June 8th – 9th , 2010
Vancouver, BC

NASPI North American SynchroPhasor Initiative

North American SynchroPhasor Initiative
Working Group Meeting

Synchrophasor Activities in CIGRE Countries

Dr. Daniel Karlsson
Principal Engineer
Gothia Power AB

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Speaker

- Daniel Karlsson
- Senior Consultant, Application Specialist

- Major experiences
  - Wide Area Protection
  - Power System Analysis
  - Power System Protection
  - Utility and Manufacturer Background

- Personal motto:

  ” Supporting our customers is not only my job, it's my pleasure”

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Presentation Outline

- Cigré Activities in General
- WG B5-14: Wide Area Protection and Control Technologies
- Central Europe
- Sweden
- Iceland
- Belgium
- Slovenia
- Brazil
- Tasmania and Australia
- China
- Conclusions

Cigré Organization and Activities

- 16 Study Committees

- Study Committee B5: Protection and Automation
- Study Committee C2: System Operation and Control
- Study Committee C4: System Technical Performance

- Strategic Plan and Action Plan
- Advisory Groups -> Working Groups and Task Forces

- www.cigre.org

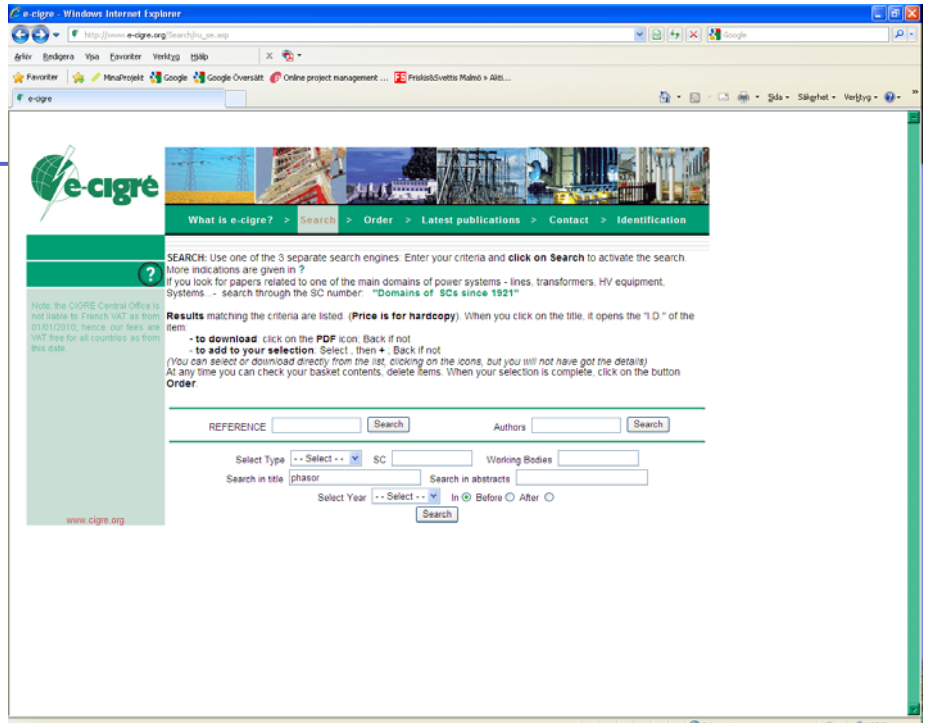
Cigré - Working Groups

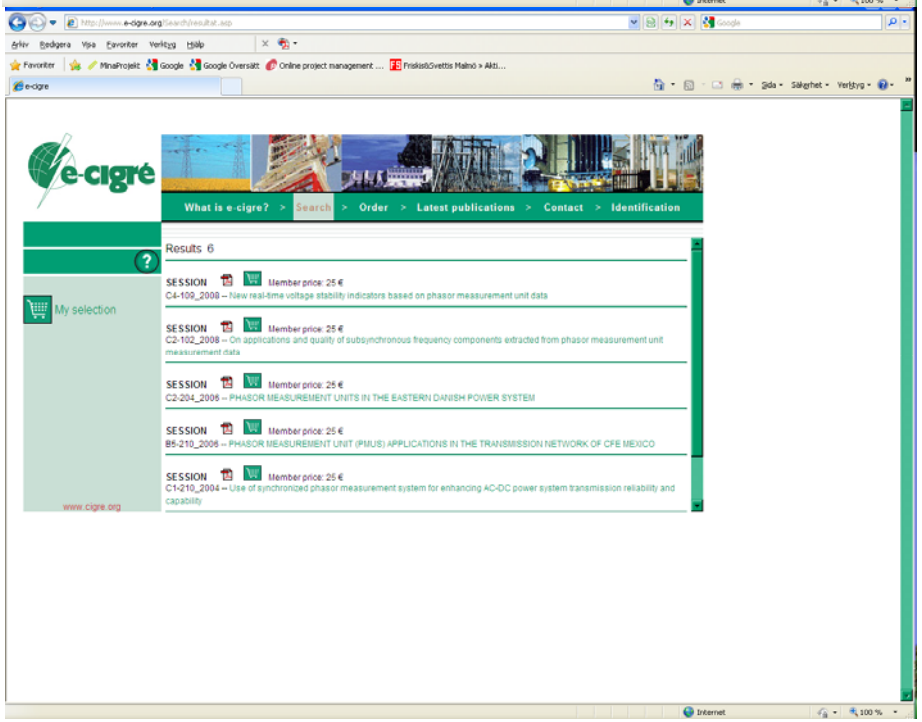
- WG C4-601: Wide Area Monitoring and Control for Transmission Capability Enhancement
  - Technical Brochure (Christina Rehtanz)
- WG B5-14: Wide Area Protection and Control Technologies
  – Ongoing working group (Vladimir Terzija)
- WG C2-12: Applications of Synchronised Phasor Measurement in Power Systems
  – Ongoing working group
- WG C2-21: Lessons Learnt from Recent Emergencies and Blackout Incidents
  – Ongoing working group

