U.S. DEPARTMENT OF ENERGY TRANSPORTATION PROGRAMS — COMPUTERIZED TECHNIQUES

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ABSTRACT

The U.S. Department of Energy is currently sponsoring the development of four specialized computer-based transportation programs at Oak Ridge National Laboratory. The programs function as research tools that provide unique computerized techniques for planning the safe shipment of radioactive and hazardous materials. Major achievements include the development of interactive rail and highway routing models, an emergency response assistance program, a data base focusing on legislative requirements, and a resource file identifying key state and local contacts. A discussion of the programs and data bases is presented, and several examples reflecting each project's applications to the overall DOE transportation program are provided. The interface of these programs offers a dynamic resource of data for use during preshipment planning stages.

INTRODUCTION

One of the major thrusts of the transportation programs at the Oak Ridge National Laboratory has been the development of a number of computerized transportation programs and data bases. The U.S. Department of Energy (DOE) is supporting these efforts through the Transportation Technology Center at Sandia National Laboratories and the Transportation Operations and Traffic Management (TOTM) organization at DOE Headquarters. Initially this project was centered on research activities. However, because these tools provide traffic managers and key personnel involved in preshipment planning with a unique resource for ensuring the proper movement of radioactive materials, additional interest and support have been generated from the operational arm of DOE.

The major accomplishments of these programs include the development of two routing models (one for rail shipments and the other for highway shipments), an emergency response assistance program, a data base focusing on legislative issues, and a resource file containing key state and local contacts. This paper discusses the most recent advances in, and additions to, these computerized techniques and provides examples of how they are used.

INTERLINE

INTERLINE (2) is an interactive program designed to simulate routing practices on the U.S. rail system. Because the rail industry is divided into a large number of independent, competing companies, INTERLINE decomposes the U.S. rail network into 95 separate subnetworks. Routing within each subnetwork is conducted independently in order to replicate the routing practices of an individual company.

The data base used by INTERLINE was originally obtained from the Federal Railroad Administration and reflected 1974 data. Consequently it has been extensively modified to reflect corporate mergers, correct errors, reflect line abandonments, incorporate new construction, and include line classification changes as railroads have modified and rationalized their routing practices since 1974.

An important element of the data base is the transfer file, indicating where traffic may move from one subnetwork to another. Because transfers between railroads involve additional cost and delay, penalties are assigned to these movements to replicate the tendency of traffic to remain on a single railroad's lines when possible.

The model finds the minimum impedance path between the origin and destination, which are identified by both the location and the railroad providing service at that point. Calculations are performed within the constraints imposed by line ownership, interchange locations between railroads, line classification, and originating railroad advantage. The INTERLINE program is designed to run as an interactive

program despite the large size of the network (approximately 17,000 links).

The user has the option of specifying a number of parameters in the routing, although defaults are provided to represent typical practices in the industry. By varying the parameters, the user can find alternative routes and examine the effect of restricting movement through specified areas, such as specific cities or specific railroad systems. Another important capability is the estimation of short-line mileages between points, which are distances that disregard the effects of competition among carriers and represent the basis of freight rate calculations using class tariffs.

Printed descriptions of routes are provided to the user at a terminal. A map of the route may also be produced, either at the terminal or offline, allowing the user to more quickly understand the implications of different scenarios or routing policies. A typical route map is shown in Fig. 1 for two possible routes from Richland, Washington, to Barnwell, South Carolina. The actual route used will depend on negotiations between the railroads and the traffic manager responsible for the particular shipment.

HIGHWAY

The HIGHWAY (3,4) program provides a flexible tool for predicting highway routes for transporting radioactive materials in the United States. The HIGHWAY data base is essentially a computerized road atlas that currently describes over 240,000 miles of highway. A complete description of the interstate highway system and all U.S. highways (except those that parallel a nearby interstate highway) is included in the data base. Most of the principal state highways and a number of local and county highways are also identified. Recent additions to the data base include local roads that connect nuclear facilities and major airports with the rest of the network.

