NASA SpaceFibre Flight Demonstration

SpaceWire Working Group Meeting

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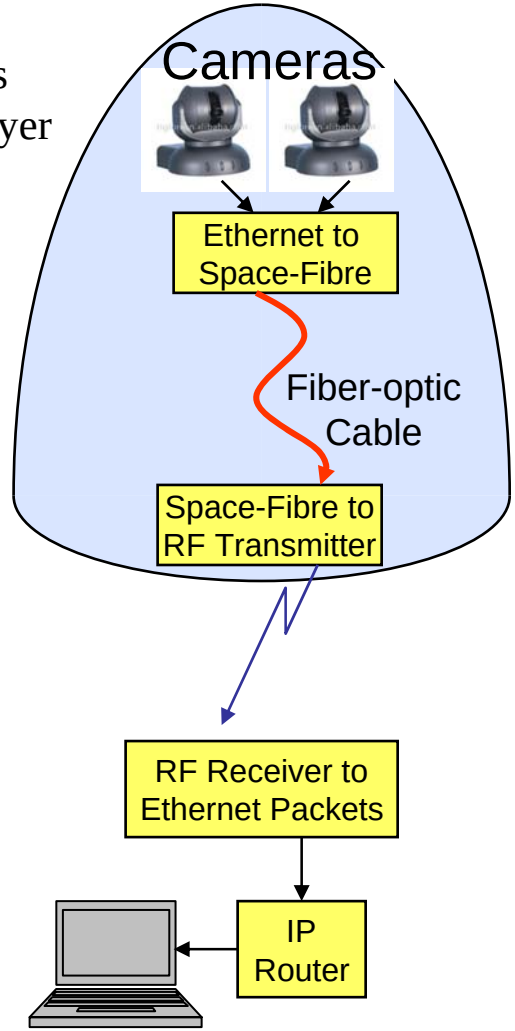
Presented by
Glenn Rakow – NASA/GSFC
Glenn.P.Rakow@nasa.gov

Outline

- Overview/Background
- Benefits
- General Findings
- Architectural Recommendations
- Virtual Channel Assumptions
- Virtual Channel Recommendations
- Programmatic Recommendations

SpaceFibre Technology Demonstration – Overview/Background

SpaceWire is a commonly used robotic mission data communications protocol. This technology demonstration will upgrade the physical layer to a optical interface enabling greater distance (~100 meters), greater data volume (~2.5 Gbits/sec), electrically isolated and lower mass harnesses (8g/m).



Goals of Technology Demonstration:

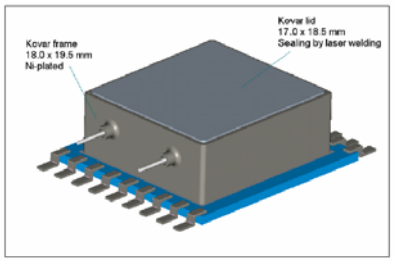
1. Demonstrate beta version of SpaceFibre to provide a standardized simple large data volume solution for avionics
2. Identify advantages, risks and potential mitigations of non-wire harness design
3. Demonstrate de-centralized instrumentation approach for launch vehicles

