The Impact Of Interior Design And Psychology On Creating A Suitable Long-Term Living Environment In Space

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April 2020

"Space: the final frontier. These are the voyages of the starship Enterprise. Its five-year mission: to explore strange new worlds. To seek out new life and new civilizations. To boldly go where no man has gone before!" - Captain James T. Kirk, Starship Enterprise, Stardate 1312.4 (the Space Review, n.d.)

Whereas this might sound like something far in the future, space exploration is happening as we speak. The International Space Station (ISS) has been continuously inhabited since November 2000. The longest continuous period by a single person thus far has been 340 days, by astronaut Scott Kelly, while his identical twin stayed down on Earth to observe differences in both physiology and psychology after Kelly's return to Earth (Howell, 2018). Orbiters and Explorers have been sent to Mars and beyond, to gather data and take pictures (NASA Mars, n.d.). Elon Musk plans to have people landing on Mars by 2024 (SpaceX, 2016).

This essay will explore the past, present, and future of space travel, and aims to explain the effects of long term off-world living on the human body and psyche, and the role proper interior design can play in mitigating the negative effects of space travel.

Space travel saw its first major milestones in the 1960s. Driven on by the Space Race between the United States and the Soviet Union, the first men were sent into Earth orbit, with the highlight being the US Moon landing in 1969. On both sides, the respective crew cabins were cramped.

For example, figure 1 shows an illustration of the interior of the first crewed spacecraft 'Vostok 1' in 1961. The cabin was almost spherical and had three small portholes. The interior was littered with buttons, switches, and cables. Underneath the cabin was the rocket, fuel supply, and other additional equipment (Khurana, 2018).

Another example is the 'Friendship 7' which was the American counterpart to the Vostok 1. Figure 2 shows how tight the astronaut 'couch' was. Because the spacecraft was so small, astronauts made the joke that *"you don't get in it, you put it on*". It was successfully launched into orbit in 1962 (Paone, 2017).

Lastly, figure 3 shows the interior of the Command Module of Apollo 11, which landed on the Moon. It demonstrates that there is hardly any room to stretch or manoeuvre around to conduct experiments. While this might be acceptable for short missions, it is not sufficient for long-term space flights. It is therefore surprising that the design of the crew cabin has not changed significantly over time (NASA Space Science Data Coordinated Archive, n.d.).

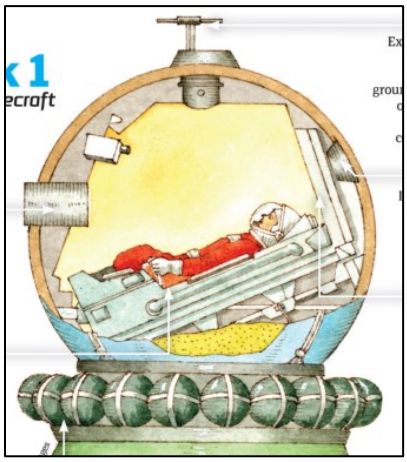

Figure 1 Khurana, 2018, *Inside Vostok 1,* [cropped online image]

Figure 2 Paone, 2017, '*Couch' Of The Friendship 7*, [online image]

Figure 3 Kluger, 2019, *Inside Apollo 11 Command Module*, [computer generated image of 3D scan]

After landing on the Moon, the next milestone is reaching Mars. Before we can get there, more studies need to be conducted on long-term off-world living. To reach Mars, and to potentially colonise it, new design typologies will be necessary. Water access, gravity, and radiation issues need to be addressed.

Spatial design challenges include, but are not limited to, a need for privacy as well as social spaces, and methods to prevent feelings of claustrophobia and isolation from Earth, loved ones, and the other crew members. Additionally, daylight, seasons, and temperature are decidedly different in space than on Earth, and a way must be found to make people feel at home in the severely hostile environment of space (Hoad, 2018).

