

Risk Management Plan Technical Report

Prithvi Chakraborty

Virginia Aerospace Science and Technology Scholars

Master Teacher: Dr. Tyiesha Gainey

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A long-term mission to Mars creates a lot of risks from the human perspective because astronauts have to live in a closed environment and system for months without the possibility of fast resupply or direct help from Earth. Unlike missions that are in low Earth orbit, a crew traveling to Mars cannot simply turn around and come home if something goes wrong. They are committed to the mission for months at a time. Communication with Earth also comes with long delays, so astronauts cannot rely on instant advice from mission control and should rather be prepared to make important decisions and solve problems on their own. Due to this, basic systems involving food supply, air control, and communication become extremely important when it comes to the survival of the astronauts and overall mission success (Casas, 2026). This risk management plan focuses on three major issues that include nutrition, breathable air, and communication. Each section explains the causes of the risk, how it is different during interplanetary travel and surface stay, and how engineers and crews can reduce the danger with solutions, but also real constraints in mind.

Nutrition

Causes and Risks

Nutrition poses a large risk because astronauts have to rely on stored food for the most part for nearly two to three years total, including both travel time and surface stay. Over these long periods, there is a high likelihood that vitamins like vitamin C and vitamin D can degrade alongside fats, potentially oxidizing. This would both reduce the nutritional value and the taste of food. There is the chance that if astronauts don't consume enough calories or consume important nutrients, they may face muscle loss, fatigue, weakened immune systems, and reduced concentration. Because exercise is needed to maintain one's bone and muscle health in reduced gravity, poor nutrition can directly weaken the effect of any of these countermeasures. When

completing tasks that are demanding from a physical viewpoint, like habitat construction or extravehicular activities, undernutrition in the long term can increase the risk of injury (Cranford, 2025).

Potential Hazards: Interplanetary Travel vs. On-Surface Stay on Mars

During the trip to Mars, the main issue is the limited variety of food and the complete dependence that is placed on prepackaged meals. There is no possibility of fresh resupply, so if food does spoil or loses nutrients faster than the rate expected, the crew has no replacement source or method of regeneration. On the Martian surface, astronauts might require more calories than on the way there because of the increased physical workload during extravehicular activities and habitat maintenance. Surface operations also introduce the potential of dust contamination risks when food is being handled. Even though small controlled systems for plant growth could provide fresh vegetables, these systems involve water, power, and maintenance. Furthermore, if they were to fail, they cannot be relied on as a primary source for food (Gajbhiye, 2025). It can be seen that both transit and surface phases need strong planning, but the surface phase adds a higher demand for energy and complexity from an operational viewpoint.

Solutions and Constraints

In order to reduce risks related to nutrition, mission planners have to design menus that consider long shelf life and stable nutrient content alongside enough variety to maintain appetite. Supplements can be used to help replace nutrients that are known to degrade over time. The health of astronauts should also be monitored through regular body mass measurements and blood testing, which can help detect any deficiencies early. Based on such monitoring, customized meal plans with suggestions and scheduling embedded can be devised. On the surface of Mars itself, there can be small-scale plant growth systems to provide fresh produce for both nutrition and morale, but they should be considered as a more supplemental and side aspect

rather than being a primary source (Gajbhiye, 2025). The main constraints involved are mass, volume, and power. This is because adding a greater variety of food increases weight at launch, while refrigeration improves quality but uses power. Crop systems also require water, lighting, and take away time from the crew to complete other tasks.

Breathable Air

Causes and Risks

Breathable air is another risk when it comes to Mars mission planning, as it can turn into a life-threatening issue almost immediately, depending on the scope of the occurrence. The crew depends fully on Environment Control and Life Support Systems (ECLSS) to maintain oxygen levels while also removing carbon dioxide and controlling humidity and trace contaminants. Human metabolism constantly provides carbon dioxide, and this can build up very quickly if proper removal is not in place. Even if there were small increases of such, harm could be done to the astronauts in relation to headaches, fatigue, slower reaction time, and impaired judgment. On the other hand, if oxygen levels themselves were to drop heavily, the situation can become fatal within minutes. In addition, materials inside the spacecraft can slowly release small amounts of chemicals into the air over time, which must be filtered out to prevent long-term health problems (Ridgeway, 2025). Due to the sealed habitat and no breathable atmosphere on Mars, a major system failure or structural leak presents a direct threat to one's survival.

