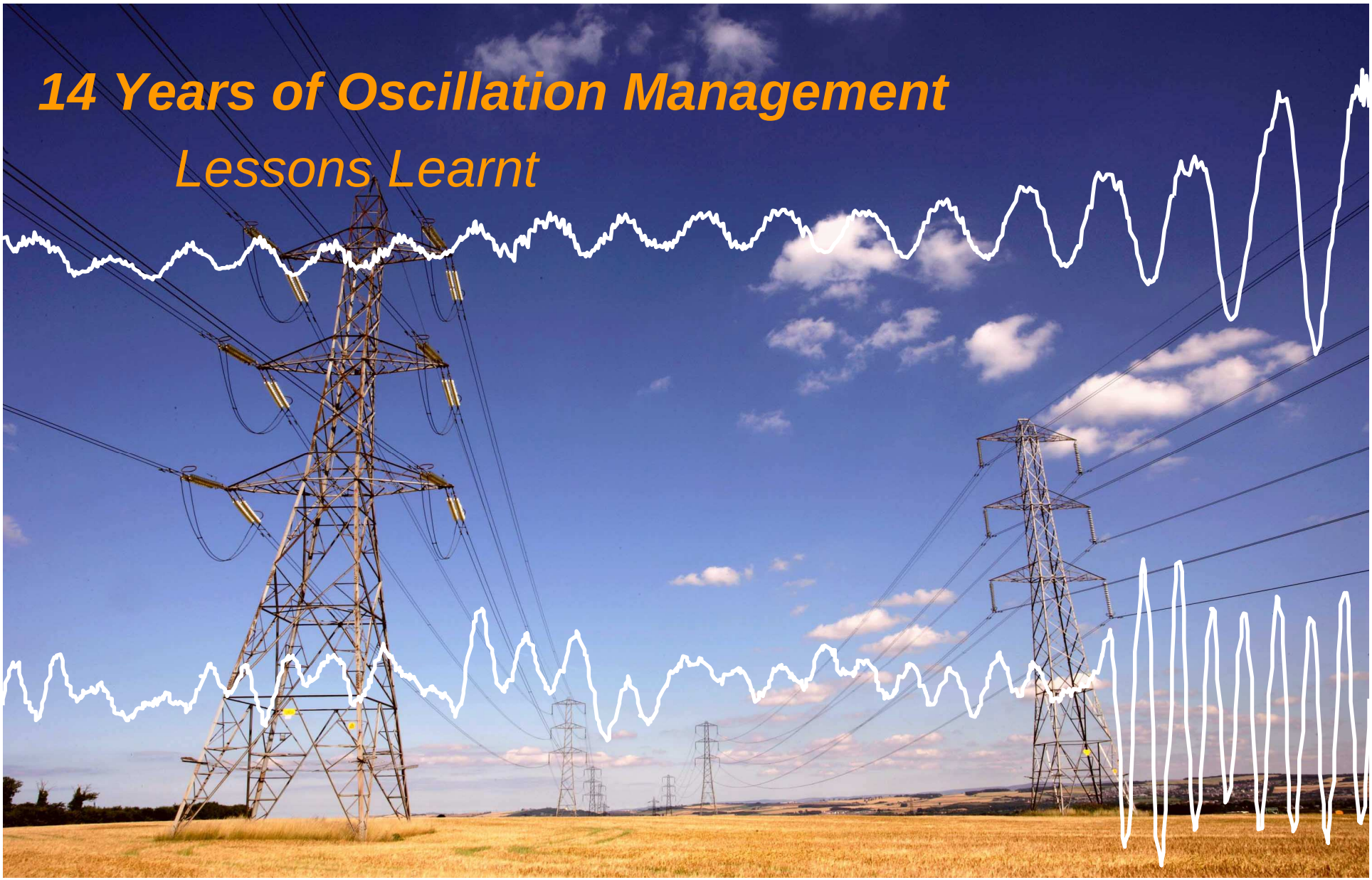
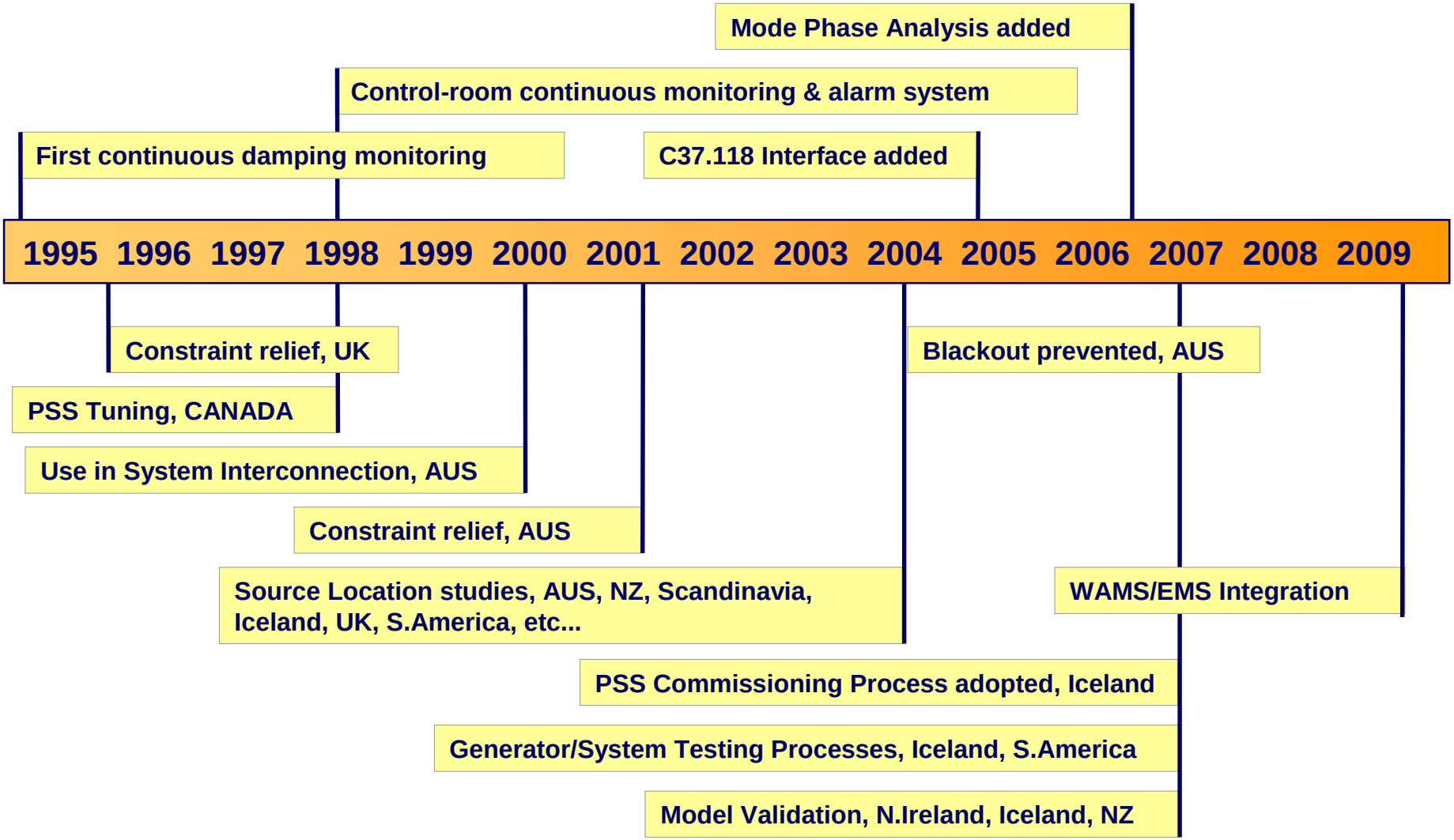
14 Years of Oscillation Management

