This webinar brought to you by the Relion® product family

Advanced protection and control IEDs from ABB

Relion. Thinking beyond the box.

Designed to seamlessly consolidate functions, Relion relays are smarter, more flexible and more adaptable. Easy to integrate and with an extensive function library, the Relion family of protection and control delivers advanced functionality and improved performance.

ABB Protective Relay School Webinar Series

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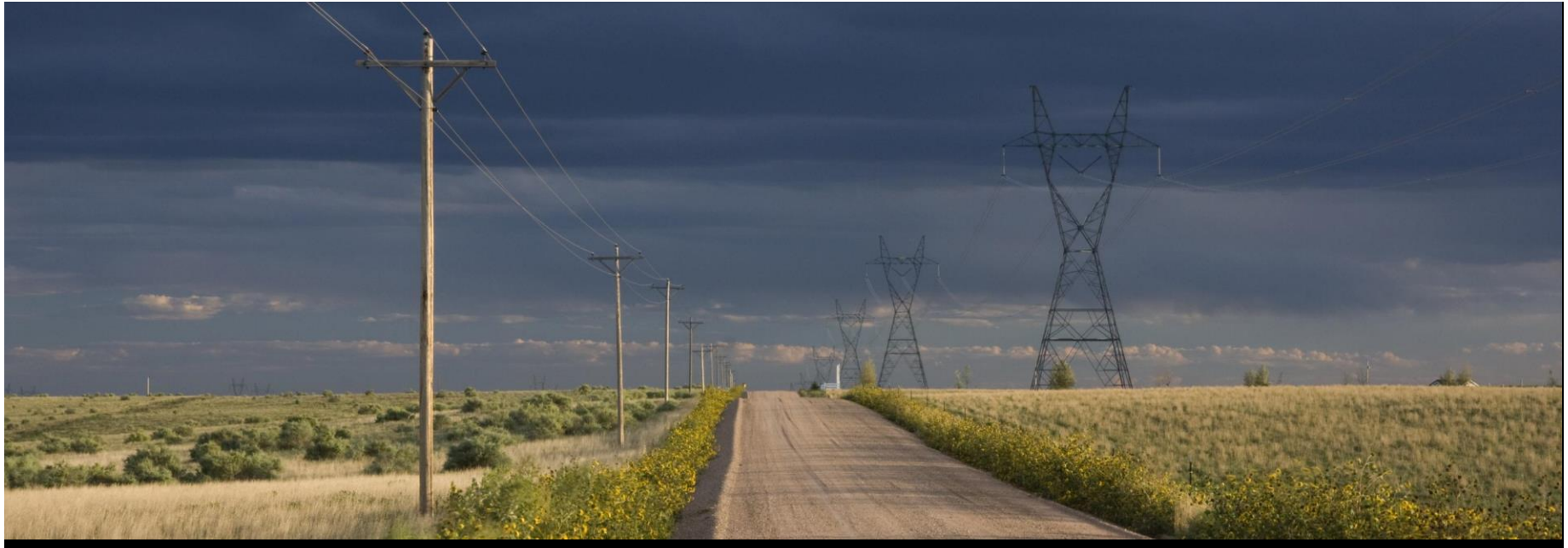


ABB Protective Relay School Webinar Series

Benefits of Digital Substation

Steven Kunsman

October 21, 2014

Presenter

Steven Kunsman

- Steve Kunsman is ABB Vice President of Business Development where he leads ABB's Substation Automation businesses in North America for the complete solution and product portfolio within the industrial and utility customer base.
- Steve's ABB career began in 1984 when he joined protective relay group as an Electrical Designer. Steve has held various engineering, technology and product management positions within the North American and global substation automation organizations.
- He is also recognized as a Substation Automation specialist with his areas of expertise including: over 30 years in substation automation, protection and control applications, communications technologies (IEC 61850 and DNP), cyber security for substation automation, and Relion product family of protection and control relays.
- He is an active senior member in the IEEE PES Power System Relaying and Substations Committee including a PSRC main committee member, past working group chairs for substation cyber security and relay quality processes, past IEC TC57 US delegate in the development of the IEC61850 communication standard and resides on the UCA International Users Group Executive Committee as co-chairperson since the organization's founding.
- Steve holds a BS in Electrical Engineering from the Lafayette College in Easton, Pennsylvania and an MBA in management of technology from Lehigh University in Bethlehem, Pennsylvania.

Market movement

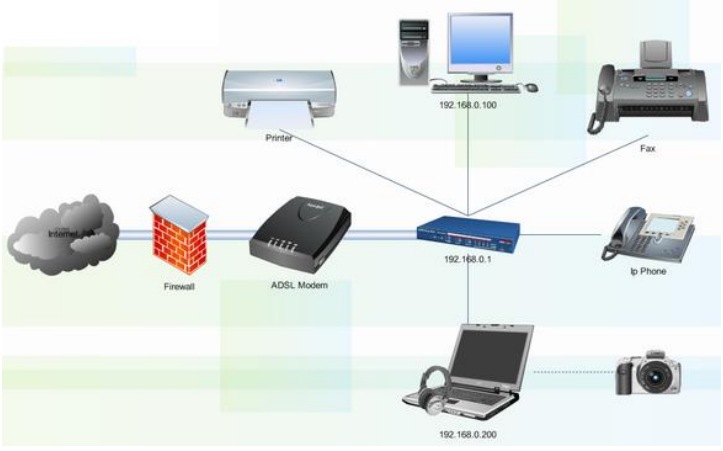
Trends

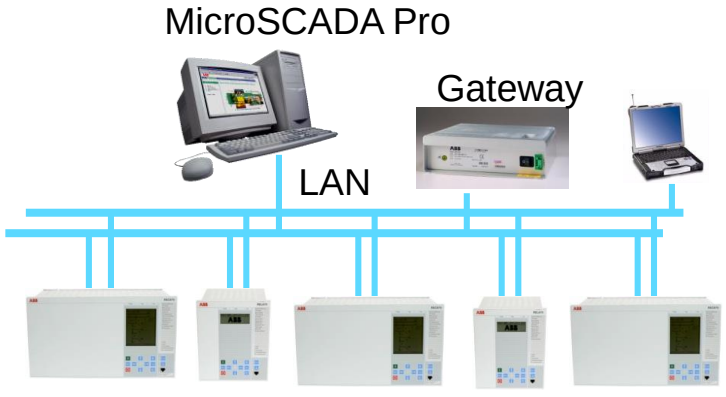
- Focus on reliability, availability, power network stability
- Increased pressure from regulators on reliability and security
- Growing interest in the digital substation to lower overall cost and improve performance, reliability and safety

Factors constraining market adoption

- Utility resource constraint leads to inability to evaluate and approve new technology
- Protection engineers are conservative and reluctant to change
- IEC 61850 has been viewed as a European standard
  - Benefits of the “digital” substation are enabled by IEC 61850
  - Positive market perception of GOOSE messaging for wire reduction
  - Greatest interest in Process bus (IEC 61850-9-2)

Communication
The new kind of communications





Home / Office Network

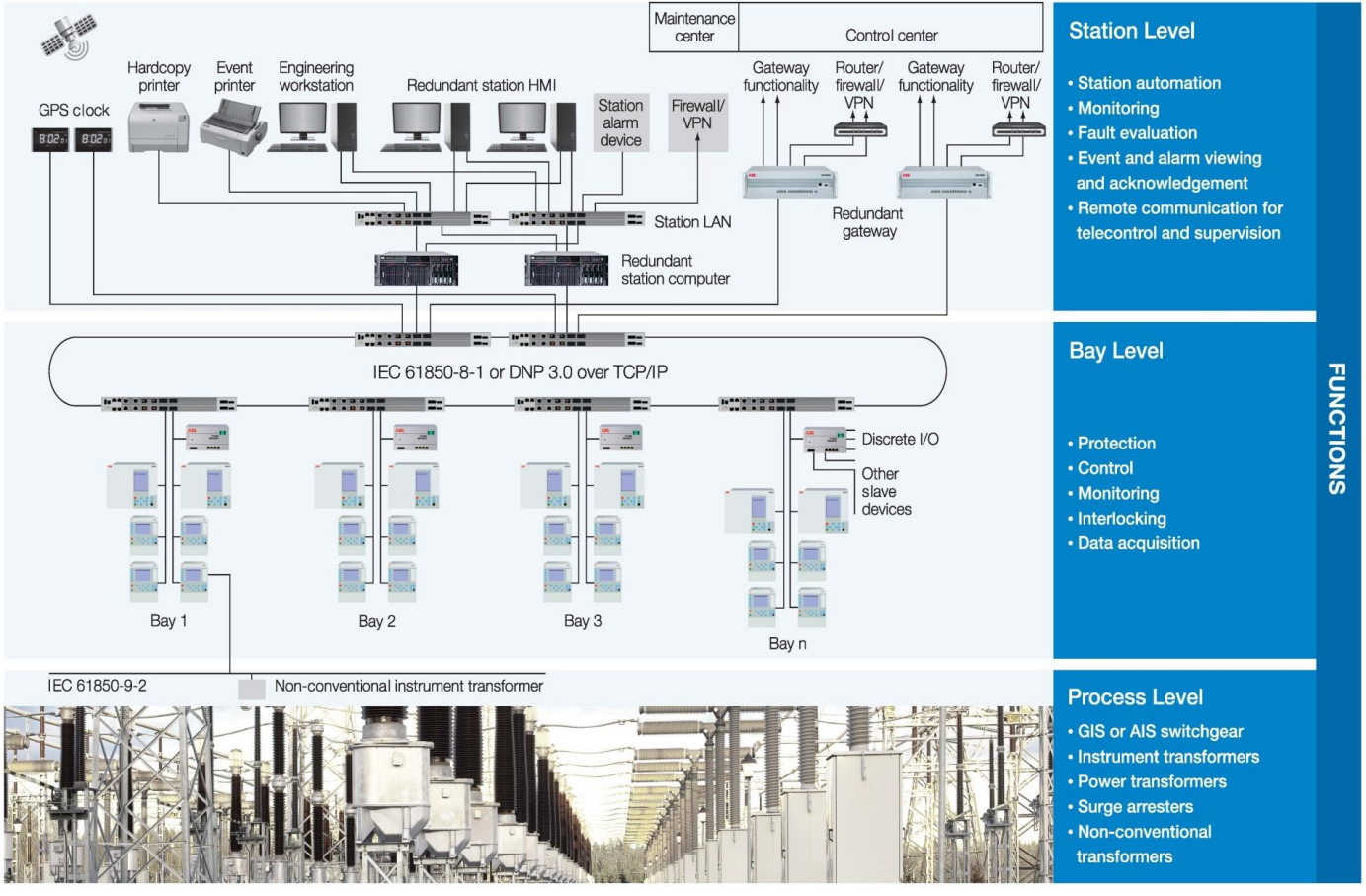
Plug and Play Technology –

Phones, Printers, computers, mobile phones, network devices, Laptops, and many more devices

