Chapter

Educational and Scientific Analog Space Missions

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Abstract

Analog space missions in Poland include international scientific, technological, and business projects designed and realized by a private research company Analog Astronaut Training Center Ltd. (AATC) devoted to the future Moon and Mars exploration. Growing experience in educational aspect of the training as well as continuous development of the habitat and its professional space science laboratory equipment correspond to increased interest of educational organizations, universities, and individual students. We serve unique practical platform for space engineering, space master, and even space doctoral theses. In addition to a wide range of training courses offered for future astronauts, for example, diving, skydiving, rocket workshops, and stratospheric missions, AATC provides a private laboratory to simulate the space environment. It carries out scientific experiments focused on biology and space medicine, as well as addressing several multidisciplinary issues related to the Moon and Mars exploration, including space mining. The main goal of each our analog simulation is to get publishable results, what means that our analog astronauts obtain not only certification of completion of the training but also ability to continue studies and to perform it individually. This chapter summarizes methodology used by us, didactic tools, and obtained results for both educational and scientific analog simulations.

Keywords: analog missions, lunar and Martian science, space education

1. Introduction

Analog Astronaut Training Center (AATC) is a private company, which main mission is to develop activities for safe human spaceflight available for all in spirit of the New Space era. Sending humans to Moon and Mars is definitely one of the largest challenges for humanity of the twenty-first century. It will bring smart solutions to climate change problems. Failure is not an option since it's not only a matter of money but a matter of life. Human spaceflight studies rapidly increase the price and quality of human spaceflight studies. But such work gives the largest return of investment: new science, new technologies and new lifestyles for everyone including not only humans but all living creatures. Among several variants of testing platforms for human spaceflight R&Ds, analog simulations seem to be more and more efficient in releasing advanced TLR projects, where TLR means Technology Readiness Level – a standard parameter used by space sector community. We organise and coordinate scientific studies, introduce new technologies, incubate new start-ups and facilitate carriers for space passionates. The initial motivation to create AATC was a project titled "Time Architecture" developed in 2016 at Advanced Concepts Team in European Space and Technology Centre (ESTEC), Netherlands [1]. The main idea of the time architecture concept is to modulate time perception in human brains in a way to decrease ageing processes and to optimise the circadian clock performance to keep the optimal health of people working and living in isolated spaces. In order to prove the concept, there was a need to perform appropriate investigations on humans in special laboratory conditions. Available in Europe, chronobiological chambers (laboratories to study biological clocks on humans) were very expensive to use and restricted to perform experiments only for two people at the time, limiting the statistical power of generated results. Therefore, the cheapest and the most efficient solution was to create a new, specially customised laboratory to test humans in isolation from sunlight and time. Because experiments on time perception require a minimum 1–2 weeks of stay in isolation, it was reasonable to combine biological clock experiments with trainings simulating the space mission. In order to make trainings attractive for people, a unique program of training was elaborated, and the foundation for analog astronaut mission scenarios was developed for lunar, Martian and orbital simulations.

Origins of analog missions in Poland were hard, what is presented on the **Figure 1**. We had laboratory equipment, mission scenarios, mission protocols, passionated collaborators and analog astronauts, but we struggled with inadequacies in infrastructure. Despite all obstacles, every year we moved forward: in 2016, we built Modular Analog Research Station (M.A.R.S.) in Turza and organised the first lunar analog simulation at Queen Jadwiga Astronomical Observatory in Rzepiennik. In the beginning of 2017, M.A.R.S. base was moved 700 km north to a different

