The goal of this subtopic is to develop innovative chemical propulsion component technologies that improve the safety, operability, reliability, and performance of propulsion systems required for human and robotic exploration missions. Components should be applicable to earth-to-orbit or long-duration in-space transportation systems (both primary propulsion and reaction control systems) for a variety of exploration mission phases, including trans-lunar injection, decent to the lunar surface, ascent to lunar orbit, and return to Earth.

System masses will be critical in these far-reaching missions, dictating the use of lightweight components and the use of propellants harvested or manufactured on the surface of the Moon, Mars, or other destinations—an approach known as in situ resource utilization (ISRU). Candidate ISRU propellants include hydrogen, oxygen, carbon monoxide, carbon dioxide, methane, various other hydrocarbons, and compounds derived from these materials.

In some scenarios, one propellant may be manufactured in situ while its oxidizer or fuel is brought from Earth. Because the use of ISRU propellants represents a departure from the state-of-the-art and from the existing base of engines and technologies, a new suite of propulsion system and component technologies will be required.

These new in-space propulsion systems are expected to encounter conventional challenges such as regulator leakage, valve leakage, valve heating (on pulsing engines), solubility effects (such as combustion instabilities caused by gas bubble evolution in liquid propellants), and propellant acquisition (i.e., extracting gas-free propellant from the tank and delivering it to the engine). In-space chemical propulsion systems that incorporate long-term use of cryogenic propellants such as hydrogen, methane and oxygen present new challenges, including efficient, reliable, and durable propellant cryocooling, storage, acquisition (from tanks), transfer (through feed lines), gauging and flow measurement; however, these particular challenges are addressed by a separate sub-topic, X3.03 Cryo and Thermal Management.

Chemical propulsion component technologies that demonstrate improved capabilities using a variety of propellant combinations are of interest, including:
• Advanced turbopumps with wider throttle range and improved cavitation control, plus specific turbomachinery components such as bearings, turbines, and impellers that demonstrate greater reliability and lifetime;

• Injectors with low thermal mass and long-duration reliability (e.g. for high duty-cycle attitude control thrusters);

• Long-life combustion chambers (e.g., based on use of advanced materials);

• Innovative thruster valve designs that tolerate high thermal loading due to heat soak-back during pulse mode operation;

• Innovative concepts for fast acting valves to enable use of larger thrusters for small impulses (i.e. spacecraft fine pointing);

• Highly-reliable long-duration seals;

• Long-life, high-reliability ignition systems;

• Lightweight, highly reliable gas compressors for pumping gaseous propellant into pressure vessels either in-flight or on a terrestrial surface;

• Novel pressurization approaches that minimize dissolution of pressurant gas in storable propellants (e.g., nitrogen tetroxide, hydrazine, and hydrazine derivatives)

• Novel concepts that increase performance or decrease mass of pressurization systems;

• Development of advanced materials that exhibit high compatibility with gaseous oxygen;

• Propulsion components based on microelectromechanical systems (MEMS) technology;

• Advanced nozzle concepts for in-space propulsion systems;

• Reaction control system thrusters that burn in situ and non-toxic propellants;

• Innovative thruster designs that minimize or prevent high heat soak-back during pulse mode operation;

• Highly reliable, lightweight compressors for use in gaseous propellant storage and distribution systems;

• Advanced lightweight multi-use positive expulsion devices for storable propulsion systems; and

• Other innovative chemical propulsion system components that improve system safety, affordability, or effectiveness.

Note: Related technologies of interest but covered under other SBIR subtopics include:

• X3.03 Cryo and Thermal Management

• X7.01 Chemical Propulsion Systems and Modeling
- X8.01 Vehicle Health Management Systems