



# SpaceWire-RT

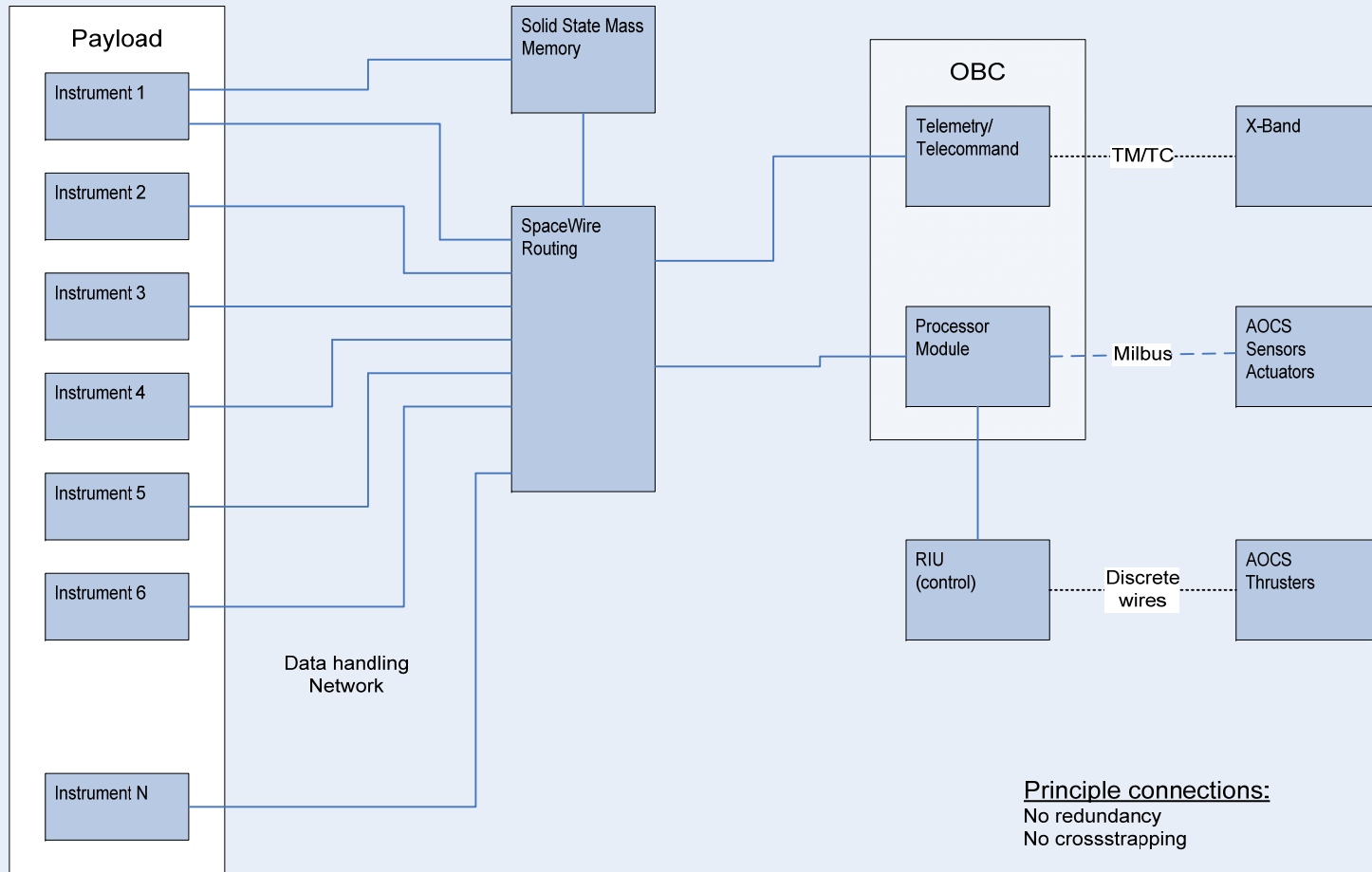
RF and EU combined initial Requirements

- University of Dundee
- Saint Petersburg State University of Aerospace Instrumentation
- SUBMICRON
- ASTRIUM
- ELVEES



