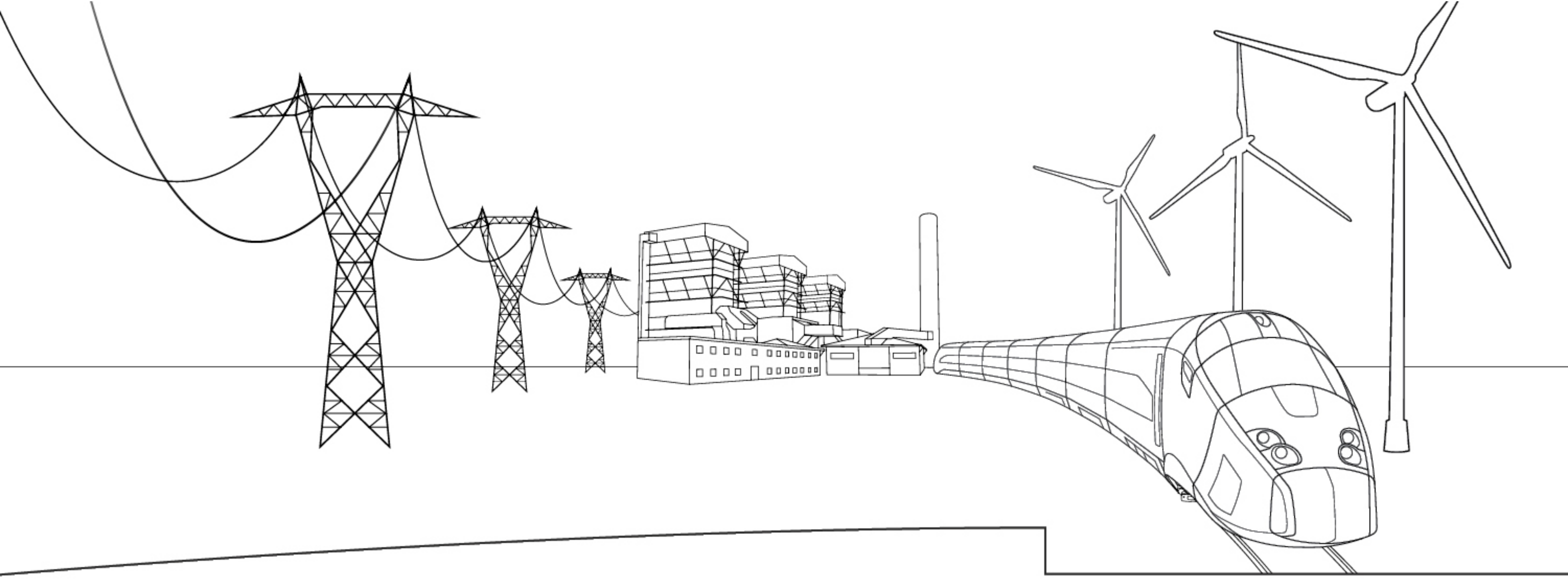

Practical Experiences from Synchrophasor Deployment

Manu Parashar and Barbara Motteler

NASPI

10/22/2013

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Shaping the future

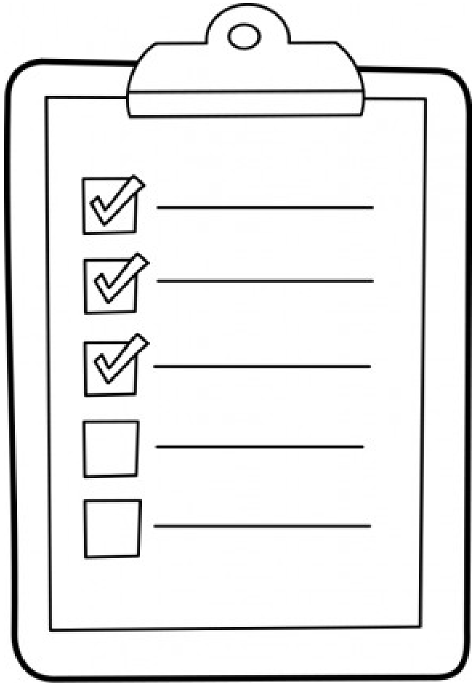
- Data Collection & IT Planning
- Application Readiness
- Operator Acceptance

Data Collection & IT Planning

- IT and Communication Issues
- Data Collection Issues
- Naming Convention

Planning for IT support

Getting PMU data from the field to Control Center



- Network configuration:
  - Firewall configuration
  - Routers
  - Assignment of IP addresses
- Network Planning:
  - Bandwidth
  - TCP vs. UDP vs. Multicast
- Checklists
  - Have a checklist!
  - IT support must be scheduled, can have long lead time

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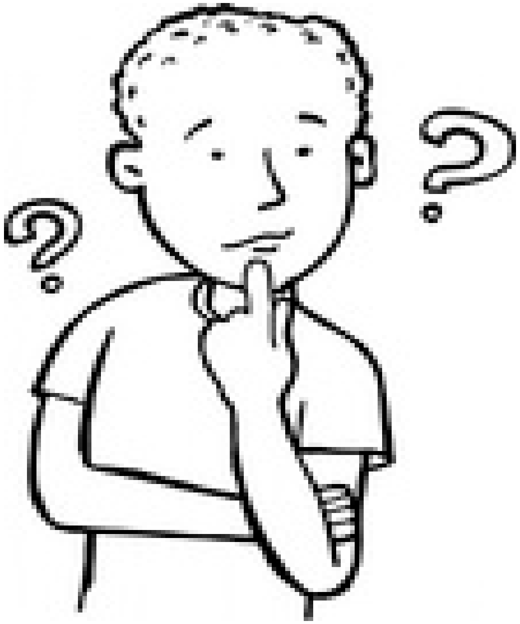
Data, Data, Where is the data?

