DOE/OE Transmission Reliability Program

NERC Load-Generating Reserves Reliability Control Standards

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Automatic Reliability Reports - GARR Project

- MISO delivered 30-samples/second Phasor Grid data under current Data Confidentiality Agreement (DCA). Algorithms and visuals-reports using data.
- University of Illinois continue with algorithms research, improvements, and validations.
- Field Test demonstration at MISO on hold because delivery of requested State Estimator data and One-line diagrams require additional DCAs with MISO. MISO Legal is currently defining new DCAs requirements.
- Coordinate with MISO the deployment of latest algorithms, visualization and Automatic Reports at MISO using their PMU data and infrastructure
- Execution of propose Field Test plan at MISO to get their feedback.
- Risk - Field Test delays because of MISO definition of additional DCAs for the remaining data requested for validations.

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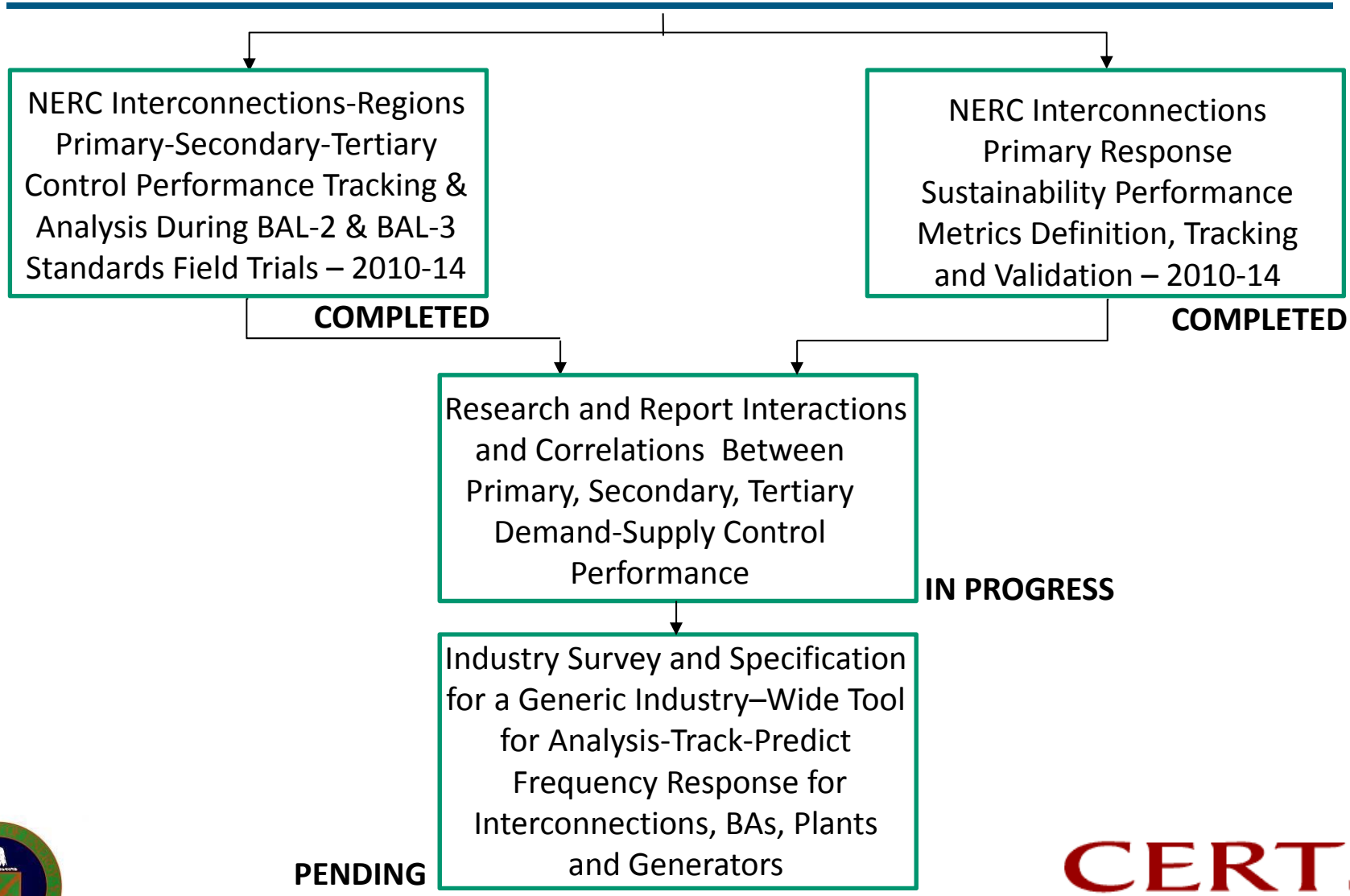
Overall Project Objectives



