# PMU versus SCADA Video Events Summary

**March 2014 NASPI Control Room Solutions Task team Meeting**

The Control Room Solutions Task Team [CRSTT] would like to thank Kevin Chen, Lupe Garcia, and Jim Dyer at EPG for their efforts to pull together these videos.

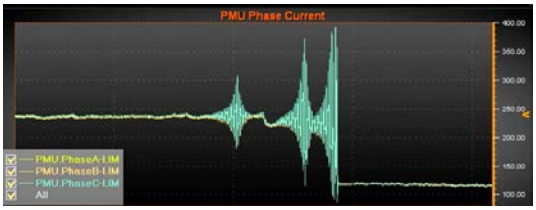
CRSTT also like to thank Jared Bestebreur at SEL for work he did to pull together a sample video for us.

A short list of the videos and a high level of overview of the data displayed follows:

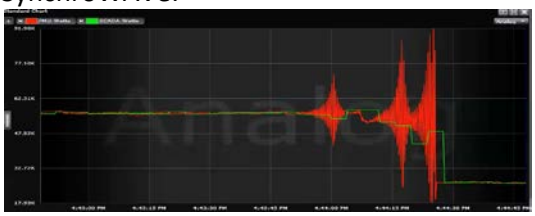
- Event 1: Video files RTDMS_P MU_vs_SCADA_naspi1.wmv

  *We had an issue on our 138 Kv system associated with new controls were being tested on a 65 MW max rated gas turbine. When enabled the controls caused the unit output to swing rapidly for approximately 30 seconds and also caused small scale voltage oscillations on the system. Eventually the unit was taken offline and the problems ceased. The event data in the replay is the line current and bus voltage as recorded by a PMU at the substation monitoring one of the two 138 Kv lines leaving the substation and an RTU at the same substation scanned every 4 seconds.*

  RTDMS:

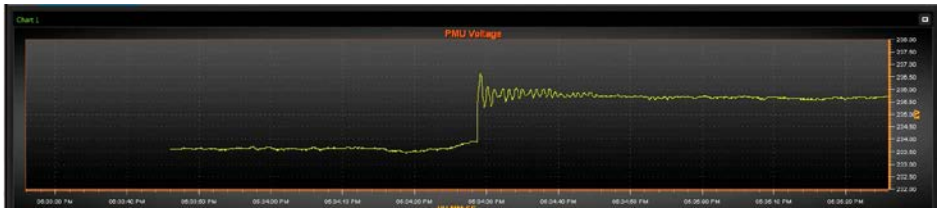
  
  

  SynchroWAVe:

- Event 2: Video file RTDMS_PMU_vs_SCADA_naspi2.wmv

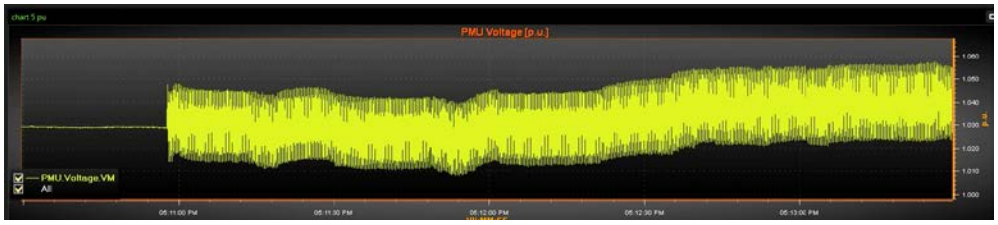
  *Voltage oscillations observed on the 230 kV system when a water pump was taken offline.*

- Event 3: Video files RTDMS_PMU_vs_SCADA_naspi3.wmv

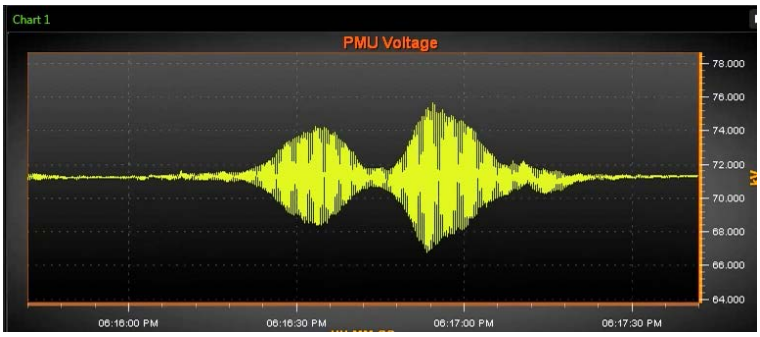
  *These oscillations were found to be occurring during periods of high wind generation, above 80% of the nameplate capacity. The voltage oscillations observed were as high as 5% fluctuation at an oscillatory frequency of around 14Hz. In this example, the oscillations began abruptly when a*

