IAC-15.E5.2.2

EXOHAB1 DEVELOPMENT: SPIN-IN/OUT FROM SPACE HABITAT TO DISASTER MANAGEMENT FACILITY

Authors: Dr. Irene Lia Schlacht
Politecnico di Milano, Italy, irene.schlacht@mail.polimi.it

Prof. Bernard Foing
ESA/ESTEC, The Netherlands, Bernard.Foing@esa.int

Prof. Giulio Ceppi
Politecnico di Milano, Italy, giulio.ceppi@polimi.it

Abstract

The ExoHab1 project aims at providing a bench technology for testing the technology/knowledge spin-in and spin-out for a laboratory/habitat module in extreme environment from entities that work for space and other extreme environments outside the space sector, such as disaster management. The laboratory/habitat should be set up quickly immediately after a disaster as a safe location from where to operate in autonomy from, for example, contaminated area. The technologies applied in ExoHab1 aim to increase laboratory/habitat autonomy in terms of resources, communication, and safety. Water, energy, and communications are the main areas of focus from the technological side, while research on human factors design is also applied for the safety performance and comfort of the user. The habitat system is supposed to be as regenerative as possible to achieve maximum autonomy and also support the best interaction with the user. This technology will refer to the improvement of the ISS's space habitat system. Not only the technology will be tested and transferred from and to space, but also the knowledge and the research done in the areas of human factors, ergonomics, design, psychology, architecture testing, as well as cultural application.

In particular, the first step of the Exohab1 project is presented here, achieved with the testing of a mission simulation performed with the ExoLab module - appositely developed as a first functional mock-up - and the ExoHab habitat module, which has already been operational since 2009 at ESA ESTEC (European Space Research and Technology Centre in the Netherlands). This paper also presents the first results of the possibility for design development developed at Politecnico di Milano. The goal of this phase is to get multidisciplinary experts from the engineering, scientific and artistic fields involved in the development, testing, finalization, and optimization of the habitat (minimum space, time, and costs).

In the next step, the operational habitat will be used to test procedures and technologies for living and working in extreme environments. The Exohab1 project targets the capability to address large organizations, such as aid agencies that need to work in disaster environments, and is intended to be applied for testing technology spin-in and new know-how in the space sector.

I. INTRODUCTION

In the context of building a minimum autonomous modular architecture for the Moon & extreme environments on Earth, a simulation has been performed that also considered the potential use for art- and science-related applications. More specifically, ExoHab and ExoLab have been set up as technical mock-ups at ESTEC for the purpose of multidisciplinary mission simulation [1,2, 3].

In this context, different projects for the development of the best structure have been developed involving experts from the fields of art, design, architecture, and engineering.

II. ART & SCIENCE

Space should be a place for both scientific and cultural applications, "Art in Space will give a new dimension to the artistic production expanding human culture" (B. Foing in [4]). In this context, art has been selected as a discipline with great potential for generating new ideas and applications for both the space industry and the arts.

As explained by the Royal Academy of Art [5], artists specializing in art & science are artists who translate their experience of the world into visions that could enhance the quality of life with future forms of art. Those artists are inspired both by art & science and are able to create new types of mediums for art projects. Particularly by questioning the human-environment relationship from both an artistic and a scientific point of view, these artists propose developing new mediums and new ways to support space missions. A form of collaboration in "which scientific concepts are seen as a kind of 'content', and where the artist translates these concepts into images, sounds or other experiences" may trigger radically new kinds of artistic development [6] .

III. THE DESIGN PROJECT

Different structural and conceptual projects have been developed for ExoLab and ExoHab, in particular during the TodaysArt workshop and in cooperation with different universities. We report here on last design concept developed with the cooperation of Politecnico di Milano and presented in an IAC paper.