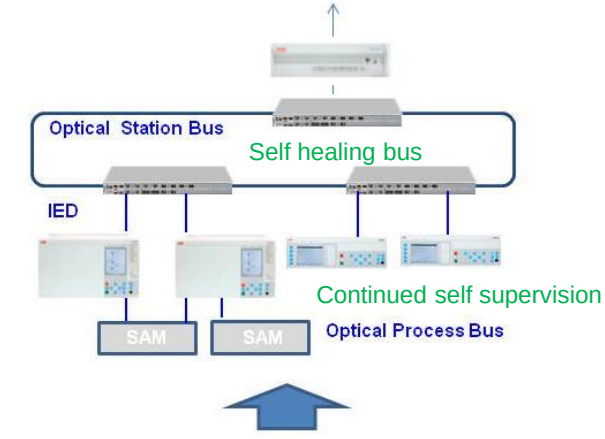
Digital Substation deploys similar Ethernet networking technology to Substations

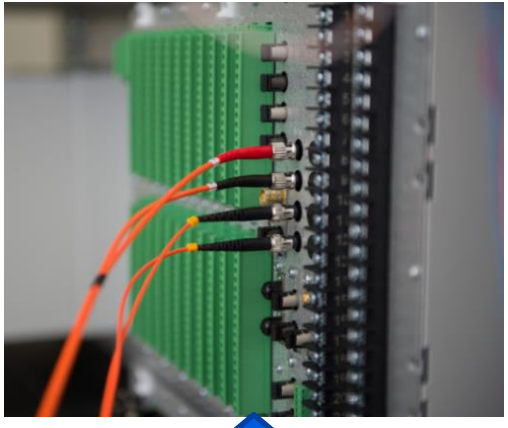
All the devices are connected in the substation Local area network that includes devices from multiple vendors.

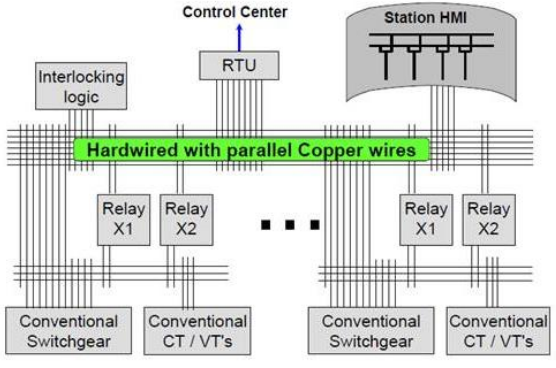
Applications
Digital substation



What is so special about the digital substation?
Footprint, copper wires, safety, reliability and cost





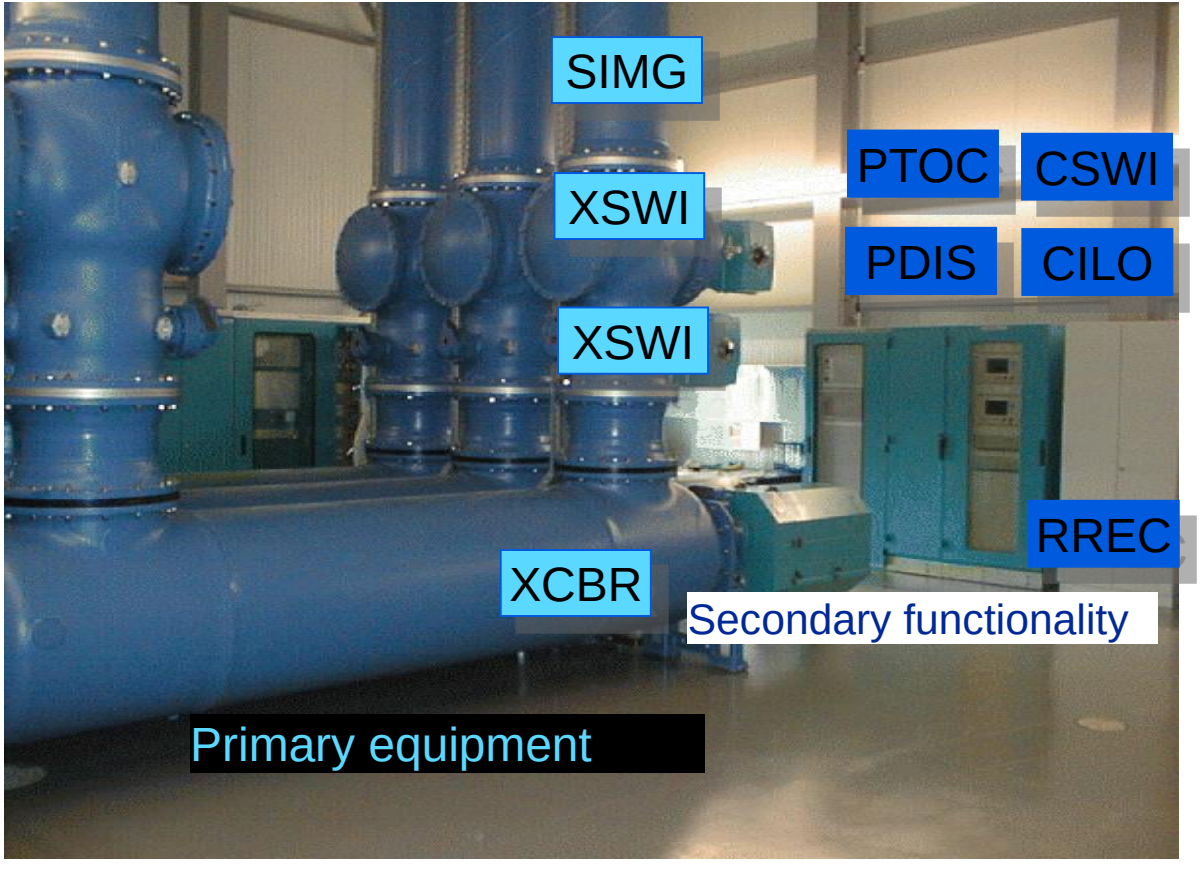


Basics - A breakthrough for Substation Automation

Goal of the Standard

- **Interoperability**
  - Exchange information between IED's (Intelligent Electronic Device) from several manufacturers
  - IEDs use this information for their own function
- **Free Configuration**
  - Free allocation of functions to devices
  - Support any philosophy of customer – centralized or decentralized systems
- **Long Term Stability**
  - Future proof
  - Follow progress in mainstream communication technology
  - Follow evolving system requirements needed by customers

Basics – Standardized Data Models



Basic - Digitizing Copper

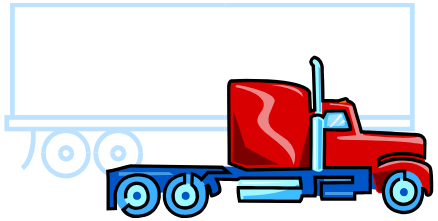
Digitize copper (GOOSE + SMV)

- Thanks to Ethernet technology and previously mentioned data model we are able to digitize copper:
  - Binary signals (GOOSE)
  - Analog signals (GOOSE)
  - Analog signals as input to protection and metering functions (SMV in the Process Bus)

Basics - What is GOOSE message ?

- GOOSE messages are based on change event
- GOOSE messages include diagnostic functions (a “heart beat” to all devices subscribed is sent periodically)
- GOOSE messages are managed by GCBs (GOOSE control block) inside IEDs
- GOOSE messages send “Data Sets” upon changes of state

Data set (information)

