Synchrophasors and Next Generation Energy Management Systems (EMS)

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Celebrating the Visions of Synchrophasor Pioneers: Arun Phadke and Jim Thorp

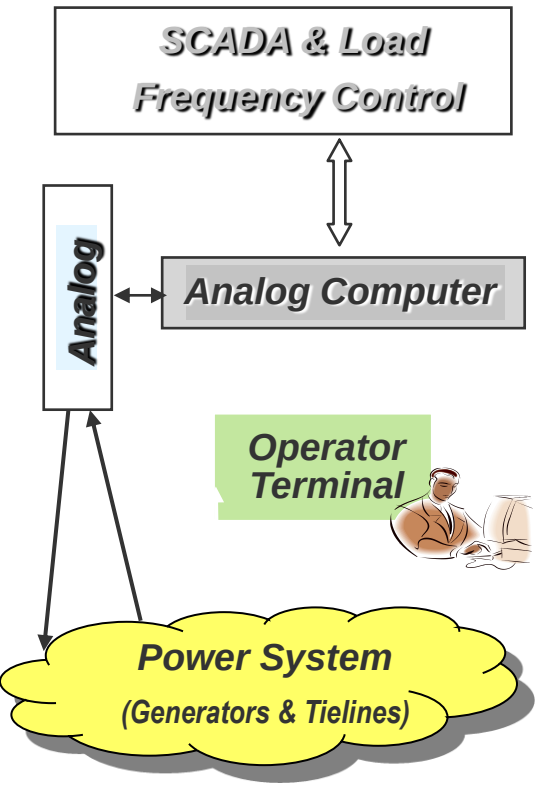
May 9th, 2013

Changing Landscape

60's & 70's

Analog / Hardwired

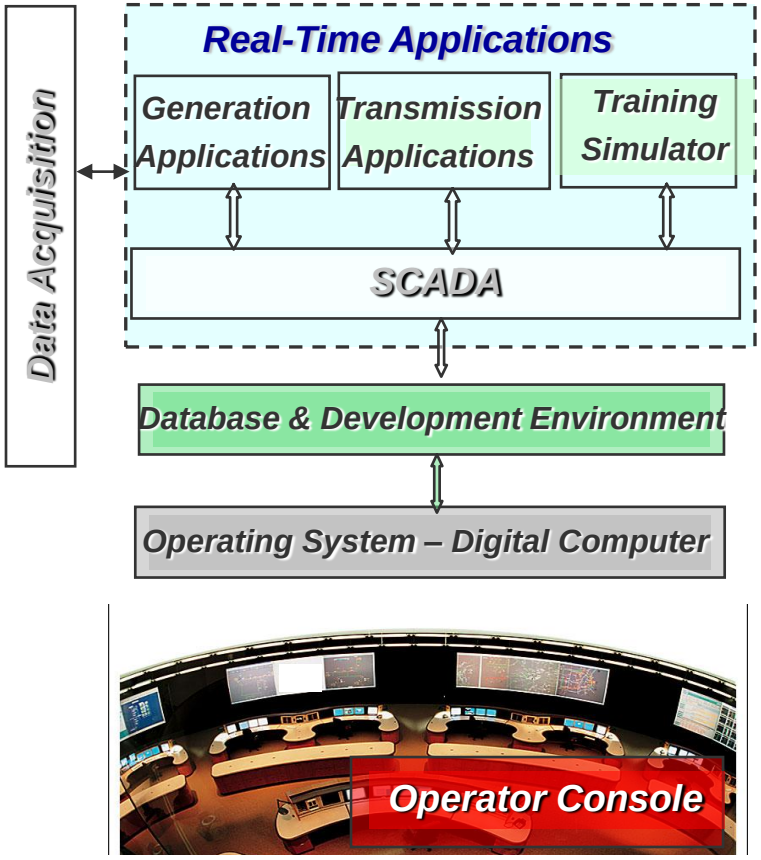
Centralized systems…



80's & 90's

Digital /Study Mode / Modeling

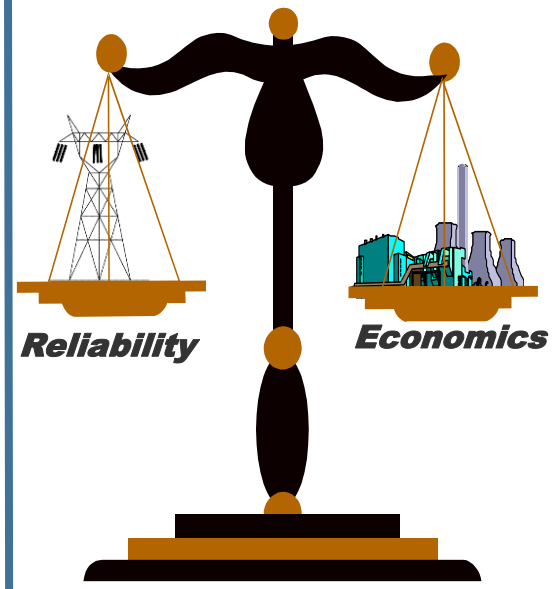
Offers "predictive" capabilities…



Late 90's

Energy Markets

Adds uncertainty…



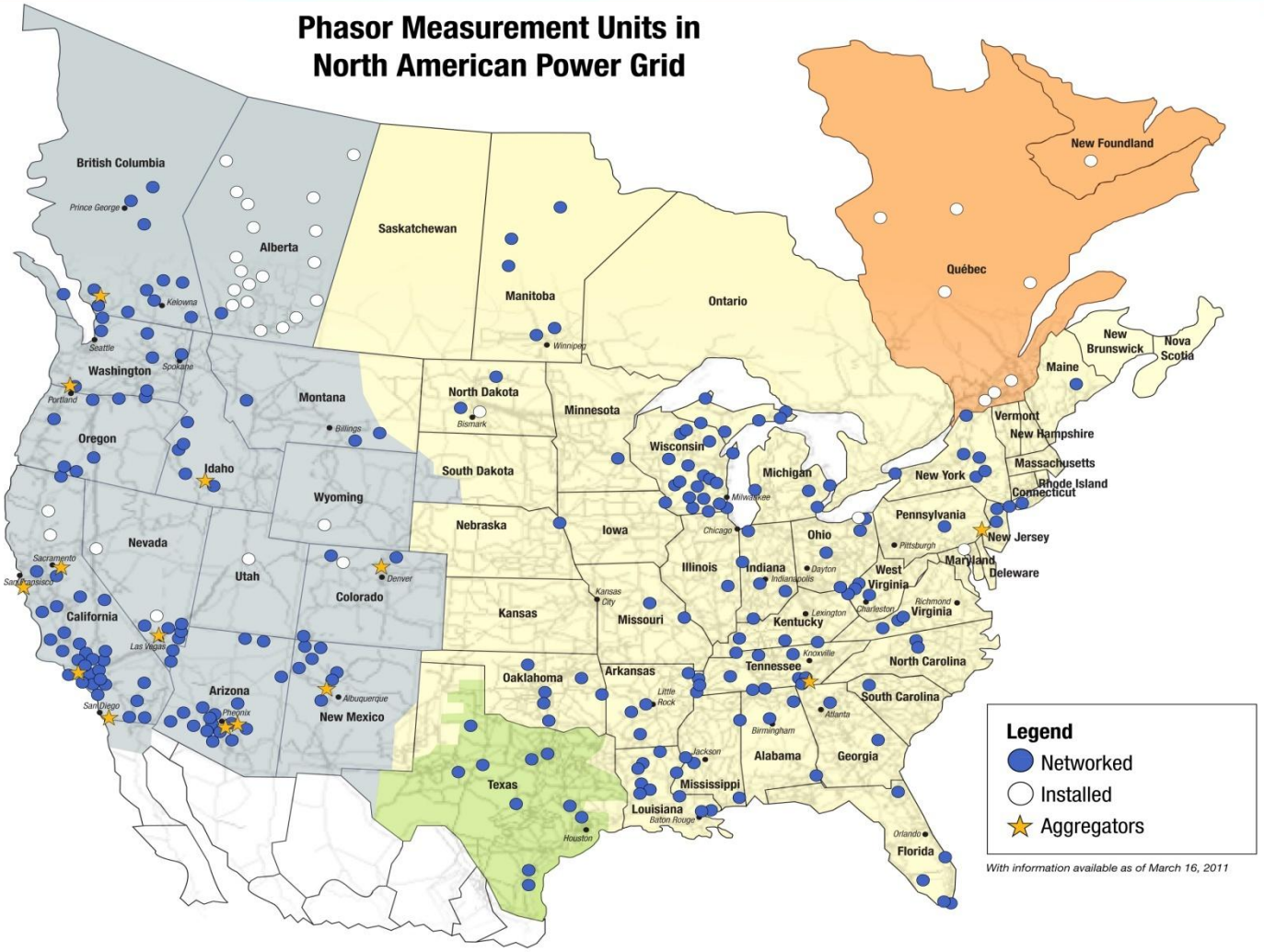
Vertically Integrated Industry p2 **Deregulation**

PMU Deployment within North America

North American SynchroPhasor Initiative (NASPI)

Currently 200+ PMUs Installed.

