

DOE/OE Transmission Reliability Program

Eastern Interconnection Phase Angle Base Lining Study

Bharat Bhargava

 **Electric Power Group**

bhargava@electricpowergroup.com

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Topics

- Project Objective
- Study / Analysis Steps
- Major Technical Accomplishments
- Deliverables and schedule for activities to be completed under FY14 funding
- Risk factors affecting timely completion of planned activities as well as movement through RD&D cycle
- Early thoughts on follow-on work that should be considered for funding in FY15



Project Objective

- Perform Baselining Analysis for 4 ISO's to establish Typical Ranges for Operations
- Utilize State Estimator Data Conduct Internal Angle Pair analysis for four ISOs
- Identify Phase Angle Pairs – Based on Data and Inputs from ISO's
- Investigate Data Stitching across ISO's for Wide Area Angle Pair Analysis



Study / Analysis Steps

- **Data Extraction**
- **Data Checking - evaluate data quality and other attributes**
 - Data Availability
 - Time synchronization
 - Time stamp
 - Data formats
- **Data Aggregation or Stitching for Wide Area Analysis**
 - Combine data from different ISOs
 - Data conversion to a common format
 - Data extraction for selected angle pairs
- **Perform Statistical Analysis**
 - Box – Whisker and Time Duration Analysis
 - Correlation with Power Flow and Bus Voltage
 - Establish Typical Ranges for Selected Angle Pairs
- **Outlier Analysis – Values Outside the Range - Identify Root Cause**



Major Technical Accomplishments

- **Analysis completed for internal angle pairs using 2010-2011 SE data**
- **Based on the input from ISOs/TAG**
 - Selected Twenty two Angle pairs
 - Data required from Fifteen substations to analyze the above 22 angle pairs
- **Problems in analyzing wide area angle pairs using SE data**
 - Data not time-synchronized
 - Offset errors vary when SE data from different ISOs is combined
- **Draft Report completed for SE data analysis for**
 - Internal angle pairs
 - Wide Area Angle pair analysis using SE data
- **Based on TAG recommendation, decided to use Phasor System data for Wide area angle pairs across ISOs as phasor system data is now available**
 - Data received from all four ISOs
 - Data checking and analysis is in progress



