

FPGA based I&C products today and innovative approaches

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10th International Workshop on Application of FPGAs in NPPs
Gyeongju, South Korea

Agenda

- ▶ **CPLD/FPGA technology TELEPERM XS platform**
 - ◆ **Configurable Logic Module**
 - ◆ **Configurable Analog Module**

- ▶ **R&D on innovative FPGA based automation solution**
 - ◆ **Objectives**
 - ◆ **Concepts**
 - ◆ **Platform architecture**
 - ◆ **Feasibility demonstration**

▶ CPLD/FPGA technology TELEPERM XS platform

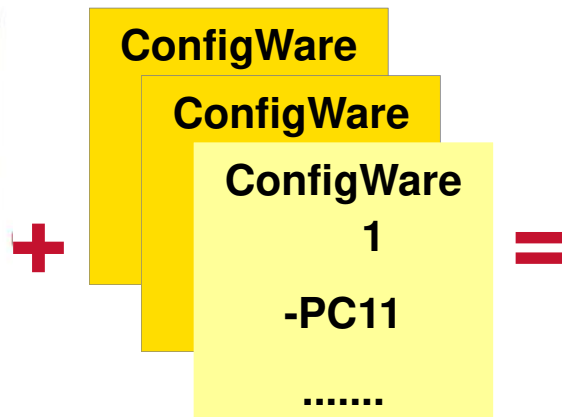
- ◆ Configurable Logic Module
- ◆ Configurable Analog Module

▶ R&D on innovative FPGA based automation solution

- ◆ Objectives
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Configurable Logic Module PLD* Technology Supplements Digital Platform

1 x basic hardware module + N * ConfigWare → N types of modules



Function examples:

- Cabinet monitoring logics
- Controller for RodPilot
- Simple logic functions for e.g. backup solutions (OL3 HBS)
- Class 1 diversified priority module (-PC11)
- Functions for pump speed measurement (1 MHz)

**PLD = Programmable Logic Device*

**TELEPERM XS Configurable Logics Technology
for specific pre-developed functions up to class 1**

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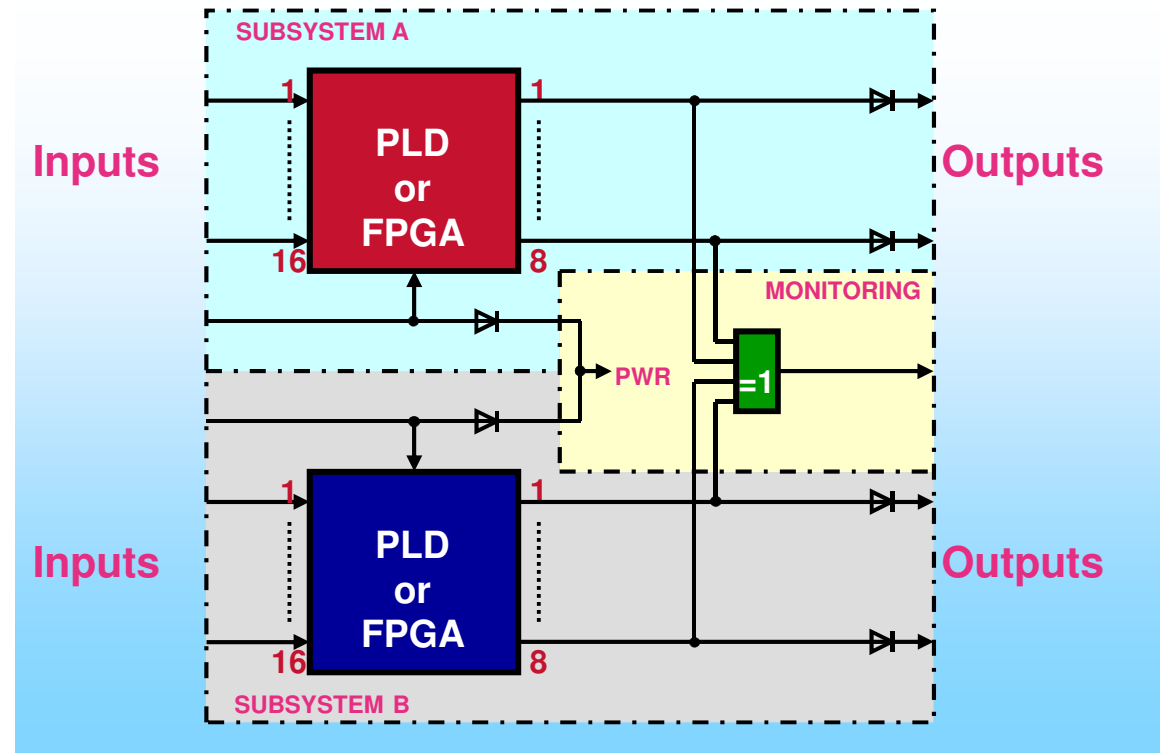
2nd Generation Configurable Logic Module Principle

