AHTD TRC TRANSPORTATION RESEARCH COMMITTEE

TRC0309

Evaluation of Variables in Route Selection

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Final Report

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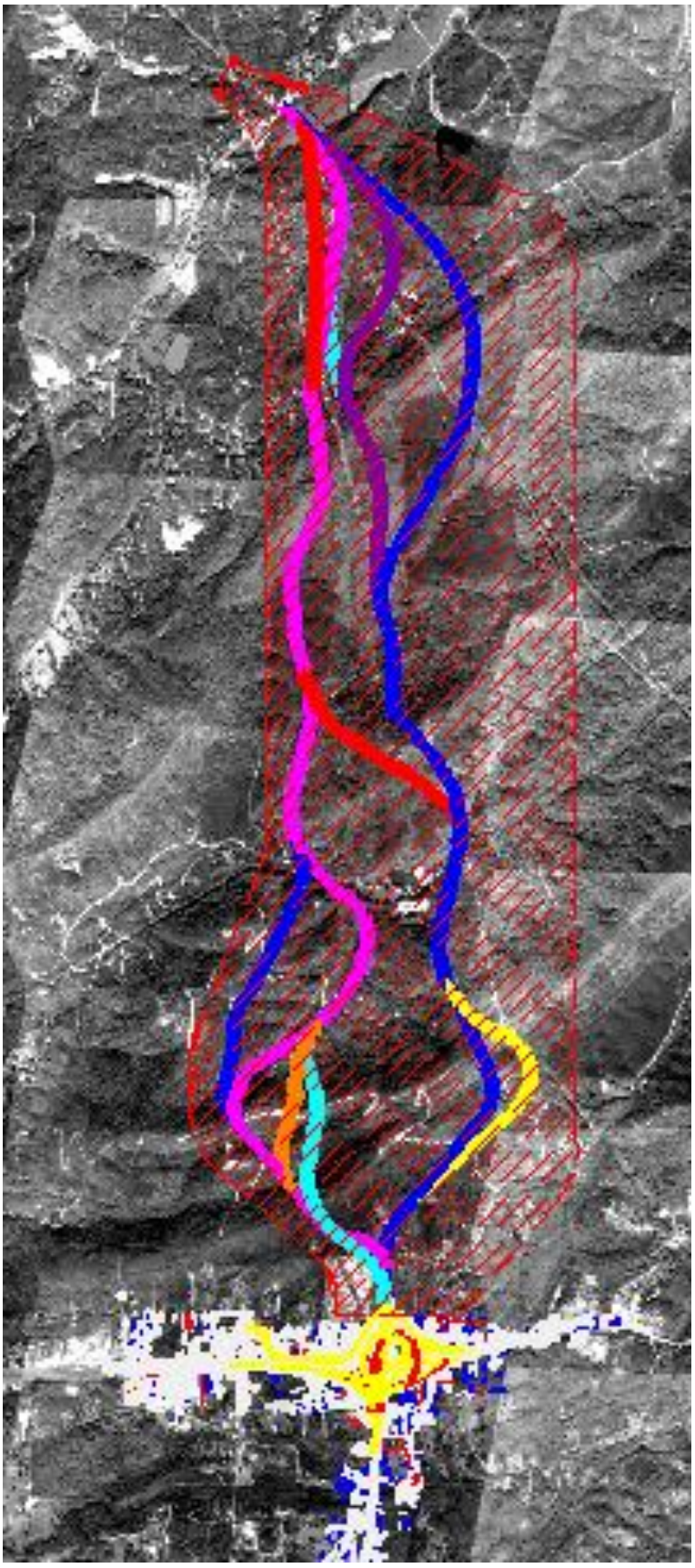
Introduction

Quite often when determining the location of a new highway, the final alignment is neither the most cost effective route nor a straight line between the two end points. In actuality, the route selection process frequently evolves into a route elimination process. As with major construction projects, the evaluation of variables in route selections includes a multifaceted collection of environmental, ecological, social, political, geological, historical and cultural choices that does not always revolve around building costs or shortest distances. Although experienced highway planners can sometimes accurately predict a preliminary highway route roughly based on past knowledge of the region's geography or topology, it will often be the interaction of a mixture of variables that will determine the final alignment. An automated method was needed to assist planners that could quickly integrate and analyze the available information and provide it in presentation form for assessment or review. The evaluation of an Australian based company Quantm™ was initiated due to reported claims of substantial savings in construction alignments costs.