*345kV line was switched out of service. The oscillations continued for almost 30 minutes until the wind plants were able to be curtailed enough to stop the oscillations. The wind plants had to be curtailed to 45% of nameplate for the oscillations to cease.*



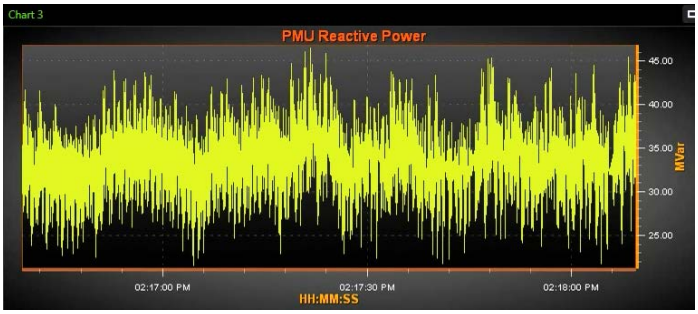

- Event 4: Video file RTDMS_PMU_vs_SCADA_naspi4.wmv

*Similar to event 3 this event also involves a wind plant. It is 60MW plant looped in on a pretty weak 69kV line. On the date of the event the stronger source was switched out for maintenance, which put the plant into an unstable state. Plant output prior to the switching was 73% of nameplate and it immediately dropped to 48% with some significant ringing. It stabilized for about 5 minutes, and then started oscillating at 3Hz when the MW output began to rise. We were immediately notified with our FFT oscillation detection program. The magnitude of the voltage fluctuation at its peak is about 12%.*



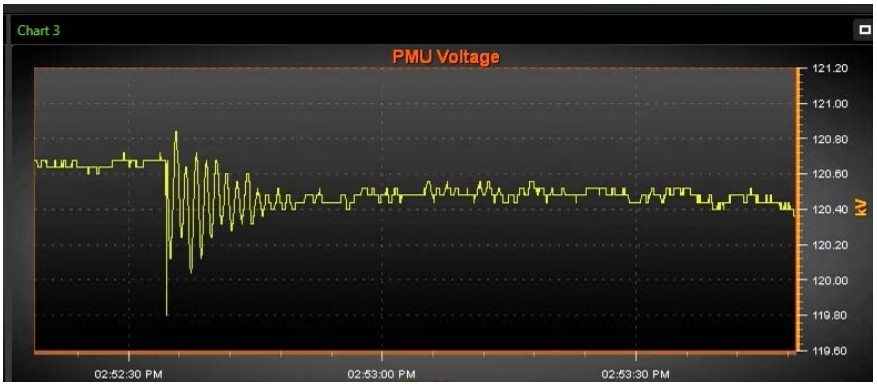

- Event 5: Video file RTDMS_PMU_vs_SCADA_naspi5.wmv

*During analysis of a system event in 2011, technical staff observed high frequency oscillations at multiple locations across the system, and correlated the oscillations with high amounts of wind generation. However, because there was no visibility of wind generation at the time, we were unable to determine whether the oscillation was due to a specific wind power plant, or a general phenomenon. Recently, PMUs have been installed at wind sites, providing visibility of 13-15 Hz oscillations occurring at specific locations – the data provided is an instance of high wind output from one of these locations.*




- Event 6: [Video file RTDMS_PMU_vs_SCADA_naspi6.wmv]

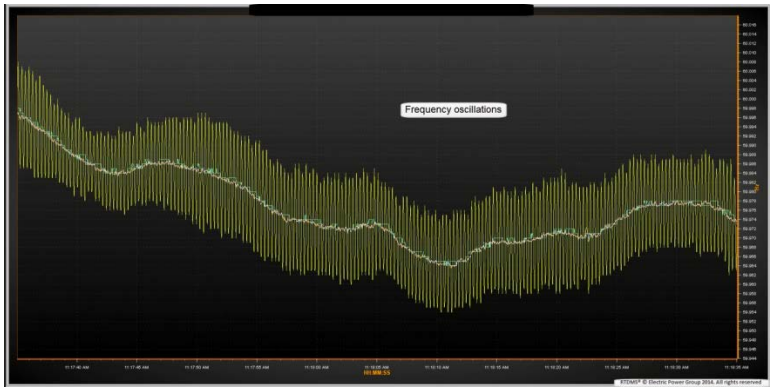
  *A large unit trip via relaying in the West caused system frequency to drop to 59.873 Hz momentarily and returned to normal in seven minutes. Post trip oscillations in voltage and power flow were observed on data from an area PMU.*




