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02

Conceptual Innovations in Healthcare Design:

Therapeutic Community as a Translational Laboratory

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Abstract

This investigation was conducted for a conceptual design competition, specifically focusing on the design of a therapeutic community for space travel. The competition encouraged innovation by asking participants to solve challenges anticipated in the future delivery of healthcare without the usual restrictions tied to budget, schedule, and codes. This research focused on Translational Medicine, or “bench to bedside,” which is an important frontier in healthcare applications. This approach in medicine relies on the use of new knowledge obtained in clinical practice to scientific research in the laboratory. The research raised questions about how Translational Medicine might drive innovation in healthcare design, especially with respect to emotional well-being and behavioral health. If we conceived a research and healthcare environment as a “therapeutic community,” how would this approach impact the program and spatial adjacencies? What if the community lived where it conducts its research? How might the spaces be designed to allow for resilience in response to “disturbances” in the community, be they biological (e.g., outbreak), social (e.g., conflict), or behavioral (e.g., depression)?

Our research drew knowledge from literature reviews, interviews with healthcare experts on best practices in behavioral health design, research on viral behavior and human health in space flight; and principles of lab productivity and biophilic design. We ultimately applied our research to the conceptual design of an interplanetary vehicle, Vooster Lab, intended to host a “therapeutic community” for the three-year trip to Mars in 2035.

Keywords: *translational medicine, healthcare design, wellness environments, innovation, behavioral health, interdisciplinary program*

1.0 Introduction

The healthcare industry is complex and complicated. Between regulations in policy, codes and standards, healthcare reimbursements, clinical applications, operations and delivery to research and discovery, technical advancements for treatment and much more, it can all be overwhelming to comprehend. But, as all of this advances at such a rapid pace, Healthcare Design magazine framed the following questions in the form of a conceptual design competition called Breaking Through: 1) what are the frontiers of healthcare innovation, and 2) where do scientific innovations intersect with innovation in healthcare design?

As our own planet becomes more hostile to human life and interplanetary migration becomes more probable, our team decided to investigate the healthcare design applications of extraordinary environments. Translational medicine—that is, the “translation” of laboratory, clinical, or population research into implementable clinical tools to improve health outcomes—provided the most powerful and provocative avenue for thinking through the possibilities of a cohesive organization of spaces. When we discovered early in our research that viruses can be reawakened in space flight, changing their behavior, as humans do, under duress, we found the driver for designing a program where viral and human responses to stress could be observed and treated in a single dynamic environment. As we researched further, the initial impetus to take make the interplanetary vessel an experiment extended the meaning of translational medicine into a program where collection, study, collaboration, education, personal health, social activity, collective endeavor, and communal safety can take place in the absence of the crucial sensory aspects of human need.[1]

2.0 Conceptual Approach and Literature Review

For this conceptual design competition, the team started with brainstorming possible ideas to explore and investigate. Of the many ideas discussed, we narrowed down our investigation to two scenarios that respond to extreme conditions: 1) diagnostic and treatment environments under global-pandemic social constraints, and 2) the simultaneous study of human and viral behavior under extreme stress. We then committed to researching and developing the conceptual design of a small-team research environment for the second scenario. We could simulate physical and emotional distress through selective sensory deprivation in a Rubik's Cube–like revolving configuration of program and plan. Human and viral response to these extreme conditions could then be observed and adaptive behaviors tested.

We conducted an extensive literature review, performed interviews with health experts in the behavioral health field, and considered design scenarios that would inform the program for the conceptual design of an interplanetary vehicle, Vooster Lab, intended to host a "therapeutic community." Our research followed four lines of inquiry as the design developed: the physiological (1) and mental (2) health hazards of space flight, the technology for generating resources (3) to support Earth-native organisms in space, and the lab and workplace considerations (4) for translational research. American astronaut Scott Kelly's autobiographical testimony about enduring and recovering from his extended space flight (11 months) informed our research into artificial gravity and cosmic-radiation shields. Studying the regenerative support systems on the International Space Station guided our research into producing water and oxygen through Sebatier reactors and electrolysis. NASA documentation of Scott Kelly's experience and conditions on the International Space Station led us into the potential applications for behavioral health on Earth of behavioral health under the hostile conditions of space flight. We consulted designers with expertise in behavioral health facilities about how the architecture supports reintegration into social settings and looked at strategies employed by innovative facilities such as the Behavioral Sciences Center in Houston. Once the decision was made to create three kinds of environments and separate the living and research environments, we drew on the work of NASA's Translational Research Institute for Space Health (TRISH) to understand how the application of scientific findings in the Testing (research) Environment to the Sensory (living) Environment as well as institutions and facilities on Earth.

We had launched our design process by allowing the limited space and scale considerations to drive the research. However, our research into behavioral health environments quickly led us to shift our drivers from design constraints to the health impacts of program and plan configuration. Our interviews with healthcare experts led us to reconsider the scale of our proposed environment, especially how the scale reflects the relationship between individual well-being and collective adaptation. Our approach applied innovative principles in lab productivity and biophilic design to pivotal considerations for behavioral health environments to achieve the benefits of a "therapeutic community" under conditions of extreme duress.

3.0 Addressing the Conceptual Design Challenge

The competition required us to address the specific challenges anticipated in the future delivery of healthcare, who would be affected, what will emerge in future healthcare environments, and why there is a need to explore new opportunities.

Research into this subject led the team to believe that interplanetary migration is no longer a far-fetched fantasy. It is increasingly within the realm of probability. New environments, in the form of other planets as well as the vessels that transport humans between planets, will necessarily introduce new pathogens. They will also cause existing pathogens to behave differently. Similarly, these new environments will elicit new behavioral and mental-health phenomena.

