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## MEMORANDUM

**TO:** Katy Walton, Caltrans

**FROM:** Brad Mettam, Yucca Mountain Project Coordinator *BARM*

**DATE:** July 28, 1993

**SUBJECT: OVERWEIGHT TRUCK SCENARIO**

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The attached paper was delivered at the International High-Level Waste Management Conference in Las Vegas during April '93.

Charlie Hill offered this as an alternative to the light weight tractor - feeling that the light weight tractor causes performance and driver environment problems.

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## MARGINAL OVERWEIGHT OPERATING SCENARIO FOR DOE'S INITIATIVE I HIGHWAY CASKS

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### ABSTRACT

This paper assesses the potential transport of high-capacity Initiative I highway casks under development by the Office of Civilian Radioactive Waste Management (OCRWM) as permitted *marginal overweight* shipments that: exceed a gross vehicle weight (gvw) limit of 80,000, but weigh less than 96,000 pounds; follow axle and axle group weight limits adopted by the Surface Transportation Assistance Act (STAA) of 1982; conform to dimensional restrictions to operate on most major highways; and comply with the Federal Bridge Formula. The marginal overweight tractor-trailer would operate in normal "over-the-road" mode and comply with all laws and regulations. The vehicle would have a sleeper berth and two drivers—one to drive while the other provides escort and communications services and accumulates required off-duty time.

### I. BACKGROUND

OCRWM's Initiative I highway cask system capacities represent dramatic increases over the current generation of spent fuel casks. Increased capacity has been a prime driver in these new cask designs because of the potential safety and economic advantages of reducing the number of fuel shipments.

Maximizing payload has resulted in the need to minimize total cask system weight, including the transporter. DOE's Cask Systems Development Program allocated Initiative I highway cask system weight as follows:

Component	Allotted Weight
Loaded Cask	54,000 lbs.
Semitrailer	9,000 lbs.
Tractor	16,000 lbs.
Unallocated	<u>1,000 lbs.</u>
TOTAL	80,000 lbs.

Events that could make the 80,000 pound design weight unachievable include adding non-fuel bearing components to the payload (e.g., adding nine channels to the GA-9 would add about 1,000 pounds); weight growth in design and fabrication; tractor or trailer modifications after testing; and regulatory requirements that increase the weight of tractors.

#### A. Past Work and Recommendations

In previous work to support DOE programmatic decisions on overweight truck (OWT) cask development and

operation, an OWT system for transporting spent nuclear fuel (SNF) and issues impacting such operation were examined.

To address unresolved issues, DOE established a management-level working group on overweight nuclear shipments that included DOE, the American Association of State Highway and Transportation Officials (AASHTO), the Federal Highway Administration (FHWA), and carrier representatives. To develop a consensus among all states on a uniformly acceptable overweight permit for transporting SNF, the group sent questionnaires to state and turnpike authorities, and a readily permittable OWT was identified. It was the final recommendation of the group that an overweight vehicle (see Figure 1) be approved as the upper bound vehicle for uniform permitting for the transport of spent nuclear fuel.<sup>1</sup>

The AASHTO/DOE study also addressed whether a shipment of SNF should be considered a divisible load. The FHWA restricts states from issuing overweight permits to move loads that could be divided into two or more legal weight loads. Typically, an overweight load consists of a single large piece of equipment or machinery that cannot be readily disassembled.

A response to questions posed by DOE was received on November 13, 1987, stating that "the Federal Highway Administration construes casks and their contents as nondivisible loads for the purpose of State compliance with 23 U.S.C. Section 127...Each State can determine, pursuant to its law, if the cask would qualify for a permit without fear of losing Federal-aid funding."

The study discussed above also sought to define the maximum overweight system that would be widely accepted by the states.<sup>1</sup> DOE completed an additional study to identify a configuration that would be widely accepted while meeting the requirements of the Federal Bridge Formula.<sup>2</sup> The results of these two studies have been used to develop the marginal overweight concept.

