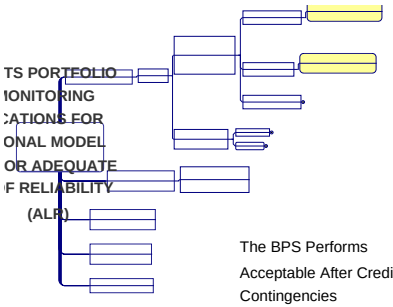
NERC – CERTS
Frequency Monitoring and Analysis (FMA)

NERC-CERTS Portfolio of Reliability Monitoring Applications



Grid Resources Adequacy Applications Portfolio

Steady State

Dynamics

The BPS Performs Acceptable After Credible Contingencies

CERTS-PSERC Research on New Security Algorithms and Monitoring Applications

The BPS Is Designed To Contain Instability And Cascading Outages

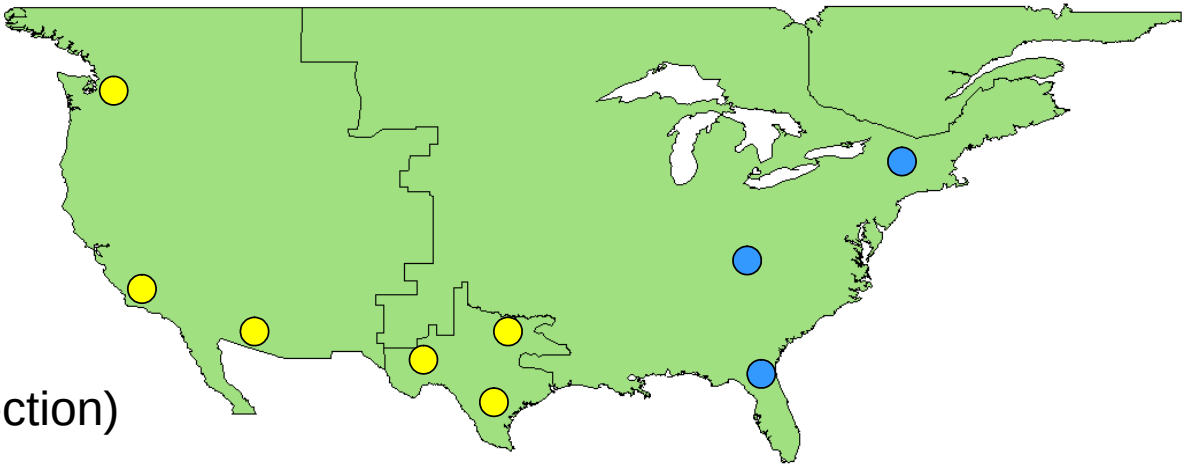
BPS Facilities Are Protected From Severe Damage

The BPS's Integrity Can Be Restore If It Is Lost

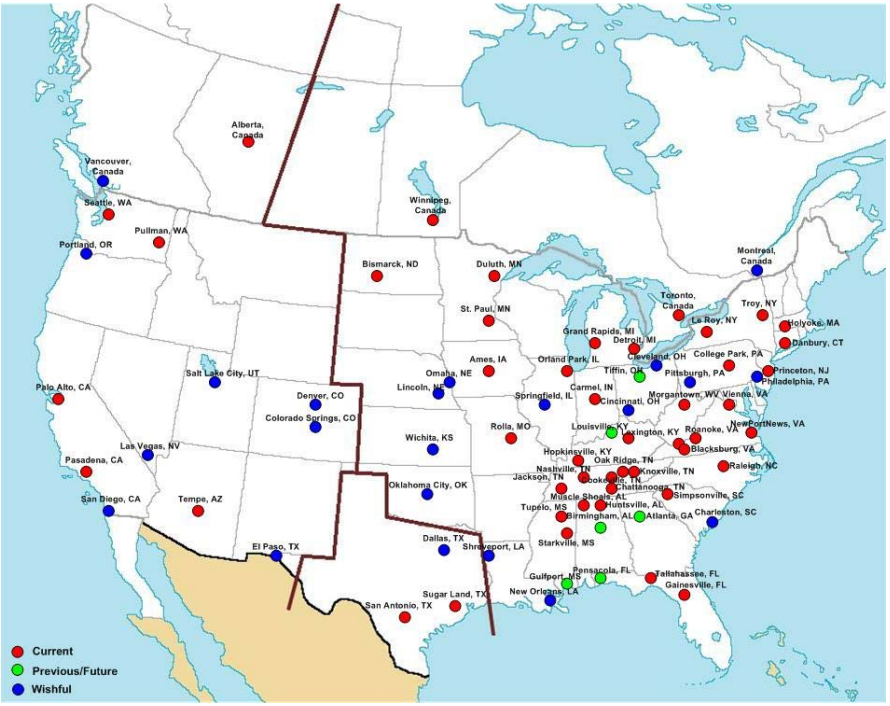
Phasor Data Sources Geographic Location

PMU Phasor Data Sources
(30 Samples/Sec.,3-Per Interconnection, averages Over 1-Sec)

