



Using PMU data to Validate a State Estimator

Sarma (NDR) Nuthalapati
Principal Engineer, Grid Operations Support

ERCOT



Using State Estimator to Validate PMU data

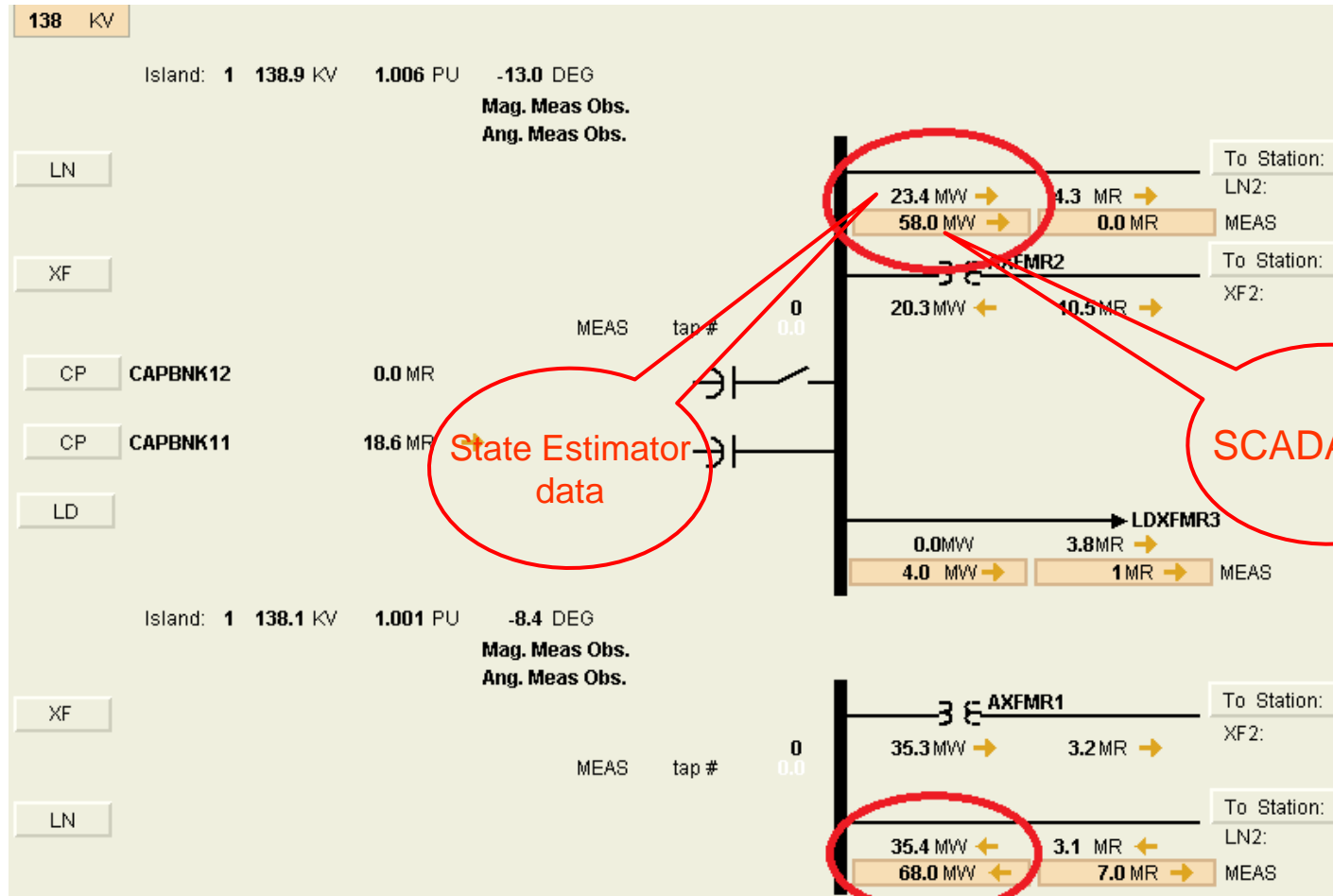
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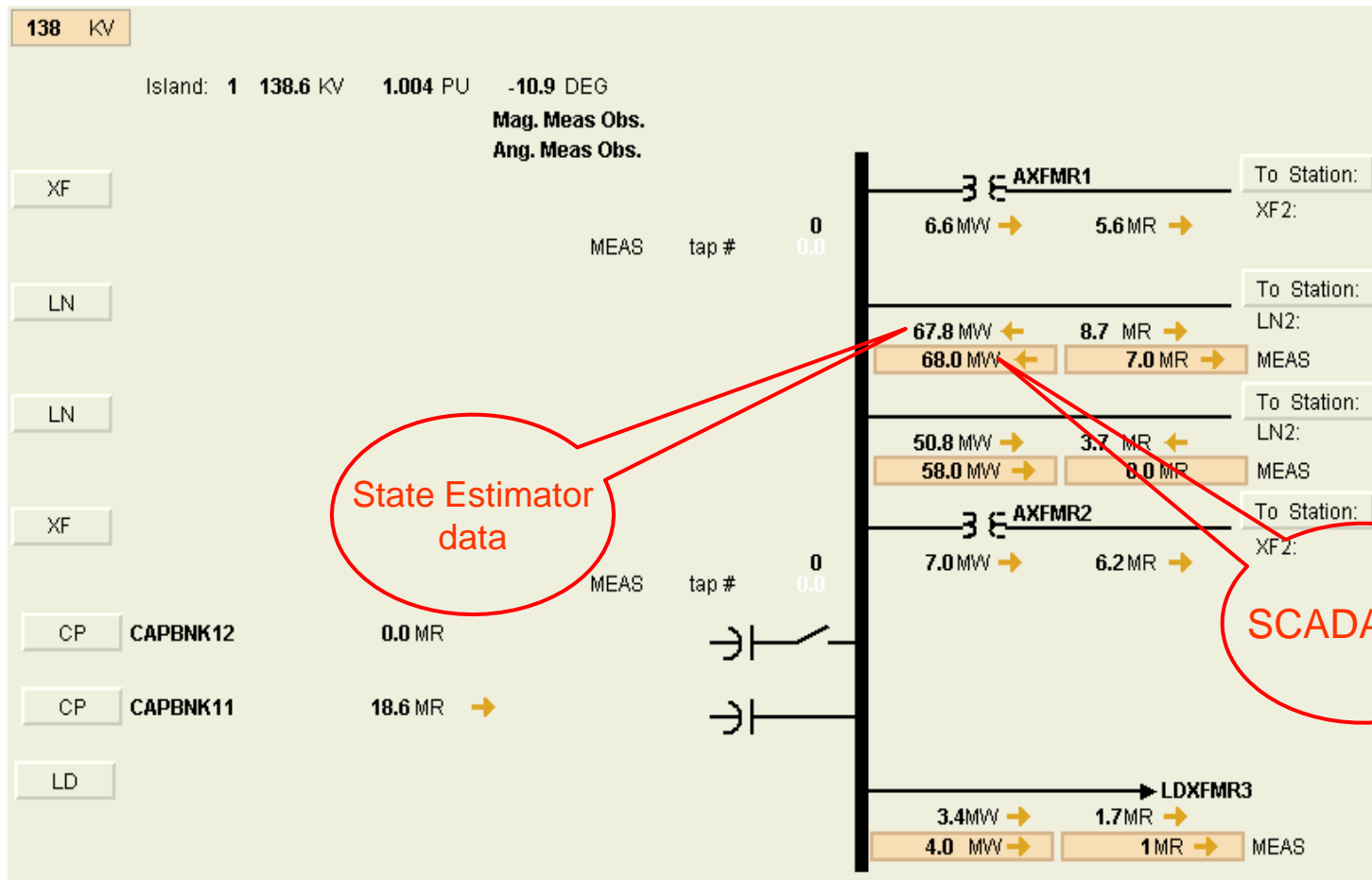
ERCOT



