

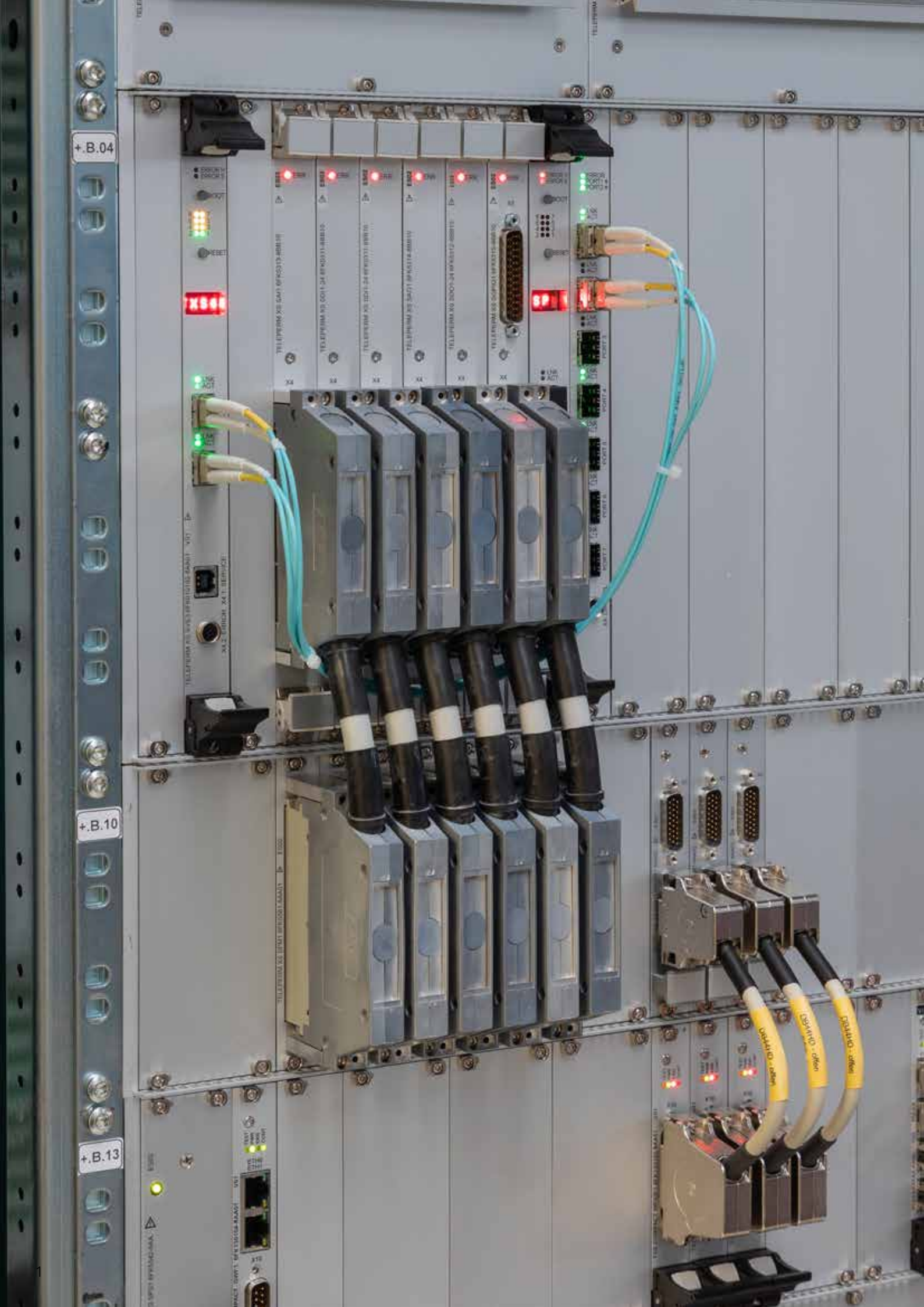
framatome

TELEPERM

XS

The comprehensive
safety I&C platform
for nuclear plants







TELEPERM XS

Next Level Technology
Next Level Certainty
Next Level Operation

You face critical choices every day about the ongoing safety and reliable operation of your plant. Obsolescence and licensing issues can directly impact the lifetime of your nuclear assets.

For these challenges and others, Framatome offers TELEPERM XS, an instrumentation and control (I&C) solution for the present and the future — a solution that provides greater safety, quality, licensability and reliability along with seamless integration and cost-effectiveness — and does it with certainty.

CONTENT OVERVIEW

TELEPERM XS at a glance	04
Expertise and experience.....	06
Support, service and training.....	08
Platform evolution and success.....	10
Qualification – Built for nuclear.....	12
Application and main features.....	16
Platform modularity and architecture	18
CPU-based automation computer.....	20
FPGA-based TELEPERM XS Compact.....	22
Mechanical equipment and cabinets	24
Human-machine interfaces.....	26
Electronic modules.....	28
Design and engineering tests.....	30
Technical data	32

TELEPERM XS at a glance

➤ **TELEPERM XS is Framatome's flexible and modular system platform for safety I&C systems in nuclear power plants.**

This comprehensive and innovative solution comprises all hardware and software components, including the tools required for engineering, testing, commissioning, operating and troubleshooting safety I&C systems.

Hardware and software have been developed and qualified in accordance with the most stringent safety requirements. Experts from independent test institutions have assessed and certified the relevant safety features. TELEPERM XS complies with all requirements for I&C equipment that performs category A functions as defined in International Electrotechnical Commission (IEC) 61226.

Primary applications:

- Reactor protection system
- Reactor control and reactor limitation systems
- Neutron flux measurement
- Core monitoring and control
- Rod position indication
- Emergency diesel generator control



New installations and modernization

TELEPERM XS is suitable for all reactor types, whether for new construction or upgrading existing plants. Modernizing I&C systems increases operational efficiency and eases maintenance effort. That in turn, extends your plant's life and optimizes its performance. Upgrading your I&C with TELEPERM XS comes with the benefits of a smooth licensing process, the shortest possible outage period for modernization migration and lower risk of subsequent plant unavailability.

TELEPERM XS qualification data is regularly updated to meet ever-evolving requirements:

- Software and complex electronic components
- Environmental condition testing, mechanical load, seismic, electromagnetic compatibility
- Cybersecurity
- Application-oriented languages and code generation

Less maintenance and testing

Virtually maintenance-free, TELEPERM XS significantly reduces service effort compared with traditional hardwired systems. A majority of I&C functions are implemented in the software, which is not subject to aging. The high level of system hardware component reliability along with the wide scope of the self-monitoring mechanisms means intervals for periodic testing have been extended to several years in some cases. Integrated self-monitoring and engineered monitoring functions cover close to 100 percent of testing requirements.

All hardware and software is fully owned by Framatome and complies with all technical, quality, validation and verification requirements. The platform's cybersecurity, ensured by product design, features a systematic approach to cyber risk minimization that meets all international codes and standards.

Benefits of TELEPERM XS

- Highest reliability and availability
- Reduced operating and maintenance costs
- Long-term support
- State-of-the-art technology
- Comprehensive design and integration experience
- Cybersecurity by design

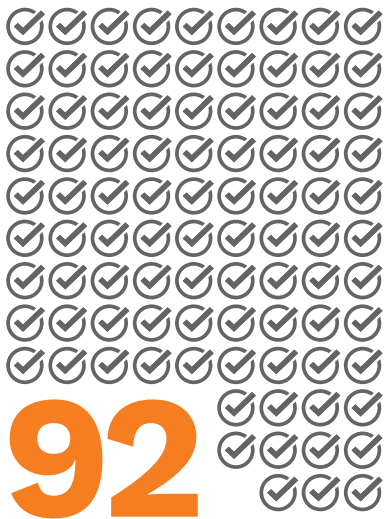
The latest generation of the TELEPERM XS CPU-based automation computer features best-in-class software architecture along with simple communication protocols — anticipating and meeting future requirements to facilitate licensing while improving performance.

