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TXS Compact Platform Topical Report

NRC/Framatome Phase "0" Meeting

Framatome

July 23, 2024

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NRC/Framatome Meeting Agenda
July 23, 2024

TXS Compact "Phase 0" Meeting Agenda

1. Purpose and Introductions   1:00 – 1:15

2. Framatome Business Overview   1:15 – 1:35

3. Framatome I&C References   1:35 – 1:50

4. TXS Compact Platform Overview   1:50 – 2:50

5. Break   2:50 – 3:05

6. TXS Compact Topical Report Structure   3:05 – 3:20

7. TXS Compact Phase 1 Submittals   3:20 – 3:35

8. TXS Compact Phase 2 Submittals   3:35 – 3:45

9. TXS Compact Roadmap   3:45 – 3:55

10. USA Licensee "Expression of Interest" Letters   3:55 – 4:05

11. Framatome Request for NRC Support   4:05 – 4:20

12. Summary of Questions and Action Items   4:20 – 5:00

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Framatome Business Overview

Framatome

For over 65 years, Framatome's teams have been involved in developing safe, competitive, clean, low-carbon nuclear energy worldwide by:

- Designing nuclear power plants
- Supplying and commissioning nuclear steam supply systems
- Designing and manufacturing components and fuel assemblies
- Integrating automation systems
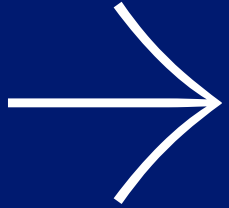- And servicing all types of nuclear reactors

The original equipment manufacturer of **84** nuclear power plants in operation.

€4.1 billion revenue in 2023

€4.8 billion new orders

Vision

High-performing people and technologies for safe and competitive nuclear plants worldwide.

SAFETY

FUTURE

PERFORMANCE

PASSION

INTEGRITY

Values

Our values define our identity.
More than just principles, they guide our actions and determine how we work with our customers, partners and employees.

Worldwide presence

France
- Beaumont
- Chalon-sur-Saône
- Cherbourg
- Frans
- Grenoble
- Jarrie
- Jassus-Riot
- Jeumont
- Le Creusot
- Les Achards
- Lyon
- Marseille
- Massy
- Maubeuge
- Montbard
- Montreuil-Juigné
- Orsan
- Paimboeuf
- Paris
- Romans-sur-Isère
- Rugles
- Rungis
- Saint-Marcel
- Saint-Paul-lez-Durance
- Sully-sur-Loire
- Ugine

Germany
- Erlangen
- Karlstein
- Lingen

USA
- Benecia
- Charlotte
- Christiansburg
- Cranberry Township
- Jacksonville Houston
- Lynchburg
- Mansfield
- Richland

China
- Beijing
- Daya Bay
- Deyang
- Haiyan
- Lianyungang
- Shanghai
- Shenzhen
- Taishan

Rest of the world
- Belgium: *Brussels*
- Brazil: *Rio de Janeiro, Angra dos Reis*
- Bulgaria: *Sofia, Kozloduy*
- Canada: *Pickering, Kincardine, Montreal*
- Czech Republic: *Prague, Dukovany*
- Finland: *Olkiluoto*
- Hungary: *Budapest, Paks*
- Japan: *Tokyo*
- Romania: *Bucarest*
- Russia: *Moscow*
- Slovakia: *Bratislava*
- South Africa: *Cape Town*
- South Korea: *Seoul, Daejeon*
- Spain: *Zaragoza, Tarragona, Madrid*
- Sweden: *Helsingborg*
- Switzerland: *Leibstadt*
- Ukraine: *Kiev*
- United Arab Emirates
- United Kingdom: *Bristol, Cranfield*
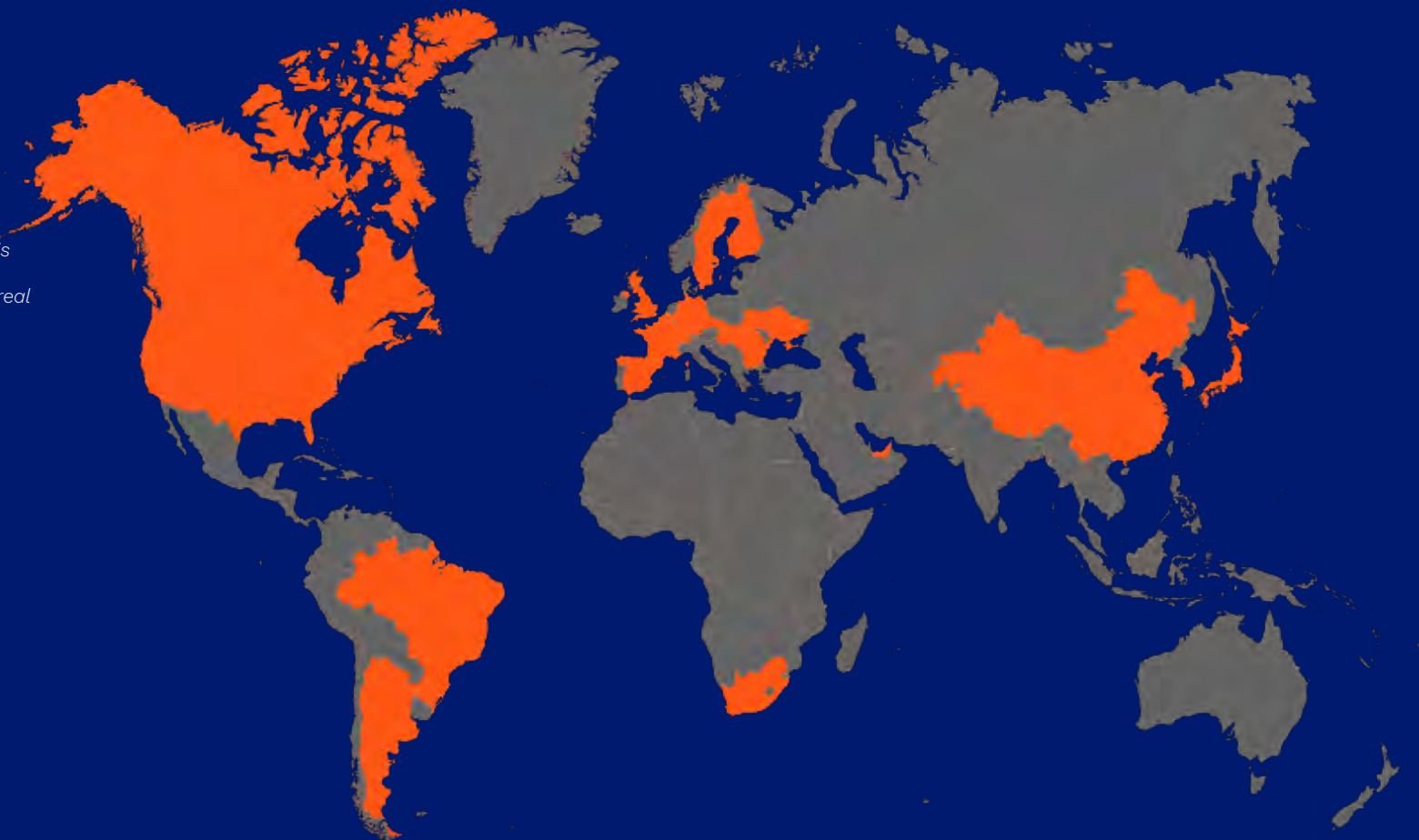
+18,000 employees   **+70** sites*   **20** countries

* Locations can have multiple sites

Activities

Engineering & Design Authority:
Development, design and licensing of nuclear steam supply systems (NSSS) and associated services, including worldwide Technical Centers.

Fuel: Development, design, licensing and fabrication of fuel assemblies and core components for all types of light water reactors (PWR, BWR, VVER) as well as for research reactors. Development of zirconium alloy components.

Projects and Components Manufacturing: Design and manufacturing of heavy and mobile components for nuclear islands. Management and execution of nuclear reactor new build projects, and component replacement projects.

Installed Base: Products and services to maintain, modernize and extend the service life of facilities in operation; commission new facilities and support to decommissioning & dismantling activities.

Instrumentation & Control:
Design and manufacturing of automation and instrumentation technologies for the safe, sustainable and economic operation of nuclear power plants.

Instrumentation & Control

THE BRAIN AND CENTRAL NERVOUS SYSTEM OF THE PLANT

Our solutions adapt to the design of each reactor throughout its lifecycle to ensure long-term operation:

- A variety of instrumentation and control systems :
  - Safety
  - Operational
  - Autonomous (cluster control, turbine control and protection, diesel control)
- Nuclear and conventional instrumentation
- Training and engineering simulators
- Industrial cybersecurity solutions
- Instrumentation and control services (expertise, spare parts, training, maintenance)

+440 comprehensive I&C systems in all reactor designs across the world

including **+200** complete nuclear instrumentation systems

+300 new power plant full-scope simulators delivered

Vision and Mission of the I&C BU

Vision

Safety is the top priority in nuclear energy.

