In early robotic missions, and later in outpost missions, permanently shadowed regions of the Lunar surface (e.g., the bottoms of craters in the polar regions). These areas appear to remain at temperatures of 50°K to 80°K (-223°C to -193°C). Current surface exploration hardware has demonstrated capability to operate in the range of 158K to 273K (-115°C to 0°C) on Mars. However, the technical challenges of developing and demonstrating hardware that can operate over 100°C colder than current capabilities are significant. The major technology drivers of the low temperature mechanism technology development are to significantly enhance operation of mechanized parts by (1) lowering the operating temperature for the life of the component and (2) improving mechanism performance (e.g., torque output, actuation performance, lubrication state) at the lunar environment conditions of cold and vacuum. The targeted application of the technology is to provide for operation of motors and drive systems, lubricated mechanisms, and actuators of lunar rovers and mobility systems, ISRU machinery, robotic systems mechanisms, and surface operations machinery (i.e. cranes, deployment systems, airlocks), lunar sortie and the lunar outpost missions. This topic area is responsible for mid-level technology research, development, and testing through experimental and/or analytical validation.

**Subtopics**

**X5.01 Motors and Drive Systems for Cryogenic Environments**

*Lead Center: GSFC*

*Participating Center(s): GRC, JPL, JSC, LaRC*

This subtopic focuses on the development of selected hardware and support technologies for motors, drive systems and related mechanisms that will operate in cryogenic temperature environments such as permanently shaded craters on the Moon, and/or on the lunar surface exposed to the day/night cycle. In the former situation such mechanisms may be exposed to, and will need to operate in, sink temperatures as low as approximately 25K. In the latter situation they will need to operate over a temperature sink range of approximately 83K to 146K (-190°C to +127°C). Actual operational temperatures may be somewhat different. The component technologies developed in this effort will be utilized for rovers, operational equipment, instruments, drills, crushers, and other such facilities. The nearer term focus for this effort is for lunar missions, but these technologies should ideally be translatable to applications on Mars. These components must operate in a hard vacuum and/or planetary environment, with partial gravity, and full solar radiation exposure. Additional requirements include high reliability, ease of maintenance, low-system volume, low mass, and minimal power requirements. Low out-gassing is desirable, as are modular design characteristics, fail-safe operation, and reliability for handling fluids, slurries, biomass, particulates, and solids. While dust mitigation is not specifically included in this subtopic, proposed concepts should be cognizant of the need for such technologies.
Specific areas of interest include gear boxes, suspension systems, material components (i.e., wiring, harnesses, insulating materials, and jackets/covers) that are flexible in cryogenic environments; advanced lubricants and lubrication technology; and an accelerated means of life testing for cold temperatures.