Figure 1.
The history of analog missions in Poland. The first analog mission was organised in 2016 under the M.A.R.S. affiliations. The first simulation was 6 days long and was crucial to gain the know-how and the initial experience to adjust mission scenarios for future activities. All people involved at this stage of the project were Polish with various specialisations and levels of professionalism. In the same year, a Space Garden company was established to act as an incubator for start-ups related with development of space technologies (that is why we named it garden). In 2017, the base (6 containers and dome) was transported through the whole country to military airport in Piła. The base was expanded with a large isolated from sunlight EVA training terrain. The base was renamed from M.A.R.S. to LunAres. New environments and possibilities followed modernisation of the mission scenarios and opening up of new training opportunities for educational purposes. Another 8 missions were organised gaining critical experience. LunAres became independent unit belonging to Space Garden, operated by Space is More company, which until now organised 8 additional analog missions not depicted on this graphics. In 2019, in the south of Poland an additional base—independent and fully private Analog Astronaut Training Center—was created; it is now located in a confined 57 m^2 smart space fully controlled by multiple sensors and completely isolated from sunlight and time. AATC is focused on organisation of scientific and educational analog simulations. Until now, we have organised 30 analog missions in this location.

location—a military airport in Piła. The new base was expanded by merging six M.A.R.S.'s containers and dome with a hangar dedicated for EVA trainings.

The base was renamed as Lunares. In 2017, after organising eight scientific and educational missions, we moved back to Rzepiennik, establishing the Analog Astronaut Training Center to be completely an independent private organisation. In this paper, we present results from lunar and Martian analog missions organised in Poland. A series of technological, operational, medical, biological, geological, ecological and human factors projects towards the goals of the future manned space missions were initiated and successfully developed. The results from these missions provide recommendations for future manned expeditions to increase the quality of simulation. Additionally, we focussed on optimisation of procedures and scheduling methods as well as science return based on improved resource allocation and crew habitation.

2. Educational analog missions

By educational analog mission, we mean hands-on experience of multidisciplinary experiments and tasks mounted in the space mission scenario. Objectives of this type of training are clearly defined and easy to evaluate, even in the form of self-evaluation. AATC elaborated three types of trainings adjusted to three basic levels of education: primary school kids, high school pupils and students. For each group, we prepared different types of trainings based on the participants' background.

In the case of primary school kids, we organised Junior Space Camps [2]. The main aim of these types of trainings is practical application of STEAM subjects and learning of effective teamwork. Attention is given to the development of exploration skills and skills related to decision making, asking questions, being sceptical, hardworking, precise and patient. Multiple puzzles mixed with the development of manual skills are implemented in the training process and this makes such analog missions continuously exciting, engaging multiple senses and skills at the time. We developed short and long time duration trainings. Short trainings are designed in a way, that each participant receives a working card with 20 assignments to be realized under specific responsibilities and roles. Such work is presented on **Figure 2**. Each assignment is evaluated considering the quality of performance and time of realisation. The document (a working card) contains elements of a real astronaut training such as solving mathematical, linguistic, technological problems as well as cognitive tasks. Each working card is different for each participant depending on selected role and responsibilities. For example, commander receives a dedicated working card containing planning and management tasks, astrobiologist receives tasks related with space biology experiments, data officer will work on collecting environmental and physiological data, etc. All working cards are complementary and require performing dedicated tasks in the right order what requires good communication and management skills within the crew. Working cards are designed according to the time of the educational mission. Some of them can be performed at school for 3 h; other training programmes are made to run in the habitat. This type of training can be longer, even until 7 days in the form of Green School or Junior Space Camp.

For secondary school pupils, we also focussed on STEAM subjects, but this time, orienting the training towards efficient support in the selection of future careers. Most of the secondary pupils are interested in testing themselves in different roles such as mission commander, scientist, engineer, communication officer, data officer, journalist, medical surgeon, astronomer, planetary scientist, geophysicist, mathematician, computer scientist and so on. In order to obtain the best results, participants are able to try all interested roles, potentially their future jobs (even 3 role shifts at the time of training, if necessary), and then decide, which role suits them the best. All pupils whom we trained like this, approved that this type of training was unique and very helpful for them to decide what to do in the future. The training itself was based on the pre-training phase, familiarising with the mission manual and habitat procedures. After pre-training, participants are requested to select their roles for the analog mission. Each role with its responsibilities is described in the mission manual. Each role is assigned to separate scenarios and dedicated tasks incorporated in the mission schedule. Each scenario is designed in a way that it is interlocked with scenarios of other roles; so a single scenario cannot be realised without the support of interlocked components. Each participant receives an individual training manual (mission scenario), with specified tasks to be done in a specific order. Pupils are requested to write reports and solve all tasks in the way it is described in the training manual. The mission success is determined by the realisation of all required tasks, timing, motivation of the crew, quality of performed tasks and independence (parameter computed based on number of contacts with remote mission control centre). At the end of the analog mission, participants present their results on the summary meeting. Everyone elaborates the lessons learned.

