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Transmission Line Route Refinement with Simultaneous Geomorphological Assessment

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SUMMARY

In all transmission line projects, selecting the line route is a key driver to establish feasibility and cost of the project. Making the best engineering decision may be tedious for promoters, utilities, and private companies as they are often faced with strict timeframes to perform the tasks as well as limited expertise. In assisting various clients over time in many transmission line projects, BBA, in collaboration with Poly-Geo, has developed an optimized work process for selecting line routes that has not only allowed to make sound engineering decisions and produce high-quality deliverables, but that has also improved efficiency and communication to meet aggressive timeframes.

The technical process developed comprises five different steps in which the transmission line (T-Line) engineer and the geomorphologist work closely together:

1. Preliminary line route definition;
2. Geomorphological preliminary assessment;
3. T-Line engineer design coordination with geomorphologist;
4. Geomorphological detailed mapping;
5. Line route refinement.

In sum, this particular work process holds many benefits:

- Work sessions with the T-Line engineer and geomorphologist allow particularly effective communication and capitalizes on the complementarity the two professionals' skills;
- Transmission line route selection with simultaneous geomorphological assessment allows real-time optimization of the line route at an early stage;
- Increased knowledge of soil conditions made possible through photo-interpretation allows targeting of problematic areas at the early stages of the project and improves field investigation planning. This can considerably reduce the costs related to mobilization/demobilization of resources and to helicopter flights that are often required for remote areas;
- Better understanding of ground conditions leads to more accurate cost estimates at all project stages (foundation types, structure types, material, construction equipment and manpower);
- Increased knowledge of the terrain leads to a heightened understanding of construction challenges;
- Quick identification of potential showstoppers.

KEYWORDS

Transmission lines, line route, geomorphological, ground, soil, engineering and constructability.

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INTRODUCTION

As the selection of the line route has direct impact on the cost and feasibility of any given project, one must ensure that all necessary steps are taken to alleviate risks inasmuch as possible. Timeframes are understandably short and promoters, utilities and private companies struggle with the need to make the best engineering decision possible with, unfortunately, limited expertise. An optimized work process for selecting line routes, such as the one developed by BBA and Poly-Geo is of the utmost importance when time is of the essence. This work process is also essential for any Client that wishes to make advised engineering decisions while improving efficiency and communication.

Selecting a line route has many challenges:

- Manage, process and analyze a large amount of data (LiDAR, aerial imagery, environmental assessment, land tenures and many more.);
- Communicate with various stakeholders including, for instance, utilities, promoters, environmental impact assessment teams, law firms, populations, and others;
- Conform to environmental and social constraints and land agreements;
- Spot (distribution of structure) a large number of structures and validate their implantation based on norms and regulations;
- Assess ground conditions and optimize line route to favour land with adequate soil conditions;
- Assess line route from a constructability standpoint to improve feasibility and lower construction costs;
- Meet aggressive timeframes.

Selection of a line route may occur at different stages of a project, for example:

- Prefeasability study;
- Feasability study;
- Permitting and authorizations;
- Detailed engineering;
- EPCM.

This paper breaks down the expertise needed to perform such a task and the particular work process that was developed over time, as well as all the benefits that may be reaped in the process.

ABOUT THE EXPERTISE

T-LINE ENGINEER

Transmission line route selection and refinement consist of all activities needed to properly locate the transmission line to be built with respect to structure performance, standards and regulations, geomorphological conditions, environmental and social impacts and land matters. Some of the numerous activities involved in the process are listed hereunder:

- Find the most favourable routes for the transmission line and prioritize long straight line segments instead of multiple angles;
- Find areas with adequate soil conditions to locate structures within the study corridor;
- Validate clearances to ground and spans between structures;
- Validate setbacks to bodies of water, roads, communication line, First Nation land, etc.;
- Produce plan and profile drawings to be used by different instances.

GEOMORPHOLOGIST

The geomorphologist is an expert of spatial analysis of the ground. Geomorphological analysis is performed with on-screen 3D photo-interpretation using vertical aerial photographs and high-resolution digital elevation models generated from LiDAR data. Combining these sophisticated tools with the expertise of the geomorphologist allows for a good understanding of soil conditions and construction constraints. Here are some of the many tasks performed by the geomorphologist:

- Evaluate the ground conditions (landforms, soils and drainage conditions) in order to delineate the most favourable corridors and routes for transmission line projects;
- Pinpoint the main constraint areas for the transmission line route and map them within a specified study corridor, and more specifically along the line right-of-way (ROW);
- Map ground conditions and constraints in order to optimize structures distribution, better estimate costs and plan further geotechnical investigations.

