ADCSS 2018

Communication Standards for Command & Control

17th of October 2018

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Needs for Command/Control communications

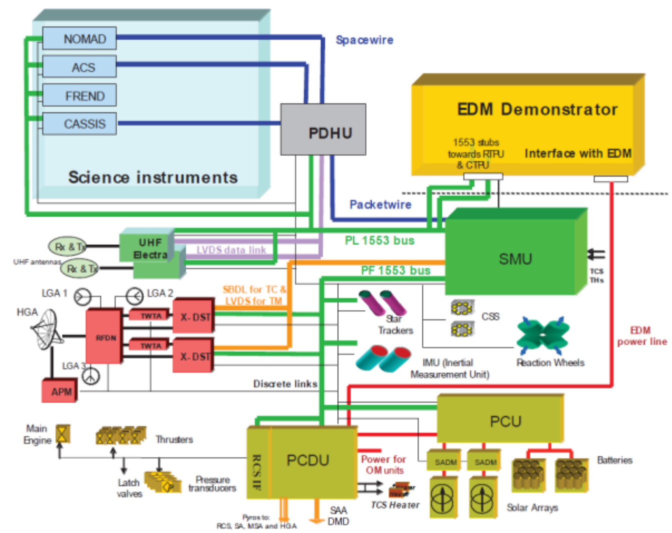
Non-functional needs:

- **Cheap, small IP footprint, simple OBSW drivers, low power consumption, standardized, multi-sourcing, large community, easy configuration, FDIR & testability**

Quality of Service & data rates:

- **Deterministic data deliveries for Command/Control packets: Bounded latency, Acknowledgements of critical data transfer**

- **Flexible data rates & number of connected units**
  - In current missions: <1Mbps & less than 30 connected units
  - In future missions: often the same as for current missions, sometimes improved with 10-100Mbps (STR, future RW, vision-based nav, others); sometimes > 40 units; sometimes very long connexions requiring decentralization



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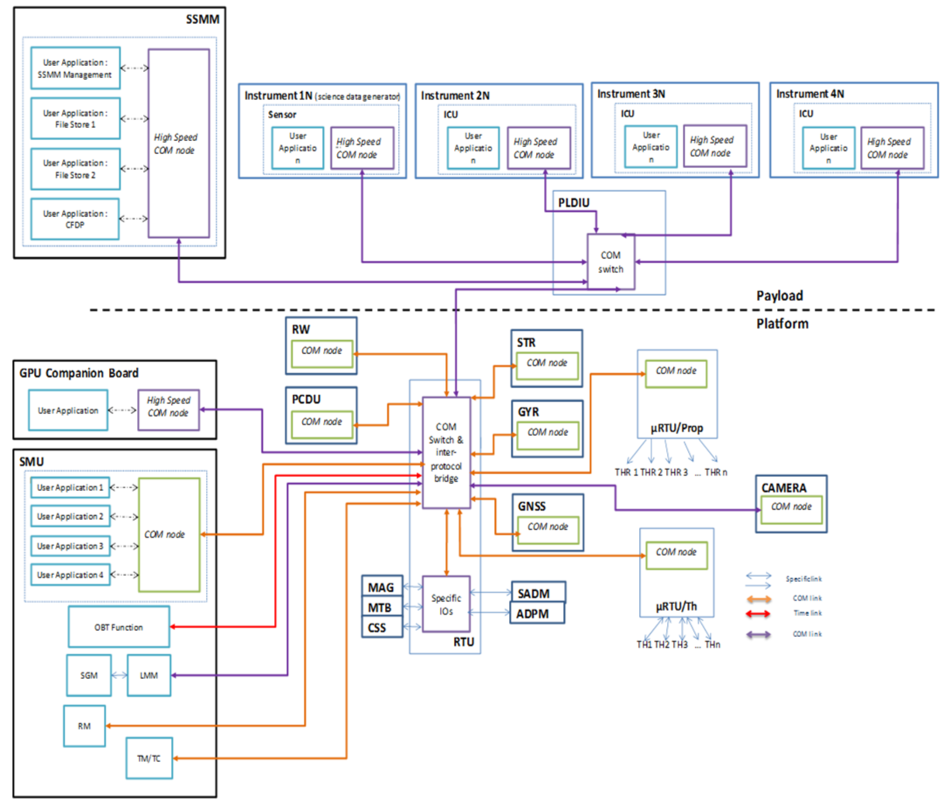
Needs for Command/Control communications

Drivers for evolution

- **Centralization of functions, increased on-board autonomy and sensors/actuators evolutions drive the future need for high to very high speed links, and point-to-point links might not be viable in order to get an optimized architecture. Networks will become more and more attractive.**

