Fibre Optics: Trends in Spacecraft Avionics.

G. Furano
ESA/ESTEC - Data Systems Division, the Netherlands

Intra-satellite Fibre Optic Links Workshop
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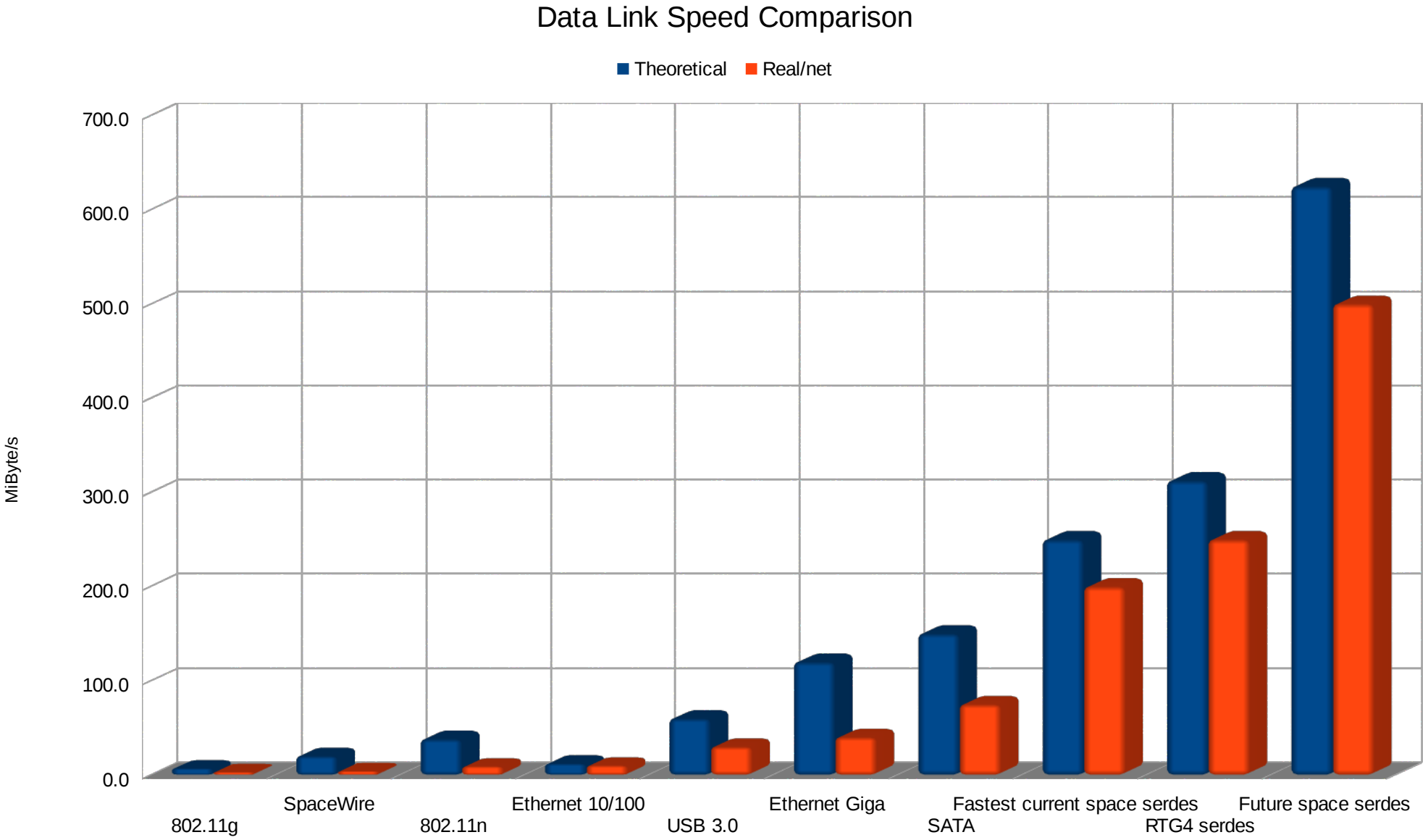
Outline – FO in Space DHS Systems

- Advantages of FO: what do we really care for
  - Copper vs. Fibre (you can't always win)
  - Current perceived risks
  - Current 'real' risks
- Mapping of FO use to current DHS
- New possibilities opened by use of FO

Advantages of FO – What do we (as DHS) care for

- The major advantages of using fiber optic systems for spacecraft subsystem communication over conventional electrical systems are:
  - Ease of integration,
  - Fewer electromagnetic interference (EMI)
  - Fewer electromagnetic compatibility (EMC) concerns,
  - Reduced mass
  - Increased link speed
- Ease of integration is the primary advantage as technology for “better, faster, cheaper” spacecraft. Fewer EMI/EMC concerns reduces design as well as test time. Mass performance is another advantage, however the majority of the mass loss may be realized by using any standard bus in lieu of a full custom, point-to-point or parallel design.

Copper vs. Fiber, in space.



