Development and Application of Space Flight Performance Shaping Factors for Human Reliability Analysis

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A human space system must provide two primary functions with respect to its crew: protect the crew members; and use the crew members' capabilities. These are fundamental tenets of human rating a space vehicle, and designers must consider these functions in their candidate designs. They must manage both the risks that may cause harm to the crew members and the risks that may negatively impact crew members' abilities to perform their tasks.

The importance of crew performance during space missions is widely recognized, as the human ability to respond to new and dynamic situations depends on effective performance capabilities. This motivates the need to understand factors that influence performance so that factors with positive influences can be enhanced, and factors with negative influences can be minimized. Analysis of these factors and resulting performance within operational scenarios can lead to insights for improving current environmental conditions or future designs of mission elements such as the spacecraft and operations approach.

Methods exist for analyzing the reliability of human performance within the context of operational scenarios, and they are appropriately called Human Reliability Analysis methods. Most of the existing methods have their roots in nuclear power plant operations. While perhaps similar, the factors influencing performance used in these methods do not take into account the unique conditions of space flight. Therefore, this research identified factors that influence human performance of tasks during space missions and organized them into a functional hierarchy. Example factors include how a crew member's presence in microgravity causes physiological changes to occur, such as reduced aerobic capacity and bone strength. These changes can in turn alter the capability to perform a given task. Psychological and cognitive factors are also introduced from living in an isolated and confined environment, vehicle habitability factors, and high public interest and visibility. Research is aimed at incorporating these factors into a Human Reliability Analysis method, which can subsequently be included in a Probabilistic Risk Assessment for analyzing human space missions. This research is investigating approaches for quantifying the effects of these factors on reliability using existing human performance data from space and ground studies to inform the statistics. The ensuing analysis techniques can also help to define risk mitigation strategies, such as biomedical countermeasures, operational procedures, and crew training. The resultant design and/or operational solutions may then be considered for inclusion in the system.

Fig. 1. *Crew members perform tasks on the International Space Station.*

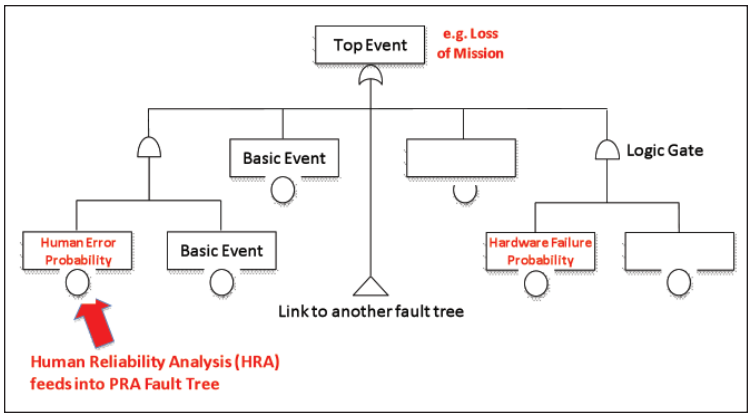

Fig. 2. *Human Reliability Analysis results inform Probabilistic Risk Assessment efforts.*