The largest group we educate are students who want to develop their career in space sector. Analog simulations are attractive, short term and efficient internships to gain unique experience and condensed knowledge in practice. Analog simulations help to win international internships at ESA, NASA and scholar grants. One of our analog astronauts participating in the mission Spectra—Dr. Sian Proctor flown to space in the first civilian mission "Inspiration 4" organised by Space X in September 2021. Increased number of engineer, master and doctoral theses realized at AATC approve, that analog missions are no longer game or exclusive holidays but can be useful in shaping future careers. This new approach oriented on personal development increases the credibility of such type of trainings. Analog astronauts are no longer funny people wearing blue suits. Global situation and increased interest in commercialisation of human spaceflight catalyse the transition of analog simulations into platform for scientific studies and development of technologies.

Figure 2.
Lunar educational mission "Youth for Moon" consisted on 25 pupils divided into two groups: analog astronauts and mission control center. All analog astronauts and mission control center participants were working point by point according to their printed versions of working cards (visible in the hand of one of individuals).

Students are selected based on the mission call, where they are asked to send CV and cover letter. Using this information we adjust training system relevant to the background of the mission candidate. The main part of this training is to perform experiment inside the analog environment. This task requires multiple decisions to be made, considering the limitations of time and distance, restricted communication, simple tools and workspace. Work is performed in a noisy environment similar to that in a space station. Artificial lighting and crew mates mounted in the mission schedule create demanding conditions which induce stressful environment and need to explore new ways of solving completely new problems. Effects of training during educational missions are cooperation, creative problem solving, building a common strategy, systematic work, professional commands/language, organisation of work time, delegating tasks, providing information transfer and fast decision making.

Analog mission is based on established simulations.

We simulate:

- language specific for astronauts and mission control centres,
- isolation from external environment,
- mission schedule, mission procedures, astronaut food, wet wipes, physical activity, reporting
- experiments in simulated microgravity on Random Positioning Machines
- experiments on lunar and Martian regolith simulants

