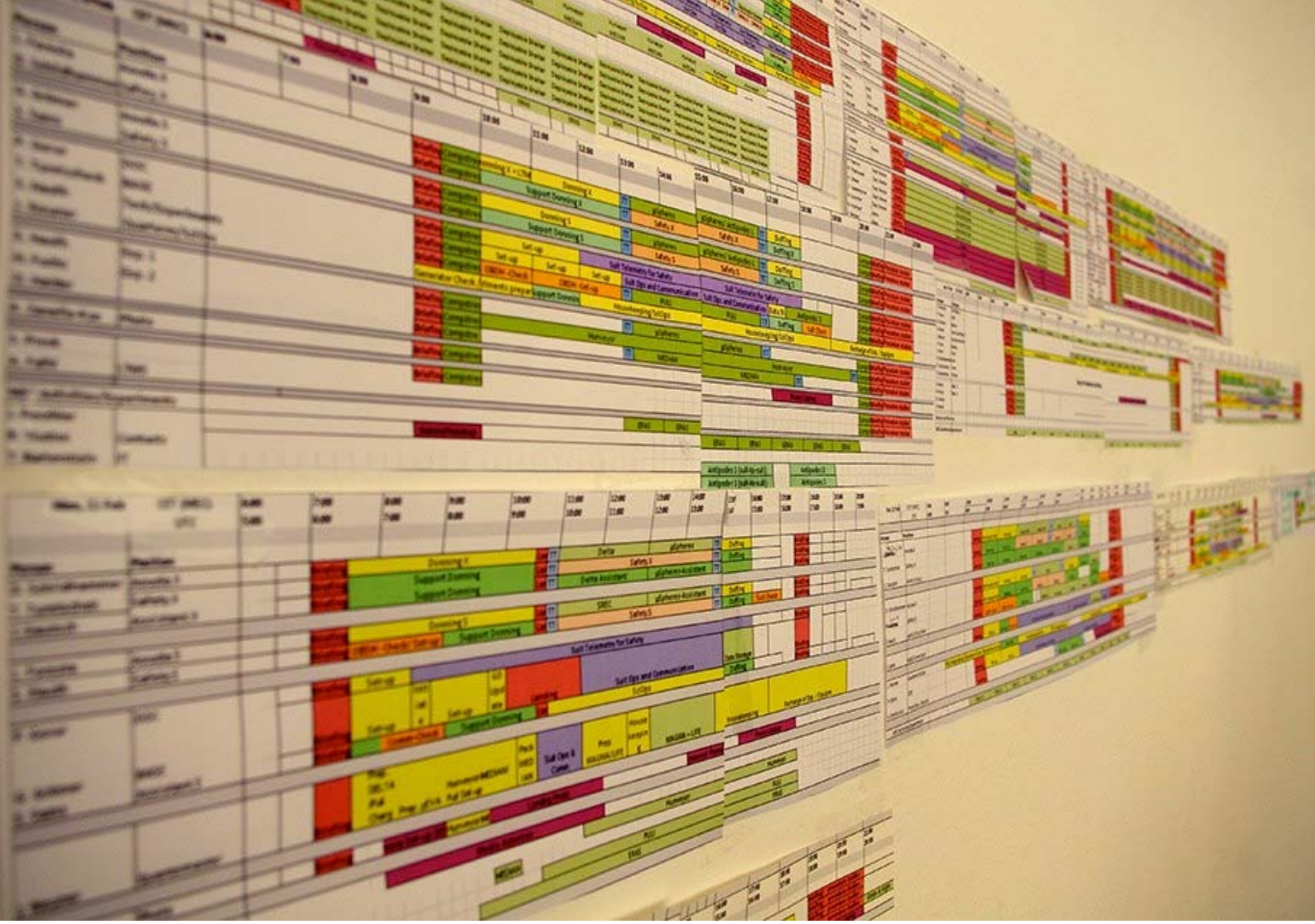

25-26MAY2013, VIENNA UNIVERSITY OF TECHNOLOGY, AUSTRIA

MARS2013 SCIENCE WORKSHOP

ABSTRACTS

VERSION 1.0, 20MAY2013

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GEOLOGICAL TRAINING FOR ANALOGUE ASTRONAUTS: LESSONS LEARNED FROM THE MARS2013 EXPEDITION, MOROCCO

