EXPLORESPACE TECH
TECHNOLOGY DRIVES EXPLORATION

NASA Envisioned Future for Advanced Avionics Technology

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EXPLORE: Develop next generation high performance computing, communications, and navigation

Developing flight computing architectures and advanced avionics to enable increased onboard intelligence and autonomy for future exploration missions in harsh environments

Go *Rapid, Safe, & Efficient Space Transportation*	• Develop nuclear technologies enabling fast in-space transits. • Develop cryogenic storage, transport, and fluid management technologies for surface and in-space applications. • Develop advanced propulsion technologies that enable future science/exploration missions.
Land *Expanded Access to Diverse Surface Destinations*	• Enable Lunar/Mars global access with ~20t payloads to support human missions. • Enable science missions entering/transiting planetary atmospheres and landing on planetary bodies. • Develop technologies to land payloads within 50 meters accuracy and avoid landing hazards.

Live *Sustainable Living and Working Farther from Earth*	• Develop exploration technologies and enable a vibrant space economy with supporting utilities and commodities
	  • Sustainable power sources and other surface utilities to enable continuous lunar and Mars surface operations.
	  • Scalable ISRU production/utilization capabilities including sustainable commodities on the lunar & Mars surface.
	  • Technologies that enable surviving the extreme lunar and Mars environments.
	  • Autonomous excavation, construction & outfitting capabilities targeting landing pads/structures/habitable buildings utilizing in situ resources.
	• Enable long duration human exploration missions with Advanced Life Support & Human Performance technologies.

Explore *Transformative Missions and Discoveries*	• Develop next generation high performance computing, communications, and navigation. • Develop advanced robotics and spacecraft autonomy technologies to enable and augment science/exploration missions. • Develop technologies supporting emerging space industries including: Satellite Servicing & Assembly, In Space/Surface Manufacturing, and Small Spacecraft technologies. • Develop vehicle platform technologies supporting new discoveries.

Entry Descent & Landing (EDL)
Computing for Real-Time Precision Landing Algorithms (TX 9.0)

In Situ Resource Utilization (ISRU)
Computing for Autonomous Robotic Systems (TX 7.2.3)

Environmental Control and Life Support System (ECLSS)
Computing for Autonomous Clinical Care (TX 6.3.1)

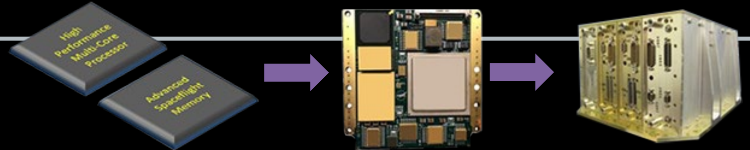
Avionics
TX 2.1 Avionics Component Technologies
TX 2.2 Avionics Systems and Subsystems
TX 11.1 Software Development, Engineering, and Integrity

Autonomous Systems & Robotics
Computing for State Estimation, Terrain Mapping and Classification, 3D Modeling, Object Recognition, Path Planning, Fault Prognosis, Anomaly Detection, Resource Planning and Scheduling, Autonomous Navigation/Obstacle Avoidance, Autonomous Management of In Situ Activities (TX 4.0)

Rendezvous & Capture
Computing for Rendezvous and Docking Algorithms (TX 4.5)

Sensors and Instruments
Computing for Instrument Control and Science Data Processing (TX 8.1, TX 8.3)

Advanced Avionics – Envisioned Future



HIGH PERFORMANCE SPACEFLIGHT COMPUTING

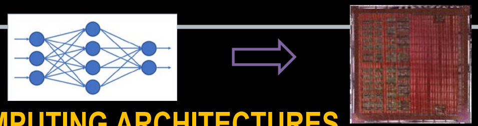
- Radiation-hardened general-purpose processor with increased performance and flexibility to adapt to mission specific performance, power, and fault tolerance needs
- Advanced spaceflight memory with radiation tolerance and increased capacity and performance
- Intelligent, efficient, multiple output Point-Of-Load (POL) power converters
- High performance Single Board Computer (SBC) incorporating high-performance general-purpose processors, advanced memory, point-of-load converters, and real-time operating system in industry standard form factors and bus architectures
- System software tools to leverage the capabilities and manage the complexity of advanced multi-core processors

INTERCONNECT

- Radiation-tolerant interconnects to support low latency onboard video, multi-gigabit instruments, onboard science, and enhanced autonomy applications; including end points, switches, physical layer devices, and software support
- Highly reliable, high-bandwidth deterministic wireless networks

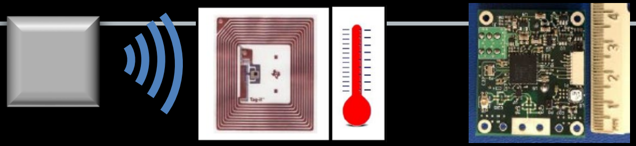
CREW INTERFACES

- Radiation-tolerant displays that can operate reliably for long durations mission beyond LEO
- Radiation-tolerant graphics processing that can operate reliably for long mission durations beyond LEO
- Heads Up Displays for Exploration EVA
- Crew voice and audio systems for deep space missions providing efficient compression of multiple streams, acoustic echo and noise cancellation, speech recognition and voice control, and wireless capabilities



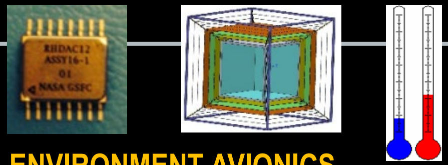
OTHER COMPUTING ARCHITECTURES

- Artificial Intelligence (AI) coprocessors to enable autonomous landing, surface navigation, robotic servicing/assembly, fault detection/mitigation, distributed systems operations, science data processing, and tip and cue for remote sensing missions
- Spaceflight quantum computers
- Low power embedded computers to support distributed robotics architectures



DATA ACQUISITION

- Wireless sensor networks to reduce harness mass and complexity, simplify integration and test, and improve system flexibility, serviceability, and expandability
- Low-cost, robust, high-accuracy data acquisition systems to enable distributed in situ monitoring of structures and subsystems on cost constrained missions



EXTREME ENVIRONMENT AVIONICS

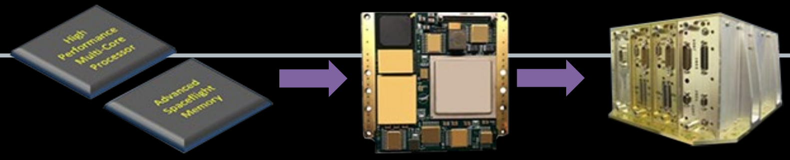
- Extreme temperature electronics capable of operating in environments with both high radiation and wide temperature ranges, including lunar/planetary surfaces and nuclear systems
- Avionics packaging and thermal management technologies to enable avionics operation in extreme environments

FOUNDATIONAL TECHNOLOGIES

- Advanced 2.5D/3D packaging and heterogeneous integration enabling miniaturization and improved performance
- Advanced semiconductor process nodes and libraries to enable next generation radiation hard devices
- Low-cost, radiation-hardened mixed-signal ASICs

<u>All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.</u>

Advanced Avionics – State of the Art

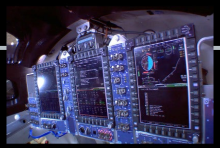


HIGH PERFORMANCE SPACEFLIGHT COMPUTING

- Processors – Current missions either using radiation-hardened processors with limited performance, or higher performance redundant COTS-based processors limiting power efficiency
  - *Target - 3-5X performance improvement over current space processors for general purpose processing (GPP), parallel processing acceleration, and flexibility to adapt performance, power, and fault tolerance to mission needs*
- Memory – Radiation-hardened memories lack capacity and/or performance, while COTS-based memories are susceptible to radiation induced upsets
  - *Target - Radiation-hardened memory with 4-8X the capacity and/or performance of existing radiation-hardened memories*
- Point-Of-Load (POL) Power Converters – Current POL converters provide a limited number of outputs and lack embedded fault tolerance
  - *Target - Radiation-hardened, high efficiency POL converters with at least 3 outputs, bus interface, and embedded fault tolerance*
- Single Board Computer (SBC) – Current SBCs using radiation-hardened processors have limited performance, and limited capability for power and performance scaling
  - *Target - Radiation-hardened SBC in industry standard form factor with 5X GPP improvement, parallel processing, and ability to scale power and performance*
- HPSC Software Tools – Current system software tools do not support the complexity of the High Performance Spaceflight Processing (HPSC) multicore processor
  - *Target - System software tools that allow developers to fully leverage the GPP and parallel processing capabilities and flexibility of the HPSC processor*

