Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Regina Tania Tan
Student number	6010881

Studio		
Name / Theme	Lunar Architecture and Infrastructure	
Main mentor	Henriette Bier	Architecture
Second mentor	Ferry Adema	Building Technology
Third mentor	Arwin Hidding	Robotics
Argumentation of choice of the studio	Personal interest in space exploration and wanting to explore a research-based design that is well-thought and connected to the current research in space architecture. Usually, opportunities for extraterrestrial habitat projects is presented in fast-paced competitions that is either very realistic or utopian. Doing it in a graduation studio allows a proper synthesis of informed considerations for a feasible yet innovative project. Especially on this studio since it is interdisciplinary, there is opportunity to discuss and meet experts from other discipline, which is very valuable to achieve a robust and thoughtful design that I am looking to achieve in a graduation project for a meaningful and useful contribution in the discipline.	

Graduation project	
Title of the graduation project	Terraforming Moon: Humanizing Lunar Habitat through Human-centric Design
Goal	
Location:	Connecting ridge on the **west** of Shackleton Crater **(89.45°S, 222.69°E**), South Pole, The Moon
The posed problem,	Multiple nations are restarting the "space race," which has been stagnant since the last manned lunar landing on December 1972. NASA's Artemis program aims for manned lunar mission by 2025 and China by 2030, all in sight to set up a permanent lunar base as a step forward in space colonization. Integral to the space colonization is the habitat which will house the humans amidst the extreme extraterrestrial conditions. Yet, existing research in space habitats mostly focused on functional optimization and safety, leading to functionally-driven design reminiscent of prison

	architecture to some extent, as it lacks the necessary social and psychological qualities for long-term habitation. Living on the moon with majority of the time spent within the habitat means the habitat need to cater to the diverse needs of the users. As humans are social beings, social integration becomes an important factor to be addressed for long-term lunar habitation. From past mission excerpts, it is apparent that lack of spaces with varying privacy leads to frustrations of limited types of human interactions. With the advancement of space science and technology compared to the last lunar landing 50 years ago, and forecasting the speed of innovation in the near future, now is the time to push new possibilities of lunar habitat design with new methods and perspectives. With that in mind, it is important to adopt a different design approach compared to the existing space station and short-term mission precedents, one that is driven more by human-centric design principles for a more humanized lunar habitation. In conclusion, the problem statement is: **Lack of space architecture precedents that prioritizes human behavior in the design.** The social and psychological effects of long-term isolated nature of lunar habitation requires more human-centric design approaches.
research questions and	*Research Question* How to incorporate **user-defined spaces** based on **human-centric design principles** in designing long-term lunar habitation that balances between social interaction and private boundaries for the psychosocial well-being of the inhabitants? Sub-questions • What are the human-centric design principles? • How can past experiences in analogue missions, space station missions, and lunar expeditions help to create user-defined spaces? • How does a habitat with user-defined spaces achieve balance between promoting social interaction and establishing private boundaries? • How to architecturally represent the different human interaction and personal preferences taking place in long-term isolated environment of the lunar habitat? • What is the appropriate construction system and assembly for a habitat consisting of user-defined spaces on the moon?

design assignment in which these result.	To address the need for more human-centric design approach in lunar habitat, this thesis will delve into **designing a long-term lunar habitat with heterogenous spaces that is user-defined, with the aim to balance between social interaction and private boundaries, within the isolated nature of space habitat.** This means the habitat should allow different social interactions to take place, from promoting social interaction into establishing private boundaries. By using a variety of different methods and departing the design from the human aspects: lifestyle, activities, and preferences, this inform a design direction to provide a habitat with distinct spaces to allow different social functions to take place, aside from the main work mission, to provide a better work-life balance and improve the overall well-being of the users. Translating it to a concrete design assignment means to design each space based on their need, in which the form will follow the technical and social function. It is important to also not over-customize each space to allow each users to make some modification. The idea of providing option to personalize would allow creativity which can alleviate the boredom of living in confinement. While the project takes into account the technical feasibility, since the focus of the project departs the design from social integration, it will not be limited to current possibilities. Speculations on future technologies will be integrated in the project, such as In-Situ Resource Utilization (ISRU) as it allows mass customization within a component-based construction system and it's scalable, which suits the project approach towards user-defined spaces.

Process

Method description

Designing a lunar habitat with human-centric design approach requires various methods to investigate the different human interactions and translating them into a set of design principles, which will be the base for design decision making. Listed below is each method with description of the use and aim.