FY15 Deliverables, Risk Factors and Follow-On Work

FY15 Deliverables:

a) Completed paper on industry utilization of CERTS-NERC tools, accepted for IEEE publication. b) Final report for NERC Staff and Reliability Subcommittees including research results and recommendations on NERC Interconnections and two Regions primary, secondary and tertiary control performance during the BAL-02 and BAL-03 2010 to 2014 Field Trials, including accurate and validated primary response sustainability performance metrics. c) Functional and database specification for an industry-wide tool for analyzing and tracking Frequency Response for Interconnections, Balancing Authorities, plants and generators.

Risk Factors:

- Phasor data quality increases substantial development time for data alignment and extrapolations
- Lack of consensus on frequency events selection criteria and its MW Loss originate discrepancies and debates for assessing and comparing demand-supply control performance metrics.
- Delay from stakeholders feedback reviewing preliminary reports could delay final deliverables

Follow-on Work to Consider for FY16:

The project will be completed during FY15. For an effective transfer of project's results to industry:

- Present and get feedback from NERC Staff, Reliability Subcommittees, and Regions on the final research results report, and Frequency Response analysis and tracking tool functional specification.
- Coordinate with PNNL on the implementation and deployment of additional functional specification capabilities in their Frequency Response Tool (FRTool2).
- Coordinate and participate with EPG on the monthly analysis and validation of NERC interconnections monthly frequency events report require for BAL-003 Frequency Response Performance.

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NERC Interconnections and Regions Primary-Secondary-Tertiary Control Performance During New BAL-2 BAL-3 Standards Field Trials – 2010-2014

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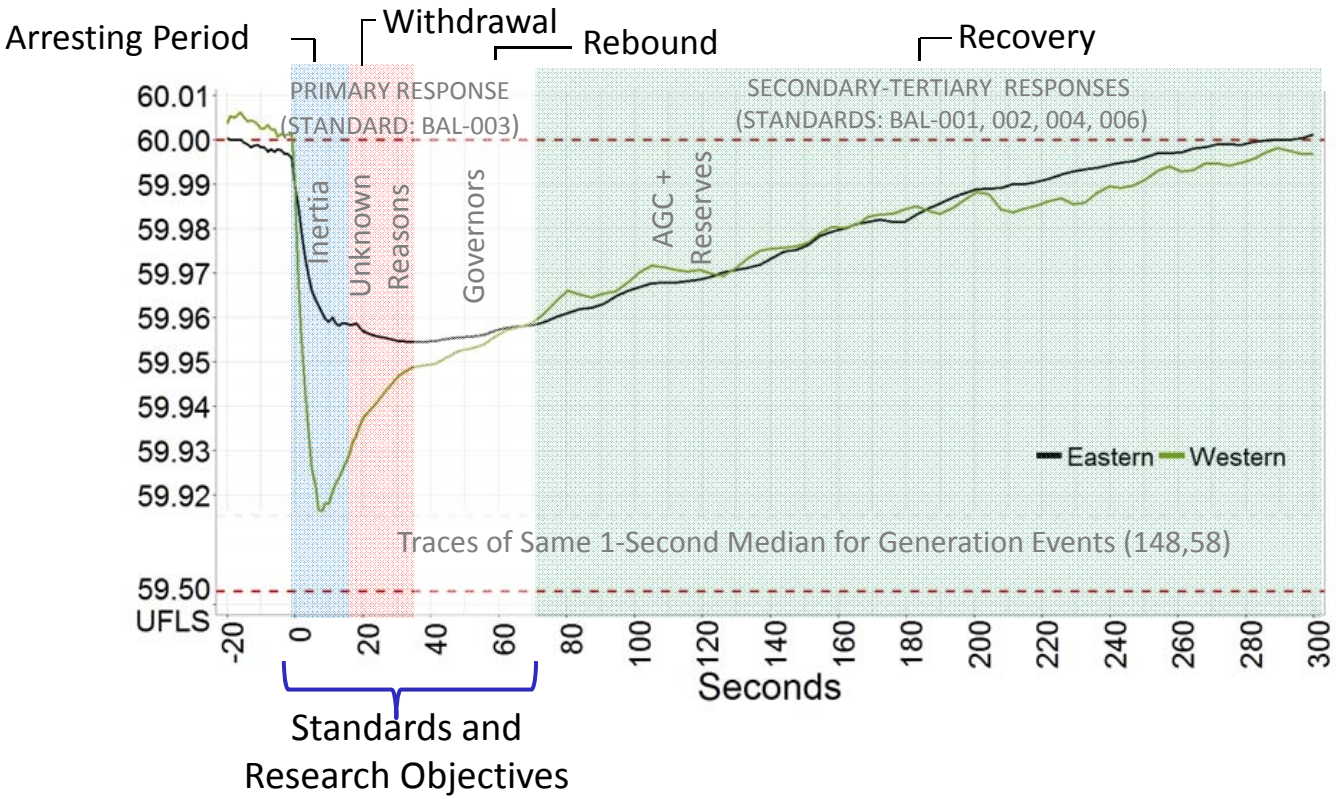
Background - Events Typical Frequency Traces and BAL-2, 3 Field Trial Data Collected



