

Implementation of Synchrophasors at BPA

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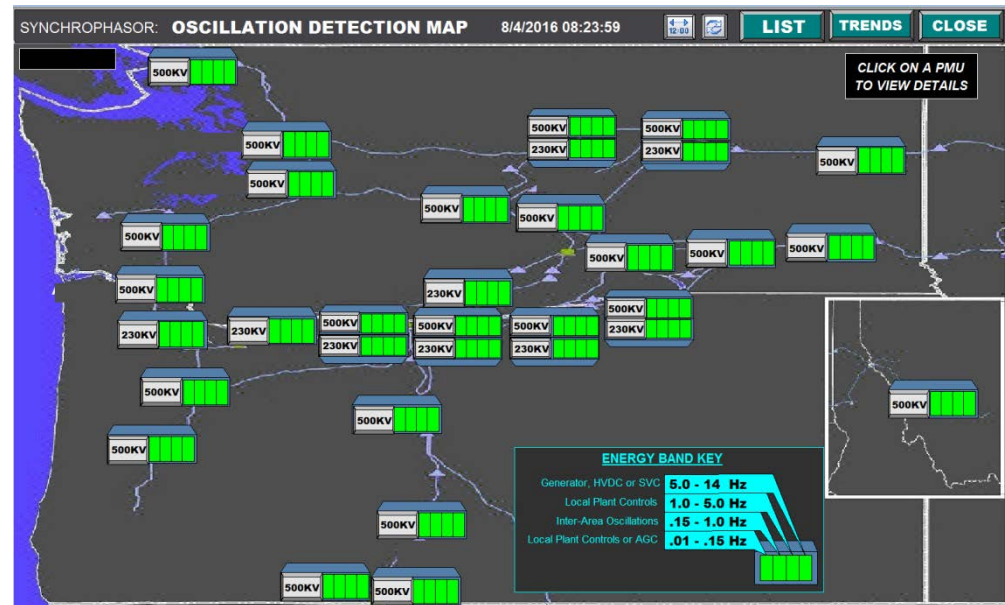
Outline

- Oscillation Detection Monitor
- Frequency Disturbance Source Detection
- Phase Angle Monitoring
- Synchrophasor Remedial Action Schemes

Oscillation Detection Monitor (ODM)




ODM

- 68 PMUs, 150 total measurements monitored for oscillations
- Filter Oscillations in 4 frequency bands:
 - Band 1: 0.01-0.15 Hz
 - Band 2: 0.15-1.0 Hz
 - Band 3: 1.0-5.0 Hz
 - Band 4: 5.0-14.0 Hz