We are the world's most reliable partner for stability – today and in the future
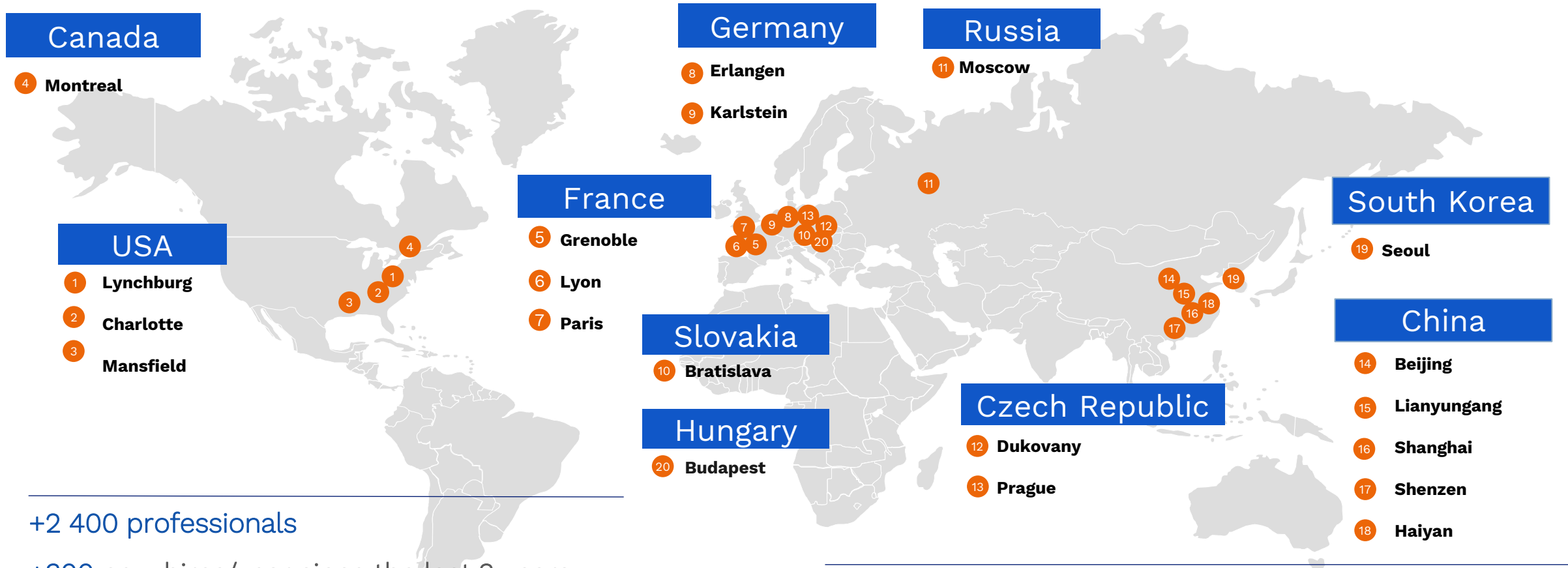
Mission

We develop safe technologies – because we know nuclear.
And we know how rapidly markets can change.
We work transparently and proactively with our customers to ensure the economic operation of their plants over the long term.

I&C BU Footprint - Global Expertise for Local Customers

Canada
- 4 Montreal

USA
- 1 Lynchburg
- 2 Charlotte
- 3 Mansfield

France
- 5 Grenoble
- 6 Lyon
- 7 Paris

Slovakia
- 10 Bratislava

Hungary
- 20 Budapest

Germany
- 8 Erlangen
- 9 Karlstein

Russia
- 11 Moscow

Czech Republic
- 12 Dukovany
- 13 Prague

South Korea
- 19 Seoul

China
- 14 Beijing
- 15 Lianyungang
- 16 Shanghai
- 17 Shenzen
- 18 Haiyan

+2 400 professionals

+300 new hires/year since the last 2 years

20 sites in **10 countries**

Manufacturing or assembly plants located in **France, Germany** and **USA**

Delivering **solutions for many different nuclear power plant designs worldwide**

Global presence and **unique expertise** to deliver **certainty** to our customers

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I&C BU Manufacturing and Assembly Plants

- **Cabinet** assembly
- **Incore detector** manufacturing and lab
- **Stand Alone Systems**, manufacturing and lab
- I&C Test bay
- Engineering Competence Center
- Labs for materials testing, radio chemistry, hot cells
- Full-scale test facilities for component qualification
- Technical Training Center

I&C Plants

- **France**: Grenoble
- **Germany**: Erlangen-Eltersdorf
- **USA**: Lynchburg, Mansfield
- **Canada**: Montreal
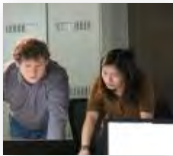
Customer Benefits at a Glance

Perfectly matched safety and non-safety I&C solutions for all tasks in nuclear installations of any type and rating.

Seamless integration of modern solutions into existing I&C systems

Licensing certainty: I&C systems meeting the latest relevant & most stringent regulatory requirements

Asset & lifetime management through leading I&C service solutions

From Stand-alone to distributed control systems - comprehensive solutions from one source

Project certainty delivered through unique nuclear process know-how

Operation certainty by ensuring high availability and safety of your nuclear installation

Allowing customers to:

- Reduce operating and maintenance costs

- Improve safety and performance of nuclear facilities

- Extend and optimize service life of nuclear power plants

A One-Stop Shop for All I&C Needs

SAFETY AUTOMATION
Digital and non-digital solutions
Legacy analog solutions

INSTRUMENTATION SOLUTIONS
Qualified for all safety & process purposes

SIMULATORS
From Engineering simulators to full-scope simulators

NORMAL OPERATION AUTOMATION
Requirements, Interfaces, solutions

I&C LIFECYCLE SOLUTIONS
Global range of services to ensure the safety and long-term operation of delivered systems

REQUIREMENTS, SPECIFICATIONS, ARCHITECTURE & SYSTEMS DESIGN

PROJECT MANAGEMENT, HMI+HFE, CYBERSECURITY, V&V SERVICES, INSTALLATION & COMMISSIONING

UNIQUE WORLDWIDE LICENSING AND REGULATION EXPERIENCE

Planning, design and construction of instrumentation and control systems - ensuring effective integration

Instrumentation & Control
Product Portfolio Overview

SAFETY AUTOMATION & AUTOMATION SYSTEMS FOR NORMAL OPERATIONS

- Safety systems (both digital and non-computerized) for RPS, ESFAS, DAS, QDS, etc.

- Normal operation: NSSS control systems, BOP, turbine/generator controls, data acquisition systems

NUCLEAR INSTRUMENTATION

- Incore & Excore solutions
- Level measurement
- Radiation monitoring
- Boron concentration measurement

LIFECYCLE SOLUTIONS

- Outage support
- Maintenance & upgrades
- Obsolescence management
- Spare parts supply
- Repair & refurbishment
- Reverse engineering
- Hotline & Technical support
- Engineering studies
- Training

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Instrumentation & Control
Product Portfolio Overview (Cont'd)

SIMULATORS FOR TRAINING AND ENGINEERING

- Full-scope simulators
- Engineering simulators
- Digital control rooms

GLOBAL I&C ENGINEERING EXPERTISE

- Cybersecurity
- Verification & validation
- I&C architecture & detailed design
- Licensing support

HUMAN PERFORMANCE

- Human-machine interface design & engineering services
- Human factors consulting services, human factors training services