SpaceFibre Technology Demonstration Benefits

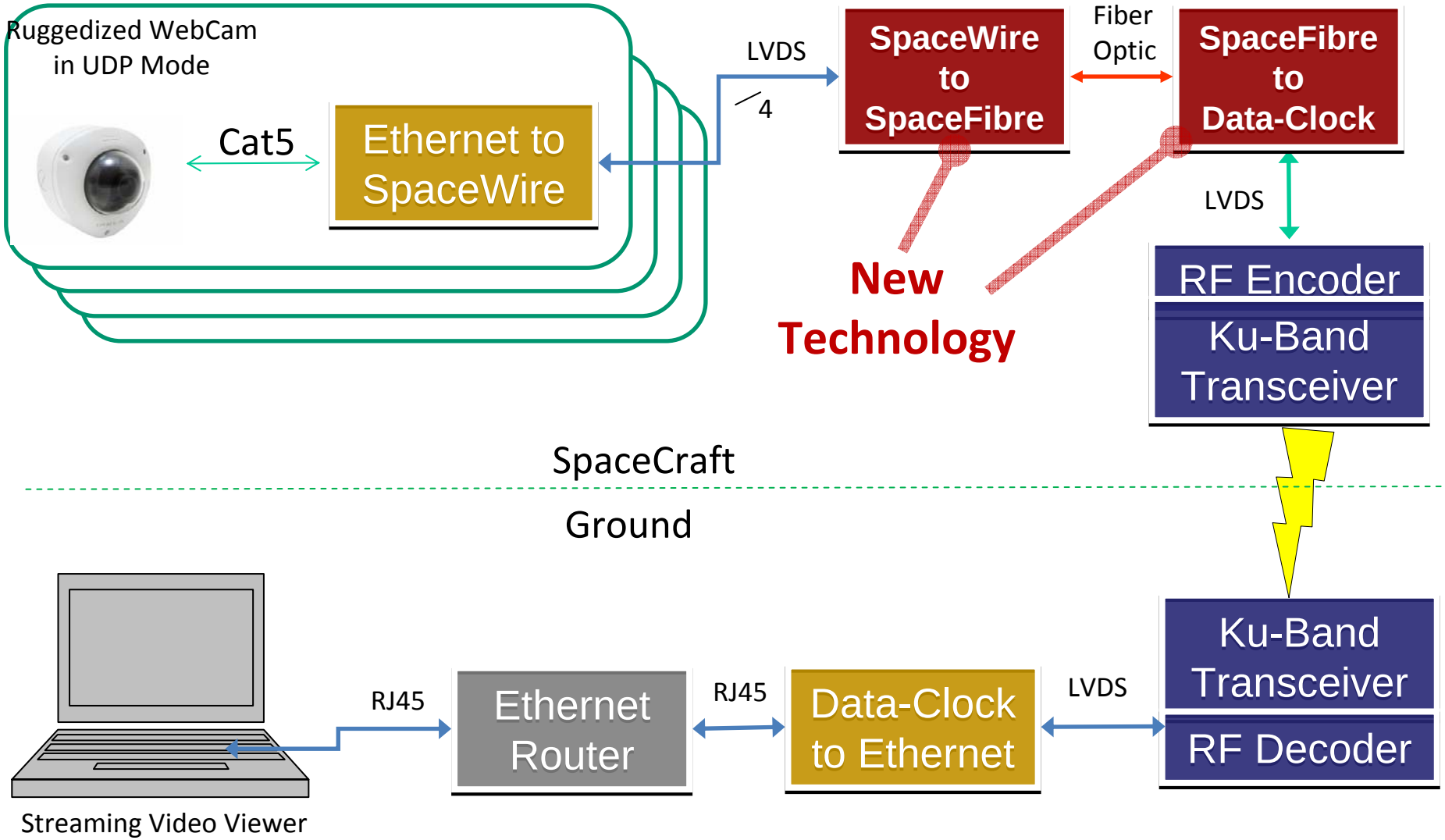
- Cooperation with ESA to create new standard
- Demonstrate the process of rapid development of complex electronics from concept to launch (quickly increasing TRL)
- Provide possible technology solution to address high performance, low power, small mass avionics for crew and robotic missions
- Specific to MLAS
  - Alternative camera views to complement data set
  - Education Outreach Camera – show view more interesting to public

SpaceFibre Technology Demonstration Process

- SpaceFibre specification review/definition
  - Collaboration with ESA, US government and industry to formulate a new standard (SpaceFibre) specifically for spacecraft applications (low power and mass)
    - Bridge to SpaceWire
    - Standard group - European Cooperation for Space Standardization (ECSS)
- Develop COTS hardware to implement system to demonstrate SpaceFibre
  - Define demonstration => Video on rocket
  - Select components => COTS FPGA board, Camera, Transponder and Ground Equipment
  - Develop electrical designs => SpaceFibre, Camera Interface, Transponder Interface, Ground Equipment Interface
  - Develop mechanical design => Camera mounts, Electrical Chassis
  - Environmental test of COTS hardware => Vibration
  - Integrate to MLAS rocket

