EuroMoonMars 2018-2019 and VUSE IGLUNA: External Exploration of the Moon Village.

R.B Korthouwer[1] and B. de Winter[2], M. Heemskerk[3] , M. Daeter[3], B. Foing[3,4,5] and VU Amsterdam IgLuna Team [1] VU, Amsterdam, Netherlands (rbkorthouwer@gmail.com), [2]VU Amsterdam, Netherlands (dewinterbram@hotmail.com). [3]VU Amsterdam, [4]ESA ESTEC, [5]ILEWG.

Introduction: IgLuna [1] is as a demonstrator pilot project aimed at supporting and accelerating the ESA_Lab initiative. Coordinated by the Swiss Space Center, the purpose of this mission is to investigate an approach for realizing a human habitat on the moon, directly built in the ice craters near the poles and will be tested in a similar extreme environment inside a glacier cave in Zermatt, Switzerland. IgLuna started in September 2018, is almost finished with the designing phase and will soon enter its building and testing phase, which will take place later on in 2019 from March until June. The project is an ice habitat on Earth, but simulates the characteristics and parameters on the Moon. In June the simulation will consist of a working habitat in a glacier near Zermatt, Switzerland. The project is meant for the Moon, but is tested on Earth. That brings different conditions for the simulation. A few differences between the Earth and the Moon must be considered. The lack of atmosphere, the difference in gravity, the amount of sunlight, the amount and intensity of radioactive energy coming in and different climate conditions. When this is successful, more research and more realistic tests will be done to make a habitat in ice on the Moon a reality.

External lander: The external lander will be outside the habitat. It will be at a sunny place on the Moon outside the glacier. Because the glaciers on the moon will be in craters which never see sunlight, the optimal place for the external lander is on the edge of those craters. The main objectives for the ExoGeoLab [2] are to charge equipment, to investigate the surrounding areas, remotely explore the space above it, scan the surrounding environment, drill samples of underlying material and provide power to the habitat below the ice. Equipment on board will be cameras, a remote controlled telescope, environment sensors, drill, lander power system, lander computer, solar panels and weather protection for the incoming radioactive energy.

Drones in exploration: Drones on the moon? It is more likely than to be thought. NASA's recent research towards planetary exploration shows it is possible [3]. The scientists of NASA and Swamp Works have come up and built a drone that can fly without gravity and atmosphere (Fig. 1). The machines being built fall under the name Extreme Access Flyers. The drone is thought to be able to operate on Mars and the moon for several minutes and hours on asteroids.

Drones in space are more complicated. Because of the lack of atmosphere, they use jet propulsion to move around. NASA's drone works in a similar way. NASA's drone flies with cold-gas jets using oxygen or steam water vapor. For collecting samples, designers envision a modular approach. The drone would take one tool at a time and can gatter about seven grams of material per run. That is enough to run tests and analyze the sample on its composition. The Swamp Works scientists have assembled several models, testing aspects of the final machine. The actual prototype for space missions is five feet across

Fig. 1. A prototype built to test Extreme Access Flyer systems in different environments.
Credits: NASA/Swamp Works
Source: <https://www.nasa.gov/feature/extreme-access-flyer-to-take-planetary-exploration-airborne>

Two drones, provided by ILEWG, are present at the ExoHab on ESTEC facility in Noordwijk, Zuid-Holland, The Netherlands. The drones will be a help in exploration of the celestial object and collecting samples it can pick up and return them to the Lander. Rovers cannot always reach all the places. Exploration of lava

tubes, where the rover is not able to go and cannot explore the area anymore, is a great use for a drone. Furthermore, exploring craters for water to turn into fuels and air for the humans. The attention to drones is well in place since they are a great addition to the exploring team. The drone can be programmed to do everything remotely or controlled by humans when accuracy is needed in exploration.

This has successfully been tested before on ESTEC. The small drone, which is a Parrot Mambo (Fig. 2),

Fig.2. The Parrot Mambo flying around on ESTEC's Open day with some members of the IgLuna team. The drone has just grabbed a piece of paper. In the background is the ExoGeoHab visible.

is able to fly for about 6-10 minutes on a full charge and is able to pick up a small sample of maximum 1 cm in diameter. The bigger drone, a DJI Spark, is able to operate for about 10-15 minutes (fig. 2)

Fig. 3. The DJI Spark flying over a large quarry, Hühnenberg Basaltsteinbruche, in northern Eifel, Germany.

The drone is able to pinpoint its position with the GPS on board and is thus more stable to fly around and stay in one place when needed.

Tests and Goals: So far the IgLuna Team has done several tests. The team ran multiple simulations of how the habitat could work with the external explorers focusing on the science side of things. The team succesfully simulated in October 2018 in the Eifel region in Germany a remote sample collection mission with analog astronauts. They tested out the landers functions, operating the telescope, several flights with the drone, trying to collect small rock samples and returning them. In the future there are going to be more test and simulations. In May 2019 the team is going to run preparation tests on different locations and different environments, to ensure perfect protocols for the science experiments and knowledge about how to perform them. The actual simulation will be in June.

Acknowledgements: We acknowledge the VU Amsterdam Science Experiments (VUSE [4]) IgLuna team. We thank the coordinators of IgLuna and Swiss Space Center (Including T. Benevides, O. Kirchhoff, K. Kunstmann, D. Bass and Y. Delessert). We thank ESA and ILEWG (Prof. B. Foing) for supporting and guiding the VUSE project.

References: [1] M. V. Heemskerk (2019), LPS50, Abstract #2416. [2] Foing, B.H. et al. (2009) LPI, 40, 2567. [3] Siceloff, S., NASA's Kennedy Space Center 2017, *Extreme Access Flyer to Take Planetary Exploration Airborne*, <https://www.nasa.gov/feature/extreme-access-flyer-to-take-planetary-exploration-airborne>.
[4] B. de Winter (2019), LPS50, Abstract #1588.

Additional Information: If additional information is needed, visit the IgLuna website (http://www.spacecenter.ch/igluna/). Any specific questions about the topic regarding this abstract, please contact me (rbkorthouwer@gmail.com).