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VPX Optical Interfaces: Standards, Protocols & Applications

Embedded Tech Trends

January 2015

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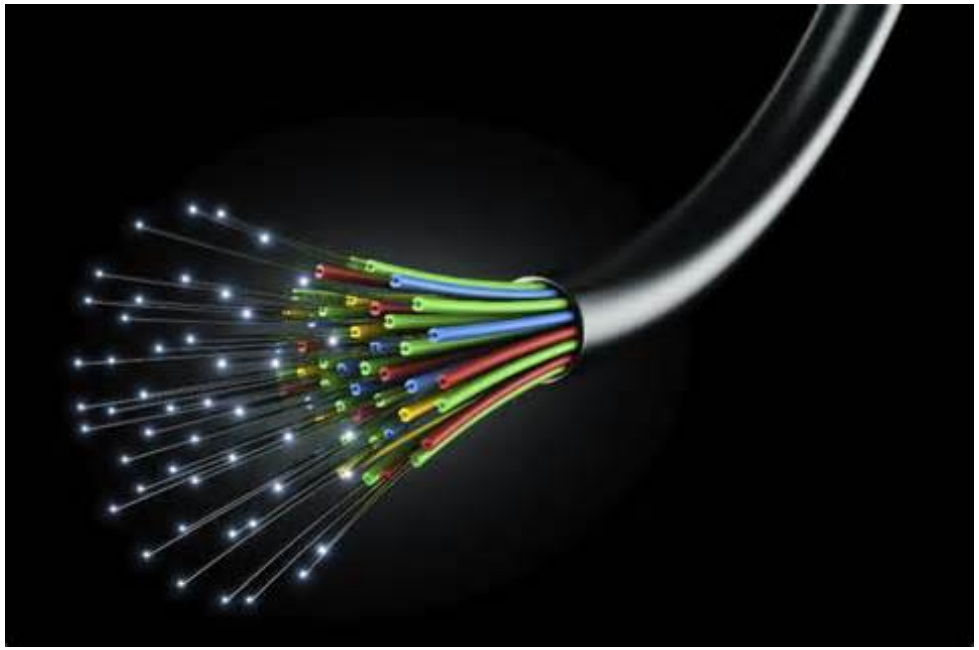
Topics

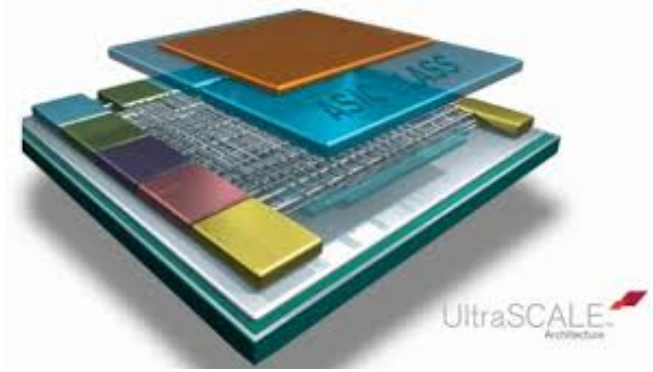
- Embedded System Requirements
- Optical Gigabit Interface Technology
- Optical vs. Copper Links
- VITA Standards for Optical Links
- VITA 49 Radio Transport Protocol
- Application Strategies



Embedded System Technology Requirements

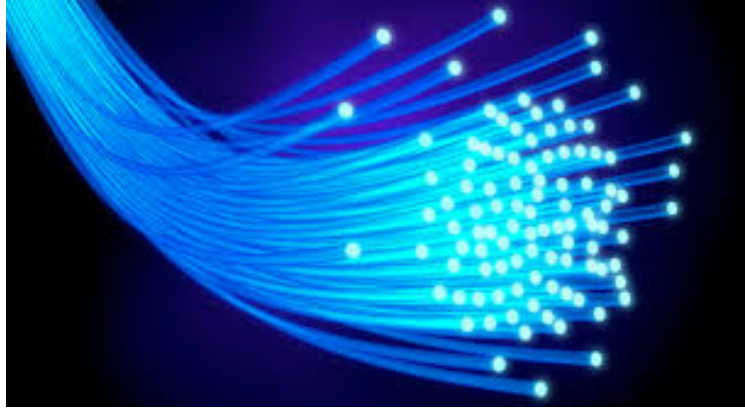
- Wider Bandwidths: Video, Comms & Radar Signals
  - Improved image resolution, target identification, signal detection & exploitation
  - More traffic within each expensive slice of the allocated radio frequency spectrum

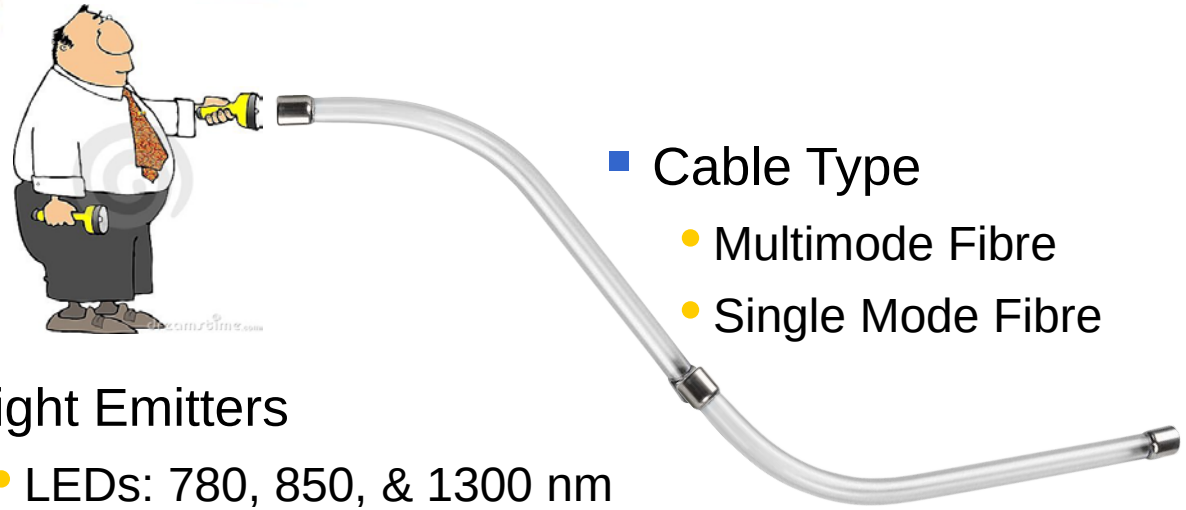
- Faster Sensors, Data Converters and DSPs
  - Multi-gigahertz sampling rates required to digitize these wideband signals
  - DSP improves spectral efficiency, minimizes interference, and supports more users
  - Faster interfaces required on each device



