Space Avionics Open Interface Avionics Architecture

SAVOIR Overview

A common undertaking between the Control, Software and Data Systems divisions

European Space Agency

Introduction: On-board Data 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)

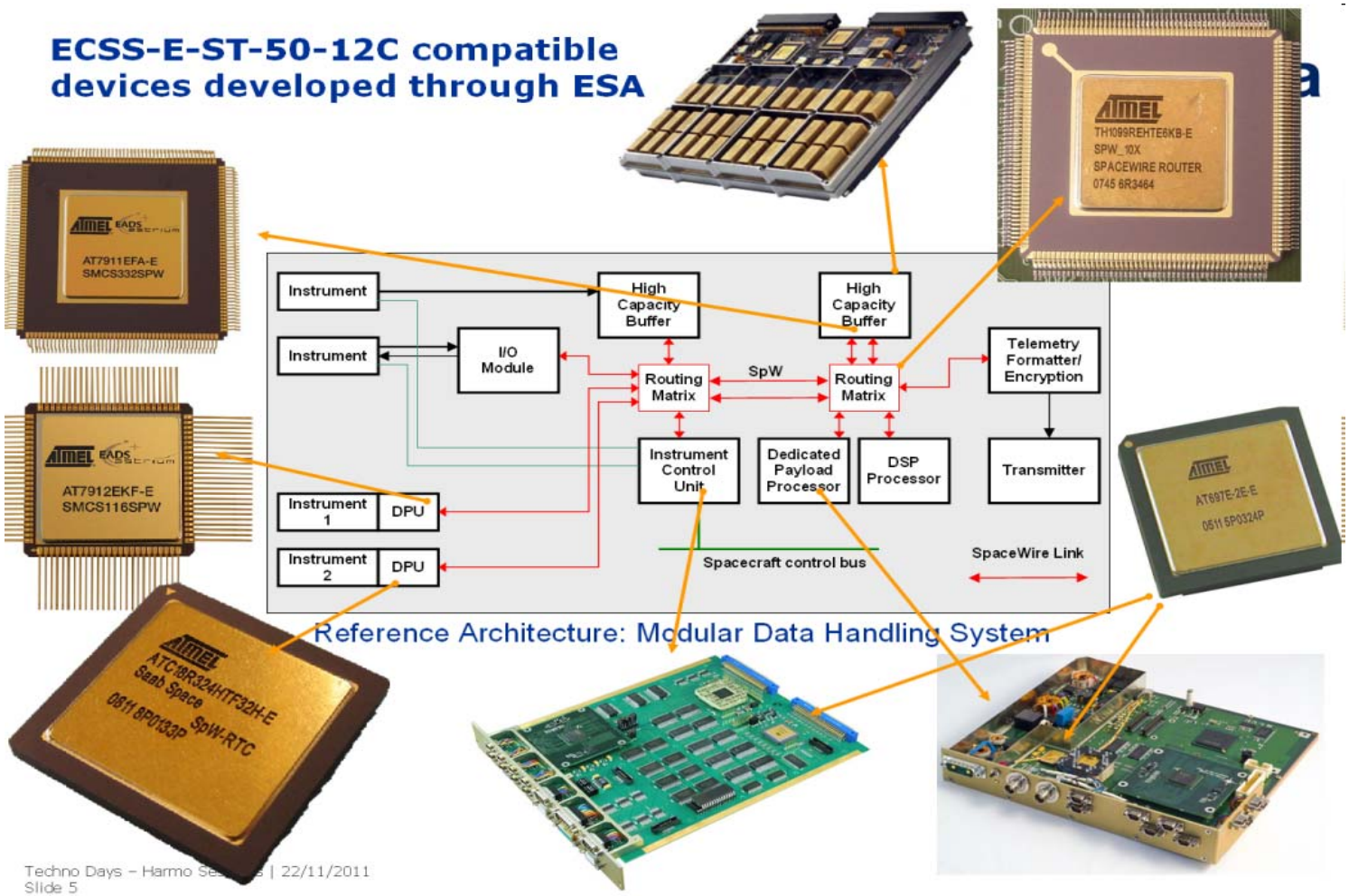
- Provide project Users with:
  - Components (Rad Hard)
  - *Units (Fitting well the needs, via equipment suppliers)*
  - *Tools to build and configure DHS*

Introduction : Data Handling Systems (2/2)

