FY12 DOE/NETL Transmission Reliability R&D Internal Program Review

Automated Reliability Reports (ARR)

Grid Reliability Performance Metrics Using Model-Less Algorithms Prototype Development and Field Demonstration at MISO

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Presentation Outline

- Automatic Reliability Reports (ARR) Background
- Grid Reliability Metrics Prototype Objectives
- Technical Accomplishments during FY2012 and Next Action Items
- Risk Factors Affecting Timely Completion
- Follow up Work for FY13
- Overview of prototype at MISO: Architecture, Grid Monitoring Visualization and Grid Reliability Tracking Grid Automatic Reliability Report (GARR)

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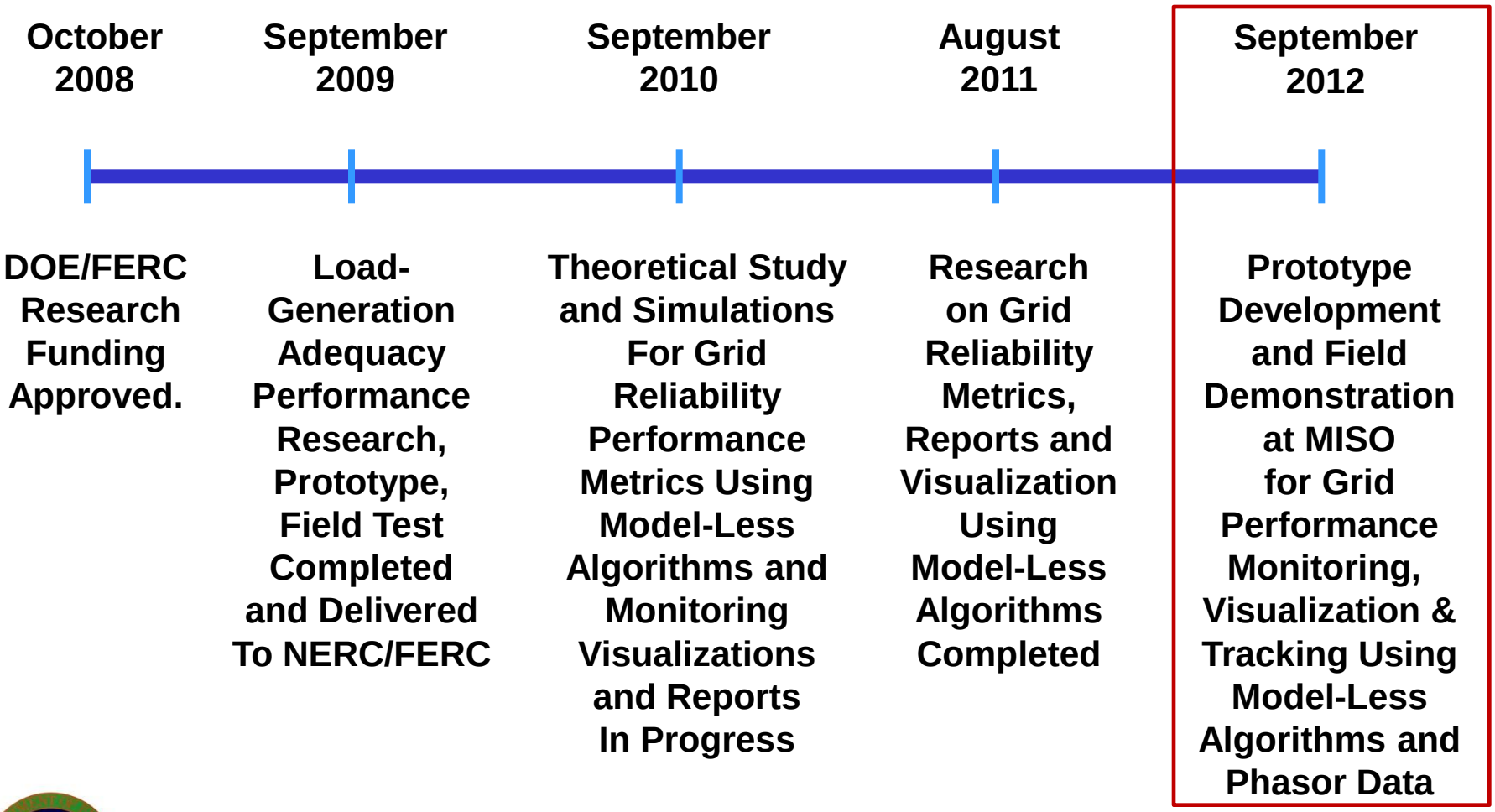
Automatic Reliability Reports (ARR) Background and 2012 Objective