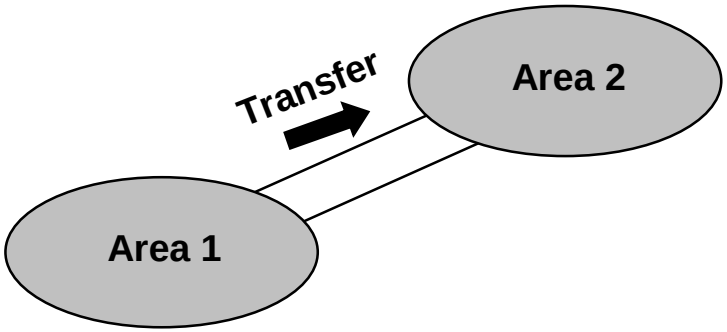
Lessons Learnt

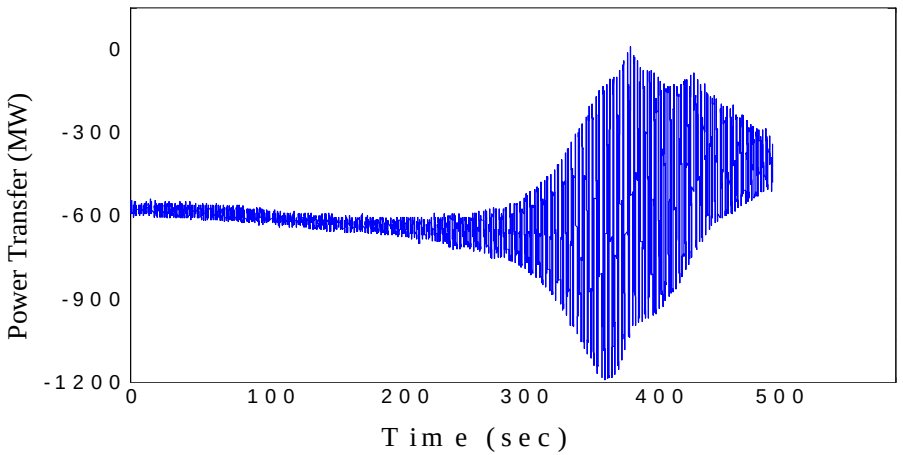


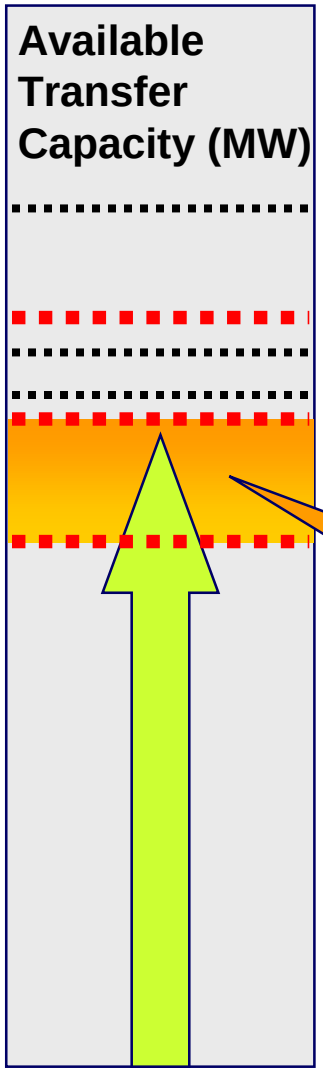
Landmarks in Oscillation Monitoring



Transfer Constraint Relief







Thermal Limit

True Damping Limit

Transient / Voltage
Stability Limits

Model Damping Limit

Model Damping Limit
with Margin

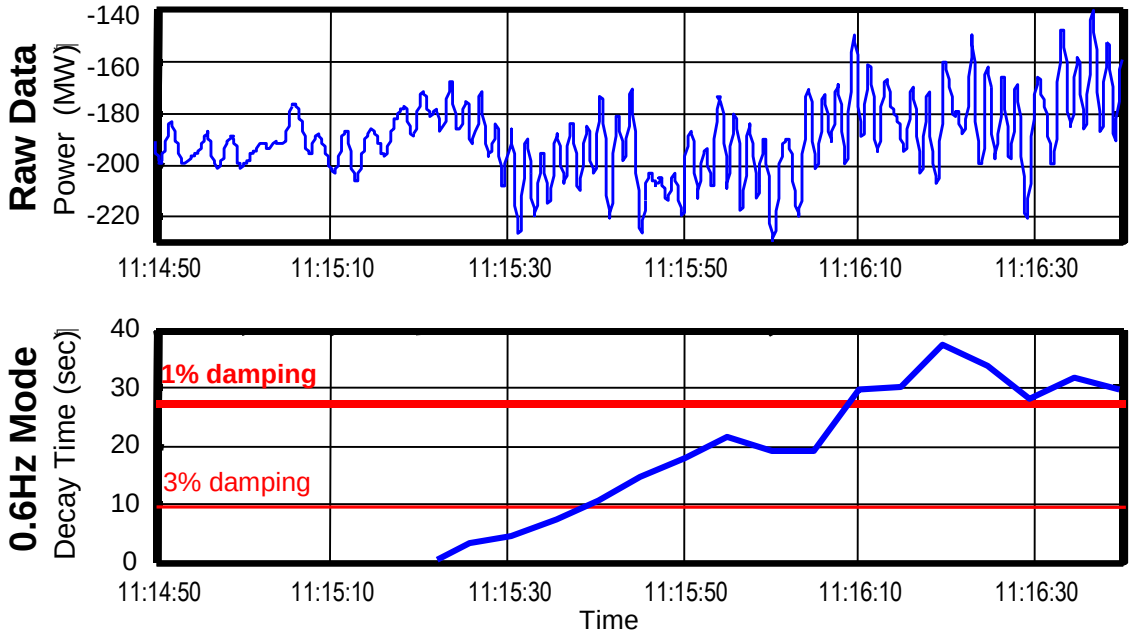
Applied in Australia & UK
+300MW

Capacity available provided measured damping is acceptable

Security Management – Australia

- Sudden instability in a normally well-damped mode
- Alarm generated in <90 seconds of the onset
- Operators awareness, prompt action despite EMS alarm flood
- Alarm on damping - measured oscillations small, but >300MW at source
- System splitting and blackout avoided