- SE Statistics (SESTATS)

- SESTATS is a tool developed in-house at ERCOT.
- Monitors SE performance and metrics, aids in identifying possible topology errors.
- Measures performance on several metrics
 - Quality of the real-time telemetry based on the estimates computed by SE
 - Detected measurement residuals (categorized based on equipment types)







SE STATS - Measurement Quality

SESTATS_QUALITY_OVERALL, SESTATS[EMS] EPW0006(A) Page: 1 - Viewport A - LocalHabitat

File Navigate HABITAT Applications EMP Applications Transmission Frequency Related Displays Help

Application: Realtime Network
Overall Measurement Quality

Overall bus inj. mis. | XF with KV meas. | not mapped CB flow meas. | Ln/Xf 2 ends tr

Execution Summary
Topology Changes
Measurement Availability
Observability
Measurement Quality
Estimates Quality
Convergence of Solution
Analyst Parameters
Bus Voltages and Angles
SE Monitoring Message Log

Status: Monitoring

Sol. Begin Time	Analog Measurements					Status Measurements		
	Auto Disabled	Anomaly	Available	Good	Replaced	Available	Good	Replaced
27-May-2014 15:22:27	519	6	28107	24748	177	36413	36302	93
27-May-2014 15:17:27	200	6	28457	28235	177	44244	44133	93
27-May-2014 15:12:27	197	6	28462	28246	177	44310	44199	93
27-May-2014 15:07:27	194	6	28447	28246	177	43903	43792	93
27-May-2014 15:02:27	198	6	28434	28216	177	44010	43899	93

- Dead Equipment with Active Measurements
Tracks discrepancies between equipment status and analog telemetry values

Application: Realtime Network Status: Monitoring

Dead Equipments with significant MW/MVar measurements

Overall bus inj. mis. | XF with KV meas. | not mapped CB flow meas. | Ln/Xf 2 ends meas. | Dead equip. w/ active meas. | Meas. with 0 resi.

State Estimation Sol. Begin Time	Dead equipment with P measurement >5MW						Dead equipment with Q measurement >5MVar					
	Line	Transformers	ZBR	Unit	Load	CB	Line	Transformers	ZBR	Unit	Load	CB
13-Oct-2009 17:03:32	6	2	0	0	24	1	9	0	0	10	11	3
13-Oct-2009 16:58:32	6	2	0	0	22	1	9	0	0	10	10	3

SESTATS_DEAD_POPUP, SESTATS[EMS] ERPEMSA(DEAD_LNP_18) Page: 1 LocalHabitat

Dead equipments with significant measurements

SE Begin Time	Meas.	Meas.	Abs.	EQ ID1	EQ ID2	Notes
13-Oct-2009 16:58:32	SSWWWW LN	OM	-327.00	327.00	AAALN1	1 FR:WWWW Dead Line with P >5 MW
13-Oct-2009 16:58:32	SSWWWW LN	AB	58.29	58.29	WWW.SSSW2H	1 FR:WWWW Dead Line with P >5 MW
13-Oct-2009 16:58:32	SSSWWW LN	MI	44.86	44.86	SSSWW	1 FR:SSSWWW Dead Line with P >5 MW
13-Oct-2009 16:58:32	SSSWWW LN	21	17.00	17.00	SSSW2H	1 FR:SSSWWW Dead Line with P >5 MW
13-Oct-2009 16:58:32	SSWWWW LN	RI	11.80	11.80	LNA_B	1 FR:SSWWWW Dead Line with P >5 MW
13-Oct-2009 16:58:32	SSWWWW LN	54	10.05	10.05	LN1	1 FR:SSWWWW Dead Line with P >5 MW

13-Oct-2009 16:08:31 6 2 0 0 21 1 8 0 0 10 12 3



Estimates Quality

- SE STATS Tracks Residuals

SESTATS_QUALITY_RESIDUAL, SESTATS[EMS] EPW0006(A) Page: 1 - Viewport A - LocalHabitat

File Navigate HABITAT Applications EMP Applications Transmission Frequency Related Displays Help

Application: Realtime Network
Measurement Anomalies Summary
 Status: Monitoring

Execution Summary
 Topology Changes
 Measurement Availability
 Observability
 Measurement Quality
Estimates Quality
 Convergence of Solution
 Analyst Parameters
 Bus Voltages and Angles
 SE Monitoring Message Log

Application: Realtime Network
Line Analog Measurement Residuals
 Status: Monitoring

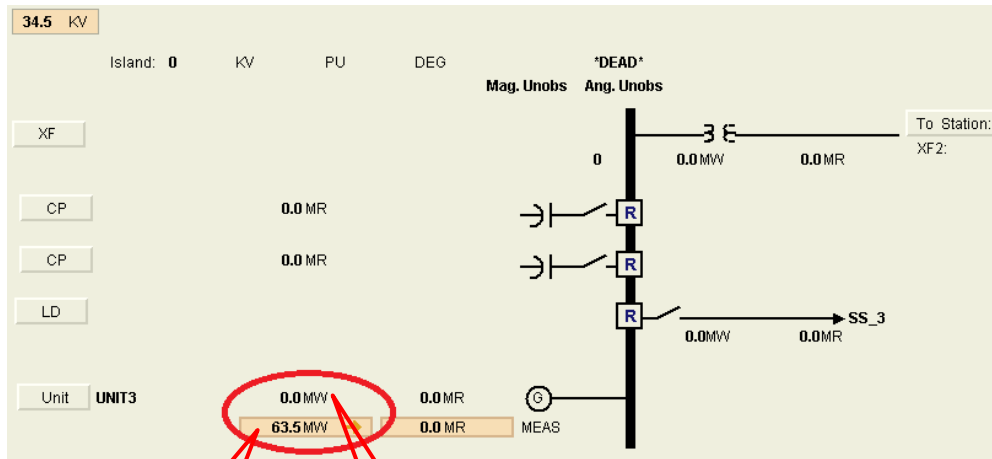
Application: Realtime Network
Unit Analog Measurement Residuals
 Status: Monitoring

State Estimation Sol. Begin Time		MW Measurement Residual						MVar Measurement Residual						TOTAL	
>5.0	>15.0	>25.0	Max.	Meas. Loc.	Perf. Index	>= 3.0 %	>5.0	>15.0	>25.0	Max.	Meas. Loc.	Perf. Index			
0	0	0					0	0	0				0	6	
0	0	0					0	0	0				0	6	

