HTV Exposed Pallet and its Mechanisms

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The first HTV (H-II transfer vehicle) was launched by the H-IIB rocket from the Tanegashima Space Center to transport various cargoes to ISS (International Space Station) on Sept. 11, 2009. Two exposed payloads were carried to ISS by the Exposed Pallet. All mechanisms manufactured by IA were successfully operated, and the experiments on orbit started. The Exposed Pallet is a module mounted on HTV to carry various exposed payload. This paper describes the mission operation and the system outline of Exposed Pallet, two unique mechanisms, HCSM (HTV connector separation mechanism), and HCAM (HTV cargo attachment mechanism). HCSM is the mechanism to keep electrical connector mated to provide heater power to the payload during launch and separate the connector on orbit. HCAM is the structural latch mechanism. A payload is supported by four HCAMs during launch and is disengaged from Exposed Pallet on orbit.

1. Introduction

The H-II transfer vehicle (hereinafter called HTV) was launched by the H-IIB rocket from the Tanegashima Space Center to transport various types of cargo to the International Space Station (hereinafter called ISS). The Exposed Pallet is a module mounted on the HTV to carry various types of exposed payloads (**Fig. 1**). This paper describes the mission operation and the system outline of the Exposed Pallet, as well as the unique mechanisms that were developed for it to ensure a successful mission operation.

2. Mission operation for the Exposed Pallet

A module that can carry several exposed payloads, the Exposed Pallet is mounted in the HTV's Unpressurized Logistics Carrier (ULC) and then launched into orbit. After the HTV docks with the ISS, the Exposed Pallet is grasped by the Space Station Remote Manipulation System (SSRMS), which is a robotic arm operated by the ISS, removed from the ULC, and then handed over to the Japanese Experiment Module Remote Manipulator System (JEMRMS), which is a robotic arm operated by the Japanese Experiment Module (JEM : also called "Kibo," which means "hope" in Japanese).

The Exposed Pallet is positioned at the end of the JEM Exposed Facility by the JEMRMS, and is then mechanically connected to the JEM Exposed Facility by the Equipment Exchange Unit (EEU), at which point it is supplied with electricity and a communication interface from the JEM. The exposed payloads on the Exposed Pallet are grasped by the JEMRMS, disconnected from the Exposed Pallet mechanically and electrically, transferred to a predetermined position in the JEM Exposed Facility,

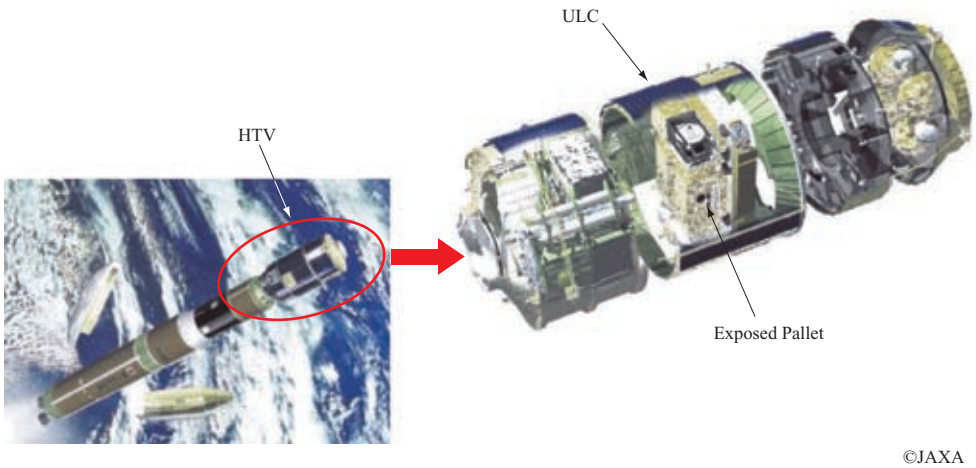

Fig. 1 HTV (H-II transfer vehicle) and Exposed Pallet

secured on the JEM Exposed Facility by the EEU, and then put to use in conducting experiments.

The empty Exposed Pallet is grasped by the JEMRMS, disconnected from the JEM Exposed Facility by the EEU, and handed over from the JEMRMS to the SSRMS. It is then inserted into the HTV ULC by the SSRMS, and mechanically secured to the ULC in preparation for separation from the ISS and re-entry.

