Jicable'15
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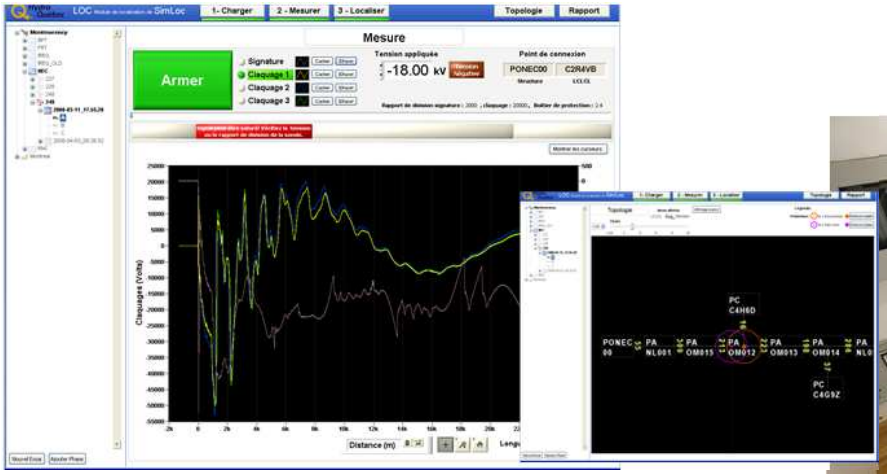
Prelocating and pinpointing faults on underground medium voltage cables :

review of Hydro-Quebec's experience



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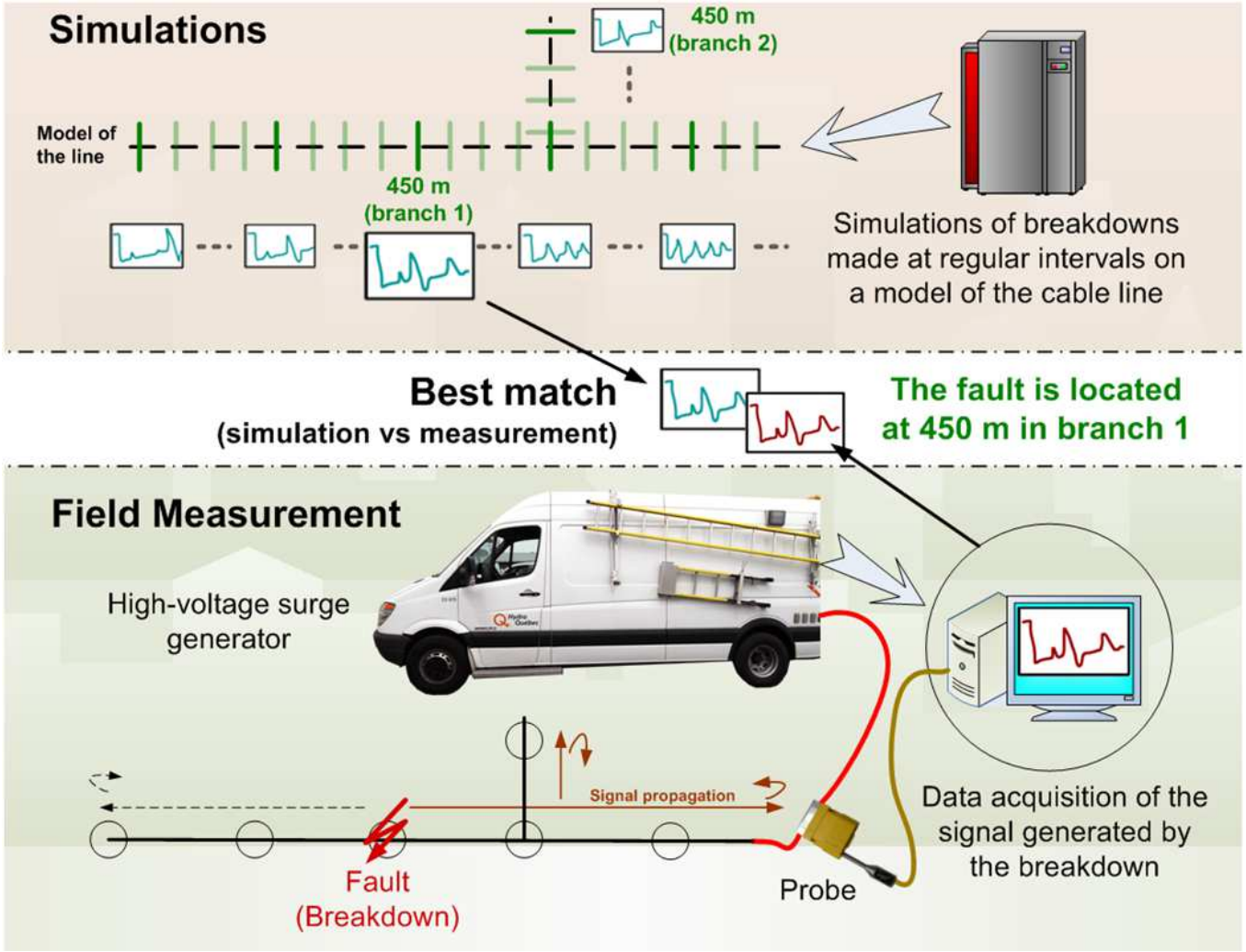
Hydro-Québec Distribution : François Gervais, Jacques Côté

