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SpaceFibre

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NASA GSFC

UNIVERSITY OF DUNDEE

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- SpaceFibre
- SpaceFibre standard
- SpaceFibre implementation
- SpaceFibre cable and connectors
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  - Demonstration overview
- Conclusions

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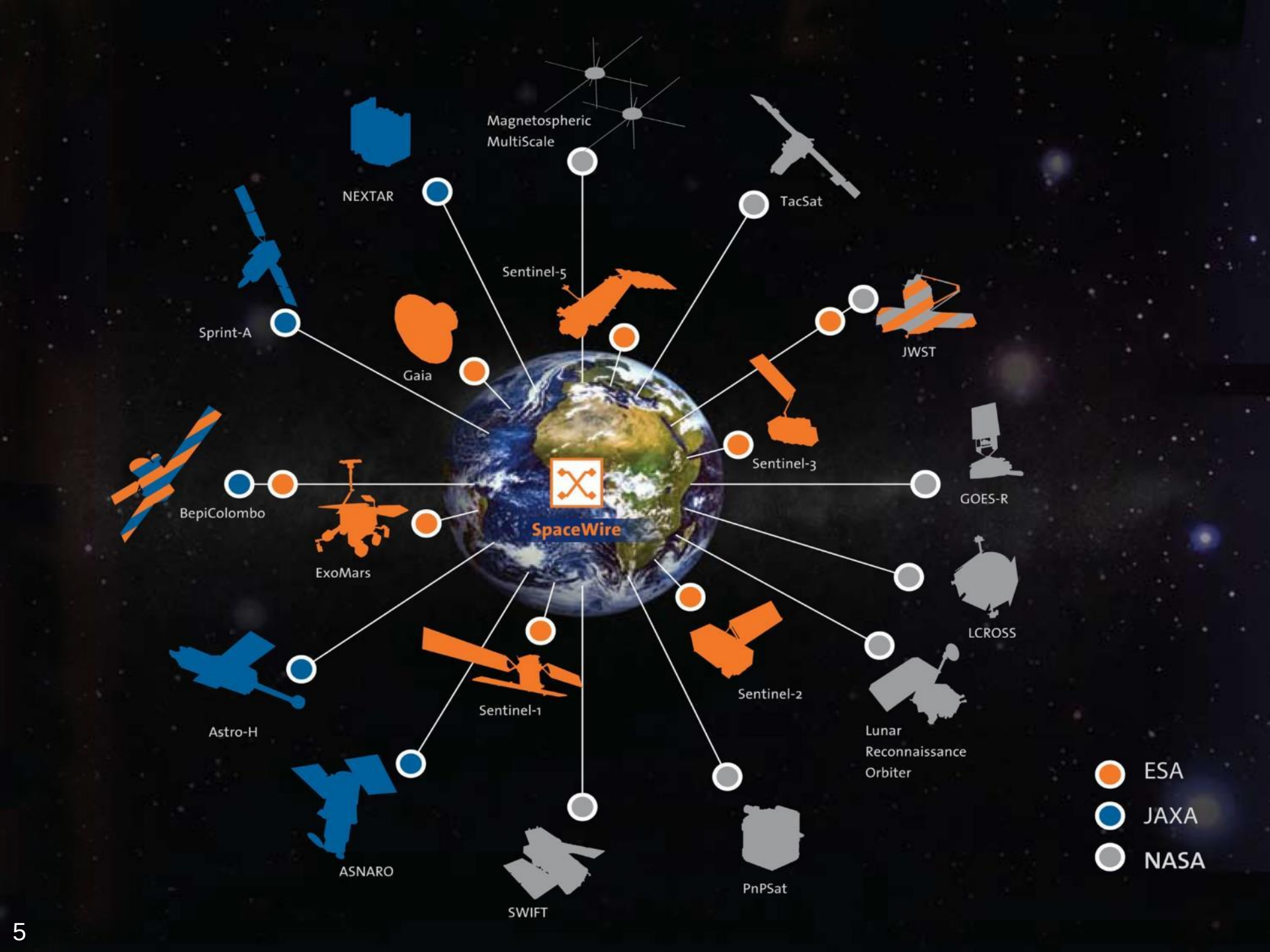
SpaceFibre


Magnetospheric
MultiScale
NEXTAR
TacSat
Sentinel-5
Sprint-A
Gaia
JWST
Sentinel-3
BepiColombo
GOES-R
SpaceWire
ExoMars
LCROSS
Sentinel-2
Sentinel-1
Astro-H
Lunar
Reconnaissance
Orbiter
ASNARO
PnPSat
SWIFT
ESA
JAXA
NASA

SpaceFibre

- SpaceFibre is
  - A spacecraft on-board data link and network
- SpaceFibre runs over
  - Electrical and fibre optic cables
- SpaceFibre designed specifically for spaceflight
  - Integrated QoS
  - Integrated FDIR capabilities
- An improvement on SpaceWire
  - Performance x10 to x100
  - Power per bit x0.2
  - Lower mass x0.75 electrical, x0.5 fibre
  - Mass per bit x0.075 electrical, x0.05 fibre
  - Robustness: galvanic isolation, FDIR
  - Capabilities: virtual links, virtual networks, time distribution, event signalling, deterministic data delivery

SpaceFibre Key Features

- High performance
  - 2.5 Gbits/s current flight qualified technology
  - 3.125 Gbits/s soon (6.25 Gbits/s coming)
  - Multi laning of up to 16 lanes (40 Gbits/s)
- Innovative integrated QoS
  - Priority
  - Bandwidth reservation
  - Scheduling
- Novel integrated FDIR support
  - Transparent recovery from transient errors
  - Error containment in virtual channels and frames
  - “Babbling Node” protection
- Low latency
  - Broadcast codes
- Compatible with SpaceWire at packet level

