

INTRODUCTION

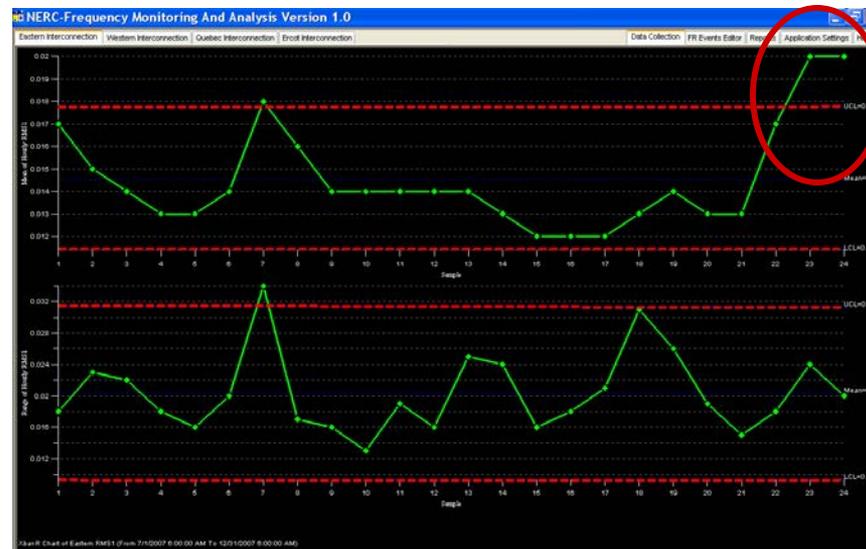
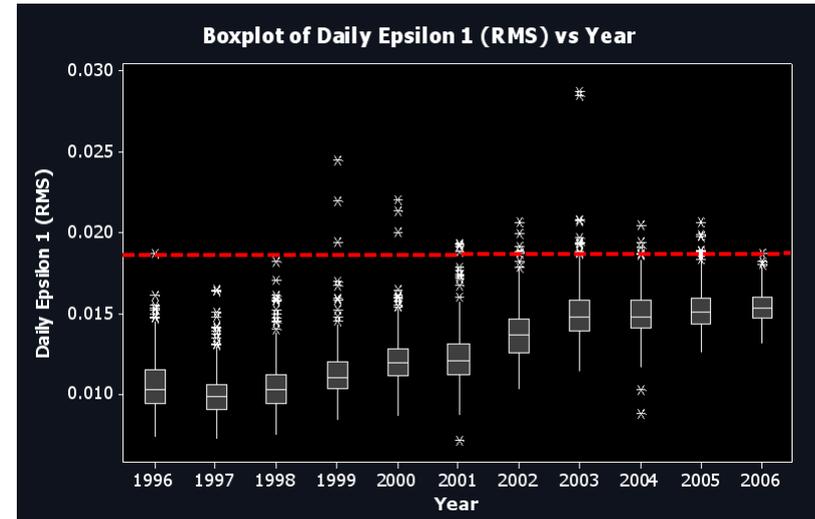
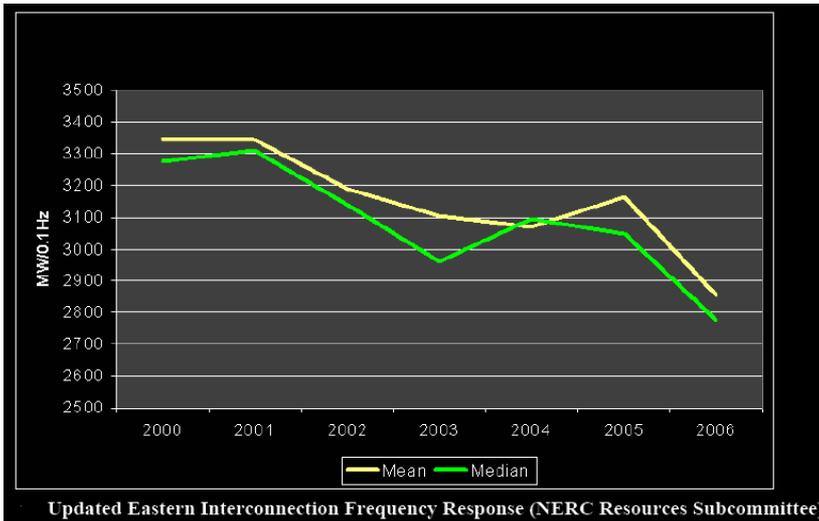
FMA Responds to Industry Need to Analyze Control Performance During Events

- Control Performance is Critical for Reliability Management
- In 2002, NERC Operating Committee Requested that Control Performance and Frequency Response Should be Analyzed
- Control Performance Areas of Concern Include:
 - Declining Generation Frequency Response Trend
 - Violations of Performance Thresholds and Guidelines
 - Frequency Excursions During Hours 21 and 22
- NERC Resources Subcommittee defined FMA functional needs
- FMA leverages and builds upon CERTS research
- CERTS researched design and architecture for FMA which was reviewed and approved by NERC Resources Subcommittee
- FMA Description Covers:
 - Control Performance Trend Examples
 - Overview of FMA Application
 - Examples and Demo of Use of FMA
- FMA Demo Covers:
 - Load-Generation Control Performance Analysis for Second Half 2007
 - Event Collection, Analysis, Tracking and Archiving for August 4, 2007 Event

