MISO

Smart Grid Investment Grant Update

Kevin Frankeny

kfrankeny@misoenergy.org

NASPI Workgroup Meeting

October 17-18, 2012

MIS○

NASPI North American SynchroPhasor Initiative

ARRA Disclaimer

"This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

Project Participants

- **Lead sponsor**
  - David Zwergel, Project Sponsor, dzwergel@misoenergy.org
  - David Luedtke, Project Manager, dluedtke@misoenergy.org
  - Kevin Frankeny, Business Owner, kfrankeny@misoenergy.org

- **Research and Development Partners**
  - University of South Florida
    - Applications for Power System Protection
    - Dynamic State/Parameter Estimation
  - University of Tennessee at Knoxville
    - Deployment of FNET Devices
    - Frequency Monitoring Tools

Project Participants

As of 10/11/2012

- ## Transmission Owners 2012 (MISO SGIG only)

| Organization	MSA Executed	PDCs Connected	SOW Devices	Confirmed Sites	PMUs SOWs	Connected Devices	Validated PMUs
Ameren	Yes	1	3	21	21	9	9
American Trans Co.	No	1	0	0	0	0	0
Duke Energy	Yes	1	3	16	16	21	20
Great River Energy	Yes	1	2	10	8	6	2
Hoosier Energy	Yes	1	1	7	7	7	7
Indianapolis P&L	Yes	1	1	7	6	7	7
International Trans Co.	Yes	1	2	15	15	12	9
Manitoba Hydro	Yes	1	3	23	24	28	24
MidAmerican Energy	Yes	1	3	15	12	8	4
Minnesota Power	Yes	1	1	4	3	1	1
Montana Dakota Utilities	Yes	0	0	5	0	0	0
Northern Indiana Public Service	Yes	1	3	8	8	9	7
Ottertail Power	Yes	2	2	14	8	10	9
Vectren (SIGE)	Yes	1	1	4	4	1	1
WAPA	Yes	0	2	4	4	0	0
XCEL Energy (NSP)	Yes	0	3	11	10	19	0
TOTAL	**15**	**14**	**30**	**164**	**145**	**138**	**100**

Project Participants

As of 10/11/2012

- ## Transmission Owners 2012 (All MISO Organizations)

| Organization	MSA Executed	PDCs Connected	SOW Devices	Confirmed Sites	PMUs SOWs	Connected Devices	Validated PMUs
Ameren	Yes	1	3	21	21	15*	15*
American Trans Co.	No	1	0	0	0	38*	38*
Duke Energy	Yes	1	3	16	16	21	20
Great River Energy	Yes	1	2	10	8	6	2
Hoosier Energy	Yes	1	1	7	7	9*	9*
Indianapolis P&L	Yes	1	1	7	6	7	7
International Trans Co.	Yes	1	2	15	15	12	9
Manitoba Hydro	Yes	1	3	23	24	30*	26*
MidAmerican Energy	Yes	1	3	15	12	8	4
Minnesota Power	Yes	1	1	4	3	1	1
Montana Dakota Utilities	Yes	0	0	5	0	0	0
Northern Indiana Public Service	Yes	1	3	8	8	9	7
Ottertail Power	Yes	2	2	14	8	10	9
Vectren (SIGE)	Yes	1	1	4	4	1	1
WAPA	Yes	0	2	4	4	0	0
XCEL Energy (NSP)	Yes	0	3	11	10	19	0
TOTAL	**15**	**14**	**30**	**164**	**145**	**186**	**148**

*includes legacy devices

Project Map 2012
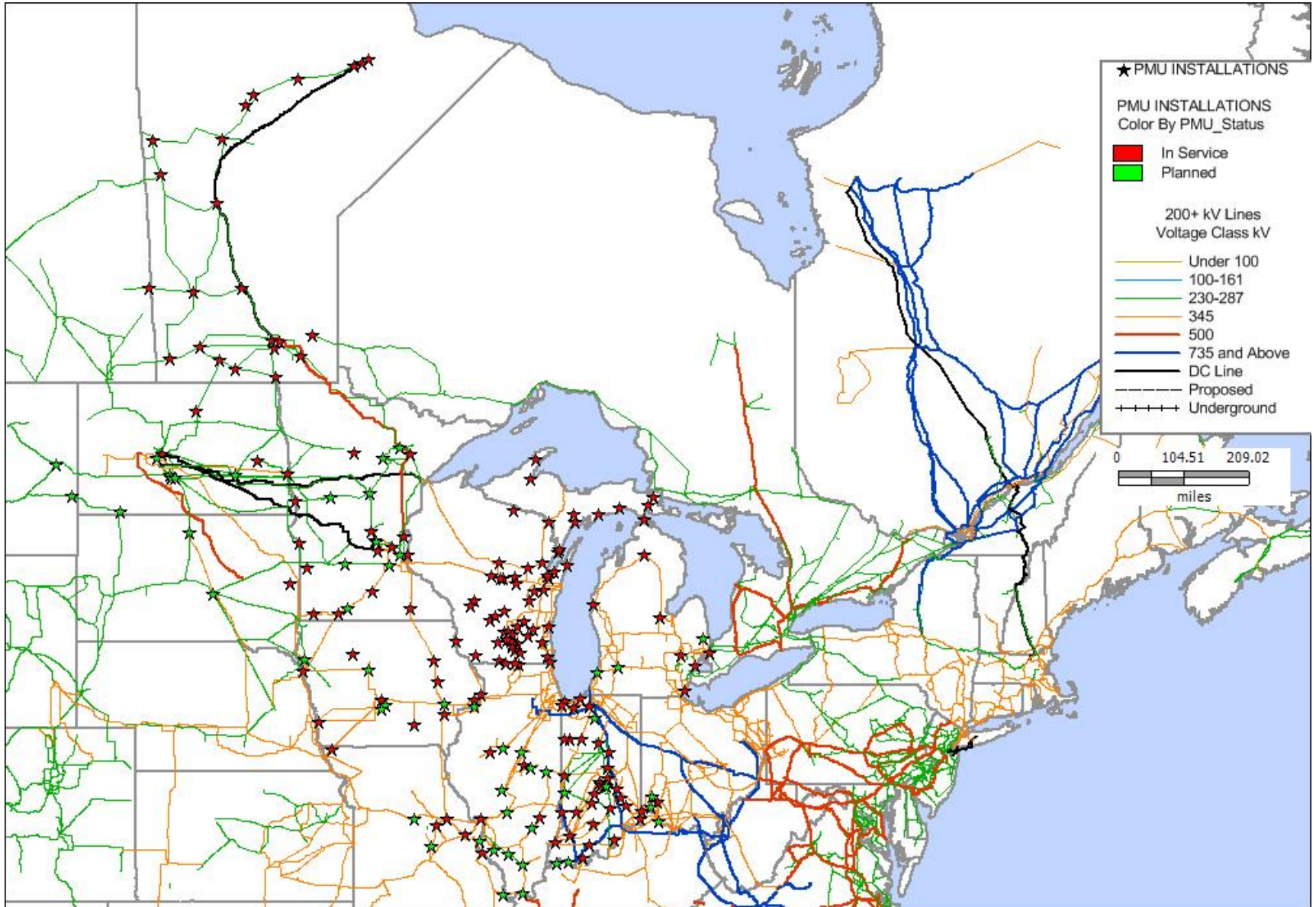
Project Highlights

- **Project is on-schedule and under budget**
- **Over 50% of PMUs are installed <u>and</u> verified**
- **Key 2012 Milestones**
  - Event Analysis and Model Improvement applications went live this year
  - Real-time applications start parallel operations in early 2013
  - Hosted Transmission Owner Solution will be deployed this year
- **Key risks are associated with newness of technology**
  - Data quality continues to be a concern
  - Commercial synchrophasor application offerings do not fully meet visualization requirements so the project is enhancing an internally developed real-time visualization product

