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ESTIMATION OF THE SPACE TRANSPORTATION SYSTEM'S PERFECTION REQUIRED FOR THE MANNED MISSION TO MARS

Abstract

At the 61th International Astronautical Congress (2010), we presented the analysis of the manned Mars mission with 1,000 days duration. We showed that due to such a large duration we can realize the manned mission to Mars with a relatively small mass of the orbital complex and small capacity of the nuclear power plant. In this paper we analyzed the dependence of the maximum allowable specific mass of electric power and propulsion systems on two characteristics: a) the mass of the manned spacecraft on the radiation-safe orbit mo; b) time of the mission T (ranging from 1.5 to 3 years). The unregulated electric propulsion is considered. Its thrust and specific impulse (in the range of 5000...9000 s) are optimized. These characteristics determine the electrical power of the nuclear power plant. Some mass characteristics are fixed. The research algorithm includes the following stages: • Optimization of the spacecraft trajectory to Mars with return to the Earth is carried out by the criterion of the minimum fuel required. The end-to-end optimization is performed with the use of the maximum principle which reduces the problem to the three-point boundary value problem for an arbitrary set of mo, T, thrust and specific impulse of electric propulsion; • The parametric optimization of electric propulsion characteristics (thrust and specific impulse) for an arbitrary set mo and T is carried out by the criterion of the maximum specific mass of electric power and propulsion systems; • The analysis of the dependence of the maximum permissible specific mass of electric power and propulsion systems on mo and T is conducted. In particular, the analysis has shown that if the specific mass of electric power and propulsion systems could be reduced to 5 kg/kW, the manned Mars mission with 1.5 years duration can be realized by the spacecraft with mo=366.1 tons on the radiation-safe orbit. In this case, the thrust and the specific impulse of electric propulsion are equal to 400 N and 7800 s respectively; the output electric power is equal to 19.153 MW. Increasing the duration of the mission up to 2 years can significantly reduce the initial mass of the spacecraft to mo=231.15 tons. In this case, the optimal thrust and specific impulse of electric propulsion are equal to 146 N and 9000 s respectively. The required output electric power plant is reduced to 8.084 MW to become more than twice smaller.