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Mobility on Mars surface: an essential aspect of human Mars exploration

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On the surface of Mars, the astronauts must have at their disposal means for exploring a suitable area of the planet. A ground vehicle was tested for the first time outside Earth during the Apollo program, but the longer stay and the wider extent of the exploration will make similar vehicles designed for Mars larger, faster and more complex. Transportation on the planet will require, possibly in later missions, also aerial vehicles and finally the realization of a whole transportation infrastructure. Also robotic rovers will be required to assist the astronauts in their exploration duties.

In designing transportation devices for the astronauts on Mars, the first point is to decide what are the goals and the extent of the exploration mission, because the mobility needs depend strictly on them.

The first consideration is that the landing zone must be located in a place where landing is easy and safe enough. Since these places are, generally speaking, not those of greater interests to scientists, exploration travels need to be performed at distances from the landing area which may be large. For instance, Valles Marineris and similar deep canyons are potentially very interesting for science, but it is very difficult to land somewhere close to them and, moreover, also difficult to reach them by travelling on the ground. If the surface

of Mars is subdivided into a zone where humans may enter and a zone which can be explored only by robots, the latter must be given the required mobility.

Clearly the type of mission influences the type of land mobility required: a short stay mission cannot include long range exploration travel for the simple reason that there cannot be enough time. On the contrary, in a long stay mission the explorers have all the time required to include in their journeys a large area of the planet.

In spite of the fact that ground vehicles may be supported and propelled by

- wheels,
- tracks,
- legs,
- snakelike, or apodal, devices and
- other means of locomotion, often referred to as unconventional,

at present the exploration of Mars is performed by using robotic rovers which rely on wheels for going around on the planetary surface.

Other types of land locomotion devices have been several times proposed, but never tried in actual missions, with the exception of the earliest rovers sent on Mars in 1971 on the Russian Mars 2 and 3 probes, which used a sort of skis. Their intended range was about 15 meters from the lander, but Mars 2 crash-landed on the planet and Mars 3 ceased transmissions 20 seconds after landing so the rovers could not be tested.

Vehicles moving in Mars atmosphere may be supported by aerostatic or aerodynamic forces. Also here there are other alternatives like jet sustentation.

Finally, hoppers taking off under rocket propulsion, performing a parabolic flight and then landing braked by the same rocket used to take off or parachutes can be used on Mars.

Hoppers propelled by springs or electromagnetic actuators have also been proposed, but they are likely to be suited more in case of very low gravity bodies than of Mars. Other possibilities like electromagnetic propulsion have been proposed but seldom studied in details.

The various alternatives in the design of robotic (either autonomous and teleoperated) and human carrying rovers are designed in some detail with particular emphasis to human carrying wheeled rovers.