

Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences



Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examcommissie-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	Ivan Chavdarov Velev
Student number	5248434

Studio		
Name / Theme	Explore Lab / Orbital Space Architecture	
Main mentor	Ir. R.R.J. van de Pas	Architectural Engineering
Second mentor (Building Technology)	Ir. H.L. van der Meel	Architecture and the Built Environment
Third mentor (Research)	Prof.dr. G. Vrachliotis	Theory of Architecture and Digital Culture
Argumentation of choice of the studio	<p>Selecting Explore Lab as my graduation studio has been on my mind since the time I was writing my motivational letter to apply for the master's program at TU Delft. I ideated on a subject for my thesis related to extreme environments and extraterrestrial architecture. I have aimed to work on the topic at any possible moment. The title of my history thesis was "Cohousing in 'Space' and Time". I conceptualized using the cohousing model as a way of living in space. I realized that there is a lot that architects could add to the design of future space habitats. Explore Lab was the place where I could expand my research and interest in the topic.</p>	

Graduation project	
Title of the graduation project	<p>Celestial Architecture as a Home. Designing a space station that can sustain 30 humans for at least 5 years; a place where, although far from Earth, people can live happy and productive lives and have a sense of belonging.</p>
Goal	
Location:	Earth-Moon Lagrange point 5 (L5)
The posed problem,	<p>Designing a space station with the occupants as the starting point instead of the mission's goal and engineering.</p> <p>Since Tsiolkovsky's daring visions of a society spreading through the solar system, scientists and artists have pondered over our future in the sky. Architects imagined</p>

flying and moving cities and even space stations. Georgy Krutikov in the 1920s in his graduation thesis proposed an unseen scheme of residential areas hovering over public life on the ground. Fritz Haller implemented his concept of modularity and systems to the rotating space cities of Gerard K. O'Neill. There have been numerous similar examples from the previous century. Most of them have served as a 'What if?' testing ground for preconceived notions on Earth where, while asking different questions about problems, lessons can be learned about life or architecture on Earth.

More recently, architects have shifted towards a more pragmatic role of actual designers of potential future space habitats. There are specialized space architecture companies like Liquifer in Austria. BIG have been working with NASA to design a functioning Moon village and other large studios have dedicated time and resources to make extraterrestrial designs. However, currently, the main issue with those proposals is that they predominantly suggest an outer shell that is later populated with a regular layout and program that is identical to those on Earth (fig.1, fig.2). This does not take into account human factors in relation to isolation, enclosure, and reduced gravity, or at least are not communicated explicitly in resources.



Fig.1

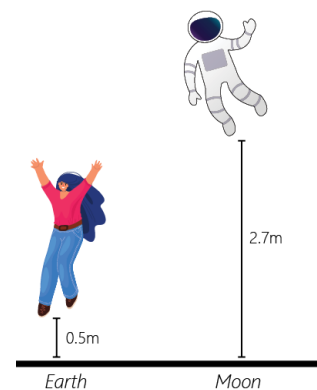


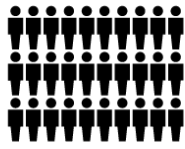
Fig.2

Fig.1 Moon village design for the 2021 Venice Architecture Biennale by SOM. It features a spiral staircase with riser same as on Earth, while the gravity on the Moon is significantly lower.

Fig.2 Comparison of the average height to which a person can jump on Earth and on the Moon. On Earth, a person can jump to 0.5m and on the Moon to 2.7m. This shows that, for example, staircases in the two situations do not need to be the same.

