The purpose and scope of the subtopic is to develop technologies and concepts for servicing, maintenance, and repair of space exploration systems. These systems include crew living quarters, laboratories, airlocks, ground transportation systems, and space transportation systems. The related support systems include environmental control systems, waste collection and processing systems, food storage and preparation systems, power systems, pneumatic systems, fluids systems, computer systems, communications systems, instrumentation systems, various structures and mechanisms, and other tools and equipment. Commodities may include gaseous and liquid nitrogen, oxygen, hydrogen, methane, carbon dioxide, and water. Operational environments include micro- and partial-gravity, possible corrosive reactivity, thermal extremes, possible low visibility, high potential for static discharge, possible cosmic radiation, and extensive permeation of dust-like materials. Requirements include safe operation, high reliability, ease of use, multiple uses, low-system volume, and low power. Operational concepts include limited direction from Earth-based mission control teams, minimized crew times in performance of these activities, optimal system autonomy, and optimal system readiness. In addition, all failure scenarios are expected to be designed to be “fail operational–fail safe.” NASA seeks highly innovative technologies and concepts to address efficient, accurate and cost-effective servicing, maintenance, and repair of space exploration systems. Specific technical areas include the following.

**Upgradeable and Reconfigurable Systems Concepts**

Support systems for the space exploration systems need to be developed which provide for a “Zero Outage” environment. Support systems must have the capability to be upgradeable through incremental component level upgrades. Support systems must also have the capability to be reconfigurable through the use of subsystems, components and connections that are multi-use, multi-commodity, and used in multiple environments. These reconfigurations must also have the capability of being performed autonomously to restore critical functionality. Expected products include concept papers, and subsystem or component level prototype demonstrations.

**Standards, Interfaces, and Architectures**

Standards, Interfaces, and Architectures need to be developed that support common and abstract definitions of both physical and behavioral characteristics, as well as shield internal technology-specific details from external system elements. The goal is to develop truly modular components that provide “Plug and Play” functionality between spacecraft and spaceport, between spacecraft elements, and between spacecraft and in-space or surface elements. Expected products include concept papers, and subsystem or component level prototype demonstrations.
Modular Orbital Replacement Units

It is expected that certain maintenance and repair actions will be performed by astronauts during Extra-Vehicular Activities (EVA). Astronauts will remove, replace, and retest units having characteristics of multiple functionality, integrated intelligence, adaptive interfaces, and interconnections. In addition, development of the associated equipment, tools and procedures, will be required to ensure a successful recovery from a system-level failure. Expected products include concept papers and prototype demonstrations.

Modular Component Replacement Units

It is expected that certain maintenance and repair actions will be performed by astronauts in a laboratory setting. Astronauts will remove, replace, and retest components contained within higher level units. Characteristics to be addressed include component mating surface preparations such as cleaning and polishing, electrical component contact soldering or annealing, and multiple functionality of the spare components. In addition, development of the associated equipment, tools, and procedures will be required to ensure a successful recovery from a component level failure. Expected products include concept papers and component level prototype demonstrations.

Propulsion System Refurbishment and Repair

The goal is to develop propulsion system component level technologies that support in-space modular replacement, commodity servicing, and in-place diagnostic and health determination. Capabilities need to be developed for remote and NDE inspection and testing of system components. The capability to repair or replace fluid lines either by human EVA or robotically operated tools will need to be developed. In addition, development of capabilities to safely isolate, inert and disengage fluid, mechanical and electrical interconnects will need to be developed. Expected products include concept papers and subsystem or component level prototype demonstrations.

Refueling and Fluids Resupply Support Systems

Multiple elements will have interfaces that will require the transfer of commodities between them to allow for integrated systems operations. These commodities will typically be electrical power, data, communication, pneumatics, coolant fluids, cryogenic fuel and oxidizer, and other systems related commodities as required. Umbilicals are mechanisms that enable these connections between multiple elements and can be manually operated or autonomous. Depending on the specific operation, both manual and automated umbilicals will be required to enable deployment and operation of space-based equipment, facilities and habitation modules. It is expected that these umbilicals will have leak detection capability, remote sensing, use self-healing characteristics and low-maintenance sealing technologies. In addition, the systems being serviced must have advanced volume-gauging systems. These servicing systems must also demonstrate safe and secure operation. Expected products include concept papers and subsystem or component level prototype demonstrations.

Structural Materials-Level Repair Systems

Develop in-space capabilities and technologies for material repair both via human EVA and robotically operated disassembly, welding, bonding, insulation application and reassembly. It is also highly desirable to develop technologies for polymeric and composite materials that mimic the self-healing repair processes of biological systems. Applications for self-healing processes of inanimate materials can be found in areas where failures could result in catastrophic consequences. Examples include: failure of structural members, failure of electrical wire insulation materials or failure of polymeric membranes used in critical life support systems for separations of...
gaseous and liquid commodities. Expected products include: concept papers and laboratory demonstrations.