Results for Angle Pairs in NYISO Area - State Estimator Data

**NYISO West-East
(Generation – Load) High
Wide Area Angle Pair**

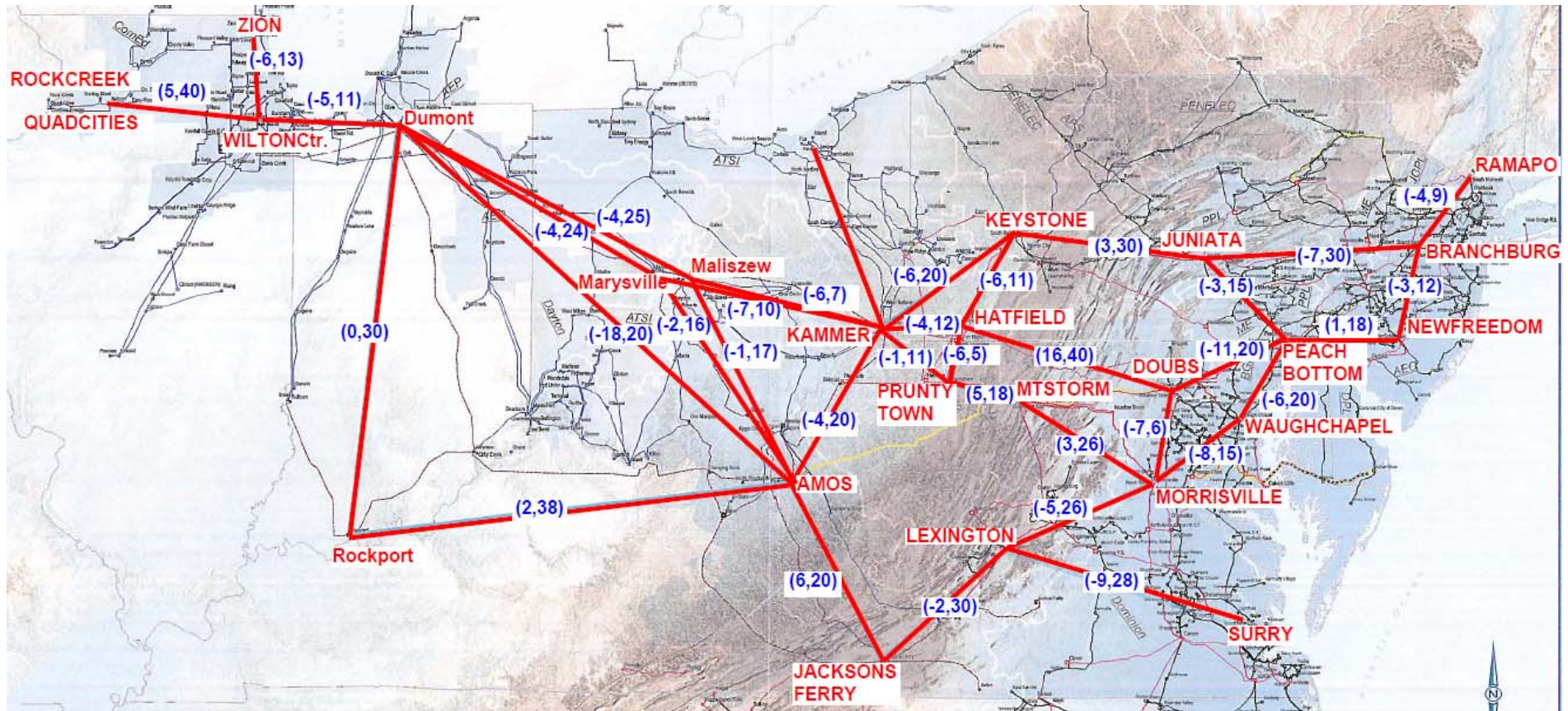
Angle Pairs Type	NYISO Angle Pairs	Sep 2010 to Dec 2010		Jan 2011 to Apr 2011		Suggested Limits	
		Min (deg)	Max (deg)	Min (deg)	Max (deg)	Min (deg)	Max (deg)
Wide Area	Niagara - Farragut	4	102	21	97	4	102
	Marcy - Farragut	7	63	16	60	7	63
	Gilboa - Farragut	4	45	5	36	4	45
	Niagara - Sprainbrook	4	90	20	96	4	96
Common Area	Marcy - Sprain Brook	6	54	16	58	6	58
	Marcy - Sprain Brook	7	53	17	54	7	54
	Oakdale - Dun Woodie	7	48	14	49	7	49
	Oakdale - Dun Woodie	8	47	15	48	8	48
	Gilboa - Pleasant Valley	0	23	2	22	0	23
	Gilboa - Pleasant Valley	0	59	2	22	0	59
	Fraser - Millwood	4	34	8	36	4	36
	Fraser - Millwood	5	34	8	33	5	34
Segment Area Zone 1	Niagara - Clay	-11	33	-7	34	-11	34
Segment Area Zone 2	Clay - Marcy	3	13	1	12	1	13
	Marcy - Leeds	0	31	8	30	0	31
	Leeds - Millwood	3	25	4	26	3	26
Segment Area Zone 3	Marcy - Pleasant Valley	3	43	12	44	3	44
	Gilboa - Leeds	-3	9	-1	9	-3	9
	Leeds - Pleasant Valley	2	15	2	15	2	15
Segment Area Zone 4	Millwood - Sprain Brook	1	5	0	5	0	5
	Pleasant Valley - Sprain Brook	2	16	2	15	2	16
	Sprain Brook - Farragut	0	14	0	2	0	14



