INTEGRATING TERRESTRIAL AND MARINE DATA SETS IN A GIS ENVIRONMENT

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1. ABSTRACT

The telecommunications industry has been benefiting from the power of Geographic Information Systems (GIS) for many years. In fact this sector represents one of the largest vertical markets within the GIS industry. All of the major telecommunication companies have invested heavily in GIS technology and operate enterprise solutions within their organizations. Despite this widespread acceptance of GIS technologies within the telecommunications industry, it has only been within the past couple of years that marine cable departments have started to establish their own GIS environments and harness the power of GIS. Ironically, these systems are evolving independent of terrestrial systems and with little or no consideration towards connectivity to terrestrial systems and terrestrial data.

This paper will look at how the terrestrial and marine telecommunications industries are currently using GIS and GIS solutions to see if there is any potential overlap in the solutions that are currently available "on land" with those required "under water". Although there are significant differences in the environments and in some of the data types, it is proposed that similar analytical tools could be applied in both systems. Some of these may already exist in the more advanced terrestrial GIS applications. In addition, the joint accessing of data held in separate terrestrial and marine databases, within a single GIS environment could allow more efficient installation and maintenance programs to develop. The paper will also examine the data itself and see how marine and terrestrial data sets, historically separated, can be potentially be connected. There are likely some areas where data integration is possible and this would benefit the industry, as a whole.

ESRI, the world's largest vendor of geographic information systems and spatial data management systems and Thales Survey, an ESRI business partner, providing customized GIS solutions to the marine cable industry, have been studying this problem for some time. Their findings and recommendations are presented in this paper.

2. INTRODUCTION

The submarine cable industry is changing and changing rapidly. We have seen more changes in the past four years than in the previous forty. Not only is transmission technology changing at an unprecedented rate, but so also are the commercial relationships, business practices, and network philosophies. We are no longer dealing with isolated submarine networks, but are really looking at global networks that include both submarine and terrestrial components. Companies like FLAG, Global Crossing, and most recently, TyCom are now pushing the global network concept. As networks evolve from interconnected continental groups to globally interconnected networks, the delineation between submarine systems and terrestrial systems will take on a different proportion. Submarine links will come to be considered part of global networks. Such an approach makes a great deal of sense, as it provides carriers with a "one stop shop", that eliminates the need to create their own global networks from an integration of many different sub-networks supplied by many different vendors.

This concept presents significant challenges from a spatial data management perspective. Traditionally, the submarine world has been quite isolated from the terrestrial world. Submarine cable operators and installers have traditionally only been concerned about designing, installing, and operating a cable from beach manhole to beach manhole or terminal station to terminal station. Similarly, terrestrial cable owners and operators have not been concerned with the marine cables that connect their terrestrial networks. Each group had their own needs and there was really little or no sharing of information and technologies.

3. GIS IN TELECOMMUNCIATIONS

The power of GIS is that all features and layers in a GIS map are geo-referenced, meaning they are tied to a coordinate system. In a GIS environment, precise coordinates are available, measurements and other analyses can be easily performed, and spatial data are directly linked to database tables.

GIS has been used with great success in the terrestrial and wireless telecommunication sectors for many years now. It has been used for market analysis, engineering and design, support and maintenance, and billing. ESRI services a large portion of the terrestrial and wireless telecommunication industry.

It has only been recently however, that the submarine cable industry has started to utilize the power of GIS. Several GIS-based products are now available and are being used successfully by submarine cable owners and installers. One such product is Thales Survey's Cable Analyst, described later in this paper.

The following sections will look more closely at the evolution of GIS solutions in the telecommunications industry. The use of GIS in terrestrial mapping and facilities management will first be examined. This will be followed by an examination of how GIS is currently being used in the submarine telecommunications industry.

3.1 Terrestrial Mapping and Facilities Management

Terrestrial GIS applications for the telecommunications industry have various backgrounds. Linear networks (fiber, copper, coaxial) were traditionally documented using paper maps and sketches. The first phase in the automation of mapping departments was focused on the conversion of these paper maps to Computer Aided Drafting (CAD) files using digitizing tablets. In a second phase, operators wanted more intelligence associated with their digital maps, which meant that CAD files had to be converted to GIS formats.

GIS formats are more demanding than CAD for two reasons. First, CAD programs rely on drawings, stored as files. GIS applications are driven from the database. This means all data, including the geographic data (poles, cables, access points) have to be stored in database tables and support regular database rules. In order to query a geographic data layer on the basis of its attributes (e.g. *"display all pole under 25 feet within two miles of this Central Office location")*, relationships between the geographic features (*poles*) and regular database tables (*pole height*) need to be stored and maintained correctly. A second differentiator between CAD and GIS is that a GIS uses location itself as a query tool (*within two miles*). In other words, a CAD system ideally knows where things are, a GIS also knows where things are relative to other things. This means that the actual location of the geographic features matters greatly, because this is the basis for further analysis.

Once networks had been digitized and properly converted, functions such as automated design, tracing, loop make-up, and cable-throw became possible and greatly enhanced the workflow of the telecommunications companies. Similar applications started serving the utilities (electric, gas, water) and pipeline companies. This group of GIS applications became known as Automated Mapping/Facilities Management (AM/FM) Systems.

