GE Digital Energy

The Future of Grid Control: Smart Grid and Beyond

John D. McDonald, P.E.

Director
Technical Strategy & Policy Development

IEEE Fellow
IEEE PES President (2006-2007)
IEEE Division VII Director (2008-2009)
IEEE-SA Board of Governors (2010-2011)
IEEE Smart Grid Steering Committee
CIGRE USNC VP, Technical Activities

Adv. Grid Tech. Workshop/ADMS at NREL
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Agenda

- Key Industry/Societal Trends
- Holistic Solutions
- Integration of Renewables
- Big Data, Analytics and Enterprise Data Management
- Industry Standards Vision
- ADMS Software Applications

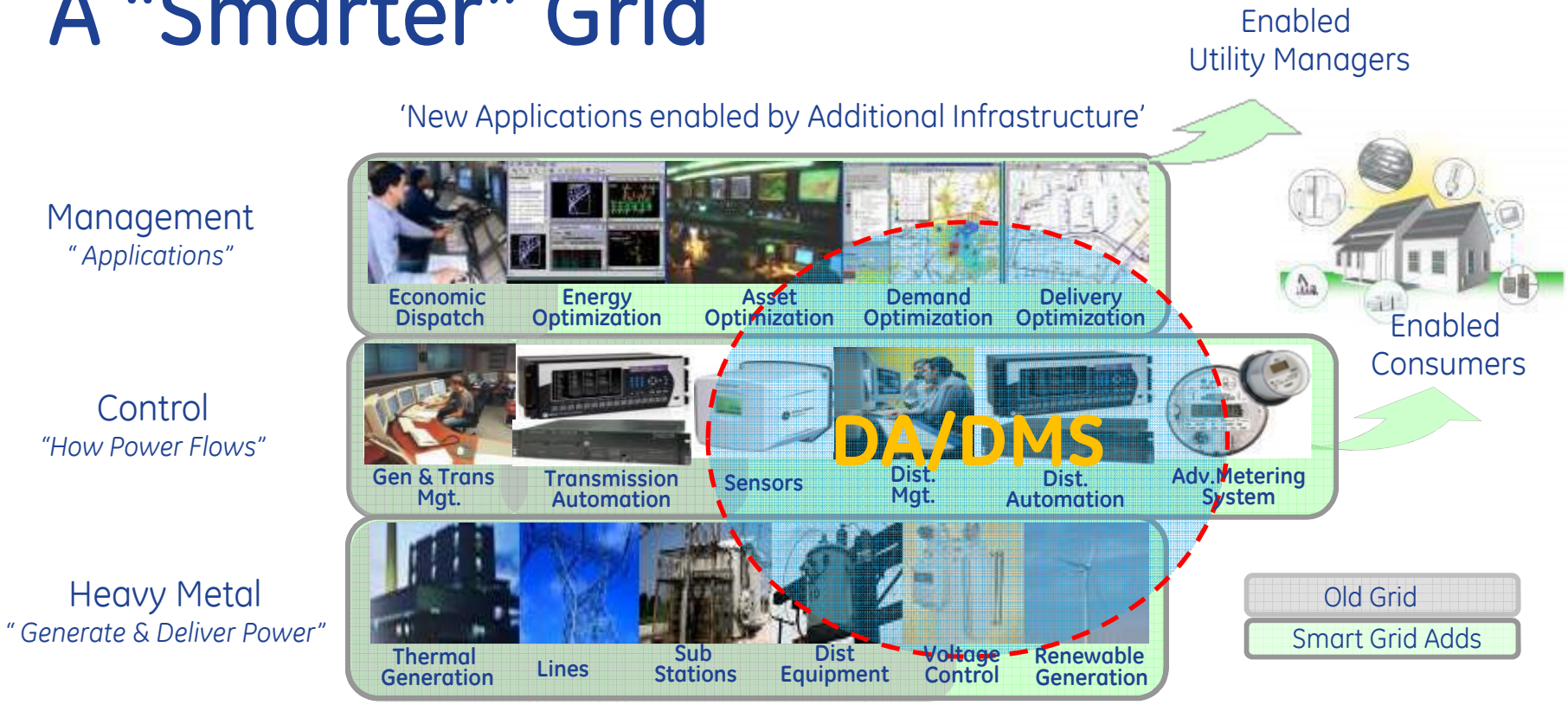
Key Industry/Societal Trends

Key Industry/Societal Trends

- ✓ Transitioning from Devices/Systems to Holistic Solutions
- ✓ Success = Technology, Standards, Policy
- ✓ Grid Flexibility + Self Healing + Reconfigurable
- ✓ Electrical Power Distribution Infrastructures Resiliency
- ✓ Big Data, the Cloud and Use of Social Media
- ✓ Convergence of IT and OT to Support Enterprise Data Management

Holistic Solutions

A "Smarter" Grid



Old Grid

- You call when the power goes out.
- Utility pays whatever it takes to meet peak demand.
- Difficult to manage high Wind and Solar penetration
- Cannot manage distributed generation safely.
- ~10% power loss in T&D

Smart Grid

- Utility knows power is out and usually restores it automatically.
- Utility suppresses demand at peak. Lowers cost. Reduces CAPEX.
- No problem with higher wind and solar penetration.
- Can manage distributed generation safely.
- Power Loss reduced by 2+%... lowers emissions & customer bills.

