

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ORNL/TM-8419
TTC 0401
~~Limited Distribution~~

Contract No. W-7405-eng-26
CHEMICAL TECHNOLOGY DIVISION

ORNL/TM--8419
DE84 000541

NUCLEAR WASTE PROGRAMS
Traffic Manager Support
(Activity AR 05 10 05 K, ONL-WN08)

✓
HIGHWAY,
A TRANSPORTATION ROUTING MODEL:
PROGRAM DESCRIPTION AND USERS' MANUAL

D. S. Joy
P. E. Johnson
S. M. Gibson

NOTICE
This report contains information of a preliminary nature and was prepared primarily for internal use at the originating installation. It is subject to revision or correction and therefore does not represent a final report. It is passed to the recipient in confidence and should not be abstracted or further disclosed without the approval of the originating installation or USDOE Technical Information Center, Oak Ridge, TN 37830.

Date Published - December 1982

Work sponsored by Office of Defense Waste and Byproducts Management,
U.S. Department of Energy.

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

MASTER
DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

~~DISTRIBUTION OF THIS DOCUMENT IS LIMITED~~
No Automatic Distribution or Announcement
Refer all requests **ORNL**

leg
EEB

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	1
1. INTRODUCTION	1
1.1 Routing Model Development	1
1.2 HIGHWAY Data Base.	2
1.3 Naming Conventions Employed.	2
1.4 General Routing Considerations	4
1.4.1 Setting the routing criteria	4
1.4.2 Toll bias	5
1.4.3 Number of drivers	5
1.4.4 Routing constraints	7
2. HIGHWAY PROGRAM USERS' MANUAL	7
2.1 Using the ORNL Timesharing Option System	7
2.2 Making the Computer Connection	8
2.3 The Procedure for Logging-On	9
2.4 Executing the HIGHWAY Routing Program.	11
2.4.1 KEYWORD commands	14
APPENDIX	43

HIGHWAY,
A TRANSPORTATION ROUTING MODEL:
PROGRAM DESCRIPTION AND USERS' MANUAL

D. S. Joy
P. E. Johnson
S. M. Gibson

ABSTRACT

A computerized transportation routing model has been developed at the Oak Ridge National Laboratory to be used for predicting likely routes for shipping radioactive materials. The HIGHWAY data base is a computerized road atlas containing descriptions of the entire interstate highway system, the federal highway system, and most of the principal state roads. In addition to its prediction of the most likely commercial route, options incorporated in the HIGHWAY model can allow for maximum use of interstate highways or routes that will bypass urbanized areas containing populations >100,000. The user may also interactively modify the data base to predict routes that bypass any particular state, city, town, or specific highway segment.

1. INTRODUCTION

1.1 Routing Model Development

A routing model has been developed at the Oak Ridge National Laboratory in support of the Waste Transportation Studies sponsored by the Department of Energy (DOE) through the Transportation Technology Center (TTC) at Sandia National Laboratories and through the Transportation Operations and Traffic Management (TOTM) organization. Initially, a commercially available routing model and a highway data base (COMPU.MAP) was purchased from Logistics Systems Incorporated, and the computer programs associated with COMPU.MAP were completely rewritten at Oak Ridge National Laboratory (ORNL). The new routing model, HIGHWAY, provides a flexible tool to be used in predicting highway routes for transporting radioactive materials. The proprietary COMPU.MAP highway data base was retained as part of the HIGHWAY model; however, it has been carefully checked for accuracy and substantially modified to include locations of specific interest to DOE and its contractors.

1.2 HIGHWAY Data Base

The HIGHWAY data base is essentially a computerized road atlas that currently contains more than 17,000 highway segments and 12,000 intersections. 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. Data included for each highway segment are: highway designation, distance between end points, estimated average driving speed, and whether a toll is charged.

1.3 Naming Conventions Employed

The highway naming convention for the model uses the first letter of the highway name to identify the road as follows:

I = Interstate highway (i.e., I40, I75);

U = U.S. highway (i.e., U66, U30);

S = State highway (i.e., S147, S1);

T = Turnpikes that are not part of the interstate highway system

C = County roads; and

L = Local roads.

Toll roads are followed by a \$ sign (i.e., I35\$), and a pound sign (#) is used to indicate that a toll bridge is included in a highway segment.

All highway intersections are named; any name which is not followed by a directional and/or an intersection modifier is located in the center of a city or town. Other intersections located in the vicinity of a town will be followed by a direction modifier (such as N, S, W, NW) and generally will also include an intersection description (e.g., I35, U64). Fig. 1 illustrates the highway and intersection naming convention used in the HIGHWAY program.

The example shows a section of the highway network in the vicinity of Stillwater, Oklahoma. Interstate 35 (I35) is the main north-south highway, and there is a junction with U.S. 64 (U64) located west of the

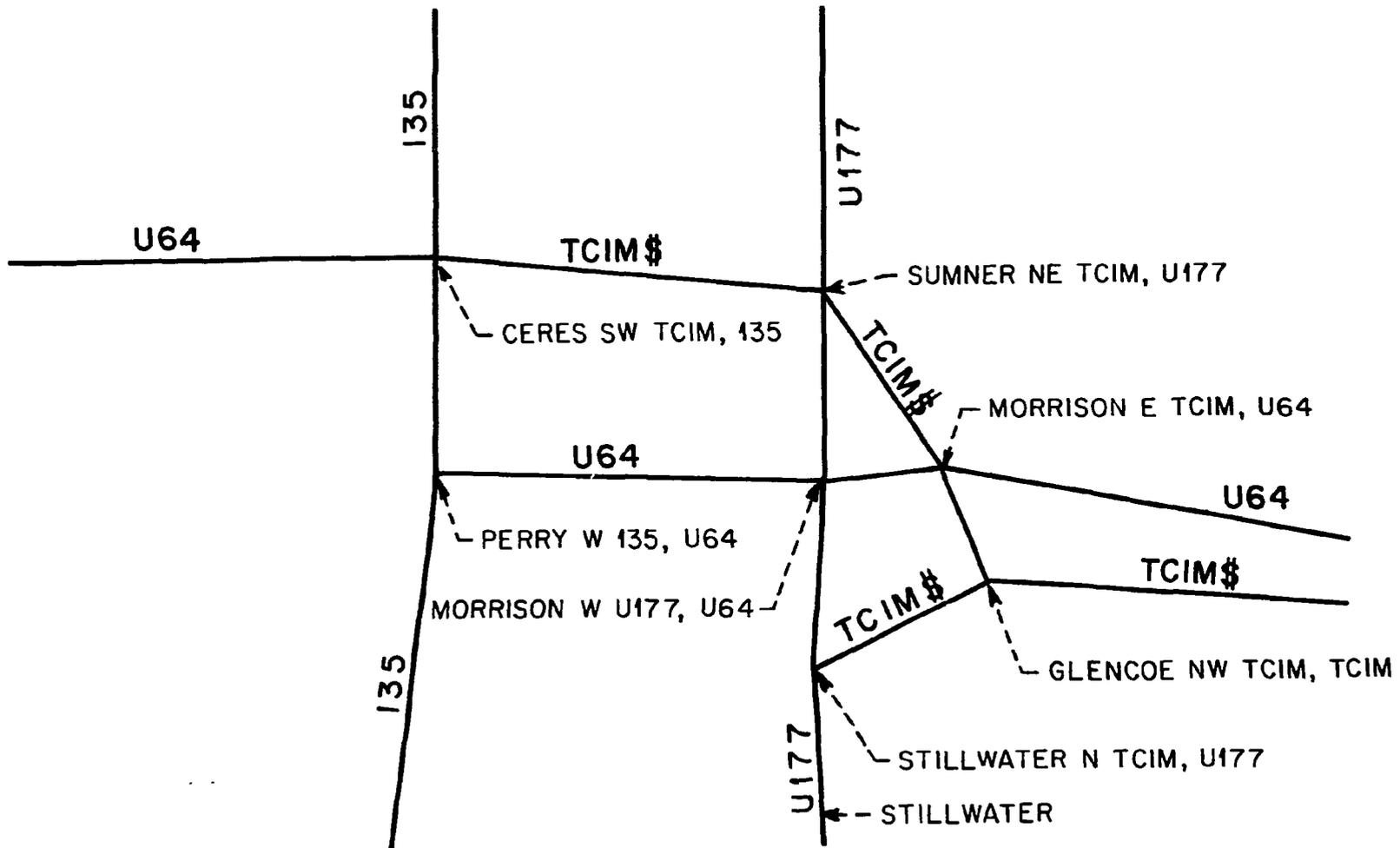


Fig. 1. Example showing highway and intersection naming conventions.

town of Perry, Oklahoma. This intersection is labeled PERRY W I35, U64, showing the nearest town, Perry; location of the intersection, west; and the junction of Interstate 35 and U.S. Highway 64. It will be noted that there are two junctions in the vicinity of Morrison, Oklahoma. The junction of the Cimarron Turnpike and U.S. 64 (MORRISON E TCIM, U64) is east of Morrison, and the junction of U.S. 177 and U.S. 64 is west of Morrison (MORRISON W U177, U64).

