SpaceWire-RT
Project and Baseline Concepts

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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

Overview of SpaceWire-RT Project

- SpaceWire-RT will:
  - use virtual channel concepts for a variety of QoS;
  - provide broadcast and multicast capability;
  - increase performance;
  - provide low latency message delivery;
  - include extremely low latency time and out-of band signalling mechanisms;
  - incorporate novel fault detection, isolation and recovery methods;
  - make network fully responsible for information transfer;
  - decouple application and data transfer;
  - implement appropriate communication mechanisms in relatively simple hardware.

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SpaceWire-RT QoS

- Address QoS examining the following aspects:
  - Responsiveness
    - Ability to
      - react rapidly to real-time events
      - deliver information with low latency
    - Concerned with network latency, data-rate and priority.
  - Determinism
    - Ability to
      - deliver a message and to flag and recover from errors within specific time constraints
    - Concerned with network resource reservation.

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SpaceWire-RT QoS

- Robustness
  - Ability to
    - continue to deliver messages in the event of transitory and permanent faults,
  - Concerned with
    - acknowledgements, retry mechanisms, redundancy,
    - autonomous or managed fault detection, isolation and recovery.
- Durability
  - Ability of network to
    - provide the required network services
    - without intervention for long periods of time,
  - Concerned with network management, fault isolation and recovery.

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SpaceWire-RT QoS

- Performance
  - Ability to:
    - Handle high bandwidth data streams
    - Provide scalable performance
    - To match application requirements using a range of appropriate communications media
  - Enabling power/mass versus performance selection.
- Integrated quality of service
  - Comprehensive set of quality of service capabilities
    - Avoiding need for applications to have to be concerned with network quality.
    - Decoupling applications from the message delivery service
    - Leading to simpler, more reusable, application software.

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SpaceWire-RT QoS

- Integrated out-of-band signalling
  - Highly capable and robust out-of-band signalling techniques
  - Integrated within the network
  - To remove the need for additional wires and control/configuration networks.
- Fault Detection, Isolation and Recovery:
  - There is no integrated FDIR policy for SpaceWire.
  - While it is simple to cross strap links and provide underlying redundancy thanks to the topological freedom provided by SpaceWire, there is no standard means of managing FDIR.
  - Integrated FDIR capability at appropriate level.

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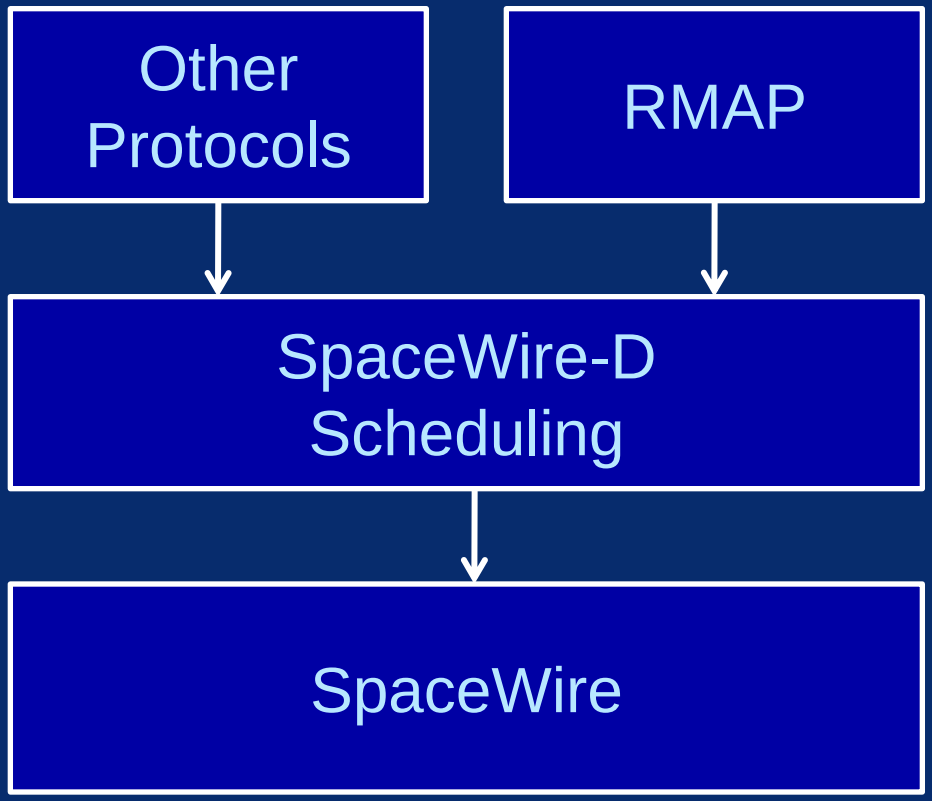
SpaceWire for Avionics



