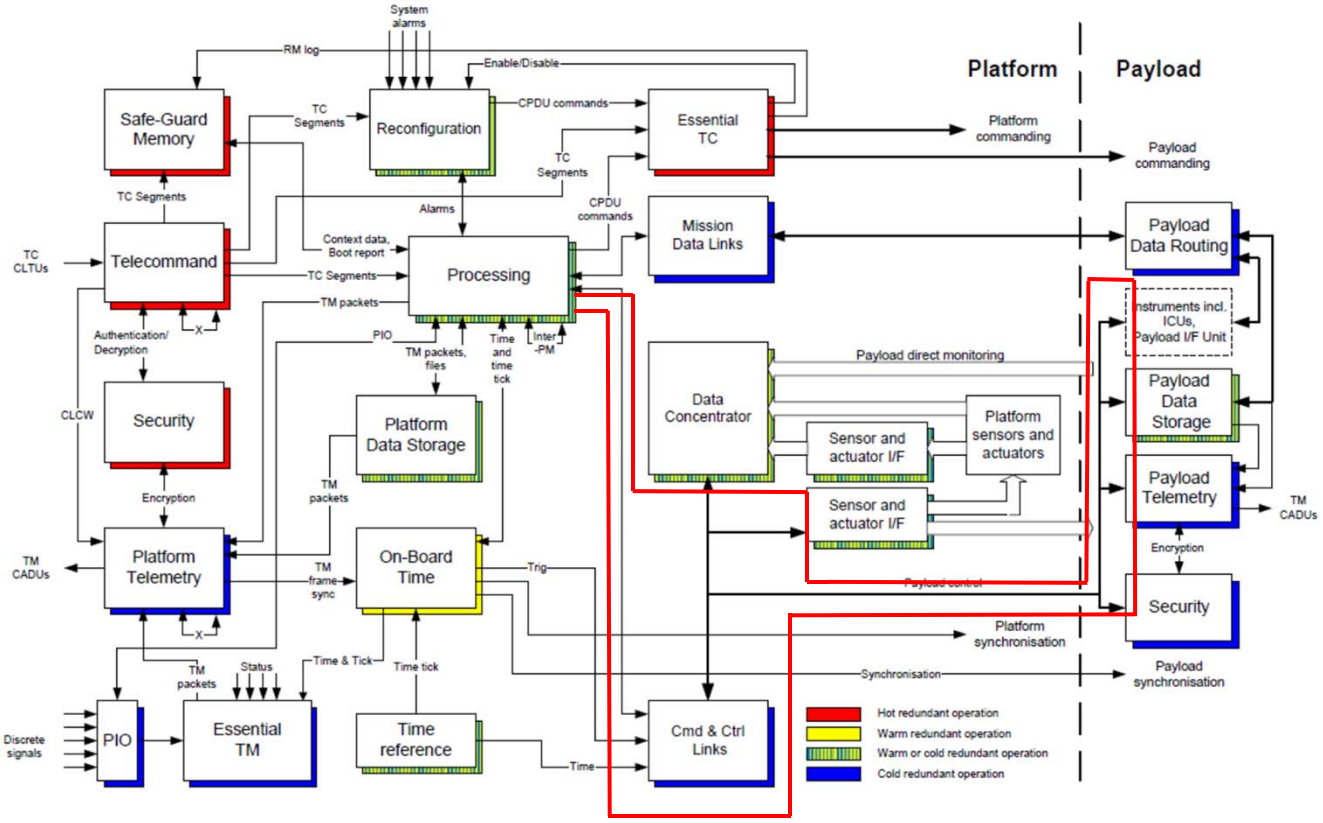
Command & Control Interfaces: status quo and medium/long term evolution