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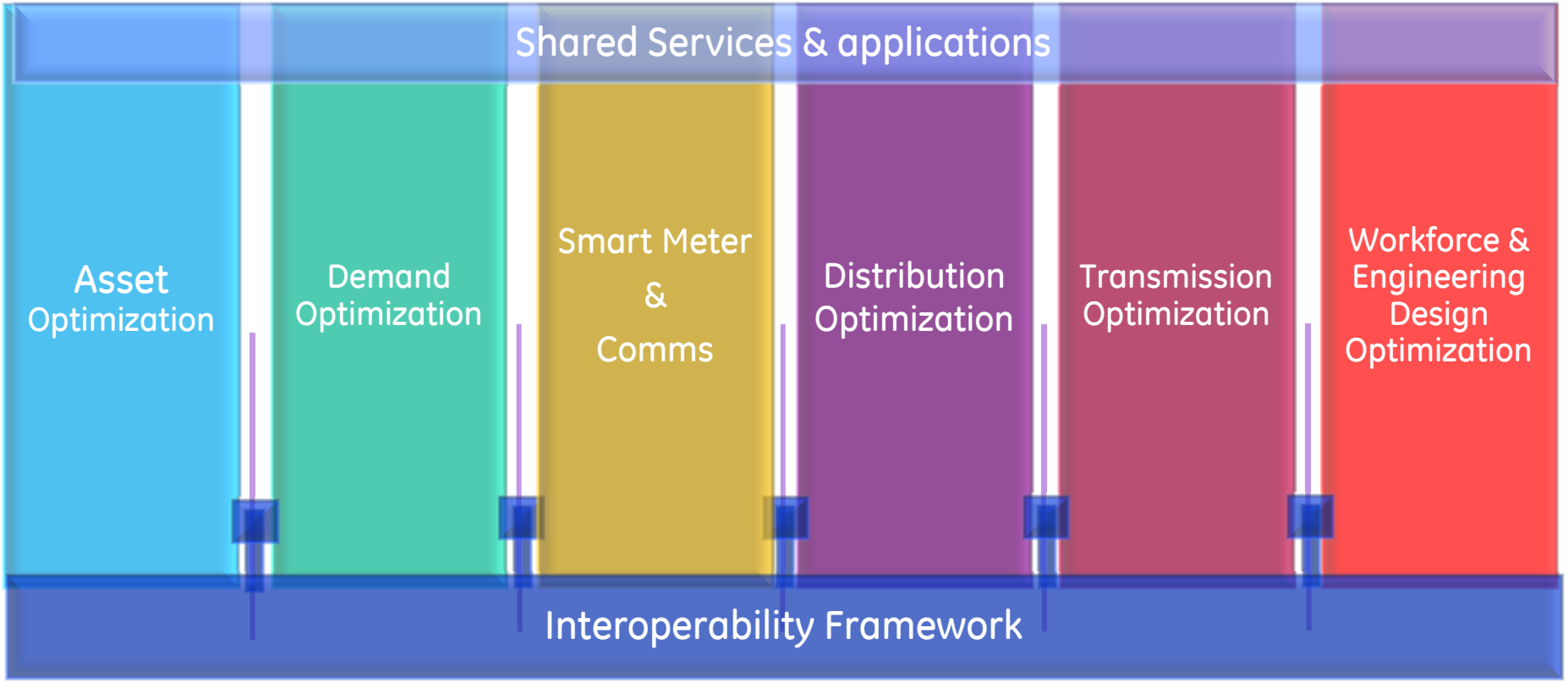
Smart Grid Holistic Solutions



Transitioning from products/systems to holistic solutions

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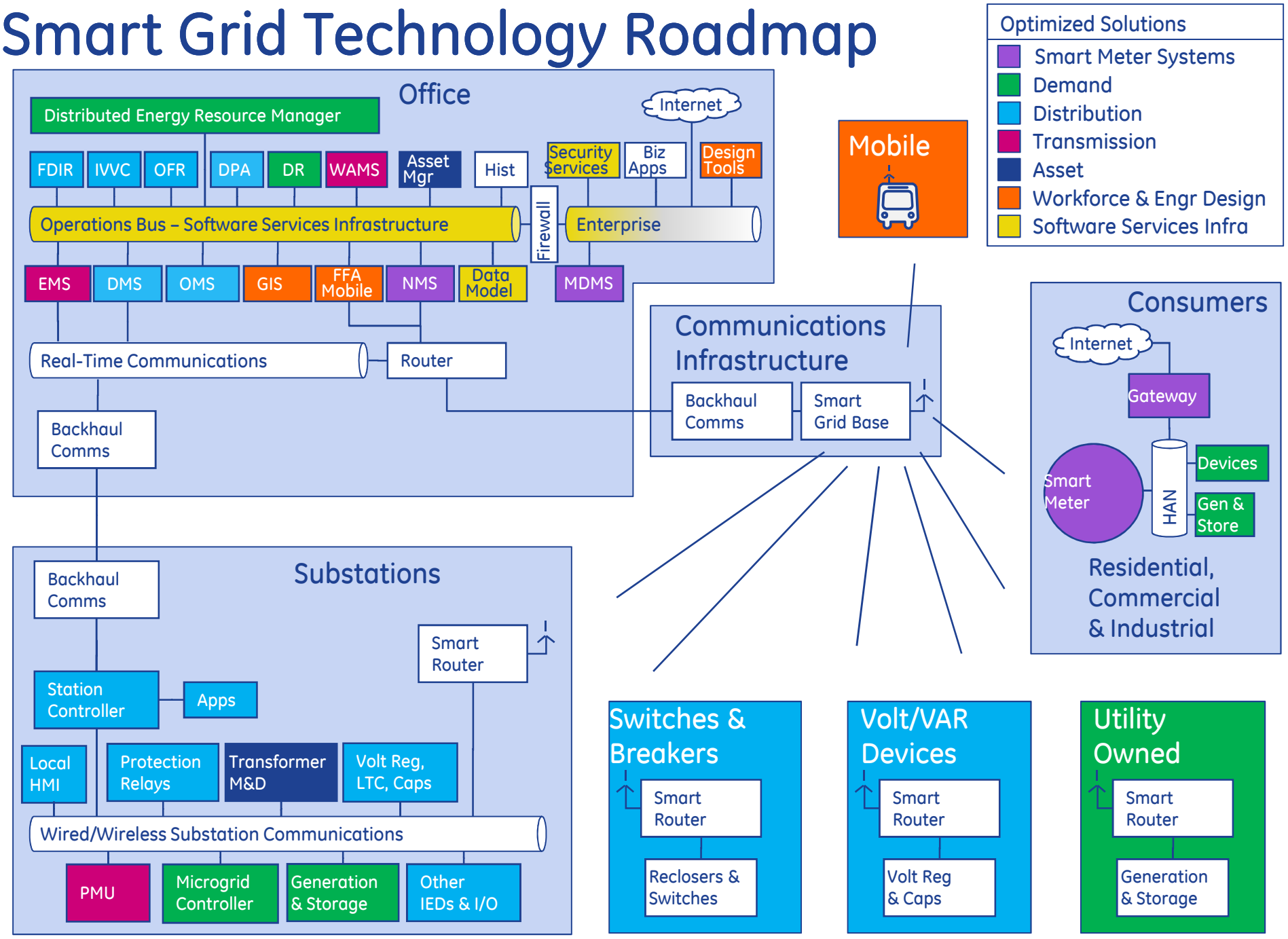
Smart Grid Technology Roadmap