State Estimation Sol. Begin Time		MW Measurement Residual						MVar Measurement Residual							
>5	>15	>25	Max.	Meas. Loc.	Perf. Index	>5	>15	>25	Max.	Meas. Loc.	Perf. Index				
2	0	0	9.4	C	18	5708	487.1	88	21	13	-63.7	F	24	4712	31301.7
3	0	0	9.3	C	18	5708	456.4	85	19	9	-65.2	F	24	4712	29854.2
2	0	0	9.2	C	18	5708	479.5	87	20	11	-64.0	F	24	4712	29992.3
2	0	0	8.8	C	18	5708	482.3	86	20	12	-64.9	F	24	4712	29755.6
2	0	0	9.1	C	18	5708	545.5	90	20	13	-63.9	F	24	4712	29510.9
2	0	0	8.9	C	18	5708	463.4	85	19	11	-62.9	F	24	4712	29732.3
3	0	0	9.4	W	20	5976	489.2	86	19	12	-65.2	F	24	4712	29648.7
4	0	0	11.3	W	20	5976	607.4	87	19	12	-64.9	F	24	4712	29827.8

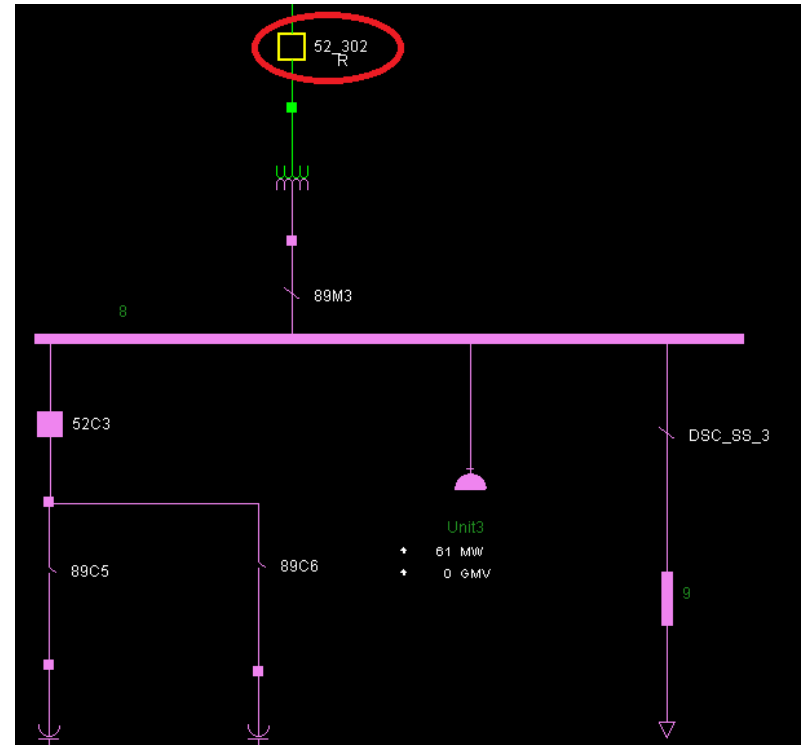


Coherency Check Using SESTATS



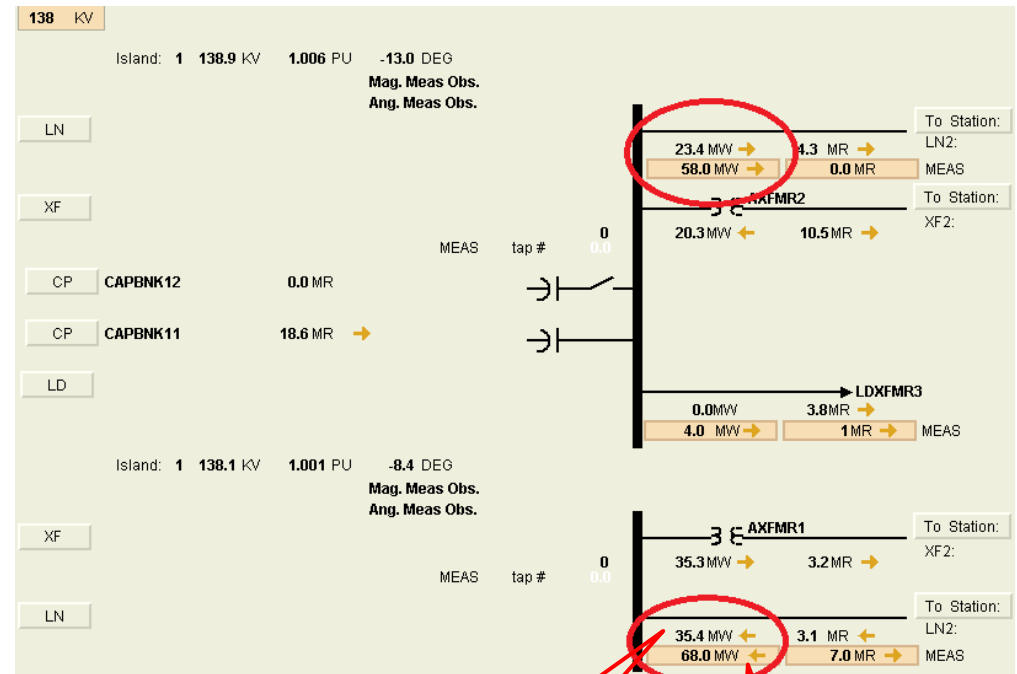
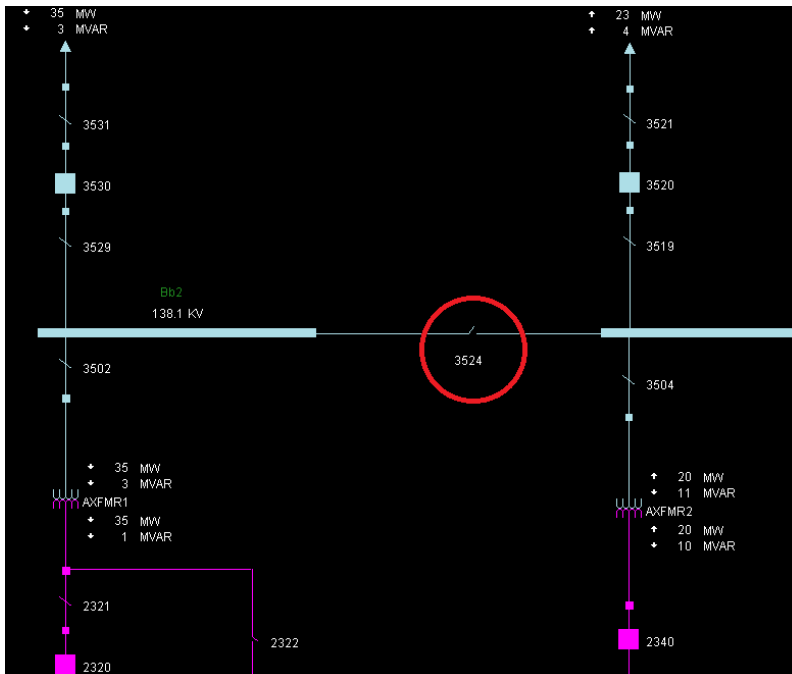
SCADA Data