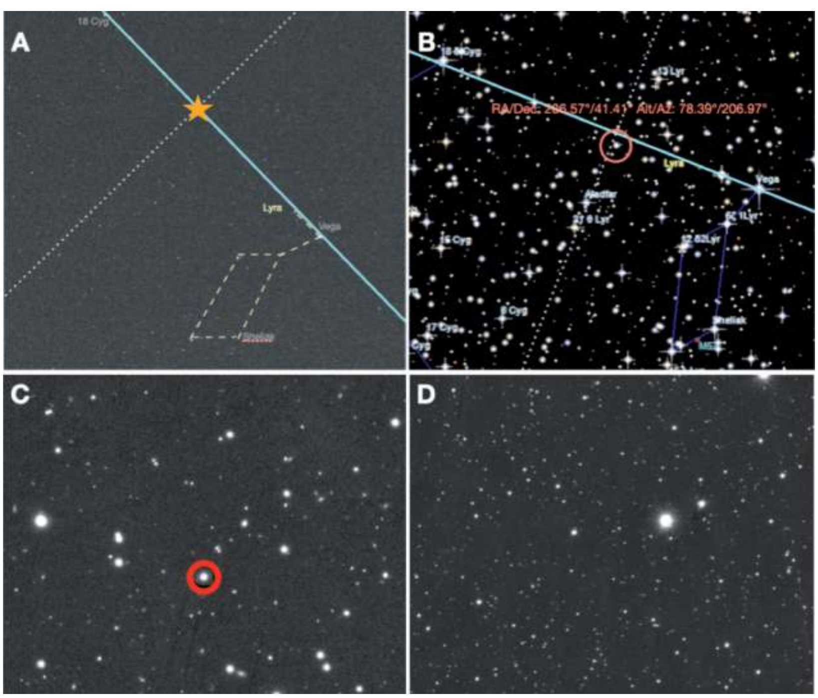

Figure 3.
Example of astropuzzles. A: find coordinates of yellow star. B: solution of this puzzle presented in the training manual of one of our pupils. Participants are requested not only to find numbers but also to describe the method which they used. C and D: astropuzzle: find a star labelled in the red circle on the D image. This kind of astropuzzles is used to find constellations of points. When all points are correctly defined, they create a specific shape which is the final answer for the task.

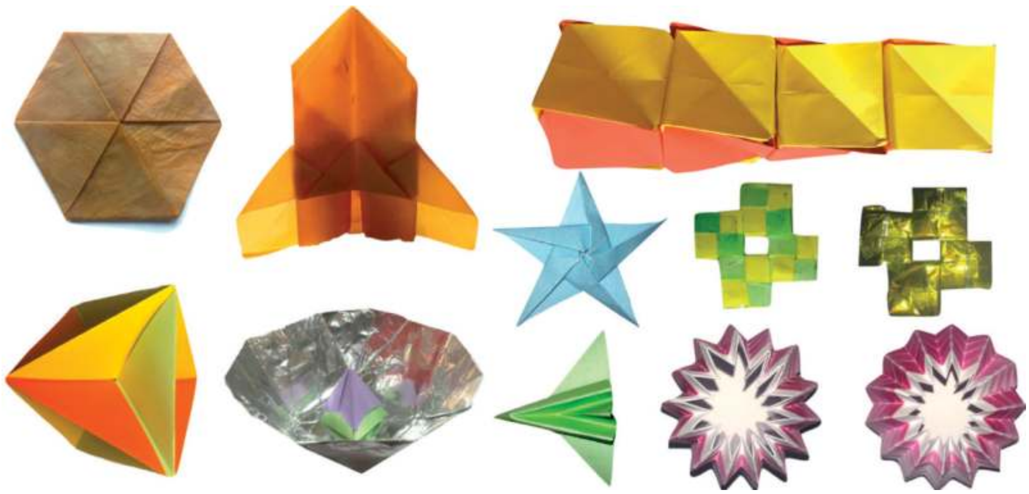

Figure 4.
Space origami is a manual training and practical demonstration bringing lots of joy in learning of space topics. Folded structures are made using space technologies such as hydrogel materials, NRC foil and other composites. Hexagons, flexagons, cubesats, antennas, radar reflectors, solar panels, space shuttles and rockets are some of examples used in the training.

Figure 5.
The final day of the educational training at the Modern School in New Delhi. Happy analog astronauts with their certificates after 1 week of training. Visible on the table awarded projects of lunar and Martian bases, designed mission patches and astronaut helmets.

- flight suits, EVA suits and airlock mock-ups
- emergency situations

Remote analog missions are based on training manuals and realisation of mission tasks that do not require the habitat environment. These tasks are based on processing satellite data, monitoring space weather, making astronomical observations, solving astropuzzles (**Figure 3**) and folding space origami (**Figure 4**). Because of huge interest in space origami, we published a small booklet with models, which can be freely downloaded from our website [3].

At the end of each successful analog simulation, we generate certificates. What is important to note is that we organise analog missions not only inside the habitat, but remotely and at schools around the world, for example in New Delhi (**Figure 5**).

