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Space Architecture: Habitats, Habitability, and Bases (1)

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HOLISTIC OUTPOST DESIGN FOR LUNAR LAVA TUBES

**Abstract**

As the space industry continues its rapid development, humanity is poised to expand beyond Low Earth Orbit (LEO), seeking to establish permanent presence on the Moon and beyond. While space travel has traditionally been the domain of a small number of highly specialized professionals, a new era of human exploration, involving non-space actors and stakeholders, is now becoming a reality.

In spite of this development, most space habitats are still designed for a narrow target group. This paper seeks to address this deficit by rethinking the established design approaches, typically limited to tackling technological and physiological challenges of human space exploration (such as radiation or hypogravity), by instead adopting an interdisciplinary ‘big picture’ perspective encompassing social, psychological and cultural aspects of future space habitats.

In collaboration with the European Space Agency (ESA), we have conducted an extensive literature review and interviews featuring both industry experts, as well as members of the public. On these grounds, we then present a broad overview of key considerations and relevant human factors surrounding the design of future large-scale space habitats with a lifetime that spans generations of settlers.

Drawing on elements from architecture, urban studies and design fiction, we synthesize our findings into a hypothetical lunar settlement concept. Realized by in-situ resource utilization (ISRU) and 3D printing, we propose the construction of sub-surface living spaces in lava tubes, with respect to the rough internal terrain, close to the lunar poles.

We take a holistic human-centered approach prioritizing the fostering of community, belonging and identification with the habitat. To this end, the concept encompasses 7 different module types each tailored to meet specific human needs such as private, social as well as multi-purpose spaces. This approach purposefully distances itself from traditional centrally planned settlements, by instead enabling inhabitants to autonomously and organically grow their colony over an extended period of time. The theoretical urban development is illustrated by a conceptual 25-years plan starting from 2030. Our aim is to present a concept that is generalizable and applicable to destinations beyond the Moon.

By elaborating and reflecting on our concept, this paper seeks to demonstrate the importance of a trans-disciplinary approach to designing thriving sustainable colonies beyond LEO. We demonstrate the potentially key role of design as mediator in advancing macro-strategies promoting thriving existence and sustainable growth. With this approach we tackle big-picture questions about humanity’s future and prospects amongst the stars.