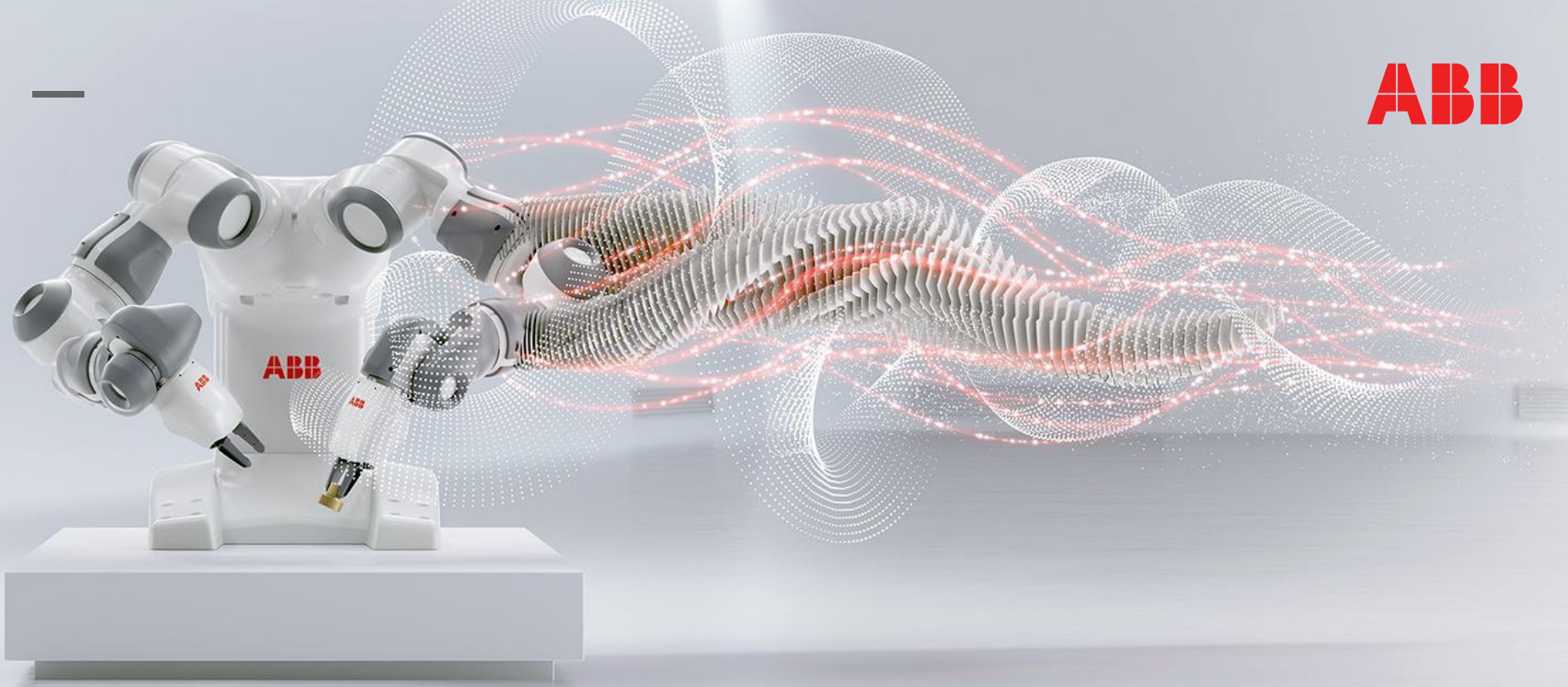


ABRIL 2017

Subestaciones Digitales

Jornadas Técnicas ABB

Thiago Lopes
Gerente Regional de Ventas – Protección, Contról y Comunicaciones.

April 17, 2017

ABB Digital Substations

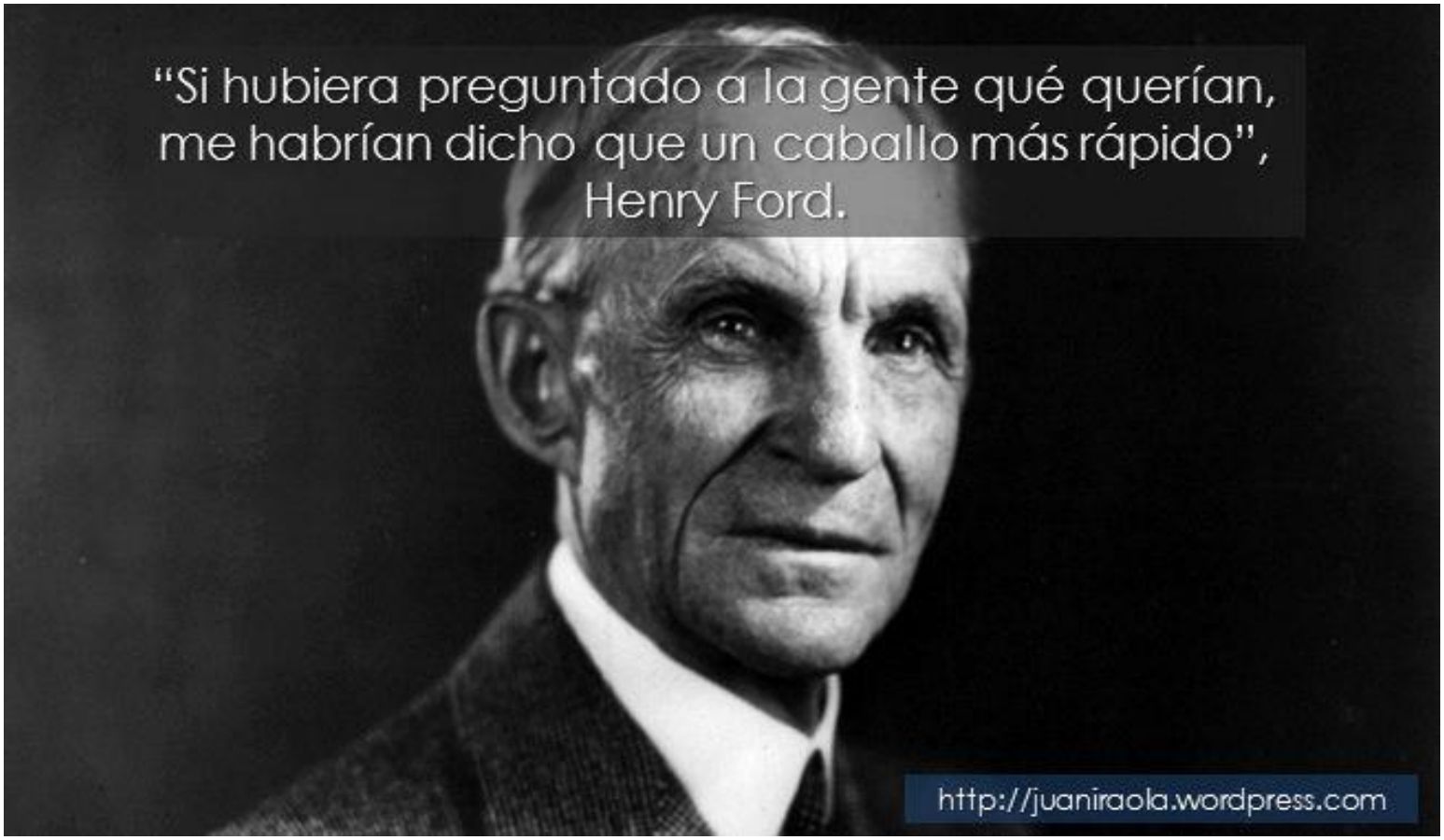
Thiago Lopes

- 36 años edad
- Brasileiro pero hoy en día tengo dificultad de hablar português.
- Ingeniero Eletricista y Maestria en Gestión de Negocios.
- 18 años de experiência en eletricidade y 10 años en Sistemas de Potencia, todos en ABB.
- 5 años como especialista en relés de protecciones y sistemas de protección y control.
- Aficionado por Tecnologia, Subestaciones Digitales, Smart Grids, Internet de las cosas.
- Fanático por futebol y por las bromas.