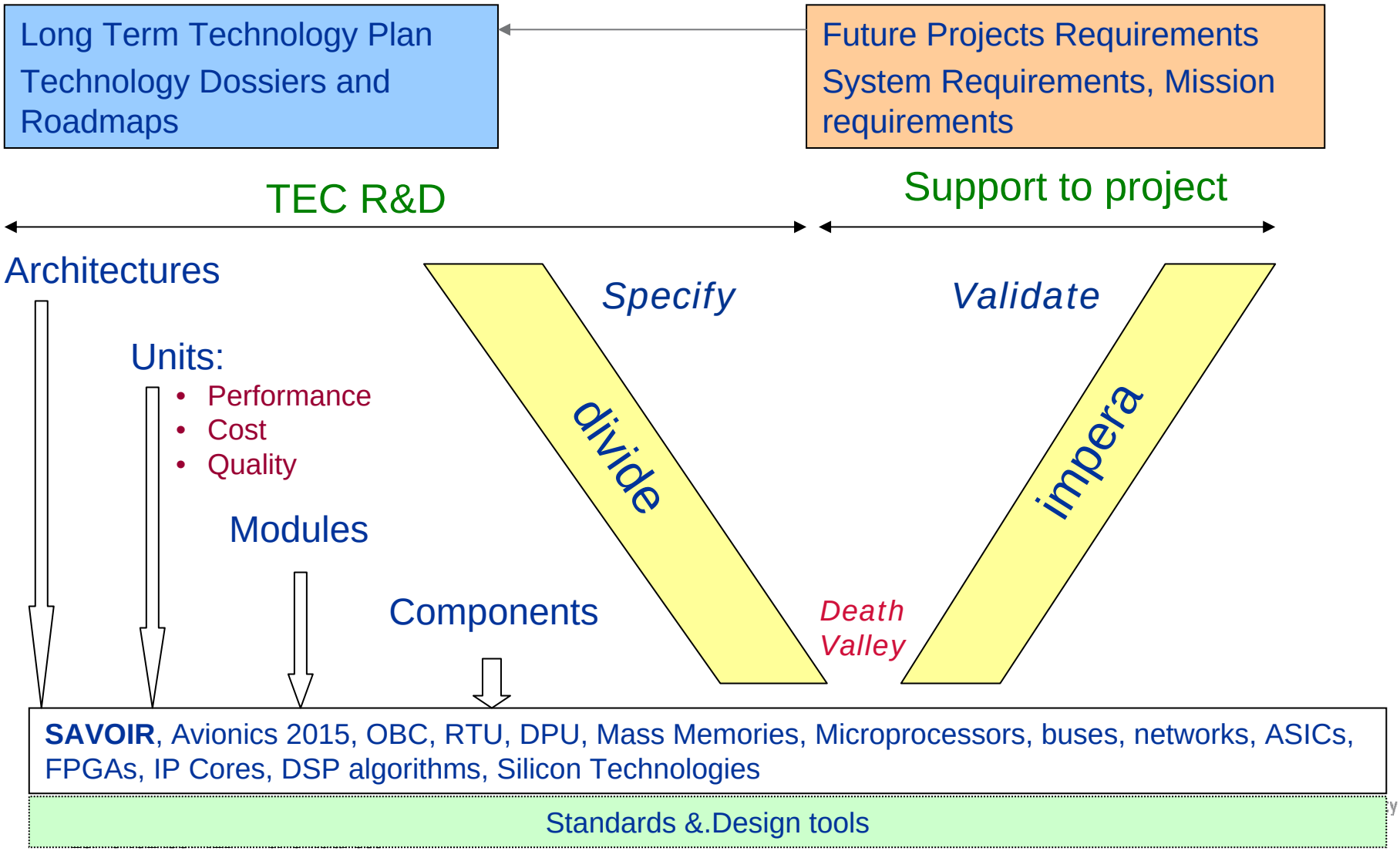
Approach

- 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*

On-Board Payload Data Processing



Global paradigm : “divide et impera”



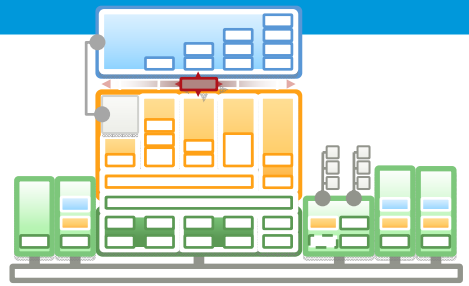
SAVOIR

- 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

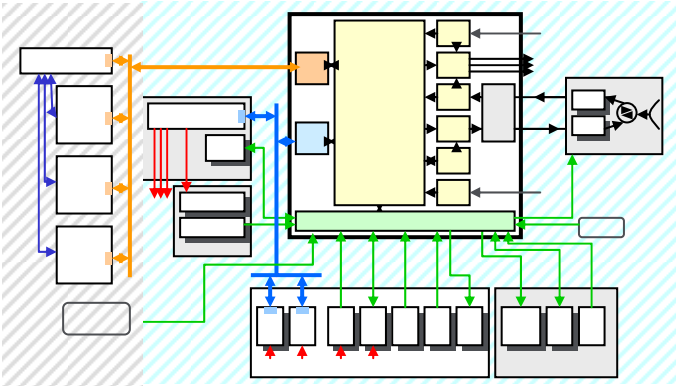
– Focus is on the system functionalities to be implemented and on the relation to their environment

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

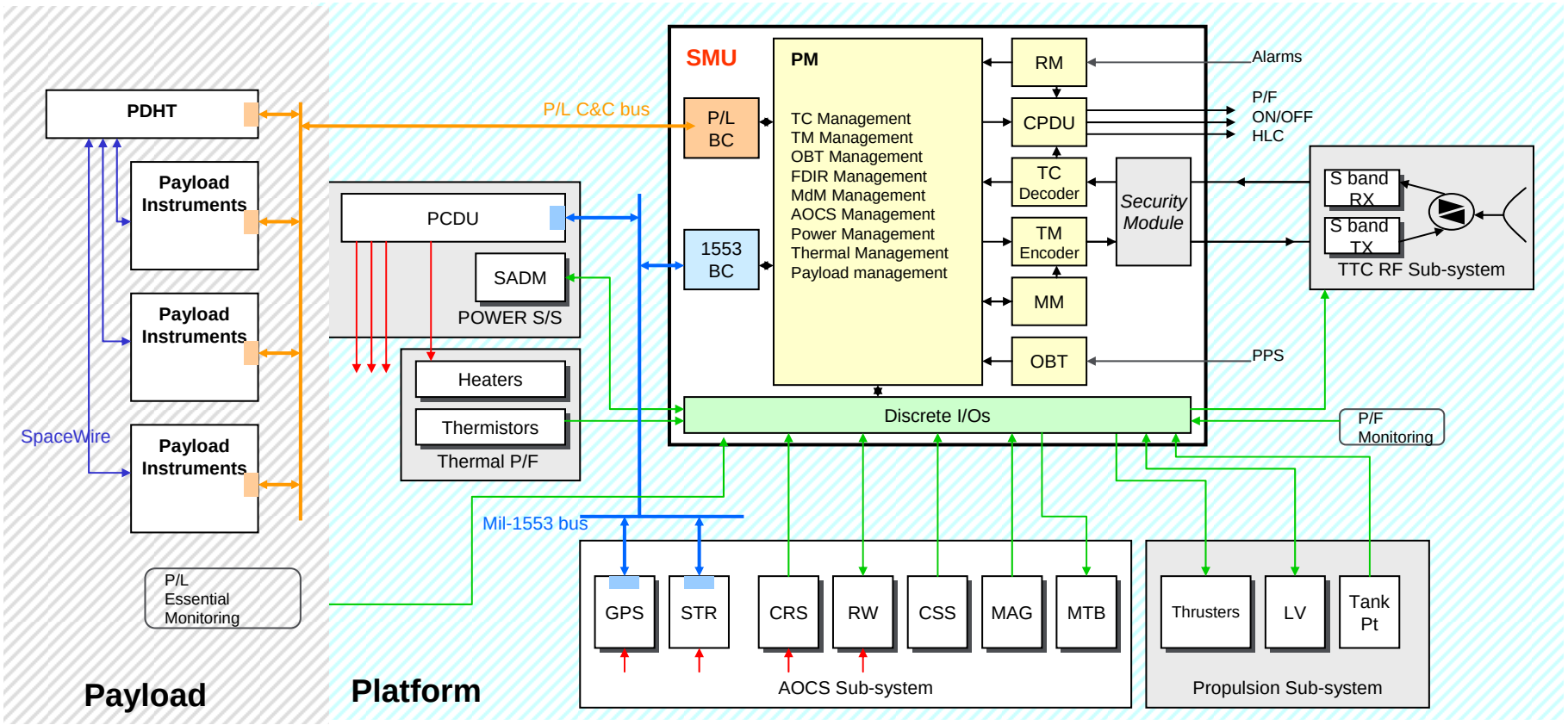
Set of ECSS Standards (E-50)
CCSDS (SOIS) and
Generic spec's

