

# *An Update on Hydro-Québec Advanced Distribution Automation Program*

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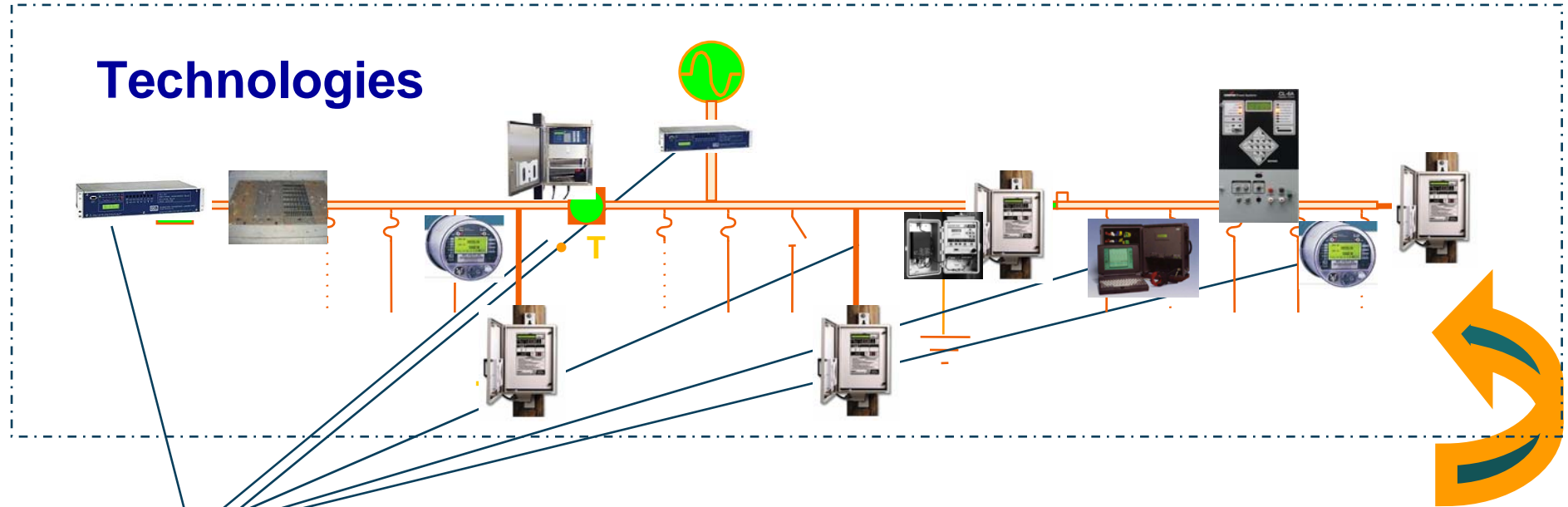


# Outline

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**

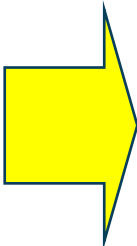
# Intelligent Distribution Network

## Flow of Information



**DATA**  
(Using what?)

- Voltage
- Fault Currents
- Load Currents
- Temperature



**Applications**  
(How?)

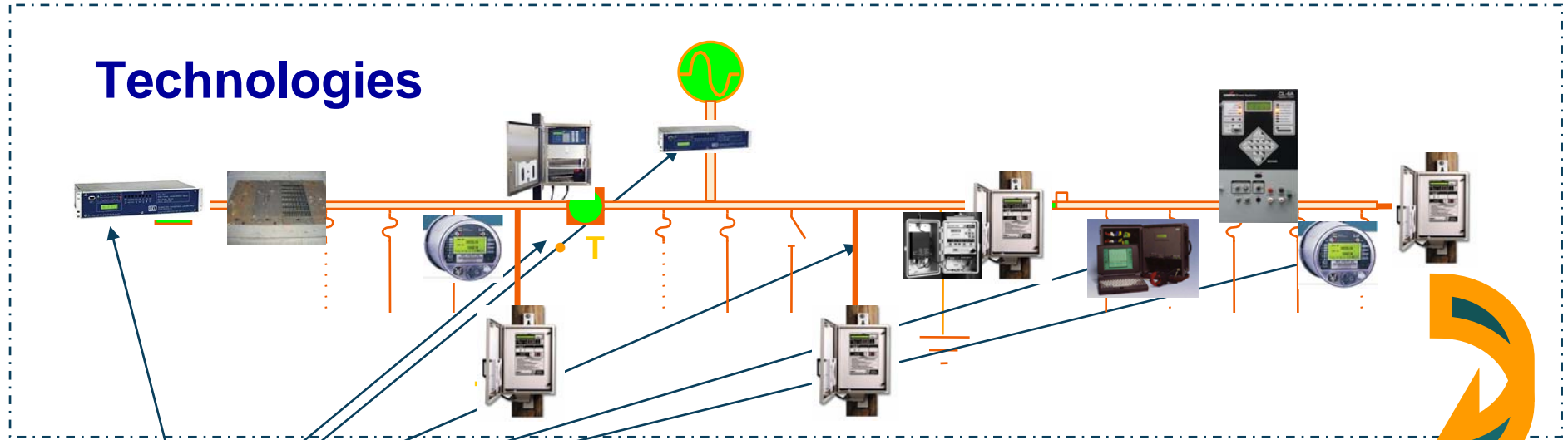
- Voltage Control
- Optimised Load Flow
- Fault Location
- Faulty Equipment
- Power Quality Evaluation



**Business drivers** (Why?)

- Energy Efficiency
- Reliability
- Distributed Resources
- Customer Satisfaction

# Intelligent Distribution Network Flow of Decision



**DATA**  
(Using what?)

- Voltage
- Fault Currents
- Load Currents
- Temperature

**Applications**  
(How?)

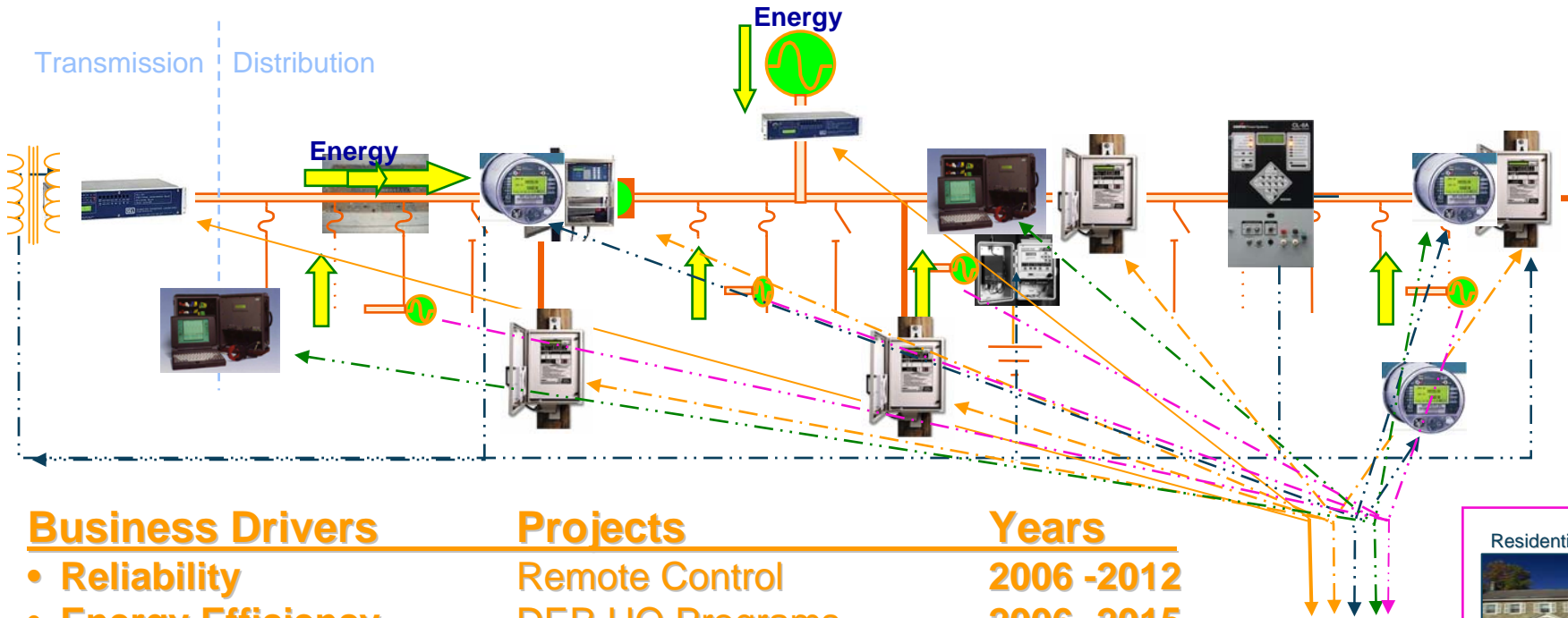
- Voltage Control
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**Business drivers** (Why?)

