SAVOIR Implementation Strategy
The Hardware Perspective

Ph. Armbruster, C. Taylor, G. Magistrati (TEC-ED)

In cooperation with

A. Benoit, R. Jansson, G. Ortega (TEC-EC)
K. Hjortnaes and J.L Terraillon (TEC-SW)

ESA/ESTEC
25/10/2011

SAVOIR Implementation Strategy
The Hardware Perspective : Outline

- Introduction
- SAVOIR : the three pillars
  - Standardisation of interfaces
  - Generic Specifications
  - Building Blocks
- Data Handling and AOCS BBs
- SAVOIR Validation and Demonstration Approach
- Avionics 2015
- Conclusions

Introduction: Data Handling Systems (1/2)

Long Term Quest (started in the 80's)

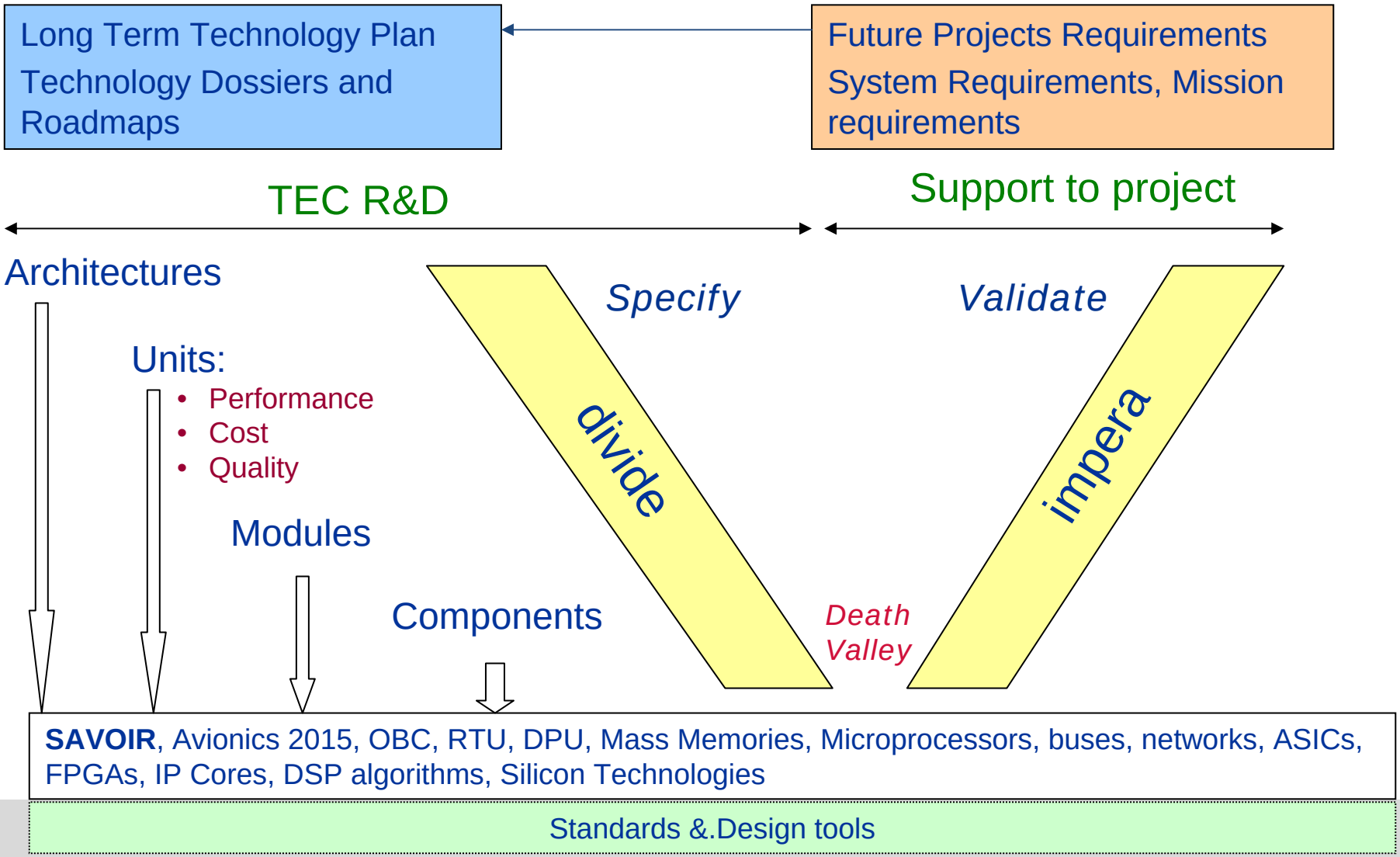
- Rationalise the development of Data Handling Systems (DHS) in order to constrain development costs
- Insert technology advances where ever it has a significant impacts on budgets (reduced volume, mass, cost and enhanced reliability)
- Provide project Users with:
  - Components (Rad Hard)
  - *Units (Fitting well the needs, via equipment suppliers)*
  - *Tools to build and configure DHS*

Introduction : Data Handling Systems (2/2)

Approach

- Step 1 : Standardization of interfaces; first ad-hoc (OBDH, Mil1553B) and then in a systematic manner via ECSS
- Step 2a : Adopt/adapt/develop missing communication links, busses: SpaceWire, CAN, Sensor Bus, RS422 protocol, Wireless, High speed interfaces and standardise them via ECSS
- Step 2b: Define and standardize Communication Services : SOIS via CCSDS
- Step 3: Global approach
  - Define Architectures
  - Identify Building blocks
  - Validate BBs in application context : *focus of this presentation*

Global paradigm : “divide et impera”



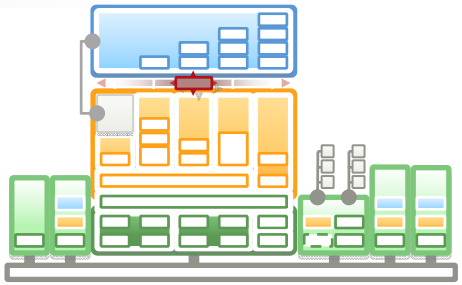
SAVOIR

- Provides a new paradigm to foster innovation and competitiveness for Avionics while benefiting from technology evolutions
- Provides a frame and associated methodologies : System decomposition in sub-elements, Building Blocks identification and usage
- Is multidisciplinary: Avionics seen as a system integrating Data Handling, Control and SW aspects contributing to a major Satellite sub-system.
- Associates all stakeholders: Agencies, Primes, Suppliers and Projects around a consensual paradigm

SAVOIR views

Reference architecture

– A set of architectural design principles and a mapping of the usual functions implemented by the software and the hardware



Functional architecture

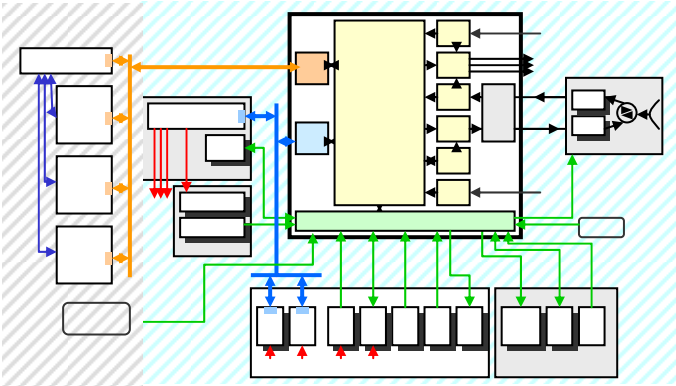
– Focus is on the system functionalities to be implemented and on the relation to their environment

– A functional architecture is built, independently from the issues brought by the integration on an execution platform.

Set of ECSS Standards (E-50)
CCSDS (SOIS) and
Generic spec's

Physical architecture

– The Physical architecture describes the processing nodes of the system (i.e. on-board computer), sensors and actuators, the network topology (buses/point-to- point links/serial lines) that interconnects them and the communication protocol used by the physical communication layers.



