

*SynchroPhasors to Enhance Control Center
Capabilities*
NASPI Working Group Meeting

GRID

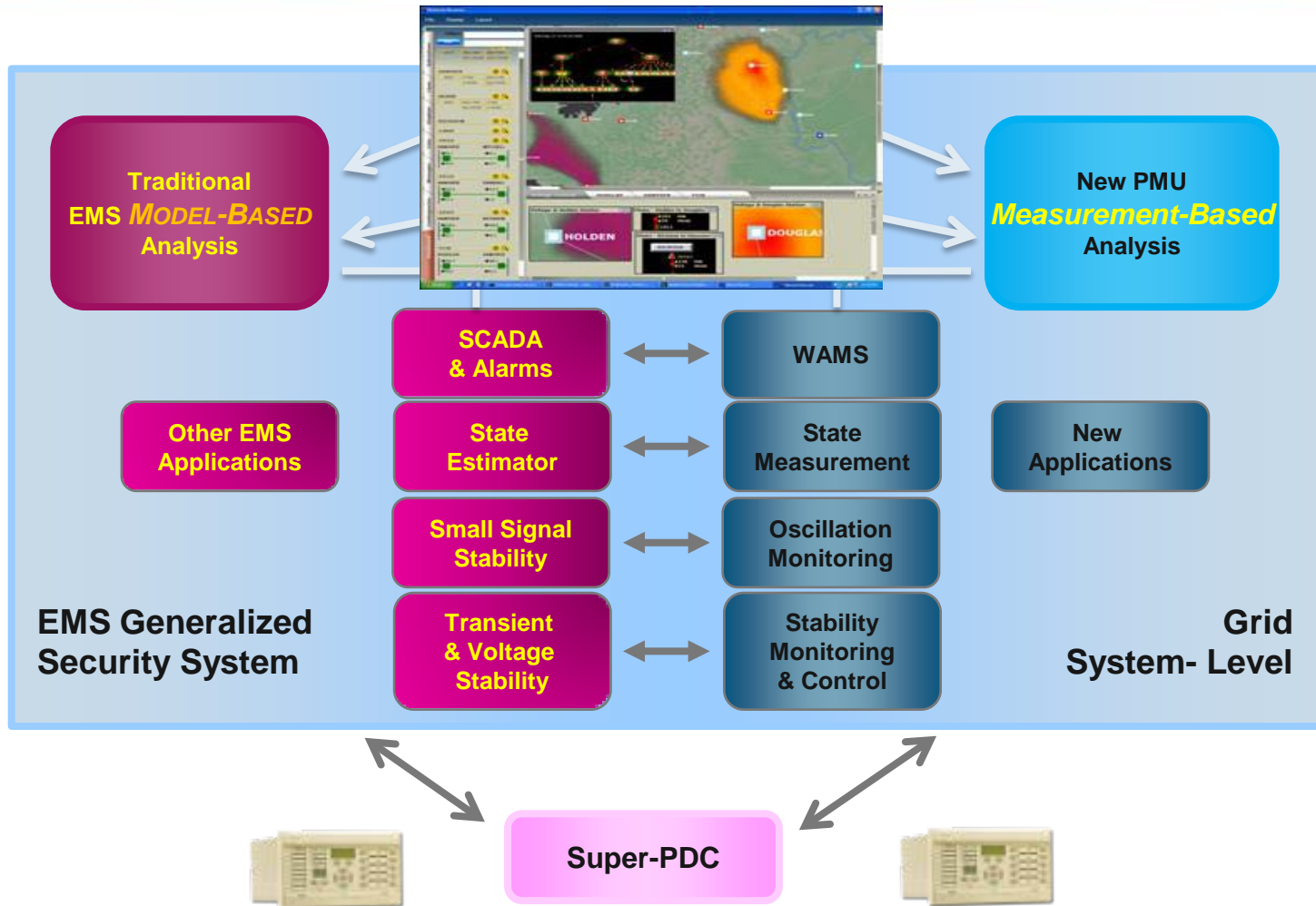
Manu Parashar
February 23rd, 2011

ALSTOM

Presentation Outline

1. **Our Vision & Partners**
2. **ALSTOM's Integrated SynchroPhasor Solutions**
3. **Customers Successes**
 1. *PG&E SynchroPhasor Project*
 2. *ISO-NE SGIG Project*
4. **Our Products: PMU, PDCs, Visualization, Applications**
5. **Concluding Thoughts**

Our Vision



Our Partners



Commercial provider of synchronized measurement & monitoring solutions:

