Small Wheeled Rovers for Unmanned Lunar Surface Missions

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Other than on the Earth, unmanned mobile vehicles have so far been successfully operated on the Moon and on Mars. Early US studies on unmanned, 60 kg-class lunar surface rovers in the framework of the Lunar Surveyor program in the mid 1960's were abandoned for schedule and cost reasons, and the Soviet Union finally succeeded in operating the first of two teleoperated LUNOKHOD rovers on the Moon in late 1970, less than a year before the APOLLO 15 crew utilized the first of the manned, 4-wheeled US Lunar Roving Vehicles (LRV).

The 8-wheeled LUNOKHOD was quite large and had a mass of some 800 kg. Just like the LRV, it was clearly optimized to cover distances of several 10's of km on rather benign Mare terrain, albeit at a slower cruise speed than the LRV. Up to now, no other unmanned rovers have been delivered to the lunar surface.

The first unmanned roving vehicle to be successfully operated on Mars has been the 6-wheeled SOJOURNER rover of the US PATHFINDER lander mission in 1997. Having been a derivative of studies for a long-range rover suitable for rocky Martian terrains, SOJOURNER was optimized for negotiation of surface rocks due to its sophisticated "Rocker-Bogie" chassis with passive suspension. It was nevertheless quite small with a mass of some 10 kg. Whereas its mobility system was capable of traversing up to several 100 m of distance in a reasonable amount of time, it was only driven out to about 12 m range from the lander, but indeed covered some 100 m of cumulated driving path over a time span of some 70 days. Future NASA Mars rovers are currently under development with masses of around 60 kg and which will support the collection of samples.

In the present paper, besides giving the historical perspective, European development efforts for small wheeled mobile devices applicable to unmanned planetary missions are being reviewed in light of their potential use on the lunar surface. These developments include the preparation of design schemes which can reliably predict the locomotion performance of small vehicles for a given terrain and gravity level. Corresponding wheel drive mechanisms and small wheels themselves have subsequently been developed, tested and integrated into a chassis for a 4 kg-class, short range device which utilizes a novel ground clearance control system for facilitating scientific measurements, for reducing stowage volume and for implementing a self-righting capability in case of roll-overs in rocky terrain and on severe slopes. These same mechanism technologies and wheel designs (elastic wheels vs. rigid wheels, various grouser implementations and different types of running surfaces) can equally be employed for longer range, small size roving vehicles as could be attractive for regional exploration of lunar terrain up to ranges of at least several 100 m. A corresponding vehicle had been preliminarily defined in the context of previous lunar landing mission studies conducted in Europe.

ICEUM4, 10-15 July 2000, ESTEC, Noordwijk, The Netherlands