1. **ANSALDO – ABB OEM Agreement**

Ansaldo Energia provides plant engineering and construction for turnkey power plants, including process, mechanical, civil, installation and start-up engineering. The main components manufactured by Ansaldo are gas turbine, steam turbines and electrical generators, where the advanced technology is designed to satisfy the most demanding customer requirements in terms of efficiency, reliability and environmental impact.

Ansaldo Energia is leading provider of services for all types of electric power plant, offering assistance at all levels of complexity for its own and third party machinery. It handles all after sales issues with a broad range of global services, ranging from repairs and spare parts, to on-site work including overhauls and upgrades, right through to full service or O&M Long Term Agreements.

ABB is a global leader in power and automation technologies. ABB is a leading provider of integrated power and automation solutions for conventional and renewable based power generation plants. The company’s extensive offering includes turnkey electrical, automation, instrumentation and control systems supported by a comprehensive service portfolio to optimize performance, reliability, and efficiency while minimizing environmental impact. For more than 40 years, ABB has provided control systems for turbine applications, equipping all types of rotating machinery worldwide, representing over 30 different turbine OEMs.

Cooperation between Ansaldo Energia, as turbine manufacturer, and ABB, as control system provider, has started more than 30 years ago, and, during such a long history, has produced standard solutions for hundreds gas and steam turbine packages as well as plant DCS application based on INFI 90 and Symphony Harmony ABB products.

In the last years Ansaldo Energia gave particular attention to the up-to-date requests of the power market joined to its experience in the rotating machine manufacturing.

In the last years new requests have gained an increasing demand by customers and/or plant engineers on the design and on the manufacturing of automation system for power plants, the requests are particularly focused on to obtain:

- Shorter time to erect and to commission the automation systems, reducing at the same time the cost of the activities;
• Higher degree of reliability for the protection systems, in order to increase the safety of the most critical items in the power plants and to minimize the chance to have malfunctions due to spurious events;
• Wider opportunity to integrate different automation systems in a simple way using standard commercial products based on Ethernet TCP/IP communication system.

At the beginning the abovementioned requirements were applied only to the automation system related to the balance of the plant, nowadays they start to be asked for the rotating machine automation systems. That is the reason why ANSALDO and ABB studied an advanced gas and steam turbine control systems taking into account the latest technological solution available on the market. The new ABB Symphony plus (S+) platform, evolution of previous Symphony Harmony, was then considered because allows the advantage of the up to date technology together with the possibility to utilized the past experiences made with previous ABB technology.

To reach this goal ANSALDO and ABB signed on 2010 an OEM agreement in order to re-design the gas and steam turbine control system based on S+ .

The idea was to develop, starting from all past experiences, a dedicated and specialized new GT and ST turbine control and protection system that collects most of the needs expressed by the customer for the automation of the rotating machines and engineered and tailored for the specific ANSALDO needs. This approach includes also the ANSALDO branding of these new GT and ST control systems extended also to hardware components like processors and electronics cards.

The main advantages and improvements that have brought ANSALDO to adopt S+ technology have been the followings:

1) **Up-to-date technology**: possibility to use the most advanced technologies of the automation inside a rotating machine control and not only in systems foreseen for the balance of plant, consequently it is possible to develop an homogeneous power plant system.

2) **Maintenance easiness**: maintenance is helped by the capabilities offered by smart sensors:
   • The primary elements using HART protocol can be configured by HMIs
   • The automation system is able to collect data about the behaviour of the sensor and the operating life of the auxiliaries. This kind of information can assist the technicians in the selection of the proper time to foresee maintenance.

3) **Fully integration with the power plant distributed control system (DCS)**: communication with external systems, mainly the DCS, based on TCP/IP Ethernet standard link with OPC protocol allows to transfer all information generated inside the gas and steam turbine automation system in a short time. In this way it is possible to design the same graphic pages on DCS HMIs hiding to operators the presence of an automation system different from the main one. This opportunity leads to have a cost reduction on the personnel training for power plant operation, as they have to know only one system.
4) **Reliability of the safety functions:** increase of the reliability of the safety functions as the protection system is certified to Safety Integrity Level (SIL), in accordance with the IEC 61508 and IEC 61511 standards.