Real-time Monitoring

Synchrophasor Enabled Capabilities

Model Improvement

Event Analysis

MIS
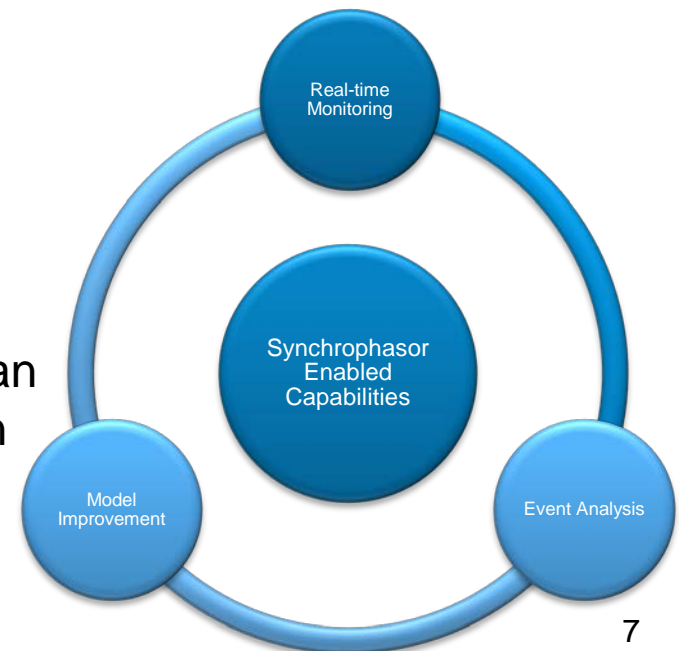
Project Highlights (continued)

- **Parallel Operations Readiness**
  - Training
    - Five rounds of Operator Synchrophasor Training Completed.
    - Training for Operations Engineers and other specialists completed.
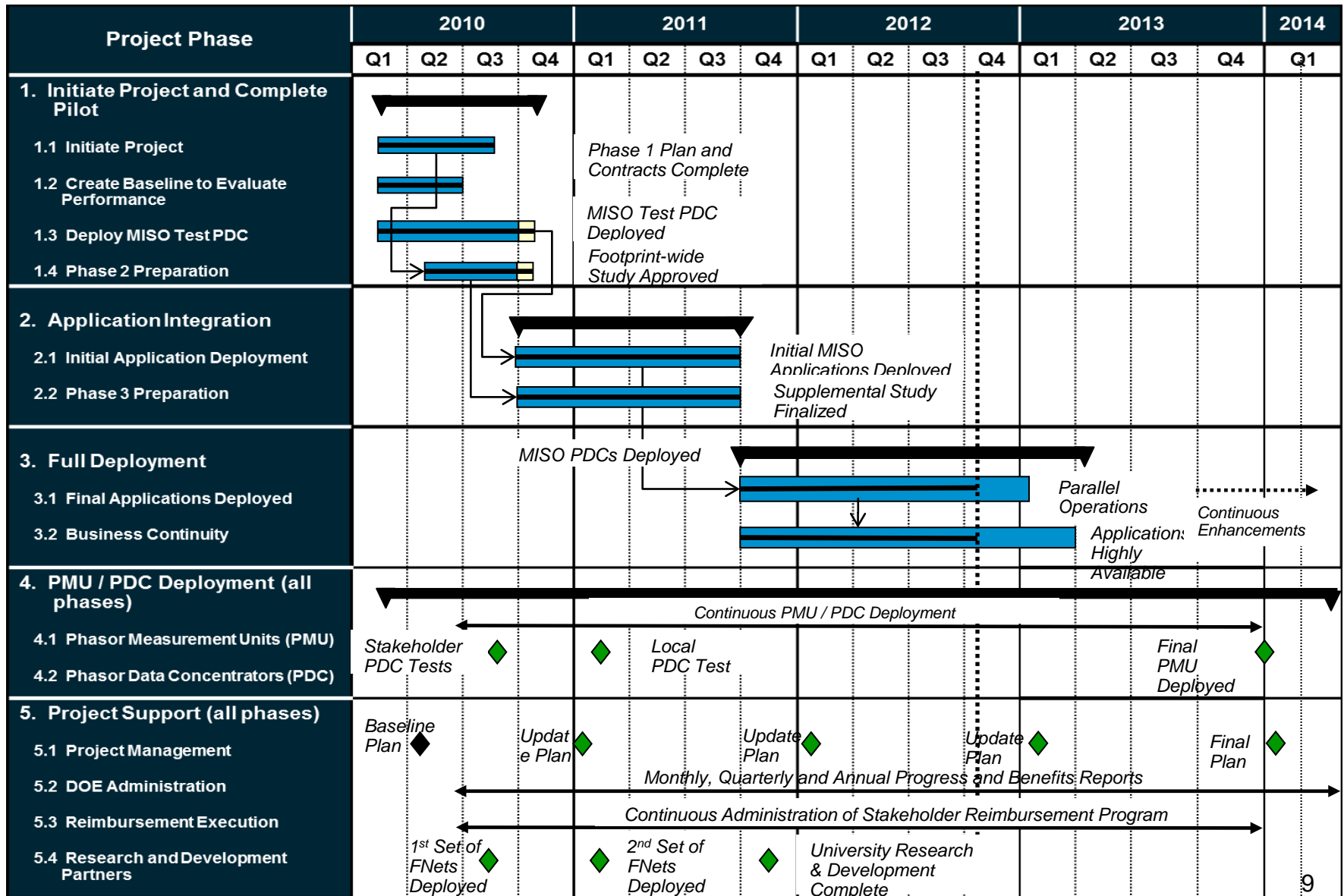   - Started training program with Transmission Owners on MISO-hosted applications.
  - Software
    - Continue incremental enhanced Real-time Display (eRTD) releases (play-back, gradient and improved performance)
    - PhasorPoint installed and in testing
    - Working on Integration with EMS, Control Room Alarms and VSAT/TSAT
 - Infrastructure
    - Applications deployed into Production Environments
   - Business Continuity Testing to take place in 2013

Project Timeline

Project Phase	2010				2011				2012				2013				2014
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1