Smart Meters/AMI Integration with GIS, OMS and DMS

Smart Meters/AMI

- Meter Readings
- Voltage => DMS
- Last Gasp Communication => OMS

GIS

- Network Model Information => OMS, DMS

DMS

- Status Changes => OMS

Customers

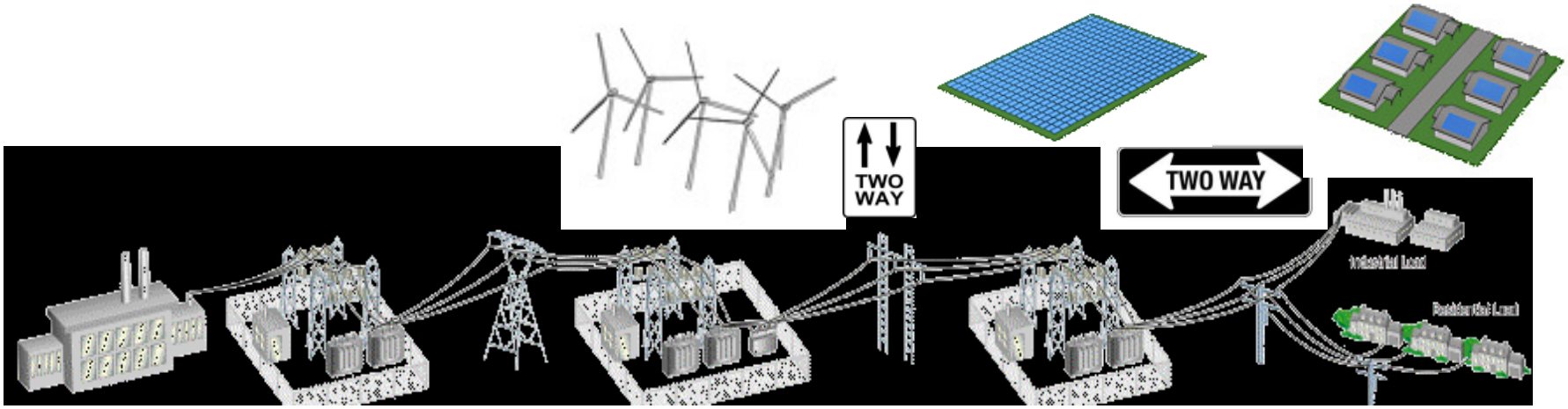
- Phone Calls => OMS
- Social Media => OMS

Integration of Renewables

Distributed Generation

Industry Challenge

A wide array of DG is creating unique challenges in the grid: two-way power flow, voltage regulation concerns.



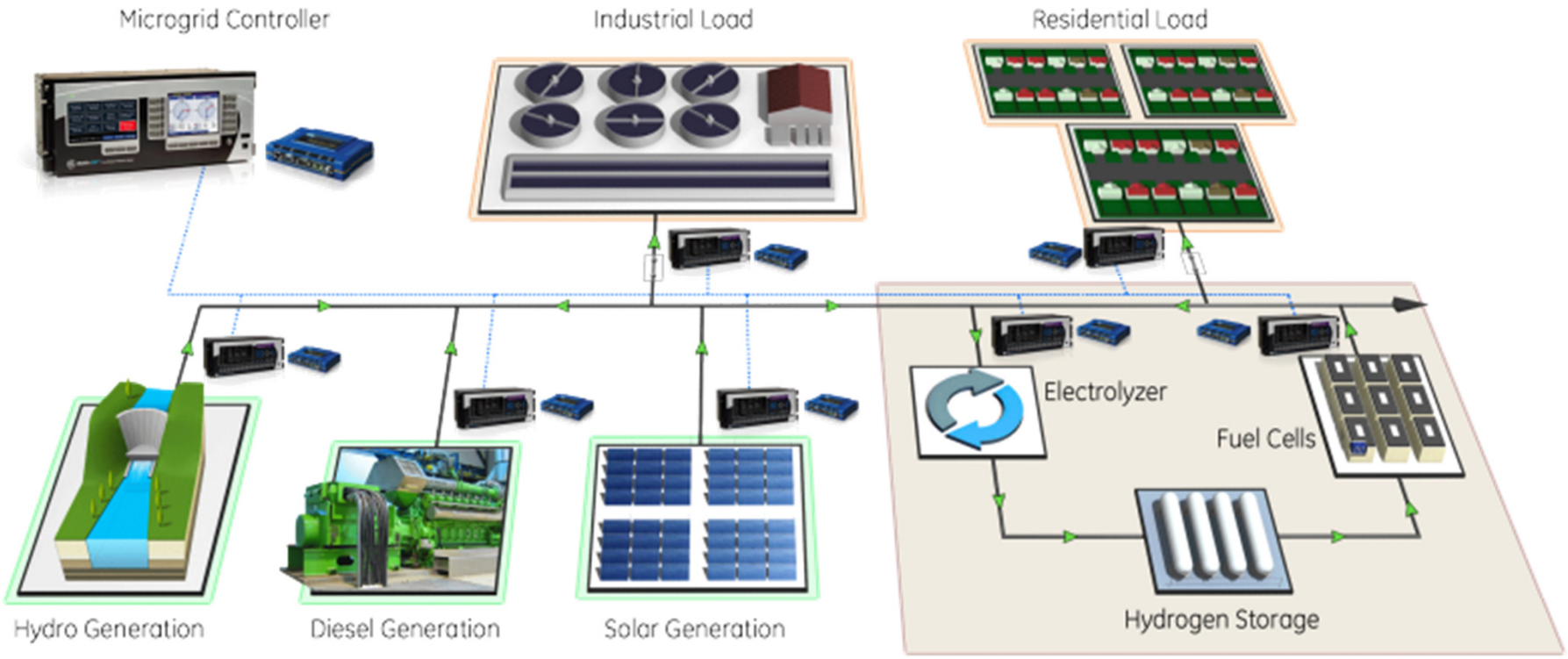
Power Generation | Generation Switchyard | Transmission Substation | Distribution Substation | End User

