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Author: Mr. Zak Wilson
United States

UTILITY OF ADDITIVE MANUFACTURING ON MARTIAN ANALOGS AND MANNED MARS MISSIONS

Abstract

The potential utility of additive manufacturing was explored during an 8 month Mars analog mission at the HI-SEAS (Hawaii Space Exploration Analog and Simulation) habitat.

A manufacturing capability is critical to a successful Mars mission. Breakdowns of important equipment are inevitable. The ability to manufacture replacement parts can reduce the number of spares required and therefore the cost of the mission. Unanticipated problems over the course of a long mission will require improvised solutions. A flexible manufacturing method like additive manufacturing allows the greatest variety of parts to be produced from the minimum of raw materials and equipment.

During the course of HI-SEAS mission 3 more than 730 individual pieces were made, mostly based on the 60 or so parts designed by crew members. About 2/3 of these were practical parts (e.g. habitat repair/improvement, tools, scientific instruments) while the remaining 1/3 were fun parts (e.g. toys, presents for crew members, parts for games). In addition to the practical upsides there were less tangible benefits as well. Life during the mission was quite predictable, surprises tended to be generally negative (e.g systems breaking or not working properly). Especially during travel to and from Mars, monotony, boredom and depression have the potential to reduce team effectiveness/preparedness. The ability to manufacture presents and fun items (including ones made from digital files sent by family and friends on Earth) have the potential to increase moral. The ability to manufacture parts provided the crew with a sense of independence and satisfaction.

The manufacturing was done on a consumer level fused deposition modeling type machine that uses a few types of plastic (e.g ABS, nylon, PET and PLA). While these materials were useful in a Mars analog they aren't well suited to either the vacuum of space or the environment of the Martian surface due to extreme temperatures and low pressures. There are other types of 3D printers, like selective laser sintering, that can make parts out metal powders which might be more appropriate.

There are few characteristics that make 3D printers well suited to this particular use. They produce minimal waste when compared to traditional subtractive manufacturing. The raw materials they require (generally filament, powder or pellets) tend to be easier to produce than the material required for subtractive manufacturing (larger blocks) as well, meaning local production or recycling of unneeded parts is more feasible.