Cigré - Publications

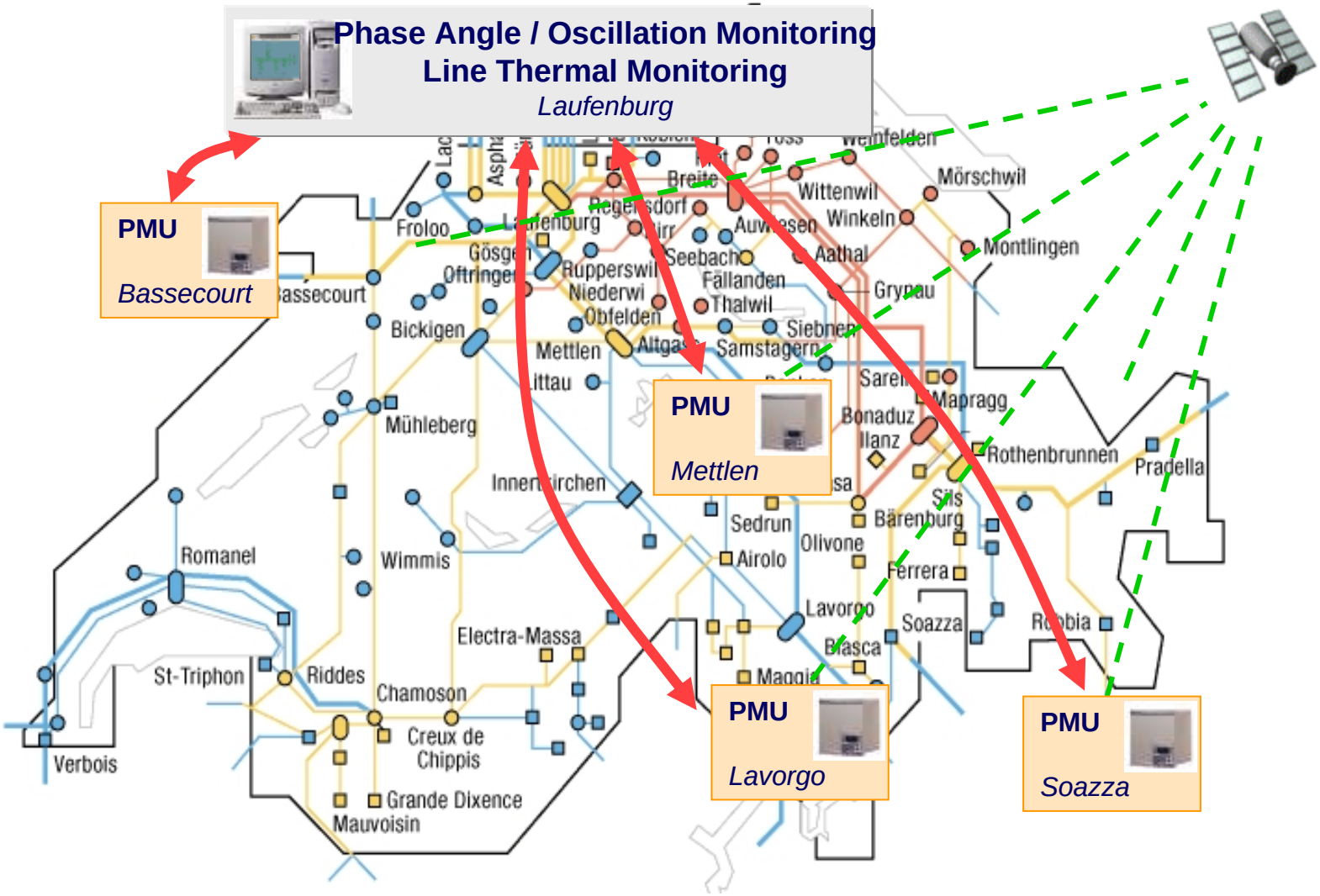
- Electra Magazine
- Electra Papers
- Technical Brochures
- Session Papers
- Symposia Papers

- www.e-cigre.org





First WAMS in UCTE – 4 PMUs in Switzerland



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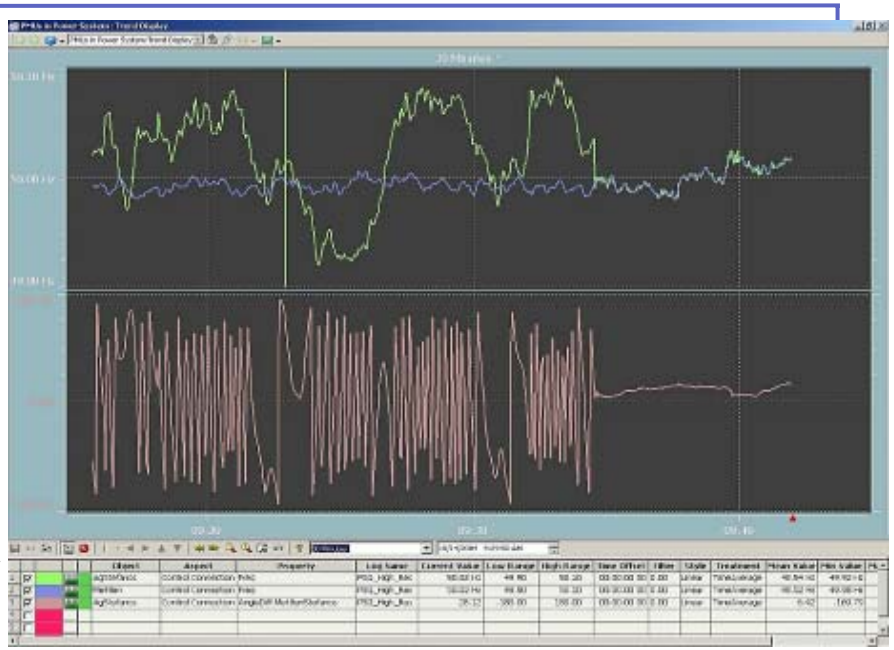
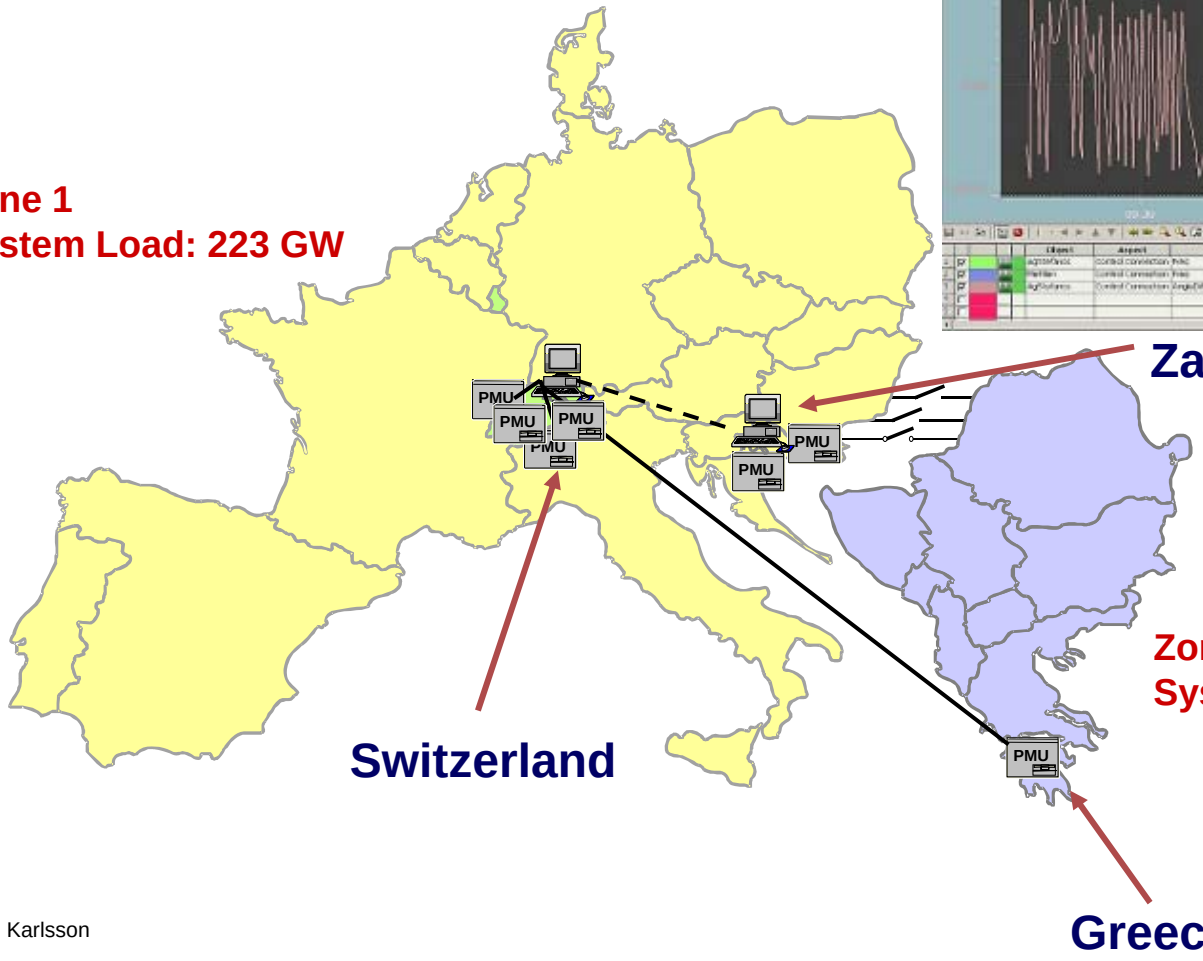
Wide Area Monitoring for System Dynamics

