Wide-Area Voltage Control of Dynamic Shunt Compensation using Synchrophasors

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Presentation Overview

> **Hydro-Québec and the IREQ Research Institute**

> **The GLCC Project**

- Context
- Synchrophasor solution
- R&D Pilot project
- Results and conclusion

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Hydro-Québec and the IREQ Research Institute

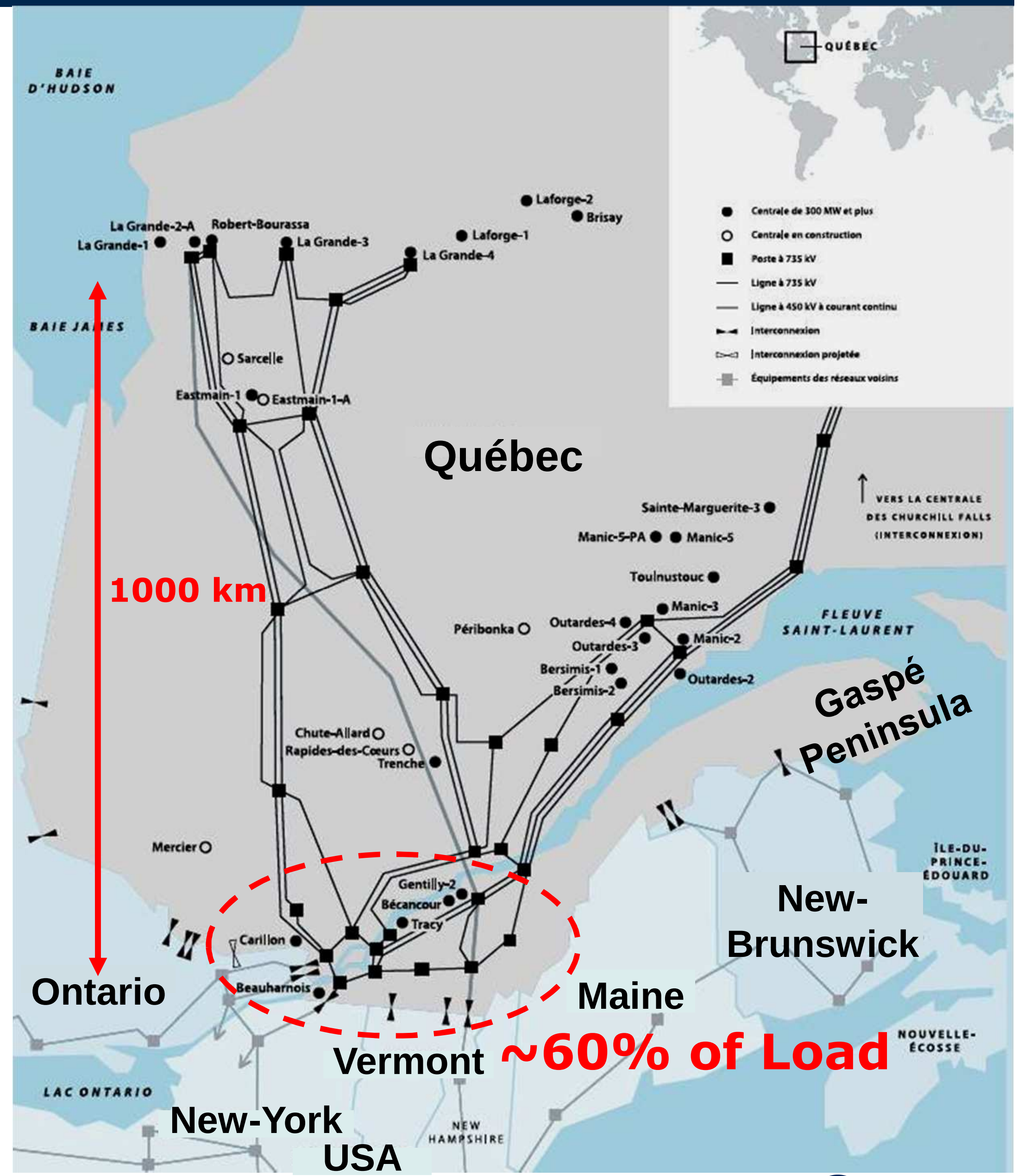
Hydro-Québec Power Grid

> **Production:**
- 43GW Capacity
- 98% Hydro

> **Transmission:**
- 735kV
- Serie compensated
- 34,000km of lines
  - 12 000km 735kV
- 17 asynchronous interconnection

> **Distribution:**
- 60% of Load in Montreal

Major concerns are power system stability and voltage control.