Control Performance Issues and Trends

Frequency Response was 3,750 MW/0.1Hz in 1994 vs 2,800 in 2006.
 For largest events greater than 35 mHz as low as 2,600 in E.I.
 (NERC Standard Drafting Team Defining FR Standard)

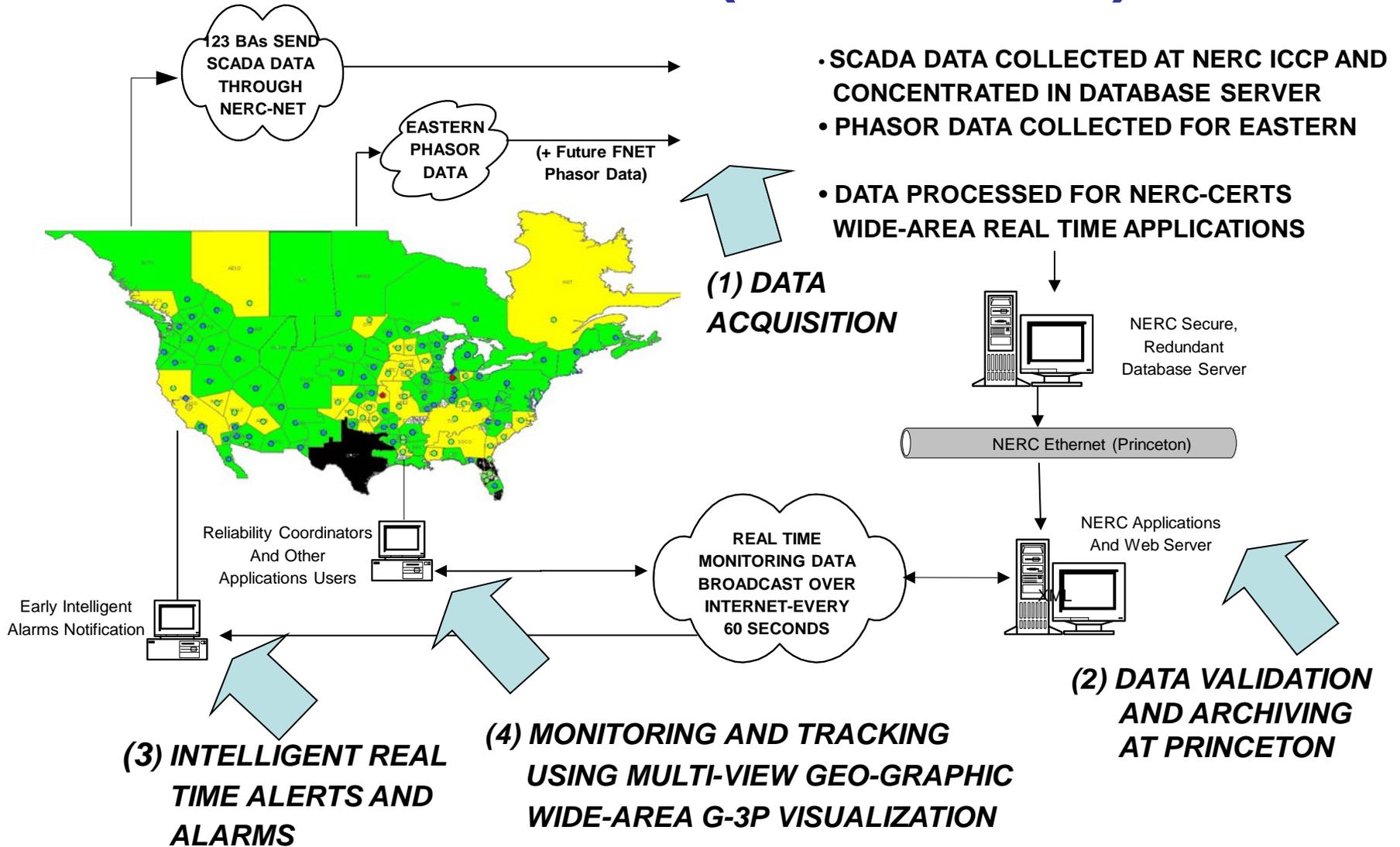
Frequency Deviation from schedule getting closer to
 NERC Standard reliability limit of 18 MHz in E.I.