▶ Main enhancements

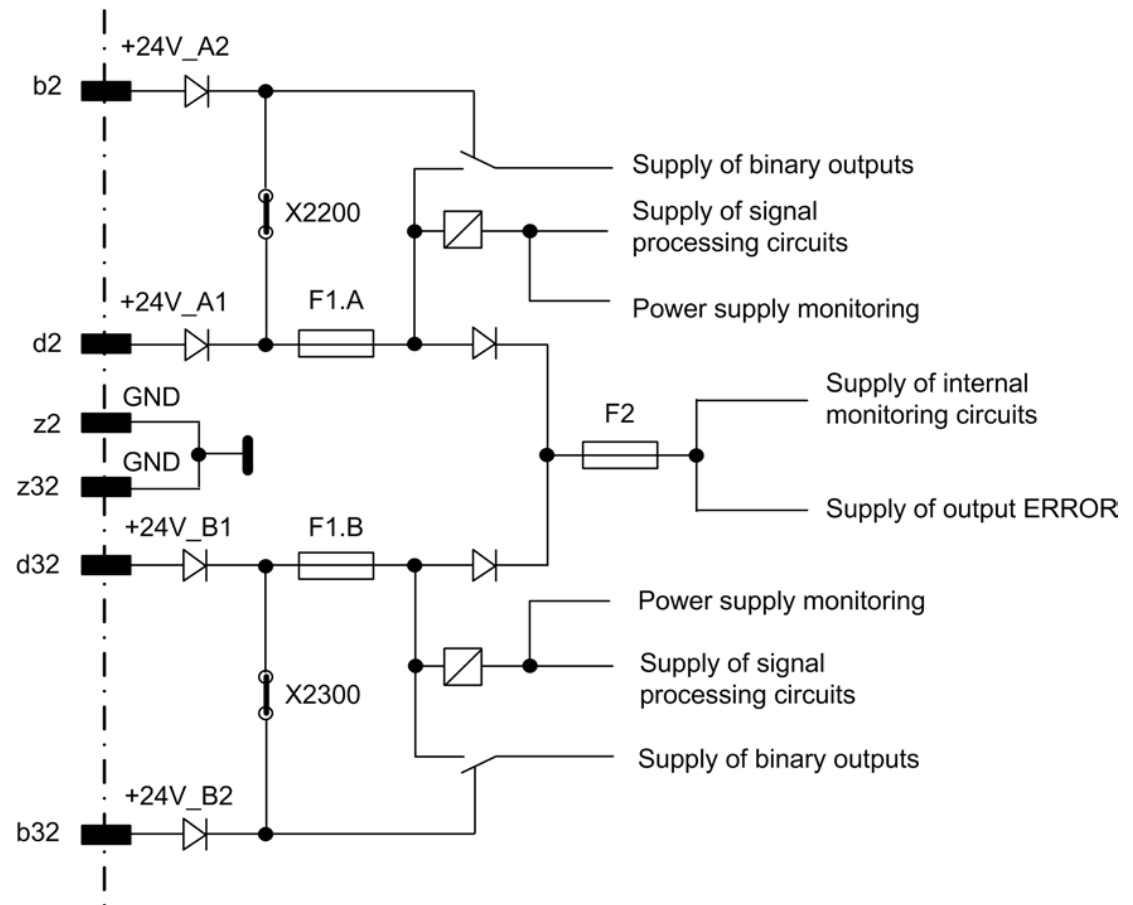
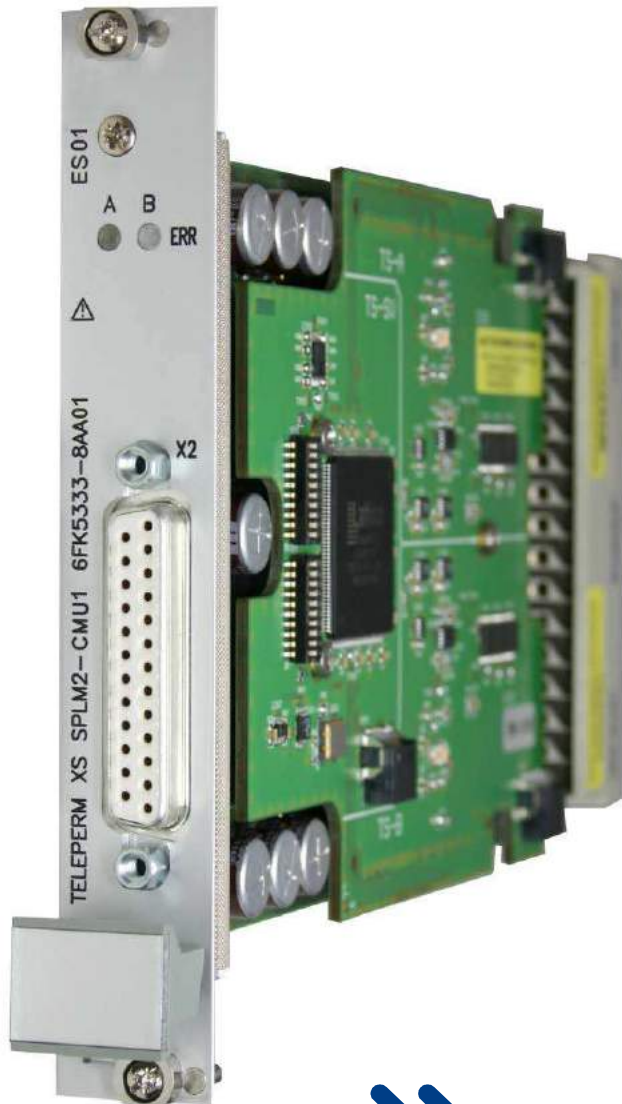
- ◆ Two variants of piggy-back available: 2xPLD or 2xFPGA alternative
- ◆ Direct data communication supported between the FPGA
- ◆ External EIA485 communication port
- ◆ Monitoring logic can optionally be implemented on the FPGA itself