Physical architecture

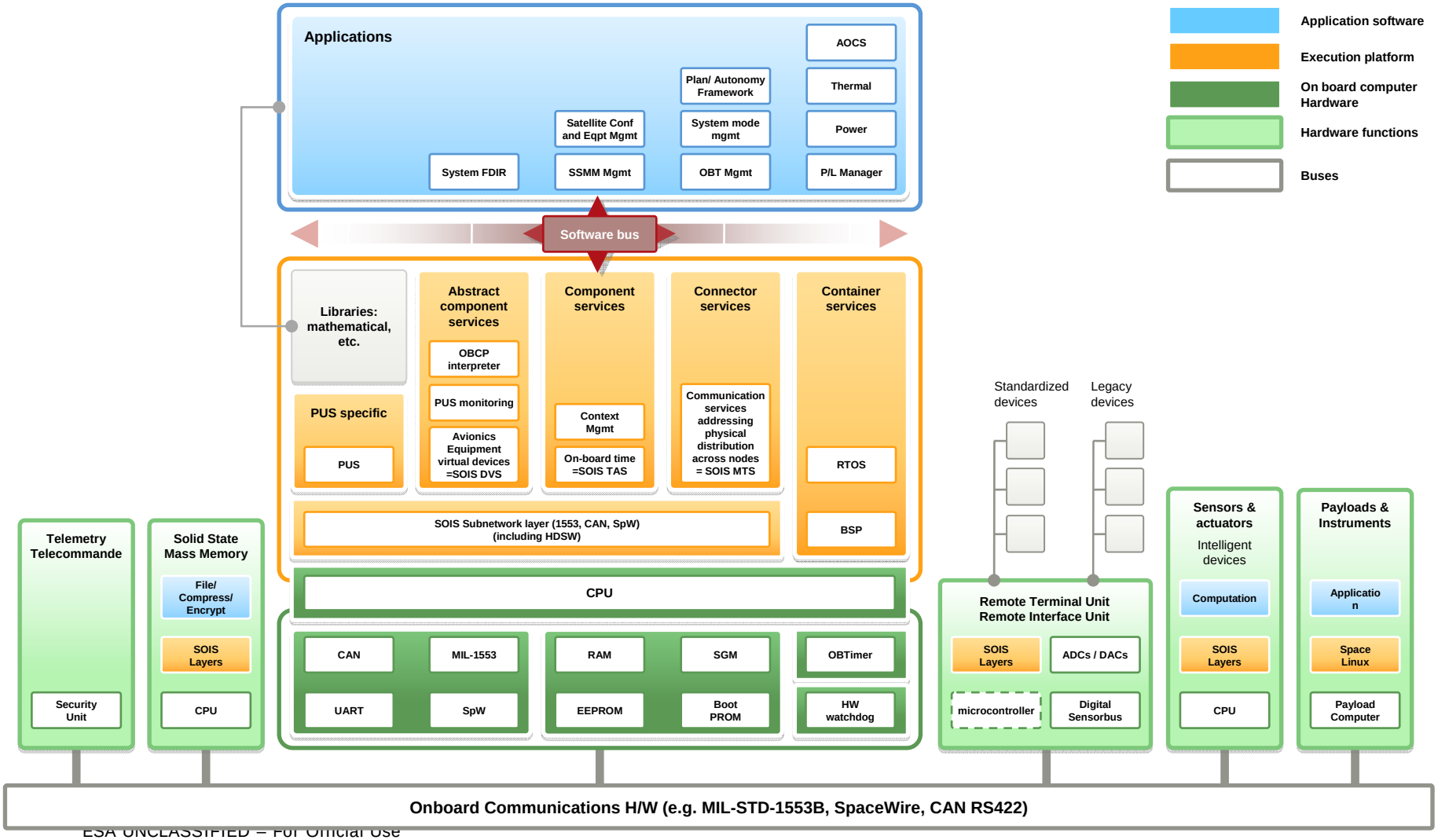
– The Physical architecture describes the processing nodes of the system (i.e. on-board computer), sensors and actuators, the network topology (buses/point-to- point links/serial lines) that interconnects them and the communication protocol used by the physical communication layers.