IREQ – Hydro-Québec Research Institute

> **<u>Research Areas:</u>**
- Smart grid
- Efficient use of electricity
- Renewable energy
- Aging materials and viability
- Battery materials

> **Team of 500 scientists, technicians and engineer**

> **<u>Annual investment:</u>**
- **100M$ Innovation project**
- **5M$ University chairs and contracts**

> **128 Partnership agreement**

> **850 Patents over 40 years**

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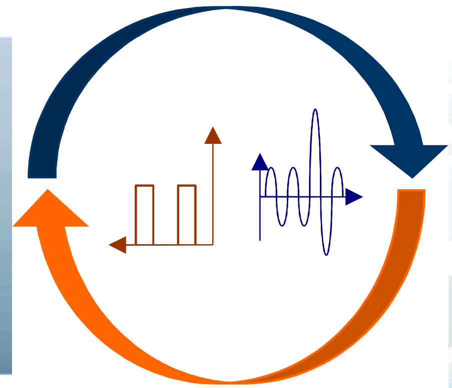
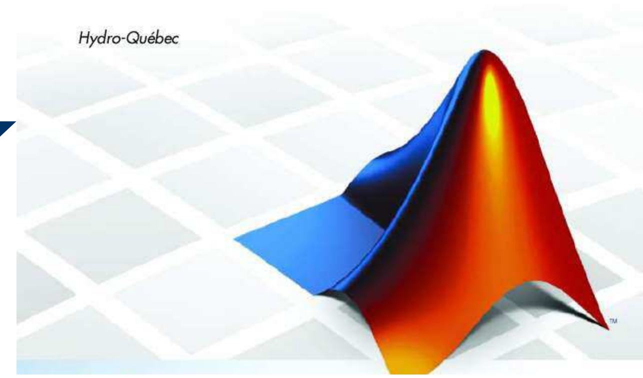
IREQ Power System Simulation Lab

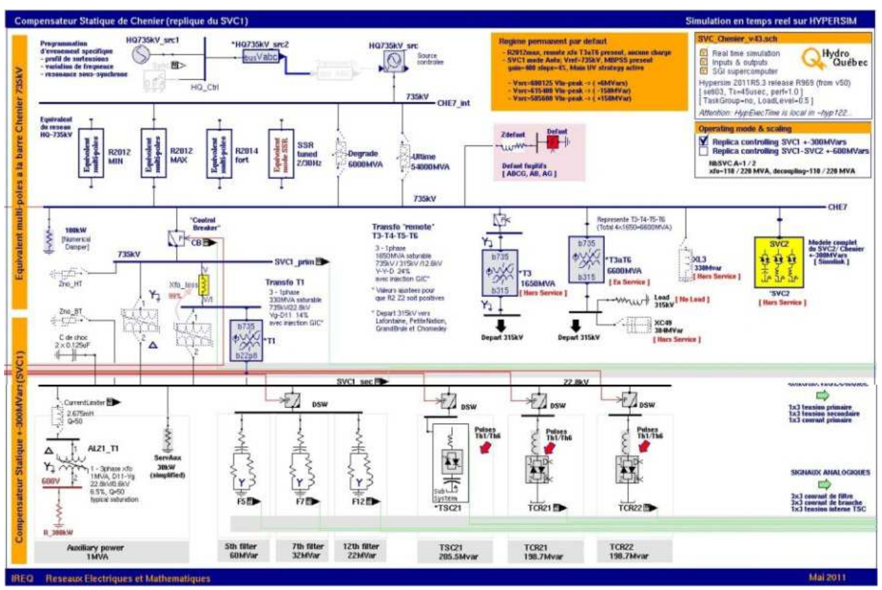
HYPERSIM
Power System Real-Time Simulator

SimPowerSystems™
User's Guide

MATLAB® & SIMULINK®







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The GLCC Project:

Global and Local Control of Dynamic Shunt Compensator using Synchrophasors

Context

> Shunt compensation installation

- 9 Synchronous Condenser (CS)
- 14 Static Compensator (SVC)
- Total capacity of
  7000 MVAR capacitive
  4000 MVAR inductive

