

# International SpaceWire Conference

## SpaceWire: A key technology for Modular Data Systems

### A long haul strategy

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**on behalf of M. Courtois, Head of the Technical and Quality Management Directorate**  
**European Space Agency**

## Overall goals

The Avionics sub-system corresponds to about 60% on the overall development costs for a satellite.

Therefore, ESA is paying special attention to means allowing to decrease these costs by:

- Defining generic architectures, e.g. common to a series of missions, for instance Earth Observation, Science and Exploration missions
- Standardising interfaces, developing communication services and protocols
- Fostering re-use of building blocks
- Developing tools and methodologies for composing a system from already validated building blocks.

## Reference Architectures: Concepts

Reference architectures are being defined in cooperation with Industrial primes and equipment suppliers, in order to:

- ✓ Identify generic functions (such as computing, storage, TM/TC ,I/O units and/or modules)
  - ✓ Specify building blocks and their corresponding interfaces (via ECSS and CCSDS standardisation bodies)
  - ✓ Develop components in a coherent manner
- 
- Building blocks and components can be validated in a domain encompassed by the reference architecture
  - Reference architectures are then mapped onto specific missions needs to instantiate a data systems with the required services (e.g. FDIR, PUS, CFDP, etc)

*This is being done presently while addressing highly reliable and available data systems, being integrated around one main computer or decentralised.*

## Reference Architectures: Modular Data Systems

Already in the 90s, it appeared clearly that a generic interface would be very useful on-board spacecraft, in order to ease the interconnection of:

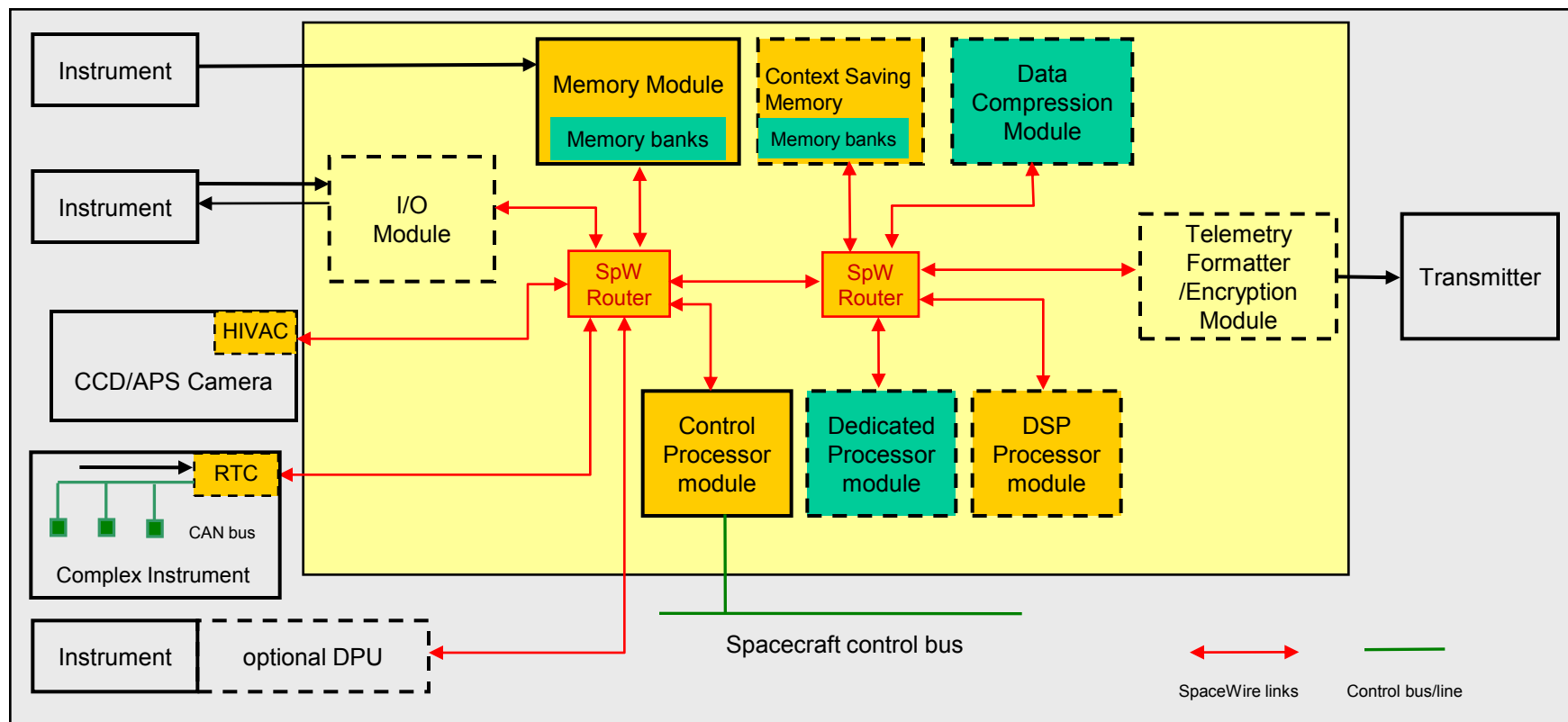
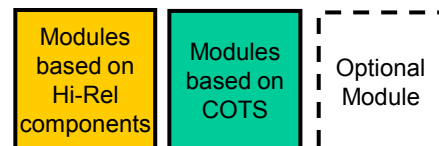
- Sensors
- Mass-memories
- Processing units, and
- Downlink telemetry sub-systems.

