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Monitoring of T&D Systems

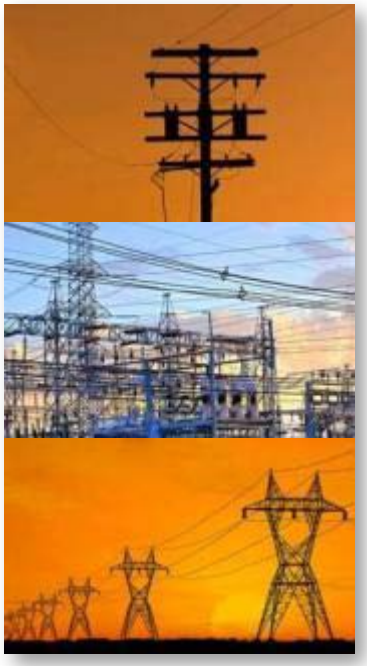
Is there something useful in all the data?

Paul Myrda
Technical Executive

Stanford University
May 7, 2013

Electric Power Research Institute

Generation



Delivery

Customer

Independent, Objective, Collaborative

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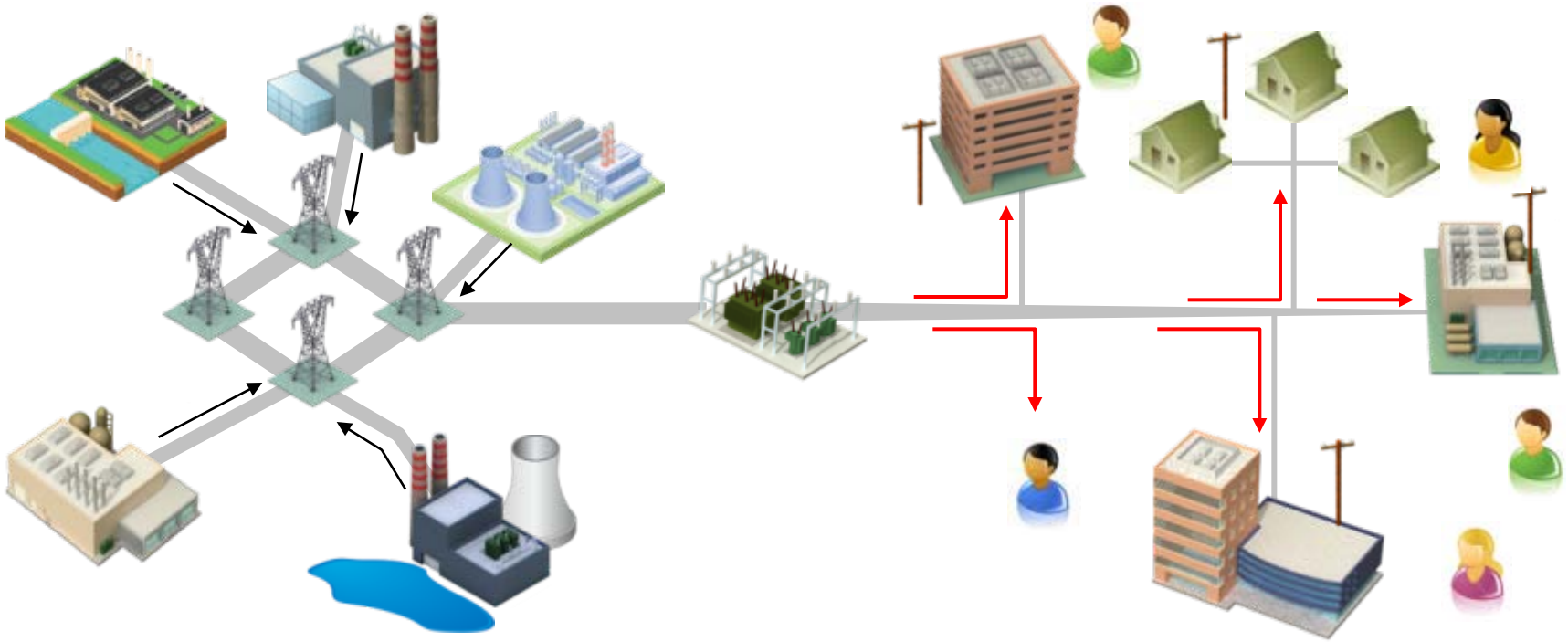
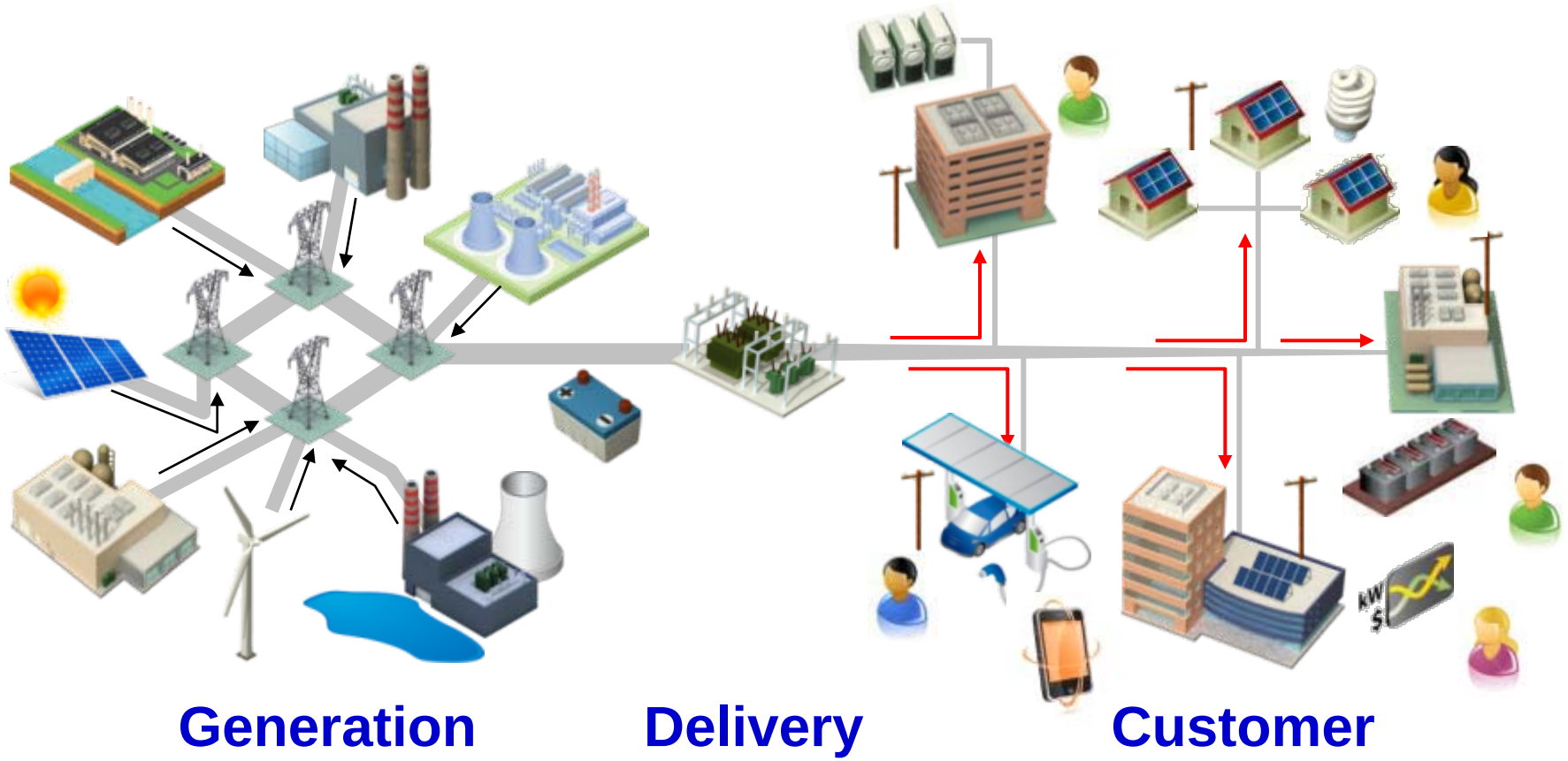
Today's Power System



Generation **Delivery** **Customer**

Base Load Generation	+	Load Following Generation	+/–	Bulk Energy Storage	=	Customer Demand	–	Interruptible Load DR

Customer



How will customers use electricity?

Smart Grid Challenges

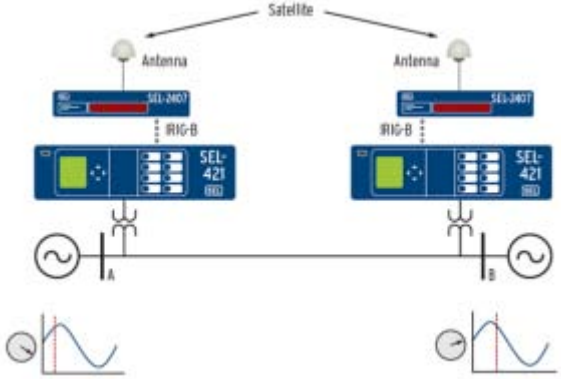
Top Down - 10 Smart Grid R&D Challenges
Standards & Interoperability
Communications Technology
Energy Mgmt Architecture & Integration
Security & Privacy
Renewable & DER Integration
Data Mgmt, Analysis & Visualization
Grid Management & Planning (Bulk)
Smart Grid Cost Benefit Analysis
Customer Integration Strategies
Advanced Technology Assessments

Challenges: *Turning Data into Opportunity & Value*

Industry is creating more and more data

- From 1 Meter Read/mo to Hourly (720/mo)
- =71,900% increase in Data (((720-1)/1)*100%)

- No. Of PMU's installed has doubled in the past 12 months
- Generating Terabytes of data
- Transitioning from Implementation to Analysis