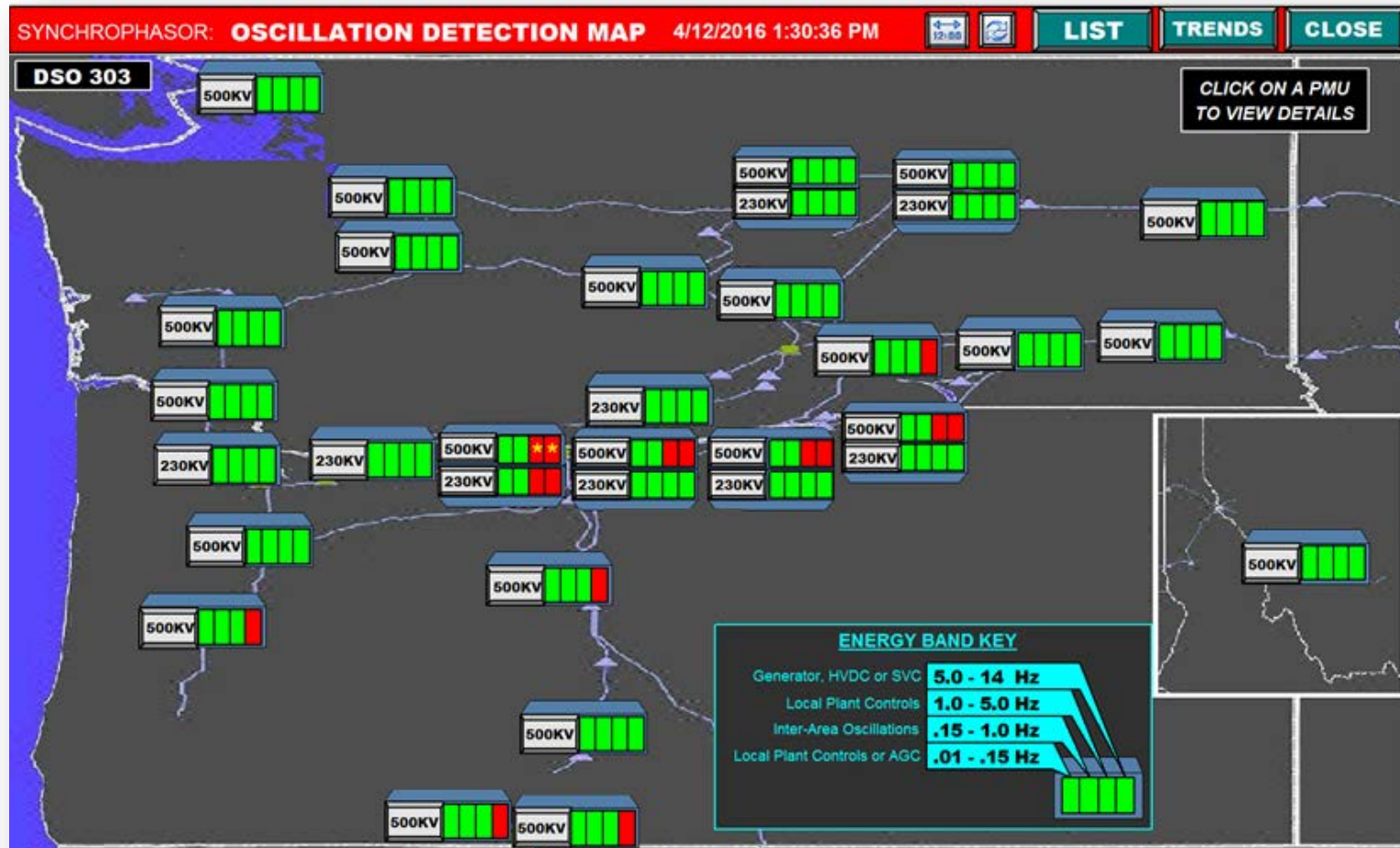


ODM

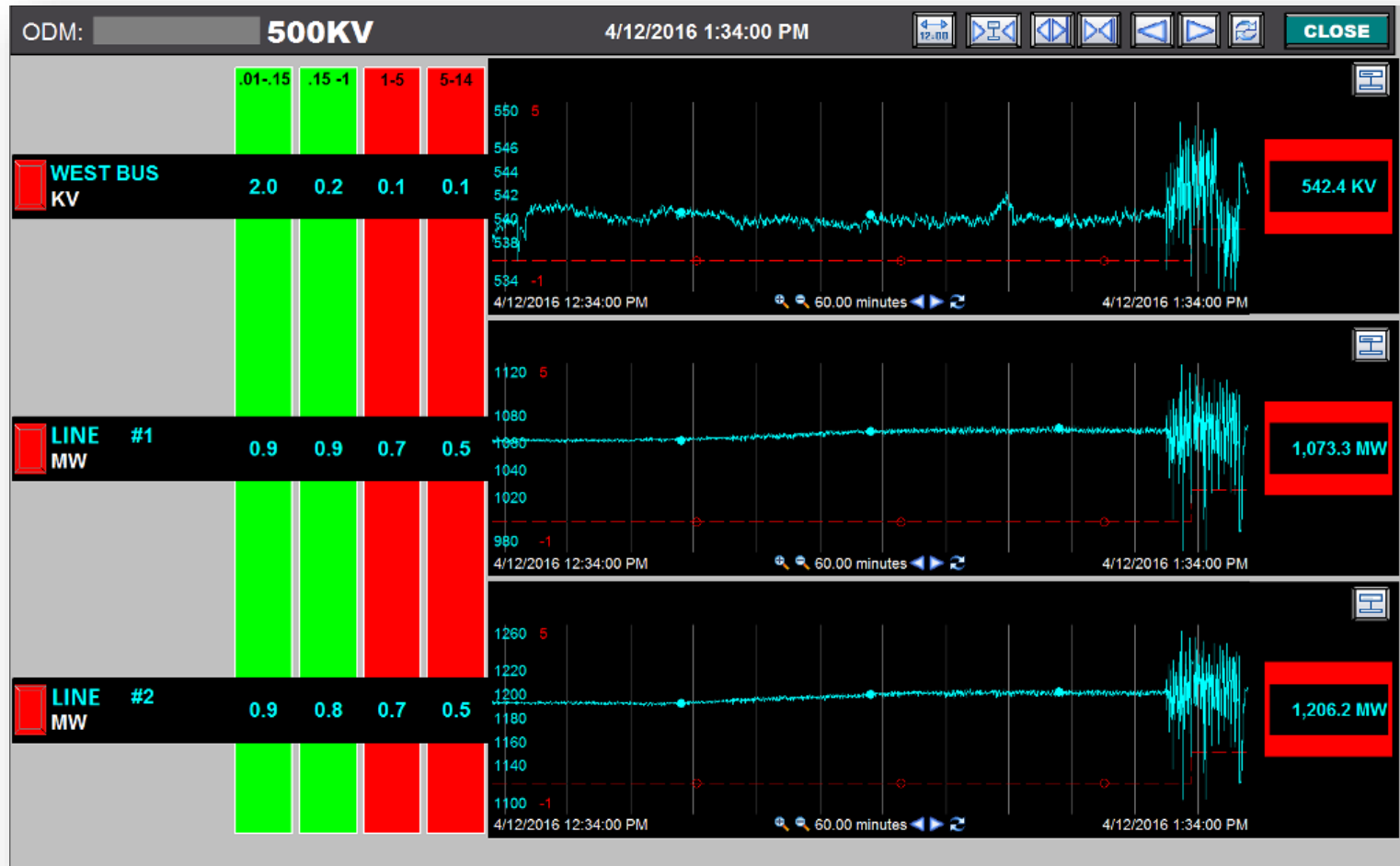
- Landing page for App
- Step forward and back through time to show more events.