SAVOIR first pillar: Standardisation of Interfaces and Services

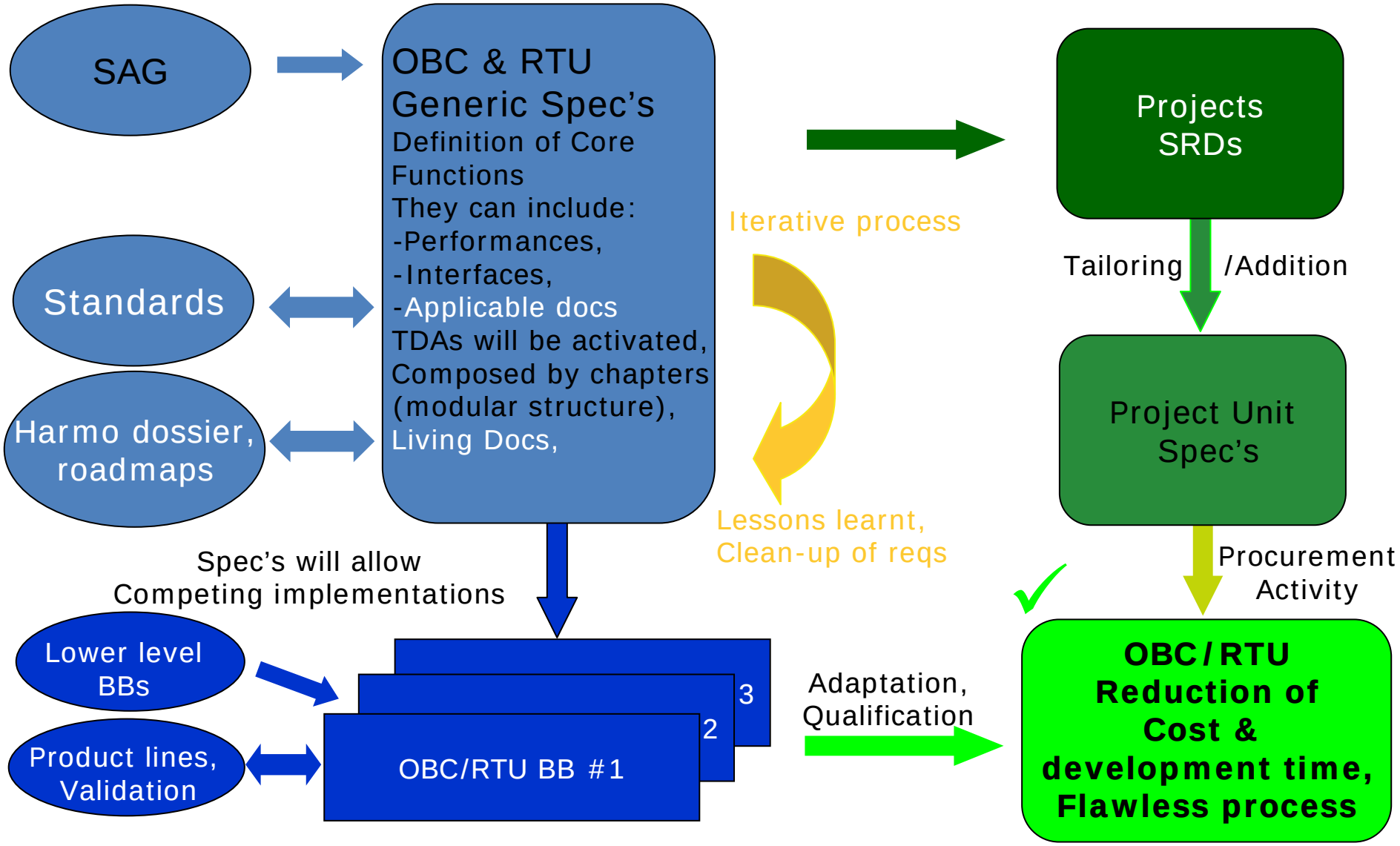
ECSS

- ECSS-E-ST-50 C Communications
- ECSS-E-ST-50-01C Space data links - Telemetry synchronization and channel coding
- ECSS-E-ST-50-02C Ranging and Doppler tracking
- ECSS-E-ST-50-03C Space data links - Telemetry transfer frame protocol
- ECSS-E-ST-50-04C Space data links - Telecommand protocols, synchronization and channel coding
- ECSS-E-ST-50-05C Rev2 Radio frequency and modulation
- ECSS-E-ST-50-12C SpaceWire - Links, nodes, routers and networks
- ECSS-E-ST-50-13C Interface and communication protocol for MIL-STD-1553B data bus onboard spacecraft
- ECSS-E-ST-50-14C Spacecraft discrete interfaces
- ECSS-E-ST-50-51C SpaceWire protocol identification
- ECSS-E-ST-50-52C SpaceWire - Remote memory access protocol
- ECSS-E-ST-50-53C SpaceWire - CCSDS packet transfer protocol
- Applicable documents
- Reference

CCSDS

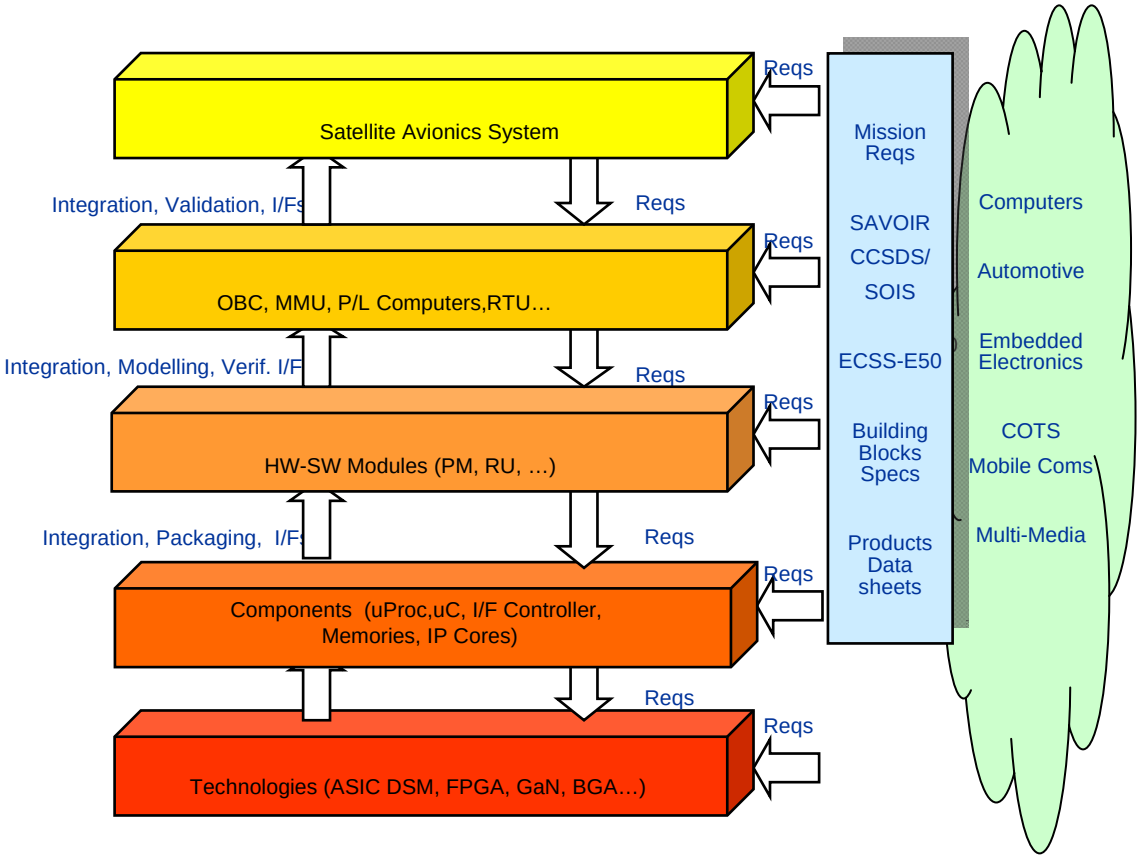
- CCSDS 850.0-G-1 Spacecraft Onboard Interface Services. Green Book.
- CCSDS 851.0-M-1 Spacecraft Onboard Interface Services--Subnetwork Packet Service. Magenta Book.
- CCSDS 852.0-M-1 Spacecraft Onboard Interface Services--Subnetwork Memory Access Service. Magenta Book.
- CCSDS 853.0-M-1 Spacecraft Onboard Interface Services--Subnetwork Synchronisation Service. Magenta Book.
- CCSDS 854.0-M-1 Spacecraft Onboard Interface Services--Subnetwork Device Discovery Service. Magenta Book.
- CCSDS 855.0-M-1 Spacecraft Onboard Interface Services--Subnetwork Test Service. Magenta Book.
- CCSDS 872.0-M-1 Spacecraft Onboard Interface Services—Time Access Service. Magenta Book.
- CCSDS 880.0-G-1 Wireless Network Communications Overview for Space Mission Operations. Green Book

SAVOIR second pillar: Generic Specifications e.g. for OBC and RTU : logic



SAVOIR third pillar: Building Blocks

- Elements of a Technology Stack
- Developed within TRP, GSTP, ECI, other
- Have to reach:
  - a given TRL (e.g. > 4-5)
  - in a prescribed timeframe



How do we implement SAVOIR ?

