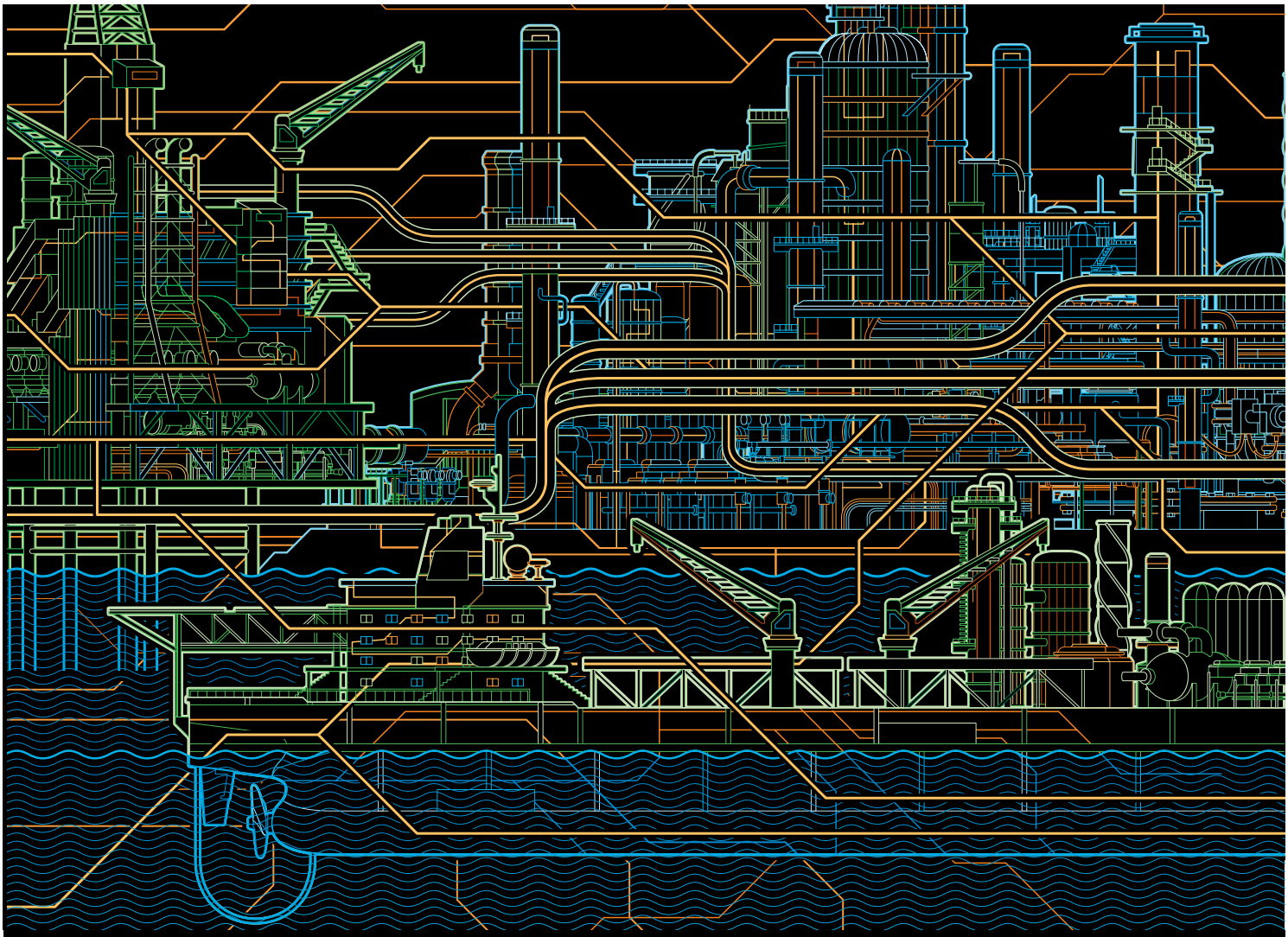
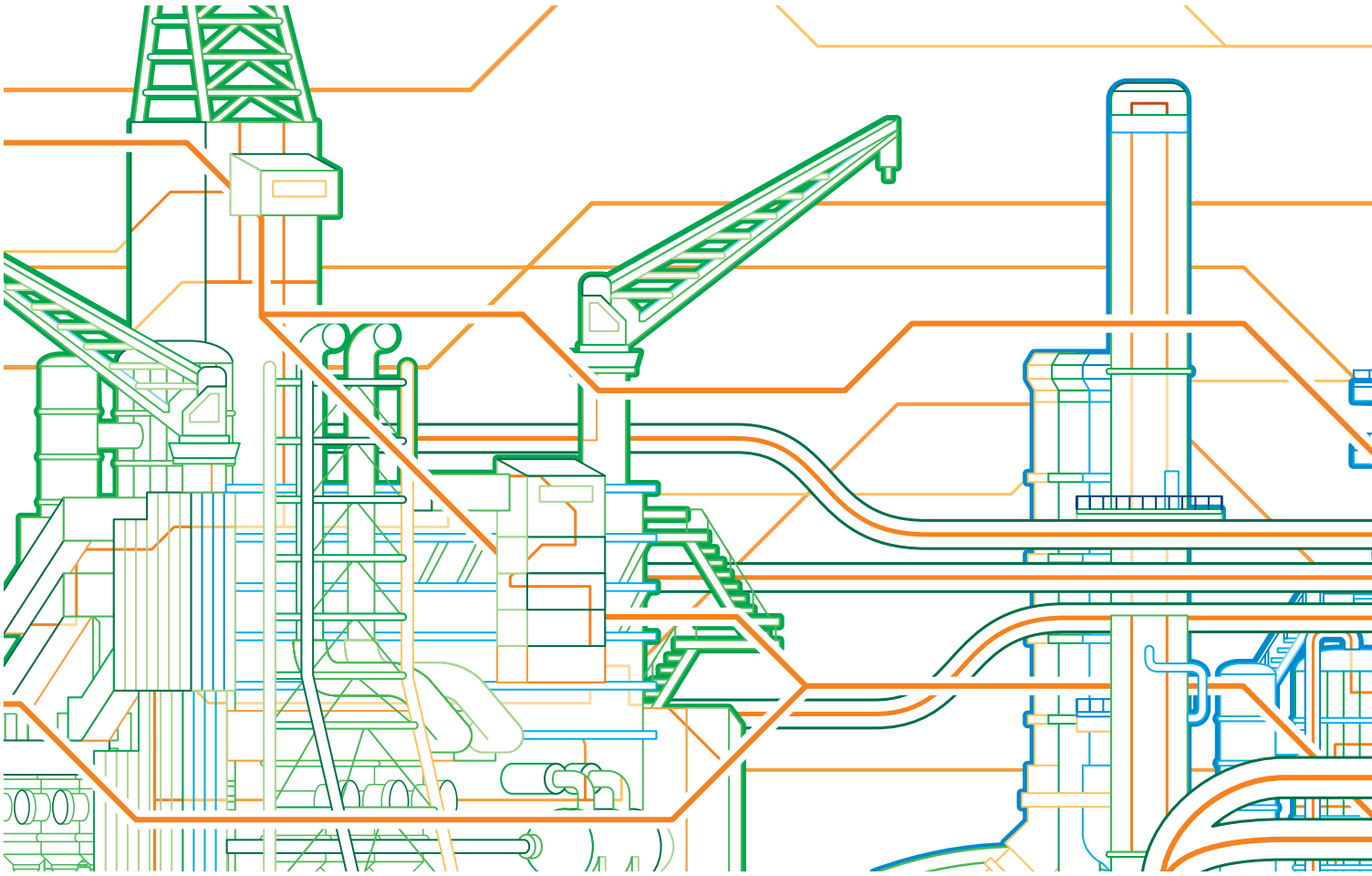


