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DESIGN CHALLENGES OF DEPLOYABLE AERO-DECELERATORS FOR MARS ENTRY VEHICLES

Abstract

Mars lander missions require entry vehicles with heatshields to protect their payloads during the high temperature atmospheric entry, and to decelerate from high hypersonic speeds to the low supersonic speeds needed to deploy parachutes or retropropulsion systems. Past Mars missions have all comprised fixed diameter entry vehicles up to 4.5 m to fit within existing launch vehicles, enabling up to 1 tonne of surface payload to be safely landed. Larger diameter entry vehicles are necessary to enable higher mass payloads, lower peak heat fluxes, greater precision landing, and higher elevation landing sites for future Mars missions.

Deployable aero-decelerators are stowed during launch and Mars transfer, and then deploy outwards in space to create a larger diameter prior to atmospheric entry. A number of possible deployment configurations have been proposed and investigated over recent years, but there are many design challenges associated with such a vehicle that inhibit development. In addition, no coherent and like-for-like mass assessment of the potential configurations has been performed. The major design challenges are:

- High heat fluxes experienced during entry, requiring a high capacity heatshield to protect the payload.
- High dynamic pressures that must be withstood by both the heatshield material and the supporting deployable structures and mechanisms.
- Deployable thermal protection system material that can withstand the high heat fluxes and pressures, but also bend and fold during stowage without permanent damage and transfer.
- Aero-elastic behaviour of the deployable elements due to aerodynamic loading, leading to external shape deformation and potential effects on the trajectory that must be simulated.
- Thermal control and dissipation to ensure heat transferred through to the structure does not cause excess deformation, and that the payload temperature stays within limits.
- Attachment of the thermal protection system material to the deployed elements.
- Structure and deployment mechanism designs that are mass and volume optimal, and highly robust to failure.

This interactive poster will outline and illustrate the deployable aero-decelerator design challenges, and present some configuration solutions that are currently being investigated by Imperial College London and Airbus for future Mars missions.