Deterministic High Speed Data Communication in Space

MPCV ESM Overview and related development

J. Hartmann/ B. Wolff // 23.10.2013, 16:00h

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Motivation

- Challenging user requirements on data throughput and –speed of avionic busses are calling for new media.
- Simplification and reuse of architectures and components to realize cost reduction are requested.
- Different bus types were used in the past to fulfill the technical requirements of:
  - determinism and exactly time correlated data , and
  - high performance data management

Motivation (cont‘d)

- Most suitable technology, providing both “determinism for critical data as well as high speed data management” for space applications, is the TTEthernet standard (SAE AS6802) used and verified by commercial and aviation industries.

  This standard has been selected by NASA being the communication and data management backbone for the entire MPCV/ORION spacecraft. Critical data as well as non-critical data will be transferred using the same physical lanes.

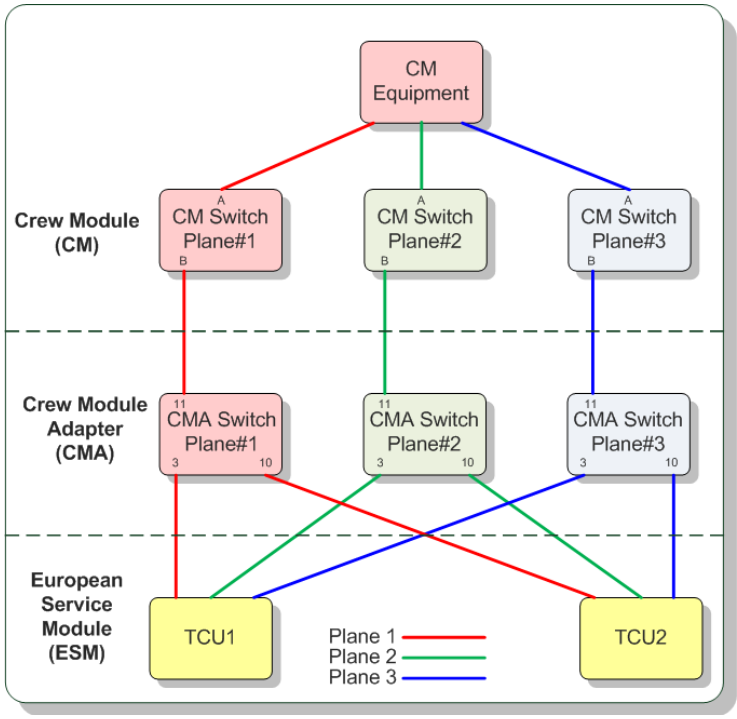
Motivation (cont‘d)

- Facilitate industrial spin-in into space technology
- Enabling missions of ESA and national programs by developing technology
- Supporting the competitiveness of European industry
- Fostering innovation by creating new space products
- Improve European technological independence and the availability of European sources for critical technologies. (ITAR free)

TTEthernet Highlights

- Technical
  - Determinism by self-contained time synchronisation
  - VL defined communication paths
  - Combinable with standard LAN
  - High Data Bandwidth up to 1Gbit/s
  - Supporting three message classes (BE, RC, TT)
  - Not depending on special physical layer (FX, SX, T, CX…)
- Industrial and Space Maturation
  - Wind Energy, Automotive (e.g. Audi)
  - Industrial network solutions (CISCO)
  - Aviation industries (helicopters backbone, airplane backbone)
  - NASA: MPCV/ORION spacecraft

MPCV ESM Avionic Bus Architecture (ODN)



- Triple redundant TT-GbE network
  - 3 Planes (not required to all equipment)
  - More than one switch between end systems
- TT-GbE (Time Triggered Giga bit Ethernet)
  - Time Triggered Ethernet according to SAE 6802
  - Physical Layer 1000BASE-CX in accordance with IEEE802.3 Clause 39
  - Bandwidth 625MHz (10x 1000BASE-T)
  - 25m distance (max) between network devices
- Star-Topology using 12 Port Switches
  - Each equipment or equipment channel is directly connected to switches