- PhasorPoint (SynchroPhasor Framework)
- PMU-based applications



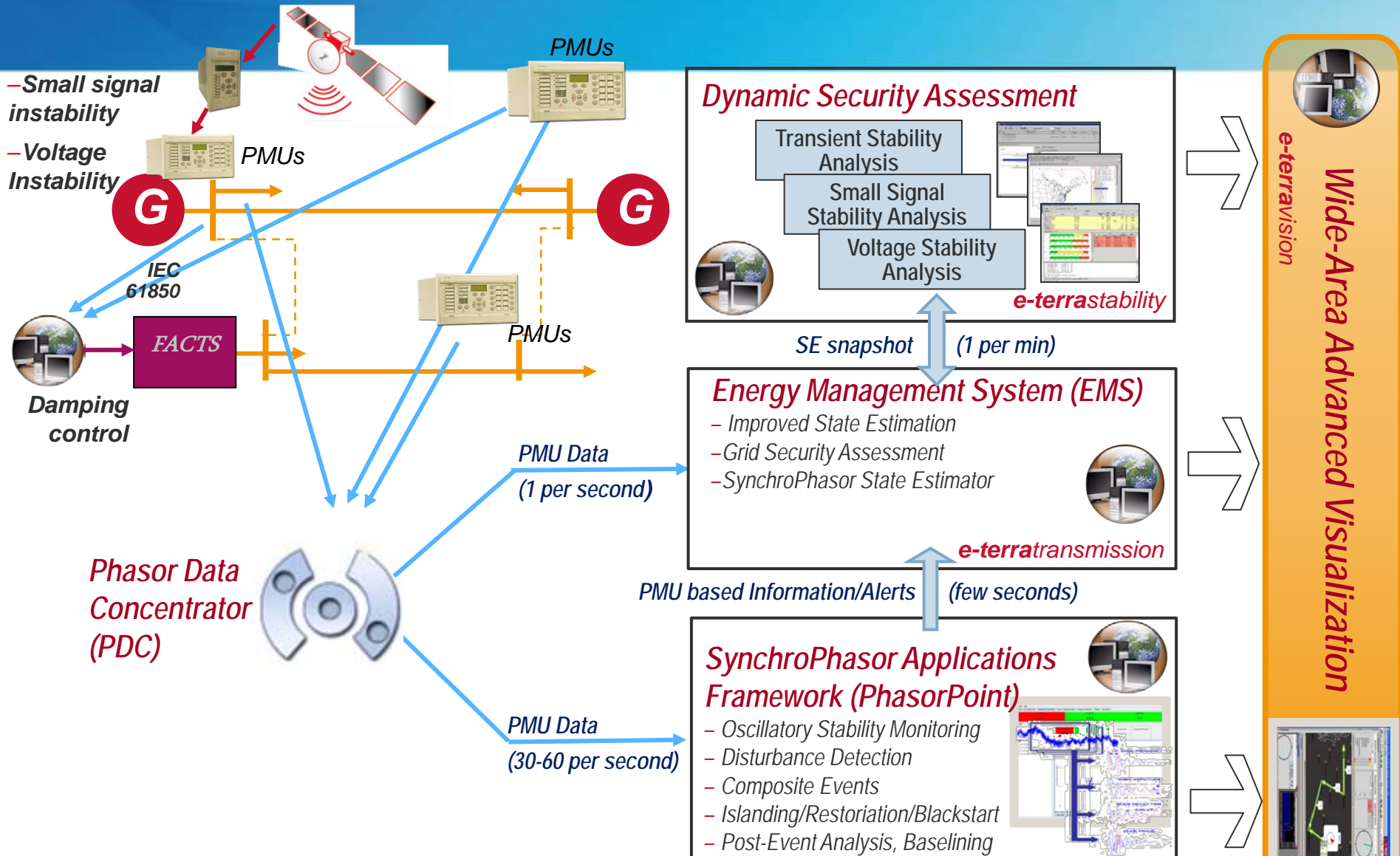
World-wide leader in providing technology solutions for transmission & distribution of energy.



Model-based dynamic analysis:

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

ALSTOM's Integrated SynchroPhasor Solution

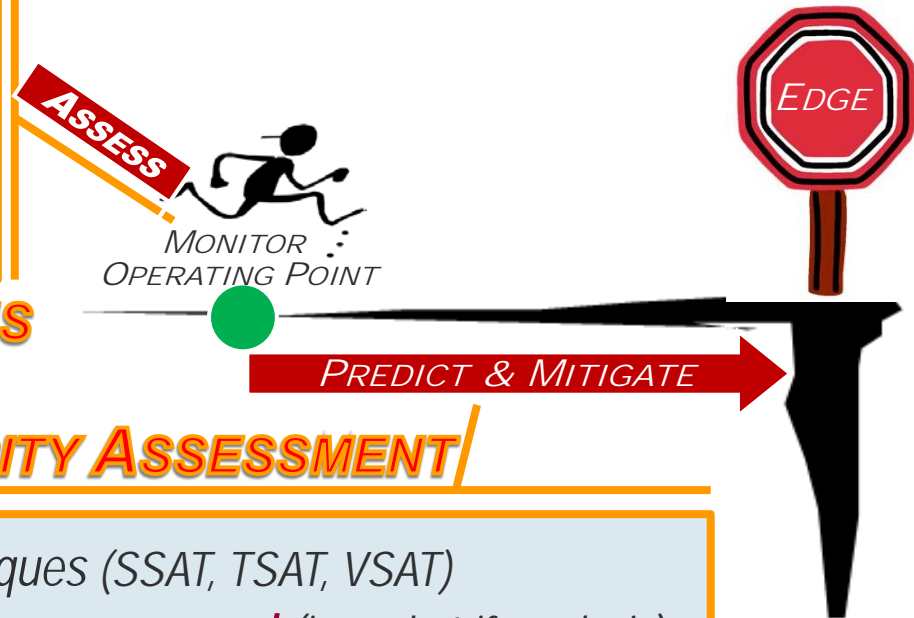


Online Stability Solutions

An **integrated measurement-based** and **model-based stability** assessment application that **runs in real time**.