5) New faster Date Highway based on 100 Mbyte ethernet protocol

6) Redundancy of the cards which drive the fuel control valves

7) More powerful processors and operator interfaces

8) Possibility to use the SW developed and tested with the previous technology Symphony Harmony.

9) Possibility to visualize on line by the operator station the logics associated to each drivers

10) Possibility to centralize the I/O cards with the processors or decentralized near to the equipment

In addition the S+ technology has the potential capability, in particular for GT and ST auxiliaries controls, to integrate both traditional I/O cards and the “intelligent” I/O using the standard Profibus net.

The solution to use fieldbus connection has the following advantages:

- **Reduces cable length, modules and marshalling.** These reductions determine a shorter time required for erection and commissioning, less probability to make mistakes having less connection points and also less malfunctions during the normal running of the steam turbine due to anomalies of the contact/cable set.

- **Reduces connection-oriented configuration data.** It is dramatically minimized the engineering activity to generate data-base for identifying the from/to points of the signals and the cables.

- **Reduces the space taken up.** The use of fieldbus allows to have less cable route, less automation cabinets for managing the I/O signal

2. **SYMPHONY PLUS**

Symphony Plus is the new generation of ABB’s Symphony Harmony family of control systems – the world’s most widely used automation system in the power industries. No other automation platform has such large installed base in power applications as Symphony Harmony. For more than 30 years, the Symphony family has evolved, ensuring that each new generation is enhanced and is backwardly compatible with all previous versions of the system. Therefore the new Symphony Plus platform today available is backward compatible with all previous versions of Symphony family, including the older Network90 and Infi90 product lines, all in accordance with ABB’s long held policy of “Evolution without Obsolescence”.

Symphony Plus includes a comprehensive suite of hardware and software modules to fulfill whatever application requirement in power industry, and particularly the most challenging one, that is gas and steam turbine control. The scalable platform meets all needs from distributed
process control to supervisory control and data acquisition (SCADA). Use of Profibus, Modbus, and Ethernet networks facilitate the integration of any intelligent field devices and also integration in the plant DCS, even if it is not based on ABB’s solution.

The core of the system is the new generation S+ Control’s HPC800 controller. It is the system’s high-performance, high-capacity process controller that is used to execute demanding process control applications, such as turbine control that are both data and program intensive. Redundancy is available as standard at control and communication level, but can also be extended optionally at I/O level, resulting in maximum flexibility and availability of the system.

The system communications rely on high-performance, Fast Ethernet-based plant network allowing to take advantage of Ethernet technology in power industry. Communications with remote location can be realized in a variety of differing ways including use of WAN, LAN, or wireless connections. Through these communication options, Symphony Plus provides remote connection capabilities for the controlling, monitoring, and troubleshooting of remote applications, irrespective of where the equipment is located.

Operator effectiveness is fundamental to power plant overall performance. With fewer operators, a generational shift in the operator workforce, and increasing complexity of system technology (and networks), this is becoming ever more challenging, but not insurmountable. Symphony Plus, with its intuitive, easy-to-use human machine interface (HMI), leads operators to greater awareness, faster response, and ultimately to better decisions.
3. Gas and Steam Turbine Symphony Plus Control System

Ansaldo Energia and ABB have worked together to develop new standard solutions based on Symphony Plus products for Steam and Gas Turbine control systems. The result of this activity is a new engineered system, which includes both hardware and software, where components are branded Ansaldo Energia, to represent the link between control and turbine worlds. The two Companies have developed a pilot project both for steam and gas turbines, generating standard solutions, named GTCMPS and STCS for all type of Gas and Steam turbines manufactured by Ansaldo Energia.

