Northwest Energy Systems Symposium

Enhancing Snohomish County PUD Grid Operations and Reliability Utilizing Smart Grid Technologies

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ALSTOM

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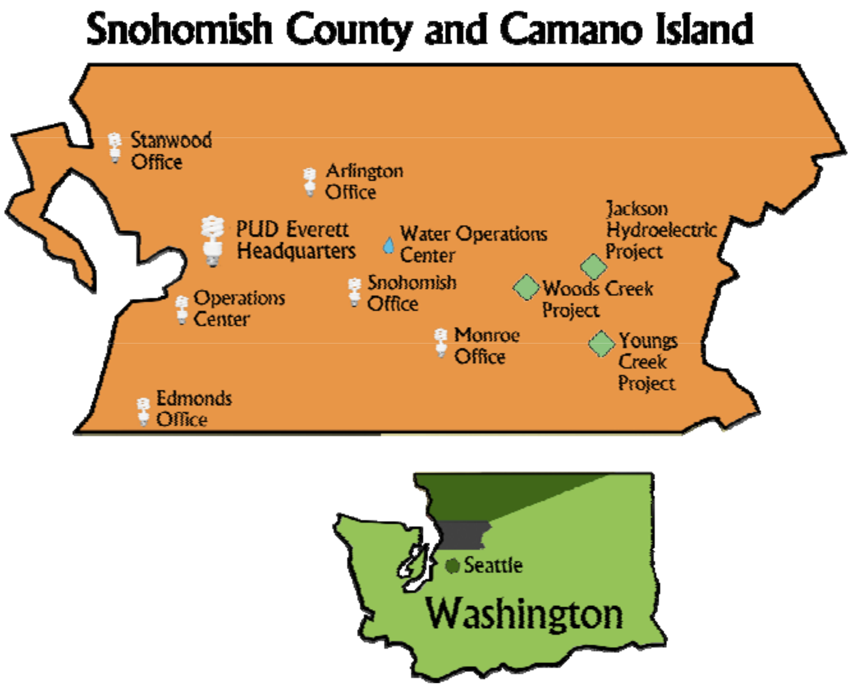
Agenda

- Background
- Smart Grid Strategy
- Smart Grid Benefits
- Smart Grid Projects
- Systems, Domains and Process Integration
- DMS Architectural Overview
- DMS System Configuration
- DMS Situational Awareness
- DMS Expected Benefits
- Challenges

Company Profile: Snohomish PUD

- **Total Electrical Customer:** 320,000
- **2010 Energy Sales:** 8,073,332 MWh
- **Generating Capacity:** 164 MW
- **Residential Rates:** 8.3¢ per kWh
- **# of Substations:** 86
- **# of Circuits:** 396
- **Resource Mix:** 8% Renewables



What is a Smart Grid?

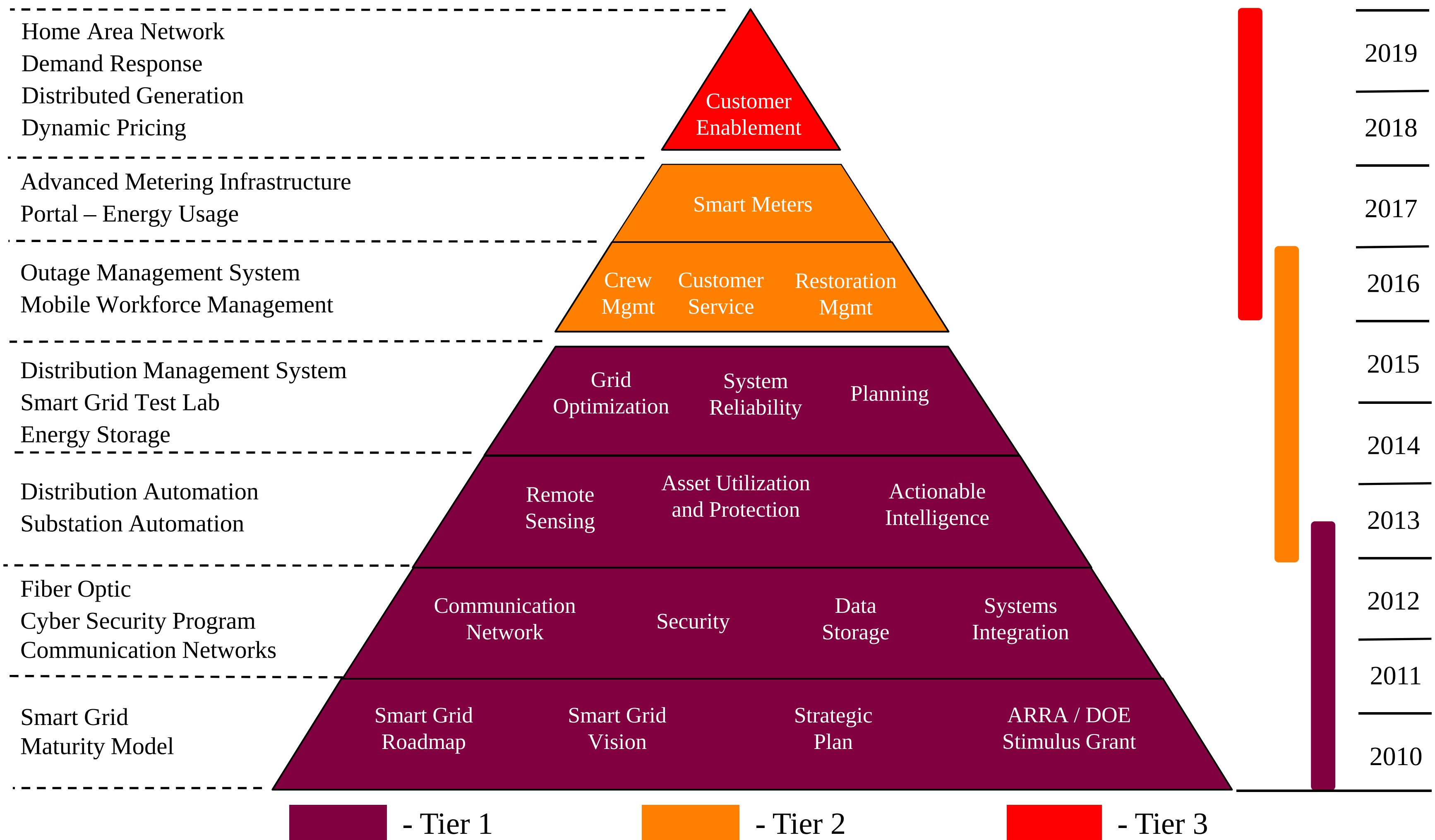
The integration and application of real-time monitoring, advanced sensing, communications, analytics, and control, enabling the dynamic flow of both energy and information to accommodate existing and new forms of supply, delivery, and use in a secure and reliable, and efficient electric power system, from generation source to end-user.

North American Electric Reliability Corporation (NERC)