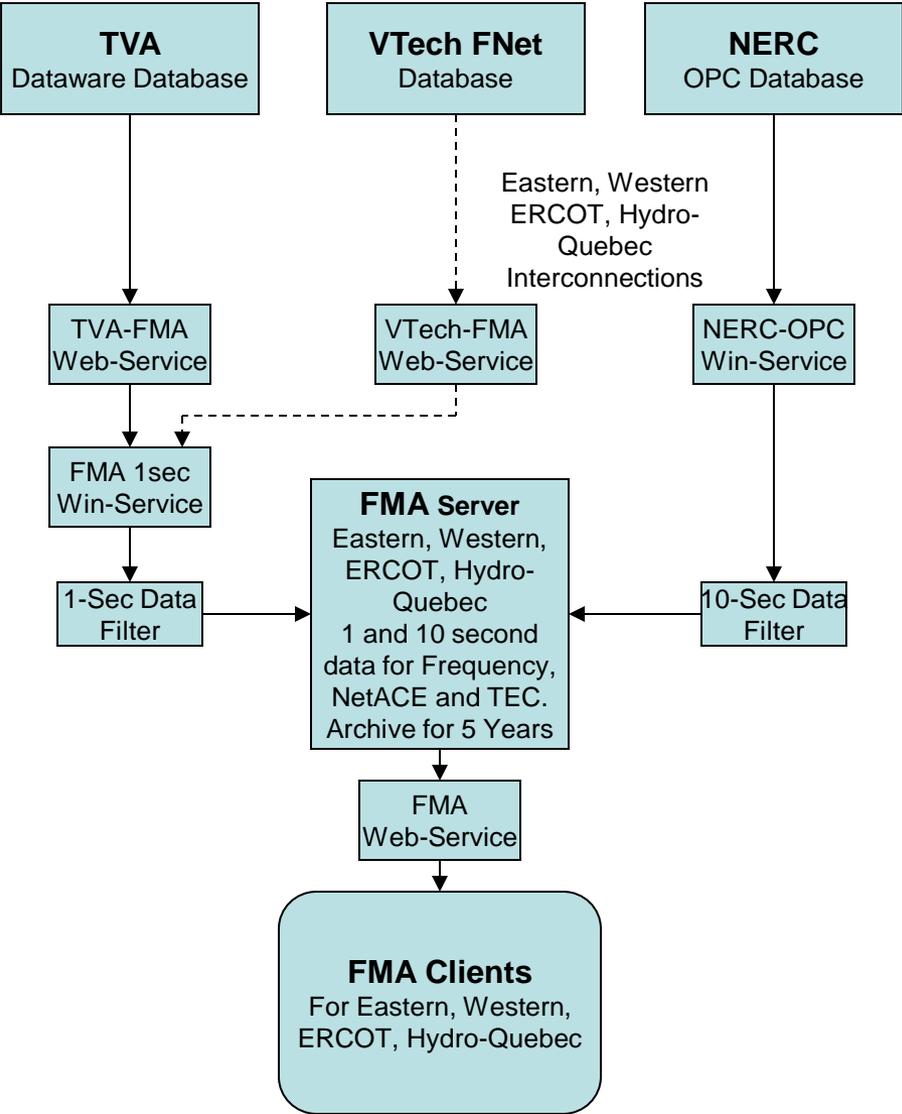
Control of Hours
 22 and 23
 beyond
 recommended
 Process Control
 Limits in E.I.

ARCHITECTURES

NERC-CERTS Applications Architecture (Illustrative)