SYNCHROPHASOR OSCILLATION EVENT HISTORY					9/19/2017 08:04:54		  	
					DETAILS	MAP	TRENDS	CLOSE
Event Time	Duration (Minutes)	Maximum Energy	Energy Band	Measurement with Maximum RMS Energy	Site Count	Multiple Bands		
09/12/2017 07:47:00	26.2	3.80	2	01.L500 PH 1.MW	1			
09/01/2017 04:20:40	3.7	2.73	3	01.T500BANK2 1.MW	2			
09/01/2017 04:08:10	6.2	2.79	3	01.T500BANK2 1.MW	1			
09/01/2017 03:59:20	4.3	2.50	3	01.T500BANK2 1.MW	1			
09/01/2017 03:40:10	13.2	2.46	3	01.T500BANK2 1.MW	1			
09/01/2017 03:25:50	6.5	2.42	3	01.T500BANK2 1.MW	1			
09/01/2017 03:15:00	6.8	2.44	3	01.T500BANK2 1.MW	1			
09/01/2017 03:08:10	3.2	2.53	3	01.T500BANK2 1.MW	1			
09/01/2017 02:45:30	15.3	3.49	3	01.T500BANK2 1.MW	1			
09/01/2017 02:35:50	3.2	2.22	3	01.T500BANK2 1.MW	1			
09/01/2017 02:12:40	6.2	2.20	3	01.T500BANK2 1.MW	1			
09/01/2017 01:40:50	6.5	2.37	3	01.T500BANK2 1.MW	1			
09/01/2017 01:09:40	6.0	2.40	3	01.T500BANK2 1.MW	1			
09/01/2017 01:02:20	3.0	2.45	3	01.T500BANK2 1.MW	1			
09/01/2017 00:41:40	2.5	2.58	3	01.T500BANK2 1.MW	2			