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

- Track current damping levels.
- Detect & alarm on dangerous oscillations & sudden events.



SYNCHROPHASOR APPLICATIONS

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 levels)
- Recommend controls based on sensitivity information.

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

Select Customers for SynchroPhasor Applications

- 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)
- *Active proposals being submitted to others.....*

PG&E SynchroPhasor Project

Vahid Madani – Project Technical Leader

Strategic Team:

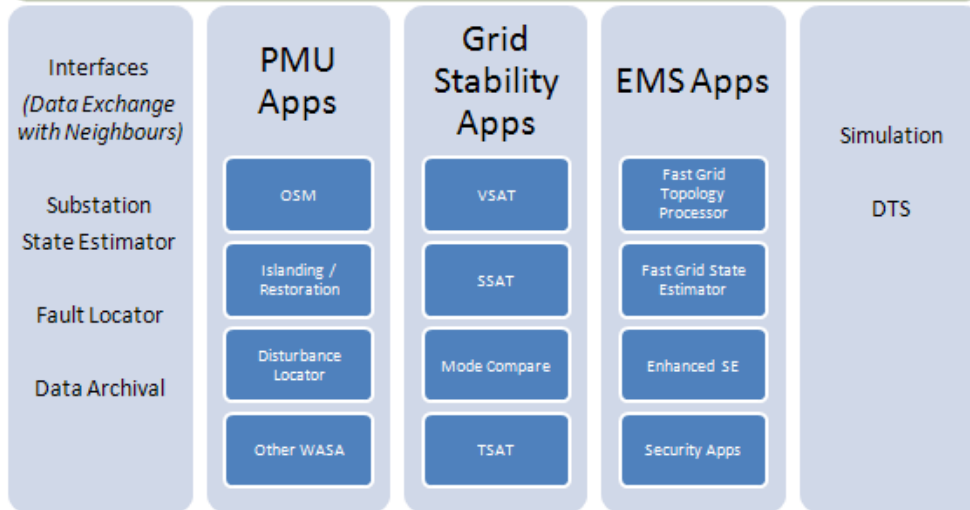
PG&E, ALSTOM, GE, Mississippi State Univ., Quanta

Academic & Testing Partners:

GeorgiaTech, Omnicron/VirginiaTech, Washington State Univ.

EMS Visualization and Alarming Platform

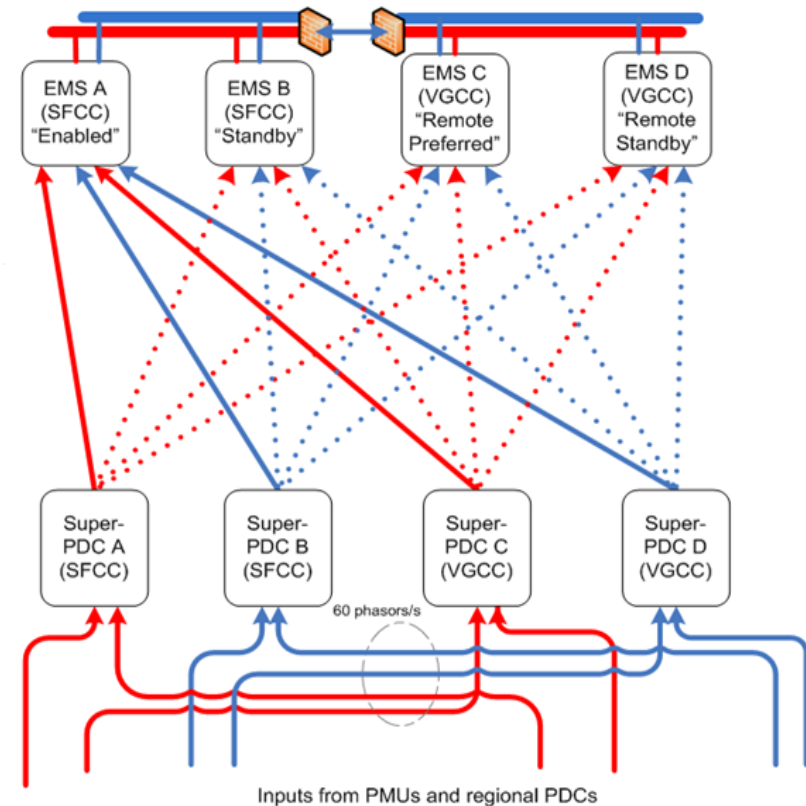
(Cognitive Task Analysis & Information Processing)



PMU and SCADA Data

(Redundancy/Data Synchronization)

