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Author: Prof. Giulio Avanzini
Università del Salento, Italy

Dr. Emanuele Luigi de Angelis
Alma Mater Studiorum - University of Bologna, Italy
Dr. Fabrizio Giulietti
Alma Mater Studiorum - University of Bologna, Italy

# PERFORMANCE ANALYSIS AND SIZING GUIDELINES OF ELECTRICALLY POWERED EXTRATERRESTRIAL ROVERS

**Abstract**

In recent years, a number of missions have been planned and conducted on planets such as Mars, which involve the use of robotic ground vehicles. Rovers are typically used to explore planets, scout natural resources, conduct scientific observations, carry out a variety of simple construction tasks, and analyse samples of the planet soil. For extraterrestrial missions, power is at a premium, and for a planetary rover mission, energy-efficient locomotion is critical. Mars Exploration Rovers like Spirit, Opportunity, and Phoenix, used solar power. When fully illuminated, the rover solar arrays generate about 140 watts of power for up to four hours per sol, provided that the rover needs about 100 watts to drive. The power system for the Mars Exploration Rover includes two rechargeable batteries that provide energy for the rover when the Sun is not shining, during the Martian night. Clearly, an accurate energy balance between energy generated by the panels, stored in the batteries, and used for motion and systems is crucial for maximizing the scientific return of the mission.

The objective of this paper is to offer some quantitative guidelines for optimizing vehicle performance within available battery capacity and solar panel power generation, thus providing useful data for rover designers and scientific mission planners. More in details, the paper describes an analytical and experimental framework for investigating performance of electrically-driven ground vehicles powered by battery packs, providing simple indications for preliminary sizing of vehicle battery pack and solar panel array.

Starting from the analysis of power requirement at an approximately constant speed, a recent battery-discharge model, valid for constant-power discharge processes, is used for the first time in this framework to derive a closed-form expression for cruise range, including the effects of different ground scenarios and battery charge process. The proposed approach, which also allows to determine the best range speed conditions, is demonstrated by means of numerical simulation for a relevant Martian environment. Optimal cruise results are validated by an experimental campaign, with application to a wheeled ground-based rover platform.