A SpaceVPX-compliant transceiver for low-SWaP instrument applications

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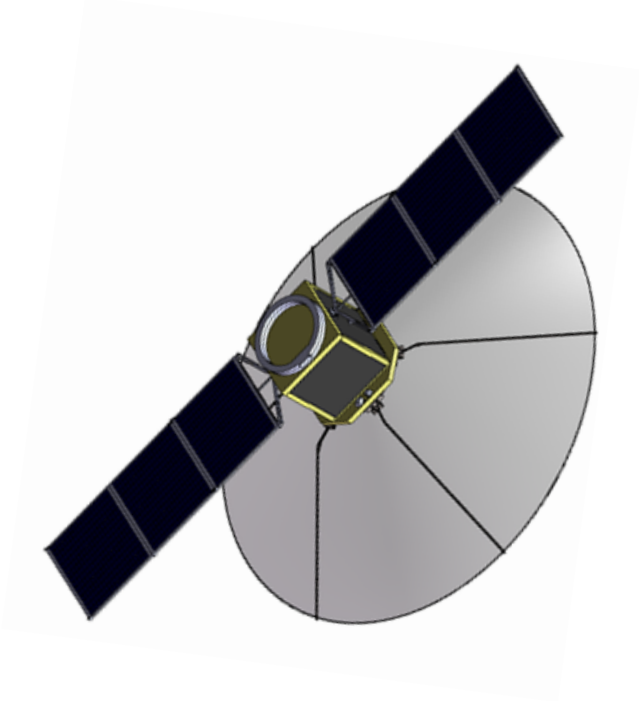
Acknowledgements



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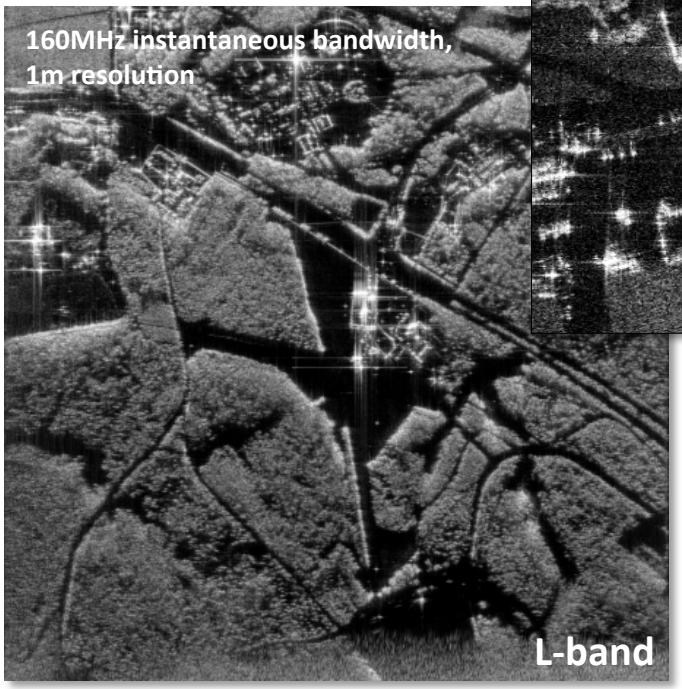
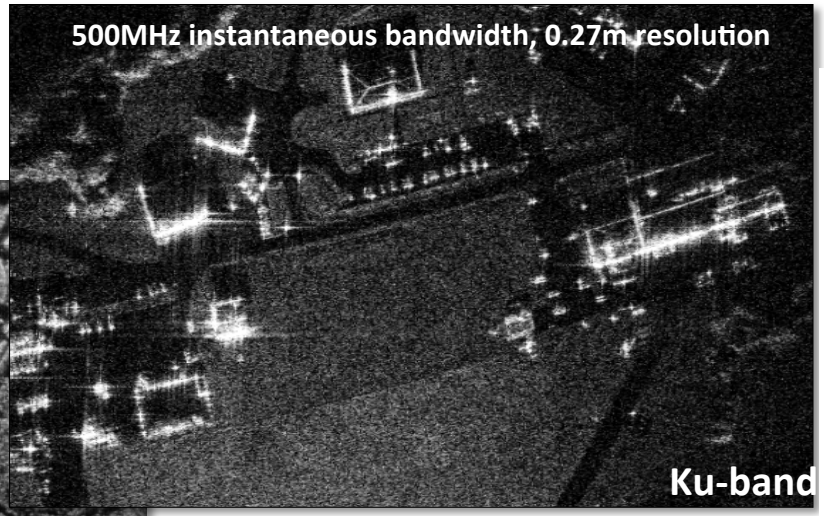
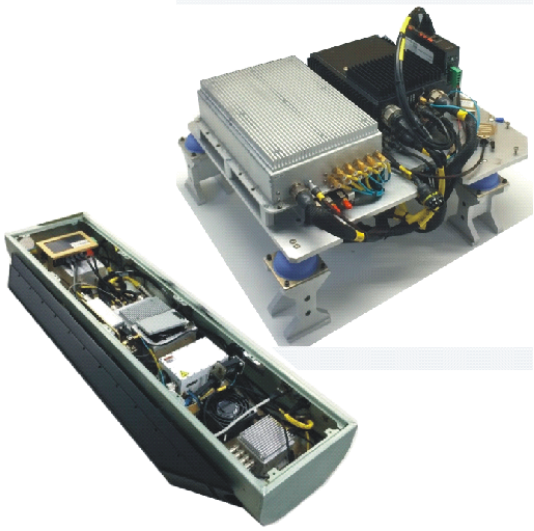
Thanks to Dr. Greg Sadowy and his team at the JPL Radar Science and Engineering Section, and Robert Jones of NASA, for their guidance and support.

