Hydro Québec Distribution

Une division d'Hydro-Québec

An Update on Hydro-Québec Advanced Distribution Automation Program

Georges Simard

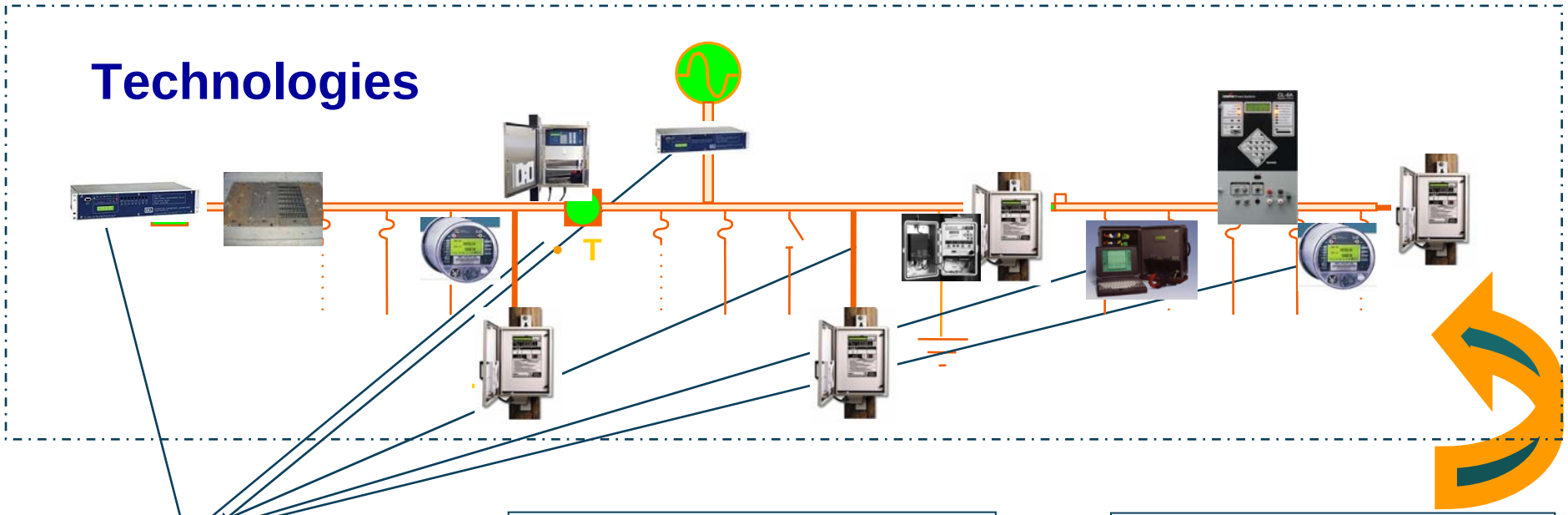
Orientations du réseau

Direction Gestion de l'actif - VPRD

Outline

1. **General approach**
2. **Hydro-Québec's ADA projects**
    1. Volt and VAR Control
    2. Fault location
    3. Underground Vault
    4. PQ Data from Distribution substation
    5. Data management – software analysis
3. **Next steps**
4. **Hydro-Québec's Distribution roadmap**
5. **Conclusion**

Intelligent Distribution Network
Flow of Information



DATA
(Using what?)

- Voltage
- Fault Currents
- Load Currents
- Temperature
- Number of Operations

Applications
(How?)

- Voltage Control
- Optimised Load Flow
- Fault Location
- Faulty Equipment
- Power Quality Evaluation

Business drivers (Why?)

- Energy Efficiency
- Reliability
- Distributed Resources
- Power Quality
- Customer Satisfaction

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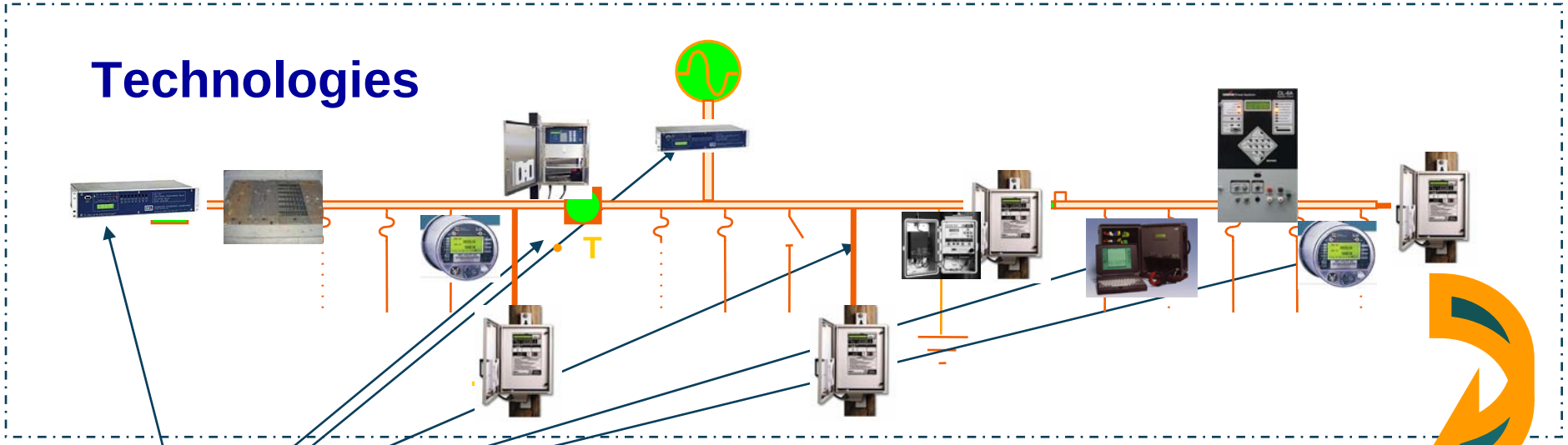
Intelligent Distribution Network
Flow of Decision



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(Using what?)

Voltage

Fault Currents

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Number of Operations

Applications
(How?)

Voltage Control

Optimised Load Flow

Fault Location

Faulty Equipment

Power Quality Evaluation

Business drivers (Why?)

Energy Efficiency

Reliability

Distributed Resources

Power Quality

Customer Satisfaction

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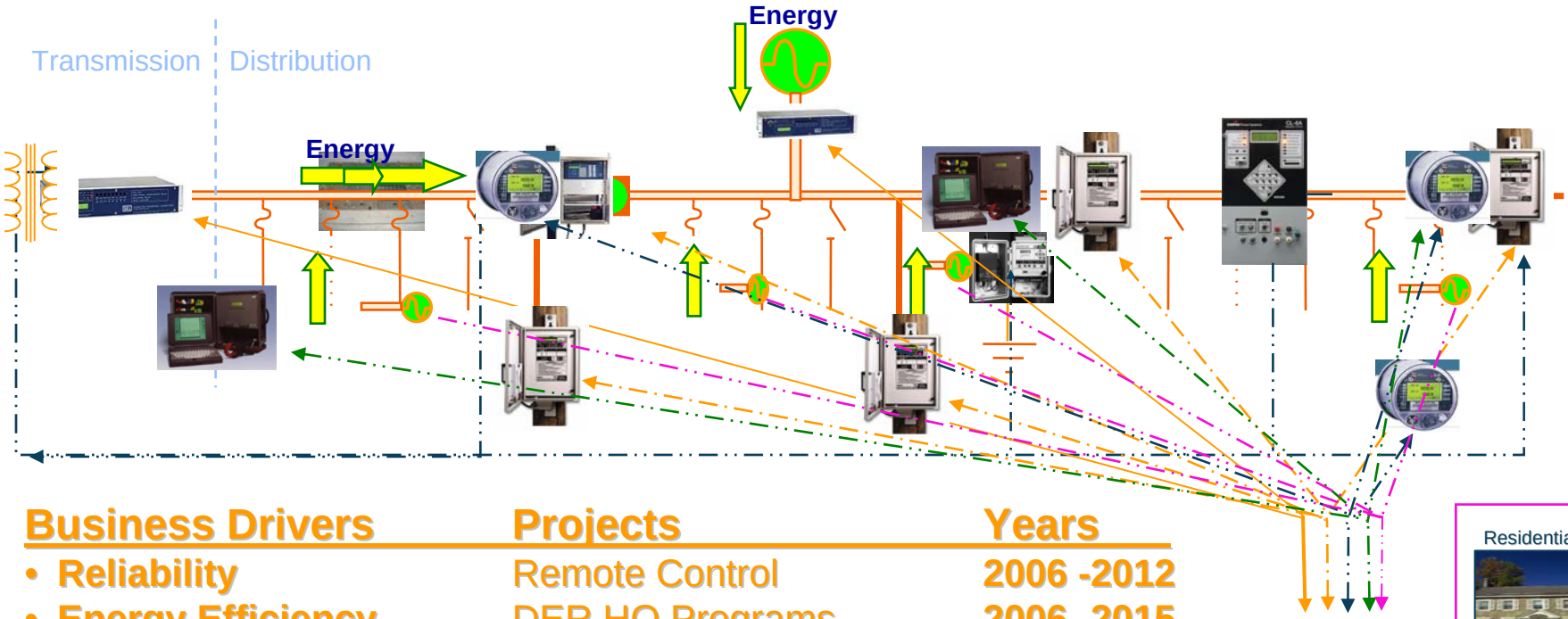
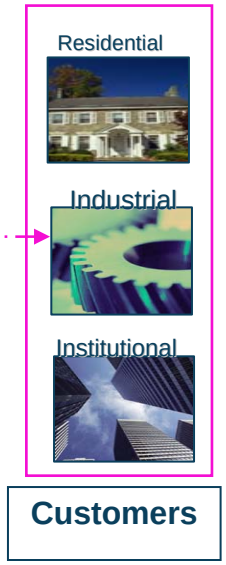
Distribution Network – DA Roadmap



Business Drivers	Projects	Years
• Reliability	Remote Control	2006 -2012
• Energy Efficiency	DER HQ Programs	2006 -2015
• Energy Efficiency	Voltage Control	2008 -2015
• Reliability	Fault Location	2008 -2015
• Reliability	Underground Vault	2008- 2015
• Power Quality (PQ)	PQ Monitoring	2008 -2015
• Energy Efficiency	Load side Management	2009 -2015
• Customer Satisfaction	Predictive Maintenance	2009- 2015
• Reliability	Automatic Reconfiguration	2010 - 2015
• Customer Satisfaction	Customer Portal	2010 -2015
• Energy Efficiency	Micro-grid	2015 ->