Scientists and health researchers need to be able to conduct studies and experiments in situ outside Earth's atmosphere on the factors that affect human health outside Earth's atmosphere. Until human life on another planet is a sustained reality, that built environment will to a large extent be the space shuttles and stations that transport humans to and from Earth. Existing shuttle and station design has limited capacity to grow and manipulate organic matter, much less the most swiftly moving targets of study (e.g., viruses and mental health). In addition, its utilitarian focus—however sophisticated and efficient relative to function—deprives humans of the sensory stimuli they need for psychological well-being.

The designs of interplanetary vessels need to be as adaptable and resilient as the environments we are only now beginning to design for climate change and global health emergencies on Earth. When they are, they will provide testing grounds for the healthcare advances needed for life on other planets, life in space, and the life that continues on our planet of origin.

4.0 Vooster Lab: Studying Humans and Viruses in Spaceflight

Our Breaking Through entry considered NASA's plans for a 3-year trip to Mars by 2035 and created a concept for an interplanetary vessel for the joint study of highly mutable disease and psychological resilience on a mission that nearly triples the longest flight any human has made to date.[2] The Vooster Lab concept was initially envisioned as a revolving configuration of plan and program to support a handful of "Environeers" as they make scientific observations and are themselves subject to observation while living in an environment largely absent the sensory aspects of human need.

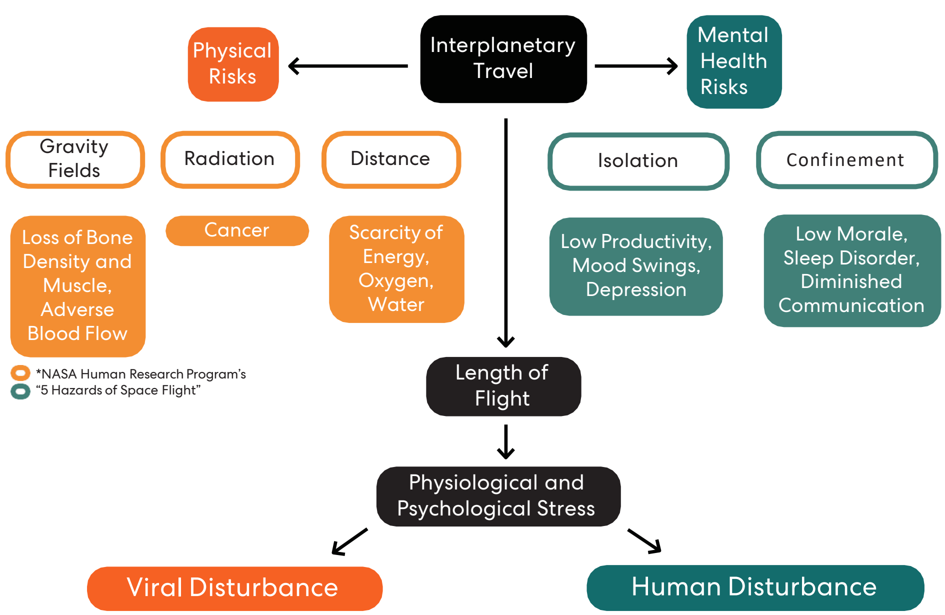

Figure 1: *Understanding viral and human behavior in response to stress in interplanetary travel.*

Because viruses, like humans, alter their behavior under extreme and prolonged stress, the combination of viruses and humans suggested itself as a specific application for Vooster Lab.[3] The intent was three-fold: 1) to discover extraterrestrial viruses and mental-health phenomena; 2) to understand the impact of space travel on viruses and disorders that originate on Earth; and 3) to pursue applications of psychological resilience in space for the treatment of trauma and stress on Earth.

From our interviews and literature reviews, we redirected our conceptual design to address two considerations. First, a psychological or emotional disturbance is better healed by integration in social settings rather than by confinement in the typical hospital room. Second, a potent countermeasure for the sensory deprivations of isolation is the sense of belonging to a community and the sense of greater purpose that comes with community identification.[4] With these correctives in mind, we began to reconceive our experimental Rubik's Cube environment as a series of environments where a "therapeutic community" of people can form through participation as both investigators and subjects in scientific study.

NASA's Translational Research Institute for Space Health already recognizes that space exploration has relevant impacts for health on Earth. Our Vooster Lab concept intended to make the case that building a therapeutic community as a translation research laboratory for space exploration has relevant impacts for healthcare on Earth as well.