SynchroPhasor Applications for the Control Center



Multi-host Redundancy (ISD Link)

GRID

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Expansion of IEC 61850 outside Substation environments

IEC 61850 as communication interface
with EMS

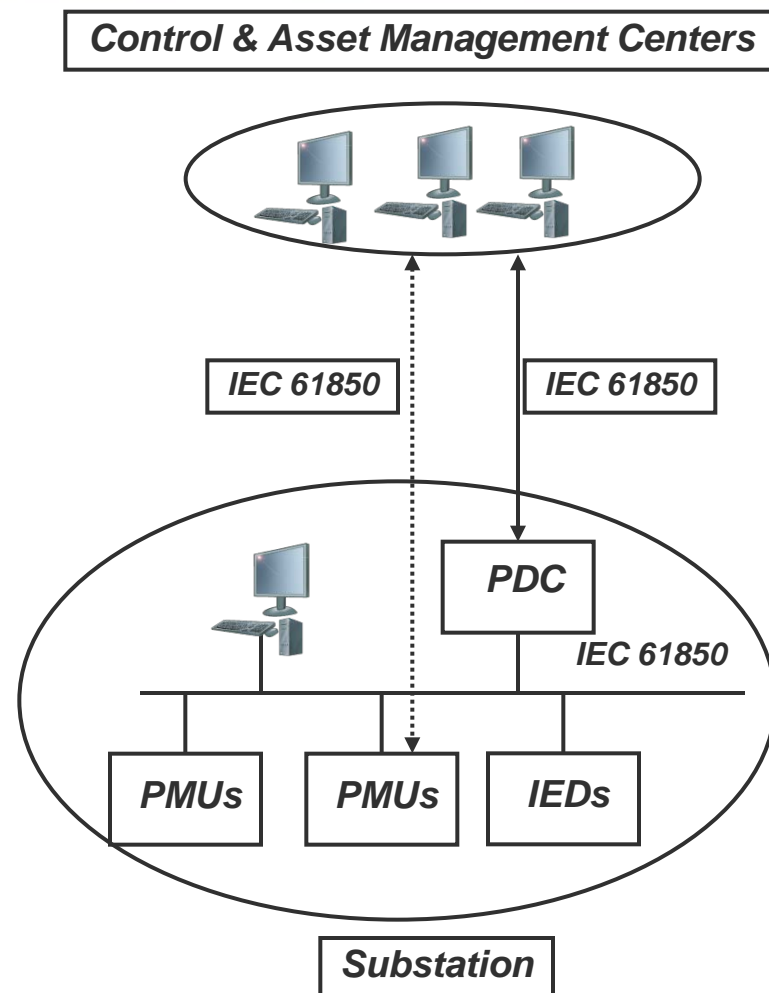
- Simplified Substation integration

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 backbone to support Wide Area Automation

Support for Enterprise Level Applications



- ISO-NE SIDU project scope:
 - increase synchrophasor data measurements from key transmission substations within New England region and
 - provide analytical tools based in part on phasor data.
- ISO-NE using OpenPDC as foundation
- Alstom Grid selected as the prime vendor for integration services of OpenPDC at ISO-NE as well as seven Transmission Owners(TO). These services include:
 - Installation/configuration/testing at ISO-NE and TO sites;
 TO PMU(s) → TO OpenPDC → ISO-NE OpenPDC
 - Coordination of OpenPDC releases with ISO-NE;
 - Management of OpenPDC releases as GPA releases new versions;
 - Creation of OpenPDC installation, testing, administration and user documentation;
 - Training;
 - As needed support for maintenance and troubleshooting;
 - Consulting services.

MiCOM P847 Series PMU Functionality



Analog Channels

- $V_a, V_b, V_c, V_1, V_2, V_0$
- $I_1, I_2, I_0, I_a, I_b, I_c$
- Frequency & Rate of Change of Frequency