Project and customer acceptance / confidence needed

New platform conforming to new architecture (Industrial validation)

SAVOIR Working Groups (SAIF, SOIS, EDS, SAFI)

Stable Agreed Standards

Component developments needed to support new standards

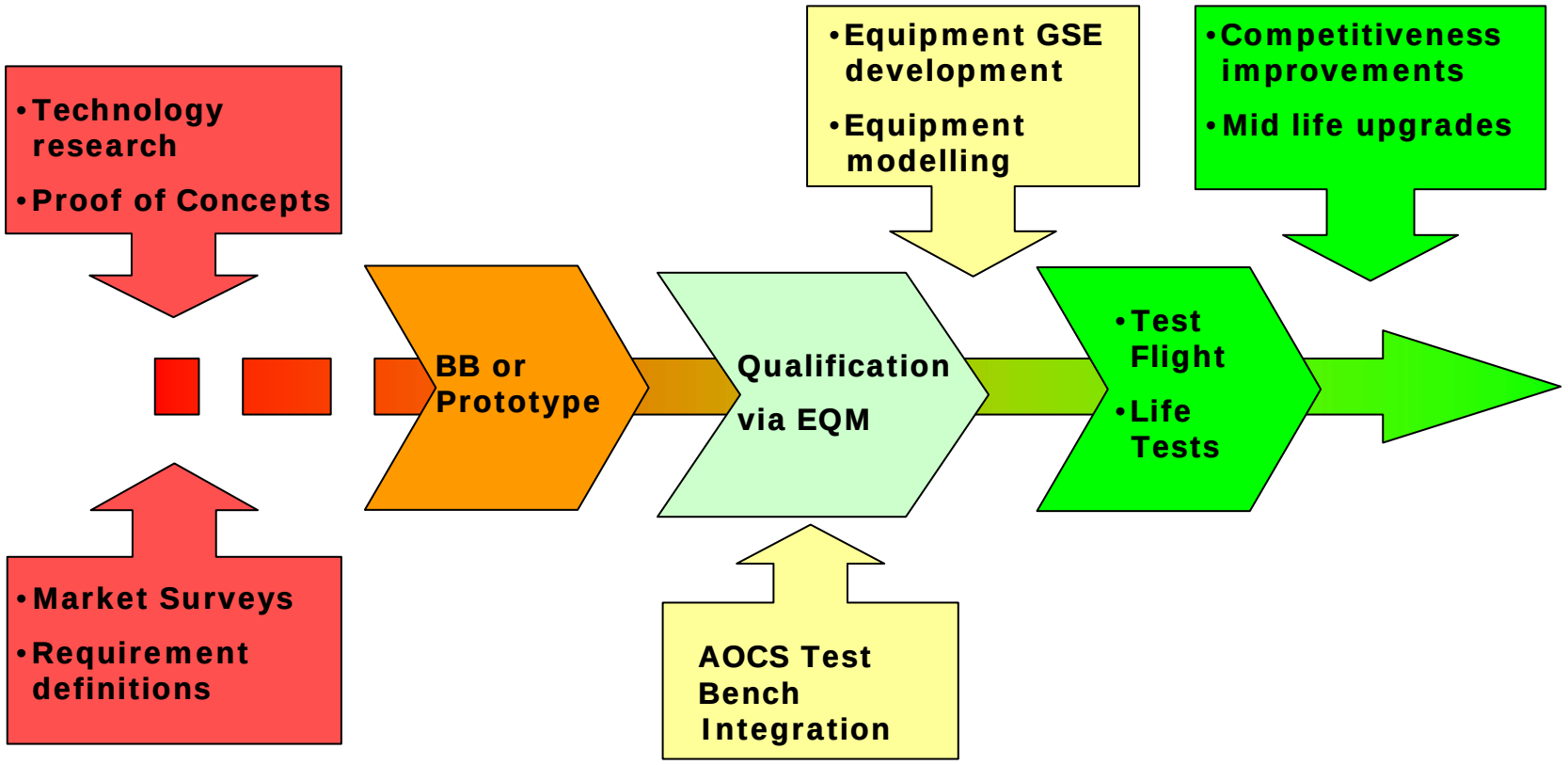
Equipments / Units supporting Standards

ESA and Industrial Benches validating architecture

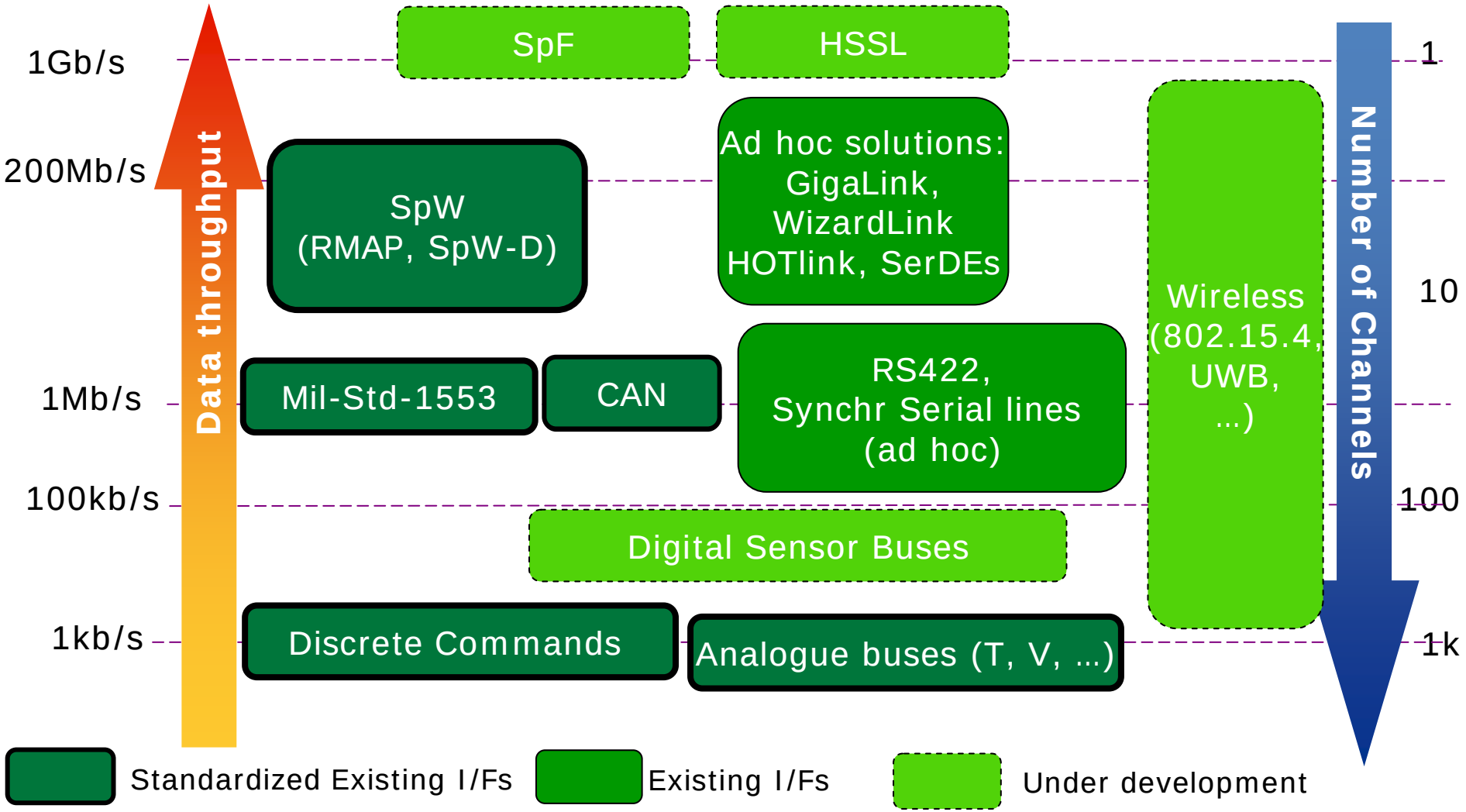
Avionics 2015

Building Blocks Generic Development approach

The generic development approach follows a similar philosophy for all units and is shown schematically below. Depending on the maturity of the unit/ idea the development will start at a different point within the chart.

