Interdisciplinary Solutions to Complex Problems: Going to Mars

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THE WORK IN CONTEXT

The notion of interdisciplinarity is inherent in the principles of human factors and ergonomics. HFE can be described as a multi-disciplinary, user-centric 'bundling science,' in that it applies theory, principles, and data from many relevant disciplines to the design of work systems, taking into account the complex interactions between the human and other humans, the external environment, tools and equipment, and technology to enhance human performance and well-being.

The mission to Mars is the ultimate opportunity to make a strong contribution with these three dimensions. First, this bold human exploration is human-centered and human habitability will be highly dependent upon the design of human-machine interfaces. Second, multiple areas of expertise will be needed to come up with a suitable design, requiring a systems approach rather than a singular focus. Finally, mission success and the welfare of those involved are both critically important for long duration and sustainable performance. The stakes are high. This presentation addresses how we can enhance the perceived value of HF/E by partnering with other disciplines to solve a critical organizational problem. We use the example of the Mars spacecraft habitat design to illustrate how HF/E and other disciplines can intersect to create a living, working and recreational space that supports astronaut health, wellbeing and performance.

KEYWORDS

Interdisciplinary, teams, space, macroergonomics

A brief outline of the work carried out

A combination of environmental, technological, psychosocial and team factors pose a significant risk for future long-duration space exploration missions. The planned mission to Mars will present challenges to crewmembers no one has experienced before. Factors such as insufficient volume, shared spaces, little to no privacy, living inside a machine (can), medical emergencies, logistics and space requirements for supplies all impact the success of the mission. Locating a spare part in a critical time to repair situation can be challenging and stressful. The crew's *physiological* well-being concerns include human body deconditioning, vision impairment, cardiovascular deconditioning, muscle atrophy, and bone loss. The crew's *psychological* well-being concerns include long-term isolation and confinement challenges, sleep disorders, radiation environment, work stressors, circadian rhythm disruptions, and cognitive disorders.

Psychosocial and team factors add to the risks. A vivid description of what lies ahead is provided by Salas and colleagues (2015):

> *Imagine living and working in a small, confined space with five other teammates*

for over a year. Your team needs to complete a series of scientific experiments and perform other rigorous tasks, eventually exploring a distant location in a dangerous, even life-threatening mission. If you are successful, you will then spend 6 months "commuting" home in the same confined quarters and challenging conditions. During this assignment, headquarters cannot provide you with quick advice or coaching, because there is up to 20-minute communication delay (one-way), but you still need to coordinate as a team with people back at headquarters. From a personal perspective, during these 2 to 3 years, you cannot see Earth, feel gravity, or spend time with your family. And if you or any of your teammates are having a bad day, you cannot simply go out for a walk or call in sick. (pp. 200-201).

Additionally, technology and automation will be rife in future space habitats. If poorly designed, they will contribute to frustration, degrade performance and potentially cause or exacerbate accidents and even social, emotional and cognitive breakdowns. On the other hand, some of the core psycho-social problems inherent in space travel and living may well be mitigated by technological interventions.

Findings/solutions (the outcome)

In this follow up to a panel discussion at the 2019 HFES meeting (USA), we examine how HF/E practice can enhance its effectiveness and perceived value by partnering with other disciplines to solve critical organizational problems. We use the example of the Mars spacecraft habitat design to illustrate how HF/E and other disciplines can intersect to create a living, working and recreational space that supports astronaut health, wellbeing and performance. We discuss habitat design from the perspective of team and psycho-social factors, how architectural and engineering factors affect astronauts' physiological and psychological well-being, and the role automation and technology will play in habitat functioning to satisfy basic human needs and keep astronauts safe and healthy. Finally, we discuss the role of HF/E in the design of suitable human interfaces and consideration of how all elements function together as an effective system.

Impact

HF/E plays a critical integrative, interdisciplinary role in creating a work/living system that meets all needs and is effective for keeping space crews alive, productive, and well.

Salas, E., Tannenbaum, S. I., Kozlowski, S. W. J., Miller, C. A., Mathieu, J. E., & Vessey, W. B. (2015). Teams in space exploration: A new frontier for the science of team effectiveness. *Current Directions in Psychological Science*, *24*(3), 200-207.