

# TRANSPORTATION ROUTING ANALYSIS GEOGRAPHIC INFORMATION SYSTEM—TRAGIS, PROGRESS ON IMPROVING A ROUTING TOOL

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## SUMMARY

The Transportation Routing Analysis Geographic Information System (TRAGIS) model provides a useful tool to calculate and analyze transportation routes for radioactive materials within the continental United States. This paper outlines some of the features available in this model.

## INTRODUCTION

About 20 years ago, Oak Ridge National Laboratory (ORNL) developed two models to assist in the analysis of transportation routes within the continental United States: HIGHWAY, which predicts truck transportation routes, and INTERLINE, which predicts rail transportation routes. In the past several years, the U.S. Department of Energy (DOE) has funded a project to enhance and transform the capabilities of the models into a geographic information system (GIS). This paper will discuss recent developments of the new TRAGIS model, its associated databases, and future plans for the system.

## TRAGIS CONCEPT

TRAGIS is designed to be a user-friendly, GIS-based transportation and analysis model. The older HIGHWAY and INTERLINE models are useful to calculate routes, but they cannot display a graphic of those routes. Many users of the older models have encountered difficulty in determining the proper node that identifies specific facilities and have been confused by or misinterpreted the text-based listing from the routing models. Because of these difficulties, some of the primary goals for TRAGIS are to improve the ease of selecting locations for routing, enable calculated routes to be graphically displayed, and providing for additional geographic analysis of the route.

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TRAGIS is written primarily in the Avenue™ and C++ programming languages and requires the use of ArcView™ software, which is marketed by Environmental Systems Research Institute, Inc. (ESRI). TRAGIS was developed in this way to take advantage of many of the GIS functions available with ArcView. Currently, TRAGIS operates on a Sun® UNIX platform running the Solaris™ 2.5.1, or later, operating system.

Currently, TRAGIS is developed to route using the following transportation modes: rail, truck, and waterways. The rail network used in the initial version of the model is the latest network database in the INTERLINE model. This database, developed for the Federal Rail Administration in the mid-1970s, is not a fixed-scale database and has been extensively modified since by ORNL. The truck database is a 1:100,000-scale database developed from the U.S. Bureau of Census Topologically Integrated Geographic Encoding and Referencing (TIGER) system. Information for the inland waterway systems is based on the 1:2,000,000-scale U.S. Geodata. Offshore deep-water routes are depicted in TRAGIS as straight-line segments. Plans exist to incorporate 1:100,000-scale databases to use in the model so that all modes are at a consistent scale.

## **FUNCTIONALITY OF TRAGIS**

One of the features of TRAGIS is that it has a consistent user interface between the transportation modes; that is, the same functions are used to run rail, truck, or waterway routes. However, some mode variations occur, such as prompts requesting the name of the railroad company to be used when shipping sites are selected for rail routing. Overall, when one portion of the TRAGIS system is learned, it will not be difficult to run other portions of the model.

TRAGIS allows one to select the origin and destination of a route by two methods: if the geographic location is known, the system can be used to zoom in on the site and select the node. Conversely, if a specific location is unknown, a location can be selected from a list of node names. Using this second method, the model displays a list of state abbreviations from which any one can be chosen. Next, a list of node names within that state is displayed from which any one can be selected. After selecting the node, TRAGIS identifies the selected node with its name. In addition to nodes for nearly every major city and intersection, TRAGIS databases contain hundreds of specialized nodes for nuclear reactors, DOE sites, military installations, and other important locations.

After an origin and destination are selected, the model is ready to calculate a route based on criteria established by option settings. A set of default criteria is active for each transportation mode in the model. When calculating a route, TRAGIS displays it on the screen as a bold line. A text listing of the route and population density information can be used as source data for RADTRAN or RISKIND risk analysis models.

The Options menu provides a mechanism to change various parameters used by the model for route calculations. Examples of some of the options include adjusting the penalty factors for the mainline classifications for rail routing, penalty factors for truck routing, using

preferred routes for radioactive materials for truck routes, and running alternative routes for the different transportation modes in TRAGIS.