### II. THE MARGINAL OVERWEIGHT CONCEPT

A marginal overweight system is assumed to include special designs for the tractor and the trailer. In this paper, a marginal overweight vehicle: exceeds the gvw legal limit of 80,000 pounds; follows the axle and axle group weight limits adopted by the STAA of 1982; conforms to dimensional restrictions to operate on major highways and complies with the Federal Bridge Formula. This report will contrast the constraints

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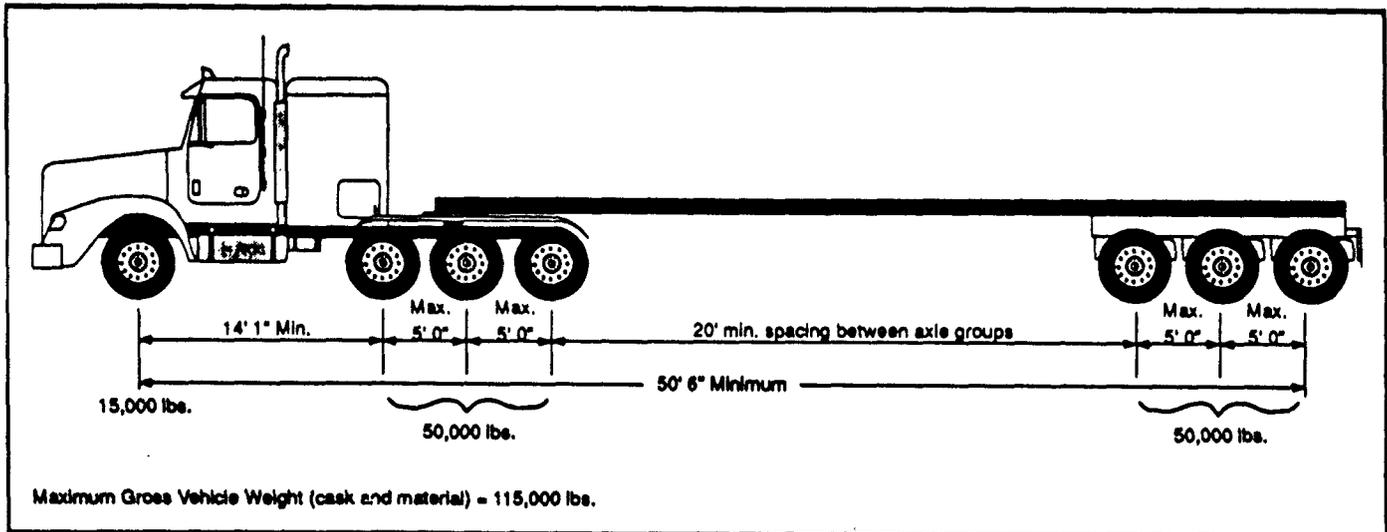


Figure 1. AASHTO Proposed OWT Dimensions and Weight

incurred by shipping spent fuel as *marginal overweight* (between 80,000 and 96,000 pounds) compared to permitted *overweight*.

Although overweight permitting practices vary from state to state, most states have procedures to expedite the processing of permit applications for vehicles within certain weight ranges.<sup>3</sup> As long as the applicant's vehicle does not exceed the limits for this "routine" permitting, the issuance of an overweight permit is automatic. "The criterion used to define 'routine' permits . . . was that the requested weight was low enough not to require an extensive engineering analysis, bridge division check, or extensive route analysis." The most restrictive states require compliance with the Bridge Formula (which also defines the marginal overweight vehicle) as the upper limit for routine permitting.

The first two conditions of the marginal overweight definition are straightforward. The gvwt legal limit on interstates and other major highways is 80,000 pounds. Axle and axle group limits are 20,000 pounds on one axle and 34,000 pounds on tandems (groups of two axles less than eight feet apart). The third condition is that a marginal overweight vehicle must comply with the Federal Bridge Formula relationship between overall length, axle spacing, and axle and gvwt because so many states use the formula to define routinely permissible loads. Under the Bridge Formula a vehicle can, in theory, be configured to accommodate any amount of weight (by adding length and/or axles). The fourth condition, conforming with dimensional restrictions, is more complicated. Although the STAA of 1982 barred states from placing length limits on tractor-trailer combinations operating on the National Network of highways, states can and do still set and enforce length limits for routine legal operation on state highways. Some states limit trailer length to 45 feet. Others limit the overall length of the tractor-trailer to 60 feet, which restricts the length of the trailer. Still others regulate the wheelbase of the trailer (kingpin to rear axle) to as little as 39 feet, which can limit the weight carried on the trailer to comply with the Federal Bridge Formula.<sup>4</sup> Compliance with state restrictions on routine legal operation on state highways could simplify the permitting process.