BAL-003 2010-2014 FIELD TRIAL FREQUENCY EVENTS DATA																		
Intercon	Eastern					Western					ERCOT					Hydro Quebec		
Year	2014	2013	2012	2011	2010	2014	2013	2012	2011	2010	2014	2013	2012	2011	2010	2014	2013	2012
Events	263	177	68	114	139	44	61	69	64	84	49	94	74	101	123	55	90	57

Data Sources: 2010-2014 1-second averages from 10 Samples/Second Phasor Frequency Data, and SCADA 4-Second Data

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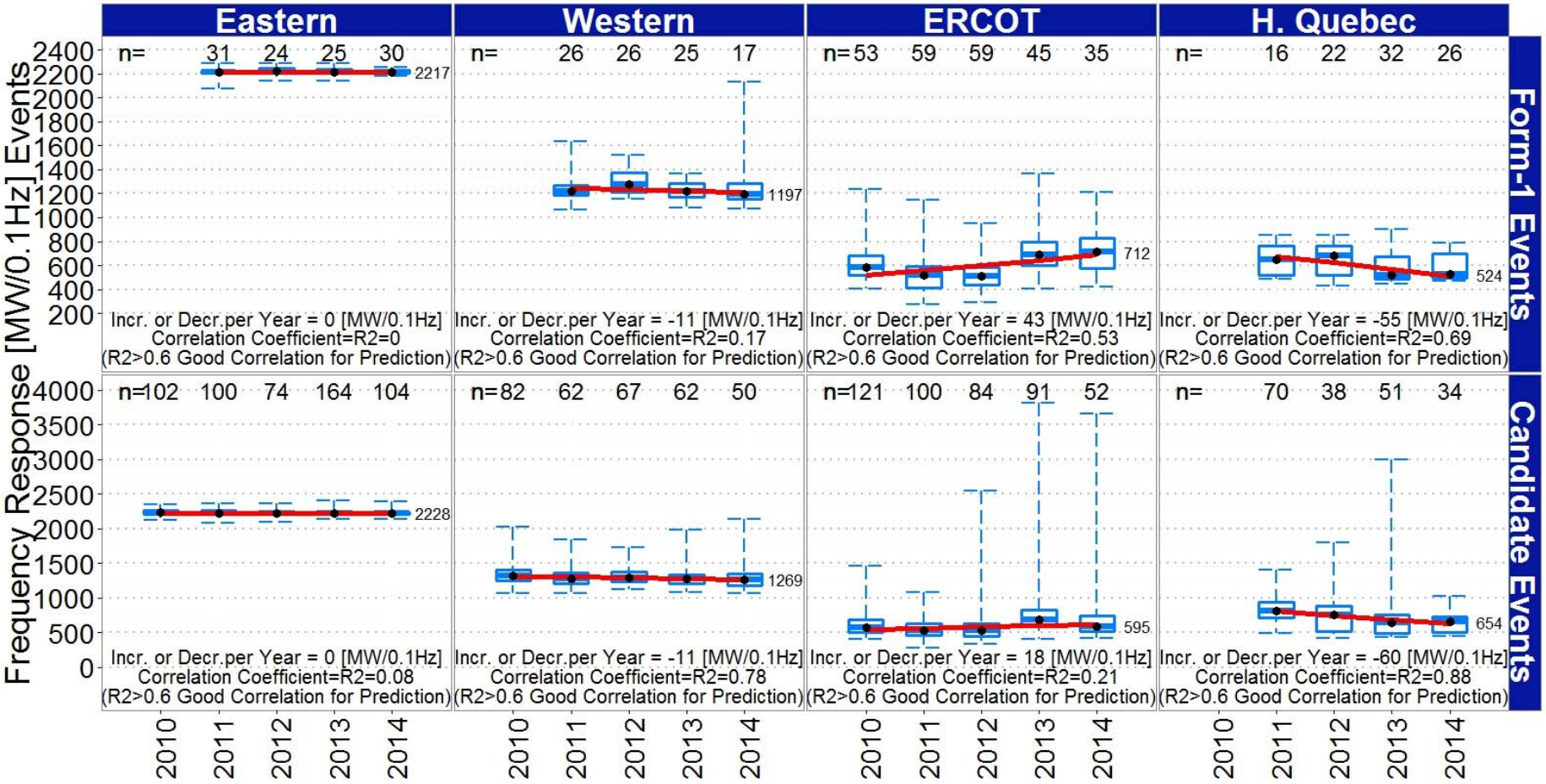
NERC Interconnections Primary Frequency Response Performance Trends