The Modify menu provides functions that permit temporary modifications to the routing networks. Individual nodes and links can be graphically selected; conversely an area can be defined in which all nodes and links are blocked from the network. Individual states can also be selectively removed from consideration. In the rail network, the transfer penalties between different rail systems at interchange locations can be modified.

Multimode transport is also a capability of the TRAGIS model. Currently, only rail-water intermodal routing capability is active. To calculate a rail-water intermodal route, the intermodal transportation mode must be selected. Full intermodal routing capabilities will be developed in the future.

## **STATUS OF TRAGIS**

Beta testing of TRAGIS was completed during 1997 and the problems identified during the testing have been corrected. TRAGIS is now ready for distribution. A user's manual for TRAGIS has also been developed. The manual describes the capabilities and features of the model and provides specific directions for using the system.

## **EXAMPLES FROM TRAGIS**

This section provides several illustrations of how TRAGIS is used. The first example involves the development of a truck route between ORNL in Oak Ridge, Tennessee, and the Hanford Reservation in Washington state. First, the transportation mode must be selected. The Mode pull-down menu allows one to select between rail, truck, water, and rail-water. Truck was selected as the transportation mode for this example. Next, routing options were chosen. For this example the preferred routes for radioactive material option was selected. With this option, TRAGIS calculated a route that follows U.S. Department of Transportation regulations for the movement of highway route controlled quantities of radioactive material. These regulations specify that the shipment must follow the shortest path to an Interstate highway and then use the quickest route on an Interstate highway, using beltways around major cities. This example also placed a 15% penalty on the use of toll roads. (The effect of the penalty was to increase the distance of any toll road by 15%, making it less attractive.) After this, the Origin submenu was selected from the Route menu. Figure 1 displays a screen of the local area in the vicinity of Oak Ridge, Tennessee, with the node "ORNL" selected. TRAGIS displays the nodes of the database as small dots and the links are displayed as connecting line in different colors based upon the type of the highway. Upon careful examination, more than 25 nodes can be identified in the vicinity of ORNL, as shown on Fig. 1. Most of the government facilities have a node representing their location. Nodes exist at all junctions and other key locations along links. Next a destination (in this case, Hanford, Washington) was selected. After an origin and destination are selected, the route is calculated using previously defined criteria. After the route is calculated, TRAGIS

