

OMAINTEC 2107, 23 OCTOBER 2017

ABB Digital Substation

Digital Substation, bridging the gap between analogue and digital technologies.

Claudio Marchetti, Power Grids, Global Product Manager



INTRODUCTION:

- ABB Digital substation are synchronizing technologies for reliable power.
- Bridging the gap between analogue and digital technologies brings unseen.
- Opportunities for modern utilities. Built on the international standard IEC 61850.
- ABB's world-leading digital substations achieve new heights in reliability.
- Interoperability and real-time performance. We protect investments while stepping up to meet the challenges of tomorrow.

COURSE OBJECTIVES:

- Introduce digital substation concept and its components and benefits.

COURSE CONTENT

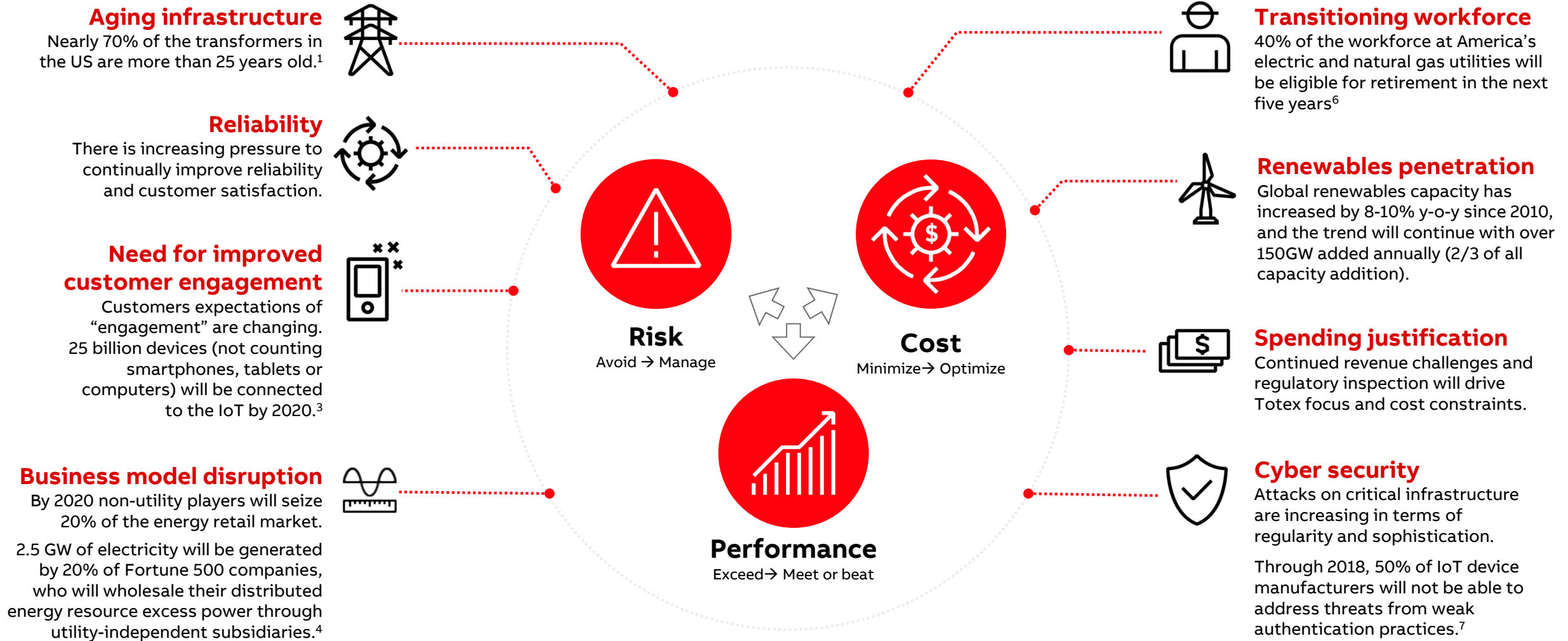


- Introduction and context
- Rational for Digital Substation
- Digital Substation Concept
- Digital substations for Transmission and for Distribution applications
- Non-conventional instrument transformers
- Solutions for retrofit
- Monitoring and Diagnostics
- Long term field experience
- Customer values
- Summary



Introduction

Current challenges and changes facing utilities



Grid of the Future

Rapid rate of change and requires higher velocity of decision making

The world of energy is changing

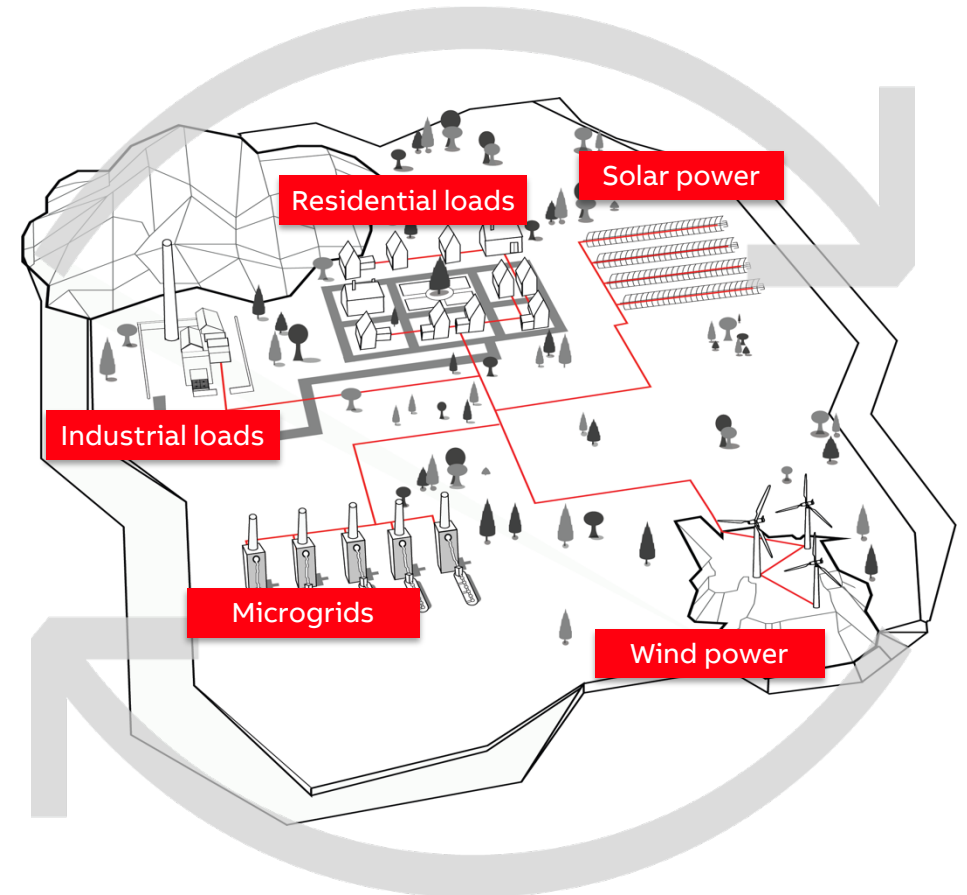
Supply

- Dramatic renewables growth
- Increasing intermittency
- Greater volatility, less predictability
- More feed-in, take-off points(eg, data centers and ev-charging)
- Increasing complexity, need for stability On-and off-grid Control
- Automation on “local” level

Demand

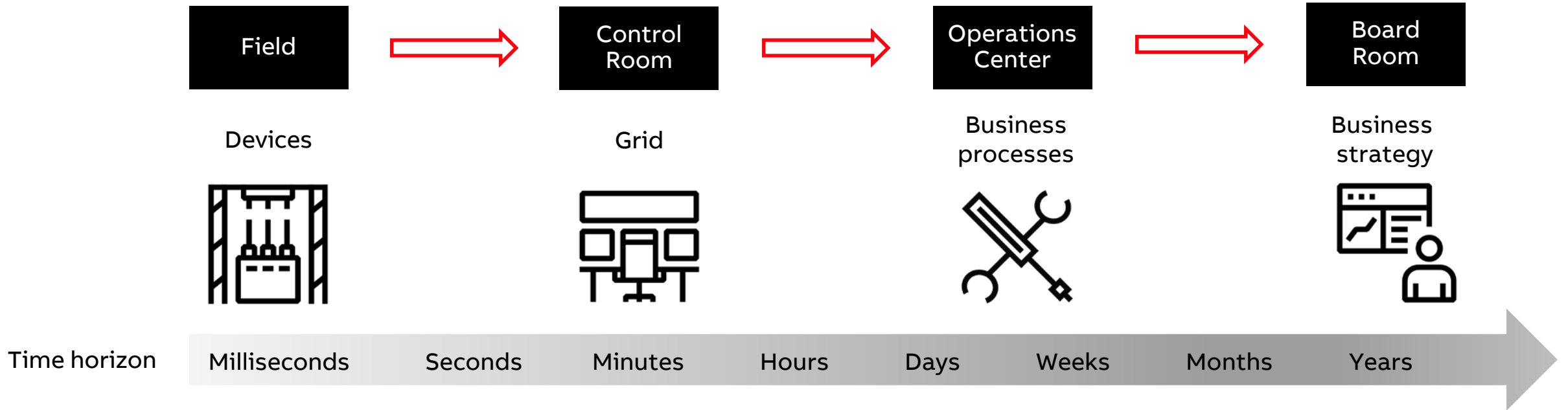
- Continuing electrification of society
- Emerging market consumption growth

Control & information flow is key



Utility customers will increasingly have to deal with very **dynamic grids**

The need for **faster decisions** and **real-time action** requires **visibility** of the entire business



Digitalization is the only answer for the necessary agility and decision-making velocity

ABB – uniquely positioned and a pioneering technology leader

Enabling a smarter stronger greener grid

Stronger

Ultra High Voltage DC and AC
Resilient transformers
Power quality solutions & FACTS¹
Interconnectors



Continuously breaking records:
more power over longer distances
(12 GW over 3,000 km)

Smarter

Digital substations
Grid automation
Sensor-based technologies
Enterprise software solutions



Digital substation: smart
configuration and interoperability,
up to 80% less cabling, up to 50%
less outages

Greener

Eco-efficient Gas Insulated Switchgear
Ultra low loss, amorphous core and
biodegradable oil transformers
HVDC Light² and FACTS for renewable
integration



Transformers: up to 70% less losses
GIS³: up to ~100% less greenhouse gases
FACTS: more capacity in existing lines

What is a Digital Substation?

How ABB Ability™ solutions deliver value

What is Digitalization?

Digitization Conversion of analog information in any form to digital form with suitable electronic devices so that the information can be processed, stored, and transmitted through digital circuits

Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; moving to a digital business.

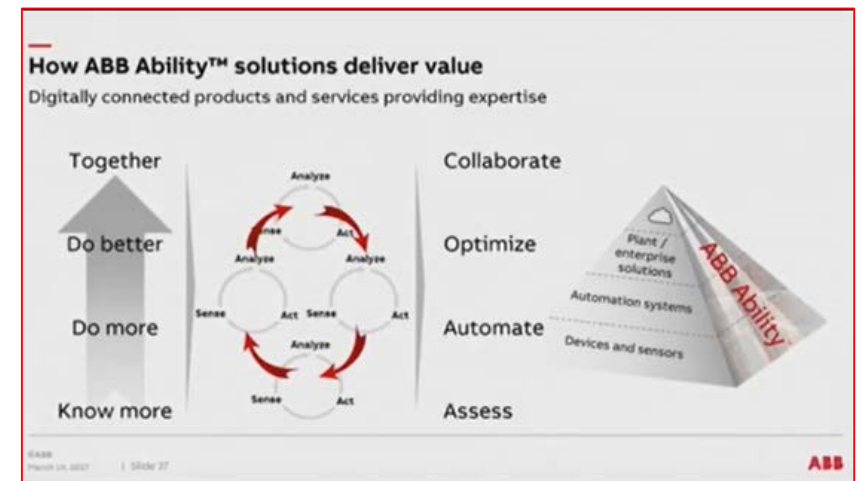


ABB Ability™ value proposition – expertise

Providing **expertise** to our customers conveys clear customer benefit.

Expertise will be the focus of differentiation to position ABB as a high-value provider using a combination of people, products/technology, and digital know-how.

Partnerships will be key



Digital solutions with ABB Ability

Providing an **end-to-end solution** from the field to the board room

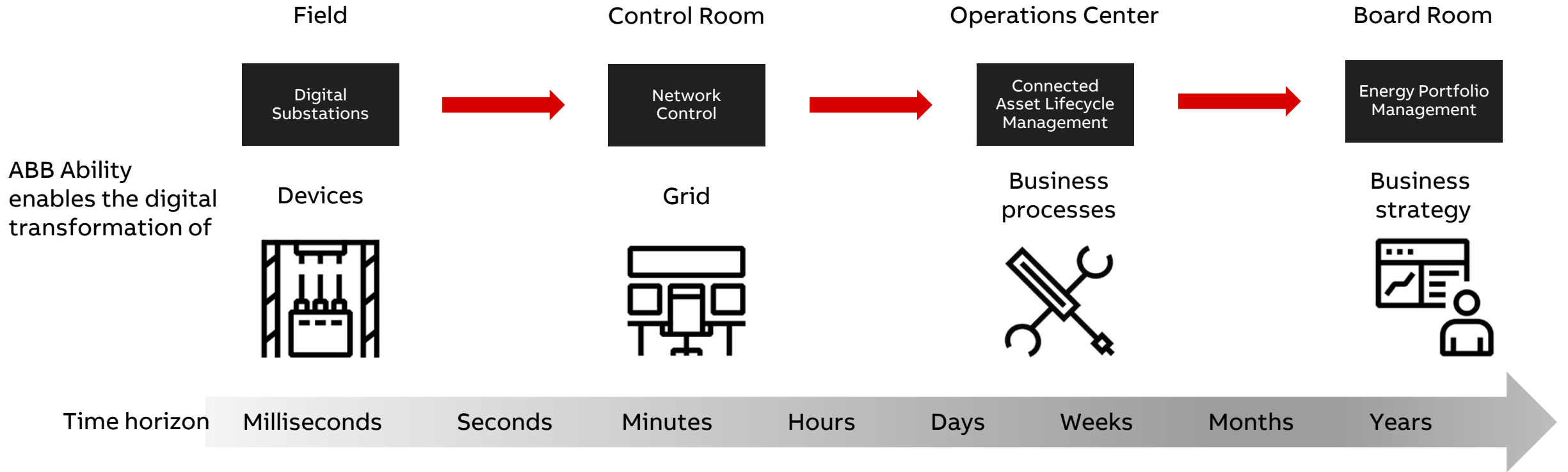
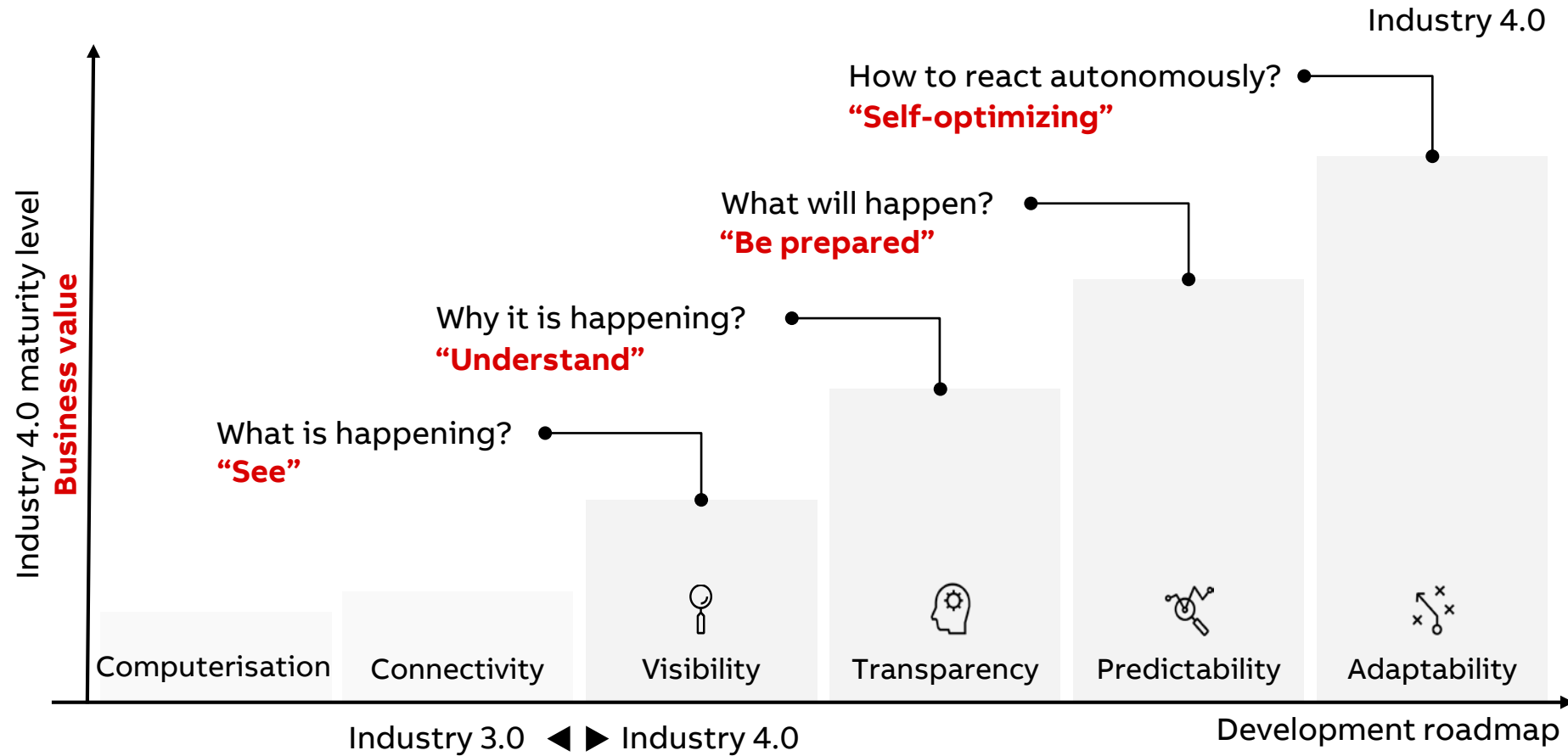


ABB Ability = ABB's deep expertise + Digitalization + Best in Class Partner capabilities