Customers

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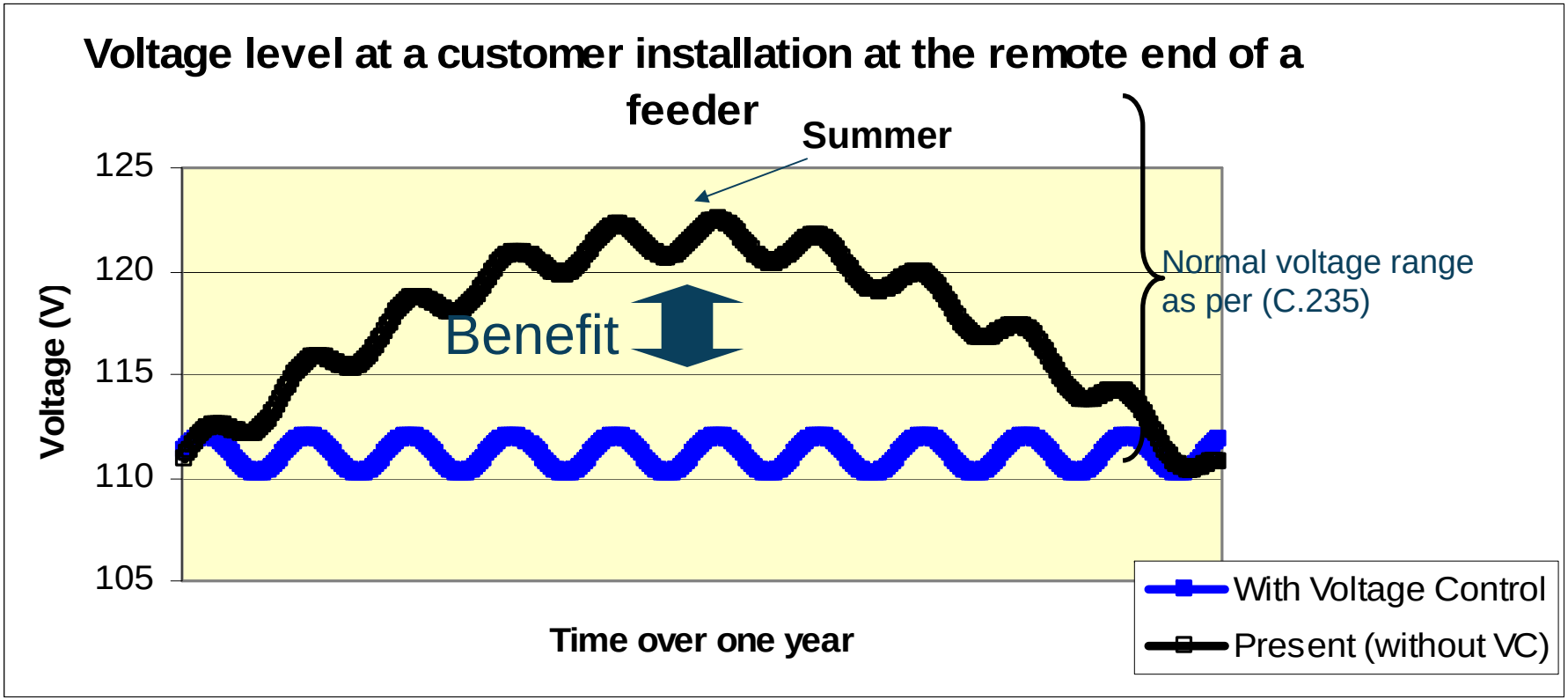
VOLT and Var Control

Project Objectives

- **Improve energy efficiency by reducing the voltage**
  - The amount of energy bought at marginal price (8,3¢/kWh) and delivered to customers (6,5¢/kWh)
  - Peak load of the system
  - Energy losses

Voltage control benefit



Voltage control leads to energy saving.

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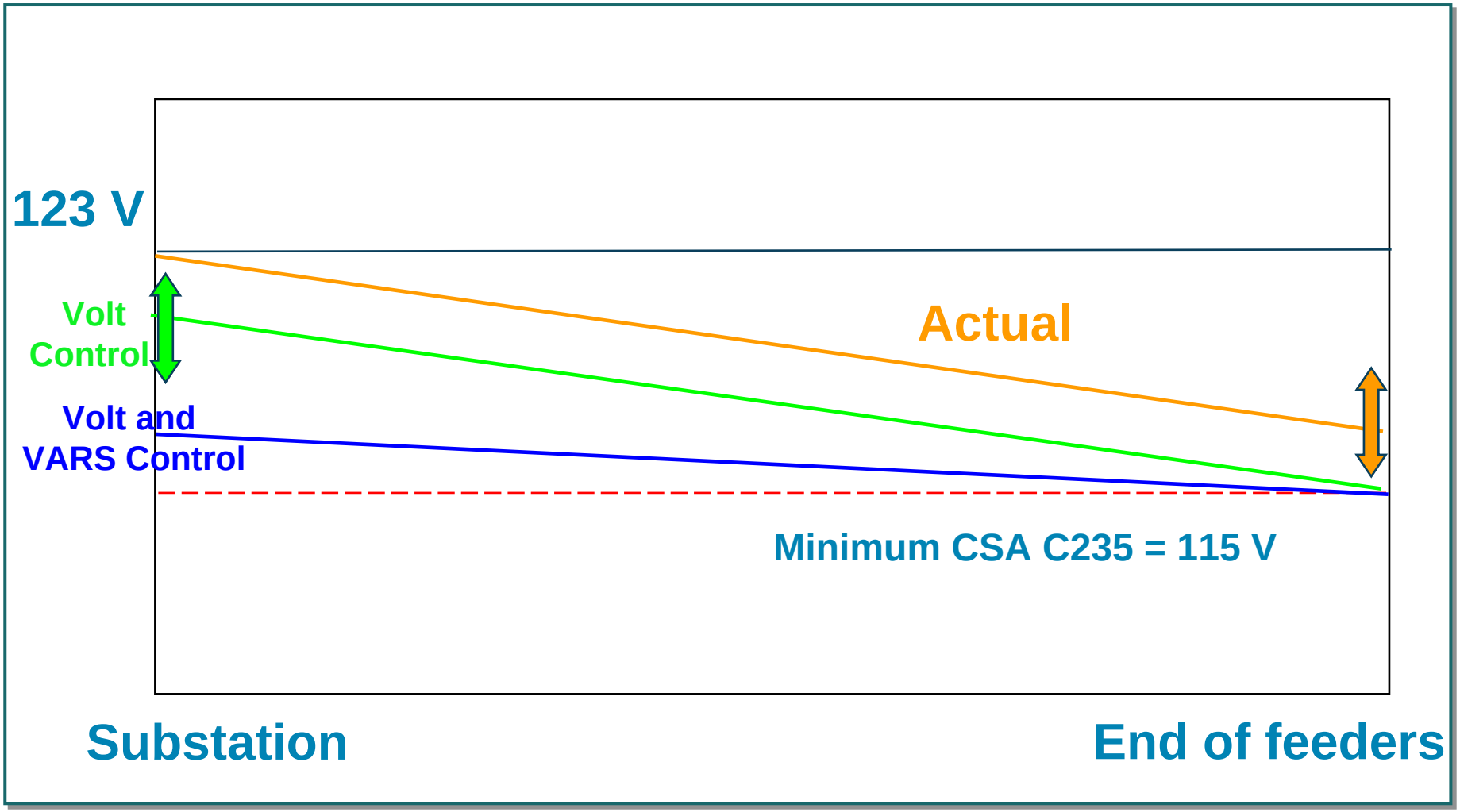
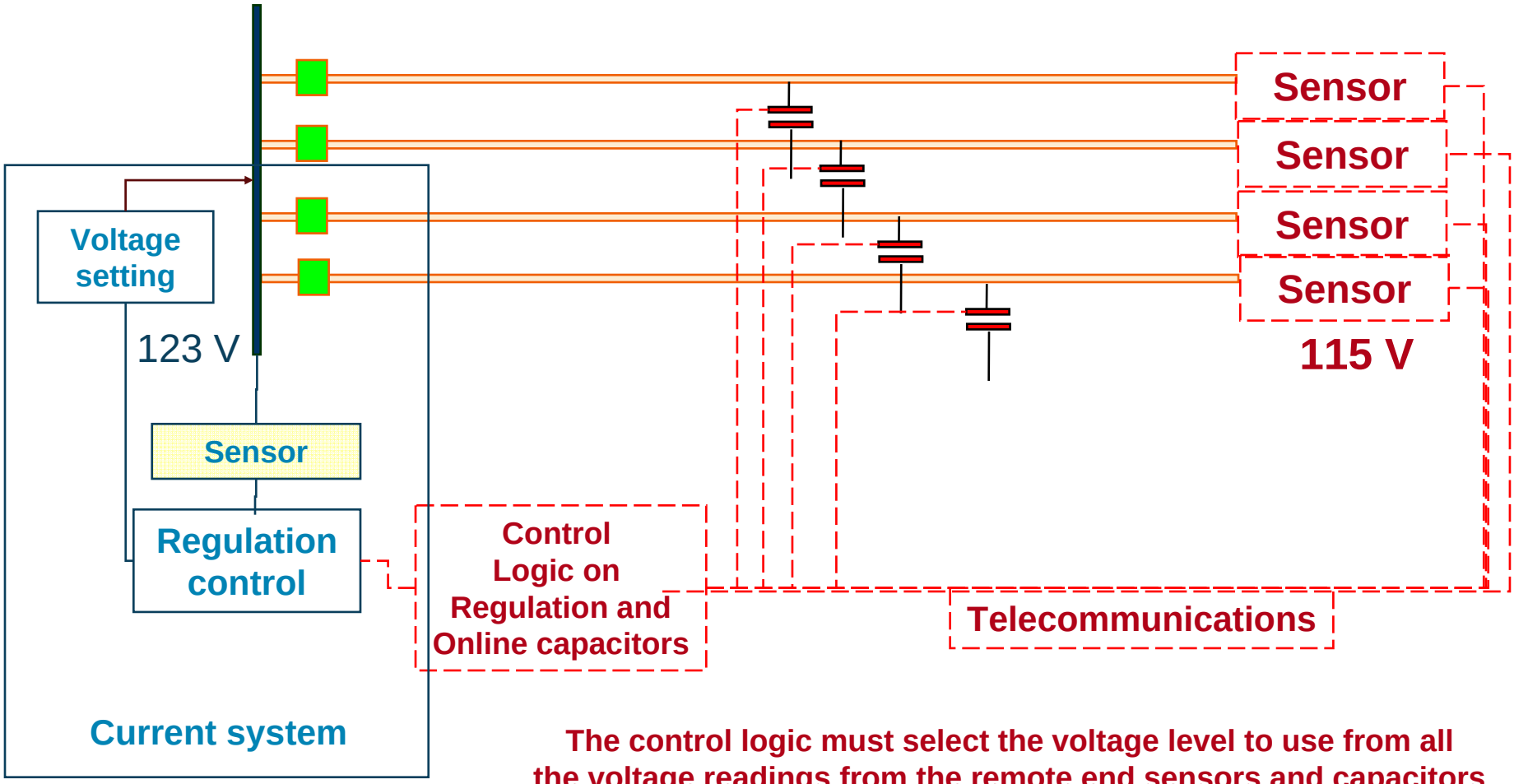
Volt and VARS Control Project Concepts