The Cimarron Turnpike is a toll road and is identified by the symbol TCIM\$. The T indicates that it is a turnpike and the \$ that a toll is charged for its use. The other roads shown in Fig. 1 are toll-free.

1.4 General Routing Considerations

1.4.1 Setting the routing criteria

Several different types of routes may be calculated, and each route type can be constrained to follow certain criteria. 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 segment, and the program calculates the set of links between the origin and the destination that minimizes these factors:

$$L = \text{Min} \sum_i (\alpha D_i + \beta T_i), \quad (1)$$

where D_i = distance of segment i , miles; T_i = time required to travel along segment i , min; α = distance modifier; and β = time modifier.

By varying the values of the time and distance modifiers, different types of routes can be predicted. For example, if $\alpha = 1.00$ and $\beta = 0.0$, the shortest possible route will be calculated. Setting $\alpha = 0.0$ and $\beta = 1.00$, the quickest route will be estimated. A compromise between these extremes is the "practical" route, where α and β are defined to be 0.3 and 0.7, respectively. This is the criterion used in verifying the routes predicted using the HIGHWAY model with actual trucking routes used for a number of DOE shipments. The user can select any combination of distance and time modifiers desired by simply defining the value of β . The distance modifier is then automatically set by Eq. (2):

$$\alpha = 1.0 - \beta, \text{ where } 0 \leq \beta \leq 1. \quad (2)$$

Theoretically, the criteria outlined above could produce different routes between any two points. However, in actual practice two or occasionally all three of the criteria will produce identical routes. Figure 2 shows a set of routes generated between Morris, Illinois and Richland, Washington, using the various routing criteria. In this example, the quickest and most practical routes are identical, following I-80 west across Iowa, Nebraska, Wyoming, and Utah for a distance of 1943 miles and an estimated driving time of 36 h 46 min. The shortest route follows a more northerly path through Minnesota, North Dakota, and Montana, covering a distance of 1879 miles. While the shortest route is 64 miles less than the practical route, the estimated driving time is 41 h 2 min, or 4.25 h longer than the practical route.

The "practical" routing criterion, with its compromise between the shortest time and distance, closely approximates the most likely commercial routes used by various trucking companies.

1.4.2 Toll bias

The use of toll roads and/or toll bridges can be controlled by the toll bias. Routes calculated with a large value of the toll bias will avoid all toll roads. Setting the toll bias to zero does not place any special penalty on the use of toll roads; in such cases, toll roads and other highways are treated equally. The default or normal value of the toll bias is 1.15. This will generally exclude the use of toll roads, unless a significant advantage can be gained by using one.

1.4.3 Number of drivers

The estimated time of travel is reported for each route. Normally, times are based on a two-driver team where a shipment is assumed to move for 4 h, then stop for a 0.5-h break. This cycle is repeated until the destination is reached.

The user has the option of specifying a single driver, and in this case the shipment is assumed to move for 5 h, stop for a 0.5-h break,

ORNL DWG 82-1002

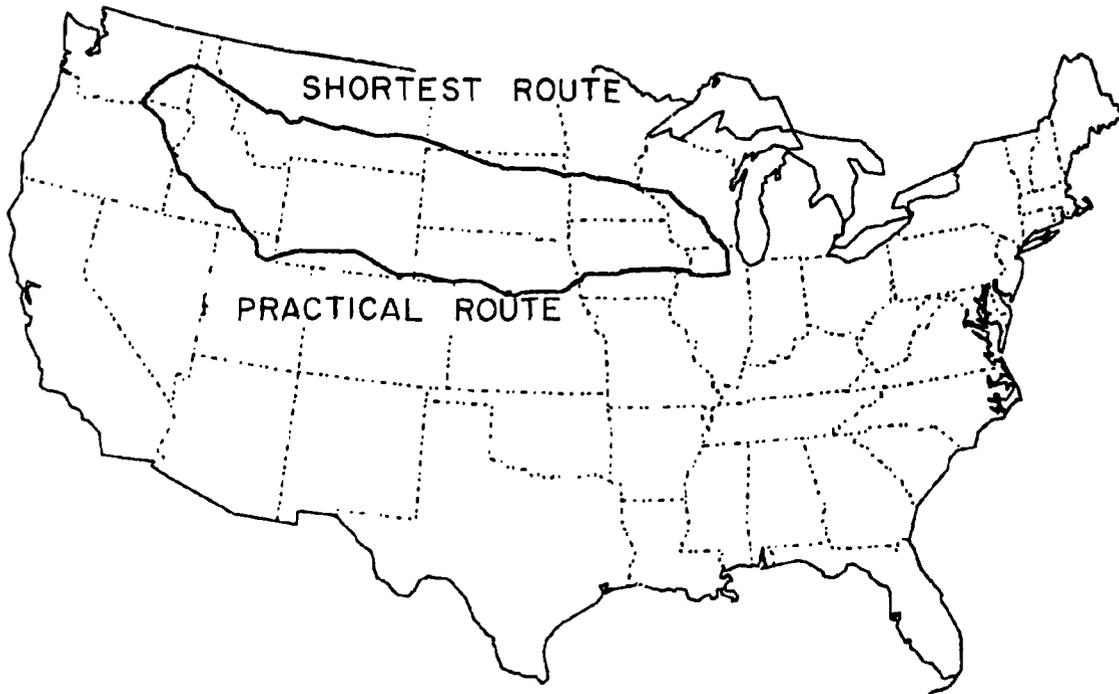


Fig. 2. Comparison of the fastest ("practical") and the shortest route between Morris, Illinois, and Richland, Washington.

and move for an additional 5 h, after which an 8-h break is taken. This pattern is repeated until the destination is reached. The number of drivers does not change the estimated route, but it does affect the time required to make a particular shipment.

1.4.4 Routing constraints

In addition to the route type criteria already discussed, several additional constraints can be imposed during the calculations. Frequently, routes are needed which bypass major population areas. A data base has been added to the HIGHWAY model which deletes 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.

Another commonly used constraint is one which will maximize the use of interstate highway systems. This does not require the use of a special data base. A highway modifier is defined in the model for each type of highway: (i.e., interstate, U.S., and state). Normally all highway modifiers are set equal to 1.0, but it is a simple matter to change these values. Routes which will preferentially follow the interstate highway system can be generated by setting all modifiers except the interstate highway modifier to another value, i.e., 2.0.

2. HIGHWAY PROGRAM USERS' MANUAL

This users' manual is designed to provide a complete description of the HIGHWAY routing model functions that can be performed with computer terminals outside of the Oak Ridge area. Additional program functions which are designed to use the specialized graphics equipment at ORNL are not included here.

The beginning user should completely master the procedures described for connecting with the computer and for executing the HIGHWAY program, the ROUTE command, and the STOP command before trying the other functions.

2.1 Using the ORNL Timesharing Option System

The HIGHWAY transportation routing program is run as an interactive program on Union Carbide Nuclear Division's IBM 3033 time-sharing option

(TSO) system, located in the Computer Sciences Division at the X-10 site. This is a time-sharing system, which means there usually will be a number of users connected to the machine at the same time; the speed of calculations is a function of the number of users. The interactive programs will present a series of questions on the terminal, and the answers supplied by the user will set up the conditions and give the necessary data for calculating routes over the U.S. highway network.

The HIGHWAY model has been designed to minimize the data input by the user. Any information typed by the user must be followed by a return (denoted as <CR>). This signals the computer that the typed statement should be processed. The TSO system does not have a type-ahead feature, so the user must wait for the question to be asked before supplying data. If a mistake is made, such as hitting the wrong key, the error can be erased by backspacing, and the correct information must then be reentered from that point to the end of the statement. Many terminals do not have a backspace key, but a control H will act as a backspace. A control H is typed by holding the control key (usually located on the left side of the keyboard) down while typing the letter H. Each time the H key is pressed, one character will be erased.

In some instances the spacing and punctuation of the input data are critical. This manual uses a <CR> to represent a return, and an @ to represent a blank space. Input data for the HIGHWAY model must be placed in the proper position on a line. For the few cases where several numbers must be placed in a specific location, a guide (consisting of dashes) will be typed. The appropriate numbers should be placed beneath the dashes; any blank spaces under dashes will be interpreted as zeros. It is advisable to place a number under each dash.