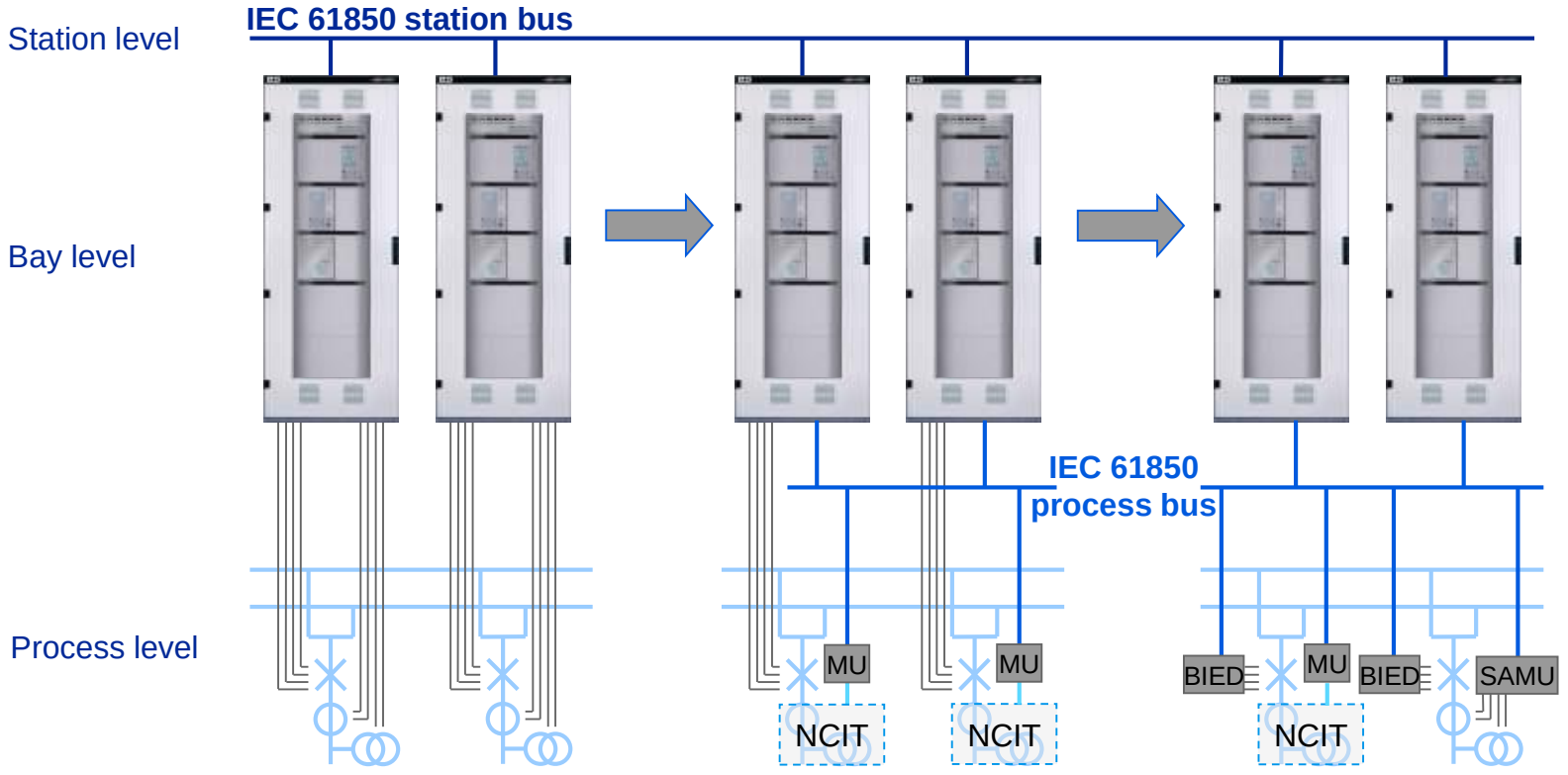


GCB

Network

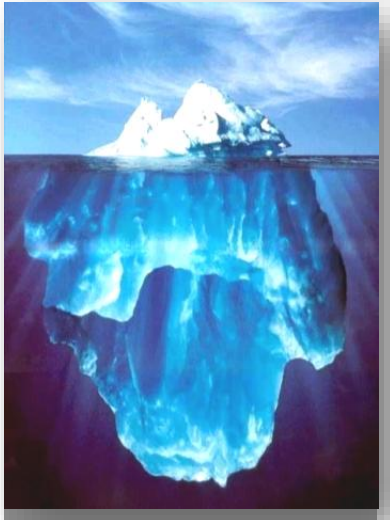
Basics - Process Bus

What is Process Bus



Why Care? - Lower Total Cost of Ownership
An efficient, flexible, cost effective & powerful solution

- Do more with less - functional consolidation and flexibility
  - *Fewer devices = fewer panels = less space required for the control building and supporting infrastructure*
- Process bus ready – the next step in your evolution of protection and control
- Advanced self monitoring and diagnostics reduce maintenance and periodic testing
- Ease of repair and restoration with fewer spare parts minimizes support and increases system-wide availability
- Streamlined repeatability of protection schemes shortens engineering and commissioning times
  - One engineering tool for the entire product family
  - Advanced network forensics and protection and control diagnostic tools
  - Learn one product, know them all



Significant reduction in TCO with Relion

Proofs - The Digital Substation
Solutions for utilities‘ critical needs

Leveraging utility experience to provide transformative digital solutions that deliver significant improvements over traditional approaches

Enhanced safety....

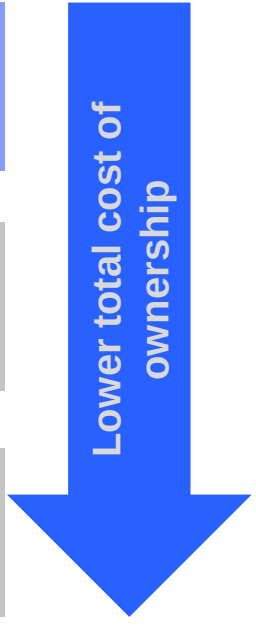
Reduce risk of fire and safety hazards for your personnel

Functional consolidation....

Next generation multi-function capabilities significantly reduce footprint

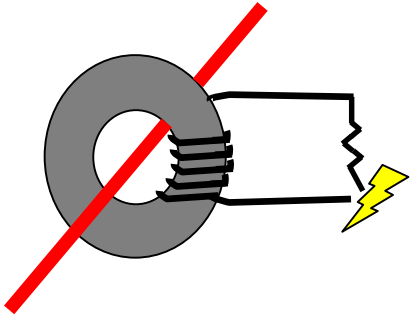
Improved reliability and efficiency through simplicity....

Reduced complexity improves reliability and efficiency



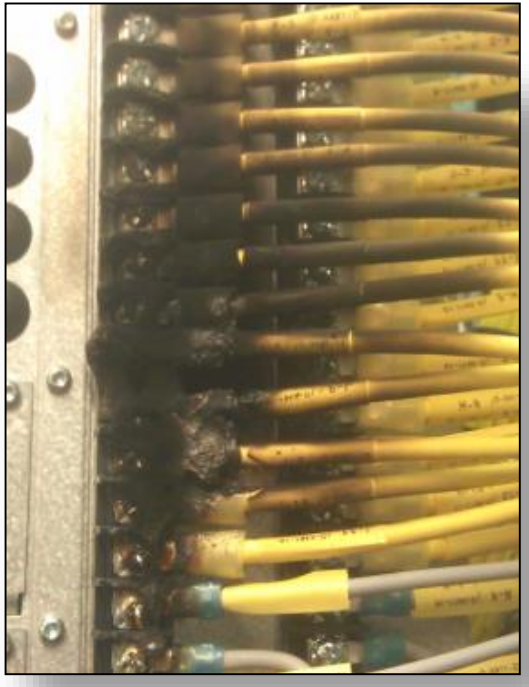
Proofs - Enhanced safety
Known risks of open current transformer circuits

Open CT arcing



WARNING!!! The secondary circuit of CTs should never be opened or left open when current is flowing in the primary. If the secondary circuit is open, the primary current will drive the core to saturation, inducing abnormally high and possibly lethal PEAK voltages.

Damage due to CT arcing



Proofs - Enhanced safety

Reducing open CT risks in the control house

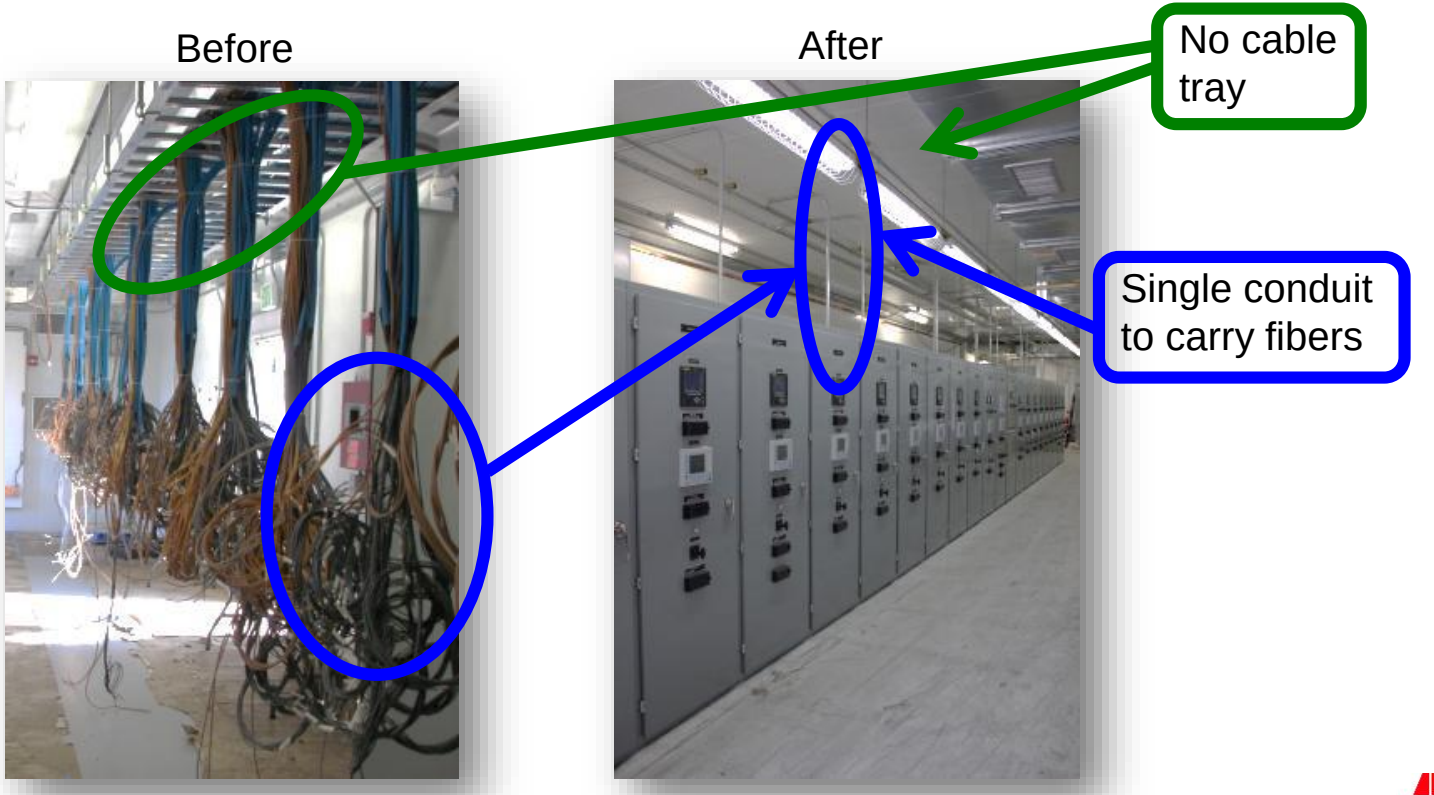
- Reduce risk of injury when conventional instrument transformers, voltage and current signals are connected to a digital interface at the primary equipment safely away from field personnel
- Safely replace relays without taking the substation out of service

