Synchrophasor Solutions Deployment at PG&E Off-Line Analysis

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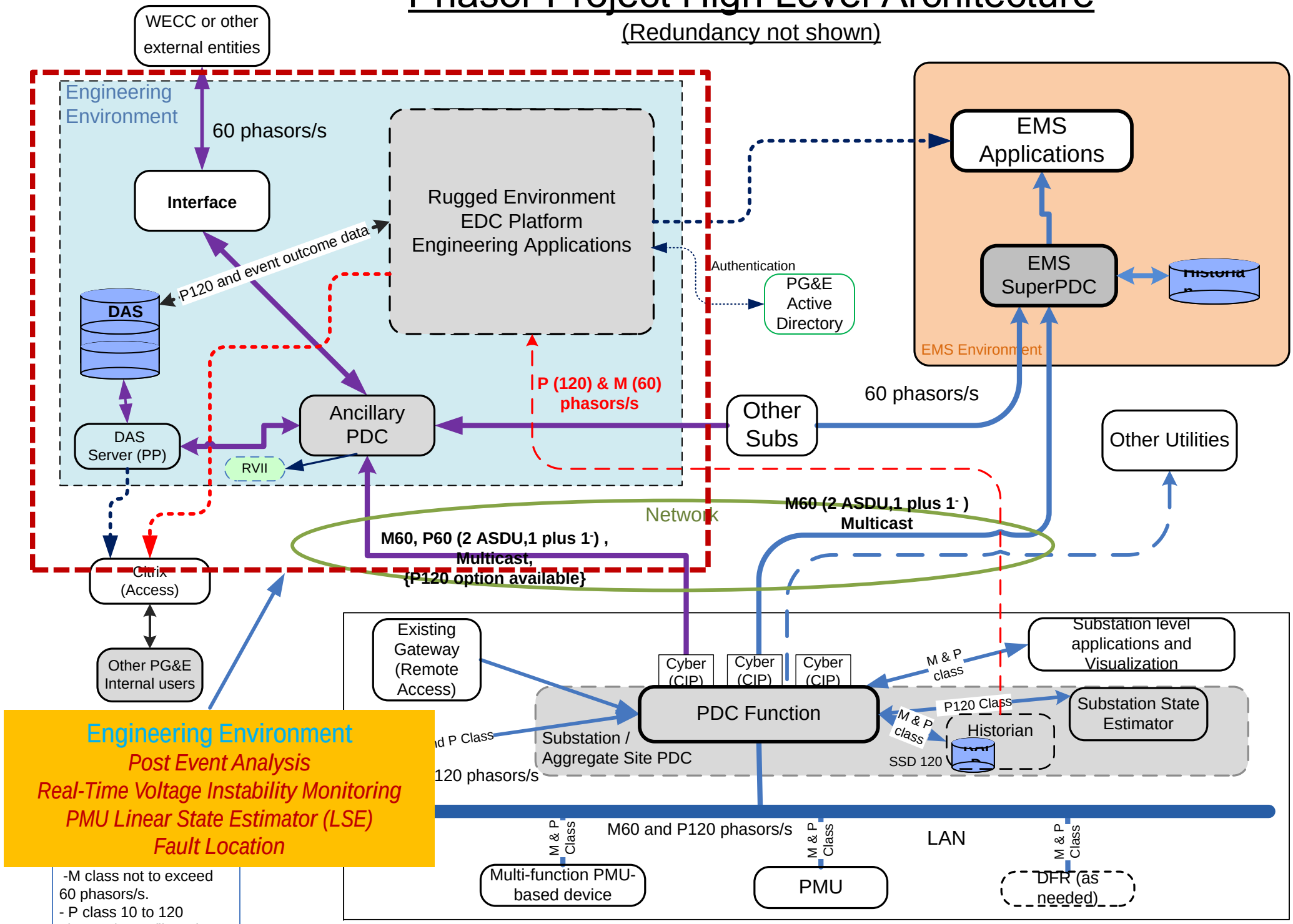
Outline

- Offline Engineering Applications at PG&E
- Post Event Analysis (May 30th Event)
- Dynamic Performance Baselining
- Dynamic DTS and Historical Playback
- Linear State Estimator (LSE)

Phasor Project High Level Architecture

(Redundancy not shown)



Offline Engineering Analysis Use Cases

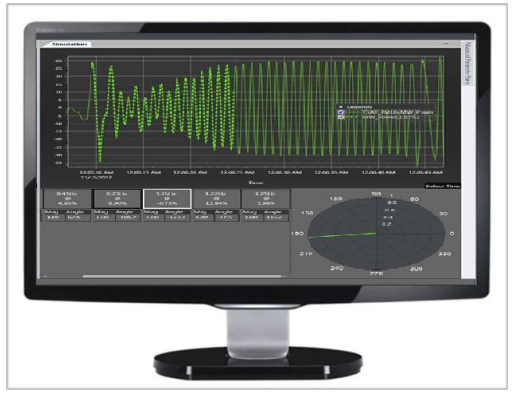
Leveraging WAMS in Operations Planning

Post Event Analysis
- Quicker post-mortem analysis.
- Sequence of events & root cause analysis.

Dynamic Model Validation
- Dynamic model verification.
- Generator model calibration.
- Load characterization.

Baselining
- Assess dynamic performance of the grid.
- Steady-state angular Measurements
- System and asset performance analysis
- System disturbance impact measures

Compliance Monitoring
- Primary frequency (governing) response.
- Power System Stabilizer (PSS) tuning



Synchrophasor benefits for Post-Event Analysis

Phasor data are also valuable for investigation of grid disturbances, improving both the speed and quality of analysis.

In the case of the 2007 Florida blackout, NERC investigators used phasor data to create the sequence of events and determine the cause of the blackout in only two days; in contrast, lacking high-speed, time-synchronized disturbance data it took many engineer years of labor to compile a correct sequence of events for the 2003 blackout in the Northeast U.S. and Ontario.

NERC RAPIR Report, 2010.