One of the most challenging aspects of reaching Mars is the long travel time involved. During the optimal launch window, it would take nine months to arrive. Unfortunately, this launch window occurs only every 26 months, so longer travel times must be considered (Redd, 2017). When you cram groups of people into a small space for a long period of time, behavioural issues will occur, no matter how well trained the crew is. Perez (2016) describes common problems that can arise, such as depression, decline in cognition and morale, and interpersonal and/or cultural conflicts. Sleep disorders are also an issue because the natural circadian rhythm of humans is disrupted in space. For example, one Earth orbit only takes ninety minutes, meaning sunrise and sunset occur within those ninety minutes. That is substantially faster than the 24 hours it takes on Earth. Additionally, there are the noisy and the visually chaotic environment of the spacecraft, the lack of fresh food, a severe lack of privacy, and even boredom once the novelty of being in space wears out. As a result, these problems elevate the stress hormone levels of the crew, which can cause more psychological troubles, which can even lower the immune system (Perez, 2016). For an overview of these problems from the crew's perspective, please see a selection of anonymous crew journal entries in Appendix A.

So, what can we do about this? Kanaani & Kopec (2015: p242) argue that *"Environmental psychology should inform the manipulation of the elements and principles of architecture and interior design, to facilitate the intended function of the space and fulfil the emotional needs of the end user."* This means the answer lies in applying environmental design psychology knowledge to interior design choices. There are no clear guidelines yet how environmental design psychology should be implemented in space interior design specifically, but clues can be found in other areas, such as hospitals, schools, and offices.

For example, Costa et al. (2018) looked at the effects of interior colour choices on studying and mood. They found that students preferred a blue wall colour and white ceilings. These were associated with feelings of calm and serenity that students wanted in their residential spaces. In contrast, warm colours such as orange and red were disliked, presumably because red is often associated with danger and excitement. In addition, long-wave colour such as these can cause higher states of arousal than short-wave colours such as blue. This suggests that spaceship interior design should consider a cool

colour scheme for crew chambers and labs to promote relaxation and focus, and warmer colours for the exercise room to promote arousal.

One of the main objectives of the earlier space missions was to examine the effects of micro-gravity on the human body. The 1965 Gemini 5 mission, or *"eight days in a garbage can"*, as the crew liked to call it, provides us with some initial insights. Conrad, one of the astronauts, recalls it as *"the longest thing I ever had to do in my life."* (Evans, 2015a). The cramped interior of the spacecraft made it nearly impossible to get comfortable, it caused knee pains, and there were long periods of boredom due to experiments failing, but sleep was hard to come by nonetheless. There was no room for exercise or even stretching, and it was reportedly quite cold. When the astronauts eventually returned to Earth, their cabin was littered with rubbish and freeze-dried shrimp that had escaped their packaging earlier. Despite everything, NASA learned that the astronauts were physically back to their pre-flight selves mere days after returning to Earth (Evans, 2015b). Continuing on this overall successful flight, improvements were made for the following missions. Crew members were given sleeping bags, medication against space sickness, they were advised to bring a book against boredom, and the food delivery system was improved upon, in addition to the waste disposal system (NASA Space Science Data Coordinated Archive, n.d.).

Furthermore, to properly visualise the design requirements, it is important to understand *why* humans want to go deeper into space. Elon Musk (SpaceX, 2017) said *"Like the Apollo astronauts before them, these individuals will travel into space carrying the hopes and dreams of all humankind, driven by the universal human spirit of exploration."* People will generally accept a certain degree of uncomfortableness to get something they want. For example, if we refer back to the Gemini 5 mission, the astronauts knew it would not be a comfortable trip, yet they went anyway.

Cosmonaut Mikhail Kornienko, after spending a full year on the ISS, said that psychologists have to consider the point that people will miss the Earth as a whole. Not just obvious things like friends and family, but simple things like air and wind, and the luxury of showering. He goes on to explain that people can get used to a lot of things if necessary – like only cleaning yourself with a wet wipe – but that the hardest thing was a lack of greenery. He asked the ground crew to send pictures of nature on a resupply ship, *"just views of nature. […] I hung all of this around the module, so the flight would be more joyful. You grab onto it with your gaze, look at the little birch tree, and things get easier."* (National Geographic, 2016).

Prior to considering any long-term space flights, or even habitats on other planets, we need more data on what *exactly* those flights do to the human body and psyche. For this purpose, various analogue simulation experiments have been conducted here on Earth. Analogue missions are carried out to test

new technologies such as vehicles or habitats, highlight operational challenges, and to test human performance in extreme environments and stress. Testing locations include the desert, volcanoes, the arctic, underwater habitats, and low Earth orbit (NASA, n.d.).