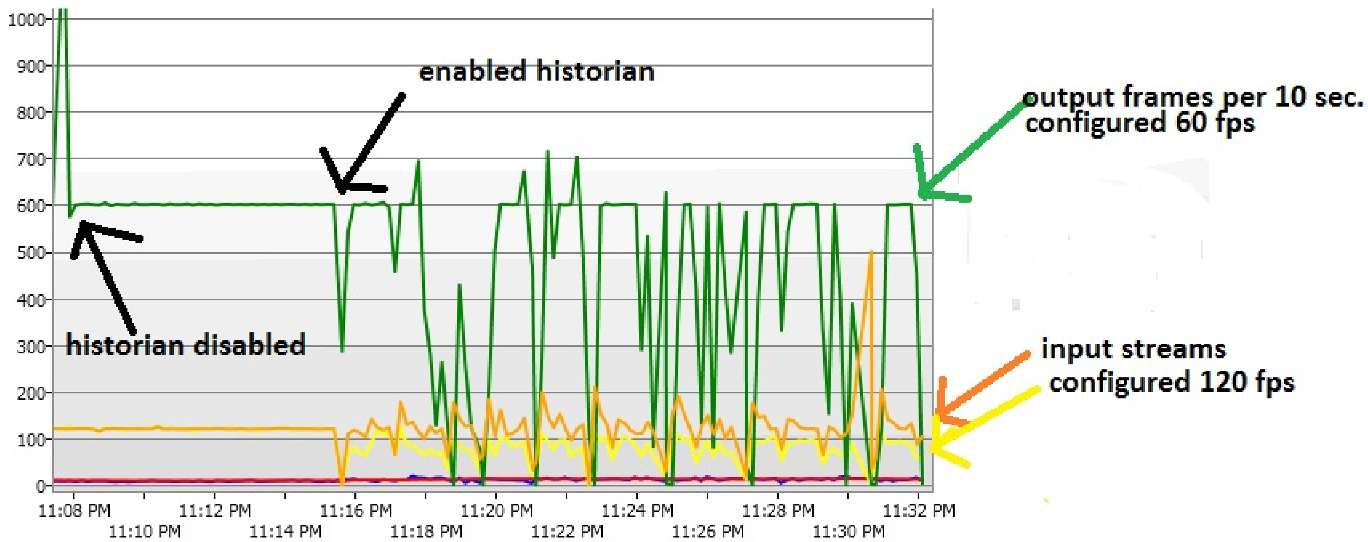
Common causes of missing or bad data

- Time Synchronization issues
  - PDC clock drifts.
  - PMU not correctly synchronized.
  - Output stream wait time too small.
- Performance Issues
  - Network
  - Disk
  - CPU (garbage collection, etc.)
  - Buffer sizes



- Open lines
  - Phasor angle is arbitrary (meaningless) but still marked as good quality by the PMU.
  - Frequency measurement by PMU on open line may be incorrectly reported (constant) but still marked as good quality

Effect of Disk Activity on UDP Streams



- When local historian enabled, disk IO interfered with UDP buffer processing.
- Solved by using remote historian.
- Alternate solutions include more powerful CPU or faster disk.

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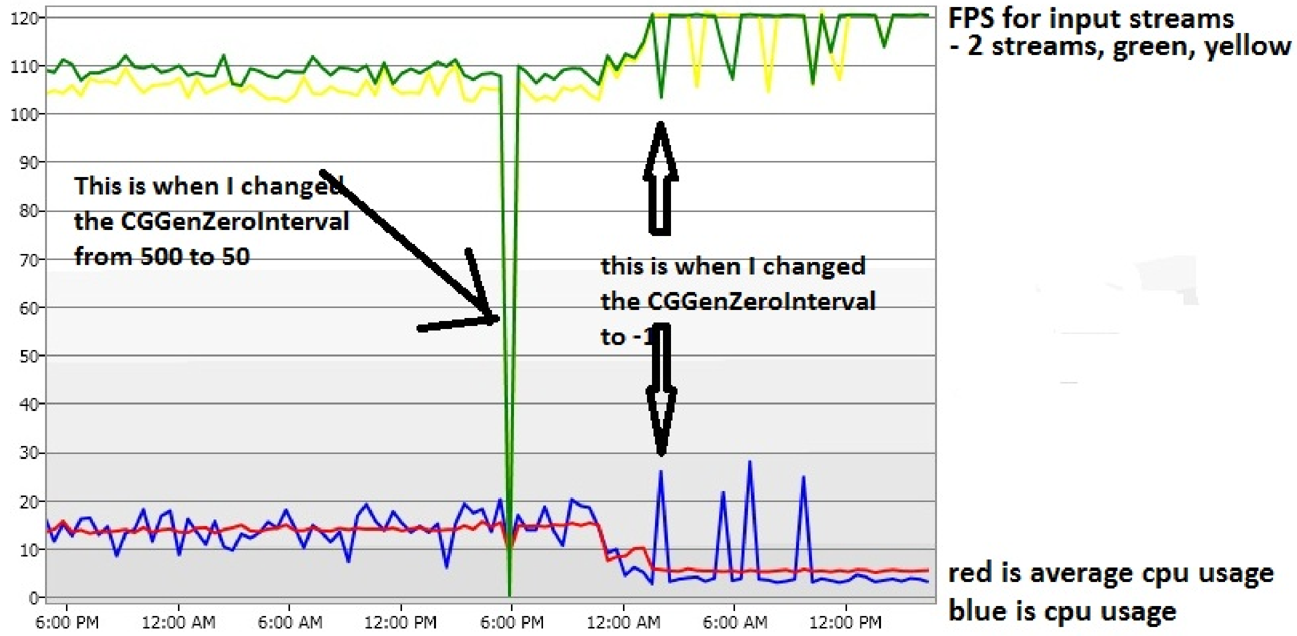
Effect of CPU Activity on UDP Streams



- Two UDP input streams, 120 fps each
- I changed .NET garbage collection parameters to manipulate CPU usage.
- We see the effect as missing data from input streams due to UDP buffer overflow.

Effect of network errors or overload on UDP Streams

- Large UDP frames are broken into smaller packets for network transmission, then re-assembled at the other end.
- If even one of these packets is lost, the frame can’t be re-assembled and the entire UDP frame is discarded.
- Resulting frame loss can be very high (more than half).
- Packets can be lost due to buffer issues, NIC capacity, network capacity, etc.
- Problem worse for larger frames.

