

Exploring New Ways to
Simplify Spacecraft Software
and System Architectures



ESA ADCSS 2019

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Old & New

2

A6, Moon, Mars

3

Technology, Chip, **Equipment**

4

Outlook

- ✓ Regular exhibitor – TTTech is still TTTech
- ✓ The other two constants are ~~Aeroflex~~ Cobham and ~~Atmel~~ Microchip
- ✓ SAE standard on Time-Triggered Ethernet almost 10 years old...
- ✓ First ADCSS for two colleagues (David “EPOS” Jelem and Ivan Masar)
- ✓ Our (new) partner for space equipment: ~~Saab~~ RUAG Space Austria

Achieving 2024 – A Parallel Path to Success

Artemis will see government and commercial systems moving in parallel to complete the architecture and deliver

NASA Programs SLS and Orion

Artemis 1

First flight test of SLS and Orion as an integrated system

Artemis 2

First flight of crew to the Moon aboard SLS and Orion

Artemis 3

First crew to the lunar surface; Logistics delivered for 2024 surface mission

Between now and 2024, U.S. industry delivers the launches and human landing system necessary for a faster return to the Moon and sustainability through Gateway.

Commercially Provided Elements

Human Landing System

PPE	Crew Module	Transfer	Descent	Ascent
Power Propulsion Element arrives at NRHO via commercial rocket	Small pressurized crew module launches to Gateway on a commercial rocket	Transfers lander from Gateway to low lunar orbit	Descends From Transfer vehicle to lunar surface	Ascends from lunar surface to Gateway

Up to three commercial rocket launches, depending on distribution of the Transfer, Descent, and Ascent functions.

current draft as of 5/21/2019

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Launchers, landers, orbital infrastructure – global cooperation, US lead

Avionics for “System of Systems”

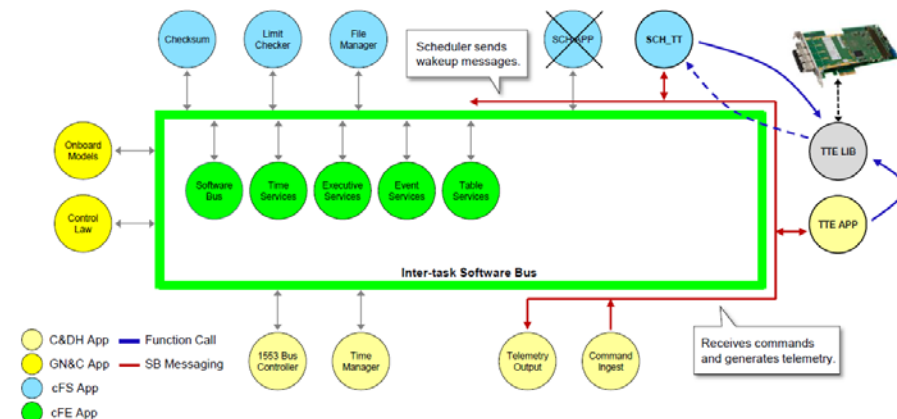
- ✓ International partnership requires open, international standards:
www.internationaldeepspacestandards.com
- ✓ “Networks for vehicle command and control functions need to support various voting schemes such as exact match, fault-tolerant averaging...”
- ✓ Rendezvous and docking (IRSIS): “Inter-element networking”
- ✓ “A synchronized, unified time information shall be maintained by all vehicles in the overall architecture, including visiting vehicles as well as the target vehicle.”
- ✓ “Utilization of **strong space-time partitioning** to accommodate mixed criticality and data types” (similar to Distributed Integrated Modular Avionics – DIMA approach in aeronautics)
- ✓ Simple, ideally “COTS” interfaces for crew and science => Ethernet!