In terrestrial systems, telecom applications are organized around work-orders. A large local phone company will receive up to 100,000 service orders per day, with 20,000 service technicians and vehicles to manage. The work-orders receive data from AM/FM Systems, defining their area of interest. Through database connections, inventory and customer data is generated automatically as a result of the geographic query. This determines the necessary parts and technician skill sets as well as time windows for the work order to be fulfilled. Automation of these processes results in significant benefits, including better customer service, faster emergency response as well as cost savings.

Geographic data used in terrestrial telecom applications include street-center lines, municipal zoning, local exchange areas, switch locations, customer locations, tax boundaries, and of course the outside plant facilities. More advanced systems will include broadband management layers, juxtaposed over regular infrastructure. Examples of the latter are IP, ATM, SONET/SDH, and Virtual Private Networks.

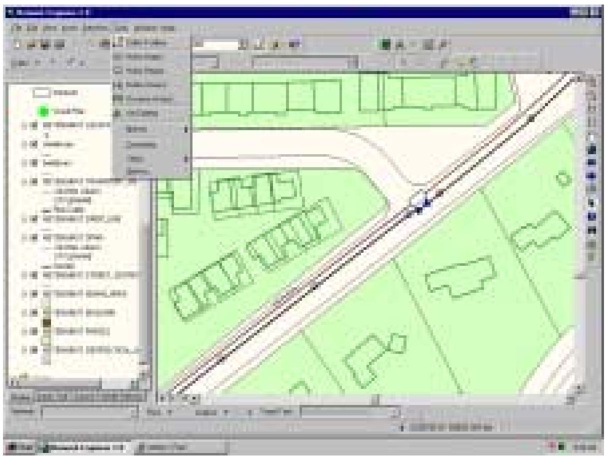

Figure 1 Network Engineer – AM/FM Application

In the wireless industry, the use of GIS resides in the same workflow niches. However, the geographic nature of wireless networks is very different from linear networks, thus wireless engineering applications focus on wave propagation modeling, real estate, and signal quality, in general. More recently, ultra-high frequency technologies such as LMDS have spurred yet another generation of GIS analysis, based mainly on line-of-sight and rooftop modeling.

An additional benefit of GIS is the ability to integrate with other database support systems, such as call-centers, trouble ticketing, outage management, billing, marketing, and sales support. This allows departments to share and view each other's data, integrated through their location, in what is referred to as "Enterprise GIS".

3.2 Submarine Cable Data Management

The use of GIS in the submarine telecommunications industry is relatively new, when compared to its terrestrial counterpart. It is easy to see similarities in the evolution of GIS solutions in both environments. In terms of solutions, the submarine industry is roughly where the terrestrial industry was ten to fifteen years ago.

Like the early terrestrial telecommunications industry solutions, submarine telecommunications deal primarily with linear networks. Similarly, these linear networks were documented using paper maps and sketches. It was only five years ago that submarine cable mapping departments began collecting and archiving data in electronic format. These data were typically provided in CAD files and were generated by either AutoCAD or Microstation mapping software. While new data is now being delivered electronically, by enlarge, historical data still resides in paper format. The industry has yet to take the significant step of digitizing their paper charts into CAD or other electronic formats.

The submarine telecommunication industry is just starting to move from CAD to GIS environments. RPL and other related submarine cable data are just now starting to be databased. As in terrestrial communications, once data have been digitized and properly converted, functions such as automated design, tracing, loop make-up, and cable-throw will be possible. Only then will the solutions previously developed for terrestrial applications be available for submarine environments. The key then is a solid database of submarine cable data.

3.3 Cable Analyst: A Marine Cable GIS Solution

One of the GIS solutions recently introduced to the submarine cable industry is Thales Survey's Cable Analyst. Cable Analyst was developed to provide a GIS-based planning, data management, and data archival tool that was focused for the submarine cable maintenance market. Thales Survey built on ESRI's core GIS technology and created an Extension Module that "plugs in" to ArcView GIS. This Extension provides menus, tools, and features that are very specific to submarine cable data and the submarine cable industry. At the same time, all of the power and capabilities of the core ArcView GIS products are still available.

This initial release of Cable Analyst represents Thales Survey's base GIS product. Over the next several months, an optional add-on, submarine cable data model will be developed that will expand the capabilities and power of this product. The core product is designed primarily to work with (display, chart, print, manage, and archive) RPL data. This could be planned, as-built, repair, or historical data.

With Cable Analyst, the user has the ability to store, query, maintain, update, graphically display, and plot cable system data. Additionally, all cable data can be overlaid over existing metadata, such coastline, bathymetry, nautical charts, and side-scan imagery for example. Cable Analyst provides powerful tools to load and modify cable systems with easy to use wizards and dialogs. Furthermore, with the included worldwide coastal and bathymetry data, the user can create detailed future cable routes, with specific cable events such as repeaters, and splice boxes.