▶ Status

- ◆ PLD variant fully qualified and in
- ◆ FPGA variant available as a prototype



Configurable Logic Module FPGA based



2-fold redundant FPGAs, redundant power supply

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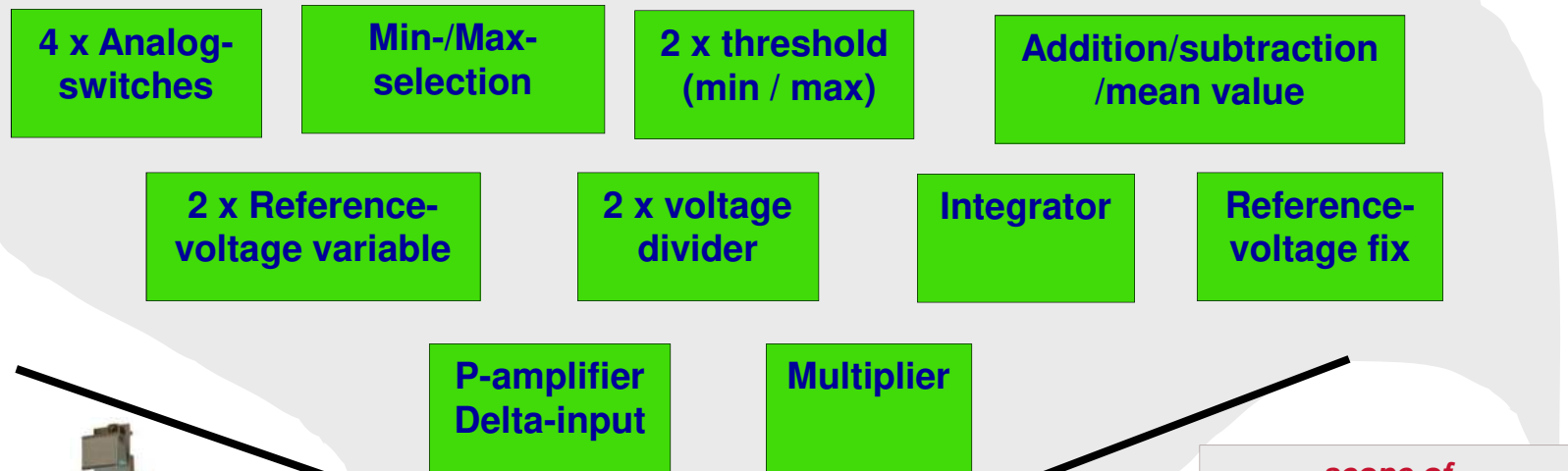
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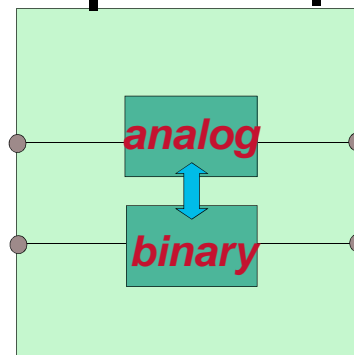


Configurable Analog Module

Wide Variety of Analog Signal Processing Purposes



*scope of
an analog hardware
platform
in one single module*



Configurable Analog Module (Class 1)

- „Slot“ programmable analog function
- CPLD based computer interface for parameterization, recurrent testing, diagnosis

▶ CPLD/FPGA technology TELEPERM XS platform

- ◆ Configurable Logic Module
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▶ R&D on innovative FPGA based automation solution

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Automation System FPGA-based Objectives

▶ Provide a Class 1 innovative solution for “small scale system”

◆ Simplicity

- No software and complex microprocessors for execution of safety functions
- Same flexibility for engineering as conventional CPU based digital systems.
- Safety I&C functions based on functional block diagrams without knowledge of FPGA technology.

◆ Competitiveness

- Reduce HW Costs compared to current technology based solutions while maintaining the overall functionality.
- Evolution easiness.
- Compactness : 3Ux160mm modules.

◆ Optimization of Licensing

- No black-box or grey box components.
- Simplicity of mechanisms to reduce V&V effort.
- Determinism demonstration easiness due to FPGA static timing execution.

◆ Performance and robustness

- Cybersecurity high protection. No operating system, no executable code. Safety function are stored as sequences of FBs. No way to execute malware
- Increase (x2 minimum) the computing capacity for application program by compared to current technology based solution.
- Parallel computing contributes to higher performance.

◆ Portability

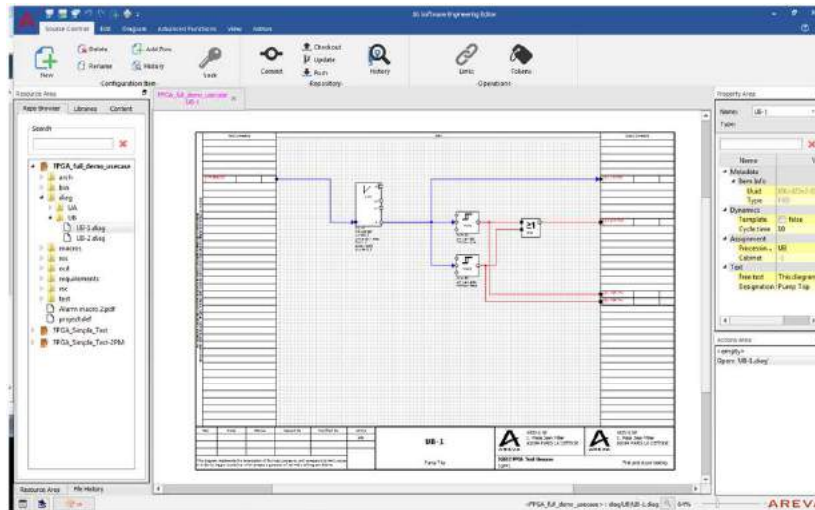
- FPGA technology allows a significant degree of design portability.
- Minimum use of IP from vendors (e.g. PLL)

◆ Scalability

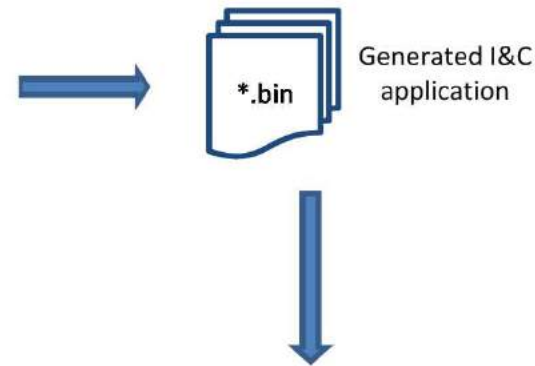
- Single rack or multi-rack architecture
- Single, Master-Checker or Master-Slave processing mode

