SpaceWire-RT Update

EU FP7 Project

Russian and European Partners

SUAI, SubMicron, ELVEES

University of Dundee, Astrium GmbH

Contents

- SpaceWire-RT project
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Overview of SpaceWire-RT Project

- Aims
  - The SpaceWire-RT research programme aims to:
    - Conceive and create communications network technology,
    - suitable for a wide range of demanding space applications
    - where responsiveness, determinism, robustness and durability are fundamental requirements.
  - A critical component technology for future spacecraft avionics and payloads.
  - QoS layer will be developed to support mixed avionics and data-handling applications.

The SPACEWIRE-RT project has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under Grant Agreement no. 263148

Aims

	Distance	Rate	Latency	Packet size	QoS
Data-handling network	Short to long	Low to very high	Not important	Short to long	Reserved bandwidth
Control bus	Short to long	Low	Low	Short to long	Deterministic delivery
Telemetry bus	Short to long	Low	Low	Short	Reserved bandwidth
Computer bus	Short	Very high	Low	Short to long	Reserved bandwidth
Time-sync bus	Short to long	Low	Very low	Short	High priority
Side-band	Short	Low to high	Very low	Short	High priority

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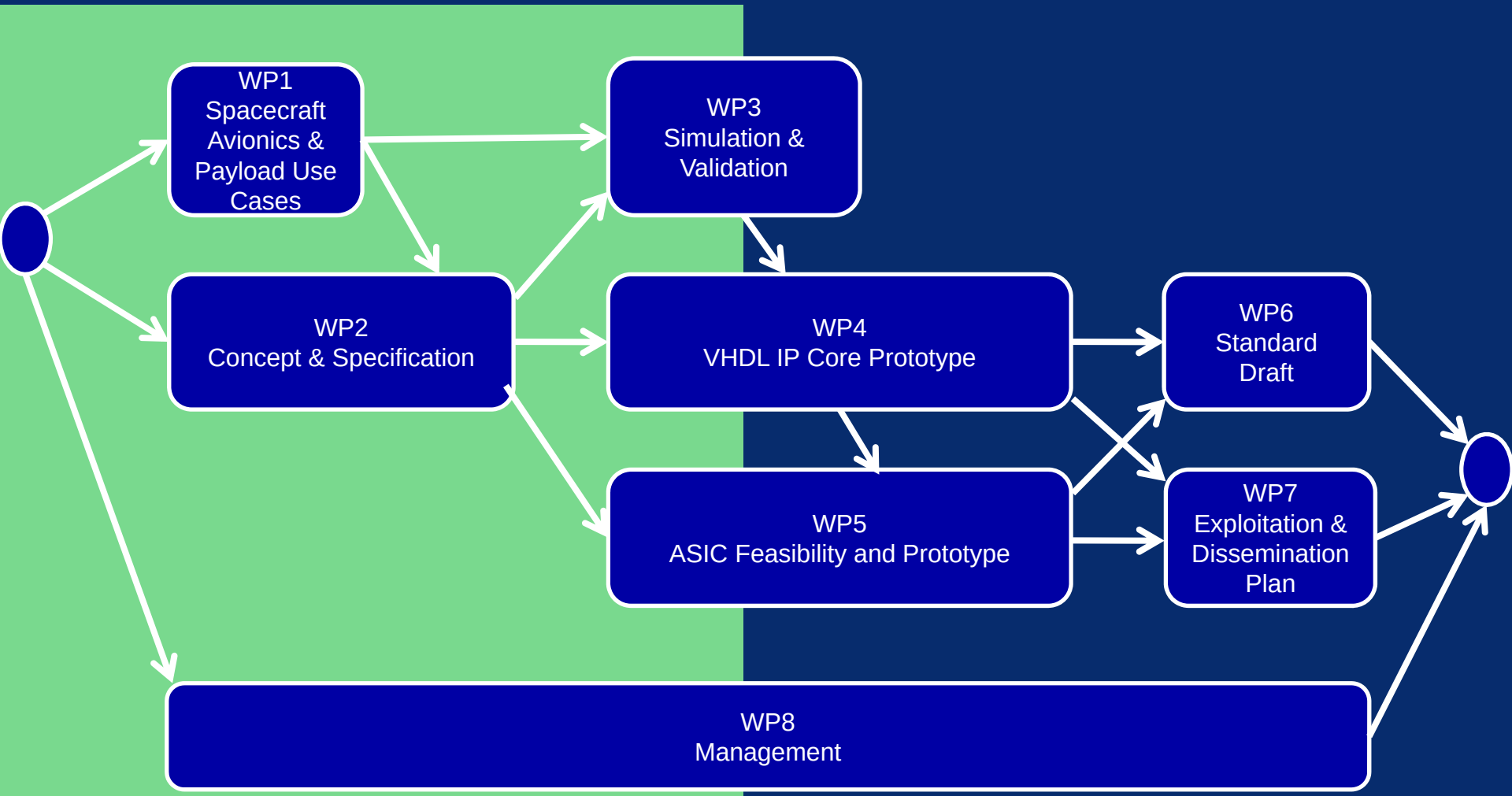
SpaceWire-RT Research Plan