3. Scientific analog missions

Scientific experiments in space are limited by strict policy rules as well as size and mass limits. Most of the scientists cannot afford to send their experiments to space because of high costs. Creating analogous environment on the Earth enables alternative and much cheaper opportunities. The Analog Astronaut Training Center develops multidisciplinary scientific projects in collaboration with research centres, universities, space agencies and private space companies. These projects are often the development of master, engineer, and PhD theses, investigating high-risk hypotheses.

The following are the scientific projects with AATC:

1. VIS/NIR reflectance and fluorescence spectrometric studies of minerals, water, organics and biomarkers in MoonMars analogue samples [4]
2. Bacterial cellulose for clothes production in space using kombucha microbial consortium [5]
3. Hydrogel bacterial cellulose: a patch to improved materials for new eco-friendly textiles [6]
4. Cardiorespiratory profiling during simulated lunar mission using impedance pneumography [7]—doctoral thesis
5. Circadian clock and subjective time perception: a simple open-source application for the Analysis of Induced Time Perception in Humans [8]
6. Human Nature: The Subject and the Headache of IoT-Based Sociometric Studies [9]
7. Sunlight simulator for isolated spaces [10]
8. Remote research in lunar and Martian analog international missions to rise knowledge about life in isolation [11]
9. The influence of diet on behaviour in simulated space mission conditions [12]—doctoral thesis
10. Effects of sunlight simulator lighting system on serotonin, melatonin and physiological parameters related with circadian clock of the analog astronaut crews performing simulation of space mission in the AATC habitat in Poland [13]
11. Non-circulative hydroponics to preserve plant health during a long-time power failure in a space colony [14]
12. CPR and rescuer's position in microgravity [15]
13. HabitatOS—operating system with IoT sensors and machine learning/data analysis—master's thesis
14. HabitatOS sensor data analysis for analog simulations at AATC habitat from 2016 to 2020 [16]
15. Reliability in Extreme Isolation: A natural language processing tool for stress self-assessment [17]

16. Design and shielding for a future Moon habitat—master's thesis [18]

17. Design of the first colony on Mars—master thesis [19]

18. Experiments which cannot be done on Earth—Alldream institute [20]

19. Using a state-of-the art human centrifuge to simulate space flight with Soyuz MS-10 rocket and re-entry into the atmosphere

20. Comparative analysis of mass loss, digestion and aggression in cockroaches exposed to sunlight simulator lighting system in an analog habitat environment [21]

Analog missions for students require preparations before the mission launch. The optimal time of mission preparations is 2 months. After the recruitment phase, students are asked to fill in a spreadsheet with basic information concerning communication, interests, affiliations and proposed experiments. AATC encourages students to bring their own experiments to the habitat. Each experiment must be described in a special research collaboration form. After approval, students transfer their experiment title, description and procedures to the main mission document, which is called the Mission Manual. The Mission Manual is an internal document describing the whole mission scenario including mission objectives, mission procedures, operations and the main expected results. Based on this information there is a possibility to evaluate the quality of the mission and analog astronauts' performance.

Analog Astronaut Training Center serves as unique laboratory platform for multidisciplinary projects covering geology, robotics, telecommunication, space architecture, biology, nutrition, medicine, ecology, life support systems and agriculture. For each mission we prepare customised laboratory equipment, chemical reagents and tools dedicated for specific projects. We collaborate with several laboratories, research centres and engineering teams to get algae, plant or animal species, specific yeast and bacteria lines, liquid nitrogen, dry ice, regolith simulants, centrifuges, microscopes, rovers, landers, lidars and spectrometers.

AATC aims to expand activities in the following areas:

- work optimization in interdisciplinary environments;
- multiculturalism;
- smart biohacking;
- ecology and in situ resource utilization;
- smart telerobotic technologies based on artificial intelligence
- technologies related to health and safety in areas isolated from the natural environment
- life support systems and sustainability
- space tourism
- applying and realisation of grants
- start-up incubation

Figure 6.
Sunlight simulator system to generate various cocktails of light with unique functionalities such as raising serotonin and vitamin D levels.