Typical DHS architecture: Physical View



The avionics reference architecture



DHS: Functional Specification

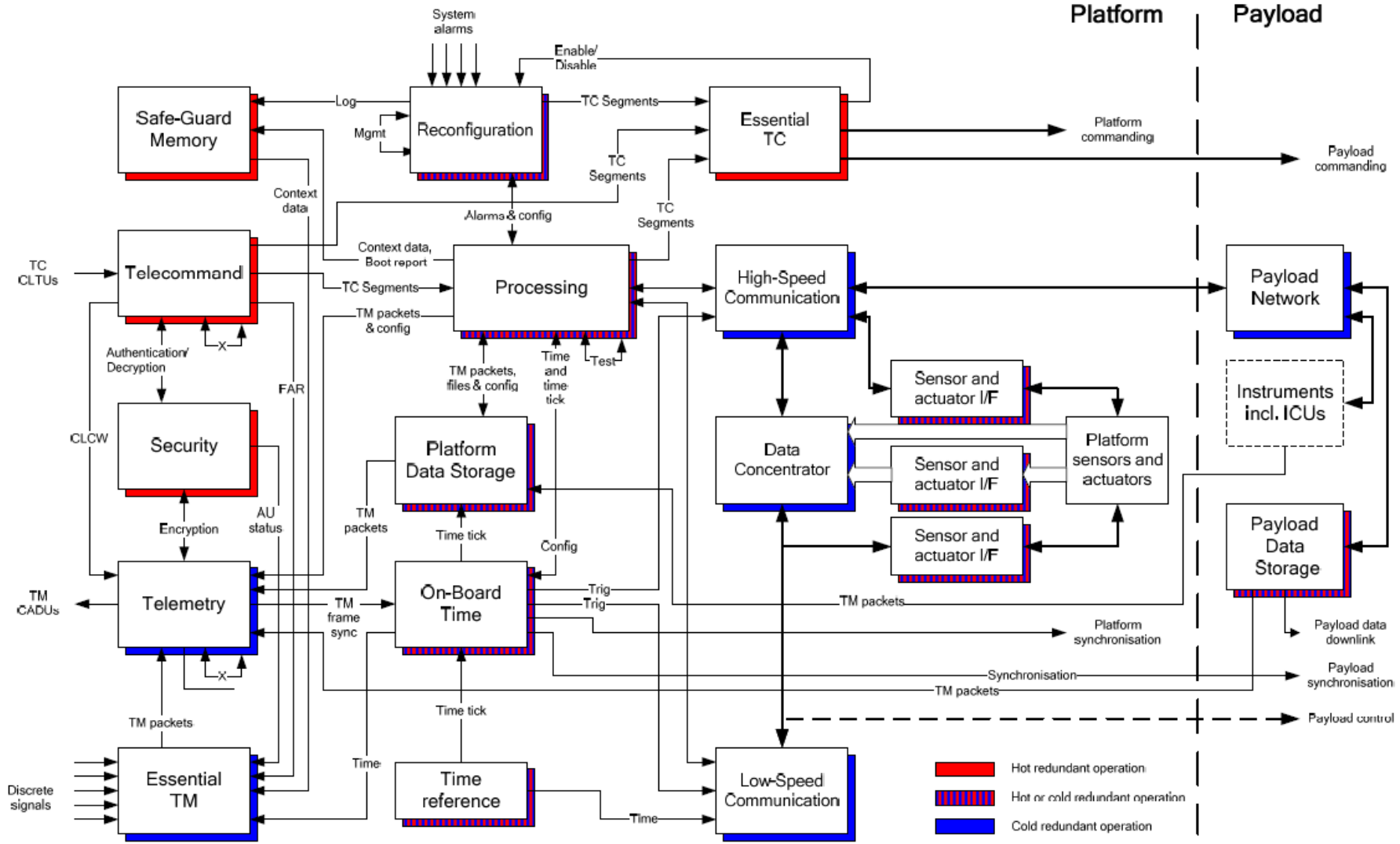


Figure 4 SAVOIR avionics functional diagram including closely related payload functions