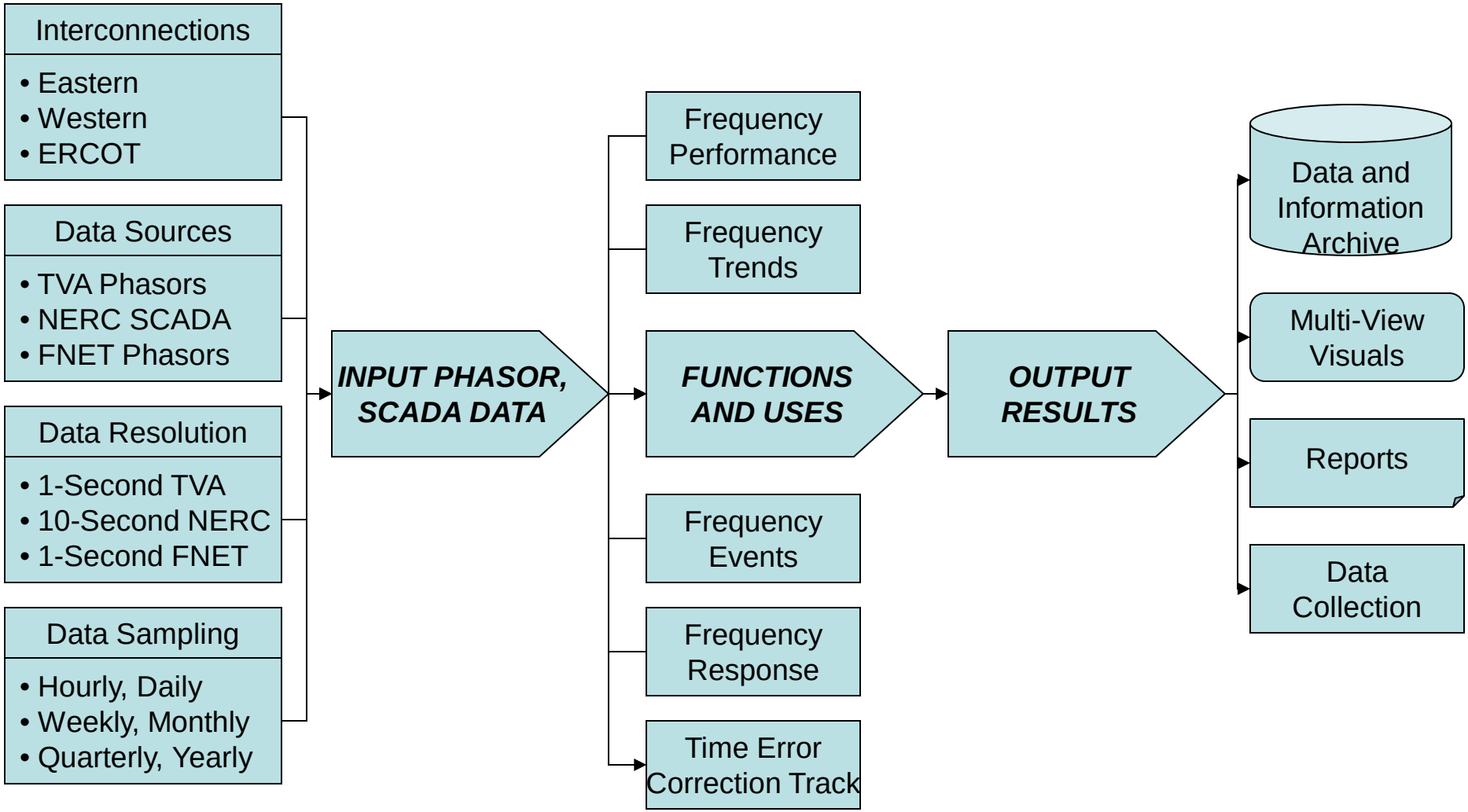
SCADA Balancing Authorities Data Sources
(10-Sec Data 3-Per Interconnection)