4. Technology development

Scientific approaches and researching to solve fundamental problems for safe colonisation of Moon and Mars lead to the development of new technologies. AATC realises technology grants based on concepts and prototypes implemented and tested inside the habitat. The first technology developed in AATC is the sunlight simulator lighting system to synchronise biological clocks (**Figure 6**). Several prototypes have been made and tested in isolated conditions on plants, animals and humans (under bioethical committee approvals).

Other technologies that are being developed in AATC in collaboration with scientific partners are as follows:

- hydroponic systems
- aquaponic systems
- air purification systems
- hypergravity simulators
- clothes in space
- 3d printed materials from bacterial nanocellulose
- telemedical devices
- gravity machines for scientific purposes
- habitat operational system based on machine learning integrated with multiple sensors,
- advanced crew medical restraint system—platform for advanced cardiovascular life support (ACLS) procedures for microgravity CPR, IV/IO access and advanced airway management on incapacitated astronaut for commercial human spaceflight applications

5. Habitat

Technology development in AATC is a natural process triggered by needs to create the optimal space for performing analog simulations at the highest quality. Actually

Logo	Name	Date	Type	Location	Crew	Affiliation
	Lunar expedition 0	August 15–21, 2016	Lunar	Queen Jadwiga Astronomical Observatory	6	M.A.R.S.
	PMAS	July 29, 2017 to August 13, 2017	Martian	LunAres	6	Space Garden
	Lunar expedition 1	August 15–30, 2017	Lunar	LunAres	6	Space Garden
	Youth for moon	September 11–13, 2017	Lunar	LunAres	6x2	Space Garden
	ICAres-1	October 08–21, 2017	Martian	LunAres	6	Space Garden
	Spectra	July 15–28, 2018	Lunar	LunAres	6	Space Garden
	Ares-3	August 4–16, 2018	Martian	LunAres	6	Space Garden
	Artemis	July 14–20, 2019	Lunar	AATC	4	AATC
	Expedition 11	July 22–29, 2019	Martian	AATC	4	AATC
	Optima	September 22–29, 2019	Lunar	AATC	4	AATC
	Bright 1, 2	July 1–30, 2020	Lunar	AATC	4 + 4	AATC
	Bright 3 ,4	August 1–30, 2020	Martian	AATC	3 + 4	AATC

Logo	Name	Date	Type	Location	Crew	Affiliation
	Bright 5, 6	September 1–30, 2020	Lunar	AATC	3 + 4	AATC
	Eternity	October 1–7, 2020	Lunar	AATC	5	AATC
	Destiny	October 8–15, 2020	Martian	AATC	3	AATC
	EMMPOL 1, 2	October 16–30, 2020	Lunar	AATC	5 + 4	AATC

Authors listed only organised or co-organised missions by themselves without considering 13 missions in 2021. Four more missions were organised in Lunares habitat.

Table 1.
Analog missions organised in Poland.

