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Author: Mrs. Ekaterina Belyaeva
Rocket Space Corporation Energia, Russian Federation

Dr. Rafail Murtazin
Rocket Space Corporation Energia, Russian Federation

DEPLOYMENT OF LUNAR ORBITAL STATION IN HIGH CIRCULAR ORBIT: ALTERNATIVE TO NRHO

Abstract

Currently, the issue of sending humans to a lunar orbit and landing on the surface is being considered. At present, the polar lunar orbits have a particular interest because scientists have discovered large reserves of water in the form of ice at the South Pole of the Moon. One of the main ways to deliver a crew to the Moon is a direct flight to a low lunar orbit, similar to the Apollo program. In this approach, delta-v cost required to form a near-lunar orbit with an altitude of 200 km would be about 900 m/s. NASA proposes the Deep Space Gateway concept: deploying a lunar orbital station in a Near-Rectilinear Halo Orbit (NRHO) that would be used as a Spaceport for deep-space missions. One of the main advantages of NRHO is the minimum delta-v cost for its formation: about 450-480 m/s, depending on the inclination of the near-Earth departure orbit. As an alternative idea of the Spaceport, it is proposed to deploy the orbital station in a circular polar High Lunar Orbit (HLO) with an altitude of 10,000 km. The advantages of HLO in comparison with NRHO are the long-term orbit stability and better capabilities for contingency return to the Earth. The delta-v cost for the direct insertion into this orbit will be about 700 m/s. This paper proposes a bi-elliptical transfer to HLO using an intermediate orbit with an apoapsis in the vicinity of the Moon's gravispheric boundary. Calculations show that the "gravispheric" method allows reaching HLO with lower delta-v costs, if compared with the direct HLO transfer or NRHO insertion, and requires about 335 m/s. The performed analysis of boundary conditions showed the application area of the "gravispheric" method. This method is effective for polar lunar orbits with an altitude higher than 4,000 km. At the same time, the formation of the considered polar HLO with an altitude of 10,000 km is impossible for some inclinations of the near-Earth departure orbit. The paper describes a transportation system to deliver the crew to the South Pole of the Moon with the use of the "gravispheric" transfer to the Lunar orbital station in HLO.