Advanced life support and thermal systems are essential to enable human planetary exploration. 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. Innovative, efficient, and practical concepts are needed for regenerative air revitalization, ventilation, temperature, and humidity control. Advanced active thermal control technologies in the areas of heat acquisition, transport, and rejection are also needed. In addition to long-duration space applications, innovative approaches that could have terrestrial application are encouraged. 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. Innovations are solicited in the areas that follow below.

Air Revitalization

Oxygen, carbon dioxide, water vapor, and trace gas contaminant concentration, separation, and control techniques for space vehicle applications (International Space Station, Moon, or Mars transit vehicle) and long-duration planetary mission applications.

- Separation of carbon dioxide from a mixture primarily of nitrogen, oxygen, and water vapor to maintain carbon dioxide concentrations below 0.3% by volume.
- The recovery of oxygen from carbon dioxide with some focus on an approach to deal with the by-products of the process, if any, keeping in mind the above mass, power, and expendables goals.
- Removal of trace contaminant gases from cabin air and/or a gas product stream from another system (e.g., water reclamation, waste management, etc.) using advanced regenerable sorbent materials, improved oxidation techniques, or other methods.
- Alternate methods of storage and delivery of atmospheric gases to reduce mass and volume and improve safety.
- Novel approaches to integrating atmosphere revitalization processes to achieve energy and logistics mass reductions.
• Alternate methods of atmospheric humidity control that do not use liquid-to-air heat exchanger technology (dependent on the spacecraft active thermal control system) or mechanical refrigeration technology.

**Environmental Control and Thermal Systems**

Thermal control is an essential part of any space vehicle, as it provides the necessary thermal environment for the crew and equipment to operate efficiently during the mission. A primary goal is to provide advanced thermal system technologies, which are highly reliable and possess low mass, size, and power requirements (i.e., reduced cost) for spacecraft cabin temperature and humidity control. Offerors should indicate explicitly how their research is expected to improve the mass, power, volume, safety, reliability, and/or design and analyses techniques for future thermal control systems for human space missions as compared to state-of-the-art technologies. Areas in which innovations are solicited include the following:

• Liquid-to-liquid heat exchangers that provide two physical barriers preventing interpath leakage.

• Advanced technologies to control cabin temperature and humidity in microgravity. Condensate that is collected must be able to be recovered and transported to the water recovery system.

• Technologies to inhibit microbial growth on wetted surfaces. Applications include condensate collection surfaces for humidity control and heat exchangers resident in water loops.

• Lightweight, versatile and efficient heat acquisition devices including flexible cold plates. Devices would provide cooling to electronics, motors, and other types of heat producing equipment that is internal to the cabin.

• Lightweight, controllable evaporative heat rejection devices that can operate in environments ranging from space, Mars’ atmosphere, and Earth’s atmosphere.

• Alternative heat transfer fluids that are non-toxic, non-flammable, and have a low freezing temperature.

• Energy storage devices that maintain the integrity of food or science samples. Temperatures of -20°C, -40°C, -80°C or -180°C are desired.

• Highly accurate, remotely monitored, *in situ*, non-intrusive thermal instrumentation.

• Advanced analytical tools for thermal and fluid systems design and analyses, which are amenable to concurrent engineering processes.

**Component Technologies**

Energy efficient, low mass, low noise, low vibration or vibration isolating, fail-safe and reliable components for handling gases and fluids applicable to spacecraft environmental control and air revitalization, including actuators, fans, pumps, compressors, coolers, tubing, ducts, fittings, tanks, heat exchangers, couplings, quick disconnects, and valves that 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.