International Journal of Machine Design and Manufacturing
Vol. 1: Issue 1
www.journalspub.com

# A Brief Note on Rover Design

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## INTRODUCTION

Traditionally, the space exploration is accustomed to the use of orbiting spacecraft for the fact that, it is efficient in taking humans with the much needed amenities in bulk to other space environs.

However, their design prospects limit the capability to do more exhaustive tasks on erratic planetary surfaces along with making insightful and distinctive observations.

An urge to optimize accountability on planetary research was realized and a novel design of space exploration vehicle known as surface rover spacecraft was proposed which not only maneuver across the wide surface area of a planet as well as other celestial bodies but persuade many important tasks that seemed to be as forlorn as might expected to be.

A rover is a well-equipped vehicle having wheels with some kind of lateral propulsion i.e. powered wheels.

The wheels help the rover to move across the unusual terrestrial surface except on the surface of sun or gas planets, in spite of the difficulty to operate in extremely low gravity surface such as of moon and other planetary bodies.

Rover spacecraft composes of a Solar-powered electrical system in the form of solar panels, an autonomous command module and wheelers. Figure 1 shows Mars Pathfinder spacecraft that includes rover as a small mobile instrument to be deployed on Mars. [1–3]

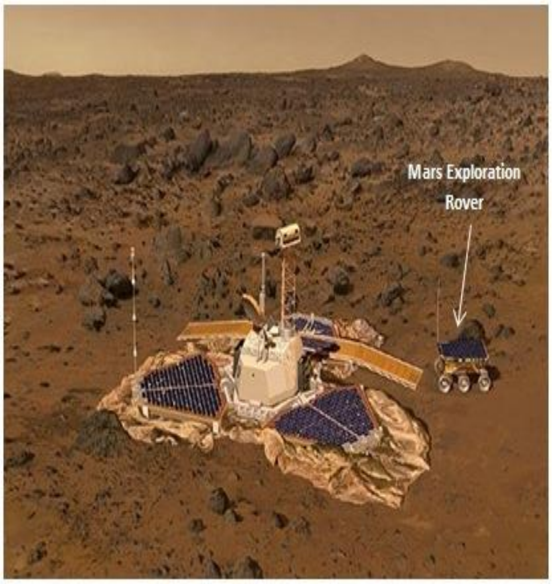


***Fig. 1.*** *Mars Pathfinder Spacecraft. Source: http://pics-about-space.com/pathfinder-mars-probe?p=4#img12328159915946181149.*

Although, rovers used for Mars Exploration usually invoke same principle as that of landed spacecraft, for landing and taking off, they possess high mobility and are capable to make detailed observation to wider planetary surface area, to take samples for laboratory examination such as dust, rocks and other substances as well as to even take pictures.

Figure 2 illustrates well-labelled Mars Pathfinder Rover with all its structural and operational components.

In the present paper, we are leaving the technical aspect of the rover operation and concentrating on its physical design.

