

# ADVANCED TRAINING FOR DISPATCHERS ON EMERGENCY PROCEDURES

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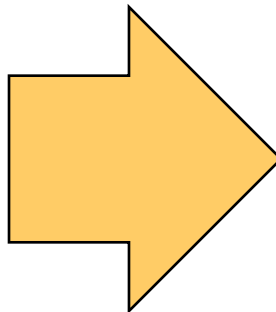
# TABLE OF CONTENT

- Advanced training for dispatchers on emergency procedures
- Full dynamic DTS for large scale system (PEGASE)
- Impact of the self-disconnection on the voltage recovery in case of large presence of rotating load

# THE EXTENDED ELECTROMECHANICAL MODEL

## Classical DTS

- ✓ Quasi-static phenomena
- ✓ Long-term phenomena
- ~~Short-term phenomena~~
- ~~Electromechanical swings~~
- ~~Loss of synchronism~~
- ~~Simulation of protective devices~~

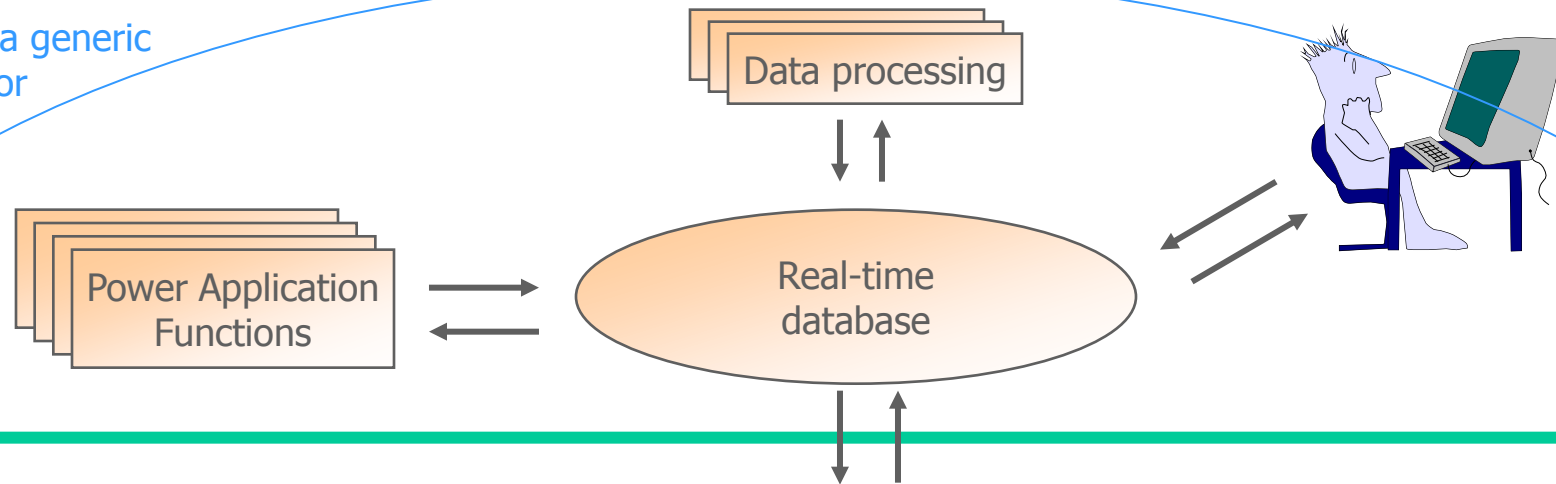


## FAST-DTS and its extended electromechanical model (EMM)

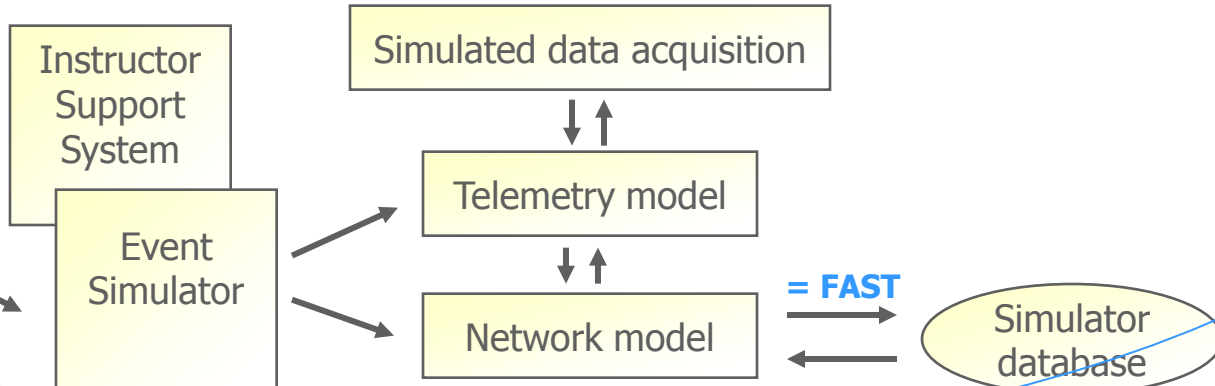
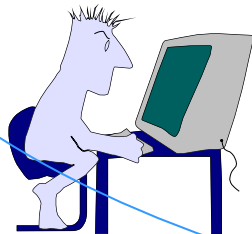
- ✓ Quasi-static phenomena
- ✓ Long-term phenomena
- ✓ Short-term phenomena
- ✓ Electromechanical swings
- ✓ Loss of synchronism
- ✓ Simulation of protective devices