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Automatic Reliability Reports (ARR) Prototype Development and Tests Objectives

- Specify, develop and field test a prototype for monitoring and tracking Grid Reliability Performance Metrics using model-less methods, monitoring visualizations and tracking reports utilizing phasor measurements to estimate reliability performance metrics pertaining for:
    - Voltage bounds
    - Thermal ratings
    - Stability limits

- Prototype development with MISO as industry partner using their phasor infrastructure, their BPS Grid phasor data and operational expertize
- Prototype Field Demonstration will take place at MISO
- Assess phasor data quality and research processes and filters for estimating grid performance metrics uncertainty

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Technical Accomplishments to Complete in FY 2012

- **COMPLETED** – Define, create and deliver the prototype functional specification including model-less algorithms, monitoring visualization and tracking reports
- **COMPLETED** – Identify and define with MISO the Grid phasor data adequate for testing and validating model-less algorithms
- **COMPLETED** – Off-line test and validation of grid reliability performance metrics using model-less algorithms and MISO Grid phasor data for agreed normal and disturbance days
- **COMPLETED** – Functional specification revision to include MISO feedback on Grid monitoring visualization and Grid reliability tracking reports
- **IN PROGRESS** – Deployment of prototype in MISO phasor infrastructure for Field Demonstration
- **IN PROGRESS** – MISO verification of off-line tests and validation results
- **IN PROGRESS** – Tune performance metrics algorithms and thresholds using results from MISO validations

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MISO Grid Prototype Next Action Items

- CERTS, June 2012 - Complete off-line model/metrics validation using 2011-2012 abnormal events phasor data – “Disturbance Days”
- CERTS, August 2012 – Tune model, metrics, thresholds, visuals and reports for MISO, using phasor data for Eastern 2011 five largest abnormal East events, and MISO critical lines from a list of 13 lines
- CERTS, August 2012 - Prepare and submit Prototype Field Test plan
- MISO, September 2012 - Review CERTS Prototype final Functional Specification and upgrade prototype code version-1 in their system
- CERTS-MISO, September 2012 - Start a six month Field Test concluding with a Final Report including conclusions and recommendations

Risk Factors Affecting Timely Completion

- **Grid Phasor Data Availability:**
  - Waiting for Host PMU installations and readiness
- **Grid Phasor Data Quality:**
  - Phasor Data Quality. Experience using phasor measurements is demonstrating the need for better phasor data quality filters and performance metrics uncertainty estimates
- **Completion of Prototype Deployment at MISO**
  - Availability of MISO personnel and IT Contractors

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Follow up Work to Consider for FY 2013 Funding

- Continue and complete the Field Demonstration with MISO for improving models, performance metrics, monitoring visualization, tracking automatic reports, and getting MISO coordinators experience
- Assess grid phasor data quality and availability using field demonstration results and research more effective phasor data quality filters and estimation of grid performance metrics uncertainties
- Research to identify and define a grid reliability composite index using this project grid performance metrics and MISO reliability coordinators experience during the Field Demonstration