For instance, the Mars-500 mission was an isolation experiment conducted by Russia, the European Space Agency (ESA), and China, from 2007 until 2011. The longest consecutive experiment conducted lasted for 520 days. The aim of the project was to observe man versus environment, and to gather data about the health and work performance of the crew in a small confined environment, simulating a flight to Mars, and problems that might arise during such a flight, like an extended duration, the high levels of autonomy required from the crew, Earth communication delay, and a limited amount of consumable resources. With this data, the researchers aimed to answer questions about whether or not such a flight would even be possible, both psychologically and physiologically, and set out to work on the requirements for a spacecraft that could make the trip to Mars (Mars500, n.d.). However, we must take into account that an emergency response crew was standing by at all times. If a crew member would get seriously ill or injured, or a severe accident would happen, they could be extracted immediately. The crew was never in any danger, unlike during a real space flight. This knowledge might have changed the behaviour of the crew, as it could have made them take risks they otherwise would not have (Mars500, n.d., Kanas & Manzey, 2008).

Similar to other human spaceflight missions, the crew was allowed to take some personal affects with them, and a selection of books, films, and other entertainment material. was provided. Communications to the outside happened via email, and communications to the 'control centre' had up to a twenty-minute delay built in, to simulate the delay experienced during a real interplanetary mission (ESA, n.d.).

Figure 4 ESA, 2010, *Interior of crew bedroom on Mars 500*

Each person only had a small private bedroom consisting of a narrow bed, a wardrobe, some shelves, and a desk (BBC, 2008). As you can see in Figure 4, it lacked inspiration. Diego Urbina, one of the crew members, said *"Art is a nice thing to have here because it gives some personal satisfaction and makes you feel 'more human'. […] I think you do need artists (real ones) in space. I'm not joking.*

Yeah, sure you need us engineers, doctors or scientists or you probably would be grounded, but I think ultimately it will be even more important to have painters and poets on Mars." (Urbina, 2011).

There was little variation for most rooms: wood panelling everywhere, complemented with the usual acoustic ceiling panels. Prioritising function over form for the ceiling makes sense if we consider ease of access to wiring and ducts, but this cannot be blindly applied to the crew quarters. Allowing the crew to personalise these before a long-term mission will do wonders to make them feel more at home. This does not need to extend to choosing detailed materials and finishes, but a simple 'would you like red or blue bedsheets' and 'how do you feel about this wall colour' would go a long way in creating a good multi-purpose personal space. After all, that is all the privacy the crew members might get for several months or even years!

In the spirit of personalisation, one must also consider cultural holidays. Religious or not, many people still celebrate the holidays. During the Mars-500 simulation mission, there was one Christmas, and half the crew wanted to celebrate. So, what did they do? They made a tree out of cardboard, printed a poster of a fireplace, and hung socks above it; they even used electrodes for make-shift Christmas lights! (ESA, n.d.). This shows that it is important to the crew to be able to take part in Earth celebrations. Some cargo space must therefore be allocated for holiday decorations.

How does this relate to my own work? Thus far, only in a theoretical fashion. Interior design for space travel is not a very well-established field as of yet, and no famous 'space interiors' exist in that sense. With the potential for longer travels and the impending space tourism, I think it is a very fascinating field to get into as soon as possible. Whether that be in a research capacity or actual design capacity is equally appealing to me.

To summarise, research has confirmed that all our environments affect us, both in space and on Earth, whether they were designed to or not. It is important to use this to our advantage for spaces where people will be isolated and confined for a long time. Admiration of something – architecture, design, or otherwise – can reduce adverse effects of mood disorders such as depression (Gunter et al., 2016). Consequently, we should give the crew something to admire, for example, by letting them customise their room.

One critical aspect in space is the lack of an Earthly day and night cycle to drive the internal clock of the crew members. Therefore, one of the most important design aspects will be the lighting scheme. There needs to be ample background lighting of the right (blue-dominant) colour during the simulated 'day' time, and reduced, more red-dominant light for the 'night' time. This needs to be supplemented by appropriate task- and emergency lighting (Kanas & Manzey, 2008).

More research is needed to be able to formulate proper human space ergonomics. Thus far, all ergonomic standards are based on the simple fact that there is gravity on Earth. When you are weightless in space, there is no need or even possibility to sit or lie down, so how can we make space travellers feel comfortable in that regard? Without gravity, there is no ‘up’ or ‘down’. This means that we as designers need to come up with an entirely new way of thinking about 3D space. How should we organize the space, how can we best use zoning, what kind of furniture can we come up with that works in zero gravity?