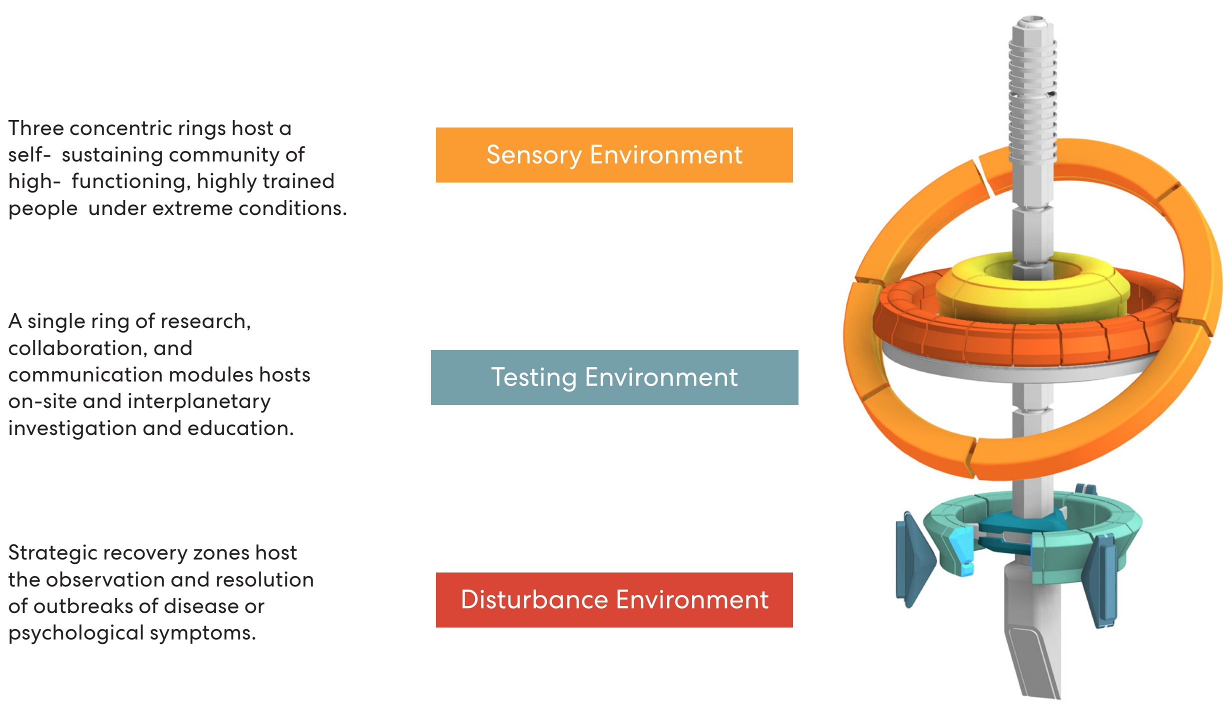

Figure 2: *A system of three community-oriented environments anchored by an axial spine of core functions make up the Vooster Lab.*

5.0 Therapeutic Community: A System of Three Environments for Translational Research

To conduct translational research on behavioral health under the stress of considerable sensory deprivation, we tailored our design to the health benefits of belonging and greater purpose. Our concept for a "therapeutic community" is an integrated system of three environments that supports holistic wellness under sensory deprivation while investigating human adaptation and specimen behavior and testing treatment options. Sensory and Testing Environments are coordinated programs of adjacencies, while the Disturbance Environment is a flexible typology dispersed cellularly throughout the system.

Using space flight as the most extreme case of a hostile yet livable environment, we used the "5 Hazards of Space Flight" identified by NASA's Human Research Program and Translational Research Institute for Space Health to guide the Sensory Environment's program.[5] Integrating countermeasures to the physical and psychological risks of austere conditions, the Sensory Environment is a kind of "live" and "play" network of spaces: it balances privacy with social settings and opportunities for movement and activity with access to organic forms and restorative settings. Specially treated glass cladding simulates circadian rhythms of daylight to help regulate the Environeers biological clock and support their psychological and physiological adaptation to spaceflight.[6]

