operational modes. The system is triple modular redundant. The system can be augmented with S-Band or Ku-Band transceivers and command units to provide a manual override capability to meet additional mission safety requirements or to enhance versatility. The Cruise Missile derived image processing system accommodates a variety of sensors. The integration of GPS/IPS/INS provides a robust, scalable and easily reconfigurable architecture. The mature system elements minimize the integration and development costs.

The Multi-Path Redundant Avionics Suite (MPRAS) advanced development program is focusing on the next generation avionics system architecture. This architecture will use standardized electronics modules to provide a scalable, open architecture with commonality across many programs. In this way, technology can easily be inserted as it matures. By leveraging the modules over many programs the cost also is reduced. Ultimately, the goal of MPRAS is to develop space qualified common modules for processors, data busses, power supplies, sensor interfaces, inertial sensors, and GPS receivers.

The Centaur modern avionics suite combined with existing Cruise Missile technology provides a very viable approach to a fully autonomous rendezvous and docking system. The image processing system also provides the added benefit of performing terrain mapping and object recognition. This capability allows the same system to be used for autonomous landing support. A fully integrated system approach provides a versatile control system with several applications. This system is being evaluated for application to the Cargo Transfer Vehicle, Space Station Resupply, Advanced Manned Launch System, High Speed Civil Transport, Common Lunar Lander, and other planetary landers. The Laboratory facilities at JSC, MSFC, LaRC, and ARC will provide the key testbed accommodations for the evaluation of this system.

Concerns / questions that arose during the presentation include: What is the probability of qualifying the super computer from the cruise missile? It is undergoing MIL qualification. Space qualification would depend on interest and funding. How much memory is in the 1750 processors? Up to 256 K bytes (16-20 bit), with present operation at 128 Kb. Is there planning to go to a four string system to meet two fault tolerance? Yes, an evolutionary system such as MPRAS would meet a FO/FO requirement whereas the TMR does not.

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An Autonomous Rendezvous & Docking System using Cruise Missile Technology

by Ed Jones and Bruce Nicholson - General Dynamics

In November 1990 General Dynamics demonstrated an AR&D system for members of the Strategic Avionics Technology Working Group. This simulation utilized prototype hardware derived from the Cruise Missile and Centaur avionics systems. The object of this proof of concept demonstration was to show that all the accuracy, reliability, and operational requirements established for a spacecraft to dock with Space Station Freedom could be met by the proposed AR&D system.

The AR&D system originally was designed to support Expendable Launch Vehicle (ELV) logistic support of SSF; integrating the best features of two mature avionics systems in meeting the stringent requirements associated with docking/berthing with the SSF. The advanced Centaur avionics system has a scalable architecture and combines a three-string INS with a redundant Global Positioning System (GPS). The communications system can be configured to support teleoperated, supervised automatic and/or autonomous operations. The Image Processing Assembly (IPA) is derived from the units currently being evaluated in the Cruise Missile flight test program. The IPA accommodates a variety of sensor inputs, has a proven record of target recognition and accurate tracking capabilities, is programmable in several computer languages including Ada, and provides performance and flexibility to rapidly reconfigure for changes in the application environment. Circuit boards are constructed with submodules that allow the designer to tailor the hardware to the target applications. A typical submodule contains a 32-bit microprocessor and four megabytes of memory. Each board can accept up to eight submodules. Available processor modular functions include video frame grabbers, graphics display drivers, interface adapters, video processors, and MIL-STD-1553 and other system interfaces. Sensors accommodated include video, forward looking infra-red, and laser sensors.

The AR&D proof of concept demonstration simulation included as much hardware as possible and required real-time system operational capabilities that were provided by the Advanced Avionics System Development Lab. The docking vehicle and SSF dynamic models were contained in the main processor where the relative positions of the vehicles also were calculated as they orbit the earth. A docking vehicle view of the SSF is generated on a graphics monitor, which is viewed by a video sensor/IPA; an INU is mounted on a three-axis table to emulate the system's inertial sensors; and the loop is closed through the autopilot and dynamic model. System performance and status is monitored on graphic monitors or workstations. Three real-time parameters can be monitored on individual, autoranged graphs. Overall system performance is evaluated by freezing and displaying the velocity and displacement parameters at the instant of contact. A dedicated window displays the simulator's operational mode and configuration. Other windows display the orbital position and firings of the RCS jets. When docking with SSF, the docking vehicle must follow specific approach procedures. The simulated ELV approach started at a range of 300 meters behind the SSF, along its velocity vector, with approach to this point based on inertial and GPS references. Though the IPS can acquire and track the SSF from more than a kilometer, it is not the primary sensor until about the 20-meter range. Initially, the target was SSF. The target transition to the SSF docking module, then to the target on the docking module, and finally to the small target on the hatch of the docking module.

Expanded use of the simulator is planned for 1992. Areas to be explored will include sensor suite mix to add robustness, optimization of IPA configuration to support terminal guidance with collision avoidance, and evaluation of autolanding capabilities for terrestrial and planetary applications. The simulation facility will be used to help integrate the AR&D system into the NASA test facilities participating in the ARD&L System Test Program. The test program potentially will involve test facilities at JSC, MSFC, and LaRC to independently test and validate the performance of key elements of this pathfinder AR&D system.

Concerns addressed during the presentation: Is the use of the image processor discussed an overkill since only four dots were being viewed? Yes, for only that function. When growth considerations such as handling multiple targets, performing docking and supporting landing are considered, there is no overkill. What are the power requirements? 80 watts, but the system is flexible and can be reconfigured according to need.

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On-Orbit Demonstrations of Automated Closure and Capture Using ESA-Developed Proximity Operations Technologies and an Existing Serviceable NASA Explorer Platform Spacecraft

by Bill Hohweisner, Fairchild and
Jean-Michel Pairot, Matra Marconi Space

Since 1984 the European Space Agency (ESA) has been working to develop an autonomous rendezvous and docking capability to enable Hermes to dock automatically with Columbus. As a result, ESA (with Matra, MBB, and other space companies) have developed technologies that are directly supportive of the current NASA initiative for Automated Rendezvous and Capture. Fairchild and Matra would like to discuss the results of the applicable ESA/Matra rendezvous and capture developments and suggest how these capabilities could be used together with an existing