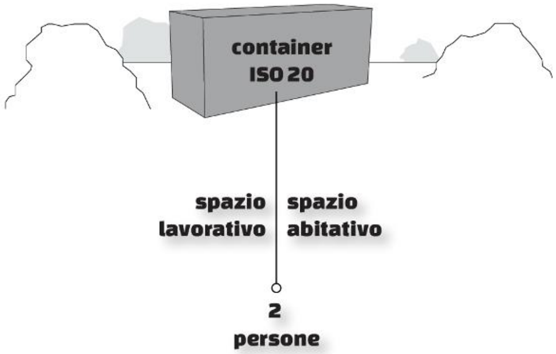

Fig. 1 Concept: Container as an international standard and modular facility to develop a laboratory for extreme environments

Fig. 2 Plan of the container structure

Fig. 3 Working, exercising and sleeping in the container

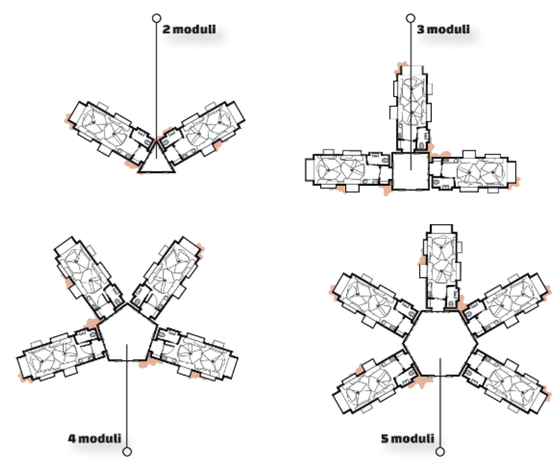

Fig. 4 Configuration with more modules to simulate Moon Village mission

The project is based on particular restrictions in order to be applicable in extreme environments. These restrictions were to organize a living space for two scientists inside an ISO 20 container – about 15 square meters in size. On the project the space is multifunctional and convertible; the different areas (working station, kitchen, and lounge area) are mostly open and common, but guarantee privacy when convenient. Shapes, colors, materials, scents, and sounds are an essential part of the project.

The project apply three different systems: rotating platforms placed at various heights, a ceiling rings trestle, and flippable shelves. The rotating platform were designed to create different combinations with platforms of the same support, platforms on the other support, or with the flipping shelves. These four shelves are placed exactly under expandable bow-windows to elongate the space even more and obtain more surface. When not in use, they can be flipped back into the walls. The trestle is attached to the ceiling; it consists of several rings that can be used for gymnastic purposes or as support for external elements such as hammocks or other hanging elements. The space is arranged following the logic of placing the entrance on the short side of the container, where we also put the airlock as a filter to protect the interior. Inside the hab on the right, there is a small bathroom and on the left side is a kitchen area that opens up to the remaining space where all of the technologies are located. That space is where the majority of daily activities happen.

This is how this project meets the requirements and demonstrates how to create a flexible, volumetric, and osmotic living and working environment [7].

IV. THE SIMULATION

On 29 May 2015, ExoLab was structured and equipped as a technological mock-up to perform a space mission simulation. A team of nine members was invited by the ILEWG to address specific tasks as part of the simulation to verify how persons from different humanistic and technical fields could add value to a space mission.

Crew structure & background

The crew had a classical task and hierarchy structure, but with members from different humanities & scientific fields, divided between: remote support, ExoHab & ExoLab module, and ATV observatory.

• Remote support: Campaign director (Bernard Foing – science, technology & logistics), Commander (Irene Lia Schlacht - design & engineering), Mission Support (Jolanda W. Preusterink – operations and education)

• ExoLab: Executive Officer (Miha Tursic - art); Crew Engineer (Desmet Guillaume - engineering architecture); Health & Safety Officer (Eva Petric – art & psychology)

• ExoHab: Crew biologist (Spela Petric – bioart)

• ATV observatory: Crew Astronomy Specialist (Ludwig Pasenau – exoclimatic art); Crew Scientist (Natali Blugerman – Art & Science)

Simulation

During the simulation, the crew performed research of form of life in EVA, while the crew astronomer and the biologist worked in their fields of research, also getting inspirations for cultural applications. During the EVA, a communication breakdown was planned and two astronauts in EVA performed a safety emergency procedure while the crew biologist and the crew health & safety officer were left alone, each in one of the modules, to try and reconnect the communication. The crew members left alone experienced psychological reactions related to the feeling of isolation.

Equipment & Procedure

Ordinary equipment was used to simulate professional equipment for extreme environments in order to perform the simulation at this first stage. For example, instead of an EVA helmet, a motorbike helmet was used, a backpack with weights was provided to simulate the oxygen tank, etc. This provided the opportunity to easily perform the first simulation, learning and understanding which equipment development will need to have priority in order to increase the quality of the simulation level in the next step of the project.