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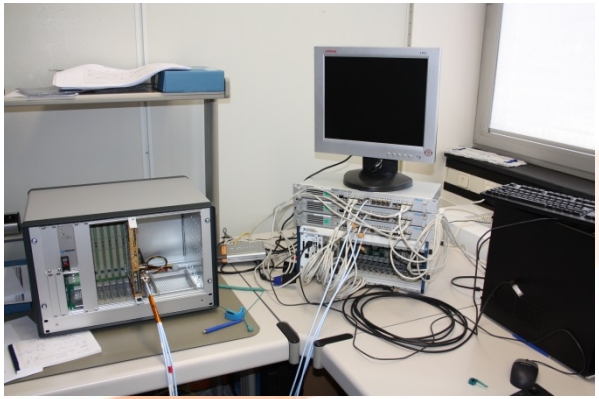
Field of Astrium ST Experience & Status

- MPCV ESM Equipment Test Environment
  - Breakdown of the ORION Data Network (ODN) topology into ESM equipment relevant communication lines.
  - Definition of ODN topology on equipment test system level for verification and qualification.
  - Test system setup for ESM PDE
- Driver development for Honeywell End-System (SNIC) on SPAICE SBC.
  - Integration of a Standard Integrity Network Interface Card on SBC of SPAICE
  - Implementation/Modification of given driver to operate under VxWorks 6.7.
  - Design and coding of application SW enabling data communication via SNIC by ODN to equipment test system.



TTEthernet (SNIC) Test system setup for MPCV ESM

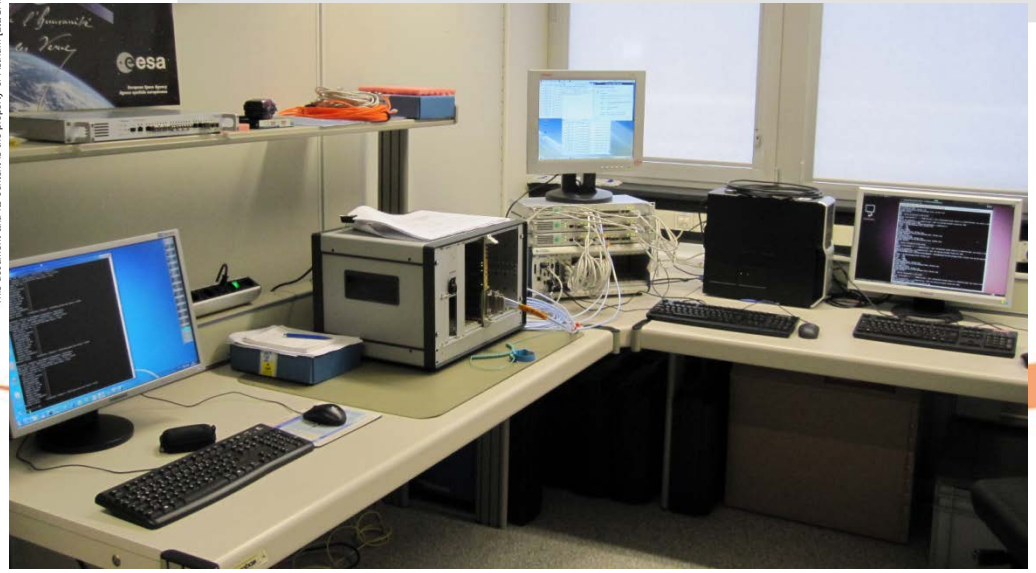
TTEthernet/SNIC Implementation on Astriums SPAICE flight CPU