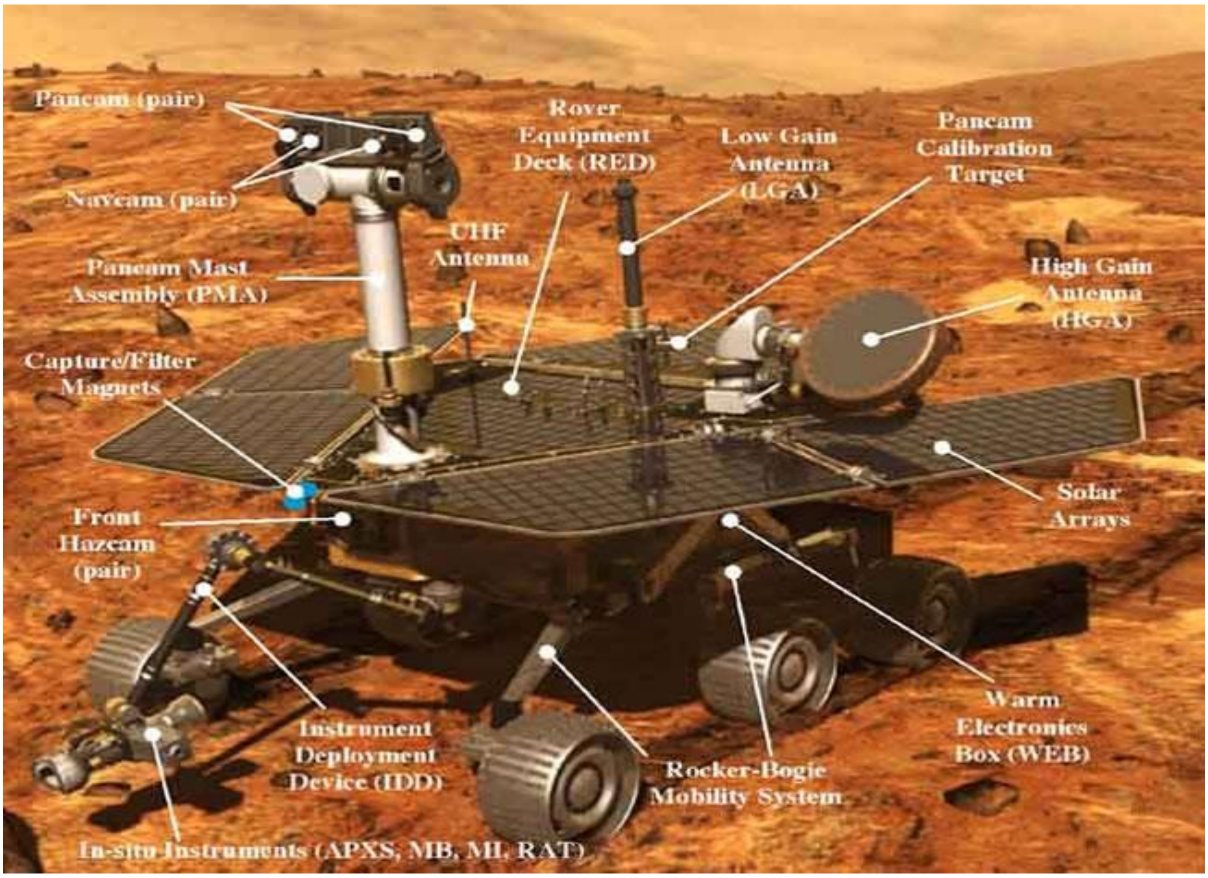


***Fig. 2.*** *Mars Pathfinder Rover.*
*Source: http://astro.hopkinsschools.org/course_documents/solar_system/innerplanets/mars/rover_detail_large.jpg.*

There have been several other rovers developed for Mars exploration by Russian Space Agency and they are semi-autonomous as well as steerable from Earth, useful in taking images and soil analysis for telemetering back to Earth. [1]

## ROVER DESIGN ANALYSIS

Rover design influences majorly on its efficiency to perform at erratic planetary surfaces. Despite of its substantial qualities in making a planetary research mission successful, risks are realized in its performance, mostly during landing as well as due to its current mobility designs that can make its movement complicated using many wheels or legs. It is likely to open to mechanical failures caused by unfavorable environmental conditions on a planet. Other complications may involve technical system issues.

### Basic Dimensions of a Rover

Length: 9 feet, 10 inches (3.0 meters) (not counting arm);
Width: 9 feet, 1 inch (2.8 meters);
Height at top of mast: 7 feet (2.1 meters);
Arm length: 7 feet (2.1 meters);
Wheel diameter: 20 inches (0.5 meter)

### Categories in Rover Design

Rover design is modified into several categories, according to the missions that they are intended to fly - some in view of avoiding giant stationary spacecraft look but still accommodating spaceflight crew members, others are designed into partially or fully self-governing robot. Rover is also designed based on the number of wheelers attached to it. Some rover vehicles may have four wheelers or six wheelers.[9]

  

Roman *et al.* [2] discussed in his paper about the design of a four-wheeled rover and its reliability to operate on rough and uneven planetary terrain. He mentioned that, a rover is considered to have a high degree of mobility in natural terrain if it can surmount obstacles that are large in comparison to the size of its wheels. A rover must have enough traction from its rear wheels to push the front wheels against an obstacle with enough force so that they can climb up it. Typically a four wheeled rover cannot climb obstacles larger than a wheel radius because the rear wheels do not have enough traction. Without traction the wheels will slip and there will not be enough forward thrust to keep the front wheels in contact with the obstacle. [2]

The rocker bogie suspension can surmount obstacles head on that are larger than a wheel diameter because it uses an extra set of wheels to provide more forward thrust. The extra wheels also reduces the normal force on each wheel by about 1/6 the weight of the rover. Less forward thrust is required because the front wheels only have to lift 11 1/3 of the weight of the rover. Together the rear four wheels have enough traction to keep the rover from slipping. [2]

(a) (b)

***Fig. 3.*** *Link Style Mobility Systems, (a) Pantograph (b) Rocker-Bogie.*
*Source: http://c3p0.ou.edu/IRL/Theses/Roman-MS.pdf (images reproduced from NASA).*

Figure 3(a) and (b) show the two different types of mobility systems in 6 wheeler rover design. Both deliver distinct mobility styles and functionalities.

