Phasor Measurements in ERCOT

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System Operation
ERCOT

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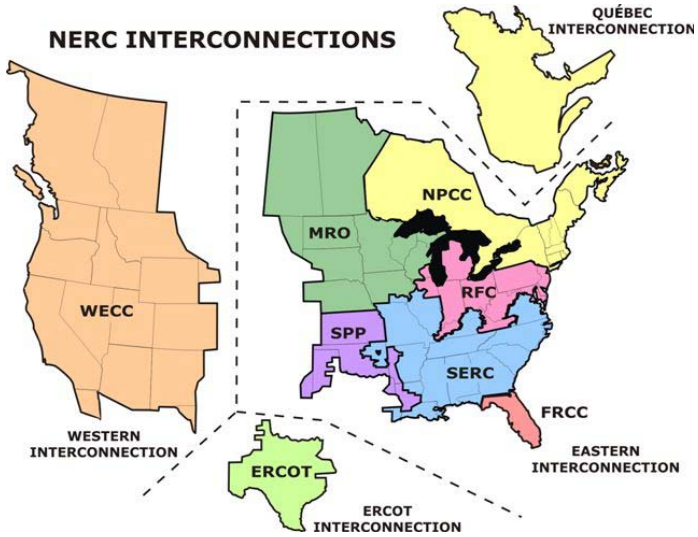
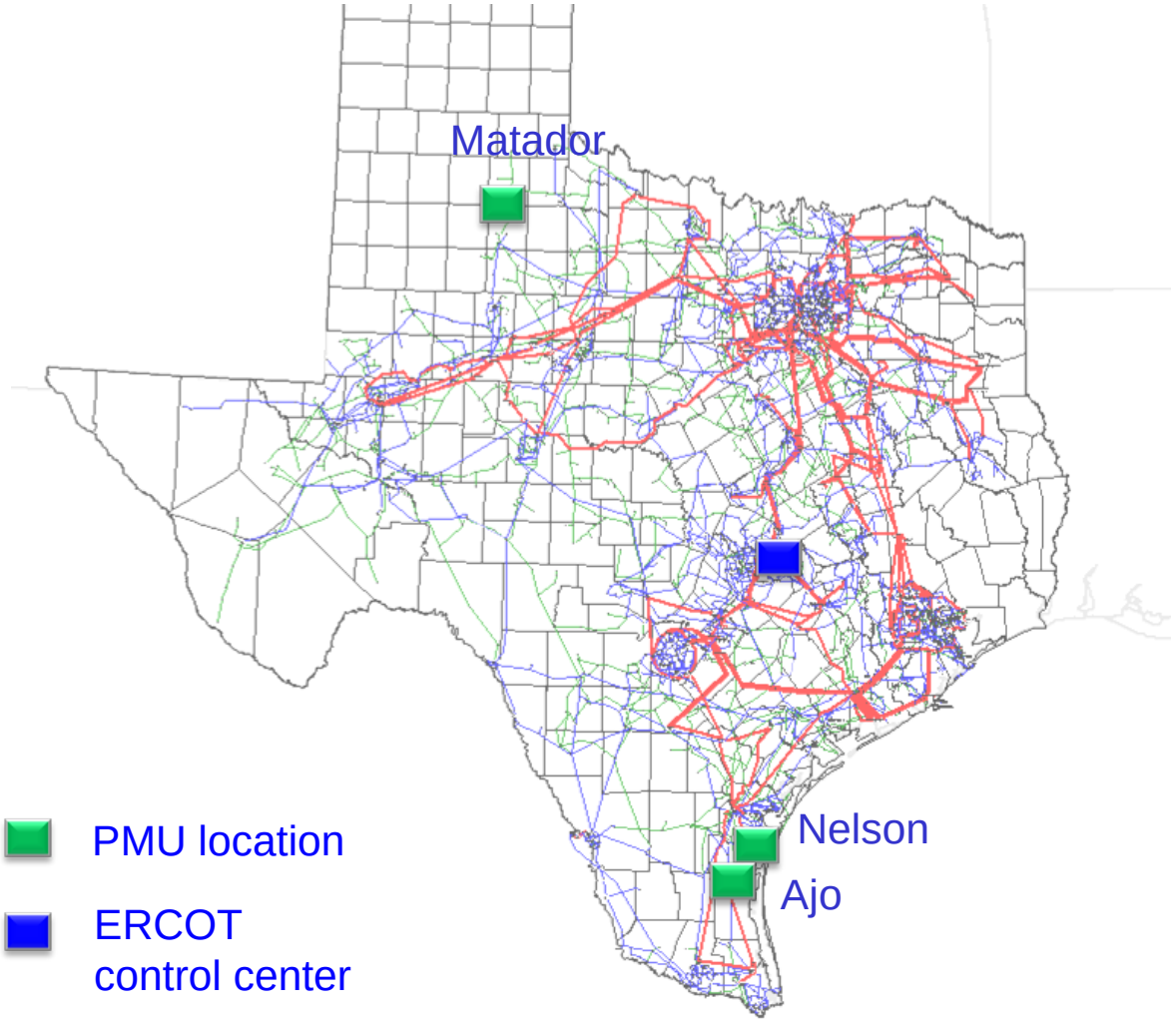
The ERCOT System