- Faster Links Between Embedded System Elements
  - Higher data rates between boards within a chassis
  - Higher data rates between systems and racks
  - Digitizers and front end DSP operations are moving closer to the antenna
  - Longer data transmission paths to remotely located acquisition sub-systems

Optical Link “Nuts and Bolts”





- Cable Type
  - Multimode Fibre
  - Single Mode Fibre

- Light Emitters
  - LEDs: 780, 850, & 1300 nm
  - LASERs: 1310, 1550, & 1625 nm
  - VCSELs: 650 to 1300 nm

- Light Detectors
  - PIN Diode
  - Avalanche Photo Diode

- Modulation Schemes
  - AM - Simple, low performance
  - FM - Better, but limited bandwidth
  - Digital - Best speed and signal integrity
    - Costs are dropping rapidly

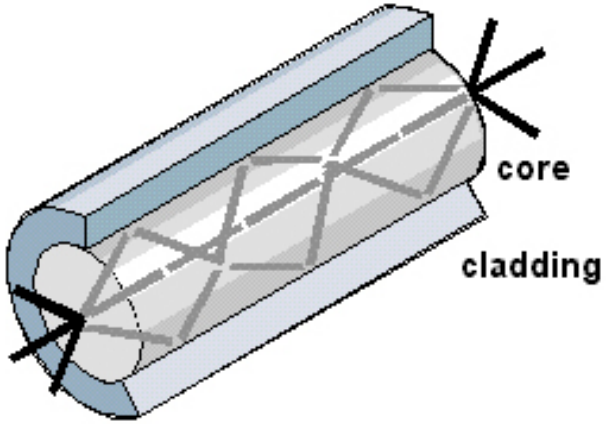
www.fiber-optics.info

Table 1 - Comparison of AM, FM, and Digital Encoding Techniques

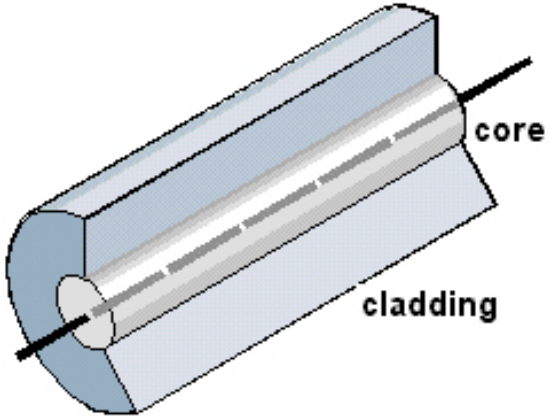
Parameter	AM	FM	Digital
Signal-to-Noise Ratio	Low-to-Moderate	Moderate-High	High
Performance vs. Attenuation	Sensitive	Tolerant	Invariant
Transmitter Cost	Moderate-High	Moderate	High
Receiver Cost	Moderate	Moderate-High	High
Receiver Gain Adjustment	Often Required	Not Required	Not Required
Installation	Adjustments Requires	No Adjustments Required	No Adjustments Required
Multichannel Capabilities	Require High Linearity Optics	Fewer Channels	Good
Performance Over Time	Moderate	Excellent	Excellent
Environmental Factors	Moderate	Excellent	Excellent

Optical Cables: Multimode vs. Single Mode

- Multimode
  - Lowest cost transceivers and cable
  - Thicker optical core allows multiple paths (modes) for light to travel
  - Core diameters of 50 or 62.5 microns + cladding diameter of 125 microns
  - Compatible with less expensive lasers at 850 or 1300 nm
  - Supports 2.5 GHz data rates across 300 meters
  - Terminations (connectors) are easier to install



- Single Mode
  - More expensive transceivers and cable
  - Thin optical core allows a single path (mode) for light to travel
  - Core diameter typically 9 microns + cladding diameter of 125 microns
  - Compatible with more expensive lasers at 1310 or 1550 nm
  - Supports 2.5 GHz data rates greater than 10 km
  - Terminations require a skilled technician



Copper vs. Optical Interfaces

Property	Copper	Optical
Interface Transceiver Cost	Low ✓	High but dropping
PC Network Interface Cards	Integrated in PC or laptop ✓	Usually optional at $100-$200
Power over Ethernet	Supported at low cost ✓	Not possible
Data Rate	1 GHz	>10 GHz ✓
Cable Loss - 100 meters	94%	3% ✓
Max Transmission Distance	100 m (cat 6)	300 m (multi-mode) 10 km (single mode) ✓
EMI Susceptibility Risk	Moderate	Zero ✓
EMI Radiation Risk	Moderate	Zero ✓
Security / Eavesdropping Risk	High	Extremely Low ✓
Termination Costs	Low ✓	High
Cable Cost per Length	High	Low ✓
Cable Weight per 1000 m	60 to 600 kg	6 kg ✓
Fire Hazard	Supports current flow if shorted	Zero ✓
Tensile Strength	25 pounds	100-250 pounds ✓

VITA 17.1 - Serial Front Panel Data Port (sFPDP)

- Replaces older VITA 17 FPDP 32-bit parallel flat ribbon cable specification
  - Limited to 160 MB/sec
  - Limited to a few meters in length
  - Simple raw data interface with flow control, single & multi-drop