State Estimator Data



Detecting Topology Errors via SE Results

- Detecting and identifying the bus splitting/merging issue via SE result

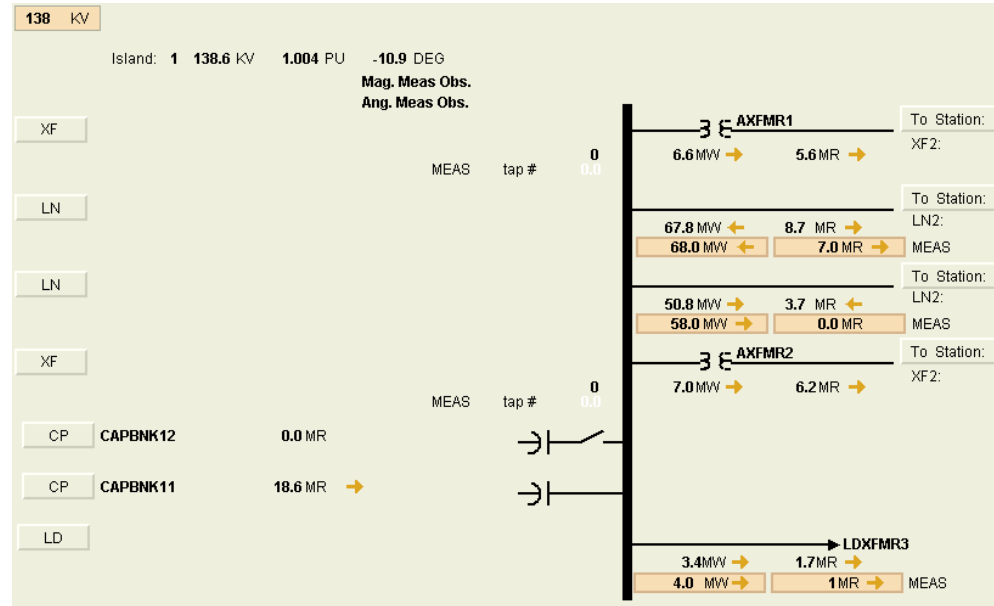
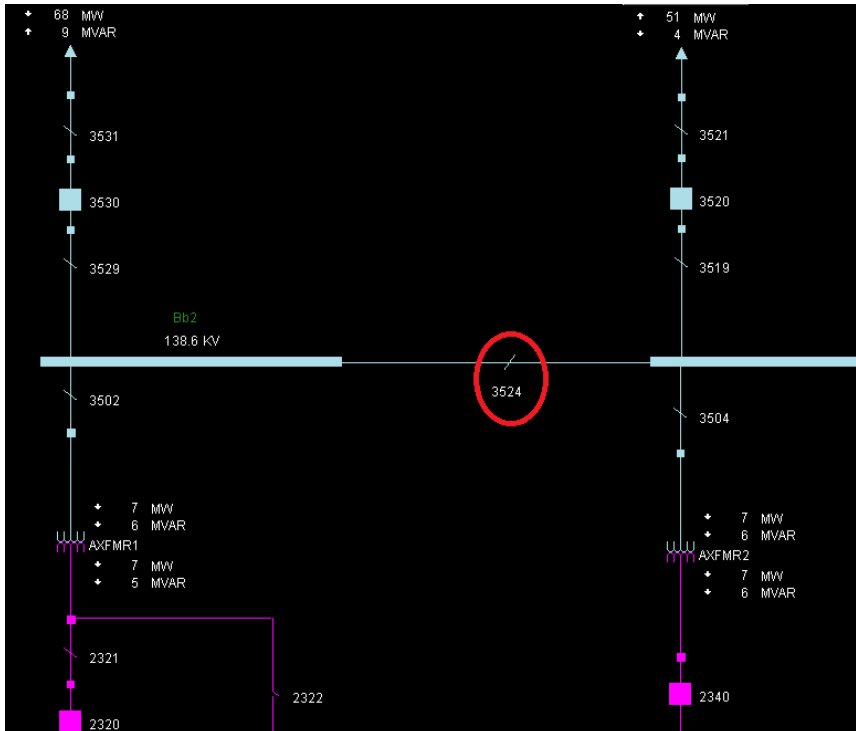


State Estimator data

SCADA Data

Detecting Topology Errors via SE Results

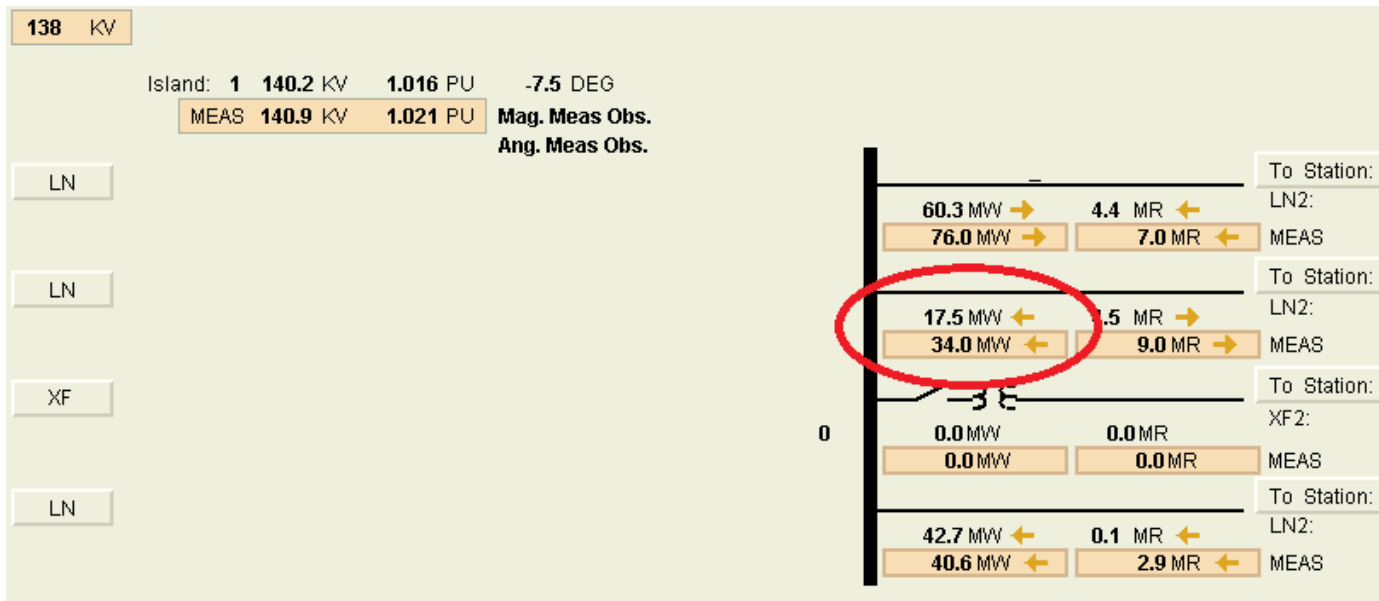
- Detecting and identifying the bus splitting/merging issue via SE result





Detecting Parameter Errors via SE Results

- Detecting and identifying line/transformer impedance



Line	Segment	Company Series	Remove	Xfer Trip Station	Owner	Dead	Open	MW	MVAR	Impedance Resistance	Impedance Reactance	Admittance Conductance	Admittance Susceptance	Charging Susceptance
		ERCOT	<input type="checkbox"/>											
	LN:		<input type="checkbox"/>	From		<input type="checkbox"/>	<input type="checkbox"/>	18	-	5.91500	27.82000	73.1	-344	0.74300
				To		<input type="checkbox"/>	<input type="checkbox"/>	-18	4					