ERCOT Capacity and Demand

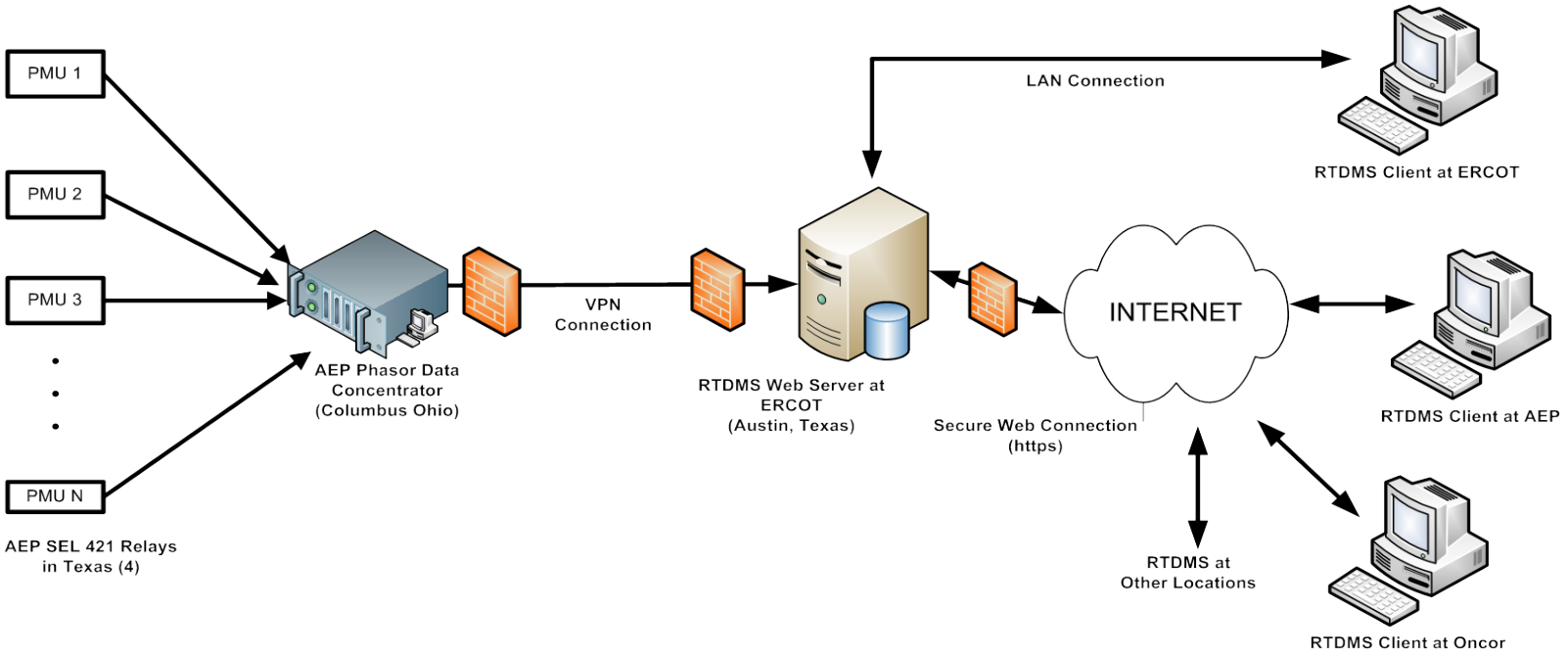
- **One of the largest single control areas in US**
  - 38,000 miles of transmission
    - 8,000 Miles of 345 kV lines
    - 16,000 Miles of 138 kV lines
  - 85% of Texas load
- **Capacity**
  - 73,820 MW Active Generation
  - Reserve Margin ~16% for 2009
- **All-time Peak Demand**
  - 62,339 MW peak load (August 17, 2006)
  - 6 Million Customer with right to choose
  - $ 30 Billion Market