INTERCONNECT

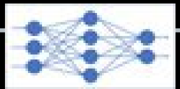
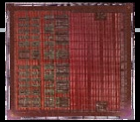
- Wired – Current onboard wired networks lack bandwidth to support increased sensor data rates of future missions
  - *Target - Wired networks with 10X bandwidth improvement*
- Wireless – Current onboard wireless networks only support low criticality needs
  - *Target - Wireless networks for critical applications in crewed and robotic missions*



CREW INTERFACES

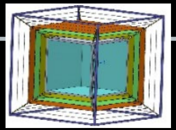
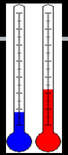
- Crew Displays and Graphics Processors – Current spaceflight technologies offer limited visual performance and have uncharacterized radiation risks for long duration missions beyond LEO
  - *Target - Radiation-tolerant displays and graphics processors that can support displays with minimum of 1080p 30fps for Lunar and Mars mission durations (note - graphics processors are also applicable for other onboard processing functions)*
- Crew Voice and Audio Systems – Current system offer limited system performance and have uncharacterized radiation risks for long duration missions beyond LEO
  - *Target - Radiation-hardened system with efficient compression, speech recognition and voice control, and active noise control for Lunar and Mars mission durations*

Advanced Avionics – State of the Art

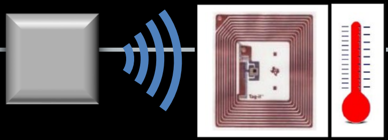
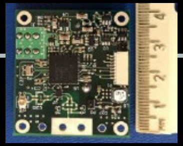
OTHER COMPUTING ARCHITECTURES

- Artificial Intelligence (AI) Coprocessors – COTS devices exist, but with unknown radiation performance and applicability to NASA onboard processing tasks
  - *Target - Radiation-tolerant AI coprocessors for NASA missions*
- Quantum Computing – Quantum computing technology is emerging, but is limited to terrestrial applications
  - *Target – Quantum computers tailored for onboard processing applications and environments*
- Low Power Embedded Computers – Current spaceflight robotics systems employ centralized architectures, which increases network bandwidth, latency, power, and system complexity
  - *Target – Low power embedded computers enabling distributed architectures*

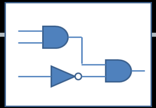
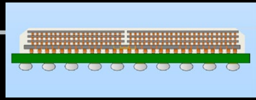
EXTREME ENVIRONMENT AVIONICS

- Extreme Temperature/Radiation Electronics – Only limited functions have been implemented that can operate in environments with both high radiation and wide temperature ranges, including lunar/planetary surfaces and nuclear systems
  - *Target – Diverse set of circuit functions to enable systems that can operate in Lunar surface, planetary surface, and nuclear systems environments with both high radiation and wide ranges of operating temperatures*
- Packaging and Thermal Management Technologies – Current approaches limit the ability to operate at extreme cold and hot temperatures
  - *Target - Packaging and thermal management technologies that can be tailored to operate across wide temperature ranges for Lunar or planetary missions*

DATA ACQUISITION

- Wireless sensor networks – Current onboard sensing requires harnessing, which incurs a mass penalty
  - *Target - Readout systems and diverse onboard wireless sensor node types*
- Data Acquisition (DAQ) Systems – Current entry descent and landing DAQ systems are too costly to deploy on wide range of missions
  - *Target - 10X cost reduction for distributed in situ monitoring of structures and subsystems on cost constrained missions*

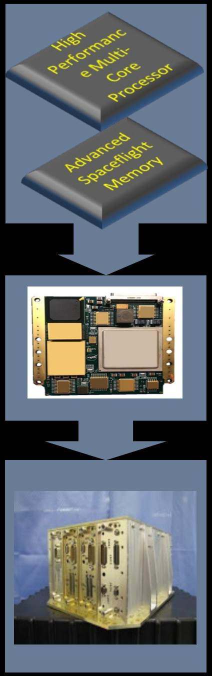
FOUNDATIONAL TECHNOLOGIES

- Advanced 2.5D/3D Packaging and Heterogeneous Integration (HI) – These exist in industry, but lack spaceflight qualification
  - *Target - Qualified 2.5D/3D packaging and HI for NASA missions*
  - Advanced Semiconductor Process Nodes/Libraries – Existing 45nm RHBD libraries lack the density and performance needed for next generation of computing devices
  - *Target - Libraries with 2X/4X the performance/density existing RHBD libraries*
- Low-Cost Mixed Signal ASICs – Custom mixed-signal ASIC NRE cost limits infusion
  - *Target - Radiation-hardened structured ASIC platforms to reduce NRE cost*

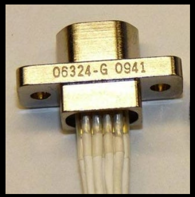
Advanced Avionics Gap Closure Plans

(Green =Funded, Yellow = Partially Funded, Red = Unfunded)

HIGH PERFORMANCE SPACEFLIGHT COMPUTING	
Radiation-hardened general-purpose processor	Define a High Performance Spaceflight Computing (HPSC) processor concept that maximally leverages microelectronics technology advances for high reliability applications. Engage industry to develop and commercialize a radiation-hardened multi-core HPSC processor that addresses the computing needs of future NASA missions and broader markets. Leverage other government computing investments, as well as COTS developments, that are suitable for NASA use.
Advanced spaceflight memory	Fund the development and qualification of radiation-hardened non-volatile memory. Leverage other government agency investments in development of other radiation-hardened memory devices. Test emerging COTS memory technologies and identify devices that are suitable for NASA applications.
Point-Of-Load (POL) power converters	Leverage SBIR to develop intelligent, radiation-hardened multi-output POL converters that leverage industry smart power bus standards. Secure program funding for post Phase II commercialization.
Single Board Computer (SBC)	Define advanced avionics architectures that leverage HPSC capabilities. Develop spaceflight computer boards to demonstrate in those architectures. Engage industry to develop and commercialize spaceflight HPSC SBCs in industry standard form factors.
HPSC Software Tools	Port real-time operating systems, develop tools, and HPSC Middleware tools to support the full HPSC architecture. Assess existing libraries for image processing, signal processing, and machine learning, and augment as needed for HPSC architecture.



INTERCONNECT	
Radiation-tolerant interconnect	Leverage the HPSC concept studies and the NESC SpaceVPX Interoperability Study to select optimal interconnect standards for further development. Engage with standards organizations to ensure that evolution of selected standards meet future NASA mission needs. Assess availability of components required (i.e. endpoints, switches, physical-layer components) for a robust ecosystem for the selected standards, and leverage SBIR to develop needed components.
Highly reliable, high bandwidth deterministic wireless networks	Engage academic institutions to develop novel techniques that extend the capabilities of space-based wireless networks in time-sensitive and safety-critical applications. Leverage SBIR/STTR as a follow on to implement for space flight demonstration.



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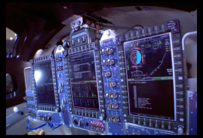
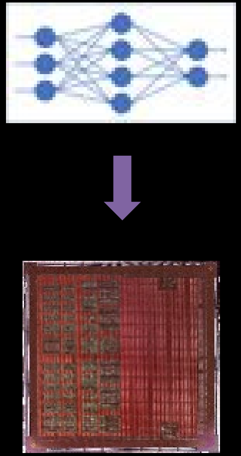
CREW INTERFACES	
Radiation-tolerant displays	Under ESDMD Polaris project, characterize the radiation performance of candidate display pixel technologies and support circuitry. Transfer knowledge from Polaris project to industry for development and commercialization of radiation-tolerant displays for future NASA exploration missions.
Radiation-tolerant graphics processing	Engage small business to characterize radiation performance of COTS Graphics Processor Units (GPUs) and develop system-level radiation mitigation approaches suitable for use in future NASA exploration missions. Specifically, develop system-level mitigation approaches for transient errors due to single event effect (SEE).
Heads Up Display (HUD) Optics	Advance development of Heads Up Display (HUD) optics under ESDMD Polaris project to advance xEMU displays. Continue development efforts for xEMU partnering with academia and industry.
Crew voice and audio systems	Engage, current NASA programs, industry partners, and small business to develop systems that can meet future mission environments and incorporate speech recognition capabilities.



OTHER COMPUTING ARCHITECTURES	
Artificial Intelligence (AI) coprocessor	Evaluate viability of COTS coprocessor devices and foundational technologies for NASA AI applications within the RadNeuro and the NEPP programs. Devise system-level radiation mitigation approaches to address susceptibilities in COTS devices. Demonstrate coprocessors and mitigation approaches via ground radiation testing and flight demonstrations. Study the optimal mapping of onboard (AI) applications to candidate processing architectures and devices.
Quantum Computing	Explore candidate use cases for onboard quantum computing and compare performance with other computing technologies. Assess radiation susceptibilities of quantum computing and potential mitigations. Define concept for spaceflight quantum computer, and develop prototype.
Low power embedded computers	Develop distributed avionics architecture to enable modular, interoperable, and reusable robotic systems. Define low power embedded computer concepts that are consistent with that architecture and can meet SWaP and extreme environmental requirements. Perform NASA development of proof-of-concept low power embedded computer, and then engage small business for further development and commercialization.