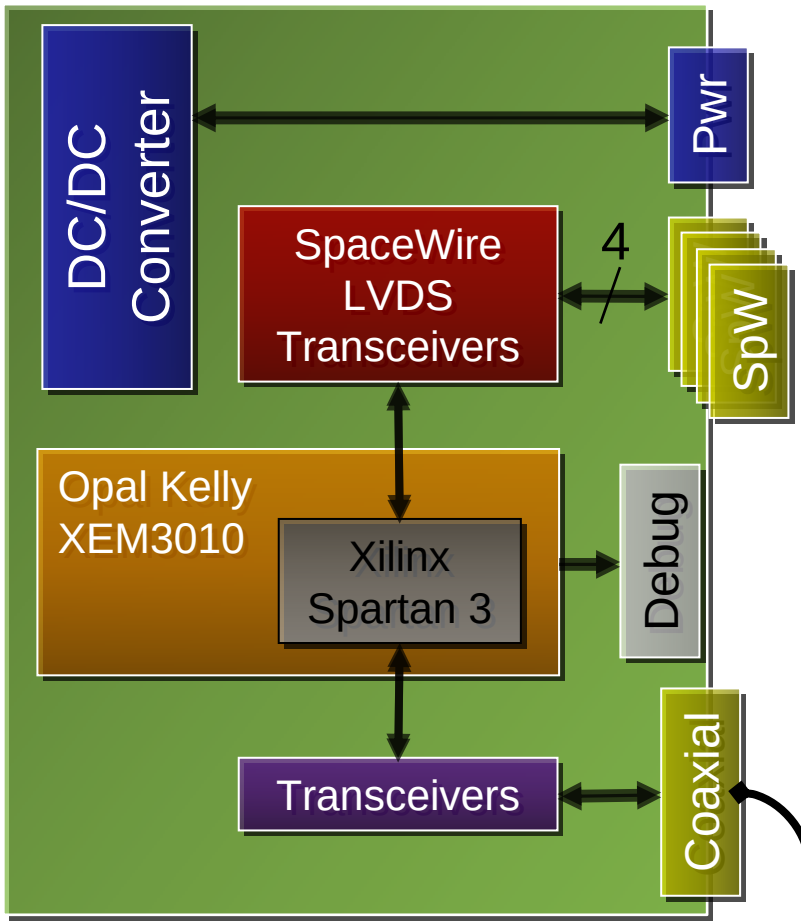


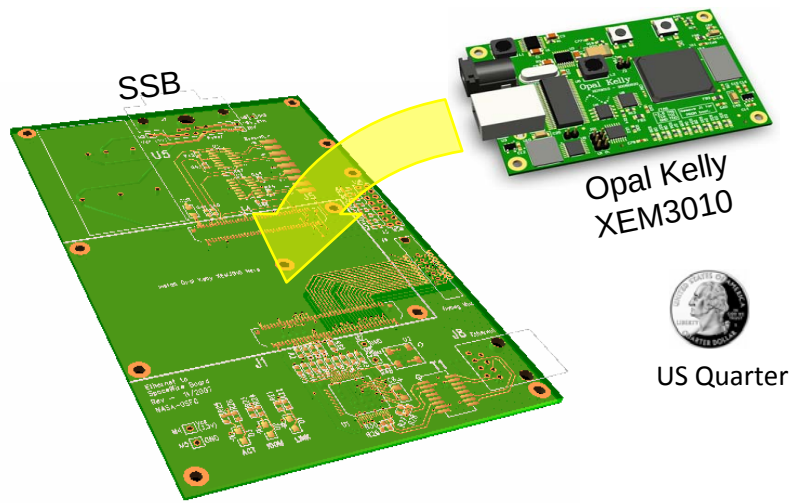
SpaceFibre Tech Demo – Data Flow

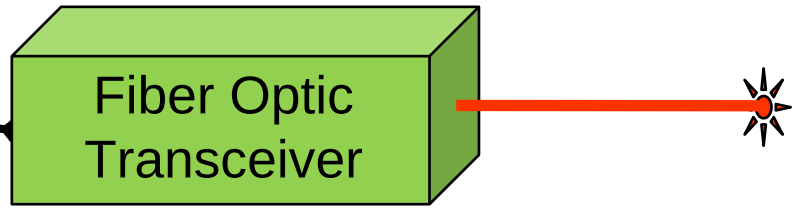


SpaceFibre Tech Demo
SpaceWire to SpaceFibre Board

- COTS: Opal Kelly XEM3010 contains Xilinx FPGA allows for rapid development
- New Technology: SpaceFibre Link IP core in Xilinx FPGA