C. Orgel (1,2), I. Achorner (2,3), A. Losiak (4), I. Gołębiowska (5), M. Rampey (6), G. Groemer (2,3) and the OeWF PolAres Team

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1. Introduction

As the result of lessons learned from the Río Tinto 2011 expedition [3], in 2012, we started to organise geological training sessions for the analogue astronauts. The idea was to give them basic geological background to perform more efficiently in the field. This was done in close imitation of the Apollo astronaut trainings that included theoretical lectures (between Jan. 1963 – Nov. 1972) about impact geology, igneous petrology of the Moon, geophysics and geochemistry as well as several field trips to make them capable to collect useful samples for the geoscientists on Earth [2] [4].

Figure 1: OeWF analogue astronaut is using hammer with the gloves of Aouda.X spacesuit simulator in Blaetterbach canyon, Italy.

Figure 2: GESU experiment with Aouda.X spacesuit simulator. Photo: Katja Zanella-Kux

In the last year the OeWF has organised three geoscience workshops for analogue astronauts as the part of their "astronaut" training. The aim was to educate the participants to make them understand the fundamentals in geology in theory and in the field (Fig.1). We proposed the "Geological Experiment Sampling Usefulness" (GESU) experiment for the MARS2013 [1] simulation to improve the efficiency of the geological trainings. (Fig.2).

2. Methods

MARS2013 – GESU experiment

In the desert of Morocco, four analogue astronauts underwent separate EVAs (Extra Vehicular Activity) along the same pathway (e.g. valley) to collect samples each time they find a new geological layer or something interesting for the scientists in the Mission Support Centre in Austria.

Based on the geological trainings, suit-testers should have been able to recognise different type of rocks (sedimentary, igneous or metamorphic rock) on the field or they should have been able to realise different appearing rocks. The suit-testers have diverse backgrounds (e.g. geophysics, physics, pilot, biology), but they received the same geological training.

Using the results of GESU experiment we were analysing the personal skills and decision working flow during the implementation of the procedure and which skills were more influencing than others using the audio files, which were recorded during the experiment. We also evaluated the geological content of the observations of the analogue astronauts.

3. Discussion & Conclusion

The quantity of the geological training sessions was not enough to implement complex geological field work for future analogue missions, thus we need to continue these trainings. The astronauts were not capable enough to describe the different geological features in detail in order to be understood by professional geologist. Future human Mars exploration definitely needs trained geologists among the crew members.

Acknowledgements

We would like to thank all people involved in the MARS2013 mission, especially the six analog astronauts of the PolAres programme for their attention and hard work during the geological trainings and the MARS2013 analogue simulation in Morocco.

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SPATIAL DECISION MAKING OF ANALOG ASTRONAUTS FROM MARS2013 PROJECT BASED ON THINKING ALOUD PROTOCOLS

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During mission many decisions has to be made by the field crew while the field explorating. An empirical study was carried out to obtain insight on how analog astronauts (not being professional geologists) make decisions on geological sample selection. During this experiment four different astronauts went during separate EVAs along the same pathway in order to collect a sample each time they find a new geological layer. The study aims at understanding of user behavior, so a qualitative approach (thinking aloud analysis) was adopted in order to answer the following questions: *In what way subjects perceive the geological structures? Can different strategies for problem solving be distinguished? What criteria are used in selecting the samples?*

The thinking aloud method was chosen as it provides direct, in-depth information on cognitive processes. It requires the subjects to voice their thoughts while working on a given problem and these responses are recorded. The audiorecording of astronauts' thinking aloud are transcribed and then segmented and coded by two coders working independently. This method is valuable in helping to understand the entire process of e.g. decision making and the strategies applied in problem solving.