Several different types of routes may be calculated, depending upon a set of user-supplied constraints. Routes are calculated by minimizing the total impedance between the origin and the destination. Basically, the impedance is defined as a function of distance and driving time along a particular highway segment. Several routing constraints can be imposed during the calculations. Frequently, routes are needed that bypass major population areas. A special data base has been added to the HIGHWAY model that depletes all highway segments located within urbanized areas containing over 100,000 people. Routes generated from this data base will not utilize any roads in these urbanized areas. Other commonly used constraints include the ability to calculate routes that maximize the use of the interstate highway system; routes that bypass a specific state, city, or town; or a specific highway segment.

The output generated by the HIGHWAY program includes a brief summary showing the origin, destination, departure and arrival times, estimated driving time, and total distance. The mileage driven in each state is also listed, along with the mileage traveled on the various highway types. A more detailed route description is also available that identifies each individual highway along with the points where the route enters and leaves the highway.

An application of the various routing options is shown in Figs. 2-4. A route between the Turkey Point reactor south of Florida City, Florida, and the Nevada Test Site, Nevada, is used in these examples. The route shown in Fig. 2 represents the most direct route. The second example (Fig. 3) is the route that would be used for the shipment of spent fuel, which must bypass a legislative restriction in Louisiana. In the third example, the route bypasses Flagstaff, Arizona, as well as the state of Louisiana (Fig. 4).

AIRPORT

The AIRPORT (5) locator program was developed to rapidly provide emergency response information for the DOE in responding to incidents that may involve radioactive materials. The program includes a data base listing approximately 3500 paved runways at airports in the continental United States that could be used in transporting specialized equipment and/or personnel to a particular site. The data base describes the major runways at each airport, including information on geographic coordinates, length, width, runway surface, runway weight-bearing capacity, and instrument approach capabilities.

The AIRPORT locator program is designed to find all the airports in the vicinity of a predetermined location which might represent the site of a transportation accident or an incident at a nuclear facility. The central position used for the search is a highway intersection derived from the HIGHWAY model. The airport locator program establishes a search window centered at this location, with approximate dimensions of 300 × 300 miles; all airports within the window that meet specified criteria are extracted from the data base. The line-of-flight distance between the airports and the central point is calculated, and the airports are listed in order of their distance from the center.

If desired, several constraints specifying airport capabilities can be included, and only the airports satisying these constraints will be reported. If no constraints are imposed, all airports within the window are considered. The user-specified constraints include minimum runway length, instrument approach capability, and aircraft landing weight.

Examples of two different airport searches are shown in Tables I andII. The central point for each search is Russellville, Arkansas. In the first example (Table I), no specific airport capabilities were imposed, and the ten major commercial or military airports closest to Russellville are identified. The airports are listed by driving time between the airport and Russellville. In the second example (Table II), only the airports capable of handling a C-5 aircraft are listed.

THE LEGISLATIVE AND REGULATORY INFORMATION SYSTEM

The Legislative and Regulatory Information System (LRIS), developed at Oak Ridge National Laboratory, operates as a computerized research tool for gathering and disseminating legislative and regulatory information that could affect the transportation of radioactive and hazardous materials. State and local government officials have expressed their concern through the adoption of specific transportation restrictions (e.g., requesting notifications to be made prior to shipment, requiring special permits and escorts, and completely banning shipments through certain areas, particularly large cities, and specific bridges, tunnels, and toll roads). The information contained in the LRIS has been organized into two specialized interrelated files, the Legislative Data Base and the Operational Restrictions and Emergency Response Contacts Data Base, which function as a unit. Data storage, information retrieval, and data base maintenance are handled through the INQUIRE data

Fig. 1. Typical rail routes from Richland, Washington, to Barnwell, South Carolina.

