TRANSNET--Online Transportation Risk Analysis for Public Use

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ABSTRACT

The TRANSNET system of transportation risk and systems analysis models and associated data bases was developed to allow access by qualified users to information and techniques developed under the sponsorship of the Department of Energy (DOE) Office of Defense Programs. The TRANSNET system allows outside users to access the RADTRAN III transportation risk analysis model as well as associated logistics, cost and network models and data. TRANSNET contains the most recent versions of models developed under DOE sponsorship. Code modifications that have been made since the last published documentation are noted to the user on the TRANSNET 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 provide default data sets for typical problems.

INTRODUCTION

Sandia National Laboratories (SNL) is the Department of Energy's (DOE) lead organization for transportation research and development. The DOE Office of Defense Programs has been the prime sponsor of development of models and associated databases used to analyze the impacts of the transportation of radioactive wastes. The TRANSNET system, announced in March 1987, was developed to enable outside users to access these models and data. TRANSNET currently has 41 authorized users with 19 from the DOE and its contractors, 4 from other Federal agencies and 18 from states or their contractors. 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.

The goals of the TRANSNET system are to speed transfer of transportation risk and systems analysis technology to qualified users by permitting access to the most comprehensive and up-to-date transportation risk and systems analysis models and associated databases. Developed by or for the DOE, these models are updated and refined as information and techniques become available. TRANSNET provides the user with the latest version of these models and databases in a timely manner. Users of the TRANSNET system are allowed to construct input files and to use or modify input files previously used for DOE-sponsored analyses. 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 prime goal is to develop and operate the TRANSNET system with a maximum of flexibility while minimizing system costs.

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 or the approval process for such availability was too lengthy and detailed to be truly responsive to the needs of other users. 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 the specific needs of the sponsoring organizations and of model development activities being centered on research purposes. As a result, significant changes to modeling 'methods and input data needs were often required prior to application. Thus, it is often more efficient to make the model 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 model 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 construction of a facility or shipment of wastes, other interested parties sometimes do not have ready access to the most current version of the code.

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 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 models are structured to permit levels of detail that correspond with typical user requirements. In addition, interfaces between the models 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 analyses using one of several models.

Currently accessible on TRANSNET are RADTRAN III, WASTES II, INTERSTAT and FRTRATE. Descriptions of these models follow:

RADTRAN III--The RADTRAN III risk analysis model developed by Sandia National Laboratories calculates the radiological risks associated with the transport of radioactive materials (1). 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, respectively;
- dose to members of the public at stops;
- dose to drivers, rail crews, etc. (occupational dose).

Each of these 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 model was developed at Battelle Pacific Northwest Laboratories under the joint sponsorship of the DOE/OCRWM Monitored Retrievable Storage and Transportation programs (2). The WASTES II model 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.

The WASTES II model 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 a facility will not be met by full core reserve or decommissioning shipments and fuel must be scheduled for shipment 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.

FRTRATE--Under the sponsorship of the SNL, Battelle Pacific Northwest Laboratory (PNL) and Rockwell Hanford Operations compiled transportation shipping tariffs for spent fuel and radioactive wastes by truck and rail (3). 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.

Each of the models 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.

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

RADTRAN III will be modified during 1988 to incorporate the following:

1. The incident-free dose calculation will be 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 will be 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 analyze 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 will be 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 (4).

5. Output from RADTRAN will be 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.

Other changes to be made in near future will include the automatic calculation of nonradiological risks (i.e., the risks of fatality from mechanical causes in transportation accidents) and an expanded number of population-

density zones instead of the three existing categories (rural, suburban, and urban).

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. The two components of this database and model are assigned the acronyms StateGEN and StateNET. StateGEN allows the user to define the transportation network of interest, construct the network, and assign link-specific attributes to the network. It permits the user to structure network data in a form compatible with the StateNET model on an IBM-compatible PC, 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, 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.

TRANSIS is a summary of the Department of Transportation Hazardous Materials Incident Report. Historical accident/incident data can be input into routing or systems models. In its initial configuration for radioactive material accidents and incidents, TRANSIS represents a summary of the SNL-developed Radioactive Materials Incident Reports (RMIR) now operated by the DOE's Oak Ridge Operations Office.

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.

TRANSIT--In the process of screening various areas of the U.S. to determine potential sites for placement of a 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 the SNL (5).

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 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.

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 committments and user interest. In the future, new screens will provide a reference

listing of user organizations and contacts and a reference listing of other available databases and models.

TRANSNET access is limited to noncommercial uses associated with DOE program activities. System access can be arranged through SNL, which reviews a potential users' 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:

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REFERENCES:

1. M.M. Madsen, et al, RADTRAN III, SAND84-0036 (Albuquerque, NM: Sandia National Laboratories, Feb,1986)

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

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

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

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