6.1 Building for Space: In Conversation with LIQUIFER (Barbara Imhof, Waltraut Hoheneder, and René Waclavicek)

LIQUIFER is an Austria-based transdisciplinary group of experts committed to innovative research and product development with both space and terrestrial applications. At their studio, architecture, science, and technology coalesce in the creation of concepts, scenarios, prototypes, systems, and products for living and working on Earth and in space. *Space Feminisms* editorial team engages with three members of the LIQUIFER team, Barbara Imhof, René Waclavicek, and Waltraut Hoheneder, on the relations between gender and space architecture.

SF *Space Feminisms* editorial team

BI Barbara Imhof

WH Waltraut Hoheneder

RW René Waclavicek

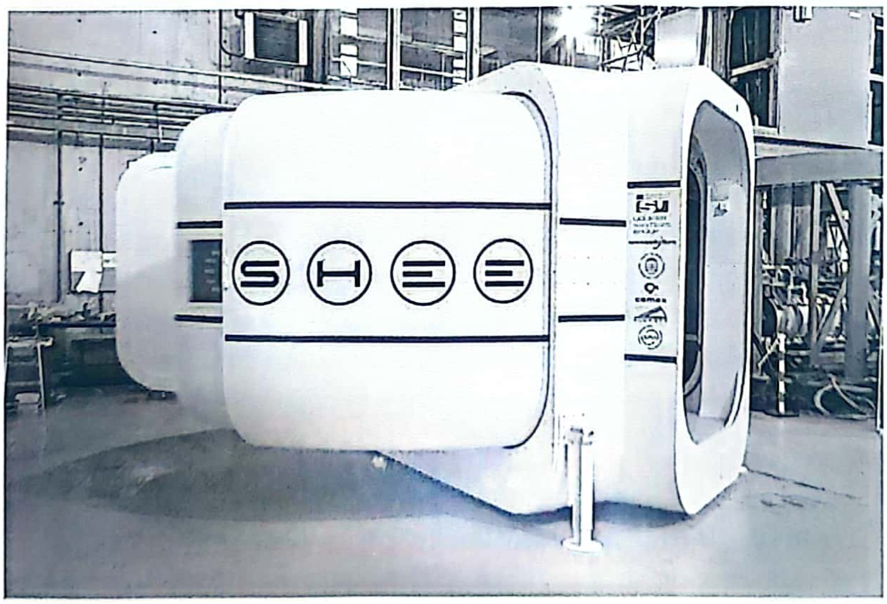

Figure 6.1.1 SHEE habitat in the folding process. © SHEE Consortium. LIQUIFER. Photo: Bruno Stubenrauch, 2015

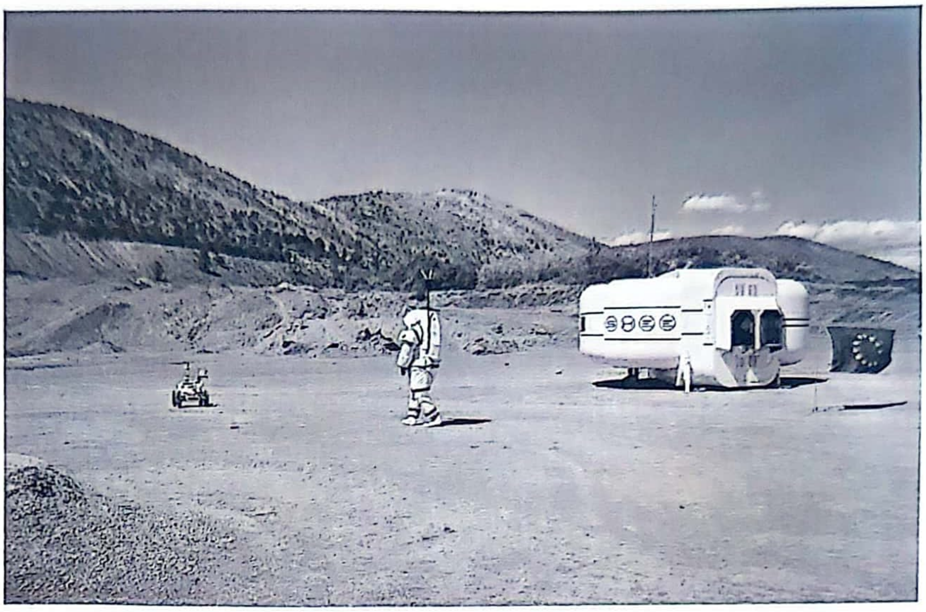

Figure 6.1.2 SHEE habitat in Rio Tinto as part of Project Moonwalk. © Moonwalk Consortium. LIQUIFER. Photo: Bruno Stubenrauch, 2016. See Plate Section 2

SF What is the point of departure of space architecture in your creative process: survivability, habitability, community, or communality? How do you integrate the human dimension?