- Flexible and modular I&C system platform for applications requiring the highest safety standards
- Comprehensive and complete with all hardware and software components
- Includes all tools required for engineering, testing, operation and maintenance
- Certified by independent test institutions
- Fast-track licensing thanks to prequalified software components



Expertise and experience

You know the expertise of Framatome — our decades of experience developing, manufacturing and maintaining I&C systems as well as our fleet-wide implementations of digital I&C modernizations. With the commissioning of our first TELEPERM XS system in 1998, we took nuclear power plant operation to the next level — a platform that integrates seamlessly into existing systems, optimizing performance, safety, and security, while allowing for easy upgrades. We've completed more than 440 comprehensive system installations worldwide, including over 250 digital safety systems in nuclear power plants of various designs. That's more recent and relevant experience in performing digital upgrades for existing plants than any other supplier.

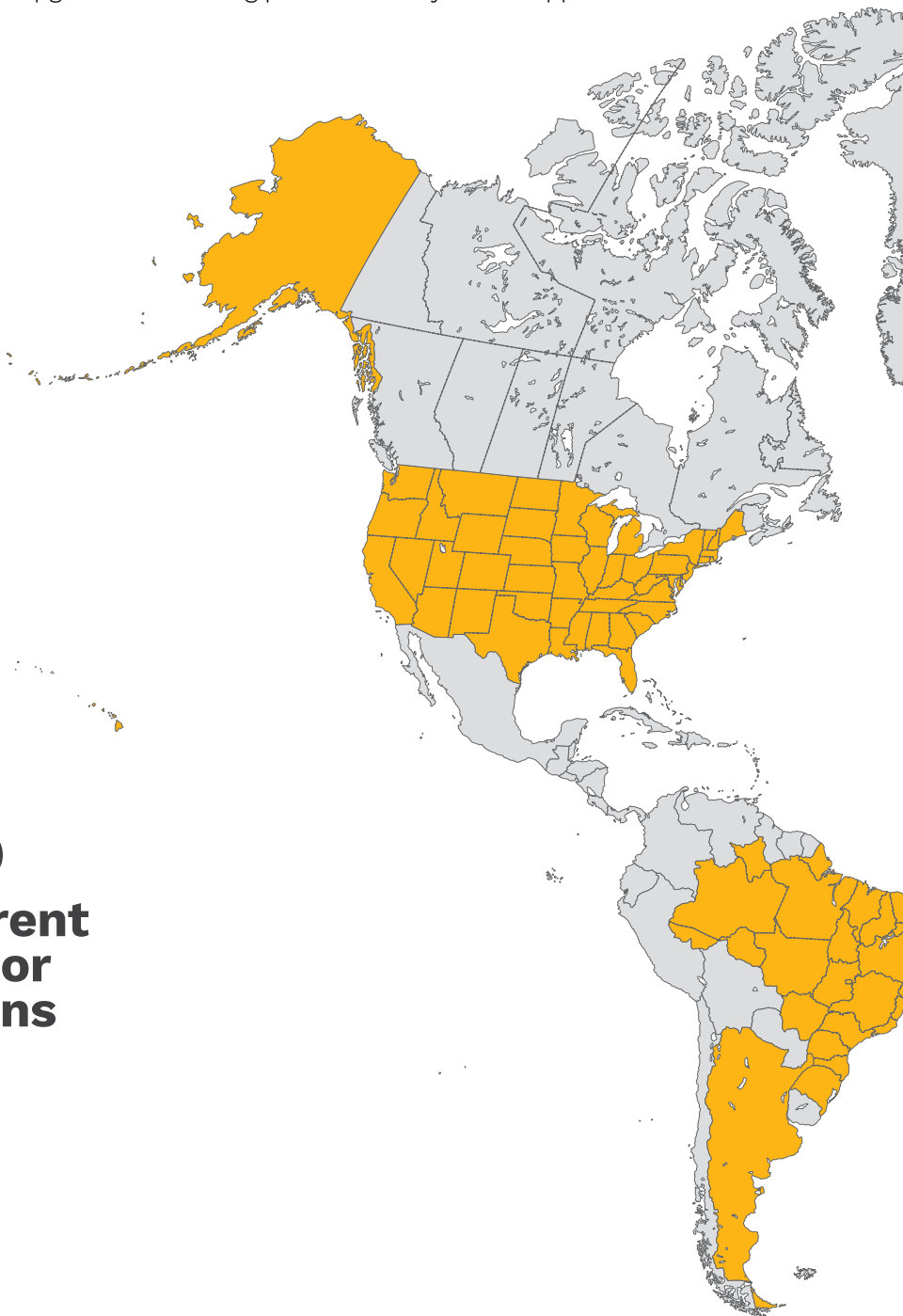


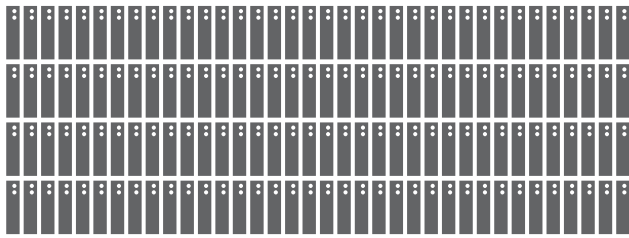
92

**installations
completed**
on



18
**different
reactor
designs**



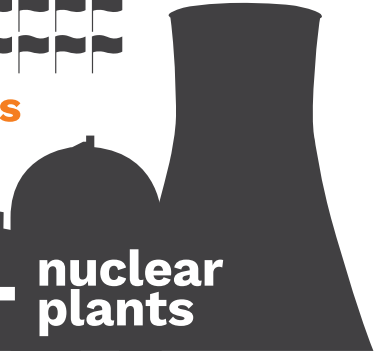


200
systems

In **17** 
countries

installed in

45+ nuclear
plants





Technology and support from a single source

The unmatched capabilities of Framatome and its team of over 2,100 I&C professionals facilitate the development and engineering of TELEPERM XS. Our support team includes the leading experts in I&C along with engineers specializing in process and safety, licensing, electrical systems, manufacturing, installation and commissioning. That's why we can guarantee repair service, long-term availability of spare parts, IT security patches for auxiliary computers and upgradability of systems.

➤ The platform offers all the flexibility needed to respond to the demands of different plant types, and meets the most stringent requirements of I&C system regulations.

Framatome commits to TELEPERM XS long-term spare parts support based on our 4-step concept.

STEP

1

Original modules

STEP

2

Form, fit, functionally compatible modules with same qualification status as the original module

STEP

3

Functionally compatible new version modules with same qualification status as the original module

STEP

4

Functionally compatible solutions

TELEPERM XS comes with comprehensive lifecycle support that reduces operating and maintenance costs, improves safety and performance, and extends and optimizes the service life of nuclear power plants. TELEPERM XS lifecycle solutions comprise:

- Outage support
- Maintenance, repair, and refurbishment
- Obsolescence management, spare parts
- Modular training program

Keeping systems running — for a lifetime

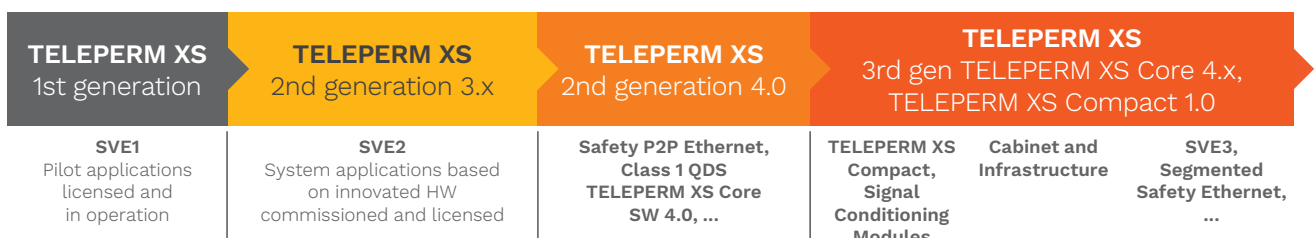
Safe, reliable and long-term plant operation with TELEPERM XS is our goal. That's why Framatome ensures system expertise is always available, and expansion and modification of existing systems is always feasible. We provide either new platforms that maintain compatibility with predecessor components or easily integrated replacement solutions for existing systems. Components from different generations can cooperate, which limits conversion work in the event of upgrades. Every component undergoes a lifecycle of development, series production, and spare part supply. We monitor the production of each individual component, implement active warehousing, and initiate the timely development and qualification of follow-on solutions.