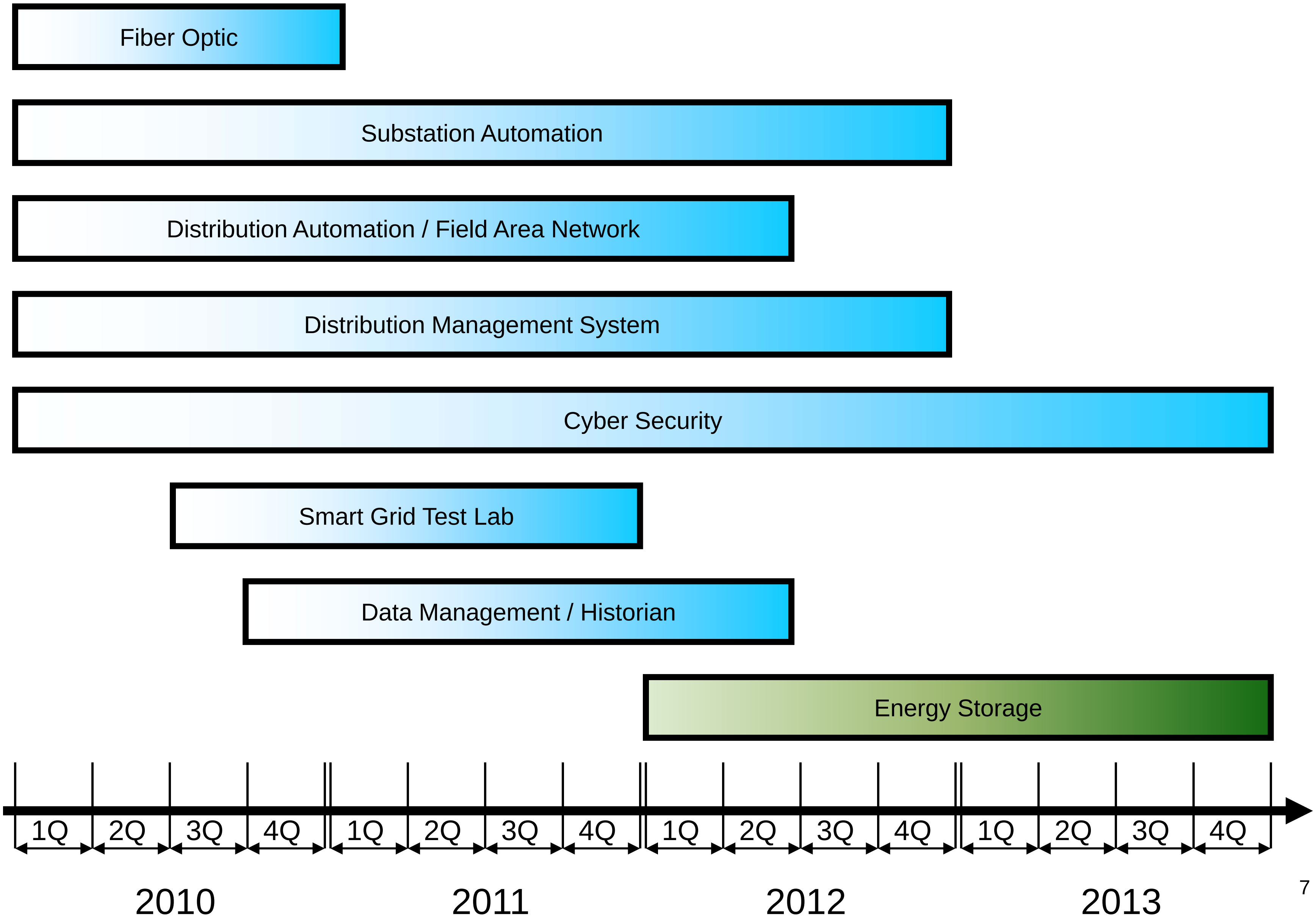
Smart Grid Benefits

- Improved power reliability and power quality
- Improved safety and cyber security
- Improved energy efficiencies
- Reduced environmental impact
- Increased energy conservation
- Customer choices
- Direct financial

Smart Grid Pyramid

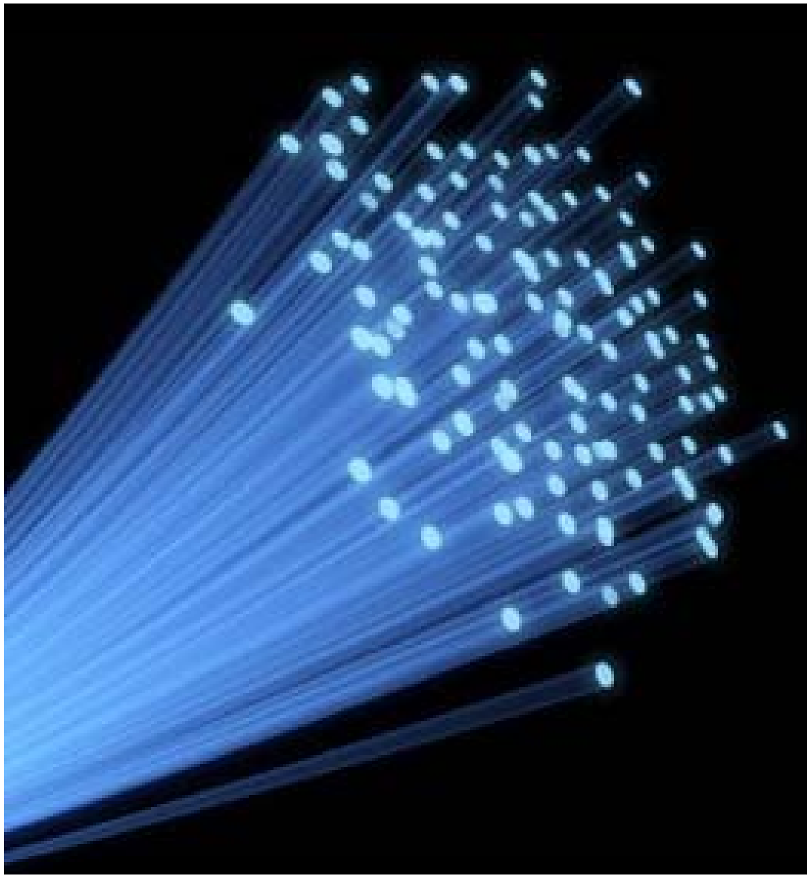


Smart Grid Projects



Fiber Optic

- Provides two-way high speed data communications to substations
- 163 miles installed
- Completed 12/2010
- Project Budget - $7M



Substation Automation

- Replace analog equipment with digital technologies
- Enhanced communication equipment and systems
- Real time access to non operational information
- 42 of 86 Substations
- Project Budget - $12.2M

Substation Automation Benefits

- Reduce Operating Expenses
- Reduce Capital Expenses
- Meet Emerging Regulatory Requirements
- Improve Grid Security

Distribution Automation (DA) and Field Area Network (FAN)

- DA is a family of technologies including sensors, processors, and automated field devices that can perform a number of distribution system functions depending on how they are implemented.
- FAN is a communication network that wirelessly connects field devices with the District Operations Center

Network Requirements by Application

Application	Bandwidth	Latency	Reliability	Security	Backup Power
AMI	10-100 kbps/node, 500 kbps for backhaul	2-15 sec	99-99.99%	High	Not Necessary
Demand Response	14kbps-100kbps per node /device	500 ms- several minutes	99-99.99%	High	Not Necessary
Wide Area Situational Awareness	600-1500 kbps	20 ms – 200 ms	99.999- 99.9999%	High	24 hour supply
Distribution Energy Resources and Storage	9.6-56 kbps	20 ms – 15 sec	99-99.99%	High	1 hour
Electric Transportation	9.6-56 kbps, 100 kbps is a good target	2 sec – 5 min	99-99.99%	Relatively High	Not Necessary
Distribution Grid Management	9.6-100 kbps	100 ms – 2 sec	99-99.99%	High	24-72 hours