- Energy Efficiency
- Reliability
- Distributed Resources
- Customer Satisfaction

4 Number of Operations

# Distribution Network – DA Roadmap



## Business Drivers

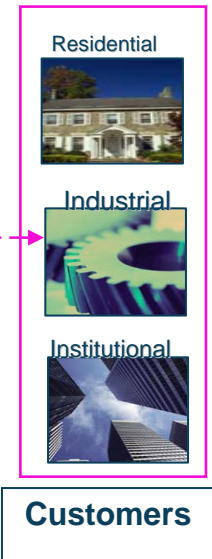
- Reliability
- Energy Efficiency
- Energy Efficiency
- Reliability
- Reliability
- Power Quality (PQ)
- Energy Efficiency
- Customer Satisfaction
- Reliability
- Customer Satisfaction
- Energy Efficiency

## Projects

- Remote Control
- DER HQ Programs
- Voltage Control
- Fault Location**
- Underground Vault
- PQ Monitoring
- Load side Management
- Predictive Maintenance
- Automatic Reconfiguration
- Customer Portal**
- Micro-grid

## Years

- 2006 -2012
- 2006 -2015
- 2008 -2015
- 2008 -2015
- 2008- 2015
- 2008 -2015
- 2009 -2015
- 2009- 2015
- 2010 - 2015
- 2010 -2015
- 2015 ->



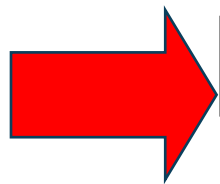
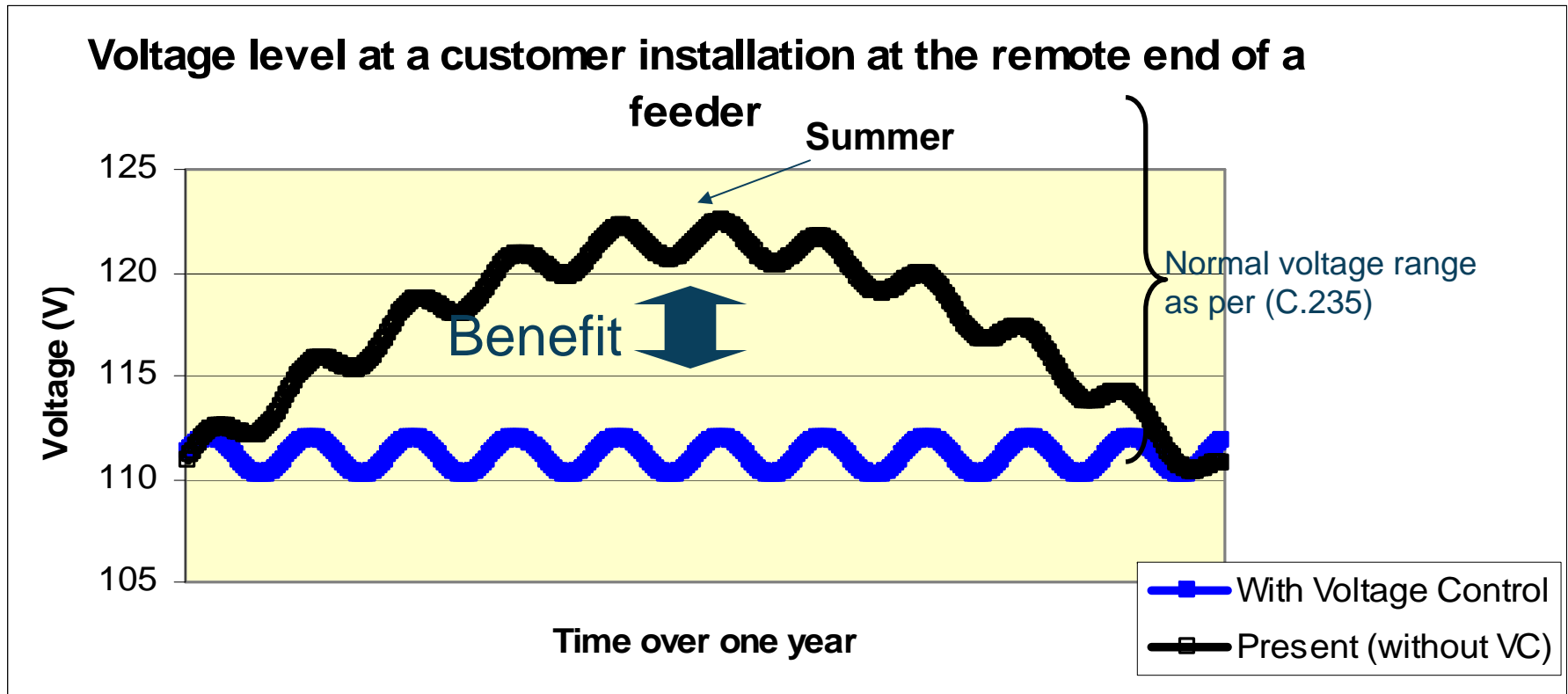
# VOLT and Var Control

# *Project Objectives*

## ◆ Improve energy efficiency by reducing the voltage

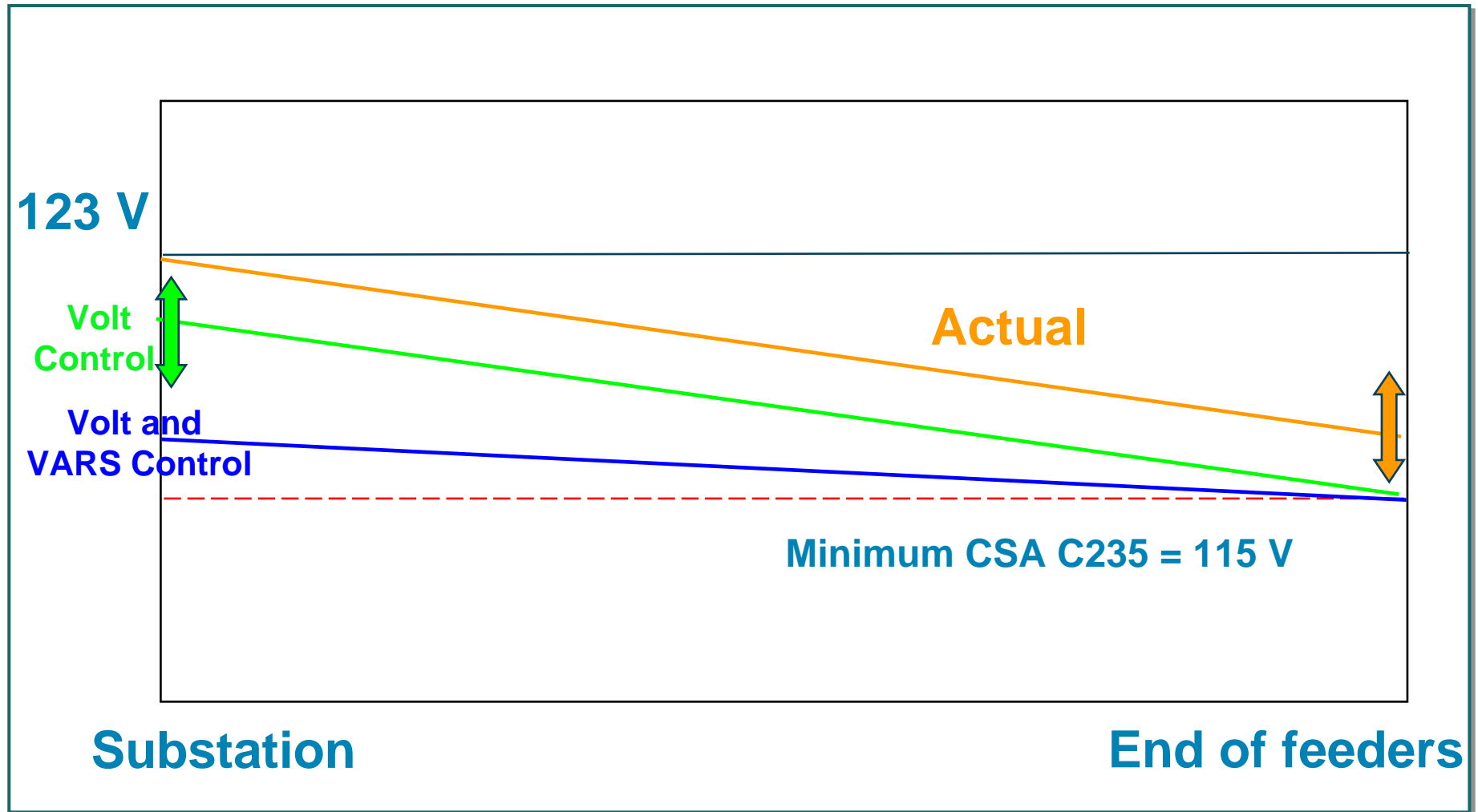
- The amount of energy bought at marginal price (8,3¢/kWh) and delivered to customers (6,5¢/kWh)
- Peak load of the system
- Energy losses