- **Mixed criticality data transfers is a good way to simplify future avionics design and manage the increased data rates at platform & payload levels while keeping timing constraints for realtime applications; also enables distributed architectures based on µNodes/µRTU/smart connectors**



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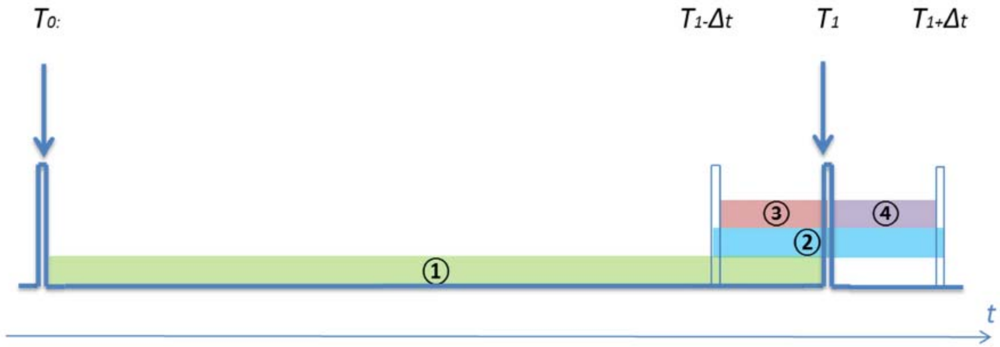
Needs for Command/Control communications: some clarifications

OSRA-NET: Determinism?

- ***Often 10ms jitter and 10ms latency is sufficient (for instance for many AOCS units)***

T_0: Start of action (process, computing, transmission…)

T_1: Expected or predicted end of action



Area① -Guaranteed action delivery (soft determinism):
The action must be performed not later than the expected time ➔ in the interval [T0 ; T1[
Area ② - Determinism :
The action must be performed at the expected time T1 with a tolerance Δt ➔ in the interval [T1-Δt; T1+Δt]
NB : Δt can be defined as equal to 0. In such case the reception time is exactly T1, otherwise the action is not valid.
Determinism - variant,
Area ③ - Determinism with early tolerance only:
The action must be performed not later than T1 with a tolerance before ➔ in the interval [T1-Δt; T1 [
This is to ensure that the action and its resulting outputs have been generated without delay and can be processed immediately.
Area ④- Determinism with delay tolerance only:
The action must be performed not earlier than T1 with a tolerance ➔ in the interval]T1; T1+Δt],
This is to ensure that the action and its resulting outputs have been generated recently enough, typically for polling application.

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Needs for Command/Control communications: some clarifications

OSRA-NET: Performance?

- OSRA-NET analysed current & near-future needs in communication systems and performed a grouping of need in 7 classes, including Command/Control and payload telemetries
- Command/Control is preferably implemented through classes 2 or 6, but can be implemented through point-to-point links using other classes

		Traffic description								Ratios		
	Equipment	Data type	Max Cargo size (bits)	Frequency (Hz)	AOCS sensitivity	Jitter requirement (ms)	Delay (ms)	Time stamp	AOCS Period / jitter	Jitter / Delay	(Jitter+ delay) / AOCS period
Sensors	Magnetometers	AOCS	12	0,1	> 1 cycle	1000	1000	Yes	10	1	20,00%
	Coarse Sun Sensors	AOCS	96	8	Low	10	10	No	12,5	1	16,00%
	Gyro	AOCS	576	08 - 10	1 cycle	1	1	Yes	100 - 125	1	1,60%
	Star-Tracker	AOCS	8194	8	1 cycle	1	10	Yes	125	0,1	8,80%
	Camera - High Res.	AOCS - Rendez-vous	41943040	8	1 cycle	10	100	Yes	12,5	0,1	88,00%
	Camera	AOCS - Nav. Cam	10485760	1	> 1 cycle	100	100	Yes	10	1	20,00%
	IR Spectrum Camera	AOCS	2457600	1	> 1 cycle	100	100	Yes	10	1	20,00%
	GNSS	AOCS	10000	1	1 cycle	10	10	Yes	100	1	2,00%
		AOCS	14	1	1 cycle	0,001	0,001	Yes	1000000	1	0,00%
Actuators	Magneto-Torquer Bars	AOCS	12	0,1	> 1 cycle	1000	1000	No	10	1	20,00%
	Reaction Wheels	AOCS	30720	8 - 100	1 cycle	10	10	Yes for some	1 - 12,5	1	16% - 200%