Appropriate procedures are one of the most important things to create the feeling of simulation and make the results reliable. The procedure used referred to a basic space mission configuration.

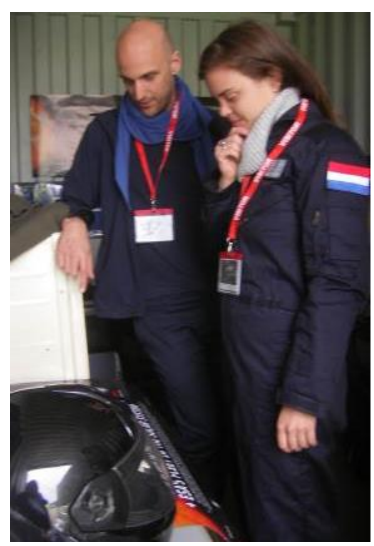

Fig. 5 Two crewmembers inside ExoLab

Fig. 6 ISO container equipped for ExoLab mission simulation

Fig. 7 Airlock to access the ISO container

Fig. 8 Airlock

Fig. 9 ExoLab interior: logistics and geological work stations

Fig.10 Crew inside the ExoLab preparing for EVA

Fig. 11 Putting on EVA suits


Fig. 12 EVA equipment check and final preparation inside the airlock


Fig. 13 Waiting during pressurization time in airlock

Fig. 14 Entering the extreme environment from the airlock

Fig. 15 Second crewmember approaching the EVA


Fig. 16 Crew in EVA measuring UV of a rock


Fig. 17 Sampling

Fig. 18 Crew in EVA experiencing communication connection problems with ExoLab

Fig. 19 Left image: Crewmember in ExoLab has no more communication connection with EVA crew. Right image: Crewmember inside ExoHab tries to connect with the crew in EVA.

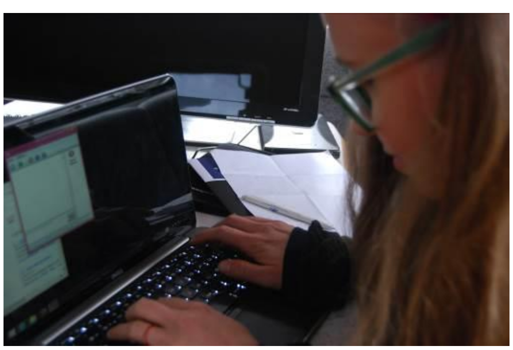

Fig. 20 The crewmember successfully communicates with the crew in EVA using the ©swyMe ow-bandwidth communication system for extreme environments

Fig. 21 The crew in EVA safely reaches ExoHab

Fig. 22 The crew is safe inside ExoHab

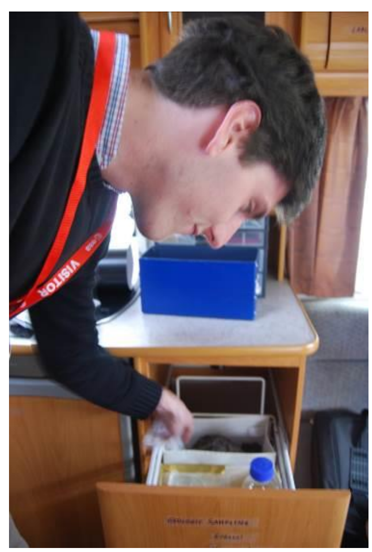

Fig. 23 Samples are stored safely

Crew tasks

Below, the simulation tasks are described in detail.