Figure 2 defines marginal overweight vehicle parameters. A six-axle marginal overweight tractor-trailer could legally weigh 96,000 pounds in most states (though the maximum recommended here is 88,000 pounds due to practical limits on

loading the tractor's steering axle). A seven-axle configuration could legally weigh as much as 104,000 pounds and qualify as marginal overweight (the recommended maximum for this configuration is 96,000 pounds).

Figure 3 presents six-axle and seven-axle marginal overweight configurations with tridem axles. Under the Bridge Formula, tridem axles may carry up to 42,000 pounds. This adds 8,000 pounds per tridem to the formula-permitted gvwt. The additional axle will add weight to the trailer (on the order of 2,000 pounds), which must be considered in the system weight configuration. For a five-axle marginal overweight vehicle, the trailer's tandem axles are separated at least ten feet to allow them to carry 40,000, rather than 34,000, pounds.

This three-axle trailer is significantly heavier than the current design of the legal weight trailer for the GA-4/GA-9 cask system. This configuration could provide operational benefits to the OCRWM transporter and be accommodated under the Federal Bridge Formula. The other configuration would employ tridems on the tractor and trailer for a possible gvwt of 96,000 pounds.

### III. SPECIAL OPERATING CONDITIONS/RESTRICTIONS

An SNF transportation system making extensive use of marginal overweight vehicles would be impacted by a number of issues, e.g., state attitudes toward issuing multiple trip permits, and movement restrictions imposed by the states. Because the vehicle will carry a permitted load, the operational restrictions of each state in route would apply.

#### A. State Attitudes Toward Overweight Shipments

Overweight shipments are more complicated because states independently set policy and regulations for such shipments. Regardless of differing regulations, carriers have found that overweight permitting has become more feasible over the past few years and an acceptable way to do business.

Table 1 illustrates the increasing use of overweight permits. The data show a small but consistent trend toward more overweight permits being issued. They also show a steady increase in the number of nondivisible load permits.