Using PMU data to Validate a State Estimator

ERCOT Synchrophasor Data Baseline Study

Bill Blevins, ERCOT

Ajay Das, EPG

March 11th 2014

NASPI

INTRODUCTION

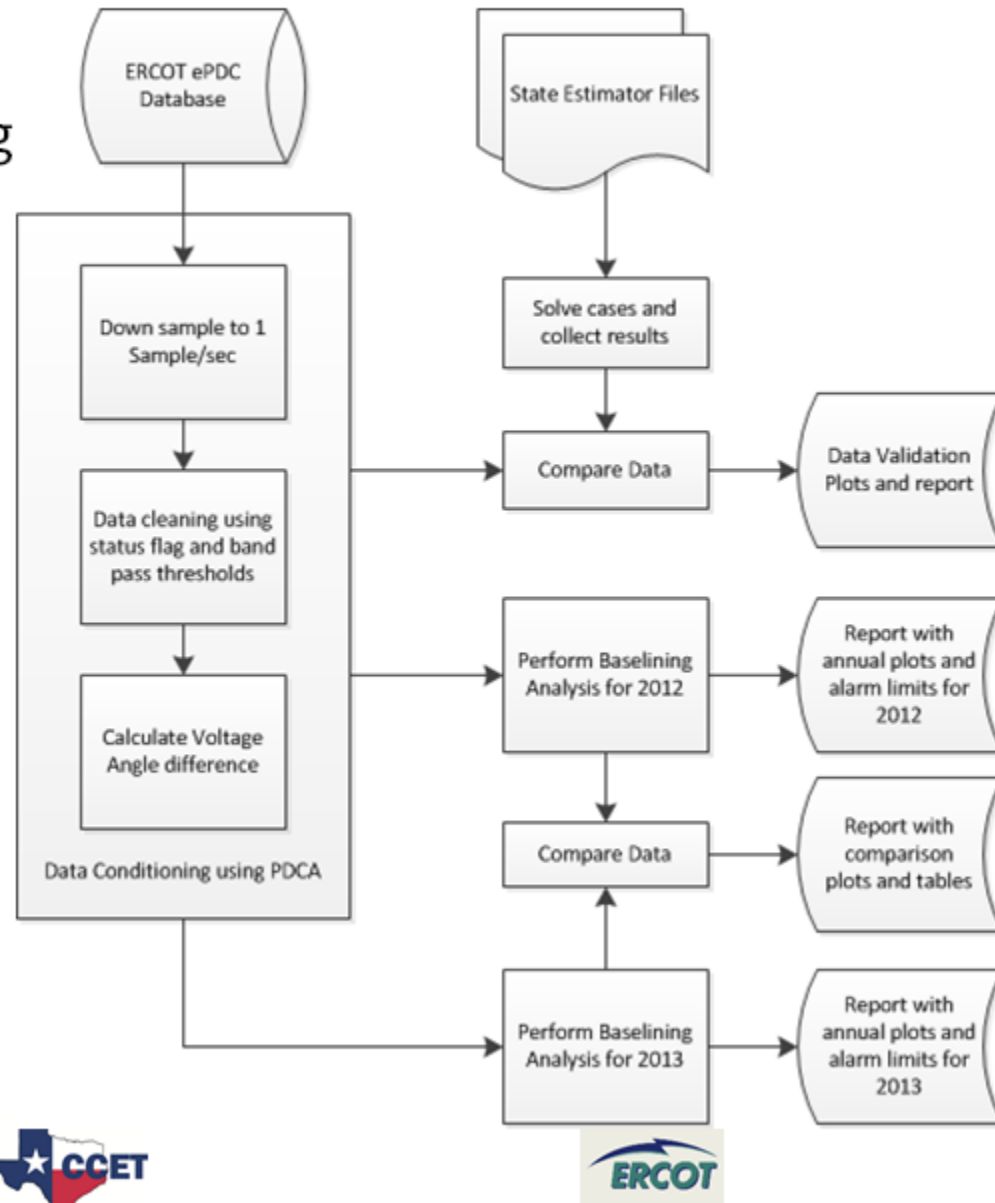
- **Three** conditions must be met for a production quality real-time phasor monitoring system at any Utility/ISO. The data must be:
 1. Flowing reliably from PMU's to Operator's console
 2. **Valid**
 3. Monitoring the critical locations (right places).
- The Data Baseline Study addresses the **second condition**

STUDY OBJECTIVE

- Perform a comparison of voltage angle differences obtained using phasor measurements versus similar results using state estimator data (phasor vs. state estimator comparison)
- Perform a **baseline analysis** for voltage magnitudes and angle differences for selected pairs of substations.
- **Identify** normal system operating conditions and **alarm limits** based on the baseline analysis.
- **Implement alarm limits** in phasor data monitoring and analysis applications to identify and analyze abnormal system conditions.
- Revise and **update the alarm limits** to compare year **2013 vs 2012**

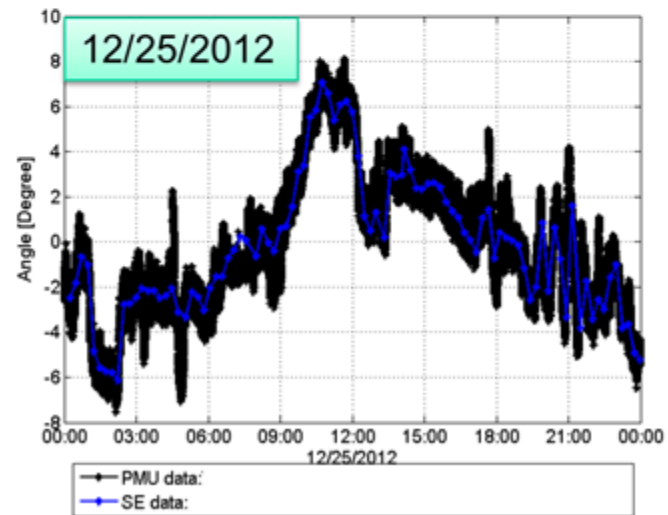
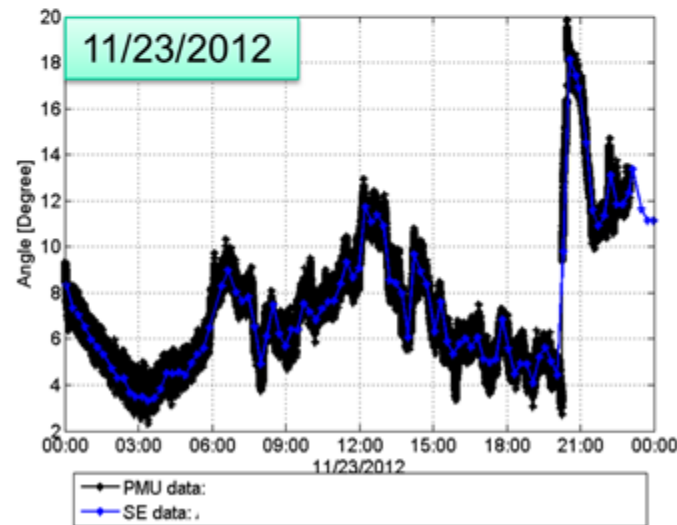
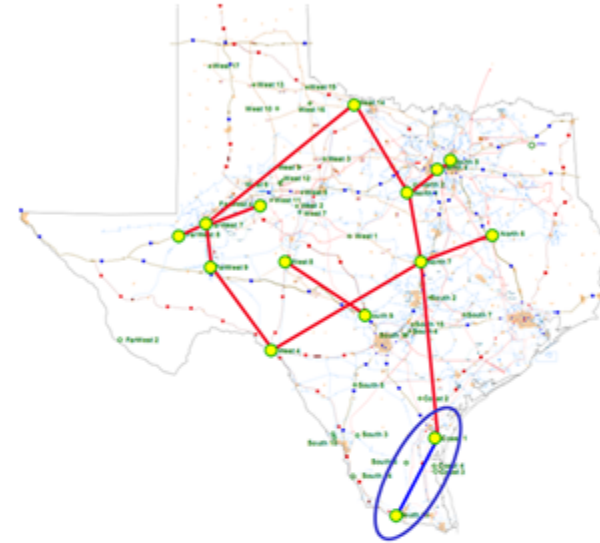
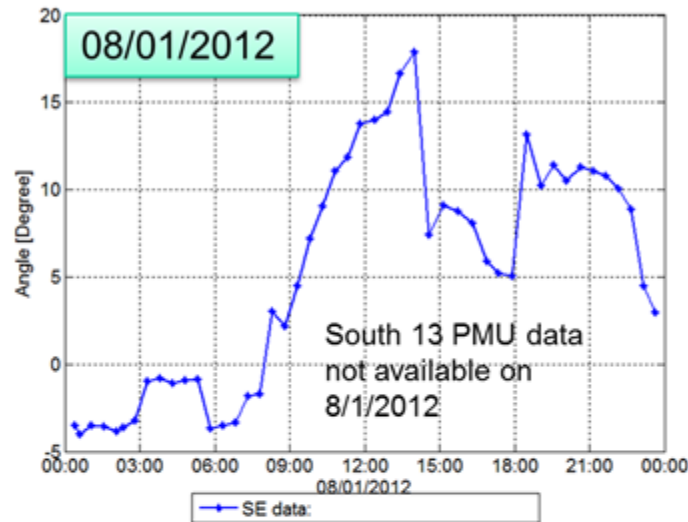
METHODOLOGY AND APPROACH