1. Initiate Project and Complete Pilot
- 1.1 Initiate Project
- 1.2 Create Baseline to Evaluate Performance
- 1.3 Deploy MISO Test PDC
- 1.4 Phase 2 Preparation

Phase 1 Plan and Contracts Complete

MISO Test PDC Deployed
Footprint-wide Study Approved

2. Application Integration
- 2.1 Initial Application Deployment
- 2.2 Phase 3 Preparation

Initial MISO Applications Deployed
Supplemental Study Finalized

3. Full Deployment
- 3.1 Final Applications Deployed
- 3.2 Business Continuity

MISO PDCs Deployed

Parallel Operations
Continuous Enhancements
Applications Highly Available

4. PMU / PDC Deployment (all phases)
- 4.1 Phasor Measurement Units (PMU)
- 4.2 Phasor Data Concentrators (PDC)

Continuous PMU / PDC Deployment

Stakeholder PDC Tests
Local PDC Test
Final PMU Deployed

5. Project Support (all phases)
- 5.1 Project Management
- 5.2 DOE Administration
- 5.3 Reimbursement Execution
- 5.4 Research and Development Partners

Baseline Plan
Update Plan
Update Plan
Update Plan
Final Plan

Monthly, Quarterly and Annual Progress and Benefits Reports

Continuous Administration of Stakeholder Reimbursement Program

1st Set of FNets Deployed
2nd Set of FNets Deployed
University Research & Development Complete

PMUs

- **There are 15 Transmission Owners on the project.**
  - Original goal was 150 PMUs; the goal has been increased twice.
    - Current goal is 195 PMUs.
  - Each Transmission Owner is selecting their own PMU and PDC vendor.
  - The PMU and PDC devices must meet the standards defined by MISO:
    https://www.misoenergy.org/Library/Pages/ManagedFileSet.aspx?SetId=341
- **Transmission elements monitored by PMUs.**
  - The chart displays the percentage of PMU voltage distribution across the MISO SGIG Footprint.

138 kV 4% 161 kV 2% 500kV 2%

230 kV 25%

115 kV 3%

69 kV 1%

345 kV 63%

MIS
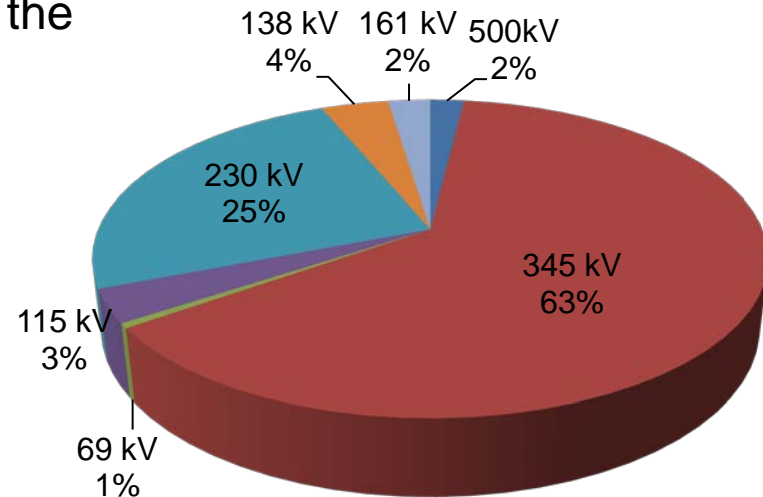
PMUs (continued)

- **Approximately 20% of the regional footprint is being monitored by PMUs (SGIG and legacy sites).**
  - By the end of the project, this number is expected to be approximately 30%.
  - SGIG currently covers 17.5% of the regional footprint.
- **Currently, there are 159 substations with connected PMUs.**
  - SGIG = 109 substations.

- **MISO transmission owners are installing stand-alone PMUs, as well as both relay-based devices and DFRs with PMU functionality.**

Pie chart: Schweitzer 44%, Tesla 37%, Arbiter 19%
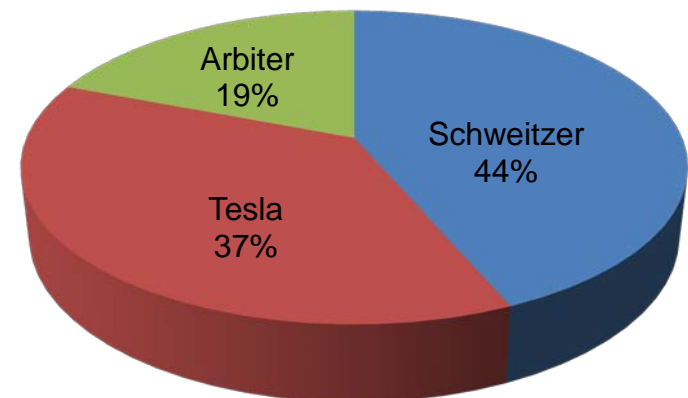
PMUs (continued)

MISO PMU Installations
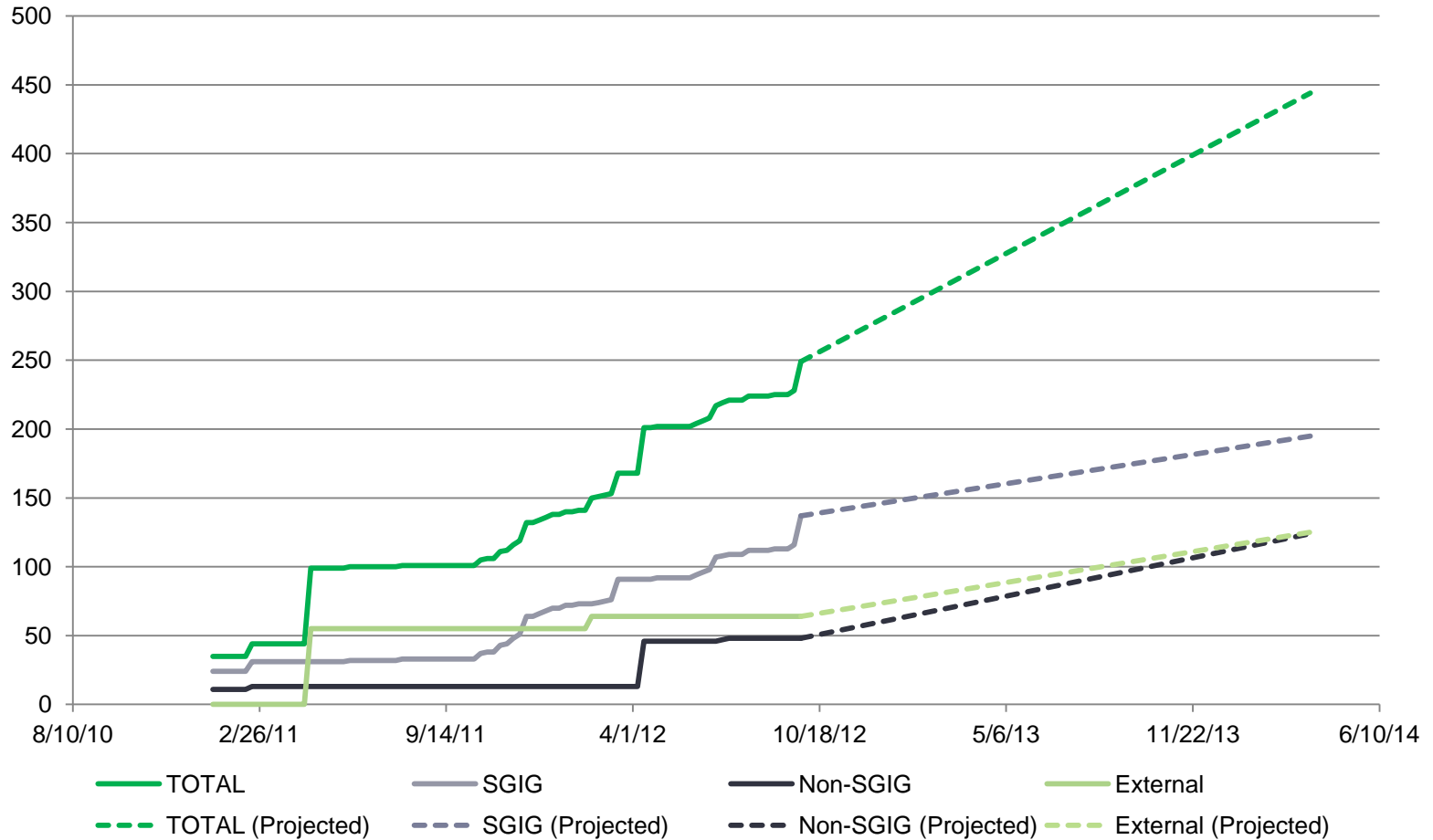
PDCs and Communications