Post Event Analysis

May 30th, 2013 Event

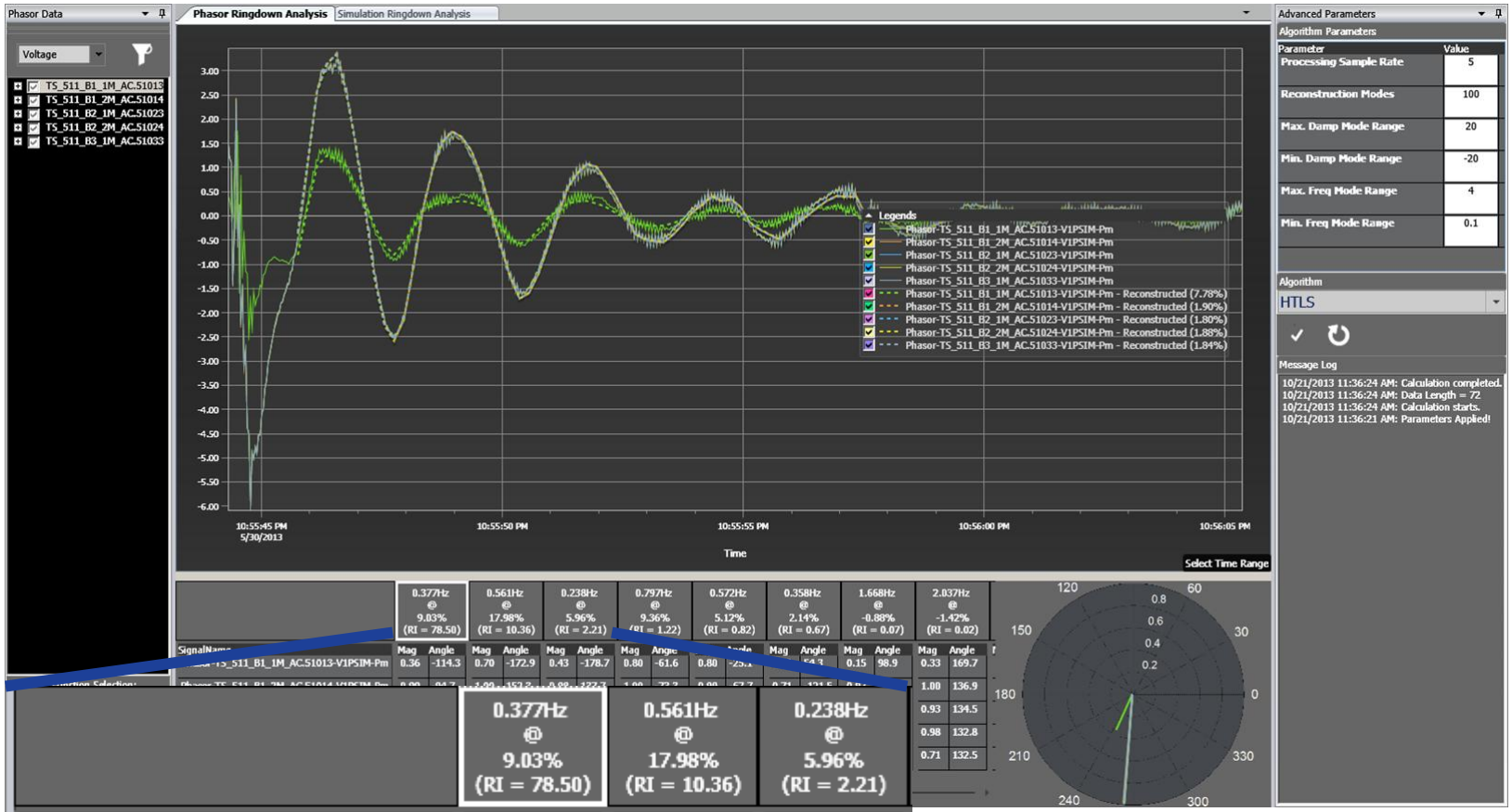
Overview of May 30, 2013 Event

Time of Event (22:55 – 22:59 UTC)

Time of Event (23:00 – 23:12 UTC)

Ringdown Analysis – PDCI block/restart

Oscillation mostly at 0.38Hz mode

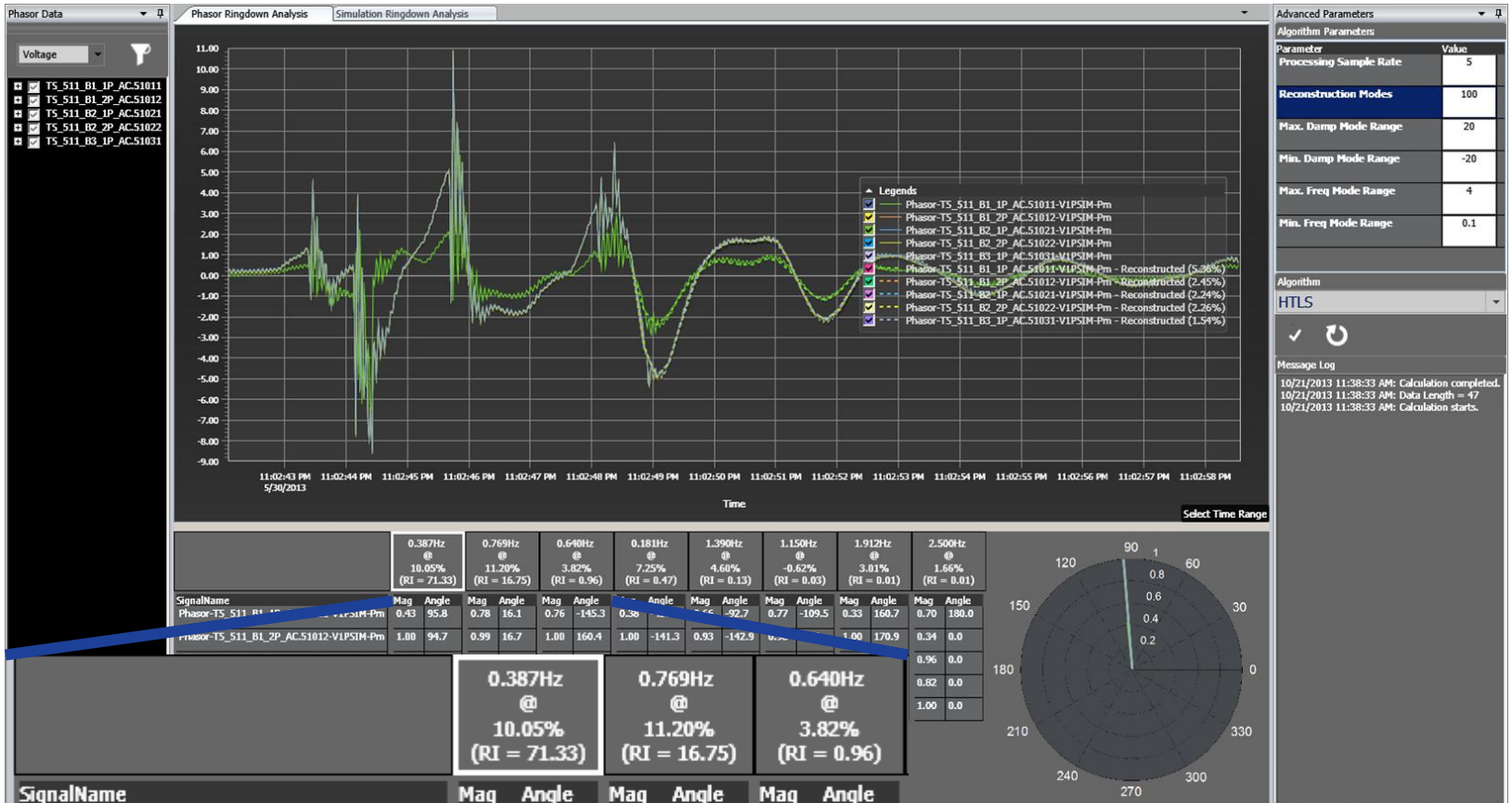


SignalName	0.377Hz @ 9.03% (RI = 78.50) Mag	Angle	0.561Hz @ 17.98% (RI = 10.36) Mag	Angle	0.238Hz @ 5.96% (RI = 2.21) Mag	Angle
Phasor-TS_511_B1_1M_AC.51013-V1PSIM-Pm	0.36	-114.3	0.70	-172.9	0.43	-178.7
Phasor-TS_511_B1_2M_AC.51014-V1PSIM-Pm	0.99	-94.7	1.00	152.3	0.98	137.7
Phasor-TS_511_B2_1M_AC.51023-V1PSIM-Pm	1.00	-94.4	0.98	151.7	1.00	138.6
Phasor-TS_511_B2_2M_AC.51024-V1PSIM-Pm	0.99	-94.2	0.97	150.8	0.99	138.4
Phasor-TS_511_B3_1M_AC.51033-V1PSIM-Pm	0.98	-94.3	1.00	151.0	0.99	138.1

- Using HTLS algorithm.
- Processed @ 5 samples/second.
- Sorted by proprietary index (RI).
- First voltage swing not considered.

