Staying Safe in Space

Policy Considerations and Recommendations on Reliability, Health, and Safety in Orbit and Beyond

This paper is a product of the Reliability, Health, and Safety Working Group of the Beyond Earth Institute Leadership Council. While the paper represents a consensus of Working Group discussions, the views and recommendations do not necessarily represent those of the members or their respective organizations.

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I Executive Summary

Humanity has always faced challenges as it explored and expanded across continents and oceans, enduring new threats to health and safety along the way. We are at a pivotal point of just such a new struggle, as we begin to expand beyond earth in this new space age. This expansion looks to be dominated with earth orbiting commercial space stations, industrial facilities, and ever more satellite constellations. These foundational activities promise to expand the global economy while stimulating exploration and expansion with moon bases and Martian outposts.

As our space technology improves to make these dreams reality, the health and performance systems focused on environmental, life support, and safety technologies of those space vehicles must improve too. These capabilities could be enhanced, or hindered, by policies we enact here on Earth. So it's important to carefully craft our space travel policies as technology and capabilities expand. The Beyond Earth Institute (BEI) explores the potential issues in reliability, health, and safety for off world migration, and has developed a set of policy recommendations for the United States (US) Government, the commercial space industry, and academia.

This report follows up on previous Beyond Earth Institute conversations regarding health and safety in space, such as a webinar panel entitled "Webinar: Human Spaceflight Safety, in Concept & Practice: Which Way Forward?" held Wednesday May 24, 2023,[1] and a supporting background paper "Achieving Safety And Reliability In Human Spaceflight; The Basic Requirements For A Human Existence Beyond Earth."[2] This work has been expanded upon by discussions over the summer of 2023 for the Reliability, Health, and Safety working group, diving into issues in the industry and developing recommendations on essential aspects that need focus.

The working group found that there has been plenty of progress developing human health and safety in space, but there is still much to be done. Data availability and variety is one of the biggest issues facing the future of human expansion beyond earth. There are too many unknown factors on human health and its response to space travel and hazards, and not enough data to apply it to all future travelers. Another issue that has been discussed but needs further clarification is the jurisdiction of space, determining what agency(ies) respond to safety concerns in orbit and who develops, and enforces, industry wide standards.

These are areas that have a focus that need further consideration.

There are other major aspects of life in space that do not have enough focus and need attention. As space tourism starts to grow the considerations taken with the health data of new flyers will also need to grow. There will be much greater variety in the health and medical conditions of the space travelers of this new age, and keeping and sharing those conditions will need to be discussed and monitored. Developing a functional medical response system for this large variety will also need to be a focus, as basic medical care is different in the hazards of space. Additionally, there is little exploration of the possible mitigation of one of these standards, and that is artificial gravity (AG). AG could potentially provide solutions to many major health and safety issues, but is woefully under-explored.

This report seeks to dive deeper into these issues and develop industry wide recommendations that could better prepare humanity for life beyond Earth.

II Background

Reliability, safety and human health in space are essential aspects of beyond Earth human travel and long term habitation. Reliability in human space flight refers to the technical durability, system redundancy, and design resilience to sustain environmental capabilities of mission systems. As future spacecraft may have to endure years in space, longevity, durability, and repairability will be of critical importance. Reliability can be measured as a probability of a system or sub-system's to provide long term functionality.

The International Space Station, which has been operational for over two decades, can serve as an indicative benchmark from which to establish standards for commercial and industrial systems reliability in near earth space. Nevertheless, the longest crewed missions beyond Earth (i.e., the Apollo missions) have only lasted a few weeks. As such, advances for deep space habitation and human exploration systems will be needed.

