Well-being in an Analog Habitat

The role of architecture in supporting psychological well-being in isolated environments for astronaut training

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Abstract

As space missions become longer and more complex, the psychological impact of isolation and confinement increases, making the support of astronauts' mental health increasingly important. This thesis investigates how to design an analog habitat that creates a spatial experience supporting psychological well-being.

Analog habitats, Earth-based facilities for isolation training, already prepare astronauts for the confined living and working conditions of future missions. However, in this project, they are also approached as experimental platforms for testing architectural strategies that would be difficult to pursue in space.

Privacy and stimulation are selected as two key challenges because spatial conditions strongly shape them. Design experiments explore how architecture can respond to these challenges.

The thesis shows that architecture can balance practical requirements and psychological effects in isolated and confined spaces, turning these tensions into a supportive spatial experience. Three design proposals explore different design responses to privacy and stimulation, from the overall organization of the habitat to the reinterpretation of basic architectural elements. Across the proposals, textiles emerge as particularly promising for future analog missions and space habitats because they are lightweight, adaptable, and currently underused in space missions.

The next step would be to develop the proposals into full-scale prototypes and evaluate them during inhabited analog missions, using existing isolation environments as a baseline. Such testing would examine whether the design strategies developed through the proposals produce meaningful effects on well-being when inhabited. The findings could contribute to future space habitats, and potentially expand architectural knowledge for Earth-based environments shaped by isolation or confinement. By using the analog habitat as an extreme case, the thesis also informs architectural education by suggesting that the psychological effects of spatial decisions should be considered throughout the design process.

1. Introduction

1.1. Living in Extreme Isolation

Astronauts are professionals who perform scientific and operational tasks as part of space exploration programmes. Throughout history, the concept of outer space has consistently inspired human curiosity and wonder. It served as a source of inspiration across various fields, while shaping cultural and symbolic understandings that extend far beyond the individuals who travel there.

Even though space is still often perceived as an open and limitless realm, representing possibilities rather than limitations, the reality of being an astronaut reveals very different conditions. Being in outer space is one of the most extreme forms of isolation humans can experience.

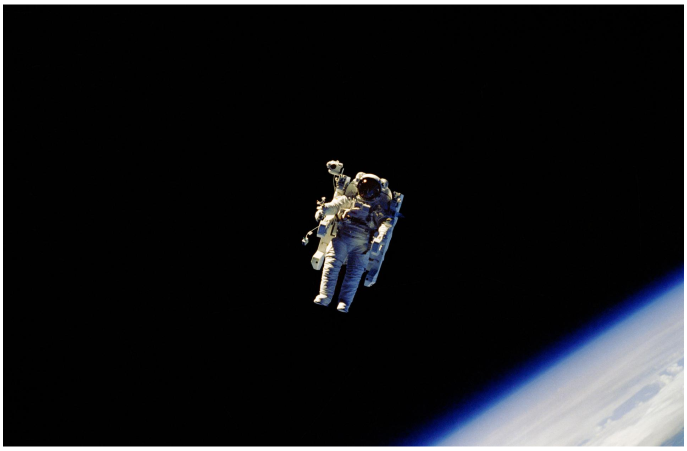

Figure 1. Astronaut in extravehicular activity (EVA), often associated with freedom. (NASA, 1984)

Astronauts' everyday life is defined by enclosure, as they must live in controlled artificial environments to survive in space. Such circumstances usually mean being in compact, isolated interiors, pushing their psychological and physical limits. For over 25 years of human presence in orbit, the International Space Station (ISS) has embodied these conditions, standing as a clear example of the realities of space design. Although it is highly optimized from a technical standpoint, the lived experience within remains constrained.

Figure 2. Interior of the International Space Station, defined by spatial density and technical infrastructure. (Wandt, 2024)

This condition is not unique to the ISS, but has its roots in the history of early space design. From the beginning, space architecture was guided by an engineering logic that prioritized survivability and operational efficiency.[1] Therefore, architectural considerations were often treated as secondary. Architecture has been underrepresented, despite the contributions of architects such as Galina Balashova[2], who remained unrecognized for decades.

Nowadays, however, the context of human spaceflight is changing. Space programmes are switching from short- to long-duration missions[3]. As they become longer and more complex, the psychological impact of isolation and confinement increases, making the support of astronauts' mental health increasingly important (Bannova, 2021; Häuplik-Meusburger & Bishop, 2021). Improved well-being directly supports crew performance, thereby indirectly contributing to the success of the mission as a whole.

1.2. Analog Habitats

Analog habitats are facilities on Earth that simulate the selected physical and/or psychological conditions of extraterrestrial environments. They differ according to their primary function. Some analog habitats, for non-astronauts, are designed to observe how people respond to isolation and confinement, while others serve as places where occupants can conduct their own experiments.

Figure 3. Living space of the Mars-500 analog habitat, used to study long-duration isolation of volunteers. Despite the use of wood – a material widely perceived as warm and natural, often associated with supportive interior environments – challenges related to well-being occurred. (Sample, 2013)

[1] The development of early space missions was closely tied to the Cold War race between the United States and the Soviet Union, in which new space achievements served as a symbol of technological progress and political dominance.

[2] Working for the Soviet space program in the 1960s and 1970s, Galina Balashova introduced a new architectural perspective to space design. Her concepts for spacecraft interiors, such as those of the Soyuz or Mir, demonstrated that livability in orbit requires more than just technical efficiency. She introduced design elements that, among other things, provided a sense of orientation and comfort. Her work began to receive broader recognition, particularly through the publications of Philipp Meuser in the 2010s. (Meuser, 2015; Stolarczyk, 2025-a)

[3] Increased mission durations are linked to the space agencies' ambitions of sustaining a human presence beyond low Earth orbit, including: lunar surface operations (under programmes like Artemis), preparatory steps toward future habitats on Mars, and deep-space exploration.

