Österreichisches Weltraum Forum
Sillufer 3a, 6020 Innsbruck, Austria
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AMADEE-15

Science Workshop and Networking Meeting

Conveners

Gernot Groemer — Österreichisches Weltraum Forum

Christine Moissl-Eichinger — Medizinische Universität Graz

Anna Losiak — ING PAN

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FFG Austrian Research Promotion Agency

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About the Austrian Space Forum

The Austrian Space Forum (Österreichisches Weltraum Forum, OeWF) is a national network for aerospace engineers, scientists and people with a passion for space. The citizen-science organization is involved in cutting-edge space exploration research and serves as a communication and networking platform between the space sector, industry, academia and the public.

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1 Workshop programme

Thursday, 18Feb2016

10:00 Opening

10:15 Gernot Groemer (Austrian Space Forum)
AMADEE-15 Mission overview

11:00 Klemens Weisleitner (University of Innsbruck, Institute of Ecology)
Applicability of Laser-induced flourescence emission (L.I.F.E.) as a life detection system

11:30 COFFEE BREAK

12:00 Maciej Dąbski (University of Warsaw, Faculty of Geography and Regional Studies)
AMADEE-15: Results of lichenometrical and Schmidt Hammer experiments

12:30 Alain Souchier (Association Planète Mars)
Cliffbot AMADEE-15 simulation tests results
Balloon Carried Camera tests results during AMADEE-15

13:00 LUNCH BREAK

14:00 Alexandra Perras & Kaisa Koskinen (Medical University of Graz)
Glacier-MASE: Current outcome and future prospects

14:30 **SPEED DATING I - Q&A with senior researchers**
Christine Moissl-Eichinger (Med. Univ. Graz/Astrobiology)
Arnold Hanslmeier (Univ. of Graz/Astrophysics)
Stephan Weiss (Univ. of Klagenfurt/Mechatronics)
Barbara Imhof (Liquifer/Architecture)
Nandu Goswami (Med. Univ. of Graz/Space Medicine)

15:30 COFFEE BREAK

16:00 **SPEED DATING II - Q&A with senior researchers**

16:30 Joshua Nelson (International Space University)
The Self Deployable Habitat for Extreme Environments (SHEE)

17:00 Astrobiology Laboratory tour & ISU Introduction (J.Nelson)

19:00 CONFERENCE DINNER

FRIDAY, 19Feb2016

10:00 Charles Cockell (Univ. of Edinburgh)
The Boulby Mine Astrobiology Laboratory

10:15 Barbara Imhof & Waltraut Hoheneder (Liquifier Systems Group, Austria)
The MOONWALK project EVA simulations on terrestrial and underwater analogues

10:45 Stephan Weiss (Univ. of Klagenfurt/AAU)
Mars Helicopter Scout: Visual and Inertial Sensor Fusion for Highly Resource Constraint Robots

11:15 COFFEE BREAK

11:45 Gernot Groemer (Austrian Space Forum)
Update on Analog Missions and Analog Research Policy Initiatives

12:15 LUNCH BREAK

13:30 Anna Losiak (Polish Academy of Sciences, Institute of Geological Sciences)
The influence of albedo and emissivity of particles laying on the surface of a glacier on their surface temperature

14:00 Mátyás Hazadi (Puli Space Technolgies, Hungary)
Puli rocks! - Rover tests during AMADEE-15

14:30 Joshua Nelson (International Space University)
Mars on Mauna Loa, the HiSEAS Project

15:00 Alexandra Zavitsanou (Dep. of Geophysics/University of Athens, Greece)
The Ground Penetrating Radar on Glaciers (GPRoG) Experiment