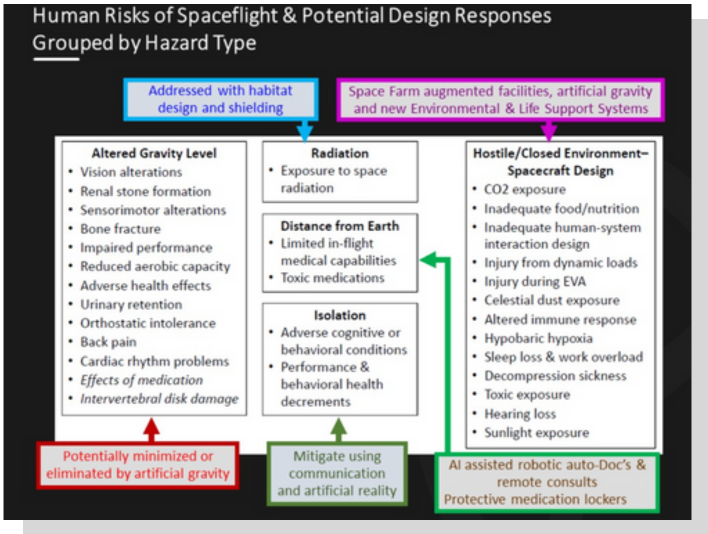
Safety refers to the prevention of accidents and injury to space-faring human inhabitants and other in-space life supporting biologics. This includes risk minimization strategies and response plans for emergency situations. Among the primary concerns for long-term crewed space travel are orbital debris mitigation, systems to mitigate the deleterious effects of microgravity (often referred to as zero-gravity), and designs to reduce radiation exposure.

Health in space refers to maintaining the good sociological, physiological, and psychological wellbeing of space inhabitants. Currently, NASA filters candidates through a rigorous screening process with high standards for physical and psychological compatibility for their space missions. For example, NASA astronauts must be scuba certified, obtain a masters degree (or equivalent), and meet anthropometric requirements.[3] Space travel, especially long duration missions, pose new and unique challenges for human health. Over 60 years of human microgravity experience has amassed a wealth of information on the deleterious impact of this environment on human health. An example of one of the most pressing concerns is the impact of microgravity on musculoskeletal health. This condition (known as spaceflight osteopenia) weakens the body's muscular and bone density, requiring daily intensive exercises and dietary supplements.

Radiation protection is another critical area of focus. Prolonged exposure to increased cosmic rays and solar radiation outside the protection of the earth's atmosphere and magnetic field can lead to higher risks for cancer and disrupt internal organ functions. Protective shields and/or other technologies to mitigate radiation impacts on humans will be needed to protect crew on deep space journeys. The figure below

1 Beyond Earth Institute, "Human Spaceflight Safety, in Concept & Practice: Which Way Forward?," (Webinar, Beyond Earth Institute, May 24, 2023), https://beyondearth.org/events/webinar-human-spaceflight-safety-in-concept-practice-which-way-forward/.
2 Ian Ching, "Achieving Safety and Reliability in Human Spaceflight: The Basic Requirements for a Human Existence Beyond Earth," Beyond Earth Symposium, October 2022, available at https://beyondearth.org/wp-content/uploads/2023/01/Achieving-Safety-and-Reliability-Paper.pdf.
3 "Becoming An Astronaut: Frequently Asked Questions," NASA, January 16, 2018, https://www.nasa.gov/humans-in-space/becoming-an-astronaut-frequently-asked questions/#:~:text=Astronaut%20candidates%20must%20also%20be%20able%20to%20pass,evaluated%20to%20ensure%20they%20meet%20the%20anthropometric%20requirements.

summarizes many, but not all of the dangers to health of current human space along with potential responses grouped by hazard type.



Design response suggestions on spaceflight hazard type summary as presented in the June 2015 briefing by Peter Norsk, NASA JSC & Jeff Smith, ARC entitled "Artificial Gravity Future Plans for ISS."

It is essential to develop and implement strategies and policies that assure the programs are established and industrial standards processes are developed covering both private space citizens and government personnel for sustained human spaceflight hazards mitigation.

