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**U.S. Automated Rendezvous and Capture Capabilities Review  
Category 4 - Operations**

**Abstract Title:** Autonomous Rendezvous and Docking Operations of Unmanned Expendable Cargo Transfer Vehicles (e.g. Centaur) with Space Station Freedom

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**Technical Details:**

This paper describes the results of the feasibility study of using Centaur or other CTV's to deliver payloads to the Space Station Freedom (SSF). During this study we examined the requirements upon unmanned cargo transfer stages (including Centaur) for phasing, rendezvous, proximity operations and docking/berthing (capture).

*Phasing* - We examined different ascent trajectories and phasing options to determine:

- Performance
- Velocity requirements
- Power requirements
- Time on orbit
- Contingency operations
- Launch windows

*Crew Control Capabilities* - We examined different command modes for the transfer vehicle.

- Fully Autonomous
- Fully Manual
- Supervised Automatic
- Preprogrammed Operations

*Control Locations* - We explored various options for centralizing the primary control authority of the transfer vehicle.

- Ground Based Teleoperated
- SSF Based Teleoperated
- SSF Based Automatic
- Vehicle Based Automatic

*SSF Operational Constraints* - We researched the SSF constraints regarding operations in close proximity with this manned base.

- Collision Avoidance
- Contamination Avoidance
- Systems Safing
- SSF Control Authority

### **Historical Origin of Capabilities:**

General Dynamics has been involved in space transportation vehicle operations for thirty years, beginning with Air Force ICBM work. Throughout that time GD has worked on various studies and programs related to space platforms, manned and unmanned space transportation vehicles, components of space transportation architectures (e.g. boosters), and space exploration. One of our more recent company funded efforts into the Autonomous Rendezvous and Docking area stems from our feasibility study of *"Atlas Deliveries to Space Station Freedom"*.

### **Level of Maturity/Current Funding:**

The results of this study were intended to provide top level requirements to assess the feasibility of using Atlas and Centaur in a SSF resupply role. GD currently has 3 and 6 DOF simulations to study Autonomous Rendezvous and Docking (AR&D), however no studies are currently underway at this time. Continuation of the Atlas/Centaur operational studies are anticipated pending SSF Program Office incorporation of Expendable Launch Vehicles into the logistics program. We also anticipate analyses of the CTV in support of the National Launch System (NLS) activities.