Department of Energy analysis - Oct. 5, 2010

Network Performance Requirements for DA

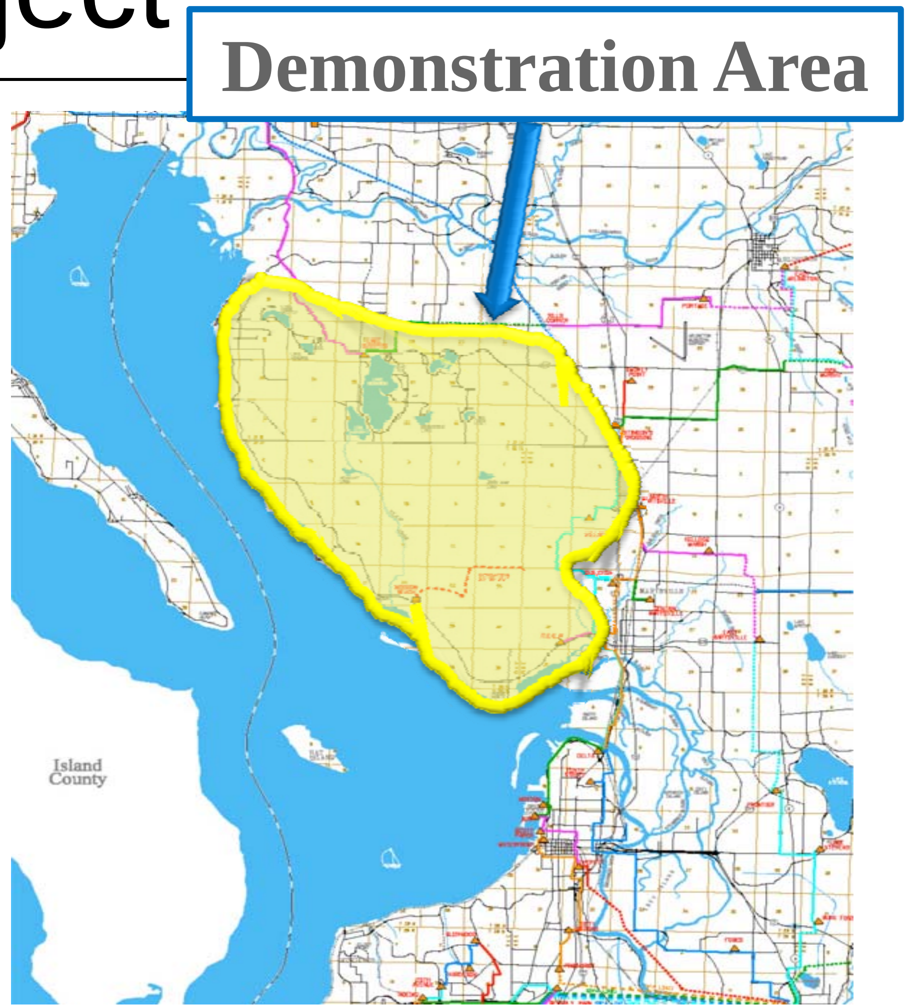
	Monitoring and Sensing	Conditioning and Control	Switching and Protection
Applications	•Asset monitoring •Power quality monitoring •Predictive maintenance	•Volt/Var optimization	•Fault detection, isolation and recovery •Feeder reconfiguration •Outage management
Grid Devices	•Transformers •Cap - bank neutral current monitors •Voltage and current sensors	•Voltage regulators •Capacitor - bank controllers •Fault Current Indicators	•Switches •Reclosers •Sectionalizers •Breakers
Bandwidth	•Low	•Low	•Medium
Latency	•High (minutes)	•Medium (seconds)	•Low (tens of milliseconds)

Comparison of Wireless Technologies for DA

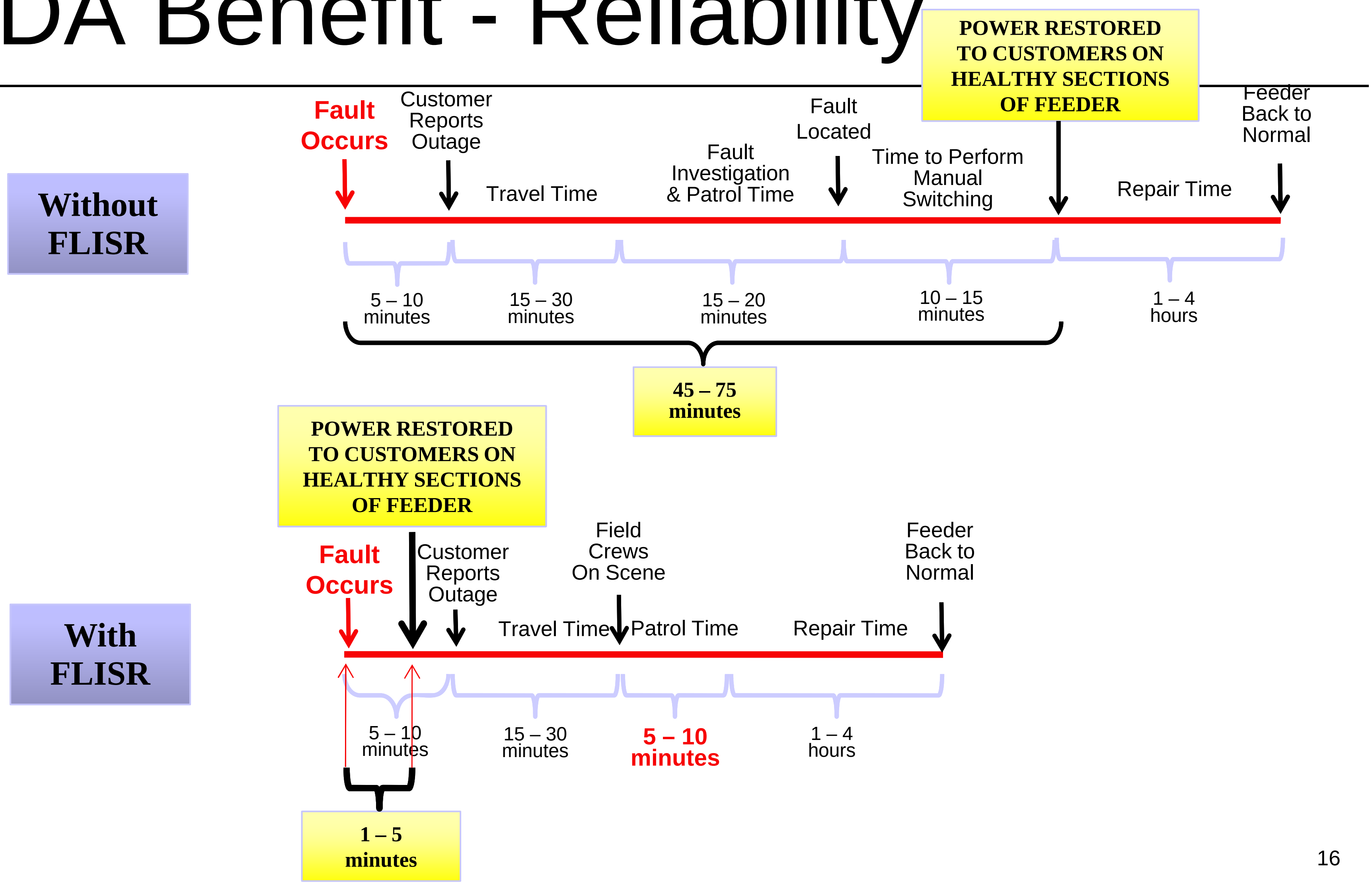
	Private Narrowband Radio Systems	Public-Carrier Cellular Networks	Private Mesh Systems
Latency	100s-1000s of ms	100s-1000s of ms	10-100 ms
Capacity	0.01-0.1 Mbps	0.1-10 Mbps	1-100 Mbps
Security	Medium	Medium-High	High
Reliability	Medium	Medium	High
QoS	Limited	Limited	Yes
Standards – Based Interoperability	Proprietary	Yes (GPRS,GMS, EDGE,1xRTT, EVDO,HSPA, LTE)	Yes (802.11/802.16 and IP)
Manageability	Limited	Very Limited	Enterprise Class
Control	Utility owns and operates	Carrier owns and operates	Utility owns and operates

DA and FAN Project

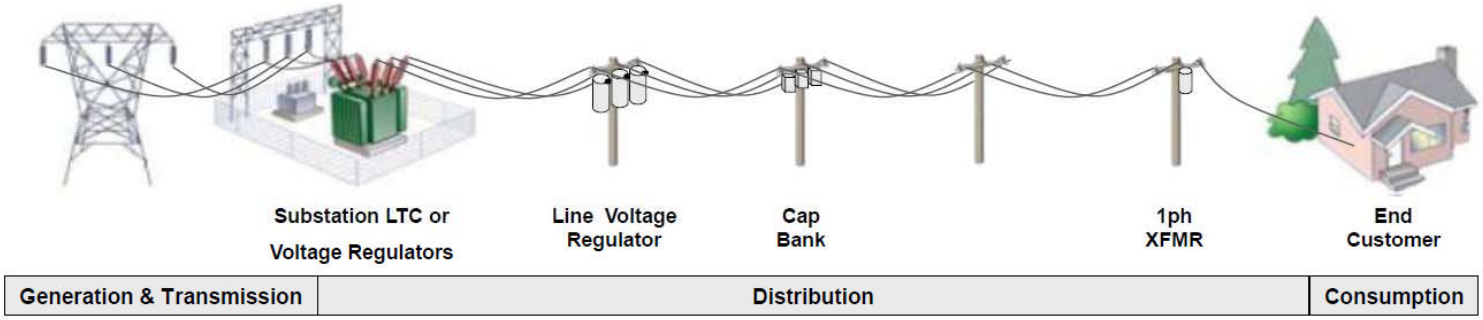
- DA Demonstration Area
  - 5 Substations & 10 Circuits
  - 9,100 Customers
- Automated Equipment
  - Switches (8)
  - Reclosers (26)
  - Regulators (39)
- Improve Reliability
  - SAIDI 4-Yr Avg 90 min/yr
- Project Budget - $3.8M



