Investigation of Robotic Vehicle Locomotion Concepts for Unmanned Lunar Missions

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Abstract. The Moon is an attractive destination for future space exploration activities due to wide-spread speculation of presence of polar-ice in lunar craters and volatiles in lunar regolith. True confirmation could be provided only by the proximity and scale provided by instruments on the lunar surface, and therefore, robotic vehicles are necessary to perform autonomous science experiments. Different concepts of robotic vehicles such as wheeled rovers, tracked rovers, legged walkers, and hybrid vehicles have been developed. Further, wheeled vehicles can vary depending on the number of wheels such as four-, five-, six-, and eight-wheeled rovers. A suitable locomotion concept should be selected based on the terrain of operation and mission objectives to be accomplished by the vehicle. A few of the wheeled concepts and related description are listed in Table 1.

<table>
<thead>
<tr>
<th>Locomotion concept</th>
<th>Locomotion chassis sketch</th>
<th>Description</th>
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</table>
| CRAB – II concept  | ![CRAB - II concept](image) | 6 motorized wheels  
4 parallel bogies  
1 differential drive  
4 steering |
| PEGASUS concept    | ![PEGASUS concept](image) | 4 motorized wheel  
Fifth wheel connected by link and freely movable;  
Passive rotary joint |
| Rocker-Bogie concept | ![Rocker-Bogie concept](image) | 6 motorized wheels  
4 rocker bogies  
1 differential drive  
4 steering |

An assessment of different locomotion concepts for operation on a lunar terrain has been completed. The lunar terrain is not uniform, as it is “sandy” on the plains and “rocky” near the crater rims. No terrain data related to nature of inside lunar crater surface is available. Hence the rover has to be able to operate in a wide range of terrain. Each locomotion concept possesses various merits and demerits that are considered for this assessment. Grading of several qualitative and quantitative parameters
such as speed of operation, range, stability, obstacle traverse capability, slope climb capability, flat, solid, and soft terrain capability, power consumption rates, mechanical simplicity, level of redundancy, lunar soil resilience, technology readiness levels and other related parameters is provided. The grades for locomotion parameters are based on experimental and simulation results. This paper thus helps in providing an insight into choosing a right concept for future mobile robot missions based on the assessment.

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Aravind S. Seeni is pursuing Master of Science in Space Studies at the International Space University (ISU) in Strasbourg, France. His undergraduate study is on Aeronautical Engineering and has interest in Space engineering and science. During his master studies at ISU, he developed particular interest on system studies of robotic vehicles. He worked as an intern investigating several subsystems of rovers and other robotic systems at the German Aerospace Center (DLR) for a moon mission.