15:30 **Plenary Discussion: Outlook on Analog Research**

16:00 Concluding remarks & End of Workshop

2 AMADEE-15 simulation results

2.1 The AMADEE-15 Mars simulation mission

Gernot Groemer [1] and the AMADEE-15 team
[1] Austrian Space Forum, Austria

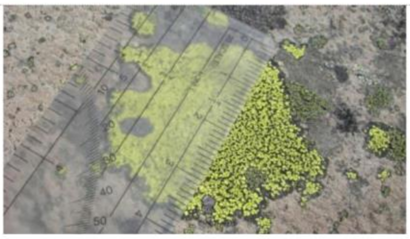
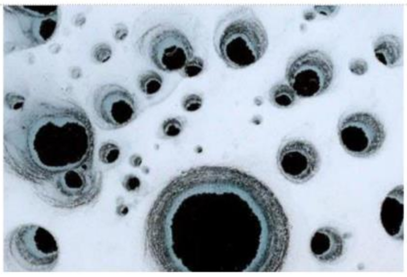
We report on the AMADEE-15 mission, a 12-day Mars analog field test at the Kaunertal Glacier in Austria. Eleven experiments were conducted by a field crew at the test site under simulated martian surface exploration conditions, coordinated by a Mission Support Center in Innsbruck, Austria. The fields of research for the experiments encompassed geology, human factors, astrobiology, robotics, tele-science, exploration, and operations research. A Remote Science Support team analyzed field data in near real time, providing planning input for a flight control team to manage a complex system of field assets in a realistic work flow, including: two advanced space suit simulators, four robotic and aerial vehicles, a dedicated flight planning group and weather monitoring service, an external control center tele-operating the PULI-rover. A 10 minute satellite communication delay and other limitations pertinent to human planetary surface activities were introduced.

This presentation provides an overview of the mission architecture. We report on the operational workflows and the experiments conducted, as well as a novel approach to measuring mission success by introducing transferrable performance indicators for analog missions in general.

AMADEE-15 marks the 12th Mars analog planetary research campaign conducted by the Austrian Space Forum. A total of 100 individuals from 19 countries participated in the AMADEE-15 mission.

At the core of mission preparation was also the selection of a group of spacesuit testers to be deployed during the campaign, resulting in the selection and training of a new class of five analog astronauts.

	Experiment (Principle Investigator)	Description	
1	**Cliffbot** (Cliff Reconnaissance Vehicle) A. Souchier, Association Planete Mars, France	The cliffbot was a vehicle designed to operate on slopes or in holes under manual operations and guidance of an operator situated uphill. Through a video camera it gave information on terrains which are not securely accessible by an operator in a spacesuit.	
2	**BCC** (Ballon-carried camera) A. Souchier, Association Planete Mars, France	Utilization of a balloon carried camera to document analog EVAs. These data could then used by geoscientists to study the geomorphology of the traversed areas. *(Note: Higher-than-expected wind pressure and lifting deficiencies impeded the measurements.)*	
3	**L.I.F.E.** (Laser-Induced Fluorescence Emission) K. Weisleitner, University of Innsbruck, Institute of Ecology, Austria	A non-destructive, in-situ laser-induced fluorescence emission technique (L.I.F.E.) was deployed based on the fact that glacier surface communities are highly autotrophic (e.g. Storrie-Lombardi and Sattler, 2009). These organisms can be traced by the detection of intracellular porphyrin derivates, which are widely acknowledged as a suitable biomarker (ibid).	
4	**glacierMASE** Christine Moissl-Eichinger, Medical University Graz, Department of Internal Medicine , Austria	As part of a larger MASE program, glacierMASE investigated the sampling process under simulated surface exploration conditions. The aim was to obtain soil and water samples to complement an inventory of extremophiles and study their survival strategies.	
5	**FOG** (Mobile water fog shower suitcase with a low water consumption) Krzysztof Jędrzejak, PROXiM, Poland	Test of the effectiveness of washing a human body in the experimental low water consumption mobile shower cabin under the conditions of limited water resources.	

