GEOLAB HARDWARE OPERATIONAL TESTING AND EVALUATION: AS INTEGRATED INTO NASA'S 2010 HABITAT DEMONSTRATION UNIT 1 – PRESSURIZED EXCURSION MODULE.
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Introduction: NASA's Habitat Demonstration Unit 1 – Pressurized Excursion Module (HDU1-PEM)(fig. 1) was designed and configured for analog operational testing of Constellation Program Lunar scenario 12.1 during the 2010 Desert Research and Technology Studies (DRATS) field campaign where two Space Exploration Vehicle (SEV) rovers exploring a planetary surface would utilize a mobile habitat.

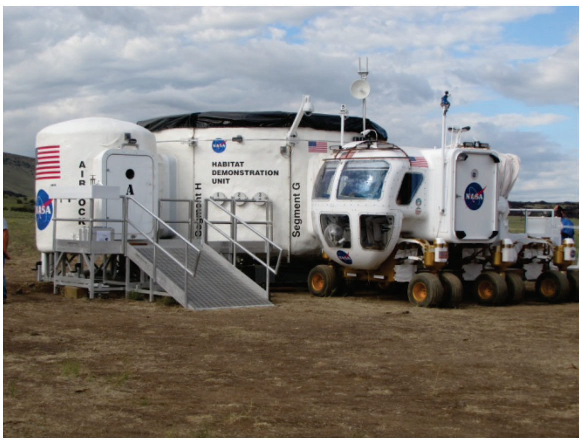

Figure 1: SEV rover docked to HDU1-PEM. The image also shows the three GeoLab glovebox pass-through antechambers and EVA porch (center).

The 2010 HDU1-PEM was a one-year rapid prototype build that featured four main workstations inside a 5 m diameter habitat. This included an extravehicular activities (EVA) maintenance workstation, general maintenance workstation, medical operations workstation, and a geological laboratory workstation, named GeoLab (fig. 2). GeoLab was designed to provide preliminary examination and characterization of geologic material collected by two rover teams inside an analog isolation containment system glovebox to help scientists prioritize samples for return to Earth [1,2]. In addition, GeoLab provided a testbed for advanced curation operational concepts and procedures for sample storage containment, preventing cross-contamination and preserving sample integrity for Earth-based scientific study [3]. GeoLab hardware testing and design evaluation was conducted at the Johnson Space Center (JSC) and DRATS to provide the HDU1-PEM and GeoLab curation team with user metrics and lessons learned for designing the next generation habitat and GeoLab configuration [3].

GeoLab Hardware Design: GeoLab was designed to provide a workstation and analog isolation containment system for preliminary examination, curation decisions, and return to Earth prioritization of geologic material collected on a planetary surface. The GeoLab was also designed to be easily reconfigured for testing different instruments – including tests of operational considerations and analytical benefits of specific instruments for preliminary examination of samples. [4,5].

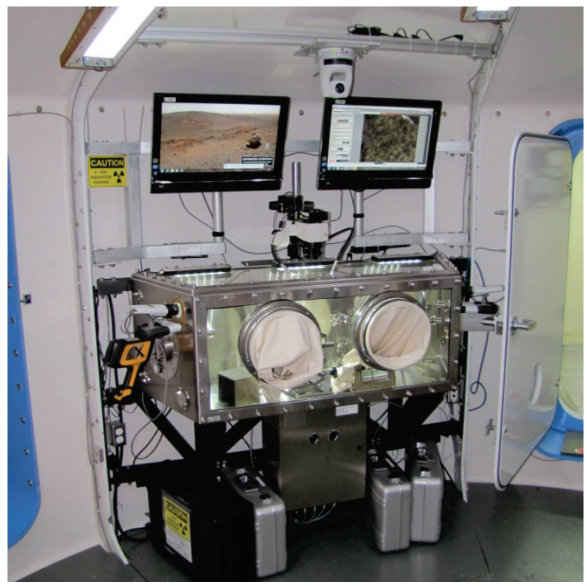

Figure 2: GeoLab integrated into the HDU1-PEM section H.