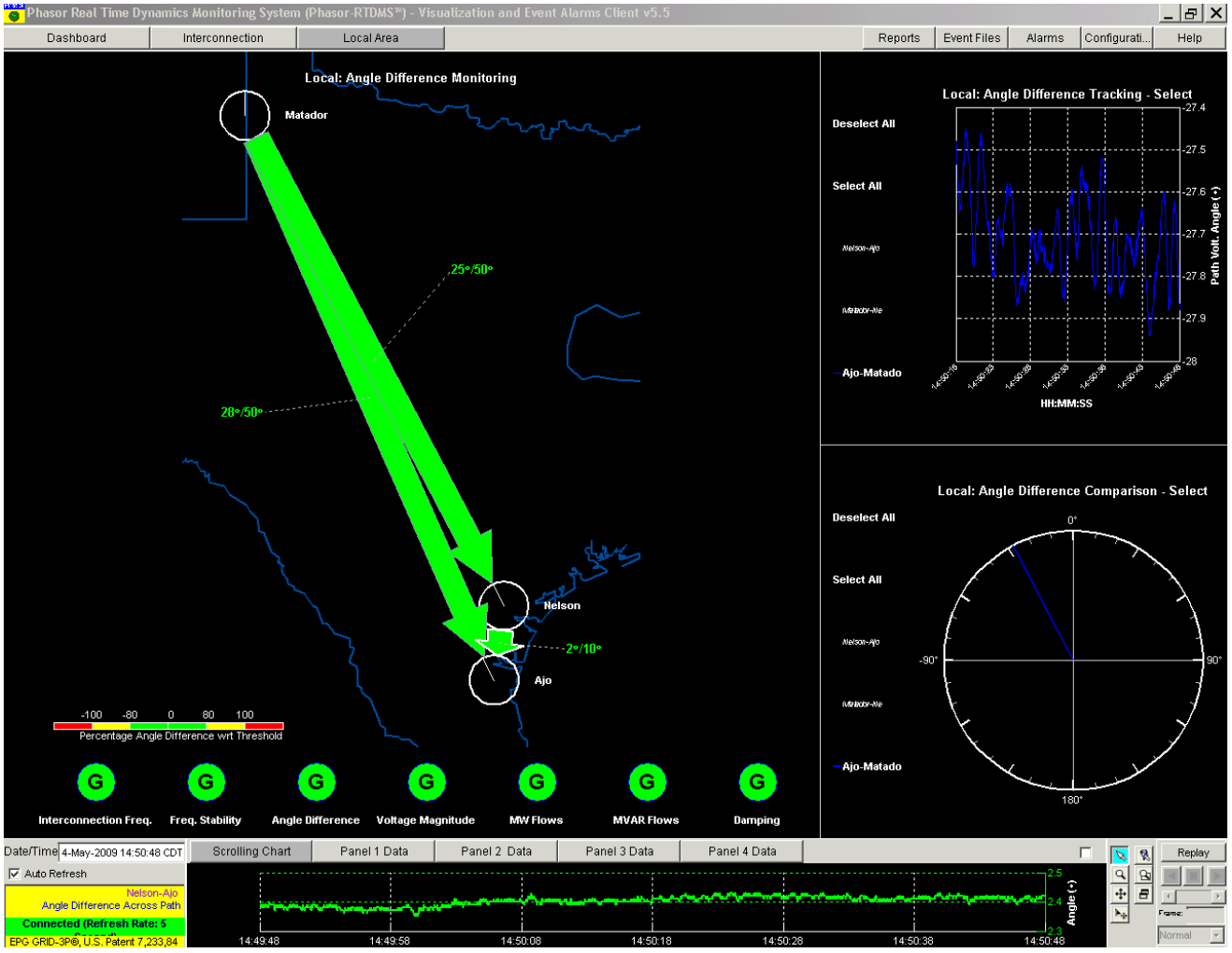
Current ERCOT Phasors



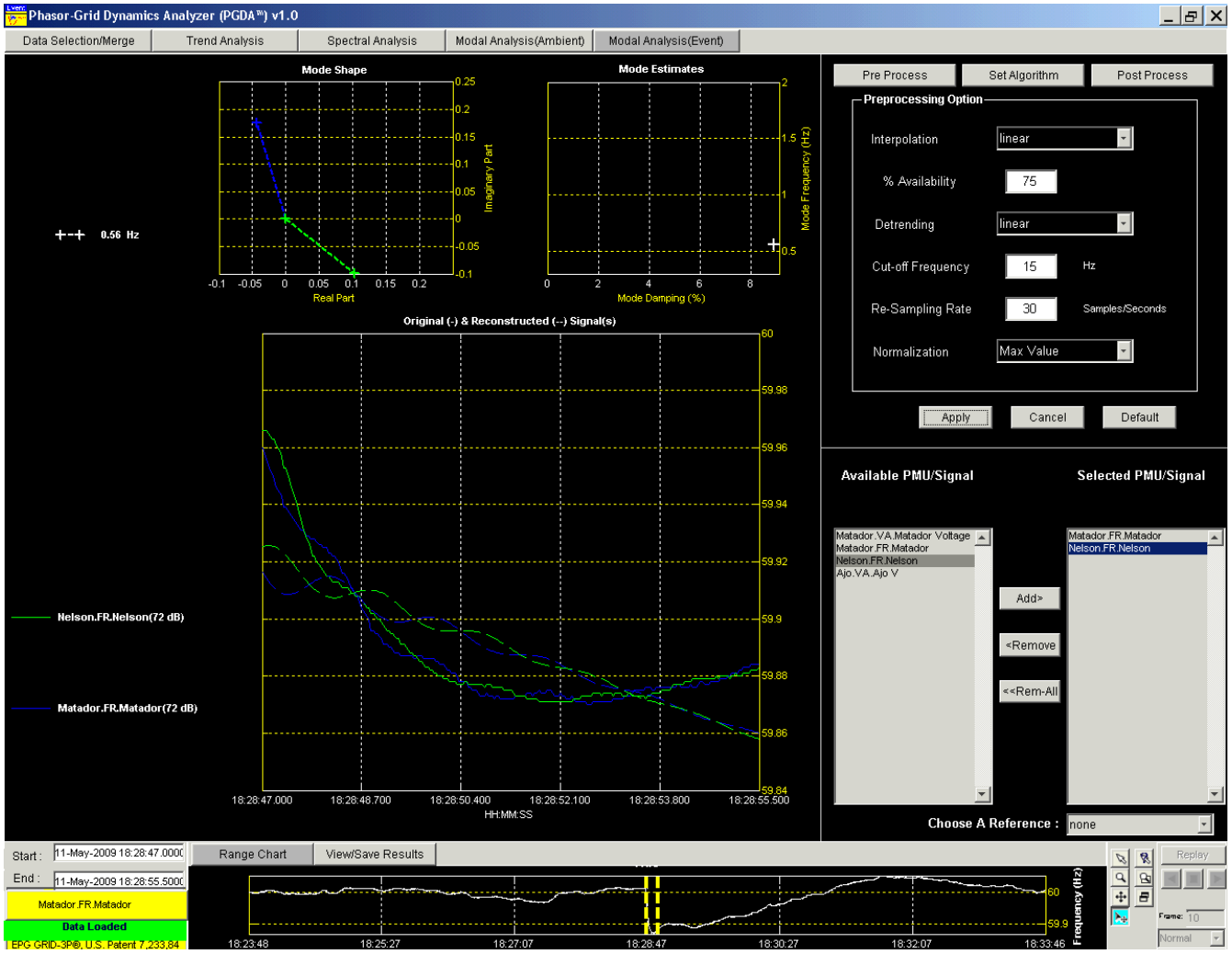
Current Architecture



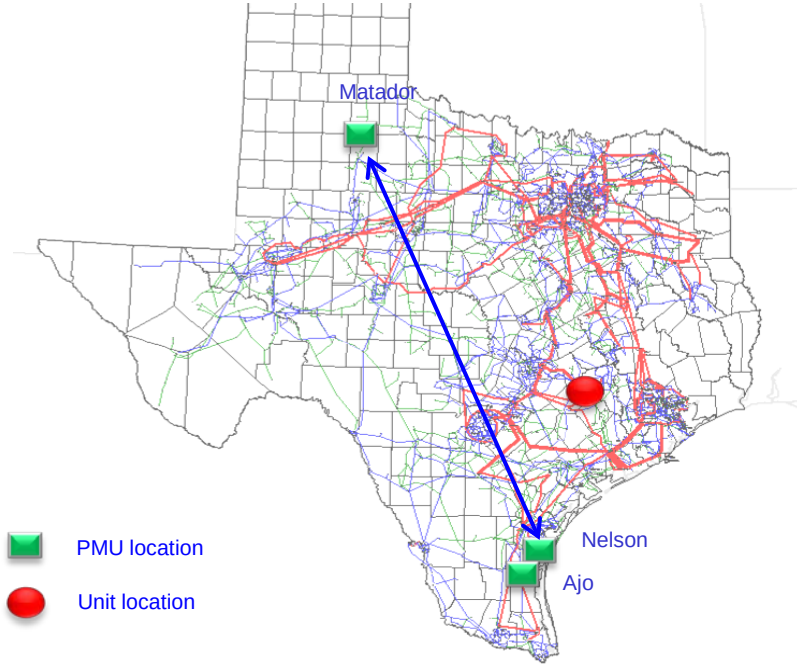