This manual will show all commands fully typed. Frequently the commands can be abbreviated to four or less characters. Table A.1, included in the Appendix, shows the acceptable abbreviations.

2.2 Making the Computer Connection

To access the HIGHWAY routing program, the user must first set up a communication channel with the computer. In these instructions, it is

assumed that the user will have a terminal similar to a Texas Instruments Silent 700. Other types of computer terminals can be used, provided the phone modem is Bell 212C compatible. The terminal should be turned on with the speed switch set to high (300 baud), the duplex switch set to half duplex, and the on-line switch set to on-line.

The phone numbers for the TSO system are: (Commercial) 615-574-7630 and (FTS) 624-7630. The phone will be answered with a whistle. As soon as the tone is heard, the phone should be inserted into the two rubber cups located at the back of the terminal. Note the direction of the cord, as shown by a picture on the terminal or a sign indicating which cup is connected with the cord side of the phone receiver. After a few seconds, the green light in the lower right corner of the keyboard will light, indicating that a connection has been established between the terminal and the computer.

2.3 The Procedure for Logging On

To activate the TSO system, the user must type: ARLOGON <CR>. The notation <CR> represents the return button, which is the large red key on the right side of the keyboard. The computer will then ask for the LOGON ID. Each qualified user will be assigned a unique three-letter identifier to be used for this purpose. For the example shown in Fig. 3, the LOGON ID was DSJ. The second item requested is the password, which is an eight-character word. The area where the password must be typed is blocked out in Fig. 3. A special password will be assigned to each authorized user.

The user assigned to each account is responsible for maintaining the account ID and password. This information should not be divulged to anyone not authorized to access the HIGHWAY model.

Once the LOGON ID and password have been entered properly, the computer will finally respond with the word READY. At this point, the computer is ready to proceed with the user's request.

If either the LOGON ID or the password is not entered correctly, the user will be asked to repeat the procedure. A check should be made to assure the accuracy of all information before proceeding. If three consecutive mistakes are made, the user will be disconnected

```
ARLOGON
ACF82003 ACF2, ENTER LOGON ID-
DSJ
ACF82004 ACF2, ENTER PASSWORD-
■■■■■■■■
IKJ56455I DSJ LOGON IN PROGRESS AT 17:23:31 ON AUGUST 16, 1982
 WELCOME TO MVS TSO AT X-10
DSJ: LINE( 069 T1076) VOLUME(TSOLE2) TSO USERS(5) X10B 05:23.34PM
READY
```

Fig. 3. Typical procedure for logging on.

from the computer. Six errors in a single day will deactivate the account, and one to two weeks will be required to reactivate the account. If the password is lost, it will take approximately two weeks to have another issued.

2.4 Executing the HIGHWAY Routing Program

After the LOGON procedure has been completed, the word READY will be displayed on the terminal, and the user activates the routing model by typing:

```
EX@HIGHWAY<CR>
```

Please note the spacing, where the symbol @ is used to signify a blank space.

The computer will respond with a single question to determine which data files will be used during this session:

```
WILL YOU BE USING THE BLOCKED NETWORK? (YES/NO) >
```

The question must be answered with a yes or no. If the user wants to calculate routes which will bypass major metropolitan areas, the answer is YES<CR>. In most cases, bypassing major cities is not required, and the appropriate answer is NO<CR>. The computer will check to determine whether a personal work file has been established for the user. If such a file does not exist, one will automatically be created, and a message will be printed informing the user of any action taken. If a new file must be copied, there will be a pause of approximately 1 min at this point.

Figures 4 and 5 demonstrate how the HIGHWAY model is executed. In Fig. 4, the question was answered with a NO<CR>. The most general data base was used, and all highways in the data base were available for route selection. Figure 5 represents a special case where calculated routes are not allowed to pass through major metropolitan areas. The first question was answered with a YES<CR>. Note that a different master file was identified and a number of highway segments are deleted in this particular data file. These are the highway segments within the urbanized area of the cities containing a population greater than 100,000 and are not normally available for route selection.

EX HIGHWAY

HIGHWAY 1.3 SUPERVISOR PROGRAM 09/01/82 11:55:57

WILL YOU BE USING THE BLOCKED NETWORK? (YES/NO) >NO

FILES ARE BEING LOADED

```
* HIGHWAY 1.3 HIGHWAY ROUTING PROGRAM *
* OAK RIDGE NATIONAL LABORATORY      *
```

```
-----
HIGHWAY 1.3
-----
***   ***   ***   ***
***   ***   ***
***   ***
***
```

INPUT DATASETS FOR THIS RUN

T.DSJ17999.INDEX.HGWPGM3	- MASTER FILE
CHEMTRAN.PEJ17999.NAMESV2	- NODE NAMES
CHEMTRAN.PEJ17999.LINK.ATTRIB2	- LINK ATTRIBUTES
DSJ.RTESTATE.DATA	- STATE MILEAGE FILE
DSJ.ROUTE.DATA	- DEFAULT MAP FILE

INITIALIZATION COMPLETE - ENTER "HELP" FOR A KEYWORD LIST.

*** KEYWORD ***

Fig. 4. Execution of HIGHWAY model using the standard highway data base.

EX HIGHWAY

HIGHWAY 1.3 SUPERVISOR PROGRAM 09/01/82 11:57:56

WILL YOU BE USING THE BLOCKED NETWORK? (YES/NO) >YES

FILES ARE BEING LOADED

```
* HIGHWAY 1.3 HIGHWAY ROUTING PROGRAM *
* OAK RIDGE NATIONAL LABORATORY      *
```

```
-----
HIGHWAY 1.3
-----
***   ***   ***   ***
***   ***   ***
***   ***
***
```

INPUT DATASETS FOR THIS RUN

```
T.DSJ17999.INDEX.BLKHW3          - MASTER FILE
  **** FILE CONTAINS 7355 DELETIONS ****
CHEMTRAN.PEJ17999.NAMESV2       - NODE NAMES
CHEMTRAN.PEJ17999.LINK.ATTRIB2  - LINK ATTRIBUTES
DSJ.RTESTATE.DATA              - STATE MILEAGE FILE
DSJ.ROUTE.DATA                 - DEFAULT MAP FILE
```

INITIALIZATION COMPLETE - ENTER "HELP" FOR A KEYWORD LIST.

*** KEYWORD ***

Fig. 5. Executing HIGHWAY model to generate a route bypassing major metropolitan areas.

particular data file. These are the highway segments within the urbanized area of the cities containing a population greater than 100,000 and are not normally available for route selection.

2.4.1 KEYWORD commands

After the initial question pertaining to the appropriate data files has been answered, the following statement will be displayed:

KEYWORD

At this point, the program is ready to accept specific instructions defining the actions to be taken. Table 1 lists the valid responses to the KEYWORD statement in the order in which they are discussed in this section.

Table 1. Valid KEYWORD commands

HELP
ROUTE
REROUTE
OPTION
REMOVE
D NODE
D LINK
STOP

HELP. The HELP command will print a brief description of the KEYWORD command list. A copy of the output generated by the HELP command is shown in Fig. 6. The HELP command is a useful reminder of the proper instructions for a user who is familiar with the HIGHWAY model.

ROUTE. The ROUTE command, which generates a route from an origin to a destination, is the most frequently used command. Figure 7 illustrates a sample of the computer output generated during the ROUTE command and will be referred to repeatedly in this discussion. In order to completely define the parameters to be used during the routing calculations, a series of prompting statements will be displayed on the terminal during the execution of the ROUTE command. The first prompting statement is:

ENTER ORIGIN CITY/STATE OR <CR> TO END

*** KEYWORD ***
HELP

HIGHWAY 1.3 KEYWORD LIST
THIS IS A BRIEF SUMMARY OF THE COMMAND SYNTAX FOR THE ROUTING PROGRAM.

"ROUTE"	ACCEPT ORIGIN AND DESTINATION NODES AND GENERATE ROUTES.
"REROUTE"	GENERATE NEW ROUTE FROM LAST ORIGIN
"FIND"	EXAMINE CITY NAME FILE FOR GIVEN STRING (CITSTG/ST).
"OPTI"	RESET DEFAULT PROGRAM OPTIONS.
"D LINK"	DELETE LINKS FROM NETWORK.
"D NODE"	DELETE NODES FROM NETWORK.
"HELP"	TYPE THIS MESSAGE AT TERMINAL.
"REMO"	REMOVE OR REINSERT STATES INTO NETWORK.
"TRANS"	CHANGE INTERSTATE TRANSFER COSTS (NORMALLY 0).
"OUTPUT"	RETYPE LAST ROUTE GENERATED
"RESET"	RESET LINK FILE (UNDELETE LINKS AND NODES)
"FILES"	SHOW FILENAMES AND FILE STATUS
"STOP"	TERMINATE EXECUTION OF PROGRAM.