FMA Architecture and Data Sources

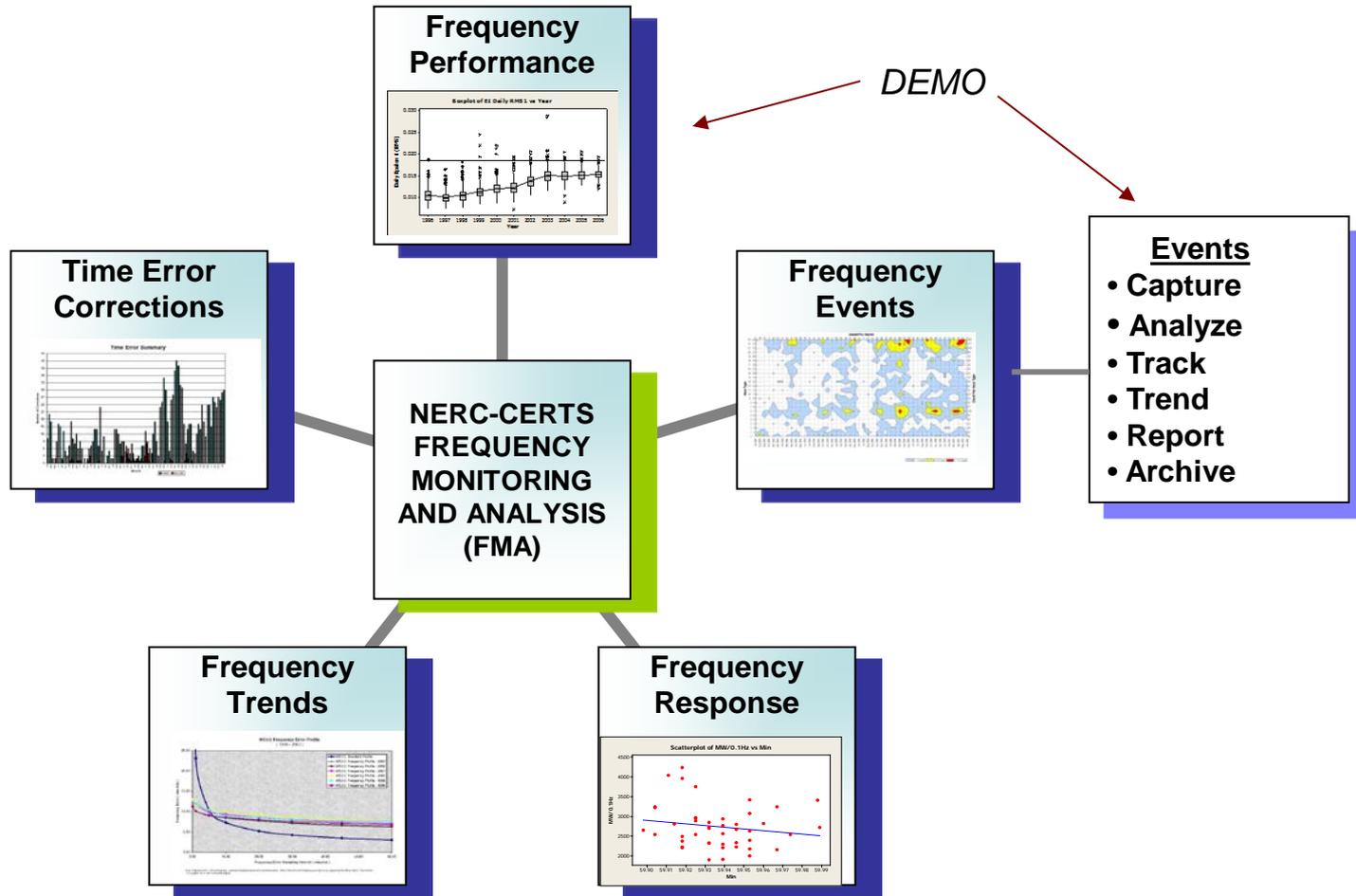


FUNCTIONAL OVERVIEW

Overview of Frequency Monitoring and Analysis (FMA) Application

- FMA designed to address industry need for timely analysis of Interconnections Resources Adequacy performance during events
- Complements Wide-Area Real Time Monitoring Tools
- Provides Analysis Capabilities for Engineers and Managers
- Assures availability of data during abnormal events by utilizing three data sources for each interconnection
- Integrates Different Data Resolutions – SCADA, Phasors and FNET
- Modules cover Resources Adequacy events, frequency response performance, trends and time error correction
- Enables
 - Identification, analysis and archiving of events
 - Analysis of Key Performance Metrics – e.g., Frequency Response
 - Root Cause Assessment and Identification
 - Review and Definition of Procedures, Guidelines and Standards

Frequency Analysis and Monitoring (FMA) Application and Visualization Modules



FREQUENCY PERFORMANCE FUNCTIONS AND DISPLAYS

CASE STUDY

Utilization of FMA for Wide-Area Load-Generation Control Performance

The screenshot shows the NERC-Frequency Monitoring And Analysis Version 1.0 software interface. The main display area is divided into three sections:

- Left Section:** Key Reliability Standard Metric Historical Performance (Does Process Comply with Standards)
- Top Right Section:** Complement Key Reliability Metric Performance (Is Process Variability Acceptable)
- Bottom Right Section:** Load-Generation Control Process Performance (Is Process Under Control ?)

A green curved arrow points from the left section to the top right section. A green downward arrow points from the top right section to the bottom right section.

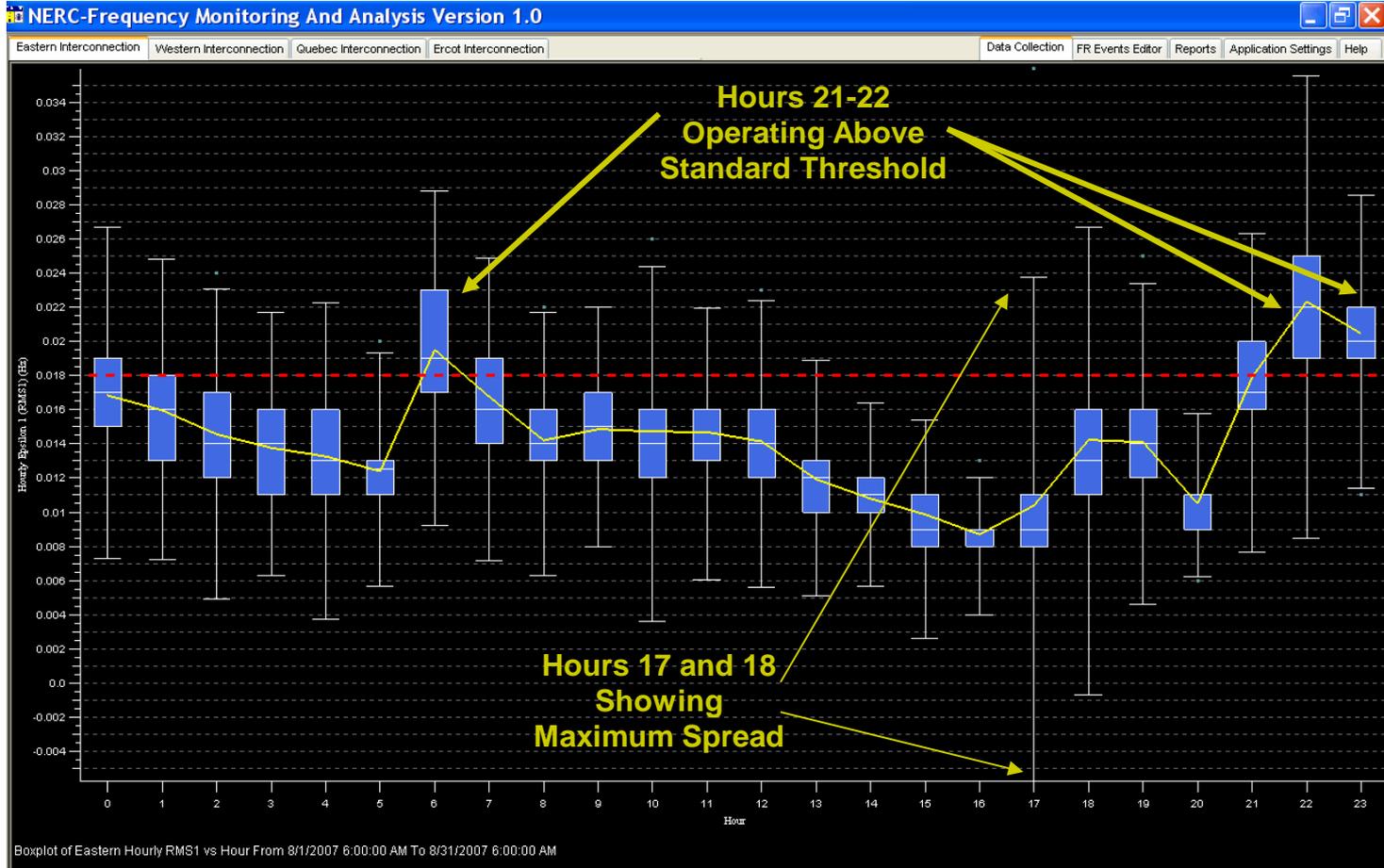
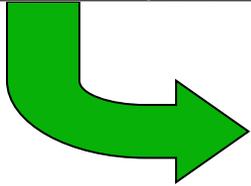
The software interface includes a menu bar with options: Eastern Interconnection, Western Interconnection, Quebec Interconnection, ERCOT Interconnection, Data Collection, FR Events Editor, Reports, Application Settings, and Help. The bottom status bar shows: Start Date/Time: 12/01/2007 06:00 AM, End Date/Time: 12/31/2007 06:00 AM, Eastern Interconnection Frequency Performance, Data Source: 1 Sec, Periodicity: Quarterly, Time Zone: Eastern, and Grid-3P® Patent 7,233,843 © Electric Power Group, LLC.