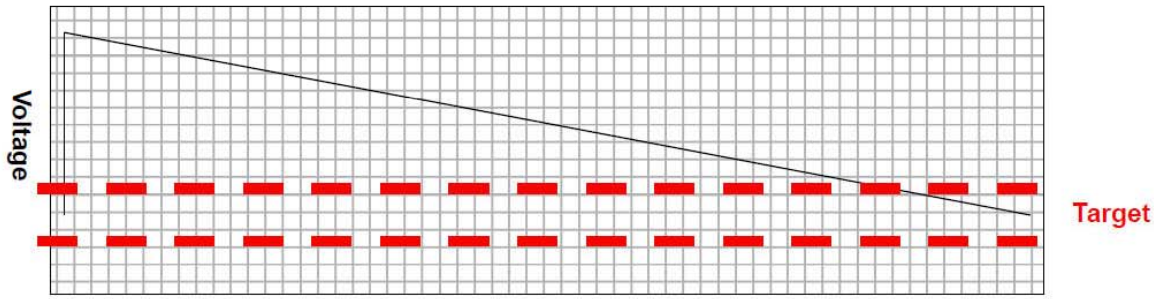
DA Benefit - Reliability



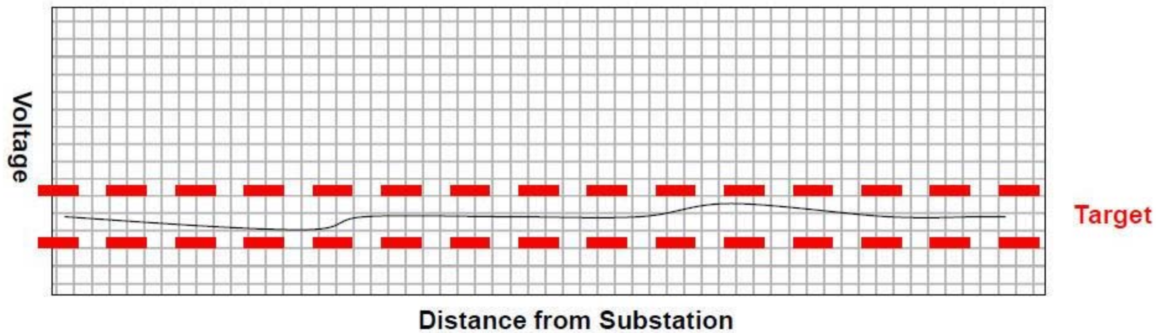
DA Benefit – Grid Optimization



No Voltage Control

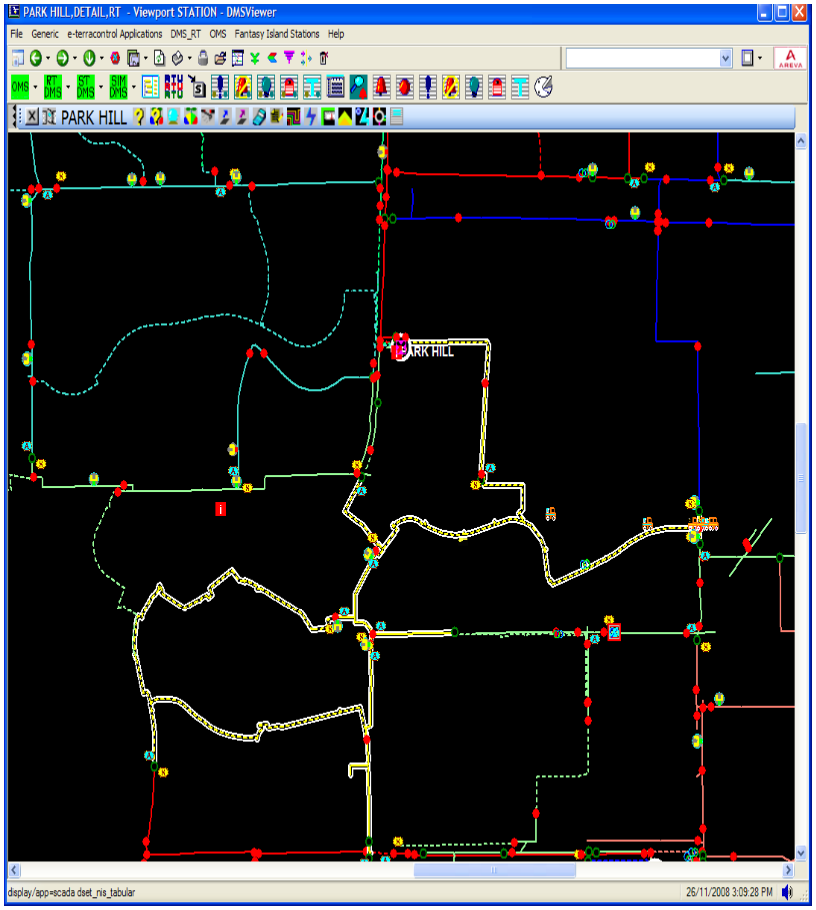


Integrated Volt/Var



Distribution Management System (DMS)

- IT system capable of collecting, organizing, displaying and analyzing real-time or near real-time electric distribution system information.
- Interfaces with other operations applications such as geographic information systems (GIS), outage management systems (OMS), and customer information systems (CIS) to create an integrated view of distribution operations.
- Project Budget - $6.1M

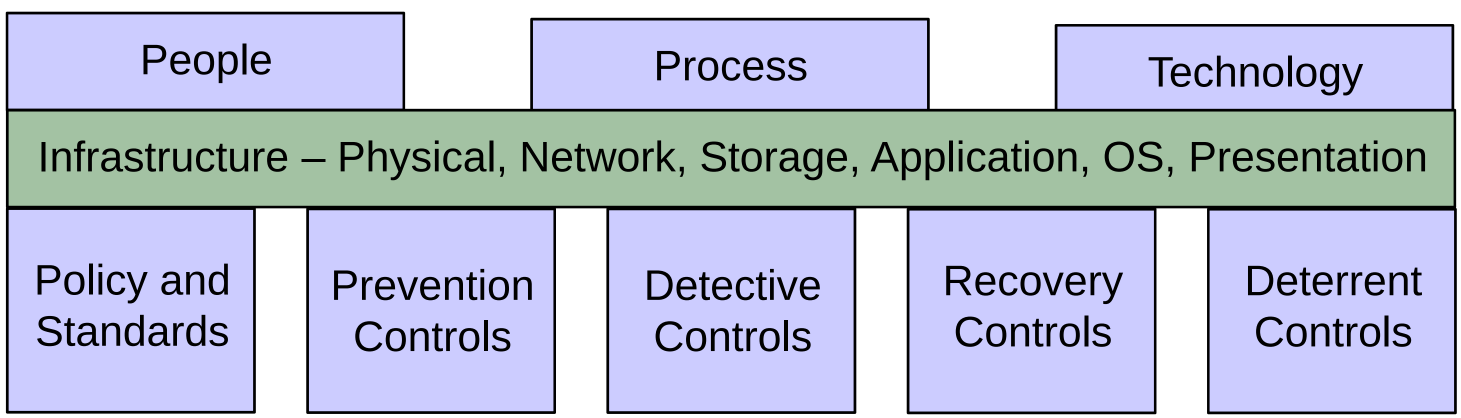


DMS Benefits

- **Powerflow**
  - Near real time calculation of voltage and flow for the electric grid
- **Switching**
  - Planned and Emergency, Tagging
  - Automatically generated Switch Plans based on Operator request
- **FLISR** (Fault Location, Isolation and Service Restoration)
  - Automatic fault location and switching of field devices
- **Feeder Load Management**
  - Predictive Powerflow
- **Voltage Optimization**
  - Set of action plans based on loss minimization