SEE THE HIGHWAY USERS MANUAL FOR FURTHER INFORMATION.

*** KEYWORD ***

Fig. 6. Using the HELP command.

*** KEYWORD ***
ROUTE

ENTER ORIGIN CITY/STATE OR <CR> TO END
OMAH/NE

1	OMAHA				NE	2	OMAHA		N	1680	U73	NE
3	OMAHA	S	I80	U73	NE	4	OMAHA		NW	1680	U73	NE
5	OMAHA	S	I480	I80	NE	6	OMAHA		SW	1680	I80	NE
7	OMAHA	W	I480	U6	NE	8	OMAHA		SW	I80	U275	NE
9	OMAHA	W	I680	U6	NE							

SELECT ORIGIN CITY

--
01

ENTER DESTINATION CITY/STATE
LAS/NV

1	LAS VEGAS		NE	I15	U93	NV	2	LAS VEGAS				NV
---	-----------	--	----	-----	-----	----	---	-----------	--	--	--	----

SELECT DESTINATION CITY

--
02

ENTER ROUTE TYPE, TIME BIAS, TOLL BIAS, DRIVERS (R/TTT/TT/D)

ENTER DEPARTURE DATE AND TIME (MM/DD/YY/HHMM)

<<ROUTING>>

FROM: OMAHA	NE	LEAVING :	5/10/82 AT 15:12
TO : LAS VEGAS	NV	ARRIVING:	5/11/82 AT 15:59

ROUTE TYPE: P WITH 2 DRIVER(S) TOTAL ROAD TIME: 24:48
 TIME BIAS: 0.70 MILE BIAS: 0.30 TOLL BIAS: 1.15 TOTAL MILES: 1295.0
 STATE MILEAGE:
 NV 82.0 AZ 29.0 UT 366.0 CO 464.0 NE 354.0
 MILEAGE BY HIGHWAY TYPE:
 INTERSTATE: 1260.0 U.S.: 35.0 STATE: 0.0
 COUNTY: 0.0 LOCAL: 0.0 OTHER: 0.0

CONTINUE WITH ROUTE LISTING? (Y/N)
Y

FROM: OMAHA	NE	LEAVING :	5/10/82 AT 15:12
TO : LAS VEGAS	NV	ARRIVING:	5/11/82 AT 15:59

ROUTING THROUGH:

0.0	OMAHA			NE	0.0	5/10/82 AT 15:12	
3.0	I480	OMAHA		NE	3.0	5/10/82 AT 15:15	
349.0	I80	BIG SPRINGS	S	I480 I80	NE	352.0	5/10/82 AT 21:34
180.0	I76	COMMERCE CITY	W	I25 I76	CO	532.0	5/11/82 AT 1: 4
3.0	I25	DENVER	N	I25 I70	CO	535.0	5/11/82 AT 1: 7
462.0	I70	SALINA		UT	997.0	5/11/82 AT 10:15	
35.0	U89	SEVIER		UT	1032.0	5/11/82 AT 10:56	
20.0	I70	COVE FORT	W	I15 I70	UT	1052.0	5/11/82 AT 11:26
243.0	I15	LAS VEGAS		NV	1295.0	5/11/82 AT 15:59	

*** KEYWORD ***

Fig. 7. Using the ROUTE command.

The user responds with the city and state of the origin or starting point of the route. City names may be spelled out completely or entered in an abbreviated form by deleting characters from the end. The city and state names are separated by a slash (/), and the standard two-letter post office abbreviations are used for states. Referring to the example in Fig. 7, the desired origin is Omaha, Nebraska, which was entered as

OMAH/NE <CR>

After the user has entered the appropriate city/state, a list of all cities in that state starting with the letters given will be displayed. In Fig. 7, nine highway intersections identified as Omaha were found. The user is asked to select a highway intersection in the origin city from this list when the following prompter is displayed:

SELECT ORIGIN CITY

--

For this example, the highway intersection in the center of Omaha was selected, which corresponds to the first entry of the origin city list. Hence, an 01 is the appropriate answer. A two-digit number is required as an answer for this question and must be typed under the dashes. If the listed origin city number is less than 10, a zero or a blank must be typed first. For numbers 10 or greater, simply enter the number. A number must be entered even if the origin city list contains only a single entry.

If the origin city list does not contain the desired entry, the selection process can be restarted by typing a carriage return (<CR>). After selecting an origin, the program will ask for the destination city/state:

ENTER DESTINATION CITY/STATE

Following the example in Fig. 7, the desired destination was Las Vegas, Nevada, which was entered as LAS/NV. Two highway intersections identified as Las Vegas are reported, and the second entry was selected by entering an 02 after the statement:

SELECT DESTINATION CITY

--

At this time the endpoint of the routes is defined, and the user will be asked for the routing criterion to be used. The following statement will be displayed on the terminal:

```
ENTER ROUTE TYPE, TIME BIAS, TOLL BIAS, DRIVERS (R/TTT/TT/D).
```

Here the user has some options with respect to the information to be entered. Each of the parameters has a predefined default value which will be used if no information is entered. The default values are listed on the first line of Table 2. Since these are the most frequently used values, the user simply has to enter a <CR>. If the user wishes to change the value of one or more of the parameters, the data for the appropriate parameters should be typed, leaving the rest of the data fields blank. Several examples showing appropriate responses are given in Table 2.

The final prompting statement is:

```
ENTER DEPARTURE DATE AND TIME (MM/DD/YY/HHMM)
```

The computer output includes a list of the dates and times the shipment is expected to reach various points along the route. Frequently the departure date and time are not important, and the user can simply enter a carriage return (<CR>) so that the computer will use the current time and date. Since the computer is located in the Eastern Time Zone, all times listed will be Eastern times. Times are expressed using a 24-h clock convention. Table 3 shows how the user would specify departure dates and times.

At this point a <<ROUTING>> statement will be displayed, which signifies that all questions have been answered satisfactorily and the routing calculations are being performed. The length of the delay before results are displayed on the terminal is a function of the number of users currently running programs on the TSO system and the particular origin and destination selected.

When the calculations have been completed, a brief summary will be printed showing the origin, destination, departure and arrival times, the route type, number of drivers, time bias, distance bias, toll bias, estimated driving time, and total distance. The mileage traveled in

Table 2. Typical route type responses

Route type ^a	Time bias	Toll bias	Drivers	Response ^b
P	70	1.15	2	<CR>
Q	100	1.15	2	Q<CR>
S	0	1.15	2	S<CR>
O	50	1.15	2	O/O50/<CR>
P	70	1.01 ^c	1	P/@@@/01/1<CR>
O	30	1.99 ^d	2	O/O30/99 <CR>
P	70	1.15	1	@/@@@/@/1<CR>

^aS = shortest, Q = quickest, P = practical, and O = other; default is P.

^b<CR> = return, and @ = blank space.

^cMinimum value allowed when answering this question.

^dMaximum value allowed when answering this question.

Table 3. Typical departure date responses

Date	Time	Answer
Current date and time		<CR>
May 26, 1982	Current time	05/26/82 <CR>
Current date	8:00 AM	@@/@@/@@/0800 <CR>
May 26, 1982	7:00 PM	05/26/82/1900 <CR>

each state is also listed, along with the mileage traveled on the various highway types. A sample output is shown in Fig. 7.

After the brief summary, the terminal will display:

CONTINUE WITH ROUTE LISTING (Y/N)

If a more detailed route description is needed, the user types: Y <CR>. If the data given is sufficient, the user types: N <CR>.

A sample of the detailed listing is also included in Fig. 7. The first line following the words: "ROUTING THROUGH" lists the origin and the departure date and time. Additional lines of information are printed for each time the highway designation for the route changes. For example, the second line of the output is interpreted as follows: The route follows I-480 for 3 miles to the intersection of I-480 and I-80, which is located south of Omaha. The cumulative distance is 3 miles and the expected time of arrival at this intersection is 15:15 (3:15 P.M.). The next line of the printout shows that the route then follows I-80 for 349 miles to the junction of I-76 and I-80, which is located southwest of Big Springs, Nebraska. The cumulative distance at this point is 352 miles, and the shipment would be expected to arrive at 21:34, or 9:34 P.M. The final line lists the destination, Las Vegas, Nevada, and the total distance, 1295 miles.

When the route listing is completed, the computer signifies that it is ready for the next command by:

KEYWORD

REROUTE command. The REROUTE command is extremely useful for generating a series of routes from the same origin. The first route must be calculated using the ROUTE command, but subsequent routes can be generated quickly with the REROUTE command, since all of the data calculated for the previous route are saved and reused in subsequent calculations. Because of the significant saving of computer resources by using calculations already performed, the user will notice an improvement in the response time.

