Towards a Versatile Robotic Mobility Platform for Planetary Body Exploration

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***Abstract*—The Jet Propulsion Laboratory (JPL) is currently developing a bio-inspired, snake-like robotic platform. This versatile and autonomous robot could potentially be used to explore planetary bodies such as the moon or Mars.**

***Index Terms*—bio-inspired robots, autonomy, space robotics**

I. Introduction

Long term human presence on the Moon and Mars will necessitate the development of versatile and autonomous robotic systems to perform tasks that are tedious or dangerous for human explorers. Fig. 1 shows one such robot called the **E**xtant **E**xobiology **L**ife **S**urveyor (EELS), currently under development at the Jet Propulsion Laboratory [1].

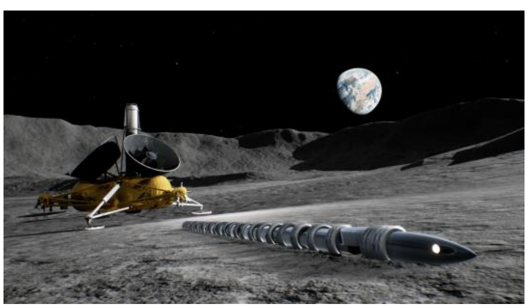

Fig. 1. EELS robot for Lunar exploration.

II. EELS Robot

EELS is a bio-inspired, snake-like robotic platform originally conceived for the exploration of icy worlds such as the vents of Enceladus to characterize habitability and search for signs of life. Successful exploration of environments with limited *a priori* knowledge requires an autonomous robot with exteroceptive sensing to build a model of the environment, a versatile mobility platform with proprioceptive capability to traverse the environment, and risk-aware autonomy software to interpret environmental data to determine how to traverse the environment and react to changes in the environment.

Other robotic mobility platforms may be more efficient for certain terrains. For instance, a rover will be more efficient on fairly flat terrain. What separates EELS is the versatility of terrains it can traverse. While rovers tend to struggle in terrain slopes approaching 30 degrees tilt, EELS can traverse a range of surface terrains including steep slopes or crater walls, and subsurface terrains such as caves, crevasses, moulins, and lava tubes, with a range of surface properties such as consolidated regolith, snow, or unconsolidated sand [2].

Other robotic platforms have been proposed for extreme lunar terrain mobility. The robotic vehicle called ATHLETE was designed for rolling mobility on moderate surface terrains and walking on more extreme surface terrains, and enabled cargo transport and manipulation capability [3]. However, the ATHLETE robot was fairly large (1,000 kg mass) and provided limited subsurface mobility [4]. By contrast, a lunar version of EELS called lunarEELS would have a target mass of <50 kg and enable both surface and subsurface mobility. Another robot called DuAxel is under development for traversing challenging terrain such as steep slopes, boulder fields, and caves [5]. The EELS robot would provide the additional capability to explore extremely tight subsurface terrain such as crevasses, moulins, or tubes with a diameter of down to 10 cm.

A snakelike robot called Cobra was proposed for lunar exploration [6]. The focus of Cobra is to provide a robotic platform for user teleoperated mobility in challenging terrain. By contrast, the focus of EELS is providing a snakelike robot that can span the range of control from user teleoperated to fully autonomous.

III. Conclusion

The development of EELS is ongoing at the Jet Propulsion Laboratory. An initial prototype was developed and has been successfully tested on a variety of surface terrain types including unconsolidated sand, snow, and ice as shown in Fig

2. In addition, EELS 1.0 will be field tested on the Athabasca glacier in Alberta, Canada, in September 2023. A second version of the robot, EELS 2.0, is currently under development with an expected completion in spring 2024. EELS 2.0 will provide advanced proprioceptive capabilities for subsurface mobility including 6-axis force/torque sensing and torque sensing at each joint. EELS 2.0 is currently planned for subsurface testing in moulins and crevasses on the Athabasca glacier in Alberta, Canada, in September 2024.

Fig. 2. EELS robot tested on a range of surfaces.

The versatility of the EELS robot makes it potentially useful for robotic operations on the Moon and Mars. EELS could perform a number of tasks that are dangerous for astronauts such as surveying of caves or lava tubes or acquiring samples, or tasks that are tedious such as external inspection of habitats or equipment.

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