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# MaMBA – a functional Moon and Mars Base Analog

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## Abstract

Despite impressive progress in robotic exploration of celestial bodies, robots are believed to never reach the effectiveness and efficiency of a trained human. Consequently, ESA proposes to build an international Moon Village in roughly 15 years and NASA plans for the first manned mission to Mars shortly after.

One of the challenges still remaining is the need for a shelter, a habitat which allows human spacefarers to safely live and work on the surface of a celestial body. Although a number of prototype habitats has been built during the last decades and inhabited for various durations (e.g. MDRS, FMARS, HI-SEAS, M.A.R.S.), these habitats are typically equipped for studies on human factors and would not function in an extraterrestrial environment.

Project MaMBA (Moon and Mars Base Analog) aims to build the first functional habitat based on the lessons learned from intermediate and long duration missions at the mentioned habitats. The habitat will serve for testing technologies like life support, power systems, and interplanetary communication. Special attention will be given to the development of the geoscience laboratory module. Crews will live and work inside the habitat to ensure its functionality.

## 1. Motivation

Simulations are crucial in today's space exploration by helping prepare astronauts for their missions in space. By principle, simulations focus on one or few aspects of the entire mission, be it physiology (such as bed rest studies, or prolonged stays at Antarctic research bases), psychology (such as the HI-SEAS [1] or (discontinued) FMARS [2] missions), or technology (Desert RATS [3], Rio Tinto expeditions [4], [5]) to name a few.

However, the most vital factor for a surface stay on the Moon or Mars is the astronauts' shelter, the so-called habitat. Although a number of habitats have been built for the purpose of simulating life on Mars, the ones that have been inhabited by crews for a significant amount of time typically focus on human factors rather than providing a realistic prototype. Today's habitats (MDRS, FMARS, HI-SEAS, M.A.R.S.) are

- located at the surface, even though space radiation is a known threat to crew health,
- built with a single (central) module, even though one single catastrophic event may then render the entire habitat uninhabitable,
- 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.

## 2. Goals

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

### 2.1 Basic habitat features

MaMBA will consist of a minimum of connected modules which can be shut off independently from each other. An example arrangement of the modules is shown in Figure 1, it is possible to add further modules and to re-arrange them (to some extent).

At the final stage, MaMBA will have closed loops for water and air and a self-sufficient power supply.

MaMBA' communication systems will address the added challenges of an underground habitat (see below) and the iron-rich environment on Mars.

MaMBA's interior design addresses the possibility of astronauts (temporary) incapacitation.

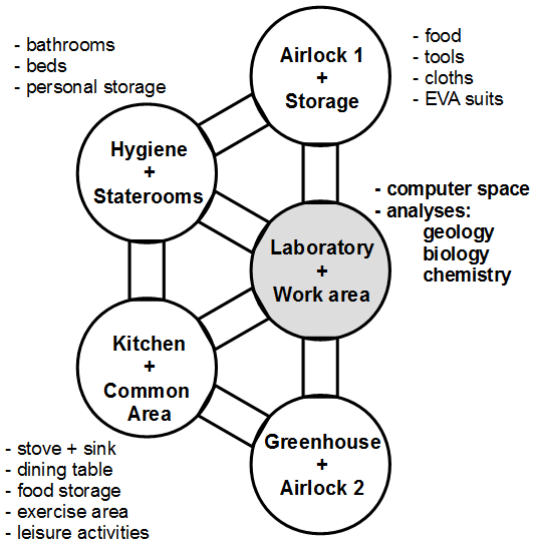


Figure 1: Rough layout of MaMBA, with the science module being the central module.

### 2.2 Laboratory Module

The laboratory module will feature equipment such as microscopes, spectrometers, etc. intended to allow comprehensive geological and (astro-)biological analyses.

Unlike previous habitat laboratories, MaMBA will be flexible in accommodating a range of needs for different, possibly simultaneous analyses, and provide efficient space for storage.

### 2.3 Testing

Crews will occupy the habitat during various stages of the design and construction process to ensure functionality.

At the final stage, MaMBA will be tested under non-laboratory conditions, that is in harsh terrestrial environments and caves.

## 3. Outlook

### 3.1 Next steps

Our first step will be to design, construct, and test the laboratory module. This prototype module will serve two main purposes: (1) be a testground for the systems mentioned in section 2.1 and (2) provide a site for short-duration simulations of exploratory work.

### 3.2 Long-term plans

Afterwards, the single module will be extended to the full habitat. Initially, the full habitat will be located at its home institution; later it will transported to and used in areas of extreme environmental conditions.

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