VITA 17 FPDP
Parallel Flat Ribbon Cable

- VITA 17.1 Features and Benefits
  - Gigabit serial data stream implementation of FPDP
  - Optical and copper implementations supported
  - Nominal data rates of 247 MB/sec
  - Data rates limited only by cable/transceiver technologies
  - Distance limited by cable/transceiver technologies
  - Full duplex operation with CRC, loop, flow control, etc.
  - Copy mode allows boards to be daisy-chained
  - Much smaller and lighter cables and connectors

VITA 17.1
LC Multimode Fibre
Optical Cable

VITA 17.1 sFPDP Deployments

Sonar upgrades for US Navy Guided Missile Destroyers

SQQ-89 program USS McCampbell

US Navy NSSN Sonar Transmit System

USS Texas

US Navy Airborne Laser Mine Detection System (ALMDS)

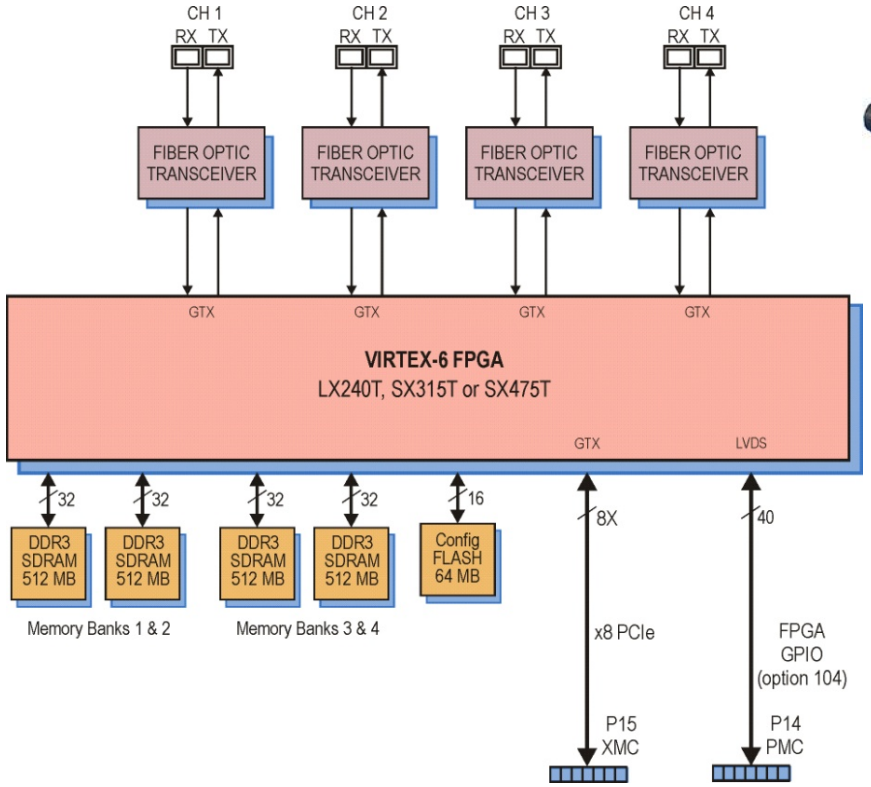
Northrop Grumman ALMDS

US Navy NSSN Simulation/Stimulation System

USS North Carolina

VITA 17.1 sFPDP Products for VPX

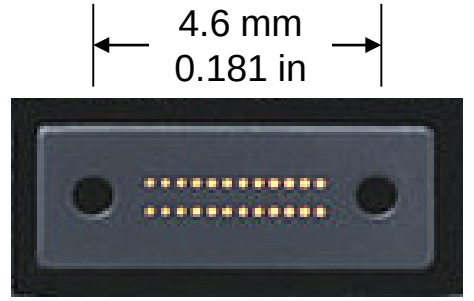
- Front panel sFPDP Connectors
  - Flexible SFP+ (small form-factor pluggable) modular interfaces
  - Copper (TwinAX) or Optical (LC), single or multi-mode
  - Low-cost industry standard with many vendors
- FPGA Functions
  - SFP+ gigabit serial interfaces
  - sFPDP protocol engine supports all VITA 17.1 modes and specs
  - PCIe Gen2 x8 interface – 4 GB/sec
  - Eight DMA engines for PCIe
  - 2 GB SDRAM memory buffers
  - CRC Support
  - Metadata packet headers
  - Simplifies system integration



Pentek 52611 3U VPX
Quad sFPDP Module
Copper or Optical

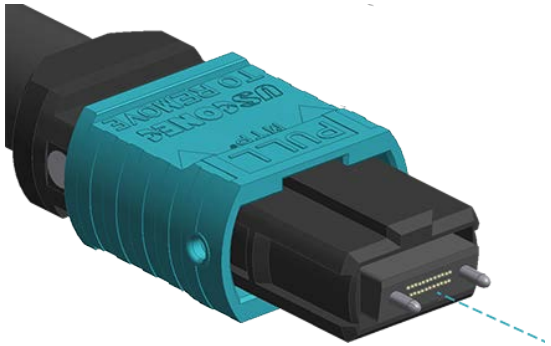
LC Optical
Cable Connector

MT Optical Interconnects



24 lane MT Female Ferrule

- MT Ferrule
  - An extremely popular connection for x4 to x24 optical lanes
  - Operates at rates up to 20 Gbits/sec per lane
  - Supports single and multi-mode links
  - Typically protected in a shell, collar or ferrule
    - Like the VITA 66.4 housing
  - Availability of 48, 72 and 96 lane MT ferrules