SAVOIR first pillar: Standardisation of Interfaces and Services

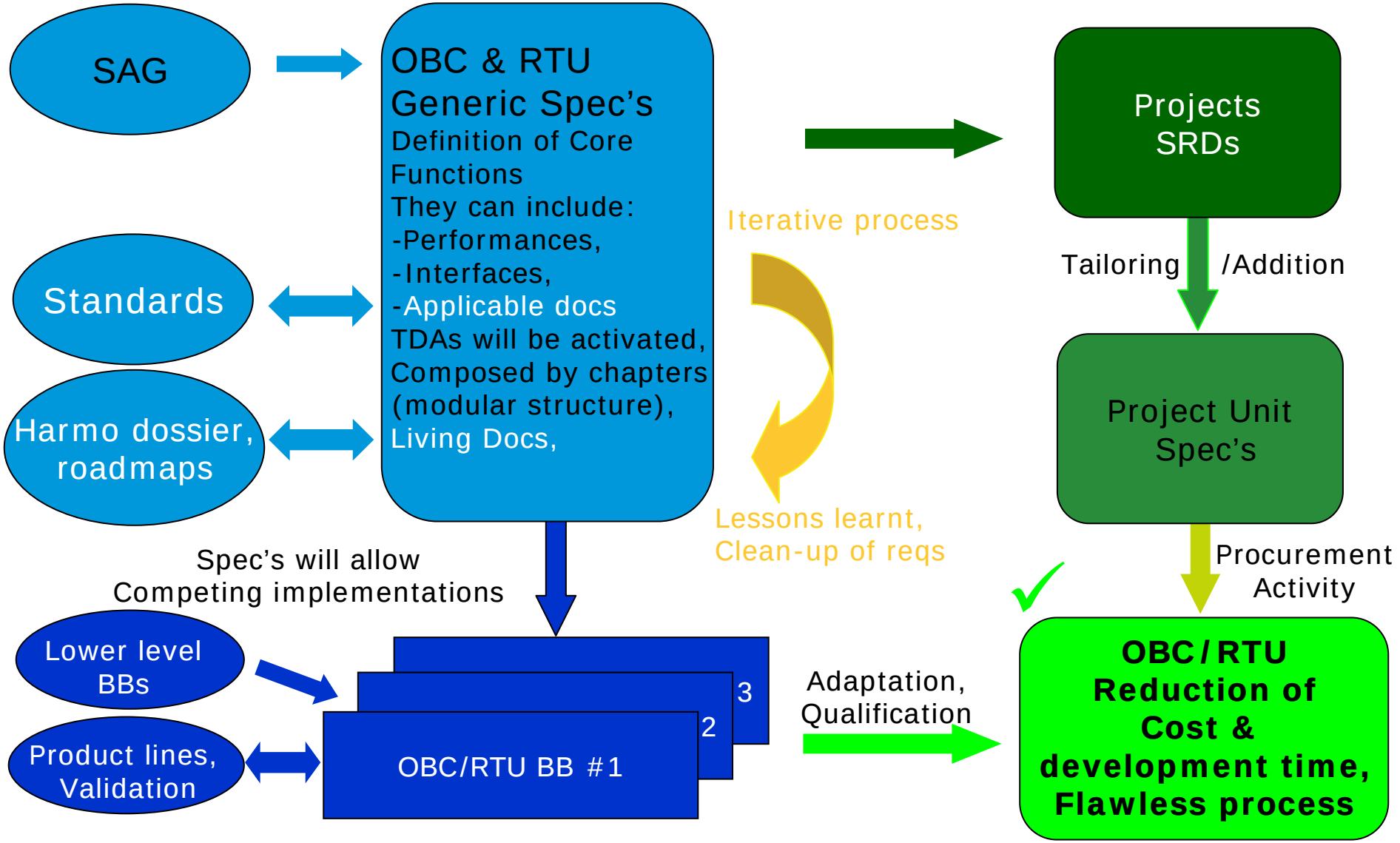
ECSS

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

CCSDS

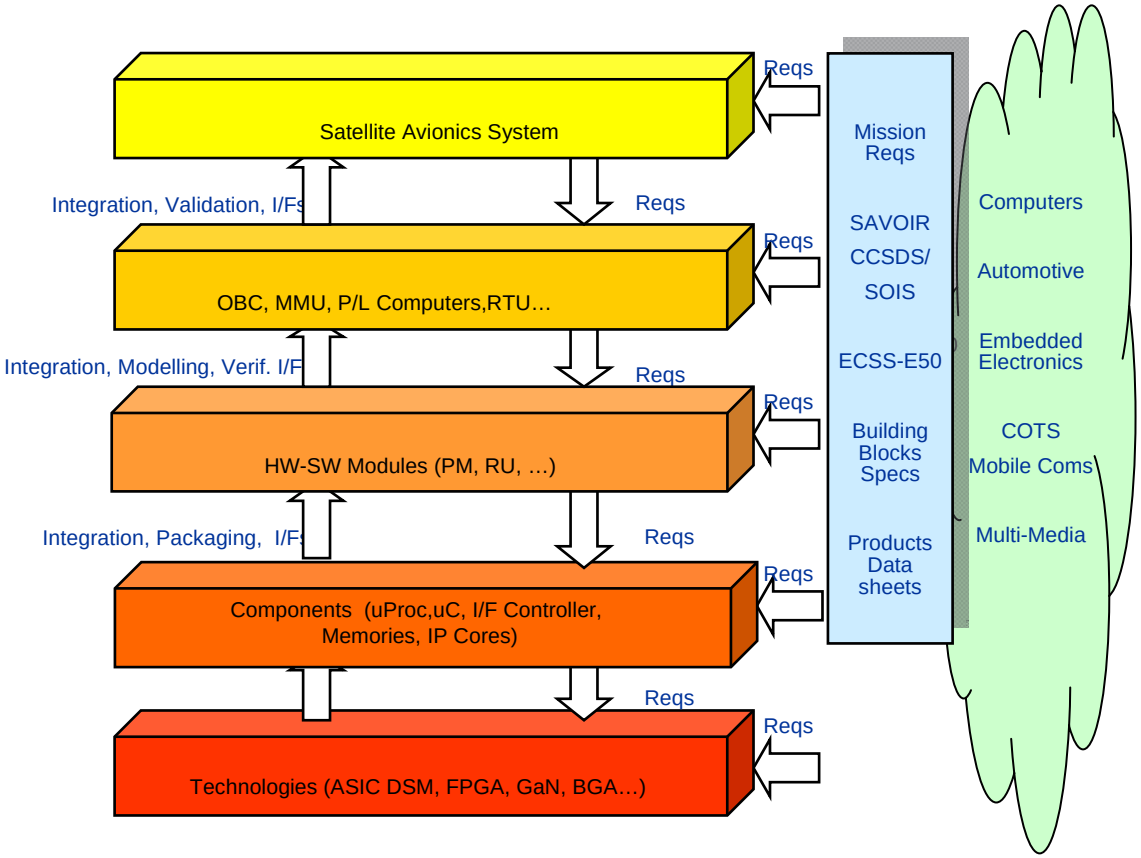
- CCSDS 850.0-G-1 Spacecraft Onboard Interface Services. Green Book.
- CCSDS 851.0-M-1 Spacecraft Onboard Interface Services--Subnetwork Packet Service. Magenta Book.
- CCSDS 852.0-M-1 Spacecraft Onboard Interface Services--Subnetwork Memory Access Service. Magenta Book.
- CCSDS 853.0-M-1 Spacecraft 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

Avionics 2015

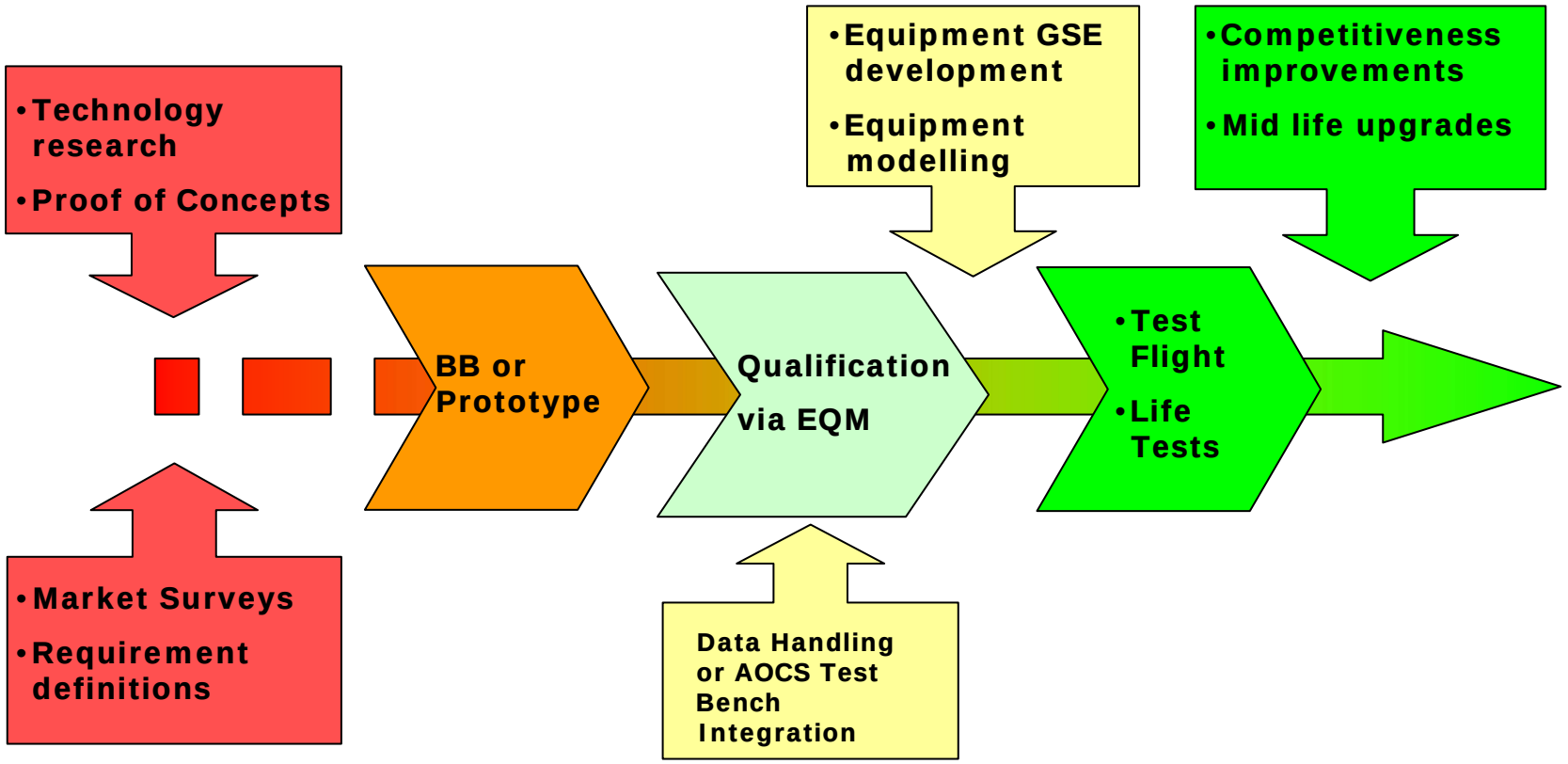
ESA and Industrial Benches validating architecture