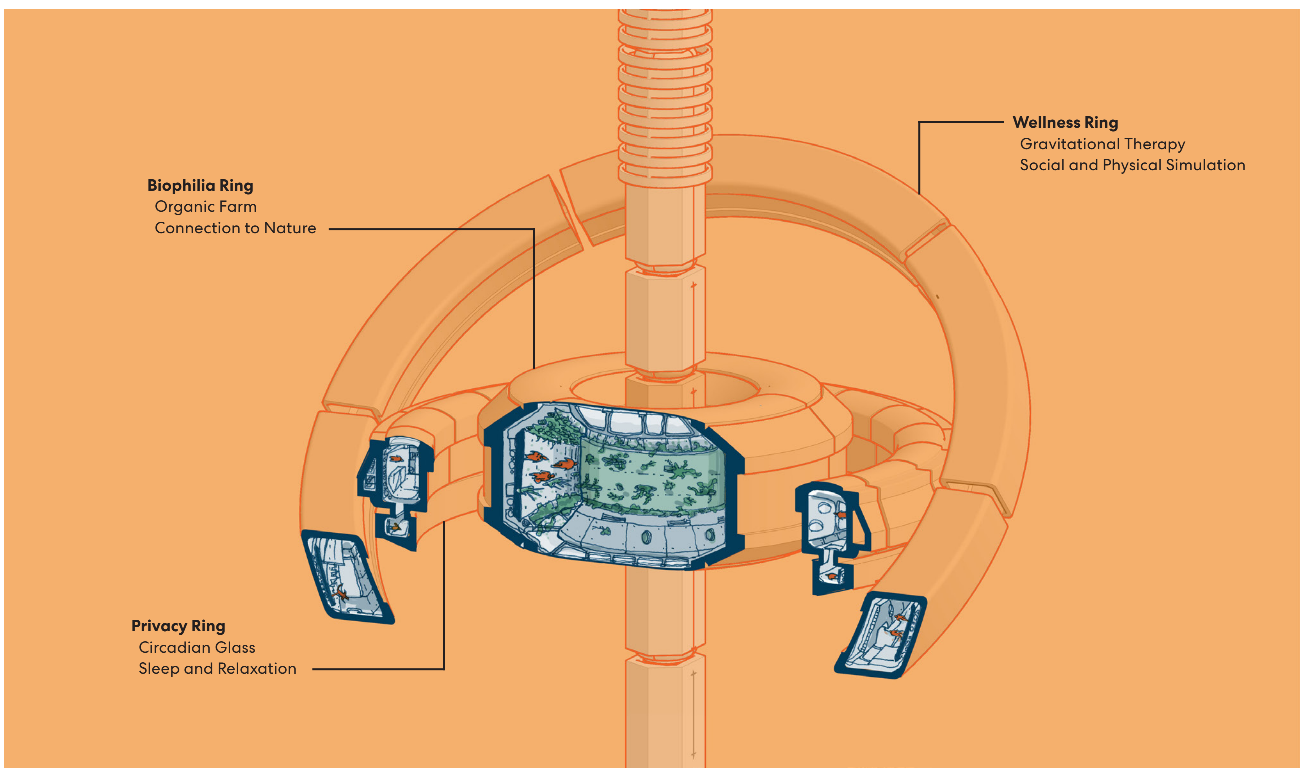

Figure 3: *The Sensory Environments of the Vooster Lab.*

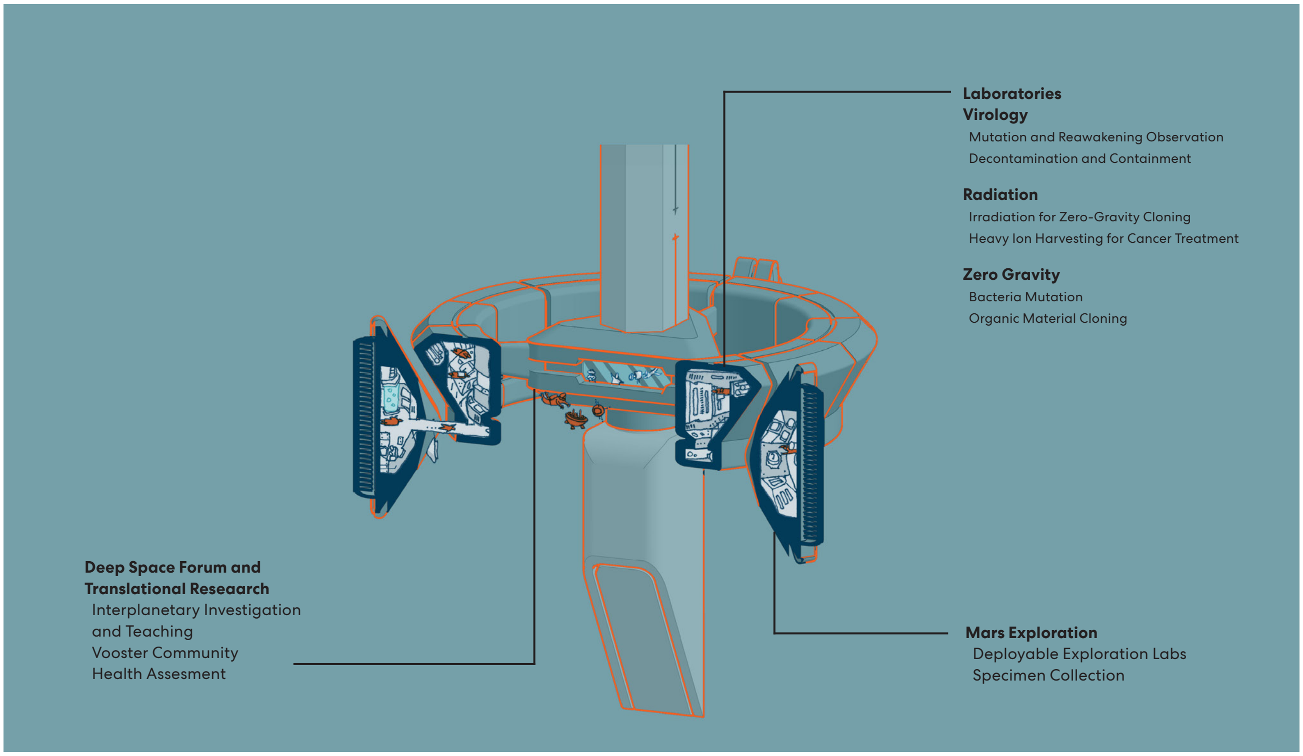

Figure 4: *The Testing Environment of the Vooster Lab.*

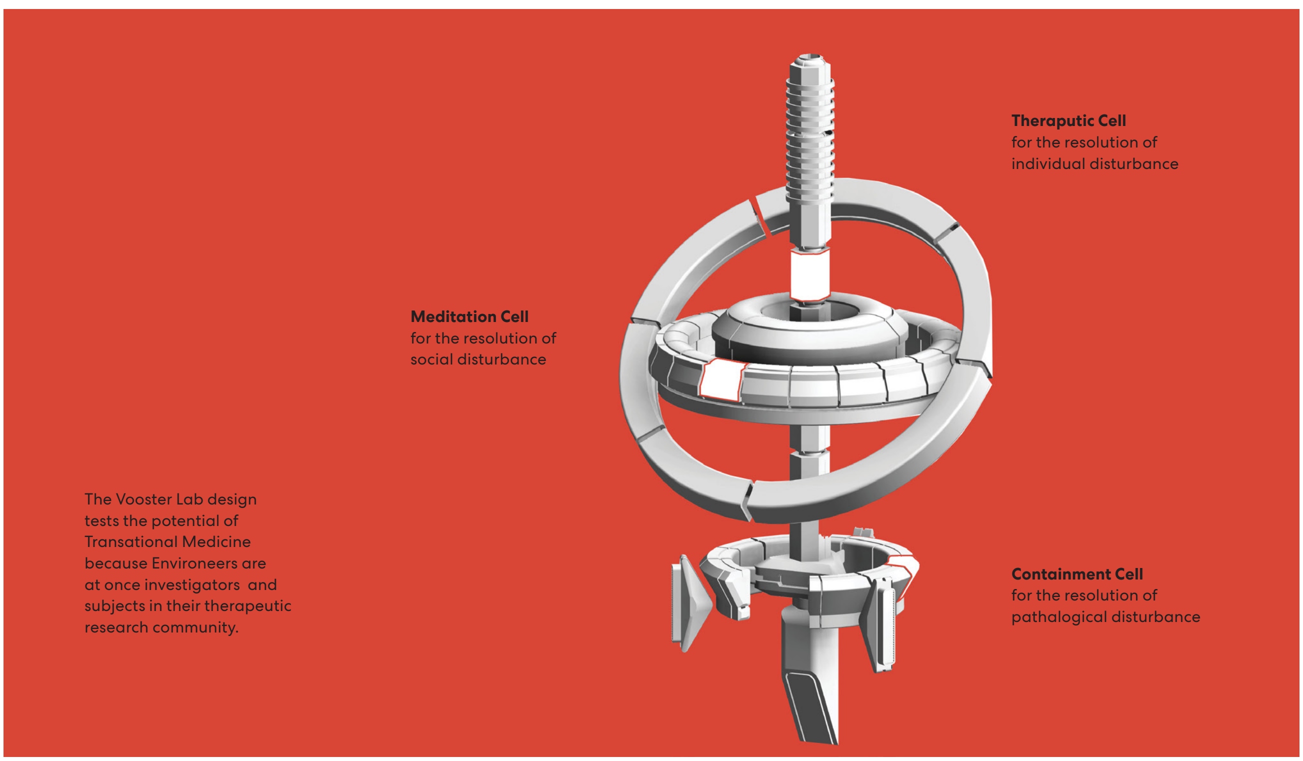

Figure 5: *The Disturbance Environments where Environeers are subjects of the Vooster Lab.*

The Testing Environment uses principles of passive contact and strategic adjacencies to spur creativity and productivity in the laboratory and research, or "work" program.[7] The therapeutic community is an interdisciplinary community, so the network of collaboration and "collision" spaces will support a collective sense of purpose around research and education.

A typology more than a distinct program, the Disturbance Environments consist of recovery zones for the observation, testing, and resolution of disease or psychological disturbance, i.e., symptoms. A Therapeutic Zone resolves individual disturbance, a Mediation Zone resolves social disturbance, and a Containment Zone resolves pathogenic disturbance. In this respect, designing the built environment for a therapeutic community pushes the frontier of translational medicine by making community members at once the investigators and the subjects in the community's research enterprise.

