The Human Factors of Additive Manufacturing on Human Extra-Terrestrial Missions

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Introduction
Additive manufacturing technologies have been successfully implemented in the concept designs for human interplanetary missions for some years. They not only play an important role in the designs of future-extra-terrestrial habitats, but the benefits of 3D printing have already been successfully tested on the International Space Station (ISS). [1] However, while such studies of in-situ manufacturing techniques concentrate heavily on applications in the area of engineering or on the potential of 3D printing sustenance, they regretfully neglect to explore the potential benefits additive manufacturing could have for the Human Factors of space exploration. [1, 2]

Based on experiments during a lunar simulation at the Hawai`i Space Exploration Analog and Simulations (HI-SEAS) habitat, this paper investigates how additive manufacturing can improve liveability in a space habitat.

Personal objects and leisure time items are indispensable for manned space exploration, as they greatly contribute to the astronauts’ mental health and psychosocial balance. Access to a 3D printer bears the potential of a much greater flexibility and variety in personal items, and could also offer the possibility to customize leisure objects to specific needs and moods of astronauts. In addition, through the limited payloads and possibilities of recycling everyday objects, additive manufacturing technology offers the opportunity to greatly enhance the sustainability of any human extra-terrestrial mission.

Methodology
In December 2019 the European Space Agency’s (ESA) EuroMoonMars (EMM) and International Lunar Exploration Working Group (ILEWG) initiated an analog astronaut simulation in cooperation with the International MoonBase Alliance (IMA). During this mission (EMMIHS-II - EuroMoonMars IMA HI-SEAS) the Human Factors of Additive Manufacturing Study was conducted as a basis for this paper. Psychological effects, changes in mood and work effectiveness, and the possibility to
create and maintain a connection to Earth by 3D printing seasonal objects and decorations, were assessed.

The study delivered positive results about the use of additive manufacturing from a Human Factors point of view, as well as the confirmation of the use in engineering. The results open up the possibilities for further studies of the Human Factors of additive manufacturing during future analog simulations.

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