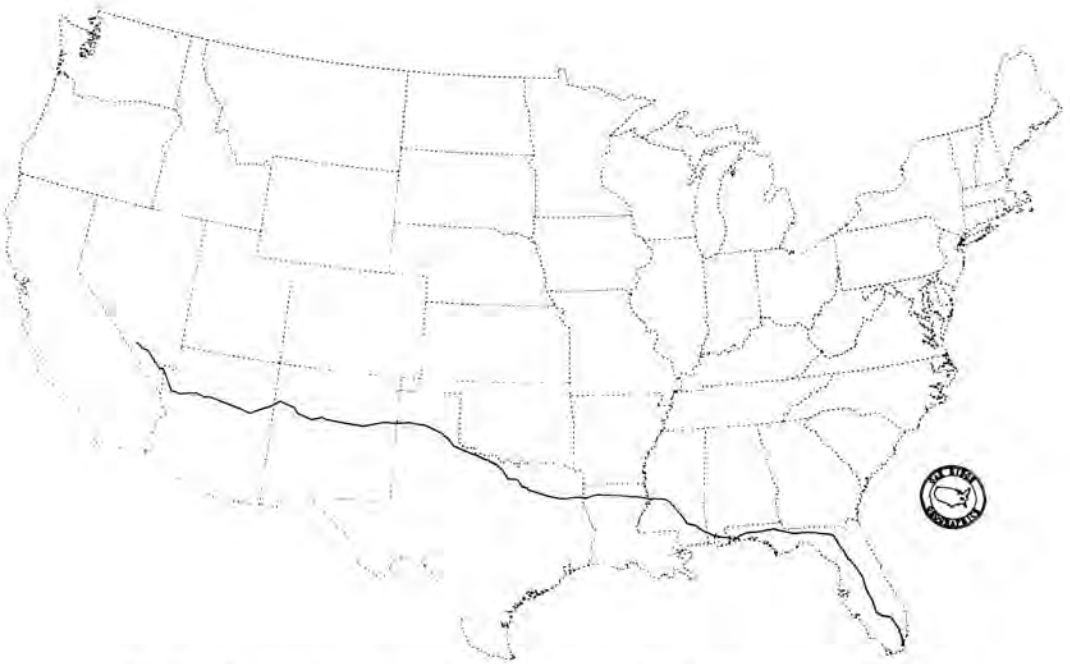

Fig. 2. Predicted truck route from southern Florida to southern Nevada.

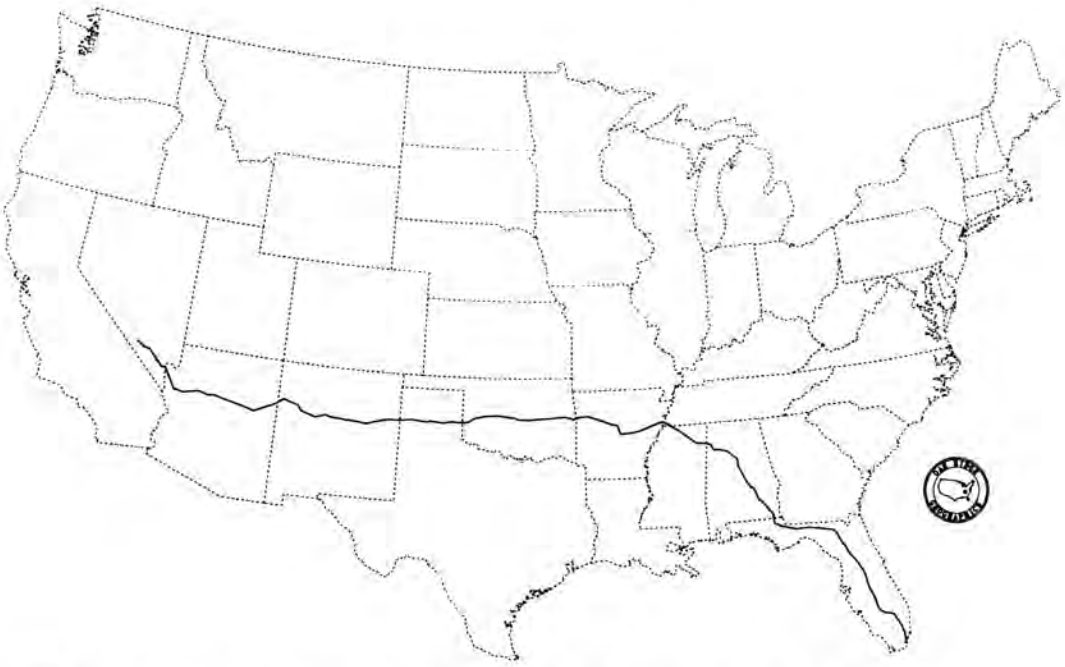

Fig. 3. Predicted truck route from southern Florida to southern Nevada bypassing Louisiana.