Airborne Sensor Heritage

Significant airborne heritage in programmable synthetic aperture radar (SAR) payloads for low size, weight, and power (SWAP) applications



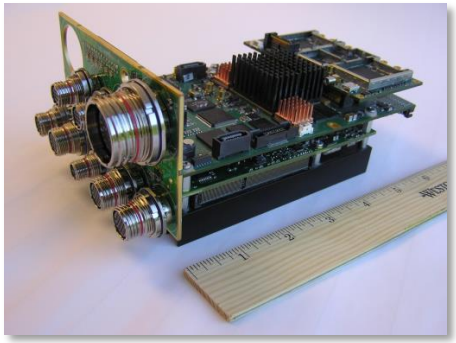


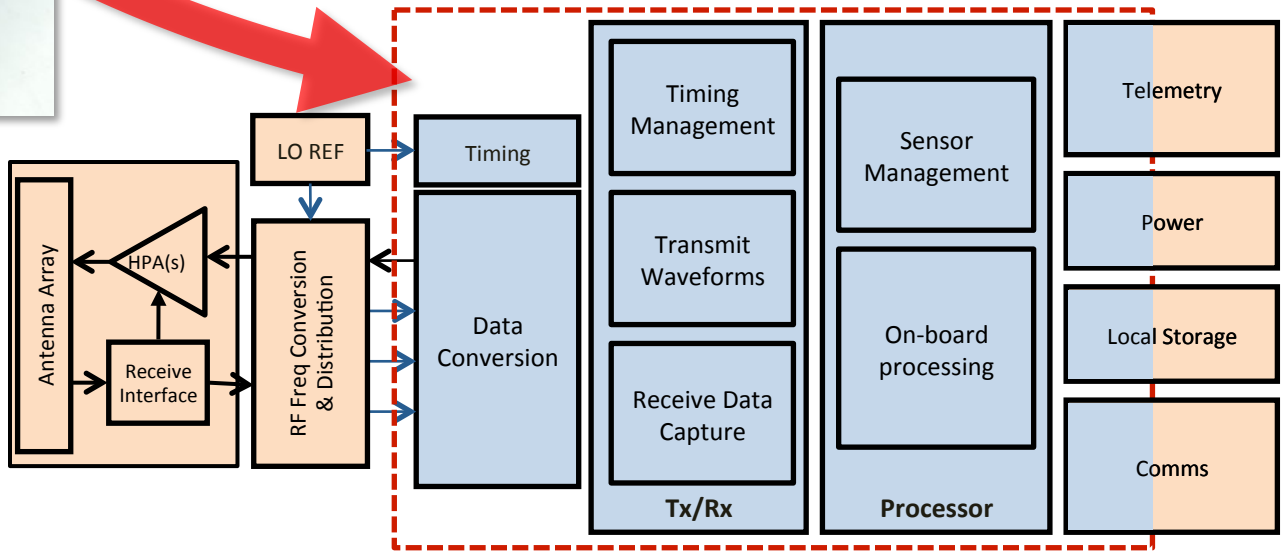


Wideband Programmable RF

Tightly integrated programmable transceiver/processor provides a highly adaptable Tx/Rx subsystem for a range of wideband or narrowband RF transmit and receive applications in any frequency band