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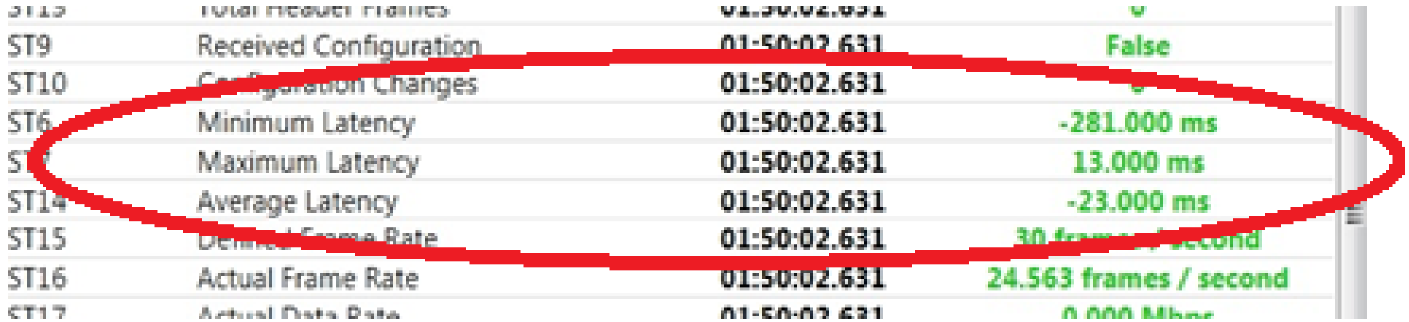
Configuring Output Stream Wait Time

- Wait too long and extra latency is introduced.
- Data discarded if wait time is too small.
- Use PDC tools to monitor input latencies.



ST9	Received Configuration	01:50:02.631	False
ST10	Configuration Changes	01:50:02.631	[illegible]
ST6	Minimum Latency	01:50:02.631	-281.000 ms
ST[illegible]	Maximum Latency	01:50:02.631	13.000 ms
ST14	Average Latency	01:50:02.631	-23.000 ms
ST15	Defined Frame Rate	01:50:02.631	30 frames / second
ST16	Actual Frame Rate	01:50:02.631	24.563 frames / second

- Set the output wait time to be larger than the maximum latency of the input streams in order to minimize data loss.

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Naming Conventions

- Don't use PMU default signal names or default device number!
- Best practice is to establish a signal naming convention up front and stick to it throughout the system.
- Best practice provides a readable name that uniquely identifies each signal.
- If names are defined at the PMU level, they automatically propagate to PDCs.

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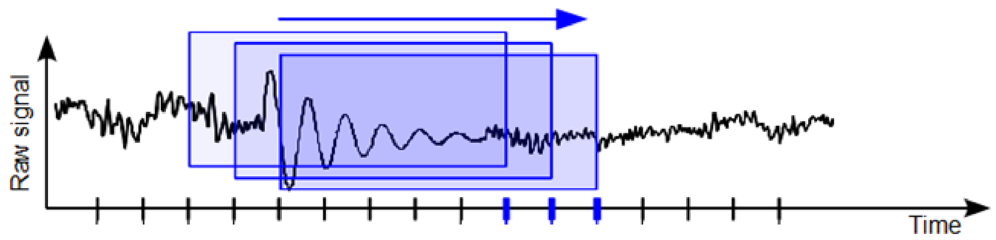
Synchrophasor Application Readiness

– Data Availability Requirements
– Application Tuning

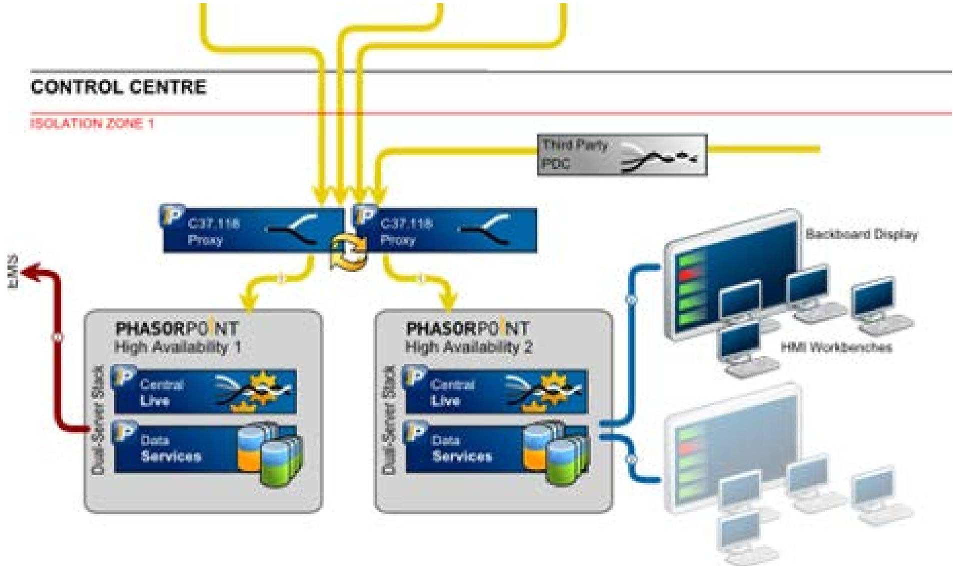
Data Availability Requirements for Synchrophasor Applications

- Advanced applications such as Oscillatory Stability Monitoring (OSM), Disturbance Characterization, and Islanding Detection rely on the recent time history of data (ranging from 1 sec to several minutes).



- Require 90% data availability or better to make an accurate assessment.