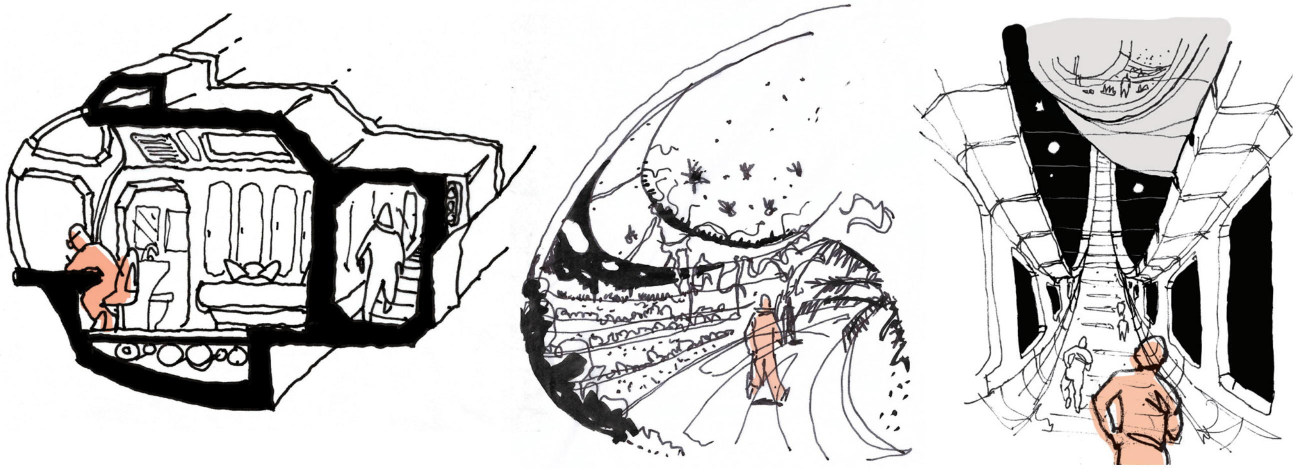

Figure 6: *Inside the Sensory Environment.*

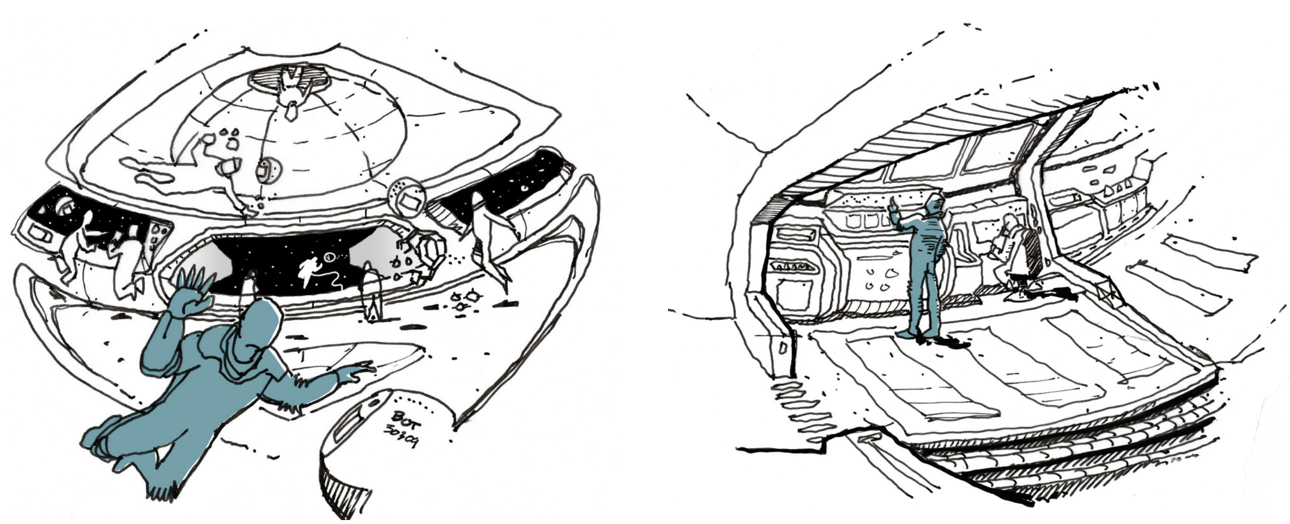

Figure 7: *Inside the Testing Environment.*

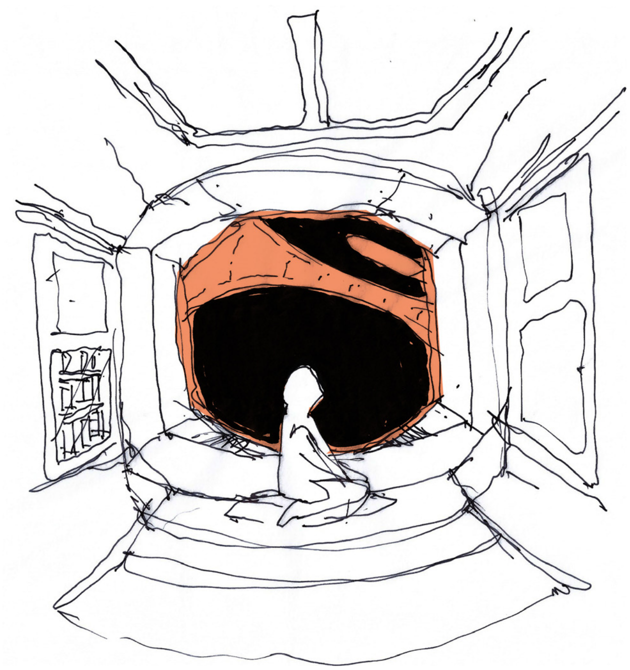

Figure 8: *Inside the Disturbance Environment.*

6.0 The Support Systems Strategy

The Vooster Lab design supports a therapeutic community studying human and viral behavior by integrating the Sensory, Testing, and Disturbance Environments along an axial circulation and systems spine. While behavioral health models and translational research needs guided the program, adjacencies, and circulation of the Environments, maximizing safety, resources, and opportunities for research in space determined the form and function of the vessel's shell. The deployable labs, for example, have the capacity to harvest ice from Mars to support the reactors that recycle oxygen into air and water, but they also assist with correcting the vessel's trajectory when in orbit around Mars. In the future, these independent vessels can transport specialized experts to assist the Environeers who will eventually inhabit Mars.

The ring design performs multiple support functions as well. The concentric rings of the Sensory Environment revolve around the axial spine to create artificial gravity on an adjustable gradient, which helps the human body

