SynchroPhasor Measurement-Based Applications for the Control Center

i-PCGRID Workshop

GRID

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ALSTOM

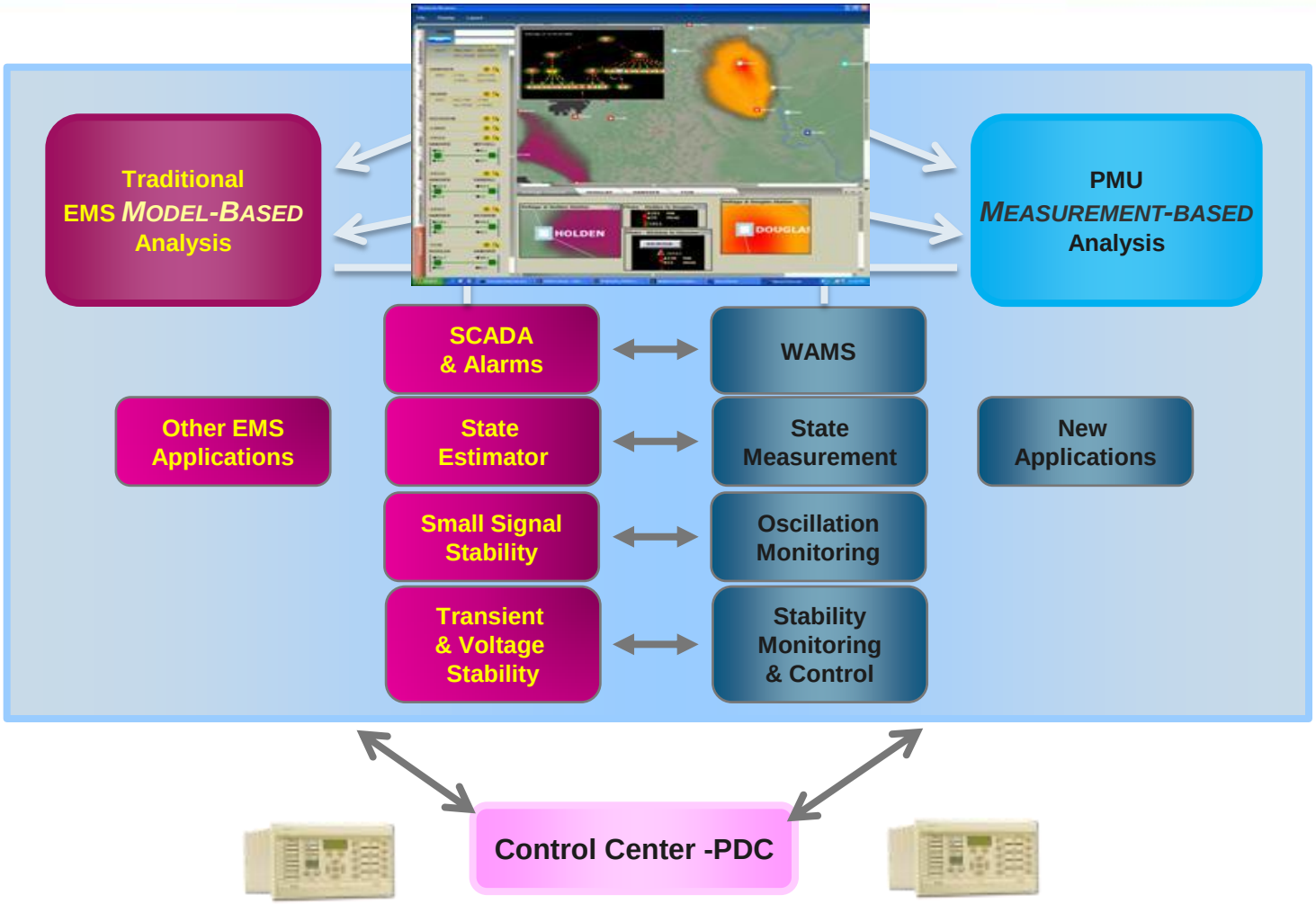
Presentation Outline

1. Synchrophasor Solutions at the Control Center
    1. Business drivers, Benefits
    2. Generalized Grid Security Analysis
2. ALSTOM Synchrophasor Solutions integrated with EMS
    1. PDC Features
    2. Synchrophasor application framework & Synchrophasor applications,
    3. EMS model-based applications
    4. Advanced visualization
3. PG&E SynchroPhasor Project - ALSTOM scope
4. Customer Deployments

Enhanced Grid Operations with Synchrophasors

- Improved operator wide area situational awareness (WASA)
  - Advanced early warning alerts for prompt operator actions
  - Quick identification of the specific location of grid disturbances
- State Estimation improvements in accuracy, reliability and robustness
  - Improved contingency analysis results (what-if scenarios)
  - Improved market system settlements
- Enhanced post-event analysis and fast event re-creation
- Enhanced simulation & operator training tools
- Maximize utilization of existing transmission system by operating assets closer to their true, real-time limits
  - Online stability solutions – fast, real-time operator alerts
- Enhanced congestion management monitoring and compliance
- Improved reliability of the interconnected power network
  - Improved SAIDI, SAIFI, CAIDI metrics
  - Improved grid operation during emergency situations
  - Adaptive Islanding and restoration
- Wide area control for improved interconnection reliability
- Local control for integration of renewable resources
- Advanced substation automation solutions

Holistic Generalized Grid Security Analysis



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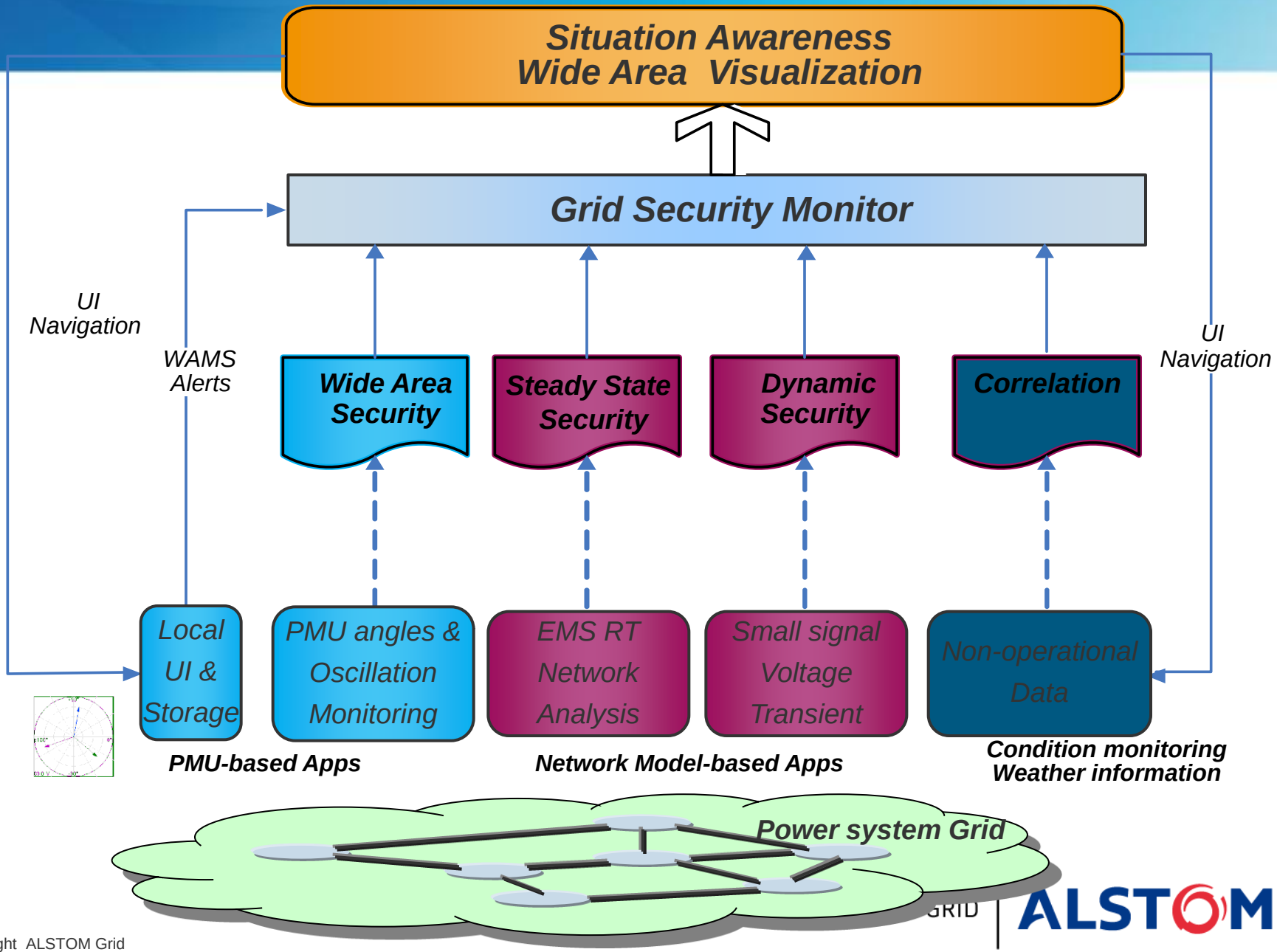
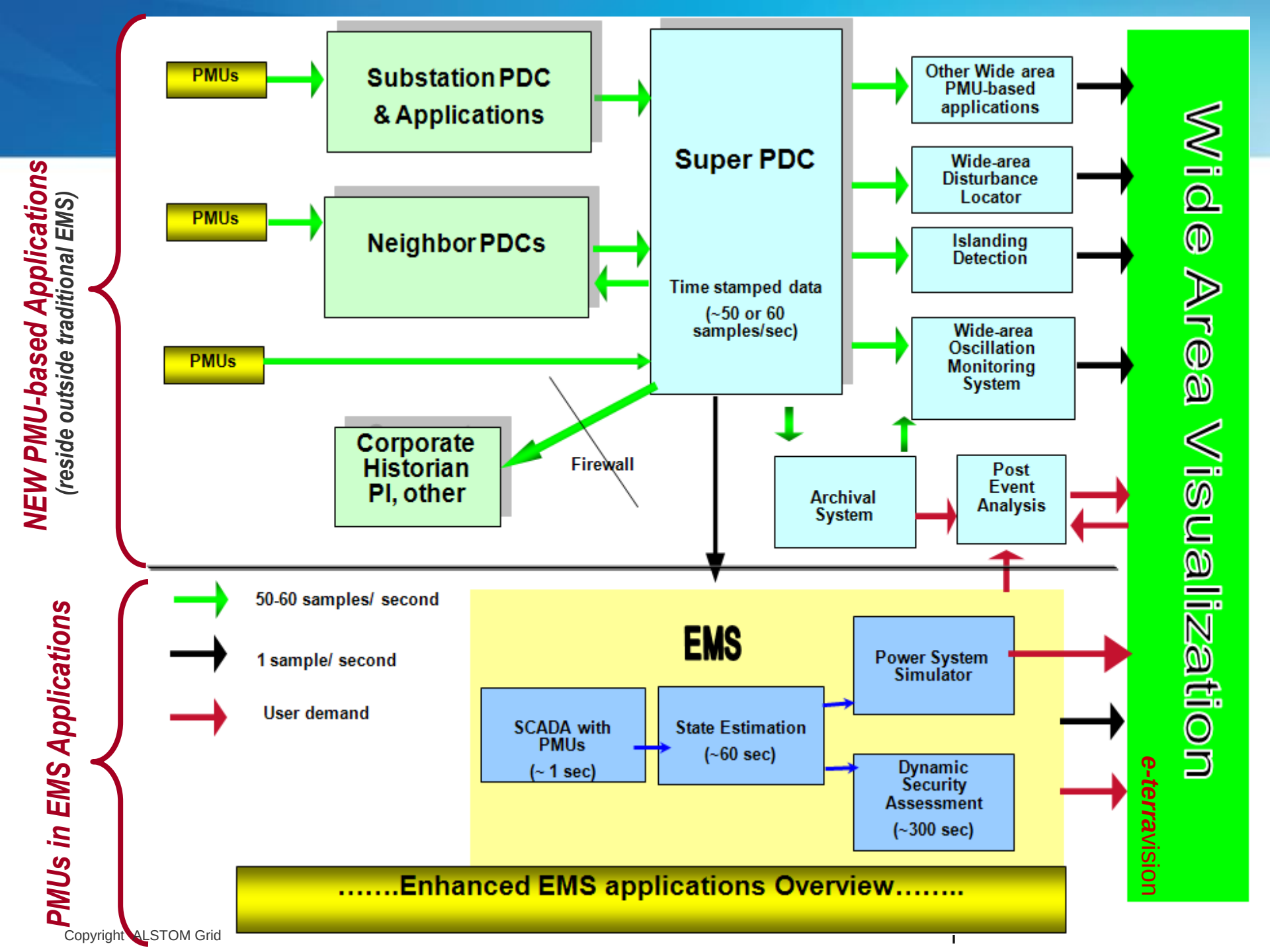
Wide Area Situational Awareness Visualization