Training

Framatome offers training in all aspects of engineering, testing, maintenance and operation of TELEPERM XS-based safety I&C systems. In addition to hardware and software training, system, basic, engineering, maintenance, and test bay training is an integral part of our instructional program. The modular training concept allows us to respond to specific customer needs and implement customized training concepts. If desired, we still provide training for systems that are more than 40 years old. The training reflects a balanced mixture of theoretical instruction, individual and group exercises, and hands-on training in the handling of a real TELEPERM XS I&C system.

Evolution meets innovation

We can look back on more than 60 years of experience in reactor design, nuclear power plant equipment, and I&C systems. With the commissioning of our first TELEPERM XS system in 1998, we took nuclear power plant operation to the next level. Since then, our developments integrate seamlessly into your existing systems to optimize performance, safety and security.



For more than 20 years, TELEPERM XS-based systems have operated in nuclear power plants around the globe. These accumulated centuries of operational experience feed directly into ongoing system development. Our goals are to meet anticipated future requirements with state-of-the-art technology, maintain backward compatibility, and improve functional, safety and security features. This approach has led to new product versions characterized by new generations of the system platform, while our long-term service agreements mean we continue to provide support and maintenance solutions for even our earliest versions of TELEPERM XS.

Continuous progress

Following the first generation of the platform using the SVE1 processing module, subsequent TELEPERM XS evolutions began with the introduction of the second generation in 2004. It featured the addition of the SVE2 module, an update of the TELEPERM XS Core software and innovations in the hardware modules.

A comprehensive range of signal conditioning modules soon followed, completing the versatile I&C platform seen today. This configuration of TELEPERM XS used the same communication topology as the first generation, i.e., Profibus for the safety network and Ethernet for the service interface. In 2019 Framatome released a new configuration of the second generation with 32-bit core software and new modules for point-to-point Safety Ethernet networking and communication. The system's Qualified Display System (QDS) is qualified as a class 1 device and the software fulfills IEC 60880 requirements.

The latest generation of TELEPERM XS contains an innovative SVE3 processing module that has five times the performance of an SVE2 with 32-bit core software, and a new, smaller-scale diverse FPGA-based platform called TELEPERM XS Compact — as well as a new family of signal conditioning modules with enhanced properties, a new mechanical enclosure, and a new cabinet infrastructure for the power supply, cabinet monitoring and fan units.

➤ **The platform offers all the flexibility needed to respond to the demands of different plant types, and meets the most stringent requirements of I&C system regulations.**



Framatome balances new market needs, obsolescence issues and evolving qualification and licensing requirements with long-term support of installed applications.

- Guaranteeing spare parts for installed systems
- Defining upgrade strategies enabling interaction of modules from different generations
- Selecting up-to-date and proven technologies to ensure long-term commitments
- Responding to new market needs and evolving nuclear requirements

Our latest developments and beyond:

- Five-fold increase in computing power provided by new processing module and software architecture
- Fiber-optic network and future-oriented, specific communication protocols to strengthen platform performance and security
- New communication processor and Class 1 network switch
- Physical data diode and media converter enables and secures all types of communication architecture
- Seismic hardness up to 5 g
- Improved cabinet cooling concept for better component cooling
- Significant reduction of system footprint thanks to increased compactness and new, flexible electromechanical infrastructure
- State-of-the-art maintenance equipment reduces test and outage periods during installation
- Easier maintenance, increased heat dissipation performance, and greater flexibility

To evolve and keep pace with ongoing changes in the industry, Framatome continuously updates and improves the TELEPERM XS platform with state-of-the-art technology that fulfills recent and future requirements. We also provide predefined spare parts and upgrade concepts for installed systems.

Qualification — Built for nuclear

Qualification and licensing

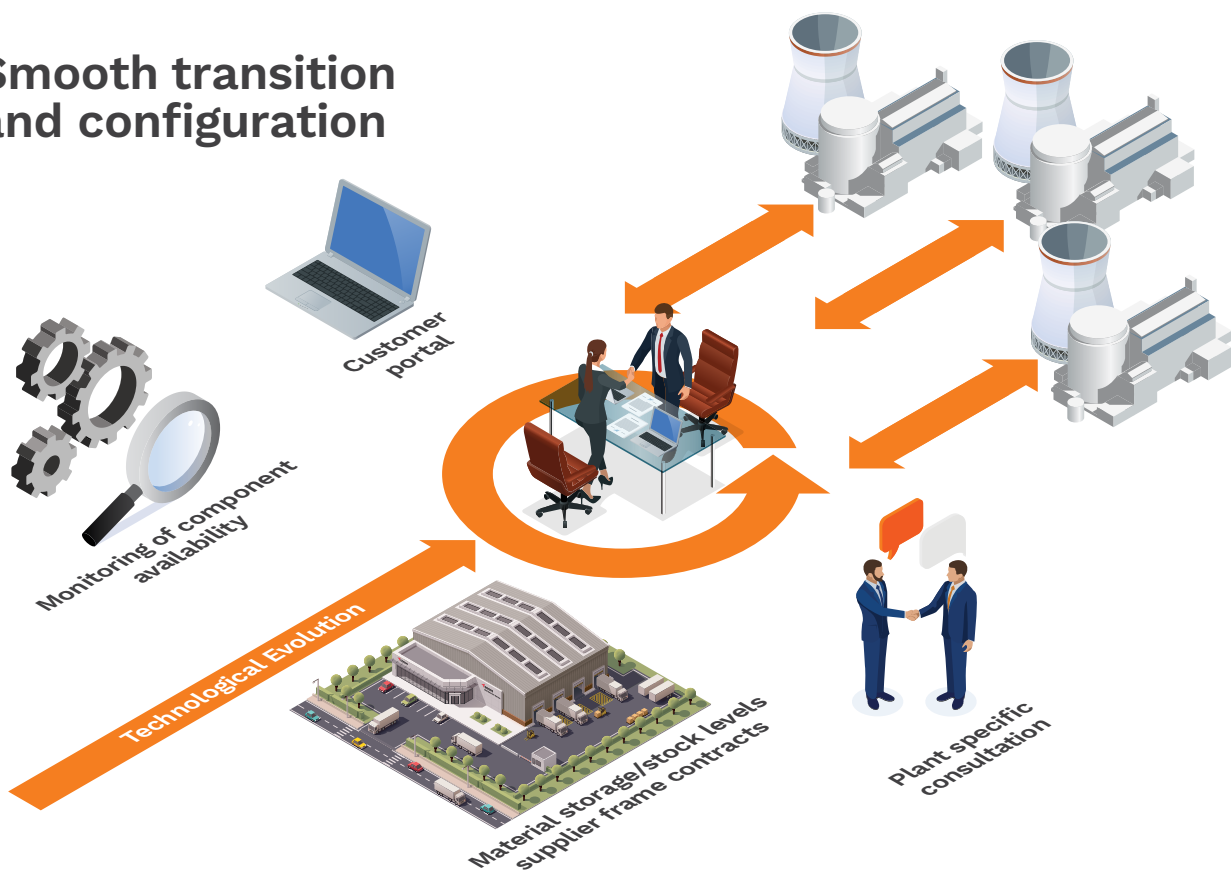
Developed in accordance with the most stringent requirements, the TELEPERM XS system platform is owned outright by Framatome, as is all evidence demonstrating compliance with technical, quality, and verification and validation requirements. Any requests for additional information and analyses imposed by a regulator can therefore be efficiently addressed. Acceptance of the generic qualification in the plant-specific licensing process means low risk. TELEPERM XS I&C system solutions include assessment documentation required by the customer's licensing authority for review and approval, as well as specifications for continuous quality assurance. Framatome also prepares detailed analyses required for the licensing procedure. TELEPERM XS hardware and software are fully owned by Framatome and developed within the framework of a nuclear grade quality assurance program. The robust hardware is type-tested in qualification programs adhering to IEC/IEEE 60780-323, RCC-E, and KTA requirements with respect to functional, environmental condition, EMC, mechanical load, and seismic exigencies.