Increased safety and reduced risk of personnel injury in the control house

Proofs - Enhanced safety

Reducing the risks in the control house

Digital substation reduces wiring complexity and resulting risks for operations & maintenance personnel



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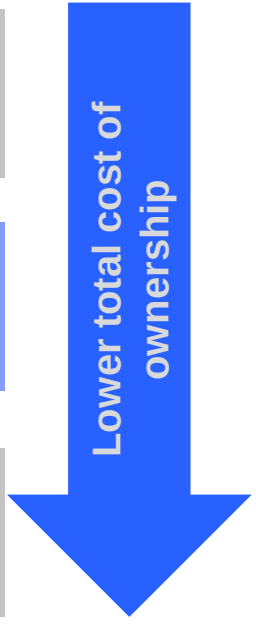
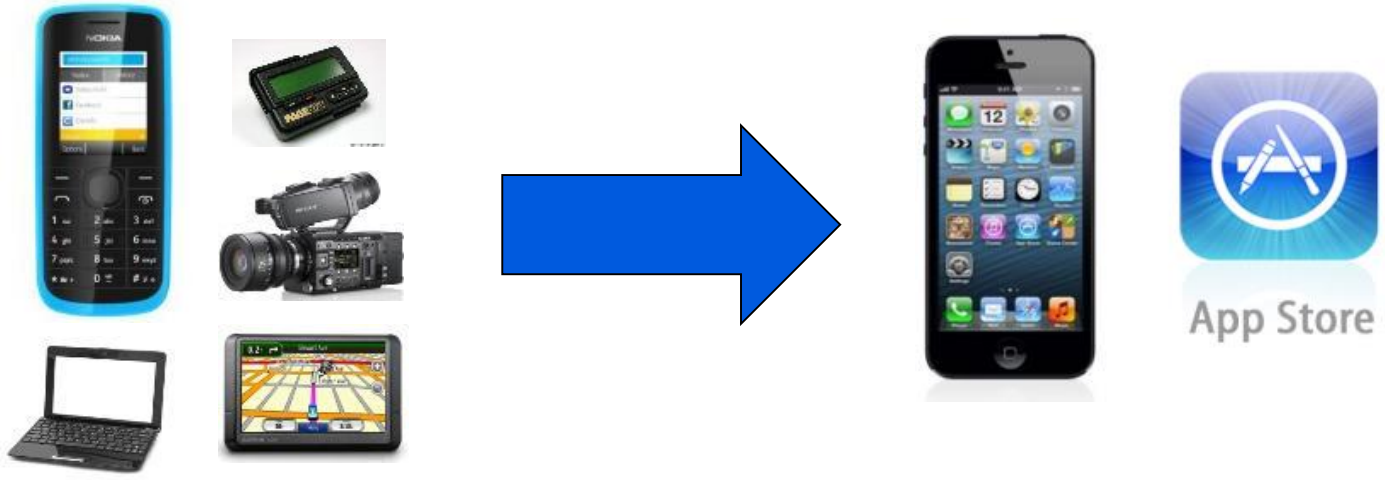


Proofs – Analogy of functional consolidation
The evolution of technology



- Technology drives consolidation of functions in all industries
- Reduces amount of inventory
- Improves the work process
- Requires new skill sets

Proofs – Free allocation of function/logical nodes
Enables functional consolidation

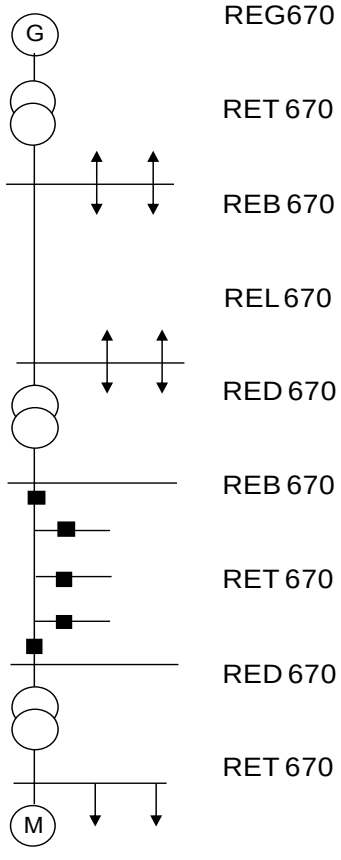
Function Library

PDIS 21	PDIF HZ	PDIF REF
PDIF 87B	PDIF 87L	PDIF 87T
PIOC 50	PIOC 50N	POCM 51/67
PEFM 51/67N	RBRF 50BF	PUVM 27
POVM 59	PTOF 81	PTUF 81
PVPH 24	PTTR 49	PSCH
RSYN 25	RREC 79	RBRF 50BF
CSWI	MMTR	MMXU

Hardware Platform

Communication

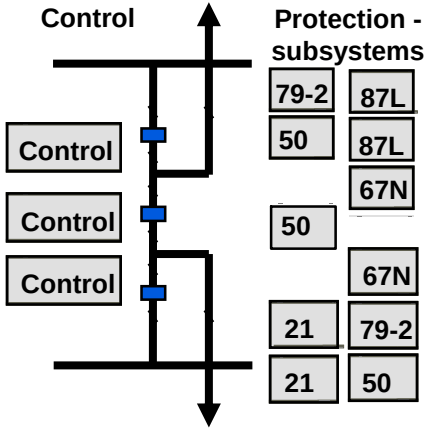
PAC Application



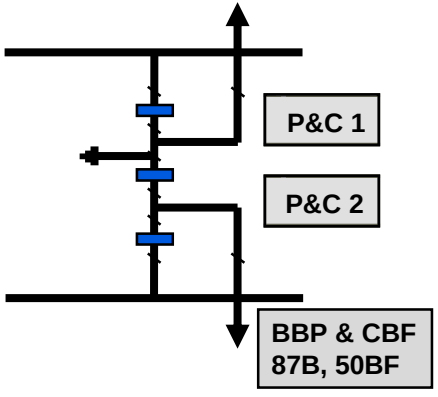
Proofs – Example of Functional consolidation
Reduced footprint, hardware and infrastructure

Reduction in panels from 3 to 1

Conventional



Digital



14 protection & control devices (Electro-Mechanical system could add 3 devices per function)

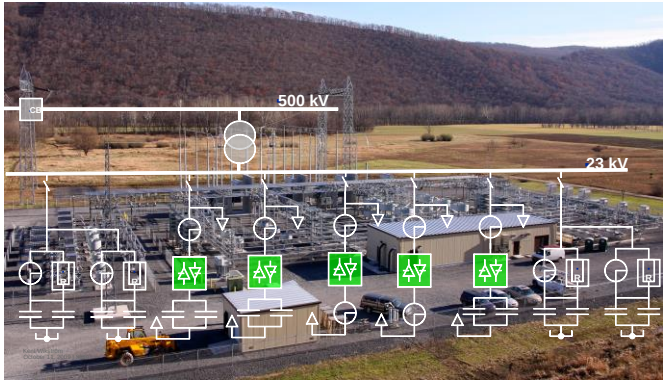
2 protection & control devices including busbar protection/backup

Advanced solution
From 3 panels to 1 panel

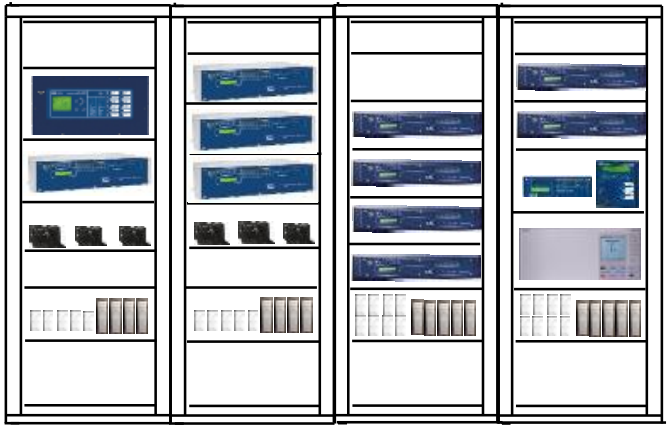
Proofs – Example of functional consolidation
Reduced footprint, hardware and infrastructure

Comparison of digital vs. traditional solution for static VAr compensator (SVC) project example

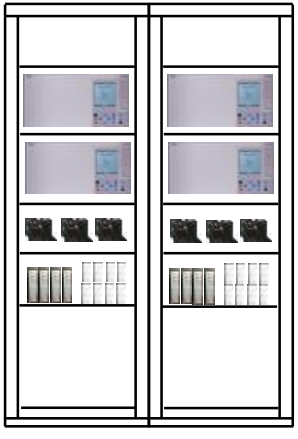
- **4** ABB Relion relays vs. **14** traditional relays
- **50%** reduction in number of panels – 4 to 2



Main protection - traditional relays



Main protection - digital substation



Proofs - The Digital Substation

Solutions for utilities‘ critical needs

Leveraging utility experience to provide transformative digital solutions that deliver significant improvements over traditional approaches

Enhanced safety....