Management (Optimization) of the Grid = Management of Data

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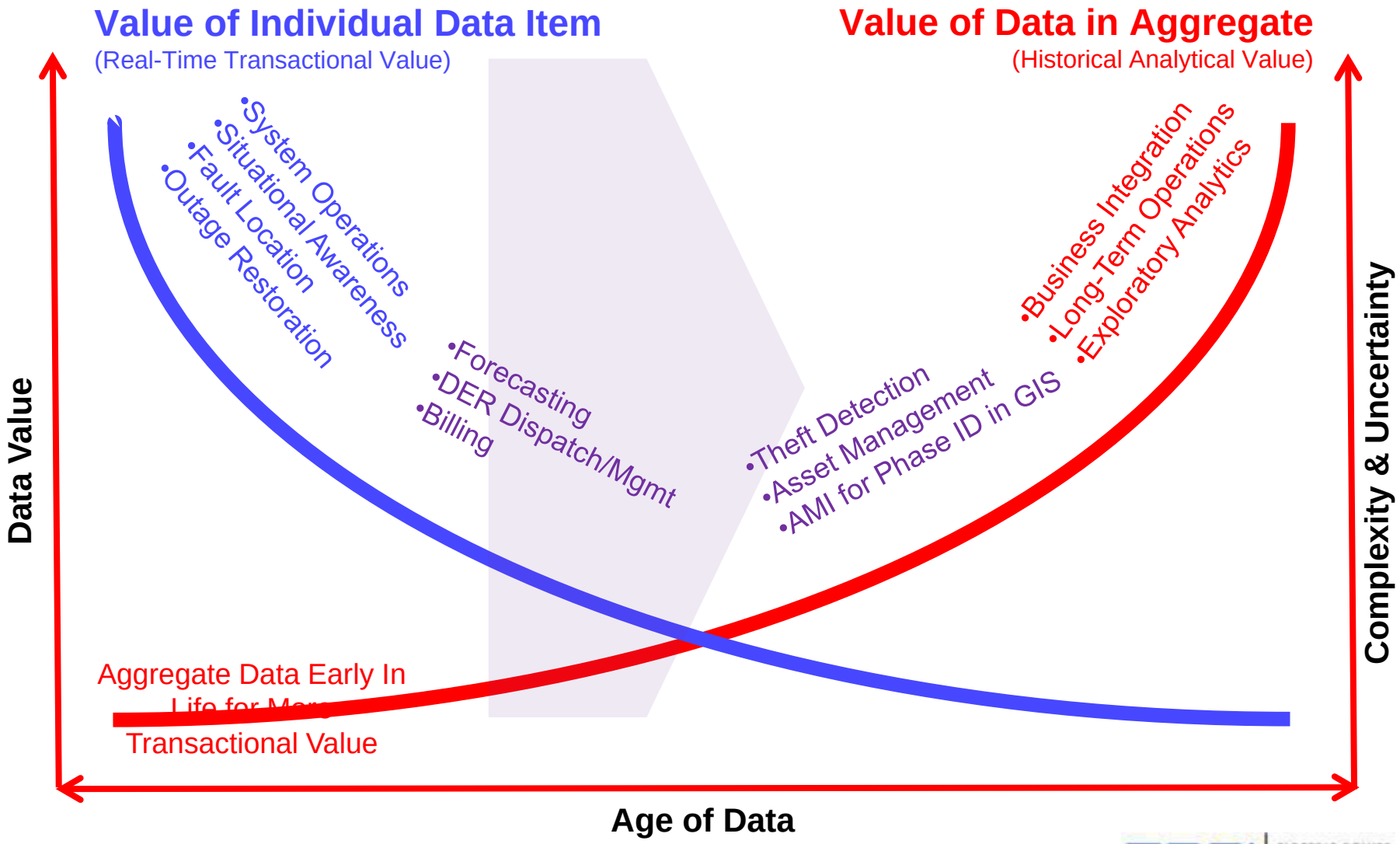
Maximizing Data Value Throughout it's Lifetime



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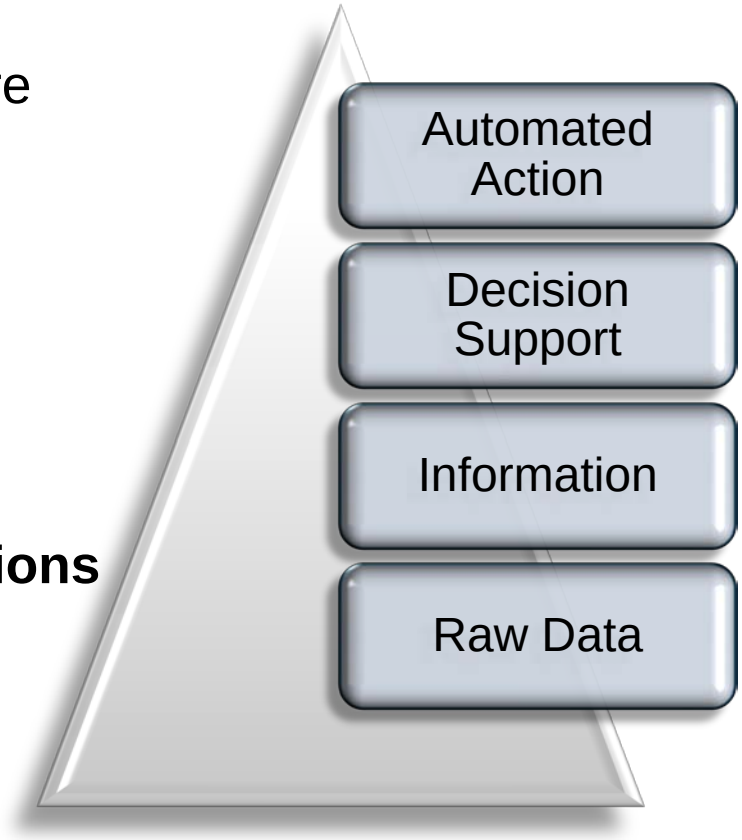
The Opportunity

- **Leverage Smart Grid Investments** that are Producing High-Quality Data
- **Integrated Data Sources** across different organizational groups
- **Apply advanced data mining algorithms**
- **Demonstrate the data analytics applications**
  - Planning Operation, and Asset Management



Improve Reliability – Increase Operational Efficiencies

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Data Integration for Asset Management and Operations

Backdrop

- Power Delivery has:
  - Asset related data available in the field
  - Knowledge about asset behavior
  - Maintenance management systems & methods
  - Sensor technology available to monitor assets

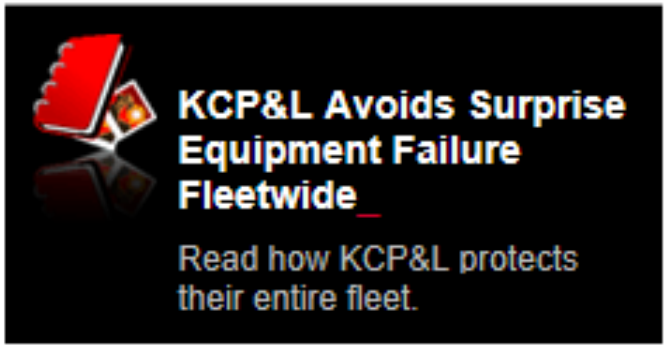
So what is the challenge?

What if I only knew….

- When this circuit breaker last operated
  - Was it slow or within specification
  - Did it clear a fault or just opened for maintenance
  - Has it seen many faults, at what energy level
  - How are other similar units doing
- Is this transformer doing okay
  - Is it gassing
  - Are its winding loosening up
  - Has it seen many faults, at what energy level
  - How are other similar units doing

Our Generation Colleagues get it

smartsignal
Now a part of GE Intelligent Platforms



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Leading Companies Use PRiSM

- Southern Company
  (PRiSM Deployed Across Fossil Plants)
- EDF Energy
  (PRiSM Used For Gas Turbine Monitoring)
- Eskom
  (Fleet Wide Generation Monitoring. Extending Transformer Monitoring)
- Exelon
  (Fleet-wide Nuclear Implementation in Central Performance Monitoring Facility)
- Progress Energy
  (Fleet-wide Implementation With Over 2,000 models built for Gas and Coal generation equipment)

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Plant Process Computers Monitor Critical Elements

