Truck Size and Weight Methodology Review Conference Proceedings

PRESENTED BY:	PANELIST:
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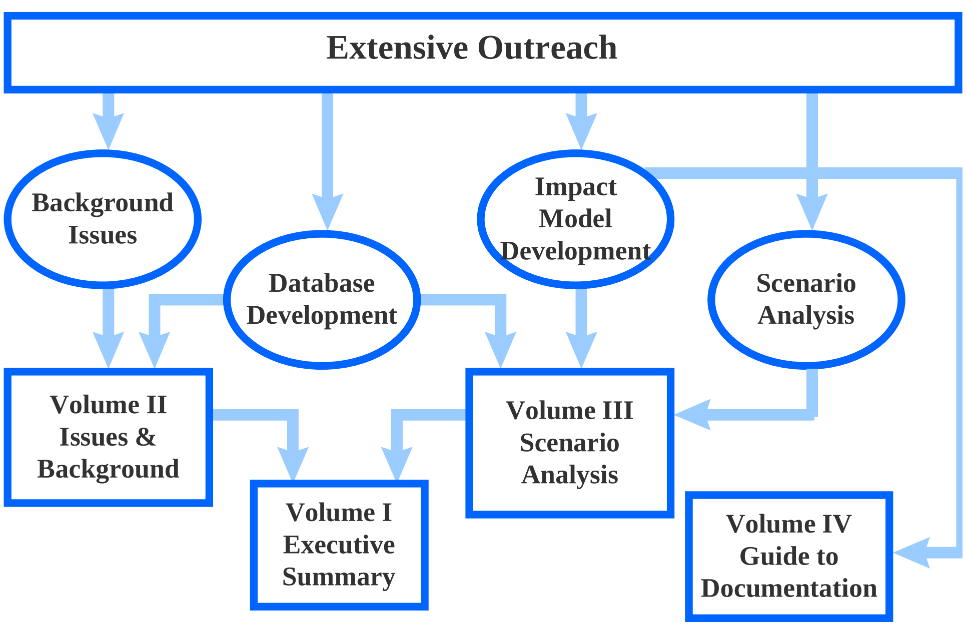
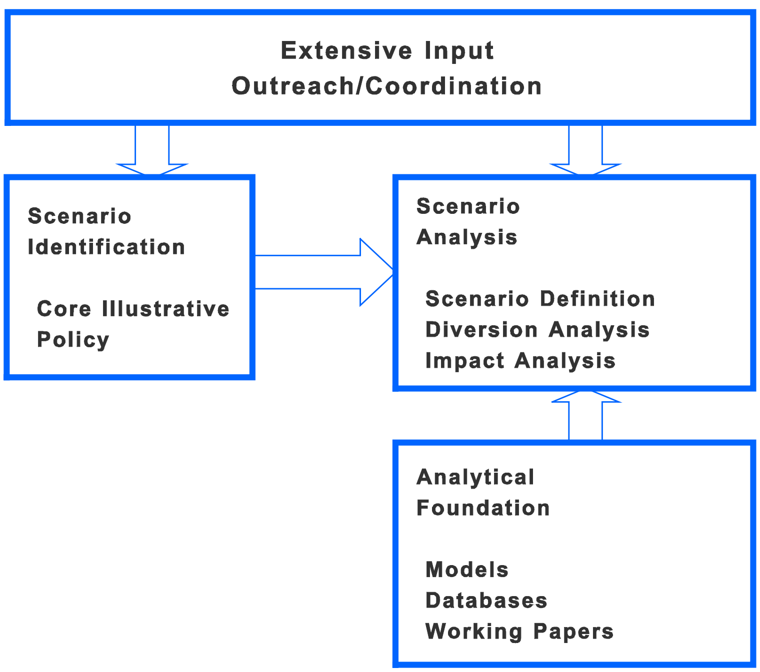
The goal of the study is to evaluate truck size and weight policies that ensure safe and efficient intermodal freight movement on North American highways. The study is designed to provide a policy architecture a decision support tool that is policy neutral and is not prescriptive of the Aright answer. Rather it will provide a fact-based framework within which to consider policy alternatives to the current Federal truck size and weight policies. There are a number of ongoing studies for which U.S. DOT has taken the same approach.

STUDY OVERVIEW DIAGRAM



In terms of process, the diagram above shows how everything fits together. Over the last year or so, a number of background papers detailing the critical issues and the state of the art were written. Those papers are available on the Truck Size and Weight Web page (http://www.fhwa.dot.gov/reports/tswstudy/tswfinal.htm) and in hard copy. The team developed critical data bases for assessments of the various impact areas and spent a great deal of time constructing and refining the impact assessment models. Utilizing the scenario Abuilding blocks@ identified in the April 25, 1996 Federal Register notice, the team and DOT study participants constructed illustrative scenarios to demonstrate the analytical tools and provide an approximation of the likely impacts of alternative truck size and weight policies. These activities are being turned into a four-volume study report. Volume II (Issues and Background) came out in June, and Volume III (Scenario Analysis) is presently in agency review and is scheduled to be released for external review in late Fall 1998. Volume I, the Executive Summary, will consolidate the information contained in Volumes II and III. Volume IV (Guide to Documentation) will help the reader with the data sources for this study.

ANALYTICAL OVERVIEW

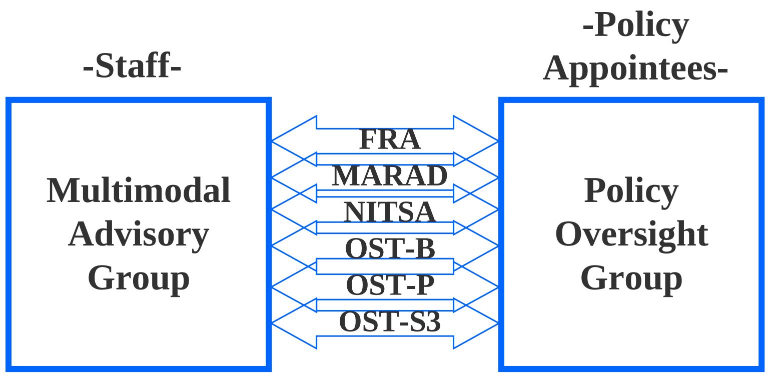


The analytical component forms the foundation of the study. Core illustrative scenarios were identified for analysis and provisions were made to analyze scenarios of particular interest to congressional members and other policy makers.

The public participation in the process was invited through *Federal Register* notices, public meetings across the country, regional focus sessions, State teleconference sessions, and review of draft documents. Many stakeholder comments were received and incorporated in the study.

DEPARTMENTAL COORDINATION/OVERSIGHT

Overview



Policy oversight and direction was provided by a Departmental Policy Oversight Group (POG). The POG is comprised of executives from throughout the Department including representatives from the Office of the Secretary of Transportation, FHWA, the Federal Railroad Administration, the National Highway Traffic Safety Administration and the Maritime Administration. The POG is chaired by the Assistant Secretary for Transportation Policy.

In addition to the POG oversight, a Multimodal Advisory Group (MAG) was established to ensure that major technical decisions shaping the study would be made on an intermodal basis. The MAG provided ongoing guidance and early review of draft documents associated with the study.

Core illustrative scenarios were selected to provide a broad range of impacts. The team wanted to get a sense how the analytic tools they had developed worked and to target some general policy issues. Two particular scenarios, one introduced by Rep. Oberstar in Congress and a triple scenario that arose out of some of the outreach meetings, were of particular interest. The team began with the development of the base case, against which all the other scenarios are compared. It represents the status quo, current law. This scenario assumes a continuation of the longer combination vehicles (LCV) freeze and the grandfather rights that are in place today.

There are three core illustrative scenarios:

$ **Uniformity.** There is a complex array of truck size and weight regulations in place across the country. Every State has its own unique set of truck size and weight regulations. Grandfather provisions allow some States to override Federal standards on the Interstate system. States may establish their own standards for highway systems off the Interstate and the National Highway System network. It has been argued that this lack of uniformity creates a barrier for interstate commerce and grandfather provisions raise equity issues. Carriers argue that productivity enhancements available in some States are not available to carriers in other States. These differences reflect variations in State economies, industrial activities, and freight flow characteristics.

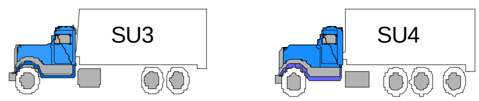
$ **Longer combination vehicles nationwide.** LCVs include Rocky Mountain doubles, turnpike doubles, and triple trailer combinations. This scenario would lift the LCV freeze that was put into place with ISTEA in 1991. Currently, LCVs account for about 1 percent of the commercial truck equipment in the fleet and 1 percent truck travel in the United States.

$ **North American trade.** Provisions of the North American Free Trade Agreement (NAFTA) were the primary focus of this scenario. In December 1992, Canada, Mexico, and the United States signed NAFTA. It established one of the largest trading communities in the world. One of NAFTA=s primary objectives was to improve the efficiency of transportation between these three countries. Differences in the truck size and weight regulations in the three countries is a major issue. The Land Transportation Standards Subcommittee, working under the NAFTA umbrella, is exploring ways to harmonize the standards across the three countries. Under this scenario, U.S. DOT will test the impact of allowing heavier vehicles presently in service in Canada and Mexico to operate in the United States. Currently the 6-axle tractor semitrailer constitutes only 3 percent of the truck traffic in the United States, but it constitutes 37 percent of the traffic in Mexico and almost 20 percent of the traffic in Canada. This would require legislation of a tridem axle weight limit and lifting the 80,000 pound gross weight limit. U.S. DOT tested weight limits of 44,000 pounds and 51,000 pounds. Introducing a tridem axle weight limit would offer other benefits beyond standardized limits among the NAFTA countries. At 51,000 pounds, the U.S. weight limit would be more conducive to international container traffic. Currently, containers loaded to weight limits established by the International Standards Organization (ISO) are simply too heavy for U.S. trucks. Introducing a 51,000-pound tridem axle weight would alleviate most of this problem. A 44,000-pound tridem axle weight would benefit short wheelbase vehicles, such as dump trucks and construction vehicles. This would allow them to carry more weight on shorter wheelbases without overstressing bridges.

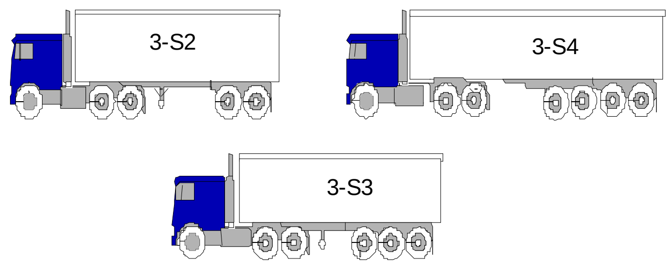
There are two policy scenariosCH.R. 551, AThe Safe Highways and Infrastructure Preservation Act@ introduced by Rep. Oberstar and Triple Trailers Nationwide. H.R. 551 is essentially a status quo proposal, which would phase out, over time, trailers longer than 53 feet, freeze the States= grandfather authority in place today, and extend Federal weight limits to the National Highway System. Triple Trailers Nationwide is a subset of the ALCV Nationwide@ scenario focusing on issues of triple trailer combinations.

There are three building blocks upon which the specific scenarios were developed: the configurations chosen for analysis, highway networks upon which these configurations would operate, and regions. The model can analyze each scenario by region. The scenarios were run on a nationwide basis for Volume III.

Single Unit Trucks

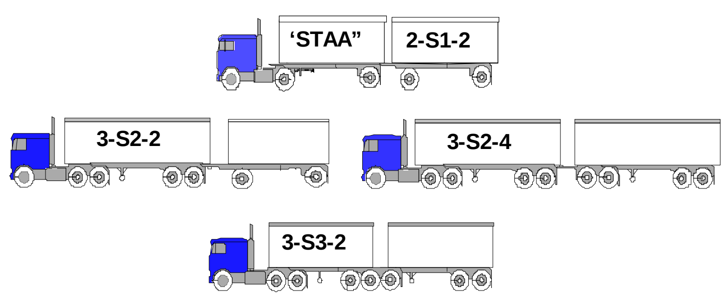


Tractor-Semitrailer Combinations

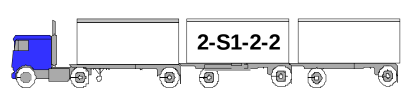


Among the configurations, the team focused on the SU4 four-axle, single unit trucks. The idea was that many fleet owners operating the SU3 three-axle, single unit trucks would find the SU4s operating at a heavier weight to be more attractive. More than 68 percent of the truck fleet is comprised of single unit trucks, which drive 42 percent of the vehicle miles traveled by trucks in the United States. On the other hand, tractor-semitrailer combinations account for 53 percent of all truck miles traveled and 26 percent of the equipment.

Double-Trailer Combinations



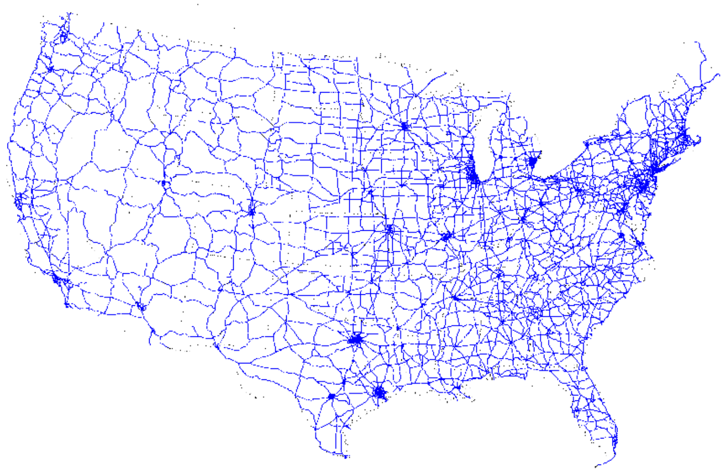
Triple-Trailer Combination



The team looked at the National Network for larger trucks (NN) and the analytical networks that were created for this study. These analytical networks were put together for the purpose of the study. The National Network for large trucks was created in the STAA legislation of 1982.

Overview

National Network for Large Trucks Map



Two networks were developed for the study to evaluate the impact of expanding LCV operations. These networks are not proposed or endorsed by the Department as LCV networks. They are for analytical purposes only. The network developed to test the operation of long double trailer combinations [Rocky Mountain Doubles (RMDs) and turnpike doubles (TPDs)] consists of approximately 40,000 miles and provides for continuous east to west travel. This network consists of access-controlled, interconnecting segments of the Interstate system and other highways of comparable design and traffic capacity. The routes connect major markets and distribution centers.

The network designed to evaluate the impact of allowing triple-trailer combination vehicles to operate Nationwide includes approximately 60,000 miles of mostly rural Interstate facilities. Some urban Interstate highway segments are included for connectivity. The network designed for the operation of triple-trailer combinations is larger than the network used to analyze long double combination operations because triple-trailer combination vehicles have more articulation points than RMDs and TPDs, and therefore fewer problems with off tracking.

Both networks are more extensive than would be politically or practically feasible, especially in more densely developed parts of the country and thus tend to over estimate the impact of truck size and weight policies addressing LCVs.

Overview

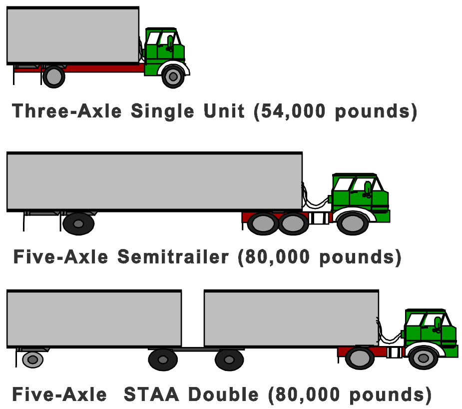
40,000-Mile Network Map

60,000-Mile Network Map

The following charts summarize the scenario specifics. The uniformity scenario assumes that Federal gross vehicle weight limits would be extended to the National Highway System, grandfather provisions would be eliminated, these vehicles would operate on the National Network as they do today, and there would be no changes to access provisions.

Overview

Scenario SpecificationsCUniformity



MAIN FEATURE:

Extends Federal GVW Limits on States Beyond the Interstate to National Highway System (Eliminates Grandfather Provisions)

AVAILABLE HIGHWAYS:

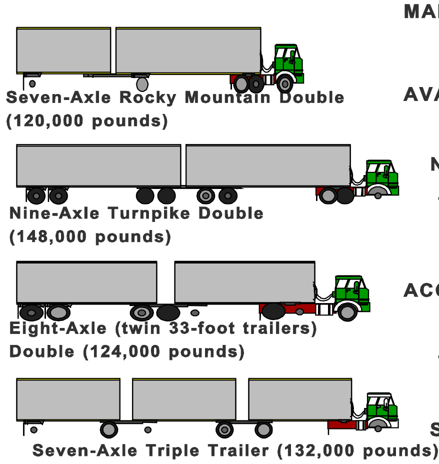
National Network (STAA 1982)

ACCESS PROVISIONS:

Current Federal and State Provisions

The LCVs nationwide scenario assumes that the freeze would be lifted to allow national operation of LCVs. Rocky Mountain doubles and turnpike doubles would operate on the 40,000-mile analytic network, triple trailer combinations would operate on the 60,000-mile analytical network, and 8-axle doubles would operate on the National Network.

Scenario SpecificationsCLonger Combination Vehicles Nationwide



MAIN FEATURE:

Broad National Operation of LCVs

AVAILABLE HIGHWAYS:

RMDs and TPDs--40,000-Mile Analytical Network

Triples--60,000-Mile Analytical Network

Eight-Axle Doubles--National Network

ACCESS PROVISIONS:

RMDs and TPDs--None off 40,000-mile System

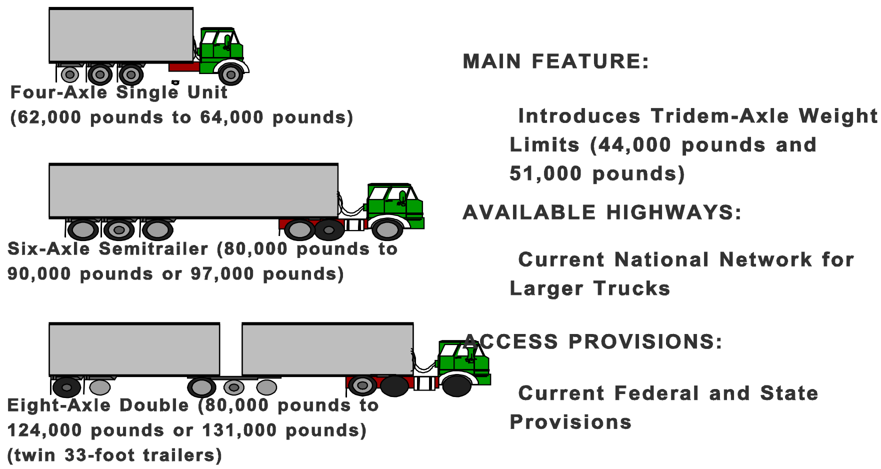
Triples-- State Issued Permits

Eight-Axle Doubles-- Current Federal and State Provisions

The North American Trade Scenario tests the 44,000-pound and 51,000-pound tridem axle weight limits. These trucks would operate on the National Network for Larger Trucks, and current Federal and State provisions would remain in affect.

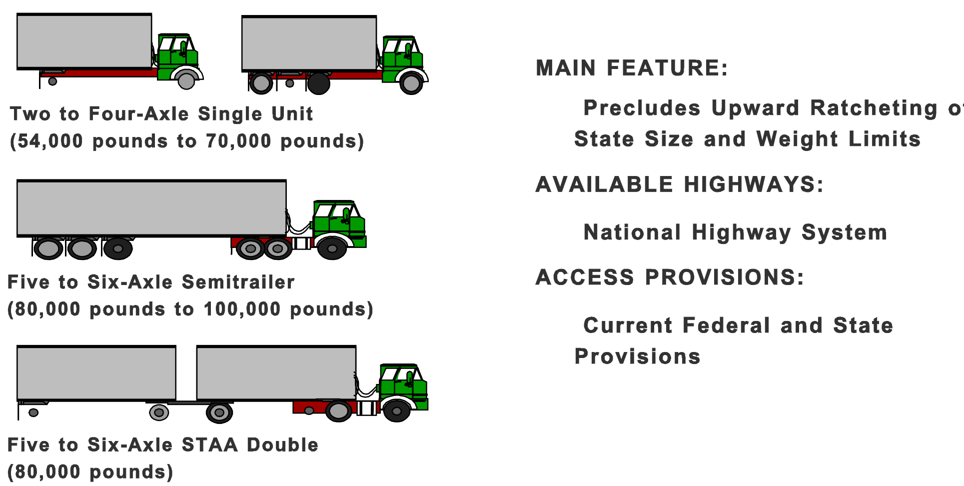
Overview

Scenario SpecificationsCNorth American Trade



The H.R. 551 scenario is not expected to show dramatic changes. This legislation is comparable to the baseline, which is the status quo. It is an important scenario because it addresses concerns about the States ratcheting size and weight limits upward.

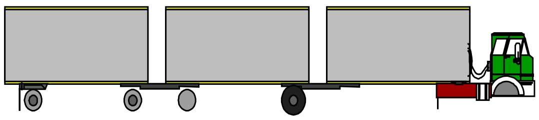
Scenario SpecificationsCH.R. 551



The Triples Nationwide scenario is a subset of the LCVs Nationwide scenario. The scenario assumes triple trailers would operate on the 60,000-mile network under new weight limits.

Overview

Scenario SpecificationCTriples Only



Seven-Axle Triple Trailer (132,000 pounds)

MAIN FEATURE:

Broad National Operation of Triple Trailer Combinations and New Weight Limits for Triples

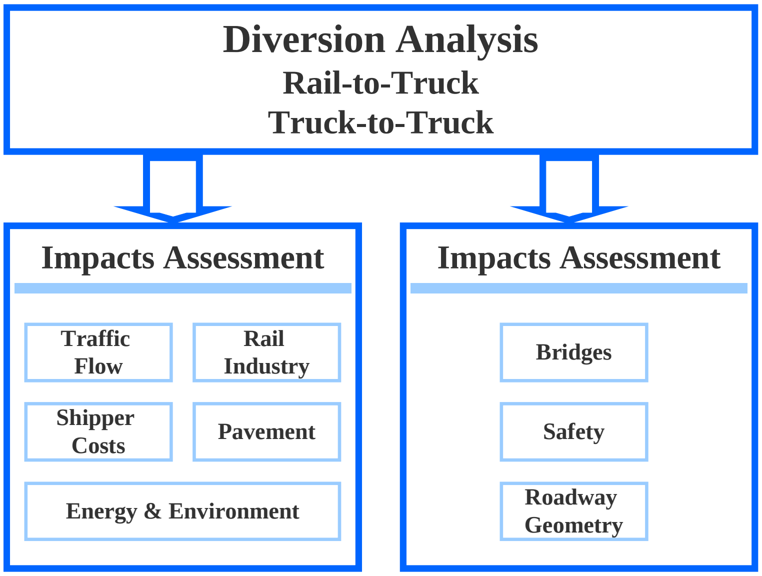
AVAILABLE HIGHWAY:

6,000-Mile Analytical Network

ACCESS PROVISIONS:

State Issued Permit

Diversion and Impact Analysis



The impact assessments in the left-hand chart are dependent upon the VMT information coming from the diversion analysis. On the right-hand chart, estimates of those impacts are not dependent upon the diversion analysis. In practice, improvement decisions at the project level will be influenced by traffic volumes but such considerations were not possible for a nationwide study. Likewise, crash rates on particular facilities would be affected by changes in the volumes and mix of truck traffic, but they would also be affected by many other factors that could not be quantified for this study.

Overview

Global assumptions that underlie the data that will be presented in Volume III include:

$ No new technology (C-train combinations, electronic braking systems, and so forth) that might mitigate safety concerns will be introduced;
$ No new driver, vehicle, or weather restrictions will be introduced;
$ No changes in highway user fees;
$ No change in highway construction practices;
$ No change in single/tandem weight limits (20,000 pounds and 34,000 pounds);
$ No change in trailer height (13 feet, 6 inches); and
$ No change in trailer widths (102 inches).

The progress of the program:

$ Draft Volume II was distributed in June 1997;
$ The Transportation Research Board initiated a peer review in January 1998;
$ The Impact Model Review Conference was held in July 1998.
$ The draft of Volume III will be distributed for review in the Fall of 1998;
$ A State videoconference will be held in the Summer of 1998; and
$ The final report will be delivered to Congress at the completion of the process.

QUESTION and ANSWERS

Did you say that the assessment of impacts on structures was not dependent on the diversion model?

$ The assessment of bridge impacts was not dependent on the diversion model. For bridge impacts, VMT is not important. The kind of vehicles operating is more important when considering bridges. Pavement is very dependent on the VMT coming out of the diversion model.

On the global assumption that there will be no changes in highway construction practices: The last time FHWA changed the weight limit from 70,000 pounds to 80,000 pounds, it took us 10 years take care of our highway system. Any comments on that?

$ It=s fair to say that we did not come out with a study that states: AThou shalt permit trucks of a particular weight on the system.@ We will provide information to the decision makers, so if they determine they want to do something with size and weight, they will have information on what the impacts are, including the impacts on the road infrastructure, the modifications, and the potential costs associated with that change. Part of the decision making process will include this factual-based document that says, Aif you go with heavier vehicles or different configurations, this is the impact on the infrastructure, this is what it is going to mean in dollars and cents to the States if you make those modifications.@

Under the global assumptions, there are no changes assumed for single/tandem axle weight limits (20,000 pounds and 34,000 pounds). What about tridem axle weight limits?

$ One of the scenarios we are evaluating is the legislation of tridem axle weight limits. We are focusing on that as one of the core illustrative scenarios, but we are not looking at a change in the single and double axle weight limits.

$ There is no specific tridem axle weight limit in current law.