Volt and VARS Control Intelligent System



The control logic must select the voltage level to use from all the voltage readings from the remote end sensors and capacitors

p.5

Project Description

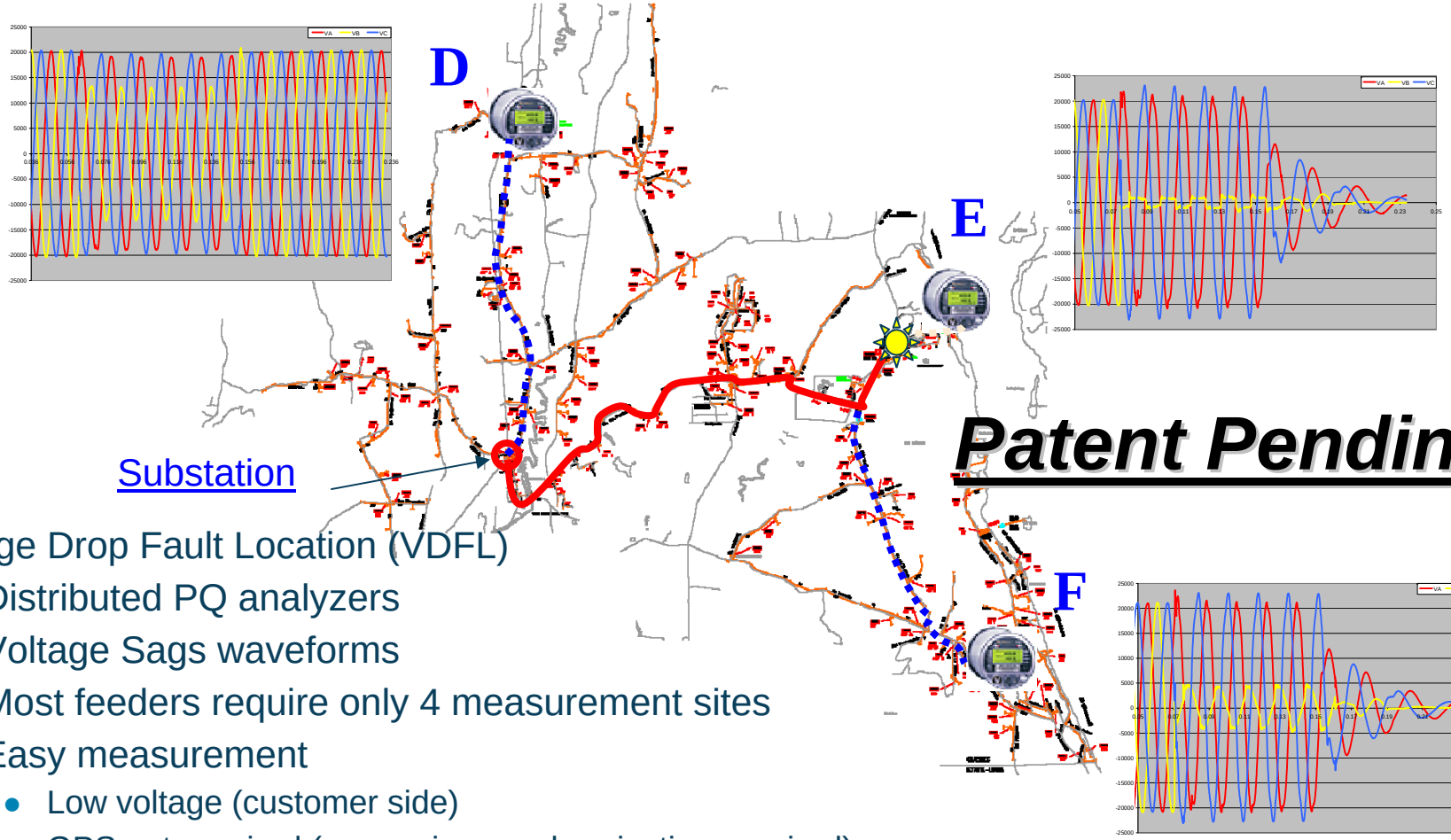
- **Phase 1: Volt Reduction**
  - Reducing voltage settings at the substation to reduce energy and peak load
    - Studies to be done to fix the voltage level (must consider type of load – constant impedance, power or current proportions)
    - Must keep a margin for dynamic operations and unbalanced loads
    - Power Quality monitoring may be needed to insure respect of C235
- **Phase 2: Volt and VARS Control**
  - Voltage and VARS controlled through remote sensors on the feeder
    - Intelligent system to optimise online capacitors management and volt control in a single system

Results and next steps

- **Phase 1 : Manual voltage reduction test at a typical distribution substation confirmed an average CVR of 0,4 over one year (1% of voltage reduction = 0,4 % of energy conservation)**
- **Phase 2 : Demonstration project – End 2008**
- **HQD aims to deploy a global Volt and VARS Control project by 2008-2015**

Fault location

Hydro-Québec's Distributed Approach



Patent Pending

Voltage Drop Fault Location (VDFL)

- Distributed PQ analyzers
- Voltage Sags waveforms
- Most feeders require only 4 measurement sites
- Easy measurement
  - Low voltage (customer side)
  - GPS not required (no precise synchronisation required)
  - Calibration not needed

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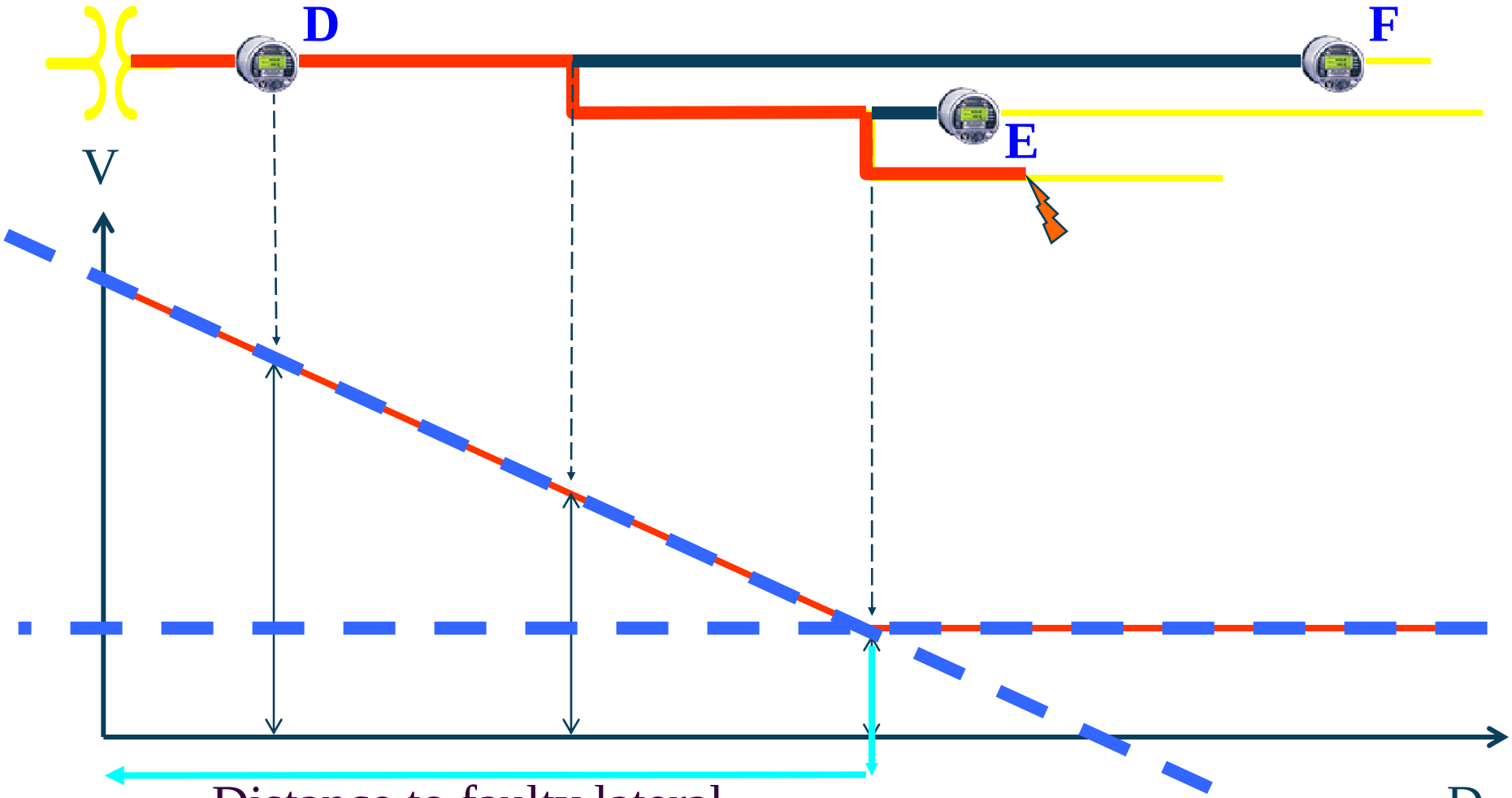
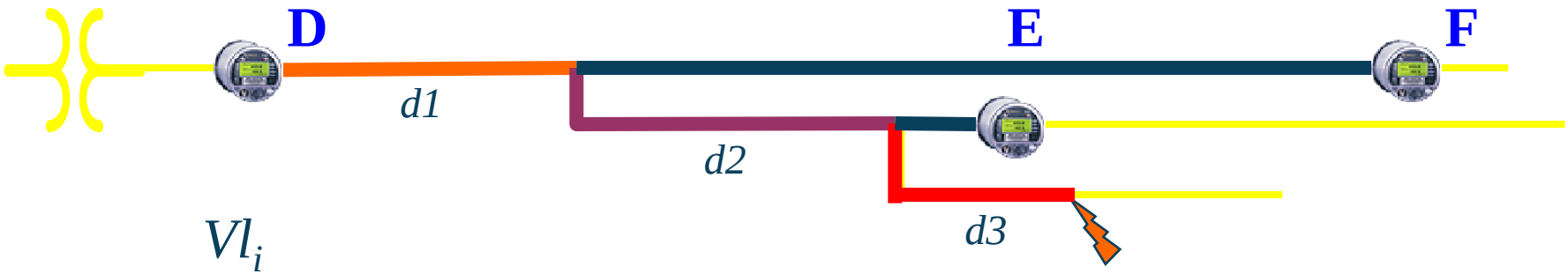
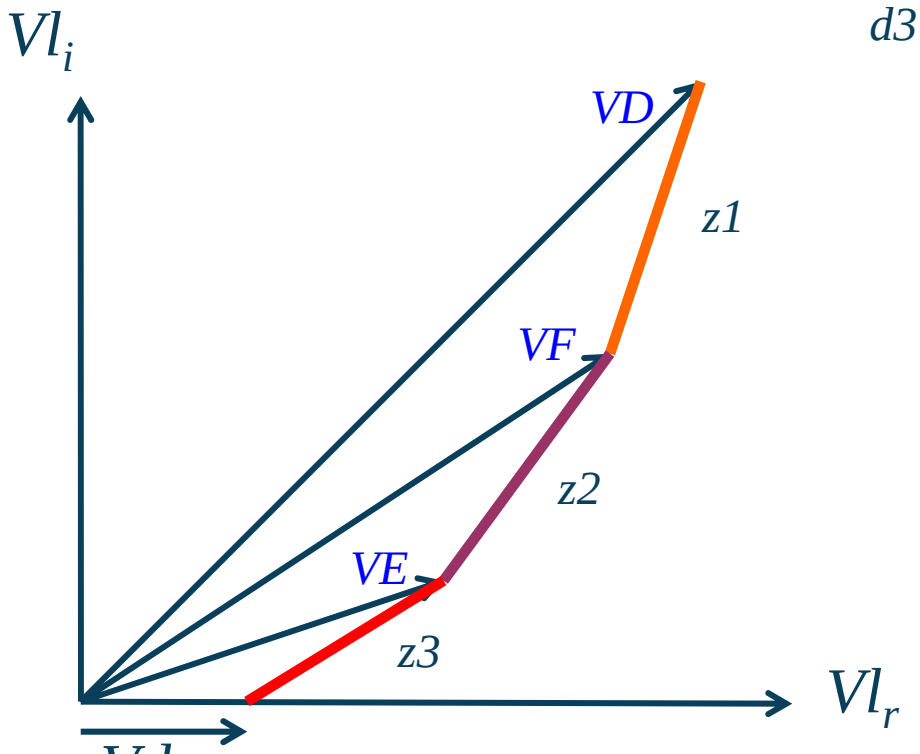
VDFL Basics (1)