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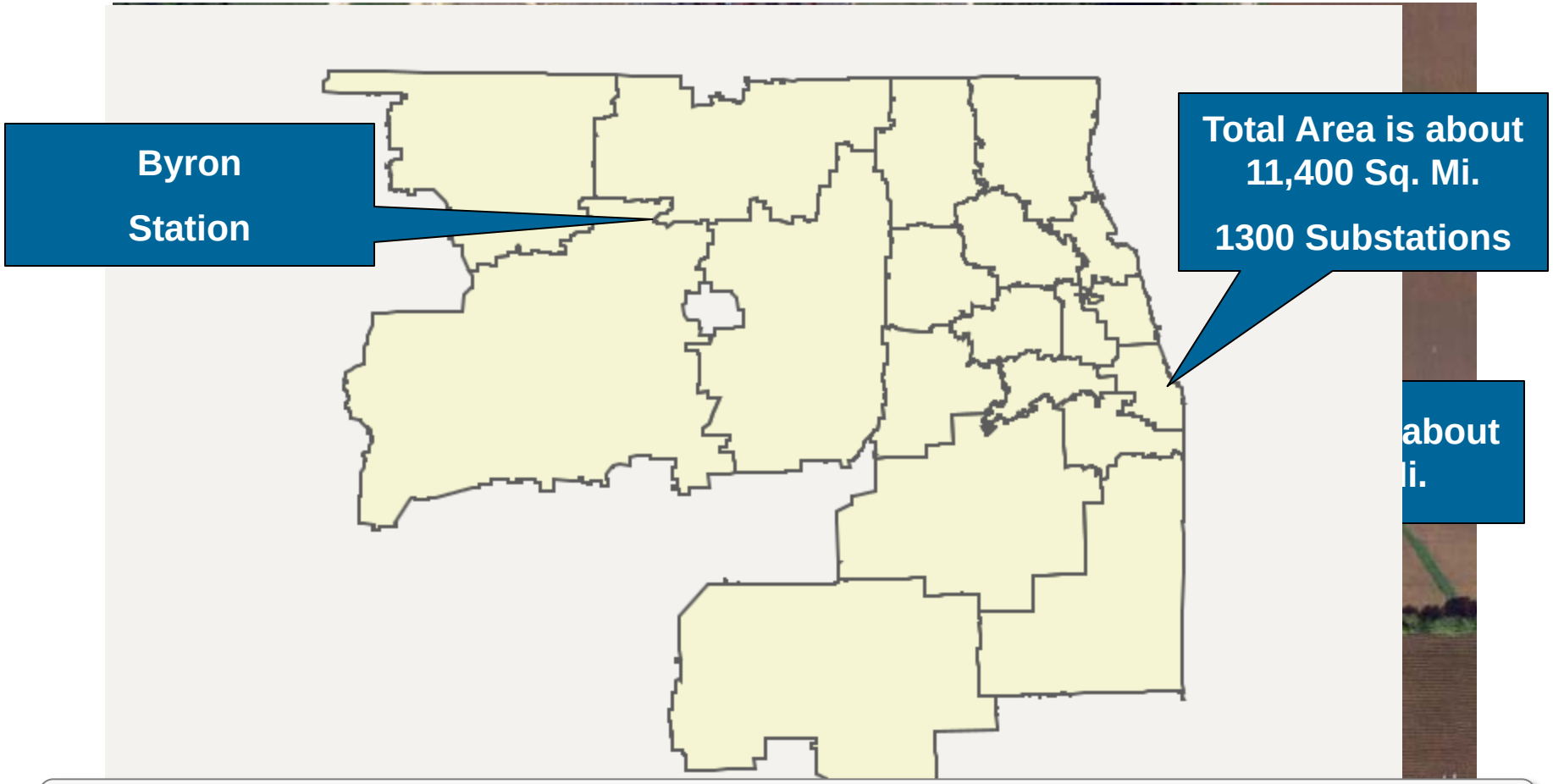
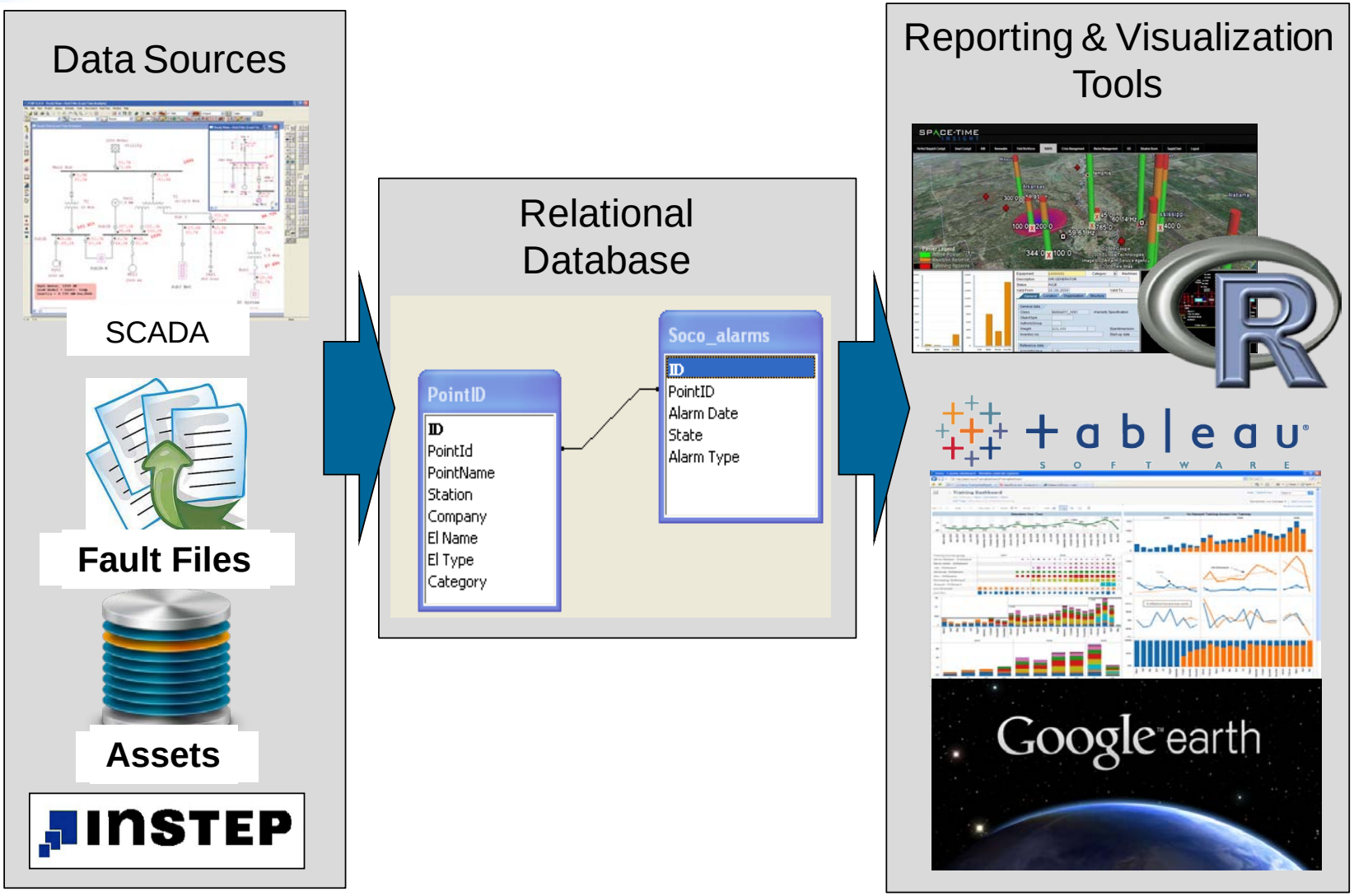
What's the problem?

How big is the gap?

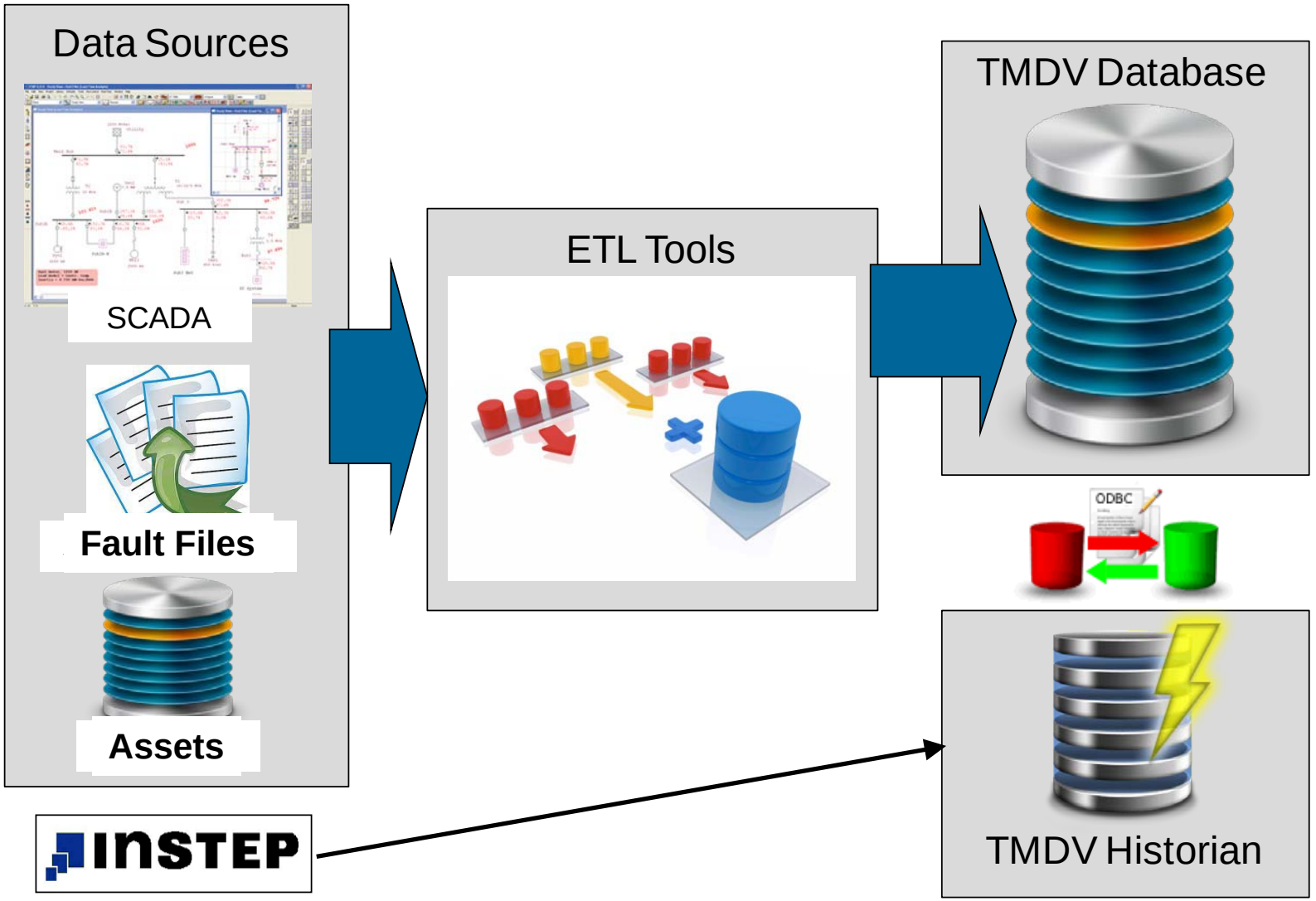


Geography is over 100,000 times as big

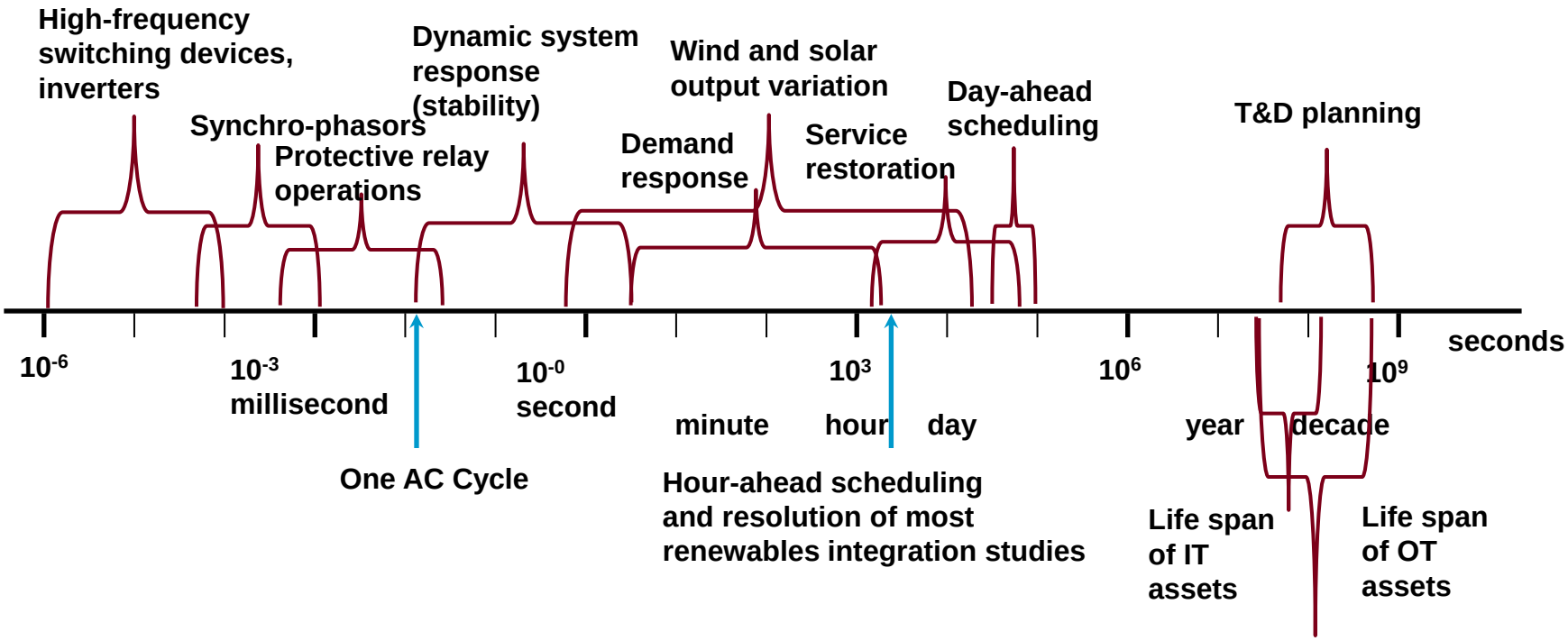
An Existing Architecture Example



An Example Future Architecture



Uniqueness of Utility Data



The uniqueness of the utility market requires unique technologies and architectures

