misalignments, translational and rotational, will be introduced within the constraints of the systems involved.

The laser sensor system being used is a brassboard version of the Laser Docking Sensor that was being developed for application in the Lunar/Mars Programs. The laser sensor being used has been tested in the 6 DOF Sensor Test Bed (Granite Rail) in Building 14 at NASA/JSC. The Shuttle and Station models are pared down from existing models and will be validated from existing test cases. The integrated test runs currently are delayed by DTS controller hardware problems. Difficulties have been encountered thus far, but progress is continuing.

An Overview of Autonomous Rendezvous & Docking System Technology Development

by Kurt D. Nelson, General Dynamics

The Centaur upper stage was selected for an airborne avionics modernization program for many reasons. The parts used in the existing avionics units were obsolete and continued use of existing hardware would require substantial redesign yet result in the use outdated hardware. Manufacturing processes also were out of date with very expensive and labor intensive technologies being used for manufacturing. The Atlas/Centaur avionics were to be procured at a fairly high rate that demanded the use of modern components. The new avionics also reduce size, weight, power, and parts counts with a dramatic improvement in reliability. Finally, the cost leverage derived from upgrading the avionics as opposed to any other subsystem for the existing Atlas/Centaur was a very large consideration in the upgrade decision. The upgrade program is a multiyear effort begun in 1989. It includes telemetry, guidance and navigation, control electronics, thrust vector control, and redundancy levels.

The new INU combines the inertial measurement system with the flight control system into a single radiation hardened package including ring laser gyros, accelerometers, processors, and electronics. This new system resulted in a weight savings of over 100 pounds and a four-to-one cost reduction. The new Remote Voter Unit (RVU) receives commands and performs a 2 out of 3 vote on the discrete commands with a center select on the analog signals. The RVU is fully internally redundant, has been developed, breadboarded, and demonstrated. The integration of a Global Positioning System receiver into the inertial navigation system has been accomplished for both the advanced Centaur and the cruise missile programs. The capability provided by this system will meet the accuracy requirements for low earth operations independent of mission duration time. It provides precision position and velocity measurements and it can be configured to provide attitude information.

An Image Processor Assembly (IPA) is in flight test and an earlier model IPA was used in a successful proof of concept AR&D ground demonstration in November 1990. This adaptable embedded processor (of Cruise Missile heritage) is modular and can be reconfigured in real-time to perform a variety of mission functions. A unit is being built for the Autonomous Rendezvous, Docking and Landing System Test Program. A typical submodule contains a 32-bit microprocessor with four megabytes of memory. Each board can accept up to eight submodules providing processor capability of eighty 32-bit microprocessors and 320 megabytes of memory with a throughput of 800 MIPS. Modular functions include frame grabbers, graphics display drivers, interface adapters, video processors, and MIL-STD-1553 and other system interfaces. The modular parallel processor approach provides performance and flexibility to rapidly reconfigure for changes in the application environment.

The Centaur modern avionics components can be combined with the Cruise Missile image processing system and GPS to provide a fully autonomous rendezvous and docking system using off-the-shelf technology. The autonomous capability provides collision and hazard avoidance in all

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

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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