Management

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**Executive Summary**

There is no doubt that the International Space Station (ISS) should continue with operations. Therefore, there is a need to review a range of vulnerabilities and consequences. Some of the risks faced by ISS include design characteristics and critical hardware that make it more vulnerable, premature abandonment, an inhabitable atmosphere, and the likelihood of a catastrophic collision. Efforts must be made to mitigate these risks and enhance the operations of the ISS program. Some of the recommendations include in-depth modeling and researching the MMOD environment, sound design practices, and regulating the quantities and types of toxic materials.

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# **Risk Management Report for Presentation to NASA International Partners and Key Stakeholders**

# Introduction and organizational overview

The International Space Station program (ISS) refers to an interwoven international partnership comprising of Canada, Russia, and the United States. There are about 16 countries that have forged a partnership or have been involved courtesy of the bilateral agreements with a partner in operating, building, and using the ISS. Other partners include the Japanese Aerospace Exploration Agency (JAXA) and the European Space Agency (ESA). The partnering countries and organizations bring in various contributions. For instance, NASA is actively involved in crew and logistics transportation, environmental control, and life support. ESA is actively involved in the Columbus Laboratory module and Autonomous Transfer Vehicle (ATV) (Coil et al., 2016). Russia has been actively involved in altitude maintenance and propulsion for attitude control, and airlock for performing spacewalks, among other contributions. Other partners also have different contributions in supporting the organization. As for some of the characteristics of the station, it has a living volume of about 15,000 cubic feet, and it weighs approximately 455,000 pounds (Coil et al., 2016). However, there exists a plan to expand it to about 33,200 cubic feet and 855000 pounds. The software and hardware are tested and developed worldwide and are operated and assembled at an altitude of about 215 nm (Allen, 2018).

There are potential risks associated with the project, along with mitigating actions to be taken. Various threats and vulnerabilities are likely to cause compromise of crew health, station destruction or make it possible for the premature abandonment of the ISS. There is a need to unravel some of these risks to develop an organizational disaster management plan. There is also a need to critically assess and evaluate the benefits and drawbacks of using a qualitative and quantitative risk matrix for classifying the various types of organizational risks. There is an in-depth assessment of the findings along with the recommendations. After reviewing the controls against the vulnerabilities, the recommendations are made, including operational controls, safety controls, and the design requirements.

# Risks faced by the ISS

There are detailed processes to assess the design characteristics and critical hardware and how they are supposed to contribute to the ISS's overall risk. The occurrence of hazards such as Shuttle Columbia led to several reviews such as original hazards and hardware assessments and the validation of the assumptions in tandem with existing historic hardware performance (Mora et al., 2016). Some of these measures have been put in place to increase system redundancy and increase system redundancy.

However, there is also a gap when it comes to the security compromise of the ground system. This is a threat to any computing network. A deliberate attack using the ground command system to issue commands to the ISS system is likely to lead to hazardous results. NASA requirements and procedures for the security of the information system require that only the National Security Agency (NSA) endorsed and approved encryption techniques and products are supposed to protect all the telecommunication and telemetry to the crewed aerospace vehicle (Mora et al., 2016). Despite these measures being put in place, there is still a likelihood that inadvertent critical command or the commands sent from a ground comptroller may lead to catastrophic results.

There is also the aspect of premature abandonment where the primary factors identified as the potential threats to premature abandonment will include the inability to maintain a pressurized environment, whereby the station crew members will be able to work safely. Other potential threats will include the inability to avail a habitable atmosphere, the loss of ground or MCC support, and the inability to maintain the major technical systems which are required for operation (Schlesinger et al., 2017).

An inhabitable atmosphere can be caused by various factors such as their contamination of the vehicle, the uncontrolled microbial growth in air or water, fire, or failures in the system that tends to control the level of Carbon (IV) Oxide or the delivery of Nitrogen and Oxygen (Coil et al., 2016). The aspects of humidity and temperature inside the modules are likely to cause the station to become unfavorable. The crew and payloads primarily cause microbial contamination. In any environment that is not sterile, a certain level of microbial growth is expected.

There are various primary factors that can be identified as potential threats to the crew and the station. For instance, there can be a catastrophic collision with the ISS by a visiting robotic arm or vehicle. An onboard fire can also emerge, which results in the loss of the crew life and the ISS vehicle. Experts have also weighed in on the possibility of having a toxic spill in the crew's habitable volume. Nevertheless, there also exists a threat of a deliberate attack of using ground assets to issue station commands that lead to a catastrophic condition. The design of the ISS can exhibit a hardware or software design flaw that may lead to crew or subsequent loss of the vehicle. Relating to the hardware again is the possibility of the MMOD penetration of the ISS pressure wall or other important hardware. These are threats that can be anticipated, and therefore measures can be put in place to minimize the potential of the threats occurring (Cooney, 2016).