The realization of the ANSALDO GT and ST control system with this new technology were focused on the followings priorities:

1. Rationalization of the software making it more modular and user friendly
2. More standardization of repetitive functions
3. Use of preformed cables to connect signals between different cabinets of the control system
4. Realization of critical protections for people and environment safety at SIL level as requested by risk analysis
5. Univocal identification of the setting parameters of all logics with the possibility to allow automatic loading/downloading by excel file or equivalent
6. Improvement of the cyber security and system logging
7. Development and common management of reference SW for every size of turbines
8. Redefinition and rationalization of supervision signals (alarms and states)
9. Alignment of all protection logics treatment
10. Modular design of SW to allow simple switch between different turbine models.

The activities of the joint development has started from the definition of a standard and complete reference gas and steam turbine in order to size the control system in terms of I/O’s and software functions to cover all the possible aspects and to minimize the personalization in phase of order.

ANSALDO and ABB have realized complete GTCMPS and STCS prototypes in order to perform all validation tests before in ABB, with simulators integrated inside the processors themselves, and then in ANSALDO with more sophisticated external simulators (realized with DSpace system and implemented by Symulink) connected hardwired to fuel controller and via profibus to other processors. All tests performed in ABB were done with simplified simulation, to verify the correctness of the implemented logics. In particular the SIL protections tests were done in ABB by 100% I/O simulation verifying also the expected response times of each protection as well as the design cycle time of processors.

Subsequently the systems have been moved in Ansaldo laboratories for the final verification of the dynamic behavior. Through a real time dynamic gas and steam turbine models connected to the prototypes the correct behavior of all systems were verified in all normal and accidental transients including component faults. For every protection will be verified again the correct functional behavior and the compliance to expected response times.
Particular attention is focused on time responses because the managements of gas and steam turbines requests very fast actions both in control and protection actions.

Additional tests were done by connecting the GT prototype to a real fuel control valves to verify the bump less redundancy of the management of fuel control valves.

### 3.1 Gas turbine control and protection system

The new GT Control Monitoring and Protection System (GTCMPS), based on the ABB platform S+, is indicated in the following simplified architecture:

All functions necessary to fully automatic gas turbine operation including start-up and shut-down procedures can be implemented at optimal cost.

The GTCMPS meets all the requirements for a gas turbine automation system with the following six sections totally integrated together:

1. GT auxiliaries control and complete automatic start-up and shut-down procedures.
2. Fuel control and speed/load control functions for the fast closed loop functions of the gas turbine
3. No SIL protection functions dedicated to not critical GT protections
4. SIL protection functions according in accordance with the IEC 61508 and IEC 61511 standards.

5. Ancillary systems control: in case that additional BOP systems are requested to added in the GTCMPS scope of supply

6. TSI cabinet including Vibrometer rack for bearing vibration measures, flames monitors and Data Logger Delphín with its pc interface

The GTCMPS system is equipped by two dedicated HMIs (Human Machine Interface) to operate locally or remote the gas turbine and one EWS (Engineering work station) to verify system configuration, setting and diagnostic. The HMIs are also the gateway to export/import real-time data to/from DCS.

The connection with DCS is realized both by TCP/IP Ethernet standard connection with the OPC protocol for the data to be implemented in DCS graphic pages and alarms/diagnostic pages.

**GT Auxiliary System Automation**

The auxiliary system automation is suitable for the automation of all the areas not subjected to safety-related requirement and with no requirements for high speed closed loop controls. It is used to drive the gas turbine auxiliaries, pick-up the process variables used for monitoring and managing the automatic start-up and shut-down sequences.

**GT Governor System Automation**

The gas turbine automation system for the fast closed loop functions is constituted by a system based on ABB Symphony + system, taking advantage of the fact that this system is the last generation of ABB Harmony evolution with more than 6.000 applications in the power and water treatment field and more than 100 applications in rotating machine control.

It is preferred to employ a well-proven governing system because in this way all the functions constituting the governing system are the ones already designed by ANSALDO, guaranteeing a reliable behaviour of the governing system.

