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IMPROVING THE ACCURACY OF GENERAL PERTURBATIONS METHODS FOR SPACECRAFT LIFETIME ANALYSIS

Abstract

The analytical atmospheric density model, including solar activity effects, developed by the authors(2015) is applied to multiple general perturbations methods. A new method of determining the cross-sectional area is also presented, which improves on the accuracy of the method recommended in Section 6.3 of the ISO standard 27852:2010(E).

These enhancements can be applied to many different methods and due to their simple mathematical nature they allow users to perform rapid Monte-Carlo analyses with thousands of permutations of the problem, such as varying launch date, initial orbit, spacecraft characteristics, and so forth, in fractions of a second. Traditional numerical, or even semi-analytical solutions would require a much greater length of time to produce a lifetime prediction for a single permutation.

Using modern mathematic tool sets, various general perturbations methods such as the method developed by Cook, King-Hele & Walker(1960) or the method developed by Griffin & French(2004) among others can be enhanced with the development of a more accurate density model and cross-sectional area-averaging model.

The enhanced solutions have then been validated using historical data. A sample of predicted lifetimes is presented, from which it can be seen that the enhancements consistently improve lifetime predictions from, in some cases, over 50% to within 10% of the historical data, and typically within 5%.

The enhanced solutions are seen to typically outperform commercial off the shelf simulation products. However their worth lies not only in the improvement in accuracy but also in the time saved when considering space debris analysis or in initial mission design where many parameters may be unknown. In these situations the ability to swiftly provide solutions for thousands of permutations of problems or to provide a range of predictions based on initial uncertainties and a confidence value for that range is invaluable.

References:

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