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PHOEBUS: A HIGH LIFT-OVER-DRAG VEHICLE FOR EARTH RE-ENTRY

Abstract

The current European and international interest in human exploration missions leads to particular focus on the return to Earth with superorbital re-entry speeds. Currently used re-entry vehicles, like capsules and the Space Shuttle, reduce their initial kinetic and potential energy during atmospheric re-entry by exploiting mainly the drag forces. Advanced re-entry vehicles with a high lift-over-drag ratio are able to perform long duration re-entry trajectories with large downrange and crossrange with good manoeuvrability by a proper utilization of lift forces. A long-duration re-entry of that type reduces drastically the g-loads to typically approximately 1 to 2 g, compared to > 8 g for ballistic capsule-type re-entry (LEO). This is especially an advantage for an ill or de-conditioned crew. These requirements lead to a winged vehicle with a low wing loading and a high aerodynamic efficiency.

The PHOEBUS concept shows a re-entry vehicle which achieves all requirements for a high lift flight. Contrary to the conventional vehicles with a maximum hypersonic lift-over-drag ratio in the range of 0.3 (capsule) to 1.2 (Space Shuttle), the PHOEBUS has a maximum hypersonic L/D of about 3. It is designed to carry a crew of three astronauts and is attached to a modular resource module, which can be adapted to different mission scenarios. The structure is designed as a hot structure concept with sharp leading edges at the fuselage and the wings and is made of state-of-the-art materials. An insulated compartment is foreseen for the crew, payload and avionics.

The outstanding flight quality of a high lift-over-drag re-entry vehicle compared to a conservative vehicle admits to fly a low-risk and smooth atmospheric trajectory with a large variety of substantial

changes of inclination and expands number of possible re-entry windows and landing sites.

The paper will show an overview of the study results for the spacecraft design, the analysis of the flight mechanics, the aero- and aerothermodynamics as well as the guidance and control techniques performed in the PHOEBUS study to show the feasibility of such a re-entry vehicle. Furthermore, the requirements for the launch and landing sites and their scenarios will be described.

As an outcome it can be summarized, that the characteristics of the PHOEBUS open up a wide range of operational flexibility concerning the re-entry windows and landing sites for exploration missions to meet their requirements including abort cases and/or medical return.