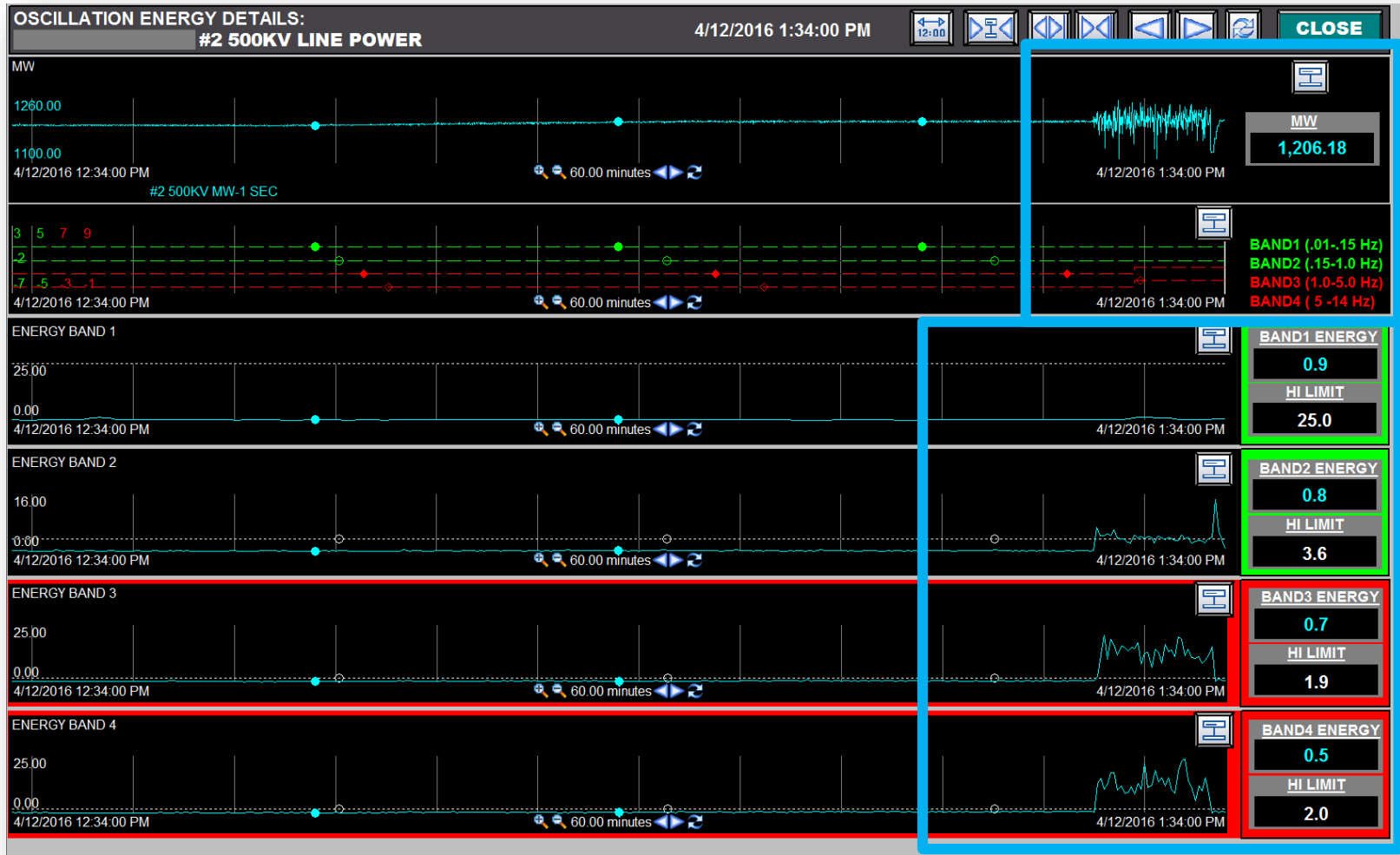
ODM



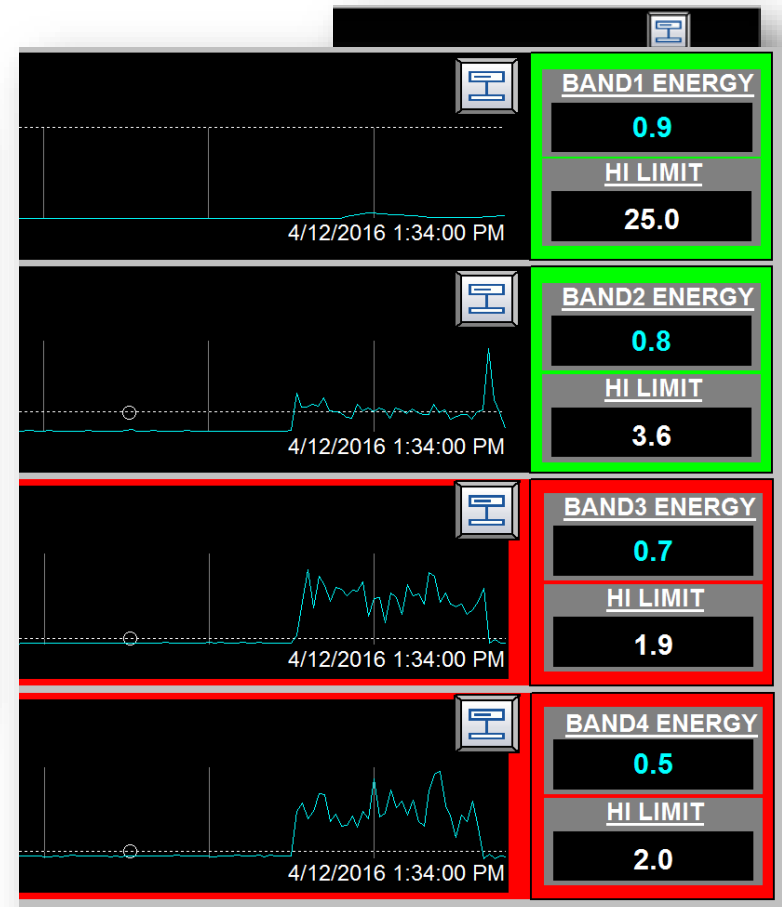
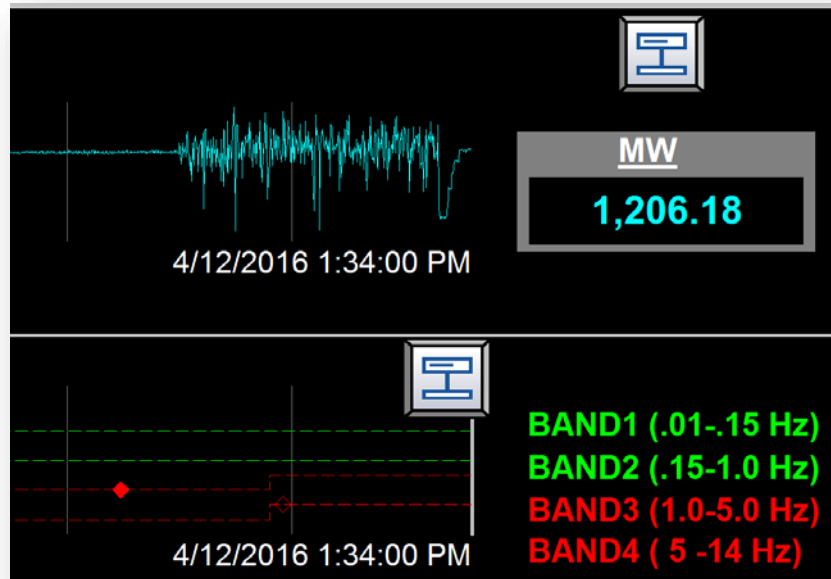
ODM



