Safety and comfort for Moon and Mars habitats: key design considerations.

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1. Introduction

Safety requirements are critical in designing for extreme environments. However, safety alone is not enough when designing for long-term missions in extreme environments on Earth and in space. Comfortable and functional design that accommodates crew's physical and psychological needs can help to improve their everyday life and work performance. Currently, a common habitat design approach is based on a linear process satisfying technical requirements of the mission and provid Barucci ing necessary life support for the crew [3]. Nevertheless, to ensure crew members' wellbeing and productivity, aesthetics and other architectural design aspects have to be given equal attention throughout the whole design process. In addition, it is important to examine habitat safety and comfort requirements according to selected construction and technical options.
Habitats in extreme conditions need to satisfy exceptional requirements for construction, environmental protection, and maintenance; they have to ensure life safety, crew's physical and psychological health, productivity, and emergency response protocols [1].
Key design aspects of planning a Moon/Mars base or settlement emerge from answering the following questions:

- Where is better to locate Moon or Mars bases and why?
- What can be learned from comparing permafrost conditions in Antarctica and Mars Polar Regions?
- How to integrate life support systems into the base design?
- How to provide safety in emergency situations?

2. Examples of effective architectures and technologies in extreme environments

Advancing crew working performance while reducing base maintenance costs is the major concern that determines habitat design requirements and design overall efficiency [14]. In particular, architecture of the whole structure or facility has to provide systems and inhabitants security, sustainability and good living standards. Such strategy fundamentally changes the approach to designing habitats and equipment for extreme conditions on Earth and in space.
Pleasing, yet comfortable and easy-to-use interior design combined with the latest technology allows multiple options for efficient use of habitat's compartments [14]. That increases functional and operational flexibility of habitats and other modules interior spaces. Elegant design with unobtrusive design elements can help the crew to relax mentally and to rest. Consequently, comfortable conditions for life and work contribute to improvement of crew's health and well-being stimulating better psychological and physical conditions of every crewmember who works under extreme conditions. With the new approach to habitat design habitat structures become more efficient due to their compactness, modularity and flexibility.
These assumptions are based on our research of the best practices and recommendations derived from experience on the medium-duration orbiting facilities including Skylab, Spacelab, Salyut 7, Mir, and the International Space Station; orbital spacecraft system Shuttle; polar research stations in the Antarctica and Arctic; and Earth-based human space mission simulators [5]. The Earth-based recent, present, and planned simulators were ranged, analysed and categorized. Virtual and parabolic flights were also considered as simulating environments (Annex 1).
In addition, selected key results from international studies on innovative technologies and structures for habitats, radiation protection, and regenerative life support systems are summarized and reviewed.
The paper summarizes with definition of current major problems in the habitat design and discusses a new architectural strategy to creating innovative and effective habitation systems for Moon and Mars applications.

3. References

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Mars Desert Research Station (MDRS): http://mdrs.marssociety.org/
European Mars Analogue Research Station Project (Euro-MARS): http://euromars.net/
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Short Summary

This paper discusses a new architectural strategy for creating innovative and effective habitation systems for Moon and Mars applications that based on identification of current major problems in design and planning of medium-duration orbiting facilities, polar research stations in the Antarctica and Arctic, and other human-space-mission analogs and simulators.