OBSERVATIONS: a) Eastern, ERCOT increasing FRM trends, Western, Hydro decreasing

b) FRM trends are equivalent using BAL-003 events and NERC ALR1-12 Frequency Response Metric

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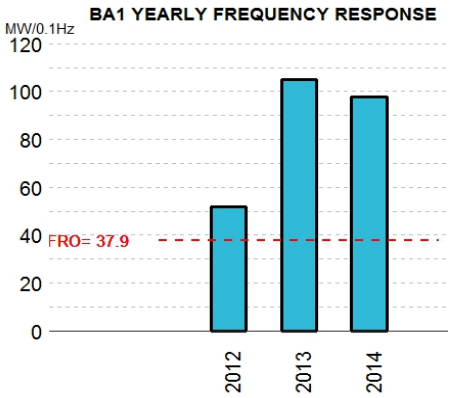
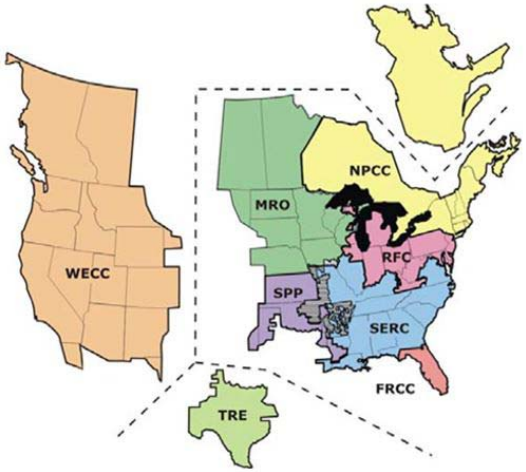
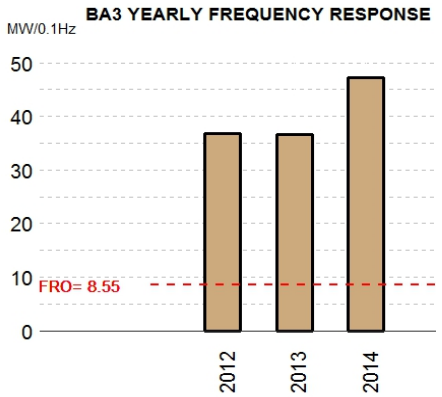
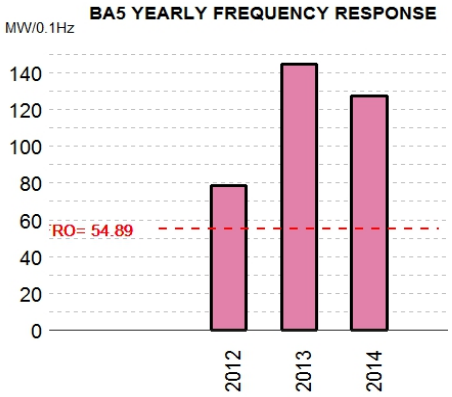
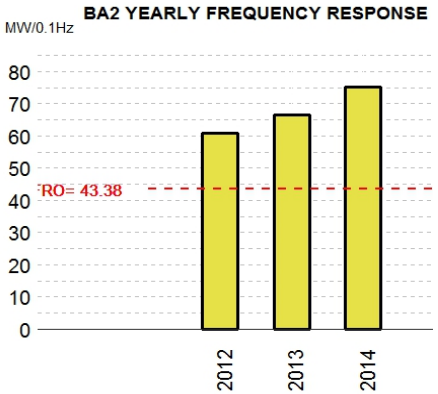
Region 1 and its 5 BAs Primary Frequency Response Performance Trends - 2012-14

