A STANDARDIZED MOBILE PLATFORM FOR LUNAR ISRU ACTIVITIES

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With the global space communities objective of having humans reside on the Moon by 2040, there has been a growing interest in researching and exploring the Earth's satellite among both the research and industry sectors [1, 2, 3]. Given that the environmental conditions of the lunar surface share similarities with that of low-Earth orbit, previous systems developed for the latter can be modified and applied to lunar exploration. NEUROSPACE GmbH and its associates aim to examine these resemblances to incorporate existing CubeSat technologies for lunar exploration [4, 5]. The implementation of a standardized approach for lunar rovers will enable future missions to focus more on practical applications rather than creating and certifying required components. This presentation introduces the HiveR rover concept and evaluates the significance of robotic systems in lunar exploration and in-situ resource utilization (ISRU).

HiveR is an ecosystem that contains a mobile platform called the HiveR rover, which carries a CubeSat as its payload [5]. The system is shown in Figur 1 during a test in an artificial lunar environment. It consists of a chassis with integrated electronics, a power system, a rocker suspension, four individually driven wheels and the CubeSat-sized payload.

Figure 1 The HiveR rover during a test in an artificial lunar environment. [6]

The HiveR system is offered by NEUROSPACE GmbH in a tiered approach, from the low-cost variant (T1) for educational and research purposes to the advanced space-proof tier (T4) that can operate on the Moon. The T4 rover uses many of the same components and working principles as the T1, but it is qualified for the lunar environment. This approach reduces development costs for real lunar missions. Table 1 presents an overview of the four tiers in which the systems are available.

Table 1 Overview of the four qualification tiers (T) of the HiveR systems. [7]

T1	T2	T3	T4
Academic	Industrial	Hazmat	Space

T1 is ideal for hands-on education and laboratory research, allowing for algorithm development and experimentation. T2 is designed for industrial applications such as automated factory inspection and mining site exploration. T3 is named Hazmat. Hazmat is short for "hazardous materials" and it refers to environments that are potentially harmful to humans. Examples of hazardous materials include chemicals, biological agents, radioactive substances, and explosives. This tier can help emergency relief crews with their response to incidents that require the control and containment of hazardous materials and the decontamination of the site. Finally, T4 is geared towards space exploration and is capable of operating in the harsh conditions on the lunar surface.

Due to the small footprint of the rover, it is conceivable to deploy multiple rovers as a swarm. Swarm-based rover technology has the potential to revolutionize lunar exploration by offering a number of distinct advantages. First, the ability of the rovers to distribute themselves across a large area allows for the comprehensive coverage of a given region, resulting in more efficient exploration. The use of swarm-based rovers also allows for the exploration of previously inaccessible areas such as lunar caves and skylights. Finally, the autonomous nature allows for uninterrupted operation, minimizing the need for human intervention thus enabling the swarm to operate as a cohesive unit, much like a natural hive. Additionally, the modular and flexible payload design of each HiveR rover enables them to take on a variety of complementary tasks, improving the overall efficiency of the swarm. For example, a high-resolution camera system can be installed to capture images of the lunar surface, and to gather data on geological structures, topography, and other characteristics. Another potential payload is a spectrometer, which can be deployed to conduct spectral analyses of the lunar surface, acquire knowledge about the Moon's history and composition, and create a database for future resource exploration. Moreover, the rover could be equipped with instruments to measure the Moon's magnetic field, radiation levels, and surface temperature, which are essential for upcoming missions. In addition to scientific instruments, the rover may also feature a drilling system to extract and examine subsurface samples as well as run biology experiments.

Another example for a payload that is proposed by researchers is a payload designed to measure subsurface thermal conductivity at various depths and locations. The proposed payload comprises of a heating element and an array of temperature sensors that will be inserted into the lunar regolith. Once inserted, the heating element will begin to heat up the surrounding regolith, and the temperature sensors will measure the resulting temperature changes. These measurements will enable the calculation of the thermal conductivity of the regolith at that specific location. Additionally, the payload will enable the measurement of changes in subsurface temperature throughout the whole lunar day cycle using only the temperature sensors, without the heating element being active. A better understanding of the thermal conductivity of the subsurface lunar regolith may refine geophysical models of the Moon and provide insights into using lunar regolith as a construction or heat storage material.

In conclusion, the HiveR rover concept offers a novel approach for lunar exploration that incorporates CubeSat technologies. The tiered approach of the HiveR system enables its usage for a range of applications, from hands-on education and laboratory research to space exploration. The development of compact payloads is expanding the capabilities of the HiveR rover in improving our understanding of the Moon's resources and how to utilize them.

References:

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