6	**VEMES V-ERAS** (Virtualization Experiment for Mars Expedition Simulations) F. Carbognani, Italian Mars Society, Italy	The V-ERAS pilot study explored the opportunities and limitations of using an immersive virtual reality system, combined with an omnidirectional treadmill, motion recorders and a gravity-offloading device to mimic the traverses of analog astronauts in the field.	
7	**PULI ROCKS** (GLXP Puli rover platform test) Tibor Pacher, Puli Space Technologies, Hungary	A robotic platform testing the terrain trafficability, telecommand and human-robotic interaction. The test site provided a wide range of terrain types, whilst the rover telemetry architecture was evaluated in a realistic setting.	
8	**GPRoG** (Ground Penetrating Radar on Glaciers) Alexandra Zavitsanou, Department of Geophysics and Seismology, University of Athens, Greece	Utilizing a commercial ground penetrating radar (GSSI SIR System 2000), the efficiency of using astronauts in a challenging terrain was studied, comparing a suited versus an unsuited data acquisition. In parallel, the subsurface ice layers of a rock glacier and the glacier itself were investigated.	
9	**MaDe** (Mars Dental Rescue) S. Haeuplik-Meusburger, Space-craft architecture, Vienna, Austria	This human factors experiment emulated a dental contingency situation, evaluating the workflow for oral 3d-scanning, Earth-based reconstruction, and in-situ producing and implanting a 3d-printed tooth-filling in the field	
10	**LICHEN** (Relative dating of morraines) M. Dąbski, University of Warsaw, Department of Geomorphology, Poland	Dating of moraines via studying lichens, boulder frequency and boulder height, depending on local topography. This experiment also included measurements with a Schmidt hammer to assess the elastic properties of the rocks. Although lichens are unlikely to exist on Mars, this test series complements other experiments and obtains a recent biogeological history of the site.	
11	**WoRIS** (Weathering of Rocks at the Ice Surface) A. Losiak, Institute of Geological Sciences, Polish Academy of Sciences, Poland	Weathering within ice has been recently proposed as one of the most important geologic processes active currently on the surface of Mars (Massé et al. 2012). WoRIS determined the influence of albedo and emissivity of objects lying on the surface of the glacier on the rate of its melting, and observe the formation of cryoconites to be then compared to a numerical model.	

2.2 Glacier-MASE: Current outcome and future prospects

Alexandra Perras [1], Kaisa Koskinen [1], Christine Moissl-Eichinger [1] and the MASE team
[1] Medical University of Graz, Graz, Austria

Preparation for life-detection missions on e.g. Mars requires proper preparation with respect to the understanding of the adaptation capability of life and optimization of the detection of biomarkers. Since Martian samples are not available, researchers focus on terrestrial Mars analogue sites in order to understand the microbial communities which managed to adapt to the most extreme sites. Mars analogues sites (i.e. harsh environments with low nutrient availability, no oxygen influence, low temperature and often high salinity or low pH value) can be found all over Europe. The MASE (Mars analogue sites for space exploration) research project (http://mase.esf.org/), in particular, is focusing on microorganisms thriving completely without oxygen — an outstanding research focus requiring specific cultivation and characterization methods in order to avoid any influence of atmosphere-derived oxygen.

Embedded in the AMADEE-15 mission, members of the MASE team sampled the Kaunertaler glacier and evaluated the sampling procedure of analogue astronauts performing the same sampling procedure under Mars mission simulation conditions, including on site anaerobic sampling and cultivation trial.

With a height of more than 3000m, and consequently considerably more radiation impact on living beings, low temperature and low nutrient availability, the Kaunertaler glacier offers an excellent area with respect to microbiology and Mars analogues research. The samples underwent a detailed 16S rRNA gene analysis concentrating on Bacteria and Archaea next to enrichment approaches. Within this talk, the MASE project itself, the sampling process, the outcome of their analysis of AMADEE-15 and future prospects will be presented.

2.3 Applicability of Laser-Induced Flourescence Emission (L.I.F.E) as a life detection system

Klemens Weisleitner [1], Birgit Sattler [1], Lars Hunger [2], Christoph Kohstall [3], Albert Frisch [3]
[1] University of Innsbruck, Institute of Ecology, Austrian Polar Research Institute, Innsbruck, Austria, [2] University of Innsbruck, Institute of Astro- and Particle Physics, Innsbruck, Austria, [3] Stanford University, Department of Physics, Stanford, CA

The development of life-detection systems for Martian environments is challenging. Invasive methods might threaten the integrity of life detection missions due to the introduction of terrestrial biogenic material (Rummel, 2001). Also, standard sampling procedures for cryospheric environments (e.g. sawing, cutting, coringand melting) imply a severe sample manipulation. The sensitivity of many psychrophiles to even moderate changes in temperature results in a falsification of in-situ conditions. Hence, non-invasive and in-situ life detection methods should be prioritized over invasive technologies.