> Main Purposes

- Post-event network stability
- Part of the voltage level control

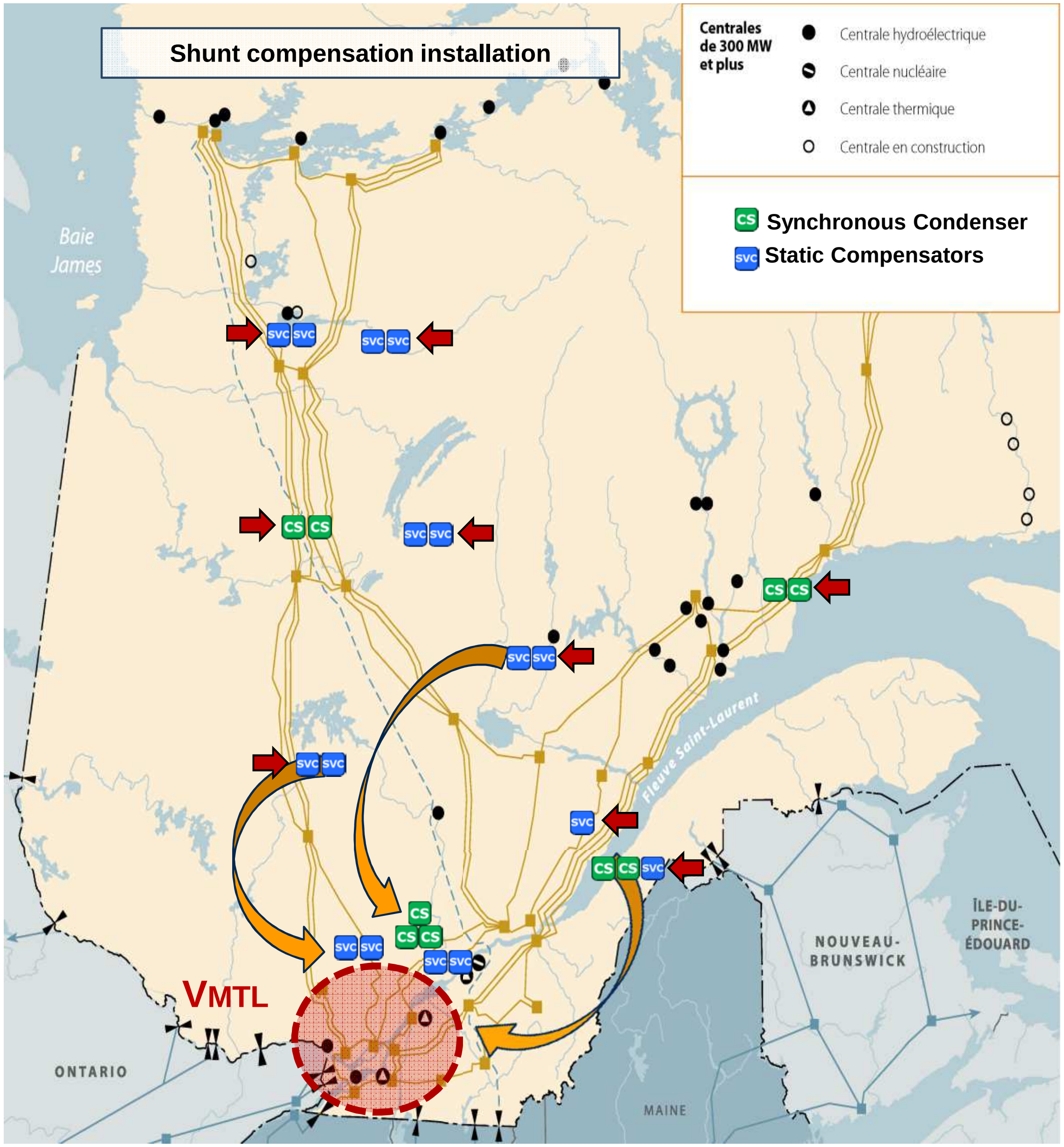
> Actual Control Strategy

- Same strategy in use since deployment in 1970-80.
- Independent voltage setpoint at each substation.

Context

- Contribution of compensators is not optimal because of the topology.
- For a voltage collapse situation in the load area, northern substations would not « see » the voltage drop, and extra MVAR wouldn't be generated by SVCs.
- **Need of a synchronized and robust solution to optimize the use of existing compensators.**

WACS Solution



Objective

Optimize the use of the actual compensator installation for voltage stability event.

Concept

Synchronized measurement of voltage variation to adjust the compensators setpoint accordingly.