Potential Hazards: Interplanetary Travel vs. On-Surface Stay on Mars

During interplanetary travel, the crew is inside a single main spacecraft environment or volume. This means that if there were to be a major air system failure to occur, everyone would be affected almost immediately, with very limited isolation options. Maintenance opportunities are also very limited, given the constraints of being in space (Guerrier, 2025). On the surface of Mars, the habitats might be built with multiple sections that are connected and backup systems,

which can be very helpful if one part fails. However, living on Mars does bring new problems, like dust potentially entering the habitat when astronauts go in and out through airlocks. The strong pressure difference between the inside and the outside of the habitat also puts stress on the walls and seals. The more modules and connections the habitat has, the more places there are where a leak could happen. While the habitats on the surface might be larger and better shielded, the risk of breathable air remains very severe, as there is no natural atmosphere to rely on (Belton et al., 2026).

Solutions and Constraints

In order to reduce risks that are related to air, missions should include multiple carbon dioxide scrubbers as well as reliable oxygen generation and storage systems. There should be measures in place for continuous atmospheric monitoring with sensors. Emergency procedures must also be clearly defined and practiced repeatedly before launch. Astronauts must be trained to be able to diagnose and repair life support failures without hesitation or the necessity of instructions from back on Earth. Having backup power systems is also very important to prevent life support shutdown if energy loss were to be experienced. An innovative approach is building a system that takes in carbon dioxide from the Martian atmosphere and uses electricity to split it chemically to release pure oxygen for breathing (Ridgeway, 2025). However, redundancy does also increase system mass and complexity. More equipment brings up the need for more spare parts and greater maintenance time. The challenge then comes down to designing systems that are both reliable and simple enough for astronauts to repair within deep space.

Communication

Causes and Risks

Lastly, communication between Mars and Earth is a major operational risk that arises because of the extreme distance between the two planets. Depending on how both planets are

aligned, signals can take between 4 and 24 minutes to travel just one way. This delay eliminates time for actual conversations and serves as a big drawback for immediate support from mission control, especially if an issue were to arise. In emergencies like medical issues, equipment failure, or habitat damage, astronauts are then left to make significant decisions on their own and independently. The delay can also be challenging from an emotional lens, given the fact that astronauts cannot talk to family or mission control in real time. The aspect of not being able to connect instantly can add to stress and make them feel even more isolated and lonely (Atkinson, 2024). Because of this, being far from Earth and not getting quick responses can feel stressful, especially during serious situations. Over time, this sort of isolation can lower morale while also affecting mental health and making teamwork hard.

Potential Hazards: Interplanetary Travel vs. On-Surface Stay on Mars

During the trip to Mars, communication relies on large antennas in space and on Earth. If any part of that system does end up failing, messages could be delayed even more or they could potentially be completely out for a period of time. On the surface of Mars, signals may go through satellites orbiting the planet, which can possibly make communication more stable. However, this still does not remove the delay in time. Astronauts who are doing spacewalks must be able to handle such problems with equipment or environmental dangers right away, without waiting for instructions from Earth, generally based on the severity of the situation. (Dooling, 2024).

Solutions and Constraints

To reduce communication risks, astronauts must train heavily in independent decision-making. Simulations before actual launch should include and account for delayed-response scenarios to prepare crews for independent troubleshooting. Crews should also include members with cross-training in other areas like engineering, medical response, and

systems management to reduce dependence on Earth specialists. The implementation of advanced software onboard and decision-support systems can also possibly help with figuring out problems and suggesting solutions to take (Garcia, 2026). However, these systems do feature the constraints of requiring more power and maintenance, and further risks could come up if there is an overreliance on these systems and the software ends up failing.

Danger Assessment

With the three presented issues and among the three of them, the greatest immediate danger appears to be breathable air because it can threaten survival within minutes. When considering the other two presented problems with nutrition usually develop over weeks or months, and communication delays mainly affect decision-making and stress levels. However, air system failures directly impact oxygen supply and the removal of carbon dioxide, which are essential for life in both phases of transit and on Mars (Atkinson, 2024). For this reason, support reliability and the consideration of creating redundancy for more stable measures must be prioritized above all other systems.

Conclusion

Ultimately, a human mission that involves going to Mars requires careful planning when it comes to issues in relation to nutrition, breathable air, and communication delays. Each issue includes the potential to affect the health of the crew and mission success in various ways. Food can lose nutrients over time, and astronauts may not eat enough, so missions need long-lasting meals and supplements, but also health checks to prevent weakness. Air system failures can become dangerous very quickly, so strong life support systems and backup equipment in place are integral. Communication delays mean that astronauts cannot get instant help or connection from Earth, so they must be trained to solve problems on their own. For future missions, safety must always come first by using reliable systems, backup, and well-trained crews to reduce the risk

involved with these and beyond as much as possible (Chappell, 2024).

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Appendix

Public Announcement/Outreach Flyer