SESSION 1
Freight and Vehicle Miles Traveled Impact

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<u>**Presented by:**</u>

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Joe Bryan
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Reebie Associates

Harry Cohen
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VEHICLE MILES TRAVELED

Karen White

The truck vehicle miles traveled (VMT) analysis is critical to the impact analyses. Truck VMT data is used in the assessment of pavement, energy and environment, traffic operations, rail and truck shipping costs. VMT is stratified by 17 different truck configurations, 50 States, and 12 highway functional classes.

The team=s goal was to develop a unified approach to analyze both truck and rail data that incorporated all types of operations, such as less-than-truckload, truckload, long haul movement and short haul movement; to provide input for other VMT-dependent impact analysis; to provide input for the rail viability analysis; and to create a reproducible analytical technique based on clear assumptions.

The team used VMT data from the Highway Cost Allocation Study (HCAS), the 1994 carload waybill sample for rail shipments, the 1993-94 over-the-road sample of truck shipments (North American Transportation Survey from AAR), and the 1992 Truck Inventory and Use Survey. Time constraints precluded the extensive use of the Commodity Flow Survey in the study.

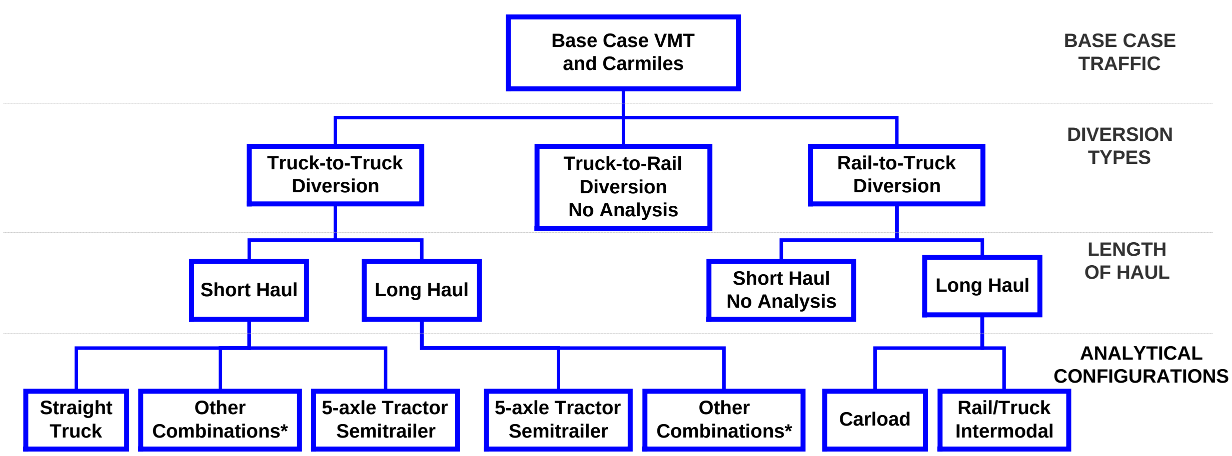
The team held a workshop during the summer of 1995 to review existing models for determining whether freight is shipped by rail or truck. The group recommended using a model that would assign freight on a shipment by shipment basis. For each shipment, the model determines whether it would cost less to ship it by rail, truck or rail intermodal.

The Comprehensive Truck Size and Weight Study utilizes the Intermodal Transportation and Inventory Cost (ITIC) model. Over the last year, three workshops were held to develop the ITIC model inputs and assumptions, its construct, preliminary outputs, and extensive sensitivity testing. While the model met most study expectations, it still needs further developmental work.

The ITIC model=s strengths include: (1) evaluation of transportation and inventory costs; (2) truck and rail shipments are analyzed in equivalent ways; (3) results can be replicated; and (4) it=s structurally flexible. A weakness of the model include the model is it takes an Aall-or-nothing@ approachCif a new truck configuration is introduced that allows cheaper shipping rates, the model assumes the shipper will divert all of that particular freight from rail to that new truck type, which may not be the case. The shipper may move only a portion of that freight from rail to truck. The model cannot estimate diversion changes from truck to rail nor short haul diversions. The latter two instances are extremely Adata hungry.@ Several metropolitan planning organizations and States have gathered data on short haul diversion, but usually the data focuses on particular truck type or commodity.

The resulting data and modeling limitations precluded a single analytical approach. The charts that follow show how the team analyzed and integrated the VMT components to develop the aggregate scenario VMT.

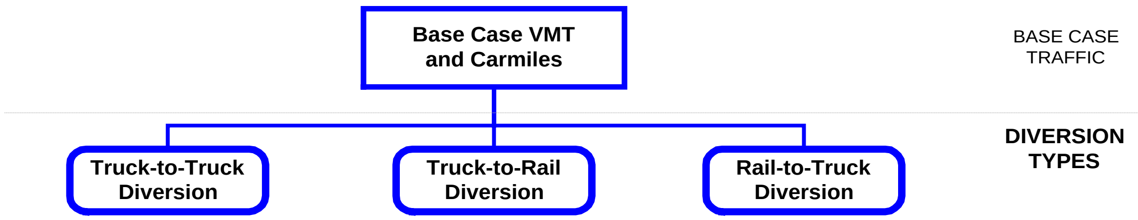
ANALYSIS OF SCENARIO VMT



*Other combinations include: 6-axle tractor semitrailer, 7-axle Rocky Mountain doubles, 8-axle B-train doubles, 9-axle turnpike doubles and 7-axle triple trailer combinations.

The chart above provides a broad overview of how the VMT is broken down. Base case truck traffic was provided by the HCAS.

ANALYSIS OF SCENARIO VMTCDIVERSION



Truck-to-air and truck-to-barge diversions were not studied for the purpose of this analysis because they were considered to be relatively marginal changes. Diversion is the change of freight from its current truck configuration or mode (truck-to-truck or rail-to-truck). Changes in truck size and weight can be analyzed within the diversion model. There are three types of diversion, see the chart above:

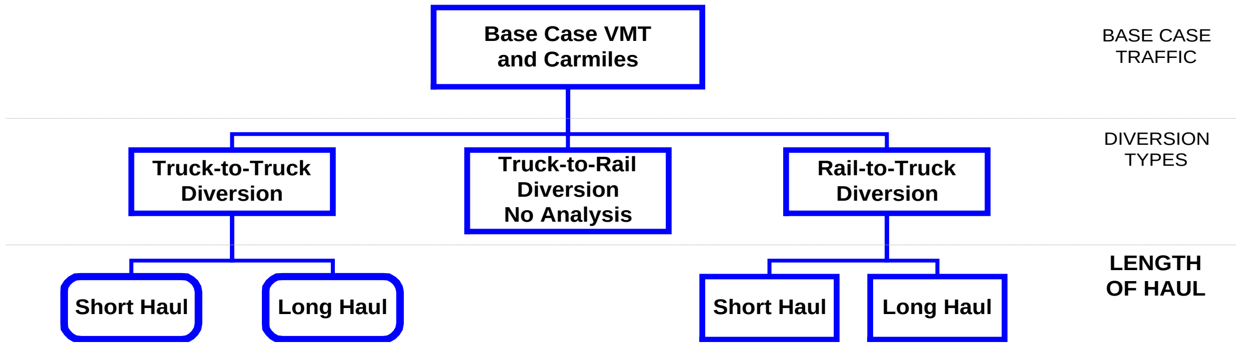
$ **Truck-to-rail.** Given a decrease in truck size and weight, freight could shift from truck to rail. This scenario has not been analyzed, but a model to analyze this scenario is being developed.

$ **Rail-to-truck.** Given an increase in truck size and weight, freight could shift from rail to truck.

$ **Truck-to-truck.** Given any change in truck size and weight, freight could shift between truck configurations. This will account for the largest changes in truck VMT.

A decision was made to set short haul limits at 200 miles. Short haul was differentiated from long haul in the study because they have different operational characteristics, truck types, and available data. Unlike long haul operations, short haul fleets don't tend to work out of large warehouses drawing on a large inventory stock. Short haul operations tend toward single unit, delivery-style trucks, and they would be less effected by changes in truck size and weight regulations than larger, long haul combination vehicles would.

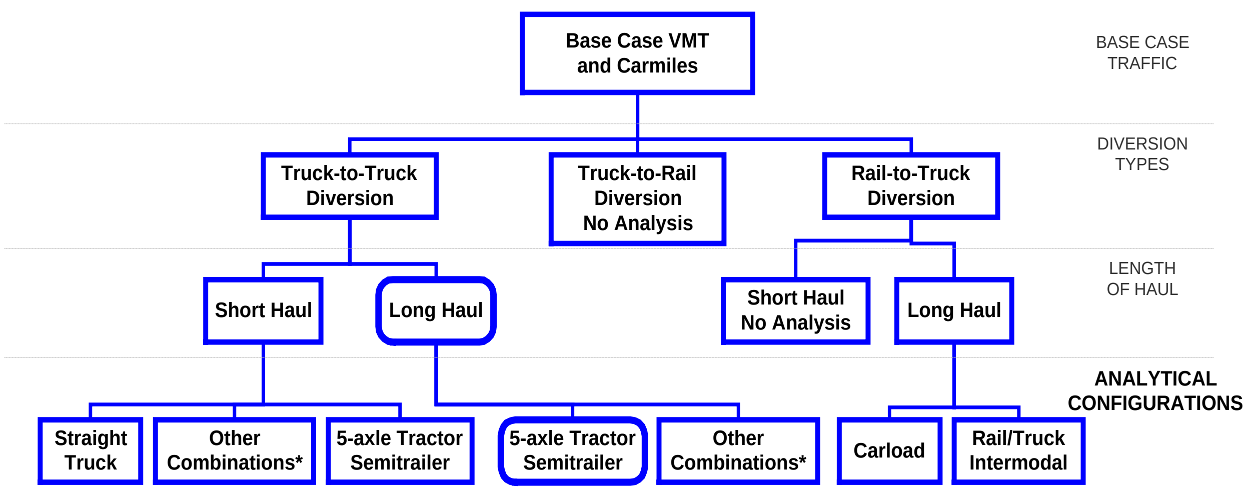
LENGTH OF HAULCTRUCK



In the truck-to-truck diversion, short haul and long haul have been split. The short haul analysis is broken out into three composite truck types: straight trucks, five-axle tractor-semitrailer, and combinations with 6- or more axles.

The short haul model can analyze what tridem axle weight limit changes would mean for three-axle straight trucks and four-axle straight trucks. For five-axle tractor semitrailer and other combinations, the short haul model utilizes ITIC analysis for long haul trucks, Highway Cost Allocation Study VMT estimates, and the 1992 Truck Inventory and Use Survey.

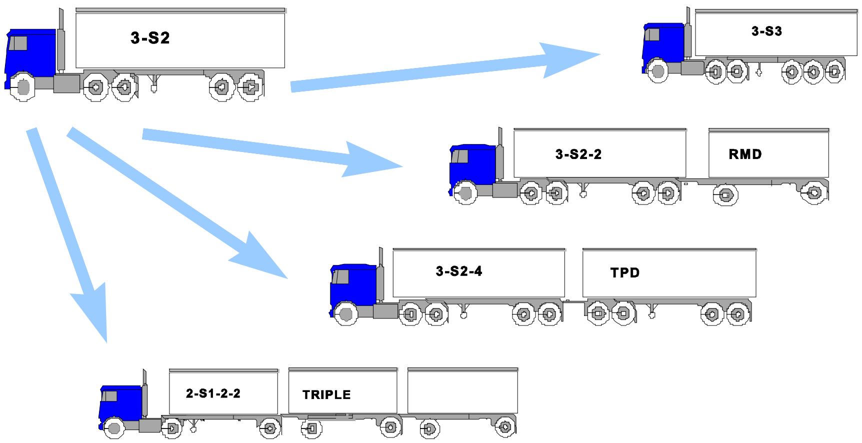
MODEL STRUCTURE



*Other combinations include: 6-axle tractor semitrailer, 7-axle Rocky Mountain doubles, 8-axle B-train doubles, 9-axle turnpike doubles and 7-axle triple trailer combinations.

Depending on the scenario, the ITIC model will analyze diversions from the base case 3S2 five-axle tractor semitrailer to other truck configurations, including those shown in the above diagram. The team analyzed the 6-axle tractor semitrailer, the Rocky Mountain double with a 53-foot trailer and a 28-foot pup, the turnpike double with twin 53-foot trailers (the far end of the spectrum), the triple with three 28-foot trailers, and other combinations. The model Aloads@ each trailer to the maximum weight and cube (dimension).

FIVE-AXLE TRACTOR SEMITRAILER: LONG HAUL

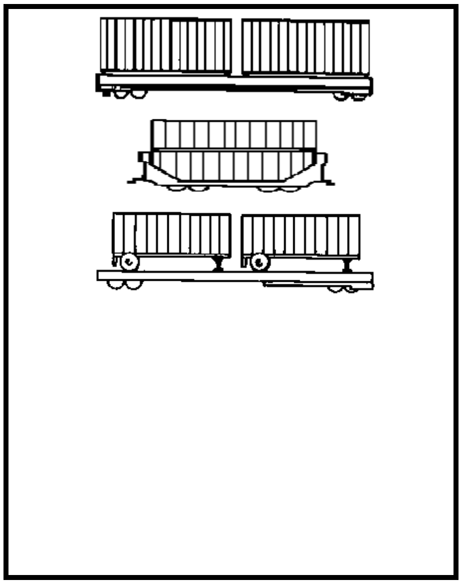


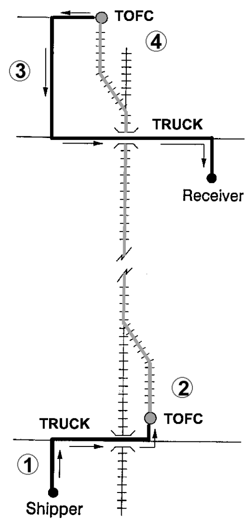
The 5-axle tractor semitrailer analysis utilizes the ITIC model analyzing the sample of 40,000 truck shipments of different commodities within the North American Truck Survey using specific roadway networks (for example, the National Network or Long Doubles Network, etc.), and data from the Commodity Flow Survey.

Long haul operations are also comprised of other configurations. Primarily, that is the diversion from the current STAA double (twin 28-foot trailers) and other configurationsCthe Rocky Mountain double, the turnpike double, and the triple trailer. The analysis for these other combinations was somewhat limited because the team was unable to use the ITIC model because no shipment-by-shipment data set exists. The team=s analysis of diversion of freight from current doubles and triples utilized case studies for specific commodities, industry experts, the 1992 Truck Inventory and Use Survey, and the Highway Cost Allocation Study weight distributions.

Rail-to-truck diversion short haul was not analyzed because short haul rail movements (less than 200 miles) would rarely divert to trucks, they are short distance rail car repositioning, rail cars used as storage, or the shipper moving cars around while he fills a load.

Rail/truck intermodal operations were designed to provide the most competition to long haul truck operations. To take freight traffic from trucks, the railroads came up with equipment that easily accommodates the equipment utilized by trucksCflatcars that carried containers, double stack containers, and trailers on flatcars.





For a typical TOFC/COFC (trailer-on-flatcar/container-on-flatcar) operation, the trailer is pulled by a tractor to the intermodal loading area, where it is loaded onto a flatcar and hauled to the nearest intermodal freight yard to its destination. There it is unloaded, hitched to a tractor and hauled to the receiver (see diagram above).

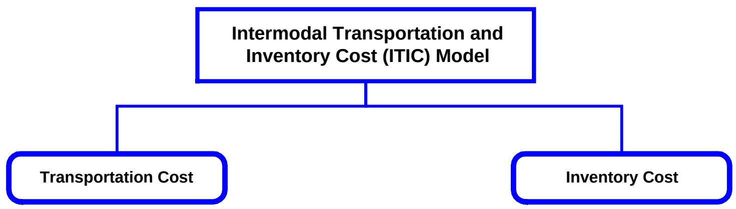
For the rail/truck intermodal analysis, the team used the 1994 Waybill, which was increased by 5.5 percent a year as estimated by DRI/McGraw Hill; the ITIC model; Commodity Flow Survey on the freight values for rail shipments; and the 1994 Waybill revenue, which was reviewed by the Surface Transportation Board. The team did not use the generalized variable costs estimated by the Surface Transportation Board, but had more specific variable costs estimated. Variable cost is important because the model allows railroads to discount down to their variable costs to retain current traffic. Freight only diverts from rail to trucks when the cost to ship by truck is less than the railroad=s variable costs.

Carload traffic refers to all rail traffic that is not intermodal; it includes boxcars, tank cars, grain hoppers, and so forth. Carload shipments that were not analyzed included coal moves of more than 500 miles (they are not truck competitive), transportation equipment (no changes in truck autotransporters is hypothesized in the current scenarios), and shipments whose origin or destination is outside the United States (the roadway network was not extended beyond U.S. boundaries).

Freight and Vehicle Miles Traveled Impact

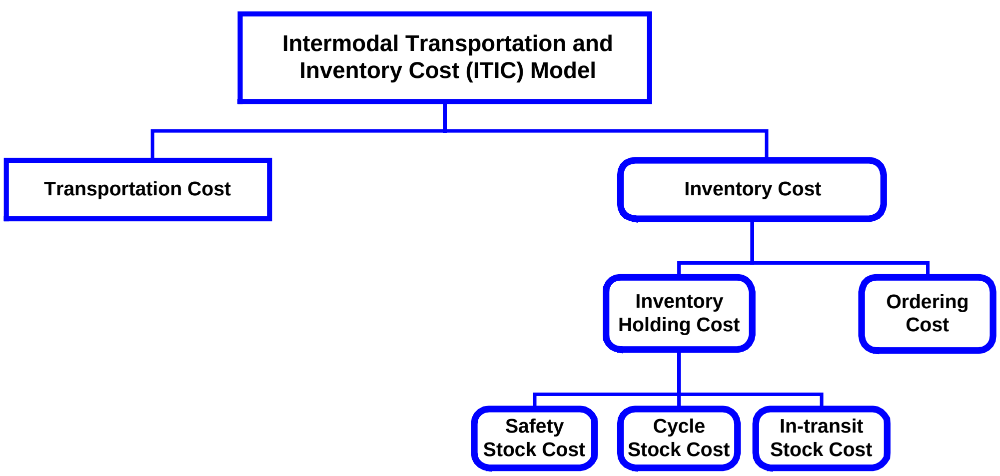
The rail carload analysis utilized the 1994 Waybill expanded by 2.2 percent per year as estimated by DRI/McGraw Hill; 1994 Waybill revenue, which was reviewed by the Surface Transportation Board; variable costs estimated by the Surface Transportation Board; the ITIC model; and Commodity Flow Survey data on freight values for rail shipments.

INTERMODAL TRANSPORTATION AND INVENTORY COST MODEL



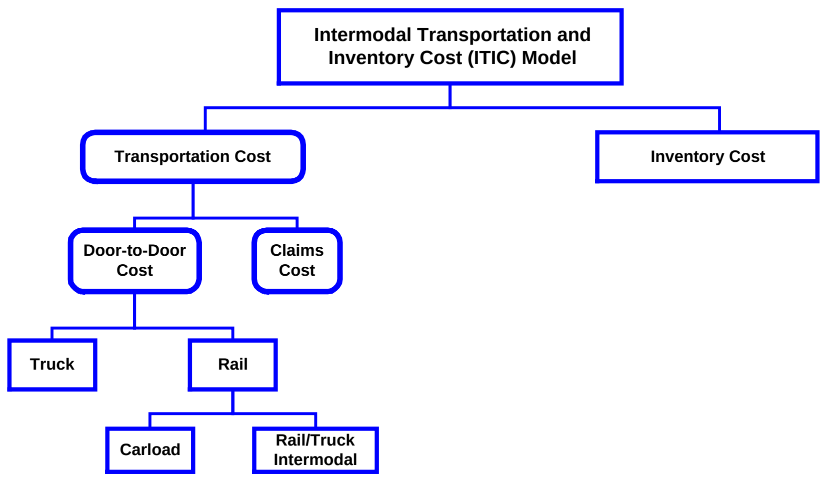
The ITIC model looks at each shipment, calculates its transportation costs and inventory costs, adds them up across modes and truck configurations, and then hypothesizes that the shipper will use the most economical mode and vehicle configuration. ITIC model features the ability to test: (1) several truck configurations at one time; (2) the integration of a precise roadway network for each truck type; (3) the incorporation of a base case model run (at current truck size and weight regulations); (4) a state-of-the-art inventory cost model; (5) truck repositioning miles (the miles a truck must travel to obtain its next shipmentCa major cost for longer, bigger configurations); and (6) a flexible structure (data and parameters can be easily entered).

ITIC MODEL INVENTORY COST



ITIC inventory considerations include the stock for manufacturing processes and meeting customer demands. Inventory costs are comprised of inventory holding costs and ordering costs (a flat rate of about $8 per shipment for placing an order with a railroad or trucking company, doing the paperwork, and so forth). Holding costs include safety stock costs (protects shippers against shipping delays), cycle stock costs (the average balance of stock on hand between shipments which is assumed to be half of the shipment size), and in-transit stock costs (capital cost of goods while they are in transit).

ITIC MODEL TRANSPORTATION COST



The two components of transportation costs are claims costs (insurance against loss and damage while the goods are in transit) and door-to-door costs.

Door-to-door costs include:

TruckCcost per mile times miles traveled;
Rail carloadCuses the revenue and variable cost figures from the Private Waybill; and
Rail/truckCover-the-road drayage costs similar to truck costs. Over-the-rail costs use the revenue figures from the Private Waybill and variable costs estimated by Reebie Associates.

Future expansions of the model include: (1) creation of a larger truck shipment database; (2) more user-friendly graphics interface; (3) inventory cost validation; and (4) integration of the short-haul truck model.

ESTIMATION of RAIL INTERMODAL SHIPMENT COSTS

Joe Bryan

This presentation outlines the analytical approach taken to determine intermodal costs in the model, using records within the 1994 Surface Transportation Board Waybill.

MARKET SEGMENTATION: MODEL COMPETITIVENESS MODAL SHARE OF CELL

	Lane Density (Annual Tons (000) by Intermodal and Dry Van)							
Highway	<100		100-400		>400		Total	
Miles	Truck	IMX	Truck	IMX	Truck	IMX	Truck	IMX
1-99	99%	1%	100%	0%	100%	0%	100%	0%
100-299	100%	0%	99%	1%	97%	3%	98%	2%
300-499	98%	2%	94%	6%	77%	23%	89%	11%
500-699	96%	4%	86%	14%	69%	31%	87%	13%
700-999	94%	6%	77%	23%	46%	54%	78%	22%
1000-1499	91%	9%	78%	22%	60%	40%	82%	18%
1500+	80%	20%	52%	48%	14%	86%	45%	55%
Total	95%	5%	90%	10%	86%	14%	89%	11%
500+	92%	8%	76%	24%	41%	59%	74%	26%
1-499	99%	1%	98%	2%	96%	4%	97%	3%

MARKET SHARE KEY:

Truck > 80% (white) Both < 80% (light blue) Rail > 80% (dark blue)

This matrix illustrates the modal competitiveness of over-the-road dry van highway traffic and rail intermodal traffic. Dry van and rail intermodal traffic of a particular type have been combined to create an entire market. How much of the entire traffic in each market moves by truck and how much by intermodal rail? Across the top of the table is lane density (the total amount of relevant freight that moves from one origin market to one destination market). The heavier the level of activity, the higher the density level. Down the left side of the table runs distance of highway miles. Moving from the upper left to the lower right of the matrix, intermodal share goes up. Conversely, highway share goes up from the lower right hand corner of the matrix to the upper left corner. The higher the density and the longer the distance, the more traffic is carried by rail.

To generate the intermodal costing, the team took 11 specific corridors selected from 11 cells in the matrix that covered 85 percent of the intermodal market. Strong intermodal and Acrossover@ markets (where there is strong truck/intermodal rail competition) were covered. Corridors were selected for their geographic and carrier diversity, mix of single line and interline traffic, and where there were reporting issues (some railroads keep a separate intermodal division and report some costs that way which makes them not comparable to other railroads) and rebilling.

MARKET SEGMENTATION: MODAL COMPETITIVENESS
MODAL DISTRIBUTION BY CELL

	Lane Density (Annual Tons (000) by Intermodal and Dry Van)							
Highway	<100		100-400		>400		Total	
Miles	Truck	IMX	Truck	IMX	Truck	IMX	Truck	IMX
1-99	1%	0%	3%	0%	23%	0%	27%	0%
100-299	5%	0%	9%	1%	17%	5%	31%	6%
300-499	6%	1%	4%	2%	4%	11%	14%	14%
500-699	5%	2%	3%	4%	2%	5%	9%	11%
700-999	5%	3%	2%	5%	1%	12%	9%	19%
1000-1499	4%	3%	1%	3%	1%	5%	6%	11%
1500+	2%	5%	1%	7%	1%	27%	4%	39%
Total	28%	13%	24%	22%	49%	65%	100%	100%
500+	16%	12%	7%	19%	4%	49%	28%	80%
1-499	11%	1%	16%	3%	45%	16%	72%	20%

MARKET SHARE KEY:

Truck > 80% | Both < 80% | Rail > 80%

Individual corridors taken as representative of an individual matrix cell were expanded to the rest of the matrix.

MARKET SEGMENTATION: MODAL COMPETITIVENESS
CORRIDOR SELECTION

	Lane Density (Annual Tons (000) by Intermodal and Dry Van)					
Highway	<100		100-400		>400	
Miles	Truck	IMX	Truck	IMX	Truck	IMX
200-499		**CLT/BHM**				**JAX/MIA**
500-699				**DEN/SLC**		**PDX/SFO**
700-999				**IND/NYC**		**NYC/ATL**
1000-1499				**SEA/DEN**		**DAL/LAX**
1500+		**FNO/MEM**		**DET/ELP**		**LAX/CHI**

MARKET SHARE KEY:

Truck > 80% | Both < 80% | Rail > 80%

High density rail corridors that were chosen include Los Angeles to Chicago, Dallas to Los Angeles, New York to Atlanta, Portland (OR) to San Francisco, Jacksonville to Miami, Detroit to El Paso, Seattle to Denver, Indianapolis to New York, Denver to Salt Lake City, Fresno to

Memphis and Charlotte to Birmingham.

