A Bootstrap Approach to Martian Manufacturing

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In-Situ Resource Utilization (ISRU) is an essential element of any affordable strategy for a sustained human presence on Mars. Ideally, Martian habitats would be extremely massive to allow plenty of room to comfortably live and work, as well as to protect the occupants from the environment. Moreover, transportation and power generation systems would also require significant mass if affordable.

For our approach to ISRU, we use the industrialization of the U.S. as a metaphor. The 19th century started with small blacksmith shops and ended with massive steel mills primarily accomplished by blacksmiths increasing their production capacity and product size to create larger shops, which produced small mills, which produced the large steel mills that industrialized the country. Most of the mass of a steel mill is comprised of steel in simple shapes, which are produced and repaired with few pieces of equipment also mostly made of steel in basic shapes. Due to this simplicity, we expect that the 19th century manufacturing growth can be repeated on Mars in the 21st century using robots as the primary labor force.

We suggest a “bootstrap” approach to manufacturing on Mars that uses a “seed” manufacturing system that uses regolith to create major structural components and spare parts. The regolith would be melted, foamed, and sintered as needed to fabricate parts using casting and solid freeform fabrication techniques. Complex components, such as electronics, would be brought from Earth and integrated as needed. These parts would be assembled to create additional manufacturing systems, which can be both more capable and higher capacity. These subsequent manufacturing systems could refine vast amounts of raw materials to create large components, as well as assemble equipment, habitats, pressure vessels, cranes, pipelines, railways, trains, power generation stations, and other facilities needed to economically maintain a sustained human presence on Mars.