10. Oct. 2004, *9:34*

System Re-connection



Zone 1
System Load: 223 GW



Zagreb / Croatia

Zone 2:
System Load: 21 GW

Switzerland

Greece

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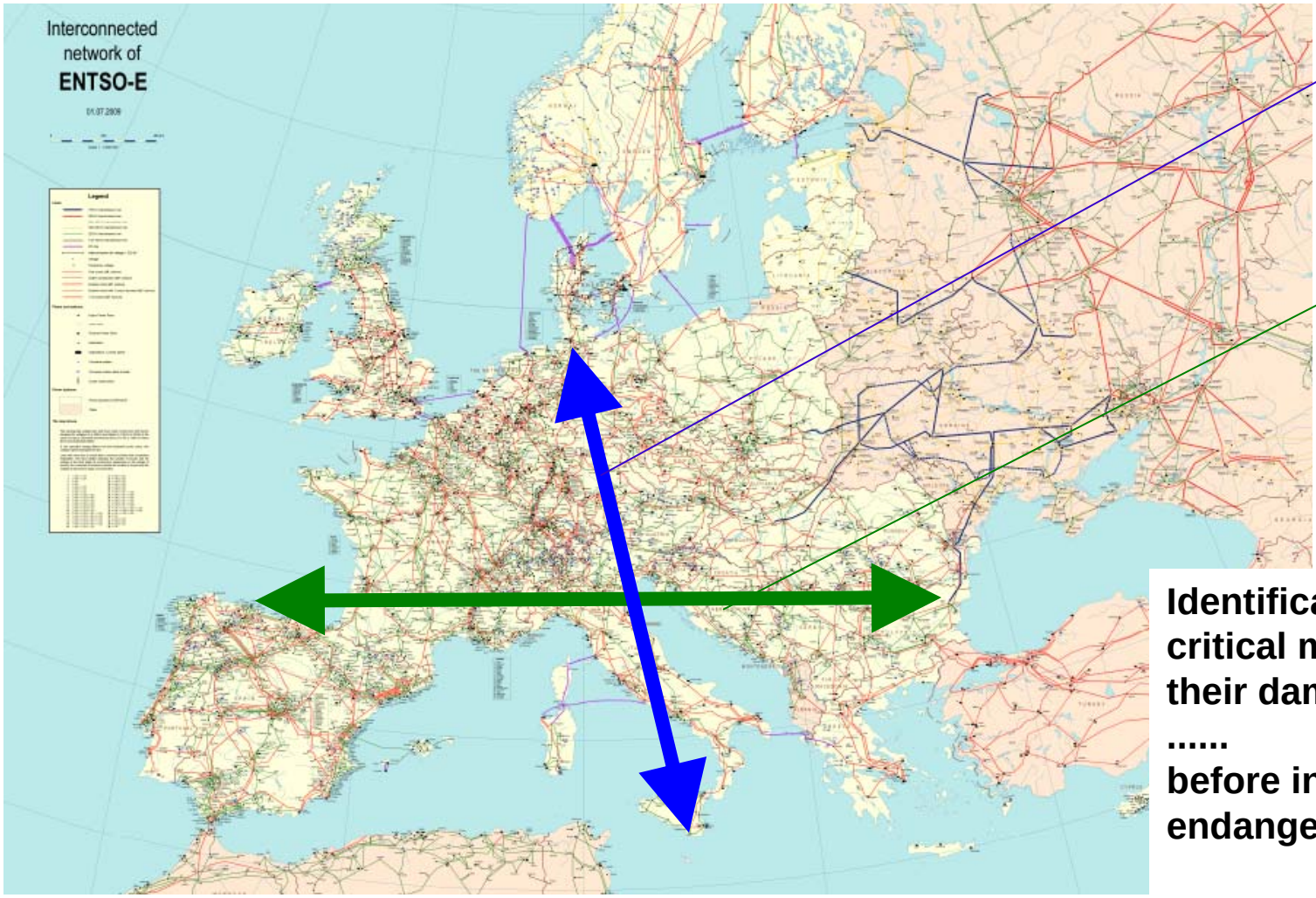
European Multimass System – Inter-Area Oscillations



North-South Mode 4 s

East-West Mode 5 s

Identification of critical modes and their damping

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before instability endangers the system

