

Prototype Low Impact Docking System

James L. Lewis
Monty B. Carroll
NASA Johnson Space Center

The only docking systems currently available for manned spaceflight are the Russian built "APAS" (Androgynous Peripheral Assembly System) and "Probe and Cone" systems. These are relatively large, heavy, and complex systems which require significantly large contact forces to engage the docking mechanisms. In order to achieve these large contact loads and provide for mating interface alignment, high contact rates are required between mating vehicles during the docking operation. The highly dynamic nature of this type of on-orbit mating makes docking a very critical operation. This criticality was clearly demonstrated during the Progress/MIR collision in 1997. The Prototype Low Impact Docking System-LIDS currently under development is the culmination of a decade of institutional NASA in-house research and development geared toward reducing the risks associated with mating of manned spacecraft and enhancing the United States capability to mate spacecraft in earth orbit and beyond.

In the Fall 1997, a team of NASA and Lockheed-Martin engineers from the Structures and Mechanics Division at the Johnson Space Center (JSC) in Houston, Texas assembled a 2/3 scale functional mating system for the X-38 Crew Return Vehicle Program. This program along with other institutional resources, provided for the continued smart docking system development activities which included the assembly and testing of a prototype system to demonstrate how the X-38 would be mated and attached to ISS (International Space Station). The prototype system functionally represents the major subsystems necessary in a mating system: an electro-mechanically actuated extension/retraction system, a load-sensing force-feedback compliant ring, electromagnets for softcapture, probes and cones for passive alignment guides, and an avionics controller with custom software and electronics.

During the 1st Quarter of 1998, the prototype hardware was tested in JSC's Engineering Directorate Six Degree-of-Freedom Test Simulator-SDTS. In this berthing simulation, the SDTS's 6DOF table simulated a RMS robotic arm delivering an X-38 with full mass and dynamics to an alignment envelope. The prototype active mating interface would then reach out, grab, and berth the X-38. The final result of the berthing simulation testing was a 100% capture success rate with a peak interface load of 10 lbs.

After completion of the berthing testing, at the request of the X-38 Program, the avionics system has been upgraded and reconfigured to control the prototype hardware for docking simulation testing which is currently scheduled for January 1999. This testing will demonstrate the LIDS capability as a docking system. This paper describes the background, design, status, testing, benefits, and future applications of the Low Impact Docking System for use in mating current and future space vehicles.