Digital Channels

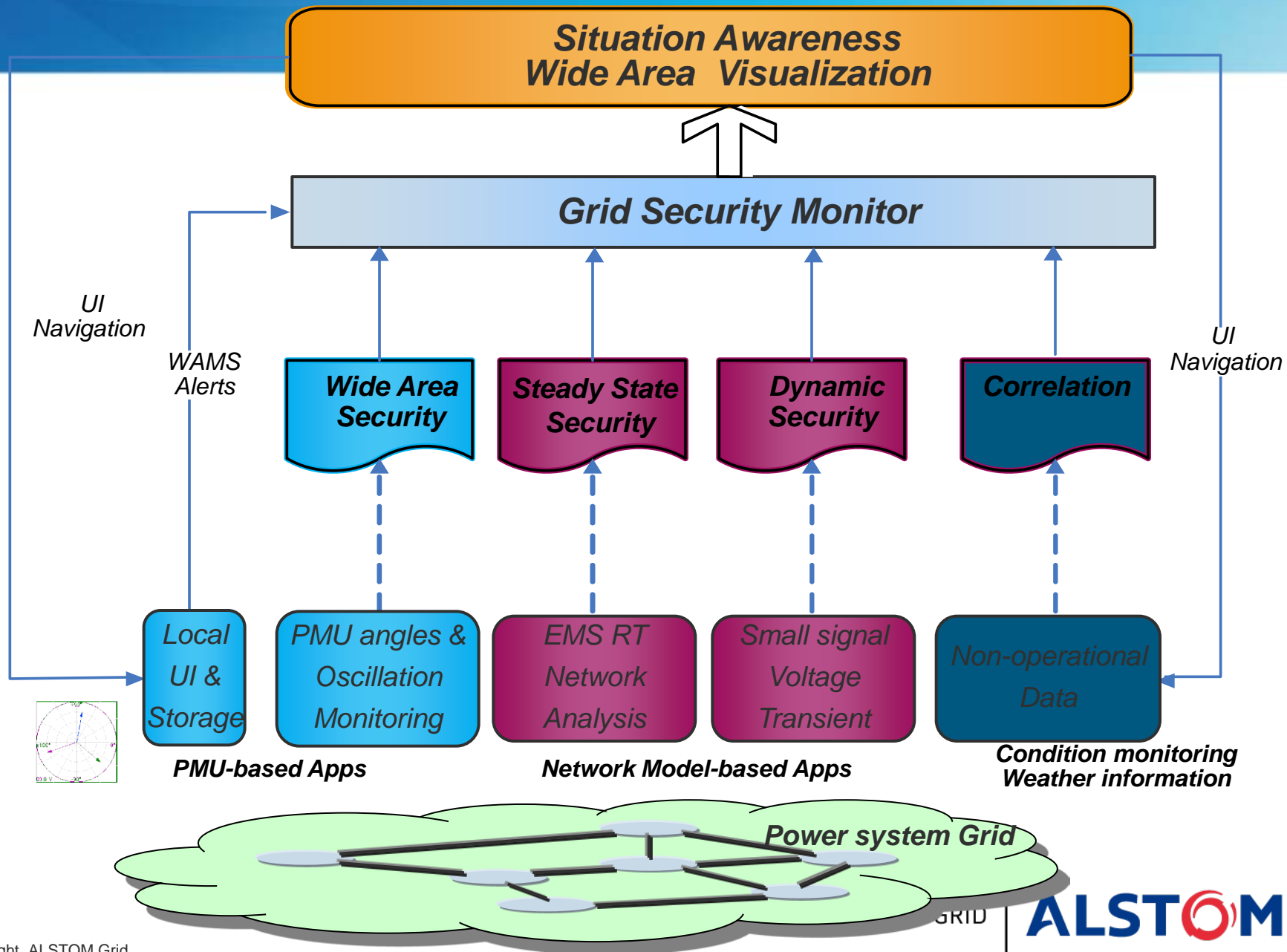
- Any 8 status signals available

MiCOM Substation PDC Functionality

- Concentrates up to 15 phasor data sources (e.g PMUs)
- Based on solid-state ruggedized PC rated for substation applications
- C37.118 data archiving
- Remote configuration, license and archive management
- Supports multiple simultaneous input and output reporting rates
- State-of-the-art graphic user interface