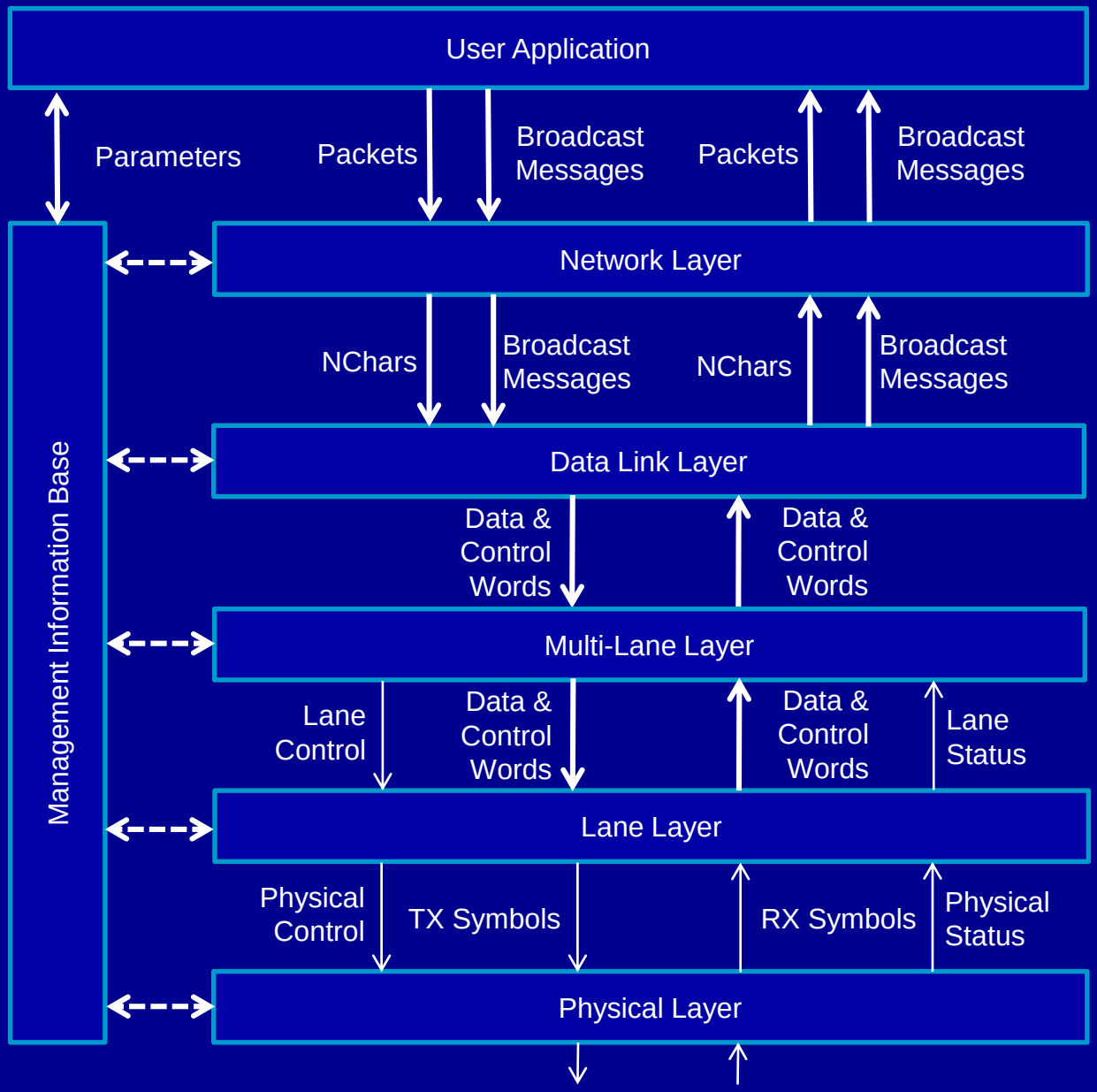
SpaceFibre Benefits

- Supports high data-rate instruments (e.g. SAR)
  - Very high data rates
- Reduces cost, schedule and risk
  - Reduction of harness mass
  - Simplification of redundancy
  - Increase in reliability
  - Straightforward error recovery
  - Very small footprint due to efficient design
- Supports integrated AOCS/GNC and payload network
  - Quality of service
  - Deterministic data delivery
- Supports launcher applications
  - Long distance
  - Galvanic isolation
- Easy to integrate with existing SpaceWire equipment

Integrated Network

- Single integrated network
  - Carrying
    - Instrument data
    - Configuration and control information
    - Deterministic traffic
    - High resolution time information
    - Event signals
  - Improves reliability, mass, cost

SpaceFibre Standard



Nodes
Routers and routing
Message broadcast
Packet definition

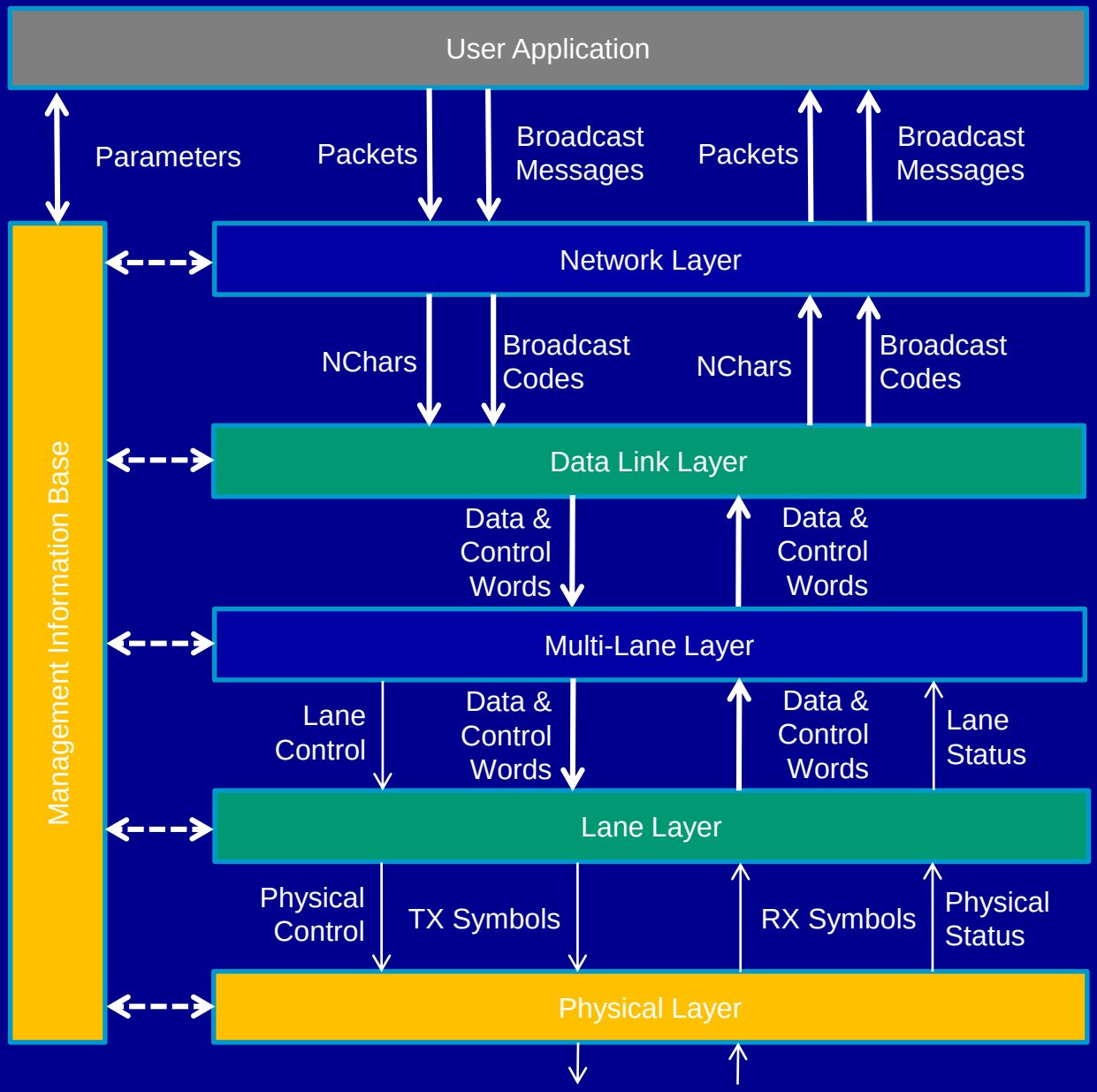
Link operation
Quality of service
Link error recovery

