



# ADVANCEMENTS IN CALCULATIONS OF TRANSMISSION LINE IMPEDANCES

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# OBJECTIVE

- To improve the current process of calculation of transmission line impedances.
- The work is divided into two parts:
  - Part 1: Improving the current traditional method of calculation.
  - Part 2: Developing a Next-Generation method and documenting the process.

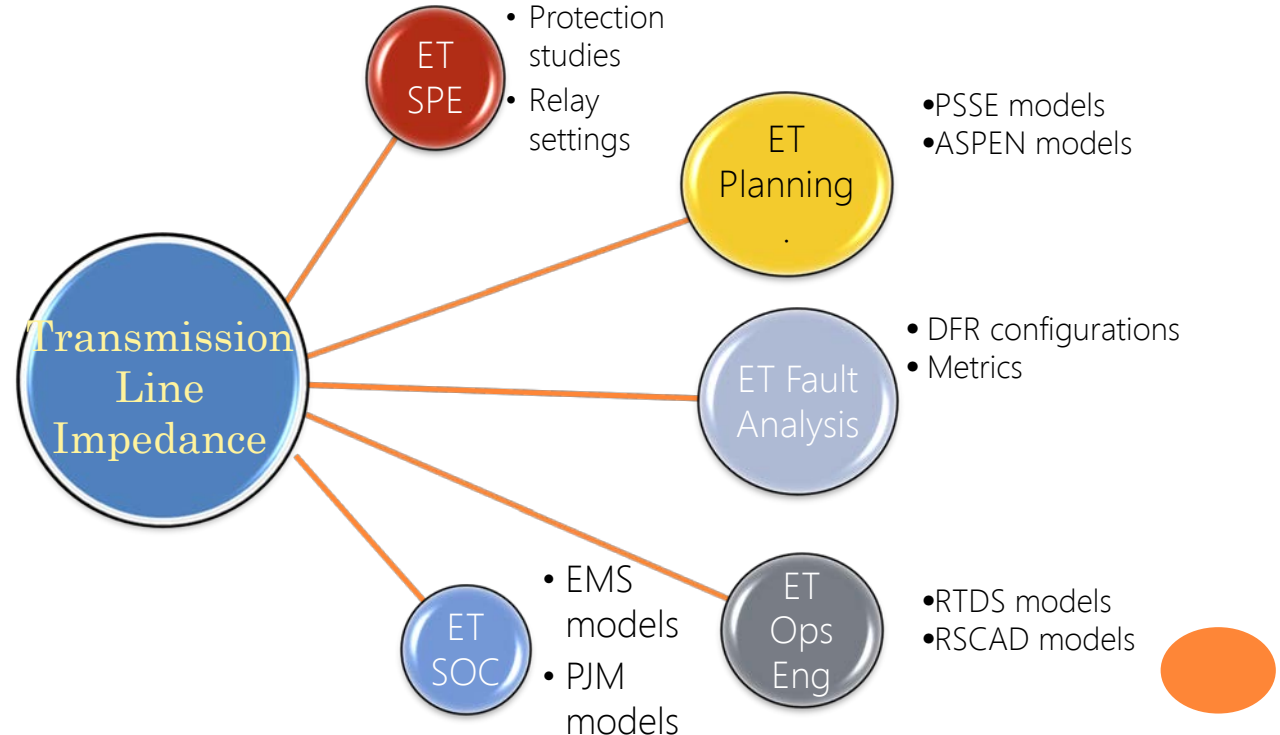


# MOTIVATION

- Transmission line impedance is a vital piece of information.
- Numerous Power System applications depend on it.
- SCADA/EMS models, Planning models, Fault Study Models, Relay Protection Settings, Fault Analytics are some of the important applications.
- Accuracy and precision of this impedance value affects the accuracy of these applications.
- Business Driver: Better Fault Location → Faster Crew Response → Better Customer Service.



