NEW TOOLS FOR CABLE ROUTE PLANNING

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1. CABLE ROUTE PLANNING

The application of digital technology to planning, installation and maintenance of submarine cables has steadily improved in recent years. The introduction of PC-based route planning software seven years ago replaced paper charts and spreadsheet-based tools with geographic information system (GIS) databases that efficiently store all data critical to route planning. Technological advancements in recent years have included tools for the incorporation of bathymetric survey data, detailed analysis of in-line and side slopes, and the capability of automatically detecting and analyzing cable suspensions.

The GIS platform, and subsequent software development, has greatly enhanced collaborative cable planning efforts by providing a common data set for inputting, storing, retrieving, manipulating, analyzing and viewing geographically referenced data (e.g., bathymetry, side-scan imagery, soil types, aerial photos, etc). The introduction of the GIS platform into cable route planning has resulted in an efficient design process, minimizing errors and time.

Before the introduction of GIS planning software, the planner did not have the tools to properly make use of the bathymetric data collected by the surveyor. Instead, the planner simply estimated the bottom profile along the selected preliminary route and made use of marine charts to detect the presence of large features and determine slopes along the route. With the introduction of GIS planning software, a more complete and automated use of the bathymetric data was partially achieved. Using the collected point data, surveyors are able to provide the planner with bottom contours along the entire surveyed swath. With these contour data, GIS planning software is able to automatically generate the bottom profile and slopes along the selected route.

As the cable planner makes modifications to the cable route to avoid large slopes and hazardous areas, the GIS planning software computes a new bottom profile and slopes along the entire route. This iterative procedure is facilitated by properly linking the plan view and the profile graphs, such that any changes in one of the views are immediately reflected in the other view (Figure 1). Following this procedure, an optimal cable route can be identified.

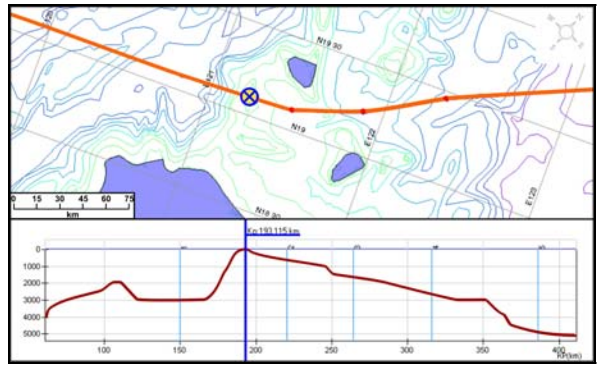

Figure 1. *Cable route planners can now link plan and profile views to efficiently manage the cable route design process. Routes are edited using click and drag techniques and precise RPL and cable assembly lists and diagrams are created automatically.*

Despite these important advances in cable route planning, which have allowed users to decrease planning time by five to ten-fold, until recently, current GIS software could not make optimum use of all the bathymetric data collected by the surveyor. Bottom contours do not always provide the planner with the most accurate representation of the true bottom features and the lateral slopes between adjacent contours.

High resolution bathymetry is particularly important when planning for plow operations and power cable routes. In the last few years, several cases have been reported where plows have been damaged and even lost at-sea as a result of hazardous seafloor features not detected when using bathymetric contour lines to define the cable route. These incidents could have been avoided by making use of the high resolution bathymetric data (i.e. point data collected by the surveyor) during the route planning process. In addition, contour data do not provide the level of accuracy required to conduct effective cable suspension analyses along the seabed (power cables are particularly vulnerable to suspensions which can shorten the life expectancy of the cable). Therefore, new methods of processing bathymetry data are required to generate the highest possible resolution that is needed for these sensitive cable planning operations.

1.1 INCORPORATING DIGITAL TERRAIN DATA IN THE ROUTE PLANNING PROCESS

Bathymetric data are usually provided by surveyors in N-E gridded files that cover the entire surveyed area. The size of the grid cells (dx,dy) in each file depends on the resolution of the data acquired (mainly determined by the footprint of a single echo-sounder beam). For a typical multibeam echo sounder with single acoustic beams of 0.5^o, resolutions of 0.5 meter and 4.5 meters can be expected at echo sounder to seabed distances of 60 m and 500 m, respectively. To decrease the footprint and improve seabed resolution in deep waters, the multibeam echo sounder can be flown closer to the seabed on a tow fish during the data acquisition process.