From launch to landing, key systems must function with risks acceptable to the mission's needs. Of key importance is the continuation of US global leadership toward advancements in safe and reliable space passenger transportation systems.

III Current Issues

Data Availability and Assessments

Perhaps the biggest issue right now with off world space travel is insufficient knowledge regarding acceptable levels of human health and safety. As of the time of this writing, just over 600 people have reached space. Historically the majority of space travelers have been former pilots, predominantly male and of a certain weight and height, with years of training and are usually in peak physical condition. Such a sample does not accurately reflect the safety and health needs of the anticipated diverse demographic in the future of commercial space exploration. This becomes especially important as the groups traveling off world become more diverse in terms of demographic gender, age, and physical health.

With the expansion of the space tourism market, there is a significant opportunity for collecting data across many different demographics and a variety of human conditions.[4] However, there are several challenges to an effective collection of human health data in space. Some key issues are the willingness of participants to provide their health data and the question of ownership of such health data.

Additionally, the sheer cost of this early commercial human space tourism and industrial passenger transport means that there will continue to be a limited group of space adventurers that can actually afford it. The projections are, however, that as the price of tickets to orbit drops the amount and type of people traveling to space will increase. This will boost the potential for human space response data on different body types and, hopefully, boost our knowledge to impact future technologies, system designs and safety standards.

To further expand on the overall lack of diverse sets of human data there is still limited information on the benefits of specific system capabilities beneficial to living off world, such as artificial gravity and medical equipment systems. Artificial gravity in particular is one area that could be improved, as there remains no orbital research data or facility where the value and levels of artificial gravity can be investigated.[5] Early studies indicate that this critical human centric space capability has the potential to counter a vast number of the deleterious physiological impacts of micro or partial gravity. It's been shown that through employment of centrifugal force induced system designs (sometimes called spin-gravity), there exists the possibility to recreate different levels of gravity in orbit. While there has been some ground-based research in this field, the studies to date done in space on mice and insects provide, at best, speculative indicators on how much gravity would be needed for humans. This is just one of the many crucial areas missing reliable data that could greatly benefit human health and safety off world.

Hazardous Work Environments

Just like with so many places on Earth, there are serious hazards to consider when living and working in space. Extreme temperatures and unbreathable air are issues we have learned to deal with, but space comes with its

4 Space Tourism Market Size, Share & Trends Analysis Report By Type (Orbital, Sub-orbital), By End Use (Government, Commercial), By Region, And Segment Forecasts, 2023 - 2030, Grand View Research, Report ID: GVR-4-68039-955-3. Space Tourism Market Size & Growth Report, 2023 - 2030.

5 Statement by Dr. Siddhita Mhatre, "Artificial Gravity: From Cinema to Reality," (Webinar, Beyond Earth Institute, January 18, 2023), https://beyondearth.org/events/be-webinar-artificial-gravity-from-cinema-to-reality-2/.

own set of challenges. One of the biggest hazards facing human health and safety in space is radiation. Earth's mass, magnetic field, and atmosphere help keep life on earth safe from harmful radiation emanating from the Sun and other cosmic sources. But in low earth orbit, especially at orbits with higher inclinations, radiation exposure increases. A recent report by the National Aeronautics and Space Administration (NASA) on the radiation exposure of a Mars mission using current technologies and systems showed an exceedance of the lifetime maximum acceptable radiation dosage.[6] Beyond Low Earth Orbit (LEO), space radiation may place astronauts at significant risk for radiation sickness, and increased lifetime risk for cancer, central nervous system effects, and degenerative diseases.[7] For humans spending long durations on the Moon, these natural Earth protective conditions are absent. And any radiation above the maximum yearly dose rates[8] can cause potentially irreparable damage to the human body.