Advanced Avionics Gap Closure Plans

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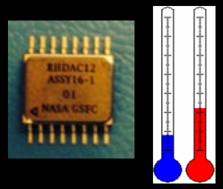
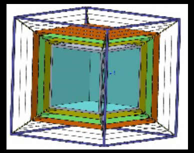
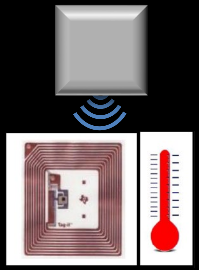
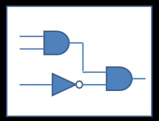
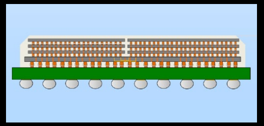
EXTREME ENVIRONMENT ELECTRONICS	
Extreme temperature/radiation electronics	Under the SMD ColdTech and HOTTech programs and STMD LSII and LuSTR programs, develop and characterize radiation-hardened extreme temperature design libraries in SiGe and SiC and implement digital and mixed-signal devices for infusion into NASA missions. Assess extreme temperature electronics from other industries for potential NASA use.
Avionics packaging and thermal management for extreme environments	Under the STMD PALETTE project, develop set of packaging and thermal management technologies to that avionics developers can utilize to implement passively controlled packaging for widely ranging mission environments. Infuse PALETTE technologies into lunar and planetary instruments and subsystems.
DATA ACQUISITION	
Wireless sensor networks	Develop and demonstrate enhanced wireless sensor nodes with an implementation path for hardware that can operate reliably in harsh environments and demonstration in testing, support, and flight applications as needed. Specific solutions for crewed missions may be compatible with the Radio-frequency identification (RFID) Enabled Autonomous Logistics Management (REALM) system, leveraging additive manufacturing technology to provide miniaturization.
Low-cost, robust, high-accuracy data acquisition systems	Leverage SBIR to develop a radiation-tolerant low-cost data acquisition system technology. Secure program funding for post Phase II commercialization.
FOUNDATIONAL TECHNOLOGIES	
Advanced 2.5D/3D packaging and heterogeneous integration	Develop conventional and additively manufactured 2.5D and 3D packaging technologies for low production volume devices. Engage Nextflex consortium to develop qualification methods for additively manufactured spaceflight electronics, and then demonstrate on smallsat missions. Engage industry on the development of qualification methods for 3D packaging.
Advanced Semiconductor Process Nodes/Libraries	Under NASA STMD funding, perform radiation characterization and modelling of the Global Foundries 22FDX process and automotive grade design libraries. Leverage other government and industry efforts in radiation-hardened deep submicron processes and libraries.
Low-Cost Mixed Signal ASICs	Engage industry to develop radiation-hardened mixed-signal structured ASIC platform to broadly meet NASA mission needs.

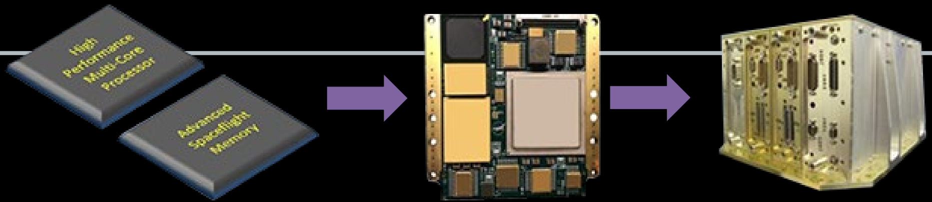
Advanced Avionics – Next Steps for Currently Unfunded Technologies

HIGH PERFORMANCE SPACEFLIGHT COMPUTING	
• Leverage SBIR to develop intelligent, radiation-hardened multi-output POL converters that leverage industry smart power bus standards.	Priority 2
CREW INTERFACES	
• Assess radiation susceptibilities and mitigations, and engage industry to develop and commercialize radiation-tolerant displays for future NASA exploration missions and crew voice and audio systems for future NASA exploration missions	Priority 1
INTERCONNECT	
• Engage with standards organizations to ensure that evolution of selected standards meet future NASA mission needs	Priority 3
• Leverage SBIR to develop technologies needed (i.e., endpoints, switches, physical components) for a robust ecosystem that supports the selected standards	Priority 7
• Engage academia to extend wireless network technology to meet the reliability and determinism needed by NASA applications for both crewed and robotic missions	Priority 8
LOW POWER EMBEDDED COMPUTER	
• Develop distributed avionics architecture to enable modular, interoperable, and reusable robotic systems	Priority 4
• Define low power embedded computer concepts that are consistent with that architecture and can meet SWaP and extreme environmental requirements	Priority 5
LOW-COST DATA ACQUISITION SYSTEMS	
• Leverage SBIR to a radiation-tolerant low-cost data acquisition system technology, then secure program funding for post Phase II commercialization	Priority 6

Advanced Avionics Envisioned Future – Key Points

- The highest priorities for advanced avionics are:
  - Continued investment in High Performance Spaceflight Computing (HPSC), and underlying technologies
  - Continued investments in crew interfaces
- The next priority should be development of interconnect technologies to enable avionics architectures that address increasing sensor bandwidth, and can leverage the increased compute capabilities provided by HPSC
- Other priorities include development of radiation-hardened multi-output POL converters, development of low power embedded computers to support distributed robotics architectures, and development of low-cost, robust, high-accuracy data acquisition systems to enable distributed in situ monitoring of structures and subsystems on cost constrained missions
- Additionally, opportunities should be sought to leverage SBIR/STTR to address lower priority gaps

Advanced Avionics – Computing Technologies



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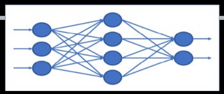

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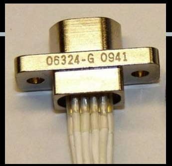
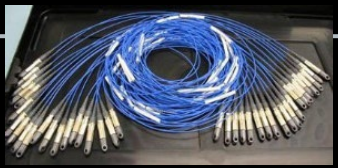
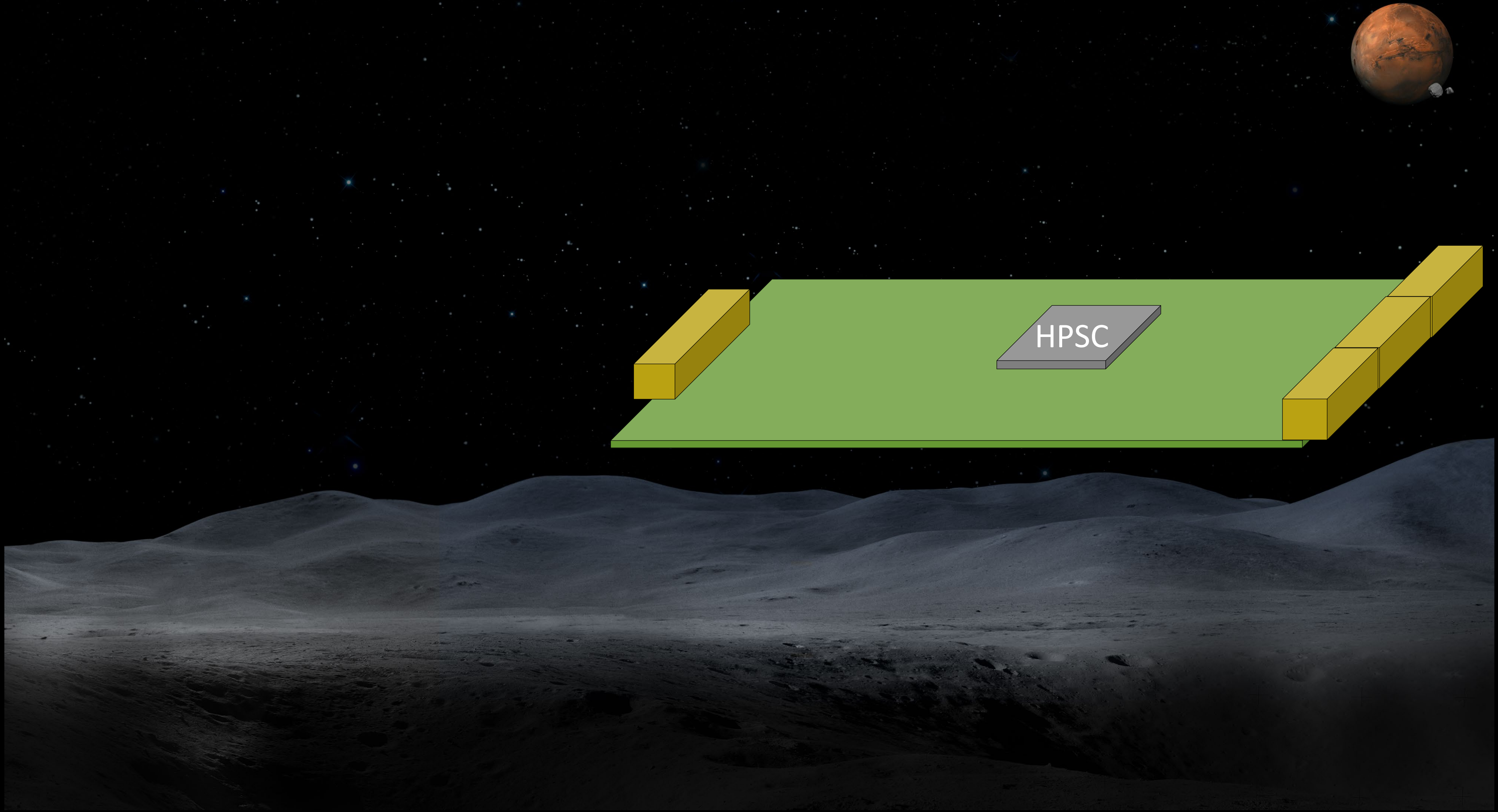