Among these, training analog habitats play a particularly significant role. They serve as key research platforms for professional astronauts, focusing on preparing them for the confined living and working conditions of their future missions.

Figure 4. Interior of the FLEXhab analog habitat, used for astronaut training. (Uhlig, 2025)

With extended missions - where isolation will have an even greater impact on psychological health - the role of analog habitats becomes crucial, both for training and testing. Architecture, as a discipline concerned with human well-being, is uniquely positioned to help address this challenge. Habitability research emphasizes that living conditions play a central role in space design, positioning architecture as an active contributor (Häuplik-Meusburger & Bishop, 2021). In this context, the experience of spaces becomes inherently sensory, where perception through the human senses shapes feelings of safety and well-being (Jurga, 2022).

Although small-scale, one successful example of testing ideas similarly is the Circadian Light Panel developed by SAGA Space Architects. As the light proved to be effective in improving sleep in analog habitat settings, it was later installed inside the ISS.[4]

Thus, analog habitats could function not only as training facilities but also as experimental platforms for testing architectural strategies, which would be difficult to pursue in space.

1.3. Project Position

Building on an understanding of analog habitats as experimental platforms, this thesis positions architectural design as a tool to support mental well-being in isolated environments.

Design Question
How can an analog habitat be designed to create a spatial experience that supports psychological well-being during extended missions?

Research Question
How can insights into psychological challenges of isolation and confinement inform the design of an analog habitat for extended missions?

[4] SAGA's Circadian Light is a smart lighting system designed to mimic Earth-like light cycles, regulating our biological clock. The first experiment with light was done in a terrestrial Moon-analog habitat (LUNARK) to refine its effectiveness. Then, an improved version was installed on board the ISS to support astronauts' sleep and daily rhythms. (SAGA, n.d.-a)

The analog habitat operates as a prototype and is not specific to any single mission. It is intentionally non-site-specific and does not respond to any particular geographic or climatic context. This allows for a focus on spatial experience rather than specific environmental factors. Isolation is therefore treated as an assumed condition.

Long-duration habitation is examined through a one-month period[5] of continuous occupancy of four astronauts, which determines the scale of the habitat[6]. The program is minimal, reflecting the constraints of long-duration habitation rather than comfort-driven variety. It includes: sleeping, working, hygiene, shared communal spaces, and support functions.

The project does not aim to design an ideal or definitive analog habitat. Instead, while the analog habitat continues to serve as a training environment, this project focuses on its potential as a medium for architectural innovation, where astronauts themselves experience and assess new ideas.

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[5] The European Space Agency's FLEXhab is designed to support medium- to long-duration analog missions for a crew of four, with training missions ranging from approximately one week up to one month. Initiated in 2024 and planned to become operational in 2026, FLEXhab positions the one-month duration as an operationally feasible and institutionally recognized timeframe for extended exposure to isolated and confined conditions. (SAGA, n.d.-b; Burgos, 2024; Sony, 2024)

[6] The project is further limited by a fixed internal floor area of 60 m², taken here as a lower functional threshold for four-person dwellings. (Ulrich, 2025) The constraint deliberately intensifies conditions of confinement.

2. Approach

2.1. Methodology

At the beginning of the project, an exploratory vedute was produced as a reflective tool to engage with the experiential qualities of isolation and confinement[7], helping to orient the subsequent research-by-design approach.

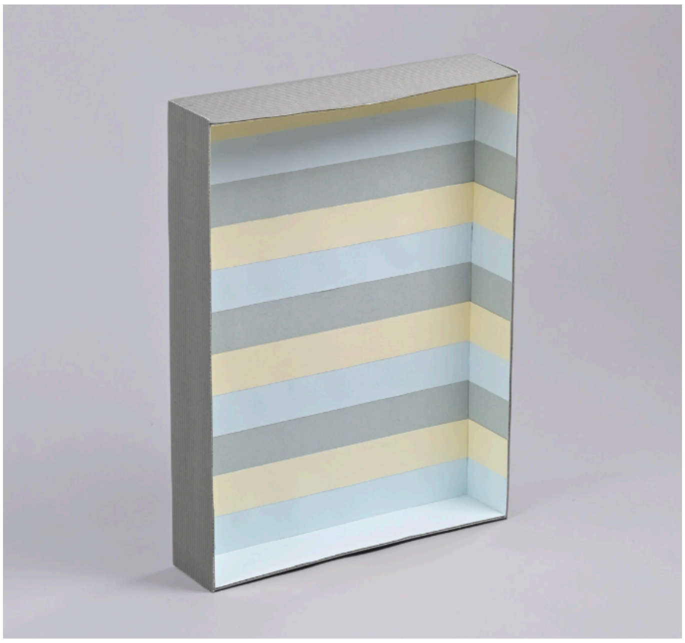

Figure 5. Exploratory vedute reflecting early considerations of spatial experience in space design. (Stolarczyk, 2025-b)

The design process begins with research and design questions. First one investigates how insights into the psychological challenges of isolation and confinement during extended missions can inform the design of an analog habitat. At the same time, the design question examines how such a habitat can be designed to create a spatial experience that supports psychological well-being during extended missions.

Design experimentation is carried out primarily through iterative sketches and spatial diagrams, allowing for rapid testing of spatial configurations and experiential conditions. Relevant criteria, studies, and project-specific knowledge emerge throughout this process. These design experiments both respond to and critically examine the evolving criteria and sources, establishing a continuous feedback loop between research and design. During the experimentation phase, additional inspirational studies may be introduced as needed to inform emerging questions and refine design direction. Additionally, selected design insights are informed by personal experience, particularly immersive spatial experiences[8], used as a reflective tool within the design process.

