National Space Biomedical Research Institute
Team: Smart Medical Systems and Technology – Team Executive Summary
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Background/Scope
Health problems associated with space travel may be related to the effects of microgravity, radiation and other risks to the body that are particular to spaceflight. They may also be independent of these effects, arising in association with a given demographic population, toxic environmental exposure or trauma. Complex interactions between these factors, as well as potential differences in the way disorders present and respond in microgravity relative to Earth, pose formidable challenges. The unique medical circumstances and limited healthcare resources in space suggest that novel strategies are required for in-flight physiological monitoring and medical assessment, diagnosis and treatment for exploration missions.

The Smart Medical Systems and Technology (SMST) Team plans a leadership role in the research and development of advanced, integrated and autonomous systems for astronaut health assessment, maintenance and medical care. This includes the delivery and evaluation of medical interventions and other countermeasures to reduce the deleterious effects of space travel as well as to enhance the overall well-being of astronauts. To accomplish this task, the SMST Team works closely with other NASA efforts in space and clinical medicine. It is anticipated that the technology developed by the SMST Team will have significant impact upon the medical well-being of astronauts as well as provide important improvements in Earth-based health and medical care.

Goals
The Smart Medical Systems and Technology Team's principal goal is to develop medical care systems that would diagnose and treat major risk, illness and trauma, as well as to provide sensors and data systems for in-flight monitoring and early detection of medical problems during flight and on planetary surfaces. A secondary goal is to provide novel training tools and onboard intelligence systems to help crews address medical issues when contact with Earth is limited or delayed.

Support of NASA Needs
The SMST Team's projects focus on key technology platforms which meet multiple objectives and mitigate multiple risks. Areas of focus currently include ultrasound, near infrared spectroscopy, lab-on-a-chip technology, and just-in-time training techniques. Expanded application of these technologies to meet NASA's needs is planned to provide excellent medical care with limited mass, volume and power. Integration of multiple sensors/technology with intelligent software is required to provide autonomous or semi-autonomous medical diagnosis and therapy. Development of novel control and analysis algorithms may take place within the SMST, but the Team will partner with NASA engineers to integrate technology into medical systems which have operational relevance.

The SMST works with NASA flight surgeons and discipline scientists to prioritize application of technology and understand the constraints of working in the space environment with the ultimate goal of producing hardware and software which can be used in an operational environment.

Deliverables
The SMST Team anticipates delivering a variety of important capabilities for NASA's planned research and exploration missions. These include: Just-in-time training of astronauts to perform complex ultrasound diagnostic testing; An onboard catalog of laparoscopic and ultrasound images of internal organs under microgravity conditions to assist in planning, diagnosis and treatment of medical conditions in space; An ultrasonic-based, acoustic densitometer for real-time assessment of bone quality and density and a therapeutic system for assessing fractures and accelerating healing; An image-guided focused ultrasound system with capability to treat a variety of conditions, such as uncontrolled internal bleeding and kidney-stone-induced obstruction; A simple, noninvasive method of monitoring intracranial pressure while in space; A lab-on-a chip system for in-flight measurement of blood samples to determine the number of white blood cells and the percentage of each type of white blood cell; and a noninvasive sensor system to measure muscle metabolic parameters to diagnose trauma, assess astronaut fitness and provide real-time metabolic rate monitoring during lunar surface exploration.

Cross-Links
The SMST Team is highly integrated with NASA's Exploration Medical Capabilities (ExMC) Program. Team projects address the issues identified in ExMC's research plan to assure astronaut health and provide medical care in space. Additionally, the Team's platform technologies reach out to help minimize risk in other discipline areas such as bone loss, risk of kidney stones, and monitoring astronauts during extravehicular activity and performance of exercise countermeasures.

Enabling Capabilities and Gaps
The SMST core expertise is in the development and application of ultrasound imaging and therapies, near infrared spectroscopy and lab-on-a-chip technology. The Team's researchers are physicians and scientists who work directly with medical and NASA colleagues to employ their technology in operational settings. The Team is looking to expand its capabilities in lab-on-a-chip applications to analyze a greater variety of analytes useful for medical care and scientific research. The Team also hopes to expand its expertise in devising noninvasive and minimally-invasive therapies for key medical risks. Finally, the Team seeks to add projects that focus on technology needed to build expert systems for autonomous medical care and optimization of countermeasures and activities to improve astronaut performance and assure safe operations on the lunar surface.

Earth-Based Benefits
Much of the technology developed by the SMST Team has direct benefits for Earth. Training techniques employed for crew medical officers have relevance for telemedicine applications to remote patient populations. Acoustic bone densitometry will allow physicians to monitor osteoporosis patients with highly detailed images; accompanying ultrasonic treatment will help accelerate fracture healing. Lab-on-a-chip devices will have wide application in clinical medicine. Technology developed for trauma diagnosis and response, such as the noninvasive metabolic monitor and high-intensity, focused ultrasound, have use for battlefield medical care, in emergency response vehicles and hospital emergency rooms.