BI Architecture is about creating a space where all living creatures can live, interact, and thrive. Space architecture is mainly about creating a habitable space for humans in an extreme environment. Recently, there have been emerging new thoughts on building reactive systems, bioreactors, or living architectures and to include not only humans, but other kinds of species like plants. The design constraints in space are harsh, and we must focus on the essential needs of humans first.

WH The duration of the space exploration mission determines the design. We are focused on survivability now, but if you think about long-term space missions on Mars, over years or generations, it will be much more about habitability.

RW Currently, we are establishing a place where people can survive. Our work is highly dominated by the machinery necessary to keep people alive. Habitability in spaceflight is different from habitability in a terrestrial environment. Space architecture is an exciting avenue for design because we are at the forefront of transforming a hostile environment into one that's habitable for human beings.

BI Space architecture is about establishing a combination of living and technological systems. We have to think of both the spaceship and the house as biospheres. That is how we have to imagine it. Our process is also about what humans need to live. One is the point of survival (e.g., oxygen, water, food, air, and pressure), the other is about being able to live in a good and productive way so that we do not kill each other or become mad. We must be able to not only function, but also to live and interact with each other. It is about ergonomics and about how humans are social creatures. We need spaces to retreat to, and private spaces where one can be in their own room. Virginia Woolf already wrote about a room of her own to live and be productive. And we need space for social gathering.

SF LIQUIFER has developed projects for space and for Antarctica. How did you negotiate both extreme environments?

WH In Antarctica, you are cut off from support and resupply for several months in winter. In space, resupply is one of the major topics. The International Space Station (ISS) is easier to resupply, but future settlements on the Moon and Mars will need to be much more self-sufficient. Another issue is the sensory deprivation that people experience in extreme environments. In a favorable environment on Earth, we go outside whenever we feel like it and enjoy a multitude of sensory stimuli that enrich our lives. In the extreme environment of Antarctica, you can only go outside if you are heavily dressed, similar to wearing a spacesuit in outer space.

RW Both environments are extreme in a way that they are hostile and remote. The difference lies in the quality of the hostility, in its severeness. In Antarctica, if a window breaks, you can fix it. Worst case, you do not go into that room anymore. If a window breaks in space, you die.

BI Antarctica is an excellent simulation analogue. It's the closest you can come to space on Earth. Practically, Antarctica is more remote than the ISS. For example, you are better connected to other parts of Earth or to mission control from the ISS than you are from Antarctica. I suspect that if you get sick you could get to an emergency infrastructure faster from the ISS than from Antarctica.

SF What are the constraints and opportunities you face when designing for environments with different gravity conditions?

RW For us architects, the micro-gravity environment is exciting not only because it's exotic, but also because we are pushed to think beyond square meters and being bound to one surface. In a room on Earth, you are surrounded by six different surfaces, each having a dedicated function. The ground is for walking; the walls are surfaces that separate rooms and where you can hang objects; the ceiling builds the floor for the next level; and the roof protects you from weather. In a zero-G environment, those functions are no longer that strict. You can use the ceiling as you use the floor and the walls on Earth. Everything acquires a different relation. On Earth, you want to have a preferred direction, such as where the light comes from to determine where you want to work, and to avoid looking directly at the Sun. In zero-G, you can break out of this way of orientation and consider novel situations or configurations that would not be possible in on Earth.

WH It involves a different way of moving through space. In zero- or micro-gravity, with a little push, you are moving, or you are pulling yourself forward. The goal is to steady yourself; you have to find constraints to fix your body. This is akin to diving, which is why diving simulations have proved instrumental in learning how to move in zero-gravity environments.

BI From an architectural perspective, one must learn everything anew. On Earth, we move on an x–y surface. Stairs take us up one floor; we sit on chairs; we go to bed and lie on a surface. In zero gravity, none of that can be taken for granted. There are no stairs, no chairs. There are tables, but they may be inclined surfaces for better visibility to what is on the table and every object must be fixed so that it does not float away. Moving and controlling the body and finding orientation must be trained and practiced. When we move in zero gravity we do not see our feet; they are always behind. We need to develop a different awareness of the space we move in. In zero gravity, we start from a position of motion with a goal of reaching stillness, whereas on Earth, we start from a position of stillness and make the effort of going into motion. That inversion has an implication on furniture design, too. Our architecture training does not apply to zero-G or micro-gravity environments, making it a fantastic space to think anew through three dimensions.

SF In addition to the constraints of radiation and dust in space, what are the differences between designing for the Moon and for Earth?

BI The Moon has one-sixth the gravity of the Earth while Mars has one-third. We plan interiors for the Moon similarly as we do for Earth, but, in reality, we have no clue if the embodied experience there is closer to zero-G or to one-G. We have knowledge about living in micro-gravity from the ISS, but no data from actually living on the Moon.

