Paper ID: 83446
student

22nd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Interactive Presentations - 22nd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (IP)

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REVOLUTIONIZING SPACE EXPLORATION : TRENDS AND CHALLENGES IN 3D PRINTING TECHNOLOGY

Abstract

3D printing technology has been widely used to produce 3D objects through additive processing methods using various materials in aerospace, medical, and automobile fields. Among them, 3D printing technology is particularly noteworthy in the space field for the following reasons.; (1) It enables the manufacture of structures too large for conventional spacecraft. (2) It reduces the costs and energy associated with transporting materials and manufacturing space vehicles by allowing in-suit production of necessary items and, (3) it speeds up the maintenance and upgrading of space vehicles by cutting down the time needed to transport materials form Earth. A notable instance occurred, in January 2024 when the European Space Agency (ESA) dispatched the world's first metallic 3D printer to the International Space Station (ISS) to assist in field manufacturing, repairs, and sustainable space missions. This initiative aims to assess the impact of the space environment on the printing process and performance by comparing the printed materials produced using metallic 3D printers with reference printed materials made on Earth. Transporting raw materials into space incurs a lot of costs and the unique challenges of the space environment such as low gravity and significant temperature fluctuations, necessitate automated construction methods. Accordingly, NASA demonstrated a technology under the Artemis program to convert dust particles on the moon's surface into solid structure a through a 3D printer build a lunar base in 2030. In this paper, we aim to explore the trends of 3D printing technology in the field of space technology and summarize the research and development cases by type and use of current 3D printing technology. Furthermore, we will derive technical challenges that 3D printing could address in space exploration.