Truck Size and Weight

Modelling Workshop

U.S. DOT Comprehensive

Truck Size & Weight Study

Report No. 3

To

U.S. Department of Transportation

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Truck Size and Weight Modelling Workshop

U.S. Department of Transportation
Comprehensive Truck Size and Weight Study
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Activity II: Task C
Refine Freight Diversion Models for All Modes

September 1995

Prepared by

Battelle
. . . Putting Technology To Work

The primary objectives of the U.S. Department of Transportation's Comprehensive Truck Size and Weight (TS&W) Study are to:

- assess the potential economic, safety, and environmental impacts of changing existing TS&W limits; and

- identify opportunities to increase the efficiency of freight transportation while preserving safety and highway infrastructure.

Reports which have been completed for the TS&W Study, to date, include the following:

(1) Synthesis of Truck Size and Weight Studies and Issues
(2) Analysis of the Truck Inventory and Use Survey from the Truck Size and Weight Perspective for Trucks with Five-Axles or More
(3) Truck Size and Weight Modelling Workshop
(4) Truck Size and Weight Performance-Based Workshop
(5) Western U.S.-Canada Crossborder Case Study.

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Executive Summary

The Federal Highway Administration (FHWA) sponsored an informal workshop on February 10, 1995, as part of a comprehensive truck size and weight (TS&W) study. The objectives of the workshop were to discuss past work in modeling issues and identify new tools for TS&W analysis. Several experts gave presentations of their models and prior TS&W work which demonstrated different analytical approaches to the TS&W issue. Following the presentations, there was group discussion of future research needs to support TS&W analysis.

Overall, there was wide agreement among the workshop that there is not one tool or combination of tools that is capable of modeling the complexity of all the possible TS&W options that may be considered. Furthermore, it was agreed that it probably will not be possible to design one, all-inclusive tool. Consideration should be given to conducting detailed case studies on specific commodities, companies, and regions to supplement (or outright replace) large complex models. Therefore, an integrated approach involving several models and different data will most likely be needed.

One major weakness that applied to all tools discussed was the lack of accurate data bases for model inputs and case studies. Some new data sources are likely to become available in the near-term. The Bureau of the Census' 1992 Truck Inventory Usage Survey (TIUS) and the Commodity Flow Survey (CFS) will hopefully offer a better understanding of commodity flow shipments in the country. In addition, the Bureau of Transportation Statistics (BTS) is making available data on cross-border flow of goods.

One final overall observation from the workshop was that FHWA should consider case studies of industry practices. This approach differs from TS&W modeling, but could be used to build a micro-approach for national TS&W analysis. For example, different specialized models or case studies representing individual commodities, geographic regions or corridors could be developed. This specific information could be combined with other case studies and built up to analyze the overall national situation.

The first workshop presentation discussed the Freight Network Policy Model (FNET) which is a component of the Highway Traffic Forecasting System (HTFS). FNET mathematically estimates the impacts of truck size and weight and highway user fee policy options on changes in vehicle-miles travel (VMT) and payload ton miles (PTM) by various operating weight classes and vehicle types, truck and rail operational costs, and truck-rail modal split.

A less mathematical but more "real world" approach are the Truck Costs issues discussed in four studies of cost diversion effects that were conducted over the last 15 years. These studies dealt with the non-linehaul costs for extra trailers, diversion potential, dedicated service, nondedicated service, cube-limited versus weight-limited freight, local restrictions, shipper requirements, effects on VMT, and transport costs.

Another approach is to study TS&W issues from the shipper's perspective. The Pennsylvania State University (PSU) conducted a survey of freight shippers. This survey information served as inputs to the Freight Transportation Analyzer (FTA). The FTA is a stochastic model which tries to find the nationwide diversion and the net effects of LCVs on shippers total logistics costs.

The last presentation was the Truck-Rail/Rail-Truck (Rail-Truck) Diversion Model. This model is a statistically disaggregate model which uses a Shippers Logistics cost model. The Rail-Truck Model is aimed at maximizing the receiver's utility while minimizing the total logistic costs. This is done by calculating the receivers utility for each transportation alternative. It also approaches the problem from the perspective of the shipper/receiver.