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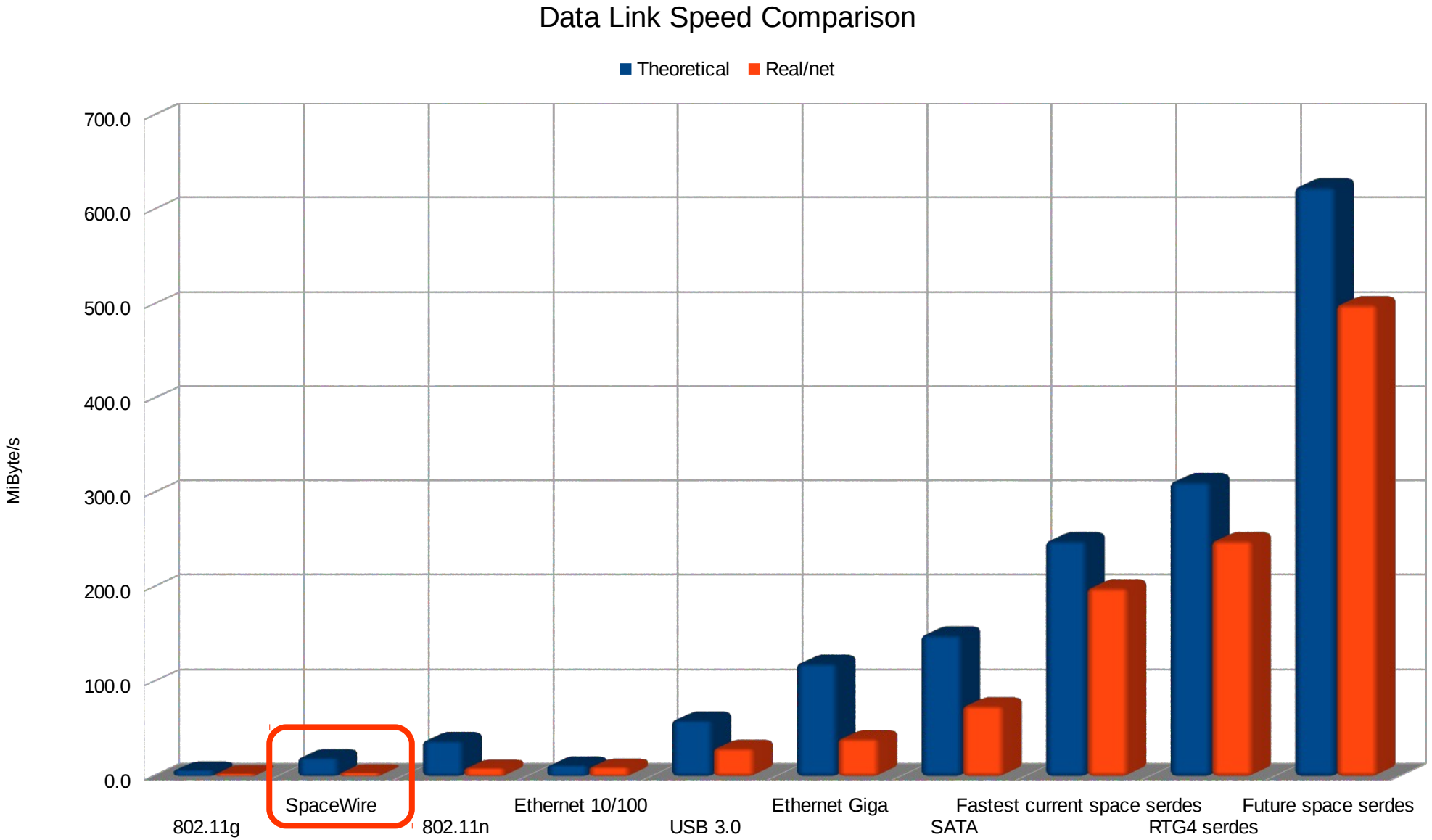

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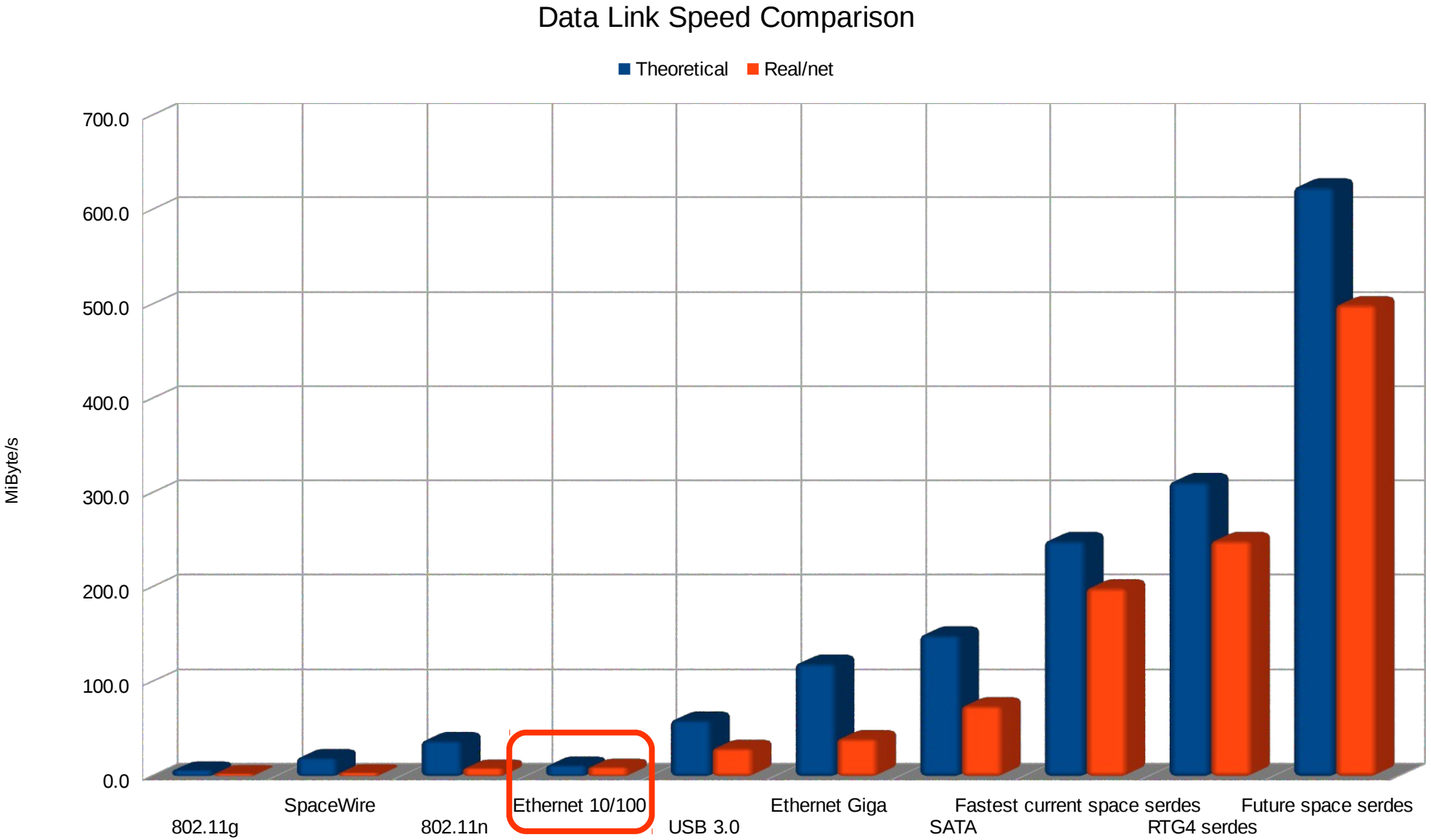

