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PASSIVE AEROSTABILITY FOR DRAG SAILS

Abstract

Drag-sails deorbiting devices are an interesting option to deorbit defunct spacecraft. They are passive devices that can be accommodated as an independent system to the spacecraft. Thus, causing nearly no impact and enabling them to be deployed after the true end-of-life is reached. Although presenting some key competitive advantages against traditional deorbiting systems (like direct deorbit burns), they also have some disadvantages. One of these disadvantages is that the drag created is a function of the cross section area with respect to the flow and hence, it is a function of the spacecraft attitude. As the drag-sail is deployed at the end-of-life, the spacecraft will not have any means to actively control the attitude, therefore it will end up tumbling. This tumbling causes a reduction on the effective cross sectional area which has a negative impact on the drag-sail performance. To mitigate this effect the drag-sail can be designed to be passively aerostable. In this case, the spacecraft maintains constant relative attitude with respect to the flow, hence maximizing the effective cross section area and therefore improving the drag-sail performance. In an aerostable drag-sail the sail provides an aerodynamic restoring torque when the attitude is not the desired one. Unfortunately this torque is conservative and if damping is not added the spacecraft would oscillate around the equilibrium point. This damping system could be mechanic (using a viscous damper) and could be activated at drag-sail deployment (so it is not active during the spacecraft active life). In this paper the performance advantages of aerostable drag-sails are examined. Then, the different design parameters (aerodynamic stiffness, and damping ratio) and their sensitivities are studied. Finally several sail geometries and different damping systems are proposed and analysed.