In addition to the models discussed at the Workshop, several data bases (new and revised data bases) were also discussed. These data bases potentially offer new and better sources of information to address continuing weakness, particularly with truck VMT and freight commodity flows.

There are several recommendations regarding specific tools and data bases needed to support TS&W's analysis. These action items need to be part of the TS&W Management Research Plan.

(1) The Rail-Truck Model should be reviewed extensively and improved to be ready to measure nationwide rail to truck diversion and rail revenue contribution impacts from changes in Federal TS&W regulations. FHWA needs to have an independent estimate of diversion potential and avoid being in a situation of solely depending on the AAR's ICM model for diversion estimates. This model needs to reflect the latest trends and cost/pricing events from a variety of studies, Battelle Team skills, and other models (FTA).

(2) The FHWA should investigate the likelihood of using North American Trucking Survey (NATS) and the National Motor Truckload Data Base (NMTDB) from the Association of American Railroads (AAR). Also, the FHWA should address the value of continuing a NATS/NMTDB-type data base collection project. Perhaps, these data could be collected every two years or be combined with other current truck data collection efforts (i.e., TIUS). Related to this decision should be a review of the Reebie data base and a collection method where the trucking industry would provide data at no cost and get national truck flow data for marketing purposes.

(3) The planned improvements to the NAPCOM need to be completed. Also, future changes to the model should include tire pressure, super single tire, and studded tire impacts on pavement.

(4) Coordinate the review of the CFS and TIUS with other U.S. Department of Transportation (DOT) offices and other efforts. These data bases will be valuable to the TS&W effort.

(5) The FNET needs to be reviewed for the data bases containing the different highway networks and the GIS interface capability. Also, we need to better the state regulation data base and its usefulness in TS&W research. Currently, the FNET is being used to estimate the benefits of completing the Alameda Corridor in Los Angeles. This exercise should be a good test case of the ease of use and completeness of the model.

1.0 Introduction

The Federal Highway Administration's (FHWA's) Comprehensive Truck Size and Weight (TS&W) study is being conducted partly in response to a legislative proposal in the 103rd Congress, HR4496, that would: 1) freeze the weights allowed by state law or permit regulations on the non-interstate portion of the National Highway System (NHS), and 2) freeze the length of new trailers at 53 feet. This bill, or similar legislation, could have a significant impact on the public and private sectors and on the safety and efficiency on the total transport system.

The current TS&W regulations were based on concerns for national uniformity and good highway system stewardship, including matching vehicle weights and dimensions with the existing public infrastructure and with mechanisms for cost recovery. At times, some states have adopted new pavement and bridge design standards to better match the weights and dimensions of the vehicles being allowed to operate on their highways. Highway engineers are concerned about premature degradation of that infrastructure and the consequent strain on public resources. As technology and shipper demand have resulted in larger and heavier trucks, concerns for highway safety (adequate brakes and vehicle handling and stability) and loss of rail service (due to loss of freight traffic to larger trucks) have become increasingly important especially with regard to longer combination vehicles (LCVs).[1] Typically, LCVs are turnpike doubles (combinations with two 40-foot or longer trailers), Rocky Mountain doubles (combinations with one 40-foot or longer trailer), or triples (combinations with all three trailers 30 feet or shorter in length).

The FHWA TS&W comprehensive study is divided into two phases. Phase I, TS&W synthesis, assessed past policy studies and recent research findings. The major purpose of Phase I was to describe what is known about the recent technical work and research related to all aspects of TS&W. TS&W studies completed within the last 15 years, as well as more recent research not covered in these studies, have been synthesized. State and Federal TS&W regulations have been summarized, and knowledge and research gaps on TS&W issues have been identified and research needs prioritized. This phase is complete and the working papers are available for public review in the FHWA docket.

Phase II, a preliminary option analysis related to the National Highway System (NHS) issue, will evaluate on a limited basis specific policy options using existing data bases and will provide regional commodity case study analyses. This analysis will be preliminary because new data for a comprehensive analysis of TS&W issues, such as the commodity flow survey (CFS) information, is not expected to be made available by the Bureau of the Census until late 1995. Therefore, Phase II policy options will include appropriate caveats regarding the limitations of earlier studies. This

[1]LCVs are multi-cargo unit truck combinations that can weigh more than 80,000 pounds, depending on state regulations.

analysis will include the impacts of changes in Federal TS&W provisions on safety, infrastructure, and economic productivity.