3. System outline of the Exposed Pallet (Fig. 2)

To successfully complete the mission operation described in **Chapter 2**, the Exposed Pallet carries the following equipment.

(1) Grapple fixtures to be grasped by the SSRMS and the JEMRMS.
(2) The HTV Berthing Camera System (HBCS), which assists astronauts in manipulating the SSRMS to insert the Exposed Pallet into the ULC.
(3) The HTV Connector Separation Mechanism (HCSM), which supplies power to the heater for exposed payloads during launch and disconnects electrically in orbit.
(4) The HTV Cargo Attachment Mechanism (HCAM), which mechanically connects the exposed payloads to the Exposed Pallet during launch and disconnects the payloads in orbit.
(5) The Payload Interface Unit (PIU), which mechanically and electrically connects the payloads to the JEM Exposed Facility in orbit.
(6) The Exposed Pallet Controller (EPC), which drives the HCAM and HCSM in orbit in response to commands from the astronauts.

4. Mechanisms for exposed payloads (Fig. 3)

This section describes the HCSM and HCAM, two unique mechanisms that were developed to secure payloads to the Exposed Pallet during launch and disconnect them from the Exposed Pallet in orbit.

4.1 HTV Connector Separation Mechanism (HCSM) (Figs. 4 and 5)

The HCSM maintains the connection of electrical connectors between the Exposed Pallet and exposed payloads during launch and disconnects the electric connectors in orbit when it receives power from the EPC. It consists of an active mechanism on the upper surface of the Exposed Pallet and a passive mechanism on the lower surface of each exposed payload. A pin puller, serving as a small, lightweight actuator, actuates a pin in response to a change in the volume of paraffin heated and melted by an electric heater.

In the event of contingencies such as a controller failure, astronauts can operate the HCSM by accessing a hexagonal bolt head from the lower surface of the Exposed Pallet during extravehicular activities (EVA) and applying a torque to the bolt head using a suitable tool.

4.2 HTV cargo attachment mechanism (Figs. 6 and 7)

Exposed payloads are secured to the Exposed Pallet by four HCAMs mounted on the upper surface of the Exposed Pallet during launch.

The HCAM grasps the HCAM-P (passive) mounted on the lower surface of an exposed payload during launch, and mechanically disconnects the payload from the Exposed Pallet in orbit when it receives power from the EPC to drive the pin puller, which releases the HCAM-P. In the event of a controller failure, the astronauts can release the HCAM-P by applying a torque in the same way as for the HCSM.

