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# DETECTION AND CHARACTERISATION OF IN-ORBIT FRAGMENTATIONS OVER SHORT AND LONG PERIODS OF TIME

**Abstract**

The recent years have seen a fast increase in space traffic as humanity relies ever more on satellite-based services. Despite the adoption of regulations for space debris mitigation, the already large population of objects orbiting the Earth is destined to grow. With it, the chance of accidents involving any of those objects grows as well, threatening current and future satellite operations. Since not all such events can be predicted or avoided, space debris must be studied and identified as soon as possible upon their formation in a reliable and efficient manner, to detect fragmentations and reduce the risk they pose for other satellites.

The PUZZLE software package was developed for this purpose at Politecnico di Milano, initially under a contract with the Italian Space Agency. As presented in previous works, the tool analyses a set of unclassified objects in the form of Two-Line Element (TLE) data to detect possible fragmentations occurred in the recent past. These objects are propagated backwards to search for a common origin in space and in time, and then matched with known objects possibly involved in the event. The fragmentation is then characterised in terms of mass and energy using the available NASA standard breakup model, which simulates the distributions of the fragments produced in the event.

In this work, we extend the functionalities of the tool to operate on periods of the order of months or years: since the accuracy of the analytical SGP4 model is limited to a few days, the long-term propagation is performed using averaged Keplerian elements, which ignore the short-periodic effects of perturbations to provide a faster integration without loss of accuracy. The choice over short- and long-term analysis is done according to the options input by the user and to the findings of an optional short-term investigation. Furthermore, to ensure an accurate long-term propagation, an estimation of the ballistic coefficients of the objects is obtained starting from the B* parameters of the given TLEs: different factors, ranging from the atmosphere model adopted for the analysis to the number of available TLEs, are considered in the estimation. The matching of the parent objects and fragments with known objects is associated to a probability index.

The operations performed during the analysis will be explained, and the application of the approach to actual fragmentation events will be shown alongside numerical results and performance data.