	<p>Outer space is a harsh environment, yet in its function, it is ultimately undefined. There are no established typologies or styles. This gives the opportunity for architects to begin thinking about space habitats with the human as the center of the design. The design process can be inspired from the inside-out or as we would say on Earth - 'bottom-up'. This research proposes a design approach that has the human and their experience as a starting point, which later converges with the massing. In an isolated and extreme environment, the need for social interactions and recreation becomes vital to the mental health of people. Therefore, this will be a driving force of the project.</p>
<p>research questions and</p>	<p>Research question: How can we design an enclosed environment that simulates the spatial experience of recreation in a public park?</p> <p>Sub questions: What does that experience consist of here on Earth? Which aspects of the surroundings facilitate a rejuvenating and relaxing experience? What is the relationship of people to their surroundings in the park?</p>
<p>design assignment in which these result.</p>	<p>Design a space station in Earth orbit for a beginning of a mining colony where life outside of Earth will be defined for permanent residence.</p>
<p>Scenario:</p> <ul style="list-style-type: none"> ● The year is 2100 ● The energy on earth is primarily renewable ● There have been people on Mars doing research for 1 year at a time - missions are 3 years because of traveling time ● Private companies are looking towards the asteroids for a place with a lot of resources to be exploited ● Space mining colonies are also space laboratories where medicine, engineering, and astronomy are researched - science, mining, and manufacturing centers. There is also a place for refueling and transit of deep space missions. ● Space exploration is well advancing and is a priority to exploit the resources available ● People spend a minimum of 5 years there - it is important to put out the maximum amount of work by people in order for their stay to be valuable for the investors ● Work is done for 4 hours a day, 4 days a week. ● The space station will be built on the spot from materials from the asteroids ● People cannot go outside unless for work - maintenance ● windows are limited due to cosmic radiation this means natural light is hard to provide ● This is one of the first steps to attempting to make the space habitat a place for more permanent residence. 	

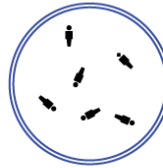
Brief:



30 people permanent residents and workers



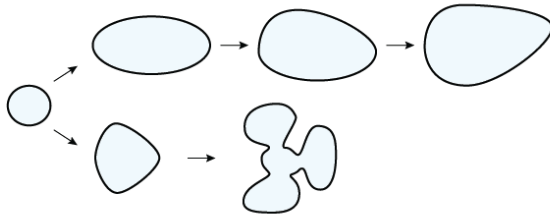
5 visitors at a time (transit crew)