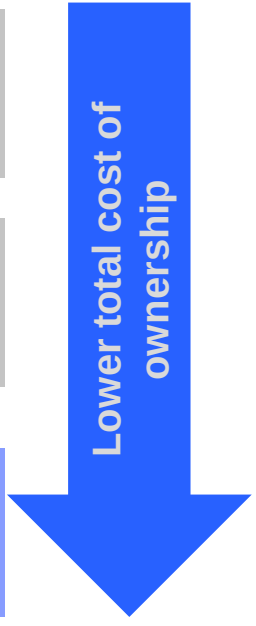
Reduce risk of fire and safety hazards for your personnel

Functional consolidation....

Next generation multi-function capabilities significantly reduce footprint

Improved reliability and efficiency through simplicity....

Reduced complexity improves reliability and efficiency



Proofs - Simplicity improves reliability

Reduces complexity and number of points of failure

Example – Hybrid digital substation implementation

Traditional Copper Wires

Conventional cabling
No of cables: 768
Conductors: 4500
Terminations: 9000

Test/Debug – Labor intensive

Maintenance – Drawings up to date?

Reliability – Many connections

Digital Communications

Partly Digital Communications
No. cables: 256
No. conductors: 1500
No. terminations: 3000

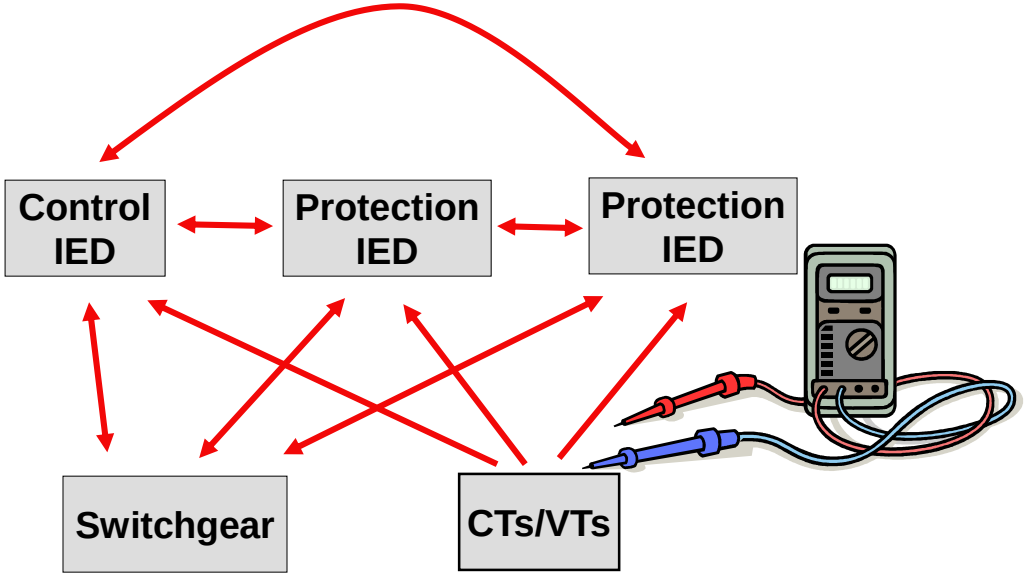
Test/Debug – Easier to test/debug using digital tools

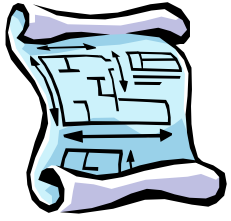
Maintenance – Digital record of connections and much simpler wiring improves maintenance

Reliability – Less connections and units to fail improves reliability (receive digital notification of an issue)

67% reduction wires

Conventional design





Circuit diagrams
Connection tables
Cable lists

Proofs - Simplicity improves reliability

Reduces complexity and number of points of failure

Example – Complete digital substation implementation

Traditional Copper Wires

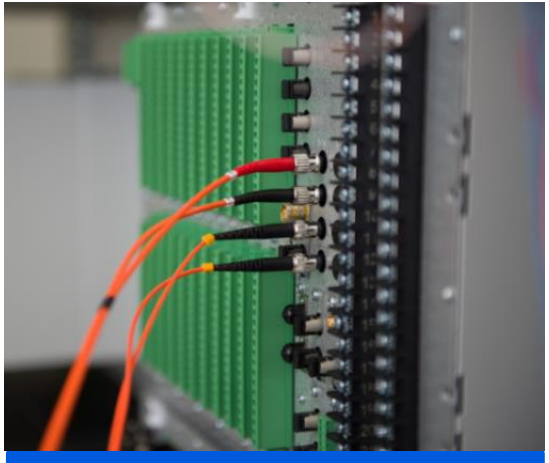
Conventional cabling
No of cables: 768
Conductors: 4500
Terminations: 9000

Test/Debug – Labor intensive

Maintenance – Drawings up to date?

Reliability – Many connections

Digital Communications



Full Communications
No. of Fiber optic cables: 4
Continuous self supervision

Elimination of wires

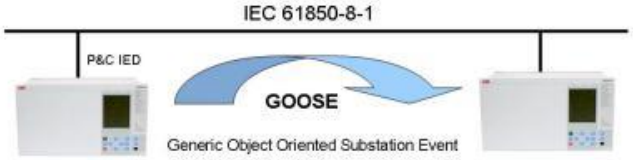
Test/Debug – Easier to test/debug using digital tools

Maintenance – Digital record of connections and much simpler wiring improves maintenance

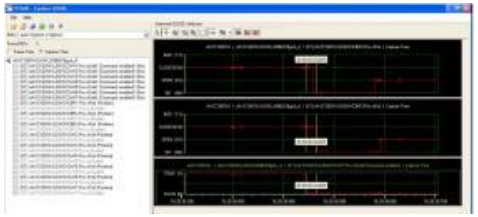
Reliability – No conventional cables and self supervision

Proofs - Simplicity improves efficiency
Tools simplify substation analysis and testing

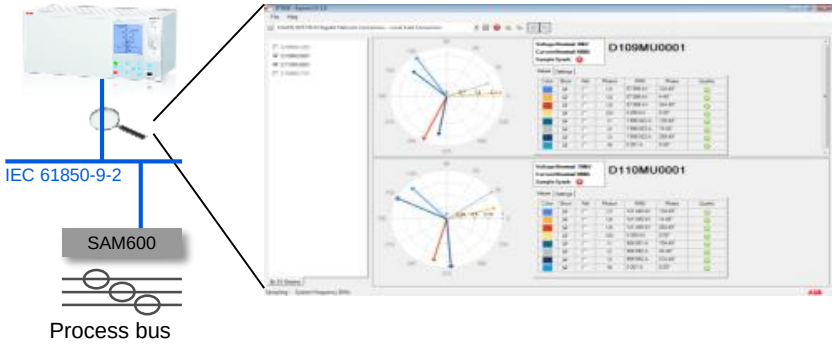
Visualization of logic within the substation



Faster troubleshooting of substation logic



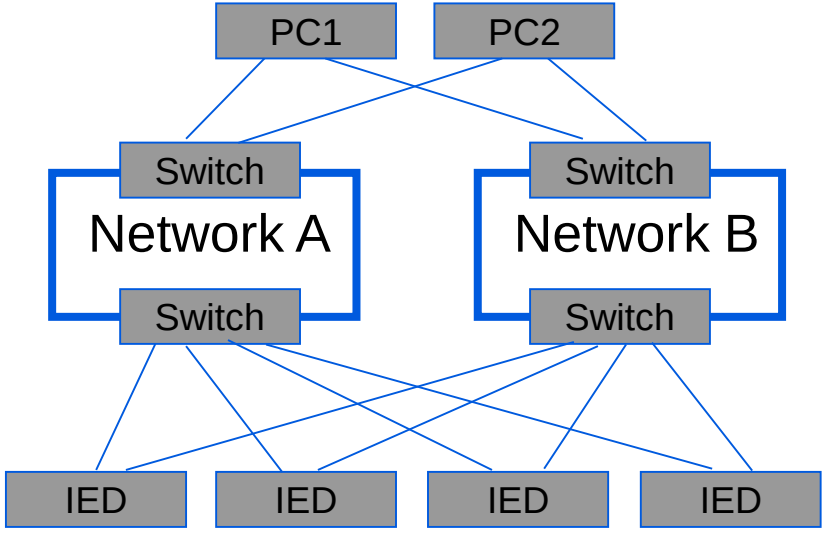
Simple Testing of Relay Sources



Easy review of voltage and current source connections for relaying (polarity of inputs)

Parallel Redundancy Protocol (PRP)