Equipments / Units supporting Standards

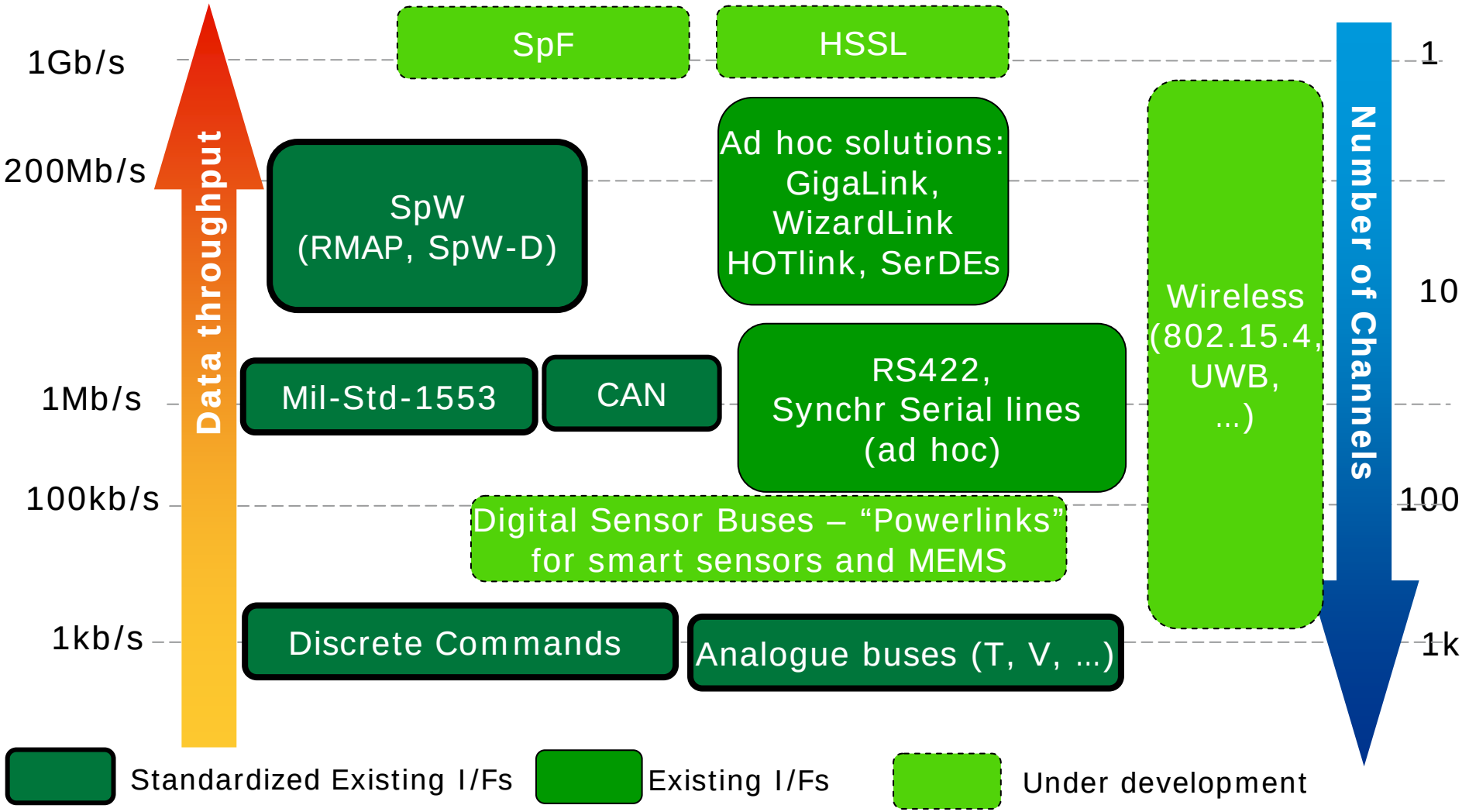
Component developments needed to support new standards

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.

