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A MAGNETOHYDRODYNAMIC ENHANCED ENTRY SYSTEM FOR SPACE TRANSPORTATION (MEESST)

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. The concept, known as MEESST (Magnetohydrodynamic Enhanced Entry System for Space Transportation), is presented here in the context of recent advances in multiple subsystems. An EU-consortium comprising universities, research institutions, and industry has been formed to develop this technology, and their individual involvement in each aspect of the project is also described herein. The project is funded under the Horizon 2020 scheme (grant no. 899298) and is scheduled to conclude in 2024 with the launch of a prototype for full-scale re-entry testing.

The combination of high spacecraft velocity during re-entry and the rapid compression of atmospheric particles by the spacecraft leads to partially ionized high-enthalpy gases forming around the vehicle. This can significantly inhibit radio communications and induce high thermal loads on the spacecraft surface. Presently, heavy thermal protection systems (TPS) are needed to dissipate the thermal loads and satellite constellations are relied upon for communication through the plasma wake. The use of physical TPS greatly increases the design effort and cost of the spacecraft and reduces the cost efficiency of the mission by sacrificing payload mass for such systems. By displacing the boundary layer of the ionized gas away from the spacecraft through principles of magnetohydrodynamics, the thermal loads can be reduced, while also opening a magnetic window for radio communications. To date, the application of this concept has not been possible due to the strong magnetic fields required, which for conventional technologies would necessitate the use of exceptionally heavy and power-hungry electromagnets. High-temperature superconductors (HTS) have now reached a level of industrial maturity sufficient for them to act as an enabling technology for this application. HTS-based coils can offer the necessary low weight, compactness and ability to generate magnetic fields on the order of several Tesla. Furthermore, this principle has the potential to be further exploited to allow a level of attitude control during re-entry, allowing trajectory optimization and lowering propellant requirements on thruster-based attitude control systems.

This paper introduces the MEESST project and the preliminary design of such a system. The latest progress and achievements of the project in terms of prototype development and numerical modelling, are summarized. The current status-quo of HTS is presented, and applications of the concept in various mission scenarios are contextualized and assessed.