THE IDA/BPT CRISIS RELOCATION PLANNING MODEL: DESCRIPTION, DOCUMENTATION AND USERS' GUIDE TO THE COMPUTER PROGRAM

Edward S. Pearsall, BPT
Robert C. Bushnell, BPT

Performed under subcontract for
Institute for Defense Analyses
Bushnell, Pearsall and Trozzo, Inc.
2300 Terova Drive
Troy, Michigan 48098

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**Authors:** Edward S. Pearsall, Robert C. Bushnell

**Performing Organization:** Bushnell, Pearsall and Trozzo, Inc.
2300 Terova Drive
Troy, Michigan 48098

**Controlling Office:** Federal Emergency Management Agency
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**Abstract:** This report describes work performed by Bushnell, Pearsall and Trozzo, Inc., under subcontract with the Institute for Defense Analyses on Task A-1 of IDA Contract No. EMW-C749 with the Federal Emergency Management Agency. Task A-1 calls for the development of a "model to simulate population movement during an evacuation from the risk area to the various host areas over a transportation network."

(continued)
This report describes, documents and provides a user's guide to a system of computer routines which perform the various computations required to apply a crisis relocation model developed jointly by IDA and BPT, Inc. The computer routines together comprise an interactive system resident on the FEMA Univac 1108 facility. The model and its attached national data base can be used to analyze in detail the evacuation of risk areas anywhere in the continental United States under a wide range of different assumptions regarding the assignment of reception areas and the performance of the transportation system during the evacuation.

Section 1 of the report is a detailed description of the IDA/BPT crisis relocation model. The four basic elements of the model are: 1) a transportation network data base which can be accessed up to 10 states at a time to construct regional highway networks at the county level, 2) a crisis relocation planning submodel to compute (or accept as input) an assignment of evacuees to reception areas, 3) a route selection and loading algorithm which generates routes and computes traffic to approximate the loadings which would result if evacuees were free to choose their own routes, and 4) an evacuation simulator, which determines the location of evacuees on the network as a crisis relocation proceeds. Section 2 is a user's guide to the programs and Section 3 is an annotated sample run illustrating program usage, input and output. Supporting material is contained in five appendices.
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"This report has been reviewed in the Federal Emergency Management Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Federal Emergency Management Agency."

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INTRODUCTION

This report describes work performed by Bushnell, Pearsall and Trozzo, Inc., under subcontract with the Institute for Defense Analyses on Task A-1 of IDA Contract No. EMW-C-0749 with the Federal Emergency Management Agency. Task A-1 calls for the development of "a model to simulate population movement during an evacuation from the risk area to the various host areas over a transportation network.”

This report describes, documents and provides a user's guide to a system of computer routines which perform the various computations required to apply a crisis relocation model developed jointly by IDA and BPT, Inc. The computer routines together comprise an interactive system resident on the FEMA Univac 1108 facility. The model and its attached national data base can be used to analyze in detail the evacuation of risk areas anywhere in the continental United States under a wide range of different assumptions regarding the assignment of reception areas and the performance of the transportation system during the evacuation.

Section 1 of the report is a detailed description of the IDA/BPT crisis relocation model. The four basic elements of the model are: 1) a transportation network data base which can be accessed up to 10 states at a time to construct regional highway networks at the county level, 2) a crisis relocation planning submodel to compute (or accept as input) an assignment of evacuees to reception areas, 3) a route selection and loading algorithm which generates routes and computes traffic to approximate the loadings which would result if evacuees were free to choose their
own routes, and 4) an evacuation simulator, which determines the location of evacuees on the network as a crisis relocation proceeds. Section 2 is a user's guide to the programs and Section 3 is an annotated sample run illustrating program usage, input and output. Supporting material is contained in five appendices.
1.0 Description of the Model

The IDA/BPT crisis relocation model consists of four major components each with its own distinct function and its own set of computer routines. These components are:

1. A transportation network in the form of a national database describing the U.S. highway system and providing information at the county level on population, area, and risk. The computer routines allow users to assemble, store and retrieve regional networks comprising up to 10 states.

2. A crisis relocation planning submodel enabling users to directly input an evacuation plan or to compute a plan as the solution to a transportation problem constructed at the user's direction.

3. A route selection and loading algorithm which generates routes and assigns traffic to the routes in a way which approximates the loadings which would actually result if evacuees were free to choose their own routes and received accurate traffic information during a crisis relocation.

4. An evacuation simulator designed to show the location of evacuees and the traffic distribution on the highway network at various elapsed times from the start of an evacuation.
1.1 The Transportation Network

The BPT/IDA model incorporates a national data base describing the U.S. highway system and providing other information at the county level. The data base was originally assembled by IDA in 1981 under a FEMA contract. Further information on county areas, 1980 population and vulnerability to attack was added by BPT under the subcontract.

In its present form the data base consists of three files holding the following:

Node File - Information for a set of approximately 3700 locations coinciding with population centroids and interchanges on the highway system. At least one node is located within each county in the continental U.S.

Link File - Information for a set of approximately 8700 two-way segments of highway joining nodes within the continental U.S.

Map File - A short file indicating the location of the information for each state within the Node and Link files.

Annotated partial dumps of the Node File and the Link File are provided in Appenix 4.5. A complete listing of the Map File is also given in the appendix.

The Node File contains the following items for each location in the data base:

- the location's 5-digit state/county FIPS code. The first 2 digits of the code designate the state; the last 3 digits designate the county within the state.

- a single-digit sequence number for the location within the county. A sequence number zero (0) indicates the population centroid for the county. Every county in the continental U.S. has a single population centroid and may have additional nodes at important highway intersection points.
northing and easting; the number of miles north and east from a reference point set beyond the southwest boundary of each state.

- a flag indicating whether or not the location is a major urban center (1 = urban, 0 = nonurban).

- place name; the name of the closest city, town or village.

- county name.

- latitude and longitude in degrees. Additionally, for nodes that are county population centroids, BPT has added the following items:
  - population of the county according to the 1980 Census.
  - area of the county in square miles.
  - a 2-digit code corresponding to FEMA's classification of the county for crisis relocation planning purposes. The first digit classifies counties according to risk in a countervalue attack as follows:
    
    0 - county not at risk
    1 - (A) county evacuation plan exists
    2 - (B) major metropolitan center; high risk
    3 - (C) intermediate-sized city; moderate risk
    4 - (D) small city or military installation; lower risk

    The second digit is a flag designating counties which have significant counterforce targets within their boundaries.

The Link File contains the following items for each two-way segment of the transportation network:

- the 5-digit FIPS code and sequence number for each end of the segment.

- the northing and easting of the two ends of the segment.

- a 2-digit code indicating the characteristics of the highway segment. The first digit designates the highway as 1 - Interstate, 2 - a U.S. Route, or 3 - a State Road. The second digit classifies the highway segment as follows:
1 - a 6-lane Interstate
2 - a 4-lane Interstate
3 - a 4-lane limited access highway
4 - a 4-lane unlimited access highway
5 - a 2-lane primary road
6 - a 2-lane secondary road
7 - a 2-lane poor quality road

- the Interstate, U.S. Route or State Road number.

For purposes of analyzing transportation problems during a crisis relocation, it is rarely necessary to perform the computations in a way which treats the continental United States as a single integrated unit. The movements of, say, Michigan's urban residents along the state's highways have little practical impact upon similar movements in New York or California. Consequently, an evacuation of Michigan's cities can be effectively studied within the context of a regional network encompassing Michigan and, possibly, several neighboring states. The IDA/BPT model is designed to economize on computer storage and processor time by utilizing only those parts of the national transportation data base which are relevant for a particular application.

The model operates on regional networks of up to 10 states which are assembled state by state from the information contained in the national data base. The states that are included in a single region need not be contiguous although one would normally expect them to be so.

In order to facilitate later computations, a certain amount of pre-processing is performed on the node and link information culled from the national data base as a regional network is assembled. Nodes are re-numbered sequentially and link endpoints are equated to the renumbered nodes. Each bi-directional highway segment of the data base is also recast as a pair of uni-directional links. These links are then sorted by origin so that the data for all of the links with a common origin
(or destination, since the network is symmetric) can be retrieved sequentially.

Finally, the distance, speed and capacity of each link is computed using the information from the database and parameter values supplied by the model user:

**Distance** - Link distances are computed as the straight-line distance between the end points of each link using the northings and eastings from the Link File.

**Speed** - Speeds are assigned by road categories as follows for normal (nonevacuation) movements along the network.

- **Class 1-3, Interstates and other 4-lane limited access roads** - 55 mph.
- **Class 4, Primary unlimited access 4-lane** - 45 mph.
- **Class 5, Primary unlimited access 2 lane** - 40 mph.
- **Class 6-7, Secondary and poor quality roads** - 30 mph.

Speeds for crisis relocation (evacuation) movements are supplied by users for the same road categories.

**Capacity** - For normal movements the network is regarded as uncapacitated; for crisis relocation the user supplies parameter values for the vehicles per lane per hour using the same road categories as speed. These values are multiplied by the number of lanes to obtain the capacity in each direction.

The number of lanes available in each direction is partly a function of traffic control during an evacuation. Users of the IDA/BPT model may choose among three options for controlling traffic during an evacuation.

- **Normal Traffic Control** - Two-way traffic on all highway segments. The number of lanes in each direction is one-half the number of lanes given in the database.

- **One-Way Outbound Traffic Control** - One-way traffic on all congested highway segments. All lanes of these segments are assigned to the outbound link. Inbound links for these highway segments are assigned zero capacity.

- **Variable Lanes Traffic Control** - All lanes are available to traffic in both directions. In effect, the model combines the traffic and available capacity in both directions along a highway segment.
Since the assembly of a regional network from the Node, Link and Map files is a somewhat tedious job, the computer program which implements the model provides for the storage and retrieval in preprocessed form of up to 10 regional networks.
1.2 The Crisis Relocation Planning Submodel

Within the IDA/BPT evacuation model, a crisis relocation plan is functionally defined as a set evacuation/reception county pairs and the numbers of evacuees to be relocated from the evacuation counties to the reception counties. Users of the model have the option of specifying the evacuation plan directly or supplying other information from which a linear program is constructed and solved to obtain an evacuation plan. This section describes the computation of an evacuation plan which conforms to criteria specified by the model user.

The linear program which is solved to obtain an evacuation plan is known, technically, as a transportation problem. Formally, the problem has the following mathematical statement: Let \( i = 1, M \) designate origin counties, \( j = 1, N \) designate destination counties, and \( X_{ij} \) denote the number of evacuees to be relocated from origin \( i \) to destination \( j \). Let \( S_i, i = 1, M \) be the numbers of evacuees to be relocated from the evacuation counties, let \( D_j, j = 1, N \) be the capacities in numbers of evacuees that can be accommodated in the reception counties and let \( t_{ij} \) be the time it takes to travel over the transportation network from evacuation county \( i \) to reception county \( j \). Then, the linear program which is solved to obtain an evacuation plan is:

Find: \( X_{ij} \geq 0 \) for all \( i \) and \( j \)

To Minimize: \[ \sum_{i} \sum_{j} t_{ij} X_{ij} \]

Subject to:

\[ \sum_{j} X_{ij} \geq S_i \text{ for all } i \]

\[ \sum_{i} X_{ij} \leq D_j \text{ for all } j \]
An efficient algorithm for solving transportation problems has been incorporated into the computer routines which implement the IDA/BPT transportation model. This algorithm is applied to solve transportation problems which are constructed employing information supplied by users. The nonzero components of the solution to the transportation problem constitute an evacuation plan.

The elements of the transportation problem which are specified directly or indirectly by users of the IDA/BPT model are the evacuation counties and the number of evacuees, $S_i$, $i = 1, M$, and, the reception counties and the reception capacities, $D_j$, $j = 1, N$. The times, $t_{ij}$, are computed as the normal travel times over the regional highway network from the population centroids of the evacuation counties to the population centroids of the reception counties. The times are determined for normal speeds over the shortest route. The rationale for inserting normal travel times into the transportation problem is, first, that the generally slower speeds of travel during an evacuation have little effect on the choice of the shortest routes and, second, a great deal of traffic at normal speeds can be expected following the relocation between an evacuation county and its reception counties. This traffic is necessary to support the relocated population and, possibly, to maintain production and services within the evacuated county.

A list of evacuation counties together with the number of evacuees from each county can be specified directly by the user. Alternatively, evacuation counties in a region can be selected according to risk categories given in FEMA's Crisis Relocation Conglomerate Listing. These categories are:
A - counties for which crisis relocation plans already exist; usually because a major military installation is located within the county.

B - the most densely populated counties; counties containing major metropolitan areas which could be targeted in the event of an attack.

C - heavily populated counties; usually the counties contain a major city with a population of several hundred thousand.

D - less densely populated counties; counties containing either a concentration of population and industry or a military installation which could make the county a target in the event of an attack.

The IDA/BPT model allows users to specify evacuation counties as 1) all A counties, 2) all B counties, 3) all B and C counties, 4) all A, B, C and D counties. In addition, FEMA's Crisis Relocation Conglomerate Listing designates those counties which would be threatened in the event of a counterforce attack. These counterforce targets can be added to the list of evacuation counties by users of the model.

The number of evacuees from each evacuation county selected in this way is computed using a set of rules as follows:

1. If counterforce targets are included in the list of evacuated counties, then all counties with counterforce targets are completely evacuated. The number of evacuees is set equal to the county's 1980 population.

2. All other counties are evacuated down to the point where the remaining population meets both of the following criteria:

   a. The population following evacuation does not exceed a percentage of the county's residents specified by the user, e.g., 10 percent.

   b. The population density does not exceed a number of people per square mile specified by the user, e.g., 200 people per square mile.

The designation of reception counties is similar to the designation of evacuation counties. Again, users have the option of directly
specifying these counties and their capacities to hold evacuees.

Alternatively, the following rules can be applied to establish a list of reception counties:

1. No evacuation county is simultaneously allowed to serve as a reception county.

2. No county is permitted to be a reception county if its resident population density is less than a specified minimum value such as 10 people/square mile. The purpose of the minimum density is to exclude as reception counties areas such as mountains and deserts which cannot support significant numbers of evacuees.

3. No county is permitted to be a reception county if its resident population exceeds a specified maximum value such as 500 people/square mile. The maximum density limit enables the model user to exclude counties which are already heavily populated but have not been designated as evacuation counties.

All counties within a region which are not excluded by 1-3 above are included as potential reception counties. The number of evacuees each potential reception county can hold is computed according to the following criteria:

1. The population of a reception county following an evacuation cannot exceed a user-specified multiple of the county's original population. For example, a multiple of three would limit the capacity of reception counties to no more than two evacuees for each resident. By limiting reception capacity in this way users can prevent the model from assigning more evacuees to a reception county than the local infrastructure can support.

2. The population density following the evacuation does not exceed a number of people/square mile stipulated by the user, i.e., 500 people/square mile. This maximum limit lets users prevent the creation of potential counter-value targets in reception counties.

The model also allows users to establish a geographic band of preferred reception counties around each evacuation county. The inner and outer limits of these bands are stipulated by the model user in the form of a minimum and a maximum normal travel time. For example, limits of
one-half hour and two hours would have the effect of establishing a band of preferred reception counties within commuting distance of most population centers.

The travel time limits are used to modify the coefficients, $t_{ij}$, of the transportation problem. If the normal travel time between an evacuation county and a reception county falls outside the limits, then 1,000 hours is arbitrarily added to the normal shortest route time between the two counties. The effect of this change is to make the model select evacuation plans in which the reception capacity within the preferred counties is entirely used up before any evacuees are assigned to reception counties outside the travel time limits. In the example given, the solution to the transportation problem would strongly favor assignments of evacuees to reception counties between one-half hour and two hours normal travel time from their homes.
1.3 The Route Selection and Loading Algorithm

The heart of the IDA/BPT crisis relocation model is an efficient algorithm for finding routes along the regional transportation network and then determining the traffic the routes would carry during an actual evacuation. The end product of the route selection and loading algorithm is a list of routes, no-less-than one for each evacuation/reception county pair in the crisis relocation plan, with an assignment of traffic to the routes such that for any given evacuation/reception pair:

1. all evacuees from the evacuation county to the reception county are assigned to one of the routes connecting the population centroids of the two counties.

