On the Results of the Manipulator Flight Demonstration (MFD) Project

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PROJECT OBJECTIVES : The Manipulator Flight Demonstration (MFD) project is to demonstrate the functions and performances of the Robot Arm similar to the Japanese Experiment Nodule (JEM) Remote Manipulator System (RMS) Small Fine Arm using the Space Shuttle prior to a JEM launch, and to reflect those results and experience to the JEM development and operations. And the objectives of the flight demonstration test are as follows :

(1) To evaluate Robot Arm functions and performances in the weightless space environment.

(2) To evaluate the human-machine interface of the Robot Arm operation system.

(3) To demonstrate the attachment / detachment of the Orbital Replacement Unit (ORU) and the open / close of the hinged door.

CONFIGURATION AND DESIGN FEATURES : The MFD system consists of the Shuttle Onboard System (MFD payload) and Ground Operations System. And the MFD payload consists of the Payload Bay (PLB) element and the Aft Flight Deck (AFD) element. The PLB element consists of the MFD Robot Arm, the ORU, the hinged door, and other elements. The AFD element consists of the hand controllers, TV monitors, and other elements. The Ground Commanding (GC) experiment to control the robot arm from the ground uses a part of the MFD payload. In addition, the MFD payload mounts as piggyback payloads, the Evaluation of Space environment and Effects on Materials (ESEM) experiment to acquire material degradation characteristics in the space environment and to collect cosmic dust, and the Two-Phase Fluid Loop Experiment (TPFLEX) experiment to test an active thermal control technology.

The robot arm has an advanced feature of a compliance control which regulates forces and torques applied to an object grasped by the robot arm. And the MFD payload has several safety features such as a jettison mechanism, EVA compatible design to secure the safe return configuration, and collision tolerant structure design.

DEVELOPMENT SCHEDULE : MFD system design was started in 1992 and the critical design review (CDR) of the MFD was completed in 1995. After the verification test of the MFD payload was completed in Japan, the MFD payload was transported to NASA Kennedy Space Center (KSC) in January, 1997. After its arrival at KSC, function and performance tests were conducted, the MFD experiments were mounted on the Multi-Purpose Experiment Support Structure (MPESS), and the shuttle interface verification test was conducted using the Cargo Integration Test Equipment (CITE). After that, the MFD payload was attached onto the Space Shuttle Discovery, and another shuttle interface verification test was conducted in June, 1997.

CONCLUSION : The MFD payload was launched on the Space Shuttle Discovery as one of the STS-85 mission

from KSC on August 7, 1997 and landed to KSC on August 19, 1997. The robot arm installed in the Shuttle Orbiter cargo bay was operated using the hand controllers by crews in the AFD of the Shuttle Orbiter. All the MFD robot arm operations were successfully conducted and an advanced experiment to control the robot arm from the ground was successfully conducted. In addition to these robot arm tests and experiments, the ESEM and the TPFLEX were conducted.

The functions, the performances and the human-machine interface of the MFD robot arm under the micro gravity condition were evaluated, and the items to be reflected to the JEM development and operations were identified.