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OSIP OFF-EARTH MANUFACTURING AND CONSTRUCTION CAMPAIGN-STUDY SCHEME

DESIGN OF A SCALABLE FRAMEWORK OF LUNAR HABITATS

Executive Summary

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European Space Agency

Hassell
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EXECUTIVE SUMMARY

"For all the different forms it takes in different historical periods, for all the worthy and unworthy motives that lie behind it, exploration—travel for the sake of discovery and adventure...is a defining element of a distinctly human identity, and it will never rest at any frontier, whether terrestrial or extra-terrestrial."
- Stewart A. Weaver

Our human species have an inherent need for discovery. In recent times, we have observed a renewed passion and investment in the pursuit of space exploration – a shared global agenda to push the boundaries of science and space travel. The long-term survival of humanity relies in our ability to evolve into an interplanetary species. The greatest challenge for architects and designers, is to design a scalable model for habitation in other planetary bodies – capable of hosting and adapting to the various needs and desires of our foreseen population growth in space.

This report documents our research and proposal for the "Design of a Scalable Framework of Lunar Habitats – an activity funded by the European Space Agency as part of their OSIP (Open Space Innovation Platform) Off-Earth Manufacturing and Construction Campaign. The aim of the study was to develop a scalable, holistic design framework for permanent human habitation on the Moon, embedding key solutions for environmental protection and mitigation, construction methodology and assembly of a scalable architecture, life support and an overall mission architecture. To ensure a holistic and integrated scheme, Hassell has partnered with Cranfield University's Master of Astronautics and Space Engineering Module which brings expertise around the system and mission architecture for our design. Together, we have conducted a comprehensive review and synthesis of technical requirements and existing space infrastructure developments to form the basis of our design solution. This approach differs from conventional design models, ensuring participation and integration of industry experts and practitioners from project inception.

Our work would not be possible without the contributions from David Cullen and his students' work from School of Aerospace, Transport and Manufacturing - Astronautics and Space Engineering at Cranfield University. The work as part of the Graduate Design Project provided crucial input towards the various sections of this report. As part of their involvement, our team would like to give special acknowledgements to:

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Historically, an architect or designer's involvement within the space industry is reserved to the production of "artistic impressions". Our alternative approach will hopefully offer the required rigour and detail that is often expected within the space community.

A major functional requirement of the design is its scalability, catering for potential expansion of lunar infrastructure and prolonged human settlement. Our activity is driven by human centric principles, ensuring long term self-sustainability and well-being. Formulation of solutions have accommodated for a constantly evolving programmatic brief, taking into consideration the physiological, psychological, and social needs of a wider inhabitant demographic.

The spatial manifestation of the architectural framework will be a direct response to the self-sustaining, infrastructural system of the overall habitat - enabling future lunar activities such as space industrialisation through ISRU and the facilitation of future exploration missions i.e. Mars.

Our research proposal departs from a systemic study conducted that looked at a holistic design of a habitat on Mars.[1]

1. https://www.youtube.com/watch?v=AIrH01N9AsE&t=1s (HASSELL + EOC Mars Habitat Project)

The final proposal will also undergo iterative reviews and verifications with a wider consortium network of space expertise from around the globe, including:

- Aaron Parkhurst *[**Space Anthropologist, UCL**]*
- David Jeevendrampillai *[**Space Anthropologist, UCL**]*
- David Cullen *[**Professor of Astrobiology and Space Biotechnology Centre for Autonomous and Cyberphysical Systems, Cranfield University**]*
- Brady Peters *[**Associate Professor, University of Toronto**]*
- Beth Healey *[**Medical Doctor Hoptal du Valais / ESA (Concordia)**]*
- John Eager *[**Director of Operations, National Centre for Atmospheric Science**]*
- Aled Roberts *[**Research Associate, Manchester University**]*
- Kate Jeffrey *[**Neuroscientist, Professor of behavioural neuroscience, UCL**]*
- Anna Talvi *[**Designer / Researcher UCL / ESA**]*
- Lars De Laet *[**Associate Professor at the Department of Architectural Engineering, Vrije Universiteit Brussel**]*
- Malica Schmidt *[**PhD Student and Guest Researcher at the German Aerospace Center (DLR e.V.)/UCL**]*
- David Nixon *[**Space Architect retired**]*
- David Green *[**Senior Lecturer of Human & Aerospace Physiology, EAC/King's College London**]*
- Philip Longhurst *[**Professor, Cranfield University**]*
- Augustin Guibaud *[**Research Fellow, UCL**]*
- James Solly *[**Director,Format Engineers**]*
- Vittorio Netti *[**Lecturer for Space Technology, SICSA/University of Houston**]*

The report synthesises decades of previous research and publications around Lunar Habitat Designs, distilling key considerations and parameters that will drive design solutions. Through a careful literary review, the report also identifies information gaps that inhibit the formulation of detailed design solutions for the lunar habitat.