Rail Routing Selection - Current Practices and Alternative Approaches for Spent Nuclear Fuel and High-Level Waste

I. Introduction

The U.S. Department of Energy ships highly radioactive materials between former production sites, research reactors, power reactors, storage and other facilities throughout the United States. Two types of highly radioactive materials are spent fuel and high-level radioactive waste that resulted from reprocessing spent fuel. Transportation of these radioactive materials includes both highway and rail modes. For highway shipments, the Department of Transportation (DOT) classifies spent nuclear fuel and high-level radioactive waste as a "Highway Route Controlled Quantity", and the materials are subject to specific regulations that address routing. Regulations like those for highway shipments do not exist for rail transport.

The purpose of the paper is to: 1) describe current rail regulations and practices regarding routing of rail shipments of spent nuclear fuel (SNF) and high-level waste; 2) identify perspectives and concerns of States and other involved parties in SNF transport as they specifically relate to rail routing; and 3) compare aspects of highway routing regulations in HM-164 to a potential regulatory regime for rail routing, and 4) identify pros and cons to alternative approaches to rail routing.

II. The Current Rail Routing System

A. Regulatory Structure

DOT/Federal Railroad Administration

Rail routing of large quantity radioactive materials such as spent fuel is treated differently from highway routing from a regulatory standpoint. Regulations like those for truck shipments do not exist for rail transport; instead, a shipper and rail carrier normally jointly plan the route considering such factors as starting and ending points, the shortest distance/time in transit, and (if needed) bridge conditions relative to the weight of the shipment load.

Over the past two decades, stakeholders have proposed that DOT promulgate rail routing guidelines similar to the highway regulations in HM-164 to address rail shipments of certain radioactive materials. Proposed legislation would require DOT to promulgate rail routing guidelines for spent fuel and high-level waste shipments. It is unclear how or whether such legislation might change current carrier routing preferences.

To reaffirm FRA's dedication to ensuring the safe and secure transportation of high-level radioactive waste and spent nuclear fuel, FRA published the *Safety Compliance Oversight Plan for Rail Transportation of High-Level Radioactive Waste and spent Nuclear Fuel*. The FRA plan addresses several safety compliance oversight tasks, such as operational integrity, emergency response, route infrastructure integrity, and security. Within the operational integrity task there is an element stating, "FRA, DOE, the offeror or agent, and the rail carriers will coordinate during the planning stages of each shipment to ensure that track classification information and criteria are considered in the route selection process". Additionally, under the route infrastructure integrity task, FRA will continue their existing inspection policy concerning routine track and signal system inspections along designated routes.

Nuclear Regulatory Commission

The NRC has established a system of physical protection requirements for shipments of spent nuclear fuel and high-level radioactive waste. This system, is designed to reduce the risk of radiological sabotage or diversion of weapons-grade nuclear materials, Shippers that are NRC licensees, are required to send the rail route plan to the NRC, which (as it does for highway) examines physical security considerations. The NRC regulations incorporate DOT's transportation rules; the NRC enforces the DOT regulations and its own simultaneously.

The NRC has identified five types of route characteristics that receive special consideration when NRC staff review routes for approval pursuant to 10 CFR 73: (1) routes through highly populated areas; (2) routes that would place the shipment or escort vehicle in a significantly disadvantageous position (for example, tunnels which would prevent the escort vehicle from maintaining continuous surveillance of the shipment vehicle); (3) routes with marginal safety design features (for example, two-lane routes or absence of guard rails); (4) routes with limited rest and refueling locations; and (5) routes where responses by local law enforcement agencies, when requested, would not be swift or timely.

B. Industry Practices

As the transportation service provider, the rail industry considers multiple factors when routing hazardous cargo, including radioactive material. Typically these factors include starting and ending points, the shortest distance/ time in transit, track classification, the amount of traffic, and external features such as bridge conditions relative to the weight of the shipment load. The consideration of track class in the route selection process serves to ensure that the highest rated track is utilized to the maximum extent practicable over the route selected.

As an operational practice, it is instructive to note that railroad carriers generally route hazardous cargo along what are commonly referred to as "Key Routes", as defined in the Association of American Railroads Circular OT-55-E.

