The objective of this subtopic is to develop technologies that can support the goal of significantly reducing the mass and volume of material required to support long-duration human spaceflight missions. Eventually, as the distance of mission destinations increases, resupply will become impossible. Therefore, unless support materials are prepositioned, it will be necessary for all required materials to be transported with the crew. The difficulty presented by this situation is compounded by the need for more material as mission duration increases. Capabilities to address these issues should be developed and demonstrated in conjunction with long duration lunar missions and, as they reach sufficient maturity, will be valuable enhancements to these missions.

This subtopic seeks proposals addressing maintenance and repair technologies that enable repair of failed hardware at all levels, technology that supports the production of replacement components during a mission, and technologies that reduce the quantity of material directly supporting the crew. Proposals are sought which address the following technology needs:

- **Real-time, non-destructive evaluation during layer-additive processing for on-the-fly quality control.** This will provide capabilities for in-process quality control and may serve as an input for closed-loop process control. Equipment should be portable, compact, and capable of integration with layer-additive manufacturing systems.

- **Non-destructive material property determination.** This will provide an in-process quality control capability to ensure that material deposited during layer-additive processing meets required material property criteria. Equipment should be portable, compact, and capable of integration with layer-additive manufacturing systems.

- **Recycling/generation of feedstock materials for deposition processes.** This will provide the capability to recycle failed parts and material removed from near-net-shape parts during machining operations to serve as feedstock material for subsequent layer-additive manufacturing. Initial focus should be placed on metallic materials. Additionally, emphasis should be placed on total system mass and volume.

- **Compact, portable multi-axis machining systems.** This will provide subtractive manufacturing capabilities to achieve final design dimensions and surface finishes following layer-additive processes that produce near-
net-shape parts. Equipment to accomplish this should be of the minimum mass and volume possible while still providing required capabilities.

- Compact, portable, vacuum-compatible multi-axis manipulator. This will provide the capability for complex manipulation of the item itself, the processing equipment, or both during layer-additive manufacturing and machining. To be compatible with the widest variety of candidate processes, manipulation equipment should be vacuum compatible. Additionally, equipment to accomplish this should be of the minimum mass and volume possible while still providing required capabilities.

Rapid manufacturing processes have advanced rapidly in recent decades. The technology has gone from a means of quickly producing models to a means of quickly producing usable hardware. NASA seeks technology improvements which extend the efficiency of rapid manufacturing and improve the properties of resulting components. NASA also seeks to identify different applications that will highlight the capabilities of rapid manufacturing in support of the Vision of Space Exploration and potential commercial applications. NASA also seeks technology focused on integration of rapid manufacturing, computer numerical control, coordinate measuring machines, Robotics and Digital Manufacturing and Simulations technologies. This technology should be focused on an autonomous system where the parts fabricated in rapid manufacturing can be positioned for machining on critical surfaces, then positioned for measurements and inspections and ultimate delivery (independently and remotely). The results should be an autonomous system where these technologies are integrated as modules to produce the end result.