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A NOVEL APPROACH FOR THE ACCURATE SIMULATION OF RE-ENTRY FRAGMENTATION

Abstract

The evaluation of the on-ground casualty risk assessments due to a controlled/uncontrolled re-entry is highly sensitive to the accurate prediction of fragmentation events during an atmospheric re-entry. Accurate knowledge of re-entry fragmentation becomes all the more important for Design for Demise (D4D) procedures to ensure compliance of future missions with Space Debris Mitigation guidelines for small and medium satellites. To address this issue, we propose a novel approach to study fragmentation during re-entry. The new peridynamic theory provides the capability for improved modelling of progressive failure in materials and structures. Peridynamics is a non-local continuum mechanics formulation developed in the early 2000's. The governing equations of peridynamics are integro-differential equations and do not contain any spatial derivatives, which provides a very attractive formulation to simulate problems including discontinuities such as cracks. The emergence of fully coupled peridynamic thermo-mechanical simulations in the recent years may provide an accurate methodology to study re-entry fragmentation in a single framework for multi-physical simulation modelling.

For this work, we use an open-source peridynamics software that has been loosely coupled with an object-oriented re-entry analysis code. The main objective is the study of start and propagation of a crack, during a re-entry conditions. We model a test case spacecraft with a junction made of a single metal, and run the simulation for various initial conditions and junction thicknesses. We analyse the subsequent break-up of the junction and compare it with the break-up criteria used by some of the state-of-the-art re-entry simulation codes. We also discuss about the development of the relevant framework and coupling methodology to enable such simulations.