IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems (4)

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CONCEPTUAL STUDY AND DEVELOPMENT PLAN OF REUSABLE SSTO TO REALIZE FREQUENT ACCESS TO SPACE

Abstract

Developments of space transportation systems by private companies are increasing, especially in the U.S. and China. In Japan, there is a government program to support private companies in developing space vehicles. We have a plan to develop a frequently reusable SSTO that meets the future requirements of massive, human space transportation in 2040. Demonstration vehicles will be developed in stages, starting with a 6-ton class vertical takeoff and landing type sounding rocket, followed by a winged vertical takeoff and horizontal landing type and their large-scaled version. These demonstrators are developed in an agile process, and model-based systems engineering is applied. The technologies developed in this process will be investigated by applying them to the flight demonstrations as soon as the ground tests are completed. Since it is a private-sector project, each demonstration vehicle will be used for space transportation services to customers rather than as one-off technological test vehicle. Therefore, the demonstration system must have capabilities of transporting payloads to space and taking them back to earth. In order to quantify the level of the technical requirements, a sizing study of SSTO was conducted by flight trajectory analyses. As a result, we could obtain the relationship between the total weight required for low-earth orbit missions. As a result, the weight reduction level and the increase in propulsion performance necessary to realize an SSTO with a reasonable weight were clarified. To achieve the goals, tri-propellant engine is necessary that is fueled by methane at the early phase of launch trajectories to suppress gravity loss and by liquid hydrogen in the latter phase at the altitude beyond the atmosphere to achieve high specific impulse. The use of methane also contributes to reducing the weight of engines and fuel tanks. Thus, we obtained the optimum fuel ratio of each fuel that maximize the launch capacity. Additionally, adopting liquid air cycle engine (LACE) technology, the amount of liquid oxygen can be further reduced. The body structure is partially made of composite materials to reduce weight. It is also contributed by weight reduction of the thermal protection system, which was a major issue that reduced the reusability of the Space Shuttle. For example, the use of transpiration cooling allows for longer maintenance cycles. The feasibility of these key technologies is discussed.