24 lane MTP Male


12 lane MTP Female

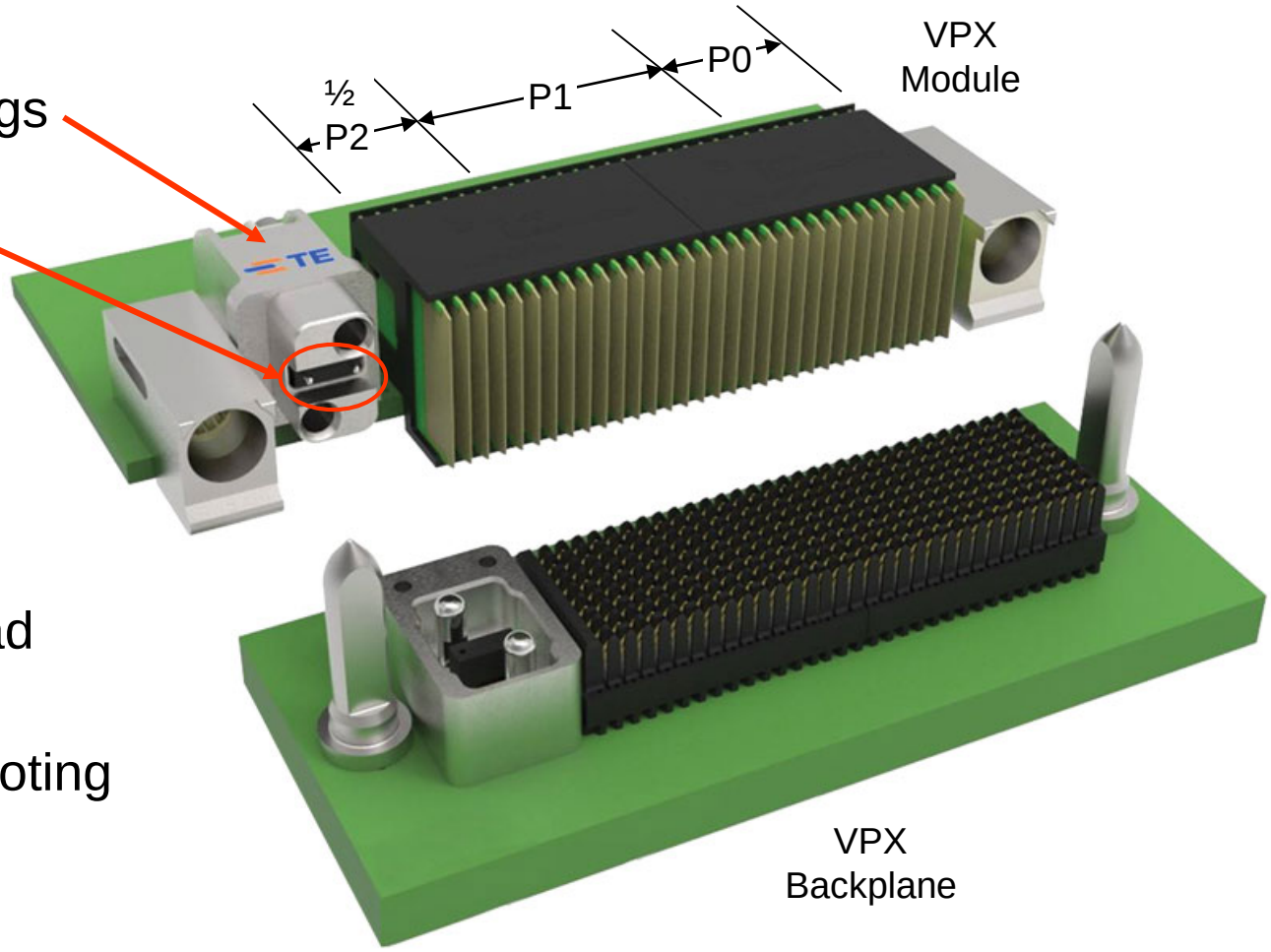
- MTP
  - MT Pluggable
    - MT ferrule inside a keyed collar with a locking tab
  - Wide variety of cables, lengths available

- Circular Bulkhead MTP
  - Full spec sealed connectors for military applications


Triple MTP Bulkhead
Connectors & Cables

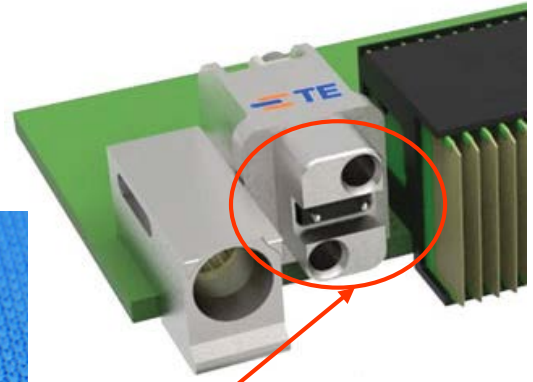
VITA 66.4 Optical Backplane I/O

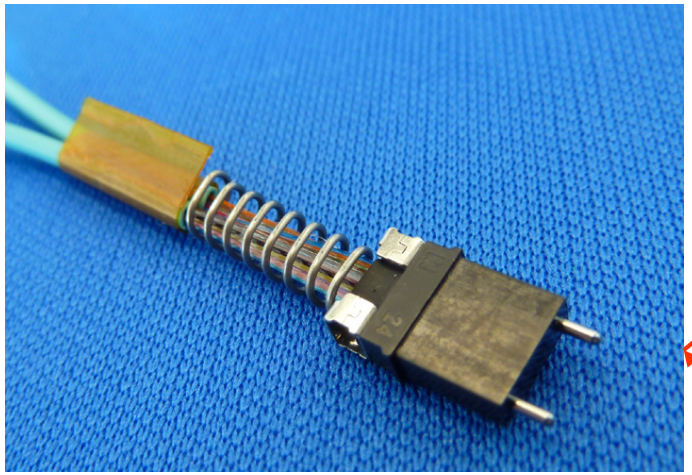
- Ruggedized Optical MT Backplane Interconnect System
- Replaces half of VPX P2
- Self-aligning, blind mate connector housings
- Floating, MT ferrule inside housings
- Eliminates front panel optical I/O
- Supports any optical protocol
  - Including sFPDP, Xilinx Aurora, 10GbE, SRIO, VITA Radio Transport, etc
- Backplane connections between modules
- Backplane connections to chassis bulkhead connectors
- Specification is being updated for final balloting and approval