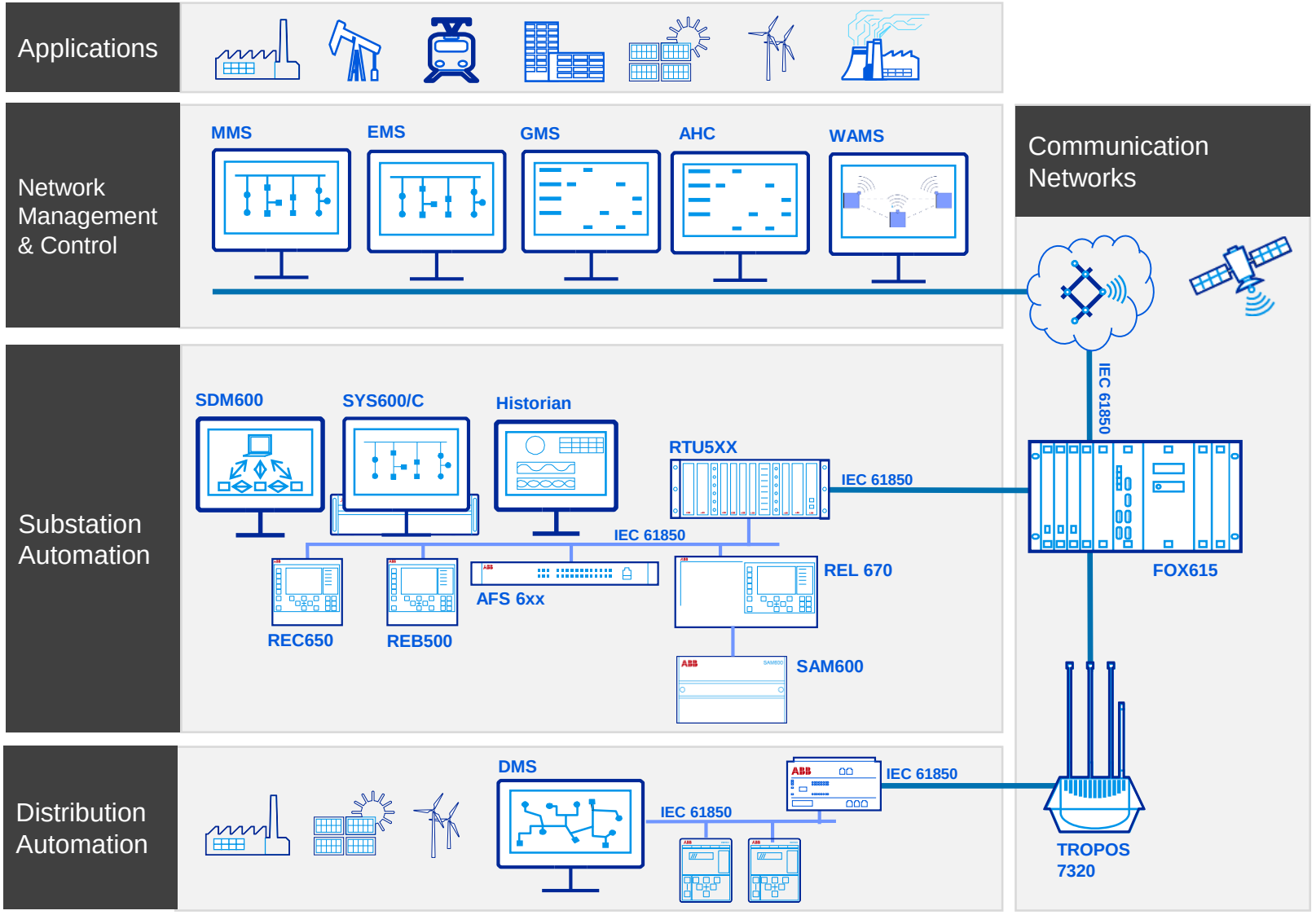
April 17, 2017

ABB Digital Substations

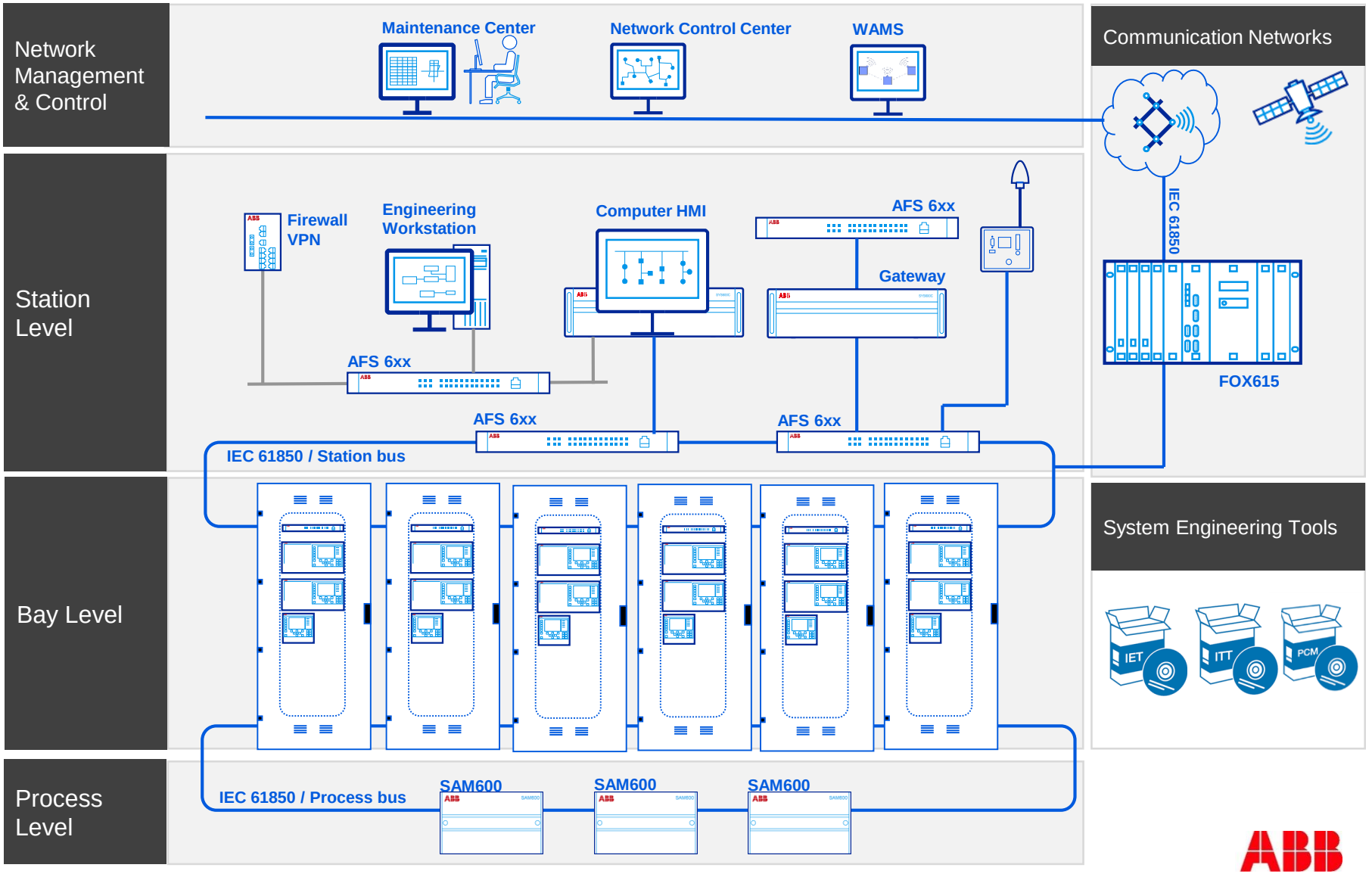
Thiago Lopes



Power Systems Network Management Portfolio Overview

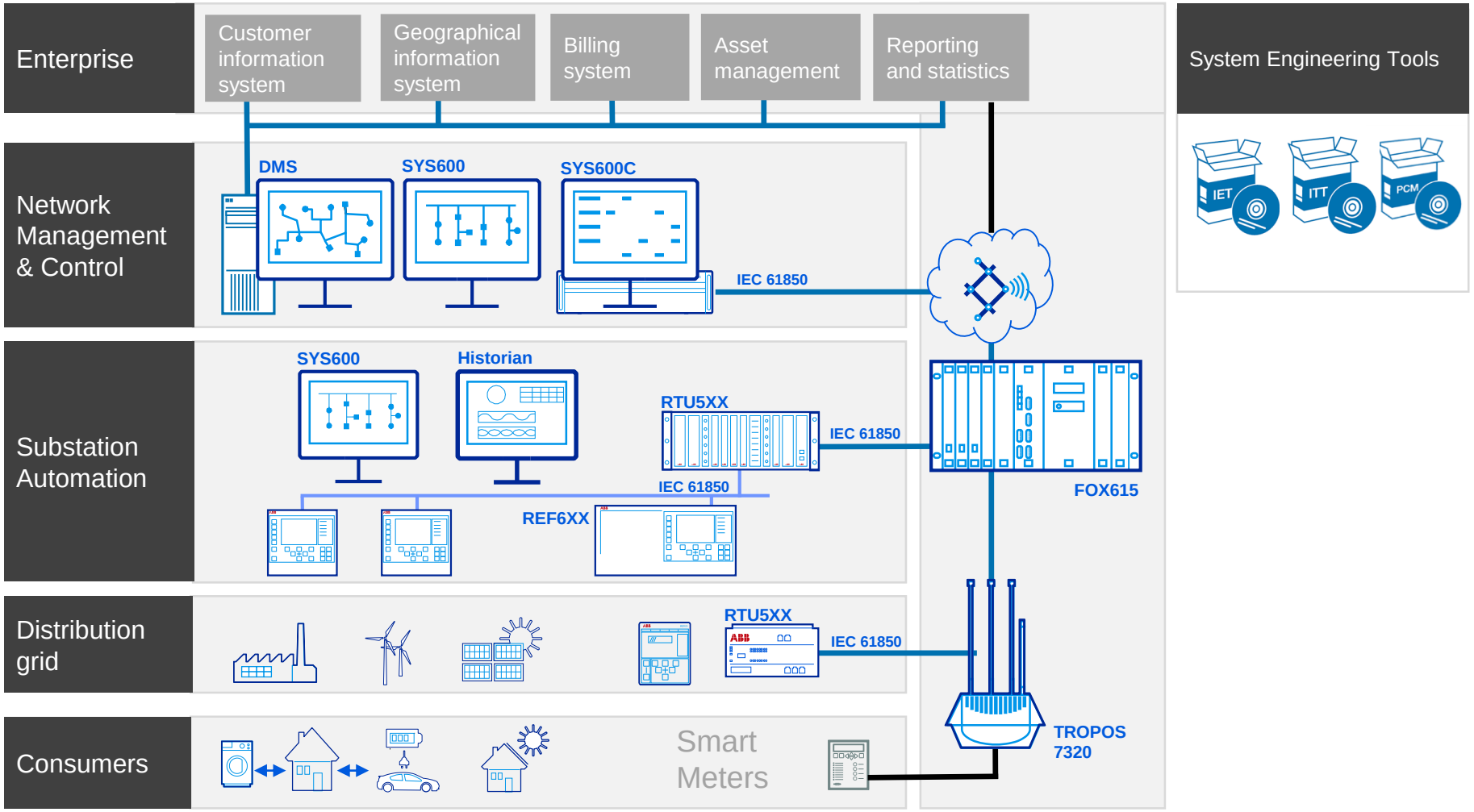


Substation Automation
Digital Transmission portfolio and architecture



Distribution Automation

Substation Automation & Communication portfolio overview



Agenda

What is a digital substation?

Benefits of digital substations

Solutions

SAM600 merging unit

Project reference cases

What is a digital substation?

ABB Digital Substations