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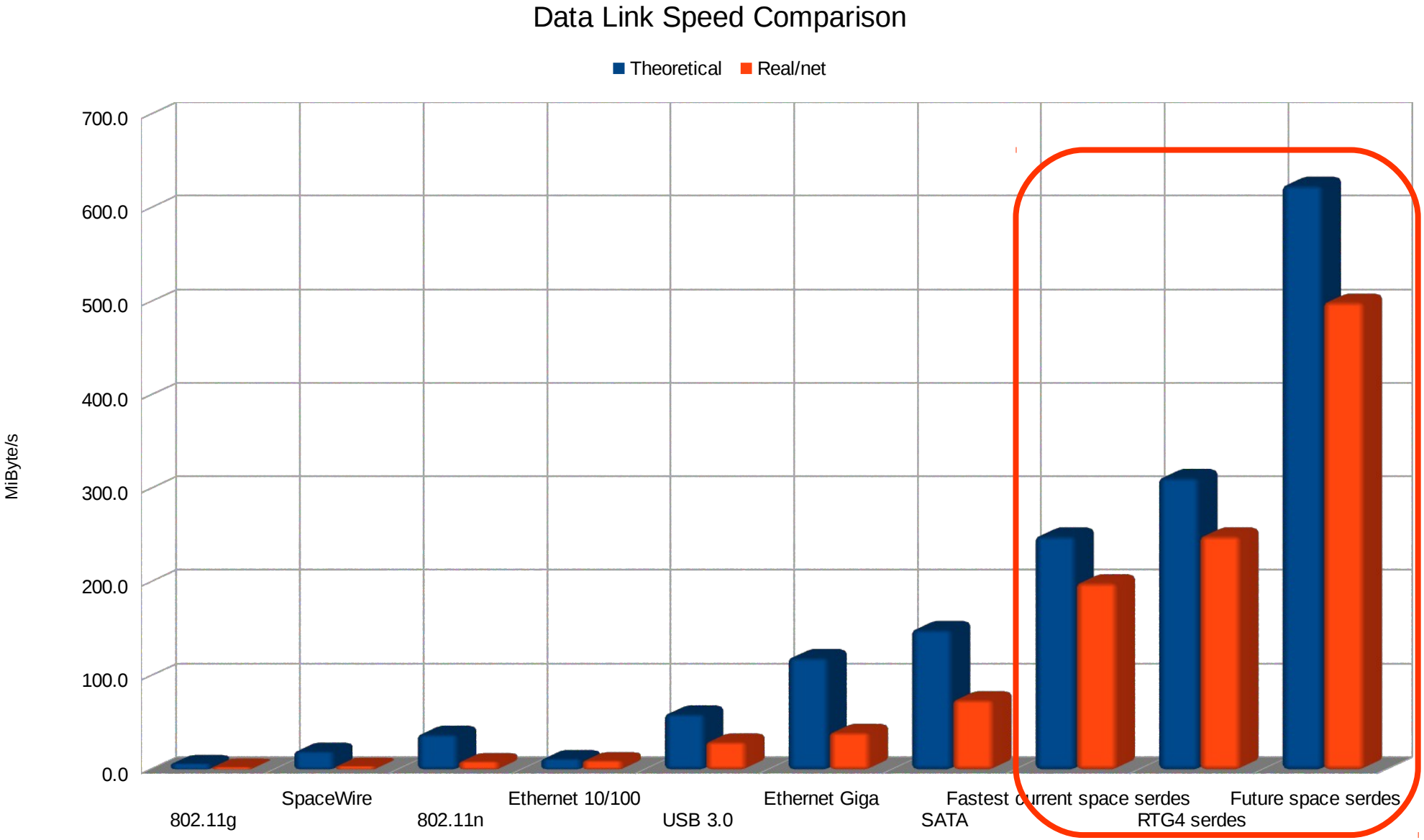
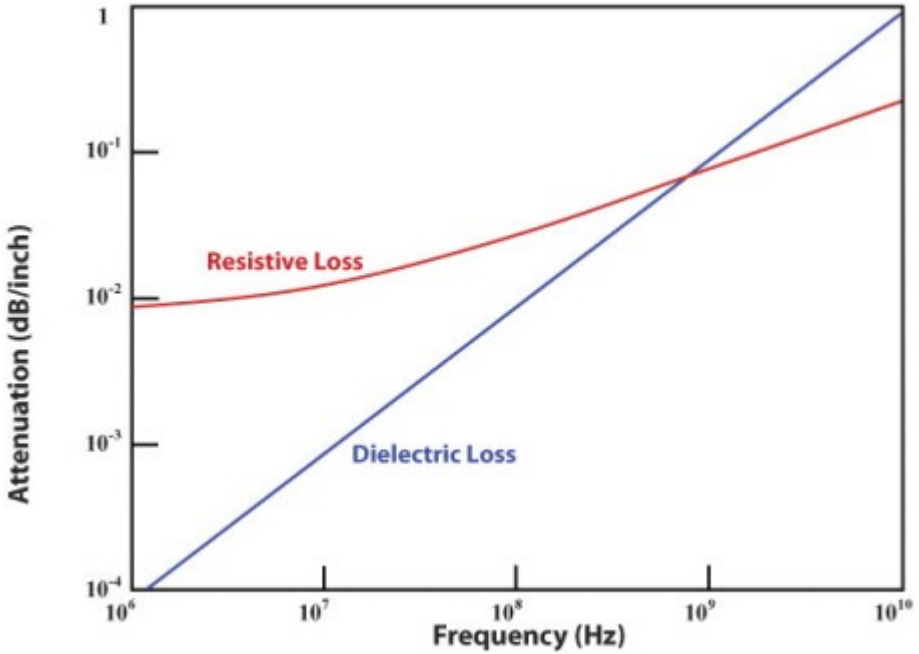