Separation avoided AUS 2004

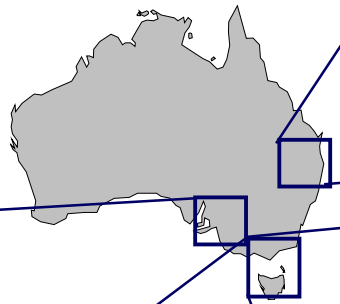


Interconnector Commissioning in Australia

- Wide-Area Dynamics Monitoring required for line commissioning
  - Pre-commissioning
    - Baseline of dynamics measured
    - System studies
  - On-line monitoring of damping during tests
    - System security
    - Conforms with expectation
  - Review dynamic performance
    - Identify degradation
    - Model validation

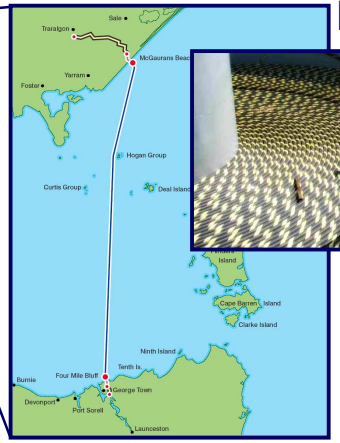
Queensland-NSW Interconnector

2000



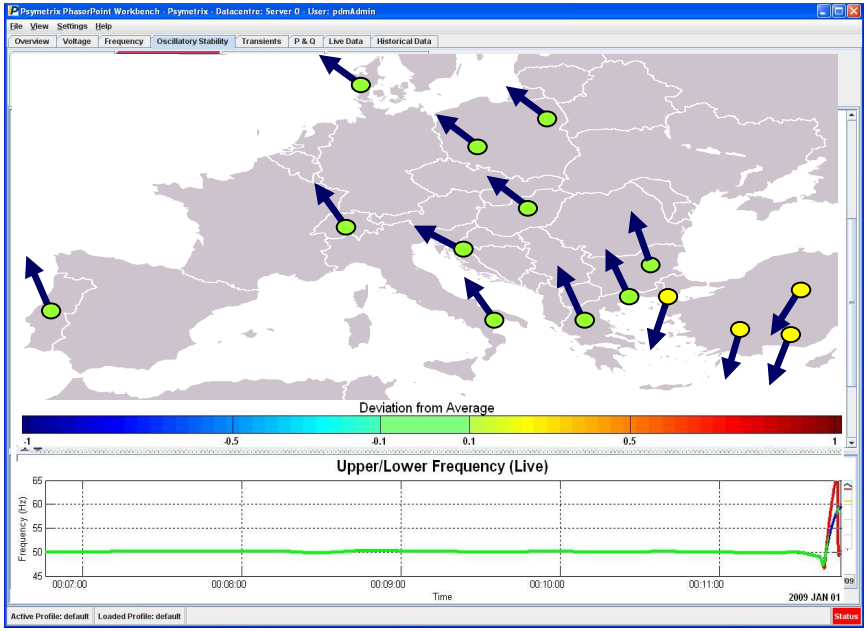
Murraylink

Basslink



Real-Time Angle & Frequency

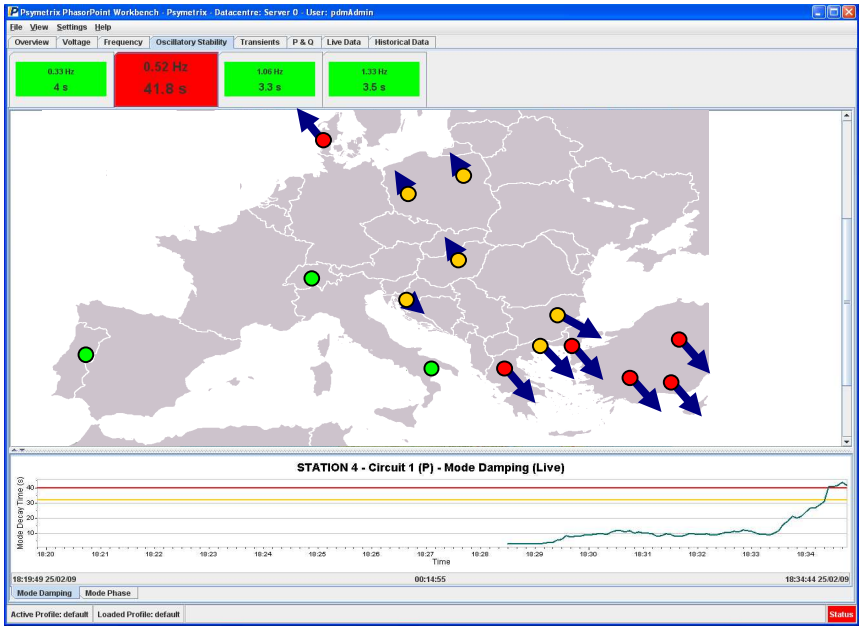
- System Integrity
- Islanding
- Angular separation (stress)



Note: Data is for illustration only, not based on a particular event

Real-Time Damping, Mode Shape

- New poorly damped low frequency modes
- Geographical pattern (mode shape)



Note: Data is for illustration only, not based on a particular event

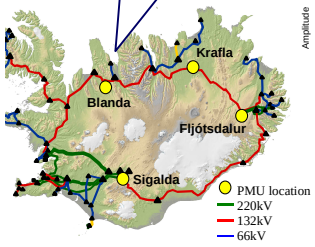
REAL-TIME STABILITY MONITORING FOR EXPANSION OF THE UCTE SYNCHRONOUS AREA

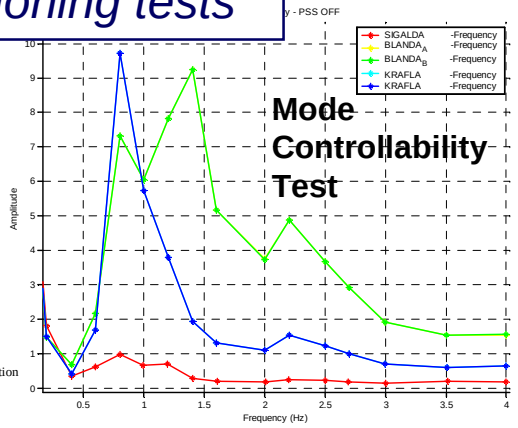
*Wilson D.H., Lubosny Z. (**Psymetrix**), Lopez-Barba S. (**Red Electrica, Spain**), APE, Poland, 2009*