With the REROUTE command, it should be noted that the routing parameters such as route type, time bias, toll bias, and number of

drivers cannot be changed. The values of these parameters are established during the last use of the ROUTE command and apply to all subsequent routes generated by the REROUTE command.

One other aspect which extends the usefulness of the REROUTE command is the route symmetry. Since the route between any two points is not a function of the direction traveled, the origin and destination may be reversed with no loss of information. For example, if a number of routes are needed from several different origins to a common destination, the REROUTE command may be used if the actual destination is considered as the origin for routing purposes. Whenever possible, the REROUTE command should be used to save computer costs and the user's time.

The prompting statements for execution of the REROUTE command are very similar to those for the ROUTE command, as shown in Fig. 8. The first statement is:

ENTER DESTINATION CITY/STATE

The user types the appropriate city and state abbreviation, as discussed for the ROUTE command. The same rules apply. The next prompter is:

SELECT DESTINATION CITY

--

Again, a two-digit number must be entered. The final prompting statement is:

ENTER DEPARTURE DATE AND TIME (MM/DD/YY/HHMM)

The user simply types a carriage return (<CR>) if the current time and date is desired. Actual dates and times can also be entered (see Table 3 for examples).

Figure 8 shows a continuation of the example given in Fig. 7, in which a route between Omaha, Nebraska, and Las Vegas, Nevada, was calculated. For Fig. 8, a route between Omaha and Idaho Falls was generated using the REROUTE command, since the origin is the same as that used in the previous run. Note that specification of the origin city, route type, time bias, and other parameters is not requested. By definition, the REROUTE option assumes the values specified in the last execution of the ROUTE command, i.e., values defined in Fig. 7.

*** KEYWORD ***
REROUTE

ENTER DESTINATION CITY/STATE
IDAH/ID

1	IDAHO FALLS	NW	I15	X119	ID	2	IDAHO FALLS	ID
3	IDAHO FALLS	W	I15	X118	ID			

SELECT DESTINATION CITY
--
02

ENTER DEPARTURE DATE AND TIME (MM/DD/YY/HHMM)

<<ROUTING>>

FROM: OMAHA	NE	LEAVING :	5/11/82	AT	9:50
TO : IDAHO FALLS	ID	ARRIVING:	5/12/82	AT	5:40

ROUTE TYPE: P WITH 2 DRIVER(S) TOTAL ROAD TIME: 19:51
TIME BIAS: 0.70 MILE BIAS: 0.30 TOLL BIAS: 1.15 TOTAL MILES: 1019.0
STATE MILEAGE:
ID 70.0 WY 494.0 NE 455.0
MILEAGE BY HIGHWAY TYPE:
INTERSTATE: 761.0 U.S.: 258.0 STATE: 0.0
COUNTY: 0.0 LOCAL: 0.0 OTHER: 0.0

CONTINUE WITH ROUTE LISTING? (Y/N)
Y

Fig. 8. Using the REROUTE command.

OPTION command. The OPTION command is used to set up all routing parameters and constraints. Eleven subcommands are defined to perform a number of operations. Several of the subcommands are described in this section.

Any parameters changed by the OPTION command remain in effect until further changes are made or until the calculation session has ended (i.e., until the phone connection is broken). When the user first executes the HIGHWAY program, all parameters are set to their most frequently used values.

To use the OPTION features, the user simply types OPTION <CR> after the KEYWORD statement. The computer will respond with

ENTER OPTION CODE

A list and a brief description of the OPTION subcommands will be printed when the user types only a carriage return (<CR>) as the option code. This list is shown in Fig. 9. Several of the parameters listed in Fig. 9 are designed for special applications at ORNL and should be ignored by the general user. These parameters are: print, detail, map prompt, deletion warning, output state mileage file for routes, and two-way link deletions. The subcommands controlling them are not discussed in this report.

The casual user will generally be interested in only the WE and RE subcommands; the other subcommands are useful to the more experienced user.

OP subcommand. The OP subcommand will print a list of the current default values for the routing parameters, as shown in Fig. 9. The toll bias, time bias for the various route types, and number of drivers have already been discussed. The default values shown in Fig. 9 are set when the model is loaded into the computer.

RO subcommand. The RO subcommand allows the user to redefine the time and distance bias for the four standard route types and to change the toll bias. The time bias and toll bias can also be changed during execution of the ROUTE command. However, those changes apply only to the route being calculated at that time, and the parameters will revert

*** KEYWORD ***
OPTION

ENTER OPTION CODE

OPTION CODES
RO ROUTE TYPE OPTIONS
DR NUMBER OF DRIVERS
PR PRINT ROUTES
DE DETAILED ROUTING
OP SHOW CURRENT DEFAULTS
MA PROMPT FOR MAP FILE
DL ALERT TO DELETED SOURCE OR SINK
WE ALLOW WEIGHTS FOR HIGHWAY TYPE IN ROUTING
ST OUTPUT STATE FILE FOR ROUTE
DI SET LINK DELETIONS 1 OR 2 WAY
RE RETURN TO CALLING PROGRAM

ENTER OPTION CODE
OP

<CR>

CURRENT DEFAULT VALUES FOR OPTIONS

TOLL BIAS FOR ALL ROUTES = 1.15
ROUTE TYPE TIME BIAS DIST BIAS
P 0.70 0.30
Q 1.00 0.0
S 0.0 1.00
O 0.50 0.50
NUMBER OF DRIVERS = 2
PRINT =F DETAIL =F
MAP PROMPT =F
DELETION WARNING =F
WEIGHT LINKS BY FUNCTIONAL CLASS =F
OUTPUT STATE MILEAGE FILE FOR ROUTES =T
2-WAY LINK DELETIONS =T

Fig. 9. OPTION commands.

to their default values after the calculations are completed. Using the OPTION command to change the time, distance, and toll bias redefines the default values for all routing.

After the user types RO<CR>, the following statement will be displayed:

CHANGE ROUTE WEIGHTS

The user must respond with YES<CR> or NO<CR>. A NO response will immediately skip to the toll bias question. After a YES response, the following question will be displayed:

WHICH ROUTE TYPE?

The user must respond with: P<CR>, Q<CR>, S<CR> or O<CR> (see Table 2 for the definitions of these route types). Then the computer will respond with:

ENTER NEW VALUE FOR TIME WEIGHT FOR ROUTE TYPE X

The user must respond with a three-digit number ranging from 000 to 100. The leading zeros must be typed. In the example shown in Fig. 10, the route type O (other) is to be changed, and the new time bias desired is 020. The letter X in the computer response will be either P, Q, S, or O depending upon the user's response to the first question. The next question asked is:

ENTER NEW TOLL BIAS?

and the user responds with YES<CR> or NO<CR>.

If a new toll bias is desired, the computer will request a new value:

ENTER VALUE

The response must be a three-digit number between 000 and 100; for example, 099 is shown in Fig. 10.

Only a single route type can be changed with each execution of the RO subcommand. Generally, the user would want to change only the other route type (O). If all route types are to be changed, the RO subcommand must be executed 4 times.

```
ENTER OPTION CODE
RO

CHANGE ROUTE WEIGHTS?
YES

WHICH ROUTE TYPE?
0

ENTER NEW VALUE FOR TIME WEIGHT FOR ROUTE TYPE 0
---
020

ENTER NEW TOLL BIAS?
YES

ENTER VALUE
---
099

ENTER OPTION CODE
DR

ENTER NUMBER OF DRIVERS
-
1

ENTER OPTION CODE
WE

ALLOW CLASS WEIGHTED ROUTING?
YES

HIGHWAY TYPE WEIGHTS
INTERSTATE: 1.00 U.S.: 2.00 STATE: 2.00
COUNTY: 2.00 LOCAL: 2.00 OTHER: 2.00
CHANGE WEIGHTS?

NO

ENTER OPTION CODE
WE

ALLOW CLASS WEIGHTED ROUTING?
YES

HIGHWAY TYPE WEIGHTS
INTERSTATE: 1.00 U.S.: 2.00 STATE: 2.00
COUNTY: 2.00 LOCAL: 2.00 OTHER: 2.00
CHANGE WEIGHTS?
YES

ENTER NEW VALUES FOR WEIGHTS - 0 TO RETAIN VALUE
INT US ST CO LOCL OTHER
-----
20. 20. 20. 20. 20.

ENTER OPTION CODE
OP

CURRENT DEFAULT VALUES FOR OPTIONS

TOLL BIAS FOR ALL ROUTES = 1.09
ROUTE TIME DIST
TYPE BIAS BIAS
P 0.70 0.30
Q 1.00 0.0
S 0.0 1.00
O 0.20 0.00
NUMBER OF DRIVERS = 1
PRINT =F DETAIL =F
MAP PROMPT =F
DELETION WARNING =T

WEIGHT LINKS BY FUNCTIONAL CLASS =T
OUTPUT STATE MILEAGE FILE FOR ROUTES =T
2-WAY LINK DELETIONS =F

HIGHWAY TYPE WEIGHTS
INTERSTATE: 1.00 U.S.: 20.00 STATE: 20.00
COUNTY: 20.00 LOCAL: 20.00 OTHER: 20.00

ENTER OPTION CODE
RE
```

*** KEYWORD ***

Fig. 10. OPTION subcommands.

