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MISSION DESIGN AND THE LANDING PLANNING FOR THE "VENERA-D" INTERNATIONAL PROJECT

Abstract

The international "Venera-D" project for the Venus studying is the next step after the successful Russian missions of the series Venera and VeGa in 1970-1980. It's planned to implement after 2024 by dint of the Russian automatic interplanetary station of Venusian series. The project "Venera-D" should provide a new level of researches by simultaneously examining Venusian natural phenomena from orbiters and Venusian surface. Unlike forerunners the landing module "Venera-D" will not execute the landing blindly, but in a terrain with a known geological context, using a radar measurement of "Venera-15,16" and "Magellan" probes. The interpretation of learned terrain types allows to choice concrete surface regions for the "Venera-D" landing. In this paper mission design of flights to Venus in 2021-2036 epoch is developing. The 2024-launch window requires the minimum Delta-V-budget, while the 2028-launch window requires the maximum Delta-V 8.11 km/s. Total characteristic velocity isolines (Porkchop plots) for all launch dates are presented on a refined scale. They are constructed interactively using the software package BalCalc developed in the KIAM Ballistic Center. The probable early launch window for the Venera-D project is 2026/05/13-2026/07/08. The velocity isolines for the all launch windows 2029-2036 are calculated. To overcome the difficulty due to large Delta-V budget, Venusian missions can be planned once in eight years or more energy efficient ballistic schemes can be used. "Venera-D"-reachability regions on the Venusian surface were mapped depending on the coordinates and the entry angle of the descent module into the Venusian atmosphere. Different surface points can be reached by varying the spacecraft orbit inclination. The reachability regions evolve with time. The initial data for finding the reachability regions on the Venusian surface are the departure date, starting asymptotic velocity, transfer orbit inclination, and the arrival hyperbola' pericenter altitude. For the given orbit inclination, the coordinates are used to solve the corresponding boundary value problem for ensuring the prescribed atmosphere entry angle. As the calculation result the launch time is refined, and the coordinates that unambiguously correspond to the given entry angle are found. Varying the orbit inclination, we can obtain the reachability stripe on the Venusian surface with launch date parameterization. Thus, we'll find the reachability region for landing on Venus without an intermediate Venusian satellite using. For the optimal launch windows in the 2022-2036 epoch, the reachability regions are presented in case of flyby through the northern hemisphere (for the southern hemisphere, the configuration is symmetric).