Introduction

- **In January 2009, Hydro-Québec Distribution gradually rolled out a new cable fault location system named SimLoc (for Simulation and Location)**
  - To reduce the average fault location time
  - To help locate faults on long lines with many branch lines.
  - To reduce the number of pulses (generated by the thumper) on the cable
  - To be used by non expert workers
- **Hydro-Québec's underground distribution network :**
  - 12,000 km of medium-voltage underground cables.
  - More than 200 lines over 10 km long (most have branch lines)
  - The system is almost entirely comprised of duct banks containing bare concentric neutral cables with 28-kV XLPE or TR-XLPE insulation

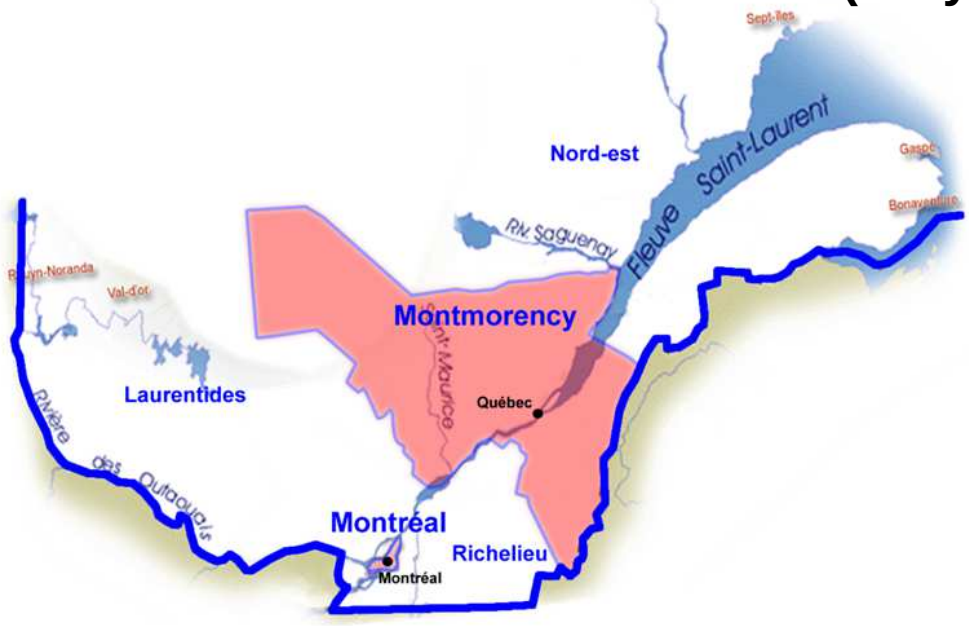
SimLoc principles



SimLoc case study

- **The current study focuses on two main service areas : Montréal and Montmorency (Québec City)**
  - Montréal : 40% of the underground lines
  - Montmorency : 20% of the underground lines

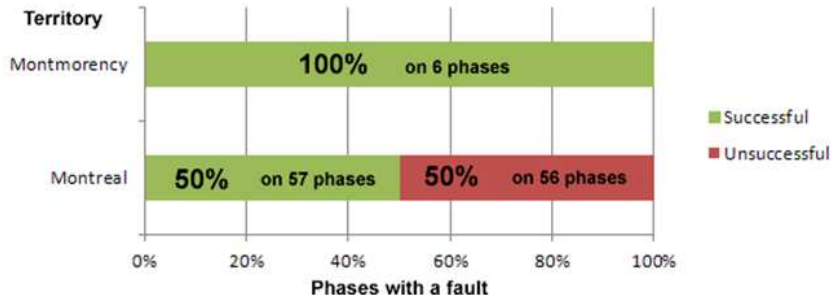
- **The statistics are based on the available data from November 2011 to the end of March 2015 (3.5 years)**