VDFL Basics (2)

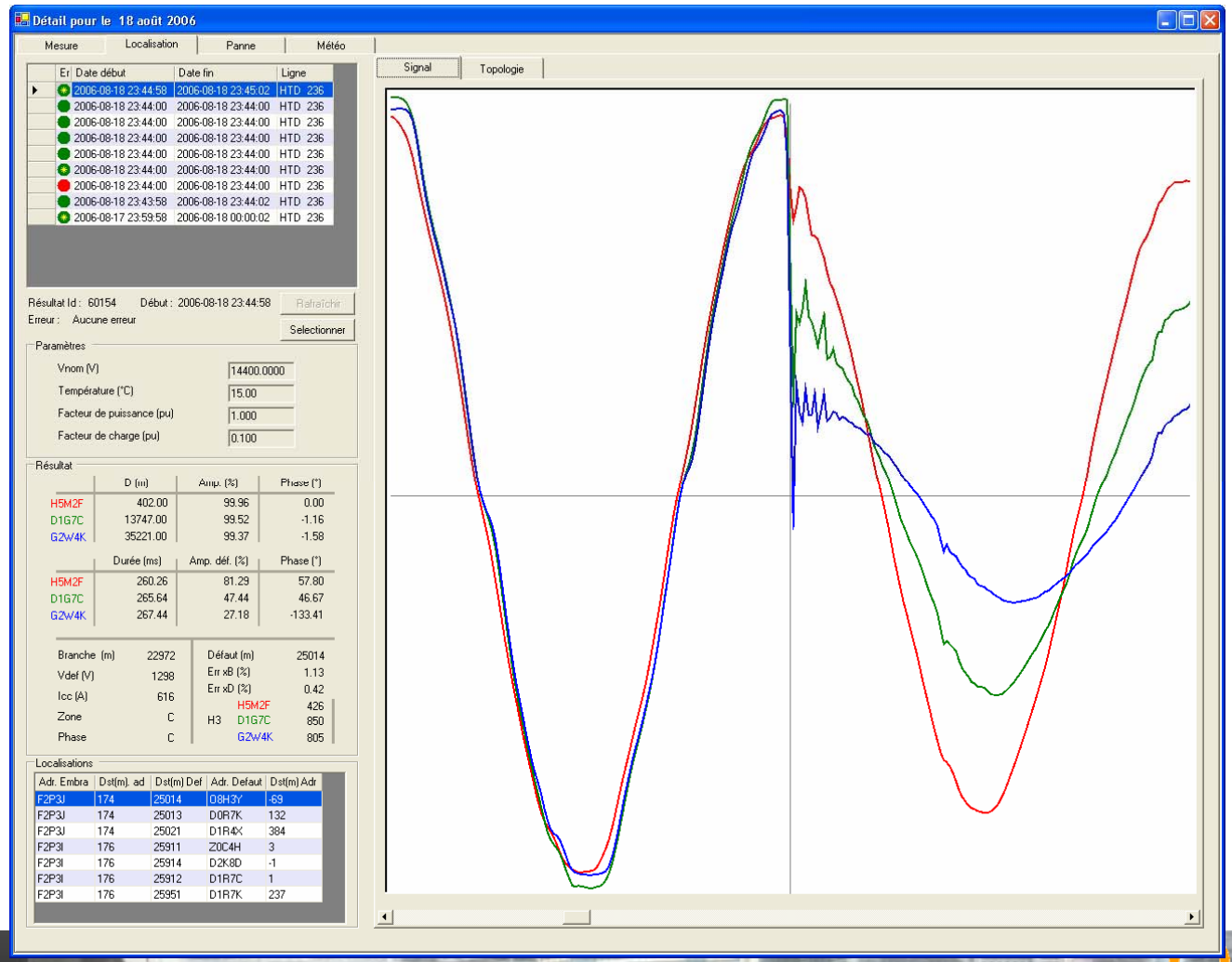




VDFL deduce :

- Fault current
- Position of faulty lateral
- Distance to fault
- Arcing voltage

MILE - Voltage drop on phase C



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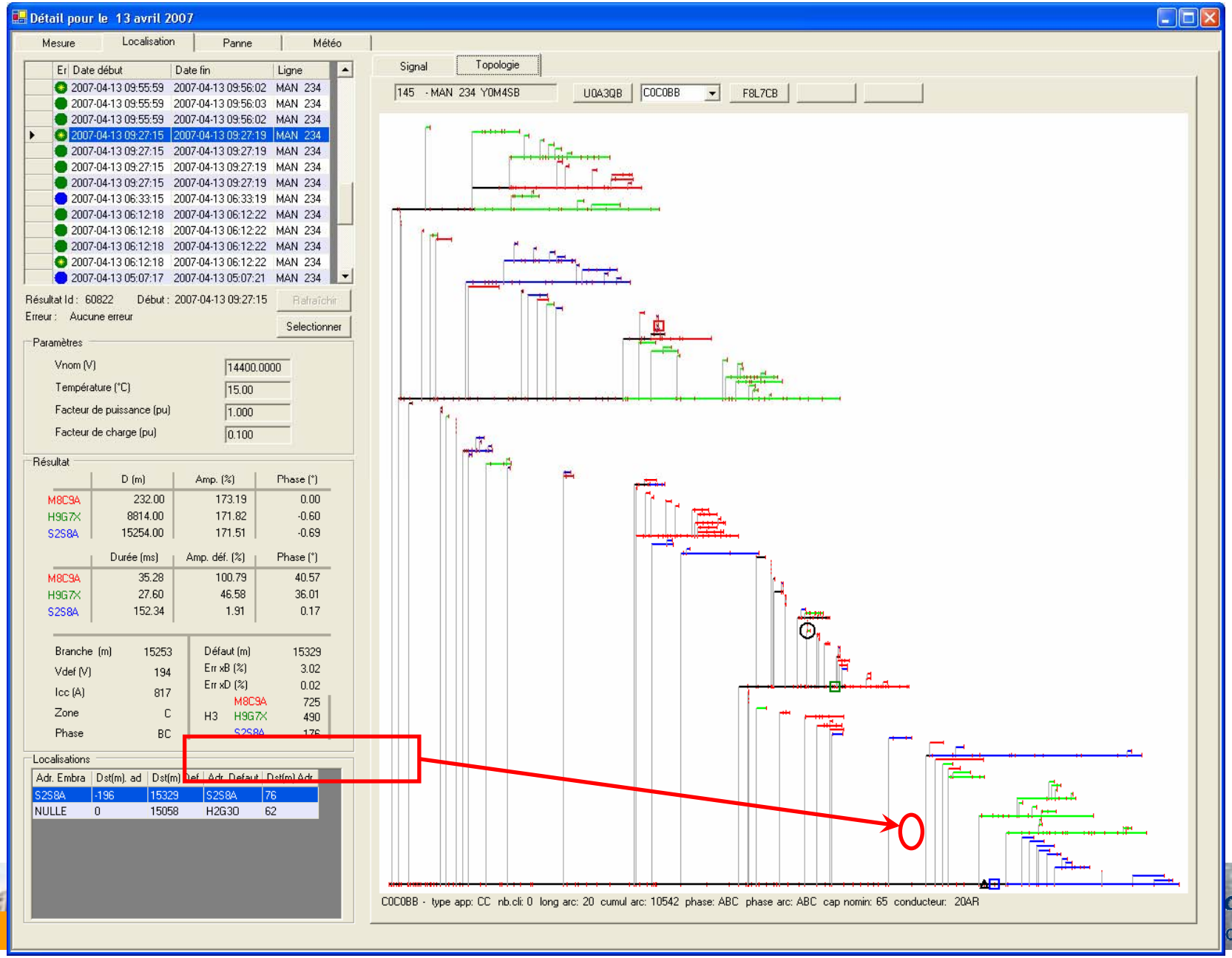
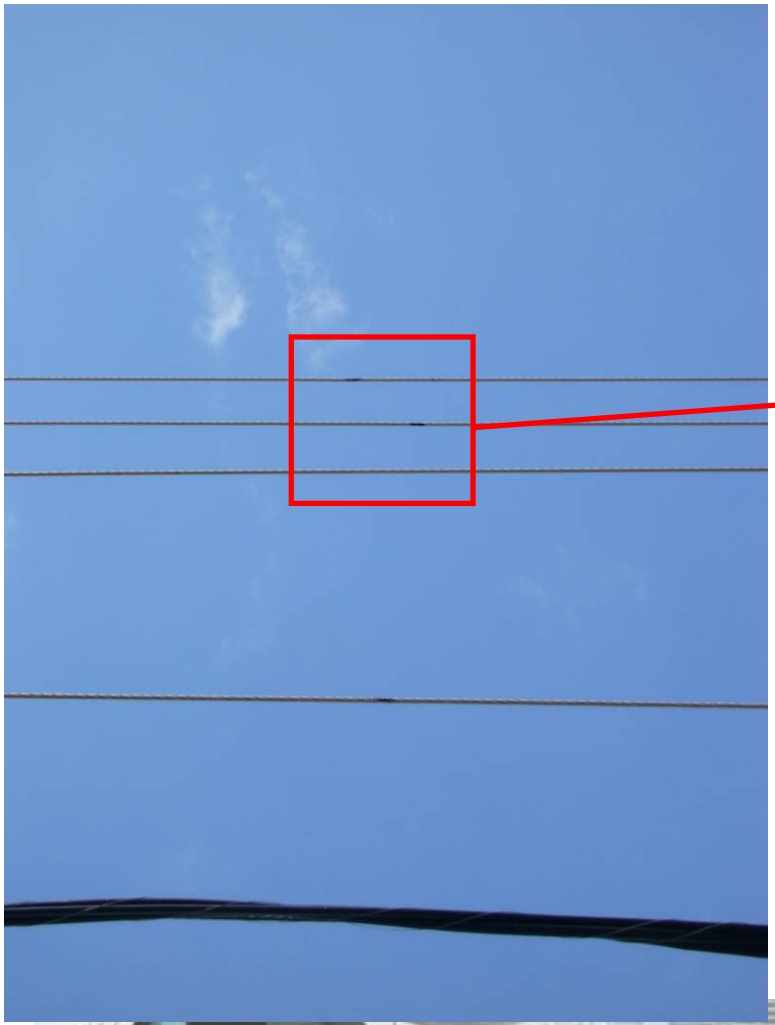
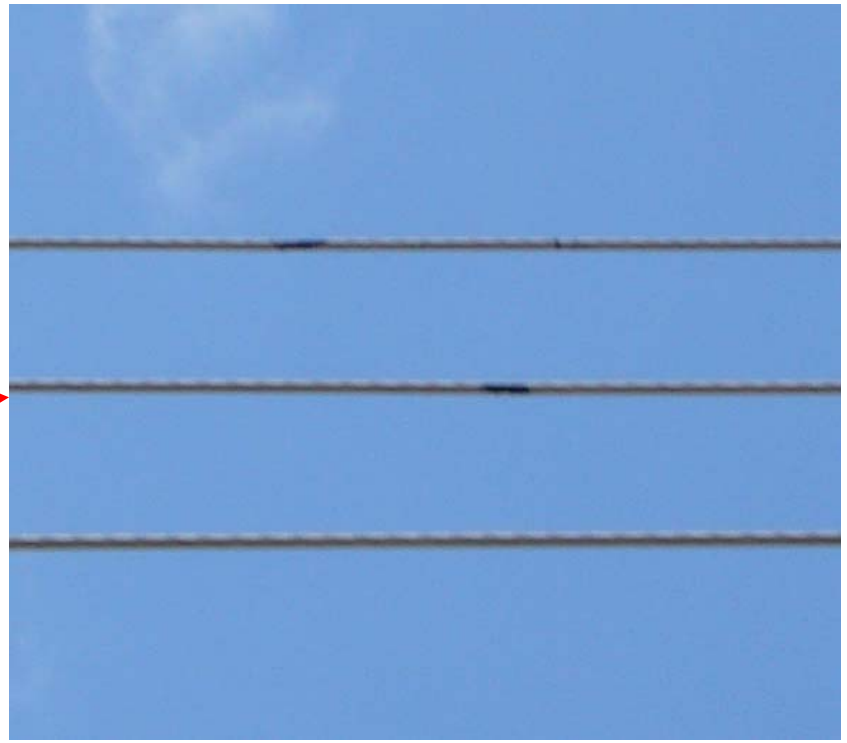
MILE – Fault Probable Locations



