2023 JACQUES ROUGERIE FOUNDATION AWARDS

Award's category : Architecture & Innovation pour l'Espace

Project's Name	The Portal: Analog & habitat hub for Mars exploration
Description	Unveiling Martian Mysteries, an Analog & Habitat Hub that Melds Reality with Spatial/Time Technological Doorways, akin to Sci-Fi Films.

FONDATION JACQUES ROUGERIE
GÉNÉRATION ESPACE MER
ACADÉMIE DES BEAUX-ARTS

[1] Space Architecture Education for Engineers and Architects: Designing and Planning Beyond Earth, Sandra Häuplik-Meusburger, Olga Bannova

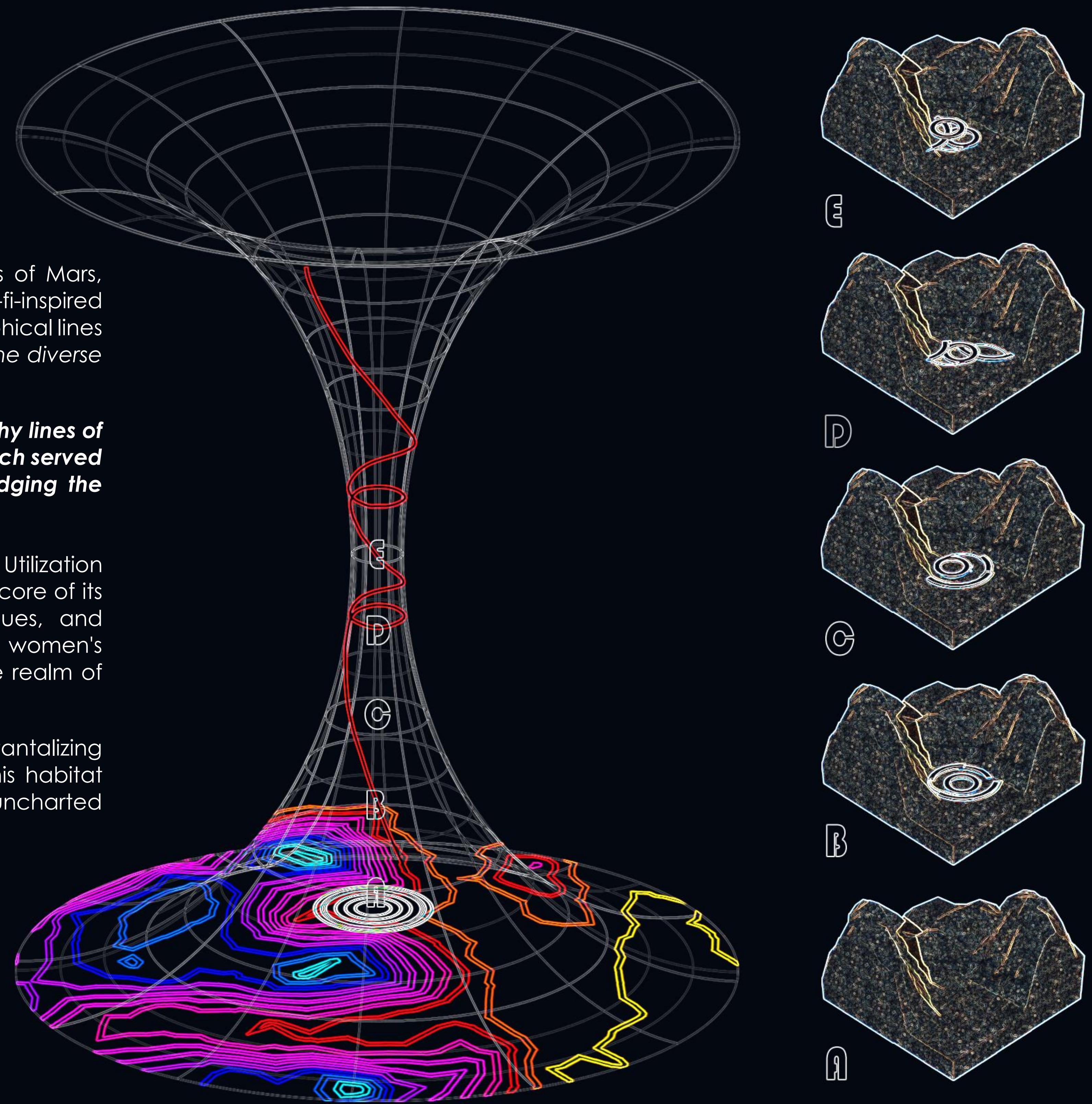
Design Conceptual Approach

The Portal emerges as an architectural marvel destined for the enigmatic landscapes of Mars, transcending the boundaries of conventional design with its thoughtfully conceived sci-fi-inspired aesthetics. Drawing inspiration from the whimsical concept of wormholes [1], the topographical lines within this visionary habitat gracefully traverse the Martian terrain, adeptly *adapting to the diverse and challenging landscapes of the Red Planet.*

The wormhole was utilized as the basis for the concept design by visualizing the topography lines of a chosen theoretical site in Wadi Rum passing through the wormhole. This visionary approach served as the genesis of our Martian habitat design, as the design falls under stage "E", bridging the lightyears between Earth and Mars.

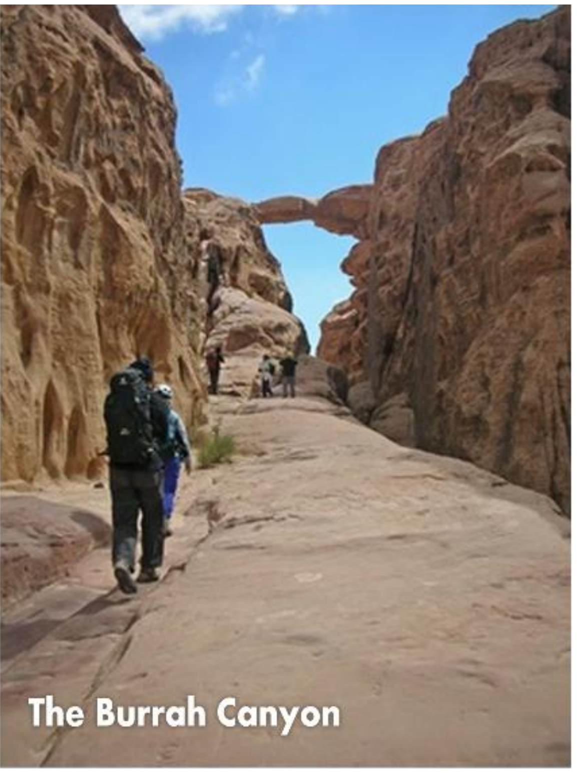
Serving as an epicentre of innovation, where the focus squarely rests on In-Situ Resource Utilization (ISRU), health, agriculture, and fostering community engagement. Sustainability is at the core of its design, leveraging indigenous Martian materials, cutting-edge 3D printing techniques, and innovative inflatable elements. Furthermore, it promotes inclusivity, with an emphasis on women's health, embodying the principles of exploration, sustainability, and gender equity in the realm of space.

As The Portal takes shape, it symbolizes the epitome of human ingenuity, offering a tantalizing glimpse into the future of Martian living. In a nod to the thrilling narratives of Sci-Fi, this habitat becomes a tangible representation of the harmonious coexistence of reality and the uncharted territories of spatial/time-technological wonders.



Environment and Site Analysis

DUNE Movie Set



The Burrah Canyon

If you are a Sci-fi enthusiast like me, envision yourself on Mars, where Wadi Rum serves as a remarkable analogue for the Martian atmosphere. This intriguing desert landscape, reminiscent of scenes from space and sci-fi movies like the latest DUNE, deeply influenced our Martian habitat concept.