Lane coordination
Lane failure recovery

Lane initialisation
Encoding of data & control words

SerDes
Driver/Receiver
Cables
Connectors

SpaceFibre ECSS Working Group



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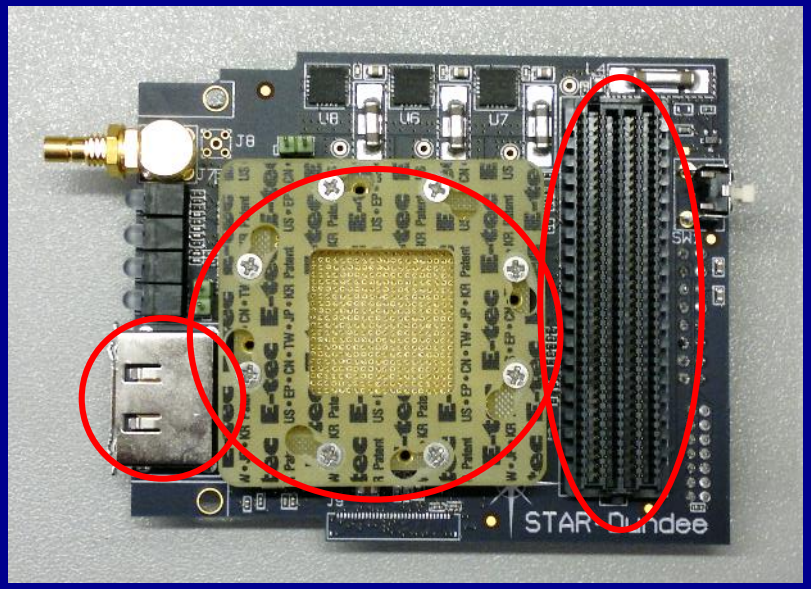
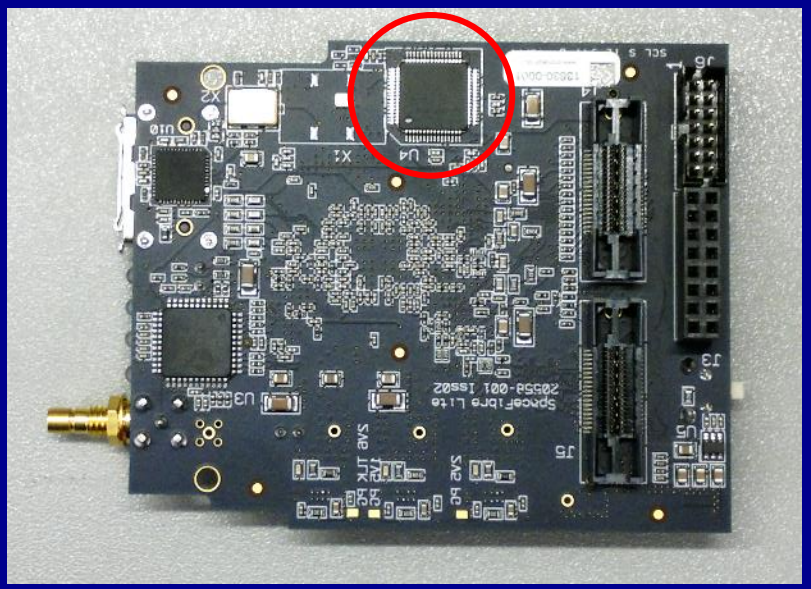
SpaceFibre Implementation

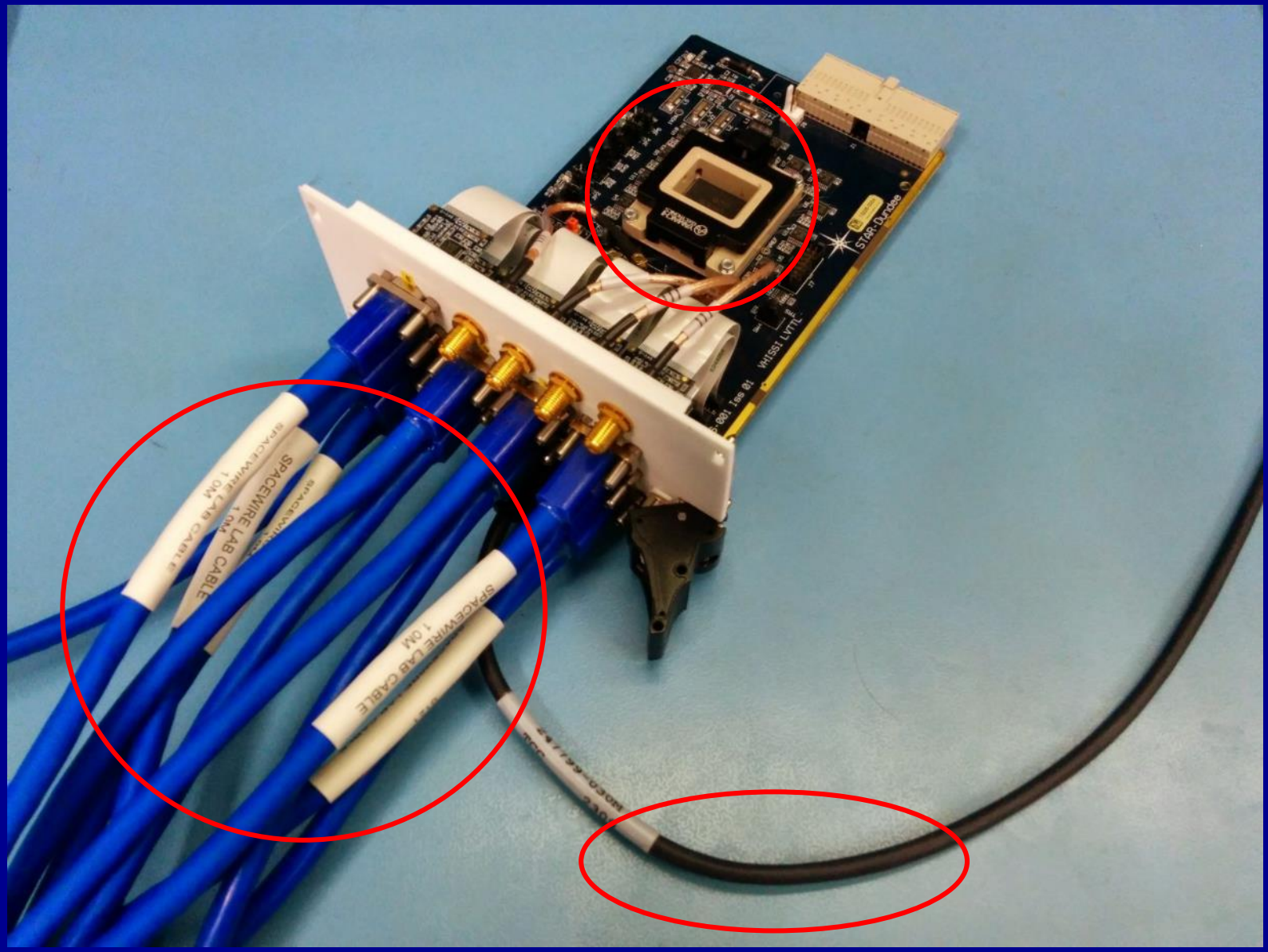
SpaceFibre Lite Evaluation Board





- Commercial equivalent of flight proven parts
  - Microsemi RTAX1000
  - TLK2711-SP SerDes
- Pre-programmed with STAR SpFi IP core
- FMC interface for connection to development boards
- 2.5 Gbits/s with 32-bit interface at 62.5 MHz
- 20% to 25% of AX1000