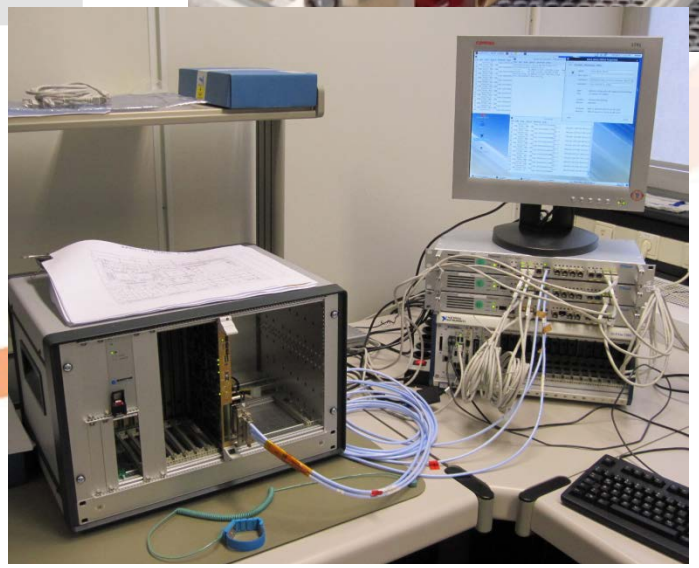
TTEthernet is the agreed baseline for the data communication system of the MPCV.

In preparation of the activities in frame of the MPCV project ASTRIUM GMBH Bremen performed a test campaign using the TTEthernet Demonstrator to verify compatibility of Astrium developments with the TTEthernet technology. A commercial TTTech cPCI card was implemented and tested in the flight CPU.

In a second step, the same was done with the SNIC interface controller, plugged on a Radiation Tolerant Single Board Computer (SPAICE RTSBC, developed by ASTRIUM).

The SNIC (provided by Honeywell) is the dedicated interface controller for all MPCV avionics which are connected to the on-board network.





Field of Astrium ST Experience & Status cont'd

- Video via TTE demonstrator/e.cube
  - Integration of TTE PMC network interface card on e.cube computer system.
  - Adaptation of TTE PMC Driver to e.cube environment
  - Development of an application software exchanging video data using Time Triggered communication. Up and Running!
- End-System implementation (OBC-SA)
  - Integration of TTE End-System IP core and LEON3 core in one Virtex5
  - TTE End-System providing 2 physical Ethernet ports
  - PHY connection via standard RGMII

TTE Video data link on e.cube

TTEthernet Demonstrator on Astriums COTS based space computer e.cube

As a first step toward a space qualified high speed data bus ASTRIUM GMBH performed a study with the main scope to characterize and trade-off different network technologies.

TTEthernet was identified as most promising technology which meets the space requirements of reliability, availability, maintainability and safety (RAMS).

Accordingly a TTEthernet Simulator/Demonstrator was designed and built incl. test software that allows the verification of the basic timing functions of TTEthernet using a COTS based space computer, built by Astrium.

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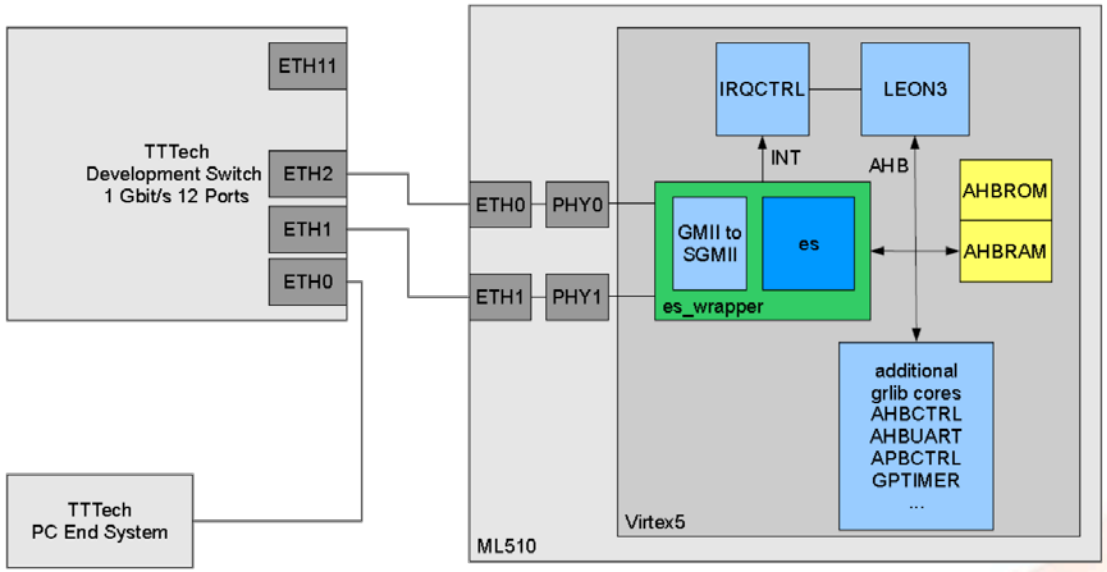
End System implementation (OBC-SA)