I&C FOR ROD CONTROL

- CRDMs for PWRs and BWRs
- Rod position equipment

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Framatome I&C References

New Build Projects
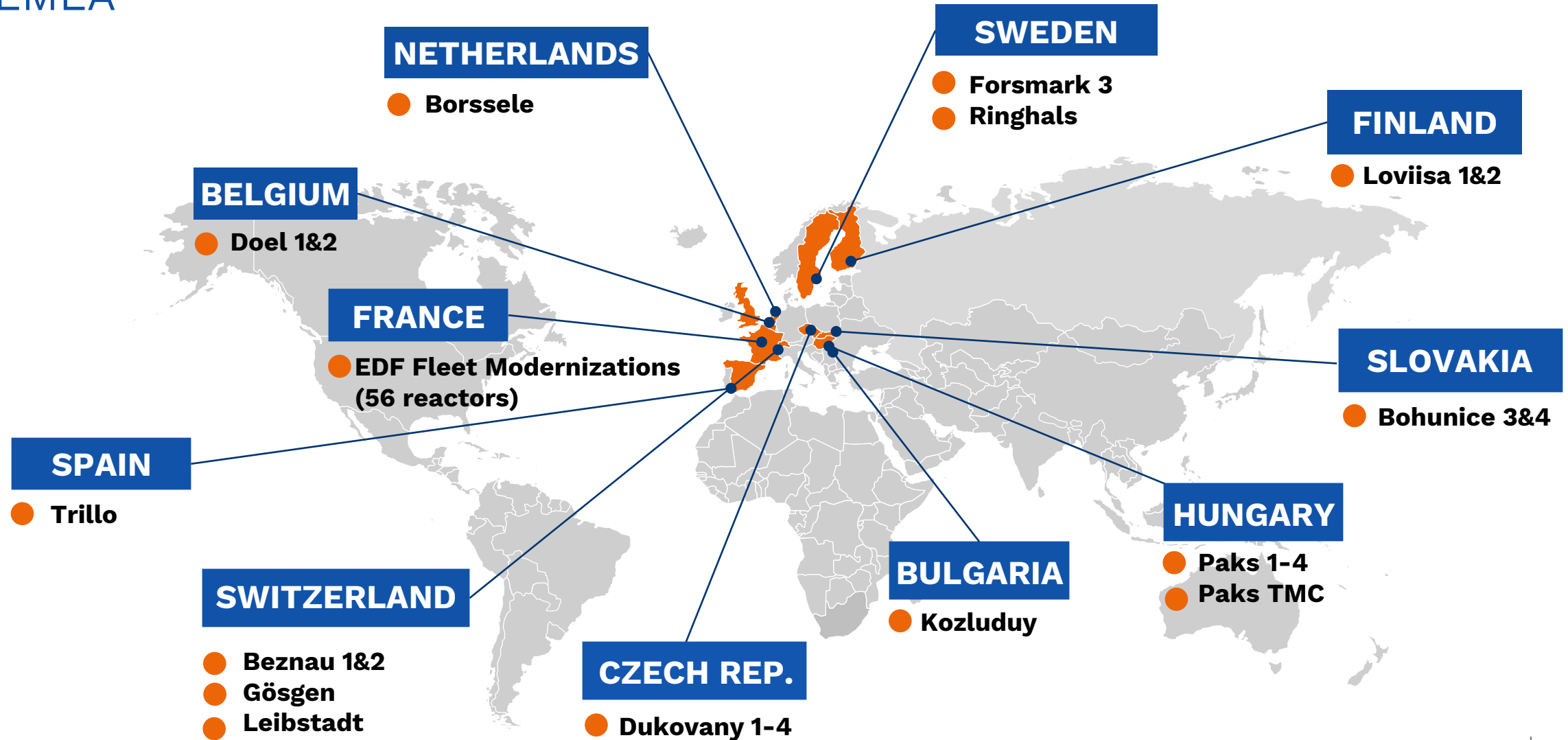

FINLAND
- Olkiluoto 3

GREAT BRITAIN
- Hinkley Point C
- Sizewell C

HUNGARY
- Paks 5&6

FRANCE
- Flamanville 3
- EPR2 fleet (6 units)

CHINA
- Taishan 1&2
- Fangchengan 3&4

BRAZIL
- Angra 3
- Labgene*

EGYPT
- El Dabaa

SLOVAKIA
- Mochovce 3&4

ARGENTINA
- Atucha 2
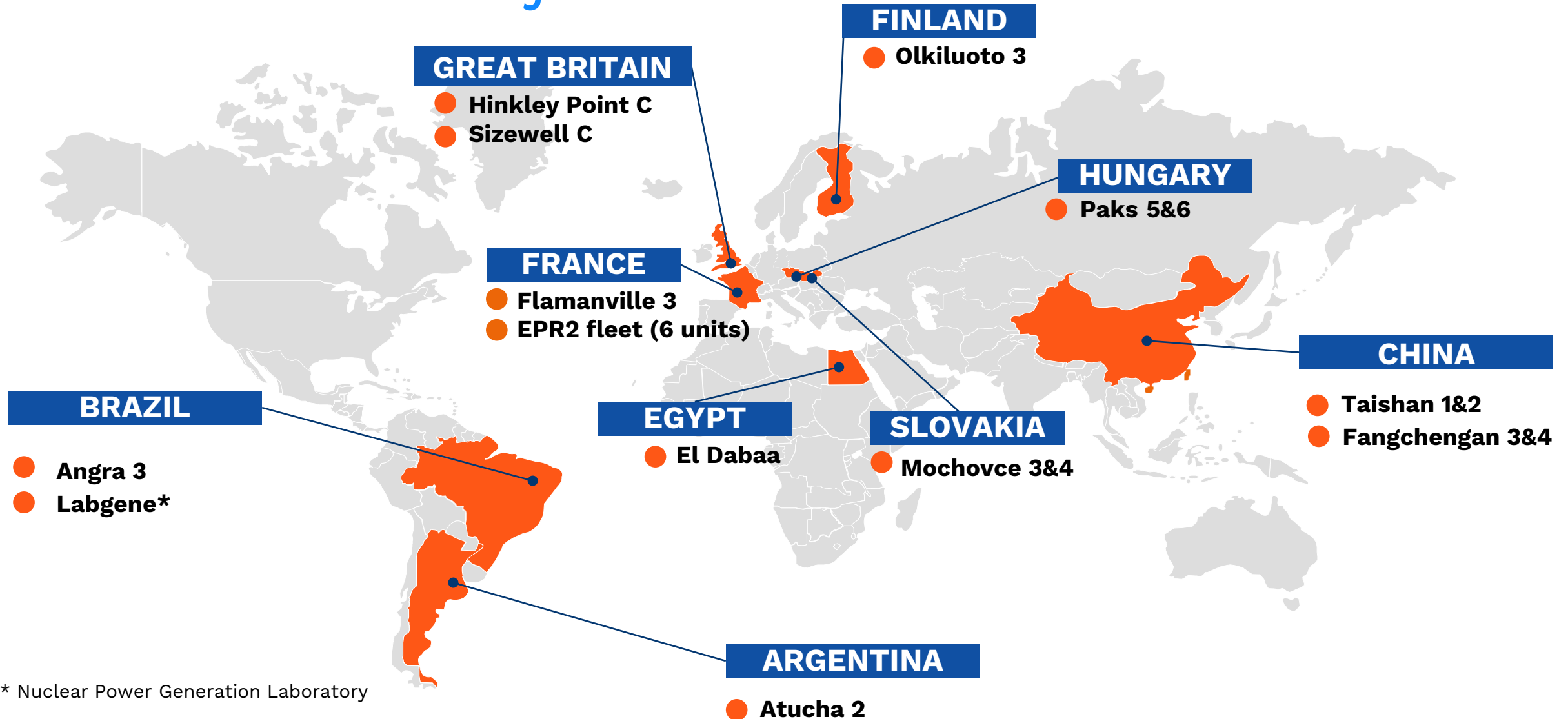
* Nuclear Power Generation Laboratory

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Modernization Projects

EMEA

NETHERLANDS
- Borssele

SWEDEN
- Forsmark 3
- Ringhals

FINLAND
- Loviisa 1&2

BELGIUM
- Doel 1&2

FRANCE
- EDF Fleet Modernizations (56 reactors)