[7] This vedute explores the contrast between the engineering-driven shell and the human-centered architectural interior. It draws on Agnes Martin's abstract, rhythmic compositions and Galina Balashova's spaceship interior drawings (a color palette that supports astronaut well-being) to reflect comfort in isolated, machine-dominated environments.

[8] This includes Doloris Meta Maze (Karmanoia, 2019), an immersive installation of maze-like rooms and passages that encourages exploration. It serves here as a reference point to support the interpretation of spatial and psychological effects.

Psychological challenges, used to define criteria, are identified using a combination of literature sources, with Open Evidence as the primary search platform. The search focuses on two complementary contexts: space missions and analog settings, as well as small enclosed work environments such as office settings. Particular attention is given to well-being, mental health, and cognitive functioning, in relation to environmental and psychosocial factors.

2.2. Theoretical Framework

Main literature on habitability in isolated and confined environments demonstrates that it extends beyond technical performance, highlighting how architecture influences psychological well-being over time.

In “Space Habitats and Habitability: Designing for Isolated and Confined Environments on Earth and in Space” (2021), Häuplik-Meusburger, an architect and researcher specializing in extreme environments, and Bishop, a social psychologist with long-standing experience in human behavior in isolation, describe habitability as a combination of physical, psychological, and social factors. Drawing on research from space missions and Earth-based analog environments, they argue that architecture plays an active role in long-term isolation.

From a disciplinary standpoint, Bannova, affiliated with the Sasakawa International Center for Space Architecture (SICSA), frames space architecture as an integrative field in “Space Architecture – Human Habitats Beyond Planet Earth” (2021). Her work emphasizes the importance of human-centered design in space architecture.

Complementing these theoretical positions, Jurga approaches isolation through sensory experience in “Szałas na Hałas: O tworzeniu poczucia bezpieczeństwa za pomocą zmysłów w domu, przestrzeni i kosmosie” [A shelter from noise: On creating a sense of security through the senses in the home, space, and cosmos] (2022). As a designer and researcher working with isolated environments on Earth and in space, she emphasizes the role of the senses in creating a feeling of safety. In this view, comfort in isolated environments does not mean luxury, but a sense of familiarity and control, shaped by the environment.

3. Results

3.1. Key Psychological Challenges

Evidence-based studies on isolated and confined environments indicate that prolonged exposure to such conditions has significant psychological effects. Among these, two challenges are particularly relevant to this project: a lack of privacy and a lack of stimulation. Their selection is based on their direct connection to spatial conditions and their strong influence on individuals' interactions with their surroundings and other people. Therefore, they represent key aspects through which architecture can influence psychological well-being.

Privacy is understood here as the ability to regulate exposure to others and control when and how interaction occurs. (American Psychological Association, n.d.; Merriam-Webster, n.d.; Cambridge University Press & Assessment, n.d.). Rather than just physical separation, it encompasses autonomy, regulation, and protection from uncontrolled encounters (Shved, et al., 2022).

Lack of privacy leads to constant social exposure, psychological crowding, and reduced personal control, which generally leads to tension, social withdrawal, and conflict (Shved, et al., 2022; Palinkas & Suedfeld, 2021). On the other hand, excessive separation can lead to isolation, reduced social cohesion, and loneliness (Palinkas & Suedfeld, 2021; Rosenberg, et al., 2022).

Stimulation is defined as the level of sensory and cognitive input from the environment. Beyond the amount of it, the nature of stimulation influences whether individuals can sustain engagement with a task without becoming overwhelmed or underwhelmed. Maintaining a proper balance is crucial, as both deficiency and excess can negatively impact mental stability.

Low-stimulation environments tend to induce monotony and reduce variability, which can contribute to boredom, poor concentration, and cognitive fatigue (White, et al., 2025; Neilson, et al., 2021). High-stimulation environments, on the other hand, can lead to stress, distraction, and sensory overload (White, et al., 2025).

3.2. Elements of Architectural Experience

While architecture may be analyzed as a collection of physical components (Koolhaas, 2014), it is also experienced through the body and senses, shaping our perception of space (Pallasmaa, 2012). Building on this understanding, architectural elements shape spatial experience and, consequently, well-being.

Within this approach, four elements became central: floor, wall, door, and window. These elements are used as drivers for design experiments.

Floors and walls are the most primary parts of any room. They define boundaries, orientation, and the body's relationship to space. Because they are so simple, they offer potential for experimentation. Meanwhile, doors and windows are thresholds between spaces, inviting us to interact. A window is a special case, as during isolation training, it is often absent (like in this project). A lack of it limits connection to the outside world, negatively impacting mental well-being. However, even the presence of a window does not necessarily guarantee meaningful engagement, as the external view may remain static. Therefore, the qualities of windows could be reinterpreted, along with those of doors.