The team used URCS based long term variable costs with appropriate adjustments made to it. The team used Plan 25 to compare over-the-road operations with intermodal operations on a door-to-door basis. The waybill does not provide a fair economic comparison because when a shipper purchases intermodal services, the railroad has options on the level of service it will provide.

Using Plan 25, the study team computes the full equipment charges plus drayage and thus produces a fair economic analysis of the two modes. The team used a headhaul basis that means 100 percent of the relevant costs were charged, including a full charge for empty containers and trailers. Costs were calculated per trailer or container. Operating factors were derived from the waybill, industry interviews, and Surface Transportation Board policy. For every corridor that was costed, the team looked at three equipment typesCspine cars, doublestack well cars and the standard 89-foot flat carsCand three scenariosCthe status quo, North American trade, and LCV=s nationwide.

Intermodal tare weights and payloads are the same for longer combination vehicles as they are for the status quo. There are productivity gains for intermodal and the highway in the North American trade scenario. If today=s standard size trailer takes on a tridem axle and is allowed to take on heavier loads, (highway-imposed) weight limitations for rail will be lifted. Rail loads must be delivered by highway. Sensitivity analysis was used for payloads and train lengths. Container costs conform to truck factors for such items as intermodal dwell time.

IMX Spine Car Costs Per Ton-mile: Status Quo and LCV Scenarios

	Lane Density (Annual Tons (000) by Intermodal and Dry Van)					
Highway	<100		100-400		>400	
Miles	Truck	IMX	Truck	IMX	Truck	IMX
200-499	**CLT/BHM:**	**$ 0.0353**			**JAX/MIA:**	**$ 0.0358**
500-699			**DEN/SLC:**	**$ 0.0329**	**PDX/SFO:**	**$ 0.0249**
700-999			**IND/NYC:**	**$ 0.0252**	**NYC/ATL:**	**$ 0.0280**
1000-1499			**SEA/DEN:**	**$ 0.0238**	**DAL/LAX:**	**$ 0.0182**
1500+	**FNO/MEM:**	**$ 0.0217**	**DET/ELP:**	**$ 0.0214**	**LAX/CHI:**	**$ 0.0175**

MARKET SHARE KEY:

Truck > 80% (white) | Both < 80% (light blue) | Rail > 80% (dark blue)

There=s a fairly consistent pattern where if the lane density and the distance increase, costs drop. Corridor costs for each of the cells were generalized to other records in the cell and interpolated to other cells in the matrix. The expansion was done on a cost per ton-mile basis. Lift costs were subtracted from unit costs. The net was applied per ton-mile. Lift costs were then added to the net figures. Rebills were considered as forwarded or received traffic. The result is a costed waybill.

Freight and Vehicle Miles Traveled Impact

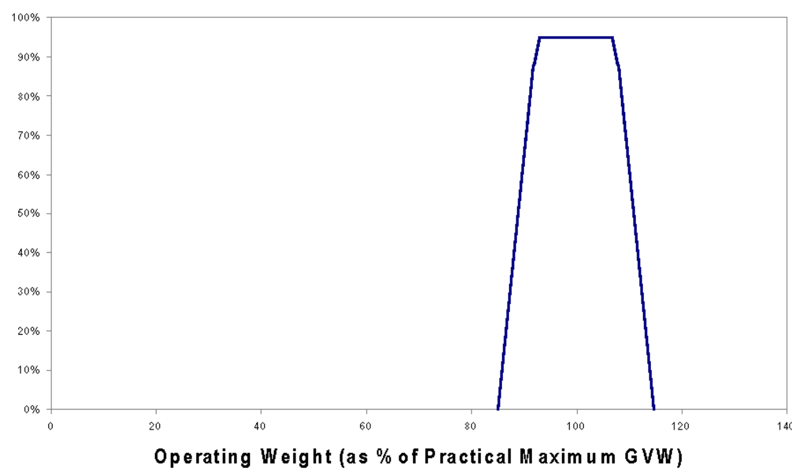
SHORT-HAUL DIVERSION and WEIGHT DISTRIBUTION ANALYSIS

Harry Cohen

The team sought to analyze the impact of truck size and weight scenarios on heavy truck VMT distributed by truck type and operating weight. This information is needed for analysis of safety, shipper costs, pavement, traffic operations, energy, and environmental impacts. The base case scenario used a Year 2000 VMT by 20 vehicle classes, State (analyzed at the State level but reported at the national level), operating weight groups (5,000-pound increments), and the 12 highway functional classes. The 1997 Federal Highway Cost Allocation Study served as the source for the base case VMT.

Initially, the team identified the truck traffic directly affected by weight limits. The team estimated the shifts between three-axle and four-axle single unit trucks. There was no available shipment-by-shipment database for short haul truck traffic, so the team used total VMT distributed by truck type and a pivot point analysis, which is based on changes in relative cost. The team then estimated the changes in weight distributions. Even if there were no shift among truck types and four-axle trucks were allowed to operate at heavier weights than in the past, the operating weight of the truck would be different. That would affect shipping costs and pavement impacts. Adjustments were made for empty VMT.

PERCENT OF TRUCK VMT AFFECTED BY WEIGHT LIMIT CHANGES

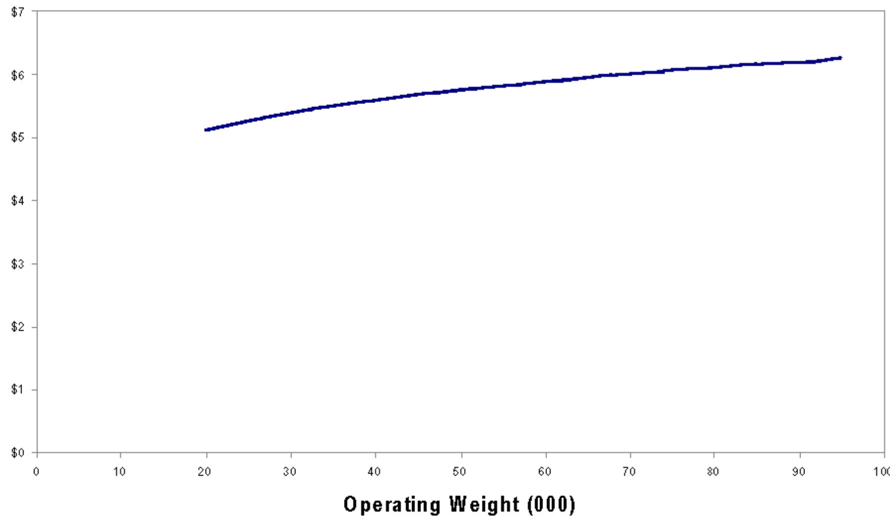


The team assumed that the loading of a truck operating close to its gross vehicle weight limit is governed by the weight limit. The team assumed that 95 percent of the trucks operating within 7.5 percent of their weight limit might shift their loading if the weight limits change. Finally, the team assumed that if a truck is operating at 15 percent over or under its weight limit, the amount of freight carried by the truck is not governed by the weight limit.

Freight and Vehicle Miles Traveled Impact

For short haul analysis of single unit trucks, the team assumed that diversion would take place between three-axle and four-axle single unit trucks. The team=s first step was to develop truck operating cost equations. The team then applied those equations to calculate cost per ton-mile under the base case and alternative scenarios, created and calibrated a diversion model, and applied the model to predict diversion.

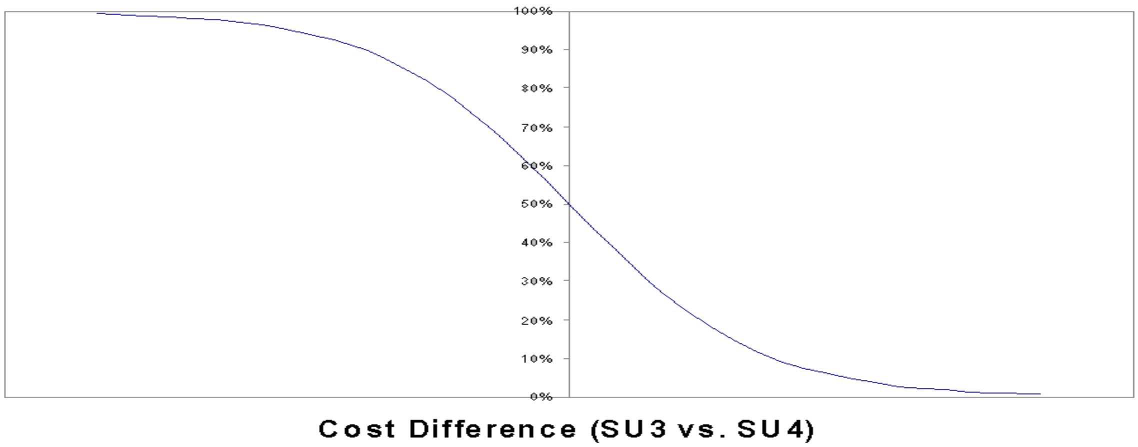
OPERATING COSTS FOR HEAVY SINGLE UNIT TRUCKS CHART



For single unit trucks, the operating costs are between $5 and $7 per vehicle mile. These costs tend to be quite a bit higher than for combination trucks. Single unit trucks operate at much lower speeds than combination vehicles and are not always in constant use. Costs for these trucks increase with operating weight. A 10 percent increase in vehicle operating weight causes a 1.3 percent operating cost increase per vehicle mile.

With cost per vehicle mile in hand, the team calculated the cost per payload ton-mile for SU3 and SU4 trucks under the base case and alternative scenarios. The calculations were based on the practical maximum gross vehicle weight, tare weight, cost per vehicle mile (by operating weight) and ratio of empty-to-loaded miles.

SU3 SHARE OF TRAFFIC



When the SU3 has the cost advantage, most of the freight moves on these trucks. When the costs to move freight on an SU4 drops relative to an SU3, freight shifts over.

It was assumed that if truck size and weight limits change, the operating weights of affected loaded trucks would change in direct proportion. It was also assumed that there would be no increase or decrease in the amount of freight carried (payload ton-miles). If trucks were allowed to run heavier loads, fewer vehicles miles would be required to move the same amount of freight as before. The team assumed heavy single unit trucks would travel one empty mile for every loaded mile. The team will add or subtract VMT at the tare weight of 22,600 pounds for the SU3 and 26,400 pounds for the SU4.

The team relied heavily on the ITIC model for its analysis of combination trucks. The analysis was based on the outputs of the rail-to-truck and truck-to-truck diversion models. The team took VMT and payload ton-miles by truck class, State, and functional class and repositioning miles by truck class and region from the diversion models. The team assumed the analysis of short haul shifts would mirror the long haul analysis. There are slight differences between long haul and short haul operations, but the team assumed that the ITIC model could handle those differences. Short haul combination trucks have a much higher percentage of empties than long haul trucks.

The truck-to-truck diversion model is based on survey data, so it must be expanded to the national level. The team examined the model output by State and highway class and, most specifically, base case VMT by 3-S2s (18-wheel tractor semitrailer) compared to Year 2000 3S2 VMT detailed in the Highway Cost Allocation Study. For rail-to-truck diversion, ITIC already produces expanded national level survey results. The team added in the VMT that the model predicted would divert from rail to truck.

To compute the average operating weight for loaded trucks, the team used data on the change of VMT and payload ton-miles (PTM) and tare weight. The team assumed average operating weight equaled (ΔPTM)/(ΔVMT) + Tare.

The adjustment for repositioning for long haul trucks was reached by a special analysis. The team assumed that short haul trucks would have a 50 percent empty rate. The split between long haul and short haul traffic was based on an analysis of Truck Inventory and Use Survey data. Survey respondents were asked about the distances their trucks operated; 62 percent of 3S2 traffic is long haul (greater than 200 miles).

QUESTION and ANSWERS

There's quite a bit of difference between the short haul approach and the long haul approach. There were problems estimating the short haul. What proportion of the total VMT is in the under 200 mile category?

Virtually all single unit traffic operates under the 200-mile limit. Since 3-S2s account for such a high percentage of combination traffic (62 percent), it's a pretty good indication of how combination traffic splits between short haul and long haul.

It would seem that single unit trucks would make up more than half of the total VMT.

The predominant vehicle on the road is the two-axle straight truck. None of our truck size and weight scenarios hypothesize any changes for the two-axle trucks. Although these trucks are the most common truck on the road, they account for a smaller proportion of total VMT than the 3S2.

Did you apply results from the long haul model to the short haul analysis?

For combinations, yes. For single unit trucks, we used the pivot point analysis that drew heavily on expert judgment and past studies. For modeling short haul combinations, we drew heavily on the ITIC results. We compared our results with other studies.

The base case 3S2: is it a 48-foot trailer or a 53-foot trailer?

We've assumed it to be a 53-foot trailer, but from the data that was collected, we don't know if it was a 48-foot trailer or a 53-foot trailer. We assumed it was a 53-foot trailer because it *could* be a 53-foot trailer. We didn't want to take any additional cube out diversion that could be on the road today.

Why did you choose a 53-foot trailer for the Rocky Mountain double and the turnpike double?

The Rocky Mountain double was a 53-foot trailer followed by a 28-foot trailer, and the turnpike double was twin 53-foot trailers. As we worked the diversion model and developed the tool, we wanted to see if the model could handle scenarios that far at the edge. We were not looking at any policy proposals.

We wanted to operate at the maximum diversion, using the largest size and weights. For the purposes of analysis, the shorter wheel base, we wouldn=t have had the maximum diversion. Decisions on which sizes and weights were used were based upon which would provide the most impact.

There could be an infinite number of scenarios, but we picked configurations for this initial testing that were at the outer bounds or would provide the most impact.

I understand your 1-to-1 ratio on empty single units versus fully loaded units. What were your assumptionsCempty versus loadedCon 3-S2s on the short haul?

We assumed a 1-to-1 ratio on the short haul. For the long haul, we had a special repositioning analysis that gave us substantially less than a 1-to-1 ratio.

Referring to the Aall-or-nothing@ diversion, could you review why you did that and how you reached your sensitivity analysis results?

AAll-or-nothing@ means a particular shipper for each shipment may choose a number of different modes to move all of his commodities. The team didn=t mean divert all of the shipment to rail intermodal, rail carload, or a particular truck configuration. This assumes that the shipper will find the least expensive mode to move a shipment between his origin and the destination. He may want to spread out a shipment over more trips. It=s an inventory issue and a commodity issue. There isn=t quite enough commodity information to understand the differences.

Why didn=t you assume that diversion occurred? What were the results of the sensitivity analysis? Apparently you found they didn=t exaggerate your findings too much or you would have backed off.

We tested each parameter for its importance within the model. Driving the model was what was important for the choice of a 3S2 or a turnpike double? We tested the parameters in the model to make sure they were working in the way that we intended them to work. We wanted to talk about the upper bound. We didn=t want to talk about where we were on a diversion curve or an adoption curve. That=s a little murky for some of the additional impact statements. After all the changes and all parameters take affect, the state of the world would be quite different given some of these truck configurations. We used the maximum sizes and weights to provide a benchmark by which to tailor future analyses.

Are you going to give us some illustrations of the outputs of these models? Are you going to provide some scenarios and show us how you built these models?

That information will be contained in Volume III.

This conference is to walk through the methodologies of how the models were obtained. They will be available later this summer.

Regarding the truck network and the costs to build the staging areas that would be built every 14 miles on the rural Interstates: have you modeled the railroad network and what would be needed for these intermodal facilities whether they exist or not? How does that impact diversion?

The intermodal network that we used was developed at Oak Ridge National Laboratories. When you get an intermodal rail shipment, you know the distance it travels over the rails, but you don=t know how much further it had to travel to get to its destination. Oak Ridge developed some methods to estimate the distance between ultimate shippers and receivers.

There set large rail delivery points where you can change your truck availability. Rail is most viable to major delivery points and staging points. It is not viable to move certain things by rail in Vermont over a short distance. There is a VMT impact. It=s okay to move commodities coast to coast by rail. That would cost a lot more by truck. But you need trucks to get goods out of the railhead.

We used the originations/destinations that are specified in the waybill. We assumed you are moving that same freight from those same originations and destinations. We didn=t hypothesize a change in the rail network.

In the straight truck conversion, does the model assume the Federal bridge weights as a determinant? In the proportional shift from one scenario to another, does the model assume you are able to take up all of the increase in the allowance or do you take into account operating restrictions where you can=t stretch the wheel base? Does your model take into account multiple weather restrictions where you can=t operate fully within the hours of service?

We ignored bridges as a weight determinant and focused solely on weight limits per axle: 12,000 pounds for a steering axle and 20,000 pounds for a single axle. We tested 44,000 pound and 51,000 pound limits for tridem axles. Taking those weights limits and axle distributions, we estimated the costs to replace those bridges that need replacing based on overstress criteria.

Freight and Vehicle Miles Traveled Impact

Are you assuming that in going to the alternative scenarios that you can infinitely stretch the wheel base of the truck to accommodate the maximum increase in weight allowance?

The wheel base is based upon the length of the trailer. If the trailer length is extended, then the wheel base is assumed to be at the outer edge of the trailer.

My question is about the straight truck, which is much more problematic.

Straight trucks have definite limits on the wheel base, not so much for the diversion model, but for the bridge analysis and the stability and control model.

Can you plug in the various inputs into the model that are savings specific? If you are repositioning at 65 percent rather than the assumed 50 percent, can you plug in significant changes in variables for each industry segment?

The model can do that. That is basically the way it works. It=s a diversion model that allows traffic to shift gradually from one type of configuration to another, as the cost of the configuration drops. The problem we have is we don=t have base case information that shows, for example, the operating weight distributions for concrete mixers or for another special kind of truck. If we had that information, we could take our model and apply it to a specific type of vehicle. Instead, we work with all three-axle single unit trucks combined and all four-axle single unit trucks combined. We have it broken down by highway functional class and operating weight, but we don=t have it broken down by type of industry. We just don=t have the data to run the model under those circumstances.

Would it be possible as you develop the models and put the outputs together to run another test with different truck lengths to get an idea of the impact of the diversion when you change them?

Sure. That=s easily done.

Regarding, rail traffic that moves less than 200 miles: What is it? Is there very much of it?

On all other traffic there are about 50,000 shipments in the 1994 Waybill that move less than 200 miles. These are mostly mineral ores and chemicals that are being put in storage, in transit, or interplant transfers.

SESSION 2
SHIPPER AND RAIL IMPACT

Presented by:	**Panelist:**
Karen White Economist Industry and Economic Analysis Team Office of Policy Development Federal Highway Administration **Scott Greene** Senior Economist Intermodal Freight and Industry Team Office of Policy Federal Railroad Administration **Chris Rooney** Managing Director Vanness Brackenridge Group	**William Gelston** Staff Director Intermodal Freight and Industry Team Office of Policy Federal Railroad Administration

SHIPPER COST IMPACT

Karen White

Shipper costs feed directly from the diversion model. The cost components for shippers are transportation and inventory costs. The team calculated the aggregate costs for moving freight for each scenario. For inventory costs, the team will calculate only the percentage change of the cost of holding goods because no comparable national figures exist. The team found figures for the value of goods held in inventory but could not find figures for the cost of goods in transit, inventory held against potential shipping delays, cycle stock, and ordering expenses. The team will present the base case change in costs.

The diversion model focuses on three shipper types: truck shippers who change truck configuration, rail shippers who change to truck, and rail shippers who remain on rail. The calculation of shipping costs for truck and rail shippers is the same. To calculate transportation costs for shippers who move their freight by truck, the team will multiply vehicle miles traveled (VMT) by configuration and weight group by the cost per mile for that configuration and weight group. For example, the VMT for a 5-axle semitrailer at 80,000 pounds is multiplied by $1.06.

Inventory costs will be presented as a percentage change from the base case.

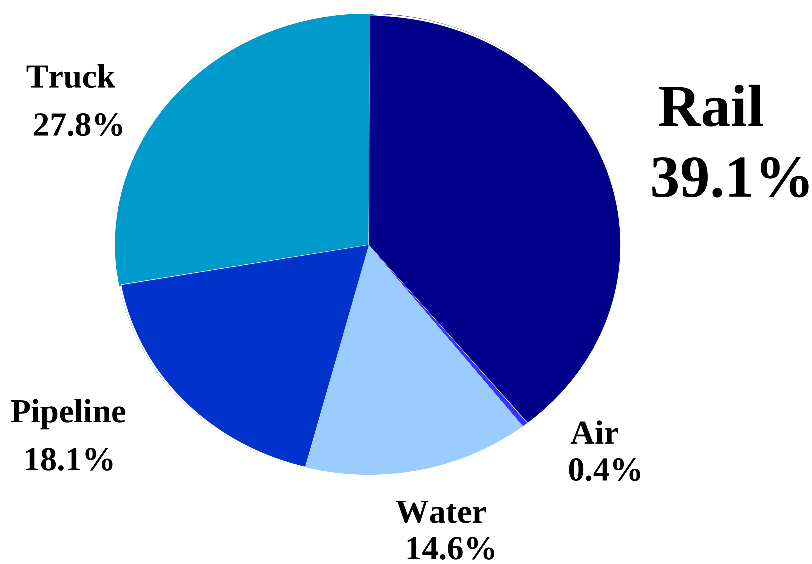
To figure transportation costs for rail shippers who remain on rail, the diversion model allows the railroad to discount its revenue down to its variable cost before losing the shipment. There is no change in inventory cost because the railroad is using the same mode and facilities.

RAIL IMPACT ANALYSIS

Scott Greene

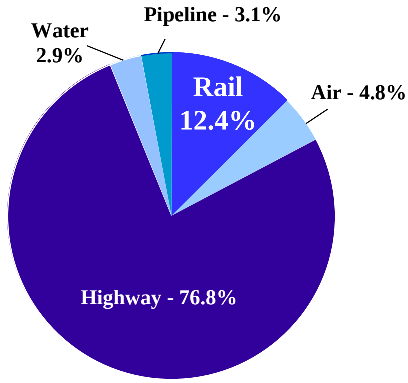
There are two reasons for conducting a rail impact analysis: To determine the total shipper cost due to truck size and weight changes and to address the potential adverse effects on the rail industry resulting from increasing truck size and weight limits. The Comprehensive Truck Size and Weight Study takes into account the total effect on the Nation=s truck and rail freight shippers to determine the net national change in shipper costs. As railroads lose traffic and revenues, their high fixed costs remain. As traffic decreases, unit costs for shippers increase.

INTERCITY FREIGHT TON-MILES BY MODE (1994)



Rail carries the majority of the intercity freight ton-miles, nearly 40 percent.

INTERCITY FREIGHT REVENUE SHARE BY MODE (1994)



Trucks earn the majorityCnearly 77 percentCof intercity freight revenues.

In 1994, the Class I railroad industry was healthy. Revenues for almost every major commodity group were up, financial performance was at its best for any single year in nearly two decades, and industry operating ratio was 81.5, an improvement over the previous year, when it was 85.1. There were 12 Class I railroad systems. The industry structure in 1994 provided a unique opportunity to look at regional impacts.

From a regional perspective, it is clear that the industry is not monolithic. Carriers have different operating characteristics, commodity mixes, lengths of haul, and geographical operating areas, to name a few differences. While the team examined the industry as a whole, the analysis focused on Santa Fe, Union Pacific, Conrail, and Norfolk Southern railroads. Railroads have high fixed and common costs. Railroads must maintain an extensive network. There are also costs associated with clerks, maintenance and operations employees, locomotives, and rail cars. Railroads are a decreasing cost industry. As traffic decreases, fixed costs are spread over fewer units of traffic. As traffic increases, fixed costs are spread over a greater number of traffic units.

Mode share will change with changes in truck size and weight. Total shipper logistics costs (transportation and inventory costs) changes are the key ingredient in load selection or truck configuration selection. The mode with the lowest total shipper logistics costs wins, that is, if truck logistics costs are less than rail, traffic that once moved by rail diverts to trucks.

What happens to the rail industry as mode share changes or rail loses traffic? What will be the effects on individual railroads? Because there are regional differences in railroads, the team gained a sense for what the impacts would be for different truck size and weight scenarios. Because this is a network industry, the effects on one carrier could spill over onto other carriers.

To answer the above questions, the team used the carload waybill sample and diversion model output from FHWA, the McCullough cost elasticity coefficients, and an analysis of Class I railroad financial and operating statistics, compiled by the Association of American Railroads from data submitted to the Surface Transportation Board.

Using the FHWA diversion model outputs for each of the three scenariosClonger combination vehicles, tridem axle vehicles, and triple trailersCthe team identified the moves that would remain on rail. Why look at moves that would continue to move by rail? The full revenue effects must be determined. In this model, there are two causes for reduced rail revenue: diversion (lose traffic, revenues, and costs) and discounting down to variable cost to hold traffic that would be lost to lower truck rates. Each leg of rail moves from the waybill is analyzed to determine the remaining car-miles, revenues, and revenue dilution for the Class I industry and the study railroads. This required an incredible amount of number crunching.

The team then calculated the percentage change in rail car-miles following diversion for the base case industry and study railroads for each scenario. For example, for the base case, if car-miles total 1,000 following diversion and 900 car-miles are left, there is a 10 percent change in car-miles. Similarly, the percentage changes in rail revenues were calculated by the Surface Transportation Board.

Rail revenues figures are not accurate. These inaccuracies are in the reporting. The revenues on the waybill do not reflect actual contract revenues because they are highly confidential and solely in the possession of the Surface Transportation Board. It doesn=t matter in most aggregate analysis, but because this model is geared to run off of individual shipments, it was important for the Surface Transportation Board to calculate these percentage changes using the highly confidential data.

The McCullough Cost Elasticity Coefficients were developed by Gerard McCullough for his 1993 doctoral dissertation at MIT. The coefficients are used to determine post-diversion freight service expense, which is equal to railroad cost. The analysis applies rail industry elasticity of freight service expense with respect to changes in car-miles. For the industry, the elasticity coefficient is 0.6101. The elasticity coefficient for each of the four study railroads was: Santa Fe, 0.7543; Conrail, 0.5795; Union Pacific, 0.7893; and Norfolk Southern, 0.7087.

