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MANNED MANEUVERING UNIT APPLICATIONS FOR AUTOMATED RENDEZVOUS AND CAPTURE

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Background

Automated Rendezvous and Capture (AR&C) is an important technology to multiple National Aeronautics and Space Administration (NASA) programs and centers. The recent Johnson Spacecraft Center (JSC) AR&C Quality Function Deployment (QFD) has listed **on-orbit demonstration** of related technologies as a near term priority. Martin Marietta has been evaluating use of the Manned Maneuvering Unit (MMU) for a low cost near term on-orbit demonstration of AR&C technologies such as control algorithms, sensors and processors as well as system level performance.

The MMU Program began in 1979 as the method of repairing the Space Shuttle (STS) Thermal Protection System (the Tiles). The units were not needed for this task, but were successfully employed during three (3) Shuttle flights in 1984: a test flight was flown in February as proof of concept, in April the MMU participated in the Solar Max Repair Mission, and in November the MMUs returned to space to successfully rescue the two (2) errant satellites, Westar and Palapa. In the intervening years, the MMU simulator and MMU Qualification Test Unit (QTU) have been used for Astronaut training and experimental evaluations. The Extra-Vehicular Activities (EVA) Retriever has used the QTU, in an unmanned form, as a free-flyer on the Johnson Space Center (JSC).Precision Air Bearing Floor (PABF).

Currently, the MMU is undergoing recertification for flight. The two (2) flight units were removed from storage in September, 1991 and evaluation tests were performed. The tests demonstrated that the units are in good shape with no discrepancies that would preclude further use. The Return to Flight effort is currently clearing up recertification issues and evaluating the design against the present Shuttle environments.

MMU Applications for Automated Rendezvous and Capture

The Manned Maneuvering Unit can be used as a controlled free-flying platform for AR&C experiments outside the Shuttle Cargo Bay. One concept involves a foot locker sized (approximately - 23 x 23 x 40 inches and 450 lbs.) avionics package attached to the MMU, similar in size and mass to the IMAX camera canister, containing docking sensors, processors, batteries, and a data recorder and/or transceiver. Adequate control authority exists on the MMU to allow for the installation of the module between the control arms. An interface between the avionics package and the MMU through the hand controllers and ground test connectors can be made, so that the MMU propulsion and control electronics systems can be accessed by the AR&C systems within the avionics module (similar to the method used by the EVA Retriever). An MMU pilot would have the capability of transitioning control of the MMU between automated and manned operations during the on-orbit demonstration. In this manner, the MMU pilot can monitor the experiment and take over manual control of the MMU as the backup return and safety system in the event of an AR&C system malfunction. Various docking/capture targets could be mounted on the orbiter RMS for emulation of target spacecraft dynamics in various lighting conditions. MMU control authority can be degraded by pulsing thrusters to simulate the Orbiter or Cargo Transfer Vehicle (CTV) so as to use similar gains in the system evaluation. The recharge capability of the MMU will make it possible for repeated experiments to be performed during a six (6) hour EVA.

The on-orbit demonstration can also be performed in an unmanned manner using only the MMU and avionics module. The EVA Retriever experiments conducted by JSC on the PABF during recent years have demonstrated the MMU's capability to be used as an autonomous conveyer for payloads. These experiments have developed the software necessary for the operation of the MMU through electrical interface between the payload and the MMU Control Electronics Assembly (CEA). The payload can be mechanically interfaced with the MMU through the existing Personal Life Support Systems (PLSS) latch and electrically interfaced through the Hand Controller connectors. The Control Arms can be removed to increase the payload capacity and expand the payload envelope. To simplify the experiment itself, the second MMU not fitted out for autonomous operation can be used as a retriever in the event of failure. A simple docking device on the payload and MMU would be sufficient for capture and return to the Shuttle as long as the experiment is within the MMU range capabilities (< 300 ft. from the Shuttle Orbiter).

Design, development, integration, test and training for such missions can be performed using existing MMU simulation facilities. The Space Operations Simulation (SOS) Laboratory at Martin Marietta Astronautics in Denver can model each element of the avionics package and provide the moving base for MMU flying tasks and algorithm development. Hardware testing and fit checks of experiments can be performed on the High Fidelity Mockup and Air Bearing Simulator (MMU - QTU) at JSC. Shuttle Cargo Bay operations such as installation on and interface with the MMU can be accomplished in the Water Emission Test Facility (WETF) also at JSC. Detail flight training and evaluation of the integrated system, the MMU and the avionics package, can be done in the SOS Laboratory.

Conclusion

The MMU is a proven performer that can be used as a tool for near term On-Orbit Automated Rendezvous and Capture experiments. The system has a track record from the satellite retrieval missions and EVA Retriever experiments for both manned and unmanned flight operations. Facilities exist, both at Martin Marietta and NASA, which are capable of evaluating designs, and providing operational training to Astronauts for either manned or unmanned flights.