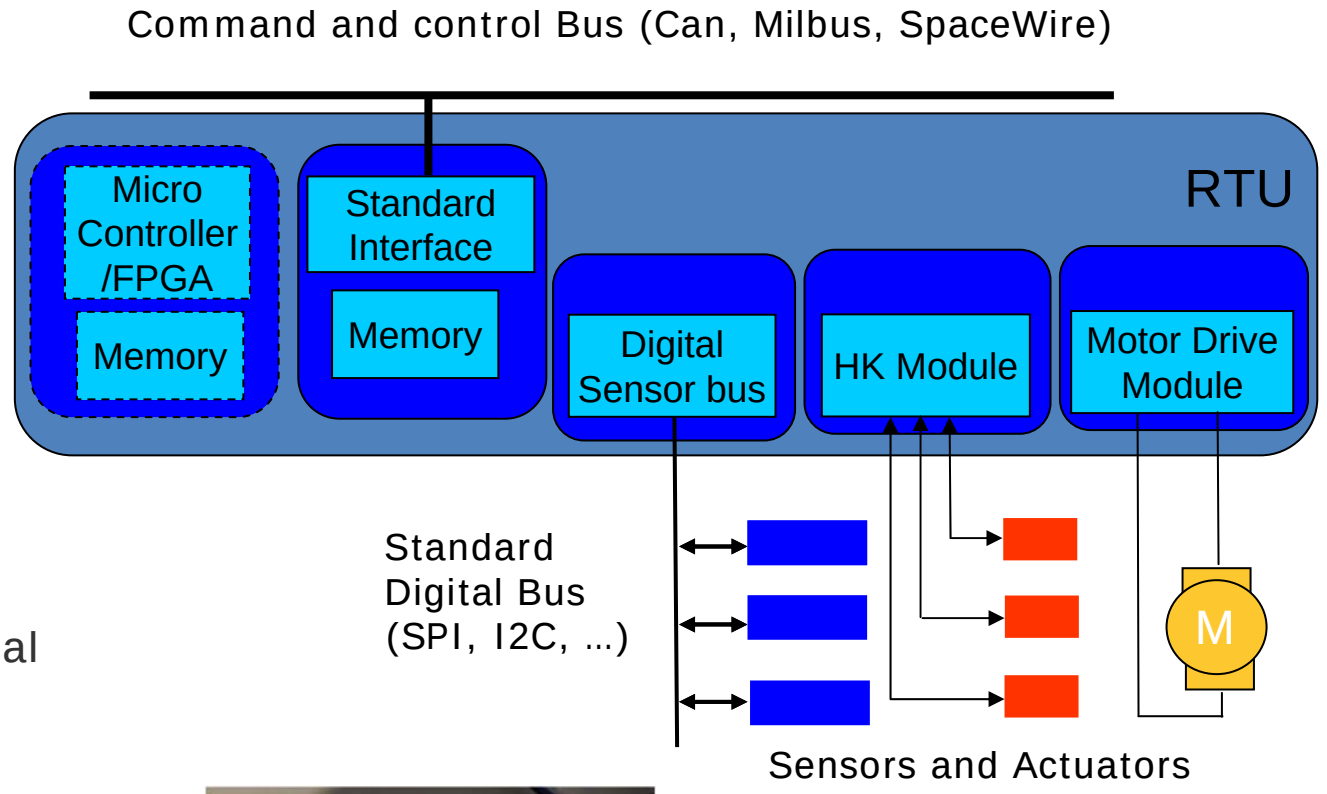


Data Systems Building Blocks, example 1 : Busses

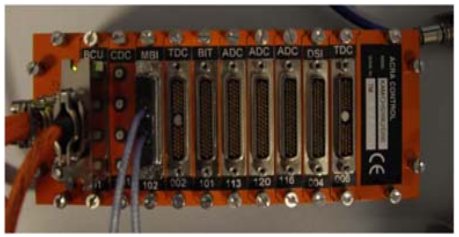


Data Systems Building Blocks : example 2 RTU 2015

- Remote terminal unit acts as a data concentrator
- Standard interface to OBC/CDMU with a standardized protocol
- Standard Serial bus to devices
- S/C may employ several miniaturised versions

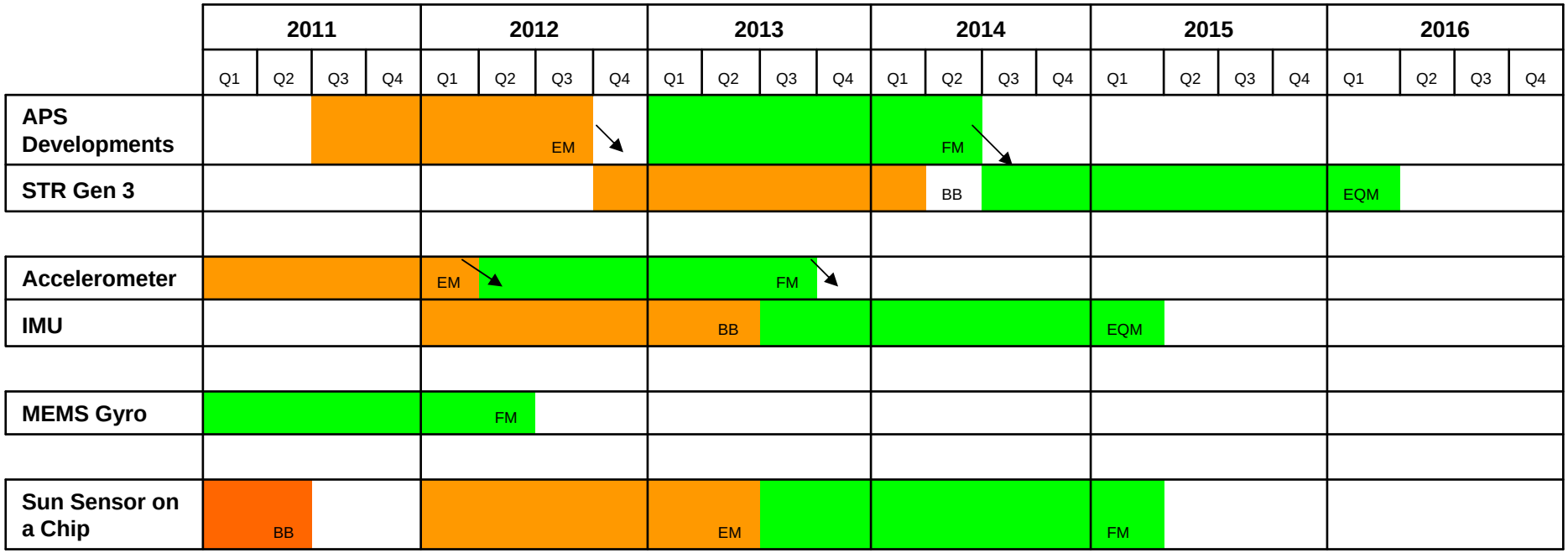


Aeronautics/Embedded examples of RTUs



AOCS BBS: Sensor / Actuator Building Blocks

The AOCS Sensor and Actuator developments follow very much the harmonisation that took place 1st semester 2009. The schedule below highlights the main current and future development of the AOCS building blocks.