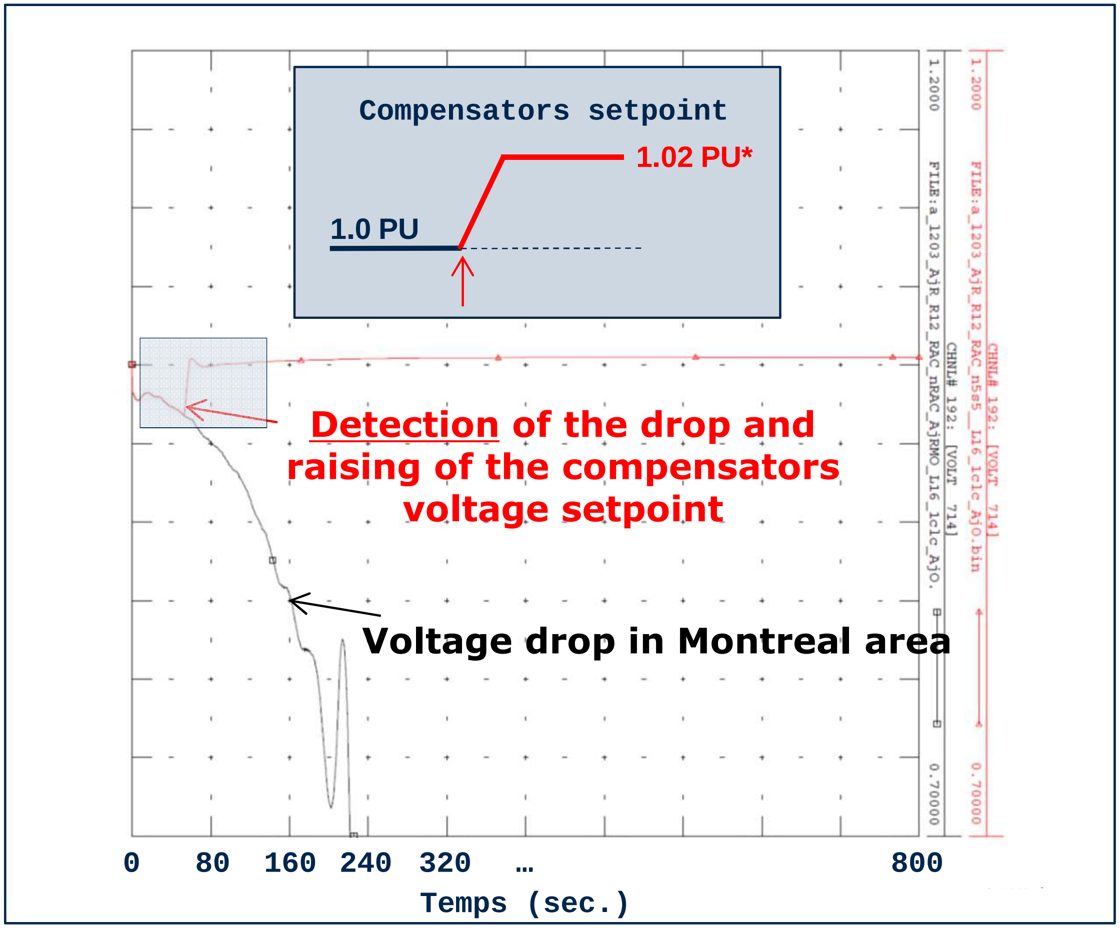
Solution

Control using synchrophasors.

GLOBAL CONTROL	LOCAL CONTROL
Use of V_{MTL}	Estimation of V_{MTL}
Telecommunication	Local PMU for V, I
PDC & SPDC	PMU & SPDC

WACS Solution

Effect on the Montreal voltage level following a severe fault* :