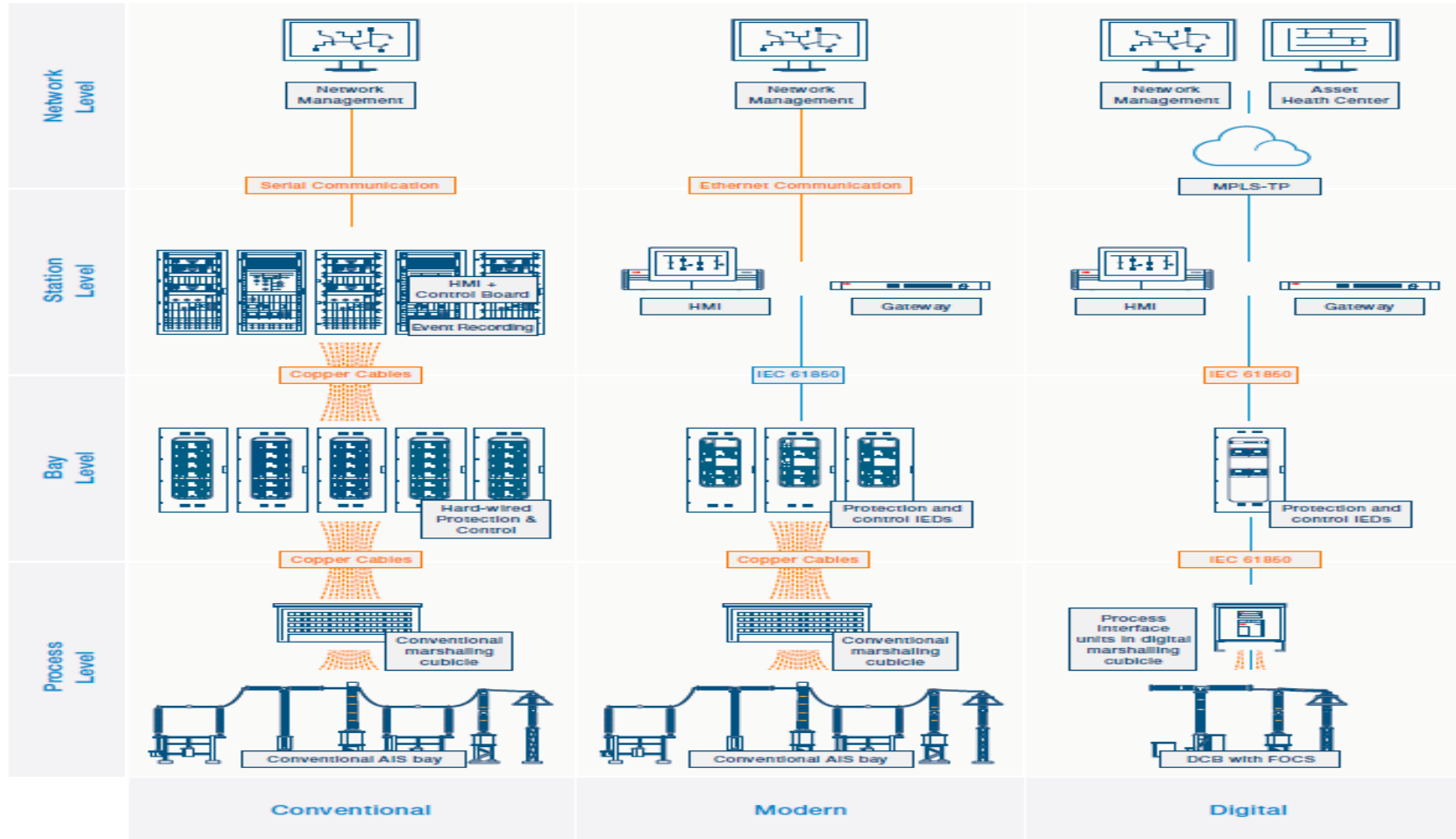
Digital substations

The power of data analysis



Substation evolution

From wired to optical communication



Digital Substation and IEC 61850

Conventional

Conventional substations

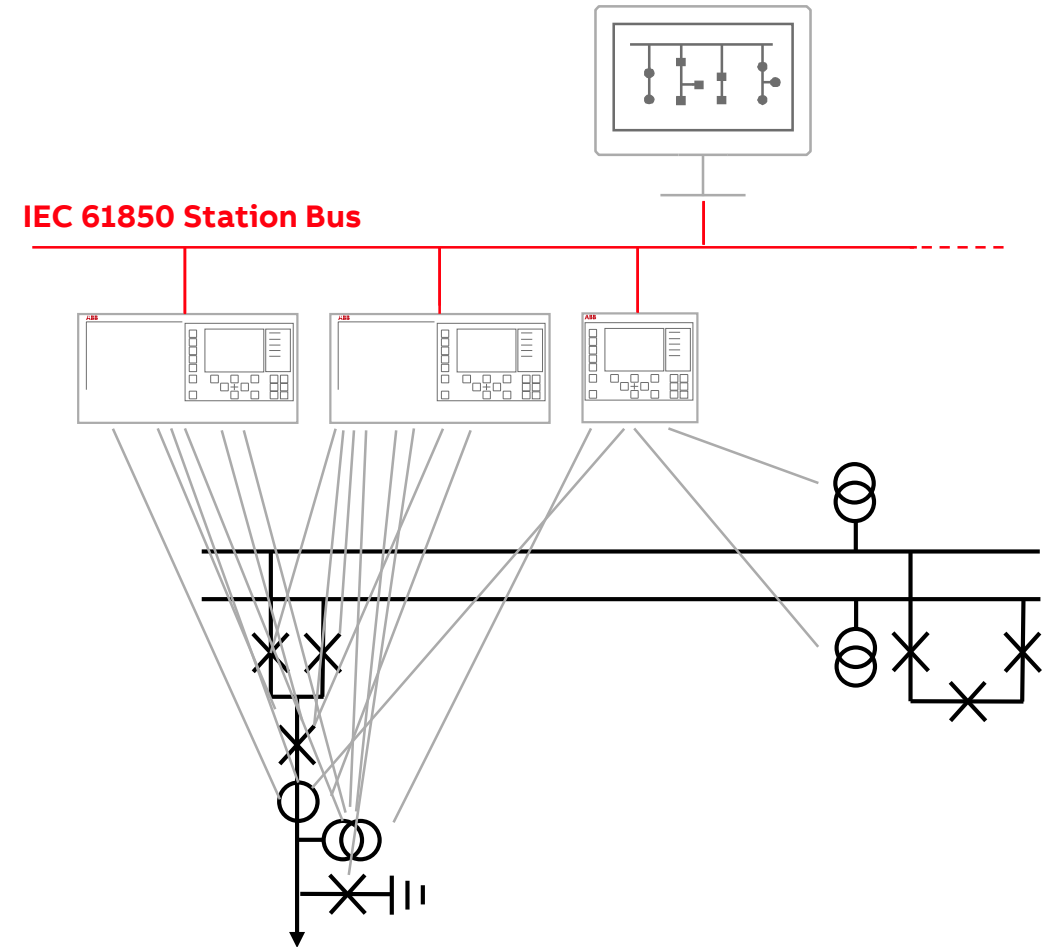
IEC 61850 Station Bus

Replace wiring and legacy protocols between bays by digital communication

Interface to field

Hardwired point to point connections between primary and all secondary equipment

Thousands of hardwired point-point connections



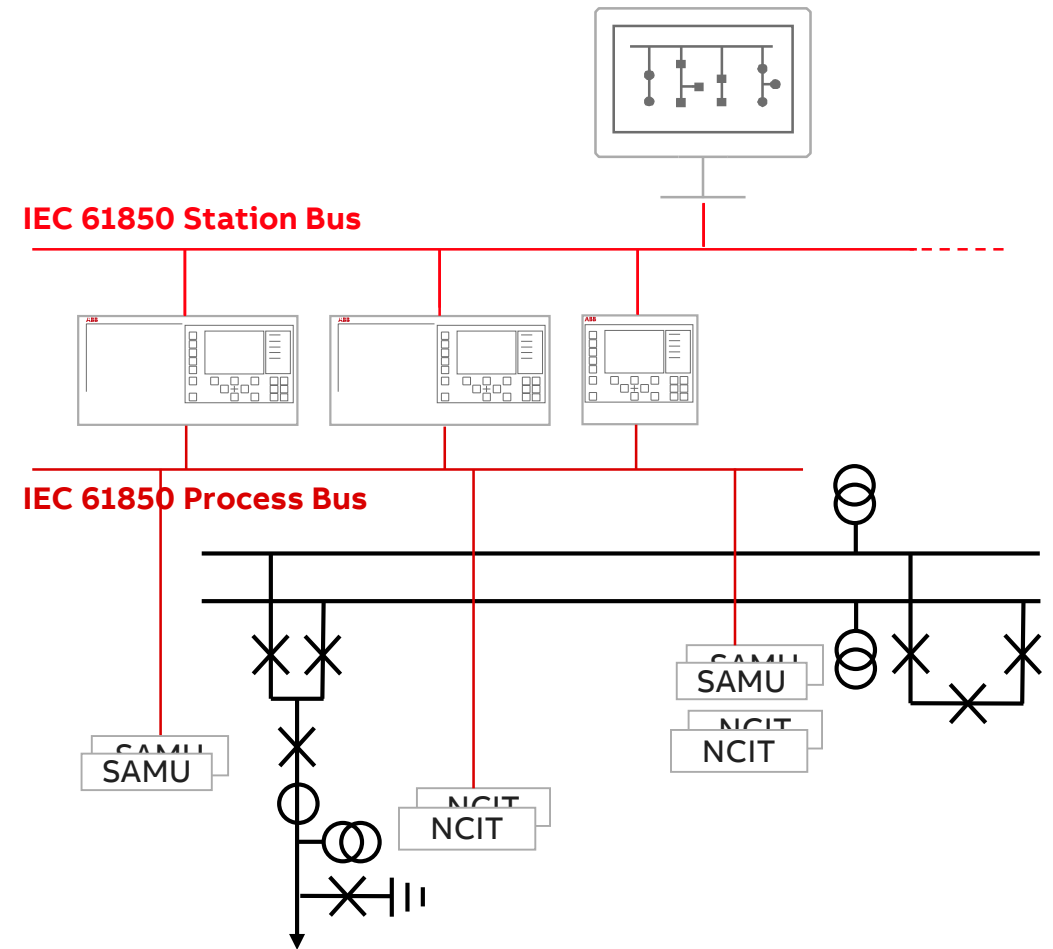
Digital Substation and IEC 61850

Digital

Digital substations with process bus

- All signals digital on station and process level
- All information available on communication network analog measurements, switchgear status, monitoring data
- Control and protection commands on highly available fiber optics
- Information is acquired ones and distributed on the bus

The process bus reduces cabling and efficiently distributes information



NCIT Non-conventional instrument transformers

SAMU Stand-alone merging units

Digital Substation and IEC 61850

IEC 61850 communication services

Client-Server

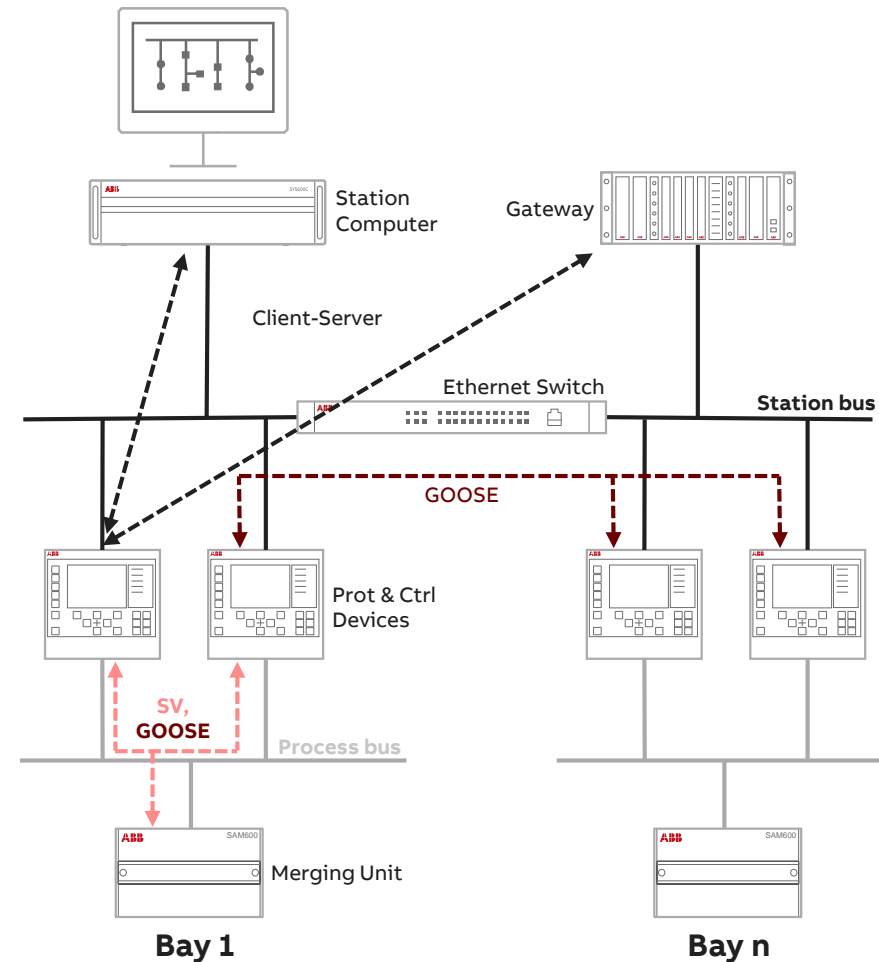
- Reliable point to point sessions for central monitoring and control
- Commands, reporting, logs, file transfer,...

GOOSE

- Real-time data broadcast for station wide applications e.g. interlocking
- Binary data, indications, commands

Sampled Values (SV)

- Real-time data broadcast for collecting measurements from process
- Sampled analog values



What is a digital substation?

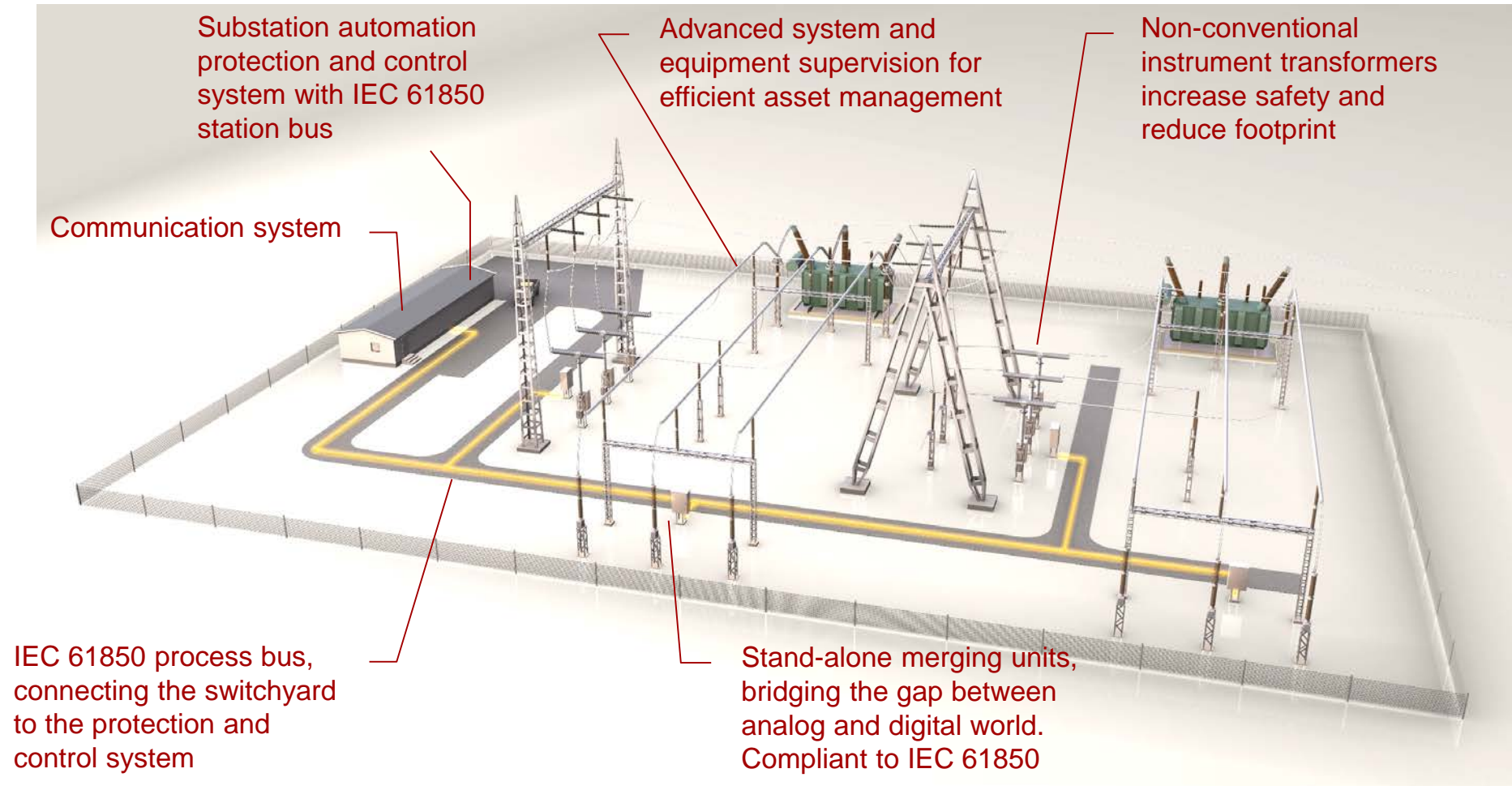


ABB Digital Substation solutions

Primary system solutions

Digital substations

Digital technology from end to end

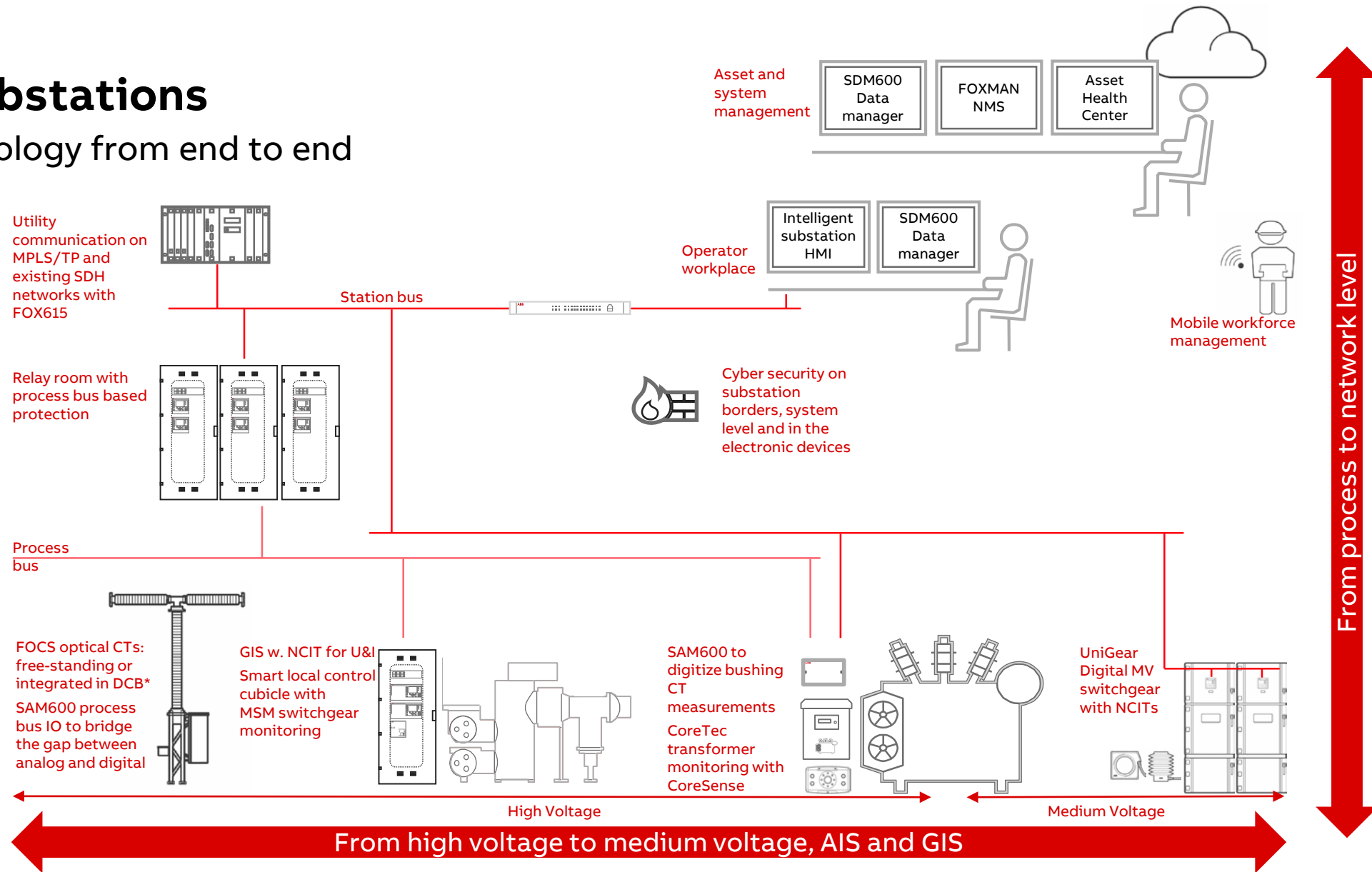


ABB solutions for digital substations

Portfolio and architecture

- Digitization of the signals in the process level
- Communication via IEC 61850
- System-wide engineering via integrated software
- Visualization, system and access control on the field level
- Connection to higher-level network management and asset management solution via MLPS-TP
- Connectivity to Microsoft Azure Cloud

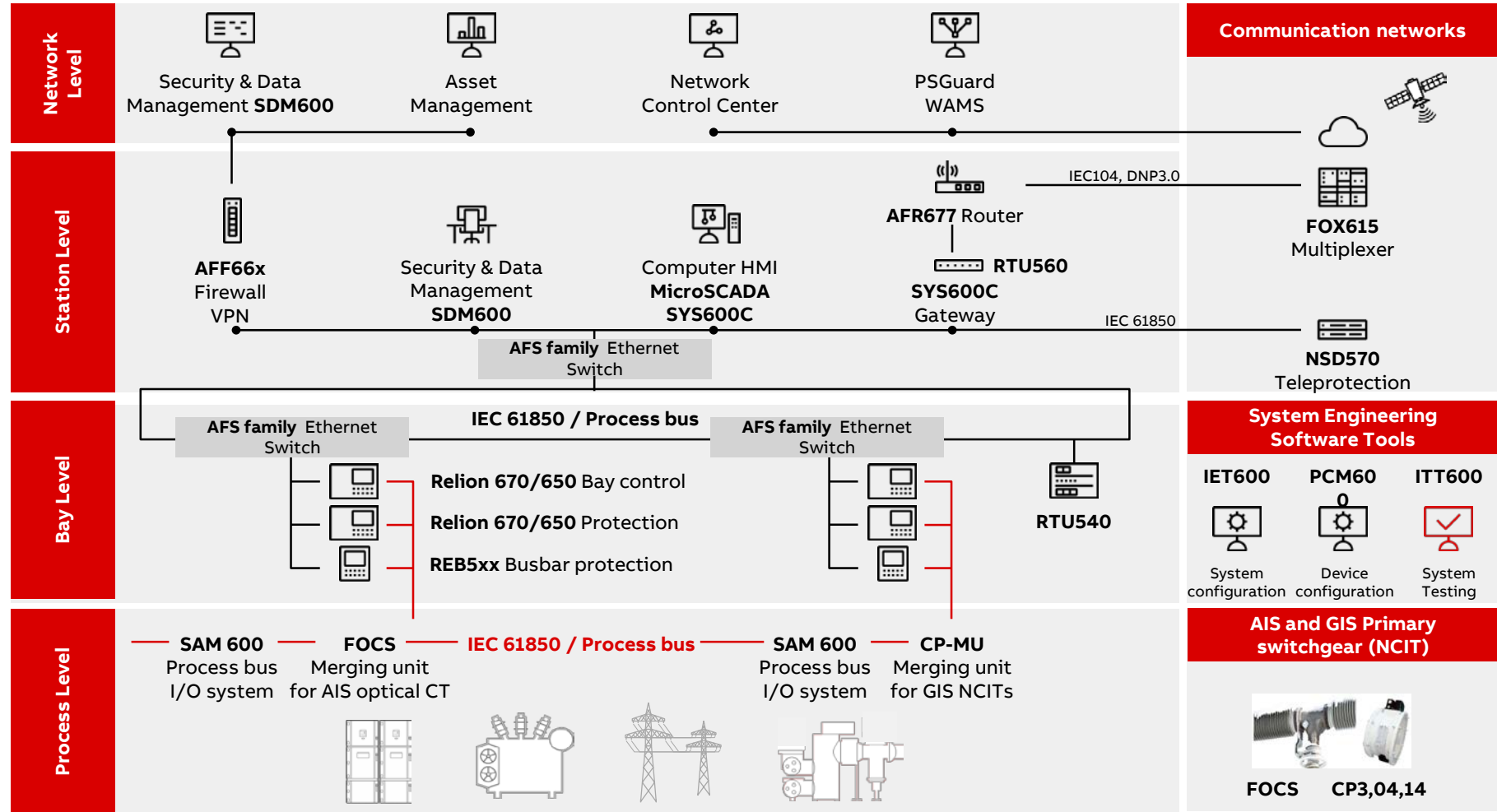
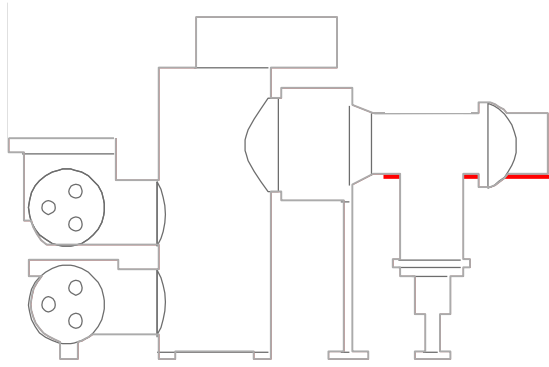
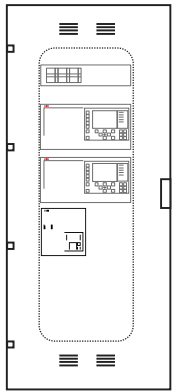