- Collect PMU and SE Data
- Perform data conditioning using Phasor Data Conditioning Application (PDCA)
- Compare PMU and SE data for selected days in 2012
 - August 1 (peak load)
 - November 23 (low load)
 - December 25 (high wind output)
- Perform baselining analysis for VM, VA and Angle Diff pairs
- Establish alarm limits
- Update alarm limits for year 2013



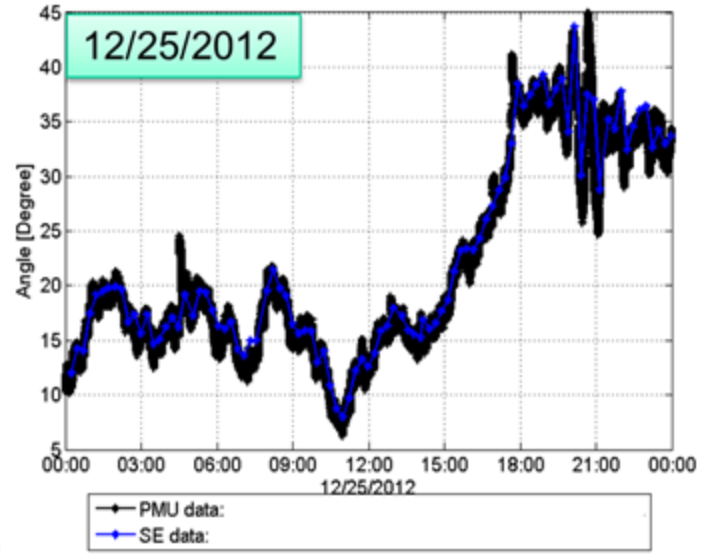
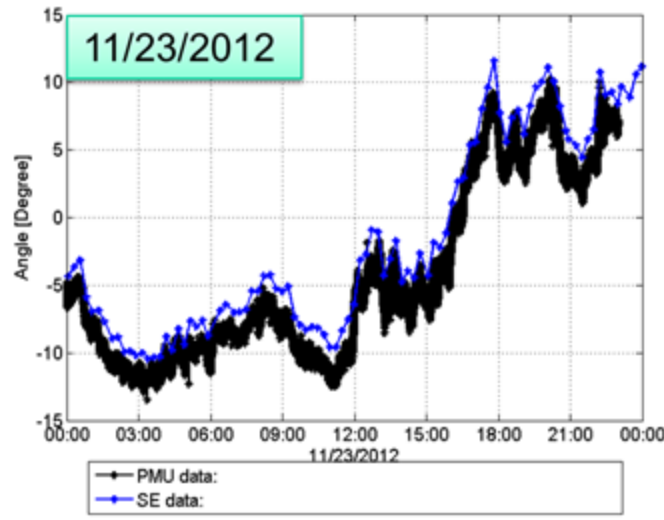
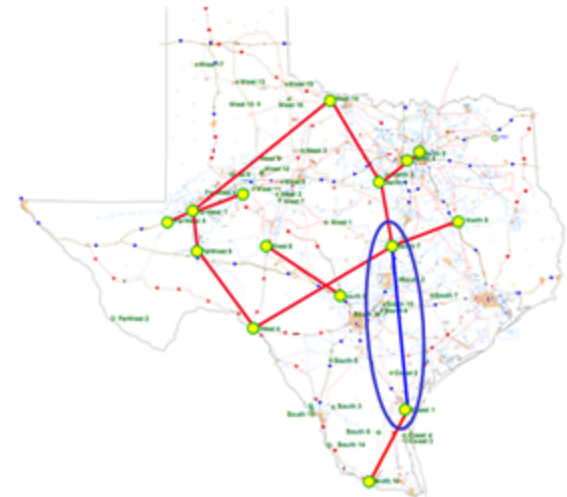
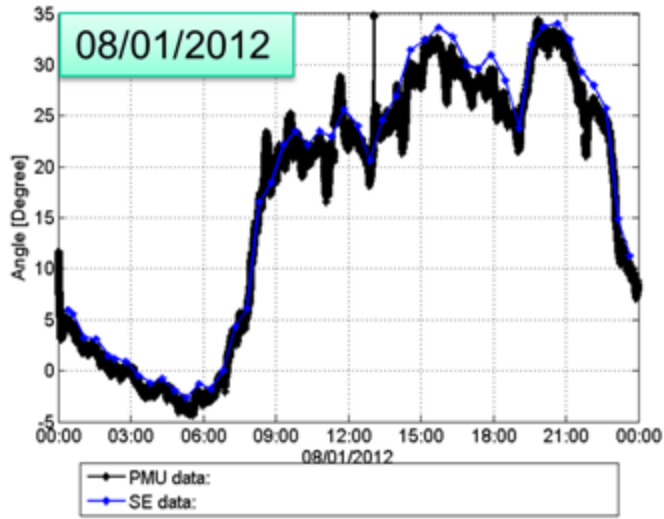
PMU DATA VS SE DATA COMPARISON -1