In order to maintain the accuracy of the data collected by the surveyor, the resolution of the original survey data must be preserved. This can be achieved by creating data blocks (or pages) along the entire surveyed route, in order to minimize variations in water depths (and therefore, footprint size) within each page. Existing software provides automated tools for selecting the appropriate grid size for each block in order to match the smallest footprint of the survey data. The goal is to accurately present the shape of the seabed features detected by the survey, while avoiding the creation of high frequency, non-existent features.

Once the data blocks have been defined, the software automatically redistributes the raw data into a grid formation, using one of the several available gridding methods. After grid creation, shaded relief images (Geotiffs) are automatically generated from the gridded data. Custom controls, such as the shading method, color selection, and light position angles allow users to target areas of concern for evaluation during cable path planning.

The generation of all the pages along the surveyed route, including reading the raw data files, generating the gridded data, and creating shaded relief images for each page, is usually completed in a batch process. Thus, this process does not have to be labor intensive. For a typical survey with 80 million data points, the entire process can take one hour. A sample of a single page generated along a route which includes a shaded relief image created during batch processing and several smaller pages of soil type data are shown in Figure 2.

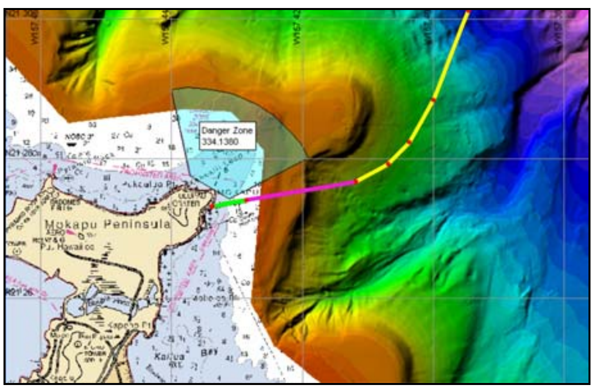

Figure 2. *Geotiffs can easily be created from the survey data and inserted into the GIS database, thereby enhancing the quality of the information available on any given site.*

1.2 SLOPE ANALYSIS TOOLS

The use of detailed geo-referenced images (usually provided by surveyors) to gain a better understanding of seafloor conditions is sometimes sufficient to select a proper route. In many cases, however, further in-depth analysis is required to gain confidence that the hazards to plowing and/or cable suspensions have been revealed and addressed. The problem the planner faces when simply using Geotiff images provided by the surveyor is that he has no access to the underlying data used to create those images, so he cannot accurately estimate the slopes and sizes of seabed features that can affect his route planning process.

To avoid this problem, current GIS software already includes engineering tools that help the route planner identify potential hazards by carefully analyzing seafloor slopes (magnitude and direction) and seabed roughness along the proposed route. As an example, a slope graph can be calculated by superimposing a cable route on gridded bathymetry data so that side slopes and directions can be calculated at any point along the route (Figure 3). Using these tools interactively while designing a cable path, the planner will obtain further confidence in the safety of the selected cable route.

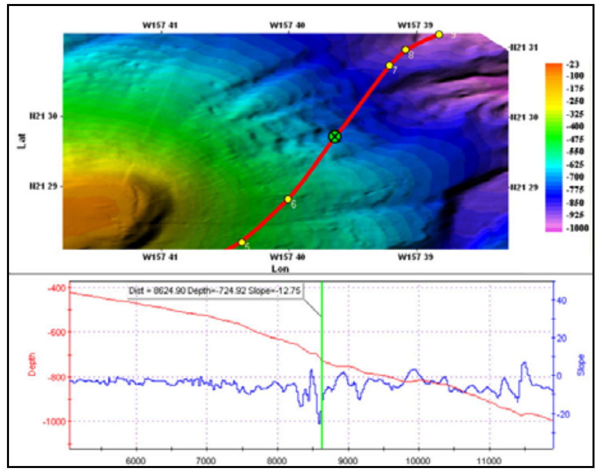

Figure 3. *User can interactively create and modify the routes and reference lines, and depth profiles and slope graphs are automatically generated.*