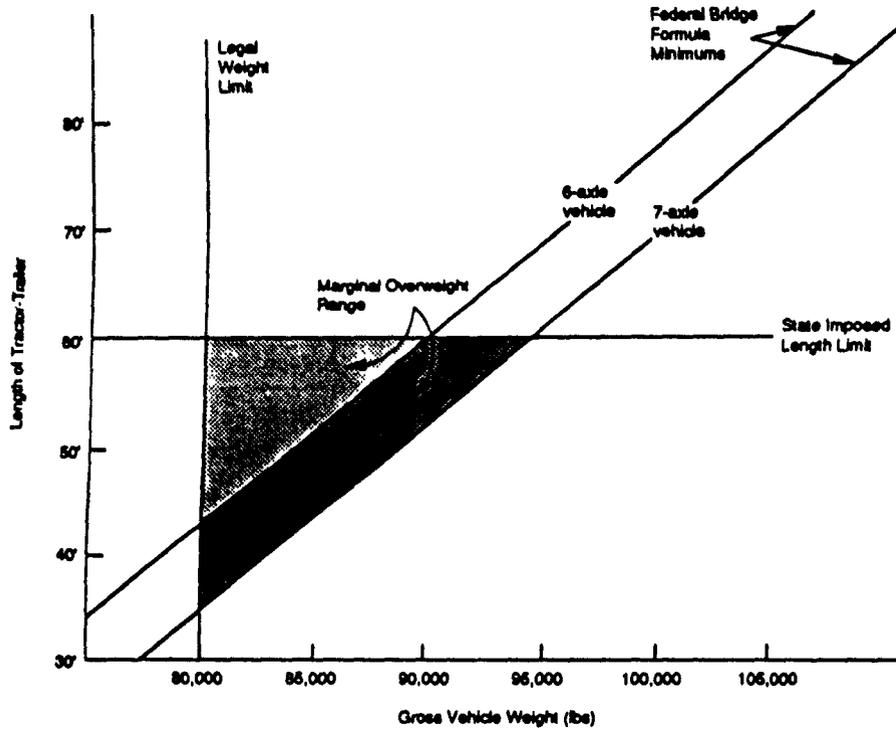
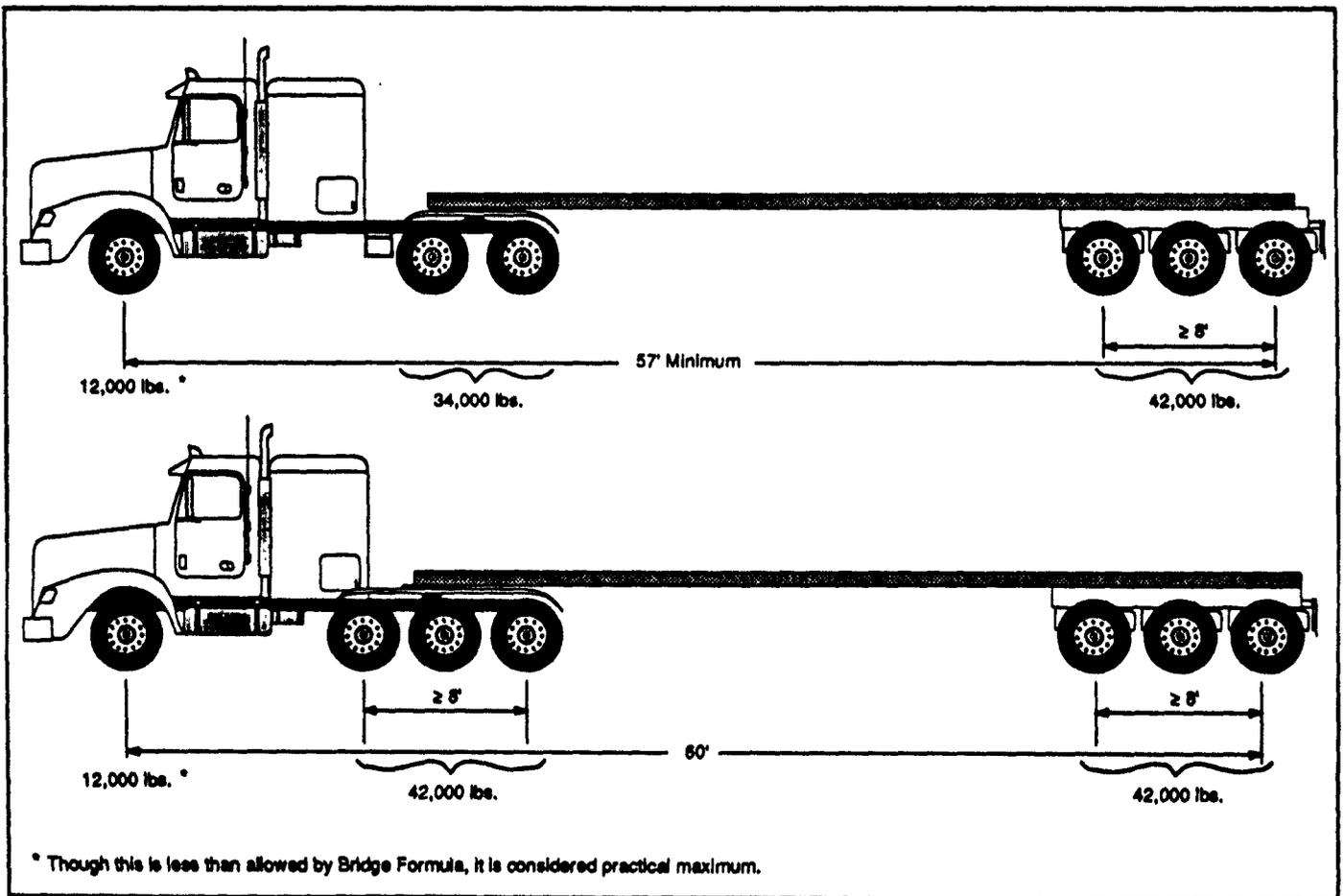


Figure 2. Definition of Marginal Overweight Vehicle



\* Though this is less than allowed by Bridge Formula, it is considered practical maximum.