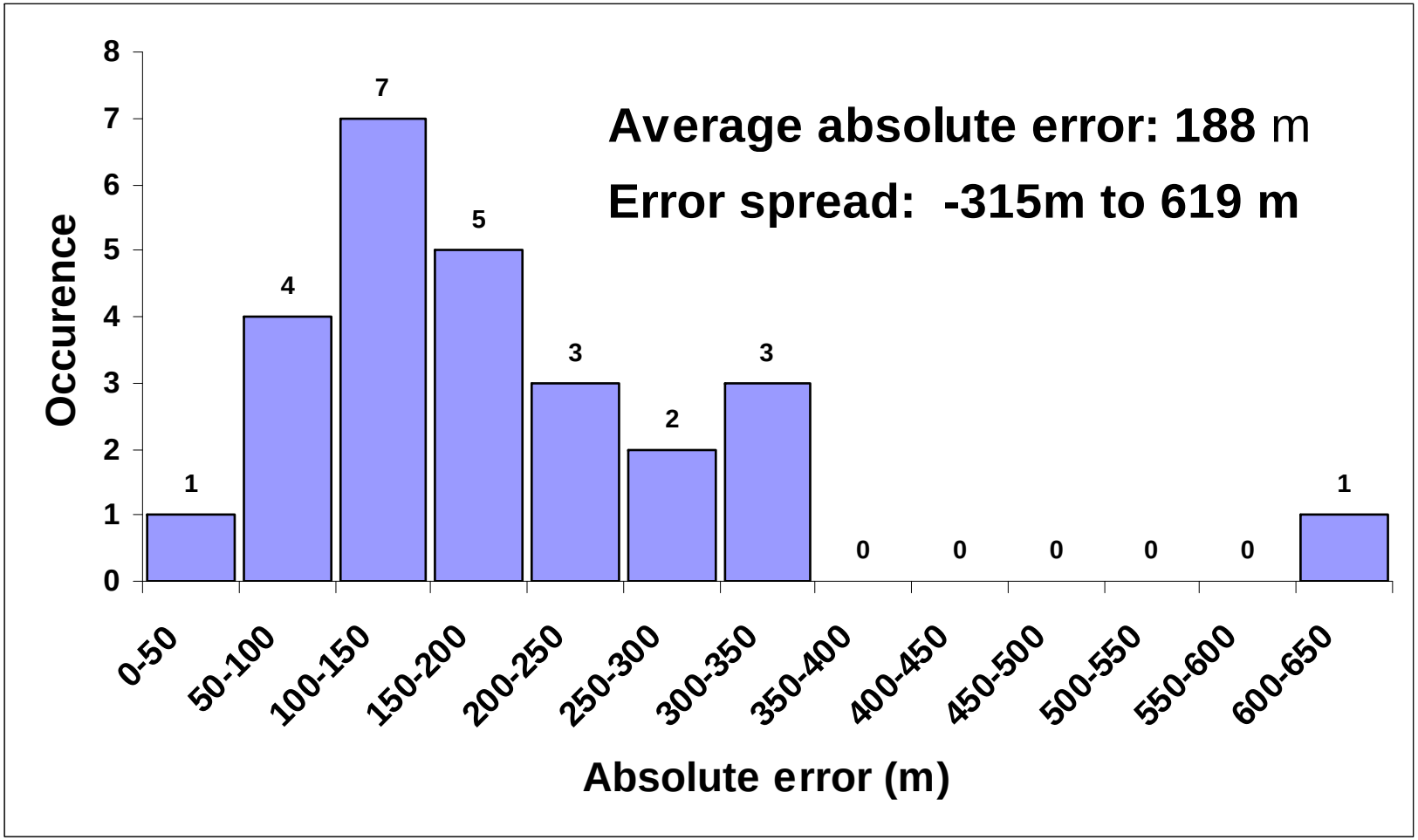
Fault located





Burning traces located on conductor at mid distance between poles.

Fault Location Accuracy



95% of the distribution faults located are within 332m

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Advantages

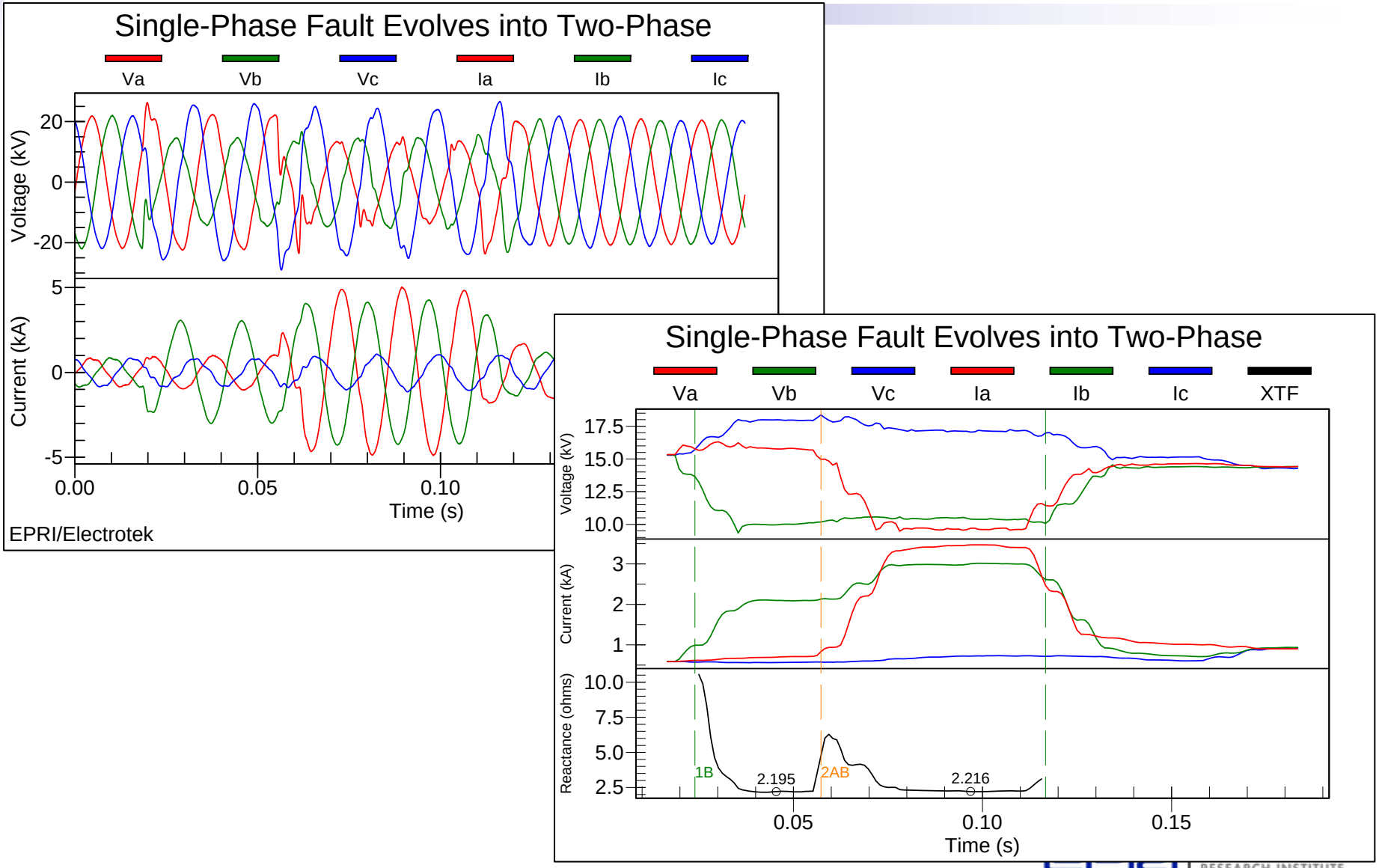
The main advantages are:

- PRECISION: faults are located within an average absolute error of 188 meters (617 ft). Independent of fault contact impedance.
- INTEGRATION: with existing distributed advanced systems such as AMI or ADA: The same sensors used for VDFL can be used for PQ qualification of the system and possibly voltage and VAR control. This system needs only software and computers to treat the data that will lead to fault location.
- TIME STAMP NOT NEEDED: waveshape synchronization is done through the software.
- ABSOLUTE PRECISION NOT NEEDED: The VDFL technique automatically compensates for lack of monitoring accuracy.