AOCS BBs Sensor/ Actuator Developments

- Star Trackers

TODAY

Data Interfaces
MIL -1553
RS-422

Power Interfaces
28V Primary
50V-100V Primary
Internal/ External LCL
Internal/ External Switching

Key Specifications
Mass: ~2.5Kg
Dimensions: ~10*10*25cm
Update rate:10Hz
Performance Class: ~ 1.5 - 2”

TOMORROW

Functional Interface

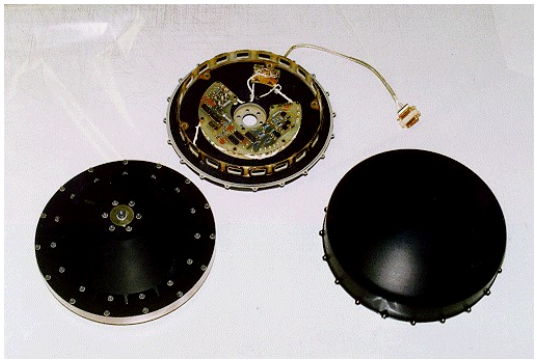
Data Interfaces
SpW
RS-422 + protocol
MIL -1553
CAN ?

Power Interfaces
28V Primary
Low voltage secondary
50V-100V Primary
External LCL
External Switching

Key Specifications
Mass: <1.5Kg
Dimensions: ~8*8*15cm
Update rate:10Hz and higher
Performance Class: ~ 1.0 – 1.5”

AOCS BBs: Sensor/ Actuator Developments

- Reaction Wheels



TODAY

Data Interfaces
Analogue

Power Interfaces
28V Primary
50V-100V Primary
Internal/ External LCL
Internal/ External Switching

Key Specifications
Mass: ~8.5Kg
Dimensions: ~30*30*10cm
Update rate:10Hz
Performance Class:
12 – 40 Nms
0.075 – 0.2Nms

TOMORROW

Functional Interface

Data Interfaces
RS-422
MIL -1553
CAN ?

Power Interfaces
28V Primary
50V-100V Primary
Internal/ External LCL
Internal/ External Switching

Key Specifications
Mass: <8Kg
Dimensions: ~30*30*10cm
Update rate: >10Hz and higher
Performance Class:
5 – 50Nms
0.15 – 0.4Nms
Improved disturbances

AOCS BBs: Sensor / Actuator Developments

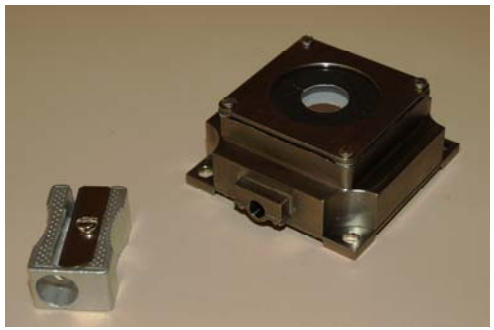
- New AOCS Equipments

IMUs

Data Interfaces
MIL-1553
RS-422 (TBC)
SpW (TBC)

Power Interfaces
28V Primary
External LCL
External Switching

Key Specifications
Mass: <2.5 Kg, 6 axis
Update rate: 10Hz
Power: <10W
Performance: <0.1deg/hr, <0.01mg



'System on Chip' Sensors (e.g. Sun Sensor on a chip)

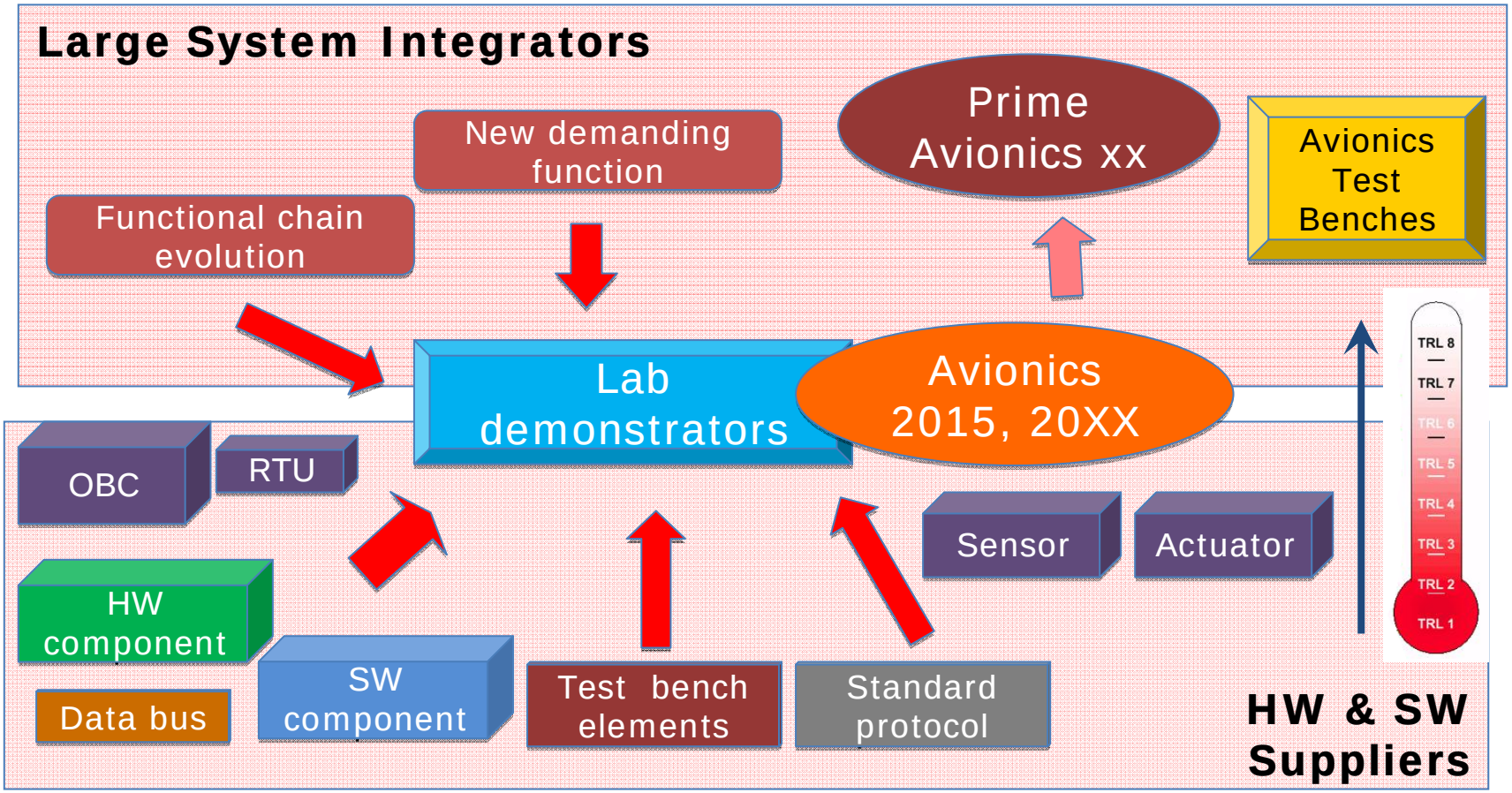
Data Interfaces
SpW
RS-422 + Protocol
Sensor Bus ?

Power Interfaces
Low voltage secondary
External LCL
External Switching

Key Specifications
Mass: <100 g
Dimensions: ~3*3*3cm
Update rate: 10Hz
Power: << 1W

Lab demonstration

- The maturity and completeness of the SAVOIR concept will be assessed by building lab demonstrators integrating consistent set of items.



WHAT is Avionics 2015 ?

Avionics 2015 is an ESA/ESTEC undertaking, in full coordination with SAVOIR.