# Voltage control benefit

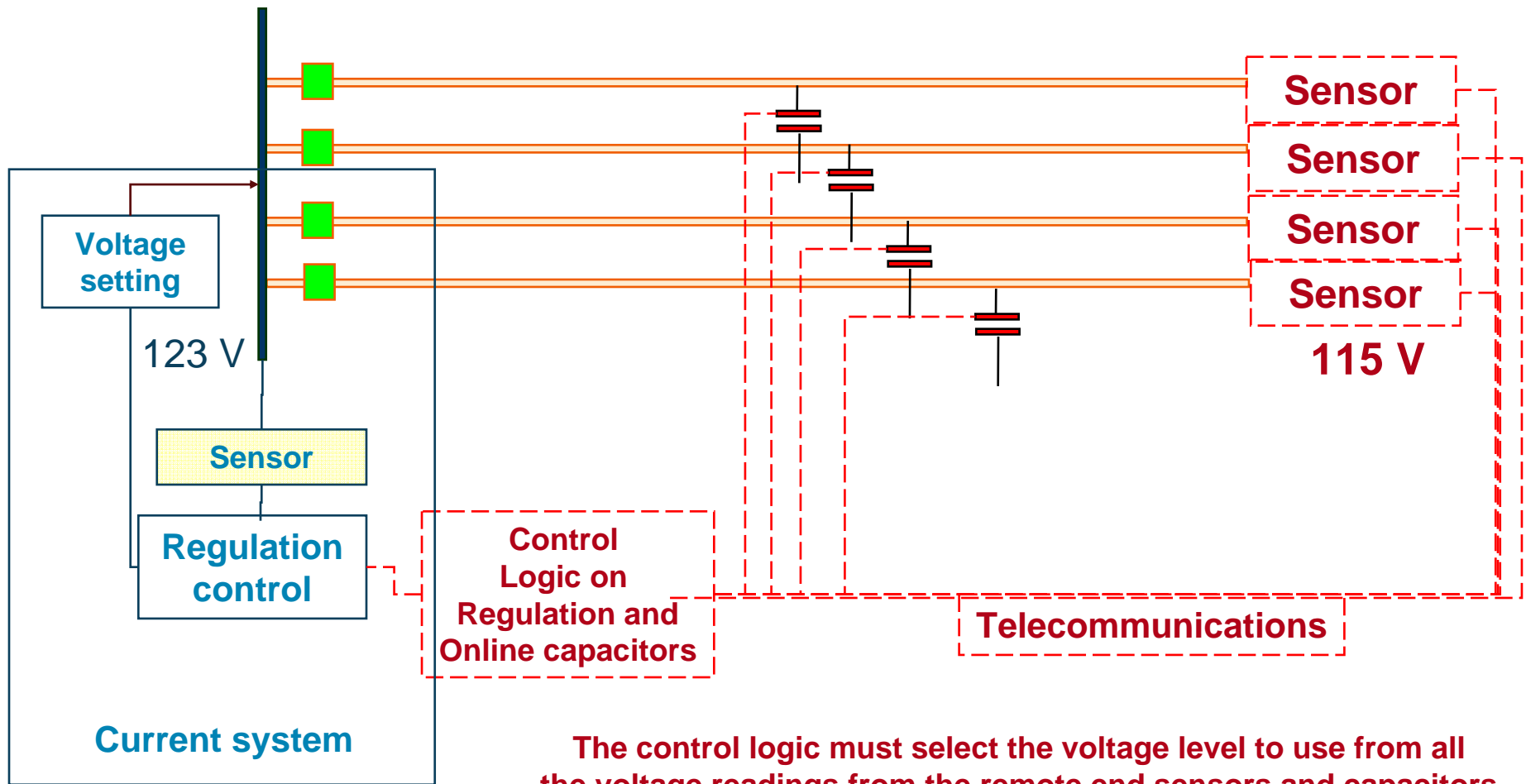


***Voltage control leads to energy saving.***

# Volt and VARS Control Project Concepts



# Volt and VARS Control Intelligent System



# 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

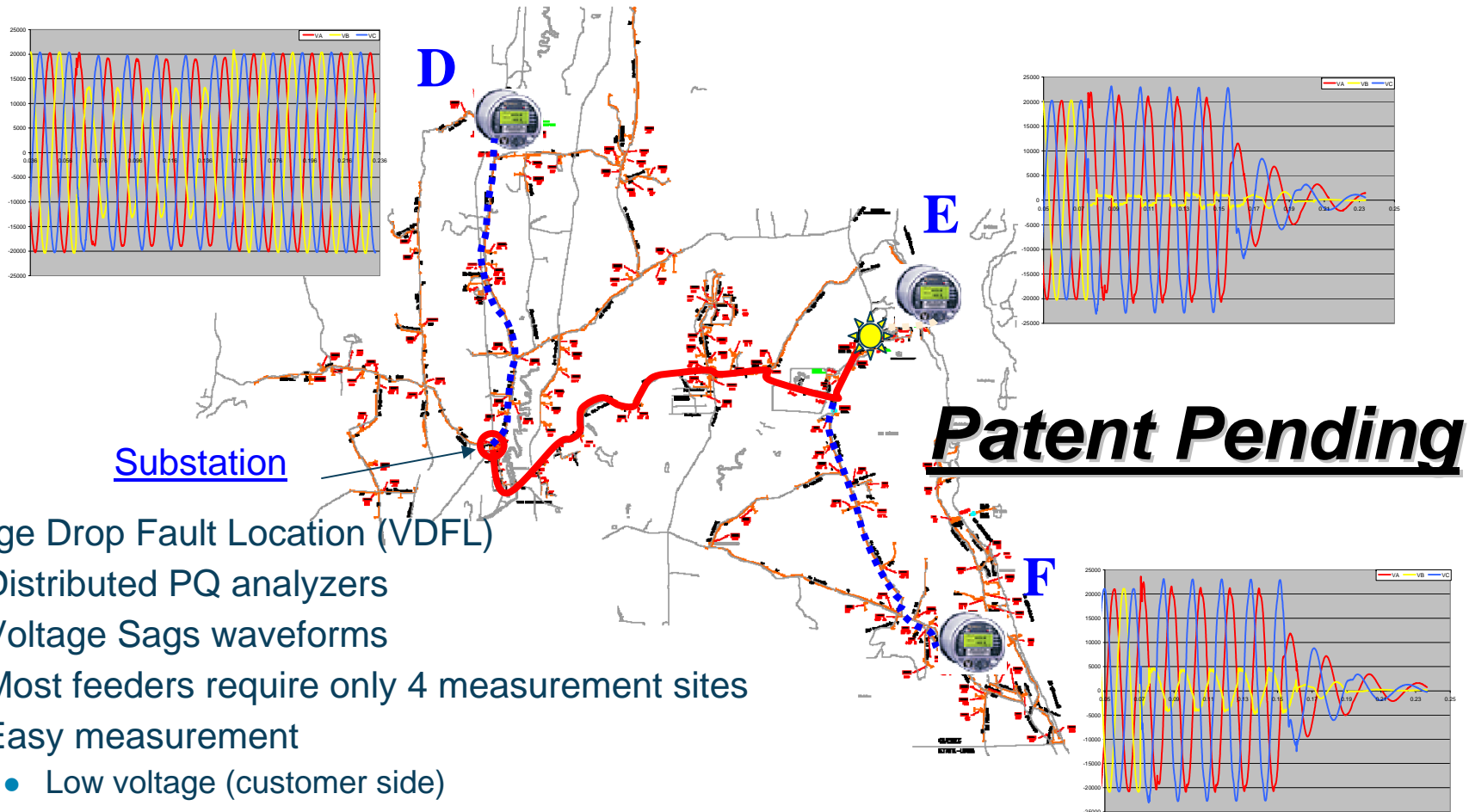
## ***Results and next steps***

- ◆ **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