# INTEGRATED ARCHITECTURE

= EMS from a generic vendor



**Instructor**



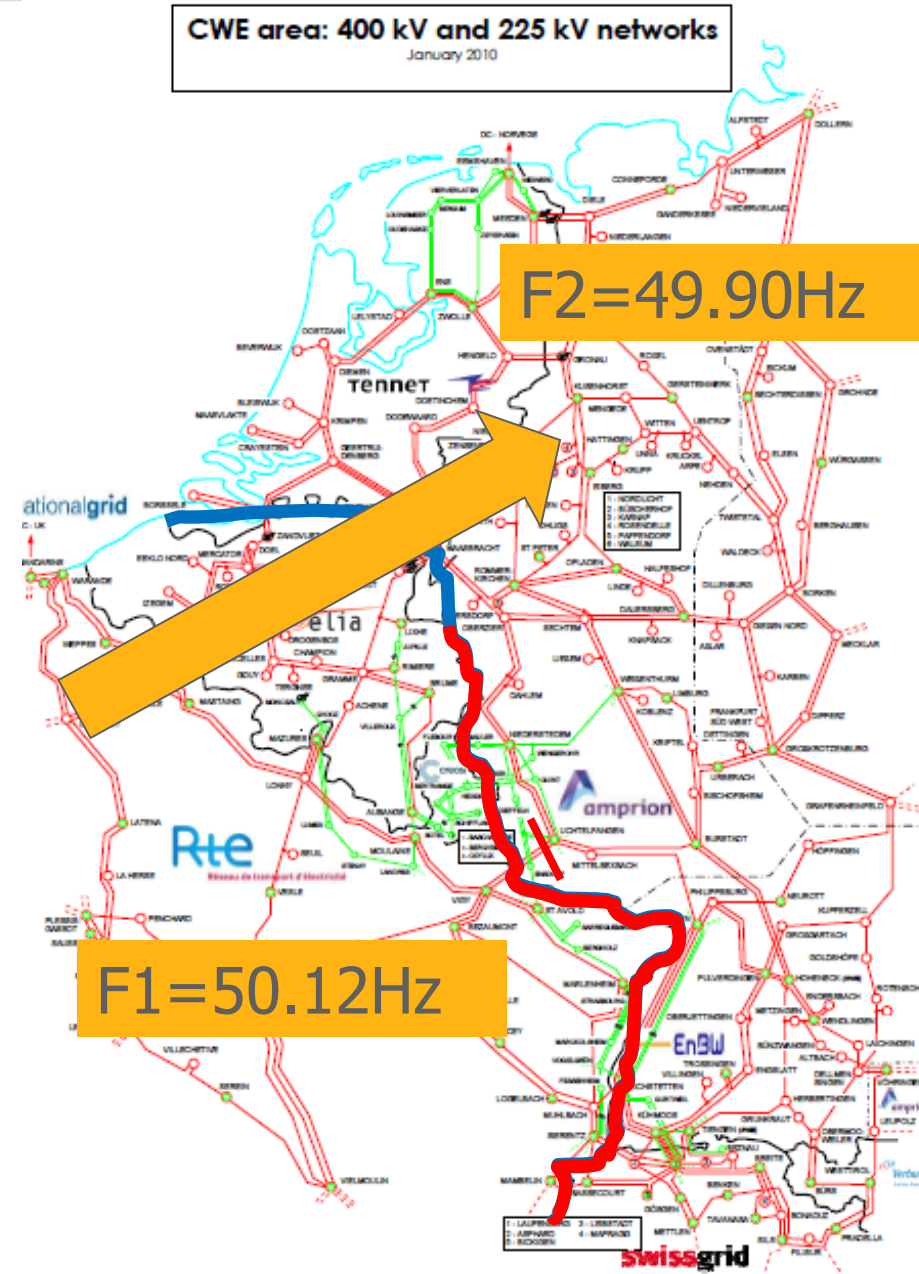
# Example of advanced scenario

## “International” scenario

- **Aim**
  - Analyze what happened on 4<sup>th</sup> November 2006
  - Reproduce a similar scenario on the DTS
  - Train the operators on the POLICY 5 of the ENTSO/E (Emergency Procedures)
    - **Frequency leader**
    - **Resynchronization leader**
  - Let the operators familiarize with the concept of
    - **Synchro check vs synchro coupler**
    - **Synchronous vs asynchronous coupling**
    - **Power and frequency control**
    - **ACE**
    - ...
- **Model**
  - Extended electromechanical model