Expected to exceed 800+ PMUs by 2013 (under SGIG Investments)



Source: NASPI Website (www.naspi.org)

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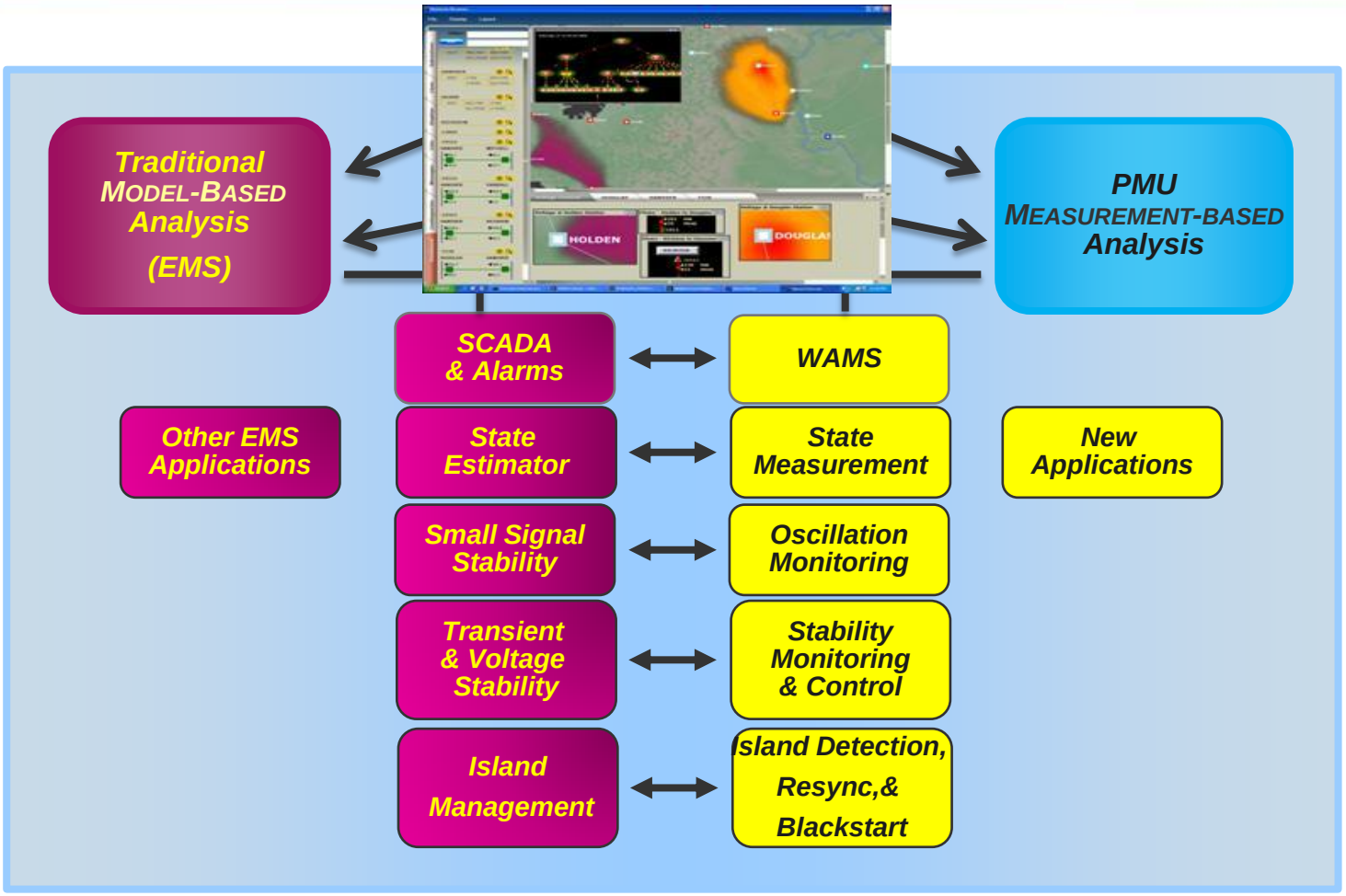
Energy Management Systems of the Future



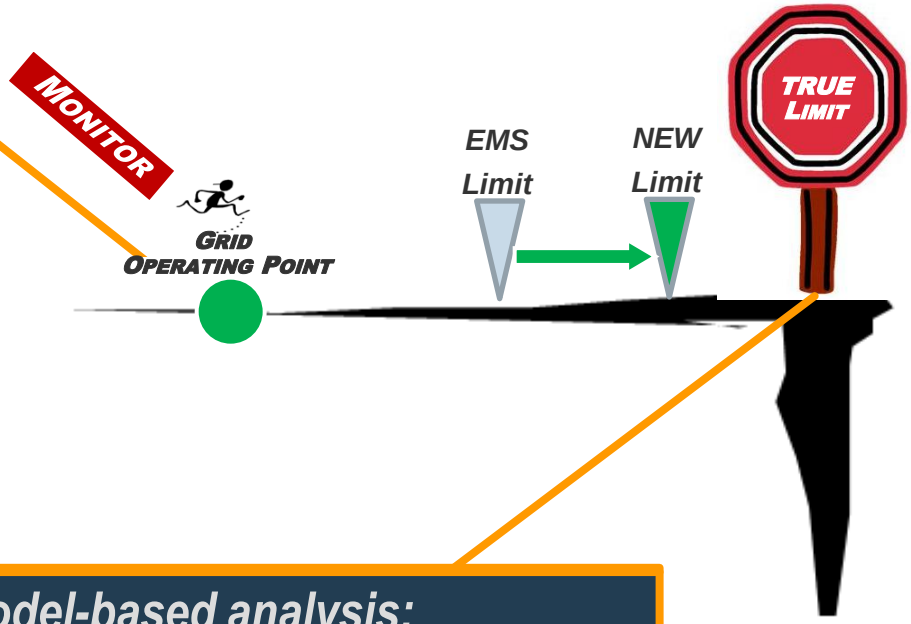
Integrated “measurement-based” & “model-based” Analysis….

A nice marriage, indeed!