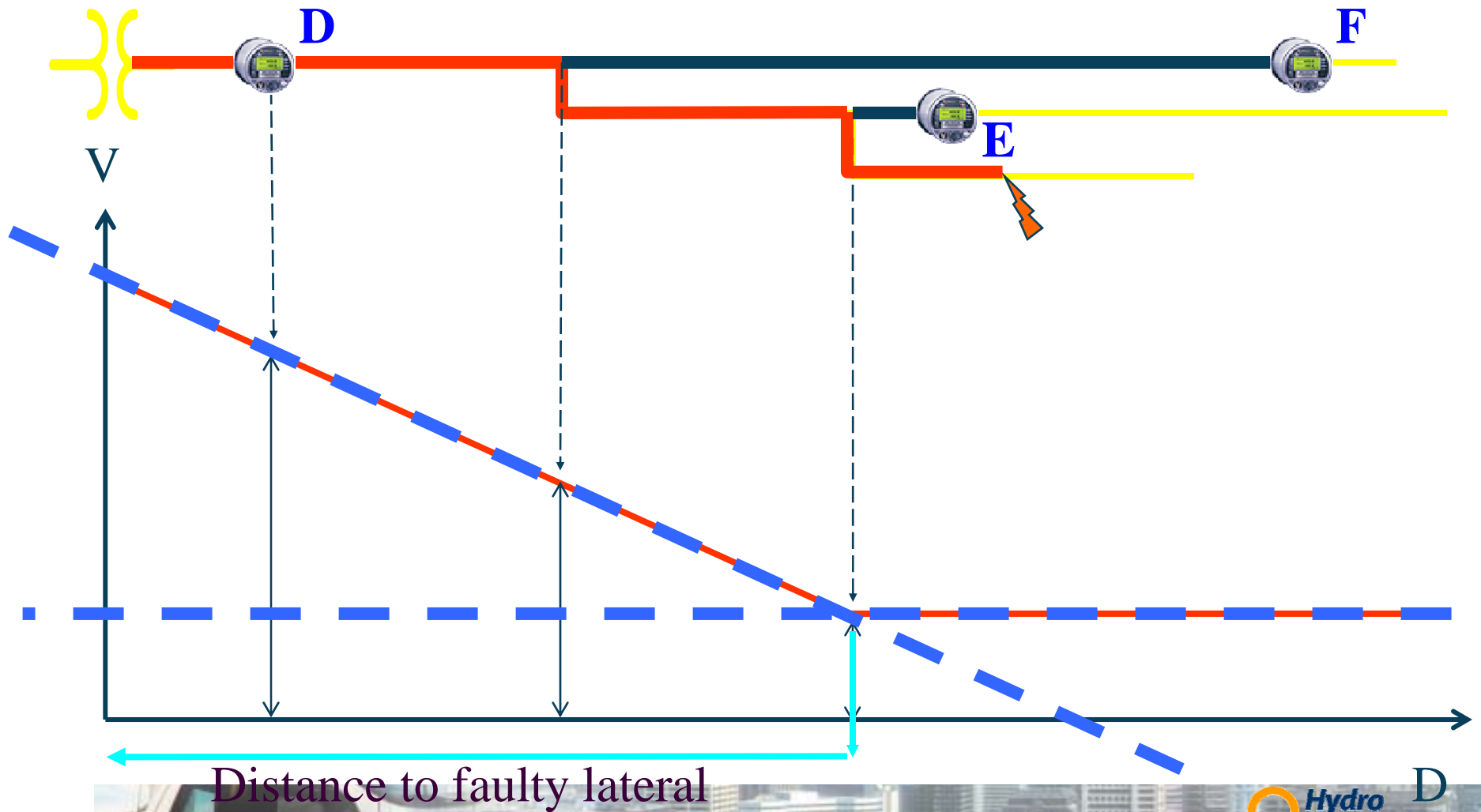
# Hydro-Québec's Distributed Approach



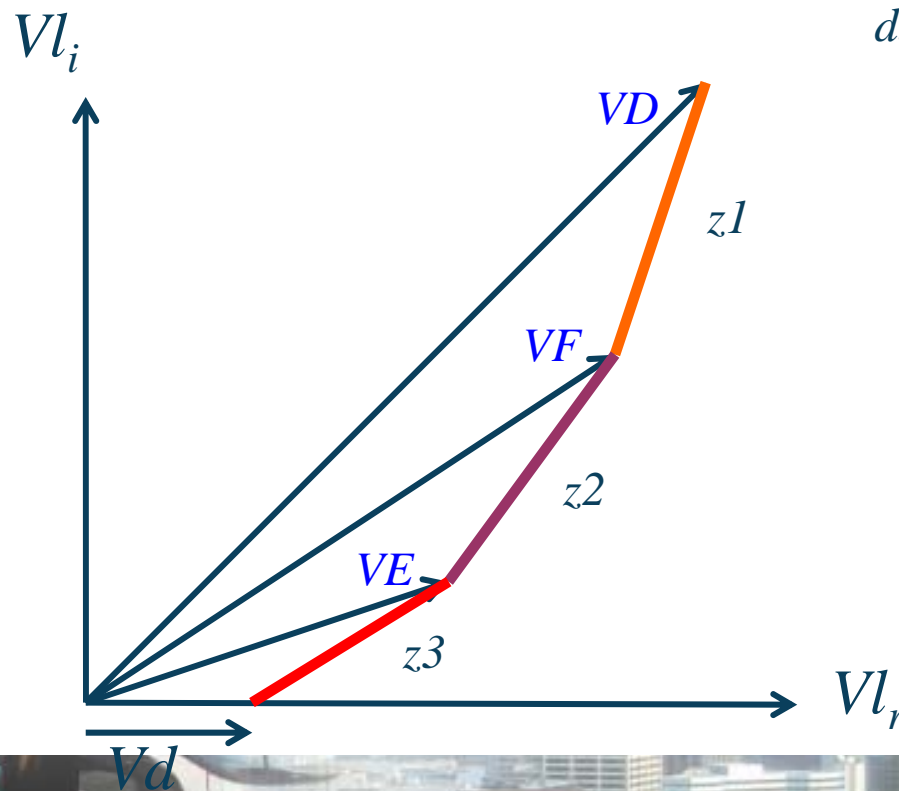
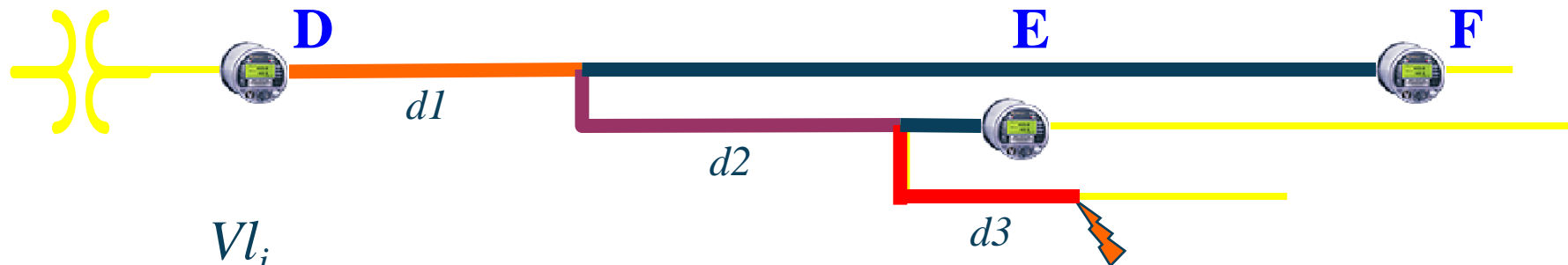
## Voltage Drop Fault Location (VDFL)

- 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

# VDFL Basics (1)



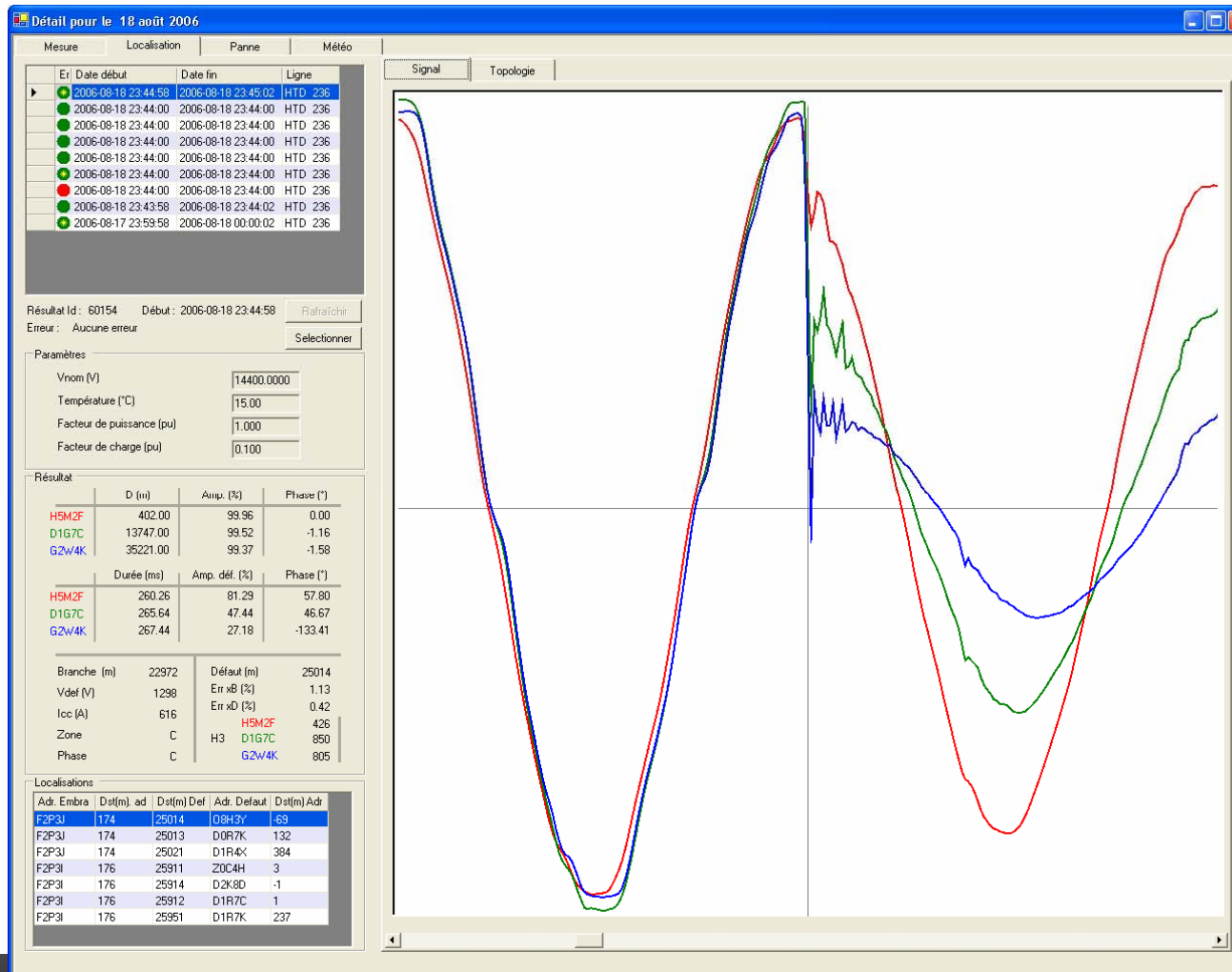
# VDFL Basics (2)



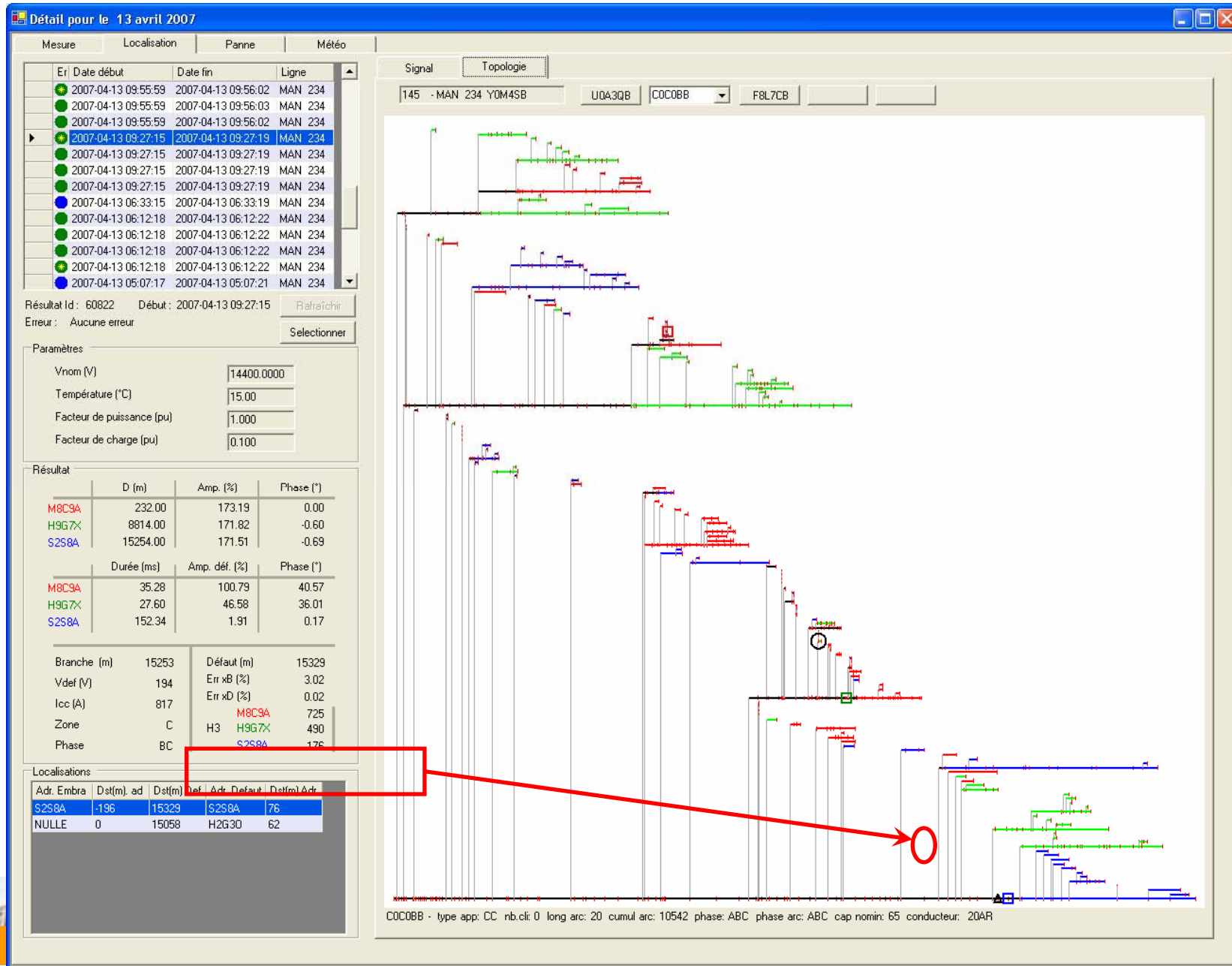
## VDFL deduce :

