IGLUNA Habitat in Ice: An ESA_Lab project hosted by the Swiss Space Center

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Introduction: IGLUNA is the first ESA_Lab interuniversity demonstrator project, and is hosted by the Swiss Space Centre (SSC) with the vision to create an analogue habitat inside lunar ice caps. 18 student teams from 9 countries across Europe will develop modular demonstrators that will be constructed and tested in the field test in June 2019. This field test will be condoned inside the moon-like extreme environment of the Glacier Palace inside the Matterhorn glacier from 17 – 30 June 2019 (fig 1). During these two weeks, all the student demonstrators will be combined to make a 36m^2 human habitat. The Glacier Palace will be open for the public during the tests, so that visitors have the opportunity to observe or even participate in the experiments.

IGLUNA is a demonstrator pilot project, aimed at supporting the ESA_Lab initiative to help the implementation of future ESA_Labs. The SSC is responsible for: coordinating and hosting the events in Switzerland, following the progress of the student projects, taking care of the main systems engineering activities, providing the institutional link between the international parties, and setting up and managing the IT infrastructure [1].

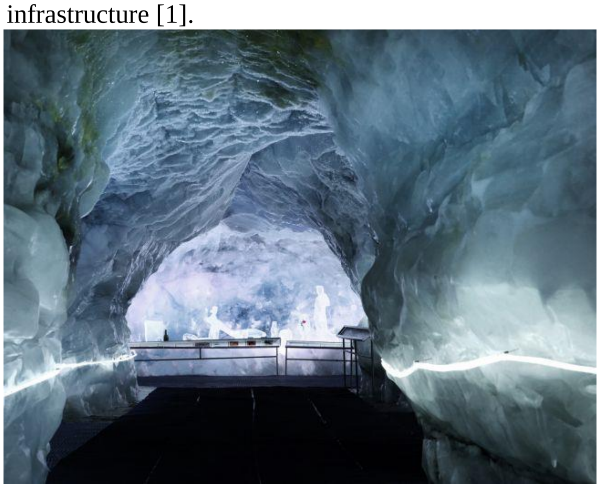

Fig. 1. Inside of the Glacier Palace, Zermatt, Switzerland. *Source: Zermatt Bergbahnen AG*

Lunar Ice: In 2008, the Chandrayaan-1 orbiter from ISRO, launched a Moon Impact Probe (MIP) onto the lunar South Pole, impacting in the Shackleton crater. Instruments on board of the MIP and Chandrayaan took over 650 measurements of the lunar surface in and around the craters on the South Pole [2].

Together with data from NASA's Moon Mineralogy Mapper (M^3) in 2009, it was concluded that there is significant absorption in the wavelengths of hydroxyl groups [3].

Later that year, NASA's LCROSS space probe detected "near pure crystalline water-ice" that got ejected from the Cabeus craters on the Moon after the impact of the upper stage of the Atlas V rocket, which launched the LRO and LCROSS [4]. After several years of more in-depth analysis, from both the LRO, as well as Chandrayaan-1, it was published in August 2018 that large ice patches can be found in lunar craters within 20º latitude from the poles, which act as cold traps.

Data from the altimeter of LRO showed that although the lunar North Pole has several smaller water ice patches, craters on the lunar South Pole, such as the Shackleton crater, are up to 22% covered by water ice [5], although likely covered by or mixed with lunar regolith.

Building a habitat in ice on the moon has several large advantages; besides not having to bring a large, pressurized habitable structure, water (ice) is a great insulator for cosmic radiation and radiation from the Sun. Furthermore, a close proximity of water is of high priority to enlarge the chances of human survival, as water is essential for life, but it can also be used to produce oxygen, as fuel, and energy storage. Lastly, building a covered or subterranean on the moon also protects against micrometeorites or dust storms from landing rockets or large nearby impacts [1].

Besides the protection inside the polar crater from heat from the sun, the exact opposite goes for some of the crater rims. There are several points known on the south pole of the moon where the sun shines for over 90% of the time during a lunar year, meaning that a solar power facility is able to almost constantly produce energy for a nearby lying facility [6].

