ABB's Digital Substations for reliable next generation Transmission Networks
"Let's write the future. Together"
Hugo E. Meier, Business Unit Product Manager Grid Automation
ABB’s Digital Substations for reliable next generation Transmission Networks

- Look and feel..
- The challenges …
- The evolution…
- Key enablers..
- Bringing it all together ..
- Experiences and References
- Benefits
- “the digital summary”
Substation
How does a substation look like?

- Large Air Insulated Substation (AIS)
- Large Gas Insulated Substation (GIS)
Substation Automation

100 years ago

today
The challenges for utilities and suppliers

Challenges in the market place
- 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
The Substation Evolution
Transition from conventional to the Digital Substation

Key enablers

Traditional substations have always relied on copper cables connecting together primary equipment like circuit breakers, conventional current and voltage transformers and protection relays. But digital technologies, communications and standards are driving the evolution of something new – Digital Substations.

- IEC61850
- IEC61950-8-1 Station bus
- IEC61850-9-2 Process bus
- NCIT nonconventional transformers
- SAM Standalone-merging units
- Sensors and actuators
Trends and technologies of control systems
From traditional to future grids

1975 1995 2010

First NCITs
IEC 61850 Standard
IEC 61850-9-2 Standard

Traditional MMI / control board
SA with station bus
SA with station & process bus

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October 30, 2017 | Slide 7
What is a digital substation
From to conventional and digital

Digital substations reduce cabling, need less space and increase safety.
What is Digitalization?

**Digitization** is the conversion of analog information in any form (text, photos, voice, etc.) to digital form with suitable electronic devices (smartphone, laptop, sensor, etc.) so that the information can be processed, stored, and transmitted digitally.

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

“By 2020, 50% of the Global 2000 will see the majority of their business depend on their ability to create digitally-enhanced products, services, and experiences. For industry leaders, the fastest revenue growth will come from information-based products and services. To facilitate the development of these products and services, worldwide investment in (digitalization) initiatives will reach $2.2 trillion in 2019, almost 60% more than in 2016.”

Source: IDC, 2016

Examples:
- Starwood's SPG Keyless Lets Guests Access Their Room With a Smartphone
- Babolat “Play” Connected Tennis Racquet Lets Players Analyze Their Game
- British Gas Provides a Smart Home Heating Controller Called Hive Active Heating
Digital Substation
NCIT (sensors) solutions for GIS and AIS

FOCS sensor head and electronics for AIS

Combined Current & Voltage sensor for GIS

IEC 61850-9-2 LE

Control and Protection
Digital Substation
Innovative solutions for a smaller foot-print

Values of smaller foot-prints

- Put SS at optimal location
- Reduce demand of land
- Less foundation costs
- Lower cost of civil work
- Less transportation
- Less material
- Prefab., pretested solutions
- Lower transportation costs
- Faster erection and commissioning
Digital Substations
Example: Space reduction in AIS

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

Reduction of GIS footprint by up to 30%
- By using NCITs for current and voltage
- By integrating LCCs to GIS switchgear

High function integration in relay room and switchyard enable space reduction

Up to 50% reduction space in the switchyard
Digital Substation

Example: Opportunities to reduce the foot-print for a 145 kV GIS
Digital Substation
NCIT for GIS hybrid in operation in Switzerland

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
Digital Substation
Example: NCIT replace conventional CT and VT in 145 kV GIS

Footprint reduction of up to 30% for HV GIS with NCIT
**Digital Substation**

Simplification of wiring and C&P panels in GIS

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**Full integration**

Thanks to the reduction of wires, IOS and IED’s the bay control and protection function can be integrated into one GIS bay. Some limitations may be given by the ratings of the primary equipment and by C&P specifications.
Digital Substation
Main components with integrated monitoring and diagnostics functions

Features
- Monitoring & Diagnostics for switchgear, transformers and IEDs
- Communication via IEC 61850 and other standards
- Connected to station monitoring and network level systems

Benefits
- Allows to shift from fixed time-based to condition or risk-based maintenance schemes
- Future: Dynamic loading (overloading in emergency)
The ABB offering for digital substations

SAM600 process bus IO system

Modular IO system for conventional CTs and VTs

- SAM600-CT for conventional current and SAM600-VT for voltage transformers
- SAM600-TS for time synchronization

Compact modules are chained into a system to optimally adapt to different applications

IO module for binary signals

- Scalable SAM600-IO device for integration of conventional breakers, disconnectors, power transformers... into IEC 61850 process bus
Transmission Automation

Portfolio and architecture

- Digitization of the signals at the process level
- Communication via IEC 61850
- Control, monitoring, supervision and visualization of the substation at station level
- System-wide engineering via integrated software
- Utility Communication via MLPS-TP
- Connectivity to Enterprise level for connected asset life cycle management

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Bringing it all together
ABB Ability™ Connected Asset Lifecycle Management™

- Unifies in a single solution asset management, maintenance and monitoring
- Combines disparate data sources to create a single source of truth
- Proactively predicts, prescribes and prioritizes maintenance
- Enables planning based on risk of failure and operational criticality
- Utilizes expert data modeling for continual improvement
- Leverages real-time operations data for improved efficiencies
- Delivers the right people to the right work at the right time
Asset Lifecycle Management is the process of optimizing the business benefit from assets throughout their lifecycle.
Bringing it all together

ABB Ability™ Connected Asset Lifecycle Management™

Integration with Substation Automation System drives work via condition monitoring
Case study
AEP American Electric Power

Territory in **11** states
*5.1 million* customers
**40K miles** of electric transmission lines
**215K miles** of electric distribution line

- **20,572** breakers
- **8,846** transformers
- **3,384** batteries

2 Years from Idea to 30,000 asset constantly managed

Prevented Multiple $5m Transformer Failures

Significant Reduction in O&M Costs

Now expanding to Cables, Capacitors & Other Asset Types
ABB’s IEC 61850 digital substation experience

Project highlights

Pilot installation NL
GIS NCIT, L+G revenue meter

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 Millimerran, AU
GIS NCIT, 670series, REB500

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

Pilot installation TPC, TW
SAM600 670series, 3rd party

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

Pilot installation CN (several)
DCB with FOCS 3rd party

Pilot installation US
DTB with FOCS, SAM600, 670series

Pilot installation BR
SAM600 670series

Real installation IN
SAM600 670, 615 series

* 3 more projects under commissioning by utility

Pilot projects are installations to verify technology and compare to traditional systems

Real projects are installations without traditional backup
Benefits of digital substations

Less copper

Reduction in copper cables by up to 80%*

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<tr>
<th>Conventional substation</th>
<th>Digital substation</th>
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<td>Up to 80% copper cable reduction</td>
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30 tons less material

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<td>Around 30t Less material</td>
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Point to point copper connections get replaced with fiber optics

Less transport, less CO2, less heavy lifting equipment required

* in transmission level AIS substations
**Benefits of digital substations**

Less space in relay room

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

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Up to 60% less space in relay room

High function integration and NCITs enable space reduction in the switchyard

Up to 50% reduction space in the switchyard

Disconnector

CT

Circuit breaker with integrated optical CT and disconnecting function
Benefits of digital substations
Shorter installation time

Shorter time for secondary system installation

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40% shorter installation time of P&C system

Shorter outage times increase system availability and utility revenues

Shorter time for secondary system refurbishment

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40% outage time reduction during P&C retrofit

Shorter installation time decreases project runtime
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*