DR subcommand. The number of drivers used to calculate travel time can be changed with this subcommand. The default value is 2 drivers (essentially around-the-clock driving). However, a single driver can be specified with this subcommand. Note that the number of drivers can be defined for a single route application as previously described on page 18. However, if a number of routes using a single driver are desired, this subcommand is very useful. The computer will respond with:

ENTER NUMBER OF DRIVERS

The user must respond with a 1<CR> or a 2<CR> (see example in Fig. 10).

WE subcommand. This is the most commonly used OPTION subcommand and is used to change the highway type modifiers, which control the type of road a route should follow. For example, if a route along interstate highways is desired, the highway modifiers for all noninterstate highways would be set to a larger value. Initially all highway type modifiers are given a value of 1.0. The first prompting question is:

ALLOW CLASS WEIGHTED ROUTING?

The user will respond with a YES<CR> or NO<CR>. A NO response will automatically reset all highway type modifiers to 1.0, and no further action is taken. After a YES response, the following information will be typed:

HIGHWAY TYPE WEIGHTS

INTERSTATE: 1.00 U.S.: 2.00 STATE: 2.00
COUNTY: 2.00 LOCAL: 2.00 OTHER: 2.00
CHANGE WEIGHTS?

The highway type weights are a recommended set of values for the highway type modifiers used in estimating routes which preferentially follow interstate highways. The user is expected to respond with a YES<CR> or NO<CR>. A NO response will accept the predefined set of highway type modifiers, and no further action is required. A YES response indicates that the user wishes to define a different set of values for the highway type modifiers. The computer response will be:

ENTER NEW VALUES FOR WEIGHTS _ 0 TO RETAIN VALUE

INT	US	ST	CO	LOCL	OTHER
-----	-----	-----	-----	-----	-----

The user must enter the desired values. Note that a decimal point is required and that the displayed pattern indicates where the numbers must be typed. In the example shown in Fig. 10, the predefined set of highway modifiers was changed. A value was not entered under the interstate highway type (INT), which has the same effect as entering a zero and specifies that the value already defined (1.00) for interstate highways will be used. A value of 20. was entered for all other highway types. (Note the spacing and inclusion of the decimal point.)

RE subcommand. The RE subcommand indicates that no additional changes are needed and returns the program to the KEYWORD statement.

Summary of parameter changes. Figure 10 illustrates changes made in several parameters. In this figure a second OP subcommand was typed, and the resulting output lists the current values of the parameters, showing all changes that have been made. The time and distance bias for the "other" route type (O) are set to 0.20 and 0.80, respectively; the toll bias is now 1.99; and a single driver is assumed. The highway type modifiers are also shown, since some of them have a value other than 1.00.

REMOVE command. The REMOVE command is one of three commands that can be used interactively to alter the highway data bases. The other two commands, D NODE and D LINK, will be discussed in following sections. The REMOVE command is used to delete an entire state from the data base, or to reinsert a state which was previously deleted.

At the start of any session using the HIGHWAY model, all states are in the data base; that is, the removal status of each state is set to false. If a state is removed, the removal status is changed to true. The removal status for that state will remain true unless the state is reinserted with the REMOVE command or the calculations are terminated with a STOP command. When the model is executed at a later time, the data base again includes all states.

If a number of states are to be removed from the data base, the user must make sure that a route exists between the origin or destination. If none exists, the ROUTE command will not be executed, and an error message will appear on the terminal.

After the REMOVE command is entered, the computer will respond with:
TYPE A TO ALTER, L TO LIST, OR X TO EXIT

An A<CR> is used to alter the removal status. The user will then be asked to identify the state:

ENTER -ST TO DELETE, +ST TO ADD

The user enters three characters: a minus sign to indicate that the state is to be removed or a plus sign to indicate that the state is to be added, and the standard two-character state abbreviation. An L<CR> will list the removal status of each state. A removal status of false (F) means that the state is not removed, while a removal status of true (T) means the state is removed. The L subcommand, while not commonly used, is useful to determine the current removal status if the user has made a number of changes.

The X<CR> will terminate the REMOVE function and return the user to the KEYWORD statement.

Figure 11 illustrates the use of the REMOVE command. In this example, the state of Utah was removed (-UT), a listing of all states was obtained (showing the removal status of UT to be true), and an exit from the REMOVE command to the KEYWORD statement was accomplished.

D NODE command. The D NODE command will remove from the data base specific highway intersections or nodes. After a node has been deleted, all routes must bypass that particular node. The D NODE command effectively blocks any shipments through a particular town or city.

Any deletions made by the D NODE command are permanent. This command actually alters the user's personal copy of the highway data base; however, deleted nodes can also be reinserted into the data base by this command. However, if a number of deletions have been made, it usually is easier to reset the data base, using the method described in the data file initialization section on page 40 of this report.

A series of examples will be given in this discussion to demonstrate execution of the D NODE option. After the KEYWORD statement, the user types:

D@NODE<CR>

Note the blank space inserted between the D and N.

*** KEYWORD ***
REMOVE

REMOVE ROUTINE

TYPE A TO ALTER, L TO LIST, OR X TO EXIT
A

ENTER -ST TO DELETE, +ST TO ADD

-UT

THE REMOVAL STATUS OF UT IS T

TYPE A TO ALTER, L TO LIST, OR X TO EXIT
L

THE REMOVAL STATUS OF AL IS F
THE REMOVAL STATUS OF AK IS F
THE REMOVAL STATUS OF IS T
THE REMOVAL STATUS OF AZ IS F
THE REMOVAL STATUS OF AR IS F
THE REMOVAL STATUS OF CA IS F
THE REMOVAL STATUS OF CN IS T
THE REMOVAL STATUS OF CO IS F
THE REMOVAL STATUS OF CT IS F
THE REMOVAL STATUS OF DE IS F
THE REMOVAL STATUS OF DC IS F
THE REMOVAL STATUS OF FL IS F
THE REMOVAL STATUS OF GA IS F
THE REMOVAL STATUS OF IS T
THE REMOVAL STATUS OF HI IS F
THE REMOVAL STATUS OF ID IS F
THE REMOVAL STATUS OF IL IS F
THE REMOVAL STATUS OF IN IS F
THE REMOVAL STATUS OF IA IS F
THE REMOVAL STATUS OF KS IS F
THE REMOVAL STATUS OF KY IS F
THE REMOVAL STATUS OF LA IS F
THE REMOVAL STATUS OF ME IS F
THE REMOVAL STATUS OF MD IS F
THE REMOVAL STATUS OF MA IS F
THE REMOVAL STATUS OF MI IS F
THE REMOVAL STATUS OF MN IS F
THE REMOVAL STATUS OF MS IS F
THE REMOVAL STATUS OF MO IS F
THE REMOVAL STATUS OF MT IS F
THE REMOVAL STATUS OF NE IS F
THE REMOVAL STATUS OF NV IS F
THE REMOVAL STATUS OF NH IS F
THE REMOVAL STATUS OF NJ IS F
THE REMOVAL STATUS OF NM IS F
THE REMOVAL STATUS OF NY IS F
THE REMOVAL STATUS OF NC IS F
THE REMOVAL STATUS OF ND IS F
THE REMOVAL STATUS OF OH IS F
THE REMOVAL STATUS OF OK IS F
THE REMOVAL STATUS OF OR IS F
THE REMOVAL STATUS OF PA IS F
THE REMOVAL STATUS OF IS T
THE REMOVAL STATUS OF RI IS F
THE REMOVAL STATUS OF SC IS F
THE REMOVAL STATUS OF SD IS F
THE REMOVAL STATUS OF TN IS F
THE REMOVAL STATUS OF TX IS F
THE REMOVAL STATUS OF UT IS T
THE REMOVAL STATUS OF VT IS F
THE REMOVAL STATUS OF VA IS F
THE REMOVAL STATUS OF IS T
THE REMOVAL STATUS OF WA IS F
THE REMOVAL STATUS OF WV IS F
THE REMOVAL STATUS OF WI IS F
THE REMOVAL STATUS OF WY IS F

TYPE A TO ALTER, L TO LIST, OR X TO EXIT
X

*** KEYWORD ***

Fig. 11. REMOVE command.