We have developed a portable dual wavelength photospectrometer, using 532nm and 405nm laser excitation for non-destructive in-situ quantification of porphyrins which are widely distributed molecules among living organisms and feature strong durability concerning temperature and low pH conditions (Suo et al., 2007). The detection of these molecules can be performed by using Laser-Induced Fluorescence Emission (L.I.F.E.) technology. L.I.F.E. occurs when matter absorbs a fraction of an incident laser beam and emits light at a longer wavelength (lower energy). This technology is arguably the single most sensitive active photonic probe of biomolecular intracellular and extracellular targets that does not require sample preparation, sample destruction, or consumable resources other than power(Storrie-Lombardi & Sattler, 2009).The L.I.F.E. instrument was already used during Mars-analog missions in the Moroccan desert in 2013 (Groemer et al., 2014) and during a rock-glacier-simulation in the Austrian Alps (AMADEE-15), both organized by the Austrian Space Forum. Here, we present the technical development of the LIFE prototype, data from both simulations and discuss the future applicability of the instrument.

References:

- Groemer G., Sattler B., Weisleitner K., Hunger L., Kohstall C., Frisch A., Józefowicz M., Meszyński S., Storrie-Lombardi M.C. &the MARS2013 team (2014). Field trial of a dual-wavelength fluorescent emission (L.I.F.E.) instrument and the magma white rover during the MARS2013 mars-analogmission. Astrobiol., 14(5):391-405.
- Rummel, J. D. (2001). Planetary exploration in the time of astrobiology: protecting against biological contamination. Proc.Natl.Acad. Sci. USA 98: 2128–2131.
- Suo Z., Avci R., Schweitzer M.H., Deliorman M. (2007). Porphyrin as an ideal biomarker in the search for extraterrestrial life. Astrobiol.7(4):605-615.
- Storrie-Lombardi, M.C. &Sattler, B. (2009): Laser Induced Fluorescence Emission (L.I.F.E.): In situ non-destructive detection of microbial life in the ice covers of Antarctic lakes.Astrobiol.9 (3):659-672.

2.4 Cliffbot AMADEE-15 simulation tests results

Alain Souchier [1]
[1] Association Planète Mars

The Cliffbot is a manually operated vehicle designed for acquisition of information on slopes or holes which are not accessible by an astronaut in spacesuit. It has been tested 5 times during the AMADEE-15 simulation, three times by the PI and two times by the analog astronauts. The presentation gives the main results obtained during the 5 tests.

2.5 Balloon Carried Camera tests results during AMADEE-15

Alain Souchier [1]
[1] Association Planète Mars

A Balloon Carried Camera (BCC) is a way of documenting analog EVAs. The balloon is tethered to the analog astronaut thus following the astronaut evolution (terrain mapping) and monitoring the astronaut activities. The BCC has been used three times during the AMADEE-15 simulation, twice by the PI and once by the analog astronauts. The presentation gives the main results obtained during the 3 tests.

2.6 Puli rocks!

Mátyás Hazadi [1], Tibor Pacher [1]
[1] Puli Space Technologies Ltd, H-1161 Budapest

Human on site exploration can be assisted by remotely controlled scouting rovers, expanding the area to be surveyed. This gives greater chance to collect relevant scientific information and samples. In the Puli rocks! experiment we have performed area mapping and collected data for our distance measurement technique. Mapping the nearby area of the base camp helped to extend the field crew's capability to explore the vicinity of the camp, to collect samples and to avoid dangerous terrain.

We have also tested and tuned our organisational procedures on how to map the area, how to navigate on it, how to avoid obstacles and to explore these harsh areas that might otherwise be dangerous for human explorers. We report on our rover accident, too, which resulted from a combination of loss of rover communication and human errors.

This is a publication of Team Puli Space, official Google Lunar XPRIZE contestant.

2.7 GPRoG Experiment

Alexandra Zavitsanou [1]
[1] Department of Geophysics/University of Athens

The "Ground Penetrating Radar on Glacier" experiment (GPRoG) was conducted during the AMADEE-15 mission aiming at the subsurface investigation of the surrounding area from the base station, located at the Kaunertal rock glacier. For the purpose of this research a GSSI SIR System 2000 GPR device was used in combination with a multiple low frequency (MLF) antenna. Data acquisition was performed by analog astronauts along specified traverses. For the first time, there would be the possibility for acquired data to be interpreted during the mission and be used to plan new traverses.