Cable Analyst has the capability to convert new, existing or legacy data from its existing format to the cable management database structure. Once Route Position List (RPL) data are loaded in Cable Analyst, a cable system editor provides several tools for identifying, tracking, and updating new and existing cable systems. Additionally, depths can be calculated, with the click of a button, from the use of included worldwide bathymetry contour data. Furthermore, Cable Analyst provides several avenues for exporting data into various formats, including Excel and Word.

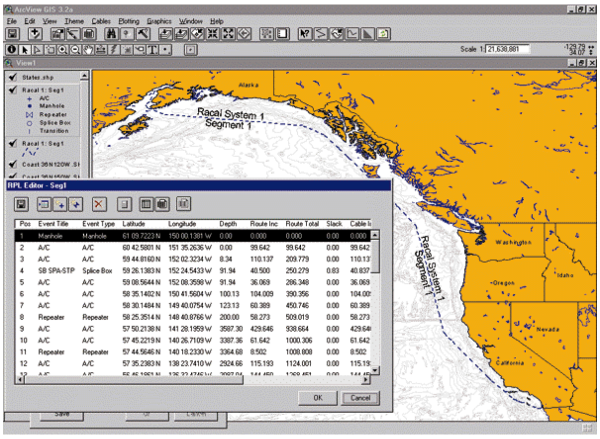

Figure 1 RPL Presentation in Cable Analyst

The system is also capable of displaying electronic nautical charts in several different formats. ArcView GIS supports the display of the VPF and S57 vector formats, as well as BSB and ARCS raster formats. This means the user can superimpose RPL data over actual nautical charts for a given area.

Another powerful capability is the Great Circle Guideline. With this tool, the user can great circle routes between desired points on the map and subsequently use this as a guideline or guide corridor for more detailed cable route planning. This combined with the coastline, bathymetry, and electronic chart data makes for rapid and accurate creation of preliminary RPLs.

In terms of analysis, Cable Analyst includes full GIS capabilities, including spatial and conditional queries, proximity analysis, areal buffer creation, intersection calculation, and much more. Capabilities also include the ability for various overlay analyses and visual modifications. In addition to viewing the cable system information digitally, Cable Analyst also includes powerful printing capabilities. Charts can be produced – singly or in series - to provide an overview of cable systems in a specific area, and sophisticated reports can convey tabular data.

4. INTEGRATION

Integration of terrestrial and submarine mapping, design, and facilities management would be beneficial to the telecommunications industry as a whole. While the terrestrial and submarine telecommunication environments are quite different, there is clearly some overlap between solutions currently available "on land" and solutions required "underwater". The data itself, historically separated, should also be able to be connected. To achieve such integration, a number of factors need to be considered, however. These will be discussed in the following sections.

4.1 Data

In terrestrial applications, data integration is usually achieved on the basis of "land base" data, such as streets or addresses, lot and parcel numbers, or Telcordia CLLI codes. In the submarine environment, these are obviously unknown or not relevant. Given this, integration of terrestrial and submarine data can be achieved in two ways:

- Using facility identifiers that are mutually known and agreed upon, which will teach the GIS when going from terrestrial to submarine exactly which network equipment types are connected

- Matching the company's facilities geographically, on the basis of their location, which creates a spatial link between the terrestrial and submarine networks. The GIS provides standard functions that will have this link persist in the database for tracing and analysis.

4.2 Software

The terrestrial and submarine GIS applications will need to have a foundation in an open, industry standard development environment. This allows the applications to share functions and/or objects. Ideally, they would use the same development environment such as Microsoft's Common Object Model (COM) or Sun Microsystems' JAVA). When different environments are used, integration will need a vendor independent integration tier, such as the Common Object Request Broker Architecture (CORBA) or the recent Simple Object Access Protocol (SOAP). Internet based applications can take advantage of inter-application scripting languages such as XML and XHTML.

In the case of Cable Analyst, integration with terrestrial applications, such as Telcordia's Network Engineer, can be achieved by using COM properties. COM allows objects and methods to be shared by two COM-compliant applications. As Cable Analyst and Network Engineer will both release versions on ESRI's ArcObjects 8.1 architecture, compliance with COM specifications is guaranteed. In addition, both use ESRI's geographic data model, the GeoDatabase, which will further tighten integration and allow single storage of data for both applications.

4.3 Organization

Before technology can be used to integrate terrestrial and submarine systems, companies need to structure their organizations along these lines. The success of these systems depends on the dedication of all departments to maintain the system, keep it current with the latest data, and react swiftly to outages or malfunctions. High-level executive support is a condition, as well as the involvement of corporate information technology (IT) departments.

5. CONCLUSIONS

GIS in Telecommunications has been deployed successfully in terrestrial network deployments. More recently, submarine applications have been making progress. Integrating the two will benefit organizations. It provides operation support, e.g. tracing from and to a terrestrial location while passing through submarine segments. It also provides management with an integrated view of facilities and operations, supports faster end-to-end network rollout and allows for better, faster decision making.

Integration will be achieved when underlying technologies and data use open standards for database, software and synchronous data sources and when executives push a closer integration between terrestrial and marine departments.

7. REFERENCES

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