0 gravity



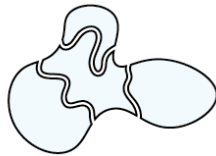
1 gravity through spinning



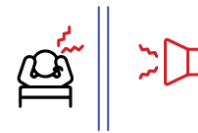
Flexible and morphing



Feeling of infinity

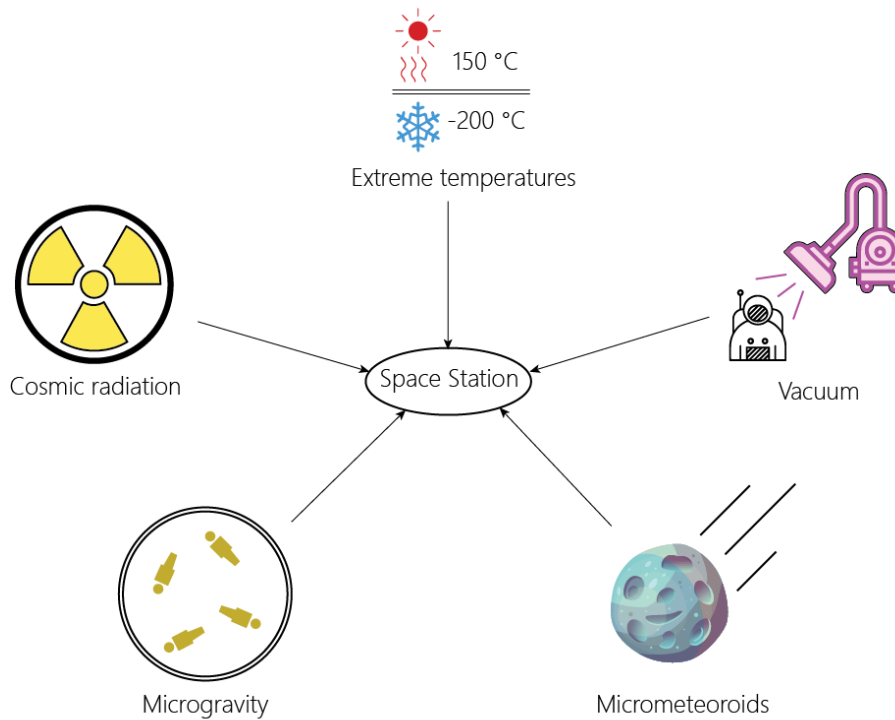


Seamless transition from one space to another

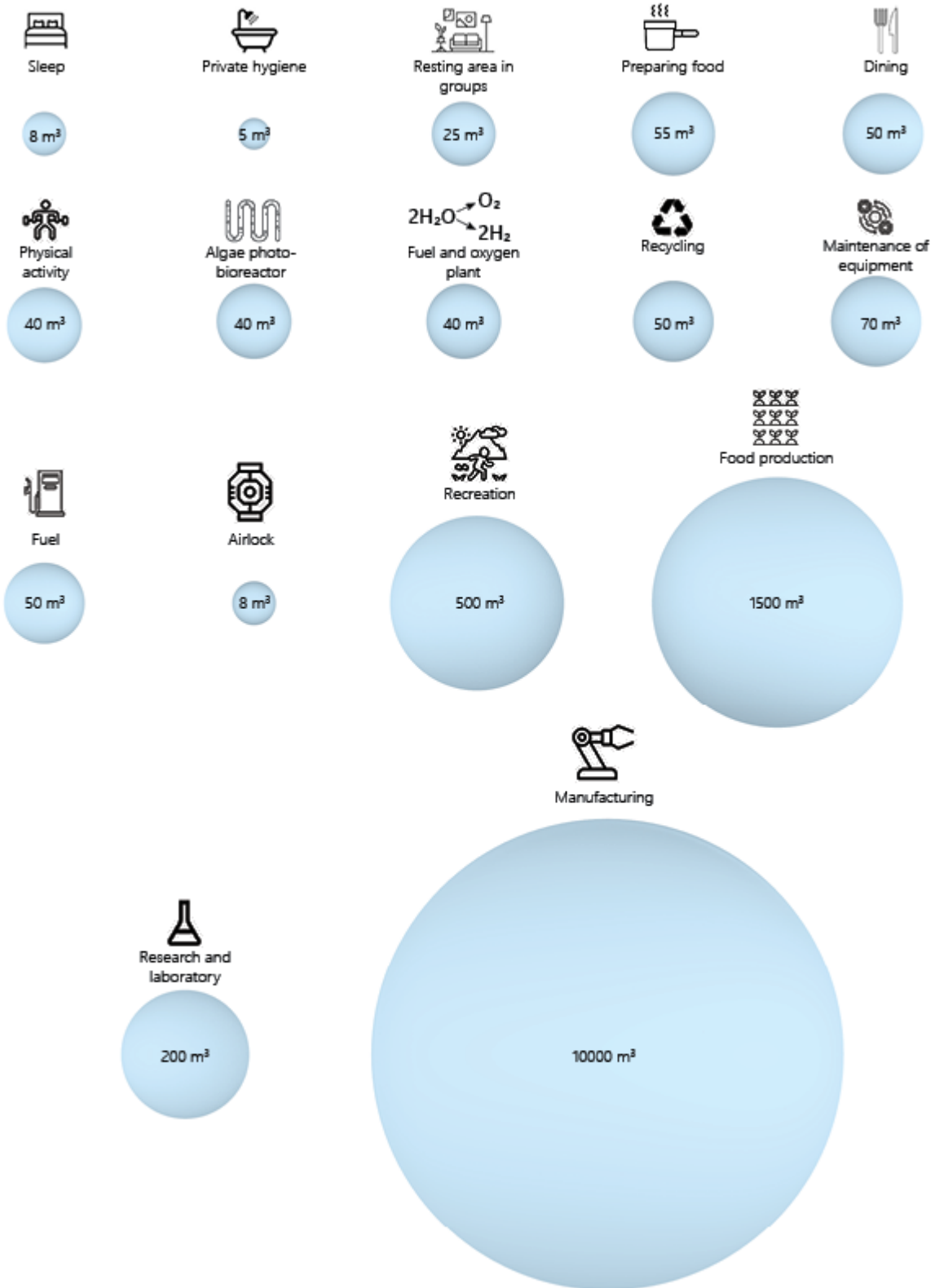


Acoustic insulation between areas in the space station is extremely important

Site constraints:



Sizes:



* Sizes are for the internal volume - they do not include shell thickness

Process

Method description

Research Method:

In order to research what is one of the most common and universal forms of recreation that exist on Earth, we will look at people's experiences in a public park. The study shall focus on a specific public park in the Netherlands - Het Park, Rotterdam. There, on several occasions in a few days from the week, recordings will be made of how people occupy the area. We shall see what is the role of the different entities in the park. To further narrow the research people sitting down will be observed in their surroundings.