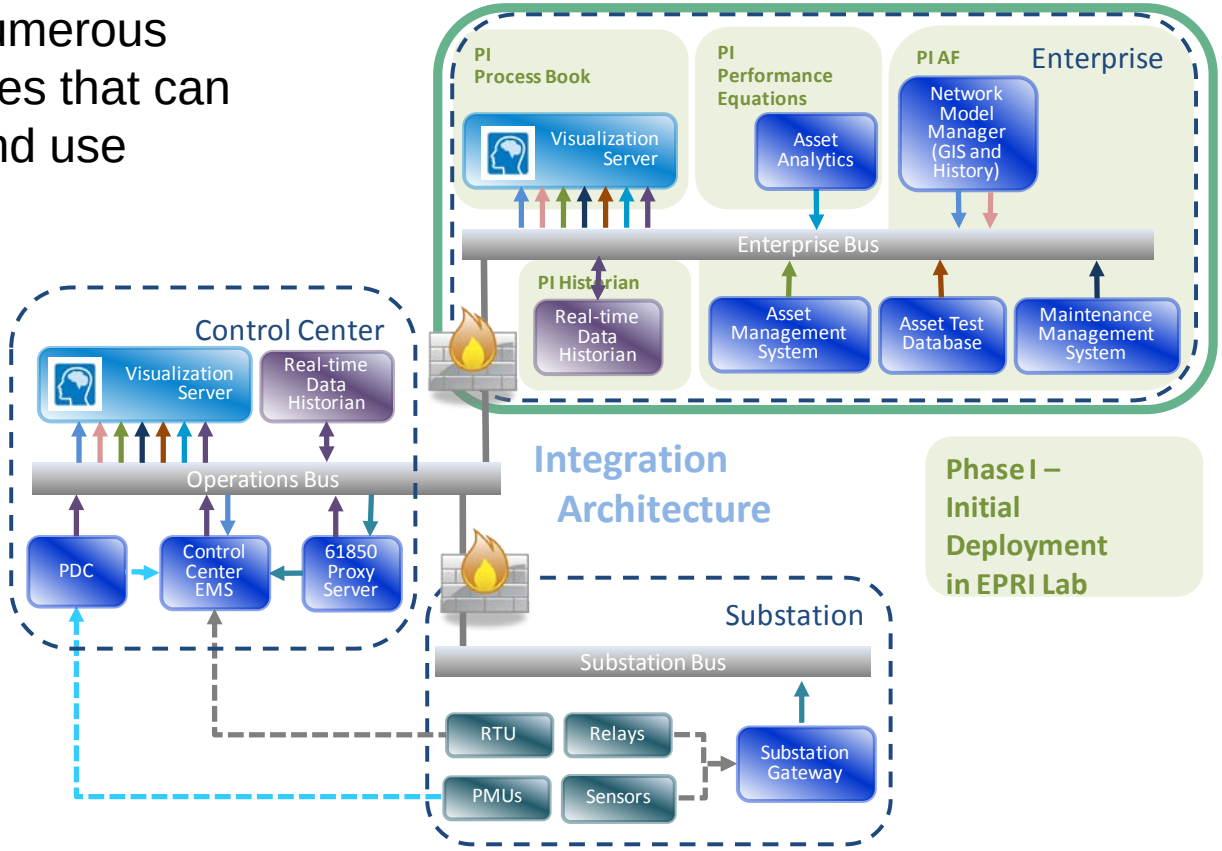
Other issues

- Data ownership
- Naming
- Location
- Understanding the broader enterprise value
- Data decimation
- Periodicity
- Latency
- Asset Testing
- System conditions
- System topology

Field Data for Asset Management and Operations

Problem: Utilities have numerous stand alone data sources that can be difficult to access and use

A Solution: Use CIM to link and integrate these data sources.



Using CIM models provides the basis for analytics that improves decision making.

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Recent Project Demonstrations

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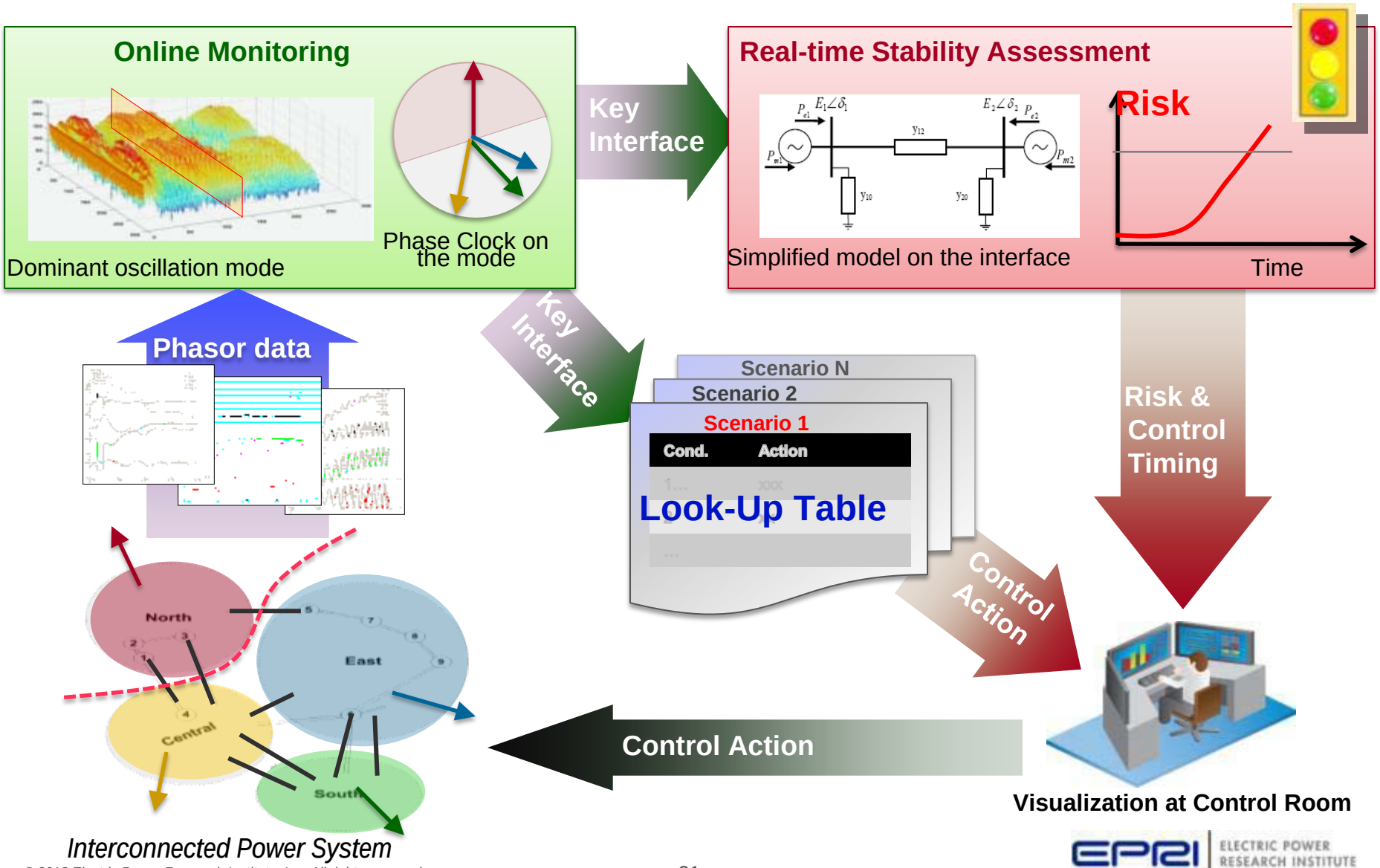
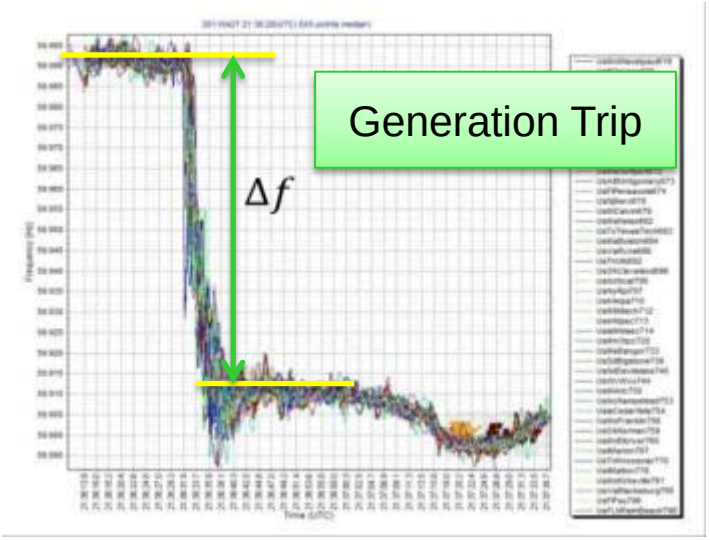
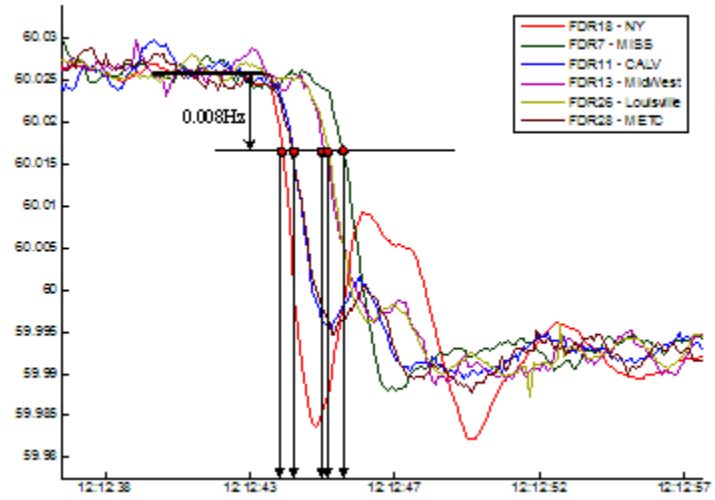
Synchrophasor-based Situational Awareness and Decision Support