we develop microgravity simulations for humans in pressurised spacesuits. Every year we develop new instruments, mock-ups and attractions for analog astronauts. All this is possible because of having independent and expandable habitat. By name "habitat" we mean fully equipped (including dedicated software), human spaceflight research facility for long-term isolated crewed projects. AATC Habitat (TRL level 5) is a bioastronautics research laboratory proving ground for future Moon and Mars missions (**Table 1**). The habitat is adjusted to mission requirements, which are isolation from sunlight, remotely controlled sunlight simulator lighting system, confined space, healthy mineral water access, healthy atmosphere, safe environment, social isolation (limit of people inside the base is 6), multiple communication channels including protected LoRaWAN network, two laboratories: clean lab and geolab to run critical experiments, smart sensors and monitoring systems implemented with the mission control, vertigo training equipment, gyroscopes, tele medical devices. The total living surface is 52.7 m^2. In 2020, we started to expand the infrastructure due to increasing demands for high quality training, education and scientific research. The new infrastructure will be 300 m^2 with more than 1 ha of specially formed EVA terrain. Perspectives for analog missions are promising. Actually we collaborate with more than 20 universities and educational centres in the world. Our next big step will be to implement educational analog missions in European Credit Transfer and Accumulation System (ECTS), so students can gain not only experience and publications but also valuable credits. Among collaborative partners we can distinguish: the International Lunar Exploration Working Group (ILEWG), EuroMoonMars, IPSA Toulouse, European Space Agency (ESA), Embry Riddle Aeronautical University (ERAU), SCK-CEN in Belgium, Military University of Technology in Poland, Polish Military Institute of Aviation Medicine, Space Research Center in Poland, Jagiellonian University, Space Technologies Center at AGH, University of Padva, Politecnico di Milano, University of Warwick, University of Glasgow, London Imperial College, KU Leuven and Italian research centers (IBFM, INFN-LNS and STEBICEF). We search for collaborations to develop unique space habitat equipment, which can be mobile and be used by universities, academic centres, companies and schools, even in the pandemic state. We also search for collaborations with artists [22, 23].

6. Training activities

Analog missions are the most dominant form of activities of AATC. However, we provide much more types of practical trainings related with commercial astronautics and future space tourism, for example, stratospheric missions, rocket workshops (in collaboration with Polish Rocket Society), underwater EVAs in neutral buoyancy, diving, open sea survival and HUET training (in collaboration with Marine School), skydiving (in collaboration with Skydiving Association in Piła), survival (in collaboration with special forces), human centrifuge training and hyperbaric trainings in collaboration with Military University of Aviation Medicine. The main objective is to provide trainings similar or identical to the real astronaut trainings. While searching for such possibilities, surprisingly we found out, that training facilities and professional equipment are available in Poland. What is even more interesting is that the prices for these unique trainings are affordable by everyone. This means, that commercial astronautics have chances to grow quickly in the era of space commercialisation. Infrastructure and teachers already exist.

7. Conclusions

Educational and scientific missions are inspiring alternatives for conventional learning. They become more and more a professional platform to perform space studies, with a wide range of opportunities for development of new technologies.

Figure 7.
Analog astronauts working with us as M.A.R.S., LunAres, or AATC. Each of this person invested private money and time in development of human spaceflight commercial programs. Thank you for sharing your passions and giving us a wonderful feedback and motivation to be better in what we love to do. Ad Astra!

They act as an incubator for innovative science, where science fiction is transformed into reality. Participants can use their imagination and creativity without limits and use it as a trampoline to jump directly into professional space projects. This is what we observe in AATC. Analog missions motivate students to write publications in relevant scientific journals and popular science media. They bring valuable experience and training dedicated to work in space sector. They are unique for team-building, with independent access and international activity. Analog missions are the most attractive form of the training which we offer. Other types of trainings require good health and coping with various extreme situations.

Acknowledgements

This work cannot be described without our analog astronauts (**Figure 7**) and people, who believed in us and supported in organisation of analog missions. The list is long (more than 100 people) and will only be longer. Thank you all for this contribution into the NewSpace era. We wish you a safe and pleasant flight to space as soon as it is possible and in as cost effective way as possible. Think about it and just make it happen.

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References

[1] Kolodziejczyk A et al. Time architecture. Acta Futura. 2016;**10**:37-44

[2] Kołodziejczyk A et al. Educational analog missions in Lunares habitat in Poland. In: Proceedings of the 69th International Astronautical Congress (IAC); 1-5 October 2018; Bremen, Germany. IAC-18,A1,7,15,x45646. 2018

[3] Kołodziejczyk A et al. Kosmiczne Origami. 2020. ISBN: 978-83-956752-2-5

[4] Vos H et al. VIS/NIR reflectance and fluorescence spectrometric studies of minerals, water, organics and biomarkers in MoonMars analogue samples. EGU General Assembly 2017. European Geosciences Union; Vienna, Austria. 2017. Abstract. EGU2017-1537