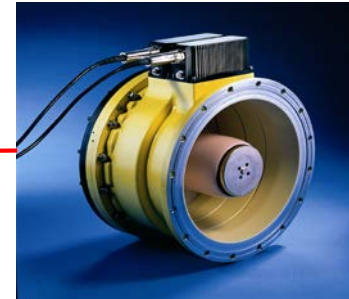
ABB solutions for digital substations

Instrument transformers with NCIT (sensors)

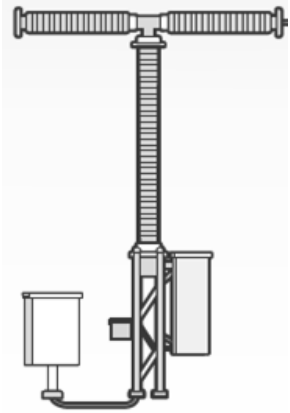
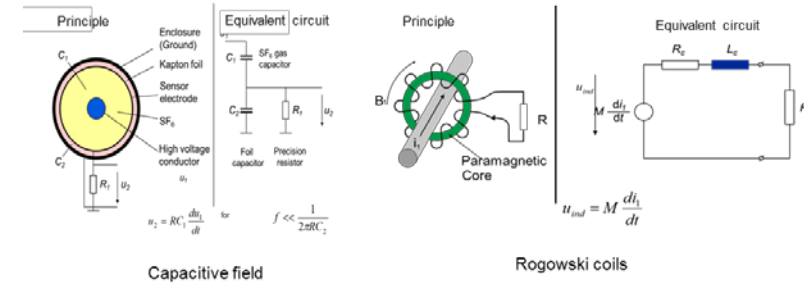


IEC 61850-9-2LE

Merging Unit



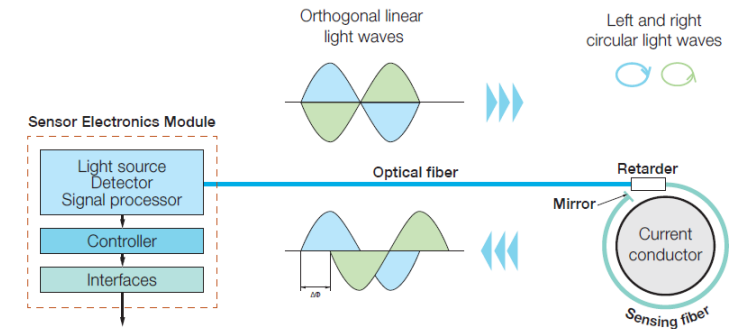
Combined Current & Voltage sensor



IEC 61850-9-2LE



FOCS sensor head and electronics



Targets of digital solutions

Smaller and saver GIS substations with reduced maintenance

Smart primary equipment

Increased safety through NCITs

- GIS with non-conventional instrument transformers for current and voltage measurement

Optical process bus replaces tons of copper cables

- Smart local control cubicles with IEC 61850 connectivity for smooth integration into substation automation systems

Digital GIS for even more compact substations with high safety and short installation time

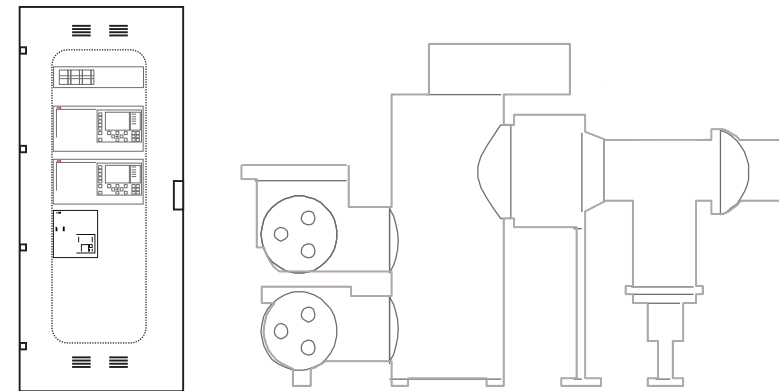


ABB solutions for digital substations

NCITs solutions for GIS

ELK-CP NCITs for GIS

- Redundant, combined current and voltage sensors for gas insulated switchgear (Rogowski coils, capacitive dividers)
- Metering, protection and control accuracy in a single device
- World's first IEC 61850-9-2LE-compliant, UCA-certified merging unit
- Available for transmission level GIS since 1997 (initially with proprietary communication)

CP3



CP14



CP04



Targets of digital solutions

Smaller and safer AIS substations

Smart primary equipment FOCS

Increased safety and higher flexibility through NCITs

- Optical current sensors eliminate the risk of open CT circuits and do not know saturation

More compact substations through combination of various functions in one primary apparatus

- Integration of optical CTs in circuit breakers
- Modular and compact mixed technology systems

Standard compliant connectivity

- IEC 61850 on process level

Digital AIS substations can be more compact, are quicker to install and safer to operate

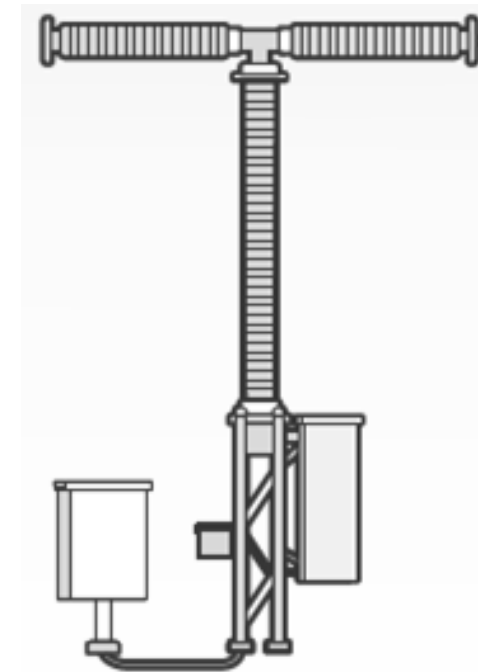


ABB solutions for digital substations

NCITs solutions for GIS

Sensors solutions for HV AIS

Free standing optical CT, FOCS-FS

- Filled with N₂ instead of SF₆ it is safe and environmentally
- Metering, protection and control accuracy in a single device

Disconnecting circuit breaker (DCB) with FOCS

- Disconnecting circuit breaker with integrated optical CT for maximum space reduction
- Metering, protection and control accuracy in a single device

FOCS sensor and electronics

- Installation of sensor heads on bushings of dead tank breakers, transformers etc.
- ✓ Redundant
- ✓ FOCS replaces many CT cores → Less foundations
- ✓ No iron core → No saturation and linear

FOCS sensor head



FOCS electronics



FOCS-FS



FOCS+DCB

ABB solutions for digital substations

Modular GIS system with direct IEC 61850 connectivity

PASS (Plug and Switch System) with Motor Drive™ 1.4

- Digitally controlled motordrive for CB operation
- Drastically reduction of moving party enables highest reliability
- Local control of all switching objects in PASS
- IEC 61850 interface for integration in protection and control system



ABB solutions for digital substations

MV switchgear solution

Unigear Digital switchgear solution

- Non-conventional current and voltage sensors
- 615 series IEDs exchange GOOSE and IEC 61850-9-2 sampled voltage values on station bus within the switchgear
- IEDs can act as publisher and receiver of sampled values
- Only voltage values are exchanged

Features

- Lower losses due to sensors
- Faster delivery due to flexibility
- Environmentally friendly
- Smaller foot-print (no extra metering cubicle)
- Easier engineering, less hard wiring
- IEC 61850 standard

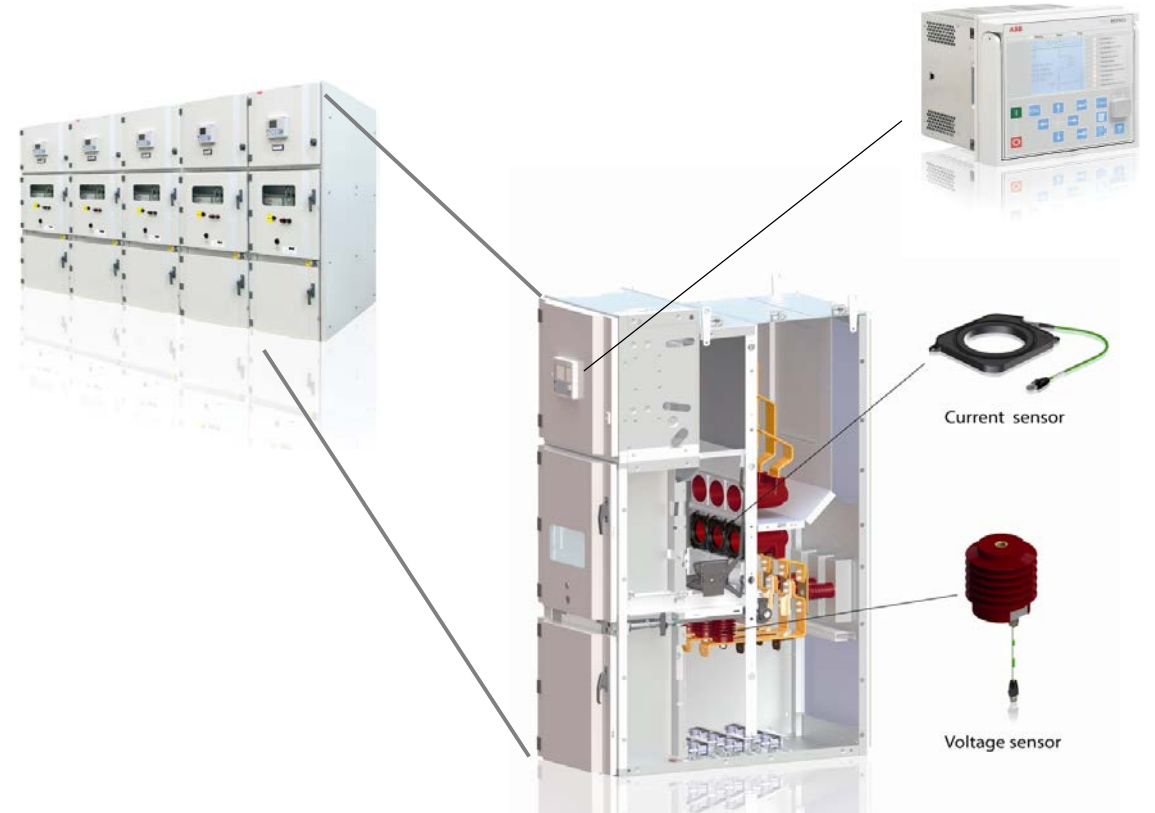


ABB solutions for digital substations

Primary equipment monitoring

MSM modular switchgear monitoring

MSM SF₆ monitoring allows users to:

- Early detect SF₆ leakages and thus minimize SF₆ emissions
- Have more time to prepare countermeasures
- Get a detailed report of banked SF₆ in the equipment and simplify preparation of SF₆ balance sheets
- Reduce inspection work and maintenance cost ¹⁾

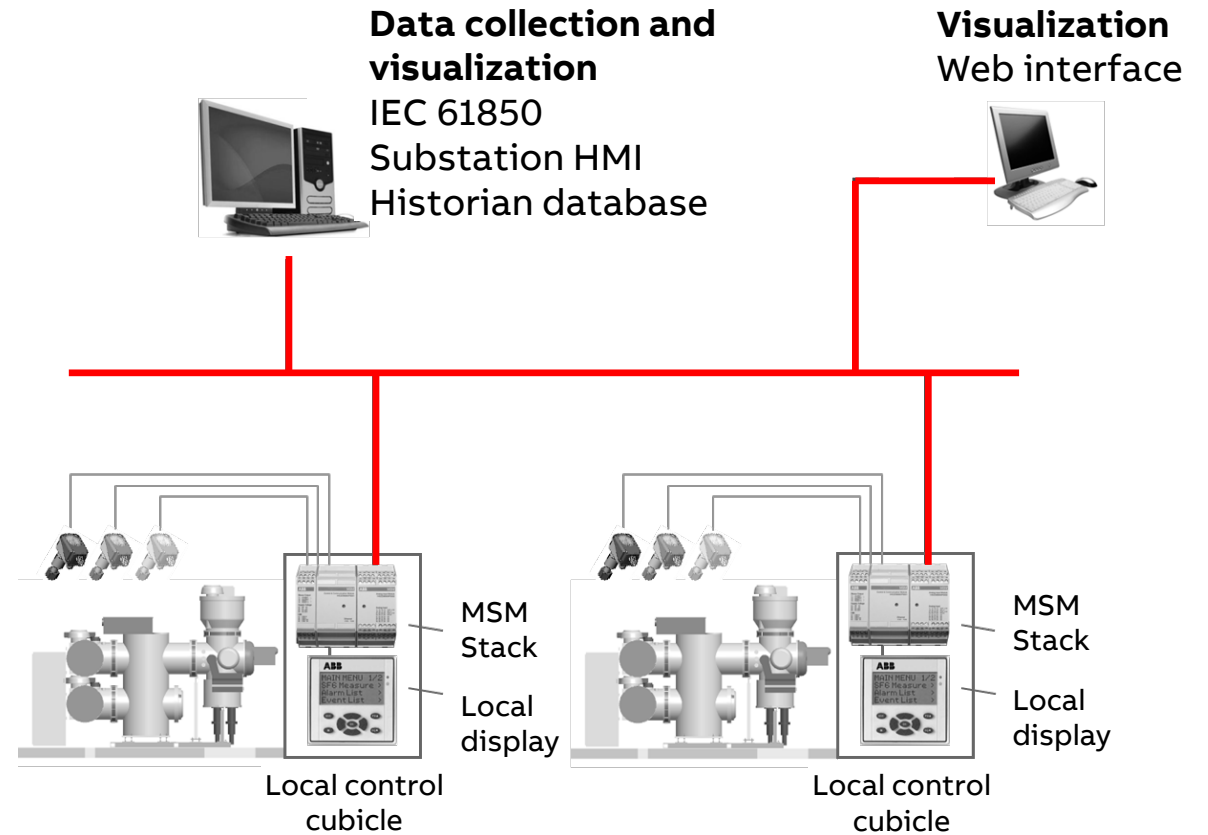
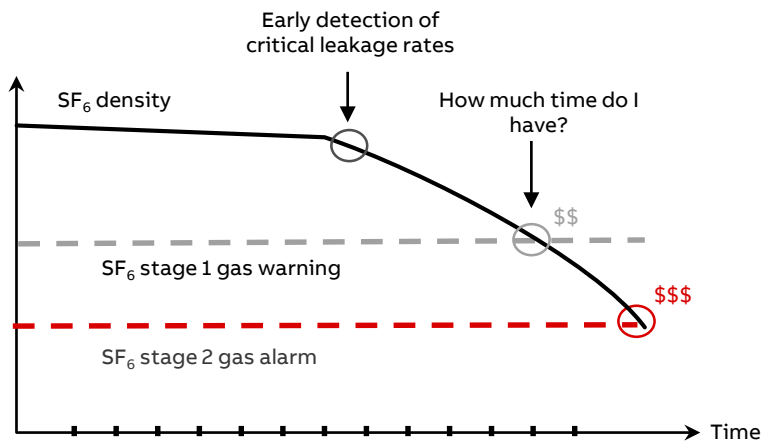


ABB solutions for digital substations

Primary equipment monitoring

CoreTec transformer monitoring

- Transformer electronic Control CoreTEC
- Monitoring and diagnostics functions
- Cooling control
- Dissolved gas analysis by CoreSense
- Connectivity of CoreTEC to IEC61850
- Data Analysis in Asset Health Monitoring to optimize operation and maintenance



CoreTEC



CoreSense

Accessories

Oil Level Indicators

Temperature Indicators

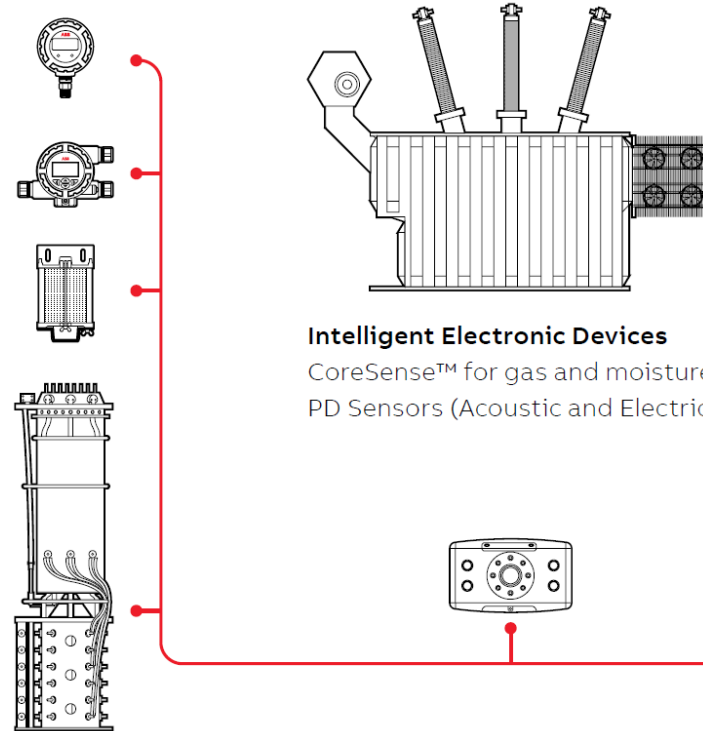
Breathers

Buchholz Relay

Tap Changers

Oil & Vacuum

Mechanical and Motor Drives



Intelligent Electronic Devices

CoreSense™ for gas and moisture
PD Sensors (Acoustic and Electric)

User Interfaces

WEB

Asset Performance Management

SCADA

CoreTec™ Intelligent Control

Monitoring and Diagnostics

Communication (DNP3 and IEC 61850)

The ABB offering for digital substations

Secondary system solutions

ABB solutions for digital substations

Modular process IO system for new and retrofit installations

SAM600 process bus IO system

Bridging the gap between analog and digital technologies

SAM600 modular process bus IO system is placed in the field to connect conventional equipment to IEC 61850 process bus

SAM600-CT

- Current measurement for protection and metering

SAM600-VT

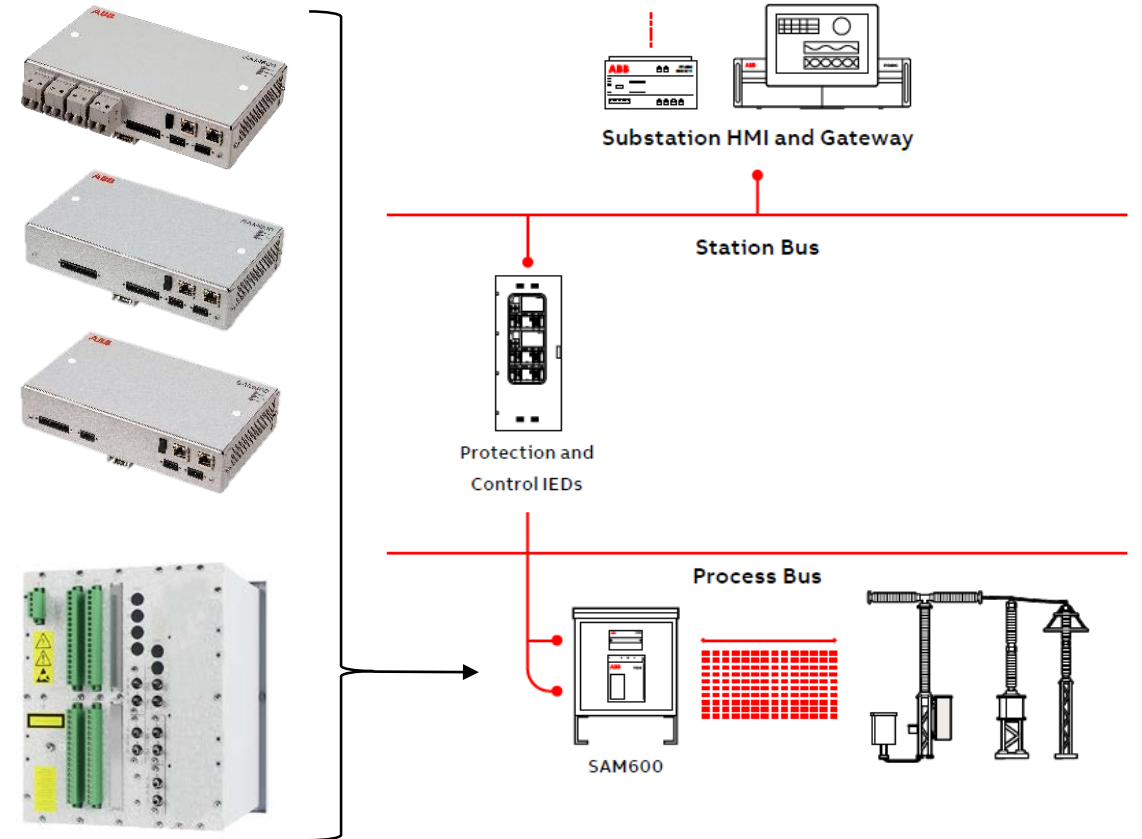
- Voltage measurement for protection and metering

SAM600-TS

- For time synch and more

SAM600-IO

- Scalable IO for binary signals from disconnectors, earthing switches, breakers, transformers...