- Substation automation challenges

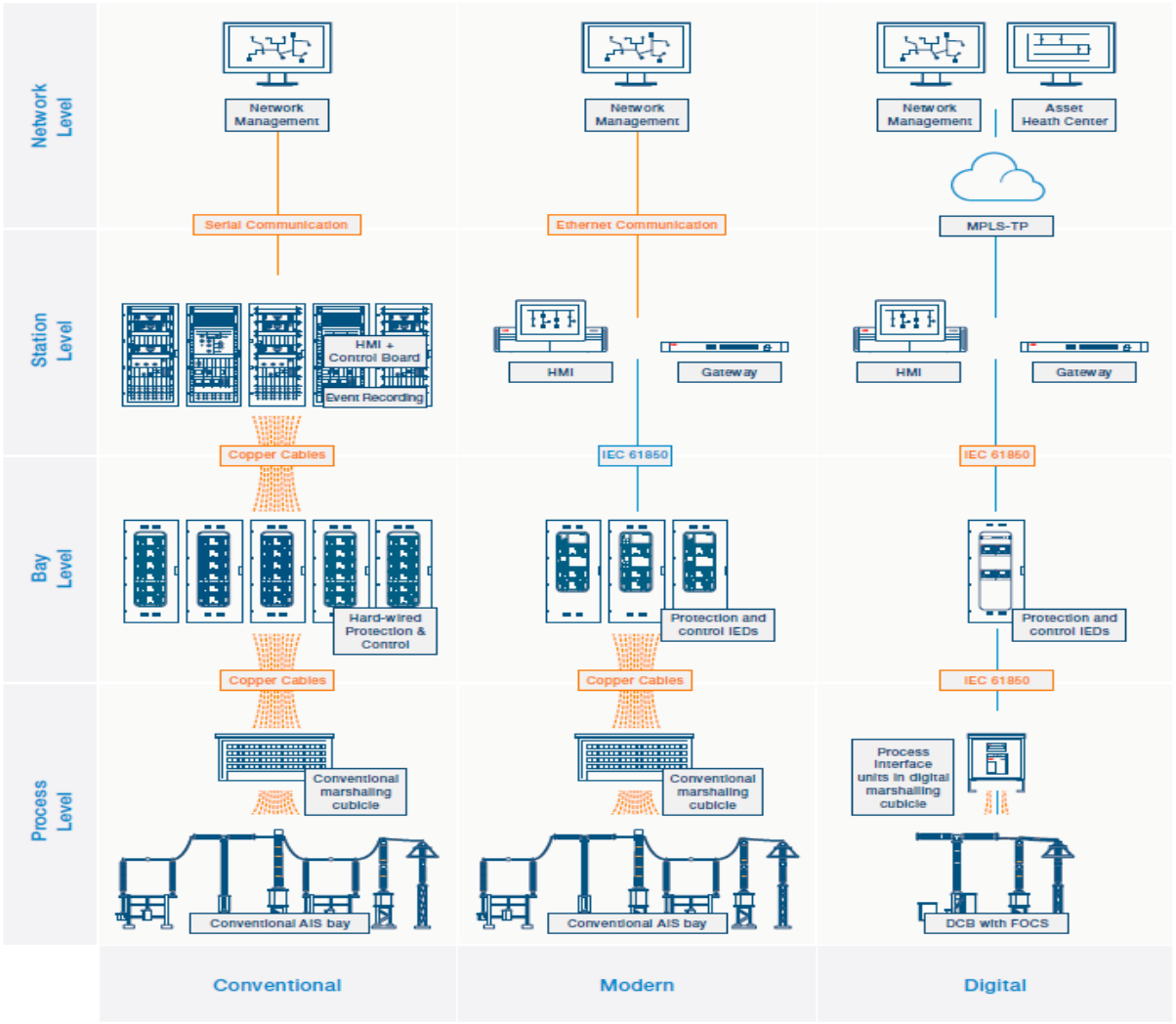
- Increasing demand on refurbishment of substations
- Project execution under increasing cost and time pressure
- Better utilization of existing assets
- Increased expectations on transmission system availability
- Safeguard investment over the entire life cycle
- Sustainability in the qualification of operators and suppliers

Digital substations respond to today's utility challenges

- Actual status

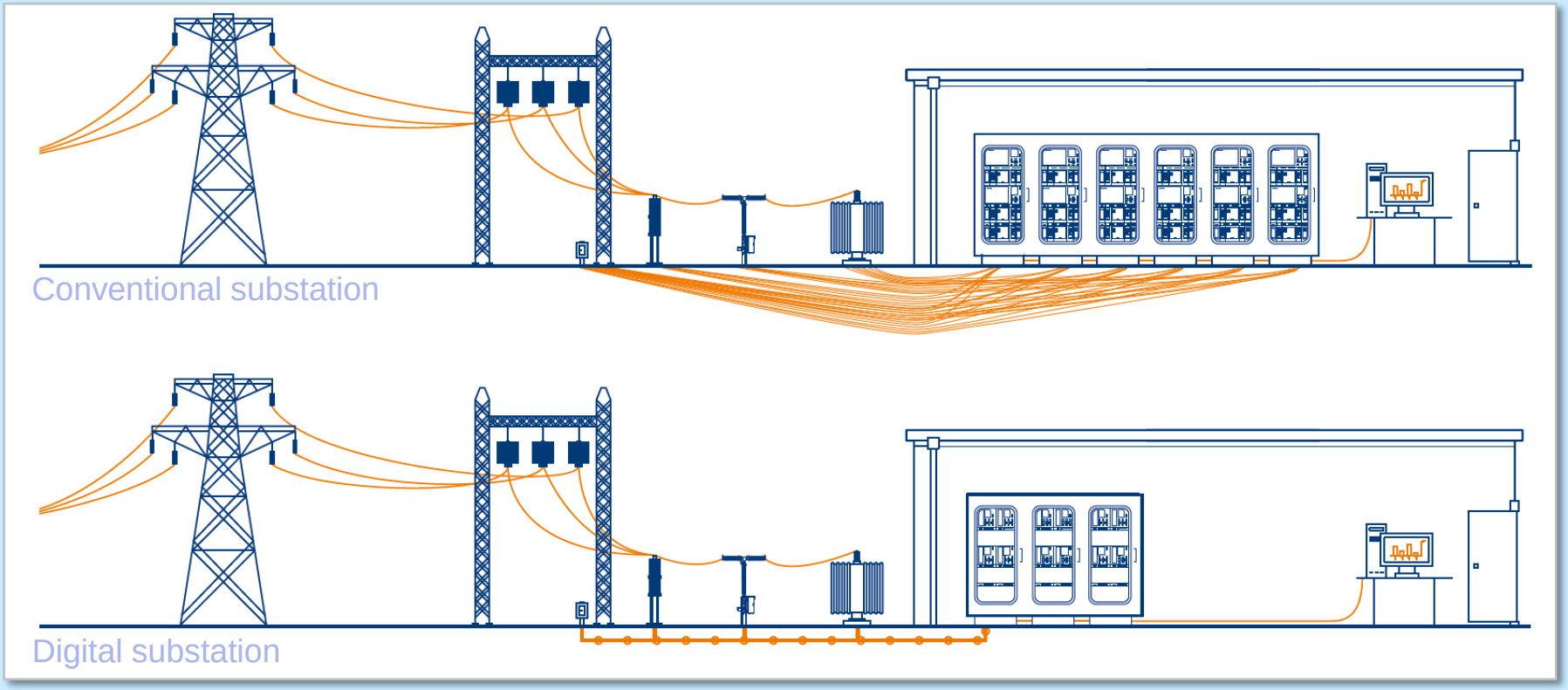
What is a digital substation?