Avionics 2015 is based on SAVOIR outputs and aims at:

- demonstrating Avionics systems making use of SAVOIR outputs in a Lab Environment
- integrating seamlessly BBs with an achieved TRL of 5-6 in 2015

Avionics 2015 : Workplan

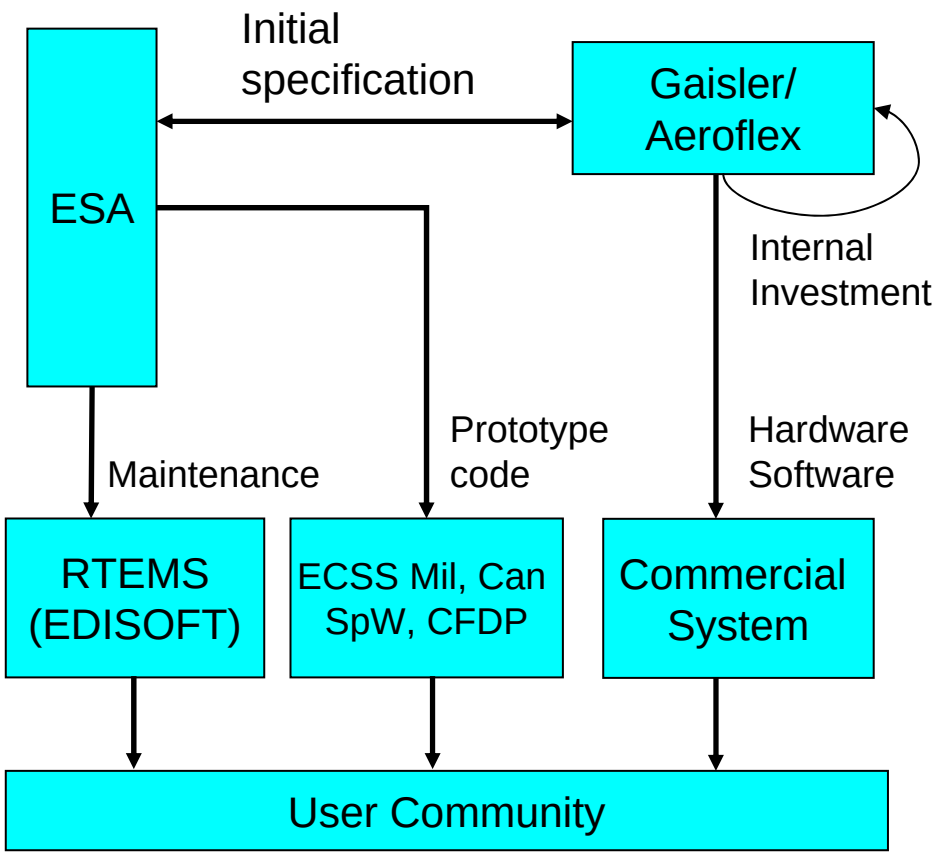
- RASTA will be used as infrastructure for prototyping activities for Data Handling and extension to Control Systems where it will act as Hardware in the loop.

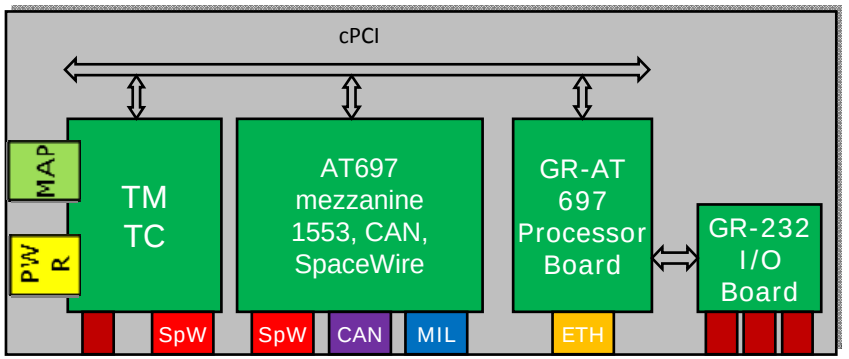
- Activities belonging to Avionics 2015 will be constrained to reach TRL5-6 in 2015, for instance:
  - RTU2015 (Modular General Purpose RTU supporting advanced low speed and medium speed serial busses) GSTP activity,
  - Standardization of Digital Interfaces for Sensors TRP activity.
  - uController2015 (Microcontroller for embedded space applications) TRP activity,

RASTA Reference Architecture System Test bed for Avionics

- RASTA is composed of a set of commercial hardware and software that may be used for prototyping HW and SW, including building blocks
- It is not built to flight standards but it is representative in terms of processor, operating system, interfaces and associated protocols
- It takes input from the following sources:
  - SAVOIR for Software/hardware architectures and building block identification
  - CCSDS for TM/TC, file transfer protocols and onboard communications services
  - ECSS for interfaces and onboard protocols
  - ESA for Processor (LEON), IP cores and key software

