Digital Substation as a Building Block for Power System Operations
Rich Hunt - GE Grid Solutions
3 Mega-trends reshaping the Energy landscape:

The “Three D’s”

Decarbonisation
Renewable Energy Sources (RES)
Electrification
Energy Efficiency
Greenhouse-effect Gas reduction

Grid 2.0
Distributed Energy Resources (DER)
Micro Grids, Prosumers
Energy Storage, EV
Distributed Grid Automation

Digitisation
Internet of Things (IoT)
Smart Grid, Digital Control
IP Networks, Cloud
Digital Business

Decentralisation

The three 'D's of Grid 2.0! Image: Younicos
What does this mean?

- Changes to power system operations will come fast
- New owners of sources
  - Operations must be negotiated / cooperative, not hierarchical
- Everyone (utilities, DER owners, customers) needs information
- Old protection and operating schemes must be adapted quickly
  - Transmission on distribution
  - Short circuit current? Stability? Capacity?
- Future must be application driven
  - Hardware and vendor independent
Our substations need to be smarter

- Key control point of power system
- Closest to loads, DERs, etc.
Digital Utility Reference architecture - Grid
Digitally Enabled Substation

Concept

Description

- Process bus to provide primary equipment data
- Everything running as independent applications in Substation Edge Device
- Quickly add/adapt/improve applications across the system
Substation Edge Device

Containers

Data – Connect to, acquire, and manage all needed data for situational awareness

Speed – develop, test, rollout new applications for system operations

Dynamism – settings based on actual operating conditions

Continual updating possible
The Digitally Enabled Substation in Action
Situational Awareness
What’s going on in our substation?

Asset Performance Management (APM)
Environmental monitoring
Safety (APM, incipient fault detection)
Optimized Maintenance
• Fewer trips
• Fewer and shorter outages
Fault Analysis and Location
APM Strategy

Use data and analytics to determine capacity, when to maintain

Connect / Collect
- Sensor Data / Alerts / Events
- Inspection Data / Alerts / History Events
Adaptive Transformer loading

Take:
- Transformer monitoring data
- Meteorological data
- Load and predicted load

Then
- Control cooling to pre-cool transformer
- Extend service life

Turn data... into action

The Substation of the Future | 21 February 2018 11
Dynamic line ratings

A problem to solve...

Static line loading ratings limit response to peaks

...with data

Use data for dynamic line ratings
- Real-time condition visibility
- Meterological data
- Predicted flow

Result:
- adjusting line conditions allows temporary over
- Up to 30% increase in flow limits
New Analytics

Storm Response

- Predictive & prescriptive analytics
- Recommend responses to forecasted storms
- Adjust system operations
- Better resource staging
- Reduce outage times

12-Hour Ahead Outage Forecast
**WAMS**

*For transmission and distribution*

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**WAMS data**

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**WAMS uses**

- PMUs and microPMUs
- Near Realtime Stability Monitoring
- Sub Synchronous Oscillations and active dampening
- Advanced Islanding Resynchronization
- Short Circuit Calculations
- System Disturbance Monitoring
- Fast Voltage Stability Assessment for Transmission

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[Image of WAMS data and diagram]
Distributed Energy Resources Management Systems (DERMS)

**Application**

- Visualize and plan DER deployment
- Calculate capacities
- Mitigate negative impacts on voltage, grid capacity, power flow
- Optimize and control DERs
- Input to market operators
Substation of the Future

Conclusions

- Fully digital and future proof
- Process bus and IEC 61850
- Fully digitally enabled
- Substation Edge Device running independent applications
- Applications quickly developed and rolled out