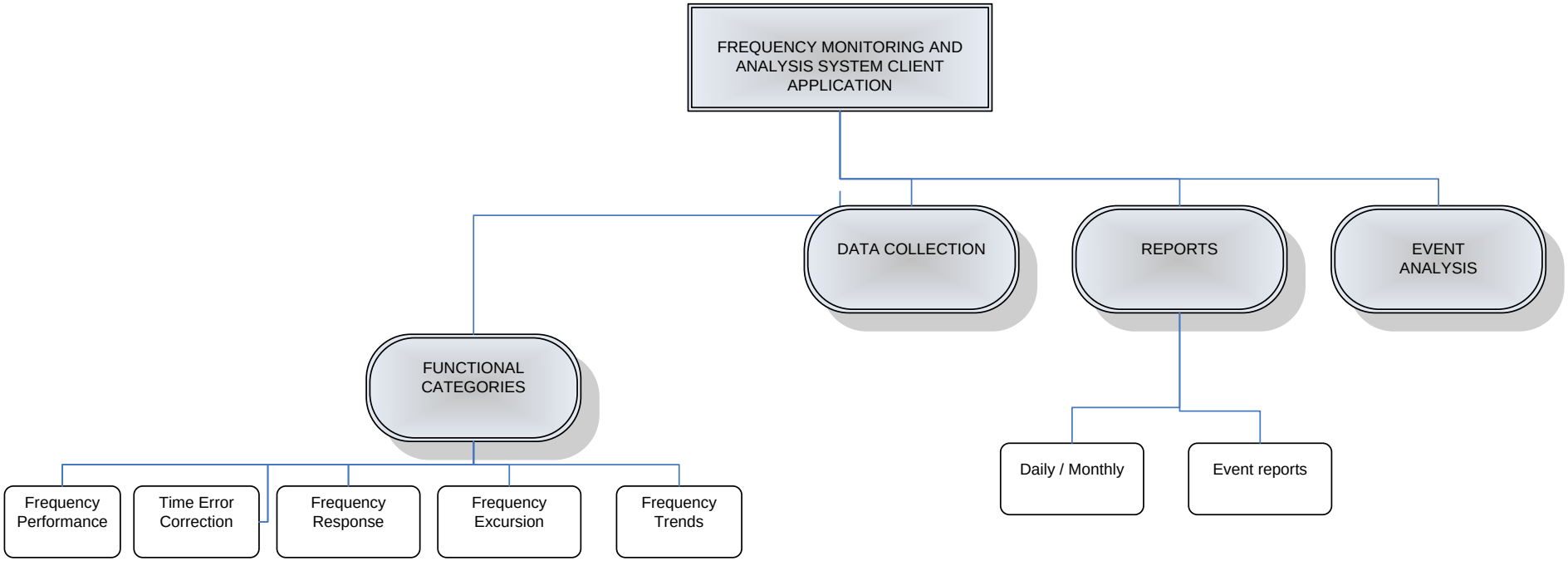
FUTURE – 2009
FNET Phasor Data Sources
(1-Sec from 10 Samples/Sec., 3-Per Interconnection – Future Currently in research mode)



NERC Frequency Monitoring and Analysis (FMA) For Interconnections – Functional Overview