SAM600 – ABB's process bus IO system

Digitizing primary signals made easy

Modular IO system

For interfacing primary equipment to IEC 61850 process bus

- Connects to conventional current or voltage transformers
- Provides time synchronization (optional)
- Adapt to different applications types by changing SAM600 modules into a system

Compact and optimized form factor

- DIN-rail mountable for fast installation and replacement
- Installation in station panel or marshalling kiosks

Termination of primary cabling on SAM600 modules

- Termination of process and auxiliary signals



SAM600 modules
in outdoor cubicle

SAM600 series

Enabling digital substation solutions

Benefits

Easy to use

- The module-per-primary object concept allows for intuitive and flexible system design

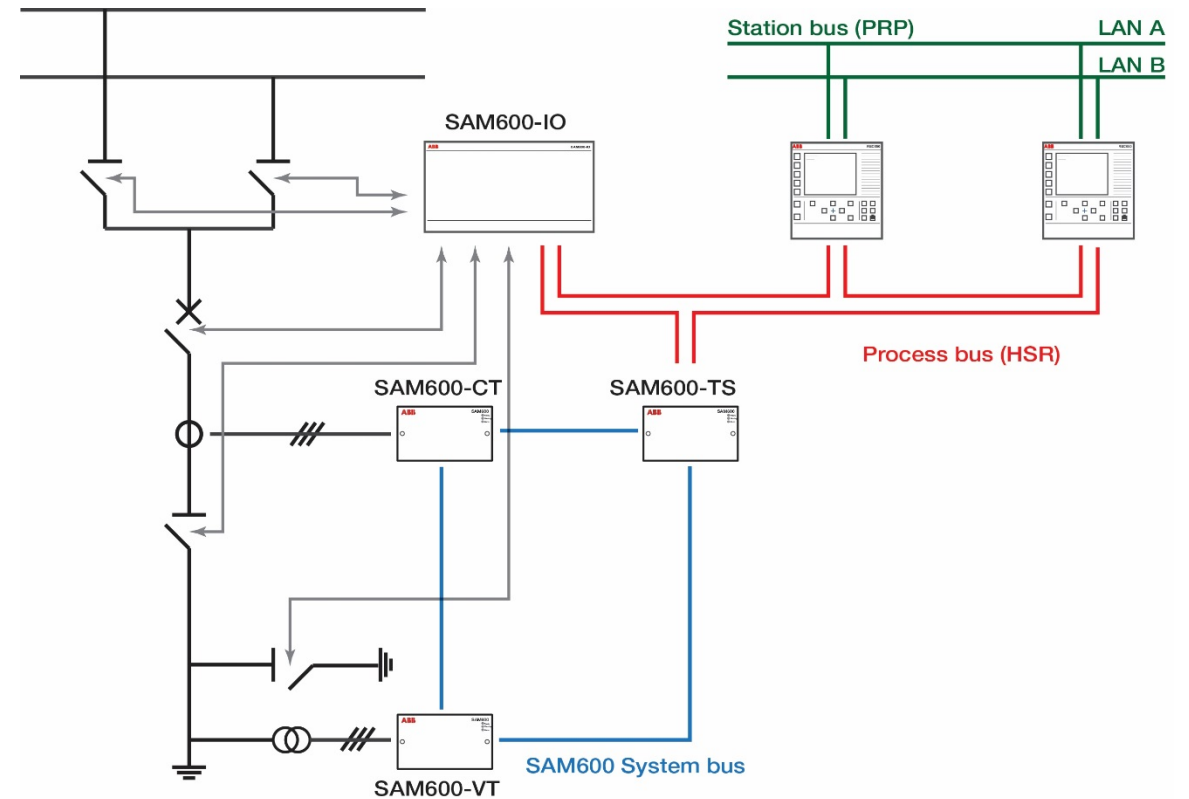
Unrivalled flexibility

- SAM600 modules fit to any substation layout (double busbar, 1½ breaker, ...)
- Large number of communication ports minimize the need for switches in process bus

Cost saving retrofits

- Modular system enables “non-invasive” retrofit with minimum outage time and step-wise commissioning

Unique modular approach



SAM600 – the digital substation enabler

Application example – transformer feeder

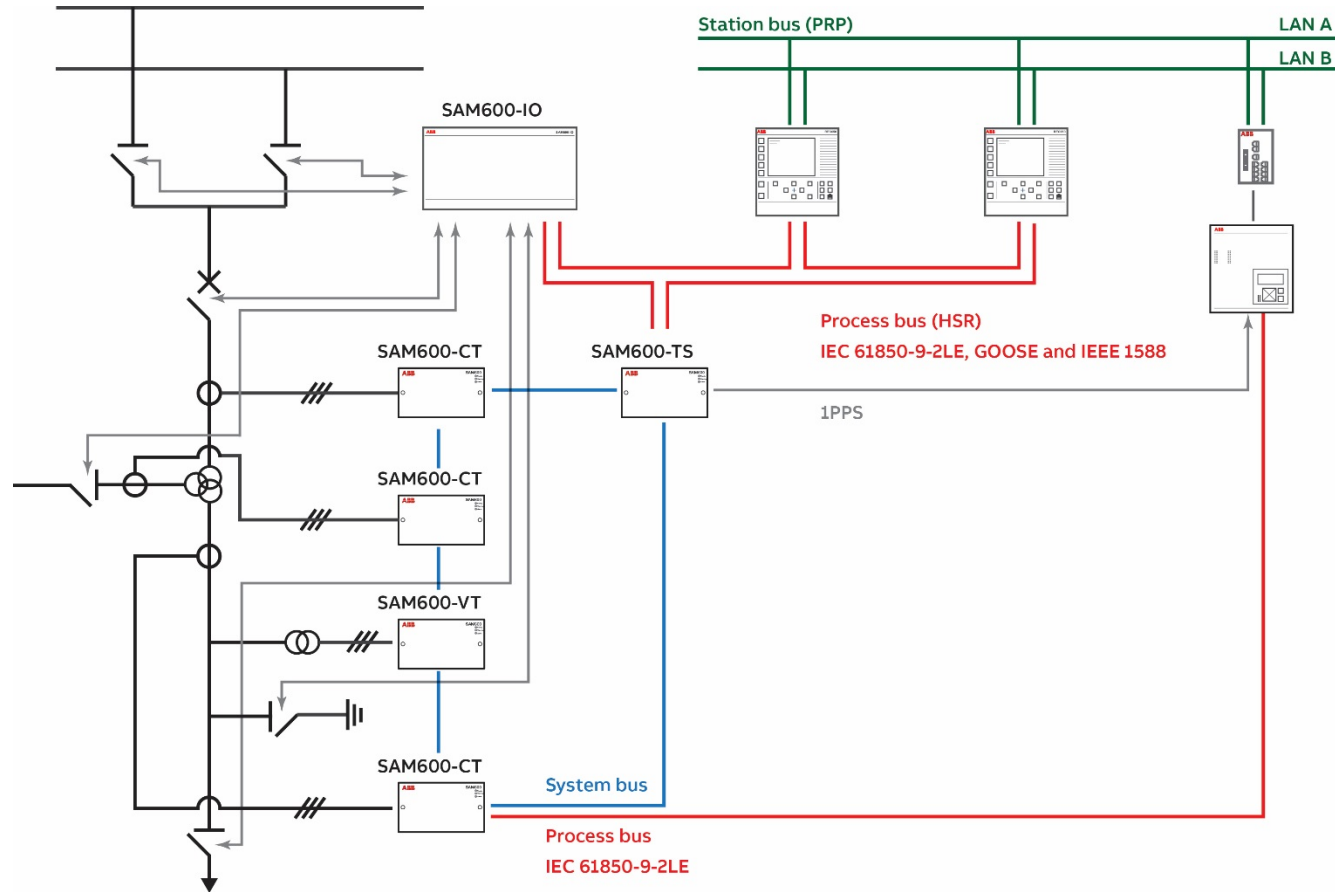


ABB solutions for digital substations

Protection and control for any application

Relion series protection and control IEDs

650/670 series protection and control IEDs

- IEC 61850 process bus for all application
- Support of pure digital as well as mixed applications with digital and conventional IO
- Redundant communication on station and process bus
- Precise time synchronization over Ethernet (IEEE1588/IEC 61850-9-3)

PWC600 Switchsync

- Controlled switching with process bus connectivity

REB500 distributed busbar protection

- For any station size and layout supports IEC 61850-9-2 process bus



Relion® 670 and 650 series

Enabling digital substations

Support for various digital substation architectures

Up to 6 Ethernet ports that can easily be configured for MUs

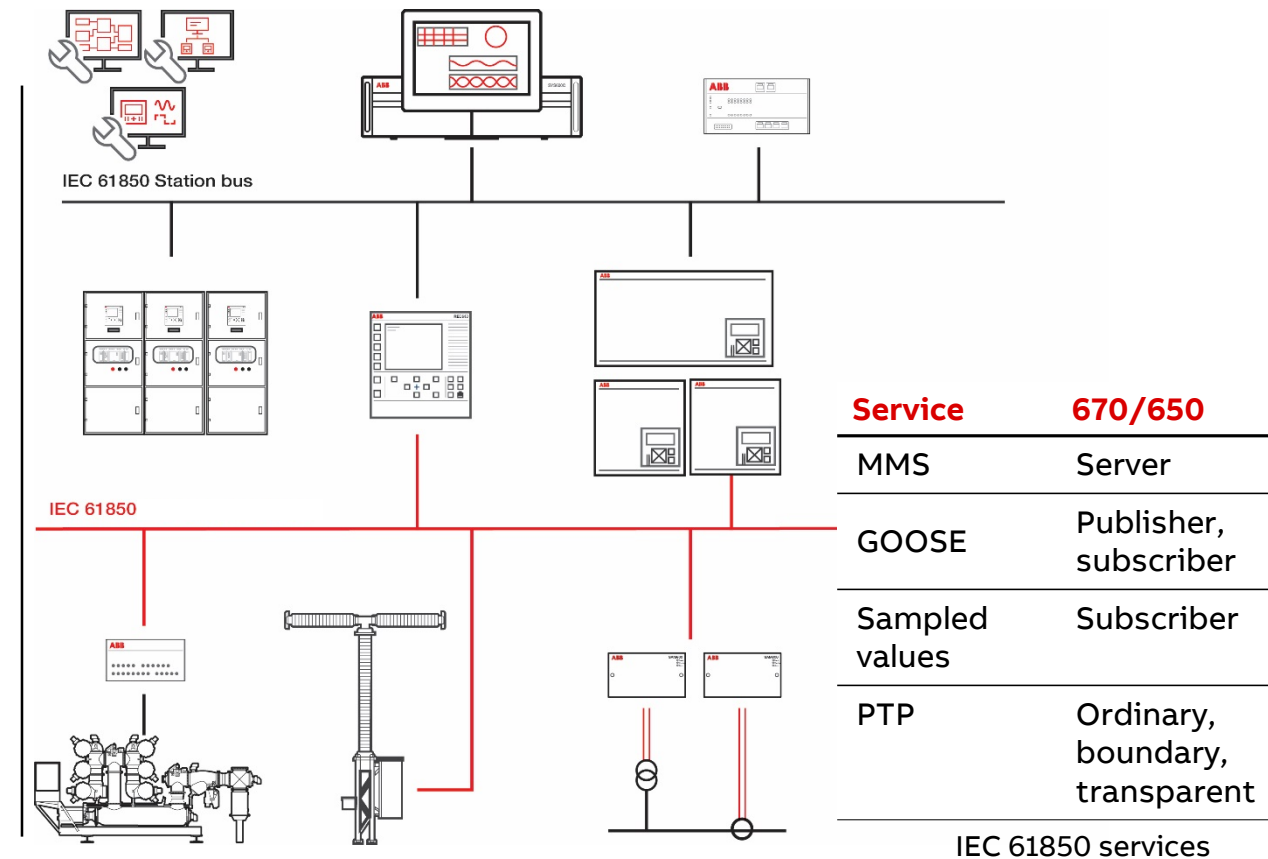
Typical solutions

- Station bus is with redundancy PRP
- Process bus with redundancy HSR
- Time sync via PTP IEC/IEEE 61850-9-3 (Legacy PPS)

Connectivity to 3rd party IEDs/sensors/MUs using standardized methods:

- Communication: IEC 61850-8-1, IEC/UCA 61850-9-2LE
- Time sync: IEC/IEEE 61850-9-3 (PTP)
- Redundancy: IEC 62439-3 (link redundancy PRP/HSR)

Easily adaptable to most digital substation topologies



Relion® 670 and 650 series

Enabling digital substations

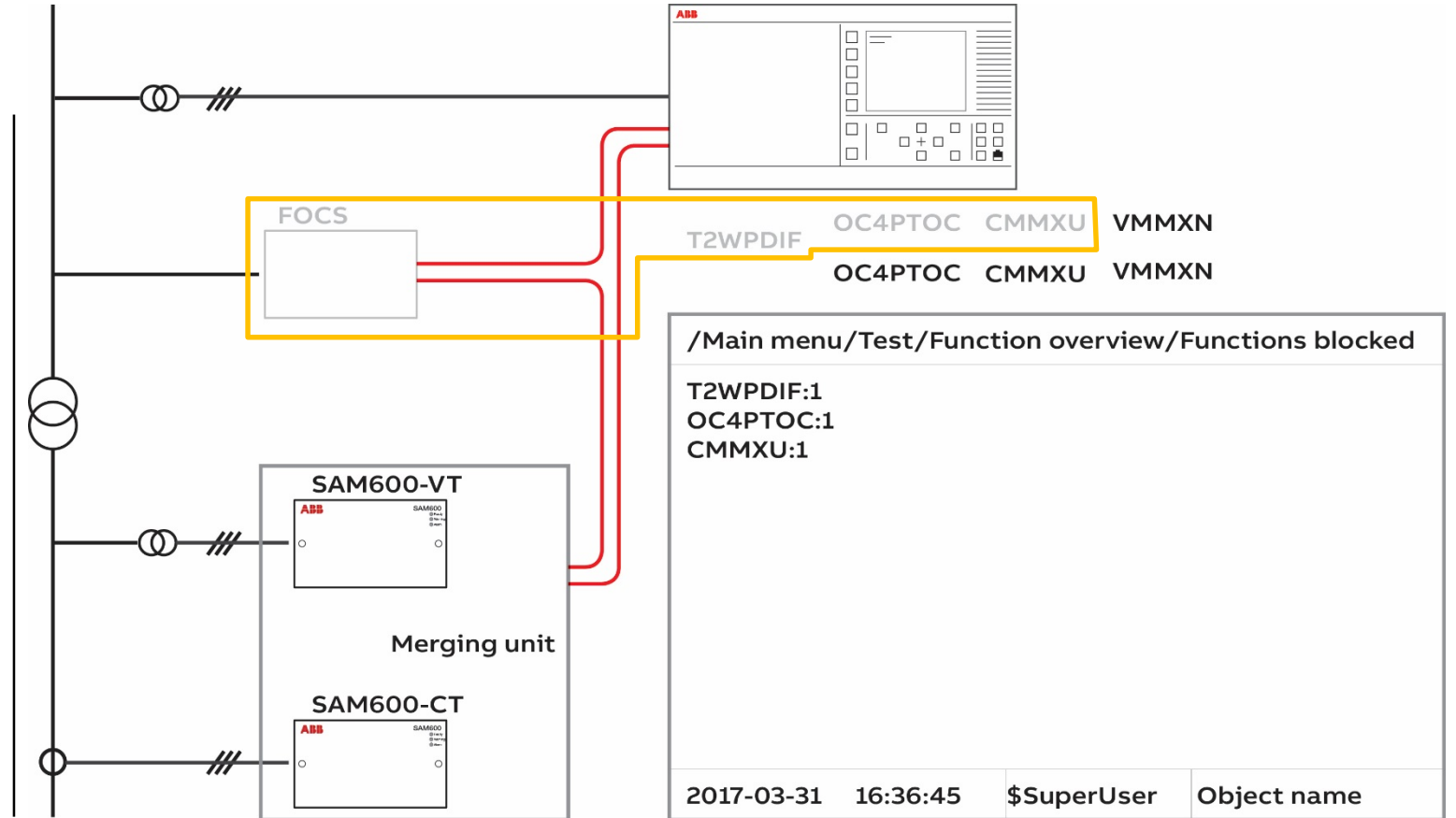
Conditional blocking

With conditional blocking, only dependent functions are blocked instead of everything

Increased availability by providing protection, control, monitoring as much as possible based on quality of inputs

In the example here: with loss of NCIT input from one side of the transformer, only dependent functions are blocked (greyed out)
E.g., OC4PTOC.Beh=Blocked

Increased availability, cost effective



Targets of digital solutions

Intelligent station HMIs

Substation data management

Station level systems and HMIs in digital substations gain on importance, fulfilling functions like

- Substation monitoring and control
- Data management
- Cyber security management
- Primary equipment monitoring
- Secondary equipment management
- Providing data to higher level asset health system

The intelligent station HMI provides better data for efficient operation and maintenance

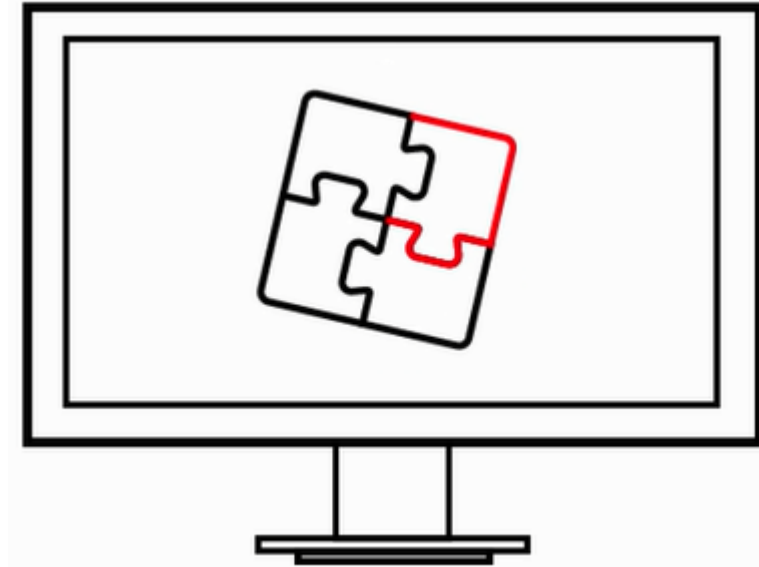


ABB solutions for digital substations

Station solutions

Station level solutions for any station size

MicroSCADA Pro

- Monitoring and control of all kinds of substations for any voltage level. From local and remote.