Having a lunar habitat inside a crater on the south pole of the moon thus seems to be the most viable option for a near-future semi-permanent human habitat. To inspire students to think about this habitat and increase international relations and experience with designing a lunar habitat, is the main goal of IGLUNA.

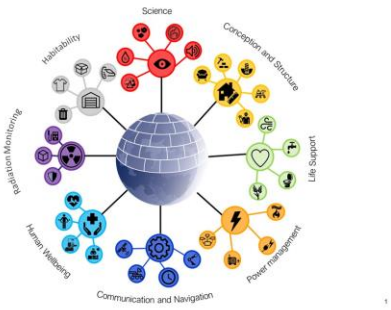

Fig. 2. Elements to build IGLUNA. *Source: SSC.*

Teams/projects: IGLUNA consists of over 120 students and young professionals, organized in 18 teams from 13 universities and 9 countries [1]:

- EPFL, Lausanne, Switzerland
- ETHZ, Zurich, Switzerland
- HSLU, Lucerne, Switzerland
- PoliMi, Milano, Italy
- RWTH, Aachen, Germany
- TUC, Crete, Greece
- TUT, Tallinn, Estonia
- UNIL, Lausanne, Switzerland
- University of Strathclyde, UK
- UPB, Bucharest, Romania
- VU, Amsterdam, The Netherlands
- WUT, Warsaw, Poland
- ZHAW, Zurich, Switzerland

The projects of these universities are divided into eight main categories: Science, Conception and Structure, Life Support, Power management, Communication and Navigation, Human Wellbeing, Radiation Monitoring, and Habitability (fig. 2). Within these eight topics, the teams – each supported by their own professors and universities – are developing modules, such as a greenhouse to grow food, an oxygen generator for life support, or an ice drill for glaciological research [7].

Timeline: At the time of writing, the student teams have met at ETH Zurich from 12-14 September 2018 for the IGLUNA kick-off event. During this event, the students got to know each other by working together and learned about design thinking tools, after which they were able to develop project descriptions and main system requirements and constraints. In the last week of November, the student teams welcomed the coordinators of the SSC in the Preliminary Design Review (PDR); During this review, the outline and realizability of each project was discussed, together with the main constraints, set by the Matterhorn Glacier Palace, the SSC and self-induced safety protocols.

Before the final field test in June, the teams will still meet twice with the coordinators of the SSC. Firstly, they will meet during the Critical Design Review (CDR) from 16 -18 January 2019. During the CDR, the teams will present all the elements of the designs via technical sketches, system overviews, and project maturity before going into fabrication. In April 2019, several weeks before the field test at the Matterhorn Glacier, the Readiness Review (RR) is planned to finalize the modular prototypes of the student teams. It is during the RR that the student teams show their final designs and get the clearance to bring their projects and modules to the field test site.

IGLUNA: Being the demonstrator pilot project of the ESA_Lab initiative, IGLUNA aims to inspire students to participate in a space project by designing a lunar ice habitat and foster international collaboration between the next generation of space experts. With the analogue base inside a (terrestrial) glacier, IGLUNA will provide public outreach and raise international awareness, by improving education about the durability and self-sustainability of space missions. IGLUNA will also function as a test for future (spacefaring) missions.

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Glossary:

CDR	Critical Design Review
Chandrayaan-1	Lunar orbiter by ISRO
EMM	EuroMoonMars
ESA	European Space Agency
ESTEC	European Space Research and Technology Center
ETH	Swiss Federal Technical University
ILEWG	International Lunar Exploration Working Group
ISRO	Indian Space and Research Organization
LCROSS	Lunar Crater Observation and Sensing Satellite
LRO	Lunar Reconnaissance Orbiter
M^3	Moon Mineralogy Mapper
MIP	Moon Impact Probe
NASA	National Aeronautics & Space Administration
PDR	Preliminary Design Review
RR	Readiness Review
SSC	Swiss Space Center
VUSE	Vrije Universiteit Science Experiments