Evolution of SAS applications



What is a digital substation?

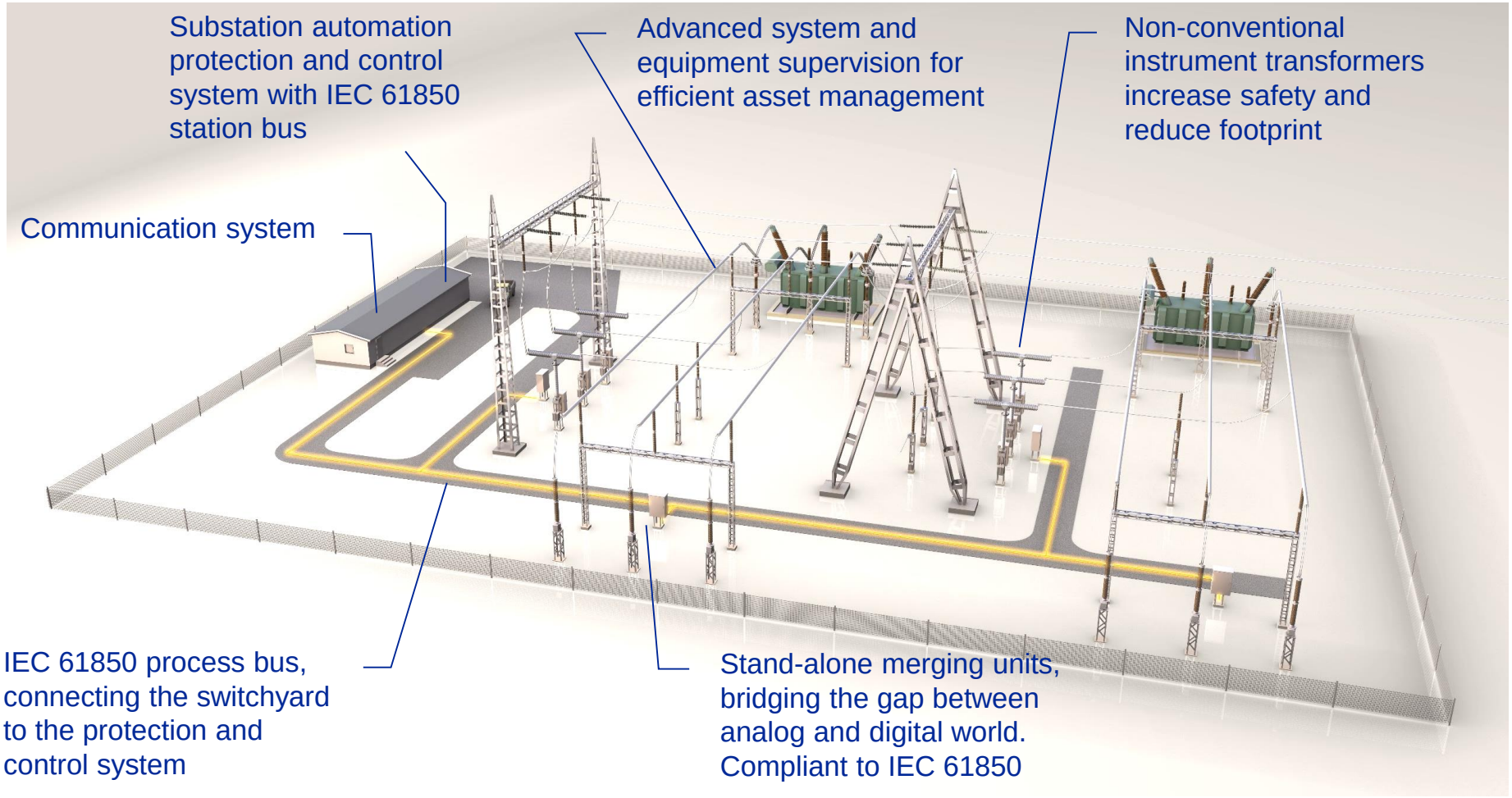
Comparison of conventional and digital



Digital substations reduce cabling, need less space and increase safety.

What is a digital substation?

Building blocks



Agenda

What is a digital substation?

Benefits of digital substations

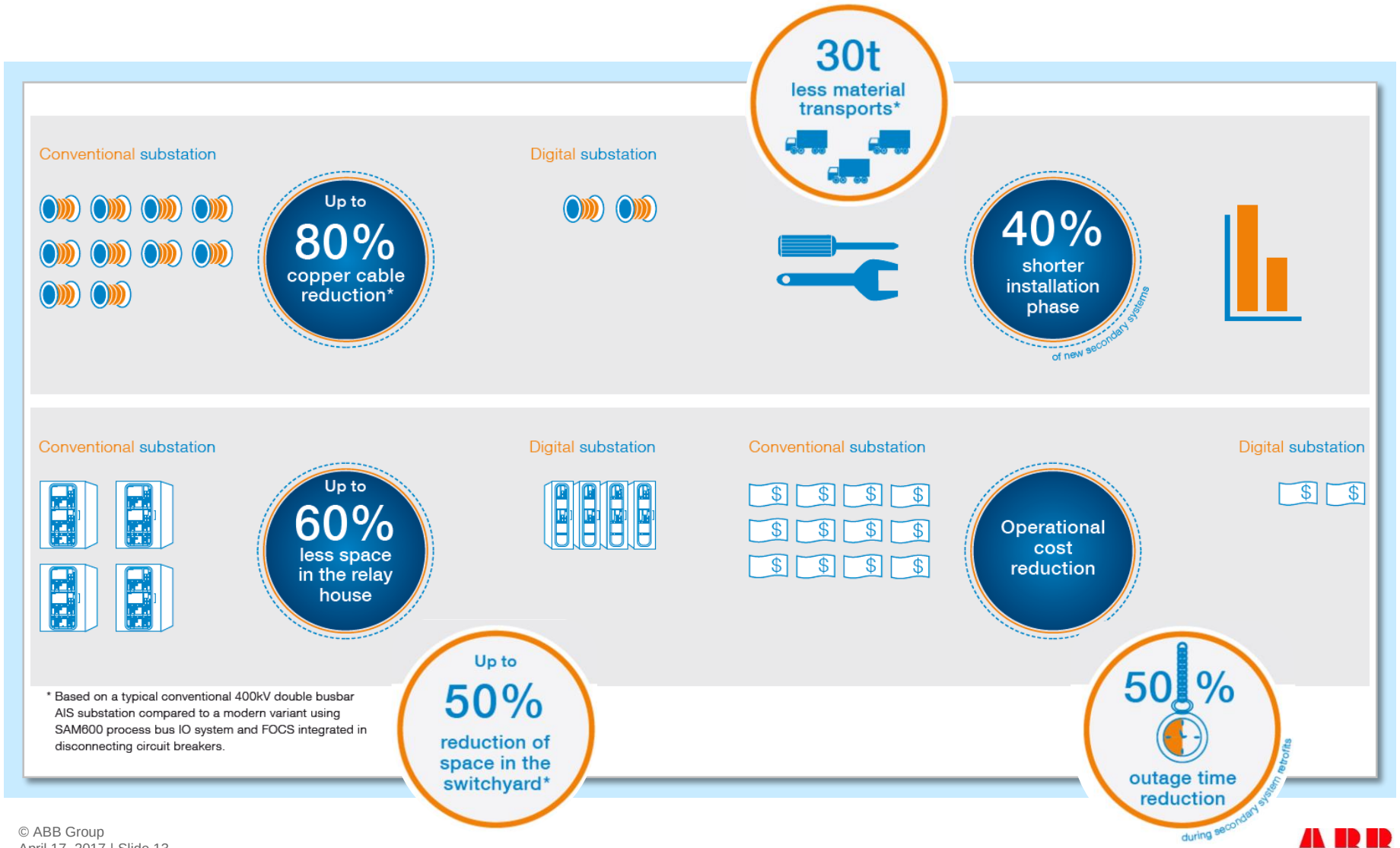
Solutions

SAM600 merging unit

Project reference cases

Benefits of digital substations

Overview



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

* in transmission level AIS substations

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 CO_2, less heavy lifting equipment used