TECHNICAL WORK PROCESS

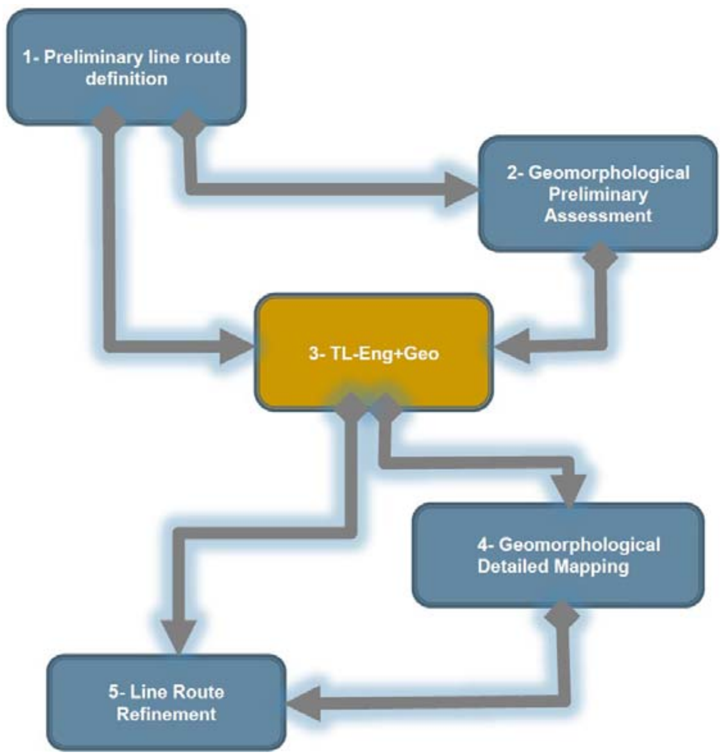

Figure 1: Technical work process diagram

1. **PRELIMINARY LINE ROUTE DEFINITION: First line route selection by the T-Line engineer**

At this first stage of the work process, the T-Line engineer defines the preliminary alignment of the line, based on all information he has on hand and on known constraints. LiDAR data, aerial imagery and environmental data are analyzed in order to perform the preliminary alignment. At this stage, the soil conditions are unknown to the T-Line engineer and further analysis is required to validate line route and tower spotting. In some cases, intuitive analysis of soil conditions may render acceptable results as it may be observed on Figures 2.1 and 2.2. For the engineer laying out the transmission line, even with little knowledge of the ground, it may be easily observed that light areas are unfavourable and should be avoided.

In some case, there might be interpretation limitations to intuitive analyses. As such, the intuitive analysis does not permit full understanding of complex landscapes or detection of high-risk terrain conditions (e.g., landslide-prone clays or permafrost zones). Situations like these, where the consequences can be costly, call for the use of spatial analysis experts, namely geomorphological experts.

Figure 2.1: Intuitive analysis

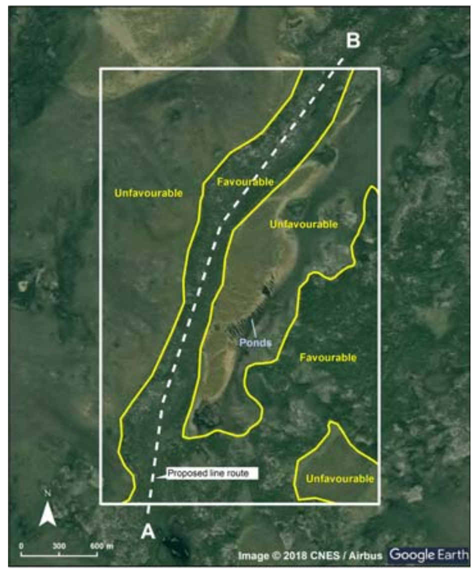

Figure 2.2: Preliminary line route definition

2. **GEOMORPHOLOGICAL PRELIMINARY ASSESSMENT: Identification of main constraints along the line route**

As soon as the preliminary line route is defined on a section, a quick overview is performed by the geomorphological experts and main concerns or challenging areas are identified along the study corridor and more precisely along the line route projected right-of-way.

The preliminary assessment conducted at this particular stage allows identification of important constraints for the line routing (and construction) such as numerous or extensive wetlands, as well as other constraints that are more localized but nevertheless important for structural stability, choice of foundation and construction methods. Such constraints include the potential presence of permafrost, clayey soils with low-bearing capacity, rock outcrop, and flooded areas (e.g., large beaver ponds, wetlands, muskeg, bog) not shown on the base maps.

3. **T-LINE ENGINEER DESIGN COORDINATION WITH GEOMORPHOLOGIST: T-Line engineer works with geomorphologist**

The T-Line engineer and geomorphologist perform a complete review of the line route. A proactive way to do so is to bring the two professionals together in front of the same technological platform. This allows the team to:

- Review first line route definition and identified constraints;
- Jointly identify alternatives and optimize line route within the study corridor, and recommend adjustments to the study corridor;
- Jointly identify challenging areas where some constructability issues could be encountered for foundation construction and implementation of features such as helipads, camps, laydown areas and access roads.

Figure 3: Design coordination work session

4. GEOMORPHOLOGICAL DETAILED MAPPING: Mapping of main constraint areas and line route optimization

At this stage, and further to the review by the two professionals, the geomorphologist performs a detailed assessment along the route alternatives selected. Depending on the level of accuracy needed, more or less detailed maps can be delivered to the transmission line engineer. Figure 4 depicts a level 2 photo-interpretation, and mapping achieved with high-resolution aerial imagery and LiDAR data which can be used for line route optimization and structure spotting.