Power System Stabiliser Tuning Process

Pre-commissioning tests

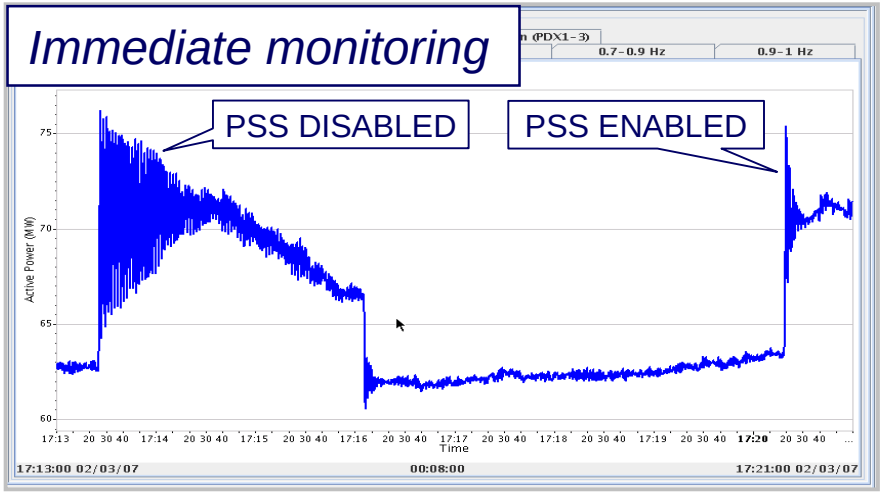
AVR input probing



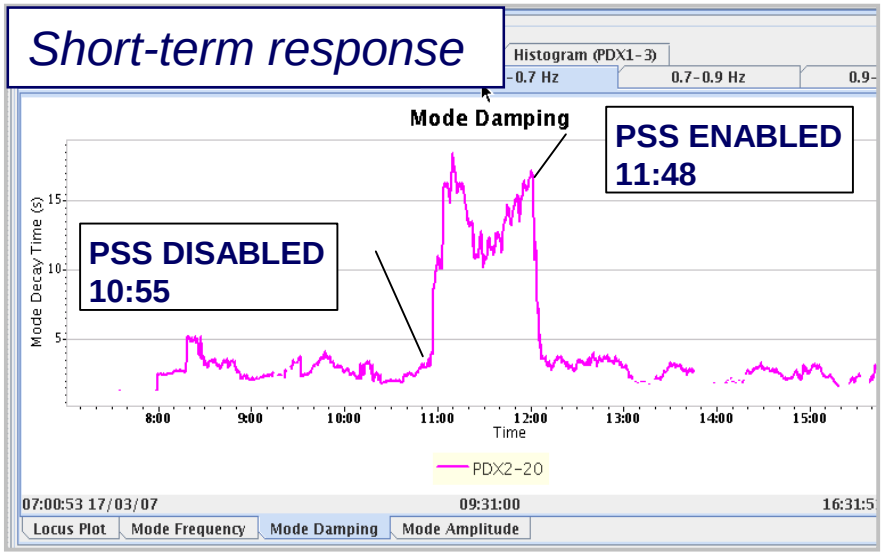


Mode Controllability Test

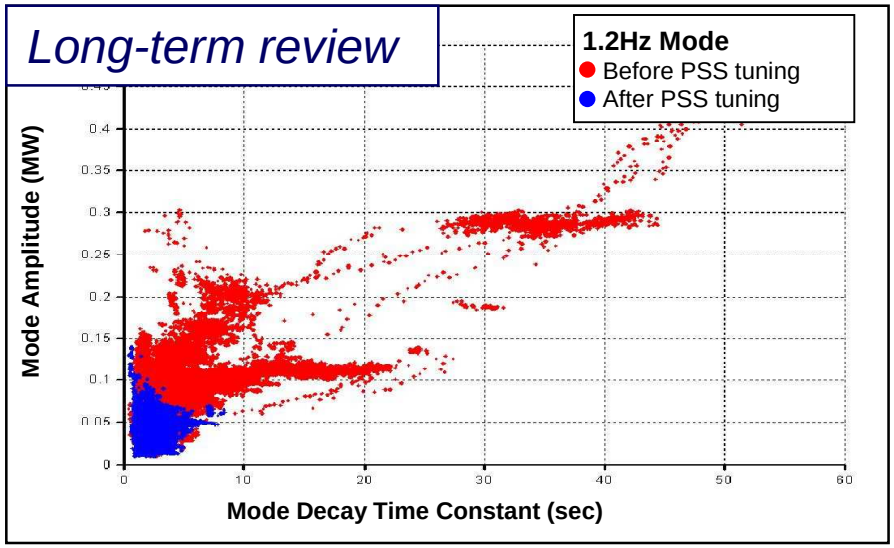
Immediate monitoring



Short-term response

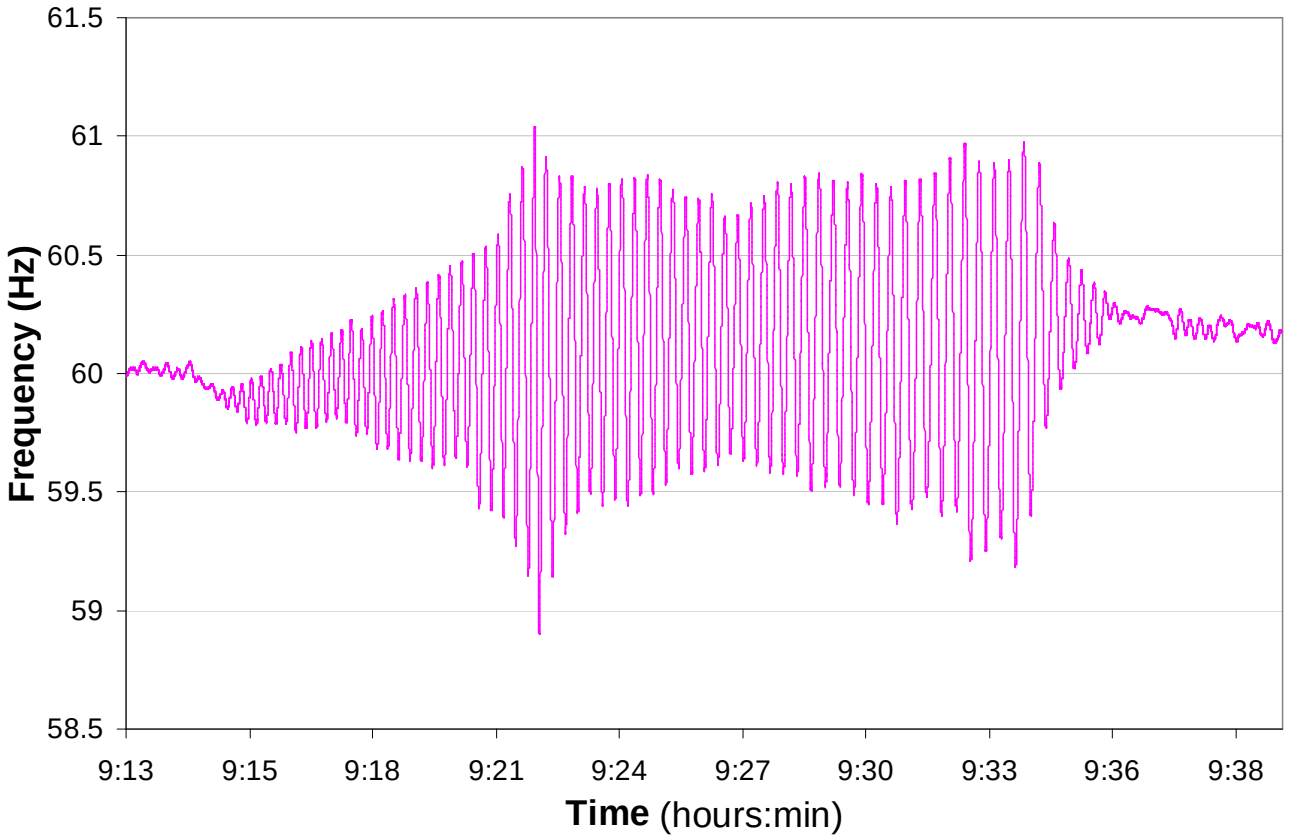


