TRANSNET—Access to Transportation Models and Databases*

J.W. Cashwell

*Sandia National Laboratories**, *Albuquerque, New Mexico, United States of America*

INTRODUCTION

TRANSNET is a compilation of risk, systems analysis, routing and cost models as well as related data pertaining to radioactive materials transportation. TRANSNET is the acronym assigned to this system of models and associated data which reside on a dedicated microVAX II. 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. The goals of the TRANSNET system are 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 the TRANSNET system are allowed to construct their own input files or edit and use existing files from DOE-sponsored analyses.

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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. In other cases model development and refinement are continuing tasks, with the documentation process sometimes lagging actual code development.

In the first case, the principal sensitivity to distribution of the source code was largely a result of codes being developed to address specific requirements or of model development activities for 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, it is often more efficient to make the necessary computer runs at the development site than to provide a copy of the source code which is consistent with the needs of the potential user.

The latter case is illustrated by RADTRAN development efforts. SNL routinely distributes formatted computerized tape copies incorporating fully documented updates (currently RADTRAN III). 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 the completed documentation. Particularly in the framework of environmental analyses for shipment of wastes, other interested parties sometimes do not have ready access to the most current version of the code.

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 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 to the codes and databases are based upon user needs, but are subject to DOE and Sandia agreement on priority and desirability. In the future, new screens will provide a reference listing of user organizations and contacts and a reference listing of other available databases and codes.

Prior to placement on the TRANSNET system, codes are modified to incorporate a user-friendly interface, if one did not already exist. The user may construct the entire input data set or use one of the default sets. Input data from analyses performed by SNL for the DOE are provided either direct use or use after editing. 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 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 70 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

Currently accessible on TRANSNET are RADTRAN, WASTES, INTERSTAT, FRTRATE, TRANSIS and StateGEN/StateNET. Descriptions of these models and databases follow:

RADTRAN III--The RADTRAN III risk analysis code, developed by Sandia National Laboratories, calculates the radiological risks associated with the transport of radioactive materials (Madsen, et al, 1986). RADTRAN may be used alone for simple origin-destination calculations or can be used to generate radiological unit-risk factors (risk per shipment-kilometer). The units of risk are dose or radiological health effects, which include latent cancer fatalities and genetic effects.

The RADTRAN III 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 calculates consequences and probabilities of accidents. 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. (occupational dose).

Each of these dose calculations is performed separately for each shipment type and for each transport mode in each of three population density zones.

In the accident module of the code, the range of possible accidents can be divided into a maximum of 8 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 population density zone. 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 III differs from its predecessors in several ways. Important changes include (a) improvements in the rail-stop model, (b) inclusion of an ingestion pathway model in the accident analysis module, and (c) inclusion of a submodule in the calculation of onlink dose that accounts more correctly for adjacent/passing vehicles.

WASTES II--The WASTES II code was developed at Battelle Pacific Northwest Laboratories under the joint sponsorship of the DOE/OCRWM Monitored Retrievable Storage and Transportation programs (Shay and Buxbaum, 1986). 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 the US 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 the receiving facility will not be met by full core reserve or decommissioning shipments therefore fuel must be shipped from facilities with non-critical storage needs. 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 can be 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.

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 the 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 currently 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 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.

Other route-specific data are being identified and placed on the system. These additional data include additional accident data or surrogates, travel speeds, traffic volumes, and geometric and structural characteristics. The system is structured to allow the user the option of weighting the desired parameters prior to the route selection calculations.

StateGEN/StateNET--To assist states and other entities 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 (Cashwell and Erickson, 1989). 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 represents the user-assigned characteristics. StateNET also permits the assignment of data into the system models such as RADTRAN. This two-component methodology is designed to minimize user telephone hookup charges and increase TRANSNET system availability.

FRTRATE--Under the sponsorship of SNL, Battelle Pacific Northwest Laboratory (PNL) and Rockwell Hanford Operations compiled transportation shipping tariffs for spent fuel and radioactive wastes by truck and rail (McNair et al. 1986) Costs were broken into components for both loaded and empty shipments of radioactive waste 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.

TRANSIT--In the process of screening various areas of the U.S. to determine potential sites for placement of 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 (McNair and Cashwell, 1985).

The TRANSIT model generates isopleths of transportation mileage, costs, risks, and fleet requirements for shipments to processing or storage sites. The model uses existing data on the location and inventory of spent fuel and wastes at generator sites. These are derived from the number and location of the various sites that might ship waste within the U.S. and the amounts of waste that would be shipped within a given time frame. 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 (radiological, nonradiological and total) per shipment, and the the weighted average cask-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.