SpaceFibre Tech Demo

Back-up Slides

SpaceFibre Tech Demo – Camera

- **Low Cost COTS**
- **Ethernet Interface**
  - Streaming video viewing software comes with camera
  - Packet-based data works well with SpaceFibre
  - UDP over IP efficiently handles data loss with real-time streaming video
  - 100Mbps, 30 FPS, MPEG
- **Trade Studies**
  - Assess three candidates for electrical and mechanical performance
    - Configuring camera into UDP mode
    - Surviving launch vibration
      - Security camera, ruggedized for vandalism
  - If none of the three candidates are sufficient, alternative interfaces will be considered
    - CameraLink

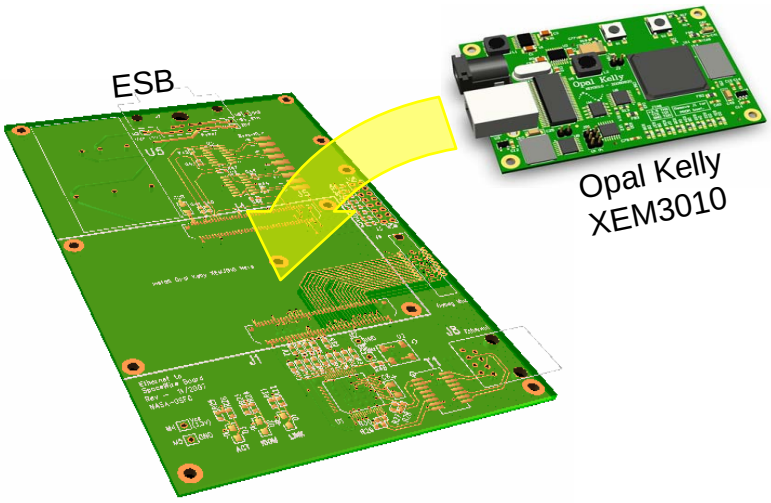
Sony SNC-DF70N

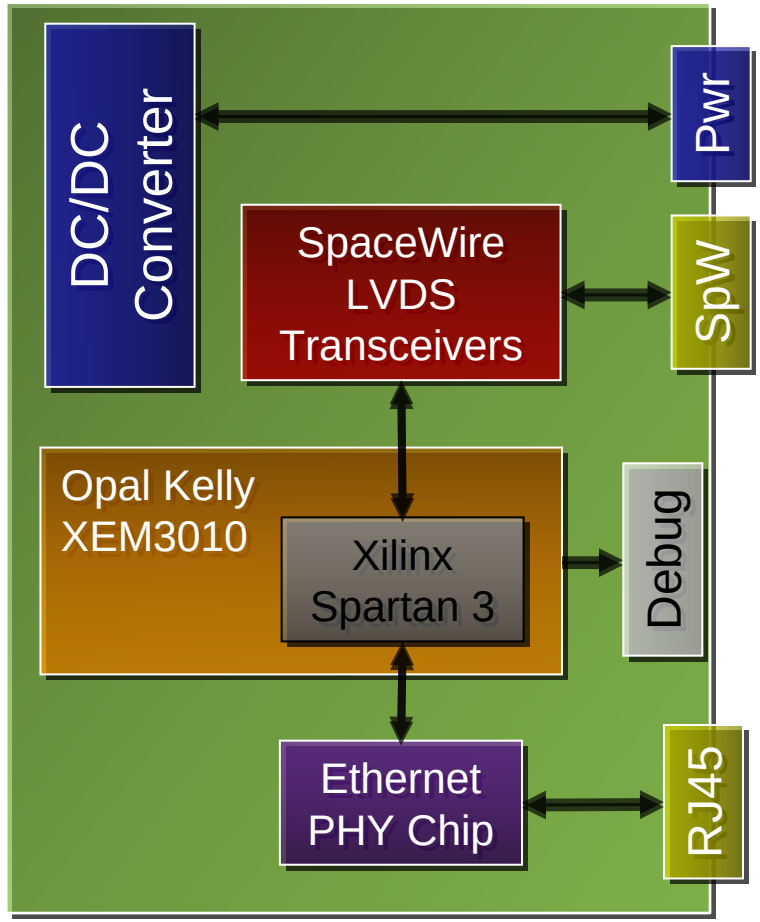
Toshiba IKWR01A

AXIS 0240-004

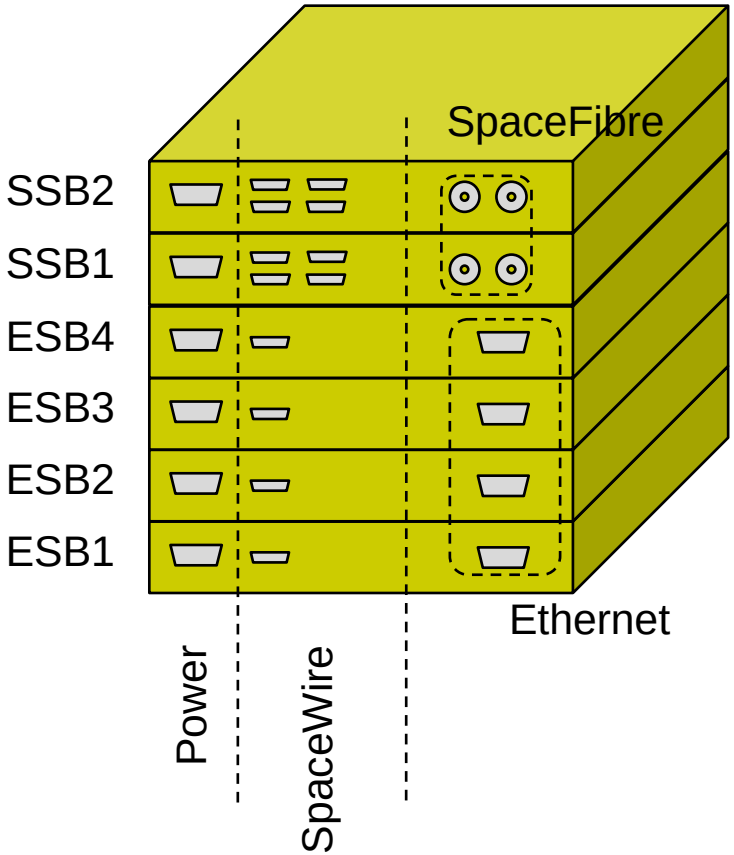
Ethernet to SpaceWire Board

- COTS: Opal Kelly XEM3010 contains Xilinx FPGA allows for rapid development
- In-House: ESB contains PHY-level components, debugging interface, power components, and connectors
- Mechanical enclosure: TBD
- Schematic, PWB artwork, and parts list available upon request