[5] Kołodziejczyk A et al. Bacterial cellulose for clothes production in space using kombucha microbial consortium. In: 69th International Astronautical Congress (IAC); 1-5 October 2018; Bremen, Germany. IAC-18,A1,7,15, x45657. 2018

[6] Kamiński K, Jarosz M, Grudzień J, et al. Hydrogel bacterial cellulose: A path to improved materials for new eco-friendly textiles. Cellulose. 2020;**27**:5353-5365. DOI: 10.1007/s10570-020-03128-3

[7] Młyńczak M et al. Cardiorespiratory profiling during simulated lunar mission using impedance pneumography. Biomedical Signal Processing and Control. 2019;**51**:216-221

[8] Kolodziejczyk et al. Circadian clock and subjective time perception: A simple open source application for the analysis of induced time perception in humans. International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering. International Journal of Cognitive and Language Sciences. 2017;**11**(3). DOI: 10.5281/zenodo.1129596

[9] Matraszek M et al. Human nature: The subject and the headache of IoT-based sociometric studies. In: EWSN '20: Proceedings of the 2020 International Conference on Embedded Wireless Systems and Networks on Proceedings of the 2020 International Conference on Embedded Wireless Systems and Networks. 2020. pp. 265-270

[10] Kołodziejczyk A et al. Sunlight simulator for isolated spaces. ICES2021. 2021

[11] Kołodziejczyk A et al. Remote research in lunar and martian analog international missions to rise knowledge about life in isolation. EGU21-8684. 2021

[12] Bubrowska N et al. The influence of diet on behavior in simulated space mission conditions. GLEX-2021,8,3,4,x62182. 2021

[13] Kołodziejczyk et al. Effects of sunlight simulator lighting system on serotonin, melatonin and physiological parameters related with circadian clock of the analog astronaut crews performing simulation of space mission in the AATC habitat in Poland. GLEX-2021,8,2,4,x62201. 2021

[14] Forgues-Mayet E et al. Non-circulative hydroponics to preserve plant health during a long-time power failure in a space colony. GLEX-2021,11,2,8,x62393. 2021

[15] Trzos et al. CPR and rescuer's position in microgravity. GLEX-2021,8,2,8,x62457. 2021

[16] Harasymczuk M et al. HabitatOS sensor data analysis for analog

simulations at AATC habitat from 2016-2020. GLEX-2021,11,2,6,x62477. 2021

[17] Alcibiade A et al. Reliability in extreme isolation: A natural language processing tool for stress self-assessment. Advances in Human Factors and Systems Interaction. 2020. ISBN: 978-3-030-51368-9

[18] Ptak M. The project of the modular, self-sustaining Mars base in the initial stage of colonisation process [master thesis]. Cracow University of Technology; 2019

[19] Nieuwborg A. Design and shielding for a future Moon habitat [master thesis]. 2019

[20] Pelc J et al. Alldream Lunar Institute, Home on the Moon Project. 2020. ISBN: 978-83-956752-1-8. Available from: www.astronaut.center website

[21] Kolodziejczyk A et al. Comparative analysis of mass loss, digestion and aggression in cockroaches exposed to sunlight simulator lighting system in analog habitat environment. Poster at COSPAR. 2021

[22] Pell S. Apollo and the Muses: A preliminary discussion of the cultural and technical inspirational knowledge embedded in the lunar space arts of an analogue mission. In: 70th International Astronautical Congress (IAC); 21-25 October 2019; Washington D.C, United States: 2019. IAC-19-E5,3.11

[23] Pell S et al. Human spaceflight performance: Bootstrapping the intersection of biometrics and artistic expression through planetary mission analogue EVAs. In: 70th International Astronautical Congress (IAC); 21-25 October 2019; Washington D.C, United States: 2019. IAC-19-B3.9.2