# Life in the Outpost: Applying Work-life Research to Interplanetary Habitation

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Interplanetary habitation brings alien constraints that may be detrimental to humans. Non-terrestrial bodies, such as Mars, are not naturally suited for well-being. They offer unbreathable air, temperature extremes, rocky terrain, and undeveloped resources. While these physical constraints are important, the success of habitation on Mars also rests in the healthy work-life of its crew and citizens. This paper argues that planning for work-life on Mars is important and can benefit from research about well-being in terrestrial jobs. The expected issues to overcome on Mars, such as isolation, communication latency, and interpersonal boundaries are well-studied. We explain how this existing research can be modified from an Earth to Mars context. Finally, we articulate two challenges that, when solved, stand to benefit work-life issues on both Earth and Mars.

Additional Key Words and Phrases: work-life, isolation, mixed-initiative tasks

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## 1 INTRODUCTION

Interplanetary habitation introduces alien constraints that may be detrimental to humans. Non-terrestrial bodies, such as Mars, are not naturally suited for well-being. They offer unbreathable air, temperature extremes, rocky terrain, and undeveloped resources. Non-earth environments are expensive and dangerous. While physical constraints are important, the success of habitation on Mars also rests in the healthy work-life of its crew and citizens.

Researchers have used analogous contexts to study work-life in space. Kitmanyen et al. developed close-quarters environments to simulate non-earth crew deployment [6]. The Mars 500 project [2] simulated the isolation and tasks of a Mars trip and mission with 6 crew. Stuster compares the long confined conditions of spacecraft to sailing ships marooned by polar ice caps [12]. While the physical locations of these research projects were terrestrial, the experiences of crew approximate aspects of those expected for space travel and habitation. This is important because the nature of the human condition remains constant across contexts. As Stuster [12] phrases it, this creates "highly predictable behavioral responses to isolation and confinement."

The expected issues to overcome on Mars, such as isolation, communication latency, and interpersonal boundaries would also benefit people on Earth. In this paper, we explain how existing research can be modified from an Earth to Mars context. Finally, we articulate two challenges that, when solved, stand to benefit work-life for Earth and on Mars.

## 2 WORK-LIFE FOR MARTIANS

Our discussion is grounded in a period of time in which people have inhabited Mars in clusters of self-sufficient teams we call *hubs*, scattered across the Martian surface. Each hub serves an outpost designed to house 1 to 30 people. Early structures would be cramped and spartan. Early inhabitants would be scientists, engineers, and specialists working together to construct and connect habitation supporting structures. With the dangers of outside air, we anticipate that crew would spend most, if not all, of their time in hubs. Like spacewalks on the ISS, walks on the Martian surface would be rare and motivated by necessity rather than pleasure.

Most of the inhabitants tasks on Mars would be performed from hubs. From a hub, operators would be enabled to command, control, and utilize a fleet of cheap rovers and drones for every-day work. Crew would be responsible for tasks such as setting up solar panels, digging trenches, constructing farms, readying and surveying land for incoming modules flown from earth, and exploring the Martian surface. Supporting robotics would have AI and mitigate the need for physical human effort. However, most decisions and details would be managed by crew.

Over time, we anticipate that these hubs would form a network of small communities. On Earth, rural communities form densely connected social networks [5]. In the same way, we expect that clusters of inhabitants would need to rely on each other for mutual benefit. Unlike communication from Mars to Earth, the latency from hub to hub would be similar to those found in terrestrial computer networks.

### 2.1 Isolation

Like the Mars 500 crew, Martians would likely suffer from feelings of isolation from their family and friends on Earth. Crew from the Mars 500 had felt isolated from family and friends as the latency in communication increased [2]. This homesickness caused and exacerbated lethargy. In addition, we imagine a majority of work on Mars would be performed from hubs. Rovers controlled from low-latency robotics [4] could assist in construction, drilling for samples, photography, or scientific pursuits dictated from Mission Control. Ordinary solutions to enhance well-being, such as taking walks and changing physical surroundings, would be costly.

Physical contact is an important part of well-being. During COVID-19 on Earth, this physical contact has been largely removed because people working from home face similar isolation. New research has shown workers miss the water cooler talk they once had [3, 13]. COVID-19 has brought with it a transformation in jobs, pushing the ubiquity of remote work further than ever before [1]. Recent studies have shown that the rapid shift to working from home has left information workers feeling more socially isolated from coworkers [13]. While the communication to earth will face high latency, the community of hubs will have an internet that connects them together. At this speed, Martians in pods will have the opportunity to collaborate and socialize with video chat and VR applications.