ALSTOM Online Stability Solutions

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PSYMETRIX

Commercial provider of synchronized measurement & monitoring solutions:

- *PhasorPoint :*
  - *SynchroPhasor Framework*
  - *PMU-based applications*

ALSTOM EMS Applications

Powertech

Model-based dynamic analysis:

- *Voltage Stability Analysis (VSAT)*
- *Small Signal Stability Analysis (SSAT)*
- *Transient Stability Analysis (TSAT)*

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"Measurement Based Analysis Integrated with Model-based Analysis In the EMS"

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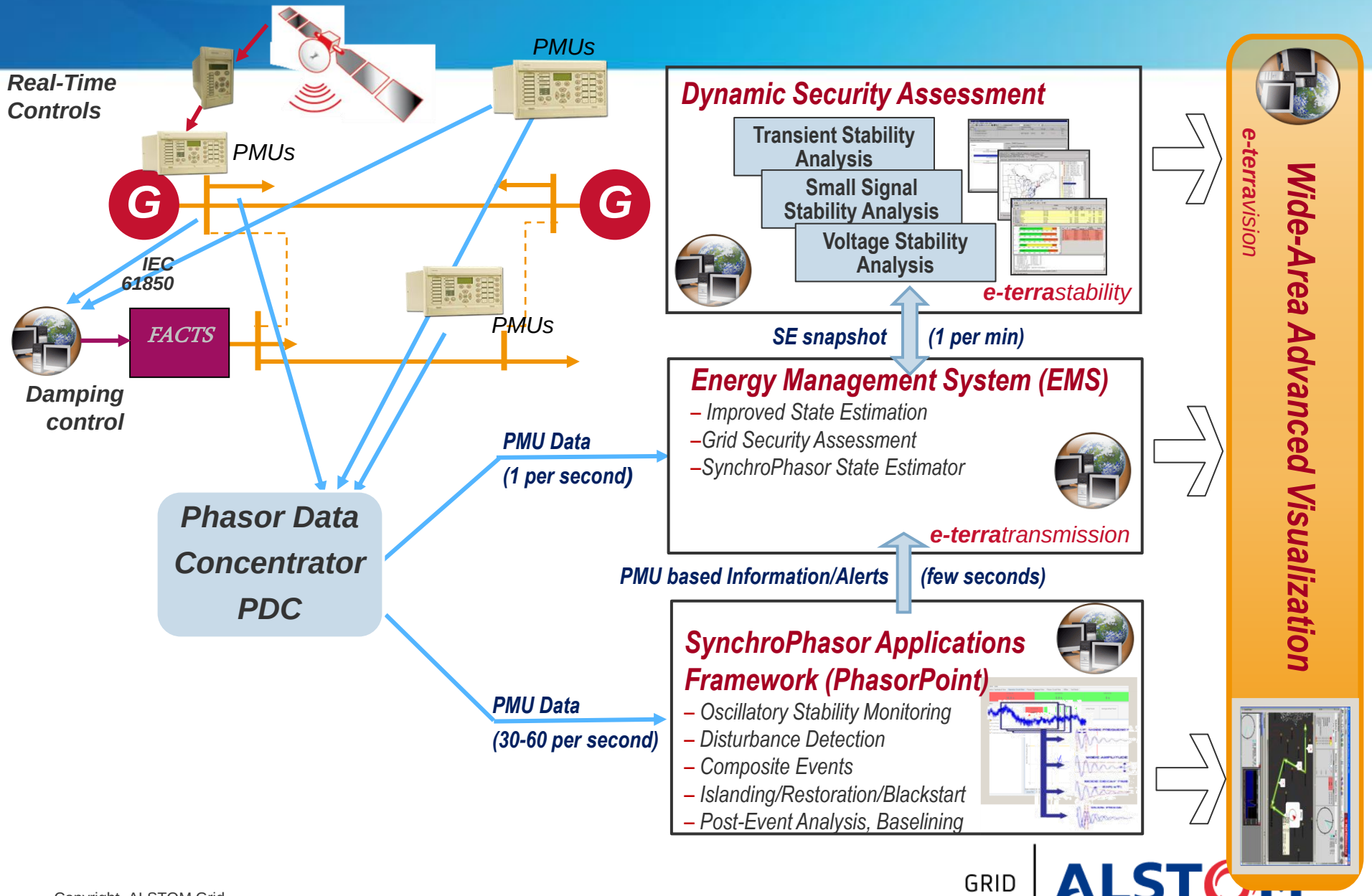
EMS Integrated with SynchroPhasor Solutions



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Phasor Data Concentrator (PDC)

Features

- Handles a wide variety of ***PMU formats*** *:*
  IEEE C37.118, IEEE 1344, BPAStream, Comtrade, etc

- *Can handle* ***over 100 PMUs*** *at 30-60 measurements/second :*
  process & archive

- ***Scalable - horizontally and vertically***

- Designed for high availability:
  - ***Active-Active redundancy*** configuration
  - Maps multiple ***inputs from redundant substation PMUs/PDCs*** to a common point.
- Extensive ***data quality and performance statistics monitoring***.