RTU500 series

- Flexible and modular RTU to adopt to a variety of electrical and process automation applications

SDM600

- Substation data manager for service and security data across substations. E.g. to:
 - Collect disturbance records
 - Consolidate version information
 - Manage user accounts and receive security events



ABB solutions for digital substations

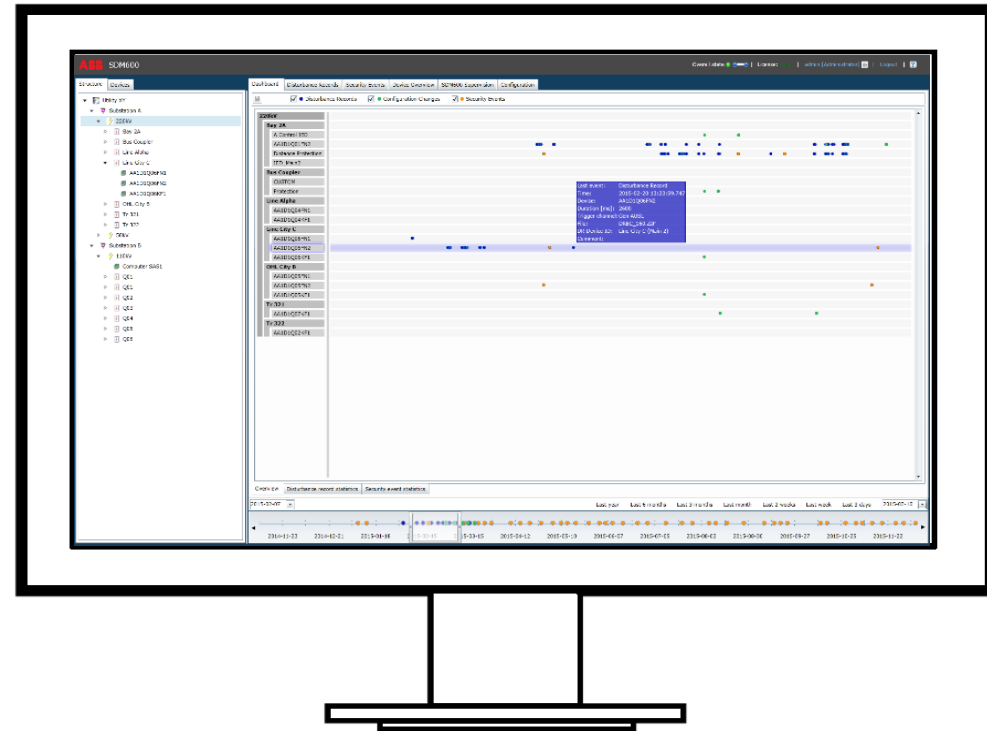
SDM600 System data manager

See the unseen from a new perspective

The comprehensive software solution for automatic management of service and cyber security relevant data across your substations

- Disturbance recorder handling
- Cyber security management
- Maintenance and service data management

SDM600 sets new marks in ease of configuration and visualization of data

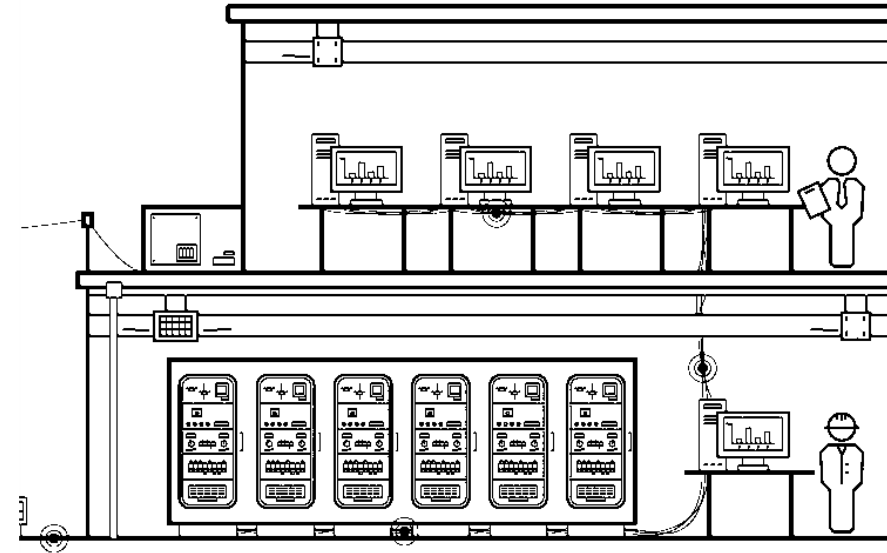


System Data Manager SDM600

Management of disturbance recorder data

Independent and automatic

- Automatic upload of disturbance recorder (DR) files from IEDs
- Supported protocols: IEC 61850-8 (MMS), FTP, ABB RTU500 and Windows File System access to integrate legacy protocols
- Polling the IEDs for new files
- Seamless integration into existing substation automation system
- Send DR info and Short Report via email
- Visualization of DR Data
- Export DR files to file system for integration into another system

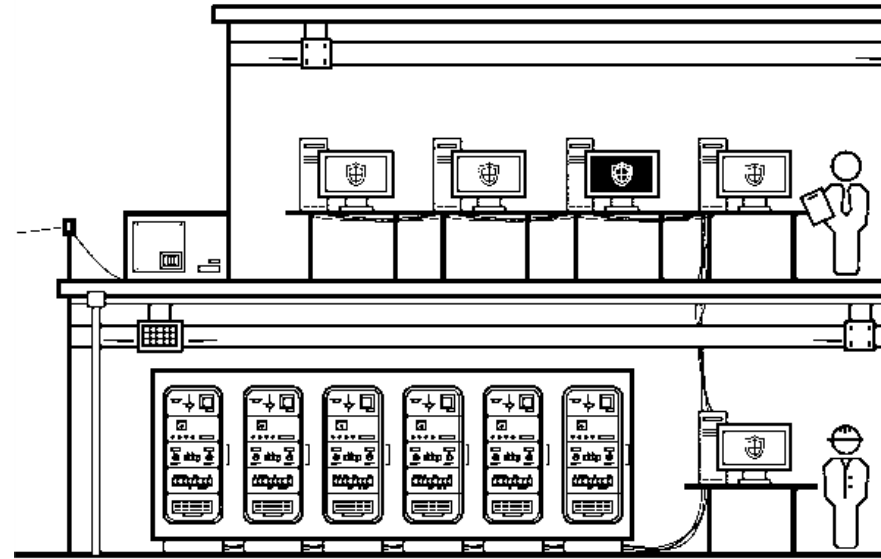


System Data Manager SDM600

Central user account management

Manage your users

- System wide user management
- Role based access control (RBAC) according IEC 62351-8
- Enforce password policies
- For Relion 670/650 2.1, Windows PCs, MicroSCADA Pro and any RADIUS capable device.
- In accordance with NERC CIP and BDEW whitepaper requirements

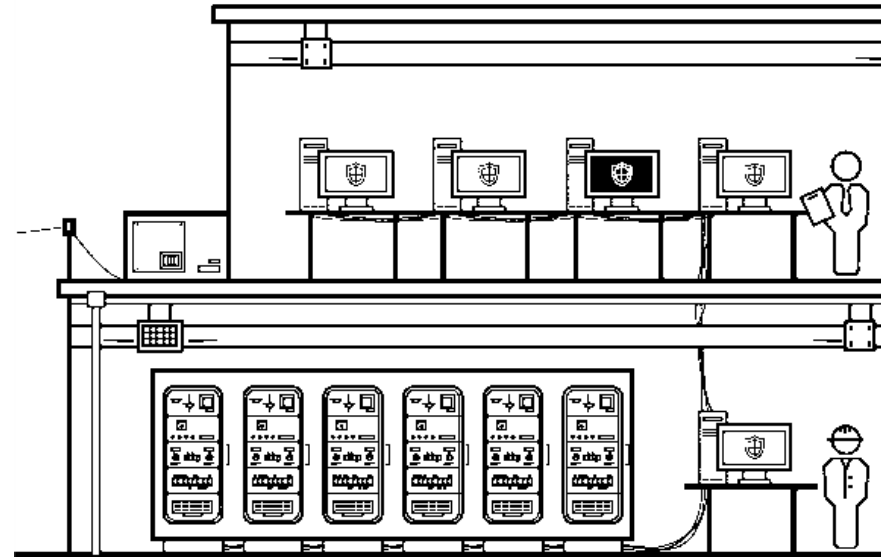


System Data Manager SDM600

System wide cyber security event logging

Monitor your system

- Store user activities and other security events from IEDs or system level components
- Integration of any device using Syslog protocol (UDP and TCP)
- Integration of Windows computers (converting Windows Event Logs)
- Categorization of unknown events based on rules
- Built in visualization and reporting
- Integrate SDM600 into an existing event logging system

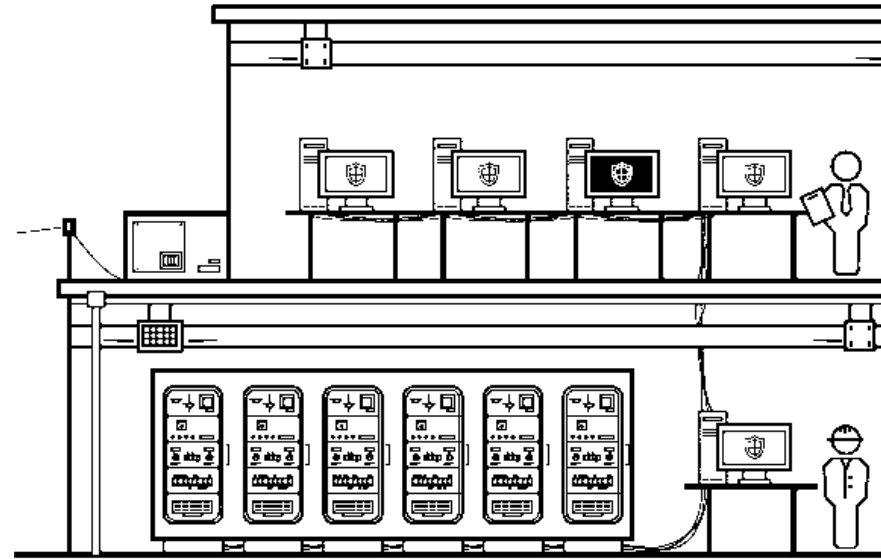


System Data Manager SDM600

Track service relevant data

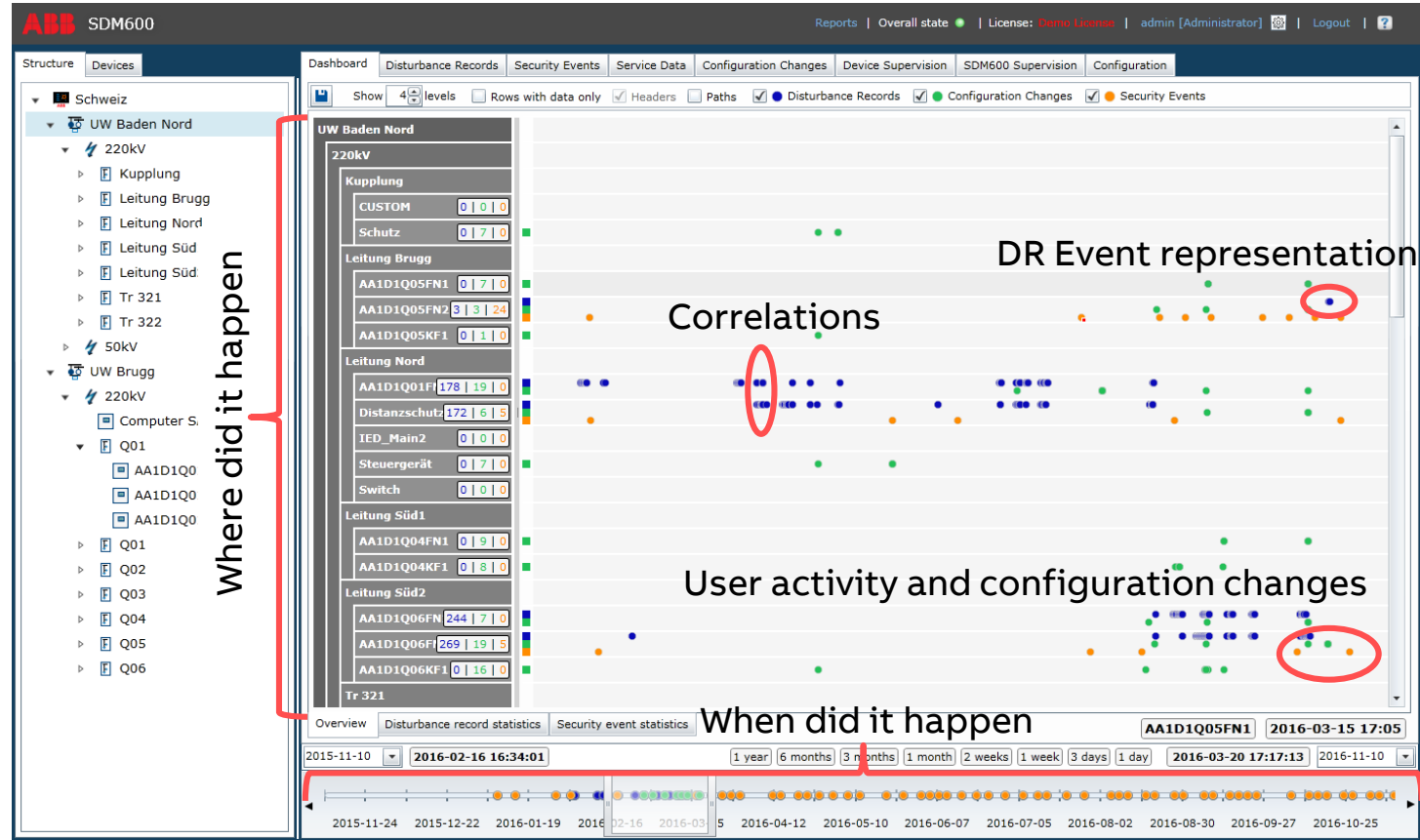
Collect and track service data

- Reading service relevant data from supervised Devices
- Tracking configuration versions from IEC 61850 IEDs, Windows PCs, RTU500 and SNMP devices
- Visualization of changes in the dashboard and dedicated event list



System Data Manager SDM600

User interface



Targets of digital solutions

Highly available and reliable utility communication

Technology shifts in utility communication

IEC 61850 instead of copper wires for truly digital integration of utility communication equipment

Using the benefits of IEC 61850 to communicate across substations

Move from TDM to packet-switched communication for operational, maintenance and protection data

Utility-grade equipment to ensure the reliable operation of the power grid is required

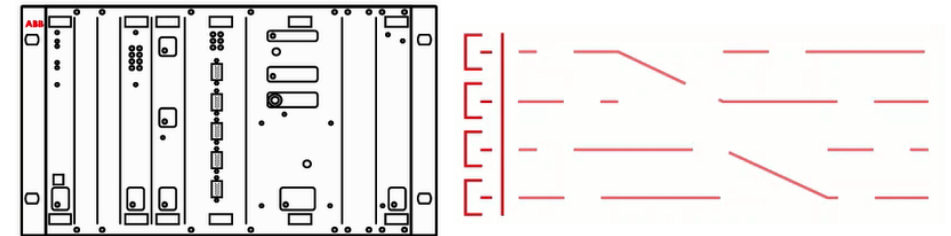


ABB solutions for digital substations

Utility communication

Utility communication for digital substations

FOX615: fiber optic multiplexer

- Hybrid SDH/MPLS-TP multiplexer with integrated teleprotection functionality and IEC 61850 GOOSE interface

NSD570: teleprotection

- Solution for the transmission of protection commands over all kind of communication media.
- Support for IEC 61850 GOOSE

AFS switch family

- IEC61850 Ethernet family including switch, router and firewall functionality



ABB solutions for digital substations

Revenue meters for digital substations

Metering with IEC 61850-9-2 process bus

Landis+Gyr E880

- Grid meter with IEC 61850-9-2LE connectivity.
- First installations already back in 2004
- Proven track record on accuracy with ABB NCITs
- (See Cigré paper B3-211, Cigré 2014 von Jakob Widmer, Landis+Gyr)

Prosoft ARIS EM

- Revenue meter capable to handle multiple IEC 61850-9-2LE streams

ABB NCITs provides measurements with 0.2s accuracy class *)

SAM600 provides measurements with accuracy of 0.1%



Concepts and applications

Digital substations

Station and process bus concepts

Separate station and process bus

Fully separated station and process bus

- Fully separated station and process bus enables highest availability, performance and security.
- Mission critical data (e.g. SV and goose for trip) is separated from the bulk data on station bus
- Highest performance on process bus network
- Clear separation of bulk and protection data enables safe and simple maintenance
- Separate security zones

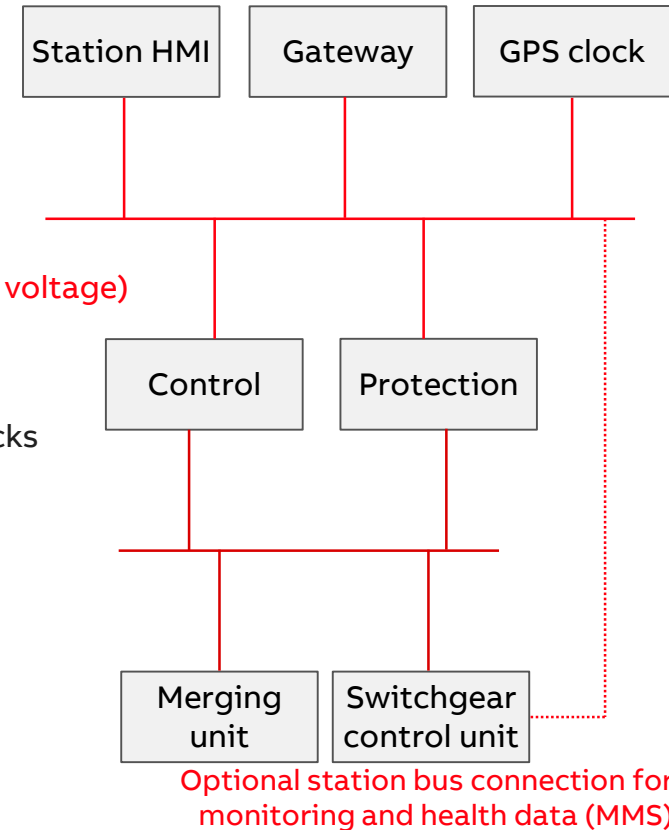
Critical for control
"only"

Critical for protection
and control

Station bus
MMS, GOOSE
PTP (SV of BB voltage)

Bay level IEDs
acting as PTP
boundary clocks

Process bus
GOOSE, SV
PTP



Digital substations for greenfield and brownfield

Modular process IO system for new and retrofit installations

SAM600 process bus IO system

Bridging the gap between analog and digital technologies

SAM600 modular process bus IO system is placed in the field to connect conventional equipment to IEC 61850 process bus

SAM600-CT

- Current measurement for protection and metering

SAM600-VT

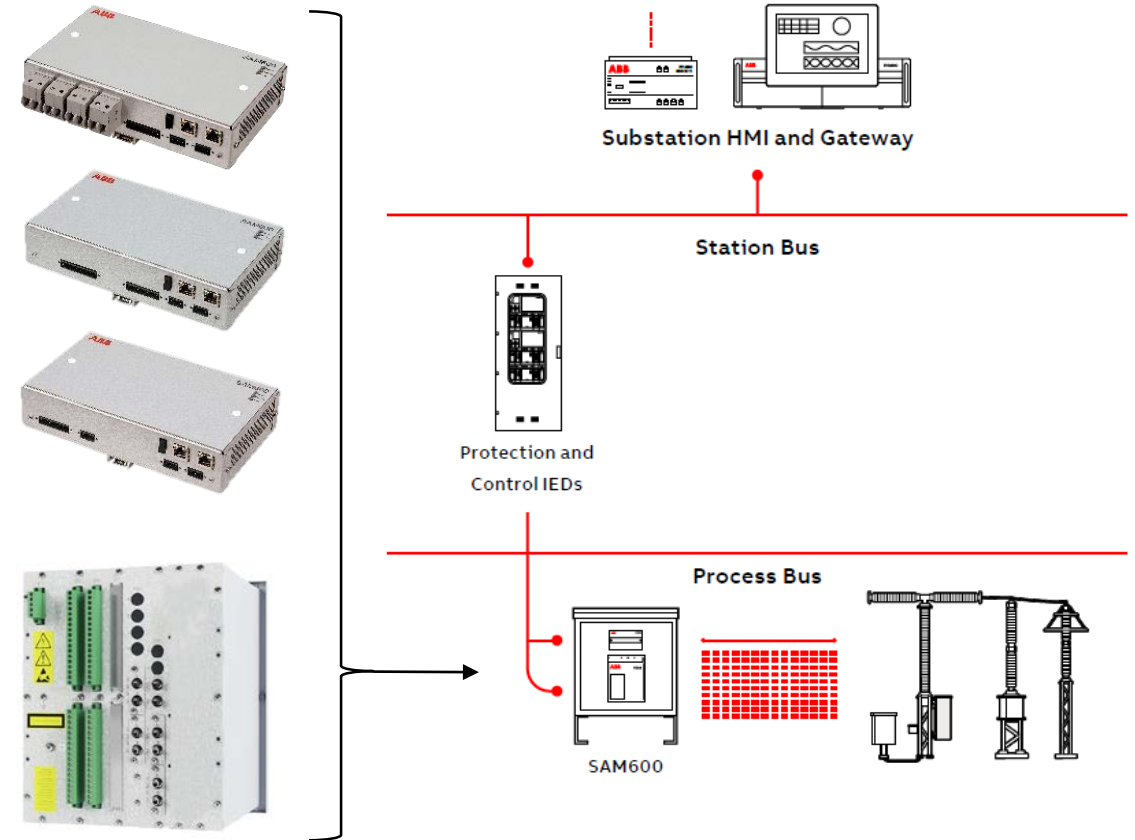
- Voltage measurement for protection and metering

SAM600-TS

- For time synch and more

SAM600-IO (release Q4/17)

- Scalable IO for binary signals from disconnectors, earthing switches, breakers, transformers...