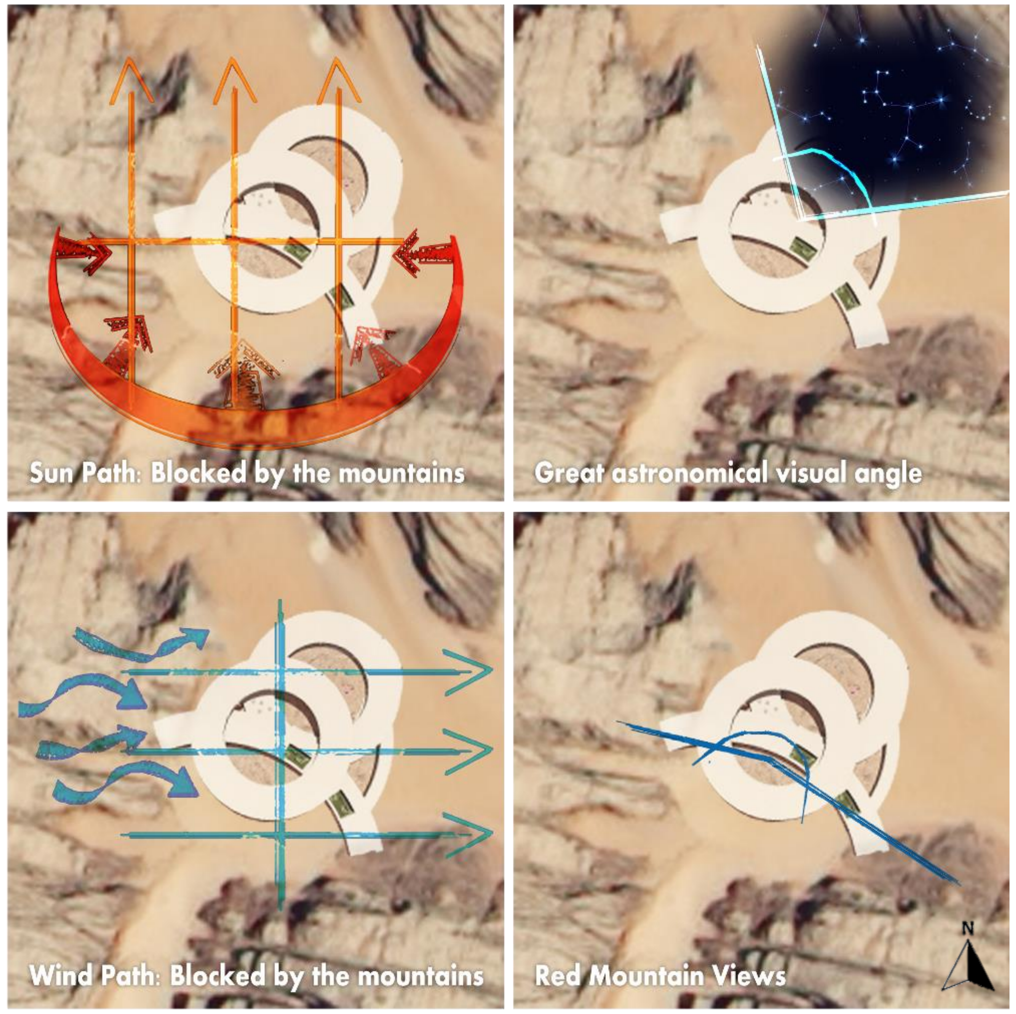
Designing for Mars presents an exceptional challenge due to the absence of direct experience. With no human footprints on the planet, Mars remains a speculative dream. Essential architectural questions arise: **How does it look? How does it feel? How does it sound?** To begin grasping answers to these questions, my journey led me to Earth's closest Mars analogue: The Wadi Rum Desert. Stepping into this arid landscape provided invaluable insights into isolation, deprivation, and the visual nuances of the red Martian terrain, largely attributed to the concentration of iron oxide.

In my endeavour, I wanted to go through the traditional architectural pre-design studies and site analysis to create this untraditional project, the selection of the site was guided by meticulous terrain studies, analyzing sunlight, and wind patterns, and identifying iconic landmarks. The site adjacent to the Burrah Canyon was chosen for several compelling reasons:

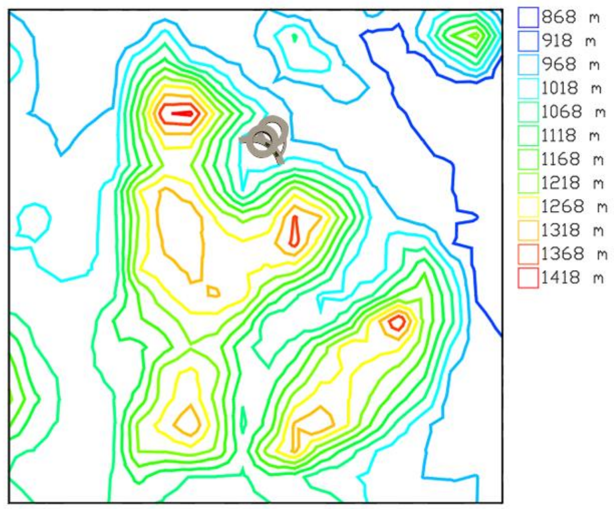
- The surrounding mountains, positioned to the East-South and South-West, shield the structure from the harshest sun hours, ensuring a comfortable environment.
- These same mountains serve as a natural barrier against seasonal winds, preventing the spread of dust and offering effective dust mitigation.
- This site aligns seamlessly with our adaptable design, suited to various terrain types.
- Lastly, the facility boasts numerous spaces designed to engage and educate visitors about space and astronomy. Its proximity to the highly frequented Burrah Canyon ensures effortless transportation, attracting a steady flow of visitors eager to explore the mysteries of the cosmos.

As I embark on this Martian odyssey with "The Portal," I represent my country's identity by drawing inspiration from Wadi Rum's theoretical Martian environment, fostering a deeper understanding of the challenges and opportunities that await us on the Red Planet.

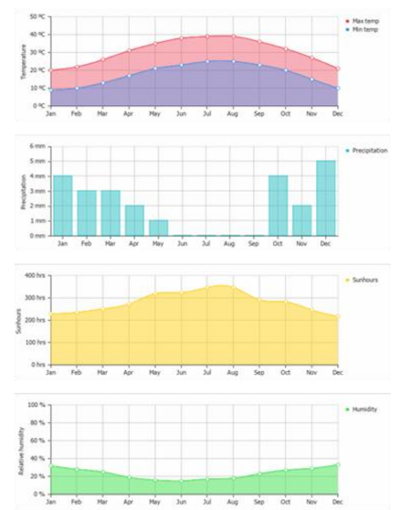
This inspired me to design a versatile module for an Analog and habitat Hub that Melds Reality with Spatial/Time Technological Doorways can be constructed on Earth and Mars, contributing to bridging this gap between our two realities.



Topography Study: Case 2



Climatic Study



[2] ISRU Capability Roadmap, Gerald B. Sanders, Dr. Michael Duke, 2022
[5] JSRIs YouTube channel, Dr Samer Al Sayari Webinar, Q&A

Space research areas & its incorporation

- **ISRU robotics & dust mitigation**

Eva space on a natural landscape to test dust mitigation and ISRU, with a natural ramp for easy rover testing, and an EVA preparation and storage room for the equipment, airlock, and sanitary module [2]. Also, a form of Dust mitigation in the design is in the building placement and orientation guarded by mountains to mitigate the unwanted afternoon sun and blinding dust-filled wind.

- **Community engagement**

By allocating more than enough areas for lounging and communication and leaving a huge space indoors (Mars Version) and outdoors (Earth Version) for different community events. And let us not forget about the wide range of books about all things space in the public library that views the red inspiring landscape.

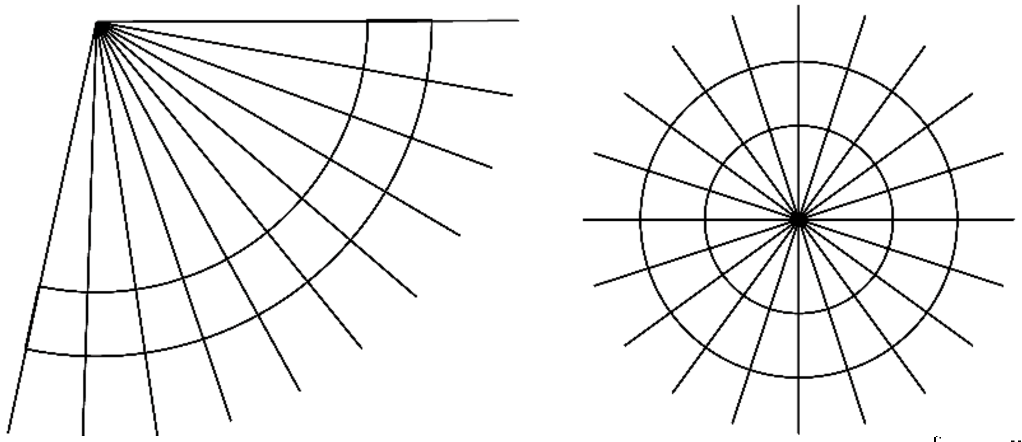
- **Agriculture & Renewable energy**

A more resource-efficient potato crop, including roots and fruits, is being developed where the whole plant can be consumed. Such crops will play a pivotal role in addressing food and nutritional security on Earth and in space. Atriums were added to study different space agriculture (Mars Version) and a desert garden (Earth Version) to showcase desert agriculture. Hydroponic gardening would be a great choice as it is space-efficient and takes little water [5].

