FUTURE TECHNIQUES FOR TRACKING OF SYNCHRONOUS SATELLITES

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The study of the Tracking and Data Relay Satellite System, in which synchronous satellites would be used for tracking and data relay purposes, provides an opportunity to consider future techniques for tracking of synchronous satellites. The desire to minimize the number of ground stations used and to utilize the tracking and data relay measurement system itself, leads to the consideration of new techniques, other than the conventional ground to synchronous satellite tracking, for determining and refining the orbits of synchronous satellites. Two measurements will be considered here:

(1) Range sum and range-rate sum measurements through a synchronous satellite to a user satellite.

(2) Range sum and range-rate sum measurements through a synchronous satellite to a ground-based transponder.

The tracking link (see Figure 1) originates at a main ground station, is relayed through the synchronous satellite to a user satellite, and is returned to the main ground station via the same link, thus providing range sum measurements $(r_1 + r_2)$ and range-rate sum measurements $(\dot{r}_1 + \dot{r}_2)$ to a user satellite. Similarly, the transponder measurement link originates at the main ground station, is relayed through the synchronous satellite to a ground-based transponder, and is returned via the same link to the main ground station, thus providing range sum and range-rate sum measurements to a ground-based transponder.

A tracking system error analysis computer program is used to study the feasibility of these measurements. Error analysis transforms expected uncertainties in the measurement system itself, namely the measurement noise and bias, and uncertainties in the locations, namely ground station location uncertainty and *a-priori* uncertainties in the orbits of the synchronous satellite and user satellite, into expected uncertainties in each of the orbits after tracking. The orbit determination technique employed will be to simultaneously update the orbits of both the user satellite, taken here to be in a Nimbus orbit, and the synchronous satellite, taken to be in an ATS orbit. It is the orbit determination for the synchronous satellite that is of concern here. The measurements are simulated at the rate of one per 10 s for 1, 2, and 3 Nimbus passes. Resulting uncertainties expected for the ATS orbit, when the range sum and range-rate sum measurements to the Nimbus satellite are processed, are given in Table 1.

The results show that the 500-m ATS *a priori* position uncertainty can be reduced to 150 m after 3 Nimbus passes. One reason for this reduction is the dynamic nature of this tracking situation, where the range sum and range-rate sum measurements vary due to the Nimbus motion. This is in contrast to the nearly static situation with conventional ground to synchronous satellite tracking where the range and range-rate measurements are nearly constant.

The next case adds the ground-based transponder range sum and range-rate sum measurements. These measurements have an effect after 3 passes and further reduce the ATS position uncertainty to 100 m.

In conclusion, both of the measurement types considered here, the range sum and range-rate sum measurements through a synchronous satellite to a user satellite, and the range sum and range-rate sum measurements through a synchronous satellite to a ground-based transponder, would prove useful in the future for determining and refining the orbits of synchronous satellites.

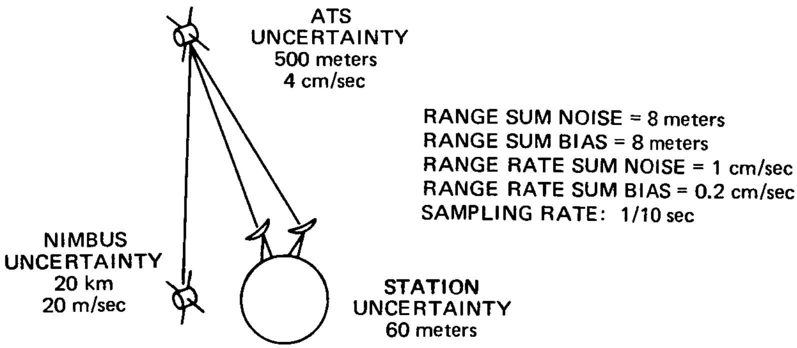

Figure 1—ATS/Nimbus error analysis modeling.

Table 1—Solving for ATS and Nimbus orbits.

NIMBUS PASSES	ATS POSITION UNCERTAINTY (1σ) USING RANGE SUM & RANGE RATE SUMS
1	350 meters
2	200 meters
3	150 meters
NIMBUS PASSES	ATS POSITION UNCERTAINTY (1σ) USING RANGE SUM & RANGE RATE SUM + TRANSPONDER MEASUREMENTS
1	350 meters
2	170 meters
3	100 meters