Figure 3. Marginal Overweight Vehicle Concept

Table 1. Number of Overweight Permits Issued in the U.S.

Year	Nondivisible Single Trip	Nondivisible Multi-trip	Total Overweight Permits Issued
1984	1,022,186	40,308	1,227,772
1985	1,072,776	46,451	1,272,869
1986	1,149,625	59,274	1,359,068
1987	1,136,649	67,132	1,358,364
1988	1,151,732	61,222	1,390,710
1989	1,205,394	76,687	1,485,544

Source: Compiled from 1987 and 1989 Annual Reports to Congress.

Ten states issued no multi-trip permits from 1987 through 1989, which indicates that, unless special arrangements are made, each trip through these states would have to be permitted separately.

Throughout the United States, a number of efforts have been undertaken to develop uniform permitting practices on a regional and national basis. The New England Transportation Consortium (NETC) undertook a project to develop a uniform permitting process for trucks operating in the five member states.

Two other regional agreements are in place, and one is being developed. A midwestern group comprised of ten states (Illinois, Indiana, Missouri, Iowa, Kentucky, Michigan, Minnesota, Kansas, Ohio, and Wisconsin) has been implemented. This agreement group will permit vehicles for all ten states up to 108,000 pounds. Axle weight limits also apply though they are not nearly as stringent as the Federal Bridge Formula dictates. A Western Regional Agreement is also operating that consists of Idaho, Oregon, and Washington, with Arizona and Utah planning to join later this year. This group issues routine permits for loads up to 160,000 pounds with axle limits also applying. Finally, a southern regional group consisting of twelve states is working to develop a draft agreement. Plans call for this group, when implemented, to issue routine permits for loads up to 108,000 pounds with axle weight limits applying.<sup>3</sup>

#### B. Potential State-Imposed Restrictions

The 1982 STAA required states to allow trucks weighing up to 80,000 pound gvw to operate routinely on the designated National Network. With the exception of three states that allow more weight, this is a uniform limit on the Interstate system. The principal inconsistencies across states occur with overweight vehicles. Special restrictions commonly applied by states include: restrictions on time of day, no travel on holidays and weekends, and seasonal restrictions.

1. Time of Day. Numerous states restrict movement of overweight shipments for certain periods of the day. National Cooperative Highway Research Program (NCHRP) Report 68 identified 39 states that did not allow nighttime movements in 1989.<sup>4</sup> Nine states employed restrictions of movements during rush hour traffic.

Additional information on time-of-day restrictions was found by the AASHTO Subcommittee on Uniform Permitting for Truck Transport of Spent Nuclear Fuel, which distributed a questionnaire to states in order to determine if a specified

overweight vehicle would be permissible.<sup>1</sup> In the survey, 23 states indicated they do not allow overweight shipments to move at night. Each of these states was contacted by the subcommittee to see if they would reconsider their position, and only one state, Tennessee, indicated they were not willing to reconsider their nighttime restriction and support a uniform effort for continuous movement.

Interviews with fleet managers involved with overweight operations indicated that states rigorously apply time-of-day restrictions only to oversize vehicles but may not apply them to the legal size, marginal overweight OCRWM shipments. This leads to the tentative conclusion that time-of-day restrictions may be less significant than would appear from looking at the printed regulations.

2. Holidays and Weekends. Overweight shipments are also subject to movement restrictions on holidays and weekends in certain states. From the NCHRP-68 report, 43 states have these restrictions.<sup>6</sup> From the DOE/AASHTO study, 18 states indicated they would not allow weekend movements for the specified vehicle, but only one state, Tennessee, said they would not reconsider their position.<sup>1</sup>

States also differ on when a weekend begins and when a particular holiday occurs. Some states would include Friday as part of a weekend, while others may only specify Saturday and Sunday. Also, some holidays are celebrated on different days in different states. These types of issues would have to be resolved during the planning phase of a campaign for shipping SNF. It is conceivable that weekends could be avoided for long-haul shipments by carefully scheduling when the movement begins.

