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3D PRINTING RECYCLABLE SPACEWEAR ON MARS: EQUIVALENT SYSTEM MASS TRADEOFF WITH TRADITIONAL TECHNIQUES

Abstract

Spacewear is a crucial factor in human space exploration and strongly impacts present capabilities and future perspectives. Special attention will have to be addressed to these aspects when considering future human permanent settlements on other celestial bodies. Present day manned programs, like the International Space Station (ISS), mainly rely on expendable clothes, heavily contributing to mass and volume budgets of the mission. Conventional washing can largely extend clothes life at the cost of high water consumption. Alternative sanitation techniques currently under investigation, on the other side, are showing higher level of complexity and clothing wearout. In the present paper the possibility of 3D-printing recyclable spacewear on Mars surface to support crew life and activities is assessed. Using 3D-printing unlocks new capabilities that are not provided by traditional technologies: to adapt garments to crew size and needs, to tune physical properties and to unlock unprecedented design opportunities. On top of this, the utilisation of recyclable materials extends clothes lifespan and introduces further advantages, like the opportunity to repair clothes or to transform useless garments into more needed ones. Such a system can also reveal highly compatible with future EVA suits design and manufacturing. A preliminary tradeoff for a ten years mission between disposable clothing, traditional washing and drying and a 3D printing system is presented, based on the Equivalent System Mass concept. The model includes a recycling unit integrated to the 3D printer. Latest advancement in clothes 3D printing on Earth and on ISS were used as a reference. Results obtained show how 3D printing can reach a break-even point against disposable clothes 50% earlier than washing machines, even with higher materials degradation. This is mainly due to net mass and water savings, along with increased flexibility, autonomy and optimization of clothing management strategies. These findings demonstrate how 3D printing of recyclable spacewear can reveal a promising technique in enabling human Mars exploration and in advancing life support technology.