VR SIMULATION TESTBED: IMPROVING SURFACE TELEROBOTICS FOR THE DEEP SPACE GATEWAY. M. E. Walker , J. O. Burns, D. J. Szafir. Center for Astrophysics and Space Astronomy, University of Colorado. michael.walker-1@colorado.edu, jack.burns@colorado.edu, daniel.szafir@colorado.edu.).

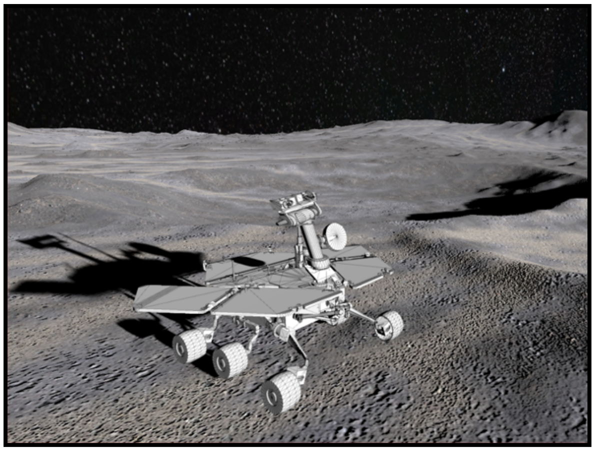

Figure 1*: A virtual MER-A rover 3-D model in the VR environment with full teleoperation control.*

Introduction: Developing new capabilities for surface telerobotics represents a complex, multifaceted problem that typically requires significant time and resource investment. In this work, we describe the design of a virtual reality (VR) simulation testbed for prototyping surface telerobotics that may reduce such barriers and enable more rapid and iterative development processes. This testbed enables exploration into the design of robot autonomy algorithms and new interfaces that support ground control, and/or crew operation (teleoperation and/or supervisory control) of surface robots from the Deep Space Gateway (DSG) to significantly improve critical NASA lunar exploration missions.

Virtual Reality Immersive Simulation: We have constructed a Virtual Reality (VR) simulator with a multiphysics engine core to provide a real-time and robust physics-based environmental model. A VR head-mounted display (HMD) allows users to utilize immersive first-person control of the robot to simulate teleoperation of the robot on the lunar surface from the DSG (Figure 1). This work will be extended to create a high-fidelity testbed with realistic terrain, authentic rovers, and state-of-the-art planning and control interfaces.

Environment and Terrain: Lunar topography will be simulated with high-resolution synthetic terrain modeled after the actual surface of the moon. NASA's Resource Prospector Group has provided our team with a synthetic digital elevation model (DEM) with authentic terrain features such as crater density and distribution, elevation deltas, etc. (Figure 2). Surface optical properties like specularity, reflectivity, albedo, sky-map, etc., will be simulated to give a feel of limitation for autonomous Simultaneous Localization, and Mapping (SLAM) algorithms. Rover-terrain interactions will be modeled to provide realistic slip and skid.

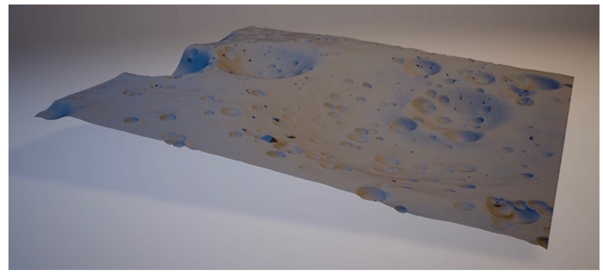

Figure 2*: High-resolution, authentic synthetic terrain.*

Rover Virtual Prototype: The rover will be fitted with auxiliary environment perception sensors and multiple strategies (visual odometry, wheel odometry, dead reckoning, etc.) will be used for reactive path planning and semi-autonomous avoidance of obstacles. This research will generate data which will feed into requirements, layout, and placement of onboard sensors.

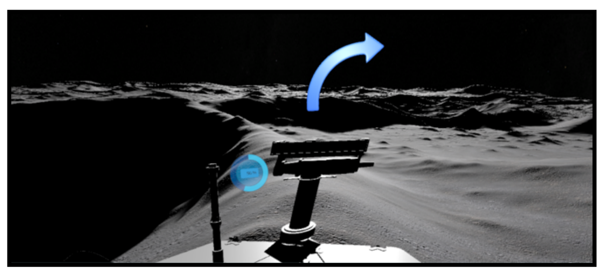

Figure 3*: User interface prototype to ease teleoperation, environment navigation, supervisory control and command, and hazard marking and avoidance.*

Planning and Control Interface: The interface will provide real-time situational awareness (latency 0.4s) as would be provided by the DSG. We will evaluate interfaces for human-in-the-loop supervision and direct teleoperation and will focus on improving both the intuitive control of the rover and user telepresence. Navigational data will be overlaid on the DEM to assist robot localization. We will also explore methods to overlay scientific and instrument specific data like spectral, and photogeological mapping on the lunar environment so as to aid in easier scientific exploration. We propose to use this system for mission trainings, rehearsals, and real-time contingency state evaluation for astronauts as well as rapidly prototyping user interfaces (Figure 3).