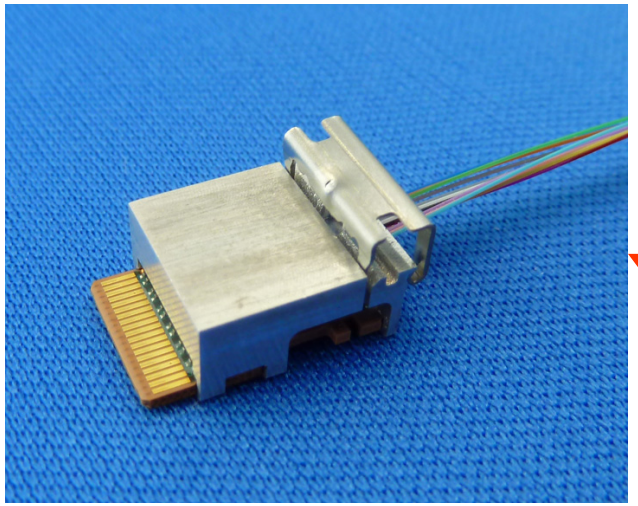


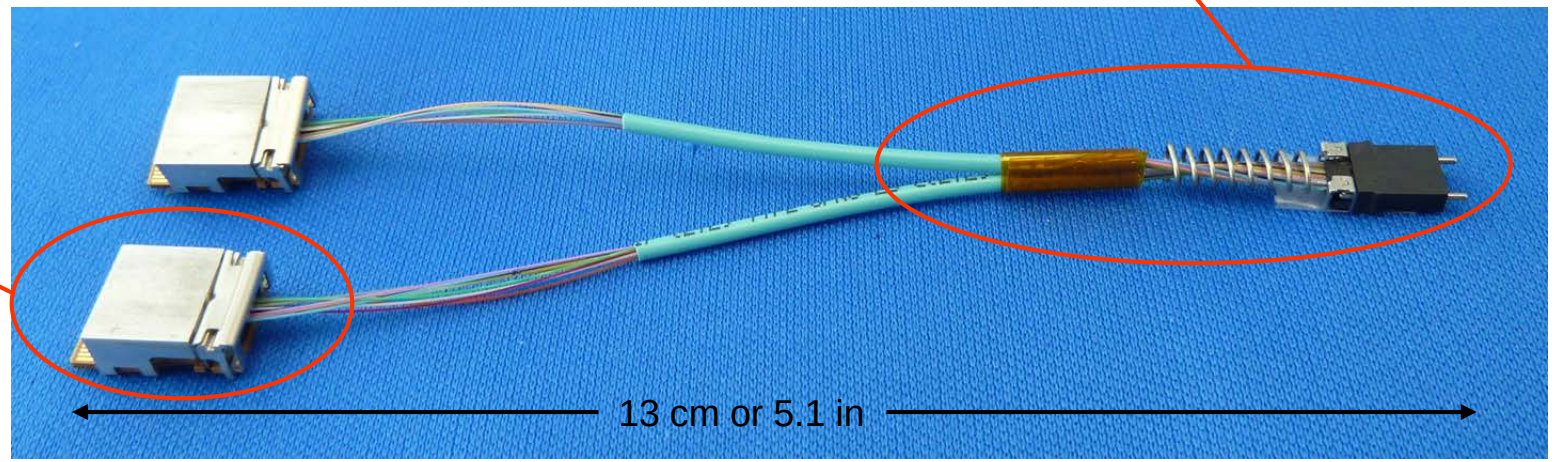
Samtec FireFly™ Micro Flyover System

- Complete Electrical-Optical Transceiver Assembly
- Uses 24-lane male MT connector
- Spring-loaded, fits inside VITA 66.4 housing
- One 12-lane optical receiver
- One 12-lane optical transmitter
- Provides 12 full-duplex optical links
- Data rates to 14 Gbits/sec per optical lane