C. DOE Practices

As a shipper, DOE considers routing an important logistical aspect of routine transportation planning and operations. With regard to rail shipments of spent fuel, DOE's position has been that the carrier ultimately is responsible for selecting the route. However, in recent campaigns DOE has worked closely with the carrier and other federal, state, tribal, and local authorities in early identification of potential routes.

Routing determinations are critically important to the Department, and as a matter of course DOE consults closely with the carrier and affected states in making the final selection. In cases of shipping campaigns where multiple shipments over an extended period of time are scheduled, DOE has often undertaken a routing identification process using its analytical routing tool called TRAGIS for both highway and rail transport. The purpose of this route identification is to help facilitate transportation planning in conjunction with affected state, local, and tribal authorities, and in preparation of specific campaign transportation plans.

The DOE has established a set of standard transportation practices for Departmental programs to use in planning and executing offsite shipments of radioactive materials. These practices are presented in DOE Manual 460.2-1, *Radioactive Material Transportation Practices Manual.* The Manual includes a section on routing, which addresses the identification and selection of highway and rail transportation routes for shipments of DOE radioactive materials. In considering rail routing associated with spent nuclear fuel, the Manual emphasizes that DOE or its designated shipper specifies carriers and interchange points between carriers, and that DOE will coordinate routing options with rail carriers and stakeholders. In selecting rail routes, the following factors are considered: (1) the time and distance traveled; (2) the number of interchanges between railroads along the route; (3) the use of higher-class track, for example, "key routes" as defined in Association of American railroads Circular OT-55D; and (4) operational input from carriers.

D. State Practices

Unlike Highway Route Controlled Quantity shipments via truck, states have no formal regulatory role in determining routes for rail shipments. The states have been involved in the route selection process used by DOE as the shipper for spent nuclear fuel. DOE has, on several occasions in the recent past, successfully consulted with the states on prospective rail shipping routes. This interaction has allowed the states to express specific concerns associated with proposed routes, and through discussions with the shipper and carrier, identify routes acceptable by the state. The states recognize that

without a regulatory role their involvement is dependent on DOE's route selection process.

E. Evaluation of Existing Practices

Existing practices for rail route selection generally focus on the shipper and carrier planning the route based on a loosely defined set of parameters. This process is supplemented by an interface between DOE, as the shipper, and States and Tribes. Several additional parameters are typically discussed at this point before a final route decision is made. The existing practices have been successfully applied to shipments of SNF; however, there are identified strengths and weaknesses to the process. The pros and cons of the existing practices for selection of rail routes are summarized below.

Pros:

- Rail shipment of SNF today is generally considered safe. Issues related to routing of rail shipments periodically arise, but are usually limited in scope or are superceded by other transportation-related issues.
- SNF is no more (and likely far less) risky to transport than other types of HAZMAT shipped every day by rail; its public policy-related connotations are not sufficient to warrant disparate treatment in routing, and current practices do not.
- The current regime would likely accommodate substantial increases in SNF rail shipment volume without the potential for undue disruption of rail operations.
- The current voluntary/guidance-based approach is flexible and readily adaptable to changes and lessons learned.

Cons:

- Some States are dissatisfied with the current regime and, since they have primary responsibility for public health and safety, should have a greater ability to ensure their people and resources are adequately protected.
- Voluntary industry practices and recommended DOE guidelines, without enforcement mechanisms either by regulation or through contract, may be disregarded.

- While shipments have been conducted uneventfully for decades, the total number to date is comparatively small. It would be prudent to increase safety/security for SNF shipments until the true risk is better known through experience, and risk-based rail routing regulations can do so.

III. Alternative Routing Approaches

1. Regulatory Alternative to Rail Routing

Over the past two decades, stakeholders have proposed that DOT promulgate rail routing guidelines similar to the highway regulations in HM-164 to address rail shipments of certain radioactive materials. Through the designation of alternative routes, states can influence the selection of highway routes; however, states have no such role in rail routing. To date, DOT has not promulgated rail routing guidelines or regulations. This section provides a comparative analysis of the highway methodology to rail routing, and lists some pros and cons of applying potential routing guidelines to rail shipments of spent nuclear fuel and high-level radioactive waste.