Case Study Description

- On August 4, 2007 the Eastern Interconnection frequency reached 59.868 Hz the lowest value in 2007
- The event resulted in a five units outage for a total generation lost of about 4,300 MW with a load of about 500,000 MW
- Recovery of the event fell within the NERC DCS standard requirement of 15-minutes. The interconnection frequency was restored to 60 Hz in 8-minutes.
- The interconnection frequency recovery over-responded, reaching 60.06 Hz in 14-minutes.

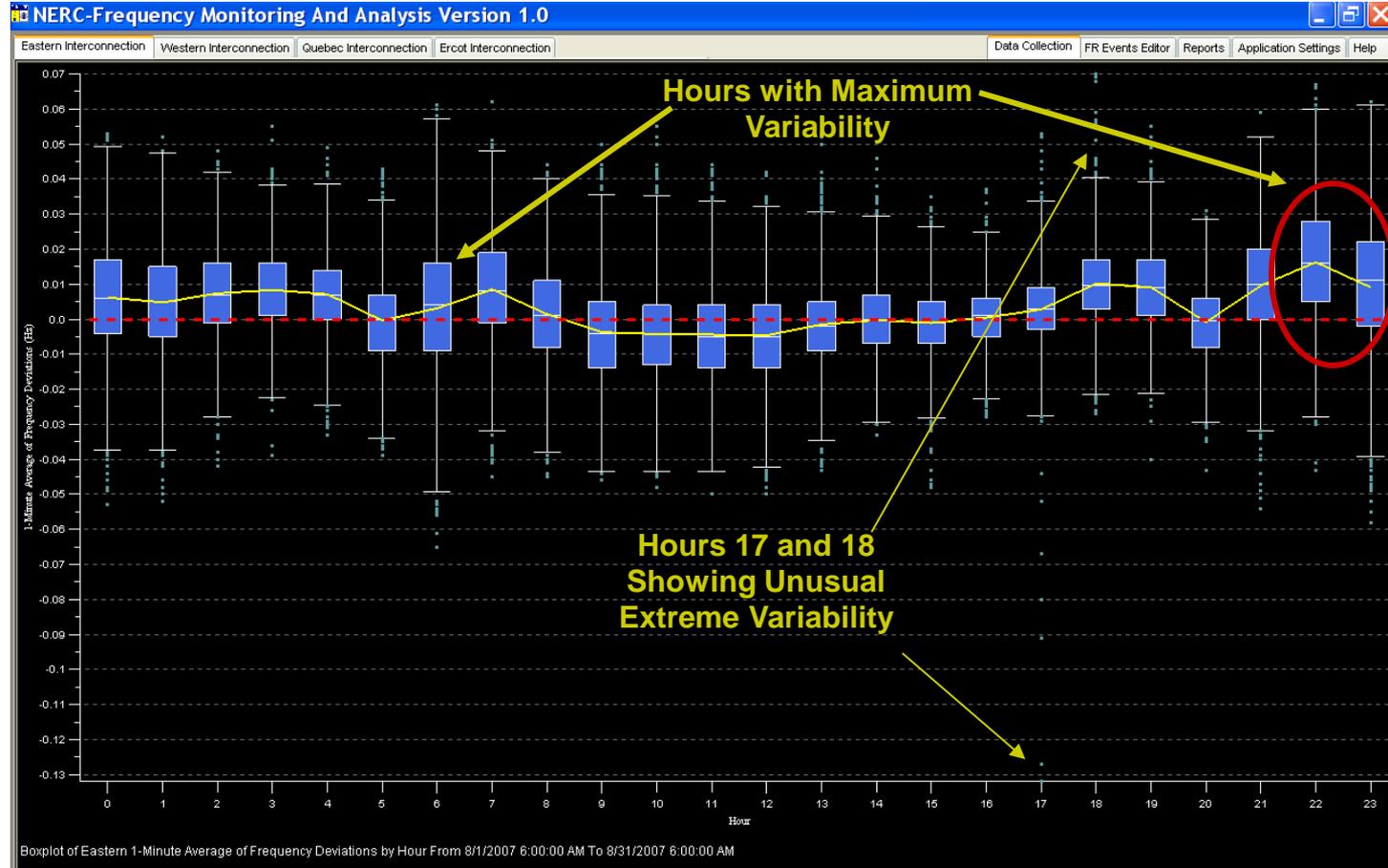
Utilization of FMA for Evaluating Load-Generation Control Compliance with Standard