The simulation was performed considering two scenarios:

- Scenario 1. Moon
- Scenario 2. Radioactive disaster on Earth

Task 1. Preparation brief on equipment function & their preparation

Steps:

a. EVA: Air Lock/EVA suits/helmets/gloves
b. Communication: power, PC, Internet walkie-talkie, Swy me, camera.
c. Geo sampling of life: UV lamp, sampling container, labeling tools, PC for communication, walkie-talkie.
d. Astronomy: binoculars small and large, with projection

Task 2 EVA preparation

Steps:

a. Crew set up DRAFT: person – 2 ExoHab, 2 ExoLab, 2 EVA, 2 monitoring and reporting (Irene, Yo)
b. ExoHab -> As remote control center: EVA communication set up with swy me
c. ExoHab -> As remote lab: EVA communication walkie-talkie/ EVA geo sampling coordination/ astronomy
d. EVA -> at ExoLab: communication walkie-talkie/ geo sampling activity/ astronomy

Task 3 EVA

Steps:

a. ExoLab: gather the equipment to be taken
b. Air Lock: dress and place the equipment to the body close the airlock and exit
c. Communication: check the communication and proceed to EVA for geo sampling exploration getting the ExoLab update
d. Find rock with life, take picture of location, collect, label, take a picture with labeling to memorize it as a reference to the location picture.
e. Communicate with ExoHab using ©swyMe (Safety verification: simulating a breakdown of communication with ExoLab)
f. Re-entry mission to ExoLab
g. Proceed through airlock and return equipment

Task 4 Debriefing

a. Consider relevant issues related to safety, performance, and comfort for the following factors: physiological, operational- technical, environmental, psychological, socio-cultural
b. Each person selects the most important issue and discusses this with the crew: relevance, how to solve it if it is a problem, how to use it if it is a positive challenge.
c. Crew discusses the feasibility and relevance of applying the procedure in Scenario 2
d. The coordinators takes notes

Task 5 Astronomy

a. Moon
b. Sun projection

Fig. 24 Mission simulation: astronomy tasks

V. SIMULATION RESULTS

The simulation was performed successfully; each task was addressed appropriately. During Astronomy Task 5, the Moon was observed and also a Sun projection was made; moreover, an artistic video was also realized.

Fig. 25 Space weather Artistic Video, based on Sun projection on a paper created during the astronomy task © Pasenau.

Fig. 26 Artistic picture created during the astronomy task © Pasenau.

During task 3: EVA, the crew collected rocks and experienced the communication breakdown. During the communication breakdown, the crew was supposed to find a solution; however, they needed advice from the remote support team in order not to disrupt the simulation and to improvise a solution. This caused a delay regarding the planned time. The configuration was: 2 crew members in EVA (c3,c4), 1 crew member in ExoHab (c1), and 1 crew member in ExoLab (c2). The EVA started from ExoLab with the search for signs of life on rocks. After the communication breakdown with ExoLab, the crew decided to get in contact with ExoHab. The crew member in ExoHab communicated to them the way to reach the ExoHab module, while the member in ExoLab was left alone with no communication connection.

The complete EVA took about 60 minutes, and the ExoLab crew member left alone experienced isolation.

Debriefing

After the EVA, the simulation concluded with a debriefing, performed in accordance with the "Habitability Debriefing" procedure, which holistically considers all human factors involved in the mission. The debriefing results are reported here anonymously and divided according to the factors from the procedure.

Operational factors problems: Communication (c1,3,4), Nothing was working in ExoLab (c2), Could not use track pad with gloves (c4), during the day, the UV instrument had no darkness to properly work and identify the right sample.

Physical & environmental factors problem: Cold (c1,2,3,4).

Socio-cultural and psychological factors problem: You saw a cat and got very surprised (c3). I did not see a cat; he had a hallucination. However, I could still rely on him (c4). I got bored, I checked the equipment, and I panicked because of the boredom. I felt hungry and I did not find the water to prepare the food, then I got the communication task (c1) –*note that the crewmember recognized that the water labels indicating the water locations were easily visible in ExoHab; however, during the simulation she was not able to find it* –; panic, no equipment was working, I focused on sensory perception and I could listen to the people on EVA – *as they were close* – but then there was no more sound. I was scared and was in panic; I tried to calm down by remembering socio-cultural past experiences from my life.

After the discussion of the problems, improvement suggestions, successful achievements, and lessons learned were discussed.

Improvement suggestions: social care (c2,3) need for dedicated equipment for communication technology, sampling technology (no dark area for UV), gloves.

Successful achievements: the sampling was performed successfully (c1,2,3,4); experiencing the feeling of isolation (c2); getting documented – *accessing literature available on ExoHab, the crew member was inspired* – & learning to avoid boredom (c1); time was slowed down (c4); sharing hands with the others when using instruments (c3); waiting time was interesting (c3).