Another major hazard that is rapidly growing is orbital debris. Each year, dozens of near-collisions occur between active satellites or pieces of debris in Earth orbits. With more satellites saturating Earth's orbital planes, there are greater chances that collisions will happen. Such collisions generate multiple new debris — all of which fuels what many fear could become a destructive hazardous cycle.[9] The thousands of pieces of debris in orbit travel at speeds up to 17,500 mph. This situation not only poses a threat to satellites and equipment but also a significant hazard to private and government astronauts. Whether during a spacewalk or just maintaining vehicular operation, monitoring and mitigating risks, through system design or taking active measures to clean orbital debris, is extremely necessary to the safety of people living and working in space. Right now there are dozens of studies looking at possible debris response solutions across governments, industries, and universities. While progress has been made, more must be done including the potential for a multi-step solution.

Jurisdiction

Currently there is no consensus on which organization will mandate and enforce health and safety standards in space. In the United States, the Occupational Health and Safety Administration (OSHA) oversees space safety standards during ground operations. Once airborne, the Federal Aviation Administration (FAA) assumes responsibility. For frequency management and licensing, authority rests with the Federal Communications Commission. These and other organizations oversee the space industry activities until and before a space vehicle crosses the threshold of space.

Once a vehicle enters space, the jurisdiction becomes confusing. The bewildering burden to commercial activities is who is in charge? Do private astronauts follow FAA guidelines and report issues to OSHA? Who should be given the authority and funding to develop and enforce policies and regulations? The answers to these questions remains unclear at a time of increased space travel, which creates a complex situation encouraging missteps and issues pertaining to process activities.

There have been attempts to develop answers to these questions through international jurisdictional considerations, which include five broad international activities agreements. The most recent agreement is the Artemis Accords,[10] which strive to reinforce the commitment by the United States and signatory nations to the Registration Convention,[11] the Rescue and Return Agreement,[12] best practices and norms of responsible behavior that NASA and its partners support, and the public release of scientific data. These documents however are only a guide to overarching goals and in space activities. The actual enforcement of provisions and the terms and definitions of these agreements are not unanimously agreed upon.

Space regulation remains with individual nation states, with each developing their own means of oversight and governance for implementation activities. Much like the maritime tradition, space is unlikely to be governed by a unified, singular international entity. Instead, nation states remain responsible and liable for the actions of citizens and commerce.

While there is currently a lack of enforceable international regulations and commercial standards for crewed exploration across government and private missions, especially referring to reliability and safety, the importance of such governing guidance cannot be understated. Such guidance is needed to establish precedence on behavior norms with the first missions beyond earth. One example of where we could see these issues soon is if a space station from one nation has an issue in safety, would there be any political issues with getting help from an unfriendly space station? And what happens after that assistance has been applied? While there has been progress towards answers to these questions, there's still a long way to go.

6 S. Robin Elgart, "Space Radiation Environments and Research Directions," (conference presentation, American Society for Gravitational and Space Research International Conference, 2022, Houston TX).

7 "Why Space Radiation Matters," NASA, April 23, 2017, https://www.nasa.gov/analogs/nsrl/why-space-radiation-matters.

8 10 CFR Part 20 ("Standards for Protection Against Radiation," establishes the dose limits for radiation workers. Although the limits vary, depending on the affected part of the body, the annual total effective dose equivalent (TEDE) for the whole body is 5,000 mrem (5 rem)...).

9 Shikha Subramanian et. al., "Space Dodgers," Washington Post, January 13, 2023, https://www.washingtonpost.com/technology/interactive/2023/space-debris-game/.

10 The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids, NASA (Oct. 13, 2020).

11 Registration of Objects Launched into Outer Space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15.

12 Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Object Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119.