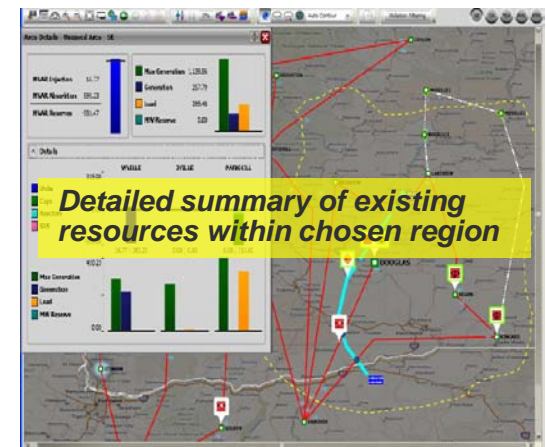
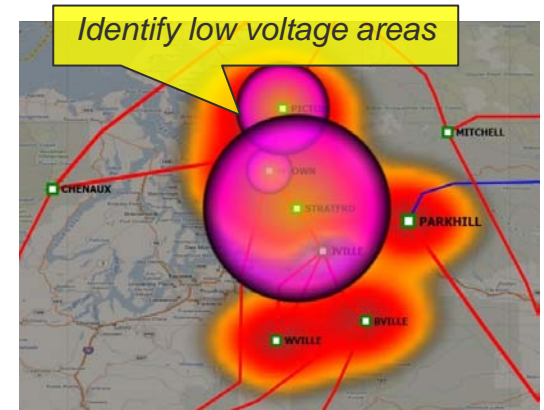
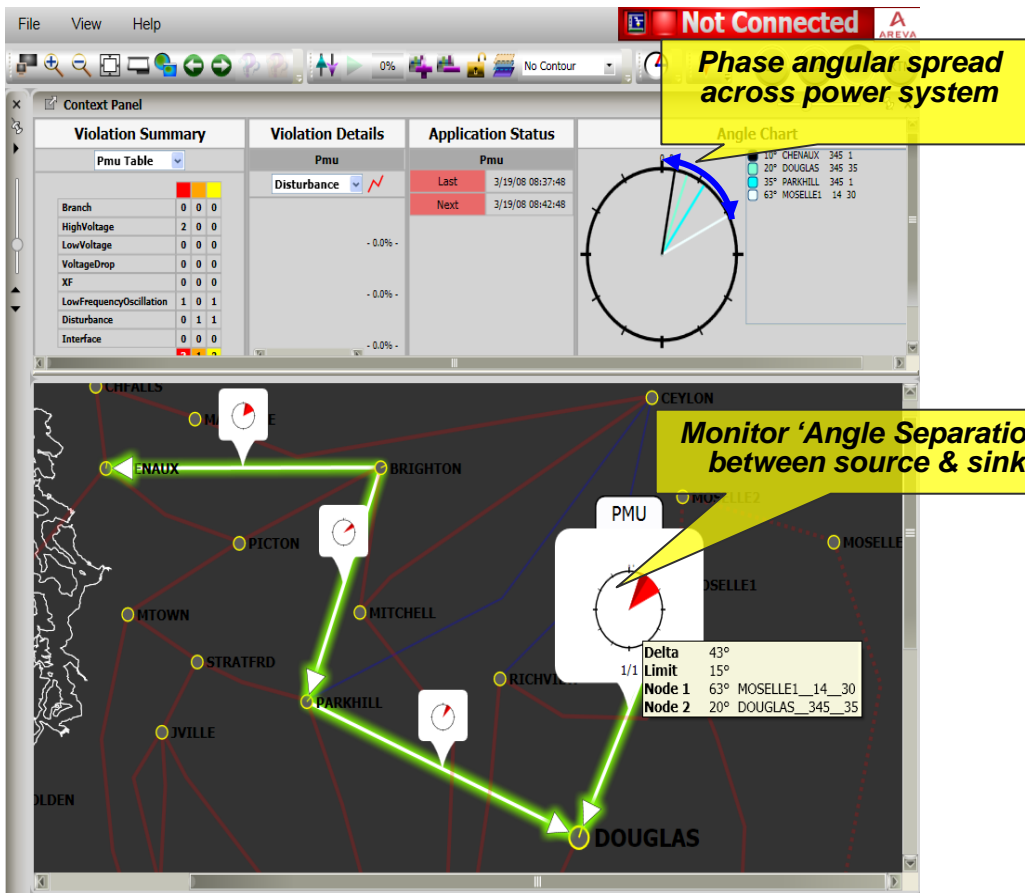
Wide Area Situational Awareness Visualization



Wide-Area Situational Awareness with PMUs

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)



OSM Visualization within e-terra^{vision}

Modes shapes, amplitudes, damping, frequency, etc

Real-time alerts on poorly damped oscillations

Track oscillatory stability in real-time

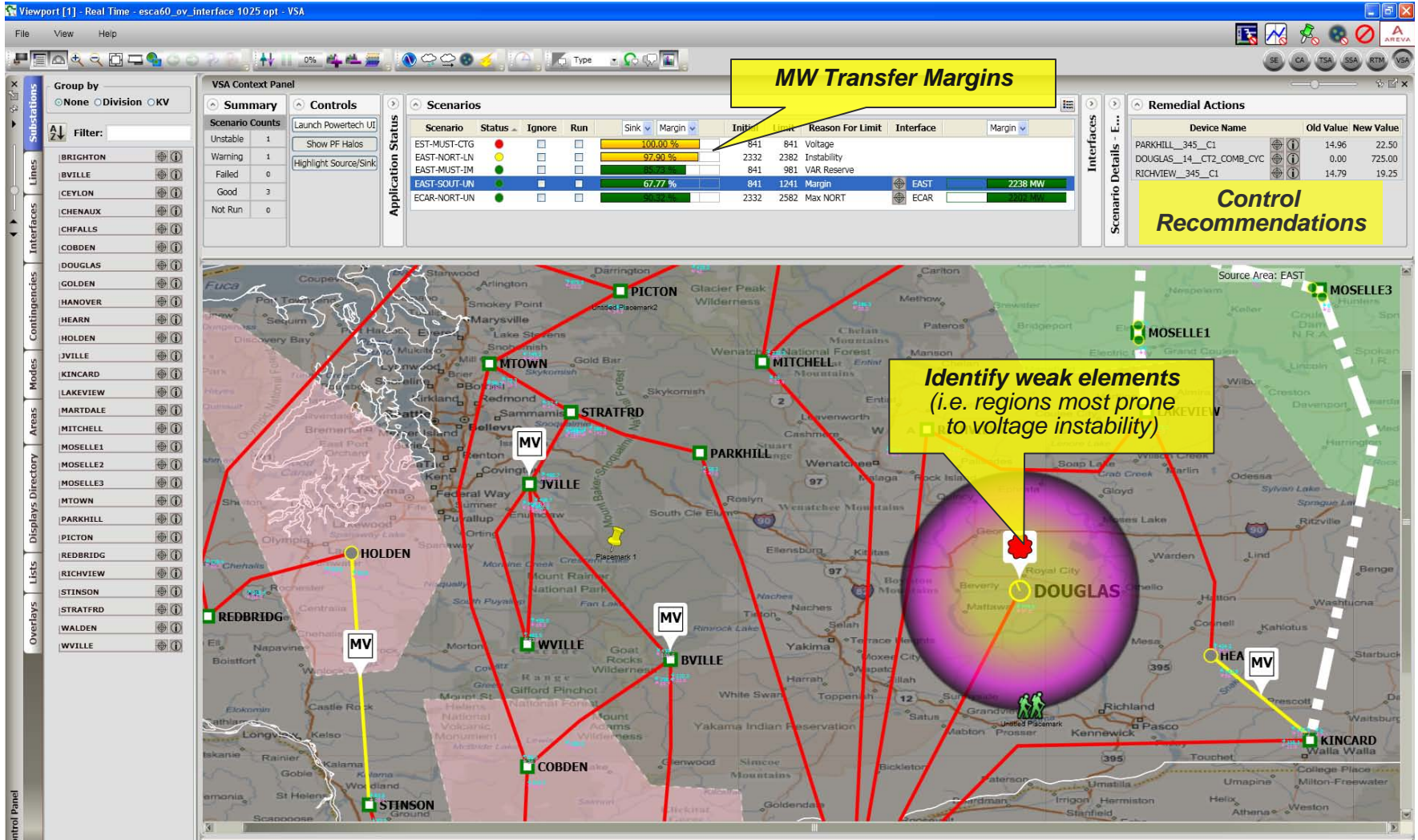
Identify regions where inter-area oscillations are observable