The functions implemented inside the governor partition of the automation system are mainly:

- speed control
- speed measure management
- continuous generation of the speed reference and of the acceleration reference
- load/drop control
- synchronization
- fuel control valves position control (3 valves for fuel gas and 3 for fuel oil)
- closed loop for the IGV control
- turbine cooling control
- purging water control
- automatic minimum load pick-up
- continuous generation of the load reference and gradient reference
- interface with the power plant coordinated control
- load drop anticipator, logic based on a detection of fast load changes and acting directly on the grid disconnection
- Over-speed tests logic management

**GT Protection System Automation**

The steam turbine protection system is used to implement safety controls that are subject to the Safety Integrity Level (SIL) certification, in accordance with the IEC 61508 and IEC 61511 standards.

All the I/O signals relevant for the protection are exchanged hardwired. The system is integrated with the other sections of the automation via internal system software connection. This solution permits to integrate all the data generated by the protection system in the common operator station of the whole steam turbine automation system.

The trip system is also able to manage the electronic over speed protection by means of a TÜV-certified tachometer system provided in 2-out-of-3 triple modular redundancy.

The challenge has been to design the system in such a way as to prevent dangerous failures or to control them when they arise.

**GT Ancillary System Automation**

The ancillary system automation is suitable for the automation of all the areas not subjected to a requirement for safety-related controllers, no requirements for high speed closed loop controls and is dedicated to additional systems which can be added to the GT automation but which are external to the gas turbine standard packages.
3.2 Steam turbine control and protection system (STCS)

The steam turbine automation system (STCS) is based on the following system architecture using the platform ABB Symphony +:

All possibilities starting from almost manual operation of the steam turbine to fully automatic operation including start-up and shut-down procedures can be implemented at optimal cost.

The STCS meets all the characteristic automation requirements for a steam turbine automation system with just three sections of an integrated system:

- General automation tasks ranging from the control of the auxiliary systems through to complete automatic start-up and shut-down procedures.
- Protection functions. It is in form of equipment certified to Safety Integrity Level 3 (SIL 3), in accordance with the IEC 61508 and IEC 61511 standards.
- Governor functions for the fast closed loop functions of the steam turbine.

The STCS is equipped by two dedicated HMIs (Human Machine Interface) to operate locally or remote the gas turbine and one EWS (Engineering work station) to verify system configuration, setting and diagnostic. The HMIs are also the gateway to export/import real-time data to/from DCS.
The connection with DCS is realized both by TCP/IP Ethernet standard connection with the OPC protocol for the data to be implemented in DCS graphic pages and alarms/diagnostic pages.

**ST Auxiliary System Automation**

The auxiliary system automation is suitable for the automation of all the areas not subjected to a requirement for safety-related controllers and no requirements for high speed closed loop controls. It is used to drive the steam turbine auxiliaries, pick-up the process variables used for monitoring and managing the automatic start-up and shut-down sequences.

**ST Protection System Automation**

The steam turbine protection system is used to implement safety controls that are subject to the Safety Integrity Level 3 (SIL 3) certification, in accordance with the IEC 61508 and IEC 61511 standards.

All the I/O signals relevant for the protection are exchanged hardwired. The system is integrated with the other sections of the automation via internal system software connection. This solution permits to integrate all the data generated by the protection system in the common operator station of the whole steam turbine automation system.

The trip system is also able to manage the electronic over speed protection by means of a TÜV-certified tachometer system provided in 2-out-of-3 triple modular redundancy.

The need to increase the reliability of the safety functions is due to the fact that the steam turbine protection systems are usually complex, making it hard in practice to fully determine every failure mode or to test all possible behaviour. It is difficult to predict the safety performance, although testing is still essential.

The challenge has been to design the system in such a way as to prevent dangerous failures or to control them when they arise.

**ST Governor System Automation**

The steam turbine automation system for the fast closed loop functions is constituted by a system based on ABB Symphony + system, taking advantage of the fact that this system is the last generation of ABB Harmony evolution with more than 6.000 applications in the power and water treatment field and more than 100 applications in rotating machine control.