2. all routes assigned traffic are equivalent in terms of average total transit time. Total transit time consists of actual travel time from origin to destination plus the length of the average delay imposed by the most congested link along the route.

3. all other possible routes have longer average total transit times than those which are assigned traffic by the model. (NOTE: See comments on setting the delay time termination limit.)

In brief, the algorithm contained in the IDA/BPT model selects routes and loads them in a way which approximates the loading which would result if evacuees were aware of the travel and delay times occurring on the network and were free to choose their own routes.

Normally, the U.S. highway system is uncongested except for certain links at well-known hours, i.e., the George Washington Bridge at rush hour and U.S. Route 50 between Washington and Baltimore at noons during the summer. However, during the evacuation model, it would place such extraordinary demands on the network.
congestion of major outbound highways would become the rule rather than the exception. This fact has two important implications for evacuation studies and plans. First, the technical characteristics associated with highway usage such as average speed and lane capacity can be expected to degrade and should be somewhat influenced by traffic control during an evacuation. Second, roundabout routes which would ordinarily be of little interest become important as alternatives to the heavily congested shortest routes.

The IDA/BPT model allows users to stipulate the major performance parameters of the highway system during an evacuation. These performance parameters are:

1. Vehicles/lane/hour for four highway categories: Class 1-3: Interstates and other 4-lane limited access roads, Class 4: Primary unlimited access 4-lane highways, Class 5: Primary unlimited access 2-lane highways, Class 6-7: All other roads.

2. Average speeds of movement in miles/hour for the same four highway categories.

3. Traffic control; three options are available: normal two-way traffic, one-way outbound traffic on congested links and, variable lanes control in which the traffic and capacity in both directions along a segment is pooled.

4. Average number of passengers per vehicle. The number of passengers per vehicle is used to convert evacuees to vehicles along routes. Normally, the number of occupants per vehicle is low, between one and two. However, enforced car pooling, intensive busing and the fact that families would typically evacuate as a unit should raise the average during an evacuation.

5. Normal evacuation time in hours. It would take time to effect an evacuation even if the highway system imposed no additional delays. Evacuees must be informed that an evacuation is underway, they must assemble with their families, do a necessarily minimal mount of preparation and then begin the evacuation by travelling on local roads to the major arteries of the highway system. The time it would take for the last evacuees to reach the highway system and begin moving outbound is the nominal
evacuation time. Half the nominal evacuation time is the average delay encountered by evacuees just reaching the regional transportation network.

Formally, a route is defined as a sequence of links which begins at the population centroid of an evacuation county and ends at the centroid of a reception county. The total transit time for a route is composed of two parts as follows:

1. Average travel time: the total time required to travel the route computed as the sum of the times required to cross each link at the speed established for the links by the model user.

2. Average delay time: one-half the lesser of the nominal evacuation time or the length of the delay imposed by the most congested link on the route. The delay imposed by a link is computed from the formula:

\[
\text{Average delay} = \frac{\text{number of evacuees traversing the link} \times \text{passengers per vehicle}}{\text{vehicles per lane per hour} \times \text{number of available lanes}}
\]

The number of evacuees traversing a link is the sum of all evacuees assigned to routes which include the link (in both directions for variable lanes).

The route selection and loading algorithm is an iterative process in which route generation and network loading are alternated until no new routes can be found to improve the solution.

Step 1 - Initialization; all links on the regional transportation network are unblocked and may be included in routes. The list of routes is empty.

Step 2 - Route generation; the shortest route following an unblocked sequence of links is generated for each origin/destination pair of county centroids in the relocation plan. The method used to generate the best route from an evacuation county to a reception county is described below. A route is added to the route list if it does not duplicate a route already on the list and its transit time is shorter than the transit times of the routes already on the list for the same origin/destination pair.

Step 3 - Route loading; if no new routes are added to the route list in Step 2, the algorithm terminates. Otherwise, loadings for the new list of routes are computed using an iterative method for assigning traffic to a given set of
routes. The iterative method is described below. It converges fairly rapidly on a route loading which equalizes total travel times for all routes connecting the same origin/destination pairs. (If Step 3 is being executed for the first time, then the route loading is computed simply by assigning the evacuees for each origin/destination pair to the single route on the route list for that pair.)

Step 4 - Link blocking; the network is scanned for the unblocked link with the longest average delay time implied by the route loadings of Step 3. This link and all other links with comparable delay times are blocked. In practice all links with delay times of 90 percent or more of the longest average delay time are blocked. Blocking a link removes the link from the network only for the purpose of generating routes in Step 2. Blocking links has the effect of forcing the route generator to find link sequences which avoid those parts of the network which will cause delays during an evacuation.

Step 5 - Link list editing; if the longest average delay time found in Step 4 is less than a user-specified delay time termination limit, the algorithm terminates. Otherwise, the link list is edited by deleting unloaded or highly loaded routes with transit times which significantly exceed the transit times on loaded routes between the same origin/destination pair. The algorithm then returns to Step 2.

Routes are generated in Step 2 by applying an efficiently programmed version of the well-known Ford-Fulkerson method for finding the shortest route between two points along an uncapacitated network. The algorithm is more-than-adequately described in many operations research textbooks, for example, Principles of Operations Research by Harvey M. Wagner. (2nd edition, 1975, Prentice-Hall, Englewood Cliffs, N.J.)

Basically, there are two phases to the computations. First, the shortest time to the destination node is determined for every point on the network. These times are then used in the second phase of the algorithm which is to determine the actual shortest route from any given origin to the destination.

The efficient programming of the algorithm is made possible by the presorting of the network links described earlier. This device for speeding computations was developed by BPT in a previous project for the
Department of Transportation of the State of Michigan. The presorted network simplifies the computations in both phases of the Ford-Fulkerson method by allowing the link list to be processed sequentially in segments.

In applying the Ford-Fulkerson method to generate routes in Step 2, the usual computational roles of the origin and destination are reversed. Times are computed from every point on the network to each evacuation county and routes are generated as though evacuees were moving from reception counties to evacuation counties. Since the network is symmetric, routes generated in this way are identical when the link sequence is inverted to those which would be generated if origins and destinations were not reversed. However, the reversal of the origins and destinations speeds computations since the first phase of the Ford-Fulkerson method is performed once for each evacuation county rather than once for each reception county. Ordinarily, there are far few evacuation counties than reception counties.

Route loading is performed in Step 3 of the algorithm by employing a simple iterative process. The process begins with the route loading from the previous execution of Step 3. Transit times for each route on the route list are computed using this initial loading. The route with the shortest transit time for each origin/destination pair is determined and a provisional network loading is constructed by assigning all of the evacuees for each origin/destination pair to the route with the shortest transit time. A new network loading is now obtained by forming a weighted average of the original network loading and the provisional network loading.

The process is now repeated with the new network loading replacing the network loading used to initiate Step 3. A new provisional loading
is constructed, a new weighted average is formed, and the new network loading is used to initiate another cycle of the process.

The process is continued for a fixed number of iterations. The weights which are used to form the weighted average are a function of the number of iterations. Let \( N \) be the number of iterations, then the weight applied to the provisional loading at iteration \( N \) is given by \( W = \frac{2}{N + 19} \) and the weight for the original loading is \( 1 - W \). One hundred iterations are performed for each execution of Step 3. At the termination of the route selection and loading algorithm an additional four hundred iterations are performed to refine the final network loading.

The overall route selection and loading algorithm terminates if either one of two conditions exist. These are:

1. In Step 1, if the route generator fails to find any new routes to add to the existing route list. After several iterations through Step 4 the regional highway network tends to get reduced and disconnected. At some point so many links may be blocked that there exist no new routes meeting the criteria for inclusion on the route list in Step 1.

2. In Step 4, if the delay times on all of the remaining unblocked links in the network are less than the delay time termination limit. If the delay time termination limit is set less than or equal to half the nominal delay time then the algorithm will not stop until there are no more routes with longer average total transit times than those which are assigned traffic by the model. If the delay time termination limit is set higher than half the nominal delay time then the algorithm will terminate earlier with fewer routes. However, since the algorithm generates the best routes first there is frequently little to be gained by carrying computations to the point where every possible route has been examined. Usually, a good computational strategy is to set the delay time termination limit above half the nominal delay time but at a level which is still small in comparison to the delays likely to be encountered by evacuees on the most congested links of the network.
1.4 The Evacuation Simulator

The IDA/BPT model enables users to perform a computer simulation of an evacuation conducted according to a previously generated set of routes and route loadings. The simulation provides a picture of the progress of the crisis relocation at intervals of 2, 4, 6, 8, 12, 16, 20, 24, 32, 40, 48, 60, 72, and 84 hours after the start of the evacuation.

The simulation is performed route by route by determining the location of evacuees at each of the elapsed times given above. Evacuees are assumed to embark on each route in a steady stream commencing at time zero and lasting for twice the length of the average delay time for the route. The number of evacuees embarking per hour is the total number of evacuees assigned to the route by the route loading algorithm divided by twice the average delay time. The rate at which vehicles are fed onto the route is obtained by dividing the number of evacuees per hour by the average number of passengers per vehicle. In effect the delay which attaches to the use of a route is imposed on evacuees at the start of the route and not at the location of the most congested link which would actually be responsible for the delay.

The stream of evacuees using a particular route is of a fixed length in time and volume in vehicles per hour. As this stream proceeds out over the route towards its destination in a reception county the links along the route are successively entered, covered and exited by the stream of vehicles. The situation for a typical time in mid-evacuation is shown below. The arrow represents the stream of vehicles using the route. Its
progress along the route is governed by the speeds of movement on the sequence of links that form the route. When the stream completely covers a link, such as line 2, the volume of the stream is added to the traffic using the link. Where a link is only partly covered, such as links 1 and 3, a proportion of the volume equal to the fraction of the link which is covered by the stream, is added to traffic on the link. A record is also kept of the numbers of evacuees not yet departed from the evacuation county and already arrived at the reception county.

The status of the crisis relocation at each interval of time is summarized for model users in a series of tables which display:

- The status of all evacuees as at risk (unevacuated), en route or at destination.
- The distribution of departures by evacuation counties.
- The distribution of arrivals by reception counties.
- The distribution of traffic on the regional highway network.
2.0 User's Guide to the Computer Program

The IDA/BPT crisis relocation model has been programmed in FORTRAN and made available, together with the data files comprising i.s data base, on FEMA's Univac 1108 computer.

All of the model's source data and source programs are available as public files on the Univac 1108. Procedure files which may be added to the run stream to compile, assemble and execute the source programs are listed in the appendix.

The computer program is designed for interactive usage from a suitable computer terminal signed on to the Univac 1108 in the demand processing mode. A suitable terminal should have a BAUD rate of 300 or greater and be capable of printing single lines of 132 characters. After signon, users should set the line length to 132 characters with an @@TTY or @@DCT command. FEMA users may run the IDA/BPT computer program by adding three prepared files of commands to the run stream with the commands:

@@ADD BPT * EXECUTE. COMPIL
@@ADD BPT * EXECUTE. ASSEMB
@@ADD BPT * EXECUTE. RUN

The commands must be executed in the order given. The first command compiles the ASCII FORTRAN source code. The relocatable object code is stored in a temporary file named OBJECT. The second command assembles the relocatable object code in an element named OBJECT. MAIN. The third command links the source data files to the channels 8, 9 and 10; links channel 7 to a temporary file named "ROUTES" and links channels 11 through 20 to temporary files named FILE11, FILE12, etc. which can be
conveniently referenced by their channel numbers. The program is then run.

We have attempted to make the operation of the model as self-evident and forgiving to a terminal user as possible. Thus, users are always prompted with an appropriate question or request at all points where the program requires user-supplied information. In addition, a sufficient amount of terminal output is supplied to enable users to verify input values and to confirm the completion of major computational segments.
2.1 Master Control Sequence

Subject to several sequencing rules, the order in which the major components of the IDA/BPT model are exercised is under the control of the user. The computer program always begins by reproducing the following listing of control options at the terminal:

0 - Repeat List of Control Options
1 - Input/Compute Crisis Relocation Plan
2 - Run Route Finding/Loading Algorithm
3 - Simulate the Evacuation
4 - Assemble Network from Source Files
5 - Read Stored Network
6 - Save Network
7 - Reassign Input Channel for Parameter Values
8 - Reassign Output Channel for Summary Tables
9 - Reassign Output Channel for Route Listing
99 - Terminate Program

After execution of major program segments, the program always returns to the master control sequence with the following printed request:

INPUT CONTROL OPTION NUMBER

The user's response at the terminal determines the next major program operation subject to the following sequencing restrictions:

1. Options 1 and 6 cannot be selected until after either Option 4 or 5 has been executed.

2. Option 2 cannot be selected until after Option 1 has been executed and a crisis relocation plan input or computed.

3. Option 3 cannot be selected until after Option 2 has been executed and a route loading has been computed.

Since exercising control options often causes the loss or destruction of internally stored computational results, the program requires the verification of control option numbers with the request:
CONTROL OPTION n TYPE "OK" TO EXECUTE

The response "OK" leads directly to execution of the option; any other response recycle the master control sequence.
2.2 Input/Output Channel Options

The program receives parameter values, prints summary tables following most major computational segments and prints detailed listings of routes on completion of the route finding/loading algorithm. Initially, parameter values are input via the terminal (channel 5), summary tables are printed at the terminal (channel 6) and route listings are sent to a temporary file named "ROUTES" which is attached to the channel 7 and can be referenced by users as "7."

These assignments can be altered by selecting Options 7, 8 or 9. Following selection of each of these options, a request for a channel number is printed at the terminal:

```
INPUT NEW CHANNEL NUMBER (5 or 6 = TERMINAL)
```

Assignments of new channel numbers must obey the following rules:

1. Parameter values may be input through channel 5 and channels 11 to 20.

2. Summary tables and route listings may be output through channel 6 and channels 11 to 20. The route listings may also be output through channel 7.

3. Different channels must be used for parameter values, summary tables and route listings.

If a channel other than 6 (the terminal) is designated for the summary tables, copies of the very short tables which are printed at the terminal are also output through the summary table channel. Summary tables which are output through channels other than 6 are also numbered. The numbering system follows the numbering of the control options. Following is a complete list of the tables produced by the program:
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Crisis Relocation Input Parameter Summary</td>
</tr>
<tr>
<td>1.1</td>
<td>Evacuation/Reception County Lists</td>
</tr>
<tr>
<td>1.2</td>
<td>Evacuation/Reception County Pairs</td>
</tr>
<tr>
<td>2.0</td>
<td>Network Finding/Loading Parameter Summary</td>
</tr>
<tr>
<td>2.1</td>
<td>Algorithm Iteration Record</td>
</tr>
<tr>
<td>2.2</td>
<td>Route Characteristics and Loadings</td>
</tr>
<tr>
<td>2.3</td>
<td>Route Listings</td>
</tr>
<tr>
<td>3.0</td>
<td>Simulation Summary</td>
</tr>
<tr>
<td>3.1</td>
<td>Evacuation Departure Summary</td>
</tr>
<tr>
<td>3.2</td>
<td>Reception Arrival Summary</td>
</tr>
<tr>
<td>3.3</td>
<td>Network Link Characteristics and Loadings</td>
</tr>
<tr>
<td>4.0</td>
<td>Regional Network Assembly</td>
</tr>
<tr>
<td>4.1</td>
<td>Population Centroid List</td>
</tr>
</tbody>
</table>
2.3 Network Assembly, Storage and Retrieval

Control Options 4, 5 and 6 provide users with the ability to assemble regional transportation networks from the source data files, save assembled networks and retrieve previously-saved networks.

