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First results of GPS orbit determination with GRAPE package using a square–root information filter

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The zero–differenced carrier phase measurements contain the distance between the phase centres of receiver and transmitter antennas biased by unknown integer number of cycles (phase ambiguities). The internal precision of such measurements is at submillimetre level. Nevertheless one could attain the millimetre precision provided that the various effects affecting the measurements are properly modelled (among these the most important ones are ionosphere and troposphere refraction, satellite and receiver clock errors, multipath). This allows us to use such measurements for GPS satellite dynamics study as well as for high-precision satellite orbit determination. In the case of GPS the problem of solar radiation pressure modelling is of primary importance. Besides this, the correct description of eclipse effects on satellite motion (solar panels orientation restoring after the satellite quits the shadow zone) needs to be also considered.

The most useful estimation tool for processing zero–differenced measurements is the Kalman filtering/smoothing algorithms, which allow to obtain sequentially estimates of deterministic and stochastic parameters. Meanwhile, as it is noted in [1], for the satellite dynamics study a more comprehensive approach would be to apply the so–called information–related filtering algorithms (SRIF/SRIS) constructed in terms of the square–root of the covariance matrix (information matrix). Such algorithms are more stable to improper a priori knowledge of unknown parameters and their covariances and less influenced by the round–off errors in comparison with usual Kalman filtering approach.

The SRIF/SRIS algorithm was implemented in GRAPE package developed in Institute of Applied Astronomy in accordance with the algorithm considered by Biermann [2]. Following this monography, the state vector is divided into three parts as follows:

- bias parameters (phase ambiguities),
- purely stochastic parameters (clock errors),
- dynamic parameters (initial satellites position vectors).

To represent satellite dynamics one needs the matrices of partial derivatives of satellite position vector for arbitrary epoch t with respect to its initial position vector $K_e(t_0, t)$ and to parameters of radiation pressure models $K_p(t_0, t)$. In our case these matrices are contained in conditional equations whereas a transition matrix for these parameters is simply the identity matrix.

This paper presents the first results of GPS satellite orbit determination obtained with GRAPE package on the base of the square–root filtering/smoothing algorithm. The monthly series of phase measurements collected with about 20 permanent IGS stations were processed. The following criteria were used to select GPS stations:

- good Earth surface coverage,
- these stations must provide phase and P-code measurements at the both frequencies.

The results of GPS satellite orbits determination are presented and some aspects of realized methodology are discussed.

It should be noted that in this paper we restricted ourselves by estimation of only initial satellite positions and velocities. Parameters of empirical solar pressure model described in [3] were determined from pseudo–observations and remained fixed. Their inclusion into the estimation scheme will be the next stage of our investigation.

References

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