Space vs. Earth scenario

Finally, a comparison between the scenarios was discussed. The aim was to discover the applicability and the use of simulation in disaster contexts, such as Fukushima radioactive scenario on Earth.

The comments were as follows: yes, the procedures are the same, just looking for radioactivity instead of for rocks and life (c4); psychologically, there is a great difference between a dead landscape – *the Moon* – and a killed planet – *Earth after a nuclear disaster* – that is your home (where a cat is not a hallucination); the only thing they have in common is that they are both a battleground for survival (c3,1); both are hostile environments: in the second scenario, you can easily reach safe conditions even if the communication breaks down (2); it is a different psychological approach: in a radioactive environment on Earth, performing a mission is not a wish, while in space it is (remote support c); the Moon is different than the Earth (another kind of remote support c).

VI. CULTURAL RESULTS

The simulation inspired the members on the cultural and artistic level. With the approval of the crew members, we summarize the results that are relevant to artistic inspiration derived from the simulation.

• Executive Officer Miha Tursic: performed the EVA search for life forms. Was inspired by questions of developing new life or life-like forms to inhabit the Moon or other planets.

• Crew Scientist Natali Blugerman: performed EVA & planet observation. Was inspired in her project on ice observatory as a connection between humans and space with elementary elements such as ice and fire developed with an ice lens.

• Crew Astronomy Specialist Ludwig Pasenau: performed a telescopic solar observation to prevent the crew from suffering from radiation. Was inspired by a video (Image1) shooting of the Sun and the atmospheric activity to develop a series of space weather videos. These works could nurture an exoclimatic art project for future astronauts engaged in a long-duration mission.

• Crew Biologist Spela Petric: provided communication support for the EVA team. Was inspired on a new artistic concept regarding the differences in growing biological life on different planets in our solar system.

• Health & Safety Officer Eva Petric: was isolated in the ExoLab module. Got access to her body perception, memories, and personal inner emotions. Was then inspired to write a text about her sensory perception.

Fig. 27 Discussing cultural applications

Fig. 28 Artwork inspired by the universe ©Eva Petric

VII. CONCLUSION

The ExoHab and ExoLab were structured and equipped to successfully support a mission simulation. The mission simulation was applied to 2 scenarios: moon and earth disaster context.

During the simulation EVA, astronomy and biology research was performed, which was also inspired from the artistic and cultural applications.

During the EVA, a communication breakdown was planned and two astronauts in EVA performed a safety emergency procedure while the one crew member in ExoHab and the one crew member in ExoLab were left alone trying to reconnect the communication and experienced the feeling of isolation.

THANKS to the team and all the people, entities and institutions involved

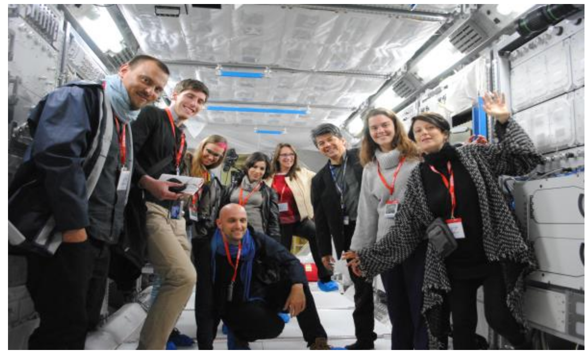

Fig. 29 The mission simulation team, ESA ESTEC 2015

RELATED PUBLICATIONS

• Schlacht, I.L., Ono, O., Karga, V., Mangeot, A., Roetting, M., Masali, M., Foing, B. (2012). Extreme Living Solutions: Autonomous habitats IT for extreme environments based on space technology. IAC- IAC-12.E5.3.9. IAC2012 1-5/10/2012. Napoli: Italy. http://www.iafastro.net/download/congress/IAC-12/DVD/full/IAC-12/D4/4/manuscripts/IAC-12,D4,4,2,x15800.pdf

• Blume Novak, J. (2000). Summary of Current Issues Regarding Space Flight Habitability. Aviation, Space, and Environmental Medicine, Vol. 71, No.9, Section II, September 2000 (pp. A131-A132)

• AA.VV (1999). SSP 50005 International Space Station Flight, Crew Integration Standard. Revision C (NASA–STD–3000/T). ASI, CSA, ESA, NASA, NASDA.