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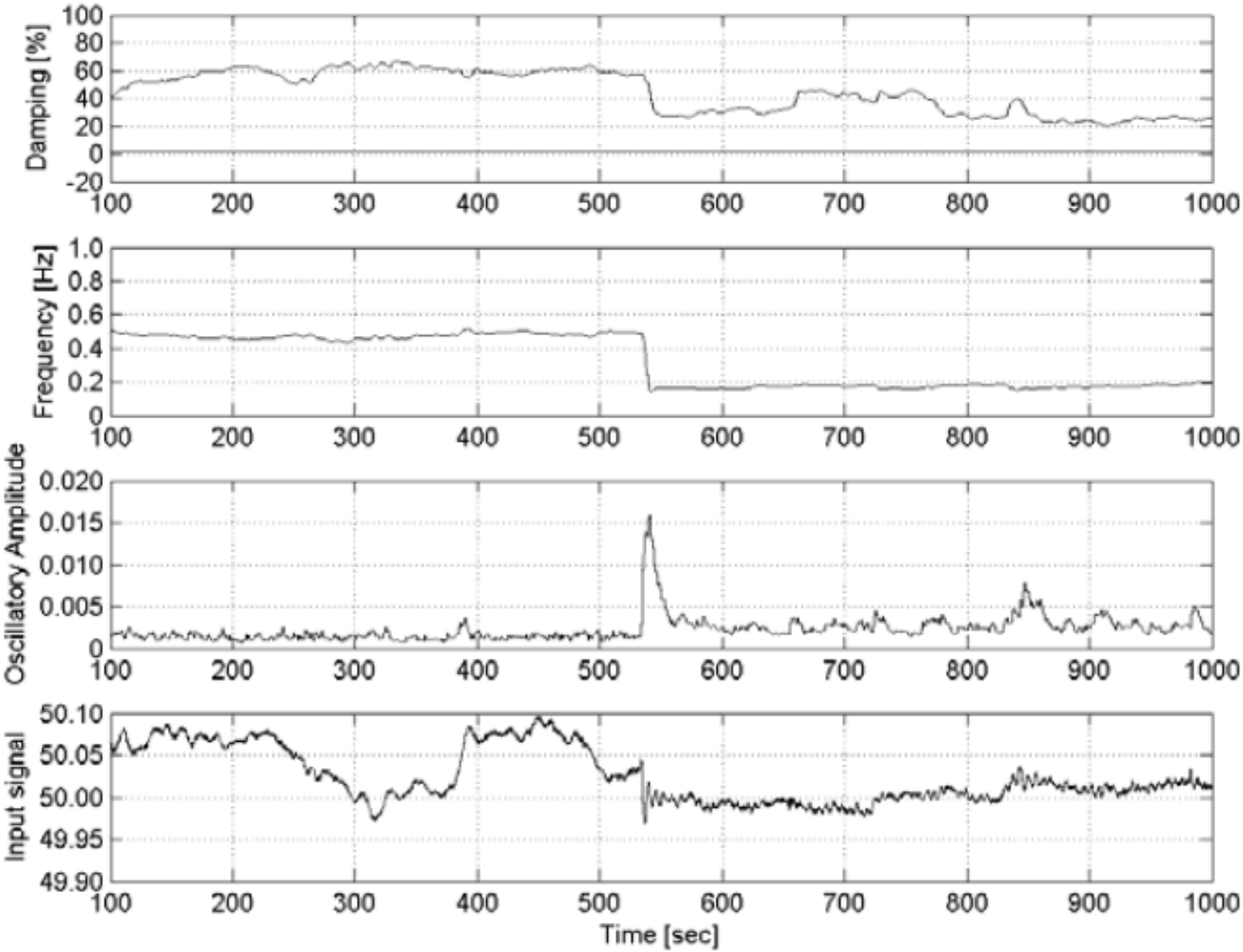
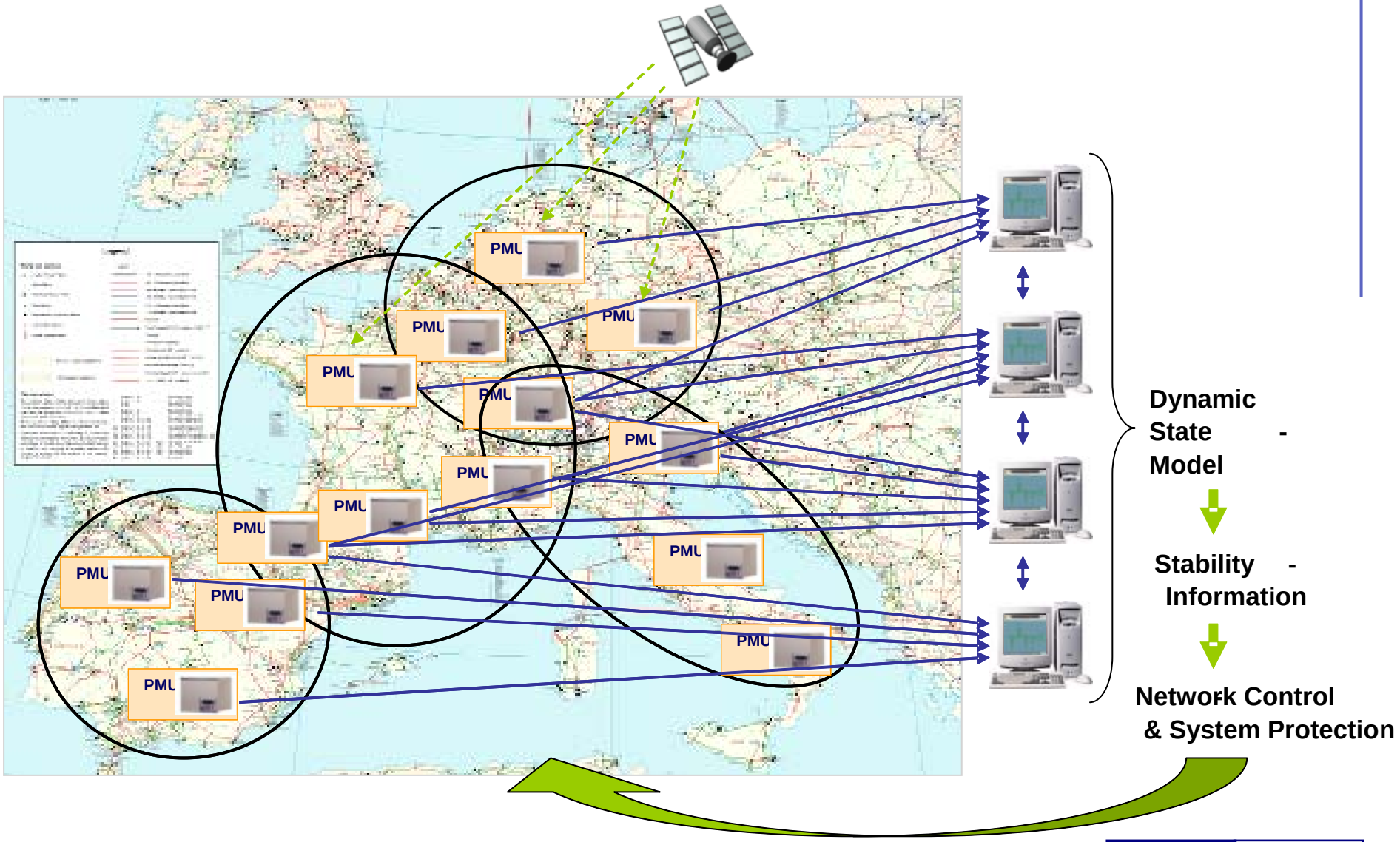
Oscillatory Stability Monitoring



Vision



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Overall Situation in Central Europe

- Increased number of industrial (TSO) applications
  - voltage phase angle difference monitoring
  - line thermal monitoring
  - voltage stability monitoring (online P–V curves)
  - online monitoring of system damping (online modal analysis) with online parameter estimation
  - intelligent alarming if pre-defined critical levels are exceeded
  - online monitoring of system loading

- Increased effort for linking with the SCADA systems

- Increased number of inter-TSO PDC links

Main Challenges and Future Developments

- Damping of Inter-Area Oscillations
  - West-East mode currently successfully damped due to important and successful PSS tuning activities within Spain an Greece
  - Increased activity of North-South mode
- Connection of Turkey
  - Preparations for system connection already finished
  - Planned parallel connection autumn 2010
- Include more TSO PDC links
- Enhance the WAM – SCADA links
- Develop more WAM applications

Conclusions – For Central Europe

- WAMS is getting mature in terms of data concentrators and algorithms
- Algorithms for monitoring are well covered
- Expectations are very high on intelligent alarm processing and decision support - but no specific algorithms yet
- WAMC is primarily for system security (voltage stability, oscillations) and only indirectly for transmission increase
- Setting up of WAMC is complex and expensive - Simple and transparent algorithms are needed
- Productification of algorithms will support WAMS and WAMC
- WAMS / WAMC functionality will move into SCADA/EMS