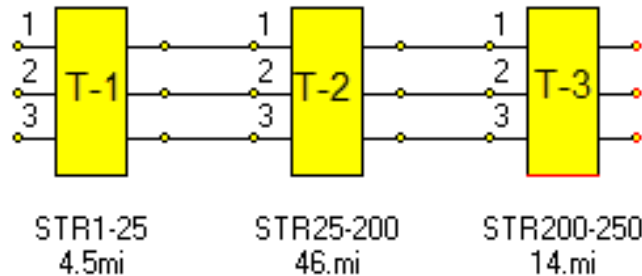
# USE OF LINE IMPEDANCES



Departments within Dominion which make use of TL impedance

# CALCULATION METHOD IN USE

- Still the ideal way because it significantly reduces the number of calculations required.
- Dividing Transmission Lines (TLs) in sections which are **somewhat** homogenous in terms of spatial arrangement of conductors, soil resistivity, static wire configurations, transposition of phases etc.

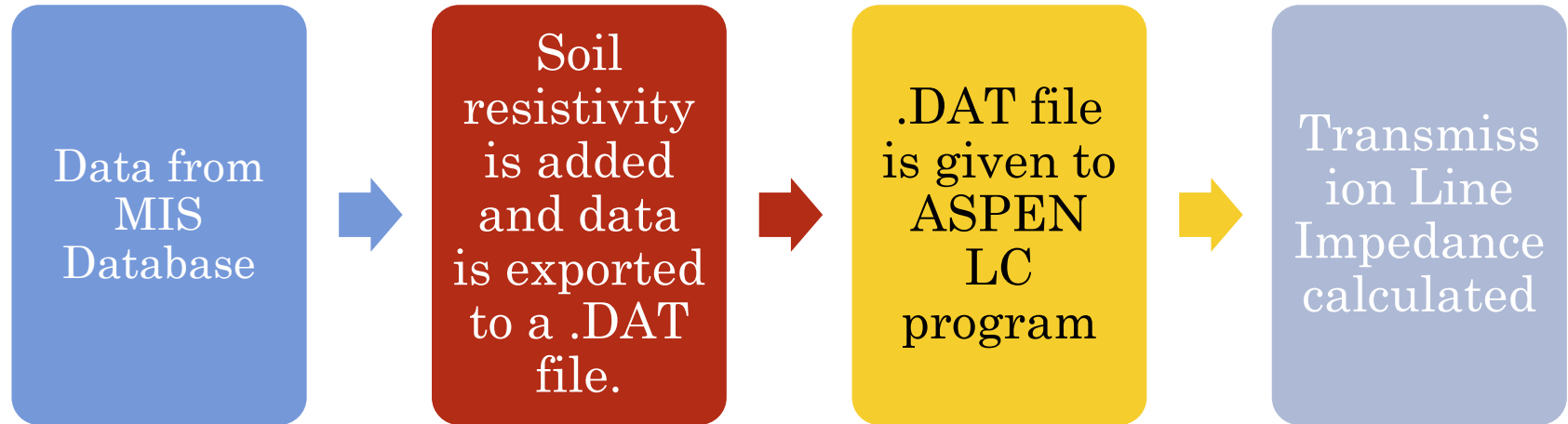


# CALCULATION METHOD IN USE

- In each homogeneous section, all transmission lines in the Right-of-Way (ROW) must have the following parameters defined:
  - Phase & Static Conductor spatial arrangement
  - Phase & Static Conductor type with electrical parameters
  - Static Conductors segmented or not
  - Bundled Conductors
  - Soil Resistivity
  - Conductor Sag
  - Voltage level
- All data is entered manually into a database.