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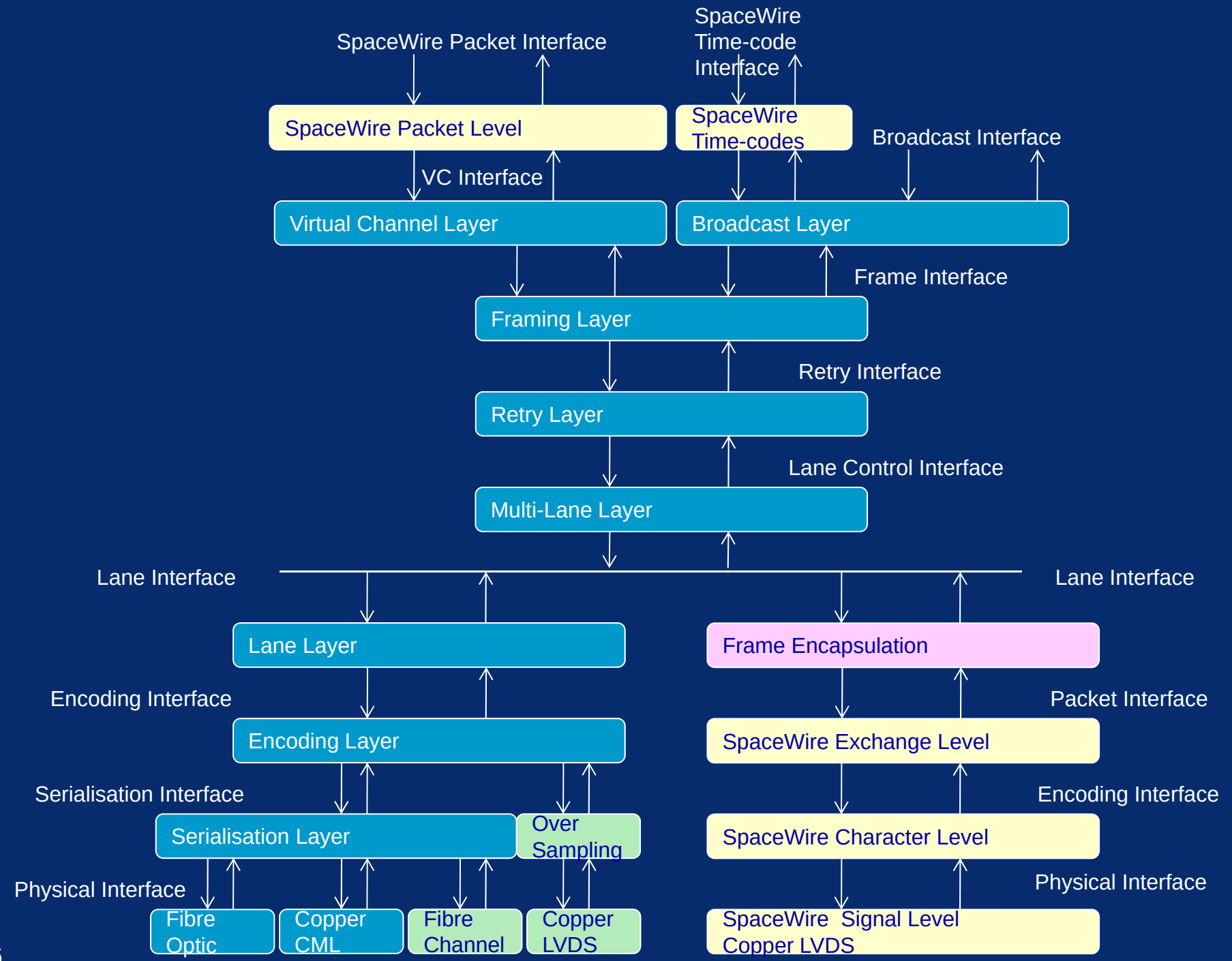
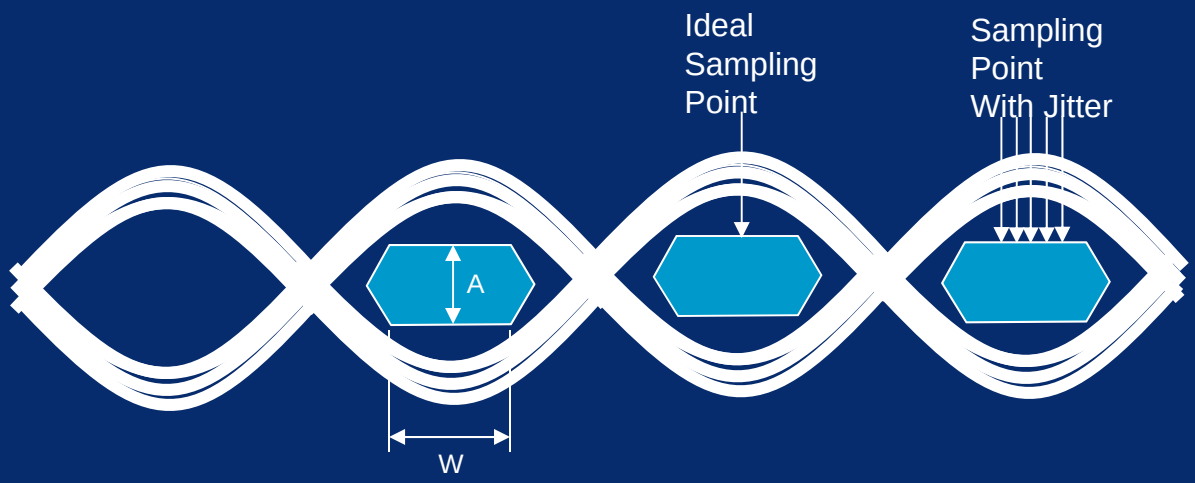