SYNCHROPHASOR APPLICATIONS

PMU Measurement-based analysis

PhasorPoint



Improve Model data

Calculate Online Limits

Model-based analysis:

Corrective actions based on ‘what-if’ analysis

DYNAMIC SECURITY ASSESSMENT

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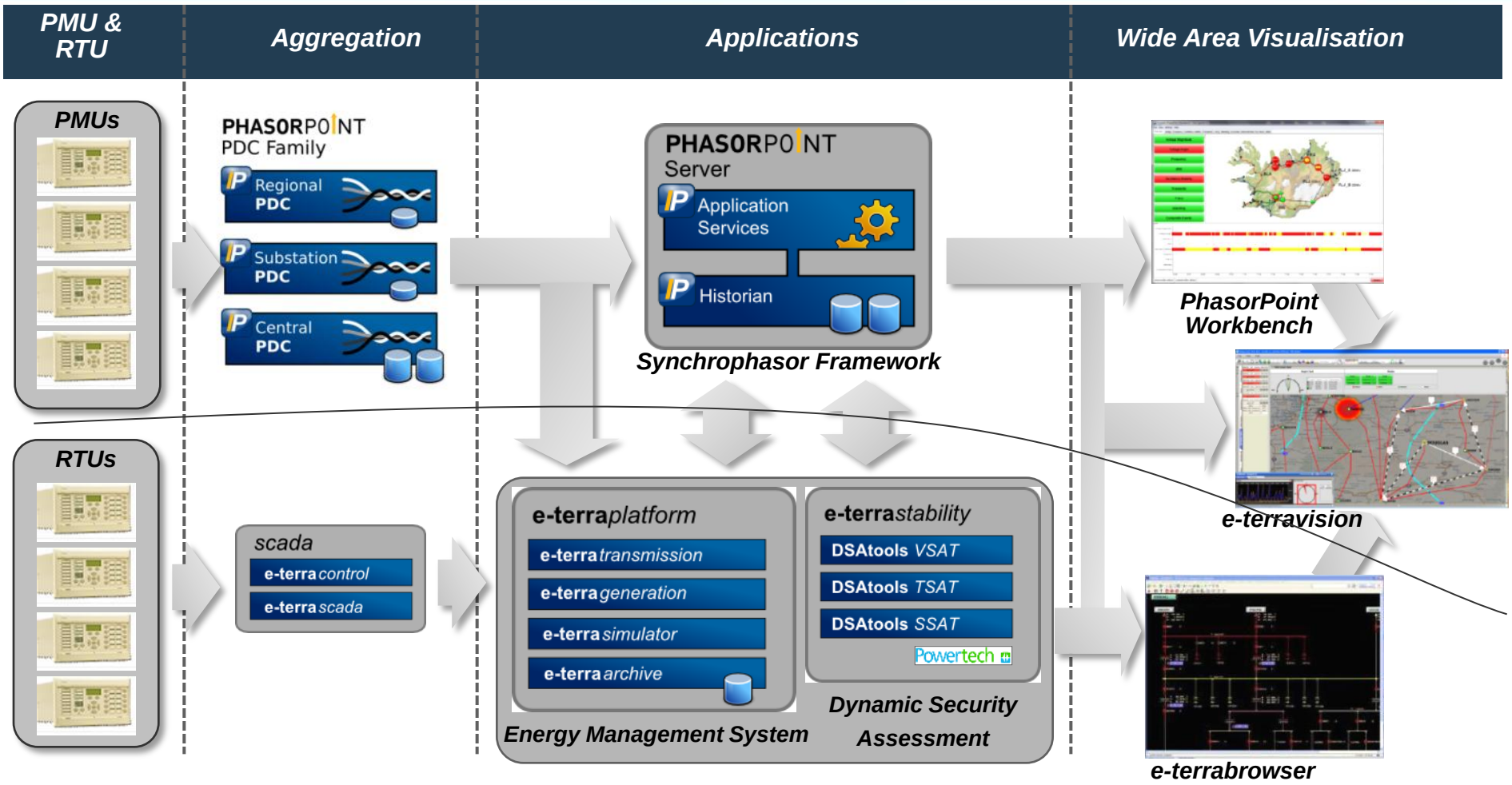
Alstom Solution Architecture



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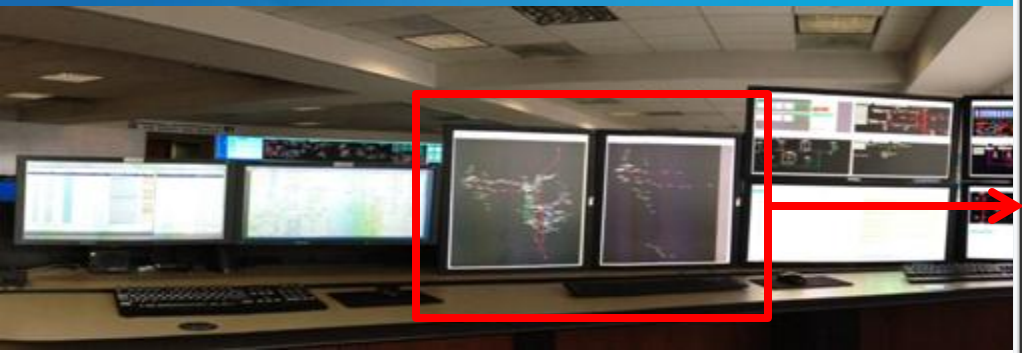
PG&E SynchroPhasor Project

Vahid Madani – Project Technical Leader



EMS Visualization and Alarming Platform

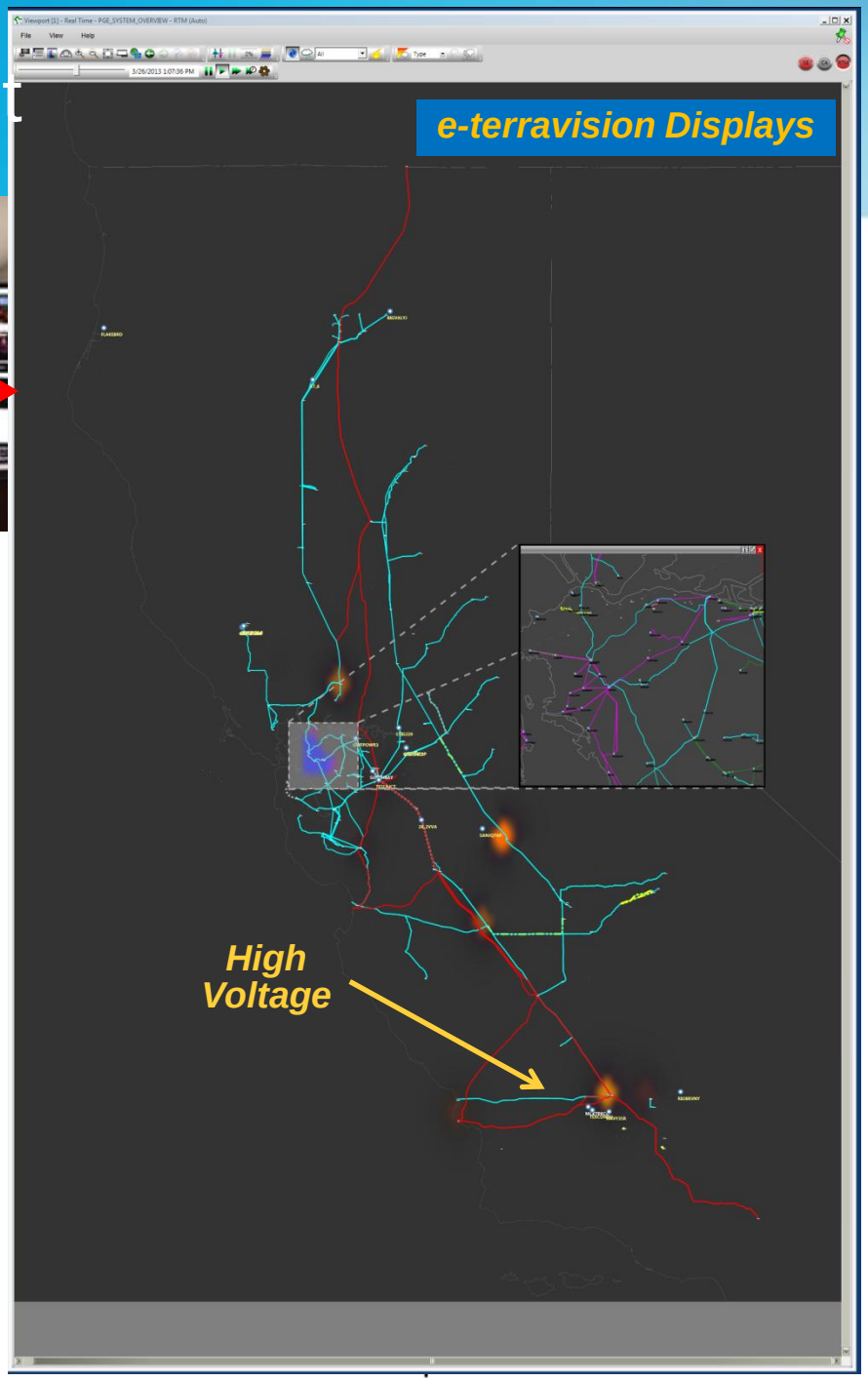
(Cognitive Task Analysis & Information Processing)