Long-term review



Diagnosing Dynamics & Control Issues

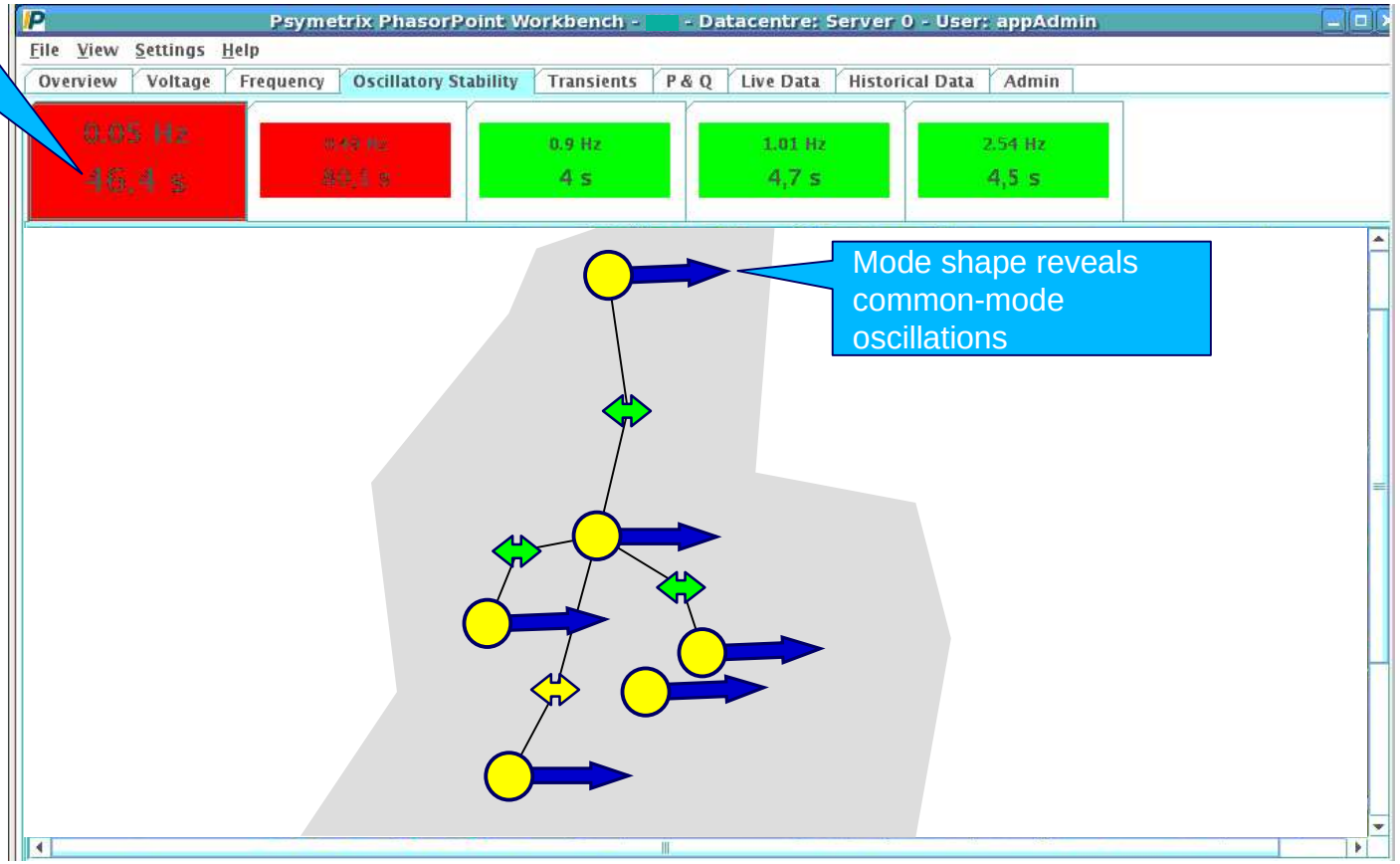
- Frequency Control Problem
  - Interconnector tripping
  - Load-shed relay tripping
  - Generator stress
- Unknown source of problem
- Several recurrences
- Conventional measurement insufficient to diagnose



