H-II TRANSFER VEHICLE TRAJECTORY PLANNING AND FLIGHT OPERATION RESULTS

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ABSTRACT

H-II Transfer Vehicle (HTV) is the cargo transportation vehicle to the International Space Station (ISS), which is developed and operated by Japan Aerospace Exploration Agency (JAXA). HTV1 and HTV2 were successfully flown in 2009 and 2011 respectively, and completed the cargo transportation service to ISS as planned. HTV3 flight is coming in July 2012 and subsequent flights are scheduled once per a year.

HTV provides safe and on-time flight for cargo transportation, harmonized with the ongoing ISS mission operation. In this paper, it is presented how the safe and on-time flight is realized in terms of trajectory planning based on experiences from the accomplished two HTV flights and the upcoming third flight. It focuses on the trajectory planning process how to harmonize with the frequently changing schedule of ISS operation and other mission constraints, such as launch window, flight duration and system capability (propellant and power resources, engines performance, etc.). The planning of whole mission trajectory is categorized to three phases.

1) Far-field rendezvous phase (launch ~ approx. 200km range from ISS)
2) Proximity rendezvous phase (approx. 200km range ~ berthing on ISS)
3) Reentry phase (release from ISS ~ reentry to the pacific ocean)

Strategy of trajectory planning is discussed for each flight phase, ensuring safety and on-time arrival at ISS, and reentry to the Earth. The strategic trajectory is presented as the results of actual flight profile as well as the planned flight profile, with the experiences of trajectory planning considering harmonization with the real ISS operation timeline.

In addition, HTV has the flexible attitude and maneuver control capability to allow wide range of cargo mass property, realizing the versatile cargo transportation and disposal service to ISS. It can manage large difference of mass property between delivery cargo to ISS and disposal cargo from ISS, and also difference of mass property for every mission. Since the stable control system is basis of safe and on-time flight, control parameters are tuned prior to launch and departure from ISS for every flight. These parameters are determined through the validation process and uploaded to the on-board software. The process is discussed, how the flexibility of cargo accommodation capability is realized, in terms of control system performance.

In order to achieve the safe and on-time flight, both aspects of the vehicle on-board capability and the support of ground flight controller team are important. Major features of on-board

capability are discussed, which contribute to realize the safe and on-time flight, such as maneuver guidance and control capability, accurate navigation technique, and FDIR (Failure-detection-isolation-recovery) function to protect mission success and safety. The ground flight controller team is responsible for housekeeping of vehicle and proceeding with the flight safely. Several decision points are defined based on the trajectory planning, to allow the vehicle to continue the flight or terminate it. Ensuring the safety and on-time flight to ISS, the ground controller team is authorized to make decision of Go or No-go at these points. Also, the ground control team conducts on-orbit checkouts for the critical functions and periodic updates of trajectory planning using the latest state vectors. During the proximity operation with ISS, the operation of HTV and ISS is jointly conducted by both flight controller teams. Coordination between two teams is important to continue the safe flight for both of HTV and ISS. Considering these particular points of HTV flight operation, it is discussed what activities are conducted by the ground control team to ensure the safe and on-time flight, from the viewpoints of real-time operation, offline flight preparation and operation training.

Furthermore, the quick summary of HTV3 flight results are also presented, highlighting the differences from HTV1 and HTV2.