Interfaces	PMU Apps	Grid Stability Apps	EMS Apps	
(Data Exchange with Neighbours)	OSM	VSAT	Fast Grid Topology Processor	Simulation
Substation State Estimator	Islanding / Restoration	SSAT	Fast Grid State Estimator	DTS
Fault Locator	Disturbance Locator	Mode Compare	Enhanced SE	
Data Archival	Other WASA	TSAT	Security Apps	

PMU and SCADA Data

(Redundancy/Data Synchronization)

SynchroPhasor Applications for the Control Center



PG&E Proof of Concept (PoC) Laboratory

Vahid Madani – Project Technical Leader

PG&E POC facility has been instrumental in gathering the expertise to provide the industry with direction and a fast track process for maturing the standards such as the IEEE C37.118.2, C37.238, 242,244, and IEC-61850-90-5

-- "Going Beyond the Abstract"

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Improving Situational Awareness in the Control Room

Situation Awareness Visualization

Generalized Security Assessment

Wide Area Visibility

Steady State Security

Dynamic Stability

RT & Look-ahead trends

Correlation

Synchrophasor Applications

EMS Applications

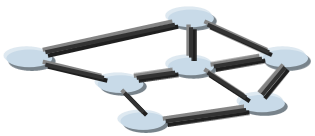
DSA Applications

Production Forecast

Non-operational Data

"Measurement-based" Applications

Network Model-based Apps



Weather conditions

Condition Monitoring

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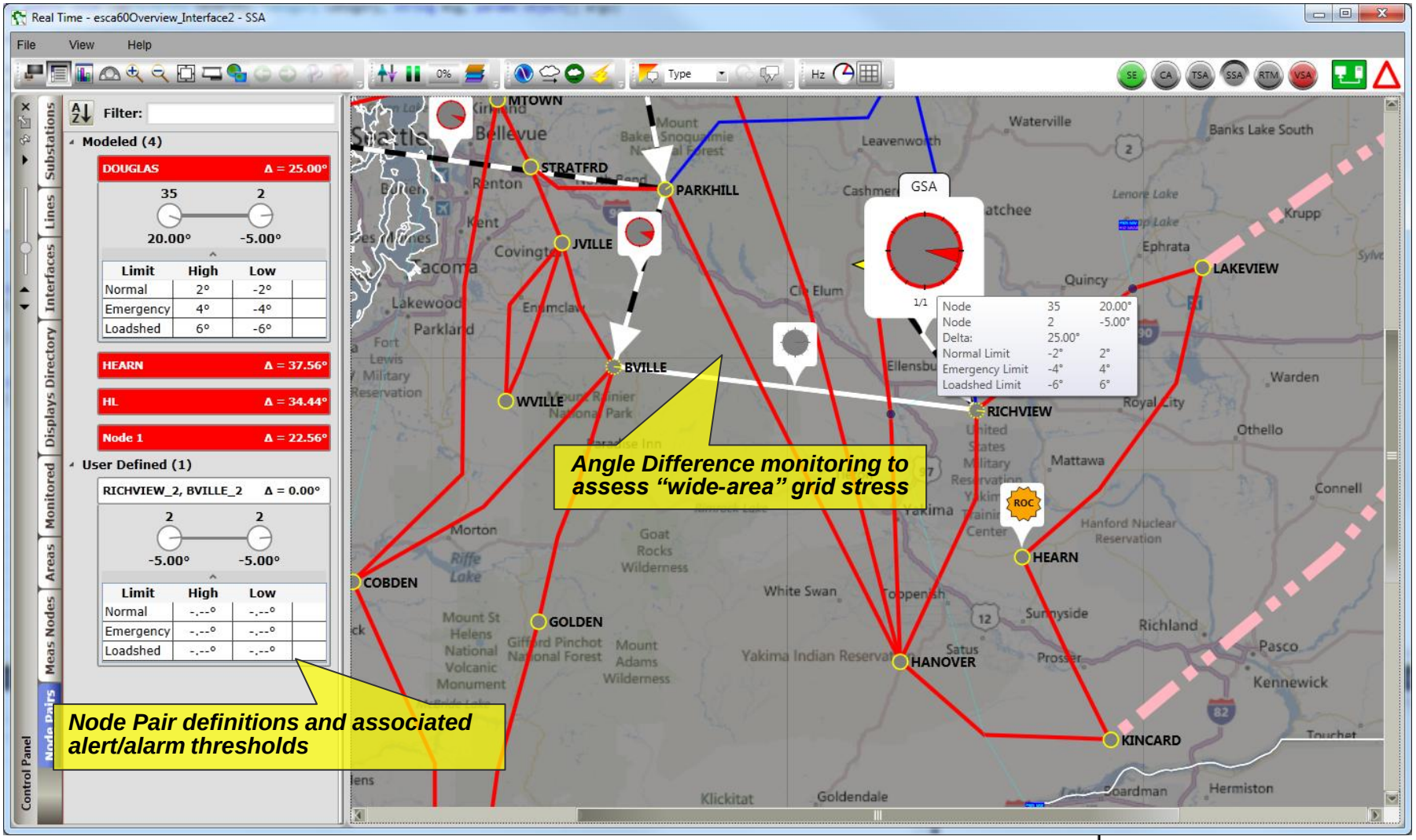
SynchroPhasor Wide Area Visualization (e-terra*vision*)



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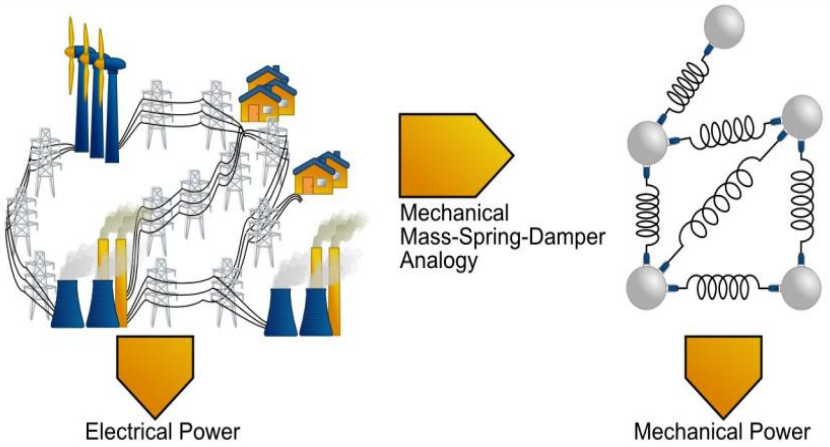
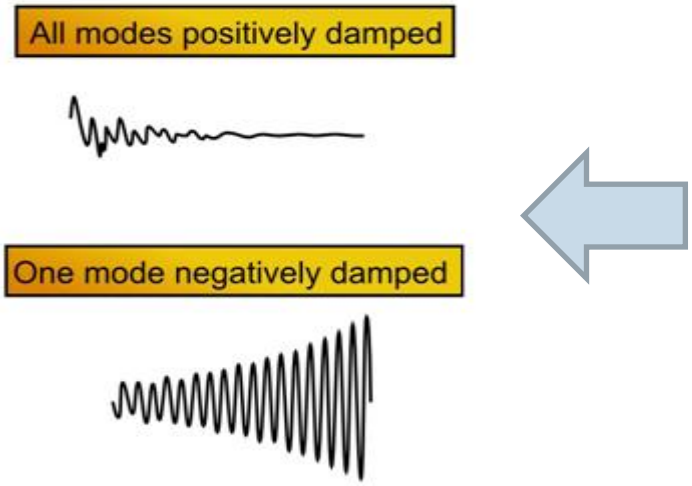
Dynamic (Oscillatory) Stability Management