The computer will respond with:

NODE DELETE/REPLACE ROUTINE

WILL YOU BE ENTERING DATA FROM THE TERMINAL?

The answer to this question must be YES<CR>. A brief set of instructions will be typed, and the user will be asked to identify a city and state:

ENTER CITY/ST OR <CR> TO END

The user gives the identification in the same way the origin and destination cities are specified (see ROUTE command).

In Fig. 12 (Example 1), the city of Waterloo, Iowa, is specified by typing WATER/IA<CR>. The computer then prints a list of all cities in Iowa starting with the letters WATER, and the user is asked to select the desired city or cities as follows:

SELECT ONE CITY, A RANGE, OR <CR> TO END
-- --

Since in Fig. 12 only a single Waterloo was found, an 01 was typed under the first two dashes. (Note that, as in the ROUTE command, a two-digit number must be typed.) The computer continues to ask the user to select a city from the list until all the desired nodes have been deleted; the user terminates this action by typing <CR>.

The user will then be asked to specify another city/state. If no more cities are needed, a <CR> will end the D NODE operation and return the user to the KEYWORD statement, after typing a message showing the number of nodes deleted or replaced.

Example 2, in Fig. 13, shows how to delete a number of nodes rapidly. In this case all three nodes in the vicinity of Des Moines, Iowa, are to be deleted. When the computer prompts the user to select a city or a range, the user should respond with:

01@03 <CR>

This signifies that all cities from No. 1 through No. 3 in the list are to be deleted.

The more complicated Example 3, shown in Fig. 14, deletes a number of nodes in the vicinity of Omaha, Nebraska. Here the first four nodes and the seventh node are to be deleted, so the range command was used to delete the first four nodes by typing 01@04<CR>, and the seventh node was deleted by typing 07<CR> after the user is again asked to select a city. Note that a total of five nodes were deleted.

*** KEYWORD ***
D NODE

NODE DELETE/REPLACE ROUTINE
WILL YOU BE ENTERING DATA FROM THE TERMINAL?
YES

ENTER CITY/ST FOR LIST. THEN CHOOSE INDIVIDUAL CITIES OR A RANGE.
DELETIONS ARE PERFORMED UNLESS A "+" IS ENTERED IN COLUMN 10.

ENTER CITY/ST OR <CR> TO END
WATER/IA

1 WATERLOO IA

SELECT ONE CITY, A RANGE, OR <CR> TO END

__ __ _
01

SELECT ONE CITY, A RANGE, OR <CR> TO END

__ __ _
<CR>

ENTER CITY/ST OR <CR> TO END

<CR>

1 NODES DELETED 0 NODES REPLACED

Fig. 12 . D NODE command (Example 1).

*** KEYWORD ***
D NODE

NODE DELETE/REPLACE ROUTINE
WILL YOU BE ENTERING DATA FROM THE TERMINAL?
YES

ENTER CITY/ST FOR LIST. THEN CHOOSE INDIVIDUAL CITIES OR A RANGE.
DELETIONS ARE PERFORMED UNLESS A "+" IS ENTERED IN COLUMN 10.

ENTER CITY/ST OR <CR> TO END
DES/IA

1	DES MOINES	W	I235	I35	IA	2	DES MOINES	IA
3	DES MOINES	N	I235	I35	IA			

SELECT ONE CITY, A RANGE, OR <CR> TO END
-- --
01 03

SELECT ONE CITY, A RANGE, OR <CR> TO END
-- --

ENTER CITY/ST OR <CR> TO END

3 NODES DELETED 0 NODES REPLACED

Fig. 13. D NODE command (Example 2).

*** KEYWORD ***

D NODE

NODE DELETE/REPLACE ROUTINE

WILL YOU BE ENTERING DATA FROM THE TERMINAL?

YES

ENTER CITY/ST FOR LIST. THEN CHOOSE INDIVIDUAL CITIES OR A RANGE.
DELETIONS ARE PERFORMED UNLESS A "+" IS ENTERED IN COLUMN 10.

ENTER CITY/ST OR <CR> TO END

OM/NE

1	OMAHA				NE	2	OMAHA		N	I680	U73	NE
3	OMAHA	S	I80	U73	NE	4	OMAHA		NW	I680	U73	NE
5	OMAHA	S	I480	I80	NE	6	OMAHA		SW	I680	I80	NE
7	OMAHA	W	I480	U6	NE	8	OMAHA		SW	I80	U275	NE
9	OMAHA	W	I680	U6	NE							

SELECT ONE CITY, A RANGE, OR <CR> TO END

-- -- _

01 04

SELECT ONE CITY, A RANGE, OR <CR> TO END

-- -- _

07

SELECT ONE CITY, A RANGE, OR <CR> TO END

-- -- _

ENTER CITY/ST OR <CR> TO END

5 NODES DELETED

0 NODES REPLACED

Fig. 14. D NODE command (Example 3).

Figure 15 shows how a node or a set of nodes can be reinserted into the data base. For this example, the three nodes near Des Moines, Iowa, which were deleted in Example 2, will be replaced. The procedure is identical to that used for deletion until the selection of a city is requested. To replace the three nodes, the user types:

```
01@03@@@+<CR>
```

The plus sign at the end of the statement indicates the nodes are to be added rather than deleted. Note that the final message indicates three nodes are to be replaced.

While the D NODE command is a powerful tool, the average user probably will not need to exercise this capability.

D LINK command. The D LINK command is used to remove a specific highway segment or link from the data base. As with the D NODE command, deletions made with the D LINK command are permanent, since the user's personal copy of the highway data base is altered. Deleted links can be manually reinserted; however, if a number of deletions have been made, the user should consider using the technique described in the data file initialization section for reentering the data base.

Examples of the D LINK command operation are shown in Figs. 16 and 17. Figure 16 shows how a particular link may be removed, and Fig. 17 illustrates reinsertion of a link, using the D LINK command.

After the KEYWORD statement, the user types D@LINK<CR>. (Note the blank space between the D and L). The computer responds with:

```
LINK DELETION/INSERTION ROUTINE - DEFAULT MODE IS 2-WAY  
WILL YOU BE ENTERING DATA FROM THE TERMINAL?
```

The answer to this question must be YES<CR>.

The computer types a short set of instructions and then request the user to specify a city and state:

```
ENTER CITY/ST OR <CR> TO END
```

A city name is entered, using the same rules previously described in the ROUTE command section. A city list is displayed, and the user is asked to select the desired city:

```
SELECT A CITY OR ENTER A <CR> TO END
```

As previously described, a two-digit number must be typed.

All highway segments associated with the selected city will then be listed, labeled as the forward star for that city. In Fig. 16, four

*** KEYWORD ***
D NODE

NODE DELETE/REPLACE ROUTINE
WILL YOU BE ENTERING DATA FROM THE TERMINAL?
YES

ENTER CITY/ST FOR LIST. THEN CHOOSE INDIVIDUAL CITIES OR A RANGE.
DELETIONS ARE PERFORMED UNLESS A "+" IS ENTERED IN COLUMN 10.

ENTER CITY/ST OR <CR> TO END
DES/IA

1	DES MOINES	W	I235	I35	IA	2	DES MOINES	IA
3	DES MOINES	N	I235	I35	IA			

SELECT ONE CITY, A RANGE, OR <CR> TO END
-- -- -
01 03 +

SELECT ONE CITY, A RANGE, OR <CR> TO END
-- -- -

ENTER CITY/ST OR <CR> TO END

0 NODES DELETED 3 NODES REPLACED

Fig. 15. D NODE command (Example 4).

*** KEYWORD ***
D LINK

LINK DELETION/INSERTION ROUTINE - DEFAULT MODE IS 2-WAY
WILL YOU BE ENTERING DATA FROM THE TERMINAL?
YES

ENTER CITY/ST FOR NODE LIST. CHOOSE A NODE AND THE LINKS EMINATING
FROM THAT NODE WILL BE DISPLAYED. THEN CHOOSE LINKS FROM LIST.
DELETIONS ARE PERFORMED UNLESS A "+" IS ENTERED IN COLUMN 10.

ENTER CITY/ST OR <CR> TO END
HURON/SD

1 HURON SD
SELECT A CITY OR ENTER A <CR> TO END
--
01

FORWARD STAR FOR HURON SD

1	NET#14287	HGWYS:S37	TO WOONSOCKET	E	S34	S37	SD
2	NET#14177	HGWYS:U14	TO WOLSEY	S	U14	U281	SD
3	NET#14288	HGWYS:S37	TO FRANKFORT	E	U212	S37	SD
4	NET#14178	HGWYS:U14	TO ARLINGTON				SD

ENTER LINK#, A RANGE, OR <CR> TO END
M D
-- -- --
02

ENTER LINK#, A RANGE, OR <CR> TO END
M D
-- -- --
04

ENTER LINK#, A RANGE, OR <CR> TO END
M D
-- -- --
<CR>

ENTER CITY/ST OR <CR> TO END

4 LINKS DELETED 0 LINKS INSERTED

*** KEYWORD ***

Fig. 16. Removing links from the data base using the D LINK command.