FMA Navigation



Data Availability

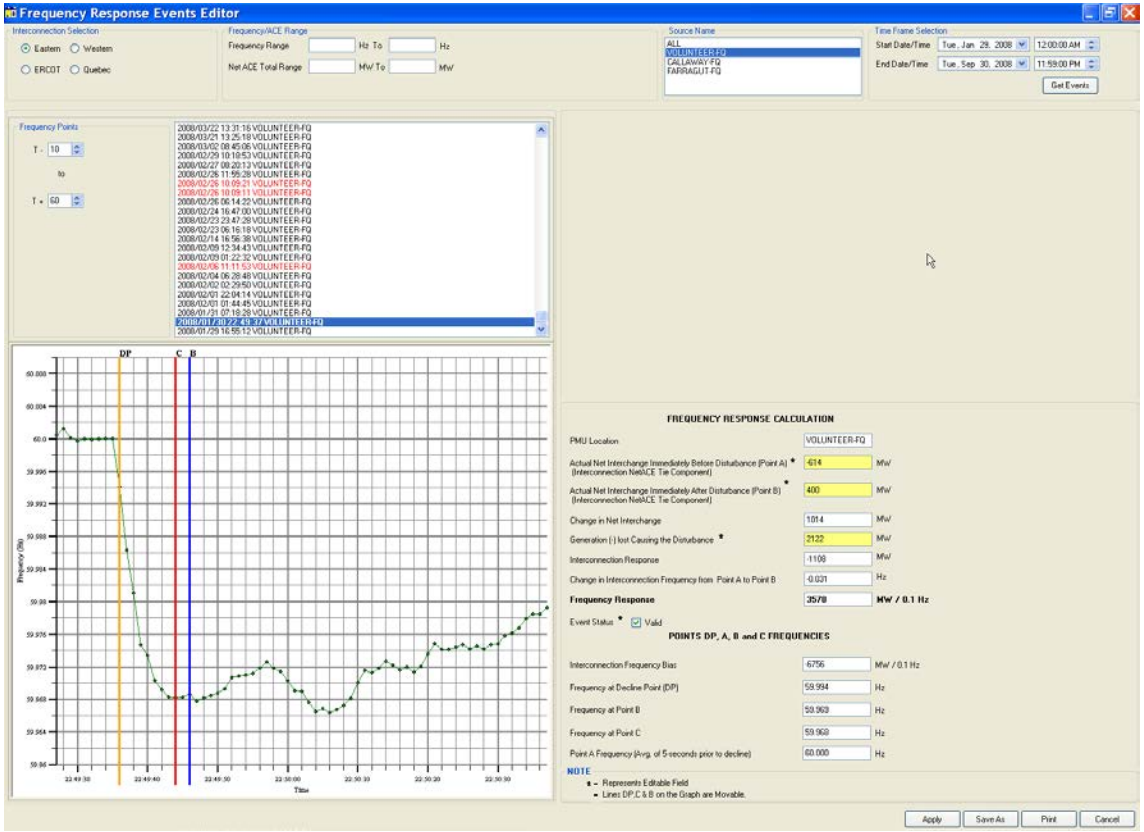
FMA Phasor 1-Second and SCADA 10-Second Source Devices Data Availability