IV Industry-Wide Standards

There are growing concerns that the lack of commonly accepted (legislated and/or ratified) space systems and operations standards may be leading toward harmful conditions in the burgeoning space environments. The lack of a more unified policy has prompted independent actions and recommendations from US Government agencies, but also ignited activities within industry. On the government side, these actions include the FCC adopting a new '5-Year Rule' for the deorbiting of spent satellites, the American National Standards Institute, in conjunction with the National Institute of Standards and Technology of the Department of Commerce, working to develop space system safety standards, and the Federal Aviation Administration's Office of Commercial Space Transportation (FAA/AST) and the Commercial Space Transportation Advisory Council (COMSTAC) developing and making recommendations on space systems safety, regulations, innovation and infrastructure.

From the industrial side, the Consortium for Execution of Rendezvous and Servicing Operations is recommending guiding Principles for Commercial rendezvous and proximity operations (RPO), and are beginning to develop on-orbit satellite servicing (OOS) recommended design and operational practices. Additionally, the American Institute of Aeronautics and Astronautics hosts numerous committees and working groups publishing both independent and industry collaborative reports on space safety and operations. Overall, there does seem to be an agreement between industry and government that some type of regulation of reliability and safety in space travel would be beneficial.

The fundamental policy conundrum remains: Do we let these government agencies, organizations and industrial groups continue to work independently in a free-market environment or is policy-level guidance and authority assignment required? Regardless, safety standards and who enforces them is an issue that needs solid guidance soon, especially as space tourism continues to expand. The Beyond Earth Institute recommends that the US government establish a dedicated space safety agency that can focus on developing industry wide standards for reliability, health, and safety. This could be done in concordance with industry leaders to ensure that real concerns are addressed. This process would likely require several iterations, but the benefits to safe and sustainable space travel will be monumental.

V Critical Path Development

Data Privacy

As the amount of data increases, one area of concern that needs to be considered is the medical privacy of private astronauts. While NASA government astronauts are required to share their medical information while flying, this is not a requirement of private astronauts. Many do share regardless, but as the numbers start to increase this will become less of a guarantee. And to request medical information, whether it's medical history or new inflight data collected through smartwatches or sensors or other technology, run into the same issues seen on Earth with regards to personally identifiable health information (e.g., Health Insurance Portability and Accountability Act (HIPAA), General Data Protection Regulation (GDPR), etc.).

Additionally, there is the legal question of ownership of collected medical and health data. Currently different private flight providers have no system to share health data that is collected on their flights, which could be a missed opportunity. For example, while Space Company A may have their own database of proprietary medical information, Space Company B may have a very different database, yet both can be beneficial to the other and the industry as a whole if they could share information on similar demographics or health conditions. Extensive discussions and considerations are needed on this subject to affect and support development of fair policies and practices. This initial debate could start with the question of those practices, procedures and legal potentials to facilitate data collection in the context of the value of and terms for sharing for the benefit of expanding human space travel and for risk management in the industry.

Overall, it is clear that there needs to be specific policies and discussions regarding the medical and health data of astronauts, both from federal space programs and private flyers. There needs to be agreed upon standards across government, commercial, and academia sectors as to how this data is collected, shared, and reported upon. The Beyond Earth Institute recommends the development of such data collection and sharing standards through the collaboration of industry actors. This will be crucial to improving human health in space as well as protecting patient privacy.

Artificial Gravity

Artificial gravity is one area that has monumental implications for life beyond Earth yet remains severely under examined. There are limitations of exploring these systems, such as the impracticality of testing them on Earth, which is a contributing factor to the lack of data. The biggest limiting factor, however, is cost. Currently there is not a sufficient amount of incentives in the industry or from the government to fund research into artificial gravity, and this leads to misunderstanding of the potential benefits from such efforts.

Early data on artificial gravity analogs indicate that there could be some significant benefits to human health in orbit or on planets with less than 1G. But these theories need to be further explored. There are crucial questions that need to be answered, such as do we really need to spin for human health? If we do then how fast? What are the resources needed to maintain that spin? And there are applications and knowledge to be gained beyond just "when can a person live." At what spin would you no longer need cooling systems and astronauts can sleep without fans?