For a 10 percent decline in rail car-miles, rail cost would decline only 6.1 percent. Reductions in costs do not decrease on a 1-to-1 ratio with car-miles as traffic is diverted. Railroads shed cost much more slowly because of high fixed and common costs. Comparing, for instance, Union Pacific (0.7893) with Conrail (0.5795) would show that the impact of diversion would not be as great on Union Pacific as it would be on Conrail. Union Pacific loses more cost as car-miles decline.

The outputs from the percentage change in car-miles and revenues and the McCullough Cost Elasticity Coefficients provide the inputs to the railroad financial impact model. The examination of rail impacts goes beyond what was done in the past to address cost and revenue effects. A more complete understanding of truck size and weight changes on the rail industry takes us one step closer to understanding the national changes in shipper costs.

Shipper and Rail Impact

DISCUSSION of the RAIL FINANCIAL MODEL

Chris Rooney

The industry and four railroadsCSanta Fe, Union Pacific, Conrail, and Norfolk SouthernCwere chosen to give a range of susceptibility to the financial effects of the loss of revenue from diversion. Why look at these effects in depth through an integrated financial model? There are a number of audiences for these decisions. We ought to be cognizant of the overall condition of the rail industry as seen by its management, customers and Wall Street.

The purpose of the analysis is to provide a creditable view of the effects of the loss of business railroads could suffer due to diversion. The major objectives of this analysis were to create a test case to project the Association of American Railroads *Green Book* statistics from 1994 (base year) through 2000. The team extrapolated base case revenues and expensesCfactoring in no diversionCand varied the car-miles and revenues to quantify the effects of diversion losses. The team used McCullough=s Cost Elasticity Coefficients to forecast the effect of lost volume on costs. The team calculated the increased cost per car-mile associated with the truck diversions. Railroads are characterized by higher fixed costs and lower variable costs than the trucking industry. The team also looked at profit contributions after diversion. What does the total financial picture look like after diversion impacts have been factored in?

The team utilized the Vanness Brackenridge model, which was subjected to peer review.

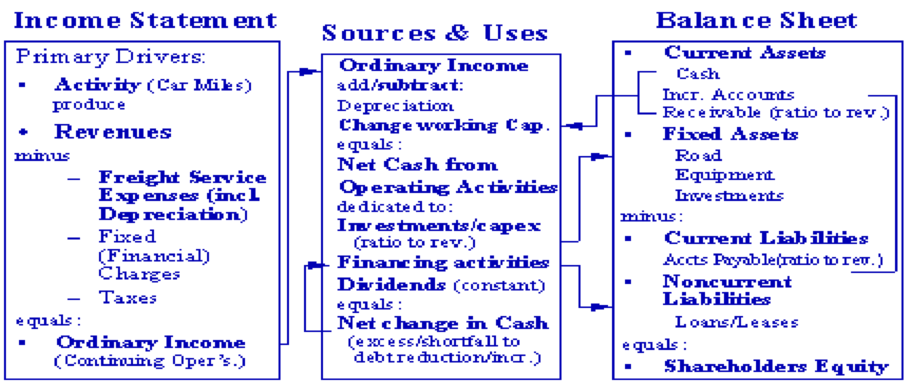
Model Structure Diagram

Overall Reporting Sectors:	**The Model Can be sensitized to:**
Activity Levels	Activity levels by type/distance
- Statement of revenues	Tariffs by type/distance/other
- Statement of expenses	Rates
- Income Statement	All Expense Categories
- Cash Flow Statement	Capital Program by specific elements
- Balance Sheet	Return on Investment
	Return on Assets
Capital Investment Schedule(s)	Weighted Average Cost of Capital
	Revenue Adequacy
Investment/Debt Portfolio	

Activities within the model include statements of revenues, expenses, income and cash flow and a balance sheet. The model=s income statement is configured in the same way as the report that Class I railroads make to the Surface Transportation BoardCthe R1 format. The model also is adjusted for the railroads= capital investments and investment/debt stock portfolio to create a fixed charges relationship (interest).

The model can be sensitized to activity types by type and distance; tariffs by type, distance and other rates; all expense categories; capital programs by specific elements; return on investment; return on assets; weighted average cost of capital; and revenue adequacy.

WIRING DIAGRAM OF THE INTEGRATED FINANCIAL MODEL



The income statement=s primary drivers are car-miles and revenues minus operating and maintenance expenses (including depreciation, fixed charges, and taxes), which equal income from continuing operations. The team then feeds the income figures into the sources and uses cash flow statement. The model looks at non-cash charges that do not result in a cash outlay, such as depreciation, and changes in working capital. These figures equal net cash from operating activities. Funds are dedicated to capital costs for investments, financing activities (debt service), and reserve funds. The net change in cash is the bottom line. The team assumes that any net cash is channeled back into debt reduction. The cash flow statement drives the balance sheet and determines the solvency of the company.

The reasons for going into this level of detail are to produce a picture of what management and Wall Street would see and what would compel management to cut back on investments or maintenance if they perceived a financially perilous future. This global fashion, rather than an incremental revenues minus expenses perspective, allows the team to forecast whether a railroad is likely to head for another Penn Central failure.

Shipper and Rail Impact

The team assumes industry revenues will grow by 2.4 percent. To generate some of these coefficients, the team took historical data and generated a composite average for some concepts, such as depreciation. Income tax rates were close to 37 percent for taxable income. Railroads pay a great deal of deferred taxes due to their heavy investment schedule.

The team looked at the railroads in 1994 to see what state they were in and determine their efficiency. There is a section in Volume III that provides a snapshot of each railroad=s efficiencies and characteristics.

Modeling issues include the railroads= first response to diversion (reduce rates to variable costs to retain business). Railroads will generate lower levels of revenue while moving reduced levels of traffic, while retaining their costs. The result is a loss of profits and cash flow. Is there any place where the railroads might replace that cash contribution? Can costs be shifted? Are there any captive shippers that might pay higher rates? Are there any areas where the railroads might replace revenues lost to diversion?

The team hopes to take the diversion model output to reflect accurately the probable financial conditions of the railroads and the economic cost of handling freight that remains on the railroads. The team hopes to quantify and define the cost differential resulting from diversion and the marginal cost increase of handling freight that railroads retain.

QUESTION and ANSWERS

Did you look at the changes in rail service that might result and not just the shipping costs?

$ I don=t think so. Whether it is the truck side or the rail side, the study is pretty much a static analysis. We did wrestle with the question of whether the improving railroad productivity trend would continue to the year 2000. That trend, we think, is pretty much busted. The low-hanging fruit in railroad productivity gains has already been harvested. There seems to be a consensus developing in the railroad industry that further gains of any worth are going to require massive capital investments.

Why did you look at individual railroads? The four railroads you looked at are completely different today (compared to 1994). They have all undergone consolidations, and Conrail is on its way out. What does that mean to your analysis? How do these changes effect the elasticity of each railroad?

$ That=s a very relevant question. We had to use the data that were available. That=s an interesting point.

$ It wasn=t that those points didn=t occur to the team. The purpose of our efforts was not to try to reflect the reality of the situation today or in 2000, as far as this part of the analysis went. Most previous size and weight studies have been interested only in rail diversion to see what it does to VMT on the truck side. Things have gotten very particular on the truck side with the different configurations and regions of the country. The rail industry is not monolithic. We wanted to produce something that would show the diversity of the impacts. This study started 3.5 years ago.

$ There was a purpose in staying with these breakdowns which have not gone forward into the future. The railroads we looked at specialized in certain types of traffic more so than the larger merged railroads are going to be. Therefore, we were able to get a better snapshot of how a company which is primarily based around intermodal operations is effected versus a railroad that focuses on resource hauling.

$ The point about elasticity coefficients occurred to the team as well. When the team looked at six studies conducted since 1974, they found there has been almost no change in the elasticity coefficient for the industry. Will the elasticity coefficients allow us to be precise in our forecasts for 2000? No, but our analysis will be very close, certainly close enough for the purposes of our work. We are still using McCullough=s elasticity coefficients because they are the latest tools we have. We don=t think they are going to distort the results. If things haven=t changed much over the past 20 years, why should we think things are going to radically change now?

$ The economy is constantly changing. We are in a dynamic environment. The motor carrier industry changes, as well. Maybe not as dramatically as the Class I railroads have changed. As long we make clear in the reports and other materials what our assumptions are, the readers will know why we went with the data that we did and why the data are applicable. They will know the caveats about what happened. That=s the best that we can do. We can=t stop and wait until we have data on the situation in 1998.

I found another table where Gerard McCullough gave elasticity for four or five major carriers for two or three points in time in the late 1980s and early 1990s. It shows a greater increase in elasticity than the present study shows. Could you take a look at this data?

$ If there=s better data to put into the model, fine. This is the best data we could find.

You can calculate the elasticity of average cost directly off the total cost elasticity.

$ The major issue regarding rail impact is, when freight shippers experience cost savings from running the bigger trucks, rail shippers rates are likely to go up. There seems to be a consensus that the net national saving is the difference between each scenario.

The scenarios worked for diversion; some of the illustrative scenarios point to the grandfather rights, which theoretically could mean increased traffic for the railroads. How do the elasticities and the model work going in the opposite wayCincreases in traffic and not diversions of traffic?

$ It goes back to the ITIC model, which doesn=t work in that direction. The model is not able to estimate rail revenues and rail variable costs on a shipment by shipment basis for current truck moves. That is something the model lacks at this time.

When you increase truck capacity, you increase the capacity of the road system. When you ship by rail, you have built-in capacity. Some of our local railroads are operating at capacity and keeping adding extra capacity at 2.5 percent a year. It becomes a question of where do you put the extra capacity. Our primary local intermodal yard in St. Paul is operating at capacity and is skimming. Our only choice is more trucks and bigger trucks. How are you developing that whole equation?

$ We are growing the investment at the composite historic rate, which was pretty high in 1994. The railroads were rebuilding their capacity at that point. The composite rate should apply for the next five years. The model does provide for additional investment as the traffic grows. The railroad capacity alignment issue is a big stair step. The trucking industry is characterized by homogeneous additions to capacity in very small stepsCbuying a new truck or building a new terminal. Building or rebuilding a railroad is very expensive. Land acquisition and gaining enough right of way is a major issue for the railroads. In some urban areas, the railroads are constrained because operate on their own rights of way, and there are limited condemnation possibilities under eminent domain. The model does provide for additional investment as the traffic grows.

$ The team hasn=t hypothesized where capacity would grow for either truck or rail. On the East Coast, there are capacity questions for highways as well as railroads. The model takes 1994 capacity and moves more VMT and freight over the highways and the rails.

Shipper and Rail Impact

SESSION 3
PAVEMENT IMPACT ASSESSMENT METHODOLOGY

Presented by:	**Panelist:**
Jim March	**Roger Mingo**
Team Leader, Systems Analysis	President
Office of Policy Development	Mingo & Associates
Federal Highway Administration	

The States have a tremendous investment in their pavement systems. They spend billions of dollars each year to maintain that infrastructure, which is critically important to the overall productivity of the national economy. Changes in truck size and weight policy will have major impact on pavement systems and costs.

Pavement impact estimates are based upon the pavement cost model within the Highway Cost Allocation Study. A number of revisions were made to that model to apply to truck size and weight scenarios. New FHWA research on tridem axle impactsCparticularly the relationships between axle loads, axle spacings and pavement deteriorationCalso was incorporated in the estimates. The goal was to develop optimum axle load and spacing criteria that took into account potential bridge impacts. Data from a recent National Cooperative Highway Research Program (NCHRP) study on pavement response to heavy vehicle loading was also utilized.

Pavement impacts depend upon a number of factors, probably the least of which is the gross vehicle weight of the truck. Important factors include the number and type of axles on a truck, the load upon each axle, the type of pavement (asphalt or concrete), the pavement design (the base, subbase, pavement thickness, shoulders, drainage, and so forth), and environmental factors. Pavement impacts are also influenced by vehicle suspensions (leaf or air suspensions), tire pressure, and tire type (radial, bias, or super single tiresCeach has a different effect on pavement deterioration). The analysis does not quantify these secondary, vehicle-specific characteristics because they are less important to pavement deterioration than pavement type and axle weight. Many of these secondary impacts have been summarized in the Organization for Economic Cooperation and Development=s ADynamic Interaction Vehicle-Infrastructure Experiment.@

The model develops the mechanistic relationships between pavement distress and axle loadings. The team looked at the stresses that axle loadings place on pavement and their contributions to distresses such as loss of serviceability, load-related cracking, rutting, loss of skid resistance, expansive clay-related roughness, and thermal cracking. The first four factors are related to load, while the last two are entirely environmentally related. These models do not use load equivalency factors from the AASHTO road test as have been used in previous truck size and weight studies. The team has estimated load relationships and exponential relationships for each type of distress. For most of them, the exponent ends up being slightly less than the fourth power relationship developed from the AASHTO road test but have several higher exponents. With load, the affect is not as great as the simple AASHTO simple road test relationship found for loss of serviceability.

The model is based upon the Highway Performance Monitoring System (HPMS) data base of 100,000 records of pavement sections provided by the States every two years. These records include detailed design characteristics of the pavement, the highway system, and the traffic that uses that particular segment of the system. Based upon total traffic volumes of a particular highway functional class within a State, the team simulates pavement distress for a particular section caused by 20 vehicle classes on an annual basis over a 20-year period. The analysis takes into account pavement thickness, design features, type of pavement, drainage and other environmental factors that are not included in the HPMS sample reports. The team has created a weighted pavement condition index that is the basis for deciding whether a pavement improvement must be made.

Load related rigid pavement distresses include loss of serviceability, faulting, loss of skid resistance, and cracking. Depression and swell-related roughness are entirely nonload related. Spalling can be both load-related and nonroad-related depending upon the circumstances. All distresses are weighted by environmental and other factors. Like flexible pavement, the exponential relationship for rigid pavement varies across distresses but is generally less than four. For one or two types of rigid pavement it may be four or a little bit more. Distinct load-related responses exist for each distress type.

Pavement Impact Assessment Methodology

Load Equivalency Index
(Based on 18,000 Pound Single Axle)

Axle Type	Load (pounds)	Rigid Pavement	Flexible Pavement	
			Fatigue	Rutting
Steering Axle	12,000	0.6	1.4	1.3
	20,000	3.1	4.0	2.2
Single Axle	17,000	0.9	0.9	0.9
	20,000	1.6	1.5	1.1
Tandem Axle	34,000	4.1	1.6	1.9
Tridem Axle	44,000	0.6	1.4	2.4
	51,000	1.1	2.5	2.8

The above table shows the relationships between the type of axle, axle loading, and load equivalency. The comparison is based upon an 18,000 pound single axle. In general, the greater the weight, the higher the equivalency. There is also a variation depending on the type of pavement. Notice the differences between fatigue and rutting.

Relative Load Equivalency per 100,000 Pounds of Payload

Axle Type	Gross Weight	Number of Vehicles	Rigid Pavement	Flexible Pavement	
				Fatigue	Rutting
3-axle SU	54,000	3.18	213	146	119
4-axle SU	64,000	2.66	156	118	112
5-axle Combination	80,000	2.02	100	100	100
6-axle Combination	97,000	1.33	58	60	72
8-axle Double	124,000	1.17	63	57	70

Note: 5-axle Combination = 100

For comparison sake, the team has assumed in the above analysis that the vehicles are fully loaded. The team has attempted to compare the relative damage caused by fully loaded trucks with different axle configurations, numbers of axles and gross weights. The number of trucks required to haul the 100,000-pound payload varies with each vehicle type. Higher gross weight trucks can carry the same weight cargo in fewer trips. The impacts on the pavement vary with these factors. If you carry more payload in fewer trips without increasing the axle loads to the point of neutralizing savings, there are some savings that can be realized in pavement costs.

To estimate the impacts of various scenarios, the team ran the base case scenario through the model using the traffic figures in the Cost Allocation Study and existing pavement conditions. The team estimated the required pavement improvement costs over a 20-year period at this level of traffic. For the scenario analysis, the team took estimated changes in traffic from the diversion model, ran the traffic through the pavement models, and then estimated changes in highway improvement costs. The analysis took into account which States the traffic would operate in, the different State highway systems that would be affected, and the diversion from rail and the shifts among different truck types.

QUESTION and ANSWERS

The analysis here covered just pavement costs. Is there anywhere where we can see bridge and pavement costs combined? You can=t look at just the pavement alone because the gross weight on a bridge is the biggest factor. On pavement, the weight is distributed, but you have to leave the pavement to get across the bridge. This causes the damage to bridges.

$ This is one of the important factors to consider in changing bridge formulas. It has as much impact on pavement as it does on bridges.

In the relative load equivalency table, does the four-axle single unit, do 56 percent more damage than the baseline five-axle combination vehicle? And flexible pavement 18 percent more damage? Can you explain why the five-axle combination has the same impact on both flexible and rigid pavements?

$ These figures show difference in influence of tridem axles on rigid pavement versus flexible pavements.

Are we talking about the same thing as the AASHTO ESALs?

$ It is not the AASHTO EASL but it is the same concept. Equivalency factors vary for each distress and for rigid versus flexible pavement.

When you used the five-axle combination, you had the same number.

$ That was just an index number that was used to compare the relative damage caused by different vehicles on the different pavement types, standardized to 100.

When you talk about no changes in vehicle suspensions, is that the same as no changes in vehicle spacing in the tandem units? Are we assuming a 52-inch spacing on tandems and tridems and no changes in interaxle dimensions?

$ That was not a policy variable in the analysis.

It would only get better as we expand, and our stress columns wouldn=t overlap.

$ One thing to note; in Europe they give weight bonuses and other incentives for trucks to adopt the more pavement friendly suspensions. In this country, carriers are adopting the air suspension systems fairly widely, especially for tractors. It=s not clear that incentives are that effective. Driver comfort and payload protection are among the leading reasons why air suspensions, which are more pavement friendly, are being adopted in this Country.

My question is specific to interaxle dimensions in the tridem configuration. You are still assuming a 52-inch spacing?

$ We do have a split tandem class that you see on flatbeds in particular that act as two single axles.

You said that most of your analysis was based on the data you received from the States. Am I correct in assuming that?

$ Yes, it was supplemented with a lot of other, particularly environment, data that we used to augment what we got from the States.

Did you check on the reliability of the data from the States? Do you have any indication how reliable that data are?

$ A lot of the data came from secondary sources. The data that came from the HPMS provided traffic data and some rudimentary information about the pavement. There isn=t a lot on there that tells you much about what you need to know. All the environmental variables came from other sources. Regarding reliability, most of the State information dealt with traffic levels per lane. We calibrated the figures, even if the State data was not too accurate, so that the total traffic figures came out right. We had to adjust the traffic levels on the State-provided figures to match what we think is a better estimate of traffic. We think the distribution is about right, but we adjusted the levels to match the studies.

The results that are shown here are probably average impacts. Are you using averages for the damage impacts or are there ways you could smooth the highs and lows to give the numbers?

$ We have 5,000-pound weight intervals and the amount of travel observed from weigh-in-motion operations in the various States that we use. Certainly there is variability at specific sites, but with the millions of observations that we use, we figure that statistically we are not aware of particular sources of bias. We should be getting fairly representative distributions of operating weights.

Is it worthwhile to put in the deviations for people who will read this report?

$ One of the important issues for weigh-in-motion operations is they are dynamic loadings on axles. If the spring is compressed when the axle rolls over it, it shows a greater weight than the axle weight over a longer period of time. We had millions of observations, and the case might be made that the dynamic loading is more accurate than the static loading for pavements and bridges, anyway. Since we used statistical sampling of the dynamic loadings, which if they are not systematically biased because of the geometry of the pavement in the vicinity of the weigh-in-motion station, they should provide us a pretty good average.

Maybe you could provide the average plus or minus the standard deviations.

$ The average has a lot of richness within it. We used the distribution of the axle weights. There could be some bias in particular weigh-in-motion stations because the pavement geometry results in more than average axles being compressed or not compressed when it went over the scales.

Did you observe the ratios between flexible and rigid inventories in the networks.

$ On the Interstate it was roughly a 50/50 ratio, and on the smaller systems, the pavement was predominantly flexible. It reflects pretty accurately the statistics FHWA publishes every year. Their source is the same as ours, the samplings of 118,000 pavement sections.

$ That is the data item for which there is the least uncertainty.

When you looked at fatigue, rutting, and other distresses, where did you get your data?

$ Those data came from the NCHRP Report 323. Flexible pavement fatigue is measured by the stress on the bottom of the top layer of pavement, and rigid pavement fatigue is measured by the stress at the bottom of the slab. We actually measured stress attributed to different loads.

Pavement impact is influenced by tire pressure and tire type. Why didn=t you consider that in your study?

$ We figured that was not as important a policy variable. There are very few levers we can pull to influence tire pressure. It isn=t nearly as important to overall pavement impact as the axle loads. We wanted to isolate those factors that were of primary policy importance, recognizing that there are these other factors that influence pavement wear.

The axle is related to the tire that puts pressure on the pavement.

$ The model does include tire pressure for some distresses, notably rutting. There is a function within the pavement model that expresses tire pressure as a function of axle loading. We accounted for it; we just didn=t vary it in the analysis. We used what we considered average tire pressures. You could analyze, using this model, what would be the impact if systematically tire pressures went up for one class of axles. It wasn't an important policy variable.

The interaction between tire loads and pavement is very complex. It's not as simple as it is made out to be. On asphalt pavement, a fully loaded truck going uphill is going to do more damage than a truck going downhill because of the speed of the truck. Concrete pavement is a little different. Fatigue is a function of the stress on the bottom of the top layer of pavement. It's a very complex subject, one that has to be addressed very carefully. The size and weight of the new vehicles are going to do a lot of damage to our roads.

Pavement Impact Assessment Methodology

SESSION 4
ECONOMIC IMPACTS OF LARGER TRUCKS ON HIGHWAY STRUCTURES

Presented by:	**Panelist:**
Jim Saklas Transportation Engineer Systems Analysis Team Office of Policy Development Federal Highway Administration	**Gedeon Picher** President Mainesurf, Inc.

Despite all the outreach and political ramifications, the studies that have been presented thus far are really cost/benefit studiesCthe engineering economic evaluation of alternatives. There=s the Ado nothing alternative,@ that is change nothing about truck size and weight, and there are various scenarios that change vehicle size and weights. We look at all the costs; we look at all of the benefits. Until now we have concentrated primarily on benefits, mostly reduced shipping costs. Now we will begin discussing the costs involved with the various scenarios.

Increased pavement damage and bridge replacement due to longer and heavier trucks are two potential infrastructure costs. For pavements however, the costs generally would be marginal unless all load limits were increased. Pavement damage is primarily a function of axle loads and repetitions. Consequently if the scenario trucks have more axles than the trucks they replace then it is possible that, despite increased GVW, axle loads may not increase (and could even decrease) and total axle miles (i.e. repetitions) may also decrease, thereby generating marginal decreases in pavement damage.

The big costsCnot just in concrete and steel, but also in user and non-user costsCwill be incurred by bridge replacement. The key issue to highway agencies is the infrastructure costCthe money that will be needed to replace bridges because of larger trucks. A larger cost, in many cases, is the user cost because bridges are not built overnight. Building, expanding or replacing a bridge is a long-term process, which can lead to traffic delays, especially in urban areas. These construction projects translate into costs in lost time for drivers who use those bridges. When there is congestion, there is also air pollution, which can affect even non-users of the bridge.

The objective of the study was to develop a set of tools that would permit the rapid analysis of the impact of larger truck configurations on highway structures, determine which bridges must be replaced due to larger trucks, estimate the agency costs to replace those bridges, and estimate the nonagency costs associated with replacement bridge construction. In addition to bridge replacement costs there will be some additional costs to newly constructed bridges. Although the highway system is nearly complete, new roads will be built, and there will be new bridges. If we allow larger trucks to use these roads, bridges may have to be built to an HS 22.5 or HS 25 standard (as opposed to HS 20 standards). This will increase the costs of these new bridges.

Data and model sources

The model used in this study was developed to calculate the nationwide bridge costs on the highway infrastructure for each new truck configuration. The data sources for the model included the National Bridge Inventory (NBI), a data set of all the bridges in the United States, maintained by FHWA and supplied by the States, and the *Impacts of Heavy Trucks on Bridge Investment* study conducted by Transtec, Inc. for FHWA. In meeting one objective of this study, the Transtec team designed nearly 1,000 bridges that allowed them to determine the live load/dead load ratios for 13 types of bridges from steel girder bridges to prestressed T-beam bridges for span lengths form 20 to 240 feet. A second objective of this study was to develop a model that could compute the dead load and live load moments of any truck configuration and compare that moment with either the inventory or operating rating of the bridge as recorded in the NBI. In addition, the user has the ability to apply a multiple to either of these ratings.

The model also computes user delay costs and pollution costs incurred during the construction of the replacement bridges. When a bridge is being replaced, this model sets up a standard queuing-based model for a construction zone that estimates the delay based on input volumes and output volumes of the queue. Working on certain assumptions of how bridges will be replaced (shutting down the two lanes on a northbound Interstate, for instance, diverting the traffic to the southbound bridge and then reversing the process), we can estimate the queue based on input volumes to come up with delay. The NBI does not contain hourly volumes for specific bridges. The team gathered hourly distribution data from the States, using average annual daily traffic data within the NBI. The team then estimated the hourly volumes for each functional class and a function of volume.

Procedure

The team can compute the total moment (dead load + live load) on every bridge generated by the existing fleet of vehicles. Some bridges need to be replaced now to accommodate the existing fleet; they are already overstressed. The team computes the moment of the existing fleet to determine the base case for these bridges. The team then calculates the moment of the candidate vehicles based on inventory ratings in the NBI, the team then computes the total moment for each bridge.