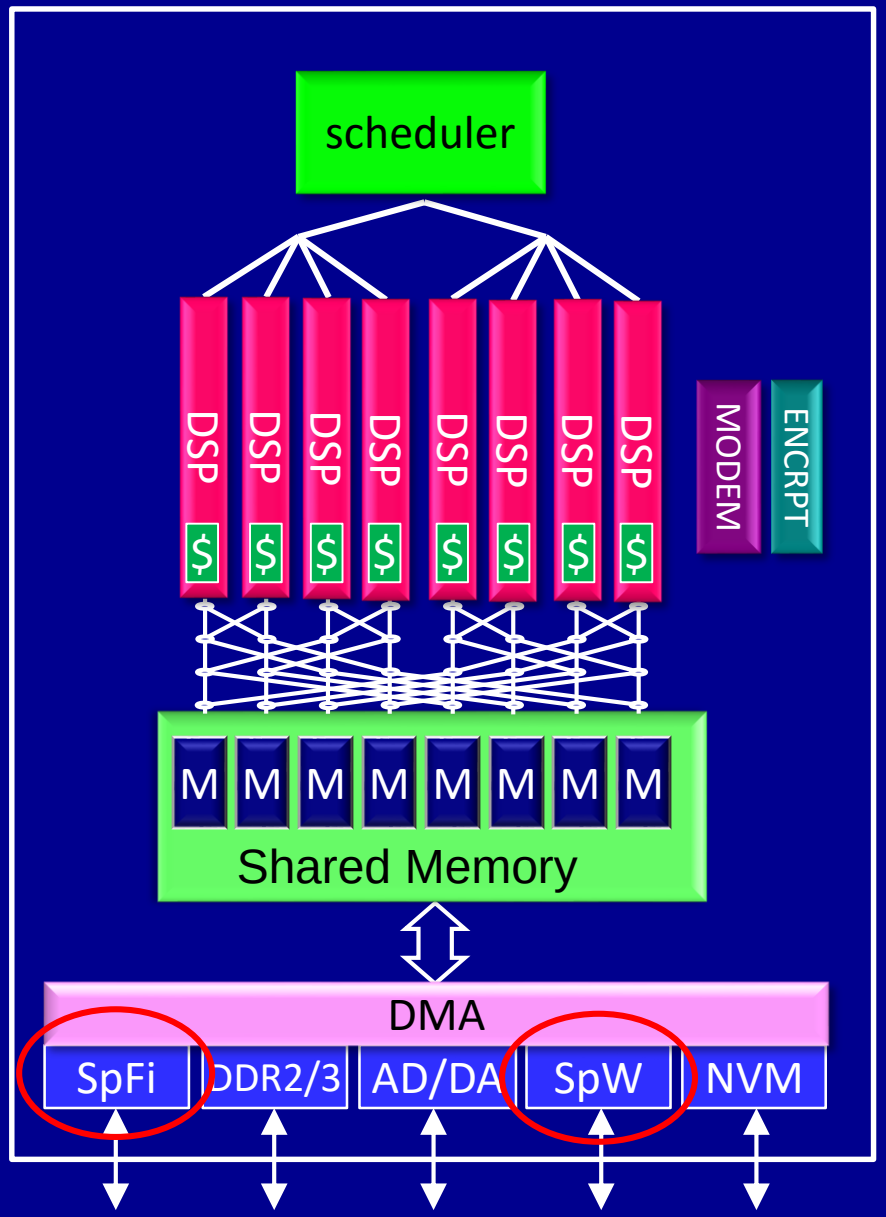
Radiation Tolerant SpaceFibre ASIC

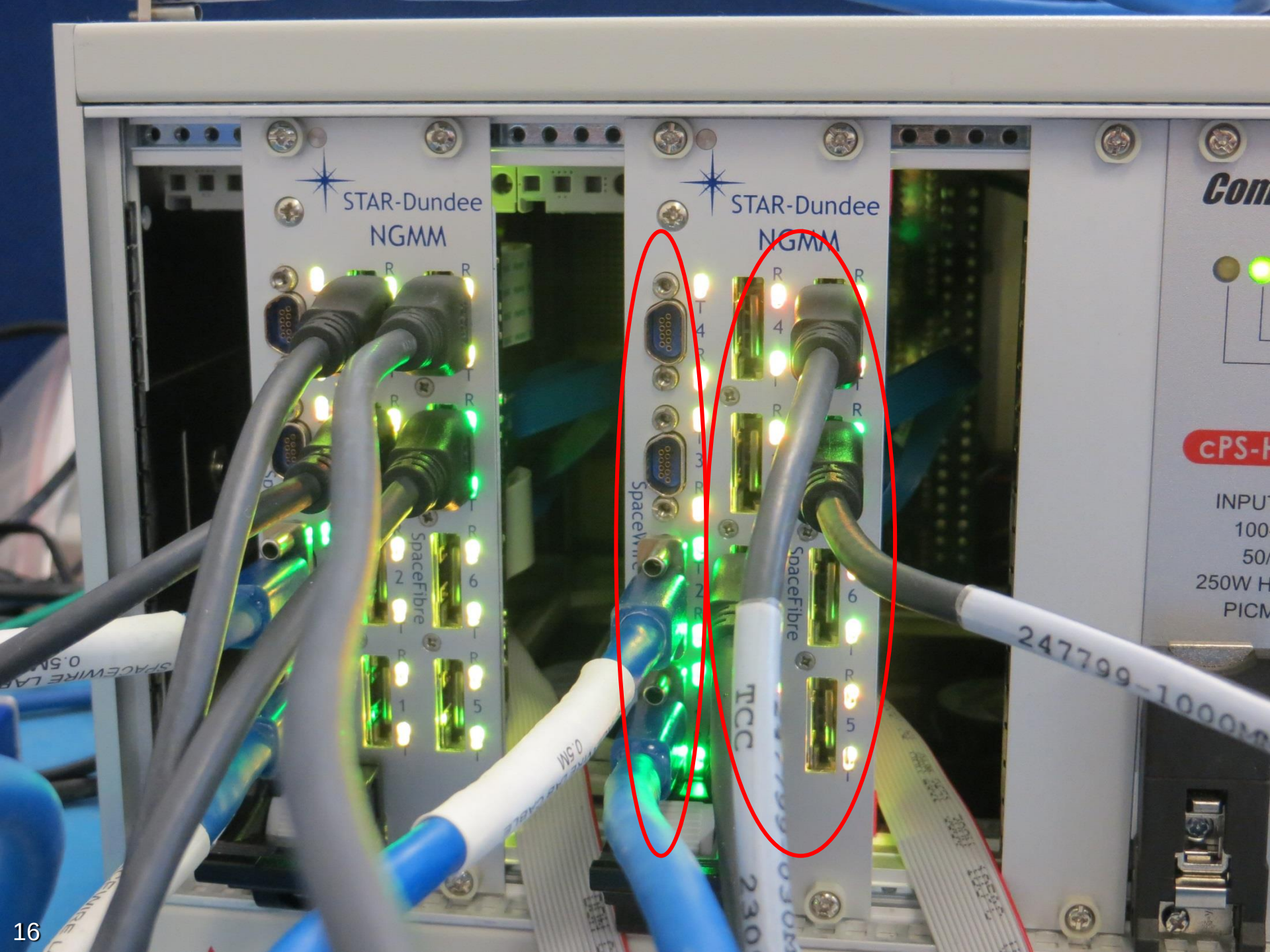


STAR-Dundee RC64 Many Core DSP Processor

Ramon Chips

- 64 fast CEVA X1643 DSP with FP extension and HW scheduler
  - 300 MHz
  - 38 GFLOPS, 150 GOPS
- Modem and Encrypt accelerators
- 4 Mbyte on-chip shared memory
- Fast I/O
  - 12x SpaceFibre, SpaceWire
  - DDR3, AD/DA LVDS I/F, NVM
- Rad-Hard, for space
- Advanced technology
  - TSMC 65nm LP
  - CCGA / PBGA / COB
  - 10 Watt
