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DESIGNING LIGHT MARS ASCENT VEHICLES

Abstract

The design of a Mars ascent vehicle (MAV) has been addressed in numerous studies. Complex tradeoffs have to be considered among the parameters, such as the number of astronauts, the possible dual use (landing and ascent or only ascent), the living volume and the selection of life support systems, which can be designed for a few days in order to join a bigger vehicle or for the entire return trip, the possible refueling of propellant using ISRU, and finally one or two stages for propulsion systems. Many options depend on the chosen mission architecture. However, considering NASA reference mission, the landing vehicle transporting the MAV is so heavy that the complexity and cost of the architecture become redhibitoire. A detailed analysis of the different options is therefore needed to structure the architecture, and not the other way round. According to our analysis, a key problem is to design a light Mars ascent vehicle. If it is light enough, it can indeed be sent directly to the surface of Mars without requiring a complex LEO assembly and the use of complex entry, descent and landing systems. It is shown that the number of astronauts has an important impact on the mass and complexity of the MAV. For instance, for a crew of six, it is simpler and more cost effective to send two small 3-astronauts-MAV to the surface rather than one big 6-astronauts-MAV. Another important result is that several interesting design options allowing important mass savings have never been explored. Provided that the duration of the return to Mars orbit and junction with the return vehicle is not too long, life support systems can indeed be significantly simplified. In addition, going back to the surface might be a strategical abort strategy, improving safety and allowing light life support systems at the same time.