INTERCONNECT

- Radiation-tolerant interconnects to support low latency onboard video, multi-gigabit instruments, onboard science, and enhanced autonomy applications; including end points, switches, physical layer devices, and software support
- Highly reliable, high-bandwidth deterministic wireless networks

Computing Technologies – System Context



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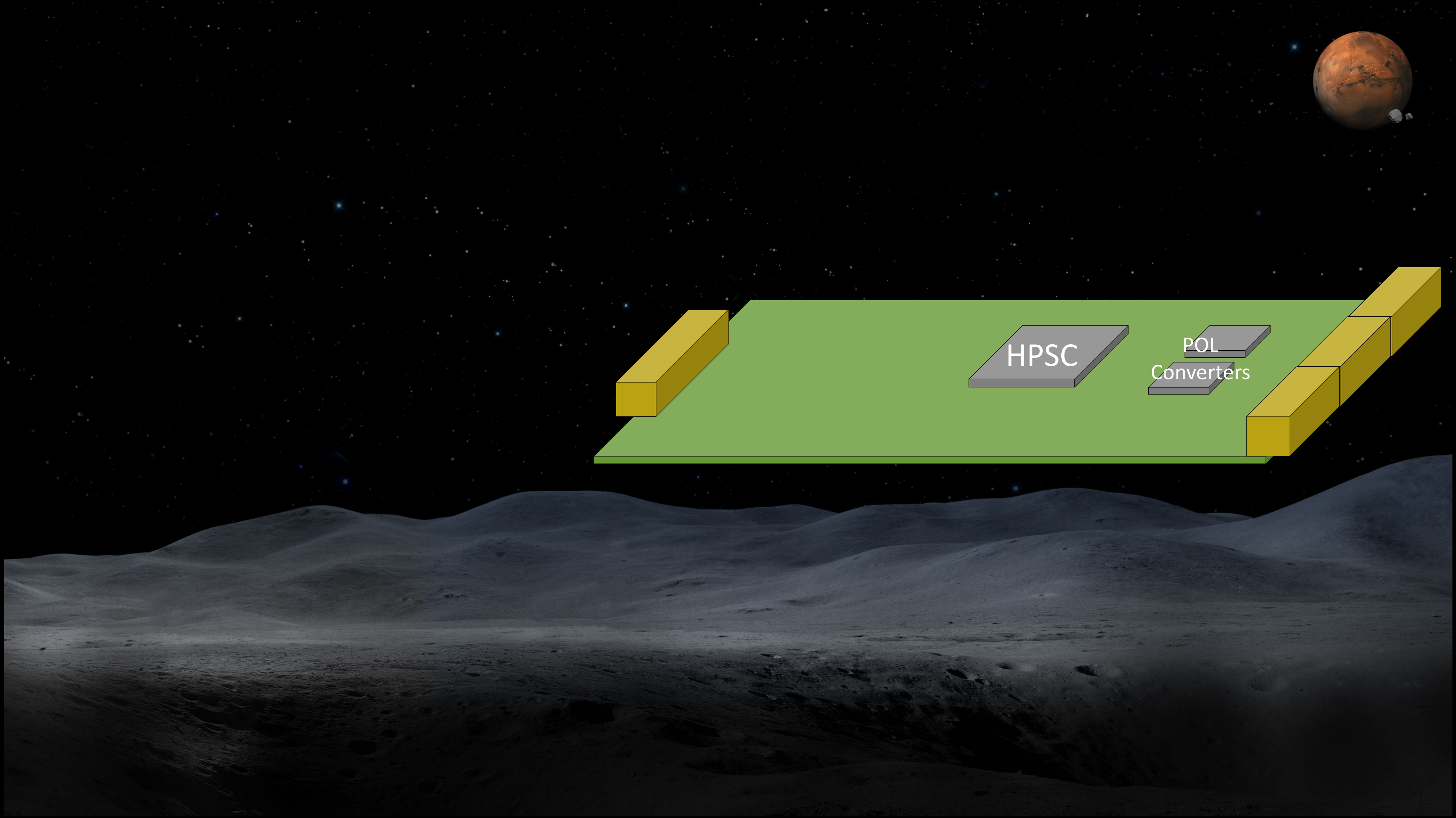

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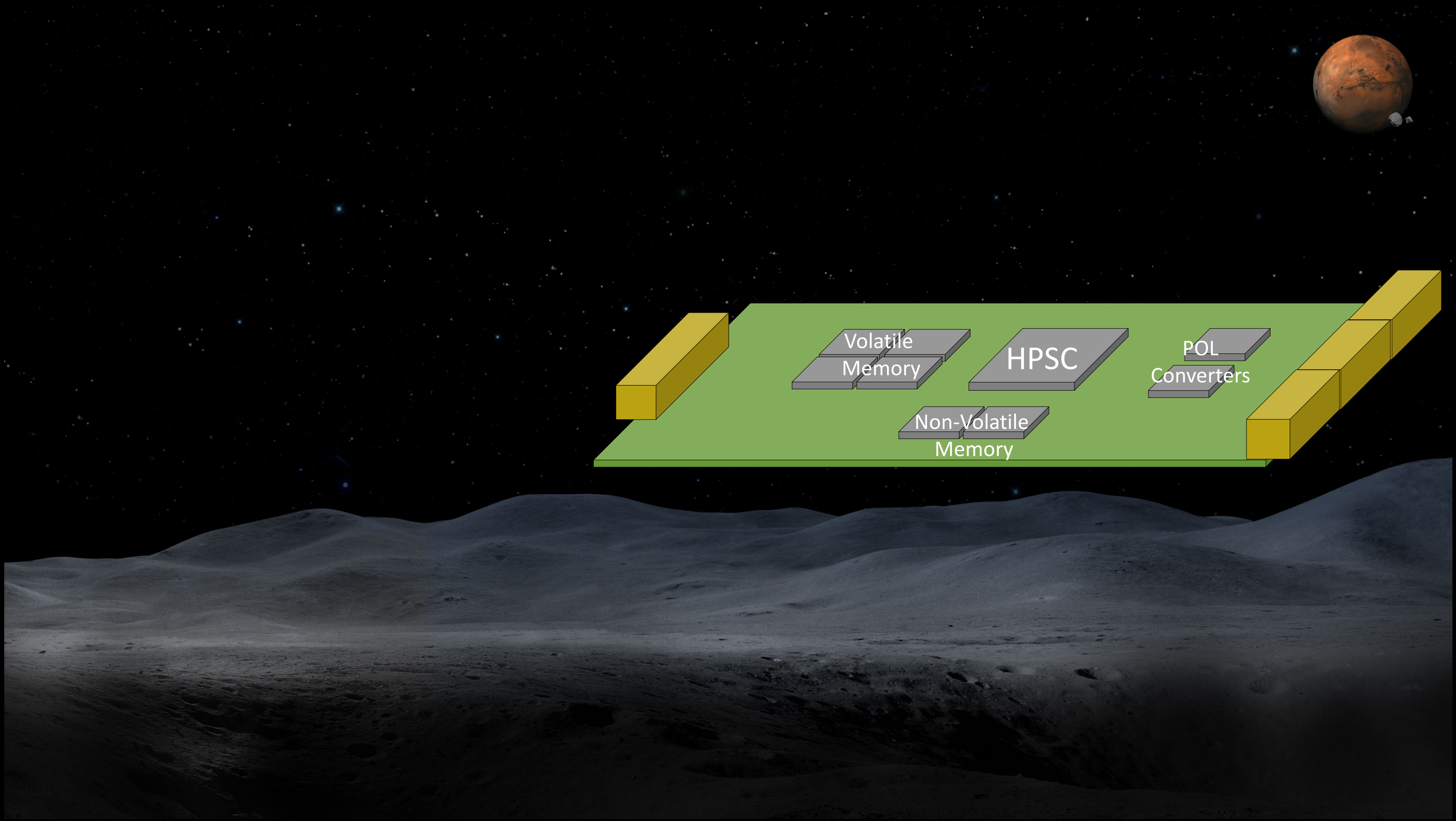

