Abstract EUCASS

Title: Cryogenic propellant technologies validation in microgravity in FLPP/CUST program

Authors: A. Sirbi, J. Kauffmann, G. Pilchen, B. Schmitz, P. Behruzi, M. Dreyer, A. Schuette

En essential enhancement of future launch vehicles is the re-ignition capability which allows mission versatility, flexibility and improved performance. To support the reignition feature, the propellant management and conditioning shall be done in a controlled and reliable way. A number of technologies, gravity dependent, necessary for handling of cryogenic propellant, were developed and tested in microgravity, in the frame of the CUST (Cryogenic Upper Stage Technologies) project of ESA's Future Launchers Preparatory Programme (FLPP). A conceptual description of the following technologies and their will be presented:

1. Propellant Management Device (PMD), to ensure gas free liquid towards engine
2. Gas Port Phase Separator (GPPS), to ensure liquid free gas on the depressurisation line
3. Propellant preconditioning, to ensure subcooled liquid during the entire launcher mission

The microgravity tests already performed for technologies development were focused on drop tower tests and sounding rocket tests; in both cases substitute fluids at room temperature and liquid nitrogen were used to simulated the cryogenic propellants.

An overview on the test design and test execution, performed in ZARM, focused mainly on technological components of PMDs and GPPS, will be described. The limitations of the tests will also be addressed.

Besides the drop tower tests, a more complete PMD technology test in microgravity, from functional point of view, using liquid nitrogen was performed with the TEXUS 48 flight. The two payloads were simulating the LOX PMD and LH2 PMD and in both cases a reduced scale PMD was designed.

After description of both payloads concepts, the flight results compared with the predictions will be discussed. The outcome of the flight allowed a better understanding of the heat distribution inside PMD and contribute to the improvement of mathematical models simulating the cryogenic propellant interaction with the PMD. Another important outcome of the flight that will be discussed is a better understanding of the helium dissolution into cryogenic fluids.

In parallel to these specific developments, ESA initiated a more thorough study with institutions (ZARM) and Industry (Astrium GmbH) to assess the cryogenic upper stage needs in terms of mathematical tools validation, to be able to simulate the performances of a cryogenic upper stage. Discussion of potential upper stages flight sequences for which a good knowledge of the propellant behaviour and technologies' efficiency is mandatory. For all these phases (e.g. ballistic phase, engine pre-cooling phase, re-ignition phase, payload release etc) it is critical to have the necessary numerical tools validated with tests data to be able to make prediction with a good accuracy.

A dedicated activity called Functional System Analysis Software (FSAS) which objectives will be presented, will make the link between upper stage system and validation of available tools, closing the loop at system level.

The outcome of above mentioned studies will be discussed in the paper together with the proposed inflight experimentation logic. The flight results shall support the industry to reach a maturation level in

different fields such that predictions and quantification of upper stage capabilities can be performed for various upper stage configuration.

Furthermore, the inflight experimentation will be used also to increase the Integration Readiness Level(IRL) of upper stage technologies. An overview of foreseen technologies will be provided.

The paper will conclude by presenting a short term plan for in flight demonstration of technologies and functions of a cryogenic upper stage.