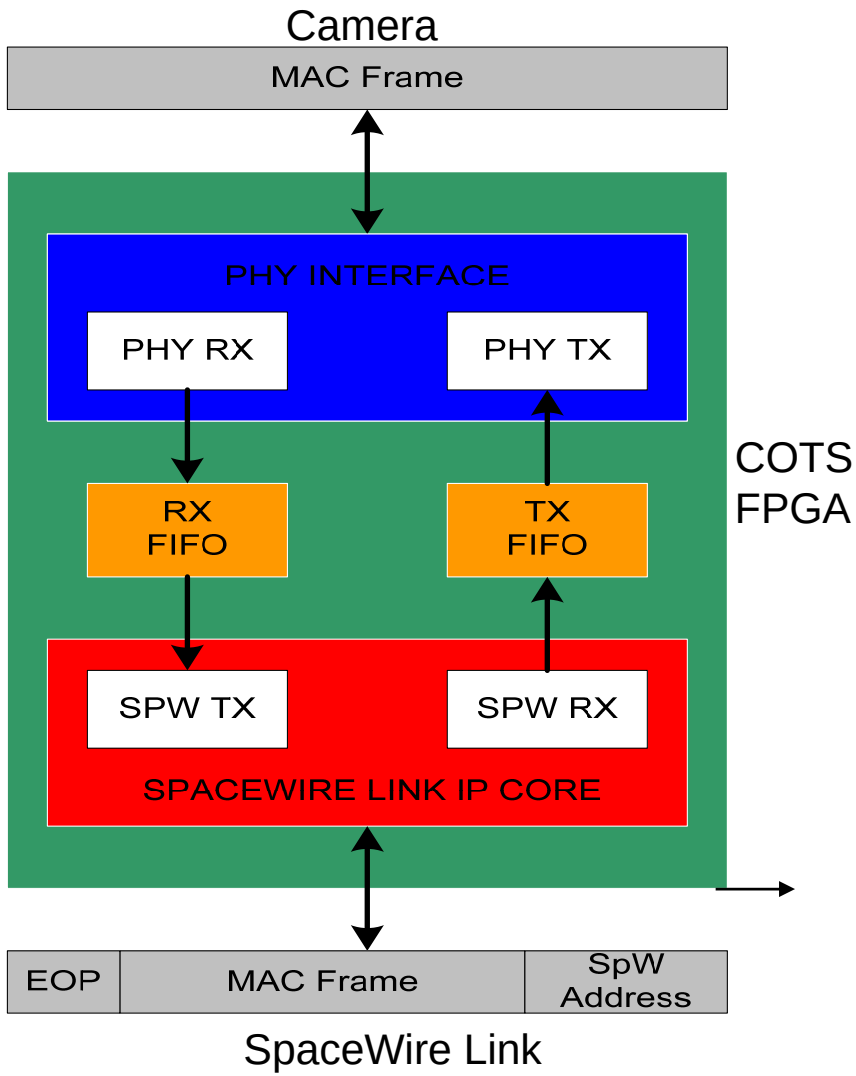
SpaceFibre Tech Demo
Box Design Concept



- Preliminary Concept
- SSB contains fiber optic transceiver
- All connectors on one face
- Mounts to spacecraft on left or rear face
- SpaceWire and fiber optic cables have large bend radii