Visualization Tools - RTDMS

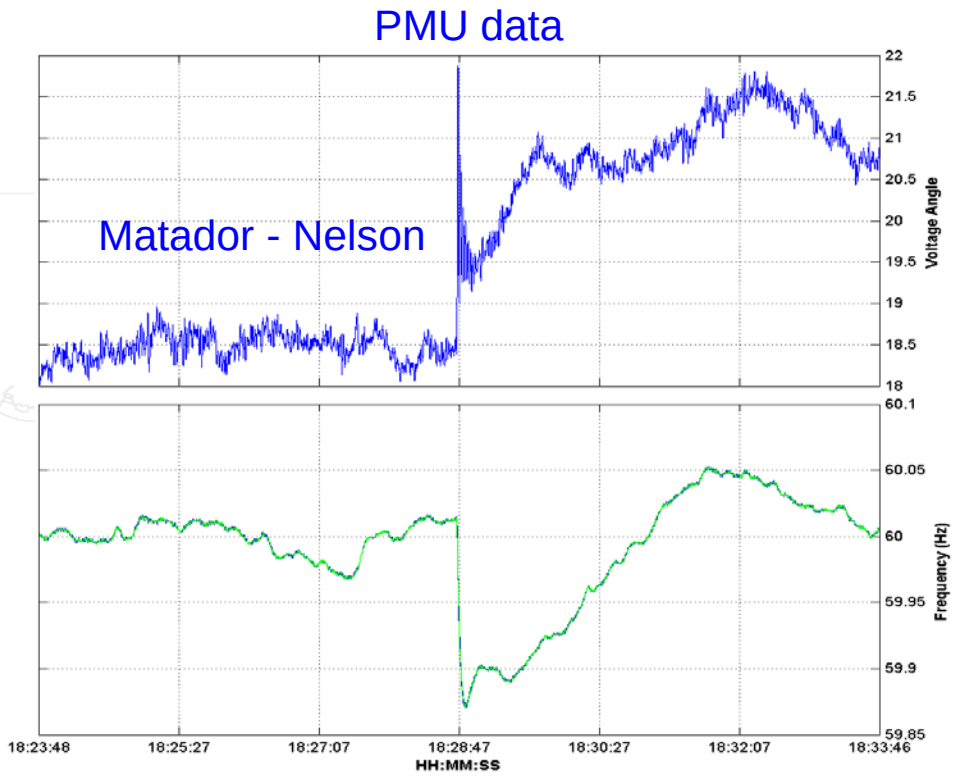


Off-line Analysis Tools - PGDA

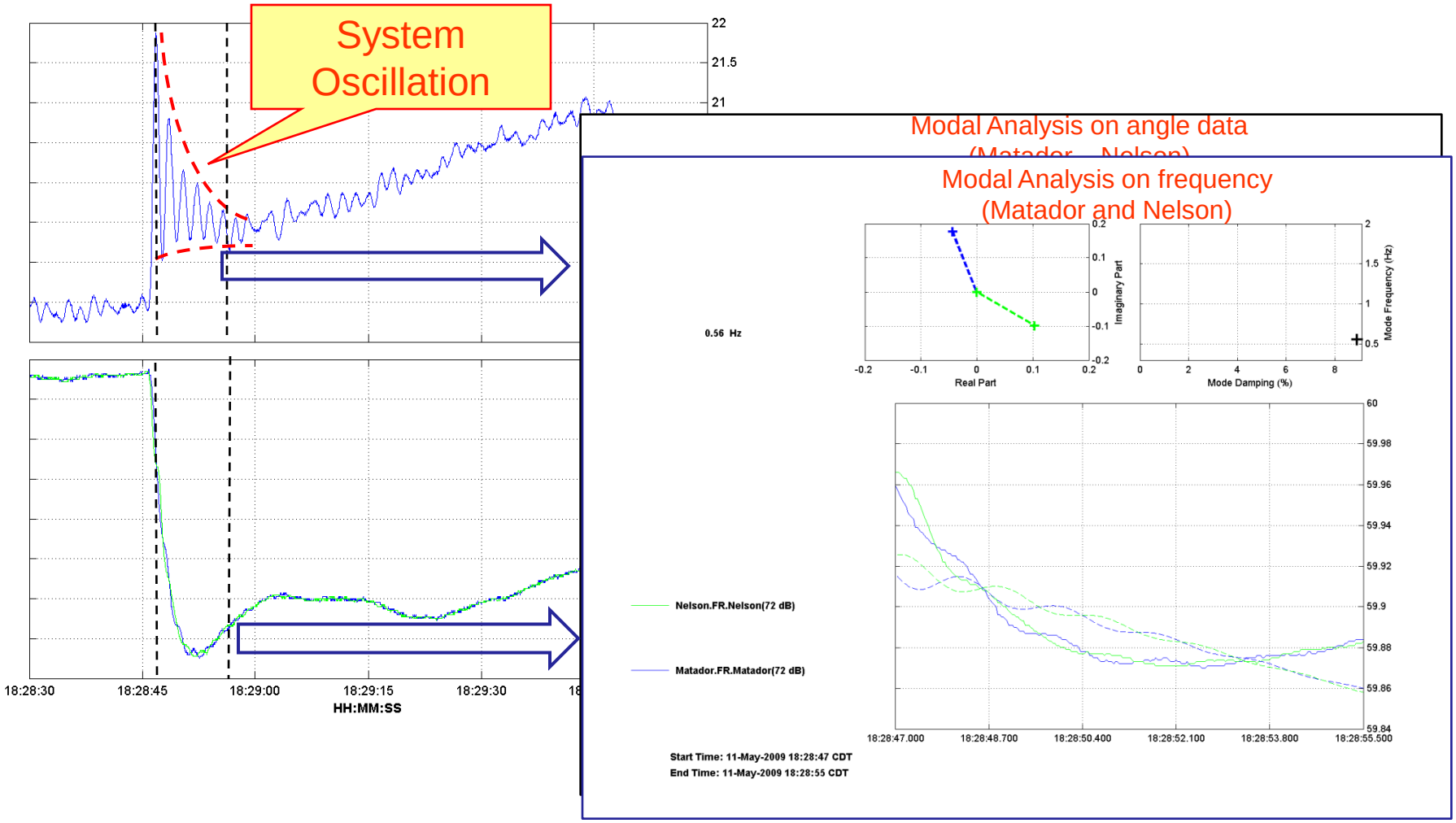