- Event 7: [Wind Farm Oscillation Detection and Mitigation]

  *Title: Video demonstrating Wind farm Oscillation detection and Mitigation using Synchrophasor Technology*

  *The operators at the ISO control center observed oscillations on the Electric Power Group (EPG)'s Real Time Dynamics Monitoring System (RTDMS) oscillation monitor. The oscillations were traced to a PMU located at the wind farm. The oscillation frequency was 3.3 Hz and damping was less than 1%. The ISO operators tried to reduce the oscillations by reducing the wind farm output from 56 MW to lower outputs in steps. At wind farm output of 40 MW, the oscillations stopped. The ISO operators contacted the wind farm operators to determine the cause of oscillations. The wind farm operators in turn contacted the manufacturer, who confirmed that changes were made remotely to wind farm controller settings. These changes were concurrent with the time oscillations started. The manufacturer then reverted to initial controller settings. Subsequently, no oscillations were observed even when the wind farm was ramped up to higher power outputs. This video demonstrates the benefit of Synchrophasor Technology in identifying and mitigating the oscillations in the system.*

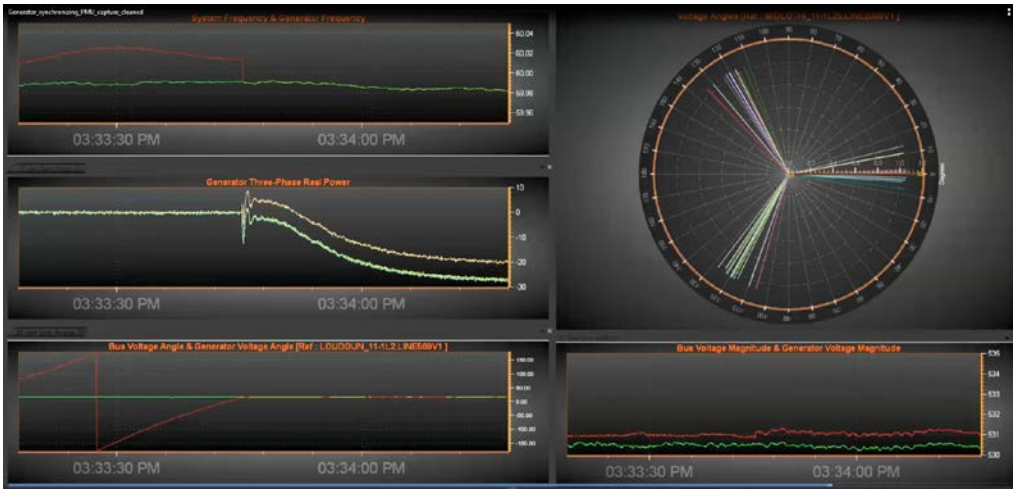



- Event 8: Clip 1 (230Kv and 500Kv Voltages and flows), Clip 2 (Select Unit MW and Mvar output), and Clip 3 (System frequency and voltage angles)

  *A 230kV fault followed by a loss of a large generation plant caused system frequency to drop approximately 72mHz momentarily, while having an impact on nearby system voltages and online generators.*