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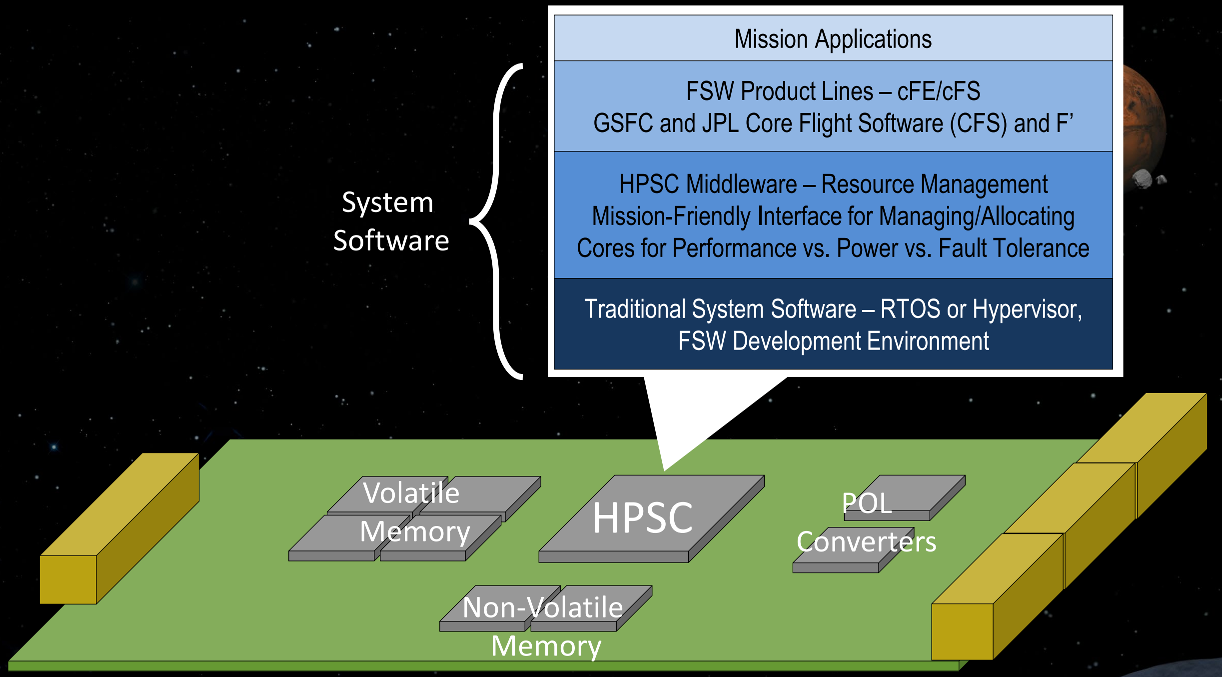
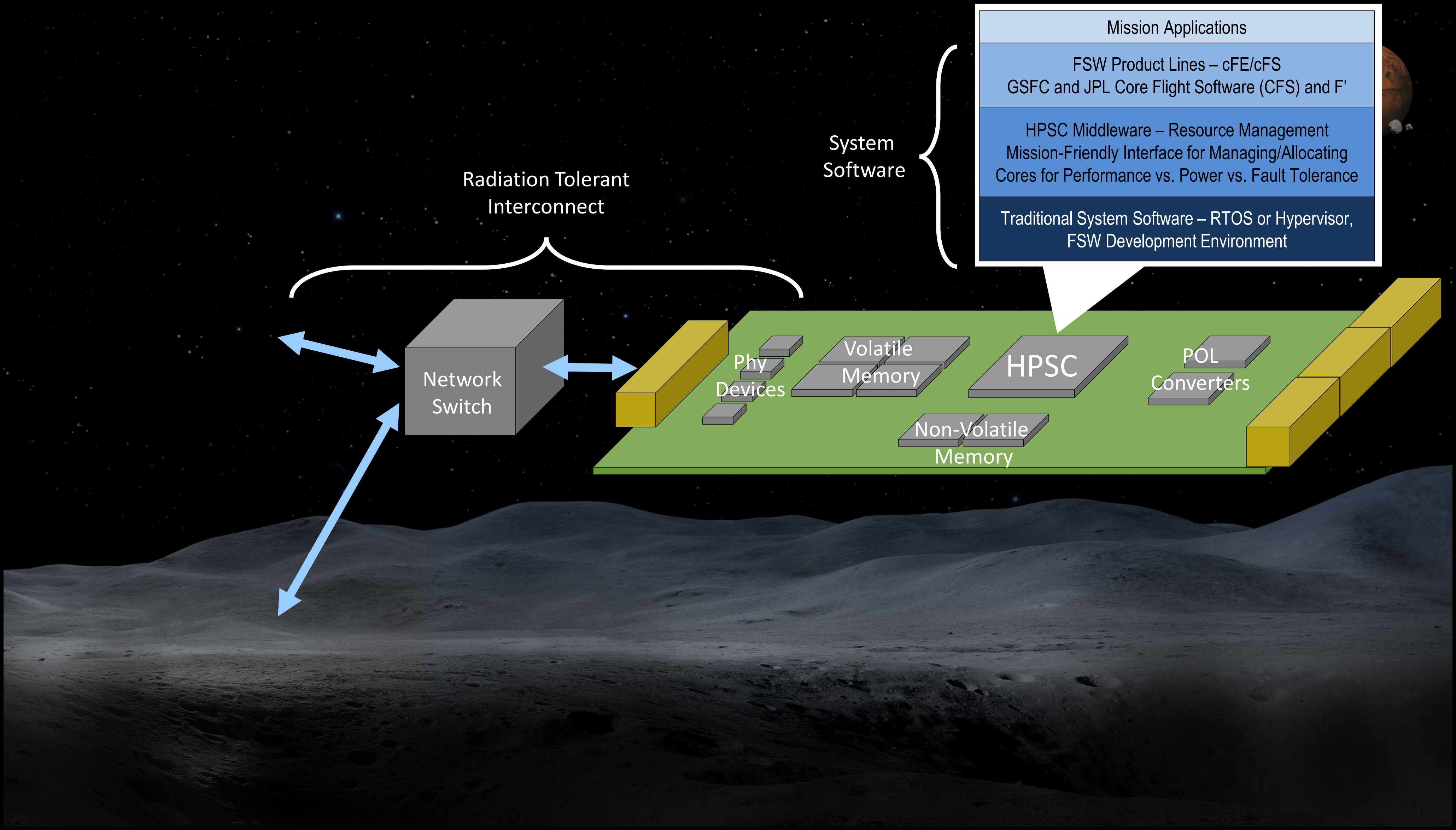
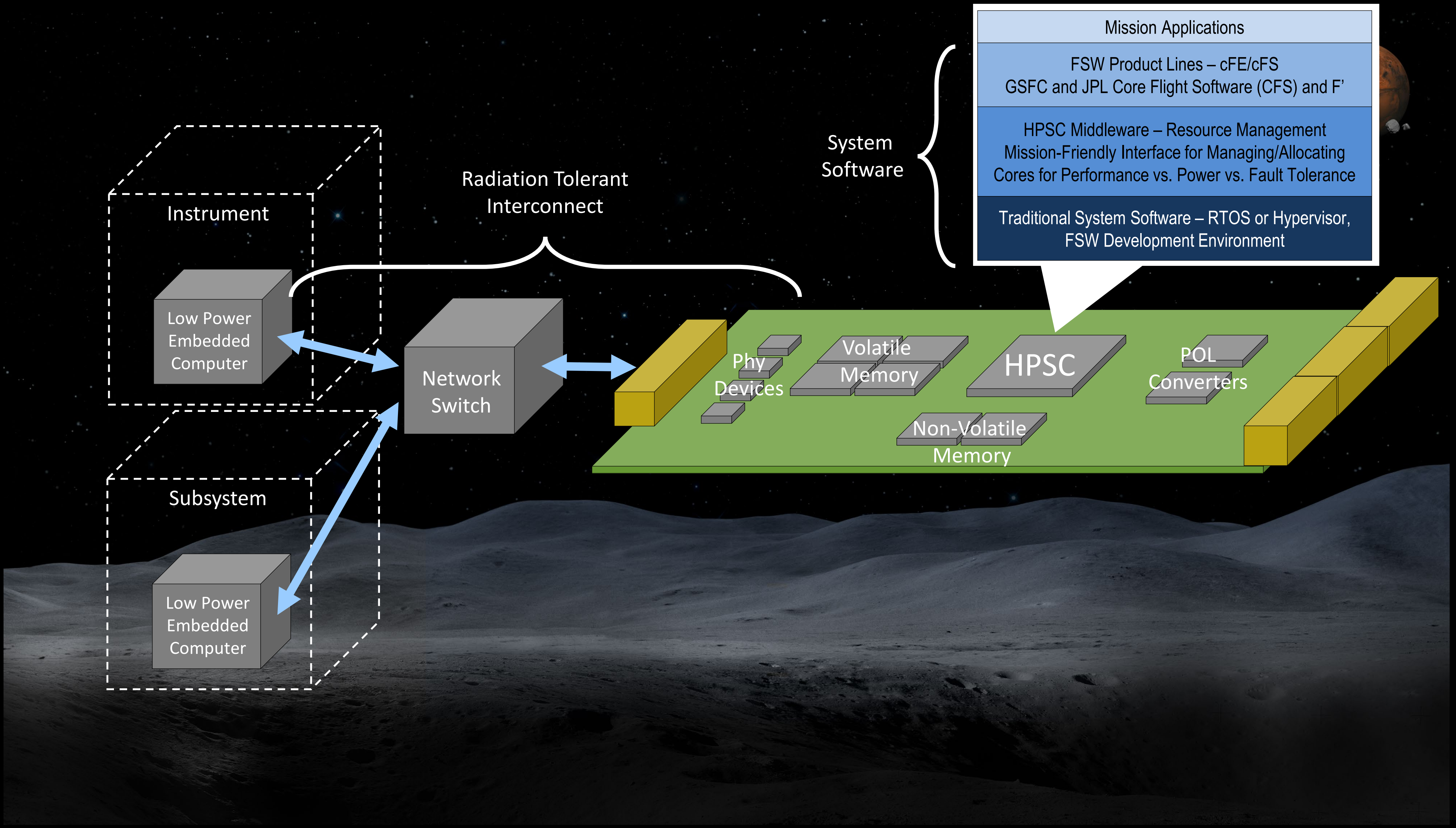