The research is structured in three dimensions which form separate chapters.

1. The first is the total immersion into the wholeness of being in the park. To provide a most meaningful idea about this aspect people will be sketched in great detail while they are sitting down in the park. Specific environmental conditions that seem to have significance for their experience will be highlighted. This way relationships between the person and their surroundings will become more apparent. With such a method, we can evaluate details that might be unnoticeable for the everyday person.
2. Secondly, we look at the social dimension of being in nature and how the presence of other people might affect the feeling. This is done through the consistent observation of specific people who are sitting down for longer periods and sketching how the scene changes when external strangers come into view.
3. Thirdly, the materials and details of the park are gradually zoomed on through photographs. This exhibits qualities of the entities that evoke personal memories of interacting with those details. Some feelings of closeness to those materials shall be explained alongside the photographs.

With these methods, the research tries to gain insight into what is considered the most important aspects of a person's experience in a particular environment. The goal is to extract insights from what are the constituent elements of that environment that add to the positive, leisure, and relaxing, and enjoyable experience of being in nature.

Design Method:

After performing extensive and specific research on an Earthly environment, the project will continue with the design of a space station. The leading concept behind the space station is livability and a sense of infinity within the areas for people, thus narrowing the topic of the design. In a restricted size habitat where people co-exist for a long time, adopting spaces for various uses can create a sense of diversity. The smartness of a certain volume that can shift, adapt, and morph could be what residents need in the future and this could be the starting point of a new view of what architecture on Earth is like too.

Steps to reach a design:

- Form generating experiments (complete)
- Case study (complete)
- Concept and diagrams (complete)
- Brief and program (complete)
- Ideas sketching (in progress)
- 3D massing (in progress)
- Orientation to the Sun, Earth, Moon. Energy generation and space station openings. First sections 1:500.
- Program matching to massing. Initial planning.
- Key room for recreation - drawing and modeling. Detailed view of how it exhibits.
- Relation of the architecture to the space environment.
- Flow of people and functions of different parts of the station.
- Material definition - shell, dividers, interior
- Researching of details - initial sketches.
- Detail drawings.

Literature and general practical preference

The general research stems from the ambition to design a new form of architecture in a new age of technology within potentially unseen social constructs and political dynamics. This has brought up historical examples where architecture had to be rethought and reimagined. A particular period and school of thought at the dawn of society and architecture as we know it was thoroughly researched. The period is at the end of the industrial revolution and the study is on the human in their environment.

From body to architecture

In order to understand how to use the person's experience as a design guide for future habitats, it would be of use to position the research within the wider view of architecture as it has been advanced in the past by similar notions. By doing this, we would hope to extrapolate not only a logical continuation of a branch of an established theory in architecture but also a method used to study the body and its environment. Primarily we analyze 20th-century avant-garde art and architecture in the industrial and technological context. Before that, there is a line of human-scale fascination that has continuously foreshadowed major architecture or art movements - Vitruvius, Leonardo da Vinci, Le Corbusier, Neufert. This returning to the fundamentals of the body attests to the persistent presence of the body as a central role in the theory of architecture.

From craftsmen to industry

In our contact with the complete reorganization of stuff and labor, which was the industrial revolution, the classical model for art and architecture became nonrepresentative of the change in the social and demographic conditions (Artists Network Staff, n.d.). After careful tracing of the industrial societal transition through the mechanization process and Art Nouveau, Art Deco, and Bauhaus, it can be seen