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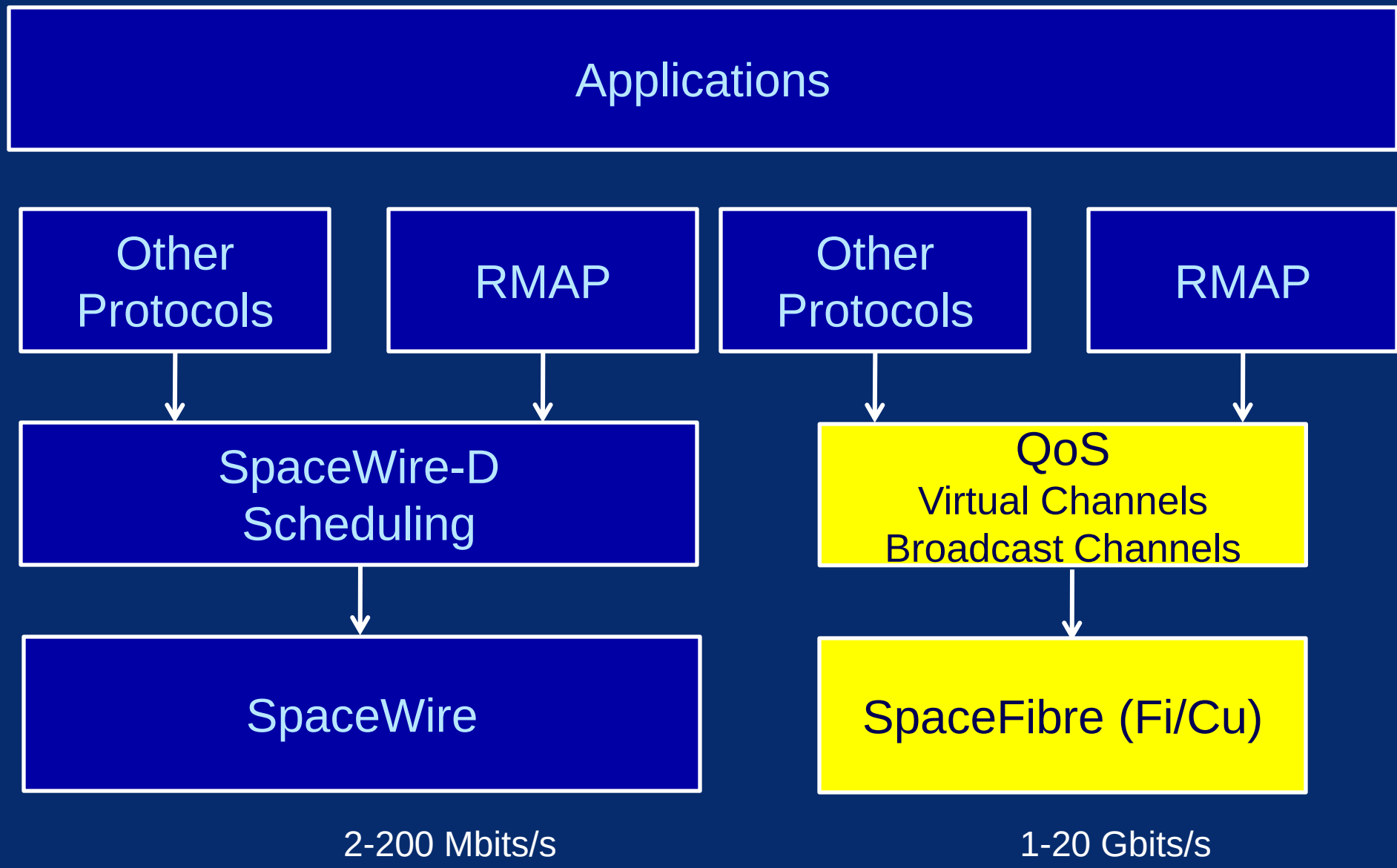
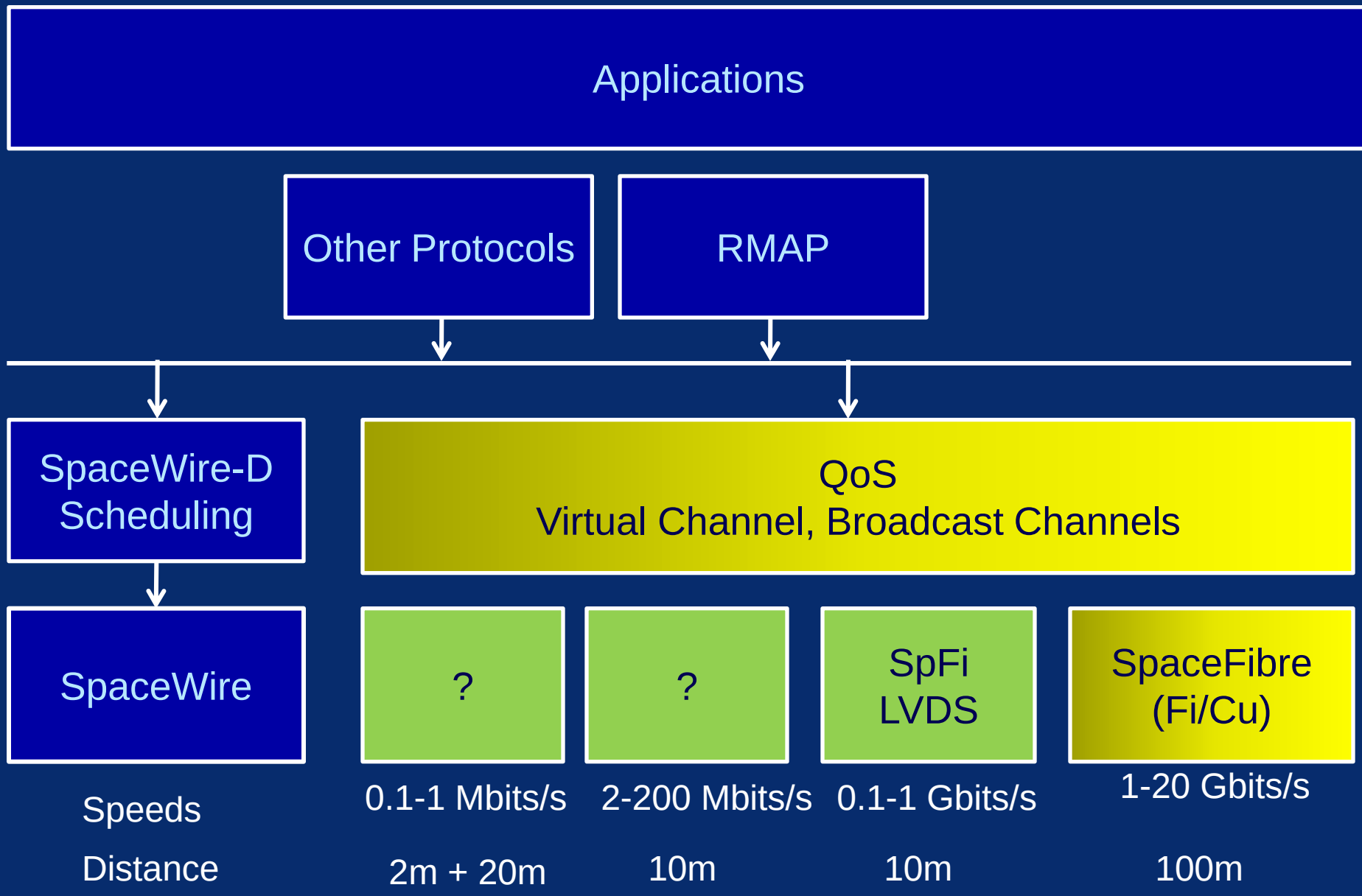