ODM



ODM



ODM

- Operational on June 1st, 2016
- BPA System Operators must respond to alarms
 - Dispatch Standing Order
- Single PMU Site Alarm
 - System Operators contact field staff at alarmed measurement point.
- Multiple PMU Sites Alarm
 - System Operators take more proactive approach

Frequency Disturbance Monitor (FDM)

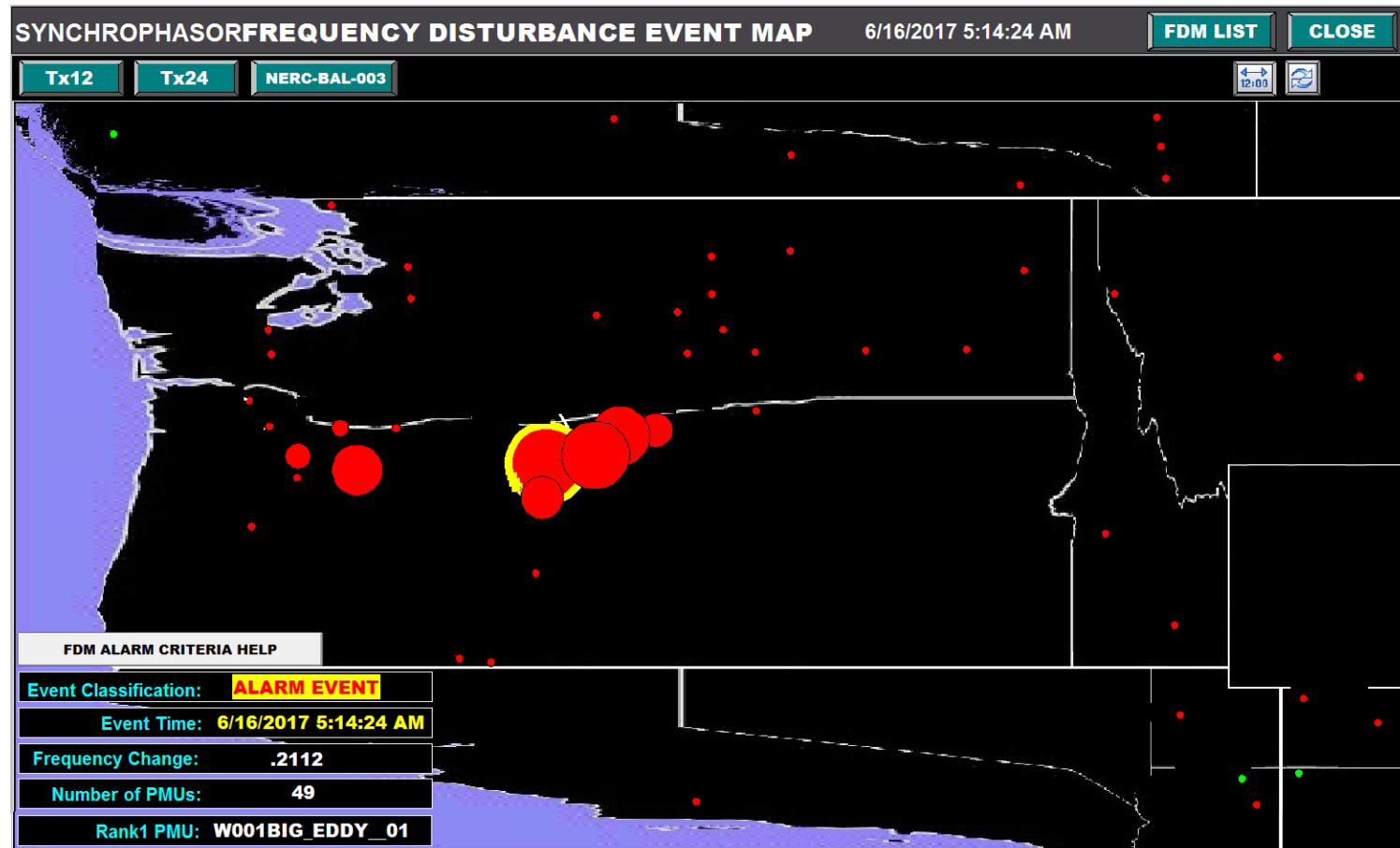
FDM

- Monitoring 52 PMU installations across Western Interconnection
- Alarm Event:
 - 10 or more PMUs detect event
 - Drop of at least 0.04 Hz from pre-event frequency
 - 0.04 Hz deviation persists for at least 10 seconds
- Non-alarm Event:
 - At least 4 PMUs, but less than 10 PMUs detect event
 - Deviation of at least 0.04 Hz from pre-event.
 - 0.04 Hz deviation persists for at least 10 seconds

FDM

SYNCHROPHASOR: FREQUENCY DISTURBANCE SUMMARY					9/19/2017 09:36:29	CLOSE
SRM	MWF %DEGdX	MWF %LIMIT	FDM MAP			
Event Start Time	Magnitude (Hz)	Rank1 PMU	PMU Count	Alarm Event	SRM Out-of-Plane Count	
09/17/2017 14:49:45	.0405	SRP	47	Alarm		
09/17/2017 06:28:27	.0461	TSGT	47	Alarm		
09/14/2017 21:04:45	.1342		47	Alarm		
09/14/2017 14:55:09	.0591	SRP	48	Alarm		
09/14/2017 08:52:39	.0500	WAPA	48	Alarm		
09/11/2017 17:23:52	.0735	SRP	48	Alarm		
09/09/2017 20:45:56	.1107		48	Alarm		
09/09/2017 15:42:06	.0465	AESO	48	Alarm		
09/02/2017 14:17:22	.0124		33		14	
09/02/2017 05:13:55	-.0129		41			
09/01/2017 15:33:47	.0308		39		17	
08/21/2017 23:41:26	.0442		48	Alarm		
08/20/2017 16:05:43	.0863		48	Alarm		
08/19/2017 13:02:33	.0404	SRP	46	Alarm		
08/15/2017 12:27:28	.0432	TSGT	44	Alarm		