If the moment generated by any of the existing vehicles exceeds the rating moment by a preestablished criterion, the bridge is flagged for replacement. Then the moment for the scenario vehicles is computed and compared to the rating moment for each bridge. The NBI supplies the length and number of lanes for each bridge. FHWA has figures on bridge replacement costs per square foot (it differs from State to State). Once the number of bridges to be replaced in a State has been determined, the team calculates the agency=s construction cost attributable to the existing fleet and scenario fleet. The team then estimates the non-agency delay and air pollution costs during construction. The team=s working assumptions on the costs of various pollutants were based on the EPA=s Mobile model. The difference between the bridge replacement costs for the existing fleet and the scenario fleet is the cost attributable to that scenario. Due to time constraints, the team determined costs for a sample of States and then expanded its estimates to the rest of the Nation.

Assumptions for Moment Analysis

The team assumed that every bridge that had been flagged (overstressed according to the specified criterion) will be replaced and not strengthened. This assumption has been used in all previous nationwide truck size and weight studies by the Department of Transportation and the Transportation Research Board. There are some types of bridges that lend themselves to some strengthening. Sometimes strengthening is so time-consuming that delays and user costs might exceed the savings in concrete and steel.

All bridges are designed with a large factor of safety. A bridge is considered overstressed when the level of stress endured by the bridge when a vehicle passes over it is greater than the bridge=s inventory rating. The overstress criteria was based mostly on the data used to develop Bridge Formula B. For an HS bridge, vehicles, based on their axle loading and spacing, are not allowed to exceed the stress rating by 5 percent. For all H bridges rated less than or equal to H17.5, trucks are not allowed to exceed the stress rating by 30 percent. For all H bridges rated greater than H17.5, the limit is 15 percent. All bridges have unmodeled redundancy.

When bridges are replaced, they are typically built about 25 percent larger (longer or wider) than the bridge they replace to improve alignment, safety, to make inspections easier, or to add a walkway. This 25 percent does not include added capacity. Under normal circumstances, FHWA adds 20 to 40 percent beyond standard costs to build these larger bridges, but the research team felt that not all of this added expense could not be attributed to the scenario trucks. The bridge is being enlarged to accommodate the larger trucks, but it also is built bigger to meet safety and inspection regulations as well. The team felt 25 percent more accurately reflected the added cost for building new bridges to accommodate the scenario trucks.

Expansions

During preprocessing, it was discovered that the NBI contained a great deal of bad dataCnon-bridges, such as culverts and tunnelsCthat were identified and removed from the main analysis set. They ere placed into a separate file. A few other bridges were eliminated for other reasons. The moment analysis also caught other inconsistent data and non-analyzable structures, such as moveable bridges, trusses, and suspension bridges. These Aimproper@ records were also identified and eliminated from the analysis set and also placed into a second Abug@ file. Results from the analyzed bridges were Aexpanded@ to account for the bridges placed into the two bug files, and the expanded results were again expanded from the sample of eleven states to the national totals.

QUESTION and ANSWERS

You alluded to some bridge replacement costs by the square foot? Are those numbers correct?

$ They were just examples. They weren=t incorrect.

What are the comparisons on the square foot costs for an HS bridge and an H bridge?

$ The costs I used in the presentation were for an HS20 bridge. The cheapest rate would be about $45 (per square foot) in Texas and some of the Southern States. The most expensive is probably New England at up to $150 a square foot.

You talked about bridge replacement and the impact that the larger trucks will have on bridges. Did you mention anywhere what it=s going to cost us if we run 97,000 pound trucks on the Interstate system? What affect will the fatigue issue play?

$ We ignored the fatigue issue for some very good reasons. If a bridge is built today, the fatigue code is such that it should not fail if it is properly maintained. We did find some research at Penn State on fatigue in detail. A lot of fatigue problems are confounded with out of plane bending and other problems of that type that it=s hard to say Athis problem is due purely to fatigue.@ Secondly, in general, fatigue can be fixed easily. Less than 50 percent of bridges built today are made of steel. Most fatigue happens in steel bridges, although it can occur in concrete. To fix it, you bolt up a plate on the bottom and you are done at a very cheap cost. You drill a hole to stop a crack. If a State inspects well, there shouldn=t be a fatigue problem.

$ As to the cost part of your question, we don=t have output here at this meeting. When you read Volume III, you will have, to the dollar, our costs for running any group of trucks nationwide. Our process as to run the status quo scenario, and compute the cost to rebuild all the bridges currently overstressed. We changed certain vehicles in line with the illustrative scenarios and then reran the model for the sample States. After making the necessary expansions the difference between the two is the cost due to that scenario.

When Volume III comes out, it will contain some costs?

$ Absolutely.

Bridge costs and pavement costs have to be considered together. You can=t look at one without the other. One of these factors will control the other. The road that we model is going to be limited by the weakest point. If it=s a bridge, then the bridge is going to control the situation, unless you plan to replace the bridge.

$ The engine that drives this is the scenario truck. If there is a bridge in a particular corridor that can safely currently accommodate the existing fleet, and analysis shows that the scenario truck overstresses the bridge beyond the stated criteria, then that bridge has got to be replaced. The cost of replacing that bridge is attributable to that scenario. The benefits are from reduced shipping costs and so forth. If the scenario trucks add pavement costs, that=s a cost we add into the formula. Some multiaxle trucks will have pavement benefits but also require that bridges be replaced. The scenario truck is the driving force, not the weak links in the equation.

$ In Volume III, each impact will be identified distinctly rather than being combinted with other impacts.

You said the assumptions you used are critical to the success of the study. The assumption on overstress overrides all other considerations. Everything else is a secondary factor. When you use a variety of factors, you wind up in negotiations that pit fiscal constraints against the amount of risk that the engineers are willing to accept. It winds up as a pure policy consideration. There is a great deal of disagreement about how much risk is acceptable. Some people feel these bridges will stand up no matter how much you load them within reason.

$ I cannot disagree with you. Most bridges built in the last 30 years are designed for the HS20 design vehicle. As soon as they allow overstress beyond the HS20 criteria, these bridges Akick out@ as needing to be replaced. If someone argues AI want a 2 percent overstress,@ the cost is going to be huge. If someone argues for a 20 percent overstress, the cost can be small because these bridges are designed for HS20 standards. It is very sensitive. Not only is it a political negotiation; engineering is involved as well. The existing Formula B allows vehicles that will Aoverstress.@ Does that mean the bridge is going to fall? Overstress is over a very conservative factor of safety. Most States don=t have bridges falling down because trucks out there now only overstress those bridges by 5 percent. Formula B has worked for the last 30 years.

$ There=s no political negotiation because there is no outcome that=s given to us. What we are trying to do is to provide a framework of reasonable tools and techniques to analyze the situation. There=s no need to hold down costs because no one has said that there is an outcome we should be looking for.

I would disagree with that because in the presentation there was an implicit ...

$ The point I was trying to make was why do you use a 30 percent figure with an H10 bridge and 5 percent with an HS20 bridge? I tried to deflect that question by saying we don=t know why that decision was made, maybe it was a political decision that was made 30 years ago. Maybe because the old H10 bridges were short span reinforced concrete slab bridges. Reinforced concrete has a huge dead load. Maybe they felt 30 percent was still within the margin of safety for these bridges.

$ These percentages we are using are not fixed. The model can accept any percentage. We can adjust that any way we want. We=ve created a tool that allows us to analyze any situation.

You are basing your data on the working stress ratings of all of these bridges?

$ We are basing our work on the rating as given in the NBI.

It=s a total load factor?

$ It=s possible, yes. In 30 years when this study is redone and we have a lot more working stress percentages... As more bridges are working stress designed, the working stress factor becomes a little more critical. It=s a new way to design bridges that is material efficient. You look at the factor of safety based on the live load and not the dead load. Today load factor and load resistance factor don=t make up 5 percent of the bridges in this country.

$ Both this study and the Cost Allocation Study will be updated on a 3 to 4-year cycle.

If the safety factor built into these bridges is so huge that we don=t have much to worry about if don=t overload them too much. Didn=t the engineers know anything back then? Why did they build with such a large safety margin?

$ Contractors usually don=t follow designs very carefully. Design engineers blame the construction people, the construction people blame the fabricators. When pavement fails, you get a flat tire. When a bridge fails, you get a disaster. They purposely cranked in a very large margin of safety. We are giving up only 10 percent of the factor of safety.

I appreciate your efforts to look at all of the agency costs. Clearly, there are shipper costs that you are not looking at. Will we get a chance to look at your methodology to identify benefits?

$ The shipper impacts will show benefits through lower costs to the shippers who choose to move to the new truck configurations.

I=m concerned about cutting into the safety factor. The safety factor was made large so we wouldn=t have to rebuild bridges every time trucks get larger. And they have been getting larger the last 50 years. If bridges are overstressed, they have to strengthen it, which has been done, or replace it if you have to. There=s enough safety factor for the kind of increases we=re talking about. We talking about total load, not a concentrated load. This got a little confusing about replacing a lot of bridges. I don=t see that happening.

$ When Volume III is issued you will the numbers of bridges and costs. You will get that soon.

There=s a lot of talk about replacing bridges, and I assume you are talking about off (own?) systems structures beyond the Interstates and other roads system. That=s the problem we are going to have in our State. We have about 17,000 off system bridges. I would classify that as a Third World country.

$ It depends on the scenario. If the scenario lets larger trucks on these local road bridges, then we have to analyze them. If the scenario only allows them on the NHS, then we only analyze those bridges on the NHS. There=s been a lot of talk about where they will be allowed. If they are allowed everywhere, then we have to go to those Third World country bridges and look at the cost of replacing them.

When you start looking at the factor of safety, we can handle an LCV on our system structures. When you go off system the factor of safety is often way below one. We probably lose between one and three bridges a year.

$ Our analysis will show that. If you are doing a good job in Texas on your ratings, you probably have H8 or H6 rated bridges. Our model will kick them out.

$ The scenarios we chose were illustrative. They were selected by FHWA, FRA, and the rest of the department. We could have selected more, but we selected those to have a range.

$ If the truck operates under permit or access provisions on any highway, then that bridge was tested.

$	The bridges you are speaking of would kick out on the base case. That bridge should be replaced for the existing fleet. The cost of replacing that bridge would not be attributable to the scenario vehicles.

Where do you tie in that factor of safety? It=s that factor of safety that lets people in our rural and urban areas get home at night. If you get behind a garbage truck with too much weight on its axles, you may not get home at night.

$	That=s a problem that wouldn=t show up on our scenarios, but it=s a problem for Texas DOT.

SESSION 5
IMPLICATIONS CONCERNING ROADWAY GEOMETRY LIMITATIONS

Presented by:	**Panelist:**
William Glauz Principal Advisor Engineering & Materials Sciences Department Midwest Research Institute	**Phil Blow** Transportation Specialist, Industry & Economic Analysis Team Office of Policy Development Federal Highway Administration

Objectives

The objectives of this study were to examine what impact the new truck configurations would have on the geometric elements of the current roadway system, determine what geometric improvements are needed to accommodate these new trucks, and estimate the costs of these improvements. The focus of this research was to compare the new truck configurations with common, existing large trucks and not with automobiles.

The baseline trucks used for this study were the standard tractor-semitrailer combination (48-foot trailer)Cthe 3-S2Cwith an 80,000-pound operating weight and the western twin combination with two 28-foot trailersCthe 2-S1-2Coperating at 80,000 pounds. The study identified 89 truck configurations by specific body type, specified set of axle spacings, and one of 15 basic configurations. They were assigned to 11 highway cost allocation classes.

15 Basic Configurations

$ 3-axle Single Unit Truck	$ 3-S1-2 Western Twin (6-axles)
$ 4-axle SU Truck with twin steer axles	$ 3-S2-2 Western Twin (7-axles)
$ 4-axle SU Truck with three drive axles	$ 3-S2-2 Rocky Mountain Double (7-axles)
$ 3-S2 Tractor-Semitrailer	$ 3-S3-2 Rocky Mountain Double (8-axles)
$ 3-S3 Tractor-Semitrailer	$ 3-S3-2 B-Train Double (8-axles)
$ 3-2(F) SU Truck with 2-axle full trailer	$ 3-S2-4 Turnpike Double (9-axles)
$ 3-4(F) SU Truck with 4-axle full trailer	$ 2-S1-2-2 Triple (7-axles)
$ 2-S1-2 (5-axle) Western Twin	

Researchers looked at four truck operating issuesCspeed maintenance and acceleration on grades, braking, passing on two-lane highways, and offtrackingCthat could impact road geometry.

Speed Maintenance and Acceleration

Grade data. The team utilized the Highway Performance Monitoring System to examine highway grade data for the 48 continental States, excluding Hawaii and Alaska. The team divided the country into five regionsCNortheast, Southeast, Midwest, West, and CaliforniaCand highway typesCrural freeway, rural multilane, rural two-lane, urban freeway, and urban arterials.

Summary of Grade Data

Grade %	**0 - 0.4**	**0.5 - 2.4**	**2.5 - 4.4**	**4.5 - 6.4**	**> 6.4**
Mileage (000)	64.7	47.4	15.2	4.6	1.2
Percentage	48.6	35.6	11.4	3.4	0.9

Most of the highway system is flat. Grades from 4 percent to 6 percent are of the most concern to trucks. Grades of 6 percent or more are found in only 7 States.

State requirements. As part of the research, the team looked at current State requirements regarding trucks on grades. U.S. DOT has compiled this information State-by-State. They include:

- $ Idaho and North Dakota require trucks to maintain a 15-mile-an-hour minimum speed under normal traffic conditions;
- $ Nine States require trucks to maintain a 20-mile-an-hour minimum speed;
- $ Five States require trucks to maintain a 40-mile-an-hour minimum speed; and
- $ Indiana requires trucks to maintain a 45-mile-an-hour minimum speed.

Alaska (which was not included in the study) require trucks to have at least a 400 horsepower engine. Michigan requires large trucks to have no more than 400 pounds per horsepower.

Industry experience. Fleet owners who operate large trucks (mostly in the West), were asked about their experience with combination vehicles. They said they purchase trucks with large enough engines that allow drivers to maintain reasonable and cost efficient speed. Tractor manufacturers say trucking companies and individual drivers want and buy trucks with very large engines. Engine manufacturers build engines with up to 550 horsepower. One manufacturer now offers a new 600 horsepower engine. Over the past 20 to 30 years, trucks have gotten heavier. Engine power has grown at a more rapid rate than the weight. Trucks today maintain speed and accelerate better than they ever have.

Gradeability and horsepower. Simply speaking, the power needed to move a truck up a grade is a function of the truck=s gross vehicle weight, speed, and the grade of the highway. Other factors, such as the aerodynamic drag of the truck, also affect the power needed to move a truck up a grade. Engine torque is a primary consideration when a purchaser considers which truck to buy.

Startability. What is required to start a truck moving from a standstill. The problem is wheel spinning. In the formula At $\leq$ N * f@, At@, the tractive force, can be no greater than the weight on the axle (N) times the coefficient of friction (f). The coefficient of friction is high on dry pavement, but decreases in snow, ice, or rain conditions to the point where the wheels start spinning. The weight allowed on a tandem driving axle is 34,000 pounds. On a single driving axle, the limit is 20,000 pounds. Twin and triple trailer combinations have a problem if they stop on a snow-covered road. They may not be able to start moving again. Colorado has specially built tractors to push these trucks if they have this problem. Aside from startability, maintaining speed and acceleration are not issues for twin and triple trailer combinations because those units already on the road have enough engine power to keep up with other traffic.

Braking. How is braking on larger combination vehicles when compared to the baseline trucks? Braking can be represented by the formula Af_r = f_p * TF * BE * CE.@ F_r is rolling friction, f_p is peak friction, TF is the tire tread depth factor, BE is the braking efficiency (0.55 to 1.00), and CE is the driver control efficiency (~ 0.62). The peak friction coefficient for a truck tire is lower than that for an automobile because the truck tire is manufactured using a rubber composition designed for longer life than car tires. As tire tread wears down, there is a lower friction coefficient.

Braking efficiency is determined by how braking is balanced among the different axles of the truck. If it is balanced perfectly, the efficiency is A1.@ If the braking is unbalanced or the load on the truck forces some axles to brake more than others, then the braking efficiency is lowered. Driver control efficiency is a measure of how well the driver uses his brakes. Braking a large truck is a complicated and difficult process compared to braking a car. Driver experience plays a large role in how well the brakes on a truck are used. Tests have shown that most drivers use about half of the capability of their brakes.

Many things can happen when brakes aren=t functioning properly. An experienced driver can compensate (letting up on the brakes or making steering corrections) in some instances when brakes lock up, but in the case of a truck jackknifing, the driver has lost control of the truck, and there is nothing he can do. Antilock brakes prevent axles from locking up; law requires all trucks to have them.

Braking

Braking capability depends on the number of braked axles. If a truck is uniformly loaded to its full weight capacity, full braking will not lock up any axles. Problems of skidding occur when the truck is not carrying a full load or the load is unbalanced. Tests have shown that multiple trailers add braking stability. There is less tendency for the truck to skid or move out of its lane. The rear trailer acts like an anchor and holds the truck in line. Triples brake better than doubles.

On wet roads, the front tires splash water out of the truck=s pathCthe squeegee effectCand create a somewhat drier surface for the rear axles to brake. That adds to braking capability. Research shows that the longer combination vehicles, especially triples, brake as well, and possibly better, than the tractor-semitrailer units. Antilock braking systems will do away with loss of control problems. Engine brakes and retarders, a valving change, allow the engine to provide braking drag for the truck. This function is used quite a bit in the mountainous States. Engine brakes only act on the driving axle, which may not be a big advantage in a seven-axle triple combination.

Passing Maneuvers

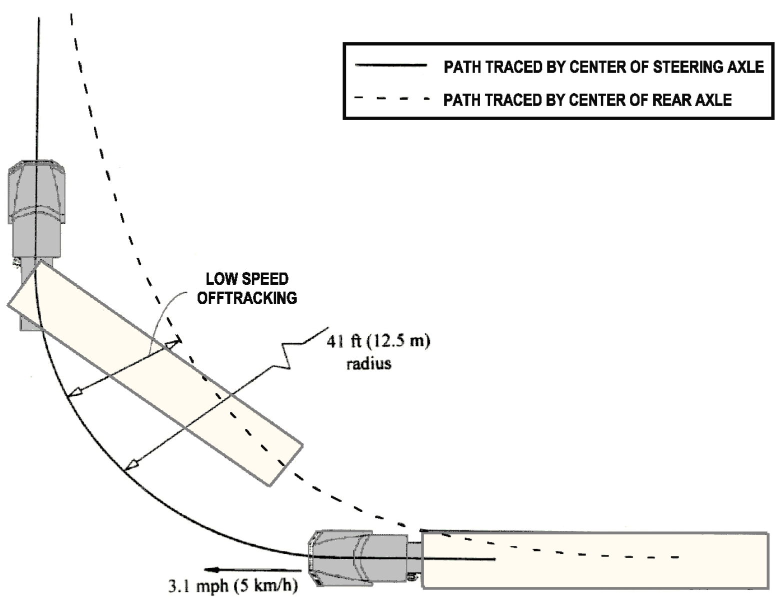
The researchers looked at cars passing trucks and trucks passing cars. The important issues for trucks in passing maneuvers are the length of the truck (the longer the truck the greater distance it takes to pass or be passed by another vehicle), the power to weight ratio (how fast can the truck accelerate?), and the maximum speed capability (many fleet owners put governors on their truck engines to enhance fuel economy).

Passing/no passing zones are marked based on sight distance criteria (how far ahead can a driver see an oncoming vehicle) and are based on cars passing cars (designed for the most part for 1930s era cars and have not been updated since then). Passing zones are marked based on passenger car considerations and do not take into consideration trucks of any kind. Longer combination vehicles are less able to pass other vehicles than baseline trucks. All trucks (and cars) must use discretion in passing. Longer combination vehicles shouldn=t change road geometrics in this instance.

Offtracking

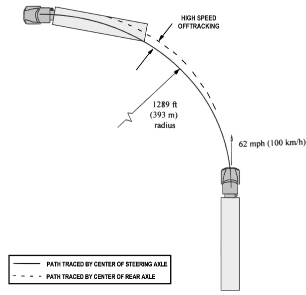
While the acceleration, braking, and passing ability of longer combination vehicles will require no changes in existing road geometrics, the offtracking characteristics of the larger trucks are markedly different than existing trucks on the road. The researchers looked at the low-speed and high-speed offtracking and swept path width of the longer combination vehicles.

Low Speed Offtracking



High Speed Offtracking

Implications Concerning Roadway Geometry Limitations



The lines show the drive path of each truck axle. The distance of the radial difference of each axle drive path is defined as offtracking. For the purposes of this study, researchers examined the maximum value of these distances. The difference between the arc followed by the front left corner of the truck and the arc followed by the right rear corner is called the swept pathCthe amount of roadway space the truck needs to make the turn without hitting something.

Three models were used. At low speeds (the speed a truck travels making a right turn after stopping at an intersection), the truck=s offtracking increases to a maximum before decreasing as the truck straightens. Fully developed offtracking occurs when a truck reaches a maximum offtracking distance on broad curves or in large turning maneuvers and stays in that position. In situations where the outside curve of a highway is Asuperelevated@(higher than the inside curve) the offtracking increases at low speeds. In high-speed offtracking, as the truck negotiates a curve at highway speeds, the back end of the trailer tends to swing outward. It=s low-speed offtracking adding the outward swing to get the total. High-speed offtracking is dependent on the truck=s speed and suspension and the superelevation of the road.

These models were applied to a series of highway curves designed to American Association of Highway and Traffic Officials (AASHTO) standards, which prescribes a minimum radius for a given design speed. Tests were conducted using minimum radii at 30, 40, 50, 60 and 70 miles per hour design speeds. For each of the test vehicles, the high-speed offtracking was calculated at each of the design speeds and the low-speed offtracking that the truck might encounter during rush hour congestion. The offtracking would be acceptable if the swept path was less than the AASHTO-approved lane width (12 feet or wider). For high-speed offtracking on highway curves, all of the longer combination vehicles can maintain their lane position. For low-speed offtracking, all of the test vehicles except Turnpike Doubles passed the test.

The research team examined the swept path width of the test vehicles to see if they could make a right-hand turn without encroaching on the oncoming traffic lane or the curb. The test was conducted on four-lane roads only because two-lane roads do not accommodate baseline trucks without violating the encroachment criteria. On a two-lane road, a tractor with a 48-foot trailer must use the oncoming traffic lane to negotiate a right-hand turn. If the trucks were in the left lane when they made their turn, they were allowed to encroach upon the right lane. All of the study vehicles were tested on curb radii of 30, 40, 60, 80, and 100 feet. Tests showed that 12 of the 64 study vehicles offtrack more than the baseline 48-foot tractor trailer unit. In the order of offtracking:

$ B-train double with two 33-foot trailers (barely more than the baseline truck);
$ Triples with 30-foot trailers (barely more than the baseline truck);
$ 3-S2 and 3-S3 with 53-foot semitrailer (with axles at the back of the trailer);
$ 3-S2 and 3-S3 with 57.5-foot semitrailer (with axles at the back of the trailer);
$ Rocky Mountain double with 48- and 28-foot trailers, and with 53-foot and 28-foot trailers;
$ Turnpike doubles with 42-, 48-, and 53-foot trailers.

Roadway Geometrics

The four roadway geometric elements critical to accommodating truck offtracking are mainline horizontal curves, horizontal curves on ramps, curb return radii for at-grade ramp terminals, and curb return radii for at-grade intersections. Data on the dimensions of these elements were collected for a sample of roadways in two States in each of five regions: Northeast (New York and Pennsylvania), Southeast (Florida and Tennessee), Midwest (Illinois and Missouri), West (Kansas and Washington) and California. Looking at the five highway types in the sample States, researchers determined the mainline curve radii from the Highway Performance Monitoring System (HPMS) data. Where the HPMS data was not available, the sample States provided existing aerial photographs and as-built plans on ramp curve and curb return radii at ramp terminals and intersections.

The research team sampled roughly 25 rural interchanges, 25 urban interchanges, 25 rural at-grade intersections, and 25 urban at-grade intersections in each of the sample States. Each of the locations were chosen because they carried substantial truck traffic. The data collection included gathering the radius of each horizontal curve and curb return for right turns. The team estimated the feasibility (just add a little more pavement), moderate difficulty, or extreme difficulty (requiring major construction or demolition of existing structures) of widening each radius. The sample data was expanded to the National Truck Network. Estimates were made for the number or mileage of locations that need improvement and the amount and cost of widening for each truck that offtracks more than the baseline tractor with a 48-foot semitrailer and for each roadway type and geographic region.

The amount of widening was based on the offtracking of the specific trucks. For horizontal curves and ramps, the team decided that no encroachment of shoulders or adjacent lanes would be allowed. For intersections and ramp terminals, the team decided that trucks could not encroach upon shoulders, curbs, opposing lanes, or more than one same direction lane.

Implications Concerning Roadway Geometry Limitations

The cost of widening some existing highway features is generally required even for the baseline truck. There are bridges and highway curves that cannot accommodate existing trucks. What is the cost of widening these facilities to accommodate the baseline truck? The cost of widening for larger truck types is based on the amount by which the cost exceeds the estimate for the baseline vehicle. The FHWA 1993 HPMS Needs Analysis provided the cost data.

If the worst offtracking trucksCthe turnpike doubles and the Rocky Mountain doublesCwere allowed to go everywhere in the truck network, including urban areas, the costs to widen highways to accommodate them could be huge. The concept of staging areasClarge parking lotsCwas developed, and would be used by truck drivers who pull in and decouple their trailers. Staging areas are assumed to exist at key rural interchanges and the fringes of major urban areas.

Researchers studied how often staging areas would be used, where they would be located, and what they would cost. On rural freeways, staging areas would be needed every 15.6 miles. On non-freeway rural highways, staging areas would be needed about every 50 miles. Trucks with trip origins or destinations in an urban area would use urban fringe staging areas. Through trucks would use the Interstate or other freeway systems to their destination. Depending on the truck type, between 250 and 1,000 staging areas would be needed to service the 125 largest urban areas in the Nation, research showed. Building the staging areas would reduce improvement costs for local access interchanges and arterial streets in urban areas.