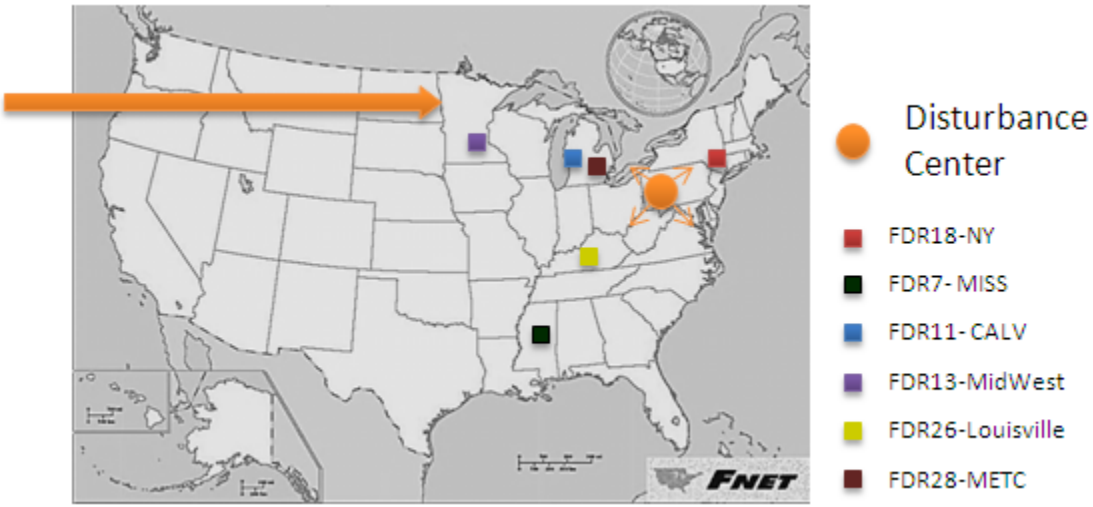


Synchrophasor & Other Data for Disturbance Location Identification



- Use data from PMUs and other sources to identify disturbance location and magnitude
  - frequency wave propagation
  - ΔF and system frequency bias





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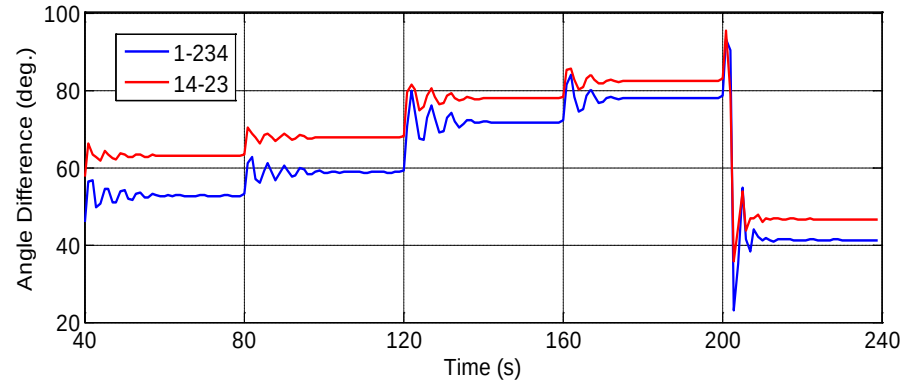
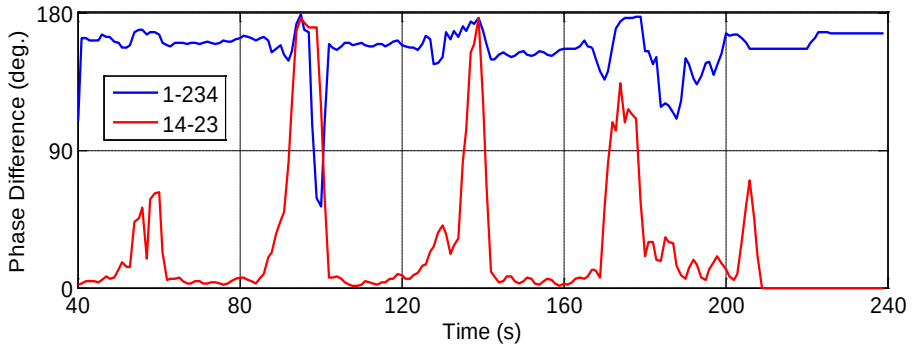
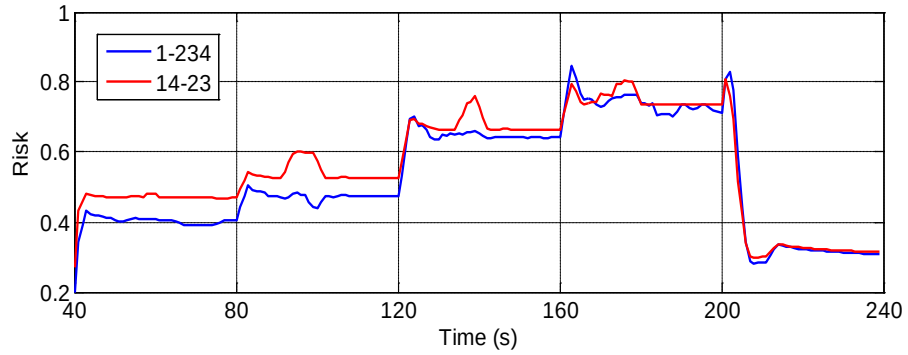
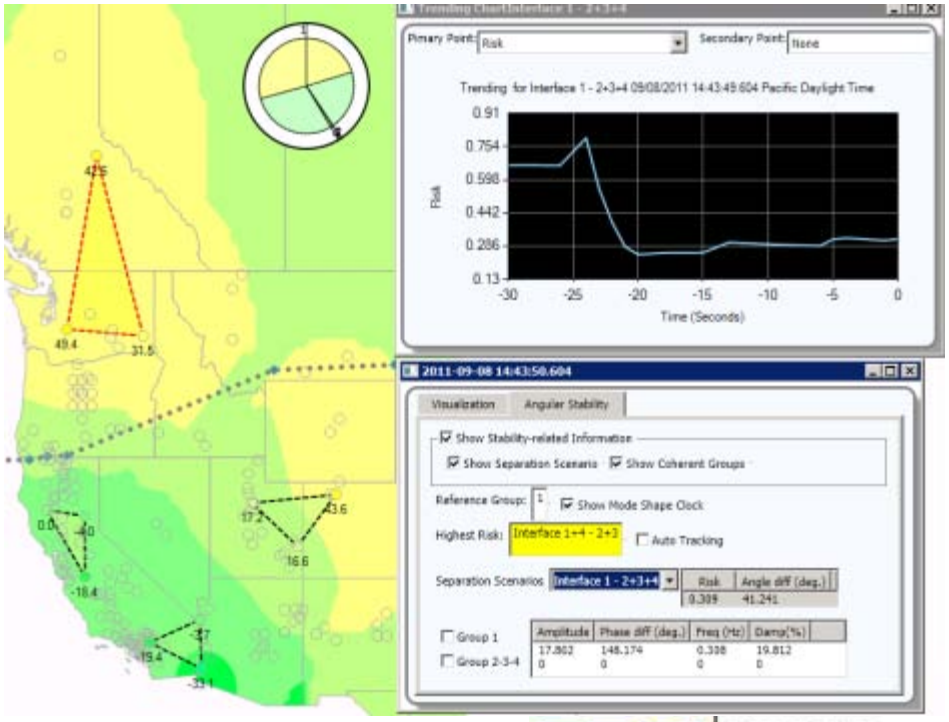
Synchrophasor-Based Early Warning of Inter-Area Oscillations







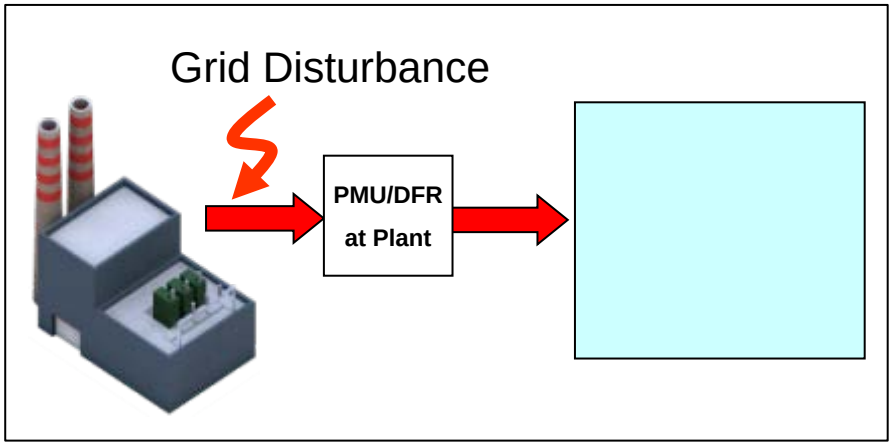
- Identifying vulnerable grid interfaces based on mode shapes of inter-area oscillations
- Providing a risk index of angle separation on the grid interfaces