- **Women's Health**

This proposed design makes women's health a priority on earth and in space, it helps women facility users maximize benefits, for example, providing daycare for moms, and a beauty centre for residing females and males, and it allocates a research area for women's health and pharmaceuticals in space.

[6] Vortex: Architecture of the Circle, Philip Jodidio
[8] Weather and climate, international weather reporting site
[17] Argo Dual-Purpose Mars Habitat, Robert B, Gitten, Haroon N. Syed, Takumi Date, Benjamin J. Greaves, Sindhu S. Jayakala, Sweeya P. Tangudu, Annika K. Stoldt, Anna Mariella Pulvermüller

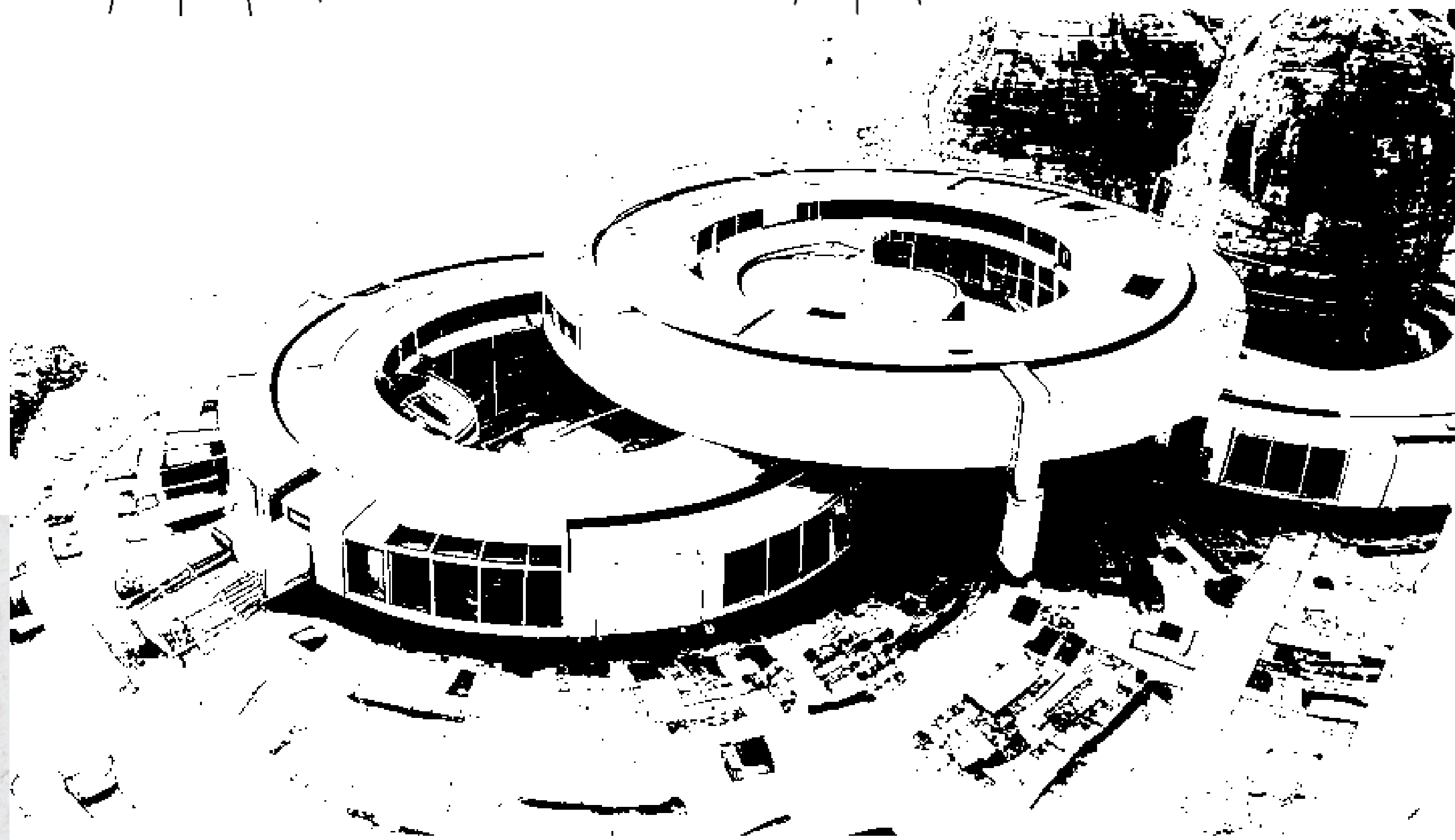


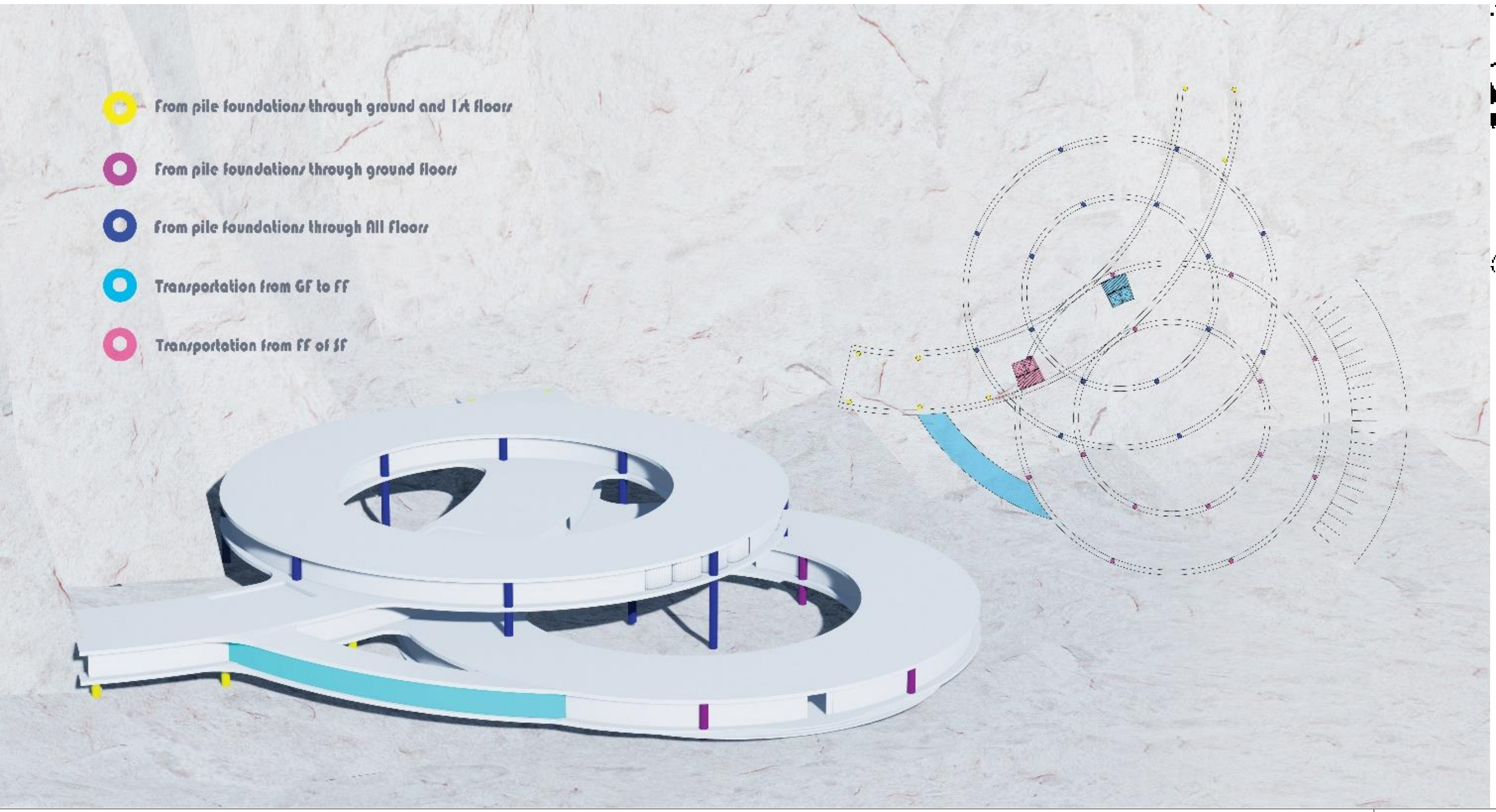
Planning Methodology: The Circular Grid

As a true Al Hussein Technical University Architecture student, I wanted to make a constructible concept, so after studying multiple columns arraignment, planning scenarios and what foundation type would fit, I chose the ***circular grid*** which is best for modularity and clear circulation in circle plans [6] [17], and ***pile foundation***, which is best for wadi rums sandy soil [9], that connects the structure firmly to the ground, and the piles go up through the roof holding it still and making construction more systematic and standardized, hence, easier to build.