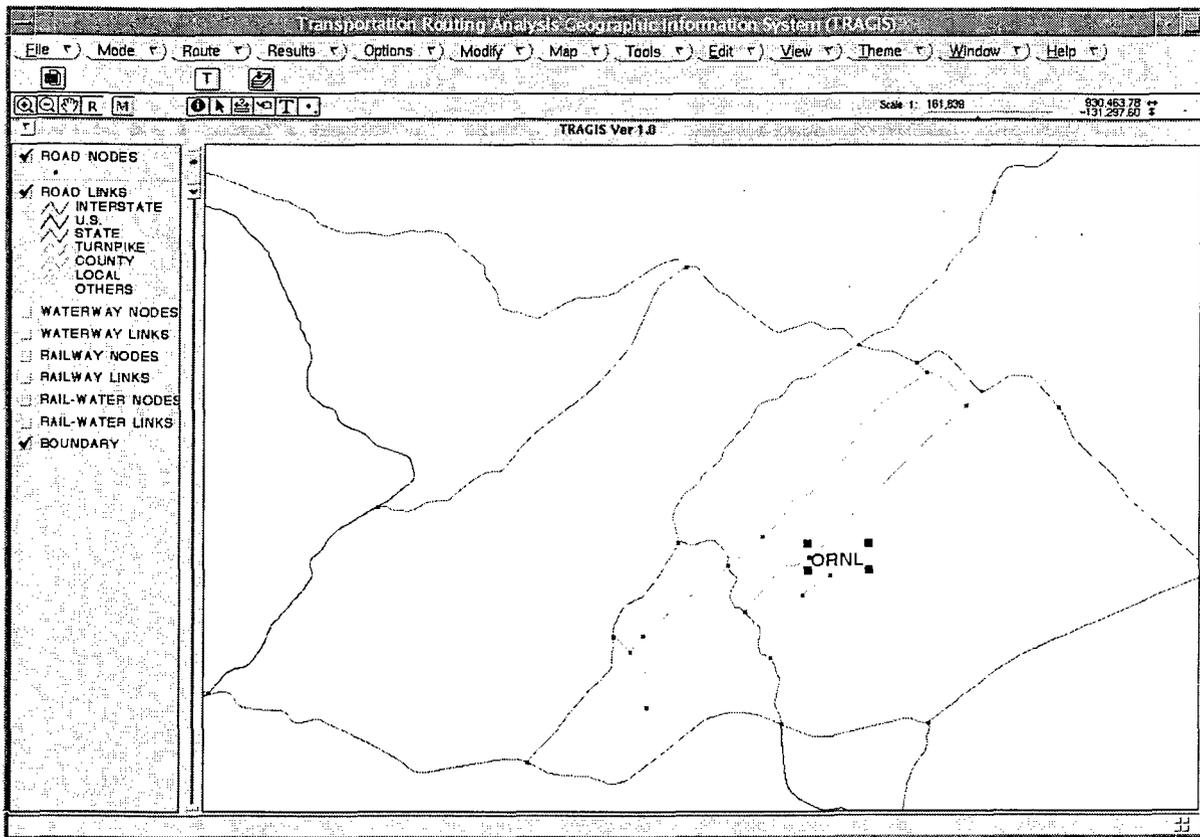


Figure 1. Example of selecting a node in the truck routing database.

displays the route, as shown on Fig. 2. At this point information can be gathered about the route using the Results menu. For example, either standard or detailed route listing can be selected. The standard route listing identifies those nodes where a change in a road name occurs. A detailed route listing provides the names of all nodes encountered along the route. Population density information is also available from the Results menu. Information is available on the length of the route within twelve different population density categories by state. A summary of the population density data by rural, suburban, and urban categories for use by the risk analysis models is also provided. Alternative route calculation is another feature of the TRAGIS model.

An alternative route can be calculated by penalizing previously used links by a specific amount (e.g., a default value for this distance penalty is an additional 10%). When the alternative routing option is selected, different penalty values can be entered. Figure 3 displays the original base route and the two alternative routes calculated by TRAGIS. Table 1 provides a summary of these three truck routes. Alternative 1 is actually shorter than the base route between ORNL and Hanford, but a portion of Alternative 1 is a toll road. Also, the driving time between these two routes is essentially identical. Alternative 2 is about 300 km longer than the other two routes and has a significantly higher proportion of the route in suburban and urban areas.

The next example demonstrates the rail routing capability of TRAGIS. The United States has many rail companies providing rail service in different areas of the country. In order to