Cyber Security

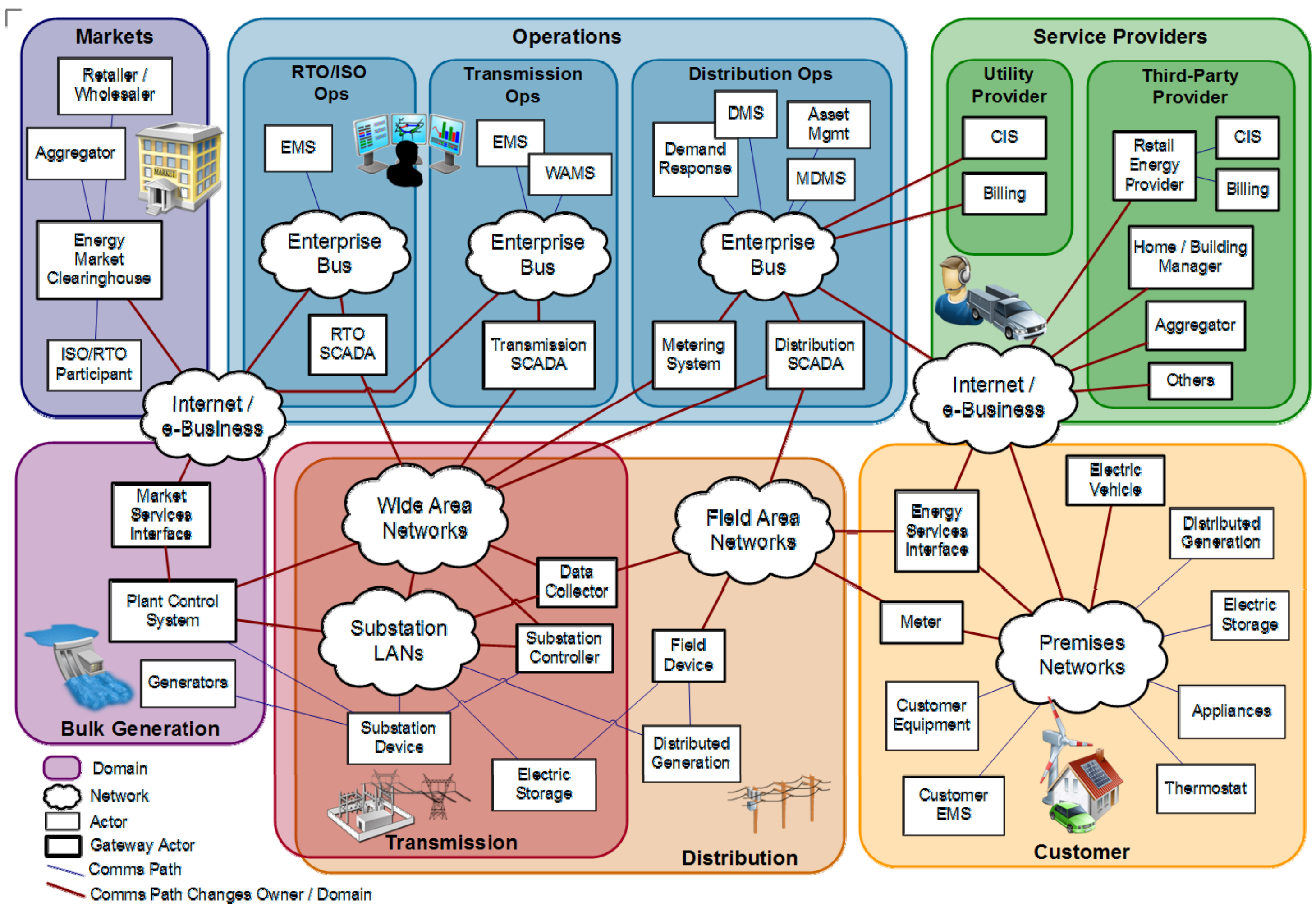
The cyber security program provides assurance that the confidentiality, integrity and availability of systems are maintained at an acceptable risk level.



Smart Grid Test Lab

- Safe environment to test compliance of products and services with existing and new standards
- End to end testing of new products and services for compliance and interoperability with other systems prior to field deployment
- Training platform for smart grid system installations, operations and diagnostics
- Project Budget $450k

Smart Grid System Integration



Source: NIST Smart Grid Framework

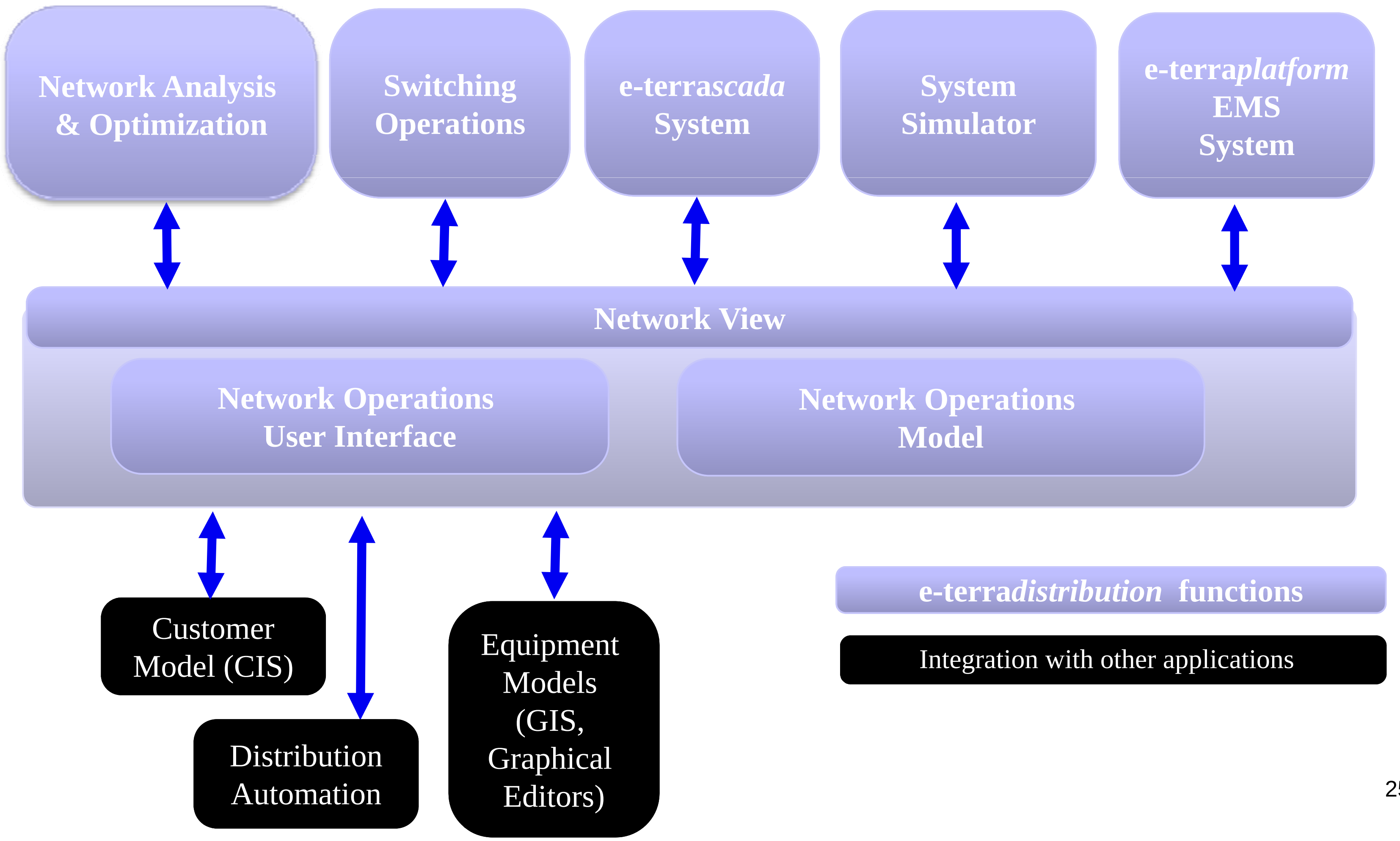
Smart Grid Domains

SMR	**Strategy, Mgmt & Regulatory** *Vision, planning, governance, stakeholder collaboration*	TECH	**Technology** *IT architecture, standards, infrastructure, integration, tools*
OS	**Organization and Structure** *Culture, structure, training, communications, knowledge mgmt*	CUST	**Customer** *Pricing, customer participation & experience, advanced services*
GO	**Grid Operations** *Reliability, efficiency, security, safety, observability, control*	VCI	**Value Chain Integration** *Demand & supply management, leveraging market opportunities*
WAM	**Work & Asset Management** *Asset monitoring, tracking & maintenance, mobile workforce*	SE	**Societal & Environmental** *Responsibility, sustainability, critical infrastructure, efficiency*

