Enhancements for Modeling Future Characteristics with the new ESA-DELTA

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ABSTRACT

The new version of the ESA tool DELTA 4 (Debris Environment Long Term Analysis) was developed at the Institute of Space Systems of the Technische Universität Braunschweig, under a contract with the European Space Agency ESA. The work included the development of a completely new framework as well as essential enhancements of the functionalities. The new features will be explained in the paper alongside with results of demonstrative reference simulations which highlight the desired effects.

With the help of the new plugin-based framework, three algorithms for calculating collision probabilities are now available in DELTA 4: CUBE, Orbit Trace and a flux-based algorithm. In addition, possible collision events can now be further differentiated with the consideration of possible appendages for payloads. For an individual blend between non-catastrophic and catastrophic collisions, it is possible to deviate from the previous variant of a fixed critical energy-to-mass ratio (EMR) of 40 J/g. DELTA 4 now allows the definition of an unlimited number of setups with different critical EMRs for individual object groups and types. Additionally, the user has the option to define his own functional relationship of a critical blending parameter using the newly implemented function parser.

The function parser is one of the most important achievements of the new version. The parser allows assigning parameters of space debris objects as well as simulation parameters to variables of the used function. This allows a new type of parameter definition, via the associated input file, in different areas of the simulation functionalities. A limitation of the validity of the setup to certain objects is supported by the introduction of a filter system. The objects of the considered population can be filtered according to their body and orbit parameters for different setups. Furthermore, the fragmentation model was improved and extended: In the new DELTA 4 it is possible to manipulate the Δv-distribution of fragments with a deviation from the standard isotropic distribution. Likewise, the amount of assigned Δv can be increased or decreased using a factor. This counts for collisions as well as for explosions. Also here setups can be assigned to certain objects with the help of object filtering.

The concepts of object filtering and the function parser are also applied in the new structuring of the setups of mitigation measures. With the implementation of compliance level setups, the behavior of objects with regard to mitigation measures can now be defined individually. The principle of compliance level describe a sub-setup for used mitigation measures and allows the manipulation of their parameters for certain object types and groups during the simulations. This includes active debris removal, passivation, slag prevention, re- and deorbit. Effects on e.g. success rates can now be defined object related as well as set into a temporal dependency by using the function parser. In order to comply with future-oriented simulations, DELTA 4 also supports the use of electric propulsion systems as well as solar and drag sails. Orbit insertion maneuvers as well as accelerated de-orbit maneuvers can be simulated and their impact can be further examined.

With these extensions the new ESA-DELTA supports an important step towards the object-type oriented simulation of certain individual behaviour patterns and possibly more realistic evaluations of the long-term development of the space debris environment.