Digital AIS substation

Air insulated switchgear

Station level:

MicroSCADA Pro station HMI and gateway
RTU500 series as Gateway, HMI, data collection
SDM600 Substation data manager
IET600/ITT600/PCM600 on engineering workstation

Protection and control panels:

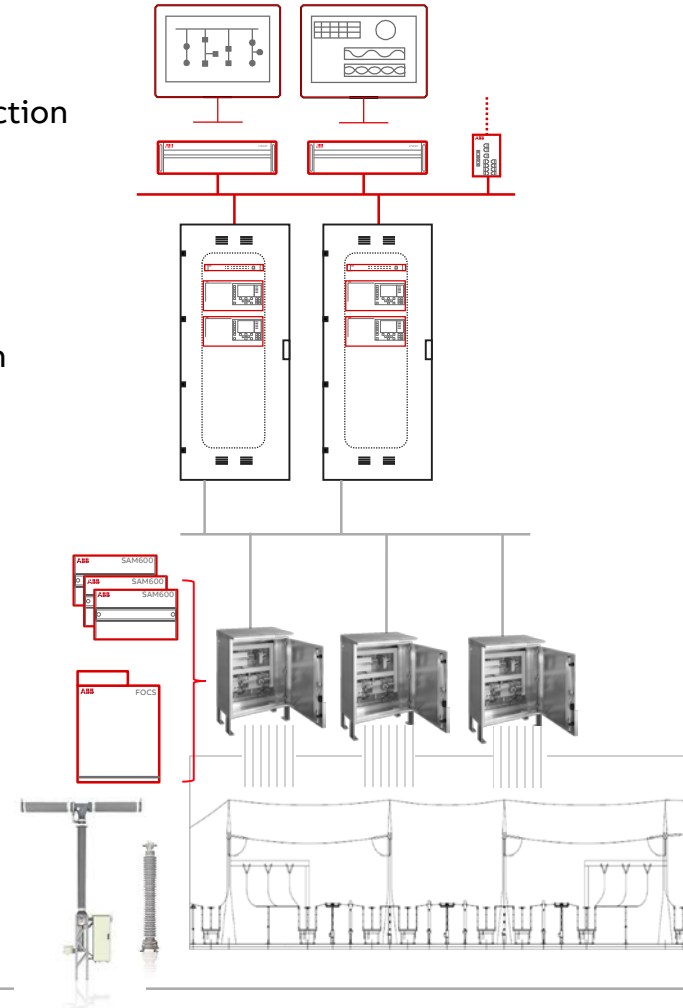
Relion series protection & control IEDs with IEC 61850 station & process bus
9-2 revenue meters (e.g. from Landis+Gyr)

Outdoor panels:

SAM600 process bus IO system
FOCS opto-electronic modules/merging units

Primary equipment:

Disconnecting CB with integrated FOCS optical CT
FOCS-FS, free-standing optical CT



Digital GIS substation

Gas insulated switchgear

Station level:

MicroSCADA Pro station HMI and gateway
RTU500 series as Gateway, HMI, data collection
SDM600 Substation data manager
IET600/ITT600/PCM600 on engineering workstation

Protection panels:

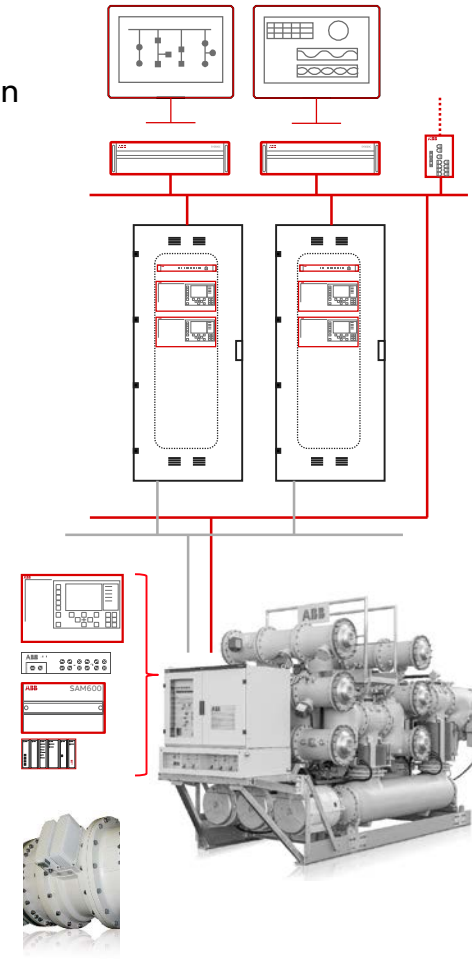
Relion series protection IEDs with IEC 61850 station & process bus
9-2 revenue meters (e.g. from Landis+Gyr)

Integrated local control cubicle (LCC):

REC650/670 bay control IED and process interface
Merging units for NCITs and CITs (where required)
MSM switchgear monitoring

Non-conventional instrument transformer:

ELK-CP NCITs for current and voltage



Digital GIS/AIS substation

Power transformers

Station level:

MicroSCADA Pro or RTU500 station HMI and gateway, including IEC 61850 data from CoreTec
CoreTec Web HMI
Data connection to Asset Health center

Transformer protection and control:

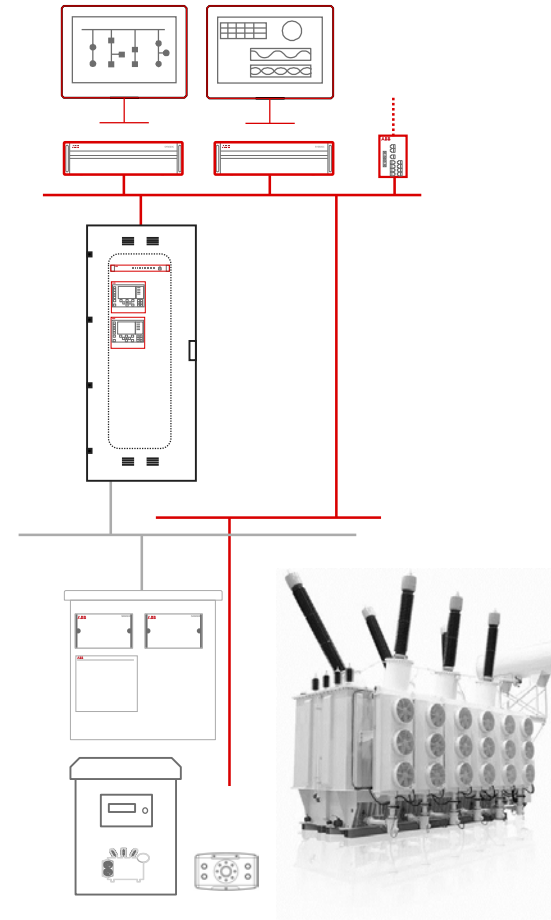
RET670 transformer differential protection with 9-2 (and conventional inputs)
Tap change control in separate IED or integrated in RET670

Outdoor cubicle:

SAM600 stand alone merging units to digitize bushing CT measurements
SAM600-IO for binary data (e.g. tap changer positions and controls)

Monitoring equipment

CoreTec with CoreSens and other sensors...





Testing and maintenance

Engineering and testing of digital substations

Tools overview

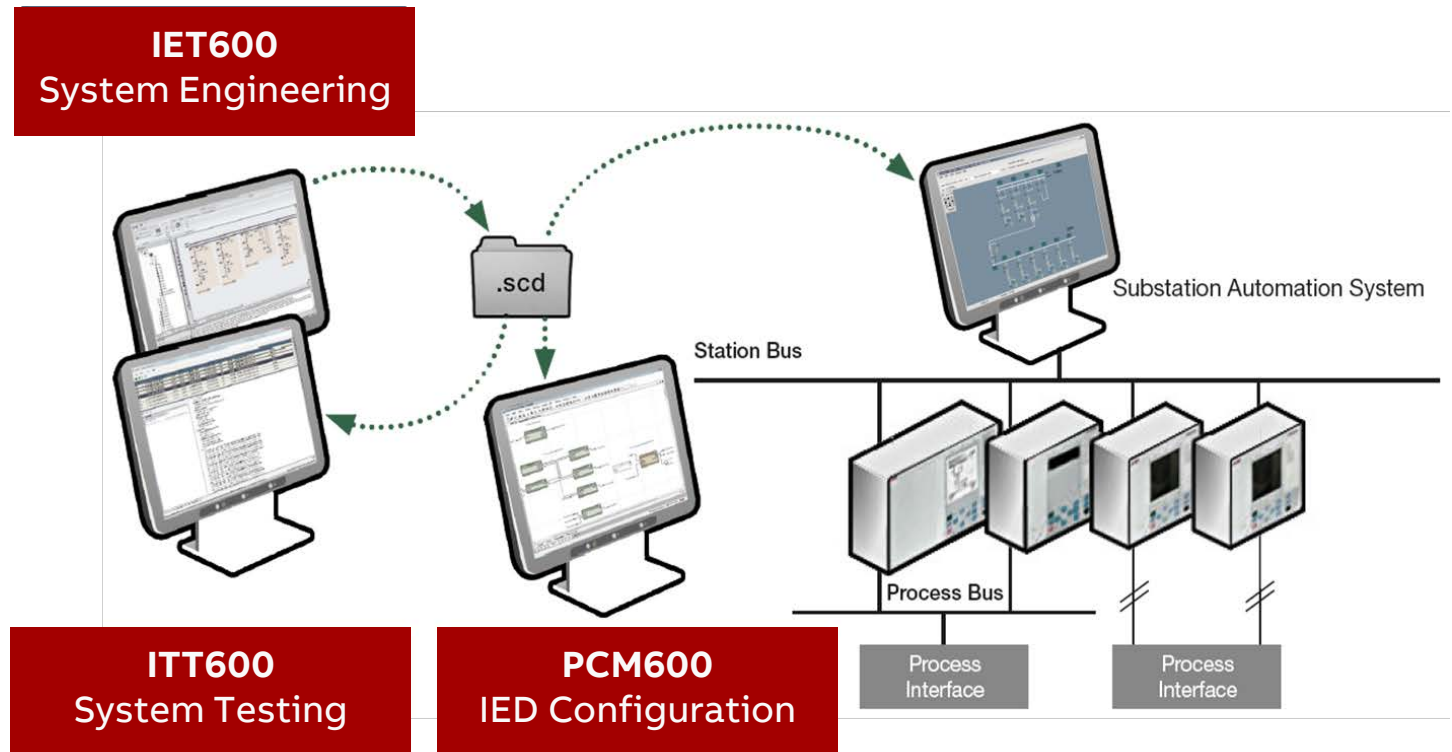
Conformance certified configuration tools

Interoperable system design using conformance certified engineering tools.

- IET600 system configuration tool and PCM600 IED configuration tool are IEC 61850 Ed.2 conformance certified

Simple and save testing using easy to use software

- IET600 SA Explorer is a easy to use IEC 61850 testing tool for station and process bus



Testing and maintenance

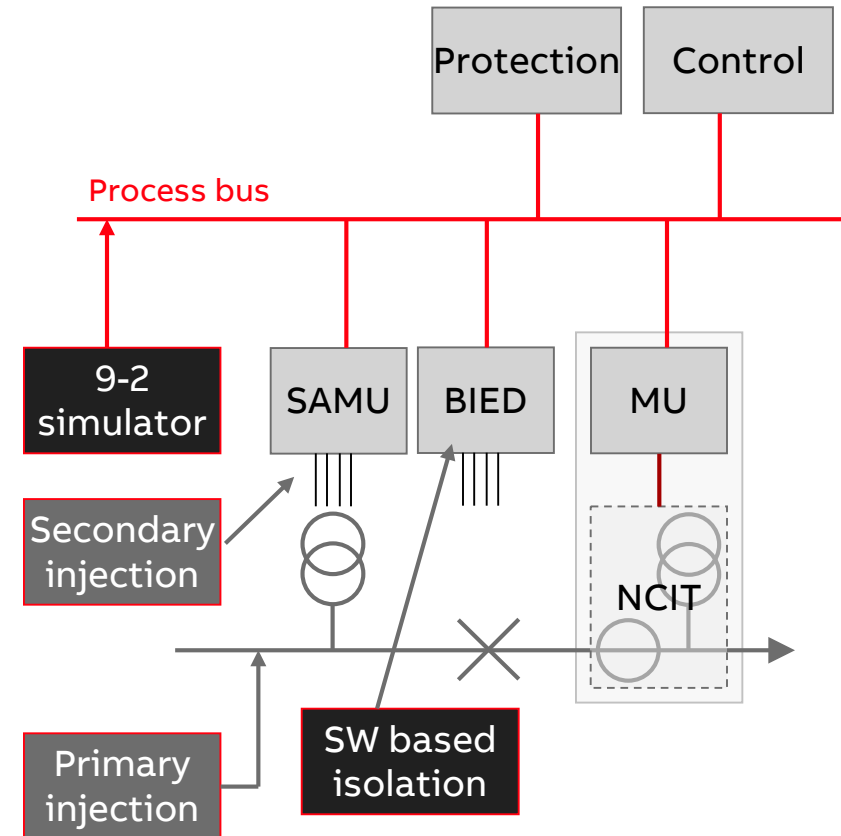
Impact on protection and control testing

“Wiring” test

Done automatically through self-supervision features of NCITs, MUs and IEDs

Protection and control testing

- “Non-conventional” secondary injection
 - Simulation of IEC 61850-9-2 LE traffic instead of secondary injection
- Test modes to simulate U/I, by
 - NCITs and merging units
- Primary injection
 - Stability and directional tests
- Software based isolation of trip circuits



Efficient analysis of digital data

Testing of binary signals

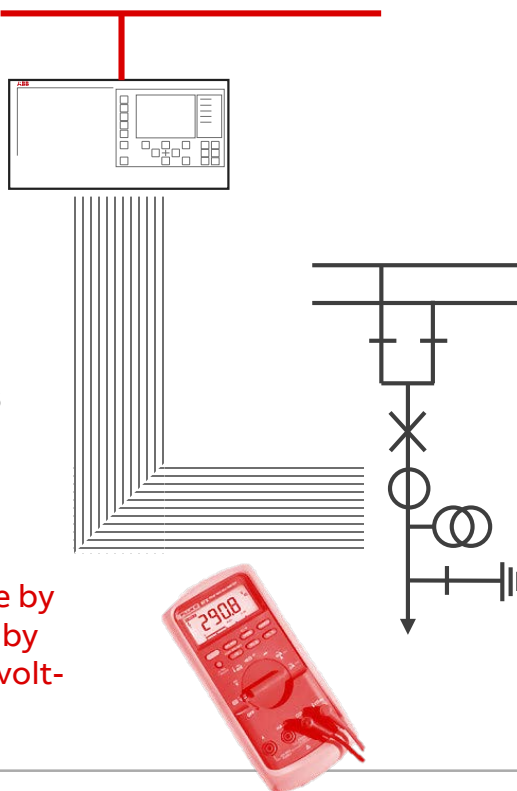
Hardwired signal exchange

IEC 61850 station bus

Bay level IEDs

Hardwired connections

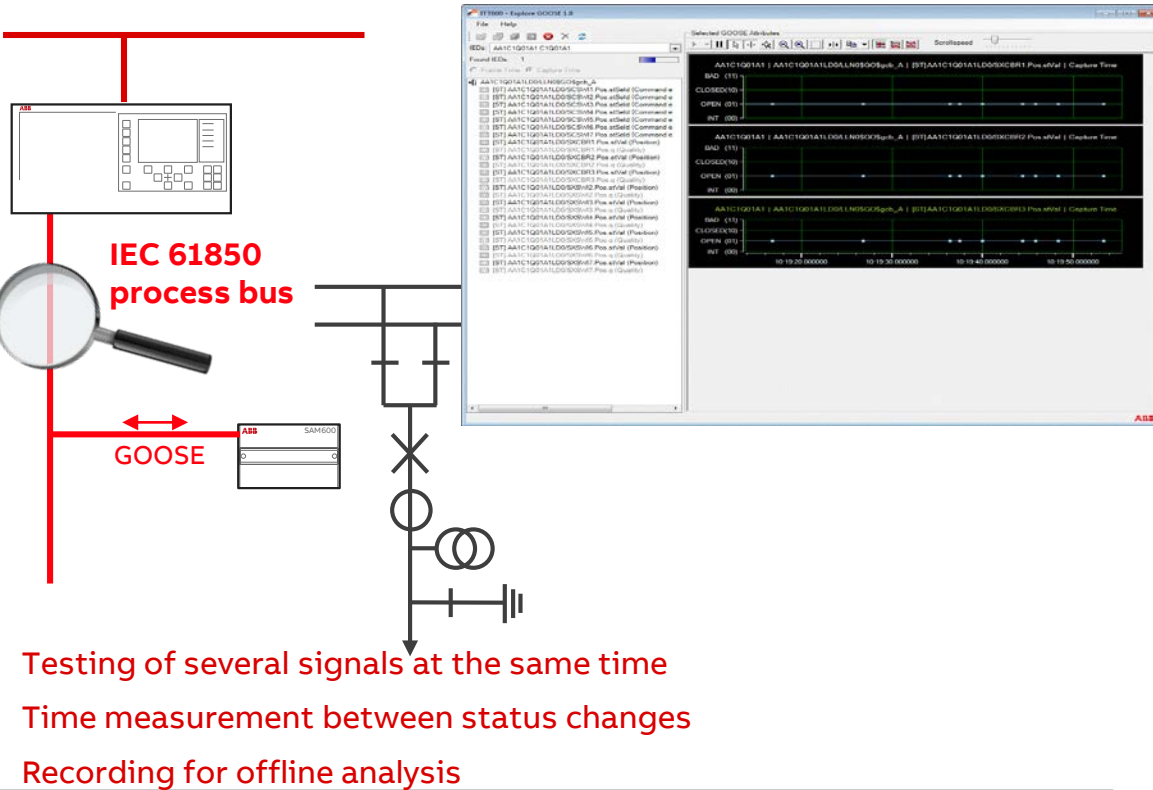
Testing wire by wire, signal by signal with volt-meter