# METHOD FLOWCHART



# PROBLEMS WITH THE METHOD IN USE

**Too many assumptions!**  
**Actual characteristics  
change  
from tower to tower**

**Significant manual data  
entry work required**

**Just focused on  
decreasing  
computational effort**

**Inaccuracies contained  
within the data**





# OTHER WAYS HOW IT CAN BE DONE

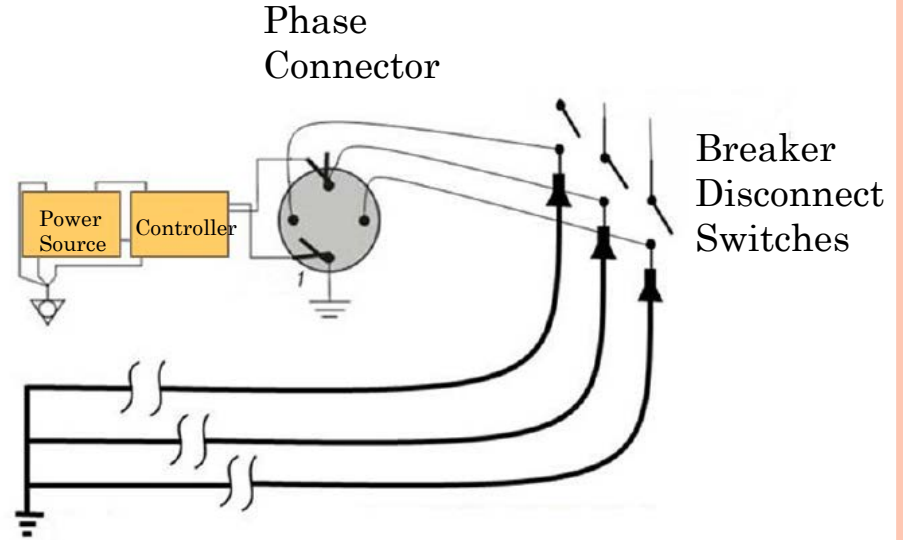
- There are some other methods by which transmission line impedance is calculated. These are:
  - Offline Method
  - Online Method
  - Next-Gen structure-to-structure method