Field Trip

The studio arranged a voluntary field trip to Sicily, Italy, where we explored lava tube caves and visited Mount Etna volcano. The field trip main objective is separate from this thesis, testing implementation of autonomous scanning robot in a lava tube which has a comparable similarity with the moon surface. The extreme terrain and secluded location of the caves alongside packed schedule gave the author a first-person insight on a fraction of experience of a lunar mission, which is reflected in the thesis as personal observations of analog mission.

Data Collection & Case Studies
Due to limited data on actual human experiences on the moon, this thesis tapped on various sources in order to make informed speculations on living on the moon, mainly on excerpts from astronauts, crew members, and related experts and professionals in the interdisciplinary field of space architecture, as listed below:

1) Mission-related experiences from analogue missions on Earth (Hi-SEAS Missions, Antarctic Research Centers, Mars Desert Research Station), space station missions in Low-Earth Orbit of outer space (ISS, Skylab, MiR, Salyut), short expeditions in 1960-70s on the lunar surface (Apollo Missions) as qualitative guidelines on informing importance of design in space habitats, giving insight on interpersonal relations, individual preferences and behaviors, as well as psychological, social, and physical considerations of a habitat. This also includes consulting space agency archives, blogs, vlogs, and research papers as primary source for photos, interview excerpts, and journals to gain first-hand insight from the related users.
2) Guidelines and Best Practices by NASA, ESA, and research papers and journals by experts as baseline for minimum requirements of the habitat, mostly technical.
3) Symposiums and lectures facilitated by the studio gives insights on current and future scientific and technological advancement in space colonization, as well as informal discussion with the experts for information and feedbacks for some speculations which could be implemented in my project.

The data are used as the baseline, but also revisited with each design iteration to provide continuous internal feedback loop on the design direction.

Personas and Activity-based Design
This is a main method of translating the data into feasible design guidelines for the further design exercise of the project. Using personas simplified the complexity of the various intangible requirements into a set of design parameters. The personas are then used to guide the activity-based design, where extrapolating the future user schedule is used to guide the needed program requirements as well as the characteristic of each space within the habitat. Designing for different activities specific to the lunar mission thus allows the heterogenous spaces to be organically developed from bottom-up approach.

Literature Review
Technical and scientific research papers are consulted to inform speculations of future lunar living and habitat construction, such as future conditions of lunar base, upcoming planned missions, and possible technologies to be implemented.

Theories of human-centric design methods are consulted to set the design parameters and setting strategies for a user-defined space. On the macro-scale, phenomenology as implementation of the experiences and habitability as baseline habitat needs. On the meso-scale, looking into proxemics to guide the spatial scale of privacy boundaries and third place theory to guide adjacencies and social activator spaces. In the micro-scale I looked into theory of affordances to develop the interfaces of the space with the human.

Computational Design
The customization nature of designing heterogenous space can be made feasible by using computational design to aid in the process. Using different computational rule by setting up program adjacencies, differentiated surfaces, scales, and combinations can further explore geometrical iterations. It also streamline the design process, so changes on some aspects of the design can be made partially and seen the effects holistically, rather than remaking and redesigning the model each time. This could work due to the bottom-up nature of the project, in developing smaller scale system first before delving on the larger scale.

Workshop
The construction method of using In-Situ Resource Utilization and Human-Robotic Interface Assembly that is intended for this project has undergone proof of concept through the workshop in the beginning of this studio. In the workshop, we created a 1:1 prototype of a set of stackable Voronoi-based components, which can be the base construction system as it allows mass-customization and it is scalable, allowing transition from micro to macro scale. The component logic can be translated to various additive and subtractive method of construction, which are currently highly researched as a sustainable option for building on the moon.

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Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

My graduation topic of exploring human-centric design for a more humanized lunar habitat is directly connected to the studio topic, which is Lunar Architecture and Infrastructure. The project scale itself is architectural, thus directly relates to my master track architecture.

