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# Autonomous Reconfigurable GPS/INS Navigation and Pointing System for Rendezvous and Docking

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The briefing describes work using the Global Positioning System to determine position of spacecraft, and development of computer tools to utilize these position determinations to enable autonomous rendezvous. Using GPS data in conjunction with Inertial Navigation Systems (INS) provides the capability for absolute spacecraft navigation, navigation of one spacecraft relative to another, and attitude determination. Some results presented are based on limited observations, though simulation results are documented. A GPS/INS navigation flight experiment could provide a platform for evaluating approaches for autonomous operation and reconfigurability of the navigation and attitude determination subsystem for future space vehicles.

Current emphasis is on the development and demonstration of an Onboard Mission Manager (OMM) and a Multi-Mode Navigation Kalman filter. Sensor data will be handed over to the OMM, which will determine the appropriate response and generate commands for the Kalman filter to use to reconfigure itself. GPS measurements and INS data will be processed in the integrated navigation filter and used to compute errors in position, velocity, and attitude. INS instrument errors (biases, scale factors, etc.) also can be estimated. The OMM then will use a knowledge base to determine appropriate system response. GPS is good for missions that have attitude pointing accuracy requirements within the 100 to 200 arcsecond range.

Several techniques are available for using GPS based data to determine attitude. These techniques include velocity matching, interferometric, and attitude matching. They are used, either singly or in some combination, with either an absolute or a relative GPS/INS navigation mode, to determine the appropriate Kalman Filter configuration. In the report, nine filter configurations were identified to demonstrate the reconfigurability concept.

The Kalman filter software and the OMM software are being developed in the Ada programming language. Emphasis in this development is placed on modularity with a high degree of reconfigurability built into the system. The intent is to support anticipated future expansion requirements and the capability to perform on-board modification of the Kalman filter using a knowledge base. Capability to accept a wide range of sensor input (horizon sensors, sun sensors, star trackers, etc.) also is incorporated in the system.

Preliminary results from the use of both real GPS data and simulations were provided. These results indicate a capability to determine position in a static or benign environment to within 1-2 meters. In a dynamic environment, indications are that position may be determined to within 5-10 meters. These analyses point out the need to develop high fidelity models of ionospheric and multi-path errors to provide improved accuracy.

Some questions arose during the presentation. Did Mayflower incorporated the degradation due to the DoD selective availability (SA) implementation? Mayflower had not incorporated SA in their analysis at this time. What are the GPS limitations in the short range? The multipath effects and obscuration by structures must be closely analyzed. This is especially true for Space Station Freedom due to its size. Finally, a question came up regarding the viability of using receivers from different manufacturers. The use of different receivers should not be a problem as long as they are cooperative and are tracking the same satellites. There may be some degraded performance (on the order of 10 meters) in some mixes of receivers.