- Modular
  - Payloads can employ many RC64
- Versatile
  - Designed for all space missions
  - Planned for 2020—2050
- Re-programmable in space



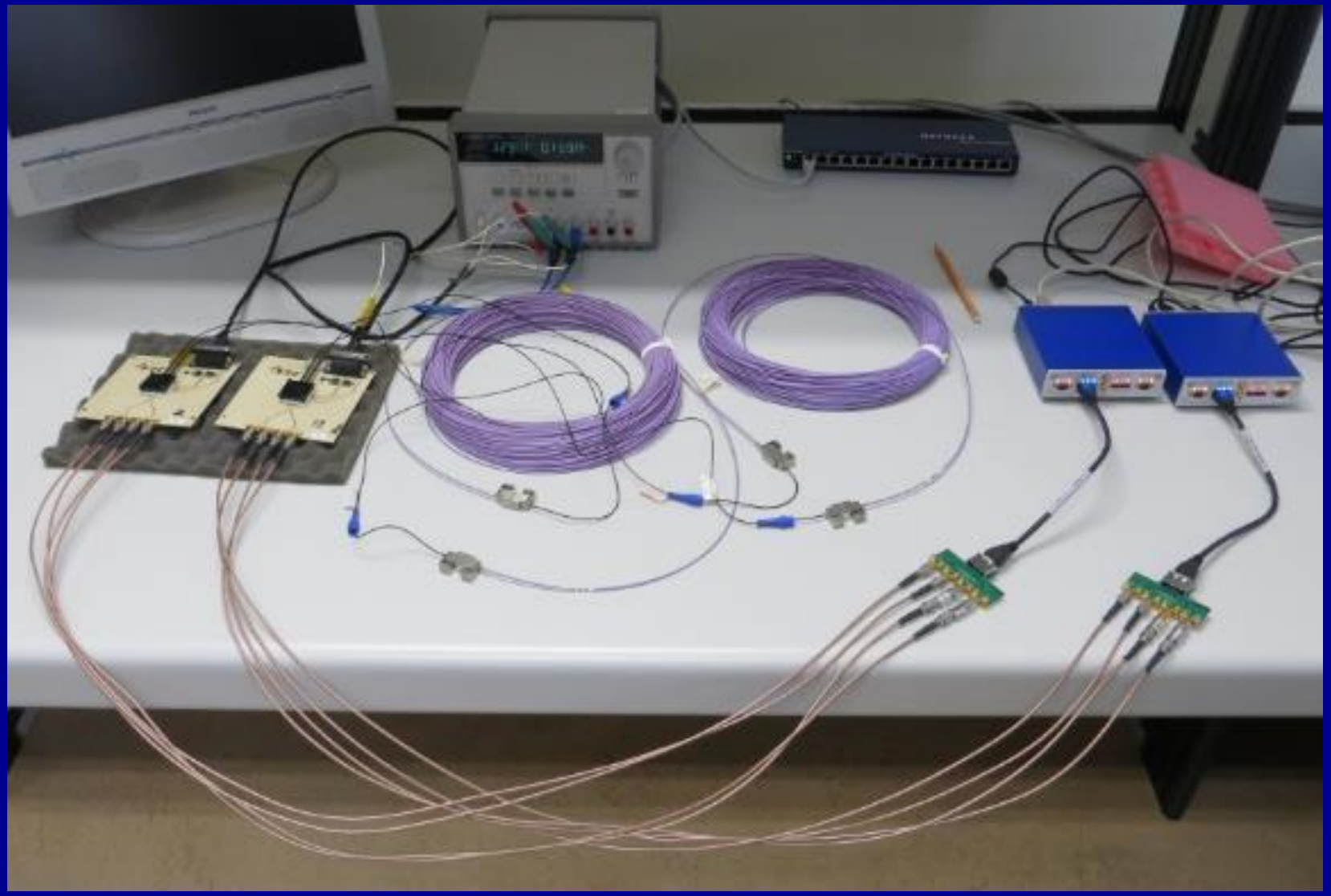

STAR-Dundee
NGMM
STAR-Dundee
NGMM
SpaceFibre
SpaceFibre
TCC

SpaceFibre Electrical Cables

- SpaceFibre can operate over 5m electrical cable
- Electrical version uses CML (current mode logic)
  - Differential
  - High-speed
- Flight cables and connectors based on Axon AxoMach
- Lab cables and connectors use eSATA