A SERDES is not enough.

- SERDES-driven protocol on copper/PCB/backplane may still be good enough for many intra-unit application.
  - We put at 5 meters the maximum copper/PCB length for ~ 3GBps
  - Optical PHY is then justified when large distances are involved
- RTG4 FPGA and future generation SERDES support the implementation of multiple High Speed Serial protocols using multiple PHY standards



A successful switch to optical: MIL-STD-1760

- MIL-STD-1760 in its AS5653 version provides a digital data command and control interface similar to MIL-STD-1553 based on fibre but operating at a 1-Gbaud data rate
  - Control of weapons on aircraft was the design driver:
    - High data rate
    - Immunity to EMI
    - Easy separation
    - Large distances
      - bus length 20 mt, wing area of F-35 is ~ 70 m^2

FO perceived vs. real risks

- Reliability
  - Glass Fibre is perceived by (space) designers as “fragile”.
    - Solution: stop calling it “Glass Fibre”
  - Electro/optical IF is the key component for robustness, but can be made in the same reliability ballpark of other complex IF as (e.g.) 1553 or Ethernet
- Handling
  - STP bundles (like SpaceWire) are as bulky and non-bendable as most of the classic fibres.
    - Solution: avoid pears and apples comparison
  - MicroD connectors are as fragile as Fibre connectors
  - Vacuum Feedthroughs (and in general, test connectors) are SIMPLER with fibres (DFT is the new paradigm!)

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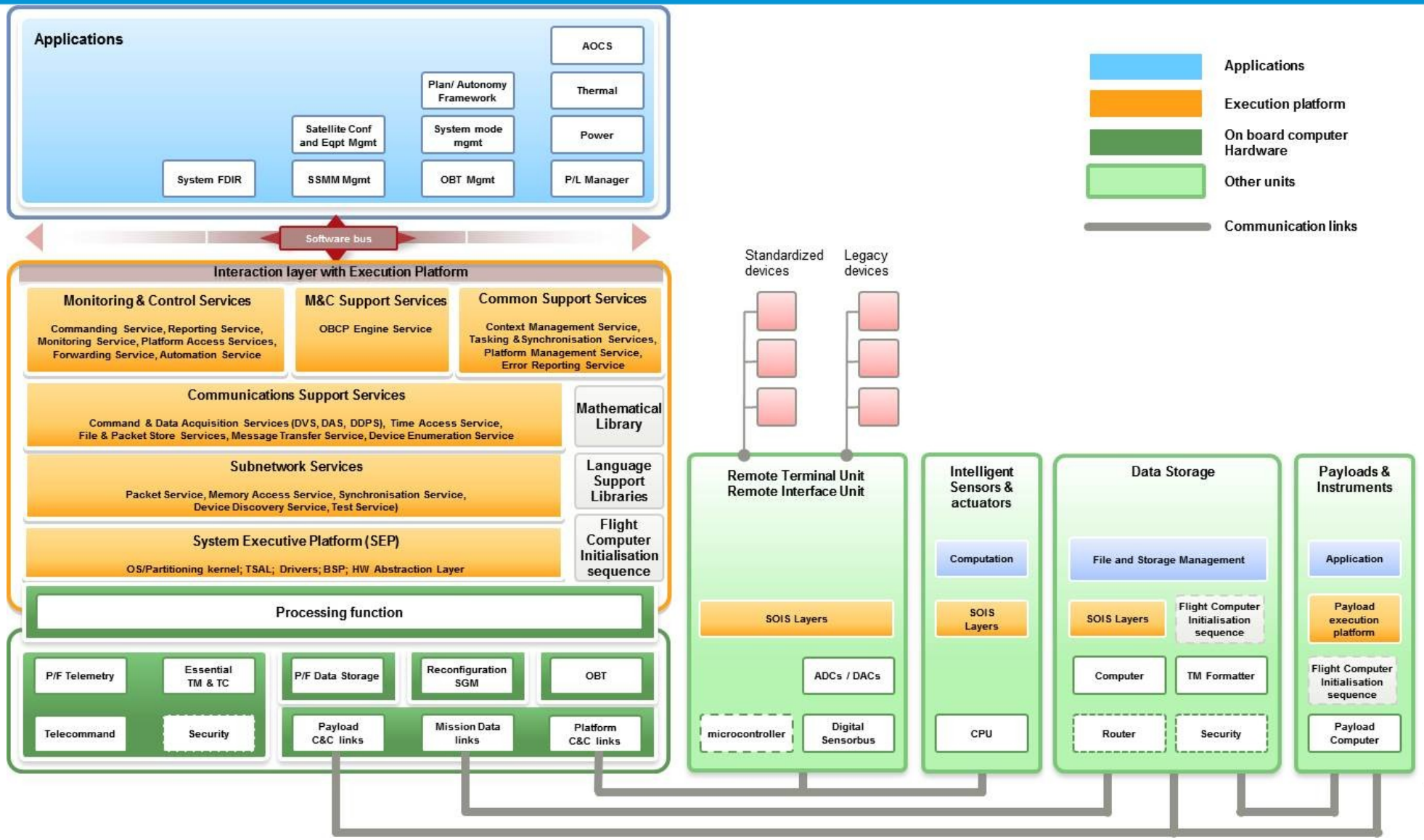
SAVOIR – Reference Building Block architecture