Cost Estimation Model

A cost estimation model was developed to calculate the cost of geometric improvements for any specified highway network and longer combination vehicles. The model can estimate costs for geometric improvements for scenarios defined by truck configuration and offtracking performance, roadway mileage on network by roadway type and region of the country, staging area costs (if appropriate), and reduced geometric improvement costs if staging areas were provided.

Conclusions

Many truck characteristics were examined for their potential to impact roadway geometrics. Only offtracking is likely to impact roadway geometrics. Costs of geometric improvements to the roadway required to accommodate increased offtracking can be determined with a cost estimation model.

QUESTION and ANSWERS

Where did you get the figure for the B-train double 33-foot trailers?

$ We worked with Roaduser International on developing a number of truck scenarios. That was the one we picked. I don=t know if there are any of those in existence right now.

$ John Woodrooffe developed dimension information on axle spacings for these configurations. He provided this information to Midwestern Research Institute.

Did you speak to bridge formula to make them that long?

$ No, it was a consideration of vehicle stability. Shorter trailers are more unstable. Small increases in trailer length in this range dramatically improves their dynamic road stability. That, tied with greater cubed capacity and its offtracking characteristics, make the B-train a very stable configuration.

$ That type of truck is used mostly in Canada. They are used for their gross vehicle weight more than their cubed capacity. They get up to 100,000 pounds.

We don=t use the double 33-footers.

$ I don=t know whether the biggest trailer being used in Michigan, where they use some B-trains, is the 33-foot trailer or not. They are probably shorter.

How does the methodology handle the economic cost issues presented by staging areas? How do staging areas feed into the overall efficiency of the system and shippers costs?

$ It doesn=t directly in terms of what we did. We looked at one aspect, which has to be combined with pavement, bridge, and safety considerations. FHWA is putting these things together to develop the full picture.

What happens to braking distances when you increase the mass of a truck?

$ The additional axles have brakes. You add more brakes, and you get more braking capability. The added mass isn=t a problem.

The triple trailer with nine axles is a non-existent system at this point. Triples with three 30-foot trailers, aren=t allowed anywhere that I am aware of. One of the earlier presentations talked about a triple at 132,000 pounds, which may be allowed by bridge formula, but doesn=t generally exist. Why are these vehicles showing up in your studies?

$ Some of these are hypothetical, future vehicles. Current triples can go up to 132,000 pounds if allowed by the State but this would exceed the bridge formula.

Not with seven axles you can=t.

$ Yes.

$ We looked at 30-foot trailers because there are a couple of States that allow twin 30-foot trailers on doubles. We looked at pup trailers at 28 and 30 feet. Many truck configurations were looked at, more than are currently on the road. Earlier in the study we looked at many configurations that we later rejected as not performing well in terms of stability and control or not being very practical. As the modeling got more difficult, particularly in terms of diversion modeling and capabilities of that model became more limited in the number of vehicles we could consider, our set of test vehicles got much smaller. What we have selected for our evaluations is the sum of the axle weight limits. A 7-axle triple has 6 axles bearing 20,000 pounds and a steering axle which can bear 12,000 pounds, which adds up to 132,000 pounds.

$ Companies that run triples now, where they are allowed, typically carry 105,000 to 115,000 pounds but do not approach 132,000 pounds.

When you talked about rail diversion, we used 53-foot trailers with 28-foot pups. On the offtracking study, you used 48-foot trailers as the baseline. Are we looking at a worse case scenario? Is there a way to bring the two together, either use 48-foot trailers for the diversion or 53-foot trailers for the baseline?

$ The 53-foot trailer would be the longest one to be allowed. This work began early. At that time the research team looked at the 48-foot trailer as the baseline vehicle. The two have the same offtracking characteristic if both have a 41-foot kingpin setting. Later on, we chose to analyze the diversion model using the maximum cubes and the maximum weights.

$ If the baseline is any different in each of the impact areas, we should state why we do so.

Implications Concerning Roadway Geometry Limitations

To follow up on the issue of hypothetical vehicles and the geometrics and costs associated with them, are we going to look at cost data associated with these vehicles?

$ Yes. That will be a portion of Volume 3.

Implications Concerning Roadway Geometry Limitations

Is exit ramp rollover one of your criteria?

$ That may be covered tomorrow. To add to the 48-foot question, we chose that configuration because the STAA mandates that no State can deny 48-foot trailers on the National Network. They are everywhere. The 53-foot trailers are becoming more common, but they are not Federally mandated.

You are looking at geometric impacts of these vehicles going around corners. Are you looking at the operating costs of the LCVs sitting behind a vehicle that it is trying to pass and delaying traffic behind it, or the delays of an LCV trying to change to a left lane for a right-hand turn on a four-lane highway?

$ Delay at intersections. It hasn=t been calculated or estimated.

You said the 48-foot trailers aren=t currently handled on the 2-lane highway system. In Wisconsin, they are.

$ If there=s an intersection with two, two-lane roads, the 48-foot semitrailer, cannot negotiate that turn without going into the other lanes.

That=s not the way we designed our intersections.

$ Obviously, if you put in a 300-foot radius, then you could negotiate that type of turn. I=m familiar with research done in Wisconsin which collected data on trucks trying to negotiate those kind of curves.

The bottom line, is, then, if we go to longer than a 48-foot trailer, the highway system can=t handle these trailers. We=re going to have to absorb the cost. That=s not figured into this analysis.

$ It=s a matter of deciding which roads you=re going to allow the larger combinations to operate on.

$ The study doesn=t focus on who will absorb costs. It simply says what might be the costs for a scenario vehicle. The study doesn=t say that a State or anyone else will have to absorb the costs.

Do you take into account that ISTEA allowed the States to develop their own design standards and that many States have taken advantage of that flexibility? Also, the AASHTO geometrics that you are dealing with may not be the standard, which may add additional costs to the States. We already have an encroachment problem with the 48-foot trailers on two-lane highways. The longer vehicle increases the safety problem and will

increase the encroachment and the traffic tie-ups that follow.

$ That=s a good point. Yes, we did think about that. There are roads that have been modified, widened, beyond what AASHTO requires. We couldn=t measure every road. We were dealing with aerial photography. We assumed that roads met minimum AASHTO requirements.

SESSION 6
SAFETY IMPACT

Presented by:	**Panelist:**
Robert Clarke Chief, Safety Division Office of the Assistant Secretary for Transportation Policy U.S. Department of Transportation	**Phil Blow** Transportation Specialist Industry and Economic Analysis Team Office of Policy Development Federal Highway Administration **John Woodrooffe** Managing Director Roaduser Research Canada, Inc. **Ken Campbell** Director, Center for National Truck Statistics Transportation Research Institute University of Michigan

Over the years there have been a number of ways by which the safety performance of trucksCparticularly heavy trucksChave been judged. One major way is accident data analysisClooking at the safety history of different size vehicles. Also, over the past 10 to 15 years, the study of vehicle dynamics (stability and control) and comparative analyses of how different vehicles operate in traffic have grown in importance.

VEHICLES INVOLVED IN ALL CRASHES 1995

Vehicle Type	Number	Percent of Total
Passenger Cars	8,159,000	69.1
Light Trucks/Vans/Sport Utilities	3,136,000	26.6
Medium/Heavy Trucks	376,000	3.2
Combination-Units	204,000	1.7
Single Unit	172,000	1.5
Others*	136,000	1.1
Total	**11,808,000**	**100.0**

Source: GES, 1995; * Buses, motorcycles, emergency, equipment, etc.

Over the past 10 years, heavy trucks in general have gotten safer. Heavy and medium weight trucks (10,000 pounds and above) were involved in 3.2 percent of all vehicle crashes in the United States in 1995. This proportion has been relatively constant over the last 10 or 15 years. The overall number of heavy/medium truck accidents has dropped.

VEHICLES INVOLVED IN FATAL CRASHES 1995

Vehicle Type	Number	Percent of Total
Passenger Cars	30,940	54.7
Light Trucks/Vans/Sport Utilities	17,587	31.1
Medium/Heavy Trucks	4,472	7.9
Combination-Units	3,319	5.9
Single Trailer	2,973	5.3
Multiple Trailers	162	0.3
Bobtail (tractor w/o trailer)	184	0.3
Single Unit	1,153	2.0
2 Axles	718	1.2
3 or More Axles	435	0.8
Others*	3,525	6.2
Total	**56,524**	**100.0**

Source: FARS, 1995; * Buses, motorcycles, emergency, equipment, etc.

In the case of fatal accidents, heavy and medium trucks were involved in nearly 8 percent of all fatal crashes in 1995. In the late 1980s, the proportion was 12 percent. Comparing different configurations, combination units were involved in nearly three times the number of fatal accidents as single unit trucks (3,319 versus 1,153). Longer combination vehicles tend to average five times the number of vehicle miles traveled annually as single unit trucks. The larger trucks generally operate at higher speeds. When larger trucks are involved in a crash, it tends to be more severe. Single trailer combination trucks were involved in more fatal crashes (2,973) in 1995 than any other heavy/medium configuration.

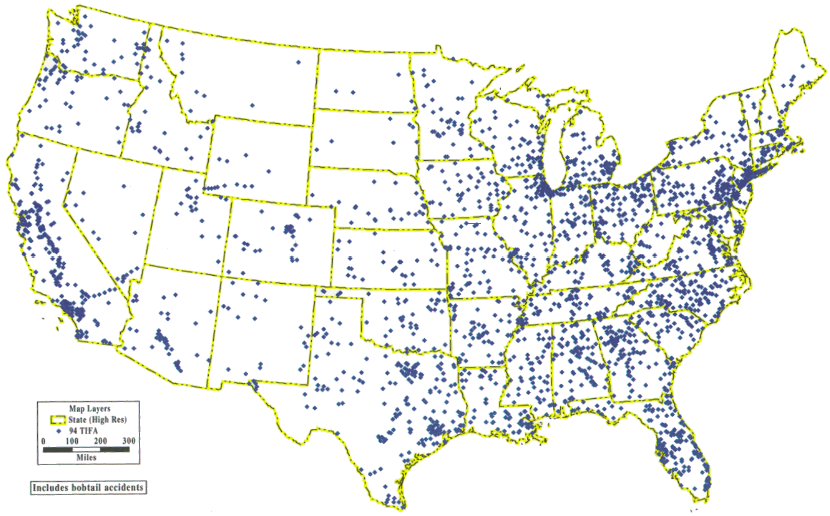
FATALITIES AND INJURIES IN MEDIUM HEAVY TRUCK CRASHES 1995

Trauma Outcome	Occupant of Other Vehicle Involved in Collision	Truck Occupant	Pedestrian, Cyclist, Other	TOTAL
Fatalities	3,835	644	424	4,903
Injuries	83,000	30,000	6,000	119,000

Source: GES, 1995; * Buses, motorcycles, emergency, equipment, etc.

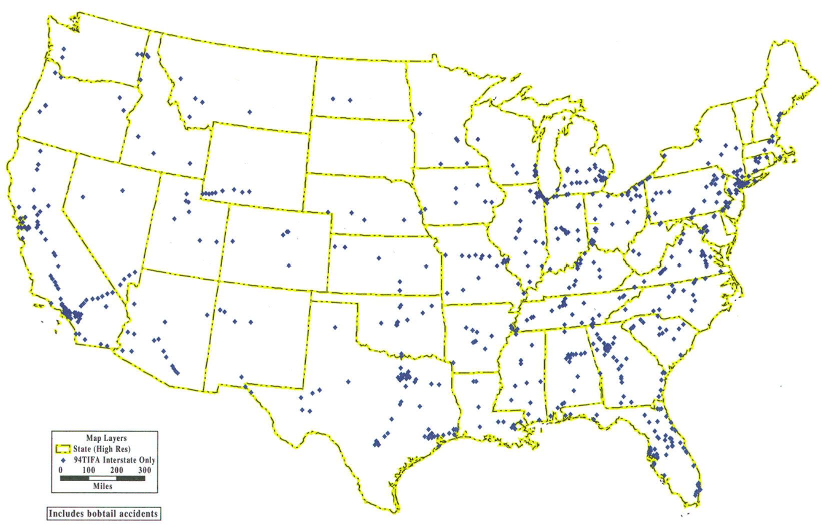
As one might expect, the occupants of smaller, lighter vehicles tend to suffer more injuries and deaths in collisions with medium/heavy weight trucks. Truck safety is really a car (and pedestrian) safety issue. On the bright side, over the past 10 years, truck occupant fatalities have dropped from more than 1,100 in the late 1980s to 644 in 1995. There have been significant safety improvements incorporated into truck designCfor instance, better seat belt systems. Seat belt usage by truck drivers has increased markedly over the past decade. This is reflected in the reduction in truck occupant deaths.

TRUCKS INVOLVED IN FATAL ACCIDENTS ON ALL ROADWAYS IN 1994

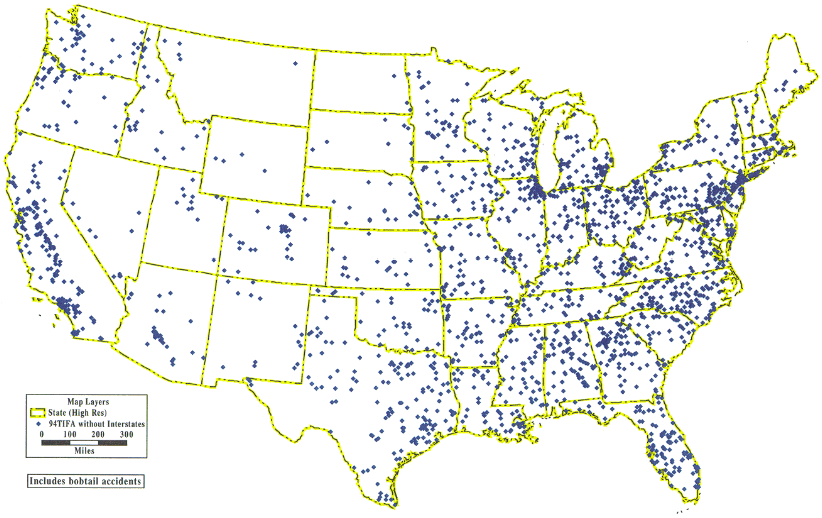


As this map shows, the bulk of the fatal accidents involving trucks take place in the East where most of the population is centered. It is interesting to note that in the West, outside California and Texas, where most longer combination vehicles operate, the accident rate is lower than in the East. There is a very heavy East/West split.

TRUCKS INVOLVED IN FATAL ACCIDENTS ON INTERSTATES IN 1994



TRUCKS INVOLVED IN FATAL ACCIDENTS ON NON-INTERSTATE ROADS



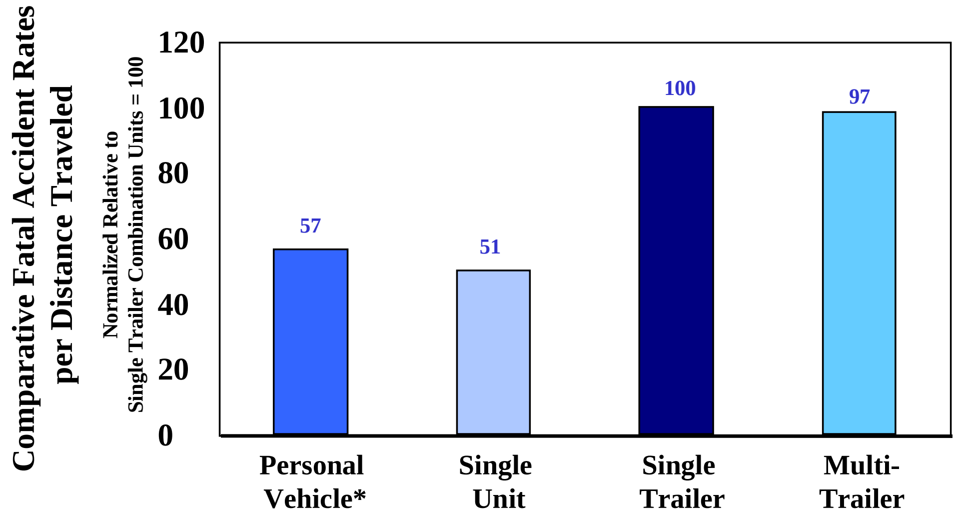
Comparing these two maps, it becomes apparent that the Interstate systemCwhich was designed to be very safeCis much safer than lower quality, smaller roads. Smaller roads with at-grade intersections and undivided lanes present a risky operating environment for larger trucks.

U.S. REGIONAL DIFFERENCES

	Western 2/3's of United States	Eastern 1/3 of United States
% of All Larger Truck Travel (1991-1995)	32%	68%
% of Nation's Highway Miles (1995)	39%	61%
% of All Fatal Truck Crashes (1991-1995)	28%	72%
Truck Fatal Crash Rates (per 100 VMT)	2.12	2.57 (+17.5%)

Highway Cost Allocation Study data shows 17.5 percent more fatal crashes per miles traveled occur in the East than in the West. Statistical analysis shows 72 percent of fatal truck crashes happen in the eastern third of the country.

FATAL CRASH RATES PERSONAL VEHICLES AND HEAVY TRUCKS



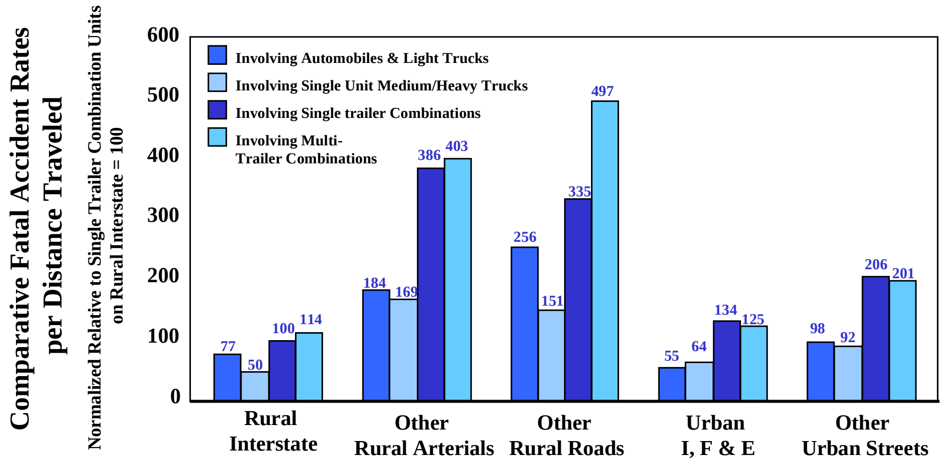
* Includes automobiles, light trucks, and sport utility vehicles.
Source: FARS 1991-1995 (crash data), HCAS, 1997 (travel data)

Dividing all fatal accidents by all miles traveled (normalizing on single trailers being 100) produces the above comparative accident rates for personal vehicles (automobiles, light trucks, and sport utility vehicles), single unit trucks, and multitrailer combinations. It has been widely reported over the years that multitrailer combinations in general are safer than single trailer combination vehicles.

For the sake of this discussion, multitrailer combination trucks have been used as a surrogate for longer, heavier trucks because there are very few longer combination vehicles operating across the country, and there are very little accident and exposure data on them. This makes it difficult to compute comparable rates. There are only 2,500 to 4,000 longer combination vehicles operating in this country. Many longer combination vehicles are multitrailer vehicles and handle and operate in similar ways. The STAA twin 28-foot double is the most prolific multitrailer combination on the road today and will serve as the discussion vehicle.

FATAL CRASH RATES PERSONAL VEHICLES AND MEDIUM/HEAVY TRUCKS BY ROADWAY FUNCTION CLASS

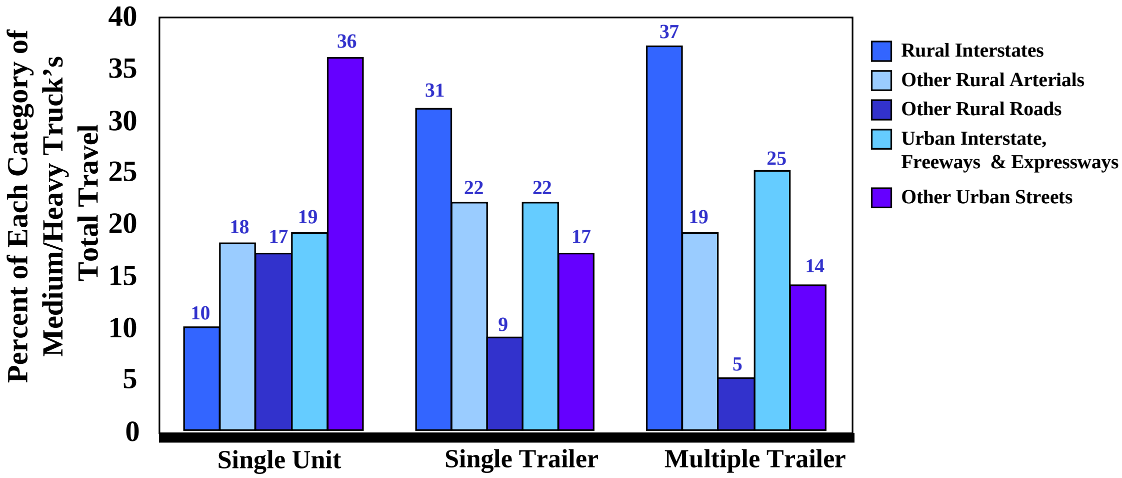
Safety Impact



Source: FARS 1991-1995 (crash data), HCAS, 1997 (travel data)

In this chart, the rates for all vehicles have been normalized (100) relative to single trailer combinations traveling on rural interstates. Travel on the Interstate system for all vehicles is much safer than it is on other types of roads. When compared to single unit medium/heavy trucks, multitrailer combinations and single trailer combination trucks suffer two to three times as many accidents on rural roads, which is where most of these trucks= VMT will travel.

DISTRIBUTION OF TRUCK TRAVEL SINGLE UNIT AND SINGLE AND MULTIPLE TRAILER COMBINATIONS



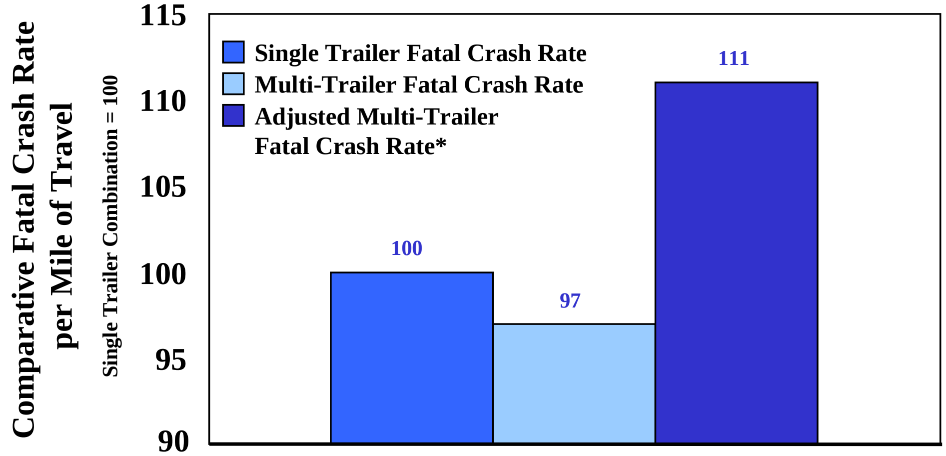
Source: Highway Cost Allocation Study, 1997
* based on distribution estimates for 1994.

Multitrailer and single trailer combination trucks spend most of their travel time on rural

Safety Impact

Interstate HighwaysC37 percent and 31 percent respectively. These trucks accumulate the highest relative percentage of fatal accidents on rural Interstate Highways, the safest roads. The team has attempted to even out operating environment differences between single unit heavy trucks and multitrailer vehicles.

NORMALIZED AND ADJUSTED FATAL CRASH RATES SINGLE AND MULTITRAILER COMBINATION TRUCKS



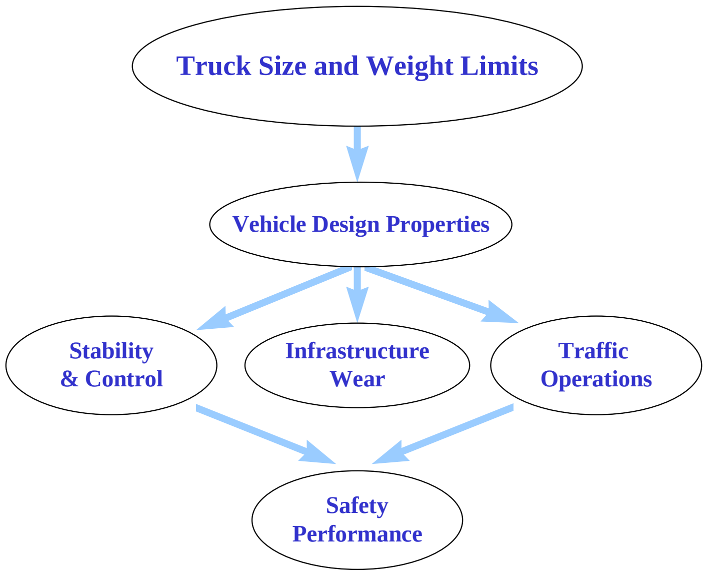
*** The adjusted multi-trailer fatal crash rate was computed by applying the single trailer VMT distribution by highway classification to the multi-trailer VMT, multiplying the resultant by multi-trailer rates and then deriving an adjusted number of multi-trailer of fatal crashes.**

By applying these mileage distribution patterns to comparative fatal crash rates (single trailers versus multitrailers), analysis shows that the multitrailer crash rate is 11 percent higher than the single trailer fatal crash rate when roadway differences are factored out.

Analysis shows that the roadway and operating environment is a critical risk factor. Shifting any truck traffic off Interstate highways significantly increases crash risks. Increasing traffic density significantly increases the opportunity for accidents. Aggregated data masks subtle differences among configurations.