TEC-ED/SW/SA

17/10/2018

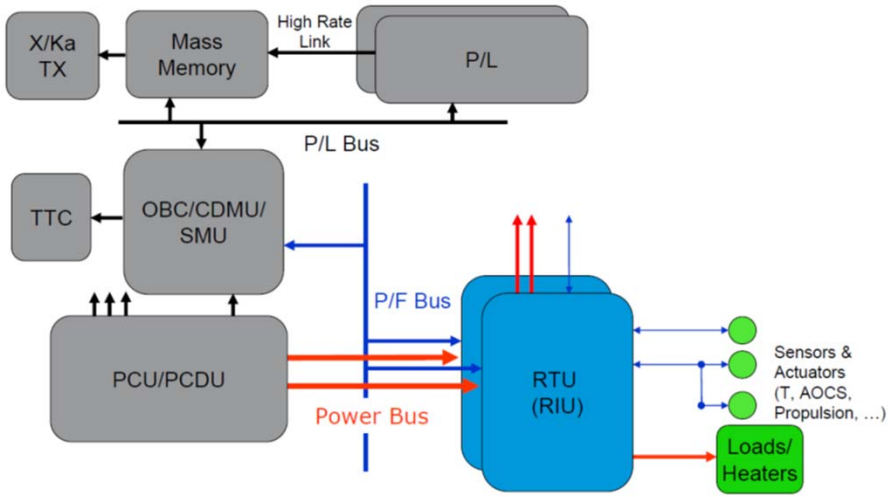
Command & Control I/Fs function in SAVOIR arch



The **Spacecraft Command and Control interfaces** interconnect the platform and payload processing and space-ground communication resources with on-board entities which act as data producers/consumers or sensors or actuators:

- **Platform sensors/actuators** directly interfaced,
- Platform Input/Output concentrators (**RTUs**) which then interface platforms sensors/actuators
- **Platform subsystems units** (e.g. PCDU) which generate hk telemetry and need configuration cmds
- **Payload units**: Payload RTU, ICU, Channel Amplifiers, …

Command & Control I/Fs function in SAVOIR arch



Modular RTU SoW GSTP (2011)

The command & control I/Fs function is in general implemented as two data buses:
P/F command and control bus
P/L command and control bus

Data throughput needs are generally limited such that implementation solutions belong to the "**low speed data bus**" family (a few hundreds of kbps).

The normal **number of nodes** (remote terminals) in a platform is generally from 20 to 30, and the trend goes towards an increase of the bus interfaces. For P/Ls the number of nodes can be even more than 100…

Protocols provide determinism to be compatible with control laws of up to several tens of Hz (HK, Commands loop, AOCS,….)

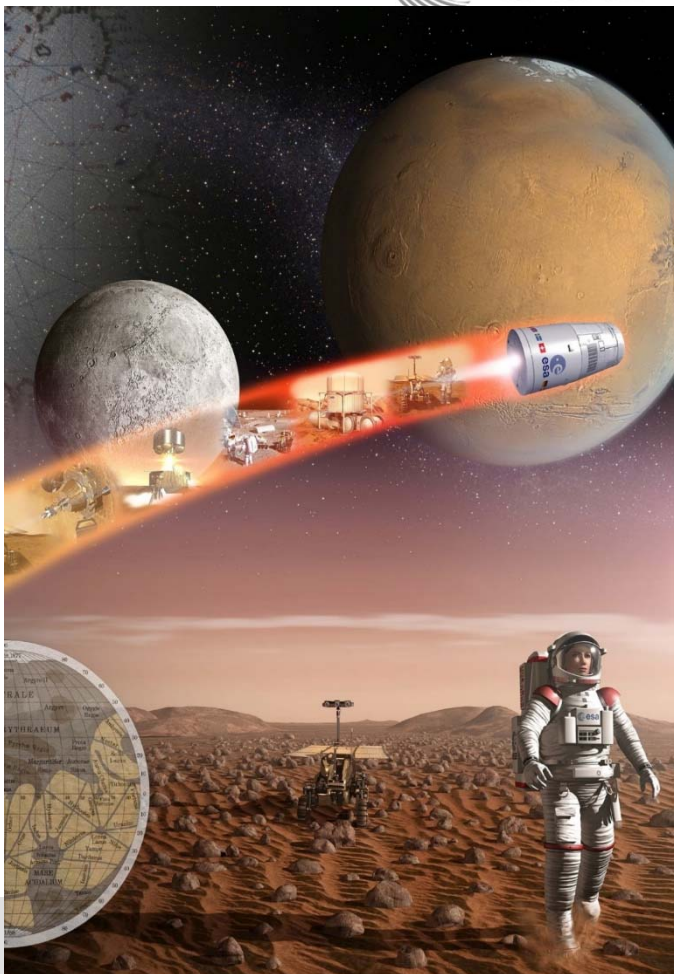
Command & Control I/Fs function in SAVOIR arch

Centralized architectures have dominated so far but **decentralization** has started to appear as a new paradigm.