THE ROLE OF MAPS IN PLANETARY AND ANALOGUE MISSIONS

Ania Losiak (1), Izabela Gołebiowska (2), Csilla Orgel (3,11), Linda Moser (3,11), Jane MacArthur (4), Steffen Wittek (6), Andrea Boyd (7), Isabella Achorner (8), Mike Rampey (9), Natalie Jones (10), Ulrich Luger (11), Alejandra Sans (11), and Sebastian Hettrich (11), Nina Sejkora (8, 11), Aline Dinkelaker (11,12), Isabela Pfeil (11,13), Quentin Scornet (11), Robert Terlevic (11)

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Maps are a crucial part of planning, execution and analysis of every planetary science mission. The usage of various maps during the exploration of extraterrestrial bodies started during the Apollo era and it continues until now. Maps play many different roles during the mission: e.g., they are crucial for defining the aim and limitations of the mission; they are necessary when choosing final landing sites; they allow scientists to define a proper scientific hypothesis; they are crucial for executing the mission; they allow appropriate planning (especially during the long-duration missions); and they can be used to develop appropriate safety measures. Usage of maps is also essential in post-mission data analysis leading to the final product – a new, updated map.

Until now, maps were not an important part of the OeWF analogue missions. Also, during MARS2013, the usage of maps was introduced very late (in December). The RSS team proposed and prepared a set of thematic maps (consisting of overview maps, geological map, suitability maps-one for every experiment, and danger map) aiming to facilitate the everyday mission planning and work of the field crew.

The evaluation if the maps played their expected role will be conducted based on two different approaches:

1) spatial analysis of the maps created during mission i.e., quantitative comparison of planned activities' locations with executed ones, the analysis among selected experiments' locations and well as across selected timeframes.

2) an analysis of the map usage process during the mission: questionnaire among all members of field crew and flight planning team, observation of planners actions during traverses development and daily activities for astronauts, as well as interview with a member of field crew.

The very initial results suggest that even though the maps were useful in the work of flight planners, they were used in a very limited scope by the field crew. We will discuss the reasons behind this situation and suggest some changes for the future. The empirical data collected during the mission (questionnaires, video recordings and audio recordings) on the map use processes and map users' opinions is a valuable source of information on how to improve maps in future missions.

EFFICIENCY ANALYSIS OF THE MARS2013 PLANNING STRATEGY

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[1]Austrian Space Forum, [2]University of Innsbruck, [3]University of Strathclyde, [4]Vienna University of Technology, [5]Space Application Services N.V.

On future human Mars missions, surface duration and resources will be limited and expensive. One possibility to approach a positive cost-benefit ratio of a human Mars mission will be to maximise the scientific research on Mars within the operational, environmental and experimental limitations. Sophisticated mission operations and advanced planning strategies will be a basic requirement for Mars exploration and therefore making operations research also a subject to current studies during Mars analogue missions conducted by the Austrian Space Forum.

The Morocco Mars Analog Field Simulation MARS2013 was with its four week duration in February 2013 and a simulated time-delay of ten minutes for communication between Field and Mission Support, the most advanced Mars Analogue Mission conducted by the Austrian Space Forum so far. Due to the long duration and the delayed communication, planning strategies based on real-time adjustments and ground-control were not applicable,, leading to the application of a “3-days-in-advance”-planning strategy. In this article we will discuss the analysis of the mission log files regarding time usage and achieved scientific goals in order to obtain a solid overview on the science efficiency of the MARS2013 mission and the suitability of the employed planning strategy.

ASTRONAUT VERSUS STOPWATCH:

THE DELTA EXPERIMENT OF THE MARS2013 MISSION

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(2) European Space Agency, Noordwijk, The Netherlands

(3) University of Osnabrück, Germany

Mars analogue mission planning is strongly influenced by the complexity of selected experiments that need to be accommodated. Up to now, one of the unknown yet planning-relevant factors was the time delay accumulated in field operations when operating with certain types of analogue space suits, as compared to a reference non-suit scenario. The DELTA experiment undertook to benchmark one of the most advanced Mars analogue space suits, the Aouda.X spacesuit simulator of the Austrian Space Forum, deriving for the first time and on sound statistical ground an algorithmic value of time delay experienced when conducting various standard activities using this spacesuit. The DELTA Value and its subsets will allow to better quantify or qualify Estimated Need Times (ENTs) for activities conducted during analogue field missions, leading to an improved mission flight planning through time allocation optimization. The presentation at the MARS2013 Science Workshop will give first insights into the data analysis of DELTA and is expected to show preliminary results.

