SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Systems and Infrastructures to Implement Future Building Blocks in Space Exploration and Development (2)

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RETHINKING SPACECRAFT HABITABILITY: THREE INNOVATIVE IDEAS TO FACE HUMAN FACTORS CHALLENGES IN LONG DURATION SPACE EXPLORATION MISSIONS TO MARS

Abstract

With the aim to pursuing the endeavor of human space exploration to Mars, the challenges related to reliable transportation, habitability and other critical capabilities are to be consistently met. Hence, the spacecraft systems engineering needs to be combined with the application of sound human factors principles, at a very early stage of the design project. Indeed, in extended duration missions, the crew will have to cope with unprecedented level of self-sufficiency along with a certain number of latent and overt stressors. The human-environment relationship is therefore of paramount importance in strengthening the crew's ability to perform their mission successfully and return safely to Earth.

In this context, the current paper rethinks spacecraft design with a human-centered approach. The main objective, indeed, is to create a travelling, working and living place where it is possible to maintain physiological homeostasis, psychosocial integrity and avoid sense deprivation. These conditions define the minimum sustainable level of habitability in order to face the main human factors challenges, such as the prolonged co-living and co-working in small groups, under conditions of confinement and isolation.

After an accurate analysis based on spacecraft usability, flexibility and livability, three innovative ideas on how to counteract the aforementioned challenges are discussed: modularity, interlocking design and a sensorial stimulation area. The paper shows that the concept of modularity facilitates recovery of up to 15.3% of the spacecraft habitable volume, by making use of intelligent and transformable environments while respecting the structural constraints. Additionally, the use of the interlocking design is presented. Given the positive impact of the environmental variability, flexible usage, and personalization on unforeseen social and mission related changes, this new concept helps to customize elements of the environment and to rearrange crew's personal habitat. Furthermore, in order to recall normal physical and psychological earthly conditions, the design of a dedicated area for sensorial stimulation is considered. Finally, a special emphasis is put on the benefits of fostering crew's imagination by encouraging artistic and recreational activities. The use of some design artifices such as interactive screens, mirrors and interchangeable walls are proposed to improve the crew's perception of space, along with a new concept for the cupola to counteract the Earth out of view phenomenon.

In conclusion, in order to test the discussed concepts in a relevant environment, this paper suggests the use of space analogues. This will allow refinement of the human-centered design, helping prepare missions to Mars.