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MULTIPLE ENTRY TRAJECTORY SCENARIOS FOR RETURNING FROM THE MOON: ADVANTAGES AND DISADVANTAGES

Abstract

When a reentry module returns from the Moon, it enters the atmosphere with near-parabolic velocity, which results in considerable thermal and inertial loads not typical for descends from low-Earth orbits. The Earth atmosphere provides a natural method for decelerating an interplanetary module: after the first atmosphere transit the orbit is an ellipse, whose apogee rapidly decreases with successive entries in the atmosphere. For returns of a spherical capsule, there is a critical perigee altitude after which an object falls to the Earth without the second revolution. Moreover, trajectories are also possible for which it takes only a few revolutions for the orbit of the reentry module to degrade to an ellipse with apogee 200 km—this only insignificantly increases the transfer time from the Moon, but the descend conditions approach those of the well proven descend scheme from LEO. Modules with nonzero lift-to-drag ratio can skip out of the atmosphere depending on combination of the SC balancing angle of attack, its velocity, and the target apogee altitude. Here one can mention successful "Zond 6, 7, 8" projects of 1960s in which the reentry module approached the Earth with target perigee about 45 km and then used its aerodynamic features to increase its altitude to approximately 200 km and then to land in the Indian Ocean. In using multiple atmosphere entry scenarios one should find a compromise between the desire to rapidly decelerate the object and the wish to obtain a trajectory with smallest overloads. However, one should also take into account the thermal processes resulting from the interaction between the module surface and the atmosphere. So, in the ballistic capsule setting, the thermal loads with direct entry in the atmosphere exceed those for the entry from the second revolution with apogee 200 km, but they are not so lengthy. As a result, a two-entry scenario becomes more advantageous from the acceleration point of view, but on the opposite side under this approach the module requires stronger thermal protection. The report is concerned with possibilities of bouncing off from the atmosphere by "Soyuz" and "Apollo"-type modules. Parameters of orbits with specific incidence angles and target perigee altitudes are presented. Advantages and flaws of multiple atmosphere entry scenarios for returning from the Moon are analyzed in terms of thermal and inertial loads.