ORBIT AND ATTITUDE DETERMINATION

FROM IMAGERY MEASUREMENTS OF

GEOSYNCHRONOUS SATELLITES

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Over time periods extending from one day to a week it is possible to accurately navigate imagery data from the SMS-2 or GOES-1 satellite using the SSEC Navigational Model with appropriate parameter values to represent the orbit, attitude and imagery centering effects for each satellite. This paper examines a possible approach towards acquiring such sets of parameters. However, it is emphasized that the word "appropriate" in this context does not mean that every parameter acquired will correspond as an accurate measure of its physical counterpart, but rather tha set of parameters accurately models the apparent motion of the earth in a time sequence of imagery frames. For an observer of data with respect to the earth's surface this is the true measure of the accuracy of a navigational model.

If the spin axis of the satellite coincides with the perpendicular to the orbital plane and the principal axis of the satellite, then every measurement of an identifiable landmark enables one to compute the angle between the perpendicular to the orbital plane and the vector from the earth's center to the landmark. Since the coordinates of this vector in an inertial frame can be calculated from the latitude and longitude of the landmark, each landmark measurement determines a circular loci on the celestial sphere to which the perpendicular to the orbital plane is constrained. Two or more such measurements enable one to make a unique determination of the pointing direction of this perpendicular in inertial space. This determination gives the inclination and ascending node of the satellite orbit.

Since the spin axis generally does not coincide with the orbital plane perpendicular and the principal axis of the satellite, a procedure to compensate for these effects is necessary. The most obvious effect of

this lack of coincidence is the excursion of the center of the earth away from the nominal picture center line in a sine wave plus constant type motion. This apparent motion can be modeled in a two step procedure: (1) measure the element chord distance between left and right earth edges as a function of different line numbers through a time sequence of frames and (2) model these chord measurements by using a nominal geosynchronous orbit and varying the attitude and picture center line until a best fit is achieved between the measured chord lengths and predicted chord lengths. This yields an estimate for the true picture center line and for the relative attitude between the satellite spin axis and the orbit perpendicular. These estimates combined with earth center element estimates enable us to transform the imagery frames to the case where the spin axis coincides with the orbit perpendicular and the principal axis of the satellite.

This transformation enables us to determine the angle between the vector to the satellite and a vector to a landmark, with both vectors originating at the earth's center. This angle combined with the inertial coordinates of the landmark vector and the inertial coordinates of the orbit perpendicular yields a range measurement of the position of the subsatellite point. By fitting the angular motion of the satellite in its orbital plane as the sum of a linear curve and a sinusoidal perturbation one gets estimates of the semimajor axis, mean anomaly, eccentricity, and perigee.

The primary motivation for this approach is the accessibility and simplicity of the computations. Users principally interested in the earth location of their data can check and quality control each step of the navigation. Finally, the computations can be made on a relatively small machine in a couple of minutes.