NASA SBIR 2017 Phase I Solicitation

H3.04 Logistics Reduction

Lead Center: JSC

Participating Center(s): ARC, LaRC

Technology Area: TA6 Human Health, Life Support and Habitation Systems

All human space missions, regardless of destination, require significant logistical mass and volume that is directly proportional to mission duration. As our exploration missions increase in distance and duration, logistics reduction becomes even more important since they may need to be pre-deployed 2-5 years before a crew arrives. Reducing the initial mass and volume of supplies, or reusing items that have been launched, will be very valuable. Logistics unique to a spacecraft system (i.e., life support and propulsion) are not addressed by this subtopic and are not requested. Three of the largest logistics consumables are the logistical packaging (e.g., cargo bags, foam, retention straps, and cargo support pallets), clothing, and food. Approximately 1,000 cargo bags (0.053 m3 each) may be required for a Mars mission's logistics. Cargo is typically packed in foam, placed in a bag, and strapped to the vehicle or a cargo pallet/structure in the vehicle. Clothing is currently disposed of on the Space Station when it becomes too dirty to wear because there is no way to clean it. Food nutritional content and quality decreases over time and depends on the specific nutrients, food matrix, food packaging, and storage environment. Food may need to be stored up to five years before consumption, and maintaining stable nutrition is a significant challenge. Reductions in food mass, nutrient studies, and nutrient generation are not requested as part of this subtopic. All proposals should consider maintainability as well as dormancy periods without crew.

Vehicle Level Cold/Alternate Atmosphere Food Storage

Innovative use of materials, insulation, and heat removal systems are requested. Standalone systems as well as innovative approaches integrated into portions of the vehicle structure and thermal loops are acceptable. One method of increasing food nutrient shelf-life is with cold stowage and/or alternate atmospheres (i.e., low oxygen composition). Stored food volumes of 2-8 m^3, with average packaged food density of 250-500 kg/m^3, may be required at temperature ranges of -80° to +20°C. Oxygen levels <21% and food compartment pressures less than one atmosphere are being studied for their effects. Ability to control the atmosphere and pressure in the cold stowage volume is beneficial but is not required of a submitted technology, nor is the full temperature range listed above required. Systems must be capable of surviving launch loads (6g axial and 2g lateral) when fully loaded and be capable of autonomous operation for up to five years in microgravity. Concepts must be volumetrically efficient, mass efficient, and highly reliable since loss of food quality can result in loss of crew performance. The advantages of proposed concepts compared to the ISS Refrigerator/Freezer Rack (RFR) and terrestrial high efficiency freezers must be described. The ISS RFR, which never flew but achieved temperatures of -22°C and +4°C in freezer and refrigerator modes, had a secondary mass penalty of 1.36 kg for every 1 kg of food due to cabinet, drawers, insulation, cooling system and rack masses. (NASA/TP-2015–218570) The goal is to lower this secondary mass penalty for cold stowage below 0.2 kg per 1 kg of food. For long term storage of food, drawers are not required. At the same time, the refrigeration and insulation systems should be efficient enough to run (at steady state) on less than 0.15 Watts per kg of food frozen at -22°C in a 23°C ambient.

Alternative Launch Packaging of Logistics and Cargo

Alternatives to the existing ISS use of Cargo Transfer Bags (CTBs), foam, straps, and cargo pallets is required. Cargo densities of 510 kg/m3 (single CTB capability) must be supported during launch acceleration of 6g axial and 2g lateral. Total packaging mass efficiencies of all required materials between the cargo and the vehicle pressure shell structure should be less than 0.3 kg packaging/kg of cargo. Concepts should be capable of scaling between logistics vehicles with diameters of 3-8 meters and lengths of 4-10 meters. Logistics vehicle atmospheric pressure may vary from 0-1 atm for launch and 0.5-1 atm during crew use.

Innovative Crew Clothing Systems to Extend Duration of Wear

Innovative systems that refresh crew clothing to extend the duration of wear are requested. Crew exercise clothing, for example, is currently discarded into the trash after 2-3 uses because there are no space laundry systems. The goal is to extend the duration of wear by 2-3 times or more for several types of garments. Systems must be capable of sanitizing/refreshing a small set of crew clothing that includes exercise t-shirts, exercise socks, exercise shorts, male and female undergarments, and male and female daily wear, such as crew polo shirts. The system should provide odor control while preserving the appearance, color and brightness, and the physical and mechanical properties of the fabrics, which include cotton, wool and modacrylic. Odor control can be through absorption, adsorption, denaturation, or neutralization of pH and odorous compounds, etc. Innovative use of technologies, such as ultraviolet light, microwaves, vacuum, ozone, steam, CO_2, charcoal filtration, minimal water, or other technologies will be considered. The crew clothing sanitizing/refreshing system must be capable of operating for a minimum of 3 years in microgravity with minimal consumables, crew time requirement and electrical power. Cleaning/washing agent should be limited to less than 10 grams of consumables per kg of crew clothing for each refresh. No water or extremely low water usage systems are preferred, but if water is used, water usage should be less than 200 grams per kg of clothing washed. No hazardous gases or particles can be released into the crew atmosphere during or after operation. Concepts must be volumetrically efficient, mass efficient, not adversely impact the closed loop life support systems, and be highly reliable. Cleaning/washing systems may be used during outbound transit to Mars, then be dormant for up to 18 months prior to the return trip to Earth. Controlling microbial activity and odor during this dormancy is important to habitat and crew health.

Additional information on NASA needs can be found in NASA Technology Roadmaps including but not limited to sections TA06 6.1.4.11 and TA07 7.2.1.9. These roadmaps are available at the following link: (http://www.nasa.gov/offices/oct/home/roadmaps/index.html). Examples of conference papers on refrigeration technologies such as Merlin, and the ISS Refrigerator Freezer Rack can be found at the Internal Conference on Environmental Systems, and food storage issues are described in the Human Research Program Investigators Workshop. Specific references include: Winter, J., Zell, M., Hummelsberger, B., Hess, M. et al., "The Crew Refrigerator/Freezer Rack for the International Space Station," SAE Technical Paper 2001-01-2223 and http://www.nasa.gov/mission_pages/station/research/experiments/MERLIN.html

Phase I Deliverables - Detailed analysis, proof of concept test data, and predicted performance (mass, volume, thermal performance). Deliverables should clearly describe and predict performance over the state of the art.

Phase II Deliverables - Delivery of technologically mature components/subsystems that demonstrate deployments and/or automated features are required. Prototypes should be full scale unless physical verification in 1-g is not possible. Ability to sustain launch loads and on-orbit crew loads needs to be demonstrated. A minimum of 2 months of cold stowage/alternate atmosphere performance should be demonstrated if relevant.