# OFFLINE METHOD



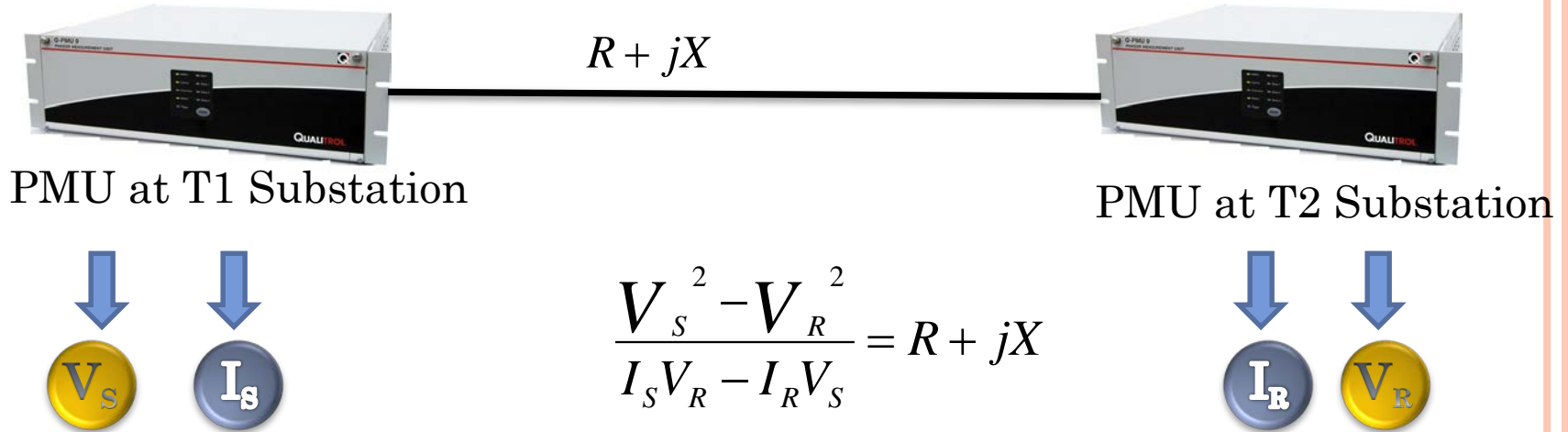
Omicron CPC-100 Line Testing Equipment



De-energized Transmission Line

Test Setup for offline method

# ONLINE METHOD

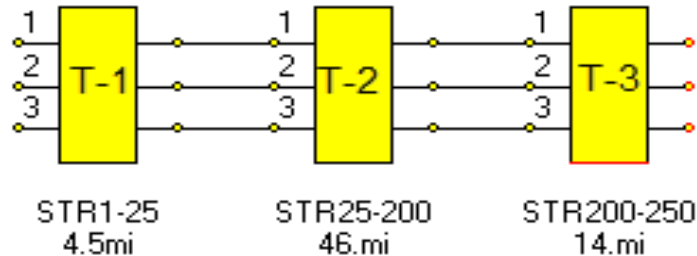


- Exactly one of the applications being built for the OpenECA project.



# NEXT-GEN STRUCTURE-TO-STRUCTURE METHOD

- This method would no longer utilize homogeneous sections, but would instead calculate the impedance of every line segment between two structures.



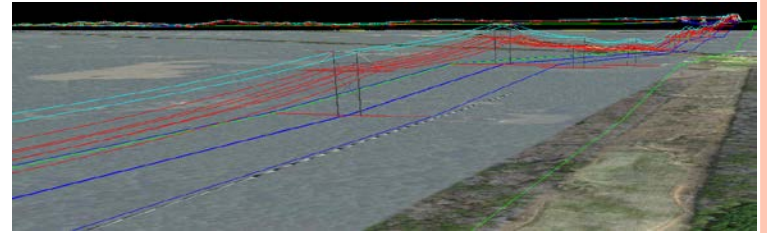
## PART 2: OUR NEXT-GEN METHOD

### ▣ Structure-to-Structure Method.



# OUR NEXT-GEN METHOD

- LiDAR (Light Detection and Ranging) is used to map the Transmission Lines.
- This LiDAR data is combined with CAD models to provide a comprehensive model.



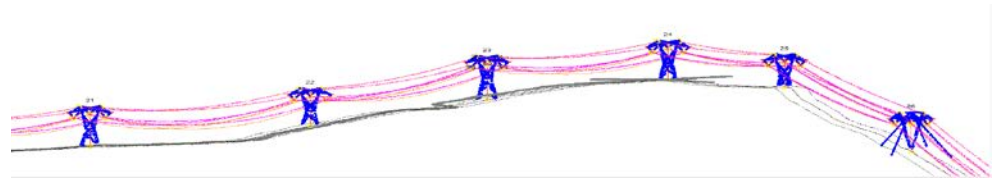
Transmission Line mapped via LiDAR

- PLSCADD is a tool used by Transmission Line engineers for design and drafting of TLs.
- The LiDAR data is combined with PLSCADD.



# OUR NEXT-GEN METHOD

- Using these comprehensive 3D models, the accurate GPS coordinates of each phase conductor and static conductor can be extracted.



Section of a 3D PLSCADD TL model

- Info about phase conductor types, line length and numbers of wires per phase (in case of bundled conductor) also is extracted from the model.



