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U.S. Automated Rendezvous and Capture Capabilities Review
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Abstract Title: The development of an Autonomous Rendezvous and Docking Simulation using Rapid Integration and PrototypingTechnology

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Technical Details:

A generic planar 3 degree of freedom simulation has been developed that supports hardware in the loop simulations, guidance and control analysis, and can directly generate flight software. This simulation was developed in a small amount of time utilizing rapid prototyping techniques. This paper describes the approach taken to develop this simulation tool, the benefits seen using this approach to development and will also describe on-going efforts to improve and extend this capability.

The simulation is composed of 3 major elements: (1) Docker dynamics model, (2) Dockee dynamics model, (3) Docker Control System. The docker and dockee models are based on simple planar orbital dynamics equations using a spherical earth gravity model. The docker control system is based on a phase plane approach to error correction.

The simulation development took advantage of the hiearchical nature of the development environment by reusing model structures. For example, the translation dynamics model for the Docker is the same as the Dockee - on orbit masses driven either by thruster forces or gravity acceleration. Software reuse was also used in the Docker Control System Development.

The simulation was developed in order to support hardware in the loop simulations. This means that any avionics hardware that may be ready for use be integrated into the simulation and tested under real-time conditions. Examples of avionics hardware that may be used include a rendezvous sensor, flight computer, hardware controller units, and navigation sensors. Further, if the hardware elements have software germane to the rendezvous and docking problem, they can be designed, developed and tested within this environment.

An important aspect of the simulation system is how the basic model elements are integrated into the hardware in the loop version of the simulation. Version includes inputs for handcontrollers, image processors, real time simulation computer and avionics flight computer. A powerful interface to drive impressive 3D images has also been developed. The 3D imaging is important not just from the point of view of understanding what is occurring in the simulation but can also be used to test rendezvous and docking sensors based on video processing.

The simulation as a whole is readily extensible to include other disturbances and effects. These other disturbances will become important during the development of a robust autonomous rendezvous and docking system.

Historical Background:

The development approach taken on this project was developed under an ALS/NLS advanced technology project known as Adaptive Guidance, Navigation and Control Project 2203. The goal of that project was to investigate methods to drive the cost to develop GN&C systems by either making the process of design more efficient and better integrated or by increasing the adaptiveness or robustness of the flight control system so that mission to mission changes are not required. The simulation itself was developed to demonstrate the capabilities RIP to develop spin off applications for the high-energy Centaur upperstage.

Technology Maturity:
Elements of Rapid Integration and Prototyping (RIP) technology is mature enough to be used on production programs today. The integration of these design technologies is the area that needs development.

Test Experience:
The simulation described in this paper/presentation has been developed by the AGNC team in the advanced avionics department of GDSS. It has been operated in real-time. It is currently under further development to support simulation and design studies for autonomous rendezvous and docking.

Sponsorship & Funding:
The Rendezvous and Docking simulation was developed on GDSS discretionary funds during 1990. Enhancements to the simulation model, in particular a rendezvous and docking sensor model is under development funded by a NASA/JSC CRAD. The development methodology and environment (Rapid Integration and Prototyping) concept was defined and developed on the Adaptive Guidance, Navigation and Control Advanced Development Project. The Advanced Avionics group at GDSS plans an IR&D for 1991 that will further develop and enhance RIP capabilities.