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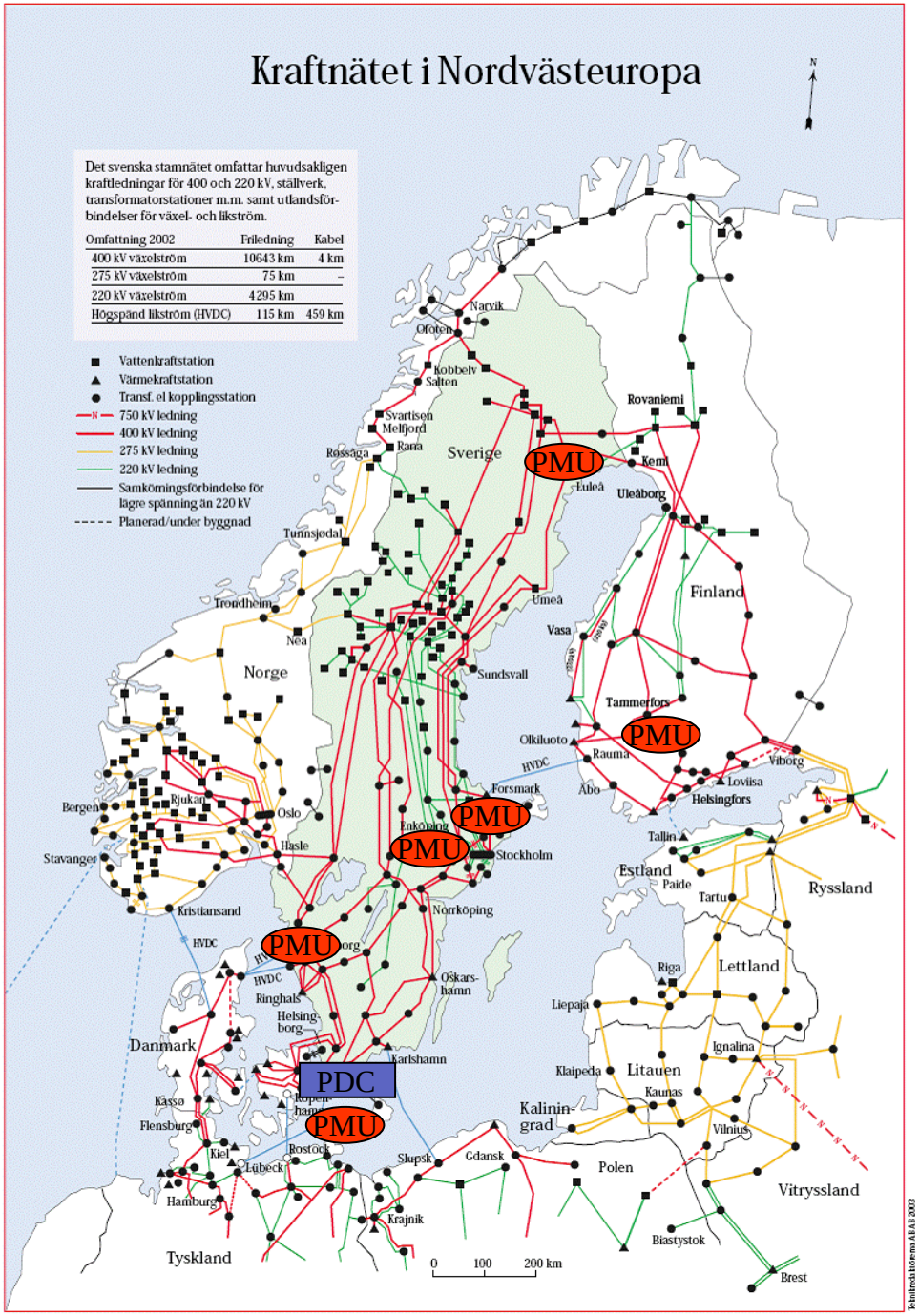
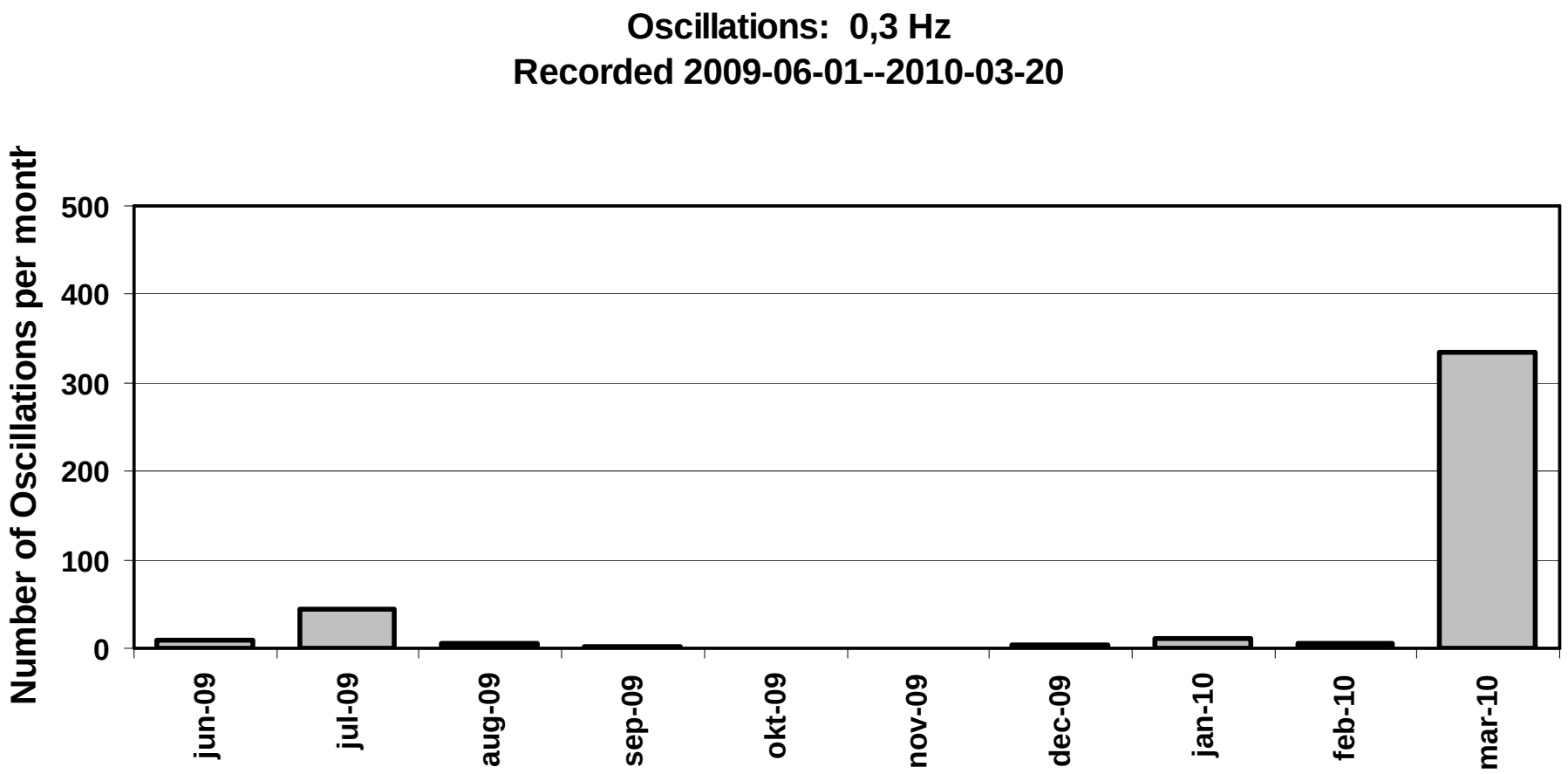
Sweden

- University system
- 400 V connection
- Open to research
- Great overview of system wide events