Unit Trip Event

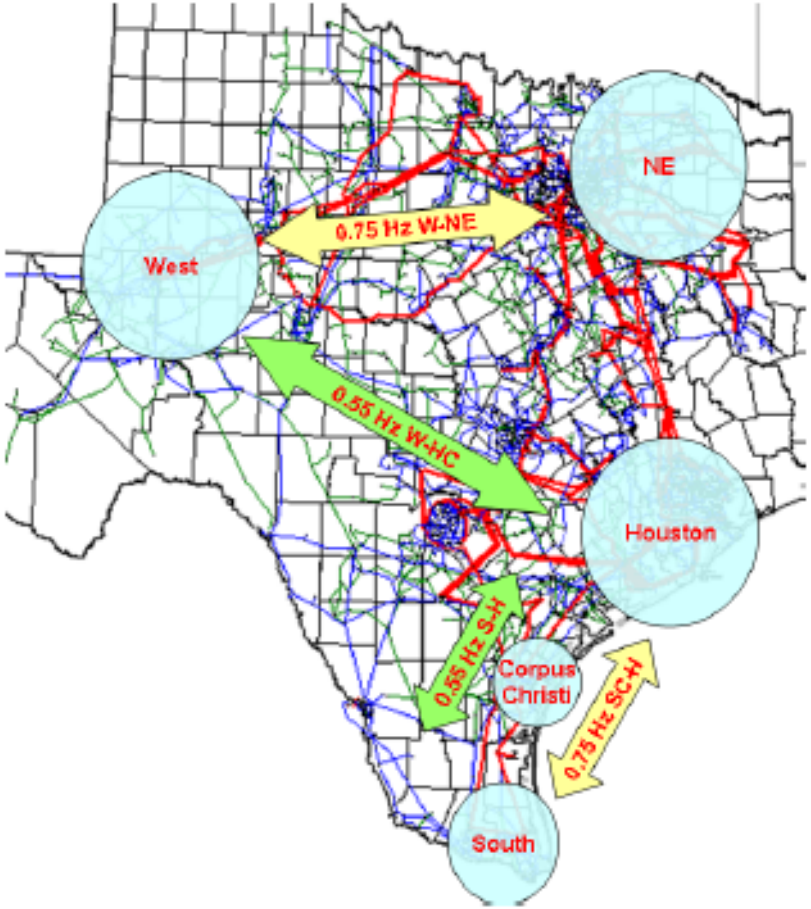




Event Analysis

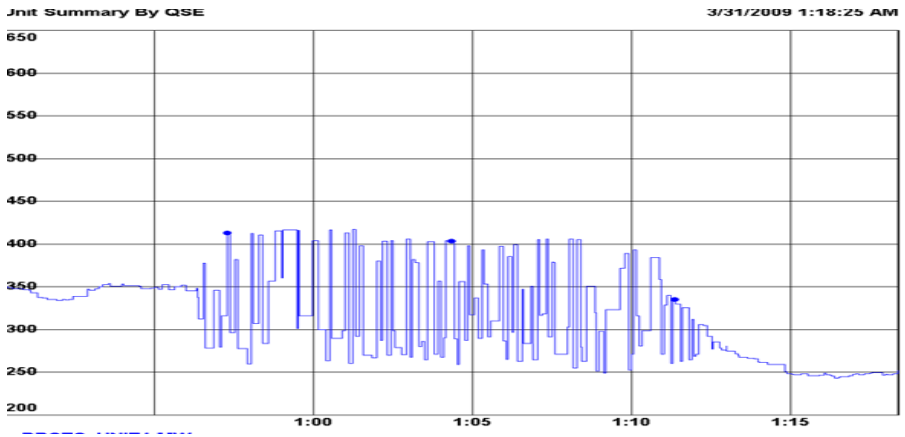


Comparing to Simulation Results



