NASA SBIR/STTR
Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2021 Phase I Solicitation

S3.08 Command, Data Handling, and Electronics

Lead Center: GSFC

Participating Center(s): JPL, LaRC, MSFC

Scope Title:

Command, Data Handling, and Electronics

Scope Description:

NASA's space-based observatories, flyby spacecraft, orbiters, landers, and robotic and sample-return missions require robust command and control capabilities. Advances in technologies relevant to command and data handling and instrument electronics are sought to support NASA's goals and several missions and projects under development.

The 2021 subtopic goals are to develop platforms for the implementation of miniaturized highly integrated avionics and instrument electronics that:

- Are consistent with the performance requirements for NASA missions.
- Minimize required mass/volume/power as well as development cost/schedule resources.
- Can operate reliably in the expected thermal and radiation environments.

Successful proposal concepts should significantly advance the state of the art. Furthermore, proposals developing hardware should indicate an understanding of the intended operating environment, including temperature and radiation. Note that environmental requirements vary significantly from mission to mission. For example, some low-Earth-orbit missions have a total ionizing dose (TID) radiation requirement of less than 10 krad(Si), whereas planetary missions can have requirements well in excess of 1 Mrad(Si).

Specific technologies sought by this subtopic include:

- Radiation-hardened mixed-signal structured application-specific integrated

circuit (ASIC) platforms to enable miniaturized and low-power science sensor readout and control, with sufficient capability to implement 12-bit digital-to-analog converters (DACs) monotonic and 12- to 16-bit digital-to-analog converters (ADCs) (<100 kHz 16-bit and 1 to 2 MHz 12-bit) and also charge-sensitive amplifiers for solid-state detectors and readout integrated circuit (ROIC) for silicon photomultipliers.
- Radiation-hardened ASIC devices to enable direct capture of analog waveforms.
- Multiple-output point-of-load power regulator: This module, preferably implemented utilizing one or more controller ASICs, will source a minimum of three settable output voltages when provided with an input voltage between +5 and +12 V. Output voltages shall be independently settable to any voltage between 3.3 and 0.9 V with efficiency of at least 95%. Regulation, noise filtering, and other operational specifications should be commensurate with industry standards for space-based systems. Output current in the 10 A range to handle field-programmable gate array (FPGA) core requirements. The module should provide standard spacecraft power supply features, including overvoltage protection, fault tolerance, load monitoring, sequencing, synchronization, and soft start and should allow control and status monitoring by a remote power system controller. Using fewer external components is also highly desirable. There is also interest in a capability to provide data over power line communication to the converter for control and monitoring functions. The offeror should determine radiation-tolerance levels achievable utilizing commercially available processes and indicate, in the proposal, the radiation-tolerance goals.
- High-density high-reliability interconnections: A high-reliability connector or interconnect mechanism that can operate in space environments (vacuum, vibration) and deliver hundreds of signal/power connections while using as little physical board area as possible is desired. The connector wiring and cabling in addition to the connector shape and size should be considered in providing a complete system that further reduces the size and weight of the harnessing. The design should handle everything from carrying power to high-speed (10+ Gbps) impedance-controlled connections. The design should be scalable in different sizes to accommodate fewer connections and save board space. Low insertion force is desirable. Right angle and stacking design options should be considered.

Expected TRL or TRL Range at completion of the Project: 3 to 5
Primary Technology Taxonomy:
Level 1: TX 08 Sensors and Instruments
Level 2: TX 08.3 In-Situ Instruments/Sensor
Desired Deliverables of Phase I and Phase II:

- Prototype
- Hardware
- Software

Desired Deliverables Description:

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

Desired Phase II deliverables:

- For mixed-signal structured ASIC platforms—include a prototype mixed-signal ASIC implemented with a proof-of-concept end-user design. The proof-of-concept design should demonstrate the stated performance capabilities of the ASIC.
- For the direct analog waveform capture ASIC—should include a prototype ASIC device implemented on a test board and demonstration of the wave form capture capabilities of the device.
- For the multiple output point of load switcher—a prototype multi-output point of load regulator. The regulator should be integrated onto a test board and be performance tested under varying resistive, capacitive, and transient load conditions.
- For the high density high-reliability interconnect—prototypes of the connection system (different size, orientations, wiring, etc.). The connector should be integrated onto a test board where its performance (speed, cross talk, etc.) can be verified.

State of the Art and Critical Gaps:

There is a need for a broader range of mixed-signal structured ASIC architectures. This includes the need for viable options for mixed ASICs with high-resolution, low-noise analog elements, especially 12-bit DACs and 12- to 16-bit ADCs. The current selection of mixed-signal structured ASICs is limited to 10-bit designs, which do not provide the accuracy or resolution to perform the science required of many of the instruments currently being flown. Mixed-signal structured ASICs can integrate many functions and therefore can save considerable size, weight, and power over discrete solutions—significantly benefiting NASA missions. The lack of parts with high-precision analog is greatly limiting their current application.

There are multiple output point-of-load converters available from commercial companies. The existing commercial parts require many external components, eliminating their space savings. Commercial parts are not built on radiation-tolerant processes.

Current connectors and interconnect harnessing are too large, especially for small satellites and CubeSats. As the size of the printed circuit boards has shrunk, the percent of board space being used by the input/output (I/O) connectors has become unacceptable. The connectors are taking away from circuitry and sensors that could be providing additional functionality and science products. High-density commercial connectors tend to be lacking in their general ruggedness, outgassing, and ability to prevent intermittent connections in high-vibration environments like orbital launches.

Relevance / Science Traceability:

Mixed-signal structured ASIC architectures are relevant to increasing science return and lowering costs for missions across all Science Mission Directorate (SMD) divisions.

However, the benefits are most significant for miniaturized instruments and subsystems that must operate in harsh environments. These missions include interplanetary CubeSats and SmallSats, outer planets instruments, and heliophysics missions to harsh radiation environments. For all missions, the higher accuracy would provide better science or allow additional science through the higher density integration.

Multi-output point-of-load converters and high-density high-reliability interconnects are relevant to miniaturizing electronics. Miniaturized flight electronics allows one to fit more functionality into less volume, allowing smaller spacecraft to perform science that was previously done by larger satellites. These missions include interplanetary CubeSats and SmallSats, outer planets instruments, and heliophysics missions.

References:

The following resources may be helpful for descriptions of radiation effects in electronics:

- NASA Technical Reports Server: https://ntrs.nasa.gov/
- NASA Electronic Parts and Packaging Program: https://nepp.nasa.gov/
- NASA/GSFC Radiation Effects and Analysis Home Page: https://radhome.gsfc.nasa.gov/top.htm