IMPACTS OF NUCLEAR MATERIAL FLOWS ON TRANSPORTATION ROUTING ALTERNATIVES*

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INTRODUCTION

Research and development activities to support the U. S. Department of Energy (DOE) sponsored efforts in nuclear waste transportation are coordinated through the Transportation Technology Center (TTC) at Sandia National Laboratories. Computerized logistics and routing models have been developed at Oak Ridge National Laboratory under the sponsorship of the TTC. These models are utilized to predict future flows of nuclear waste materials, forecast transportation requirements, and identify corridors through which these materials might be shipped.

Routing alternatives for shipment of these materials between sites are evaluated with the HIGHWAY (truck) and INTERLINE (rail and barge) computer models. While actual routings of shipments are usually determined by the carrier, use of these models allows simulation and evaluation of applicable alternatives.

Originally developed to more accurately simulate travel distances, times and resultant costs for input into analyses of waste management system parameters, these models also allow material flow information to be graphically depicted on a realistic transportation network. By utilizing the material flows estimated by the Nuclear Materials Transportation Logistics Model (NMTLM) together with the graphic routing capabilities, flow densities are illustrated on the routing network for scenarios of interest.

This capability is utilized to identify significant transportation corridors, thus providing a definitive characterization of transportation logistics for specific waste management requirements.

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ROUTING MODELS

The HIGHWAY and INTERLINE computer models are applied to simulate possible transport routes associated with the movement of nuclear waste by truck and rail, respectively.

The HIGHWAY model is based upon a commercially available data base (COMPU.MAP) which has been modified to meet the specific needs of the DOE program sponsors. The COMPU.MAP data base, licensed by Logistics Systems, Inc., is essentially a computerized road atlas, containing data describing over 15,000 road segments (links) and approximately 10,500 intersections (nodes). The data base includes interstate highways, the U.S. highway system, and most principal state highways. Data for each of the links includes highway identifiers, distance, and estimated driving speed. Node descriptions include intersection identifiers, latitude and longitude.

The INTERLINE model uses the Federal Railroad Administration data base which has been updated to include recent rail mergers and line abandonments and contains over 20,000 links and 15,000 nodes. Rail link descriptions include track classification, ownership and distance. Applicable barge routes have also been added to the INTERLINE data base.

Prediction of rail routings must reflect the ownership of track and equipment by the approximately 100 independent companies. These companies simultaneously compete for business and cooperate with each other to ensure delivery. Since the originating railroad will attempt to schedule the long haul, the route between two sites is often a function of direction, i.e. a different route would be used for an eastbound shipment as compared with a westbound shipment. In addition, the railroads tend to concentrate traffic on the better maintained routes, even though the trip might be lengthened. The INTERLINE model simulates these operational characteristics to aid in the determination of accurate trip distances and transportation costs.

These models are used to better identify travel routes and times, thus permitting greater accuracy in projected costs of transportation. Mapping algorithms have been linked to the routing models, enabling graphic depiction of the routes between waste source and destination.

LOGISTICS MODEL

The Nuclear Materials Transportation Logistics Model (NMTLM) is used evaluate the impacts of changes in various waste management system parameters upon projected transportation requirements, as well as the sensitivity of these projections to changes in specific transport characteristics. System parameter options such as storage or packaging facility locations, receiving and processing rates and facility operational dates are varied at the request of the program sponsors. Transport characteristics, such as operating speeds, routing restrictions, turnaround times, and shipment mode options are specified in accordance with the objectives of each analysis. Transportation requirements are often reported as numbers of shipments and shipping containers as well as total capital and operating costs.

The NMTLM has three basic functions:

1) to prepare a shipment schedule that depicts the rate at which radioactive waste shipments enter and leave the transportation system,

2) to evaluate the appropriate shipment destinations and packagings (should choices be available) using an optimization technique to minimize transportation costs, and

3) to calculate and report the transportation data describing the information gathered above for the particular scenario under consideration.

Scenarios of recent interest have focused on spent nuclear fuel, using the planning base case spent fuel discharge rates projected by the DOE[4,5]. This case assumes maximum utilization of existing storage and the reactor sites but allows for a full core reserve.

FLOW DENSITY DIAGRAMS

Illustrations of the transportation flow densities shown in Figures 1-4 are generated by linking the routes predicted with the HIGHWAY and INTERLINE models with the material quantity schedules forecast by the NMTLM. The width of the line graphically depicts the relative quantity of spent fuel shipments forecast to utilize the route.

