INERTIAL REFERENCE UNIT

Frederick J. Kull

The Inertial Reference Unit, referred to as the IRU, is a high performance gyro attitude reference system designed and built by the C.S. Draper Laboratory at MIT for use on the OAO Spacecraft. The IRU is a three axis system, which provides both rate and attitude information for spacecraft control.

The purpose of the IRU is to reduce the dependency on gimballed startrackers and, in turn, simplify the OAO ground operations by eliminating the need for the continual programming of gimballed startracker assignments in accordance with computed occultation schedules. During normal operations, it is used to control the pitch and yaw axes during experiment occultations and during spacecraft reorientations. The roll axis is continuously under control of the IRU except during brief periods for attitude update.

To provide for these capabilities the IRU must be able to perform two basic functions. One is to maintain an inertially fixed reference for spacecraft control and the second is to accurately reorient the reference upon command.

The accuracy of a spacecraft reorientation is primarily a function of the accuracy and stability of the torquer pulse weighting factor and gyro alignment relative to the spacecraft control axes. The performance goal established prior to launch was to have the capability of reorienting the spacecraft up to thirty degrees, and acquiring a target star within the field of view of the Princeton Experiment, which is ±4 minutes of arc. This capability was demonstrated in orbit prior to the conduct of the slew calibrations. The degree to which this goal will be exceeded, especially after the slew calibration and alignment data are available, is not known at this time.

The capability of the IRU to maintain a fixed inertial reference is limited by the effective drift level. The high performance drift characteristics achieved by the IRU are based on the use of gyros and torque rebalance loop electronics which have extremely stable characteristics and the capability for in-orbit commandable drift compensation. The performance goal was to achieve a compensated drift rate of less than 10 arc seconds per hour. This goal has been exceeded by more than an order of magnitude. The IRU has demonstrated the capability for maintaining an inertially fixed reference with an accumulated error of less than one arc second per hour. This level of performance has proved extremely valuable on the OAO spacecraft and provides a basis for the expanded use of precision gyro reference systems. Improvements in this drift performance are limited by both the ability to accurately measure drift at this level and the granularity of the in-orbit compensation term.

An interesting by-product of the IRU drift determinations, and one which demonstrates the problems associated with the measurement of these low levels of drift, is the direct measurement by the IRU of the velocity aberration phenomena.

Figure 1, which relates to the pitch axis, indicates the IRU attitude error while the spacecraft is pointing at a specific star under control of the Princeton Fine Error Sensor. The breaks in the data are due to occultation of the experiment and ground contacts when the spacecraft is controlled by the IRU.

The curve defines the deviation between the IRU reference and the Princeton Fine Error Sensor reference. The ramp component of the curve is the IRU drift, which in this case is less than one tenth of an arc second per hour, or about ¼ degree per year. The sinusoidal component of the curve is the spacecraft motion resulting from the response to an apparent sinusoidal motion of the target star. Although the star is inertially fixed, its apparent position varies as a function of the velocity of the spacecraft normal to the line of sight to the star source. This is the velocity aberration phenomena. The magnitude of the maximum velocity aberration error is within a few percent of that theoretically predicted for the OAO orbital characteristics.

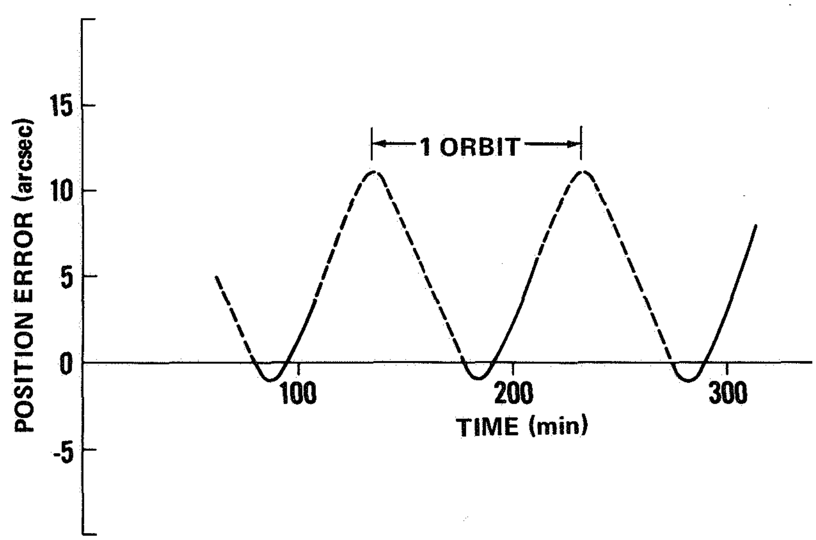

Figure 1. IRU/PEP differential error.