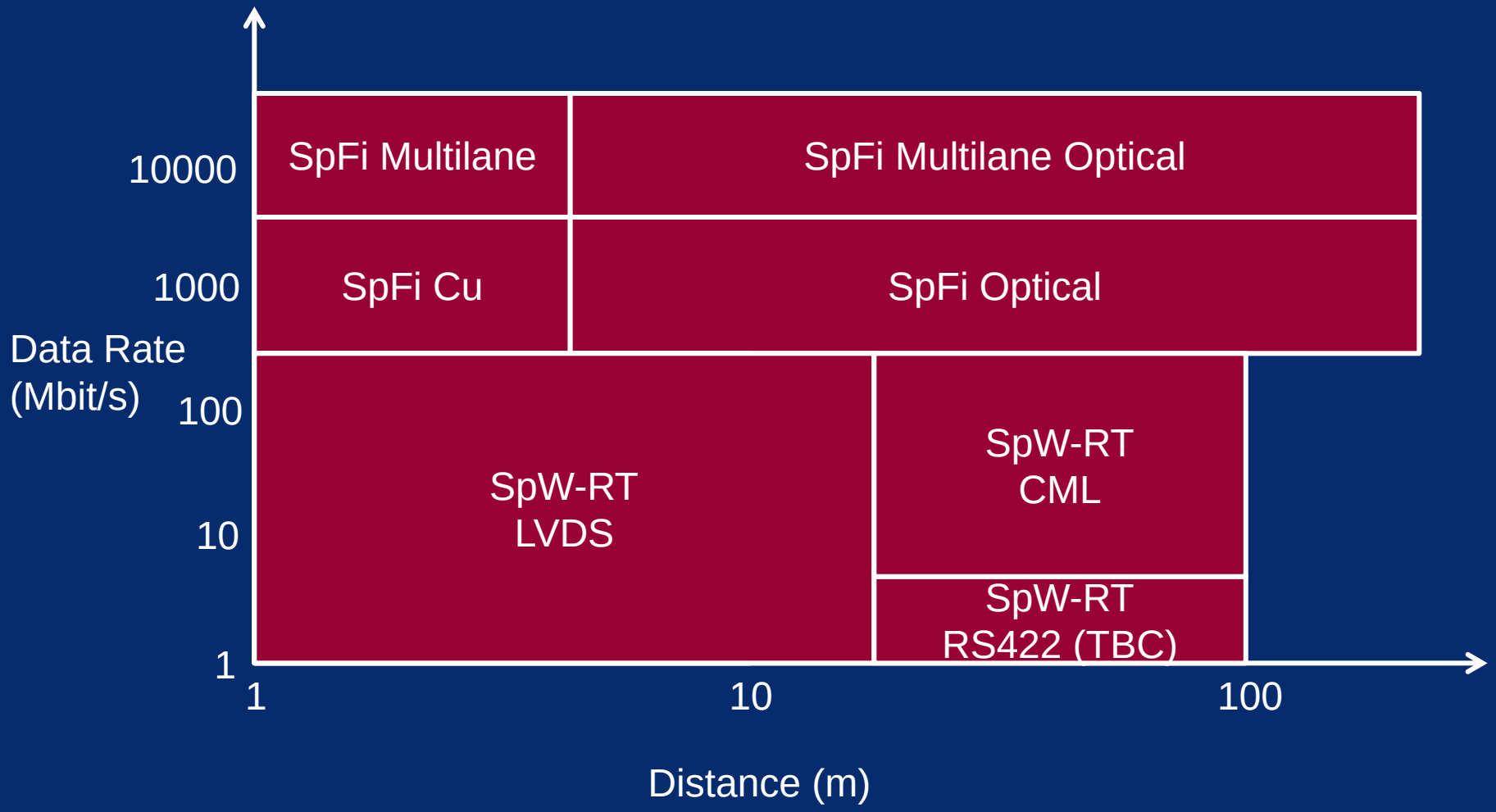
SpaceFibre as basis for SpaceWire-RT