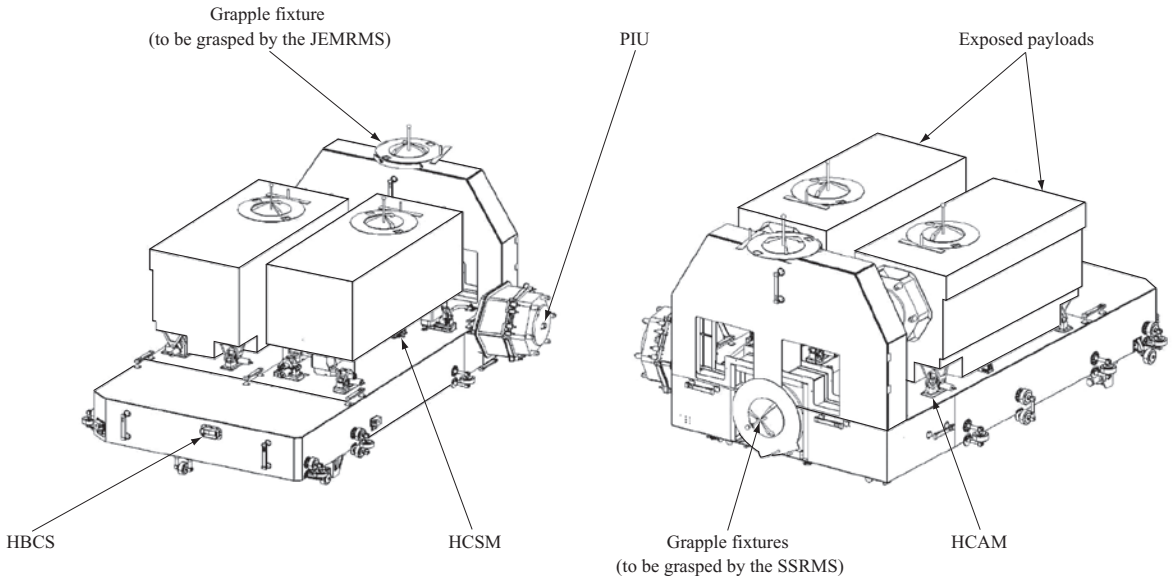

Fig. 2 Illustration of Exposed Pallet

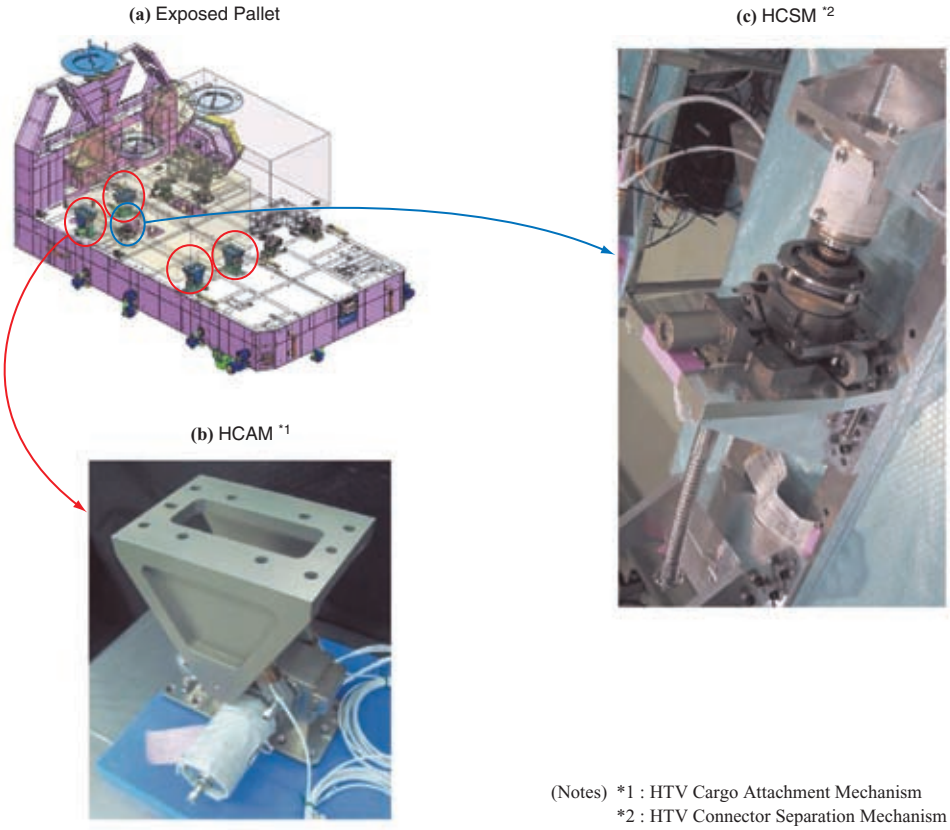

Fig. 3 Mechanisms for exposed payloads (HCSM and HCAM)