Evergreen safety solutions
Evolving from TRI to HI technology

Power and productivity
for a better world™

ABB

Sustain the availability and productivity of your plant
Evergreen safety solutions by ABB

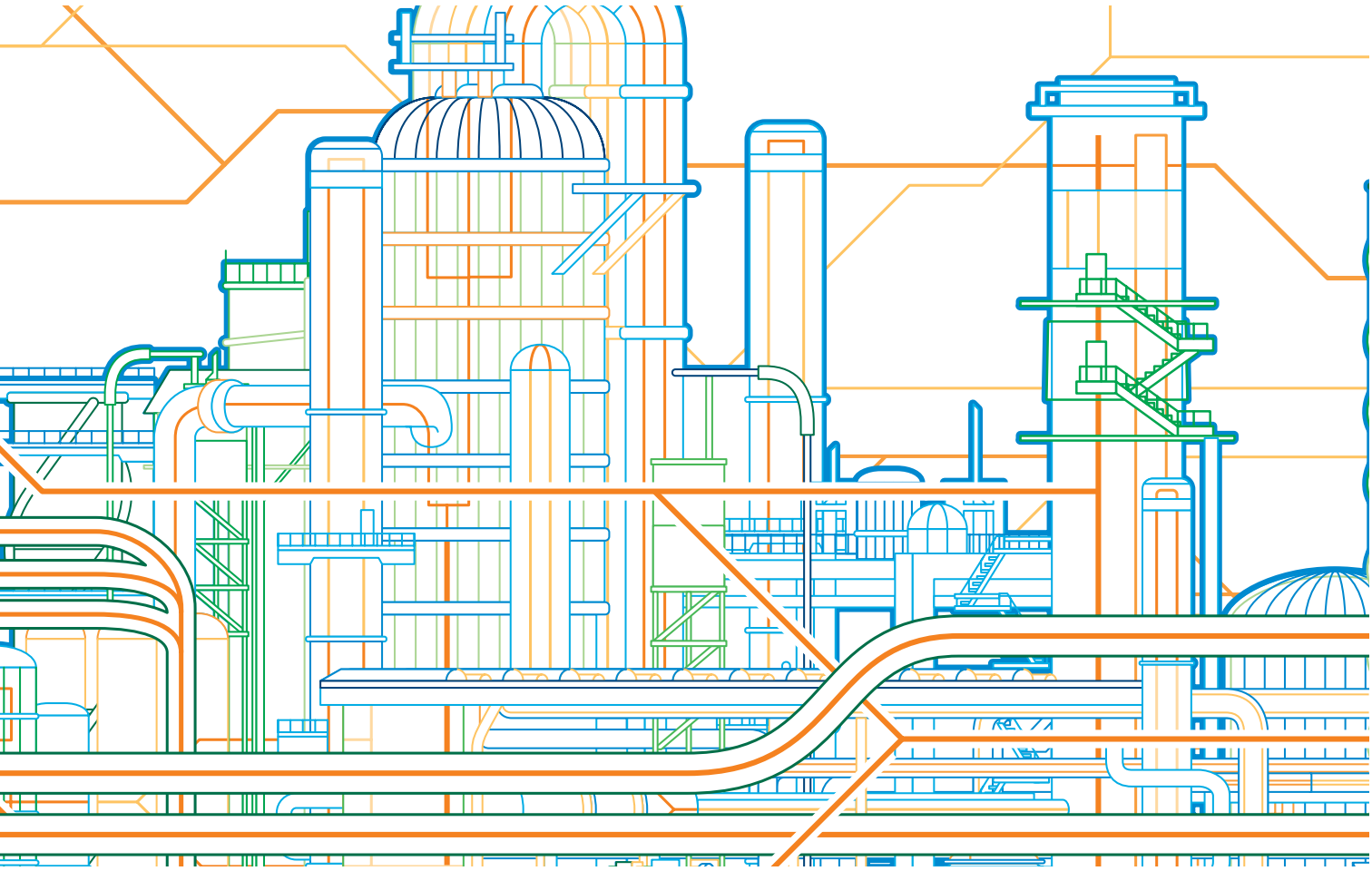


Many existing safety systems are not in compliance with today's safety standards and lack the basic functionality and compatibility with other process control systems and related applications needed to sustain the availability and productivity of your plant. ABB's evolution process can help you to get there.

"ARC estimates that the value of the installed base of process safety systems reaching the end of their useful life could be in the neighborhood of $8 billion worldwide. Replacing or migrating process safety systems, however, carries with it a unique set of concerns and considerations compared to process automation systems. Conforming to international safety standards, such as IEC 61511, means that end users must conduct a hazards and risk analysis in addition to allocating safety functions to protection layers." – ARC INSIGHTS December 2012.