Distribution controls and protection traditionally take advantage of and are designed only for uni-directional power flow

Distributed Generation Integration

Technology Solution

Optimal dispatch of complex energy resources

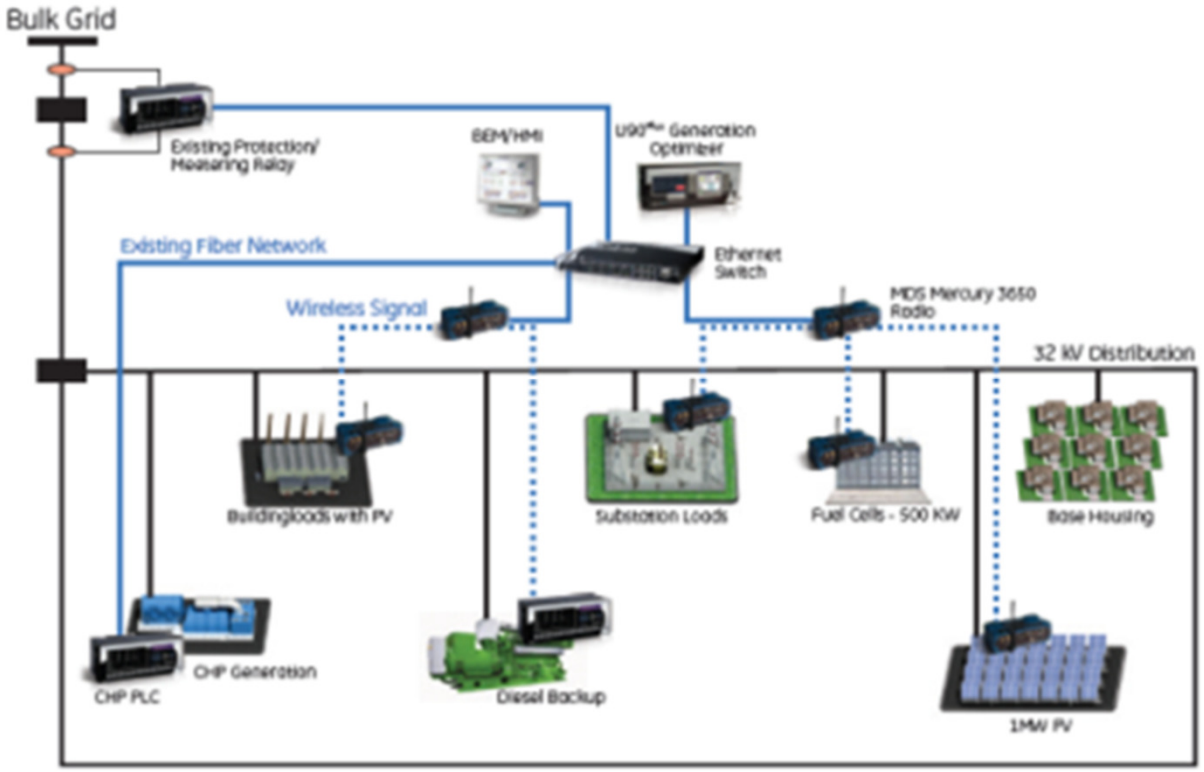


Smart control system to optimize and manage generators, energy storage and loads featuring:

- Optimal Dispatch
- Supervisory Controls
- Islanding/Tie-Line Controls

Grid Edge Controllers and Microgrids

Edge of grid transforming into Microgrids



Impact of High Penetration of Rooftop Solar PV on the Distribution System

New Applications of Power Electronics (my Power Electronics magazine article – August 22, 2013 issue)

- Substation Transformer On-line Tap Changer
- Low Voltage Network Dynamic Grid Edge Controllers
- Increased capability from Inverters

The Death Spiral (Intelligent Utility magazine article – November /December 2013 issue)

- Impact of High Penetration of Rooftop Solar PV in the State of Queensland, Australia

Big Data, Analytics and Enterprise Data Management

Internet of Things (IoT)

Drive the next productivity revolution by connecting intelligent machines with people at work

The "II" Connects…

1. Intelligent Machines

Leverage technology & communication to cost-effectively connect machines

+2. Big Data & Analytics

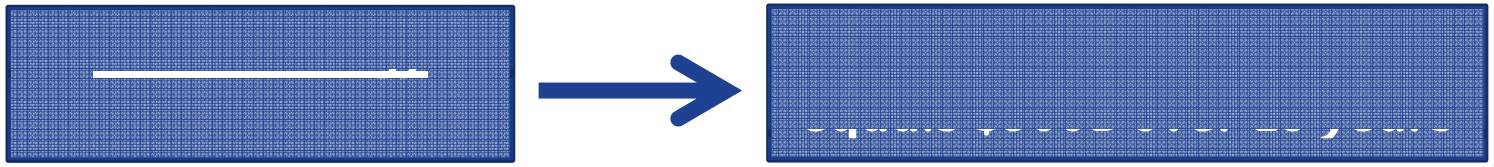
Combine the power of big data, big analytics, and industry physics

+ 3. People at Work

Connecting people any place, any way, and any time for intelligent operations

= A world that works better, faster, safer, cleaner and cheaper

Energy Value:



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Analytics

Meter Insight
(in development)