Revision: 02.19.09

FMA Data Type	Data Source Name	Jan-07	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	2008	2009
TVA Phasor 1-second	VOLUNTEER-FQ-EI						1%	90%	98%	98%	100%	100%	98%	96%	98%	59%	99%	100%	100%	98%	100%	98%	99%	84%	98%	96%	98%	99%	93%	98%	90%	92%	98%	98%	96%	94%	96%
	CALLAWAY-FQ-EI						1%	97%	98%	98%	99%	99%	97%	94%	98%	59%	98%	99%	99%	97%	99%	98%	99%	84%	97%	95%	97%	97%	92%	98%	80%	65%	17%	82%	96%	93%	82%
	FARRAGUT-FQ-EI						0%	72%	41%	49%	61%	63%	79%	88%	91%	63%	89%	95%	92%	46%	0%	69%	95%	82%	95%	94%	94%	91%	89%	95%	76%	81%	0%	0%	0%	75%	62%
ERCOT 2-second	ERCOT2Sec													100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%	100%	100%	97%	100%	100%	32%	0%	0%	100%	73%
NERC SCADA 10-second	ISNE-EI							69%	100%	99%	92%	92%	99%	98%	91%	98%	100%	100%	100%	99%	98%	90%	81%	100%	99%	97%	98%	80%	100%	98%	96%	99%	97%	95%	84%	96%	94%
	PJM-EI							69%	99%	99%	92%	92%	99%	98%	92%	99%	100%	100%	100%	99%	99%	90%	81%	100%	99%	97%	98%	80%	98%	97%	96%	99%	97%	95%	84%	96%	94%
	TVA-EI							60%	100%	99%	92%	90%	99%	98%	92%	99%	98%	100%	100%	99%	99%	90%	80%	100%	99%	97%	98%	80%	97%	99%	97%	99%	97%	92%	84%	96%	94%
	BCTC-WECC							68%	99%	98%	92%	92%	99%	95%	92%	99%	100%	100%	99%	98%	99%	83%	76%	100%	99%	97%	98%	0%	0%	0%	0%	0%	0%	0%	0%	95%	20%
	PNM-WECC							68%	99%	99%	92%	92%	100%	96%	92%	100%	99%	100%	98%	98%	99%	83%	76%	100%	99%	97%	98%	80%	97%	99%	97%	99%	97%	95%	84%	95%	94%
	HQT							68%	99%	99%	92%	92%	100%	98%	91%	99%	100%	100%	100%	99%	77%	90%	80%	100%	99%	97%	98%	80%	98%	99%	97%	99%	97%	95%	84%	94%	94%
	ERCOT(Start 10/08)																					19%	62%	82%	77%	90%	92%	91%	91%	91%	90%	89%	89%	88%	87%	60%	90%
TEC 10-second	EI	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	98%	92%	99%	100%	100%	100%	100%	99%	90%	81%	99%	99%	97%	98%	81%	98%	97%	96%	99%	94%	98%	87%	96%	94%
	ERCOT													100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	22%	0%	0%	0%	0%	0%	0%	0%	0%	100%	12%
	WI					29%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%	83%	75%	99%	99%	97%	98%	81%	97%	99%	96%	99%	97%	98%	86%	96%	95%
FNET Phasor 1-second (In Progress)	EIVirtual	92%	88%	97%	73%	96%	92%	86%	83%	88%	80%	92%	87%	99%	99%	98%	97%	100%	100%	100%	100%	100%	100%	99%	96%	99%	98%	95%	100%	99%	95%	98%	99%	100%	99%	99%	98%
	FSU - Tallahassee, FL	86%	88%	80%	34%	96%	92%	83%	69%	78%	0%	0%	0%	0%	0%	0%	0%	3%	97%	0%	40%	0%	0%	0%	0%	95%	96%	92%	0%	98%	95%	97%	97%	100%	99%	12%	87%
	IMPA-Carmel, IN	95%	90%	99%	83%	95%	88%	0%	22%	87%	85%	94%	88%	99%	95%	43%	21%	99%	30%	71%	77%	100%	100%	98%	96%	98%	98%	95%	96%	98%	95%	98%	97%	100%	99%	77%	98%
	UMR - Rolla, MO	49%	34%	48%	62%	96%	42%	81%	1%	0%	0%	0%	83%	98%	95%	94%	97%	99%	88%	34%	21%	0%	1%	0%	23%	45%	0%	22%	0%	74%	95%	55%	97%	100%	93%	54%	58%
	VT-Blacksburg, VA	95%	91%	99%	77%	96%	86%	88%	84%	87%	84%	85%	87%	95%	3%	94%	97%	100%	98%	97%	98%	99%	100%	99%	69%	92%	98%	95%	94%	86%	77%	74%	79%	74%	78%	88%	85%
	ERCOTVirtual	91%	81%	96%	80%	91%	92%	31%	73%	87%	65%	65%	10%	67%	83%	98%	100%	100%	100%	100%	100%	99%	99%	99%	75%	6%	22%	19%	98%	82%	0%	75%	98%	100%	99%	93%	60%
	Houston	94%	84%	99%	83%	91%	92%	31%	77%	87%	70%	65%	10%	0%	14%	97%	99%	98%	100%	99%	99%	39%	1%	98%	44%	1%	5%	14%	94%	82%	0%	71%	92%	100%	99%	66%	56%
	UTSA - San Antonio,	87%	83%	87%	79%	86%	91%	32%	73%	20%	0%	0%	0%	0%	3%	93%	93%	90%	80%	44%	26%	0%	0%	0%	0%	5%	17%	6%	0%	0%	0%	67%	36%	0%	0%	36%	13%
	WECCVirtual	91%	88%	95%	78%	96%	91%	86%	83%	88%	80%	94%	87%	99%	99%	98%	99%	100%	100%	100%	100%	100%	100%	99%	96%	100%	99%	99%	100%	100%	95%	98%	100%	100%	99%	99%	99%
	Alberta - Edmonton, A	69%	37%	89%	66%	75%	57%	70%	55%	2%	0%	0%	26%	22%	18%	0%	0%	0%	0%	0%	4%	8%	0%	0%	0%	22%	0%	4%	41%	59%	93%	55%	0%	0%	0%	4%	27%
	EPRI-Palo Alto, CA	94%	90%	99%	21%	57%	50%	86%	76%	85%	81%	93%	85%	96%	94%	96%	98%	99%	98%	99%	99%	99%	99%	97%	89%	82%	97%	97%	95%	99%	94%	94%	78%	0%	0%	97%	74%
	LA-Pasadena,CA	0%	0%	12%	84%	95%	91%	86%	77%	88%	85%	94%	88%	96%	97%	97%	99%	99%	98%	100%	100%	87%	99%	97%	96%	96%	99%	98%	22%	0%	48%	93%	89%	86%	0%	97%	63%
	NewWSU - Pullman, W	47%	42%	35%	26%	12%	0%	0%	0%	0%	71%	0%	0%	0%	0%	0%	0%	0%	3%	100%	45%	0%	0%	0%	0%	83%	9%	0%	0%	97%	94%	0%	43%	78%	95%	12%	50%