Active-Active
High Availability (HA)



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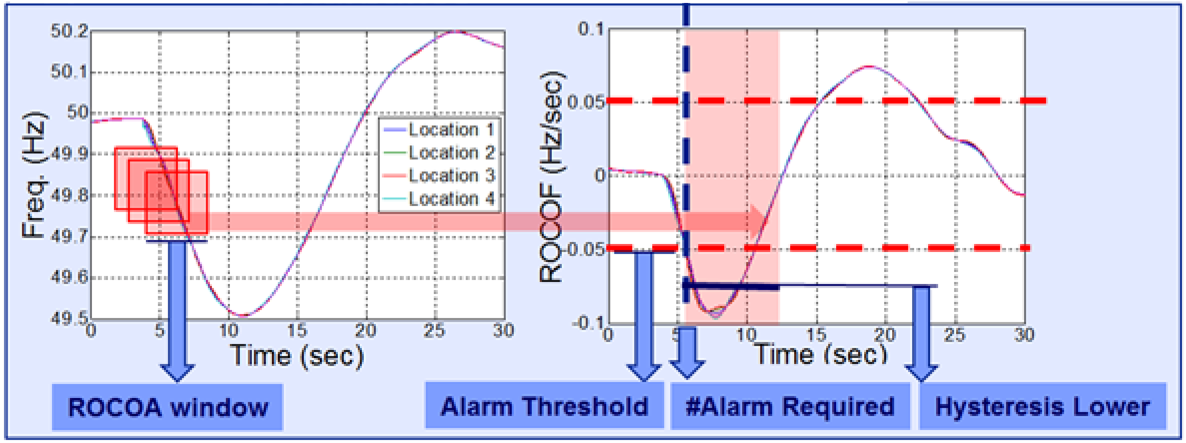
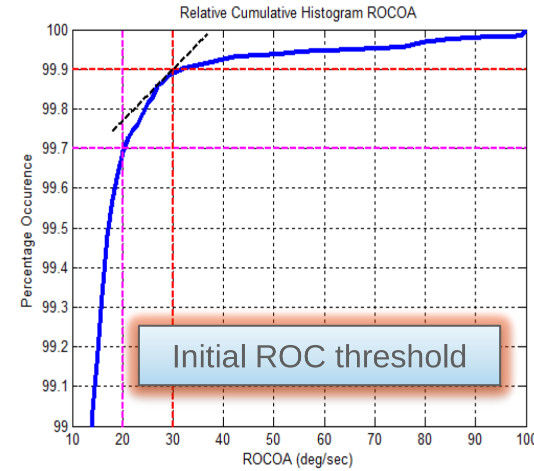
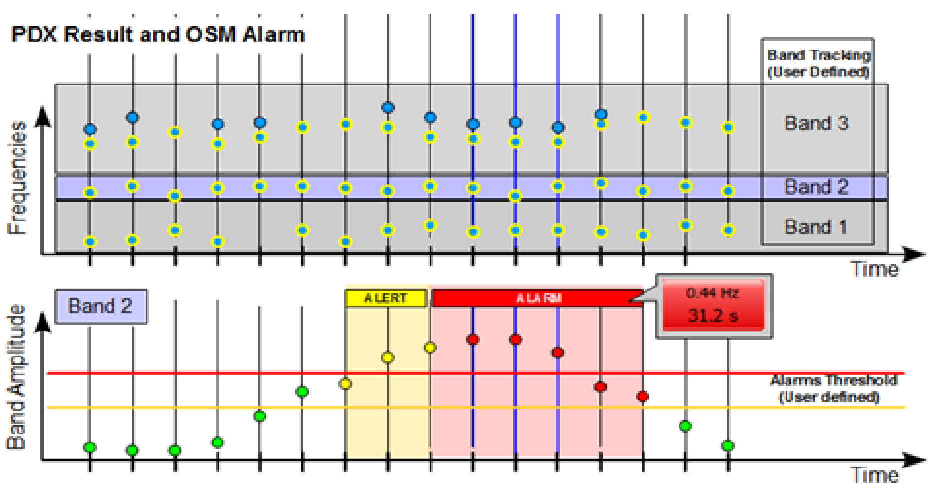
Application Parameter Tuning

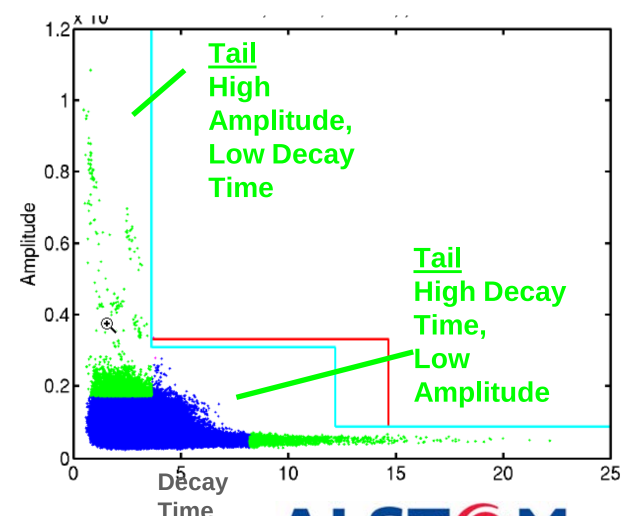
System Disturbance Characterization





Oscillatory Stability Monitoring





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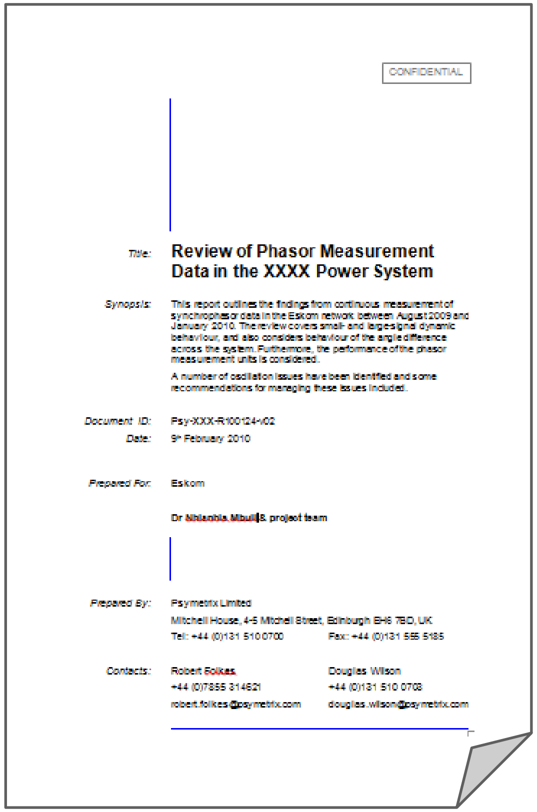
Performance & Threshold Report Contents

- Executive Summary
  - Comment on Observed Risks
  - Proposed Management
  - Summary of Oscillations & Disturbance
  - Monitoring Infrastructure performance
- Review of Modes of Oscillation
  - Baseline - normal behaviour patterns
  - Unusual events – source location
- Review Disturbances
  - Examples of Post-Event Analysis
- Threshold Settings
  - OSM Oscillation Alarms
  - SDM Disturbance parameters
  - Angle Behaviour Templates & Alarms



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Title: **Review of Phasor Measurement Data in the XXXX Power System**

Synopsis: This report outlines the findings from continuous measurement of synchrophasor data in the Eskom network between August 2009 and January 2010. The review covers small- and large-signal dynamic behaviour, and also considers behaviour of the angle difference across the system. Furthermore, the performance of the phasor measurement units is considered.