Results for MISO System – Angle Pairs and Value Range



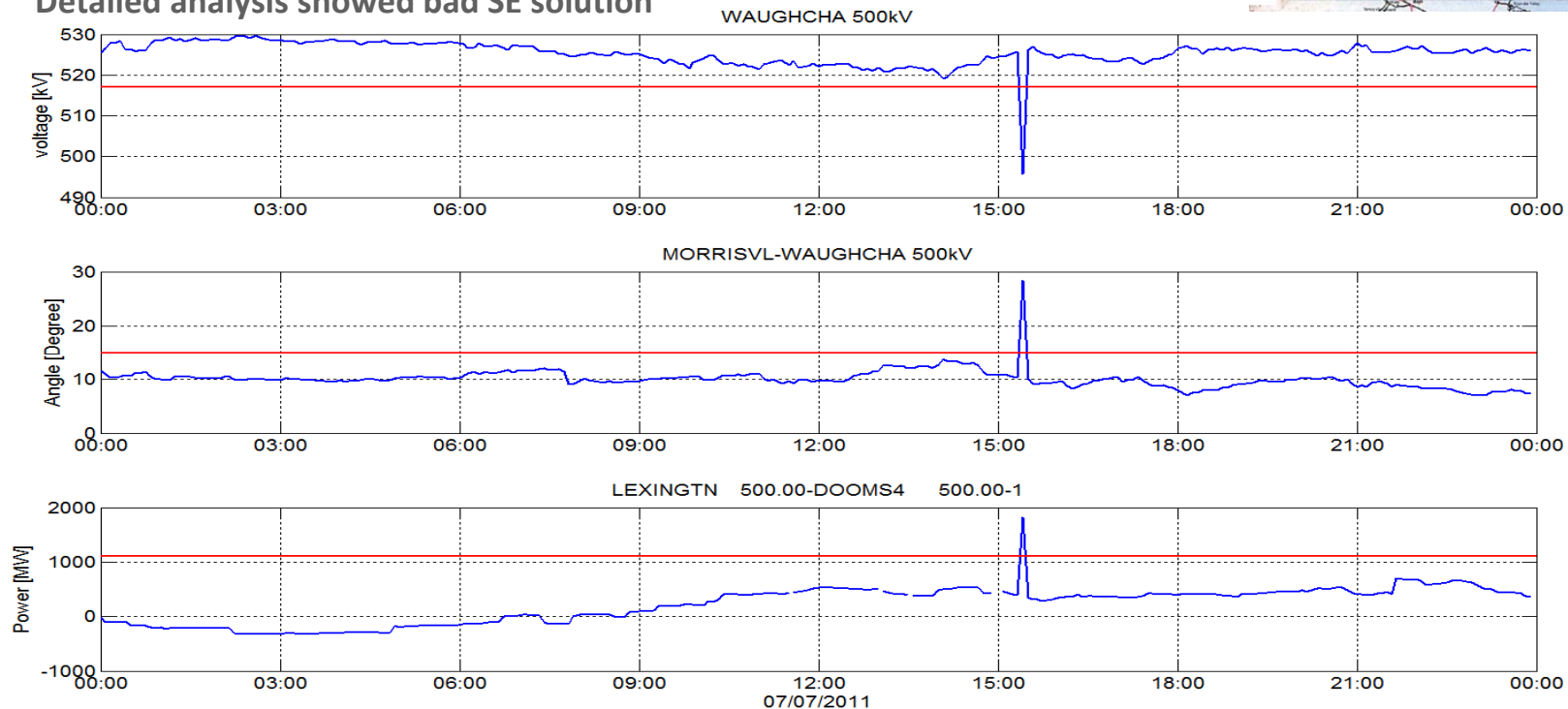
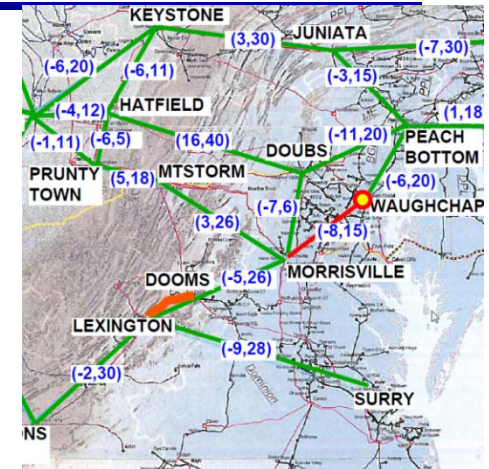
Results for PJM for 35 Selected Angle Pairs - Angle Pairs and Value Range