R&D on innovative FPGA based solutions

Concepts studied



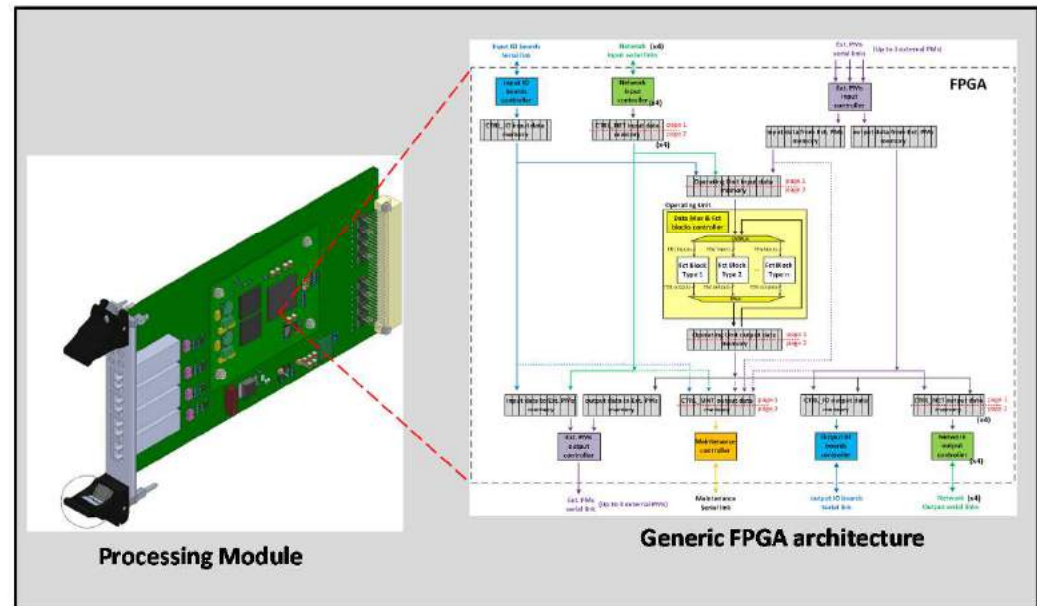
The Software Engineering Editor



Generated I&C application

- ▶ The safety I&C application is designed and generated via a new ergonomic Software Engineering Editor.
- ▶ The AS FPGA based platform implements a generic processing unit able to compute all I&C FBs.
- ▶ FPGA and VHDL are code completely independent from the application
- ▶ The generated application program is executed by the AS FPGA based platform.