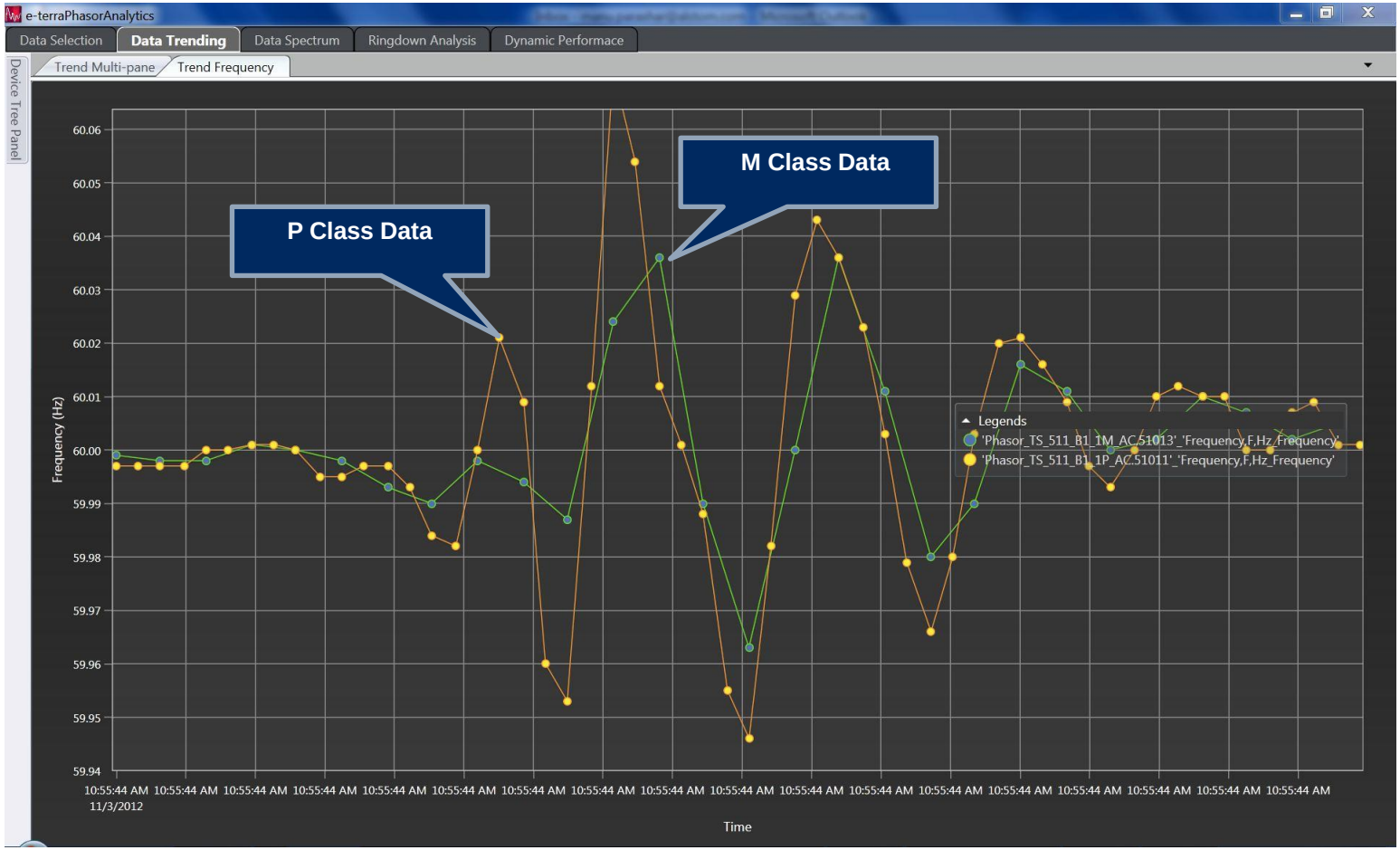
Ringdown Analysis – PNW Generation Drop

Damping of 0.38 Hz improves



- Using HTLS algorithm.
- Processed @ 5 samples/second.
- Sorted by proprietary index (RI).
- First couple voltage swings not considered.

M and P Class Data



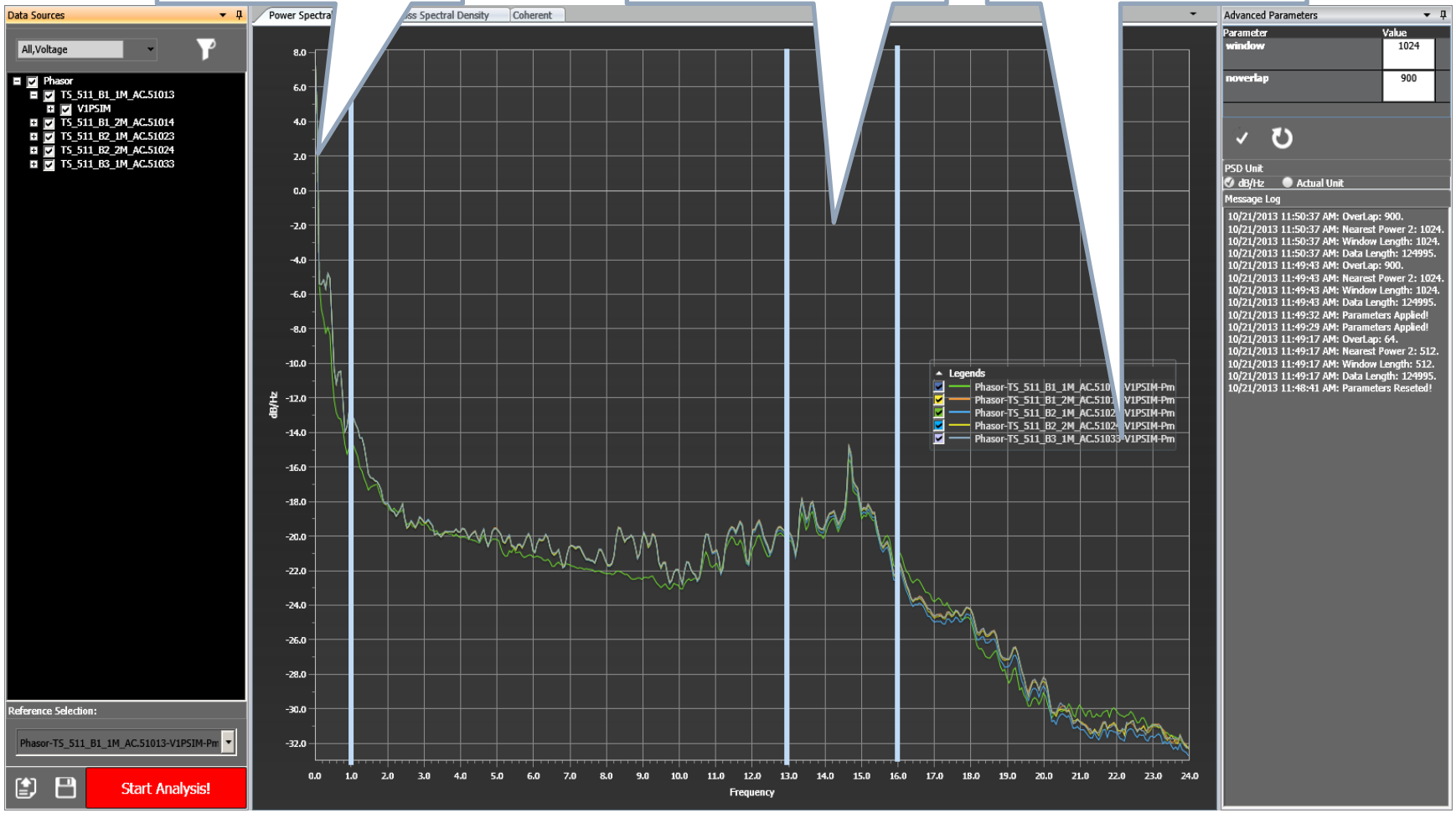
Spectral Estimation – M-Class

- Phasor reported once every cycle – 60 phasors/sec.
- More accurate phasors.