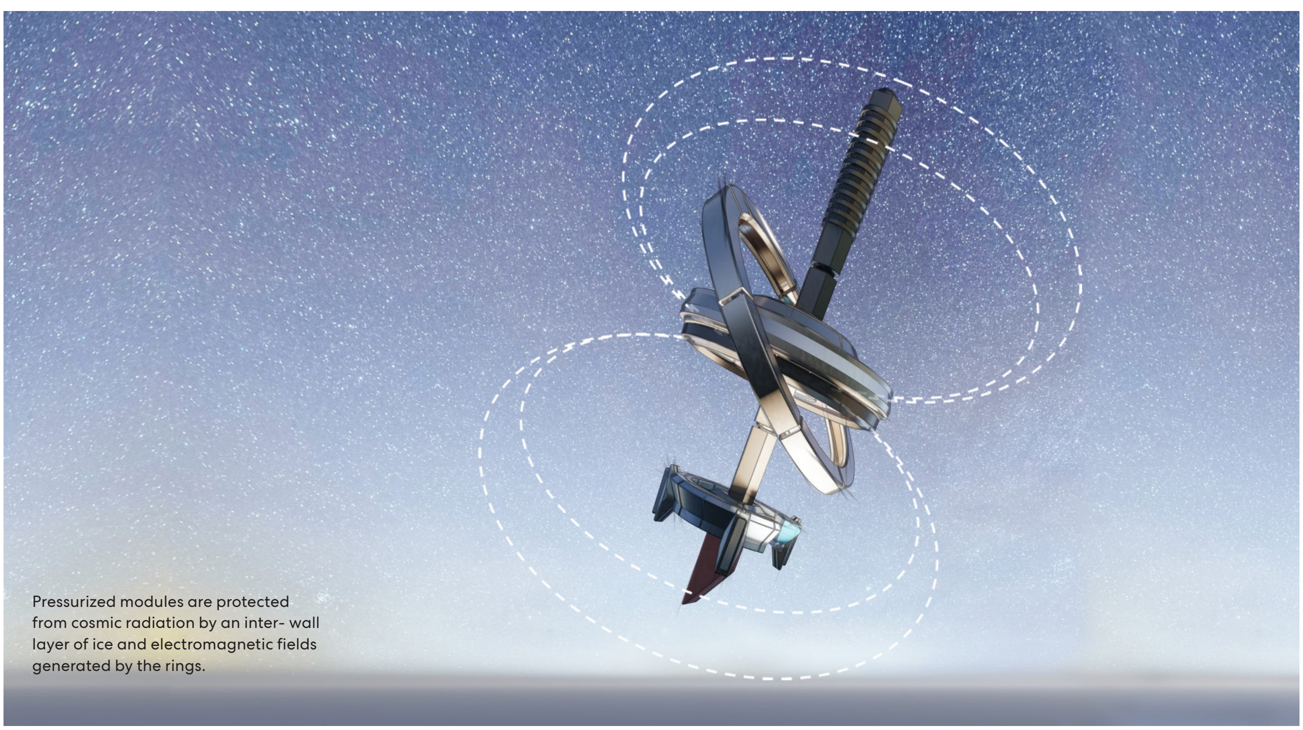

Figure 9: *Radiation protection strategy.*

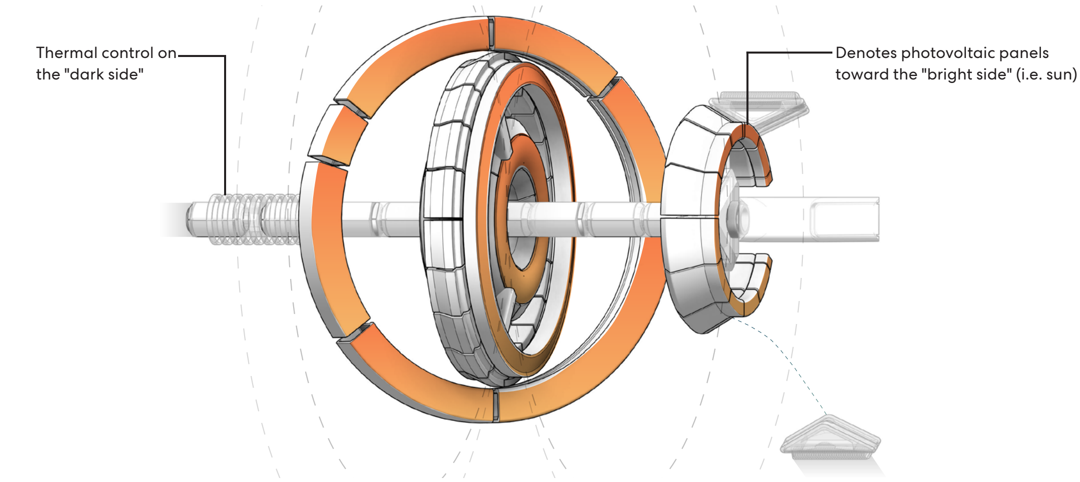

Figure 10: *Solar energy strategy for the Vooster Lab.*

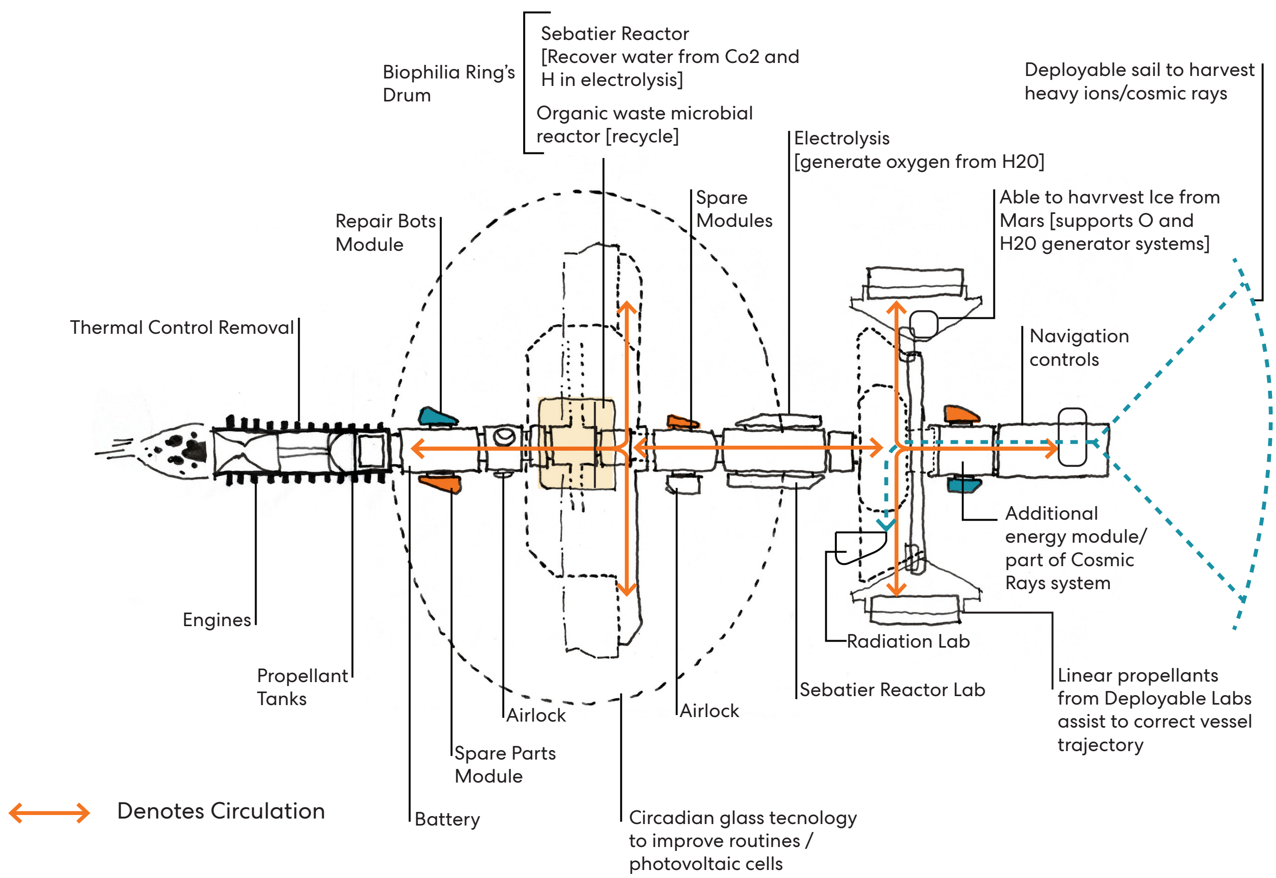

Figure 11: *The support systems strategy for the Vooster Lab.*

and brain adapt to variable gravitational fields between Earth and Mars.[8] In combination with the Testing Environment ring at the other pole of the spine, the Sensory Environment rings generate an electromagnetic field that, in combination with an interwall layer of ice, protect the pressurized modules from cosmic radiation.[9] Photovoltaic panels attached to the rings generate all the energy required for the vessel's systems to function.