The conventional approach to planning is a manual process where a planner will utilize a combination of USGS Topographical maps, aerial photography, Geographic Information System (GIS), and Computer Aided Drafting (CAD) software to assist them in the assessment of a route. This process is time and resource intensive and has no mechanism for dealing with the extreme complexity that arises from a need to meet multiple, and sometimes conflicting, environmental and community constraints, and then deliver an economic solution that maintains the viability of the project. The approach is also not conducive to calculating realignment costs where new constraints will arise and the reassessing process may take weeks before the project team is able to demonstrate the benefits from the alternatives. Figure 1 shows a preliminary set of route locations prepared by the traditional planning method.

Figure 1



The ability to readily assess any changes in the design criteria is at the core of Quantm's cost savings. Quantm uses the customer furnished roadway design criteria and specifications for programming its computer-based system. Specifically designed to analyze the sometimes considerable quantities of design variables and calculations necessary for optimizing possible highway construction corridors and alignments, it is reported to be able to shorten the process considerably by being able to analyze and model design and constructions costs that would otherwise take much longer than traditional methods. Typical optimization turnaround times on design changes have been completed overnight.

Primarily used for the special purpose of assisting infrastructure planners through the process of selecting possible roadway alignments, it incorporates such design variables as environmental protection, cultural heritage, community values, terrain, geometric/design standards, crossing of features and costs. It can also integrate geo-referenced and topographical information from various engineering packages such as GIS and CAD programs, aerial photographs and route contour maps, and can perform noise modeling, energy consumption, and operation modeling conducive to the route selection process. The system uses an advanced Intelligent Transportation (IT) infrastructure and Quantm Integrator proprietary software (over the Internet) that links Quantm with local project planners establishing the design criteria unique to the roadway corridor or alignment. It also allows Quantm's Client Service Engineers to monitor initial runs to ensure that the planners are maximizing the benefits available from the system and to provide ongoing support. The Quantm system would be used on an appropriate corridor to compare current selection processes with the Quantum system.

Problem Statement

When evaluating variables in route selections for new construction projects, it is imperative that all the variables be comprehensively analyzed individually and in relation to each other. A system was needed to support infrastructure planners through the complex process of selecting alignments while confronted with a wide range of issues that include environmental protection, cultural heritage, community values, terrain, geometric/design standards, crossing of features and costs. It must also be capable of integrating technology from various packages such as GIS, noise modeling, energy consumption and operation modeling that will allow planners to utilize the information.

Objectives

This project will consist of, but not limited to, evaluating the most cost effective route selection within a corridor and maximize the number of variables considered in the selection process using the Quantm system.

Evaluation Background and Significance of Work

The Quantm system has enabled planners to deliver improved alignments (meeting design standards and environmental/urban constraints that were violated by the best alignments derived conventionally.) and substantially lower alignment construction costs. Typical alignment construction cost savings in excess of 20% have been achieved when compared to conventional industry best practice planning methods. Savings from 11% to 37% have been delivered where the system was restricted to vertically optimizing alignments that were horizontally fixed by environmental, social and urban constraints. Potential savings will allow the Department to maximize the number of variables considered in the route selection process.

Work Plan

A work plan was determined for the projects evaluation. An evaluation of this project by the project's planners would determine the potential for implementing the Quantm system on a continuing basis.

Phase 1: The subcommittee will determine the route to be considered in the project. The project will be approximately 7 miles in length.

Phase 2: The Quantm system will be acquired and Department personnel trained on the system.

Phase 3: The Department will send to Quantm available terrain data for conversion into a Quantm Digital Elevation Model.

Phase 4 Geometric constraints, geology, unit costs and associated data will be transferred via the Internet to Quantm Pathfinder.