STRESS, EMOTION AND GROUP DYNAMICS DURING MARS2013 – PRELIMINARY DATA

***Luger TJ*[1,3], *Stadler A*[1,3], *Gorur P*[2], *Terlevic R*[3], *Sansone P*[3], *Luger M*[1], *Toferer E*[1] & *Beck T*[4]**

[1]Dept of Anesthesiology and Critical Care Medicine, Innsbruck Medical University, Austria, [2]Dept. of Anesthesiology, University College Hospital, London, UK, [3]Austrian Space Forum, Innsbruck, Austria, [4]Dept. of Medical Psychology, University of Innsbruck, Austria

INTRODUCTION: During international science based Analog Mars missions participants are faced by stress, emotion and group dynamic effects when they are living in isolation and working together in a well defined habitat over a long lasting time (1,2). Less is known about the magnitude of these effects in a dessert environment (=Mars) in relation to a populated environment, such as the MSC (=Earth) working under the condition of a well-defined prospective work flow, the flight plan. Thus the goal of this study was to examine stress, sleeping behaviour, emotional status and groupdynamics in the field crew in comparison to the members of the MSC.

METHODS: During a five weeks lasting MARS2013 mission participants in the field (group F, N=14) and in the MSC (group M, N=14) were evaluated by means of validated questionnaires in a randomized, stratified, prospective study approved by the Ethical Committee of the Innsbruck Medical

University: Differential Emotion Scale (DAS, 3), Short Questionnaire Assessing Current Stress (KAB, 4), emotional experience and regulation (EER, 5), stress coping strategies (SV120, 6) and a group dynamics questionnaire. Measurements were performed at baseline, preparations week, and up to week 4 after start of the mission. Statistics: ANOVA for repeated measures and unpaired t-test; $P<0.05$=sign.

RESULTS: The groups were comparable with respect to demographic data, Stanford sleepiness scale, Epworth sleepiness scale, EER and the astronaut's behavioural questionnaire.

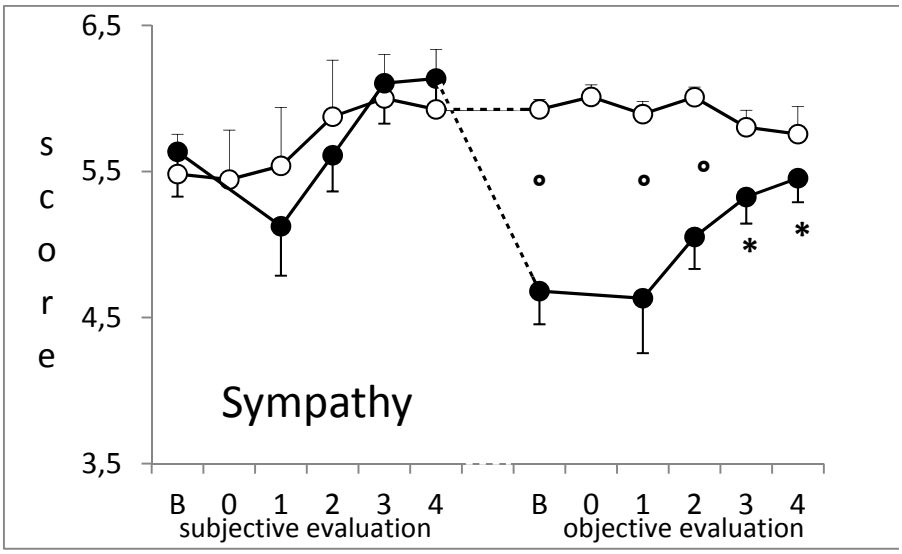

Fig. 1: Objective parameters of sympathy in group F (open dots) and group M (closed dots). Teamwork, and social competence showed comparable results. P ≤0.05, ° between group and * within group comparison.