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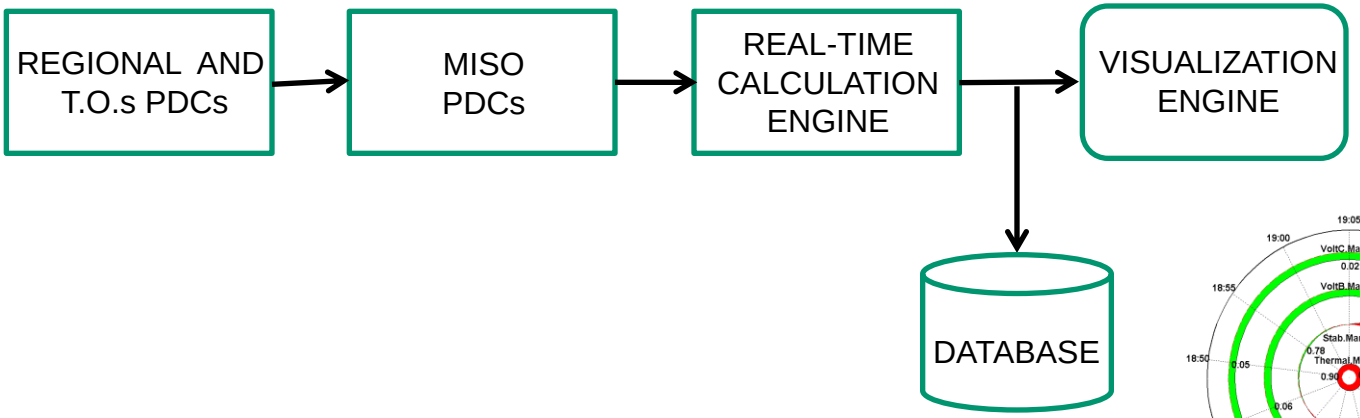
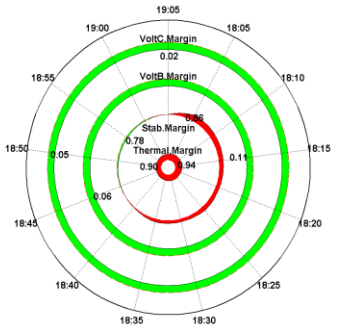
Prototype Development at MISO

Prototype Code Version-1
Running in Real-Time





Prototype Radial Visual for Multiple Simultaneous Grid Performance Metrics

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MISO 345KV BPS Grid Used for Prototype Preliminary Off-Line Validations

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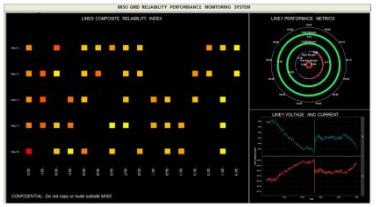
Prototype Monitoring and Tracking System

OBJECTIVE : Monitor frequency, voltage and stability in an *integrated* manner, using *consistent* notifications, *simple* graphical visualizations, *model-less* algorithms and *phasor* measurements

Target Users: MISO Reliability Coordinators

GRID RELIABILITY ALARMS
Using NERC Criteria Identify:
Frequency Alarms
Voltage Alarms
Angle-Across-System Alarm

GRID MONITORING VISUALIZATION
3 level visuals: composite index, performance metrics and measurements



GRID RELIABILITY TRACKING
Automatically and On Demand Create & Broadcast the 24 Hour Grid Perform. Report