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

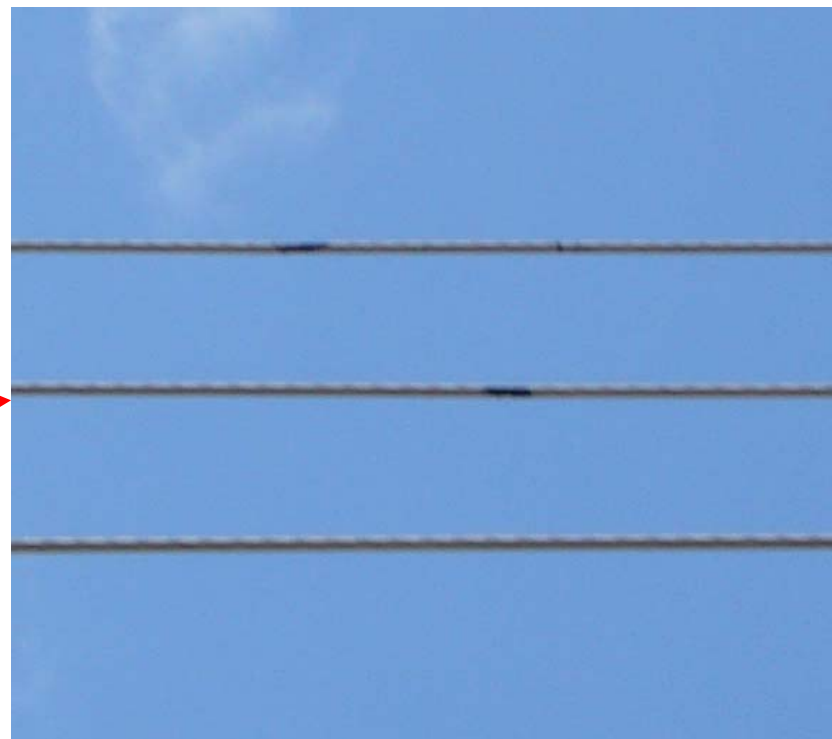
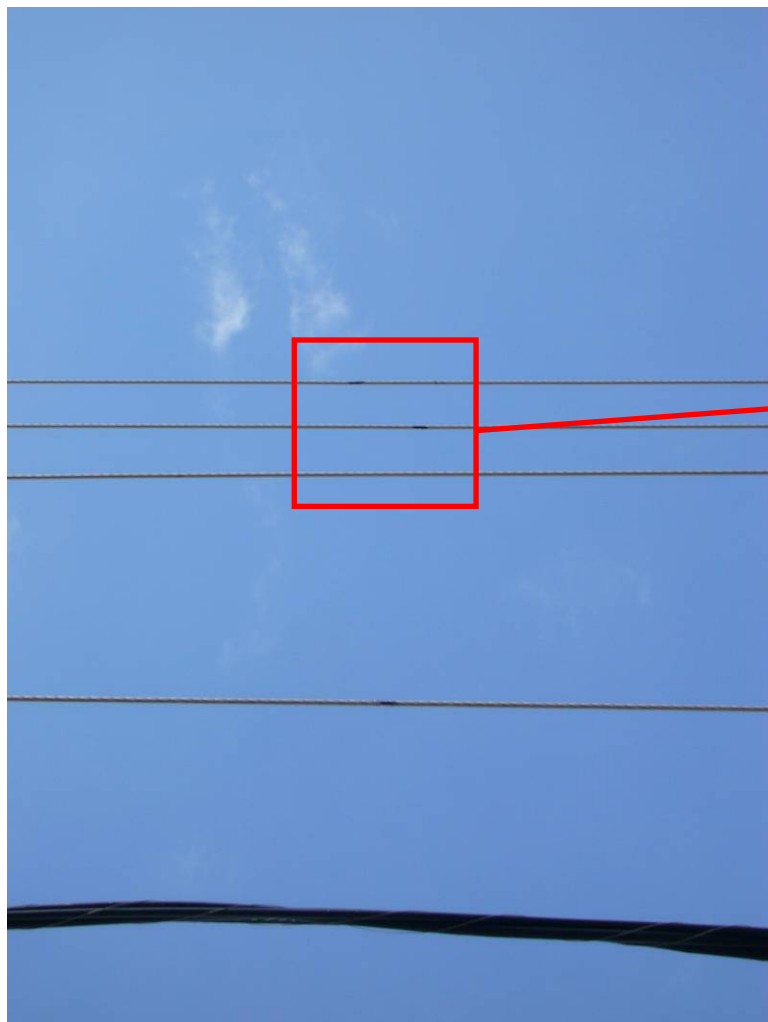
# MILE - Voltage drop on phase C



# MILE – Fault Probable Locations

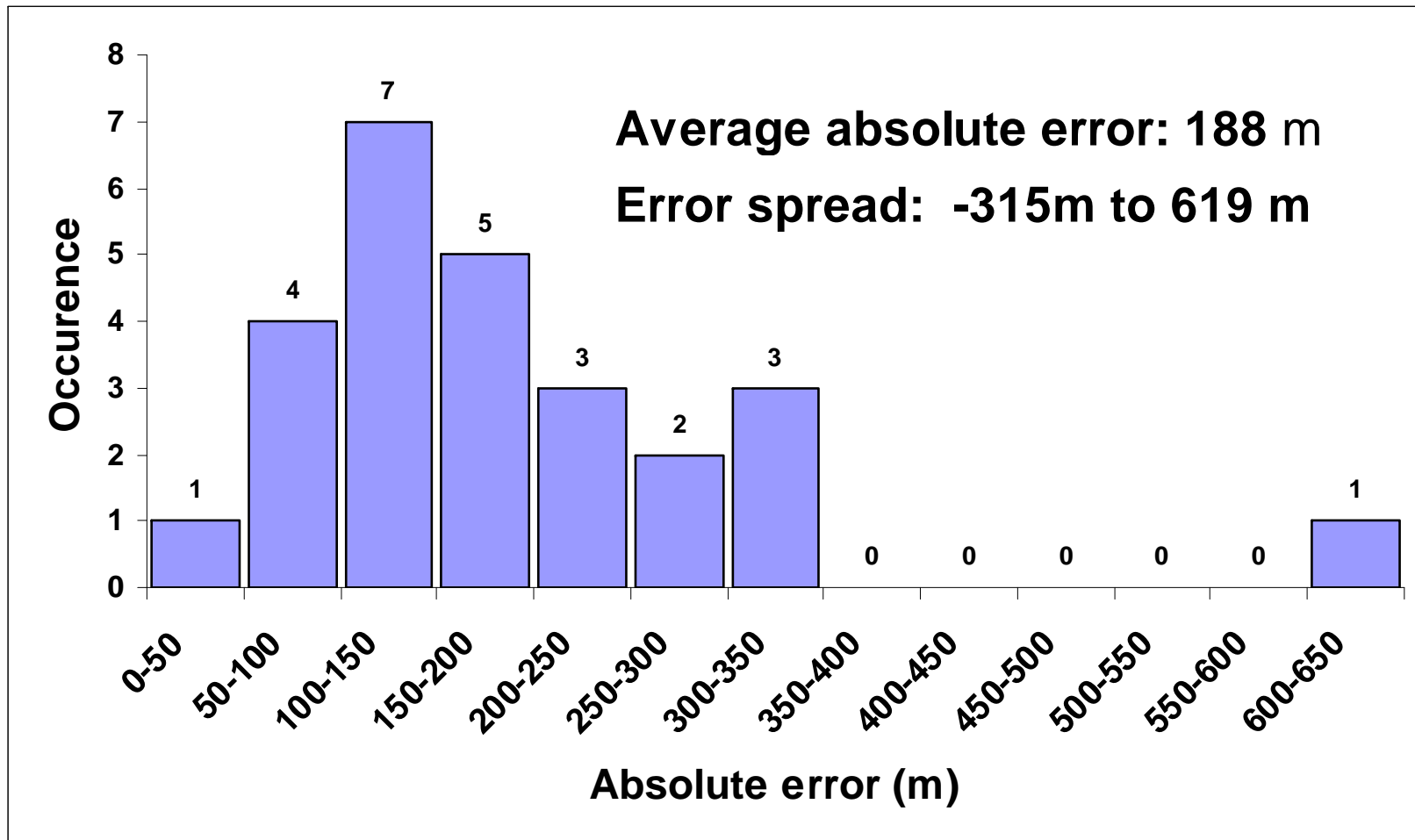


# *Fault located*



Burning traces located on conductor at mid distance between poles.