TTTech IP core integration

ASTRIUM GMBH in Bremen has implemented the TTEthernet IP for end systems (provided by TTTech) together with a LEON3 processor in a XILINX Virtex-5 FPGA.

The Virtex-5 is available in standard COTS quality as well as radiation tolerant, space qualified device and cold be used as intermediate solution for the integration of end systems in a TTEthernet network.



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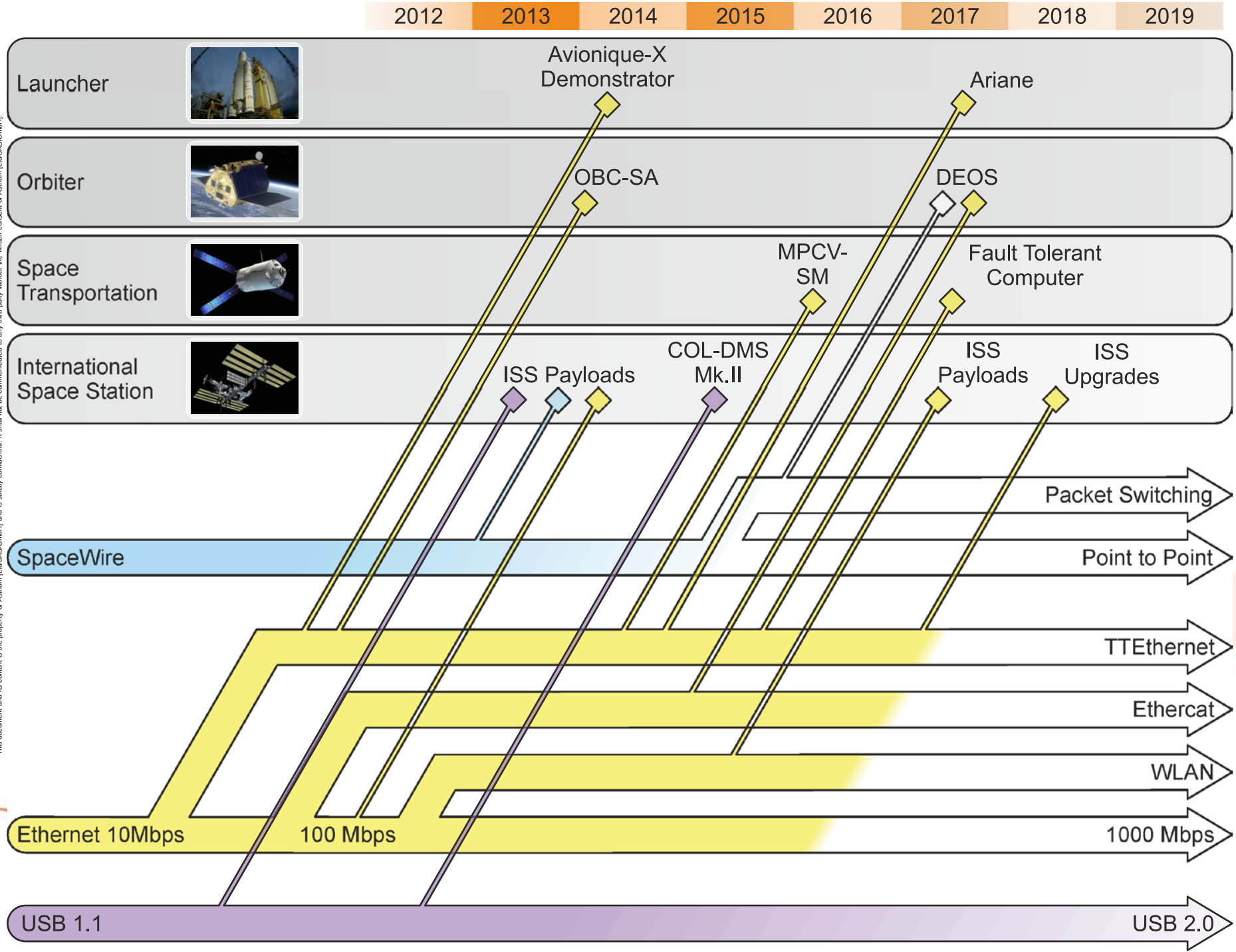
Cooperations