A number of oscillation issues have been identified and some recommendations for managing these issues included.

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Date: 9th February 2010

Prepared For: Eskom

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Operator Acceptance

- Integrated Solution (with existing EMS)
- Provide required “context” to PMU-based monitoring
- Operator Guidance
- Establish Familiarity & Demonstrate Benefits
- Operator Training Environment

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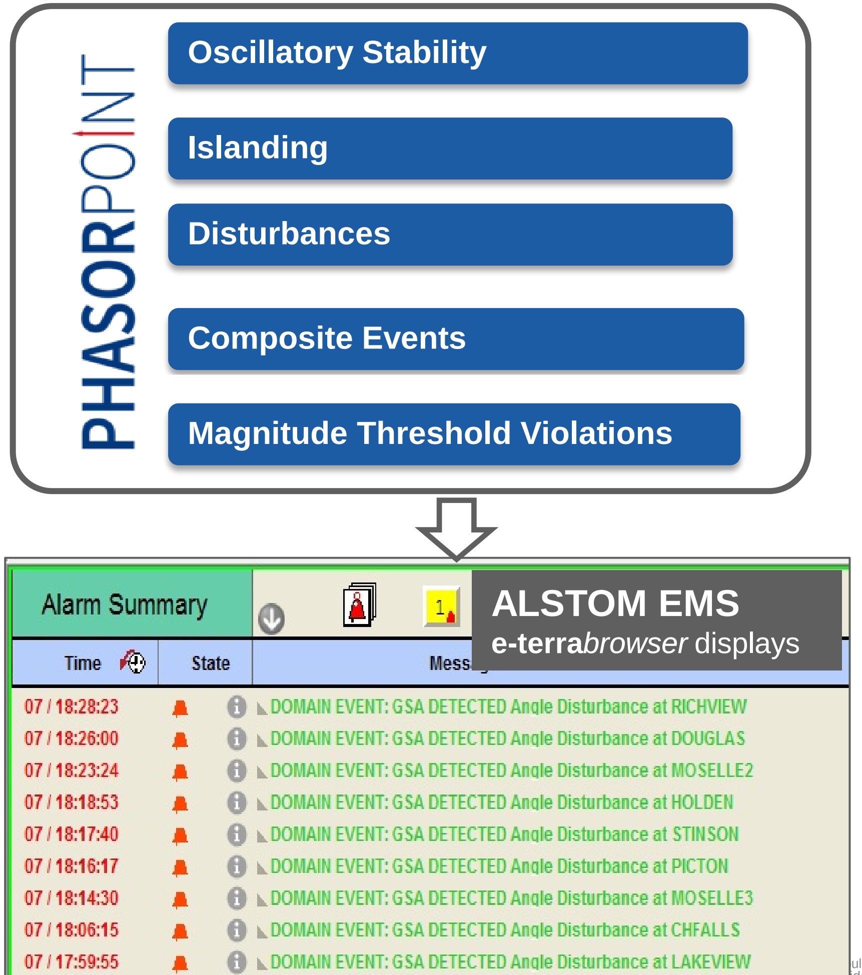
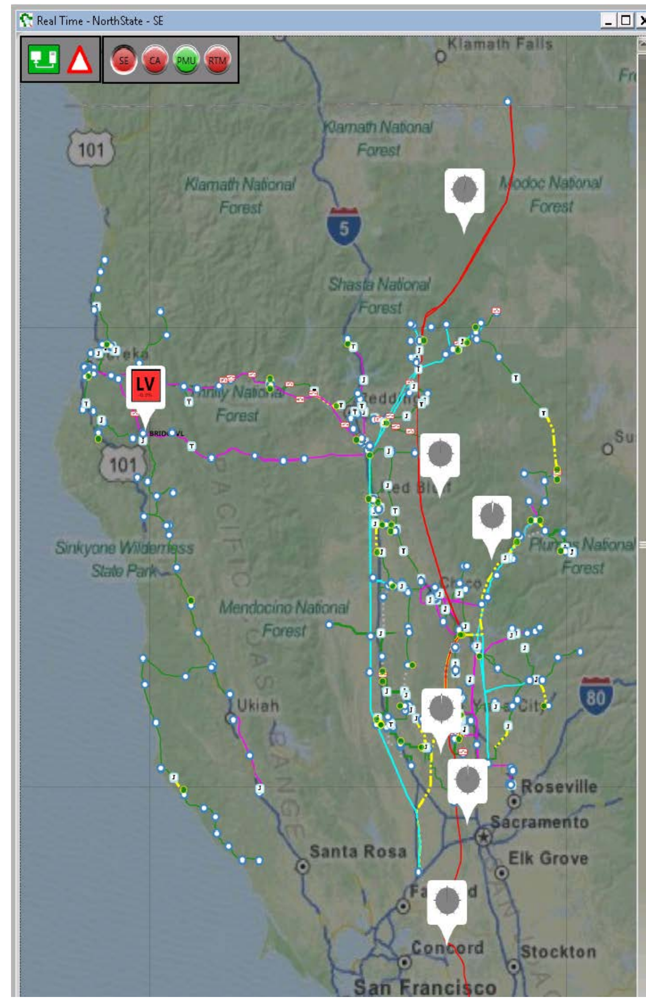
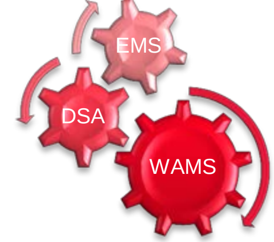
Integration with existing EMS and Visualization

All alarms *(including WAMS alerts/alarms)* maintained and managed at a centralized location with the EMS Alarm Management System.