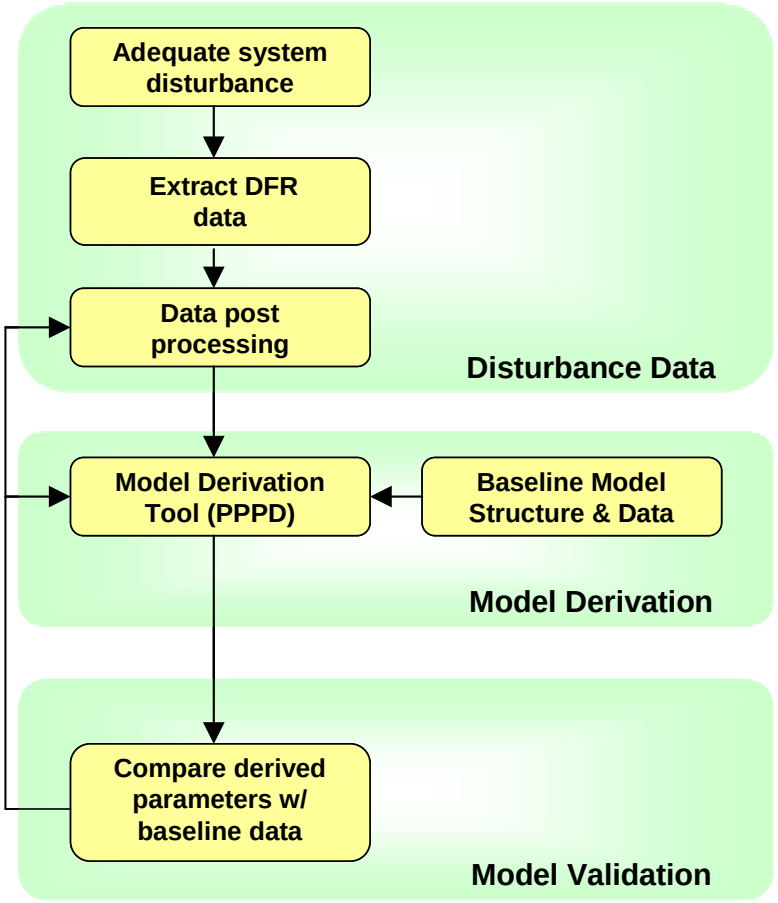


Synchrophasor & Other Data for System Dynamic Model Development & Validation

Process Basics

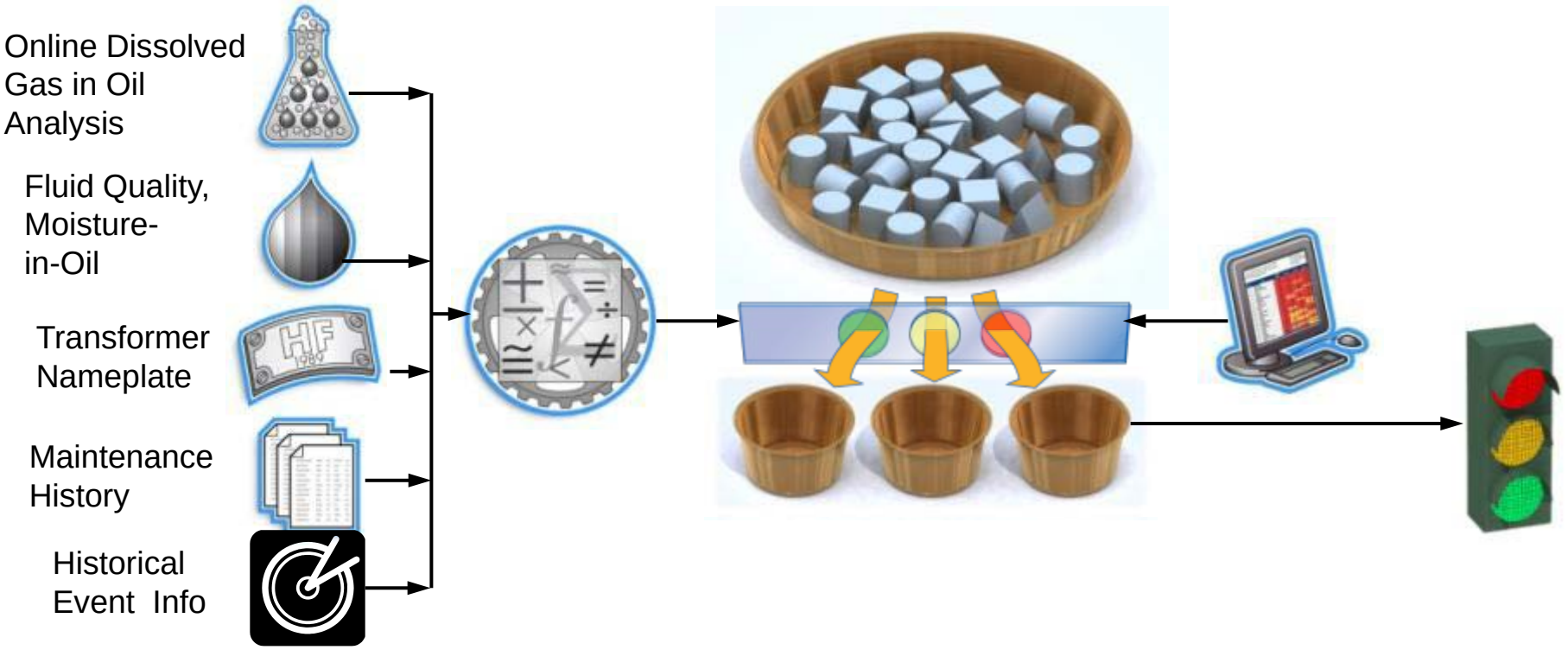
- Use on-line disturbance data or staged test data from generators, loads, et. al.
- Software tool to determine appropriate generic dynamic model parameter values
- Validate individual component models and overall system response





Validate Power Plant Models for NERC MOD-26/27 Standards

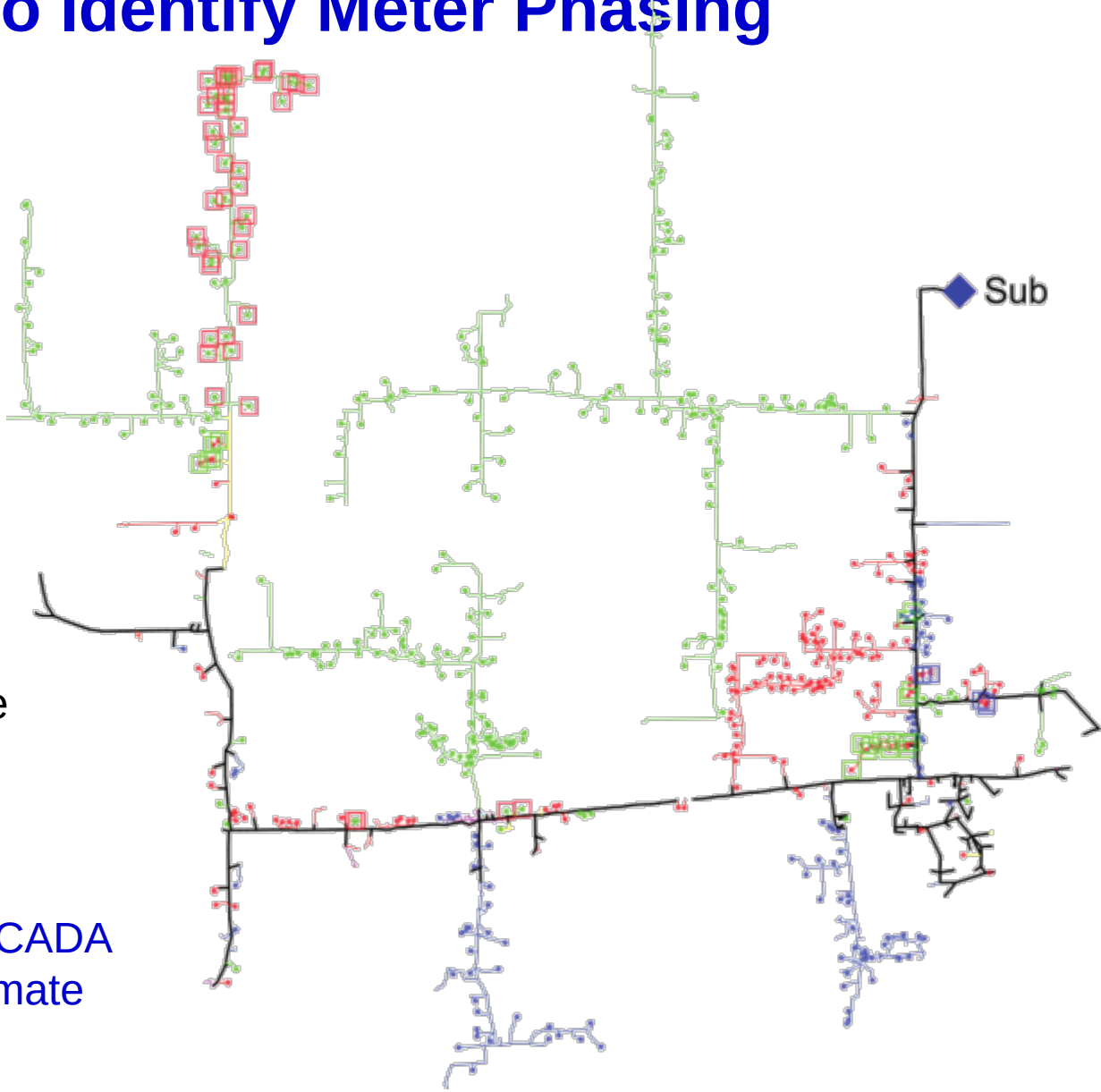
The Power Of Holistic Analytics



Readily Available Information	EPRI Analysis Engine	Sorting Process	Additional Information	Condition Indices

Number of Units	Effort	# of Units	Effort

Using AMI Data to Identify Meter Phasing



Problem: Phasing errors are common in GIS data.

A Solution: Use voltage and current from substation SCADA and customer AMI to estimate phasing.

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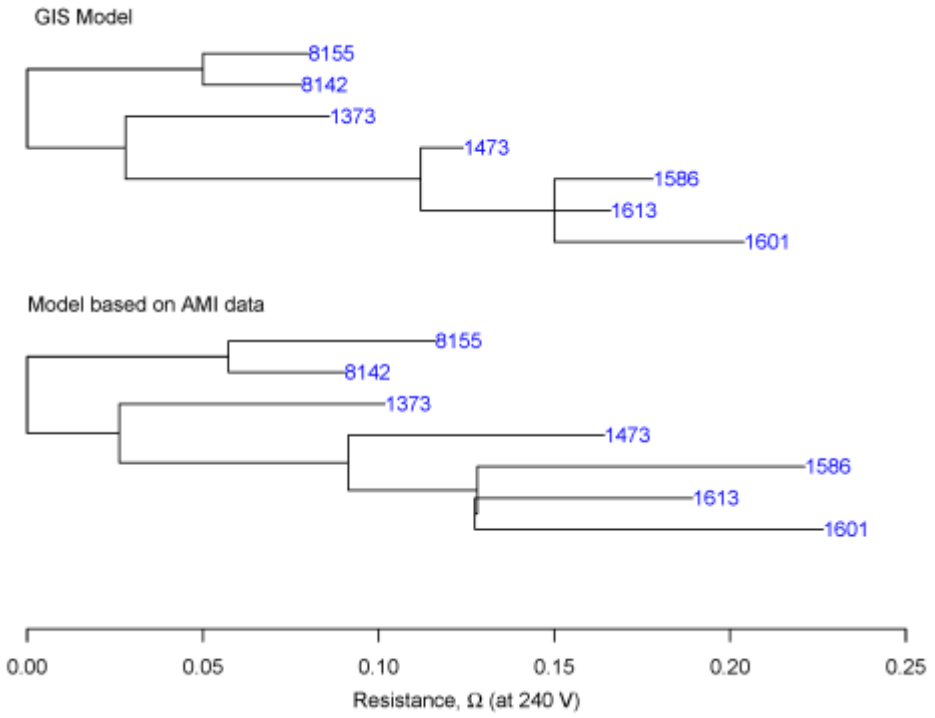
Using AMI Data to Auto-Generate Secondary Circuit Models

Problem: Utilities don't have models of secondaries, or they are poor.