# Fault Location Accuracy



95% of the distribution faults located are within 332m

# Advantages

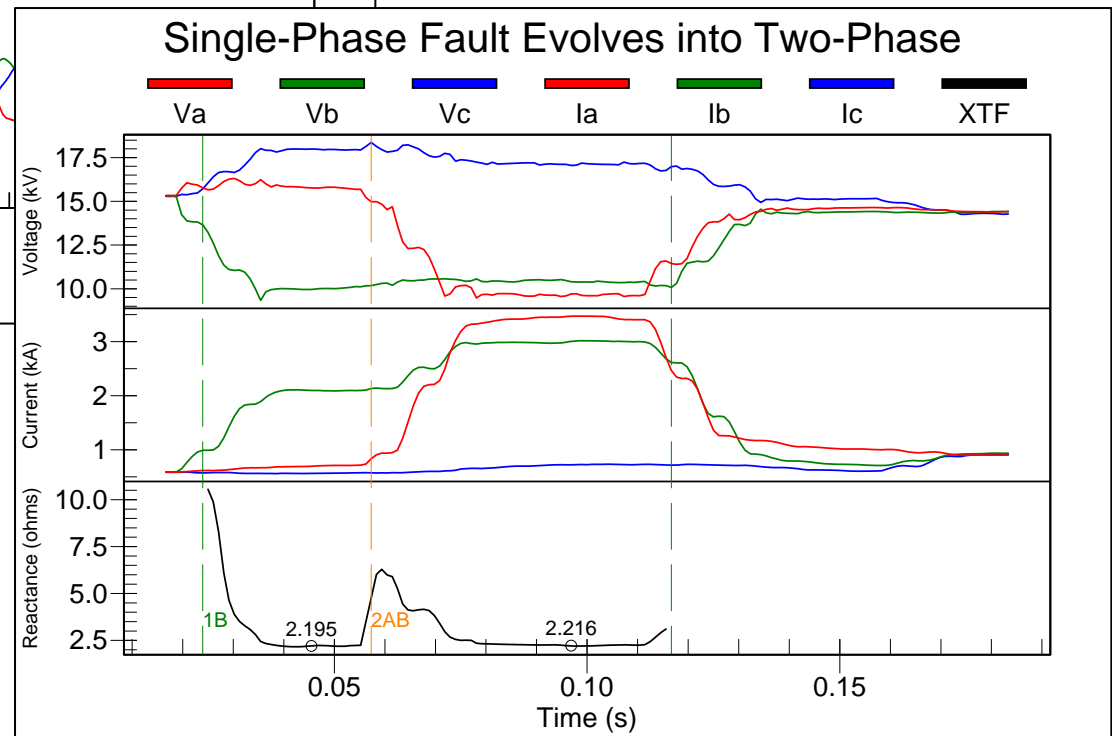
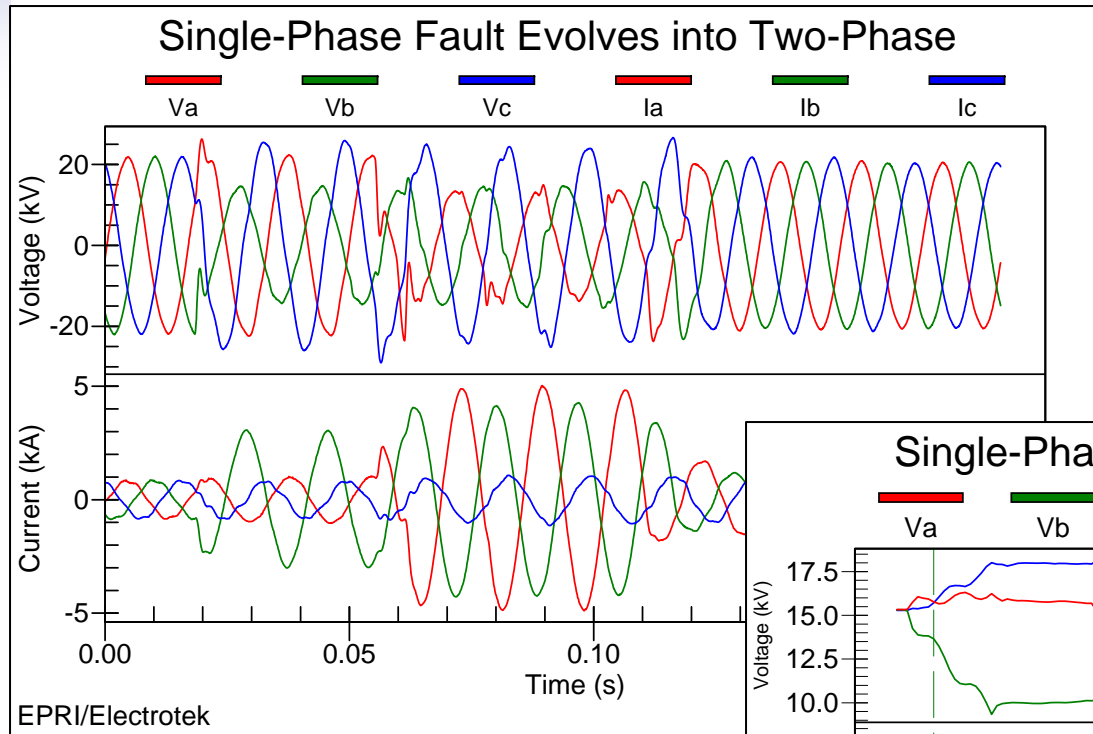
## The main advantages are:

- **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.