• Schlacht I.L. (2012). SPACE HABITABILITY: Integrating Human Factors into the Design Process to Enhance Habitability in Long Duration Mission. Doctoral Dissertation, Technische Universität Berlin, Germany. Published from the TU-Berlin. Online http://opus.kobv.de/tuberlin/volltexte/2012/3407/ ISBN 978-3-00-041524-1

• Schlacht, I.L., Roetting, M., Masali, M., Foing, B., Toriizuka, T., Imhof, A. B. (2012). Human Factors in the Space Station Design Process IAC-12.B3.2.8. IAC2012 1-5/10/2012. Napoli: Italy. www.iafastro.net/download/congress/IAC-12/DVD/full/IAC-12/B3/2/manuscripts/IAC-12,B3,2,8,x15793.pdf

• Spin-in is the transfer of innovation from Earth to Space; spin-off is the transfer of innovation from Space to Earth.

• B.H. Foing et al., Astrobiology field research in Moon/Mars analogue environments International Journal of Astrobiology / Volume 10 / Special Issue 03 / July 2011 http://journals.cambridge.org/action/displayIssue?jid=IJA&volumeId=10&seriesId=0&issueId=0

- Outreach ILEWG euroMoonMars campaign: https://www.google.nl/webhp#q=euromoonmars+ilewg&tbm=isch https://www.google.nl/webhp#q=euromoonmars+ilewg
- "Usually the assessment is done without equipment, if an equipped container is provided in loco it will be used". ASB Samaritan International from EU: Head of catastrophes & Humanitarian foreign help (Edith Wallmeier courtesy personal communication, 28.02.2013)
- Karga, V., Schlacht, I.L. (2012). Self-sufficient and sustainable technology for habitat systems from Space to Earth. IAC- IAC-12.E5.3.9. IAC2012 1-5/10/2012. Napoli: Italy. www.iafastro.net/download/congress/IAC-12/DVD/full/IAC-12/E5/3/manuscripts/IAC-12,E5,3,9,x13292.pdf www.technologyforum.com/fileadmin/technologies/1358932822_1493_Radiation_Shielding.pdf http://www.nasa.gov/pdf/167129main_Systems.pdf
- Schlacht, I.L., Roetting, M., Masali, M., & Micheletti Cremasco, M. (2009). Human Factors in Space Mission. In: Lichtenstein, A., Stößl, C., & Clemens, C. (Ed.). Der Mensch im Mittelpunkt technischer Systeme. Proceeding of 8. Berliner Werkstatt Mensch-Maschine-Systeme, 7-8.10.2009, Berlin, Germany. ZMMS Spektum Band 22 (Print Abstract p. 142; Paper in Cd-rom pp. 326-330). Düsseldorf: VDI-Verlag. ISBN: 978-3-18-302922-8
- Schlacht, I.L., Voute, S., Irwin, S., Mikolajczak, M., Foing, B., Westenberg, A., Stoker, C., Masali, M., Rötting, M., Crew 91 & Mission Support (2010). Moon-Mars Analogue Mission at the MDRS. EuroMoonMars-1 Mission. Code: GLUC-2010.3613. GLUC 2010 Congress (Beijing).
- Schlacht, I.L, Ono, A., Bates, S., Peldszus, R., Masali, M., Roetting, M., Ligabue Stricker, F., Foing, B., Westenberg, A., Stoker, C. (2010). Mars Habitability Project at MDRS. Sensory Experience and Creative Performance for Manned Planetary Exploration. IAC-10.E5.1.1 Prague.
- Mangeot, A., Hendrikse, J., Schlacht, I.L., Ono, A., Rai, B., Poos, W., Zhao, W., Rammos, I., Rodrigues, L. (2012). Human-Robotic Partnerships and Performance: Lessons Learned From ILEWG Euromoonmars Campaigns 2012 and 2011. IAC-12.A5.3-B3.6.2. IAC2012 1-5/10/2012 Napoli: Italy. www.iafastro.net/download/congress/IAC-12/DVD/full/IAC-12/A5/3-B3.6/manuscripts/IAC-12,A5,3-B3.6,2,x15802.pdf
- Hendrikse, J., Theatre, k., Lan San, A., Benchenafi, R., Bourges, Q., Ansart, M., Dompnier, R., Ono, A., Schlacht, I.L., Ferreira, I., Rai, B., Foing, B. (2012). Human Robotic Partnerships: experience from terrestrial analogues campaigns. GLEX-2012,04,P,5.p1,x12685. Global Space Exploration Conference 2012 (GLEX). 22-24 May 2012 Washington, DC, USA