Since Dr Samer Sayari continuously encouraged me to explore more and made us believe that the sky is not the limit, space is, and space is infinite.

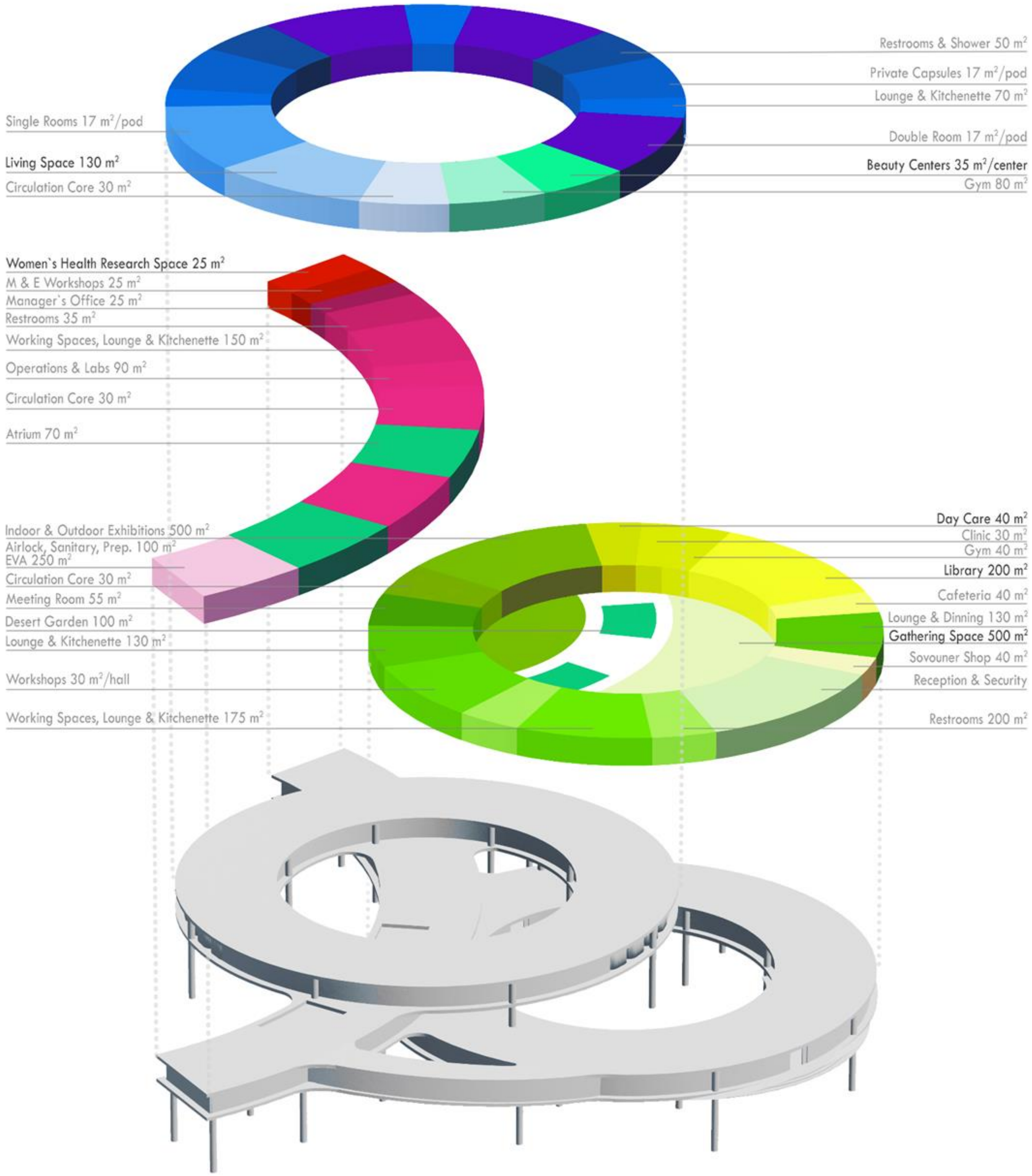
Every possible scenario and need that the facility should serve was studied, and all the minimum requirements of Analogue and Habitat Architecture were added and much more!