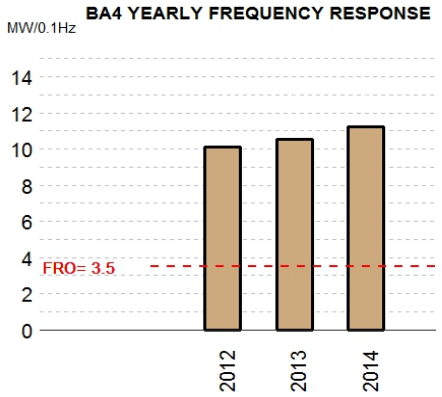












OBSERVATIONS: a) Small BAs FRM are closer to its FRO when compare to large BAs

b) Outlier events have a very significant impact on FRM estimations using regression models

c) All BAs show increasing FRM trends since starting BAL-03 Field Trial

Note: Region and BAs Anonymous Names Because Data Confidentiality Agreements

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Region1 Frequency Response Estimations Comparison Using Median and Regression

REGION1 2012-2014 FREQUENCY RESPONSES MEASUREMENTS (FRM) USING MEDIAN AND REGRESSION MODELS (Excluding Outlier Events)					
Region1 BAs	Year	Frequency Response Measurement (FRM)		Mean Absolute Percentage Error (MAPE)	
		Median [MW/0.1Hz]	Regression [MW/0.1Hz]	Median	Regression
BA1	2012	-33.1	-32.8	121.9 %	121.5 %
	2013	-104.9	-130.6	122.3 %	150.3 %
	2014	-94.5	-96.7	373.3 %	380.9 %
BA2	2012	-54.2	-46.1	204.4 %	177.02 %
	2013	-66.4	-64.2	144.8 %	141.3 %
	2014	-75.2	-71.3	216.1 %	205.8 %
BA3	2012	-36.9	-33.4	107.6 %	97.7 %
	2013	-36.5	-38.3	30.4 %	32.3 %
	2014	-47.3	-42.2	88.5 %	79.5 %
BA4	2012	-9.9	-7.9	93.1 %	87.7 %
	2013	-10.5	-11.6	141.7 %	156.7 %
	2014	-11.2	-11.04	167.3 %	165.03 %
BA5	2012	-74.7	-66.01	188.7 %	173.3 %
	2013	-140.9	-98.63	83.2 %	70.7 %
	2014	-117.7	-118.2	172.9 %	173.6 %

OBSERVATIONS:

- 60% of FRM estimations produce lower MAPE using the Median Model
- Large BAs FRM estimations produce lower MAPE using the Regression Model

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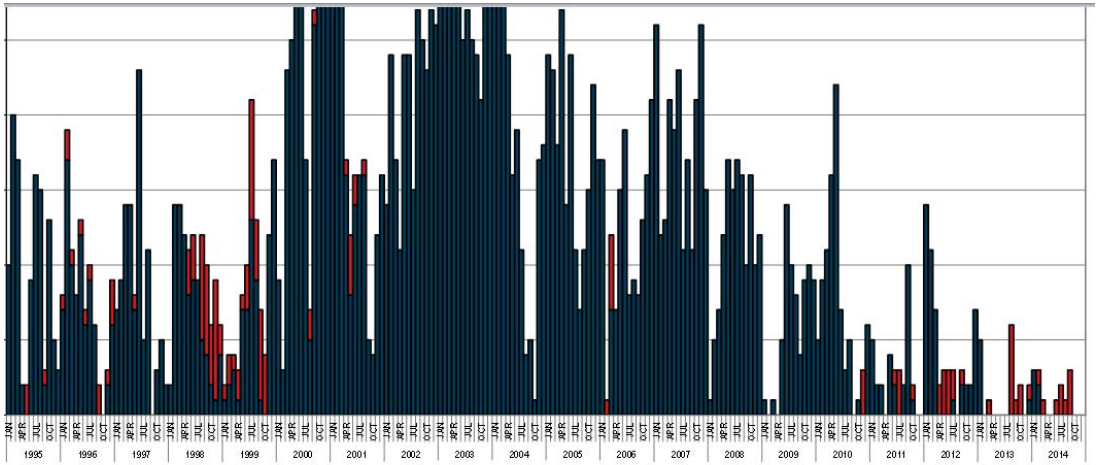
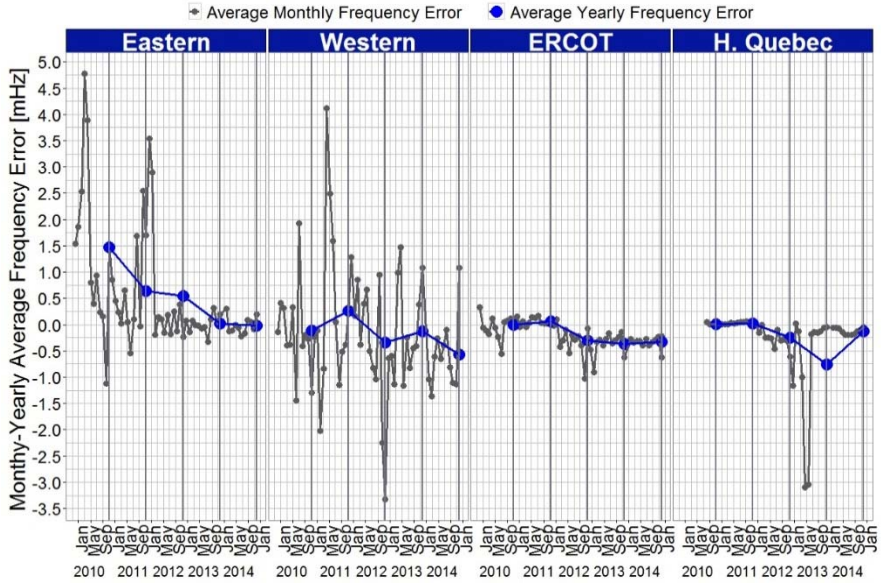
NERC Interconnections Secondary Control Performance Trends