"The interconnected electric power grid is one of the largest dynamic system of today"



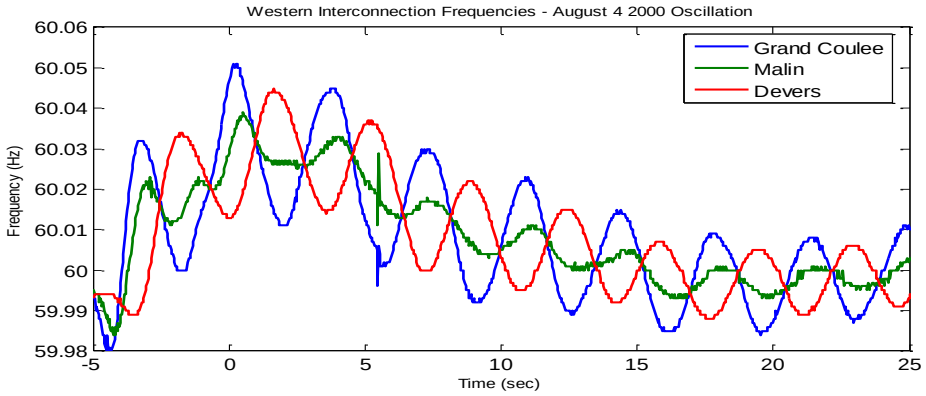


Oscillations seen by SCADA and PMU data

- Numeric SCADA displays today

Rapidly changing digits on a numeric display

- ***With synchro-phasors – high resolution trend display***



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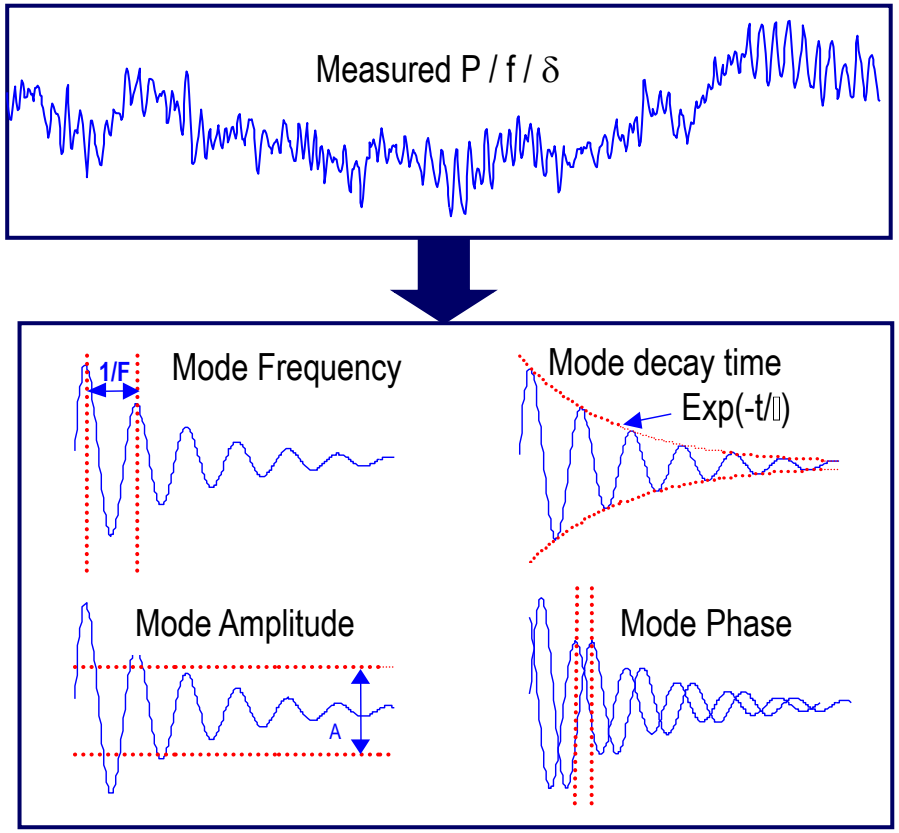
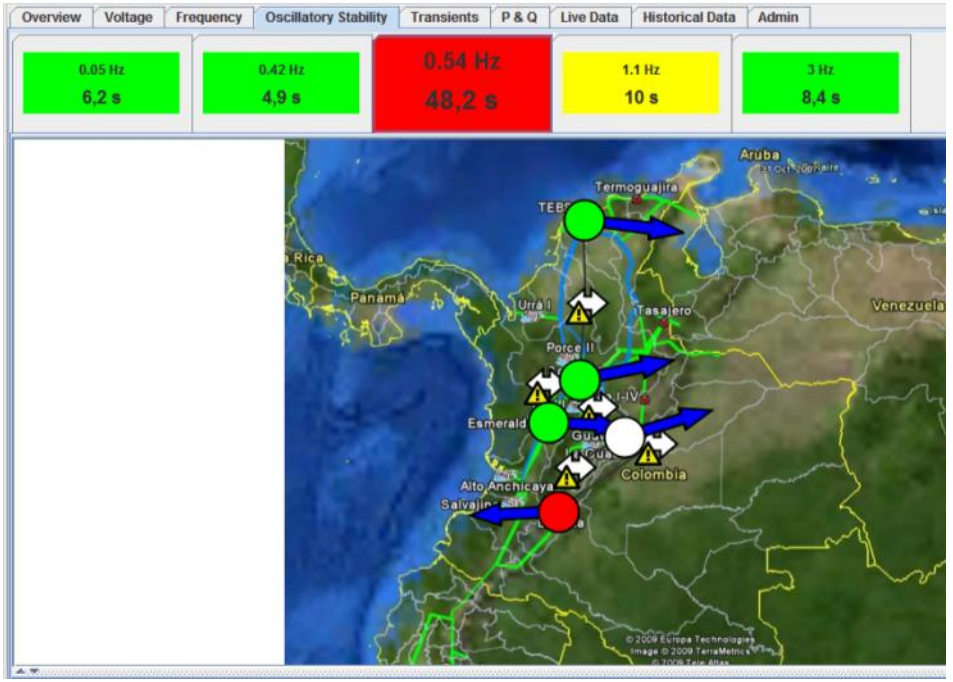
Oscillatory Modes Observed in Colombia (2009)





Operations	Early warning alarms of poor damping
Planning	Dynamic model validation / plant performance

Inter-area mode at 0.49Hz (Colombia-Ecuador). Opposing phase in South

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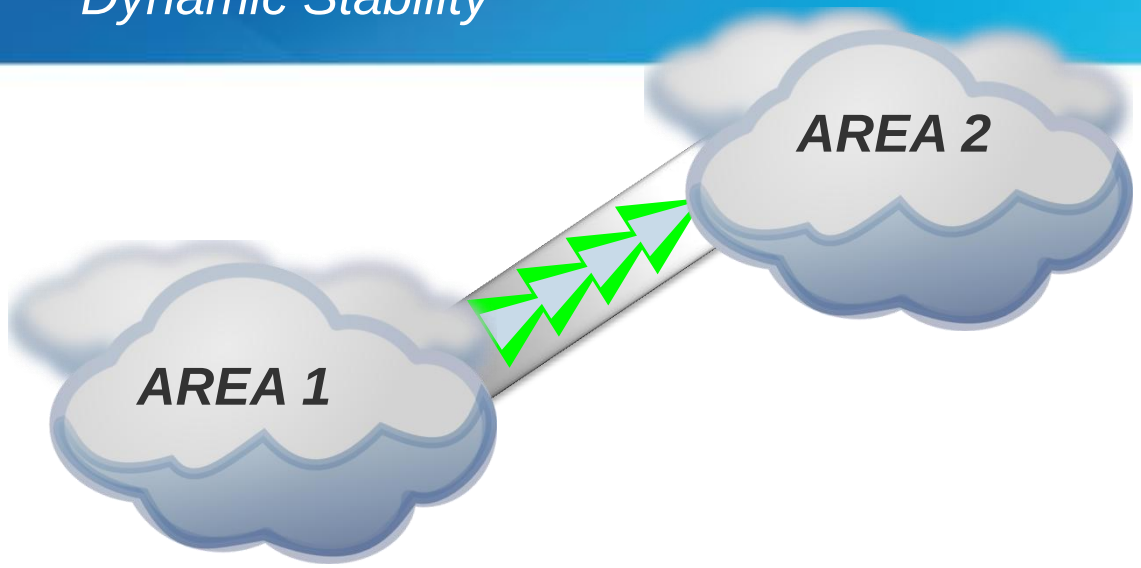
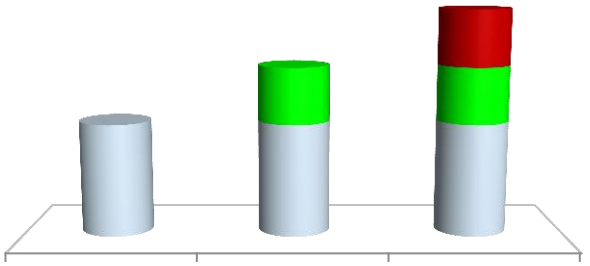
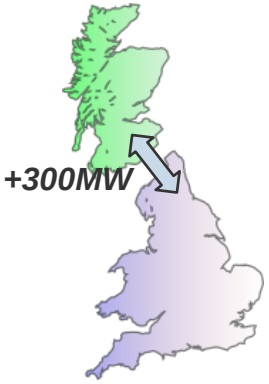
Congestion Relief
Dynamic Stability