Under Option 4 regional networks of up to 10 states can be assembled from the source files comprising the model's data base. The size of the regional network is limited to no more than 500 nodes and 2,000 one-way links. This is sufficient to accommodate most regional networks of interest and the limits can readily be expanded if necessary.

To assemble a regional network, the user must specify the number of states to be included in the network and the FIPS numbers for the states in response to the requests:

INPUT THE NUMBER OF STATES IN THE REGION

and

INPUT n STATE NUMBERS

A directory of states listed by FIPS number is displayed in the table on the following page. The state's FEMA region number is also shown as an aid to users. The computer program echos the FIPS numbers and names of states to be included in an assembled regional network. Users must verify the list of included states by replying "OK" to the request:

TYPE "OK" TO ASSEMBLE NETWORK

As nodes and links are assembled for each state from the Node File and the Link File, a short message is printed at the terminal. If more than 500 nodes or 2,000 links are found, an error message is printed and the network assembly is aborted. Occasionally, a link is read with
<table>
<thead>
<tr>
<th>FIPS No.</th>
<th>State/District Name</th>
<th>FEMA Region</th>
<th>FIPS No.</th>
<th>State/District Name</th>
<th>FEMA Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alabama</td>
<td>4</td>
<td>29</td>
<td>Missouri</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Alaska</td>
<td>10</td>
<td>30</td>
<td>Montana</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>31</td>
<td>Nebraska</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Arizona</td>
<td>9</td>
<td>32</td>
<td>Nevada</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Arkansas</td>
<td>6</td>
<td>33</td>
<td>New Hampshire</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>California</td>
<td>9</td>
<td>34</td>
<td>New Jersey</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>35</td>
<td>New Mexico</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Colorado</td>
<td>8</td>
<td>36</td>
<td>New York</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>Connecticut</td>
<td>1</td>
<td>37</td>
<td>North Carolina</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Delaware</td>
<td>3</td>
<td>38</td>
<td>North Dakota</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>Dist. of Columbia</td>
<td>3</td>
<td>39</td>
<td>Ohio</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>Florida</td>
<td>4</td>
<td>40</td>
<td>Oklahoma</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>Georgia</td>
<td>4</td>
<td>41</td>
<td>Oregon</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>Guam</td>
<td>9</td>
<td>42</td>
<td>Pennsylvania</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>Hawaii</td>
<td>9</td>
<td>43</td>
<td>Puerto Rico</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>Idaho</td>
<td>10</td>
<td>44</td>
<td>Rhode Island</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>Illinois</td>
<td>5</td>
<td>45</td>
<td>South Carolina</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>Indiana</td>
<td>5</td>
<td>46</td>
<td>South Dakota</td>
<td>8</td>
</tr>
<tr>
<td>19</td>
<td>Iowa</td>
<td>7</td>
<td>47</td>
<td>Tennessee</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>Kansas</td>
<td>7</td>
<td>48</td>
<td>Texas</td>
<td>6</td>
</tr>
<tr>
<td>21</td>
<td>Kentucky</td>
<td>4</td>
<td>49</td>
<td>Utah</td>
<td>8</td>
</tr>
<tr>
<td>22</td>
<td>Louisiana</td>
<td>6</td>
<td>50</td>
<td>Vermont</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>Maine</td>
<td>1</td>
<td>51</td>
<td>Virginia</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>Maryland</td>
<td>3</td>
<td>52</td>
<td>Virgin Islands</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>Massachusetts</td>
<td>1</td>
<td>53</td>
<td>Washington</td>
<td>10</td>
</tr>
<tr>
<td>26</td>
<td>Michigan</td>
<td>5</td>
<td>54</td>
<td>West Virginia</td>
<td>3</td>
</tr>
<tr>
<td>27</td>
<td>Minnesota</td>
<td>5</td>
<td>55</td>
<td>Wisconsin</td>
<td>5</td>
</tr>
<tr>
<td>28</td>
<td>Mississippi</td>
<td>4</td>
<td>56</td>
<td>Wyoming</td>
<td>8</td>
</tr>
</tbody>
</table>
endpoints which cannot be matched to any location on the node list. When this occurs a one-line message is printed and the network assembly is allowed to continue. When the data assembly is completed the total numbers of nodes and links in the regional network are printed and the network is sorted.

Up to ten regional networks can be sorted in ready-to-use form on files attached to channels 11 through 20. Option 6 stores an assembled network and Option 5 retrieves one which was previously stored. Users must supply the program with a channel number. When a network is retrieved, the program lists the states included in the region and the number of nodes and links in the network.

Following the assembly or retrieval of a regional network, users are given an opportunity to list the information pertaining to the population centroids in the region. The response "YES" or just "Y" to the question:

LIST THE POPULATION CENTROIDS (YES OR NO)?

results in the production of Table 4.1 presenting the data from the node file for each centroid.
2.4 The Crisis Relocation Plan

Control Option 1 directs the program to obtain a new crisis relocation plan either directly from the user or by constructing and solving a linear program (the transportation problem) according to directions. A simplified flow chart for this segment of the program is presented on the next page.

The interactive sequence begins with:

INPUT EVACUATION PLAN (YES OR NO)?

To directly input an evacuation plan a user responds "YES" or just "Y." Any other response is interpreted as a "NO." If the response is "YES," the program then requests from the user a list of numbers, three numbers for each evacuation/reception county pair in the crisis relocation plan:

FOR EACH PAIR INPUT: EVACUATION COUNTY NO.,
RECEPTION COUNTY NO., NUMBER OF PEOPLE

The three numbers for each pair must be typed on a single line and separated by commas. The county numbers are 5-digit state/county FIPS codes. Example: The line

26163, 26115, 100000

calls for the relocation of 100,000 people from Wayne County (26163) Michigan to Monroe County (26115). The program echo checks information as it is input. If a nonpositive number is input for the evacuation county, the result is to delete the immediately preceding evacuation/reception pair. To terminate the input sequence for the crisis relocation plan, the user types the line:
The program prints the whole plan and returns to the master control sequence.

If the crisis relocation plan is not input directly, the program computes one by constructing and solving the transportation problem described in 1.2. First, users are given the opportunity to directly input the evacuation counties and the number of evacuees from each county:

**SPECIFY EVACUATION COUNTIES (YES OR NO)?**

If the user answers "YES" or "Y," the program interrogates the user as follows:

**FOR EACH EVACUATION COUNTY INPUT:**

**COUNTY NO., NUMBER OF PEOPLE**

For each evacuation county the user types the county's 5-digit FIPS code and the number of evacuees from the county separated by a comma. For example:

26163, 2000000

instructs the program to treat Wayne County (26163) as an evacuation county with 2,000,000 residents to be relocated. The data is echoed on input, a nonpositive county number deletes the previously input evacuation county, and the input sequence is terminated by typing the line:

999, 999

If the user does not directly specify the evacuation counties, then they will be indirectly specified by a set of controls and parameter values which must be provided by the user in response to a series of information requests appearing at the terminal:
INPUT VULNERABILITY GROUP CODE (1 TO 4)
The user supplies the first digit of FEMA's crisis relocation county classification system. All counties with a first digit which is less than the supplied parameter value (except for A counties) are considered evacuation counties, i.e., the response "3" has the effect of treating all B and C counties as evacuation counties.

INPUT MINIMUM PERCENT TO BE EVACUATED
The user supplies a number in the range 0-100. This percentage is applied to each evacuation county's 1980 population to determine the minimum number of evacuees.

EVACUATE COUNTERFORCE TARGETS (YES OR NO)?
If the user responds "YES" or "Y" then all counties which have significant counterforce targets, as indicated by the second digit of the FEMA classification code, are added to the list of evacuation counties. All of the populations of counties with counterforce targets are evacuated.

INPUT POST EVACUATION MAXIMUM DENSITY IN EVACUATED COUNTIES IN PEOPLE/SQUARE MILE
The number supplied is compared to the normal population density of each evacuation county. If the normal density exceeds the maximum, then the number of evacuees required to reach the maximum density is computed. This figure is then compared to the number of evacuees previously computed using the minimum percentage. The larger of the two numbers is retained as the number of evacuees from the county.

A similar sequence is followed for reception counties and their capacity to hold evacuees. To directly input reception counties and capacities the user answers "YES" or "Y" to:

SPECIFY THE RECEPTION COUNTIES (YES OR NO)?
For each reception county, the user supplies the county's 5-digit FIPS code and the number of places for evacuees in the county. For example:

26115, 100000

indicates that Monroe County (26115) is a reception county capable of accommodating 100,000 evacuees. The data is echo checked on input, a nonpositive county number deletes the previously input evacuation county, and the input sequence is terminated by typing the line:

999, 999

If the reception counties are not specified, then a set of controls and parameter values are used to identify reception counties within the region.

INPUT MINIMUM, MAXIMUM PRE-EVACUATION RECEPTION AREA DENSITY IN PEOPLE/SQUARE MILE

Two numbers, separated by a comma, are typed at the terminal. The list of non-evacuation counties is then scanned for counties whose 1980 population density falls within the stipulated limits. Such counties are included on the list of reception counties. For example, the response:

20, 500

would limit the selection of reception counties to those with 1980 population densities between 20 and 500 people/square mile. The lower limit serves to exclude areas such as mountains and deserts which cannot sustain evacuees while the upper limit excludes counties which are densely populated but have not been selected for evacuation.

INPUT MINIMUM, MAXIMUM TRAVEL TIME IN HOURS X 100

The response to this request establishes a travel time band around each evacuation county. Travel times are measured along the fastest route at normal highway speeds. As the transportation problem described in 1.2
is constructed the travel times \( t_{ij} \) assigned to movements from evacuation counties \( i \) to reception counties \( j \) are the normal travel times between the counties. However, when these normal travel times fall outside the travel time band, the travel times are artificially increased by 1,000 hours. In effect, reception counties within the travel time bands of evacuation counties are filled before any use is made of reception counties which lie outside the time bands. For example, the values:

50, 400

establish a band from half an hour to four hours around each evacuation county. The program will relocate evacuees from an evacuation county to reception counties within this band until the reception capacity of these counties is expended before using any other reception counties. The lower limit (one-half hour) pushes evacuees beyond the immediate suburbs of most cities while the upper limit (four hours) holds evacuees within the range of a one-day round trip from their homes and places of work.

INPUT MAXIMUM RESIDENT POPULATION MULTIPLE X 100

The maximum resident population multiple is applied to each reception county's 1980 population to determine the number of evacuees which the county can accommodate. For instance, a response of "300" is interpreted to mean that reception counties can hold two evacuees for every pre-evacuation resident. Thus, the capacities of the reception counties would initially be set at two times each county's 1980 population.

INPUT POST EVACUATION MAXIMUM DENSITY IN RECEPTION COUNTIES IN PEOPLE/SQUARE MILE

The area of each reception county is multiplied by the maximum density supplied by the user to obtain the maximum number of people which the
the county can hold following an evacuation. The 1980 population is then subtracted to yield the maximum number of evacuees. This maximum is compared to the reception capacity computed using the maximum resident population multiple and, if smaller, it becomes the county's reception capacity.

At this point in the program, all of the information required to formulate the transportation problem described in 1.2 has been input and processed. A short table is printed at the terminal displaying the total number of evacuation counties, evacuees, reception counties, reception capacity and the values of all parameters supplied by the user. The table listing is followed by the line:

```
TYPE "OK" TO COMPUTE EVACUATION PLAN
```

If the user responds with an "OK," a standard algorithm is applied to either solve the transportation problem or to determine that it is infeasible. A short message is printed at the terminal reporting the outcome of the attempt to solve the problem. Any response other than "OK" returns the program to the master control sequence without solving the transportation problem.
2.5 Route Selection and Loading

Control Option 2 results in the selection and loading of routes for a crisis relocation plan as described in 1.3. A simplified flow chart appears on the following page.

To select and load routes a certain amount of additional information about the operation of the highway network during an evacuation is needed. This information must be supplied by the user when requested by the program.

**INPUT VEHICLES/LANE/HOUR FOR 1) LIMITED ACCESS, 2) PRIMARY 4-LANE, 3) PRIMARY 2-LANE, 4) SECONDARY HIGHWAYS**

Four numbers are input giving the emergency carrying capacity in vehicles/lane/hour of four general classes of highways. The capacity of each link is found by multiplying the number of available lanes by the vehicles/lane/hour for the type of highway comprising the link. Example:

2000, 1500, 1400, 1200

Speeds of movement during an evacuation are input for the same highway classes in response to the following request:

**INPUT AVERAGE SPEED IN MILES/HOUR FOR 1) LIMITED ACCESS, 2) PRIMARY 4-LANE, 3) PRIMARY 2-LANE, 4) SECONDARY HIGHWAYS**

Normal nonevacuation speeds along the highway network are taken to be 55, 45, 40 and 30 miles per hour. Slower average speeds would likely prevail during an evacuation. For example:

40, 35, 35, 30
Start

Input Parameters and Initialize

Execute Algorithm

Yes

Select Routes, Add to Route List

Load Network

Block Links Print Status

Test for Termination

No

Print Summary Tables and Route Listing

No

Yes

Return
As discussed in 1.3 three options exist for controlling the use of highway lanes during an evacuation. One of these options must be selected by the user in response to:

INPUT HIGHWAY CONFIGURATION COPE

1) NORMAL,
2) ONE WAY, 3) VARIABLE LANES

The responses "1," "2" and "3" correspond to the three options described in 1.3.

INPUT PASSENGERS/VEHICLE X 100

The user-supplied number is needed to convert evacuees to vehicles along routes.

INPUT NOMINAL EVACUATION TIME IN HOURS X 100

Half the nominal evacuation time is imposed as an initial minimum average delay for all evacuees on all routes.

INPUT DELAY TIME TERMINATION LIMIT IN HOURS X 100

The route selection and loading algorithm terminates if the delay times on unblocked links are all less than the termination limit supplied by the user or half the nominal evacuation time.

A short table is printed at the terminal echoing the input parameter values followed by:

TYPE "OK" TO GENERATE ROUTES

The response "OK" is immediately followed by execution of the route selection and loading algorithm described in 1.3. Any other response returns the program to the master control sequence. As the algorithm proceeds a short listing appears at the terminal describing the progress of the computations. The listing describes the status of the link list after each pass and the links which are blocked prior to the next pass through the Ford-Fulkerson route selection routines.
2.6 Evacuation Simulation

Control Option 3 directs the program to simulate an evacuation along the regional highway network according to a previously computed set of routes and loadings. No additional input is required from the user. At the conclusion of the simulation, a short table is printed at the terminal showing the percentile distribution of evacuees as at risk (unevacuated), en route, or at their destination.
3.0 Sample Run

A sample run using FEMA's UNIVAC 1108 computer illustrates the interactive usage of the IDA/BPT model and provides examples of the variety of tables that can be generated by model users. There are three parts to the sample run:

1. The on-line (terminal) input/output stream.
2. Summary tables output through channel 20.
3. Route listings output through channel 19.
3.1 Terminal Input/Output Stream

The sample run is a straightforward application of the model to a small but typical problem, the evacuation of the major population, industry and military centers of New England. The terminal listing has been annotated to show the major elements of the computations:

1. The control options are listed as the program begins execution.

2. Route listings are routed to channel 19 which is linked to the file FILE 19.

3. Summary tables are routed to channel 20 which is linked to the file FILE 20.

4a. The New England regional transportation network is retrieved in preprocessed form through channel 11. Previously it had been stored on FILE 11, or,

4b. The New England network is assembled from the transportation network data base.