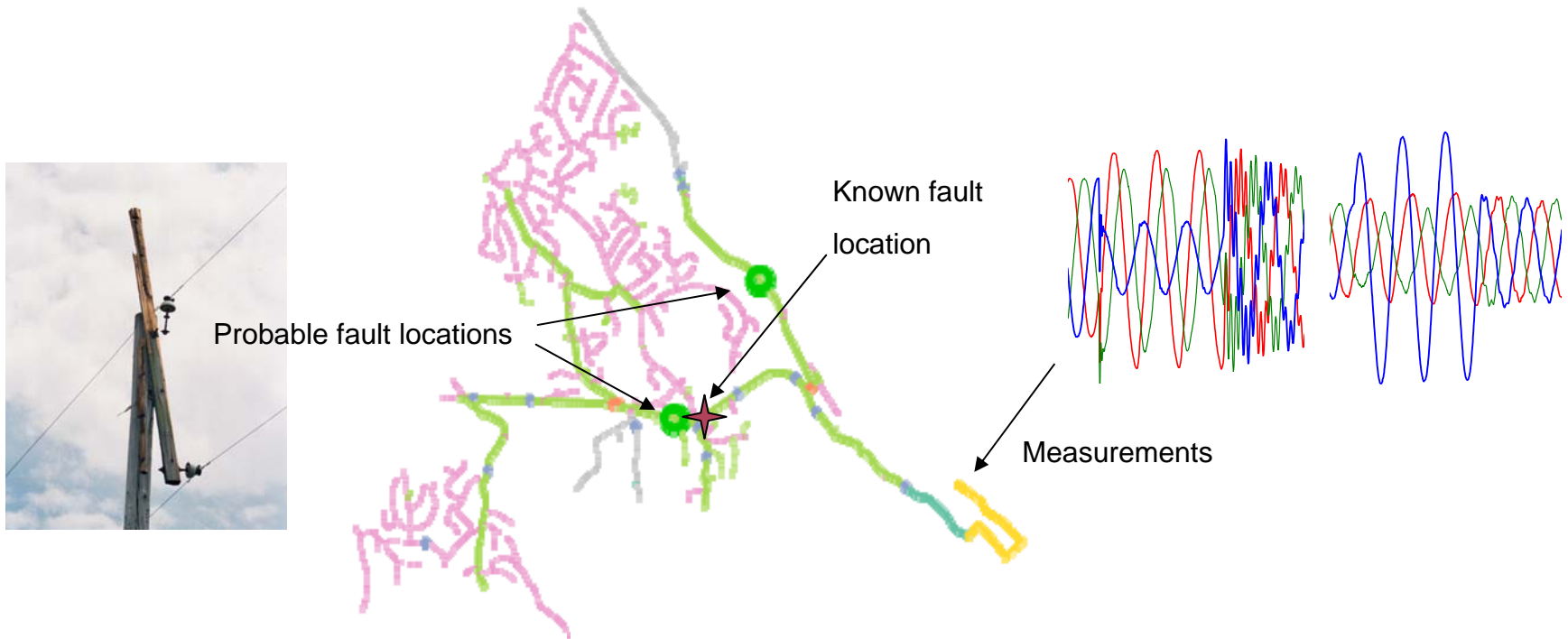
# Approaches for fault location

- 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

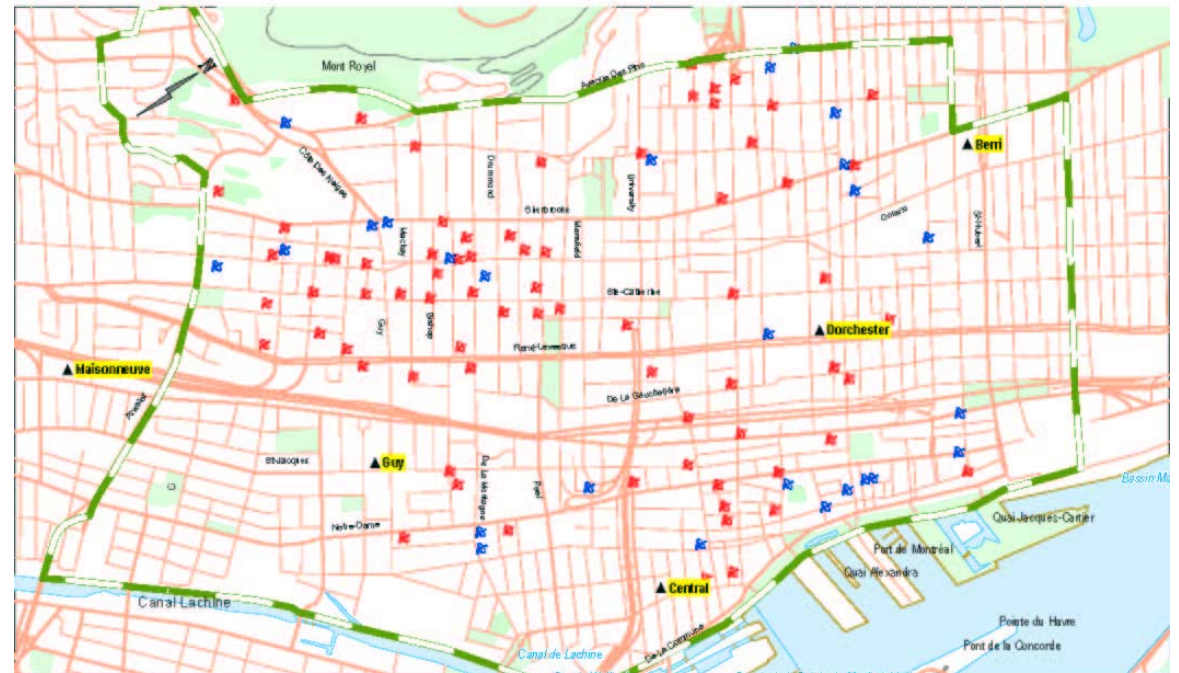
# Underground DA program

**Justification: improve downtown Montreal SAIDI**

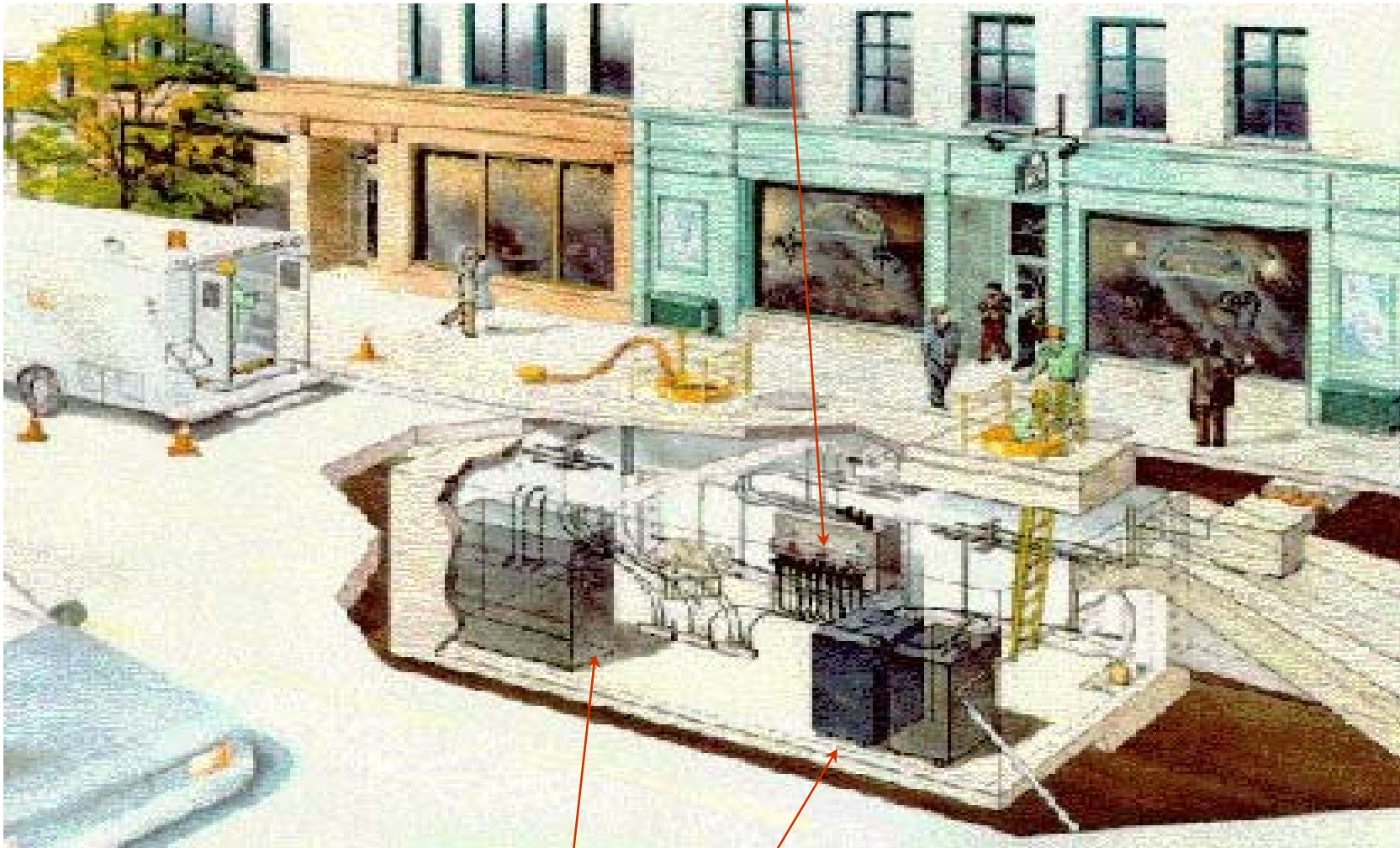
**Completed in 2006 (~ 100 remote controlled underground switches)**

**Optical fiber is used for telecommunication**

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



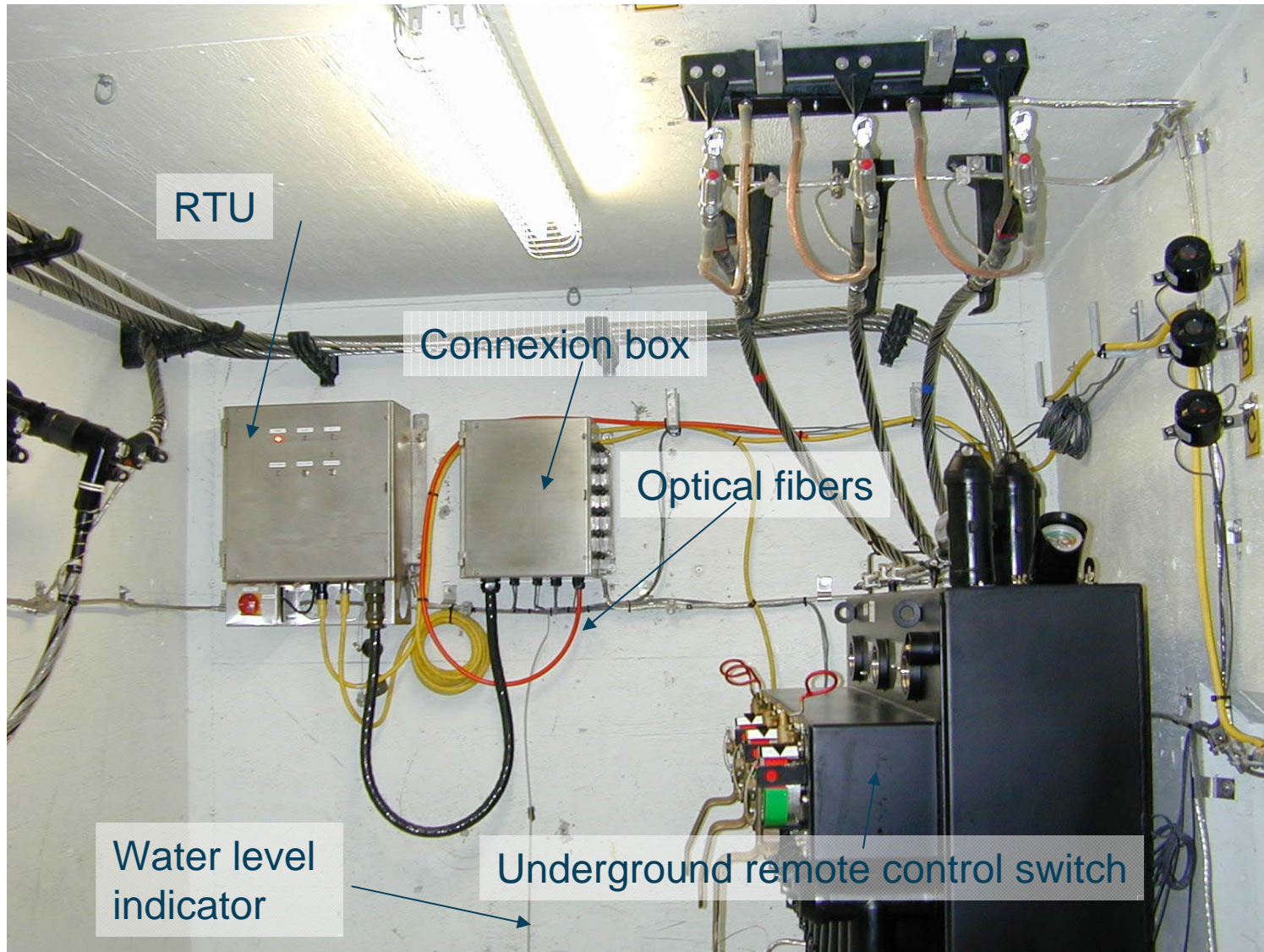
Sectionnalyzing



3ph Transformers

1Ph Transformer

Underground transformer vault



Teaching installation, 1 st. prototype

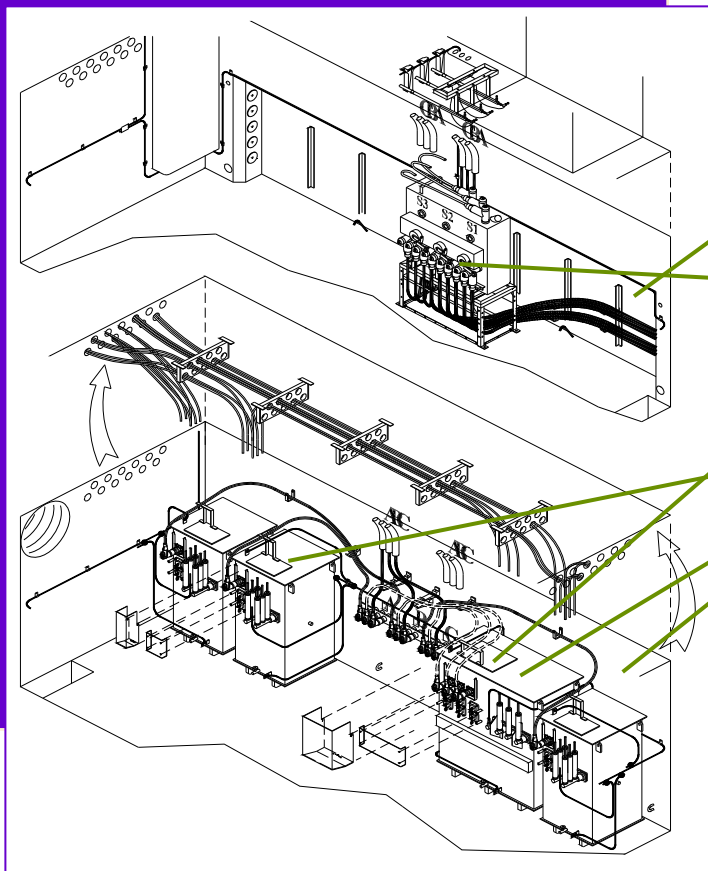
## *Underground Vault of the future*

- 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  
3 $\emptyset$ , 500 or 750 MCM Al, 25 kV,  
XLPE, cn Cu  
1 $\emptyset$ , 3/0 Al, XLPE, Nc Cu