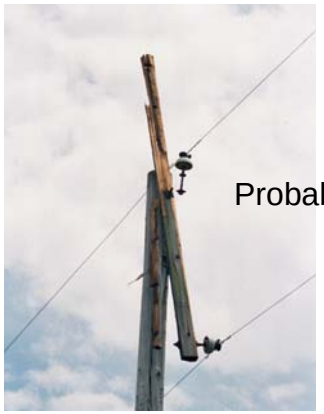
Approaches for fault location

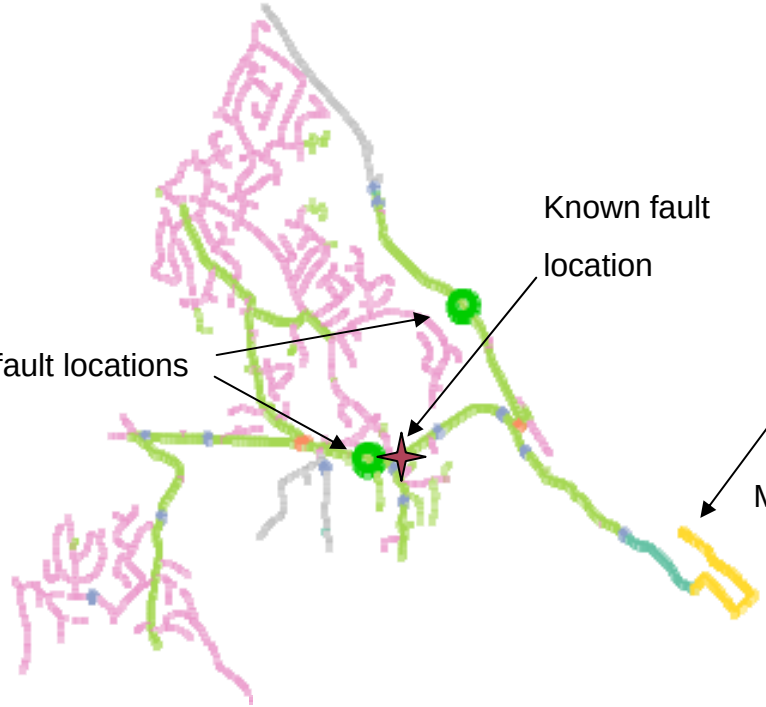
- Fault location based on voltage monitoring at distribution system locations (Hydro Quebec)
- Fault location based on voltage and current monitoring at substation (EPRI PQView)
- Fault location with fault current indicators (communicating)

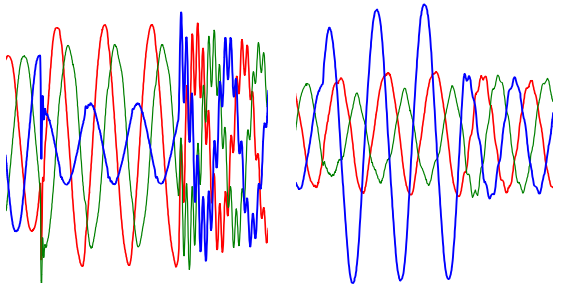
Example of waveforms used for fault location



Key Application – Fault Location







Fault location next steps

- Collaboration between EPRI and Hydro-Québec (2 mirror projects):
  - Hydro-Quebec will expand its actual fault location project by implementing fault current measurement in a HQ substation and using EPRI's concept through PQView.
  - EPRI will find a partner among US utilities to implement Hydro-Québec's fault location system as a demonstration project
- Hydro-Québec continues to improve its fault location system (Cost of sensors and telecommunication, MILE predictive capabilities…)

Underground Vault

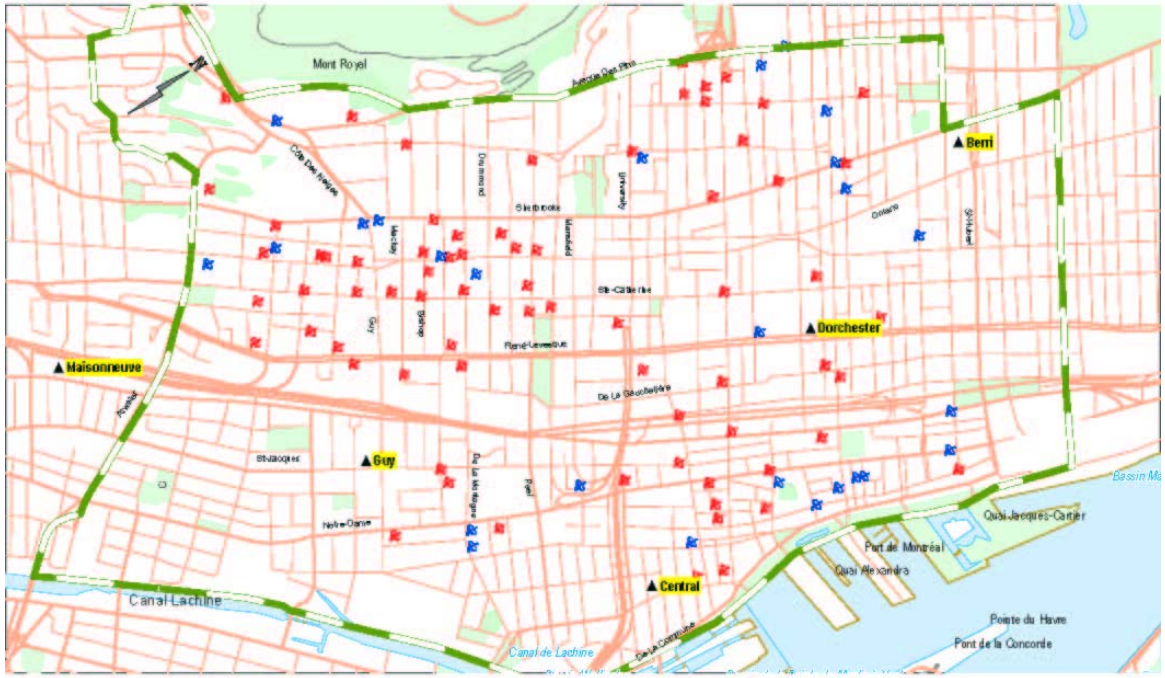
Underground DA program

Justification: improve downtown Montreal SAIDI

Completed in 2006 (~ 100 remote controlled underground switches)

Optical fiber is used for telecommunication

Project to extend data acquisition for the underground system (system of the future)



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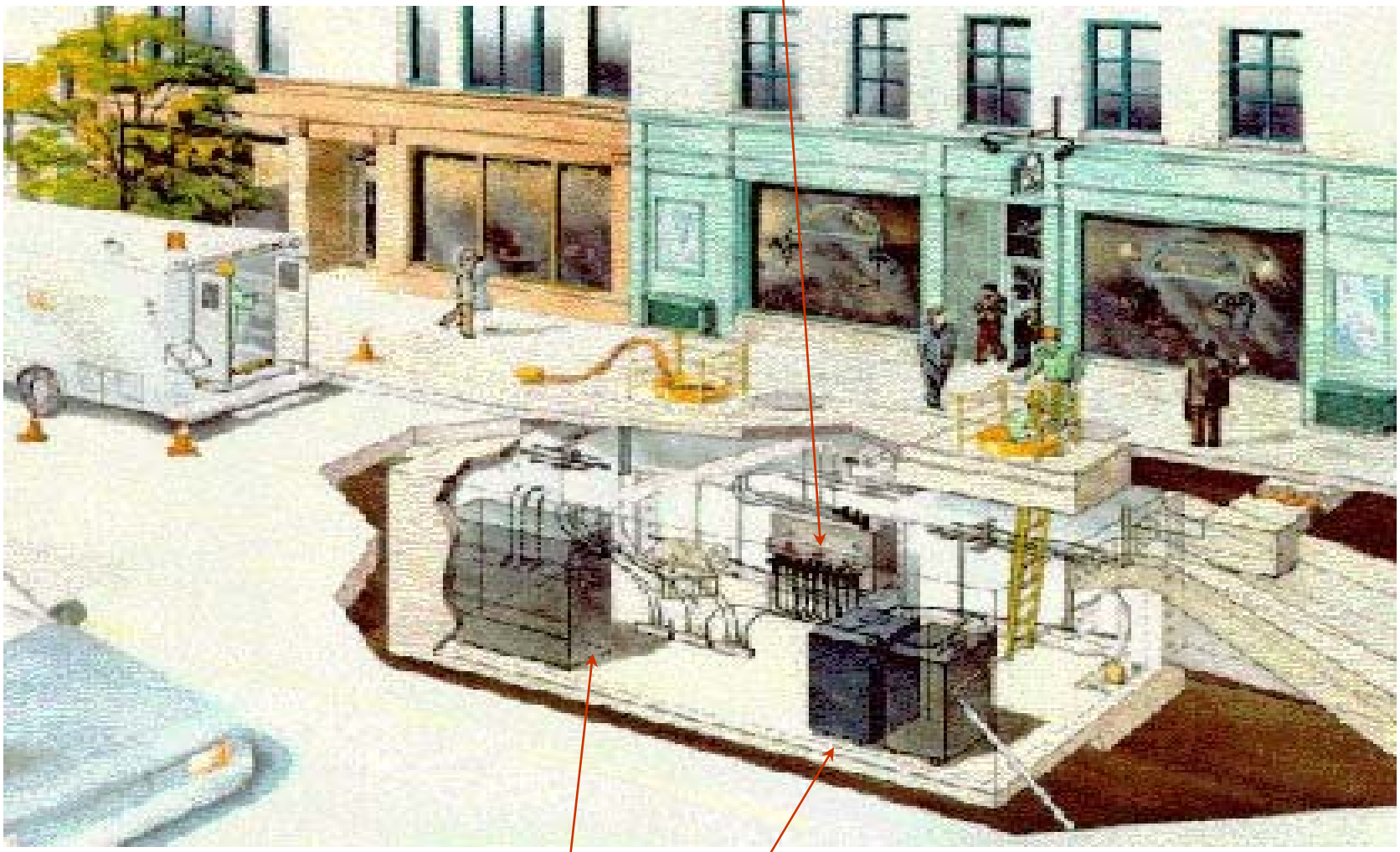
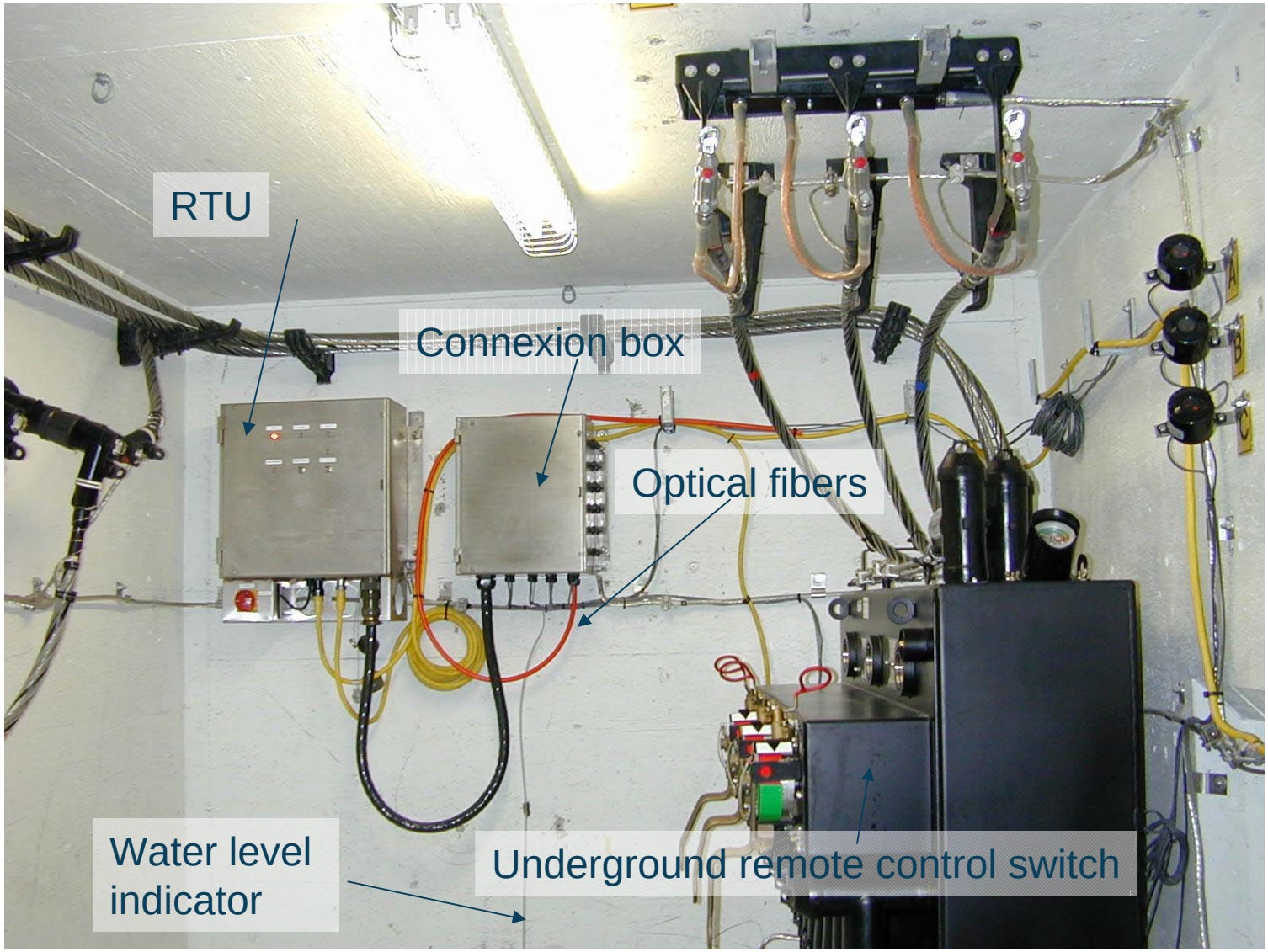
Sectionnalizing