5. Table 4.0 is printed.

6. The controls and parameter values for the crisis relocation planning submodel are input.

7. Table 1.0 is printed; the transportation problem is solved.

8. The controls and parameter values for the route selection and loading submodel are input.

9. Table 2.0 is printed; the route selection and loading algorithm is begun.

10. Table 2.1 is printed as the algorithm progresses. Each line of the table shows a link to be blocked at the next iteration of the route selection procedure. Also shown is the size of the route list after each pass.

11. The evacuation is simulated; Table 3.0 is printed.

12. End.
LIST OF CONTROL OPTIONS

NO. CONTROL OPTION
0 REPEAT LIST OF CONTROL OPTIONS
1 INPUT/COMPUTE CRISIS RELOCATION PLAN
2 RUN ROUTE FINDING/LOADING ALGORITHM
3 SIMULATE THE EVACUATION
4 ASSEMBLE NETWORK FROM DATA FILES
5 READ STORED NETWORK
6 READ GENERATED NETWORK
7 PENSION INPUT CHANNEL FOR PARAMETER VALUES
8 PENSION OUTPUT CHANNEL FOR SUMMARY FILES
9 PENSION OUTPUT CHANNEL FOR ROUTE LISTING
99 TERMINATE PROGRAM

2 INPUT CONTROL OPTION NUMBER
9 CONTROL OPTION 9 TYPE "OK" TO EXECUTE
OK
INPUT NEW CHANNEL NUMBER (6=TERMINAL)
19

3 INPUT CONTROL OPTION NUMBER
8 CONTROL OPTION 8 TYPE "OK" TO EXECUTE
OK
INPUT NEW CHANNEL NUMBER (6=TERMINAL)
20

4a INPUT CONTROL OPTION NUMBER
5 CONTROL OPTION 5 TYPE "OK" TO EXECUTE
OK
ASSIGN INPUT CHANNEL FOR SAVED NETWORK
11

5 NUMBER STATE NAME
9 CONNECTICUT
23 MAINE
25 MASSACHUSETTS
33 NEW HAMPSHIRE
44 RHODE ISLAND
50 VERMONT

NUMBER OF NETWORK NODES 170
NUMBER OF NETWORK LINKS 788

4b INPUT CONTROL OPTION NUMBER
4 CONTROL OPTION 4 TYPE "OK" TO EXECUTE
OK

INPUT THE NUMBER OF STATES IN THE REGION (UP TO 10)
6
INPUT 6 STATE NUMBERS
9, 23, 25, 33, 44, 50

5 NUMBER STATE NAME
9 CONNECTICUT
23 MAINE
25 MASSACHUSETTS
33 NEW HAMPSHIRE
44 RHODE ISLAND
50 VERMONT

TYPE "OK" TO ASSEMBLE NETWORK
OK
READING 37 NODES FOR STATE 9
READING 25 NODES FOR STATE 23
READING 39 NODES FOR STATE 25
READING 33 NODES FOR STATE 33
READING 15 NODES FOR STATE 44
READING 11 NODES FOR STATE 50
READING 200 LINKS FOR STATE 9
READING 114 LINKS FOR STATE 23
READING 224 LINKS FOR STATE 25
READING 184 LINKS FOR STATE 33
READING 76 LINKS FOR STATE 44
READING 118 LINKS FOR STATE 50

NUMBER OF NETWORK NODES 170
NUMBER OF NETWORK LINKS 788
6 INPUT CONTROL OPTION NUMBER
   CONTROL OPTION 1 TYPE "OK" TO EXECUTE

   INPUT EVACUATION PLAN YES OR NO?
   YES

   INPUT NUMBER OF EVACUATION COUNTIES (YES OR NO)
   NO

   INPUT NUMBER OF RECEPTION COUNTIES (YES OR NO)
   NO

   INPUT SPECIFY VULNERABILITY GROUP CODE (1 TO 4)
   1

   INPUT WHICH PERCENT TO BE EVACUATED
   90

   INPUT COUNTERFORCE TARGETS YES OR NO?
   NO

   INPUT SPECIFY EVACUATION MAXIMUM DENSITY IN EVACUATED COUNTIES IN PEOPLE/SQ MILE
   50

   INPUT SPECIFY RECEPTION COUNTIES YES OR NO?
   NO

   INPUT SPECIFY MINIMUM, MAXIMUM PRE-EVACUATION RECEPTION AREA DENSITY IN PEOPLE/SQ MILE
   10, 50

   INPUT SPECIFY MINIMUM, MAXIMUM TRAVEL TIME IN HOURS X 100
   0.5, 5.0

   INPUT MAXIMUM RESIDENT POPULATION MULTIPLE X 100
   1.0

   INPUT POST-EVACUATION MAXIMUM DENSITY IN RECEPTION COUNTIES IN PEOPLE/SQ MILE
   500

   NUMBER OF EVACUATION COUNTIES 11
   EVACUATED POPULATION 263996
   NUMBER OF RECEPTION COUNTIES 41
   RECEPTION AREA CAPACITY 4251722
   VULNERABILITY GROUP CODE: 1
   MINIMUM EVACUATED POPULATION: 90 PERCENT
   COUNTERFORCE TARGETS ARE EVACUATED
   MINIMUM RECEPTION AREA DENSITY: 10 PEOPLE/SQ MILE
   MAXIMUM RECEPTION AREA DENSITY: 500 PEOPLE/SQ MILE
   MINIMUM TRAVEL TIME TO RECEPTION AREAS: 0.5 HOURS
   MAXIMUM TRAVEL TIME TO RECEPTION AREAS: 8.00 HOURS
   MAXIMUM RESIDENT POPULATION MULTIPLE: 3.00
   POST-EVACUATION MAXIMUM DENSITY IN EVACUATED AREAS: 500
   POST-EVACUATION MAXIMUM DENSITY IN RECEPTION AREAS: 500

   TYPE "OK" TO COMPUTE EVACUATION PLAN
   OK

   EVACUATION PROBLEM IS FEASIBLE
   NUMBER OF EVACUATION/RECEPTION COUNTY PAIRS 29

7 INPUT CONTROL OPTION NUMBER
   CONTROL OPTION 2 TYPE "OK" TO EXECUTE
   OK

   INPUT VEHICLES/LANE/HOUR FOR 1) LIMITED ACCESS, 2) PRIMARY 4-LANE, 3) PRIMARY 2-LANE, 4) SECONDARY HIGHWAYS
   2000, 1600, 1200, 800
   INPUT AVERAGE SPEED IN MILES/HOUR FOR 1) LIMITED ACCESS, 2) PRIMARY 4-LANE, 3) PRIMARY 2-LANE, 4) SECONDARY HIGHWAYS
   45, 40, 35, 30
   INPUT HIGHWAY CONFIGURATION CODE 1) NORMAL, 2) ONE WAY, 3) VARIABLE LANES
   3
   INPUT PASSENGERS/VEHICLE X 100
   400
   INPUT NOMINAL EVACUATION TIME IN HOURS X 100
   800
   INPUT DELAY TIME TERMINATION LIMIT IN HOURS X 100
   600

8 HIGHWAY CLASS VOLS/LANE/HR MILES/HOUR
   LIMITED ACCESS 2000, 45
   PRIMARY 4-LANE 1600, 40
   PRIMARY 2-LANE 1400, 35
   SECONDARY 1200, 30
   HIGHWAY CONFIGURATION: ONE WAY OUTBOUND TRAFFIC
   AVERAGE PASSENGERS PER VEHICLE: 4.00
   NOMINAL EVACUATION TIME: 3.00 HOURS
   DELAY TIME TERMINATION LIMIT: 6.00 HOURS
   TYPE "OK" TO GENERATE ROUTES
   OK
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**INPUT CONTROL OPTION NUMBER**

1. TYPE "OK" TO TERMINATE PROGRAM

2. EXECUTE PROGRAM
3.2 Summary Tables

The summary tables 1.0, 2.0, 2.1, 3.0 and 4.0 reproduce tables from the on-line input/output stream and are not duplicated below. All of the other summary tables from the sample run are shown below. Variable definitions are given in the notes accompanying each table.

Notes for Table 4.1

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Notes for Table 1.1

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Notes to Table 2.1

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Notes to Table 2.2

ROUTE - route list sequence number
PAIR - evacuation/reception pair number
EVACUEES - loading of the route
CITY - name of county center
COUNTY - county name
DISTANCE - length of route in miles
TRAVEL - average travel hours at evacuation speeds
DELAY - average delay hours
TOTAL - TRAVEL plus DELAY time

Notes to Tables 3.1 and 3.2

EVACUATION/RECEPTION COUN:Y - county name
EVACUEE - number of people evacuated from or to the county
PERCENTAGE - percentage of evacuees departed from or arrived at the county at the elapsed hour shown

Notes to Table 3.3

FROM/TO - name of county center
ROUTE NAME - highway type and number
DISTANCE - length of the link in miles
SPEED - evacuation miles/hour
CAPACITY - evacuation vehicles/hour for all available lanes
PERCENTAGE - percentage of capacity in use for the evacuation plan at the elapsed hour shown
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**TABLE 2.1**

**ROUTE CHARACTERISTICS AND LOADINGS**

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### TABLE 3.1

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### TABLE 3.2

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3.3 Route Listing

Each route is displayed in detail in Table 2.3. The routes appear in the same order in which they are summarized in Table 2.2. Since Table 2.3 is long and quite detailed, only the part of it corresponding to the first nine routes of Table 2.2 has been reproduced below.

The sequence of nodes proceeding from the origin to the destination is shown for each route. For each node (or link into the node) the following information is given:

- **NODE** - the 5-digit FIPS code of the state/county with the node's single-digit sequence number added as the sixth digit.
- **CODE** - a code number embedding the highway segment's characteristics and number.
- **TRAVEL** - elapsed travel time to the node at evacuation speeds.
- **DELAY** - elapsed delay time, i.e., the longest average delay time imposed by a congested link already listed.
- **TOTAL** - TRAVEL plus DELAY time.
- **DIST** - accumulated distance in miles.
- **SPEED** - link evacuation speed in miles/hour.
- **CAP** - link evacuation capacity in vehicles/hour for all available lanes.
- **VCLS** - number of vehicles using the link according to the route loading.
- **PLACE NAME** - name of county center.
- **COUNTY** - county name.
- **ROUTE NAME** - highway type and number.
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<td>350A</td>
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**ROUTE 4**

<table>
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<th>CODE</th>
<th>TRAVEL</th>
<th>DELAY</th>
<th>TOTAL</th>
<th>DIST.</th>
<th>SPEED</th>
<th>CAP.</th>
<th>VCL</th>
<th>NAME</th>
<th>PLACE</th>
<th>COUNTY</th>
<th>ROUTE NAME</th>
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<tr>
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<td>300A</td>
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**ROUTE 5**

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<th>DELAY</th>
<th>TOTAL</th>
<th>DIST.</th>
<th>SPEED</th>
<th>CAP.</th>
<th>VCL</th>
<th>NAME</th>
<th>PLACE</th>
<th>COUNTY</th>
<th>ROUTE NAME</th>
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**ROUTE 6**

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<th>DELAY</th>
<th>TOTAL</th>
<th>DIST.</th>
<th>SPEED</th>
<th>CAP.</th>
<th>VCL</th>
<th>NAME</th>
<th>PLACE</th>
<th>COUNTY</th>
<th>ROUTE NAME</th>
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<tr>
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<td>300A</td>
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<tr>
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</table>
4.1 Program/Storage Size Limits

A number of constraints are imposed by program storage limits on the size of problems which can be handled by the model. These constraints are shown in the following table.

<table>
<thead>
<tr>
<th>Constraint Item</th>
<th>Limit</th>
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<tbody>
<tr>
<td>Input/Output Channels 11-20</td>
<td>10</td>
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<tr>
<td>States per Regional Network</td>
<td>10</td>
</tr>
<tr>
<td>Regional Network Nodes</td>
<td>500</td>
</tr>
<tr>
<td>Regional Network Links</td>
<td>2000</td>
</tr>
<tr>
<td>Evacuation Counties</td>
<td>40</td>
</tr>
<tr>
<td>Reception Counties</td>
<td>500</td>
</tr>
<tr>
<td>Evacuation/Reception County Pairs</td>
<td>200</td>
</tr>
<tr>
<td>Routes on the Route List</td>
<td>500</td>
</tr>
<tr>
<td>Links per Route</td>
<td>19</td>
</tr>
</tbody>
</table>

These constraints limits have been set to conserve computer memory without excluding most applications. If necessary, the limits can be expanded by increasing array dimensions and making other minor changes in the programs.
4.2 Subprogram Descriptions

MAIN - A dummy main program which only calls MASTER.

MASTER - Operates the master control sequence.

PASS - Operates the route selection and loading algorithm.

ORDER - Reorders the link list for a regional network.

PRICE - Performs the first stage of the Ford-Fulkerson fastest route computation for a given destination.

ROUTE - Finds the fastest route from a given origin to a given destination.

COUNTY - Prints a table of county population centroids within a region.

LOCK - Locates a renumbered node from its FIPS code and sequence number.

STACK - Gets the nodes of a regional network from the Node File.

ROADS - Gets the links of a regional network from the Links File.

SAVER - Saves/retrieves preprocessed regional networks.

SHOW - Prints summary table and route listing on completion of the route selection and loading algorithm.

SOrTR - Twig sort routine called by ORDER.

BUILD - Operates the assembly of a regional transportation network from the data base.

SETUP - Operates the direct input or computation of a crisis relocation plan.

LOADL - Performs an evacuation simulation for a single network link

EVAC - Operates the simulation of an evacuation given a set of route loadings.
LOADER - Computes traffic on all links given the number of evacuees using each route.

BLOCK - Blocks congested links at Step 4 of the Route Selection and Loading algorithm.

IFSAME - Checks a new route to see if it duplicates a route on the route list in Step 2.

TIMER - Computes average travel, delay and total time for a route.

HEADER - Prints a table heading.

TRNPLX - Main calling sequence for solving the linear program transportation problem.

RESET
XCK
SWAP
RESD
ROW
GET
DELTA
MIN
NEW
PIVOT

- Subroutines called directly/indirectly from TRNPLX.
4.3 Procedure Files. Elements

BPT*EXECUTE.COMPILE

Compiles source code to relocatable elements.

BPT*EXECUTE.ASSEMBLE

Assembles relocatable code elements.