SpaceWire Packet Interface
SpaceWire Time-code Interface
SpaceWire Packet Level
SpaceWire Time-codes
Broadcast Interface
VC Interface
Virtual Channel Layer
Broadcast Layer
Frame Interface
Framing Layer
Retry Interface
Retry Layer
Lane Control Interface
Multi-Lane Layer
Lane Interface
Lane Interface
Lane Layer
Frame Encapsulation
Encoding Interface
Packet Interface
Encoding Layer
SpaceWire Exchange Level
Serialisation Interface
Encoding Interface
Serialisation Layer
Over Sampling
SpaceWire Character Level
Physical Interface
Physical Interface
Fibre Optic
Copper CML
Fibre Channel
Copper LVDS
SpaceWire Signal Level Copper LVDS

Oversampling SpaceFibre

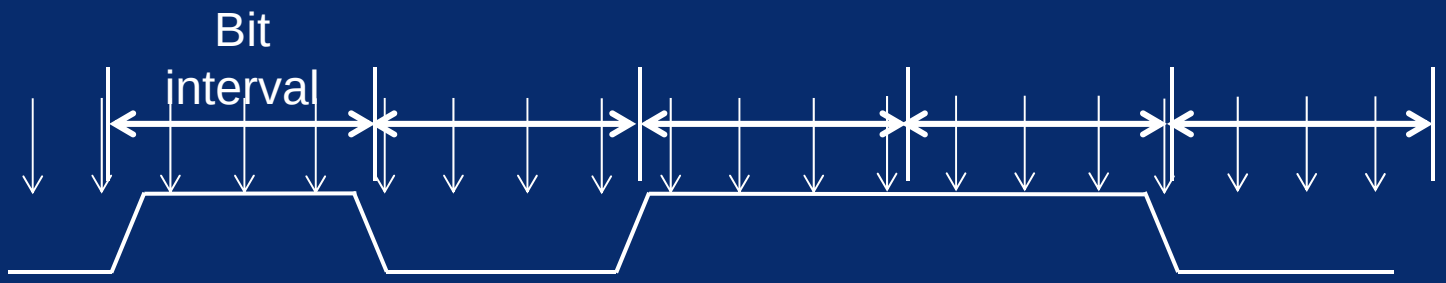
- Aims:
  - Simple implementation of SpaceFibre
  - In standard flight FPGA
  - No special clock and data recovery (CDR)
    - E.g. Phase-locked loop
  - Operate at modest speeds
    - E.g. 200 Mbits/s
  - Use LVDS instead of CML
  - Provide all the benefits of SpaceFibre
    - QoS
    - FDIR
    - Galvanic isolation
  - Key issue is recovering the data from the bit stream

