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**Abstact title**

A Structured Approach to Scenario Generation for the Design of Crew Decision Support Tools

**Abstract text**

Long-duration human space exploration mission is an honourable and exciting undertaking, however, it is challenging even for most technically trained and mentally prepared cosmo/astronauts. Communication delays will ensure that the crew cannot depend on the ground crew to support them in real-time. The crew will be required to operate the spacecraft semi-autonomously, while travelling through the hostile environment of space. They must independently resolve a broad range of safety-critical situations, some of which are likely to be unforeseen. Hence, there is a need for many different stakeholders, including but not limited to, mission planners, designers and human factors experts, to consider the range of safety-critical scenarios that crews might encounter before embarking on the detailed development of any system(s) that will support the crew of an exploration mission to other planets.

A range of experience and expertise can be used to guide the development of computer-based tools that will be used to support the crew on future space missions, including experience gained from failures in other safety-critical systems (Johnson, 2003). Additionally, the systems can be informed from experience gained on the ISS and Mir Space Stations (Manzey, et al, 1998; Kanas, et al, 2003). This ‘real world’ evidence helps to identify and refine hypothetical scenarios that can be systematically developed. This paper will describe the approach used to help elicit stakeholder discussion about these scenarios. First, techniques used to analyse contributing factors in previous system, failures and mitigating actions taken by crews and by ground teams are investigated; then how these insights can be used in the development of potential future scenarios and in the requirements definition for decision support and training tools for a future crew are investigated.

However, past experience is not enough to predict future challenges. Our approach, therefore also integrates the Psy-Matrix that was developed for the ESA project on Tools for Psychological Support in future Space Missions (Solodilova-Whiteley, 2007). This initial study used the matrix to map out a space of interacting factors. The Psy-Matrix is based on cross-referencing interacting factors that can create psychologically challenging situations during exploration missions. Similarly, the matrix for generation of scenarios in support of safety-critical system design can be generated through the following steps:

1. Analysis and understanding of factors that cause or can cause system failure during exploration missions.

2. Extraction of factors that cause system failure using relevant accident and incident data.

3. Supplementary factors are also generated using context-defining dimensions of the matrix (see Figure 1). These dimensions provide the necessary elements to model any potential situation, e.g. individual workload (i.e. substance), which is part of a larger hierarchical structure that happens in a specific place (i.e. space), and changes over time with information and energy input. These six dimensions are also suitable for describing both the essence of issues the crew will face and possible solutions.

This matrix system helps teams of different stakeholders to predict or forecast potential problem situations as well as providing a framework that can help to identify ways of resolving problems, including through the intervention of crew-decision support tools. This matrix is a first step in providing a methodological approach that can aid early-design processes for support tools for complex missions. The advantage of this classification is that it allows placement of potential situations, problems and solutions into the same framework.

Once the matrix is established the scenarios can be tailored for specific operations, for example:

• Orbital station operations;

• Crew transportation vehicle;

• Planetary surface habitat

It is also important to stress that this approach relies upon close interaction with a range of domain experts. The framework and matrix provides a forum for the exchange of information and ideas during the initial stages of development and planning for support tools against potential problem scenarios. This systematic and multi-disciplinary approach is important to find innovative solutions for the next generation of human-flight in space.

Johnson C (2003) Failure in Safety-Critical Systems: A Handbook of Accident and Incident Reporting, University of Glasgow Press, Scotland

Manzey D, Lorenz, Polyakov, V (1998) Mental performance in extreme environments: results from a performance monitoring study during a 438-day spaceflight. Ergonomics, 41: 537-559

Kanas N, Manzey D (2003) Space Psychology and Psychiatry, Kluwer Academic Publishers, ISBN 1-4020-1341-8

Solodilova-Whiteley I (2007) ESA Tools for Psychological Support for exploration missions to the Moon and Mars study (ESA 20257/06/NL/EK), SEA, UK

**Topics**

02 Safety on long duration manned missions

**Presentation Preference**

Oral

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