Benefits of digital substations

Space reduction

- Space requirement reduced by half

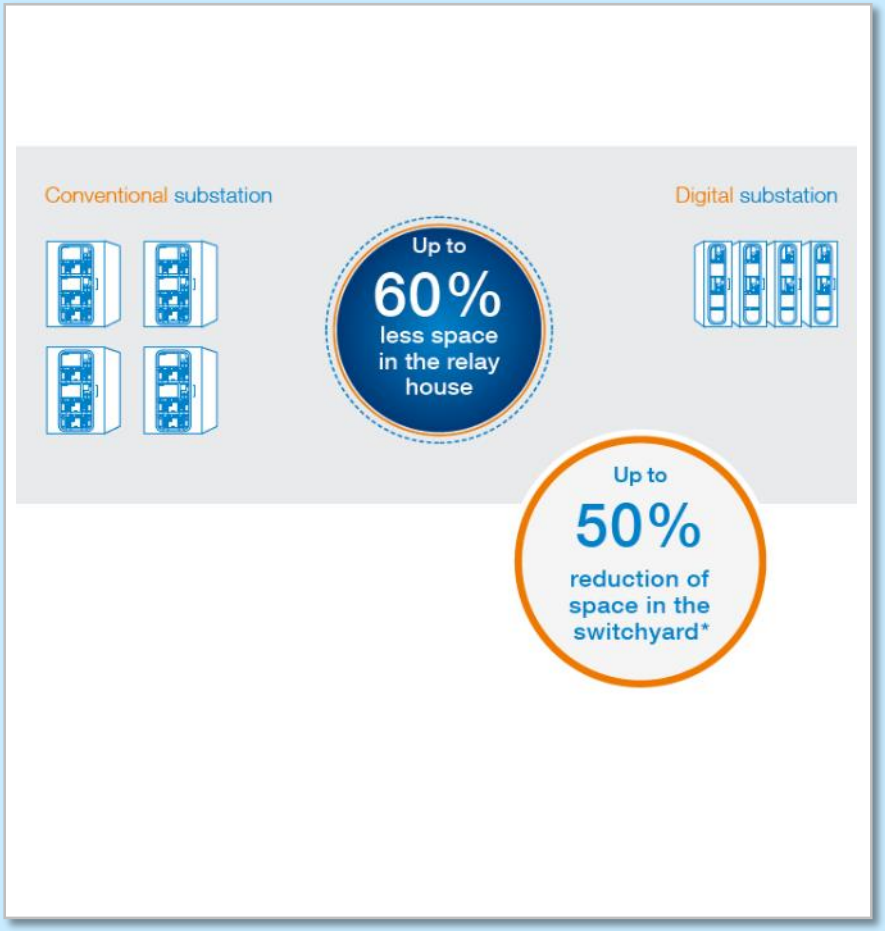
30 to 60% reduced space for protection and control panels

- Same number of IEDs require less space due to absence of conventional IOs
- Higher integration of control and protection functionality allows for further space reduction

Reduction of switchyard footprint by up to 50%

- By using circuit breakers with integrated disconnecting functionality and optical current transformers

High function integration in relay room and switchyard enable space reduction



Benefits of digital substations

Less installation and outage time

- Shorter time for secondary system installation and refurbishment

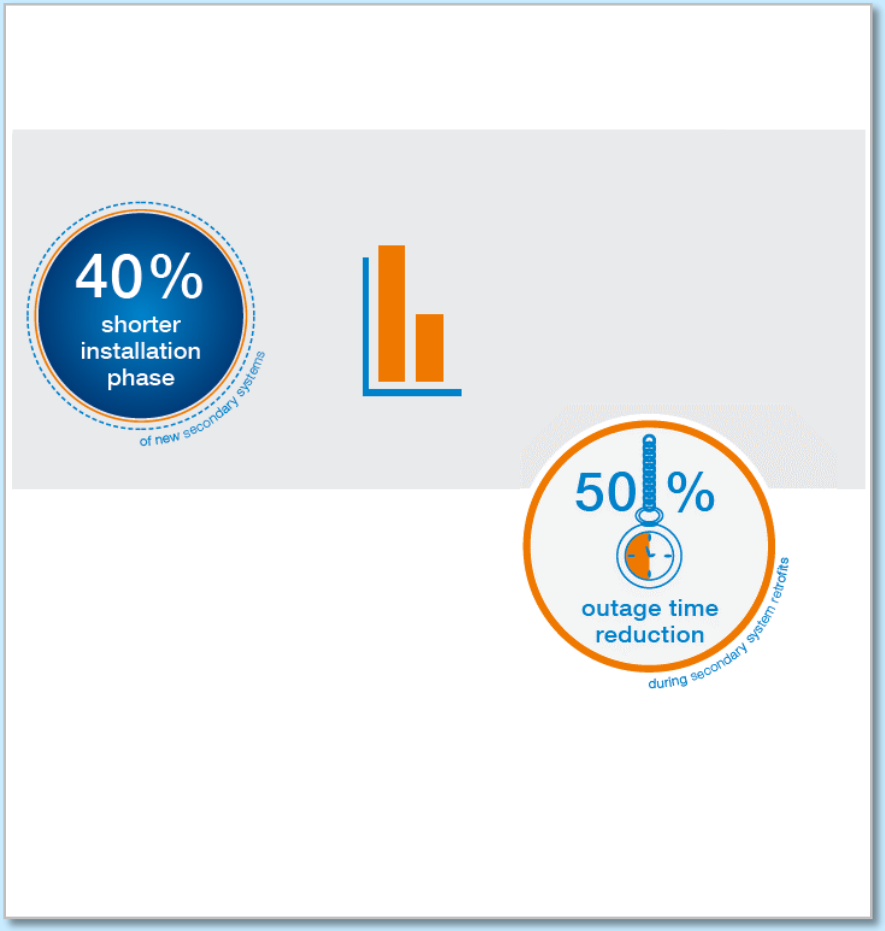
40% reduction of installation time for new protection and control systems.

- Fewer panels to install
- Fewer cables to be pulled, connected and tested

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

Shorter outage times increase utility revenues



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

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

Benefits of digital substations

Installation and operation phase

Installation phase

Standardized and factory-tested panels

Building blocks, e.g. analog and binary IO kiosks

Late customization, even after project delivery

All communication digital based on IEC 61850

Material reduction

Less P&C panels, cabling & cable engineering. Less CT/VT cores, space reduction

Outage time reduction

Faster installation through pre-tested process bus systems

Operational phase

Increased safety

Digitizing all signals right at their source reduces the risk of electrical hazards

