AN IMPROVED DRAG MODEL FOR CBERS SATELLITE ORBIT DETERMINATION AND PROPAGATION

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ABSTRACT

The CBERS-2B was the latest satellite of CBERS (China-Brazil Earth Resources Satellite) series, launched in 2007, and the follower CBERS-3 will be launched in late 2013. CBERS satellites have polar sun-synchronous orbit with an altitude of 778km, crossing Equator at 10:30am in descending direction, frozen eccentricity and perigee at 90 degrees, and provides global coverage of the world every 26 days. With such characteristics its orbit, besides gravitational forces, is mainly perturbed by the atmospheric drag and solar radiation pressure, amongst others (third body attraction, tides, etc.). However drag perturbation has shown to be most difficult to model in view of the need of accuracy for long lasting predictions. The current model for orbit propagation, used by the CBERS Control Center at the National Institute for the Space Research (Brazil), considers a constant value for the drag coefficient. In fact, the drag was estimated during orbit acceptance phase, which resulted a mean value of 2.7. This model was then frozen, with little variation allowed, and it is still being used for orbit determination and propagation in the INPE´s control center. Nevertheless it is known that the atmospheric drag depends on a multitude of different parameters with several sources, in particular the Mach number, the surface temperature and accommodation coefficients. In this work it is considered a model for the drag forces on CBERS based on the kinetic theory of gases, as proposed by Schaff and Cambré (1961). The algorithm considers that the external satellite geometry is described by a boundary representation (b-reps) similar to that used in computer graphics such as OpenGL software pakage. Satellite surface is divided in a finite number of triangles, each one described by its vertex coordinates. Geometry is stored in an ASCII file using a subset of NASTRAN commands for the mesh description. Once the mesh is stored in memory, the forces and torques acting on the satellite (e.g. drag and / or solar radiation pressure) can be calculated by integrating it all over the external surface. The computation burden for computing drag forces with this approach is, of course, several times higher than the constant coefficient model. The main goal of this work is to compare this model with the quasi-constant drag coefficient results from the control center, in a long term basis, for instance one month at least (between maneuvers). Therefore it is able to retrieve eventual discrepancies and the orbit elements deviation can be promptly analyzed. The atmospheric properties were obtained from an analytical model proposed by Mueller (Mueller, 1982), based on the Jacchia's 1977 model (Jacchia, 1977). Indeed any density model could be used as reference to draw the essential conclusions. The results have shown that there were some significant improvements in orbit prediction, when applied for long arcs (e.g. one month). Since computing time is not a very constraining requirement nowadays, it is expected that either the variable drag coefficient on-line computation or a corresponding

suitable empirical parameterization (e.g. Ziebart, 2005) can be successfully applied in the upcoming CBERS missions.

References:

SCHAAF, S. A.; CHAMBRÉ, P. L. *Flow of rarefied gases.* Princeton, Princeton University Press, 1961. (Princeton Aeronautical Paperbacks, 8).

Jacchia, L. G. *Thermospheric Temperature, Density and Compostion: New Models*. Cambridge, Ma, SAO, 1977. (SAO Special Report No 375).

Mueller, A. C. *Jacchia-Lineberry upper atmosphere density model*. Huston NASA, 1982. (NASA-CR-167824).

Ziebart, M. Generalized analytical solar radiation pressure modeling algorithm for spacecraft of complex shape. *Journal of Spacecraft and Rockets*, 41 (5), pp. 840-848, 2004.