System and Process Changes

- Processes that will be Replaced with DMS
  - Use of the tool Switch Order Request
  - Use of the paper Hot Log
- Processes that will be Duplicated in DMS until Replaced
  - As Operating Model on Wall Board and Underground Drawing Updates
- Processes that will be New or Changed
  - Near real time updating of GIS (GIS, Crews, Engineers)
  - Daily GIS updates to DMS including QC check (New)
  - Real Time Distribution Optimization (New)
  - Planning and Protection Processes
  - Switch Operation Processes
  - Closed Loop Switching Operations (New)
  - Reporting and tracking of outages for SAIFI and CADI
- OT vs IT
  - Past and future support roles between IT and OT need consideration

IDMS Functional Components at the PUD



DMS Applications

Network Analysis

- State Estimation
- Power Flow
- Load Allocation
- Limit Monitor
- Power Quality
- Short Circuit
- Loss Analysis
- Load Model & Forecast
- Fault Location
- Protection Validation

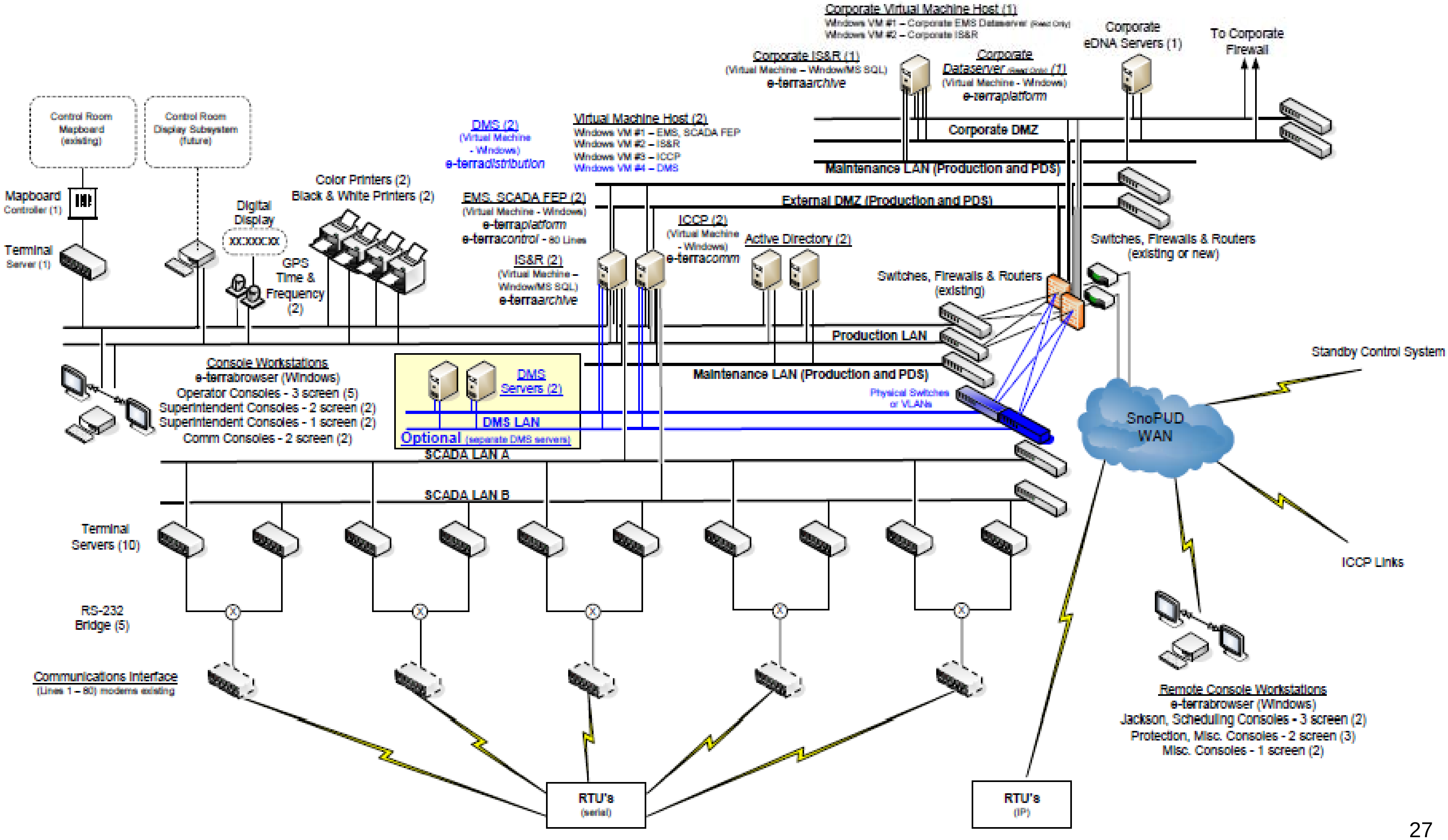
Network Optimization

- FISR
- Feeder Reconfiguration
- Planned Outage Study
- VVC
  - Loss Minimization (also includes CVR, VAr support)

Switching Operations

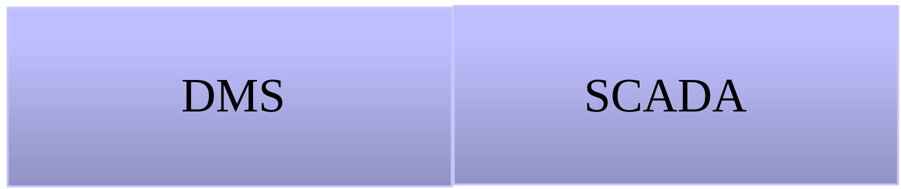
- Creation, Validation & Execution of Switching Orders
- Creation and Management of Safety Documents