Fig. 4. Predicted truck route from southern Florida to southern Nevada bypassing Louisiana and Flagstaff, Arizona.

Table I Airports in the vicinity of Russellville, Arkansas

Airport	Location	Distance (mi)	Driving time (h)
LIT	Little Rock, Arkansas	82	1.53
FSM	Fort Smith, Arkansas	86	1.60
LRF	Jacksonville, Arkansas	92	1.78
FYV	Fayetteville, Arkansas	114	2.38
PBF	Pine Bluff, Arkansas	126	2.43
HOT	Hot Springs, Arkansas	76	2.53
BVX	Batesville, Arkansas	136	2.73
HRO	Harrison, Arkansas	90	3.17
CDH	Camden, Arkansas	171	3.43
TXK	Texarkana, Arkansas	210	3.87

Table II Airports in the vicinity of Russellville, Arkansas, that accommodate C-5 aircraft

Airport	Location	Distance (mi)	Driving time (h)
LRF	Jacksonville, Arkansas	92	1.28
TUL	Tulsa, Oklahoma	203	3.27
MEM	Memphis, Tennessee	215	3.48
NQA	Millington, Tennessee	228	4.32
TIK	Oklahoma City, Oklahoma	259	4.75
JLN	Joplin, Missouri	210	4.83
BYH	Blytheville, Arkansas	246	4.97
BAD	Shreveport, Louisiana	267	5.68
F39	Sherman-Denison, Texas	300	6.10
SZL	Knob Noster, Missouri	295	7.77

management system. (INQUIRE is the registered trademark of Infodata Systems, Inc., Rochester, New York.)

Legislative Data Base

One component of the LRIS, the Legislative Data Base (6-8), functions as a comprehensive information file that contains detailed data on federal-, state-, local-, and operational-level legislative and regulatory actions affecting the transportation of radioactive and hazardous materials. Because of their relevance to the transportation issue, actions involving areas such as disposal and storage of radioactive and hazardous wastes, moratoriums on power plant construction and siting, radiation safety and control, emergency response, and remedial action studies (i.e., decommissioning of surplus facilities) are also included in the data base.

The routine task of actively searching for newly introduced legislation on the federal, state, and local levels involves scanning a large variety of source literature as well as maintaining close communication with state officials for current actions of interest. As new information is received, the status of the legislative action is updated. Each entry is categorized as either pending, adopted, or denied. Those bills classified as having been denied are maintained in the data file along with the adopted laws for purposes of conducting trend analysis studies.

The data base consists of about 3000 entries that have been abstracted and indexed into a specialized format to provide a mechanism for storing, selectively searching, and documenting specific pieces of legislation. Thus, a user can easily identify and extract specific restrictions applicable to the transportation of radioactive materials anywhere in the United States. A sample record from the Legislative Data Base is shown in Fig. 5. This particular bill summarizes a law in the state of Virginia requiring a five-day prior notice (including route) for the shipment of hazardous radioactive material.

Directory of Operational Restrictions and Emergency Response Contacts

A second component of the LRIS that operates as a supporting tool to the overall program is the online directory highlighting those operational restrictions that prohibit or restrict the use of specific highways, rail lines, bridges, tunnels, and toll roads. The Operational Restrictions and Emergency Response (ORER) Contacts Directory Data Base (9,10) identifies the key state, county, or local contact agency/person responsible for the transportation of radioactive and hazardous materials through a particular jurisdiction. Emphasis was placed on determining the contacts in each state who are accountable for providing detailed information concerning operational restrictions encountered in the movement of radioactive and hazardous materials. These operational restrictions include acquiring permits; notifying proper state officials with the estimated route of shipment or requests for escorts; meeting weight limitations on particular bridges; and determining areas that have been banned from the shipment of these materials.