1st generation safety systems

In the 1st generation safety systems, reliability and availability were often blurred. Redundant fault tolerant hardware architectures were used to compensate for the fact that internal diagnostics were limited and dangerous failure modes could occur. Because of technology limitations, these systems did not fully address diagnostic coverage or common cause failure issues and concepts like systematic failures or the quality and integrity of embedded software were not applied.



2nd generation safety systems

With the introduction of the IEC safety standards and the 2nd generation of safety systems, some of these issues were addressed. While additional diagnostics were available, they still relied on redundancy for safety as well as availability and focused on identical paths and voting for safety. There was little attention to diversity of technology or systematic capabilities in these systems and only some of these systems are certified to IEC 61508 Edition 2.

Is your current safety system meeting your needs?

About 66% of the programmable electronic systems used in safety applications were installed between 11 and 30 years ago; before IEC 61508 and IEC 61511 / ISA 84 were issued and recognized as good engineering practices per ARC. The same ARC report indicates that many users have extended the lifespan of their systems beyond their supplier's obsolescence notice.

Additionally, there are many relay-based safety systems that missed the initial wave of automation or were left alone as installing a digital programmable electronic system was not economically feasible for the plant in those applications at the time.

The question is: can these 1st and 2nd generation systems meet your current and future safety, availability and business requirements, or should you evolve to the "next generation" safety system. This brochure will help you answer that question.

Evolution from ABB delivers the "next generation"

A "next generation" safety system like ABB's System 800xA High Integrity, meets all the current, relevant safety standards, but unlike previous certified systems, it can actually meet SIL3 without the need for redundancy or voting. This means you get a certified safety system at a lower cost with a smaller footprint. In addition, the innovative design ensures that all detected faults are reported and leaves the controller operating in a safe mode or initiates a safe action. When high availability is required simply add redundancy.

Evolution of your first generation to System 800xA High Integrity will enable you to be safe, secure and compliant while still transforming your operation to meet you business goals.

Safety lifecycle solutions
Bringing you into the 21st century

Reducing failure rates and downtime, eliminating component obsolescence, enhancing diagnostics, simplifying integration and managing maintenance costs – as a plant operator and owner of a process safety system, you recognize these challenges. You can count on ABB to support you with industry leading technology, expert services and an evolution plan designed to modernize your aging safety assets.

30 years in safety

ABB has over 30 years of experience in the design, manufacture and implementation of process safety systems. With operations on all continents and dedicated safety system teams around the world, ABB provides not only highly-qualified technical resources during project delivery, but also ensures competent local support and service in operation. We work hard with end-users to maintain and evolve existing installations, thereby maximizing customer value and ensuring safe plant operation. We support safety systems everywhere you are.

With our earliest installations going online as far back as 1979, ABB can truly be considered one of the pioneers of programmable electronic safety systems. As a corporation built on innovative products, ABB is an acknowledged development leader. Dedicated and focused teams coupled with a strong corporate ethos of responsibility have ensured continuous strong performance in the safety systems market.

Safety execution centers (SEC)

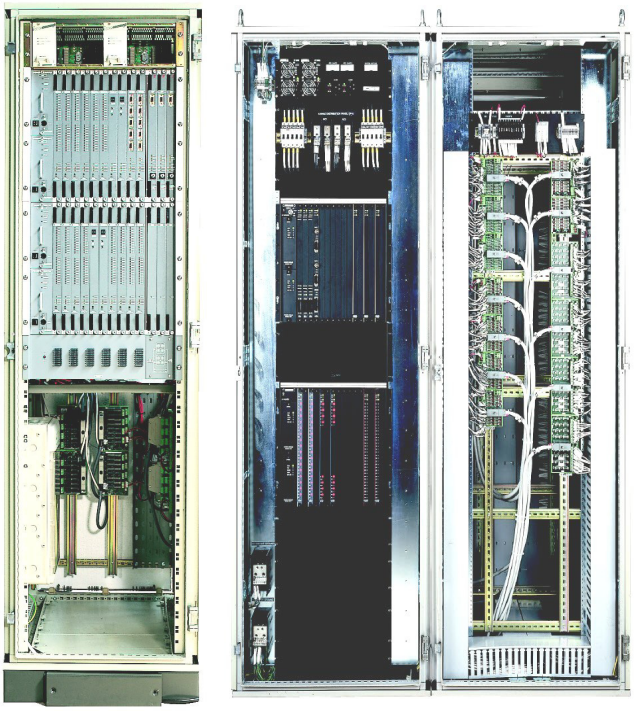
ABB's Safety Execution Centers (SEC's) have been created for the implementation and delivery of safety system projects according to ABB's TUV certified functional safety management system. We have over 24 centers (10 certified by TÜV), more than any other supplier in the industry.
They are responsible for:

- Design and system integration according to our FSMS and the customer's safety requirement specification
- Proving TÜV certified (CFSE) and competent safety engineers / experts (over 250 globally)
- Offering safety consultancy and expert services

These centers can be found in every region ABB serves, including:

- Argentina
- Australia
- Brazil
- Canada
- Columbia
- China (2 offices)
- Denmark
- Egypt
- France
- Germany
- Hungary
- India
- Italy (2 offices)
- Korea
- Mexico
- Norway
- Singapore
- Taiwan
- Thailand
- UK (2 offices)
- United States

Safety system evolution for TMR systems



1st generation triple modular redundant (TMR) systems

Evolution planning process

Evolution planning is an ongoing, collaborative process between ABB and our customers. It identifies customers' business needs, goals and priorities. The process results in a short and long term roadmap for system enhancement and enables a phased approach to keeping your safety system current.

If you own a first generation triple modular redundant (TMR) safety system and are experiencing spare parts availability issues, long delivery times and high prices, limited product and/or technical support, difficulty in finding someone to repair your system, the ABB Evolution program for TMR systems is for you.

Our innovative approach

During each step of the evolution process, we work closely with the customer to ensure the standards are met, while still considering the business needs of the plant. The steps include:

- Discover (understand the current status of the system and business)
- plan (develop the desired end, the evolution plan, result for the system and the business)
- Propose (finalize the plan including products, processes and phases and deliver a proposal)
- Deliver (deliver the evolution project on time and on budget)

From a simple hardware replacement project, to a complete evaluation including HAZOPS and SIL assessment, the evolution planning process ensures that the safety requirements, as defined by the IEC 61508 and IEC 61511 standards, are followed not only for the safety controllers, but for the design, implementation and operations phases of the safety lifecycle. Each evolution planning step will be executed by certified safety engineers and will be fully documented per the steps below.

