EPSC Abstracts
Vol. 12, EPSC2018-599-2, 2018
European Planetary Science Congress 2018

Updated Design Concepts of the Moon and Mars Base Analog (MaMBA)

Christiane Heinicke (1), Leszek Orzechowski (2), Rawel Abdullah (1), Maria von Einem (1), Marlies Arnhof (3)
(1) ZARM, University of Bremen, Germany, christiane.heinicke@zarm.uni-bremen.de, (2) Wroclaw University of Science and Technology, Poland, (3) ESTEC, Noordwijk, The Netherlands

Abstract

Surface habitats are among the many technical challenges for human space flight to commence beyond low Earth orbit. Dozens of test habitats have been built around the world in the past few decades. These habitats typically serve training purposes, psychological studies, and/or tests of specific pieces of hardware. However, all habitats that exist to date are of rather low fidelity, i.e. they would not function on the surface of either Moon or Mars. The project Moon and Mars Base Analog (MaMBA) aims to close this gap. Here, we will present the updated design concept for both the overall habitat and its scientific core, the science module. Construction of the mock-up or first iteration of the habitat laboratory is scheduled to begin later this year.

1. Introduction

With the International Space Station having been operational for almost 18 years, ESA is promoting the Moon Village concept and NASA leading preparations for human exploration even further away, most notably the Deep Space Gateway and the integrated SLS rocket and Orion spacecraft.

However, no concrete plans exist yet for the time when astronauts reach the surface of the Moon or the proposed next step, Mars. A number of test habitats have been built during the last decades and inhabited for various durations, among them the American experiments HI-SEAS [1] and HESTIA [2,3], or the Chinese Lunar Palace 1 [4,5], to name a few. However, these and similar habitats are primarily equipped for studies on human factors and would not function in an extraterrestrial environment.

In particular, existing habitats share the following flaws (in varying combinations):

They
• are built for terrestrial simulations and often rely to some extent on the resupply of resources (air, water)
• sit at the surface, that is they possess no means of shielding against space radiation
• consist of either a single module or rely on a central module
• use space inefficiently
• become unusable by injured astronauts (some even provoke accidents)
• contain an ineffective laboratory (scientific objectives were usually added after the end of the design phase).

Project MaMBA (Moon and Mars Base Analog) aims to build the first functional habitat, drawing from lessons learned at existing habitats. The habitat will serve as testbed for mission critical technologies such as life support, power systems, and interplanetary communication, among others.

2. Goals and Updated Timeline

As a consequence of the above stated problems, we aim to build a habitat that would be functional under extraterrestrial conditions.

2.1 Long-term

In particular, the goal of project MaMBA is to create a base that
• consists of six separable modules that can house consecutive crews of 6 for 10 years (see fig. 1 for a rough sketch of the base layout)
• can be inhabited if/when placed on Moon or Mars, i.e. is adequately shielded from radiation, provides air, water, and energy to the astronauts, fosters their physical and mental health, etc.
• enables meaningful biological and geological analyses, plus studies that could lead to a permanent human presence on Moon and Mars
• remains usable after accidents (this includes damage to both crew and habitat)

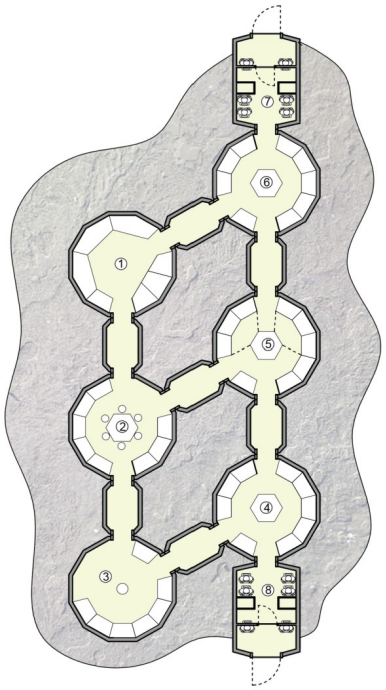

Figure 1: Floorplan of the six-module habitat: 1 - sleeping + hygiene module, 2 - kitchen module, 3 - window and leisure module, 4 - greenhouse and exercise module, 5 - science module, 6 - workshop and storage module, 7+8 - airlocks.

2.2 Mid-term

Being the core of any scientific surface mission, the science module will be the central module. This not only means that the module will be at the center of the habitat, but it will also be the first to be developed and tested. Moreover, the science module will serve as the blueprint for the other modules, in particular with respect to the outer shell design and integrated life support system components.

It should be noted here that the project team is *not* planning to develop all critical system components, but rather to integrate existing systems where possible and to provide an infrastructure for high fidelity tests of said components. Collaborators for these subsystems are sought both in academia and industry.

2.3 Current status

We are currently in the process of developing the outer shell and interior layout of the science module. Construction of a mock-up or first iteration of the module design (that will not yet be fully functional) is scheduled for the late fall this year and will take approximately half a year.

Following construction and outfitting, we will run a series of short-duration simulations (several hours each) to test the usability of the habitat laboratory. The occupants will be scientists performing geological and biological analyses, using the on-board equipment and resources.

Acknowledgements

The project is funded by the Klaus Tschira Stiftung gGmbH foundation.

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