- Revenue Protection
- Power Quality and Reliability
- Load Forecasting and Research

Outage Insight
(in development)

- Automated KPI data validation
- Dynamic KPI dashboards
- Outage Event Recorder
- Planned outage optimization
- Predictive Outage Analytics
- Accurate ETR

Reliability Insight
(in development)

- Predictive vegetation management
- Asset health analysis
- System health analysis
- Lifecycle analysis and portfolio optimization

Renewables Insight
(in design)

- PV load (dis)aggregation/ hotspot analysis
- Wind load (dis)aggregation and hotspot analysis
- EV penetration/ impact analysis
- DER load orchestration

Consumer Insight
(in design)

- Social media integration
- Customer Segmentation
- Customer Engagement
- Sentiment Analysis

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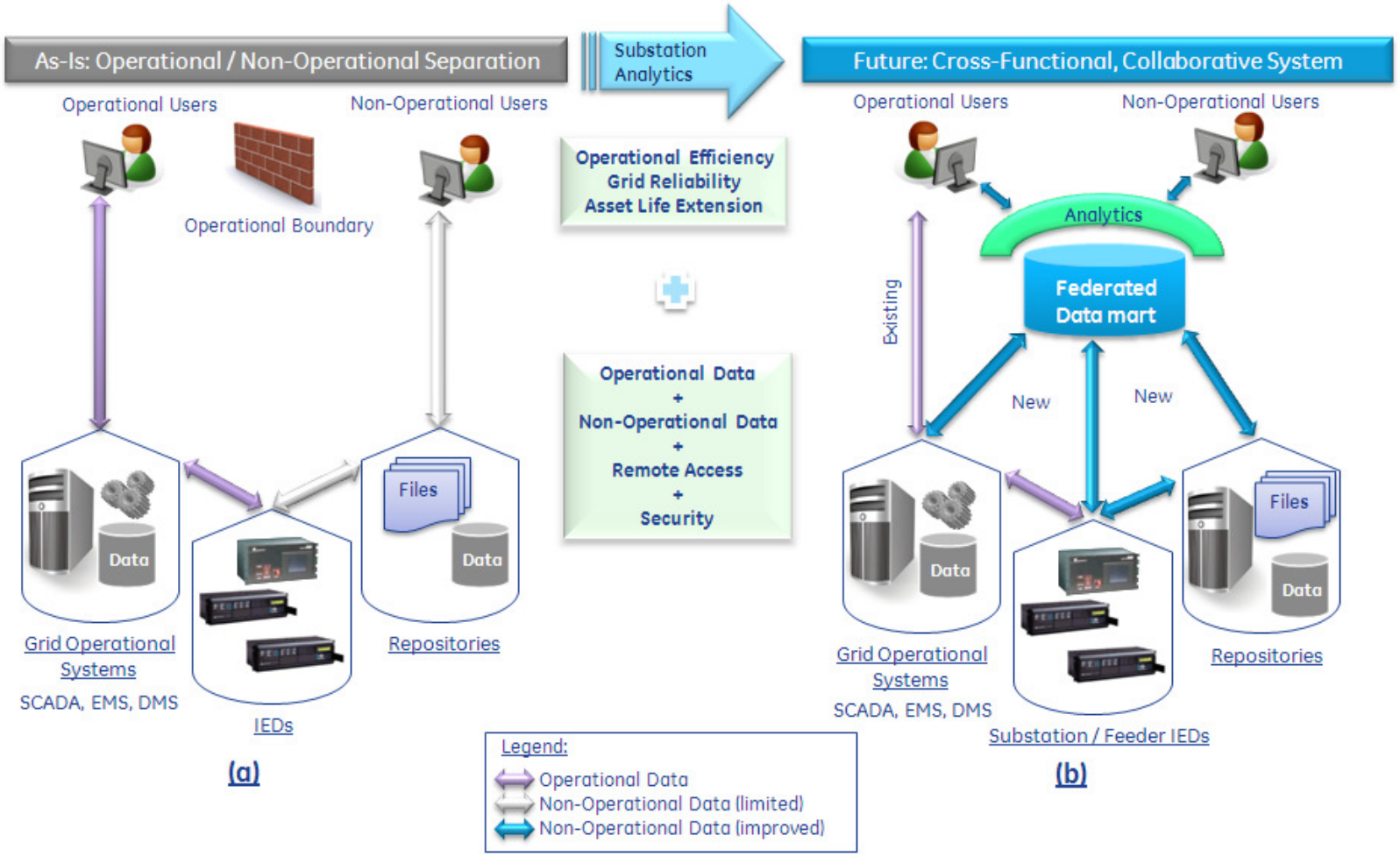
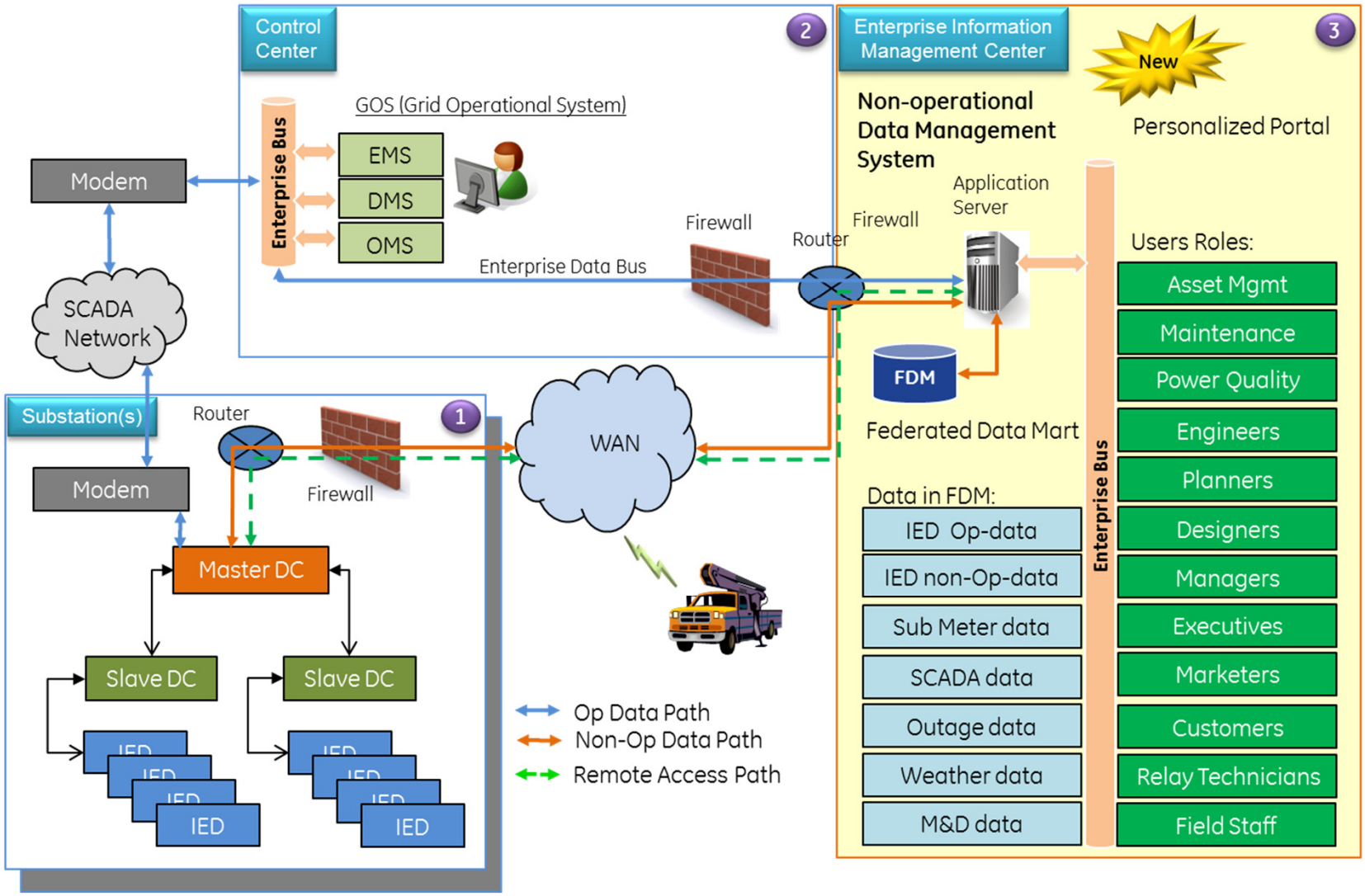
Enterprise Data Management

