SPACE DEBRIS SYMPOSIUM (A6)
Modelling and Risk Analysis (2)

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OVERVIEW OF THE RESULTS OF ATV-1 RE-ENTRY OBSERVATION CAMPAIGN

Abstract

Early on Monday 29 September 2008, ESA's Automated Transfer Vehicle began a controlled destructive re-entry. It broke up at an altitude of approximately 75km with the remaining fragments falling into the South-Pacific Ocean. To observe the events occurring during the re-entry, a joint ESA/NASA multi-instrument aircraft campaign was performed using two aircraft equipped with a suite of optical instruments including video systems and spectrographs covering the near-UV, visible and nearIR wavelengths. Preliminary analysis showed that several major fragmentation events occurred, as well as a distinct explosive event. A complete analysis of the data gathered was performed under ESA contract by an international consortium lead by GMV, and formed by: IRS(Germany), LIME(The Netherlands), ISA(France), FGE(UK), GMV(Spain).

This paper summarizes the results and analyses performed in order to: detect fragments, reconstruct trajectories, characterize explosion events, and determine the impact footprint. From the spectroscopic data recorded and the 3DOF/6DOF reconstruction of the trajectory it was possible to assess the most probable causes of the explosion events observed. This rebuild showed that the initial tumbling motion

is damped out and the vehicle is coning when the explosion occurs. This suggests that one end of the vehicle is heating more than the other, creating a higher likelihood of an outer shell failure leading to the explosion. Since the lithium seems to be released progressively and that the start of the emission is several seconds after the main explosion, it is thought the scenario with an explosion initiated by the MMH is the most probable.

In order to be able to obtain the impact footprint, automatic fragment trackers were implemented and triangulation strategies were developed. The information obtained was used to estimate initial conditions, ballistic coefficients and footprint of the multiple identified ATV fragments considering the uncertainties on the initial conditions. Several algorithms from the theory of optimal estimation were applied. The estimation of fragments conditions is carried out with a weighted least squares batch filter. Accurate fitting of triangulation data is achieved although the knowledge is directly linked to the observations quantity and quality. The footprint analysis was performed with an unscented covariance analysis in order to efficiently approximate non-linear distributions.

The results obtained from the ATV1 explosion assessment and footprint analysis are specifically relevant for safety proposes in order to better understand the processes underlying reentry and explosion that could assist to improve reentry models and safety analysis of future reentry missions.