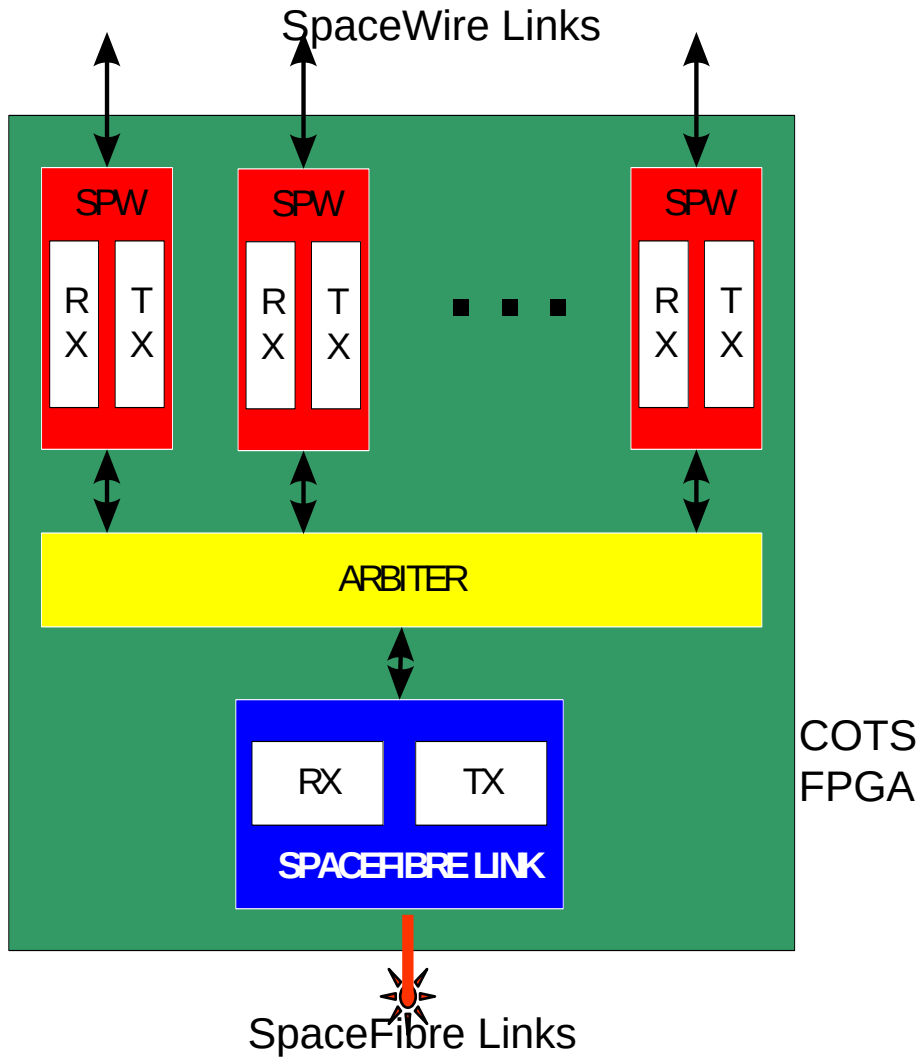
Ethernet to SpaceWire FPGA

- Accepts Ethernet MAC Frames (Video Data) from Camera (Ethernet PHY), adds SpaceWire Header and End of Packet character and transmits packet via SpaceWire protocol.
- Receives SpaceWire packets (Camera Configuration), removes SpaceWire Header and End of Packet and transmits MAC frame via Ethernet PHY.
- Does NOT validate MAC frames.
- PHY Interface
  - National Semiconductor DP83848I Ethernet Physical Layer Transceiver
  - 10/100 Mega-bits per second
- SpaceWire Link IP Core