To further ground our concept in the engineering reality of spaceflight, we researched the complex support systems that would need to operate within the axial spine. In addition to engines, batteries, propellant tanks, and navigation controls, the spine houses a variety of reactors to recycle waste molecules into air and water. The spine also houses deployable sails that can harvest cosmic radiation and heavy ions for testing within the vessel's laboratories or back on Earth.[10] Repair bots are available to assist the aerospace engineers onboard.[11]

7.0 Conclusion

Vooster Lab's design answers a dynamic yet integrated plan for three environments supporting translation research during extended spaceflight. The Testing Environment resembles a conventional laboratory, outfitting experiments with specimens collected in space or on Earth, including dormant viruses that may awaken once a body leaves Earth's atmosphere. The Disturbance Environment is maximally flexible. Featuring a porthole view into outer space, it is programmed to observe and resolve the outbreak of disease, psychological, or social symptoms. The Sensory Environment is the most ambitious. Three concentric rings create a gradient of artificial gravity and host a self-sustaining community of high-functioning, highly trained people under extreme conditions.

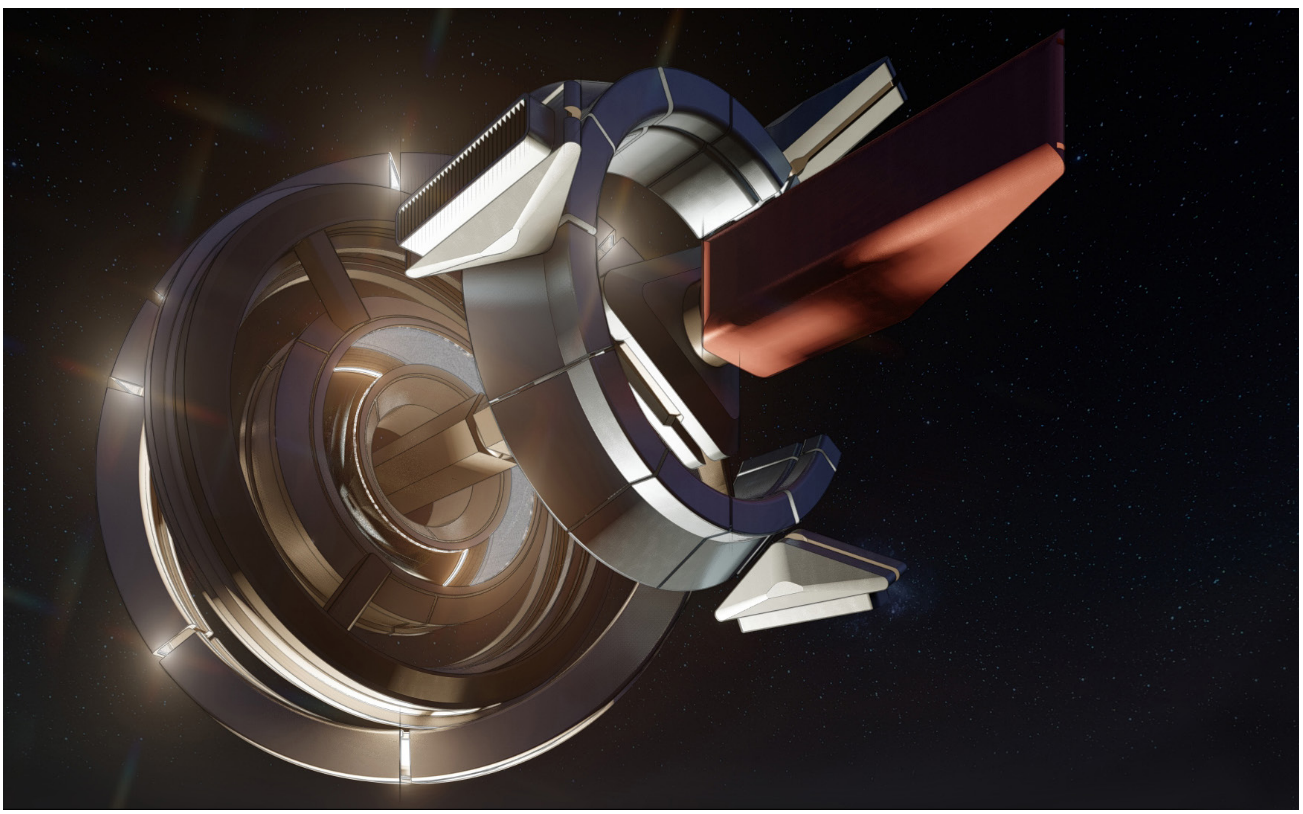

Figure 12: *A conceptual rendering of the Vooster Lab.*

While Vooster Lab is without question a conceptual flight of fancy, its design innovations are twofold. The thorough integration of support systems and research technologies, synergy-promoting adjacencies, varied but coordinated social and wellness programs, and experimentation environments is a conceptual feat. The second, more significant innovation of Vooster Lab is the convergence of space flight technology, behavioral health programming, and translational research in the concept of a “therapeutic community.” It imagines how the unique experiment that is any given space flight must scale up as interplanetary travel becomes a reality, but it also models an approach to the social character of highly programmed clinical and research environments, where it is imperative that the design negotiate and support the resilience of the individual, the collective endeavor, and the greater environment.

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