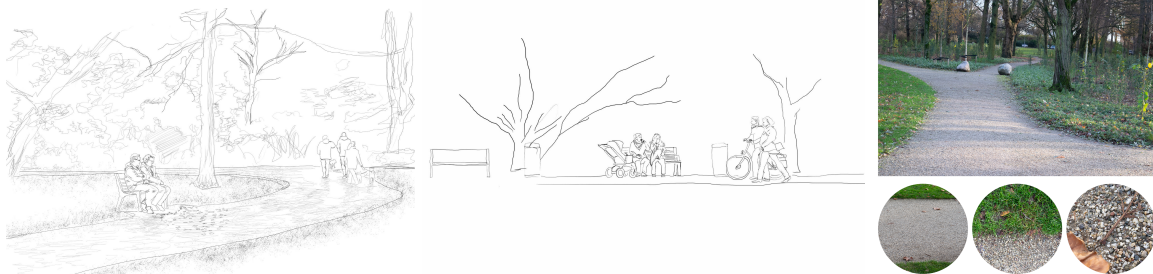
that the place of the human in the new world was of great concern. Functionality and pragmatism permeated designs, which were to be built for specific functions only. Some descendant of the Frankfurt kitchen is in most homes today.

In that regard, Bauhaus represented a fundamental step towards the practice in architecture today. That ambition led to the question of the place of people in their environment both physically and consciously. Here Oskar Schlemmer's work served as a beacon of the exploratory presence of the human in space. It guides the research towards a fundamental shift of the notion of human scale and its importance to the future of architecture. A person can only express oneself within the environment that they inhabit. Thus, one might ask, how can we discover new forms of the design if all is based on the human body and scale? We ought to find new situations and new environments where the person can be studied in the way they take advantage of any environment natural or artificial.




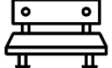



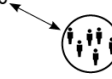


From idealized body to environmental affordance

The study of the way people can take advantage of objects goes beyond the purely single purpose, 'perfect design', according to a single size measurement of the body. Focusing on the surroundings and the opportunities it can provide for us could be an inspiration for the next generation of designs. Thus the design directive of the concept comes from a test and evaluation process, rather than the person themselves as the starting point. Out of this last strain of the background theory sprouts the research of the recreation in the public park.

Examples of research results:



Examples of the research in the three dimensions - total immersion, social, and material.

	Shadow and light - contrast between a darker area and a part that is bright.
	A path that bends and the end of it cannot be seen.
	A branch that reaches down to a pool of water and dips into it lightly.
	A place to sit.
	A view of trees.
	The sound of water.
	Other people.
	A place to be away from others.
	A tree above for shelter.
	The texture of bark.

Examples of the conclusion of the research. These are some of the entities that stood out as important for recreating the feeling that being in a public park instills in people.

Design research:

The alien nature of such architecture could use inspiration for its typology. The first step of the design is to perform a set of experiments that exhibit a form of morphing and transformation that is not seen in current architecture.