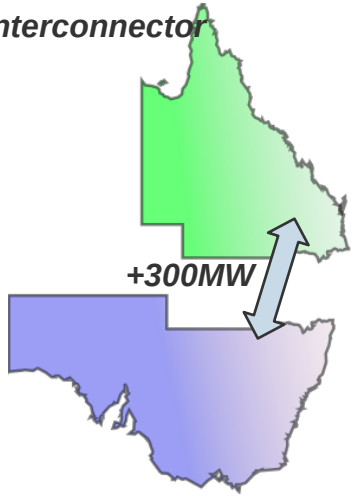
Transmission Corridor
Net Transfer Capacity

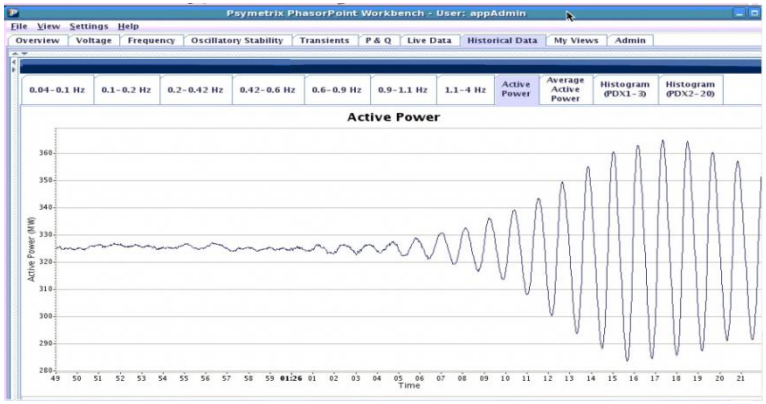


Great Britain
Scotland – England
Interconnector



Australia
Queensland – NSW
Interconnector





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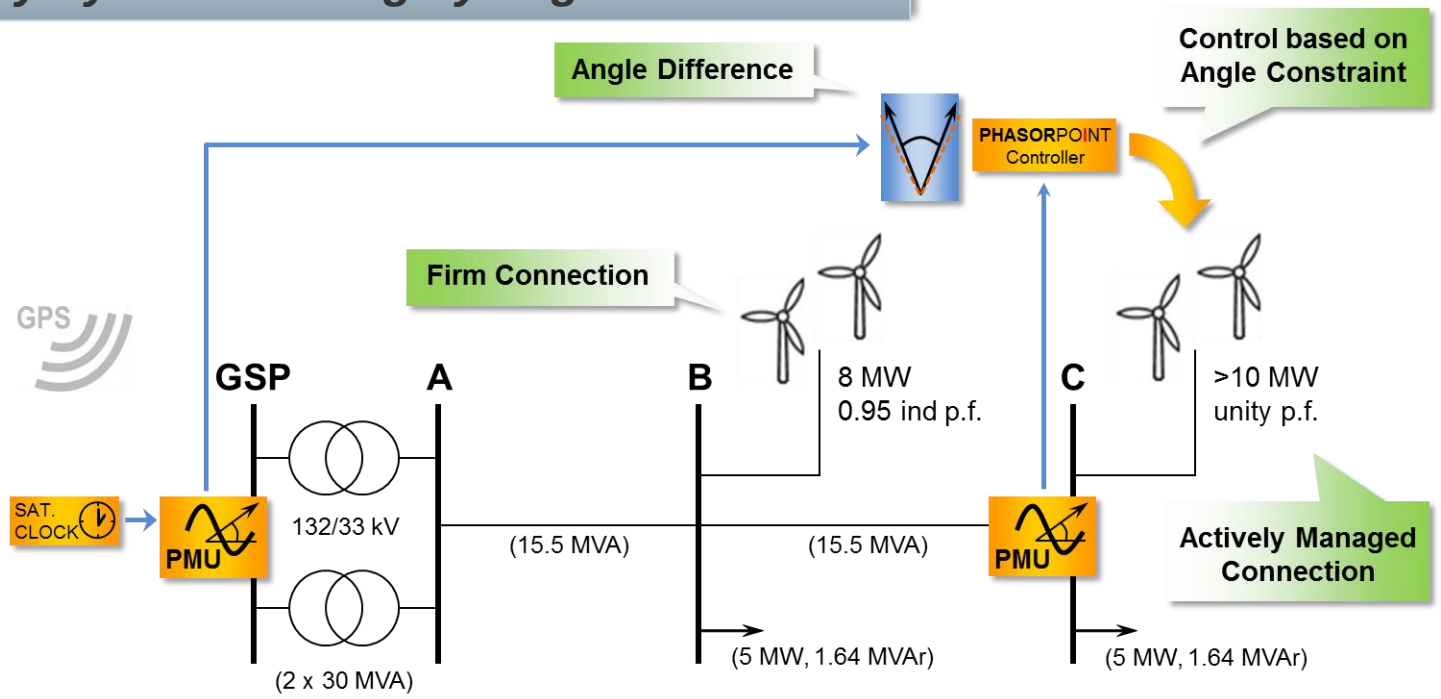
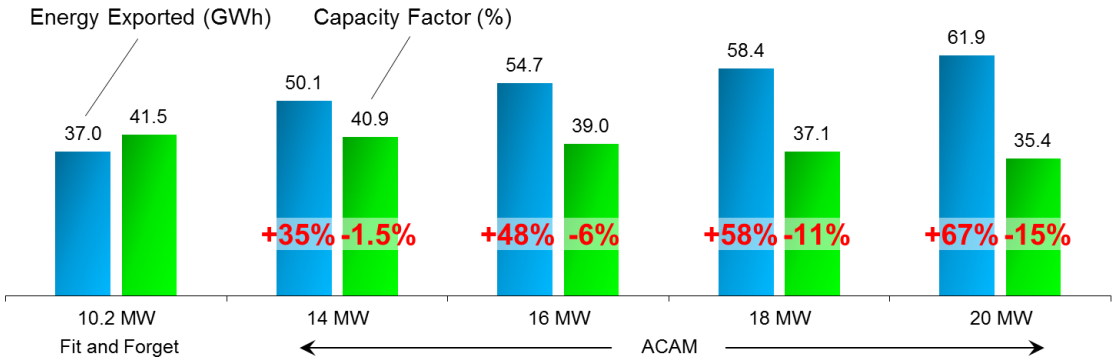
Renewables Integration – Scotland (2012)