- ***Consistent with the NASPI net Vision:***
  Real-time and *Historical data access /subscription APIs*

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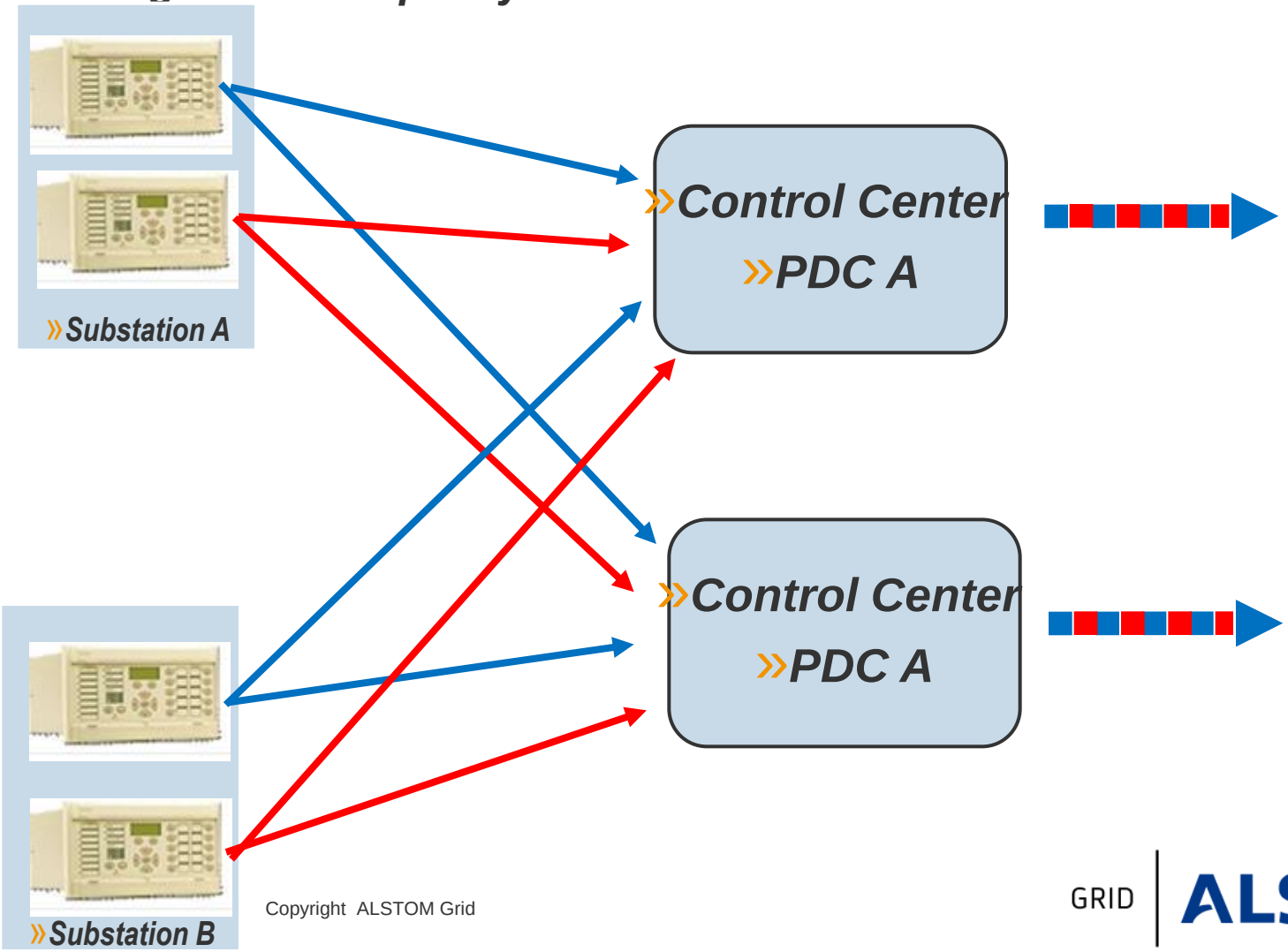
Redundant Substation PMUs/PDCs

High availability of PMU data

Automatically select data from redundant ***PMU/PDC streams*** based on ***first available "good" data quality***.



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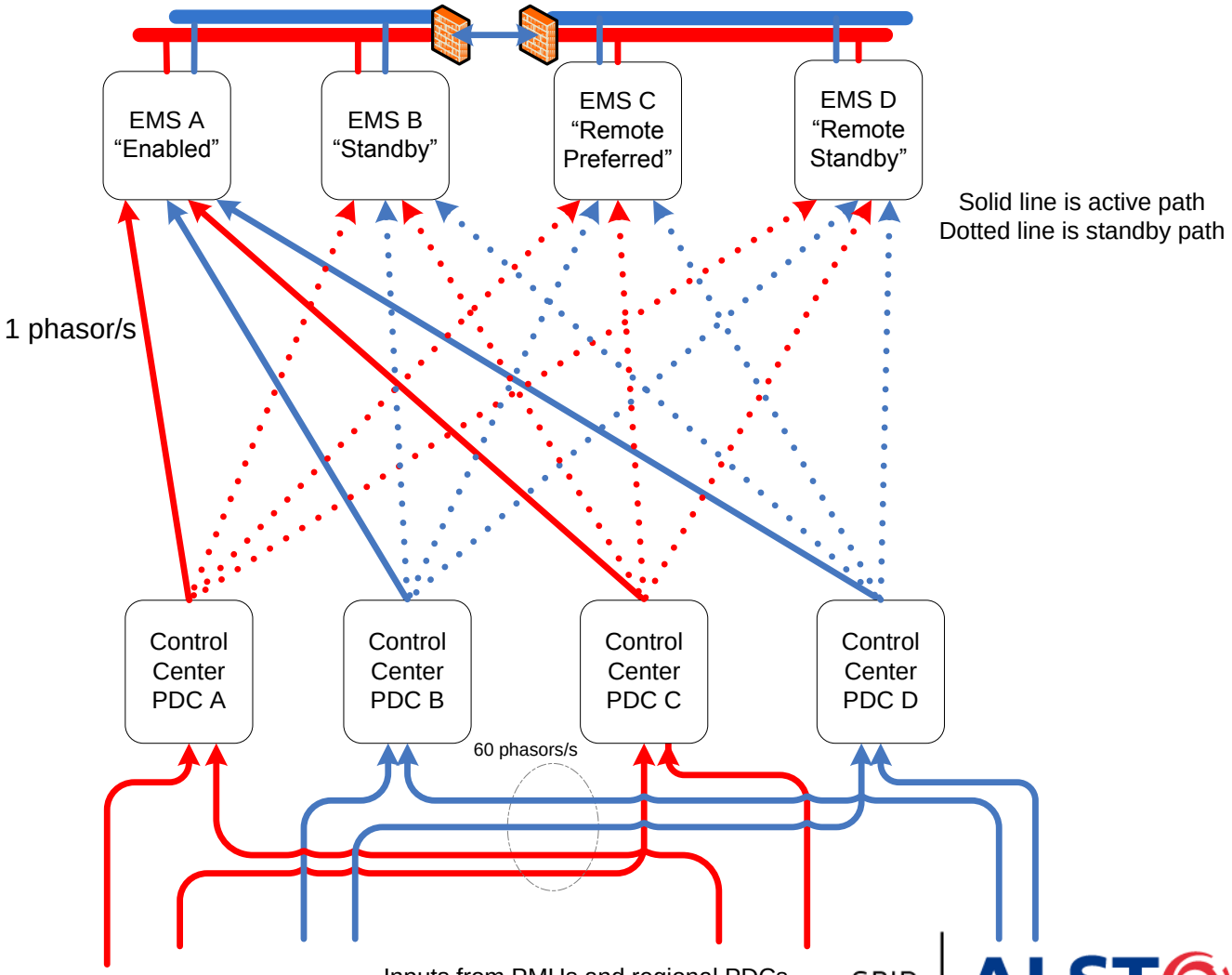
Control Center PDC configuration –

Multi-Host Redundancy with EMS for high availability



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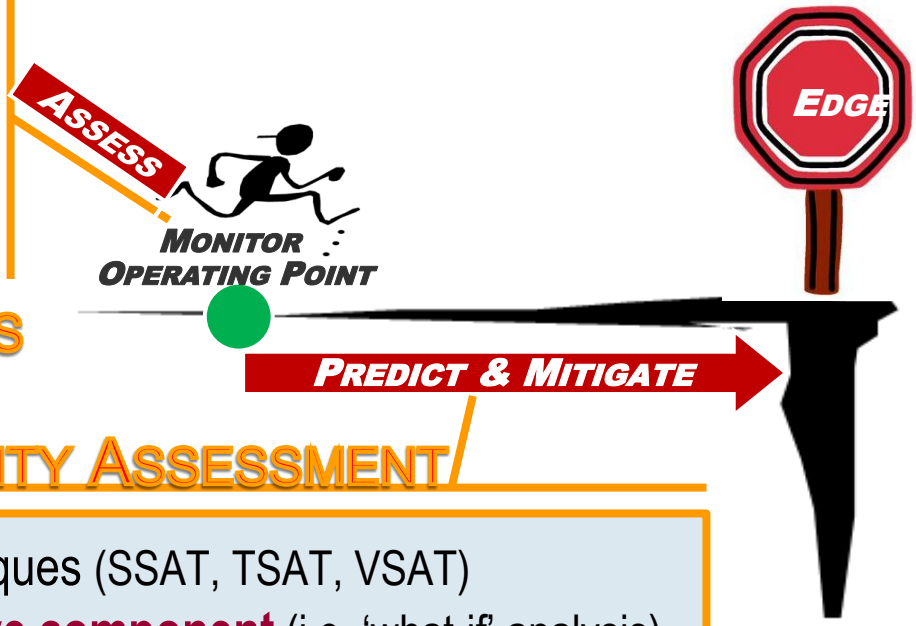
Online Stability Solutions

Integrated measurement-based and ***model-based stability*** assessment applications that ***run in real time.***

PMU **measurement-based** methods **monitor grid stability in real-time**:

- Track current damping levels
- Detect & alarm stability risks & sudden events



SYNCHROPHASOR APPLICATIONS

Validate Dynamic Limits

DYNAMIC SECURITY ASSESSMENT

Model-based techniques (SSAT, TSAT, VSAT) provide the **predictive component** (i.e. 'what-if' analysis)

- Available MW transfer capability ('distance' to the edge)
- Assess impact of critical contingencies. (e.g. change in damping)
- Recommend controls based on sensitivity information.