FDM

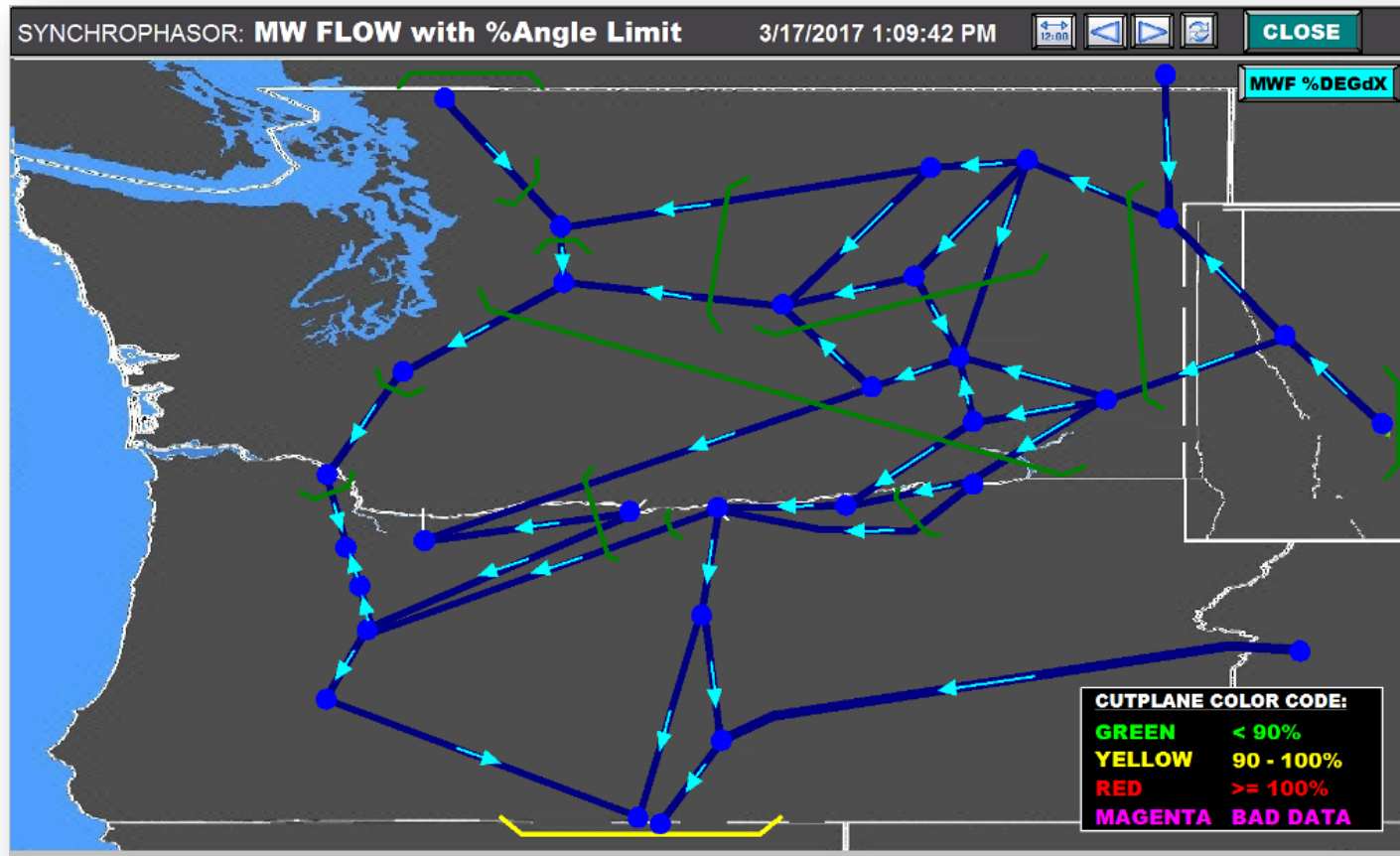


FDM

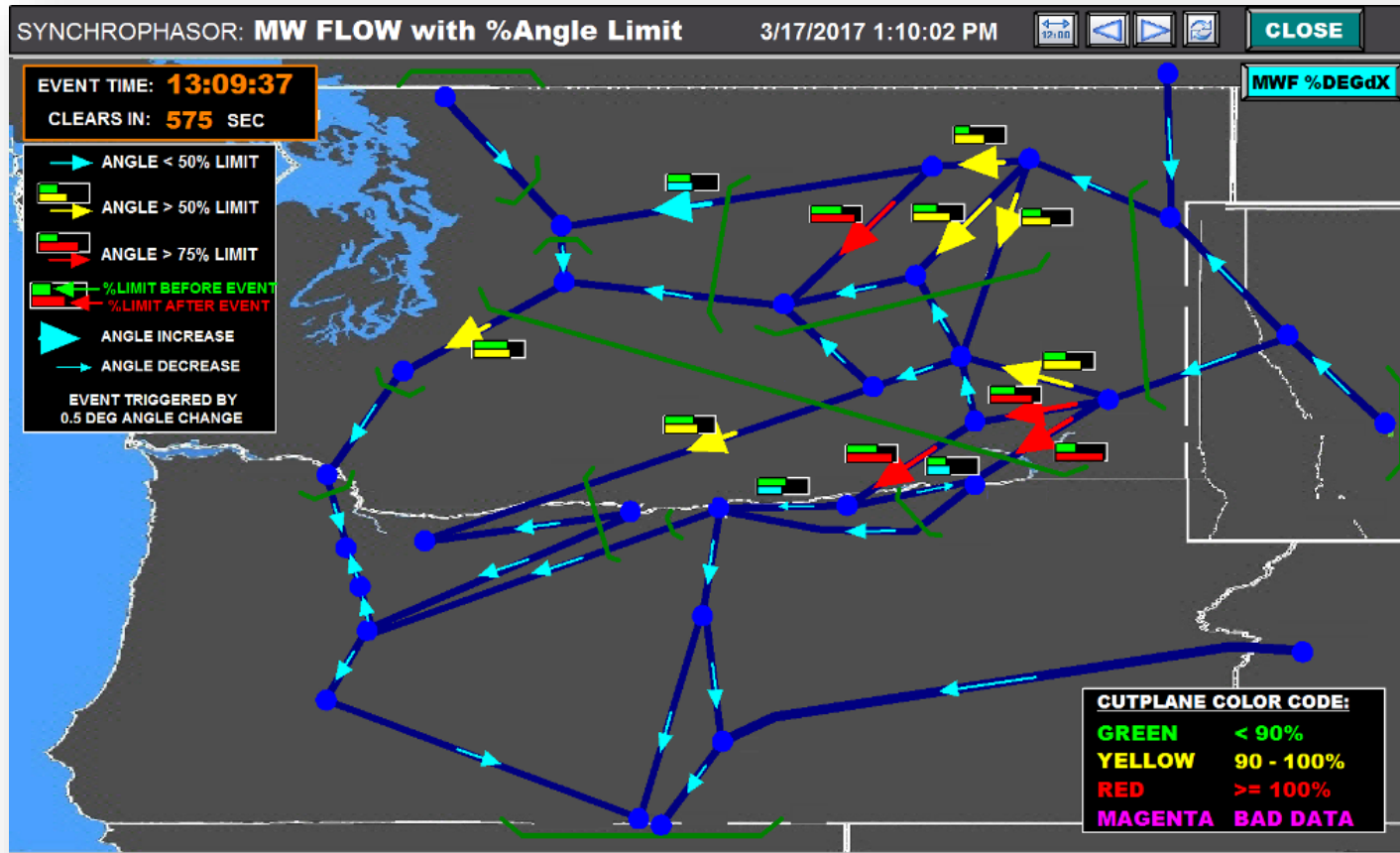


Phase Angle Monitoring

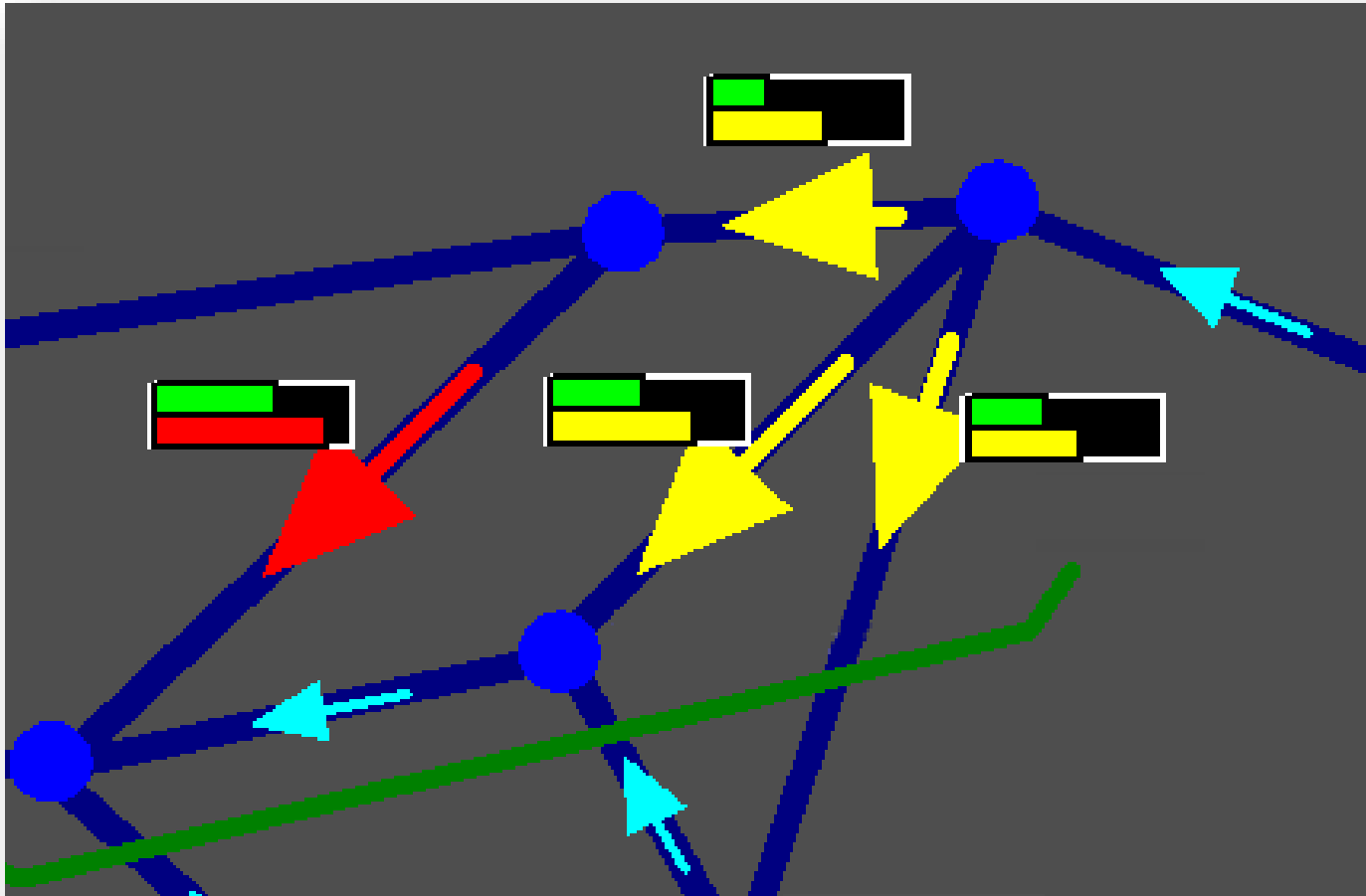
Phase Angle Monitoring



Phase Angle Monitoring



Phase Angle Monitoring



Synchrophasor Remedial Action Scheme (RAS)

Synchrophasor RAS

- Response Based RAS
 - Operational in April 2017
 - WECC approved
 - First PMU sourced RAS system
 - Uses data from 6 PMUs (4 substations) to conditionally operate reactive grid devices.

Questions

Special thanks to Jeff Anderson, Kliff Hopson, Dmitry Kosterev, Nick Leitschuh