New habitats on Mars: What role for Interior Design on the Red Planet?

Fig.1 (Cover): Empire Design (2019) *'Moving to Mars' exhibition* [poster], The Design Museum, London

ABSTRACT

Moving to Mars is still a very abstract concept for the majority of the population. Bringing a new population to a second habitable planet is probably the greatest challenge for designers and engineers can face during their career. The role of the interior designer is fundamental for a successful settlement, from both a practical point of view and well-being. Many needs have to be considered and solutions found to sustain the settlers' lives on the Red Planet. As discussed in this dissertation, design agencies are constantly looking for solutions to inhabit Mars, a number of which have already been presented to the public, notably at the 'Moving to Mars' exhibition at the Design Museum London in 2019. The collaboration between architects and engineers has led to fascinating innovations in terms of materials which must be able to withstand the harsh and inhospitable conditions on Mars. This has been discussed with professionals during my research. With projects such as the opening of a space hotel programmed for 2027, space is no longer as inaccessible as it was in the past and more and more articles and journals are being published about the future inhabitation of Mars. Through the comparison and analysis of the proposed designs, this dissertation is intended as a study of the role of interior design on the Red Planet. Consequently this gives right to the debate as to how designing for life on Mars could benefit Earth, which is enduring more and more severe environmental conditions.

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INTRODUCTION

Designing to live on Mars is now the most ambitious and exciting challenge for designers and engineers of the twenty-first century. What seemed to be a fantasy in the past is now a reality and the most burning subject in the current context of space exploration and development. Many design agencies are currently working on habitation projects which respond to the challenges of building and living on Mars. One of the biggest considerations is the needs of the settlers who would live more than fifty million kilometres away from Earth, a journey taking on average seven months.

Science has always stimulated my curiosity and I am fascinated by how designers and engineers are able to collaborate on certain projects. On my visit to the 'Moving to Mars' exhibition at the Design Museum in London in 2019, I immediately knew I wanted to pursue my research on this subject. Designing habitats to sustain human life on the Red Planet is, in my opinion, the ultimate challenge.

The aim of this dissertation is to analyse some of the solutions proposed by design agencies to enable us to inhabit the Red Planet and overcome the extremely challenging and harsh environmental conditions. This research will also provide a critical insight into the proposals and methods used by specific design and multidisciplinary agencies including AI SpaceFactory, Hassell Studio and Bjarke Ingels Group BIG. Learning about and researching design solutions for Mars could benefit Earth, particularly the way in which we can use available raw materials.

The first chapter of this dissertation will introduce the ‘Moving to Mars’ exhibition and how it relates to the context of space exploration and its current developments. The exhibition also showcased solutions to the future settlers’ basic needs, such as food and clothing, and also their physical and psychological well-being. For Tim Alatorre, co-founder of Orbital Assembly, “making visiting space accessible to everyone” (Alatorre, T. 2019) is one of the aims of designing and opening the first space hotel in 2027. He is one of the senior architects of this project, commissioned by the Gateway Foundation. This could be considered as a first stepping stone to living in space with the long-term aim of populating Mars.

In the second chapter will analyse and provide a critical assessment of the technical aspects of building on Mars to sustain life and how these have been inspired by existing designs on Earth. This includes how these habitats are constructed in such challenging environmental conditions and how the raw materials available on the surface of the Red Planet can be repurposed to accommodate a human population. Mars being so far away, no errors can be made, and we have “to learn from our mistakes on Earth and create a zero-waste, clean energy-powered, sustainable planet” to quote Annabel Hallam, publications officer at the Royal Aeronautical Society, in her review of the ‘Moving to Mars’ exhibition in 2019. Experimenting before the ‘big move’ is therefore essential, and this is currently being undertaken in the desert of Dubai with the building of Mars Science City by BIG Bjarke Ingles Group.

The third and final chapter will explore how design research for Mars could benefit Earth. Designing on Mars is, in my opinion, the most challenging project a designer can face due to

the lack of materials and resources. Learning how to use the existing and available materials to adapt buildings and habitats to the worsening climate conditions of our own planet, such as desertification and the thinning of the ozone layer, could help minimize our environmental impact on Earth. Indeed “surviving on Mars could teach us how to live more sustainably on earth” says Justin McGuirk, the Design Museum’s Moving to Mars exhibition curator.

This dissertation will therefore explore the role Interior Design plays in the future inhabitation of the Red Planet, responding to its many challenges. It will also endeavour to answer the question which arises from this subject: how could the conclusions and solutions found for Mars benefit Earth?

CHAPTER 1 – THE ‘MOVING TO MARS’ EXHIBITION AND SPACE TRAVEL

This first chapter will put into context current developments in space exploration with the ambitious project to build habitats on Mars for a future human population. An analysis and understanding of the settlers’ basic needs such as food and clothing will also be given. This research is mainly supported by the ‘Moving to Mars’ exhibition at the Design Museum in London in 2019 which questioned many aspects of living on the Red Planet, and the extremely important consideration of the psychological aspect and well-being. This puts the role of Interior Design on the front line for thoughtful and successful habitats and settlements.

The ‘Moving to Mars’ exhibition took place at the Design Museum in 2019 and showcased a number of proposals from design agencies to accommodate a human population on the Red Planet. Living and moving to Mars is a subject which particularly inspires the younger generations who will undoubtedly be able to witness the first settlements. The Design Museum therefore collaborated with students from the Royal College of Art and Imperial College to find potential design and engineering solutions to sustain life on the second most habitable planet in our solar system (Baldwin, E. 2020). While taking the visitors on an experimental and multi-sensory tour, the aim of the exhibition was to make them question and shape their own opinion about the potential of this exciting move. This public exhibition and the questions it raised is also a way of promoting space travel, making it seem more accessible to everyone.

The first step is to visit space. This will begin with the opening of the first ever space hotel by the Gateway Foundation, named Voyager Station, set to open in 2027 (Fig.2), where “going to space will just be another option people will pick for their vacation” (Alatorre, T. 2019). We can however question how accessible and realistic this vacation would be from an economical point of view, with an estimated cost of five million dollars for a three-and-a-half-day stay according to Travel and Leisure. Only an extremely small percentage of the world’s population would be able to offer themselves a holiday in the cosmos. Yet despite the financial aspect, space tourism has already become a very real concept with the first launch of Blue Origin in 2021, offering passengers a short flight to experience the lack of gravity. However space tourism, although not accessible to the public at large, could also come with vast environmental costs; as one rocket expels between 200 and 300 tonnes of carbon dioxide into the atmosphere (Marais, E. 2020).

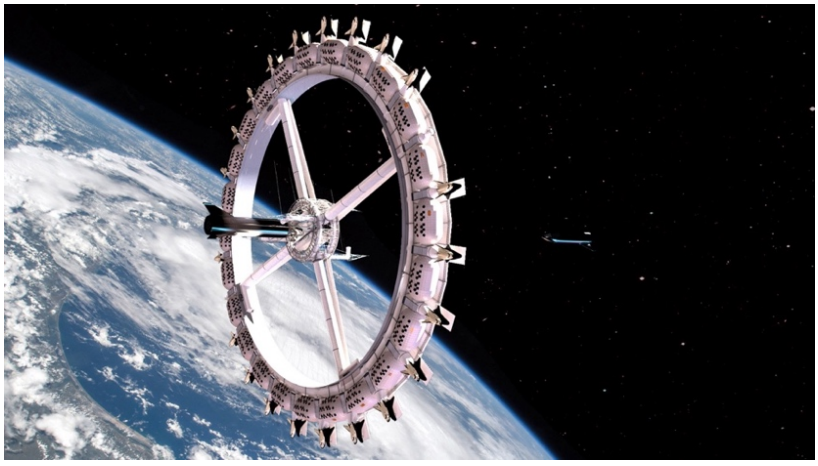

Fig.2: Orbital Assembly (2022) *Voyager Station* [image], Orbital Assembly, Rocklin, California

While these short excursions into space obviously need to respond to the travellers’ basic needs, to say nothing of a few luxuries, they are not as challenging as the requirements of actually living on a completely deserted planet such as Mars. Cultivating food is probably one of the most important aspects of survival. Far from the famous dehydrated food

astronauts ate on board Skylab, the first orbital space station designed by NASA, other solutions have been found to produce authentic food such as can be produced by GrowStack's vertical farming method, showcased at the 'Moving to Mars' exhibition. The first lettuce grown in space was aboard the International Space Station in 2015 and took the astronauts about one month to cultivate under LED lights (Blunden, M. 2020). As Xavier De Kestelier, principal and head of design technology at Hassell Studio in London, explains, bringing everyday elements with us to Mars is essential and the taste of earthly food could help lift Martian astronauts' spirits. This greatly inspired the agency for the design of its greenhouse in their habitat on Mars and the integration of a "circular farming pod inspired by library archive shelves" (Fig.3) (Blunden, M. 2020). Cultivating plants and vegetation in an unhospitable environment is also a way of integrating biophilia into the designs, essential to the well-being of the settlers as "we do better if there's a connection to nature in some ways", whether this is the colour green from plants or a woodgrain and its pattern (Hunter, I. 2023).