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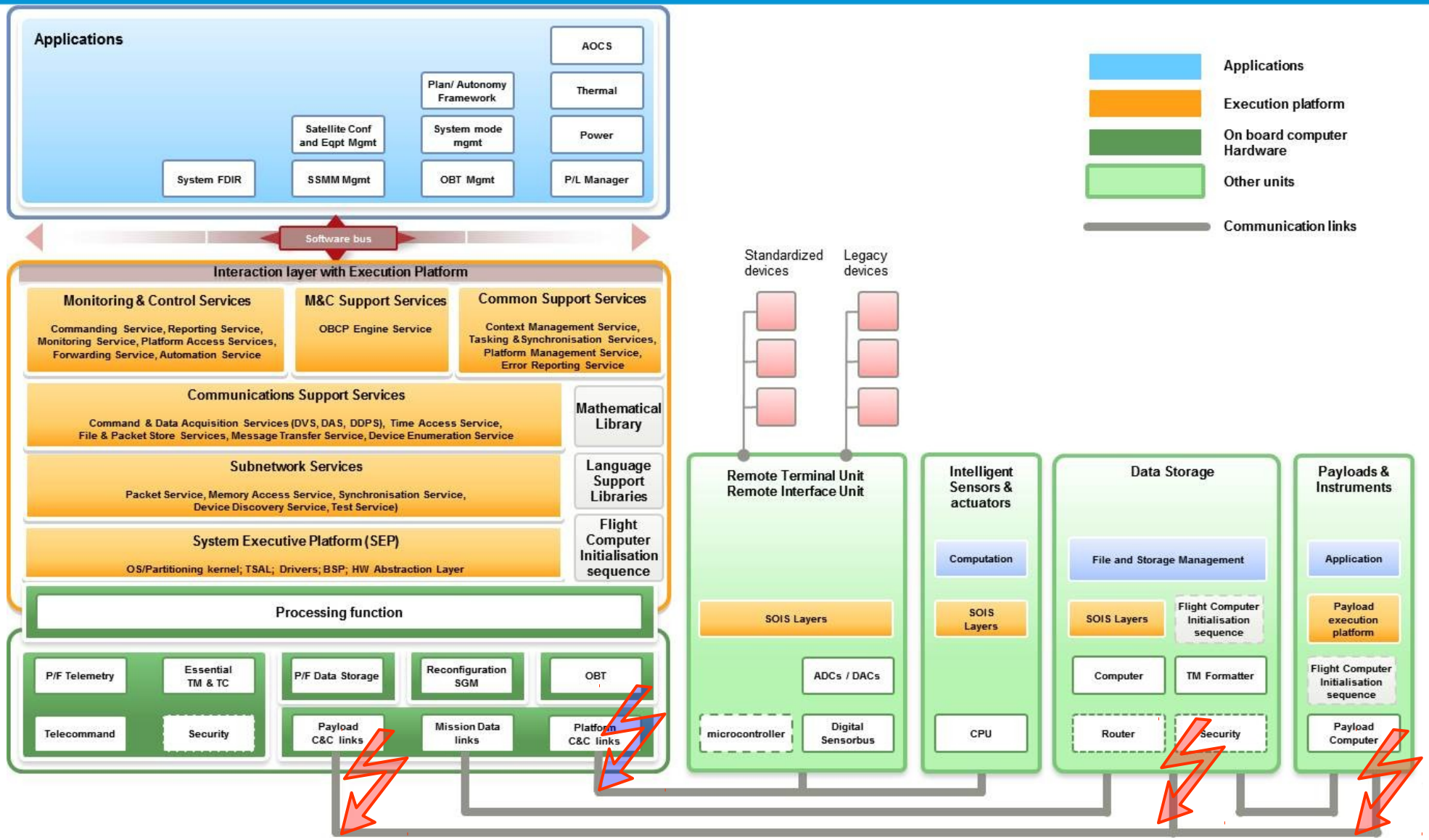