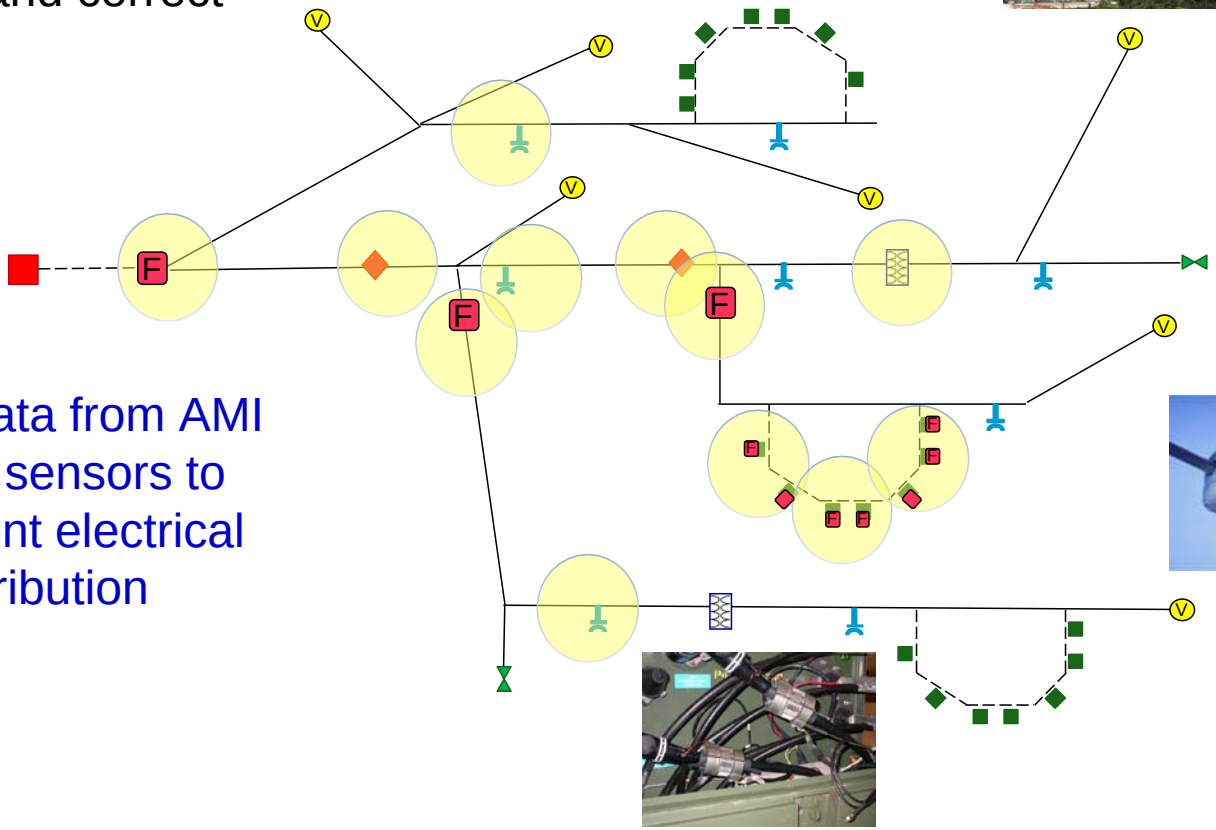
A Solution: Use voltage and current from AMI to auto-build secondary circuit models.



Secondary model based on AMI data was better than the utility model

Using AMI and Sensor Data for Distribution State Estimation (DSE)

Problem: Utilities don't have way to identify and correct "bad" data

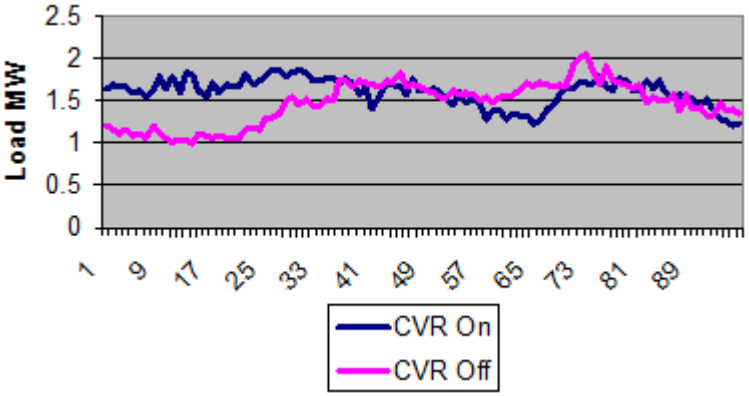


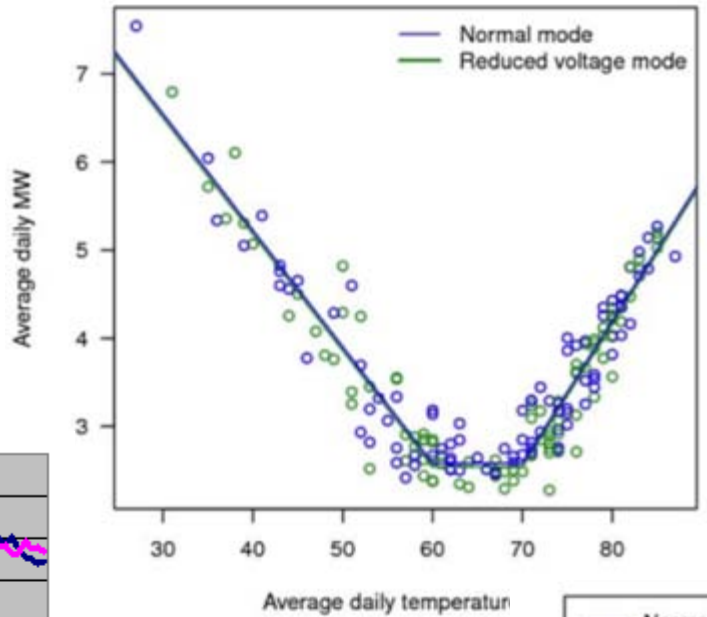
A Solution: Use data from AMI and distribution sensors to determine current electrical state of the distribution system

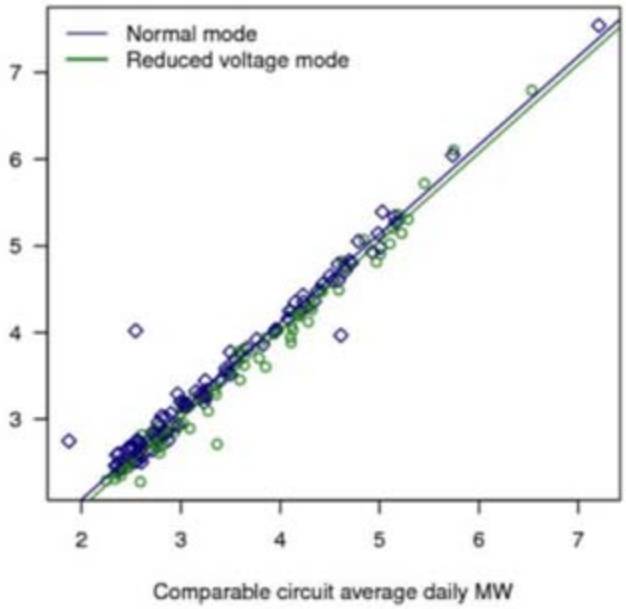
DSE improves reliability of advanced distribution applications

Example: Combinations of Related Data Items

Problem: Utilities don't have way to evaluate efficiency improvement benefits (e.g. Voltage optimization)







A Solution: Combine data from similar circuits and weather data to identify benefits

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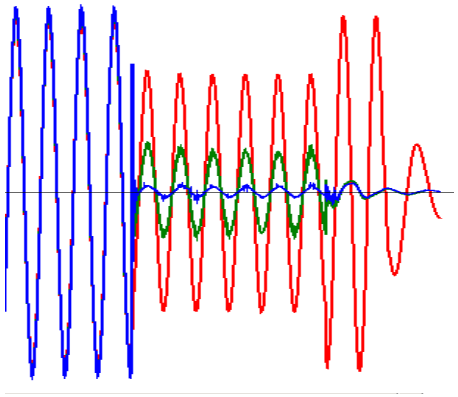
Pattern Recognition

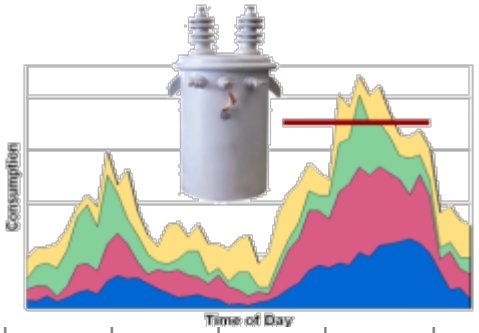
Hydro Quebec: Using Feeder Monitors to Locate Faults and Estimate Cause

