

Technology Roadmaps for Space Exploration (09)  
Enabling Technologies for Exploration (3)

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TECHNOLOGY DEVELOPMENT TO SUPPORT HUMAN HEALTH AND PERFORMANCE IN  
EXPLORATION BEYOND LOW EARTH ORBIT

**Abstract**

In the course of defining the level of risks and mitigating the risks for exploration missions beyond low Earth orbit, NASA's Human Research Program (HRP) has identified the need for technology development in several areas. Long duration missions increase the risk of serious medical conditions due to limited options for return to Earth; no resupply; highly limited mass, power, volume; and communication delays. New space flight compatible medical capabilities required include: diagnostic imaging, oxygen concentrator, ventilator, laboratory analysis (saliva, blood, urine), kidney stone diagnosis treatment, IV solution preparation and delivery. Maintenance of behavioral health in such an isolated, confined and extreme environment requires new sensory stimulation (e.g., virtual reality) technology. Unobtrusive monitoring of behavioral health and treatment methods are also required. Prolonged exposure to weightlessness deconditions bone, muscle, and the cardiovascular system. Novel exercise equipment or artificial gravity are necessary to prevent deconditioning. Monitoring of the degree of deconditioning is required to ensure that countermeasures are effective. New technologies are required in all the habitable volumes (e.g., suit, capsule, habitat, exploration vehicle, lander) to provide an adequate food system, and to meet human environmental standards for air, water, and surface contamination. Communication delays require the crew to be more autonomous. Onboard decision support tools that assist crew with real-time detection and diagnosis of vehicle and habitat operational anomalies will enable greater autonomy. Multi-use shield systems are required to provide shielding from solar particle events. The HRP is pursuing the development of these technologies in laboratories, flight analog environments and the ISS so that the human health and performance risks will be acceptable with the available resources.