Effective maintenance

More supervision → knowing better what & where equipment failed

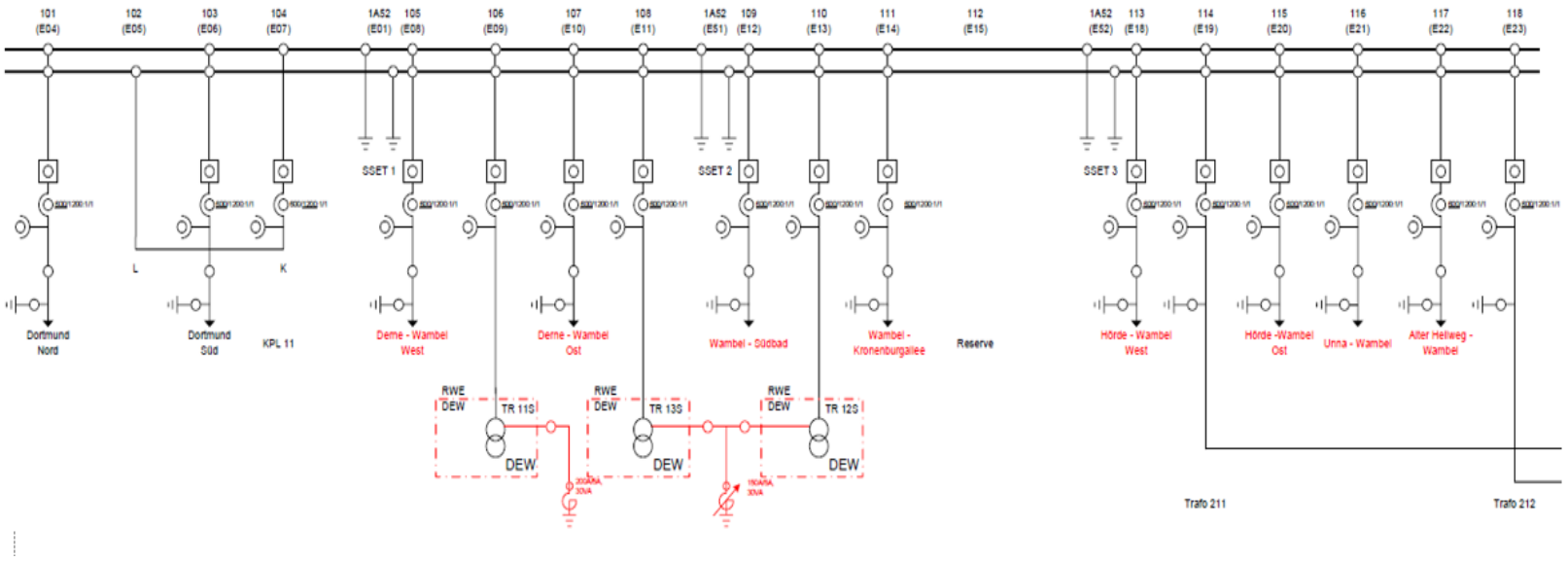
Easier maintenance

Upgrading equipment with less need for outages

Standardized process interface

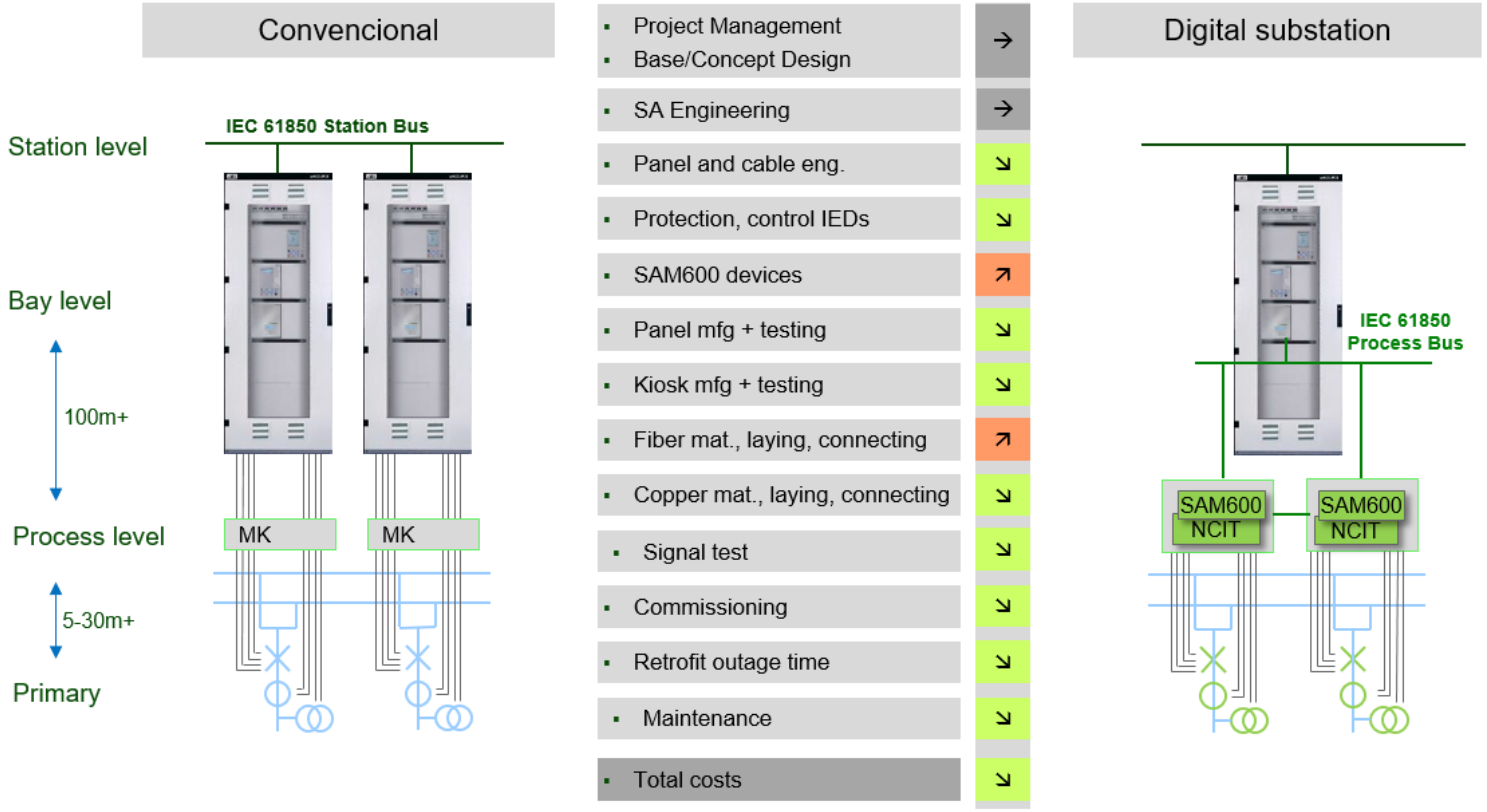
Fast replacement process and bay electronics during primary equipment lifetime

Benefits of digital substations
Study case by ABB Switzerland



- The single line diagram above is a reference to Wambel, voltage level 110kV in Switzerland. The study performerd with the customer has considered the following scope:
  - 10 bays/breakers;
  - 1 tie;
  - 3 power transformers

Benefits of digital substations
Study case by ABB Switzerland



- The comparison shows the costs of a conventional AIS substation and a solution with process bus.

Benefits of digital substations
Study case by ABB Switzerland

4	Electronics	Station			244800		408320
4.1	Station level devices (uSCADA, GW, GPS, EngPC, Switches	Station	1		56000		56000
4.2	Bay level devices (P&C IEDs, switches, Meter)	Feeder	10		188800		172320
4.3	Process level devices (SAM600)	Feeder	10		0		180000
5	Manufacturing	Feeder			176710		95080
5.1	Panel manufacturing and testing	Feeder	10		84590		53080
5.2	Kiosk manufacturing and testing	Feeder	10		92120		42000
6	Material outdoor	Feeder			514800		127300
6.1	Fiber cable materials	Feeder	10		0		45400
	Fiber cable from feeder to station	Feeder	10	0	0	4	40800
	Fiber cable between cubicles	Feeder	10			2	3400
	Fiber cable between kiosks in feeder	Feeder	10	0	0	1	1200
6.2	Copper cable materials	Feeder	10		514800		81900
	Cable type 21x1.5	Feeder	10	13	187200	6	14400
	Cable type 42x1.5	Feeder	10	8	230400	0	0
	Cable type 8x2.5	Feeder	10	4	43200	1	1800
	Cable type 2x4	Feeder	10	0	0	13	11700
	Cable type 2x4	Feeder	10	10	54000	10	54000
7	Field work	Feeder			267372		206004
7.1	Decomissioning	Feeder	10		111600		111600
7.2	Fiber installation and testing	Feeder	10		0		10560
	Amount of fibers from feeder to station	Feeder	10			4	9600
	Amount of fibers between kiosks	Feeder	10			0	0
	Amount of wires total connections	Feeder	10			4	640
	Amount of wires verification	Feeder	10			4	320
7.3	Copper installation and testing	Feeder	10		150272		78344
7.4	Commissioning	Feeder	10		5500		5500
	Total (USD)				**1732022**		**1344534**

- The table presents the costs differences between both solutions (conventional and process bus).

Agenda

What is a digital substation?

Benefits of digital substations

Solutions

SAM600 merging unit

Project reference cases

The ABB offering for digital substations

Relion® family protection and control IEDs

- 670 series protection and control IEDs with IEC 61850-9-2LE process bus for any application

- REB500 distributed busbar protection system supports IEC 61850-9-2LE

Digital Substations

Bridging the gap between analog and digital technologies

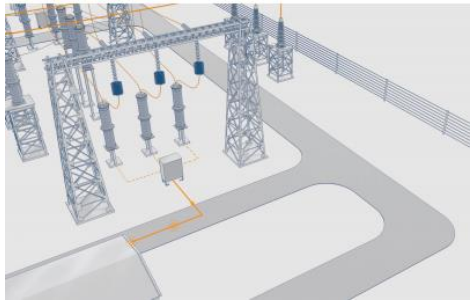
- Bridging the gap with digitalized technology solutions

+10,000

IEC 61850 Substation Automation Systems installed worldwide

+15

IEC 61860-9-2 Digital Substation projects in 2015



Worlds 1st

IEC 61850 Edition 2 Conformance tested system and device engineering tools

Process Bus developments

Stand alone merging unit (SAM600) process bus IO systems enabling efficient upgrades and retrofitting

Agenda

What is a digital substation?