Summary of Highway Routing Requirements and the DOT Guidelines for Route Selection

The DOT has established specific highway routing requirements for certain radioactive materials. These requirements are codified in 49 CFR 173.22 and 177.825 and are extensively discussed in the January 19, 1981, Federal Register (Docket HM-164, 46 FR 5298). The routing requirements identify "preferred routes" which are defined in the rules as any route designated by a "State routing agency" and any Interstate system highway for which an alternative highway has not been designated by a State agency.

Implementation of the routing regulations for highway route controlled quantity shipments of radioactive materials necessitates a methodology for selecting preferred routes. For this purpose, DOT has developed an approach entitled, *Guidelines for Selecting Preferred Highway Routes for Highway Route Controlled Quantity Shipments of Radioactive Materials, DOT/RSPA/HMS/92-02.* A number of factors can be important in comparing available routes and the methodology provides a systematic treatment of these factors. Overall, determining a route that will minimize radiological impacts is the cornerstone of the process.

The risk comparison factors used in the DOT methodology are categorized as either radiological impacts or non-radiological impacts. Additional factors influencing the risk of radioactive materials transportation include certain actions that have the potential of mitigating exposure to radioactive material. The DOT believes that the primary objective in route selection should be placed on the risk that is associated with the radiological nature of the cargo. Consequently, the following are considered to be primary route comparison factors:

1) Radiation exposure from normal transport;
2) Public health risk from accidental release of radioactive materials; and
3) Economic risk from accidental release of radioactive materials.

Other factors may be useful to consider in the route selection process, but only after careful analysis reveals that alternative routes have essentially the same level of risk based on the three primary comparison factors. The following are considered secondary comparison factors:

1) Emergency response effectiveness;
2) Evacuation capabilities;
3) Location of special facilities such as schools or hospitals; and
4) Traffic fatalities and injuries unrelated to the radioactive nature of the cargo.

In the DOT process, the primary route comparison factors form the basis for route selection decisions. The remaining secondary factors are used if no clear-cut choice emerges from evaluation of the primary factors, or if unusual conditions exist in the State that increase the importance of one or more of the secondary factors.

Comparative Analysis of the Highway Methodology to Rail Routing

The use of the highway methodology for rail route selection presents a challenge since there are significant differences between the two modes of transportation. In the context of route selection, these differences, which are summarized in Table 1, are discussed below.

Table 1
Characteristics of Routing

Highway	Current Rail
1. Requirement that carriers follow "Preferred Routes" for HRQC of radioactive material	No required rail network is identified
2. State routing agency identified as responsible for alternative route decisions	No rail routing authority identified.
3. Reduce time in transit required	No requirement for time in transit
4. Explicit deviations from preferred routes are provided in regulations	No explicit deviations have been identified
5. Interstate highway system provides a large array of potential alternative routes	The rail network is comparatively smaller and does not have as many suitable potential alternative routes
6. Business decisions for specific transportation operations do not typically play a significant role in highway routing.	Business decisions for overall operations play an important role in rail routing because infrastructure is privately owned and maintained.

A network of "preferred routes" has not been established for rail transportation. This concept is really the basis for the highway model in that a defined set of routes is pre-established for highway route controlled quantities of radioactive material. Without this point of reference, a rail routing scheme would be difficult to implement. The Association of American Railroads (AAR) has recommended using designated "key routes" for certain hazardous materials, including spent nuclear fuel and high-level radioactive waste. These key routes have certain characteristics, including the requirements for 1) wayside-defective bearing detectors; 2) main track inspections by rail defect detection and track geometry inspection cars no less than two times each year; and 3) use of Class 2 track or higher. Key routes might be a good analogue for the "preferred" system of highway routes.

For the highway methodology, state routing agencies have been identified as responsible for alternative routing decisions. Given their responsibility for highways within State boundaries, this authority has worked well. However, the rail infrastructure is owned and operated by private rail companies. If an alternative rail routing system were to be implemented, a rail routing authority would have to be identified. Considering the highway model, states would have to designate a lead agency for routing decisions.

