How to live on Mars

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1. Introduction

Human space flight to another planetary body has gained new momentum over the past few years: ESA hopes to reach the Moon within 15 years, and NASA currently aims for Mars in about 20 years. Private companies occasionally announce more ambitious timelines. Nevertheless, important technologies still have to be developed and improved before humans can face the risks and difficulties of interplanetary travel. However, astronauts on long-duration space flights will have to overcome additional challenges, such as the psychological effects of isolated, confined, and extreme (ICE) environments [2-4].

In order to understand and prepare for these psychological challenges, a number of analog habitats have been built in the recent past, including habitats such as HI-SEAS [1] or LUNARES. These have been the locations of record-breaking and innovative concept studies, of which two will be presented in this paper: some lessons learned from the one-year simulation of life on Mars HI-SEAS 4 (section 2), as well as lessons from the first ever mission with a physically handicapped (analog) astronaut, ICAres-1 (section 3).

Both mentioned stations, however, are designed for human factors studies. They share some fundamental design flaws that result in their being inherently limited to terrestrial use. That is, they are true analog habitats, rather than technologically functional prototypes of habitats for extraterrestrial use. However, it is obvious that a mission to another planetary body does not only require rockets and boosters, but also a shelter for the astronauts at their destination. Thus, the final section of this paper will present MaMBA, the proposal for a functioning habitat prototype.

HI-SEAS: 1 year on simulated Mars

In August 2016, the longest simulation of life on Mars on American soil has ended. Six volunteer scientists and engineers had been living inside the HI-SEAS habitat for one year under Mars-like conditions: confined to the 110 sqm habitat, only allowed to leave in mock space suits, and with communications that were delayed by 20 minutes in each direction to simulate the large distance between Earth and Mars.

HI-SEAS stands for Hawaii Space Exploration Analog and Simulation; and the simulation study has been conducted by the University of Hawaii in collaboration with NASA as part of a series of long-duration missions. The HI-SEAS facility is located on the barren slopes of the Mauna Loa volcano in Hawaii.

The constraints of life on Mars are numerous, and some are less obvious than others. For example, resources were limited, including water and research equipment. Despite these limitations, the HI-SEAS 4 crew worked on a number of projects in the fields of geology and biology, both conducting field work and lab analyses, as well as studying EVAs and Human Factors.

Figure 1: The HI-SEAS habitat (left) and a HI-SEAS 4 crew member (right).

ICAres-1: Mars with handicap

The first mission to date that included a physically disabled analog astronaut was conducted at the LUNARES habitat in Poland in October 2017. Unlike other analog habitats (such as MDRS or HI-SEAS), the design of LUNARES allows the simulation of accidents that could result in damage to both the habitat and/or astronauts.

The crew of ICAres-1, which stands for Innovative Concepts for Mars, was composed similarly to the HI-SEAS 4; both crews were international and consisted of 3 males and 3 females. However, due to the special circumstances, the average age of ICAres-1 was higher than at HI-SEAS 4 and 3 crew members instead of just 1 had a medical background.

Living conditions at LUNARES were similarly Mars-like, most notably, the crew could only communicate with mission support via time-delayed emails.

MaMBA: A shelter for Mars (and the Moon)

Today's habitats are (1) located at the surface, even though space radiation is a known threat to crew health, (2) built with a single (central) module, even though one single catastrophic event may then render the entire habitat uninhabitable, and are (3) designed around the crew's living space, with limited attention to the realistic instrumentation of the laboratory which arguably is the most important module for a scientific mission.

MaMBA, the Moon and Mars Base Analog proposed here, will learn from these design flaws: It will consist of separate, connected modules which can be shut off independently from each other, and will adress the possibility of astronauts (temporary) incapacitation. The central piece of the habitat will be the laboratory module; and scientists will play an integral part in the design process for the laboratory. Moreover, as MaMBA aims to be a functioning habitat prototype, it will have closed loops for water and air and a self-sufficient power supply at its final stage. Functionality will be verified during short and medium-duration simulations with analog astronauts.

Summary

Analog habitats are important for studying human factors influencing the success of interplanetary missions. Some existing habitats have recently been used to extend our knowledge about extended life under extreme conditions. However, although these habitats are invaluable for understanding and predicting human factors, they fail to realistically represent the technological challenges remaining today. Therefore, an analog base is suggested that may serve as a prototype for a non-analog base.

References

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Short Summary

Analog simulations are vital in understanding the influence of human factors on the success of an manned interplanetary mission. We will discuss two analog missions that have broken records (HI-SEAS 4) and been innovative (ICAres-1), and present the lessons learned from them, particularly with respect to future habitat design (MaMBA).