3.3. Key Design Insights

One of the main challenges in designing an analog habitat for privacy is subdividing spaces without inducing claustrophobia. It became clear early on that excessive use of partition walls performs rather poorly in such settings (Figure 6) and non-traditional means of separation must be researched to achieve different degrees of privacy.[9]

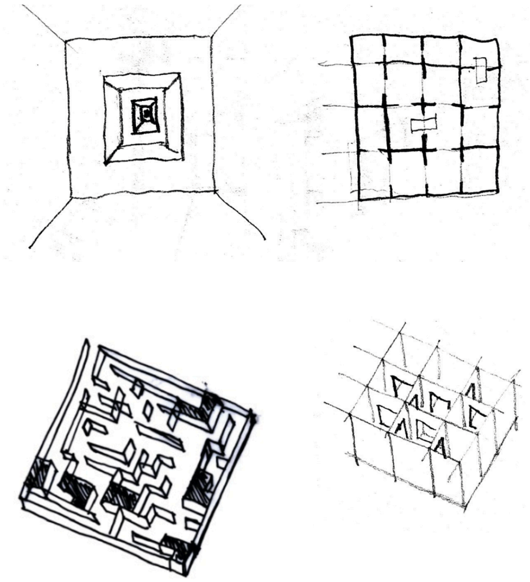

Figure 6. While a labyrinth-like configuration enables maximum privacy and easy ways to hide, it induces anxiety and results in inefficient use of space. Observations align with experiential insights from the Doloris Meta Maze (Karmanoia, 2019), where comparable spatial sequencing of doors heightened tension rather than comfort.

The separating function of the wall and the floor is broken down into its components, and different devices achieve barrier-to-access, acoustic, and visual separation. Spatial and visual hierarchy emerges through the use of curtains, level differences, ceiling heights, light levels, or even through the designed difficulty of access.[10] Flexible, adaptable separating elements are preferable to fixed layouts, not only for efficient use of space but also for fostering a sense of freedom[11] (Figure 7). Interpersonal distance can also be modulated through lateral orientation, informed by proxemics.[12] Gradual transitions between more public and private zones further help reduce direct exposure (Figure 8).

The variation introduced through these spatial strategies creates a more engaging environment, fostering a sense of discovery and playfulness that supports mental stimulation.

[9] Privacy is a spectrum of enclosure; it should be treated as a gradient through the whole building. Filtering is favored over hard separation, "to make the transition imperceptible." Openness does not mean a uniform, undivided field; successful designs establish a network of interrelated rooms within a shared space (Jara, 1995; van Rooyen, 2022).

[10] Spatial hierarchy should be achieved primarily through section rather than plan to maintain a continuous volume; split-levels, ceiling height variation, and sunken/raised platforms all contribute to this effect (Jara, 1995).

[11] Fixed, fully determined spatial layouts should be avoided; rigidity results in monotony and a sense of loss of control. Users need clearly defined personal territories, and controllable separation is essential to avoid crowding (van Rooyen, 2022; Hall, 1966).

[12] Proxemics, the study of interpersonal spatial relationships, shows that regulating distance is essential for psychological comfort: appropriate distances reduce stress and physiological arousal, while violations of personal space increase anxiety. Environments that allow users to control proximity and adjust interpersonal distance according to context support autonomy, social cohesion, and overall well-being in shared or confined spaces. (Candini, et al., 2021; McCall, 2016; Novelli, et al., 2010; Rocca, et al., 2019; Shved, et al., 2022; Welsch, et al., 2019)

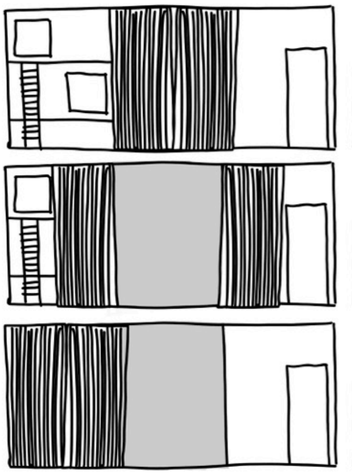

Figure 7. Curtains enable flexible spatial subdivision, hiding visual clutter when needed.

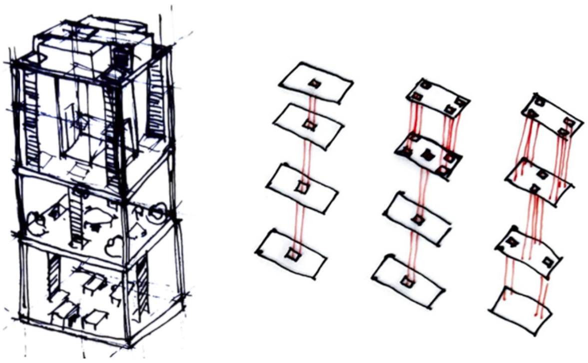

Figure 8. Different circulation strategies test how shared and private routes can regulate exposure.

Whereas a window would provide different light conditions and changing views, these need to be compensated for with different surface textures and colors, for instance, to break the space's homogeneity. In windowless spaces, visual cues should also be introduced to aid spatial orientation. A symbolic or illusory replacement of a window can also be a powerful tool for reducing claustrophobia and increasing sensory stimulation[13] (Figure 9, 10). Creating keyhole-sized apertures or one-way views by other means allows one to perceive others without being seen, giving the viewer a strong sense of privacy (Figure 11, 12).

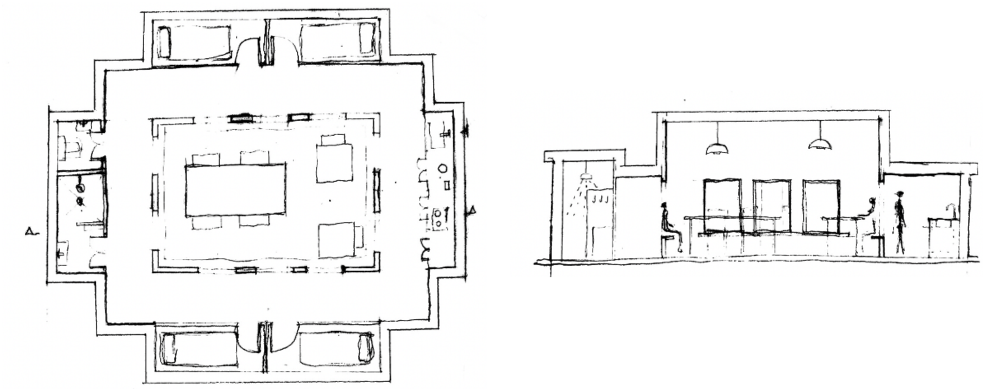

Figure 9. In the absence of external windows, a central shared space acts as an internal "courtyard," creating an illusion of the outside.