IEC 61850 GOOSE signal exchange

IEC 61850 process bus

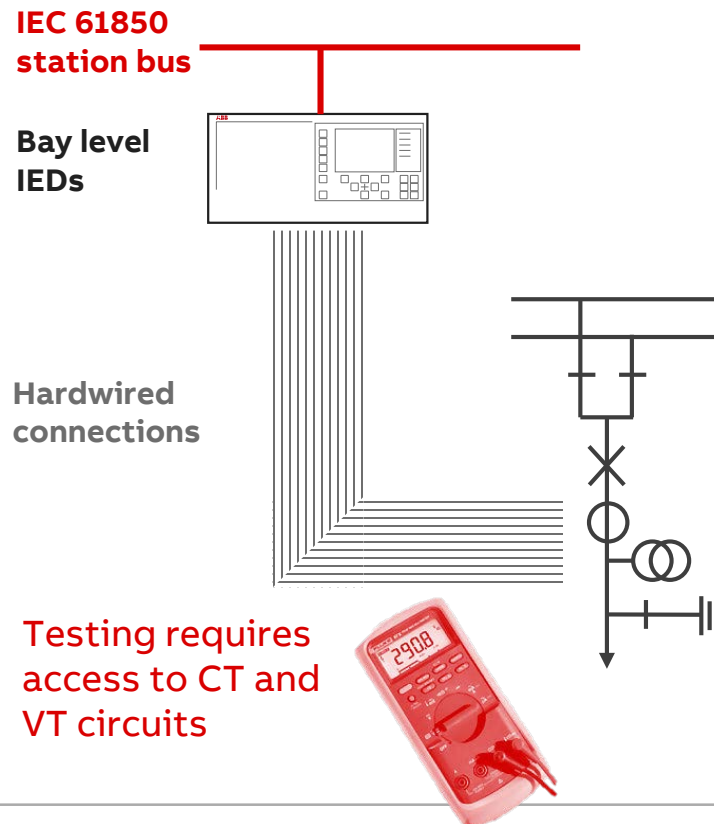
GOOSE



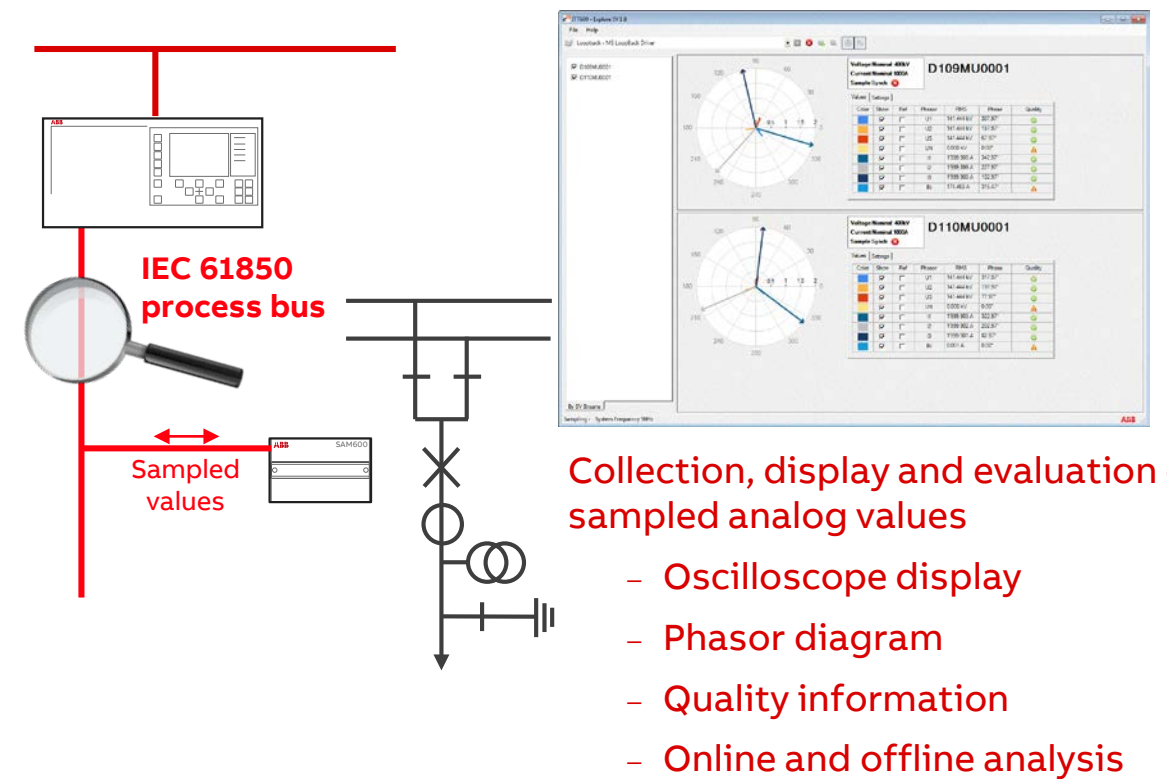
Efficient analysis of digital data

Testing of analog measurements

Hardwired CT/VT connections



IEC 61850 sampled analog values

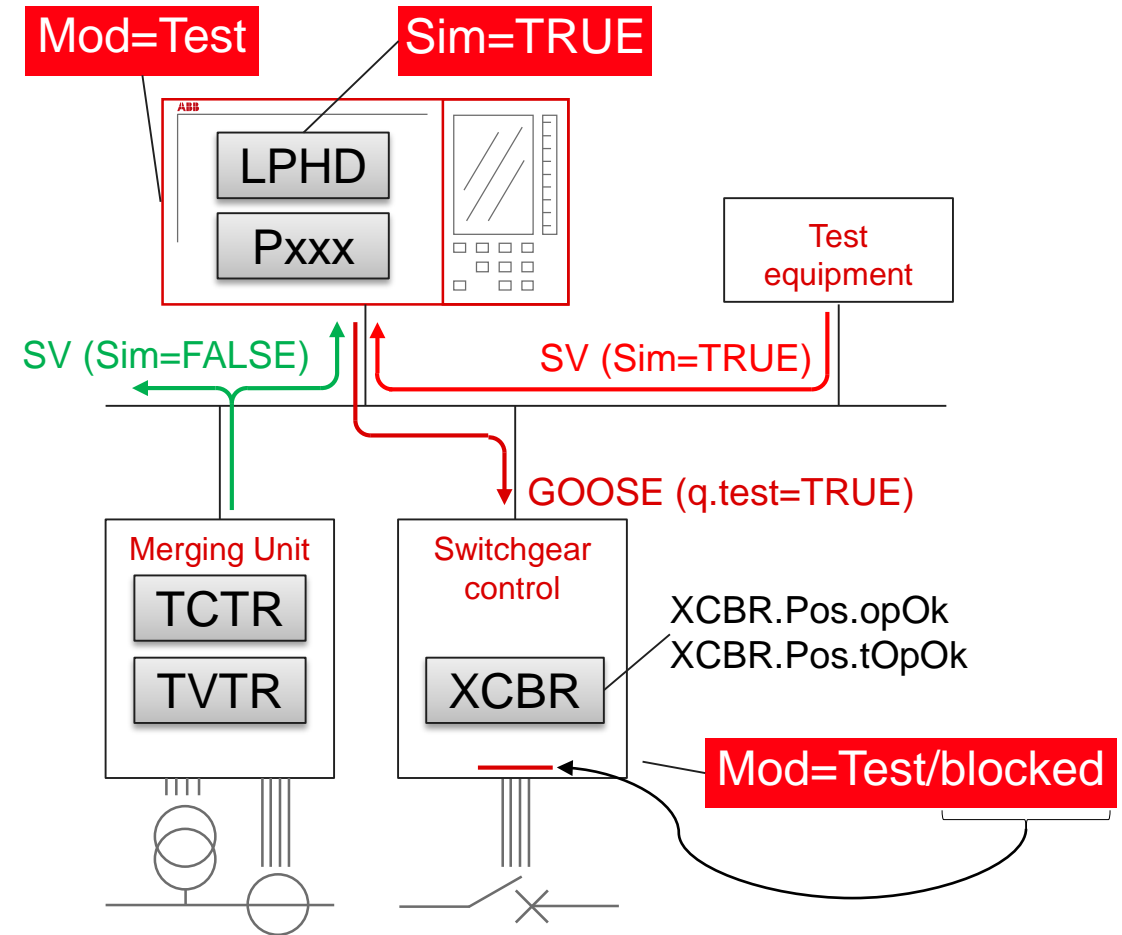


Efficient testing without system down time

IEC61850 Ed2 – Test mode and simulation

Testing procedure

1. Prepare protection IED and Switchgear controller for testing by setting IEC 61850 “Mod” and “Sim” attribute
 - The protection IED shall accept simulated SV and send GOOSE marked as test
 - The switchgear controller shall accept GOOSE marked as test but block its trip outputs
2. Connect test set to Ethernet network
3. Start injection of simulated values from test set
4. Protection IED will initiate a trip with q.test=TRUE
5. XCBR will receive GOOSE but not trip
XCBR output can be verified through OpOk and tOpOk attributes



Operation and maintenance

System supervision for simple fault finding

Clear information for operators

For efficient operation and maintenance:

- Permanent system supervision of all intelligent electronic devices.
- From communication gateways to MUs and NCIT electronics
- Supervision diagrams for fast overview of the substation health
- Not requiring expert know-how of operation personnel

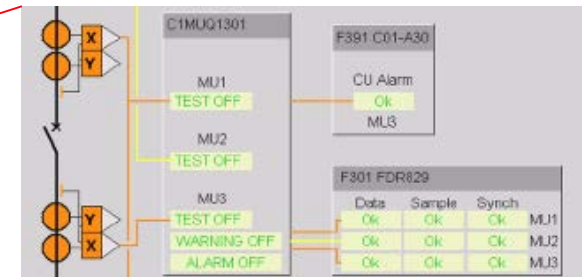
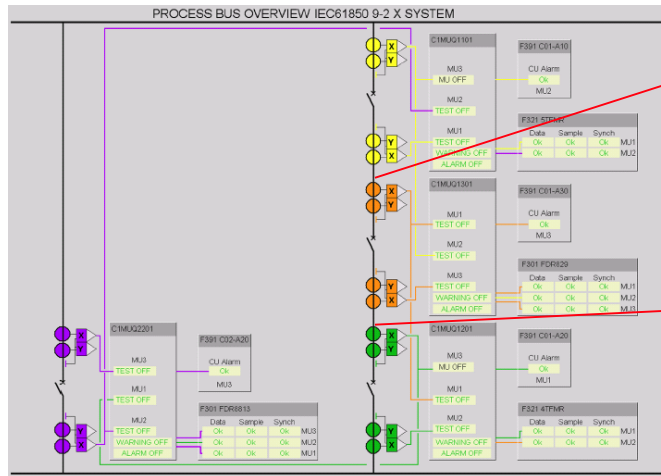
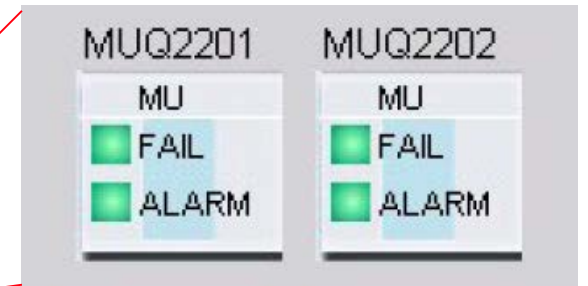
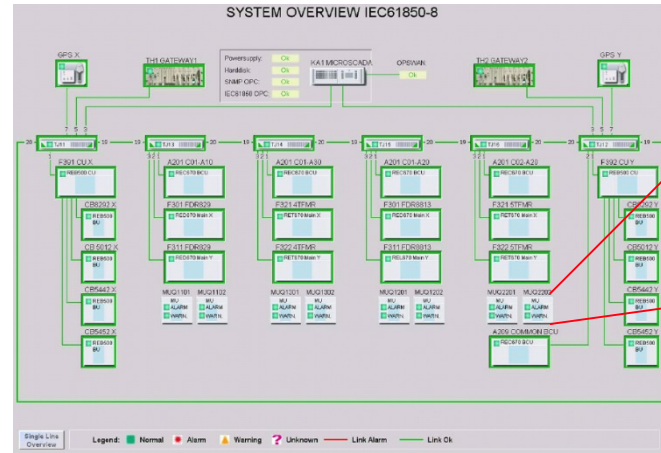


ABB Ability™ Asset Health Center™

A fleet-wide analytics platform to improve processes through risk-based optimization

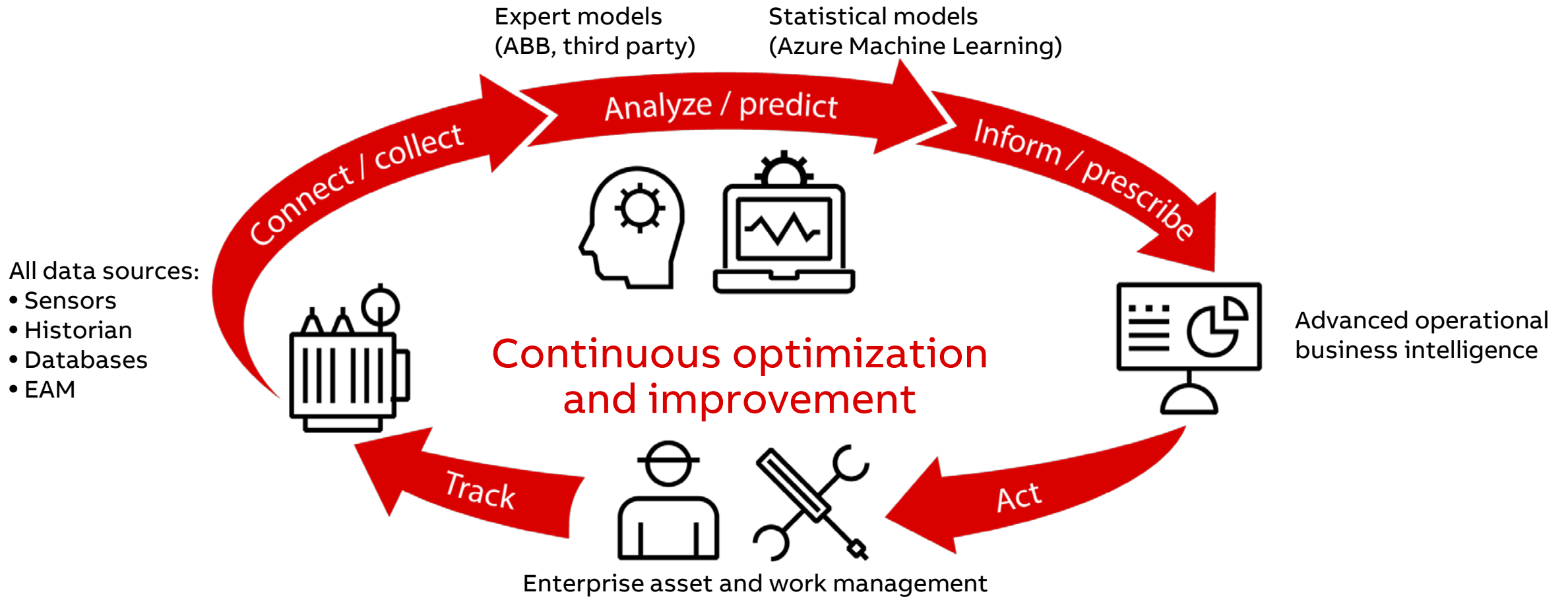


ABB solutions for digital substations

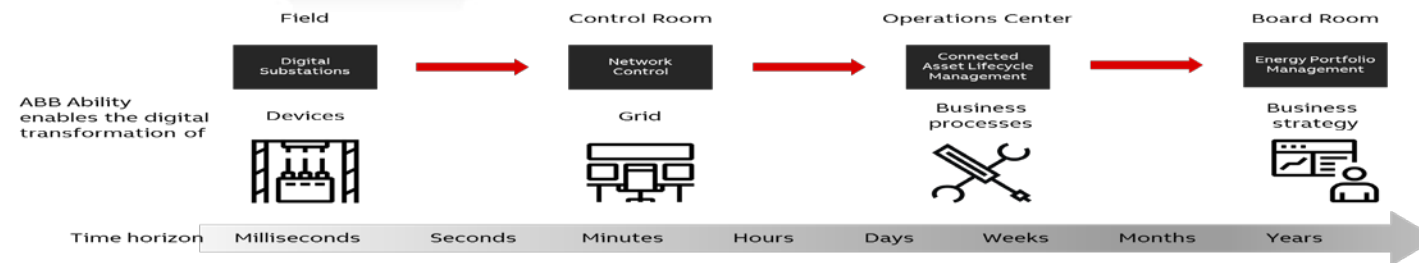
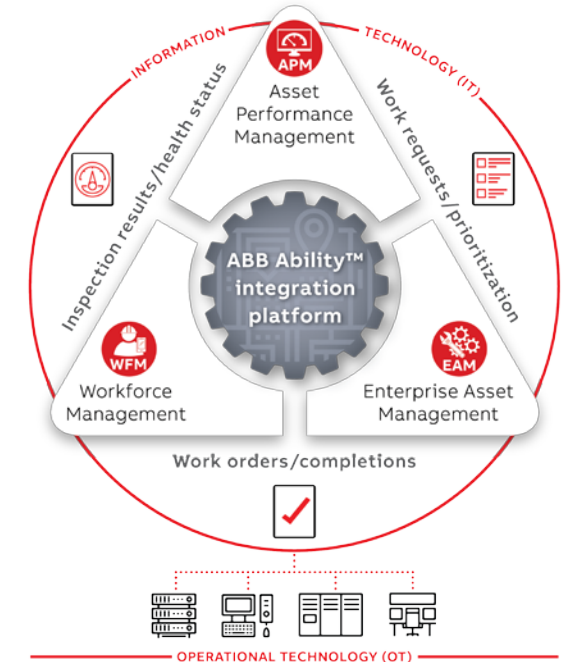
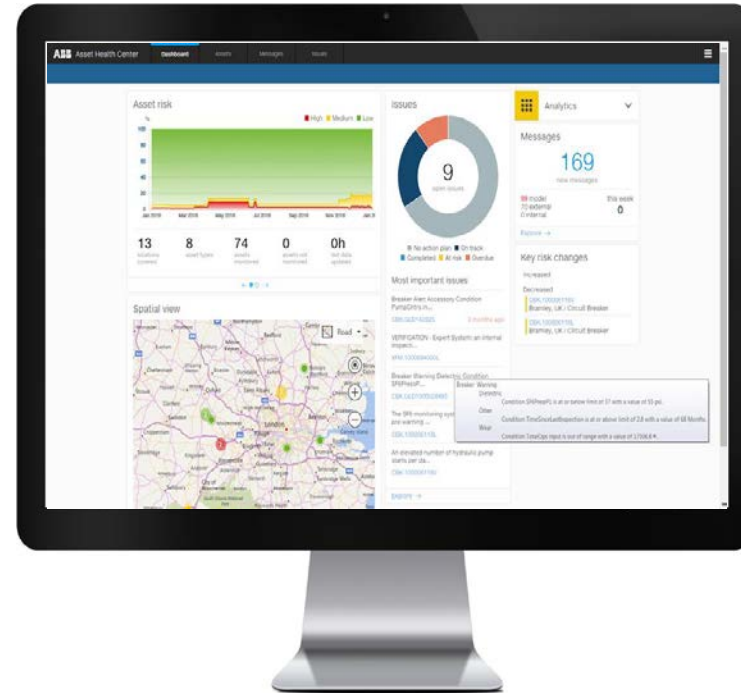
Operation and maintenance efficiency

Condition instead of time based maintenance

Asset Health Center, part of ABB Connected Asset Lifecycle Management™ leverages ABB's substantial, industry-leading expertise in electrical equipment manufacturing and service to ...

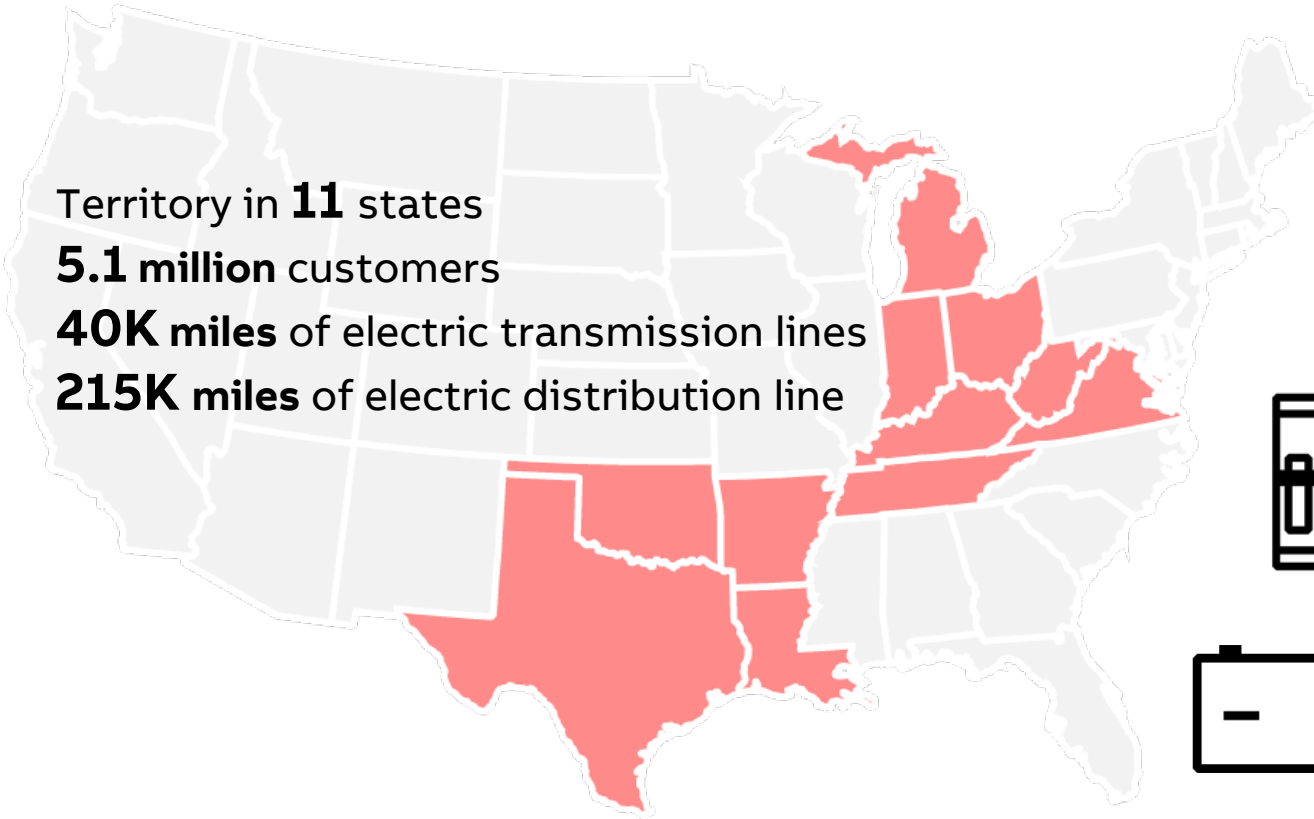
- Consolidate information from a variety of sources
- Determine current condition of electrical assets
- Predict and enables planning based on risk of failure and operational criticality
- Leverages real-time operations data for improved efficiencies
- Provide recommendations for corrective action
- Improves responsiveness by delivering the right work at the right time to the right people
- Prioritize maintenance and replacement across the fleet and aid in creation of Work Requests

Predictive analytics for efficient asset maintenance and management



Asset Health Center reference

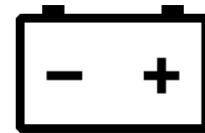
US transmission owner



8,846
transformers



20,572
breakers



3,384
batteries

33%
Transformers over
50
years old

18%
Transformers over
60
years old

Prevented at least one \$5M transformer failure in the first year!



