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ATMOSPHERE IMPACT ASSESSMENT ON THE TRAJECTORY CONTROL PROBLEM FOR A DESCENT MODULE RETURNING FROM THE MOON

Abstract

The current trends in the development of the world's cosmonautics include the resumption of manned flights to the Moon in the near future. When the landing module returns from the Moon, it enters the Earth's atmosphere with a near parabolic velocity, which causes substantial thermal and inertial loads. For aerodynamic vehicles, a descent with several dives can be used. Due to the correctly selected input parameters, the descent on the last dive will be close to that from a low Earth orbit, which has been successfully and repeatedly worked out in practice. Schemes with multiple dives provide more comfortable conditions for the crew and reduce the intensity of thermal and inertial loads, but the corresponding loads are longer. The atmospheric density and input parameters may differ significantly from the nominal values, which will lead to a deviation from the expected trajectory. In such conditions, it is important to have an efficient control algorithm capable of delivering the landing module to the vicinity of the specified landing point. At present, Soyuz-type vehicles use control principles based on tracking the deviations from the nominal trajectory. However, these control algorithms are not capable of qualitatively solving the problem of high precision delivery of a landing module to a given landing point when returning from the Moon due to disturbances from the thermodynamic parameters of the atmosphere. To build a fundamentally new control algorithm, it is necessary to analyze the possible density deviations from standard values. The paper assesses the effect of seasonal-latitudinal and random atmospheric density variations in multiple entry trajectory scenarios. In this study, we consider one possible option for constructing terminal control algorithm variants to ensure high-precision landing. The algorithm is much more computationally intensive than the applied software control algorithms. On the other hand, this algorithm provides better accuracy in delivering the vehicle to the landing point. In the report, we consider the possibility of using multiple dive descent schemes when returning from the Moon for vehicles with low aerodynamic quality. We analyze the effect of atmospheric density variation to the descent characteristics. One possible option for constructing a terminal control algorithm is presented, and its performance is analyzed by simulating the descent path in the Earth's atmosphere with due account of perturbations.