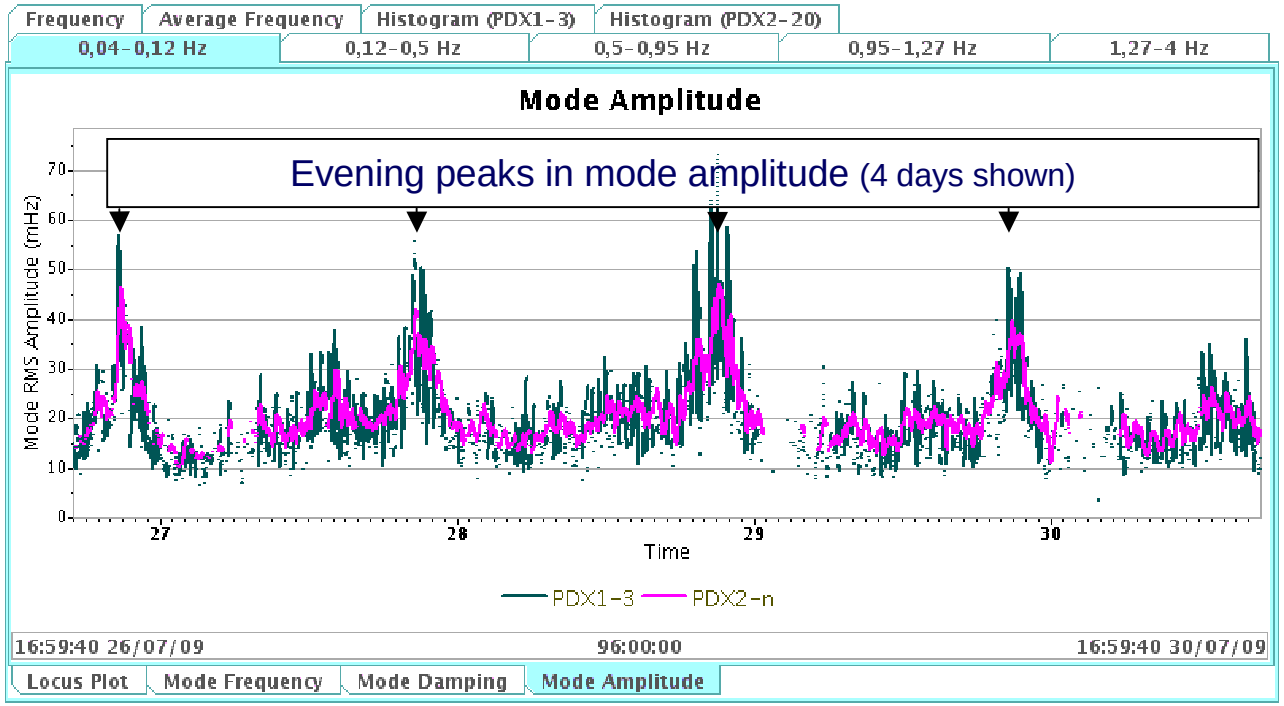
Diagnosing Dynamics & Control Issues

- WAMS with PMUs at key nodes

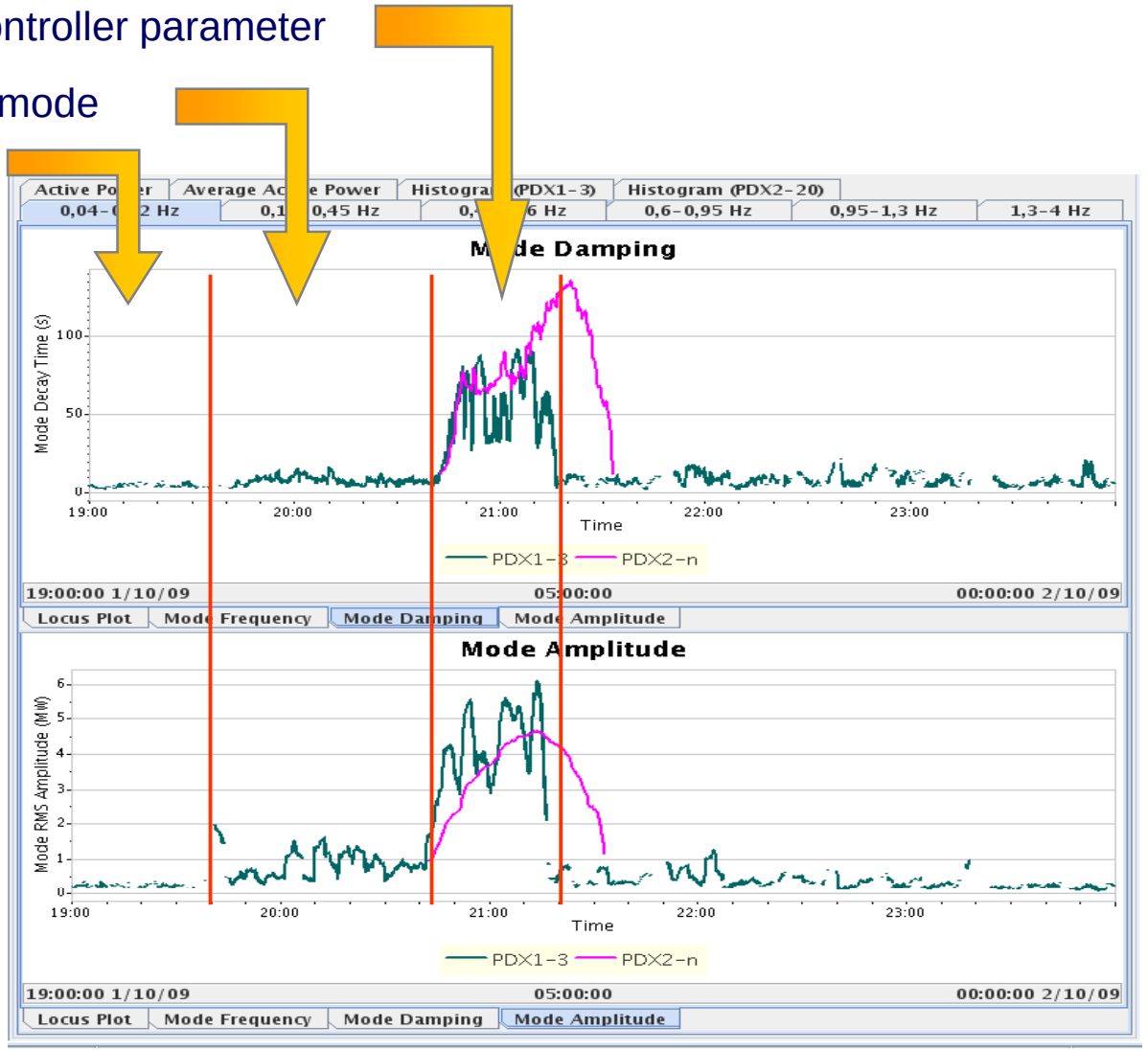
Poorly damped small-signal oscillations - ***diagnose without waiting for instability***



- Pattern of mode amplitude in time
  - Correlate changes with SCADA records
  - Choose appropriate time for system tests

