

SPACE DEBRIS SYMPOSIUM (A6)
Modelling and Risk Analysis (2)

Author: Mr. Xianzong Bai
National University of Defense Technology, China, baixianzong@163.com

Prof. Lei Chen
National University of Defense Technology, China, clwhl@263.net
Prof. Guojin Tang
National University of Defense Technology, China, tanggj@nudt.edu.cn

GEOSTATIONARY ORBIT ANOMALY DETECTION BASE ON DISPERSION OF DRIFT RATE

Abstract

The detection of space events such as spacecraft maneuvers, collisions, explosions, fragmentations, sudden changes in ballistic coefficients and space weather is an important component of Space Surveillance and Space Situational Awareness. Timely awareness of such events is significant for spacecraft owners and operators so as to assess risk and take mitigation action. Orbital anomaly of space object is an principal indicator of space event. Geostationary ring is one of the most important and valuable regions, and due to its specialty and uniqueness, is also one of the most crowded regions in space. Geostationary orbit (GEO) spacecrafts have to conduct station-keeping maneuvers frequently to overcome the position drifts caused by perturbation, this makes challenge for the orbit anomaly detection. This paper develops a GEO orbit anomaly detection method based on drift rate dispersion of theoretical and practical mean longitude and inclination. Orbit anomaly is defined as abnormal dispersion between practical and expected values of orbit characteristic parameters. Based on this conception the basic procedure for detecting orbit anomaly is presented, the procedure consists of selection of orbit characteristic parameters, generation of dispersion data, outlier detection of dispersion data, assessment of detection method, and cause analysis of orbit anomaly. The mean longitude and inclination are taken as the orbit characteristic parameters. The formulae of theoretical drift rates of mean longitude and inclination are provided through perturbation analysis. The historical orbit data are processed using cubic smoothing spline technique. The theoretical drift rates of mean longitude and inclination are computed using processed orbital data. The practical drift rates of mean longitude and inclination are estimated using derivative of smooth function. The time sequences of drift rate dispersions are available by comparing the practical and theoretical values. Outliers in dispersion data are detected jointly using Mahalanobis distance between data point and origin point, these outliers in dispersion data can indicate the orbit anomaly. The detection method is implemented and tested on two GEO satellites' historical Two Line Elements (TLE) data, most of the longitude and inclination maintain maneuvers and abnormal changes of inclination are readily detected. The method considers perturbation and drift characteristics of GEO, depends solely on historical data, can detect orbital anomalies of GEO orbit effectively. The method can be incorporated into data processing system of Space Surveillance and Space Situational Awareness.