In a centralized architecture the OBC acts as **bus/network master** (physically on strict master-slave bus like 1553, functionally on **multimaster-capable CAN**) and peripherals are simple remote terminals.

Routed networks (like Spacewire) or star controls (like UART serial) are of the point-to-point type.
In current space implementation, point-to-point networks require **upper level protocols** and lead to interface multiplication to account for redundancies.

Also **combination of solutions** are possible: a point-to-point link with the OBC may be used to perform the command & control of a specific unit while the other units remain connected through data buses. An example is the connection of star tracker optical heads.



Command & Control I/Fs solutions

Which solutions? (here limited to what is currently flying or present in your clean rooms or flat-sat)

- **MIL-STD-1553B** data bus, the most common solution today, particular due to the large offer of spacecraft sensors/actuators available with a qualified 1553 connection,
- **CAN bus**, which has already flown in several missions and is baselined for applications such as planetary rover vehicles and landers, small-medium satellites, Telecommunication platforms and payloads,…
- **SpaceWire** routed and point to point links, currently used as Star Tracker command and control interfaces or as OBC-RTU link (as in Bepi-Colombo) or as payload C&C network (Solar Orbiter, JUICE),
- **UART** (well aka RS422…) used for some AOCS units, for P/L units,
- **TTEthernet** used as Command&Control bus in Ariane6 and MPCV(-ESM).

TAS-F image

Perfection is not of this world…

All the solutions are coming with pros and cons…

MIL-STD-1553B bus is extremely robust but (medium-high) power dissipation*, (limited) max number of terminals, data throughput are limits…(E(xtended)1553 and HyPer-1553 were stopped!)

CAN bus allows large number of terminals, low power dissipation**, but limited data throughput (but CAN FD),

SpaceWire is not a bus ! Low power dissipation ***, high data throughput, however reduced common mode tolerance (if you use ANSI-TIA-EIA-644A LVDS…), and fully deterministic SpW protocol (*SpW-D*) is still at its definition phase,

TTEthernet not a bus. high data throughput, extended common mode tolerance but reduced availability of building blocks,

UART easy and cheap solution, commercial IC counterparts exist, hwr no protocol standardization (true?), not a bus, limited throughput, impacts on CPU load of main processor,

Other solutions are possible…**PowerLink** (combination of a secondary power bus with C&C bus for small sensors/actuators)… **SpFi** (evolution of SpW with higher bandwidth and QoS), **TSN Ethernet** and **Ethernet, I2C** used in cubesat, …

* 761mA as Max current 100%duty cycle, @1MHz transceiver UT63M143 from cobham
** <18mA as Typ current @ 1Mbps Transceiver SN55HVD233-SP 3.3-V from TI *** typ 60mA for 2 Drv/2 Rcv

Why this session at ADCSS…

The aim is to collect needs and to present required evolutions to cope with requirements derived from new missions (HRE, SCI, EO, launchers, …)

We see new architectures/paradigms/constrains (decentralization, higher integration, combination of different classes of data traffic, distinction btw P/F and P/L not valid in all cases, reduction of AIT cost and development time), SAVOIR and SAVOIR Union initiatives are trying to collect them !

Let's discuss together and help us to define R&D and Standardization activities for deterministic, reliable and simple C&C links of the new era of Space!

Agenda

time	duration	Session on C&C I/Fs Day-2 17 Oct-2018	Presenter	Company
		ESCAPE		
09:00		**Start of the Day**		
09:00	5	Welcome	A.Zadeh	ESA
09:05	15	introduction to the session	G.Magistrati	ESA
09:20		**1-Programs Views**		
09:20	20	Science	P Falkner	ESA-ESTEC
09:40	20	Launchers	I. Pardos	ESA-ESRIN
10:00	25	Exploration	L.Bolognino/M. Montagna	ESA-ESTEC/TAS-I
10:25	20	Earth Observation	J.Rosello	ESA-ESTEC
10:45	30	Coffee Break/Visit to exhibition corners		
11:15		**2-Primes Views**		
11:15	20	ADS view	R.Roques	ADS
11:35	20	TAS view	B.Dellandrea	TAS
11:55	20	Current spacecraft data handling interfaces and future needs at OHB	D. Felbach	OHB
12:15		**3-Conclusions**		
12:15	30	Round Table and Wrap-up	G.Furano, all	ESA
12:45		End of the mtg		