RECOMMENDATION – Before Setting the time-window and type of data to use for your analysis, check the percentage data availability from the above and next four slides tables, and adjust your analysis results accordingly

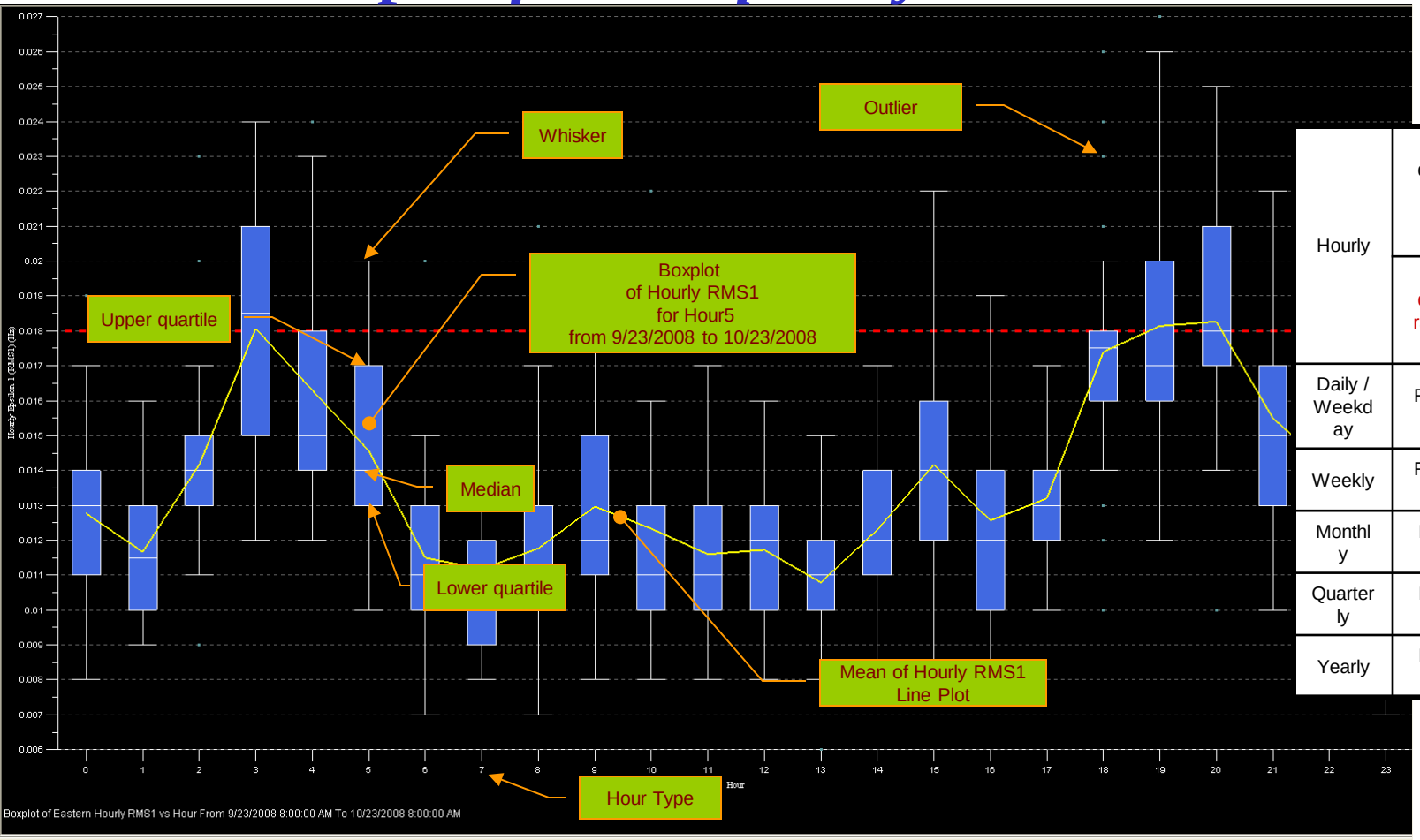
Events Frequency Response Editor Capability