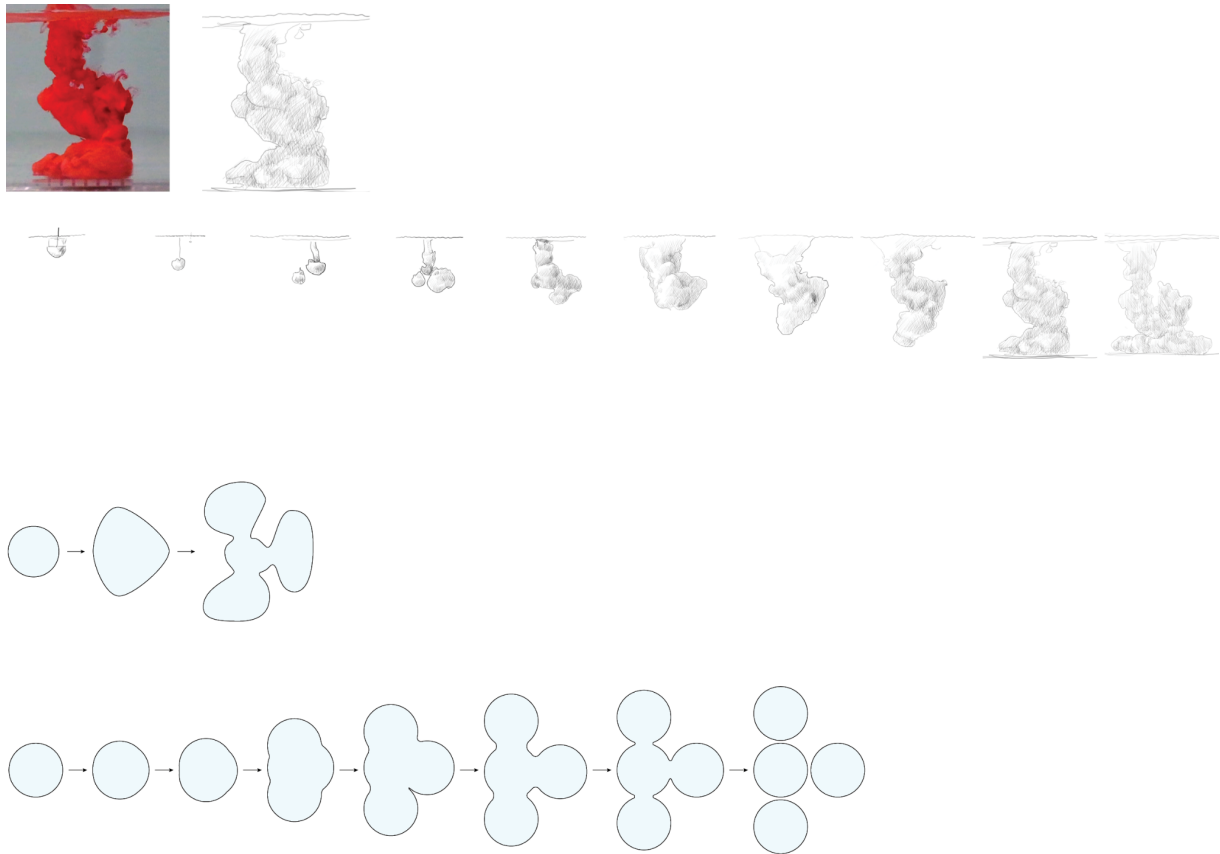


Fig.3 Paint in water folds onto itself and grows. The diagram depicts observed behavior.

Case studies: Paralleled to the semi-controlled experiments, a few case studies of theoretical and built projects are studied to learn about work that has been done by other people.

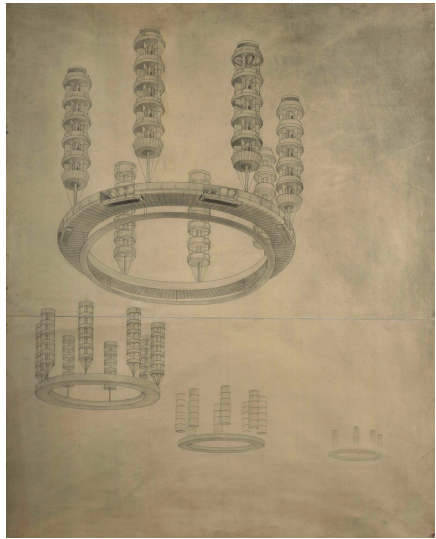


Fig.4 Georgii Krutikov's thesis (Example pages from case study research done.)

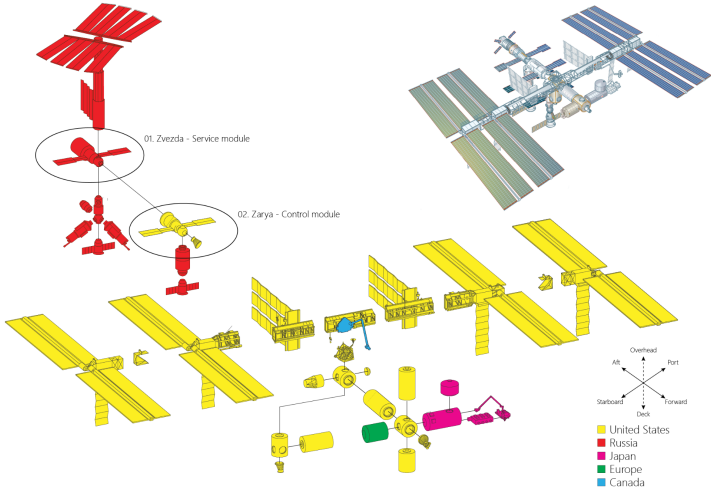


Fig.5 International Space Station

Other precedents that have been analyzed:
 Halley VI
 SOM - Moon Village

MIR space station
NASA - TransHab
Yona Friedman - Ville Spatiale
Luis Daniel Pozo - Diploma Project
Paolo Soleri - Asteromo
Gerard K. O'Neill - O'Neill cylinders
Greg Lynn - New City and N.O.A.H.
Biosphere 2

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Reflection

The realistic view:

The project that has been undertaken speculates on the future. It is an exploration of what architects might have to tackle as social, political, and design issues not so far ahead in time. It argues that wherever people may go architects will follow to be the ones to think about the human factors and place the experience and wellbeing of

people in the center of the habitat design while maintaining synergy with the surroundings.

