# SPACEWIRE NETWORKS FOR PAYLOAD APPLICATIONS

**Session: SpaceWire networks and protocols**

**Short Paper**

Christophe Honvault, Olivier Notebaert

*Astrium Satellites SAS, 31 rue des cosmonautes 31402 Toulouse cedex 4*

*E-mail: christophe.honvault@astrium.eads.net, olivier.notebaert@astrium.eads.net*

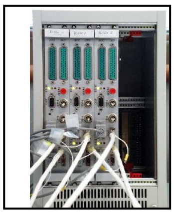
## ABSTRACT

SpaceWire aims at becoming a candidate data-handling network for use onboard spacecraft, which could bring modularity and scalability to future onboard data processing systems. The use of routers brings several advantages as flexibility and scalability while the number and length of links can be decreased. However, the routers introduce constraints and limits in term of overall data throughput and latency. The increase of the link speed can push back the limits but do not solve the issue. Several other ways for improvement need to be explored: new router arbitration schemes, new multiplexer devices, implementation of dedicated communication protocols, the development of a methodology and associated tools for network analysis are possible ways for improving the scope of possible future usage of SpaceWire networks onboard spacecrafts.

## 1 SPACEWIRE EXPERIENCE

Astrium gain a strong experience on SpaceWire by leading several R&D studies and by contributing to the development of the main relevant building blocks for future space systems.

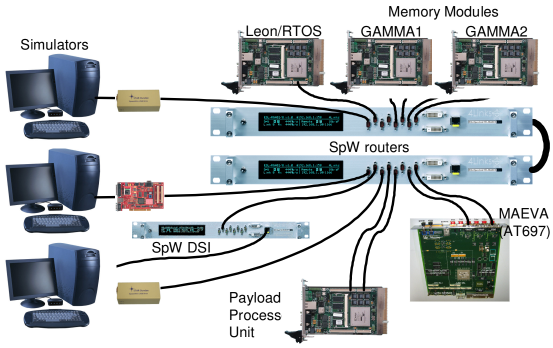
A SpaceWire codec IP core [1] has been developed and connected to Leon2 and Leon3 IP cores. It has been used in many studies making possible the identification of improvements. These improvements are presently under development and the new version of the IP core will be integrated in the SCOC3 system.



A3M [2] used point-to-point communication between three Leon based computers to implement and validate a safe and reliable distribution system. As an additional result, A3M has shown that SpaceWire disconnection detection can be used to implement fast failure detectors.

GAMMA [3] used a SpaceWire network including an eight ports router to implement and validate a distributed mass memory architecture in which several multi-threaded Leon based users can simultaneously access one or several mass memory modules.

PADAPAR [4] is an Astrium Satellites internal study that aims to define a generic architecture for future payloads that can match mid-term needs while optimizing the development process through standard building blocks definition. The main building blocks are implemented and interconnected by means of a SpaceWire network.




These studies and developments have made possible a fine characterization of the SpaceWire and make possible the confirmation of SpaceWire advantages and drawbacks.

## 2 IDENTIFICATION ADVANTAGES AND DRAWBACKS

The advantages and drawbacks of the SpaceWire can be easily identified in the ECSS standard [5] and are clearly confirmed by test. The advantages that are, among others, a great simplicity, the ease to use, a high data rate and a low consumption are not detailed in this short paper that prefers to focus on drawbacks in order to request or propose ways for improvement.

From mechanical point of view, with a maximum of 80 grams per meter, the SpaceWire links can be considered as heavy. This is weight can become an important problem when the SpaceWire is used in a point-to-point configuration. The use of routers can help to reduce the number and the length of the links. However, the routers themselves should be redounded.

The use of routers brings other numerous advantages as a great flexibility and scalability to the SpaceWire networks. However, the routers introduce constraints and limits in term of overall data throughput and latency. The overall data throughput of the system is reduced as soon as one of a device is not working at the maximum speed. A latency is introduced by each crossed router. The value of this latency mainly depends on the number and the size of all the messages that are transferred to a same output port. The phenomenon is amplified by the wormhole routing when several routers are crossed. If the worst case of data throughput and latencies can be easily determined, it can also be very restrictive at the time of the definition of a system. The increase of the link speed, the restriction of the size of messages exchanged and the use of the group adaptive routing can push back the limits but do not solve the issue.

Of course, these problems are not specific to SpaceWire and exist in other packet switched networks as Ethernet and explain, at least partly, why Ethernet is not used in real-time space systems.

# 3 POSSIBLE WAYS FOR IMPROVEMENT

## 3.1 DEVICES

The implementation of the arbitration policy in SpaceWire routers is generally limited to round-robin. The implementation of new arbitration policies (e.g. priority based), should make possible to extend the use of the SpaceWire networks to command and control. The implementation of configurable traffic controller in routers is another that could be considered.

The SpaceWire standard defines the broadcast and multicast distributions. However, no existing SpaceWire device presently implements one of these distribution mechanisms. When managed at the lowest level, these two distribution modes can be very useful to implement safe and distributed systems.

Multiplexer and high data rate devices should make possible the decrease of the overall latency while optimizing the data throughput by the supporting the concentration of the data traffic generated by the slowest units in the system. In addition, the number of links required to establish the connections would decrease.

## 3.2 PROTOCOLS AND STANDARD

New protocols are required to ensure the time constraints of applications. This approach has been followed with success on the Ethernet standard and is at the origin of AFDX [6] used on civil and military aircrafts as the Airbus A380 and A400M. Several time-triggered protocols could be envisaged as TTP [7], FlexRay [8] and even isochronous or asynchronous protocols as the one studied within the A3M activities.

The definition of new protocols that match the specific constraints of the space application must de defined. These protocols must comply with the low-level layers of the space communication networks as SpaceWire and take into account the needs of space applications. Of course, these protocols must also be compliant with the CCSDS SOIS standards.

## 3.3 TOOLS

The support tools must ease the definition, analysis and validation of system based on SpaceWire networks by taking into account the characteristics of all its components. Such tools exist for other standard networks (e.g. OpNet) and could be configured to SpaceWire. The possibility to mix simulation and connection of real hardware will be an asset.

# 4 CONCLUSION

The SpaceWire standard must remain as simple and efficient as possible. It must serve as the basis for the development of new devices, high-level protocols and support tools. The new devices and protocols should ensure the time constraints of critical applications and minimize the latency of the messages they exchange. The support tools must ease the definition and validation of system based on SpaceWire networks by taking into account the characteristics of all its components.

## 5 REFERENCES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