This first generation GeoLab was developed around a custom built stainless steel 304/polycarbonate window positive pressure nitrogen environment glovebox. The glovebox has three pass-through antechambers through the habitat bulkhead, allowing geologic samples to enter (and exit) the main glovebox chamber directly from the outside, minimizing potential contamination from inside the habitat. The glovebox also incorporates a state-of-the-art environmental monitoring system that can be remotely controlled. The main chamber of the glovebox is equipped with O_2 (ppm), pressure (mbar), humidity, and temperature sensors as well as pressure sensors for the three antechambers. Four Axis Communication video surveillance cameras provide live situational awareness of the GeoLab workstation and EVA porch area. The 2010 suite of instruments included a manual focus Leica M80 stereomicroscope with IC80 HD video camera capable of image data "downlinked" to a remote science team for microscopic inspection and image capture of collected samples. An Innov-X handheld Delta DP6000 X-ray Fluorescence (XRF) spectrometer was integrated into the GeoLab for whole rock geochemical fingerprinting; the XRF data were also "downlinked" to a remote science team for analysis. The glovebox also contained a mass balance and scale for collecting sample mass and size. All instrumentation and cameras are controlled at the workstation with two HP Touchsmart 600xt all-in-one touch screen computers which are integrated into the HDU1-PEM avionics system and can be fully viewed and controlled in real-time on the remote network for collaboration between the astronaut crew and a supporting science backroom.

HDU Integrated Testing and Evaluation: Four separate studies were conducted for testing and evaluating GeoLab hardware: (1) initial GeoLab testing with HDU1-PEM subsystems were performed at JSC with the Habitat Testbed (HaT) and integration engineers in April-June 2010, (2) 8 SEV crew members conducted real-time GeoLab operation during DRATS 2010, (3) 14 volunteer scientist crew members operated GeoLab during non-integrated times at DRATS 2010, and (4) 18 JSC curation and scientist volunteer crews operated GeoLab in November 2010 at JSC. All test subjects operated GeoLab with no prior training, with the exception of limited training provided to the DRATS SEV crew members. Each test was conducted with one or two crew members and a GeoLab test observer. After running through the GeoLab procedures with geologic samples at least twice, all 40 crew members provided feedback about the GeoLab design and operations.

The results of the surveys and integrated subsystem testing provided an assessment for future redesign. The general results showed no major redesign on the overall workstation and operational procedures. However, most evaluations reported a need to enhance the ergonomic design, crew interface displays, and the habitat voice communication system. Ten important lessons learned are as follows: (1) better sample preparation and staging techniques are needed for imaging and XRF measurements. Further development of in-situ geochemical analytical instruments are needed; (2) the stereomicroscope needs to be better stabilized from habitat vibrations and enhanced mechanical/software autofocus to aid high resolution focusing; (3) further development of customized software interfaces with analytical instruments, cameras, and sensors would help with crew efficiency and ease of use; (4) better mechanized mobility of the overhead camera would help with imaging capabilities; (5) improved vertical adjustment of HP computers is required for crews < 1.778 m in height. Optional keyboard and mouse would enhance productivity; (6) human factors ergonomic assessment concluded that the height of the glovebox was 152 mm too low, (note that HDU shell dimensions predetermined the glovebox height); (7) glovebox antechamber flanges, doors, locks, and viton seals were too bulky and cumbersome. The antechamber doors should have a more lightweight design with a quick-locking mechanism while still meeting vacuum pressure requirements. In addition, the doors should have a pressure indicator redundant to the remote environmental monitoring system to verify door seals; (8) HDU1-PEM section A airlock door needs to be redesigned to allow better access to the right side of the glovebox when the door is open; (9) more durable primary sample bags and containers are needed for collected rocks; (10) particle/sediment traps need to be installed into the bottom of the glovebox. The glovebox is already equipped with sediment trap ports, however, a cleaning system was not fabricated. Cleaning tools and methods also need to be further developed to clean the glovebox quickly and efficiently.

The majority of survey results and conclusions were identified and considered prior to development and design of the workstation. However, due to budgetary constraints and time, many design upgrades were not implemented in the first generation of GeoLab. We also found that a well trained crew is essential for effective and efficient use of the Geolab facility. In the future, we would like to incorporate testing of well trained crew members to collect quality metrics on timed curation procedures.

Future Designs: The GeoLab is a unique workstation design that incorporates for the first time a curation glovebox and analytical instrumentation for preliminary examination, curation, and return to Earth prioritization of geologic material collected on a planetary surface. Future HDU and GeoLab designs will incorporate these lessons learned in the second generation design within the constraints of resources available. The GeoLab is already being incorporated into the Habitat Demonstration Unit – Deep Space Habitat (HDU-DSH) and will be reconfigured with new instrumentation and procedures reflecting the DRATS 2011 campaign.

References: [1] Shearer, C. et al. (2010) Review of Sample Acquisition and Curation During Lunar Surface Activities, CAPTEM and LEAG Analysis Report. [2] Treiman, A.H. (1993) JSC-26194 and Office of the Curator Pub. #187. [3] Evans et al. (2011) *LPSC XLII,* this volume. [4] Evans et al. (2010) *LPSC XLI,* Abst. #1480. [5] Calaway et al. (2010) *LPSC XLI,* Abst. #1908.