3. Seasonal Restrictions. One of the most damaging periods for highways is during the seasons when freezing and thawing occur. During winter freeze and spring thaw, pavements are weakened by moisture in the sublayers, which in turn makes the pavement much more vulnerable to heavy loads.

To counter this phenomenon, several states impose "frost laws." Some states require loads to be reduced during the period frost laws are employed. Some states may not issue overweight permits, and others reserve the right to close certain highway sections during such periods. Another mitigating measure is for states to reroute traffic from highways that are particularly susceptible to freeze/thaw conditions.

The 1986 DOE study on overweight truck shipments of spent nuclear fuel reported that 18 states have "frost laws."<sup>7</sup> For the AASHTO study, the states were asked if frost season restrictions existed within their boundary that would prevent year-round movement on interstate routes and connecting roadways to individual nuclear power plants. Thirteen states said "yes" to this question.

#### IV. IMPACT ON OPERATIONS

Overweight shipments create unique impacts on marginal overweight vehicle operation. The analysis of some of these impacts, such as safety, driver work environment, and DOE versus state control of overweight shipments, is qualitative in nature. Other factors, such as cost and radiation exposure, lend themselves to quantitative comparisons.

### A. Safety

While numerous studies of the relationship of weight to accidents have been conducted over the last 25 years, the results often conflict. Generally, vehicle characteristics have less impact on accident frequency than the driver or the environment.

### B. Driver Work Environment

The design, features, and overall performance of the vehicle affect driver recruitment and retention. Federal requirements for driver certification, increased concerns about drivers' safety records, and the job-imposed lifestyle create difficulty in attracting and retaining desirable drivers.<sup>7</sup>

If OCRWM places requirements on its drivers similar to those placed on drivers in other DOE programs, such as the Waste Isolation Pilot Plant Project (e.g., highly trained, exceptional safety record, and extensive driving experience), the driver pool will be further restricted. Top-flight drivers hired for OCRWM shipments will certainly be actively recruited by private sector fleet operators. Good pay, working conditions, and equipment become necessary components in staffing a fleet under these circumstances.

The driver's work environment may affect anything from employee satisfaction, to safety, to equipment reliability. Adding weight to the tractor would increase the feasibility of adding options to improve the work environment (e.g., more powerful engine, larger sleeper berth).

### C. DOE Control

All overweight shipments are subject to individual state policies and regulations. If a state decides not to permit a vehicle, the shipment must be rerouted through other states (where the same problems could occur), or the load must be transported in a legal weight configuration.

Overweight SNF shipments have occurred for over 30 years. While administrative problems, cost, and differing state regulations complicate the permitting procedure, state overweight permitting for SNF shipments is relatively routine. One carrier indicated that the nature of the cargo overshadowed the fact that the shipment weight was over the legal limit of 80,000 pounds.<sup>8</sup> If insurmountable problems with permitting are

found during a campaign, those shipments would have to be moved in a legal weight configuration using an alternative operating strategy.

### D. Quantitative Comparisons of Campaign Scenarios

In comparing various scenarios for operating a truck fleet under varying conditions, the same set of assumptions was used to assure valid conclusions. The set of operating assumptions included: 800-mile and 2,000-mile one-way trips; continuous movement of overweight shipments vs. night-time shut down; and cask load intervals of 24 and 72 hours.

1. Radiation Exposure. Annual radiation exposure was calculated for a marginal overweight tractor-trailer configuration using radiation data from the 70% Design Package and the Transportation Systems Data Base (TSDB).<sup>9</sup> Exposure per day was calculated for each driver based on two drivers splitting driving, guard, and sleeper berth time evenly. It was also assumed that the drivers would travel 840 miles per day and 75,000 loaded miles per year (150,000 total miles per year), which gives a total of 89.3 days each year in the tractor while carrying SNF. In a worst case scenario, each driver received an annual dose of approximately 596 millirem (mrem), although the actual dose received would likely be somewhat lower. This dose compares to a calculated annual dose of approximately 687 mrem for each driver in a legal weight team driver configuration using the same assumptions. A dose of 596 mrem would require that a radiation badge monitoring program be implemented.