  - $\pm 7000$  equations integrated and solved 50 times a second (20 ms step size)
  - Connected to the real scada of the TSO

# Scenario International (ELIA)

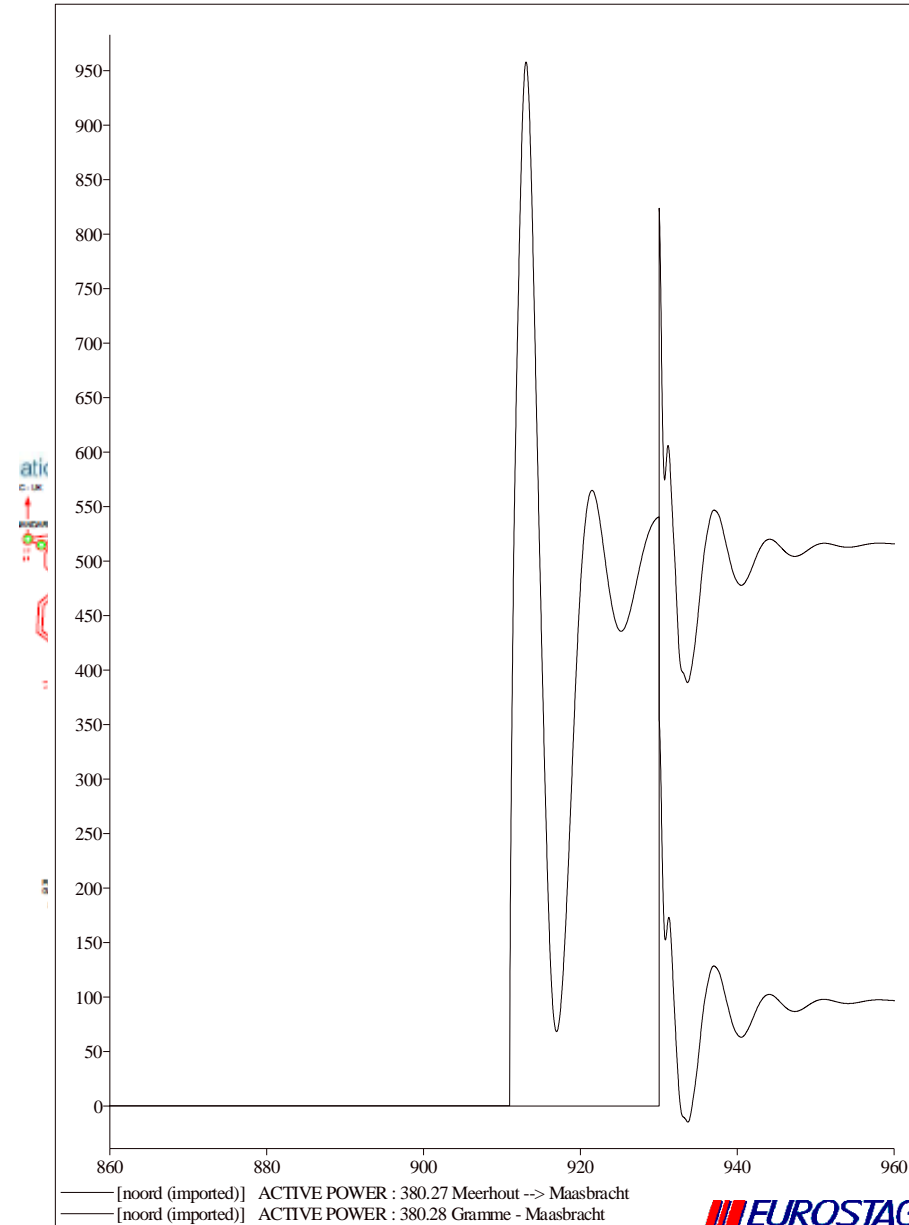
- Sequence of events
  - Trip of two lines (Vigy [FR] – Ensdorf [DE] – I+II )
  - Consequent overload of trips with a total split of FR-DE, FR-CH, FR-IT (due to trip of overload protections)
  - All the flows FR->DE goes through the lines FR-BE-NL
  - Overloads on the lines FR-BE with consequent trip and split
  - WEST system with FR & BE → over-synchronous ( $f \approx 50.12$  Hz)
  - EAST system with DE & NL-CH → under-synchronous ( $f \approx 49.90$  Hz)