Time In	Name	Violation Type	Description	Frequency	Amplitude
2/7/2008 3:53:44 AM	MOSELLE_345_312	Disturbance		13.00Hz	130.00
2/7/2008 3:53:44 AM	MOSELLE_345_323	LowFrequencyOscillation		13.00Hz	130.00
2/7/2008 3:53:44 AM	STINSON_345_123	LowFrequencyOscillation		13.00Hz	130.00
1/3/2009 4:59:04 PM	DOUGLAS_345_111	LowFrequencyOscillation		13.00Hz	130.00
1/3/2009 4:59:04 PM	HEARN_345_17	LowFrequencyOscillation		13.00Hz	130.00

Mode	SSA	Mode	SSA	Mode	SSA
Frequency: 0.15 Hz	Mode: 55A31	Frequency: 1.05 Hz	Mode: 55A30	Frequency: 1.52 Hz	Mode: 55A33
Damping: 3.4900		Damping: 7.8200		Damping: 8.7500	
Magnitude: 3.97		Magnitude: 6.60		Magnitude: 9.57	
Time: 9/4/09 22:58:00		Time: 9/4/09 22:58:33		Time: 9/4/09 22:57	

Voltage Security Analysis in e-terra^{vision}

Voltage Contours, MW Margins, Weak Elements, Remedial Actions



SynchroPhasors in EMS

Enhanced State Estimator with PMU data at the 1 sample/sec rate

Utilization of PMU data (voltage & Current Phasors) in SE to improve round-the-clock reliability & robustness.

- Increase the number of 'Valid Solutions' ⇒ **improved reliability**
- Reduce dependency on 'Critical Measurements' ⇒ **better observability**

- Improved SE solution quality to minimize 'Variance of State'

⇒ **higher accuracy**

- Fewer SE iterations

⇒ **faster performance**

The screenshot shows a web browser window with the title 'TELE PMU BUS PDEG DATA RTNET [ONLINE]'. The main content is a table titled 'Telemetered PMU BUS Data' with columns for Station, Device Type, Device, Analog, Quality, SCADA, Value, Weighted Residual, Standard Deviation, and Bias. The table lists various stations and their associated PMU data. A callout box in the bottom right corner contains the text 'Compare PMU with SE Results' and 'Courtesy Jim Graffy (BPA)'.