Oversampling SpaceFibre



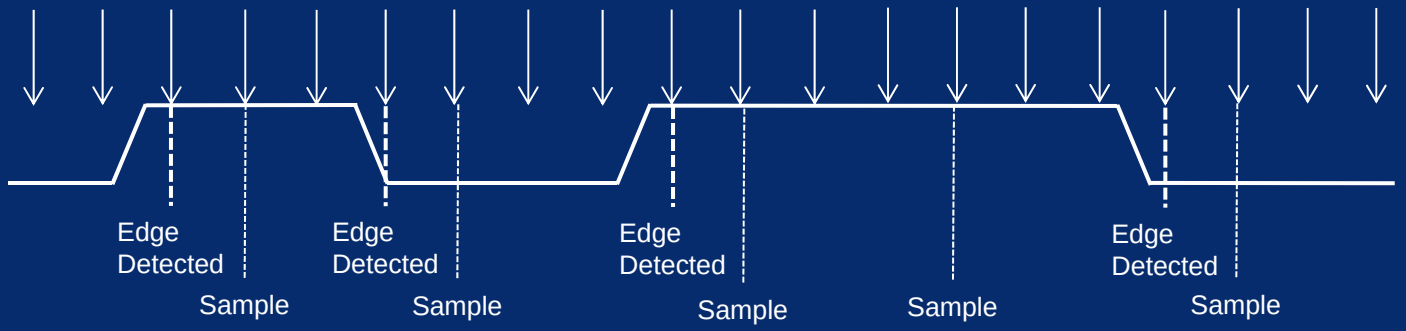
a) Received eye pattern and sampling

Oversampling SpaceFibre



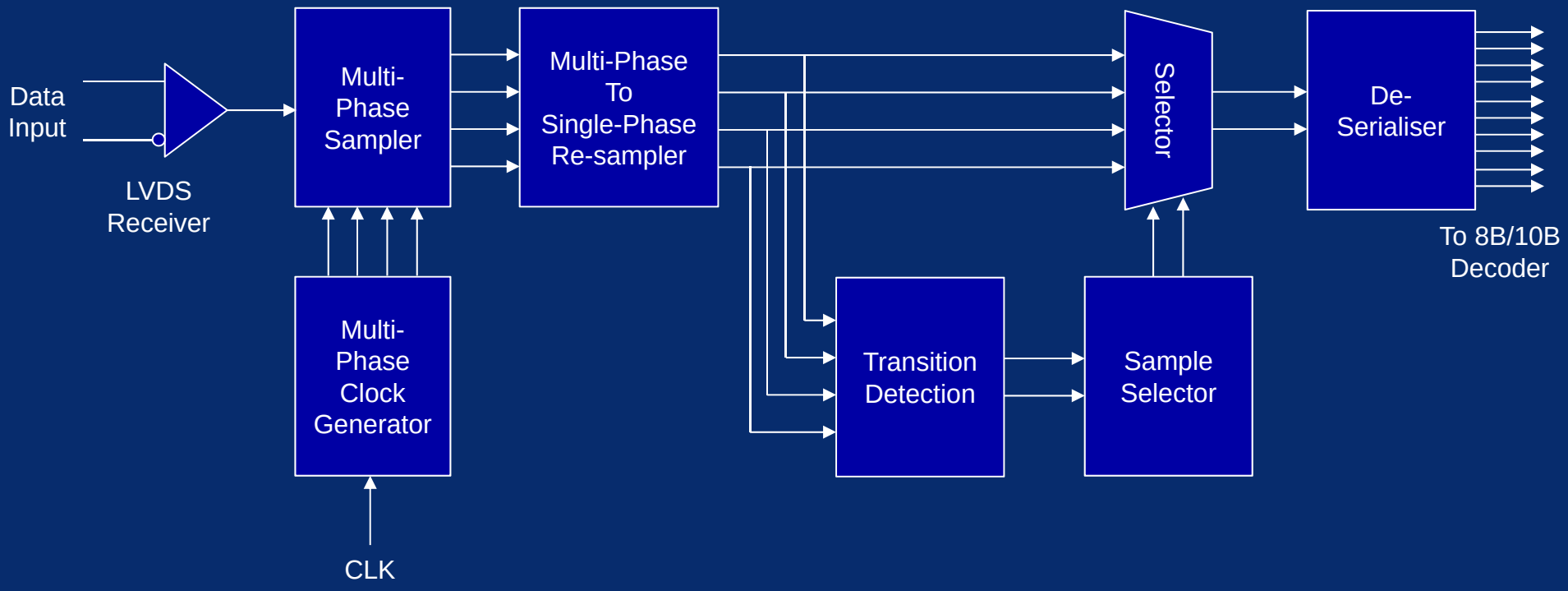
b) Oversampling

Oversampling SpaceFibre



c) Selecting the sample

Oversampling Architecture



Oversampling SpaceFibre

- Advantages:
  - Clock recovery does not require PLL
  - Covers 1 Mbits/s to 200 Mbits/s (TBC) speed range
  - Lower cable mass than SpaceWire
  - Minor extension to the SpaceFibre standard