SLOVAKIA
- Bohunice 3&4

SPAIN
- Trillo

HUNGARY
- Paks 1-4
- Paks TMC

SWITZERLAND
- Beznau 1&2
- Gösgen
- Leibstadt

BULGARIA
- Kozluduy

CZECH REP.
- Dukovany 1-4

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Modernization Projects

Asia

CHINA

- Qinshan I-1
- Qinshan II 1&2
- Ling Ao
- Daya Bay
- Changjiang
- Zhangzhou
- Tianwan 3
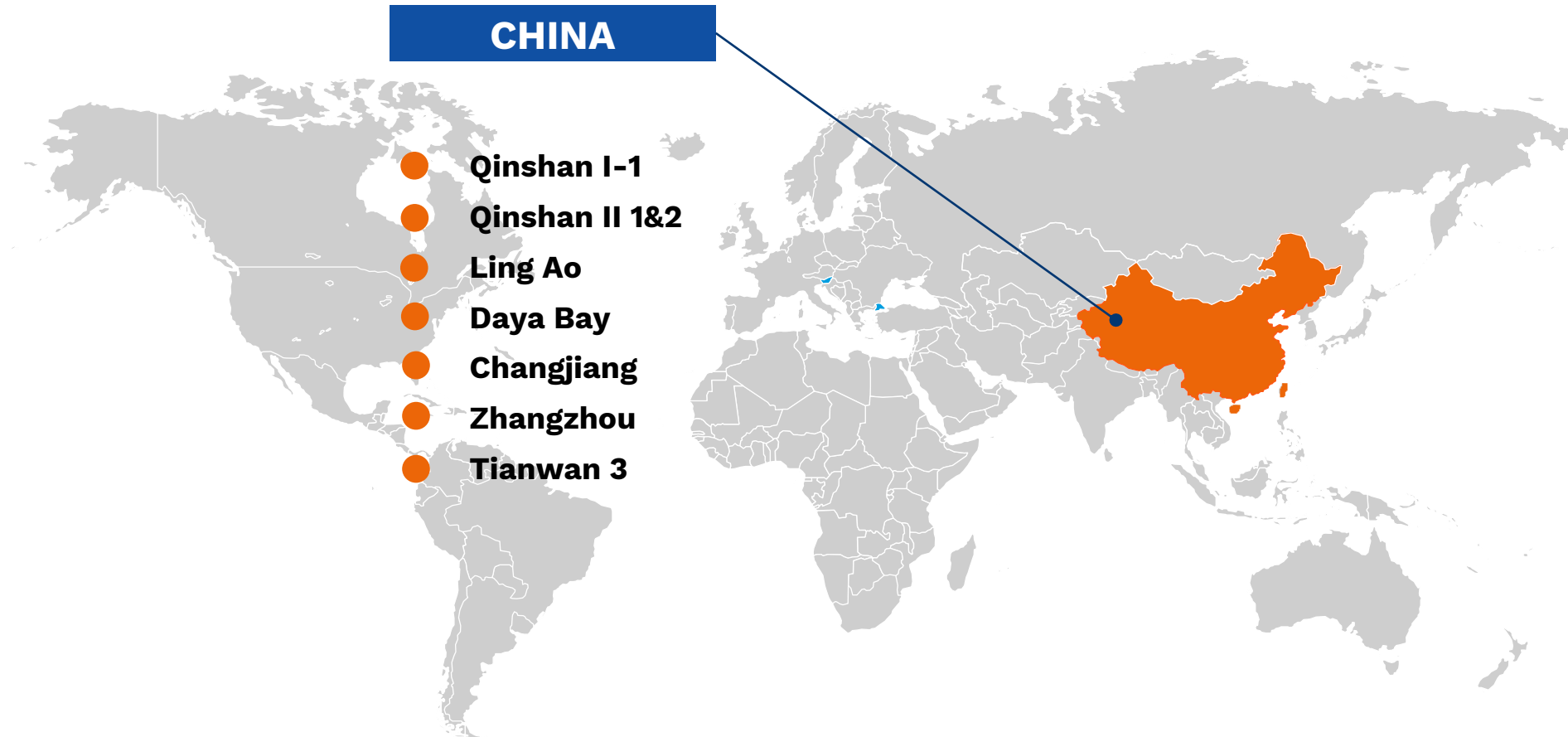
Modernization Projects

America

CANADA
- Bruce Power 3&4

USA
- Surry FIDS
- Duke Oconee 1–3
- Calvert Cliff
- Salem
- Turkey Point 1E
- Duke SFF
- BEA ATM & ATRC
- Millstone 3

ARGENTINA
- Atucha 1

TXS Compact References

- **Paks-II units 5 & 6** (Hungary): Diverse Protection System
- **Millstone** (USA): AMSAC system

- **French Fleet renovation** – 36 units: Protection system renovation (SIP 900MW, RPR N4)
- **EPR2** (France) – 6 units: DEL system (chillers)

TELEPERM®XS - References

A Worldwide Leader in Safety I&C

- ✓ Continuously growing fleet of applications
- ✓ Growing global experience and feedback

Status: June 2024	Commissioned	Ongoing Projects
Reactor Protection	49	9
Reactor Limitation	31	4
Reactor Control	31	2
Neutron Flux Monitoring	23	9
Diesel Load Sequencer	14	1
Core Cooling Monitoring	21	4

	Commissioned & Ongoing Projects
Units	92
Plants	47
Countries	17
Nuclear Island	18*

* Russian VVER Designs merged
* Chinese CGN and CNNC Designs merged

And other applications:
Rod control, Rod position monitoring, Safety related HMI (QDS), Diesel load sequencer, Emergency feed water control, HVAC control, Boron measurement, Turbine protection, Turbine control, Turbine frequency controller

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Non-proprietary information suitable for public disclosure

(*): TELEPERM XS is FRAMATOME safety platform

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TXS Compact Platform Overview

TXS Compact Concept at a Glance

Highly flexible, versatile & performing PLC-like platform, integrated into the TELEPERM XS family

→ Framatome expertise for an open & adaptable solution

- Can be integrated in a Framatome TXS cabinet/encasing OR in any standard industrial 19-inch cabinet or box (rack depth 240mm) for renovation project

- Feature-equivalent to traditional CPU-based PLC, including computing power, service and maintenance capabilities, and self testing and monitoring

- Field signals can be connected on the front of the racks thanks to SubD connecters
  - → easy integration in existing environment with simple cables
  - → allows back to back or back to wall cabinet configurations

- Support for remote I/O: can be configured as a remote rack (outside a cabinet) without additional equipment

- Generic qualification of the platform, independent of any system/function/architecture
  - → system-specific I&C functions programming done using only function block diagrams
  - → no re-licensing of the product needed when the I&C functions evolve
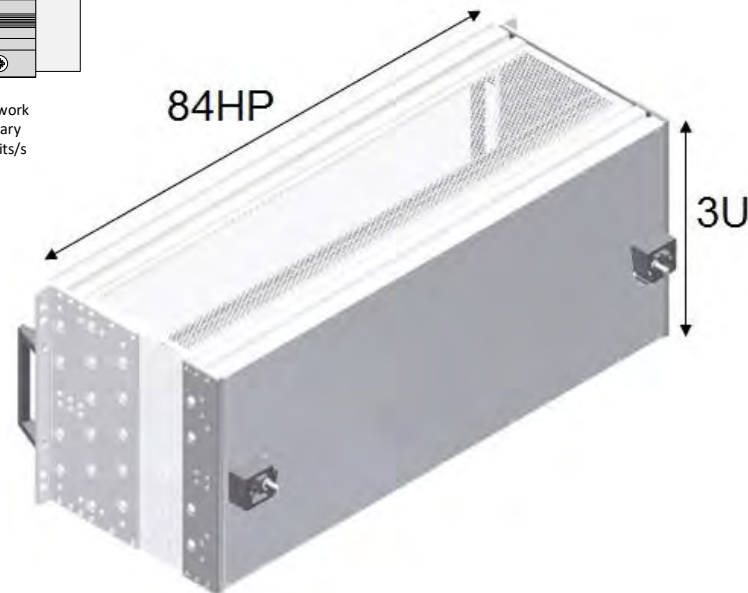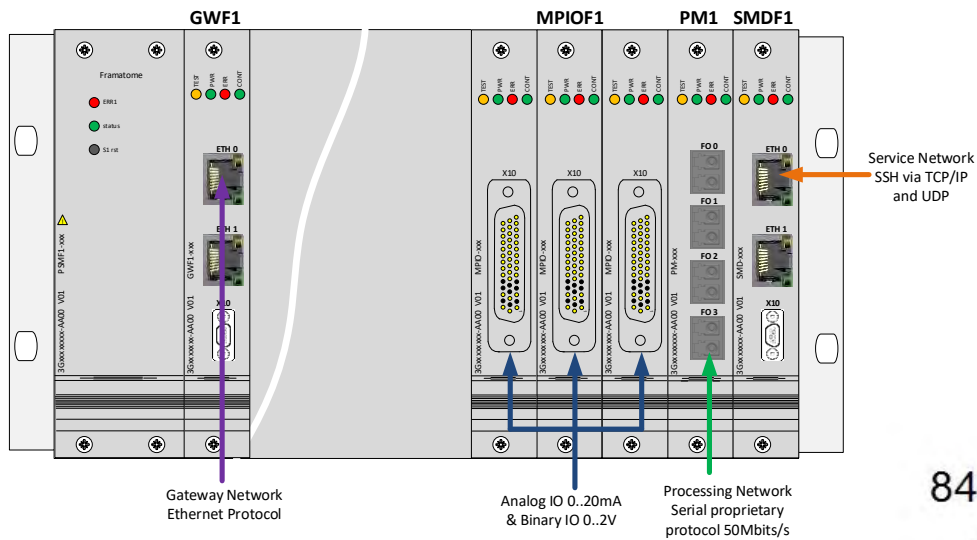