Coast 1-South 13



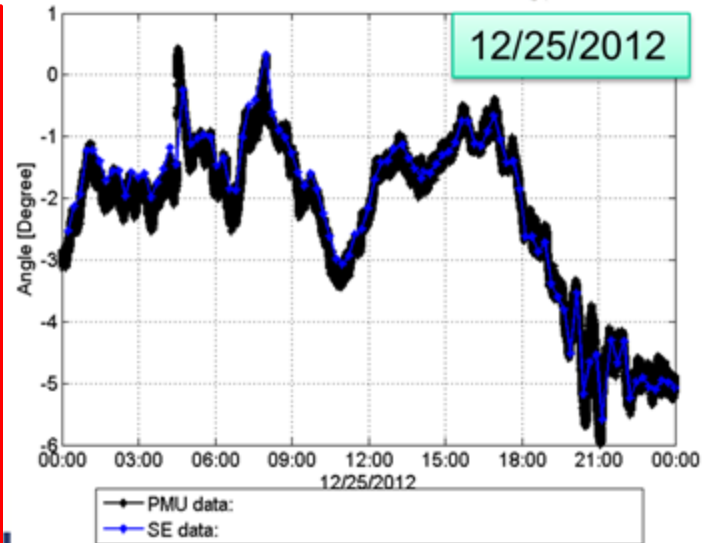
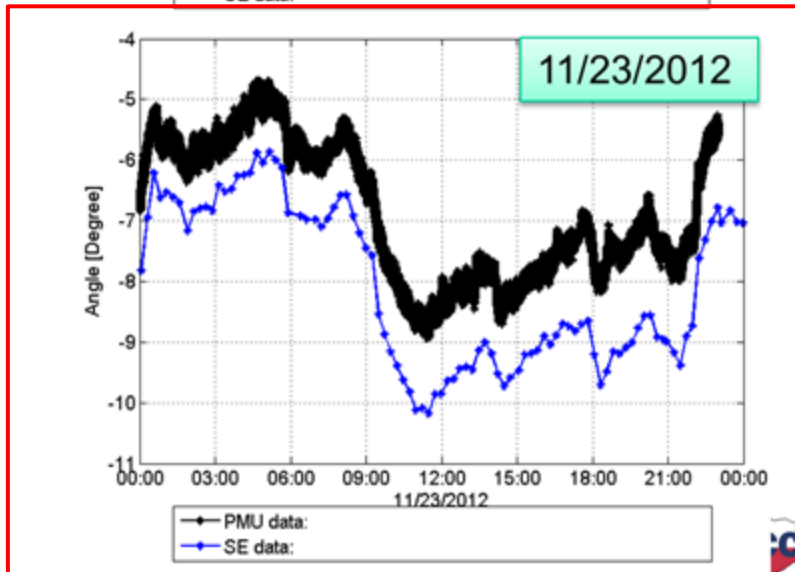
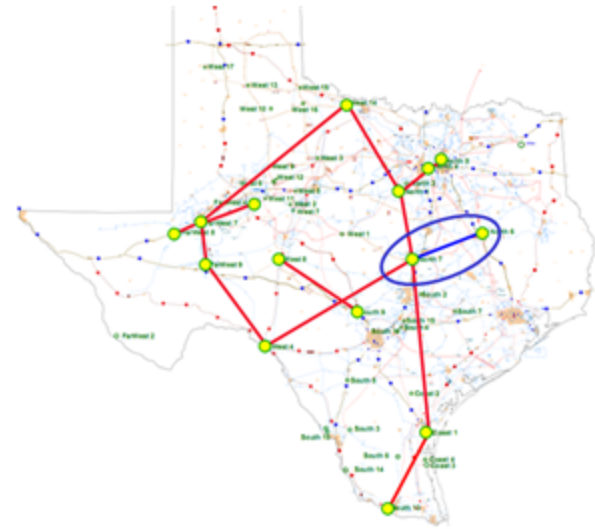
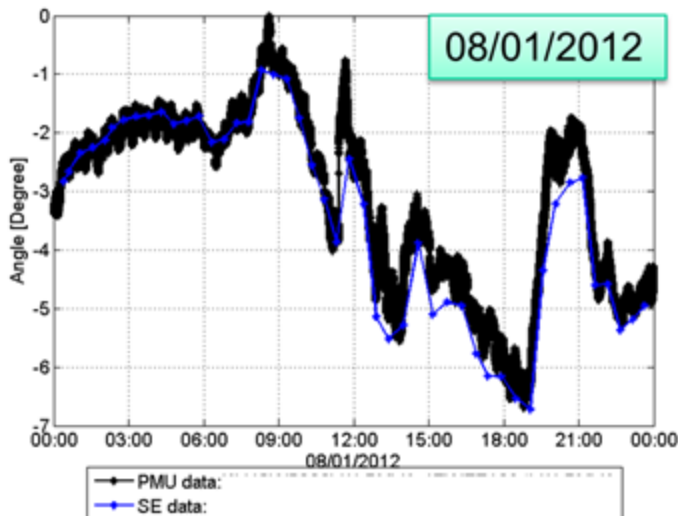
PMU DATA VS SE DATA COMPARISON - 2

Coast 1-North 7



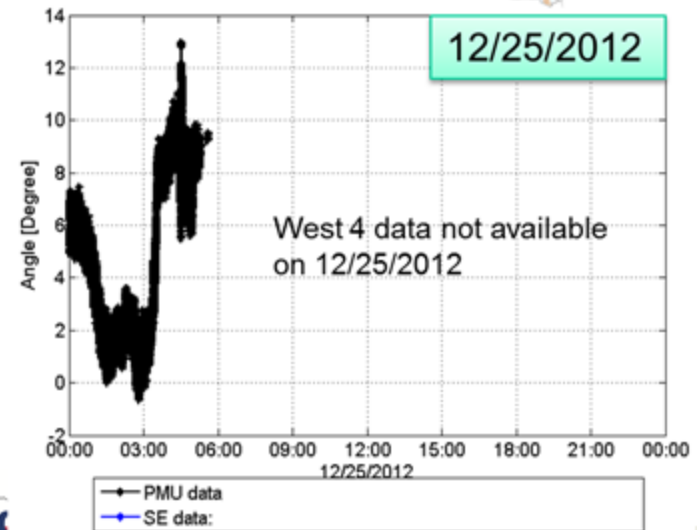
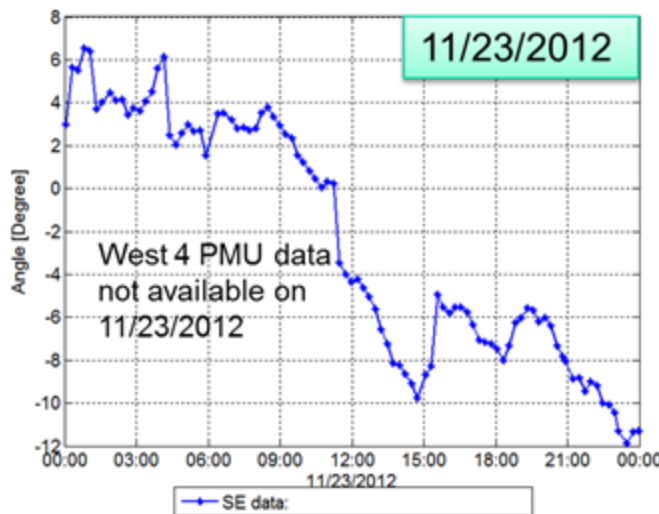
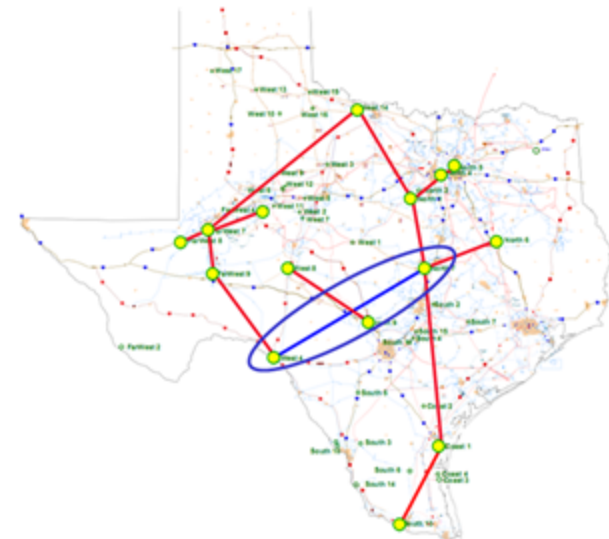
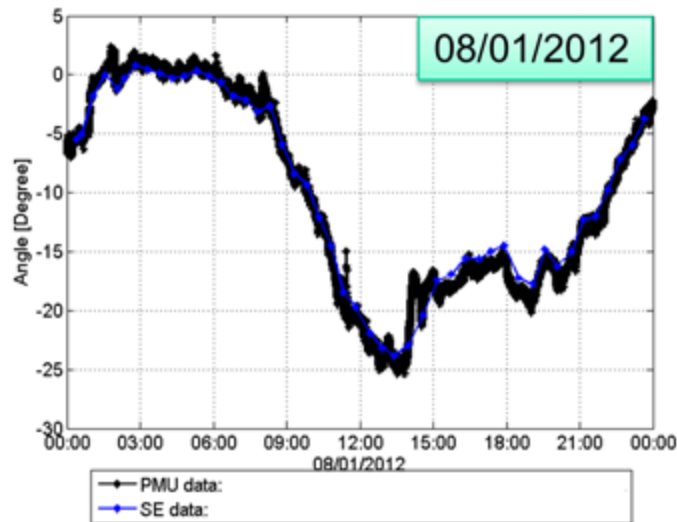
PMU DATA VS SE DATA COMPARISON - 3