Technology - FPGA or Micro-processor - is transparent for I&C system designers



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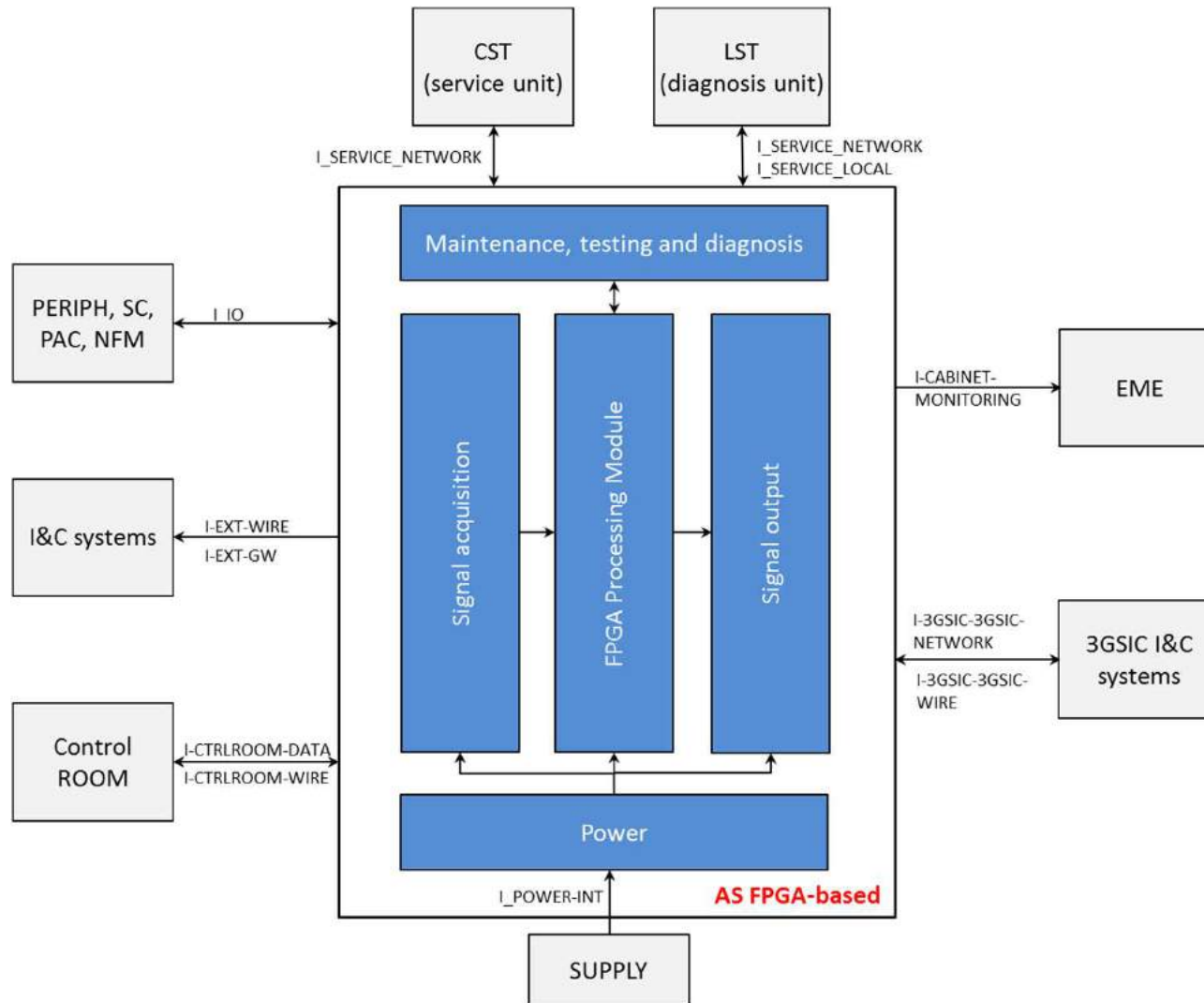
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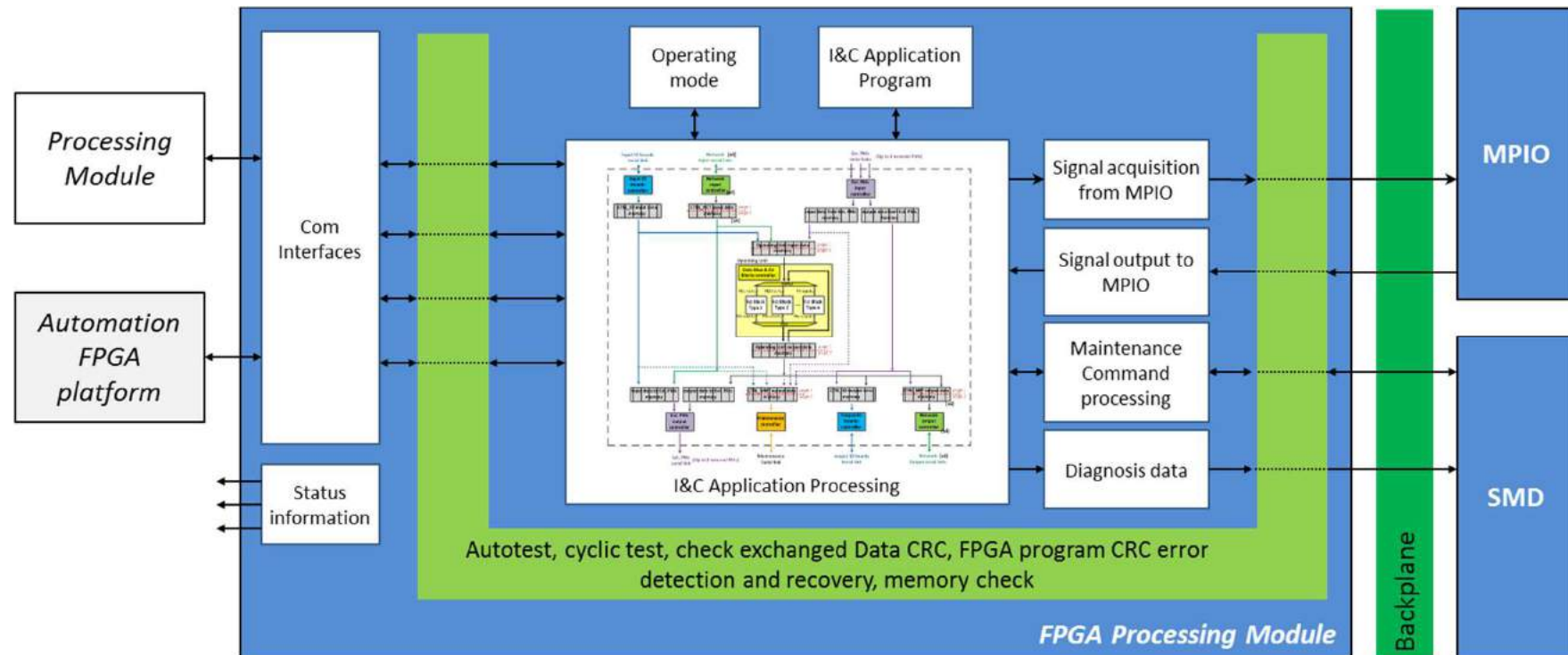
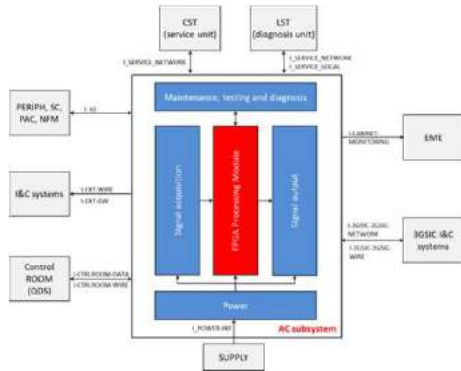