Fig.3: Hassell Studio (2019) *GrowStack in Martian circular pod* [image], Hassell Studio, London

Another very important use of plants is for the creation of textiles, both for the necessity of clothing but also to be able to integrate plant-based textiles and fabrics in the design of interiors. Anna Talvi, MA graduate from the Royal College of Art, has created a range of "microgravity-wear, which has been designed with a Mars mission in mind" (Design Indaba, 2020) (Figs. 4 & 5). The designer has combined disciplines such as biomedical engineering and material science to produce an innovative piece of clothing "which acts as a sort of 'wearable gym'" (Hahn, J. 2019). This fashionable revolutionary space wear aims to keep the astronauts safe and help "to combat bone loss and muscle atrophy in space" due to the lack of gravity and exercise (Design Indaba, 2020). "The entire range is informed by the enormous changes that human physiology and psychology undergo in a microgravity environment" (Design Indaba, 2020). Indeed the use of textiles can be taken much further since it is crucial in the creation of a liveable and comfortable space (Neighbor Editorial Team, 2022). Integrating textiles into an interior space adds depth and visual interest and, when applied carefully, "designers can create homes that are not only aesthetically pleasing, but also meaningful and inspiring" (Johnson, E. 2023). However no soft furnishings were exhibited at the 'Moving to Mars' exhibition and these would surely contribute to the comfort of the settlers, both physically and psychologically. To what extent have these been considered in the interior design of Martian habitats? Fabrics and textiles can easily be obtained from natural fibres from plants grown directly on Mars under LED light, for example bamboo plants as they grow perfectly under artificial lighting (Halleck, L-F., 2023). Integrating hand-made elements is also a very important aspect to general well-being as humans truly enjoy the feeling and signs of human activity. Designing in a deliberate way "tells us stories about the past, how other people have been there and ultimately tells us we are not alone" (Hunter, I. 2023). This natural fabric and textile production can be in

complement to man-made fibres obtained following a chemical reaction between water, carbon monoxide and a chemical reactor resulting in the creation of polyethylene plastics (Bjarke Ingels Group BIG, 2017).

Fig.4: Ottilie Landmark (2019) *Anna Talvi's Microgravity-wear* [photograph], Design Indaba, London

Fig.5: Ed Reeve (2019) *NDX-1 spacesuit* [photograph], The Design Museum, London

The 'Moving to Mars' exhibition also showcased a life-size home designed by Hassell Studio and Eckersley O'Callaghan which visitors could actually step into (Fig.6). This 3D prototype gives a sense of what living in the proposed habitats would look and feel like. Its minimalist aspect makes "the habitat look spacey" (De Kestelier, X. 2020), enhanced by the transparent 3D-printed chairs made from recycled plastic. This is actually due to the printing process which works best when done in a continuous sweep (De Kestelier, X. 2020). The integration of circular economies in the design of habitats is essential to create a zero-waste environment on Mars. As Xavier De Kestelier stated in his interview with journalist Christopher Barker, integrating a circular system in the construction process was very challenging. Hassell Studio had to adapt and rethink the use of robots so they would combine different functionalities,

from digging into the regolith to printing pieces of furniture (De Kestelier, X. 2020). The agency sought to organise their Martian habitat in a circle, almost with a central courtyard, which would enable people to see and to be seen by others. The thinking behind this is to avoid a feeling of isolation and loneliness but without the obligation of always interacting with one another (De Kestelier, X. 2020).

Fig.6: NAARO (2019) *Full-size prototype of Hassell Studio's 3D printed habitat* [photograph], The Design Museum, London

Entertaining people and keeping them physically and psychologically active is also a very complicated challenge when living on an inhospitable planet, and where going out for a walk is not an option. "Mars travellers are likely to have much more personal time. How should they fill it? Their psychological health will be crucial, and is rated by NASA as one of the major unknowns and major risk factors" (Nahum, A. 2019). The 'Moving to Mars' exhibition aimed to show people what it would be like to live on Mars but also how to thrive on the Red Planet. It introduced the idea of "Earth-like spa rooms on Mars" and therefore the need for structures which have a positive impact on our well-being (Hallam, A. 2019). On the Red Planet, habitats will have to fulfill all of the settlers' needs, from working to recreation and resting, in a confined space. This is

very similar to what we experienced during the various lockdowns due to the COVID-19 pandemic, where our home became our sanctuary. According to Andrey Ustyugov, CEO at Planner 5D, an easy-to-use home design platform powered by AI, AR and VR technologies, people want more from their homes now. They "will invest more and more in their personal space to have more comfortable and specialised zones for specific household routines, ranging from work to playing with kids" (Ustyugov, A. 2021). Dividing up homes for different uses and clearly separating the work and personal space has become essential. This has led to many people realising that their home did not work for them and their activity (Ustyugov, A. 2021). Designing functioning and functional habitats for the settlers on Mars is crucial for their well-being and happiness, especially since it will not be possible to make any frequent changes to or refurbishment of the habitats. The role of Interior Design in this case is more important than ever and fundamental for the design of a successful home for the future Martian population. Jonathan Eastwood, director of the Space Lab at Imperial College London, explains that "the biggest challenge in terms of a sustained presence on Mars is not the engineering challenge, but the human and personal one" (Eastwood, J. 2020). This not only questions how we can survive on the Red Planet but essentially how can we thrive while living on a new inhospitable planet (Koronka, P. 2020).

The image we have of space habitats and their finishes is "usually clinical, white, glossy and with too many corridors" (De Kestelier, X. 2020). This preconceived idea is a consequence of science-fiction movies and these space-looking designs are the outcome of a robotic process. Across the centuries, we have moved away from maximalist design and

architecture and now “have a preference for minimalism, sophistication and refined elements” (Hunter, I. 2023). While interior designer Sharon Blaustein believes “minimalism and functionality go hand in hand” (Blaustein, S. 2019), for designer Robert Brown, this style “allows something other than the space to be the focus […] the people in the space or the view from the window might be more important” (Brown, R. 2019). At the same time it is well-known that minimalist interiors and architecture can make a space feel uninviting and very cold, making the choice of material and thoughtful design essential to obtaining a resolved space (Myers, S. 2019). However minimalism does not go with our natural instinct and it is rather cultural influence that has drawn us towards it (Hunter,I. 2023). Ian Hunter, material consultant at Material Council, questions whether architects and designers should lean towards our instinctive qualities of finding prosperity in bright, colourful and abundant environments or continue to design with a minimalist approach. This brings to mind a particular design principle found in French eighteenth century architecture, where wall plaster mouldings would reflect personal interests and be related to something that you would like (Giraud, C. 2023). As discussed with Christophe Giraud, interior architect and scenographer at Scénos-Associés in Paris, these deliberate and thoughtful elements were a way of entertaining and creating a conversation with your guests. This principle has already been applied to a space context and inspired Stanley Kubrick, director of the famous *2001: A Space Odyssey* film from 1968. The set design “had to outpace emerging technology to successfully look futuristic” especially as the science fiction movie was being filmed at the same time as NASA’s Apollo missions (Muraben, B. 2019). Stanley Kubrick took the visual identity of French eighteenth century architecture and applied it to a modern and futuristic interior in a very successful way (Fig.7). This may be an idea which could be reintegrated into Martian designs to create entertaining and visually engaging habitats (Giraud, C. 2023).

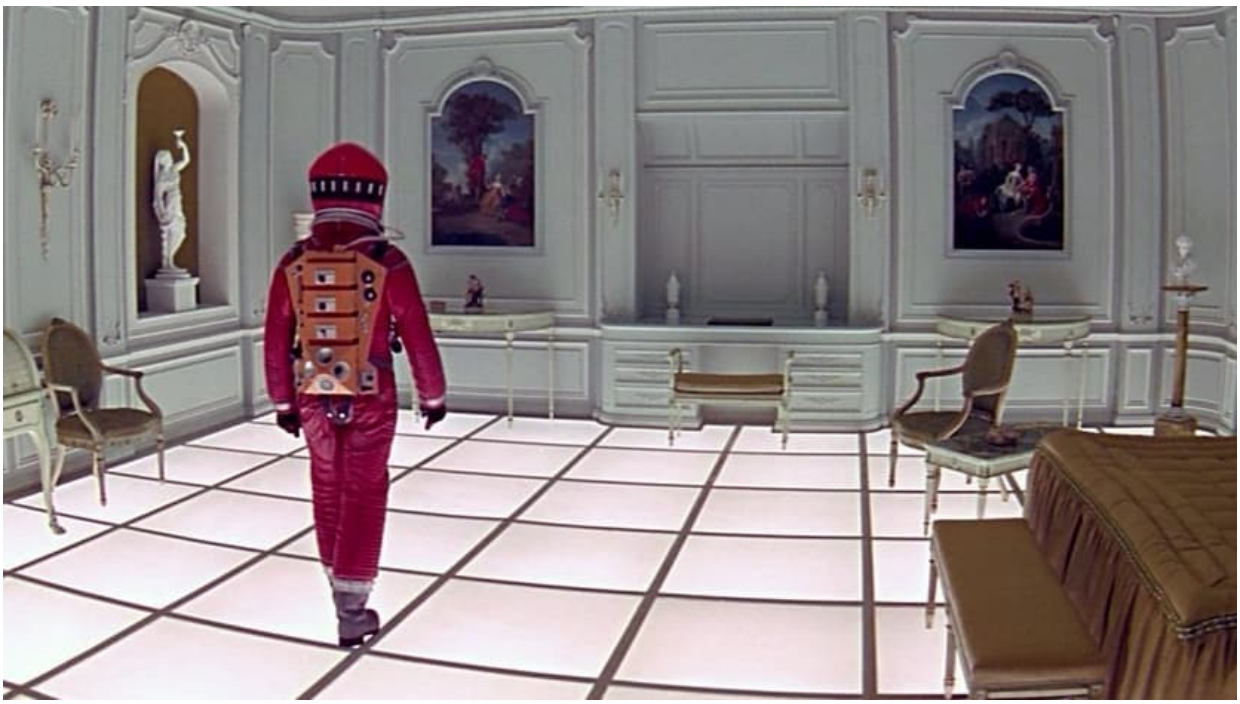

Fig.7: Léo Mouren (2018) *2001: A Space Odyssey* [film still], National Air and Space Museum, Washington

CHAPTER 2 – BUILDING TO SUSTAIN LIFE

In this chapter, in-depth research and critical analysis of proposed design solutions for habitats on Mars will be presented and discussed, the majority having been exhibited at the Design Museum in London and selected by NASA. Responding to the extreme environmental conditions and technical aspects of building on a very different planet is a major challenge, but possibly less complex than the psychological impact of moving to Mars. This research will be supported by analysis and comparison of existing designs for challenging conditions on Earth and how these have informed the designs of future habitats on the Red Planet. In this context, Interior Design has also been inspired and influenced by the Modernism movement in its search for solutions, as discussed below.