- **MISO has both "local" and "regional" PDCs.**
  - The local PDC receives transmission owner data and the regional PDC receives data from other Regional Entities such as PJM and TVA.
- **All Transmission Owners will have redundant PDCs.**
  - MISO currently receives data from 14 Transmission Owners' PDCs.
  - Additionally, 10 TOs have contracts in place for Highly Available PDCs at their control center.
- **Communication links to TOs**
  - MISO is using its existing WAN connections to its transmission owners for the transmission of Synchrophasor data. Detailed analysis was performed to ensure that there was adequate bandwidth.
- **Regional data exchange and standards are important capabilities to MISO.**
  - MISO is working through the NERC User Groups to identify opportunities to reuse ICCP tools and infrastructure.
  - MISO is receiving test PMU data from New York ISO, PJM and TVA. Planning on connecting with Entergy soon.

MIS

Communications and Data

- **MISO is using a temporary SQL Server database while a permanent, Oracle-based solution is being architected.**
  - This database will be designed to store at least 7 years of Phasor data.
    - 250 Internal PMUs – Frequency; A,B,C and positive sequence voltage and current
    - 250 External PMUs – Frequency; positive sequence voltage and current
  - Data retention policy is still being finalized. Currently is
    - 1 year of full fidelity data including all phases and positive sequence
    - 3 years of full fidelity data for positive sequence (dropped A,B,C phasors)
    - 7 years of 1/sec data (keeping top of second)
  - Currently, MISO has all of the data collected since the first quarter of 2011
    - ~4 TB of data + 65 GB daily for 180 PMUs

System Architecture

Measurement	Acquisition	Manage	Analysis, Visualization and Alarm
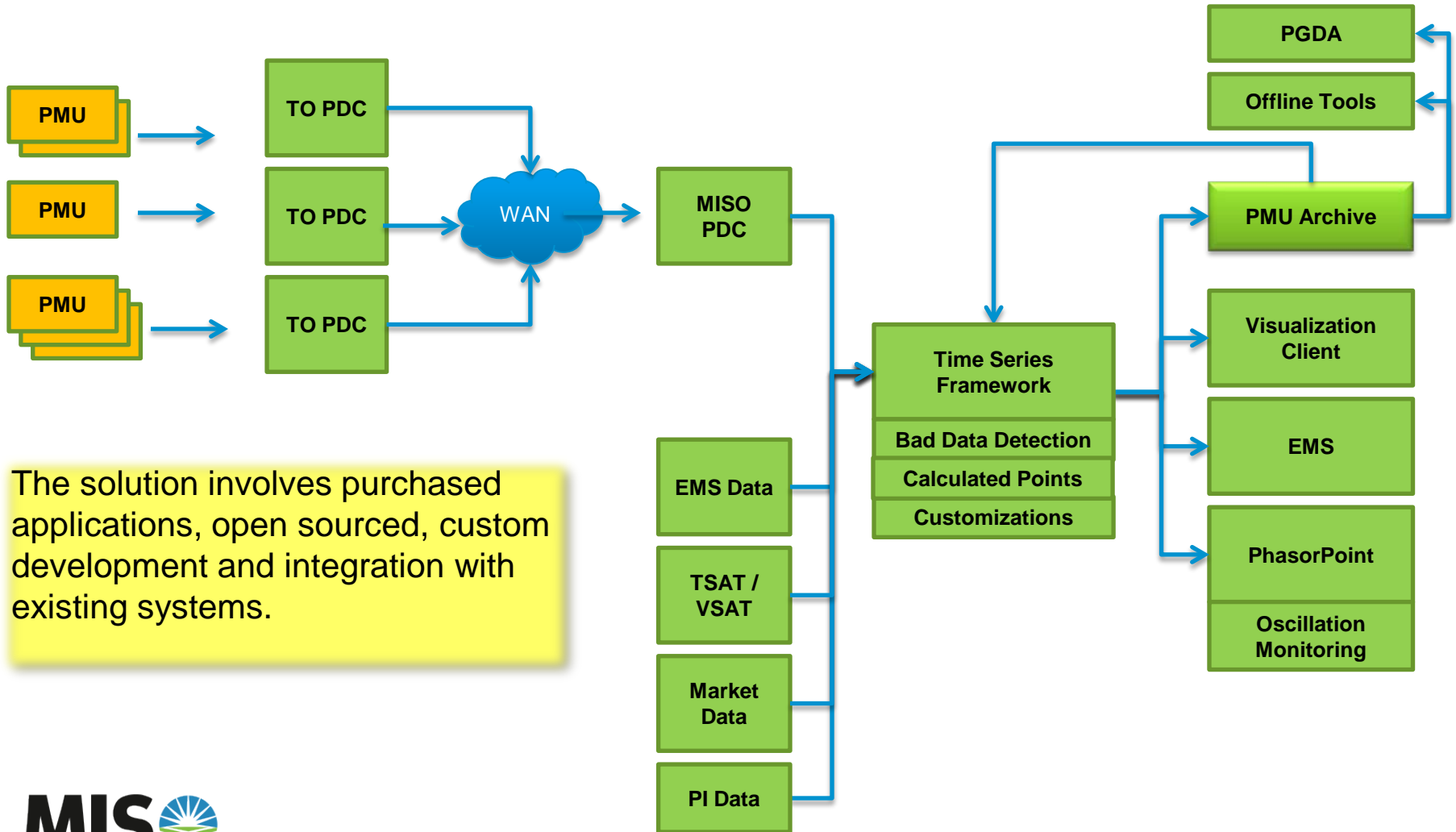
The solution involves purchased applications, open sourced, custom development and integration with existing systems.