- Schlacht, I.L., Hendrikse, J., Hunter, J., Karga, V., Mangeot, A., Ono, A., Rai, B., Ferreira, I., Benchenafi, R., Foing, B. (2012). MDRS 2012 ILEWG campaign: Testing habitability and performance at an analogue moon base infrastructure outpost on earth. IAC-12.A5.1.2. IAC2012 1-5/10/2012. Napoli: Italy www.iafastro.net/download/congress/IAC-12/DVD/full/IAC-12/A5/1/manuscripts/IAC-12,A5,1,2,x14231.pdf
- Schlacht, I.L., Brambillasca, S. & Birke, H.(2009). Color Perception in Microgravity Conditions: The Results of CROMOS Parabolic Flight Experiment. In: Microgravity-Science and Technology Journal. Springer, 21 Nr. 1, pp. 21-32.
- Magazine: Schlacht, I.L. (2010). Designing Moon Life Experience. Volume 2010 #3 Getting There Being There. Amsterdam, Holland: Stichting Archis. pp. 174-181, ISBN: 9789077966259 Magazine E013694
- Schlacht, I.L. (Chapter Ed.). (2010). Chapter 3. Habitat Design. In: Benaroya, H. (Ed.) Lunar Settlements. Rutgers University Symposium, Boca Raton, FL, USA: CRC Press, Taylor & Francis. ISBN: 978-1-4200-8332-3
- Schlacht, I.L. (Ed.). (2011). Chapter: Space Extreme Design. In Personal and Ubiquitous Computing. Volume 15 Number 5 pp. 487-526. Formerly Personal Technologies (2000-2000). Online www.springerlink.com/content/1617-4909/15/5/ ISSN: 1617-4909 (Print) 1617-4917 (Online) Magazine E130274
- Schlacht, I.L. (2009). Quality of Life in Space. Life on Earth as Simulation to the Psychological Stability in Space. Workshop on Human Behaviour and Performance in Analogue Environments and Simulations, 7-8.12.2009 ESA/ESTEC, Noordwijk, The Netherlands.
- Messerschmid, E., et al. (2009). SSDW 2009 Final Report. IRS Workshop Report, Institute of Space Systems, Universität Stuttgart. http://www.irs.uni-stuttgart.de/ssdw/history/results2009.en.php http://www.irs.uni-stuttgart.de/ssdw/documents/SSDW09_FinalReport.pdf
- D. Quantius, D. Schubert, V. Maiwald, R. París Lopéz , J. Hauslage, W. Seboldt, O. Doule, I. L. Schlacht, S. Ransom; „Initial design of laboratories

for sustainable habitation“, Acta Astronautica, Vol. 94 (2014), pp. 541-562

- Schlacht I.L. (2012). SPACE HABITABILITY: Integrating Human Factors into the Design Process to Enhance Habitability in Long Duration Mission. Doctoral Dissertation, Technische Universität Berlin, Germany. Published from the TU-Berlin. Online http://opus.kobv.de/tuberlin/volltexte/2012/3407/ ISBN 978-3-00-041524-1
- American Heritage Dictionary retrieved from http://www.answers.com/topic/disaster
- As an example, the current development of the habitation around Mt. Vesuvius in Naples, Italy.
- Escalation of both the frequency and severity of disasters is also caused by global warming and unstable land forms, coupled with deforestation, unplanned growth proliferation, and non-engineered construction.
- http://ec.europa.eu/commission_2010-2014/georgieva/hot_topics/european_disaster_response_capacity_en.htm
- Disaster retrieved from http://disastermanagement1.blogspot.de/
- EU 2007-2013 Research and Innovation program http://ec.europa.eu/research/fp7/index_en.cfm?pg=security
- Personal Communication: Edith Wallmeier, Head of catastrophes & Humanitarian foreign help of ASB Samaritan International from EU.