Stability assessment ***visualization*** within **e-terra***vision*. & PhasorPoint

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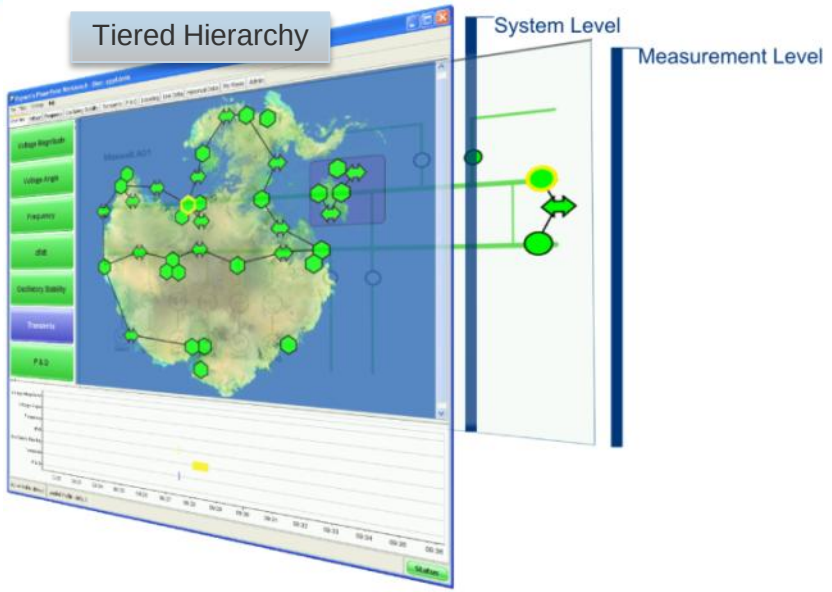
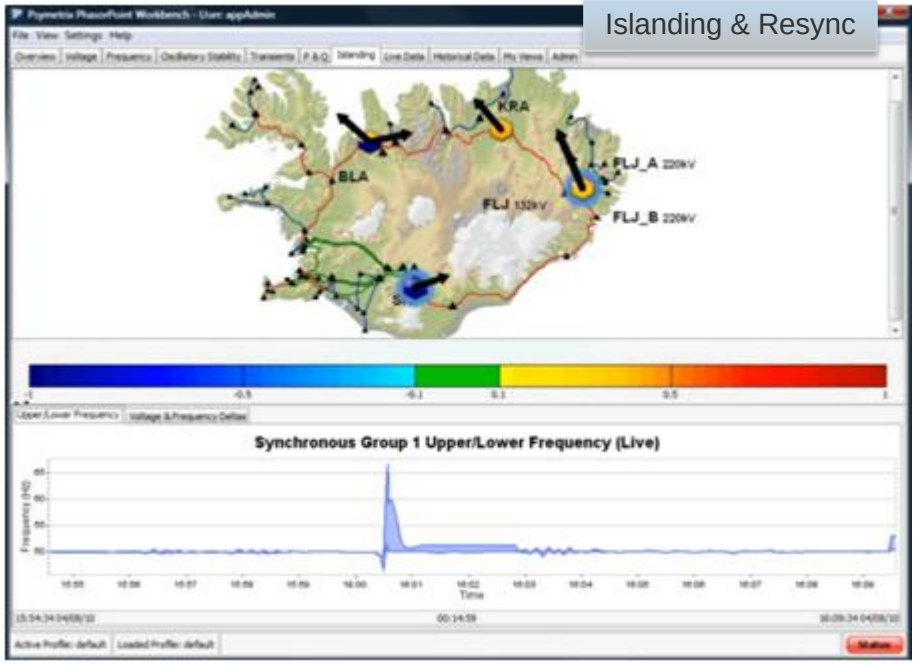
PhasorPoint – Synchrophasor Applications Framework

- ***Oscillatory Stability Monitoring***
- ***Disturbance Detection***
- ***Islanding & Resynchronisation***

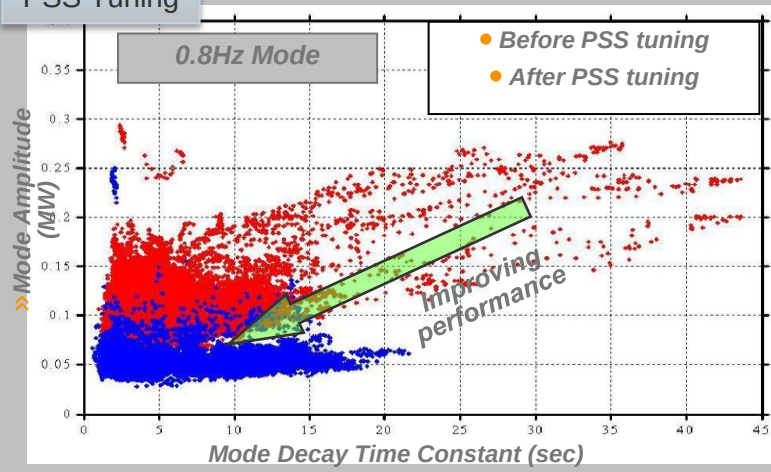
Tiered Hierarchy



Islanding & Resync



PSS Tuning



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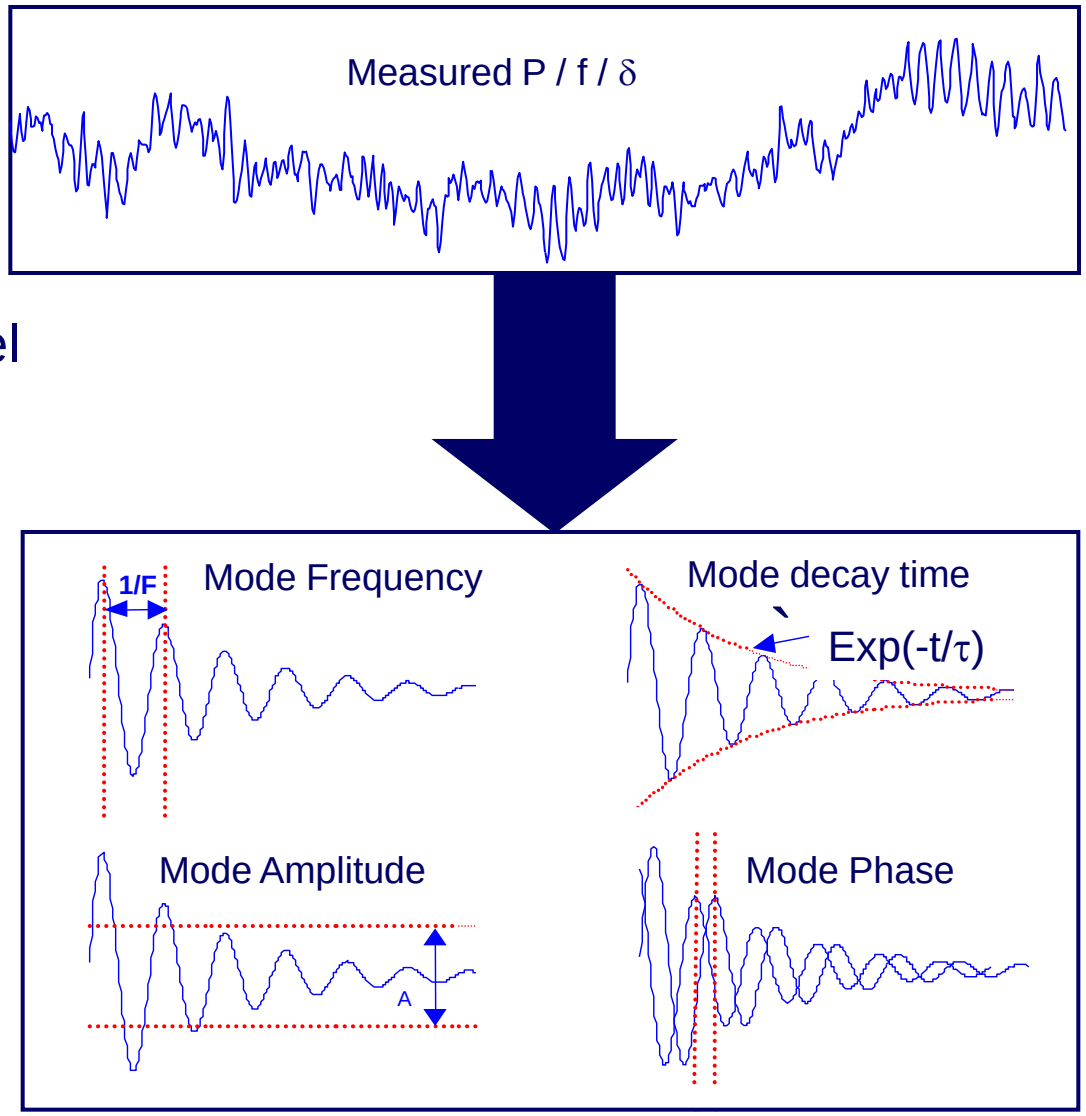
Oscillation Identification