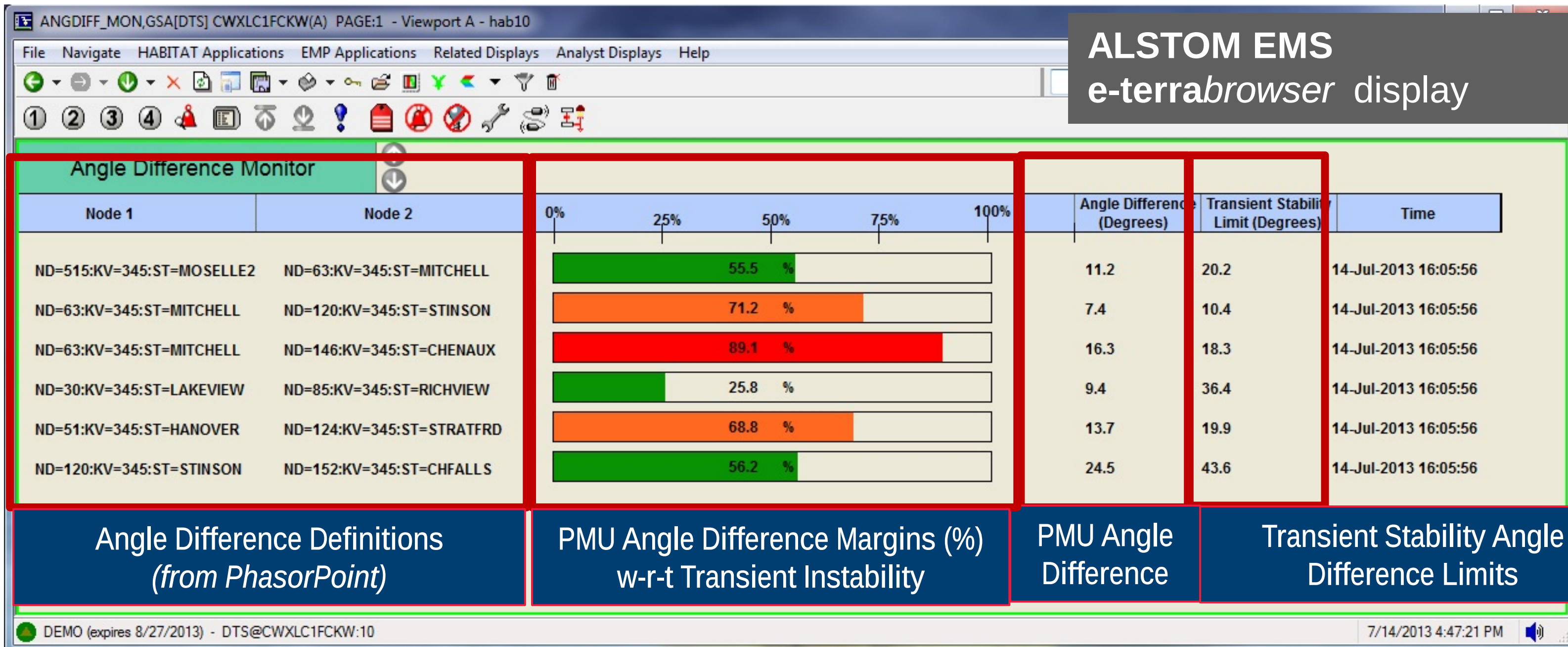






Providing a “Context” to PMU-based Monitoring

Combining ***measurement-based*** (PhasorPoint) and ***model-based*** (Powertech’s DSA tools) technologies to provide dynamic limits



Node 1	Node 2	0% 25% 50% 75% 100%	Angle Difference (Degrees)	Transient Stability Limit (Degrees)	Time
ND=515:KV=345:ST=MOSELLE2	ND=63:KV=345:ST=MITCHELL	55.5 %	11.2	20.2	14-Jul-2013 16:05:56
ND=63:KV=345:ST=MITCHELL	ND=120:KV=345:ST=STINSON	71.2 %	7.4	10.4	14-Jul-2013 16:05:56
ND=63:KV=345:ST=MITCHELL	ND=146:KV=345:ST=CHENAUX	89.1 %	16.3	18.3	14-Jul-2013 16:05:56
ND=30:KV=345:ST=LAKEVIEW	ND=85:KV=345:ST=RICHVIEW	25.8 %	9.4	36.4	14-Jul-2013 16:05:56
ND=51:KV=345:ST=HANOVER	ND=124:KV=345:ST=STRATFRD	68.8 %	13.7	19.9	14-Jul-2013 16:05:56
ND=120:KV=345:ST=STINSON	ND=152:KV=345:ST=CHFALLS	56.2 %	24.5	43.6	14-Jul-2013 16:05:56

Angle Difference Definitions
(from PhasorPoint)