**High speed Serial links** in contrast to parallel interfaces have been selected due to their potential of constituting an homogeneous solution to interconnect components, board and units.

They allowed as well to define a reference architecture with native modularity and scalability.

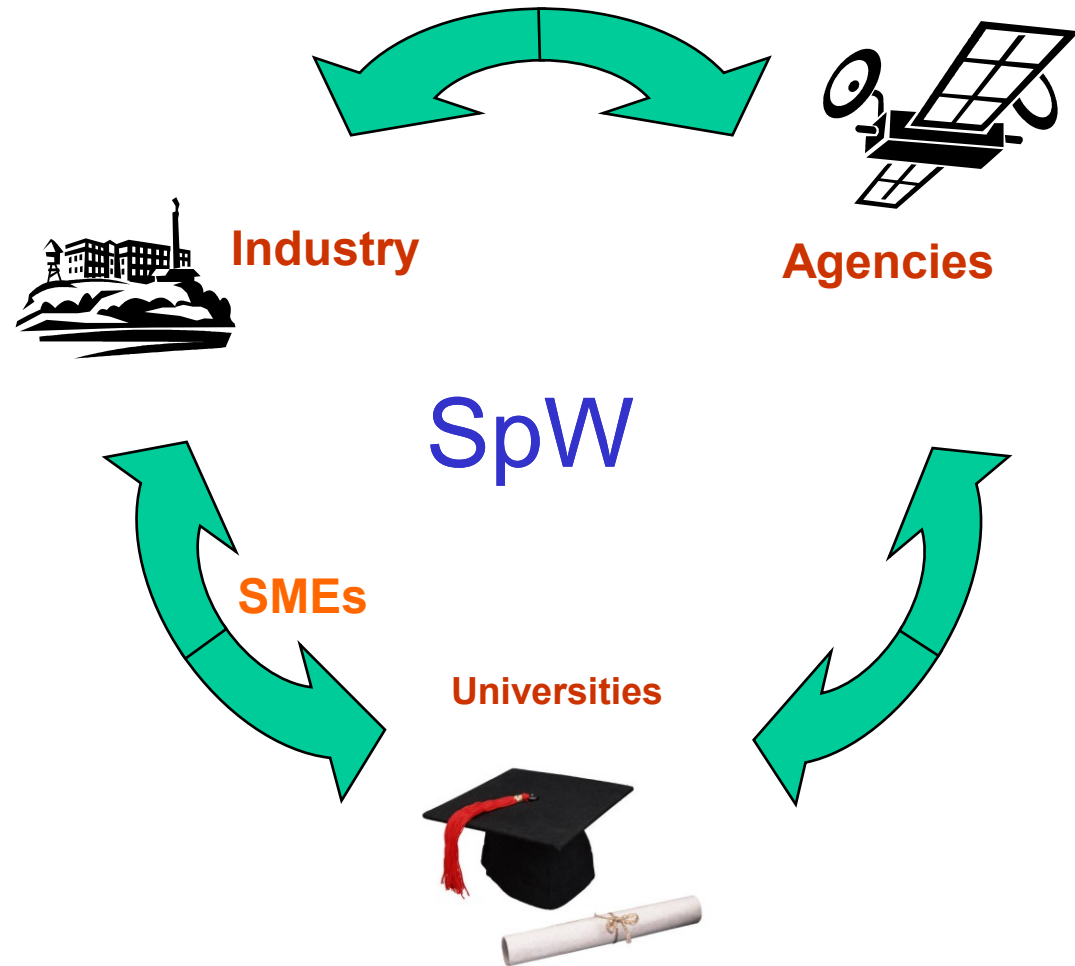
# Reference Architectures: Modular Data Handling System

