Demographic and Transportation Parameters in RADTRAN*

J.D. Brogan[1], J.W. Cashwell[2], K.S. Neuhauser[2]

[1]*Sandia National Laboratories**, Albuquerque, New Mexico (on sabbatical leave from the University of New Mexico)*
[2]*Sandia National Laboratories**, Albuquerque, New Mexico, United States of America*

INTRODUCTION

Recent efforts at Sandia National Laboratories have focused not only on modification of the RADTRAN transportation risk analysis code but also on updating the default parameters for population, land use, and roadway characteristics used by the code. Changes to the code have been discussed earlier in this Conference (Neuhauser and Reardon 1989). This paper summarizes the results of a review of transportation and demographic parameters, performed to complement recent model modifications.

DISCUSSION

A set of default parameters, mostly derived from national average data, has been made available with every version of the RADTRAN code. These values are often used because of the difficulty and expense of obtaining more specific data. Their use is appropriate for relative risk analyses that involve national-scale shipping campaigns. However, use of the default parameters in relatively small-scale (e.g. state or local level) risk analyses as part of a route selection exercise, for example, may not be appropriate. Therefore, it is important to thoroughly discuss and document the derivation of these default parameters and, if necessary, update them. This information, when made available on the TRANSNET system (Cashwell 1989), will greatly assist the RADTRAN user in defining input parameters for route-specific risk analysis.

In RADTRAN 4.0, many parameters that formerly were constrained in some way will be made user-definable. For example, in earlier versions of RADTRAN the user was constrained to use pre-defined population density zones, but in RADTRAN 4.0, the user may assign any desired population density to each route segment. These assignments could still be derived from the population density zones used in routing codes such as HIGHWAY, but actual data or projections may also be used. A number of other parameters were previously

*This work performed at Sandia National Laboratories, Albuquerque, New Mexico, supported by the United States Department of Energy under Contract No. DE-AC04-76DP00789.

**A United States Department of Energy Facility indexed to population density zone. This meant that the value assigned to one of these parameters in a given population density zone could not be varied for different segments of travel in that same population density zone without performing a separate analysis. Examples of these parameters are vehicle velocity and traffic density. In RADTRAN 4.0, these parameters may be specified separately for each segment. Other parameter values, however, cannot be altered by the user and remain imbedded in the RADTRAN 4.0 coding. The latter include values such as lane width by roadway type that are usually well-defined and subject to little variation. However, if user experience shows that some of these need to be made user-definable, RADTRAN can be modified albeit with a more complicated procedure than changing input data.

This paper describes the default parameters for each of the three major variable categories -- transportation network, land use, and population -- in the current version of the RADTRAN code. Changes in the variable assumptions associated with the release of RADTRAN 4.0 will then be described as will the options for users to supply locally-available , rather than national-level, default values. Finally, long-term enhancements anticipated for the code will be discussed.

TRANSPORTATION NETWORK VARIABLES

The RADTRAN risk analysis model combines meteorological, demographic, health physics, transportation, packaging, and materials factors to evaluate both the incident-free ("normal") and accident risks associated with the transportation of radioactive materials. Both the incident-free and accident modules in the code rely on a number of variables describing the transportation system over which such movements take place. Such variables relate both to physical descriptors of the network itself (roadway segment lengths and cross-sectional widths) and to the aggregate characteristics of the vehicle flows operating on the network (speeds, accident rates, etc.). Major transportation network-related variables in the code are listed in Table 1.

Perhaps the most important transportation-related variable, and certainly one of the most controversial issues at least in the accident module of the RADTRAN code, is the truck accident rate value selected. Three default values, for rural, suburban, and urban travel, currently reside in the code and are shown in Table 1. These values are based on national-level large truck accident rates (National Transportation Statistics, 1985 Annual Report 1985) and have been employed in a number of recent studies (Cashwell et al. 1986; Neuhauser and Reardon 1986).

Recent technical literature in the area of large truck accidents, however, particularly at the national level, appears inconsistent. Considerable concern exists, for example, as to the adequacy and completeness of the accident data bases employed in many studies. Measures of exposure (truck vehicle-miles of travel) have also been suspect and serious questions relating to uniformity, thoroughness, and data accuracy remain (Office of Technology Assessment 1988).