2. Operating Costs. Table 2 presents operating cost estimates. The scenarios present estimated costs ranging from \$3.35 per mile (2000-mile one-way shipments, 24-hour load intervals, and continuous movement allowed) to \$4.82 per mile (800 mile one-way shipment, 72-hour load intervals, no continuous movement). The issue of whether or not continuous movement is allowed actually has little impact on the cost per mile estimates (less than 10% difference in cost). The longer load intervals, however, can increase costs over 20% on a per mile basis due to downtime for driver teams.

3. Cask Capital Costs. Cask capital costs were calculated under the various scenarios for the first ten years of Federal Waste Management System (FWMS) operation. Capital costs for tractors were embedded in the operating costs. Cask costs were calculated by developing cask fleet projections from

Table 2. Cost Comparisons for Various Operating Scenarios

<u>Marginal Overweight Vehicle with Sleeper Berth</u>								
Distance (miles)	800	800	800	800	2000	2000	2000	2000
Cask Load Interval (hours)	24	72	24	72	24	72	24	72
Continuous Movement?	Yes	Yes	No	No	Yes	Yes	No	No
<u>Marginal Overweight Operation</u>								
Cost (\$/mile)	3.98	4.48	3.97	4.82	3.35	3.48	3.49	3.62
Cost (\$/MTU)	3755	4242	3755	4566	7919	8243	8253	8578
<u>Legal Weight Vehicle with Sleeper Berth</u>								
Cost (\$/mile)	3.62	4.13	na	na	3.01	3.21	na	na
Cost (\$/MTU)	3426	3912	na	na	7120	7607	na	na

na - Not applicable. (Legal weight vehicles not subject to continuous movement restrictions.)

the Oak Ridge National Laboratory's (ORNL) Cask Fleet Projection (CSKFLEET) model and combining these with data from the TSDB. CSKFLEET calculates the number of casks required to move an amount of spent fuel. Input parameters default to TSDB values, but can be modified by the user. Parameters include cask loading and unloading times, truck and train speed, size of dedicated trains, number of days each cask type is available for use per year, etc. Other input files include distances from reactors to the destination site and the SNF shipping schedule from individual reactor sites (served by truck or rail) by year. The CSKFLEET model accumulates the number of cask days each cask type is used annually. The final cask day result is divided by the availability of that cask type and the value is rounded up to the nearest integer value.

The analysis of cask capital costs for marginal overweight operation was dependent upon the presumed average speed of the tractor-trailer. Three scenarios were examined for boiling (BWR) and pressurized water reactor (PWR) casks with an average truck speed of 40 miles per hour (mph), 30 mph, and 20 mph to cover the effects of continuous vs. non-continuous movement. Both an upper bounding case (UBC) and a lower bounding case (LBC) for annual shipping rates (based on DOE's 1990 Annual Capacity Report) were run.<sup>10</sup> For the UBC, BWR casks ranged from a low of eight to a high of nine, and PWR casks ranged from twelve to fifteen. For the LBC, BWR casks ranged from three to four and PWR casks ranged from five to six.

The TSDB assumptions on casks were used to calculate costs from these requirements. Casks were assumed to cost \$2,000,000 each and have a 25 year useful life. Straight line depreciation with no discount value for the dollars yielded an annual cask cost of \$80,000 per cask. Annual cask capital costs under the LBC could range from \$640,000 per year for the legal weight and marginal overweight continuous movement scenarios to \$800,000 per year if the truck operated as a marginal overweight vehicle that must be shut down every night. Using the UBC assumptions, the same costs could range from \$1,200,000 per year to \$1,920,000 per year.

Per-mile costs were calculated for the base case assuming each cask would run 70,000 miles per year (35,000 miles loaded). The cost of the additional casks was then divided by the number of miles that would be run in the base case. Table 3 shows that cask costs range from \$1.14 to \$1.52 per mile for the upper and lower bounding cases.