  - LVDS interfaces available on most FPGAs
  - LVDS proven in space flight
  - May save some power compared to CML (TBC)
  - Can interoperate with SpaceFibre-LVDS depending on speed used
- Disadvantage:
  - Limited maximum speed

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- Reference:
  - Sawyer N, “Data Recovery”, Xilinx Application Note XAPP225 (v2.5) July 11, 2005.

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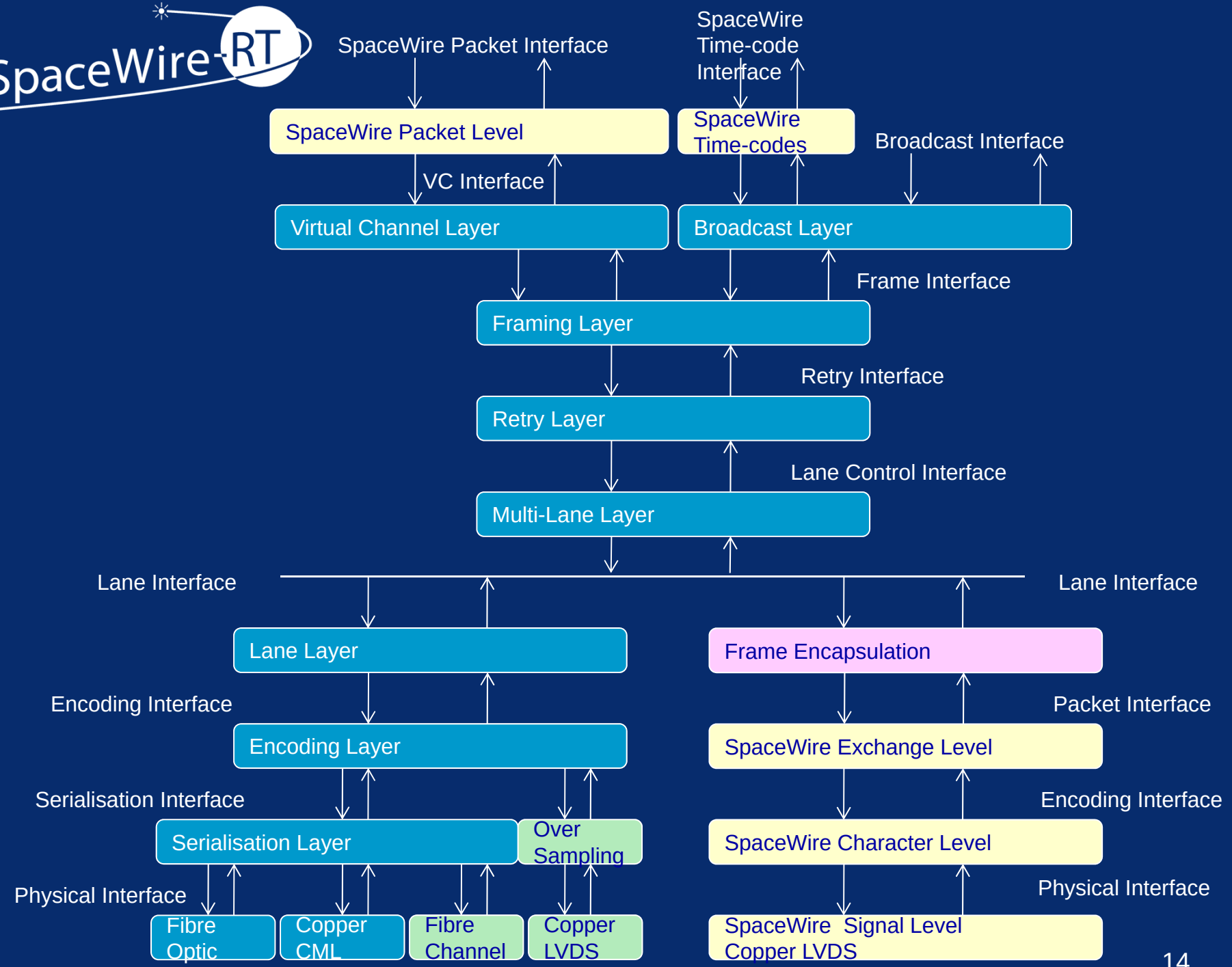
SpaceWire-RT