Discover

The discover phase consists of a site visit, where we audit the physical safety assets as well as the intellectual property (application code). Additionally, we work with the plant management to understand the business goals and challenges as well as the history of the safety system including upgrades, expansions or other issues. This information gathering phase will enable all parties to understand the current situation, so that an appropriate evolution plan can be designed.

Plan

During the plan phase, the discovery information and business goals are used to create a suitable plan that includes safety products (for the entire SIS loop), processes (i.e. HAZOPS) and phases of the project (including scope and timing). Also included are recommendations on the best method of deployment based on urgency, plant shutdown schedule and other factors. The result of this phase is the safety evolution plan.

Propose

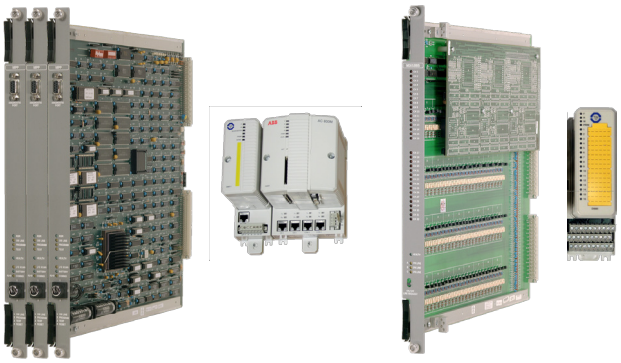
Once the plan has been completed and reviewed with the asset owner's management team, a proposal complete with pricing, financial justification (if required) and schedule will be prepared and presented.

Deliver

The delivery phase includes upgrade or replacement of the aging safety system according to the evolution plan. ABB can provide as much support during this phase as necessary from design, implementation and delivery of a new and compliant safety system, through installation support, commissioning and final SIL compliance testing.

The final result of the evolution process will be a standards compliant, next generation safety system that meets your safety and business needs, can be maintained properly over its lifecycle and will be an integral part of your operations for years to come.

Evolving TMR technology to high integrity (HI)
Benefits of next generation safety systems



Size comparison: TMR vs. high integrity processors (left) and I/O (right)

If your TMR safety system was installed with the first wave of programmable electronic safety systems from 1978-1996 and you have difficulty finding spare parts, getting support or just want more information out of your system, it may be time to evolve!

The triplicated architecture provided by 1st generation TMR safety systems is no longer the only way to achieve SIL3. Advances in technology and development techniques enable products such as ABB's System 800xA High Integrity to meet your safety requirements with SIL3 certification in a single configuration. The diverse architecture, advanced diagnostics and systematic capabilities allow us to provide cost effective safety solutions that fully comply with the latest standards (IEC 61508 Edition 2).

Benefits of new generation safety systems

In addition to having a smart modern design, these systems minimize common cause failures through diversity of both technology and development teams. Additional benefits of these systems include:

- Savings on hardware cost: You aren't buying three processors or redundant I/O modules to meet your SIL requirements.
- Cabinet space: New generation systems are DIN rail mounted rather than 19" rack mount and require less total hardware.
- Spare parts costs: spares for modern safety systems are much more affordable than 1st generation boards with obsolete components or limited lifecycles.
- Maintainability: fewer people have the experience necessary to make modification to or maintain first generation safety systems. The retiring workforce is a major issue. The 800xA HI has the same modern engineering tool, utilizing function diagram programming, and hardware as the system 800xA DCS. Training and support are not an issue.
- Meeting the Safety Standards: 1st generation systems were introduced prior to the current IEC safety standards and while they were a good first step, they cannot be certified against latest editions of thestandards. New generation systems were designed from the ground up to comply with the standards and can be certified to the latest editions.

Installation is easier than you think

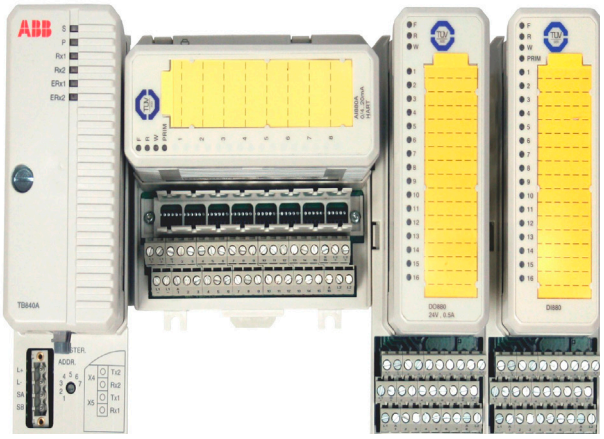
ABB's evolution offering for TMR systems considers all aspects of an upgrade or replacement, from reusing field wiring, to code conversion to redundancy for high availability. The benefits you will achieve are will worth the investment in next generation technology.

Installation details

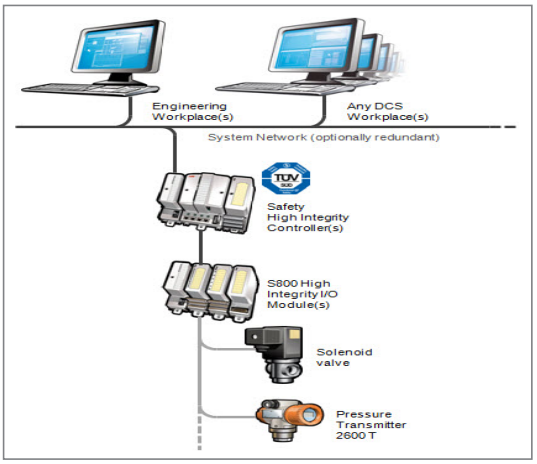
Replacement of TMR hardware will be the most visible component of your evolution project. In order to make this as painless as possible, we provide the following efficient hardware solutions:

- Cost effective remote I/O solutions. The TB826 Long Range optical media converter enables conversion between local and single mode field providing up to 20 km remote I/O installation.
- Footprint reduction. Significantly smaller I/O modules and optional redundant hardware will reduce overall safety system footprint.
- Support for HART I/O maintenance functionality. The SIL3 AI module can be configured for HART routing in three levels (full, read only, disabled).
- On-line firmware upgrades. The High Integrity safty system comes with the ability to do on-line firmware upgrades (in redundant mode) without shutting down or restarting the process safety controller.

