**GEOLAB RESULTS FROM THREE YEARS OF ANALOG MISSION TESTS**

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**Introduction:** GeoLab is a prototype glovebox for geological sample examination that was fully integrated into NASA’s Deep Space Habitat Analog Testbed. GeoLab allowed us to test science operations related to contained sample examination during simulated exploration missions. Mission operations using a mature GeoLab-like system will aid decisions about sample prioritization, sample handling, and also provide key data to support real-time science planning activities.

**Legacy:** The conceptual design for GeoLab came from several sources, including ongoing spaceflight research and instruments used on International Space Station (e.g. Microgravity Science Glovebox), other terrestrial analog studies, existing Astromaterials Curation Laboratory hardware and clean room procedures, and mission scenarios developed for the former Constellation program.

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**Three Years of Analog Tests**

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<thead>
<tr>
<th>Year</th>
<th>Description</th>
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<tr>
<td>2010</td>
<td>Test basic analytical tools (cameras, microscope, scales, data recording) and operations with science team support</td>
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<tr>
<td>2011</td>
<td>Test glovebox configurability with new instrument (ASU-JPL Multispectral Microscopic Imager), new crew interfaces for the instruments, web-based data displays for the science team</td>
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<td>2012</td>
<td>Test robotic arm – basic operations and efficiencies</td>
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**Results**

In 3 years of tests in the Deep Space Habitat Testbed, GeoLab conducted 19 days of simulated mission testing in full analog settings, and monitored operations with 18 different test subjects. We also conducted stand-alone tests with nearly 20 other operators. Our results indicate:

1. **The GeoLab design supports autonomous crew operations of the basic glovebox functions.**
   Operations are similar to how research is conducted on the International Space Station, including independent crew operations and operations with PI involvement. A trained crew enhances science returns by providing real time and spontaneous observations; this is especially important when time delays preclude real-time science team involvement.

2. **Good sample imagery is key for preliminary characterization.**
   Imagery collected at a range of scales forms the basis for additional characterization and aids sample handling operations. All tests indicated that basic microscopy was the most valuable data for rapid assessment of samples.

3. **Robotic assists for sample handling are critical in microgravity.**
   Robotics aid crew and enable precision sample handling for operations and data collection. Our 2012 tests validated the quantity and quality of microscopy that could be achieved with a robotic sample holder. The sample holder made possible one-person operations (crew efficiency), flexibility in sample positioning (six degrees of freedom allow positioning in complete X-Y-Z space), systematic and repeatable sample positioning, allowing for registration and mapping of the sample in Cartesian space for future analyses. Finally, proper robotic sample handling can result in less sample handling, mitigating the risk of damaging or compromising a sample.

4. **A combination of imaging and robotic tools provides significant flexibility for designing facilities and operations related to sample characterization and sample handling.**
   Progressive tests using robotic interfaces will help develop requirements, instruments and procedures for different exploration scenarios.

5. **Early sample characterization provides data for smart decisions during mission operations.**
   Data provides insight into unusual sample details, enables sample prioritization, and a better understanding the regional geology. Data can be easily distributed for broad participation by scientists and students on Earth.

**Future Work**

Sample handling and curation techniques are dependent on exploration destination, mission design, sampling strategies and types of samples. GeoLab tests can feed forward to future planetary surface operations, and help frame different sample handling strategies. These tests provide visibility for sample handling and curation requirements, and potential preliminary examination protocols.

**References**

2011.12.008 ; Young, K.E. et al. (2012) Am.Geophys. Union Fall meeting, V33B-2867