PMU Data Quality and Availability

- 99.98% Availability (Validated PMUs)
- 86.7%   'Excellent and on time'
- 10.6%   Not 'Good' data because of various issues (All PMUs)
- 1.8%   Due to long outage
- .9%   Due to local problems
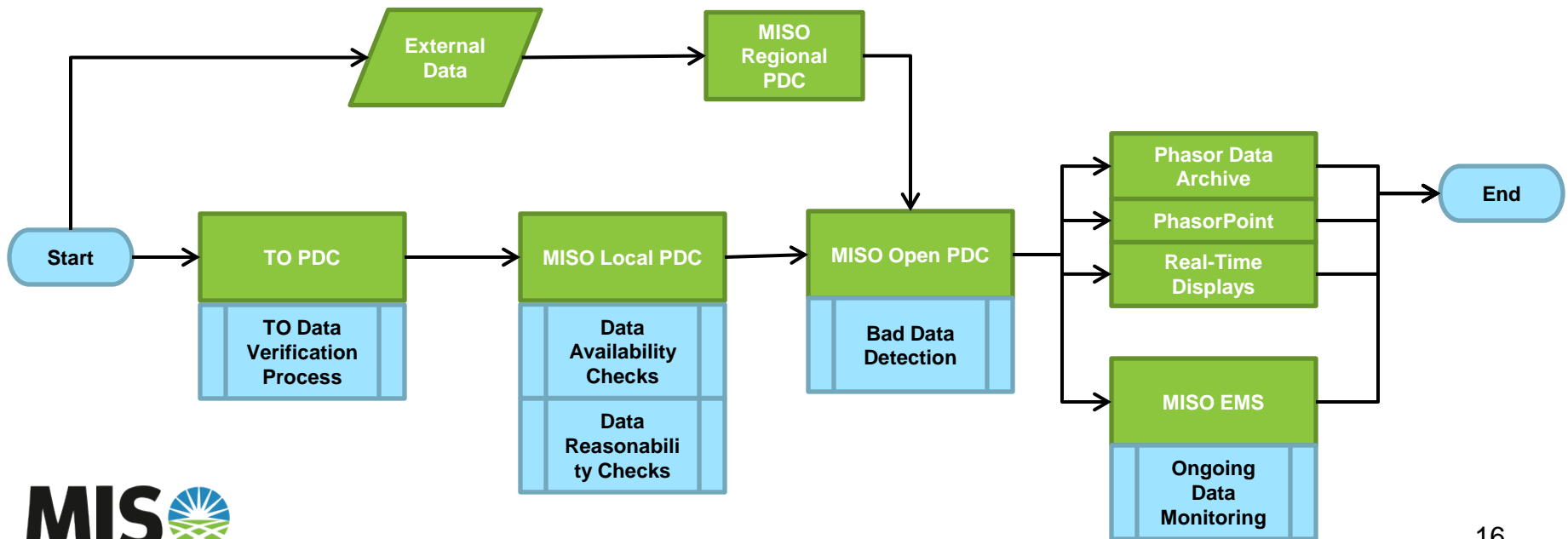
MISO Applications

- **Wide-area situational awareness**
  - Wide Area Overview is being developed. The final solution will involve eRTD and PhasorPoint applications.
    - Real-time Operators participated in eRTD "hands-on" training in August 2012 .
    - PhasorPoint is being configured for operators in early 2013.
  - Operators will be trained for Parallel Operations in early 2013.
  - TSAT / VSAT and wall boards were upgraded. A Proof of Concept was completed to optimize the performance.

MISO Applications:
MISO-hosted TO applications

The diagram below represents a high-level conceptual overview of TO solution.