R&D on innovative FPGA based solutions

Functional platform architecture



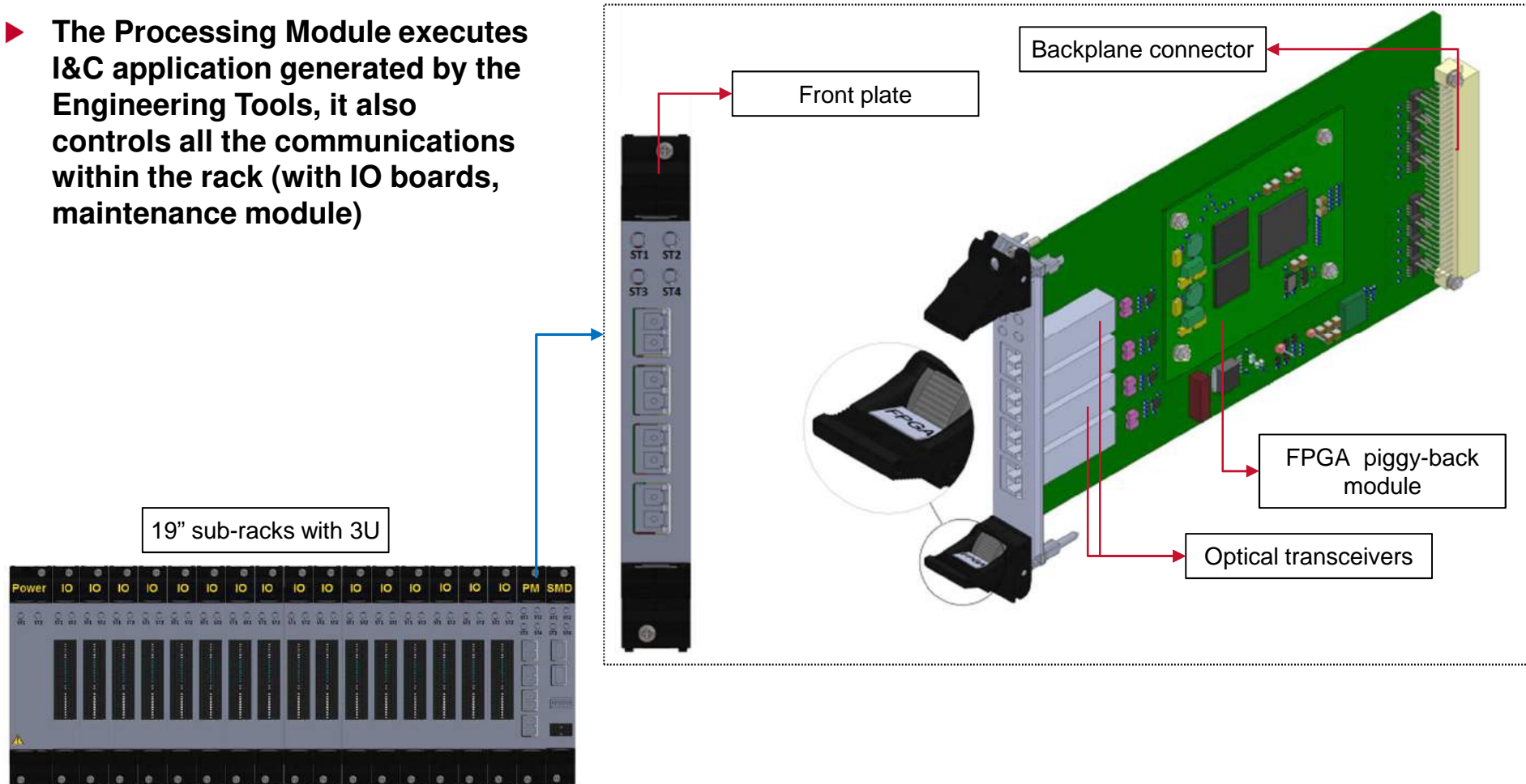
R&D on innovative FPGA based solutions Processing Module Functional architecture



R&D on innovative FPGA based solutions

PM Board Architecture

- ▶ The Processing Module executes I&C application generated by the Engineering Tools, it also controls all the communications within the rack (with IO boards, maintenance module)

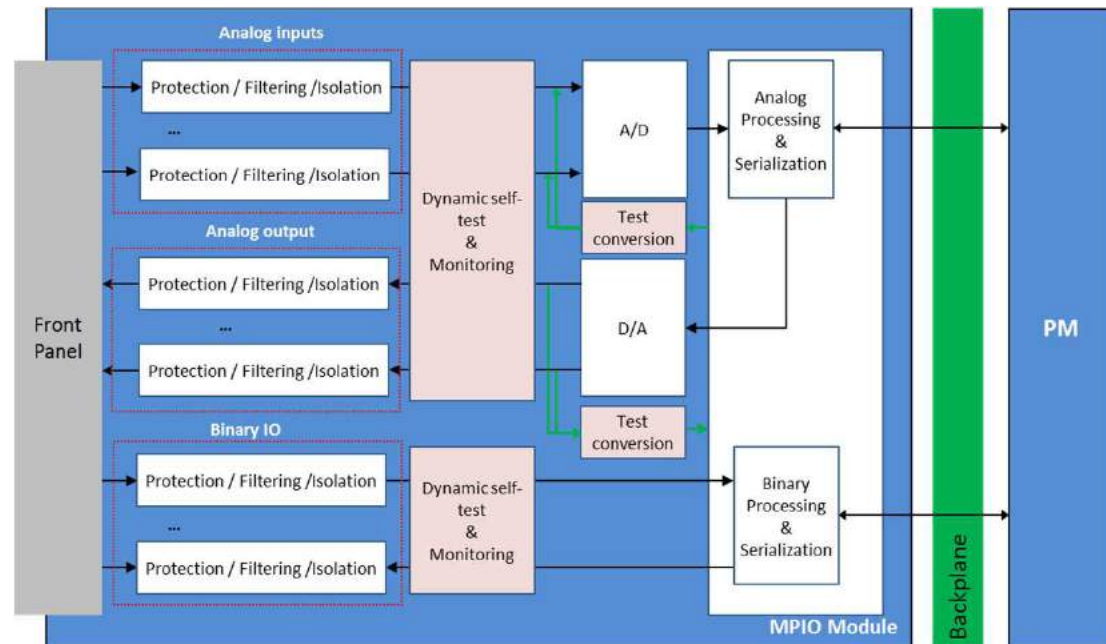
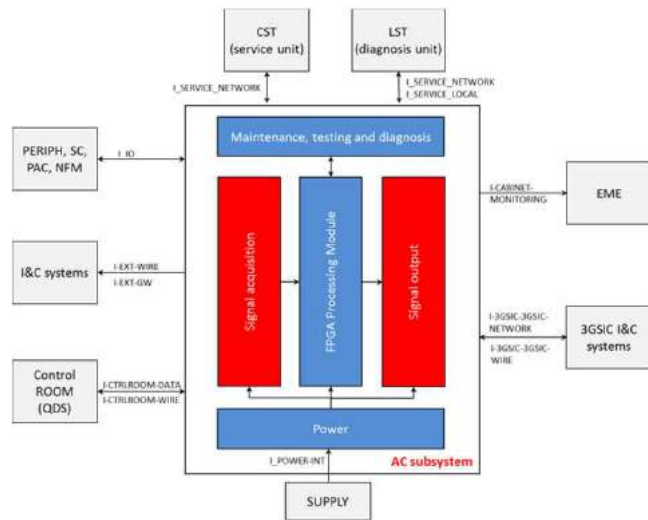


