Development of an Uncertainty Framework for Risk Analysis During Atmospheric Re-entry*

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Abstract. The impact location of an object re-entering the atmosphere is affected by uncertainties in initial conditions, atmospheric characteristics, object's properties, and fragmentation events. Hence, it is of utmost importance to correctly assess the ground impact risk of surviving fragments. A Monte-Carlo (MC) dispersion analysis can be used to do this in the state-of-the-art re-entry analysis tools. This method simulates a large number of trajectories using a randomly sampled set of initial circumstances and parameters. The MC approach can provide a realistic distribution for the output of interest due to uncertainties in the input parameters, however, it does so with a very high computational cost as it requires a large amount of sampling of the stochastic input domains and expensive function evaluations. The objective of this work is to implement a more efficient and sophisticated High-Dimensional Derivative based uncertainty quantification and propagation approach into the open-source trans-atmospheric flight simulation tool, currently being developed at the University of Strathclyde. Moreover, a bayesian model updating framework is also implemented to allow for the update of the uncertainty distributions in the initial parameter space when telemetry/observation data is available. The current research work is showcased using a couple of representative test cases with and without fragmentation events.

Keywords: Atmospheric Re-entry · Uncertainty Quantification · Model Updating · Design for Demise

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