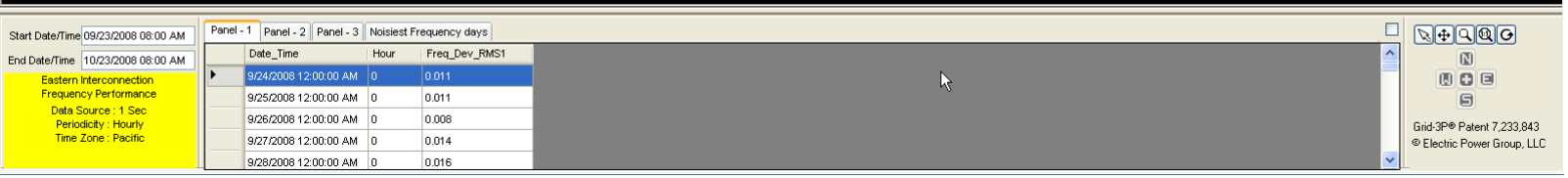
Frequency Response Calculation Method	Frequency Data Source	Frequency at Point A	Frequency at Point C	Frequency at Point B	MW Loss Source	Frequency Response Calculation
FMA Method (Uses NERC Guide in Training Document)	TVA 1-second phasor data	Average of the **5** Frequencies before the decline point *	Lowest frequency for the next **10** seconds after the decline point	Highest frequency for the next **5** seconds after Point C	Calculated value using NERC 10-second NetACE Bias data **	FMA automatically calculates Frequency Response using the NERC-Guide method (Training Document -2/20/2003)

Decline Point Definition Used by FMA: The Decline Point is Defined at the Time When the Standard Deviation of 8 Consecutive Frequencies is Greater than Predefined Threshold.
**** Loss MW Calculation in FMA** = Interconnection NetACE Bias at Point A – Interconnection NETACE Bias at Point B.
Yellow Text Box, Valid Check Box, Line DP, C and B – Are Editable. User can See the Changes of calculated Frequency Response by Moving or Change These Information. Only Authorized User Have the Ability to Save the Changes into the Database by Clicking Apply button. Once These Changes are Saved, They are Available to All the UIsers.
Valid status - Frequency Response Event Detected from Primary Data Source is Initially Marked as Valid. The Event Detected from non-Primary Data Source is Initially Marked as Invalid. The Event with Calculated Frequency Response is not in [0,8000] MW/0.1Hz is Initially Marked as Invalid. Invalid Events are Shown in Red in Event List. Valid Events are Shown in Black in Event List.
Frequency/ACE Range – Can Help to Further Narrow Down the Event Shown in Event List. If User doesn't Want to Narrow Down, He does not Need to Enter Anything. ACE Range is Used to Define the Range of NetACE at Point C. Frequency Range is used to Define the Frequency Range at Point C.

Frequency Performance Displays Set Boxplot for Frequency Deviation RMS1



Hourly	Selected date/time range <=48 Hours	RMS1 for each **10-minute period** of range selected
	Selected date/time range >48 Hours	RMS1 for each **hour** of range selected
Daily / Weekday	RMS1 for each **hour** of range selected	
Weekly	RMS1 for each **hour** of range selected	
Monthly	RMS1 for each **day** of range selected	
Quarterly	RMS1 for each **day** of range selected	
Yearly	RMS1 for each **day** of range selected	