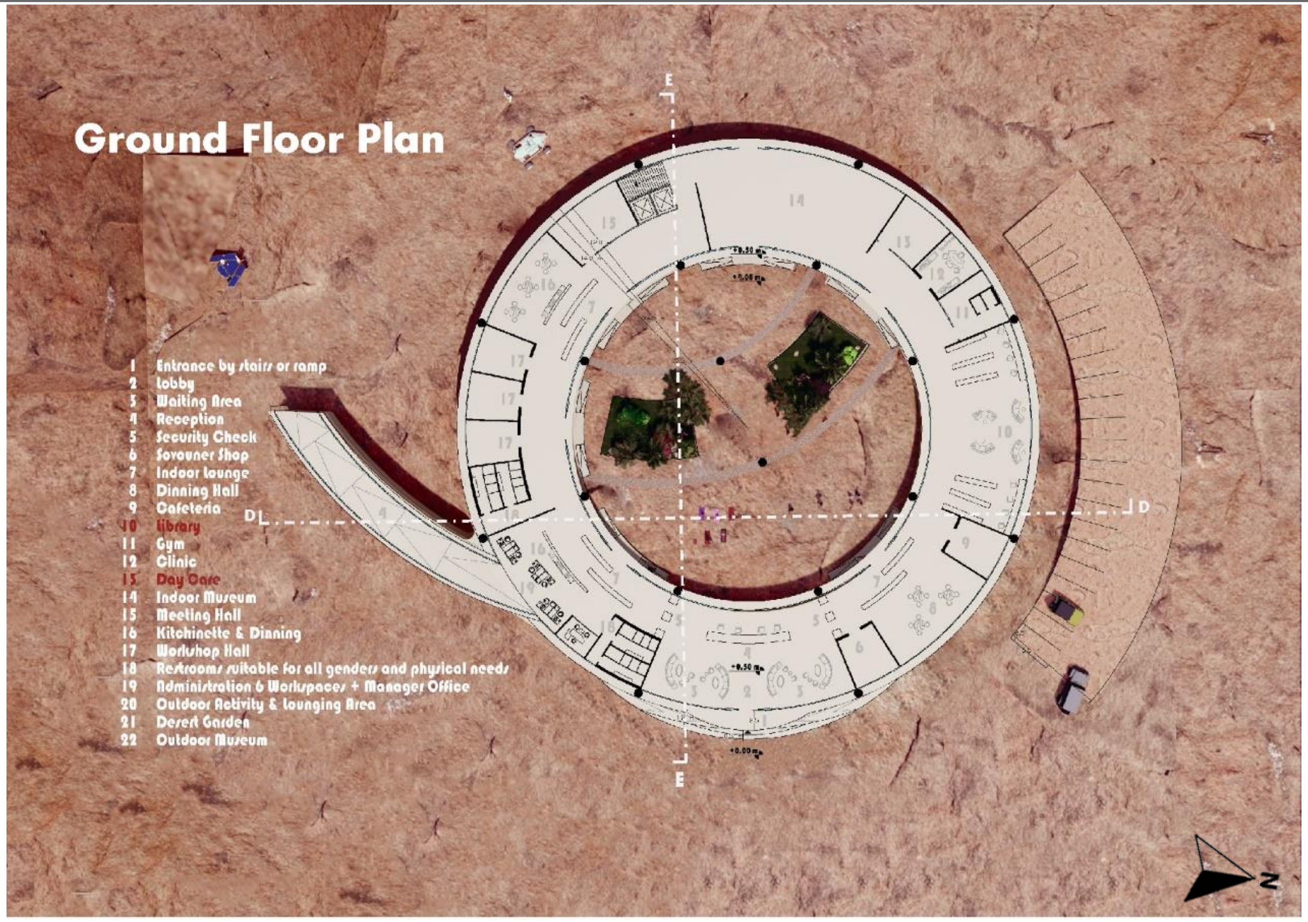


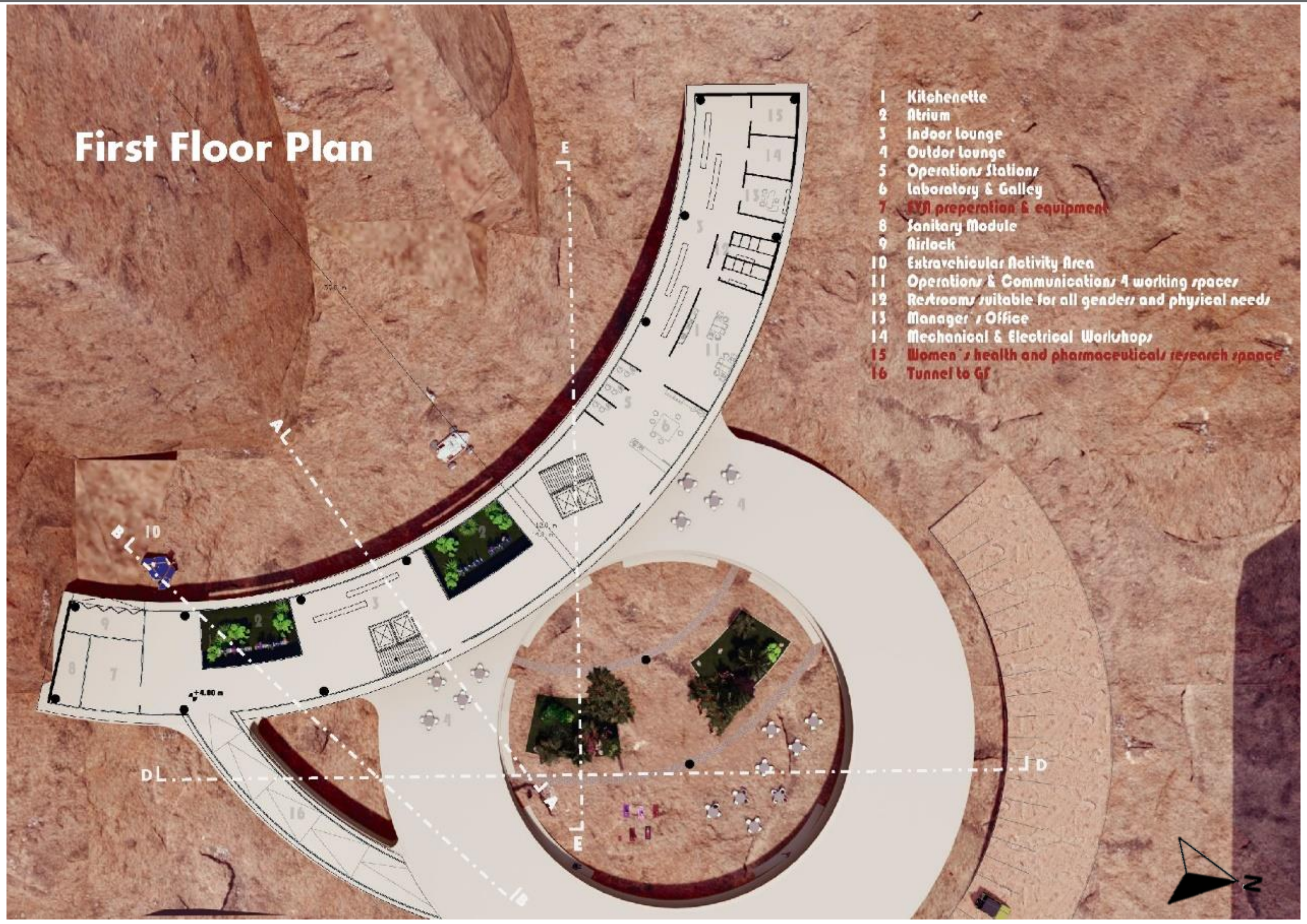
The facility design also highlights the following:

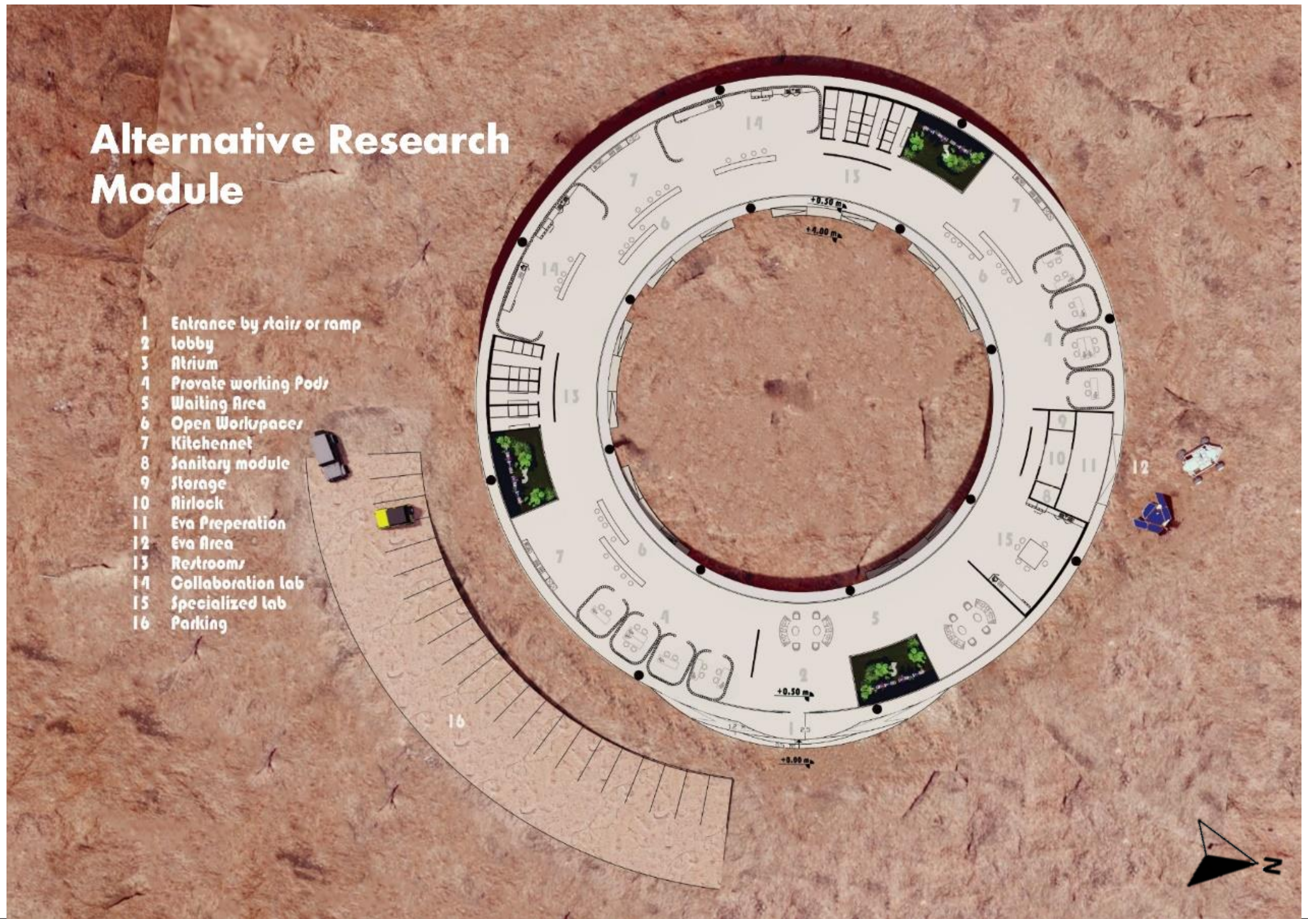
- Bathrooms, showers and changing rooms that also include options for people who use wheelchairs or any manually operated or power-driven device for use by an individual with a mobility disability
- Space-inspired material and construction methods and choices that use minimum space and maximum standardized forms and components that avoid costly customizations.