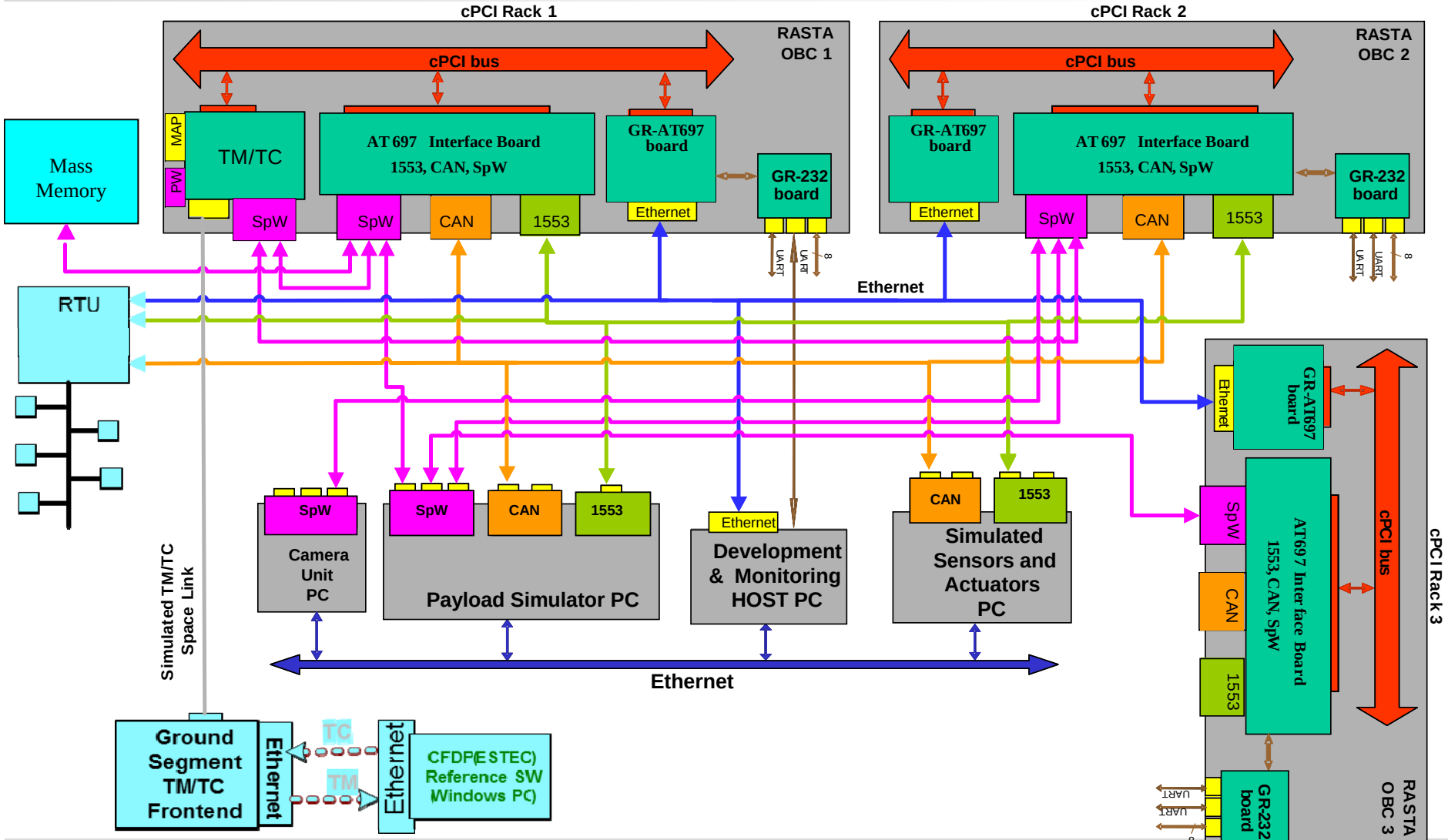
RASTA Development



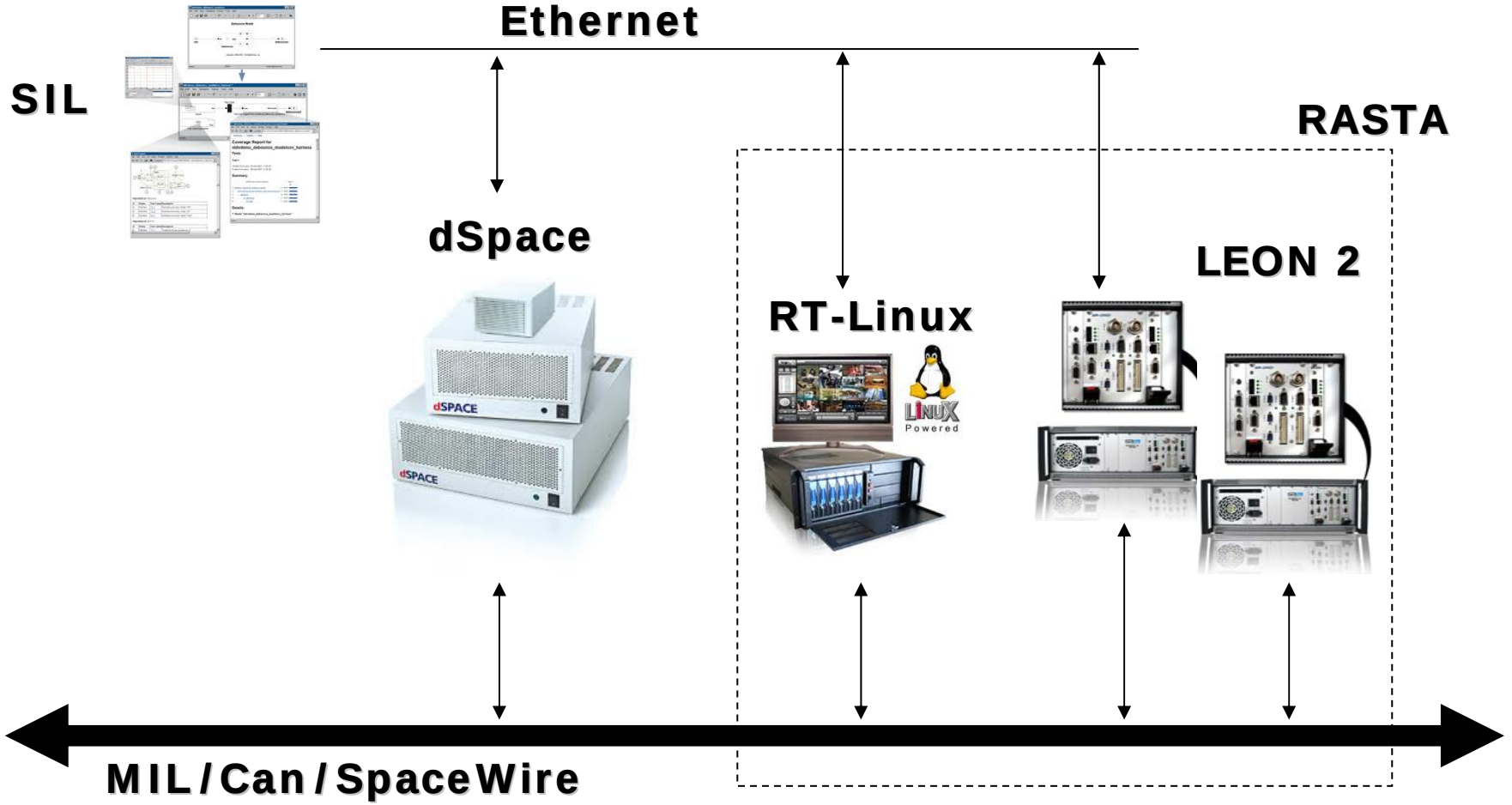


More than 40 systems sold world wide: EADS, TAS, RUAG, SciSys Spacebel, ESA etc

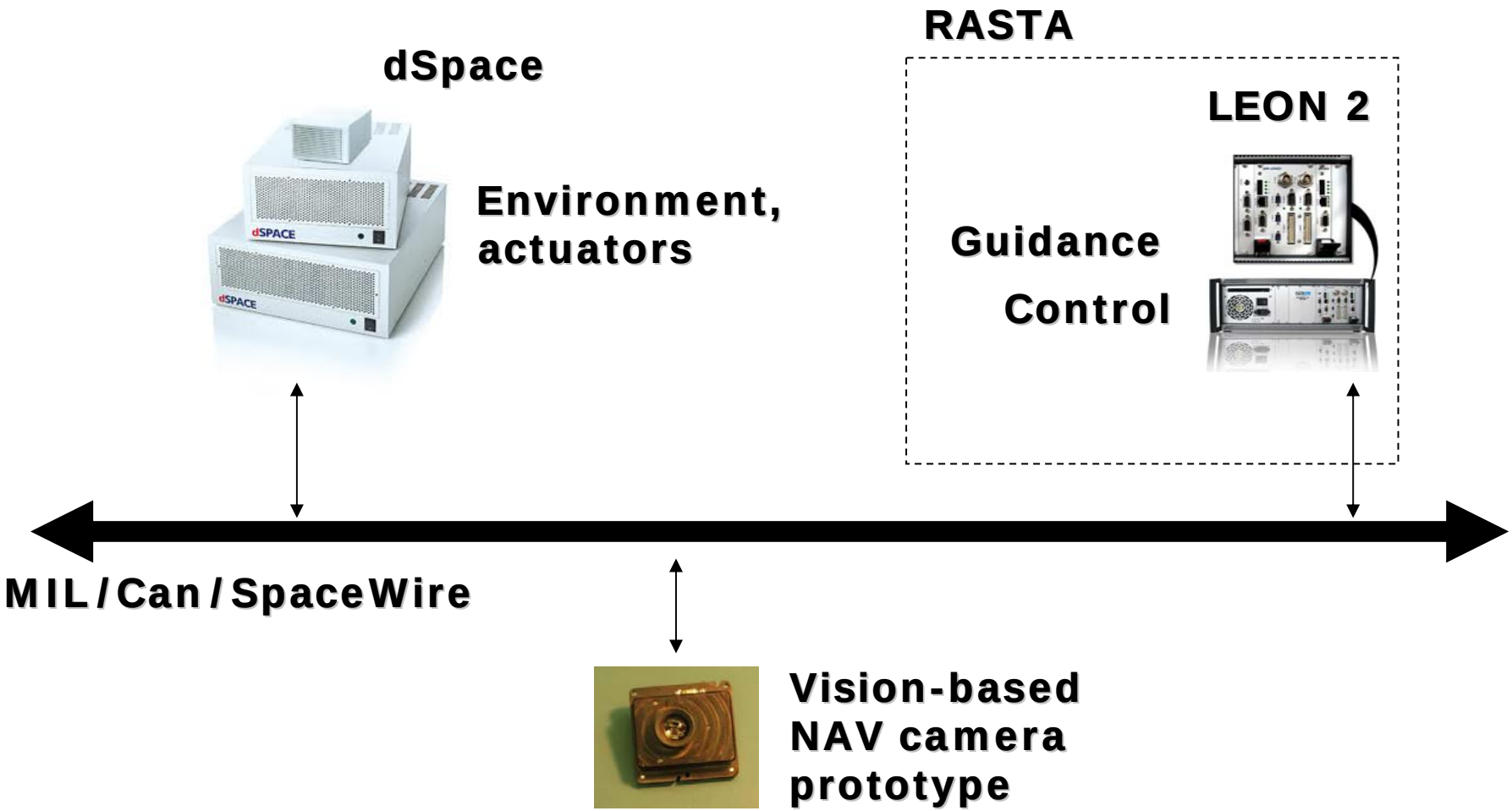
RASTA – Generic Test Configuration



AOCS: Example of lab setup using RASTA and TASTE



AOCS Hardware in the Loop with RASTA and TASTE



Conclusions

- SAVOIR provides an integrated approach to develop Avionics for space projects
- SAVOIR
- SAVOIR is TRL and programmatically conscious by embedding Validation and demonstration steps, such as Avionics 2015