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 (Cashwell and McClure, 1989). 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 1988) data on approximately 240 transportation and 230 handling accidents and 790 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.

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 III 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:

RADTRAN 4.0 incorporates the following changes:

1. The incident-free dose calculations are changed to allow gamma and neutron contributions to be calculated separately. This will enhance modeling capabilities for materials such as older spent fuel, in which a significant fraction of the radiation is emitted as neutrons. If the gamma-neutron split is not known for a particular material, then it can still be conservatively modeled as a 100% gamma emitter.

2. A radionuclide data base is incorporated. Input parameters that must be input to the code for each radionuclide in a package (e.g., half-life, photon energy, ingestion dose factors) are now in a data base within RADTRAN; they are automatically called each time the user designates a radionuclide. This will reduce the time necessary to construct an input data set, especially for complex materials that contain many radionuclides.

3. RADTRAN has been modified to allow the user to sequentially analyse several route segments separately in a single run. The user may input distinctive features of each segment to account for differences in traffic count, vehicle velocity, or any other input parameter. The output gives separate risk results for each segment. This feature is particularly useful for route-specific relative risk analysis.

4. The accident-severity category matrix is expanded to allow the user to have up to 20 accident-severity categories; formerly a maximum of eight were available. This change is consistent with the 20-category accident-probability matrix developed for truck and rail transport in the Modal Study (Fischer et al. 1987).

5. Output from RADTRAN is modified to accommodate an 80-column format. This will allow output to be easily printed by PC-based printers and eliminate cumbersome printer reconfiguration steps. In addition, RADTRAN output will be modified to include the results of several intermediate calculations performed for the risk analysis. These include deposition levels (Ci/m^2) in each isodose area of the plume, radiological consequence data broken down by severity category and population-density zone, and additional economic consequences information. The user has the option of requesting these data to be printed; otherwise only risk output tables are printed.

6. RADTRAN 4.0 includes the automatic calculation of nonradiological risks (i.e., the risks of fatality from mechanical causes in transportation accidents).

7. RADTRAN 4.0 also permits the use of an expanded number of population-density zones instead of the three existing categories (rural, suburban, and urban).

StateGEN/StateNET has been modified to specifically address the needs of users wishing to apply the Guidelines for Selecting Preferred Highway Routes for Highway Route-Controlled Quantity Shipments of Radioactive Materials (US/DOT, 1989).

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.

RAILSTAT and BARGESTAT are automated databases and networks used to determine 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.

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.

SUMMARY

TRANSNET access is limited to noncommercial uses associated with DOE program activities. System access can be 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 currently no user access charges--just the telephone bill for the hookup 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:

J.W. Cashwell
Division 6321
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

REFERENCES:

Cashwell, C. E., McClure, J. D., An Historical Summary of Transportation Accidents and Incidents Involving Radioactive Materials, (1971-1988), SAND89-7071C, Albuquerque, NM: Sandia National Laboratories, June 1989.

Cashwell, J. W., Erickson, C. M. StateGEN/StateNET--A Structured Method to Perform Route Comparisons, SAND89-0980C, Albuquerque, NM: Sandia National Laboratories, June 1989.

Fischer, L. E., et al, Shipping Container Response to Severe Highway and Railway Accident Conditions, NUREG/CR-4829, Livermore, CA: Lawrence Livermore National Laboratory, February 1987.

McNair, G. W., Cashwell, J. W. TRANSIT: A Model for Providing Generic Transportation Input for Preliminary Siting Analysis, SAND84-2046C, Albuquerque, NM: Sandia National Laboratories, March 1985.

McNair, G. W., et al, Truck and Rail Charges for Shipping Spent Fuel and Nuclear Waste, PNL-4064, Richland, WA: Pacific Northwest Laboratory, February 1986.

Madsen, M. M. et al, RADTRAN III, SAND84-0036 Albuquerque, NM: Sandia National Laboratories, February 1986.

Shay, M. R., Buxbaum, M. F. WASTES: Waste System Transportation and Economic Simulations--Version II, PNL-5714, Richland, WA: Pacific Northwest Laboratory, February 1986.

U.S. Department of Transportation, Guidelines for Selecting Preferred Highway Routes for Highway Route Controlled Quantity Shipments of Radioactive Materials, DOT/RSPA/OHMT-89/01, January 1989.