Architecture used by ESA as a reference for medium-range Data Handling Systems and the definition SpaceWire devices (SpW Router, SpW RTC, SMCS-SpW, ...)



## Development paradigm:

- *Well defined objectives and clear requirements in full accordance to effective needs*
- *Technology with a growth potential (e.g. speed)*
- *A close cooperation between Industrial, Academic and Institutional sectors, across space agencies*
- *Commercialization of components and development tools, involving SMEs*



## Serial links, technology selection

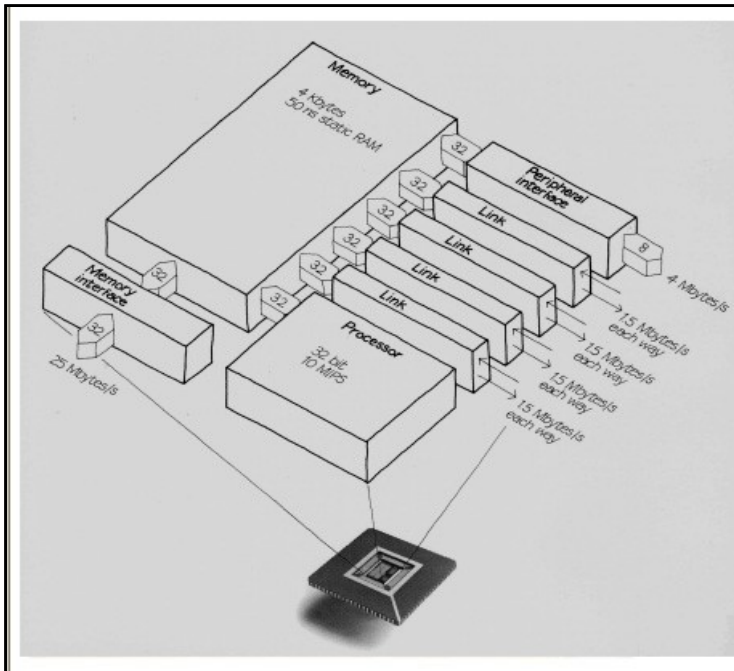
- Dual use was a pre-requisite with the elaboration of a space worthy solution based on a commercial technology. Deviations from the commercial standard was deemed acceptable only with a strong justification (e.g. connectors, cables, higher level protocols, ....).
- Formal standardisation via ECSS was envisaged in an early stage in order to provide Space Users with a directly usable specification.