System 800xA high integrity



AC800M HI processor and safety module with SIL3 I/O



Independent HI system with engineering and DCS

ABB's System 800xA high integrity safety systems provide the highest level of quality and safety functionality available on the market today. The high integrity offering is available as integrated with ABB's award winning System 800xA DCS system and independently as a physically and functionally segregated safety solution.

Meets industry standards

High integrity systems are delivered and supported in accordance with the strictest current standards. The system meets among others the IEC 61508, IEC 61511, EN 954, NFPA 85 & NFPA 72, ISO 13849-1 and IEC 62601 standards.In addition to defining product requirements, these standards specify procedures and routines for all activities required to manage safety throughout the entire lifecycle of the SIS system. This includes planning, design, implementation, documentation, training, operation, and maintenance. TUV has certified high integrety to IEC 61508 edition 2 based on our deverse design and implementation, diagnostics and systematic capabilities.

AC800M high integrity controller

The AC 800M HI offers a SIL3 TÜV certified control environment for process safety in a single controller. The AC 800M high integrity controller is realized by combining the processor module (PM865) with the safety module (SM811). The PM865/SM811 pair create a hardware and software diverse CPU. flexible redundancy schemes enable controller configurations up to and including Quad configuration.
In SIL rated applications, it is possible to choose between three IEC 61131-3 languages, function block diagram, structured text, and sequential function chart. For non-SIL applications, all five IEC 61131-3 languages are available for use.

High integrity I/O

The high integrity S800 I/O is a distributed, highly modularized and flexible I/O system, providing easy installation of I/O modules and process cabling. S800 I/O modules and their termination units can be mounted and combined in many different configurations to fit any space requirements or meet the needs of any application. A comprehensive assortment of I/O modules and accessories are available for safety critical and non-critical use.

Diverse and systematic design section

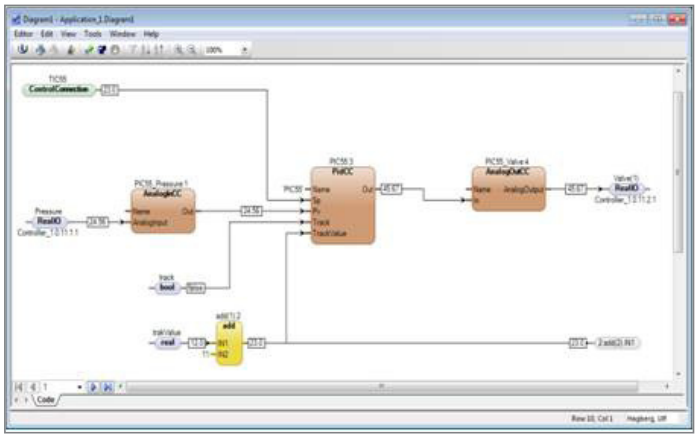
The diverse design of the high integrity system enables us to deliver SIL3 without redundancy according to the latest version of the IEC 61508 standard. We also employ systematic design concepts using separate development teams in separate locations to develop the controller (Vasteras, Sweden) and safety module (Malmo, Sweden) and test with a third team (Oslo, Norway) by people with different backgrounds. This organization creates diversity that helps offset any possible common cause failures due to combining development teams.

"Outstanding Features"

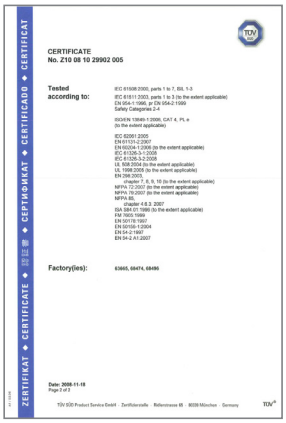
The outstanding features of the High Integrity product are:

- Available redundancy for high availability (~99.999%)
- In a redundant configuration, a single failure will not result in degrading our SIL rating or result in a time restriction unlike many first generation systems.
- Near 100% diagnostic coverage without hardware fault tolerance factors or voting
- Over 4000 safety controllers and 500,000 SIL certified I/O points installed globally since the release of High Integrity in 2005.

The next generation safety system



Control Diagram Editor: connecting functions, function blocks and control modules on one page



TUV Certificate for System 800xA high integrity

Integration with System 800xA

The 800xA high integrity safety system was designed with a flexible architecture. It can be fully integrated with System 800xA, installed on a separate network from 800xA, process control and safety can be combined in the same controller and it can be installed independently and interfaced with any other DCS or HMI.

The diverse design of high integrity reduces the likelihood of common cause failure while delivering SIL3 safety in a single controller. Integration of the process control and safety systems provides:

- Built-in familiarity to minimize operator and maintenance errors
- Common audit trail, alarming, asset management and access control
- Efficient engineering with common look and feel

Control builder engineering

The High Integrity object oriented engineering environment with SIL compliant function libraries efficiently supports the entire safety lifecycle. The engineering environment includes safeguards against non-SIL compliant configurations. The engineering system will automatically limit user configuration choices and will prevent download if SIL requirements are not met.

A series of safety measures are implemented both for the downloading process and runtime environment including CRC protection on different levels, double code generation with comparison and compiler with revalidation are just a few examples of the embedded firewall mechanisms.

Certified libraries

Control builder is delivered with an extensive set of predefined type solutions stored in standard libraries. These include data types, functions, function blocks and control modules that can be used to create safety applications. The SIL certified objects and functions in the standard libraries are identified with a SIL marking in the engineering tool.

All necessary SIL certified objects and functions can be found in the certified engineering libraries. Other available libraries contain some components certified for use in SIL compliant applications. See the AC800M high integrity safety manual for details.