PMU Angle Difference Margins (%)
w-r-t Transient Instability

PMU Angle
Difference

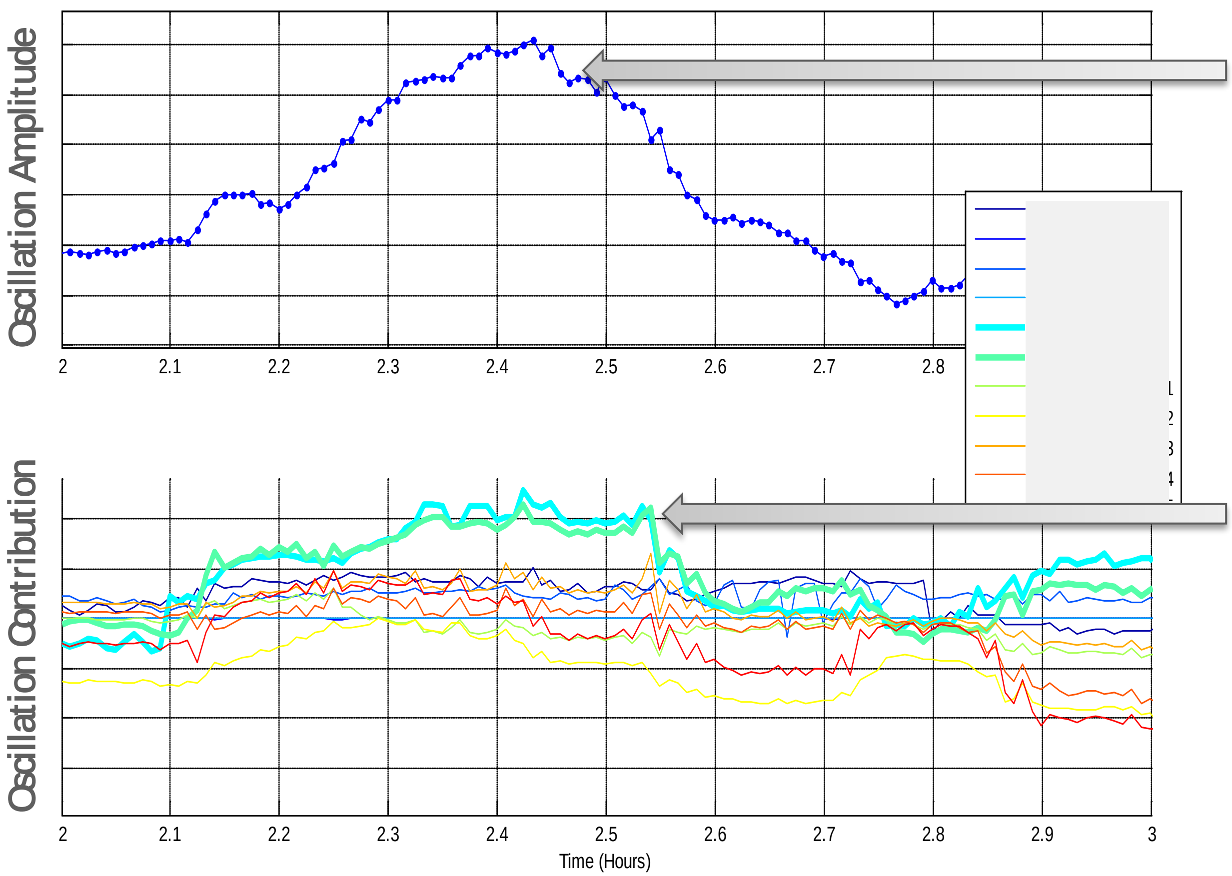
Transient Stability Angle
Difference Limits

PHASORPOINT

Dynamic Security
Assessment (DSA)
Powertech

Operator Guidance

Manitoba Hydro 0.009Hz Governor Mode



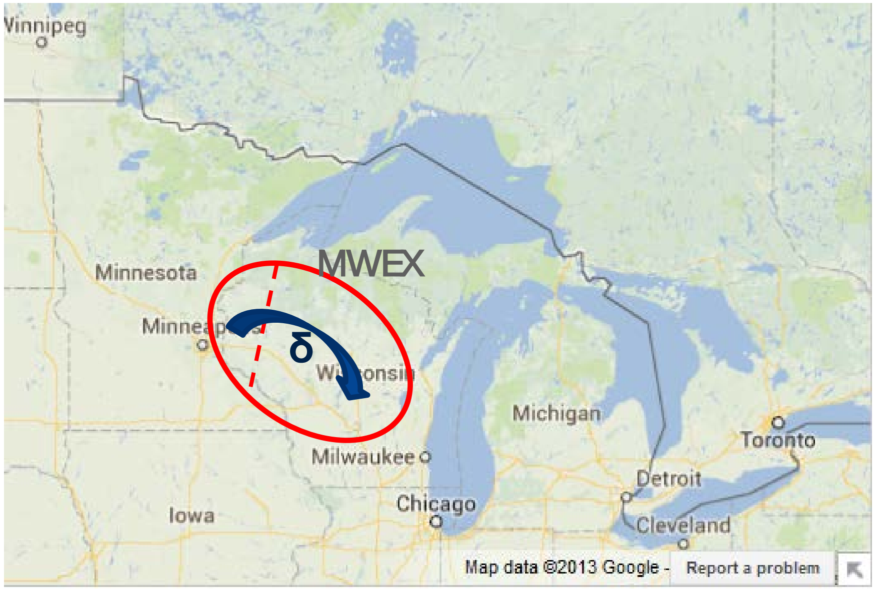
Raised oscillation amplitude

Specific signals show raised Contribution *(NOT Amplitude)*

Establish Familiarity & Demonstrate Benefits

MISO – MWEX Corridor Monitoring & Constraint

- Derive equivalent δ across MWEX corridor
  - Better than 2-bus δ
- Investigate expressing constraint as equiv δ
  - Prototype
- Investigate use of DSA & WAMS
- Success → design & implement transfer management tools & process