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[13] In underground environments, the absence of windows has been identified as a key factor contributing to reduced stimulation, loss of orientation, and a heightened sense of confinement, highlighting the importance of reproducing their perceptual functions through design. (Carmody & Sterling, 1993)

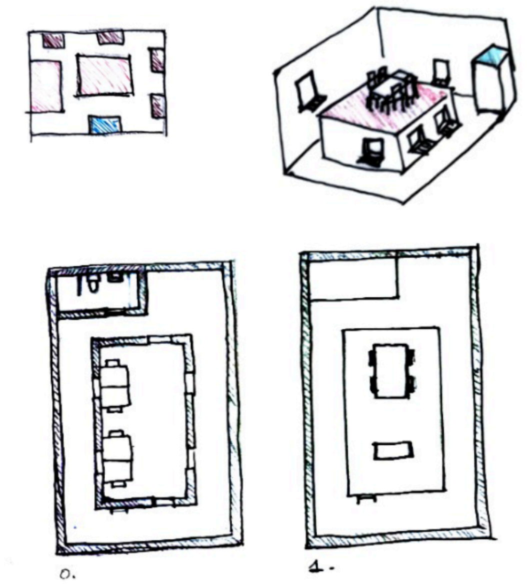

Figure 10. In the absence of external windows, a room placed within a larger open volume creates visual depth and enables substitute 'window' relationships between spaces.

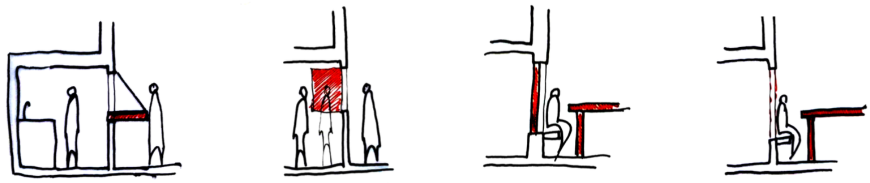

Figure 11. Thresholds support interaction while regulating privacy.

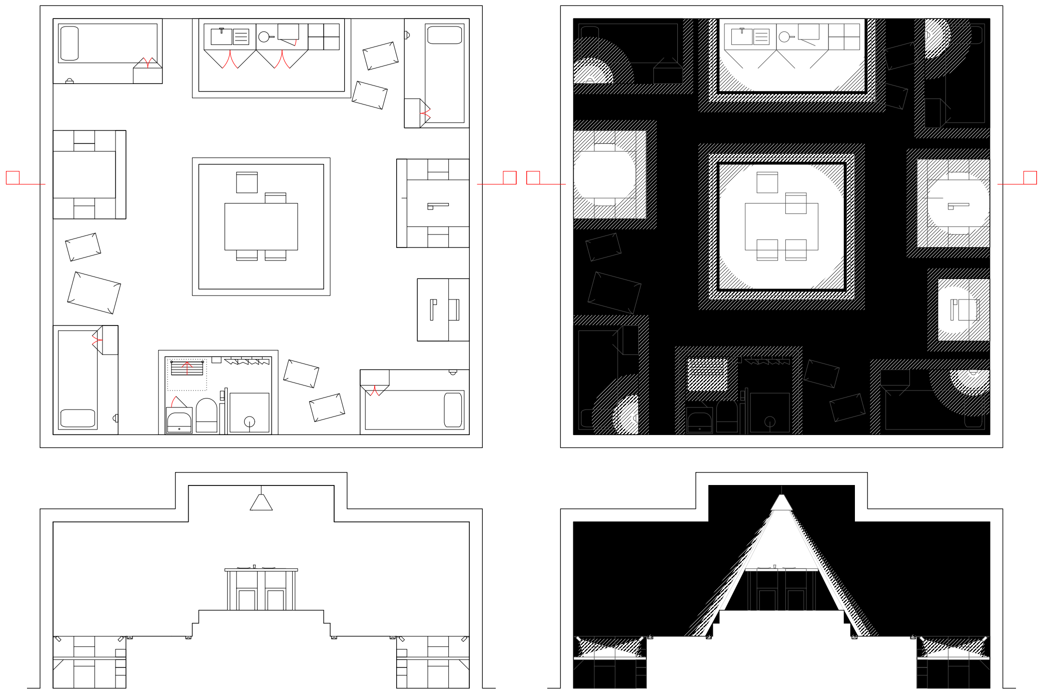

Figure 12. Separation is achieved through contrasts of light and darkness, enabling selective visibility, much like being on a stage where the performer is visible while the audience remains unseen.

Achieving long-distance views is another crucial aspect of visual stimulation.[14] An illusion of depth can be created by breaking the flat plane of a wall, suggesting space beyond. Similarly, mirrors can further extend or redirect views. In a convoluted layout, cutting openings can create unexpected vistas, introducing an element of surprise. Furthermore, those framed areas are perceived as more spacious than if our view into them was unframed[15] (Figure 13).