Benefits of digital substations

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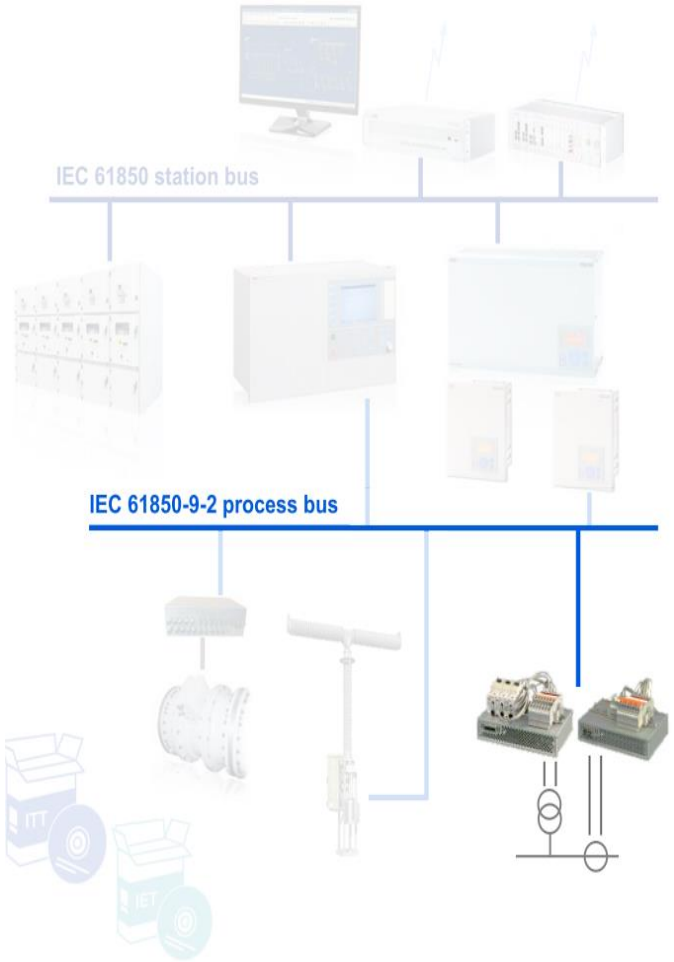
SAM600 merging unit

Project reference cases

SAM600 merging unit
Process bus solution



- For each primary equipment there´s a SAM600 module (CTs and VTs);
- The modules are interconnected to support several applications topologies;
- SAM600 hardware is compact and allows the installation on DIN rails for rapid and easy handle;
- Time synch between SAM modules PTP IEEE 1588.

SAM600 merging unit
Modular system

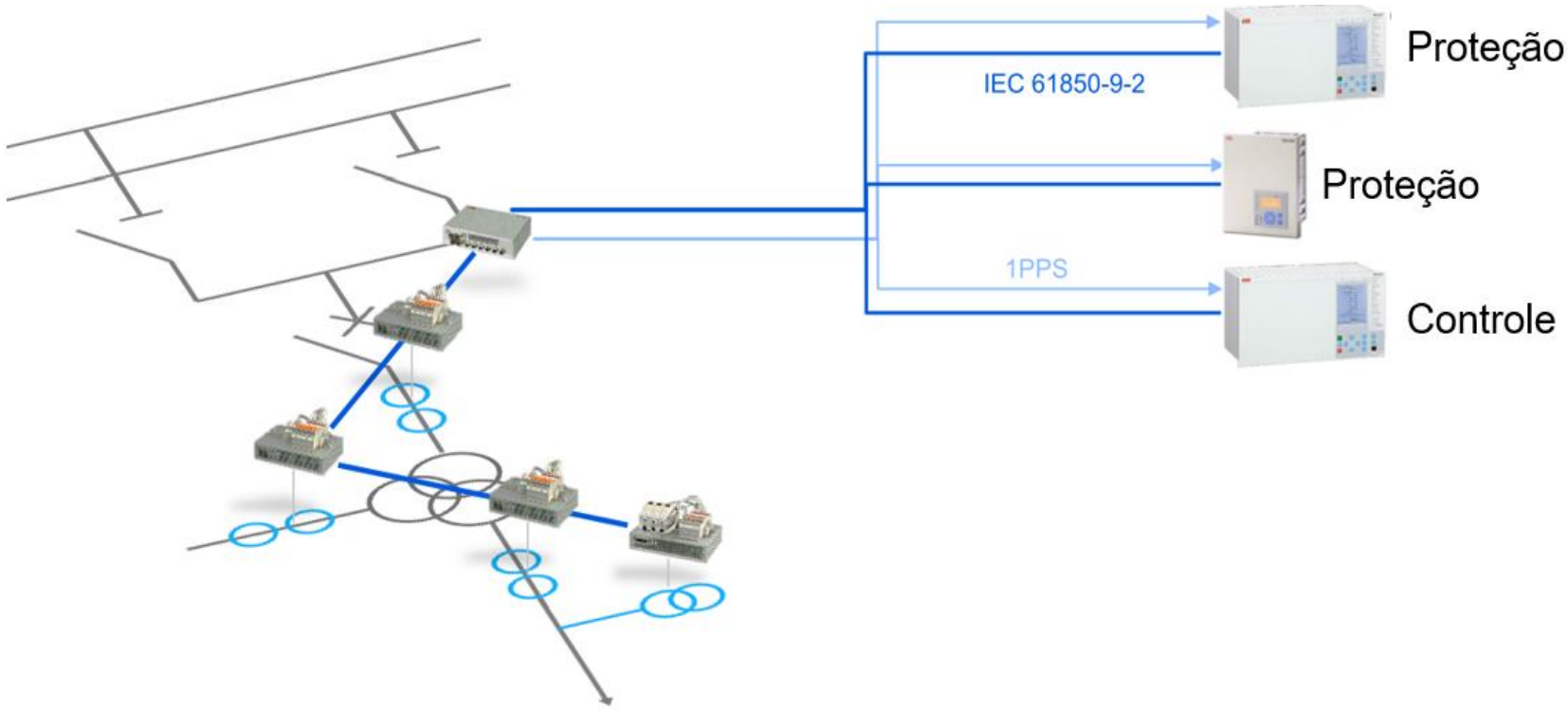
SAM600-CT
for current measurements

SAM600-VT
for voltage measurements

SAM600-TS
for optimal time synchronization

- The set of SAM600 is composed by voltage unit module (VT), current unit module (CT) and a synch unit (TS).

SAM600 merging unit
Interconnections



- The synch between SAM units is performed by PTP. In the same chain it´s possible to connect up to 7 modules (CTs and VTs). The IEDs are synchronized via PPS signals.

Agenda

What is a digital substation?

Benefits of digital substations

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SAM600 merging unit

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ABB's experience with IEC 61850-9-2 process bus

Project highlights

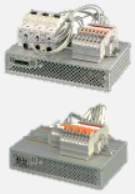
Pilot installation Braemar, AU
GIS NCIT, 670series

Pilot installation SvK, SE
DCB with FOCS, 670series

Pilot installation Nehden, DE
3rd party NCIT, REB500

Real installation Millmerran, AU
GIS NCIT, 670series, REB500

Pilot installation Vattenfall, SE
AIS 3rd party NCIT, 670, 630, 615series



Pilot installation TW
SAM600 670series, 3rd party

Real installation UK
SAM600, FOCS 670series, 3rd party

2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016

Pilot installation Laufenburg, CH
GIS NCIT, 670series, REB500

Real installation Loganlea, AU
GIS NCIT, 670series, REB500

Pilot installation CH
GIS NCIT, 670series, 3rd party

Real installation Braemar, AU*
GIS NCIT, 670series, REB500

Pilot installation UK
GIS NCIT, 670 series

Pilot installations CN
DCB with FOCS 3rd party

Pilot installation US
DTB with FOCS, SAM600, 670 series

Pilot projects are installations to verify technology and compare to traditional systems
Real projects are installations without traditional backup

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

*MTBF: mean time between failures

IEC 61850-9-2 process bus and NCITs - Switzerland

First NCIT and process bus installation

- Since 6+ years in continuous operation

NCIT and IEC 61850-9-2 pilot installation

- ELK-CP3 NCIT for current and voltage
- REL670 line, REB500 busbar protection
- E880 revenue meters from L+G

- Simple commissioning thanks to in-built supervision features of used products
- System in permanent and stable operation since 2009
- Protection performance is same as conventional system
- Measuring accuracy meets expected class 0.2s

Customer:
EGL, Swissgrid - Switzerland

Year of commissioning:
2009

Voltage level:
400kV

IEC 61850-9-2 process bus and NCITs - Sweden

FOCS with disconnecting circuit breaker

- Fiber optic current sensor FOCS

Project description

NCIT and IEC 61850-9-2 pilot installation with optical CT, integrated in disconnecting circuit breaker and REL670 line protection

Installed in parallel to conventional system to assess performance and long-term behavior

Pilot experience

FOCS (optical CT) measurements meets expected accuracy

Protection is running stable and meeting performance requirements

Followed by official release of life tank breaker with integrated optical CT

Customer:
Svenska kraftnät - Sweden

Year of commissioning:
2010

Voltage level:
400kV

IEC 61850-9-2 process bus and NCITs - Australia

Full substation with NCITs and process bus

- Retrofit of NCIT substation

Customer's needs

Secondary system upgrade of existing substation with ABB NCITs, protection and control with proprietary process bus

Future proof, fully IEC 61850 compliant

ABB's response

Upgrade to IEC 61850-9-2 compliant system by keeping primary equipment and sensors

Conformance tested CP-MU merging units, Relion 670 series and REB500 protection IEDs