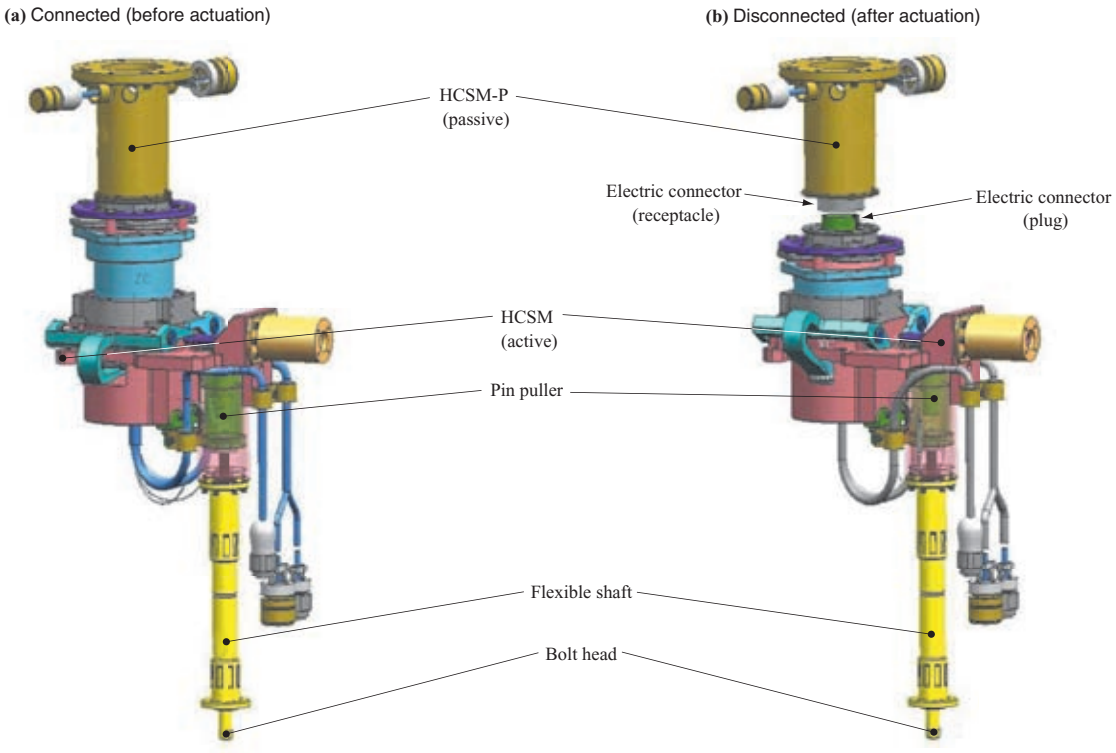

Fig. 4 Illustration of HCSM

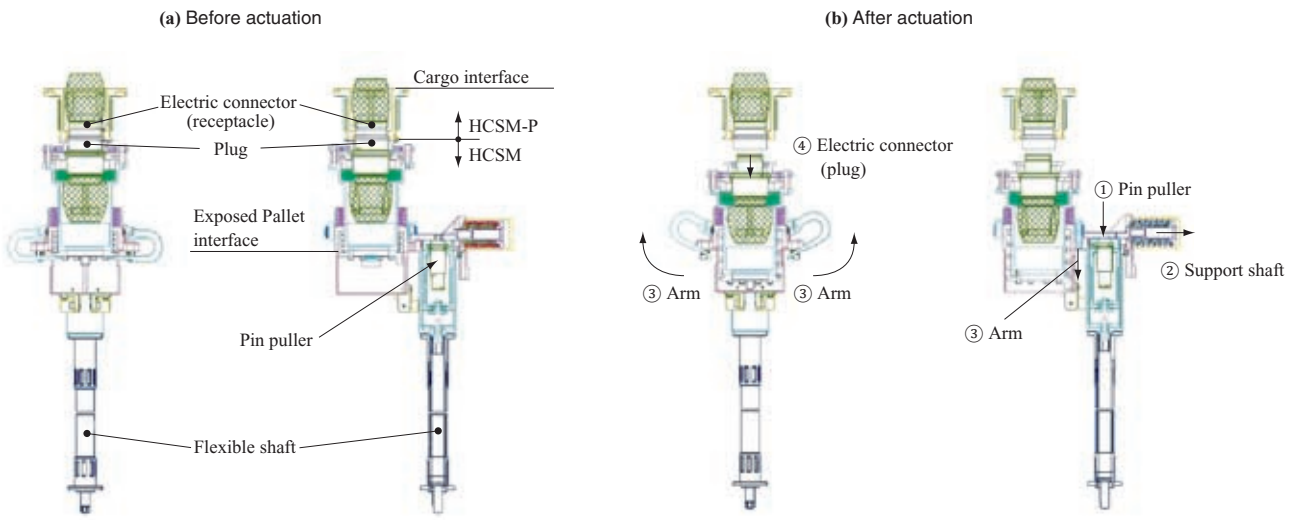

Fig. 5 Operating mechanism for HCSM

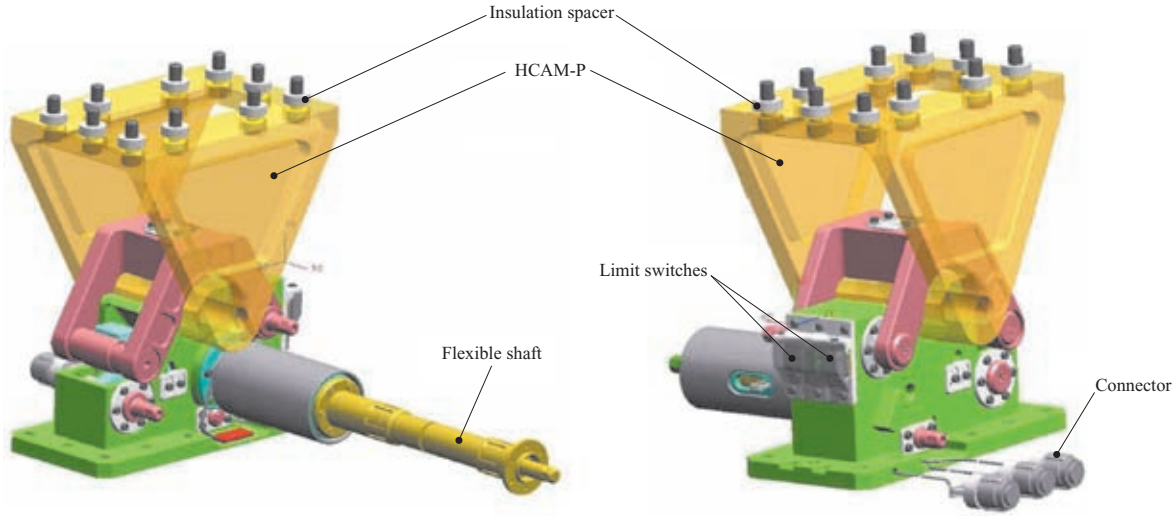

Fig. 6 Illustration of HCAM

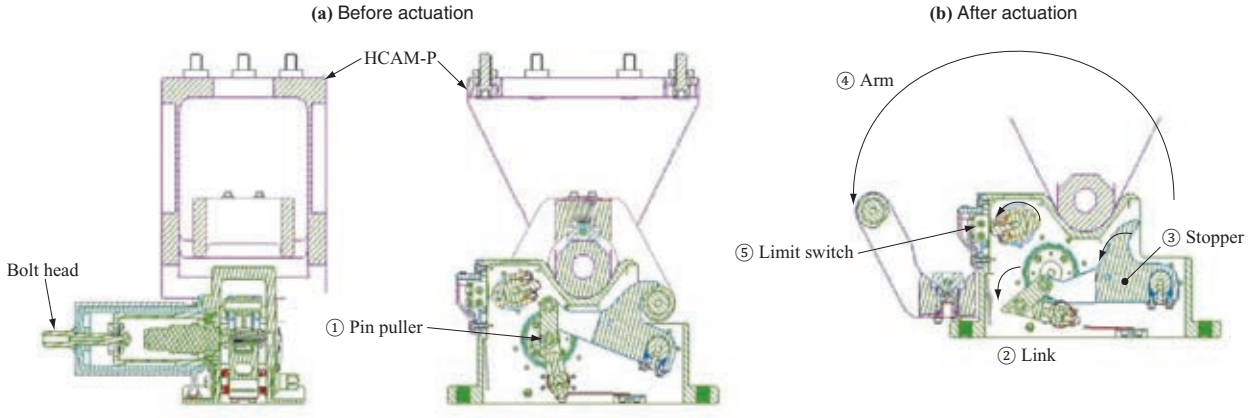

Fig. 7 Operating mechanism for HCAM

5. Conclusion

The Exposed Pallet for the HTV-1 was launched into orbit from the Tanegashima Space Center on September 11, 2009 carrying the following two exposed payloads (**Fig. 8**).

(1) JAXA payload
The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

(2) NASA payload
The HICO (Hyperspectral Imager for the Coastal Ocean) & RAIDS (Remote Atmospheric and Ionospheric Detection System) Experiment Payload (HREP)

All the mechanisms developed and manufactured by IHI Aerospace Co., Ltd. (IA) performed well without