BPT*EXECUTE.RUN

Executes program.
BPT*EXECUTE, COMPILE

BPT*OBJECT.
BPT*FU BPT*SOURCE.COMMON.BPT*SOURCE.
BPT*FU BPT*SOURCE.MAIN.BPT*SOURCE.
BPT*FU BPT*SOURCE.MASTER.BPT*SOURCE.
BPT*FU BPT*SOURCE,MIX.BPT*SOURCE.
BPT*FU BPT*SOURCE,ORDER.BPT*SOURCE.
BPT*FU BPT*SOURCE,PRICE.BPT*SOURCE.
BPT*FU BPT*SOURCE,ROUTE.BPT*SOURCE.
BPT*FU BPT*SOURCE,STACK.BPT*SOURCE.
BPT*FU BPT*SOURCE,COUNTY.BPT*SOURCE.
BPT*FU BPT*SOURCE,LOCK.BPT*SOURCE.
BPT*FU BPT*SOURCE,ROADS.BPT*SOURCE.
BPT*FU BPT*SOURCE,SAVER.BPT*SOURCE.
BPT*FU BPT*SOURCE,SHOW.BPT*SOURCE.
BPT*FU BPT*SOURCE,SORT.BPT*SOURCE.
BPT*FU BPT*SOURCE,BUILD.BPT*SOURCE.
BPT*FU BPT*SOURCE,SETUP.BPT*SOURCE.
BPT*FU BPT*SOURCE,LOADL.BPT*SOURCE.
BPT*FU BPT*SOURCE,EVAC.BPT*SOURCE.
BPT*FU BPT*SOURCE,LOADER.BPT*SOURCE.
BPT*FU BPT*SOURCE,BLOCK.BPT*SOURCE.
BPT*FU BPT*SOURCE,IFSAME.BPT*SOURCE.
BPT*FU BPT*SOURCE,HEADER.BPT*SOURCE.
BPT*FU BPT*SOURCE,TRPLX.BPT*SOURCE.
BPT*FU BPT*SOURCE,RESET.BPT*SOURCE.
BPT*FU BPT*SOURCE,ICK.BPT*SOURCE.
BPT*FU BPT*SOURCE,SWAP.BPT*SOURCE.
BPT*FU BPT*SOURCE,RESD.BPT*SOURCE.
BPT*FU BPT*SOURCE,ROW.BPT*SOURCE.
BPT*FU BPT*SOURCE,GET.BPT*SOURCE.
BPT*FU BPT*SOURCE,DELTA.BPT*SOURCE.
BPT*FU BPT*SOURCE,MIN.BPT*SOURCE.
BPT*FU BPT*SOURCE,NEW.BPT*SOURCE.
BPT*FU BPT*SOURCE,PIVOT.BPT*SOURCE.
BPT*EXECUTE* ASSEMBLE

@ASG-A BPT*USND.
@ASG-A BPT*USLD.
@MASC-A BPT*MAP.
@ASG-T FILE11.
@ASG-T FILE12.
@ASG-T FILE13.
@ASG-T FILE14.
@ASG-T FILE15.
@ASG-T FILE16.
@ASG-T FILE17.
@ASG-T FILE18.
@ASG-T FILE19.
@ASG-T FILE20.
@ASG-T ROUTES.
@USE 8, BPT*USND.
@USE 9, BPT*USLD.
@USE 10, BPT*MAP.
@USE 11, FILE11.
@USE 12, FILE12.
@USE 13, FILE13.
@USE 14, FILE14.
@USE 15, FILE15.
@USE 16, FILE16.
@USE 17, FILE17.
@USE 18, FILE18.
@USE 19, FILE19.
@USE 20, FILE20.
@USE 7, ROUTES.
@STEP OBJECT.SMAIN

BPT*EXECUTE* RUN
4.4 Source Code Listings

COMMON Block Insert
Main Program

Subprograms:

MASTER
PASS
ORDER
PRICE
ROUTE
COUNTY
STACK
LOCKS
ROADS
SAVER
SHOW
SORTR
BUILD
SETUP
LOADL
EVAC
LOADER
BLOCK
IFSAME
TIMER
HEADER

Transportation Subprograms:

TRNPLX
RESET
XCK
SWAP
RESD
ROW
GET
DELTAS
MIN
NEW
PIVOT
SUBROUTINE MASTER

C MASTER CONTROL SEQUENCE
INCLUDE SOURCE, INSERT
DIMENSION NREG(60), INREADY(3)
DATA KIN1,KIN2,KOUT1,KOUT2,KOUT3/5,5,5,5,5/
DATA YES,OK,NO/1,1,1,1,1/
DATA NREADY/0,0,0/0
REWIND 10
10 READ(10,501) J, (MAP(I,J),I=1,4), (SNAMES(I,J),I=1,4)
501 FORMAT(15E2,2X,4A4A)
GO TO 9
10 WRITE(KOUT1,601)
601 FORMAT(1X,'CONTROL OPTION NUMBER')
READ(KIN1,*,ERR=20) 1
IF(1.NE.99) GO TO 25
WRITE(KOUT1,608)
608 FORMAT(1X,'TYPE OK TO TERMINATE')
READ(KIN1,605) AYN
IF(AYN.NE.YES) GO TO 20
WRITE(KOUT1,609)
609 FORMAT(1X,'PROGRAM ENDS')
IF(KOUT2.NE.6) WRITE(KOUT2,620)
IF(KOUT3.NE.6) WRITE(KOUT3,620)
620 FORMAT(1X)
IF(KOUT2.NE.6) ENDFILE KOUT2
IF(KOUT3.NE.6) ENDFILE KOUT3
RETURN
25 IF(J.LT.0.OR.J.GT.9) GO TO 20
WRITE(KOUT1,602) I
602 FORMAT(1X,'CONTROL OPTION '+2X,TYPE OK TO EXECUTE')
READ(KIN1,605,ERR=20) AYN
605 FORMAT(1X)
IF(AYN.NE.YES) GO TO 20
IF(J.GE.4.AND.J.NE.7) GO TO 40
WRITE(KOUT1,603)
IF(I.LE.3.AND.OR(1).EQ.1) GO TO 40
IF(I.LE.3.AND.OR(1).EQ.1) GO TO 40
IF(I.LE.3) WRITE(KOUT1,611)
IF(I.LE.3) WRITE(KOUT1,611)
IF(I.LE.3) WRITE(KOUT1,611)
I=I+1
GO TO (10,20,100,250,200,300,360,320,320,320,11)
30 CALL SETUP(KOUT1,KOUT2,KIN2,NL,NREG,MPR,INF)
NREADY(1)=1
IF(INF,EQ.1) NREADY(2)=0
NREADY(3)=0
GO TO 20
100 CALL PASS(KIN2,KOUT1,KOUT2,KOUT3,NL,NPR,NRT,HRS,PV,KTCC,1R(1001))
NREADY(3)=1
IF(NRT.LE.0) NREADY(3)=0
GO TO 20
200 CALL BUILD(KIN2,KOUT1,KOUT2,NL,NREG,ALY)
260 NREADY(1)=1
IF(INF,LE.0.OR.NL.LE.0) NREADY(1)=0
NREADY(2)=0
NREADY(3)=0
GO TO 20
250 CALL EVAC(KOUT1,KOUT2,NL,NPR,NRT,HRS,PV,KTCC,1R(1001))
GO TO 20
300 KS=1-4
CALL SAVER(KS,NREADY,KIN1,KOUT1,KOUT2,NL,NREG)
IF(I.EQ.5) GO TO 350
GO TO 20
310 WRITE(KOUT1,606)
READ(KIN1,*,ERR=310) KI
IF(KI.EQ.KOUT1.OR.KI.EQ.KOUT2.OR.KI.EQ.KOUT3) GO TO 330
IF(KI.LE.10.AND.KI.NE.5) GO TO 330
IF(KI.LE.30) GO TO 330
KIN=K
GO TO 20
320 WRITE(KOUT1,607)
READ(KIN1,*,ERR=320) KO
IF(KO.EQ.KIN1.OR.KO.EQ.KIN2) GO TO 330
IF(KO.LE.10.AND.KO.NE.5.AND.KO.NE.71) GO TO 330
IF(KI.EQ.9.AND.KO.EQ.KOUT2) GO TO 330
IF(KO.LE.30) GO TO 330
IF(KO.EQ.KOUT2) KOUT2=K0
IF(KI,EQ.9) KOUT3=K0
GO TO 20
330 WRITE(KOUT1,610)
GO TO 210
606 FORMAT(I4,' INPUT NEW CHANNEL NUMBER (5=TERMINAL)'
607 FORMAT(I4,' INPUT NEW CHANNEL NUMBER (5=TERMINAL)'
610 FORMAT(I4,' ILLEGAL CHANNEL SELECTION'
END

SUBROUTINE PASS(KIN1,KOUT1,KOUT2,KOUT3,NL,NPR,NRT,HRS,PV,KTCC,1RST)
C IN WASS
INCLUDE SOURCE,INSERT
DIMENSION MPV(4),MPH(4),XPH(4),XPH(4),TST(1)
DATA YES/'OK'/
DO 3 L=1,NL
UMIT(L,1)=.FALSE.
3 UMIT(L,1)=.FALSE.
C INPUT NETWORK PARAMETERS

900 WRITE(KOUT1,600)
600 FORMAT(14, INPUT VEHICLES/LANE/HOUR FOR 1:LIMITED ACCESS, 2:PRIMARY 4-LANE, 3:PRIMARY 2-LANE, 4:SECONDARY HIGHWAYS)
READ(KIN1,*,ERR=300) MFI(K),N=1,4
900 WRITE(KOUT1,500)
500 FORMAT(14, INPUT AVERAGE SPEED IN MILES/HOUR FOR 1:LIMITED ACCESS, 2:PRIMARY 4-LANE, 3:PRIMARY 2-LANE, 4:SECONDARY HIGHWAYS)
READ(KIN1,*,ERR=400) MFP(K),N=1,4
6

C INPUT PARAMETERS

900 WRITE(KOUT1,600)
600 FORMAT(14, INPUT VEHICLES/LANE/HOUR FOR 1:LIMITED ACCESS, 2:PRIMARY 4-LANE, 3:PRIMARY 2-LANE, 4:SECONDARY HIGHWAYS)
READ(KIN1,*,ERR=300) MFI(K),N=1,4
900 WRITE(KOUT1,500)
500 FORMAT(14, INPUT AVERAGE SPEED IN MILES/HOUR FOR 1:LIMITED ACCESS, 2:PRIMARY 4-LANE, 3:PRIMARY 2-LANE, 4:SECONDARY HIGHWAYS)
READ(KIN1,*,ERR=400) MFP(K),N=1,4

C READ IN LANE INPUT PARAMETERS

DO 100 K=1,N
   IF(K.EQ.1) THEN
      WRITE(KOUT1,510) MFI(K),MFP(K)
   ELSE IF(K.EQ.2) THEN
      WRITE(KOUT1,520) MFI(K),MFP(K)
   ELSE IF(K.EQ.3) THEN
      WRITE(KOUT1,530) MFI(K),MFP(K)
   ELSE IF(K.EQ.4) THEN
      WRITE(KOUT1,540) MFI(K),MFP(K)
   END IF
100 CONTINUE

C READ IN LIMITED ACCESS TIME PARAMETERS

WRITE(KOUT1,550) MFI(K),MFP(K)

C READ IN PRIMARY 4-LANE PARAMETERS

WRITE(KOUT1,560) MFI(K),MFP(K)

C READ IN PRIMARY 2-LANE PARAMETERS

WRITE(KOUT1,570) MFI(K),MFP(K)

C READ IN SECONDARY 2-LANE PARAMETERS

WRITE(KOUT1,580) MFI(K),MFP(K)

C READ IN SECONDARY 4-LANE PARAMETERS

WRITE(KOUT1,590) MFI(K),MFP(K)

C READ IN AVERAGE PASSENGERS PER VEHICLE

WRITE(KOUT1,600) MFI(K),MFP(K)

C READ IN N NOMINAL EVACUATION TIME LIMIT

WRITE(KOUT1,610) MFI(K),MFP(K)

C READ IN DELAY TIME TERMINATION LIMIT

WRITE(KOUT1,620) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,630) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,640) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,650) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,660) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,670) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,680) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,690) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,700) MFI(K),MFP(K)