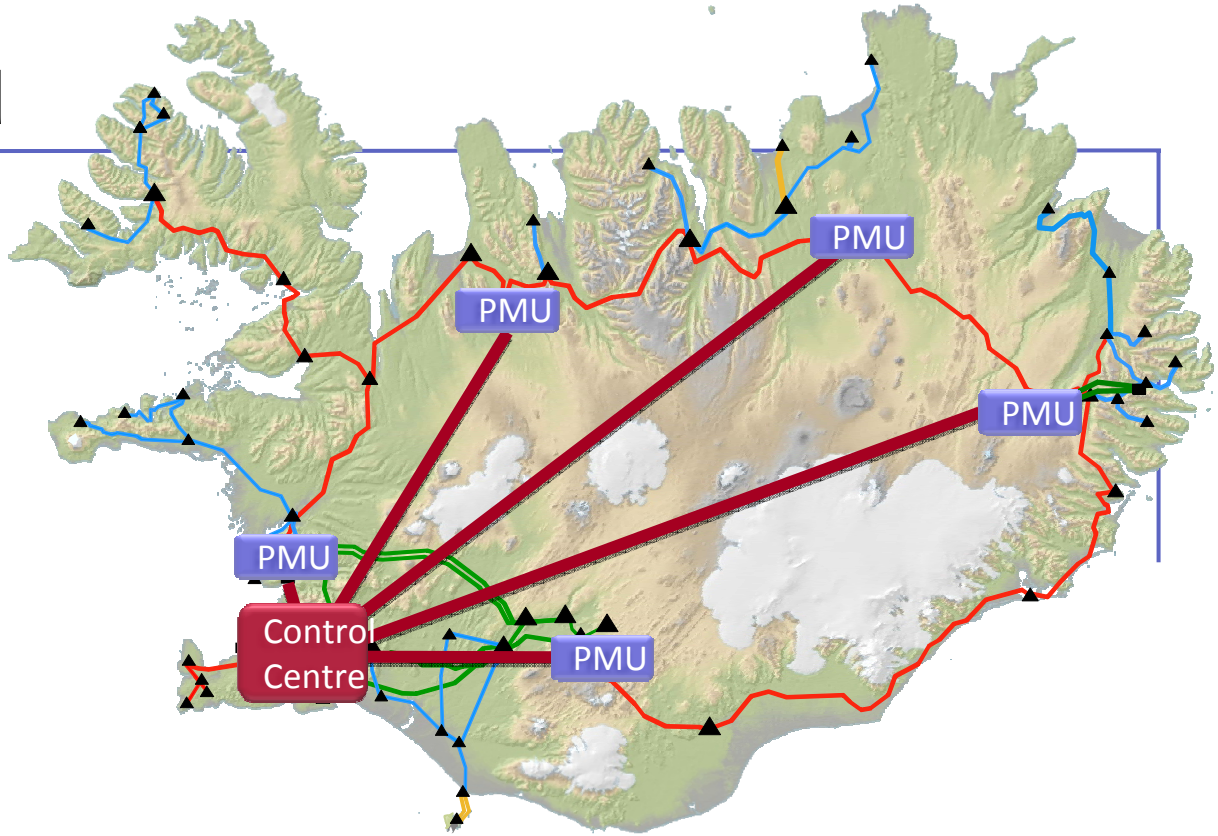
- A TSO system on its wa
- PMUs installed in new and refurbished s/s
- Damping – most urgent



Sweden – A new mode suddenly showed up



WAMS in Iceland



- PMUs at 5 places
- 8 PMUs in total
- Using the WAMS in the Control Center for
  - monitoring system stability
  - fault and system analysis
  - tuning AVRs, PSS and governors in power stations

- The plan is to develop the tool into a Wide Area Control System, and hopefully that task can start next year

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Drivers – Belgian System Enhanced Utilization

- Massive integration of renewables
- Need for additional grid capacity
- Push the grid to its limits
- The algorithms developed will be converted to tools

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Belgium – Power Flow Control with Phase-Shift Transformers

- Coordinate the phase shifters on the borders and probably on the Dutch – German border to enhance the network capacity in the region
- Work out Dynamic Line Rating with on-line measurement of the overhead line temperature
- PMUs and dedicated software tools are used to
  - push the grid to its thermal limits, while
  - safeguarding the dynamic stability of the system
- Minimal reduction of transit flow, taking into account both preventive and corrective coordinated adjustments of the phase shifters.
  - One idea is to minimally reduce the transit flow (sometimes called loop flow) so that the other TSOs of the interconnection are minimally disturbed by the transit flow redirection

Belgium - Expected benefits

- Demonstration of coordination with all Central Western European TSOs willing to participate
- Real time estimation of the available margin for additional wind generation

PMU

- Access to short and medium (particularly intraday and day ahead) **available capacity** on the TSO's lines
- Implementation of **new procedures** using the possibilities of Power Flow Control **to extend grid capabilities**
- Wide-area advanced **monitoring** with appropriate indicators for oscillatory stability assessment
- **Visibility** of the effects of coordinated control of several power flow controlling devices

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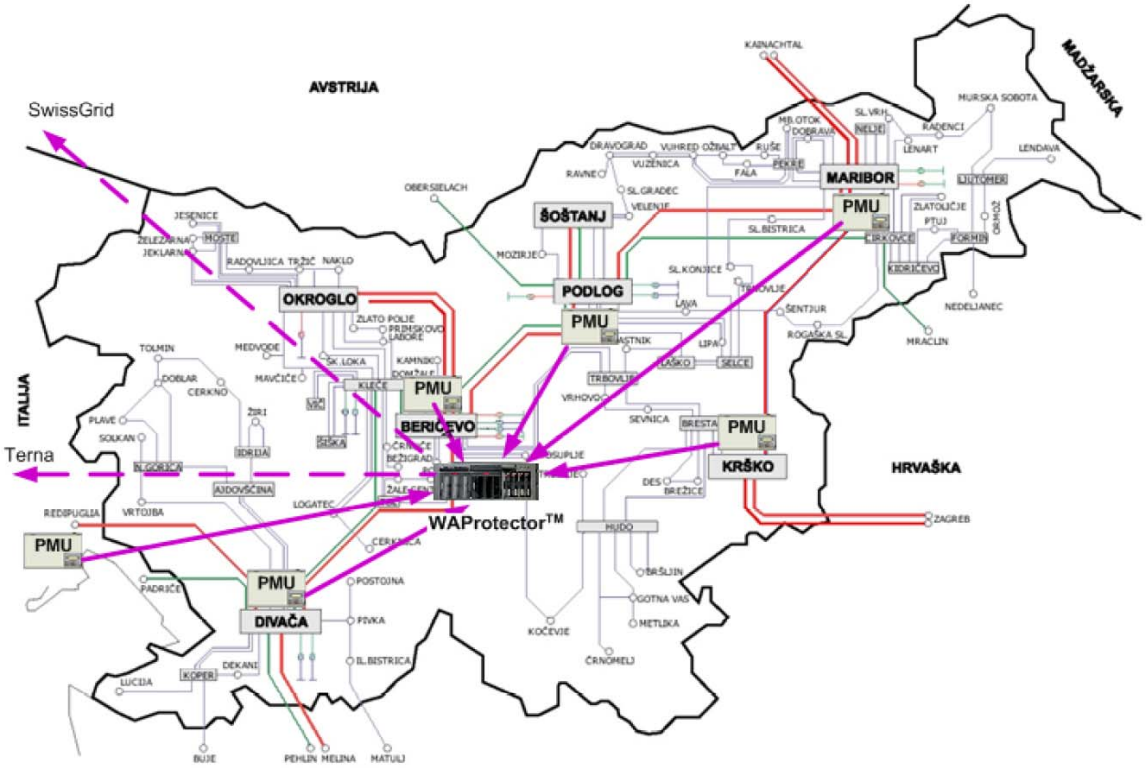
Wide Area Measurement System in Slovenia

- The system enables real-time exchange of selected phasors between transmission system operators
- 10 voltage and 28 current phasors
- Data exchange with Switzerland and Italy