Example of Outlier Analysis - July 7, 2011

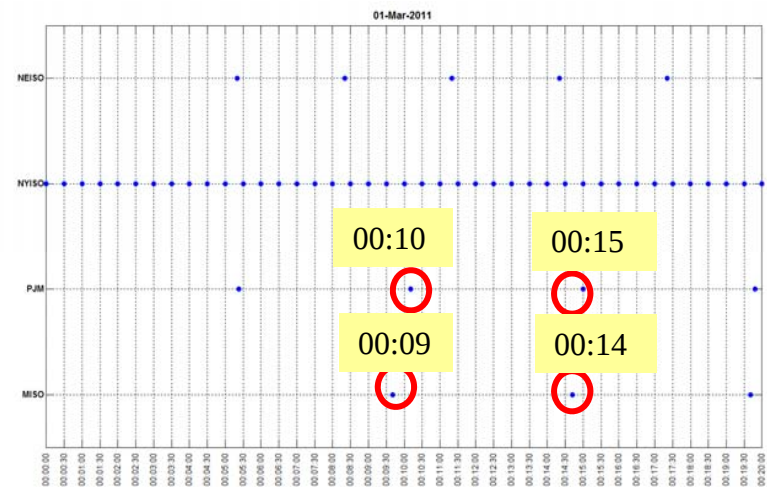
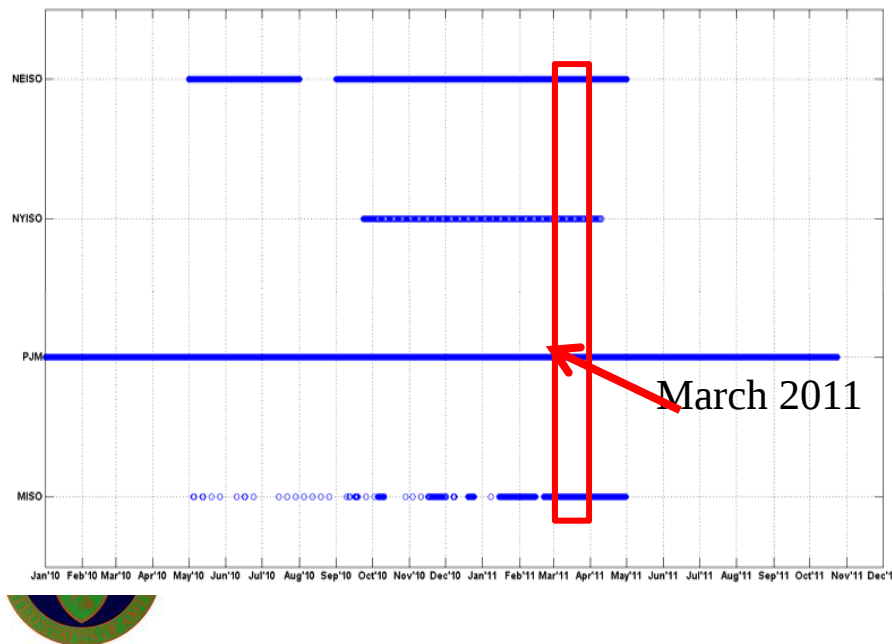
Event

- Morrisville to Waughcha Outlier analysis – root cause assessment and severity level
- Result compared with PNNL result
- This outlier shows violation of
 - Power flow
 - Angle difference
 - Voltage level
- The situation may be classified as level 3 and requires alerting operator
- Detailed analysis showed bad SE solution



