



TESTING ROVER COOPERATION CONCEPTS IN MOON ANALOG SITE

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Introduction

Future interplanetary exploration will be done by human-machine collaboration. But initial exploration is typically done without humans, by rovers. These rovers can perform exploratory tasks, perform preparational tasks before human arrival or support human exploration. Research into rovers in moon/Mars analog environments has been performed before, even investigating human-rover collaboration. Rover-rover collaboration in moon or Mars analog environment, however, is a new ground for research.

In this research, performed at the HI - SEAS (Hawai'i Space Exploration Analog and Simulation) analog habitat as part of the EMMIHS-III (EuroMoonMars - International Moonbase Alliance - HISEAS) mission from January 18th to the 1st of February 2020, both individual exploration tasks and collaboration between different rover concepts were investigated.



Three rovers being tele-operated simultaneously in lunar analog environment near the HISEAS habitat.

Apparatus

Three tele-operated rovers were used for this research. The first is PISCES' (Pacific International Space Center for Exploration Systems) rover called Helelani. Helelani is the biggest rover of the three and weighs over 700 lbs. It is able to carry 240 lbs of payload and is driven by four 24 inch wheels. When equipped with a levelling blade or a compacting roller it is capable of preparing the ground for constructions or pathways. In a previous test, Helelani was used to prepare and compact the ground for a Vertical Take-off and Landing pad.

The second rover is the six-legged Zebro. Originally designed as swarm robot, Zebro is able to accomplish complex tasks autonomously, as well as in collaboration with other Zebros. A Lunar Zebro is being built to walk the moon in just few years time. The Zebro tested features a camera for tele-operation.

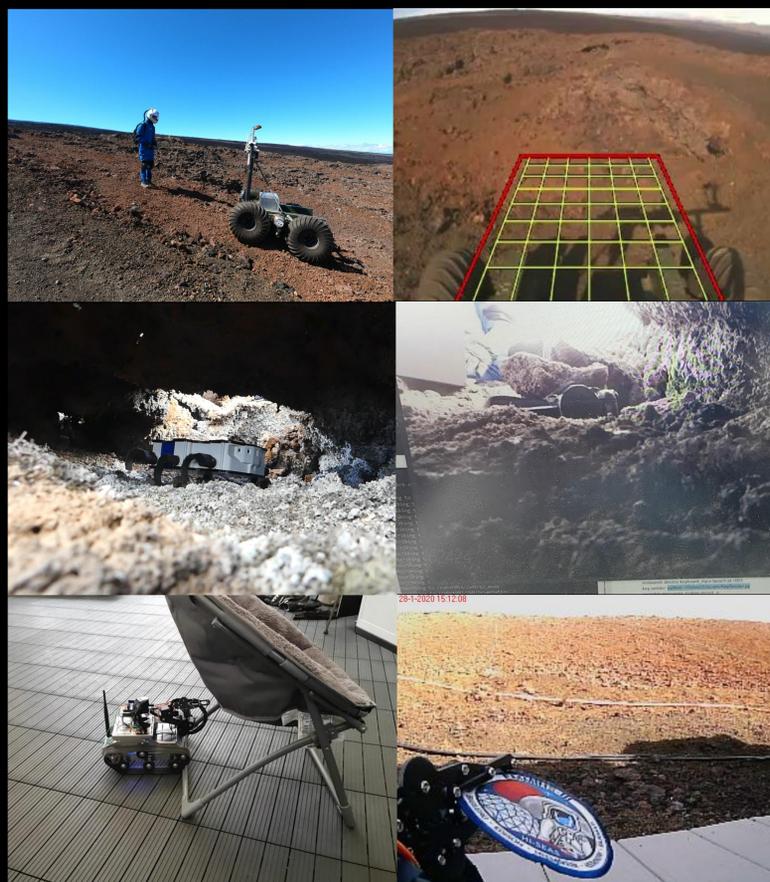
The third rover, REMM, is a small toy rover provided by EuroMoonMars. It is equipped with a remote controlled arm and camera gimbal. Its movement is powered by two tracks.



The three rovers: (f.l.t.r.) Helelani, Zebro and REMM.

Individual tests

To determine realistic scenarios where collaboration between the rovers is essential, the boundaries of all individual rovers were tested. Driving tests were performed on different surface types, for distinct surface roughness and with various levels of inclination/declination. Other tests focussed on control range, drive range, visibility, and rover-specific tasks.



Individual tests: (f.t.t.b.)

Helelani going down an 17° decline (and its camera view (r)), Zebro exploring a tunnel only 7 inches high (and its camera view (r)), REMM passing a 1 inch obstacle (l) and grasping a mission logo patch (r).

Rover cooperation tasks

The three rovers could cooperate in the following tasks:

- Navigation support: One rover recording the other to provide extra positional information if its own sensors are insufficient, e.g. due to occlusion or sensor range.
- Communications relay: One rover providing a communication relay to other rovers out of range, to rovers behind line-of-sight, or to smaller terrain-specific rovers.
- Rover transportation: One rover providing logistic support to other rovers with short drive range.
- Rover rescue: One rover helping the other through rough terrain, or big rover retrieving a smaller rover.
- Task specific: One rover paving the way for a less mobile rover, or one rover taking samples that another transports.



The REMM and Zebro recording each other.

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References: PISCES (Pacific International Space Center for Exploration Systems), Hilo, Hawaii. Lunar Zebro team, Delft (NL). All included photographs were taken during the EMMIHS-III mission by the EMMIHS-III crew members.