Use of StateGEN for the Routing Analysis of Transporting Radioactive Materials

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INTRODUCTION

In January 1987, the Nevada State Legislature passed Assembly Bill No. 47. The bill required the Nevada Department of Transportation (NDOT) to develop plans for routing shipments of highway route controlled quantities of radioactive materials and high-level radioactive waste.

NDOT contracted the College of Engineering at the University of Nevada-Reno (UNR) to perform an analysis of the risks involved in the transportation of said materials. UNR proposed to investigate existing data bases and routing/risk models that could be used in the selection of the routes.

One of the eight routing/risk models investigated was StateGEN. UNR selected this model to identify alternative routes to transport the radioactive materials in Nevada.

STATEGEN MODEL

StateGEN is a routing model developed by the Transportation Technology Center at Sandia National Laboratories which is the Department of Energy's lead ortganization for transportation research and development (Cashwell 1987). StateGEN can be used in any compatible IBM PC. It is provided by Sandia in executable form on a 5-1/4 inch diskette.

The objective of the model is to assist users to develop highway networks that address local concerns about the transportation of radioactive materials (Erickson 1988). Three executable modules constitute StateGEN: 1) "Files" is

the primary StateGEN program. It allows the user to modify data in all the files. 2) "Routes" calculates a route between any origin and destination on the network by minimizing or maximizing a single parameter. 3) "Conting" inspects the data for proper operation of the routing algorithm.

StateGEN allows users to create a network of roads by defining nodes which are highway intersections on the network and by identifying the links which are the segments between the nodes. Once the network has been created, a dictionary file is developed to list the parameters (up to 30) of interest to the user (accident rates, population densities, etc). The user must then obtain data about each parameter and assign a numerical value to each link for each parameter identified.

The selection of alternative routes is based on minimizing or maximizing one of the parameters used in the network. The user selects origin and destination points, and the parameter that he/she wishes to minimize or maximize. Thus, several routes can be obtained between the specified origin and destination. StateGEN permits a modification to the network. Links in the network can be removed temporarily making that link unavailable to the routing algorithm.

The following information is reported for each route selected by the program:

- Parameter minimized or maximized
- Origin and destination
- Highways used
- Intersections (nodes) in order of travel
- Counties traveled
- Miles between intersections
- Total distance between origin and destination
- Summation of numerical values of each parameter
- Weighted average of the numerical values of each parameter

The user can select a route by comparing the parameters of all the alternative routes found by the model. In some cases, the summation of the numerical values of the parameter is appropriate for comparing the alternative routes (number of schools, hospitals, etc.) while in other cases, the weighted average, taking into consideration the distance of the alternative routes, is more appropiate (accident rates, ADT, etc.).

NEVADA'S NETWORK

The network created for Nevada contains most of the major highways in the state and is made up of 121 nodes and 159 links. Twenty six parameters were included in the network. These parameters can be divided into four categories.

1) Traffic characteristics:
Average daily traffic for all vehicles and trucks only, accident rates for all vehicles and trucks only, high accident locations, average speed and time of travel.

2) Roadway Characteristics:
Number of lanes, shoulder widths, critical grades, critical curves, railroad crossings at grade, structural capacity of bridges, pavement condition and surface type.

3) Special Facilities:
Hospitals, schools, fire stations and rest areas.

4) Environment:
Population densities, rainfall and snowfall per year, dust, crosswinds and flood prone areas.

Creating a Network

The first step in creating a network is to determine which roads to include for the analysis. Once this network has been established and mapped, it is divided into segments according to the user's wishes. Individual segments can be of any length and must be numbered systematically throughout the network. Usually, divisions are made at city limits. The reason for this is that in rural highways most of the values of the parameters are constant, but they change drastically in urban areas.

The beginning and ending points of each segment is what StateGEN calls "nodes." StateGEN provides a menu to enter information about the individual nodes. What is required here is the highway intersection of the node (I-80 and US 395), the name of the closest city and the county where this node is located. The "nodes" menu allows for addition, delition and editing of the individual nodes.

Once all the nodes are entered into the computer, the user goes to the "links" menu. What is required here is information about each segment between each set of nodes which includes a definition of the beginning and ending

points of each set of nodes (Reno to Sparks), the highway number connecting these two points and the distance between the two points. The "links" menu allows for addition, delition and editting of the individual links.

After all the information about the nodes and the links have been entered, the user needs to run a check to be certain that all links have valid nodes connecting them. This is accomplished by using the "conting" module provided by StateGEN. If errors are found, they must be corrected before entering the parameter data.

The user can now create files for each parameter (up to 30) using the "properties" menu. What is needed here for each parameter, is a numerical value for each link in the network. For detail explanations about StateGEN, see the user's manual (Erickson, 1988).

Assessment of Alternative Routes

The assessment of the risk to transport hazardous materials involves two equally important factors: accident probability and gravity of consequences (Rowe,1983). Therefore, risk assessments involve the measure of the probability of occurrence of an accident and the probability that certain consequences will result from the accident (Geysen, 1987).

Accident rates reflect the likelihood that a shipment will be involved in an accident (Saccomanno, 1987). The probability that an accident will occur has been defined as the accident history of the highway segment under consideration (Scanlon and Cantilli, 1985).

Truck accident rates reflect the probability that a truck will be involved in an accident. The likelihood that a shipment of radioactive materials will be involved in an accident is dependent upon the frequency of those shipments as a portion of total trucks on a segment of highway.

Assessment of the consequences requires estimates of the population-at-risk and incorporates population densities (Pijawka and Foote, 1985).

StateGEN identified several alternative routes in Nevada by minimizing the parameters used in risk assessments: accident rates and population densities. Truck accident rates were used in the analysis. An alternative route was also identified by minimizing distance which was used as a control. For example, if the route with least accident

rates is significantly longer than the shortes route, clearly, the route would not be a preferred route.

To select a preferred route, a comparison of all the parameters for the alternative routes was made.

CONCLUSION

StateGEN was selected because:

1) The model allows the user to create a network of roads specific to the user's needs. Therefore, he/she is not limited by someone else's network and database.

2) The model allows the user to include up to 30 parameters specific to the highways under consideration.

3) The model selects alternative routes by minimizing or maximizing a specified parameter. It is possible to find several routes between two points and to compare all the parameters for each selected route to determine the best route.

4) Creating a network of roads and inputting information about all the parameters is time consuming. StateGEN can be used in any IBM compatible PC. Therefore, there is no need to hook-up to a host computer, eliminating telephone charges.

5) Sandia National Laboratories is always ready to provide technical support. StateGEN was modified several times by Sandia in response to Nevada's requests.

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