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Title

ReFEx: Reusability Flight Experiment – Flight Safety Analysis

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Abstract

The German Aerospace Center (DLR) project ReFEx aims at flying a trajectory representative for aerodynamically controlled RLVs, demonstrating autonomous GNC capabilities. The flight experiment will be launched from the Koonibba Test Range (KTR), a launch facility in Southern Australia operated by Southern Launch, towards the Woomera Prohibited Area (WPA). In order to comply with Australian regulation a flight safety analysis needs to be provided to the Australian Space Agency (ASA). Key factors in the flight safety analysis are factors such as maximum third-party collective risk (casualty expectancy number), maximum third-party individual risk per launch and risk areas, as detailed in the ASA Flight Safety Code 2019 [1]. The analysis presented in this paper focuses on the payload (i.e. the ReFEx flight experiment only) and does not include the launcher.
In order to ensure the safety of the mission, a Flight Termination System (FTS) is integrated into the vehicle, giving a Flight Safety Officer on the ground the capability of cutting power to the aerodynamic actuators, canards and rudder. The combination of the FTS with a spring integrated in the rudder destabilizes the vehicle, resulting in uncontrollable and unstable motion. An extensive campaign was conducted, confirming that this behavior remains unaltered after factoring in any other potential failures (e.g. failure of one or more of the aerodynamic actuators).
As the aerodynamics of the unstable vehicle are not well known, several scenarios have been considered with different degrees of conservativeness. Monte-Carlo campaigns have been conducted for each of these scenarios, accounting for uncertainties in the vehicle and in the environment and assuming the FTS is triggered at an arbitrary time. Each of these campaigns results in a set of touch-down locations. These sets are then used, in combination with the probability of mission failure, to estimate the casualty expectancy, based in the procedure defined by ASA [1]. Being an essential flight safety parameter, the casualty expectancy number is calculated as a product of impact probability, casualty area and population density summed over the population centers considered. Additionally, a debris analysis was conducted, to assess the consequences of a vehicle breakdown.

References

[1] Australian Space Agency: Flight Safety Code, August 2019