Smooth change and configuration management

Framatome tracks all TELEPERM XS operating experience and project applications. Processes and tools are in place that include each project's regulations and activities in order to:

- Register change requests concerning TELEPERM XS software or hardware components and manage analysis, planning, decision and implementation of related changes
- Handle returned goods, perform fault analysis and repair, and continually monitor failure statistics and causes of single faults
- Analyze lessons learned, and process identified non-conformances
- Communicate through service letters product-related information to customers
- Allow electronic component storage for long-term availability of TELEPERM XS hardware
- Plan and implement modernizations and upgrades of I&C systems

Smooth transition and configuration



Conformity with all IEC nuclear standards

Generic qualification of TELEPERM XS hardware and software components minimizes the effort required for qualifying plant-specific solutions and streamlines the licensing process.

Type tests not only confirm the functional and electrical properties of all hardware components, but also the fulfillment of all requirements for all expected applications with regard to environmental conditions, EMC, mechanical and seismic properties. Automation units provide all the safety features required for implementing Class 1 safety I&C systems.





Hardware Qualification Methodology

Equipment Qualification Method

Visual Inspection
IEC 60664; IEC 60529

Initial and Final Functional Tests

Electrical Tests

Climatic Tests
IEC 60068-2-xx

Mechanical Load Tests
IEC 60068-2-yy;
IEC/IEEE 60980-344

Electromagnetic Compatibility Tests
IEC61000-6-2; IEC 61000-6-4;
61000-4-x; IEC 62003

Supplemental Tests
(of Integrated
HW configurations)

Hardware — including embedded programmable components

TELEPERM XS hardware components are designed for installation and operation in air-conditioned electronic equipment rooms. For hardware qualification, a blanket approach of type-testing is used in ambient conditions covering international IEC standards, selected national standards, and requirement profiles of all anticipated safety applications. To standardize the type-test approach, an enveloping procedure is used with the IEC/IEEE 60780-323, RCC-E, and KTA 3503 as the main methodological references. This procedure confirms every hardware module fulfills specifications regarding:

- Functionality
- Electrical characteristics including electrical safety
- Environmental conditions
- Electromagnetic compatibility
- Mechanical load

Practical type testing

Supervised by experts from independent accredited test laboratories like TÜV Nord, TÜV Süd, and TÜV Rheinland, practical testing is a common practice for: inspection of the hardware development and manufacturing process according to IEC 60987; evaluation of the compliance of the firmware with IEC 60880 or IEC 62138; and programmable hardware designs with IEC 62566. Extensive type-test and inspection reports are summarized in certificates, attesting to the positive results of these qualification tests and verifications. The certificates are the basis for demonstrating the hardware's qualification in licensing procedures. When there are specific requirements not covered by the standard qualification procedure (for example, an extended range of environmental or seismic conditions or a special national testing requirement), Framatome is ready to meet those requirements by undergoing supplementary qualification testing.

Software design: operational system software and application software

Application software for TELEPERM XS-based I&C systems is engineered by interconnecting function blocks and hardware blocks according to network diagrams stored in the project database. The executable code is automatically produced by code generators, compilers, and linkers based on these specifications. This ensures production of simple code structures that fulfill the highest test requirements, completely documented in graphical form.

The high-level application-oriented programming language uses the generic function blocks. Understanding and analyzing the application doesn't require knowledge of the function block internals or the operational system software programming details. Assessors in charge of approving the design of a safety I&C system can focus on the application aspects.

The reusable software components — the function blocks and system software components — were developed, verified, and tested in a lifecycle model consistent with the requirements of IEC 60880. This includes implementing sufficient development stages, phase and document reviews as well as adequate independence of specifiers, programmers and testers.

All development documentation is owned by Framatome. All reports from tests, stack analyses and test coverage analyses of software characteristics are available for auditing. Summary test reports and compliance analyses showing the fulfillment of IEC 61513 and IEC 60880 requirements are available. These documents facilitate an understanding of the software concepts and help interpret the standards.

Similar to the approach used for hardware type-testing, independent inspection bodies are involved in verifying software development processes, the quality of the documentation, and the adequacy of testing and analyses. Summary test reports, compliance analyses, inspection reports, and certificates are a perfect basis for supporting the plant-specific licensing process.

Safety features

Demonstrating the safety of I&C systems relies in large part on realizing a set of key safety factors ensured by hardware and software interactions in the automation units.

- Automation units belonging to different redundancies must be independent: The failure of one unit must not affect the others.
- Minimizing hardware and software failure impacts: If malfunctions occur, this is ensured by fail-safe behavior of individual hardware components and automation units.
- Minimizing fault-propagation via communication interfaces between subsystems by excluding malfunction-affected signals from processing.
- Protect systems from unwanted influences: lower classified equipment and unauthorized access.
- Deterministic software execution providing predictable and easy-to-calculate response times of automation solution.

A set of corresponding safety features has been defined as TELEPERM XS system properties. The generic qualification of the platform includes all evidence that these system properties are correctly implemented via the interaction of hardware and software, and that they're consistent with the requirements of nuclear standards like IEC 61513 (system elements), IEC 60671 (surveillance testing) and IEC 60709 (separation). As a complement to the type-testing of hardware and software components, the implementation of the system properties is also subject to assessment by independent bodies.

Crediting the system properties makes it easy to show that safety I&C systems comply with safety requirements. This is a strong element in facilitating the licensing process.

One system platform – many possibilities

TELEPERM XS offers a flexible, task-oriented architecture that allows for economical and space-saving solutions for nuclear power plants of every type and size. The platform supports a long system lifespan by using interfaces and communication standards wherever possible as well as up-to-date methods for engineering and maintenance.



According to nuclear power plant safety requirements, the safety I&C system must be divided into physically separated trains. Typical architecture features include two, three, or four redundant channels. The automation unit hardware is assembled from standard modules based on the specific I&C applications. TELEPERM XS system hardware consists of qualified and task-specific modules with extensive operating experience. The configuration of each automation unit can be adjusted by the designer using hardware and software modules provided by the system platform.

Automation unit features

- Documentation of plant engineering automation: guaranteed optimal consistency and validity
- Highly efficient engineering and diagnostic tools to support engineering, monitoring, tests and diagnostics
- Digital signal processing unaffected by hardware component drift or electromagnetic interference
- Electrical isolation of automation computers using fiber optic data communication
- Early fault detection: full self-monitoring, high coverage of peripheral devices
- Protection from faulty signal propagation by data transmission fault detection measures
- Introduction of signal status that masks faulty signals allows for higher fault tolerance compared to hard-wired systems

The third generation of the TELEPERM XS platform provides diversified and fail-safe technologies. Applications can be realized by CPU- and/or FPGA-based processing.

- Cybersecurity by design
- Safety Ethernet
- Advanced cooling concept
- Optimized power supply units
- Monitoring

Safety I&C systems

In the area of reactor protection systems, typical applications include Engineered Safety Features Actuation System (ESFAS). These systems place the most stringent demands on system reliability, fault prevention and fault control. TELEPERM XS fulfills these demands with:

- Implementation of structures with high redundancy levels in accordance with plant requirements
- Isolation of redundant subsystems using fiber-optic cables
- High quality software, engineering and manufacturing
- Systematic handling of priorities between systems in different safety classes

Control of safety-related auxiliary and ancillary systems

TELEPERM XS provides protection-actuation signals with safety-related protection interlocks for emergency diesel generator controls. It also manages the actuation of a large number of auxiliary systems with operational functions.

