is essentially a two-step process, consisting of a latched, but loose, coupling between the spacecraft followed very quickly by a braking procedure, hard docking and rigidization.

In the alignment state, the two spacecraft are rotated relative to one another to ensure they will be lined up close enough for the fluid connector halves to mate. Once the two spacecraft are aligned, the fluid connector mechanism draws the two connector halves together in preparation for the fluid exchange experiment. The two spacecraft will undock and dock several times to fully test the system.

The three primary technology areas to be validated by this demonstration are navigation sensors, docking mechanism, and fluid exchange system. The major subsystems of the baselined ARD demonstration include: GPS receivers on both spacecraft for relative position and velocity information during rendezvous and close proximity operations, video-based, closed-loop sensing and processing for position, attitude, and rate information during close proximity/docking operations, a single-point, probe-type docking mechanism with enough compliance for autonomous docking, and a fluid connector interface mechanism to allow efficient transfer of fluid resources.

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Experimental Validation of Docking and Capture Using Space Robotics Testbeds

by John Spofford, Martin Marietta

Docking concepts include capture, berthing, and docking. Definitions of these terms, consistent with AIAA, are: Capture (Grasping) - the use of a manipulator to make initial contact and attachment between transfer vehicle and a platform. Berthing - positioning of a transfer vehicle or payload into platform restraints using a manipulator. Docking - propulsive mechanical connection between vehicle and platform. The combination of the capture and berthing operations is effectively the same as docking; i.e., Capture(Grasping) + Berthing = Docking.

Accurate estimation of target vehicle position and attitude is critical to successful autonomous rendezvous and capture. Computer vision is a sensing technique that can provide accurate position data at close ranges. With appropriate targets, the required computing power for target feature extraction is minimized. An advantage of using computer vision-type sensors is that human operators also can use the direct video image.

Martin Marietta has a 20 x 30 foot epoxy air bearing floor. Three testbeds, a Free Flying Vehicle, a Large Space Manipulator and a Dexterous Manipulator, provide a three DOF environment that closely approximates zero gravity. The testbed vehicle has three maneuvering DOF: two translational and one rotational. The vehicle has mounting points for additional test mechanisms and interfaces.

There are a few technical challenges to address. First, an integrated simulation of the complete capture and berthing operation, incorporating vehicle, platform and manipulators, should be implemented on a hardware testbed. Second, the control of a manipulator from a free flying vehicle is still an R&D activity. Finally, flight validation of the autonomous capture and berthing method will have to occur before user confidence is complete.

Questions / concerns addressed following the presenting: How does one determine the range, using the video system? With a five point non-planer target of known geometry and based on the viewed image, the range is calculated as well as out of plane parameters. How is the gap between rendezvous and capture bridged? Some other system, perhaps laser based, is needed for range of one kilometer and out.