SpaceFibre over SpaceWire

- Basic idea is
  - Replace SpaceFibre lane with SpaceWire
  - Encapsulate all SpaceFibre frames and control words
    - Into individual SpaceWire packets
    - E.g. a SpFi ACK would be encapsulated into its own SpaceWire packet
  - Provides
    - End to end flow control
    - Retry
    - Limited QoS
      - Scheduled
      - Limited bandwidth reservation
  - Does not provide
    - Full QoS
    - Broadcast messages (with high priority)

Preliminary Characteristics

Table 11-1 SpaceWire-RT Protocol Characteristics				
Characteristic	**SpFi-FO**	**SpFi-CML**	**SpFi- LVDS**	**SpFi over SpW**
Media	Fibre Optic	Copper CML	Copper LVDS	Copper LVDS
Encoding	8B/10B	8B/10B	8B/10B	Data-Strobe
Speed Range	0.1 to 20 Gbits/s 50 Gbits/s in future	0.1 to 20 Gbits/s 50 Gbits/s in future	1 to 600 Mbits/s 1 to 200 Mbits/s OS	1 to 300 Mbits/s
Distance	100 m	5 m	10 m	10 m
Galvanic Isolation	Yes	Yes	Yes	No
Packet Size	Arbitrary	Arbitrary	Arbitrary	Arbitrary
SpaceWire Packet Level	Yes	Yes	Yes	Yes
Latency (TBC)	1 µs	1 µs	1 µs	10 1 µs
Cable Mass	< 30g/m	< 60g/m	< 40g/m	~87 g/m
Power (TBC)	< 200 mW	< 200 mW	< 200 mW	< 400 mW
QoS BW Reserved	Yes	Yes	Yes	Yes with limitations
QoS Priority	Yes	Yes	Yes	No
QoS Scheduled	Yes	Yes	Yes	Yes
QoS Best Effort	Yes	Yes	Yes	Yes
Broadcast Message	Yes	Yes	Yes	No
Determinism	Yes	Yes	Yes	Yes
Reliability	Yes	Yes	Yes	Yes
Fault Detection	Yes	Yes	Yes	Yes
Fault Isolation	Yes	Yes	Yes	Yes
Retry	Yes	Yes	Yes	Yes
SpaceWire compatible	Packet level only	Packet level only	Packet level only	Yes

Summary

- SpaceWire-RT aims to
  - Extend SpaceFibre to cover
  - Broad range of space applications
  - Including mixed data-handling and avionics
- SpaceFibre
  - QoS Mechanisms
  - FDIR capability
  - Protocol validation by simulation
  - Operation over different media
    - CML
    - LVDS
    - Fibre Channel physical layer