Evaluation of 1-Second Frequency Data Graphs for Eastern Interconnection August, 2007



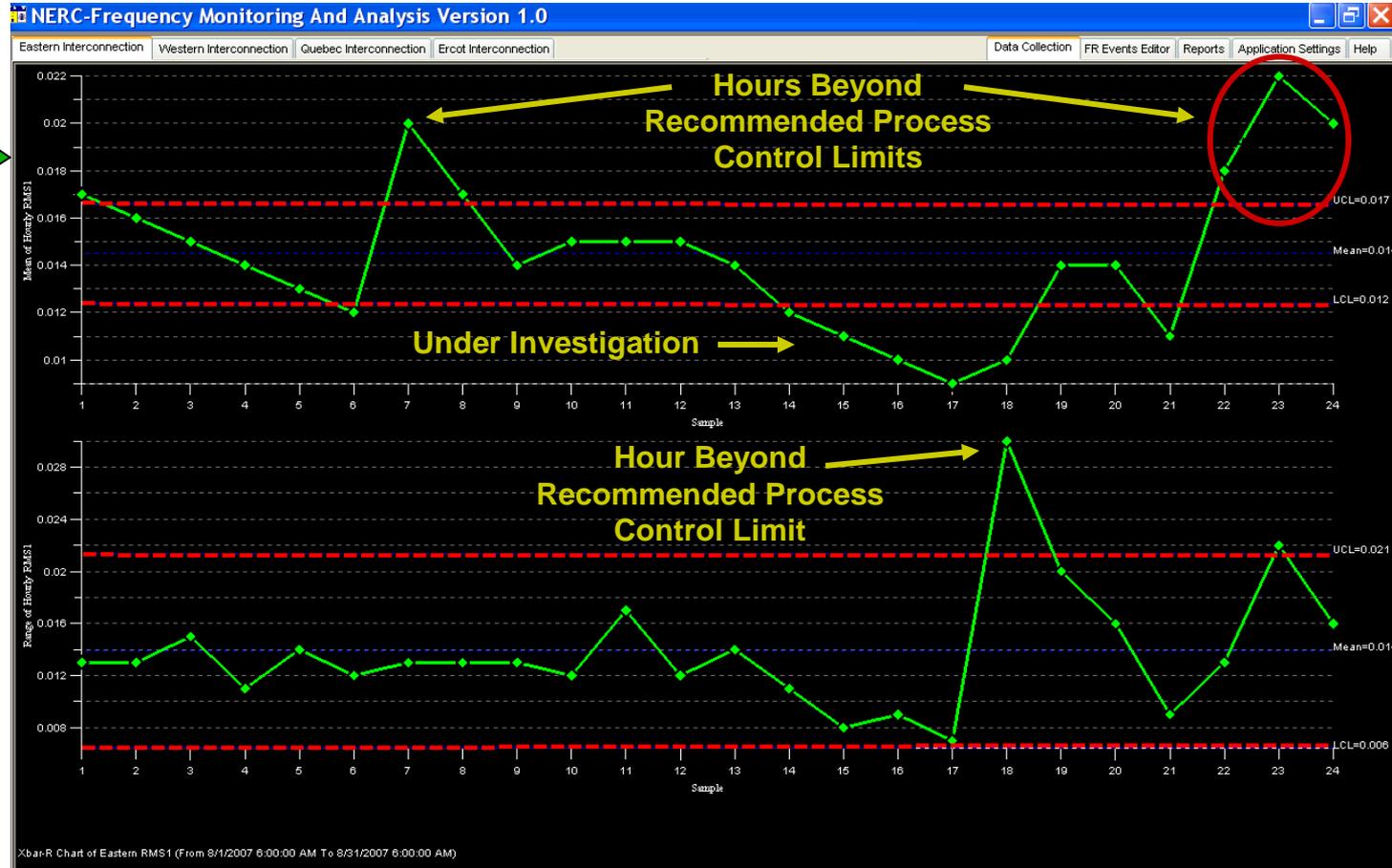
Utilization of FMA for Wide-Area Evaluation of Load-Generation Variability

Evaluation of 1-Second Frequency Data Graphs for
Eastern Interconnection August, 2007