Simulating a GPR prospecting using a terrestrial glacier analog provided the opportunity to check whether this geophysical operation can be conducted smoothly under the OEWF mission simulation conditions. These conditions are referred, first, to the fact that the user is in a spacesuit simulator which limits their mobility and capability of GPR instrument operation, second, the practically impossible prior examination of the study area by the PI regarding the terrain accessibility and third, the direct communication difficulty in case of unexpected problems in the field. These conditions proved to be quite unfavorable to acquire valuable data. A review of the experiment procedure and alternative suggestions in the case of problematic points will be discussed.

3 The Self Deployable Habitat for Extreme Environments

Joshua Nelson [1], Barnaby Osborne [1], Barbara Imhof [2], Waltraut Hoheneder [2], Rene Waclavicek [2], Stephen Ransom [2], Peter Weiss [3], Virginie Taillebot [3], Thibaud Gobert [3], Alvo Aabloo [4], Priit Kull [4], Jeremi Gancet [5], Joseph Salini [5], Gonzalo Rodriguez [5], Vratislav Saleny [6], Michal Vajdak [6], David Sevcik [6], Ondrej Doule [7]
[1] International Space University, [2] LIQUIFER Systems Group GmbH, [3] COMEX SA, [4] Institute of Technology, University of Tartu, [5] Space Applications Services N.V. / S.A., [6] Sobriety s.r.o., [7] Space Innovations s.r.o.,

The Self Deployable Habitat for Extreme Environments (SHEE) is a rigid segment deployable habitat test bed designed for use in space analogous environments. SHEE was developed under a three year European Commission FP7 grant.
The objective of the SHEE project was to develop a self-deployable habitat test bed that will support a crew of two for a period of up to two weeks in duration. During this time the habitat provides for all of the environmental, hygiene, dietary, logistical, professional, and psychological needs of the crew.

Unlike most space analog habitats, the SHEE can be transported via commercial transportation infrastructure, allowing for cost effective transportation to space analog sites across Europe. Once on site, the habitat can deploy autonomously with no human intervention required, and re-packs itself with minimal human assistance.

The primary structure and robotic deployment mechanisms for the habitat were completed in January of 2015, at which time the habitat was transferred to COMEX in Marseille for integration of habitat subsystems and furnishings. Testing of the completed habitat was at the International Space University in Strasbourg between July to December of 2015.

At the conclusion of the project, the SHEE was made available to the European scientific community for analog space simulations. The first field deployment of the SHEE will occur in April of 2016 as part of the Moonwalk H2020 campaign in Rio Tinto, Spain. It is anticipated that elements of the SHEE design will find practical applications in any hostile environment requiring an extended human presence, on or off the Earth.

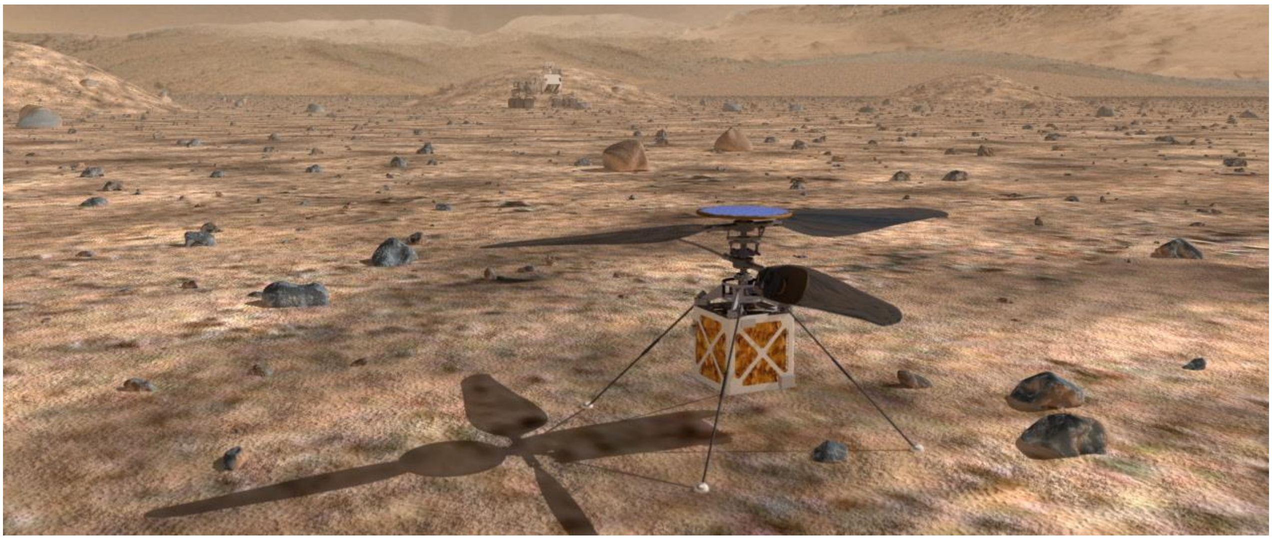
4 Mars Helicopter Scout: Visual and Inertial Sensor Fusion for Highly Resource Constraint Robots