SimLoc success rate

- **The calculated overall success rate* for SimLoc appears to be 52%.**

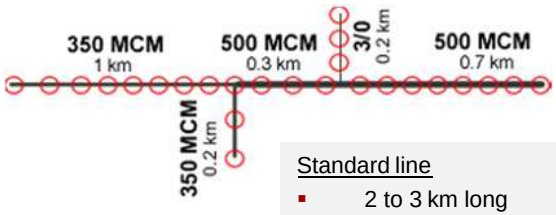
  *Location is successful when SimLoc predicts the fault location with a precision of less than two manholes



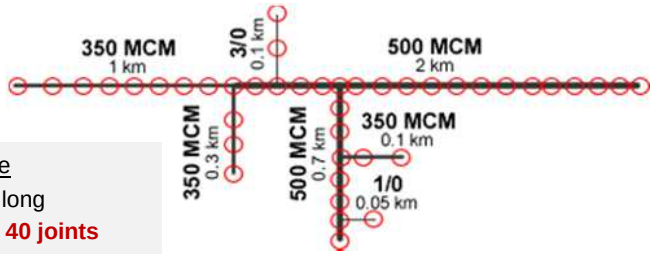
  - Low number of fault locations for Montmorency (only 6 phases)
  - In Montreal, the statistics are weaker than expected (close to 50% of success rate)

Low success rate in Montreal : explanations

- **The proportion of complex lines is higher in Montreal than in Montmorency**



Standard line
- 2 to 3 km long
- 20 to 25 joints
- 1 to 2 branches



Complex line
- 4 km long
- **30 to 40 joints**
- **2 to 8 branches**

- **Other fault location methods were preferred in 67% of the cases ⇒ missed opportunities for the workers to develop their skills**
  - fault location was visible
  - the support team is off duty to initiate the necessary simulations of the fault location
  - Even if it is made for non expert workers, the worker's experience can help interpret the results when there is an ambiguity

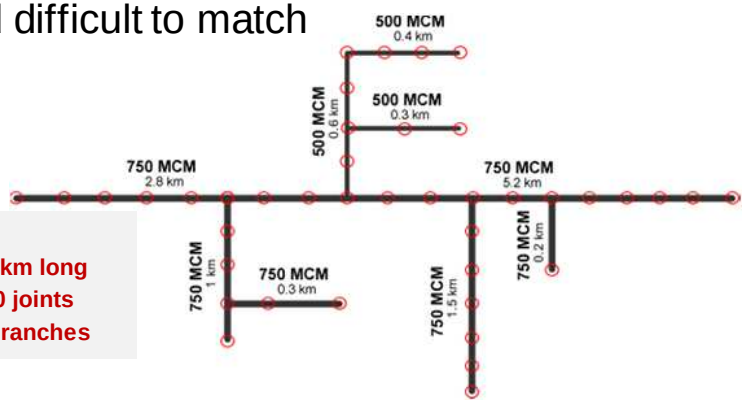
100% success rate in Montmorency: explanations

- **Only the data for 2015 was logged into the system for Montmorency.**
  - The information is incomplete for this service area, not enough data

- **Based on test campaigns made between 2007 and 2010 in Quebec city (148 locations), the real success rate for Montmorency should be closer to an 85%**

- **The 15% of unsuccessful fault locations mainly occurred on complex lines because of their many branches.**
  - When fault is far ⇒ signal is weak and difficult to match

Standard line
- 6 to 8 km long
- 30 to 50 joints
- No branch



Complex line
- **6 to 13 km long**
- **30 to 50 joints**
- **2 to 8 branches**

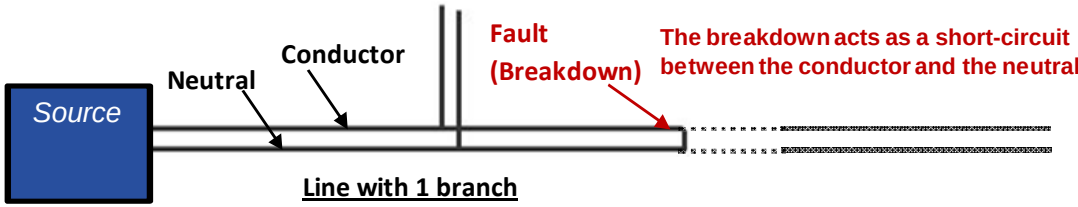
Coloc (Confirmation of Location) objectives