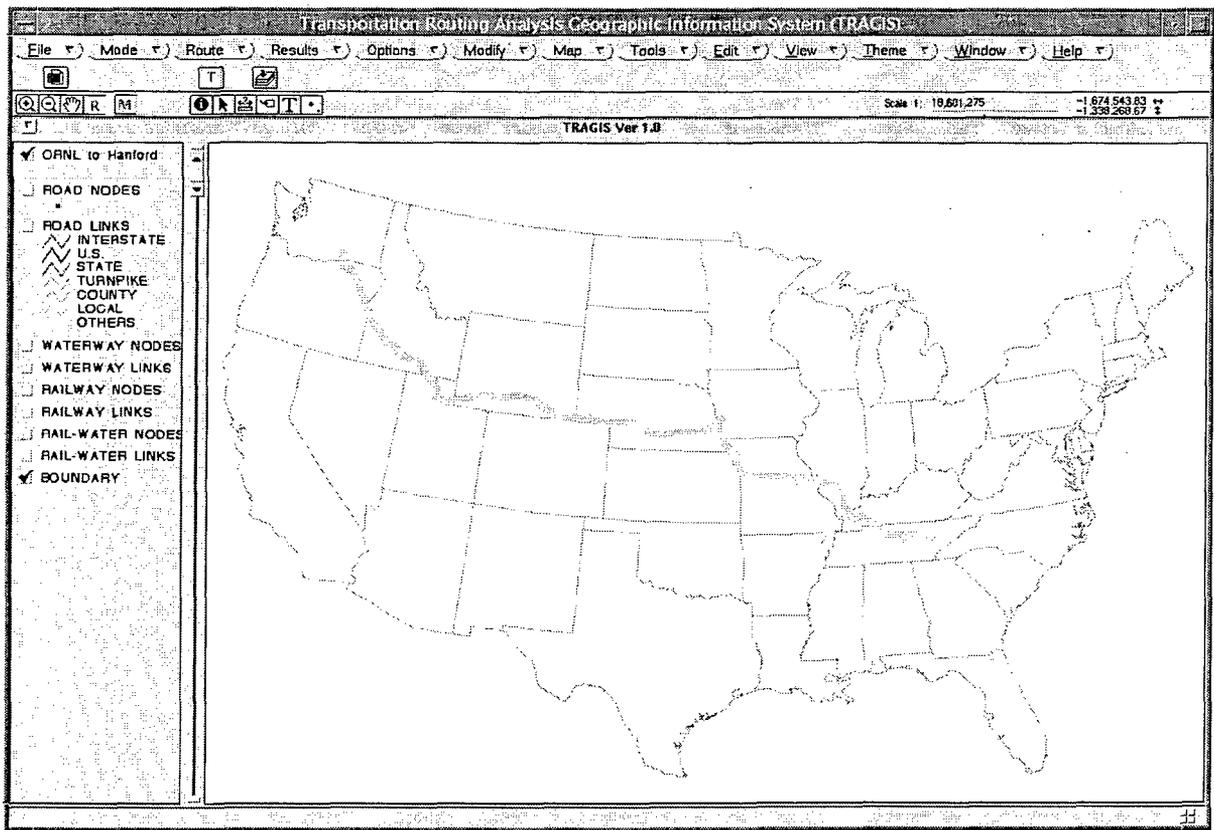


Figure 2. Example of a truck route from ORNL to Hanford.

simulate routing practices of railroads, each company is represented in the TRAGIS database as a separate system. Traffic can be interchanged between rail systems only at locations where transfers are permitted. The TRAGIS database identifies these interchange locations which are displayed on the network map with special symbols. Rail routes are calculated to maximize the distance traveled on lines with higher traffic volume. Line segments in the TRAGIS rail database are designated as A mainlines, B mainlines, A branchlines, and B branchlines, with A mainlines representing those lines with the highest traffic volume. A rail route is determined by multiplying the distance of each link by a factor based on the line classification of the link. An additional penalty is added to change from one rail system to

Table 1. Summary of truck routes between ORNL and Hanford

Route	Driving time, h:m	Distance, km	Percentage of route within		
			Rural	Suburban	Urban
ORNL to Hanford	43:53	4006.5	89.5	10.0	0.5
Alternative 1	43:51	3963.3	88.8	10.5	0.7
Alternative 2	47:41	4272.8	83.1	15.5	1.4