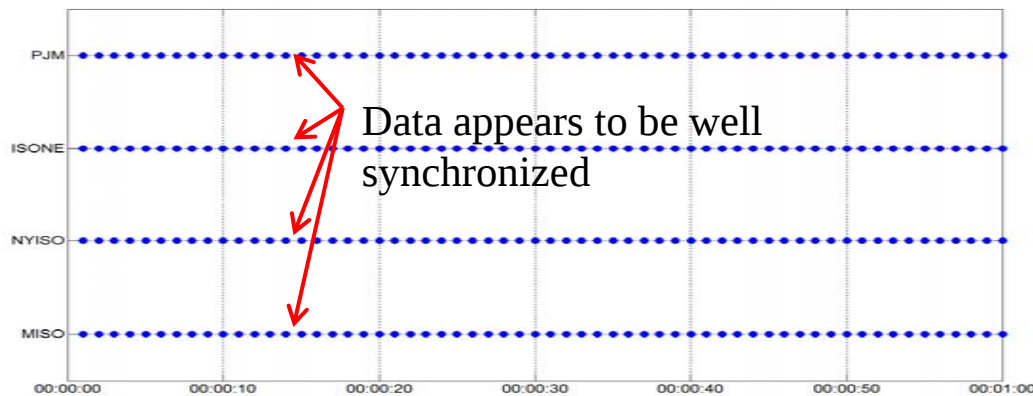
Risk Factors – Wide Area Angle Monitoring with State Estimator Data

- Difficulty in combining SE data for wide area angle pair analysis
 - Poor data synchronization
 - Poor data availability
 - Offset errors vary when SE data from different ISOs is combined