# Scenario International

- ENTSOE Policy 5 application
  - ELIA synchronization leader
    - Drives the frequency leaders
    - Synchronization on the busbars of the interconnection lines with NL (380kV)
    - May use the PST to minimize the post-reconnection flow
  - RTE frequency leader WEST
    - Decrease the frequency
  - RWE frequency leader EAST
    - Increase the frequency

CWE area: 400 kV and 225 kV networks



# Scenario International Conclusions

- Deep analysis of the events of 4<sup>th</sup> November 2006
- ENTSOE Policy 5 application on a practical case
- Dynamical modeling of the system of fundamental importance
  - Prime movers and speed governor of the interested units
  - Frequency response of the system (loads, prime movers...)
  - Voltage angles and synchrochecks/synchro couplers
  - UFLS
  - Equivalent model of the foreign units (for correct redistribution of the flows)
- Other scenarios simulating a black-out and reconstruction
  - Analysis of the dynamical behavior that brings to a blackout (e.g. short-circuits, consequent loss of synchronism, voltage collapses...)
  - Analysis of the dynamical behavior and of the limitation of the capability of the machines in case of blackstart (e.g. UEL, capability curve, frequency regulation, units OEL, frequency stability ... )



# The next step: the PEGASE project

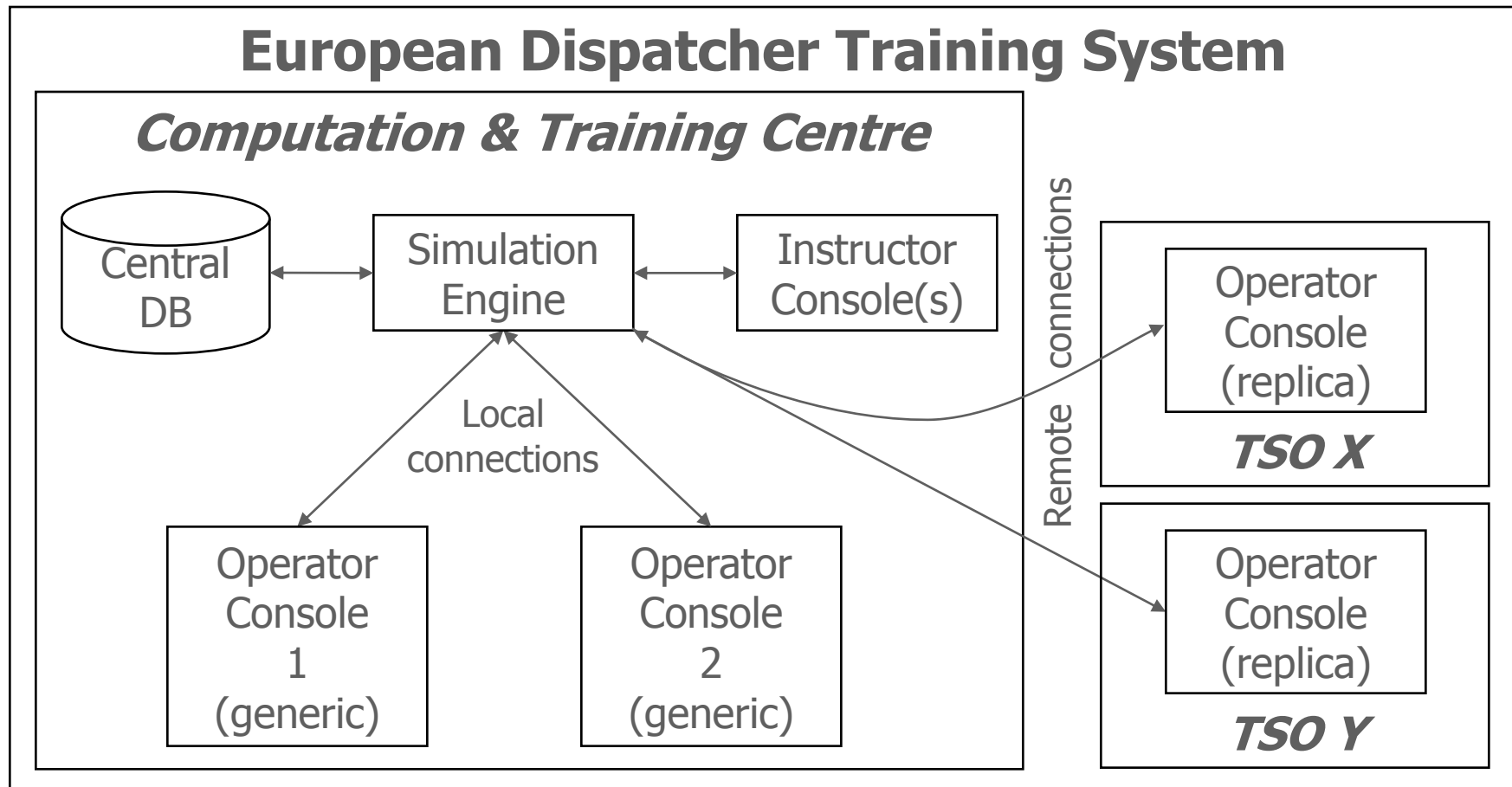
- **PEGASE**
  - Pan European Grid Advanced Simulation and State Estimation
  - Funded by the European Commission / Seventh Framework Program (FP7 - Energy)
  - 4 years (→ June 2012)
  - 20 Partners (TSOs, expert companies, leading research centre)
  - Advanced algorithmic, build prototypes of software, demonstrate the feasibility
    - **System Modelling**
    - **Real-time state estimation (SE)**
    - **Steady State Optimisation (OPF)**
    - **Time domain simulation (including DTS)**
    - **Validation, demonstration and dissemination**

