Asynchronous geological exploration operations at the HI-SEAS planetary surface analog mission simulation in Hawaiʻi

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Time Delay → Need Autonomous Crews

1.3 s
Moon
21 min
Mars
53 min
Europa

Image Credits: NASA
• “Demonstrate autonomous crew operation capability.”
• “Explore landing sites of interest for extended durations.”
• “Conducting high priority science benefiting from human presence.”
• “Characterizing human health and performance.”
• “Demonstrate extended crew mobility and habitation systems.”
Why HI-SEAS?

To mitigate risk on long-duration, high-latency missions via:

- High-fidelity mission profile and environment.
- Site that allows both crew isolation and easy access year-round.
- Astronaut-like crews.
- Tracking crew cognitive and team performance through collaborative field tasks.
Use analogs to **discover** problems, test solutions, **design** in the context of use, **integrate** people + systems in realistic scenarios.

*Image Credit: NASA*
HI-SEAS Missions

Habitat Design & Construction

1st Grant 04-08/13

2nd Grant 03-07/14

2nd Grant 08/15 – 07/16

Today 10/14 – 06/15

Mission 1

Mission 2

Mission 3

Mission 4
Site Geologic Overview

- Mauna Loa (2500 m)
- Disused quarry
- Very little vegetation
- Pāhoehoe and ‘a‘ā flows from mid 1800s to mid 1900s
- Skylights, lava tubes, lava channels, tumuli

Image Credit: USGS
Ground defines the task.

Ground assigns task to crew.

Crew plans how to carry out task.

Crew makes EVA Request(s).

Crew carries out the task.

Crew submits report(s).

Ground approves of EVA(s).

Ground decides on next task.

CAPCOM
In Habitat

40 minute two-way delay

Mission Support

How it Works
Geological Exploration Tasks

- Team oriented
- Progressive
- Quantifiable metrics
- Compare with control and across missions
- Given every 2 weeks
- Specify ‘What’ not ‘How’
Volume of spatter cones feature

• Explore vicinity of habitat and exercise planning/GPS skills.
Density of samples from the feature

- Sample collection.
- Use habitat’s lab equipment.

Image Credit: Kurt Hollocher
• Use pit craters and road cut to draw cross section.
Geologic Mapping

- Find relative age sequence of units.
- Ground-truth imagery.
Tumuli exploration

- Measure size and characterize morphology of tumuli features.
Lava tube exploration

- Measure and identify accessibility of skylights and lava tube systems.
Emergency Simulation

- Identify safe skylight.
- Create evacuation plan.
- Execute evacuation.

Image Credit: NASA
Improvise.  
Repair Equipment.

Crewmember repairs EVA suit backpack.

*Figure 12: 3D printed T-joints for helmet*

*Figure 13: Completed helmet*
Crew-led Projects

- Develop a hypothesis to test and plan EVAs to collect data.
Planned vs. Actual EVA Traverses

\[ \text{Figure 1: Planned route on the left (a), actual route on the right (b)} \]
Going forward

• Lava tube geophysics study during 12-month mission.

• More missions during 3rd NASA grant from 2016-2019.

• Continue to study autonomous crew EVA operations on high-latency, long-duration missions.
Questions??

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The HI-SEAS Habitat