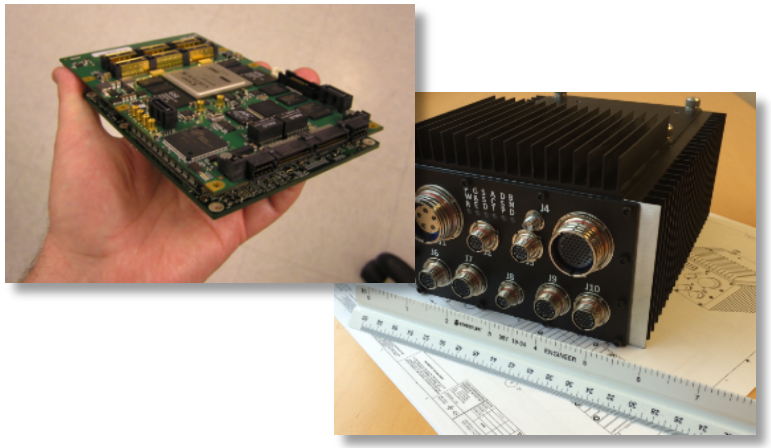
- Gigasample ADC/DAC/PLL subsystem
- Direct digital RF sampling operation > 2GHz
- Tight coupling to Xilinx Virtex-5 FPGA
- Deep fast memory (multiple banks QDR SRAM & SDRAM)
- Wide/fast data paths to processing & storage
- Flexible I/O & peripheral interfaces
- Power aware





Transition to Space

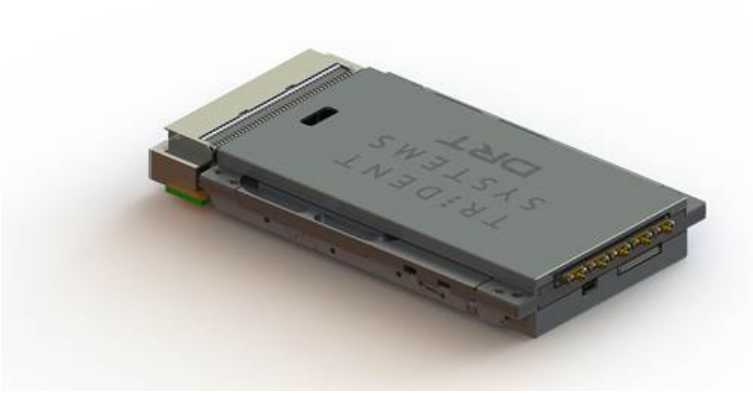
Trident UAV Multi-Function RF Transceiver