❯ Safety meets high flexibility

TELEPERM XS Compact | Built for nuclear
Built on success
Built for the future

(*): TELEPERM XS is FRAMATOME safety platform

TXS Compact Chassis

3U height, 19 inches width, 240mm depth standard chassis which can be installed in virtually any kind of cabinet

Service Network
SSH via TCP/IP
and UDP

Gateway Network
Ethernet Protocol

Analog IO 0..20mA
& Binary IO 0..2V

Processing Network
Serial proprietary
protocol 50Mbits/s

84HP

3U

TXS Compact Modules

- Modules available for the baseline (already available)

PM1	SMDF1	GWF1	MPIOF1
Processing and communication module	Service, maintenance and diagnosis module	Class-1 gateway to Qualified Display System	Multi-purpose I/O module (2xAI, 2xAO, 4xBI, 4xBO, 1xCPT)

- Modules for platform evolution (under development, prototypes available)

BIF1	BOF1	AICF1/AIVF1
Binary input module (9xBI, 3 isolation groups, 0-24V)	Binary output module (9xBO, 3 isolation groups, 0-24V)	Analog current (resp. voltage) input module (8xAI, 2 isolation groups, 0/4-20mA) or (8xAI, 2 isolation groups, 0-10V)

> Reduced number of references to ease maintenance/spare parts management

PM1

SMDF1/GWF1

MPIOF1

3U RACK

TXS Compact System Programming
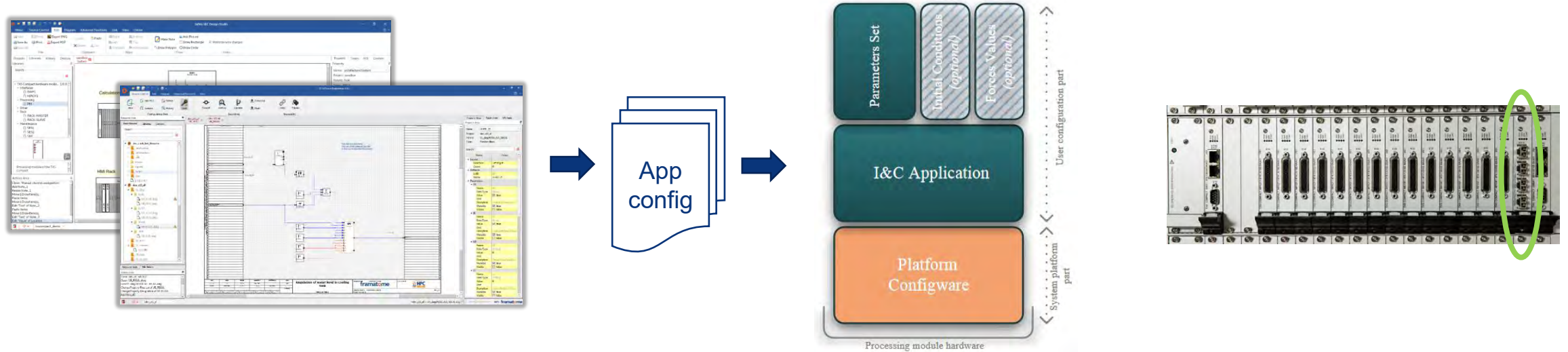
- TXS Compact is a _generic_ platform: the HPD is programmed, qualified and licensed once for all. The processing module PM1 implements a generic processing unit able to compute all I&C Function Blocks in any order.

- The safety I&C application configures the generic processing unit to realize a specific set of functions. It is designed and generated using proprietary software made by Framatome.

- Not a single line of VHDL code is required by system engineers to design the I&C functions ➔ only automation skills needed

➤ **Clear and strong segregation between platform design and system design**

TXS Compact System Aspects

- An I&C system realized with TXS Compact is a collection of loosely-coupled Automation Units.

- An Automation Unit is a least one chassis with one processing module (PM1) and one service and maintenance module (SMDF1).

- Each Automation Unit acquires signals, processes I&C logic, communicates with other Automation Units and outputs results of its calculations.

- Up to 4 chassis can be stacked in the same Automation Unit to increase the number of I/O (local or remote).

One single-chassis Automation Unit

TXS Compact System Aspects

- Typical 2-trains redundant architecture with 4 automation units

TRAIN A   TRAIN B
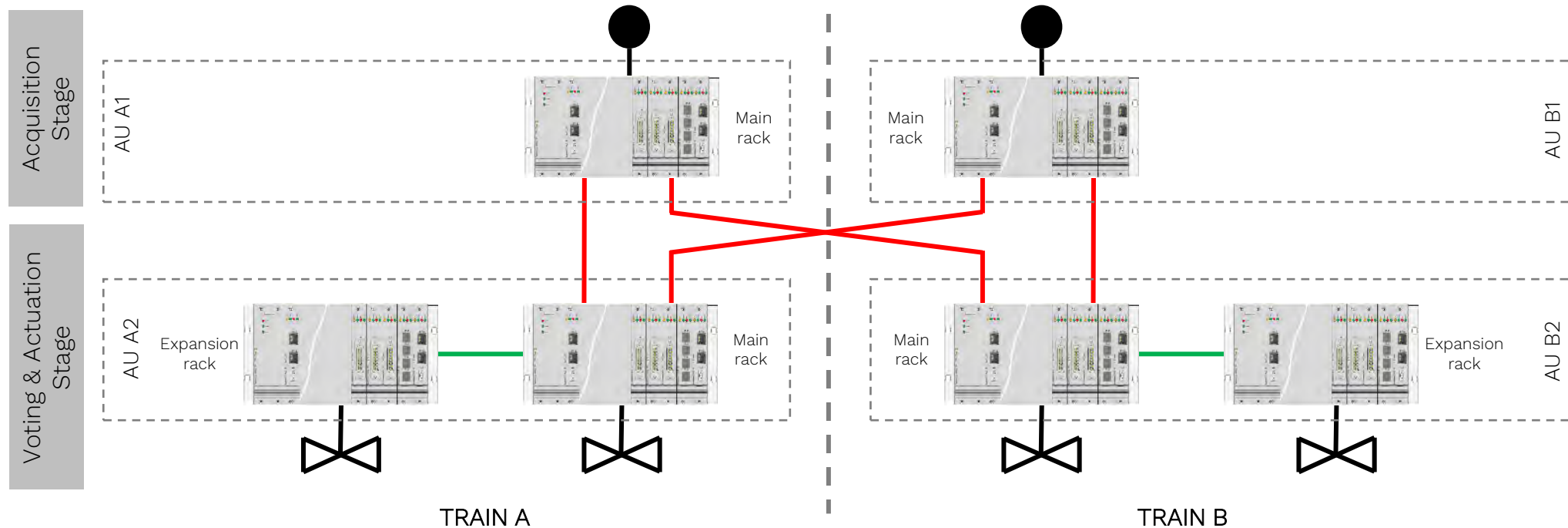
TXS Compact Modes & Releases

Each TXS Compact Automation Unit (AU) has a predefined set of modes with well defined possible transitions.

- **OPERATION** mode guarantees safe operation and predictable error management.