Crashes are caused by a number of factors: driver behavior, performance and skill level, vehicle design and condition (the Truck Size and Weight Study is about changing truck designs), roadway design and condition, weather and light conditions, motor carrier management practices, and institutional issues (enforcement technique, size and weight policy, and so forth).

TRUCK SIZE AND WEIGHT LIMITS



Truck size and weight policy dictates truck design in many instances. It dictates numbers of axles, wheelbases, overall lengths, allowable numbers of trailers in combinations, drawbar loads, axle loads, and overall weights. Vehicle design influences handling and stability properties, traffic operations, infrastructure wear. Stability and traffic operations effect safety performance.

There have been a number of vehicle performance metrics developed over recent years. They are dynamic performance tests and analytic techniques designed to measure a truck's ability to stay on its wheels. Static roll stability, the measure of a truck's ability to make a steady-state or sweeping turn (for instance on a freeway exit) without rolling over, is a primary metric. The cargo center of gravity height is a major determining factor of whether a truck will roll over. Loaded trucks, not empty trucks, roll over. The higher the cargo center of gravity, the greater the chance the truck will roll over.

Evasive maneuvering stability, the truck's ability to swerve at high speeds to avoid unanticipated accident threats, is another major performance metric. This is primarily an issue for multiple trailer combinations, and less so for single trailer combinations. It is also an issue for very short wheelbase single unit trucks. The truck's ability to avoid obstacles becomes a greater issue when the truck is traveling at highway speeds (40 miles per hour and above) than at low speeds. As the truck abruptly changes lanes to avoid an obstacle, the lateral acceleration is amplified as the truck moves left and then right. Under these conditions, the rear trailers can either skid out of their lane, or if the lateral acceleration is excessive, the rear trailers can roll over. There are two metrics used to study this phenomena: load transfer ratio and rearward amplification.

Safety Impact

There are other attributes of truck design that can raise safety concerns: low speed offtracking, the ability to negotiate a tight 90 degree left or right turn without encroaching on the inside lane; passing and being passed (primarily a function of length); and hill climbing and acceleration capability.

VEHICLE DESCRIPTIONS AND SPECIFICATIONS

Configuration	Loaded Weight (in pounds)	Number of Axles on Power Unit, Trailer(s)	Box or Trailer Length(s) (in feet)	Number of Articulation Points	Type of Trailer-to-Trailer Hitching
Five-Axle Semitrailer (Baseline Vehicle)	**80,000**	**3,2**	**53**	**1**	**None**
Three-Axle Single-Unit Truck	**54,000**	**3**	**20**	**0**	**None**
Four-Axle Single-Unit Truck	**64,000**	**4**	**25**	**0**	**None**
Six-Axle Semitrailer	**97,000**	**3,3**	**53**	**1**	**None**
Five-Axle A-Train STAA Double	**80,000**	**2,1,2**	**2@28**	**3**	**A-Dolly**
Five-Axle C-Train STAA Double	**80,000**	**2,1,2**	**2@28**	**3**	**C-Dolly**
Seven-Axle Rocky Mountain Double	**120,000**	**3,2,2**	**1@53, 1@28**	**3**	**A-Dolly**
Eight-Axle B-Train Double	**124,000**	**3,3,2**	**2@28**	**2**	**B-Train**
Seven-Axle A-Train Triple	**132,000**	**2,1,2,2**	**3@28**	**5**	**A-Dolly**
Seven-Axle C-Train Triple	**132,000**	**2,1,2,2**	**3@28**	**3**	**C-Dolly**
Nine-Axle Turnpike Double	**148,000**	**3,2,4**	**2@53**	**3**	**A-Dolly**

This table examines the full gamut of vehicle designs and configurations and hitching specifications. The next graph compare the handling stability metrics mentioned above relative to the base line vehicleCthe five-axle tractor semitrailer.

VEHICLE SAFETY PERFORMANCE COMPARISON RELATIVE TO A FIVE-AXLE TRACTOR SEMITRAILER

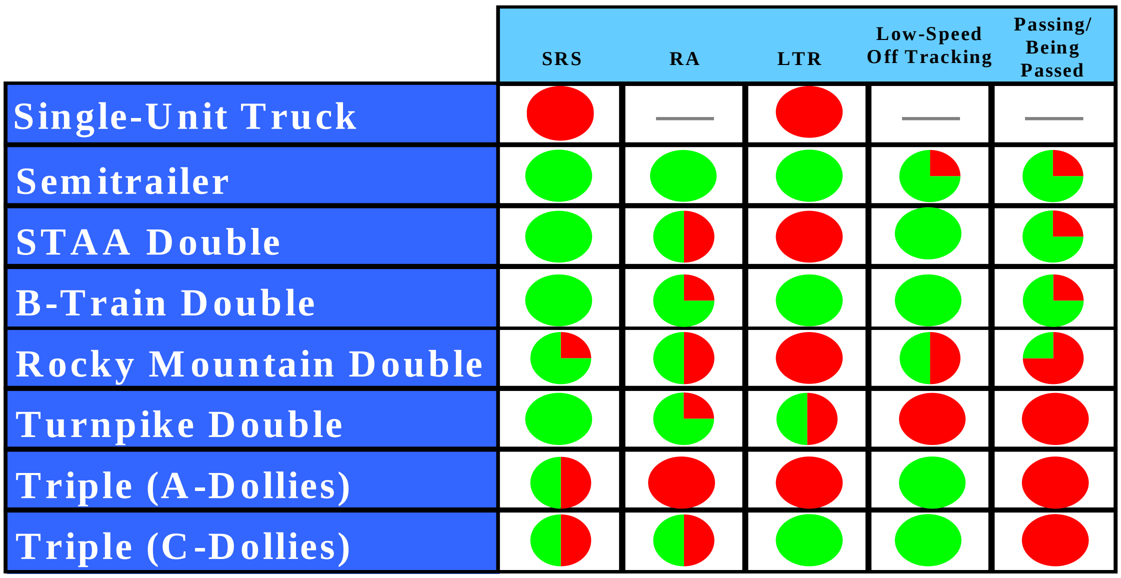
It is important to note that most larger combinations, with notable exceptions, exert less static roll stability than the standard five-axle tractor semitrailer. Oddly enough, a fully loaded three-axle single unit truck at 54,000 pounds exerts nearly 25 percent less stability than the base case truck. In general, the larger trucks operate at a 5 percent to 10 percent worse static roll threshold.

As this chart shows, the longer combination vehicles are more susceptible to rearward amplification than the base case truck. The seven-axle A-train triple trailer combination vehicle is especially susceptible to this phenomena.

Safety Impact

All of these longer combination vehicles do not perform as well as a standard tractor semi-trailer as they now are designed and configured.

<u>COMPARATIVE STABILITY AND CONTROL AND TRAFFIC OPERATIONS PERFORMANCE CHARACTERISTICS OF VARIOUS CONFIGURATIONS</u>

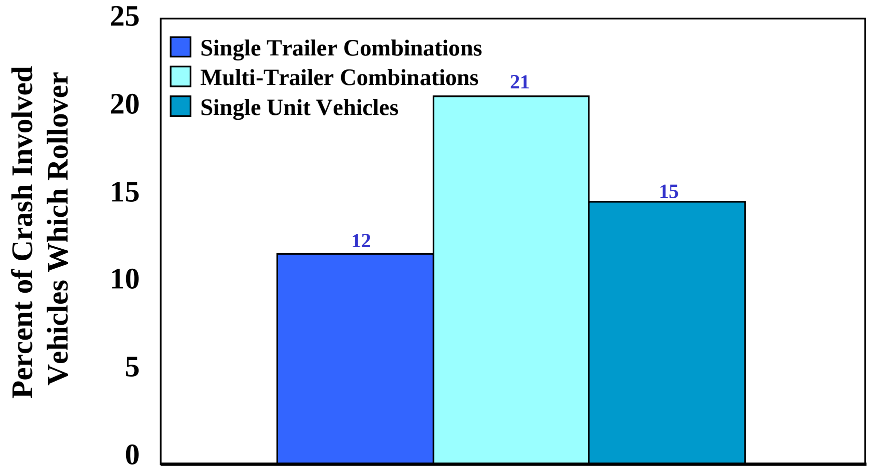


Worse than a 5-axle tractor semitrailer
Better than a 5-axle tractor semitrailer

This Consumer Union chart provides a relative (not scientific) comparison of static roll stability, rearward amplification, and load transfer ratios of different truck configurations versus the base case tractor semitrailer. There are strengths and weaknesses for each configuration.

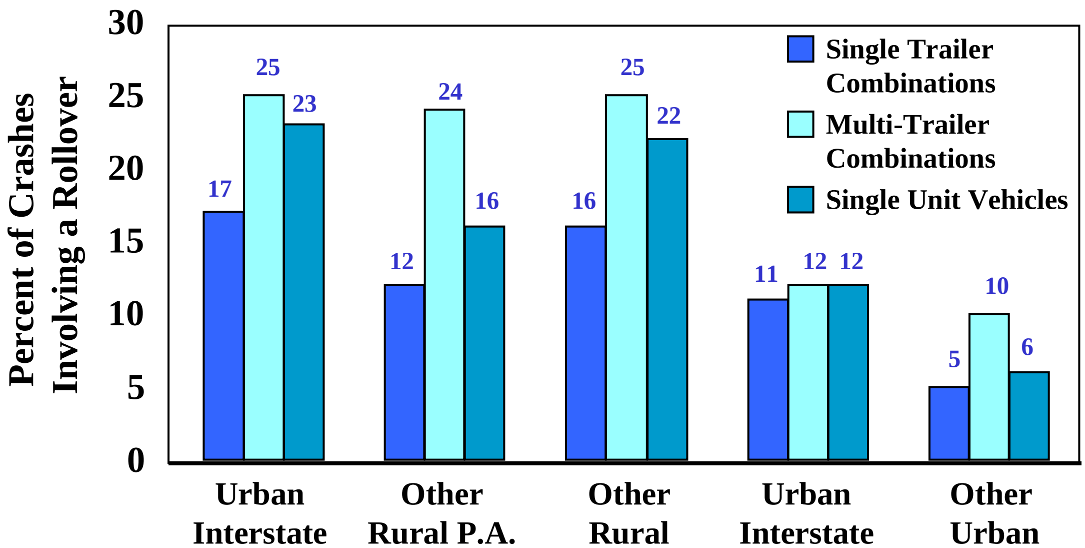
Safety Impact

MEDIUM/HEAVY TRUCK ROLLOVERS IN FATAL CRASHES



There are data that confirm that these handling stability properties do manifest themselves in accidents. This chart illustrates relative proportions of fatal rollover crashes for multitrailer, single trailer and single unit trucks.

MEDIUM/HEAVY TRUCK ROLLOVERS IN FATAL CRASHES BY HIGHWAY FUNCTIONAL CLASSIFICATION



These data confirm the link between handling and stability engineering properties being

Safety Impact

surrogates for safety in the real world. These figures have been used in Canada and throughout the world as a way to judge the relative safety performance of any combination unit vehicle. Efforts to improve handling and stability will translate into safety improvements.

To conclude, current larger/heavier trucks do not perform as well as current tractor semitrailer combinations. Design and configuration changes can minimize and, in some cases, eliminate some of these handling and stability deficiencies.

Traditional strategies to handle larger trucks include prohibiting their use, modifying vehicle design, restricting the roads they may use, and imposing additional precautions to their usage. There has been a longer combination vehicle freeze in this country for some time. In the West, these larger trucks have been restricted to the safer, better-designed highways. Additional precautions include driver requirements and operational use restrictions.

There is little crash data presently available on longer combination vehicles. This is not likely to change in the foreseeable future. There are so few of these vehicles on the road that it is difficult to get reliable accident data and exposure data to develop accurate accident rate comparisons with other truck types. The majority of past risk exposure history of the larger trucks has been in the benign environment of the Western United States. Traffic volumes there are light and roadway geometries and conditions are favorable.

The inherent stability and control properties of the larger/heavier trucks are not as good as current vehicles. Any exposure shift by these vehicles to lower order roads is problematic. Because of the crash rate uncertainties, it is unlikely that driving larger/heavier trucks fewer miles in the East than they do in the West will not offset these vehicles= inferior safety performance.

QUESTION and ANSWERS

In your talk there appeared to be some vehicles with improved safety performance over the base case vehicle. It appears like the 6-axle 97,000 pound configuration has an improved static roll threshold, rearward amplification and negligible degradation of the load transfer ratio. Is that correct?

$ I think that is generally correct. Its performance is better than some of the other vehicles.

When you did those calculations, were they based on the tridem axle configuration for the trailer?

$ Yes.

Was it based on six wheel bases that would be equivalent to a five-axle configuration?

$ No. What we need to do is shift the trailer wheel base to have water level loading (ensuring that the level of freight is equal throughout the length of the trailer). That is how design engineers would configure the trailer off the board. In our simulations, we tried to replicate vehicles in the appropriate and proper design condition. We therefore have a means to compare conditions more realistically.

The third axle wasn=t simply added on the inside bridge. Was it perhaps added on the outside bridge to increase the wheel base?

$ Yes.

$ The center of the tridem would be at the same point as the center of the tandem.

Yesterday, we looked at roadway geometry and C-train double 33-foot trailers, which will increase the geometric costs. We also looked at B-train double 28-foot combinations. There are some of those in existence, but they=re not a problem. When you did your comparisons, why did you use configurations that are on the road in Canada but can=t operate in this country at this time?

$ When we began the study, we considered B-trains that could operate in this country at this timeCtwin 28-foot trailers. We were not specifically attempting to evaluate the Canadian B-train. Just recently, we decided to look at longer combinations. We could generate comparable data for twin 33-foot trailers based on the Roaduser data base.

If we lowered the center of gravity for some of these longer combinations we would negate the rollover comparisons?

$ There=s no question that varying the geometries of these vehicles changes all of the data on the graphs. The comparisons in the graphs are static. We picked some configurations and some dimensions. We ran the numbers (through the model), and the figures we saw earlier are what came out. Change the basic assumptions about wheel bases and weights, and all of those graphs will change. Any effort to optimize performance could result in much better safety numbers in some cases. There was no attempt to optimize the figures in these analyses. These analyses are comparisons of existing vehicles.

The first half of the presentation gives us an excellent overview of what we know right now about the different configurations out there and their crash experience. In the latter half of the presentation, we looked at static roll stability and rearward amplification. That is a test tube approach toward vehicle dynamics, performance, and safety. The thing that bothers me is: yesterday there was a lot of talk about outputs. Are you going to model the different base line vehicles, the fundamental geometry and cross section realignments and operating conditions of a rural Interstate segment and lower class rural two-lane roads? Will you show us what the magnitude of the disparity will be for the different baseline vehicles if they are narrowed or widened in the case of a multitrailer rig as opposed to a single trailer rig or a single unit truck? If you don=t have that in Volume III, then I have to tell you that the safety mission of the study has failed.

$ That=s quite a challenge. The closest you are going to get to it is the set of curves we showed with the relative rates on the various roadway classes of multitrailers versus single trailers. That is the best historical data we are going to get on this issue. There are very few of these vehicles operating out there, and collecting accident data and matching it to exposure data in similar operating environments is virtually impossible to pull off. There are no data collection systems out there that enable that to be done. Therefore, you must rely on the surrogate approaches that we showed here today. They give about the best forecast that is possible on this issue.

What I found fundamentally disturbing in the latter half of the presentation, was the discussion of the displacement of some larger vehicles due to poor operating design and context and traffic conditions. You characterize that as problematic. I agree with you. I know the attempts that have been made with longer combination vehicles to find out what is accurate data and what is not. Generally speaking, they all have failed. There is a responsibility to take the best tested information and real-world experience and expertise to give us a modeled approach. Show us how those vehicles operate both on a high quality road and a low quality road.

$ How do we link the test tube dataCthe vehicle stability and control numbersCwith the real world dataCthe accident or crash rate data? Is that correct?

Yes. It=s not radically different than what was done in the first half of the presentation.

$ We worked very hard to do that. In the end we concluded that was not possible today because we did not have sufficient data in the detail to distinguish between doubles and triples and between long doubles and short doubles.

$ We did a study in the mid-1980s where we tried to get accident data with a sufficiently detailed description of the vehicle. We saw some crude relationships between some handling characteristics and some specific types of accidents. The replication of that kind of study is a multiyear and multimillion dollar effort. It wasn=t feasible for this study.

$ The problem is we are hamstrung by the lack of quality data that we can link to different attributes of vehicle performance. That=s not to say it doesn=t exist. We just don=t have it in a form that we can use at this time. There are other ways to approach this problem. Best engineering practice is very important principal to use when you try to construct any kind of vehicle regime. We have the technical tools to do this. The aircraft industry does not wait to collect accident data before it fixes a problem. They do it before the plane flies. I think we need this kind of mindset in the size and weight arena. We have the scientific capability. Perhaps we have to look at this issue from that point of view rather than in retrospect.

Anyone who has been around the trucking industry would agree with your analysis 100 percent. I=m a bit concerned about the six-axle configuration being safer than the five-axle configuration because there aren=t as many of them out there, and if you want to compare them apples to apples, you have to have an equal base. I would questions whether these trucks are safer on the Interstate, a high design road, than on other roads. Currently, Federal law allows a 34,000 pound tandem axle. Many States allow much higher tandem weights on roads other than the Interstate. In a sense, we have forced the heavier loads to lower class roads. Are we guilty of creating the problem through policy and law that the States can=t do anything about?

$ It=s a possibility. The data aren=t fine enough to answer that question with any certainty. It=s an interesting and reasonable speculation, but we can=t confirm or refute it.

$ There are many features of the Interstate besides that tandem loophole that might come into play.

$ The principle attributes of Interstates that make them so wonderful are no at-grade intersections, divided highways, gentle road geometries, and ample lane widths. That=s what makes them safe for all vehicles.

Safety Impact

The same design features exist on many freeways and other arterials. When you classify Interstates with all other roads, it throws the numbers. Will these findings have any effect on Federal policy in regard to restrictions on tandem axle weight as currently exists?

$ The purpose of the study is to provide the framework for analysis and not to propose any policy change at this point.

It would be useful to have empirical numbers. We are working from your interpretation relative to the base vehicles. We don=t know whether we are comparing apples to apples. The biggest safety consideration in any of these vehicles is the driver. You can take any of these vehicles in their worst case and best case scenarios and put them side by side, and neither is more dangerous than the other. The driver determines the safety performance of any truck. All of these numbers have to be kept in context.

$ You are absolutely right. Driver performance and behavior is a key ingredient, if not the key ingredient, to ensuring highway safety. No one is arguing that point. When confronted by an unanticipated situation, even the most skilled driver has less of a margin for error in the larger trucks than in the base case truck.

$ The difference in driver behavior for each configuration should be minimized. We want a fleet that handles similarly with no surprises. It is the surprise that creates the accident. It is not one design flaw that creates the accident. It is four or five things that add up to create the accident. By using a disciplined engineering approach to vehicle design, you can ensure that minimal behavior characteristics that are important to drivers can be achieved.

You said there are two bases for looking at safety assessments. I would like to offer a third. Every day thousands of trucks and drivers undergo safety inspections at the roadside. We look at that as a safety solution rather than as a measure of how well we are doing. Over the last 15 years, the vehicle defect rate for the fleet was roughly 30 percent for vehicles that are stopped every day. Other studies of longer combination vehicles show the condition of the drivers and vehicles are superior to the regular fleet. If the longer combination vehicle fleet is expanded, will that condition hold? You might look at the difference between out of service rates for drivers and longer combination vehicles and regular combination vehicles. Secondly, driver fatigue is seen as one of the largest contributors to longer combination vehicle accidents. It is difficult to drive a longer combination vehicle for 10 hours straight without getting a major restriction at a State border. If we change the operating network, what will that mean for possible accidents and fatigued drivers? We already know there is a shortage of parking spaces at wayside rest areas for regular combination vehicles. What happens when we try to accommodate larger trucks? Has any type of diversion modeling been done to determine what type of shippers

would use these vehicles, what types of corridors and routes might they use, what would be their hours of service, and what would be the impact on carrier management and operations?

$ I don=t take issue with anything you=ve said. All of the factors come together at one point in time to create the conditions under which an accident can occur. Those conditions are no different for one type of vehicle or another. What we are talking about are the marginal differences associated with the vehicles. They contribute to causing the accident or preventing one from occurring. Isolating the contribution that causes the accident has been the challenge of this study. That=s not to minimize the points you made. If maintenance is poor, it creates bad situations. You can compensate by being cautious.

$ We=ve struggled with this topic. We want to home in on size and weight implications. This is not an overall safety study. It is hard to separate the issues; they are interwoven.

Has there been any attempt to rationalize the larger vehicle types in the Canadian fleet versus regular size vehicles?

$ There was a study done of the impact of the Canadian weights and dimensions study of 1986. It looked at how the Canadian study influenced vehicle characteristics. There=s been a remarkable decrease of A-trains in Canada. The B-train has become the double of choice. It was done for reasons we didn=t anticipate. We thought we had a handle on the dynamics of the trucking system. This study humbled us. The B-train is easier to back up than the A-train. It has one less articulation joint so it is more maneuverable. It offtracks better.

My question went to the accident experience of those vehicles.

$ We don=t have good data on the accident rate by vehicle class.

In the charts on relative stability, you used gross vehicle weights of 148,000 pounds and 132,000 pounds. Can you explain what happens if those weights are reduced or raised?

$ All of these analyses assume what is called water level loadingCuniform loading front to back, side to side. Adding more weight raises the center of gravity height. Taking weight off would lower the center of gravity height. One would expect that effect in the real world. Lower center of gravity height improves all of those metrics to some degree. Lower weights on a vehicle in general tends to improve the metrics.

$ You may want to use the cube out, gross out scenario to look at trucks that are completely full and are volumetrically occupied when they achieve maximum axle weight. You may look at adjusting constant density of the cargo to get the gross vehicle weight that you want. We found that a selection of suspensions and other aspects of vehicle design could provide improved performance. We were able to get a 3-S3 up over 97,000 pounds.

What is the methodology to evaluate different illustrative scenarios? You talked about the need for a multiyear, multimillion dollar program. This has been a multiyear, multimillion dollar study. On top of that, we are faced with the TEA-21 (Transportation 21?) study, which is a multiyear, multibillion dollar program that could provide the funds to begin to solve these problems. Are we looking at a funding program that would fill in the gaps and provide the data that we all need?

$ It has been a multiyear study with considerable resources. Those resources had to be deployed to cover all of the impact areas and not just safety. Safety studies alone could consume all of the resources and more. The funds also had to cover extensive outreach when the study started. Will we have the resources to continue this effort? We will want to have the study updated on a 2-, 3-, or 4-year cycle. Regarding TEA-21, I haven=t put my finger on the resource that is going to specifically fund this effort. We will do everything we can to get those resources.

$ We have tried to explain how we are attempting to get the information you describe. To find historic data that are specific by roadway type, configuration, and regional boundaries that would enable a precise calculation is a daunting challenge. There have been studies to do that for 15 or 20 years, and people on this panel can describe those efforts. The ones that have come closest have been criticized roundly for small sample sizes and associated problems. You are then left with surrogate approaches.

$ It=s a chicken and egg scenario. These trucks shouldn=t be allowed to operate until you can demonstrate they have the crash rates to allow them to operate; you can=t get the crash rates until they are operating. How do you overcome that problem? Maybe we should follow the aircraft industry lead: assess these trucks with our best engineering models and then go with them.

Did you look at the crash rates based on weather conditions or rainy conditions?

$ No.

If you look at single trailer combinations versus multitrailer combinations, the multitrailer unit has a 97 percent accident rate in comparison. If you allow the multitrailer to run everywhere the single trailer units run, the accident rate is 111 percent. Is that a reasonable assumption? The accident rates for the big trucks could be pumped up because we=re assuming they are traveling on urban streets.

$ We were thinking primarily lower order rural roads.

Safety Impact

$ I=m trying to see where this is leading to because it ultimately comes down to what is the accident rate per unit of load transport or volumetric measurement. Is this a vehicle substitution issue? Will this be addressed in Volume III?

$ The vehicle substitution approach has been suggested by many. Don=t worry about the underlying propensity to be involved in an accident. Substitute fewer trucks for more trucks and everything is a wash. That masks these apparent differences and is problematic at best.

What is the bottom line going to be? Is someone going to look at the different crash rates based on what you found, start multiplying that by some dollar figure per crash, and dump in some dollars to study the costs? Everything else in the study is about cost. Don=t you think this is going to turn out this way?

$ I would not be a proponent of doing that.

Have you given thought to using permit records for users who operate on certain roads?

$ Efforts like that have been attempted before and have run into difficulty. It gets back to the issue of attempting to construct a well-controlled study where you can get that kind of information. That is conceptually doable, but very difficult to pull off.

Are you going to use the diversion study to come up with scenarios about what would happen if there are fewer trucks on the road, and the projected accident rates based on shippers moving from one type of vehicle to another? Are you going to build in those rates and what they mean to the longer combination vehicles?

$ That is doable in terms of vehicle miles traveled calculations. If we knew with precision what the accident rate differences of these vehicles would be, you could multiply those rates by some mileage and come up with an expected number of accidents. That=s very problematic in the face of very little data on those trucks= accident rates.

That ties into your diversion model as a best guess. No one knows whether the shipper will go this way or not.

$ The last slide said Acounting on VMT changes to offset the inherent qualities of these vehicles is risky business.@

After all that we have heard yesterday and today, it sounds like there are a lot of gaps that need to be filled. Idaho is launching a new truck size and weight study. Will Volume III contain the data we need to fill in those gaps and connect to the Federal data so we won=t

have to repeat our efforts in 2 years?

$ In quick summary, you need good comparative data on all truck types on all road types in terms of accidents and mileage so you can compare vehicles on specific roadways segments.

$ Utah is collecting detailed crash data. Idaho has considered collecting crash site data for some time. The problem is Idaho and Utah would have to do that for 20 years or more to develop reliable crash rate. If other States would join Utah and Idaho, then the time requirement would decrease.