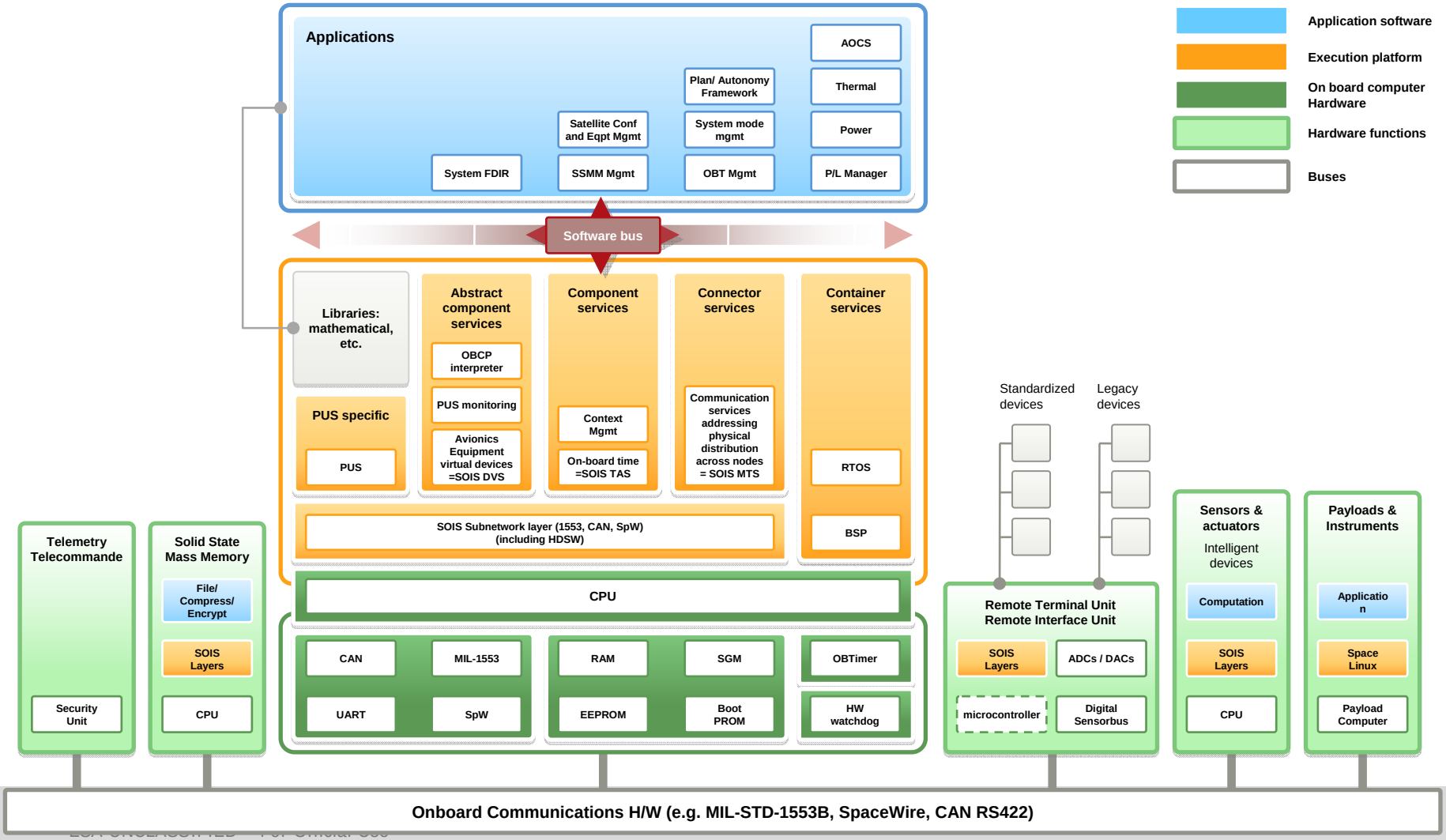
"SAVOIR: The sky is not the limit, it's the baseline" *(inspired by IBM)*

"SAVOIR is more than a concept, it's a life style" *(inspired by Kjeld Hjortnaes)*

Questions ?

Backup-up slides

The avionics reference architecture



DHS: Functional Specification

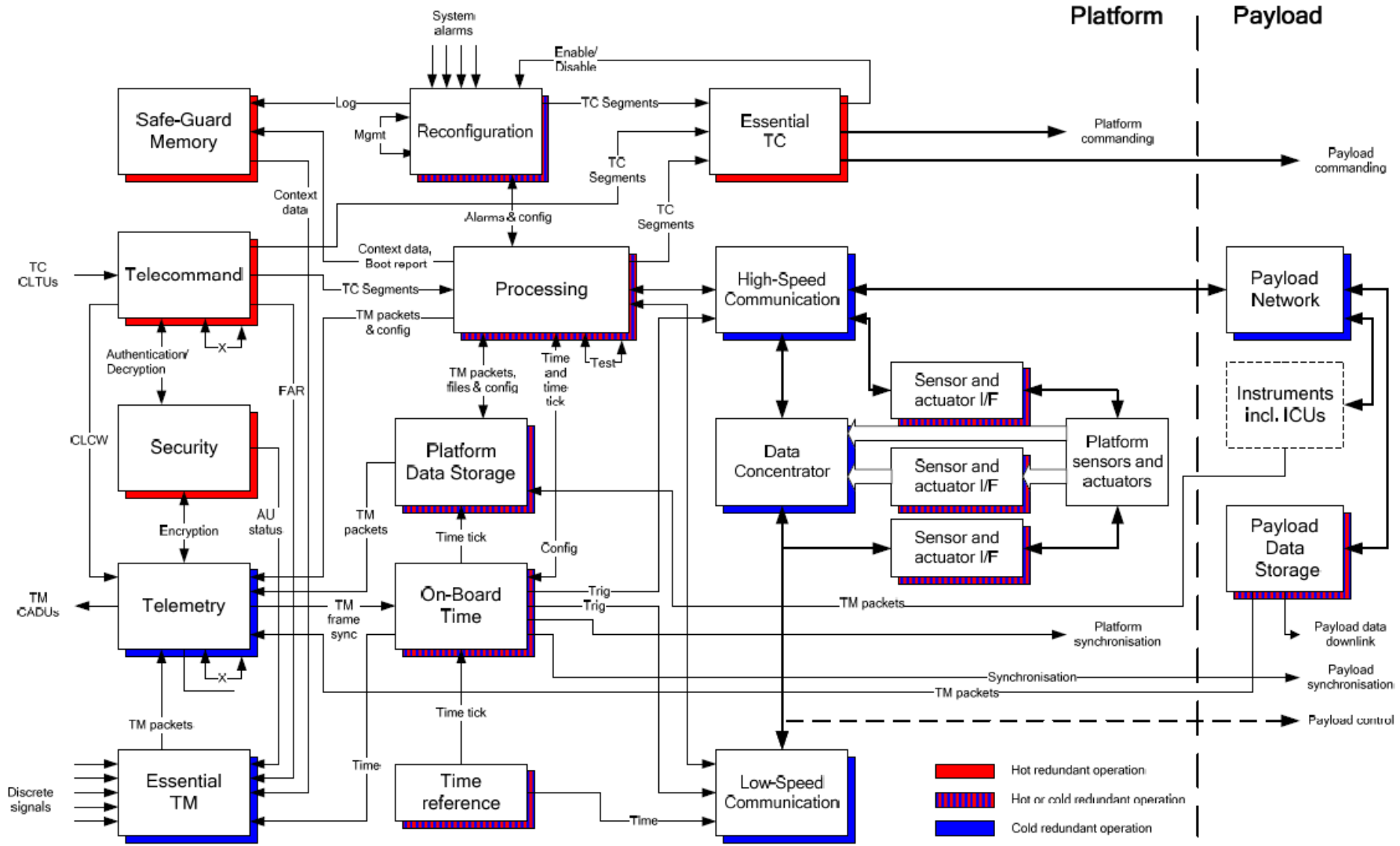


Figure 4 SAVOIR avionics functional diagram including closely related payload functions

Typical DHS architecture: Physical View