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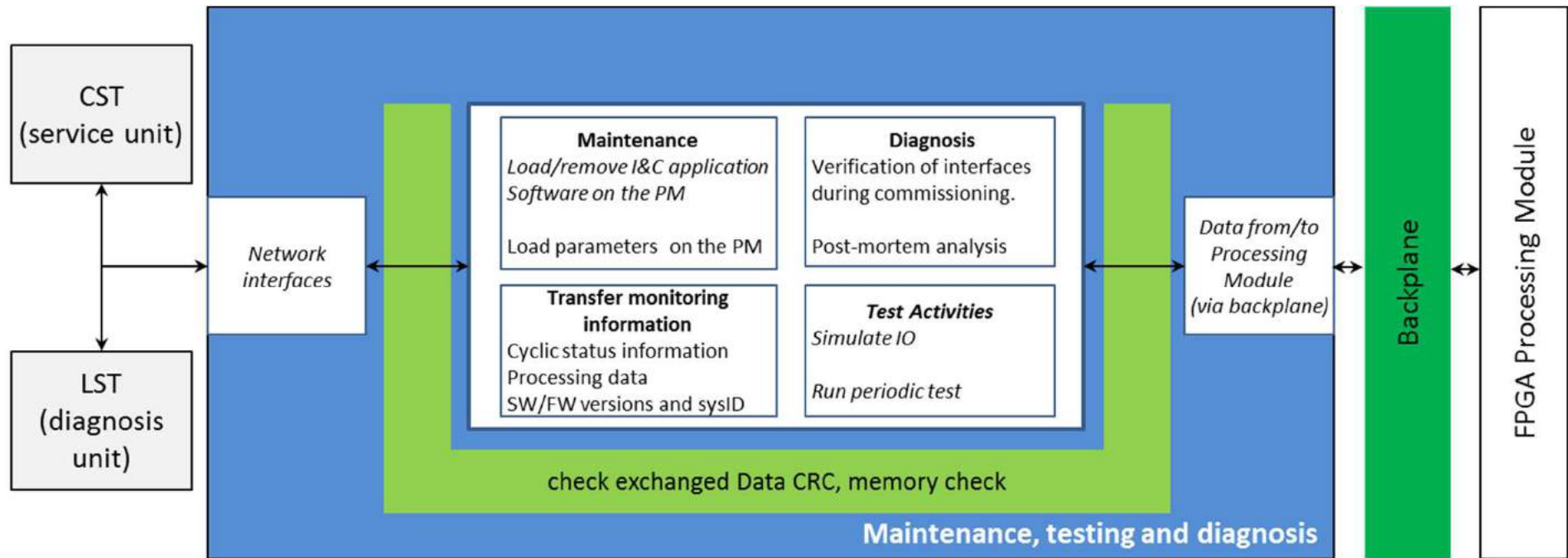
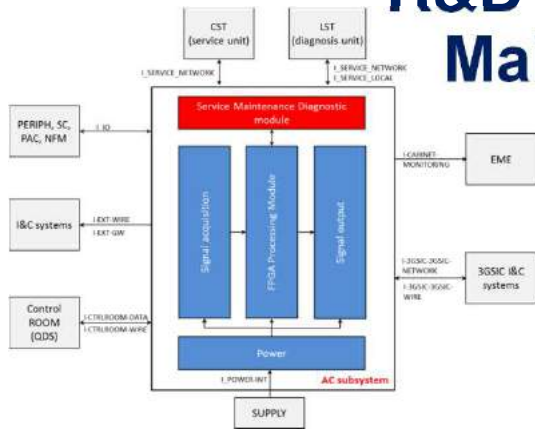
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R&D on innovative FPGA based solutions

Signal acquisition / signal output functional architecture



R&D on innovative FPGA based solutions Service Maintenance Diagnostic Functional architecture