SpaceWire-RT Protocols



Speed vs Distance



Baseline Concept

- Based on SpaceFibre protocols
  - SpaceFibre provides high-speed version
  - SpaceWire-RT provides slower speed
- SpaceWire-RT
  - Minimise number of wires (i.e. cable mass)
  - Avoid use of PLLs
  - Provide galvanic isolation
  - QoS and FDIR from SpaceFibre
  - Simple connection to existing SpaceWire devices
  - Compatible at SpaceWire packet level

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Table 1: SpaceWire-RT protocols compared to SpaceWire				
	SpaceWire-RT **SpaceFibre-CML**			**SpaceWire**
Max Data Rate	0.1-5 Gbps x N			200 Mbps (400 Mbps)
Media	Fibre/Copper, 4 wires 100m/5m			Copper, 8 wires
Line Drivers	CML			LVDS
Galvanic Isolation	Yes			No
Encoding	8B/10B			D/S
Backwards Compatible	Packet and Network			-
QoS Priority	Yes			No
QoS Bandwidth Resv.	Yes			No
QoS Scheduled	Yes			No
FDIR (Retry)	Yes			No
Virtual channels	256			No
Broadcast Channels	256			Time-codes

Table 1: SpaceWire-RT protocols compared to SpaceWire

	SpaceWire-RT SpaceFibre-CML	SpaceWire-RT SpaceFibre-LVDS		SpaceWire
Max Data Rate	0.1-5 Gbps x N	0.1 to1 Gbps x N		200 Mbps (400 Mbps)
Media	Fibre/Copper, 4 wires 100m/5m	Fibre/Copper, 4 wires 100m/5m		Copper, 8 wires
Line Drivers	CML	LVDS		LVDS
Galvanic Isolation	Yes	Yes		No
Encoding	8B/10B	8B/10B		D/S
Backwards Compatible	Packet and Network	Packet and Network		-
QoS Priority	Yes	Yes		No
QoS Bandwidth Resv.	Yes	Yes		No
QoS Scheduled	Yes	Yes		No
FDIR (Retry)	Yes	Yes		No
Virtual channels	256	256		No
Broadcast Channels	256	256		Time-codes

Table 1: SpaceWire-RT protocols compared to SpaceWire				
	SpaceWire-RT SpaceFibre-CML	**SpaceWire-RT SpaceFibre-LVDS**	**SpaceWire-RT**	**SpaceWire**
Max Data Rate	0.1-5 Gbps x N	0.1 to1 Gbps x N	1 to 100 Mbps x N	200 Mbps (400 Mbps)
Media	Fibre/Copper, 4 wires 100m/5m	Fibre/Copper, 4 wires 100m/5m	Copper, 8 or 4 wires 100m	Copper, 8 wires
Line Drivers	CML	LVDS	LVDS, CML, RS422 ?	LVDS
Galvanic Isolation	Yes	Yes	Yes	No
Encoding	8B/10B	8B/10B	8B/12B + D/S 8B/10B Oversampling	D/S
Backwards Compatible	Packet and Network	Packet and Network	Packet and Network	-
QoS Priority	Yes	Yes	Yes	No
QoS Bandwidth Resv.	Yes	Yes	Yes	No
QoS Scheduled	Yes	Yes	Yes	No
FDIR (Retry)	Yes	Yes	Yes	No
Virtual channels	256	256	256	No
Broadcast Channels	256	256	256	Time-codes

Evaluation Criteria

- Able to support all or most spacecraft onboard communication requirements:
  - Instrument interfacing
  - Device and sub-system networking
  - Inter-processor communications
  - Gathering housekeeping information
  - Deterministic command and control
  - Time distribution
  - Sub-system synchronisation
  - Event signalling
  - Device enumeration

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Evaluation Criteria

- Coherent set of protocols covering:
  - Full range of operational speeds
    - 1 Mbit/s to 20 Gbit/s
  - Full range of operational distances
    - 0.1 m to 100 m
  - Using a range of physical media and signals

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Evaluation Criteria

- FDIR
  - Fault detection
    - Ability to detect faults occurring in the network
  - Fault isolation
    - Prevention of fault propagation
    - Prevention of faults affecting other data flows
  - Fault recovery from transient faults
    - Transient faults that don't cause re-initialisation of link
    - Persistent faults that cause and are recovered by re-initialisation of link
    - Permanent faults that cannot be recovered by link re-initialisation

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Evaluation Criteria

- Compatible with SpaceWire at the packet level
  - How important is this?
- Arbitrary topology

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Evaluation Criteria

- Suitable for space applications
  - Radiation tolerant components
  - Managed complexity
    - Which is a complex way of saying “simple”
  - Low mass
  - Low power consumption
  - Rugged

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Principal Benefits of SpaceWire-RT

- Spacecraft onboard network technology with the key features
  - Responsiveness
  - Robustness
  - Determinism
  - Durability
- Allowing advanced avionics systems and integrated data-handling/avionics systems to be implemented readily.

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