SPACE ART LINK

1. Tulips on the Moon http://www.astrobio.net/index.php?option=com_retrospection&task=detail&id=1618&fid=2&pid=
2. David RAITT, Cultural and Artistic Events in Space: ESA's Perspectives http://olats.org/space/13avril/2005/te_dRaitt.html
3. Roger Malina, Contextualising Zero Gravity Art http://www.olats.org/space/colloques/artgravitezero/t_Malina_en.html
4. Annick Bureaud, The Reasons for a Symposium http://www.olats.org/space/colloques/artgravitezero/t_Bureaud_en.html
5. Arthur R. Woods, Space Options for the 21st Century (.pdf attached)
6. Bernard Foing, If We Had No Moon http://www.astrobio.net/index.php?option=com_retrospection&task=detail&id=1880
7. Bernard Foing, Noah's Ark on the Moon http://www.astrobio.net/index.php?option=com_retrospection&task=detail&id=2507
8. Meike Wiedemann, Florian P.M. Kohn, Wolfgang R.L. Hanke, Harald Rosner, (Nonlinear Physical Science) (.pdf attached)
9. Mark Waldron, Spooky Spaceflight, http://www.astrobio.net/index.php?option=com_retrospection&task=detail&id=1124&fid=2&pid=
10. Planetary Clouds May Expand the Habitable Zone, http://www.astrobio.net/pressrelease/5544/planetary-clouds-may-expand-the-habitable-zone
11. Rare Earth: Odds of Complex Life, debate. http://www.astrobio.net/debate/239/odds-of-complex-life
12. Artistic Astrobiology: Bridging Biology and Space. http://www.astrobio.net/index.php?option=com_retrospection&task=detail&id=4896&fid=11&pid=
13. Studying Cycles: Chemistry and Climate. http://www.astrobio.net/index.php?option=com_retrospection&task=detail&id=3751&fid=1&pid=

REFERENCES

[1] Schlacht I.L. (2012). SPACE HABITABILITY: Integrating Human Factors into the Design Process to Enhance Habitability in Long Duration Mission. TU Berlin, Germany. http://opus.kobv.de/tuberlin/volltexte/2012/3407/

[2] Schlacht, I.L. Foing, B., Ceppi, G. (2015). Exohab1 development: spin-in/out from space habitat to disaster management facility. 66th IAC 2015 www.iafastro.net/download/congress/IAC-15/DVD/full/ (insert on the search: Schlacht)

[3] Schlacht, I.L. (Ed.). (2011). Chapter: Space Extreme Design. In Personal and Ubiquitous Computing. Volume 15 Number 5 pp. 487-526. Formerly Personal Technologies (2000-2000).

[4] Schlacht, I.L., & Ono, A.(2009). Creative Processs to Improve Astronaut Reliability. IAC-09.B3.2.4. Proceeding of 60th IAC, 12-16.10.2009, Daejeon, Korea. pag.4 www.iafastro.net/download/congress/IAC-09/DVD/full/ (insert on the search: Schlacht)

[5] KABK (2015). Art & science. www.kabk.nl/pagewideNL.php?id=0002

[6] KABK (2015). www.kabk.nl/pagewideNL.php?id=0007

[7] Cenini, E., Desole, E., Facchinetti, M., Schlacht, I.L., Foing, B., Artusi, M., Ceppi, G. (2015). Moon habitat module: New ways of living in extreme spaces. IAC-15.A3.IP.43. 66th International Astronautical Congress 2015 (ISSN 1995-6258 Magazine E214844.

REFERENCE OF THIS PAPER

Schlacht, I.L., Foing, B., Ceppi, G. (2015). ExoHab1 development: spin-in/out from space habitat to disaster management facility. IAC-15.E5.2.2 66th International Astronautical Congress 2015 (ISSN 1995-6258 Magazine E214844). On line at www.extreme-design.eu/publications.html

Contact Persons:

Prof. Bernard Foing (Presenter at IAC)
Bernard.Foing@esa.int

Dr. Irene Lia Schlacht,
irene.schlacht@mail.polimi.it