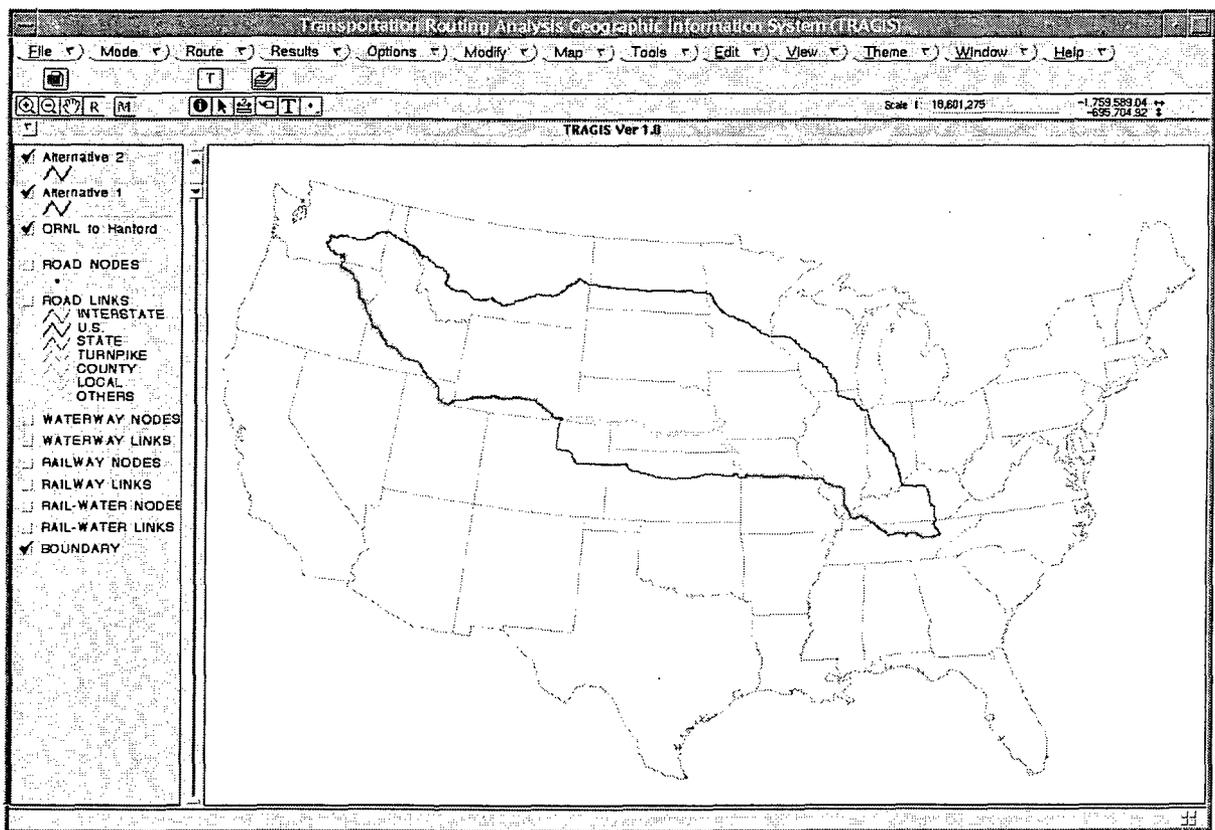


Figure 3. Example of alternative truck routes between ORNL and Hanford.

another. In this example, the origin selected is in the Oak Ridge, Tennessee, area with Norfolk Southern (NS) Railway as the originating carrier and the selected destination is Hanford, Washington, which is served by the Burlington Northern Santa Fe (BNSF) Railway and Union Pacific (UP) Railroad. An alternative route is also calculated between Oak Ridge and Hanford. Alternative rail route penalties are treated differently than are truck routing penalties. Previously used (base) links are penalized by 20% and the factors for interchange locations used in earlier routes are doubled. Figure 4 shows the two rail routes calculated for this example. The primary route uses NS to Chicago, Illinois, and then BNSF to Hanford. The alternative route follows NS to Kansas City, Missouri, and then uses UP to the Richland, Washington. Output data provides distance information as well as population density information on each rail system used.

Waterway routing is also available in TRAGIS. Inland waterways and deep-water routes connecting the Great Lakes, and the Atlantic, Gulf of Mexico, and Pacific coasts are included in the database. Lock and dam locations are included at node locations in the database. Currently, waterway routing is based on travel distance. For an example of TRAGIS waterway routing, a barge route between Knoxville, Tennessee, and the port of Tulsa, Oklahoma, is displayed in Fig. 5. This route follows the Tennessee River from Knoxville, Tennessee, to the Ohio River, and the Ohio River to Cairo, Illinois. From Cairo, the route follows the Mississippi River to the Arkansas River between Memphis, Tennessee, and Vicksburg, Mississippi, and then proceeds up the Arkansas River to the head of navigation at the port of Tulsa. Population density information is also available for