Phase II will include an extended impact analysis. We will be able to use the new data and revised tools that become available in 1995 and 1996 to prepare in-depth analyses of the TS&W policy options. It will incorporate results from a parallel Highway Cost Allocation (HCA) Study, which the FHWA is undertaking to determine whether the various highway users including heavy vehicles, are paying their fair share into the Highway Trust Fund. Specific TS&W policy options will be analyzed using improved tools and information on freight commodity flows and truck use. This phase will address the full range of costs and benefits estimated to derive from these options.

FHWA recently sponsored an informal workshop on TS&W study. The purpose of this workshop was to develop strategies for integrating past work, developing new analytical tools, and identifying key data base issues for the TS&W study.

2.0 Description of the Models Presented at the Workshop

2.1 Highway Traffic Forecasting System (HTFS)

Dave Greene and Shih-Miao Chin, ORNL

The Highway Traffic Forecasting System (HTFS) is a national freight forecasting model with three main components: 1) a national aggregate vehicle miles of travel (VMT) forecasting model, 2) a freight network policy model (FNET), and 3) a large data base which is iterative and proportional. The VMT data base provides inputs to the FNET which forecasts travel network and mode.

2.2 Freight Network Policy Model (FNET)

FNET attempts to estimate the impacts of TS&W and highway user fee policy options on changes in VMT and payload ton-miles (PTM) by various operating weight classes and vehicle types, truck and rail operational costs, and truck-rail modal split.

FNET is a freight forecasting model based on the four-step transportation planning process: trip generation, distribution, mode split, and assignment. FNET builds upon the Oak Ridge National Laboratory (ORNL) National Highway Planning Network and utilizes a Minimum Cost Route decisionmaking process. VMT is distributed by type of truck and gross operating weight distribution. FNET can hold up to five different data bases which allows the model to accommodate grandfathered rights (such as Oklahoma's 90,000-pound truck limit) and state differences (such as Nebraska running empties).

In the FNET model, different networks can be specified which could allow modeling the NHS by assigning weight limitations to various road segments. A geographic information systems (GIS) interface could establish the different "links" to share the same restrictions. There are 6,440 links in the FNET network. Although forming new network links is tedious, updating established links becomes much easier.

2.2.1 FNET System Implementation

- Computers: 80386-, 80486- and Pentium-based MS-DOS desktop computers.
- User Interface: TransCAD or GisPlus Interface.
- Network: Interstates, Federal Primary, and other highways abstracted from National Highway Planning Network developed by ORNL.

- Study Zone: 181 BEA regions (excludes Hawaii and Alaska).

- Origin/Destination: Tonnage information for 23 commodity types based on Reebie data.

2.2.2 Strengths of the FNET Policy Model

- The model analyzes NHS policy options because the model deals with actual road networks not simulated networks. The model assigns flows to specific paths.

- This model is sensitive to TS&W policy (state and Federal) because of geographical-based highway networks.

- The network has weight attributes corresponding to individual state laws. These attributes can be set to state limits and/or truck limits.

- Freight loads are looked at on a network basis.

- Some consensus that this is a good representation of the highway network.

2.2.3 Concerns of the FNET Policy Model

- Changes in TS&W regulations reflect the change in truck VMT. The concern is whether this can be used for rail/truck diversions. Model lacks rail competitive information which impacts rail diversion.

- FNET excludes the local truck movement (less than or equal to 50 miles).

- There is no differentiation between two- and four-lane traffic on road networks.

- Tedious process to select "links" for NHS or other systems.

- Logistic costs are not explicitly considered in the model. Complex logistic decisions are being made for truck and rail trips and are summarized into generalized costs such as the cost per trip (truck costs) and the cost per mile versus the payload unit costs. This model is unable to represent other issues such as on-time delivery and other related issues. The multinomial logistics approach does not represent real life decision-making processes.

- LCV access issue is not included in the model. (Note: There was a suggestion to add a constant to the equation to address this issue.)

- Errors are mostly in the "schedules". Averaged three or four paths to accommodate for this error.

- General disagreement with the preliminary results presented at the workshop that indicated there would be no VMT growth with the elimination of the grandfather clause. The workshop members strongly felt that there should be VMT growth due to decreased weight limits. This issue was not resolved. Chin indicated that the model was not complete and that he wanted to check his notes and continue development of the model.

