AUTONOMOUS ORBIT CONTROL PROCEDURE, USING A SIMPLIFIED GPS NAVIGATOR AND A IMPROVED GROUND TRACK PHASE DRIFT PREDICTION METHOD, APPLIED TO THE CBERS SATELLITE

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ABSTRACT

In a former study [1], it was analyzed a version of an autonomous orbit control procedure that makes use of improved orbit estimates provided by a simplified Global Positioning System - GPS navigator [2] and of variable amplitude semi-major axis corrections, in order to keep the ground track phase drift at the Equator of a CBERS-like sun-synchronous satellite within its allowed variation range. The CBERS (China-Brazil Earth Resources Satellite) satellite program is a Chinese-Brazilian joint project aimed at the monitoring of Earth's natural resources. A polynomial approach [3] recently proposed to calculate the second time derivative of the ground track phase drift of such kind of satellites was also used in that former work [1]. The simplified GPS navigator improves the coarse geometric navigation solution provided by GPS receivers. This is done by directly using the GPS solution as input (observations) for a real time Kalman filtering process. The orbital state vector has been extended in order to include the systematic error that is imposed to the GPS geometric solution by the changes in the set of satellites which are visible to the receiver. These improved outputs were used in the computational implementation of an autonomous control system for the ground track phase drift of the spacecraft orbit. The ground track phase drift is the parameter that presents the higher frequency of corrective maneuvers application for heliosynchronous orbits in phase with the Earth's rotation.

The results obtained by the method used in [1] to calculate the second derivative of the ground track drift helped reducing the uncertainty present in this parameter, allowing more precise calculations of the semi-major axis maneuver amplitudes and contributing to reduce the number of applied maneuvers, as originally desired. This remained true even when tight operational limits were considered, instead the nominal ones.

Thorough investigation of the results obtained in the previous work just described [1] allowed to observe that, even after the application of a smoothing procedure, a periodic variation still remained in the output corresponding to the first time derivative of the ground track phase drift. Since this derivative is needed to foresee the time evolution of the ground track phase drift itself, the more accurate the first derivative estimation is the more accurate is the prediction for the time evolution of the ground track drift. The precise knowledge of the future time evolution of the ground track drift, by its turn, is required in order to increase the accuracy of the orbit correction maneuver computation process. One observed that the period of this cyclic variation was of about one day. In this paper, this periodic variation is modeled and filtered from the smoothed output

obtained in the former work [1]. This new filtering process can be thought of as being a second smoothing layer applied to the ground track drift first derivative. This is done with the help of a curve fitting process, where a curve, resulting from an algebraic expression, is used to match the time evolution curve resulting from the first smoothing layer. The parameters of the algebraic expression are the unknown variables of the curve fitting process. In this way, the curve fitting process becomes an optimization process where one desires to find out what are the parameters that best minimize the residuals obtained by subtracting the two curves. Here, these parameters are found with the help of an Evolutionary Algorithm developed in [4]. As a bonus, the mentioned procedure also provides another way to determine the value of the second time derivative of the longitude phase drift, besides the one given by [3].

The behavior of the system is evaluated by means of simulations of CBERS-like phased remote sensing satellite orbits. For the CBERS satellite series the maximum allowable variation range for the ground track longitude phase drift at the Equator is of ±4km. The aim of the paper is to verify the impact the addition of the second smoothing layer of the ground track drift derivatives on-board estimates has on the performance of the entire system, when compared to the results already obtained for the same satellite in the previous works.

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