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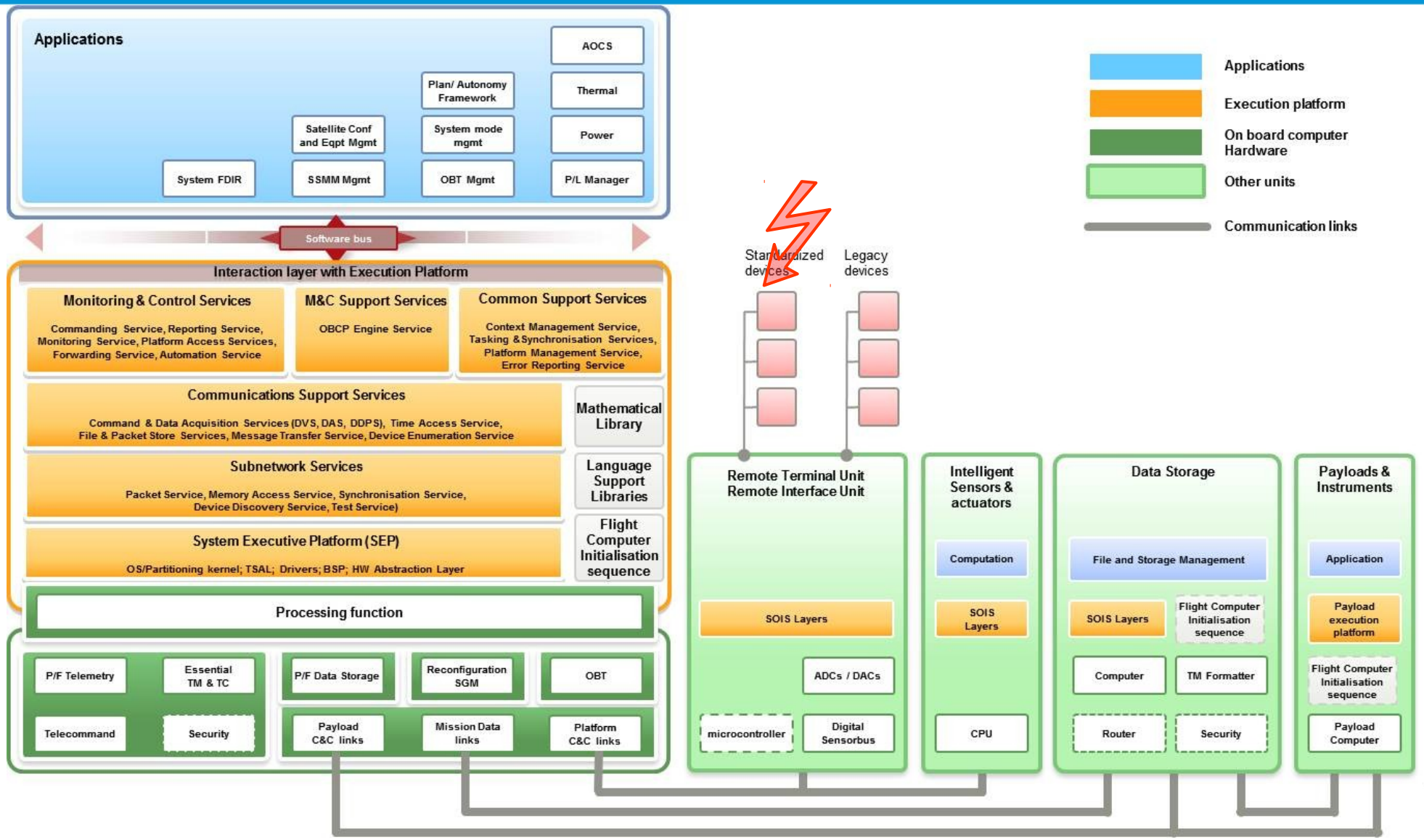

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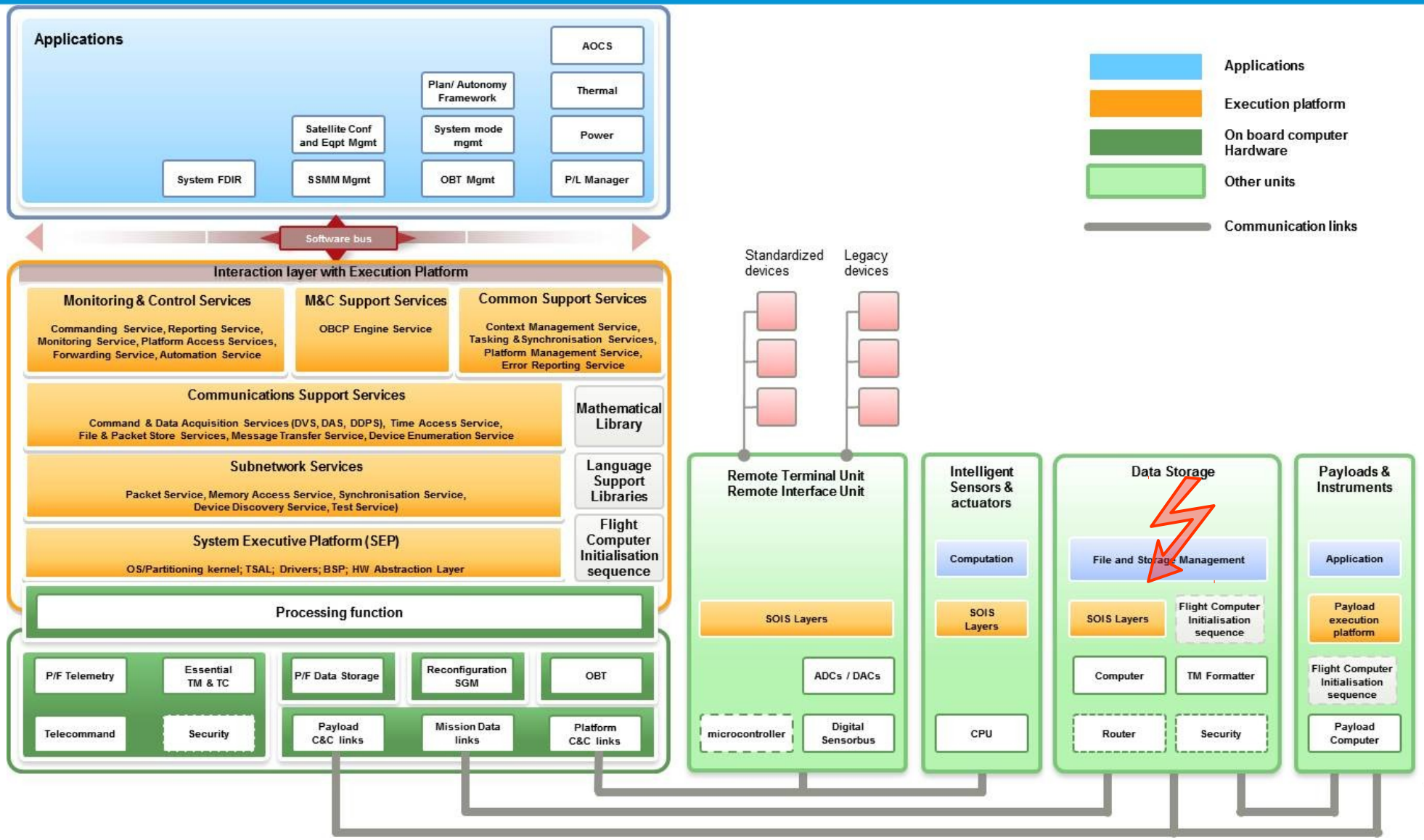