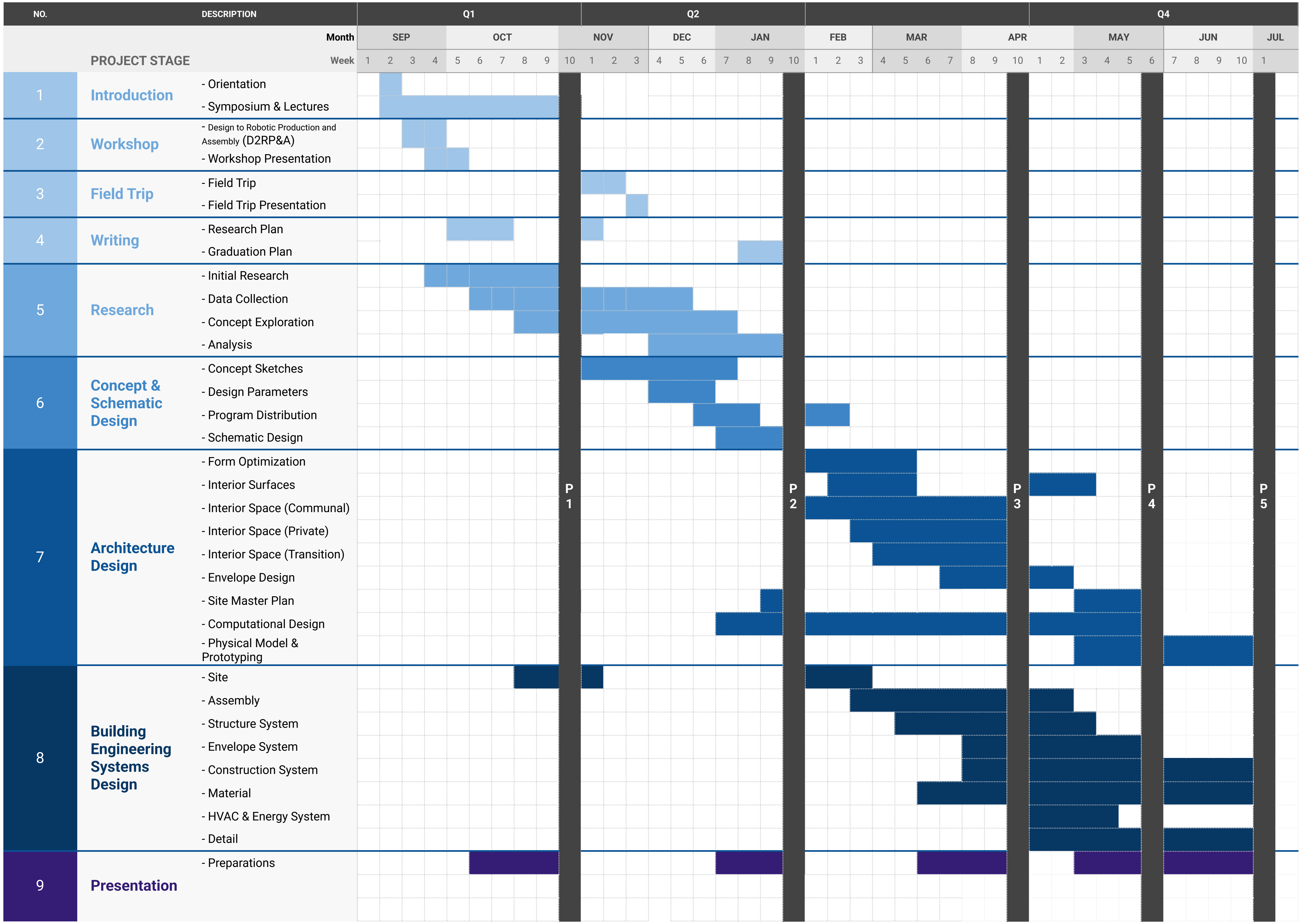
2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

Space architecture is currently advancing rapidly on various disciplines, yet there is a lack of architectural approach, thus there is a research gap of designing with an architectural framework – a design that synthesize the technical requirements of a lunar habitat with the psychosocial needs of the user. This is very important because past experiences has shown mishaps and frustrations within the habitat due to overlooked social and psychological functions of the astronauts. Within the field of space architecture, it is hoped that this thesis could contribute another possibility of approach in designing a more humanized space habitation.

Aside from space architecture, rethinking lunar habitat design is also correlated to architecture in extreme environments and designing in isolation. Due to the nature of lunar habitat that is a self-sufficient habitat within a inhabitable environment, this means the user will spend most of their time within the habitat. It is precisely the transferrable aspects of this project, in dealing with interiors of confinement. It questions the basic nature of the relationship of the human and building again, with the bottom-up approach of designing the building from human interaction.

The unique limitations and conditions of building on the moon inadvertently requires various technological innovation to be incorporated to the project – as has been done with a lot of space exploration initiatives in the past. The scarcity of resource and limitations of human capital requires rethinking of the construction method, such as incorporation of in-situ resource utilization, which is currently still a developing method that has a lot of potential for circular architecture. All in all, the progressive nature of extraterrestrial construction can push novel methods of designing, which hopefully these innovation can be brought back for terrestrial applications.

PROJECT TIMELINE



P3 16 Apr

P4 28 May

P5 2 Jul