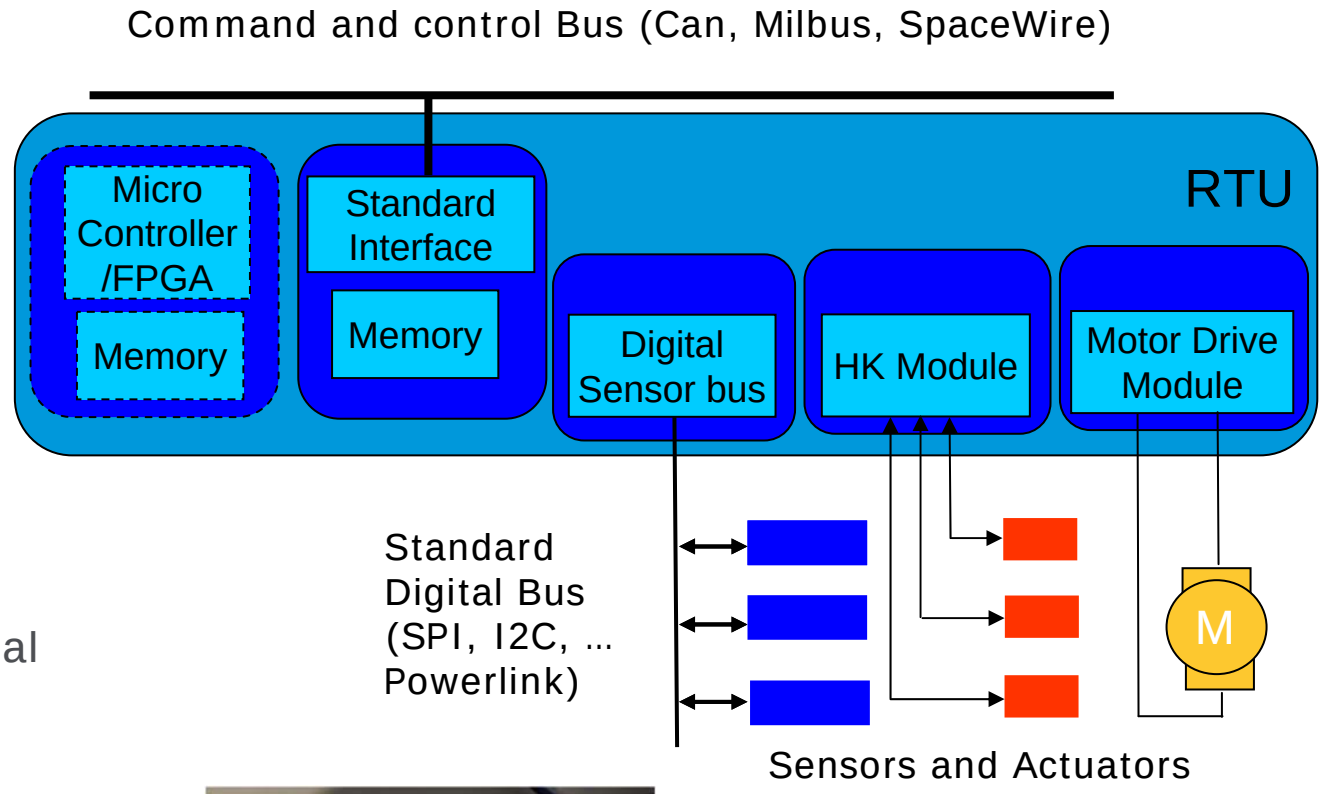


Data Systems Building Blocks, example 1 : Busses

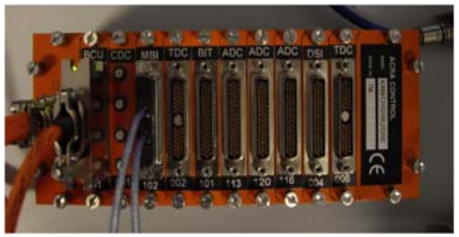


Data Systems Building Blocks : example 2
RTU 2015

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



Aeronautics/Embedded examples of RTUs



AOCS BBs Sensor/ Actuator Developments

1. 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

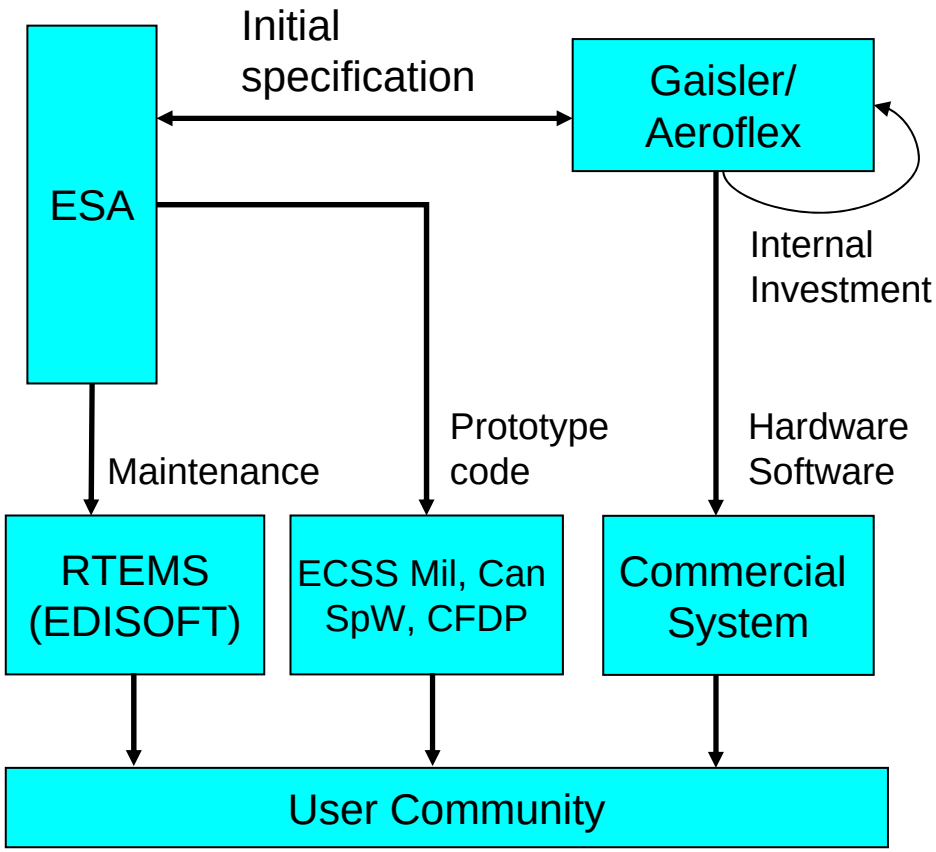
Functional Interface

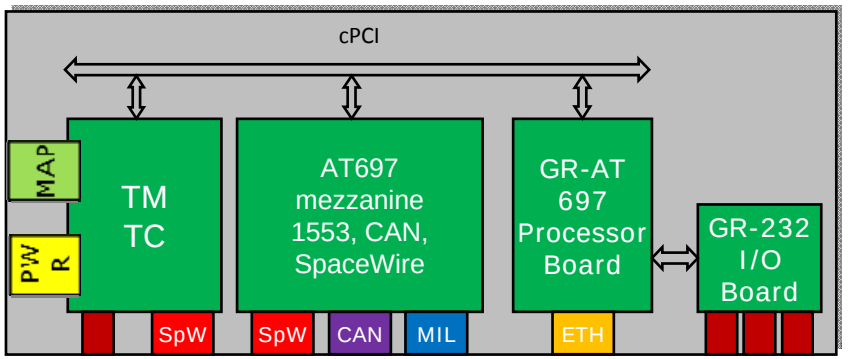
Data Interfaces
SpW
RS-422 + protocol
MIL -1553
CAN ?

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”