Phase 5: Quantm Pathfinder costs and considers route options that meet the client-defined constraints before delivering a range (20-50) of "best option" alignments to the planner for review, using Quantm Integrator.

Phase 6: The centerline of the selected alignment can be exported into standard CAD packages for detailed design or to utilize the 3D visualization capability for line of sight analysis.

Quantm was contracted for evaluation on a construction project with a length no greater than 7.0-miles. An agreement was made to furnish into Quantm Integrator adequate data for the Technology to determine alignments for the Project, as defined in the Data Requirements Schedule and that Department personnel be trained in the Quantm system. Following the selection of an evaluation test location, preliminary planning design routes would be prepared and later compared to the Quantm design routes. At that time, an evaluation may be made on any imagined benefits, estimated time or costs savings the Department may have realized under this project.

Project Implementation

The 5.5-mile Highway 70 East to Highway 7 North Project in Garland County was selected for an evaluation test site. The Department began the process of providing all available, requested, foreseeable, and pertinent information relating to the proposed highway corridor. Included were geometric and geo-technical standards, geology data, linear features, urban developments, and known environmental, social and other special treatment zones and their crossing requirement unit costs.

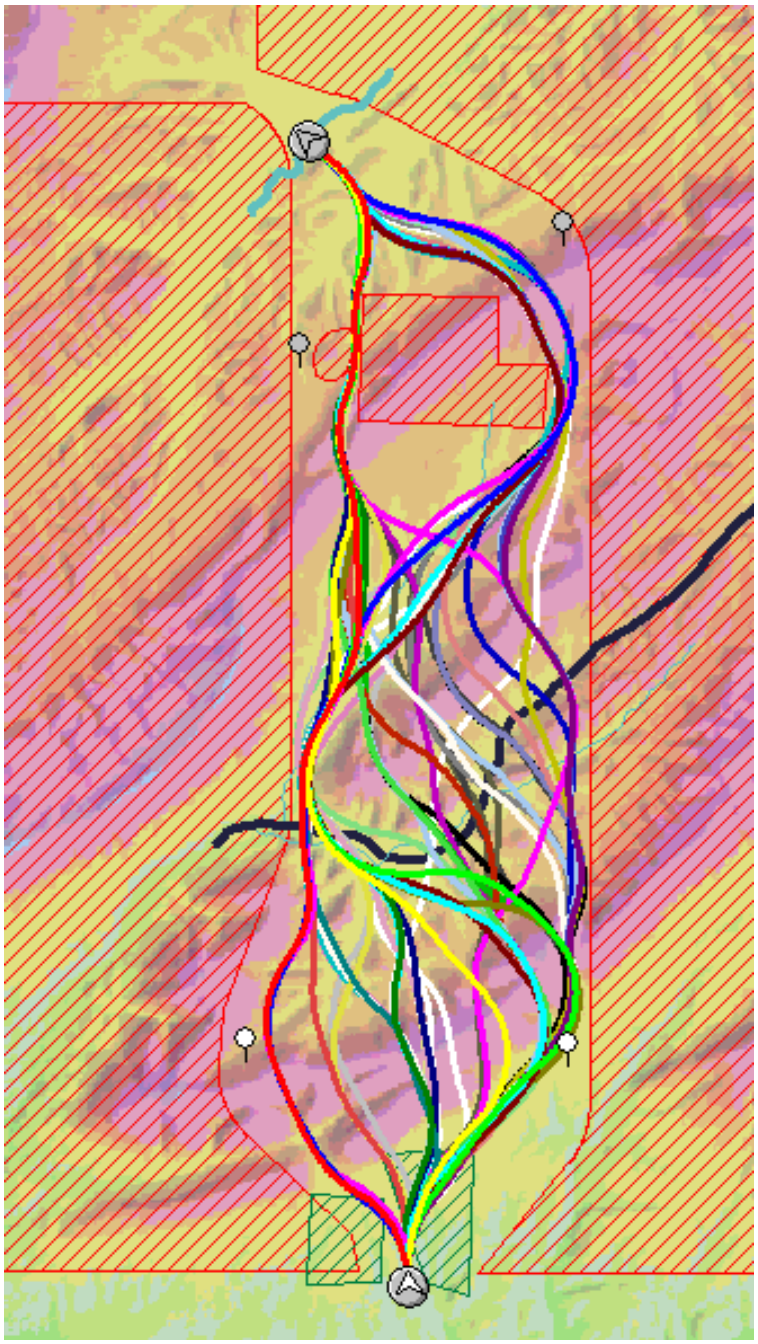
An initial comprehensive data requirements questionnaire was distributed within the Department to aid in gathering the necessary data. Although it was stated that not all the data was necessary prior to commencement of the project, the optimization process may have finished earlier had the information been available.