  - GSFC Developed SpaceWire Core
  - Used on numerous programs including: JWST, LRO, SWIFT, MMS, LCROSS, GPM, TacSat4, GOES-R and NRO missions.
  - 100 Mega-bits per second (Technology Dependent)



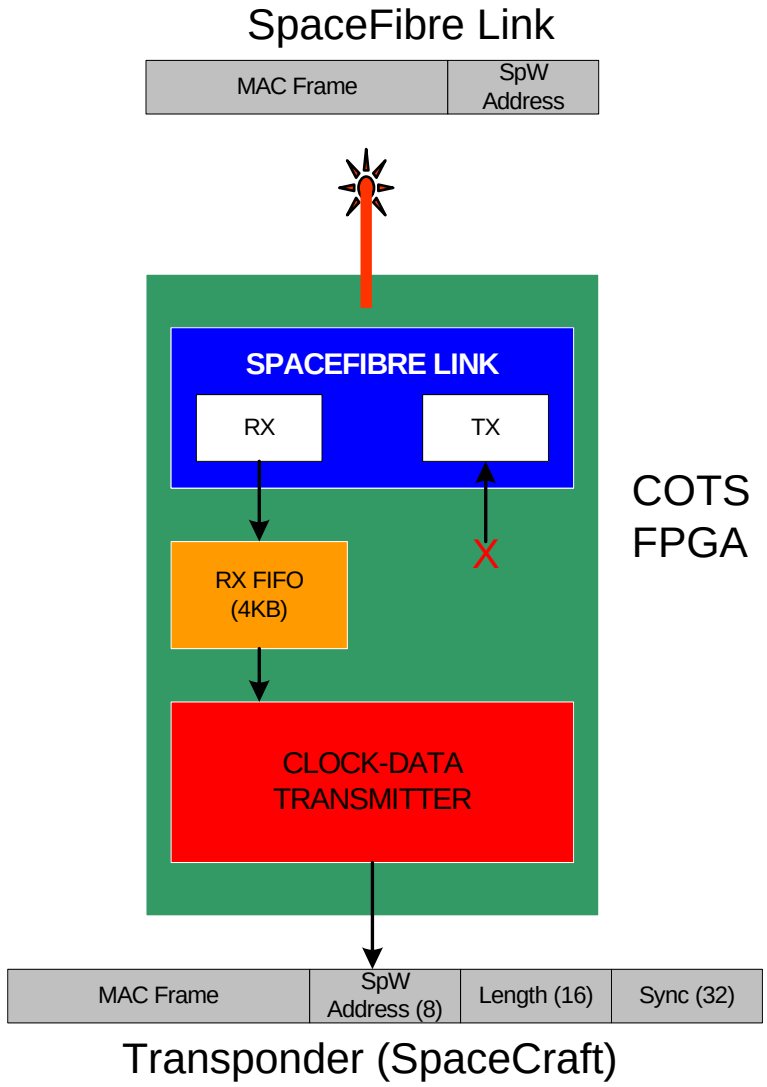
SpaceWire to SpaceFibre FPGA

- Provides “fair” round robin arbitration between four to six SpaceWire Links to the SpaceFibre Link Transmit Interface. (Dependent on number of Cameras)
- Routes packets from the SpaceFibre Receive Interface to one of the SpaceWire Links’ Transmit Interface