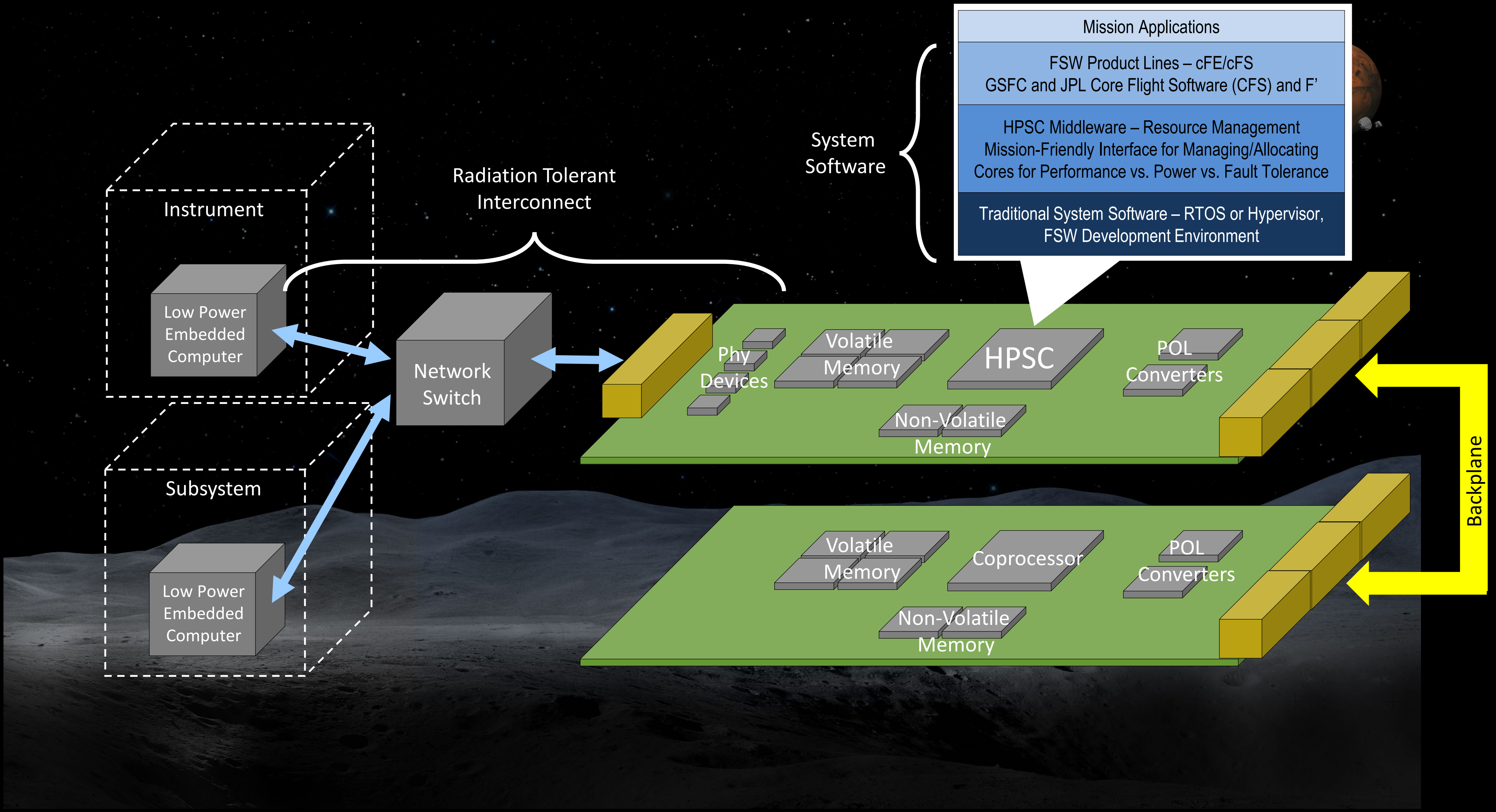
Computing Technologies – System Context



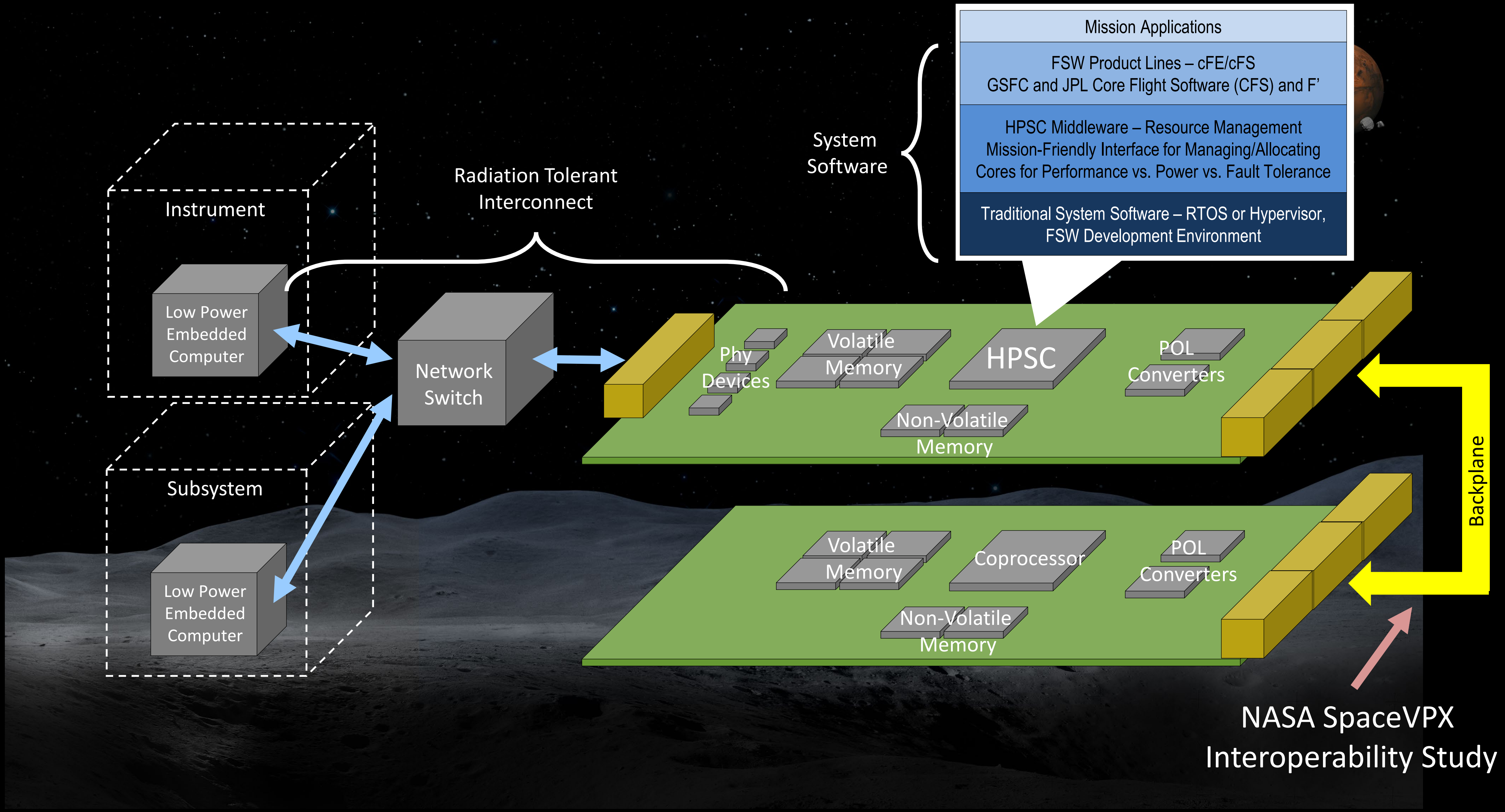
Computing Technologies – System Context



Computing Technologies – System Context



Computing Technologies – System Context



NASA and SpaceVPX

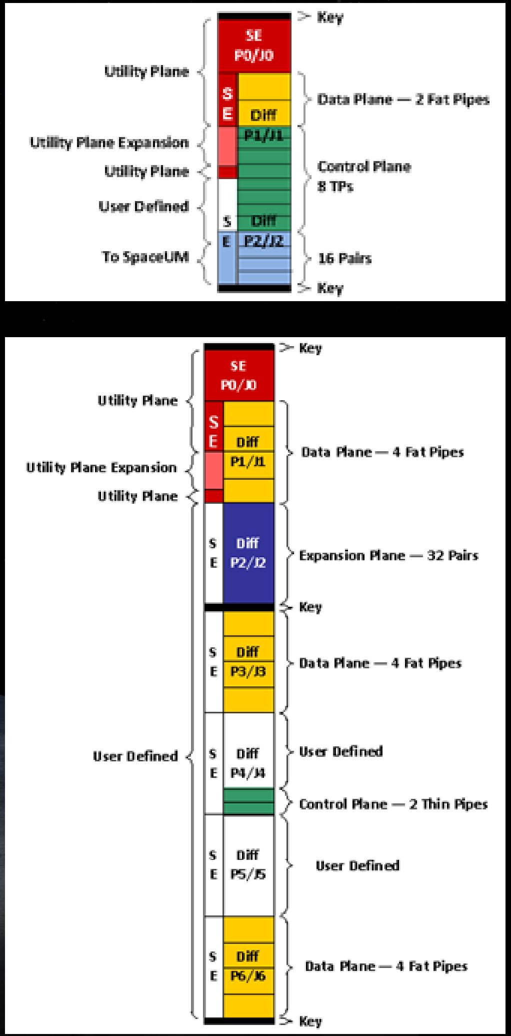
As NASA exploration moves beyond low-Earth-orbit (LEO), the need for interoperable avionics systems becomes more important due to the cost, complexity, and the need to maintain distant systems for long periods

The existing SpaceVPX industry standard addresses some of the needs of the space avionics community, but falls short of an interoperability standard that would enable reuse and common sparing on long duration missions and reduce NRE for missions in general

- It is possible to implement two different modules that are fully compliant with SpaceVPX yet cannot interoperate
- Even modules with identical slot profiles will not talk to each other if one uses SpaceWire and the other SRIO for datal plane network protocols
- There are 48 separate slot profiles defined (not including variations in length and pitch)
- Required redundancy in several areas limits the development of single string systems
- Limits types of fault tolerance architectures and implementations (natively only supports dual redundancy, and does not map directly to other system level fault tolerance patterns)

A NASA Engineering & Safety Center (NESC) study was conducted to address the deficiencies in the SpaceVPX standard for NASA missions and define the recommended use of the SpaceVPX standard within NASA

The future infusion of HPSC into SpaceVPX systems was a consideration in this study

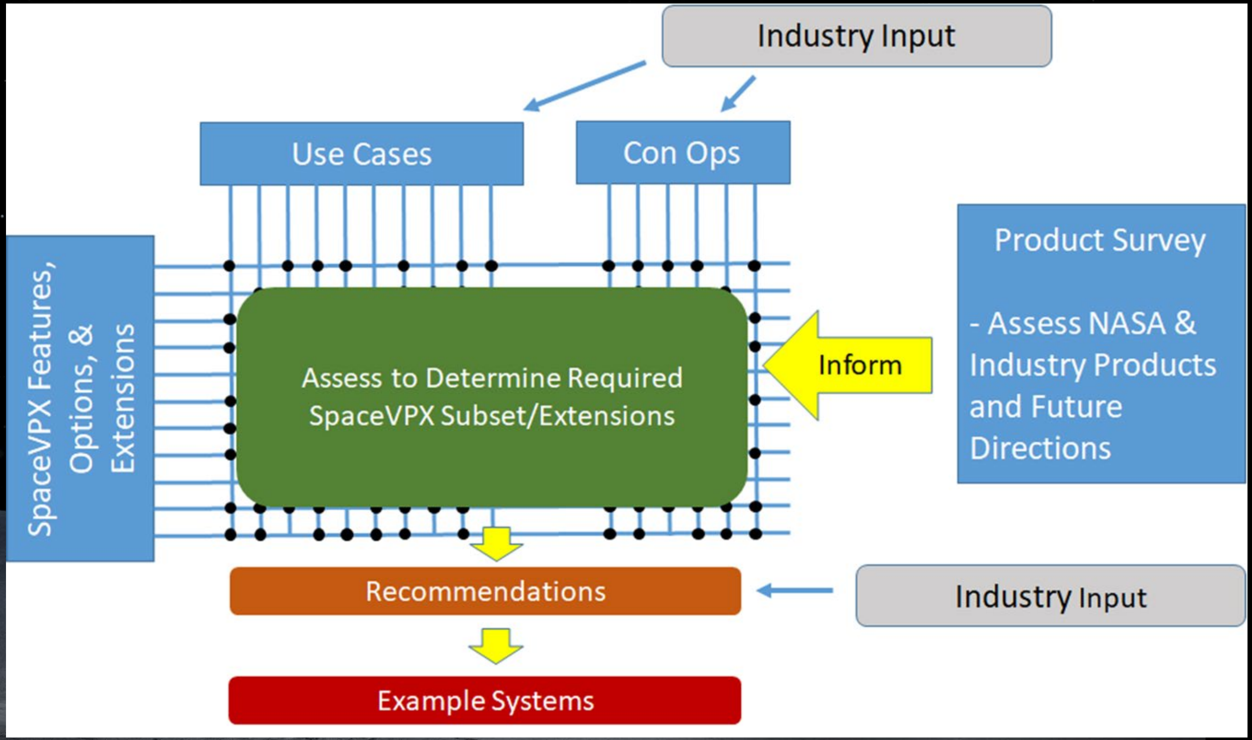


3U and 6U Slot Profiles [VITA-78]