Eastern Time Error Correction Trend



From NYISO

NERC Intercons. Average Frequency Deviation Trend



Possible Reasons for Improved Secondary Control Trends:

- 2005 Energy Policy Act ERO creation.
- Additional emphasis on NERC Control Standards
- Participation on Field Trials for BAL-2 and BAL-3 Standards
- Reduction in number of Eastern and Western Control Areas (2011=100, 2014=75).
- Tools that better indicate current performance, such as the Intelligent Alarms from NERC-CERTS Resource Adequacy Application
- Inadvertent Interchange Tool, which gives BA's a heads up that their control may require some investigation
- Economy (Recession)

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NERC Interconnections
Primary Response Sustainability and Frequency Events MW Loss Probabilistic Estimations - 2010-2014

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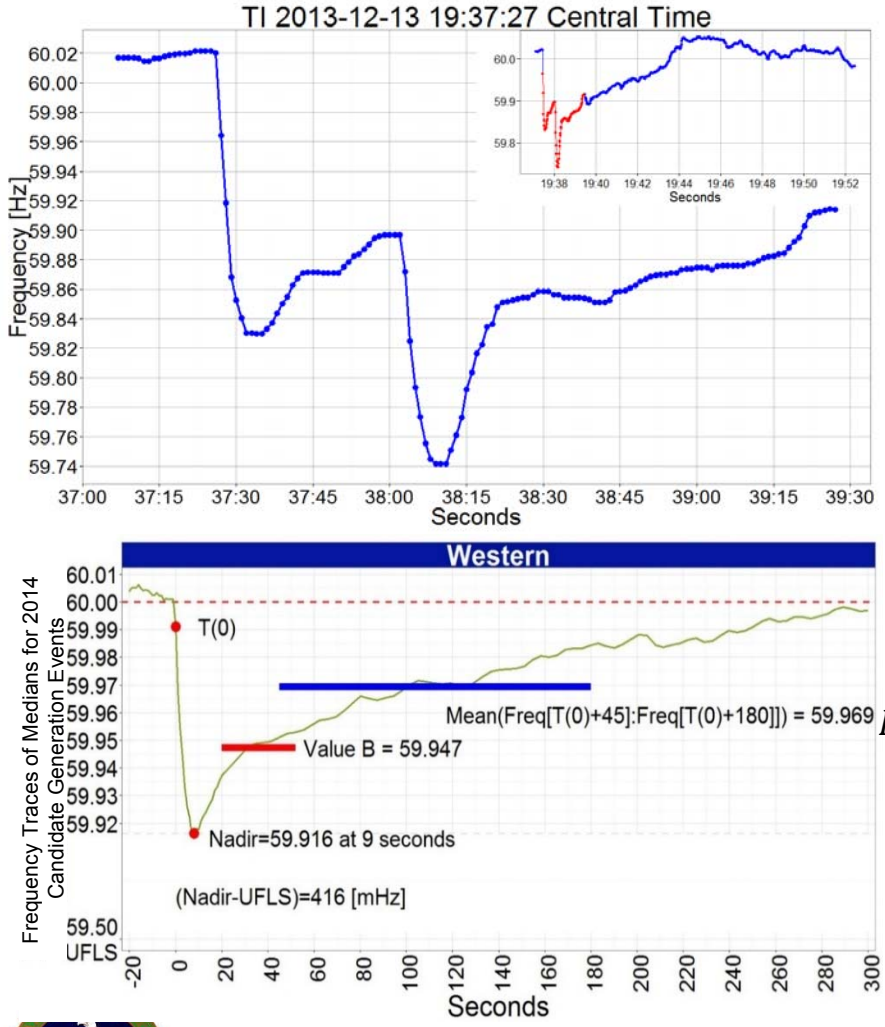
Reliability Risks for Early Withdrawal and Sustainability Condition Identification Metric



