Construction of Lunar Radio Astronomy Telescopes leveraging Low-Latency VR/AR Teleoperation.

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Introduction: NASA is working to achieve the goal of returning humans to the Moon by 2024 and then create a sustainable human lunar presence by 2028. NASA has also begun construction of the Gateway, a lunar orbiting habitation and science laboratory. The Gateway's proximity to the lunar surface will allow for real-time communication with surface assets, therefore enabling the use of low-latency lunar surface telerobotics. Astronauts on the lunar surface can also utilize low-latency telerobotics to perform surface tasks. In addition, high-latency teleoperation from Earth is a viable and inexpensive option. In order for humanity to create a sustainable lunar presence, well-developed collaborations between humans and robots are necessary to perform complex tasks such as surface assembly of radio telescopes and ISRU stations.

Our research team is involved in designing the scientific mission FARSIDE (*Farside Array for Radio Science Investigation of the Dark Ages and Exoplanets*), requiring the use of intricate surface telerobotics [1]. FARSIDE is a NASA-funded concept that would place a low radio frequency interferometric array on the farside of the Moon. The mission design requires a rover and a lander. The rover would be teleoperated to deploy antenna nodes from the lander onto the lunar surface. (Figure 1)

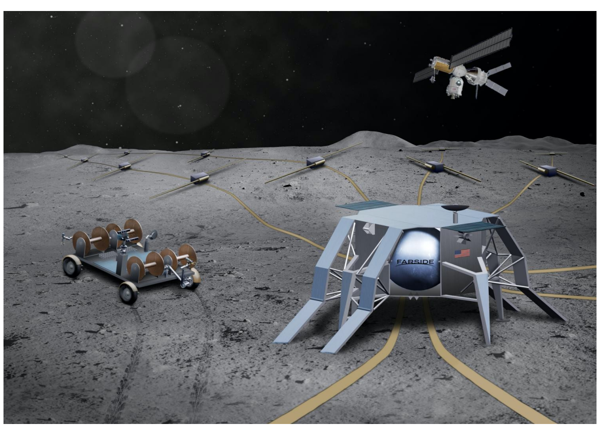

Figure 1: FARSIDE, a NASA-funded concept that would place a low radio frequency interferometric array on the far side of the

Sustainable lunar presence creates a platform for low-latency robotic operations on the lunar surface. This enables missions such as FARSIDE, which may require real time human-robot operations. Further, missions using these methods will also require new methods of failure recovery.

Leveraging stereo imaging capabilities, we intend to create VR/AR interfaces for both teleoperation and simulated failure recovery. By developing our virtual recovery sandbox (figure 2), we can create a virtual space representative of the rover's current state and environment. This provides the ability to troubleshoot problems as if the operator were next to the rover itself, in an exocentric perspective. With current imaging capabilities, this sandbox could ideally be created and assessed in real time. If proven to support teleoperated failure recovery, this sandbox method may be leveraged in a variety of robotic applications.

On completion of our virtual recovery sandbox, we may then compare our model with traditional control and failure recovery methods. These developments aim to provide a platform for low-latency teleoperated failure recovery, with the focal point on construction of lunar telescopes.

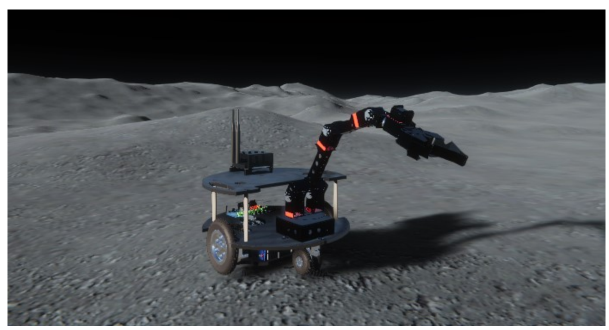

Figure 2: The Armstrong rover viewed from the exocentric standpoint, within the virtual recovery sandbox; A risk-free virtual solution development environment.

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References: [1] J. O. Burns, (2020) *Transformative Science from the Lunar Farside: Observations of the Dark Ages and Exoplanetary Systems at Low Radio Frequencies, astro-ph.IM*