Utilization of FMA for Wide-Area Load-Generation Control Performance Analysis

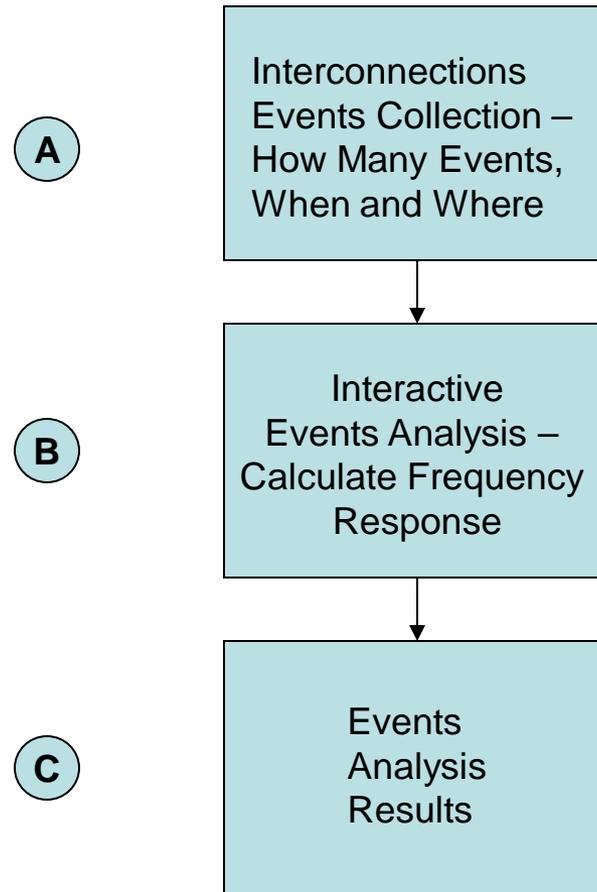
Evaluation of 1-Second Frequency Data Graphs for Eastern Interconnection August, 2007



FREQUENCY EVENT ANALYSIS

CASE STUDY

Utilization of FMA for Analysis of Frequency Response During Events - Steps



Utilization of FMA for Analysis of Frequency Response During Events

Frequency Response Events Editor

Interconnection Selection: Eastern Western ERCOT Quebec

Frequency/ACE Range: Frequency Range [] Hz To [] Hz; Net ACE Total Range [] MW To [] MW

Source Name: ALL, **VOLU-FQ**, CALY-FQ, FARR-FQ

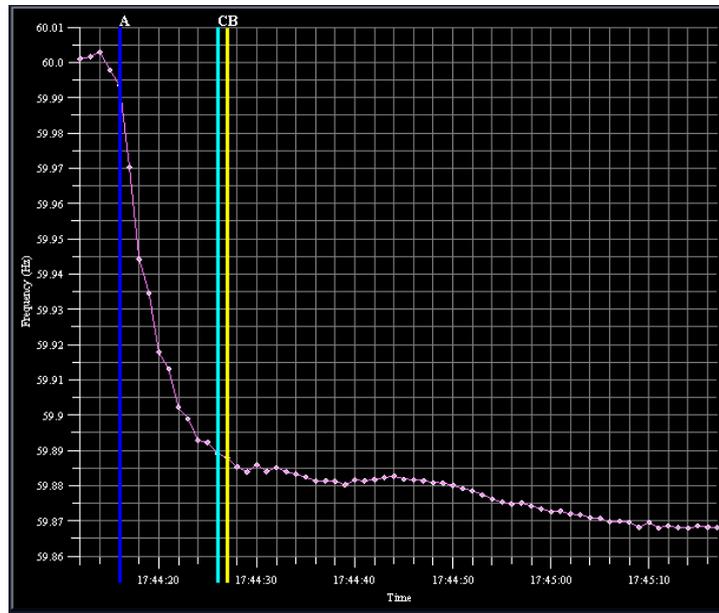
Time Frame Selection: Start Date/Time: Wed, Aug 01, 2007 12:00:00 AM; End Date/Time: Fri, Aug 24, 2007 11:59:00 PM; **Get Events**

Frequency Points: T - 5 to T + 60

2007/08/24 03:50:14 VOLU-FQ
 2007/08/23 16:30:54 VOLU-FQ
 2007/08/22 12:06:59 VOLU-FQ
 2007/08/15 23:27:00 VOLU-FQ
 2007/08/10 01:58:17 VOLU-FQ
 2007/08/10 00:57:41 VOLU-FQ
 2007/08/06 13:11:24 VOLU-FQ
2007/08/04 17:44:17 VOLU-FQ
 2007/08/03 12:39:29 VOLU-FQ

August 2007 Events

A
 Events Phasor Data Collection



FREQUENCY RESPONSE CALCULATION

PMU Location: VOLU-FQ

Actual Net Interchange Immediately Before Disturbance (Point A) * -25 MW

Actual Net Interchange Immediately After Disturbance (Point B) * 4318 MW

Change in Net Interchange 4343 MW

Generation (-) lost Causing the Disturbance * 7629 MW

Interconnection Response -3286 MW

Change in Interconnection Frequency from Point A to Point B -0.113 Hz

Frequency Response 2908 MW / 0.1 Hz

Event Status * Valid

OTHER INFORMATION

Frequency Bias Values -6756 MW / 0.1 Hz

Frequency at Point A 59.994 Hz

Frequency at Point B 59.888 Hz

Frequency at Point C 59.889 Hz

Avg. Frequency at Point A 60.001 Hz

**2908 MW/0.1Hz
 VS
 NERC-RS
 Estimate
 Of 3000**

C
 Events Frequency Response Results

B
 Interactive Events Analysis

Utilization of FMA for Analysis Report of All Events During Selected Period

Requested Events Frequency (Hz) Points A, B, C and Frequency Response (MW/0.1Hz)