Local and inter-area modes

Unknown dynamics

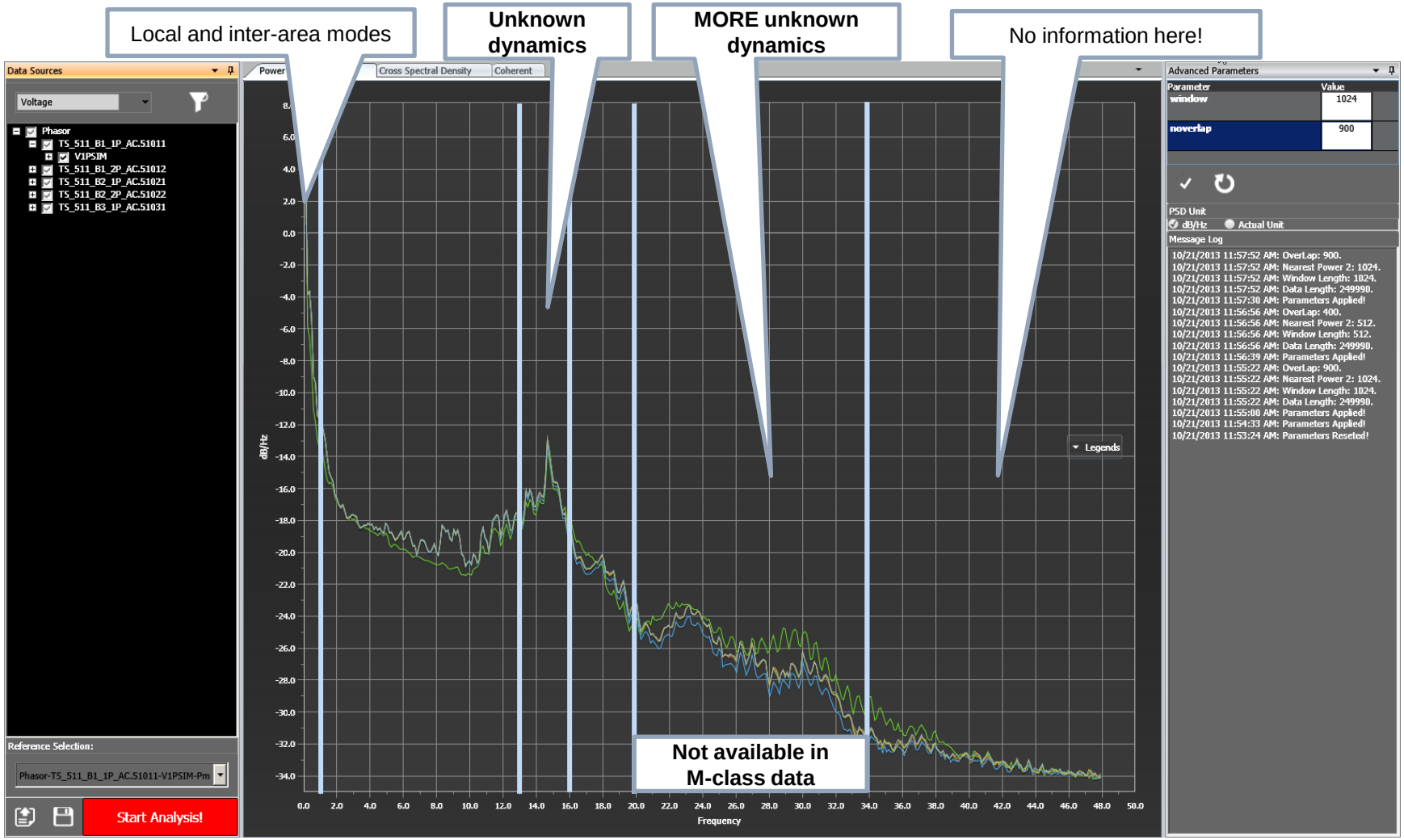
No information here!



Frequency axis shown up to 24Hz.

Spectral Estimation – P-Class

- Phasor reported once half cycle – 120 phasors/sec.
  - Double freq. resolution as M-class.
- Captures faster dynamics – more high frequency content.



Frequency axis shown up to 48Hz.

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Baselining

Dynamic Performance

Dynamic Performance Baselining

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Questions we are looking to answer are:

- ***What*** *oscillatory modes are we seeing in our system (governor, inter-area, local, forced, etc)?*

- ***Where*** *(i.e. location) are we seeing these oscillatory modes and their 'typical' damping and amplitude (MW, mHz, etc).*