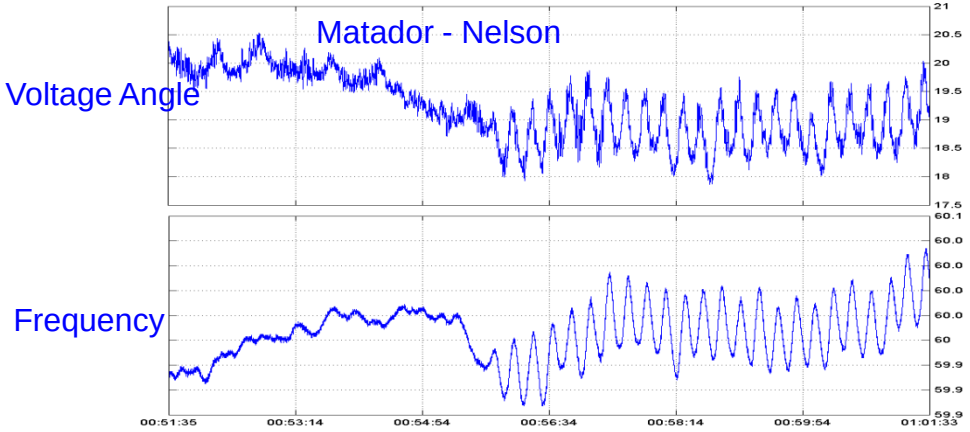
The observations during the unit trip event is very close to the results of the simulation study for dynamic stability limit.