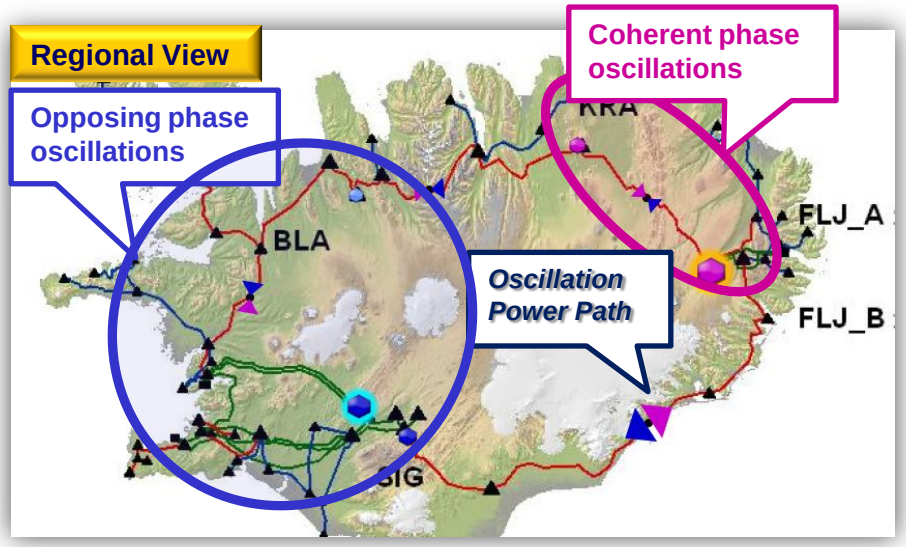
- Real-time operation
- Direct from system measurements
  - single-point and wide-area coverage
- Does not use system model



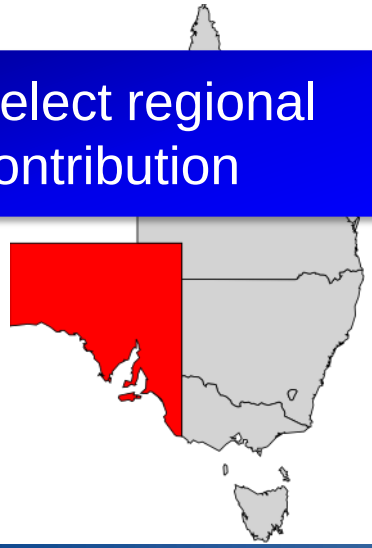
- Identification of oscillation source/control location

Mode Power Path

- Identify contributions from regions
- Uses only PMU data
- All region boundaries monitored
- “Regions” can be any size



1 Select regional contribution

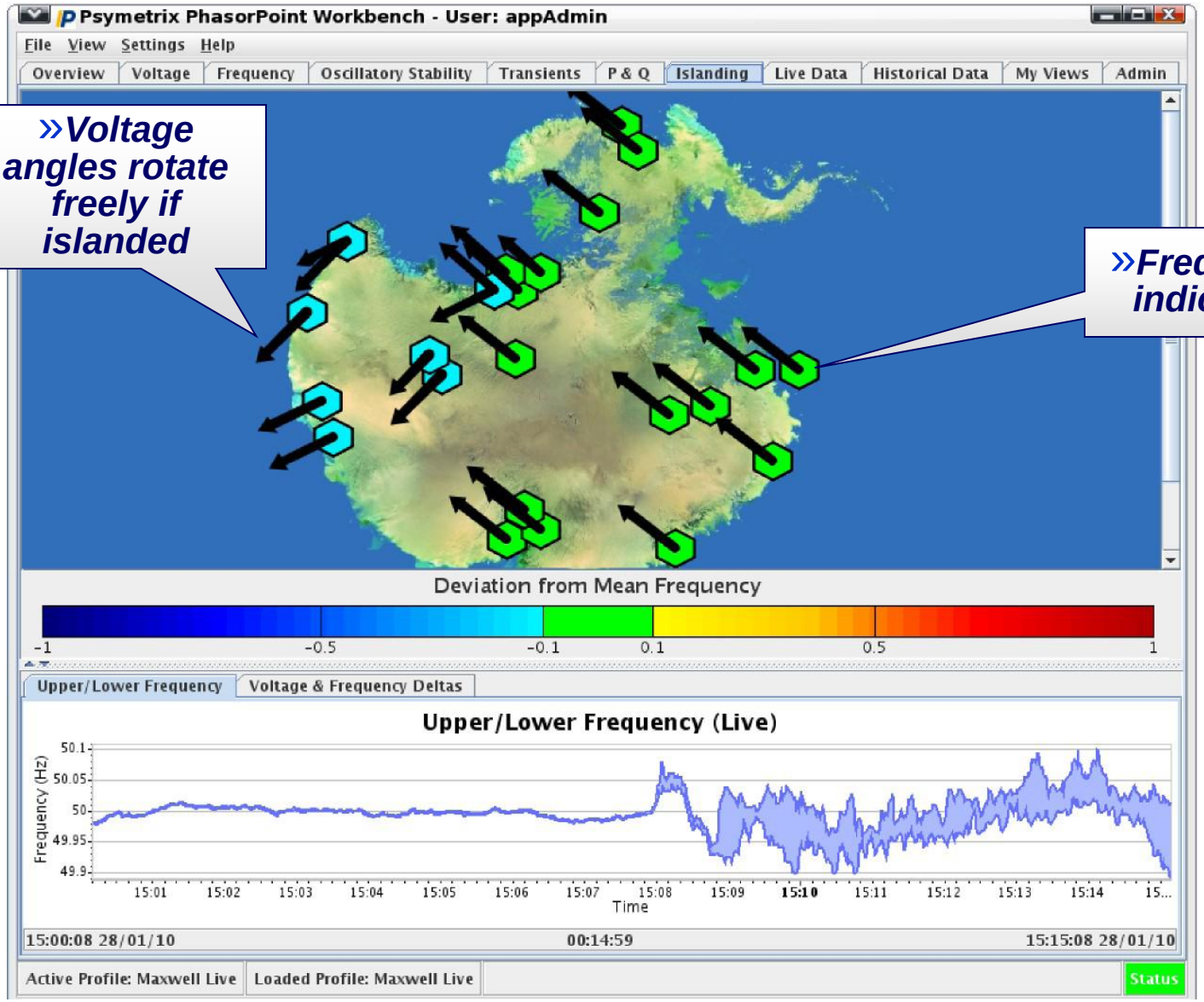


2 Identify local contribution

3 Action guidelines

Auto-Report

Islanding, Resynchronisation & Blackstart

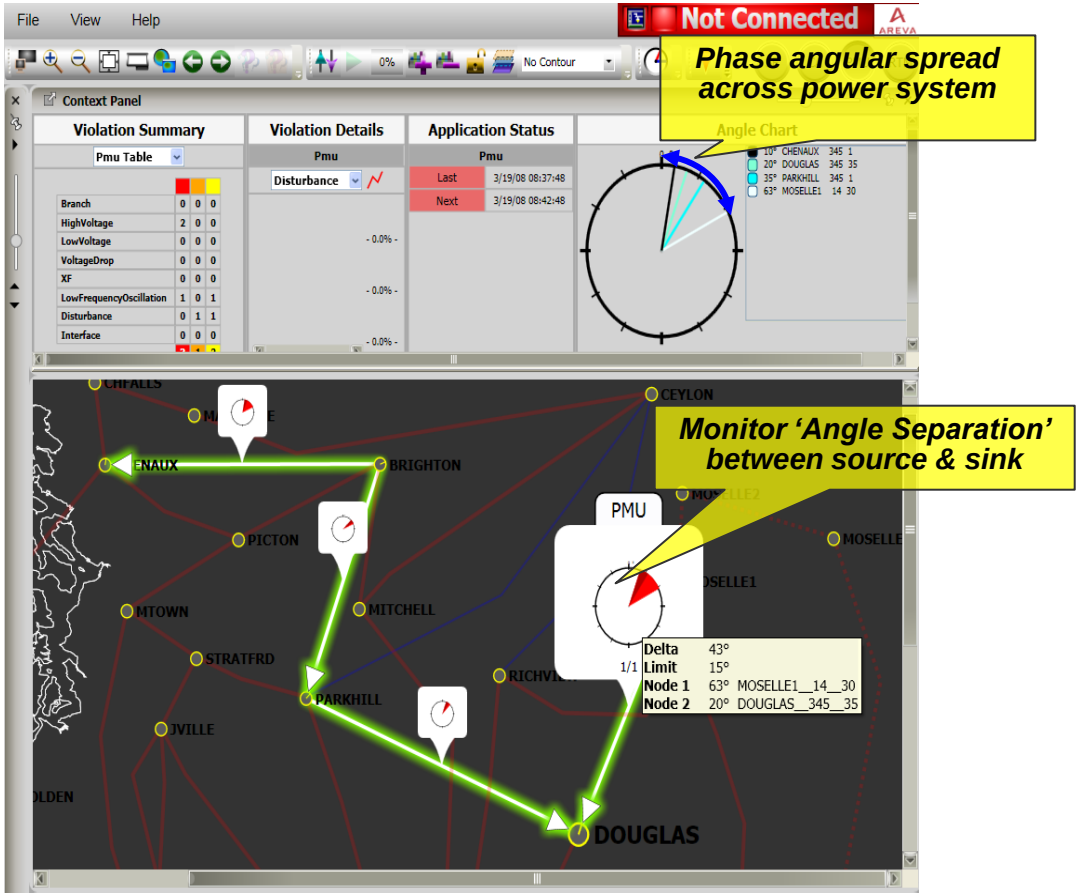


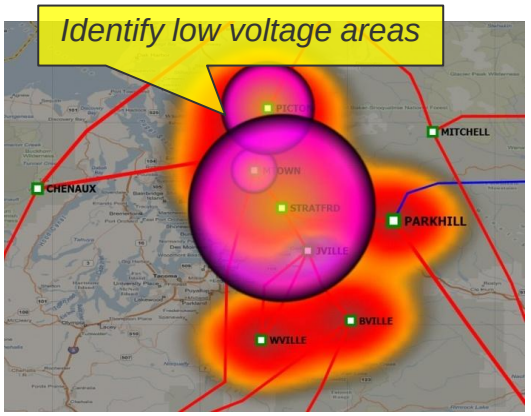
- ISR Map
- Frequency Deviation Colour key
- Chart Selector tabs
- Live Max/Min Frequency Deviation Chart