The examples cited in this presentation were generated for the National Academy of Sciences and are used for illustration purposes only. Although a number of storage/disposal facility options were investigated, a single, national facility located in the west and a regional storage concept are used to illustrate the projected shipments in the year 2004. Two types of transportation systems were analyzed, a truck-only system and a mixed truck and rail transportation system. The latter of these options assumes that a reactor will ship by rail if that mode is available on site. Intermodal shipments were not included in this analysis. Federal, state, and local regulations prohibiting the transport of nuclear wastes through specified metropolitan or other land areas are not illustrated in the attached figures. Such constraints could, however, affect the routes chosen for the routes chosen for the scenarios of interest.

Figures 1 and 2 illustrate the projected annual spent fuel shipments for a mixed truck and rail system to a single western storage site in 2004. Rail shipments are concentrated in a corridor stretching from northeastern Kansas to southern Nevada. A

Fig. 1. Projected Annual Spent Fuel Shipments to a Western Storage Site in 2004. Basis: Reactors with rail service (for demonstration purposes only).

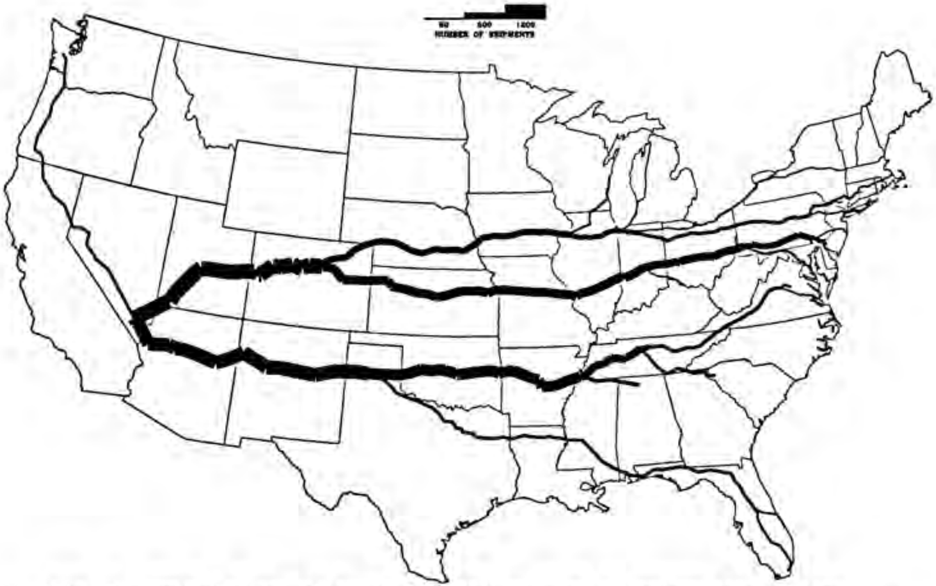

Fig. 2. Projected Annual Spent Fuel Shipments to a Western Storage Site in 2004. Basis: Reactors with truck service only (for demonstration purposes only).

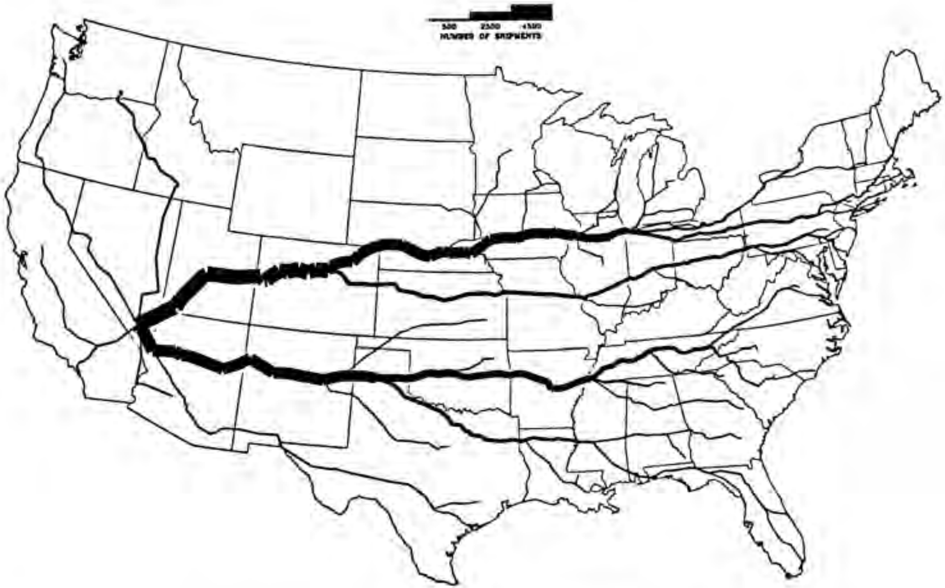

Fig. 3. Projected Annual Spent Fuel Shipments to a Western Storage Site in 2004. Basis: Truck shipments from all reactors (For demonstration purposes only).