NASA SpaceVPX Study Approach

The effort was divided into the following tasks:

- Notional use case analysis
- Product surveys
- Study focus area analysis
  - Interconnect
  - Power management and distribution
  - Form factor and daughtercards
  - Fault tolerance
- Engagement with other organizations
- Definition of proposed NASA SpaceVPX specification
- Identification of candidate modules
- Definition of example SpaceVPX systems



Study Approach

Proposed NASA SpaceVPX Specification

	Proposed NASA Specification
RT-1	**General** Support dual redundant and single string SpaceVPX systems.
RT-2	**Power distribution and management** Utilize the 5-output SpaceUM (SLT3-SUM-5S1V3A1R1M3C-14.7.2) for 3U implementations with a 5V main power voltage. Utilize the 8-output SpaceUM (SLT6-SUM-8S3V3A1B1R1M4C-10.8.1) for 6U implementations with +12, +5, and +3.3 main supply voltages.

RT-3	**Interconnect**
	Support the following interconnect protocols:
	• Data Plane – Support for Ethernet 10GBASE-KR as specified in IEEE 802.3ap with support for TSN as specified in IEEE 802.1AX, CB, AS, Qbv, Qav, Qci, Qcc, and 802.1Q clauses 8.6.5.1 and 8.6.8.2
	• Control Plane - SpaceWire as defined in ECSS-E-ST-50-12C
	• Expansion Plane – JESD204C
	• Expansion Plane – Support for PCIe Gen 3.1
	• Utility Plane – IPMI and DAP as specified in VITA-78
	• User Defined signals with the requirement that they are user programmable
	  • SERDES.- 1600mV peak-to-peak AC-coupled differential signaling; 8b/10b encoding; data rates of 1.25 Gbps, 2.5 Gbps, 3.125 Gbps, 5 Gbps, 6.25 Gbps, and 10 Gbps (note that some modules may not support all of these rates)
	  • Single ended - 2.5V LVCMOS signaling
	• Low-Rate Interconnect – I2C
	• JTAG
	• Provide pin on a front panel to disable JTAG for flight.