3ph Transformers

1Ph Transformer

Underground transformer vault



Teaching installation, 1 st. prototype

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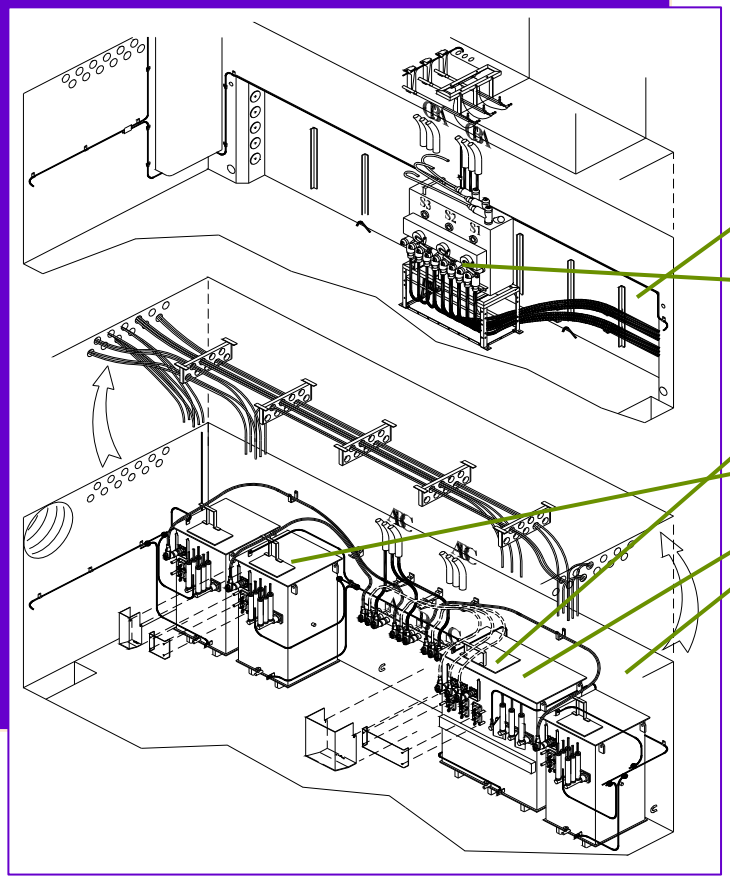
Underground Vault of the future

- First stage of the project (defining the needs)
- From 8 potential benefits, 2 were selected
  - Transformers and underground cable overload
  - Teledetection of thermal anomalies

Underground Vault - Today

Underground vault Today (Year 2000)



Medium voltage cables
3ø, 500 or 750 MCM Al, 25 kV, XLPE, cn Cu
1ø, 3/0 Al, XLPE, Nc Cu

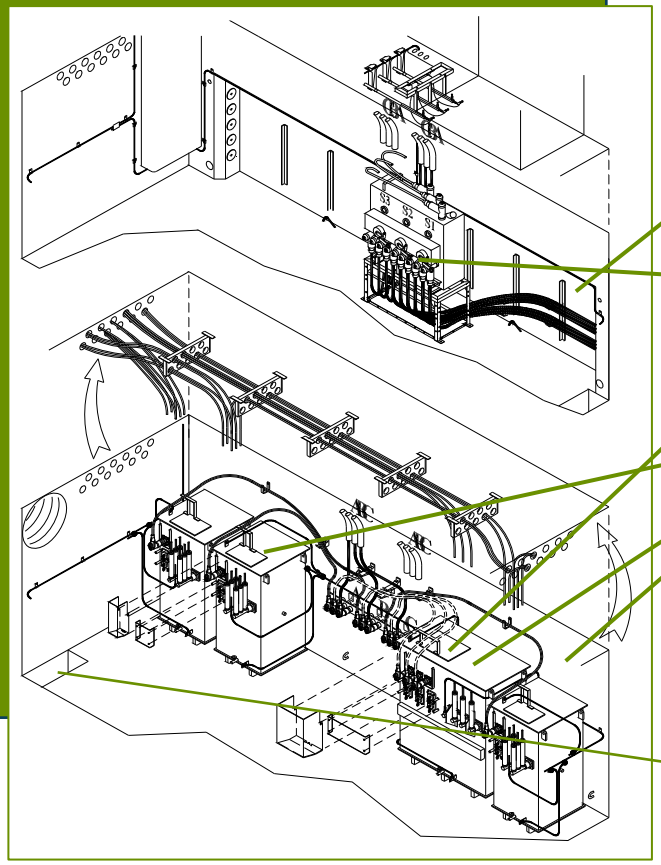
MV connections :

Transformers :

Underground Vault of the future

Telemonitoring

Underground vault Tomorrow



Medium voltage lines and Sectionnalizer :

- Fault detection
- Feeders currents
- Overload

MV connections :

- Detection et teleindication of thermal anomaly

Transformers :

- Overload
- Water level
- MV voltage
- LV Protection opération

Data acquisition system

Load profile

- Follow-up of thermal evolution
- Water presence
- Waterpump monitoring

PQ data from Distribution substations

PQ data from Distribution substations

- **Hydro-Québec's substations belong to the transmission company (TransÉnergie)**
- **Substations PQ monitoring equipment selected in 2006: ION 8600 / 8800 from Schneider-PML**
  - One PQ meter per MV busbar or Power Transformer
- **More than 50 meters installed by the end of this year, (57 planned for 2008)**
- **Joint working group (HQ Distribution / TransÉnergie) to optimize the data management (Secure Data access, Data architecture and software, standard reports, specific PQ analysis…)**

Data management software analysis

DATA Management – Sotware analysis

The goals are:

- Analyze the Software available to manage the distribution equipment (Reclosers, Remote Controlled Switches, Voltage Regulators, Meters…) installed on Hydro-Québec's distribution system:
  - Precision and accuracy
  - Compatibility, file format
  - Ease of use
- Gather information to optimize the data management for Hydro-Québec's technical staff

RESULTS - Control, relay & meter software interface characteristics

Interface Software

Control	Software	Alarm		Data format supported	Clock synchro	Polling	PQ functionality	Comm Ports	Associated Graphical Software
		local	remote						
SEL 351R	AcSELerator QuickSet	Yes	No	.cev(.txt), .log(.txt), .txt	Manual	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-232, RS-485	Sel-5601
SEL 351J	Sel-5010	Yes	No	.cev(.txt), .log(.txt), .txt	Manual	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-232, RS-485	Sel-5601
SEL 651R	AcSELerator QuickSet	Yes	No	.cev(.txt), .log(.txt), .txt	Manual	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-232, RS-485	Sel-5601
Cooper Form 6	ProView 4.0	Yes	No	.txt	Manual	Yes	Waveform Capture, Sags, Swells, Harmonics, etc	RS-232, RS-485	*
ABB PCD-2000	Afsuite	Yes	No	.txt	Manual	Yes	Waveform Capture, Sags, Swells	RS-232, RS-485, FO	*
ABB SCD	Afsuite	Yes	No	.txt	Manual	Yes	Waveform Capture, Sags, Swells	RS-232, RS-485, FO	*
S&C M Series	IntelliLink	*	No	*	*	Yes	*	RS-232	*
Cooper CL-6A	(CCI)	*	No	*	*	*	Harmonics, etc	RS-232, RS-485, FO	*

* Test on IED and corresponding software not performed yet

RESULTS - Control, relay & meter software interface characteristics

Control	Software	Alarm		Data format supported	Clock synchro	Polling	PQ functionality	Comm Ports	Associated Graphical Software
		local	remote						
PML ION 8600	Management Console	Yes	Yes	SQL	Auto	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-232, FO, RS-485, 10BaseT	Vista
PML ION 8800	Management Console	Yes	Yes	SQL	Auto	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-232, FO, RS-485, 10BaseT	Vista
EI NEXUS 1252	Communicator Ext	Yes	Yes	SQL, PQDIF, COMTRADE	Auto	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-485, IR, 10/100BaseT	Power Graphs
EI NEXUS 1270	Communicator Ext	Yes	Yes	SQL, PQDIF, COMTRADE	Auto	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-485, IR, 10/100BaseT	Power Graphs
FUTURA+	Futura+ Communicator	Yes	No	.txt	Manual	Yes	Waveform Capture,	RS-485	Power Graphs
GE kV2c+	MaterMate	Yes	Yes	* (HTML)	*	Yes	Waveform Capture	RS-232, FO	*
AREVA BiTRONICS M571	70 Series Software	Yes	No	.dat, .cfg, .ini, (.txt)	Auto	Yes	Waveform Capture, Sags, Swells, Harmonics, Flicker, etc	RS-232, RJ11, IRIGB, RS-485, 10BaseT	Wavewin

* Test on IED and corresponding software not performed yet

CONCLUSIONS - Control, relay & meter software interface characteristics

The analysis of the software results in the following conclusions:

- Software Interface:
  - All the different equipments present on the distribution system have their own proprietary software not compatible to each other, making very difficult for distribution engineers and technicians to communicate with the equipments, retrieve and interpret the data.
  - Most of the software interfaces were found to be user friendly.
  - Some interfaces are more complex and difficult to use (Versatility).
  - PQVIEW is the most versatile software so far

- Data file format:
  - Several file formats are used: text, PQDIF, COMTRADE, SQL, etc.
  - So far, an SQL database has shown great advantages.

