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TRIANGULAR FORMATION FLYING UNDER THE ELLIPTIC RESTRICTED THREE-BODY PROBLEM FORMULATION

Abstract

Formation Flying can greatly answer some very complex mission goals at the cost of a quite challenging trajectory design and station keeping problem solving. The dynamical properties of a low-acceleration environment such as the vicinity of libration points associated to a restricted three body system, can be effectively exploited to design formation configurations able to satisfy tight relative position and velocity requirements. The present work steps forwards in the comprehension and understanding of the relative dynamics related to a highly unstable and non-linear environment such as the one provoked by multiple gravitational sources. The free dynamics of a Formation Flying under the Elliptical Restricted Three-Body Problem formulation is discussed. A three spacecraft triangularly-shaped formation is assumed as a representative geometry to be investigated. Initial configurations, which provide the best performance in terms of formation keeping, have been investigated and key parameters, which mainly control the formation dynamics within the three-body system, have been identified. Formation keeping performance is quantified by monitoring shape and size changes of the triangular formation. The analysis has been performed under four degrees of freedom to define the geometry and the orientation of the triangle in the synodic rotating frame: one parameter defines the size of the triangle and three angles describe the orientation with respect to the rotating frame. A further degree of freedom is then represented by the location of the formation within the three body system: many possibilities have been explored in terms of reference trajectory, considering different orbits about collinear libration points. The results of the analysis are then compared to the case where disturbance due to Solar Radiation Pressure is considered, in the Sun-Earth system. This study highlights the importance of the initial orientation of the triangular formation and of the choice of its reference orbit, while the initial size of the formation seems to have only small influences on formation keeping performance. In general the triangle can be representative not only of a formation of spacecraft but also of a single spacecraft, shaped as a planar triangle. From this point of view, the change in shape and size of the triangle can be seen as stresses in the structure of the single spacecraft and then, as deformations, considering a real deformable body: the more the triangle is able of maintaining its initial shape and size, the less the structure is subject to stresses and deformations.