The life imagined by Philip K. Dick in his Martian Time-Slip science-fiction novel could soon become our new reality. However before actually going to Mars, much research and experimentation must be carried out on Earth. No risks can be taken when sending humans fifty million kilometres away from their original habitat. Danish multi-disciplinary agency BIG Bjarke Ingels Group is currently developing a Mars-simulation complex of over 180,000 square metres in the desert just outside the city of Dubai. This Mars Science City (Fig.8) is an experimental centre where researchers will live for one year and includes laboratories, a museum, offices and exhibition spaces (McGuirk, J. 2019). This experiment will enable designers and engineers to receive feedback from the researchers and consequently implement any changes to make the settlers' lives more comfortable and practical. The physical and psychological well-being of the latter must not be underestimated. "Working and living in Mars Science City will allow us to gain experience with climate control, safety,

quality of construction, and resilience of human-made ecosystems that will be invaluable when we finally go to Mars" (BIG, 2017). This prototypical test site will be the first Martian settlement to accommodate life while still being on Earth.

Fig.8: Bjarke Ingels Group (2017) *Mars Science City* [image], Bjarke Ingels Group, Dubai

Mars Science City will eventually be accessible to visitors who wish to experience what living on Mars could be like. The series of interconnected domes can constantly expand as the population on Mars grows, "eventually forming villages and cities in the shape of rings" as announced by the United Arab Emirates who wish to colonise Mars within the next hundred years, according to their Mars 2117 programme (Koronka, P. 2020). The pressurized biodomes are made out of a polyethylene membrane and "since there is very little atmosphere on Mars, the heat transfer will be very low, meaning that the air inside the domes will not cool down as fast as it would on Earth" (Lange, J. 2020). This will significantly help on saving energy as the simulation city will rely entirely on solar energy. The biodomes will mainly be used to produce vegetation and the settlers' living space will be built underground by excavating the desert sand. With rooms as far as twenty feet underground,

protected from radiations and meteorites, inhabitants could feel claustrophobic. One solution found by Jakob Lange is to integrate water-filled skylights which would provide protection against radiations but also allow light into the underground spaces (Lange, J. 2020) (Fig.9).

Fig.9: Bjark Ingels Group (2017) *Underground space* [image], Bjarke Ingels Group, Dubai

In appearance, the buildings are relatively simple in terms of form and shape, but the technical aspects of the materials are very complex as these have to resist the inhospitable conditions of the Red Planet and protect the inhabitants from any radiations and extreme temperatures. Engineers and architects have explored many options concerning the construction of habitats and have concluded on the combination of different building methods. Architects have had to completely rethink the way they design habitats to adapt to low gravity, low atmospheric pressure, extreme cold and very high levels of radiation. The average temperature on Mars is minus sixty-five degrees Celsius, similar to the temperature in Antarctica (NASA Planetary Fact Sheet). As illustrated in BIG's diagrams below, three

techniques are being experimented such as the use of inflatable pods, 3D-printed shell structures and, finally, the excavation of Martian soil (Figs.10 & 11), all of these taking inspiration from methods we have developed on Earth.

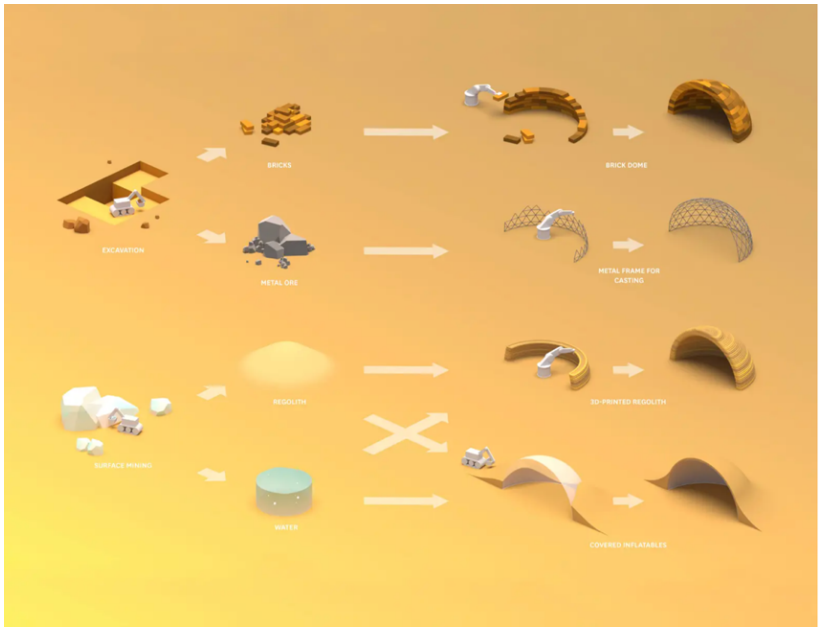

Fig.10: Bjarke Ingels Group (2017) *Building methods* [diagram], Bjarke Ingels Group, Dubai

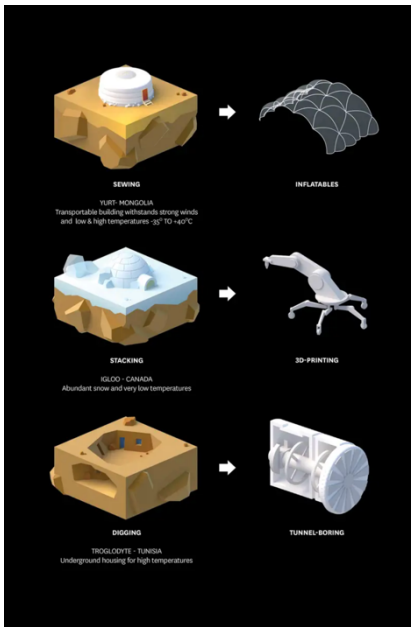

Fig.11: Bjarke Ingels Group (2017) *Building methods* [diagram], Bjarke Ingels Group, Dubai

Building in such extreme cold temperatures has already been achieved on Earth, as can be seen in Antarctica with the Halley VI British Antarctic Research Station (Fig.12) designed by Hugh Broughton Architects and opened in 2013. The sun does not rise here for one hundred and five days during winter and the researchers have to live in a completely confined place and yet still be comfortable and stimulated (Hugh Broughton Architects, 2004). Here, the uncertainty of the terrain was the biggest challenge the architects faced since Halley V had "flowed too far from the mainland to a position at risk of calving as an iceberg" (Hugh Broughton Architects, 2004). Hugh Broughton Architects designed a self-supporting steel structure upon which each module rests to enable easy relocation. Each module is dragged

on skis over fifteen kilometres and supported on “hydraulically driven legs that allow the station to mechanically ‘climb’ up out of the snow every year” (Hugh Broughton Architects, 2004). The modular design concept is arranged in a straight line with a central module acting as the social heart of the relocatable science research station (Fig.13). The latter is organised on two levels with a spiral staircase as its centre piece, reminiscent of Modernism architecture, as discussed further in this dissertation with reference to the MARSHA habitat by AI SpaceFactory. Due to the extreme harsh environmental conditions, access to Halley VI by ship and plane is limited to a three-month window during summer. This greatly restricts the importation of food, and equipment generally, thus making a no-waste environment essential. Living in such harsh environmental conditions is extremely challenging from a technical point of view but, as Mr. Broughton says, “these projects are about using architecture as a means of improving both well-being and operational efficiency.”

Fig.12: James Morris (2013) *Halley VI British Antarctic Research Station* [photograph], Hugh Broughton Architects, Antarctica

Fig.13: Hugh Broughton Architects (2013) *Isometric view central module* [image], Hugh Broughton Architects, Antarctica

Successfully designing habitations and research stations in these conditions on Earth can help us better understand and imagine life on Mars and also enable us to learn from these designs (Hunter, I. 2023). Halley VI in Antarctica became an inspiration for Xavier De Kestelier, head of design technology at Hassell Studio, as he discussed his research with the commander of the winterisation crew of the British research station. Feedback received from the crew, who stayed up to eight months in the station, included the desire for more tactile elements. “So they took some packaging crates from their supply drops and used it to build a wooden wall in their living area, making it look kind of like a local pub” (De Kestelier, X. 2020). This reflects the importance of the role of Interior Design, especially in confined spaces where people are required to spend months at a time. The feedback from Halley VI has inspired the design of Hassell Studio’s Martian habitat by integrating bamboo, as “it grows easily, looks tactile and is a completely different aesthetic to what we might normally see in sci-fi” (De Kestelier, X. 2020) (Fig.14). Wood is relatively cheap on Earth but, as states Ian Hunter, it will be such a luxury on Mars. Anything that is imported on Mars from Earth will be at great cost and space will be extremely limited on the spacecrafts. Any natural Earthly material on Mars will be a luxury and will probably change the vision we have of our use of materials on Earth (Hunter, I. 2023).

Fig.14: Hassell Studio (2019) *Interior view of Martian habitat* [image], Hassell Studio, London

Hassell Studio and structural engineers Eckersley O'Callaghan (EOC) collaborated on the design of a Martian habitat (Fig.15) with the intention of "putting people first and moving beyond the idea of astronauts as operators, to create a habitat where people can not only survive life on Mars but really thrive there" (Ross, A. 2019). The habitat features the same principle as the Mars Science City in Dubai with a 3D-printed Martian regolith exterior shell and a series of interconnected inflatable pods (Fig.16 & 17). This shelter offers astronauts a place to live, work, rest, play and "make humans a multi-planetary species" (Ross. A, 2019). At Hassell Studio, the design team's intention was to create a true sense of community by using a modular approach and a continuously expandable settlement (De Kestelier, X. 2019). The agency used a moveable rack system in the arrangement of the pods with their circular greenhouse, as described previously. With the United Arab Emirates' aim to colonise Mars within the next century, we can question to what extent these habitats can be expanded and at what rate. How long does it take to build one habitat and how many people do the UAE wish to send to the Red Planet as part of their Mars 2117 programme?