Non-wheeler approach is also applied in other rover construction especially for surface exploration of low gravity celestial bodies. Their mechanism however utilizes walking on robotic legs, hopping, rolling etc. Stanford researchers are able to develop one of a non-wheeler rover named as 'Hedgehog', as shown in Figure 4. It is a cube-shaped planetary robot. It can perform important movements such as to controllably hop and even spin out of a sandy sinkhole for escaping. [4–8]

***Fig. 4.*** *Hedgehog-Non-Wheeler Rover.*

 

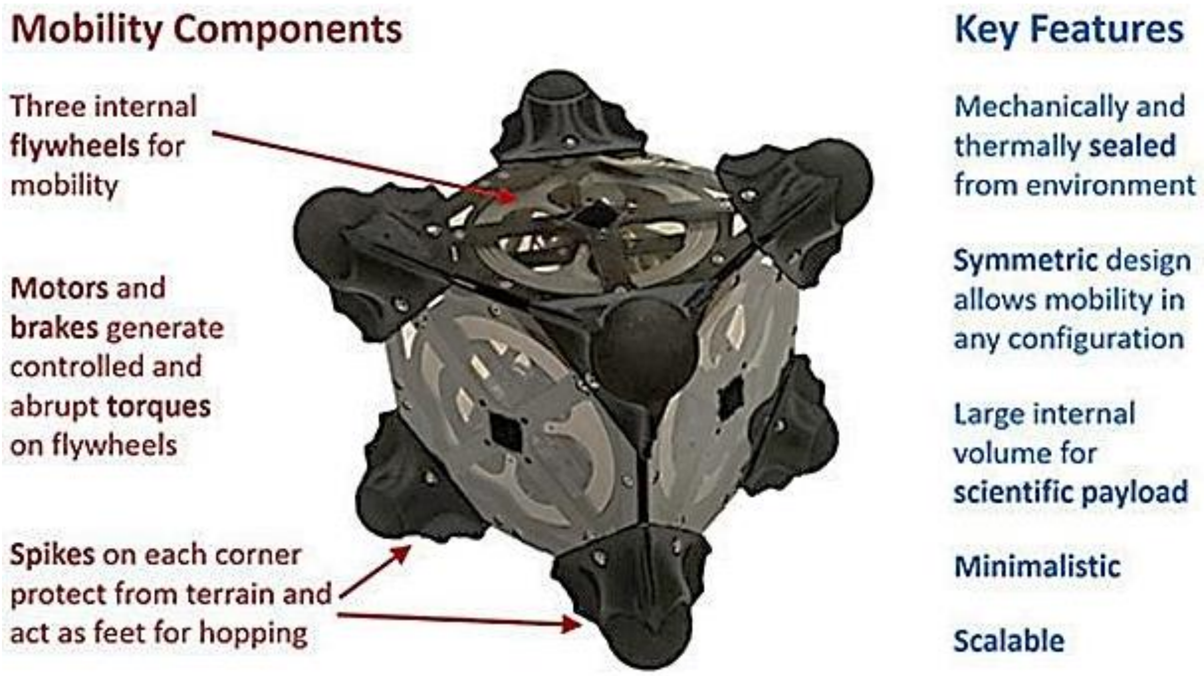


***Fig. 5.*** *Structural Features of Hedgehog Non-Wheeler Rover.*
*Source: http://thenewstack.io/wp-content/uploads/2015/09/hedgehog-robot-1.jpg.*

Figure 5 illustrates the mobility features and key components of a Non-wheeler Rover used for planetary exploration missions.

**Design Parameters**

As compared to Earth, other planetary bodies may have very distinctive environmental conditions which ensure some demands on rover design. The parameters considered for rover design and development for safe and successful operation on planetary rover mission are discussed below:

**Reliability:** It is an important parameter to be considered during the construction stage, as a rover need to withstand high levels of acceleration, varying temperatures, pressure, dust, corrosion, cosmic rays thereby remaining functional without repair for a needed period of time.

**Compactness:** Rovers are designed as small mobile instruments which can be easily packed and can be placed in a spacecraft because they have limited capacity and are needed to be deployed safely on other planetary surfaces. They can be deployed in other way, by being attached to a spacecraft and so the devices are installed, for removing these connections.

**Autonomy:** Rovers which land on celestial bodies far from the Earth, such as the Mars Exploration Rovers, cannot be remotely controlled in real-time since the speed at which radio signals travel is far too slow for real time or near-real time communication. For example, sending a signal from Mars to Earth takes between 3 and 21 minutes. These rovers are thus capable of operating autonomously with little assistance from ground control as far as navigation and data acquisition are concerned, although they still require human input for identifying promising targets in the distance to which to drive, and determining how to position itself to maximize solar energy. Giving a rover some rudimentary visual identification capabilities to make simple distinctions can allow engineers to speed up the reconnaissance. [9]

## DESIGN MODIFICATIONS

Roman *et al.* [2] expressed an important limiting factor of the rover mobility design such as that of SR-II, which comes from the lack of wheel traction when climbing obstacles. He hypothesized a more compliant wheel design that would be advantageous in many ways.

It would reduce the impact forces on the suspension caused when driving off obstacles.

Also, a wheel that would provide more tractive force than the current design could bring the mobility characteristics of SR-II up to the level of the rocker bogie. A more detailed analysis of the angled approach toward an obstacle needs to be done in order to better define the physical limits of SR-II.

A possible 95 increase in mobility may come from modifying the control system behaviors while traversing an obstacle. Traction forces may be maximized if the control system is designed to reduce the amount of wheel skidding. [2]

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