SpaceFibre Flight Fibre Optic Cables

- SpaceFibre demonstrated over 100 m Fibre Optic



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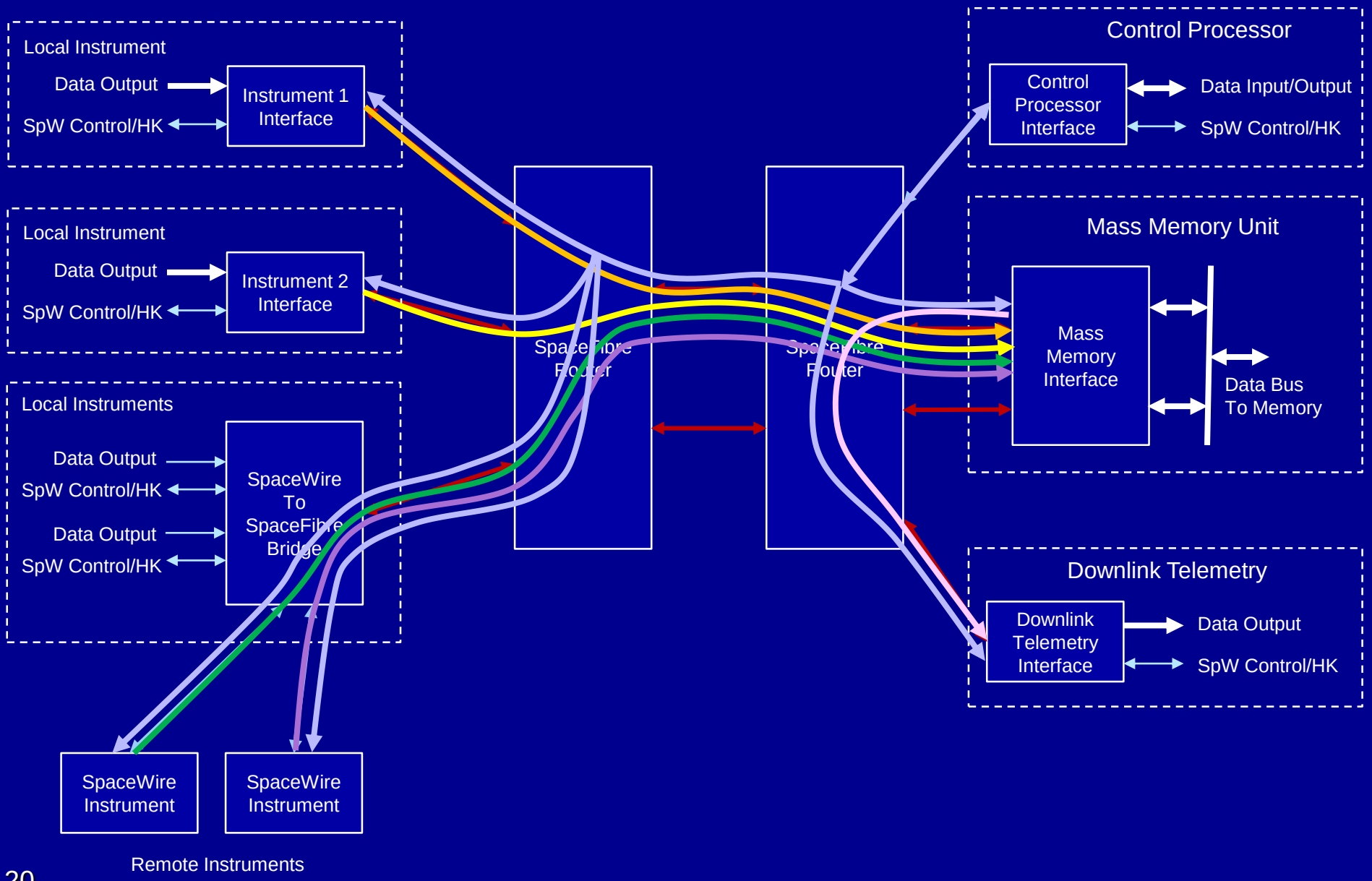
SUNRISE Demonstration

Demonstration Architecture



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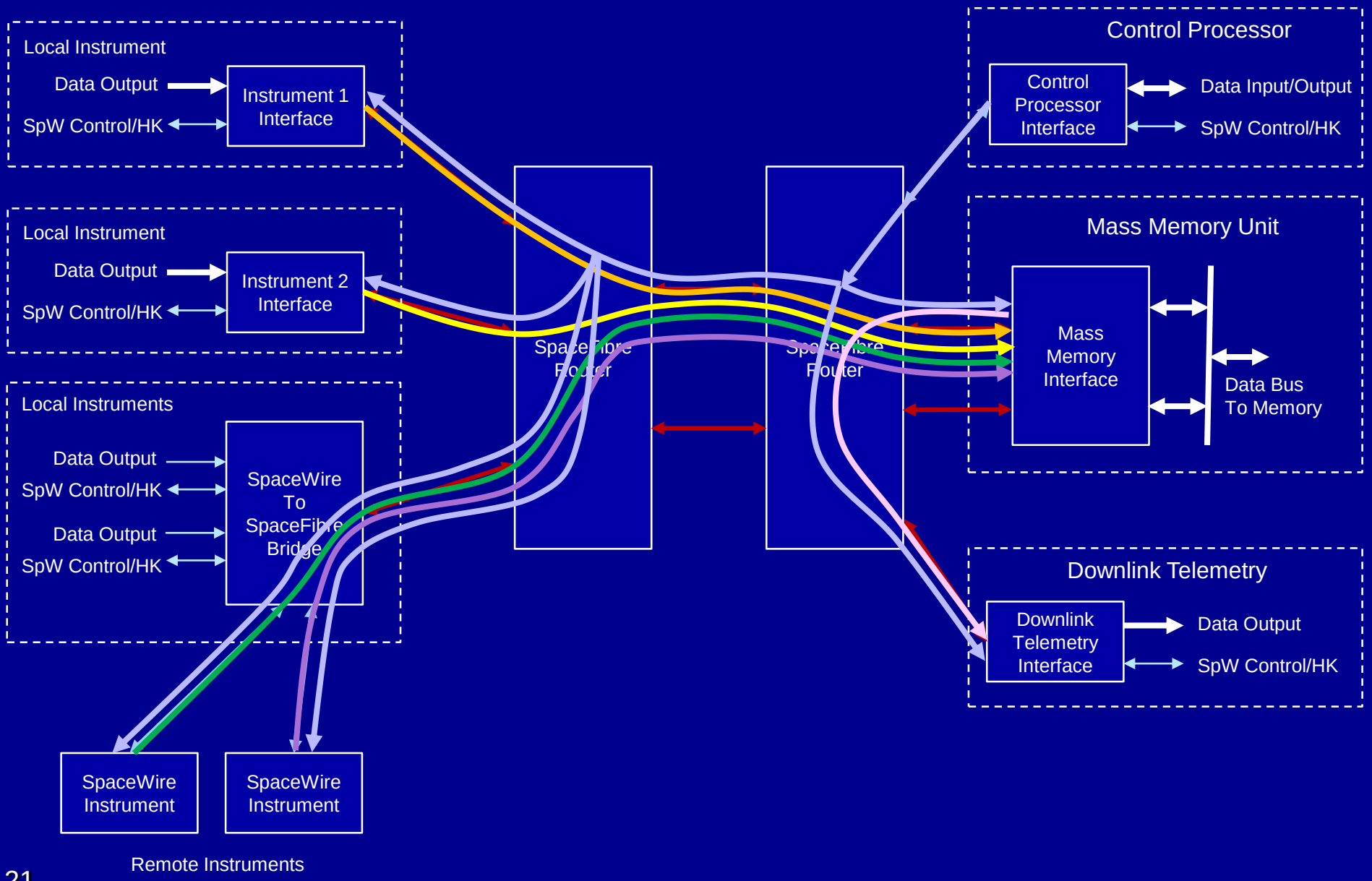