Collecting Data for Data Analytics



Enterprise Data Management

Breaking Down the Silos



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Industry Standards Vision

Smart Grid Foundational Standards

SmartGrid

NIST National Institute of Standards and Technology

NIST- Recognized Standards Release 1.0

Following the April 28-29 Smart Grid Interoperability workshop, NIST deemed that sufficient consensus has been achieved on 16 initial standards

On May 8, NIST announced intention to recognize these standards following 30 day comment period

NIST's announcement recognized that some of these standards will require further development and many additional standards will be needed.

NIST will recognize additional standards as consensus is achieved

Standard	Application
AMI-SEC System Security Requirements	Advanced metering infrastructure (AMI) and Smart Grid end-to-end security
ANSI C12.19/MC1219	Revenue metering information model
BACnet ANSI ASHRAE 135-2008/ISO 16484-5	Building automation
DNP3	Substation and feeder device automation
IEC 60870-6 / TASE.2	Inter-control center communications
IEC 61850	Substation automation and protection
IEC 61968/61970	Application level energy management system interfaces
IEC 62351 Parts 1-8	Information security for power system control operations
IEEE C37.118	Phasor measurement unit (PMU) communications
IEEE 1547	Physical and electrical interconnections between utility and distributed generation (DG)
IEEE 1686-2007	Security for intelligent electronic devices (IEDs)
NERC CIP 002-009	Cyber security standards for the bulk power system
NIST Special Publication (SP) 800-53, NIST SP 800-82	Cyber security standards and guidelines for federal information systems, including those for the bulk power system
Open Automated Demand Response (Open ADR)	Price responsive and direct load control
OpenHAN	Home Area Network device communication, measurement, and control
ZigBee/HomePlug Smart Energy Profile	Home Area Network (HAN) Device Communications and Information Model

Communication Protocols

Control Center to Control Center

- IEC 60870-6/TASE.2 – Inter-control Center Communications Protocol (ICCP)