C READ IN TRAFFIC CLASS LIMIT

WRITE(KOUT1,710) MFI(K),MFP(K)
IF(KOUT2.EQ.2) GO TO 400
CALL HEADER(KOUT2,2.0)
WRITE(KOUT2,650) XPV(K),XPH(K),K=1,4
IF(KOUT2.EQ.1) WRITE(KOUT2,661)
IF(KOUT2.EQ.2) WRITE(KOUT2,662)
IF(KOUT2.EQ.3) WRITE(KOUT2,683)
WRITE(KOUT2,684) F,PHRS,STL
CALL HEADER(KOUT2,2.1)
410 WRITE(KOUT1,633)
IF(IX1.EQ.500) ERR=400 
RETURN
N=10,YES=10 
FORMAT(1X, TYPE "OK" TO GENERATE ROUTES?) 
500 FORMAT(42)
N=0 
NRT=NRT 
NIT=NIT+1 
NE=0 
DO 70 KPR=1,NPR
IF(DENPR(KPR).LT.1.0) GO TO 30
JR=1,JP=1,KPR
IF(NE.EQ.0) GO TO 20 
DO 10 JE=1,NE 
IF(JR.EQ.20) GO TO 30
10 CONTINUE 
20 NE=NE+1 
JEPNE=JLJR 
WRITE(11,601) NE,JR 
CALL PRICE(KPR,KN,Y1,NE),LFR,MFR,CFR,OMIT(1,2),NODES,IA(1001) 
30 CONTINUE 
COLD=CMAK
CMAX=9999.0 
400 COLD=CMAK
CMAX=9999.0
KMAX=0 
DO 70 KPR=1,NPR
IF(DENPR(KPR).LT.1.0) GO TO 70
JR=1,JP=1,KPR
IS=1,JP=1,KPR
DO 50 JE=1,NE 
IF(JR.EQ.60) GO TO 70
50 CONTINUE 
GO TO 70
60 IF(Y1(JE).EQ.0) GO TO 70
IF(Y1(JE).LE.CMAK) GO TO 70
CMAK=Y1(JE)
KMAX=KPR
JMAX=JE
70 CONTINUE 
IF(KMAX.EQ.0) GO TO 200
IF(NRNM.EQ.500) GO TO 200
NRT=NRT+1 
CMAX=CMAK 
KMAX=KMAX 
IS=1,JP=1,KPR 
CALL ROUTE: IS,JR,(IFNO,NRT,1,JR,Y1(KMAX),S,LFR,MFR,CFR,OMIT 
11,1),NODES) 
Y1(IS,JAX)=1.0E10 
IF(YA(JE,JAX)) NE=NE+1 
IF(YAM.EQ.0.AND.RFAME(NRT,NRS,1,JR),ED,0) GO TO 80
75 NRT=NRT+1 
GO TO 40
80 IF(NRNM.EQ.0) GO TO 40
TYPH(TMER,NRT,FV,HR,RS,T1,T2) 
DO 85 KRT=1,NRS 
IF(1,JR(2,KRT,ED,JAX,A,KRT)) GO TO 40
35 CONTINUE 
GO TO 75
200 IF(NEW.GT.0) GO TO 87
205 LAST=1
DIV=100.0
GO TO 125
87 LAST=0
IF(NRT.LE.NRS) GO TO 155
DIV=1.0
IF(NIT.GT.1) DIV=19.0
120 CALL LOADER(NRT,NL,KTCC)
130 NRS=1
140 IF(IS(NFR+1000).EQ.0)
121 TST(KPR)=1.0E20
DO 150 KRT=1,NRT
IF(DENFR(VKPR).LT.1.0)
150 CONTINUE
I RT::IS3PR+1000)
S(JRT)=DENFR(KPR)
DIV=DIV+1.0
W1=2.0/DIV
W2=1.0-W1
KHG=0
DO 150 KRT=1,NRT
IFABS(DR(KRT)-S(KRT)).GT.100.0)
KHG=KHG+1
150 CONTINUE
WRITE(6,602) (DR(KRT),KRT=1,NRT)
602 FORMAT(1X,1UF12.2)
IF(DIV.LE.500.0) GO TO 175
IF(NRS.GT.10.0 AND DIV.NE.100.0) GO TO 120
CALL LOADER(NRT,NL,KTCC)
160 DO 131 KPR=1,NPR
131 CONTINUE
DO 138 KRT=1,NRT
IF(ABS(DR(KRT)).GT.0.02*DEPFR(KPR))
138 CONTINUE
NRS=NRS+1
140 CALL LOADER(NRT,NL,KTCC)
155 CALL BLOCK(KOUT1,KOUT2,NN,NL,KTCC,PV,HRS,T1,NIT,NRT)
175 CALL SHOW(KOUT1,KOUT2,NRT,NRT,NR,NE,PV,HRS,A)
RETURN
END
SUBROUTINE ORDER(NN, NL, LFR, IFR, JTO, MFR, CFR, ISS, ID)
C REORDER LLK_LL
DIMENSION LFR(1), IFR(1), JTO(1), MFR(1), CFR(1), ISS(1), ID(1)
C TALL TIME(1)
DO 10 K = 1, NL
10 IFR(K) = LFR(JTO(K) + 1 + MFR(K))
CALL SORTFR(1, IFR, NL)
11 DO 11 K = 1, NL
C WRITE (9, 901) K, LFR(K), IFR(K), JTO(K), MFR(K), CFR(K)
900 FORMAT (1X, 5I6, F10.3, 12X)
11 V = IFR(K)
20 ISS(K) = K
DO 30 K = 1, NL
20 I0 = IFR(K)
20 J0 = JTO(K)
20 M0 = MFR(K)
20 CFR(K) = CFR(K)
K = LFR(K)
20 IFR(K) = IFR(K0)
20 JTO(K) = JTO(K0)
20 MFR(K) = MFR(K)
20 CFR(K) = CFR(K)
20 IFR(K) = I0
20 JTO(K) = J0
20 MFR(K) = M0
20 CFR(K) = 0
K = ISS(K)
ISS(K0) = K
30 LFR(K) = K
30 DO 25 K = 1, NN
30 LFR(K) = 0
30 J0 = J0
DO 30 K = 1, NL
30 IF (JTO(K).EQ. J0) GO TO 40
J = JTO(K)
LFR(J) = K
40 CONTINUE
N1 = NN + 1
N2 = N1 + 1
LFR(N2) = NL + 1
DO 50 K = 1, N1
50 K = K + 1
IF (LFR(K).EQ. 0) LFR(K) = J
50 J = LFR(K)
DO 60 K = 1, NL
L = L + 1
IF (JTO(K)).EQ. 12 AND MFR(L).EQ. MFR(K)) GO TO 70
60 CONTINUE
GO TO 30
70 CONTINUE
DO 80 K = 1, NL
80 L = ISS(K)
C WRITE (9, 901)
C K, LFR(K), IFR(K), JTO(K), ISS(K), MFR(K), CFR(K), IFR(L), JTO(L), ISS(L), MFR(L)
900 FORMAT (1X, 5I6, F10.3, 12X)
90 JTO(K) = ISS(K)
RETURN
END
SUBROUTINE ROUTE(IS,JR,IPNO,JR,IR,CY,S,LTO,JTO,MTO,OMIT,NODES)
C FIND THE BEST DISTINCT ROUTE FROM IS TO JR
LOGICAL OMIT
DIMENSION 1R(1),1.(1),CY(1),S(1)
DIMENSION LTO(1),JTO(1),MTO(1),CTO(1),OMIT(1),NODES(3,1)
DATA LRM.TOL/19,1.001/
DO 5 L=1,1407
C J=LTO(L)
C NJO=1000+NODES(1,J)+10*NODES(2,J)+NODES(3,J)
C WRITE(5,602) L,LTO(L),LTO(L+1),J,NJO,MT0(L),CTO(L),Y(J)
C 5 CONTINUE
C WRITE(5,602) JR,IS,JR
IFNO=0
   IL=0
   IF(FL*FL+IL*IL.LT.QL) GO TO 70
20 CONTINUE
   IF(IFNO.EQ.1) RETURN
   C WRITE(6,600) I,J,IS,IS,JR,L,MTOL(L),CKR+CTO(L)+Y(J),Y(IS),Y(JR)
600 FORMAT(1X,619,5F9.3)
   IF(CKR+CTO(L)+Y(J).LT.CTEST) GO TO 55
50 CONTINUE
   IFNO=1
   C WRITE(6,600) I,J,IS,JS,JKR,MTOL(L),Y(J),Y(IS),Y(JR)
600 FORMAT(1X,15,2F9.3,20X)
   RETURN
55 CONTINUE
   C WRITE(6,600) I,J,IS,JS,JKR,MTOL(L),Y(J),Y(IS),Y(JR)
600 FORMAT(1X,15,2F9.3,20X)
   RETURN
C LIST POPULATION CENTROIDS
DIMENSION XLOC(1L),LLOC(1L),NODES(3,1L),ANAMES(7,1L),ALPH(16)
DATA ALPH/"A","B","C","D","E","F"/
   IF(KOUT2.NE.6) CALL HEADER(KOUT2,4)
   WRITE(KOUT2,601)
DO 10 J=1,NH
   IF(NODES(3,J).GT.0) GO TO 10
   K=1000+NODES(1,J)+2*NODES(2,J)-1
   POP=XLOC(K)
   AR=XLOC(K)/10
   IF(1.LT.EQ.0) LI=5
   L2=LLOC(J)-10+LI*5
   ALPH(L1)
   RETURN
602 FORMAT(1X,15,2X,4A4,2X,3A4,1H12.0,2F9.0,3X,1A1,1X,1A1)
601 FORMAT(1X,’POPIATION CENTROID LIST’/ 
11X,’FIPS PLACE NAME’,8X,’COUNTY’,8X,’POPULATION AREA’, 
2X,’DENSITY FEMAMA’)
   END
SUBROUTINE COUNTY(KOUT2,NN,XLOC,LLOC,NODES,ANAMES)
C LIST POPULATION CENTROIDS
DIMENSION XLOC(1L),LLOC(1L),NODES(3,1L),ANAMES(7,1L),ALPH(16)
DATA ALPH/"A","B","C","D","E","F"/
   IF(KOUT2.NE.6) CALL HEADER(KOUT2,4)
   WRITE(KOUT2,601)
DO 10 J=1,NH
   IF(NODES(3,J).GT.0) GO TO 10
   K=1000+NODES(1,J)+2*NODES(2,J)-1
   POP=XLOC(K)
   AR=XLOC(K)/10
   IF(1.LT.EQ.0) LI=5
   L2=LLOC(J)-10+LI*5
   ALPH(L1)
   WRITE(KOUT2,602) K,(ANAMES(1,J),J=1,7),(POP,AR,DEM,AL,CF)
10 CONTINUE
   RETURN
602 FORMAT(1X,15,2X,4A4,2X,3A4,1H12.0,2F9.0,3X,1A1,1X,1A1)
601 FORMAT(1X,’POPIATION CENTROID LIST’/ 
11X,’FIPS PLACE NAME’,8X,’COUNTY’,8X,’POPULATION AREA’, 
2X,’DENSITY FEMAMA’)
   END
SUBROUTINE ROADr6(NET,NREG,MAP,KOUT1,NN,NL,CIJ,IJ,NOLOC,NODES)
C CONSTRUCT ROAD LINKS FROM ROADNET FILE
DIMENSION CJJ(1,3),CIJ(3,1),NOLOC(2,1),N0D(3,1)
DIMENSION NET(1),NREG(1),MAP(4,1)
DEFINE FILE 9(100000,100,E,NE)
NL=0
DO 30 JR=1,NR
IF(MAP(3,J).EQ.0.OR.NREG(J).EQ.0) GO TO 30
I=CJ(J,1)
J=MAP(4,J)
NNS=NS-NR+1
WRITE(KOUT1,9)NNS,J
601 FORMAT(1X,91,13,10,9,13) LINKS FOR STATE I2
DO 30 JR=NR,NF
READ(9,NR,503;ERR=25) IT,IJ(1,1),IJ(2,1),IT,CJ(1,1),IJ(3,1)
NREG(1)=IT
JS=MAP(3,J)
IF(JS.EQ.0.OR.NREG(J).EQ.0) GO TO 30
I=I+1
J=J+1
I=I+1
J=J+1
IJ(1,L3)=IJ(1,L3)+(IJ(2,L4)*IJ(3,L4))**.5
IJ=ILOCK(IJ(1,1),IJ(2,1),IJ(3,1))
IJ=ILOCK(IJ(1,1),IJ(2,1),IJ(3,1))
IF(IJ.EQ.0.OR.NREG(J).EQ.0) GO TO 30
KODE=(KODE+1)*10000*K(2-1)
IF(KODE.EQ.0) GO TO 18
DO 10 L=INL
IF(J.NE.IJ(1,L)) GO TO 10
IF(J.NE.IJ(2,L)) GO TO 10
IF(J.NE.IJ(3,L)) GO TO 10
II=II+1
10 CONTINUE
18 INL=INL+1
I=I+1
J=J+1
IJ(3,NL)=KODE
CIJ(NL)=D
GO TO 30
25 WRITE(6,602)J,JR
602 FORMAT(1X,9,13,10,9,13)
30 CONTINUE
40 CONTINUE
502 FORMAT(2X,13,12,215,3X,13,12,215,1X,211,15)
503 FORMAT(12,13,12,215,1X,12,13,12,215,1X,211,15)
RETURN
END

SUBROUTINE SAVR(KFLAG,READY,MIN,KOUT1,KOUT2,NN,NL,NREG)
C SAVE OR RETRIEVE ORDERED ARRAYS TO BYPASS ORDERING
INCLUDE SOURCE, INSERT
DIMENSION NREG(1)
DATA 'YES'/YES'/
READY=0
IF(KFLAG.EQ.0) RETURN
IF(KFLAG.EQ.2) GO TO 100
5 WRITE(KOUT1,601)
READ(KIN,*(ERR=5) IF
IF(KIN.EQ.11.OR.IF(6,30)) GO TO 10
READ(IOF,*(ERR=200) NN,NL,NRE(K),K=1,601)
READ(IFR,*(ERR=200) LFR(K),K=1,NN)
RETURN
END
READ(IFILE,ERR=200) (IFR(J),J=1,NL)
READ(IFILE,ERR=200) (JTO(J),J=1,NL)
READ(IFILE,ERR=200) (IFR(J),J=1,NL)
READ(IFILE,ERR=200) (IDSTLK(J),J=1,NL)
READ(IFILE,ERR=200) (IXLCC(J,K),K=1,NN),J=1,2,(LLCC(K),K=1,NN)
READ(IFILE,ERR=200) (INODES(J,K),K=1,NN),J=1,3)
READ(IFILE,ERR=200) (IANAMES(J,K),K=1,NN),I=1,7)
WRITE(KOUT1,651)
TO 10 I=1,60
IF(NREG(I,EA.3),GOTO 561)
WRITE(KOUT1,652) K, (SNAMEs(J,K),I=1,4)
END
CONTINUE
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WRITE(6,666) JRT,(I.R(1,K,RT),KL,F),(IjR(2 ,K,JRT),K=1,Wf)

C GO TO 100
8 L=IR(NF,3.T)
I=IFR(LO)
NR=E=1(000~*NO2ES (1,
I
I-10i(2*Nr@ES(2,
I)-1+OEQ
1
W#N
1
NC'1
NLN
'CDE-MFR(L)+10000
C ARITE(IFILE,600)

MODE=MFR(L) /10000
WRITE(IFILE,600) NODE,MODE,STOT,DTOT,SPD, (ANAMES(K,NON),K=1,5) >M=1
T=0,0
1 t=1
5 L=+H
IF(U.EQ.2) GO TO 25
10 L=IR(NL+1,JRT)
IF(U.EQ.2) GO TO 12
L=IR(NL+1,JRT)
GO TO 20
12 I=IFR(2.KPR)
20 DST=DSTLMK(L)
SPD=SPLMK(L)
CAP=BFR(L)
15 T=T+DST/ADS(SPD)
24 STOT=T
DTOT=DTOT+ST
SPD=ABS(SPD)
VCL=BFR(L)/PV
TIM+VCL/(2.0*CAP)
IF(TIM.GT.TIM) TIM=TIM
TOST=STOT
NODE=NODE+NODES(1,1)+10*2+NODES(2,1)-1)*NODES(3,1)
NON=1
25 CONTINUE
XL (NL,JRT)=STOT
NH=MFR(L)-10000*HFR(L)/10000)
NH=MFR(L)/10000+1
MODE=MFR(L)+10000
*I(L,Ed) WRITE(IFILE,604) NODE,MODE,STOT,DTOT,SPD, (ANAMES(K,NON),K=1,5)
1VCL=(ANAMES(K,NON),K=1,7),NH
IF(K.EQ.2) WRITE(IFILE,603) NODE,MODE,STOT,DTOT,SPD, (ANAMES(K,NON),K=1,7),NH
IF(K.EQ.2) WRITE(IFILE,602) NODE,MODE,STOT,DTOT,SPD, (ANAMES(K,NON),K=1,7),NH
30 IF(J.LT.F) 90
X(2,JRT)=STOT
C 60 WRITE(IFILE,605) NODE,MODE,STOT,DTOT,SPD, (ANAMES(K,NON),K=1,5)
WRITE(IFILE,606)
606 FORMAT(11)
T=TIMER(RT,PV,HRS,TI,T2)
WRITE(KOUT,620) RT,1,JRT,GR(JRT),ANAMES(K,NO),K=1,7),NH
1ANAMES(K,NO),K=1,7),COT.T1,T2,T3
620 FORMAT(1X,15.2X,14.2X,F10.0,3X,7A4,4X,7A4,2X,F8.1,3X,F8.2))
200 CONTINUE
210 CONTINUE
RETURN
604 FORMAT(1X,16.2X,15.3F8.2,2.3F8.1,2F8.0,2X,7A4, 'STATE
1,13)
603 FORMAT(1X,16.2X,15.3F8.2,2.3F8.1,2F8.0,2X,7A4, 'U.S. ROUTE
1,13)
602 FORMAT(1X,16.2X,15.3F8.2,2.3F8.1,2F8.0,2X,7A4, 'STATE ROAD
1,13)
609 FORMAT(1X, ROUTE (I,A)
610 FORMAT(1X, NODE CODE, TRAVEL DELAY, TOTAL DIST, SPEED)
1,13)
601 FORMAT(1X, ROUTE CHARACTERISTICS AND LOADINGS (2X, FROM, 2X, TO
1,14X, AVERAGE HOURS, AVERAGE SPEED, EVACUEE CITY
1,13)
600 FORMAT(1X, TOTAL )
SUBROUTINE SORTRN(IDAT,INDEX,L)
    INTEGER INDEX,L
    DIMENSION IDAT(1),INDEX(1)
    DIMENSION L(1)
    L(0)=0
    M(0)=0
    I(0)=0
    J(0)=0
    M=1
    J=1
    IF(M.LE.1) GO TO 440

C CLIMB THE TREE
290 IF(M.LE.K) GO TO 320
  A=K+1
  B=K+1/2
  SI=IFIX(B)
  TI=T4+(B2-SI)*K2
  GO TO 290

C INITIAL CALCULATIONS
320 T4=2-T4
  B2=K2/2

C NEXT TWIG
350 IF((K1.LE.KI)) GO TO 540
  T1=K1+1
  T1=K1+1
  B1=BL
  T3=T2

C ADD 1 TO REFLECTED BINARY COUNTER AND CARRY
400 T1=T1/2.
  IF(IFIX(T1).LT.T1) GO TO 470
  M1=M1+1
  T1=T1-B1
  B1=B1/2.
  GO TO 400

C TWIG CALCULATIONS
470 T1=T1+B1
  IF(SI.ED.2) GO TO 550

C 3-TWIGS & 4-TWIGS
  IF(T1.LT.T4) GO TO 550

C 4-TWIG
  M1=M1+1
  GO TO 630

550 IF(T1.LT.T4) GO TO 610

C ...3-TWIG
560 M1=M1+1
  I=I+1
  L(I)=I
  L(J)=I
  M=I+1

C ...2-TWIG
610 M1=M1+1
  630 I=I+1
  L(I)=I
  L(J)=I
  L0=J
  J=J+1
  I=I+1
  L2=I
  L1=I
  L(J)=I
  GO TO 750

C MERGE LEAVES AND BRANCHES
700 J=J-1
  L0=J-1
  L1=L(L0)
  L2=L(J)
  750 IF(IDAT(L0).LE.IDAT(L2)) GO TO 820
  L0=L0=L2
  770 L2=L0
  L0=L0(L0)
  IF(L0.LEQ.L0) GO TO 870
  IF(IDAT(L0).LT.IDAT(L2)) GO TO 770
  L0=L0=L2
  820 L0=L1
  L1=L1(L0)
  IF(L1.NE.L0) GO TO 750
LILIQ=NL2
GO TO 880
870 LILIQ=LI
680 M1=M1-1
IF(M1.GT.0) GO TO 700
IF(M1.EQ.0) GO TO 350
C GENERATE END HALF OF A 4-TWIG
610 M1=M1
GO TO 350
C END
840 CONTINUE
RETURN
END