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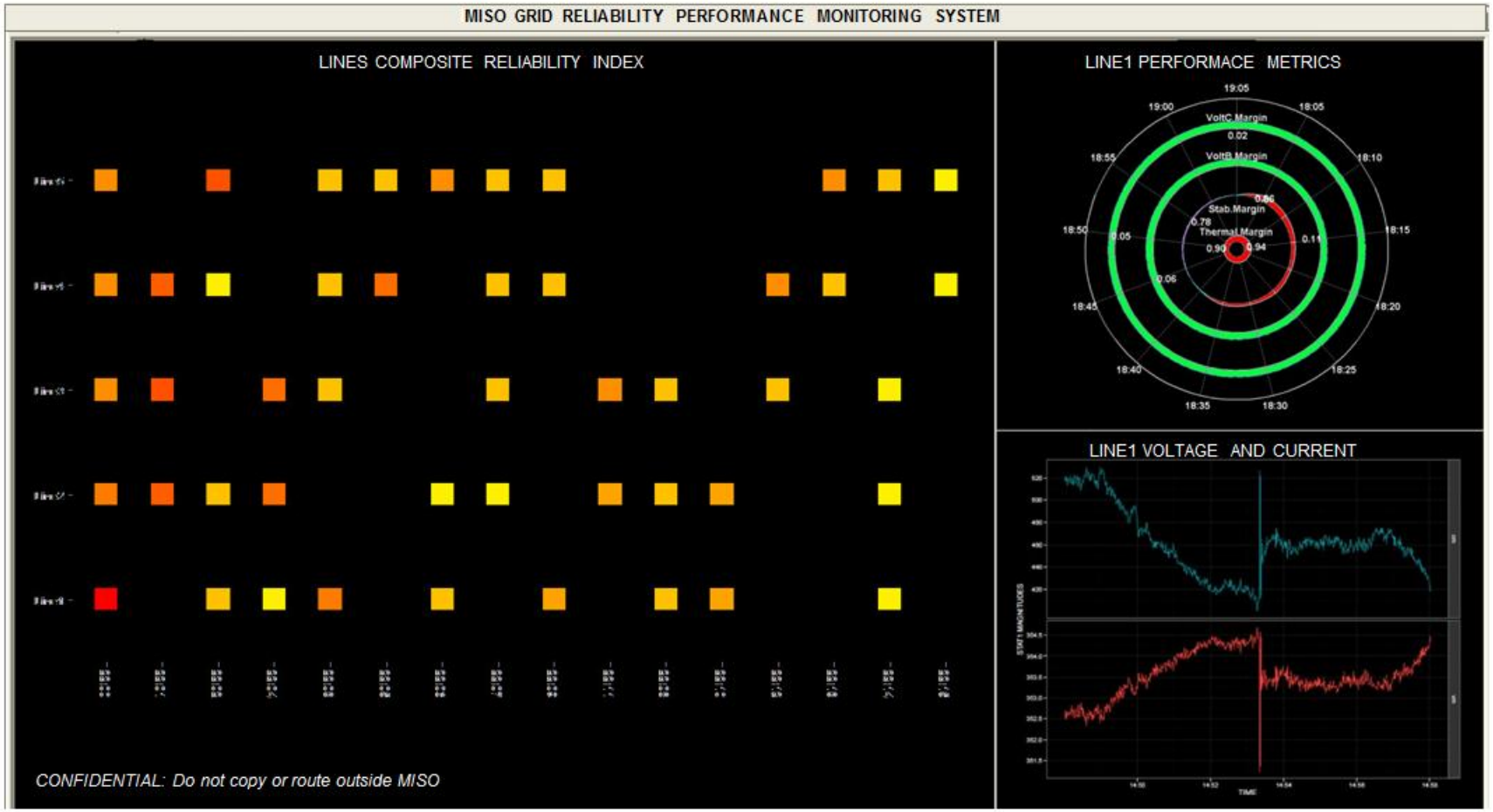
Prototype Monitoring Visualization

INFORMATION LEVELS DESIGN: interactive Composite Index, Performance Metrics and Specific Grid Phasor Measurements



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Prototype Grid Reliability Tracking Using a Daily Report Template – 2 Page Summary

MISO DAILY RELIABILITY PERFORMANCE REPORT

Report from: 03/02/12 12:00 AM to 03/02/12 11:59 PM Page: 1

1. INTRODUCTION

The objective of this report is to provide a daily summary of load-generation control and Grid reliability performance for the MISO Bulk Power System (BPS) using phasor measurements. The MISO daily report presents:

Largest Frequency and Voltage Event of the Day:

- Frequency-Time profile for the largest frequency event of the day
- Estimation of Frequency Response and key parameters for largest frequency event
- Voltage-Time profile for the largest voltage event of the day
- Estimation of Voltage and key parameters for largest voltage event

Grid Adequacy Performance Section:

- Summary table with largest stability, voltage and thermal margins for key transmission lines
- Statistical performance boxplot charts for the voltage and current profiles at key transmission lines.

2. LARGEST FREQUENCY AND VOLTAGE EVENTS OF THE DAY

2.1 Largest Frequency Event Data - 1 Second Frequency Time Graph

Event Frequency at points A, B, and C are shown in the frequency response table. The frequency for this event dropped 0.065Hz (point-A - point-C) and stabilized (point-B) in 21 seconds.