***... Learn about the future***

***by looking at the past ...***

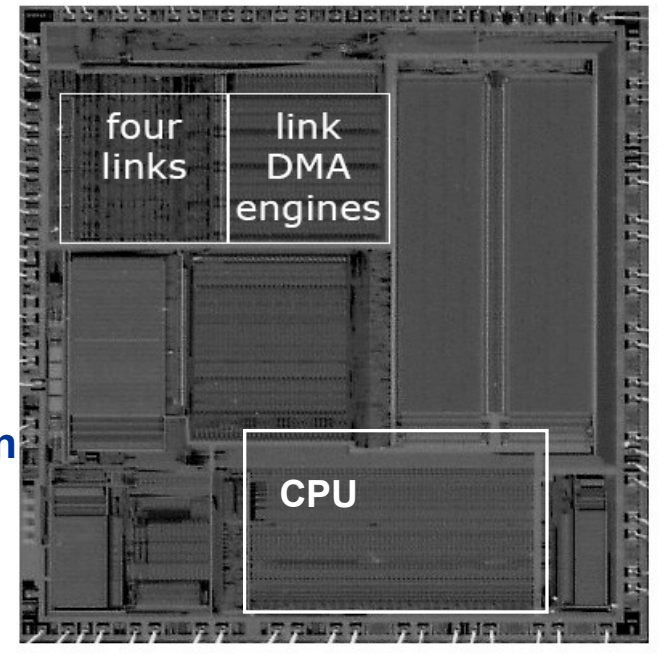
*Tamil Proverb, India*

# Transputers T800:



## T800

- 16-bit CPU
- Local memory
- 4 communication links



*Transputers were designed in the eighties for parallel processing support at HW and SW level*



# Transputers T9000: a 32-bit CPU, Local memory and 4 DS Links

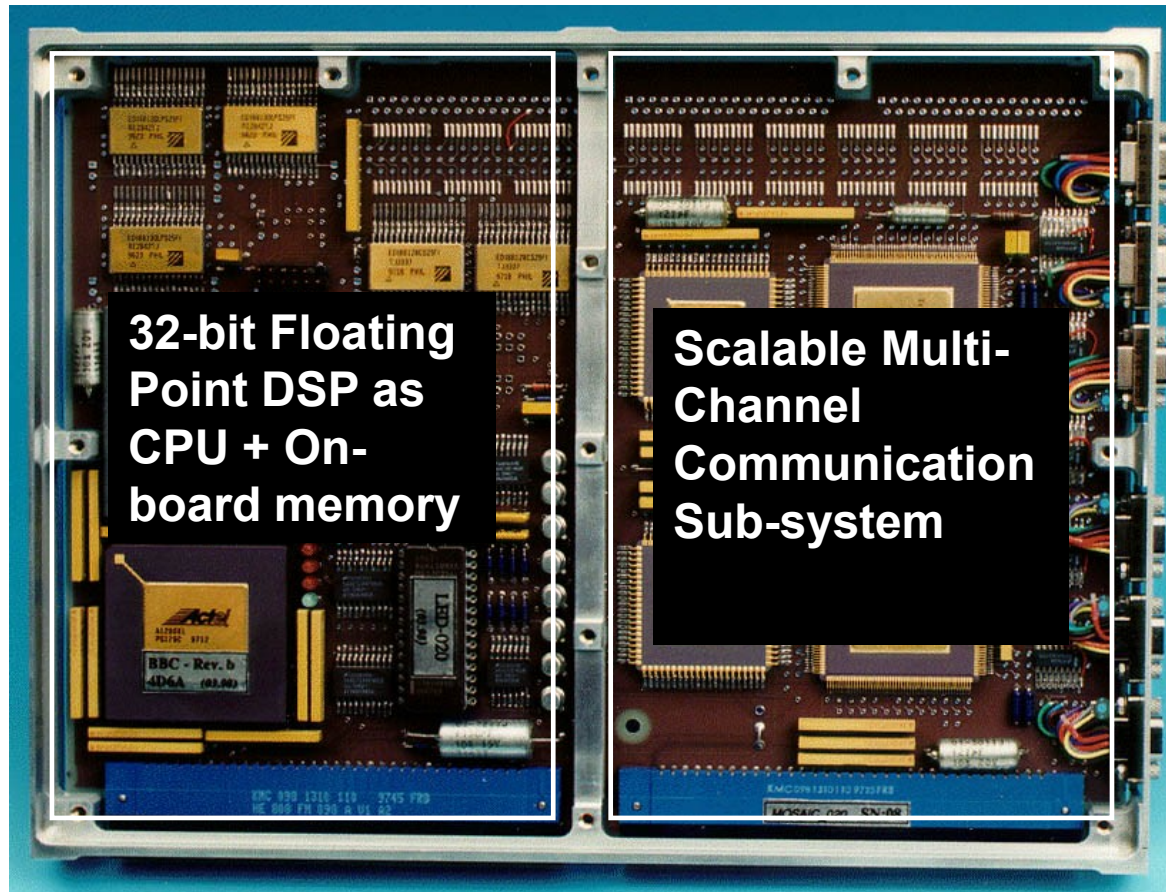
## T9000 Data/Strobe (DS) Link:

- Serial, Asynchronous, Symmetrical
- Flow-Controlled, Point-to-point
- Data/Strobe, 100Mb/s+
- Packet protocol, Routing switches
- Modular & Scalable

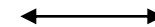
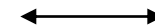
The T9000 packet-based link protocol formed the basis of the  
**IEEE 1355** serial interconnect standard

(IEEE Std 1355-1995 Standard for Heterogeneous InterConnect (HIC) Low Cost Low Latency Scalable Serial Interconnect aka ISO/IEC 14575 DIS)

## First Development – MOSAIC 020 Board



3 IEEE1355  
Links/LVDS



3 IEEE1355  
Links/LVDS



*Technologies used on several ESA missions, e.g. Rosetta, Herschel Planck, Cryosat, ...*

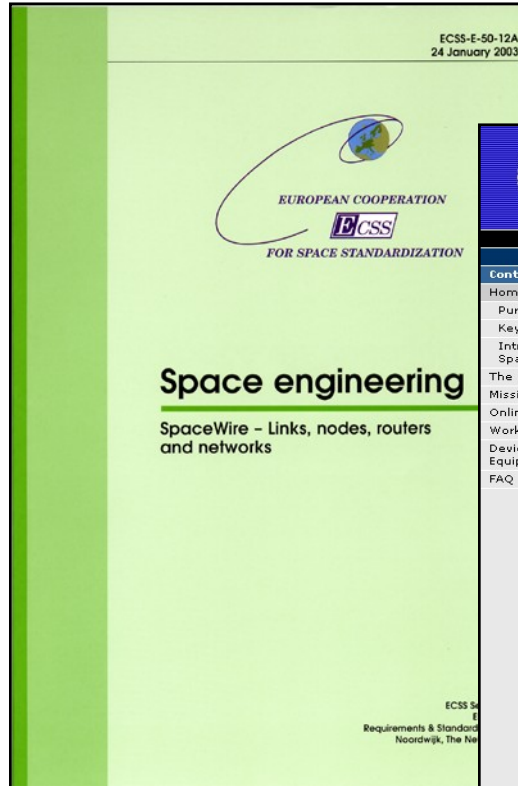
## ***Following steps:***

- ***Revisit IEEE1355, from physical to higher layers, customise it to space constraints and produce an ECSS standard***
- ***Extend the concept of serial links to Modular Systems based on On-board Networks ...***

## From IEEE1355 to ECSS-E50-12A (SpaceWire)

- The IEEE1355 standard has been defined for commercial, ground based applications.
- This standard has been revisited by space engineers, federated by the SpaceWire working group, in order to define a standard for space applications, covering: Links, nodes, routers and networks.
- This work has been done from the physical level (e.g. LVDS, connectors, initialization state machine) up to higher level protocols (e.g. SpW-SnP-RMAP). This is going on with the mapping of CCSDS-SOIS services and protocols on SpW networks.
- SpaceWire is an open standard. It is supported by major agencies such as NASA, ESA, JAXA, RSA and Industry.