There are also numerous system design, cost and engineering implications of artificial gravity. With gravity-like accelerations the use of existing terrestrial equipment cooling systems may be practical, reducing procurement, maintenance and logistics costs. Complex habitat air circulation systems including the special fans needed in microgravity space stations to prevent astronaut oxygen deprivation during sleep might be eliminated. With a spin induced artificial gravity field new ways of thinking on system architecture and design will likely emerge.

The tests to discover the answers to these questions can not be completed on the ISS. They can be accomplished on specific facilities, such as large orbital radius centrifugal facilities, a type of facility that does not currently exist. The potential value of such a facility is massive. From discussions during space conferences and at previous BEI Symposiums, there is growing evidence that investigations like these have recognized value and growing support both in industry and National space agencies.

During the late 1960s and early 1970s there were spin gravity human studies done at NASA Ames, Langley and Johnson Space Centers. These focused on the impacts of the Coriolis Effect and studying different levels of motion sickness. However, no Earth-based experiments can eliminate the pull of earth's gravity, which will not exist on a spinning space station. So in essence, these studies, though yielding useful insights, can never truly match what will happen in space, and thus further investigation is not only warranted but encouraged.

The potential benefits to artificial gravity are plentiful but largely unexplored. A greater focus on research in AG should be a goal of the space industry, but research often requires a financial incentive. That's why the Beyond Earth Institute recommends the development of an established market need for artificial gravity to encourage further research.

Supply Chains

As humanity explores living beyond Earth, two of the biggest health and safety challenges are going to be supply chains pertaining to human physiology and food. There is precedence for this: look at supply chains out at sea and how those have been handled.

Throughout history, ships left port with food and medical supplies, but these faced issues out at sea with weather, microorganisms, scavengers, and time. New diseases were found, along with new treatments, such as scurvy and citrus.

Traveling in space introduces a new set of supply chain challenges. Medical equipment will require new equipment designs, storage and procedures, especially in microgravity applications. For example Standard medical equipment will change. For example, a recent study found that space-based radiation can affect the epinephrine in EpiPens traveling to space making them toxic.[13] This is a basic piece of medical equipment that essentially is rendered useless by normal operations in this new environment. Maybe the solution to this is different storage containers or just to develop a new treatment. Further research into this and many other basic medical equipment is needed.

So how do we prepare for extended space stays, remote outposts and longer voyages? The space industry must consider and study the basics of everything we assume to be standard for significant, long duration space flights and stays. For instance, researchers can study how radiation impacts medkits and other essential first aid components. These studies are possible on Earth, and these need to happen soon. The Beyond Earth Institute recommends a greater focus on research on the effects of space hazards, such as radiation, on logistics equipment and commodities along with procedures to deal with microgravity and varied gravity environments. We are truly at an unprecedented era of exploration. Ancient explorers meeting new cultures around the world had the benefit of seeing locals living off the land and surviving harsh conditions, and could learn from them. The first humans living on the Moon and Mars may not be so lucky, so this research must be accelerated.

Medical Treatment in Space

While there are plenty of concerns with tracking human health and bringing effective medical equipment on missions, one of the most important areas that needs further investigation is the application of first aid in space. There are a lot of challenges with providing medical treatment in space, especially in dealing with radiation and micro or partial gravity. Most missions to space contain highly trained individuals with a wide variety of backgrounds, many of them with some kind of medical training. As we move to a new space age with more private and civilian flights we are going to see a wider variety of backgrounds, expertise, and medical conditions heading to space.

13 Margaret Osborne, "Kids Discover That EpiPens May Not Work in Space," Smithsonian Magazine, March 6, 2023, https://www.smithsonianmag.com/smart-news/kids-discover-that-epipens-may-not-work-in-space-180981749/.