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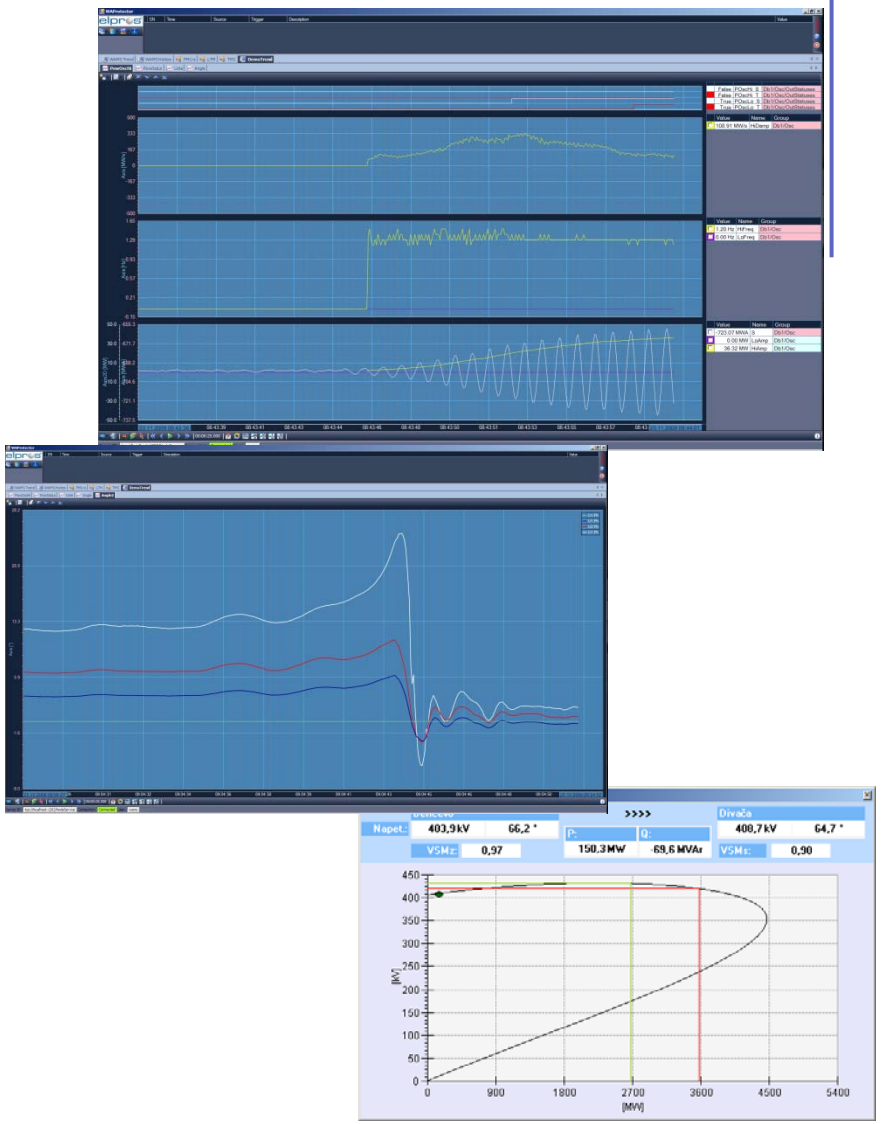
Slovenia – Elpros – WAProtector Real-time Analysis I

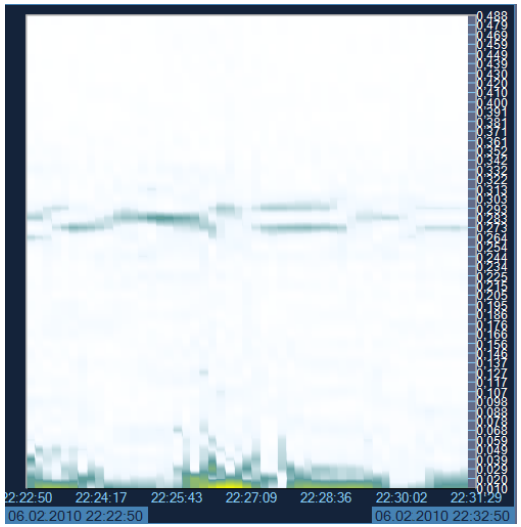
- Time synchronized data in all analysis functions
- In real-time:
  - Stability detection functions:
    - Phase angle difference detection
    - Low frequency oscillation detection
    - Voltage stability detection
    - Thermal monitoring detection
    - Over/under value detections
    - Synchro-check detection
    - Islanding detection
    - Oscillation source detection
  - Bus-bar topology
    - power calculation
    - stabiliy detections



Slovenia – Elpros - WAProtector Real-time Analysis II

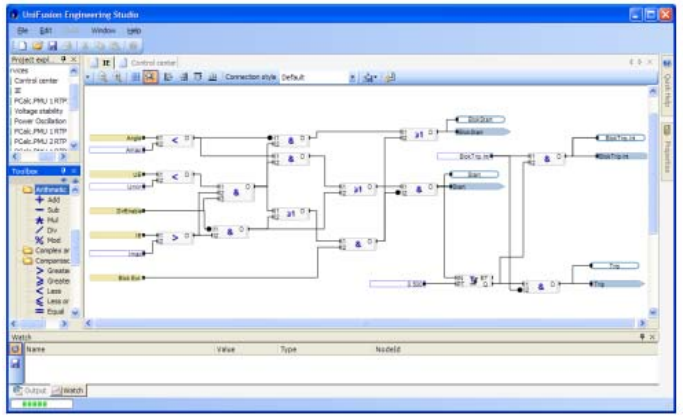
Signal processing functions

- Fast Fourier transformation
  - For analyzing low dynamical (static) situation; usually between 0.01 and 4 Hz
  - Detection of permanent oscillation sources



User programmable functions

- Logical functions (and, or,…)
- Arithmetic operations (+, -, *, /,…)
- Comparison functions (>,<, =, ...)
- Etc.



Remedial action schemes

- Based on user programmable functions
- Based on detection functions

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Brazil

- 85 000 MW
- Lines: 75 000 km
- Size: 3 900 km
- Up to 765 kV AC
- 600 kV DC
- 350 s/s

Brazil – Synchrophasor Applications

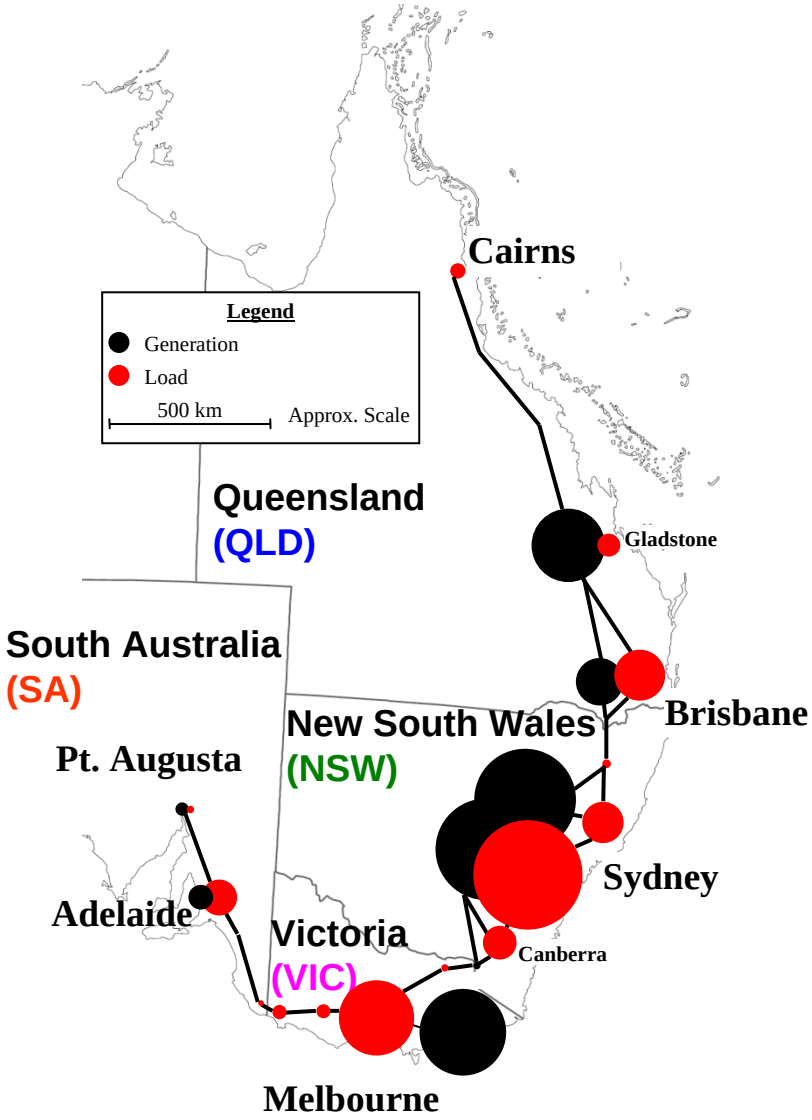
- Dynamic disturbance recording
- Real-time monitoring and state estimation enhancement