# SpaceWire Standard (SpW), a standard for Space Applications



<http://www.ecss.nl>

esa SpaceWire European Space Agency  
<http://spacewire.esa.int>

**Contents**

- Home
- Purpose
- Key Features
- Introduction to SpaceWire
- The Standard
- Missions
- Online Journal
- Working Group
- Devices and Equipment
- FAQ

**Introduction**

SpaceWire is a standard for high-speed links and networks for use onboard spacecraft, easing the interconnection of:

- sensors
- mass-memories
- processing units, and
- downlink telemetry sub-systems.

SpaceWire is being widely used on many space missions by:

- ESA
- NASA
- JAXA

SpaceWire equipment is connected together using SpaceWire links which are:

- serial,
- high-speed (2 Mbits/sec to 200 Mbits/sec),
- bi-directional,
- full-duplex.

Application information is sent along a SpaceWire link in discrete packets. Control and time information can also be sent along SpaceWire links.

SpaceWire is defined in the European Cooperation for Space Standardization ECSS-E50-12A standard.

For further information on the purpose and key features of SpaceWire and for a brief technical introduction please click on the following links:

- Purpose
- Key Features
- Technical Introduction

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If you have any questions or comments regarding this website, please contact the webmaster.

<http://spacewire.esa.int>

esa SpaceWire European Space Agency

**SpaceWire Working Group – ESA – JAXA – NASA**

**Group Meeting, 18<sup>th</sup> and 19<sup>th</sup> of May 2006**

A group meeting has been held at Estec on Thursday the 18<sup>th</sup> and Friday the 19<sup>th</sup> of May 2006.

at [SpW-WG-Mtg6-Proceedings](#)

**Meetings and Workshops**

- 18<sup>th</sup> (PM), 16<sup>th</sup> and 17<sup>th</sup> of November 2005: [SpW-SnP-WG-Mtg5-Proceedings](#)
- 18<sup>th</sup> (PM), 20<sup>th</sup> and 21<sup>st</sup> (AM) of July 2005: [SpW-SnP-WG-Mtg4-Proceedings](#)
- 15<sup>th</sup>, 16<sup>th</sup>, 17<sup>th</sup> (AM) of February 2005: [SpW-SnP-WG-Mtg3-Proceedings](#)
- 10<sup>th</sup> PM, 11<sup>th</sup>, 12<sup>th</sup> (AM) of November 2004: [SpW-SnP-WG-Mtg2-Proceedings](#)
- 1<sup>st</sup> and 16<sup>th</sup> (AM) of September 2004: [Mtg1-SpW-SnP-WG-Mtg1-Proceedings](#)
- September 2003: [ISWS-proceedings](#)
- September 19&20, 2001: [QDPD-proceedings](#)

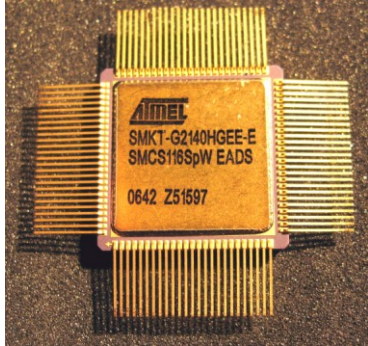
If you would have questions concerning On-board Payload Data Processing Systems, please contact:

<http://conferences.esa.int/01C25/>





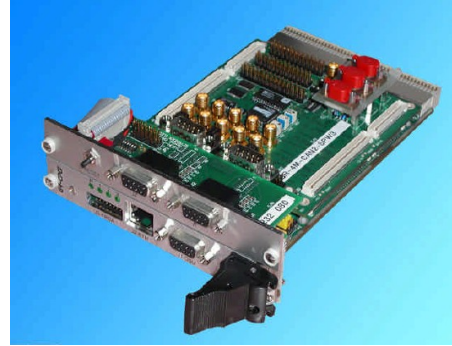
## ESA Products (non exhaustive)



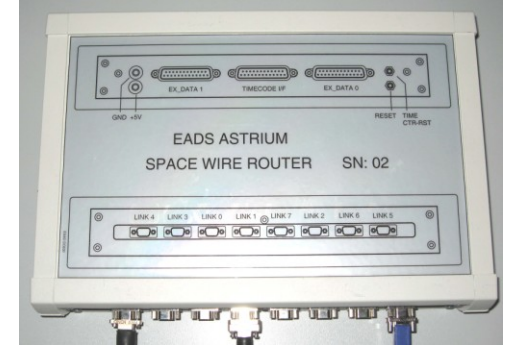
SMCS116-SpW



SMCS332-SpW



RTC SpW BB



FPGA/ASIC SpW Router

## Other commercial Products (non exhaustive)



PCI and cPCI SpW boards



SpW-USB



SpW Link Monitor



SpW cable



Diagnostic SpaceWire Interface

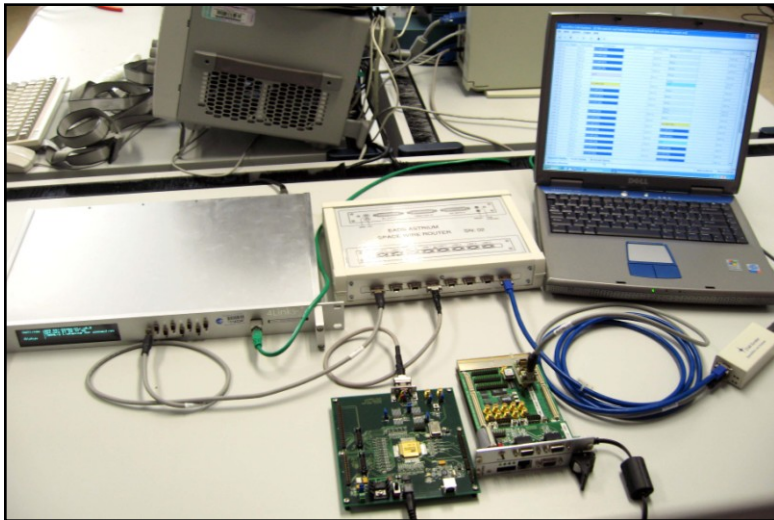


UT200SpW Transceiver

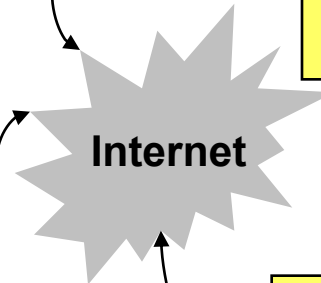
# Top Net: Virtual Satellite Integration : concept

Decentralized integration of SpW-based data handling sub-systems that are geographically separated using a SpaceWire Internet Tunnel device