Control Center to Field Equipment

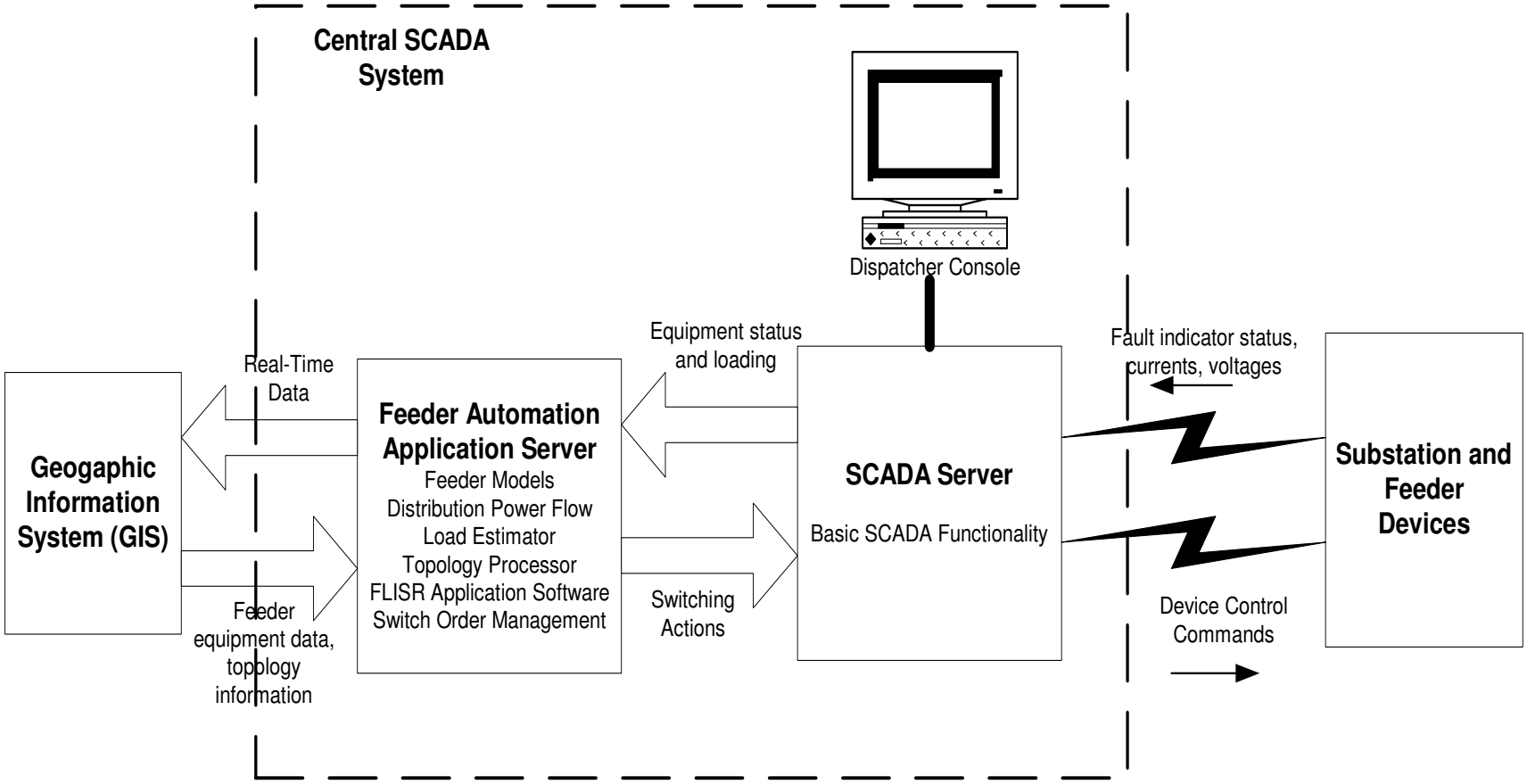
- IEEE 1815 (DNP3) – North American Suppliers
- IEC 60870-5 – European Suppliers
  - 101 – serial communications
  - 103 – protection devices
  - 104 – TCP/IP (network communications)

Field Equipment

- IEC 61850 – substation automation and protection
- IEEE 1815 (DNP3) – substation and feeder device automation

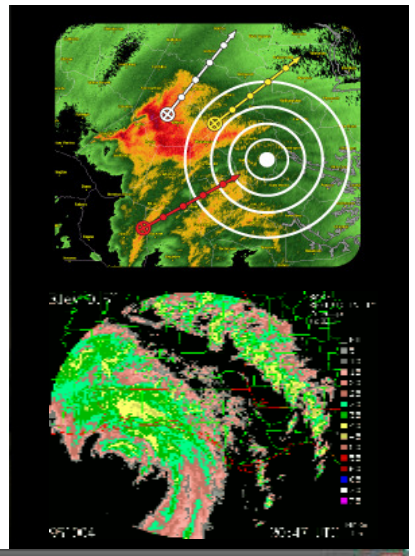
ADMS Software Applications

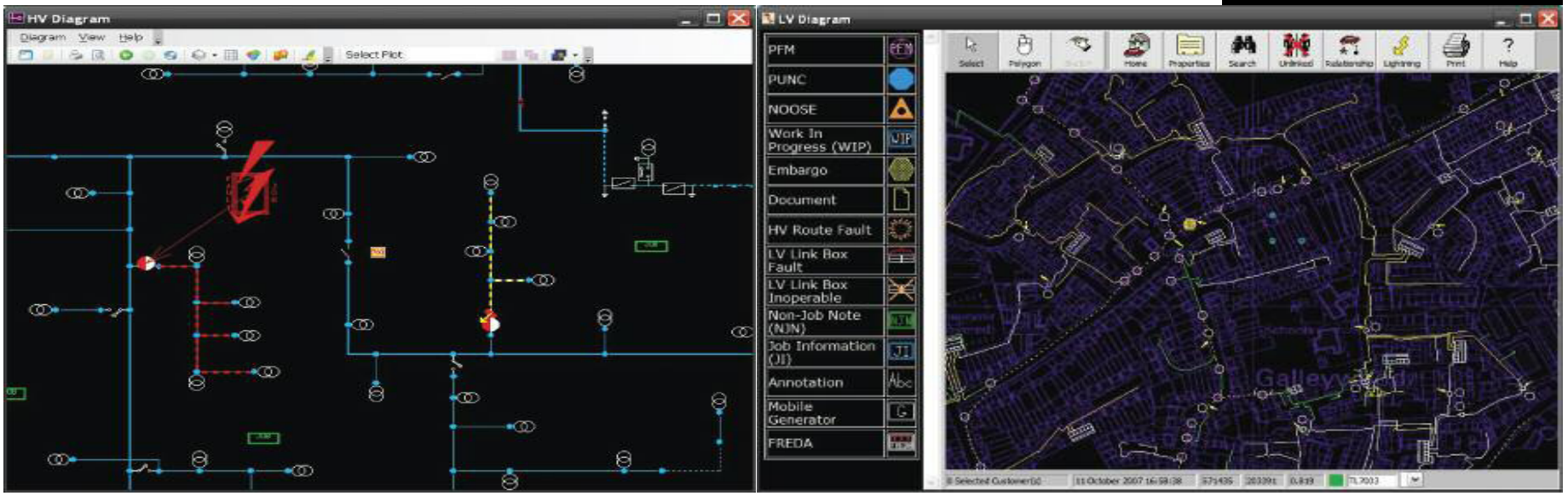
Feeder Automation – Centralized Control



Advanced Real Time DMS Applications

- ❑ Topology Processor (TP)
- ❑ Integrated Volt/Var Control (IVVC)
- ❑ Fault Detection, Isolation, Restoration (FDIR)
- ❑ State Estimation (SE)
- ❑ Load Estimation (LE)





