A Quick Look at a Mars Rover Design and the Drive System Requirements

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The mobility of a planetary surface rover should generally increase with the number of degrees of freedom and size of the vehicle, at least as far as ground clearance, vertical step and crevasse crossing are concerned. Vehicle mobility, power and interplanetary transportability together place realistic constraints on the rover design. The following general specifications are intended to facilitate more specific research into rover drive motors and control techniques.

Recent research [4,6] has suggested that a realistic Martian robot rover might comprise a two or three segment articulated frame that rides on parallel pairs of wheels, providing support for power, navigation, communication, computation, tool, cargo and analysis systems. More specifically, this rover would be about 4m long and 2m wide. It would ride on six, 1m diameter wheels and have a total mass of about 1000kg. It is generally expected that a vehicle can overcome obstacles up to a size similar to itself. The above vehicle design does indeed follow this basic rule [4,6], and should allow the rover to climb 1m vertical steps, cross 1m or greater crevasses and clear obstacles less than 0.5m in height.

There are a few other performance specifications, stated in the literature, which may be of particular significance to the analysis of the drive system: The rover should be capable of maintaining a nominal speed of about 10 cm/s [1,4,6] on what will likely be loose sand or otherwise rugged terrain [4,6]. This speed is constrained on the upper side by navigation and power limitations and on the lower side by exploration expectations. The rover should also be capable of climbing a 60% grade [4,14], perhaps at significantly reduced speed. The drive power will generally be limited by current technology, which includes generation by direct solar-electric conversion or use of a Radioisotope Thermoelectric Generator (RTG) [4,6,12,13]. Either or both of these technologies may be used in combination with an energy storage system. Nominal power expectations range from 50W to 1000W [12,13], depending on the rover size and the technology used, and might be expected to peak by a factor of 4.5, remaining at this level for up to 30 seconds [12]. The above rover design is based on current RTG technology [4,6], which should provide from 250W to 500W of continuous electric power [6]. It is assumed that the drive system will consist of electro-mechanical actuators, which will be the primary consumers of power when the rover is in motion.

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[4] L.S. McTamaney, B.D. Douglas and S.Y. Harmon, "Mars Rover Concept Development", *Mobile Robots III*, Proc. SPIE, vol. 1007, pp. 85-94, 1989.

[6] B.H. Wilcox, D.B Gennery and A.H. Mishkin, "Mars Rover Local Navigation and Hazard Avoidance", *Mobile Robots III*, Proc. SPIE, vol. 1007, pp. 72-6, 1989.

[12] P.M. O'Donnell et al., "Energy Storage Considerations for a Robotic Mars Surface Sampler", *23rd Intersociety Energy Conversion Engineering Conference*, vol. 2, pp. 385-9, 1988.

[13] A. Chmielewski, "RTG's for Space Exploration at the End of the 20th Century", *24th Intersociety Energy Conversion Engineering Conference*", vol. 2, pp. 715-20, 1989.

[14] J. Bares, M. Herbert, T. Kanade, E. Krotkov, T. Mitchell, R. Simmons and W. Whittaker, "Ambler: An Autonomous Rover for Planetary Exploration", *Computer*, pp. 18-26, June, 1989.

Rover Specifications for Drive Motor Selection

Length:	4 m
Width:	2 m
Mass:	1000 kg
Wheel (6) diameter:	1 m
Nominal speed:	10 cm/s
Acceleration:	~ 10 cm/s^2
Maximum grade:	60% (~31°)
Total drive power:	250 - 500 W
Martian Gravity:	3.7 m/s^2

Max. Climbing Force: $F = (1000)(3.7) \sin 30° = 1850$ N

Max. Single Wheel Torque: $T = (1850)(0.5) / 6 = 154$ N·m

Max. Total Power: $P = (1850)(0.1) = 185$ Watts

Note: Motor, transmission and traction losses have not been considered.