TRANSNET--A MEANS OF ACCESSING HAZARDOUS MATERIALS TRANSPORTATION MODELS AND DATABASES

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ABSTRACT

TRANSNET is a compilation of risk and systems analysis codes, routing and cost models and related data that address hazardous and radioactive materials transportation. TRANSNET is the acronym assigned to this system of models and associated data which reside on a dedicated MicroVAX 3800. After obtaining a password, users may access TRANSNET with a modem-equipped personal computer. TRANSNET was developed by Sandia National Laboratories (SNL) under the sponsorship of the United States Department of Energy (DOE) Office of Defense Programs (subsequently reorganized to the Office of Environmental Restoration and Waste Management). The goals of the TRANSNET system are to speed transfer of technology and data to qualified users by permitting access to the most comprehensive and up-to-date transportation risk and systems analysis models and associated databases.

BACKGROUND

First announced in March 1987, TRANSNET is being used to support DOE site environmental analysis, risk assessments and systems analyses for the defense and repository programs, routing assessments for the DOE and states, and operational analyses as well as basic research. Users of TRANSNET may access the most recent versions of the models and data developed by or for Sandia National Laboratories. Code modifications that have been made since the last published documentation are noted to the user on the introductory screens. To permit a greater spectrum of users to have access to the models, considerable attention has been given to making them user-friendly and to providing default data sets for typical problems.

User operating and equipment costs are minimized by establishing the TRANSNET system on a centralized computer and allowing access via a modem- equipped personal computer. This realizes another goal to develop and operate the TRANSNET system with a maximum of flexibility while minimizing system costs. Users of codes on the TRANSNET system may choose either to construct their own input files or edit and use existing files from DOE-sponsored analyses.

The TRANSNET facility consists of a dedicated computer with telephone ports on which these codes and databases are maintained and modified. The equipment required to use the system is minimal; users need only an IBM- compatible personal computer (PC), a Hayes-compatible modem with communications software, and a telephone. Maintenance and operation of the TRANSNET facility are underwritten by the program sponsor as are updates to the respective codes, models, and data. Thus, the only charges to the user of the system are telephone hookup charges.

TRANSNET introductory screens briefly describe each of the models and databases and provide a list of references for each. In addition, the user is informed about upcoming changes to the TRANSNET system and the approximate date of implementation. Changes are prioritized based upon DOE commitments and user interest.

Prior to placement on the TRANSNET system, codes are modified to incorporate a user-friendly interface, if one did not already exist. Input data from analyses performed by SNL (and others) for the DOE are structured to allow either direct use or use after editing. The user is also permitted to construct an input data set. Output files from each of the codes are structured to permit levels of detail that correspond with typical user requirements. In addition, interfaces between the codes and data sets are built to permit direct data transfer between codes.

In the past, models and data developed by and under the sponsorship of the DOE have received limited distribution and use. In some cases, models or data developed to support transportation analyses either were not made available for outside use or the approval process to make codes available was too time consuming to be truly responsive to potential users. In other cases, model development and refinement are continuing tasks, making it difficult to issue the necessary code documentation in a timely manner.

The principal barrier to timely distribution of these codes is largely a result of their being developed to address specific requirements, often for primarily internal research purposes. As a result, significant changes to modeling methods and input data were often required prior to general application or use by others. Thus in these cases, it is more efficient to make computer runs at the development site rather than to provide a copy of the code.

The latter case is illustrated by RADTRAN development efforts. SNL routinely distributes formatted computerized tape copies of the code incorporating fully documented updates (currently RADTRAN 4). While such documentation is being developed, however, program sponsors often have needs for analyses that require further code refinements. Such analyses often are released prior to completion of formal documentation. Particularly in the

framework of environmental analyses for shipment of radioactive materials, other interested parties sometimes do not have ready access to the most current version of the code.

In some cases, models constructed to perform specific analyses for the DOE are modified to speed analysis capabilities on TRANSNET. An example of this is the Interstate routing algorithm INTERSTAT, which was constructed to determine the sensitivity of a route choice to specific data inputs. INTERSTAT has been modified to allow the TRANSNET user to approximate a route for direct input into the RADTRAN code. In addition, user-defined network files can be uploaded into the TRANSNET system for analysis using one of several models.