MAJOR GAIN ON POWER FLOW LIMITATIONS

*** Simulated 2015 network using PSSE**
Fault at the La Vérendrye substation, loss of line 7016 and 1 SVC

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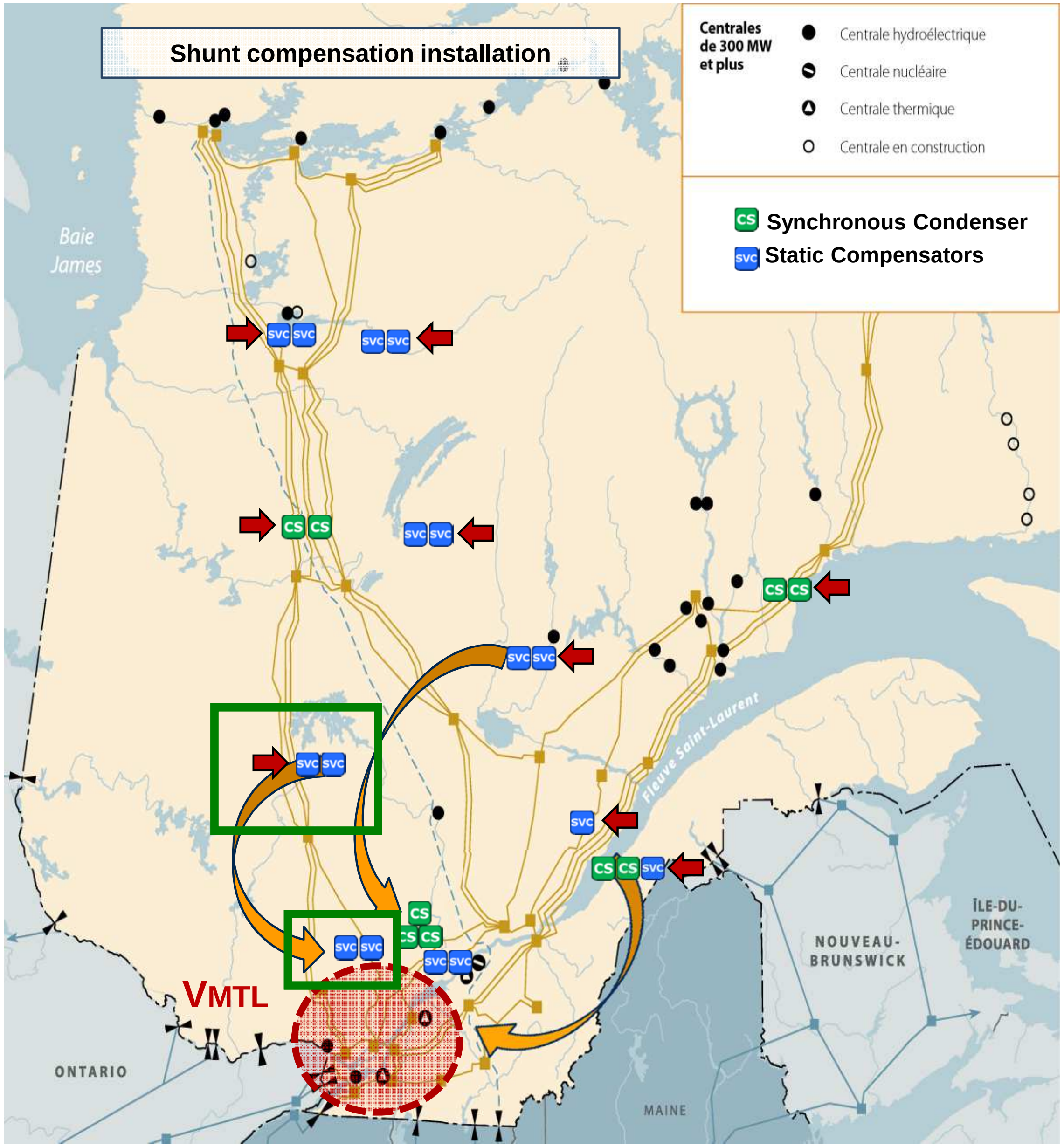
WACS Solution



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GLOBAL CONTROL

- **Use of V_{MTL}**
- **Telecommunication**
- **PDC & SPDC**

LOCAL CONTROL

- **Estimation of V_{MTL}**
- **Local PMU for V, I**
- **PMU & SPDC**

R&D PILOT PROJECT : LA VÉRENDRYE

1 SVC, 3 Substations and IREQ

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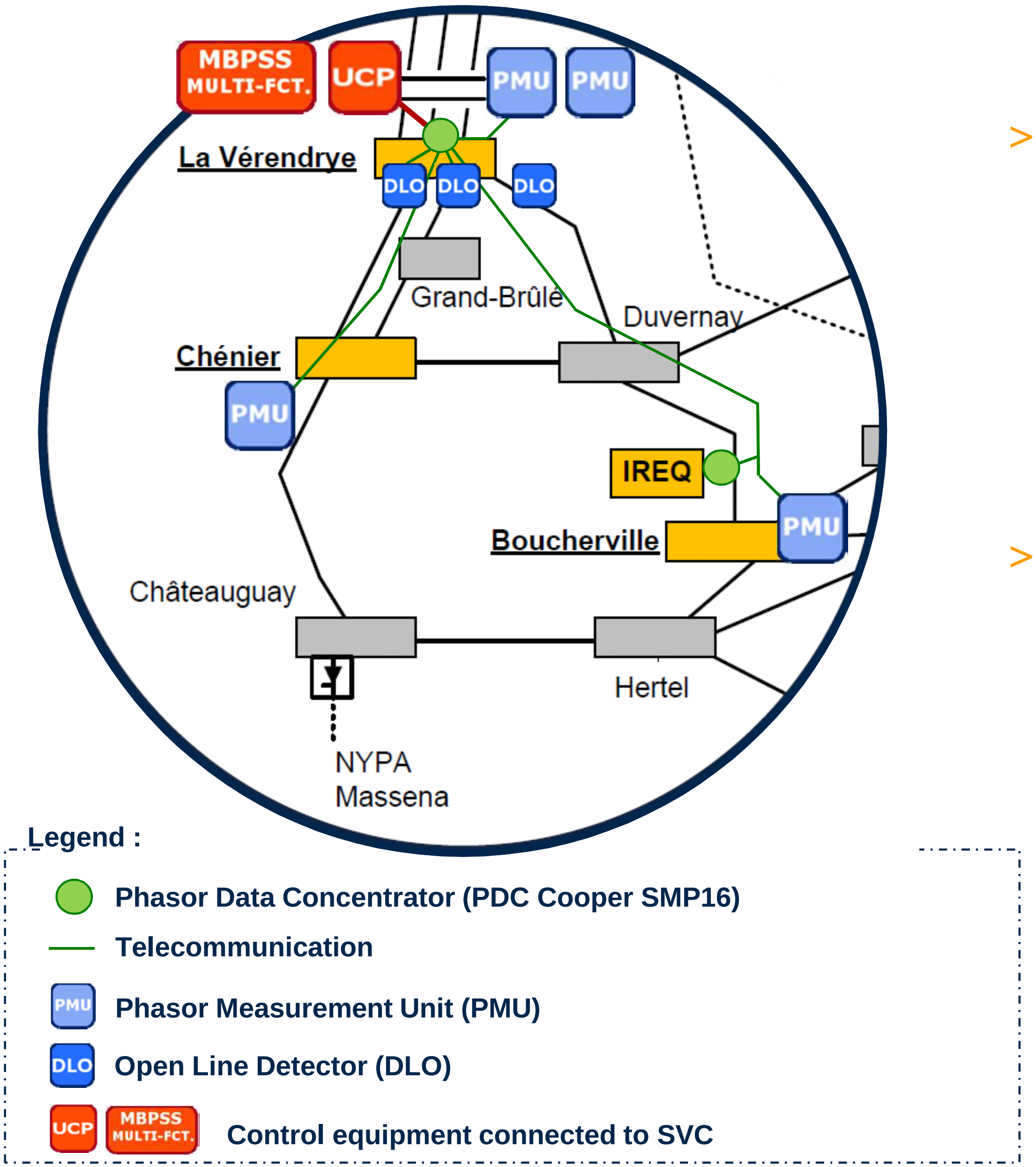
R&D Pilot Project



