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MAGNETOHYDRODYNAMIC ENHANCED ENTRY SYSTEM FOR SPACE TRANSPORTATION (MEESST) AS A KEY ELEMENT FOR HUMAN SPACEFLIGHT MISSIONS

Abstract

This paper outlines the initial development of a novel magnetohydrodynamic plasma control system intended to mitigate shock-induced heating and the radio-frequency blackout phenomenon encountered during atmospheric entry. An EU consortium comprising universities, SMEs, research institutions, and industry has been formed in order to develop this technology, known as MEESST. The project is funded by the European Commission's Horizon 2020 scheme (grant no. 899298). Atmospheric re-entry imposes one of the most demanding environments which a spacecraft can experience. The combination of high spacecraft velocity during re-entry and the rapid compression of atmospheric particles by the spacecraft leads to high-enthalpy, partially ionised gases forming around the vehicle. This inhibits radio communications, and induces high thermal loads on the spacecraft surface. For the former problem, spacecraft rely on satellite constellations to communicate through the plasma wake and therefore avoid telecommunication blackout. On the other hand, expensive, heavy, and non-reusable thermal protection systems (TPS) are needed to dissipate the thermal loads. Such TPS can comprise up to 30The use of electromagnetic fields to exploit magnetohydrodynamic (MHD) principles has long been considered as an attractive solution for the problems described above. By displacing the boundary layer of the ionized gas layer away from the spacecraft, the thermal loads can be reduced, while also opening a magnetic window for radio communications and mitigating the communication blackout phenomenon. The application of this has not been previously demonstrated due to the large magnetic fields required (on the order of Tesla), which for conventional technologies would demand exceptionally heavy and power-hungry electromagnets. High-temperature superconductors (HTS) have reached a level of industrial maturity sufficient for them to act as a key enabling technology for this application. Thanks to superior current densities, HTS coils can offer the necessary low weight and compactness required for space applications, with the ability to generate the strong magnetic fields needed re-entry protection. This paper introduces the MEESST project and the preliminary design of such a system. The latest progress of the project in terms of prototype development and numerical modelling, are summarised. The applications of the concept for human spaceflight missions (Lunar Gateway, crewed Mars flight) are contextualised and assessed.