- **MAINTENANCE/DIAGNOSIS/COMMISSIONING** modes allow special maintenance capabilities while the unit is safely bypassed:
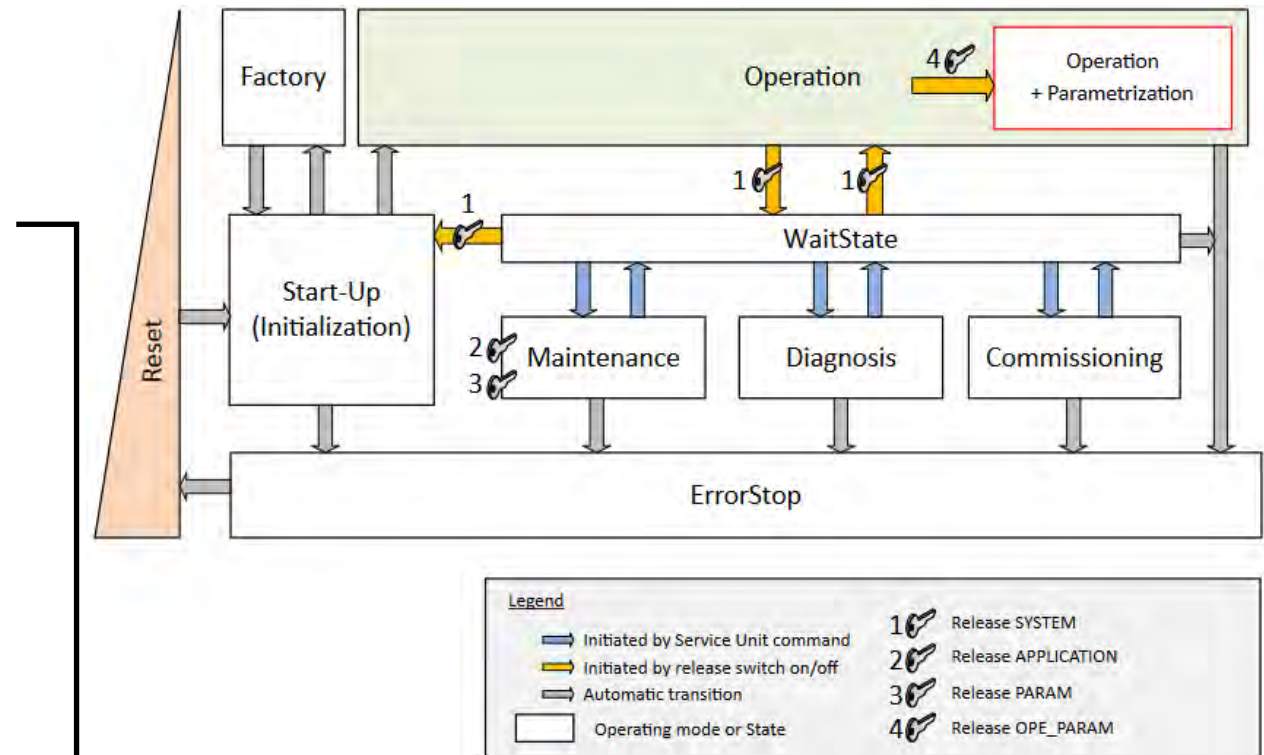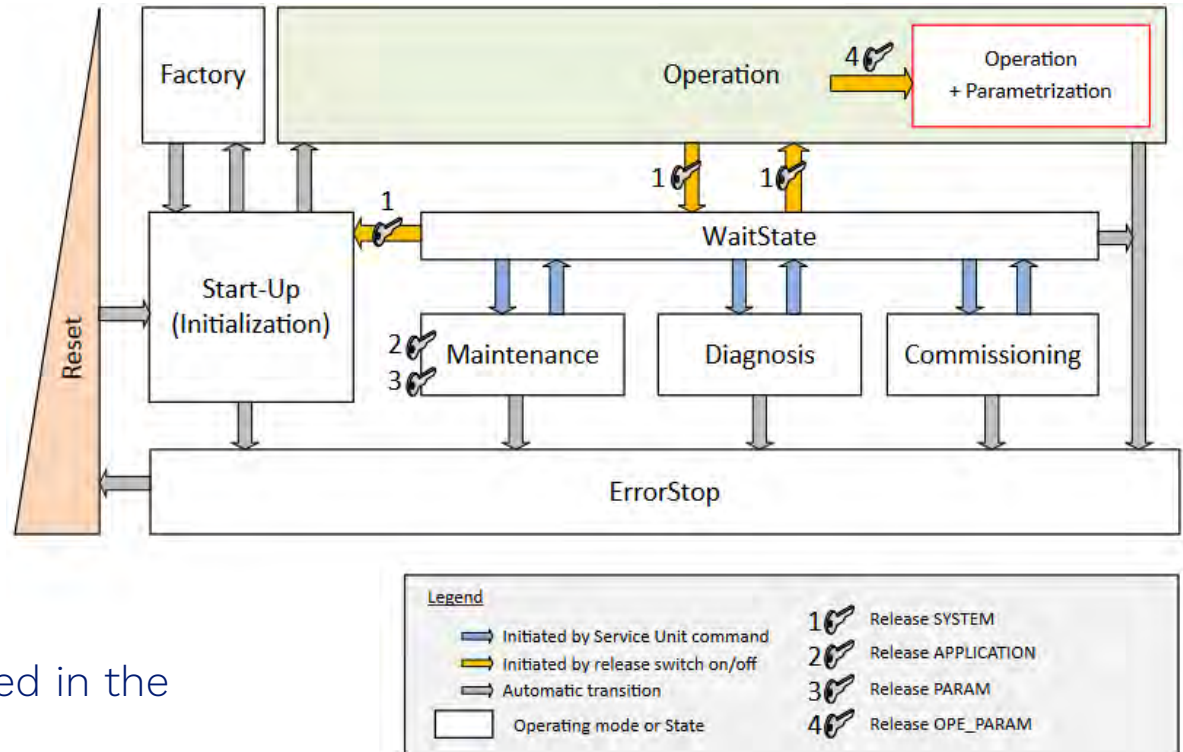
TXS Compact Modes & Releases (Cont'd)

Each TXS Compact Automation Unit (AU) has a predefined set of modes with well defined possible transitions.

Transitions between modes are protected by **RELEASES** which are activated by the application logic.

→ Protects both safety and security of the system (forbid updating parameters/application)

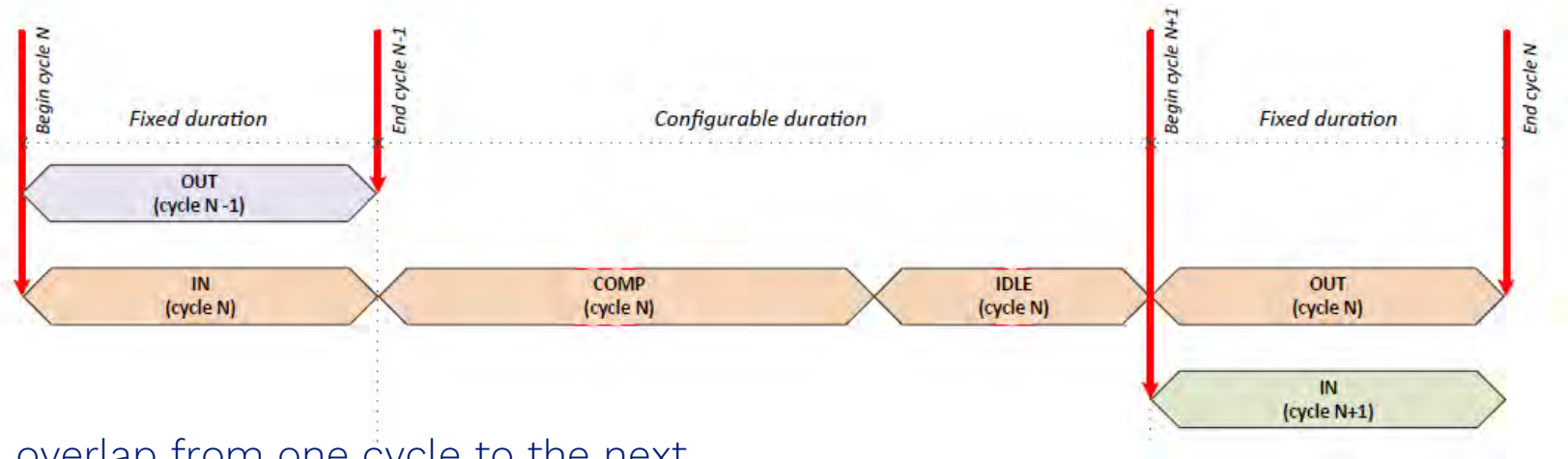Details of modes/releases management are documented in the Topical Report.

Typical application design is to wire releases to binary input, and then to a key switch.

TXS Compact Calculation Cycle

Highly deterministic behavior thanks to fully cyclic processing, constant execution time and low variability:

...and again and again...

Acquisition/sending phases overlap from one cycle to the next.

TXS Compact Calculation Cycle (Cont'd)

The execution model is extremely simple, and low variability is observed:

[ ]

AGT tool verifies that the target user-specified cycle time for each automation unit is sufficient to accommodate execution of all the specified logic.