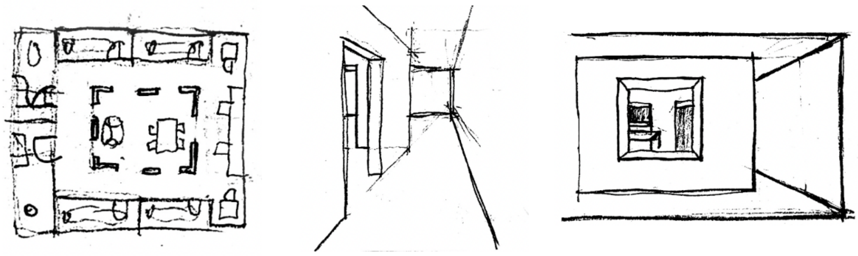

Figure 13. Without the introduced partitions with openings, the central space would appear smaller.

Using spaces of different sizes can also make a place feel more spacious. Moving from smaller areas (like sleeping pods or small activity spaces) into larger rooms helps create this effect and makes the habitat feel bigger (Figure 14).

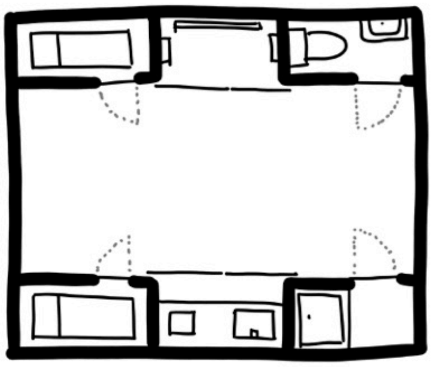

Figure 14. Sleeping cabins are integrated into the wall, creating a contrast with the larger surrounding space upon exit.

The way people enter shapes their first impression and affects how they experience the space during their stay. Even though the habitat's entrance is only used twice (when entering and leaving), its design is important in this perception[16] (Figure 15). Introducing contrast of scale at this point, like entering from a lower or tighter space, could make the main space feel taller and more open[17] (Figure 16). Placing the entrance in the middle of the largest room is generally unsuccessful, as it leaves us very exposed. Entering through intimate spaces such as the bathroom should also be avoided, as it can later create the feeling that someone from the outside can intrude on us at any time. Alternatively, the entrance can emphasize protection and isolation, for example, by using a thicker wall section to create a stronger sense of enclosure (Figure 16).

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[14] The preference for visual depth and long views is often explained through evolutionary theories, particularly the concept of prospect, which states that humans prefer environments offering extended views a complete spatial overview. (Hildebrand, 1999)

[15] Framed views often enhance the perceived depth and improve our understanding of the size of spaces. (HOKO, 2015)

[16] The entrance is the point within the interior where one feels most exposed, it is unknown yet what to expect inside. (Abercrombie, 1990)

[17] Personal experience in the Doloris Meta Maze (Karmanoia, 2019) shows that a medium-sized room can feel monumental after crawling through tight spaces.

Figure 15. A seamless interior can make a space feel larger, but when the same finish continues outside, the threshold becomes less clear and the sense of enclosure is weakened.

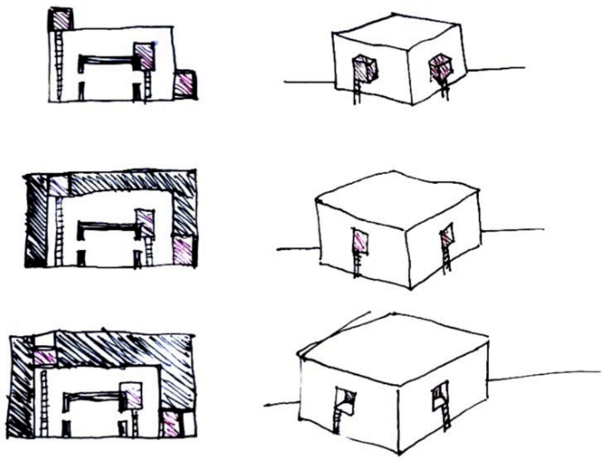

Figure 16. Entrance conditions shape spatial perception: thicker wall sections enhance isolation, while entry through external volumes creates contrast and makes the main space feel more open.

3.4. Structural Logic

The structural decisions were not fixed constraints from the start. They emerged through the analysis of the brief, alongside the development of the design insights.

Since isolation is treated as the main condition of the project, it is additionally intensified. The habitat is conceived as a thick, enclosed interior without any visual connection to the surroundings. As a result, the external context becomes secondary. The design, therefore, begins from the interior, with each habitat prototype developed as a one-off spatial proposition for isolation.

Each prototype is then paired with a representative environmental profile. This does not mean that the habitat is redesigned around the climate. Instead, environmental conditions are used to resolve the outer technical layer.

At the same time, the Earth is approached as a planetary context that requires preservation.[18] This results in minimizing physical footprint and avoiding extensive site intervention. Together, these conclusions lead to a prefabricated system composed of lightweight, transportable elements, assembled without permanent construction infrastructure or heavy machinery.

This structural logic enables deployment in accessible, remote locations. Such locations enhance the feeling of isolation, while the lightweight system makes the project feasible as a temporary test environment.

[18] Planetary protection can be understood as framing sustainability in space exploration as an ethical commitment to preserving the planetary environment, both as a shared heritage and as an ecological system. This requires responsible design that prevents contamination and minimizes the irreversible impacts of human activity (COSPAR, 2020).

The building serves several missions at a given location for a period of 1-2 years. Once the testing phase is complete, the habitat is dismantled and removed, restoring the site to its original condition. The primary structure is subsequently gifted to the nearest human settlement for reuse as building material, while other components are retained for potential future reuse. In certain sites, where continued presence is appropriate, it may be kept on site for continued use as a temporary research station or emergency shelter.

Although the habitat is designed to feel as isolated as possible, it should not appear fragile when encountered from the outside. Its form should convey stability and the perception of the habitat as a protective enclosure. Including escape routes will increase this confidence. The choice of interior materials should ensure comfort and safety during extended stays.

