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FEASIBILITY ASSESSMENT OF A CONTAINMENT TETHER TO REDUCE LEO SATELLITES' ON-GROUND CASUALTY AREA

Abstract

LEO satellites with a mass above 500kg recurrently struggle to meet an on-ground human casualty requirement of less than 1 in 10,000. The recently introduced discipline of design-for-demise collects technical solutions on different levels to promote the atmospheric demise (ablation or melting) of spacecraft components to reduce the casualty risk on ground. This effect can also be achieved by other methods called containment. They reduce the casualty risk by connecting several non-demisable fragments into one, thus reducing the total ground impact area.

This paper introduces a containment tether and provides results of a first feasibility assessment. The advantage of combining several components known to be non-demisable with a tether is the simplicity of the solution: The overall satellite design can remain largely unchanged. If at all, the units to be connected have to be modified in order to attach the tether reliably because the attachment must not fail during re-entry. Likewise, the process of satellite assembly, integration and test is not impacted majorly by such a solution. Finally, the cost of the tether itself as a simple, passive structural item is relatively low and so is the effort for integration due to the simple interfaces to the spacecraft.

The feasibility of the concept has been assessed considering the following aspects: Heat flux on the tether, tether material selection, attachment to units, tether geometry, tether topology and aspects of assembly, integration and test. The performance of the tether has been evaluated by assessing the potential reduction of casualty risk for a reference mission using SCARAB simulations. These have shown that the casualty risk could be reduced by 42% for the reference mission changing it from being non-compliant to compliant with the applicable requirement. This combination of high performance and low expected cost and risk make the containment tether an attractive solution among the variety of design-for-demise techniques.

The work has demonstrated a first feasibility and shown that the performance is very promising. A way forward on how to develop the proposed technology until qualification level has been elaborated. In future design iterations several physical aspects have to be addressed together to confirm these results. These include the aerothermodynamics, kinematic properties of loosely connected rigid objects, aspects of shock-shock or shock-surface interaction and material properties at elevated temperatures and potentially in oxidized state.