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

## Scientific Satellite network structure



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*SpW-RT shall support the following types of network functionalities*

- **Data-handling network** for connecting instruments to mass-memory units, data compressors, signal processor, etc.
- **Control bus** for commands from control modules to devices and equipment of spacecraft.
- **Telemetry bus** for collecting housekeeping information (status, temperature, etc.) from devices on the spacecraft.
- **Computer bus** for data exchange between computer modules in the course of data and signal processing.
- **Time-synchronisation bus** for space-borne clock synchronisation.
- **Side-band signal lines** for signalling and control in hard real



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# Communication requirements

	Distance	Rate	Latency	Data size	QoS
Data-handling network	Short to long	Low to 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 Requirements

Requirements are sorted in following categories

- Data Rate
- Distance
- Galvanic Isolation
- Transmission medium
- Packet size
- Maximum latency
- Quality of Service
- Mass interconnect
- Power consumption



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## Data Rate

### ***REQ-10 Data Rate (data handling)***

SpW-RT shall be capable of a range of data rates up to 20 Gbits/s.

Rational: this is necessary to support high data rate Earth observation missions like imagers or synthetic aperture radar.

### ***REQ-11 Data Rate (all others)***

SpW-RT shall be capable of data rates up to 400 Mbits/s.

Rational: this is necessary to get a low latency in routing elements. For the pure data throughput SpW-RT could also run on lower data rates.



## Distance over link

### ***REQ-20 Distance (control bus)***

SpW-RT shall operate over a distance of up to 100 m.

Rational: this is necessary to use SpW in launcher and piloted spacecraft applications where equipment may be arranged in a larger distance.

### ***REQ-21 Distance (all others)***

SpW-RT shall operate over a distance of 1 m to 10 m.

Rational: this is necessary to operate on high data rates which a small to moderate distance and the equipment is close together.



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# SpaceWire-RT Requirements

## Galvanic isolation

### ***REQ-30 Galvanic isolation (control bus)***

SpW-RT shall provide galvanic isolation.

Rational: this is necessary to support long distance applications like launchers or test equipment. If galvanic isolation is implemented an appropriated coding mode has to be used resulting in a DC-balanced output.

### ***REQ-31 Galvanic isolation (all others)***

SpW-RT may provide galvanic isolation.

Rational: most of the other applications are located inside a unit or box where galvanic isolation is often not required.

In EU there is only a need for galvanic isolation in long distance applications but in Russian Federation (RF) galvanic isolation is a most common requirement.



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## *Transmission medium*

### ***REQ-40 Transmission medium (data handling, control bus, computer bus)***

SpW-RT shall operate on twisted pair, co-ax or fibre.

Rational: this is necessary to run over existing network infrastructure also.

### ***REQ-41 Transmission medium (telemetry bus)***

SpW-RT shall operate on twisted pair.

Rational: twisted pair is sufficient for lower data rates and has lowest cost.



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# SpaceWire-RT Requirements

## *Packet size*

### ***REQ-50 packet size (data handling, computer bus)***

SpW-RT shall support application packet sizes up to at least 32 Mbytes.

Rational: Application packets of up to 32 Mbyte are used for transferring raw data.

### ***REQ-51 packet size (control bus, telemetry)***

SpW-RT shall support packet sizes in the range from 8 bytes to 64 Kbytes.

Rational: The minimum packet size is used for control commands; e.g. an RMAP write reply packet has 8 bytes. Packet sizes between 1 Kbyte and 64 Kbytes are used in memory load/dump commands.



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# SpaceWire-RT Requirements

***Maximum latency (time from sending a character to receiving this character)***

## ***REQ-60 Maximum latency (control bus)***

SpW-RT shall support a maximum latency of less than 100 us.