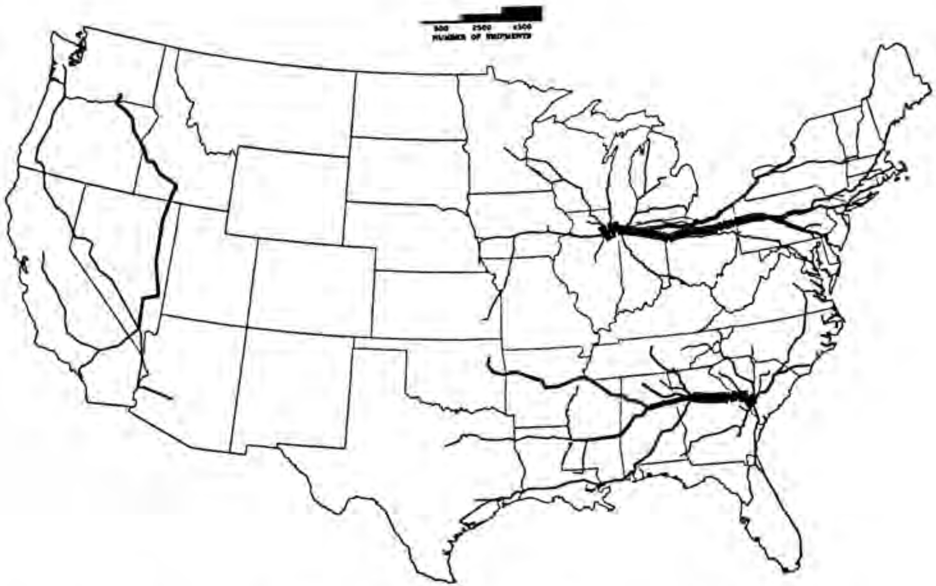

Fig. 4. Projected Annual Spent Fuel Shipments to Regional Storage Sites in 2004. Basis: Truck shipments from all reactors (For demonstration purposes only).

number of populated areas lie along this corridor, reflecting the development of urbanized areas along major transportation routes.

The highway shipments form three separate east-west corridors. The southern corridor follows I-40 from Tennessee to southern Nevada. The northern corridors follow I-70 and I-80 westward from the eastern states, joining in northeastern Colorado. The combined flows then follow I-70 and I-15 to southern Nevada. As with the rail corridors, a number of large urban areas lie along these routes.

Figure 3 illustrates the flow density diagram for a truck-only shipment scenario. The change in scale of the bandwidth between this and the previous figures should be noted. Flow densities along the I-40 corridor and the western I-70 corridor are 3-4 times greater than for the mixed-mode option. The I-70 corridor east of Colorado does not appear to experience a large change in shipping density, however, the northernmost corridor (I-80) is substantially impacted by the all-truck alternative.

The shipment patterns for the regional storage concept, assuming all shipments would be made by truck, is illustrated in Figure 4. In this example, the three regional storage sites are located in the southeast, midwest and western areas of the country. The scale compares with that of Figure 3. As can be noted, the trip patterns for the regional concept eliminate the large, cross-country corridors in the western and southwestern areas of the country shown for the single facility example. Two heavily-traveled corridors are identified: I-80 between Pennsylvania and Illinois and a southern corridor along I-20 in South Carolina, Georgia and Alabama.

CONCLUSIONS

The illustration of material flows along a transportation network provides DOE program sponsors with a new method of communicating the potential impacts of various waste management scenarios. While the method combines the outputs of other tools utilized to evaluate system impacts, it also must be utilized with an appropriate amount of caution. Routes projected by the HIGHWAY and INTERLINE models are mathematical simulations of carrier transport and are not intended to explicitly define the actual routes. Determination of the actual routes will depend upon facility operational constraints such as construction, road conditions, weather, and constraints imposed by federal, state and local governments. Routes will thus be selected at the time the shipment is being scheduled by the shipper and carrier.

Within the limitations of the available input data, the flow density diagrams graphically depict possible traffic impacts for a given scenario. This information allows identification of affected states or regions and can provide an assessment of the relative influence of this traffic upon the highway and railway networks.

REFERENCES

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