- ***When*** *are we seeing 'dangerous' oscillations (i.e. outliers)?*

- ***How*** *are these correlated with control actions (i.e. MW flows)?*

Dynamic Performance Baselining Example

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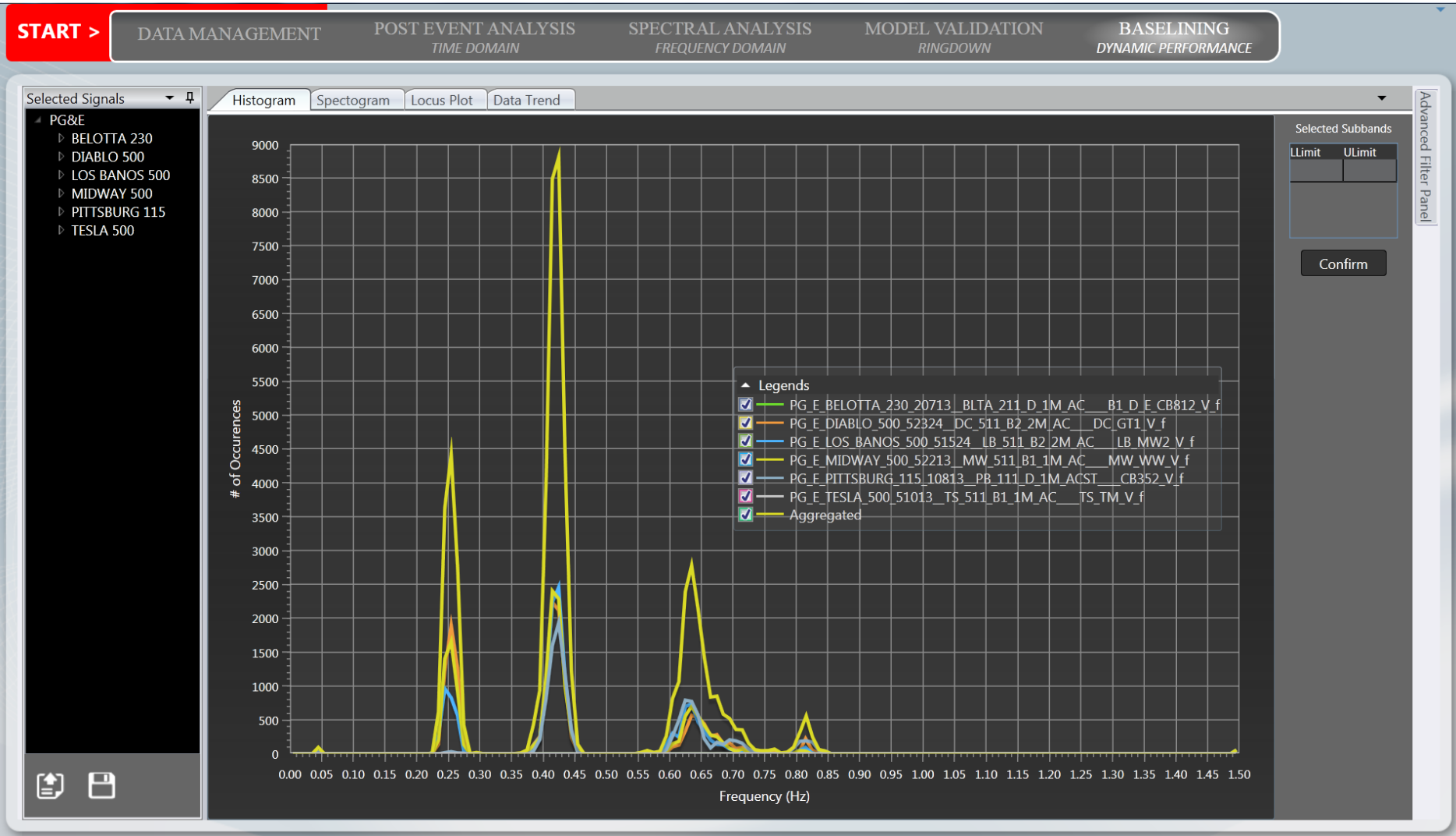
Histogram of observed modes *(48 hour dataset)*



Dynamic Performance Baselining Example

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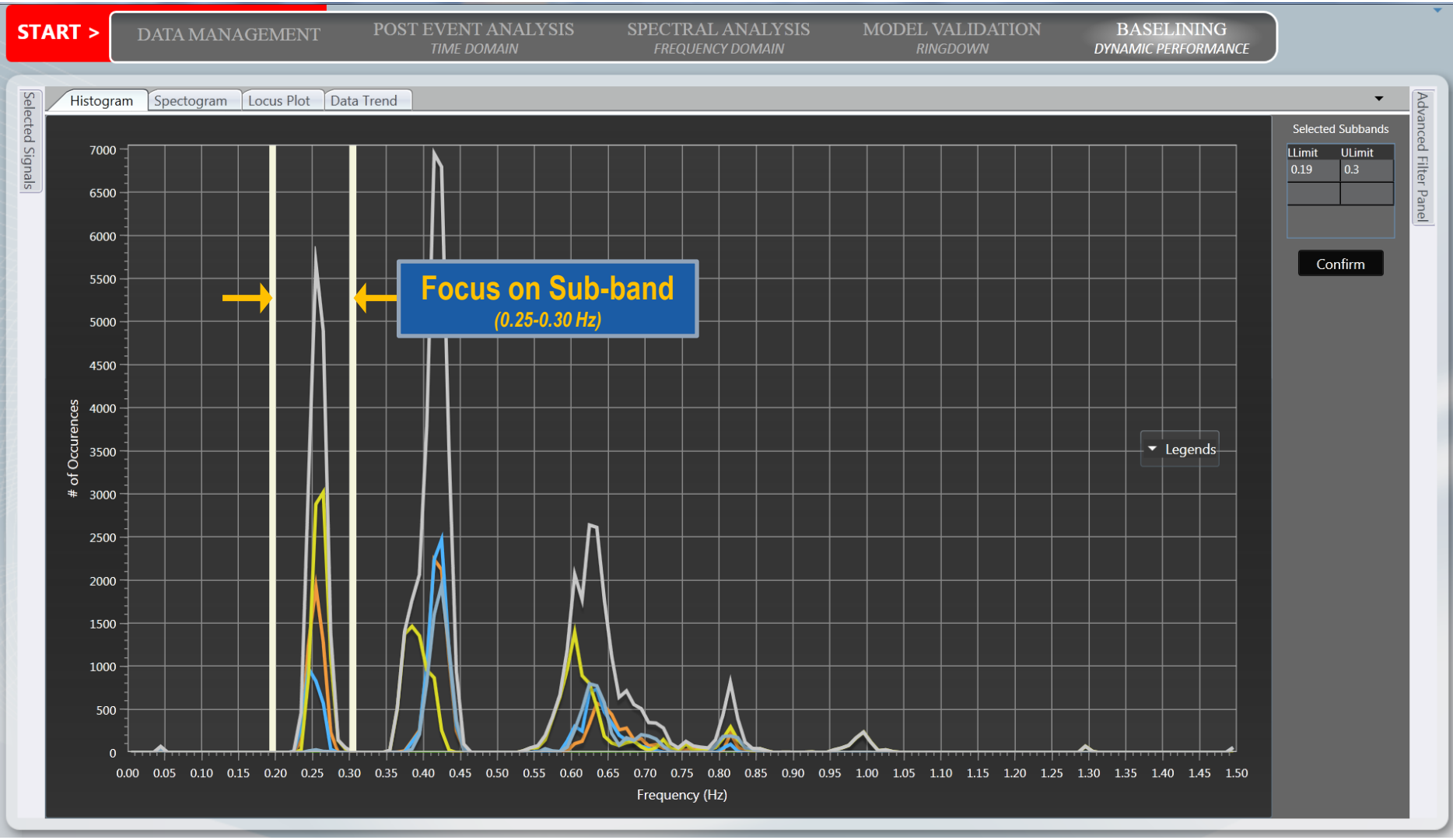