We will have to make certain our space travellers will not forget where they came from. We will need to design the long-term spacecraft in such a way that it prepares the travellers for an entirely new world that is nothing like our own, while still making them feel at home, and we must give them something they recognise and can take comfort in during their long journey.

Table of Figures

Bibliography

BBC (2008) Inside the Mars-500 “spaceship”, 3 March 2008. Available at http://news.bbc.co.uk/1/hi/sci/tech/7267689.stm [Accessed 19 March 2020].

Costa, M. et al. (2018) Interior Color and Psychological Functioning in a University Residence Hall, *Frontiers in Psychology.* [Online] Vol 9, 2018. Available at https://www.frontiersin.org/articles/10.3389/fpsyg.2018.01580/full [Accessed 11 March 2020]

ESA (n.d.) *Mars500: study overview*. [Online] Available at http://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Mars500/Mars500_study_overview [Accessed 18 March 2020].

ESA (n.d.) *Of emergencies and Christmas trees - an exciting end to 2010*. Available at http://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Mars500/Of_emergencies_and_Christmas_trees_-_an_exciting_end_to_2010 [Accessed 19 March 2020].

Evans, B. (2015a) *‘Eight Days in a Garbage Can’: 50 Years Since Gemini V (Part 1)*. *AmericaSpace*. [Online] Available at https://www.americaspace.com/2015/08/22/eight-days-in-a-garbage-can-the-mission-of-gemini-v-part-1/ [Accessed 6 March 2020].

Evans, B. (2015b) *‘Eight Days in a Garbage Can’: 50 Years Since Gemini V (Part 2)*. *AmericaSpace*. [Online] Available at https://www.americaspace.com/2015/08/23/eight-days-in-a-garbage-can-50-years-since-gemini-v-part-2/ [Accessed 6 March 2020].

Gunter, C. *et al.* (2016) *Space Arbors HESTIA*. [Online] Available at https://www.nasa.gov/sites/default/files/atoms/files/uofa_tree_design.pdf [Accessed 19 March 2020].

Hoad, L., Erlandson, T. A. and Mulyani, V. (2018) *Mars: Design for the Red Planet*, Interiors. [Online] 9(1), pp. 30–41. Available at https://www.tandfonline.com/doi/full/10.1080/20419112.2018.1485382 [Accessed 20 February 2020]

Howell, E. (2018) *International Space Station: Facts, History & Tracking* [Online] . Available at https://www.space.com/16748-international-space-station.html [Accessed 15 March 2020].

Kanaani, M. and Kopec, D. (2015) *The Routledge Companion for Architecture Design and Practice: Established and Emerging Trends*. London, UNITED KINGDOM: Routledge. Available at

http://ebookcentral.proquest.com/lib/herts/detail.action?docID=4185899 [Accessed 11 March 2020].

Kanas, N. and Manzey, D. (2008) *Space Psychology and Psychiatry*. [ebook] Dordrecht: Springer Netherlands. Available at http://link.springer.com/10.1007/978-1-4020-6770-9. [Accessed 21 February 2020]

Khurana, S. (2018) *VOSTOK 1 : FIRST MANNED SPACEFLIGHT IN HISTORY*. [Online] Available at https://medium.com/@sukantkhurana/vostok-1-first-manned-spaceflight-in-history-f19849d21649 [Accessed 5 March 2020].

Mars500 (n.d.) *«Mars-500» project*. [Online] Available at http://mars500.imbp.ru/en/index_e.html [Accessed 18 March 2020].

NASA (n.d.) *Analog Missions and Field Tests*. [Online] Available at https://www.nasa.gov/pdf/541196main_AnalogFactSheet.pdf [Accessed 18 March 2020].

NASA (n.d.) *NASA Space Science Data Coordinated Archive*. [Online] Available at https://nssdc.gsfc.nasa.gov/nmc/spacecraft/ [Accessed 29 March 2020].

NASA (n.d.) *NASA Space Science Data Coordinated Archive - Apollo 8*. [Online] Available at https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1968-118A [Accessed 9 March 2020].

NASA Mars (n.d.) *Mars Exploration Rovers*. [Online] Available at https://mars.nasa.gov/mer/ [Accessed 15 March 2020].