MISO Production

MISO PDC

eRTD

MISO RT Displays

Archive

TO Applications

eRTD

TO RT Displays

Phasor Grid
Dynamics Analyzer

TO After-the-Fact Tools

CITRIX

TO User

TO User

MISO Website

MIS◉

MISO Extranet
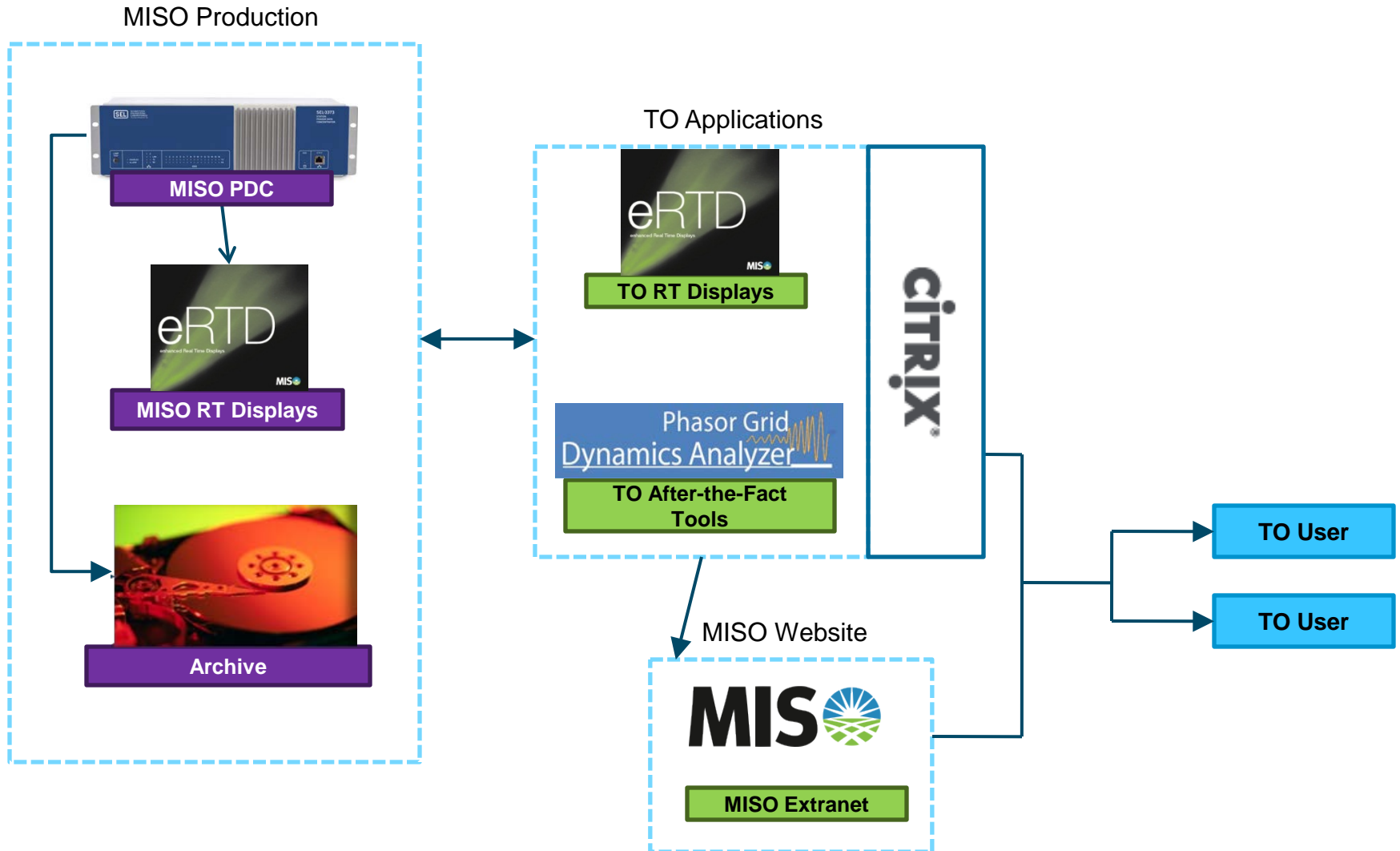
MISO Applications:
enhanced Real Time Displays
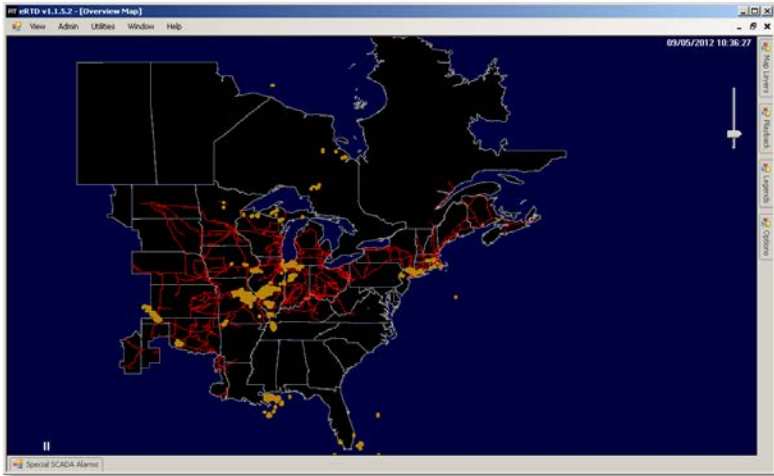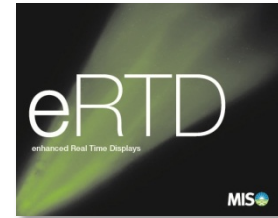
eRTD Overview Map w/ Lightning and Transmission
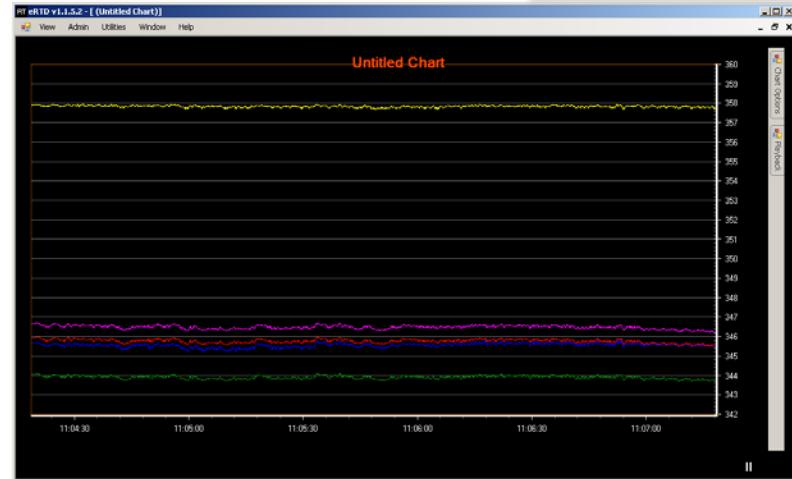
eRTD Trend Real-Time Voltage

eRTD Trend Playback Voltage Magnitude
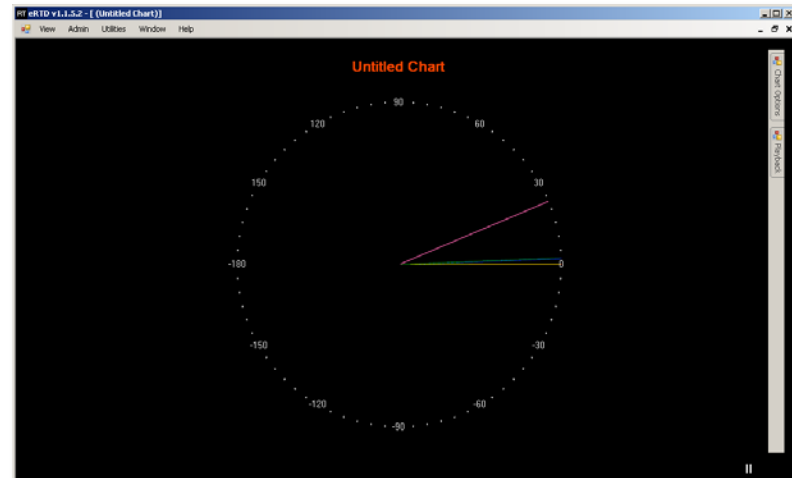
eRTD Trend Real Time V Angle Gauge (w/ref ang)

MISO Applications:
enhanced Real Time Displays

- **Overview Available to Transmission Owner for individual viewing**

- Real Time Trend of any PMU points that are available.

- Playback Trend of any PMU points that are available.

- Stop/Start of Playback Trend

- Weather data (lightning) on Overview Map.

- Transmission system by voltage layer on Overview Map.

