NASA SBIR 2016 Phase I Solicitation

H3.02 Environmental Control and Life Support for Spacecraft and Habitats

Lead Center: ARC

Participating Center(s): GRC, JSC, KSC, MSFC

Solutions and innovations are needed for technology that supports the mass- and energy-efficient maintenance of closed air, water, and waste systems in spacecraft habitats that operate on planetary surfaces such as Mars and that operate in the microgravity environment of space. Three specific focus areas have been identified:

New Applications of the Heat Melt Compactor for Contaminant Control and Waste Management

NASA is seeking new uses for the Heat Melt Compactor (HMC) to extend its capabilities as a multipurpose/multiuse platform with a focus on addressing the needs for Mars surface and planetary protection. These may include:

- Membrane bags and/or liner inserts to initially contain unprocessed trash and other wastes within the compactor chamber but that will allow water and gas to pass through during processing. The bags/liners can melt at process temperatures >120° C but upon cooling must encapsulate the solid dry trash and waste for long-term stable storage. The encapsulation of the processed final product should prevent inoculation by external microorganisms.
- Methods and supporting hardware, including consumables such as membrane bags and/or liner inserts, for safe drying, sterilization and compaction of feces, which allow for water to pass through during processing.
- Methods and supporting hardware, including consumables such as membrane bags and/or liner inserts, for safely recovering water from urine and wastewater brines.
- Design and demonstration of a modular subsystem that uses the existing functional capabilities of the HMC as an autoclave.

New applications of the HMC are not to be limited to the above aforementioned areas, as new and innovative uses for the HMC are welcome. Other considerations are the benefits that can arise from recycling and reutilization of materials from the trash and waste, and the recovery of useful resources such as water and oxygen. The system must work in the Mars gravity environment with micro-gravity operation highly desirable.

A detailed description of the HMC can be found in technical paper number ICES-2014-24, entitled “Generation 2 Heat Melt Compactor Development,” authored by Mark Turner, John Fisher and Greg Pace, 44th International Conference on Environmental Systems, 13-17 July 2014, Tucson, Arizona. The paper is available at the following link: (http://repositories.tdl.org/ttu-ir/handle/2346/59662). The HMC was primarily designed to compact and sterilize bulk trash and waste into a reduced volume, stable and sterile hard tile that is impregnated and encapsulated with plastics from the trash. The HMC consists of a nine inch wide cubic chamber (729 cu in) which can be heated to 180 C. Gas pressure in the chamber is controllable between 3 and 14 psia. A ram at one end of the chamber can create compression loads on materials within the chamber from 2000 to 4000 lb force. The downstream effluent processing system can collect approximately 200 ml of water per hour and oxidize noxious/toxic gases that evolve from processed materials.

Cleaning Agents and Physicochemical Treatments for Habitat Housekeeping and Laundering Clothes

Crew contact surfaces (hand rails, Velcro, acoustic blankets, racks) and food contact surfaces (utensils, table surfaces) are currently cleaned with pre-moistened wipes that are consumable intensive. A mechanism for the in-situ generation of cleaning/sanitizing solutions is needed that will enable these solutions to be applied to reusable fiber based wipes to remove particulate, food, and body oil soiling of surfaces. Solutions must be effective against a range of microbial organisms; their effectiveness against representative organisms must include, but is not limited to, food based bacteria, iodine resistant bacteria, and fecal coliform bacteria. Specific challenges include direct crew contact with cleaning/sanitizing solutions and direct off-gassing and accumulation of solutions in cabin atmosphere. Technologies that can reliably generate, provide short term storage, and dispense cleaning solutions are desired. Prepackaged cleaning solution wipe technologies are not requested.

There is currently no space based laundry technology. Traditional laundry surfactants combined with water and substantial agitation can return clothing to near original condition. However, used surfactants result in a substantial organic contaminant burden on downstream wastewater processors. Future space laundry or refreshing systems will not be required to fully restore clothing to its original condition but should enable clothing to be reused a number of times. Current clothing materials include cotton, poly blends, wool, modacrylic, elastic bands, metallic zippers, metallic snaps, Velcro®, Nomex®, Gore-Tex®, and will likely expand to include fabrics present in many current athletic garments. Generation of cleaning solutions or gases for refreshing/sanitizing clothing are needed that address particulate/dander, salts, body oils (such as squaleneor other representative compound), and bacteria that cause odors (including Staphylococcus epidermidis and Pseudomonas aeruginosa). Specific challenges include capability to adequately disperse cleansing solutions through a wide range of fibers and materials, minimize mineral and organic load to wastewater processors, and minimal foam generation. Processes are desired that can recover unused cleaning solution or regenerate >70% of consumables. This request is not specifically for the laundry/sanitation device that interacts with the garments. The capabilities of the future laundry device would provide ability to agitate, partially remove liquids, and garment drying. Use of fabric brighteners, fragrances, pearlizers, and other aesthetic compounds are undesirable.

Surface treatments that limit biofilm and scaling within water processing system plumbing lines

NASA is seeking technologies or surface treatments that limit biofilm and scaling within water processing system plumbing lines. Both laboratory and flight systems have shown a strong tendency towards biofilm formation and occlusion in wastewater collection systems, particularly small diameter plumbing (3-13 mm internal diameter). Accumulation and sloughing of biofilm increases pressure drop, reduces flow rate, and can cause blockage or premature component change out within wastewater piping. Prevention technologies are sought that will limit microbial growth in piping and water recovery system components for up five years but short timeframes are also useful. Periodic inactivation or remediation technologies that use introduced compounds should be capable of being generated in-situ or recovered after use to minimize consumables.   Specific challenges include high microbial and total organic carbon loads. Technologies should be effective for wastewater typical of the International Space Station (urine and humidity condensate) as well as exploration ersatz body hygiene wastewater (see “Advanced Life Support Baseline Values and Assumptions Document”, NASA/CR-2004-208941, available at the following link: (http://ston.jsc.nasa.gov/collections/TRS/_techrep/CR-2004-208941.pdf)). Proposed solutions should demonstrate compatibility with ISS type water processors, an ability to protect the wastewater system for a long quiescent period in a clean state, and the ability to withstand intermittent exposure to wastewater followed by additional quiescent periods.

Additional information on NASA needs can be found in draft 2015 NASA Technology Roadmaps including but not limited to sections TA06 6.1.4.1, TA06 6.1.3.3, TA06 6.1.4.6, TA06 6.1.4.8, and TA07 7.5.2.3. These roadmaps are available at the following link: (http://www.nasa.gov/offices/oct/home/roadmaps/index.html).