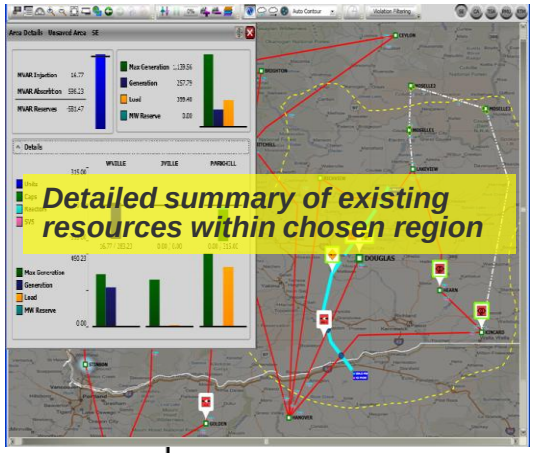
PMU Visualization in e-terra*vision*

Monitor 'angular separation' as an indicator of increased grid stress due to:

- *increased transmission path loading between 'Sources' & 'Sinks' of power*
- *sudden events such as line outages (i.e. weakening of the grid)*







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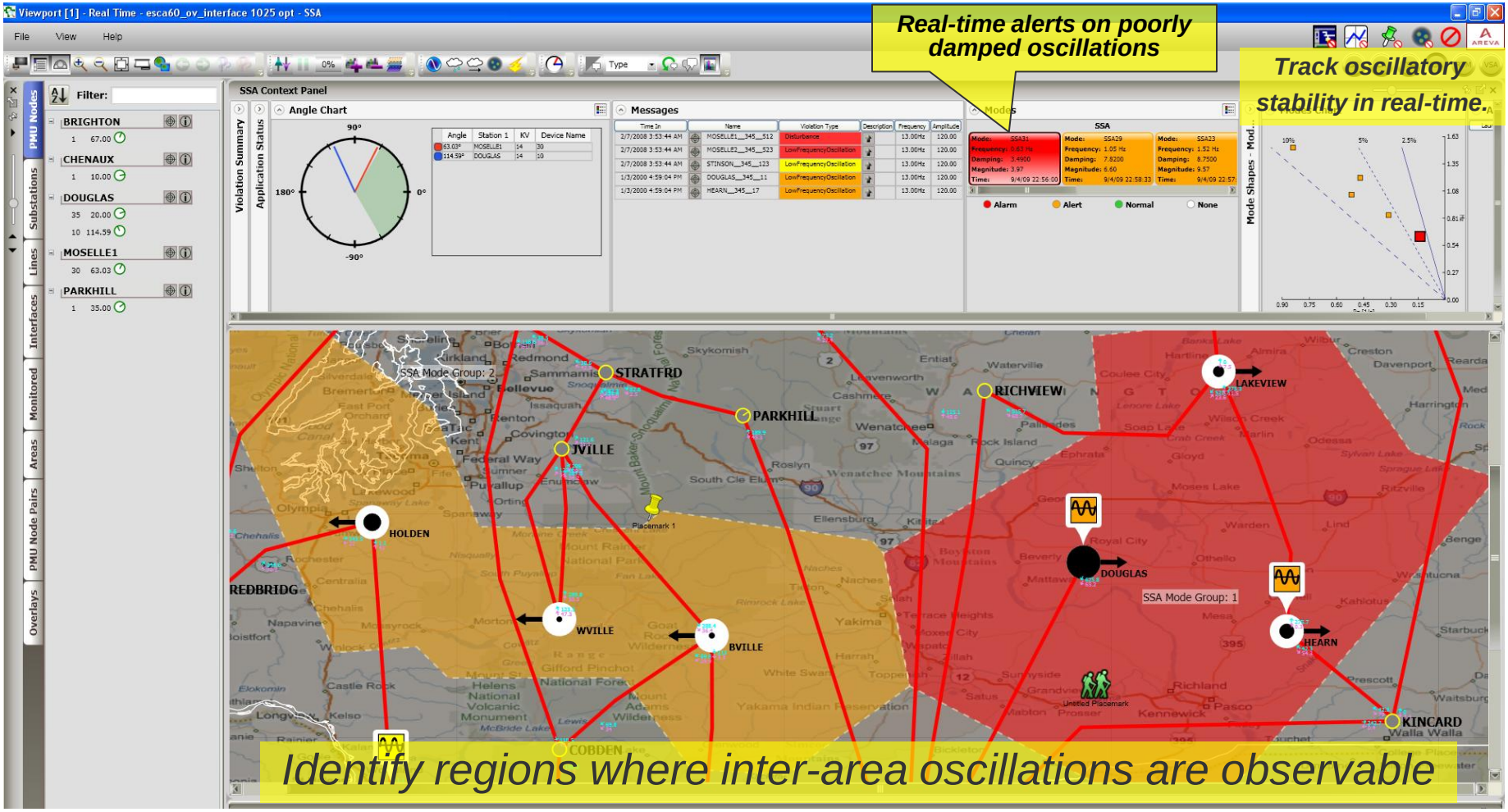
Small Signal Oscillation Visualization within e-terra*vision*

Modes shapes, amplitudes, damping, frequency, etc



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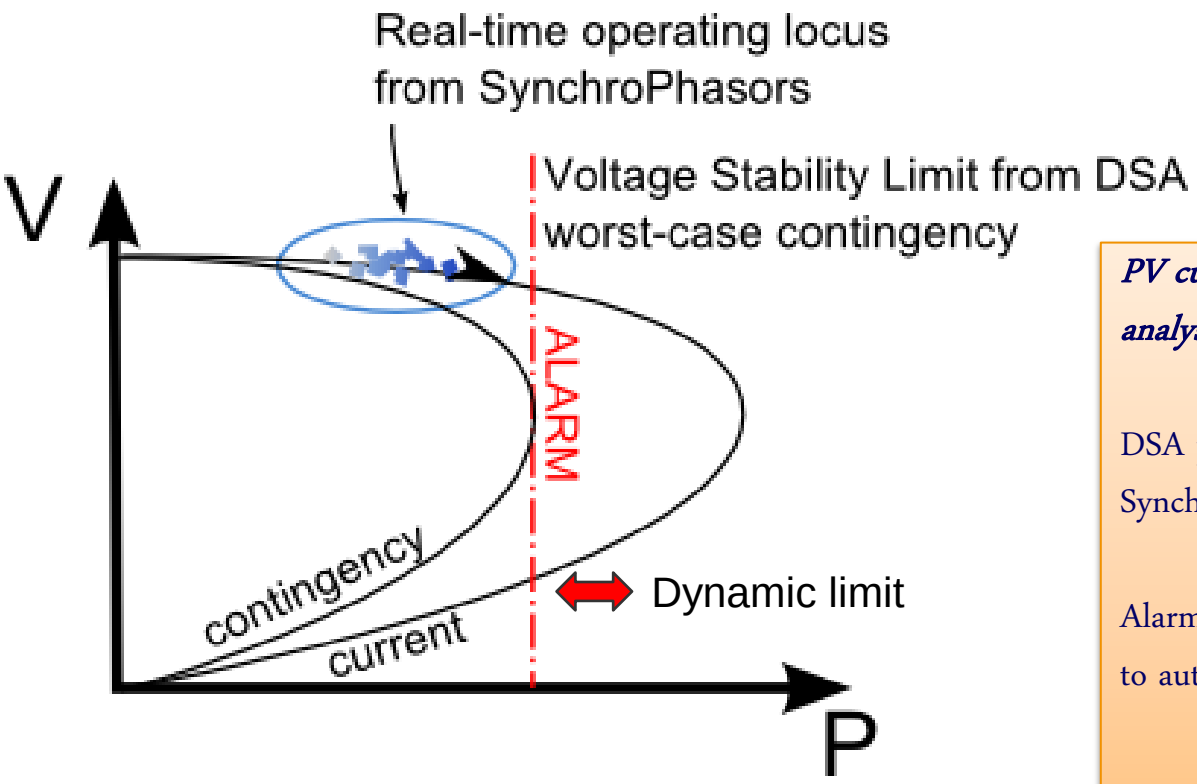
Voltage Stability Assessment using PMUs



PV curve only useful with contingency analysis

DSA provides contingency analysis; Synchrophasors provide operating locus.