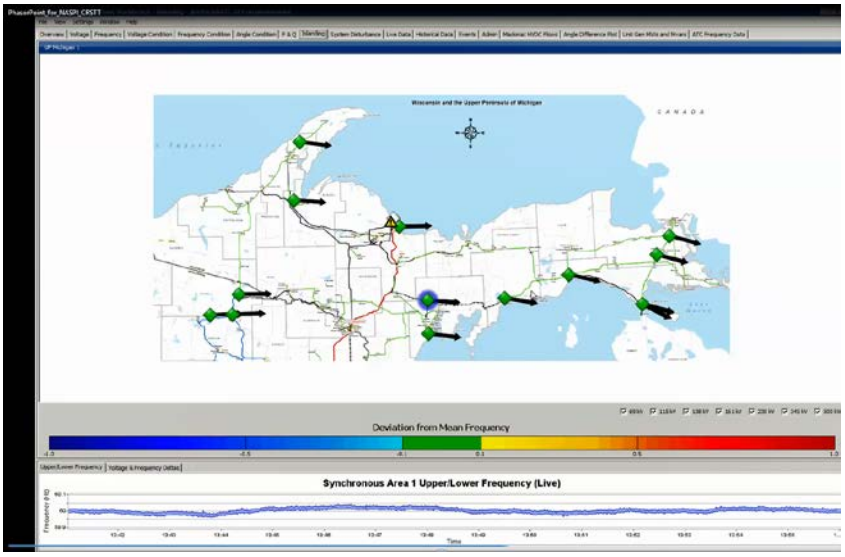

- Event 9 (Generator synchronization to grid)

*This video captures the actual synchronization of a large generator to the electric grid. The windows in the visualization tool capture frequency, output power, voltage angle, and voltage magnitude of the generator and at a reference point on the electric grid.*



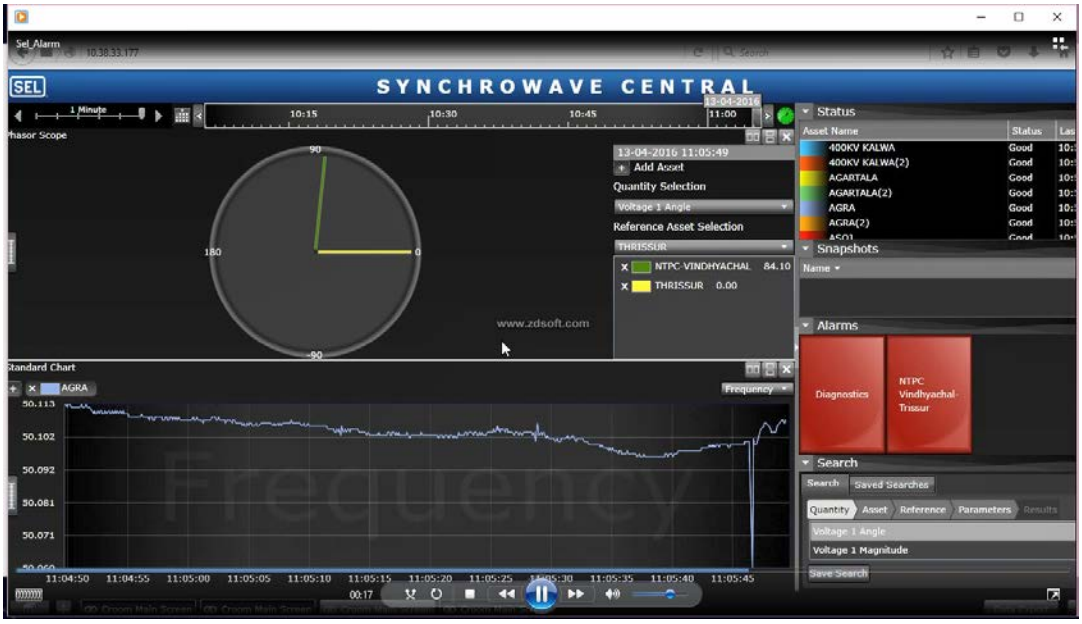

- Event 10 (Quick overview of the capabilities of the PhasorPoint application as implemented at ATC)

*No event is associated with this video. It is a quick review of some of the screens available in the PhasorPoint application as implemented by ATC.*