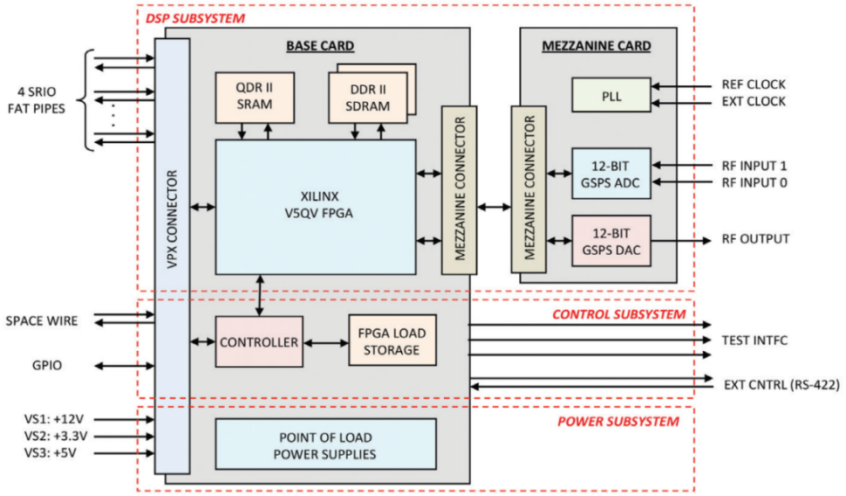


Trident Space Qualified Multi-Function RF Transceiver

- Originated as NASA SBIR Phase I program in 2012
- Additional NASA investment from Maturation of Instruments for Solar System Exploration (MatISSE) program
  - *Multi-Mission Subsurface Imaging Radar (MMSIR) – PI: Dr.Greg Sadowy/Jet Propulsion Laboratory/California Institute of Technology*
- Adaptation of airborne programmable digital transceiver to space environment
  - *Direct translation* of Virtex-5 based airborne RAPTOR design to Virtex-5QV version
  - Rad-hard watchdog processor for upset detection & recovery
  - Radiation-tolerant devices—most direct replacement
  - Space-compatible materials, devices, interfaces, processes
  - Design for space vacuum, thermal, shock/vibe environment per JPL/NASA standards & best practices
  - Standard form factor and interfaces (3U OpenVPX/ SpaceVPX) for 3rd party hardware compatibility
  - Maintains mezzanine card data conversion & PLL-based timing interfaces for flexibility

Space Qualifiable Digital RF Transceiver

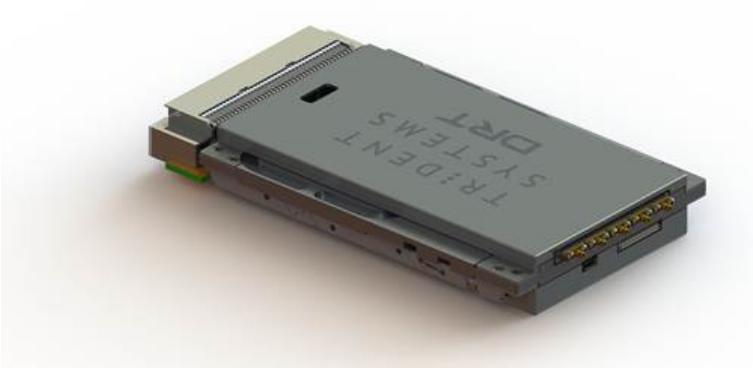


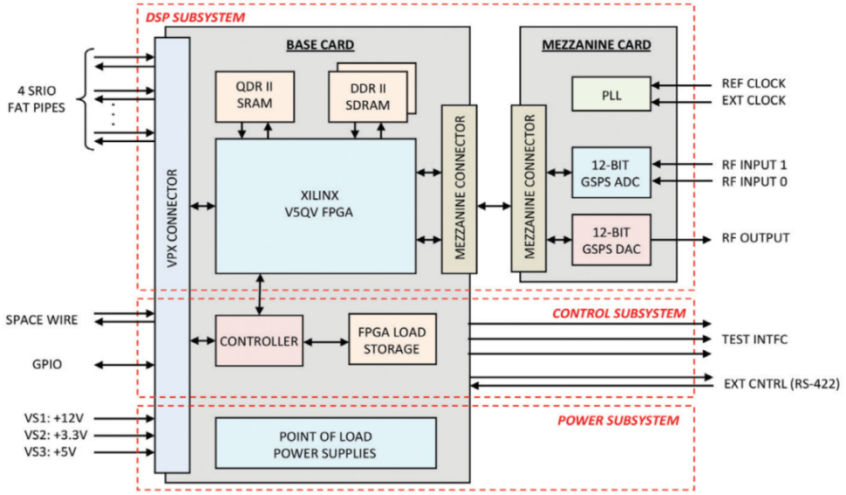


A 3U SpaceVPX programmable wideband transceiver/ processor adaptable to radar, scatterometry, and radiometry applications.