Alarms produced quickly – can be linked to automated response

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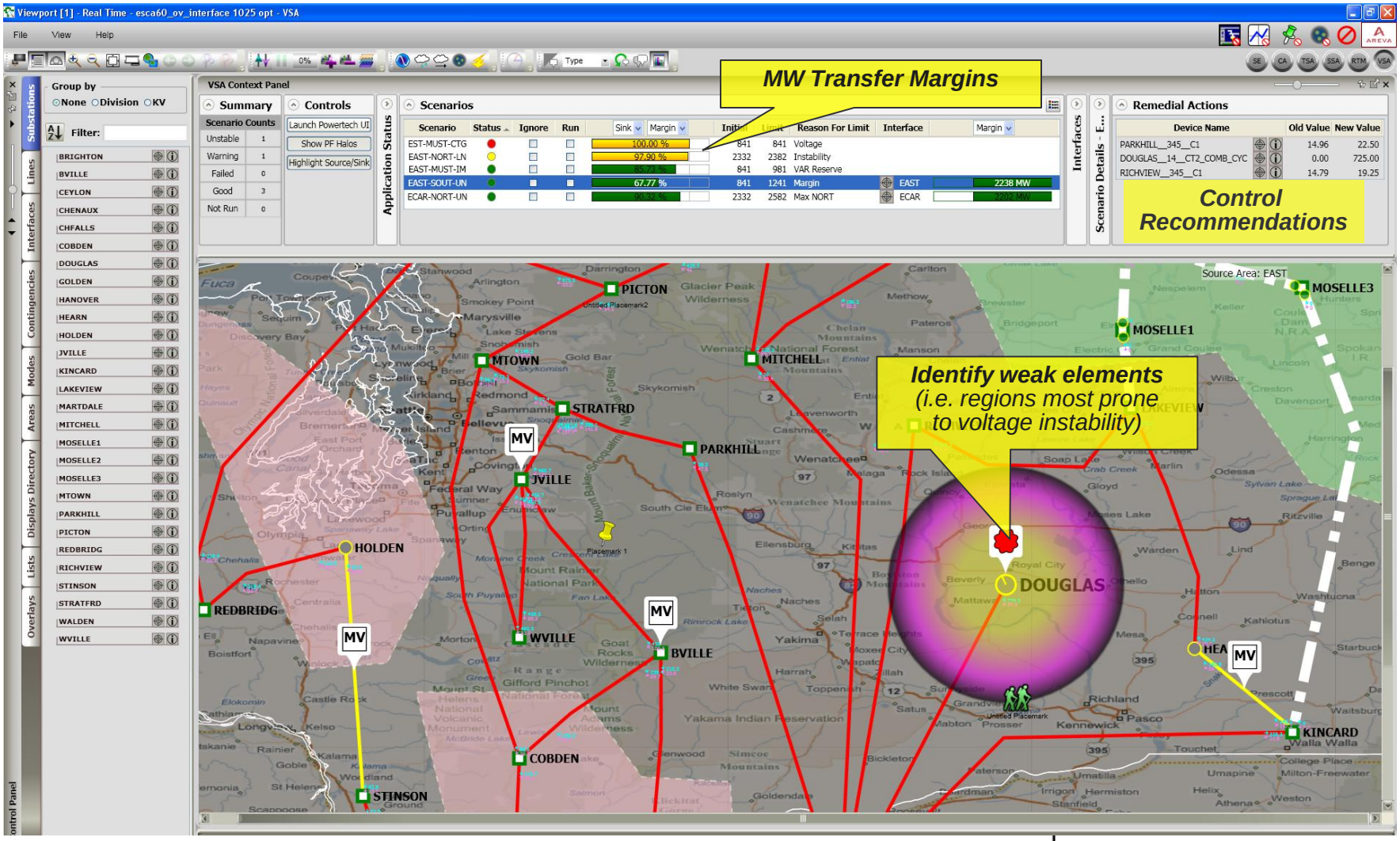
Voltage Stability Assessment in e-terra*vision*

Voltage Contours, MW Margins, Weak Elements, Remedial Actions



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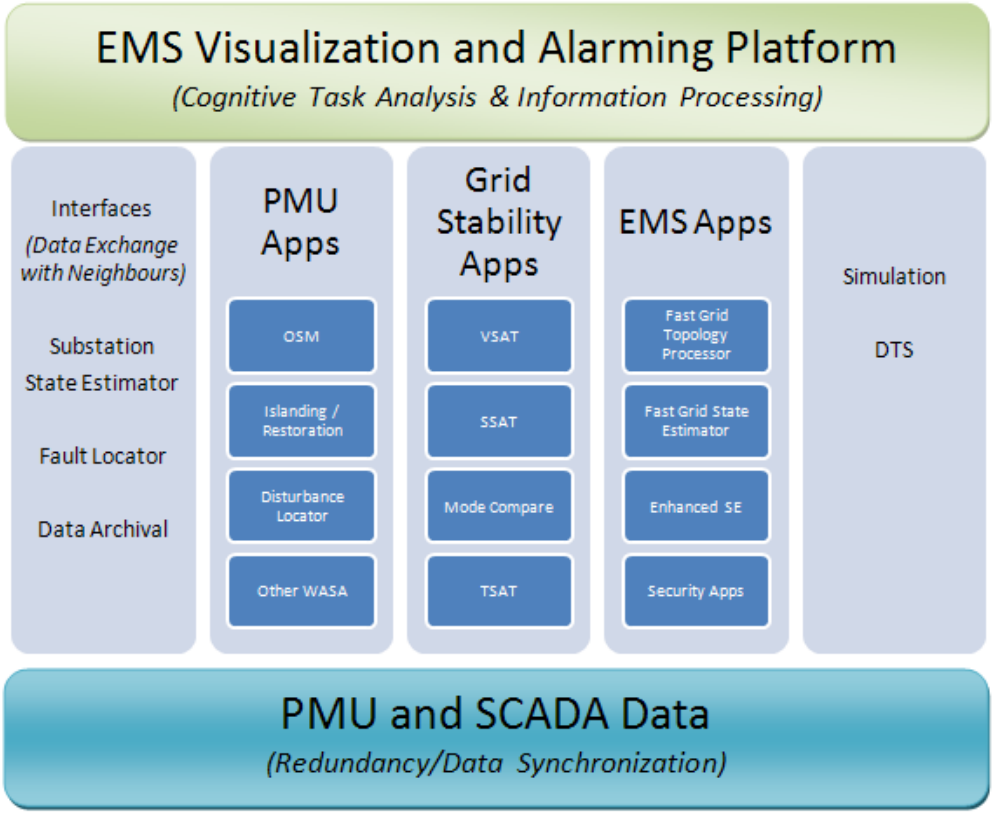
PG&E SGIG SynchroPhasor Project

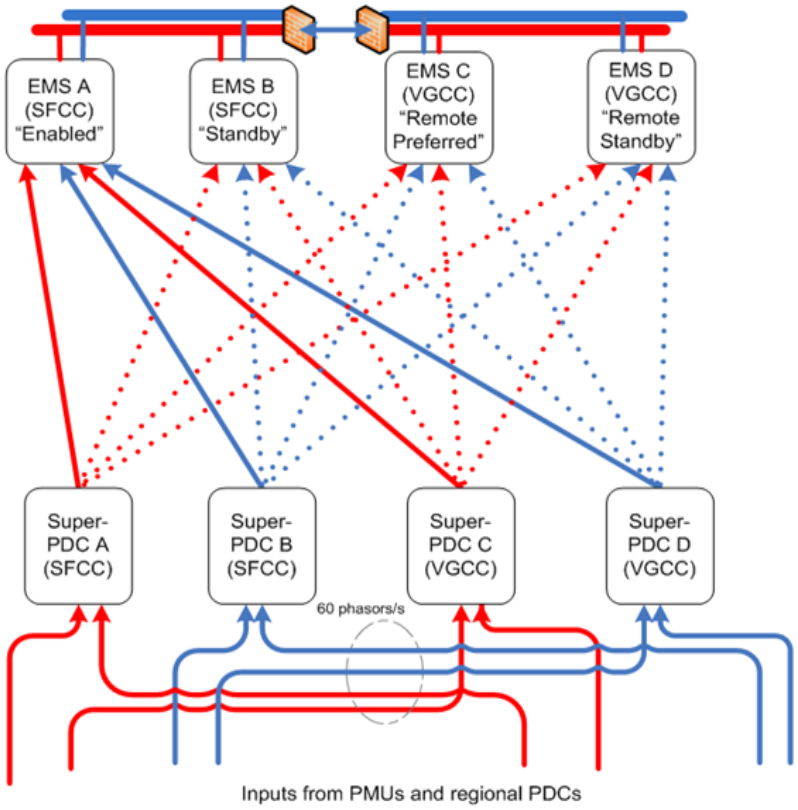
Vahid Madani – Project Technical Leader

Strategic Team: *PG&E, ALSTOM, GE, Mississippi State Univ., Quanta*

Academic & Testing Partners: *GeorgiaTech, Omicron/VirginiaTech, Washington State Univ.*



SynchroPhasor Applications for the Control Center



Multi-host Redundancy (ISD Link)