Dynamic Performance Baselining Example

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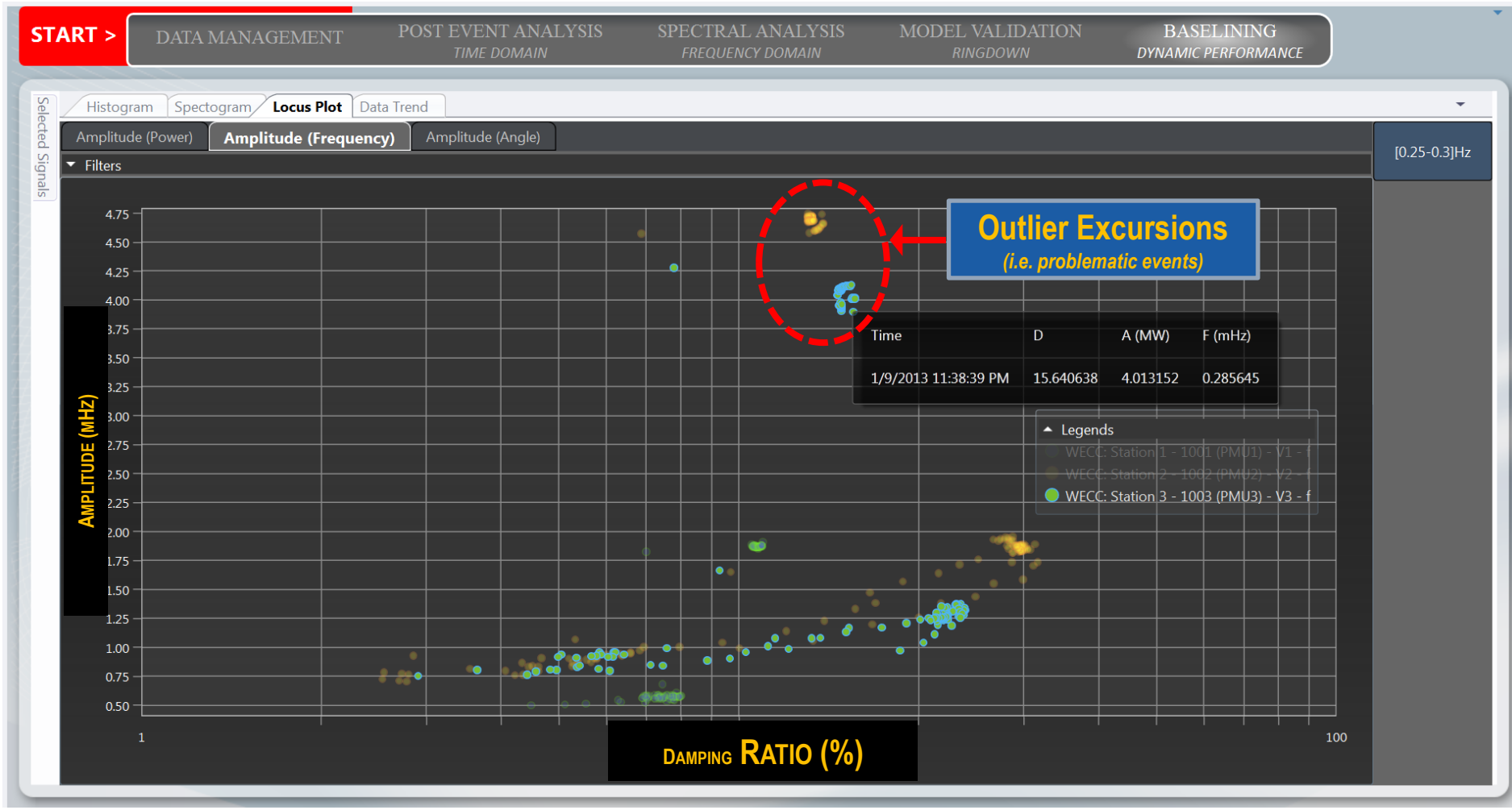
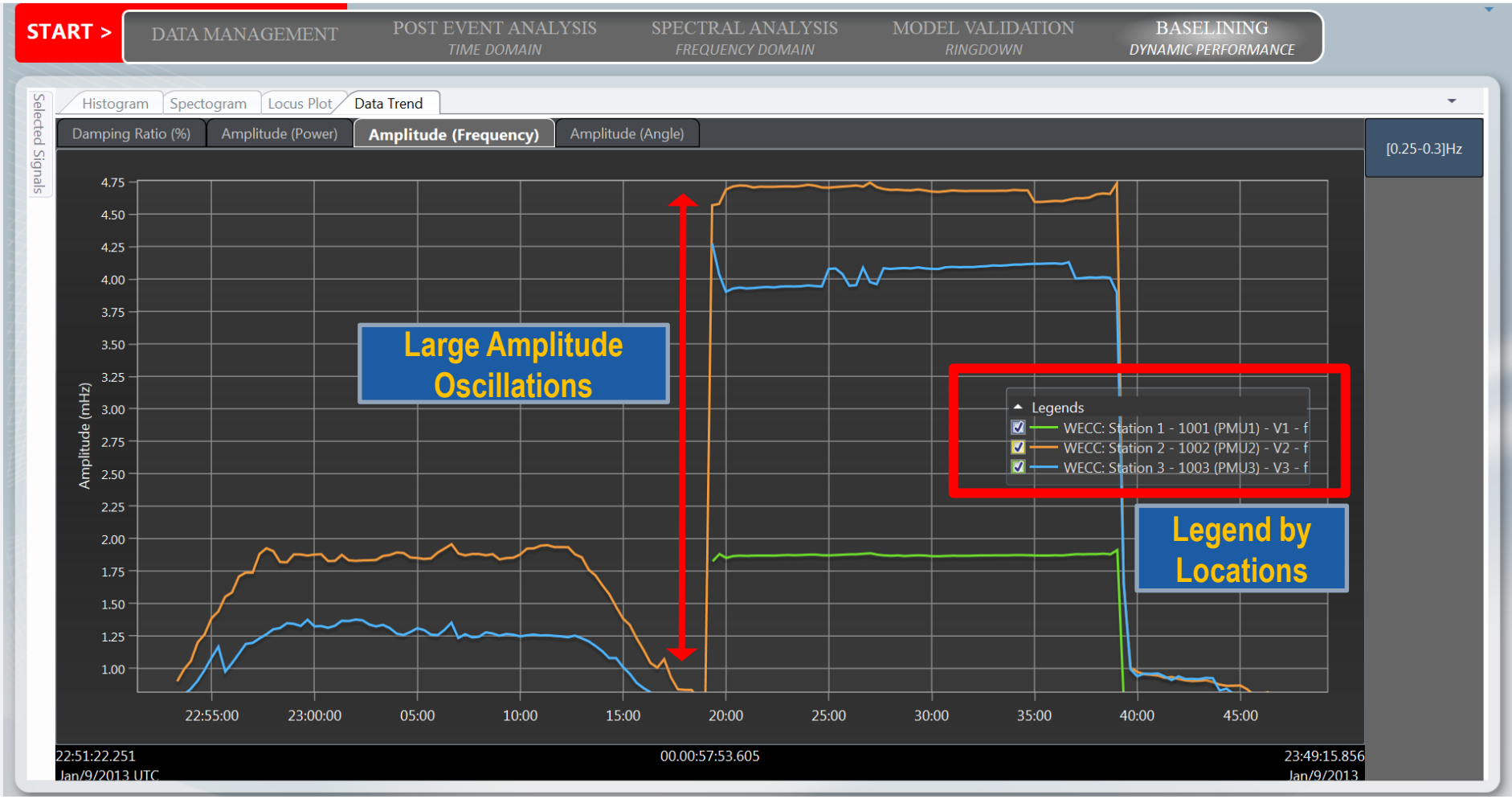
Locus of particular oscillatory mode **(to identify outliers)**