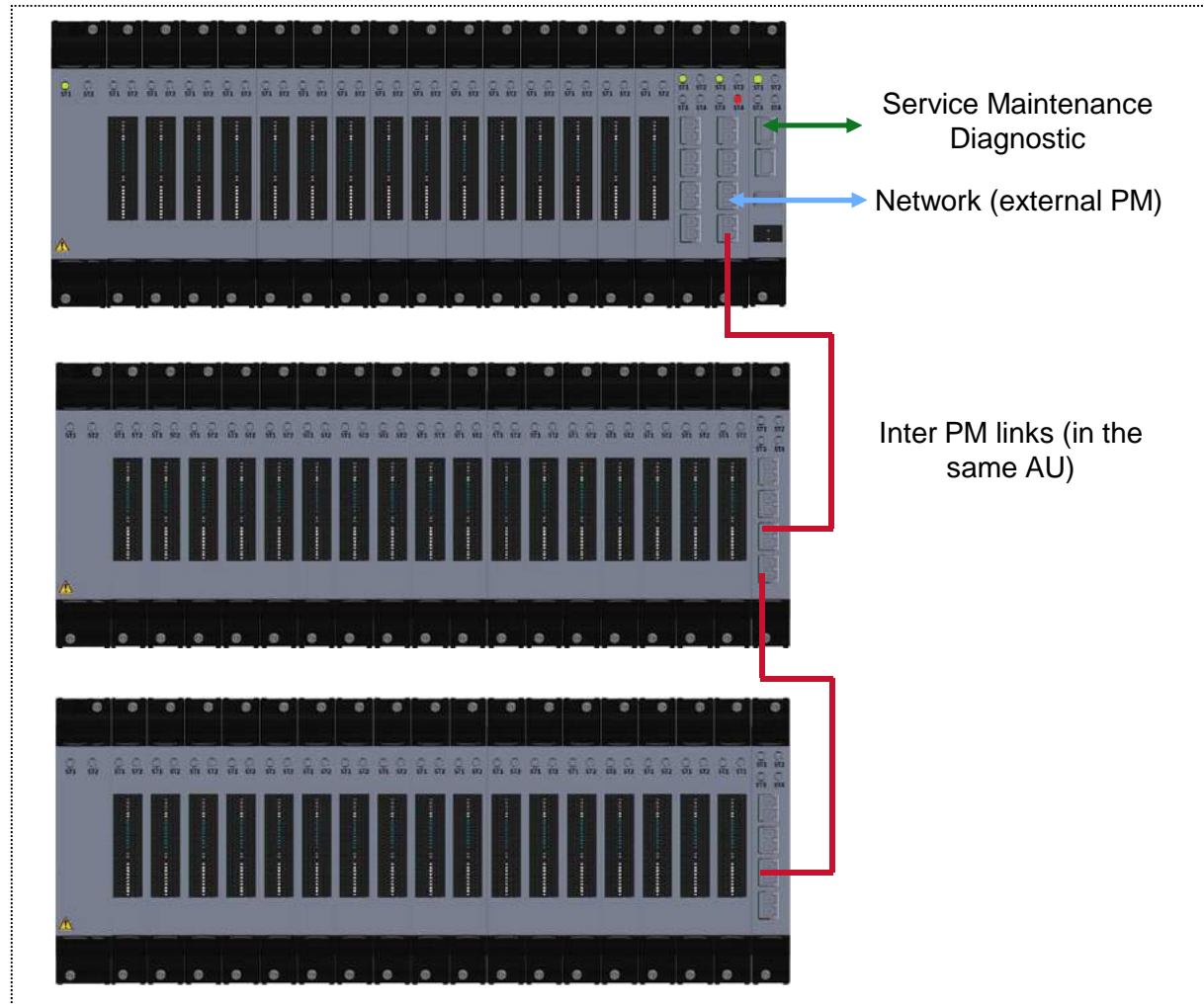
R&D on innovative FPGA based solutions

Single or Multi-PM Multi RACK architecture

- ▶ The multi-PM architecture can be realized by a several racks that operate together synchronously as an automation unit (AU).
- ▶ Each PM can access to all IO boards of the AU.
- ▶ Only one SMD is necessary for the maintenance of the AU.



Cabinet



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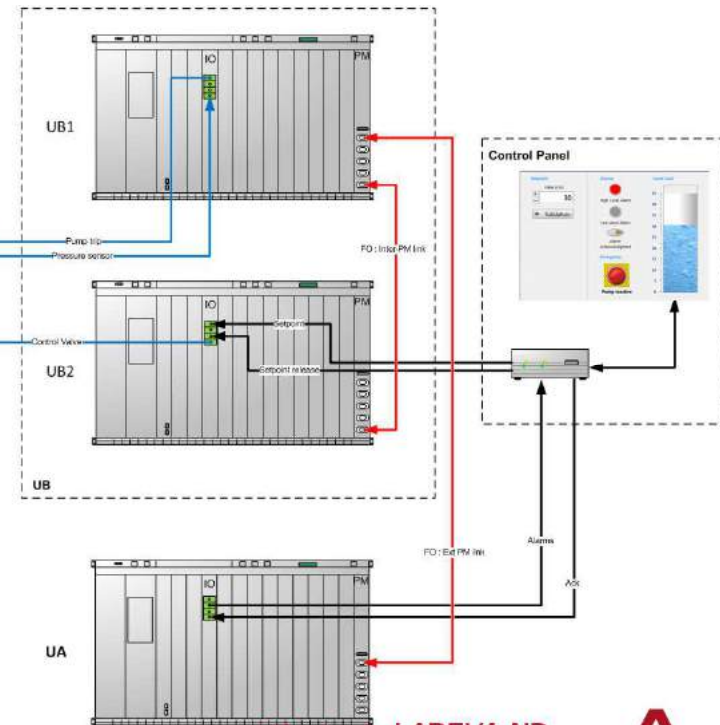


R&D on innovative FPGA based solutions

Validation of main concepts

► Demonstrator V1 successfully launched end of 2016 → Mid of 2017

- ◆ HW pre-existing design for processing and I/O boards
- ◆ The design and the automated generation of safety I&C functions (the application program) via a dedicated software engineering editor (SEE tool).
- ◆ Validation of main concepts for I&C function execution and I/O communication.
- ◆ The multi-processing modules configuration (network communication).
- ◆ The processing performance.



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Summary

- ▶ **FPGA and PLD based solutions have been used since a long time in nuclear technology for various applications and they are integral part of the TELEPERM XS platform**
- ▶ **Technology selection should be made based on technical requirements for the specific application**
- ▶ **Use of FPGA based automation platform is compatible with microprocessor based for I&C system design workflow**
- ▶ **Up to now, microprocessor based safety I&C systems offered more flexibility for complex applications.**
- ▶ **FPGA based systems are more and more used in the industry. AREVA NP is ready if the same tendency will be observed in nuclear industry for complex safety I&C systems.**

Automation System FPGA-based

Thank you for your attention



Any questions ?



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