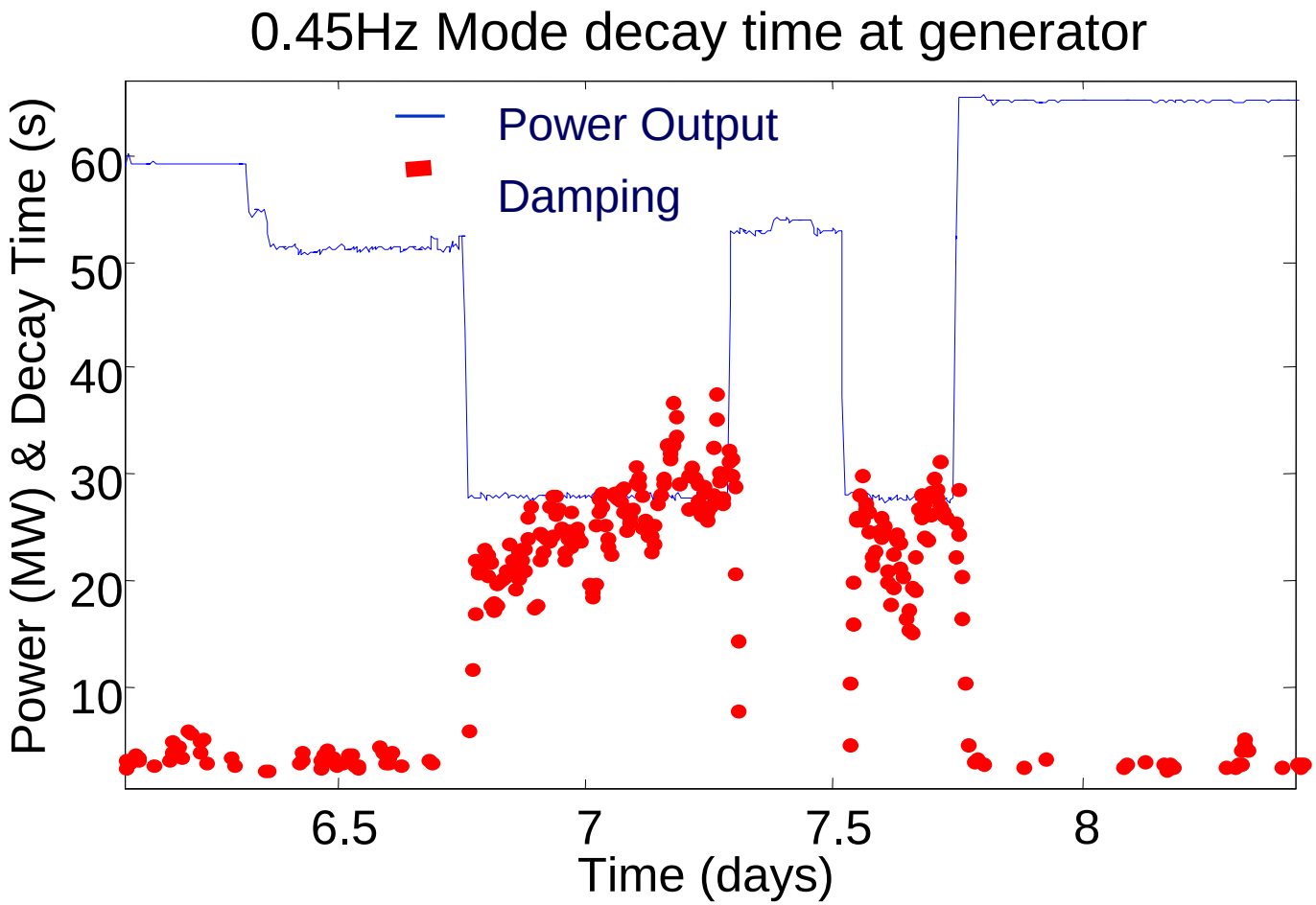


- Test by changing Control Mode
  - Sensitivity to controller parameter
  - Normal control mode
  - Known safe control mode



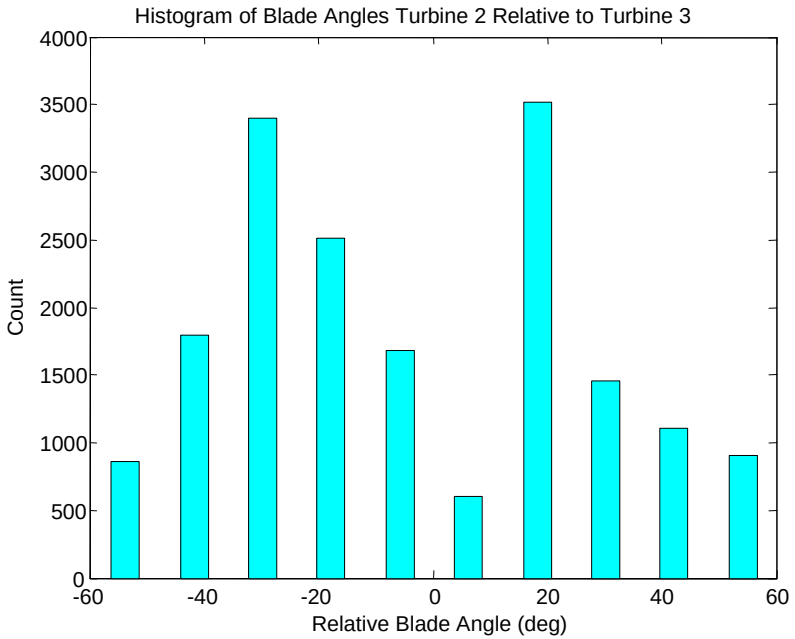
Diagnosing Dynamics & Control Issues

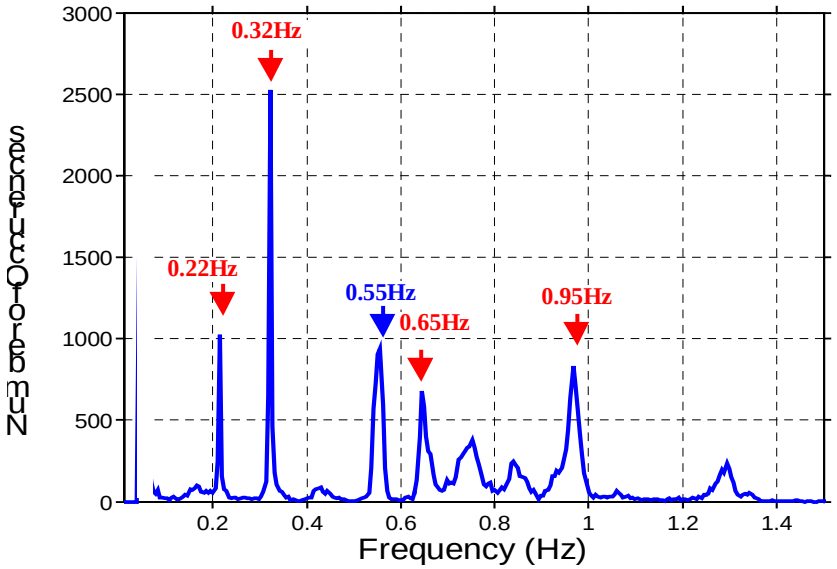
- *Iceland:* Oscillation problem found by correlating EMS data with damping
- Approach used in Australia, Scandinavia, South America, UK
- Sensitivity important for defining response