North 7-North 6



PMU DATA VS SE DATA COMPARISON - 4

West 4-North 7

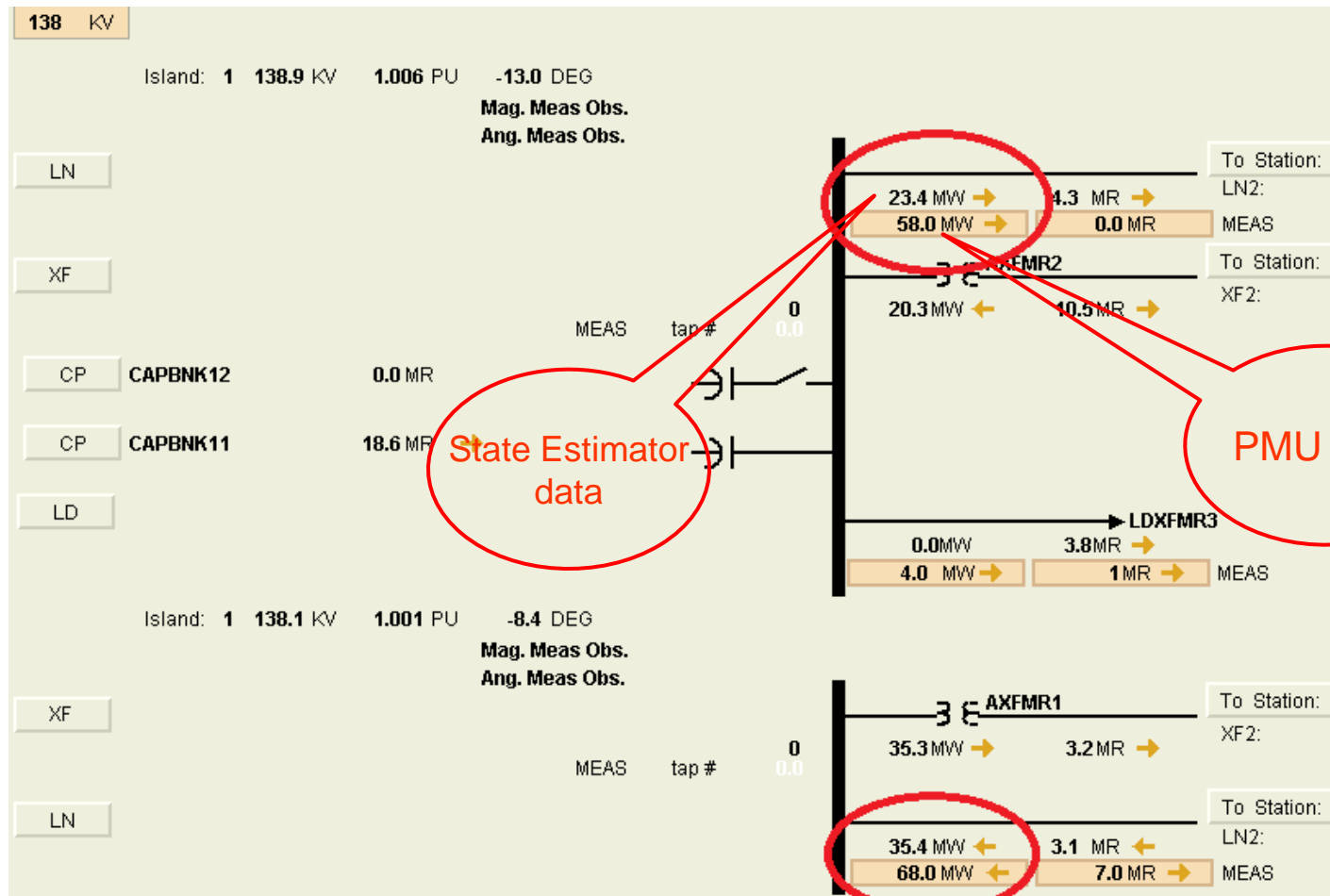


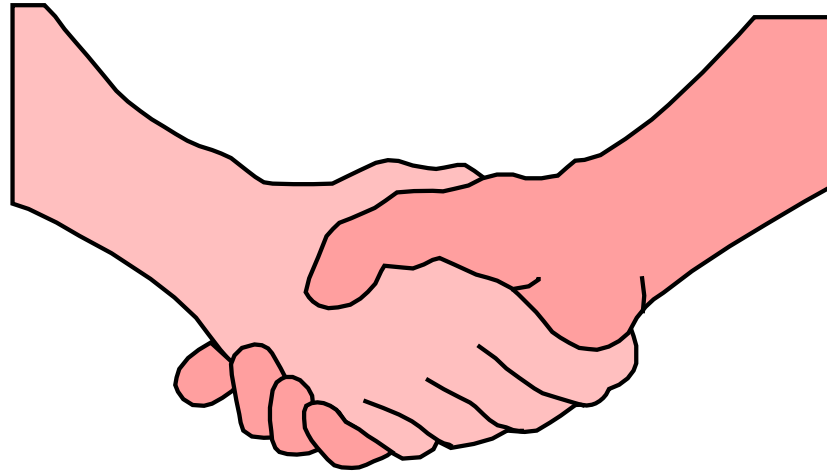
BENEFIT AND SUCCESS STORY

- Phasor data tracked closely with State Estimator data during comparison tests which validates phasor data for use in operations
- Baseline analysis provided information regarding normal and abnormal operating conditions, which enabled alarm limits to be established and made operational in phasor data monitoring and alarming application
- Update in baselining analysis resulted in revised alarm limits and also provided insight into change in system operating conditions due to significant addition of new transmission lines



- Integration of PMU data in EMS system





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