Other Event

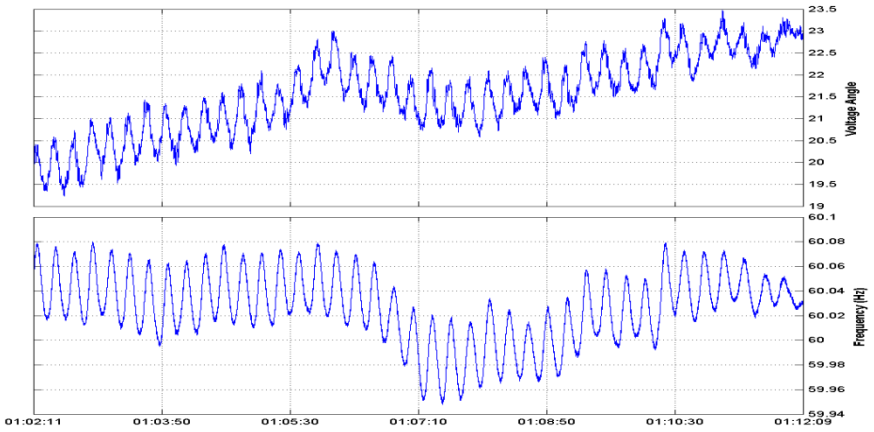


The unit MW output during the event

An oscillation imposed by a large generating unit malfunction



Event began at 00:55 AM CDT

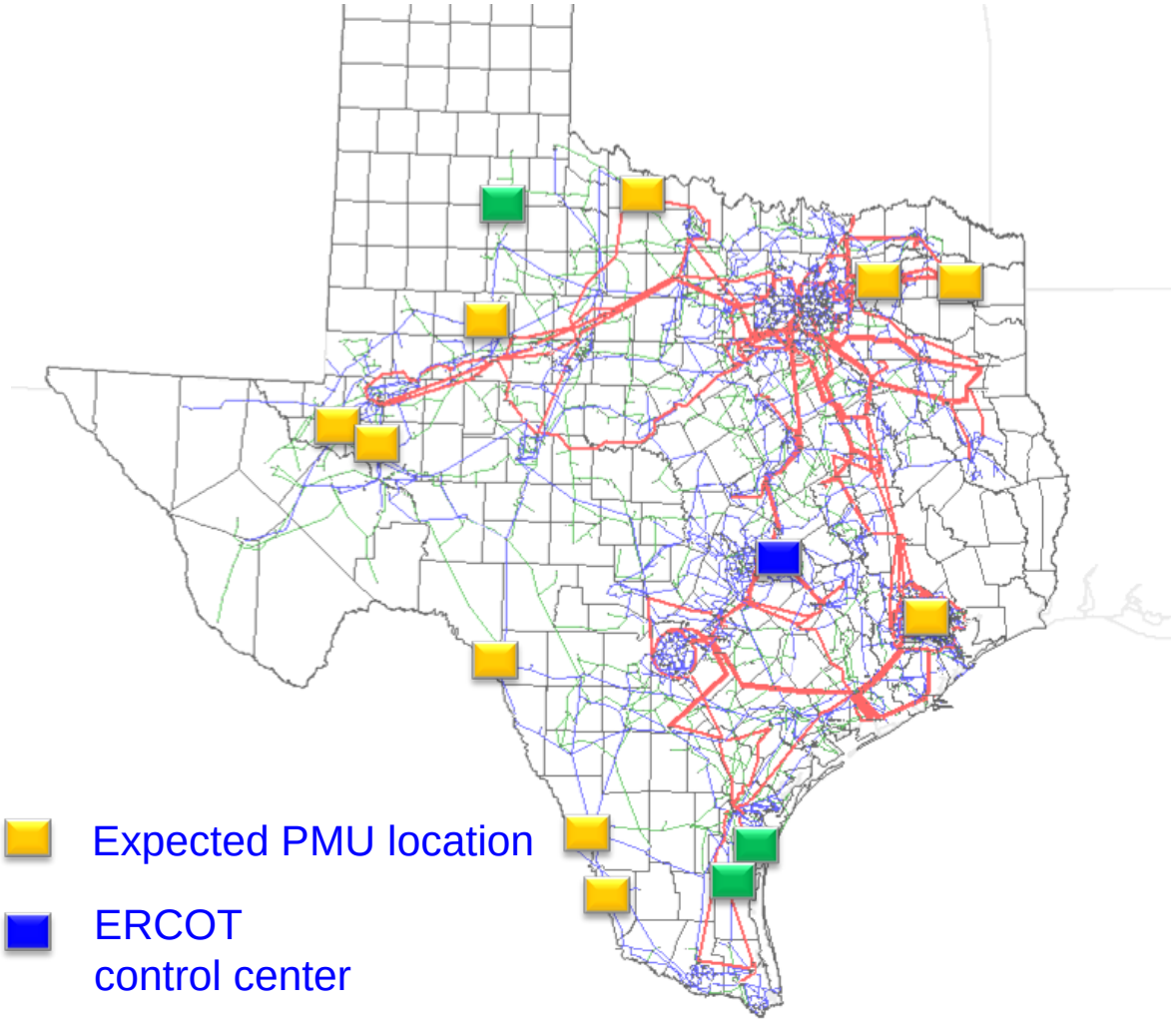


Event ended at 01:12 AM CDT

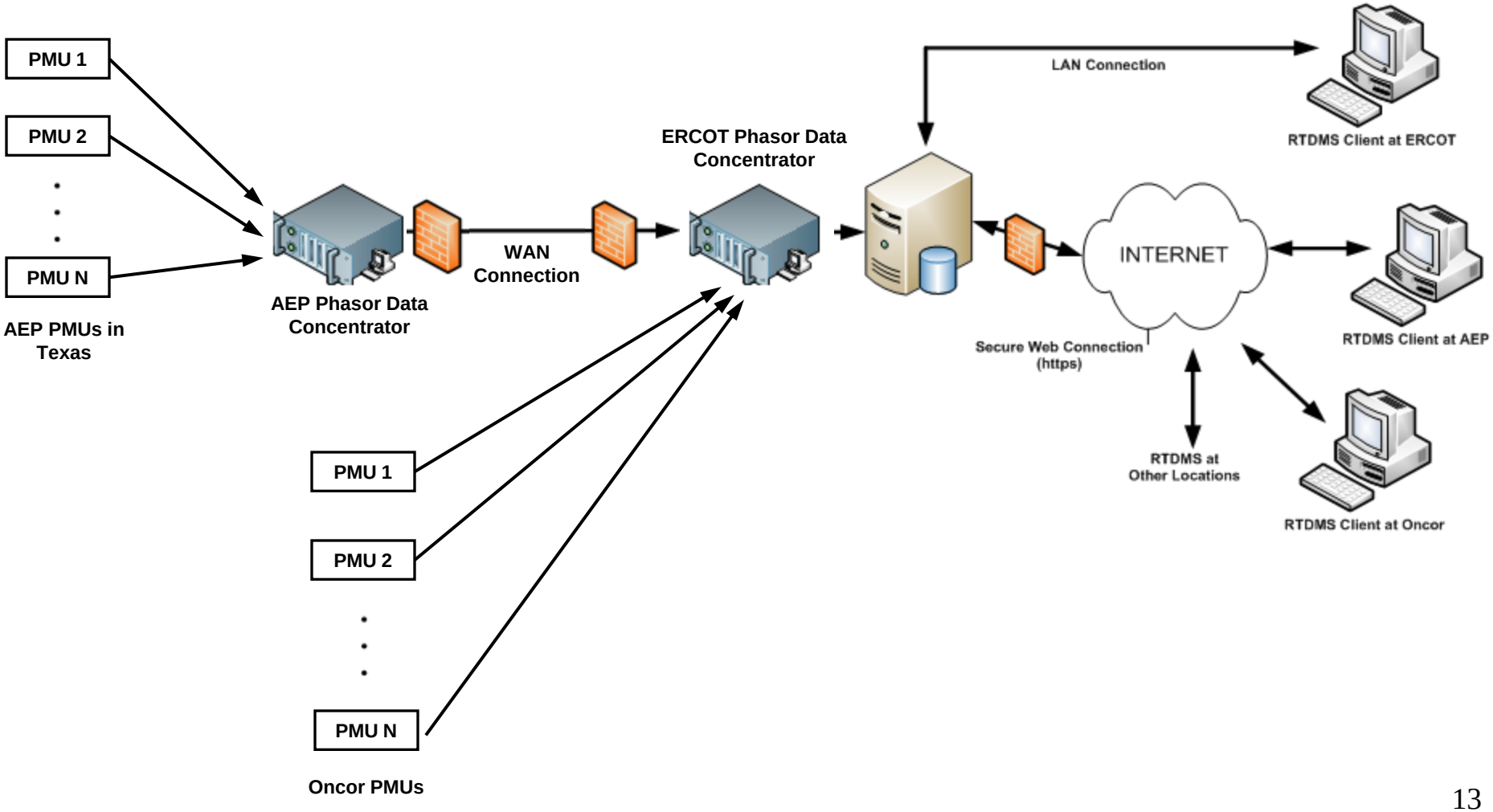
Phasor Project Work Tasks (2009)

- Off-line analysis for disturbances and events
- Generation model verification study using PMU data
- Angle pattern study utilizing PMU data
- Dynamic studies to identify and establish damping limits

Future ERCOT Phasors



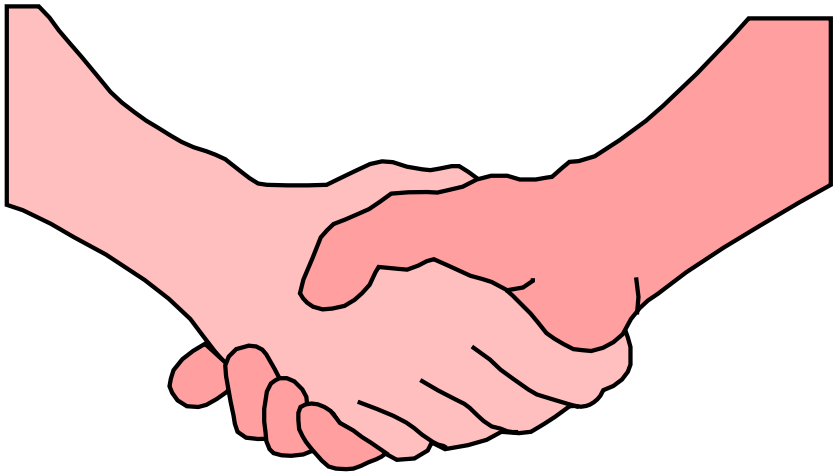
Future Architecture



Future Goals