Stephan Weiss [1]
[1] Alpen-Adria Universität Klagenfurt, Klagenfurt, Austria

Visual-inertial state estimation has significantly gained on importance in the last few years in both research and Industry. With the advent of powerful computation units, even more complex approaches are now capable of running on-board mobile devices. However, the latency and computational complexity of these algorithms still is an issue for closed loop control of highly resource constraint and agile mobile robots. In particular for space missions, computation power is very limited, while a high degree of autonomy of the mobile robot is desired.

This talk will discuss a visual-inertial state estimation framework that has ultra-low computational complexity but still has the ability of system self-calibration and, maybe more important, system self-healing upon sensor drop-out or algorithm failure. The framework seamlessly fuses visual odometry based position control with velocity control from inertial and optical flow cues to obtain a fast deployable platform which is robustness against otherwise critical events.

The self-calibration and self-healing aspect, and the continuous estimation of the robot state using only one camera and inertial cues render the approach ideal for autonomous robot navigation in remote environments. We will discuss how this framework is planned to be used in a technology demonstration for a small helicopter on Mars. The helicopter will scout and analyze the terrain to enable faster and safer motion of the rover on the ground. The challenges include autonomous take-off, area reconstruction, ego-motion estimation, and safe landing site detection all with a single camera and inertial cues.