In distribution network, increase connection capacity by constraining by angle





» ***Marginal reduction of capacity factor***

➔ ***More capacity***

➔ ***More energy***

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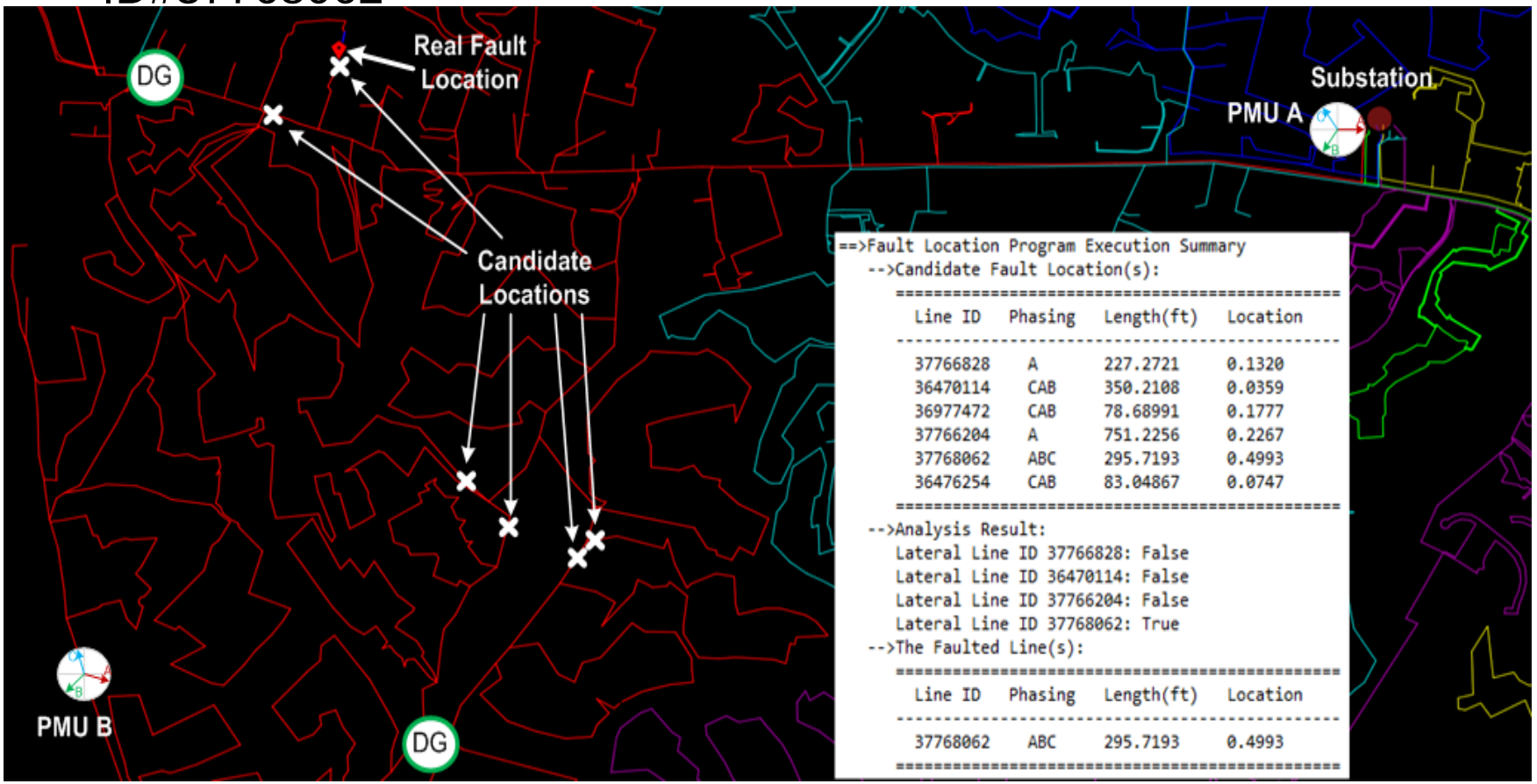
Distribution Fault Location using Synchrophasors

A single phase to ground fault with resistance of 100 ohm on Line ID#37768062



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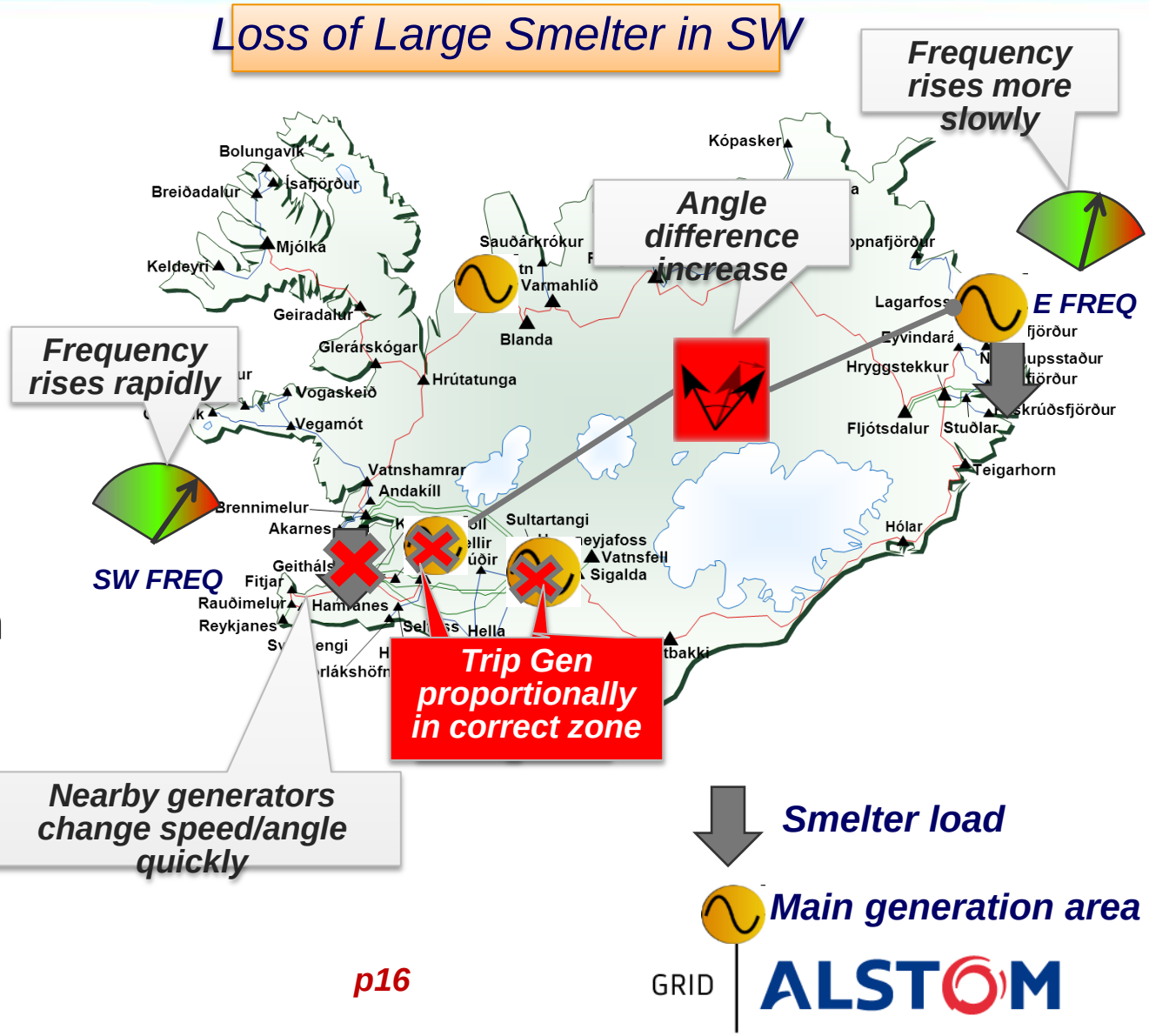
Wide Area Protection Scheme – Iceland (2012)

Smart Grid in the Future:

- Protective control schemes *that **dynamically adapt** to current power system conditions*, to preserve the "***integrity of the grid***" as an entity.
- Tightly integrate fast sub-second measurements with fast sub-second controls (FACTS, HVDC, etc)