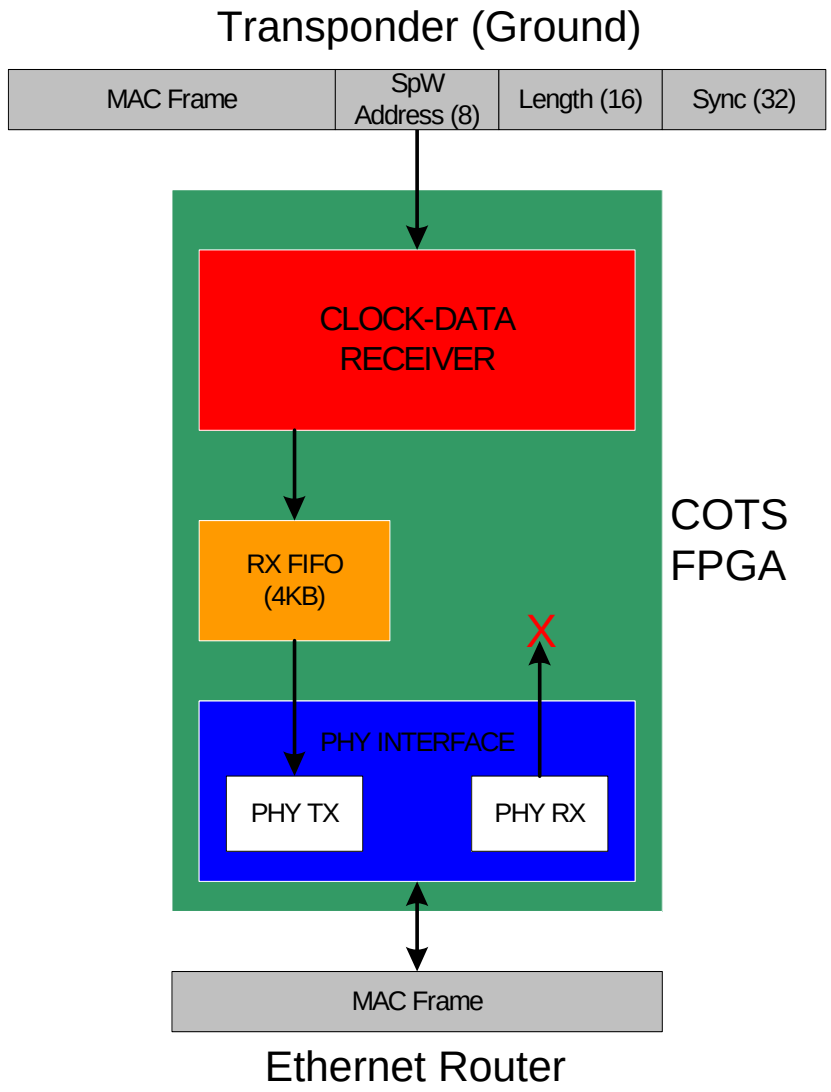
SpaceFibre to Data-Clock FPGA

- Receive Packet from SpaceFibre Interface, add 16 bit length and 32 bit Sync Pattern.
- Clock-Data Transmitter
  - Serialize packet least significant bit first, and transmit to RF Encoder.
  - 100 Mega-bits per second.
  - Idle transmit fives.



Data-Clock to Ethernet FPGA

- Receive packets via Clock & Data Interface, removes SpaceWire header, Length and Sync fields.
- Transmits packets via Phy Interface.
- Clock-Data Receiver
  - Deserialize packets and “find” sync pattern to extract packet.
  - 100 Mega-bits per second



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