- **Instantaneous bandwidth: 800MHz**
- **# channels: 1 12-bit Transmit, 2 12-bit Receive (dual I&Q)**
- **Spur Free Dynamic Range: 60dB across bandwidth**
- **Instrument Data: Serial Rapid I/O**
- **Control Interface: SpaceWire**
- **Data Throughput: 20Gbit/sec, input and output**
- **Highly customizable transmit and receive processing flow**
- **Fully documented ICD with MATLAB tool support**

Space Qualifiable Digital RF Transceiver





DSP Subsystem

- FPGA for multiple RF mode implementations, enables on-orbit re-progammability
- QDR II+ SRAM for high-speed DSP algorithm memory
- Two 64M x 72-bit DDR II SDRAM banks for storage of wideband data
- SRIO for high-speed data transfer, SpW ports for Command and Control
- Flexible sample clock architecture (internal/external)
- Existing FPGA firmware modules for digital filtering, DDC
- Arbitrary waveform generation

Control Subsystem

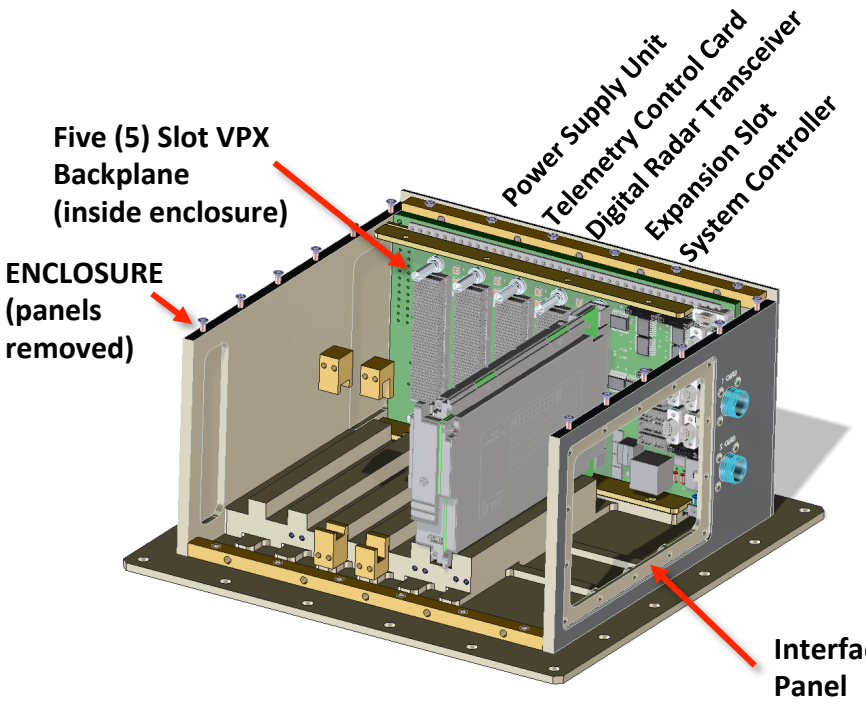
- MRAM for storing multiple FPGA configuration files
- Fault-tolerant Microsemi CPLD to configure FPGA and implement FPGA external configuration management
- General purpose signal resources between FPGA and CPLD

Point of Load Power Subsystem

- Accept +12V, +3.3V, +5V from system backplane
- Radiation-hardened synchronous voltage converters
- Radiation-hardened Low Dropout Regulators (LDOs)