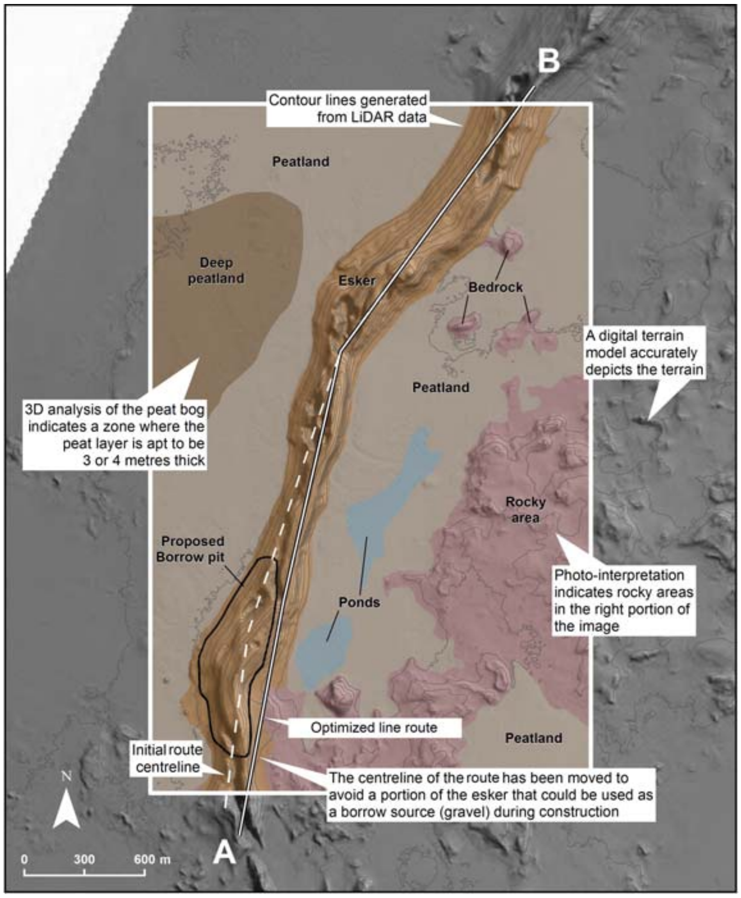

Figure 4: Detailed ground conditions mapping

5. LINE ROUTE REFINEMENT: T-Line engineer performs final route refinement

At this final stage, the T-Line engineer integrates the data received from the geomorphologist to refine the final line route. The engineer can then quickly adjust the distribution of the structures to avoid constraints or move the axis of the line to optimize the layout by taking advantage of landform alignment and favourable soil conditions. Once the adjustments are completed, plan and profile drawings can be produced and submitted to different instances. The problematic areas that may remain at this stage can be summarized in a constructability report and submitted to further on-site investigations (geomorphological or geotechnical surveys).

Figure 5.1: Line route refinement

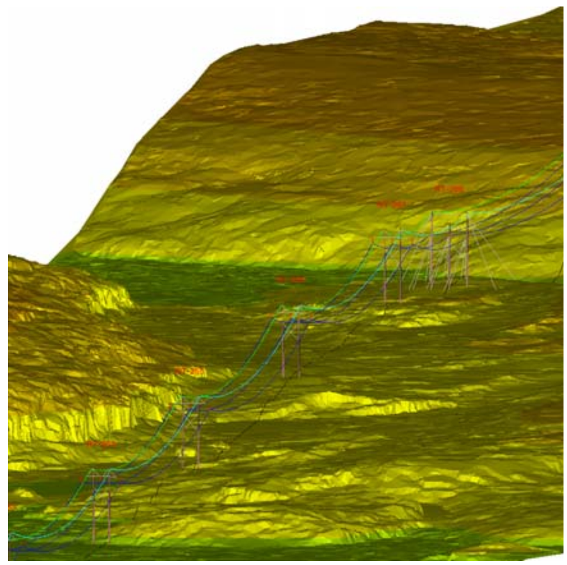

Figure 5.2: Ground clearance validation

BENEFITS OF THE SOLUTION

In transmission line projects, sooner the changes to the line route are made, less are the financial impacts. Accurate and efficient line route selection and structure spotting can be very advantageous.

As a short recap, the following benefits of the work process described herein are as follows:

- Effective communication and capitalizing on complementarity by combining work sessions with T-line engineer and geomorphologist;
- T-Line line route selection with simultaneous geomorphological assessment allows real-time optimization of the line route from the first stages of a project;
- Improvement of field investigation planning and targeting of problematic areas, very early on in the project, by acquiring better knowledge of the soil condition through photo-interpretation
- Cost reduction on mobilization/demobilization of resources and on helicopter flights that are often required for remote areas;
- More accurate cost estimates at all project stages (foundation types, structure types, material, construction equipment and manpower) due to better understanding of ground conditions;
- Better understanding of construction challenges due to the knowledge acquired with regard to the terrain;
- Quick identification of potential showstoppers.