Table 1.
Transportation Network-Related Variables
in RADTRAN

Variable	Units	Default Value
accident rate	accidents/km	1.4 E-07 (rural) 3.0 E-06 (suburb.) 1.6 E-05 (urban)
fraction of urban travel during rush hour	percent	8
fraction of urban travel on city streets	percent	5
fraction of rural-suburban travel on freeways	percent	85 (truck) 25 (p. van)
one-way traffic count	vehicles/hour	470 (rural) 780 (suburban) 2,800 (urban)
sidewalk width	meters	3.0
street width	meters	20.0
shipment velocity	meters/sec.	24.58 (rural) 11.18 (suburban) 6.71 (urban)
vehicle occupancy	persons/vehicle	2.0

Alternative sources of truck accident data are state and locally-available data bases. State-level data on accidents and vehicle-miles of travel by vehicle type are routinely collected by state departments of transportation and by a number of local agencies as well. Large truck accident rate data are undergoing constant improvement at these levels, and some recently-completed efforts offer examples of states with successful data collection programs relating to large truck accidents (Wolff 1989) and provide techniques for the state and local-level analyst to employ in evaluating the impact of truck accident rates on the route selection process (Brogan 1989). These state and local data are more appropriate for use in risk analysis of radioactive materials shipments than commodity-specific rates (e.g. American Petroleum Institute) where specialized vehicles are commonly used (Fischer et al. 1987).

In the absence of quality data at the state or local level, or for risk and routing issues at the national level, combination (truck tractor-trailer) truck accident rates may be calculated by employing readily available accident data from the National Accident Sampling System - NASS (U.S. Department of Transportation 1987) and exposure data for large trucks from annual estimates of vehicle-miles of travel by highway type provided by the U.S. Department of Transportation (Highway Statistics 1987, 1988).

Other transportation network data, particularly geometric data such as roadway and right-of-way widths are less likely to be modified by the user because of the considerable amount of standardization which exists across various highway functional types. If route-specific analyses are to be employed, moreover, the user may either select to utilize the INTERSTAT network modeling system containing the Interstate network and other selected highways on a national scale or construct a state/local network using the StateGEN/StateNET module on the TRANSNET system (Cashwell 1989). In either case, the analyst may avoid the need for primary data collection relating to geometric network features through reliance on national standards (A Policy on Geometric Design of Highways and Streets 1984).

Traffic operational information, in contrast, such as speeds and volumes by facility type (and perhaps by time of day as well) is more appropriately collected, and is more readily available, at the local level. State Departments of Transportation, regional Councils of Governments, and city Traffic Engineering Agencies have, in most cases, well-established speed collection and volume-counting programs. Rather than rely on default values imbedded in the RADTRAN code, the state or local-level analyst may better utilize this easily-available, and quickly improving in accuracy and coverage, local data (New Mexico State Traffic Monitoring Standards 1988).

Finally, the incident-free module in RADTRAN calculates radiological dose to individuals in vehicles sharing the transportation link with the shipment. A very conservative value of 2.0 persons per vehicle is currently employed as a default value in the model even though other research suggests a value of 1.4 persons per vehicle is more representative of the national average for freeway traffic (U.S. Department of Transportation 1984). If local analyses require greater refinement of this assumption, vehicle occupancy values by time of day and facility type may be available from the agencies listed in the previous paragraph.

LAND USE/POPULATION

Land use and population variables are based on the concept of population density zones employed in the current version of the RADTRAN model. Version 3.1 presently uses three such zones to represent rural, suburban and urban environments. The three default population density values are shown in Table 2 along with other major land use and population assumptions.

Table 2.
Land Use/Population-Related Variables
in RADTRAN

Variable	Units	Default Value
population density	persons/sq. km.	6 (rural) 719 (suburban) 3,861 (urban)
fraction of travel in zone	percent	90 (rural) 5 (suburban) 5 (urban)
fraction of area covered by streets (urban)	percent	32
fraction of area covered by sidewalks (urban)	percent	10

RADTRAN 4.0 will allow up to 40 population density zones to be used. The state/local user, in fact, will be able to assign any desired population density value to an individual route segment. This feature will be particularly useful for conducting route-specific analyses.