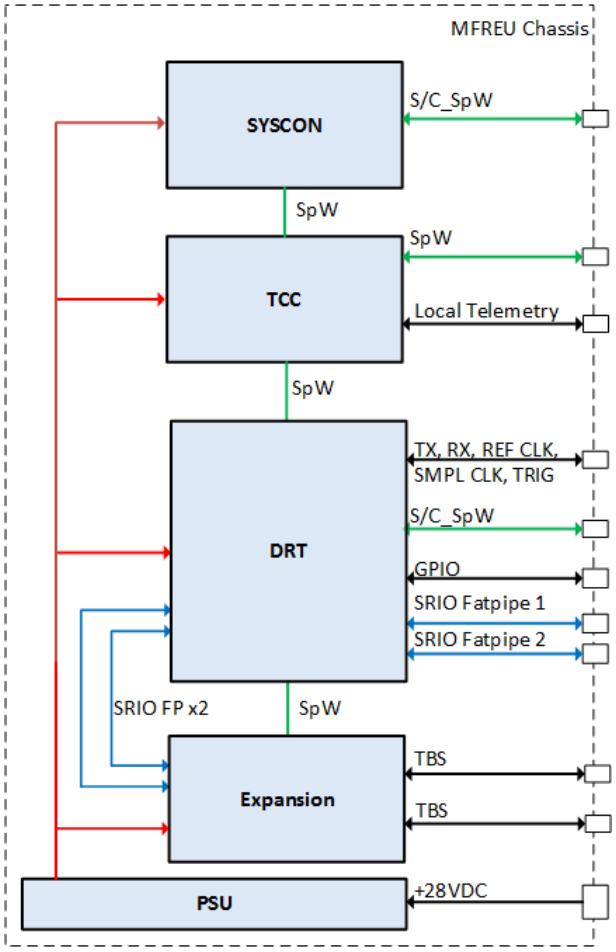
TRIDENT Multifunction RF Electronics Unit (MFREU)

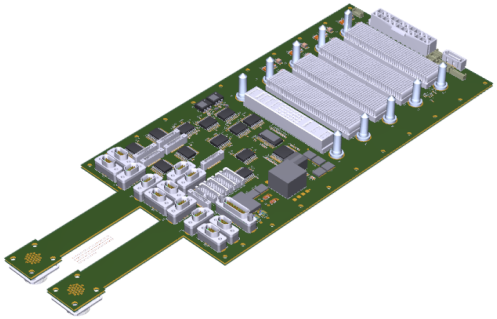
The MFREU couples Trident's programmable wideband RF transceiver/processor with command/control, telemetry, and power management to form a compact, frequency-agile programmable instrument platform.

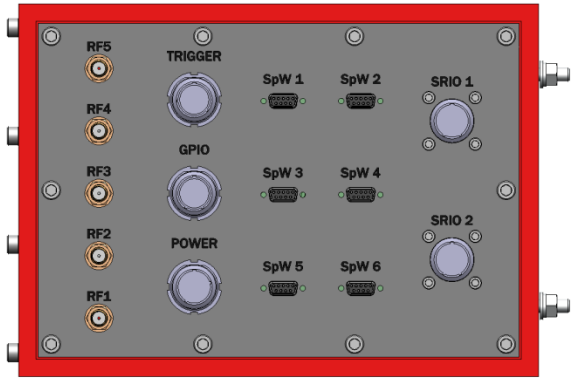


# Card Positions:	**5 3U VPX cards, 1" pitch**
Weight:	**< 13 kg**
Form Factor:	**10.7" x 10.7" (baseplate dimensions), 5.5" height**
Power:	**~85 Watts (FPGA mode & duty cycle dependent; flexible low-power & standby modes)**
Inst Tx/Rx Bandwidth:	**Programmable to 800 MHz**
# Channels:	**1 Transmit, 2 Simultaneous Receive**
Environment:	**-20 to +40 C (baseplate)** **shock/vibe per NASA and DoD test methods profiles for orbital or planetary missions**