Table 3. Cask Capital Costs per Mile

Scenario	Type Reactor	UBC	LBC
Base Legal	PWR	\$1.14	\$1.14
	BWR	1.14	1.14
OWT @ 40 mph	PWR	1.14	1.14
	BWR	1.14	1.14
OWT @ 30 mph	PWR	1.24	1.14
	BWR	1.14	1.14
OWT @ 20 mph	PWR	1.43	1.37
	BWR	1.29	1.52

4. Total Costs. Cask capital costs plus operating costs indicate that per-mile costs vary depending on the set of assumptions used. When examining continuous movement scenarios, servicing PWRs, and considering the LBC for system startup rate, total costs range from \$4.35 to \$5.27 per mile for the

legal weight operation. For the marginal overweight operation, the total cost would range from \$4.62 to \$5.62 per mile. If the truck must be shut down every night, total cost for the marginal overweight operation ranges from \$5.05 to \$6.25 per mile.

The UBC provides similar numbers. The legal weight and marginal overweight operation would cost the same as the LBC, \$4.35 to \$5.27 per mile and \$4.62 to \$5.62 per mile. If the truck cannot operate at night, the per mile cost would range from \$4.99 to \$6.19.

5. Additional Measures. Transit time and manpower requirements were also calculated. Shutdown of the marginal overweight vehicle at night did not impact transit time for the 800-mile trip and added one day to the 2,000 mile trip. Manpower requirements were impacted to varying degrees by length of trip, cask load interval, and continuous movement.

## V. CONCLUSIONS AND RECOMMENDATIONS

DOE's initiative to develop high capacity highway spent fuel casks represents a significant measure to improve the safety of spent fuel transport. Significant economic advantages would ensure the most effective expenditure possible of the Nuclear Waste Fund. Innovations required to operate these new cask systems as legal weight loads should be considered carefully when assessing a marginal overweight system. Since the mid-1980s, significant work has been done by DOE-AASHTO, the New England Transportation Consortium, and other permitting consortia to assess and improve the feasibility of operating overweight spent fuel vehicles and simplify the overweight permitting process.

One primary drawback to operating a marginal overweight permitted system is the loss of control that DOE incurs because states must permit the load. In general, this loss of control is not as critical an issue for a marginal overweight vehicle as it would be for an overweight system that does not meet the marginal overweight criteria. Two factors work to mitigate the loss of control. First, the difference between an 80,000 pound gw legal weight truck and an 88,000 pound gw marginal overweight truck is probably not significant when assessing safety or infrastructure damage due to compliance with the Bridge Formula. In recent years, most states have adopted a more progressive attitude toward overweight vehicles that should simplify operations. Limiting infrastructure capacities could be encountered, such as substandard bridges, but indications are that the difficulty of routing a sub-88,000 pound tractor-trailer should not be dramatic.

If DOE is unable to obtain an overweight permit from a particular state, at least two options remain: reduce the payload of the casks to save weight (which would result in more shipments) or power the transporter with a lighter tractor and implement a less effective alternative operating strategy.

Other, more subjective human factors should also be taken into consideration (e.g., driver comfort, fatigue, driver recruiting and retention). Adding weight to the transporter will allow OCRWM to provide a more comfortable, less stressful working environment.

DOE should pursue the option of operating the GA-4/GA-9 cask system as both a legal weight system and as a permitted marginal overweight system. Additional work may indicate that the most effective deployment of equipment and operating

strategies would see legal weight systems with 16,000-pound tractors used for one-day hauls and heavier, more powerful tractors used to power permitted overweight systems on long hauls. Much of the groundwork for efficient operation of overweight vehicles for transport of SNF has already been done. Current developments in the industry indicate that this may be a manageable way to operate.

Three near-term activities should be undertaken to further develop the marginal overweight concept for OCRWM transportation operations.

- OCRWM should continue to interact with state and regional organizations to determine uniform overweight permitting guidelines.
- OCRWM should develop a design for a marginal overweight transporter that will transport the GA-4/GA-9 cask system while meeting the operational requirements of the nation's highways.
- A detailed case analysis of an upcoming or recently completed overweight shipment should be performed.

These three activities should provide OCRWM with the information needed to make a final decision on implementing of a marginal overweight system. At that point, a study should be done on the proper cask fleet composition. Questions should be answered on whether OCRWM should commit to both the legal and/or the overweight system. If a mix is recommended, the optimal combination of legal and overweight transporters in the OCRWM fleet and the implications of operating such a fleet should be examined.

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