Passwords are issued by SNL to any interested user for noncommercial applications. Due to the structure of TRANSNET, passwords are transferable; thus other individuals with access to a password can use the system. Passwords are periodically reissued to maintain contact with those users with a need for continuing access.

There are currently approximately 80 authorized TRANSNET users. The TRANSNET user community is relatively evenly split among DOE and associated contractors and interested State and local governments.

TRANSNET SYSTEM DESCRIPTION

TRANSNET is comprised of three main subsets: Systems Analysis/Risk Codes, Routing Models, and Databases/Input Models. Currently accessible on TRANSNET are:

Systems Analysis/Risk Codes: RADTRAN, WASTES, and TRANSIT; Routing Models: INTERSTAT, INTERLINE, and StateGEN/StateNET; and Databases/Input Models: TRANSIS (RMIR), RAMPOST, and FRTRATE.

Descriptions of these models and databases follow:

Systems Analysis/Risk Codes

RADTRAN 4--RADTRAN 4, a computer code for radiological materials transportation risk analysis, was developed by Sandia National Laboratories for the Department of Energy (1). RADTRAN III was the initial code to be made available on TRANSNET; RADTRAN 4 was made available in late 1989. RADTRAN differs from most other computer codes for risk analysis in that it addresses the transportation-related problems of performing a radiological risk analysis with a moving source and of properly distributing the population dose along a route or route segments. RADTRAN may be used alone for simple origin- destination calculations or can be used to generate radiological unit- risk factors (e.g. risk per shipment-kilometer). Radiological risk is expressed in terms of dose or radiological health effects, which include latent cancer fatalities and genetic effects.

The RADTRAN code consists of two major modules: the incident-free transport module in which doses resulting from normal transport are calculated, and the accident module which uses data on consequences and probabilities of accidents to calculate accident risks. Included in the incident-free module are models describing:

- offlink dose, e.g., dose to persons within 800 meters of the transport link (highway, railway or waterway);
- dose to persons sharing the transport link (onlink dose), which includes three submodels describing doses to persons in (a) vehicles traveling in the opposite direction, (b) vehicles traveling in the same direction, and (c) passing/adjacent vehicles;
- dose to members of the public at stops;
- dose to drivers, rail crews, etc. (transportation worker dose).

Each dose calculation is performed separately for each shipment typeand for each transport mode in user-defined population densities.

In the accident module of the code, the range of possible accidents can be divided into a maximum of 20 severity categories. The probability and consequences of accidents of each severity are specified for each important radionuclide in each shipment type for each transport mode in each user-defined population density. The accident probabilities are derived from historical data for each mode. The consequences are calculated from the parameters describing the package, such as the radionuclide inventory of the contents (source term data) and the behavior of the contents under the specified accident conditions (fraction of material released, fraction of released material in aerosol form, etc.), and by the meteorological and exposure models contained in the code.

RADTRAN allows many types of shipment-specific and route-specific information, including the package behavior data and accident rate data discussed earlier, to be user-defined. While RADTRAN 4 allows the user to adjust the analysis to the specific problem being analyzed, the resolution of an analysis may be limited by the quality of available data.

In summary, while retaining the most useful and time-proven features of its predecessors, RADTRAN 4 incorporates significant advances over the earlier versions. The most useful new features are:

- improved route-specific analysis capability,
- internal radionuclide data library,
- improved logic for analysis of multiple-radionuclide packages such as spent fuel,

- separate treatment of gamma and neutron components of Transport Index (TI), and
- increased number of accident-severity categories.

WASTES II--The WASTES II code was developed at Battelle PacificNorthwest Laboratories (PNL) under the joint sponsorship of the DOE/OCRWM Monitored Retrievable Storage and Transportation programs (2). The WASTES II code is a logistics-related tool for use in analyzing the effects of certain policy decisions and/or facility operating schedules for the commercial waste management system. WASTES II uses discrete-event simulation techniques to model the generation of spent nuclear fuel, the buildup of spent fuel inventories within the system, and transportation requirements for the movement of wastes throughout the system.