*** KEYWORD ***
D LINK

LINK DELETION/INSERTION ROUTINE - DEFAULT MODE IS 2-WAY
WILL YOU BE ENTERING DATA FROM THE TERMINAL?
YES

ENTER CITY/ST OR <CR> TO END
HU/SD

1 HURON SD
SELECT A CITY OR ENTER A <CR> TO END
--
01

FORWARD STAR FOR HURON SD

1	NET#14287	HGWYS:S37	TO WOONSOCKET	E	S34	S37	SD
2	NET#14177	HGWYS:U14	TO WOLSEY	S	U14	U281	SD
3	NET#14288	HGWYS:S37	TO FRANKFORT	E	U212	S37	SD
4	NET#14178	HGWYS:U14	TO ARLINGTON				SD

ENTER LINK#, A RANGE, OR <CR> TO END
M D
-- -- - -
02 +

ENTER LINK#, A RANGE, OR <CR> TO END
M D
-- -- - -

ENTER CITY/ST OR <CR> TO END

0 LINKS DELETED 2 LINKS INSERTED

*** KEYWORD ***

Fig. 17. Replacing a deleted link using the D LINK command.

links are identified with Huron, South Dakota. At this point, a good road atlas should be consulted to visualize the physical layout of the highway network. The first link is state highway 37, heading south to Woonsocket, South Dakota. The second link is U.S. 14, heading west to Wolsey; the third is state highway 37, heading north toward Franklin, and the fourth link is U.S. 14, heading east to Arlington.

The user will be asked to specify the links to be altered:

```
ENTER LINK #, A RANGE, OR <CR> TO END
-- -- M D
```

The specific link to be deleted is entered beneath the first set of dashes as a two-digit number. A range of links can be deleted by entering the first and the last link under the first two sets of dashes (see the section on D NODE command for an example using a range). The ENTER LINK # statement will be repeated until the user has completed all of the desired deletions. At this point, the user simply enters a <CR> to end this operation.

The computer will respond with:

```
ENTER CITY/ST OR <CR> TO END
```

Another city can be selected or, if all desired deletions have been made, a <CR> will return the user to the KEYWORD statement. In the example shown in Fig. 16, links No. 2 and No. 4 were deleted in separate operations. Note that although two links were deleted, the report typed at the end of the D LINK action shows that four links were deleted. From a mathematical standpoint, it is convenient to represent each segment by two unidirectional links. Traffic can flow along a highway in two directions; to block flow along a particular highway segment, both of the unidirectional links must be deleted. The number of deleted links reported will always be twice the number of highway segments the user has actually deleted.

An example of reinserting a deleted link is shown in Fig. 17. The responses for adding a link are identical to those described for deletion, with one exception. The computer responds with:

```
ENTER LINK #, A RANGE, OR <CR> TO END
-- -- M D
```

A plus sign (+) should then be entered under the M.

STOP command. After all of the desired routing calculations have been completed, the execution of the HIGHWAY model is terminated by entering STOP <CR> following the KEYWORD statement. The computer will respond with several lines of type and eventually will type the word READY.

When work is completed, to end the connection with the computer, the user must type:

LOGOFF <CR>

After some hesitation, a few messages will be printed showing that the user has completed the session, and the following statements will appear:

SELECT A SYSTEM

TYPE RECON, TLOGON, I FOR INTERACT, OR HELP

The phone should be disconnected from the terminal and the terminal turned off.

Do not hang up without going through the proper LOGOFF sequence. If the connection is broken, the account cannot be reestablished for approximately 1-2 h. During this time, the user is already classified as an active user and will not be able to access the computer.

Other KEYWORD commands. Several other KEYWORD commands are listed in Fig. 11. These include FILES, FIND, OUTPUT, RESET, and TRANS. These commands are included in the HIGHWAY model to meet specific specialized requirements at ORNL, and their use is beyond the scope of this discussion.

Data file initialization. When a number of highway segments and intersections have been deleted from the data base, these links and nodes can be replaced with the D LINK and D NODE commands, but this is a time-consuming procedure.

The simplest way to reset the data base to its original condition is to delete the user's personal copy. A new copy will automatically be generated when the user next executes the HIGHWAY model.

To delete data bases, the computer must have just typed READY. There are two ways to obtain the READY statement. After the user has logged on, the computer will signal it is available by typing READY;

also after the STOP command has been issued, the computer will signal READY. The user then types:

```
SHOW@DA('T.xxx17999.INDEX')@ALL@SCR<CR>
```

The xxx in this command must be replaced by the user's three-letter ID. An example illustrating deletion of the data bases is shown in Fig. 18, and in this example the user's ID is DSJ. Each of the data sets is then identified, and the user is asked if this set should be deleted by the displayed message OK?. The data sets are deleted by typing YES<CR>.

```
READY
SHOW DA('T.DSJ17999.INDEX') ALL SCR

** CATALOG RESIDES ON FIRST1
T.DSJ17999.INDEX.BLKHW3
  VOLUME(FIRST1)-DEVICE(3330-1)-ADDRESS(40B)
  CREATED(5/13/82)-LAST USED(5/13/82)-LAST USER(DSJ)-USES(2)
  RECFM(F)-LRECL(11520)-BLKSIZE(11520)-DSORG(PS)-SECURITY(N)
  TRKS ALLOCATED(95)-TRKS FREE(3)-SPACE(BLK-1)-EXTENTS(1)
OK? YES

T.DSJ17999.INDEX.HGWPGM3
  VOLUME(FIRST1)-DEVICE(3330-1)-ADDRESS(40B)
  CREATED(5/13/82)-LAST USED(5/13/82)-LAST USER(DSJ)-USES(3)
  RECFM(F)-LRECL(11520)-BLKSIZE(11520)-DSORG(PS)-SECURITY(N)
  TRKS ALLOCATED(95)-TRKS FREE(3)-SPACE(BLK-1)-EXTENTS(1)
OK? YES

** 2 DATA SETS SCRATCHED-UNCATALOGING IN PROGRESS
READY
```

Fig. 18. Deletion of data sets.

APPENDIX

Table A.1. Acceptable abbreviations for commands in the HIGHWAY model

Command	Abbreviation
YES	Y
NO	N
ROUTE	ROUT
REROUTE	RERO
OPTION	OPTI
REMOVE	REMO
D@NODE	D@NO
D@LINK	D@LI

ORNL/TM-8419
TTC 0401
Limited Distribution

INTERNAL DISTRIBUTION

- | | | | |
|--------|----------------|--------|----------------------------|
| 1. | L. H. Bell | 24. | M. G. Stewart |
| 2. | R. C. Durfee | 25-29. | L. B. Shappert |
| 3. | D. E. Ferguson | 30. | V. C. A. Vaughen |
| 4-9. | S. M. Gibson | 31. | J. F. Walker, Jr. |
| 10-14. | P. E. Johnson | 32. | G. W. Westley |
| 15-19. | D. S. Joy | 33. | Patent Office |
| 20. | K. J. Notz | 34. | Laboratory Records |
| 21. | T. H. Row | 35. | Laboratory Records-RC |
| 22. | C. D. Scott | 36. | Central Research Library |
| 23. | J. D. Sease | 37. | Document Reference Section |

EXTERNAL DISTRIBUTION

- 38-52. L. G. Blalock, Chief, Transportation Branch, U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN 37830
53. D. R. Brown, U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN 37830
54. Kathy Carlson, U.S. Department of Energy, Albuquerque Operations Office, P. O. Box 5400, Albuquerque, NM 87115
- 55-59. J. W. Cashwell, Sandia Laboratories, Nuclear Materials Transportation Technology Department, P. O. Box 5800, Albuquerque, NM 87185
60. F. P. Falchi, Transportation R&D Program Manager, U.S. Department of Energy, Washington, DC 20545
61. R. F. Garrison, Manager, Transportation Operations and Traffic, U.S. Department of Energy, Washington, DC 20545
62. David LeClaire, U.S. Department of Energy, R&D By-Products Team, Defense Waste and By-Products Management Program, Washington, DC 20545
63. Office of Assistant Manager for Energy Research and Development, DOE-ORO, Oak Ridge, TN 37830
- 64-65. Technical Information Center, Oak Ridge, TN 37830