While plenty of missions could include a doctor, not all of them will. Basic medical training would be highly advised for certain members of crews and even as part of passenger pre-flight drill training for flight lasting more than a few minutes. Also the availability and type of medical resources available/required in space transports and habitats will require focused consideration moving forward. Basic medical kits and small medical devices may seem easy to include, but even those can be challenging, as we've seen with the epipen example.

Additionally, there will be a larger number of medical conditions that need to be considered and prepared for. For people that require daily medications or treatment, will they still be able to travel to space? And what kinds of technology upgrades or resources will be needed? Should there be standard levels of on-site medical care on rockets, space stations, lunar outposts, etc.? Looking ahead, the distance and time to get to a major Earth-based care facility will be a key factor in answering these questions.

Response readiness times are a crucial aspect to consider. To understand their importance in medical treatment in space, look at ships out at sea today. The response readiness times are a perfect analogy for space flight. Ships that are just off shore are going to have a relatively quick response, just like vehicles in LEO. So while they will need several medical supplies, they may not need everything. If you head a little further out to sea, or to the Moon, spacecraft will need to bring more crucial equipment to overcome response time delays. And if you're out in the middle of the ocean, or on your way to or at Mars, the people there will need full local medical response capabilities to emergencies. Research into appropriate responses, procedures and capabilities as our missions move ever outward will be of monumental importance in preparing humanity for traveling and living off world.

Looking forward, one great analogy for testing medical treatment, supply chains, and responses is shakedown cruises. Shakedown cruises are voyages at sea that head out far enough to test technologies and procedures in almost extreme situations, but close enough to shore to test these safely.[14] There is an upcoming mission that could function as a shakedown cruise for missions to the lunar surface and even on to Mars: the Lunar Gateway. Medical procedures and response times can be tested relatively safely on commercial LEO facilities. These will be in orbits close enough to investigate the time and distance delays to the moon. Such an approach to the Lunar Gateway microgravity medicine would prove extremely beneficial to developing policies, procedures, and techniques for long-term reliability, health, and safety in space.

Conclusion VI

As humanity seeks to expand beyond Earth, it will need to ensure it is done in a safe and reliable manner. There has been research conducted to improve these areas, looking at data from previous missions and determining responses to hazards of the space environment, but there is still a lot of missing information. There are lingering questions on what agency(ies) mandate health and safety standards in space, as well as what those standards should be. There are questions as to how much health data needs to be collected, and how to protect astronaut medical data. Further research is also needed on the development of standard medical systems as the demographics of space travelers begin to expand. There is also a lack of information on artificial gravity, one aspect that could significantly enhance life in orbit. Further exploration of all of these issues could greatly improve reliability, health, and safety in space.

Summary of Recommendations

Moving forward, each new crewed mission or extended stay offers an opportunity to learn more about what techniques and approaches will work as humanity ventures off world. They are also opportunities to collect new data on human health and the impact of the space environment on medical equipment. In order to move the industry beyond existing data and discussions, the Beyond Earth Institute provides four recommendations on the aspects of reliability, health, and safety that warrant further research and a more in-depth consideration, which should be considered for future missions. These recommendations are as follows:

1. Given the unexpected nature of exploring areas of intense radiation, there should be an increase in studies on the impacts of the space environment on basic medical equipment, first aid kits, as well as solutions to potential issues that arise.

2. Given the lack of data on the potential benefits of artificial gravity, there should be an established market need for an orbiting spin gravity capability to provide the investigative services and research facilities for artificial gravity.

3. To streamline and simplify the identification and development of space industrial reliability, safety, and health standards, organize the regulatory regime governing commercial space under a single regulatory, such as the Department of Commerce, to coordinate with industry.

4. Industry and the government should work together to develop a system for managing industry wide medical data, including solutions for sharing crucial information while maintaining passenger anonymity.

14 "Shakedown Cruise," Wikipedia, accessed October 22, 2023, https://en.wikipedia.org/wiki/Shakedown_cruise.

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