Planning involves many stages and the Quantm system can be used from feasibility (using just a Digital Terrain Model (DTM), simple geology, design parameters, costs, major features and any known avoid zones) through to detailed planning Environmental Impact Study (EIS) (with all of the data listed below). The system allows more detailed information to be added as the project proceeds through survey, consultation and environmental analysis. The question of compatibility with the Department equipment and possible conversion costs was raised and resolved when Quantm furnished Design files (DGN) compatible with MicroStation and GeoMedia.

The Quantm Integrator software was used by the Department planners for data entry, and communication by Internet with the Quantm Pathfinder (the alignment optimization engine based in Australia). Four Department computer locations were established for interfacing with the Quantm Integrator: (2) Environmental Division, Surveys Division, and the Statewide Planning Section of the Planning and Research Division. As new data became available to the Department, new criteria were

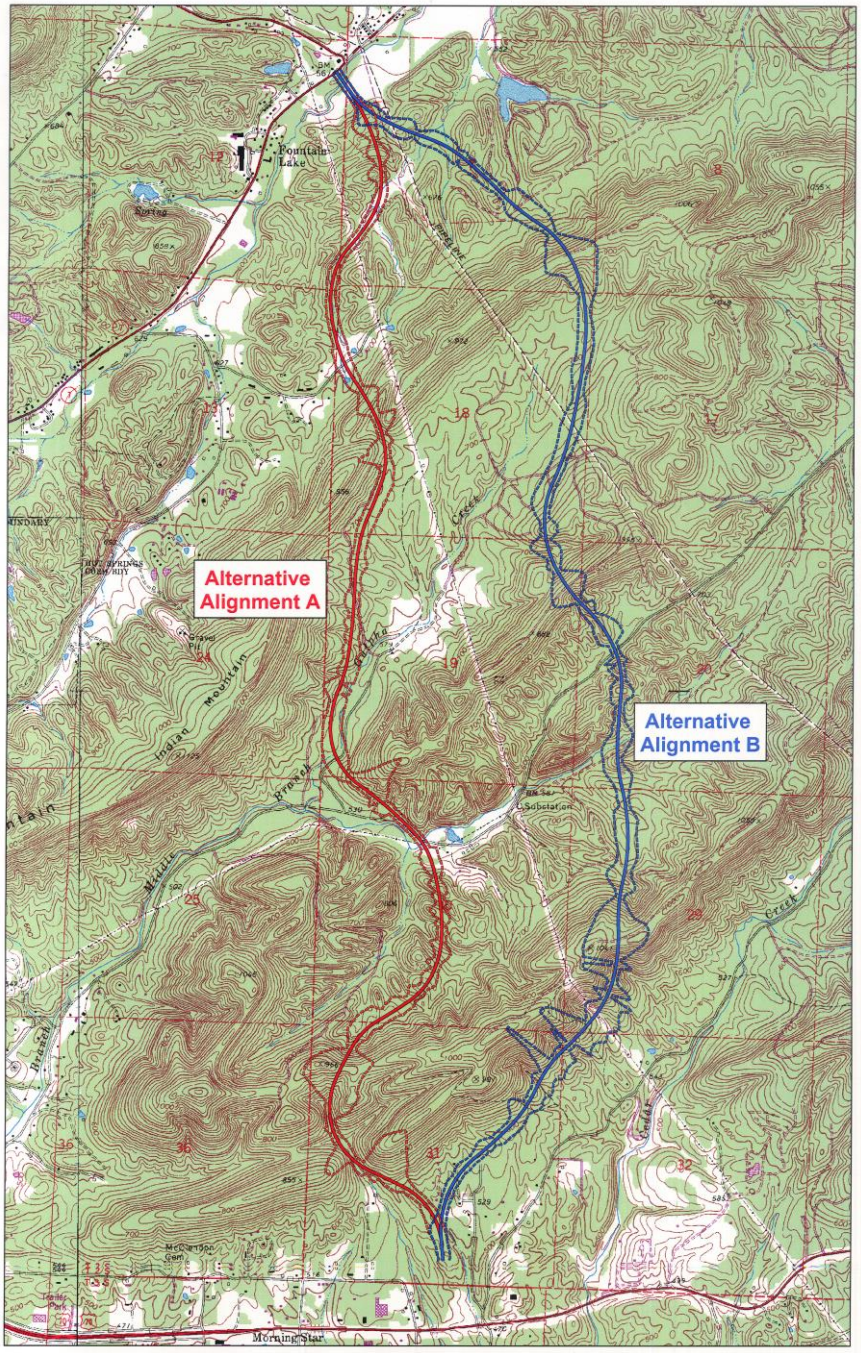
established for inclusion in the re-optimization process. It should be noted that the Integrator and Pathfinder process is on a timeshare basis and that substantial work is generally required and desired by the Department before the next optimization. After each optimization, a Project database was delivered on CD and or emailed for installation to the Department planners for review and assessment. A preliminary set of Quantm generated route locations by is shown below in Figure 2.