CONCLUSIONS - Control, relay & meter precision and accuracy

- Controls Measurement Accuracy and Linearity
  - **The accuracy of controls measurement is acceptable, but the measurements do not fully comply with international standards.**
- Meter Accuracy and Sampling Rate
  - **The accuracy of meters is higher than that of controls. The meters comply with some of the international standards. Their sampling rate ranges from 128 to 1024. Some of them qualify for class A as defined by IEC 61000-4-30.**

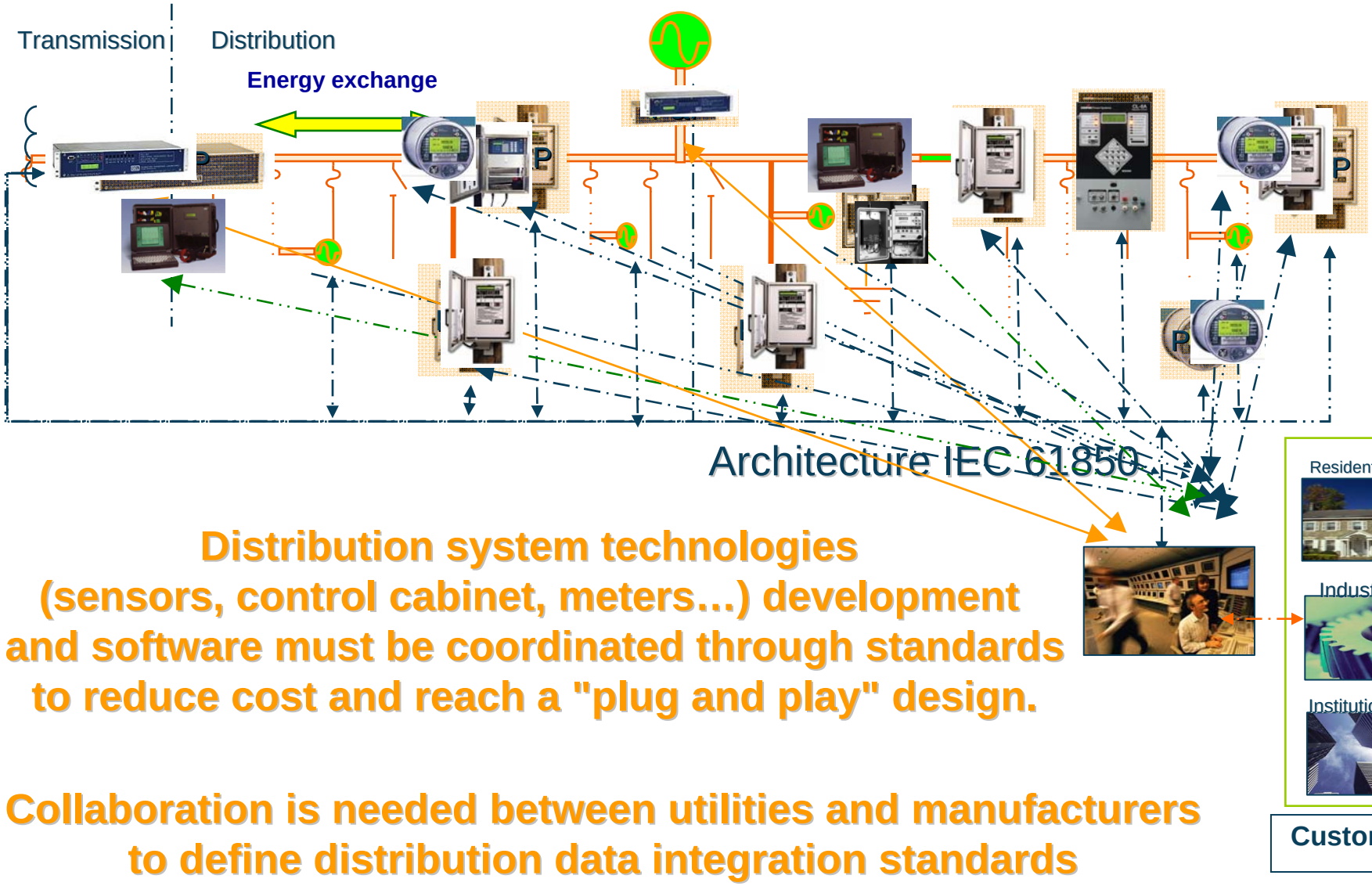
Data management Software analysis - General conclusion

Data management from today's equipment is possible but it is surely not optimal

- There is a need for data integration to reduce cost and improve data acquisition efficiency

This project brought knowledge about present distribution equipment performance and improvements to do in the future (technologies, sensors, standards…) to integrate data acquisition

Distribution Network of the future



Distribution system technologies (sensors, control cabinet, meters…) development and software must be coordinated through standards to reduce cost and reach a "plug and play" design.

Collaboration is needed between utilities and manufacturers to define distribution data integration standards based on IEC 61850 and CIM standards.

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Next steps

Next steps in Hydro-Québec's ADA program

1. Volt and VAR Control
   - Demonstration project – End 2008
2. Fault location
   - 2 mirror demonstration projects (one in Québec, one in the US) – Collaboration with EPRI
3. Underground Vault
   - Beginning of stage 1
4. PQ Data from Distribution substation
   - Joint working group (HQ Distribution / TransÉnergie) to optimize the data management from the PQ monitoring equipment
5. Data management
   - Software analysis – completed
   - Sensors analysis - 2008

Hydro-Québec's DA/DER test line

The test line has been used for

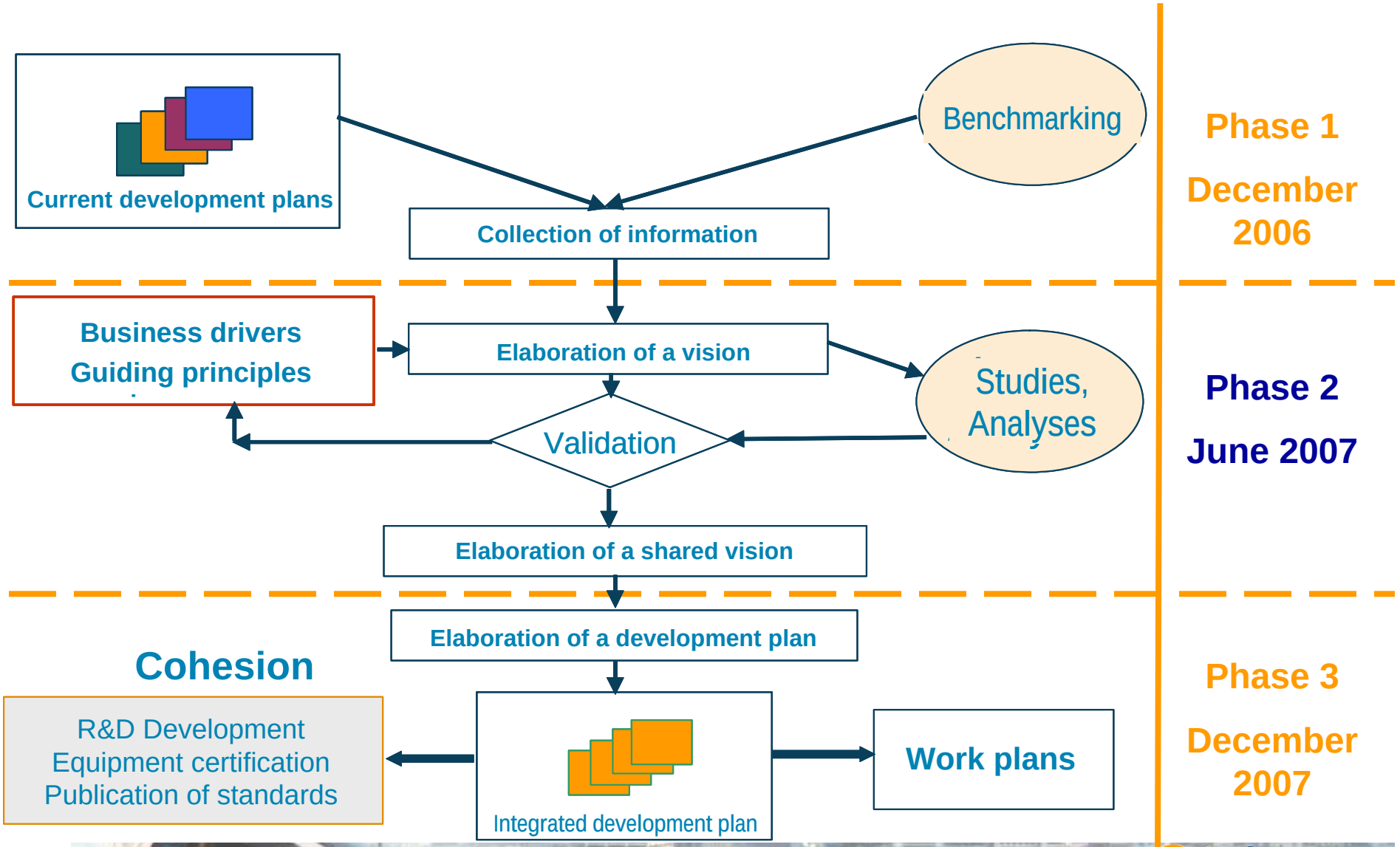
- DA equipment performances
- Broadband on Power Line tests
- Power Quality Benchmark
- Data management software

In 2008, it will be used for

- Sensors analysis
- Capacitors testing
- DER testing

Hydro-Québec's Distribution roadmap

Global Roadmap Process



Hydro-Québec's Distribution roadmap

In 2007 Hydro-Québec started a global roadmap exercise

- Technology: a contribution to efficiency
- Up to now the roadmap confirms that telecommunication technology will impact operation, maintenance and metering for the next 15 years
- The general design of both overhead and underground systems should remain the same for the next 15 years

Conclusion

Hydro-Québec has started several projects related to Advanced Distribution Automation

- Demonstration projects will be launched on Volt and Var Control and Fault location projects in 2008
- Data management studies will continue in 2008 (PQ data coming from substations and Sensors installed on feeders)

Collaboration is needed between utilities and manufacturers to define distribution data integration standards