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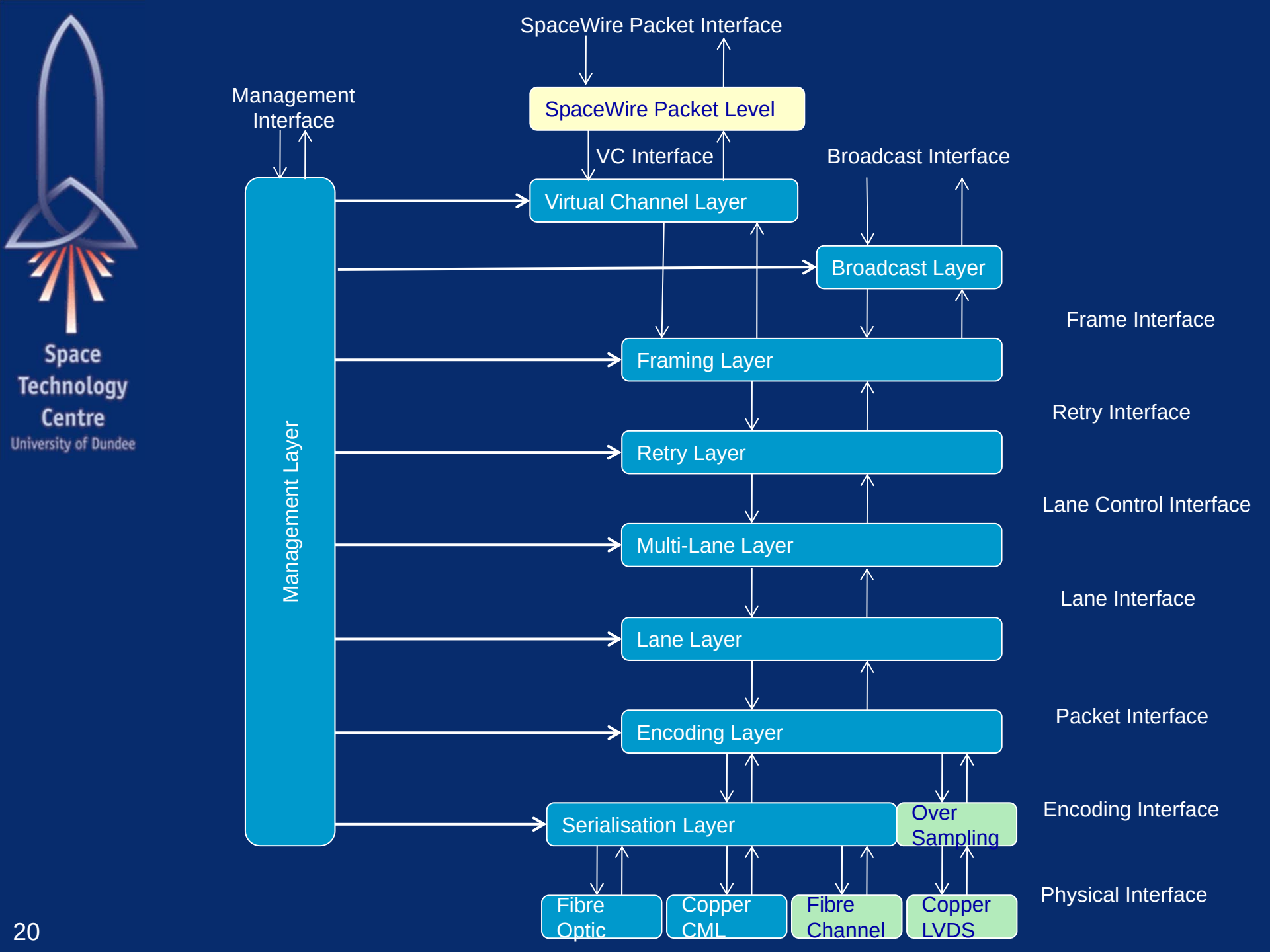
University of Dundee

Summary

- SpaceFibre over SpaceWire
  - Provides
    - End to end flow control
    - Retry
  - Has some significant limitations
    - QoS not maintained over SpaceWire network
    - Full QoS requires special SpaceWire routers
- Simpler to bridge existing SpaceWire devices to SpaceFibre network
- VHiSSI EU FP7 project includes research on such a bridge device

Summary

- Oversampled SpaceFibre
  - Lower speed SpaceFibre
  - Galvanic isolation
  - All SpaceFibre QoS and FDIR capabilities
  - Uses LVDS
  - Can be implemented in current flight FPGAs
  - Simple CDR mechanism
  - Saves on cable mass
- Currently designing prototype
  - Expect to test this early 2013



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