Less Code, Reduced Testing

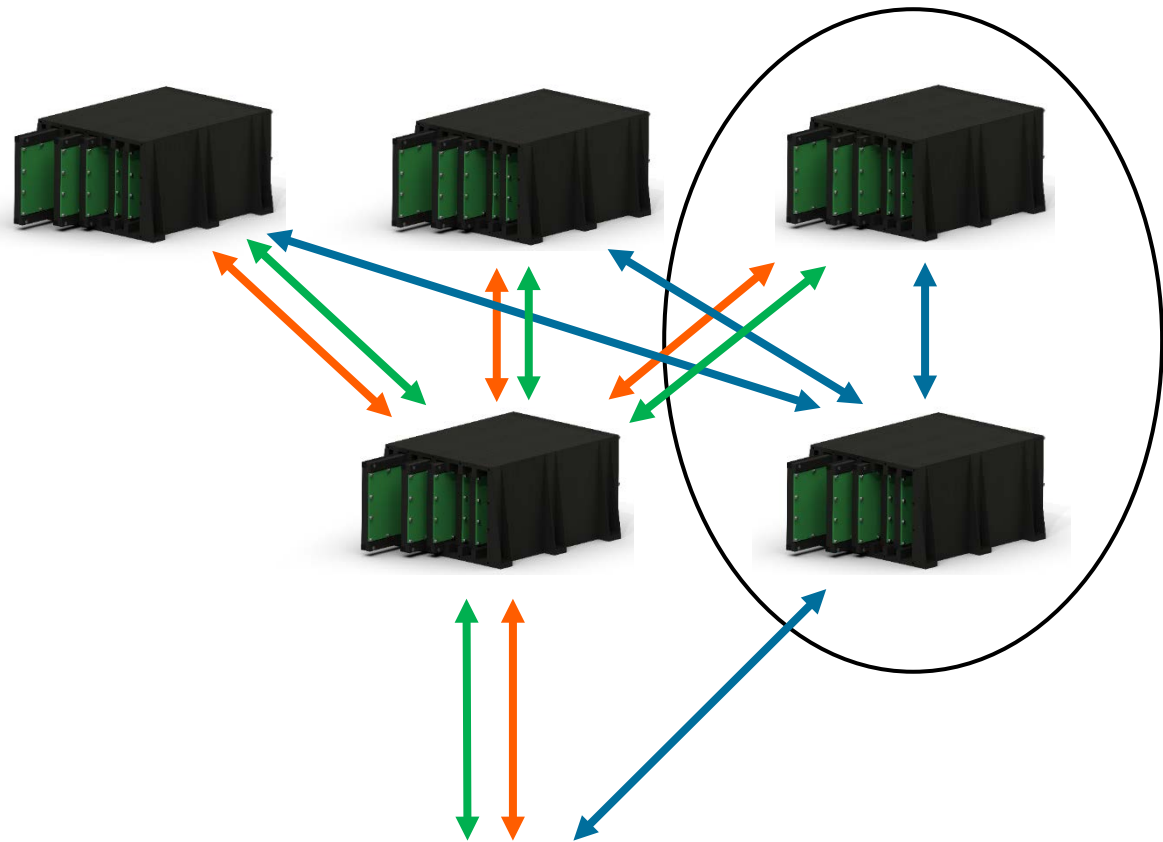
- Key elements of redundancy and fault management in hardware
- Fault-tolerant synchronization in hardware (distributed clock) – vs. in software
- Known states incl. deterministic message sending order → simplified software architecture and V&V

More Re-Use, Advanced Tools

- Common, open/openly available, but version-controlled framework – like AUTOSAR or SAVOIR
- ...or NASA Core Flight System “cFS”
 - “Flight software command, control and communication framework based on a common message distribution capability”
 - “Common developer toolset for application development and integration”



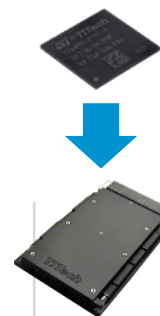
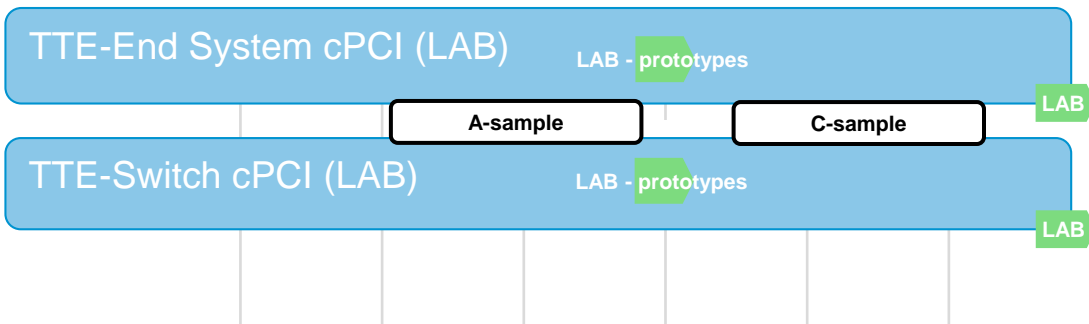
Modularity Through Common Equipment