Dynamic Performance Baselining Example



Dynamic Performance Baselining Example

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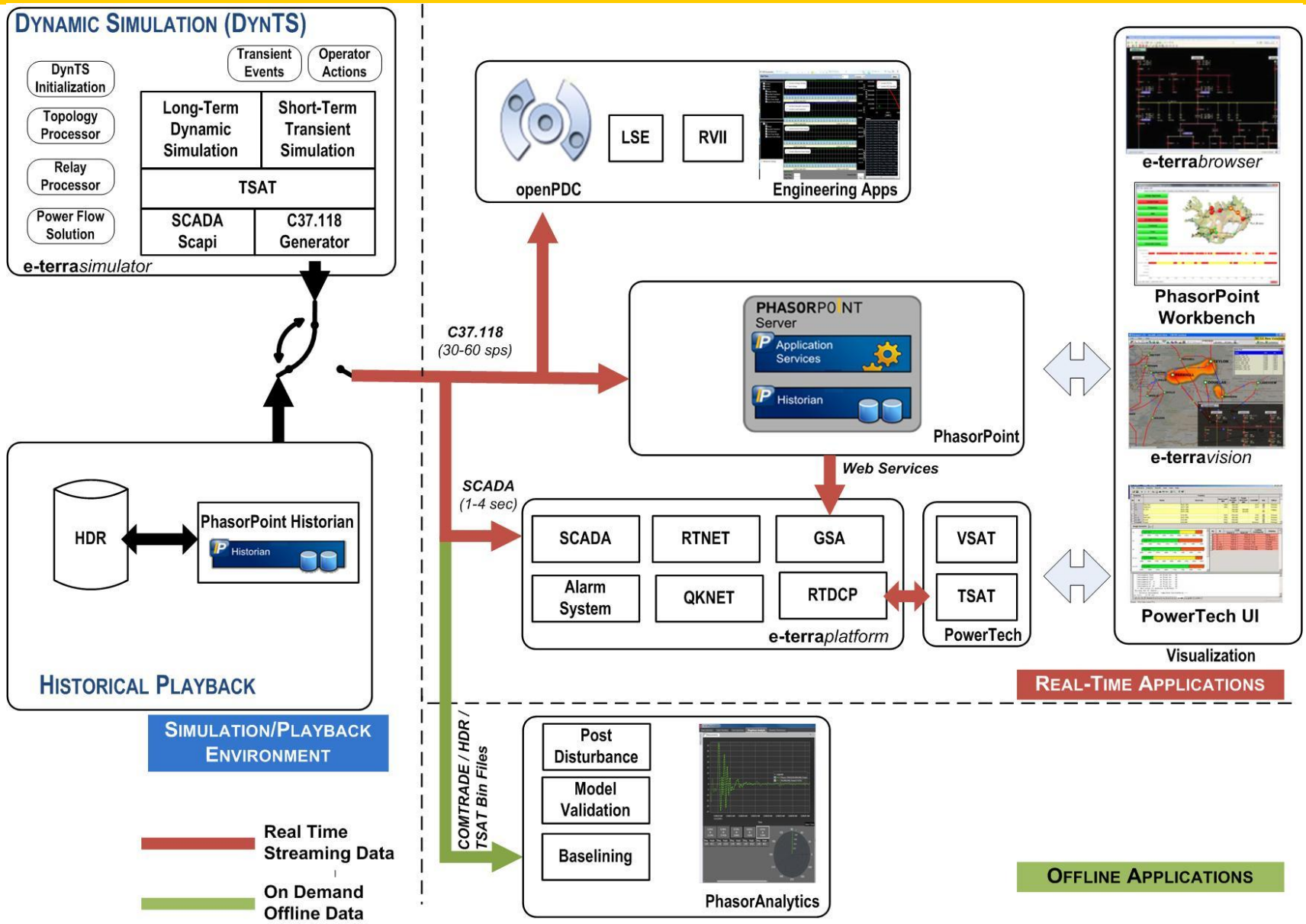
Spectrogram of mode trends