During MARS2013 emotion and stress conditions remained stable in both groups. In group F, current strain was slightly decreased during the preparation week indicating a less stressful week at the beginning of the mission. With the exception of dominance (medium level) all other mean group dynamic parameters were at a high level.

Before starting the mission and in the first two weeks sympathy, teamwork and social competence were significantly lower in group M than in group F but these objective parameters were significantly increasing in the weeks 3 & 4 (Fig. 1).

Leadership and dominance did not differ between the groups and remained stable over time. Only some inter-individual differences were seen in both groups. A longer sleeping and bedrest time with a peak in the third week was observed in group F during the simulation weeks as compared to group M probably as a result of an overfatique of the field crew. The coldness over night in the Sahara can be seen in an increased frequency and quantity of wake-ups in group F. Astronauts were not different in their psychological behaviour.

CONCLUSION: We were able to demonstrate that from the medical point of view MARS2013 was a successful mission. However, for further analogue Mars missions the following recommendations may

be helpful. For those working in the MSC preparation weeks, forming a “MSC core group” and installing “familiarizing days” just before starting of the mission would be beneficial. For the field crew holidays, working and leisure times must be an unshiftable part of the mission plan. Environmental conditions should be recognized in the biomedical preparedness.

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TRAUMATA, ILLNESSES AND NEAR ACCIDENTS DURING MARS 2013

Stadler A[1,3], Gorur P[2], Terlevic R[3], Toferer E[1], Luger TJ[1,3]

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BACKROUND: During the four weeks analogue mars mission MARS 2013 in February crew members were working either in the Sahara of Morocco representing Mars (Field), or in the Mission Support Center in Innsbruck, representing Earth (MSC). The purpose of this prospective study was to observe the incidents in the field (group F) and in the MSC (group M). Additionally analogue astronauts were calculated as a subgroup.

METHODS: The data of week 1-4 were analyzed both in group F (N=39) and in group M (N=50). Incidents included trauma and illnesses as well as near accidents, controls and vaccinations were calculated and the severity was categorized by means of NACA score. The necessary therapy was listed. Statistics were used as appropriate.

RESULTS: Demographic data indicated that the groups were comparable to each other. Group F showed a significant higher incidents rate as compared to group M mainly due to a significant higher trauma rate. In contrast, the illnesses were not different. Subgroup analyses of the four analogue

	Group F (N=39)		Group M (N=50)		x^2 value
	N	**N/100h/Person**	**N**	**N/100h/Person**	
Incidents	73	1.7	23	0,4	18.7*
Trauma	60	1.4	6	0,1	34.4*
Illness	13	0.3	17	0,3	0.03
Near accident	3	0.07	0	0	1.8
Vaccination	1	0.02	0	0	0.01
Control	4	0,09	9	0.1	0.3

Fig. 1 Incidents, trauma and illnesses during MARS 2013. * Chi² test, P≤0.05.

astronauts showed a significant higher incidents rate as compared either to group M or group F.

CONCLUSIONS: Medical preparedness and the knowledge of previous incidents especially for such huge analogue mars missions are important to reduce the risks and to be prepared for possible trauma and illnesses. The implementation of a specific incidents database will be discussed.

SAHARA AS A LARGE-SCALE MARS ANALOGUE TERRAIN

Gian Gabriele Ori (1, 2), Ida Dell'Arciprete (2), Kamal Taj-Eddine (2, 3) and Goro Komatsu (1)

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The present-day environments of Sahara are the results of a large number of climatic changes that influenced the formation of sedimentary environments and geological features. The onset of Sahara is still unclear, however the first sand deposition in the adjacent Ocean and from evidence on the continent suggest that Sahara is older than 6.5 Ma that is at the end of the Tortonian or at the beginning of Messinian.

After this periods, Sahara underwent a number of climatic changes from dry to wet climatic conditions with the last one corresponding to the shift from the Glacial environment before 12,000 ya cold and dry to wet and warm at tye climatic optimum around 8,000 ya. During this optimum Sahara was a luxuriant savana with rivers, inland lakes, deltas, ecc.