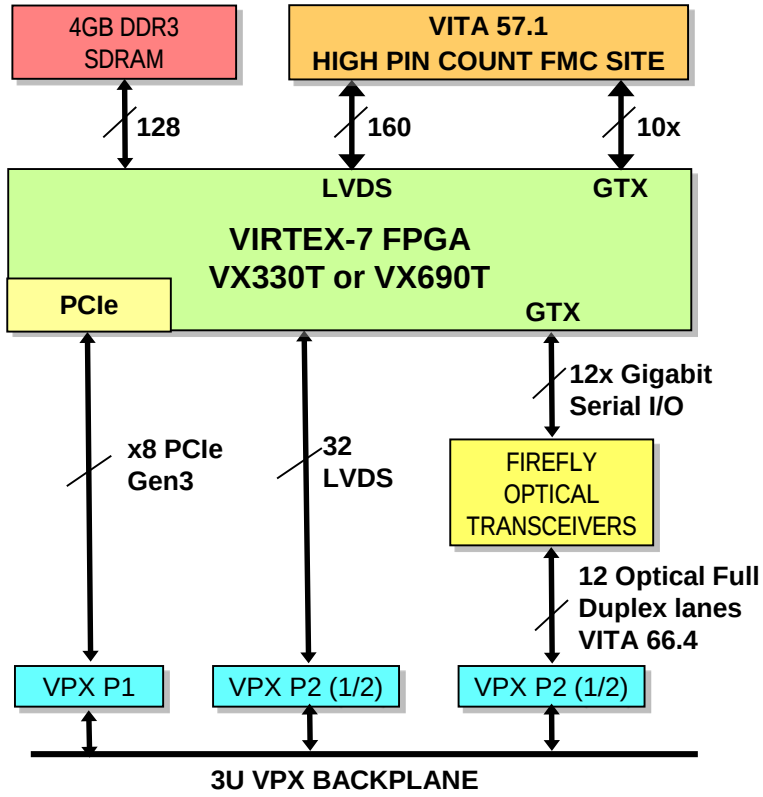


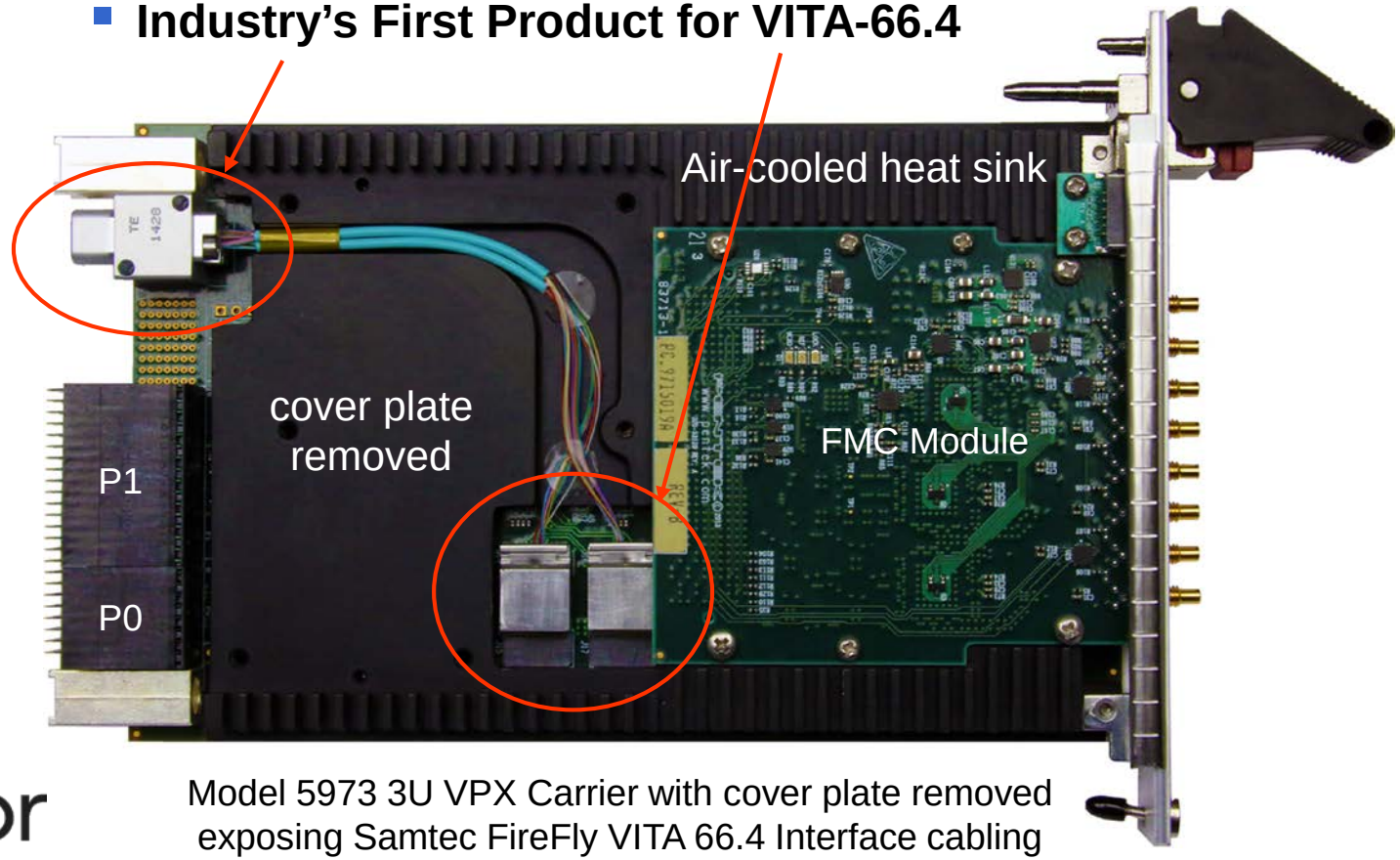




VITA 66.4 Optical Backplane Products for VPX

- 3U VPX FMC Carrier with Virtex-7 FPGA
- High Pin Count FMC Site
- x8 PCIe Gen 3 delivers 8 GB/sec
- Flexible PCIe DMA Controllers
- 4 GB 1600 MHz DDR3 SDRAM
- 16-pairs LVDS User I/O on P2
- VITA-46, VITA-48, VITA-65, VITA-57.1
- Shipping now, delivering 12 GBytes/sec optical I/O
- Air-cooled and conduction cooled versions
- **Industry's First Product for VITA-66.4**





Model 5973 3U VPX Carrier with cover plate removed exposing Samtec FireFly VITA 66.4 Interface cabling

VPX Optical Connections: System Strategies

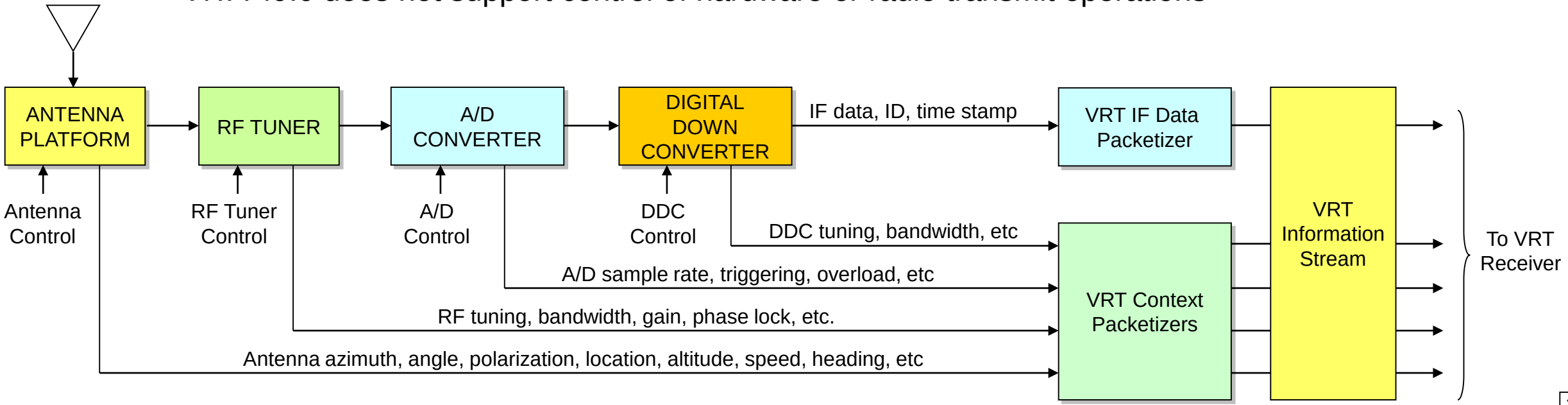
- Optical links are faster than copper for critical high-bandwidth board-to-board interconnects within a chassis
  - MT-to-MT cables are easy to install as required
- Bulkhead connectors offer external optical links
- MTP-to-MTP cables connect between chassis
  - Benefits: High Speed and Long Distance
- Small Remote Sensor Acquisition Sub-Systems
  - Exploit optical MTP cable interconnections – speed, weight, distance
- Supports a judicious mix of copper and optical interconnects to meet requirements