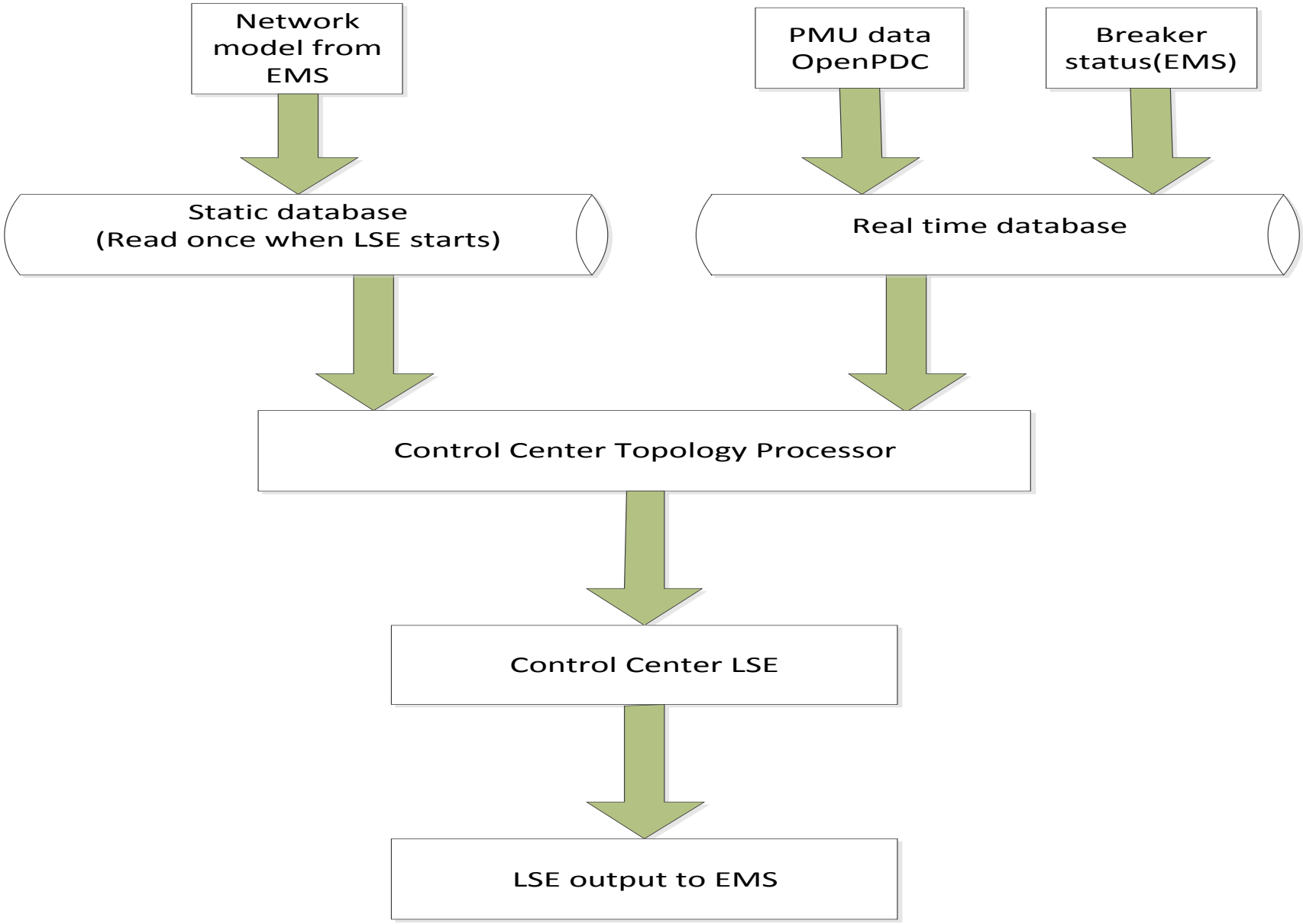
Dynamic DTS and Playback

Training Environment

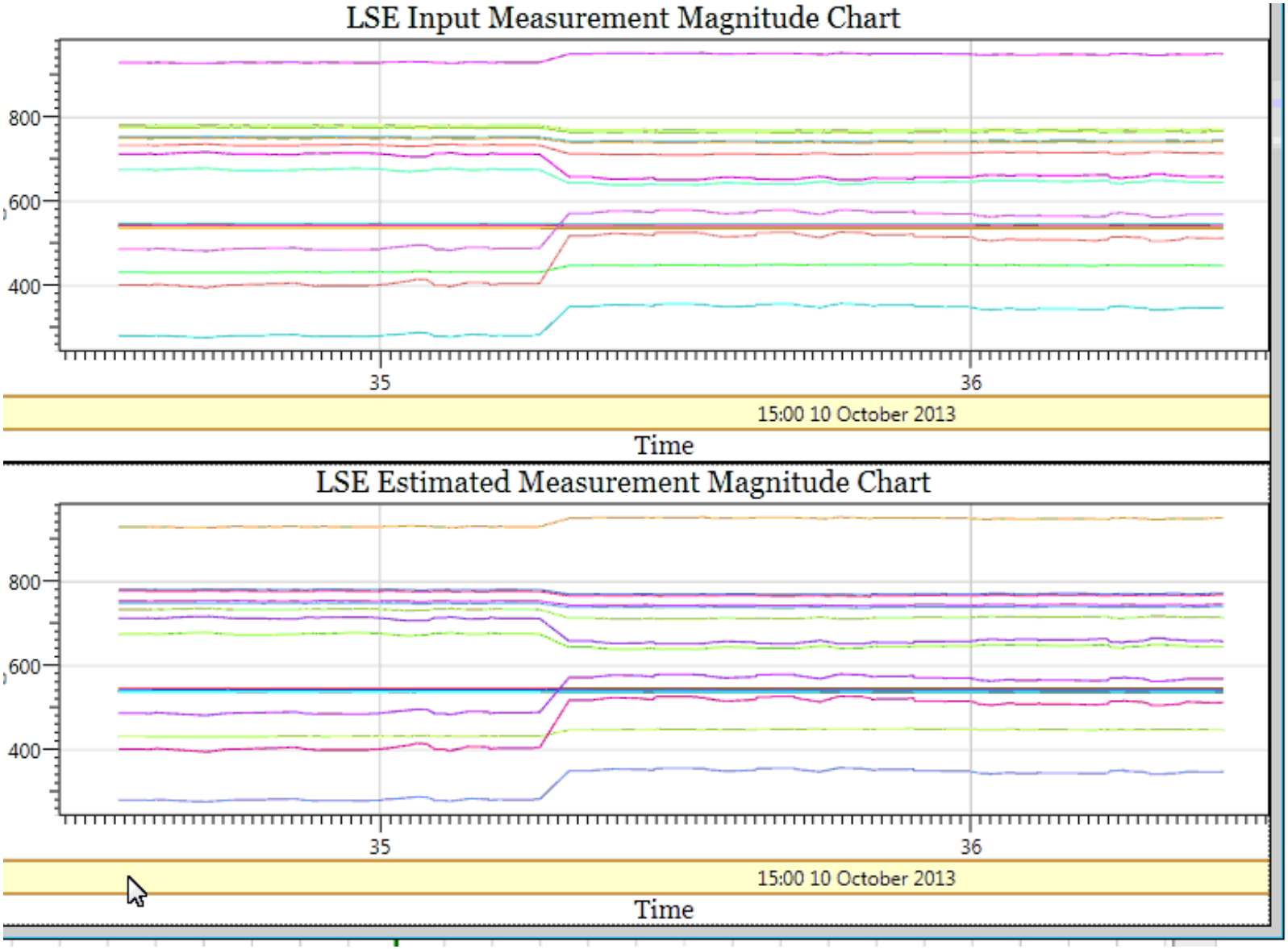
Dynamic DTS and Historical Playback



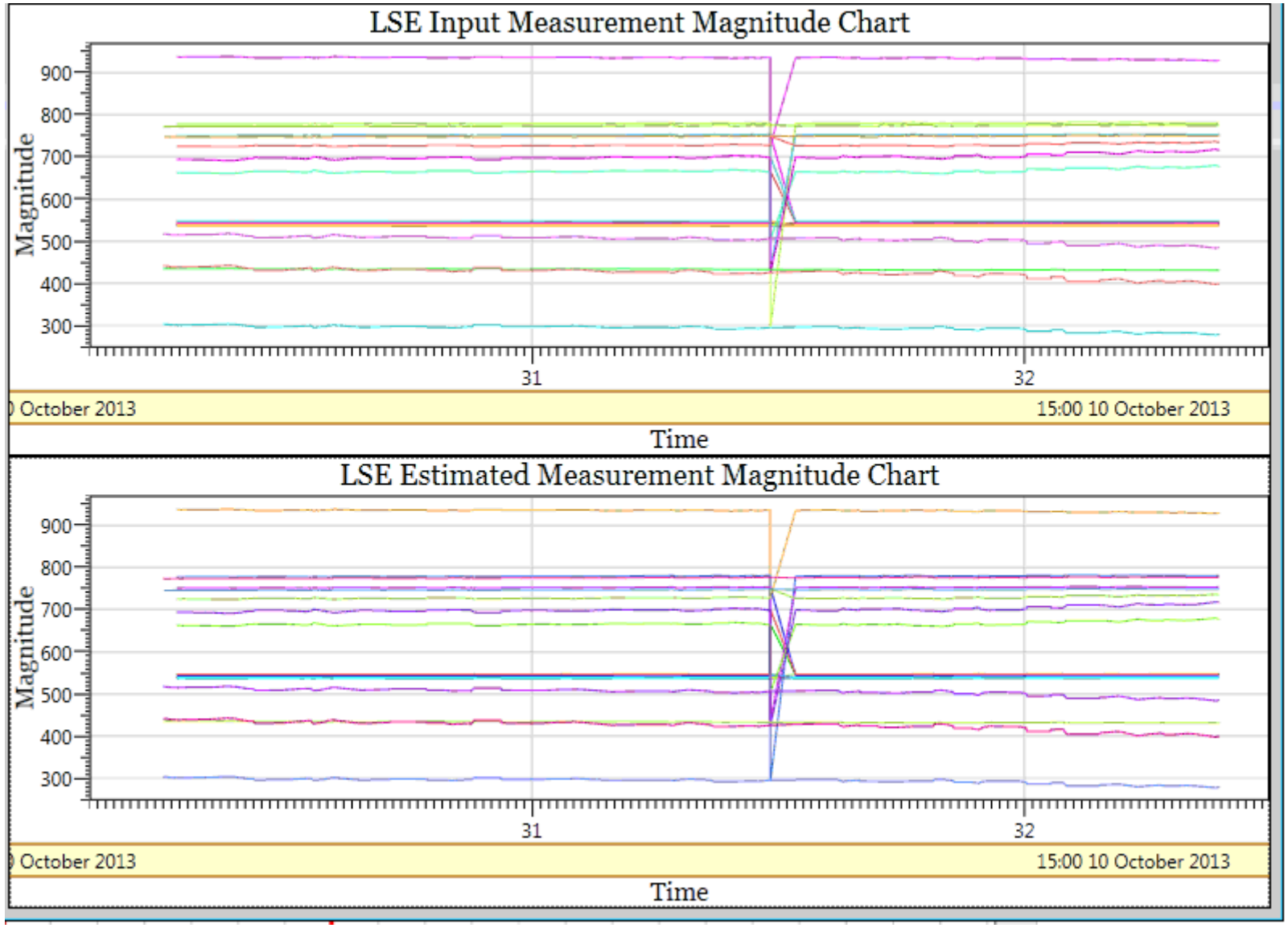
LSE Application



LSE Test – In EMS Environment



LSE Test – In EMS Environment



Framework – Parallel State Estimator