The legibility of services is also treated as part of the spatial experience. Fully hidden systems may result in anxiety, while fully exposed systems can lead to sensory overload. Different degrees of exposure can be tested across the prototypes to determine which balance best supports astronauts' well-being.

This way, the construction system introduces a productive tension that turns constraints into a design challenge.

3.5. Design Proposals

Following the brief and structural logic defined in the previous chapters, three habitat proposals are developed under the same conditions and constraints. Each habitat is conceived as a one-off design proposition. The proposals are intentionally intensified, pushing different responses to challenges related to psychological well-being in isolation and confined spaces. At this stage, the design proposals do not test these strategies yet. Instead, they define design scenarios that could be evaluated after being developed into full-scale analog prototypes and inhabited during analog missions.

Inhabited Walls

The *Inhabited Walls* proposal explores privacy as a form of protection. Instead of treating walls as thin separating elements, the project thickens them into active zones that contain the programme. Technical services follow the same logic: most systems are integrated within the wall, while one dedicated service room concentrates the main controls. Each crew member enters through a separate entrance, before reaching the shared corridor. That corridor becomes an in-between condition, while life takes place along the edges.

The corridor is darker, with low lighting along the walls guiding movement through the analog habitat. The spaces inside the walls are warmer and more saturated. Diffused lighting, soft wall paneling, and built-in furniture create a more intimate atmosphere inside each booth. Carpet is used as the main floor finish to enhance acoustic privacy by reducing the sound of footsteps. The long corridor creates a strong visual axis, while the irregular wall surface adds depth to the compact interior. Reflective panels along the corridor edges further extend the perception of space.

Veils around the private booths provide partial visual separation and sound diffusion. Frosted doors are used in hygiene areas, where only one's shadow is visible. Sleeping spaces are fully enclosed, but lighting next to the sleeping pods indicates whether the space is in use.

Courtyard Living

The *Courtyard Living* scenario explores collective life as a source of interaction and stimulation. It is organized around the internal courtyard, with the remaining functions arranged around it, creating a sense of indoor and outdoor space. The crew enters through one shared entrance hall. Services are concentrated in the corners, with some pipes remaining visible. They become part of daily use, acting as small supports, e.g., for towels or toothbrushes.

The courtyard creates a warm atmosphere with a familiar character of bookshelves or a playground. It is made more saturated and tactile through the use of plywood, sometimes colored. A larger diffused ceiling light reminds one of a skylight. Smaller lamps on the shelves create additional activity points, mainly above tables. Smooth panels around the courtyard create a quieter background. Ceiling lighting from the surrounding corridor is directed towards the middle, highlighting it. The floor also supports the same contrast: although the surface remains continuous, the central area is visually warmer and heated. It further encourages people to stay there, especially in a space where the crew moves barefoot or in socks.

Thresholds become active elements - tables, windows, and doors are built into the courtyard's structure. Some frame views towards the corridor, while others invite use from the courtyard side. Textile is used here as an element of interaction. Textile pieces indicate where to pull, open, or use the space.

Soft Boundaries

The *Soft Boundaries* proposal explores user control through an open and flexible interior. The permanent architecture is reduced to a central technical core, through which the crew also enters. They can transform the remaining area using textiles, hooks and movable furniture.

The core has an industrial character. Hard, slightly reflective surfaces make it feel durable and easy to maintain, while reducing the visibility of scratches and fingerprints during daily use. The rest of the analog habitat is kept neutral, with off-white finishes on walls and ceiling and a continuous floor. This reduces visual noise and makes the space feel larger than it actually is.

Curtains become the main atmospheric and spatial element. Main curtains allow each crew member to create a temporary room. They are double-sided, with a different color on each side, so their position alters the layout and mood of the space. Secondary curtains are translucent and can divide the plan into full sections. Their neutral character allows them to blend with the walls. In areas where the fabric is most often touched or pulled, additional stitching reinforces the material and makes it more durable. Steel hooks on the walls continue the technical character and are shaped to hold hammocks, clothes, and movable lamps. Additional lighting along both sides of the curtain rails reinforces their role in shaping the atmosphere.

4. Conclusion

4.1. Architecture as Psychological Support

The project's brief produced a set of challenges that could be addressed directly. However, direct solutions are not always supportive of well-being. In isolated and confined spaces, every practical requirement also has its psychological effects. This thesis shows that architecture can balance these tensions and translate them into a supportive spatial experience. In this sense, analog habitats can be understood as architectural laboratories: environments where design strategies for well-being can be tested. The three chosen design proposals develop this argument through different architectural positions.

The thesis also shows that psychological support in analog habitats operates across different architectural scales. It depends not only on the overall organization of the habitat, but also on how basic architectural elements are reinterpreted. Elements that are usually treated as technical or functional can become part of the spatial experience. In the chosen design proposals, this reinterpretation helps address privacy and stimulation in different ways.

The design proposals can be understood through four main tensions. Firstly, isolation has to be made spatially present, because if the inhabitants do not feel isolated, the isolation training itself becomes weaker. At the same time, isolation should not become threatening. All proposals address this through thick insulation, no windows, and unusual or layered entrance conditions, such as double doors or entry from below. These elements intensify the feeling of separation from the outside. However, the building must still feel safe from the inside, with escape routes provided.

The second question is how to make a small space feel bigger than it actually is. The challenge is also that all design strategies have to keep vertical movement to a minimum, so that the spatial richness does not become dangerous or physically tiring. It is addressed using different strategies, like adding depth (by creating views using courtyard walls with openings in *Courtyard Living*; longitudinal layout with broken wall surfaces by niches in *Inhabited Walls*), contrast of spaces (entrance area against rest of the analog habitat in all proposals; small private areas against a shared bigger one in *Inhabited Walls*), and change of arrangement over time (by curtains and movable furniture in *Soft Boundaries*).