MFREU Interfaces



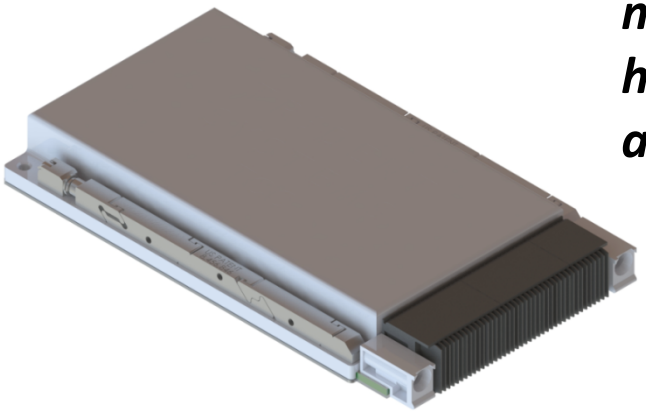


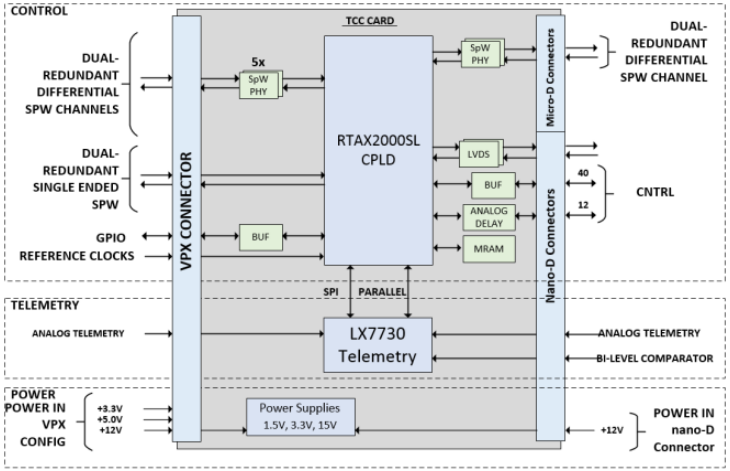


SpaceVPX backplane interconnects card slots & front panel

- SerialRapidIO for wideband RF data (20Gbps)
- SpaceWire for command/control
- RS-422 & GPIO for peripheral interfaces
- Trigger I/O for control/sync with RF front end
- 1PPS input for timing sync
- +28VDC for power
- RF interfaces for Tx out, Rx in (x2), Frequency Reference, External Sample Clock

Telemetry Control Card





A 3U SpaceVPX (or stand-alone) solution for managing and monitoring spacecraft and payload health, status, and configuration for any application.

- Based around Microsemi LX7730 Rad Tolerant Telemetry Controller IC
- Paired with RTAX2000SL CPLD for control & translation of messages between SpaceWire and discrete I/O
- Multiple single ended (2) and differential (5) SpaceWire ports (all dual-redundant)
- MRAM for non-volatile storage of control profiles, SpaceWire routing protocols, etc.
- On-board voltage/temperature monitoring
- Multiple analog inputs (up to 58, depending on configuration)
- 40 LVTTL GPIO
- Power consumption: 4W (typ), 6W (max); Low power mode <1W
- Power input: +12VDC
- Mass < 1kg
- Stand-alone (non-VPX) configuration available

Design Assurance

- **Radiation tolerance:** All components selected for high latchup immunity and total dose

	TID (component min)	LET
DRT:	50krad(Si)	65MeV-cm^2/mg
DRT (hi-rel):	100krad (Si)	65MeV-cm^2/mg
TCC:	100krad (Si)	72MeV-cm^2/mg

- **Fault Tolerance:** TMR program flow
  SEU/SEFI fault detection/recovery
  Configurable scrubbing

- **Parts/Materials/Processes:** Exceeds requirements for targeted missions; contact Trident for details

Program Status

- All circuit cards & components currently in fabrication/assembly
- Laboratory integration & test complete Q4CY16
- Engineering Development Models (EDMs) deliver Q1CY17
- Qualification testing activities CY2017
- EDMs available for order now—contact us to discuss specific applications and requirements

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