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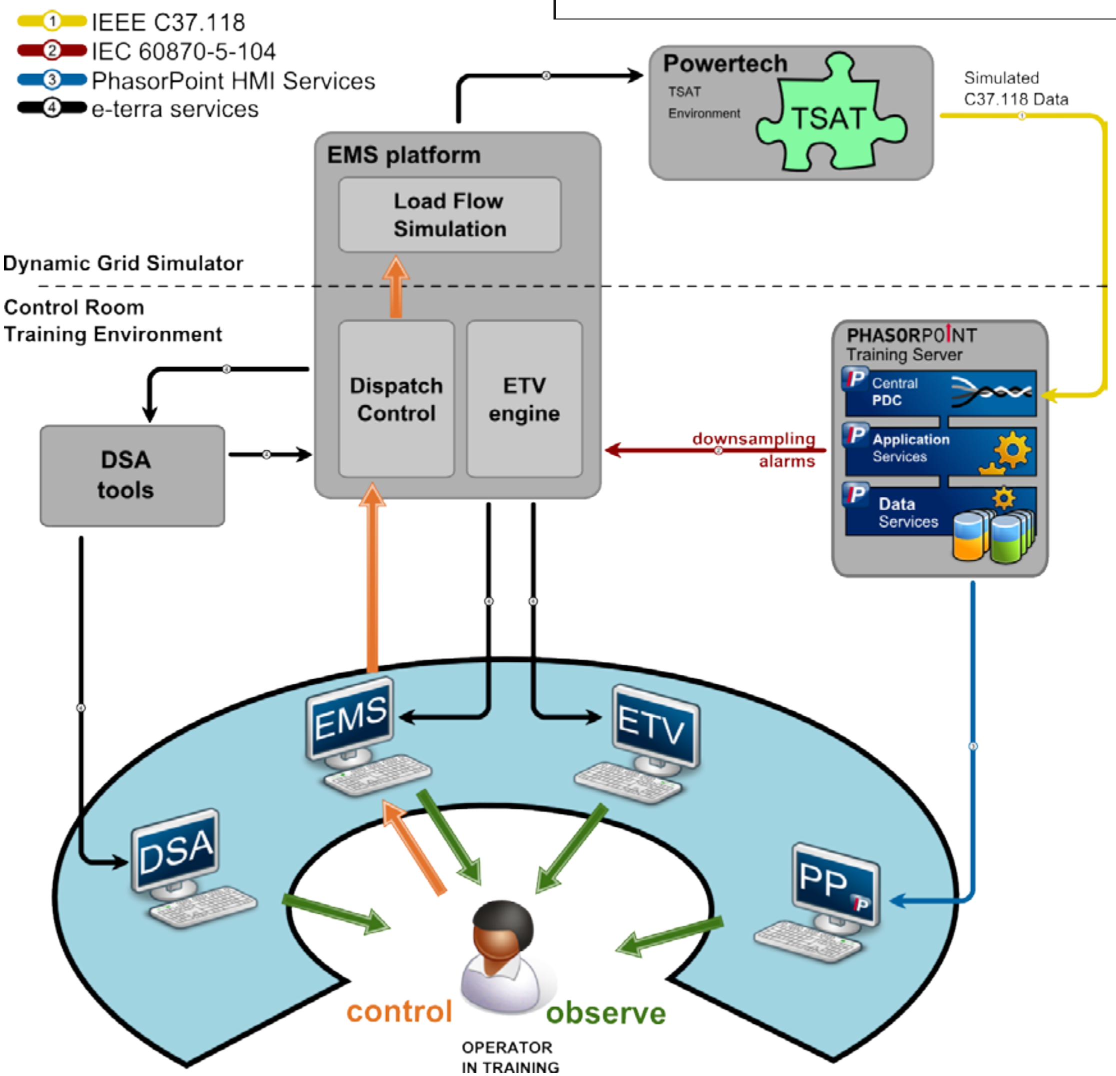
Operator Training Environment – Integrated

Integrated Dispatcher Training System:

- Real-time simulator based on Powertech TSAT
- Simulated data is fed directly into PP as C37.118 streams
- Data is also downsampled and sent to the EMS & DSA Tools
- EMS integrated with PhasorPoint and DSA tools



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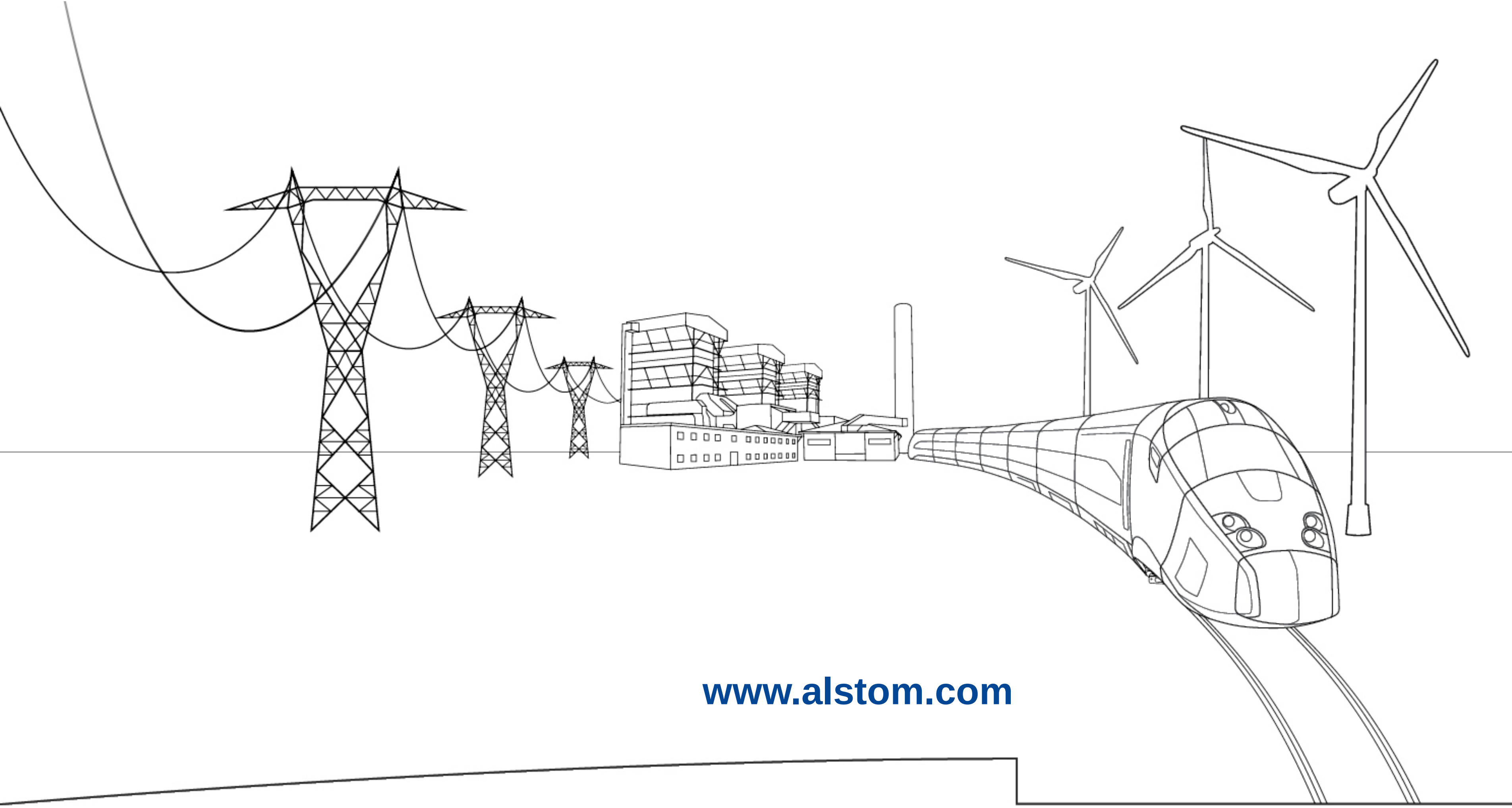

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