RW You may have seen the pictures of the lunar astronauts hopping around on the lunar surface. We were first convinced that this was an effect of the reduced gravity until we learned that it is also because of the architecture of their space suits. The suits constrain the astronauts' range of motion and impact the way they move along the lunar surface. The first outpost on the Moon will teach us about the impact of living long-term in reduced gravity.

SF Where does the visual vernacular of outer space habitat designs come from?

RW The shape is dominated by accounting for pressure differences between different spaces. The lunar habitat and the space stations are designed around how to handle interior pressure. Radiation protection is another factor that influences the shape of the shielding.

BI It looks as if we were going back to older structures like caves. We have to protect ourselves from radiation because there is no atmosphere on the Moon. There is a vacuum that implies a constant micro-meteorite shower. We need around two to three meters of thickness of heavy materials to protect humans or life in general. That can be done with lunar soil, which is abundant. We may be able to use lava tubes, but we know too little about living on the Moon to create protected habitation areas within them.

RW The surface architecture concepts we often see consist of two forms. The inner component is a kind of a bladder or a bubble-shaped pressure envelope. The other is the shielding structure, which is often a dome structure.

SF At your studio, how do you envision alternative design and architectural forms?

BI The typology of a house on Earth consists of the cube and the roof. In space, the core topology equivalent to the terrestrial one is the cylinder. That shape is easier and less expensive to produce than a sphere which is the most ideal pressure vessel shape. The rocket payloads are also cylinders. With the advent of inflatables, we can think of other dimensions and shapes apart from the transport rockets. We can create toroids and elliptical shapes.

WH Our "SHEE" habitat presents a typology of deployable shells that are connected and sealed to create a pressure vessel. This is a typology to increase the size of the habitat after transport in the rocket.

SF On Earth, habitats are designed for six-foot-tall men, from cabinet heights to cars. In zero-G, there is no such thing as being tall or short; one can grab things anywhere. But are there specific gender-based constraints that would apply in space environments?

RW NASA's System Integration Standards officially requires a specific ergonomic baseline: designers and engineers must account for both the "5th percentile Japanese female" and the "95th percentile American male." We are confronted with the lack of space and the need to squeeze people into a crew quarter. It is more challenging to fit a six-foot-tall man into a crew quarter than a small woman. In terms of user interfaces, your height will have an impact whether you are tall or short.

BI As architects, we must think about users. Design is about accommodating all kinds of people. If you have a wide range of users, the architecture cannot be biased. Differences are related to the body, and not necessarily to gender. If you are a dancer, you have a different sense of how your body relates to space and how to achieve a certain position. To my knowledge, apart from Kitsou Dubois who experimented with choreographies in parabolic flights, there is no record of experiments on space stations with an astronaut with a dance background. The challenge of diversity of mindsets of each crew in space is cultural rather than gender-based. Engineering mindsets may bind people together more strongly than national ones.

WH It is more interesting to think in terms of multifunctional space, which is not necessarily gender-related. The ISS is a cultural model because astronauts must cope with the stress of working together in an isolated place. In such confined space, giving each crew member a cabin is a big challenge. In our "SHEE" project, we created separate crewquarters with a curtain, and we develop versions of deployable crewquarters.

SF Can you tell us about the SHEE habitat? Did you have any feminist considerations when naming it?

BI It is a man who came up with the name when we were trying to find an acronym. It has inspired a lot of female and male artists and curators, including Juliana Cerceira Leite, Margarethe Jahrmann, Julian Charriere, and Nadim Samman.

WH When the SHEE habitat is deployed, the wording "SHEE" runs across the exterior, but because the exterior is split in shell segments, when they move, the "S" gets hidden and "SHEE" becomes "HE."

RW It is not a secret that women in the aerospace industry are underrepresented. The problem is not the discrimination from inside of the industry but the fact that young girls do not consider that path. Our "SHEE" project can inspire women to choose that career.

SF Do you notice parallels between underrepresentation in the space sector and in architecture?

BI Being a mostly female-owned company is a rare thing in the space business and space architecture, which is a field that does not really exist. These two non-existing things come together in our company. The older generation is not particularly against it, but they don't always take our work seriously. Because space is exotic, they are curious even if they do not know what to do with it. The need for integrating minorities and females has created a pressure for change, which we use to our advantage.

SF Does LIQUIFER practice a feminist architecture? How is the greater acceptance and integration of women into male spaces and the propelling of disintegration of gender, and how does that shift affect your work?

BI I try to do everything from a feminist perspective. It is an emancipatory challenge for men, for women, for LGBTQ+ people, for people from different geographies—for everybody. It starts with a consciousness of language that can be translated into specific behaviors and thinking about inclusion. Feminist architecture is not about designing only for a specific group. It is about being responsive to the heterogeneity of a crew and conscious of using the correct language.