Station	Device Type	Device	Analog	Quality	SCADA	Value	Weighted Residual	Standard Deviation	Bias
ASHE	BUS	PMU	PDEG	Good / Available	9.90 / 9.45	0.504	0.044	0.400	Row
BELL	BUS	500_PMU	PDEG	Good / Available	25.80 / 24.01	1.992	0.318	1.606	Row
BELL	BUS	230_PMU	PDEG	Good / Available	28.20 / 26.18	2.248	0.307	1.875	Row
BIG_EDDY	BUS	500_PMU	PDEG	Good / Available	-2.90 / -2.89	-0.015	0.104	-0.028	Row
BIG_EDDY	BUS	230_PMU	PDEG	Good / Available	-7.10 / -5.97	-1.254	0.065	-1.130	Row
CAPTJACK	BUS	PMU	PDEG	Good / Available	-17.00 / -16.02	-1.089	0.319	-1.098	Row
CHIEF_JO	BUS	500_PMU	PDEG	Good / Available	23.30 / 22.81	0.545	0.307	0.312	Row
CHIEF_JO	BUS	230_PMU	PDEG	Good / Available	26.10 / 25.42	0.754	0.302	0.500	Row
CUSTER	BUS	500_PMU	PDEG	Good / Available	7.70 / 8.98	-1.423	0.316	-1.369	Row
CUSTER	BUS	230_PMU	PDEG	Good / Available	6.00 / 7.41	-1.563	0.320	-1.521	Row
GARRISON	BUS	500_PMU	PDEG	Estimated / Unavailable	24.03 / 23.99				Row
GARRISON	BUS	230_PMU	PDEG	Estimated / Unavailable	21.83 / 21.79				Row
G_COULEE	BUS	500_PMU	PDEG	Good / Available	23.60 / 22.97	0.704	0.201	0.568	Row
JOHN_DAY	BUS	500_PMU	PDEG	Good / Available	-0.40 / -0.39	-0.172	0.010	0.002	Row
KEELER	BUS	500_PMU	PDEG	Good / Available	-5.50 / -5.30	-0.219	0.184	-0.254	Row
KEELER	BUS	230_PMU	PDEG	Good / Available	-8.00 / -7.61	-0.435	0.235	-0.473	Row
MALIN	BUS	PMU	PDEG	Good / Available	-16.90 / -16.03	-0.962	0.332	-1.084	Row
MAPLE_VL	BUS	230_PMU	PDEG	Good / Available	4.90 / 5.37	-0.522	0.227	-0.486	Row
MCNARY	BUS	500_PMU	PDEG	Good / Available	9.00 / 8.58	0.466	0.391	0.159	Row
MCNARY	BUS	230_PMU	PDEG	Good / Available	8.20 / 7.79	0.459	0.310	0.228	Row
SLATT	BUS	PMU	PDEG	Good / Available	3.20 / 3.09	0.125	0.244	-0.002	Row
SUMMERLK	BUS	PMU	PDEG	Good / Available	-13.90 / -13.21	-0.769	0.305	-0.874	Row
COLSTRIP	BUS	500_PMU	PDEG	Good / Available	38.20 / 34.66	3.936	0.258	3.306	Row
YELLOWTLP	BUS	PMU	PDEG	Estimated / Unavailable	16.84 / 16.90				Row
DIABLOPG	BUS	PMU	PDEG	Good / Available	-17.80 / -16.68	-1.247	0.361	-1.452	Row
MIDWAYPG	BUS	500_PMU	PDEG	Good / Available					Row
MOSSLAND	BUS	500_PMU	PDEG	Good / Available					Row
PITSBURG	BUS	PMU	PDEG	Estimated / Unavailable					Row
TESLA	BUS	500_PMU	PDEG	Good / Available					Row
DEVERS	BUS	PMU	PDEG	Good / Available	-31.40 / -30.92	-0.536	0.322	-0.622	Row
SYLMARS	BUS	230_PMU	PDEG	Good / Available	22.80 / 25.92	3.086	0.397	2.299	Row
VINCENT	BUS	PMU	PDEG	Good / Available					Row
AULT	BUS	PMU	PDEG	Good / Available	22.70 / 20.39	2.380	0.500	0.888	Row
BEARS	BUS	PMU	PDEG	Good / Available					Row
SHIPROCK	BUS	PMU	PDEG	Good / Available	-2.50 / -2.16	-0.373	0.250	-0.228	Row

Compare PMU with SE Results
 Courtesy Jim Graffy (BPA)

ALSTOM's Product Offerings Today!

PMU Functionality (*MiCOM P847*): Multi-function device with PMU capability.

Substation PDC (*MiCOM S800*): Ruggedized PDC for substation environment.

Control Center PDC: Processing and Synchronizing time series data.

Wide Area Situational Awareness & Visualization (*e-terravision*):

- *Monitoring angle differences for instability*
- *Identifying low voltage areas & available voltage support sources*
- *User-created, on-the-fly, dynamic dashboards*

Synchrophasor Applications:

- *Oscillatory stability monitoring (OSM)*
- *Fast detection & alarming of unexpected disturbances; Composite events.*
- *Islanding, restoration, blackstart.*
- *Post Disturbance Analysis & Baselineing.*

Improved State Estimation using Voltage and Current PMU data

Online Stability Solutions (OSS): Comprehensive dynamic security assessment

- *VSAT/SSAT/TSAT integration with Visualization platform*

Engineering Services– PMU Placement Studies, PSS Tuning, Baselineing Analysis

Alstom - Concluding Remarks

- Ready & committed to providing synchrophasor solutions for a control center environment.
- Well-defined vision & roadmap for deployment of synchrophasor technology.
- Offer a complete suite of synchrophasor products:
PMU, substation PDC, control center PDC, synchrophasor applications, visualization.
- Utilize standard technologies and protocols:
web-services, C37.118, IEC 61850
- Range of solution choices for the customer:
 - “Plug & play” with applications with other vendors’ solutions:
PDCs, non-ALSTOM EMS, Historians, visualization, etc
 - Open framework for “plugging-in” 3rd party solution engines.
 - Full suite of solutions from PMUs...to Operator Visualization.

Questions/Comments ?

Thank You