Thirdly, what has to be balanced is how four astronauts can share one compact space without constant exposure, without making them feel claustrophobic from too many separating elements at the same time. Different privacy gradient strategies aim to achieve this by providing fully private booths and placing activities at the edges (*Inhabited Walls*), choosing interaction through thresholds (*Courtyard Living*), or adjusting exposure through movable curtains (*Soft Boundaries*).

The fourth question is how to make a month of training not feel repetitive. Daily life in an analog habitat is already reduced, e.g., through short showers, limited food, or repeated tasks. As a result, the interior itself has to offer more psychological support. At the same time, creating an interesting atmosphere is difficult, as all materials used must be appropriate for a closed environment. Another factor considered is that variation should not depend too much on effort. If change requires too much work, inhabitants may stop using it, and the analog habitat becomes repetitive again. Chosen proposals aim to balance all of those through different atmospheric variations: contrasting a darker corridor with warmer booths, while light from occupied rooms and sleeping pods spreads into the shared space (*Inhabited Walls*); warmer and more tactile center, with small activity points, as well as changing views around the courtyard (*Courtyard Living*); changing arrangement by using hooks and colorful curtains (*Soft Boundaries*).

Within this, textiles emerged as particularly promising architectural devices. Across the proposals, they appeared in different roles: as a soft layer that supports privacy (*Inhabited Walls*), as a small interactive element that guides use (*Courtyard Living*), and as the main spatial device that allows the interior to be adjusted over time (*Soft Boundaries*). This suggests that textiles should not be treated as mere accessories. Their lightness and current underuse in space missions point they could become significant in future spacecraft and planetary habitats.

4.2. Implications and Recommendations

The next step would be to develop each proposal into a full-scale prototype. The testing would not aim to compare the proposals against each other, but to evaluate whether the architectural ideas behind each proposal produce meaningful effects when inhabited. The existing environments used in astronaut isolation studies could act as a baseline against which the potential added value of the new architectural strategies could be understood. Feedback from the testing would need to be collected before, during, and after the mission, which could be done using interviews, questionnaires, personal diaries, and behavioral observation.

The outcome of testing should not be a simple judgment of which proposal works best. Each prototype would need to be evaluated in relation to its own design intention: whether the occupants experienced the intended effect, what unexpected effects appeared, and which parts of the design supported or weakened well-being.

The intentionally intensified character of the prototypes is useful for testing, because each one makes a different architectural position clear. Future space habitats, however, would not necessarily repeat these proposals in such a radical form. Their design would more likely combine findings from several tests into a more balanced solution. As in this project, they would need to be translated again to account for new constraints. Some findings may be directly transferable as general principles, such as lighting strategies. Other strategies would require further adaptation, like, e.g., textile-based elements, which would need to be further developed with respect to reduced-gravity behavior. Lastly, some findings, like the prototype's structural logic, may remain Earth-specific. Together, these outcomes could form a catalogue of tested design strategies for designers to select and adapt.

Future testing should also expand beyond privacy and stimulation. These two challenges were selected for their strong spatial relevance, but they do not capture the full psychological reality of isolated missions. Further analog prototypes could address other challenges, each generating a different design proposition and testing focus.

The broader implication of the project, therefore, is methodological. It suggests that architecture could become a means of producing knowledge for future analog missions and space habitats to better support astronauts' well-being. However, the knowledge produced through testing could also be relevant for Earth-based architecture where isolation and/or confinement are present. Such contexts range from extreme environments, such as Antarctic research stations, desert habitats, or high-mountain cabins, to transportation interiors and everyday home-office settings.

4.3. Reflection

This project began with the ambition to design a single effective analog habitat for astronaut training. During the process, this aim gradually shifted. The analog habitat began to be understood as a test environment: a place where different architectural strategies for psychological well-being could be explored. This shift helped avoid the idea of a universal solution. It also allowed the three proposals to develop as different responses to the same set of challenges.

At the beginning, I followed a more typical literature-based research approach. It was useful for identifying privacy and stimulation as key psychological challenges in isolated and confined environments. However, literature alone remained too abstract to become architecture directly. Research-by-design became more productive than expected because it translated these psychological concerns into spatial problems and design responses. It also showed that design strategies cannot be judged only as separate parts. A solution that seems supportive on its own may change when it becomes part of the whole analog habitat. Starting from designing, helped test how privacy and stimulation, as well as structure and materials, worked together in a single design scenario. This process also highlighted the importance of limiting the number of themes. Instead of trying to solve every aspect of well-being, the project became clearer by isolating and intensifying each design response.

Personal experience also became useful within this process: experiences of immersive or confined environments helped me reflect on how spatial conditions can affect perception and behavior. Additional interviews also were useful because they helped ground assumptions and check whether certain spatial ideas felt relatable beyond my own interpretation. They also raised considerations that had not been clear at the beginning of the project, helping clarify which proposals were most relevant to develop further.

Looking back, the most important outcomes of the project are a stronger understanding of architecture as a way of producing knowledge and of the role architects can play in space design projects. For me, the analog habitat became a clear example of this: not only a place to apply existing knowledge, but a laboratory where architectural ideas can be tested.

From this perspective, the project also becomes relevant to architectural education. Students should learn to understand how spatial conditions affect people over time. In isolated environments, this influence becomes especially clear because inhabitants cannot easily leave the environment or compensate for its effects. In this sense, architecture as psychological support is not a separate topic - it is a part of the responsibility of architectural design.

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