During future exploration of planets, moons, and small solar system bodies (such as comets and asteroids), developments are needed in new innovative robotic technologies for surface operations, subsurface access, and autonomous software for each. Because of limited spacecraft resources, elements must be robust and have low power, volume, mass, computation, telemetry bandwidth, and operational overhead requirements. Successful technologies will have to operate in environments characterized by extremes of temperatures, pressures, gravity, high-gravity landing impacts, vibration, and thermal cycling. In particular, this subtopic seeks technology innovations in the following areas:

**Subsurface Access**
Research should be conducted to develop complete, lightweight, dry drilling systems with a penetration depth of 10-50 m and have the capability of penetrating both regolith and rocks. The development should focus on significant reduction in mass from the currently available state-of-the-art interplanetary drilling systems as well as the automation required for real-time control and fault diagnosis and recovery. In addition, because of the lack of water in most of the environments of interest, the drilling should be performed without a lubricant between the bit and rock. Of interest also is the development of ice penetrators, designed with explicit consideration of limited computation and power, which use heat to melt their way through the surface.

**Rover Technology**
Long-range autonomous navigation systems that focus on long distance (greater than 5 km) traverses through natural terrain, using no a priori knowledge of the subject terrain. Inflatable rover technology with a focus on the development of low-mass, highly capable platforms for exploration of extreme terrain through innovations in novel mechanisms and the automation required for real-time control. Concepts for new mobility systems or components, such as innovative wheel or suspension designs. Instrument placement with a focus on improved tools for the design of manipulation systems, to perform contact and non-contact operations such as drilling, grasping, sample acquisition, sample transfer, and contact and noncontact science instrument placement and pointing. Modular robotic joints that are small (0.5 kg), low power, low mass and can be used to build prototype manipulators and/or legs. Quick changeout mechanisms for planetary manipulators that can enable changing of tools or instruments on the end of a manipulator.

Of particular interest is infrastructure for research, including low-cost, mass producible, research-quality rovers and supporting elements. The development of a low-cost, Rocker-Bogie style, six-wheel steerable, robotic research platform that can drive around in rough terrain is desired.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration that will, when possible, deliver a demonstration unit or software package for JPL testing at the completion of the Phase 2 contract.