Fig.15: Hassell Studio (2019) *Exterior view of Martian habitat* [image], Hassell Studio, London

Fig.16: Author's own photograph (2019) *3D model of Hassell Studio's Martian habitat* [photograph], The Design Museum, London

Fig.17: Hassell Studio (2019) *Exploded axonometric* [drawing], Hassell Studio, London

Building on Mars, as will be discussed in further detail, could help us design more sustainably on Earth and likewise methods used to build on our planet in extreme environmental conditions could also be adapted to the Martian atmosphere. Inflatable pods are inspired by yurts, they are quick to assemble and do not require much if any human labour, and most importantly they can resist strong winds and varying temperatures. They are also very suitable for creating pressurized environments but unfortunately are not enable to withstand radiation or meteorites. However they do provide sunlight for vegetation to grow and therefore feed the potential settlers. These inflatable pods can be directly brought in from Earth and their installation is very quick, without requiring any preparation work on site (BIG, 2017).

The second stage of building habitats on Mars would be to construct 3D-printed shell structures by mining the regolith, a kind of basalt, from the surface. Regolith covers the majority of Mars and this sand-like deposit, with a high iron content, gives the planet its rusty orange hue. Robots sent to Mars before any human crew would extract the abundant regolith "which can get sorted into ice for water, stones and sand" (BIG, 2017). Although the

surface of Mars is, at first sight, very deserted, the regolith actually provides all the basic and necessary chemical elements humans need: oxygen, water, carbon and aluminium. Aluminium is a very strong and resistant material that can be used for building, interiors and everyday objects, and it can resist the atmospheric conditions on Mars (Hunter I., 2023). Using the available materials on the surface of Mars is essential since any transportation from Earth will be extremely limited and not cost- and time- efficient. The atmosphere on Mars is very rich in carbon dioxide, and, used in a Sabatier reaction, produces water, methane and carbon monoxide. These three elements, combined with hydrogen and a chemical reactor, produce soft and hard plastics which can then be used to build inflatable pods, furniture and everyday utensils (BIG, 2017) (Fig.18).

Fig.18: Bjarke Ingels Group (2017) *Circular opportunity* [diagram], Bjarke Ingels Group, Dubai

A number of designs have already been imagined using regolith, as seen in the MARSHA habitat proposal by AI SpaceFactory. The agency's wish was to design a tall home on the surface of the Red Planet which would still be safe for the settlers, rather than a dome-like habitat. AI SpaceFactory's main principle is to rethink the Martian habitat (AI SpaceFactory,

2017). Considering how technology affects the way architecture is conceived is not new and was particularly explored by Le Corbusier during the Modernism movement in the twentieth century. “MARSHA makes a strong argument rooted in an integration of form and function” (Scharmen F. 2017), following in the footsteps of Le Cobursier’s principle of the house as a machine. The four floors of the MARSHA habitat are connected by a spiral staircase, “adding dimension to daily life” (AI SpaceFactory, 2017) and this is also reminiscent of Le Corbusier’s spiral staircase at Villa Savoye which leads to all three floors of the house (Fig.19). These architectural elements act as the centre pieces of the interior.

Fig.19: T. Allard (2021) *Villa Savoye* [photograph], Pérégrinations de photographe d’architecture, Poissy, France

Although, Modernist architecture has its weaknesses and “failed to function in serving the needs of the vulnerable”, it has had a global impact on architecture and design and conquered the world (Scharmen F., 2017). Hence the importance of experimenting on Earth beforehand the potential designs of habitats on Mars to ensure an optimal living environment for the settlers. The MARSHA (Fig.20) tower is organised in different zones: working, sleeping, exercising, and socialising. These areas are spread over four floors in an interior which encourages mobility and is filled with natural light thanks to “circadian

lighting designed to recreate Earthly light" (AI SpaceFactory, 2017). As discussed with Ian Hunter, light and natural elements are extremely important for humans and have a huge impact on our wellbeing and mental health. This is also a very challenging aspect of designing on Mars as the settlers will have to adapt to not receiving direct sunlight and also to the different colours of the sky during daytime and twilight. Martian sunsets appear bluish to humans because of the fine dust in the atmosphere, which is quite disturbing to the human eye as it is a great contrast to what we are used to (NASA Science Editorial Team, 2019) (Fig.21). All these changes and differences will take time for the settlers to get used to and will probably take a few generations to become the norm (Hunter I., 2023).

Fig.20: AI SpaceFactory (2017) *MARSHA Habitat* [image], AI SpaceFactory, Secaucus, New Jersey

Fig.21: NASA (2005) *Sunset on Mars* [photograph], NASA, Washington

A key question which needs to be considered for the role of Interior Design: for whom are these habitats designed and made? This is where ergonomics becomes fundamental for the success of an interior through its impact on both mental health and well-being. It is known that “ergonomically designed furniture and equipment reduce the strain on the body, which can reduce stress and anxiety” (Corporate Wellness Magazine, date unknown). During Modernism, designers and architects based their designs on a universal system of a human subject. This was initiated by Le Corbusier’s Modulor Man (Fig.22), a six-foot tall person. He based all of his designs on this figure, from the level of a countertop to the height of a building, everything was proportioned (Scharmen, F. 2019). As Fred Scharmen explains, “in space – in architectural space, and in space architecture – everything that is designed will end up inviting certain people to use and occupy it, and (perhaps unintentionally) disinvite others” (Scharmen, F. 2019). This is a very interesting point as Interior Design will maybe have to adapt the Martian designs according to the occupants, therefore creating a more personalised habitat.

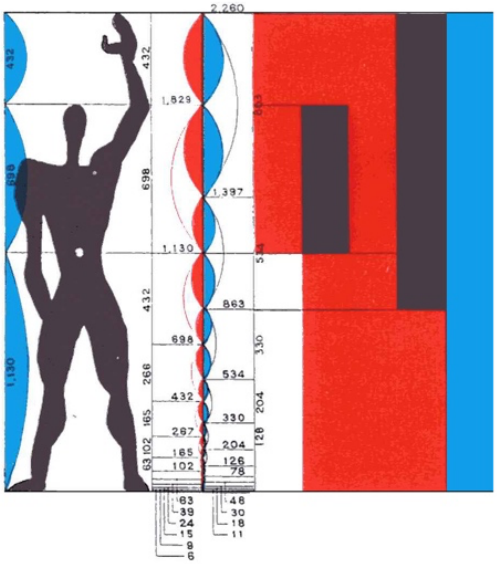

Fig.22: Le Corbusier (1945) *Modulor Man* [drawing], ICON Magazine, London

CHAPTER 3 – BENEFITS FOR EARTH

This final chapter will question and provide an insight into how technological advances in space architecture and design could benefit Earth. There could potentially affect the way in which we build and imagine our designs in terms of sustainability and well-being. Indeed designing for an inhospitable planet with very few available resources could teach us how to use only raw and unmanufactured materials. Design agencies are starting to propose new ways of building with a minimal carbon footprint and also a return to the use of ancestral materials and building methods. Ideas about how interior spaces and surroundings can influence and impact people's well-being and mental health are crucial on Mars but are also being considered more and more on Earth.

After learning to design habitats and sustain life on a completely new planet in such harsh and inhospitable environmental conditions, designing on Earth should seem like an easy task. Designing for Mars presents a huge opportunity to significantly improve the way we build and think generally. Having to "recycle our oxygen, recycle our water and reuse our waste to survive" on the Red Planet "might force us to solve those problems on Earth", explains 'Moving to Mars' exhibition curator Justin McGuirk to Dezeen. Furthermore, as discussed previously, AI SpaceFactory has developed a Martian habitat named MARSHA, greatly inspired by Le Corbusier's Modernist design principles. Following the design of this extra-terrestrial habitat, the agency has conceived an aesthetically identical home for Earth, TERA (Fig.23), designed with space-driven technology and requiring minimal material and equipment (AI SpaceFactory, 2019). TERA has already been built and is currently available to rent on a nightly basis in upstate New York, offering "a glimpse into the future of

sustainable life on and beyond our planet" (D'Angelo, M. 2019). This adaptation of a Martian habitat for the benefit of Earth is a good example of how technology developed for space exploration and digital fabrication can completely reshape the way designers and architects build. AI SpaceFactory aims to considerably reduce the amount of resources and materials brought in from elsewhere by using essentially what is available on site. TERA's exterior shell is 3D-printed using a biopolymer basalt composite, made from crops such as corn and sugar cane. This biopolymer has been tested and approved by NASA and is "50% stronger in compression and more resistant to freeze-thaw than concrete" (AI SpaceFactory, 2019). This Earth habitat "can be broken down, recycled and re-printed elsewhere without leaving any trace on the land it once inhabited" (D'Angelo, M. 2019).