Test bench in location 1



TopNet Tunnel



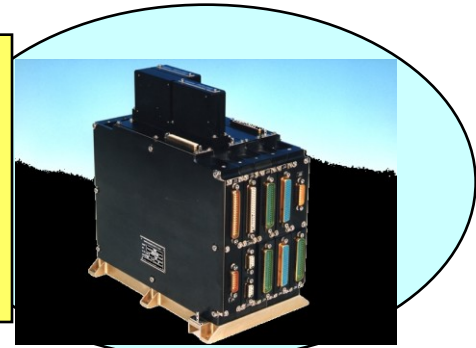
Internet

TopNet Tunnel



HR Camera EM in location 2

TopNet Tunnel



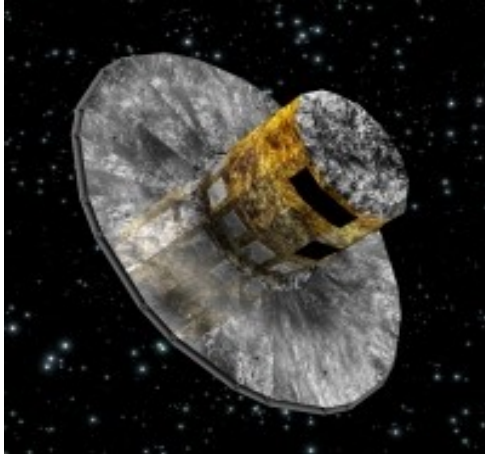
On-Board Computer EM in location 3

## Top Net: Virtual Satellite Integration: Status

- Technology elements developed and ready to be used
- Three pilot operations on-going, covering different scenarios:
  - Prime companies with multi-site premises
  - Smaller companies and interaction with Prime Investigator type of partner
  - Co-operative missions
- If the return of experience from pilot cases is positive, ESA will extend further the concept and introduce it in the end to end development process for Avionics for satellite/Avionics.



# ESA Missions using SpW Technologies



GAIA

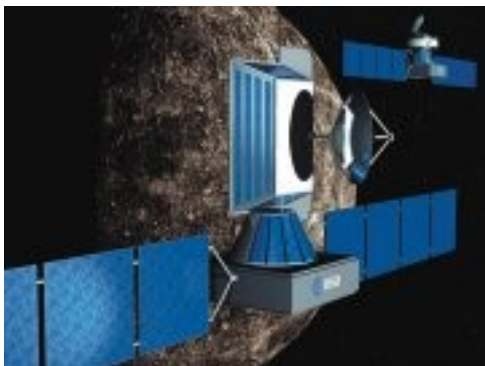


EarthCare



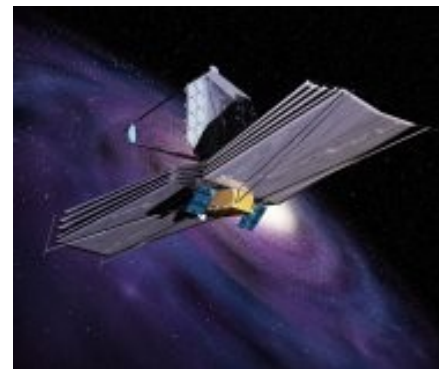
ExoMars

## Partnerships with other agencies



BepiColombo  
ESA/JAXA

17<sup>th</sup> of September 2007



James Webb  
Telescope  
ESA/NASA

Keynote Address

Slide : 17

# SpaceWire Evolutions and Perspectives

- Towards an evolution providing more and less: SpaceFibre
  - higher speed (>1Gbps), higher lengths (>> 10 meters)
  - lower mass per cable length (80 g/m to 8 g/m)
  - compatible with copper and optical fibre physical layers
- Towards better end to end integration via CCSDS SOIS protocols, up to application level
- Towards Plug and Play to support easy re-use of SpaceWire linked equipment – SpW Backplanes
- Towards generalised usage for Data and Control Systems

## SpaceWire: A successful long haul strategy

- The development model adopted by SpaceWire based on the cooperation of Agencies, Industries and Academia is certainly a key contributor to its success. Therefore, it could be applied to other domains.
- Efforts must be pursued in order to achieve a higher integration of heterogeneous networks through higher level protocols, support tools and products, covering the development process end to end.
- SpaceWire is an open standard that has been established with the contributions of many European and non-European partners.
- SpaceWire has to evolve according to return of experience of all of us - to be shared for instance in the frame of this first International conference on SpaceWire.

*With special acknowledgments to the  
University of Dundee for hosting this event.*

*Thank you for your attention and I wish to  
all of you a fruitful conference*