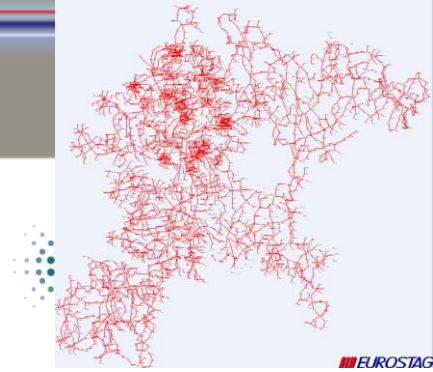


# DTS in PEGASE

- Purpose
  - Calculation engine able to run system-wide dynamic of the ETN → real-time simulation
  - Modelling flexibility → user-defined models
  - Size of the system → ~15 000 nodes / ~4000 generators / ~125 000 state variables
    - **Several control centres**
    - **Scenarios addressing cross border operational issues**
- Means
  - Parallel processing
  - Advanced algorithmic (e.g. multi rate, Schwarz, ... etc.)

# DTS architecture in PEGASE





# DTS in PEGASE

## Current status

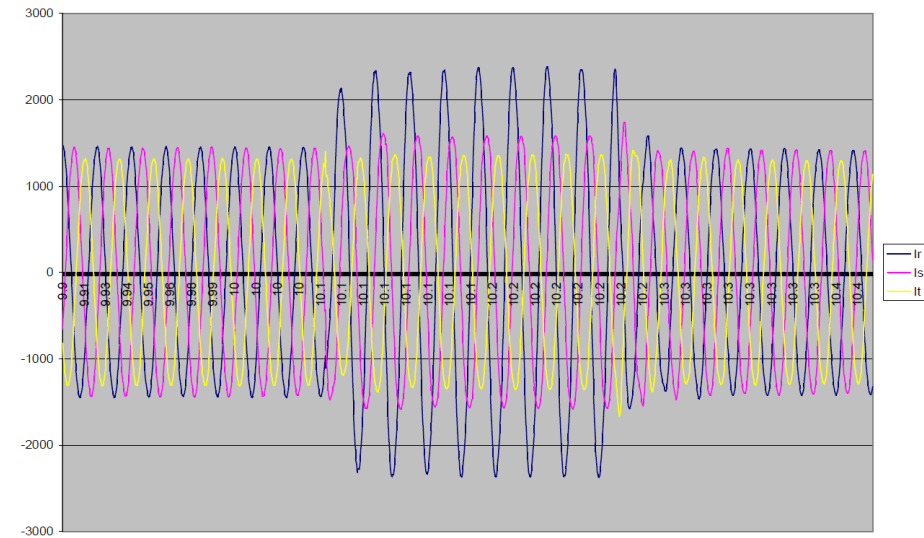
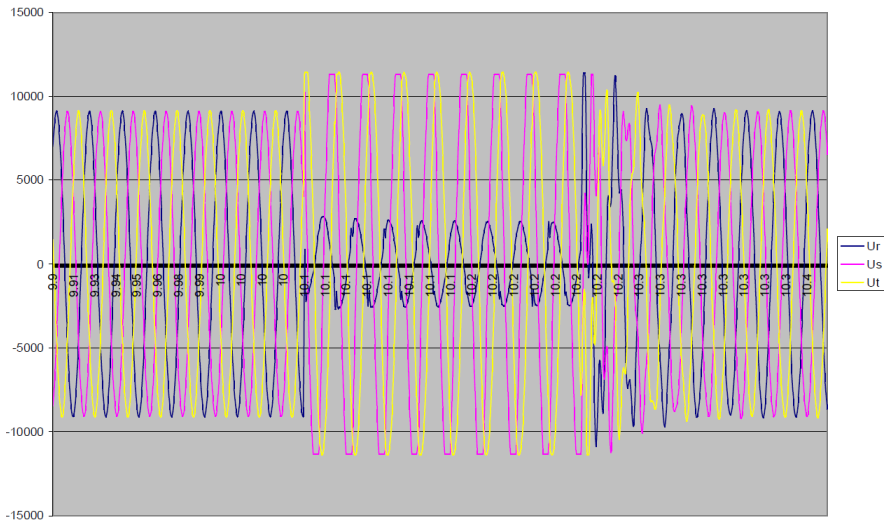
- Large scale model with detailed topology for all the UCTE system developed (~248000 physical nodes)
- Preliminary tests (similar to split 4<sup>th</sup> Nov 2006) performed
- Performance gap
  - Currently it runs at 0.5x real time in average
- SCADA Communication protocol via OPC (Open Productivity & Connectivity)
  - Ongoing
- Test MMI based on an in-house software