These features, that are the product of the climatic changes are observable also on Mars where the environment has been dominated by early (Noachian) wet climatic conditions then by a number of wet period sandwiched by long dry periods where Aeolian sedimentation and erosion prevailed. Sahara is a unique continent-wide enviroment with strong similarities with mars in term of geological history and climate changes.

A CASE FOR GROUND-BASED THERMAL INERTIA MEASUREMENTS FOR DETECTING MARTIAN CAVES

Gernot Groemer(1,2), Luca Foresta(1), Thomas Turetschek(1) & MARS2013 team

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(2) University of Innsbruck, Austria

Martian caves are regarded as one of the most interesting locations for astrobiology. Remote sensing from orbit is less capable of detecting horizontal openings and is limited by the instrument footprint. We propose that thermal inertia measurements from the ground are an effective tool to identify candidate sites for cavities. During the MARS2013 expedition, data obtained at the Hamar Laghdad Ridge in the Tafilalt region in Morocco indicate that even small cavities can show a thermal behavior characteristically of caves. A cavity featured a temperature of 14±0.1°C before sunrise, which was above the ambient air (10±0.1°C) and rock temperature (09±0.1°C) at sunrise, whereas within 30 min after sunrise the contrast was inverted, when the surrounding rock temperature rose above 15°C. These measurements were conducted under simulated spaceflight conditions, including near-real time interpretation of data and implementing the data acquisition in a complex flight planning environment. We conclude that ground-based thermal contrast measurements in the 7 to 14 µm band before and after sunset are an effective method for Mars astronauts to identify cave candidates superior to space-based or ground-penetrating methods.

ANTIPODES

Haritna Mogasanu, Kiwispace Foundation, New Zealand

THE HUNVEYOR-4 A HUNGARIAN, STUDENT MADE SPACE PROBE

György Hudoba / Alba Regia University Center, Óbuda University, Székesfehérvár, Hungary

The HUNVEYOR project is a long term experimental, complex teaching program. It is currently running at several educational institutions ranging from high school to university level in Hungary. The project (engineering, constructing and using a planetary exploration robot) integrates many fields of science. The HUNVEYOR-4 is an advanced student-made Surveyor-class environment monitoring, internet controllable robotic lander with remote access, and suitable for “learning by experience”. Participating to the Mars2013 experiment, we wanted to test our “space probe”. Although the aim of our project basically is education, and we did not intended to operate our device in harsh environment, the HUNVEYOR-4 performed well, collected valuable data, and we get a lot of experience and ideas for further improvements.

CLIFF RECONNAISSANCE VEHICLE «CLIFFBOT » TESTS DURING THE MARS2013 SIMULATION

Alain Souchier, Planète Mars association

The Cliff Reconnaissance Vehicle or « Cliffbot », developed by the Mars Society French chapter, was used during the Mars2013 ÖWF simulation in Morocco in February 2013. Twenty tests were conducted with and without the Aouda analog suit.

This presentation gives the experimentation results regarding the four main objectives: all terrain trafficability, assessment of operating difficulties in analog suit, evaluation of the vehicle situation awareness from the video data transmitted, vehicle efficiency in terrain geological characterization. Concerning trafficability two main difficulties were encountered.

The operations in analog suit have presented no problems. The vehicle situation awareness for the vehicle operator has surely to be improved (more video cameras?). On a very interesting terrain, full of fossils, the vehicle has demonstrated its detecting capability.

MASH - DEPLOYABLE AND PORTABLE EMERGENCY SHELTER FOR MARS

Sandra Häuplik-Meusburger (1), DI Polina Petrova (1), Simon N. Evetts (2), Chan Sivanesan (3), Gernot Grömer (4)

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(4) Austrian Space Forum, PolAres Programme Office, Austria

The Mars surface infrastructure as anticipated for future human missions will probably include habitation, rover and infrastructure facilities. With regards to potential EVA / science activities to be performed on Mars and related safety issues, we propose an additional crew support element: A portable and deployable shelter which can be employed in the event of an emergency requiring immediate action and where return to the base / rover is not possible in time.

Following the selection of prospective emergency scenarios and the definition of design criteria, a series of preliminary designs for an emergency shelter have been developed within an academic design studio. A 1:1 prototype has been built and tested during the Morocco Mars Analog Field Simulation in February 2013[1] as part of an operational evaluation of this deployable and portable multipurpose shelter.