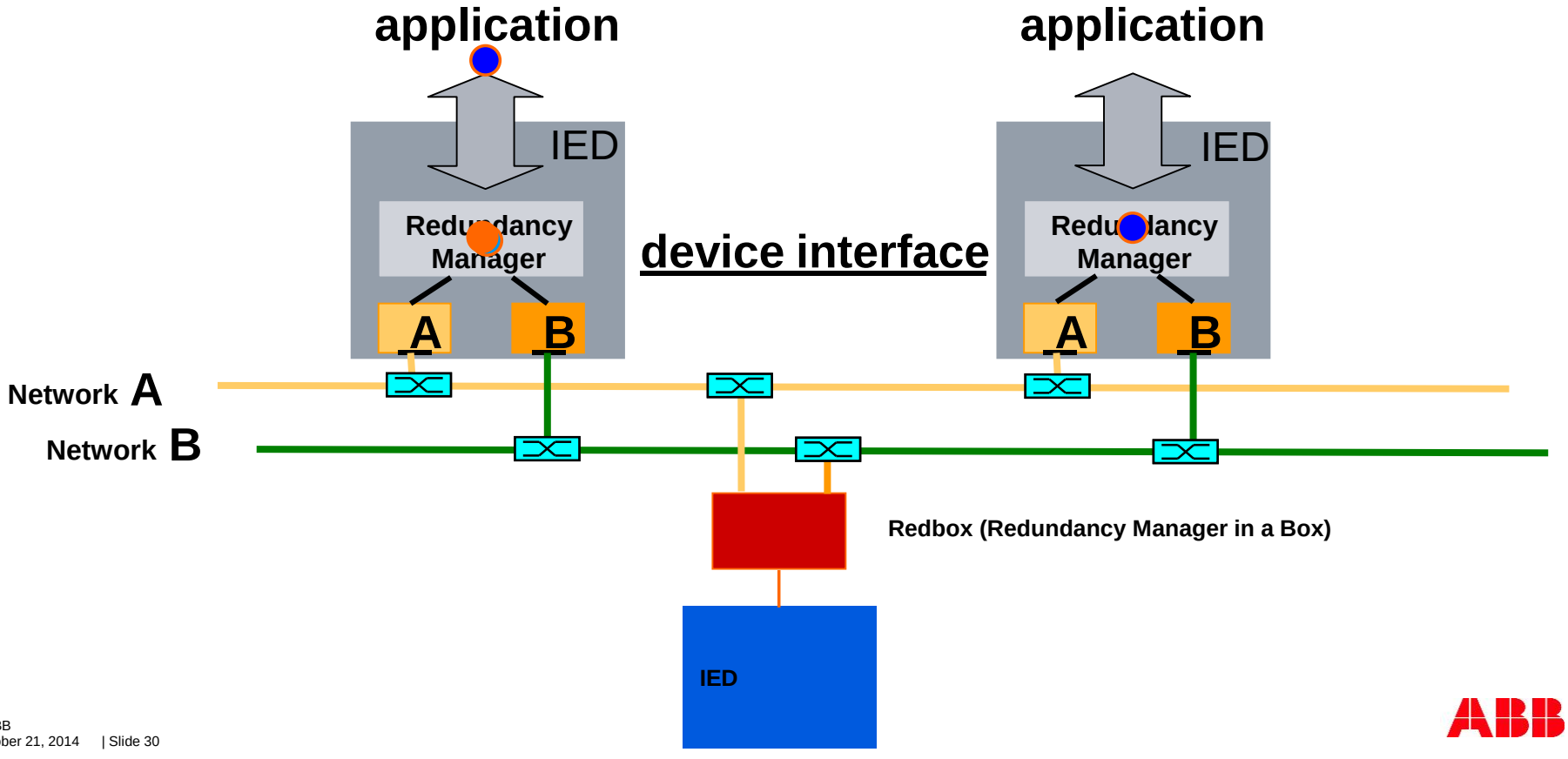
Principle



- Operation Mode
  - 2 Ports active
    - Messages are sent / received simultaneously on both ports
    - Switch over time 0ms
- Advantages
  - No recovery time
  - No messages are lost
  - Network redundancy (Network A and B)
  - IEDs are not active part of the network
  - Standard according IEC 61850-8-1/9-2 Edition 2

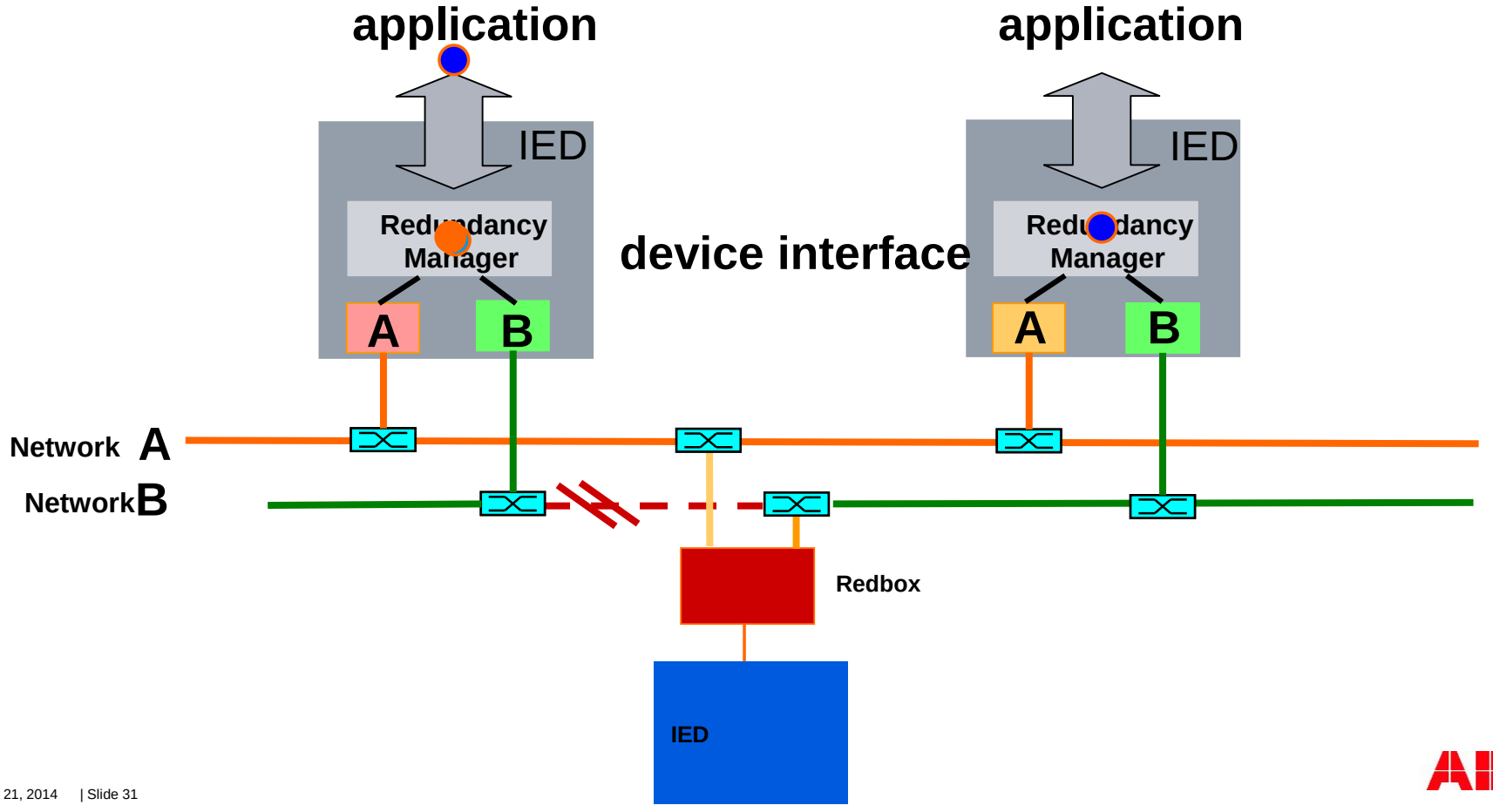
How it works

PRP Operation in normal condition



Demonstration

PRP Operation with “faulty” condition

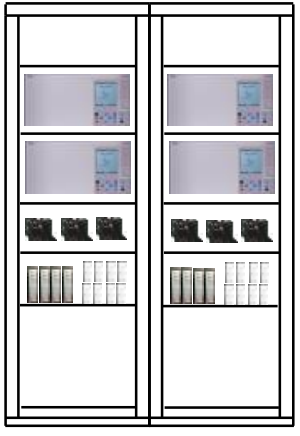


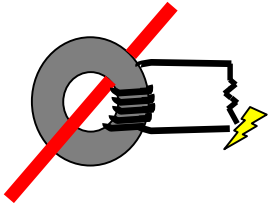
Proofs – Digital Substation Benefits
Assessment of cost impact

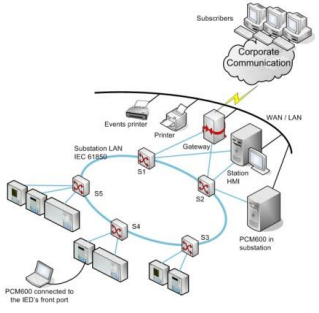
Project Management Base/Concept Design	→
SA Engineering	↗
Panel and cable engineering	↘
Protection, control devices	↘
SAM600 devices	↗
Panel mfg + testing	↘
Kiosk mfg + testing	↘
Fiber mat., laying, connecting	↗
Copper mat., laying, connecting	↘
Signal test	↘
Commissioning	↘
Retrofit outage time	↘
Maintenance	↘
Total costs	↘

- Overall reduced time to engineer, install and commission substations
- Up to 50% reduction in real estate requirements
- >70% reduction in copper wiring – installation, maintenance, and debug
- Reduced operational costs using tools to improve installation and troubleshooting needs