Digital Substation benefits

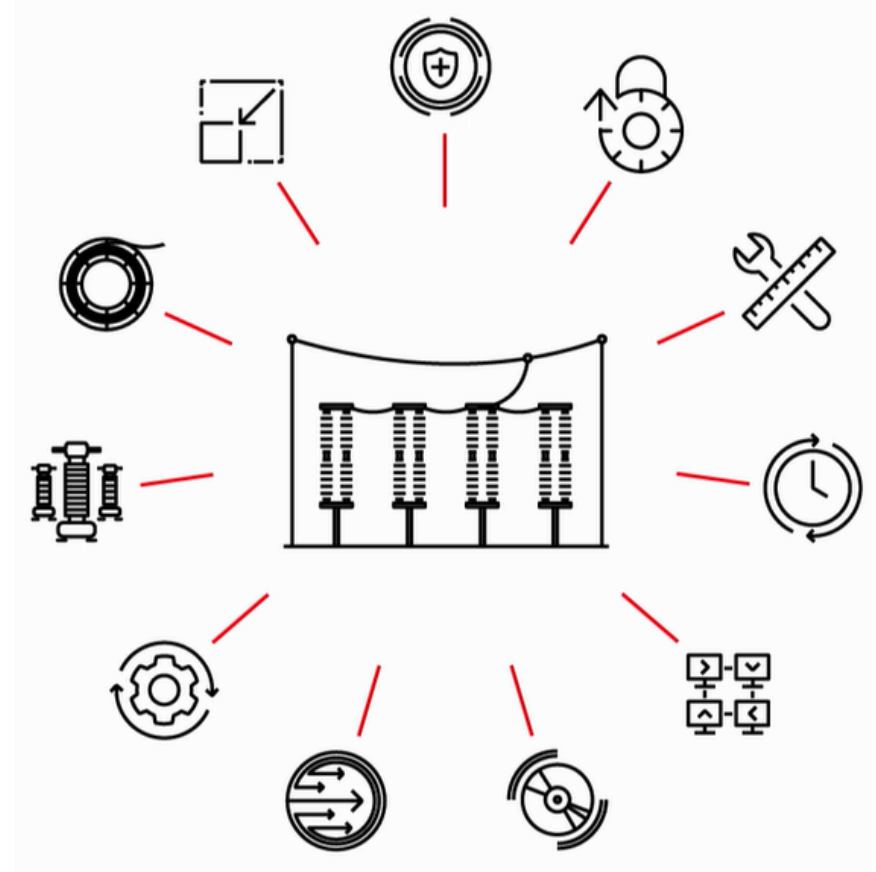
Benefits of digital substations

Overview

Main benefits

- Safety
- Reduced substation footprint
- Interoperability
- Reduces copper cabling
- Ease of configuration
- Maximum reliability and availability
- Real-time performance
- Smart Grid communications capabilities
- Reduces cost of ownership

Digital substations are safer to operate, future proof and require less space



Benefits of digital substations

Less space in switchyard

Space requirement reduced by half

Reduction of AIS switchyard footprint by up to **50%**

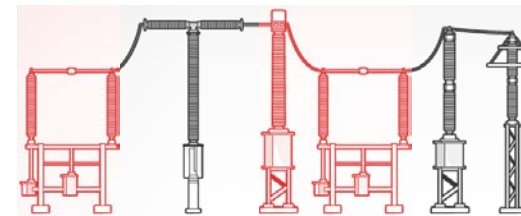
- By using circuit breakers with integrated disconnecting functionality and optical current transformers
- Less material and foundations, reduced installation and engineering effort
- Higher reliability due to less stressed equipment

Reduction of GIS footprint by up to **30%**

- By using NCITs for current and voltage
- By integrating LCCs to GIS switchgear

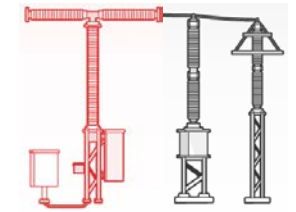
High function integration and NCITs enable space reduction in the switchyard

Conventional substation

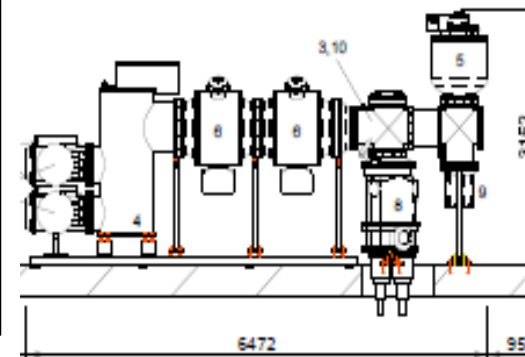


Disconnector CT Disconnector

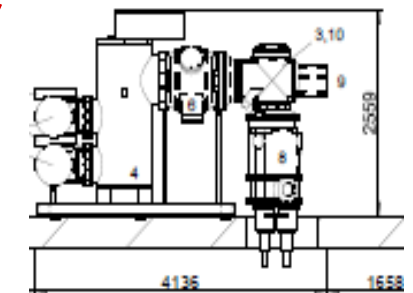
Digital substation



Circuit breaker with integrated optical CT and disconnecting function



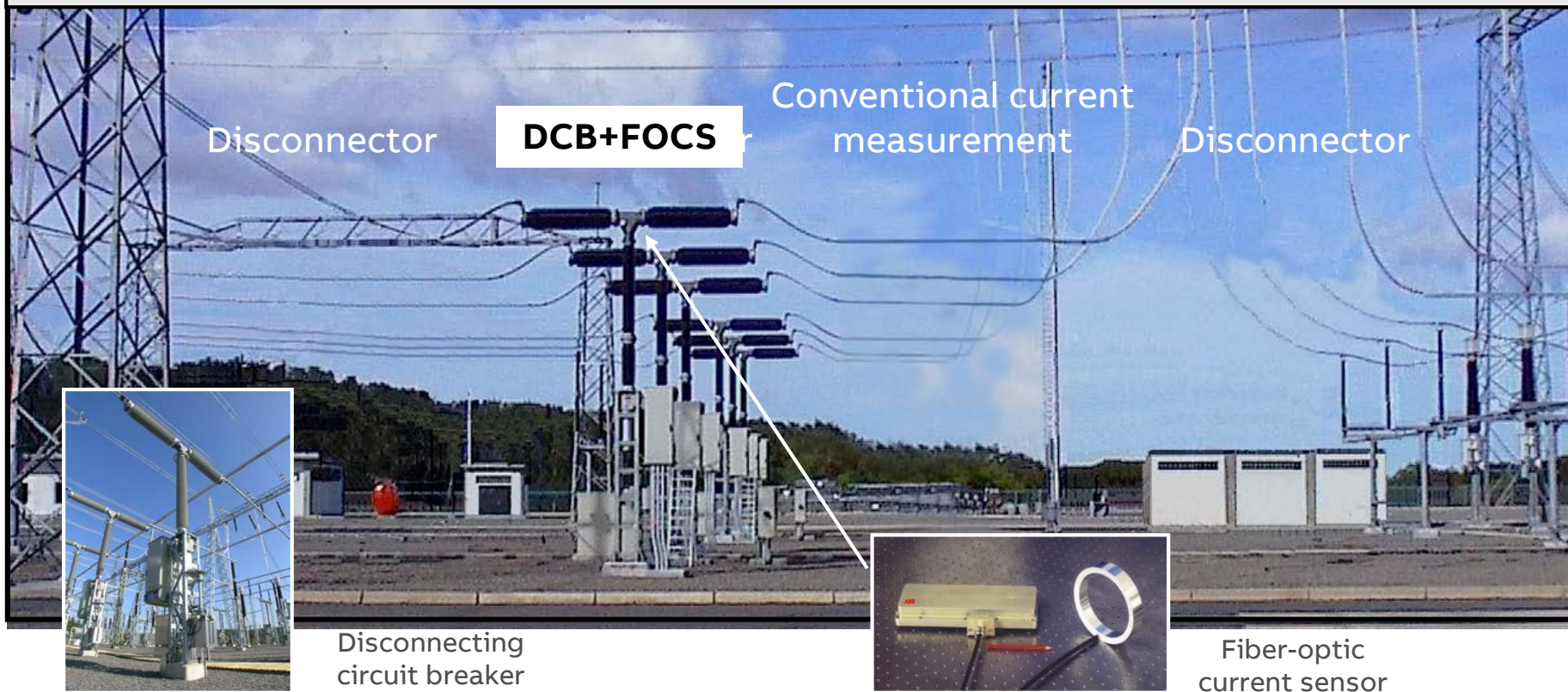
Up to **50%** reduction space in the switchyard



Benefits of digital substations

Less space required, “One bay one footing” concept

1. Reduce needed space with DCB, Disconnecting Circuit Breaker
2. Minimize the footprint even further with integrated optical CT



Benefits of digital substations

Less transport

30 tons less material

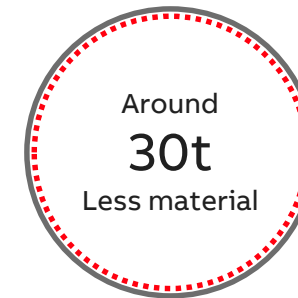
- More than 30 tons material can be saved for an average sized transmission level substation with 7 feeders
- The weight of the fiber optic cabling is around 90% less than the copper cables it replaces
- By using optical instead of conventional CTs almost 80% weight reduction on CTs is achieved

Less transport, less CO2, less heavy lifting equipment required

Conventional substation



Digital substation



Benefits of digital substations

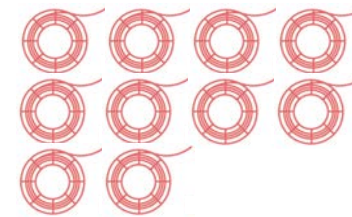
Less copper

Reduction in copper cables by up to 80%*

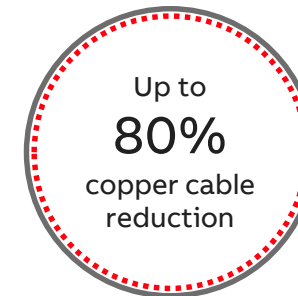
- By replacing copper cables between switchyard and relay house by fiber optics
- By replacing horizontal wiring between protection and control IEDs with IEC 61850
- By reducing number of connections between primary apparatus and redundant process interfaces modules
- Copper cables remain for power supply and short connections between primary apparatus and marshalling kiosks in the switchyard.

Point to point copper connections get replaced with fiber optics

Conventional substation



Digital substation



Benefits of digital substations

Less space in relay room

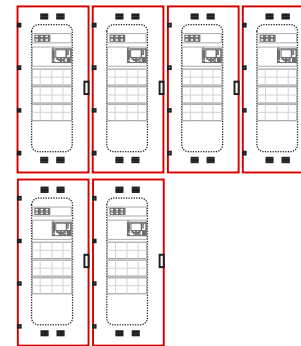
Space requirement reduced by half

60% and more reduced space for protection and control panels

- The IEDs require less space due to absence of conventional IOs
- Absence of terminals enable integration of more IEDs per panel
- Integration of more functions in IEDs enables further space reduction

High function integration, smaller IEDs and fewer conventional components enables space reduction

Conventional substation



Digital substation



Up to
60%
less space in
relay room

Benefits of digital substations

Shorter installation time

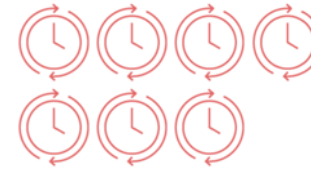
Shorter time for secondary system installation

40% reduction of installation time for new protection and control systems.

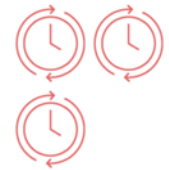
- Fewer panels to install
- Fewer cables to be pulled, connected, tested
- More testing in the factory means less testing on site

Shorter installation time decreases project runtime

Conventional substation



Digital substation



40%
shorter
installation
time of P&C
system

Benefits of digital substations

Shorter outage time during secondary system retrofits

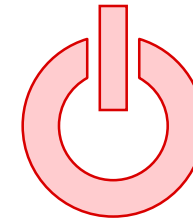
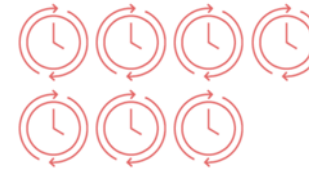
Shorter time for secondary system refurbishment

Reduction of feeder outage time by 40 to 50% during secondary system upgrades

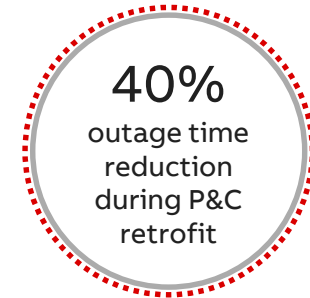
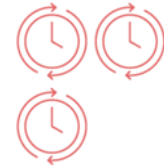
- Full system test from process IO to protection, control and scada system off-site
- Installation of new FO based system while station is in service
- Flexible placement of new protection panels, without depending on SS cabling

Shorter outage times increase system availability and utility revenues

Conventional substation



Digital substation



Benefits of digital substations

Operational cost reduction

Savings in maintenance and future retrofits

Efficient maintenance

- Supervision of all exchanged data, reduces the need for periodic maintenance testing
- Permanent supervision enables fast and precise actions in case of failures

Fast and save testing

- IEC 61850 testing and simulation features enable fast and save isolation and testing of protection functions

Standard compliance enables efficient future retrofits of secondary system

Lower operational costs thanks to supervision and standards

Conventional substation



Digital substation



Benefits of digital substations

Increased safety

Reduced risk of electrical shock

- Handling of current transformer circuits and signaling voltage poses a threat to life and equipment
- Process bus eliminates the galvanic connection between protection and control panels and the switchyard.
- Eliminates CT and VT circuits in the protection & control panels
- Replaces conventional 110/220VDC indications with fiber optics

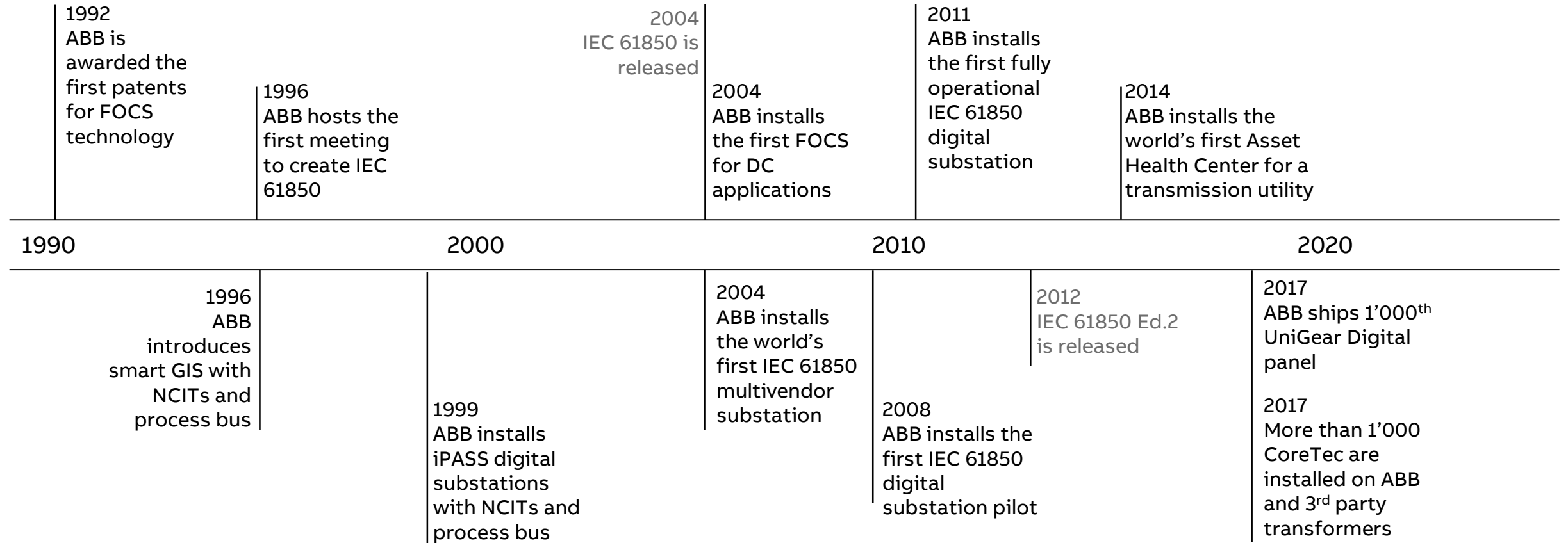
Eliminates the electrical connection between primary and secondary



ABB reference cases

Laying the foundations of Digital Substations

ABB dedicated to technology leadership



Digital substations

Highlights,
worldwide



UK, 2018*
SAM600, FOCS
670series, 3rd party



UK, 2014
GIS NCIT,
670 series



NL, 2004-2009
GIS NCIT
L+G revenue meter



Sweden, 2010
DCB with FOCS,
670series



Sweden, 2013
AIS 3rd party NCIT,
670, 630, 615series



Poland, 2017*
AIS FOCS NCIT,
670series



Germany, 2012
3rd party NCIT,
REB500



CN, 2016 (several)
DCB with FOCS
3rd party



Taiwan, 2014
SAM600
670series, 3rd party





Taiwan, 2017
SAM600
670series, 3rd party



US, 2016
DTB with FOCS,
SAM600, 670 series



 Laboratory tests
 Installations



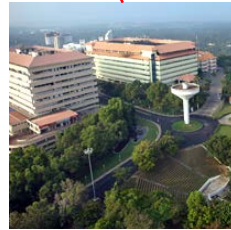
Brasil, 2017
SAM600
670series



Switzerland 2009
GIS NCIT,
670series, REB500



Switzerland 2011
GIS NCIT,
670series, 3rd party



India, 2017*
SAM600
670, 615 series



Australia 2011
67 GIS NCIT,
670series, REB500



Australia, 2009
GIS NCIT, 3rd NCIT
670series

**3 more projects in AU
are under execution**

* Under execution

NCITs and process bus - Australia

NCITs for gas insulated switchgear

Real life NCIT experience

350 pcs CP-type sensors for current and voltage measurement, installed in 6 substations of Powerlink Queensland in Australia

In continuous operation since more than 15 years (with a proprietary communication system)

- Not one of the installed primary sensors has failed
- Experience data predict MTBF of secondary converters close to **300 years**



Customer: Powerlink Queensland – Australia

Year of commissioning: 1999-2001

Voltage level: 275kV and 325kV

IEC 61850-9-2 process bus and NCITs – Australia CP Sensors for HV GIS

Full substation with NCITs and process bus, Powerlink Queensland / AU

Voltage level 275kV, Year of commissioning 1999, upgrade in 2011 with 9-2

Customer's need

- Secondary system upgrade of existing 275kV substation with ABB NCITs, protection and control with proprietary process bus
- Future proof, fully IEC 61850 compliant protection and control system with process bus

ABB's response

- Upgrade to IEC 61850-9-2 compliant system by keeping primary equipment
- Conformance tested CP-MU merging units, Relion 670 series IEDs, REB500, and PWC600 with IEC 61850-9-2 process bus

Customers benefit

- Latest generation, IEC 61850 compliant protection, control and SA system
- Minimum outage times during commissioning

Switchgear with NCITs in service since 1999!





Summary

Summary

Industry trend



Digital substations follow the industry trend for better information that enables forward looking decision making

Technology leadership

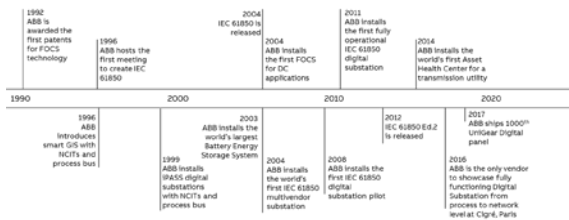
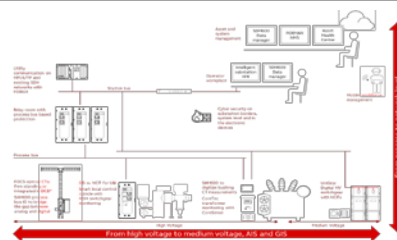


ABB is shaping the digital evolution with first patents and igniting the creation of today's most used standard in substation automation

Complete portfolio



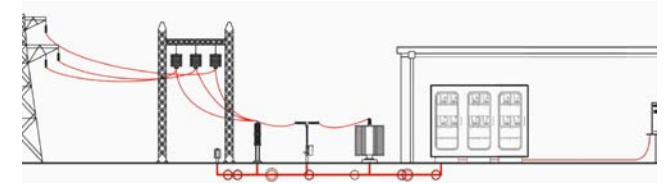
ABB's digital portfolio ranges from high to medium voltage and process to network level

Improved maintenance planning



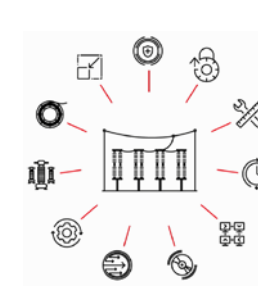
ABB Connected Asset Lifecycle Management enables better maintenance planning and dispatching of maintenance resources

Less space, safer to operate, reduce OPEX



Digital substations require less space, are safer to operate and enable reduction of operational expenditures

Main benefits



- Safety
- Reduced substation footprint
- Interoperability
- Reduces copper cabling
- Ease of configuration
- Maximum reliability and availability
- Real-time performance
- Smart Grid capabilities
- Reduces cost of ownership

ABB