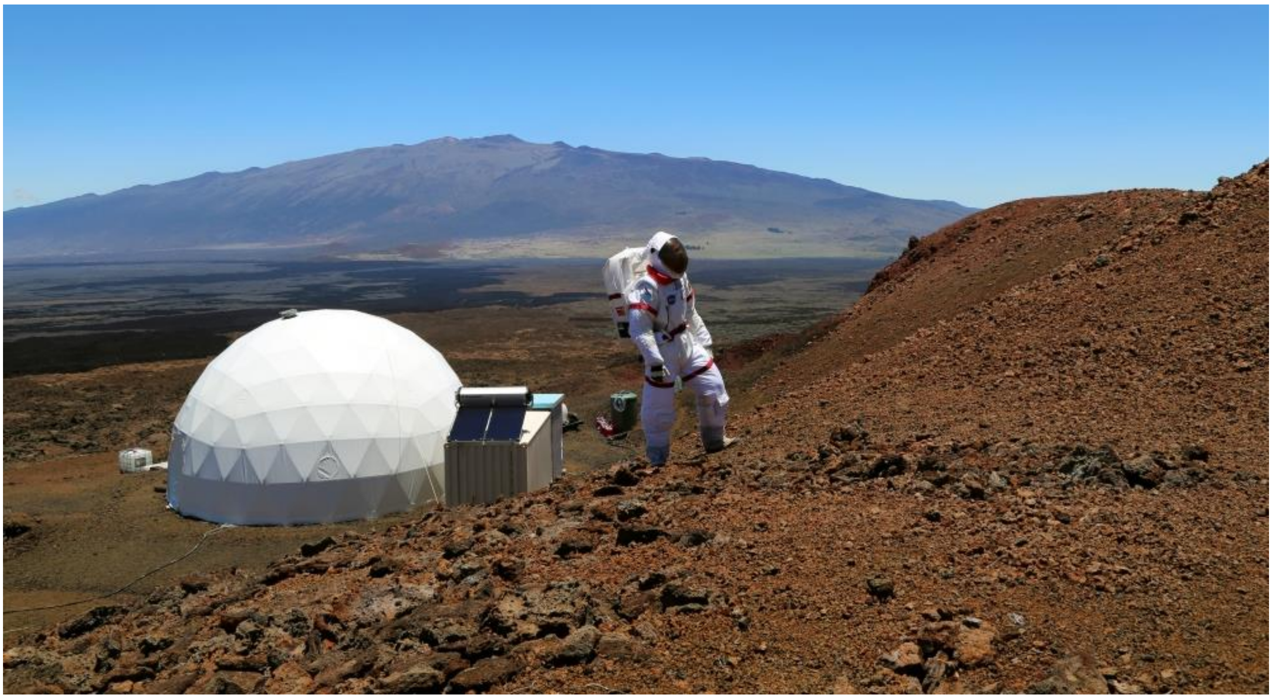
5 Mars on Mauna Loa, the HiSEAS Project

J. Nelson [1], K. Binstead [2]
[1] International Space University, [2] University of Hawaii

The Hawaii Space Exploration Analog and Simulation (HiSEAS) is a Mars analog habitat located in an abandoned quarry on the Mauna Loa volcano. Sited on an escarpment formed from a string of old cinder cones long a collapsed lava tube, the habitat provides an ideal location for analog studies. While isolated, the habitat is close enough to civilization to provide easy access for researchers, logistical support and emergency services.

With a diameter of 36 feet and a volume of 13,570 cubic feet, HiSEAS features six staterooms, one and a half baths, kitchen, dining area, lab space, technical workshop and storage areas. All extra-vehicular activities for both scientific and maintenance purposes are conducted using analog spacesuits. Mission support is provided both by a local logistics team and volunteer console operators spread around the world.

The first mission at HiSEAS occurred in 2013, with one mission conducted each year since with increasing durations. HiSEAS is currently conducting its 4th NASA sponsored analog mission consisting of six “astronauts” from four countries living and working together in the habitat for a full year. Additional missions are planned following the conclusion of the one year study and proposals for opportunistic research are always welcome.



6 The MOONWALK Project EVA simulations on terrestrial and underwater analogues

Dr. Peter Weiss [1], Dr. Virginie Taillebot [1], Thibaud Gobert [1][8], Arnaud Prost [1], Dr. Thomas Vögele [2], Mathias Höckelmann [2], Jakob Schwendner [2], Alistair Nottle [3], Dr. Barbara Imhof [4], Waltraud Hoheneder [4], Stephen Ransom [4], Robert Davenport [4], René Waclavicek [4], Diego Urbina [5], Tom Hoppenbrouwers [5], Dr. Knut Robert Fossum [6], Dr. Victor Parro García [7], Dr. Olga Prieto [7]

[1] COMEX SA, [2] Deutsches Forschungszentrum für künstliche Intelligenz, [3] Airbus Group Innovations, [4] Liquifer Systems Group GmbH, [5] Space Applications Services N.V. / S.A., [6] NTNU Centre for Interdisciplinary Research in Space, [7] Instituto Nacional de Técnica Aeroespacial, [8] Laboratoire de mécanique et d'acoustique de Marseille

The MOONWALK project (http://www.projectmoonwalk.net/) is a three year cooperative R&D project funded by the European Commission under the FP7 programme. The goal of the project is to develop and test technologies and training procedures for astronaut-robot cooperation in earth-analogue environments as it applies to Extra-Vehicular Activities (EVA) on Moon and Mars. Surface EVA will primarily include soil sampling and exobiology activities. Robots can help carrying material and equipment for the astronauts, assist in the installation of instruments, scout sites that are too dangerous for humans, or assist in search and rescue activities.

For MOONWALK, the underwater site at the Marseilles Space Analogue site will serve as a Moon mission analogue, while the Martian-like landscape of Rio Tinto in Spain will be the Mars mission analogue. Earth-analogues will enable the Moonwalk team to analyze, research and test operations and technologies to train future astronauts. The presentation will give an overview on the project's objectives and outline the planned simulations in 2016.