A second part of the directory pertains to the emergency assistance contacts identified for each state. In addition to the general contact information (name and address), a list of major emergency telephone numbers, any of which can be called on a 24-h basis, is provided for each type of material involved (e.g., hazardous or radioactive materials).

Approximately 1000 entries covering information collected for all 50 states, the District of Columbia, and the U.S. territories are currently in the directory. The data are organized to permit quick access to key contacts in a precise area of concern. Traffic managers can utilize the ORER Data Base during their preshipment planning to quickly determine any impediments along a particular route. In the case of an emergency incident involving either radioactive or hazardous materials, emergency response personnel can instantly identify the key state or local officials to be contacted for the specific type of material involved. A sample record from the ORER Data Base is shown in Fig. 6. This record identifies the fact that radioactive materials are banned from tunnels along the Pennsylvania Turnpike.

Development is under way to interface the LRIS with the HIGHWAY and INTERLINE routing programs at Oak Ridge National Laboratory. The transportation restrictions identified in the LRIS are currently being incorporated into the HIGHWAY Data Base. Knowledge gained through the interface of these programs will provide a unique tool in preshipment planning.

STATE		Virginia
LOCALE		State of Virginia
BILL NUMBER	(1)	VA-H01918
TITLE		Chapter 3.3, Transportation of Hazardous Radioactive Materials
CURRENT STATUS	(1)	Required 03/27/79
HISTORICAL STATUS	(1)	Introduced 01/22/79
	(2)	Committee (General Laws), Date Unknown
SPONSOR		Grayson; Diamonstein; Scott, R.C.; Dickinson; Murray; Michie
LEGISLATION TYPE		State
REFERENCE REPORT		None
SOURCE		Bill; NRC State Program Report dtd. 3/23/79; GA Newsletter dtd. 6/19/79; DOE-ORO Trans. Br. Chief
CATEGORY	(1)	Notify
MODE		Truck
REGION		SE; 2
KEYWORDS	(1)	RADIOACTIVE MATERIALS
	(2)	NOTIFICATION
	(3)	PROHIBIT TRANSPORTATION
	(4)	HEALTH DEPARTMENT
	(5)	HAZARDOUS MATERIALS
	(6)	DEFINITIONS
	(7)	EMERGENCY SERVICES OFFICE
	(8)	ROUTES
COMMENTS		Bill provides for defining of hazardous radioactive materials, requires 5 days prior notification (including proposed route), provides for approval of plans, and provides for notification of local officials along route. Directs the Office of Emergency Services to monitor the transportation of radioactive materials within the state. Approval would be supplied by the coordinator of the Office of Emergency Services.

Fig. 5. Legislative Data Base sample record.

STATE		Pennsylvania
LOCALE		Pennsylvania Turnpike
LEGISLATION TYPE		Operational
CATEGORY	(1)	Prohibit
	(2)	Permit
NAME		Clarence Wright, Safety Director
STREET		Administration Building, Highspire, P. O. Box 8531
CITY		Harrisburg
STATE CODE		PA
ZIPCODE		17105
PHONE		717/939-9551, ext. 222
EMERGENCY NO.		800/932-0586
COMMENTS		Shipments of hazardous materials (including radioactive materials) requiring placarding under the Code of Federal Regulations are prohibited from being transported through all tunnels on the Pennsylvania Turnpike System. The only exception to this regulation are shipments placarded: combustible, non-flammable gas, or fuel oil. Permits are required for these materials.
KEYWORDS	(1)	PROHIBIT TRANSPORTATION
	(2)	RADIOACTIVE MATERIALS
	(3)	PERMITS
	(4)	HAZARDOUS MATERIALS
REFERENCE MATERIALS	(1)	Pennsylvania Turnpike Map
CORRESPONDENCE		Phone call 8/82

Fig. 6. ORER Data Base sample record.

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