Alternative highway routing has been a viable concept partly because the nation's Interstate highway system is large and intricate. It offers numerous opportunities from a particular origin to a specific destination, using highways that are comparable in quality (i.e., divided highways, limited access). This flexibility is a key characteristic. The rail network is comparatively smaller and less intricate, and cross-country rail lines are privately owned by only a few railroad companies. This smaller network does not provide the flexibility inherent with the Interstate highway system. This in turn means fewer potential alternatives available, especially considering that DOT recognizes the shortest time in transit as being a primary consideration.

Also, there is a fundamental business difference between highway and rail transport. The rail system is privately owned and operated. In considering decisions regarding alternative routes, rail companies have to consider overall business operations. Their routing of radiological material shipments has to be taken within this larger context. The business considerations further reduce the level of flexibility required for alternative routing decisions. If rail routing requirements were implemented, the designated lead agency would need to consult closely with the affected railroads as part of the process.

If an alternative routing regime were developed for rail, both the primary and secondary risk comparison factors that are taken into account with the DOT highway routing model could likely be useful in determining rail routes. However, there are other factors, such as rail traffic, number of interchanges, track classification, and infrastructure features that are important to consider when designating routes. In addition, there are other State concerns that are not entirely captured in the secondary list of factors.

Pros and Cons for Applying the HM-164 Regulations to Rail

When considering a system that applies the HM-164 methodology to establishing designated rail routes, the benefits and impacts of such a program are important. In this section, the pros and cons of applying the highway model to rail are examined.

Pros:

- A consistent routing methodology would lend itself to providing states with the ability to influence rail routing selection as they do for highway transportation;
- Rail routing regulations would facilitate the identification of a network of routes to be used for shipping spent nuclear fuel and high-level waste;
- Following guidelines similar to those in HM-164 would ensure that rail routes, like highway routes, are selected in order to minimize radiological impacts;
- Designated rail routes could take into consideration 1) emergency response effectiveness, 2) evacuation capabilities; 3) location of special facilities such as schools or hospitals, and 4) traffic fatalities and injuries unrelated to the radioactive nature of the cargo.

Cons:

- It may not be desirable to give States greater influence over rail routing, because parochial interests/concerns could hamper use of optimal routes.
- An established network of routes could adversely affect the overall operational flexibility that is needed by the rail industry due to the relatively closed nature of the system and the need to often coordinate movements of materials shipped by rail with multiple rail carriers;
- States would need to designate an authority for alternative rail routing;
- The rail network is relatively finite and thus may limit the choices of "preferred" rail routes; and
- Limiting routing options may have an adverse impact on security/physical protection.

2. Modified Non-Regulatory Alternative to Rail Routing

Given that existing practices for rail route selection have certain weaknesses, a non-regulatory alternative is also discussed in this paper. This approach addresses many of the concerns on rail routing, while at the same time recognizing shipper and carrier requirements.

Industry Concerns

TBD

State Concerns

The states' interest in the selection of rail routes for radioactive material shipments derives primarily from their responsibility to protect public health and welfare, as well as property, from the possible effects of transportation accidents involving radioactive material. This responsibility exists regardless of whether there are few or many shipments, and regardless of transportation mode. Given the public scrutiny and concern over the transport of radioactive materials, the states also have an interest in trying to ensure uneventful transport – avoiding even minor accidents and operational errors.

Because their own role is so limited in selecting rail routes, the states perspective is that DOE, as a major shipper of radioactive materials and as a responsible government agency, should play a central role in the selection of routes for specific rail shipping campaigns.

From the states' perspective, the ideal rail route selection process would achieve four main goals:

1) Promote safety by the selection of the best and safest route, in consultation with the affected states and tribes;
2) Promote public acceptance of the shipping routes by making the federal government, not a private company, ultimately accountable for route selection;
3) Allow state and local resources (inspections, emergency response, etc.) to be focused by reducing the total number of potential routes; and
4) Give states and communities sufficient time to prepare for shipments along the selected routes.