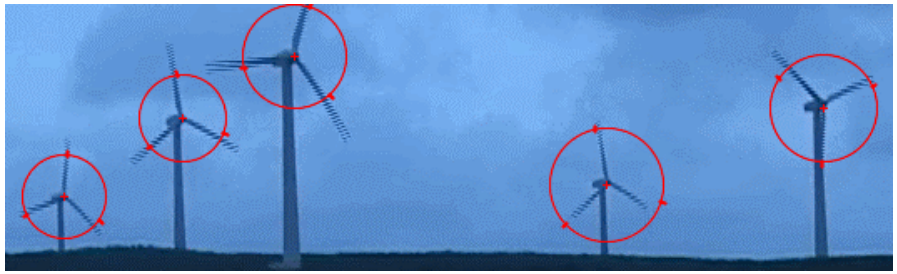


Windfarm-System Interaction

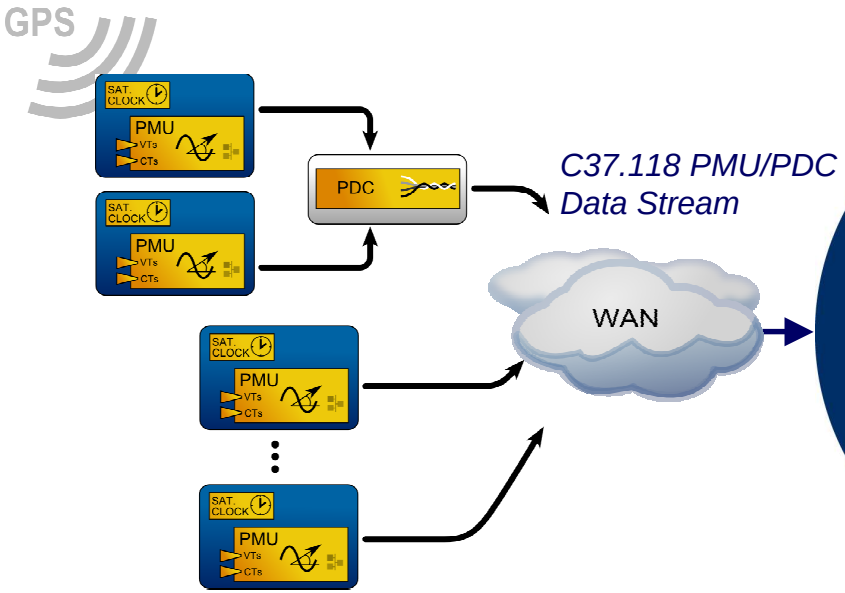
- Blade-passing frequency seen strongly in windfarm power
  - Video & blade angle recognition
  - Statistical analysis
- Measurement-based evidence of blade angle coherency
- Effect replicated in detailed model

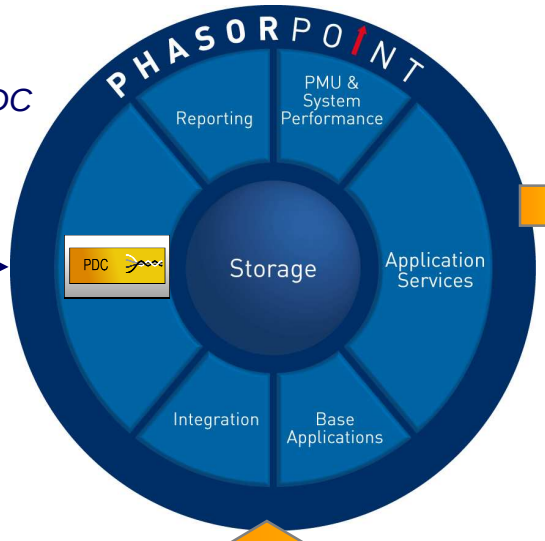




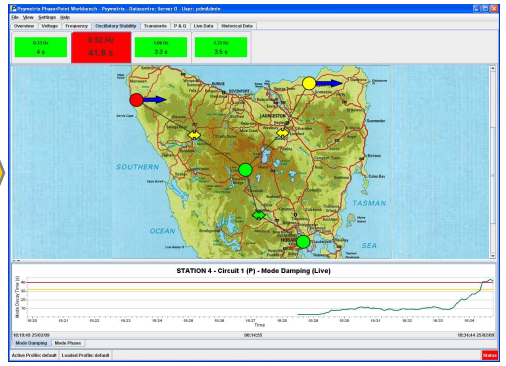


Practical Considerations

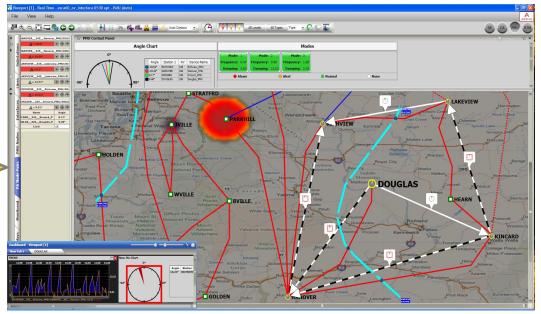




Client Applications



EMS Integration



WAMS/EMS Exchange

Phasor Measurement Units

- Address different dynamic performance
- Continuous vs on-demand PMUs

Phasor Data Concentrator

- Substation data buffering
- System tests can be several hours
- Careful filtering before downsampling

Oscillation Applications

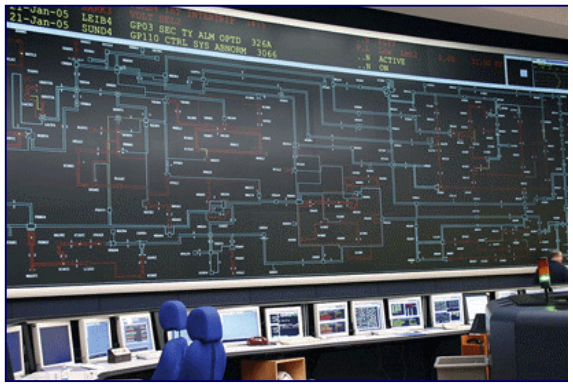
- Real-time
  - Robust against lost data
  - Fast response
  - Clear geographic pattern
  - Well set alarms
- Off-line
  - Slower response
  - Accurate & stable

Data Storage

- Continuous dynamics data storage (e.g. 1 year)
- Triggered longer-term storage
- Link SCADA & dynamics archives

Key Lessons Learnt

- CONTROL ROOM
  - Key part of situational awareness
  - Guidance / practical knowledge vital
- PLANT PERFORMANCE
  - Test process is effective & secure
  - Improve understanding of plant/system interaction
- PLANNING
  - Valuable diagnostic tool esp. where model imperfect
  - Understand the risks, facilitate control-room response



Now incorporated in Operational, Planning & Test Procedures

Dr Douglas Wilson, CTO douglas.wilson@psymetrix.com