> **SVC Control Equipment:**

- Multi-Functionnal MBPSS.
- Control the SVC voltage setpoint.
- Power limitation algorithm.
- IREQ Simulink development.
- Partnership with ABB.

> **Substation Control Unit (UCP)**

- Detection logic algorithm.
- Adjust the MF-MBPSS output with ramp signal.
- IREQ Simulink development.
- Partnership with ABB.

R&D Pilot Project – Challenges

> **Multidisciplinary project:**
- Involving 12 teams and more than 30 people.

> **Combine technologies:**
- Synchrophasors, telecommunication, substation engineering, SVC control, grid operation, real-time simulation, algorithms and hardware development.

> **Real-time test bench:**
- Complete replica of the system
- Close-loop real-time tests using **Hypersim.**
- More than **3600** reliability and security tests.

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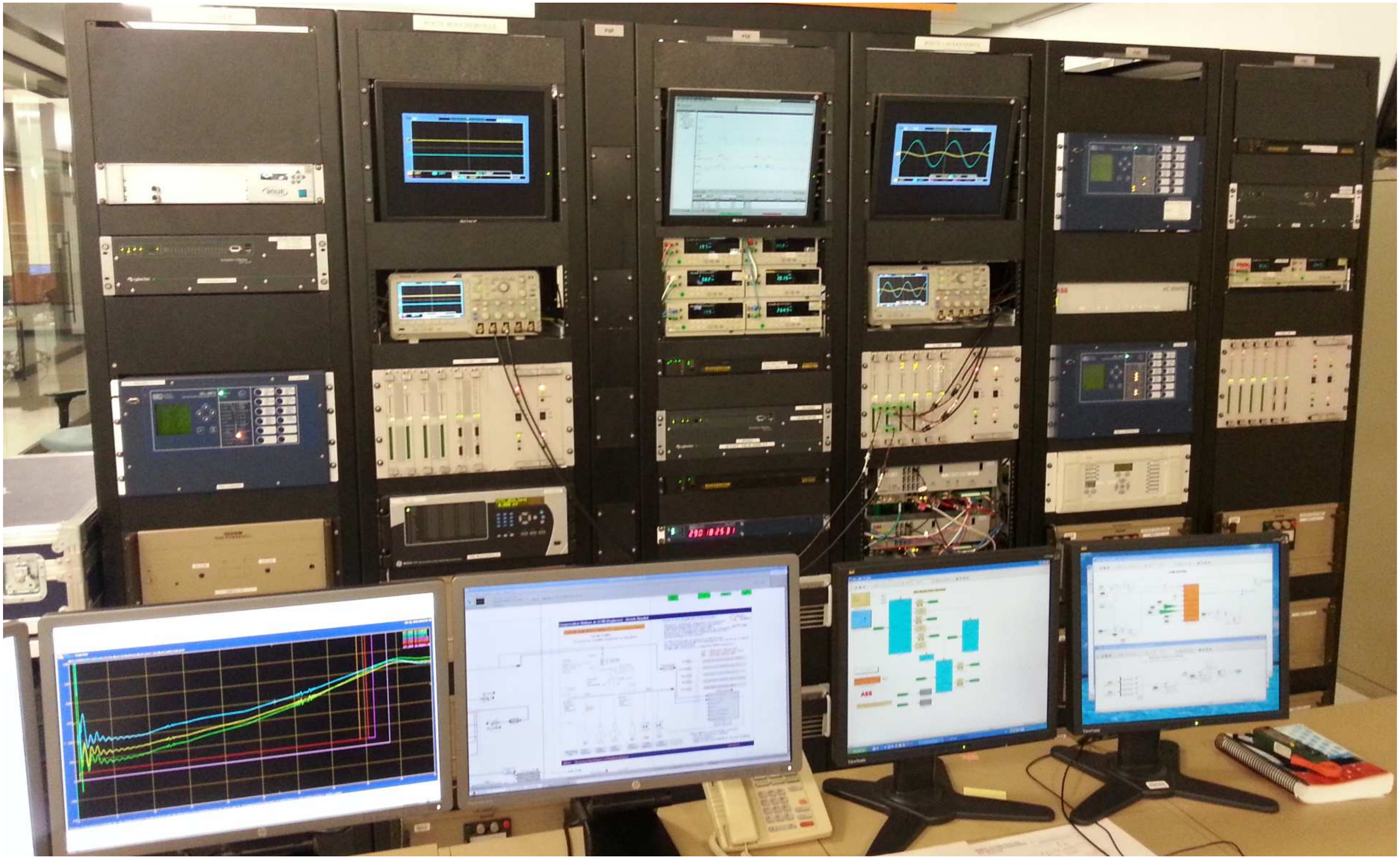
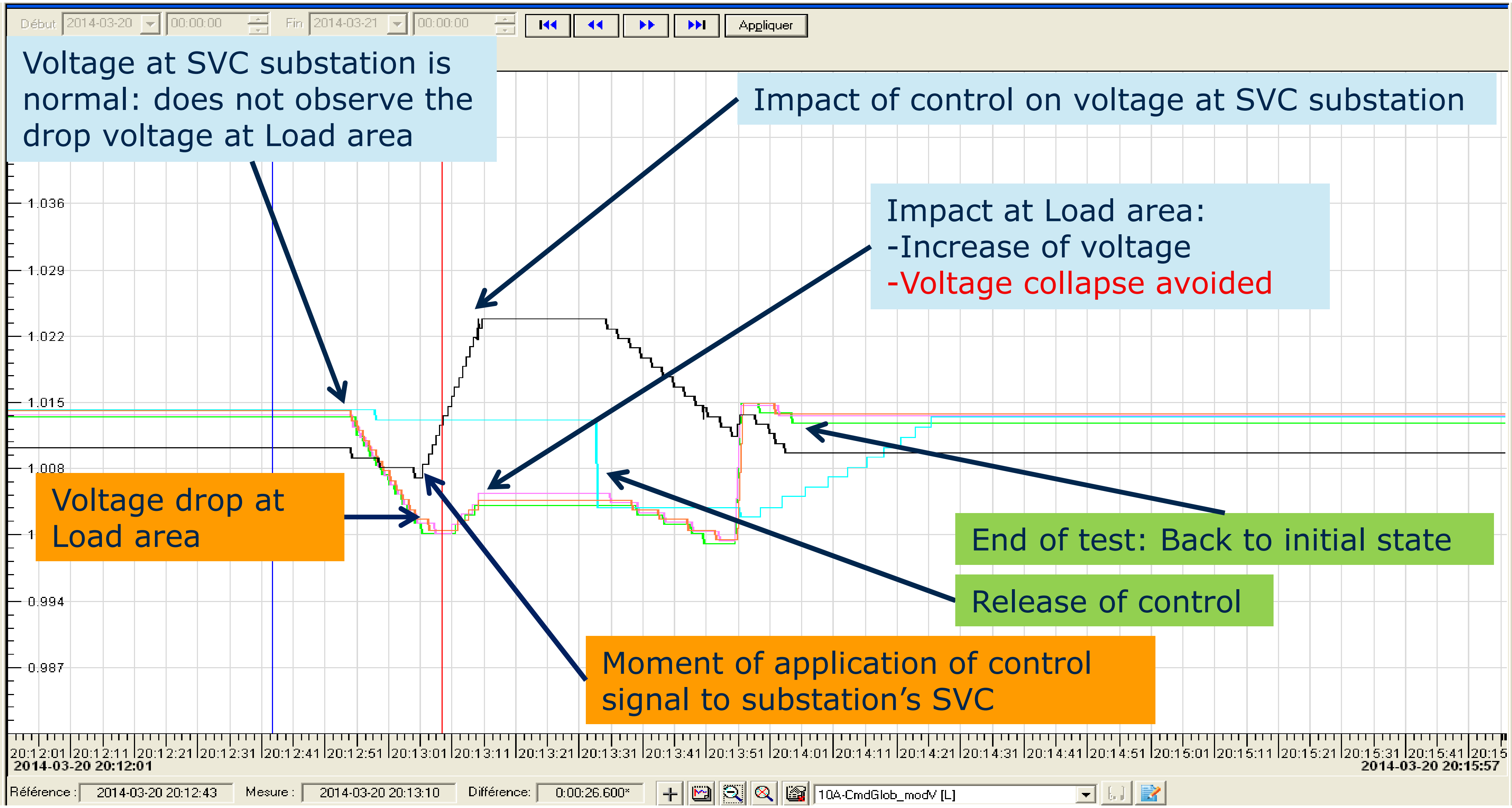
R&D Pilot Project – IREQ Test Bench