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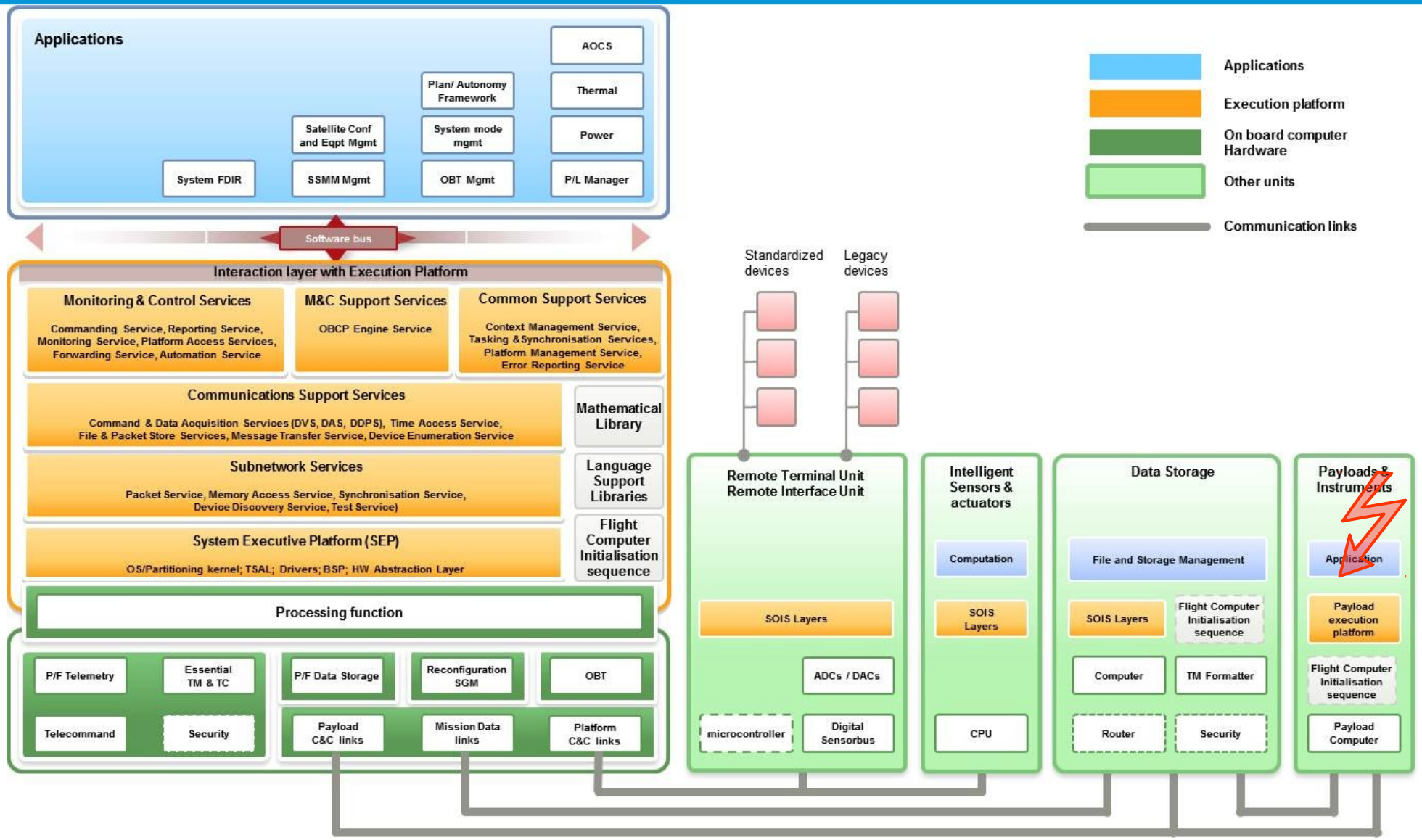


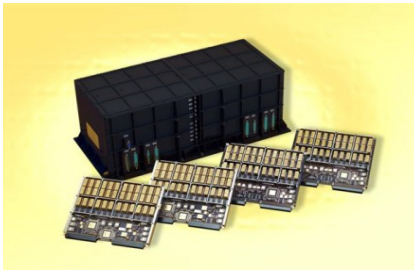
Technology Trend in space electronic systems: Mass Memories

Trends:

Hubble	1990	1 Gbit	20 Mbps
Rosetta	2003	4 Gbit	100 Mbps
GAIA	2012	800 Gbit	(7*40Mbps SpW ch)
Sentinel 2	2013	2.4 Tbit (FLASH)	2.5 Gbps

Input data rates will increase up to **10Gbps** , while **downlink** will go beyond **3 Gbps.**

TerraSAR-X MMU (Astrium)



ISSR (Astrium)

GAIA PDHU (Syderal)

