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Author: Mr. Luigi Mascolo
Polytechnic of Turin, Italy

Mr. Gianluca Benedetti
Politecnico di Torino, Italy
Mr. Erik Garofalo
Politecnico di Torino, Italy
Mr. Francesco Marino
Politecnico di Torino, Italy
Mr. Dario Riccobono
Politecnico di Torino, Italy

PRELIMINARY ANALYSIS AND DESIGN FOR AN END-TO-END MARS FLYBY MANNED MISSION

Abstract

The purpose of this preliminary investigation is to analyse an end-to-end two-person Mars flyby mission.

The main weakness of previous studies seemed to be an inadequate technology readiness level (TLR) compared to the chosen launch window, which would have required an excessive technology development, launch capacity and schedule demands for the mission.

The development of a feasible mission that could be launched between 2020 and 2024 has been, therefore, the guide line for the study in order to reach a proper TRL and, at the same time, a concrete humans to Mars program underway. On the other hand, equal importance has been given to finding the best trade-off among cost, safety and operational simplicity.

The technological advantages, gained from the postponement of the launch date to the 2022, contrast with a greater characteristic energy (C3) required to reach Mars. Nevertheless, through a Venus flyby there were simultaneously optimised two usually conflicting parameters, which are the mission Time-Of-Flight (TOF) and the total ΔV required.

An iterative design process which involved both the trajectory optimisation and the characterisation of the other parts of the mission has been conducted. In particular, concerning the flight systems (TCS, ECLSS, radiation protections, and others), has been adopted a multipurpose approach in order to optimise and integrate the exploitation of resources. Practical solutions concern, for example, a partially regenerative ecosystem-based life support system and the development of unconventional methods and components to improve the effectiveness of the radiation shield without having to use specialised components with no other purposes.

In terms of mission TOF, disposable ΔV and life support for the crew, the best result achieved resulted in an end-to-end mission of 582 days with a total $\Delta V = 6.88$ km/s for a re-entry in February 2024.

As part of a possible long-term deep space exploration plan, the return trajectory has been chosen so that it would be possible to obtain a simple and advantageous rendezvous with the ISS. In this way, in order to achieve an as high as possible reusability level, every component with a long term operational life is docked to the ISS for a fruitful future use.

A mission of this kind represents a unique springboard to merge science, technology and human achievements, not only to pave the way to the Red Planet, but also for the human deep space exploration.