X11.03  Autonomous Medical Care

Lead Center: JSC

Participating Center(s): ARC, GRC

Exploration missions require a healthy, well-performing crew supported by a robust infrastructure for the monitoring, diagnosis, and treatment of medical conditions. Since return time to Earth and communications delays during such missions will greatly reduce the effectiveness of Earth-involvement, the crew must be capable of performing the majority of medical activities independently. Therefore, this system of autonomous medical care must provide the capability for patient care as well as measure and assess fitness levels for duty during a mission with little or no real-time support from Earth. The objective of this subtopic is to sponsor applied research leading to the development of such an infrastructure with the associated medical devices and procedures that will mitigate crew health, safety, and performance risks during future flight missions to the Moon and Mars. Medical diagnostic, treatment, and monitoring devices are critical for providing health care and medical intervention during missions, particularly extended-duration spaceflight to the Moon and Mars. Of particular interest are devices with minimized mass, volume, consumables, and power consumption that are capable of multiple functions in both micro-g and sub-g environments. Design enhancements that improve the operation, reliability, flexibility, and maintainability of medical devices in the space environment are also sought. Additional considerations include innovative approaches to human-device interactivity and interface, automation of device functions, improved ease of use, and astronaut comfort.

Device for Body Chemistry Assessment

Development of an integrated, adaptable laboratory analysis system/sensor system for in-flight assessment of body fluids (including blood) and solids is desired. This system would be used to obtain quantitative measurement of dissolved gases, calcium ions, and other electrolytes, proteins, lipids, hormones, carbohydrates, vitamins, minerals and clinical drug levels with minimal or no consumables usage or specimen preparation skill. Likely candidates will be based on MEMS technology and will employ a biocompatible combination of micro-fluidics, micromechanics, micro-optics, microelectronics, and data telemetry capabilities in an integrated handheld package with a user-friendly operator interface.

Voice- and Gesture-Actuated Interactive Procedures

Astronauts working in space or on the lunar or Martian surface will require a hands-free, interactive, step-by-step environment for performing flight medical procedures. This system should have the capability to utilize links, prepare textual or graphical indication of progress through a procedure, return to previous steps, page forward/page backward, and automatically annotate verbal input relative to subject response during procedure or treatment. An inventory capability must exist for obtaining and stowing required items (including medications) as
well as a mechanism to assess the resulting consumables status after a procedure has been completed. Ground-monitoring capability is also required, at least in the early stages.

**Closed Loop Medical Respirator**

A closed loop flight and human certified medical respirator with real-time remote monitoring and remote control capability is required. This respirator must incorporate a function to limit the amount of O\(_2\) leaking into the space vehicle or surface habitat. Current O\(_2\) limits range from ~20/21% at sea level with maximum levels of 30% in a 10.2 psi environment. (This upper limit mitigates flammability concerns and is dictated by ambient pressure.) The system should incorporate real-time remote monitoring and control capabilities.

**Medical Grade Water Generation**

Methods and technologies for in-flight creation of medical grade water from any available water source are required. Because some pharmacological preparations appear to degrade in the space environment, it is highly desirable, from both a consumables perspective as well as from the standpoint of mass, to fly desiccated pharmacological substrates whenever possible and to reconstitute them only when needed. For this reason, medical grade water is required along with a low-g (e.g., 0 g, 1/3 g, and 1/6 g) system to deliver generated water to the substrate and mix as necessary. The general requirements of low mass, user-friendly interface, reliability, and automation are critical to this system. There should be a mechanism included to verify that the water produced meets standard requirements for the medical grade designator.

**Diagnostic Imaging Capability**

During long duration flights, it will be important to have medical imaging capability available to assist in diagnosis, treatment, and monitoring during and after medical events. This capability is likely to be an ultrasonic, low power, portable device that provides for diagnostic assistance via data processing algorithms. These algorithms would be expected to provide guidance for the crewmember administering the exam as well as identifying probable diagnoses options and possible treatments for each. The system should be flexible enough to provide fracture analysis, bone density levels, and body cavity status.

**In-Flight Suction**

Long duration missions must have the capability to provide medical suction for patients in the event of injury or serious illness. This system must be capable of providing suction for a variety of body orientations in multiple reduced gravity environments. It should be a stand-alone system that does not require oversight by another crewmember. In the event of malfunction, it should provide an audio alert, a display of the malfunction type, plus a safing algorithm. The contents of the suction system must be easily disposed of safely and without release of contents into the environment.

**Biomedical Signal Processing**

Assessment of an ill or injured crewmember may sometimes be accomplished in large part by the status of the biomedical signal, or EKG. This will have to be a "smart" system, which analyzes sensor placement, sensor health, signal monitoring, signal normalcy, and signal analysis. It is required that the biomedical signal be capable of monitoring cardiac health and physiological state. The processor must be fail-safe and must annunciate an audible alarm when a malfunction occurs. A display should provide a readout of the anomaly type and the system must safe itself when malfunctions occur. (NOTE: There may be a subset of malfunctions (e.g., loose lead) that will not require a shut-off or self-safing function.) The system must be volumetrically small with minimal mass.
Intelligent Software Modules

Software modules with the capability to review medical data in a SQL compliant database, assign or suggest appropriate SNOMED CT codes, and store the suggested codes in electronic format with discrete elements is highly desirable to avoid having to train hierarchical nomenclature to crewmembers. The hierarchical relationships between SNOMED codes should be maintained and stored in the output.