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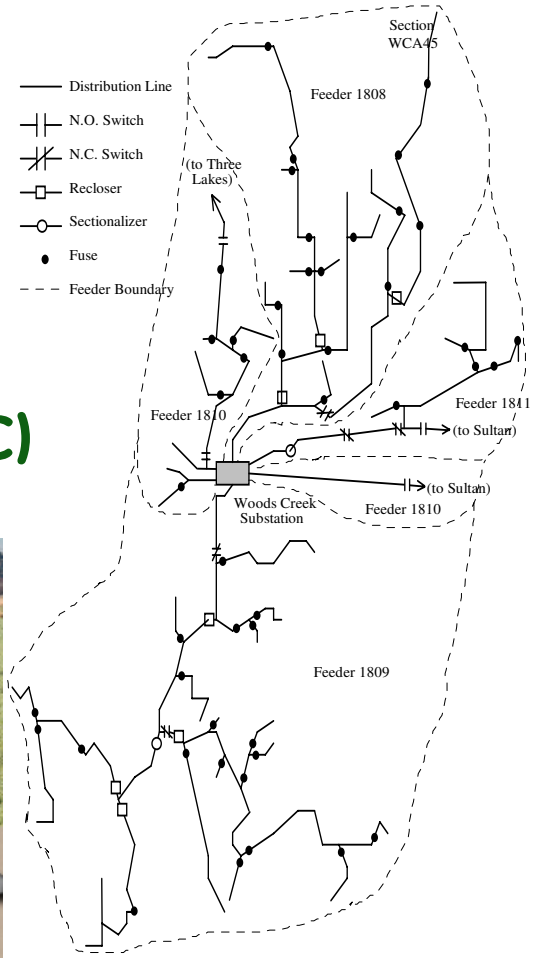
Advanced Analytical DMS Applications

- ❖ Distribution Power Flow (DPF)
- ❖ Short Circuit Analysis (SCA)
- ❖ Optimal Feeder Reconfiguration (OFR)
- ❖ Optimal Capacitor Placement (OCP)
- ❖ Feeder Relay Protection Coordination (RPC)



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Advanced Ancillary DMS Applications

- Maintenance & Outage Planning (M&OP)
- Power Quality Analysis (PQA)
- Retail Power Marketing (RPM)
- Coordination with adjacent systems
- Distribution Simulation
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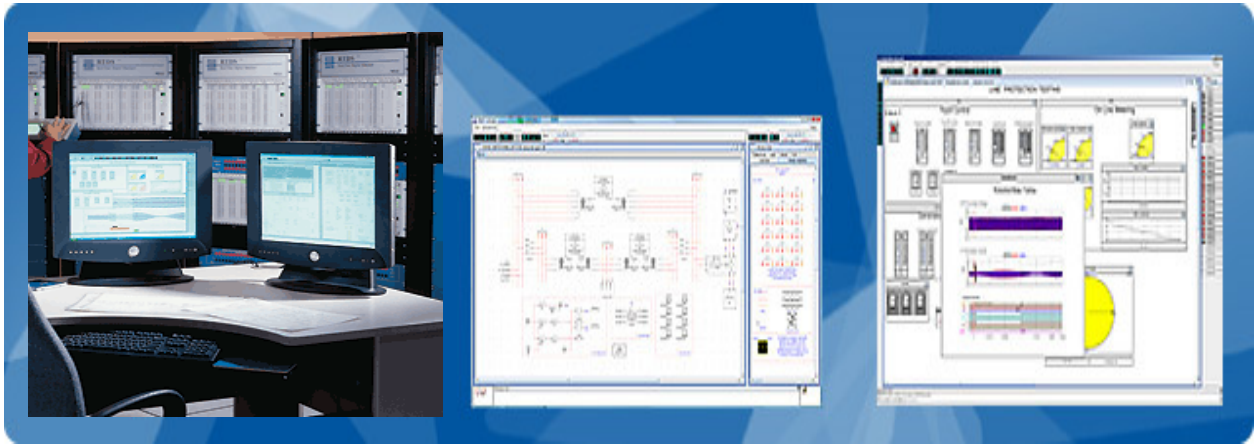

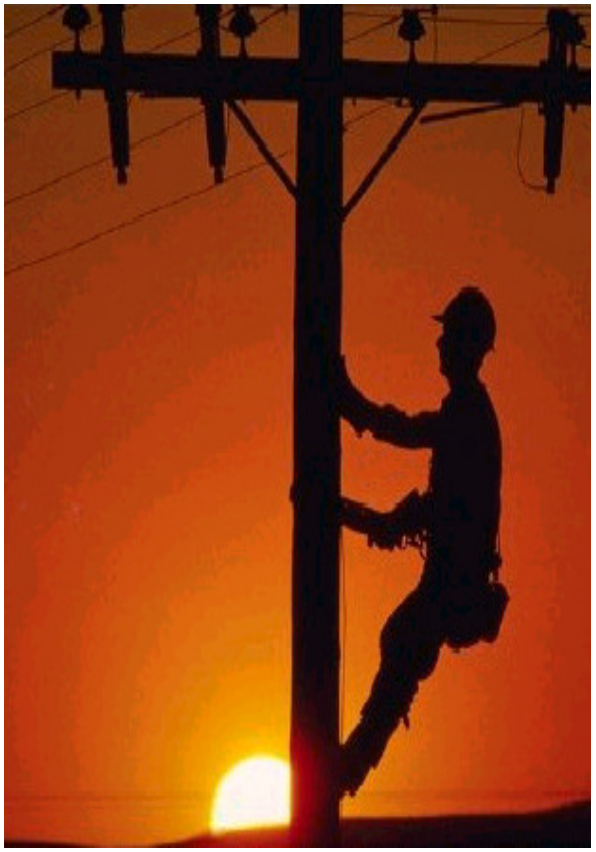

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Thank You!