- Data extraction in PGDA format or CSV file.
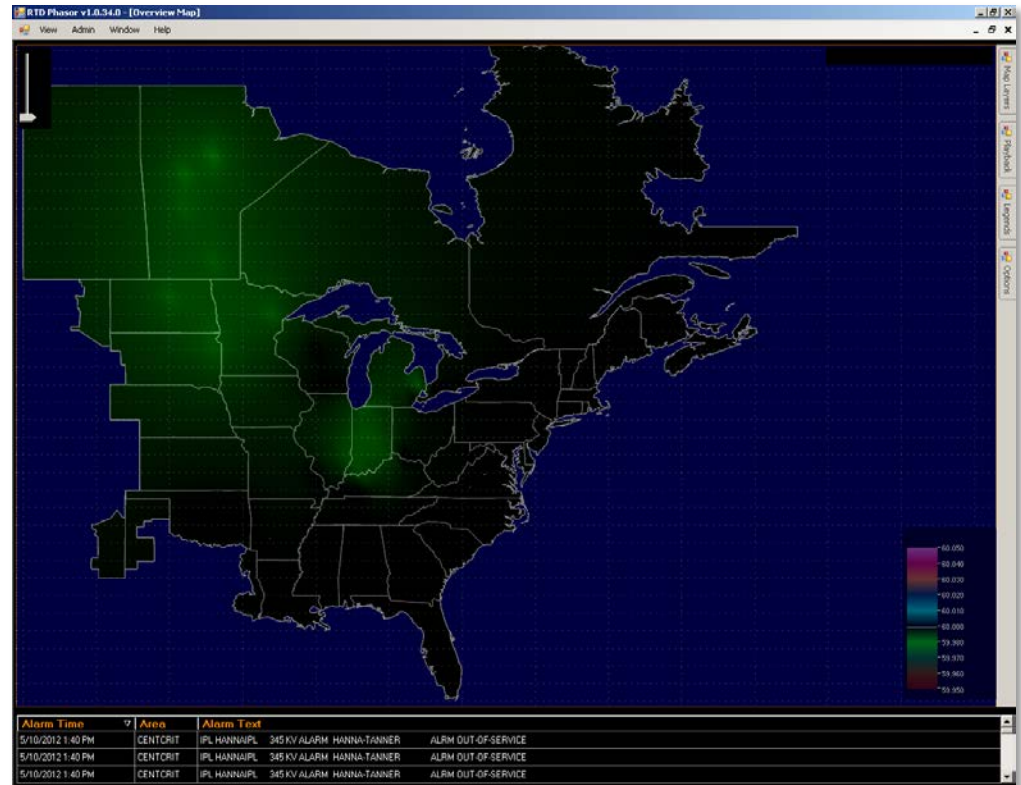
MISO Applications: PhasorPoint
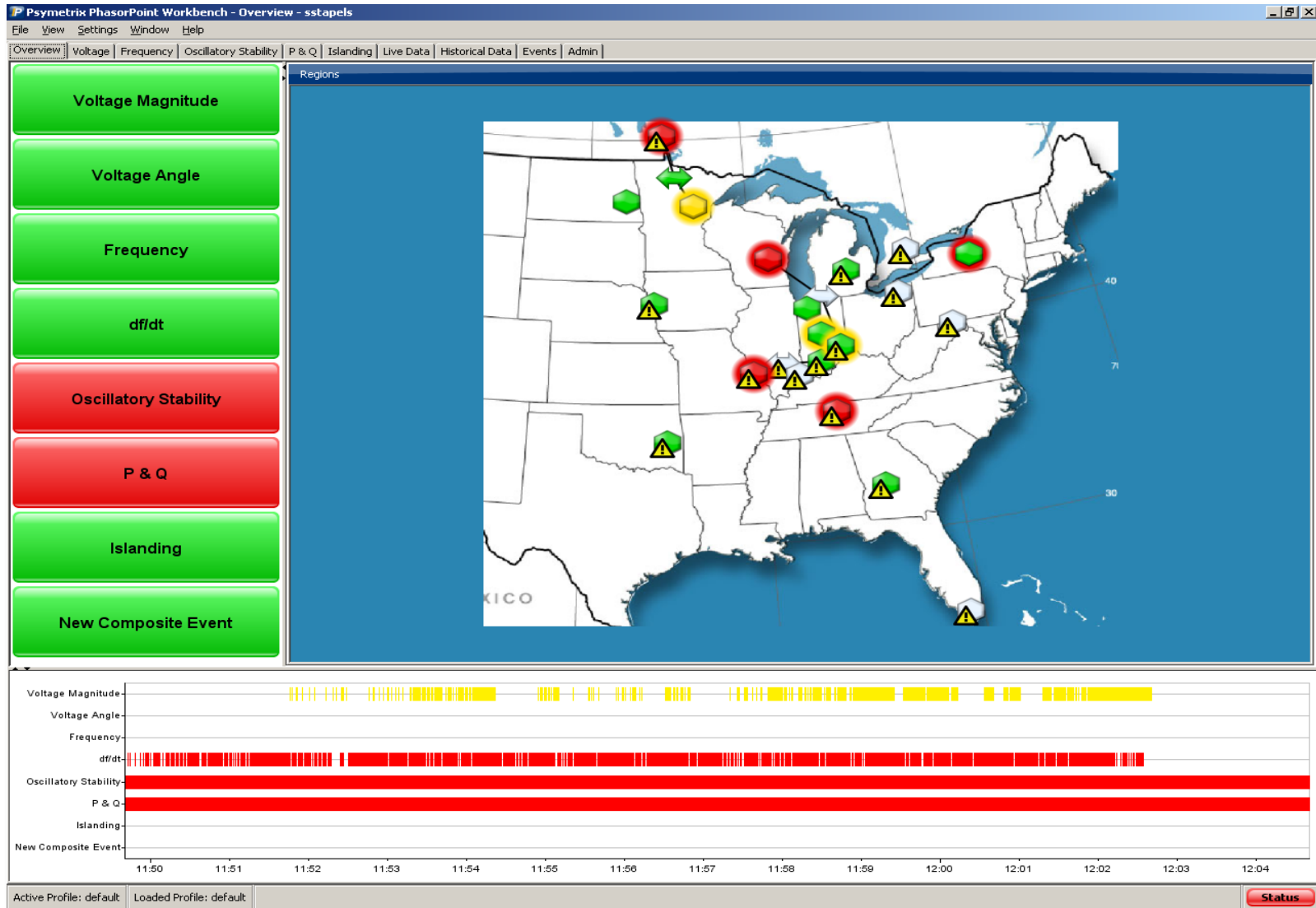
MISO Applications: PGDA

- **Full PGDA deployment on the new Citrix platform is expected in this month. This new platform will include:**
  - Trend and Map Visualization with the Phasor Data Extraction.
  - Will no longer require access to the MISO WAN, will be Internet based.
  - Will be accessible from any workstation.
  - Will not require any special configuration for access.
- **Member "hands-on" training on PGDA will take place in early Q4. The rollout and all training of Citrix PGDA will be completed by the end of the year.**

MISO Applications: Webtool

- **A model entry tool ("Webtool") is enhancing its capabilities to better accommodate Members and MISO.**

- **The Webtool will go live by the end of the year**

- **Updates include:**

  - Facilitating PMU data collection and data changes

  - Adding forms to allow Members to add a PMU electronically including automation of the PMU naming convention

MISO Applications

- **Renewable Generation Integration (2011)**
  - By the end of the project, MISO will have several PMUs near wind resources.
  - Ideally, the MISO planning team will be able to study the effect of increased amounts of wind resources on system-wide small signal stability.