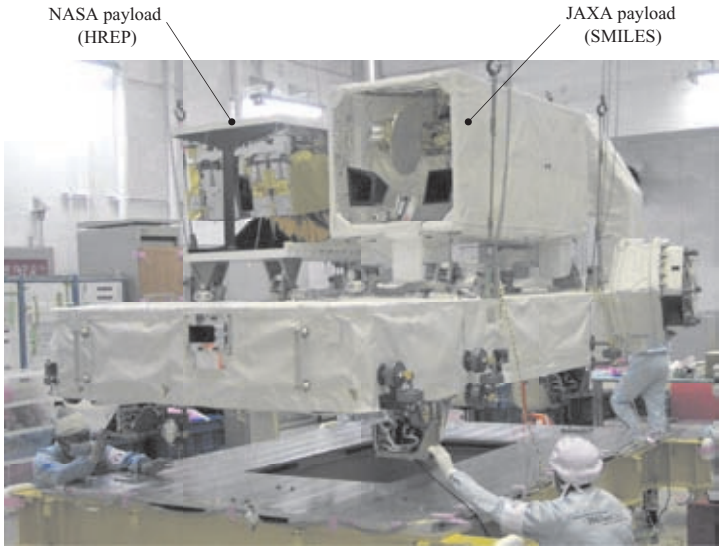

Fig. 8 Exposed Pallet for HTV-1

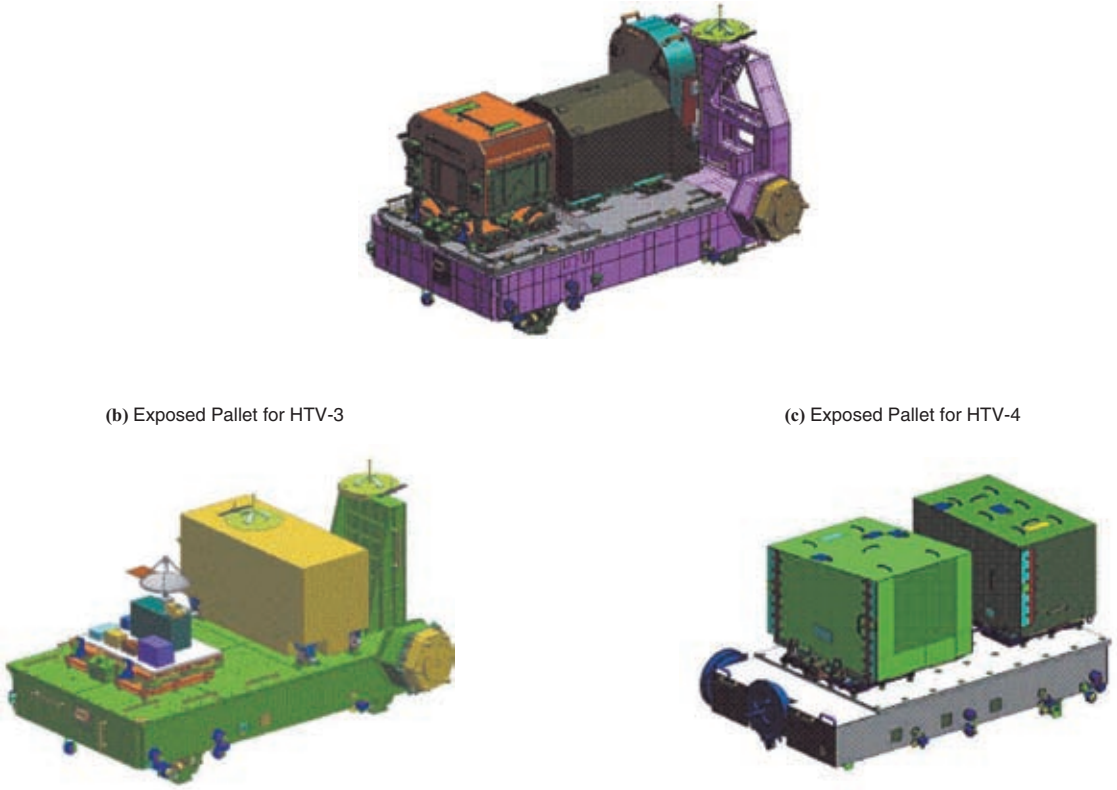

Fig. 9 Various configurations for Exposed Pallet

any problem, and these two payloads were successfully connected to the JEM Exposed Facility and put to use in conducting experiments.

HTVs are to be launched from the Tanegashima Space Center every year to transport various types of cargo to the International Space Station. In order to ensure it suits the payload to be mounted on each vehicle, the Exposed Pallet is to be manufactured according to a design configuration created through careful adjustment of the interface (see **Fig. 9**).

The authors have acquired a great deal of experience in developing the Exposed Pallet for the HTV-1 and, going forward, they would like to make use of this in designing and manufacturing Exposed Pallets with a variety of configurations, as well as in maintaining and improving the manufacturing quality.