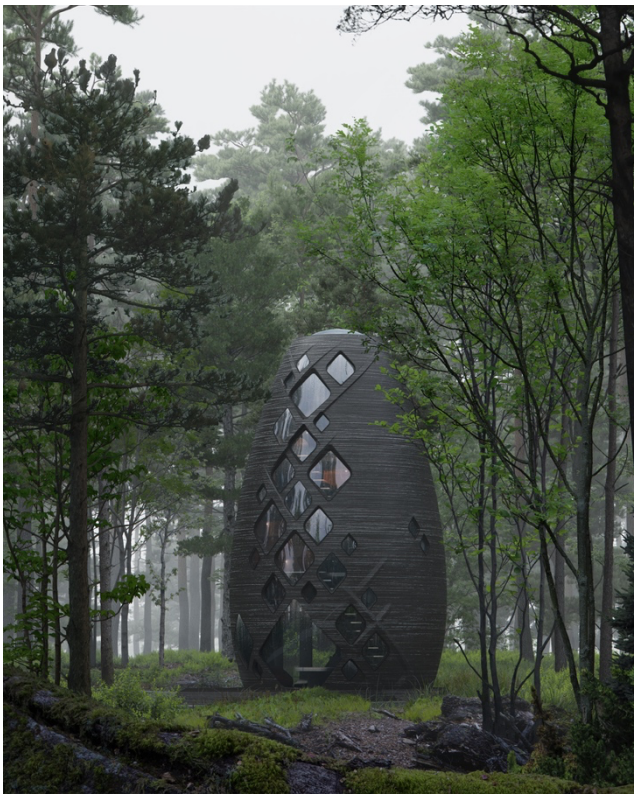

Fig.23: AI SpaceFactory (2019) *TERA Habitat* [photograph], AI SpaceFactory, Secaucus, New Jersey

Many studies have been carried out on how Interior Design can have affect mental health and general well-being. As an example, the use of curved lines has been proven to be more aesthetically pleasing and, “when compared to angular lines and shapes, induced higher positive emotions” on the inhabitants (Tawil,N.; Sztuka, I.M; Pohlmann, K.; Sudimac, S.; Kühn, S. 2021). This design principle has clearly been applied to the Martian habitat proposals analysed previously and to the TERA habitat thought out by AI SpaceFactory. As discussed, well-being is absolutely essential especially on Mars when the settlers will be travelling and living over fifty million kilometres away from Earth. Designing for Mars could help us have more consideration of the psychological aspect and well-being of living in a confined space and therefore the importance of Interior Design and its influence. One example of confined spaces which have a huge impact on mental health are prisons. The design of the Storstrøm Prison (Fig.24) in Denmark has been carefully elaborated to support the prisoners’ mental and physical well-being. While responding to the challenges of a high-security prison, “Storstrøm Prison is the setting for the world’s most humane and resocialising closed prison” (CF Møller Architects, 2010). CF Møller Architects’ approach was to create a building which resembled the surrounding area and blend into the landscape, integrating many green spaces to “keep the prison’s institutional atmosphere to a minimum” (CF Møller Architects, 2010).

Fig.24: Torben Eskerod (2017) *Storstrøm Prison* [photograph], CF Møller Architects, Denmark

Building habitats on the surface of a planet which does not offer nearly as many resources as Earth, and which will require sophisticated building techniques, could lead us to reconsider how we build on our own planet. AI SpaceFactory uses innovative resources and materials available on site for its TERA habitat, but there are other material options which have been used in past centuries and are still available today. The Design Museum currently features an exhibition named 'How to Build a Low-Carbon Home' (Fig.25) where different uses of materials, such as wood, stone and straw, are exhibited. The display suggests exploring ancient methods of building rather than constantly experimenting with new and innovative materials (The Design Museum, 2023). The exhibition seeks to educate the population "on the potential of […] three ancient low-carbon materials to address the UK's housing crisis while also meeting climate pledges" (Walsh, N-P. 2023). While habitats on Mars have been thought out to have a very minimal carbon footprint, unfortunately this is not always common practice on Earth. The exhibition's aim is to imagine "a future in which low-carbon construction is no longer a prize-winning exception but a mainstream reality" (The Design Museum, 2023). Embodied carbon in architecture includes "extraction, manufacture, transport, assembly, maintenance, replacement, and disposal of all materials that make up a building, […] these alone count for over nine percent of global carbon emissions" (Peirson, E. 2023). Building on Mars has taught us to use regolith in its raw form and directly on site, drastically reducing the carbon footprint of the construction process. This principle, combined with the robotics and technology developed for Martian construction, could be taken even further and applied to future building across the world and respond to housing crises and deteriorating climate conditions.

Fig.25: Felix Speller (2023) *'How to Build a Low-Carbon Home' exhibition* [photograph], The Design Museum, London

Although using ancestral materials can help reduce our carbon footprint, Earth still struggles greatly with gigantic quantities of plastic waste with "five billion metric tons of plastic waste on our planet" (Jiménez García, M. 2023). Solutions for repurposing this have been found thanks to Martian architecture and design which have led to an impressive development of digital fabrication and the use of robotic technology in building processes. These manufacturing improvements could benefit Earth in many ways in terms of material sustainability and "democratising production" (Jiménez García, M. 2023). Hassell Studio and Nagami, a multidisciplinary design agency, have collaborated on the design of a 3D-printed "ecological pavilion with a futuristic design" (Hassell Studio, 2023) (Fig.26). Nagami aims "to create a new reality through 3D printing" and uses this building method on medium to large scale projects (Jiménez García, M. 2020). This public pavilion, entirely made from recycled plastic, was designed in response to the global crisis of plastic waste and is "adapted to fit a variety of harsh climates and locales" (Emre, M. 2023). From snowfields to deserts, the concept is to "develop a succession of pavilions that stimulate debates about material waste and how technology might solve our planet's most pressing challenges" (Emre, M. 2023) (Fig.27 & 28).

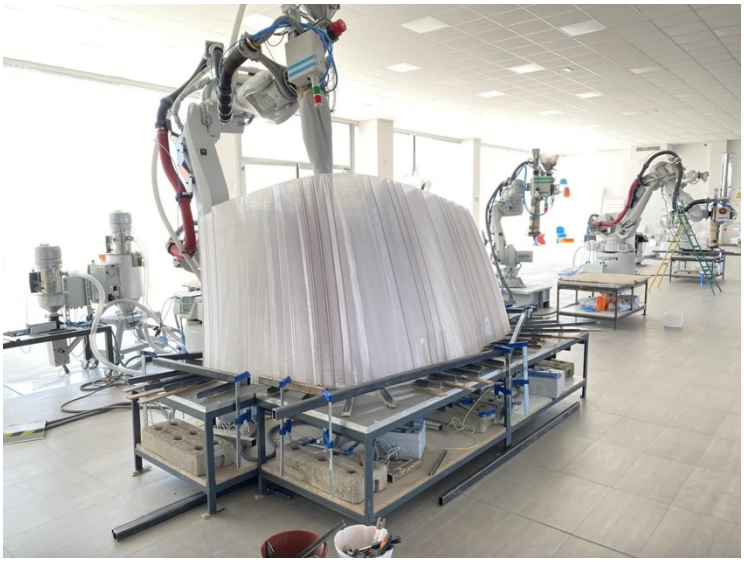

Fig.26: Hassell Studio and NAGAMI (2020) *3D printing of the pavilion* [photograph], Hassell Studio and NAGAMI, Avila, Spain

Fig.27: Hassell Studio and NAGAMI (2020) *3D-printed pavilion in the desert* [photograph], Hassell Studio and NAGAMI, Dakar, Senegal

Fig.28: Hassell Studio and NAGAMI (2020) *3D-printed pavilion in the snow* [photograph], Hassell Studio and NAGAMI, Gstaad, Switzerland

However other designers have different opinions on how inhabiting Mars could have a positive impact for Earth and, according to Ian Hunter, this will not necessarily be beneficial in terms of sustainability. “We already know what to do to help our planet but we are not doing it enough” (Hunter, I. 2023). If this is the case, then the debate is open as to what we can do to respond to the worsening climate conditions of Earth. Opinions and ideas also differ concerning the aesthetics of designing on Mars as new styles of habitats emerge from designing in a low gravity environment. This could influence building on Earth in terms of style and in the long term Martian biophilia could also make its way to Earth as this gradually becomes the norm for the population on the Red Planet (Hunter, I. 2023).

Likewise the architecture and interior design of habitats on Mars will obviously be influenced by what has already been achieved on Earth. Man has been building for thousands of years but we are still learning and adapting designs as humanity evolves. In her *Rebuilding Earth: Designing Ecoconscious Habitats for Humans*, architect Teresa Coady imagines new ways of building cities, homes and buildings for a constantly expanding population on Earth. She presents twelve principles of ‘Conscious Construction’ and strongly suggests designing for humans and life rather than machines. This statement completely contradicts the famous modernist principle of the house being a machine, as introduced by Le Corbusier (Coady, T. 2020). For Teresa Coady considering our natural environment is essential and she also suggests that architects and designers restore our instinctive connection to nature by moving away from built, unnatural environments (Coady, T. 2020). This could be from mimicking patterns and integrating materials from nature, as can be seen with the bamboo in Hassell Studio’s Martian habitat, or the creation of biophilic designs. Even if natural materials are not always available to us, another way of integrating nature is

to take inspiration from the natural arrangement of elements, better known as the Fibonacci sequence. This mathematical sequence relates to the Golden Ratio and is used to "create visually appealing proportions in art, architecture, and graphic design" (Cleveland, J. 2020). The Golden Ratio was already documented in Ancient Greece by Euclid and one of the most famous examples of its use is in the architecture of the Parthenon (Acropolis Greece, 2023) (Fig.29). This mathematical sequence, which determines harmonious proportions, is still used by architects and designers today and could one day be applied to habitats on Mars. Indeed one of the key elements of the role of Interior Design will be to create an aesthetically pleasing environment for the future settlers.