Proofs – Digital Substation Benefits
Assessment of operations impact

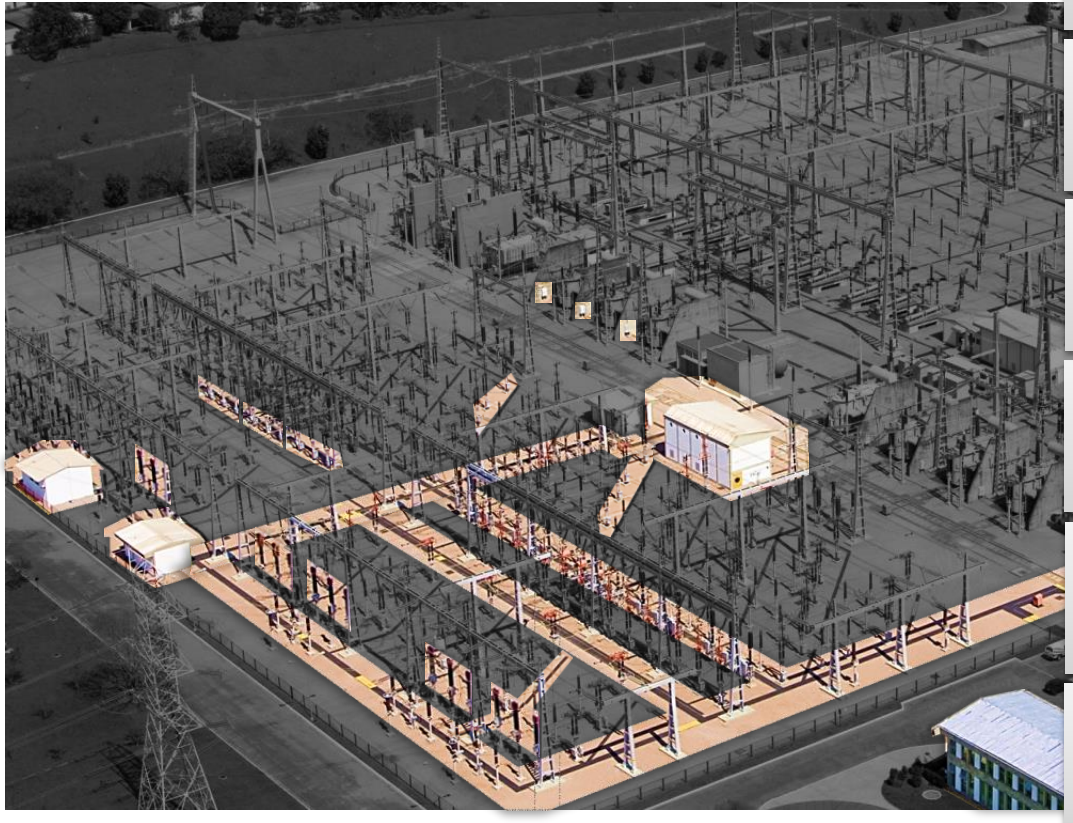






- Improved safety for personnel
- Improved documentation
- Improved reliability
- Improved maintenance and diagnostics
- Increased flexibility for future expansion
- Reduced outage time for retrofits
- Safeguards investment with a future-ready solution that provides migration to the digital substation
  - DNP 3.0 today, 670 delivered with IEC 61850 for tomorrow usage

Summary - Why the Digital Substation is so special!



Reduce amount of cables by using fiber instead of copper

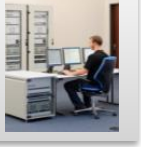
Optimize drive and interface boxes with direct process bus connection

Lower requirements on CTs/VTs by reducing burden from cabling and minimizing No of circuits

Simplify P&C panels and increase safety by full isolation from process

Include NCITs in P&C system and by that further increase safety & availability

Reduce maintenance through increased supervised area



The Digital Substation - part of the future Smart Grid
Communication, interoperability & cyber security!

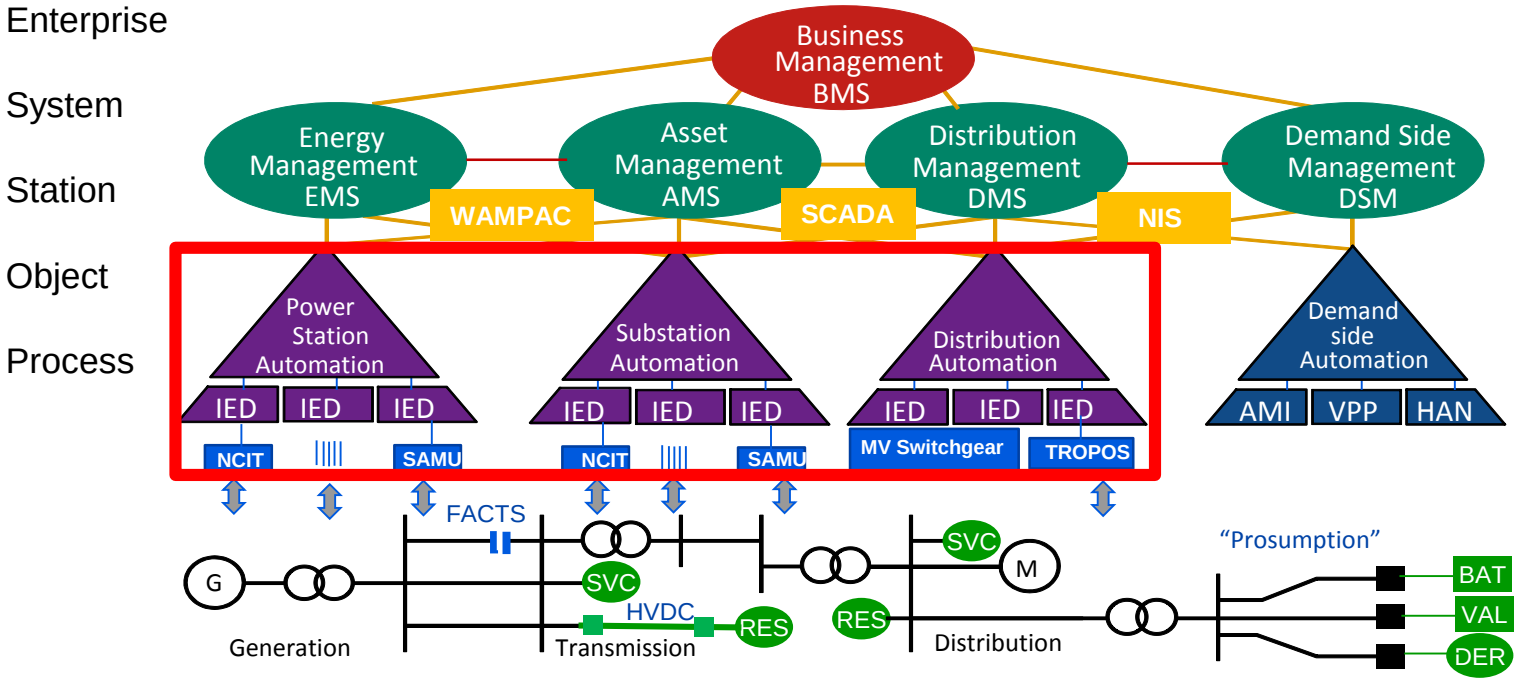
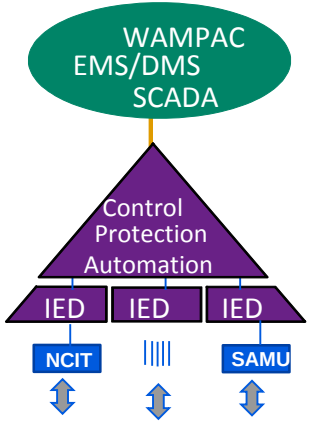


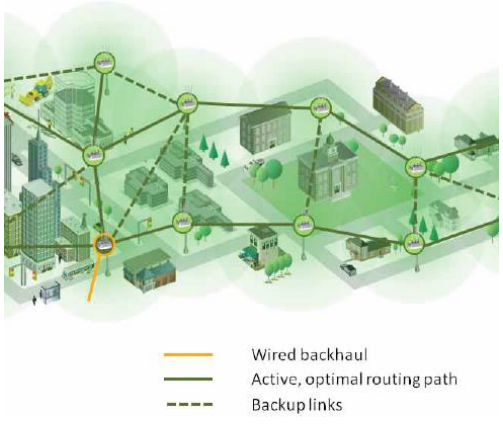
ABB has designed the building blocks to meet these requirements for the Digital Substation – ready for the future Smart Grid

Advanced protection, control and automation
Migrating to the Digital Substation



- Communication is the game changer and interoperability throughout systems of systems is the main challenge
- Change from old box-and-wire blue print to a system approach with functional specification allowing more efficient solutions with lower total cost
- Bring together Control & Protection with standardized Communication to ensure future proof interoperability and supports Cyber Security compliance
- Implement Reliability Centric Design of the complete system with self supervision and redundancy to guarantee availability and maintainability
- Plan, structure and empower involved work force in engineering, operation and maintenance
- Pilot with Proof of Concept and FAT/SAT to ensure total system performance
- Build a technology sandbox (test bed) to demonstrate the Digital Substation capabilities to your organization

Enabling advanced protection, control and automation
Extending to Asset health and Wide Area solutions

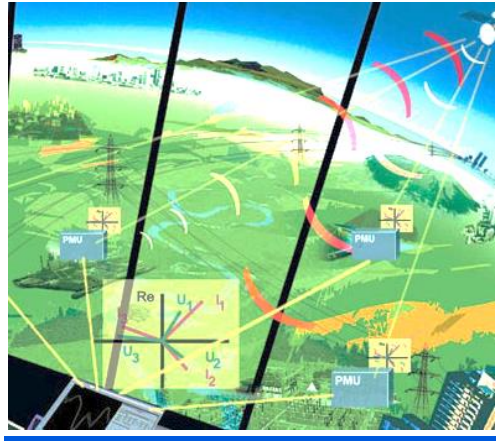


Wireless communications

- Provide a redundant communication path for critical asset health applications
- Mesh network allow communication reconfiguration
- Reliable, high capacity, low latency, secure and adaptable

Asset Health systems

- Control of the recovery allows for efficient decision making
- Transmission applications focused on grid resiliency in development
- Systems allow for managing congestion, balancing the load and maintaining reserve capacity



Proactive control systems

- Collect and analyze real-time data throughout the power grid
- Early warning system for blackouts
- Safety and stability margins analyzed
- Aids operators in making correct live decisions
- Dynamic monitoring system

