NASA STTR 2018 Phase I Solicitation

T7.01 Advanced Bioreactor Development for In Situ Microbial Manufacturing

Lead Center: ARC

Technology Area: TA7 Human Exploration Destination Systems

NASA's future long-duration missions require a high degree of materials recovery and recycling as well as the ability to manufacture required mission resources in situ. While physico-chemical methods offer potential advantages for the production of many products, biological systems are able to manufacture a wide range of materials that are not yet possible with abiotic systems.Â Microbial systems are currently being developed by academic institutions, industry, and government agencies to produce a wide array of products that are applicable to space missions.Â Relevant mission resources include, but are not limited to, food, nutrients, pharmaceuticals, polymers, fuels and various chemicals.

While current space-based research involves engineering of organisms to produce targeted compounds as well as the in-situ production of microbial media to support larger scale operations, additional enabling research is needed to develop specialized bioreactors that are highly efficient, reliable, low volume and mass, and that otherwise meet the unique rigors of space.

Advanced bioreactor research and development has been primarily focused on terrestrial applications, particularly pharmaceutical, food and chemical production systems. Some space bioreactor work regarding flight experiments and life support applications has been conducted, such as algal reactors for CO_2/O_2 management.Â However, little to no effort has been conducted on the bioreactor design and operations that are required to enable in-situ microbial manufacturing. Therefore, innovations are sought to provide:

- Bioreactors that minimize mass, power and volume, maintenance, process inputs and waste production.
- Bioreactors that are capable of operating on the surface of Mars or potentially in-flight scenarios.
- Bioreactors that incorporate novel microbial biomass separation/harvesting/purification methods, materials recycling/recovery and ease of cleaning.
- High-density bioreactors that are capable of producing extremely high levels of microbial biomass and/or product.
- Advanced bioreactor monitoring and control systems, including oxygen, temperature, pH, nutrients.
- Experimental bioreactors that exhibit the ability to scale upwards.
- Bioreactors that maximize reliability, component miniaturization, materials handling ability, gas management and overall performance.

Overall, proposals should focus on advancing bioreactor development for space applications, rather than the production of a particular product or microorganism. The Phase I STTR deliverable should include a Final Report that captures any scientific results and processes as well as details on the technology identified. The Final Report should also include a Feasibility Study which defines the current technology readiness level and proposes the maturation path for further evolution of the system.Â Opportunities for commercial and government infusion should

be addressed. Other potential deliverables include bioreactor system designs, hardware components and prototypes, and system control approaches and software.