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PHYSICAL CROSS-SECTIONAL AREA MODELING OF COMPLEX STRUCTURAL SPACECRAFT FOR LONG-TERM PRECISION ORBIT DETERMINATION

Abstract

Atmosphere drag modeling is the greatest uncertainty in the dynamics of low Earth satellite orbits, which mainly contains the ballistic coefficient, atmosphere density and the cross-sectional area. For complex structural spacecraft, the cross-sectional area varies in a wide range according to the attitude or movable components, such as solar arrays. The residual error can't be absorbed completely by estimation of the ballistic coefficient. This paper investigates the modeling and calculation of accuracy cross-sectional area of complex structural spacecraft, and applies the method to long-term precision orbit determination. First, a scheme for approximating the accuracy module contour of any complex spacecraft by triangular meshes is developed, which can be easily generated by 3d processing software. The tree structure is employed to integrate all the meshes to a combinant according to their hierarchical relationship and motion links. By this strategy, the out surface of transformed spacecraft can be represented with the motion status of moveable modules. Then, a computer graphical approach is proposed to calculate the cross-sectional area rapidly. The projected direction can be obtained by the attitude from the telemetry data or the attitude control mode. The shadow of the spacecraft can be generated by projecting the meshes using the principle and toolkit in the computer graphic, which can imply the cross-sectional area. The method also accounts for overlaps among projections, module motion, attitude change, and is capable of providing the true area in a computationally-efficient manner. This method can be generalized to satellites of arbitrary shape. The model was applied to orbit determination of Tian-gong spacecraft, and the 30-days position predicting residuals is reduced by 4%.