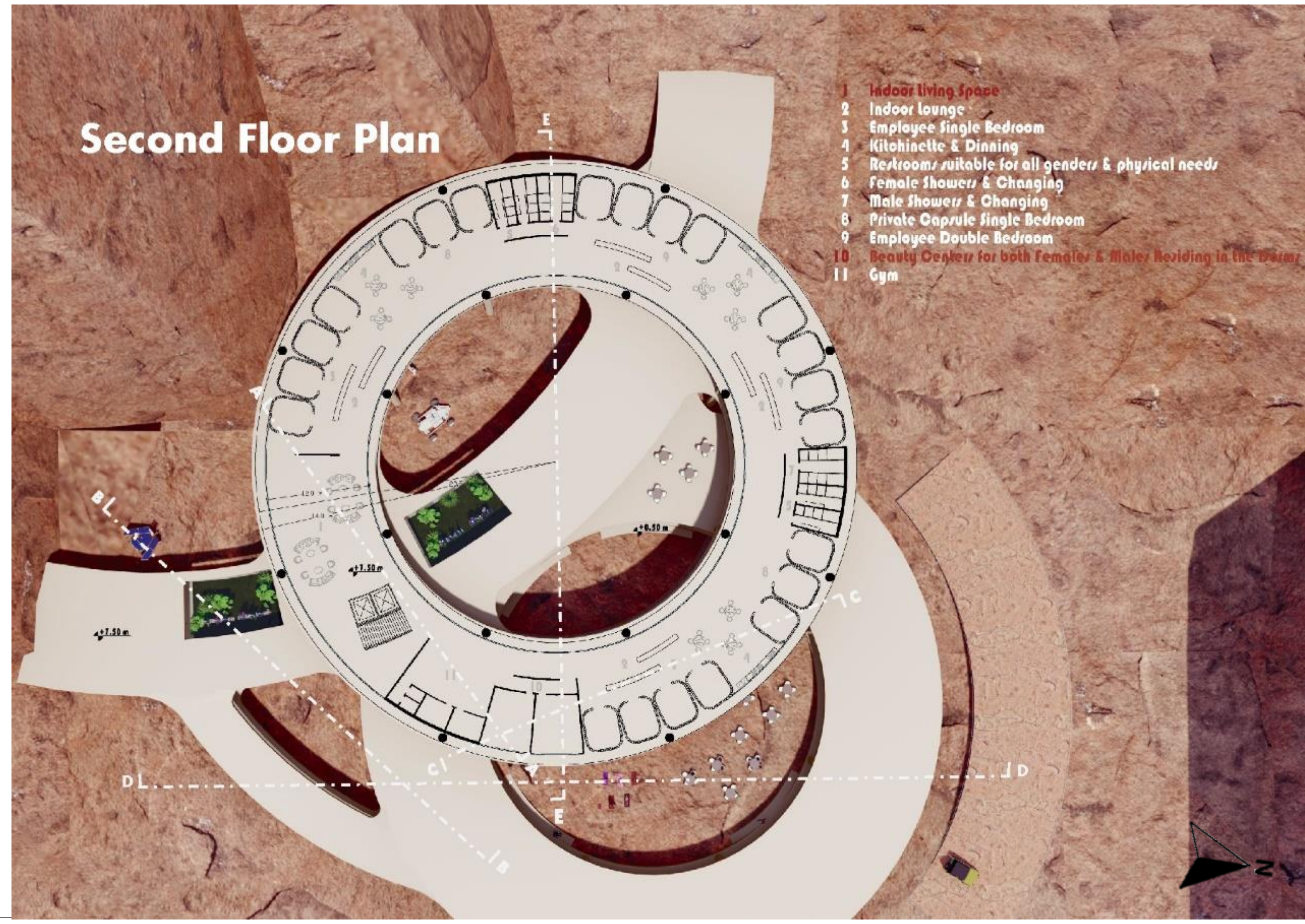


Restrooms & Shower 50 m^2
Private Capsules 17 m^2/pod
Lounge & Kitchenette 70 m^2
Single Rooms 17 m^2/pod
Double Room 17 m^2/pod
Living Space 130 m^2
Beauty Centers 35 m^2/center
Circulation Core 30 m^2
Gym 80 m^2
Women`s Health Research Space 25 m^2
M & E Workshops 25 m^2
Manager`s Office 25 m^2
Restrooms 35 m^2
Working Spaces, Lounge & Kitchenette 150 m^2
Operations & Labs 90 m^2
Circulation Core 30 m^2
Atrium 70 m^2
Day Care 40 m^2
Clinic 30 m^2
Indoor & Outdoor Exhibitions 500 m^2
Gym 40 m^2
Airlock, Sanitary, Prep. 100 m^2
EVA 250 m^2
Library 200 m^2
Circulation Core 30 m^2
Cafeteria 40 m^2
Meeting Room 55 m^2
Lounge & Dinning 130 m^2
Desert Garden 100 m^2
Gathering Space 500 m^2
Lounge & Kitchenette 130 m^2
Sovouner Shop 40 m^2
Workshops 30 m^2/hall
Reception & Security
Working Spaces, Lounge & Kitchenette 175 m^2
Restrooms 200 m^2









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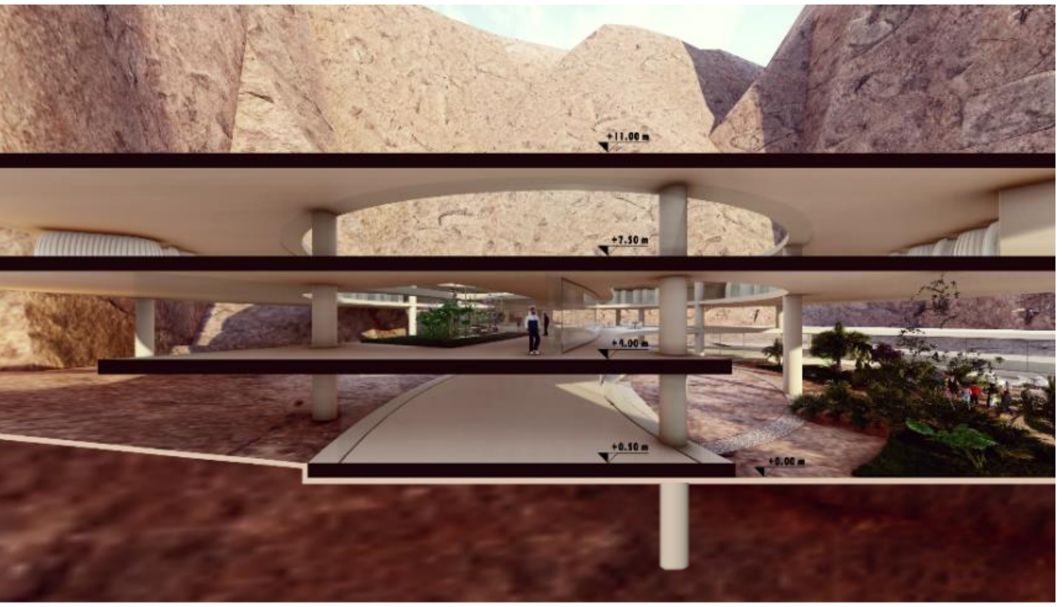
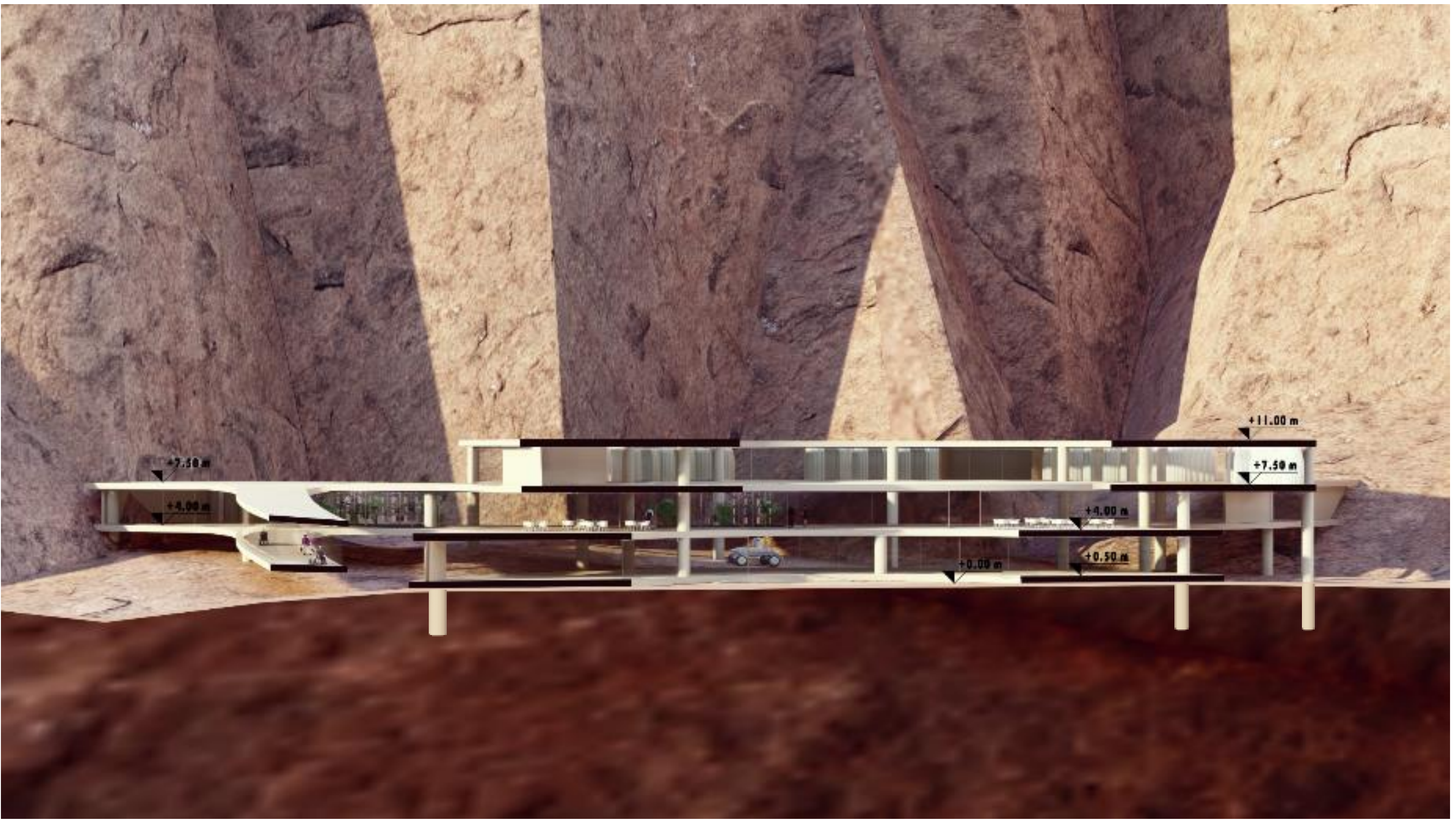
Section A-A