DMS Production System



Not Shown: Backup, Planning, QA Systems

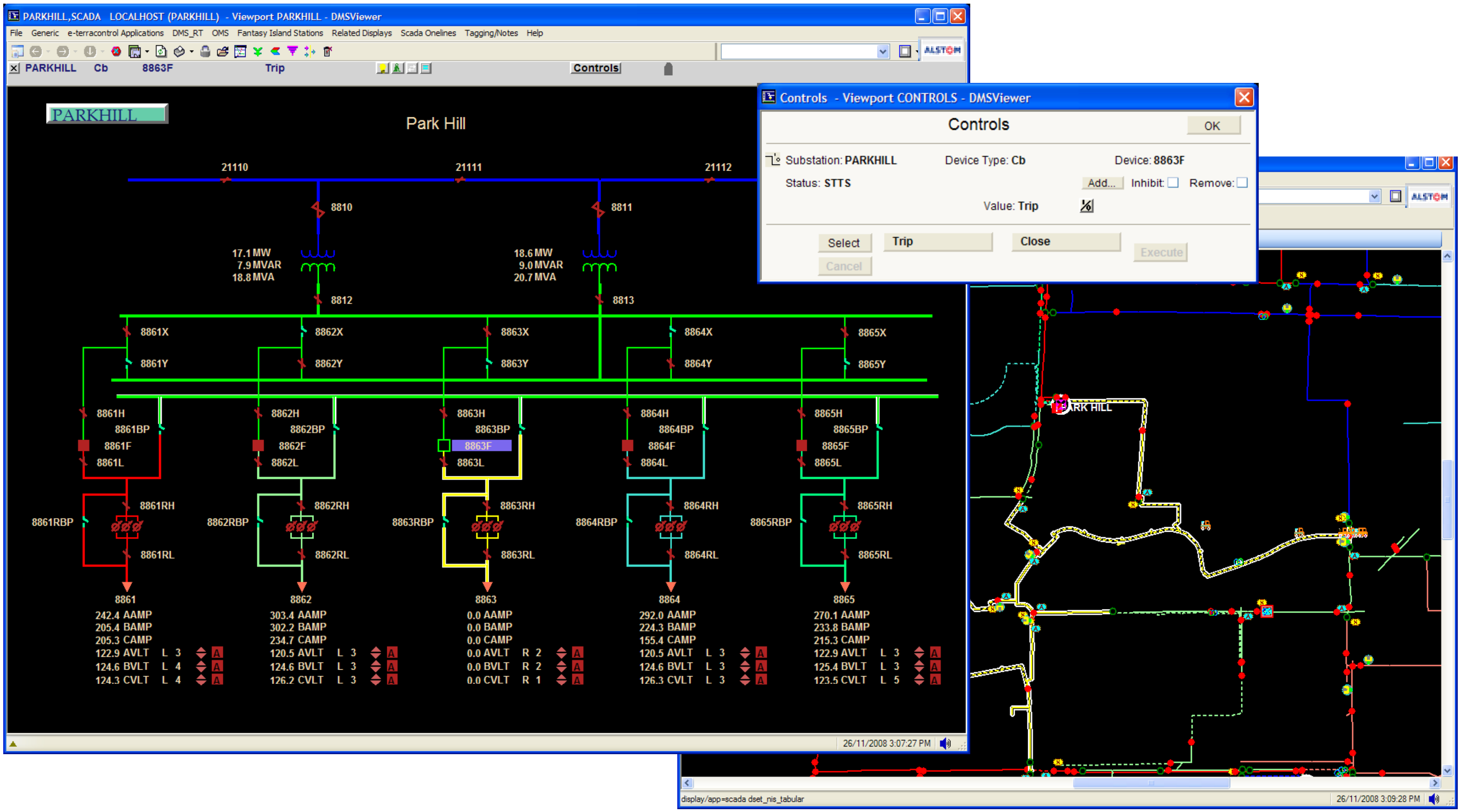
DMS & SCADA Integration



Operation is Consistent and Persistent Across Applications:

- Device control from SCADA or GIS display or both
- Common Model/Consistent Model
- Single User Interface
- Permissions (Log-in)
- Training Simulator
- Switch Orders
- Logging
- Tagging

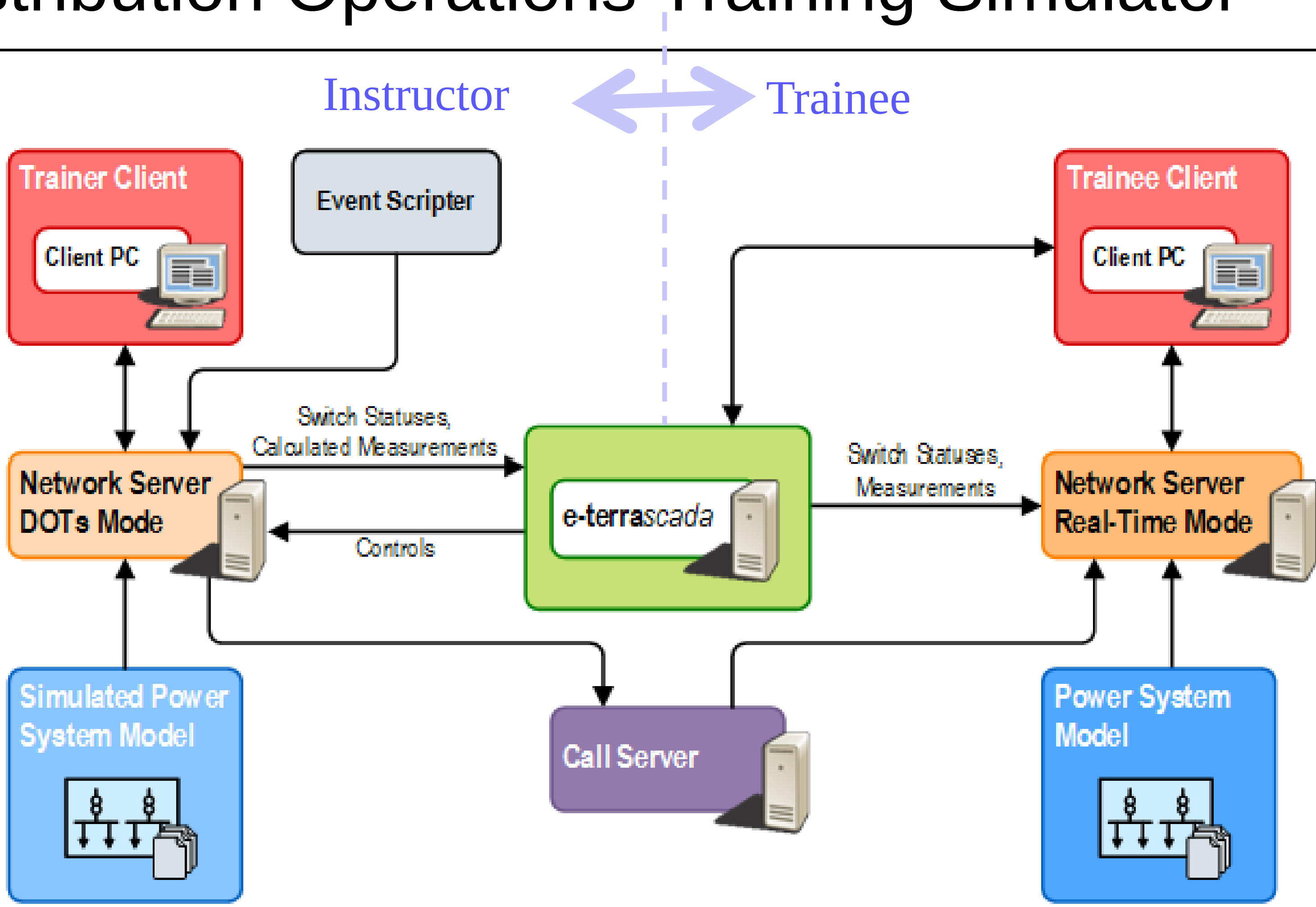
Integrated User Interface



Benefits of an Integrated Product

- **Reduced Cost of Ownership** – installation, training, maintenance
- **Increased Operator Efficiency** – higher awareness, more visibility
- **Improved Crew Safety** – completeness, consistency and persistence of data across multiple operator and crew-facing applications (e.g., tagging)
- **System Easily Scaled in Real-time** – reduce or increase the number of operators and control rooms quickly for different conditions: peak load, low load, storm/outage
- **SOA Architecture** – reduces complexity and maintenance of 3rd party interfaces