The thesis assumes many things and there is much that will remain unknown in terms of where is the edge of human capabilities within the foreseeable future. However, daring to push our industry, will inevitably test preconceived notions.

The human in space - Why should we think about settling space?

Our species has advanced from cavemen to a worldwide civilization for the past several hundred thousand years. We have gradually developed tools and methods to tame the wilderness in hot, dry, wet, and cold climates to make it safe and comfortable, as Gyorgy Kepes phrased it - "In times of self-confidence, man was able to domesticate the world and gradually bring it into his human scale." Once we felt sufficient confidence, as a result of industrialization and technological advancement, we took the next step and traveled beyond the atmosphere. A universe opened before our eyes and we saw more clearly than ever our place within it. Our expansion on Earth is limited but beyond it, we are liberated. Earth is but a speck on a cosmic scale. Should we stay here forever?

The settling of outer space is the act of bringing parts of it into our human scale. That act will make us feel comfortable to go further. By increasingly larger and more complex space stations we are adapting to the way of life in outer space and we begin to grasp its vastness and hostility. It is the next island to settle. There could be economic, political, sociological, scientific, and environmental benefits, to name a few. Based on this line of thinking this thesis assumes that the future of humanity is in space. Wherever people go there will be a habitat and as architects, we can add value to the lives of the inhabitants. Architecture in outer space is a design challenge guided by different restrictions to what we are used to and yet it is still built form for future people and it is still architecture.

The architect in space - What value can we add as architects to the current space station design?

The current space habitat where people coexist for a significant period (6 months at a time) is the International Space Station with a habitable volume of 388m³. If we build settlements for people to occupy for 5 years, it will have to feel like home (Connors, Harrison, and Akins 1985, 82-85). It will have to suit both the basic needs of residents and provide numerous leisure activities that will form communal life. 388m³ have proven to be less than sufficient for those purposes, especially with the current arrangement of the ISS. What would those activities be and how might we begin to define the conditions required for them to occur in outer space? How would they differ from the ones on Earth, if they are not justified by culture or context? Here is the point at which this research embarks and where architects can be involved.

As architects, we grapple with big questions for the past, present, and future of humanity. We put people at the forefront of our thinking. Architects ask overarching

questions about the mission itself - why do we go to space, and what makes sense to be a priority of a construction project for people in outer space? As a consequence of such a professional transition and working in a new place with new constraints, our minds might be opened to new ways of approaching a topic or a problem. We might question norms and rules that are followed here on Earth. For example, if we do not walk in microgravity, why do we need floors? Simple situations in outer space might have many thought-provoking conundrums that will stretch our perception of what is vital to us and, ultimately, how we do architecture here on Earth.

Important part of future space stations - Focus on recreational activities.

In order to give form to an environment for people in outer space, where there is no context, we can begin by thinking about the personal experience of a resident of a future colony. What might they need if they live there for 5 years at a time apart from the essential life support systems? Probably that person would expect to be able to enjoy a similarly comfortable life as they did here on Earth. A balanced fulfillment of duties and relaxation is the way we normally spend our days. The daily habits and rituals are important to us. We will have to provide an environment that allows those to occur. The understanding of the needs of people is inspired by Atelier Bow-Wow's Behaviorology.

The public park is one of the first steps from a city to the wider environment at our disposal on Earth. It is outdoors and brings wildlife and biodiversity to the city. Communities evolve within it. It houses a vast range of activities and can be adapted to many uses. The park instills calmness that rejuvenates us by reducing anger, stress, and anxiety. Our built environment is enriched by it. With so many positives, such a feature would be a necessary addition to the habitat for extended occupation. The goal of the initial research is to study the human experience in a public park in order to create an artificial environment that yields a similar mode of recreation.