$ In other reports, we have indicated our future research agenda, those areas we would like to visit or revisit.

The public policy question is going to revolve around the change in the probability that a passenger car is going to have an accident based upon the presence of a standard truck or a long truck. Is there anything in the data that would allow you to assess that?

$ We are not gathering the commensurate vehicle miles traveled car data for where these trucks are operating.

SESSION 7
EVALUATION OF TRAFFIC OPERATIONAL IMPACTS

Presented by:

Ben Ritchey
Vice President, Transportation Divsion
Battelle

Panelist:

Edward Fekpe
Research Scientist
Battelle

This model, like many of those presented over the last day and a half, was designed specifically for the Truck Size and Weight Study. It evaluates and quantifies changes in traffic operations resulting from the introduction of new truck configurations. It also estimates the costs associated with these changes. The output is expressed in vehicle-hours. This model produces changes in vehicle-hours driven.

The assumptions used in the model include: the impact on traffic operations were measured in terms of the total delay to traffic in vehicle-hours; total delay was estimated in terms of changes in passenger car equivalent (PCE); and delays were estimated for a Atypical or average@ hour. (PCE is defined in the 1994 Highway Capacity Manual as Athe number of passenger cars that are displaced by a single heavy vehicle of a particular type under prevailing roadway, traffic, and control conditions.@)

Annual vehicle-miles traveled were homogeneously distributed spatially and temporally. One or two segment geometries represent each highway functional class. Grades and the length of the grades are an important assumption in this analysis. The data was derived from the Highway Performance Monitoring Survey (HPMS) data base and other simulation models. The PCE values are a linear function of weight-horsepower ratio and the truck length. They are the two variables in the model.

Speed was chosen as the performance measure to determine the effectiveness of PCE values. Simulation models for the 12 functional highway classes and 20 vehicles in 30 weight groups were used to determine these values. These are the same truck and highway classes used in the Highway Cost Allocation Study.

To determine the PCE values, a number of simulation models were used: FRESIM for rural Interstates, TWOPAS for rural two-lane highways, and NETSIM for urban arterials. Different grades were simulated for each functional highway class.

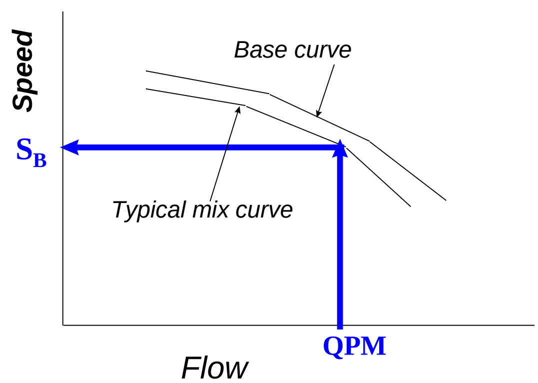
Three dimensional matrices were developed for the PCE values. Vehicle weight per horsepower ratios and their relationship to vehicle length were determined by functional class. Speed-flow curves were developed for the base case (including automobiles) and the traffic mix in the base case. These curves were developed from sample segments and alignments simulated from the different functional highway classes.

Model inputs included vehicle parameters (the weight per horsepower ratio and overall vehicle length for each class), roadway geometry (highway classification), the vehicle miles traveled for the base case and each scenario for the year 2000, and the lane miles for each highway functional class.

Each scenario determined the trucks that would be replaced or introduced and the PCE value for the base case and proposed truck configurations as a function of weight per horsepower and vehicle length. The model also calculated the flows from vehicle miles traveled and lane-miles data and the change in delay based on the differences in traffic volumes and PCE values.

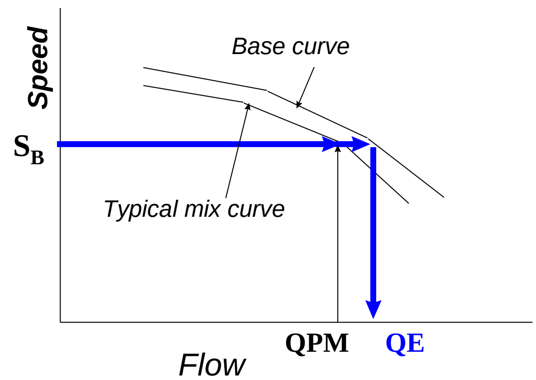
The following charts illustrate the different steps taken during the model simulations.

ESTIMATION OF CHANGE IN DELAY - STEP 1



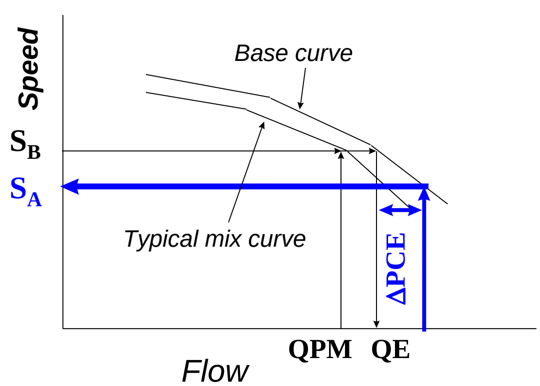
The first step was to determine the speed corresponding to the flow of the typical traffic mix.

ESTIMATION OF CHANGE IN DELAY - STEP 2



The second step was to determine the flow of the base curve corresponding to the speed of the typical traffic mix.

ESTIMATION OF CHANGE IN DELAY - STEP 3



The third step was to determine the speed corresponding to the flow from Step 2 plus the change in PCE in the base curve.

The fourth step uses the change in speed to calculate the change in total delay expressed in vehicle-hours. Unit costs also are used to calculate total costs or savings for total delay changes.

The model outputs are the change in total delay in vehicle-hours (by truck configuration and highway functional class) resulting from the truck size and weight policy scenario and the change in road user delay costs or savings for each scenario.

QUESTION and ANSWERS

How do we reconcile the shipper who wants to maximize his traffic flow in a certain area with the traffic engineer who wants to optimize traffic capacity and the guy who has to figure out whether he has to restripe his left-hand turn lanes? Generically, what are the exponential adverse impacts when you increase, say, STAA short double combinations from one quarter of 1 percent of the vehicle mix to, say, three quarters of 1 percent of the vehicle mix? What are the actual impacts going to be?

$ The model provides the changes in vehicle-hours by the 17 truck classes and the 12 highway functional classes. If you are interested in urban freeways, for instance, the model provides information on changes to urban freeways.

Basically, the model calculates for a generic class of highway, the mainline facility. How is the information segregated for the different geometric alignments for roads= entry points (diamond or cloverleaf interchanges)? That=s what practitioners need to know about any potentially adverse impact for different traffic configurations.

$ The problem is you are talking about a national study. It would be nice to know what=s going on in Springfield, Virginia. You get some respect for what we are trying to measure on a national system. We are trying to provide some information that is useful for the planner in Springfield, Ohio and Virginia. It is difficult to be specific on a Nationwide study.

Were the PCE values drawn from the Highway Capacity Manual?

$ No. They are not.

$ The question was raised about what are the changes in PCEs in making a left-hand turn at an intersection. We are nowhere near that level of detail in this analysis. The important variables are the number of lanes and the vertical grade.

Did you look at using the HPMS data, which has not been broken down into detailed truck classes? The States pump this information to the Federal government so you can analyze capacity issues and other things for the performance study. Staying with known data, whether it is right or wrong, can lead to some reproducible benefits. Did you look at the HPMS system at all?

$ Yes. Actually, the highway configurations and geometries, the selection of percentage grades, and the length of grades were taken from the HPMS data.

SESSION 8
ENERGY AND ENVIRONMENT IMPACTS

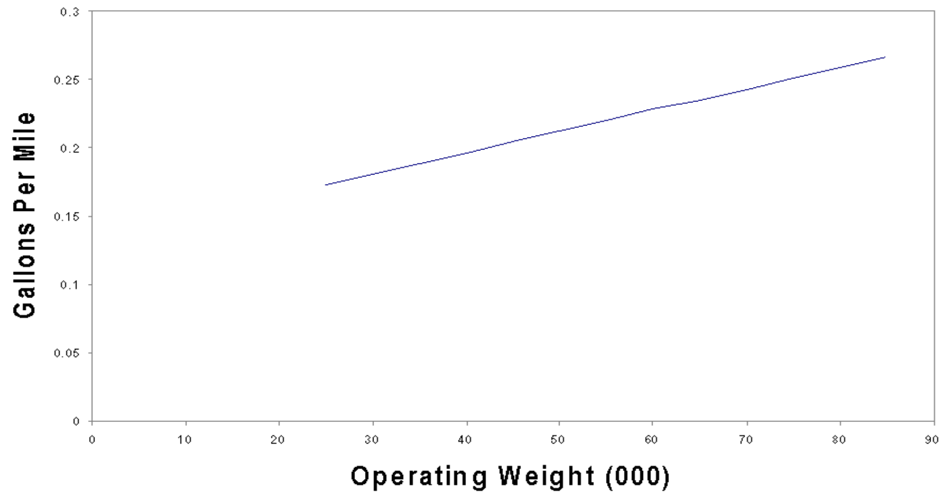
Presented by:	Panelist:
Harry Cohen Consultant Private Practice	**Jim March** Team Leader, Systems Analysis Office of Policy Development Federal Highway Administration **Kurt Heidtman** Director, Transportation Policy & Technology Deployment Battelle

ENERGY IMPACT

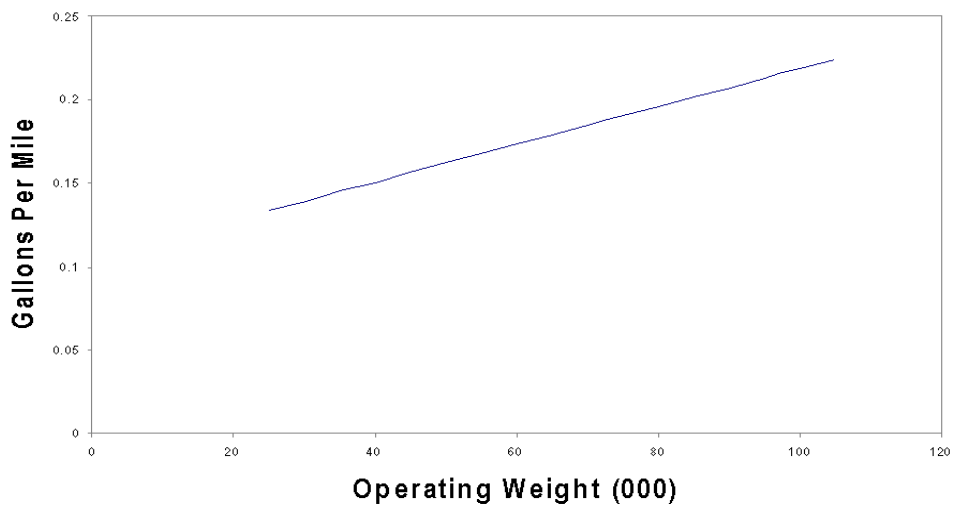
Vehicle/miles traveled (VMT) and fuel use tax figures contained within the Highway Cost Allocation Study provided the basis for the environmental and energy impact analysis in the Truck Size and Weight Study.

Input was by truck type and operating weight. A year 2000 base case VMT was developed. Using the diversion analysis, researchers developed an alternative year 2000 scenario VMT by truck type and operating weight. Gallons per vehicle mile figures from the Highway Revenue Forecasting Model that were refined for the Highway Cost Allocation Study were also incorporated into the analysis. The output of the analysis was the change in gallons used per year for heavy vehicles.

FUEL CONSUMPTION RATE: 4 AXLE SINGLE UNIT



FUEL CONSUMPTION RATE: 5 AXLE SINGLE UNIT



The above charts illustrate how fuel consumption rates vary depending on the operating weight of a truck. As the operating weight of a truck increases, the fuel consumption rate goes up and miles per gallon goes down. The larger, heavier trucks use more fuel gallons per mile than single unit trucks, but the larger trucks= VMT savings more than offset the higher gallon per mile rates. The net affect is a saving of energy.

Energy and Environment Impacts

AIR QUALITY IMPACT

Little information exists on the impact that larger, heavier trucks have on air quality. The team recently received an air quality impact study from the Environmental Protection Agency (EPA) that will serve as the basis for further research. The team had conducted early analysis based upon the best information available at that time; EPA reviewed the findings and asked if more recent research results could be added to the analysis.

The analysis will take as an input (by truck type) year 2000 base case and alternative scenario VMTs. Emission rates for particulate matter (PM), nitrous oxide (NOx), hydrocarbons, and carbon monoxide and the cost per gram emitted will be factored into the analysis. The output of the analysis will the change in air pollution cost.

Previous studies have attempted to fix a dollar value to mortality (death), morbidity (illness), visibility impairment, soiling, materials damage, and effects on plants and wildlife caused by airborne pollutants. These are extremely difficult to quantify in terms of their effects. Most past studies have attempted to quantify the dollar value of mortality caused by pollution. To date, virtually every comprehensive estimate of air pollution costs (including EPA analysis) has focused on the costs associated with additional deaths and particulate matter (usually PM 10 and PM 2.5).

Some of the key problems in dealing with air quality issues include:

$ EPA analysis (Mobile 5 and probably Mobile 6 when it is released) has not broken down emission factors by vehicle weight. Mobile 5, which was developed for air quality implementation planning at the metropolitan planning organization and State levels, provides no guidance to transportation planners examining what happens regarding emissions when trucks get heavier. EPA has Aheavy gas@ and Aheavy diesel@ categories in its Mobile 5 model, but there are no emissions rates broken down by vehicle operating weight.

$ There are huge variations in the cost per mile depending on where the pollution occursChow close it is to peopleCand other situational factors, such as temperature. Compare the affects of pollutants released in, say, Los Angeles, which lies in a basin surrounded by mountains, and a Midwest location where winds can quickly disperse any pollutants.

$ A major policy concernCwhat is the full measure and value of life? There are no generally accepted dollar values for human life. Most research to date has defined mortality as the overwhelming impact of pollution. Different agencies use different values of life. U.S. DOT in its benefit cost analysis of highway safety has used the figure $2.7

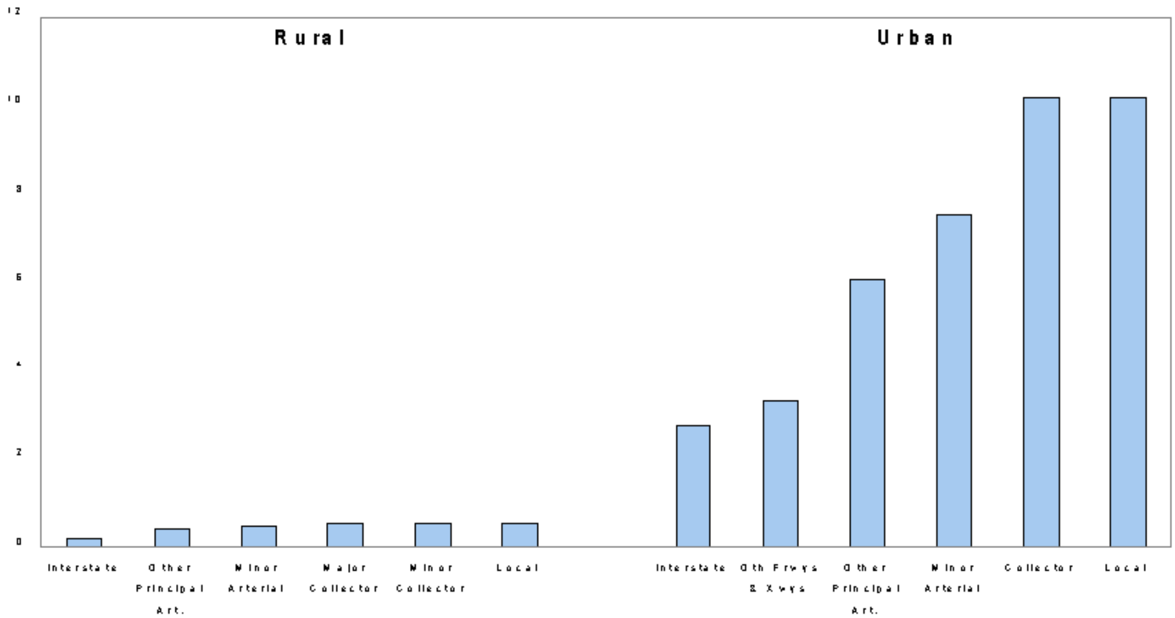
million for small reductions in the statistical probability of death. EPA has always used $4.9 million in its studies. How do you value the affect on mortality in terms of years lost versus a reduction in the number of fatalities? In terms of mortality, pollution affects different populations than highway accidents. Should the same statistical value of life be used in dealing with highway safety and air impact?

NOISE IMPACT ANALYSIS

Impacts for the analysis were base case and alternative scenario VMTs for the year 2000. Using passenger cars as the base, noise equivalents were determined under differing operating circumstances for each vehicle class and weight group. The cost per noise equivalent was estimated for each functional vehicle class. The output of the analysis was a change in noise cost.

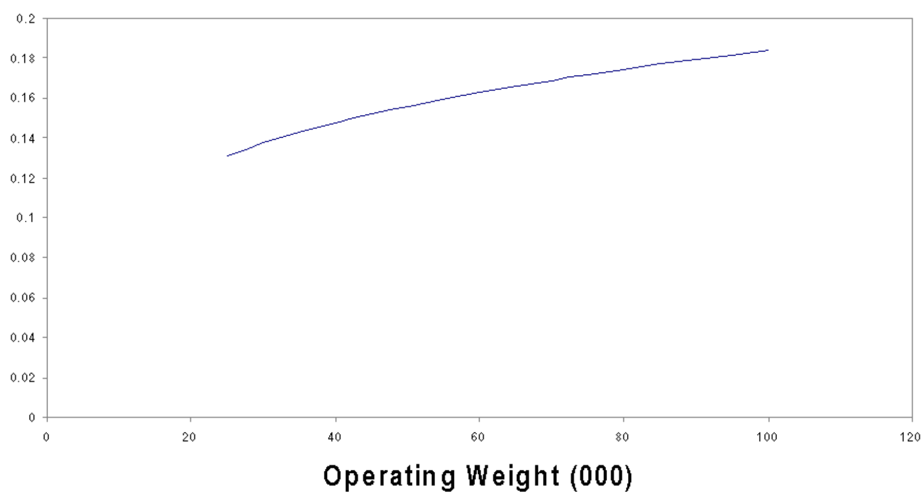
FHWA models of traffic-related changes in noise levels by truck operating weight served as the basis of noise emissions. Highway Performance Monitoring System (HPMS) data on VMT by highway class and type of development was used to determine the number of residential units affected. HPMS includes a code about the population density surrounding a particular highway segment. Finally, the team based noise cost estimates on perceived changes in residential property value. The assumption was that as noise levels increase, property values decrease.

NOISE COST FOR 80,000 POUND TRACTOR SEMITRAILER



The above chart shows how noise cost varies among the 12 functional classes of the highway system for an 80,000 pound tractor semitrailer. Each vertical bar shows cost in cents per mile for such a truck in each functional class road. Not surprising, costs per mile are much less in rural areas than in urban areas. In urban areas, the cost is higher on local streets than for Interstates and other major highways because of the density of residential populations.

HEAVY TRUCK NOISE COST ON RURAL INTERSTATES



Energy and Environment Impacts

As this chart shows, the noise cost for heavy trucks operating on rural Interstates goes up slightly with the weight of the truck. A 10 percent increase in operating weight results in a 2 percent increase in noise cost.

Global Warming Impacts

Global warming is caused by carbon dioxide released by burning fuel. To find the cost of additional tons of carbon dioxide that larger, heavier trucks will emit, researchers analyzed the change in the number of gallons of fuel used, assigned a coefficient that reflects how much carbon dioxide is produced by burning fuel, and relied on the existing literature. Data on changes in crop yields, increases in the sea level, and changes in heating and cooling requirements were incorporated in the analysis. There is uncertainty about how to translate increases of carbon dioxide into cost figures. Emissions cost estimates range from 0.1 cents to 7 cents per mile for tractor trailer combinations. The final report will include the best estimate, including high and low figures, and an explanation for the differences.

QUESTION and ANSWERS

Does the analysis of cost per unit of emission based on location and other factors utilize a wide set of variables or did the research team use single values?

$ The team will work with EPA national data analysis when it arrives. Initially, earlier efforts built up the costs using local information on pollutant concentrations, emissions, and so forth. The details haven't been settled. The capability exists in the model to take into account that a gram emitted in, say, South Dakota, will be different than a gram emitted in Southern California. We have VMT by State. Earlier analysis did have cost by State in a way that reflected the pollution costs for different States.

$ When U.S. DOT submitted its cost allocation report last year, it did not include the external air pollution costs because the definitive EPA work was not available. An addendum will be submitted to Congress that covers this information among other things.

Does environmental analysis take into account any of the diversion that may or may not occur between rail and trucks?

$ Yes, it does. When we do noise costs, we work from a VMT data set, one for the base case and one for the alternative scenario. The VMT data sets that we develop for each alternative scenario will include the vehicle miles traveled for trucks diverted from rail. The same thing will true for the air quality, energy, and global warming analyses when they are finalized. The key driver for all of these analyses are the VMT data sets, which include affects of rail, as well the affects of shifts from one truck type or operating weight to another.

Did you consider other environmental affects, such as fuel handling and storage and changes in hazardous spill rates? Did you reject them as being negligible?

$ We didn't develop quantitative estimates for those items. Issues like that were raised in the discussions during the development of the Cost Allocation Study. We didn't associate a dollar value with spills, for instance.

If I live on a street with heavy traffic, and there is an incremental change in the level of truck traffic on that street, I can't hear it. The affects are masked by the high background noise level. If I live on a rural road, the same absolute change in traffic volume is very noticeable. On the urban street, the total cost of noise is high because there are lots of people exposed to it. The sensitivities to change is different between the average and the marginal. Does your analysis take this into account?

$ It contains the net of two affects: as traffic volumes go down, the level of annoyance caused by a heavy vehicle going by is more noticeable than if there is already a lot of heavy traffic. That, to some degree, offsets the affect of population. We factored both into account. We used data from the Highway Performance Monitoring System on traffic levels on different types of highways, so that the graphs I used show the combined affect of population and different types of roads have different traffic levels. If you add a vehicle to a low volume highway, you do more noise damage than if you add it to a high volume highway. The graph showed the two affects combined.

FINAL QUESTIONS AND ANSWERS

We are having a minirevolt in Vermont against larger trucks. In all of your studies, have you added in any impacts on the general public dissatisfaction or dislike of larger vehicles? To come out and say Awe=re going to make trucks a lot bigger and heavier@ may generate a lot of public outcry.

$ We haven=t done anything in regard to the public perception. We don=t intend to come out and say anything should get bigger and longer, smaller and shorter, or wider. This study is an analytic framework which will allow you to assess on either side of the ledger on the variety of scenarios that will appear. There are a lot of perceptions out there. This study attempts to get out of the perceptions and to give the professional decision makers some analytic tools.

$ In a general sense we are taking into account public perceptions in the safety arena. We collected quite a bit of feedback from the public and drivers about how they felt about being on the road with heavier trucks. The results of those inquiries are reported in Volume II of this study. That information will not be incorporated in the scenario discussions in Volume III.

Will FHWA give us a couple of months to review the report before you present the results?

$ We need to submit a final report to Congress this fall. We would like to put out Volume III, following today=s methodologies, which gave you the bottom line results in some areas. We want to get comments back so we can consider them for inclusion when we issue the final report. When the report goes to Congress, we want to talk with everyone here and other groups and to brief congressional staff about what is contained in the report.

$ We will probably give you 1 month to review the document. If you think that a meeting similar to this would help, please get in touch with us. We would certainly consider another meeting once we have the results to talk about.

The satellite conferences held in the past for Volumes I and II were great. Could you do that for Volume III?

$ Those were the State videoconferences that were put together. They have been geared toward our State partners. We plan to hold another videoconference probably two weeks after Volume III is released and everyone has had a chance to review the document.

Will the report go into great detail on all of the factors in the models and all of the assumptions that were made? It=s absolutely critical.

$ A guide to the documentation will be produced. That will come out with the final report.

$ The level of detail you received today will be incorporated by and large in Volume III. The guide to documentation will go into great detail.

It will be difficult to come up with cogent rebuttals or comments without the detail of the formulated models.

$ There will probably be enough detail within Volume III. The detail won=t be Adown in the weeds.@ The detail won=t be as exhaustive as you would expect to see in the documentation that went along with the diversion model.

In some parts of the country there are workforce shortages, such as truck driver shortages. That has often been used as a talking point with and without data when this issue comes up with State legislatures. Would it be worth asking to what extent truck size and weight changes will effect labor requirements, meaning drivers? The issue will come up during discussions.

$ If I understand the question, it gets to safety issues: how much of a general safety study regarding drivers, their qualifications, hours of service, and so forth, is being done rather than focusing on the incremental changes for a specific size and weight scenario? We aren=t looking into that.

The issue is there are not enough truck drivers to be hired. It=s not an question of whether they are safe or not.

$ It sounds like an important issue. It=s not the theme of the study to look at the shortages in various categories of labor in the motor carrier industry.

What data is going to be pumped into the model once it is released? For instance, the waybill information is confidential. Are the States entitled to all of the rail moves that go to, from, and through their State from the Surface Transportation Board? If someone wants to do a study on a larger level than the State level, where do they get the data? Are we going to recommend a survey of truck movements because no one knows where they come and go? That=s critical information.

$ Your point is well taken. We intend to update the study on a regular basis.

Final Questions and Answers

We don't have the complete answer. Whenever people get together at a data users conference, the issue of the lack of an ongoing over-the-road truck survey always comes up. In lieu of having that survey, we have a visual freight data base created by another office at FHWA that provides a tool for State and Federal officials to use. There's also a commercial data set created by Reebie that is for sale. We will phase into using that data and the Commodity Flow.