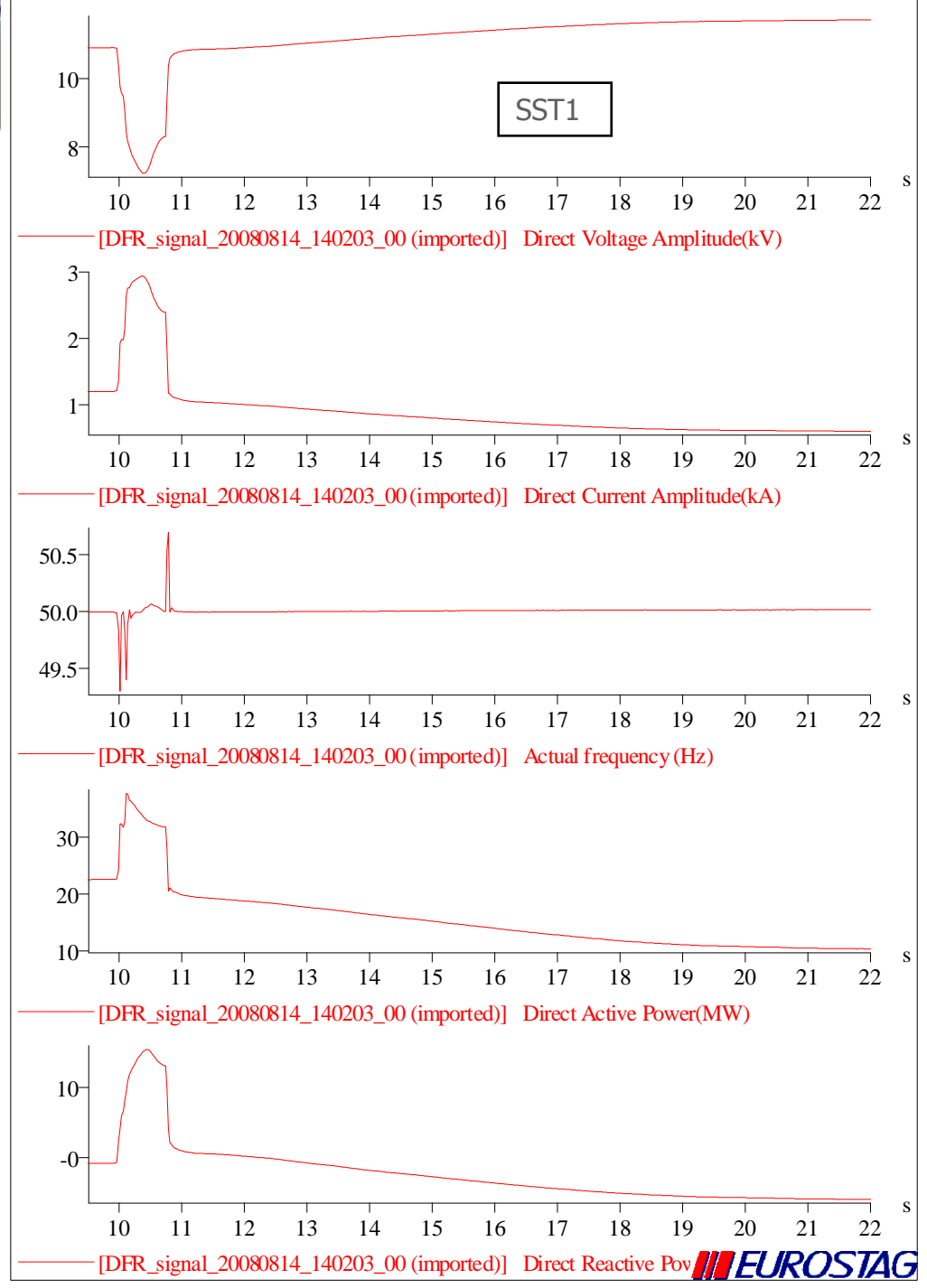