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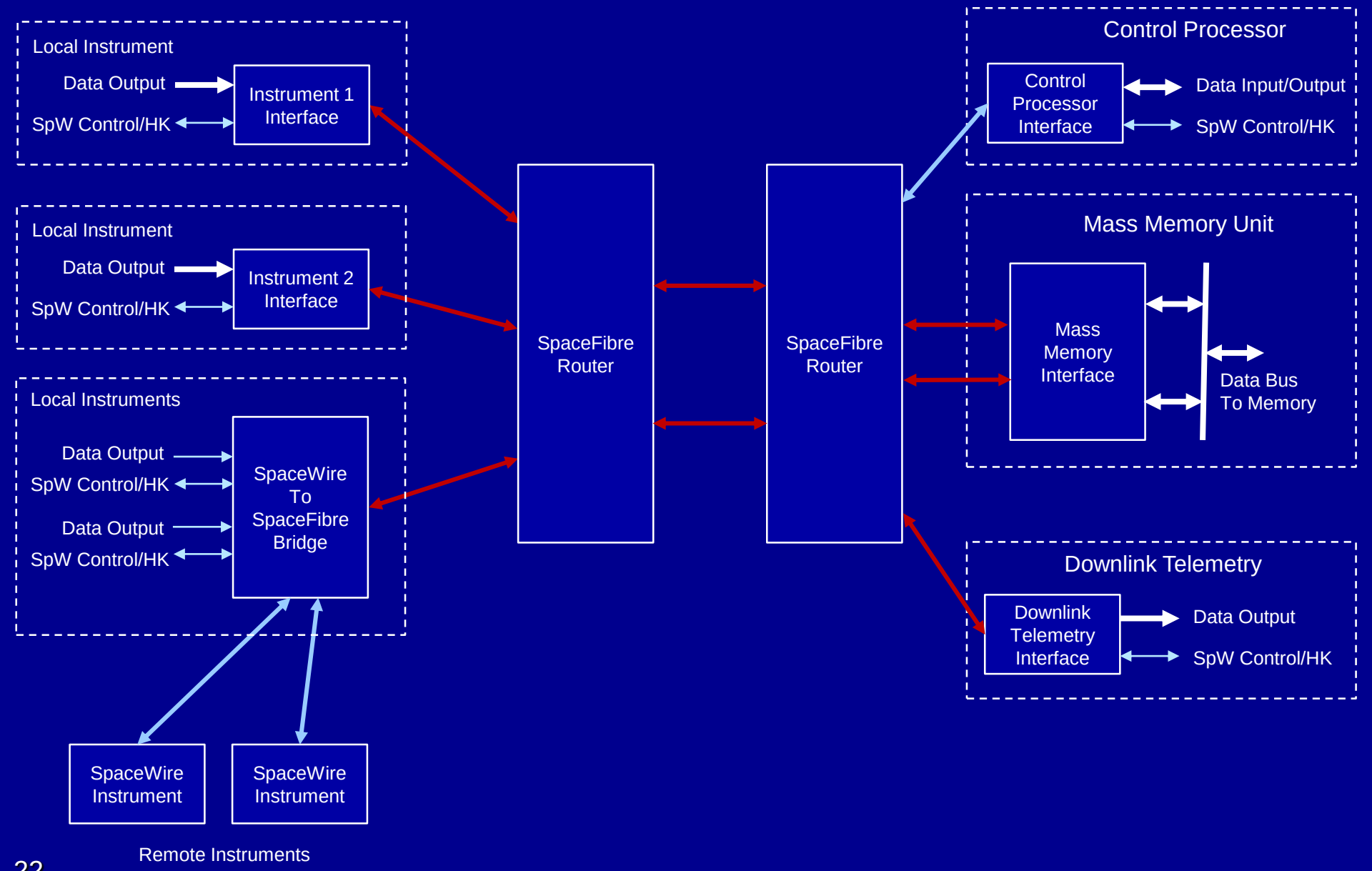


Demonstration Architecture

SpaceFibre Router

SpaceFibre Router

Control Processor

Control Processor Interface

Data Input/Output

SpW Control/HK

Mass Memory Unit

Mass Memory Interface

Data Bus To Memory

Local Instruments

Data Output

SpW Control/HK

Data Output

SpW Control/HK

SpaceWire To SpaceFibre Bridge

Downlink Telemetry

Downlink Telemetry Interface

Data Output

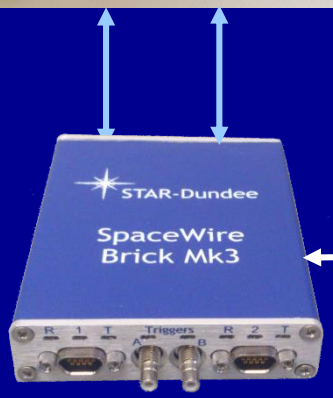
SpW Control/HK

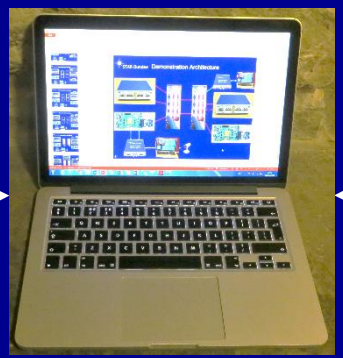
SpaceWire Instrument

SpaceWire Instrument

Remote Instruments

Demonstration Architecture





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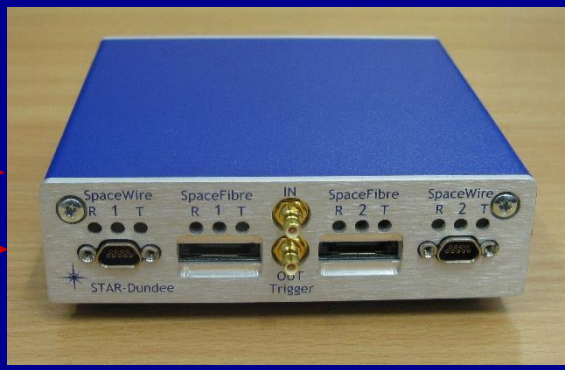

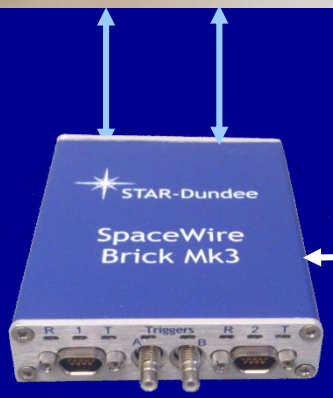

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Downlink Telemetry

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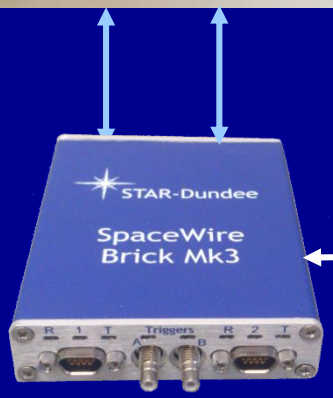