MV connections :

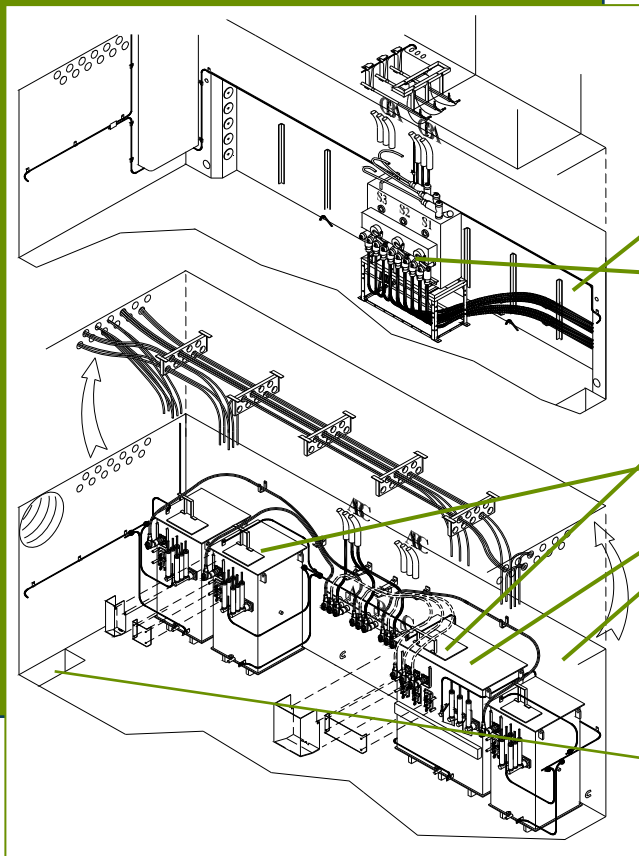
Transformers :



# Underground Vault of the future

## Telemonitoring

### Underground vault Tomorrow



#### Medium voltage lines and Sectionnalyzer :

- 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 – Software 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	 AcSELeator 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	 AcSELeator 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	 ProfView 4.0	Yes	No	.txt	Manual	Yes	Waveform Capture, Sags, Swells, Harmonics, etc	RS-232, RS-485	*
ABB P CD-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	(CC)	*	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.**

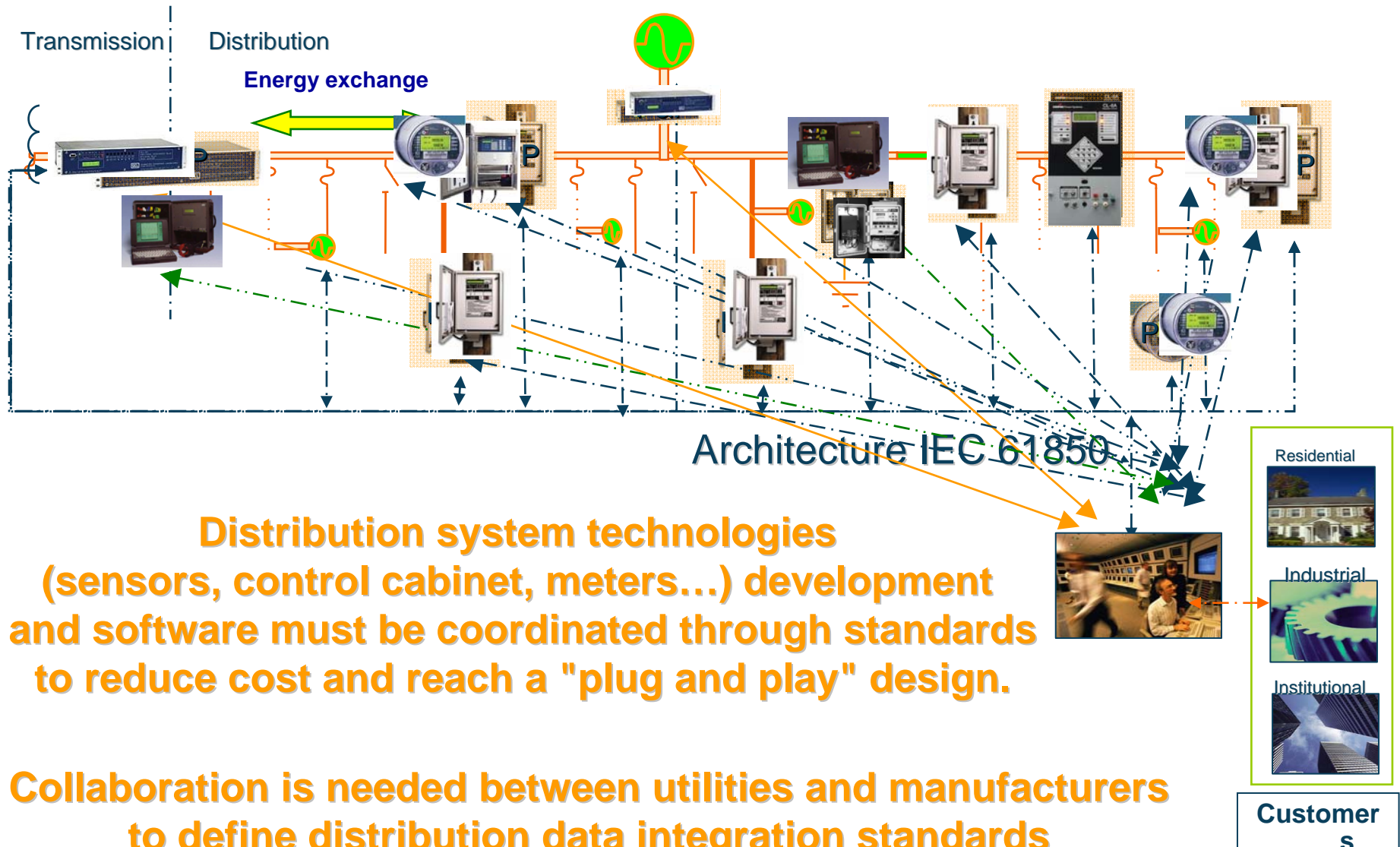
# ***Data management Software analysis - General conclusion***

**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.**

## 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

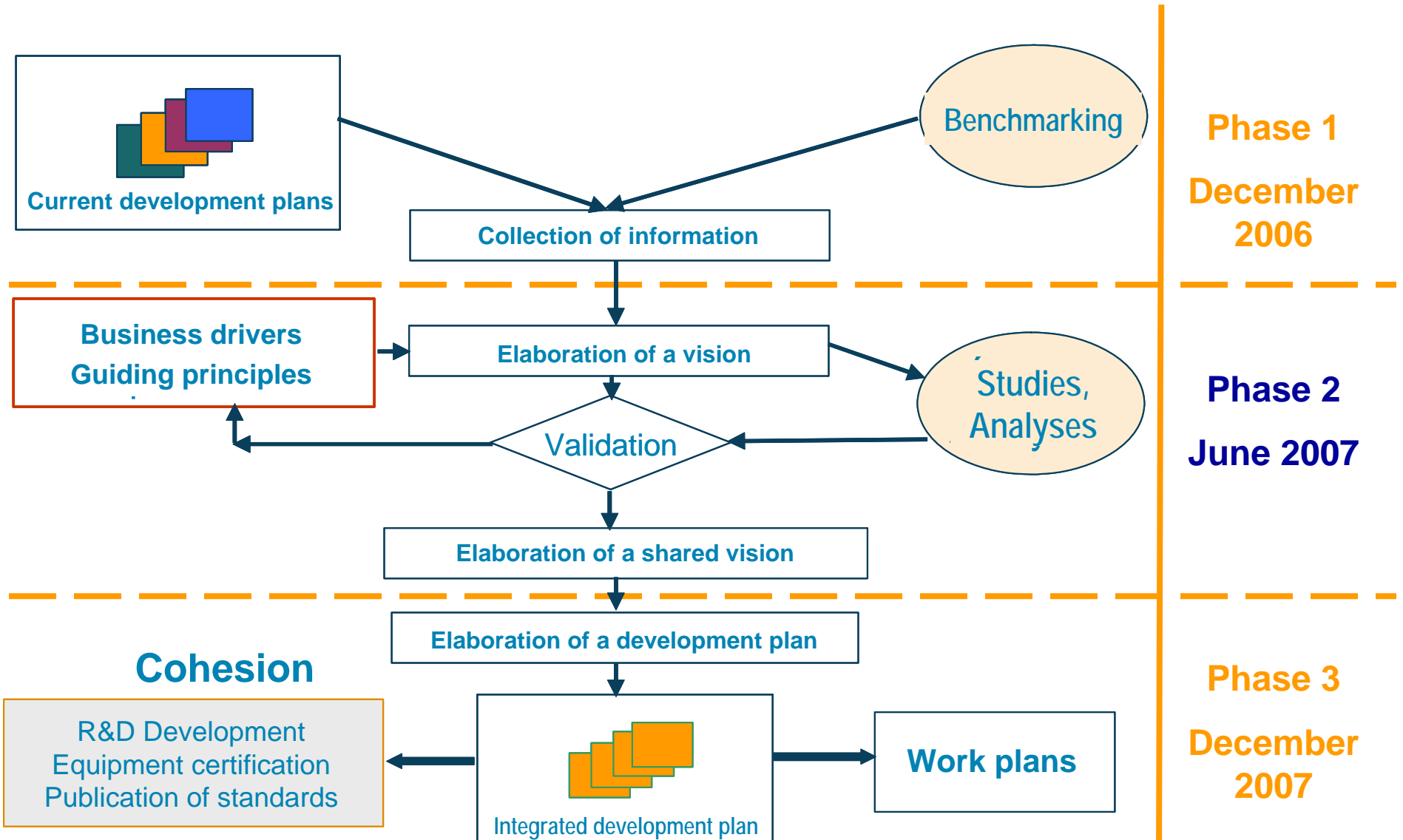
In 2008, it will be used for

- 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**