Proposed NASA SpaceVPX Specification

	Proposed NASA Specification
RT-4	**Form Factors and Daughtercards** Support 3U and 6U – 220mm form factors. Support for XMC and/or FMC daughtercards on SpaceVPX FPGA-based modules. Combined 3U/6U chassis as needed.
RT-5	**Fault tolerance** Adopt fault tolerance methodologies as defined in VITA-78.
RT-6	**Backplanes and Chassis** Use VITA-78 identified passive backplanes.
RT-7	**Connectors** Utilize SpaceVPX module and backplane that comply with VITA-46.
RT-8	**VITA-78 features not be used to ensure future interoperability** • Specified chassis and backplane profiles. • SRIO on data plane (can be implemented with User Defined SERDES). • SpaceFibre on data plane (can be implemented with User Defined SERDES). • System Controller interfacing to 4 SpaceUM modules (recommendation is 2). • Support for heritage cPCI modules. • Support for 2-output 3U SpaceUM (SLT3-SUM-2S3V3A1B1R1M4C-14.7.1). • Support for VBAT voltage. • System management discrete input and output interfaces. • Full latitude on user defined signal usage .

Candidate Module Definitions

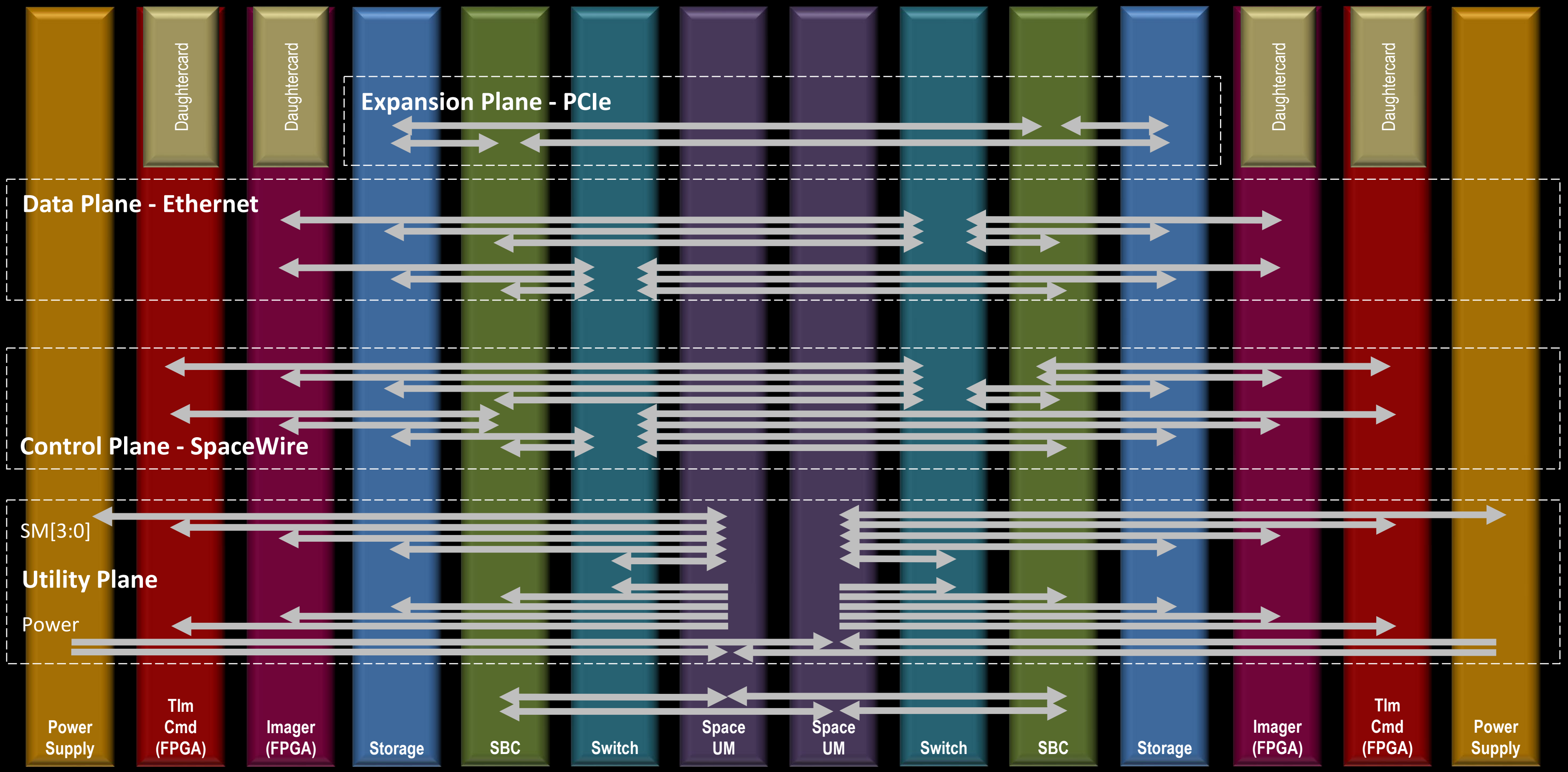
Based on the use cases and the proposed NASA SpaceVPX specification, candidate modules were defined

- Single Board Computer (SBC)
- Storage
- High Density FPGA
- Digitizer
- Low Density FPGA
- Switch

Example Systems

Based on the candidate module definitions and proposed NASA SpaceVPX specification, example systems were defined

- Redundant 3U system
- Single string 3U systems (smallsat avionics, instrument controller)
- Minimalist systems
- Interim systems supporting legacy cPCI modules



Redundant 3U System

In Closing …

NASA welcomes your inputs on envisioned future for advanced avionics

- Technologies included
- State of the art
- Priorities

NASA has recently completed a study to assess SpaceVPX interoperability challenges and define a proposed solution

- Using the NASA study recommendations as a starting point for discussion, NASA would like to engage with the spaceflight avionics community to determine if consensus can be readily achieved on developing a SpaceVPX VITA78 ‘dot spec’ that enhances interoperability
- Again, we welcome your input!

Questions?

Acronym List

AI	Artificial Intelligence	HPSC	High Performance Spaceflight Computing	POL	Point of Load
AR&D	Autonomous Rendezvous and Docking	HUD	Heads Up Display	REALM	RFID Enabled Autonomous Logistics
ASIC	Application Specific Integrated Circuit	IPMI	Intelligent Platform Management Interface	RFID	Radio Frequency Identification
cFE/cFS	Core Flight Executive / Core Flight Software	ISRU	In Situ Resource Utilization	RHBD	Radiation Hardened By Design
COLDTech	Concepts for Ocean worlds Life Detection Technology	JESD	Joint Electron Device Engineering Council Standard	RTOS	Real Time Operating System
COTS	Commercial Off the Shelf	JTAG	Joint Test Action Group	SBC	Single Board Computer
cPCI	Compact Peripheral Component Interconnect	LEO	Low Earth Orbit	SBIR	Small Business Innovation Research
DAP	Direct Access Protocol	LPEC	Low Powe Embedded Computer	SERDES	Serializer Deserializer
DAQ	Data Acquisition	LSII	Lunar Surface Innovation Initiative	SiC	Silicon Carbide
ELCSS	Environmental Control and Life Support System	LuSTR	Lunar Surface Technology Research	SiGe	Silicon Germanium
EDL	Entry Descent and Landing	LVCMOS	Low Voltage Complimentary Oxide Semiconductor	SMD	Science Mission Directorate
ESDMD	Exploration Systems Development Mission Directorate	ML	Machine Learning	SRIO	Serial RapidIO
EVA	Extra-Vehicular Activity	mm	Millimeter	STMD	Space Technology Mission Directorate
FMC	FPGA Mezzanine Card	mV	Millivolt	STTR	Small Business Technology Transfer
FPGA	Field Programmable Gate Array	NASA	National Aeronautics and Space Administration	SWaP	Size Weight and Power
fps	Frames per Second	NEPP	NASA Electronics Parts and Packaging Program	TSN	Time-Sensitive Networking
FSW	Flight Software	NESC	NASA Engineering & Safety Center	TX	Taxonomy
Gbps	Gigabits Per Second	nm	Nanometer	VITA	VMEbus (Versa Module Eurocard Bus) International Trade Association
GPU	Graphics Processing Unit	NRE	Non Recurring Engineering	xEMU	Exploration Extravehicular Mobility Unit (xEMU)
HI	Heterogeneous Integration	PALETTE	Planetary and Lunar Environment Thermal Toolbox Elements	XMC	Express Mezzanine Card
HOTTech	Hot Operating Temperature Technology	PCIe	Peripheral Component Interconnect Express		