It is preferred to employ a well-proven governing system because in this way all the functions constituting the governing system are the ones already designed by ANSALDO, guaranteeing a reliable behaviour of the governing system.
The functions implemented inside the governor partition of the automation system are mainly:

- speed control
- speed measure management
- continuous generation of the speed reference and of the acceleration reference
- speed control loop
- synchronization
- valve position control
- closed loop for the control of steam turbine control valve position (four control valves on main steam and two control valves on reheater steam)
- closed loop for the control of steam extraction control valve position (two control valves)
- full arc / partial arc automatic transfer management
- automatic synchronizer interface management
- load control
- automatic minimum load pick-up
- continuous generation of the load reference and of the gradient reference
- interface with the power plant coordinated control
- load drop anticipator, logic based on power load unbalance between mechanical power and electrical power or accelerometric protection
- valve tests logic management

4. **Symphony Plus Control System innovations**

The new solutions, if compared with previous ABB turbine control solutions, are really innovative and introduce new features in control applications. We are used, since long time ago, to read Customer’s specifications claiming for redundancy, accuracy, time response, single fault tolerance, etc… requirements. All of this are standard features of GTCMPS and STCS, that, in addition, include also innovative aspects, such us security, safety, all-in-one, modular packaging, compactness, one-point-of interface, low energy consumption.

All these innovative aspects will become in future typical requirements for control systems, but today they are already available in GTCMPS and STCS Ansaldo-ABB Symphony Plus solution.

GTCMPS and STCS include everything that is needed for turbine control, monitoring, supervision and protection. Only one system provide all automation functions, with all components integrated and fully tested at factory, before the delivery to site. By utilizing a fully integrated solution, including also plant distributed control system (DCS), all benefits of a common platform for control functions are available, including: engineering design standards, engineering tools, and operator graphics.
A common platform also minimizes the investment needed for different hardware, reduces training requirements and eliminates the need for interfaces. Additionally, the open architecture of GTCMPS and STCS allows seamlessly interfacing to any eventual other existing DCS platform in the plant.

One-point-of-interface is one of the biggest improvements of GTCMPS and STCS Symphony Plus solutions if compared with previous ABB turbine control solutions. Control system for turbine is normally composed by several parts, functionally separated, interconnected between them and interfaced with field signals. The new Ansaldo-ABB solution provides less wiring between different cabinets and the remaining interconnections among the system are executed with preformed plug-in cables, reducing time for installation at site and possibility of connection errors. All power supply connections have been moved from separate cabinets to I/O cabinets: the result is that just only one point of interface is foreseen for field signal connection: power supply and signal itself must be wired to one terminal block, without any interconnection inside the system. If we consider GTCMPS for AE94.3A4, the result is that 200 interconnection signals for solenoids and proximity switches have been removed and that the remaining 160 interconnections are realized with preformed plug-in cables. Therefore time and cost for wiring engineering and installation at site is sensibly reduced.

Time and cost for system set-up and installation at site are also reduced because new Symphony Plus has no dipswitch or jumper for hardware set-up. All main hardware configuration parameters are defined using the engineering station and downloading the application software into the system.

Symphony Plus controllers utilize DIN-rail form factor, standard 24 Vdc power inputs, and a standard Ethernet network to make installation simple and flexible. This reduces the limits on cabinet space, size or layout, and provides a broader selection of commercial power supplies and network devices, thus lowering both installation and maintenance costs. The overall dimensions of new GTCMPS and STCS are lower than previous Ansaldo-ABB turbine solutions, even if new solution is more complete and includes special arrangements, such as disconnectable terminals for each I/O signal. Compactness of the system is not just only reduced dimensions, but also lower power consumption and no need for cabinet fan that often are noisy and create uncomfortable environment. The result is that GTCMPS and STCS save 25% of space respect to previous solutions and are completely silent, producing no noise, considering that the system is fanless.