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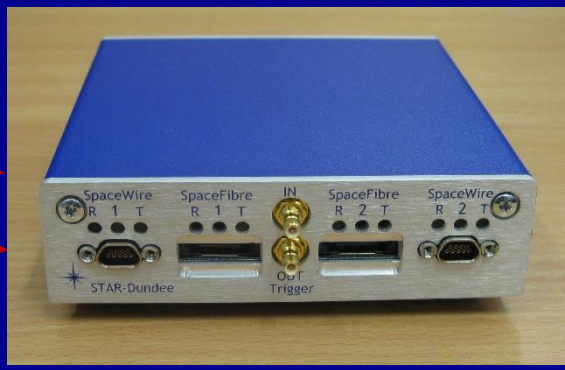

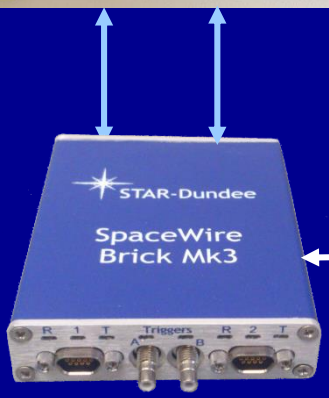

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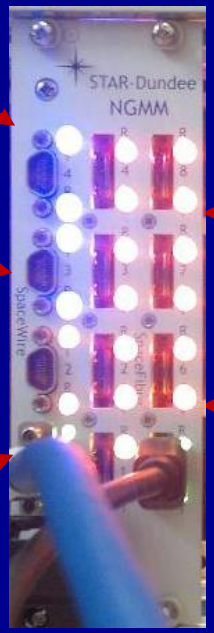
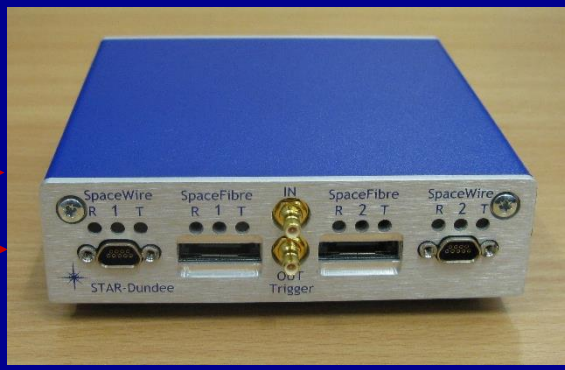
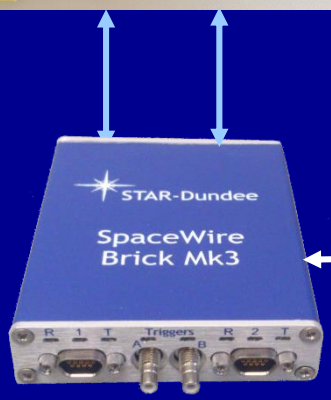


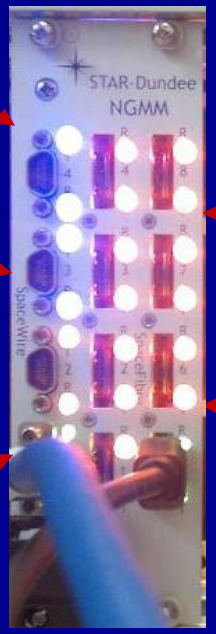


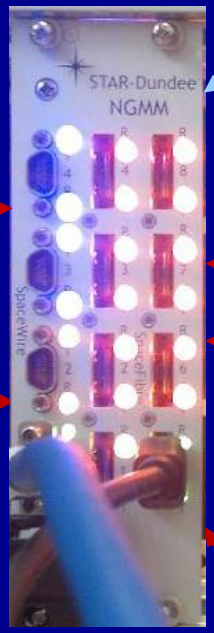


STAR-Dundee

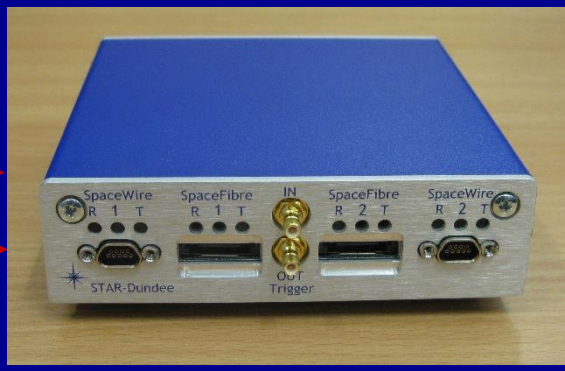

SpaceWire
R 1 T
SpaceFibre
R 1 T
IN
SpaceFibre
R 2 T
SpaceWire
R 2 T
STAR-Dundee
Out
Trigger


SpaceWire
R 1 T
SpaceFibre
R 1 T
IN
SpaceFibre
R 2 T
SpaceWire
R 2 T
STAR-Dundee
Out
Trigger


STAR-Dundee
NGMM
SpaceWire
SpaceFibre


STAR-Dundee
NGMM
SpaceWire
SpaceFibre


STAR-Dundee
SpaceWire
Brick Mk3
Triggers


SpaceWire
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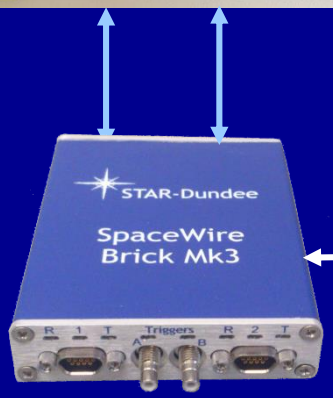
Trigger


STAR-Dundee
SpaceWire
Brick Mk3
Triggers

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SpaceFibre Network Demonstration

Conclusions

- SpaceFibre designed specifically for spaceflight applications
  - Integrated QoS
  - Integrated FDIR capabilities
  - Galvanic isolation
  - Compatible with SpaceWire packet level
  - Efficient design giving very small footprint
- Benefits
  - Very high performance
  - Reduced harness mass
  - Interoperability with existing SpaceWire devices
  - Simplification of redundancy
  - Deterministic data delivery for control applications
  - Single integrated network
- Running on radiation tolerant FPGAs now

Spacecraft Integrated Network

- Single integrated network
  - Carrying
    - Instrument data
    - Configuration and control information
    - Deterministic traffic
    - High resolution time information
    - Event signals
    - Error reports
  - Improves reliability, mass, cost

SpaceFibre Fibre Optics

- What is needed from the Fibre Optics
  - CML inputs and outputs
  - Signal present / Loss of Signal indication
  - Operating range
    - As broad as possible
    - At least 1 Gbps to 4 Gbps
  - Low power
    - Power saving modes
    - With fast (µs) recovery
  - Rugged
  - ESD protection
  - Multiple lanes
- ECSS Specification
- SpaceFibre with Fibre Optics demonstrations


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