- Real-time dispatcher decision-making support tools
  - DampMon: Monitor system oscillations and alarm for oscillations with poor damping
  - StressMon: Monitor transmission system stress based on angle difference
  - SyncAssist: Assist in resynchronizing islands using angle difference information
  - LoopAssist: Assist in closing loops using angle difference information

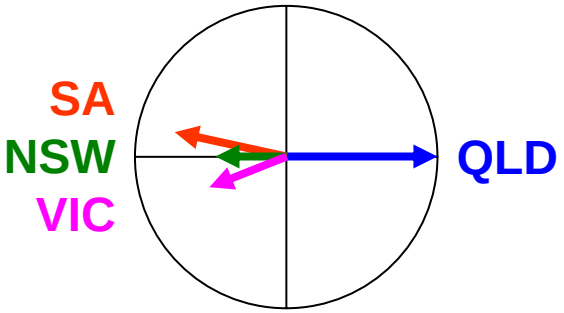
Application of Continuous Modal Estimation in Australia

- A network of GPS synchronized PMUs is under active development in Australia
- Near term potential applications
  - Forensic investigation of system events
  - Calibration of system models
  - Verification of specific plant models
- Developments
  - Technologies are continuing to evolve – support ongoing R&D
  - Rigorous performance testing of proposed developments:
    - Benchmark testing of algorithms based on signals generated from detailed models of the Australian system
    - Reveal deficiencies and opportunities for improvements
- Most important immediate requirement
  - Tools for rapid identification of the causes of poor damping events
  - Facilitate corrective action by system operator

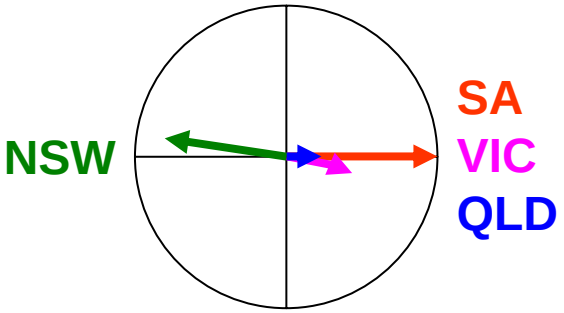
East Australian System (excluding Tasmania) – Inter-area Modes



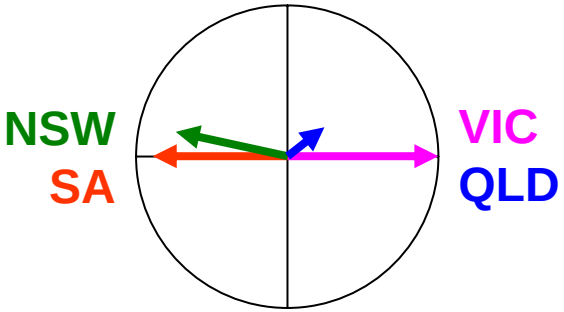
Indicative Interarea Mode Shapes and Frequencies



Mode **I20**
ω ~ 2 rad/s



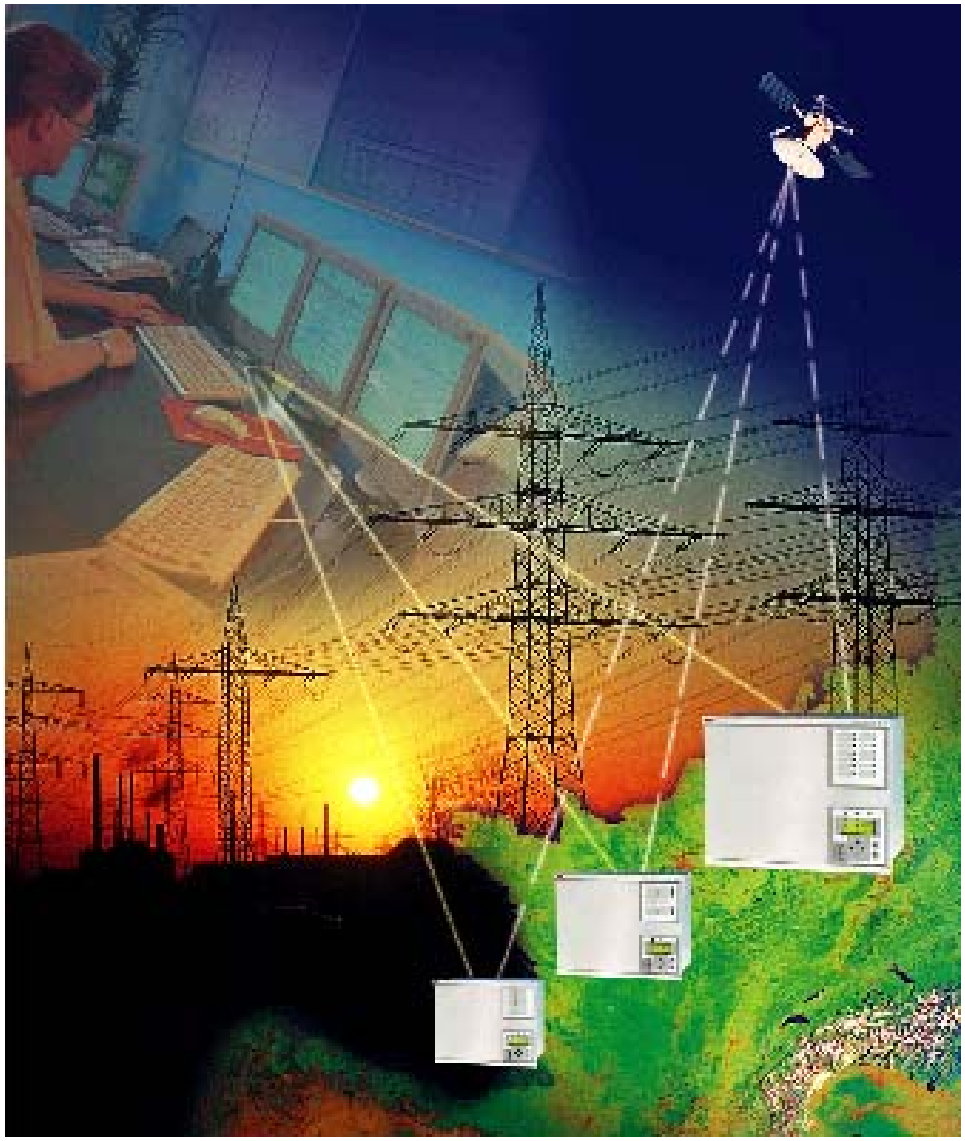
Mode **I25**
ω ~ 2.5 rad/s



Mode **I35**
ω ~ 3.5 rad/s

WAMS in China – Fast growing

Conclusions



- PMUs have greatly improved the observability of power system dynamics

  – We are now moving into the area of controllability

  …..

- Based on PMUs , wide area monitoring, control and protection systems can be designed

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Thanks to the Contributors

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