2.2.4 Suggestions from the Discussion for the FNET Policy Model

- New data (such as CFS) will improve the model on a link-by-link basis.

- LCV access issues can be dealt with by adding a constant.

- Logistic costs could be calculated off-line and then included in generalized costs.

2.3 Truck Costs—Truck Weight and Size Issues

Joe Stowers, Sydec, Inc. and
Herb Weinblatt, Cambridge Systematics, Inc.

2.3.1 Cost and Diversion Effects

There have been four studies of cost and diversion effects conducted over the last 15 years which included: 1) Carl Swerdloff's 1981 Office of the Secretary of Transportation (OST) Study, which looked at the effects of the elimination of the grandfather clause; 2) the 1988 Transportation Research Board (TRB) work; 3) the early 1990 FHWA TS&W work, which involved interviewing truck drivers (LCV and others) to better improve the modeling and analysis to date; and 4) the 1993 FHWA unpublished report prepared by Transmode, SYDEC, and Cambridge Systematics, Inc.

Stowers' work has dealt with non-linehaul costs for extra trailers, diversion potential, dedicated service (use most efficient configuration for the haul), non-dedicated service (consider issues related to overall utilization), cube-limited versus weight-limited, local restrictions, and shipper requirements. It also deals with the effects on VMT and transport costs such as the: 1) diversion to larger vehicles; 2) changes in capacity utilization, circuity, empty mileage, annual mileage; and 3) increased payload on existing vehicles. Stowers' analysis has assumed that generally: 1) taxes reflect the costs with regard to cost allocation calculations, 2) taxes are increased for heavier vehicles, 3) there is 15 percent empty operation (miles), and 4) refrigerated trucks cost more to refrigerate two trailers than one trailer.

There are six cost components identified in this model: driver, vehicle, fuel, tires, repair, and overhead. Costs have been estimated for interstate/non-interstate roads. The cost of pavement, bridges, etc. are also included, but only on Interstate System roads and only for LCV costs.

2.3.2 System Implementation

Research included:

- Trailer types studied: dry van, refrigerated van, flatbed, tank, hopper, and dump.
- Configurations studied: Up to 11 per trailer type.
- Hitches studied: A-Train, B-Train, C-Train.
- GVWs studied: three to nine per trailer-type/configuration.
- Method of research:
  - Two special runs of Association of American Railroads' (AAR) Intermodal Competition Model (ICM).
  - For each trailer type, ICM considered two alternatives to a five-axle semi.
  - Percentage of cost saving provided by us for each alternative.
  - Results for other policy options obtained by interpolation and extrapolation.

2.3.3 Results of the Research

- Found that the important issue was access costs for the LCV operations. This can be difficult to capture in a link and node network.
- ICM Outputs for the mentioned 1993 study:
  - Reduction in rail ton-miles with an increase in truck ton-miles.
  - Reduction in railroad revenue from diverted traffic.
  - Reduction in railroad revenue due to competitive route reductions.
  - To eliminate the grandfather clause, there would be an increase in pavement costs off of the Interstate System, but there would be a decrease of pavement cost on the Interstate System.

2.3.4 Strengths of the Approach Used by Sydec

- A simple, noncomputer-based method of estimating costs.
- Results may be inaccurate, but likely to be "sensible" or "reasonable."

- Relatively sensitive to load density (savings increase with an increase in density on a per ton basis, and differences in capacity utilization, circuitry, percentage of mileage empty, annual mileage, and tax rates).

2.3.5 Concerns of the Model Used by Sydec

- Percentage cost changes are relatively insensitive to:
  - Moderate changes in components of costs
  - Length of haul (above 100 miles)
  - Percentage of mileage empty
  - Annual mileage
  - Commodity types.

- The definition of a dedicated/nondedicated service.

- The definition of "capacity utilization."

- Sensitivity does not reflect fuel economics.

- This model deals with nonline-haul costs for extra trailers.

- Use of AAR's ICM. There is limited documentation due to the proprietary nature of the model. ICM does not reflect intermodal connections.

2.3.6 Suggestions from the Discussion

A new model should:

- Deal with a variety of different types of operations including access and drayage.