The Symphony Plus turbine control solution provides complete diagnostic for every type of fault that can happen. Specific system routines monitor the good operation of the system and, in case of any malfunction, system alarms are generated. Also external field power supply is monitored: for example the power supply of each solenoid valve is monitored by sensing the voltage at the output terminals of the system.
The concept of single fault tolerance is very important in power plant applications. Nowadays, with the energy market spread-out, it is necessary to guarantee the reliability and availability of units that produce electricity. An important role is played by control system that provides fully hardware redundancy for each component. Even I/O modules for turbine control (speed measurement and valve positioning) are fully redundant, avoiding any loss of power in case of single fault.

TP800 is the turbine measurement and protection module that provides a complete set of safety certified functions for comprehensive turbine protection, such as overspeed trip, load drop anticipation and power/load unbalance.

Speed 2oo3 redundancy is the state of art for every turbine manufacturer, but 100% hardware redundancy of valve positioning is peculiar of Symphony Plus solution. VP800 is the valve positioner module that provides the capability to implement a fully redundant configuration, where one VP800 is actively controlling the valve and a second VP800 is operating in stand-by mode, waiting to take over if the active VP800 fails. The two VP800’s are connected together and share both output commands and feedbacks, allowing to preserve module redundancy even in case of a
LVDT or a coil failure. Switching between the two VP800’s is bumpless and instantaneous, not affecting the valve control.

5. Turbine Protection and Safety

Turbine protection system may be configured as Safety Instrumented Systems (SIS) in compliance with the requirements of IEC 61508/61511. The safety system is fully integrated with the turbine control system, thereby providing a common operational environment.

SIL certification is not just only provided at system level, but all safety lifecycle phases, as defined by IEC-61511, are implemented, from turbine hazard and risk assessment to operation, maintenance and decommissioning of the plant.

The risk assessment has been executed determining which are the Safety Instrumented Functions for steam and gas turbine applications, and, for each of them, which are the Safety Integrity Level required and the response time for the SIS to bring the process to a safe state.

The core of the SIS is the logical solver dedicated for protective actions. The controller is realized by combining the processor module with the co-processor, flexible redundancy schemes enable controller configurations up to and including Quad configuration. For embedded safety and control applications, all functions implemented in the system are marked non-SIL or SIL1/2/3 to show their characteristics.
The definitions of the protections to be elaborated at SIL level have been done starting from a risk analysis based on the following criteria:

“In compliance with IEC 61511 and IEC 61508, the determination of the Security Instrumented Functions (SIF) and their Safety (SIL) are performed on the basis of an hazard and risk analysis related to:

- Safety of power plant staff
- Significant effects of environmental pollution”

The above as well as the complete gas turbine control system were done in conjunction with the compliance to all European directives and to the ANSALDO general policy related to the Functional Safety for all GT and ST in order to ensure:

- A high standard of safety and reliability of power plant and component
- A high standard of safety of power plant staff

All activities related to the development of GT and ST SIL protections system have been successfully completed verifying with very deep tests, the respect of the all functional and dynamic requirements and the achievement of the required SIL level.
These results are certified by dedicated reports which include all necessary calculations to demonstrate the achieved SIL level.

As an example in the following, for reference only, there is a typical ANSALDO used risks matrix for safety of power plant staff:

