NASA SBIR 2004 Phase I Solicitation

B3.06 Waste and Water Processing for Spacecraft Advanced Life Support

Lead Center: JSC

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

Regenerative closed-loop life-support systems will be essential to enable human planetary exploration. Efforts are currently focused on missions ranging from a return to the Moon and through an initial Mars mission, including using the International Space Station as a test bed for research and technology validation. These future life-support systems must provide additional mass balance closure to further reduce logistics requirements and to promote self-sufficiency. Requirements include safe operability in micro- and partial-gravity, ambient and reduced-pressure environments, high reliability, minimal use of expendables, ease of maintenance, and low-system volume, mass, and power. Recovery of useful resources from liquid and solid wastes will be essential. Innovative, efficient, practical concepts are needed in all areas of resource recovery processes, providing the basic life-support functions of water reclamation and waste management. In addition to these long-duration space applications, innovative regenerative life-support approaches that could have terrestrial application are encouraged. Phase-I proof of concept should lead to Phase-II hardware development that could be integrated into a life-support system test bed. Proposals should include estimates for power, volume, mass, logistics, and crew time requirements as they relate to the technology concepts. More information on advanced life support systems can be found at http://advlifesupport.jsc.nasa.gov. Areas in which innovations are solicited in the following areas:

Water Reclamation

Efficient, direct treatment of wastewater consisting of urine, wash water, and condensates, to produce potable and hygienic waters.

- Physicochemical methods for primary treatment to reduce the total organic carbon concentration of the wastewater from 1000 mg/L to less than 50 mg/L and/or the total dissolved solids from 1000 mg/L to less than 100 mg/L.

- Post-treatment methods to reduce total organic carbon from 100 mg/L to less than 0.25 mg/L in the presence of 50 mg/L bicarbonate ions, 25 mg/L ammonium ions and 25 ppm other inorganic ions.

- Methods for the phase separation of solids, gases, and liquids in a microgravity environment that are insensitive to fouling mechanisms.

- Methods for the treatment of brine solutions including water recovery.
• Methods to eliminate or manage solids precipitation in wastewater lines.

• Disinfection technologies, both for potable water storage and point-of-use. Development of residual disinfectants that can be consumed by crewpersons. Techniques to minimize or eliminate biofilm or microbial contamination from potable water systems and water treatment systems, including fluid handling components such as pipes, tanks, flow meters, check valves, regulators, etc.

Solid Waste Management

Concepts and methods to safely and effectively manage wastes for all future human space missions are required to perform the following functions: acceptance/collection, transport, storage, processing, disposal, and associated monitoring and control. Actual types and quantities of wastes generated during missions are highly mission dependent. For sizing purposes, however, the "maximum" waste streams have been estimated as follows, based on a 6-person crew: trash (0.56 kg/day), food packaging (7.91 kg/day), human fecal wastes (0.72 kg/day dry, 3.0 kg/day wet), inedible plant biomass (2.25 kg/day), paper (1.16 kg/day), tape (0.25 kg/day), filters (0.33 kg/day), water recovery brine concentrates (3.54 kg/day), clothing (3.6 kg/day), and hygiene wipes (1.0 kg/day). Wastes can also be assumed to be source-separated because this requirement has been identified for a majority of waste processing equipment:

• Microgravity- and hypogravity-compatible solid waste management technologies;

• Volume reduction of wet and dry solid wastes;

• Small and compact fecal treatment and/or collection system;

• Water recovery from wet wastes (including human fecal wastes, food packaging, brines, etc.);

• Stabilization, sterilization, and/or microbial control technologies to minimize or eliminate biological hazards associated with waste;

• Storage devices needed for the containment of solid waste that incorporates an odor abatement technology.

• Microgravity-compatible technologies for the jettison of solid wastes in space; and

• Other novel waste management technologies for storage, transport, processing, resource recovery, and disposal that satisfy a critical need for the referenced missions (e.g., recovery of critical resources).

Component Technologies

Energy efficient, low mass, low noise, low vibration or vibration isolating, fail-safe and reliable components for handling fluids, slurries and/or solids applicable to wastewater treatment and solid waste management. Components include actuators, pumps, conveyors, compressors, coolers, tubing, tanks, bins, fittings, couplings, quick disconnects, and valves which operate under varied levels of gravity, pressure, and vacuum. Mass flow monitoring and control devices that have similar attributes and that are easily calibrated and serviced.