Self-tests take benefit of the partitioning capabilities of FPGAs and are executed in parallel of the processing cycle. Details are documented in the Topical Report.
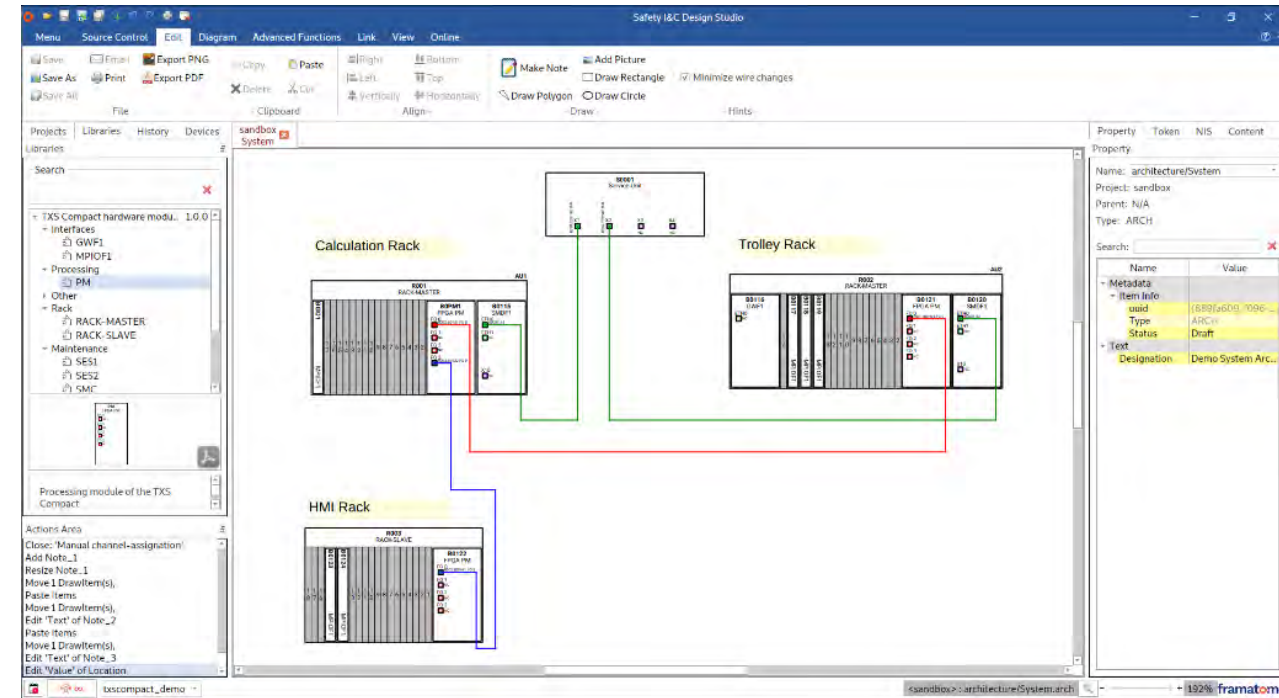
TXS Compact Engineering Tools

The TXS Compact platform supplies tools to support **system engineering** activities:

- Authoring of logic diagrams and system architecture diagrams → creation of the system's <u>technical specification</u>

- Storage and versioning of the technical specification in a secure manner

- Functional simulation software

- Automatic checking of the technical specification and automatic generation of the configuration for the automation units

- Automatic verification of the generated configuration files through a tool dissimilar to the generation tool

TXS Compact Engineering Tools (Cont'd)
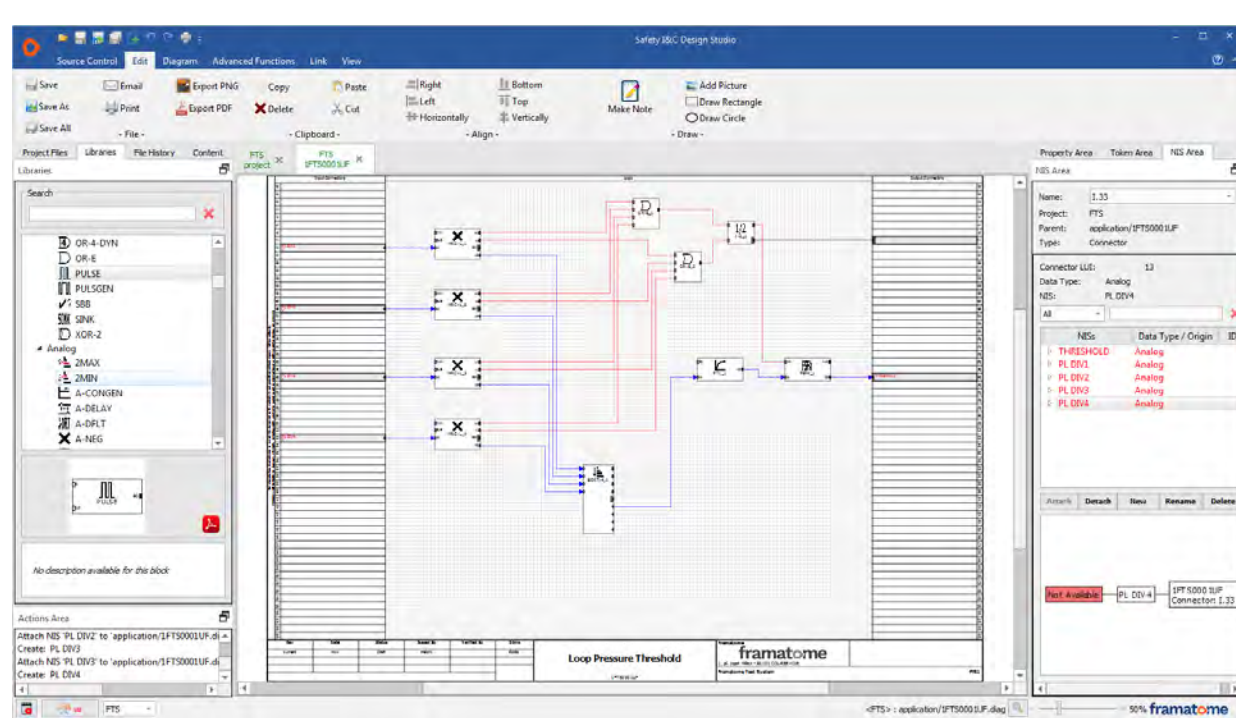
Logic diagram

System Architecture diagram

The main authoring software: TXS Design Studio.

TXS Compact Engineering Tools (Cont'd)

The logic diagrams are function block diagrams built from a library of pre-qualified function blocks which offer a wide variety of functions:

Complete list is provided in the topical report.

Function blocks follow documented and consistent graceful degradation principle when inputs gets faulty for some reasons.

Some function blocks have parameters and/or internal memories.
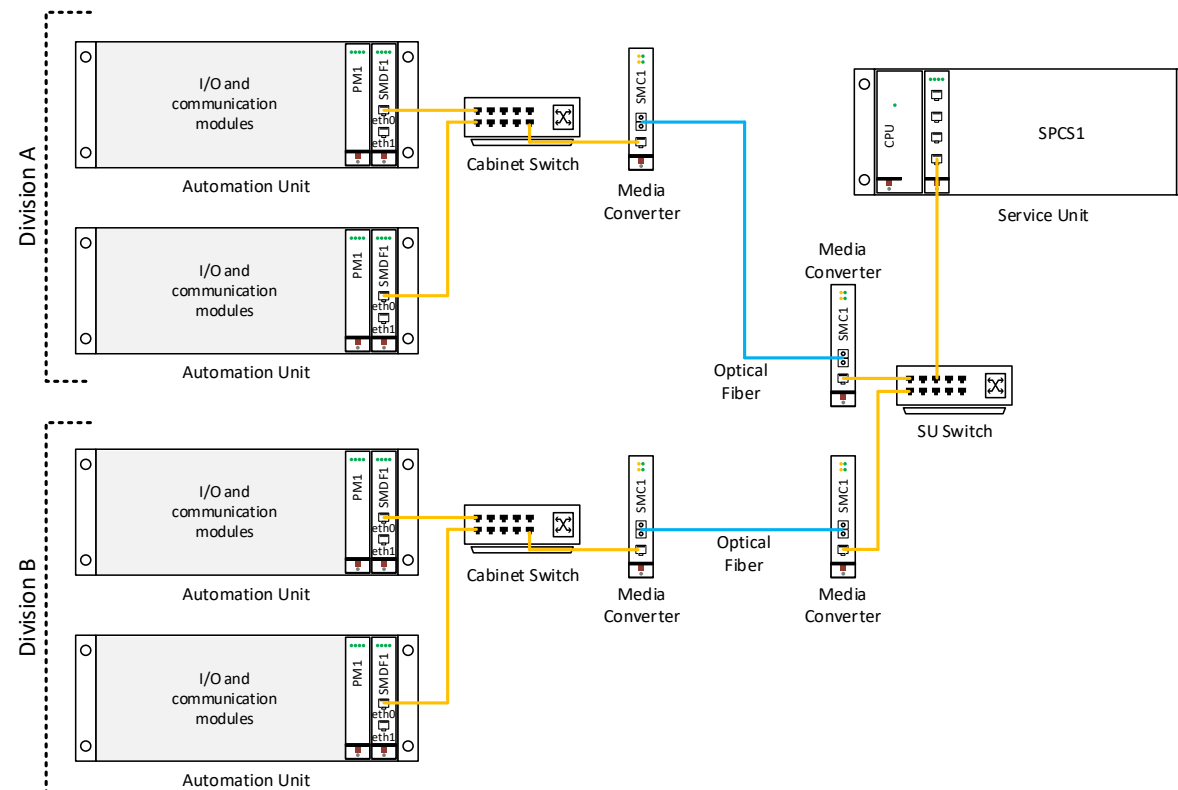
TXS Compact Service Concept