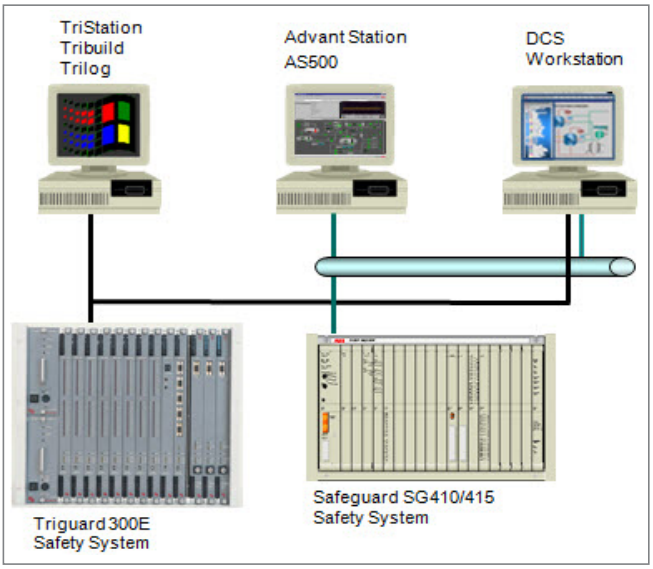
Communications, connectivity and interfacing

The TUV certified peer to peer communications supports multiple controller configurations as well as remote architectures using both MMS and the inter-application communication (IAC) protocols. High integrity also includes the connectivity modules and protocols required to connect with process panels (Modbus), other ABB control systems (Modbus or OPC) and 3rd party software and control systems. The non-interfering communications protocols enable access to the safety system data for any type of monitoring and display.

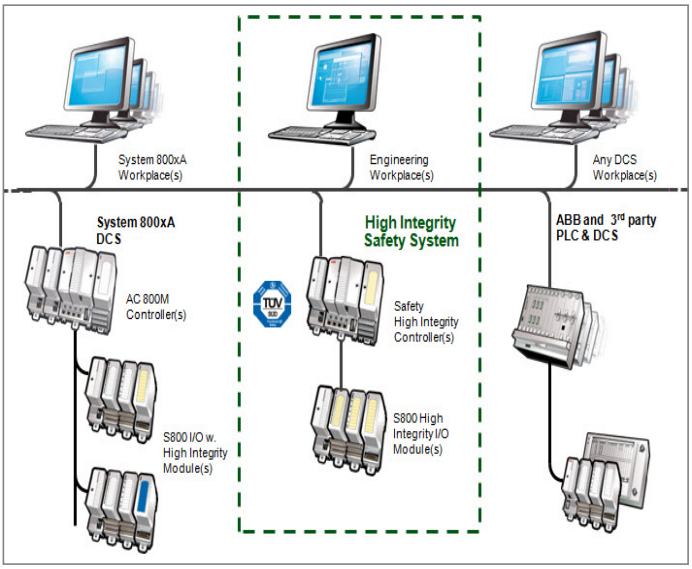
Diagnostics

There are extensive system and hardware diagnostics including CPU load, ethernet statistics and status of controllers, I/O, communication, power supplies etc. System status viewers provide detailed information about the health of each component.
By using different technologies in a redundant scheme (diverse redundancy) and combining with voting, software diagnostics and diverse implementation, it is possible to minimize common cause failures and meet the reliability SIL 3 requirements without hardware redundancy.

TRI to HI evolution program



Triguard / Safeguard Architecture



Modern High Integrity Architecture

Evolution basic program

The evolution planning process is a collaborative effort between ABB and the customer. The result of this planning process will be a plan detailing a phased approach for evolving your existing safety system to a modern compliant High Integrity system. Part of the process will be to replace the aging hardware with new controllers and I/O as well as updating the application code.

Safety hardware

The TUV certified safety hardware will be mounted into a cabinet together with all required power distribution, mounting and cabling. The standard installation will provide for landing strips for the field wiring.

Application code

ABB offers two options for the evolution of application code from your existing TMR system to high integrity. We can convert the existing code directly to equivalent code that can be loaded in the HI safety controllers using a code conversion tool. We can also develop and implement new code designed specifically to meet the safety requirements defined by a new or updated HAZOP study (see additional services). New code development will fully leverage the efficient engineering tool and certified safety libraries of high integrity. It will also support the transition from ladder logic to function diagram programming.

Testing

All hardware and application code will be fully tested at one of authorized partners or ABB TUV certified safety execution Centers to validate proper design and operation of the safety system according to the HI safety manual and safety requirement specification. ABB and our partners can also provide FAT, SAT and installation support.

Safety sentinel

The safety sentinel program is an extension of ABB's automation sentinel lifecycle management program. The sentinel programs ensure optimal operation and availability of the installed safety system, access to software enhancements and access to 24/7 support and maintenance services. It is recommended that all high integrity safety systems be enrolled in one of the maintain, maintain plus or maintain and evolve program levels (see document 3BDD015294 for details). A special safety sentinel option provides the following benefits specifically for Triguard and Plantguard TMR system owners who are planning to evolve:

- Maintain and evolve level support
- Special price on high integrity (HI) hardware
- "Buy back" program for spares and system hardware
- Emergency spares sourcing
- Dedicated technical support contact (up to and including during the evolution project)

Once the Triguard or Plantguard system has been evolved to high integrity, the lifecycle maintenance program will transition back to the standard automation sentinel program.

TRI to HI evolution program – additional services

Pemex Cadereyta Refinery: Upgrade of Triguard ESD to System 800xA High Integrity, online, October 2010

Additional services

It is recommended to re-evaluate the safety requirements for your plant during the evolution process. Many plants experience expansions, modifications, regulatory and environmental changes during the life of a typical process safety system. In order to ensure your current safety system meets your safety requirements, ABB offers a complete portfolio of expert services.

HAZOPS and process hazard review (PHR)

A new hazard study is recommended every five years or when refreshing an older safety system. This study will include a review of the process flow diagrams and is aimed at identifying and eliminating significant hazards. From there, ABB can specify what safety measures are needed and carry out the risk assessments to ensure the risk is reduced to an acceptable level.

Safety requirement specification (SRS) development

One of the key components of a safety evolution project is the SRS. This document fully defines the requirements for the safety instrumented function. The requirements are derived from the allocation of the safety instrumented functions and from the requirements identified during the safety planning process.

The requirements will be sufficient to design the SIS and will include description of all the SIFs required to meet the required functional safety, requirements to identify and address common cause failures, definition of the safe state for each SIF, proof test procedures and intervals calculations and response time requirements for the SIS to bring the process to a safe state. ABB has certified functional experts that can both develop and implement the SRS.