- **State Estimation (2011)**
  - MISO currently uses ALSTOM's EMS platform. Data will be integrated into the EMS
  - MISO will begin to use PMU angle measurements for state estimation in the future, but not during the time frame of the project.
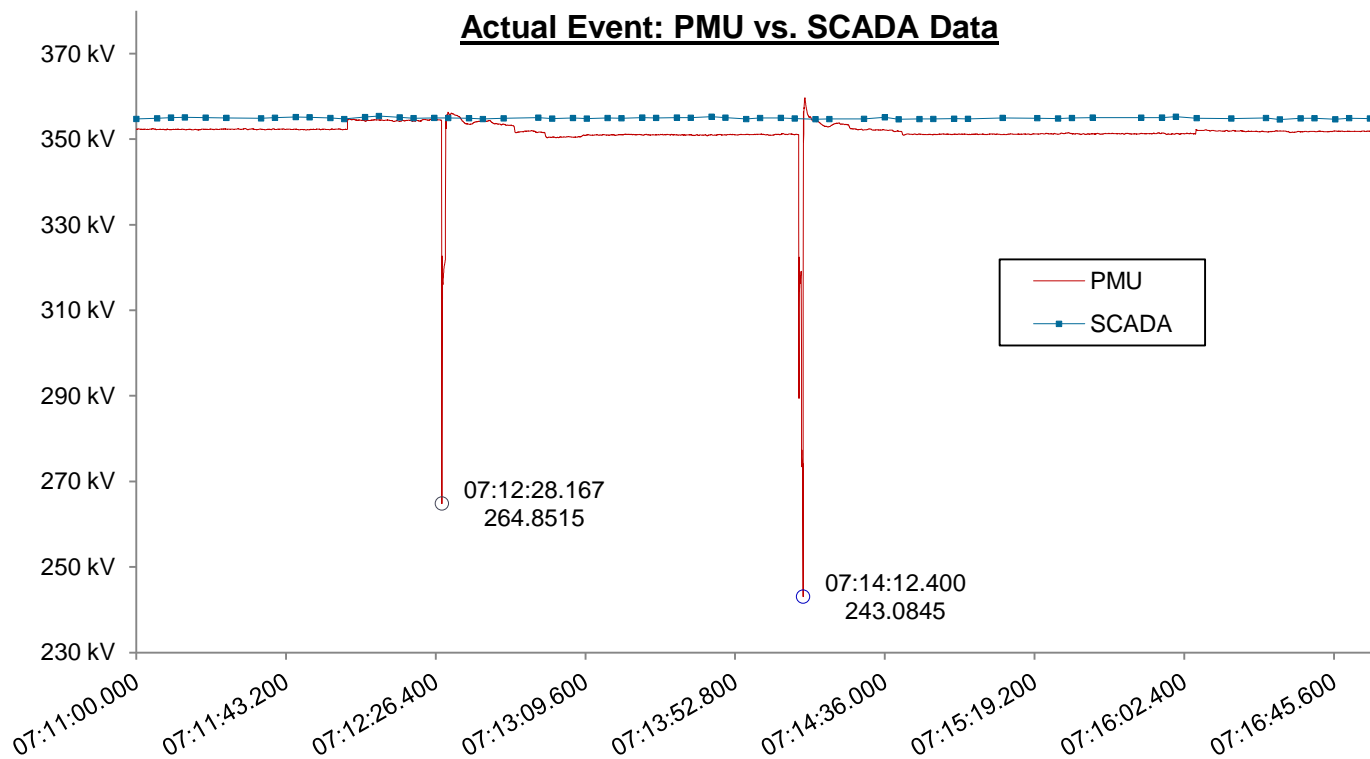
MIS

MISO Model Improvement and Event Analysis

On September 27, MISO deployed system modeling and after-the-fact event analysis into production

- The dynamic model enhancement process will increase accuracy, efficiency, and confidence in predicting and informing operators on severe issues.
- Event analysis with synchrophasor data will more rapidly determine an accurate sequence of events and how equipment responded.
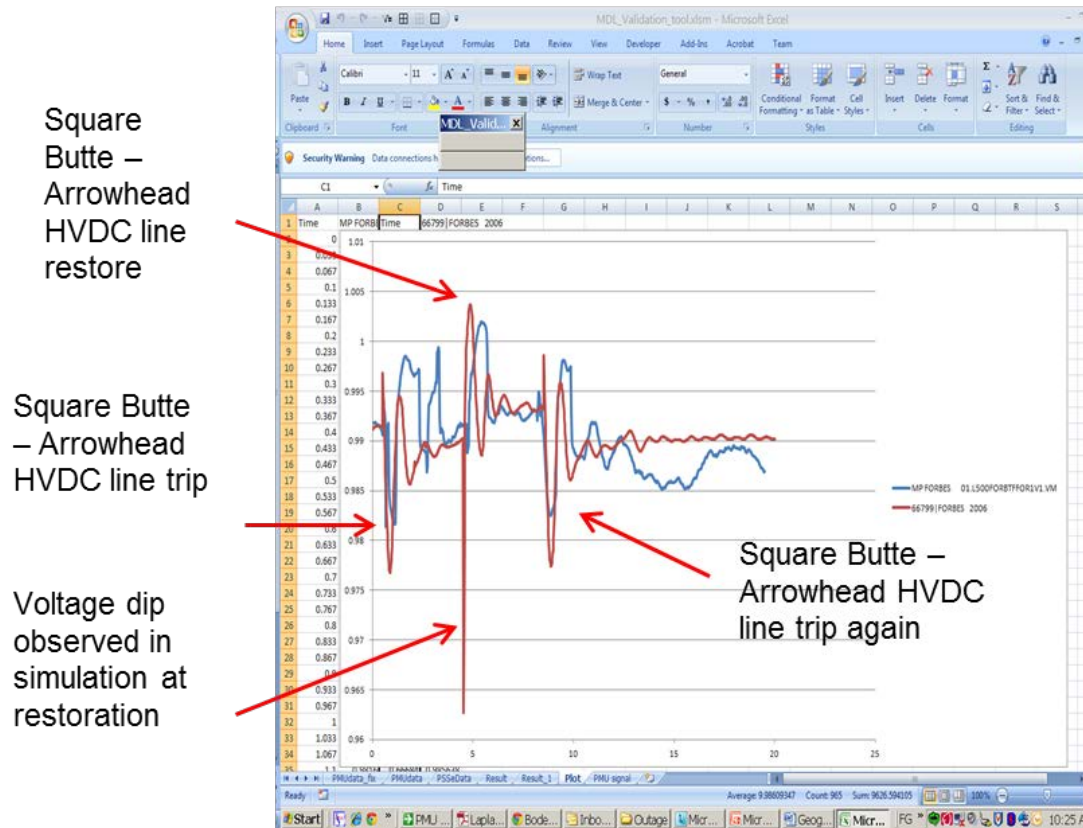
MISO Model Improvement and Event Analysis

- **Currently, the tool supports a manual effort to make changes and demonstrate that the simulations match actual PMU data.**

- **Next year, a more advanced tool from the University of South Florida will implement automation.**

Actual Event: PMU vs. SCADA Data

07:12:28.167
264.8515

07:14:12.400
243.0845

26

MISO Model Improvement and Event Analysis

Actual Event: PMU vs. MISO Model Data

Square Butte – Arrowhead HVDC line restore

Square Butte – Arrowhead HVDC line trip

Voltage dip observed in simulation at restoration

Square Butte – Arrowhead HVDC line trip again

"Today's incorporation of synchrophasor technologies into our grid analytics is the equivalent of introducing a new modern-day app to provide us with a more precise picture of system conditions on the grid, resulting in increased reliability and more efficient operations."

~ Richard Doying, Vice President of Operations, MISO

27

QUESTIONS?