Event	SourceName	Date	Time	Point-A	Time-A	Point-B	Time-B	Point-C	Time-C	FResponse
9776	VOLU-FQ	8/3/2007	12:39:29	59.964	12:39:28	59.949	12:39:37	59.948	12:39:36	3542
9780	VOLU-FQ	8/6/2007	13:11:24	59.99	13:11:23	59.954	13:11:37	59.952	13:11:32	3028
9783	VOLU-FQ	8/10/2007	00:57:41	60.016	00:57:40	59.98	00:57:53	59.977	00:57:49	4527
9784	VOLU-FQ	8/10/2007	01:58:17	59.998	01:58:16	59.961	01:58:29	59.959	01:58:24	4250
9791	VOLU-FQ	8/15/2007	23:27:00	59.994	23:26:59	59.976	23:27:10	59.969	23:27:05	4349
9796	VOLU-FQ	8/22/2007	12:06:59	59.996	12:06:58	59.966	12:07:09	59.965	12:07:08	4780
9799	VOLU-FQ	8/23/2007	16:30:54	60.001	16:30:53	59.974	16:31:05	59.973	16:31:02	4722
9801	VOLU-FQ	8/24/2007	03:50:14	59.997	03:50:13	59.971	03:50:24	59.97	03:50:21	3747
9805	VOLU-FQ	8/28/2007	13:53:14	59.993	13:53:13	59.957	13:53:25	59.956	13:53:23	3949
9809	VOLU-FQ	8/29/2007	14:59:08	59.987	14:59:07	59.978	14:59:18	59.975	14:59:13	4441
10003	VOLU-FQ	8/4/2007	17:44:17	59.994	17:44:16	59.888	17:44:27	59.889	17:44:26	2910

All Events for Period Selected

August 4, 2007 Event

Requested Events Consecutive Frequency (Hz), Net ACE Total, Ties and FBias (MW)

Event	Date	Time	Frequency	Frequency Data Quality	NetTotal ACE	NetTies ACE	NetFBias ACE	ACE Data Quality
9776	8/3/2007	12:39:09	59.974	0	-1403	-3171	1768	0
9776	8/3/2007	12:39:10	59.974	0	-1459	-3215	1757	0
9776	8/3/2007	12:39:11	59.974	0	-1459	-3202	1743	0
9776	8/3/2007	12:39:12	59.974	0	-1459	-3226	1768	0
9776	8/3/2007	12:39:13	59.974	0	-1459	-3215	1757	0
9776	8/3/2007	12:39:14	59.973	0	-1459	-3249	1790	0
9776	8/3/2007	12:39:15	59.972	0	-1459	-3325	1867	0
9776	8/3/2007	12:39:16	59.972	0	-1459	-3319	1860	0
9776	8/3/2007	12:39:17	59.972	0	-1459	-3352	1894	0
9776	8/3/2007	12:39:18	59.972	0	-1459	-3323	1865	0
9776	8/3/2007	12:39:19	59.972	0	-1459	-3370	1912	0
9776	8/3/2007	12:39:20	59.972	0	-1572	-3470	1898	0
9776	8/3/2007	12:39:21	59.973	0	-1572	-3425	1853	0
9776	8/3/2007	12:39:22	59.972	0	-1572	-3468	1896	0
9776	8/3/2007	12:39:23	59.973	0	-1572	-3407	1835	0
9776	8/3/2007	12:39:24	59.973	0	-1572	-3425	1853	0
9776	8/3/2007	12:39:25	59.973	0	-1572	-3412	1840	0
9776	8/3/2007	12:39:26	59.972	0	-1572	-3432	1860	0
9776	8/3/2007	12:39:27	59.97	0	-1572	-3569	1998	0
9776	8/3/2007	12:39:28	59.964	0	-1572	-4017	2446	0
9776	8/3/2007	12:39:29	59.955	0	-1572	-4607	3036	0
9776	8/3/2007	12:39:30	59.954	0	-1632	-4747	3115	0
9776	8/3/2007	12:39:31	59.95	0	-1632	-4979	3346	0
9776	8/3/2007	12:39:32	59.954	0	-1632	-4767	3135	0
9776	8/3/2007	12:39:33	59.953	0	-1632	-4783	3151	0
9776	8/3/2007	12:39:34	59.951	0	-1632	-4911	3279	0
9776	8/3/2007	12:39:35	59.949	0	-1632	-5062	3430	0

1-Second Data For Event Selected

FUTURE IMPROVMENTS

Frequency Monitoring and Analysis (FMA) Timeline and Plans

- Research started in 2002
- Research challenges – availability of high resolution time synchronized data, data redundancy, data analysis and user friendly interactive design
- FMA designed to take advantage of Phasor and FNET research and demonstrations
- Application Functional Description Developed in 2005
- Research on Prototype Design and Development Started in 2007
- Application Testing Started in 1Q08
- NERC Resources Subcommittee Field Trial Planned During 2Q2008
- Target to Transition to NERC Production Environment During 3Q08
- Plan to Continue Research on FMA functionality, Short-Term Intelligent Alarms for Notification, Functional Changes based on User Feedback, and Integration of FNET data