The goal of this subtopic is to develop intelligent systems and technologies that could dramatically improve the affordability and productivity of long-duration human space operations, while preserving the high degree of safety and flexibility offered by state-of-the-art approaches. The current operations models used for the Space Shuttle and International Space Station, which require large ground teams continuously managing the daily operation of the spacecraft and the activities of the crew, are a major cost driver for these programs. As the human exploration campaign ventures farther into deep space, the communications time delays and longer-duration missions will require greater crew autonomy from Earth-based support. To achieve NASA's exploration goals, technologies are needed that can enable a new paradigm for human space operations.

**Intelligent Planning and Execution Systems for Crew Autonomy**

Greater autonomy from Earth-based support implies that crewmembers will need to manage their exploration missions holistically. This will be possible only if automation helps the crew to integrate the complex interactions among many spacecraft subsystems efficiently and to manage and prioritize human and automated activities. Intelligent systems will need to be seamlessly integrated with operational procedures so that all the information required to make key decisions is continuously updated and presented to the crew in a rapidly comprehensible fashion. Crew interfaces (e.g., displays, voice recognition, etc.) will need to be intuitive and reliable. Validated, automated systems are needed that help a spacecraft/habitat crew coordinate and prioritize plans and execute nominal/off-nominal procedures in accordance with codified mission rules and objectives. These systems should improve upon capabilities already demonstrated in human space exploration missions (e.g., Space Shuttle and International Space Station).

To evaluate proposed intelligent systems technologies, it is important to identify measurable performance objectives. Such performance measures include: (1) the speed and ease by which astronauts can plan and schedule future activities and understand the consequences of exercising various planning options; (2) the reliability, speed, and ease by which astronauts can maintain comprehensive situational awareness of a complex spacecraft/habitat without cognitive overload; (3) the reliability, speed, and ease by which astronauts can derive (on demand, or in response to detection, of an off-nominal condition) sufficiently detailed knowledge of the spacecraft/habitat, to issue commands that isolate anomalies, perform recovery procedures, and make other safety/mission-critical decisions.

Modular designs that employ open architectures and interface standards are very important to assure cost-effectiveness and flexibility of intelligent operations systems. These architectures should promote extensibility/evolvability and accommodate future system upgrades. Such designs could include standalone tools that capture and manage corporate knowledge about manned spacecraft operations.

Also of interest, though of lesser priority, are innovative technologies that can significantly enhance ground operational efficiency and performance.
Intelligent Modular Training Systems
Intelligent training systems are needed that enable flight crews to operate complex spacecraft safely and effectively, retain proficiency during long-duration missions, adapt easily to an evolving and expanding set of flight systems during the course of the exploration campaign, and achieve flight certification faster and more cost-efficiently than is possible with existing systems. Plug-and-play crew training systems that employ open architectures and interface standards are very important. These architectures should promote extensibility/evolvability and accommodate future system upgrades. The intelligent training systems should enable connectivity with models from various sources, with simulated or flight data (real-time and archived), with students and teachers at multiple locations, and with various platforms including ground-based/desktop environments and in-space, zero-g/partial-g portable or control station systems. When integrated with an operational environment, these systems must demonstrate effectiveness while ensuring that the performance of the vehicle or facility is unaffected.

Focus should be on the following applications:

- Intelligent onboard technologies for human space exploration; and
- Intelligent human space exploration mission control technologies.

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

- X5.01 Software Engineering;
- X5.02 Human Autonomy Interaction;
- X6.03 Launch Site Technologies (Launch site command and control system technologies); and
- X8.01 Vehicle Health Management Systems.