Nuclear instrumentation

TELEPERM XS provides modules that convert special signals from nuclear instrumentation into standard signals. The most important applications are:

- Excore neutron flux measurement, comprising source, intermediate and power range channels
- Incore neutron flux measurement to determine reactor power and power density distribution

Turbine I&C

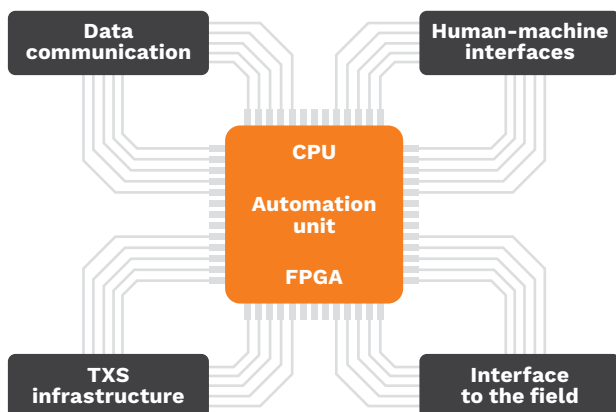
TELEPERM XS functions can also be used for non-safety related applications where short response times or high levels of reliability and performance are especially important. With the ability to implement multi-channel structures in an extremely compact design, the platform also meets the requirements of turbine control and turbine protection systems.





Modularity and technological diversity by design

Because of its modularity, TELEPERM XS can easily adapt to the structural requirements of any plant's safety systems. The platform comes with two complementary types of automation units, which are the central elements in all safety I&C systems.



Virtually every element of the safety I&C system architecture is implemented by combining sets of CPU-based TELEPERM XS automation computers and/or FPGA-based automation units in network structures. This meets all requirements for redundancy, physical separation and equipment diversity. Gateways with standard industrial protocols ease interfacing to process computers or third-party control systems.

TELEPERM XS is built on five pillars

TELEPERM XS INFRASTRUCTURE

1

- Mechanical equipment (cabinets, wall-mounted enclosures, sub-rack, rack)
- Cabinet infrastructure (power supply, fans)

HUMAN-MACHINE INTERFACES

2

- Qualified display system (QDS)
- Service, diagnostic, engineering and testing units

TWO TYPES OF AUTOMATION UNITS

3

- CPU-based automation computer (with engineered application functions, I/O modules, and network components) called TELEPERM XS Core
- FPGA-based automation unit (configured with application functions, I/O modules, and network components) called TELEPERM XS Compact

DATA COMMUNICATION

4

- Signal conditioning for analog and binary signals; temperature transmitter; speed signals
- Neutron flux measurement modules
- Drive control and priority modules

INTERFACES TO THE FIELD

5

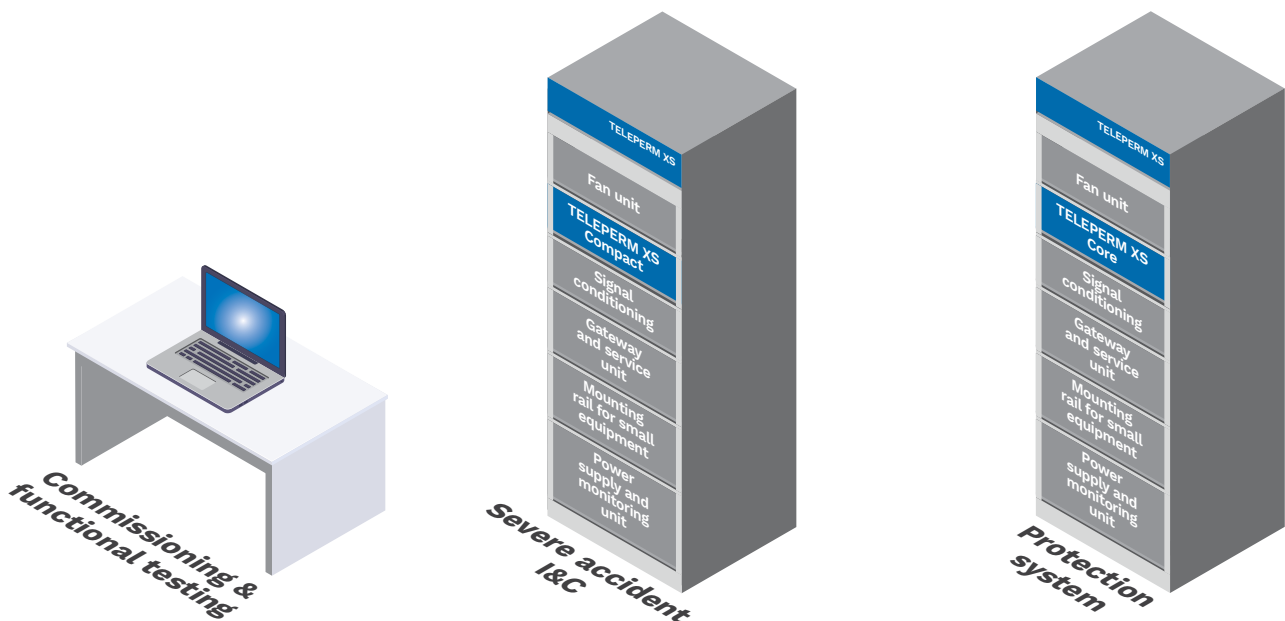
- Network communication (TELEPERM XS Safety Ethernet, TELEPERM XS Safety Profibus)
- Gateway to other I&C systems

The processing and communication core

CPU-based automation computers are the central building blocks of TELEPERM XS Core, one of the functional packages in the TELEPERM XS platform. The automation computers fulfill a variety of tasks depending on their position in the I&C system architecture. To meet the requirements of the different tasks, the TELEPERM XS platform provides a flexible configuration of components.

> A maintenance and service interface (MSI) computer serves as an interface and data transmission barrier between automation computers and/or TELEPERM XS Compact, other TELEPERM XS subsystems as well as the automation unit and classified equipment such as gateways and service stations.

The architecture of a safety I&C system based on TELEPERM XS Core consists of multiple automation computers exchanging I&C signals via the network. The CPU-based automation computer acquires electrical input signals, converts them to digital I&C signals, and performs CPU-based signal processing. The resulting digital signals are converted and transmitted by the automation computer as electrical signals. The system consists of the following components and modules:



New parameterization concept beyond the requirements of IEC 60880 and new function blocks added to the core software library

Operating and application software

Designed for reliability, the TELEPERM XS software operates on processing modules. It has a modular software structure with simple and testable components, a clear separation of I&C application-specific software code in each module, and the platform-level software code called Operational System Software (OSS).

The TELEPERM XS OSS runs on each processor during system operation. Used in all implemented I&C systems, the OSS comprises a run-time control system, input/output drivers, exception handler, communication software, application software libraries, online diagnostic, redundancy, and graceful degradation management.

The application functions are engineered using function diagrams in our new design studio. The functions offer additional features including embedded versioning and configuration management, traceability down to the individual function blocks, and an easy-to-use, modern and convenient interface. The interface enables users to select and connect the appropriate function block modules that are available from a function block library. The library is part of the OSS and contains more than 400 individual function blocks. For each processing module, the code is generated from the function diagram modules and then linked to the standard OSS. The software is designed to process the application functions deterministically.

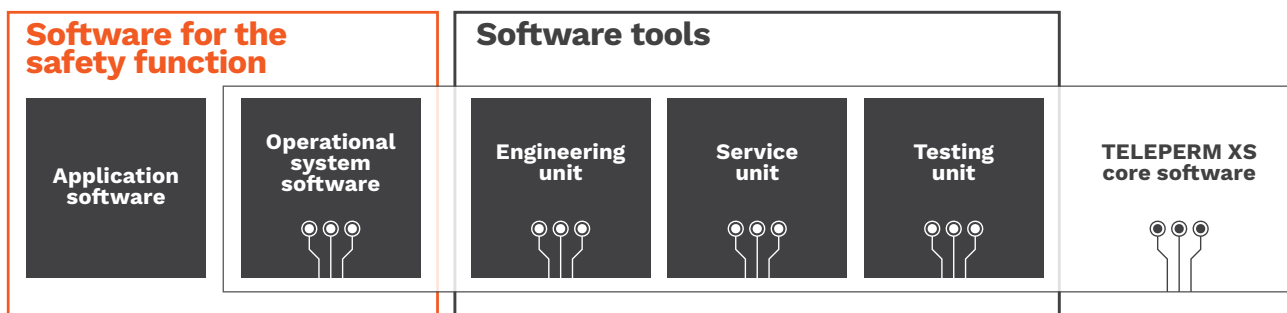
I/O modules

The entire spectrum of electrical standard signals can be acquired directly by the TELEPERM XS input/output modules. The modules use microcontrollers whose firmware is executed on a strictly cyclic basis. The firmware controls the signal input/output and data transfer to the processing module. It also performs hardware monitoring and self-tests. This extremely high level of self-testing extends the cycle of periodic testing to several years. The interfaces of the TELEPERM XS components are designed to meet national and international standards. Communication technology networking in the TELEPERM XS Core Software Release 4.0 or higher is exclusively based on Class 1 Ethernet. TELEPERM XS-Ethernet therefore “replaces” the TELEPERM XS-Profibus used in earlier versions of the TELEPERM XS platform. This eases licensing effort thanks to the simpler protocol.