Section B-B

Section C-C

Section D-D



Section E-E

3D Studies for Martian version



3D Studies for Earth version



[2] ISRU Capability Roadmap, Gerald B. Sanders, Dr. Michael Duke, 2022
[3] FIVE STEPS TO 3D-PRINTING A HOME ON MARS, MATTHEW TROEMNER
[4] Inflatable Nested Toroid Structure, NASA
[5] JSRIs YouTube channel, Dr Samer Al Sayari Webinar, Q&A
[11] In-Situ Resource Utilization, NASA
[12] Transparent aluminium oxynitride and method of manufacture, Richard L. GentilmanEdward A. MaguireLeonard E. Dolhert,
[14] Alternative materials: Transparent aluminium, Anukriti Marwah, 2018

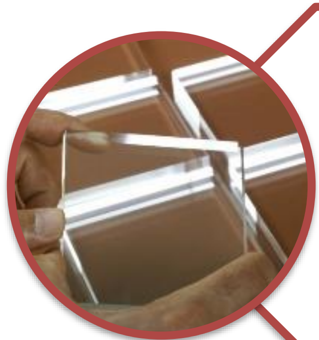
Materials and Construction

Different Space Construction methods were analyzed after reading the mentioned references, The ones chosen are:

In Situ Resource Utilization (ISRU), it is the practice of collection, processing, storing and use of materials found or manufactured on other astronomical spaces, like Mars, that replace materials otherwise brought from Earth. The construction in space will require obtaining local building materials, such as regolith. Yet, studies employing artificial Mars soil mixed with epoxy resin and tetraethoxysilane, produce high enough values of strength, resistance, and flexibility parameters, this concept can be applied to the proposed structure in wadi rum after analyzing the possibility of using wadi rums sand in the mix [2], Also, use of ISRU to provide backup life support caches on the order of 7000 to 28,000 kg have been considered for Mars missions. And, based on NASA's recent studies, using ISRU saves between 169,000 to 241,400 kg [11].

3D printing, the design utilized a modular approach, separating the elements for easy construction that can be 3d printed on-site in their location referencing the column distribution and allow the building of solid structures. It helps use new build materials, build parts or structures, and expand in the future, less weight, and Lower production cost [3]. **Martian Concrete** is the main construction component, what would be better than using the materials available in space itself! Regolith is the crushed rock layer that has been deposited on the surface of Mars over the years. Scientists are working on technologies to either build bricks or use it in other forms like 3D printing to construct on Mars. The optimal Martian Concrete mix consists of 50% sulfur and 50% regolith. [3] as it is readily available on Mars, and it doesn't need water. For testing, scientists mixed sulfur 50/50 with a basalt-based simulant from the Mojave Desert, which has an 80-90% chemical match to Martian rock.

Inflatable structures are pressurized tent-like structures capable of supporting life in outer space whose internal volume increases after launch. They have frequently been proposed for use in space applications to provide a greater volume of living space for a given mass. They represent a new possibility and a better alternative to classic rigid space structures thanks to their low costs and low masses. They are lightweight and can be packaged into small volumes: smaller launch vehicles can reduce mission costs. The shape of the module is maintained by the pressure difference between the internal atmosphere and the outside vacuum. It provides modularity and speed in construction [4]. They are found in the airtight circulation loop in the circular plan, and in the dorm modules.



ALON glass panels, as recommended by **Dr Samer El Sayary**, Aluminum oxynitride, marketed under the name ALON [5] [14], is a transparent ceramic composed of aluminium, oxygen, and nitrogen. ALON is optically transparent. It is four times as hard as fused silica glass, 85% as hard as sapphire, and nearly 115% as hard as magnesium aluminate spinel. Because of its relatively low weight, distinctive optical and mechanical properties, and resistance to oxidation or radiation, it shows promise for applications in space [12]. **Aluminum,** Aluminum was used for the spacecraft, Apollo 11, in the first-ever mission to land on the moon. Owing to its lightweight and the ability to form alloys with other materials and withstand pressure during launches, landing, and transit; the mission to build on Mars would be incomplete without Aluminum. In this design proposal aluminum was used in the glass frames, steel structure carrying the modules, and in the reinforcement of the 3d printed structure.

Modularity and open plan

It was an important decision made early on to have maximum open spaces and minimum fixed walls, I left an open path that leads to every space to make the facility spaces inviting and to leave the option of customization in spaces; to open the workshops to each other, or the outdoor and indoor museum, etc. so here are the main components which are the columns, roof, and floors are all designed to be individual pieces that can hold each other, and the rest is completely modular and open for the user experience to shape it.

