N93-22241

Applicability of Relative GPS to Automated Rendezvous between the Space Shuttle and Space Station

by Fred D. Clark and Ann Christofferson, both of Lockheed Engineering & Sciences Co. 2400 NASA Rd. 1, Houston, TX 77058
Phone- (713) 333-6284 & (713) 333-6377 respectively.
Fax- (713) 333-6908

Technical

The purpose of this study is to determine the adequacy of the Global Positioning System (GPS) in providing relative navigation for automated rendezvous and proximity operations. The study was performed using the Proximity Operations Simulator (POS), Lockheed's high-fidelity, 6 degree of freedom simulation of the space shuttle and space station.

This simulation includes identical models of GPS receivers for each vehicle. The navigation software in each vehicle includes identical Kalman filters. Each filter computes the absolute state of its vehicle, and the relative state vector is obtained by simply subtracting absolute states.

The GPS model includes errors in the ephemeris and clocks of the GPS satellites. Receiver clock errors and receiver noise are modeled, as well as ionospheric errors. Multipath and obscuration effects, however, are not modeled. The receivers can be modeled with either the precise positioning service (p-code), or with the standard positioning service (C/A code). Both filters include three state vector components for position, velocity, and unmodeled acceleration bias, one component for clock bias, and one component for clock frequency error.

The Shuttle Operational Rendezvous (SOR) profile was simulated with two exceptions. First, the orbiter was targeted to cross the +Rbar below the station and intercept the +Vbar 500 feet in front of the station, rather than targeted directly to the station. Second, when the angle between the line of sight to the station and the +Vbar reached 45 degrees, the orbiter was commanded by the guidance to remain on a 45-degree glideslope for the remainder of the trajectory.

In the simulations, five different dispersions in position and velocity were used to intialize the orbiter at a range of about 100 nmi. from the station. Simulations were run with both p-code and C/A code models and two different glideslope approach controller gains. Also, in one set of runs, estimated orbiter Reaction Control System (RCS) delta-v was used instead of Inertial Measurement Unit (IMU) data.

We found that relative GPS is adequate for controlling the trajectory of the shuttle along a 45-degree glideslope until quite close to the station. A sensor capable of estimating range, range rate, and bearing would be needed to complete the final phase of an automated rendezvous and capture.

Historical

The capability to use relative GPS for orbital relative navigation has been studied for several years. About a dozen GPS satellites are currently onorbit. The full constellation will be completed before first launch of the first space station elements. Lockheed's capability to simulate GPS navigation was first developed in 1984-5 and has evolved to a mature simulation.

Sponsorship

This work was supported by the Guidance and Prox Ops section of the Navigation & Guidance Systems branch of the Navigation, Control, & Aeronautics division at the Johnson Space Center.

Clark, Christofferson;