SpaceWire-RT Publishable Summary for 1st Reporting Period

The trend towards "Operationally Responsive Space", where spacecraft can be rapidly assembled, configured and deployed, to meet specific mission needs, e.g. disaster support, requires flexible on board communication networks with plug-and-play capability. The growing autonomy of scientific missions to remote planets requires networks that are robust and durable, able to recover from transitory errors and faults automatically. The importance of spacecraft mass reduction motivates the sharing of networks for payload data-handling and avionics. Avionics and robotics impose requirements on network responsiveness and determinism. Increasing international collaboration on scientific and Earth observation spacecraft requires standard network technology where a component developed by one nation will interoperate effectively with equipment developed by another. **SpaceWire-RT**, a project funded under the EU's Seventh Framework Program (FP7), aims to fulfil these demanding requirements with a flexible, robust, responsive, deterministic and durable standard network technology that is able to support both avionics and payload data-handling applications.

SpaceWire is a very successful first step in this direction, providing networking technology for payload data-handling on over 30 major space missions. It falls short, however, of the requirements for avionics systems.

SpaceFibre is a very high-speed serial data-link currently being developed by the European Space Agency (ESA) which is intended for use in data-handling networks for high data-rate payloads. SpaceFibre is able to operate over fibre optic and copper cable and support data rates of 2 Gbit/s in the near future and up to 6 Gbit/s long-term. It aims to complement the capabilities of the widely used SpaceWire onboard networking standard: improving the data rate by a factor of 10, reducing the cable mass by a factor of four and providing galvanic isolation. SpaceFibre aims to support Quality of Service (QoS) along with fault detection, isolation and recovery (FDIR). An important feature of SpaceFibre is that it transfers SpaceWire packets, so that several SpaceWire links can be easily multiplexed over a single SpaceWire link, and so application software designed for SpaceWire can operate over SpaceFibre.

A QoS layer is needed for SpaceWire and SpaceFibre to support mixed avionics and data-handling applications. SpaceWire-RT will: use virtual channels to provide a variety of QoS; provide broadcast and multicast capability; support extremely low latency time and out-of band signalling; and incorporate novel fault detection, isolation and recovery methods. The network will be fully responsible for information transfer, decoupling application and data transfer.

The creation of this technology will substantially strengthen collaborative bonds between the Russian and European organisations involved in the research, and lead to technology of vital importance for future space missions.

The principle aims of SpaceWire-RT are:

- 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

- Provide a 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

Activities during the first 10 months of the project focussed on defining the requirements and use cases for SpaceWire-RT, designing the baseline concept and providing inputs on Quality of Service approaches to the SpaceFibre standard being developed by University of Dundee for ESA.

Astrium GmbH and Submicron gathered requirements from spacecraft manufacturers and spacecraft equipment suppliers across Europe and Russia respectively. These requirements covered many aspects of payload data-handling and avionics networks.

An important aspect of this work on requirements was the need for a range of QoS depending on the particular application. These include the capability to reserve network bandwidth to prevent different data flows interfering with one another, deterministic data delivery for control applications, and high priority, very low-latency communication for time-synchronisation and side-band signalling.

The requirements were analysed by University of Dundee and compared against the characteristics of the planned SpaceFibre standard. It was clear that SpaceFibre would meet the majority of the requirements for SpaceWire-RT and so was adopted as the baseline network technology for very high data-rate applications. The outcome of this analysis was used to inform the work on QoS within SpaceFibre and resulted in a coherent precedence concept being proposed for QoS in SpaceFibre.

Based on these requirements a conceptual design has been produced for a range of spacecraft network protocols that integrate important QoS and FDIR capabilities and that cover a wide range of spacecraft applications.
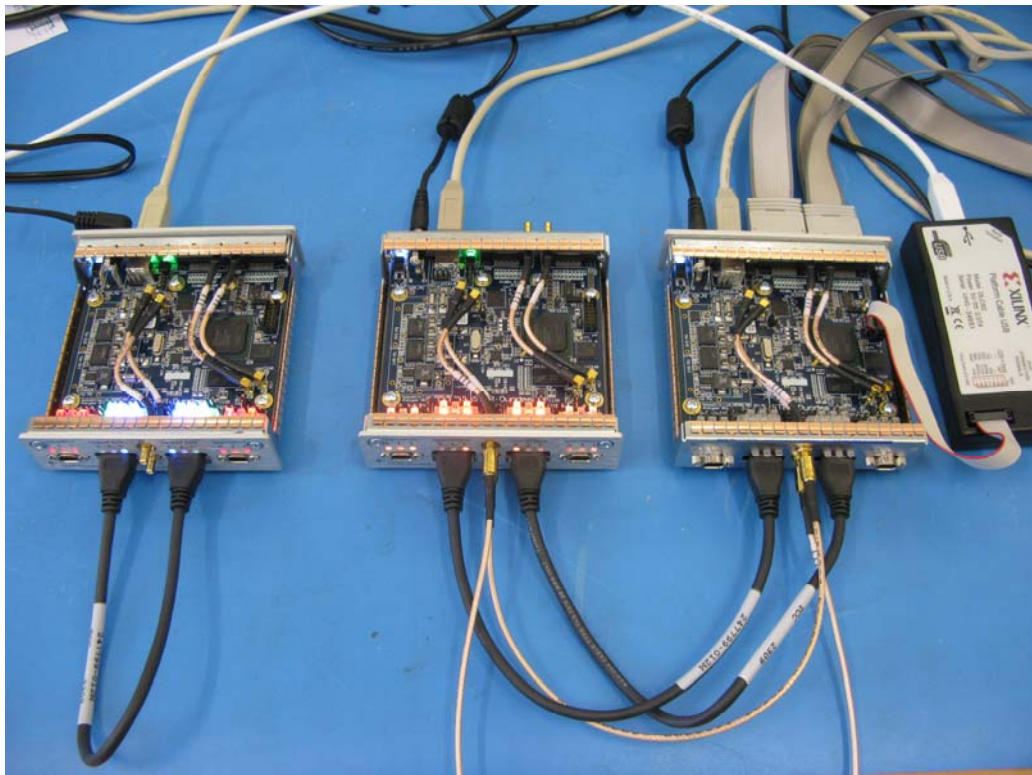
Prototype SpaceWire-RT Equipment

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SpaceWire is a European technology used by the world's space agencies and space industry on many spacecraft. The SpaceWire-RT project aims to take this technology to the next level, by providing an enhanced SpaceWire network technology that provides quality of service capabilities suitable for spacecraft data-handling and control applications, enabling it to support rapid spacecraft assembly and also making it applicable to other applications.

The creation of this technology will substantially strengthen collaborative bonds between the Russian and European organisations involved in the research, and lead to technology of vital importance for future space missions.

Project WEB Site: http://spacewire-rt.org/

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Project Partners:

Organisation	Short Name	Country
University of Dundee (Coordinator)	UNIVDUN	United Kingdom
Saint Petersburg State University of Aerospace Instrumentation*SUAI	SUAI	Russian Federation
Scientific Research Institute SUBMICRON Open Joint Stock Company	SUBMICRON	Russian Federation
Astrium GmbH	ASTRIUM ST	Germany
Electronic VLSI Engineering & Embedded Systems	ELVEES	Russian Federation