Association Planète Mars
French chapter of The Mars Society
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A RATIONALIZED APPROACH TO AN AFFORDABLE MANNED MARS PROGRAM

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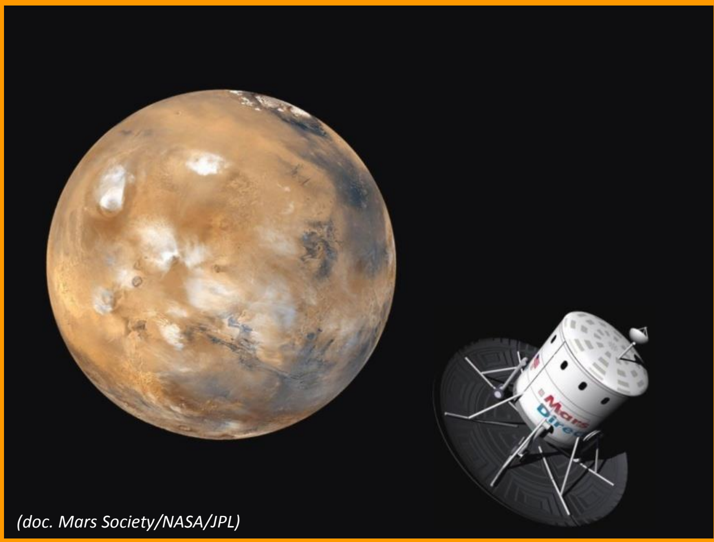

(doc. Mars Society/NASA/JPL)

This document is intended to raise concerns and propose recommendations about the implementation of a manned Mars exploration program in a near future, at low risks and sustainable costs. It has been written by a team of scientists and engineers from Association Planète Mars, the French chapter of The Mars Society.

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Because of its inestimable potential of discoveries in geology, climatology, comparative planetology and because of the possibility of an extant or extinct indigenous life there, Mars has become a particularly attractive objective for science. Furthermore, because the exploration of the unknown has always brought forceful technological and societal advances, for example in the domains of robotics, energy, smart building, environment control, access to space... it is of vital importance to pave the way to deep space.

Wrong beliefs that do a disservice to the Martian project

- The NASA DRA5 reference mission describes the best realistic scenario.
- A human mission to Mars will cost in the order of 500 billion dollars.
- The only way to reduce the Initial Mass in Low Earth Orbit (IMLEO) in a significant way is to develop nuclear propulsion

Some keys to a forbidding design and to a successful one

- In this same DRA5 reference mission, the cost drivers are:
    - -the very high IMLEO accepted and the complexity of LEO operations;
    - -the Nuclear Thermal Propulsion (NTP) development (and recurrent) costs;
    - -the proposed innovative Entry Descent Landing (EDL) systems development.
- In that project, the probability of mission failure is tightly linked to:
    - -the large number of launches (7 Heavy Lift Vehicles (HLV) + crew launcher) and of LEO rendezvous to assemble the 3 huge interplanetary vehicles;
    - -the choice of unproven EDL technologies, imposed by the large landers masses considered.
- Aerocapture at Mars (not possible for all the vehicles in the DRA5, due to the NTP choice) allows important mass savings.
- The size of the crew should be considered as an affordability variable. Six is appropriate for skills completeness, but three should allow a productive mission, while reducing significantly the IMLEO, hence the recurrent costs.
- The flight proven capsule shape for entry vehicles, rather than a lifting body, offers the best TRL (Technology Readiness Level) for aerocapture and EDL.
- Reducing the crew size eases the habitable module EDL, as size and mass are reduced accordingly.

RECOMMENDATIONS

1 - Select Aerocapture and forget NTP

In the DRA5 reference mission, aerocapture could not be proposed for the manned interplanetary transfer vehicle because of the bulky NTP hydrogen tanks volume. The performance loss resulting from the more conservative chemical propulsion option is largely balanced by the aerocapture mass savings. In the same time, the specific development cost of the NTP, as well as the problem of its public acceptance are avoided.

2 - Adapt crew size for affordability

In the DRA5 reference mission, a crew of six is proposed. If a crew of three is chosen, the mass gain is around 20 % for the consumables and life support systems, which leads to an IMLEO saving of about 300 tons for the chemical propulsion option! But the gains are even much more if we consider that:

- it is then possible to send the space vehicles directly to Mars, without the need for LEO rendezvous and vehicle preparation;
- the mass of the landing vehicles will be highly reduced (smaller heat shields, less propellant, smaller engines).

3 - Land limited size vehicles on Mars

Landing heavy payloads on Mars requires new low-TRL EDL systems which will have to be developed, tested and qualified in the Martian atmosphere. If space vehicles with a capsule shape and rigid 70° sphere cone heat shields are chosen, costs and development risks will be greatly reduced.

It is true that this design has been test-proven on Mars only up to 0.9 tons. But it is possible to improve and scale-up the technology, without the need of truly innovative devices. A heat shield diameter of 10 m, or even 12 with deployable flaps, fits in the HLV; chutes diameter still can be increased, and/or their number augmented. All in all, an entry mass of 30 tons is probably acceptable. But should this limit be less, the payload could be accordingly fitted (number of crew, science equipment complement…). It is also possible to have two smaller landers, one manned and the other one unmanned.

4 -Focus on an optimized roadmap

Two dedicated preparatory missions, no more:

- ***An unmanned full scale spacecraft landing mission***, serving a dual purpose:

  -EDL systems testing and qualification in actual conditions,

  -while also hosting a heavy **Mars Sample Return mission** equipment, thus leading to a high priority scientific achievement in a very attractive dual mode.

In addition, this mission could offer the opportunity to test Aerocapture and In Situ Propellant Production, thus becoming the key preparatory mission.

- ***A manned High Earth Orbit (HEO) mission***:

  Before sending humans to Mars, it is important to qualify the habitable modules, the zero-gravity countermeasures (artificial gravity?), and the radiations shielding, etc. during an extended period of time. HEO would be the right place to perform all the experiments with the rotation of several crews during at least 3 years.

A rationalized roadmap should prioritize the development and qualification of the required equipment, with the most demanding first. This is much more efficient and cost-effective than choosing intermediate missions, which consume limited resources and are not so useful to the actual goal of the exploration effort.

5 -Final recommendation

Considering the above recommendations, experts should be asked to redesign a reference mission with ***affordability*** – the top-level condition to political acceptability – taken as the overarching criterion.