Digital substation product portfolio

Substation interface and HMI (Station level)

- RTU560 & MicroSCADA SYS600C

Protection and Contol (Bay level)

- Relion family control and protection IEDs
  - 670 series & 650 series
  - REB500 for distributed busbar applications
  - IEC 61850 system engineering: IET600
    IEC 61850 testing: ITT600 SA Explorer

Interface to Switchgear (Process level – NCIT)

- ABB NCITs for GIS, CP-MU merging unit for ELK-CP14 and ELK-CP3 (current and voltage)
- ABB LTB with integrated
  Fiber Optic Current Sensor FOCS-MU (current only)

Process level – stand-alone merging units

- SAM600 modular process bus IO system

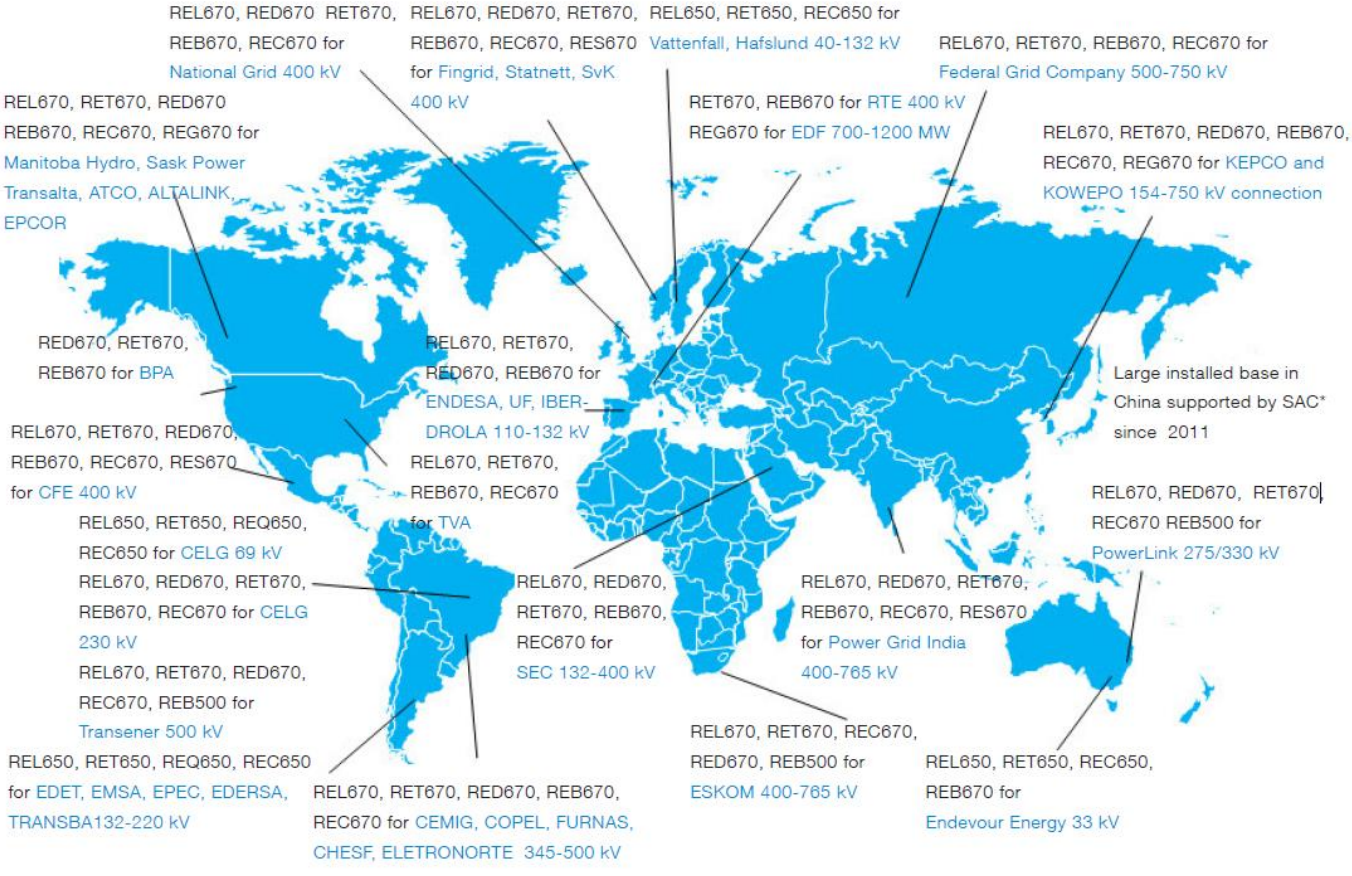
Digital Substation process bus products

Process level equipment - Sensor technology

	AIS / GIS	Voltage level	Current/ voltage	Application	Description	Status
ABB NCITs with IEC 61850-9-2 merging units						
ELK-CP3, ELK-CP14 	GIS	170 – 550kV	Current & voltage	Protection, control, revenue metering	Redundant, combined U/I NCIT, U: capacitive divider, I: Rogowski coil	Commercial operation since 1998. Since 2011 with IEC 61850
FOCS LTB 	AIS	420kV	Current	Protection, control	Redundant optical CT integrated in disconnecting circuit breaker	Pilot installation since 2010
FOCS FS 	AIS	72 – 800kV	Current	Protection, control, revenue metering	Redundant optical CT, free-standing	Commercialized 2014
ABB stand-alone merging units for conventional instrument transformers						
SAM600 	GIS & AIS	any	Current & voltage	Protection, control, operational metering	Modular IEC 61850 process bus I/O system with modules per primary object	Ready for pilot installations
SAM600	GIS & AIS	any	Current & voltage & breakers, disconnectors…	Protection, control, revenue metering	Modular IEC 61850 process bus I/O system with modules per primary object	Under development

ABB's experience with NCITs and process bus
Some project highlights

Experience in demanding applications
> 100,000 Relion 670s, > 2,000 substations with IEC61850



Examples of Relion deliveries worldwide

Your strategic partner

Questions?

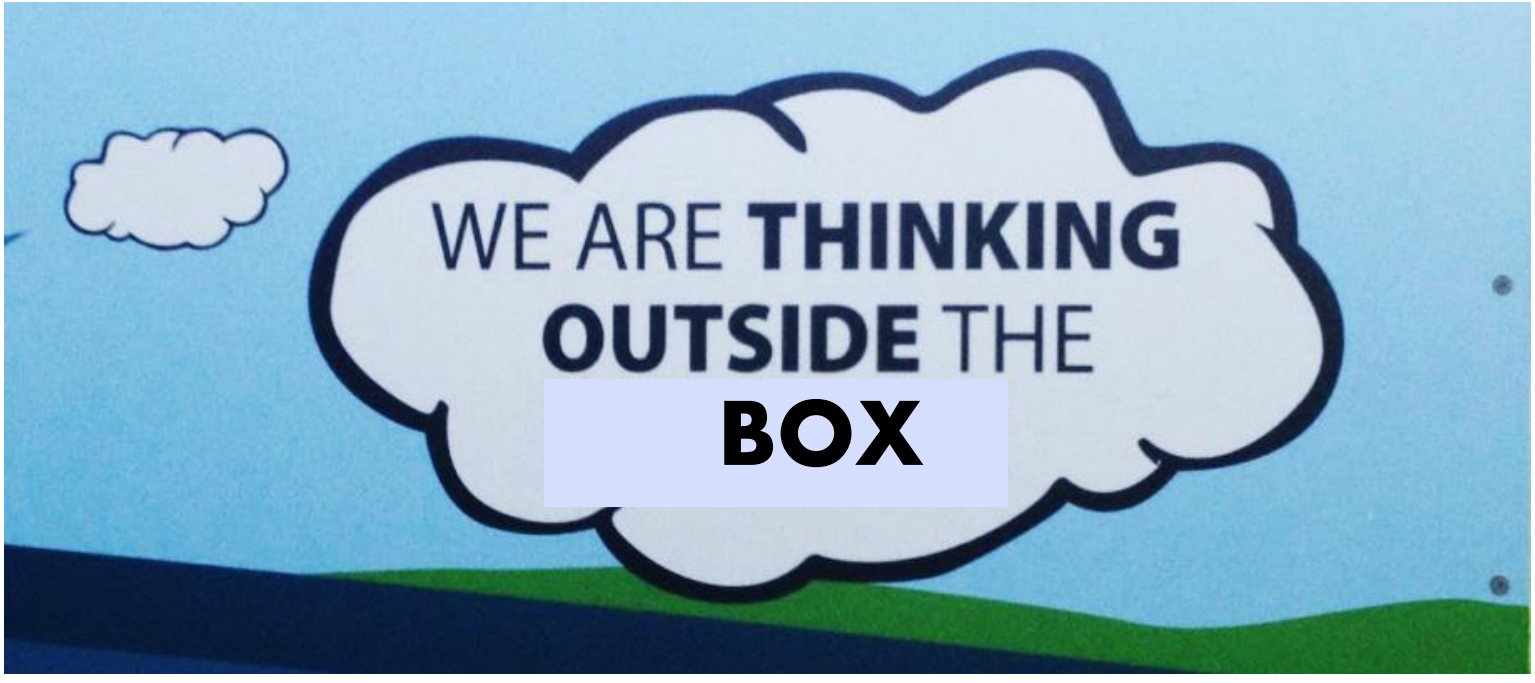


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ABB Power Systems Automation and Communication

- **Relion Series Relays** – Advanced flexible platform for protection and control
- **RTU 500 Series** – Proven, powerful and open architecture
- **MicroSCADA** - Advanced control and applications
- **Tropos** – Secure, robust, high speed wireless solutions

We combine innovative, flexible and open products with engineering and project services to help our customers address their challenges.

Thank you for your participation

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