WASTES II accepts up to a total of twelve facilities of up to four distinct types in addition to the pool and dry storage locations at U.S. power reactors. The allowable types of facilities are federal interim storage, monitored retrievable storage, reprocessing plants, and repositories. The minimum time that spent fuel must reside at each facility may be specified. In addition, the minimum age since discharge or the maximum heat generation rate allowed for receipt at each facility may be specified.

The simulation is driven by a combination of source and destination requested transfers. Source-driven transfers would occur when a reactor pool exceeds its full-core reserve storage margin or when a reactor is decommissioned. The material requiring transfer would be shipped to facilities with available capacity. Destination-driven transfers occur when the annual capacity of a receiving facility will not be met by full core reserve or decommissioning shipments and fuel may then be shipped from other. The order in which facilities ship to other facilities with available storage capacity may be specified by the user.

The user can also specify whether shipments occur optimally, proximally or sequentially. Optimized shipping can be used when exactly two destination facilities exist. Optimized shipping selects source/destination pairs so that the total shipping distance in a given year is minimized. Proximity shipping fills the closest facility to the source according to the shipment priorities. This results in sub-optimal routing of waste material but is used to approximate an optimal shipping strategy when more than two facilities of the same type are available to receive waste. In sequential filling of facilities, no attempt at optimization is made and the facilities are filled in a sequential manner based on individual facility identification numbers assigned by the user.

TRANSIT--In the process of screening various areas of the U.S. to determine potential sites for placement of a fixed facility, such as a waste receiving or processing facility, the impacts of transportation must be examined as part of the formal evaluation process. Transportation impacts evolve from a variety of different considerations. These include economics, public health and safety, environmental and socio-economic concerns. In the early stages of the screening process, it is important to obtain a first-order estimate of transportation impacts. PNL developed TRANSIT, a computerized model that evaluates the impacts of transportation upon siting, under the sponsorship of SNL (3).

The TRANSIT model generates isopleths of transportation mileage, costs, risks, and fleet requirements for shipments to fixed facilities. The model uses data on the location and inventory of material to be shipped. The model then overlays a set of grid points across the U.S. to establish equally spaced positions for potential facility locations. A weighted great circle transport methodology (applying circuity factors to more nearly approximate the actual route distance) to arrive at the total number of shipments, the weighted average cost per shipment, the weighted average risk per shipment, and the the weighted average transportation packaging-use days per shipment are then calculated for each grid point. An interpolation routine establishes isopleths between the grid points for each of these values. This information may then be used to graphically display first-order estimates of the transportation impacts over time for various regions of the U.S.

Routing Models

INTERSTAT--INTERSTAT is an automated modeling system that permits the user to assess the impacts of route-specific data on the choice of highway routes. The INTERSTAT system includes two basic networks: the Interstate highway system (and designated state alternatives) and NRC- approved routes for spent fuel shipments. Data associated with the route segments can be expanded to meet the specific needs of the user. INTERSTAT is entirely menu-driven and allows the user to forward the calculated route information directly to the RADTRAN input files for use in the risk calculations.

INTERSTAT calculates routes based upon the minimization of travel distance, population within one of two bandwidths along a route, and/or accident rate along a route. The system is structured to allow the user the option of weighting these three parameters prior to route calculations. Following determination of the route, the user is given details of the calculated route as well as summaries of each parameter in the data base for the chosen path. Alternatively, the user can specify a route between an origin-destination pair and receive parameter summaries for that route.

INTERLINE--INTERLINE, developed at Oak Ridge National Laboratory under the sponsorship of the DOE's Transportation Technology Center, is an interactive

computer program that determines likely routes for shipments over the railroad system in the U.S. (4). It is based on a shortest path algorithm modified to reflect the nature of railroad company operations and to accommodate computer resource limitations in dealing with a large transportation network.

