SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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Author: Mr. Abel Nepomuceno
Institute of Aeronautics and Space (IAE), Brazil

SOLID-PROPELLANT LAUNCHER GUIDANCE WITH LINEAR SEGMENTATION OF THE THRUST VARIATION

Abstract

The required end conditions of the ascent stage are set starting from the required parameters of the target orbit. The fulfillment of these end conditions is the objective of the three-dimensional guidance algorithm which is presented. A hybrid analytic/numerical approach is applied to perform the guidance task. In the course of the ascent stage, the remaining trajectory is recalculated in a periodical basis, by considering the on-going flight conditions. In face of the non-uniformity of the thrust of the solidpropellant engine, the thrust is modeled as linearly varying either increasing, or decreasing, or else constant, over fixed small time segments. These time segments are set conveniently the same as the time intervals for consecutive trajectory recalculations. A local reference frame is set to refer the velocity components and the attitude angles. The frame is aligned to the local geocentric plane with inclination the same as the target orbit plane inclination. The yaw attitude program is analytically determined by using spherical trigonometry and constant rate of side-speedy decrease, till a null side-speedy at the end of the stage, when the flight plane is required to be already the target orbit plane. The pitch attitude program is established through a gradient-type iterative optimization method in order to achieve the required dynamic conditions at the end of the ascent stage. However, the numerical integrations of the gradient method are all performed with an integration time step the same as the above time segment for linearization and for trajectory recalculation. This innovative approach allows a very fast yet effective iterative process, with small data storage allocation, as compared to usual numerical integration methods for trajectory optimization. Assessment of the algorithm is carried out through simulation cases, with the guidance code set to run within a launcher flight simulator. Two launch missions are used, with diverse test cases running with variations on the target orbit requirements and on the actual performance of the ascent stage engine. The solutions achieved are suitable and close to those of an earlier algorithm using usual time step size for the numerical integrations; yet each trajectory recalculation executes much faster. The results show the good performance and reliability of the proposed guidance algorithm.