Gateway unit

The gateway unit is dedicated to transferring a significant number of signals from one data-linked I&C system to another. To communicate with other I&C systems, the data need to be converted from the TELEPERM XS-Ethernet format to another appropriate format like ModBus/TCP. It's fully integrated into standard TELEPERM XS engineering tools, which means engineering data communication through gateways can be performed using the same tools and automation code generation as the automation unit of the I&C system.

TELEPERM XS software





Configured instead of programmed, TELEPERM XS Compact is a software-free, compact and scalable solution that fits easily into standard cabinets but still benefits from the full range of TELEPERM XS modules.

The compact FPGA-based alternative

Advanced and small modular reactors require a wide-ranging safety-related application that's compact, high-performance, and reliable. Framatome's solution is TELEPERM XS Compact, a series of modules for automation units based on field programmable gate array (FPGA) technology. This innovative solution for small and decentralized Class 1 systems offers a number of advantages: It's competitive, robust, compact, scalable and cybersecure by design. The simplicity of its design makes qualification easier. Safety I&C solutions used in TELEPERM XS Compact contain no CPU and no software. Instead, they operate entirely in configurable hardware logics in the FPGA and memory cells. This makes it the small-scale diverse sister technology of the CPU-based TELEPERM XS automation computer.

TELEPERM XS Compact was developed in compliance with nuclear standards (IEC and RCC-E) and is fully compatible with all components in the TELEPERM XS portfolio, including signal conditioning modules, cabinets, sub racks, power supply, etc. Signal exchange with CPU-based automation computers can be implemented via TELEPERM XS-Ethernet. It consists of four types of modules assembled to meet customer requirements: binary and analog input/output, processing, service, maintenance, and diagnostics. Communication within the rack uses a backplane, and external communication is interfaced at the front panel.

➤ A maintenance and service interface (MSI) computer serves as an interface and data transmission barrier between automation computers and/or TELEPERM XS Compact, other TELEPERM XS subsystems as well as the automation unit and classified equipment such as gateways and service stations.



- Standard industrial format: 3U/19 inches
- Cycle time configurable from 6 to 2,000 ms depending on I&C application
- Scalable architecture, up to 3 remote I/O sub racks with a single automation unit
- Point-to-point optical fiber processing network with up to 16 links per automation unit
- Cybersecure by design
- Network separation based on safety class and use
- 100 percent in-house development, no external intellectual property, no black box
- Application programming using function block diagrams only: no need for VHDL knowledge or FPGA vendor tools to design and test TELEPERM XS Compact applications
- Change, correct and upgrade the application (engineered I&C functions) and system parameters without modifying the hardware/configware

Robust and compact



TELEPERM XS Compact significantly reduces its system footprint due to a new and more flexible electromechanical infrastructure. It's based on a new mechanical enclosure and a new cabinet infrastructure that comprises power supply, cabinet monitoring and fan units.

Cabinets

I&C cabinets of the type SC9422 (900 x 400 x 2200mm) and CAB-S 9/4/20 (900 x 400 x 2000mm) with an IP30 degree of protection are usually used to house TELEPERM XS-based I&C systems. The cabinet features cable clamps with a shield bus, infeed terminals, and fault annunciation equipment. The cables and power supply are generally fed in from below and are easy to reach from the front side.

The cabinet type CAB-S 9/4/20 further improves the ability of the TELEPERM XS platform equipment to perform safety functions during and/or after an earthquake. The cabinet vibration behavior reduces the internal seismic loads in comparison to cabinet type SC9422. The TELEPERM XS platform equipment can fulfill significantly higher earthquake requirements without re-qualification. The resulting chimney design enables optimized thermal behavior. A new cooling concept allows for a reduction of the number of fans in the cabinet.

- Reduced cabinet height
- Increased cabinet capacity
- Improved thermal behavior
- Enhanced seismic resistance
- Innovative cable entry facilitates more cables and easier cable routing

For every generation of TELEPERM XS, Framatome's maintenance, diagnostic and test solutions have supported the efficient commissioning and periodic testing activities of safety I&C systems. Convenient and easy-to-handle human-machine interfaces (HMI) are crucial elements in that effort. That includes screen-based HMI for the monitoring of third-party systems during operation.

Connections

Various types of terminals are used for connecting peripheral cables. Field cables must be shielded twisted-core pairs. Buses are implemented using electrical connections inside the cabinet and fiber-optic cables outside the cabinet. TELEPERM XS can be used in plants with either large-area grounding or a central grounding point, if required.

Sub-racks

Sub-racks of various available configurations are installed in the middle section of the standard cabinet. To the right and left of the sub-racks is space to install terminal blocks and transceivers. The basic version for one automation computer features a continuous backplane bus with 21 slots. Expansion and partitioning sub-racks are available to be connected providing more slots for input or output modules when large quantities of signals need to be acquired. Configurations may also consist solely of passive modules. This may be applied to backfit individual limit values in an analog reactor protection system, for small stand-alone control systems, or other special requirements. Wall-mounted enclosures are available for small-scale system solutions such as remote sub-systems of a spatially distributed I&C installation.

Power supply

Power to TELEPERM XS cabinets can be supplied from a single source or redundantly with the two sources decoupled by means of diodes. The cabinet power supply with 24 V DC or 115/230 V AC is supported by corresponding power supply modules.

- Single or redundant infeed current up to 80A
- Two redundant diodes with EMC filters and electronic circuit breakers
- Integrated cabinet monitoring unit
- Circuit breakers: 48 circuits with up to 8A, 16 circuits with up to 800mA
- Fully pre-integrated solution and easy periodic testing of the diodes

Cabinet monitoring unit

The cabinet monitoring unit processes the cabinet monitoring signals and also monitors the signaling contacts of both the breakers and the cabinet. Messages are engineered according to the project-specific alarm concept. The layout of the cabinet monitoring unit is standard but can be modified depending on the required functionality.



➤ An advanced cabinet cooling concept extends the range of supported room temperatures, internal cabinet temperature monitoring and automatic fan speed adjustment.

Keeping an eye on the system

Maintenance, diagnostic and test solutions from Framatome have supported customers' efficient commissioning and periodic testing activities of safety I&C systems for all generations of I&C technology. Crucial elements are convenient and easy-to-handle with human-machine interfaces. Screen-based HMIs are also in place to help with functions like interface monitoring of third-party systems during operation.

TELEPERM XS service unit

The service unit is part of the on-site I&C system and serves as an interface to the Diagnostics and Maintenance Server software (DIMAS) for service and maintenance tasks. Menus and dialogue masks enable system monitoring and test execution with no programming knowledge. Additional input masks and display screens can be customized for specific applications. The service unit is therefore the universal tool used during operation to manage all tasks required for fault diagnostics, parameterization and periodic testing. All the settings that need to be changed during operation — including calibration factors and controller settings — can be read out, changed and verified from here.