INTERLINE further contains the inland waterway network in the U.S. and permits the user to determine potential pathways for use in barge transport. The INTERLINE model and associated databases were previously used to support environmental analyses and site assessments for the Office of Civilian Radioactive Waste Management program and are proposed for use in upcoming analyses (5).

INTERLINE on TRANSNET permits the user to determine the most likely route pathway based on the conditions described above and calculate the route characteristics, including population density along the corridor and pass these data directly to the RADTRAN risk model.

StateGEN/StateNET--To assist states and others to better understand the impact of state and/or local data on route choices, StateGEN/ StateNET is designed to assist the user to construct a transportation network on a PC, assign attributes to the network, and calculate routes based upon a user-specified set of weighted route attributes (6). The two components of this database structure and model are assigned the acronyms StateGEN and StateNET. StateGEN is supplied on a diskette for use on an IBM-compatible PC. StateGEN allows the user to define the transportation network of interest, construct the network, and assign link-specific attributes to the network in a form compatible with the StateNET model, thus minimizing TRANSNET hookup time and costs. StateGEN permits the user to assure continuity of the data regarding the network and perform a single parameter route selection. StateNET, located on the TRANSNET system, allows a user to either maximize or minimize network attributes of interest and assign weights to each. The StateNET model may then be used to determine the route that best satifies the user-assigned characteristics. StateNET also permits the assignment of data into the system codes such as RADTRAN. This two- component methodology is designed to minimize user telephone on-line charges and increase TRANSNET system availability.

StateGEN/StateNET has recently been modified to incorporate acomputerized version of the U.S. Department of Transportation "Guidelines for Selecting Preferred Highway Routes for Highway Route- Controlled Quantity Shipments of Radioactive Materials" (7). This permits the user to define a network and assign attributes in a structure consistent with that employed by StateGEN and to perform the intermediate and final determinations described in the DOT workbook. The software permits replication of each of the worksheets described in the workbook.

Databases/Input Models

TRANSIS is a summary of the Department of Transportation Hazardous Materials Incident Report (HMIR). Historical accident/incident data can be input into routing or systems models. TRANSIS contains the Radioactive Materials Incident Report (RMIR) database (8). Initially developed by SNL in 1981, the RMIR database contains information about radioactive materials transportation incidents that have occurred since 1971. These data were compiled from the HMIR system as well as records from the U.S. Nuclear Regulatory Commission, State governmental bodies, and publications, where appropriate. The RMIR database currently contains (through 1990) data on approximately 310 transportation and 250 handling accidents and 870 transportation incidents.

Data in TRANSIS is used to support transportation-related environmental and safety analyses, to prepare public information materials and responses to inquiries, and to assist in mitigating institutional concerns.

RAMPOST: The RAMPOST database is a summary of the U.S. DOT radioactive materials postnotification reports for Highway Route Controlled Quantity shipments (9). The DOT maintains these reports in a database entitled RAMRT. Shippers of these materials have been required to file a postnotification report that includes shipper, carrier, origin, destination, material description and route used. The RAMPOST database further refines the shipment data through interactions with industry, shippers and carriers to be consistent with the requirements of the DOE and others.

FRTRATE--Under the sponsorship of SNL, PNL and Rockwell HanfordOperations compiled transportation shipping tariffs for spent fuel and radioactive wastes by truck and rail (10). Costs were broken into components for both loaded and empty shipments of radioactive materials packagings. The results of this study were computerized to permit user access through TRANSNET. FRTRATE (freight rate) models individual shipments of radioactive material from origin to destination as input by the user. The model estimates shipping costs, cask/package utilization and anticipated lease costs that may be incurred.

Each of the models and databases described above is run in a menu-driven fashion. The user follows screen prompts for available model or data options. For RADTRAN 4 and WASTES II, the user may select data sets used by SNL, modify parameters in those data sets, or create a file from scratch. The user may also create a personal data file for temporary storage of input and output files.

