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CRYO-LABORATORY FOR THE INVESTIGATION OF PROPELLANT BEHAVIOUR AND DEVELOPMENT OF PROPELLANT MANAGEMENT TECHNOLOGIES

Abstract

The knowledge and understanding, as well as the application of intelligent propellant storage and management technologies is one of the key competences for successful design and the realization of future advanced cryogenic upper stage systems, prepared to meet the future market demands concerning more mission flexibility such as multiple restart options paired with long duration ballistic flight phases. Main functions of the propellant system are: to guarantee the gaseous and bubble free supply of propellants at the specified thermodynamic conditions during the complete mission; to minimize the boil-off losses due to evaporation particularly during the ballistic phases; to ensure no loss of propellants during venting; to avoid critical sloshing phenomena; to avoid critical pressure variations generated by heat- and mass transfer processes at the gas/liquid interface. Therefore the availability of a cryogenic laboratory is of fundamental importance, to develop, test and consolidate various propellant storage and management technologies.

In order to support the European launcher industry and to secure and to enhance the upper stage competence in Germany, the DLR decided to establish a cryo-laboratory at the Institute of Space Systems in Bremen. The cryo-laboratory and the test equipment are designed specifically for the research and development in the field of cryogenic propellant storage and management technologies. The cryogenic laboratory will be equipped with a supply system for the cryogenic propellants liquid hydrogen and liquid methane, and their respective gases, as well as gaseous helium. As test equipment, among various cryostats, a vacuum chamber and a movable platform with six degrees of freedom, useable for the investigation of sloshing phenomena, will be available. The test facilities are equipped with various measurement systems and sensors, to be able to measure forces, pressure, temperature, free surface position, flow rate, fill level and to control the experiment by video. An appropriate test environment close to the upper stage application is given by the cryogenic tank demonstrator provided by ArianeGroup Bremen serving the needs for future upper stage developments.

The aim of this paper is to present the basic intention of the laboratory and to demonstrate the available test capabilities with respect to the research field propellant storage and management technology. The quality of the cryo-laboratory will be shown on selected test examples.