Figure 2



Using Quantm Integrator, the Department's planners were able to (1) conduct a local review of Quantm Pathfinder generated alignments to assess qualitative and quantitative properties of each option, (2) generate and output earthworks and costs reports, (3) display alignments on DTM, (4) generate aerial photographs, (5) generate cross section views and vertical profile views in a CAD program. Figure 3 shows Alternative A and B alignments near the end of the selection process.

Figure 3



Conclusion

The Quantm software provided a quick and methodical method of analyzing route selections. Minor changes in the design (optimizations) would be returned most times by the next day allowing for virtually a nonstop route selection process. Although it does not eliminate "field work", Surveys Division reported it reduces the amount of work the field crews would otherwise have had to perform. The Surveys, Environmental Division, and Statewide Planning Sections involved with the project's alignment have identified a number of the beneficial aspects associated with using the program.

- Minimized cut and fill costs of possible routes without the need to send personnel into the field
- Minimized linear feet of bridge while taking into consideration the costs of cut and fill
- Generated least cost alternatives based on geology, cut and fill, and possible bridge or tunnel requirements
- Minimized the requirement of walking routes that may not be utilized because of environmentally sensitive areas
- Allowed for environmental sensitive areas to be entered into the software for avoidance
- Allowed for quick and easy cancellation of certain routes and produced options that avoided areas entered into the software upon subsequent discovery
- Saved significant amount of personal hours in calculating costs associated with bridges along several routes at once
- Allowed for quick changes to be submitted to avoid high cost underground utilities found during the planning phase
- Allows for visualization by the public for better understanding

A comparison of Figures 1 and 2 (pages 2 and 7) indicate that much of the alignment was predisposed to follow the natural terrain as predicted by Department planners. Included with Quantm's preliminary results was the use of tunnels, but due to the high recurring maintenance costs of these structures, these were excluded from the preliminary design. The Quantm system was also used as a test simulator. Deviations from the Department's standard design criteria were introduced to determine if a more cost effective solution were possible for this type project. The simulated standard design deviations did not produce enough of a cost savings to warrant a design change.

However, Quantm system simulations could produce quick results on cut and fill costs by introducing minor realignments to Alternatives A and B. Accordingly, the accuracy of these costs and even the proposed alignments depended heavily on the accuracy of the data furnished by the Department and other GIS databases used by the project planners. For this reason, the final evaluations may also compare Quantm database information to the surveyed information for accuracy. Regardless, due to the promising results experienced from the project, further evaluation would be in order for additional projects with greater diversity in both complexity and length.