UPCOMING ADDITIONS AND MODIFICATIONS TO THE TRANSNET SYSTEM

TRANSNET is currently being updated to incorporate the following models and modifications:

Systems Analysis/Risk Models

RADTRAN: The RADTRAN transportation risk assessment code undergoes continual refinement as applicable data becomes available. Refinement of modelling techniques are incorporated as they are completed. Upcoming changes to the RADTRAN code will expand the ability of the user to define route-specific data parameters and calculation of individual doses by isopleth. A detailed review of accident severity categories and corresponding packaging responses will also be addressed.

The RADTRAN user interfaces and default data menus are also under refinement. Upcoming default menus will include datasets created by other organizations as well as specific references to aid in determining applicable datasets.

TREP: The transportation risk evaluation program (TREP) will determine order-of-magnitude risks based upon unit risk factors previously calculated by RADTRAN. The TREP model can be used to approximate transportation risks based upon a minimum of shipment information. TREP will use routes determined by INTERSTAT together with total shipment numbers to be supplied by the user to combine with the existing RADTRAN results to provide this overview.

HAZCON: The HAZCON model has been created by Sandia to marry existing hazardous materials risk methodologies to assess the transportation risks of hazardous materials by category. Created under the sponsorship of the DOT, this methodology will be complemented by hazardous materials databases also to be hosted by TRANSNET.

Routing Models

RAILSTAT and BARGESTAT are automated databases and networks used todetermine the sensitivity of a rail or barge route selection to the use of specific or multiple weighted attributes. These models may be used to select routes and characteristics for input to the RADTRAN system. These models will be created in a manner similar to INTERSTAT, the existing highway routing model. BARGESTAT will be further modified to incorporate data on port and intermodal facilities.

HIGHWAY: The HIGHWAY model was established at Oak Ridge National Laboratory to calculate highway transportation routes using a shortest path algorithm (11). The HIGHWAY model is based upon a proprietary comprehensive highway network developed by Rand McNally, as modified to incorporate specific origin-destination pairs particular to radioactive materials transportation.

Databases/Input Models

TRANSPAC is a summary of packaging characteristics for the transportation of hazardous materials. Packaging characteristics of interest in risk analyses (e.g., weights, contents, capacities and transportation indices) can be directly transferred to a RADTRAN input file for specific analyses.

STORM: A jointly funded program sponsored by the DOE, DOT, NRC and FEMA, STORM is the acronym assigned to the program to perform a Survey of Transportation Of Radioactive Materials. This program will define current transport activities for all categories of radioactive materials for both industry and the government. A database of shipment characteristics, including definition of materials shipped, origin, destination, and mode utilized will be created in support of this effort.

DOETRS: A Department of Energy Transportation Risk Study (DOETRS) was initiated in FY 90. This effort will identify ongoing and projected radioactive materials shipping programs planned by the DOE for 5- and 10-year periods. This will be based on shipping requirements, as quantified in the STORM database, as well as commitments and requirements of the Department.

TRAIN: The Transportation Assessment and Integration (TRAIN) Project was initiated by the Environmental Restoration and Waste Management Program in FY 90 to assess the upcoming transportation requirements of the DOE through the 90's and beyond. Materials to be shipped under this activity are to include radioactive materials identified in the DOETRS activity as well as hazardous and mixed hazardous materials to be moved both on and off site. Aspects of this program include packaging and transport requirements as well as training, emergency response requirements and institutional impacts analyses.

METBI: Under the sponsorship of the DOT, two databases of hazardous materials were created. The most refined of these covers Materials defined to be Toxic By Inhalation (METBI). These data will be used as input to the HAZCON code previously described.

ACCIDENTPROB allows the user to determine the probability of a transportation accident on a specific highway link using historical accident rates and specific link characteristics. (12)

SUMMARY

TRANSNET access is limited to noncommercial users associated with DOE program activities. System access is arranged through SNL, which reviews a potential user's planned application of the system and issues a password for

a specified amount of time. Passwords will be reissued on a periodic basis for users requiring continuing access. There are no user access charges--just the telephone charges for the on-line period. The equipment required for access to TRANSNET includes an IBM-compatible personal computer, a Hayes-compatible modem, and communications software.

Interested users should submit a written request for access, including contact person, sponsor and intended use to:

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