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Educational analog missions in Lunares habitat in Poland

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Abstract

Lunares habitat in Poland was established in 2017 by Space Garden Company. It is fully isolated educational and research base located at the military airport in Piła, remotely operated by mission control center using habitat's operational system.

In 2017 in Lunares we organized and evaluated 3-days long educational missions for primary and secondary schools. School kids were divided into two groups: analog astronaut group and mission control group. Each person received its own role for the mission described in dedicated working cards, which contained full scenario of duties and tasks similarly to the astronaut schedule on the International Space Station. Additionally, working cards were used to write and compute data in prepared forms and tables. Limited timing and integration with other roles made this project demanding but interesting for kids. It was like a chess game, but with real players, spacesuits, laboratory equipment, lunar EVA terrain and habitat. During the mission, each person had two randomly selected roles: one day as an analog astronaut, second day as mission control member of the crew. After the mission each role was evaluated based on data from the working cards. Evaluation was focused on efficiency, quality and proper timing of realized tasks. Teachers discussed obtained results with school kids.

Beside new for kids knowledge about human missions and space exploration, multidisciplinary tasks were designed for this training. Such exercises required knowledge from school in maths, physics, chemistry, geography and biology. Analog astronauts had to follow habitat procedures, perform scientific experiments in simulated microgravity, run medical examinations of the crew, do physical exercises to generate energy for the base or create a map of simulated lunar terrain during extravehicular activities. Mission control had to help, communicate and control the quality of realized tasks.

After very positive feedback both from pupils and teachers, we observed that participation in two different groups significantly increased knowledge about human spaceflight and exploration. School kids could apply their own knowledge and talents in completely new for them situations, what increased their confidence and appreciation for education at school. Additional skills such organization, discipline, responsibility, decision making, planning and teamwork were trained. In summary, all listed above positive effects of organized educational mission allowed us to expand this activities in Lunares habitat.

We invite all interested educators and teachers to collaborate with us.

Keywords: innovative education, lunar mission simulation

1. Introduction

Lunares base was established in 2017 by Space Garden (**Fig. 1**). The idea and realization of space base project in Poland was initiated by the main author of this paper. Investor Marcin Traple sponsored administration, materials and building of developed infrastructure, Agata Kołodziejczyk sponsored initial scientific equipment of the base, scenarios and instructions for two types of mission simulations, Matt Harasymczuk sponsored the habitat operational system. The main architect of the base was Leszek Orzechowski together with his team Space is More. When described below educational mission was performed, Lunares base had no division into more complex structure, which exists now. Actually, the owner of the habitat is Space Garden Company, operator of the habitat is Space is More and Scientific Board of the Lunares Research Station takes care of R&D projects as well as scientific and educational collaborations.

Habitat Lunares was created to organize scientific, educational and exploratory missions and to train future wannabe astronauts. Lunares name derives from LUNA (Moon), and ARES (Mars), to highlight unique in the world ability to run two types of environmental analogs: lunar and martian mission simulations. Additional unique feature of the Lunares habitat is complete isolation from sunlight and time. The base is fully monitored and equipped with multiple kinds of sensors combined with dedicated operational system. Mission control center (MCC), remotely controls the lighting system inside the base. There is also possibility to alarm the base remotely in case of emergency. Extravehicular activity terrain (EVA terrain), which is connected by airlock with laboratories inside the habitat, was designed to perform planetary science experiments during analog missions. This unique terrain is located inside antinuclear, isolated from external environment hangar, with various types of lighting modes, communication and navigation systems.

Currently we study: (1) growing plants on regolith simulants; (2) water and magnetic particles extraction; (3) robotic operations in simulated lava tubes. 150 square meters of lunar-like surface was made using small basalt rocks and powder. Another 150 square meters of red rocky surface simulates martian terrain. Both surfaces were shaped with volcanoes and craters. On this rocky surface analog astronauts search for original meteorite samples and regolith simulants.