Wide-Area Voltage Control System replica on Hypersim, IREQ



R&D Pilot Project – Close loop results

> Hypersim : Voltage drop on 300 buses network



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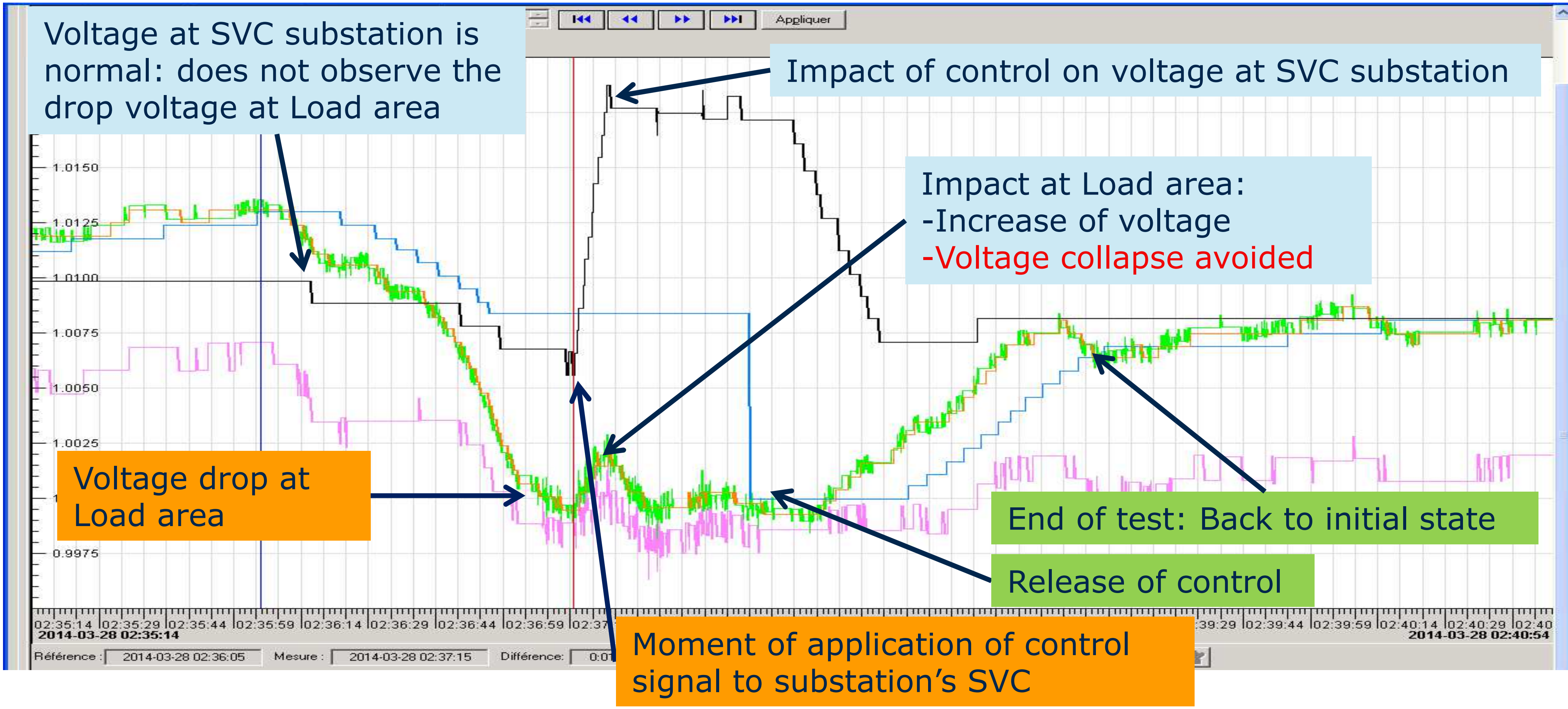
R&D Pilot Project – Close loop results

> Field test: Controlled voltage drop at Chenier



Conclusion

- **Successful R&D project leading to full WACS deployment.**
- **Voltage profile improved for extreme contingencies.**
- **Major gains on power flow limitations.**
- **Low-cost and robust solution using synchrophasors.**