A dangling phase conductor that caused multiple momentaries

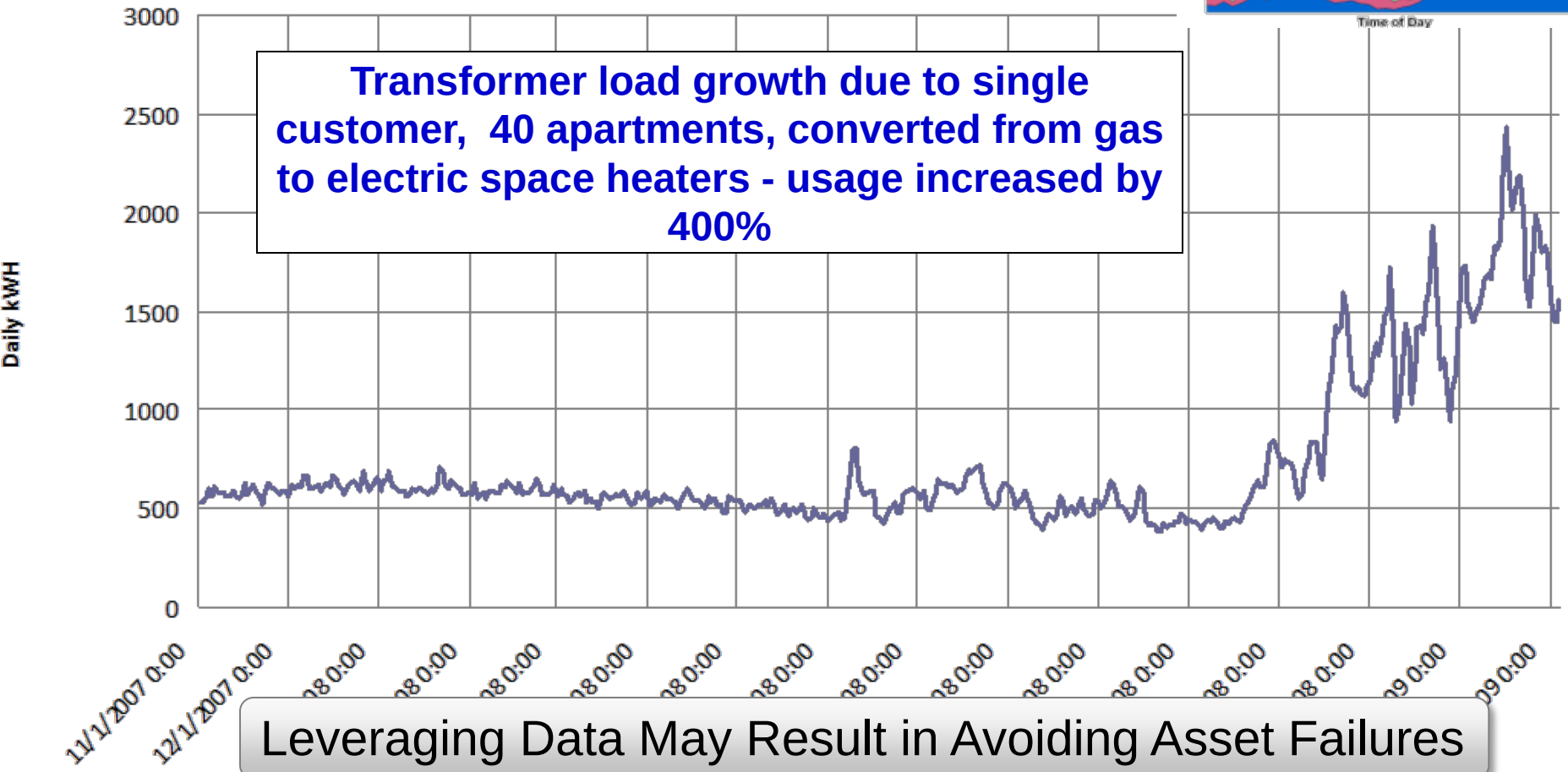


Another case of a bad insulator causing repeat momentaries

Using AMI Data to Detect Stressed Assets



Transformer load growth due to single customer, 40 apartments, converted from gas to electric space heaters - usage increased by 400%



Leveraging Data May Result in Avoiding Asset Failures

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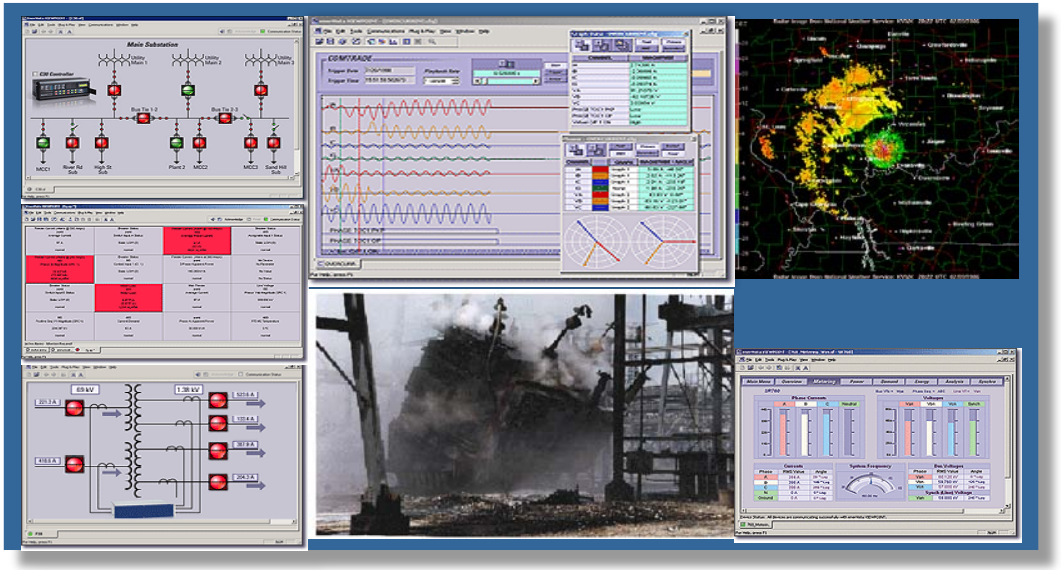
Enabling Technologies that are Emerging

- Enterprise architecture
- Visualization technology
- Database technology
- Standards for interoperability
- Sensor technology



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Some Data Examples

Relay Event Logs (event, waveform, configuration)

- 030201,13384930,-4d,Magella,SOUTHSIDE LINE PRI#16,APCo,,,04305n,07767w.SEL

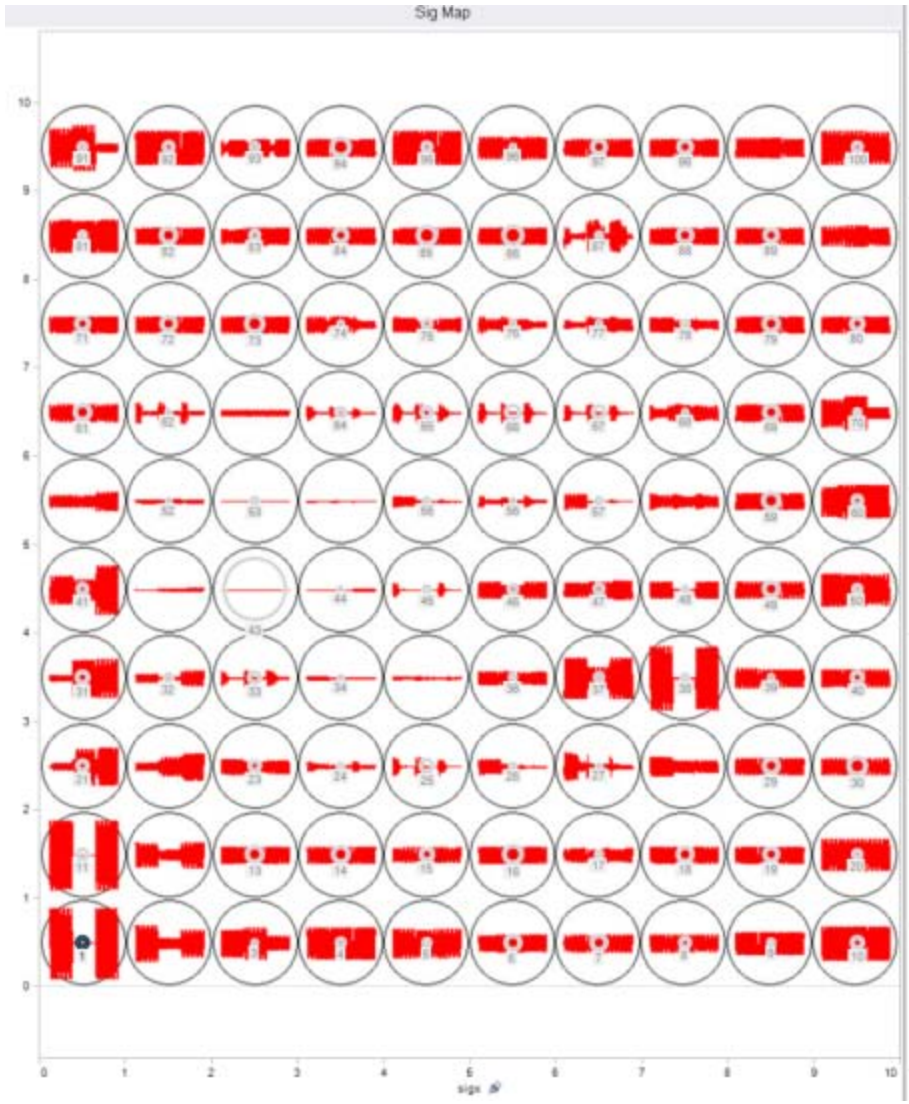
FID=SEL-121G-5-R413-V656mptr12syzfs2-D941021-E2

Currents (amps)					Voltages (kV)			Relays Outputs Inputs
								52265L TCAAAAA DPBD5E
IPOL	IR	IA	IB	IC	VA	VB	VC	01171O PL1234L TTTC2T
8	15	-8	-102	102	-63.4	57.0	6.8	....*.
0	-15	94	-64	-26	-28.8	-40.6	69.6	....*.
-8	-15	4	98	-106	63.5	-57.0	-6.8	....*.
0	30	-98	64	30	28.8	40.7	-69.6	....*.
8	-15	0	-94	106	-63.5	56.9	6.9	....*.
0	-15	98	-64	-30	-28.7	-40.8	69.6	....*.
-8	15	0	94	-102	63.5	-56.9	-7.0	....*.
0	0	-98	68	26	28.6	40.9	-69.6	....*.

Event : EXT Location : mi ohms sec
Duration: Flt Current:
R1 =0.40 X1 =2.26 R0 =1.96 X0 =6.90 LL =3.01
CTR =240.00 PTR =1000.00 MTA =75.00 LOCAT=Y
79OI1=10000.00 79OI2=10000.00 79OI3=10000.00 79RS =8000.00
Z1% =90.00 Z2% =140.00 Z3% =171.00
Z2SP =0.00 Z2DP =25.00 Z3DP =90.00

Kohonen Neural Networks

Relay Signature Analysis (cluster analysis & movie)



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Thank you!

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708-479-5543

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