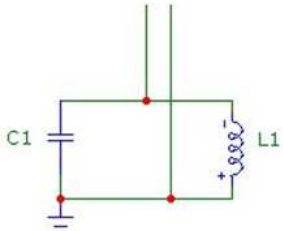
- **Hydro-Québec decided in February 2011 to mandate its research institute to develop a tool to :**
  - Locate faults that could not easily be located by SimLoc
  - Confirm the location of a fault

- **Workers will be provided with two indications :**
  - The distance from the impulse source to the fault;
  - An indication if the user has just gone past the fault, or not, while walking along the line

- **The CoLoc is a standalone tool :**
  - Will be placed near the cable (up to 3 meters away)
  - **No need to go inside the manhole**
  - Very light and portable tool
  - Works on networks with multiple branches

Coloc theory

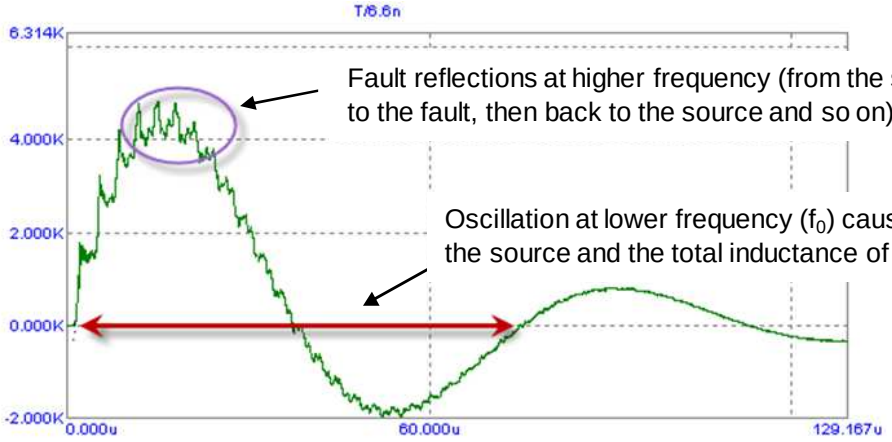




Electrical equivalent circuit during breakdown.
C1: capacity of the impulse voltage source
L1: total line inductance

The opened branch does not add any inductance to the total inductance of the line and has no effect on the calculation method.

Typical measurement of the magnetic field above a manhole



Fault reflections at higher frequency (from the source to the fault, then back to the source and so on);

Oscillation at lower frequency (f_0) caused by the capacitor of the source and the total inductance of the line (resonance).

$$f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi\sqrt{LC}}.$$

C = capacity of the impulse voltage source
L = line inductance per meter

Coloc principle

- **Before the fault, the resonance oscillation period always represents the distance from the source to the fault**

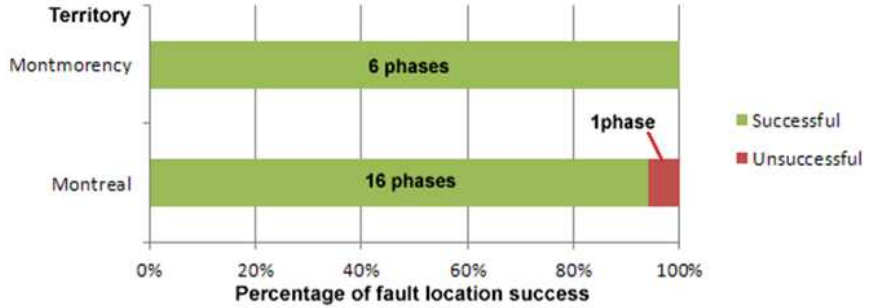
- **After the fault, the signal only contains the reflections of the breakdown to the end of the line, which is in open circuit**
  - Therefore, the shapes before and after the fault are different.

- **The amplitude of the measured signal is not a concern, only the shape is analyzed**

- **Branches before or after fault location do not have any effect on the method.**

Conclusion

- **With SimLoc, successful fault locations are below expectations for the Montreal service area.**
  - It's a question of time for the utility to fully integrate SimLoc into its operational processes, including data logging
  - Statistics for the first three months of 2015, in both the Montreal and Montmorency service areas, tend to prove this to be the case



- **CoLoc seems promising**
  - Preliminary field measurements have proven that it works for both determining the fault distance and locating the fault
  - Some results are more difficult to interpret than others ⇒ main task will be the signal treatment
  - The project is still in development

Thank you !

Questions ?

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Add-on : SimLoc Equipment

- The breakdown signal is read by a custom probe with a high attenuation (from 1/2000 to 1/20000).

- A protection equipement isolates the computer from an accidental high voltage that could occur on the probe side.