Various sensors and actuators

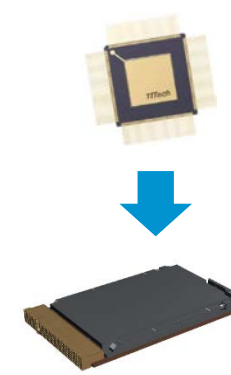
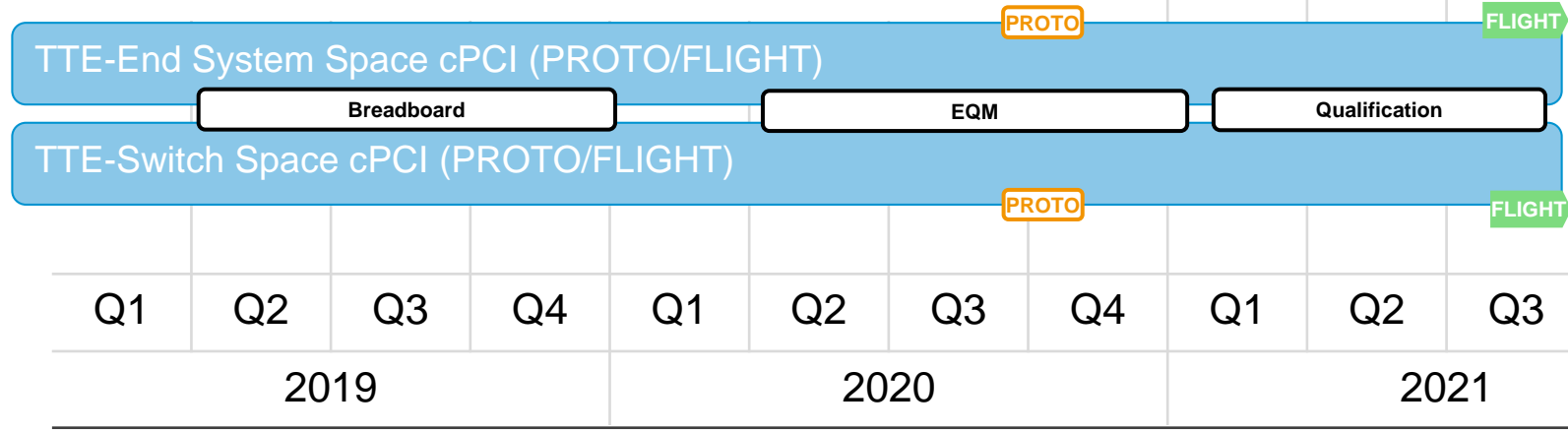
- Standardized hosting units
- Standardized fault-tolerant switches and network interface cards
- Integration of various types of on-board computers
- Partitioning and redundancy management in hardware, elimination of voting software
- Scalable...

EPOS Phase I: Lab Equipment

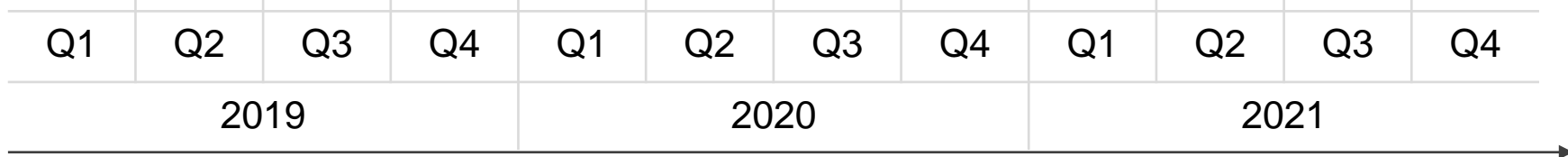


Based on TTE-Controller HiRel

EPOS Phase II: Flight Equipment



Based on TTE-Controller Space





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