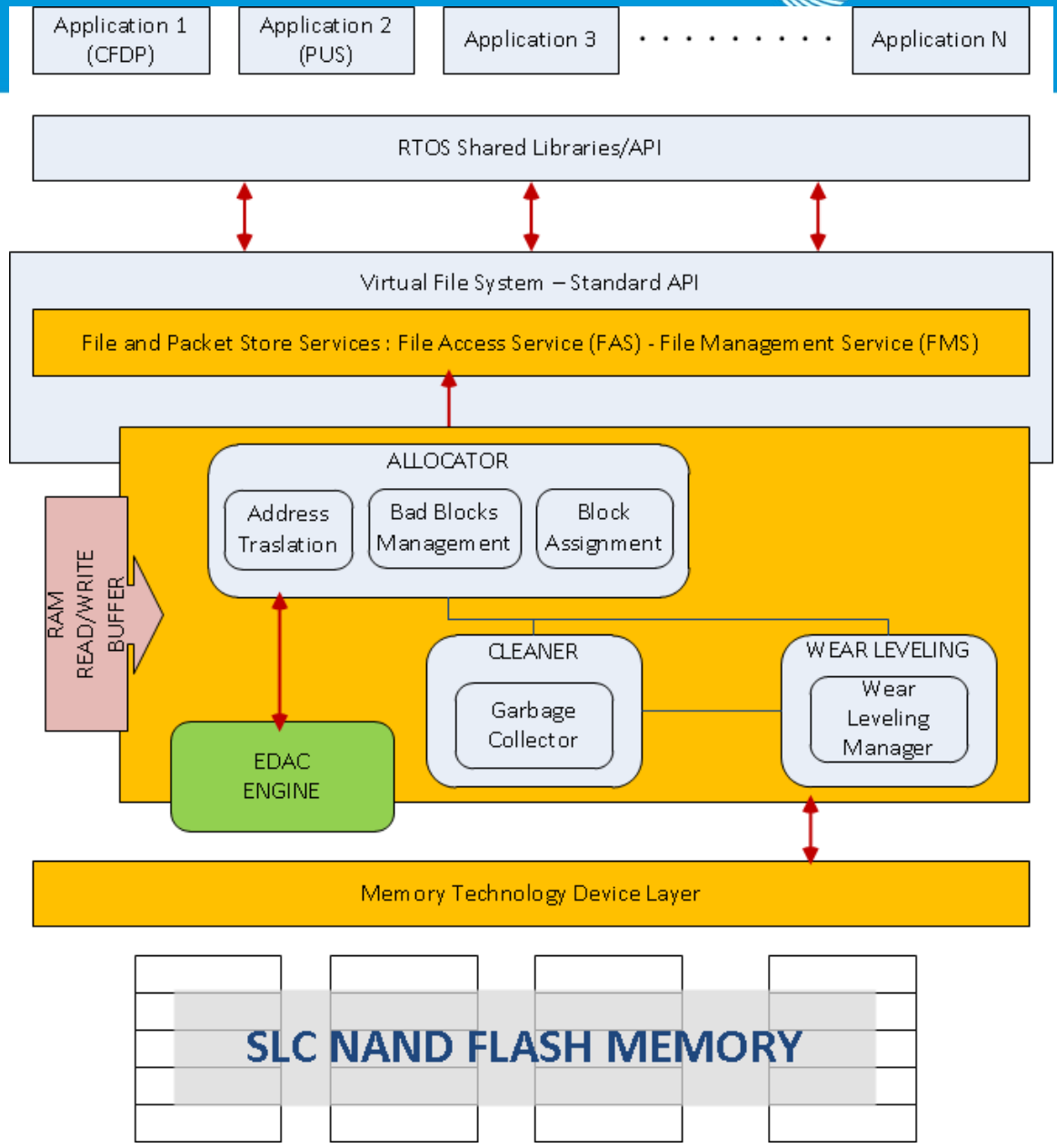
DHS Trends that could be supported by fibre optic

FLASH memories

The storage modules can be now built as memory modules connected only via a high speed serial link towards the central memory router/controller.

Each module, thanks to a block level interface, can be treated by the SSMM system controller as a ‘block device’ providing storage capabilities.

Memory device specific functions (EDAC, scrubbing, wear levelling, bad block and garbage management, cache) are ‘hidden’ beyond the module’s block level interface and may be realized using a relatively simple FPGA, which encompasses also eventual mission specific tailoring



DHS Trends that could be supported by fibre optic

- High speed debug interfaces
  - Large reprogrammable FPGAs, larger SW images and larger working memory need to go well beyond the 44Kbaud UART that was used until few years ago.
  - Big distances are often mandatory
  - Full isolation needs to be provided
  - A standard solution would be beneficial

DHS Trends that could be supported by fibre optic

- CAN Bus
  - CAN-to_fiber converters are used to get around the limitation on the number of CAN devices and the upper limit of segment lengths. Optical fiber can extend CAN to longer transmission distances since the fiber will not corrupt the CANbus signal.
  - CAN-to-fiber converters not only can solve the problem of extending transmission distance, but will also guarantee more secure data transmission and will not limit the number of CAN devices that can be used.
  - Applications in EGSE and umbilical are possible, providing Bus full observability/commandability.

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New Possibilities with FO links

- A simple list in urgency order:
  - EGSE/umbilical links
    - Fibre provides speed, distance, electric isolation.
    - Connectors with embedded E/O conversion ?
    - Fundamental for hi-performance unit observability
  - Launchers
    - Is there still time to challenge Ethernet as C&C link ?
    - Easier separation, EMI immunity
  - E/O Pyros
  - Hi-speed point-to-point links (from MM to transponders or laser terminals)
  - Sensor rings with fibre grating

Would you like to know more?

www.esa.int/TEC/OBCDH/

gianluca.furano@esa.int