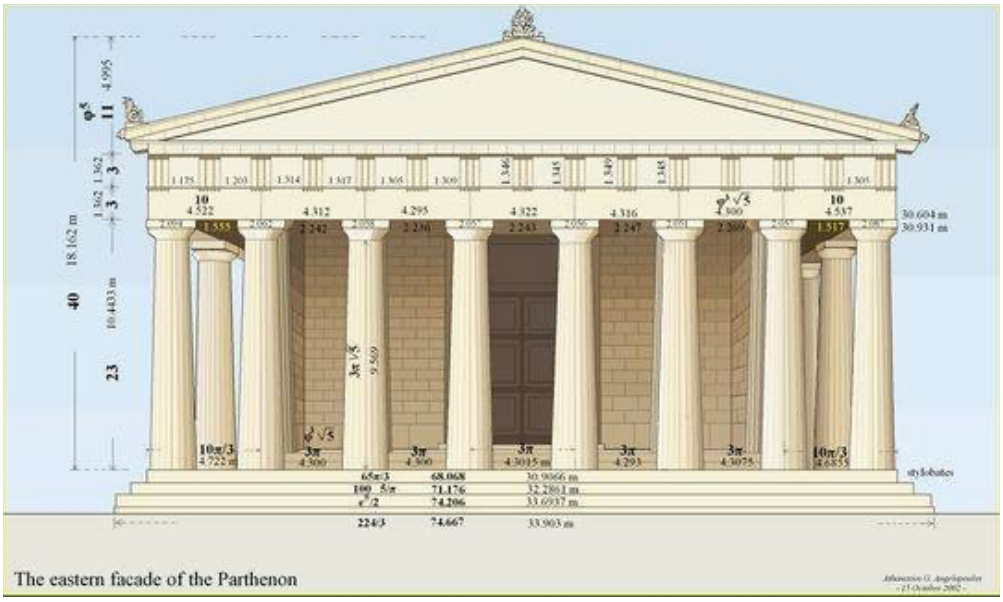

Fig.29: Quora (2018) *The Golden Ratio in the Parthenon* [drawing], Quora, Athens

CONCLUSION

In conclusion, design agencies and engineers have already addressed the majority of issues and challenges of moving to Mars and inhabiting the Red Planet. From both the psychological and technical aspect, responding to the population's needs and requirements is absolutely crucial to a successful settlement. This puts the role of Interior Design on the front line to create a sustainable, functional and desirable habitat. Once the design challenges on Mars have been overcome and settlers are ready to be sent there, other critical challenges will come to light such as territorial ones. How will Mars be divided up? Will it depend on which country manages to get there first? All these questions will soon arise and a new type of space race will rapidly emerge.

Urban design projects have already been publicly released such as Nüwa, developed by Abiboo as the first permanent city on the Red Planet. This Martian city is "conceived to be the future capital of Mars" (Munoz, A. 2021), and house up to 250,000 people. Will Mars become a mass-produced housing estate as imagined by Le Corbusier in the 1920s? Is the Red Planet intended as a second option for housing our constantly expanding population on Earth? If a quarter of a million people end up living on Mars in the next century, places of entertainment will have to be hugely expanded and able to accommodate so many people, while keeping them safe and sane. Designing for such a vast population will be a further challenge for Interior Design as more needs and requirements arise.

The journey to Mars takes on average seven months, so assuring the travellers' comfort and safety is essential. If 250,000 people are to travel to the Red Planet, spacecrafts will have to

be organised and arranged in the most optimal way possible in order to minimise the number of journeys. Interior designs from the 1960s by Galina Balashova and Raymond Loewy are still currently being used in the International Space Station, as they took into careful consideration the astronauts' physical and mental well-being. Soviet interior architect Balashova thought "about the human, and not the space itself" (Meuser, P. 2001) and American architect Raymond Loewy was the first to suggest adding a window to Skylab (Talvi, A. 2019). His carefully "considered treatment of the interior made Skylab the most comfortable spacecraft to date" (Talvi, A. 2019). Interior Design practice has and will have a decisive role in the success of spacecraft design, especially in such a confined and physically challenging environment.

In the generations to come, including those born on Mars, will humans eventually learn to adapt to the inhospitable environment of the Red Planet? How are we going to evolve and what will be the role of Interior Design in the distant future of space exploration? All these questions will be answered in time.

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Ian Hunter
I'm a, I'm a well, informed enthusiast. Yeah.

Emma Cochet
Yeah.

Ian Hunter
So I worked at Foster's when they did a project in the USA. So I didn't work on it, but a lot of my friends did. And I followed it. So I know that project quite well. Yeah. And I read a lot of science fiction. So it's something I think about quite a lot. So. Yeah, I know.

Emma Cochet
Yeah. And how do you think the materials can be used on Mars? How can they be adapted to the environmental conditions now? We need to completely rethink them or create new ones, like 3d printing?

Ian Hunter
I mean, yes, I'm a big believer in the idea that you're using what is available on Mars. And I think that's more of a consequence of the difficulty of delivering things to the planet. Not that they're not suitable. Yeah. And my sense is that a lot of the materials and products that we make will be similar. Analogues are influenced by what we know here. But there'll be produced from raw material source from space. Yeah. Exactly, exactly. But I mean, what what is regular, if it's just the same things, just different types of soil. And so it's not too different in terms of principle. But just like our industrial capacity is much lower at the moment. And that's the problem. And then we kind of have to start from the beginning. So I don't think we need to fundamentally change. But obviously, we have to design things to adapt to the lack of extreme conditions there. So of course, like, radiation defence, there's so much that we don't have to deal with on Earth. So this is like a new element for designers to think about.

Emma Cochet
No gravity. Exactly what gravity. Yeah, exactly.

Ian Hunter
Exactly. And so the principles are the same. But I think the output, it has to be different, right? Yeah, I think so.

Emma Cochet
Yeah. And they're working on projects on before starting on Mars, obviously, like the Mars Science City, in Dubai. And would you think that's possible? Is it?

Ian Hunter
I mean, it's, it's obviously, the necessary step of what we can, but of course, it's completely different conditions. I mean, I think it's probably more useful for testing humans than

materials. I think that's basically the value like how do people respond to being isolated, exactly in like in this country, with this group of people for six months or whatever? And I think that's, that's maybe what's a greater value to test? Yeah. But certainly, if we've got you, technologies and processes, say, like robotic forms of manufacturing, then we can develop those on earth and the principle is the same. And I suppose if we understand the property, something must have and we can like put numbers on an X, block, X amount of whatever X rays still test on us. So yeah, I don't I don't see why not. Yeah.

Emma Cochet
And so obviously, on Mars, everything should be zero waste as much as possible. Because on Mars, obviously, there's nothing on there. There's not nothing but much less resources than on Earth.

Ian Hunter
I challenge you on that. And I would say there's more resources on just to be provocative. A bit, to be honest. So Earth has, what 7 billion people pretty well developed. We're now reaching, you know, all of these environmental tipping points. For Mars, there'll be like, what, 100 people? And at the beginning, like, potentially limitless resources, when you're in space, do you also have easier access to like asteroids for mining as well through technology? And so I would be cautious about making too strong a statement that there's not nothing and I know, picking it but lots of think there's less diversity. And what there isn't on Mars, which is crucial birth is there's no renewable materials, everything there is infinite. Yeah. So I think I think that's the way to kind of understand it. But I mean, so I guess the question is, what the reason we don't want to harm the environment there. We just need a lot of stuff to sustain ourselves too, we don't want to make the planet uninhabitable go to a waste, blah, blah, blah. I think that there's also like the, like a psychological component, right? Like, we value nature and we value these, like, beautiful areas, and we love animals. But I think, you know, somewhere in the human spirit, it's changed. I think so. But then, you know, I don't think that is the case on Mars. Yeah. And so is it necessary to preserve the natural environment in the same way? And I think I think that's something worth exploring.

Emma Cochet
Yes for sure.

Ian Hunter
So on that front, some books, which I think you'll really enjoy, if you haven't read them already is the Mars trilogy. By Robinson. Let me Google his name. Kim Stanley Robinson, let me see.

Ian Hunter
I think it's Kim Stanley Robinson. And it's a three part sci fi book all about this very question. And it follows then from selecting people. Yeah, Kim Stanley Robinson. Because he gets quite a lot into like the technical issues of constructing on Mars, but also like, the very social and human things. And like one of the characters gets, like obsessed with the architectural quality of it. Because the first step is very functionalist, as we kind of think we would be, and he makes this argument that actually, you know, we need to have like any form of architecture to one, like, have an identity of being a motion, but to also just again, like,

there's a psychological need for like, comfort and beauty in these things. So I think it's quite an interesting, like non design or non technical exploration. So I can I can recommend that.

Emma Cochet
And I'm also looking at how designing on Mars can benefit Earth, so like in terms of materials and sustainability, so I saw that AI space factory, they did the marsha habitat for Mars, and from that they did habitats for Earth so do you think that designing on Mars is like the ultimate challenge for designers and engineers? And then, so going that step will help us design more sustainably?

Ian Hunter
I don't think so. To be honest, not necessarily. Yeah. I mean, for sure. How I can imagine it helping us on earth is that we will learn how to mine in space. Yeah. And therefore we then have access to unlimited mineral resources to be able to mine asteroids and things like this. thinking maybe increases the scaling ambition. I don't think like, we already know, this is the thing. Am I right? We already know what we need to do. Yeah. And we kind of already can do it. We don't. Yeah. And so I suppose the differences are mas were forced to it's maybe the fundamental difference, like no other way. But I, personally, I don't I don't think it'll have to they can influence me, maybe. I mean, they might you never know, like, there might be like a, like a stylistic thing develops as well. And there might be you know, this, like they seem it's gonna be quite exciting and glamorous. And we'll certainly observe what's happening there. And maybe if there is some kind of design language that emerges there, it might get replicated back on here.

Emma Cochet
In same like, looking environments or maybe in deserts.

Ian Hunter
Exactly. Doing it. Well, I suppose. Yes, it's two things. So I think one sense people will just like the aesthetic. And that could be anywhere. Yeah. And that's just like that, just like the cool factor. Yeah, but you're right, maybe then. I don't know. So to your original question, maybe then it allows us actually to build in these more hostile environments, like the desert could be the only way I would see how it could influence the designs on Earth. I mean, of course, there's going to be something but yeah, I still think Earth will be the driver.

Emma Cochet
But eventually, they might be population. Because they are already projects of building cities in the future I don't know if you saw this space hotel, planning to open in 2027. That's like, three years away.

Ian Hunter
Again, we can do, right? Yeah, we can we have a space hotel at the moment, you just have to be like a scientist to go there. So to do that, and I think there's something fundamentally different about being, like we talked about submarines, right? To be in this isolated submarine in space. And then living on the planet is like a fundamentally different one in terms of gravity. But then like you have resources to use and the responsibility for stewardship, as well, where it's like, a space hotel space station just has to be, it has to be

supported. So I can certainly at the moment, it's never going to be like independent, we'll just have to keep sending on the food. So I think that's, there's kind of two two things. And I think on Mars, it'll kind of maybe begin like that. And that's the plan, right? You send up a copy or we live inside of that. And then we start building. Even robots are building. Yeah, exactly. Yeah. Human human controls things. Yeah.