[13] Sustainable in-situ resource utilization on the moon, AlexEllery, 2020
[14] Alternative materials: Transparent aluminium, Anukriti Marwah, 2018
[15] Reprap, blog, 2020
[16] Tectoniks UK, blog, 2015

Sustainability

As with the SDGs, increased participation from international stakeholders in the space community can have and is having, a direct impact on our ability to set and achieve shared goals on Earth. And to match a few of my research areas with SDGs:

Sustainable construction & and materials

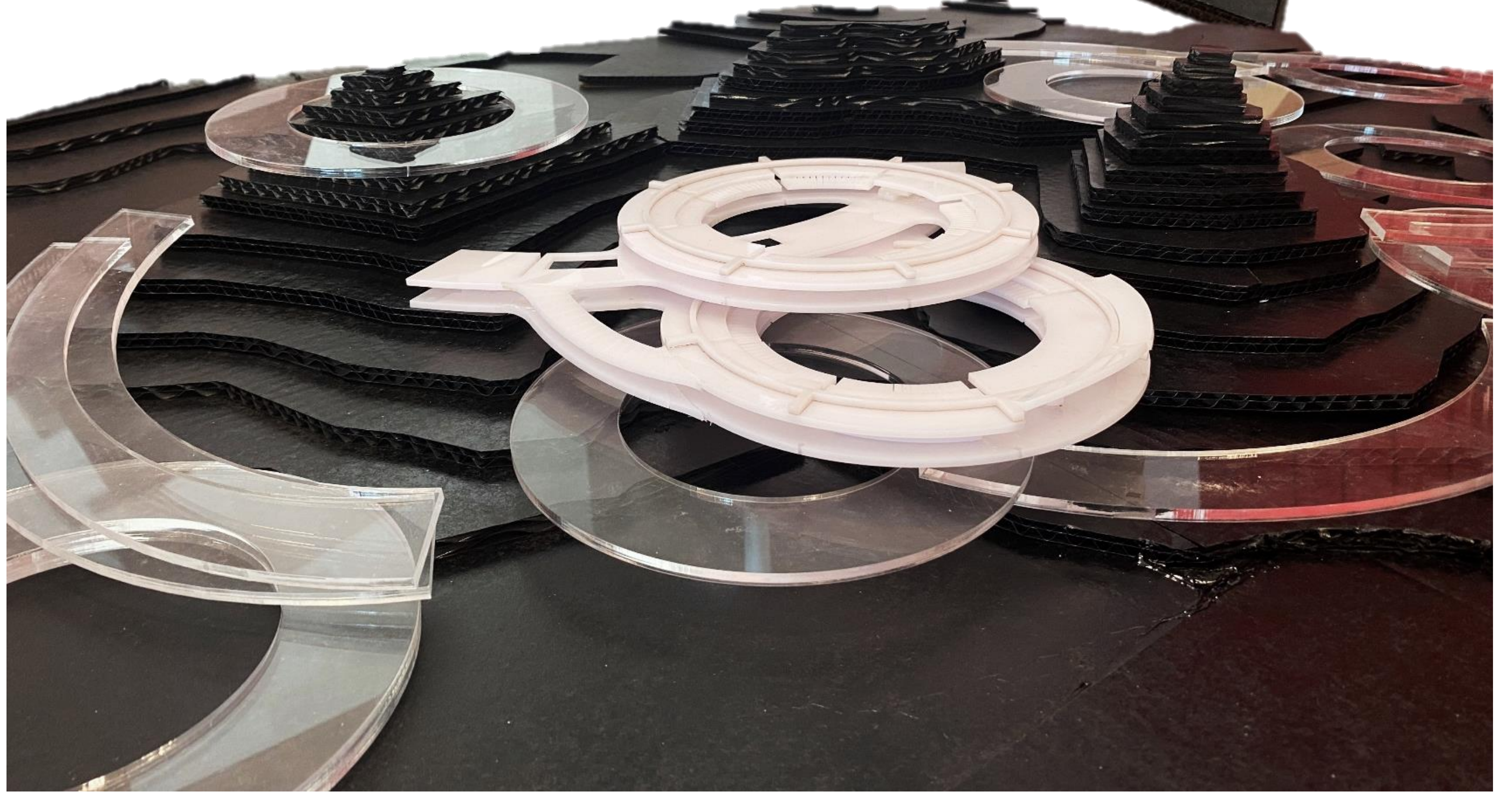
- Using regolith from the site through the ISRU robotics is itself sustainable, as it includes using the found resources and minimization of waste, it also can be an effective tool for making products less expensive using local sources [13].
- And the 3D printing uses Solar power, and the additive nature of 3D printing means that building parts are made layer by layer. It generates less wasted material than other subtractive forms of fabrication [15].
- ALON, known as Aluminum Oxynitride, is a transparent aluminium compound used in glass panels and is a sustainable building material to incorporate into their structures [14]. One of the main reasons glass is sustainable is because it is 100% endlessly recyclable. This means that recycled glass is always part of the recipe for new curtain systems.
- Inflatable pods, a technology that produces reusable and highly efficient structures in terms of the amount of material used in their construction, require no permanent foundations, are energy efficient, and can be relocated and recycled [16].

The expandable, modular, and flexible design

One of the ways to implement sustainability in architecture is to ensure the reusability and flexibility of spaces, The modular plan design allows the facility users to customize the plans according to their needs over time, also the design itself consists of individual components that can adapt to any topographic locations and designing a mars or lunar habitat with the same design. As well as expandability, the design is stackable, just like Lego pieces, more loops can stack over it as if we are going even further in the wormhole, which proves that this design concept has a clear vision for future extensions.

Physical Model

I wanted to push boundaries and showcase my concept of a transcending portal and the expandable nature of the design through a physical model on The Wadi Rum Desert contour lines.



Contributions / Consultations

Dr. Samer Al Sayari

- Assistant professor of Architecture, researcher, and award-winning architect with a passion for Outer space architecture.
- Jacques Rougerie Foundation Competition 2022, Paris, Grand Prize Winner

Dr. Samer played a pivotal role in shaping my project for "The Portal." His extensive expertise in outer space architecture, coupled with his Grand Prize Win in the Jacques Rougerie Foundation Competition in 2022, made him a valuable mentor and guide.

His contributions included technical insights into space technologies like ISRU and hydroponic gardening, as well as the recommendation of ALON glass panels. He provided unwavering support, motivation, and belief in my imaginative and research-driven approach as a future architect.

Furthermore, his success in the Jacques Rougerie Foundation Competition inspired me to participate in the 2023 edition, as I witnessed the transformative potential of innovative architectural concepts in shaping the future. Under his mentorship, I aim to make a meaningful impact in space architectural design.

Arch Hamza Zabalawi

- HTU Lecturer – School of Built Environment Engineering – Architecture
- Senior Design Architect – EDGE - Environmental Design Group E

He was responsible for ensuring that all aspects of the project aligned with my original concept, directed the process to excel in my design and made sure that I had a deep understanding of both the project's technical aspects and the goals I was trying to achieve.

Encouragement, Support for making changes, Review, and advice were given, as being the design supervisor provided guidance, and resources needed to achieve successful project delivery.

The JSRI Webinars

The webinars provided a huge insight into the details put into designing analogue and habitat facilities, and the guest lecturers gave incredible suggestions and resources, in addition to the resources and case studies provided by JSRI.

JSRI Space Architecture Series - Space Architecture...

MVA Jordan - JSRI Space Architecture Series -...

JSRI Space Architecture Series: Designing Lunar...

JSRI Space Architecture Series - Analog Habitats...

References

[1] Space Architecture Education for Engineers and Architects: Designing and Planning Beyond Earth, Sandra Häuplik-Meusburger, Olga Bannova

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[8] Weather and climate, international weather reporting site, https://weather-and-climate.com/average-monthly-hours-Sunshine,wadi-rum,Jordan

[9] Reinforcement in concrete piles embedded in the sand, Firas A. Salman, Mohammed M. Mohammed, S. M. Shirazi, Mohammed Jameel, https://academicjournals.org/article/article1380876522_Salman%20et%20al.pdf

[10] Jordanian National Building Codes, https://pic.hu.edu.jo/Upload/55000000/55090000/%D8%A7%D9%84%D8%A7%D8%B1%D8%AF%D9%86.pdf

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[16] Tectoniks UK, blog, https://www.tectoniks.co.uk/blog/2015/11/12/the-environmental-benefits-of-blowing-up-buildings/#:~:text=This%20technology%20produces%20structures%20which,easily%2C%20and%20can%20be%20recycled.

[17] Argo Dual-Purpose Mars Habitat, Robert B, Gitten, Haroon N. Syed, Takumi Date, Benjamin J. Greaves, Sindhu S. Jayakala, Sweeya P.

Tangudu, Annika K. Stoldt, Anna Mariella Pulvermüller, https://ttu-ir.tdl.org/bitstream/handle/2346/74117/ICES_2018_132.pdf

[18] Science Focus, a science blog, https://www.sciencefocus.com/space/what-is-a-wormhole/

[19] A New Kind of Inflatable Pod Could House Future Astronauts on Mars, Ameya Paleja, https://interestingengineering.com/innovation/a-new-kind-of-inflatable-pod-could-house-future-astronauts-on-mars.