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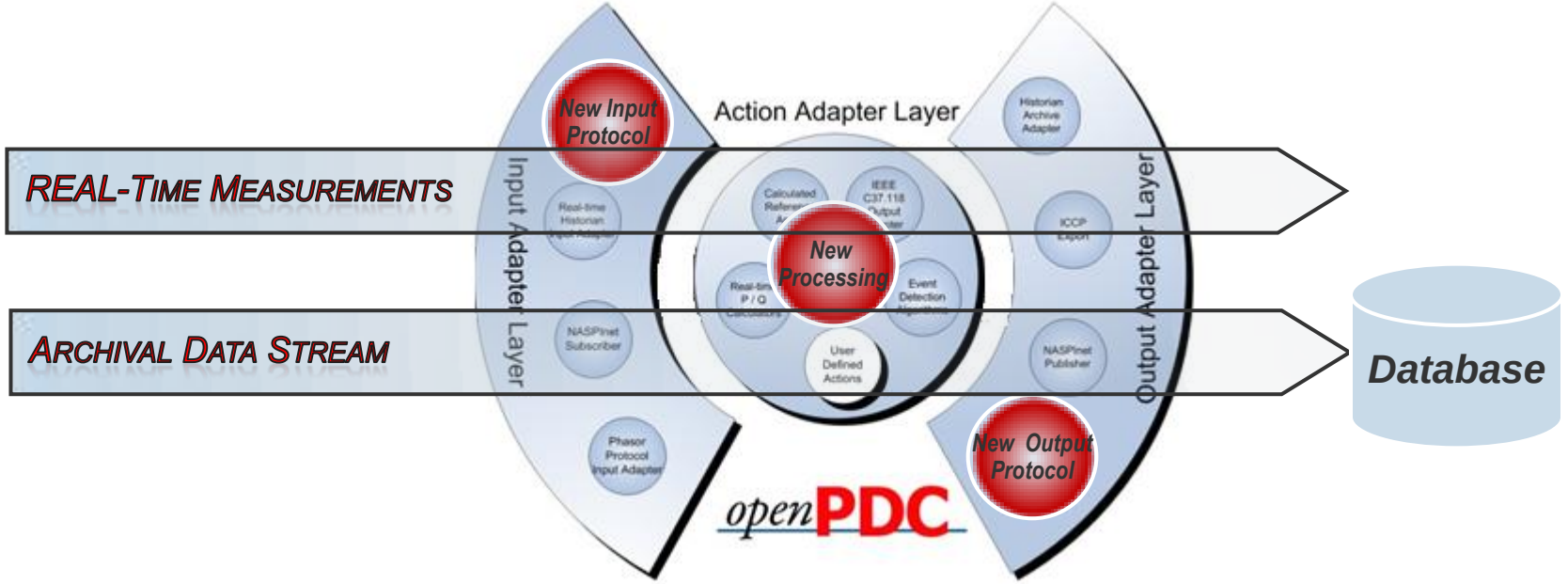
Extensible functionality through the notion of ***'Input'***, ***'Action'***, & ***'Output'*** Adapters.

- ***Input Adapters:*** process incoming data into a generic format.
- ***Action Adapters:*** perform processing functions such as sorting the input data or performing calculations (e.g. MW and MVAR, Event Detection), then transmit the results.
- ***Output Adapters:*** store time sorted data in Historians.



Source: ***http://openpdc.codeplex.com/wikipage?title=Overview&referringTitle=Documentation***

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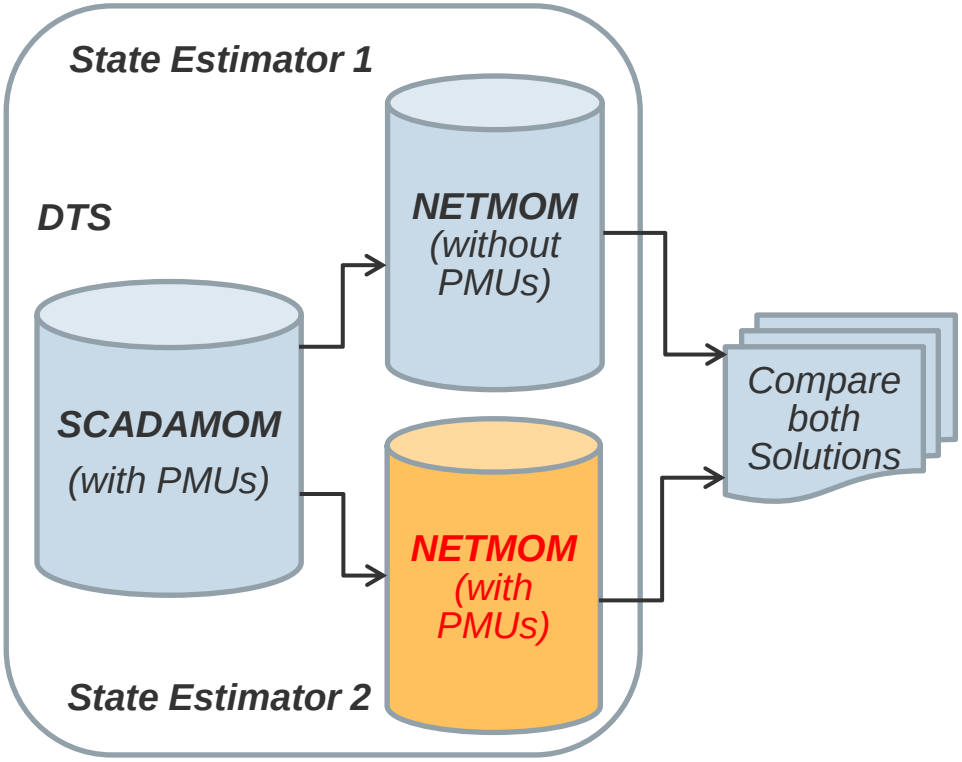
Parallel State Estimator Solutions



Detail	WECC Sep 2010 (PG&E)	Merged Model (PG&E)
Substations	6,475 (1,182)	7,716 (2,345)
Buses	12,182	13,273
Lines	10,298 (2,485)	11,195 (3,376)
Units	2,689 (540)	2,749 (604)
Loads	7,755 (1,418)	8.049 (1,637)
Transformers	4,763 (684)	4,853 (787)
Phase Shifters *DC converters*	38 (0) 34 (8)	38 (0) 26 (0)

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Expansion of IEC 61850 outside Substation environments

IEC 61850 as communication interface with EMS

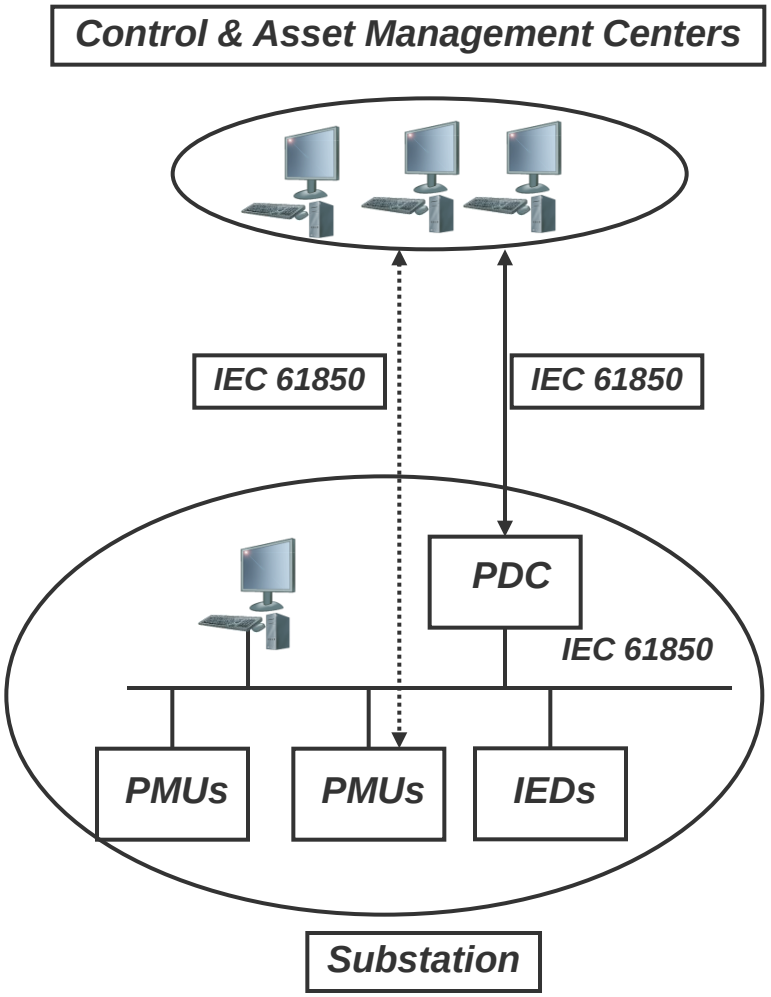
- Simplified Substation integration

IEC 61850 as single substation model

- Single IEC 61850/IEC 61850 Substation PDC used as single Substation interface
- Single access for remote control, maintenance & asset management
- Version management for Hardware, Software, Configuration and Setting

IEC61850 as a fast automation back bone to support Wide Area Automation

Support for Enterprise Level Applications



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ALSTOM SynchroPhasor Customers…

- Eskom (South Africa based Power Utility)
- Svenska Kraftnät (Swedish Electricity Transmission System Operator)
- Pacific Gas & Electric (PG&E)
- Florida Power & Light (FPL)
- Duke Energy
- ISO New England (ISO-NE)
- Energinet.dk
- ScottishPower
- AEMO (Australia Energy Market Operator)
- Iceland
- *Active proposals being submitted to others……*

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Questions?

Thank You