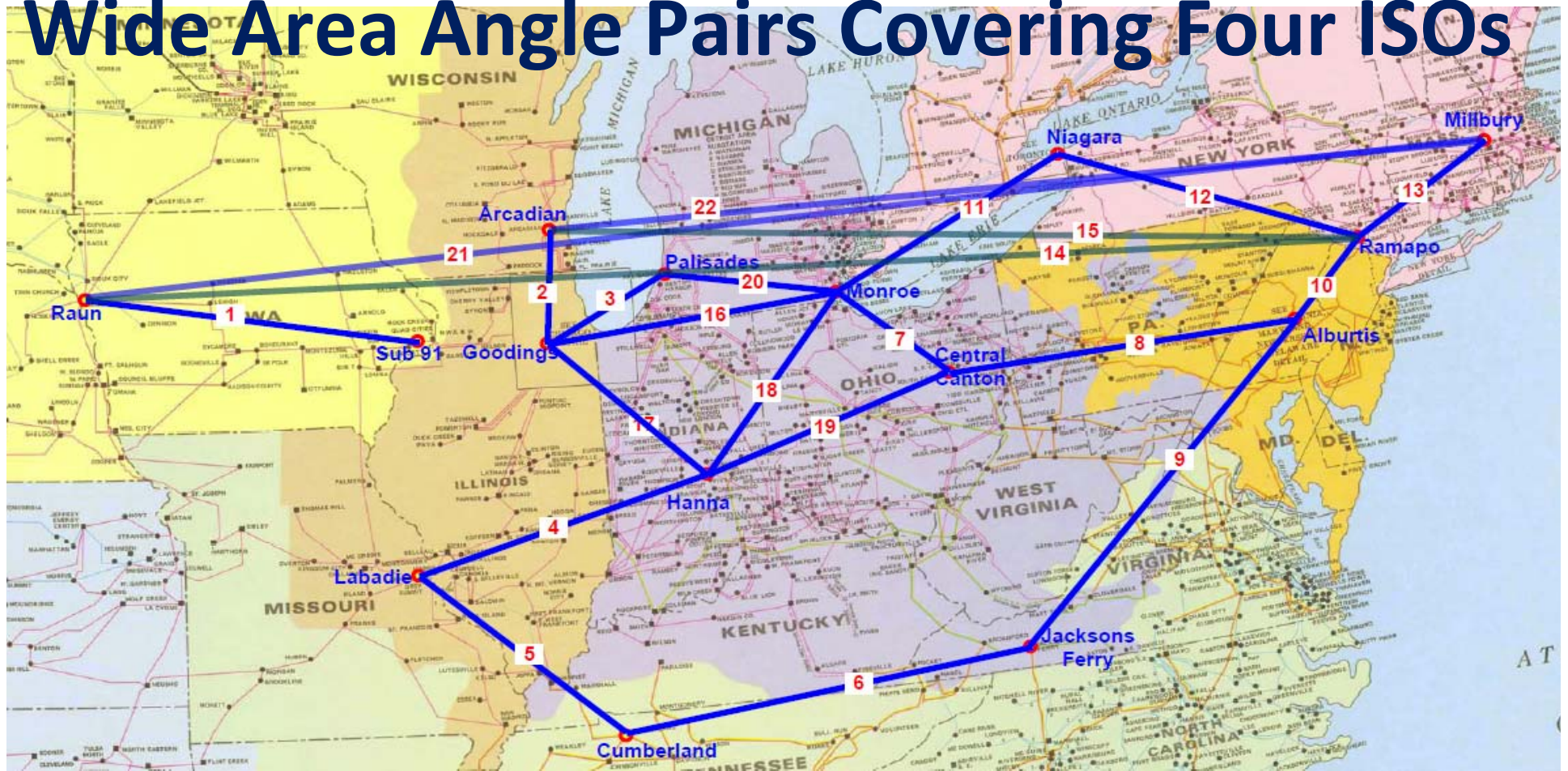


Use of Phasor Data for Baselining – Status and Next Steps

- Two months of phasor data from four ISOs received on May 7
 - Different data formats
 - Time synchronization and data availability is being checked
 - Data availability in general is high
- Considerable time and effort required for consolidating the data – for future analysis, recommend implementation of a process for synchronizing data from different ISOs before it is sent for analysis
- Goal is to validate use of the phasor data for wide area and overcome the shortcoming that was experienced with state estimator data



Wide Area Angle Pairs Covering Four ISOs



Index	From bus	To bus	Reason
1	Raun	Sub 91	IA Wind Transfers
2	Goodings	Arcadian	Wi-Chi Transfers
3	Goodings	Palisades	Chi-MI Transfers
4	Labadie	Hanna	West to East Transfers
5	Labadie	Cumberland	St Louis South Transfers
6	Jacksons Ferry	Cumberland	TVA to PJM (Southwest) Transfers
7	Canton Centr.	Monroe	SE MI Transfers
8	Alburdis	Canton Centr.	West to East Transfers (Lake Erie Loop)
9	Alburdis	Jacksons Ferry	Southwest to East Transfers
10	Alburdis	Ramapo	PJM to NYISO
11	Niagara	Monroe	NYISO to MISO
12	Niagara	Ramapo	West to Southeast Transfers

Index	From bus	To bus	Reason
13	Ramapo	Millbury	NYISO to ISONE
14	Raun	Ramapo	MISO to NYISO
15	Arcadian	Ramapo	MISO to NYISO
16	Goodings	Monroe	Close the loop
17	Goodings	Hanna	Close the loop
18	Hanna	Monroe	Close the loop
19	Hanna	Canton Centr.	Close the loop
20	Palisades	Monroe	Close the loop
21	Raun	Millbury	MISO to ISONE
22	Arcadian	Millbury	MISO to ISONE

Deliverables and Schedules

- Analysis of ISO-internal angle pairs using SE data - Completed
- Report summarizing analysis process and analysis results - Completed
- Periodic TAG meetings to report and discuss results (Three in-person meetings during FY14)
- Analysis of wide area angle pairs using two months phasor system data
 - Data received
 - Analysis started
 - Report after Completion of Analysis – target summer 2014



Early thoughts on follow-on work that should be considered for funding in FY15

- Conduct / continue wide area angle pair analysis with phasor data for longer period (12-15 months)
- Add additional substations and wide area angle pairs if desired
- Determine feasibility and establish Real-time Value Ranges
 - Data aggregation using live stream
 - Wide area angle pairs monitoring
 - Monitoring of other critical parameters such as
 - Power flows
 - Oscillations
 - Voltage and Angle Sensitivities
- Final Report of “Monitoring and Analysis”



Thank You.

Any questions ?

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