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Author: Mr. Kirin Tanishige
University of Tokyo, Japan

Dr. Kazuhiko Yamada
Japan Aerospace Exploration Agency (JAXA), Japan
Dr. Takashi Abe
Japan

MISSION DESIGN FOR MARS EXPLORATION VEHICLE COMPOSED OF FLEXIBLE STRUCTURES

Abstract

In Mars surface exploration missions, an atmospheric entry vehicle must withstand a severe environment caused by the aerodynamic heating at the atmospheric entry phase. For such a vehicle, it is important to reduce the weight of thermal protection systems which account for the large proportion of the entry vehicle, and to be landed on the ground precisely under the condition of the uncertainty atmosphere. To resolve these issues, instead of a conventional entry capsule, a concept of vehicles made up of flexible structures has been considered as a promising option. In the present study, the Mars exploration vehicle which is composed of flexible structures is designed and the feasibility of the mission based on the vehicle is assessed, assuming a combination of a membrane aeroshell structure entry vehicle and a sub-vehicle with a parafoil system, which is proposed here.

The mission overview is as follows; before the atmospheric entry phase, the entry vehicle deploys a membrane flare which is sustained by an inflatable torus. This structure enables us to lower a ballistic coefficient of the vehicle and also to reduce the aerodynamic heating on the vehicle. After the entry vehicle is properly decelerated through a hypersonic and a supersonic flight, a sub-vehicle with a scientific payload inside and an inflatable parafoil system outside is jettisoned from the main vehicle. The parafoil system maintains its canopy structure by a pressurized gas in order to make a flight in Martian unique environment: low atmospheric pressure and gusty wind. The parafoil system enables the sub-vehicle to be conveyed to the target landing site by means of the autopilot system.

The mission planning is conducted in terms of the entry trajectory, the vehicle mass budget and so on. In the trajectory analysis, we focus on both the dispersion of landing sites and the atmospheric heating environment. We quantify the dispersion and confirm capability of the guidance controls to reduce the dispersion. Other than the landing site dispersion, the aerodynamic heating experienced by the vehicle is assessed. The mass budget for the mission is also assessed. For a scientific exploration in Mars, the necessary payload weight is defined and the weight of each subsystem which is composed of the membrane aeroshell, the parafoil, and other bus modules is assessed. It is confirmed that a necessary mass budget can be allocated to the scientific payload.