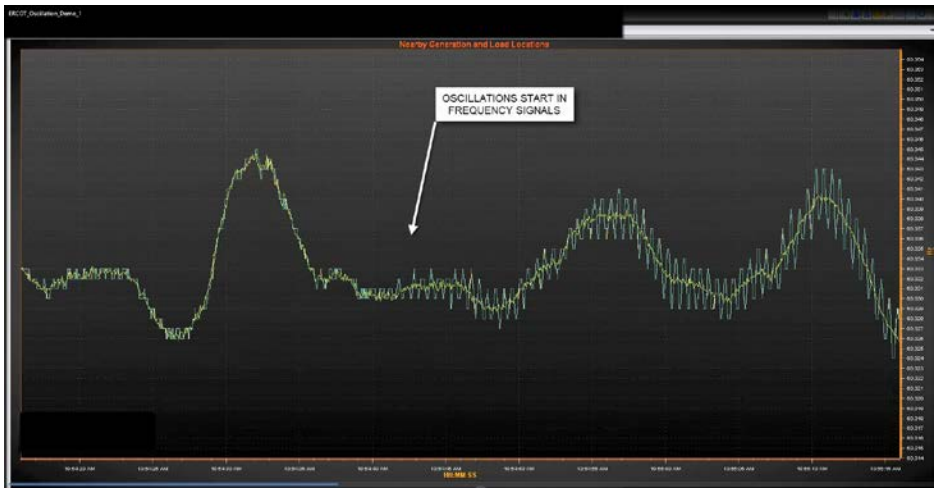

- Event 11 (Phase Angle monitoring example – SEL Synchrowave)

*No event is associated with this video. It is a quick review of some of the data plots available in the SEL Synchrowave application to facilitate phase angle monitoring and alarming.*



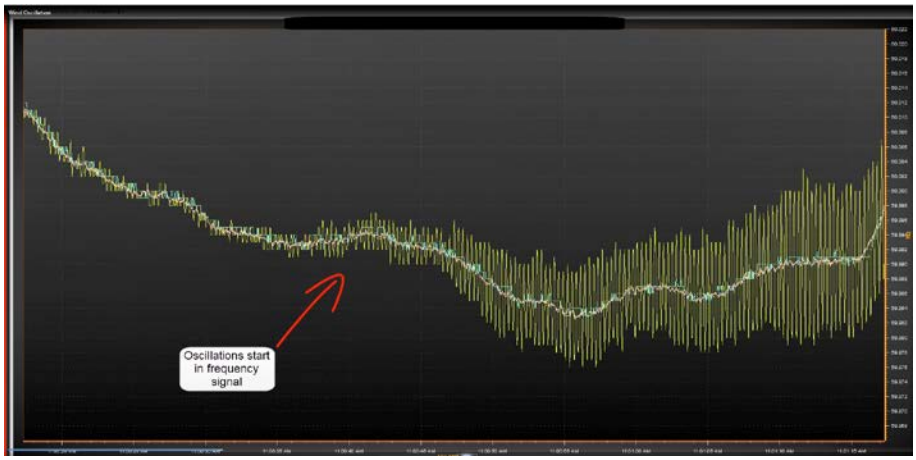

➢ Event 12 (ERCOT Customer Oscillations)

*An oscillation event on the ERCOT system displayed using RTDMS.*



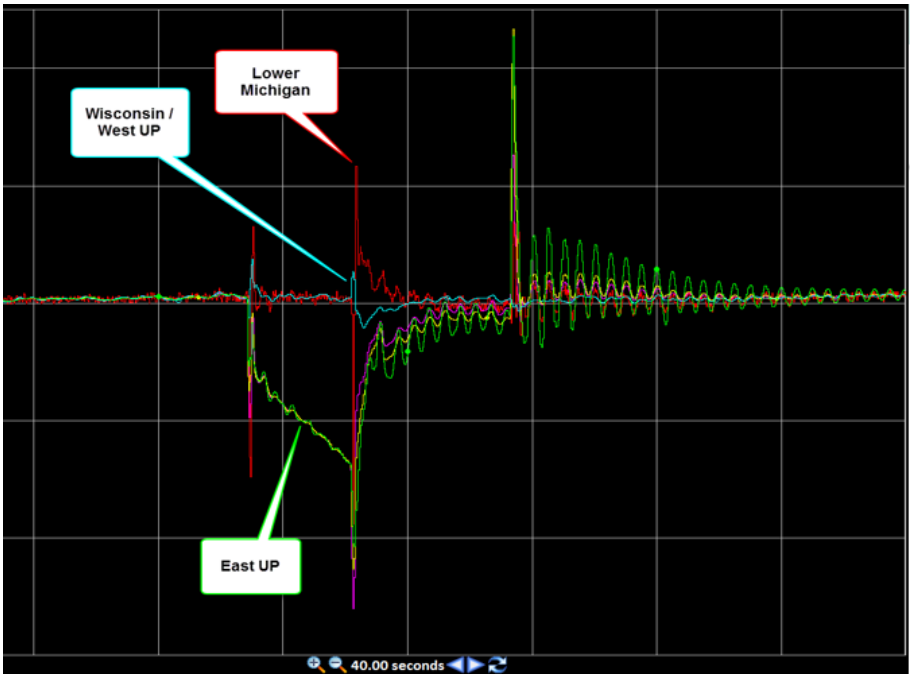

➢ Event 13 (ERCOT Wind Farm Oscillations)