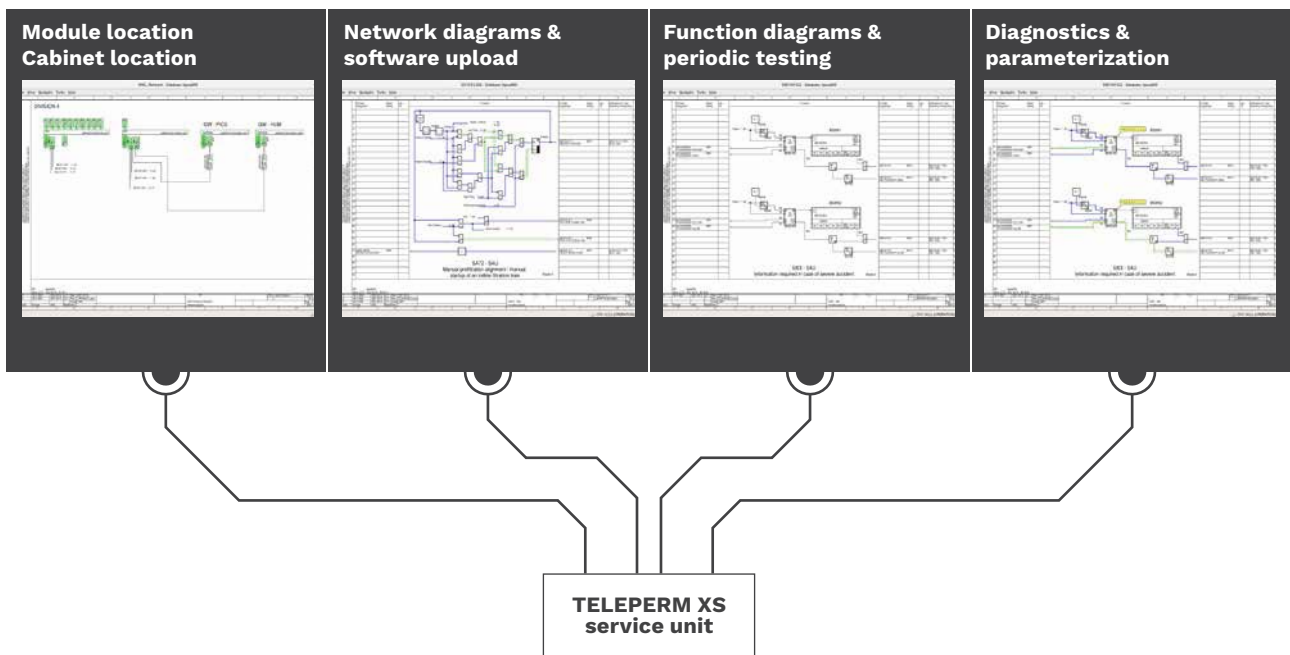
Authorizations to access the I&C system for the purpose of parameterization, test execution, or loading software are secured by key switches, which are configured system-specifically and read in by the processing module as binary enable signals. It can also be used to upload new software to the processing unit. If a fault or failure occurs, the affected area will be located quickly. Components that are faulty are immediately apparent. Lights and alarms in the I&C cabinet locally guide the service staff to the defective components that need to be replaced. The monitoring mechanisms specified in function diagrams and the diagnostic messages from the TELEPERM XS system software can also be called up and displayed to the maintenance staff.

TELEPERM XS diagnosis unit

A separate diagnosis unit is used to access a processing module locally via a serial interface. It allows the application software and changeable parameter to be loaded and diagnosis information to be retrieved. The unit is typically used in the test bay for initial software loading and later on site for troubleshooting.

Maintenance and Parameterization Tool (MPAT)

MPAT is run on the TELEPERM XS testing unit to provide the same convenience of the service unit to the parameterization and testing of peripheral modules. The unit is based on a modular data acquisition (DAQ) system that employs robust, scalable and high-performing equipment. It delivers customized testing solutions that fulfill a broad spectrum of customer needs and constitutes a state-of-the-art maintenance device.



MPAT reduces test complexity and effort, and provides all the features needed for efficient maintenance activities on site including:

- Customized graphical user interface and user functionality
- Scripts that provide a high degree of test automation and quality
- Continuous tester monitoring and configuration monitoring
- Physical security and cybersecurity
- Mobility and robustness for use in plant environments

Maintenance Test and Validation Tool (MTVT)

MTVT is the scalable test machine used for integration tests in the test bay, periodic testing during plant outages, and similar activities. It accesses the project database and permits efficient test preparation and execution. Equipped with very accurate input and output modules for simulating plant interfaces, it performs input/output testing and function testing of the entire I&C system. The number and type of TELEPERM XS I/O channels into the MTVT can be configured to meet the requirements of the application.

Qualified Display System (QDS)

Developed and tested by Framatome, QDS is the safety-classified HMI for the operator within the TELEPERM XS platform. It's used for safety-grade display of plant process parameters and also allows for manual command input by the operator, including release signals, using a touchscreen or mouse and keyboard. It clearly represents all process information (like current values and signal trends) in task-oriented displays tailored for the specific application using powerful, qualified video display units (VDU) and computers. Post-accident paperless recording is performed for up to 72 hours.

Interfaces to the field

TELEPERM XS features a package of electronic modules for conditioning and distribution of standard analog and binary field signals. Dedicated modules meet the need for special sensor/transducer power supply and signals, including speed measurement, analog rod position measurement, and implementation of nuclear flux measurement channels.

> New, fully analog signal conditioning modules provide more diversity, helping manage customer requirements and sophisticated failure assumptions.



Sensor sharing between several independent lines of defense is easily implemented, as is control and priority handling of actuators interfaced to several independent systems. The architecture responds to the most advanced requirements for defense in depth.

Signal acquisition and conditioning

Standard field signals are acquired via the TELEPERM XS signal conditioning modules. They can be distributed to lower-classified I&C systems with the aid of isolation amplifiers used as decoupling devices. Typically, the following types of measurement signals need to be conditioned by TELEPERM XS signal conditioning modules:

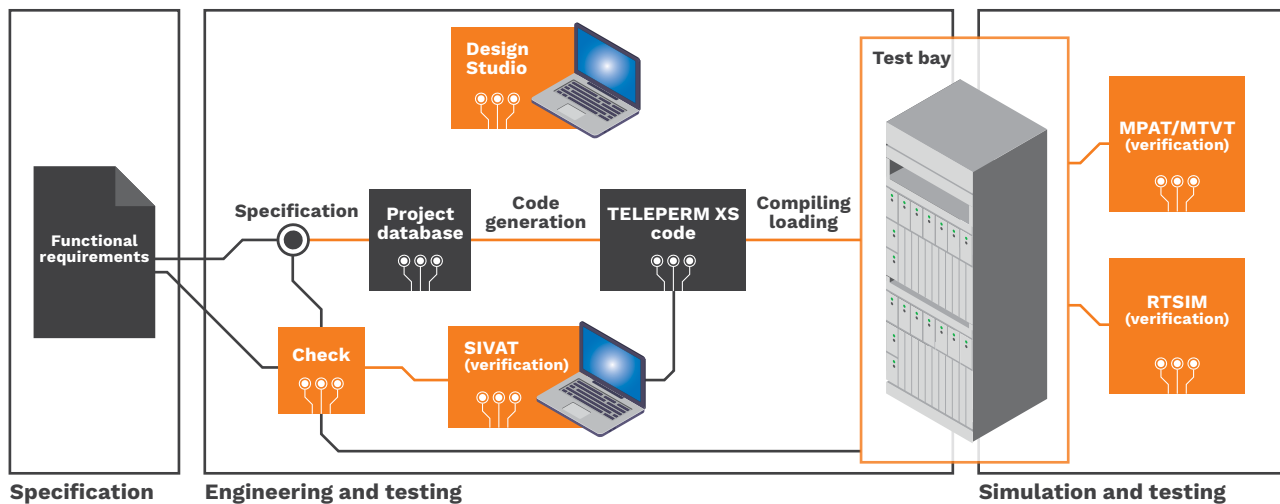
- Standard current and voltage signals (representing process variables like flow, pressure and liquid level, voltage)
- Binary signals (representing process variables like limit-switch position)
- Resistive signals (representing process variables like temperature and level)
- Pulse signals (representing process variables like primary pump speed and other rotating equipment speed)
- Special pulse and current signals (representing process variables like neutron detector signals)

These measurement inputs can be configured in a variety of ways depending on the measurement type. The measurement signals from field-side sensors, transducers and dry contacts are received by the TELEPERM XS signal conditioning modules.

