A question that arose during the presentation: What is the life time of the LEDs and their sensitivity to radiation? The LEDs should be manufactured to Military Specifications, coated with silicon dioxide, and all other space qualified precautions should be taken. The LEDs will not be on all the time so they should easily last the two-year mission.

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

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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, six-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 vehicle estimates its own state, 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 are not modeled. The receivers are modeled to provide either the precise positioning service (p-code), or 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 initialize the orbiter at a range of about 100 nautical miles from the Station. Simulations were run with both p-code and C/A code models. Also, in one set of runs, estimated orbiter Reaction Control System (RCS) delta-v was used instead of Inertial Measurement Unit (IMU) data, which has a quantization level of 0.0344 ft/sec. As expected, relative position is estimated better using p-code. Relative velocity estimation is nearly identical regardless of whether p-code or C/A code is used. If delta-v is estimated without IMU, and additional process noise is added during RCS firings, relative velocity errors are halved.

Relative GPS is adequate for controlling the trajectory of the shuttle along a 45-degree glideslope until a few hundred feet from 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.