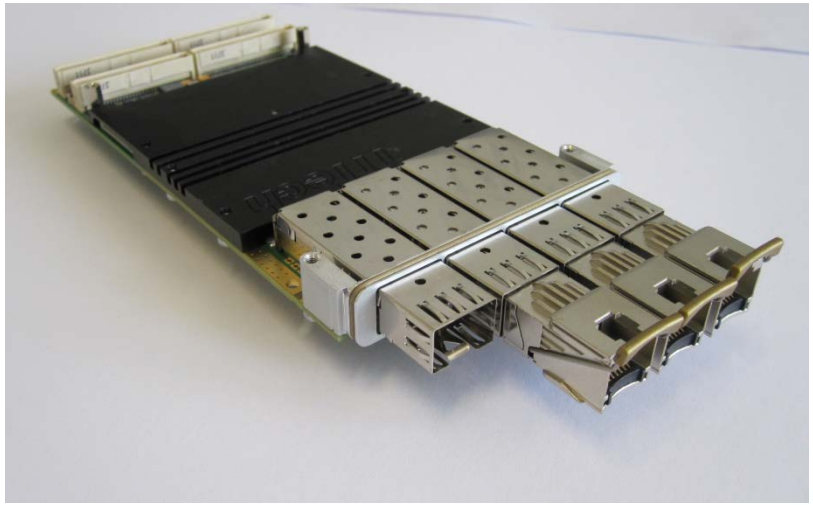
- Close Cooperation (MoU) with TTTech
  - Common maturation and industrialization approach
    - Switch
    - End System (incl. Clock Master function)
    - Physical Layer
- Partners
  - TTTech, ATMEL
  - Goal: ASIC(s) production and qualification (2016 first prototypes)
  - Implementation of End-System IP/Switch IP + Host IF + Test-Glue Logic in single chip using RAD-Tolerant/Hard ATMEL deep submicron technology.



TTEthernet End-System Module

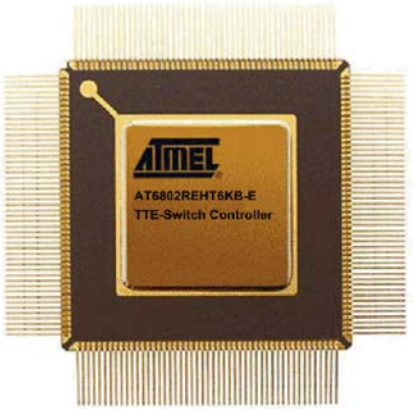
- Objectives :
  - Development of a qualifiable TTEthernet based End-System Module
  - Development of TTEthernet driver software for different operating systems
  - Preparation of at least an ECSS Standard for the next generation communication bus-system

- Estimated maturation time
  - Appr. 2 Years, start planned for 2014



TTEthernet Switch Maturation

- Objectives
  - Maturation of TTEthernet Switch to complement the TTEthernet communication system
  - Definition and implementation of switch related health and status information.
  - Trade-Off between stand-alone and integrated switch.
  - Definition and implementation of reduced Switch functionality set in FPGA based PCB
  - Prepare ASIC development



- Estimated maturation time
  - Appr. 2 Years, start planned for end of 2013

Future Perspectives

- Satisfaction of customer/market needs for matured TTE equipment
  - End-System (single lane or dual/triple redundant),
  - Switches (scalable port amount, standalone/integrated),
  - PC Based Tooling (Scheduling/Monitoring)
  - Connector and
  - Cable
- WLAN or UWB based on TTEthernet for space
  - Bandwidth > 1Gbit

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