NASA SBIR 2022 Phase I Solicitation

Z2.03  Human Interfaces for Space Systems

Lead Center: JSC

Scope Title

Display Systems

Scope Description

NASA's vision for human spaceflight requires the crew to execute increasingly complex tasks in more demanding and dangerous environments. As a result, advances in avionics technologies relevant to human interfaces for space systems are sought that can be infused into current and future human spaceflight programs, including orbiting spacecraft, surface habitats, surface mobility vehicles, and spacesuits. The 2022 subtopic goals are to advance technologies that increase the reliability of crew interface systems in the radiation environment beyond low Earth orbit (LEO), while also increasing the crew's capabilities and effectiveness in performing mission tasks. Standards-based interfaces are of particular interest to promote interoperability and equipment reuse across spacecraft.

Successful proposal concepts should significantly advance the state of the art. Furthermore, proposals should indicate an understanding of the safety-critical operations performed by spaceflight crews, as well as the intended radiation environment. Note that environmental requirements vary significantly between space systems and missions, with some spacecraft and surface vehicles supporting human operations for days and others supporting periodic crewed missions for 15 or more years.

Specific technologies sought by this subtopic include display systems capable of supporting long-duration human spaceflight beyond low Earth orbit. Multifunctional visual displays provide the highest bandwidth and most versatile means for crew to receive complex information, but unique component technologies with limited radiation performance data prevent high-reliability displays from being developed. The following design parameters and data are sought for display panel and pixel technologies:

- A scalable architecture that permits different levels of performance
- Radiation test data, analysis of failure modes, radiation-tolerant designs, and prototype hardware/software solutions
- A display panel diagonal measurement of at least 14 in. with the capability to render complex graphics, including high-definition video, at a frame rate of at least 20 frames per second.

Design and performance parameters are driven by use cases requiring crewmembers to directly control the spacecraft using live streaming video, such as in-space docking, controlled landing, robotic operations, and surface mobility.
Expected TRL or TRL Range at completion of the Project

3 to 7

Primary Technology Taxonomy

Level 1

TX 02 Flight Computing and Avionics

Level 2

TX 02.2 Avionics Systems and Subsystems

Desired Deliverables of Phase I and Phase II

- Prototype
- Hardware
- Software
- Analysis

Desired Deliverables Description

The desired Phase I deliverables include designs, simulations, and analyses to demonstrate the viability of proposed designs and components.

The desired Phase II deliverables for display systems include a prototype demonstration of a custom or modified display panel technology that mitigates radiation failure modes of electronic components. The proof-of-concept design should consider scalability and integration with other display components.

State of the Art and Critical Gaps

Commercial display technologies have been used in LEO on the International Space Station for decades, but radiation test data for complex electronics beyond LEO are very limited, and existing test data indicate displays may be more susceptible to radiation than other electronic components. As a result, spacecraft designers are forced to take an unquantified risk of equipment failure due to radiation effects and to include backup crew interface systems that take up valuable mass, volume, and power on the spacecraft. While ongoing Government and industry investments seek to improve processor and graphics processing unit (GPU) performance, quantifying and improving the radiation tolerance of display panel components remains unaddressed.

Relevance / Science Traceability

This subtopic is relevant to human spaceflight programs in the development and planning phases, including Gateway, HLS (Human Landing System), Orion, and xEMU (Exploration Extravehicular Mobility Unit), as well as to lunar and martian surface habitation systems and rovers. Technology solutions developed under this subtopic have the potential for a direct infusion path as these spacecrafts are designed and developed.

Electronic visual displays are required for human spaceflight (NPR 8705.2C, NASA Human-Rating Requirements for Space Systems) and will be at the center of any spacecraft’s crew interface architecture. By quantifying and improving the reliability of radiation-tolerant displays, spacecraft designers will be able to simplify this architecture by reducing the need for redundancy, sparing, and operational constraints while also reducing mass, volume, and power needs.

References

- NASA Electronic Parts and Packaging Program: https://nepp.nasa.gov/NASA/GSFC
Scope Title

Audio Systems

Scope Description

NASA's vision for human spaceflight requires the crew to execute increasingly complex tasks in more demanding and dangerous environments. As a result, advances in avionics technologies relevant to human interfaces for space systems are sought that can be infused into current and future human spaceflight programs, including orbiting spacecraft, surface habitats, surface mobility vehicles, and spacesuits. The 2022 subtopic goals are to advance technologies that increase the reliability of crew interface systems in the radiation environment beyond low Earth orbit (LEO), while also increasing the crew’s capabilities and effectiveness in performing mission tasks. Standards-based interfaces are of particular interest to promote interoperability and equipment reuse across spacecraft.

Successful proposal concepts should significantly advance the state of the art (SOA). Furthermore, proposals should indicate an understanding of the safety-critical operations performed by spaceflight crews, as well as the intended radiation environment. Note that environmental requirements vary significantly across space systems and missions, with some spacecraft and surface vehicles supporting human operations for days and others supporting periodic crewed missions for 15 or more years.

Specific technologies sought by this subtopic include audio systems that provide two-way voice communication between crew members and mission personnel on Earth through all mission phases and crew activities. These systems also must annunciate alarms and may provide a means of controlling systems by voice or record field notes. Robust audio system technologies are sought with the following design and performance parameters:

- Low-latency G.711 and G.729 audio encoding/decoding and routing from multiple simultaneous sources.
- Integrate with Ethernet-based spacecraft networks to route multiple simultaneous audio streams to each user.
- Support ad hoc addition and removal of end systems and in-flight configuration and extensibility.
- Leverage modular and standards-based hardware and software.
- Provide radiation tolerance and fault mitigation.
- Incorporate SOA microphones, speakers, and acoustic echo-canceling technologies that improve speech quality and intelligibility for voice communication and speech recognition in acoustically challenging environments, such as noisy habitable modules and spacesuits. NASA human spaceflight programs typically require a speech intelligibility score of 90% per the ANSI S3.2 standard using the Modified Rhyme Test (MRT) method.

Expected TRL or TRL Range at completion of the Project

4 to 7

Primary Technology Taxonomy

Level 1

TX 02 Flight Computing and Avionics
Desired Deliverables of Phase I and Phase II

- Prototype
- Hardware
- Software

Desired Deliverables Description

The desired Phase I deliverables include designs, tabletop hardware/software prototypes, and analyses to demonstrate the viability of proposed designs and components.

The desired Phase II deliverables for display systems include a prototype hardware and software audio system that can be tested in NASA network test facilities with at least three simultaneous audio endpoints. The audio system should be tested for radiation tolerance.

State of the Art and Critical Gaps

Audio systems are not currently available that meet NASA’s basic functional requirements and can perform reliably in the spaceflight radiation and acoustic environments.

Relevance / Science Traceability

This subtopic is relevant to human spaceflight programs in the planning phases, including human landing systems (HLSs) and lunar and martian surface habitation systems and rovers. Technology solutions developed under this subtopic have the potential for a direct infusion path as these spacecrafts are designed and developed.

Voice communication and auditory alarms have been included in NASA spacecraft since the Mercury Program, but this has not been sufficient to sustain a robust commercial market for space-rated audio systems. As NASA and commercial partners have increased new spacecraft development, the dearth of vendors has resulted in substantial schedule, cost, and technical integration risk.

References

- NASA Electronic Parts and Packaging Program: https://nepp.nasa.gov/
- Radiation Effects and Analysis Home Page: https://radhome.gsfc.nasa.gov/top.htm
- Space Shuttle Orbiter Audio Subsystem: https://ntrs.nasa.gov/citations/19790056509