Though existing practices emphasize DOE coordination with the affected states, that practice has not always resulted in a satisfactory route selection. The timing of the coordination can be critical in allowing DOE to work with the carrier to identify a route that is acceptable.

Another state consideration is to narrow the number of acceptable routes. Under current regulations, virtually all rail routes could be used for radioactive material shipments. The states' preference would be for a single route to be designated as the primary route. This route would be used for all shipments from a given point to a given destination, barring some event that interferes with the use of that route, such as an accident, emergency track repair or maintenance, or a security threat. Alternative routes would be identified that would be available only when the primary route is not useable, because of the conditions noted above.

Many states have suggested that the routes for shipments of high-level radioactive materials should take into consideration critical safety factors not included explicitly in federal regulations, such as: minimizing emergency response time; the ability to retrieve casks in the event of an accident; avoiding difficult-to-evacuate populations; minimizing

transit through inclement weather; avoiding "high hazards;" and imposing time-of-day travel restrictions. In addition, avoiding "dark track" and classification yards is also preferred. States would like to review these factors with DOE and its rail carriers in routing discussions. The states believe that once a route is selected it should be reflected in DOE's rail transportation services contract/Tender. Specifically, the rail transportation services contract/Tender language should require the rail carrier to utilize only these specifically designated routes, and it should clearly articulate the conditions under which route deviations may occur and the duties and responsibilities of the carrier and DOE in the event of a required deviation.

DOE Concerns
TBD

Non-Regulatory Alternative Approach

This non-regulatory alternative approach for selecting rail routes for SNF builds on existing practices acknowledged in Section II. The approach would emphasize early involvement of all interested parties, and a sequencing of activities to ensure all appropriate factors are considered in the route selection. The approach would lend consistency across DOE spent fuel shipment planning.

Process:

1. As an initial step, DOE as the shipper works in consultation with selected rail carriers to identify potential routes based on industry practices and DOE requirements. Factors to be considered include: minimizing the risk of radiological material transportation, least time and distance, fewest number of interchanges, use of higher-class track, and operational factors from carriers. Typically, this activity takes place 10-12 months in advance of the scheduled shipment. This may include a route analysis by DOE to support identified shipping requirements.
2. Once potential routes are identified, these are discussed with the transit states considering safety factors such as: minimizing emergency response time; the ability to retrieve casks in the event of an accident; avoiding difficult-to-evacuate populations; minimizing transit through inclement weather; avoiding "dark track" and "high hazard" areas, and considering time-of-day travel restrictions.
3. If not previously completed, a transportation risk assessment is made for each potential route.
4. A route selection is made by the shipper/carrier in consultation with the states, taking into account all of the above factors for a specific campaign. Utilizing a "Decision Model" to characterize identified factors and support route selection is recommend. A primary route is identified along with alternative routes. Specific conditions under which route deviations may occur will be identified. For an extended shipping campaign, a suite of potential routes may be identified.
5. The route selection and alternatives are documented in the campaign transportation plan.

Pros and Cons for Non-Regulatory Alternative Approach

Pros:

- Given the application of considering "key routes" for rail, a network of potential rail routes can be constructed in advance. This would allow DOE and the states to better target their resources for training;
- The process emphasizes early involvement between the shipper and carrier and consultation with states;
- Considering some of the same factors that are integral to highway route selection, such as minimizing radiological impacts, would create some consistency between transportation modes;
- Designated rail routes could take into consideration additional factors such as: 1) emergency response effectiveness, 2) evacuation capabilities; 3) location of special facilities such as schools or hospitals, and 4) traffic fatalities and injuries unrelated to the radioactive nature of the cargo.
- A consistent approach or DOE spent fuel would lend itself to providing states with the ability to influence rail routing selection as they do for highway transportation;
- States would not need to designate an authority for alternative rail routing;

Cons:

- Giving States greater influence over rail routing could hamper use of optimal routes because of parochial interests/concerns;
- Even an informal established network of routes could adversely affect the overall operational flexibility that is needed by the rail industry;
- Limiting routing options may have an adverse impact on security/physical protection.

IV. Summary

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