Customer's benefits

Latest generation, IEC 61850 compliant protection, control and SA system

Minimum outage times during commissioning

Customer:
Powerlink Queensland - Australia

Year of commissioning:
first SS in 2011

Voltage level:
275kV

IEC 61850-9-2 process bus and NCITs - Germany

Pilot project with 3rd party NCIT

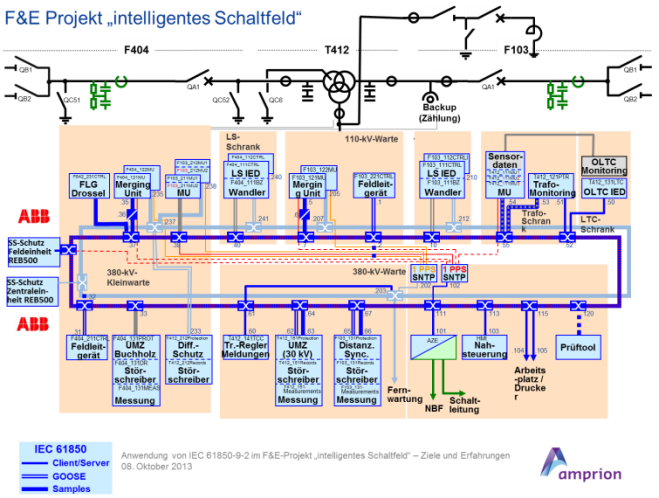
- Busbar protection with conventional and digital bays

Project description

- 3rd party optical CT with IEC 61850-9-2 and REB500 busbar protection system, intalled in Amprion's Nehden intelligent substation project
- REB500 system consists of 6 conventional and 1 bay unit with IEC 61850-9-2

Pilot experience

- REB500 system runs stable since commissioning
- Combination of conventional and process bus enabled bay units demonstrates usability of REB500 in modern substation extensions and retrofits



Customer:
Amprion, Germany

Year of commissioning:
2012

IEC 61850-9-2 process bus and NCITs - Switzerland

Pilot project with NCIT

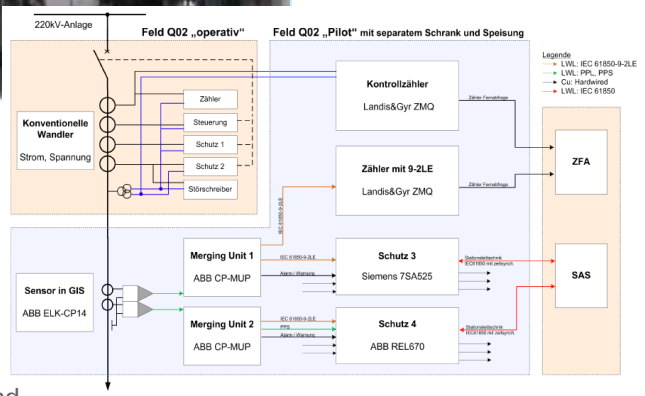
- GIS NCITs with protection and metering

Project description

- 220kV GIS substation with
- ELK-CP14 NCIT with redundant measurement of U&I and CP-MU merging unit with IEC 61850-9-2 connected to REL670 distance protection and 3rd party protection IED
- L+G revenue meters with 9-2 and conventional inputs

Pilot experience

- Initial challenges with NCIT calibration could be solved on site, during operation
- Stable operation since commissioning



Customer:
BKW, Switzerland

Year of commissioning:
2012

IEC 61850 Process bus – Brazil, Paraguay

500kV/220/66kV substations

- Process bus for binary values

Project description

- 500kV/220/66kV AIS substations
- 46 Relion series IEDs installed in the switchyard as process interface units
- GOOSE for communication to bay level IEDs
- MMS reporting of events and alarms from primary apparatus

Pilot experience

- System up and running since commissioning
- Temperature measured in the outdoor cubicles stays within the acceptable range for the installed electronics

Customer:
Itaipu Villa Hayes, Brasil, Paraguay

Year of commissioning:
2013

IEC 61850-9-2 process bus and NCITs - Switzerland

Pilot project with NCIT

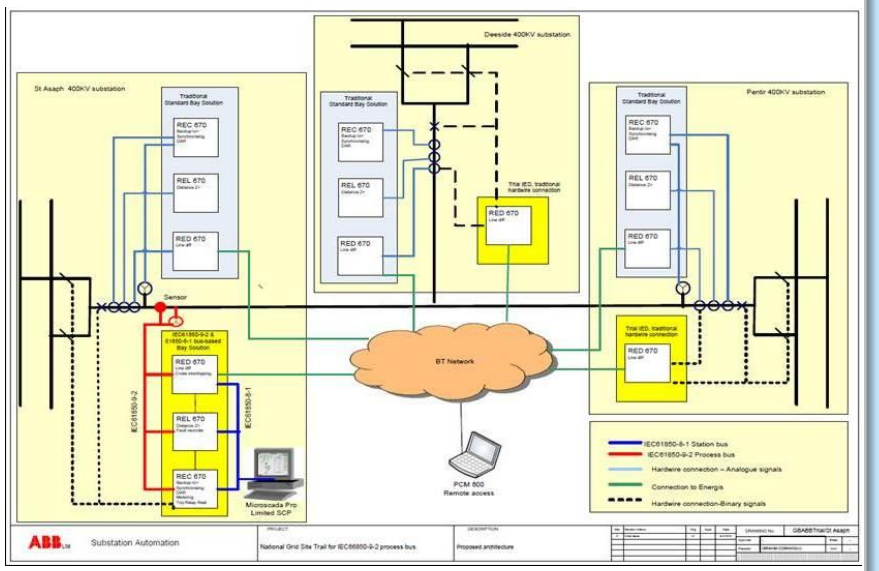
- GIS NCITs with protection and metering

Project description

- 400kV GIS substation with
- ELK-CP14 NCIT with redundant measurement of U&I and CP-MU merging unit with IEC 61850-9-2
- REL670 distance protection, RED670 differential protection, REC670 control IED
- Line differential protection with 3 line ends (local end with NCITs, the remote ends with conventional CTs)
- L+G revenue meters with 9-2 and conventional inputs

Pilot experience

- Commissioning of NCIT and protection completed



Customer:
NG, United Kingdom

Year of commissioning:
2015

IEC 61850-9-2 process bus with SAM600

Stand-alone merging units in existing substation

- SAM600 modular IO system distributed in existing panels

Project description

- SAM600 installation in existing 161kV substation
- RET670 and 3rd party protection IED with IEC 61850-9-2 process bus
- Verification of correct operation compared to traditional installation

Pilot experience

Equipment installed and successfully commissioned in January 2015

Year of commissioning:
2015

Voltage level:
161kV

IEC 61850-9-2 process bus and NCITs - UK

Wishaw 275 kilovolt (kV) substation

- SAM600 modular IO system distributed in existing panels

Customer's need

- Demonstrate interoperability in a multi-vendor IEC61850 digital substation, with optical CTs, protection, control & phasor measurements
- Expert partner to develop the FITNESS project (Future Intelligent Transmission Network Substation)

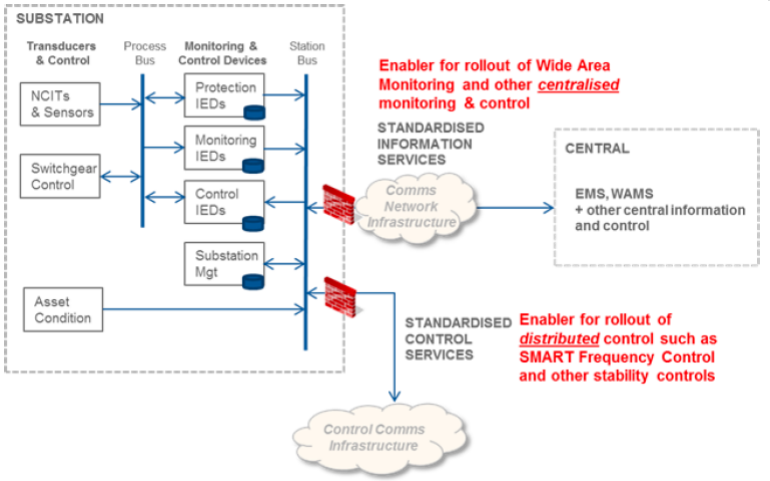
ABB's response

Process bus system with:

- FOCS optical CT
- SAM600 process interface units
- 670 series protection IEDs

Customer's benefits

- Expectation: 10 percent saving in overall substation costs; footprint reduction of around 15 percent



Customer:
Scottish Power Energy Networks (SPEN)

Year of commissioning:
2017

ABB’s experience in NCITs and process bus

Various

- ABB’s CP-MUP merging unit was the first to be UCA conformance tested by an independent accredited test lab
- Verification and validation of IEC 61850-9-2LE protection and control IEDs as well as merging units at ABB’s UCA certifed System Verification Center
- ABB protection IEDs have been used for IEC 61850-9-2LE simulation testing by test equipment manufacturers, like Omicron and RTDS Technologies
- Various testing activities at ABB’s and customers laboratories
- …

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