### 2.2 Communication Latency

Because Mars is so far from Earth, a one-way radio transmission can take up to 22 minutes. Even if one assumes a low error rate and high bandwidth, this creates a technological limitation that makes everyday communication between Earth and Mars difficult. To send and receive an acknowledgement would take 44 minutes. This makes mission critical decisions that should happen on Earth progress stopping events. Current Space Station research can provide low-latency guidance from Mission Control that relies on hierarchies of information and specialists. This can create a coordination style where scientists on Earth instruct and "drive" crew directly. Instead, crew on Mars will require more independence

from Mission Control. ISS crew have routinely used low-latency robotics to accomplish tasks where a high latency context would make these actions impossible [4].

Advances in mixed-initiative activity management [11] may also help crew members manage their time in a fulfilling fashion. Planners from Mission Control would likely be tasked with generating pools of potential tasks to accomplish analogous to crowdsourcing marketplaces in which tasks of limited quantity can be acquired and completed [15]. The perception of autonomy plays a key role in work-related happiness and satisfaction, and The perception of autonomy mitigates contemporary issues in the future of work (e.g., low compensation, lack of benefits). Workers could, in this context, accept jobs in bulk, later performing them throughout a work day much as a crowdworker does on Earth.

### 2.3 Interpersonal Boundaries

While isolation from home risks loneliness, the close quarters and long hours can foster monotony and conflict. The Mars 500 project simulated a trip to Mars and back by isolating a crew of six people [2]. Experimenters simulated latency in communication and monitored the health of participants. Overall, the crew tended to avoid conflict with each other instead of addressing interpersonal issues directly. As the mission progressed, isolation led to more frequent confrontation between the crew and Mission Control.

Work-life balance literature has explored various strategies for individual management of boundaries that provide friction and distance between work and life [8]. Creating boundaries can be accomplished by adding physical distance between work and life, setting chronological bounds on time blocks, and setting explicit expectations. However, creating physical distance from crew may be difficult in a hub. We suggest creating a time window where the privacy of crew would be better respected. Alternatives also include creating interactive systems that systematize the process of easing in and out of work and personal spheres [14]. This process of ramping up and down from work is an essential component of well-being. Workplace moods impact well-being and working with too much attention can lead to burnout [9]. Augmented and Virtual reality may also play a role in creating alternative spaces, allowing people to visit terrestrial locations in virtual space in the same way that many video games facilitate the same extraterrestrial experiences today.

Unlike missions with short stints, many of the first inhabitants on Mars will not expect to return. After a stint of hundreds of days, the crew of the Mars 500 may have grown tired of listening to Mission Control [2], causing them to act more independently and to ignore direction. Drawing from diary's from polar crews, Stuster describes how confined groups confronted with difficulty predictably become stressed and suffer behavior consequences [12]. He quotes a diary stating, "If we could only get away from each other for a few hours at a time we might... take a fresh interest in our comrades." The same VR commutes might help provide windows of time where crew can spend time away from each other. During quarantine from the COVID-19 pandemic, people with VR Headsets gathered in virtual rooms to frequent familiar "rooms" in pseudo physical ways [10]. We see this as a likely social activity that would strengthen the Martian community of hubs.

## 3 CHALLENGES AND CONCLUSION

We present two challenges that, if addressed, would promote well-being for workers on Earth and Mars.

### 3.1 Enabling Social Atmospheres for Work and Life

*Create digital analogs to water coolers.* People need informal spaces that facilitate human-to-human interaction. This is true in both low and high latency situation. When working across time zones and high latency, it is still important to build personal rapport [7]. Research should study both contexts in order to facilitate social connections with work crew.

### 3.2 Supporting Mixed-Initiative Task Management for Work and Life

*Design systems that balance assigning tasks and personal autonomy in large-latency contexts.* Provide autonomy to workers on the ground. Work-life management research should include paradigms that give workers autonomy in activity selection. Additionally, the things people do for their own well-being also impacts their performance at work. When the job is to live on Mars, well-being is especially important because the crew cannot simply return to Earth.

### 3.3 Summary

While Mars is an alien environment, its inhabitants will bring human issues and concerns. We argue that researchers should look to analogies to prepare for Martian habitation. We grounded our position in a hypothetical context motivated by modern reflections of Martian life. We concluded with a brief discussion of two challenges that would address terrestrial work-life issues and eventual needs of humans as we enter the frontier of extraterrestrial human-centered space exploration.

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