NASA invests in the development of advanced avionics, automation software, integrated system health management, and robust software technology capabilities for the purpose of enabling complex missions and technology demonstrations. The avionics and software elements requested within this topic are critical to enhancing flight system functionality, reducing system vulnerability to extreme radiation and thermal environments, reducing system risk, and increasing autonomy and system reliability through processes, operations, and system management. As a cross-cutting technology area, avionics and software are applicable to broad areas of technology emphasis, including heavy lift launch vehicle technologies, robotic precursor platforms, utilization of the International Space Station, and flagship technology demonstrations performed to enable long duration space missions. All of these flight applications will require unique advances in avionic and software technologies such as integrated systems health management, autonomous systems for the crew and mission operations, radiation hardened processors, and reliable, dependable software. Exploration requires the best of the nation’s technical community to step up to providing the technologies, engineering, and systems to regain the frontiers of the Moon, to extend our reach to Mars, and to explore the beyond.

Subtopics

X6.01 Automation for Vehicle and Crew Operations

Lead Center: ARC
Participating Center(s): JSC

Automation will be instrumental for decreasing workload, reducing dependence on Earth-based support staff, enhancing response time, and releasing crew and operators from routine tasks to focus on those requiring human judgment, leading to increased efficiency and reduced mission risk. To enable the application of intelligent automation and autonomy techniques, the technologies need to address two significant challenges: adaptability and software validation. Proposals are solicited in the areas of:

- **Automation Support Tools**: Support tools are needed to facilitate the authoring and validation of plans and execution scripts. Tools that are not tied specifically to one executive would provide NASA the most flexibility. Examples include: Graphical tool for monitoring and debugging plan execution and for creating and editing execution scripts; Tools for authoring and validating execution plans; User friendly abstraction of
low-level execution languages by adding syntactic enhancements.

- **Decision Support:** Systems Decision support systems amplify the efficiency of operators by providing the information they need when and where they need it. Examples: Command and supervise complex tasks while projecting the outcome and identify potential problems; Understand system state, including visualization and summarization; Allow the system to interact with a user when generating the plan and allow evaluation of alternate courses of action; Integration of a planning and scheduling system as part of an on-board, closed loop controller.

- **Trustable Systems:** Systems that support or interact with crew require a very high level of reliability. Tools are needed that improve the reliability and trustworthiness of autonomous systems. These include: Ability to predict what the system will do; Guarantees of behavioral properties; Other properties that increase the operator's trust; Verifiability (e.g., restricted executive languages that facilitate model-based verification).

X6.02 Radiation Hardened/Tolerant and Low Temperature Electronics and Processors

**Lead Center:** MSFC

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

Exploration flight projects, robotic precursors, and technology demonstrators that are designed to operate beyond low-earth orbit require avionic systems, components, and controllers that are capable of enduring the extreme temperature and radiation environments of deep space, the lunar surface, and eventually the Martian surface. Spacecraft vehicle electronics will be required to operate across a wide temperature range and must be capable of enduring frequent (and often rapid) thermal-cycling. Packaging for these electronics must be able to accommodate the mechanical stress and fatigue associated with the thermal cycling. Spacecraft vehicle electronics must be radiation hardened for the target environment. They must be capable of operating through a minimum total ionizing dose (TID) of 300 krad (Si), provide fewer Single Event Upsets (SEUs) than 10-10 to 10-11 errors/bit-day, and provide single event latchup (SEL) immunity at linear energy transfer (LET) levels of 100 MeV cm2/mg (Si) or more. Electronics hardened for thermal cycling and extreme temperature ranges should perform beyond the standard military specification range of -55°C to 125°C, running as low as -230°C or as high as 350°C.

Considering these target environment performance parameters for thermal and radiation extremes, proposals are sought in the following specific areas:

- Low power, high efficiency, radiation-hardened processor technologies.
- Technologies and techniques for environmentally hardened Field Programmable Gate Array (FPGA)
- Innovative radiation hardened volatile and nonvolatile memory technologies.
- Tightly-integrated electronic sensor and actuator modules that include power, command and control, and processing.
- Radiation hardened analog application specific integrated circuits (ASICs) for spacecraft power
management and other applications.

- Radiation hardened DC-to-DC converters and point-of-load power distribution circuits.
- Physics-based device models valid at temperature ranging from -230°C to +130°C to enable design, verification and fabrication of custom mixed-signal and analog circuits.
- Circuit design and layout methodologies/techniques that facilitate improved radiation hardness and low-temperature (-230°C) analog and mixed-signal circuit performance.
- Packaging capable of surviving numerous thermal cycles and tolerant of the extreme temperatures on the Moon and Mars. This includes the use of appropriate materials including substrates, die-attach, encapsulants, thermal compounds, etc.