In addition, the default values for fractions of travel in each of the three population density zones may not reflect actual conditions (Cashwell et al. 1986; Wilmot et al. 1983). In fact, despite whether a normal commerce/Interstate route or one avoiding major population centers is selected for analysis, rural and urban travel percentages are smaller than the given default values (72/83 percent for rural; 2/0 percent for urban) while travel in suburban areas is significantly higher than the default values would suggest (26/17 percent versus the 5 percent assumed in the default case).

Finally, pedestrian densities in urban areas may more appropriately be handled with locally-available data rather than relying on calculated values in the code. Some national-level guidance is available, however, which suggests that minimum pedestrian space requirements on urban sidewalks are on the order of 0.50 square meters/pedestrian (Highway Capacity Manual 1985).

SUMMARY AND CONCLUSIONS

In addition to major code improvements, RADTRAN is to be modified in 1989 to update a number of default parameters. This effort summarizes recent work relating to transportation and demographic parameters. Other default parameters used to perform risk analyses with the RADTRAN code, such as packaging characteristics and health effects, are also being examined. These improvements will be incorporated into the code available to RADTRAN users on TRANSNET.

REFERENCES

A Policy on Geometric Design of Highways and Streets, 1984, American Association of State Highway and Transportation Officials, (1984).

Brogan, J.D., Identifying Roadway Sections With Critical Large Truck Accident Rates on New Mexico's Rural Interstate System, prepared for Transportation Technology Center, Sandia National Laboratories, (1988).

Cashwell, J.W. et al., Transportation Impacts of the Commercial Radioactive Waste Management Program, SAND85-2715, TTC-0633, Sandia National Laboratories, (1986).

Cashwell, J.W. and C.M. Erickson, "StateGEN/StateNET -- Structured Method to Perform Route Comparisons," Proceedings, PATRAM '89, (1989).

Cashwell, J.W., "TRANSNET - Access to Transportation Models and Databases," Proceedings, PATRAM '89, (1989).

Fischer, L.E. et al., Shipping Container Response to Severe Highway and Railway Accident Conditions, NUREG/CR-4829, (1987).

Highway Capacity Manual, Special Report 209, Transportation Research Board, National Research Council, (1985).

Highway Statistics 1987, U.S. Department of Transportation, Federal Highway Administration, FHWA-PL-88-008, (1988).

National Transportation Statistics, 1985 Annual Report, DOT-TSC-RSPA-85-5, U.S. Department of Transportation, (1985).

Neuhauser, K.S. and P.C. Reardon, A Demonstration Sensitivity Analysis for RADTRAN III, SAND85-1001, TTC-0557, Sandia National Laboratories, (1986).

Neuhauser, K.S. and P.C. Reardon, "RADTRAN IV - Advanced Computer Code for Transportation Risk Assessment," Proceedings, PATRAM '89, (1989).

New Mexico State Traffic Monitoring Standards, New Mexico State Highway and Transportation Department, (1988).

Office of Technology Assessment, U.S. Congress, Gearing Up for Safety: Motor Carrier Safety in a Competitive Environment, OTA-SET-382, (1988).

U.S. Department of Transportation, Guidelines for Selecting Preferred Highway Routes for Highway Route Controlled Quantity Shipments of Radioactive Materials, Research and Special Programs Administration, DOT/RSPA/MTB-84/22, (1984).

U.S. Department of Transportation, National Accident Sampling System - 1985. A Report on Traffic Accidents and Injuries in the United States, National Highway Traffic Safety Administration, DOT HS 074, (1987).

Wilmot, E.L. et al., "Analysis of Population Densities Along Transportation Routes", Proceedings: PATRAM '83, pp. 153-159, (1983).

Wolff, T.A., Survey of States for Existence of Large-Truck Accident Rates and Computerized Databases That Could Be Analyzed To Obtain Large-Truck Accident Rates, SAND88-0626, TTC-0790, Sandia National Laboratories, (1989).