Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Student: **Sophia Benfield**
Academic year: **2024/2025**

Architecture tutor:	Henriette Bier
Building technology tutor:	Ferry Adema
Research tutor:	Arwin Hidding

Part 1: Graduation Plan

Personal information	
Name	Sophia Benfield
Student number	5260752
Examination period	P2

Studio		
Name / Theme	**Lunar Architecture & Infrastructure**	
Main mentor	Henriette Bier	Architecture
Second mentor	Ferry Adema	Building Technology
Third mentor	Arwin Hidding	Robotics
Argumentation of choice of the studio	Lunar Architecture was the first studio to catch my eye when reviewing my options, probably because I am a big fan of sci-fi films and books. The introductory meeting confirmed my initial interest; I felt inspired and excited to be able to tackle such an unusual subject. To reach the goals of the Artemis mission (which lie in our near future) it is necessary to realistically consider all aspects of Lunar Architecture. Contributing to that future, even if it is only a little, is an amazing opportunity. Additionally, it felt like the ultimate challenge of my acquired architectural skills, to apply them to such an extreme location after being used to designing 'terrestrial' buildings.	

Graduation project	
Title of the graduation project	**MoonSane – Designing Lunar Habitats for Mental Wellness**
Goal	
Location:	The Moon, Rimae Sulpicius Gallus, LAT: 20.25645 LON:10.45098
The posed problem,	In 1969 man first set foot on the Moon, something that had seemed impossible. Now, 55 years later, we are finally getting ready to take the next step; one of the aims of NASA's Artemis Missions is to lay the foundations of lunar bases on the surface of the Moon that can facilitate human habitation for a longer period of time. Due to the dangerous conditions out on the surface, any long-term settlers will be mostly confined to the Moon base, with only their fellow crew members to interact with. This will have a great impact on their mental wellness. For example, the monotony regarding the environment and social relations can increase feelings of isolation and anxiety because they do not provide enough new stimuli. Research has identified nearly 70 stressors created by space travel, ranging from the real possibility of dying to boredom and from crew tension to isolation. On earth a lot of relaxation can be found

	outside of the home, for example, by taking a walk outside, preferably in nature. On the Moon this will not be possible as the surface environment is very hazardous and any EVA's [extravehicular activities] need to be planned meticulously. Even looking out the window will not show the varying blue and green views we are used to, but a colourless, rocky landscape similar to a black and white photograph. Solace will need to be found within the habitat itself. In the past, the design of space bases was mostly left to engineers, without consulting architects. Russian architect Galina Balashova has spoken often about being the only one with an architectural vision besides countless engineers while working on the Soviet space modules. She was the first to consider the visual impact of the environment inside the module and incorporated colour schemes and textures to help astronauts feel comfortable and help orient them in 0-gravity. Balashova even added her own watercolours on the walls, to give the astronauts a connection to home. She was the first to realise the importance of incorporating the architectural vision into space architecture. It has everything to do with habitability in the long run; creating a space where astronauts can not only survive physically, but will also thrive mentally. During his time in space, former astronaut and physician Jay Buckey realised the necessity of maintaining a good mental health as an astronaut, stating: "the psychological aspect is a really important one to deal with, because if it's done right, the missions can be truly amazing, but if it goes wrong, it's the kind of thing that can end a mission". Through various studies, it has already been established that architectural spaces can influence human emotion and mental wellbeing. On earth this theory is already being implemented in the design of new buildings, though it is sometimes still overlooked, because other factors, like the outside environment and (large-scale) social interactions, can compensate. On the Moon, when the daily visual stimuli will be mainly provided by the habitat, without a natural, external environment to compensate, these psychological aspects of architecture will be even more important and must be utilised.
research questions and	Main research question: **How can human spatial perception be used in the design of Lunar habitats, to mitigate the negative mental health effects of living long-term on the moon?** Secondary questions: ▪ What are the main psychological stressors of living on the Moon?

	▪ How can spatial geometry be used to improve mental health of inhabitants of a Lunar base? ▪ How can lighting be used to positively influence the mental health of inhabitants of a Lunar base? ▪ How can the addition of real and artificial views be used to improve the mental health of inhabitants of a Lunar base? ▪ How can the addition of a meditation/reflection space to the habitat improve the mental health of Lunar base inhabitants ▪ How can all relevant interventions be combined into a functional Lunar base?
design assignment in which these result.	The main objective is to design a moonbase that combines various spatial interventions, that have been proven to positively impact the mental health of inhabitants/users, into a fully functional Lunar habitat. These interventions will include lighting, geometry, spatial porosity and internal- and external views and need to all be implemented into a small scale Lunar base. The challenge will be to distinguish between functions within the Lunar habitat, with regards to which mental health intervention is relevant to which function and how it should be integrated; a research lab will have different requirements than a meditation space. The integration of all the architectural interventions also needs to be combined with the safety requirements of building on the Moon, considering radiation, a life support system and an adequate construction strategy with the use of in-situ resource utilisation principles.

Process

Method description

<u>Available literature</u>
The main topic will be researched by first looking into the available literature on this subject and defining different spatial interventions to research further. General information about spatial perception in architecture will be combined with relevant information about the Lunar environment and the psychological challenges of space travel. NASA has several logs in their archives, kept by astronauts during the Apollo missions, that might hold crucial information about the crews state of mind and how it was impacted by their living space, so they will be reviewed.
Besides defining the architectural interventions for mental health, it will also be important to define the criteria that will help judge each intervention on effectiveness. This will be based on available previous studies on spatial perception in architecture.

<u>Further data collection</u>
Several lectures by experts in the field will be used to gather knowledge on the location, current innovations and previous case studies relating to Lunar habitats or

off-Earth projects in general. Among the experts are architects, a radiation scientist and a participant from the HI-SEAS analogue space mission.
Additionally, the 'Moonshot Symposium' is organised to introduce new projects, for example by ESA [European Space Agency], and give an overview of recent developments.

Research by design
The main method of investigating each intervention will be research by design, which will include testing out various options through renderings and simulations. The interventions that are considered most effective will also be tested by building real life models (various scales up to scale 1:1), to test the spatiality and how it compares to the digital version.

Computational approach
To increase the efficiency of testing and combining different interventions, Grasshopper scripts will be developed based on the interventions and their variables, for example, porosity, thickness, size etc., resulting in an adjustable 3-dimensional model that will facilitate the creation of many different schematic- and design iterations.

Workshops
Workshops about robotic production and human-robot interaction will provide more detailed knowledge on off-earth construction and in-situ-resource-utilisation (ISRU) based on current research. The workshops will show the possibilities as well as the current limitations when it comes to building a Lunar base, which can be applied to the design.

Testing
As the main objective is to research the emotional and psychological reaction of people to these different interventions, a survey about a selection of the interventions will be relevant. The developed renders and models can be used as impressions that partakers of the survey can react to. To get even more accurate results, it would be helpful to create an immersive test, with the help of virtual reality, where participants can experience different spatial interventions fully. Afterwards an interview will be conducted to gauge their reactions.
How the various options perform according to the set criteria will be compared to each other, with the end result being an overview of the best design strategies and their effects.

Finally, the outcome of the research will be applied to an actual design for a lunar base.

Literature and general practical references

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