# CONCLUSION

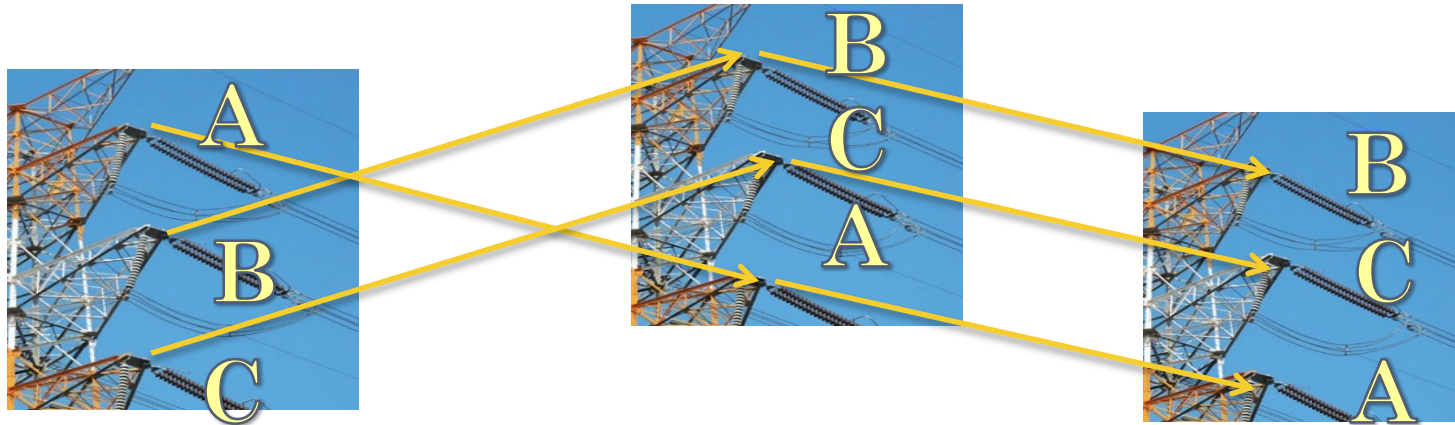
- This method is a complete process improvement.
- With the process, time and manual effort involved is reduced.
- Accuracy can be increased, providing better models and analytics.





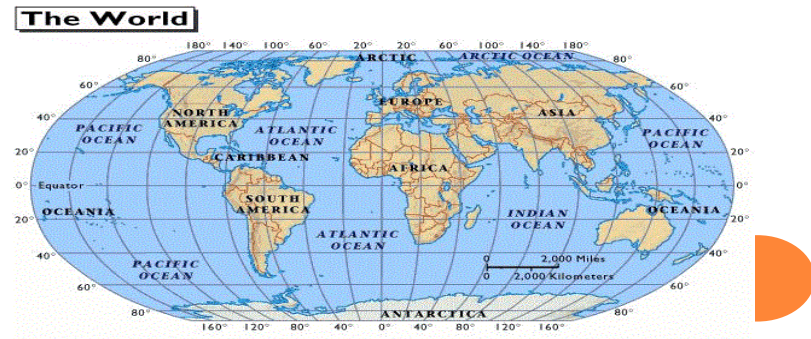
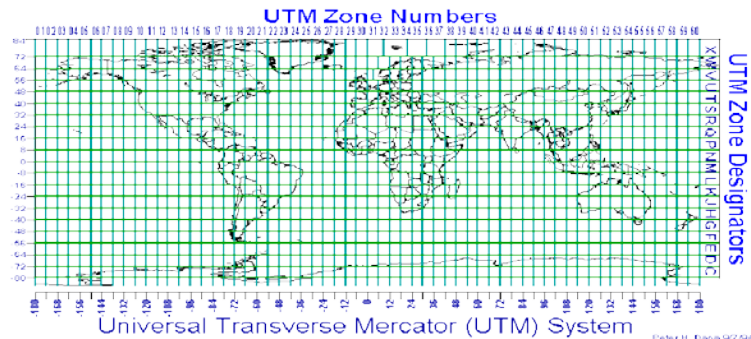
# PROBLEMS FACED

- Phase continuity of the transmission lines is not determined from PLSCADD, a separate database constructed from the phasing diagrams was required.



# PROBLEMS FACED

- Dealing with 3D comprehensive PLSCADD models required knowledge of the UTM (Universal Transverse Mercator) coordinate system as well.
- Different from Latitude & Longitude in several aspects



# FUTURE WORK

- There are different formulas within different LC programs to calculate the impedance. Each of them will be tested and results will be recorded.
- Transmission lines sharing the Right-of-Way (ROW) will be evaluated, as significant for zero sequence impedance values.
- A home-grown system would be developed wherein the extracted data will be used by an internally built LC program for calculating impedance and consequently updated on PI AF.





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Questions?