Fig. 1. *The habitat has eight functional modules around social area called Atrium (108 square meters in total): (1) Dormitory with six private chambers, (2) Biolab with hydroponics and bioreactors, (3) Analytic lab with medical equipment, 3D printer, glovebox and EVA preparations room, (4) Kitchen, (5) Operations room, (6) Storage Module with gym, (7) Sanitary Modules, (8) Airlock module with waste removal compartment connected to isolated EVA terrain inside the hangar. On the first plan of this photograph a hangar with isolated extravehicular terrain. Behind the hangar a sanitary module and a dome above the atrium are visible. Credit: Space Garden.*

2. Motivation

The main objective of organized educational analog simulation named "Youth for Moon" was to develop effective platform for dialog between teachers of primary and secondary schools and space exploration experts. Organized mission was an inspiration for young people to discover their favorite discipline within the STEAM educational approach (Science, Technology, Engineering, the Arts and Mathematics). Additionally, the aim of the project was to encourage young generation to participate in other space projects and space contests. Simulated lunar mission was not only an inspirational adventure of space dimension and extended reality, but also experiencing illusion of time and space, feeling like an astronaut or a member of a ground control crew. The scenario was designed intentionally to evoke feeling of distance from earth and meeting completely new approach for a problem solving and decision making.

3. Agenda

Educational mission was structured in two parts: learning part during the first day, where school kids trained and familiarized with the habitat manual and simulation. The second part was for public outreach, devoted for recording a professional documentary movie by Mediolia film studio (www.mediolia.com). Detailed scenario:

Day 1. Arrival of the group, accommodation in the Mission Control Center 400 m from the Lunares habitat; familiarizing with the habitat manual and with the agenda of the mission; school kids work together with their teachers.

Day 2. Common breakfast (everyone participates in breakfast preparation for a team building); dividing people for two groups: analog astronauts and mission control crew; specifying roles and responsibilities for the simulation in both groups according to prepared materials and working cards; 8h of analog simulation; summary and reporting.

Day 3. Same as Day 2 but exchanging roles: analog astronauts shifted to be MCC, and vice versa; documentary movie recording for public outreach.

4. Simulation

During the educational mission "Youth for Moon" we simulated a lunar time (www.lunarclock.org), isolation, communication, reporting, common astronaut meal using lyophilisated food, EVA procedures such as decompression in the airlock, space walks and microgravity. Additionally, pupils were supposed to design their simulation's logo before the mission (**Fig.2**), and outreach posters after the training. Posters were presented during ESA open days in October 2017 in ESTEC, Netherlands. Two lunar missions were performed. Six specific roles were divided between analog astronauts: communication officer, commander, executive officer, crew medical officer, flight administrator, astrobiologist and data officer. Mission Control Center participants could select one of proposed moderating roles: flight director, executive director, capsule communicator, flight surgeon, science data manager, habitat data officer, psychologist and scheduling officer.

Each mission consisted of routine procedures, scientific experiments and dedicated tasks. Routine procedures were related with behavior in the habitat, communication channels, collecting environmental and physiological data, generating energy on the energy-bike, preparing meals (lunch), performing briefings, debriefings, space walks and reporting. Experiments were based on learned subjects at school: geography (creating the EVA map of terrain), biology (simulation of microgravity), psychology (group dynamics). Additionally organizational skills were trained: planning, time estimation, teamwork, managing, dividing and delegating tasks, responsibility for the whole team, ethics in reporting.

Fig.2. *The mission patch designed by school kids.*

5. Materials

Participants were advised to bring their own laptops, however two laptops and two smartphones were sufficient.To decrease number of electronics (computers), printed working cards were spread among pupils. Each working card was divided for descriptive and workload parts. Descriptive part included name of participant, selected role for the mission scenario and description of responsibilities. Together with habitat manual all instructions should be obeyed during the whole period of the simulation. The second, workload part, included nine tasks for each person participating in the simulation. Each task was prepared in a way, that participants made notes and generated results directly on their cards. For comparative analysis of the mission results, times of start and end of tasks were evaluated.

6. Roles and responsibilities

Each participant of the mission was supposed to play a specific role. For each role specific responsibilities and tasks were assigned. Teachers were moderators, dividing the roles between pupils based on preliminary discussion in the group. After setting up the roles, moderators were distributing the working cards, containing instructions needed for the whole time of the mission. After each mission, moderators were responsible to collect and document collected working cards by photographing using smartphones.

Analog Astronauts Responsibilities:

1. Commander (CMDR) - responsible for daily schedule control; maintaining the habitat operations; preparing briefings and debriefings; mediating amongst the team members; controls safety by initiating evacuation and emergency procedures; operations manager; collects habitat data.

2. Executive Officer (XO) - acts as CMDR in times when Commander is not available; supports CMDR in schedule control; bike training manager; motivating astronauts; collecting sport data.

3. Crew Medical Officer (CMO) - responsible for daily astronaut medical check-ups, daily medical logs, EVA logs and sport logs.

4. Flight Administrator (FA) - sending daily mission logs to MCC; controlling the schedule; giving information about time delays and crew efficiency to CMDR, XO and MCC.