SIL determination

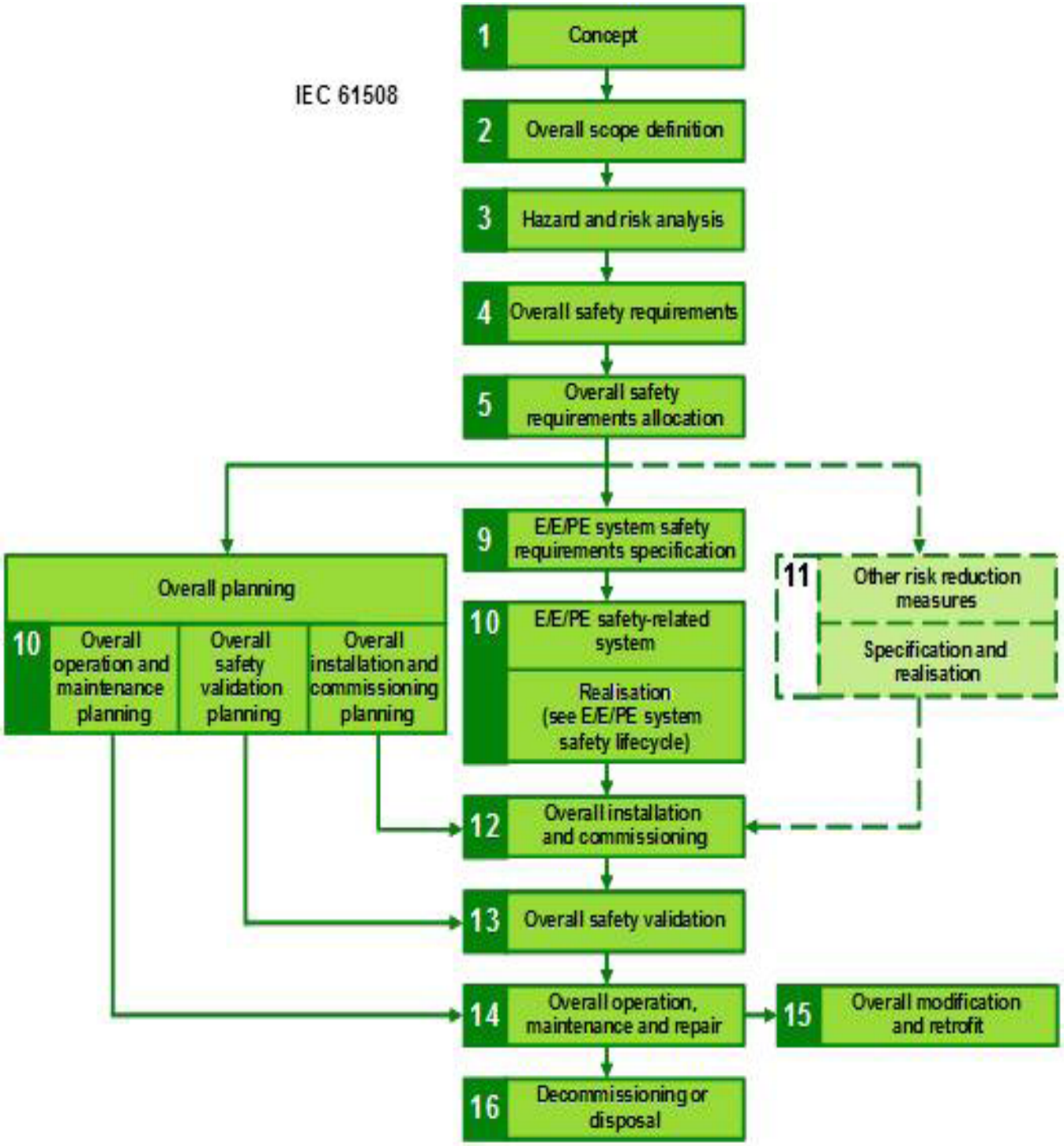
SIL assessment is the process of determining the required reliability for a SIS, taking into account the severity of the hazardous event and other independent layers of protection that are contributing to the overall risk reduction. ABB's SIL determination services (including TRAC tool) will identify the appropriate SIL level and configuration required to achieve the target.

Hot cutover

In many cases, it is not practical to shutdown the entire plant to replace / upgrade the safety system. ABB has expertise in performing an on-line installation of the new safety system hardware, with a phased "hot cut-over" to the new systems. Other advanced offerings include behavioral safety and culture consulting, a functional safety management system for end users, safety requirement specification development and periodic test Interval determination.

TRAC Test Interval Decision Matrix

Safety lifecycle solutions
Bringing you into the 21st century



Safety Lifecycle according to IEC Standards

ABB has the products, services and expertise available to support you through the entire safety lifecycle. In earlier sections, we have described the services and products that are available for the design and implementation phases of the safety lifecycle. This section will describe the additional offerings designed to support you through the operations and maintenance phases.

Overall safety validation

The installation and commissioning of an SIS system is only the beginning. The next step is to demonstrate that the target SIL for each safety instrumented function (SIF) as been achieved. ABB provides a SIL Achievement service that proves and documents that each SIF meets the criteria set by IEC 61508 in terms of architectural constraint, target failure measure and systematic capability. Only then can the target SIL be said to be achieved. Each time a change it made to the SIS, the safety measure should be re-validated.

Periodic proof testing

Every safety system, regardless of manufacturer or architecture has a periodic proof testing interval. This means that the safety system must be tested periodically to prove that it still meets the safety requirements defined during the design phase of the lifecycle. ABB can deliver a methodology designed to provide users with a benchmark of their proof testing regime in the areas of management, design, testing, records and competency. This enables the users to make necessary changes and improvements. Proof testing forms an integral part of a safety system owner's functional safety management system.

ABB also provides a procedure for an off-line proof test for High Integrity that is designed to reveal undetected faults in a safety instrumented system so that, if necessary, the system can be restored to its designed functionality.

Modification and retrofits

It is occasionally necessary to expand, modify or otherwise change an installed safety system. The IEC 61511 standard states that "An analysis shall be carried out to determine the impact on functional safety as a result of the proposed modification. When the analysis shows that the proposed modification will impact safety then there shall be a return to the first phase of the safety life cycle affected by the modification". ABB can provide the necessary HAZOPS, SIL assessments and SIS design services to ensure the system is properly updated while maintaining the required safety integrity level.