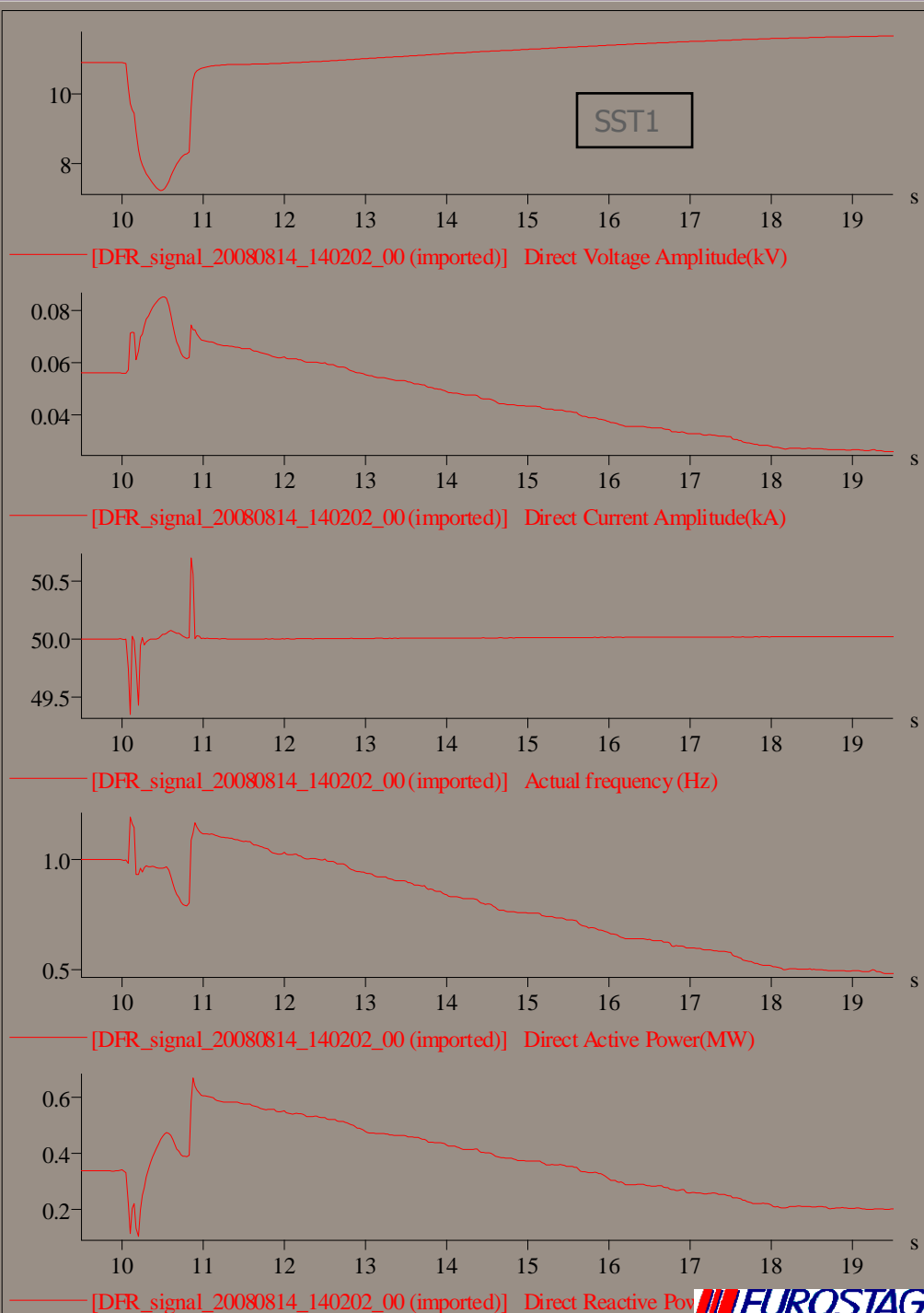


