Problems with In-Space Additive Manufacturing

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In-space manufacturing is vital to long duration space missions [1-4], it is required to ensure mission continuity when resupply becomes impossible [3, 4] such as on a journey to Mars. With pre-emptive spare parts for the ISS costing $1.241 billion [5] there is also potential for substantial cost savings if parts can be manufactured on demand in-space, using material-only inventory transport costs can also be dramatically reduced [6]. Additive manufacturing is presented as a solution to these issues, particularly as low-waste processes are essential [4].

The microgravity environment causes significant challenges and opportunities for additive manufacturing. Successful terrestrial processes, such as powder bed fusion methods become extremely challenging due to the difficulty of powder containment in microgravity [4]. Many additive manufacturing methods have not been proven for space applications without considerable post-processing, even when operating on Earth. Post-processing and quality assurance are essential in conventional manufacturing, however with limited human involvement these processes will need to be significantly automated to be successful [4]. A lack of convective heat flow in microgravity will also mean systems must be adapted to suit, microstructures will develop differently, particularly as microgravity has direct effects on microstructural segregation [6].

Further considerations include designing systems which are capable of operating within the strict limitations on infrastructure, such as power, mass and data transfer [7]. There are also areas for new manufacturing methods, including depositing materials regardless of orientation [7] and producing parts which do not need to withstand their own weight. An additional opportunity is that parts will not need to survive the demanding environment of launch, meaning the mechanical properties of such parts can be reduced. The presentation will explore these problems and opportunities in technical detail, particularly with consideration to laser processes including laser direct energy deposition and selective laser melting.

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