- Real-time system monitoring
  - Dynamic stability monitoring
  - Voltage stability monitoring
  - System stress awareness
  - State estimation

- System analysis
  - Event and disturbance analysis
  - Generation and load model verification

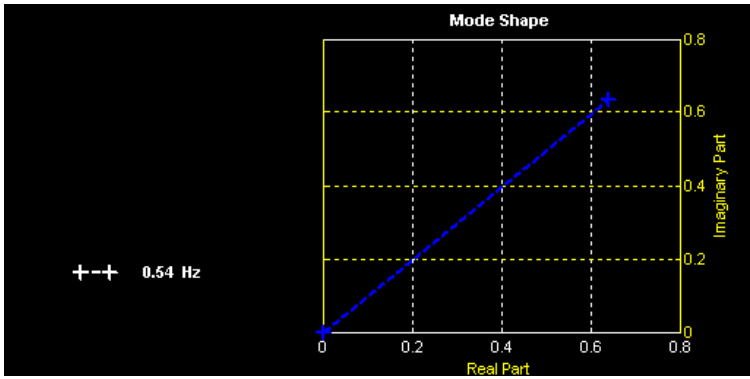


Thank U !!

Mode frequency and Damping Rate

- Any mode signal can be represented as a damped sinusoid

$$v = V_m e^{\sigma t} \cos(\omega t + \theta)$$



The figure of mode shape provides the amplitude and phase angle in a vector form $V_m \angle \theta$

The mode frequency is $f = \omega / 2\pi$

And the damping rate is $\xi = \dfrac{-\sigma}{\sqrt{\sigma^2 + \omega^2}}$