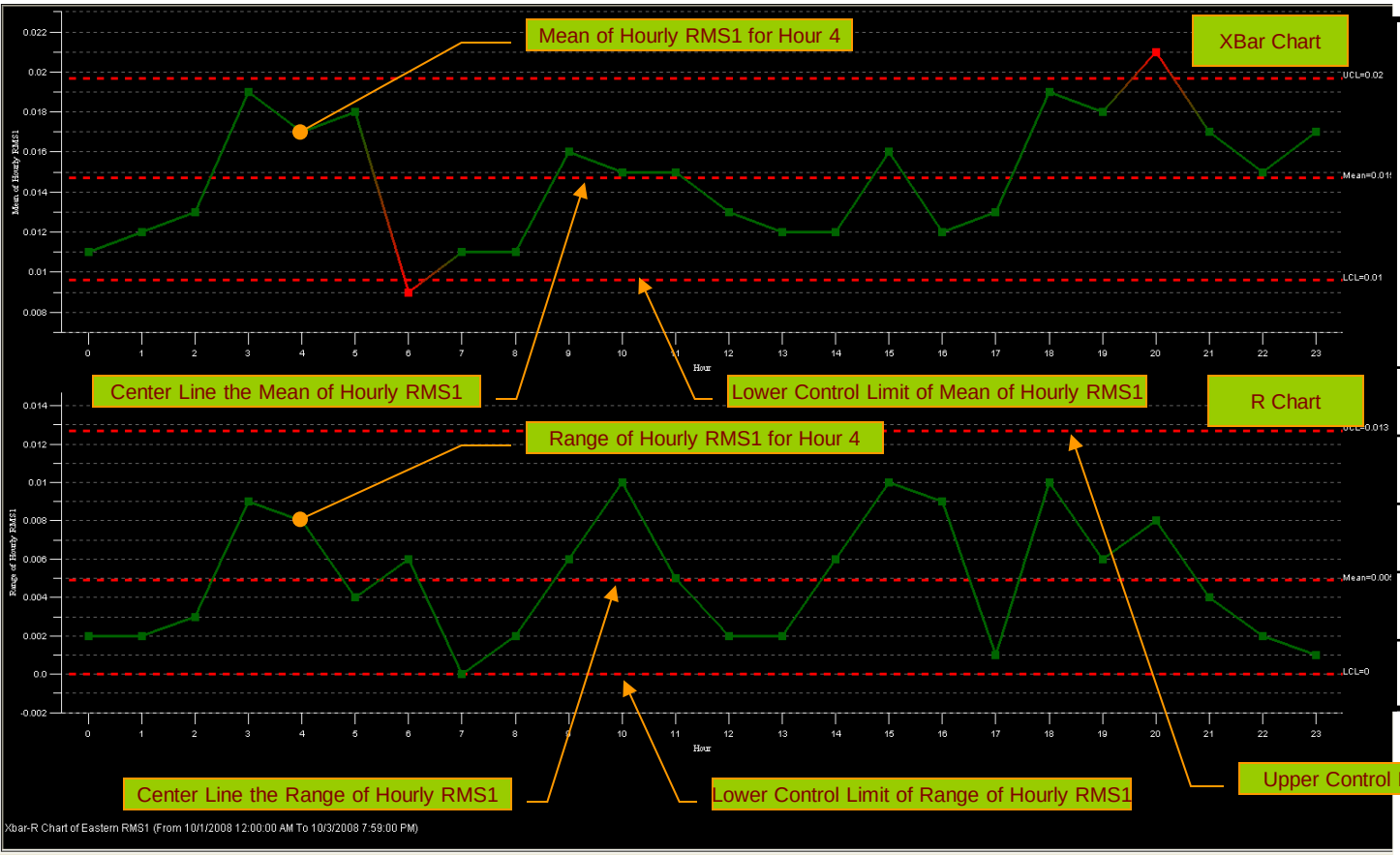


Boxplot Parameters – Boxplot produces a box and whisker plot using the sampling data for user selected timeframe. The box has lines at the lower quartile, median, and upper quartile values. The whiskers are lines extending from each end of the box to show the extent of the rest of the data. Any data observation which lies more than 1.5 IQR (interquartile range) lower than the first quartile or 1.5 IQR higher than the third quartile is considered an outlier.

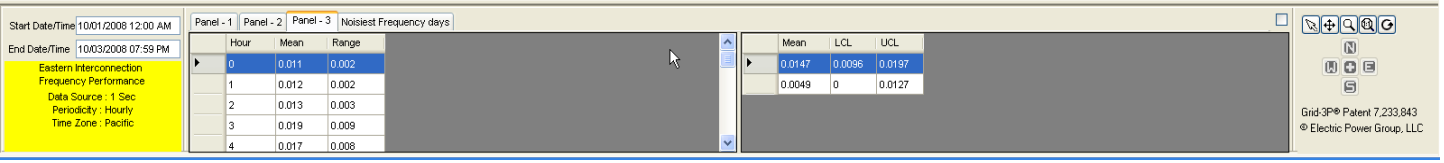
RMS1 - Root Mean Square of 1-Minute Average Frequency Deviation.

Frequency Deviation – The Deviation of Frequency from Scheduled Frequency.

Frequency Performance Displays Set Frequency X-Bar R-Chart



Hourly	Selected date/time range <=48 Hours	RMS1 for each **10-minute period** of range selected
	Selected date/time range >48 Hours	RMS1 for each **hour** of range selected
Daily / Weekday	RMS1 for each **hour** of range selected	
Weekly	RMS1 for each **hour** of range selected	
Monthly	RMS1 for each **day** of range selected	
Quarterly	RMS1 for each **day** of range selected	
Yearly	RMS1 for each **day** of range selected	



Xbar-R Chart – Xbar Chart depicts the sample means and R Chart depicts the sample ranges. The charts plot the means of the subgroups, a center line at the average of the means, and upper and lower control limits (UCL, LCL) is calculated values based on the size of sample subgroup (see http://www.qualityspctools.com/control.html for detail). Out of control measurements are marked as violations and drawn in red. The X-Bar is indicative of the variation of the Mean, and the R-Chart indicative of the sensitivity of each sample.