Risks for Early Withdrawal of Frequency Response:

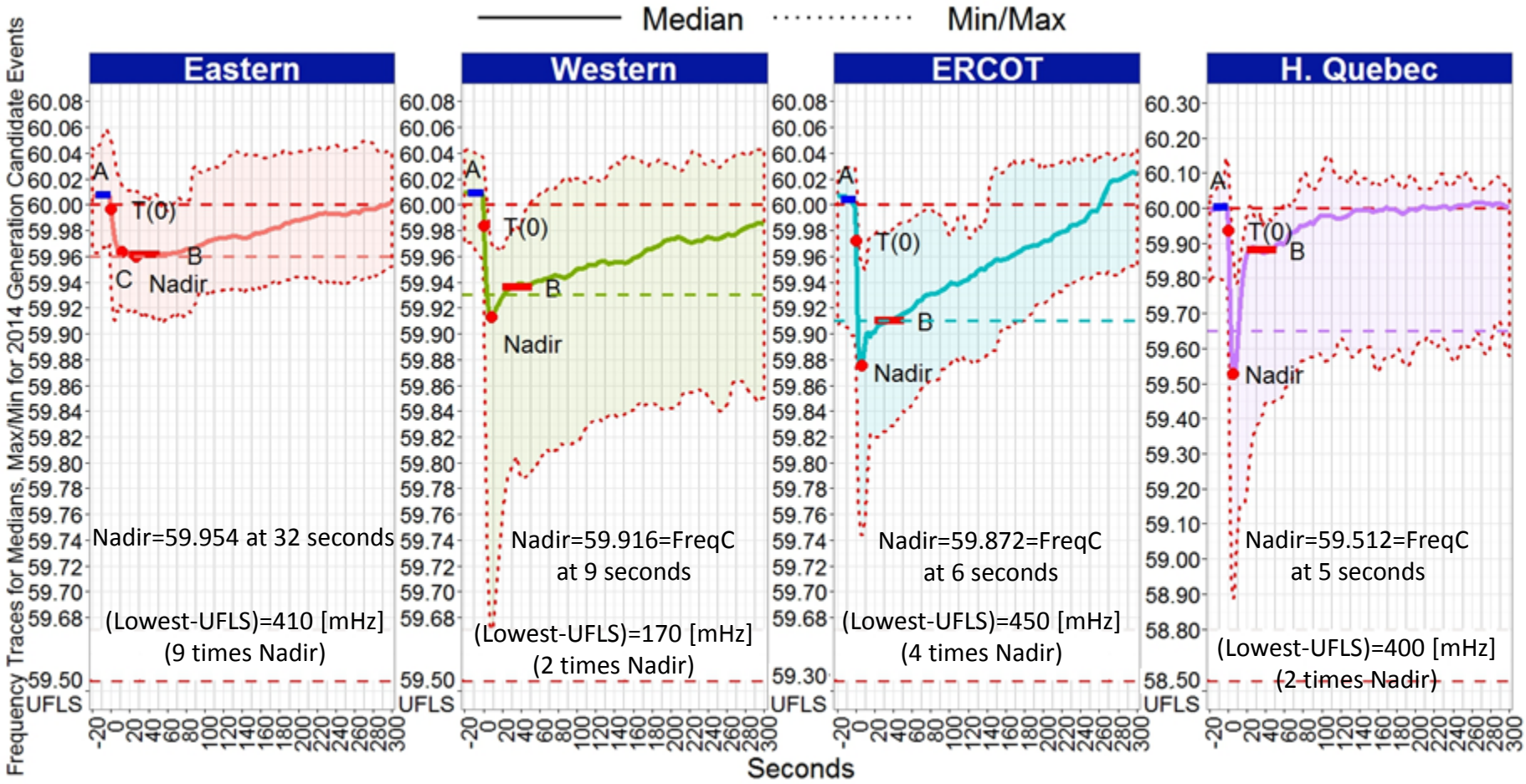
- Interconnections frequency could go closer to UFLS levels if consecutive events occur during periods of early withdrawal. For 2014 there were about 1 and 2 percent of events with consecutive events for ERCOT and Hydro Quebec respectively
- Early withdrawal could impact Secondary Response by extending the time for reaching pre-event frequencies within the 15-minutes require by BAL-002 (DCS)