VITA 49 – VITA Radio Transport Protocol

- Transport-layer protocol designed for radio equipment interoperability
  - For digitized signal sample streams for software radio systems
  - Originally, between radio receivers and signal processing equipment
  - Now, also between signal processing equipment and radio transmitters
- Target Applications
  - Spectral Monitoring and Scanning
  - SIGINT and Tactical Information
  - Communications and COMINT
  - Radar and EW Countermeasures
- Functional Objectives
  - Precision time stamping for beamforming, antenna array processing
  - Synchronization across channels and sites
  - Stream tagging for identification, content, format and operational parameters
  - Monitor status of receiver and transmitter equipment
  - Control operation of receiver and transmitter equipment

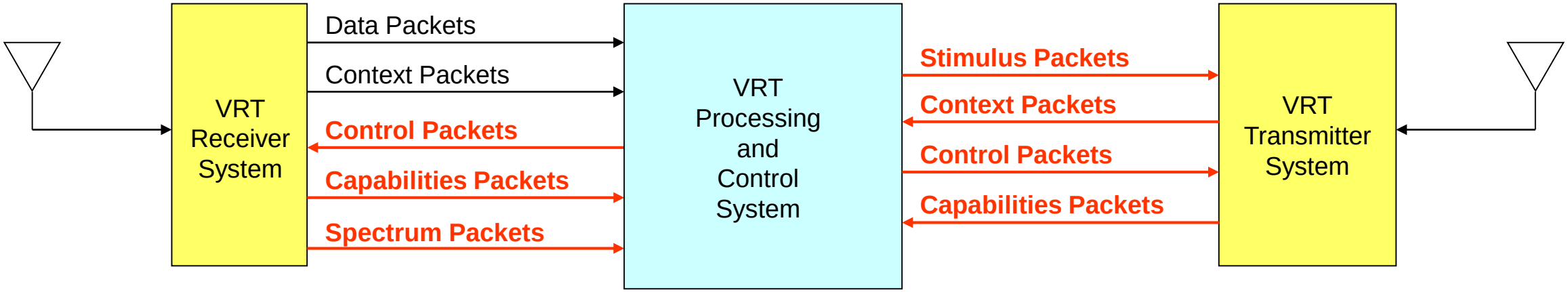
VITA 49.0 – VITA Radio Transport Protocol

- VRT IF Data Packets capture payload data, time stamp, channel and signal ID
  - Flexible data formats and support for extremely precise time stamping
- VRT Context Packets report all operational parameter values of the radio equipment
  - Standardized methodology for a wide range of standard and unique parameters
- VRT Information Stream contains IF Data Packets and Context Packets
  - VRT Receiver associates data and context streams appropriately for different applications
- Same radio hardware can be used for a wide range of applications
  - VITA 49.0 does not support control of hardware or radio transmit operations



VITA 49.2 – Transmit and Control Extension

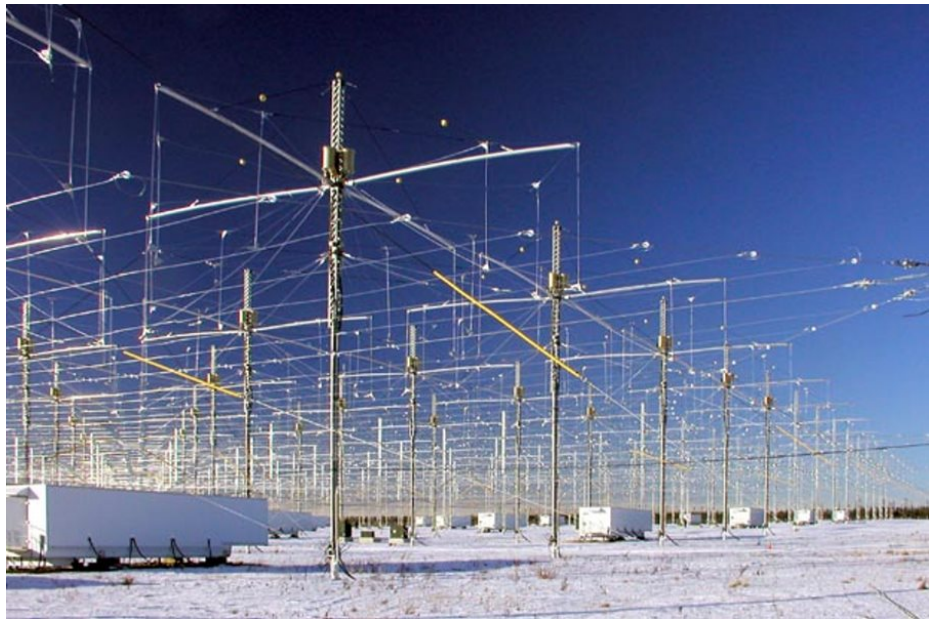
- Maintains Receive IF Data and Receive Context Packets from VITA 49.0
- Adds new protocols for complete receive and transmit systems, plus control
  - **Stimulus Packets** provide radio signals to be transmitted
  - **Capabilities Packets** announce configurable assets of each device and parameter ranges
  - **Control Packets** send operational control parameters to radio equipment with acknowledgement
  - **Transmitter Context Packets** deliver operational status and parameters of transmitters
  - **Spectrum Packets** deliver limited spectral data for monitoring and scanning