SUBROUTINE BUILD(IN1,KOUT1,KOUT2,NN,NL,NREG,CIJ,LI)
C ASSEMBLE NETWORK COMPONENTS AND SORT LINKS
INCLUDE SOURCE, INTEGER
DIMENSION CJ(111),IJ(111)
DIMENSION NET(501),NREG(1)
DATA OK,'YES',VS/ "OK", 'YES', 'Y'/
70 WRITE(KOUT1,203)
503 FORMAT(1X, 'INPUT THE NUMBER OF STATES IN THE REGION (UP TO 100)'
 calves, +, ERR=70), 40
IF(NLT.1, ERR, print, 101, 50 TO 70)
WRITE(KOUT1,502) 40
602 FORMAT(1X, 'INPUT STATE NUMBERS')
READ(IN1, +, ERR=70), I,NL
DO 50 K=1,NS
IF(NLT.1, ERR, print, 101, 50 TO 70)
50 CONTINUE
133 DO 130 I=1,60
WRITE(KOUT1,601)
120 NREG(I)=0
WRITE(KOUT1,607)
READ(IN1,501) AYN
IF(AYN.EQ.0) GO TO 70
170 CALL STACK(NET,NREG,MAP,IN1,KOUT1,KOUT2,NN,NOLOC,XXLOC,XXLOC,
INODES,NAMES)
IF(INL.LE.0) RETURN
CALL ASSEMBLE(NET,NN,NL,CIJ,LI,NOLOC,NODES,NAMES)
WRITE(KOUT1,604) NN
WRITE(KOUT1,605) NL
604 FORMAT(1X, 'NUMBER OF NETWORK NODES', 1, 15)
605 FORMAT(1X, 'NUMBER OF NETWORK LINKS', 1, 15)
IF(KOUT2.EQ.61) GO TO 200
CALL HEADER(KOUT2,4,40)
WRITE(KOUT2,601)
150 GO TO 160
160 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
200 CALL(0, 6, 603) I
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
210 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
220 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
230 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
240 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
250 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
260 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
270 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
280 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
290 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
300 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
310 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
320 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
330 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
340 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
350 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
360 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
370 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
380 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
390 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
400 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
410 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
420 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
430 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
440 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
450 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
460 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
470 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
480 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
490 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
500 CALL(0, 6, 603) I,NAMES(I),J=1,4
WRITE(KOUT1,604) I
WRITE(KOUT1,605) NL
504 FORMAT(A3)
608 FORMAT(1X, 'LIST THE POPULATION CENTROIDS (YES OR NO)'
RETURN
601 FORMAT(1X, 'NUMBER STATE NAME')
606 FORMAT(1X, 'TYPE "OK" TO ASSEMBLE NETWORK')
501 FORMAT(A2)
END
SUBROUTINE SETUP(KOUT1,KOUT2,KIN1,NN,LN,NREG,NPR,INFS)
LOGICAL B
REAL*8 L,F,P,R,XO
DIMENSION SV(100),DV(500),Z(600),IV(500),V(500),J(500),JE(500),P
(T(100),R(500),B(500)
!INCLUDE SOURCE.INSERT
DIMENSION NREV(N)
DATA OK,OK,'YES','OK','Y'/'
C =I, NL
C T(1) =.FALSE.
K1=K1+1
C.PR(L)=10000
CFR(L) =-10000*K1)/1000
T=15.0
IF(K1.EQ.4) T=45.0
IF(K1.EQ.5) T=40.0
IF(K1.GT.5) T=30.0
SPDLNK(L)=T
IF(CFR(L).LE.0.0) CFR(L)=0.01
CONTINUE
KGE=0
KGR=0
K1=0
200 WRITE(KOUT1,611)
611 FORMAT(/1X,'INPUT EVACUATION PLAN (YES OR NO)?')
READ(KIN1,511,ERR=600) AYN
511 FORMAT(A9)
IF(AYN.NE.YES.AND.AYN.NE.YS) GO TO 220
WRITE(KOUT1,612)
612 FORMAT(/X,'FOR EACH PAIR INPUT: EVACUATION COUNTY NO., RECEPTION C
OUNTY NO., NUMBER OF PEOPLE')
NPR=1
NE=0
205 NPR=NPR+1
IF(NPR.LT.0) NPR=0
210 CONTINUE
READ(KIN1,511,ERR=210) I1,J1,NUM
IF(I1.LE.999) GO TO 125
IF(J1.LE.0) GO TO 205
NPR=NPR+1
S(NPR)=0.0
IT=I1/1000
IC=I1-1000*IT+1/2
IJP(1,NPR)=LOC(1,IT,IC,0,NOLOC,NODES)
I1=IJP(1,NPR)
IT=J1/1000
IC=J1-1000*IT+1/2
IJP(2,NPR)=LOC(1,IT,IC,0,NOLOC,NODES)
J1=IJP(2,NPR)
DENPR(NPR)=NUM
IF(I1.LE.0.OR.J1.LE.0) GO TO 215
WRITE(KOUT1,615) NPR,DENPR(NPR),(ANAMES(K,11),K=1,7),
(ANAMES(J,11),J=1,7)
1,k=1,7)
DO 212 IE=1,NE
IF(JE(IE).EQ.I1) GO TO 214
212 CONTINUE
NE=NE+1
JE(NE)=I1
CALL PRICE(I1,NN,Y(1,NE),LFR,IFR,HFR,CFR,CHT,NODES,IA,5)
IE=NE
214 S(NPR)=YP(I1,JE)
GO TO 210
215 WRITE(KOUT1,651)
651 FORMAT(/X,'COUNTY NOT IN NETWORK')
GO TO 205
220 WRITE(KOUT1,613)
613 FORMAT(/X,'SPECIFY EVACUATION COUNTIES (YES OR NO)?')
READ(KIN1,511,ERR=220) AYN
IF(AYN.NE.YES.AND.AYN.NE.YS) GO TO 240
WRITE(KOUT1,614)
614 FORMAT(/X,'FOR EACH EVACUATION COUNTY INPUT: COUNTY NO., NUMBER'
1, OF PEOPLE')
NE=1
CNE=1
C(NE,LT,0)* NE=0
225 CONTINUE
READ(*,*,ERR=225) JJ,NUM
IF(J,J.EQ.999) GO TO 240
IF(J,J.LE.0) GO TO 225
CNE=1
CNE=J
C=J(J-JJ+1)*/2
J=J(J-JJ+1)*/2
CENE=J
CENE=NUM
IF(J,J.EQ.0) GO TO 235
WRITE(KOUT1,605) NE,SUN(A NAME(XJ),X,J=1,7)
CALL PRI(EJ,NN,Y(J),LFR,IFR,CFR,UNIT,NODES,IA,S)
GO TO 230
235 WRITE(KOUT1,651)
GO TO 225
240 WRITE(KOUT1,615)
615 FORMAT(A2)
READ(KIN1,*,ERR=240) KV
IF(KV,LT.1.OR.KV,GT.4) GO TO 240
WRITE(KOUT1,641)
641 FORMAT(A2)
READ(KIN1,*,ERR=240) FPEV
IF(KPEV,LT.0.OR.KPEV.GT.100) GO TO 245
FPEV=FLOAT(KPEV)/100.0
250 WRITE(KOUT1,656)
656 FORMAT(A2)
READ(KIN1,*,ERR=250) AYN
IF(AYN,NE.YE,YES.AN.D.AN..NO,EQ.1) KF=1
NE=0
GO 270 J=1,NN
IF(XLLOC(J,2,J.EQ.0.0) GO TO 270
J=XLLOC(J)/10
IF(XLLOC(J,J-10,EQ.1) GO TO 260
IF(J,J.LE.0,J.EQ.1,AND.JE,LE.KV) GO TO 250
IF(J,J.GT.1,AND.JE.KV) GO TO 260
IF(J,J.GT.0.AN.D.JE.ED.1) GO TO 260
GO TO 270
260 NE=NE+1
JNE(J)=J
SVNE=XLLOC(J,J)*PEV
IF(JF,J.GT.0.AN.D.JE.ED.1) SVNE=SVNE
CALL PRI(EJ,NN,Y(J),LFR,IFR,CFR,UNIT,NODES,IA,S)
CONTINUE
EMAX=1.0E10
390 WRITE(KOUT1,626)
626 FORMAT(A2)
READ(KIN1,*,ERR=290) AYN
IF(AYN,NE.YE,YES.AN.D.AN..NO,EQ.1) MAXE=MAXE
WRITE(KOUT1,617)
617 FORMAT(A2)
READ(KIN1,*,ERR=310) AYN
IF(AYN,NE.YE,YES.AN.D.AN..NO,EQ.1) N1E=1
WRITE(KOUT1,619)
619 FORMAT(A2)
GO TO 270
270 NR=NR-1
350 CONTINUE
READ(KIN1,*,ERR=350) JJ,NUM
IF(J,J.EQ.999) GO TO 350
IF(J,J.LE.0) GO TO 290
NR=NR+1
J=J/1000
JC=J(J-1000+E,J+1)/2
XLLOC(J,J-1,J)=XLLOC(J,J)
DVNE=NUM
JNR=J
IF(J,J.EQ.0) GO TO 365
WRITE(KOUT,605) NR,OUTPUT,PRINT010,SCALING1,JL=1.77
V(NR)=1
GO TO 300
205 WRITE(KOUT,651)
GO TO 340
210 WRITE(KOUT,619)
610 FORMAT(1X, 'INPUT MINIMUM, MAXIMUM PRE-RECEPTION RECEIVED AREAS DE-

ITY IN PEOPLE/MA, MILE)
READ(KIN1,*;ERR=3) MIN, MAX
NR=0
P=MAX+1

220 WRITE(KOUT,620)
620 FORMAT(1X, 'INPUT MINIMUM, MAXIMUM TRAVEL TIME IN HOURS X 100')
READ(KIN1,*;ERR=3) MP
IF(MP.EQ.0) MP=100000.0
PM=FLOAT(MP)/100.0
NR=0
DO 340 J=1,NM
IF(XLOC(J,1).LT.ERR(0.0)) NR=NR+1
DEN=XLOC(I,J)/XLOC(2,J)
IF(DEN.LT.MIN.OR.DEN.GE.MAX(1)) GO TO 340
330 DO 330 I=1,NE
IF(J.EQ.JE(I)) GO TO 340
336 CONTINUE
NR=NR+1
DIV(NR)=1.0E10
JR(NR)=J
340 CONTINUE
350 CONTINUE
IF(NR.EQ.0.OR.NR.EQ.M) GO TO 410
395 RM(I)=1.0E10
IF(KGR.EQ.1) GO TO 405
400 WRITE(KOUT,621)
621 FORMAT(1X, 'INPUT MAXIMUM RECEPTION POPULATION MULTIPLE X 100')
READ(KIN1,*;ERR=3) MP
IF(MP.EQ.0) MP=100000.0
PM=FLOAT(MP)/100.0
NR=0
DO 340 J=1,NM
IF(XLOC(J,1).LT.ERR(0.0)) NR=NR+1
DEN=XLOC(I,J)/XLOC(2,J)
IF(DEN.LT.MIN.OR.DEN.GE.MAX(1)) GO TO 340
330 DO 330 I=1,NE
IF(J.EQ.JE(I)) GO TO 340
336 CONTINUE
NR=NR+1
DIV(NR)=1.0E10
JR(NR)=J
340 CONTINUE
350 CONTINUE
IF(NR.EQ.0.OR.NR.EQ.M) GO TO 410
395 RM(I)=1.0E10
IF(KGR.EQ.1) GO TO 405
400 WRITE(KOUT,621)
621 FORMAT(1X, 'INPUT MAXIMUM DENSITY IN RECEPTION AREAS DE-

ITY IN PEOPLE/MA, MILE')
READ(KIN1,*;ERR=3) MAX
RMX=MAX
405 DO 23 I=1,NE
J=JE(I)
IF(SV(I).GE.ERR(0.0)) GO TO 22
SV(I)=-SV(I)
GO TO 23
22 ST(I)=XLOC(I,J)-MAX(J,J)
IF(ST(I).LT.ERR(0.0)) SV(I)=0
23 CONTINUE
IF(KGR.EQ.1) GO TO 29
DO 27 I=1,NE
J=JE(I)
25 DEN=XLOC(I,J)/CL(0)(2,J)
IF(RMAX.LE.DEN) DV(I)=1
PMAX=RMAX-DEN+CL(0)(2,J)
JV(I)=2
IF(TMAX.LE.DEN) DV(I)=2
PMAX=PMAX-DEN+CL(0)(2,J)
IF(TMAX.LE.DEN) DV(I)=3
PMAX=PMAX-DEN+CL(0)(2,J)
25 IF(TMAX.LE.DEN) DV(I)=4
27 CONTINUE
29 M=NR+1
N=NR
410 SS=0.0
DS=0.0
IF(NR.EQ.0) GO TO 420
DO 30 I=1,NE
30 SS=SS+SV(I)
420 IF(SS.GE.MP(J)) GO TO 430
DO 40 J=1,NE
40 DS=DS+DV(J)
SV(I)=0.0
430 WRITE(KOUT1,431) NE,0.0
431 FORMAT(1X,'EVPJ: WATER MAINS',15X,'RECEIVING AREAS',15X, 'RECEPTION CAPACITY')
432 WRITE(KOUT1,432) (ANAMES(K,JY),K=5,7),XLLOC(1,JY),XLLOC(2,JY),DEN,JV1
433 CONTINUE
434 WRITE(KOUT2,629) (ANAMES(K,JY),K=5,7),XLLOC(1,JY),XLLOC(2,JY),DEN,JV1
435 CONTINUE
440 CONTINUE
441 FORMAT(I1X,'EVACUATION COUNTY',4X,'RECEIVING AREAS',6X,'AREA',4X,'DENSITY',3X,'AT RISK POP.',2X,'RECE. CAPACITY')
442 WRITE(KOUT2,442) (ANAMES(K,JY),K=5,7),XLLOC(1,JY),XLOC(2,JY),DEN,JV1
443 CONTINUE
444 WRITE(KOUT2,628) (ANAMES(K,JY),K=5,7),XLLOC(1,JY),XLLOC(2,JY),DEN,JV1
445 CONTINUE
446 CONTINUE
450 CONTINUE
451 FORMAT(I1X,'RECEIVING COUNTY',6X,'RESIDENTS',6X,'AREA',3X,'DENSITY',3X,'CRITERION',2X,'RECE. CAPACITY')
452 WRITE(KOUT2,452) (ANAMES(K,JY),K=5,7),XLLOC(1,JY),XLOC(2,JY),DEN,JV1
453 CONTINUE
454 WRITE(KOUT2,627) (ANAMES(K,JY),K=5,7),XLLOC(1,JY),XLLOC(2,JY),DEN,JV1
455 CONTINUE
456 CONTINUE
460 CONTINUE
DO 50 J=1, NR
       C(J) = A(J)
   50 CONTINUE

DO 70 I=1, NR
       K(I) = I
   70 CONTINUE

20 DO 116 J=1, NR
       IF(C(J).LT.0) GO TO 125
       K(I) = I
       IF(NF(I).EQ.1) GO TO 128
       IF(NF(I).EQ.2) GO TO 129
       IF(NF(I).EQ.3) GO TO 130
   116 CONTINUE