**FUNCTIONAL SAFETY RISKS MATRIX**

<table>
<thead>
<tr>
<th>Consequences</th>
<th>Severity level</th>
<th>Classe (F+W+P)</th>
<th>Occupation (F)</th>
<th>Likelihood (W)</th>
<th>Preventability (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>5-7</td>
<td>8-10</td>
<td>11-13</td>
</tr>
<tr>
<td>CATASTROPHIC</td>
<td>4</td>
<td>Yellow</td>
<td>Red</td>
<td>1 for hour</td>
<td>6</td>
</tr>
<tr>
<td>MAJOR</td>
<td>3</td>
<td>Green</td>
<td>Red</td>
<td>From &lt;1 for hour to 1 for day</td>
<td>5</td>
</tr>
<tr>
<td>MODERATE</td>
<td>2</td>
<td>Yellow</td>
<td>Red</td>
<td>From &lt;1 for day to 1 for week</td>
<td>4</td>
</tr>
<tr>
<td>MINOR</td>
<td>1</td>
<td>Green</td>
<td>Yellow</td>
<td>From &lt;1 for week to 1 for month</td>
<td>3</td>
</tr>
<tr>
<td>INSIGNIFICANT</td>
<td>0</td>
<td>Green</td>
<td>Green</td>
<td>From &lt;1 for month to 1 for year</td>
<td>2</td>
</tr>
</tbody>
</table>

**MEANING OF THE COLORS**

- ACCEPTABLE RISK
- TOLLERABLE RISK (As Low As Reasonably Possible according to cost to benefits)
- NOT ACCEPTABLE RISK

5. Security

Industrial automation and control systems have evolved significantly over the past decade thanks to technological evolution of computerized systems. To provide end users with comprehensive real-time information and allow for higher levels of integration and control, systems have become more and more interconnected and open. Symphony Plus automation systems utilizes open standards such as OPC, PROFIBUS, IEC 60870-5-104, IEC 61850 and commercial technologies, in particular Ethernet and TCP/IP-based communication protocols. They also enable connectivity to external networks, such as office intranet and the Internet. These changes in technology have brought huge benefits from an operational perspective, but they have also introduced cyber security concerns previously known only in office or enterprise IT systems.
Cyber security risks were inherited by adopting open IT standards, but fortunately specific mechanisms are available to enable the design and development of cyber security solutions that are specifically for industrial automation and control systems, and which utilize proven technology.

Ansaldo-ABB turbine control system is addressing all of these requirements, both on a system and on a product level. All communication from the outside world to the control system can, for instance, be protected by using a firewall and/or VPN-enabled communication. Verified antivirus software is supported to protect the system’s computers from attacks and viruses.

Additionally, the system architecture can be designed using different security zones. Cyber security can be further improved by limiting the use of removable media in the system’s computers.

Features of the system allow easily addressing NERC CIP requirements and maintaining compliance according to these standards and beyond. All this can be done in an easy way using the security administration function in Symphony Plus Engineering workbench.

Overview of security features:
- User authentication
- Role-based access control
- Event logging/Audit trails
- Backup/Restore
- Hardened hosts
- Host firewall configuration
- Antivirus
- Network zones
- Security patch validation
- Patch management
- Virus pattern management
- Host intrusion detection
- Host intrusion prevention
- Network intrusion detection
- Compliance management

The Symphony Plus security model supports the definition of rights and the roles for a user or user groups with definable granularity.

Security controls a user’s authority to perform different operations in accordance with several parameters:
- The user’s credentials, as provided by the lightweight directory access protocol (LDAP) server
- The node where the user is logged in. This makes it possible to give a user a different authority according to location, e.g. close to the process equipment or in a control room
- The operation the user wants to perform

Basic access to the system is controlled by the user’s credentials entered during logon or log-over. Restrictions may be placed on factors such as password length, complexity, age and reuse.

The logover function enables a fast and temporary switch between users in a running workplace. For example, if an operation requires a right not held by an operator, another user (such as a supervisor) who holds the required right can logover to perform that operation. The log-over changes the rights and user roles but keeps an open view on the process by retaining the workplace and its present contents, supporting automatic revert to the previous user.
Symphony Plus supports configuration change management by defining each version area with three states of configuration data: design, release and running. These states can be archived and easily compared for differences. In addition, Symphony Plus maintains all used software and its versions for easy update management and comparison.

Symphony Plus maintains an audit trail of changes made to process settings as well as configuration changes. In addition, all system and security events are collected in the Symphony Plus event management system.

The archive function of information management history services supports the permanent offline storage of historical data collected in property, message and report logs, as well as the operator workplace alarm and event message buffer, including audit trail messages. The archiving mechanism copies the contents of selected logs to a designated archive media.