Class	Freq of data exchange scale (Hz)		QoS			Data Rate scale		Jitter	Latence	Level of determism			Timestamp
	Min	Max	0	1	2	Min	Max	ms	ms	None	guaranteed delivery	deterministic	Mandatory / Optional
1	0,1	1	X	X		100 bits/s	10 kbits/s	10	10		X		Optional
2-a	8	10			X		1 Mbits /s	5 - 10	10			X	Optional
2-b	8	10		X	X		1 Mbits /s	5 - 10	10		X		Mandatory
3	8	10			X		250 kbits /s	10	10			X	Optional
4	0,1	1	X	X		100 Mbits/s		up to 100	up to 100	X	X		Optional
5-a	10	1000			X		3 Mbits/s	0,5 - 1	0,5			X	Optional
5-b	10	1000		X	X		3 Mbits/s	0,5 - 1	0,5		X		Mandatory
6	1	10		X	X	100 Mbits/s		2	10			X	Mandatory
7	1	10	X	X		100 bits/s	1 kbits/s	1	2			X	Optional

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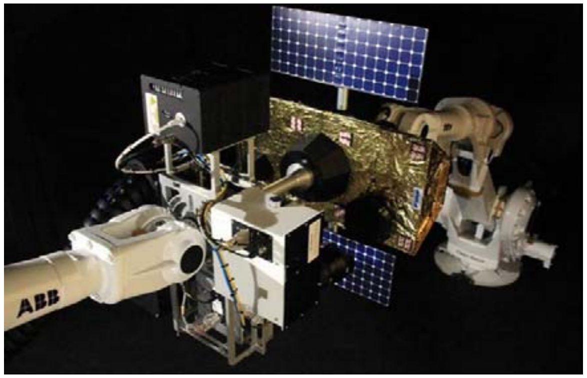
Needs for Command/Control communications

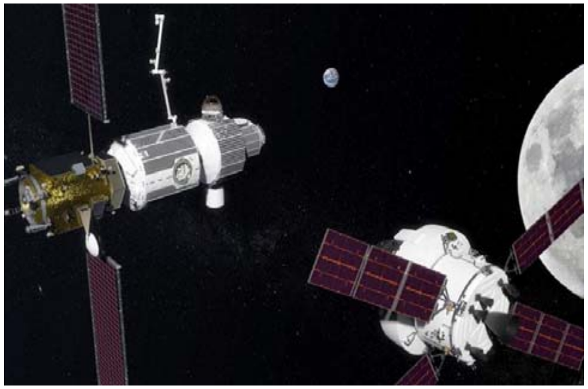
Status today

- Several technologies (UART / 1553 / CAN / SpW / Wizardlink / //LVDS) are available and allow to cover all communication needs as of today, even if not optimal in terms of number of IOs
- In the short term we see CAN taking precedence over 1553 and SpW used in all spacecraft but as point-to-point links for platforms; as networks for payloads



Drivers for evolution

- Centralization of functions, more autonomy on-board (AI on-board…), evolution of units, … drive the future need of very high speed links, and point-to-point links might not be viable in order to get an optimized architecture
- Large constellations may qualify space ground standards that could then be envisaged for all missions and bring a solution for rationalization of the communication means



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Most interesting candidates to promote for satellites

Bus solutions: 1553 → CAN: *cheaper, lighter, less power, similar functionalities*

Short, Middle & Long term for Net solutions: SpaceFibre / SpaceWire

- **SpaceFibre technology has very high potential with certainly first deployment for payloads and then possibly for platforms. But TRL shall be increased *faster than the pace of recent years* and competitiveness of the solution must be demonstrated in space for a quick start**
- **SpaceWire: developments envisaged at short term to ensure that SpW networks for C/C can be embedded on-board shall be pursued, but with maximum synergy with future SpaceFibre networks (Determinism with single or multiple masters, QoS & FDIR aspects)**

→Transaction layer: need confirmed for a transaction layer definition to manage FDIR, acknowledgements and optional services to handle various levels of determinism depending on missions *(basic '1553-over-SpW' using a single RMAP initiator is often sufficient; STP-ISS appealing for QoS & VC; SpW-D ?)*

Middle/Long term for Net solutions: Ethernet-based network

- **Potential solution where most NR activities could be covered through the development of a constellation**
- **TTE/TSN trade-offs to perform thanks to the fast increasing maturity and attractiveness of those solutions**
- **« Basic Ethernet » appealing for low-cost solutions**
- ***Applicability of those solutions to HiRel satellites will need to be investigated***

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Thanks for your attention

Questions?