On-Site, in Morocco the operability (deployment and retraction), the durability (multiple deployments), functionality (human-equipment-shelter) and adaptability (functional usability) were tested by analog astronauts. Additional issues that were explored and evaluated included spatial usability, ergonomic suitability to actions and individual perception of comfort in relation to the activities.

This paper will introduce potential emergency scenarios and the design criteria for an emergency shelter. Furthermore, selected design concepts will be introduced and the current prototype will be presented, concluding with lessons learned and updated design requirements.

MARS2013 - PULI ROVER EXPERIMENT

Hungarian Google Lunar X Prize team

The PULI rover is intended to **the Moon, a hard terrain planetary exploration rover:**

- 4 wheel legged, 10 kg construction, remotely controlled from Budapest based on stereo images
- Robotics robust architecture, solar panel charged batteries, microcontroller driven voltage/current/thermal sensors, 4 spacegrade Maxon motors
- Software system providing reliable telemetry communication, valuable pictures for navigation and social media

Designed to move large distances, navigate harsh environments (Moon/Mars) craters, rocks, steep slopes, extreme temperatures, dust.

Tested for mobility, Mission Control software, handling, navigation.

Second generation rover, **a result of** 28,000 working hours of:

- mechanical, electrical and software engineers, and supporters from wide range of professions
- 1 year trade studies and computer based planning
- 1 year rover building and testing, software development, educational/outreach activities
- 6 month equipment preparation, Mission Control Center setup, staff training

[1] Between 01 - 28.February 2013, the Austrian Space Forum conducted an integrated Mars analogue field simulation in the northern Sahara near Erfoud, Morocco in the framework of the PolAres research programme.

WORKSHOP PROGRAMME
25May2013

09:15	**Welcome adress**	G. Groemer
09:30	**The MARS2013 Mission**	G. Groemer
10:15	**Geological training for analog astronauts: Lessons learned from MARS2013**	C. Orgel
10:35	**Spatial decision making of analog astronauts from MARS2013 project based on thinking aloud protocols**	I. Golebiowska
10:55	Coffee Break	
11:10	**The role of maps in planetary missions**	A. Losiak
11:35	**Efficiency Analysis of the MARS2013 Planning Strategy**	S. Hettrich
12:05	Lunch Break	
13:45	**Ground truthing discussion - Establishing a georeference** **Comparing the georeference** **What went right/wrong/completeness**	Plenary discussion
15:45	Coffee Break	
16:00	**Astronaut versus stopwatch: the DELTA experiment**	A. Soucek
16:25	**Stress, emotion & groupdynamics during MARS2013 – preliminary data**	T. Luger
16:50	**Traumata, illnesses and near accidents during MARS 2013**	A. Stadler
17:15	**Sahara as a large-scale Mars analogue terrain**	G. G. Ori
17:40	Coffee Break (parallel: Google Hangout / Paris, 17:45)	
18:15	**Upcoming Analog Missions**	G. Groemer
18:30	**TyroMars2014 concept presentation**	S. Hettrich & C. Orgel
19:00	Conference Dinner , sponsored by the Austrian Federal Ministry for Science and Research	

Sunday, 26May2013

09:00	**Detecting Martian Caves with Thermal Inertia Measurements**	G. Groemer
09:15	**Antipodes**	H. Mogasanu / via Skype
09:30	**microEVA**	A. Noell
09:45	**MAGMA**	M. Josefowizc
10:00	Coffee Break	
10:15	**Hunveyor-4, a hungarian, studentmade space probe**	G. Hudoba
10:35	**CRV / Cliffbot**	A. Souchier
10:55	**MASH Deployable Shelter**	P. Petrova
11:15	**MARS2013 - Puli rover experiment**	A. Bardi et al.
11:35	**Vienna Statement for Analog Research**	G. Groemer
	Outlook / Closing remarks	
12:30	Lunch Break	
13:30	**Mini-Workshop (2 hrs)**	R. Albrecht / G. Groemer
	How to write peer-review papers	