Rational: low latency is necessary for transferring command packets through the network in real time applications.

## ***REQ-61 synchronization accuracy (time synchronization bus)***

SpW-RT shall support a synchronization accuracy of up to 100 ns.

Rational: this is necessary to implement accurate time distribution system.



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# SpaceWire-RT Requirements

## *Maximum latency*

### ***REQ-62 Maximum latency (computer bus)***

SpW-RT should support a maximum latency of less than 100 ns over a single link.

Rational: low latency is necessary for communication between processor modules.



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# SpaceWire-RT Requirements

## *Quality of Service*

### *Reliability*

#### *REQ-70 reliability*

SpW-RT shall provide a capability for reliable data delivery.

Rational: some data is critical must be delivered without corruption.

### *Determinism*

#### *REQ-80 determinism*

SpW-RT shall provide determinism.

Rational: this is necessary to control non-intelligent actuators and to receive data from non-intelligent sensors. Determinism allows instruments to send regular data without internal buffering.



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# SpaceWire-RT Requirements

## *Quality of Service*

### *Validity*

#### *REQ-90 validity*

SpW-RT should support a bit error rate of less than  $10 \times 10^{-15}$ .

Rational: this is necessary to reduce the effort for re-ordering on the receiving side. This is seen very important for control buses and important for computer buses.

### *Automatic acknowledgement*

#### *REQ-100 automatic acknowledgement (control bus)*

SpW-RT should support configurable automatic acknowledgement.

Rational: this is necessary to control non-intelligent actuators and non-intelligent sensors.



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## ***Automatic fault detection and identification***

### ***REQ-110 Automatic fault detection***

SpW-RT shall support automatic fault detection.

Rational: a fault should be detected as early as possible to avoid failure propagation.

This applies to any type of failure: transitory (occur occasionally), persistent (occur often) and permanent (occur always).

### ***REQ-120 Automatic fault identification***

SpW-RT may support automatic fault identification.

Rational: fault identification can be left to application. Sometimes it can be difficult to decide in hardware the nature of fault.





## ***Failure and fault tolerance of network***

### ***REQ-130 failure and fault tolerance of network (data handling network)***

SpW-RT network should be able to automatically recover from faults.

Rational: automatically recovery from faults can be handled in most applications by software. In specific applications where short reaction time is an issue, automatically recovery may be implemented on network level.



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# SpaceWire-RT Requirements

## ***Multi-path transmission***

### ***REQ-140 multi-path transmission (control bus)***

SpW-RT shall support multi-path transmission.

Rational: this is necessary for time critical commands, e.g. booster separation command.

## ***Broadcast data transfer***

### ***REQ-150 broadcast data transfer (time synchronisation bus)***

SpW-RT shall support broadcast data transfer.

Rational: this is necessary to distribute the time data and the time ticks.



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## ***Multi-cast data transfer***

### ***REQ-160 multi-cast data transfer (computer bus)***

SpW-RT shall support broadcast data transfer.

Rational: this is necessary to deliver the same data to the devices in the redundant system.



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# SpaceWire-RT Requirements

## *Out-of-band signals and information*

### *REQ-170 out-of-band signals*

SpW-RT shall transfer time-ticks and interrupts with very short latency.

Rational: this is necessary to replace single wires used for distributing the time ticks and interrupts.

## **Mass interconnect**

### *REQ-180 mass interconnect*

Mass interconnect shall be less than 30 g/m (for one lane).

Rational: this is necessary to reduce the mass of the harness which could be a significant part of the total mass.



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## *Power consumption*

### *REQ-190 power consumption*

The power consumption of a lane (two interfaces) should be in the range of 50 to 200 mW.

Rational: The power consumption has to be as low as possible because it sums up with the number of link interfaces.



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- Network size (i.e. maximum number of nodes)
- Multi-master capability (initiation of transfers by multiple users)
- transaction security
- testable network



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