*An oscillation event associated with a wind generation plant on the ERCOT system displayed using RTDMS.*



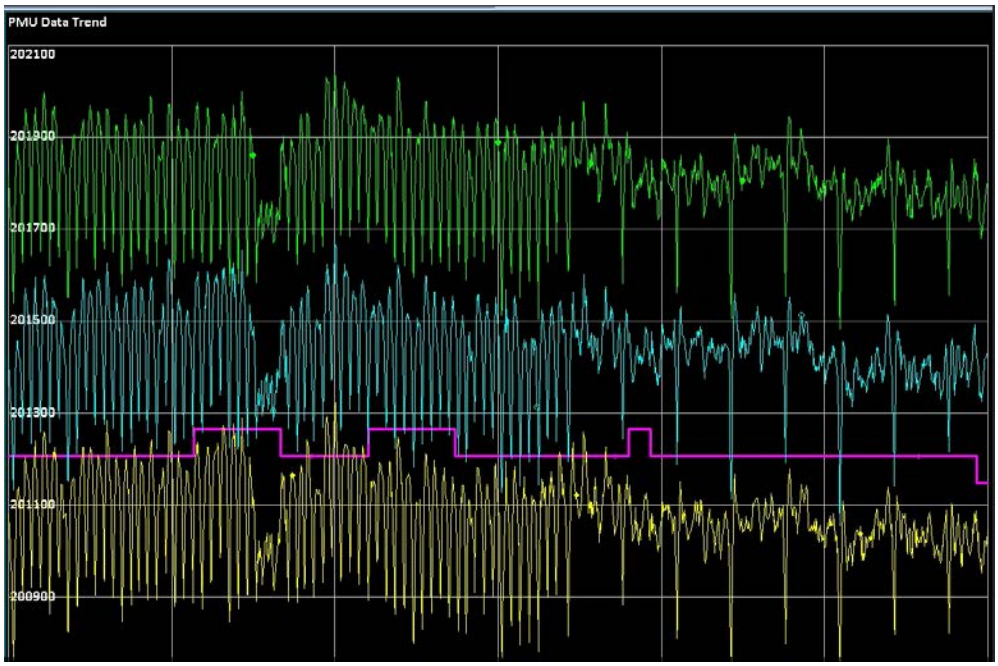

➢ Event 14 (Frequency plot showing the opening and reclose of tie lines between the Eastern UP and the central UP of Michigan)

*A double circuit outage resulted in the eastern UP being isolated from the rest of the ATC footprint. The system was served via a back to back HVDC link and when it opened and reclosed significant oscillations in frequency were observed. The video compares the frequencies in the small isolated area, the main ATC interconnection, and lower Michigan. SCADA frequency traces (green and cyan traces) are also included which show little response to what was happening during the event.*



- Event 15 (Observed voltage oscillations in southern Wisconsin not visible in SCADA)

*With the implementation of PMU monitoring in southern Wisconsin we started seeing odd oscillatory behavior in the voltage traces. The video shows the oscillations on a particular day where initially we saw the voltage oscillating at ~0.7 HZ with periodic notches in the voltage profile once every minute. It then transitioned to voltage dips that occurred once every 10-15 seconds. Despite the abundance of synchrophasor data available in the area we have yet to pinpoint the source of the oscillations.*



Change History

| Revision | Description | Author | Date |
|---|---|---|---|
| 1.0 | Added video 2 event description. | T. Carlon | 5/29/14 |
| 2.0 | Removed unused video filenames. Videos were not posted. | T. Carlon | 6/3/14 |
| 3.0 | Added Wind Farm video (#7) event description from ERCOT & EPG. | T. Carlon | 3/9/15 |
| 4.0 | April 15, 2015, added video 8 A 230kV Fault even description from Kyle Thomas, Virginia Power. | T. Carlon | 5/6/15 |
| 5.0 | Updates to include information on posted videos 9 thru 15. Added logo to first page header. | J. Kleitsch/T. Carlon | 1/18/2018 |
| 6.0 | Fixed broken links in this document. Added NASPI tracking number on cover page. | T. Carlon | 4/17/18 |