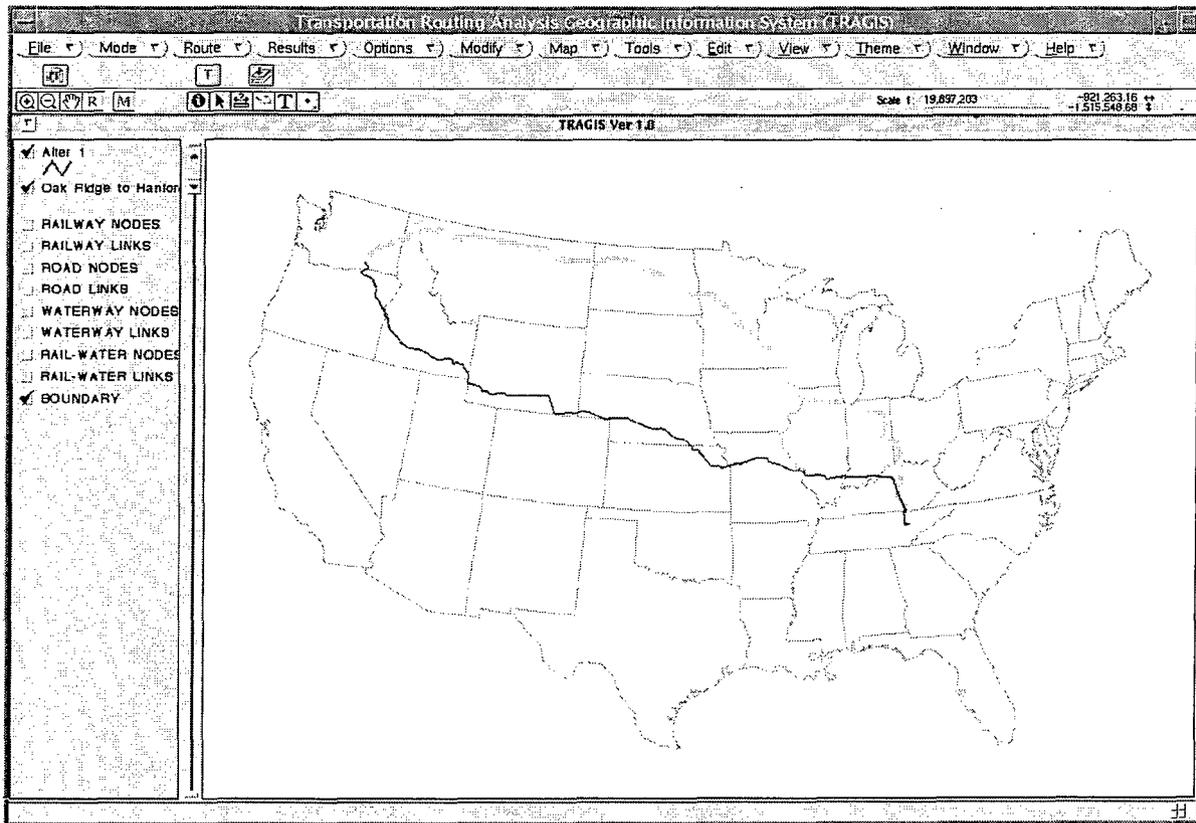


Figure 4. Examples of alternative rail routes between Oak Ridge and Hanford.

waterway routes. Data are calculated based on the centerline of navigation channels. Since many waterways form state boundaries, state by state population density information is not reported in TRAGIS.

### **FUTURE PLANS FOR UPDATES TO TRAGIS**

Currently TRAGIS operates only on Sun UNIX workstations. Because of cost considerations there are no plans to port TRAGIS to other workstations. In order to increase the availability of the system there are plans to port TRAGIS to the Microsoft® Windows™ environment. As an interim step, plans are to develop a tool called the Route Projection Module (RPM). RPM will be a world wide web application that will allow access to previously calculated TRAGIS routes. The plan is to store the graphic representation, route listing, and population density information for previously calculated routes. The system eventually will provide a capability to submit a request to TRAGIS to generate route information if the requested route is not stored in RPM.