There is likelihood of a major fault, which may lead to the loss of a critical function that is likely to lead to the premature abandonment of the ISS. This will interfere with the continuous operations of the critical functions of the station. Failure to maintain spares for the critical systems may impair the ongoing viability of the ISS vehicle (Coil et al., 2016).

# Organizational disaster management plan

A lot of work is supposed to be done to model and research the MMOD environment. This makes it possible for the program to be in a better position to identify the criteria that should be embraced for design and rationalize the level of risk from MMOD to ISS vehicle and the crew in general. The measure also makes it possible to incorporate the design solutions that are tailored towards addressing the problem. The visiting vehicle collision can be mitigated through a three-tiered approach to ensure the safety of the integrated operations with the visiting vehicles. This ought to be designed so that the first level ensures the visiting vehicles can dock to the ISS vehicle. An example of the safety requirements that can be embraced includes having independent collision avoidance maneuver functions. The second level is tailored towards establishing more protection against unexpected conditions through crew and ground command and monitoring. This is very important considering the fact that the crew and the ground exhibit different responsibilities for commanding and monitoring the visiting vehicle. Finally, the third level will require the demonstration of the important capabilities during its maiden flight to the ISS. Such well-constructed layers are likely to provide confidence tailored towards ensuring that the visiting vehicle exhibits a functioning design and that operational controls are implemented to prevent collision (Coil et al., 2016).

The risk of fire is mitigated through sound design practices. This entails a focus on specified material use and a judicious application and selection of the electronic, electrical, and electromechanical parts. The Russian and the U.S. smoke detectors located throughout the station serve as primary methods of fire detection. The portable oxygen masks should be put throughout the station, with carbon dioxide fire extinguishers (Voorhies et al., 2019). The system can be set in such a manner that when the detectors point towards a potential fire, the computers can turn off the cabin fans and stop the ventilation between the modules.

In maintaining a pressurized cabin environment, there is a need to ensure safety verification through load testing, stress analysis, and ensuring non-destructive evaluation of the risky structures. The pressurized modules, which will be launched, are supposed to go through post-test inspection and proof-pressure testing. Intensive module-level leak checks are supposed to be performed to ensure that the build modules meet the set requirements. There are various methods through which microbial growth can be controlled. There is a need to implement stringent measures that have been developed by the international body of experts for surfaces, water, and air that are supposed to be applied in the testing, design, and verification of the station (Voorhies et al., 2019).

The management plan for the toxic spills is by regulating the quantities and types of the toxic materials used on the ISS vehicle. Before the flight, every cargo is supposed to be evaluated to determine whether it contains materials, which are a toxicological threat. Toxic materials have been put into categories as threat 1, 2, and 3, whereby a material with threat level 1 may require one level of containment, while a material with threat level 2 or more will require more levels of containment (Harris and Simpson, 2016).

There are important that ensure continuous operations of the station's critical functions. They include system design and redundancy, maintenance capability, pre-flight testing, and a robust transportation system tailored towards supporting maintenance resupply requirements. Maintaining the spares for the critical system is essential to the ongoing viability of the ISS vehicle. Another remedy to the problem has to do with the assembly sequence planning. In this regard, the ISS assembly sequence is supposed to be designed to minimize the number of points where the system failure tolerance happens to be reduced as a result of any disconnections of power, data, or the thermal interfaces to install the new hardware. The strength of the system is supposed to be maintained through careful assembly sequence planning and ensuring the availability of the required support functions such as the EVA repair capabilities and the onboard hardware spares (Owens and de Weck, 2018). Careful assembly sequence planning manifests flexibility; in the long run, this provides the capability tailored towards restoring system fault tolerance in the event that failure occurs.

# Benefits and drawback of using a qualitative and quantitative risk matrix for classifying the various types of organizational risks

The risk matrix for quantitative and qualitative risk analysis analyses risks based on the likelihood, from rare to almost certain, and it takes into account the consequences and impact. It is an important decision-making tool that enables an organization to decide how various decisions will be made. For instance, high risks may require senior management notifications, while low risks can be handled through normal processes. However, the disadvantage is that the tool lacks details. Therefore, if it is used as the only method of evaluating risks, the chances are high that the intricacies of the hazard can be oversimplified. In this regard, it should only be used as a preliminary measure in the assessment of risks (Voorhies et al., 2019). The organization is stable, and measures are meant to find problems before they escalate to catastrophic levels.

# Recommendation and conclusion

The above plan stipulates most of the actions that are supposed to be taken as mitigation endeavors. For instance, the ISS program is supposed to prioritize risk reductions of MMOD. There is a need to implement and develop plans that are tailored towards maintaining ISS-critical skills. There should be efforts to monitor the service module windows for critical damage deliberately and be prepared to implement protection measures. Other recommendations include ensuring sound design practices, maintaining a pressurized cabin environment, regulating the quantities and types of the toxic materials, and upholding System design and redundancy, maintenance capability, pre-flight testing, and a robust transportation system, among other measures. All these are geared towards enhancing the operations of the ISS program.

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