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Master Thesis Work

of Mr. Name, Surname

Experimentelle Untersuchung des destruktiven Wiedereintritts einer VEGA/AVUM Oberstufe

Experimental Investigation of a VEGA/AVUM Booster Stage's Destructive Re-entry

Motivation:

Spacecraft re-entering Earth's atmosphere in an uncontrolled manner are subjected to intense aerothermal heating as their relative kinetic energy is dissipated. Unprotected returning systems such as upper rocket stages or defunct satellites will usually break up mid-flight, releasing substructures and components, which may or may not proceed to succumb to the extreme heating environment. Surviving spacecraft debris, in many cases pressure vessels may impact the ground with very little damage, posing a significant risk to life and property. To better predict the risks of future entry events, it is necessary to assess and attempt to recreate past destructive re-entries through experiment and simulation.

On November 2nd 2016, the upper booster stage (AVUM) of ESA's first VEGA rocket, originally launched on February 13th 2012, re-entered Earth's atmosphere over India. Two debris items were recovered, which constituted the remains of pressure vessels, one composed of a titanium alloy and one being a Composite-Overwrapped Pressure Vessel (COPV). The first main task of this Master thesis is to assess the damage and reconstruct local heating conditions through simple trajectory analysis and cross-examination of the available data of these pressure vessels with existing ground experiment data obtained using the IRS Plasma Wind Tunnel (PWT) facilities. The second main task is to then, through review and application of known flight-to-ground test scaling relations and facility capabilities and constraints, propose a PWT experiment design to emulate these conditions as accurately as possible for samples representing the segments of the pressure vessels. The results of this test campaign are to then be analysed in correlation to the recovered debris items.

Task description of the Master thesis work:

- Literature review of destructive re-entry in general, specific AVUM entry event data, suitable ground experiment methodologies (specifically Plasma Wind Tunnels) and flight-to-ground scaling relations.
- Assessment of AVUM pressure vessel damage phenomenology from available data.
- Analysis of pressure vessel entry conditions to be emulated in PWT testing.
- Scaling and design to relevant PWT experiment setup.
- Support of PWT test campaign and analysis of PWT experiment results.
- Documentation of the work, preferably in English.

Supervisor: Adam Pagan

Starting date: anytime

Submission until: six months later

Acknowledgement of receipt:
I hereby confirm that I read and understood the task of the master thesis, the juridical regulations as well as the study- and exam regulations.

PD Dr.-Ing. Georg Herdrich
(Responsible Professor)

Signature of the student

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