The **Service Unit** computer provides to the Plant Operator all the functions required to perform maintenance of TXS Compact based I&C systems;

- Permanently:
  - Displaying statuses of active devices and hence detecting errors and diagnosing the causes of errors ("diagnosis")
  - Monitoring the system during operation by tracing and recording signal values and signal statuses, on curves and/or by animating diagrams ("measurement")
  - Configuring the service functions and the MODBUS interface

- If authorized by the system's operational status:
  - Changing the functional parameters ("parameterization")
  - Updating I&C application ("application loading")
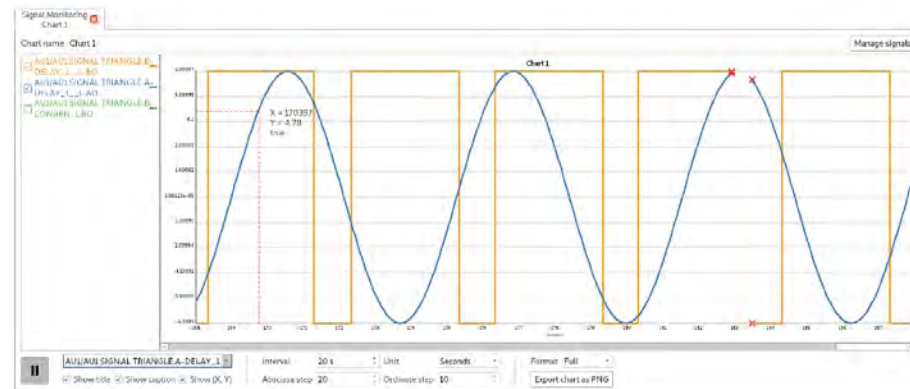
TXS Compact Service Concept (Cont'd)

Segregation of plant process data and service data on two physically separated networks:

Exemple of service network

TXS Compact Service Concept (Cont'd)

TXS Compact Self-tests, Monitoring and Calibration

Each hardware module performs **built-in self-tests and self-monitoring** and reports its status to the main PM1 module.

Complete list is provided in the topical report and an additional dedicated report.

Results can be accessed by the plant operator:

- Local LEDs on the modules' front plates for the most critical faults;

- Status panels on the Service Unit computer;

- Exported through the MODBUS interface to another plant computer.

TXS Compact Self-tests, Monitoring and Calibration (Cont'd)

Faults are categorized depending on their impact:

- Fatal errors (permanent or transient) for which the module is not considered being able to perform the intended function;

- Non-fatal errors, for which the consequences can be limited to e.g. some signals (for instance, one single electrical input has failed).

TXS Compact Self-tests, Monitoring and Calibration (Cont'd)

Calibration

- Analog channels on TXS Compact I/O modules are calibrated during manufacturing to get the right accuracy;

- Calibration does not need to be adjusted later during commissioning or operation;

- Self-tests verify that precision remains into specified range;

- In case of deviation, the whole module is exchanged and returned to Framatome.

Periodic Tests

- TXS Compact provides the ability to perform periodic surveillance tests through the Service Unit.

- Internationally, Framatome could provide a basis that the TXS platform supports a reduction in periodic surveillance testing.

TXS Compact Lifecycle, Development and V&V Processes

- TXS Compact is developed, verified and validated, and maintained according to a set of engineering procedures and Quality Assurance (QA) instructions embedded in the Framatome QA system.

- TXS Compact development process is inline with BTP 7-14 requirements

TXS Compact Qualification Concept

TXS Compact Generic Equipment Qualification

❯ Hardware testing is successfully performed and will be summarized per module in the summary qualification report.

TXS Compact Supplemental EQ Testing for Compliance with US Standards

5 Presentation Break

6

TXS Compact Topical Report Structure

TXS Compact Topical Report

- TXS Compact Topical Report has been prepared in a manner to address the Guidance and Topics provided in ISG-06 R2, "Licensing Process"

- TXS Compact Document Phase 1 and Phase 2 Document Submittals have been planned consistent with the guidance provided in ISG-06 R2, "Licensing Process Enclosure B"

- TXS Compact Topical Report provides a mapping to the guidance provided in NUREG-0800, "Standard Review Plan" Table 7-1, "Regulatory Requirements, Acceptance Criteria, and Guidelines for Instrumentation and Control Systems important to Safety.

TXS Compact Topical Report – Table of Contents

Section 1 – TXS Compact Introduction

- o Objective
- o Scope
- o Background

Section 2 – TXS Compact Platform Description

- o TXS Family Overview
- o Standard Modules
- o Operation Principles
- o Internal Communications
- o Modes of Operation
- o Cabinet and Peripherals
- o Response Time
- o Accuracy
- o Human Factors Considerations

TXS Compact Topical Report – Table of Contents

Section 3 – TXS Compact Diagnostics and Monitoring

- Application Configuration
- Diagnostics and Fault Indications
- Platform Maintenance Features
- Maintenance Terminology
- Calibration of I/O Module
- Test of I/O Module
- Access and Control of Setpoints and Parameters

Section 4 – TXS Compact Equipment Qualification

- Equipment Qualification Approach
- Assessment and Analyses
- Visual Inspection
- Initial Functional Tests
- Electrical Characteristics
- Electromagnetic Compatibility (EMC) Testing
  - Electromagnetic Emissions
  - Electromagnetic Immunity

TXS Compact Topical Report – Table of Contents

Section 4 – TXS Compact Equipment Qualification (Cont'd)

- Tests to Demonstrate Behavior Over Time / Operational Vibration and Climatic Tests
  - Operational Vibration
  - Climatic – Non Operation
  - Climatic – Operation
- Mechanical and Seismic Tests
  - Seismic Test Approach
  - Mechanical Stress During Transport
  - Mechanical Stress During Operation
- Final Functional Tests
- Compliance with US Standards
  - Seismic
  - Environmental
  - Electromagnetic Interference / Radio Frequency Interference (EMI/RFI) Withstand
  - Electrostatic Discharge (ESD) Withstand
  - Test System Application Program (TSAP)

Section 5 – TXS Compact PLATFORM Communications

- Intra-Divisional / Inter-Divisional Safety-to-Safety Communication
- Safety-to-Non-Safety Communication
- Multidivisional Control in Multiple Safety Divisions

TXS Compact Topical Report – Table of Contents

Section 6 – TXS Compact Lifecycle Management

- o Lifecycle Model
- o Development and Verification and Validation (V&V) Processes
  - Development
  - Verification and Validation
- o Production Stage

Section 7 – TXS Compact Reliability and FMEA

Section 8 – TXS Compact Quality Assurance

- o Regulatory Basis
- o Framatome Quality Assurance (QA) Program
- o Audit of the TXS Compact Platform

Section 9 – TXS Compact Security

- o Security Overview
- o People Check
- o Life Cycle Security
- o Security Attributes of the TXS Compact Platform

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TXS Compact Topical Report – Table of Contents

Section 10 – TXS Compact Training

- Training of Development Personnel
- Training of Application Personnel
- Training of Customer Personnel

Section 11 – TXS Compact REGULATORY COMPLIANCE

- Compliance to IEEE Std 603
- Compliance to IEEE Std 7-4.3.2
- Compliance to DI&C ISG-04
- Compliance to NRC BTP 7-14
- Compliance to NRC Regulatory Guide 1.152
- Compliance to NUREG 0800 Table 7-1 Criteria
- Compliance to DI&C ISG-06 Licensing Process
- Relationship Between TXS Compact Program Development in US NRC RG Criteria

Section 12 – References

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TXS Compact Phase 1 Submittals

Phase 1 Submittals

This list provides the required phase 1 documents in accordance with ISG-06 regulatory guidance.

Phase 1 Submittals (Cont'd)

Phase 1 Submittals (Cont'd)

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TXS Compact Phase 2 Submittals

Phase 2 Submittals

This list provides the required phase 2 documents in accordance with ISG-06 regulatory guidance.

Phase 2 Submittals (Cont'd)

Phase 2 Submittals (Cont'd)

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TXS Compact Roadmap

TXS Compact Roadmap

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US Licensee "Expression of Interest" Letters

Expression of Interest Letters

Expression of Interest Letters have been provided from the following :

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Framatome Request for NRC Support

Request for NRC Support

In order to maintain the TXS Compact Program Milestones identified in the TXS Compact Roadmap, Framatome is requesting NRC support:

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Summary of Questions and Action Items

framatome

Thank you

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