The Gandalf Staff: A Mobile, Self-Powered Platform for Lunar Surface Exploration. M. E. Evans[1], M. D. Leonard[2], and J. A. Morgan[3], [1]NASA Johnson Space Center ARES (2101 NASA Parkway, Houston, Tx. 77059 Mail Code XI4, michael.e.evans@nasa.gov), [2]Texas Space Technology Applications, and Research (T STAR), [3]Texas A&M University Department of Engineering Technology and Industrial Distribution

Introduction: The Artemis program is planning to deliver crew and cargo to the lunar surface. The Gandalf Staff is intended as a flexible, auxillary, self-powered platform outfitted with various components to support both crew Extra-Vehicular Activity (EVA) traverses and science exploration for long-term instrument data collection.

Gandalf Staff: The Gandalf Staff is an early prototype system developed over FY'21/FY'22 using NASA Science Technology Mission Directorate (STMD) Center Information Fund (CIF) Internal Research and Development (IRAD) grants to design, build and test "proof-of-concept" components. These components include a 24v battery powered monopole that powers a suite of subsystems, including a Graphical User Interface (GUI) for crew, surface voice and data communications, Lunar Search and Rescue (LunaSAR) navigation and communications, LiDAR, field site external lighting, 360-degree camera, and a geothermal instrument for measuring subsurface temperature gradient. The staff can be carried independently by an Extra-Vehicular Activity (EVA) astronaut, or can be mounted into a tripod for "hands free" support at a surface site being investigated. The staff can be attached to an external solar array and power storage system for long-duration operations. [1,2]

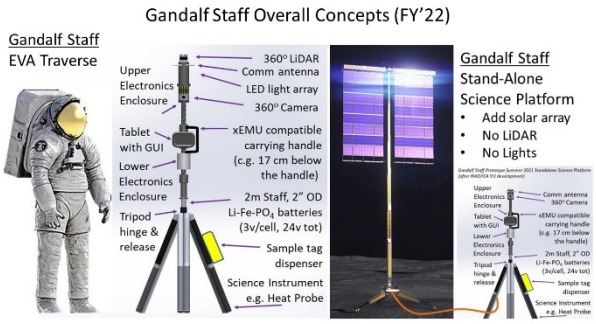

Figure 1: Gandalf Staff Components

Collaboration: To make rapid progress in the 1st year (FY'21), and also to demonstrate innovative project management techniques, NASA guided a private industry partner, T STAR, in leading Capstone Engineering student teams at Texas A&M University (TAMU) for proof-of-concept development and testing. Year1 was focused on developing the core staff (power/lighting/camera/LiDAR) supporting crew EVA and sample curation. For the 2nd year (FY'22), NASA is again collaborating with TAMU/TSTAR student teams to prototype new components. In Year2, capabilities are being enhanced for EVA support (2nd generation lighting system and handheld LunaSAR device) while adding new features for science instrumentation (subsurface geoprobe). This heat probe is based upon Apollo heritage but modified to measure subsurface volatile ice regimes at the Artemis landing site. This science instrumentation, developed in conjunction with an external solar array and energy storage system, provides a platform that is similar to the Apollo Lunar Surface Experiment Package (ALSEP) [3].

The Gandalf Staff team is also collaborating between NASA centers. The LiDAR subsystem is supported with expertise and funding from MSFC/Michael Zanetti, who provided expertise and mentoring for the TAMU student team and a graduate student studying point cloud data integration. The LunaSAR device is supported by GSFC/Cody Kelly with expertise and mentoring of the TAMU student team.

<u>Project Development Summary</u>

FY'21 IRAD Funding

Develop proof-of-concept for initial electronics

- Power: 24v LiFePO4 rechargeable battery system
- Data Comm: Using 802.11n
- Voice Comm: Using UHF
- User Interface: Using tablet and GUI
- LiDAR: Using OUSTER OS0 system
- Lights: 40 LEDs bulbs on a custom 4-card system

FY'22 IRAD Funding

Continue proof-of-concept for more electronics systems and create models for field testing and demonstrations

- Power: Develop solar array & battery sysem
- Power: Create rapid replacement battery packs
- Science: Build/test a geothermal subsurface probe
- Lights: Evolved lighting system design and testing
- LunaSAR: Create new EVA handheld unit to send emergency message to simulated satellite network
- Efficiency: Reduce overall complexity and mass

References: [1] Evans, M. E., et al. (2020), The Artemis "Gandalf's Staff" Science Suite for Crew EVA Lunar Field Geology, LPSC. [2] Evans, M., et al. (2021). Initial Prototype Work on Artemis "Gandalf's Staff"-Science Suite on a Lunar EVA Walking Stick, LPSC. [3] NASA (2008), "Apollo Lunar Surface Experiments Package (ALSEP), from https://www.hq.nasa.gov/alsj/HamishALSEP.html