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21ST JOHN V. BREAKWELL KEYNOTE LECTURE: RELATIVE MOTION

Abstract

The design and operation of satellite formations presents many challenges to the guidance, navigation and control specialists. This subject has received a lot of attention since 1998 when the USAF Scientific Advisory Board published a report recommending the investigation of this technology as a potential solution for reducing the costs of large monolithic satellites. The Texas AM team has been deeply involved in research in this area since it won one of the first three AFOSR TechSat21 grants. This presentation will cover contributions by the Texas AM team in the dynamics and control of satellite formations. Our belief was that minimum fuel control would result from first considering the dynamics and using the physics of the relative motion to reduce fuel consumption. This philosophy led to the discovery of the J2 invariant orbits, the period matching condition and a method for balancing fuel consumption among all the satellites in the formation. Because the equatorial bulge changes the physics in that it causes perigee rotation and nodal recession we realized that a dynamic model of relative motion was needed and this led to the development of the Gim-Alfriend state transition matrix for relative motion that is valid for any eccentric orbit and includes the 1st order absolute and differential J2 effects. That STM has since been extended to include the mean and short period effects of higher zonal harmonics. The GA STM was used in the design of the Magnetospheric Multiscale Satellite (MMS) and results from that work will be presented.

One of the challenges in formation design is the selection of the dynamic model needed for the relative navigation and formation control. Having a dynamic model whose accuracy is much better than the relative navigation accuracy is a waste of resources. The dynamic model needed is the one that minimizes the fuel consumption. Results of recent research on a methodology for selecting the dynamic model that minimizes the fuel consumption required for maintaining the formation and does not require significant computer simulation will be presented.