Sustainability Condition Performance Metric:

$$SM_1 = Sustainability\ Metric = Mean\left(Freq_{(T0+45)}\ to\ Freq_{(T0+180)}\right) - FreqValueB\ [mHz]$$

(a negative SM_1 metric could indicate early withdrawal of primary frequency response)

NERC Interconnections 2014 Primary Response Sustainability Trends and Impacts



OBSERVATIONS: a) The Western interconnection has the shortest distance between lowest event and UFLS (170 mHz), b) Sustainability is not severely impacting secondary-control (BAL-02, DCS), return to pre-event frequency < 15 min

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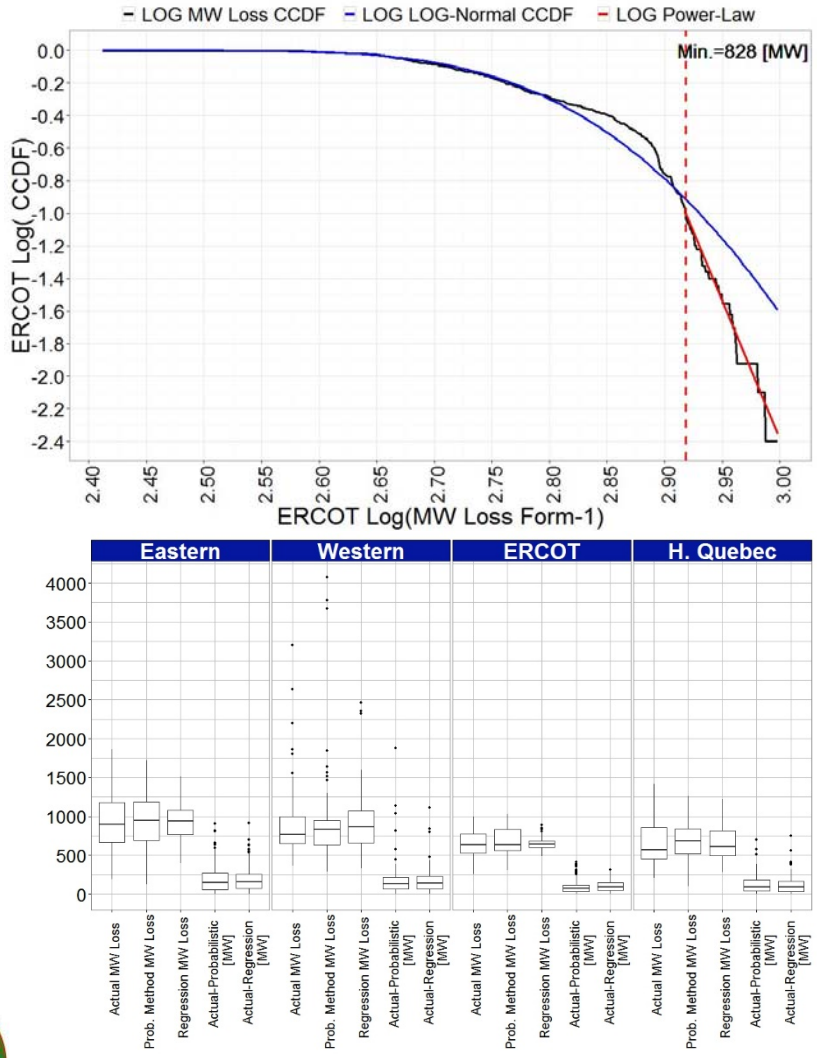
ERCOT Events MW Loss Probabilistic Model Using Power Law, Log-Normal Distributions



OBSERVATIONS:

- Research results indicate NERC Interconnections Frequency Events MW Loss can be estimate using a probabilistic model based on Power-Law and Log-Normal Distributions.
- Comparison of interconnections events actual MW Loss estimated with the probabilistic model produce errors ranging between 10-17 percent
- Errors between actual and probabilistic MW Loss estimations is smaller for small interconnections

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QUESTIONS
and ANSWERS

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