Emma Cochet
It is very, already very business oriented. So like, whoever goes there first, they're going to own it. I saw it was back in France, there was a champagne company. Yeah. I can't remember the name. They already designed, they designed a champagne bottle that you can drink in space. It won't spill. So they're aiming to be the first champagne company in space and on Mars?

Ian Hunter
I mean, I suppose. Again, just economically, the first people who get to enjoy space are going to be incredibly rich, right? So they probably already have the customers of these high end champagne brands. But yeah, it's a shame that this feels like first is going to make a new inequality.

Emma Cochet
Yeah, I think as well, because obviously not accessible to everyone. No. But then again, I suppose once it gets to the stage where we're building habitats, then we'll need workers. Yeah. So that's when ordinary people will get to go there. Like a contract. Yeah, cuz I was reading about that space hotel. And the CEO was saying, Oh, the whole point is to make space accessible to anyone. It's just a new holiday option. And then you research a bit more and it's like $3 million for three and a half-day stay?

Ian Hunter
Yeah. It's for nobody, right? That's the point. 1% But again, you know, I don't know what perspective. I mean, I don't I don't like it. But I can understand that. That's how these things start. They always start as a luxury. Yeah. And then it becomes more affordable. But that's what it takes them I suppose as well, just thinking about kind of how Mars will affect design. You said? Like still has, it has gravity, right? Not like the space hotel has no gravity unless they will take it up. Especially Mars has far less ? Like, I don't know, if you know that, like point six or something?

Emma Cochet
Right. Yeah, I think it's like 3.7

Ian Hunter
But it's perfect. So I was gonna say then. So does that affect the architecture in the way that we circulate around buildings in that actually, you could leap up or down from floors? A lot more. Because our abilities are different. The ability to run, you know, you can be like incredible. Yeah, like balancing run. So maybe actually, it could be more, more spacious. Because, one, that's kind of what happens if it takes less energy to do that. And three, there's just loads of space on your control. So certainly, first and again, that's, that's, you know, so the humans who've grown up on Earth will be like, they stupid, clumsy, but the

people born on Mars. Yeah, they're gonna, they're gonna be completely developed. And again, in this book, they talk about that. And they said, humans will be taller. Just like gravity crushes down. So like, earth, humans are like more strong and stocky, short and strong. But like most humans will be thin and tall, and kind of elegant in that sense, but like quite, quite weak and it also means that they would make you strong came to Earth, just something quite interesting physically disconnected from it. So there's something about that like hostile conditions, I find very interesting. Like ideas of comfort, as well. Right? How can you deal with that? Maybe not, maybe people have to like, the random water or something. So like, take some of your weight off? I don't know. Yeah. Yeah. And another thing I've always found interesting about this idea of taking regolith and use it to make other materials is that a lot of metal oxides, right. That's what a lot of the minerals are. In by processing, we asked oxygen byproducts, which is super helpful for even a few. So I love this idea of taking all of the byproducts from water as well. Exactly.

Emma Cochet
It's all out there. We just need like the energy to make it Yeah. It's true. True. Yeah. Like, aluminium is the most abundant mineral in our crust, so much of it? Yeah, it's really difficult to extract, it uses a lot of energy.

Ian Hunter
On the psychological effects, your well being I mean, you would assume that the principles of biophilia are going to be super, super important. And my assumption is that all of the things we know to do here to help people feel happier, better wellbeing, and more comfortable are going to apply there maybe even more you know, so like, well it's pretty funny, we do better if there's a connection to nature in some way, like it lowers our heart rate, reduces stress makes us makes us feel better, like the subjective experience. And so I think, especially on Mars, which is so disconnected from the natural world, that that's going to be even more important to generate these features. And so I think that's something interesting to explore.

Trees Yeah, find us now, right? Yeah, true. Like we are never really that far away from it, it's abundant here. It's like I say relatively cheap. Like this will be luxury on Mars. Yeah. And natural materials. Yeah. So to have like, wood in Mars is f* crazy. To have it on Earth. It's like it's the most basic thing, like any tribe could be building with wood. So I think there's something really quite interesting then about those, the luxury of natural.

Emma Cochet
Like back to basics. 100%. Yeah, exactly like the fundamentals.

Ian Hunter
And on the kind of biophilia thing as well. You always have to be careful not to be too literal about these things. So it doesn't only have to be like 360 things, it's like, by a couple of things. It's also just variety, diversity, and kind of like imperfection and a way to think like, like precious marble. This is a natural material with natural patterns and rhythms. It's not like the green organic stuff we miss or think about or Biophilia. But I think all of these things are important, relevant, or again even like a woodgrain and this I'm a huge believer in a book you might enjoy on this called joyful by a lady called Ingrid fettle, belief, f e t t e l n l ed

in Refectory joyful. And she speaks about the aesthetic qualities happiness and, you know, what is it we need in our physical environment and things that make us happy, make us feel good. And she talks a lot about these as series. So it's one thing she promotes this idea called the abundance aesthetic. It's kind of maximalism of lots of stuff. And she makes the argument that a lot of this comes from like evolutionary science, you know, the kind of the lizard brain within us. You imagine a hunter gatherer Ever. Yeah, living in the jungle or whatever? Where do you think you're going to find more prosperity like this will lack re barren landscape, or one with lots of colours, you know, flowers, flu. So this kind of like colours and brightness and variety sticks of life and kind of prosperity and like a bunch of ecosystem. And so therefore, it's argued that, you know, naturally we were more drawn to these kinds of environments. And actually, it's like, it's a cultural quality that makes us prefer minimalism, sophistication, refined things, but it's not like an instinct. It's like a learned thing. So I think there's something interesting in that, like, can you condition people like culturally, to desire or be happy? In a non, I suppose, like, biologically optimum environment? Or do we really lean into these, like instinctive qualities that we have, right? Yeah. And there's just all these ideas that modernism meet, like, colour and things like childish nonsense, but something that's kind of what we what we believe, right?

Emma Cochet
Yeah. Because obviously, you don't really want to get bored. Think about how you're seven months away from home. But like in French architecture, in the 18th century, they had on the walls mouldings in plaster, they were related to something that you liked. So you could have little animals or hunting scenes to create conversation about it. And we kind of lost it. You know, playing. Maybe that could be something that comes back to.

Ian Hunter
So I think that'd be great. Yeah, I mean, that sounds really sensible. Because again, I've gotten comfortable with it. It's very unnatural. Yeah, almost. Yeah. So therefore, maybe we need to really design in a lot more of that sense, deliberately, these kind of comforts and things. Yeah. And another sense that what you said made me think is we love to see the traces of human activity, you know, like the patina to things like walking like this. We really enjoy that. And again, there's something nice about activity, it tells us stories of the past, other people have been there, ultimately tells us we're not alone, right? Yeah. This is like a kind of fundamental a human needs is to be kind of loved and understood by others. Yeah. Tricky is like slippery stuff to deal with in design. But I mean, in Mars, it feels like, that's going to be probably the bigger challenge than the technical challenges seems to me. Yeah, I think that's certainly more, it feels less the role of the designer. Yeah, you know, I think Mars is so hostile, and challenging that really, it's like engineers and technicians who need to make things work. Yeah. No radiation, good temperatures, not good for them, and blah, blah, blah, blah, blah. But then once the engineers have given us the framework, the rules or the raw ingredients and extent of the designer, to actually make it a place we want to be framed as a species. So it shouldn't be like, you know, somebody mining colony, like miserable years ago, yeah. Exactly. So also exposure to the sky, right, you know, once you go to Mars, you're never gonna feel the air.

Emma Cochet
Yeah. It's a whole atmosphere that has to be created.

Ian Hunter
It's really interesting. Does a whole new aesthetic form. So again, we're talking about how you feel you can be first generation it gets there, it's really hostile and foreign and uncomfortable. Actually, those born there. They will be adapted to it, and maybe psychologically, too. So actually, it might take three generations, but maybe then the Martian landscape actually acts as their Biophilia in whatever the rhythms, patterns and colours, so it's going to be much more read much more oxidised and like less grief. It's amazing. So again, maybe maybe that then becomes these new kind of ideas and concepts of beauty. So we end up looking at the really long term picture, fascinating about how we adapt our environment to suit us, but how our environment also adapts us to suit a couple of generations. And surely, then, you know, if we're talking really in the future, there'll be some kind of like, genetic modification and things like that, that we can do to help us out.

What sort of timescale? Are you? Are you looking at?

Emma Cochet
I don't, I don't really have the timescale. I'm just looking at current projects that were being that had been presented at the Moving to Mars exhibition. And well also looking at space exploration.

Ian Hunter
Well, I suggest you look at what does it mean? Like tomorrow? Today? Right. Yeah. What's on the table? Now? I think some of the more interesting questions also come after further down the line. Once we solved a lot of the technical challenges we actually want to live Mars and what would be appropriate? I think it's maybe even more interesting. Because it's so so practical. Yeah. That's, that's certainly where I can tell you sci fi, that book. There's others like, really, the questions they asked, it's quite interesting. Because if you watch your character, like go through this, and how they feel like reading new motion times.

Emma Cochet
And I literally just started like, last week, yeah, but they get water delivered once a week. And so at the end of the week they don't have water left for their gardens, and there's a big river. So the main transportation is by boat, and there's a bus as well. It's funny, because they're like, Oh, we're going to fly. Us and that's a bit bonkers. Yeah. And the majority of the population is workers.

Ian Hunter
You know, what's the question? Do we just try and create more Earth? On Mars? Or is that the opportunity for a completely new way of of living? Like societally, technologically, when you've got to imagine the people who go there? Probably have more than that mindset. Imagine, to stay here, right? As you said, there'll be the commercial and economic agenda as well. But then the people actually go and live there, you'd assume they want something different. Yeah. What that is, I think is a good, a good question for you to explore as well.

Emma Cochet
So my title is How can interior design be used to inhabit the web?