Fig 1 - 1-Second Frequency-Time Graph (Extend to 15 Minutes)

2.2 Largest Frequency Event Data - Estimated Frequency Response

The event reached a lowest frequency of 59.942 (Point C) Hz and started returning to normal in about 21 seconds.

DISCLAIMER- The event Frequency Response is an approximate estimate value using the best available 1-second phasor frequency data, ACE 1-minute SCADA data, and equations shown below whose definition is being developed by NERC Subcommittees and Frequency Response Standard Drafting team. Provided solely for informational purposes	
FR = MWLoss/10*DeltaFreq	MWLoss = Max(DeltaACE(BA))-Const*10*FreqBias*DeltaFreq
DeltaFreq = FreqA - FreqB	EI Const = 0.6, WI Const = 0.6, ERCOT = 0.3
FreqA=Avg of t-2Sec to t-16Sec	
FreqA=Avg of t+19Sec to t+52Sec	
Event Summary: Date/Time	3/2/2012 2:53:18 PM
Frequency at Point A [Hz]	60.007
Frequency at Point B [Hz]	59.94
Delta Frequency	-0.067
BA with Highest Delta ACE	PJM
Highest Delta ACE [MW]	-1239
FreqBias of the BA [MW/0.1Hz]	-1497
MW Loss [MW]	1841
Estimated Event FreqResp [MW/0.1Hz]	-2747

The interconnection responded to the largest event with an estimated frequency response of about -2747 MW/0.1Hz over performing the yearly committed value of -2601 MW/0.1 Hz. (additional performance parameters will be included)

2.3 Largest Voltage Event Data - 1 Second Voltage - Current Time Graph

Figure 2 shows the voltage and current profiles at a sub-second resolution during the 03/02/12 disturbance at 14:53 EST.

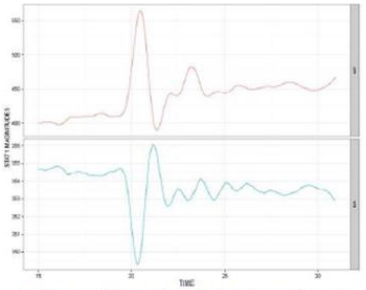

Fig 2 - Voltage and Current Profile at Disturbance on 03/02/12 at 14:53 EST

MISO DAILY RELIABILITY PERFORMANCE REPORT

Report from: 03/02/12 12:00 AM to 03/02/12 11:59 PM Page: 2

2.3 Largest Voltage Event Data - Esimated Response

Table with significant voltage event parameters (WORK IN PROGRESS)

Voltage Event Parameters					

3. MISO GRID ADEQUACY PERFORMANCE

3.1 Summary Table with Largest Stability, Voltage and Thermal Margin for Key Transmission Lines

The summary table below shows the MISO transmission line with the most critical and risky margins during the last 24 hours.

MISO Grid Performance Margins					
Hour	MISO Transmission Line	ANGLE MARGIN	VOLTAGE MARGIN	THERMAL MARGIN	Observations
20	STA1 - 2	0.309	0.718	NA	
21	STA2 - 3	0.309	0.718	NA	
22	STA3 - 4	0.309	0.718	NA	
22	STA4 - 5	0.309	0.718	NA	
19	STA5 - 6	0.309	0.718	NA	
23	STA6 - 7	0.309	0.718	NA	

3.1 Statistical Performance Boxplot Chart for the Voltage and Current Profiles at Key Transmission Lines

The boxplot show the voltage and current distribution for each hour of the day.

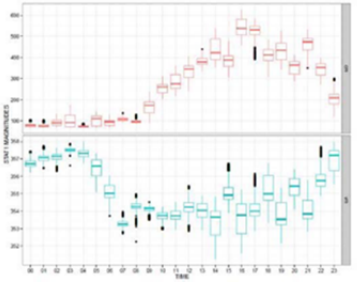

Fig 3 - Voltage and Current Distribution For Each Hour of the Day for STA1

QUESTIONS