Maintenance

There are a number of features inherent within the High Integrity system as well as ABB services that support maintenance of the SIS. These include our built-in alarm management features, audit trail capability and difference reporting. These features provide operators and maintenance the ability to keep the safety system performing as originally designed. In addition, ABB can provide services focused on operations management and management of change as well as 24/7 service level agreements, certified safety engineers, spares and repairs on both your new and aging safety systems.

Competence assurance

ABB has a wide range of programs geared towards developing and maintaining competence at our customers' sites. These programs include:

- Product training courses
- Competency training on standards, functional safety management topics such as SIL assessments
- Benchmarking and best practices
- Safety culture assessment and training

System 800xA and evolution references

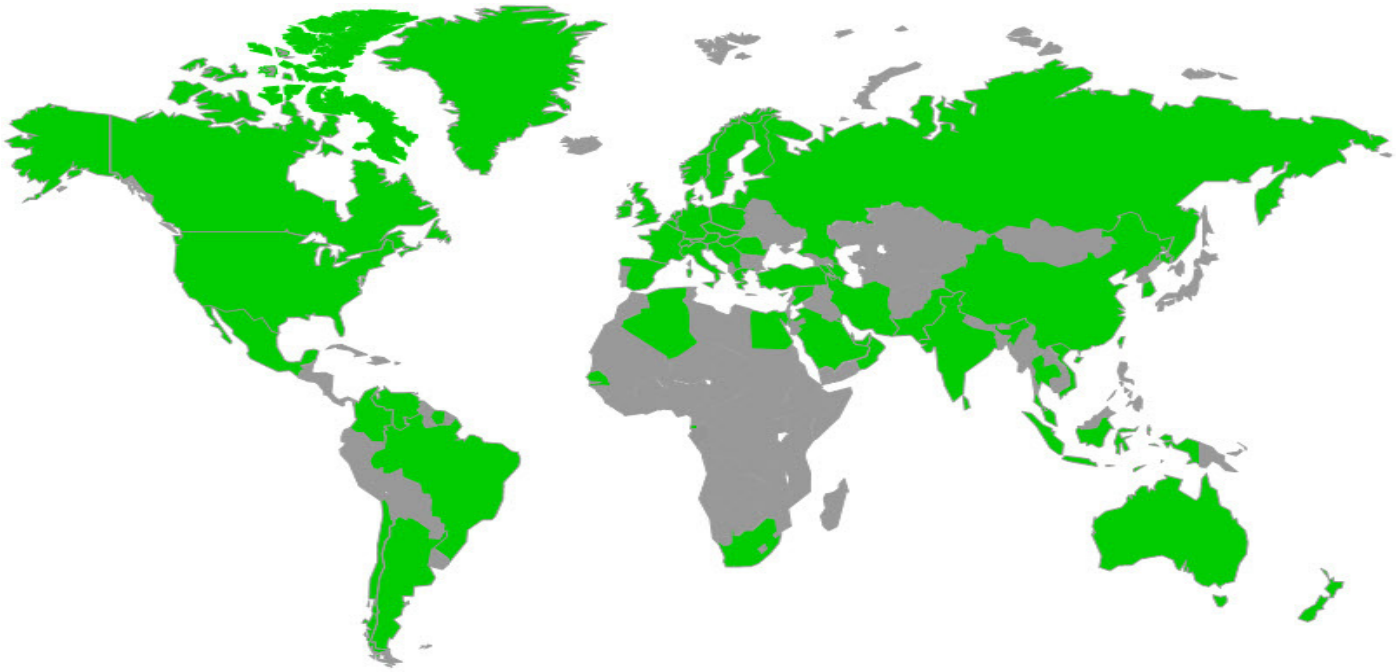


ABB has over 2000 system installations around the world using the AC 800M HI safety controller. We are present in over 55 countries with more than 4000 controllers and over half a million SIL certified I/O points. Here are some notable projects over the years.

- Statoil Gullfaks A, North Sea (ESD, F&G)
- Statoil (previously Norske Shell) Troll A, North Sea (ESD, F&G)
- Pemex, Burgos Complex, Reynosa, Mexico (ESD, F&G)
- Rexchip Electronics, Taichung, Taiwan (ESD)
- Vale, Goro Nickel, New Caledonia (BMS)
- Pemex Refining, Cadereyta, Nuevo León, Mexico (ESD)
- Repsol YPF, Lujan de Cuyo Refinery, Mendoza, Argentina (BMS, ESD)
- ADCO, Bab Thamama, Abu Dhabi, UAE (ESD, F&G, HIPPS)
- ADCO, ASAB Wellheads, Abu Dhabi (ESD, F&G)
- Inagip Annamaria Gas Field Development , Adriatic Sea (ESD, F&G)
- Shell Ormen Lange Gas Field, North Atlantic (ESD, Anti-Surge)
- Spectra Energy McMahon Sour Gas Processing Plant, British Columbia, Canada (HIPPS)
- Atanor Rio Tercero Plant, Cordoba Province, Argentina (ESD)
- Turano Lodigiano combined cycle power plant, Italy (BMS)
- Korsnäs, Gävle, Sweden, Relay Interlock replacement for Recovery Boilers and Machine Safety solution for a Paper Roll Winder

ABB has been evolving 1st generation TMR systems to our System 800xA High Integrity SIL3 safety system for the last few years. Some recent examples of these projects as described below. For additional information please contact your local ABB sales representative.

- Pemex Refining, Caderyta Refinery, Nuevo León, Mexico Triguard ESD Upgrade. Two HI Controllers, 400 I/O at Gas hydrodesulphurizer Oils Plant (HDGS). Redundant I/O, ladder logic replaced with function diagrams. Start up: October 2010
- Triguard ESD Upgrade. Two HI controllers, 200 I/O, 100 HART device objects and 800xA DCS integration at Alkylation Plant. Single I/O, ladder logic replaced with function diagrams. Start up: October 2010
- Triguard ESD Upgrade. Four HI controllers, 800 I/O, and 800xA DCS integration at Combined Plant. Single I/O, ladder logic replaced with function diagrams. Start up: October 2010
- Triguard ESD Upgrade. Two systems with two HI controllers each, 100 I/O, and 800xA DCS integration at Sulfur Plant. Redundant I/O, ladder logic replaced with function diagrams and structured text. Fast re-commissioning (5 days) Start up: December 2011

Contact us

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