# IMPACT OF EMBEDDED LOW VOLTAGE - DISCONNECTION ON THE VOLTAGE STABILITY IN CASE OF LARGE PRESENCE OF ROTATING LOAD

- Accurate understanding of power system behavior difficult without a good knowledge of load behavior
- Power plants: lumped and location of data concentrated when loads are dispersed, diverse and located behind the distribution systems
- Load model used for power system analysis
  - averaging behavior and/or dedicated model with large industrial load
  - what mix?
  - what level of non linearity to capture an adequate level of plausibility especially following large disturbances?

# EXAMPLE OF RECORDINGS WITH HIGH SAMPLING RATE

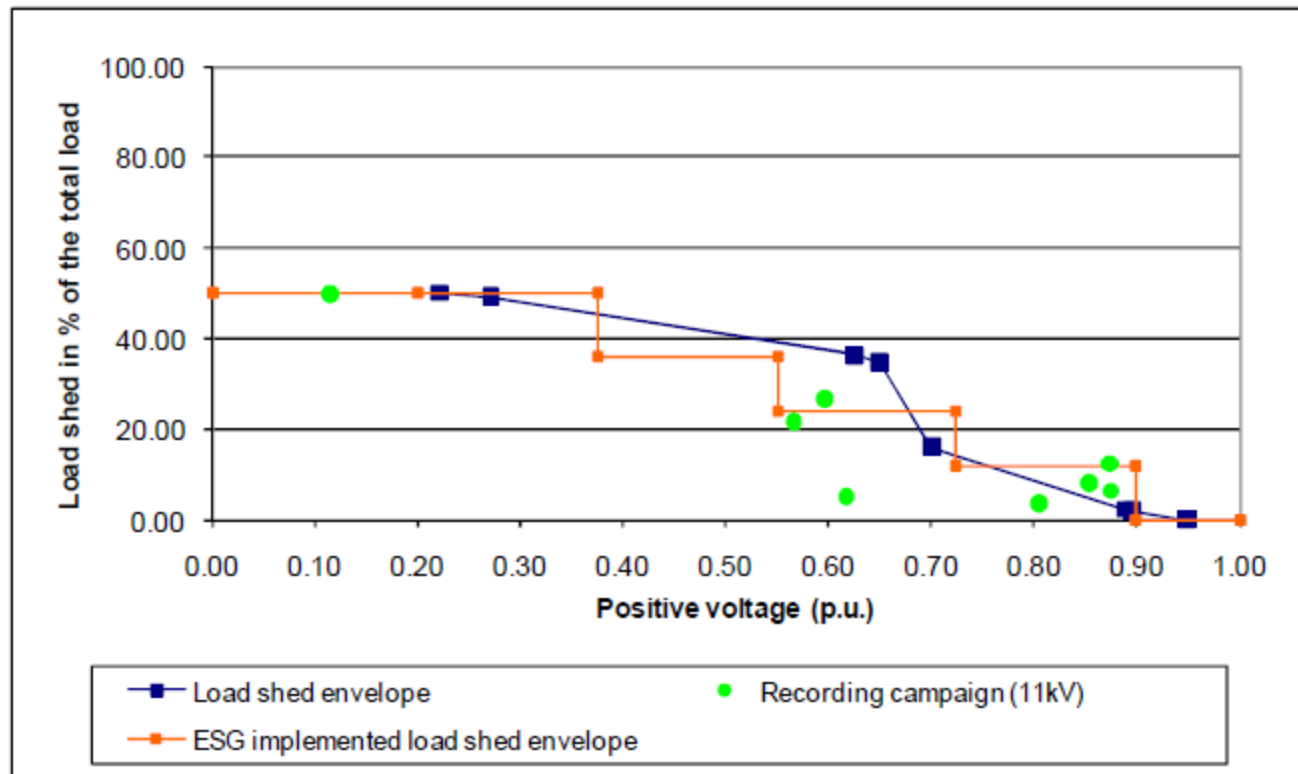




# Load model identification

## Embedded under voltage load shedding

- A common general load model is synthesized and implemented



## CONCLUSIONS

- Sensitivity to voltage and frequency are NOT sufficient to model the load
  - Mostly in presence of large amount of rotating load and power electronic driven loads
- Classical models may give stable results when the system is unstable
- Possible to derive realistic average model including the embedded load shedding using measurements
- Do EMS SA and DSA include load behaviour bifurcation ?
- What is the most efficient way to predict its impact ?