Drive control and priority management

In many switchgear systems, protection and monitoring functions are integrated directly into the switchgear unit. In this case, only a limited drive control function is implemented in TELEPERM XS. The switchgear unit is connected directly, and the required monitoring and actuation functions are executed on the TELEPERM XS automation unit. In other cases, a separate drive control interface level is necessary. When final control elements are used by both the operational I&C and the safety I&C, the priorities assigned to the individual commands must be managed. TELEPERM XS features special drive control and priority modules for this purpose.

Interfaces to the field



Process and safety design

In the requirement specification and system specification phases, the safety engineering concept is described, the I&C system architecture and the standard circuits are defined, and the process engineering tasks are identified. Systematic procedures and database-assisted tools ensure high quality in these phases. The broad spectrum of architectures necessary to meet the specific safety requirements of all types of plants can be implemented using TELEPERM XS. Quality of the software, hardware and engineering processes is in line with the highest safety requirements. All architecture choices are supported to meet the highest reliability and plant availability requirements.

Toolbox for engineering, simulation, testing and operation

TELEPERM XS is engineered, integrated and tested using a comprehensive, integrated tool chain. Function diagrams, graphical linking of modules, and signal assignments allow for easy function configuration, assembly of system structure, and integration of input/output modules with just a mouse click. Hardware and software definitions are stored in a central project database that provides data for early functionality tests, plant integration, and connection tests by software simulation, as well as failure diagnostics during implementation and operation.

The SIVAT software package allows the engineered I&C functionality to be tested by simulation early in the project. This verifies that no inadvertent changes have been introduced to the I&C functions. In addition, a test machine for smooth system integration enables testing in the test bay while simulating all plant interfaces — either as a 100 percent simulated digital twin or in any configuration with real TELEPERM XS components. Simulation tests have been shown to be indispensable when systems in operation, for example operational optimizations, need to be modified.



Properties and performance

Environmental conditions

All TELEPERM XS components are suitable for the environmental conditions listed below. The integrity of these conditions must be ensured by the design of each I&C system.

Environmental factor	Permitted range	Remarks
SUPPLY VOLTAGE		
System voltage	24 V DC	Other voltages on request
AC/DC converter solutions	115 V AC	
	230 V AC	
CLIMATE		
Ambient temperature within the sub-rack	0 ... +75 °C	
Ambient temperature (in electronic equipment room)	0 ... +45 °C	As standard: higher temperatures are supported by other solutions
Relative humidity	5 ... 85%	

Seismic testing

Various types of seismic tests have been performed on the hardware modules; the most important are listed. Qualification of cabinets is generally demonstrated by combining structural calculations and results from practical testing.

Environmental factor	Permitted range	Remarks
Sine sweep tests in accordance with RCC-E, KTA 3503; IEC 60068-2-6; and IEC 60980	Seismic stress (earthquake): <ul style="list-style-type: none"> • Frequency range: 5 ... 35 Hz • Sweep range: 1 octave/min • Acceleration: 1 g 	In mounting position
	Oscillation stress (airplane crash): <ul style="list-style-type: none"> • Frequency range 5 ... 100 Hz • Sweep range: 10 octave/min • Acceleration: 2 g 	In mounting position
Tests as a supplement to KTA 3503 and IEC 60068-2-6	Induced vibration (earthquake): <ul style="list-style-type: none"> • Frequency range: 5 ... 55 Hz • Sweep range: 1 octave/min • Acceleration: 52 m/s² 	In mounting position
	Induced vibration (airplane crash): <ul style="list-style-type: none"> • Frequency range: 5 ... 100 Hz • Sweep range: 10 octave/min • Acceleration: 44 m/s² 	In mounting position
Tests as a supplement to KTA 3503 and IEC 60068-2-57 using time-history method	Seismic test (test Ff): 5 "operating base earthquakes" (OBE) 1 "safe shutdown earthquake" (SSE) Acceleration: <ul style="list-style-type: none"> • OBE 60 m/s² • SSE 60 m/s² 	

Performance data

TELEPERM XS provides a wide range of capabilities for creating customized solutions for scaled I&C systems that meet the requirements of relevant nuclear rules and plant constraints. For example, the computing time required for cyclic processing of the function diagrams can be decreased from the typical 50-ms value to fulfill specific response-time requests. With the TELEPERM XS Core SW 4.0, a full 32-bit operation processing capacity that significantly enhances performance has been introduced, and so a higher number of FBs can be processed in one cycle.

TELEPERM XS Compact 1.0 or higher

CYCLE TIME	6 ... 2000 ms
COMMUNICATION CYCLE	6 ... 2000 ms
NUMBER OF FUNCTION BLOCK PER PROCESSING MODULE	10 ... 8190

Properties and performance

TELEPERM XS-Profibus for internal system communication

- Protocol: Profibus FDL in accordance with EN 50170 for ISO/OSI layers 1 and 2 and TELEPERM XS-specific application layer
- Media: Electrical, optical
- Data rate: 12 Mbit/s

TELEPERM XS-Ethernet used in TELEPERM XS Core Software Release 3.6.x or lower

For connecting monitoring and service interface computers and gateways, TELEPERM XS-QDS, and service units

- Protocol: CSMA/CD, LLC in accordance with IEEE 802.3 for ISO/OSI layers 1 and 2 and TELEPERM XS-specific application layer
- Media: Electrical, optical
- Data rate: 10/100 Mbit/s

TELEPERM XS-Ethernet used in TELEPERM XS Core Software Release 4.0.x or higher

The communication between automation computers is performed with a newly developed piggy-back module that provides four optical Ethernet interfaces. Each processing module can handle four piggyback modules, i.e., 16 Ethernet interfaces.

Peripheral computers (like QDS, gateways and service units) are connected to the processing modules via the electrical/optical media converter SMC1. This module contains a data diode that offers either unidirectional service communication for regular operation or bidirectional communication for service operations.

- Protocol: CSMA/CD, LLC in accordance with IEEE 802.3 for ISO/OSI layers 1 and 2 and TELEPERM XS-specific application layer
- Media: Electrical, optical
- Data rate: 100 Mbit/s

TELEPERM XS Compact safety communication protocol

The communication between TELEPERM XS Compact automation units is ensured by the means of four optical interfaces available on the processing module. Each automation unit can handle up to four processing modules in a single rack, i.e., 16 interfaces. If required, communication can be authenticated with cryptographic signature algorithms.

- Protocol: proprietary serial protocol (Manchester encoding), optional ECDSA signature
- Media: optical
- Data rate: 50 Mbits/s



TELEPERM XS Compact service network

TELEPERM XS Compact separates process and service data flows. A dedicated module provides two electrical Ethernet interfaces per automation unit, which are used to connect to the Service Unit computer. Media can be changed to optical using SMC1 module.

- Protocol: TCP/IP over Ethernet with SSH security layer for commands, UDP/IP over Ethernet for monitoring and diagnosis traffic
- Media: electrical, optical
- Data rate: 1 Gbits/s or 100 Mbits/s (depending on the network architecture)

Designed exclusively for use in nuclear power plants and for nuclear safety related applications, TELEPERM XS has the flexibility to accommodate site-specific designs so Framatome can tailor an I&C platform that fits your site's needs. Our ability to customize a solution for you, combined with our proven track record, translates into licensing, procurement, installation and operation certainty for your plant.

Framatome is an international leader in nuclear energy recognized for its innovative, digital and value added solutions for the global nuclear fleet. With worldwide expertise and a proven track record for reliability and performance, the company designs, services and installs components, fuel, and instrumentation and control systems for nuclear power plants. Its more than 18,000 employees work every day to help Framatome's customers supply ever cleaner, safer and more economical low-carbon energy.

Visit us at www.framatome.com, and follow us on Twitter: @Framatome_ and LinkedIn: Framatome.

Framatome is owned by the EDF Group (75.5%), Mitsubishi Heavy Industries (MHI – 19.5%) and Assystem (5%).



Learn more about
our I&C solutions.

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