In addition to slope, current software applications can provide high resolution depth profiles along the route. This, in turn, allows for the computation of the cable length required to achieve the desired seabed slack with accuracy greater than that computed using the conventional method of intersecting bathymetric contours. Such accurate seabed profiles are also essential to the complete analyses of cable suspensions along the route.

2.2 ANALYSIS TOOLS FOR CABLE SUSPENSIONS

With the growing number of power cables and umbilicals being planned and installed, it has become necessary to incorporate suspension analysis as one of the key elements of route and installation planning. Even suspensions that can be considered not critical for a typical telecommunication cable can be unacceptable for power cables.

New tools have been incorporated into GIS planning software that allow users to quickly calculate the location, length of expected spans, and bend radii at cable touchdown points. These tools can provide detailed engineering data, including the shear forces and bending moments acting on the suspended cable or umbilical. The additional information necessary to perform these analyses can be readily obtained from the cable manufacturer's data (e.g., wet weight and bending stiffness of the cable). With this knowledge, the user can estimate suspensions for a variety of tension values used during the installation.

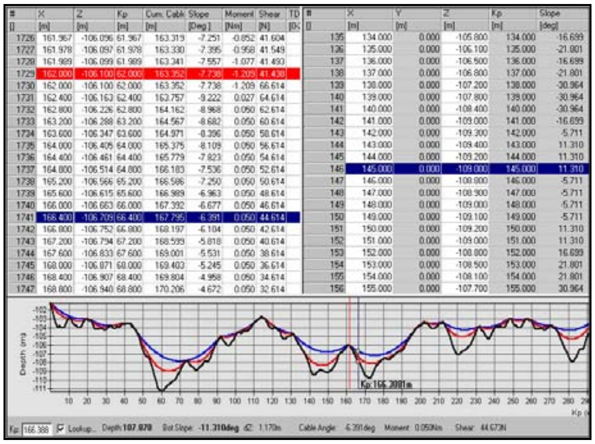

Figure 4. *Example of cable suspension analysis for two different tensions.*

Figure 4 shows a profile of the seabed route (in black) and two different cable solutions obtained along the route. Both solutions analyze the same cable with the only difference being that the solution in red has a horizontal tension equal to half of that used to obtain the solution in blue. The Kp marker (shown above as a vertical red line with associated distance) can be used to scroll along the solutions and obtain specific information regarding any point along the suspended cable. These data are shown in the information bar at the bottom of the window. The Kp marker is also linked to the route and to the solution window. As the Kp is moved along the profile window (by clicking and dragging the mouse), the solution and route windows automatically scroll to the specific Kp row allowing the user to focus on problem areas.

Sections of cable where the length of the spans exceeds the critical span length defined by the user are highlighted in red in the solution window, (see Figure 4). The same applies if the bend radius is smaller than the critical value of bend radius defined by the user.

These same cable suspension analysis tools can also be used during survey operations associated with the selection of cable and pipeline routes. As the survey takes place, computations of cable suspensions along the pre-selected route can be completed on the "fly", and adjustments to the RPL (and to the survey coverage area) can be completed, considerably reducing the time required to select an appropriate route and leading to lower survey costs.

2. CONCLUSIONS

New digital terrain mapping tools and suspension analysis tools are further improving the quality and efficiency of the route planning process by providing hard engineering data the planner can use to make decisions.

These planning tools already exist, and they are designed to work in conjunction with each other and share information in a common GIS database. When changes are made in one application (e.g., a change to the RPL), the changes are automatically updated in the other applications.

Using a single software platform that contains all the tools required to complete the desired cable path analyses increases the efficiency of the cable planning process and presents fewer possibilities for critical errors.