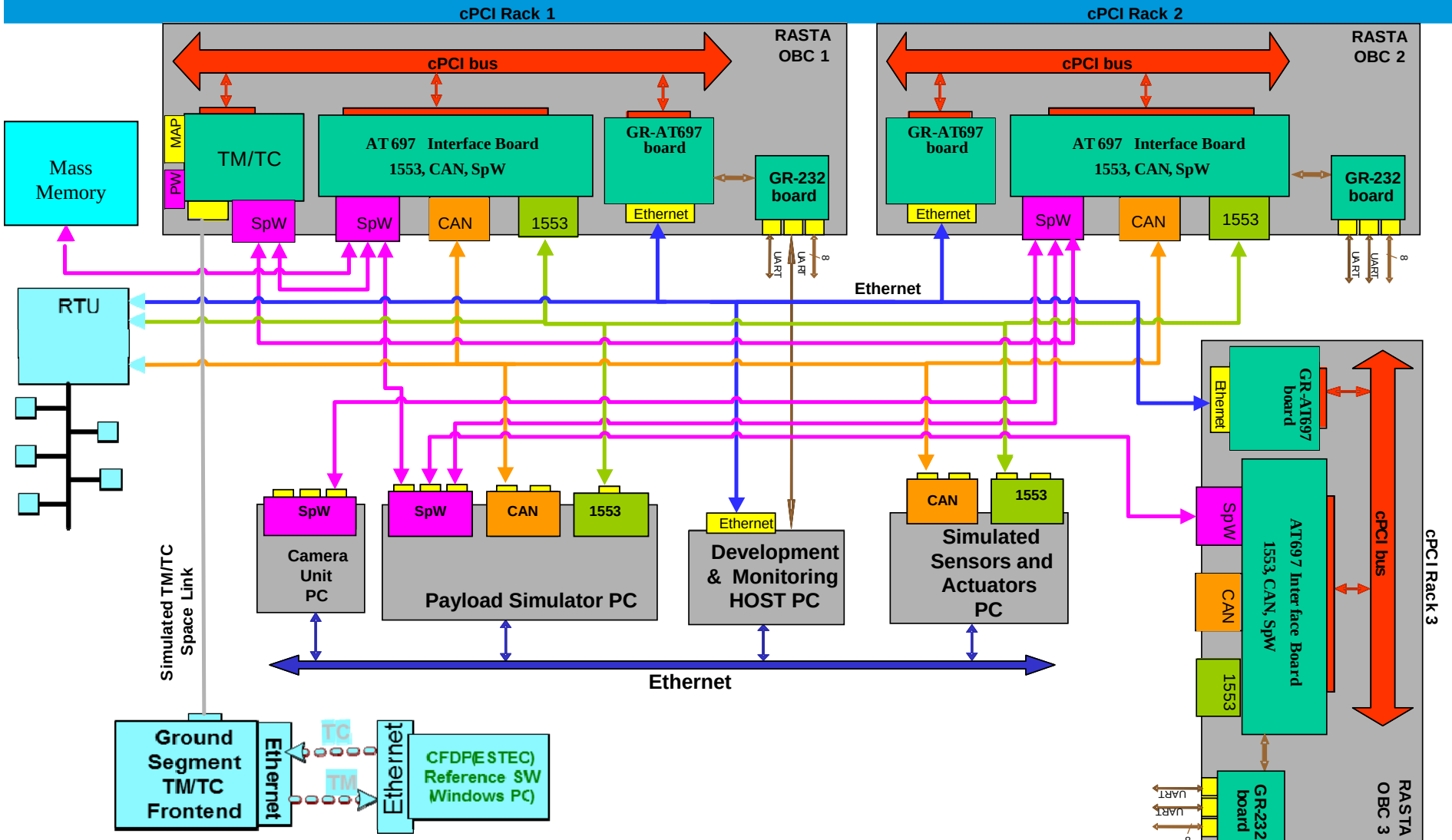
RASTA Development





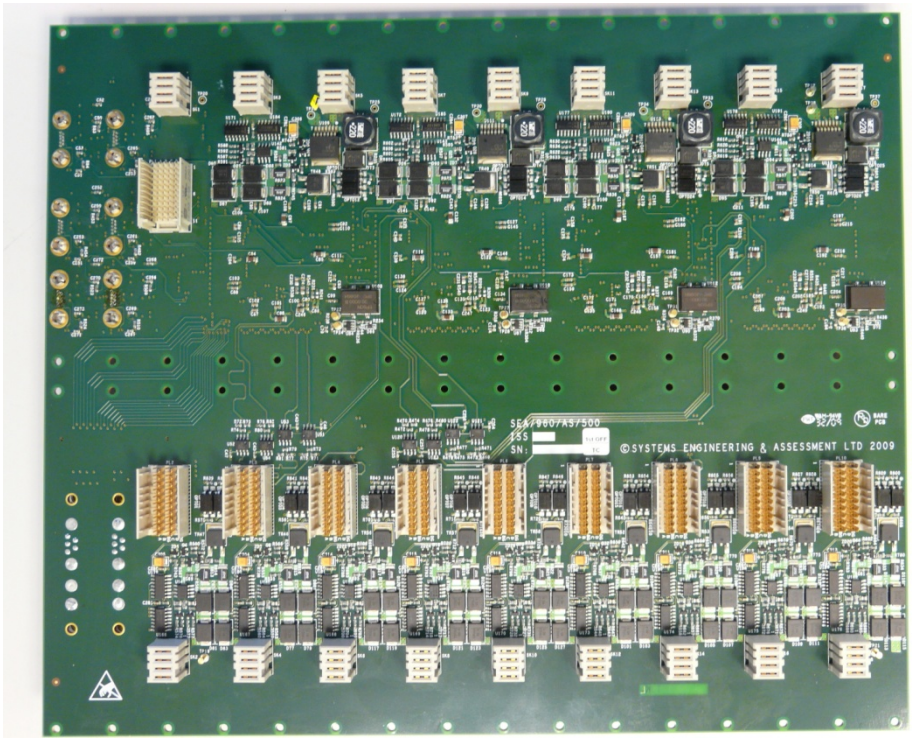
More than 40 systems sold world wide: EADS, TAS, RUAG, SciSys Spacebel, ESA etc

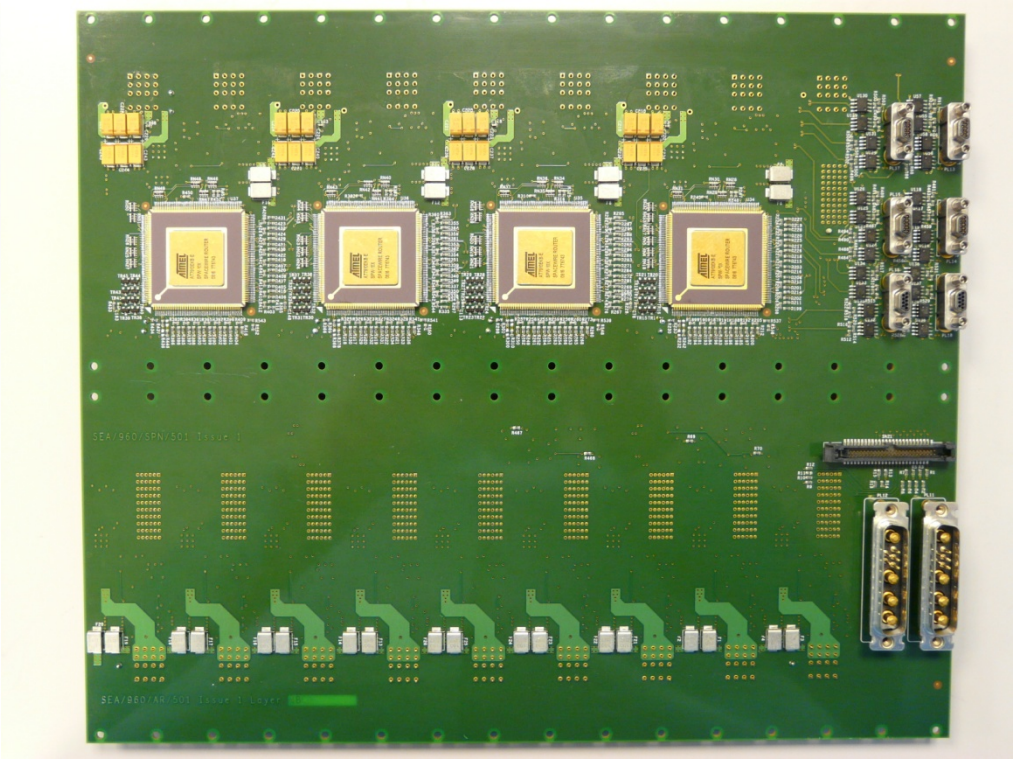
RASTA – Generic Test Configuration



MARC rack

MARC backplane





2012 Wish list

- ✓ SpW ECSS-E-ST-50-12D finalized
- ✓ SpW-RTC Supported as a standard product in a good cooperation spirit between ATMEL – UoD - Gaisler Aeroflex and RUAG
- ✓ SpW-D and related time synchronization protocols ready for standardization
- ✓ SpW PnP demonstrated
- ✓ SpW Backplanes defined and Demonstrated by MARC – MARC 2 approved
- ✓ SpaceFibre technically finalized
- ✓ SpW Handbook draft available
- ✓ SpW International Conference organized for 2013