Future development of TRAGIS will include a variety of enhancements, such as adding routing functions, intermodal capabilities, emergency responder locations, and airport facilities. Other databases, such as county boundaries, Native American Indian reservations, urbanized areas, and population data will also be made. Most of these data will be used primarily for display and analysis. Additional data will be added to TRAGIS to enhance its capabilities to perform analysis by incorporating factors such as environmental justice,

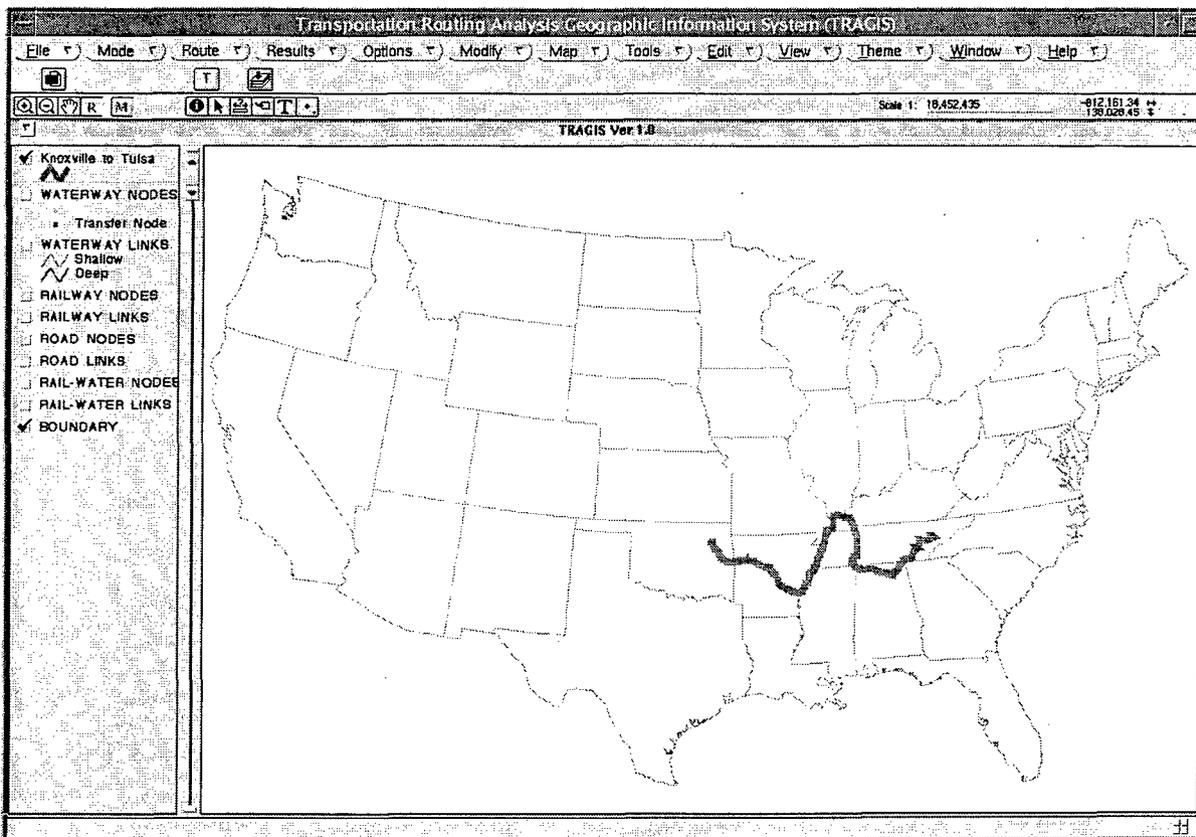


Figure 5. Example of a barge route between Knoxville, Tennessee, and Tulsa, Oklahoma.

emergency response facilities, etc. Future efforts will also include adapting enhanced network databases into TRAGIS to improve the information that the user can obtain from the system.

## CONCLUSION

TRAGIS has been developed to serve as a state-of-the-art, user-friendly routing and analysis tool for the DOE community and other interested parties. This model will help DOE perform route analyses for the expected increases in future movements of radioactive and hazardous materials.

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