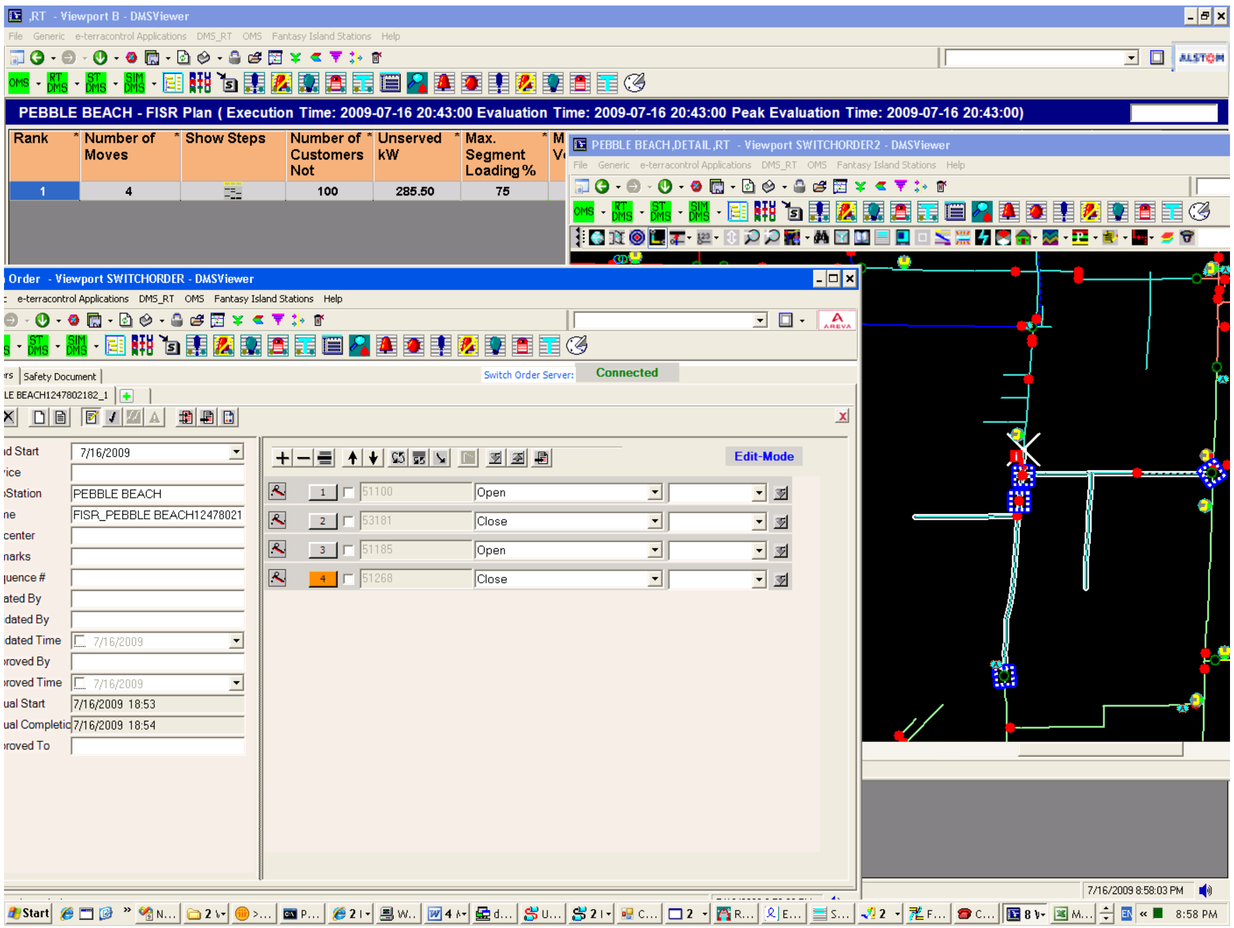
Integration Includes Distribution Operations Training Simulator



Fault Isolation and Service Restoration

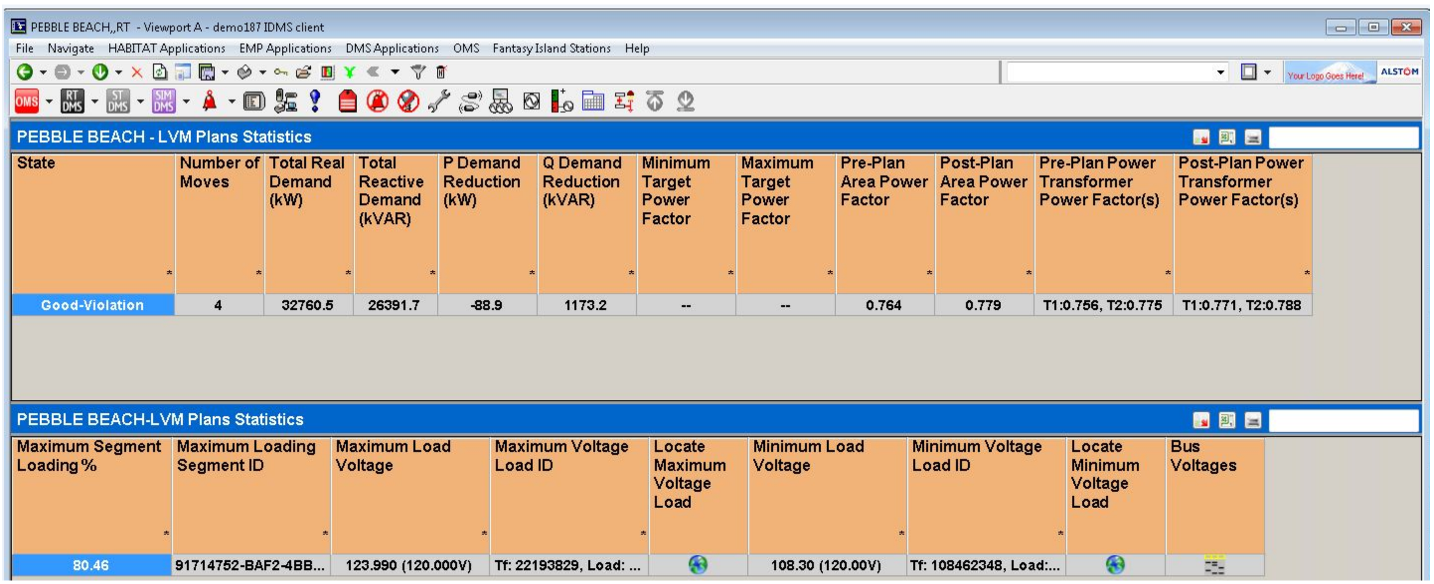
- Generates Switching Plans to Isolate Faulted Circuits, Restore Non-faulted Circuits
- Plans can be executed in Study Mode prior to implementation in Real-Time
- Can be triggered by event or on demand
- Runs in Closed-loop or Advisory Modes
- Several Problem Formulations:
  - Minimize un-served kW
  - Minimize minutes of interruption
  - Minimize number of switching actions
  - Minimize voltage drop

Switching Order Steps from FLISR Results



Optimization – Volt/VAr Control

- Distribution System Optimization *without customer involvement or impact*
  - Loss minimization (Also CVR, VAr Support)



State	Number of Moves	Total Real Demand (kW)	Total Reactive Demand (kVAR)	P Demand Reduction (kW)	Q Demand Reduction (kVAR)	Minimum Target Power Factor	Maximum Target Power Factor	Pre-Plan Area Power Factor	Post-Plan Area Power Factor	Pre-Plan Power Transformer Power Factor(s)	Post-Plan Power Transformer Power Factor(s)
Good-Violation	4	32760.5	26391.7	-88.9	1173.2	--	--	0.764	0.779	T1:0.756, T2:0.775	T1:0.771, T2:0.788

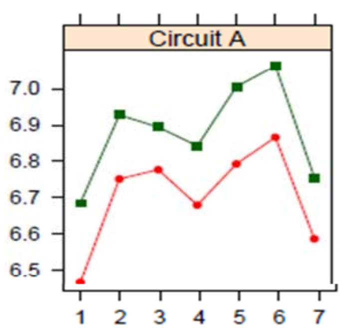
Maximum Segment Loading %	Maximum Loading Segment ID	Maximum Load Voltage	Maximum Voltage Load ID	Locate Maximum Voltage Load	Minimum Load Voltage	Minimum Voltage Load ID	Locate Minimum Voltage Load	Bus Voltages
80.46	91714752-BAF2-4BB...	123.990 (120.000V)	Tf: 22193829, Load: ...		108.30 (120.00V)	Tf: 108462348, Load:...		

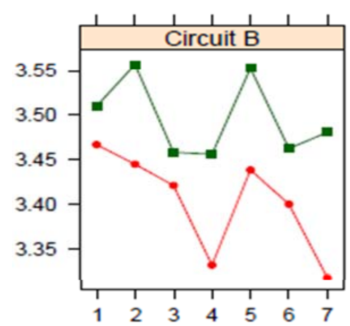
Study Mode Loss Minimization Results

Model/Optimization-Based Volt-VAr Control

Model-based, Powerflow Analysis with Optimization Algorithms

- Preferred Method
- Achieves Maximum VVC Benefit
- Works for Nominal & Backup Switching Configurations





DMS Implementation Challenges

- Data
  - All data required by DMS may not be readily available in GIS
  - Required to locate data from other sources (paper & electronic)
- Systems Integration
- Security Architecture

Required Disclaimer for DOE Funded Project

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Q & A

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