Symphony Plus provides comprehensive diagnostic functions for determining the health of the process and control system. System status can also be displayed in the context of topology diagrams. This includes the status of the system infrastructure e.g., controllers, I/O modules, switches, routers and firewalls. All events from these devices are collected, and alarms can be generated in the event of problems.

System hardening can be deployed centrally from the administration console. This includes OS hardening, application hardening, host firewall configuration, and antivirus. It applies to servers, workstations and supported network equipment.

Numerous features of Symphony Plus assist in the recovery of a system failure. Total and selective ‘backup and restores’ are possible through the system administration features. System nodes can be replaced easily by deploying all original software and configuration data in the new replacement node. Commercial third party software can be employed to restore a server- or workstation-based failure to a state in which a software and configuration deployment can be performed.

Network equipment, such as routers and switches, can be backed up and loaded from the system’s administration console.

6. **Integrated operations**

Symphony Plus’s secure and powerful ergonomic HMI, S+ Operations, provides users with a powerful tool for power plant operation. S+ Operations combines advanced technology in a scalable server less or client-server, distributed architectures. Through integration of standard communication protocols such as OPC, Modbus TCP, IEC 870-5-101/013/104, and IEC 61850, S+ Operations can easily integrate both locally and geographically distributed devices that need to be integrated in control system.

S+ Operations is a Windows-based, web enabled HMI providing outstanding information integration and user navigation within a standard Windows environment. Based on industry standards, S+ Operations provides users with detailed, well-arranged process overview displays to present better situation awareness and recognition to abnormal conditions. Context-sensitive aspect menus allow operators and engineers to share information and navigate intuitively. With
user-specific information presentation, easy navigation to data, and alarm management based on EEMUA 191 guidelines, S+ Operations delivers reliable and consistent operations.

S+ Operations’ advanced integrated alarm management system improves the operators’ capability to detect and respond to abnormal situations, increasing their success rate in returning to a normal mode of operations. Based on S+ Operations’ integrated information management module, the EEMUA 191 and ISA SP 18.2-compliant alarm analysis and alarm management module can be used to analyze trends or abnormal situations based on process messages. The system offers an extensive array of analysis possibilities such as message filters in alarm/event list and frequency statistics for defined time ranges. This can lead to a higher incidence of control room operators detecting an abnormal situation prior to alarms even occurring.

S+ Operations supports the implementation of high performance alarm management strategies offering features such as alarm grouping, filtering, shelving, hiding and suppressing (inhibiting). Color identification of different message priorities gives the operator a clear condition-based overview. Groups are organized and viewed in hierarchical structures.

S+ Operations is designed to integrate information from anywhere in the enterprise on cross-site and cross-plant information platforms. ABB’s advanced technology provides seamless integration from third-party devices, controllers and systems. What’s more, S+ Operations is able to incorporate historical data to provide users with a valuable perspective of the trends affecting their operations and businesses.

S+ Operations provides the possibility to view real-time data and historical information simultaneously in one display. Additionally, data can be accessed from multiple history servers, aggregating analog as well as digital trend data. The practical advantages are obvious when looking at trend curve values: users are able to overlay information over time without having to move from a real-time system to a separate historian. Standard report templates are easily adapted to specific requirements, including freely customized reports. S+ Operations includes ready-made templates for:

- Instantaneous value reports
- Alarm messages, status messages, operator interventions
- Filtering by priority, area, etc.
- Operation reports (shift, daily, monthly, year)
- Status report (snapshots)
- Trip reports
- Maintenance reports

7. Remote monitoring

The S+ platform can be also connected to any place far from the power plant (e.g. Client offices, ANSALDO offices etc.) for remote monitoring and/or the partial or full operability of the control system utilizing different type of commercial communication systems (e.g. WEB, VPN, satellite etc.). Different levels of security (DMZ area, router, and firewall) and log access profiles can be selected and configured to avoid undesired or dangerous accesses.
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