Ian Hunter
You really do want to ask questions that good, good. So then it is it does seem to say I think it's and I'm really so I'd be looking at and talking about ideas of kind of collaboration with like technical experts. Yeah, get to us on this, we'll have to do a lot more than on Earth. This is important to you, but it's stuff that we can all quite conveniently understand. Certainly, at first it feels more specialist. And then I think it's, as you rightly said, this, I feel like maybe efficiency, material efficiency at first in the early days. And then I think the really big picture is huge. The huge questions of kind of comfort and what what do people want?

Emma Cochet
Yeah, responding to the need to also the big question of how to feed people. food and vegetables, anything? Yeah, exactly. I just saw a video of the European Space Agency, they just started making meat out of the cellular things for the Moon. Obviously, you could apply that to Mars as well. And maybe even because you would have enough meat on some regions you would be able to, like fabricate it it's also quite interesting, isn't it?

Ian Hunter
I mean, like, there's so bad, I feel like so if you look at what always is made from carbon, oxygen, most of nature's nitrogen. Exactly. It's like these for these four elements. They are the bulk of life. And then obviously, we have you know, the solubility, there's all these and surely those elements are abundant on Mars as well, right? It's just like learning the technological manipulation to be able to build them into whatever molecular structure meat is. Yeah, or cereals or whatever it might be. Yeah. And I suppose there's also like, this is my you know, creating indoor, if we can make indoor climates that are comfortable for humans, without having to waste space suits then equally surely we can do for plants. Yeah. We kind of like indoor farming right? And so again, maybe that is the kind of thing that then can feed back into Earth as well. Yeah. In terms of urban farmers in this kind of thing. Vertical farming. That could be something quite interesting. Yeah.

Ian Hunter
Whatever molecular structure meat is, or cereals or whatever it might be. Yeah. And I suppose there's also like, you know, creating indoor if we can make indoor climates that are comfortable for humans, without having to wear space suits then equally surely we can do for plants. Yeah. Yeah, we kind of like indoor farming, right. And so again, maybe that is the kind of thing that then can feed back into Earth as well. Yeah, in terms of urban farms and this kind of thing.

Emma Cochet
Vertical farming could be something quite interesting. Yeah, I saw what I saw at the Design Museum, it was to grow stack. They made some structure for you to grow plants with UV lights. So yeah, there are some solutions. It was a student from the RCA as well, that designs spacesuits nice are more comfortable to move around. Obviously, you don't want to I don't know how heavy it is and how comfortable you

Ian Hunter

think they're very heavy. But again, once you get to space, it's not new to you. It's only an issue on Earth to kind of become more more weightless right, I think the bulk is the problem, but they are so much better. I mean, if you look at the SpaceX suits now, compared to the you know, the NASA traditional suits, yeah, it's very different a world apart. So think in that sense, kind of like a materials and technology based solution as well. So again, the same amount of thermal insulation in all vapour and permeability, or whatever it might be, but in thinner more high performing materials. Yeah. Yeah, I think it seems that digital fabrication is like a really key thing, 3D printing but a lot more as well. So do you know CI in Zurich and have these guys they are amazing. So they are E T H Zurich. Or something. They're kind of at the bleeding edge of digital fabrications. Never spell these guys grunt Max, you're not too bad. Okay. These guys are f* unreal. Look into these brothers show you. How many pieces do we think they've done a lot of work with them? Like even just robotic bricklaying. So it's still very human material, the brick, they have a robotic arm laying the bricks, okay. Again, we can get new forms. So they kind of this like organic quality you just be so time consuming with the human but with the machine, it's it doesn't matter if it makes it strange. What makes it like this is all the same to the machine. So then there's, I mean, look at that. So it offers like new forms of working with traditional materials as well as digital fabrication. So you know, could there be so it doesn't also for 3d print? And is there such a 3d printer is not always that efficient? But slowly? So you know, is there a factory setup that makes bricks from regolith? Yeah, it's compressed sintered or whatever. And then you have another machine that then leaves them

Emma Cochet
BIG, they have a lot of diagrams and how to explain how they're going to be on it. So they're going to excavate the soil on Mars and make bricks out of it. And then mount it and mix it with just water I think 3d print shells. So the whole thinking about it. Yeah.

Yeah, I think I think I widen your understanding of what digital fabrication is I think it's because 3d prints are first thing I think, you know, there's so many more interesting ways as well they did another one where they had drones laying the bricks or they had another one where they had drones like getting fibres. So these guys are other interested Institute's who are like kind of at the bleeding edge of technology and architecture. And this was fabricated, not quite by drones, but similar idea where robots were just winding filaments. And again, it's like a whole different, different form of architecture. It feels like slightly organic and a bit spidery in a way. But still, it was very high tech and natural, you know this. And again, something like this is like super lightweight form of architecture, which actually struggles on earth because of gravity. There's those possibilities. find quite interesting. And then another one that's coming to mind is Christian Mendes. So this one, Yeah, so she does really interesting material experiments. This is the name of the moment, but found this one interesting. So she just had developed a technique for 3d printing with wool Oh, wow. And I think that's really fascinating. When you have this combination of the machine aesthetic, and then this very organic quality, just as a consequence of the material. Yeah, so again, does that is that like this middle ground, we were talking about? Where has this kind of like, aesthetic and comfort that kind of speaks to us this deeper level, but still, it could be like mass manufactured with robots and this kind of stuff. And as well, even the way she developed it, is she has this so this robot arm is the one doing the work, but she also has a

technique where she first can guide it. So she moves it was her hand, builds it, and then the robot repeats.

Emma Cochet
So it saves the movement and then repeats is.

Ian Hunter
so that's a way that we can bring in the human hand. Yeah, it's robotic construction. Yeah. And again, in your craft, when we were talking about this idea of like human traces, and things like, you know, we love the handmade, we love to see the fingerprint of the maker and there's like an emotional connection to us and makes our environment richer. And so I find it fascinating that, that she has this nice hybrid. So you can see kind of a designer on Earth, manipulating a robotic arm to make something. And then you could send the file and then the robotic arm copies it. Yeah, you're gonna think there's something lovely, lovely in that. And then again, it's like, what's it still authored by me? You know, you still sign on all these kind of questions. And I think there's something super, super interesting.

Emma Cochet
Yeah, it's beautiful.

Ian Hunter
So yeah, so I think I think there's a richness in that. Yeah. That's for you to explore. Yeah, yes. I think that, from this conversation, I think this this idea of natural as luxury, I think super, super interesting and the psychological dimension. Yeah. So again, I think therefore, you should also just study like basic questions of well being principles that we already know. This is like, the mind called exploration. Yes, this group is more environmentally. Interesting. So yeah, this guy, Michael Poland. He talks about paradigm shifts on Earth, which I think would be quite interesting. Then there's another one called Derek Clement let's say, building for humans, I mean, just double check. There's a number of books. Yeah, there's a lot of books on Well, yeah, yeah. And I think you know, you want to you want to kind of codify that. And what are the different ways of thinking and what are the criteria we trying to achieve to make healthy, comfortable places on earth? Yeah. Then what are the implications for that on Mars? What's a one to one parallel? In what is completely difference? And then what do you need to translate or modify in some way? Yeah, we all want to be apart so, you know, like, one example that springs to mind is the circadian rhythm. You know, the like, rhythm of the sun? Oh, yeah, you know, we need like, cold blue light in the morning wakes us up you need like warmer light at night like releases whatever the chemical is that makes you sleepy like blah, blah, blah, all this Yeah. So there's that right. But obviously that is just an analogue of the sun's rhythm. Yeah. But as far as I've seen the sun's rhythms. It's not too dissimilar 25 hour a day, isn't it? I think

Emma Cochet
I told you the sunset, it's blue. So it's very different !

Ian Hunter
So there we go. So, so therefore does that. So the principle of circadian rhythms still apply. But maybe it needs to be a different colour spectrum. And again, this is this is where I think

this question of different times. So maybe the first people who go they actually they just live on the Earth system? Yeah. And then over time, perhaps it slowly slowly adapt into the circadian rhythms and bars can be quite fun and cool. In terms of colour palettes, and like these themes, and there must be there must be lots of different examples.

Emma Cochet
Very interesting, would you go to Mars?

Ian Hunter
100% ago if it wasn't a one way journey? Yeah. I mean, think at the moment. It is a one way journey. Why not? Come back. Why not? Yeah, maybe dangerous site? 100%. Would be totally fascinating. Yeah.

Emma Cochet
Well, thank you so much. Yeah, thank you!

TEMPLATE FOR CONSENT FORM

Name of student: Emma Cochet
Department of Critical and Historical Studies, Kingston School of Art
Title of Study: *New habitats on Mars: How Interior Design be used to inhabit the Red Planet ?*

Please initial box

1	I confirm that I have had the project explained to me, and I have read the participant information sheet, which I may keep for my records.	IH
	I understand this will involve [*researcher to add/delete as appropriate prior to use*]:	
	• being interviewed by the researcher	IH
	• allowing the interview to be videotaped/audiotaped	IH
2	This information will be held by Kingston as data controller and processed for the following purpose(s)	
	• explicit consent (special category data) **GDPR Article 9(2)(a)**	IH
3	I understand that any information I provide is confidential, and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party. No identifiable personal data will be published. The identifiable data will not be shared with any other organisation.	IH
	I understand that I have given approval for my name and/or the name of my workplace to be used in the final report of the project, and future publications.	IH
4	I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way.	IH
5	I agree to Kingston recording and processing this information about me. I understand that this information will be used only for the purpose(s) set out in this statement and my consent is conditional on Kingston complying with its duties and obligations under the General Data Protection Regulation (GDPR).	IH
6.	I agree to the arrangements for data storage, archiving, sharing.	IH
7	I agree to the use of attributable quotes in publication.	IH
8	I agree to take part in the above study.	IH

Name of Participant	Signature	Date
Ian Hunter		29/11/2023

Name of Researcher	Signature	Date
Emma Cochet		21/11/2023

When completed, 1 copy for participant; 1 copy for researcher file.