible to identify the most exposed targets. This kind of maps can be useful for operator to have a fast estimation of the increase in the long term collision risk on their missions.

The paper will discuss in detail the aspects of this application (e.g., long-term modelling, collision probability computation, the connection between the collision map and the target database) and the results for the DMSP-F13 case. Moreover, the reduced computational effort of the proposed method allows many different analyses on possible collision scenarios. Therefore, other applications of the method will be discussed such as the possibility of studying the relative influence and vulnerability among the debris objects with the highest criticality.

Keywords: *fragmentations, small debris fragments, collision probability*