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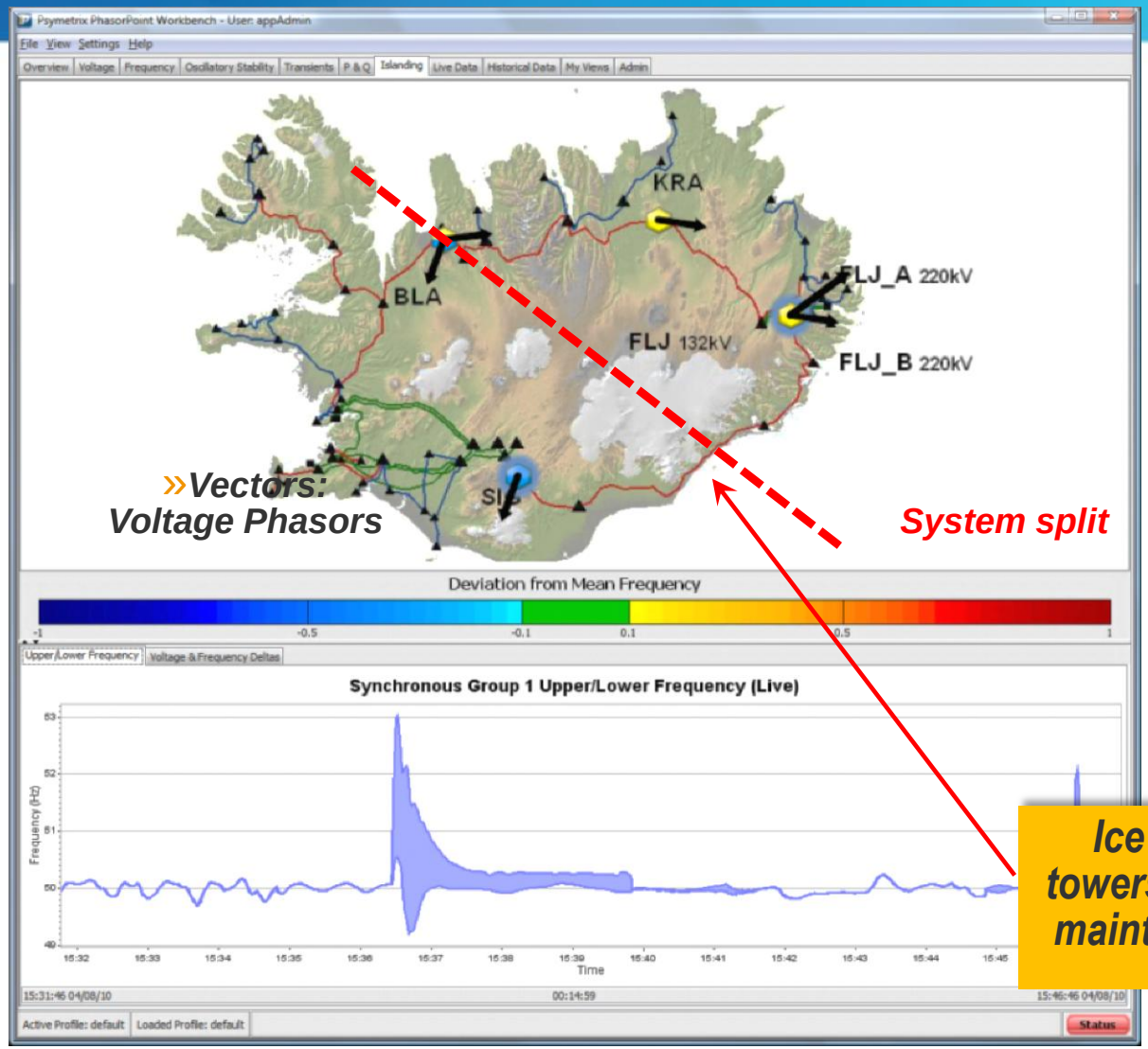
Islanding, Resynchronization and Blackstart



Identify islanding quickly

Alarm raised

Islands clearly visualized

Reduce time to resynchronize

Improve system visibility in blackstart

Ice slide destroys 2 transmission towers, IRB used to monitor system to maintain synchronisation for 2 weeks

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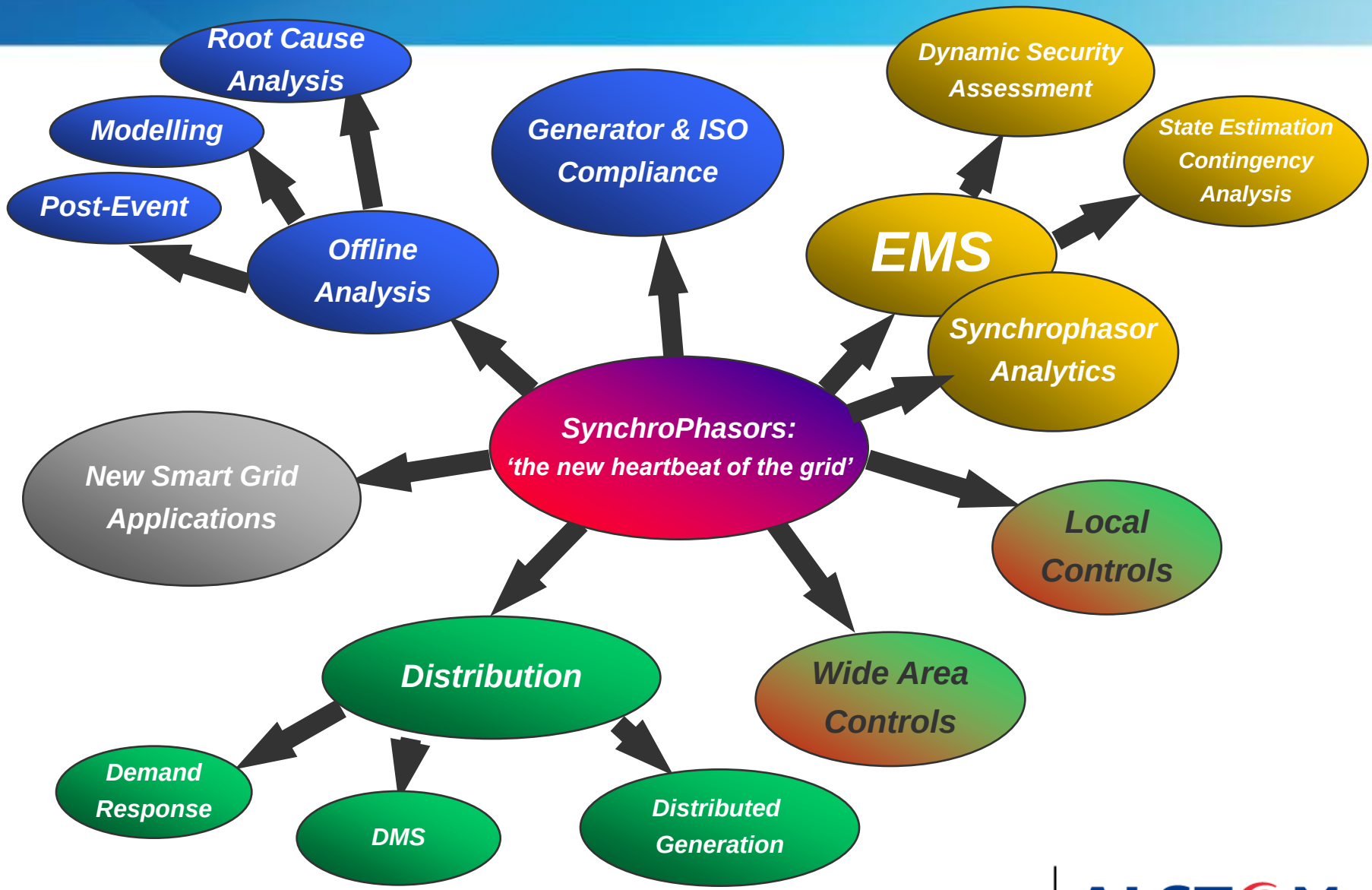
Synchrophasors: The New Heartbeat of the Grid!

Enabling Intelligent Decentralized Grid Monitoring & Control



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Thank You

we are shaping the future