National Geographic (2016) *What Did This Cosmonaut Miss About Earth After a Year in Space?* [Online] Available at https://video.nationalgeographic.com/video/magazine/00000157-ba08-da6d-a7ff-ffb98cd70000 [Accessed 21 February 2020].

Paone, T. (2017) *Getting A Closer Look at the Mercury Friendship 7 Spacecraft*, National Air and Space Museum. [Online] Available at https://airandspace.si.edu/stories/editorial/getting-closer-look-mercury-friendship-7-spacecraft [Accessed 5 March 2020].

Perez, J. (2016) *The Human Body in Space*. [Online] Available at http://www.nasa.gov/hrp/bodyinspace [Accessed 15 March 2020].

Redd, N. T. (2017) *How Long Does It Take to Get to Mars?*, [Online] Available at https://www.space.com/24701-how-long-does-it-take-to-get-to-mars.html [Accessed 15 March 2020].

Shanklin, E. (2017) *SpaceX to Send Privately Crewed Dragon Spacecraft Beyond the Moon Next Year*, SpaceX. [Online] Available at https://www.spacex.com/news/2017/02/27/spacex-send-privately-crewed-dragon-spacecraft-beyond-moon-next-year [Accessed 16 March 2020].

SpaceX (2016) *Mars*. SpaceX. [Online] Available at https://www.spacex.com/mars [Accessed 15 March 2020].

Stuster, J. (2010) Behavioral Issues Associated with Long- Duration Space Expeditions: Review and Analysis of Astronaut Journals Experiment 01-E104 (Journals): Final Report. [Online] Available at https://lsda.jsc.nasa.gov/lsda_data/dataset_inv_data/ILSRA_2001_104__1740256372_.pdf_Expedition_8_ILSRA-2001-104_2011_31_010100.pdf [Accessed 15 March 2020]

The Space Review: Boldly going: Star Trek and spaceflight (n.d.). [Online] Available at https://www.thespacereview.com/article/506/1 [Accessed 15 March 2020].

Urbina, D. (2011) *Mars500: Earth approaching!* [Online] Available at http://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Mars500/Mars500_Earth_approaching [Accessed 19 March 2020].

Appendix A – Anonymous Crew Journal Entries (Stuster, 2010)

"Suddenly I'm really appreciating the solitude that I have here. It does help to have control of your own environment if you're going to be isolated. I'm trying to picture what it would be like up here with a crew of 6. It would be totally, completely, absolutely different. It would be more fun at times, and there would be more camaraderie. That would be positive. But, the entire US segment is the equivalent of my house right now and sharing it would be huge difference. We are very lucky to be here a time when the Station is so huge, yet there are only 3 of us to share it. This is quite a luxury!"

"I still think that the ideal space station mission length (for me) would be three months. It would be a different story if we were going somewhere (moon/mars)!"

"There's only room for two at the table, so three of us just float and juggle our food. I'm not sure what the idea is for when we have six of us up here."

*"After a week here, I notice the noise on the ISS. It is markedly louder in the SM, where I wear ear plugs all the time. In the USOS, it is quieter, but still loud near the aft end of the lab. Fortunately, inside the TESS is very quiet. In the USOS, I generally wear ear plugs too, but I do give my ears stretches without. Wearing ear plugs constantly irritates the ears, so some breaks are necessary.***"**

*"I will mention a relatively minor thing that is starting to become an irritant. That is the highpitched loud noise that comes from the ___ rack. I'm pretty sure it is the ___ pump and it is way too loud. One of the environmental things I miss the most is quiet—complete silence. Unfortunately my primary work place is right in front of it because of its proximity to the ___ panel and the laptop I use most.***"**

"During the day, the Service Module feels like a steam bath. Usually there are 4 or more people in there, and the systems are just not keeping up to maintain temperature, humidity, and CO2 under control. As I fly through the Station and enter the SM, it feels like running into a blanket of muggy stale air. I am very glad that my work is generally elsewhere."

*“I always knew that this could happen [another solar flare] and it is a little disconcerting. However, there is nothing we can do about it. If we had been on a mission to the Moon or Mars, we would have taken the full brunt of the radiation. That is a problem for which we don’t have a good solution as of yet.**“***

“Since I haven’t been sleeping bag I decided to preemptively move my sleeping bag elsewhere where it might be cooler. I chose my familiar home of the airlock, but slept poorly there anyway.”

“Healthwise I’m feeling fine—occasionally I’ve had headaches brought on by CO2.”