# The Design, Development and Demonstration of Longwave Communication System for Lunar Surface Operations

T. A. Miś[1]

[1]*Warsaw University of Technology, Institute of Radioelectronics and Multimedia Technology, Warsaw, Poland, *Author contact details: t.mis@ire.pw.edu.pl*

## 1. Introduction

Widely used since 1930s for radio broadcasting in Europe, Asia and Northern Africa, the low radio frequencies (LF, longwaves; 30-300 kHz) possess significant advantages in propagation on wide ranges and through different environments. High signal stability, country-wide range achievable with ground wave and almost-global range on ionospheric wave, lower signal's attenuation in comparison with shorter waves, as well as multiple available modes of modulation and transmission, present the longwaves as a reliable medium of communication not only for terrestrial purposes.

## 2. System idea

A single LF transmitter and antenna set, installed on or below the surface (i.e. in a cave) of a small celestial body – a planetoid or a moon – with the transmitter forward power of few kilowatts shall be able to cover the entire body with high quality signal, providing instant communication with surface instrumentation and crew, regardless of their position against the transmitting antenna – no antenna visibility needed. Highly sensitive receivers, based on multiple-ferrite or magnetometric (field probe) technology, shall provide high signal readability and proper signal-to-noise ratio.

## 3. Lunar application demonstration

The idea has been conceptualized and has been developed in the GLACiER project, led in Warsaw University of Technology, Poland, as a part of the Swiss Space Centre's IGLUNA programme – an ESA_-Lab demonstrator project with the mission to simulate a lunar habitat and surface operations on the Klein Matterhorn glacier in Switzerland in June 2019 [4]. The longwave part of the project aimed to connect wirelessly the habitat – located up to 15 m inside the glacier, below the surface – with the surface instrumentation. Two-way communication was to be established using two single-loop quarter-wavelength antennas on the frequency of 270 kHz, sending binary commands in AM CW OOK modulation mode, with optional AM A3E (voice, directly to the simulated astronauts on the glacier).

The entire system has been implemented using low power (up to 1 W) due to EMC regulations in the Glacier Palace region – this however permitted for the longwave to penetrate the ice ceiling of the simulated lunar habitat and provided data transmissions from the Glacier Palace [2]. Despite the unpredicted interferences from the working construction equipment, the signal was received as far as in Finland and delivered numerous data on the emission properties, propagation characteristics and possibilities of improvements [3], including the digitalisation od the signal [1].

## 4. Conclusions

The experiment, carried out in June 2019, has demonstrated the longwave technology for the use in future lunar missions, introducing the well-known low frequencies, to be operated in digital emission, as a new, robust and reliable way of uncomplicated, safe and rapid communication in extraterrestrial environments.

## 5. References (selection)

[1] Miś T. A.: The Performance Analysis and Optimization of IGLUNA 2019 Lunar-Analogue Longwave Transmitting System, Baltic URSI 2020 (accepted)
[2] Miś T. A.: The Results of IGLUNA 2019 Trans-Ice Longwave Communication System Tests, MIKON 2020 (accepted)
[3] Miś T. A.: Design and thermal analysis of POWER MOSFET power amplifiers for LF and VLF special transmitting systems, KKRRiT Łódź 2020 (submitted)
[4] Wajoras J., Żak E., Kazaniecki M., Miś T. A., Bresler K., Grabowski D.: The GLACiER project in the IGLUNA ESA_Lab demonstrator project, 70th International Astronautical Congress, Washington, D.C. 2019