5. Astrobiologist (AB) - responsible for realization of scientific experiments related with microgravity, regolith simulants and hydroponics systems.

6. Data Officer (DO) - collecting daily mission logs and writing public outreach daily report.

7. Communication Officer (CO) - maintaining IT System, radio and all communication channels between habitat, EVA terrain and MCC Crew; the only person communicating with MCC.

Mission Control Center Responsibilities:

1. Flight Director (FD) - formal leader of the mission; sets up and ensures adherence to mission rules; coordinates actions caused by deviations from the daily activity schedule; Approves and authorizes everything what is sent to astronauts as well as each non-standard MCC activity; during the mission FD is always reachable via cell phone; writes daily report of the mission activities.

2. Executive Director (XD) - collects all formal documents; coordinates overall mission operations controlled by MCC, supports FD.

3. Capsule Communicator (CapCom) - responsible for all communication channels between MCC and the habitat.

4. Flight Surgeon (FS) - medical support in case off need, has the right to veto FD and all other in-mission activities, when it is medically appropriate.

5. Science Data Manager (SDM) - ensuring a continuous log-file of what is happening in the habitat, at the exploration site and in the MCC. Obtained log-files are crucial in reconstruction of the mission scenario, analyses of workflows, procedures, scheduling and other types of planning astronaut activities; Overall analysis of mission efficiency and success.

6. Habitat Data Officer (HDO) - collects all mission data and builds the data base.

7. Psychologist (PSY) - takes care of the mission participants on both astronaut and MCC sides; supports teams, increases morale of the mission; helps to de-stress; decreases escalations of stressful situations; mediates conversations between conflicted persons.

8. Scheduling Officer (SO) - prepares daily schedule for both analog astronauts and MCC.

Moderators were not involved in the mission scenario, but they could observe and advice. Their main responsibility was taking care of the overall safety both inside the habitat and in the MCC location.

7. The Mission Crew

Sixteen school kids from Gymnasium in Lębork, three high school pupils from Gdynia and four teachers participated in the mission. Pupils selection was based on their interest in space exploration. All team was highly motivated and skilled to perform difficult tasks. Coordinating unit was in ESTEC, Netherlands.

Fig. 3. *Analog astronauts during "Youth for Moon" analog mission following scenarios in their working cards in Lunares habitat. Credit: Mediolia.*

Fig. 4. *Analog astronauts during EVA. Top: astronauts communicating with the HubCom in the airlock during decompression. EVA procedures controlled from the habitat by the EVA controlling team (middle). Analog astronaut walking on the simulated lunar surface (bottom).*

8. Educational goals and Lessons Learned

Analog astronauts and MCC Crew were highly motivated during the whole three days of training. The only difficulty observed was related with timing in scheduling and boredom. Analog astronauts didn't know what to do when all assigned tasks were realized. Similarly in case of MCC Crew. Nine tasks were definitely not enough for enthusiastic teams. Commanders and Flight Directors were not able to create additional tasks indicating immaturity of the group. For the next time a bunch of optional tasks will be added to the mission scenario. According to obtained feedback, the most interesting tasks were related with scientific experiments. The most boring task was riding a bike to generate energy for the base. Participants of educational mission "Youth for Moon" were asked to evaluate themselves regarding satisfaction, mood, comfort, productivity and distraction. 94% of participants were superb satisfied, 81 % had superb mood, 89% felt comfortably in their new situation and roles. 87% was given for productivity and 17% for distraction. Decreased mood levels were caused by limited time for sleep during the mission days.

Educational goals of the organized mission were: learning to cooperate, finding creative solutions for given problems, building common strategy to reach the mission success, learning systematic collaboration, learning clear communication regime and discipline in procedures realization. Additionally, participants learned organization and estimating time for planned work, delegating and dividing tasks, providing the proper information flow, fast decision making, creating new procedures and flexible switching between individual and team work. All educational goals were reached. For our knowledge, this kind of educational lunar simulation was the first in Europe. School kids and teachers would like to organize and participate in next such educational initiatives.

After the mission pupils concluded that educational lunar analog simulation "Youth for Moon" in the Lunares habitat was an unforgettable adventure, which has opened their minds for a teamwork and increased confidence. They were able to experience, how school education can be applied in unexpected situations and different scenarios. This experience motivated them to learn more and better at school. Pupils were very grateful for a given trust and faith, since usually they were not treated seriously as adults. Analog astronauts and MCC Crew reported, that they never had before such responsibility and clear rules to follow, what they highly appreciated.

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