GO TO 100
END

GO TO 0
SUBROUTINE LOADL(L,NRTHR$,PVXL,T:IES,NX,NTOJT)
C
LOAD LINK L

DO 10 KT=1,14
10 XN(KT)=0.0
DO 50 JRT=1,NRT
IF(DR(JRT).LE.100.0) GO TO 50
NF=1.0
DO 50 J=1,NF
J1=NF+J
IF(JR(J1,JRT).LE.100.0) GO TO 50
J0=J-1
TYM=1.0*(T/JR(J0,JRT)+PV)
DEN=1.0/D(T/JR(J0,JRT)+TYM)
DO 45 KT=1,14
XAD=0.0
IF((X0(J0,JRT)+0.0).LE.XL(J0,JRT)) GO TO 40
25 XAD=D(T/JR(J0,JRT)+TYM)
DO 30 KT=1,14
XAD=(((XL(J0,JRT)+0.0)-XL(J0,JRT)))*DEN
30 CONTINUE
40 CONTINUE
10 CONTINUE
RETURN
END

SUBROUTINE EVAC(KCUT1, KOUT2, W,N,L,HRS,PV,XL TIMES,NX,NTOT)
C
SIMULATE THE EVACUATION

DO 10 KT=1,14
10 XN(KT)=0.0
DO 50 JRT=1,NRT
IF(DR(JRT).LE.100.0) GO TO 50
NF=1.0
DO 50 J=1,NF
J1=NF+J
IF(JR(J1,JRT).LE.100.0) GO TO 50
J0=J-1
TYM=1.0*(T/JR(J0,JRT)+PV)
DEN=1.0/D(T/JR(J0,JRT)+TYM)
DO 45 KT=1,14
XAD=0.0
IF((X0(J0,JRT)+0.0).LE.XL(J0,JRT)) GO TO 40
25 XAD=D(T/JR(J0,JRT)+TYM)
DO 30 KT=1,14
XAD=(((XL(J0,JRT)+0.0)-XL(J0,JRT)))*DEN
30 CONTINUE
40 CONTINUE
10 CONTINUE
RETURN
END
NE=0  
NR=100  
DO 200 KRT=1,NRT  
IFNE=0  
JRT=1,PR(1,FR)  
JS=1,PR(2,FR)  
IFNE=0 GO TO 120  
DO 100 =1,NE  
IFNE=0,ISS(J) GO TO 190  
200 CONTINUE  
210 NE=0  
ISS,NE=NR  
END  
130 IF(NR,EQ.100) GO TO 150  
DO 140 J=1,101,NR  
IF(J,EQ.ISS(J)) GO TO 160  
140 CONTINUE  
150 NR=NR+1  
ISS,NR=1S  
JNR  
160 DO 190 K=1,14  
T=TIMES(KT)  
TS=TIMER(KRT,PV,HRS,T1,T2)  
FD=1.0  
IF(T,GE,2.0*T2) GO TO 170  
FD=T/(2.0*T2)  
170 FOR=1.0  
IF(T,GE,1.0*T2) GO TO 180  
FOR=0.0  
IF(T,LE,T1) GO TO 190  
FOR=(T-T1)/(2.0*T2)  
180 X(KT,1)=X(KT,1)+FD*DR(KRT)  
X(KT,1)=X(KT,1)+(1.0-FD)*DR(KRT)  
X(KT,2)=X(KT,2)+(FD-FR)*DR(KRT)  
X(KT,3)=X(KT,3)+(FD-FR)*DR(KRT)  
190 CONTINUE  
1D(IK,1)=IK(IK,1)+DK(IKRT)  
XD(IK,1)=XD(IK,1)+DK(IKRT)  
XS(IK,1)=XS(IK,1)+DK(IKRT)  
200 CONTINUE  
WRITE(KOUT1,611) X(15,1)  
IF(KOUT2,EQ.6) GO TO 210  
CALL HEADER(KOUT2,3,0)  
WRITE(KOUT2,611) X(15,1)  
210 DO 230 K=1,3  
DO 220 J=1,14  
=X(100,0)*XS(KT,K)/XS(IK,1)  
220 NX(KT)=  
IF(K.EQ.1) WRITE(KOUT1,612) (NX(KT),KT=1,14)  
IF(K.EQ.2) WRITE(KOUT1,613) (NX(KT),KT=1,14)  
IF(KOUT2,EQ.6) GO TO 220  
IF(K.EQ.1) WRITE(KOUT2,612) (NX(KT),KT=1,14)  
IF(K.EQ.2) WRITE(KOUT2,613) (NX(KT),KT=1,14)  
IF(K.EQ.3) WRITE(KOUT2,614) (NX(KT),KT=1,14)  
230 CONTINUE  
611 FORMAT(1X,'EVACUEES: ',F10.0,5X,'ELAPSED HOURS: ',F7.2,4X)  
612 FORMAT(1X,'PERCENTAGE OF EVACUEES AT ROUTE: ',F9.14E5)  
613 FORMAT(1X,'PERCENTAGE OF EVACUEES IN ROUTE: ',F9.14E5)  
614 FORMAT(1X,'PERCENTAGE OF EVACUEES AT DESTINATION: ',F9.14E5)  
TE(KOUT1,WE) = CALL HEADER(KOUT2,3,1)  
WRITE(KOUT1,615)  
DO 250 K=1,14  
250 WRITE(KOUT2,616) (KOUT1,WT,K),K=1,14)  
WRITE(KOUT2,617)  
DO 270 K=1,14  
X(100,0)*X(KT,K)/XS(IK,1)  
270 NX(KT)=
SUBROUTINE LOADER(NRT,NL,KTCC)
C LOAD NETWORK LINKS
 INCLUDE SOURCE, INSERT
 DO 5 L=1,NL
 DFR(L)=0.0
 5 CONTINUE
 DO 130 JRT=1,NRT
 IF(DR(JRT).LE.1.0) GO TO 130
 130 IF(JRT.LT.0) 100,100,1
 100 CONTINUE
 110 IF(KTCC.NE.3) 150,150,1
 150 CONTINUE
 130 CONTINUE
 RETURN
END

C FORMAT (1X,'NETWORK LINK CHARACTERISTICS AND LOADINGS')
 601 FORMAT(1X,'FROM' ,7X,'TO',7X,'ROUTE NAME' ,4X,'DIST. SPEED',
 1/15X,'CAP.',6X,'PERCENTAGE OF CAPACITY IN USE AT ELAPSED HOURS',
 2/75X,'1 2 4 6 8 12 16 20 24 32 40 48 60 72 84')
RETURN
END
C DELETE CAPACITATED LNS
 inclusive score, insert
T1=0
L=0

I = 10000
IF(T1.EQ.0)
RETURN
IF(T1.N.EQ.1)
WRITE(KOUT1,601)
IF(T1.N.EQ.2)
WRITE(KOUT2,601)
T1=0
ELSE=

50 CONTINUE
IF(I.EQ.0) RETURN
IF(I.EQ.1) WRITE(KOUT1,501)
IF(I.EQ.1.AND.KOUT2.NE.6) WRITE(KOUT2,501)
T3=900*T1
D0 50 I=1,NN
LS=LFR(I)
IF(LIT.EQ.1)
GO TO 50
D0 50 L=LSLF
IF(GMIT(L)).EQ.1) GO TO 50
WRITE(KOUT1,602) T1,NN,LS,LF
IF(LIT.EQ.1) GO TO 50
50 CONTINUE
IF(LIT.EQ.1) GO TO 50
WRITE(KOUT1,603)
WRITE(KOUT2,604)
RETURN
END
FUNCTION IFSAME(LRT,NRT,IR)
DIMENSION IR(21,1)
IFSAME=0
IF(NRT.EQ.0) RETURN
N=IR(NRT+1)
C0=IR(NRT+2)
RC=IR(NRT+3)
IF(NAME(N).EQ.0) GO TO 20
RETURN
CONTINUE
IFSAME=1
RETURN
END

FUNCTION TIMER(KRT,PV,HRS,T1,T2)
C COMPUTE LONGEST TIME ON ROUTE
INCLUDE SOURCE.INC
T1=CR(KRT)
T2=HRS/2.0
NF=IR(NRT+1)
DO 40 J=3,NF
L=IR(NRT+J)
T3=DFR(I)/(2.0PV*DFR(L))
IF(T2.GE.T3) GO TO 40
T2=T3
40 CONTINUE
T1=T1*T2
RETURN
END

SUBROUTINE HEADER(IFILE,NUM)
C ATTACH HEADER
WRITE(IFILE,601) NUM
601 FORMAT(7H11H1,F3.1)
RETURN
END

SUBROUTINE TRNPLX(K1,K2,K3,K4,X,M,N,B,C,D,Y,IP,J)
C MAIN CALLING SEQUENCE
LOGICAL B
REAL*8 X,P,R,I0,A,I1,I2
DIMENSION B(1),C(1),D(1),X(1),P(1),R(1),I0(1),I1(1),I2(1)
I=1
M=M+1
I2=1.0-5
I1=1.0-6
X=0
I2=I*4
R0=1.0E19
Y0=0
DO 5 1=0,M
TO=TO+80(I0)
DO 5 2=0,N
KO=M+1+J+10
IF(KO.GT.C(1)) R0=C(K0)
5 CONTINUE
R0=1.0/20
T2=T2+T0
T3=T3+R0
KP=0
GO TO (10, 20), 11
10 CALL NEW(M,N,L,K0,T2,T1,B.C,S.D,S0,D0,X,I,K)
10 CALL RES1(M,N,L,K0,T2,T1,B.C,S.D,S0,D0,X,I,K)
10 CALL K2(M,N,L,K0,T2,T1,B,C)
11 IF Y Then 12, 11
10 IF X=0 Then 11, 11
10 IF Y=0 Then 11, 11
11 RETURN
12 IF Y=0 Then 11, 11
12 RETURN
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12 RETUR
SUBROUTINE CK(JL,ML,T2,I,J,1)
C RESET I AND CHECK FOR INFEASIBILITY
REAL*8 X
DIMENSION l(I),J(J),X(I)
J=0
DO 19 K=1,L
K7=I(K)+J(K)-1)*M
IF (GABS(I(K)),LT.T2) X(K)=0.0
IF (X(K).LT.-T2) J=1
10 CONTINUE
RETURN
END

SUBROUTINE SWAP(K,L1,I,J,X)
C SWAP LOCATIONS IN I,J AND X
REAL*8 I, X
DIMENSION I(L1),J(I),X(I)
I(L1)=I(K)
I(K)=I(L1)
J(L1)=J(K)
J(K)=I(L1)
X(L1)=X(K)
X(K)=X(L1)
RETURN
END

SUBROUTINE RESDM(N,S,D,S0,DO)
C RESET S & D FROM S0 & DO
DIMENSION S(I),D(I),S0(I),DO(I)
DO 10 I=1,N
10 S(I)=S0(I)
DO 20 J=1,M
20 D(J)=DO(J)
RETURN
END

SUBROUTINE ROW(K9,A1,L1,T2,X,Y)
C ROW SELECTION
REAL*8 X,A1
DIMENSION X(I),Y(I)
K9=0
A1=1.0E20
DO 10 K=1,L1
IF (X(K).LT.-T2.OR.Y(K).LT.0.0) GO TO 10
IF (X(K).GE.A1) GO TO 10
K9=K
A1=X(K)
10 CONTINUE
DO 20 K=1,L1
IF (X(K).LT.-T2.AND.(K).GE.-A1.AND.Y(K).LT.0.0) GO TO 30
20 CONTINUE
RETURN
30 K9=K
A1=X(K)
RETURN
END
SUBROUTINE DELTA(I7,J7,LL1,I,J,X,Y)
C
C       COMPUTE PER UNIT CHANGES IN BASIS VARIABLES
REAL*8 X
DIMENSION I(I),J(J),X(I),Y(I)
10 I=17
J0=J7
LM=1
L2=L1
K=0
5 DO 10 K=LM,L2
IF(K.EQ.0) GO TO 15
IF(K.EQ.1) GO TO 15
10 CONTINUE
IF(J0.EQ.0) GO TO 20
L1=0
K=1
L0=L0-1
L2=L2-1
CALL SWAP(K,L1,I,J,X)
GO TO 20
15 IF(K.EQ.1) CALL SWAP(K,L1,L1,I,J,X)
IF(K.EQ.0) GO TO 40
IF(K.EQ.1) GO TO 40
L0=L0+1
L1=L1+1
20 K=K+1
IF(J0.EQ.0) GO TO 30
J0=J0-1
GO TO 5
30 I=17
J0=J7
GO TO 5
40 DO 50 K=1,L
50 Y(K)=0.0
IF(K.EQ.0) GO TO 60
Y(K)=S7
60 S7=S7
RETURN
END
SUBROUTINE MIN(I7,J7,D1,D2,K6,T3,M,N,B,C,P,R)
    C MIN D-J. SELECTS VARIABLE TO ENTER BASIS
    LOGICAL B
    REAL*8 P,R,D1,D2
    DIMENSION B(I7),C(I7),P(I7),R(I7)
    I7=0
    D1=0.3
    DO 20 I=1,M
    C(J)=C(J)+1
    IF(.NOT.B(J)) GO TO 10
    D2=C(J)
    IF(K6.EQ.1) D2=0.0
    D2=D2+P(J)-R(J)
    IF(DABS(D2).LT.-T3) D2=0.0
    IF(D2.GE.D1) GO TO 10
    D1=D2
    I7=1
    J7=J
    CONTINUE
    20 CONTINUE
    RETURN
    END

SUBROUTINE NEW(M,N,L,R0,T2,T3,B,C,P,R)
    C START PHASE I
    LOGICAL B
    REAL*8 X,P,R,RO,D1
    DIMENSION B(M),C(M),P(M),R(M)
    DIMENSION K(M),P(M)
    CALL RESOC(M,N,S,D,RO,D)
    DO 5 I=1,M
    5 CONTINUE
    DO 10 J=1,N
    10 P(J)=R0
    DO 20 J=1,N
    20 R(J)=RO
    K=M*(J-1)+10
    IF(C(K).LT.P(I)) P(I)=-C(K)
    CONTINUE
    S=1.0E20
    K=1
    45 CALL MIN(I7,J7,D1,D2,K6,T3,M,N,B,C,P,R)
    K=K+1
    IF(S(I7).LT.D1(J7)+T2) P(I7)=R0
    IF(S(I7).GT.D1(J7)-T2) R(J7)=R0
    B(J7)=.TRUE.
    IF(S(I7).LT.D1(J7)) GO TO 50
    D(J7)=D1(J7)-S(I7)
    S(I7)=0.0
    GO TO 60
    50 S(I7)=S(I7)-D1(J7)
    D(J7)=0.0
    60 K=K+1
    IF(K.LE.L) GO TO 45
    RETURN
    END
SUBROUTINE PVTK,7JLI0BCIJXY
C PIVOT
LOGICAL B
REAL*8 I,XO,A1
DIMENSION S(1),C(1),I(1),J(1),X(1),Y(1)
J=1(I(9))
J=J(K9)
C=M*(J-1)+19
X=X*C(K9)*C(K9)
S(K)=.TRUE.
Y=M*(J-1)+17
S(K7)=.FALSE.
I(K9)=17
J(K9)=J7
Y(K9)=-1.0
X(K9)=0.0
DD 10 K=1,L1
C=M*(J(K)-1)+I(K)
X=X0-A1*Y(K)*C(K9)
X(K)=X(K)-A1*Y(K)
CONTINUE
RETURN
END
4.5 Data Files

**MAP - Map File**

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Dist-8

Abstract

This report describes work performed by Bushnell, Pearsall and Trozzo, Inc., under subcontract with the Institute for Defense Analyses on Task A-I of IDA Contract No. EM-C-0749 with the Federal Emergency Management Agency. Task A-I calls for the development of a model to simulate population movement during an evacuation from the risk area to the various host areas over a transportation network.

This report describes, documents and provides a user's guide to a system of computer routines which perform the various computations required to apply a crisis relocation model developed jointly by IDA and BPT, Inc. The computer routines together comprise an interactive system resident on the FEMA Univac 1108 facility. The model and its attached national data base can be used to analyze in detail the evacuation of risk areas anywhere in the continental United States under a wide range of different assumptions regarding the assignment of reception areas and the performance of the transportation system during the evacuation.


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