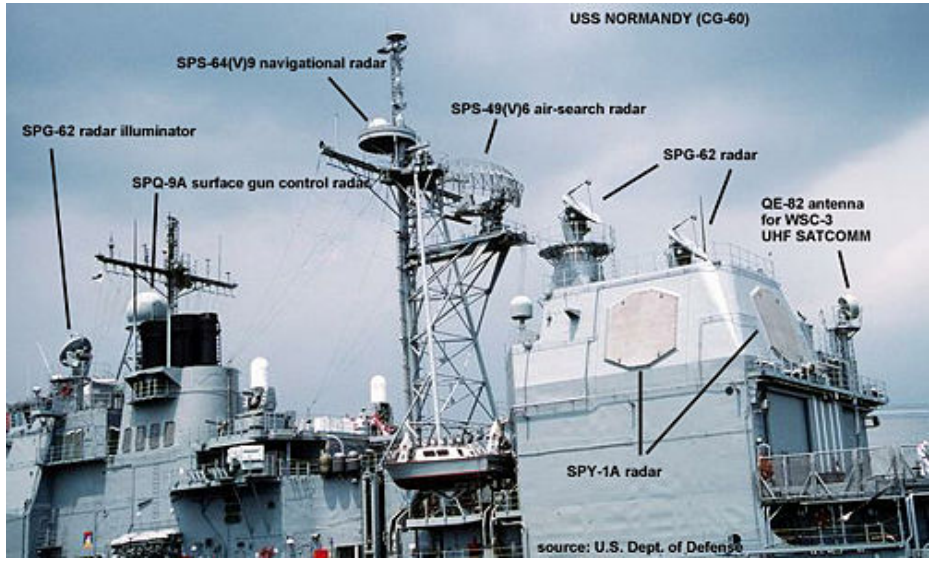


- VITA 49 working group participants are from industry, universities, and government

Remote Sensor Sub-Systems with Optical Links

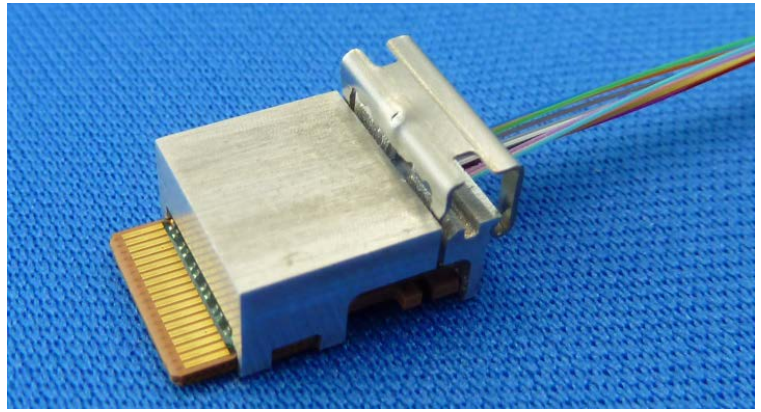
- Digitize at the Antenna across Optical Links
  - Local FPGA preprocessing tasks
    - Digital downconverters, tuning & bandwidth selection
  - Choose from popular FPGA-based protocols
    - Aurora or sFPDP: lightweight, good for raw data
    - 1 or 10 GbE: vast infrastructure, more overhead
    - SerialRapidIO: flexible, routable, scalable
    - VITA 49 VRT: complete radio transceiver protocol
  - Avoids signal degradation through long copper coaxial cables
  - Eliminates EMI susceptibility and radiation
  - Improves eavesdropping security, tamper resistance
  - Cables are immune to shorts, moisture, corrosion, easier to install, lighter and smaller diameter
  - Ideal for large ships, aircraft, antenna farms, UAVs, and SIGINT facilities

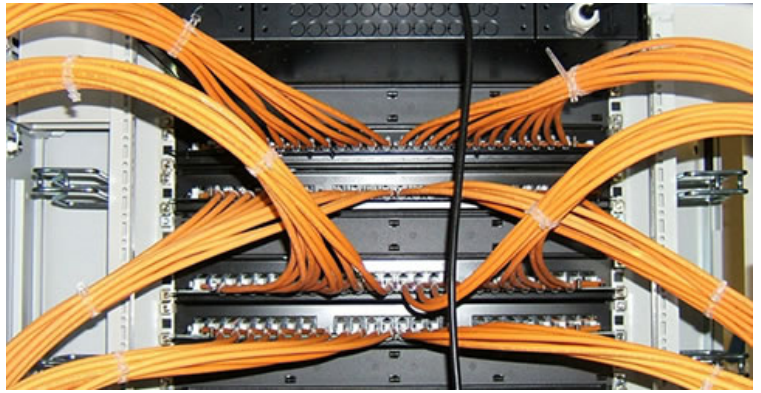




VITA Optical Standards for VPX – Leading the Way

- Optical links are replacing copper in embedded systems
- VITA 17.1 Serial FPDP offers simple, efficient raw data link
- VITA 66.4 backplane optical I/O ready for deployment
- VITA 49 VRT protocol ideal for optically-connected radio systems
- Mature and diverse optical cable and connector technologies
- Cost for optical transceivers, cables and connectors are dropping
- Optical offers lower maintenance costs and improved reliability
- Light weight optical cables benefit unmanned vehicle systems
- FPGA protocols can be installed to match the application
- Remote optically-connected sensor sub-systems make sense
- More Information: www.pentek.com





Looking into the Future

- VITA Architectures for Optical Study Group
  - Study architectures to exploit optical interfaces for embedded systems
  - Processors, carrier cards, backplanes, connectors, etc.
- Optical Interfaces on FPGA
  - Built-in optical transceivers simplifying designs
  - Eliminates separate transceivers
- Optical links embedded within backplanes
  - Replace copper traces with optical links
  - Simplifies integration
  - Standardized optical switching

Thank You – Questions?