Off-World Additive Manufacturing - A Path Towards Sustainable Mars Exploration

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Abstract

Within the past century, the notion of potential human settlement on Mars has been a topic of interest for many, whether it be in academic, economic, political, or social circles. The drive for such an ambitious goal stems from the belief that if multi-planet settlements can be established, then the likelihood of human extinction (due to planetary threats, such as meteors, climate change, and natural pandemics) can effectively be reduced. To achieve successful colonization, various advanced spacecrafts and structures must be sustainably utilized. However, the potential issue of mechanical part failure due to irreversible damage in the forms of mechanical stresses, corrosion, and thermal degradation occurs during space flights. Such damage can span from engines, heat exchangers, or even basic gears and bearings. Given the high reliance of on-earth manufacturing, repairing such structures presents a unique and challenging roadblock not only for the goal of successful settlement but also for the safety of those involved. As such, there is a critical need to sustainably fix and manufacture new components, anywhere, anytime. Although a solution to such an intricate appearing problem might seem complex, the answer is simpler than you think. This work will discuss this answer and explicate how groundbreaking portable 3D additive manufacturing (AM) technologies are a viable solution to these issues. Particularly, the feasibility of these novel innovative AM technologies for rapid and flexible repairs, as well as the utilization of surface modification techniques to improve their degradation resistance will be presented. Based on the findings, it was found that AM technologies combined with post-surface processing techniques are indeed a viable technique for rapid and degradation-resistant component repair/fabrication. Collectively, the implication of such findings will give a practical and useful direction for sustainable Mars exploration in the near future.