- Be predictive. Policy options have been analyzed in the past and were reactive, not predictive, due to the orientation of analysis.

- Address intermodalism and increased intermodal connections.

- Be given to the states. Useful tools need to be provided to the states for them to make informed decisions. Federal oversight and support needs to be provided to the states.

2.4 Logistics—Data Issues and Freight Transportation Analyzer (FTA) Model Gary Gittings and Gene Tyworth, PSU, and David Middendorf, ORNL

2.4.1 The Shippers Survey and the Productivity Effects of TS&W Policies Study, Freight Transportation Analyzer (FTA) Model

The Freight Transportation Analyzer (FTA), developed by Al Stenger of the Pennsylvania State University, Department of Business Logistics, is a personal computer-based program that calculates not only the freight costs of various transportation options, but the total logistics costs as well, including the costs of carrying inventories at the origin and destination. It essentially implements a deterministic economic order quantity (EOQ) model adapted to incorporate transportation costs. In essence, the FTA was used to find the diversion and the net effects of LCVs on shippers' total logistics costs in the study "The Productivity Effects of Truck Size and Weight Policies" prepared for the FHWA and DOE..

In this study, there are costs associated with inventory that were discovered through surveying shippers. Such costs include: product value, inventory carry costs percentage, and ordering costs. Then, there are costs associated with transportation such as weight and size. The model assumes that:

- Transport costs are a subset of logistics costs.
- Annual lane volume (ALV), which is the annual demand for a product from one point to another point. (As ALV increases, there is an average percentage reduction.)
- Annual ton-miles (ATM) analysis. (Uses the ALV to determine if there is a benefit and how much of a benefit it will be.)

The shippers survey in the study gathered information such as product characteristics, lane volumes, transportation costs, and other logistic costs and this was entered into the FTA model. The objective of the FTA model was to determine how much would shippers have to pay for LCV shipment. A survey was used with a return of 176 useable observations to conduct a sensitivity analysis. The lower bound—LCV freight charge per shipment—is equal to the single trailer charge, and the upper bound—a Rocky Mountain double—is 15 percent higher per shipment than the single-trailer charge. A turnpike double is 30 percent higher per shipment than the single-trailer charge. It is assumed that each observation of the survey is a combination of shipper, product, and lane.

The FTA model is currently being used as a teaching tool at Penn State. It is also a tool for shippers. Given inventory versus shipping costs, it gives information from a shippers point of view for potential productivity savings. From this tool, we know that inventory costs may offset (decrease) any transportation cost savings. Also, the survey indicated that shippers drive carriers' decisions for finished goods.

2.4.2 System Implementation

- PC based and uses spreadsheets to analyze data

- A deterministic EOQ model adapted to incorporate transportation costs.

2.4.3 Results of the Productivity Effects of TS&W Policies Research

- When transport costs are at least two times more than inventory costs, the LCVs will decrease the total logistics cost. When transport costs are less than two times more than inventory costs, the LCVs will increase the total logistics costs.

- As the shipment size increases, the working stock increases and the orders decrease.

- Significant logistics costs savings result when: 1) the annual lane volume exceeds 2,500,000 pounds, and 2) annual single-trailer freight costs are two or more times greater than the annual inventory carrying costs.

- It is difficult to predict how much a shipper's annual total logistics cost will change as a result of switching to LCVs. There was no effective estimator found among the variables studied, and the influence of product value was smaller than expected.

- Product value is an important factor versus the percent reduction in logistics cost. This has an influence masked by lane volume. When the product value increases, the costs (logistics) increases. Product value alone is not a determinate, but with the lane value it is important.

- LCVs were generally 15 percent higher in costs than single semi-trailers.

- The average cost reduction is in the 20-25 percent range for turnpike doubles. This may not be accurate information though because the shippers may not have been fully using the single semi-trailers.

2.4.4 Strengths of the FTA Model

- This model incorporates the speed of delivery and the reliability factor.

- Uses spreadsheets for easy management.

- EOQ model is good for in-depth outbound areas and also for being able to look at value density.

2.4.5 Concerns of the FTA Computer Program

- EOQ model is applicable only to finished goods. Distribution resource planning is what is considered to be more important.

- Many interdependent parameters. Not a single source/single destination model.

- Safety stock issue is relatively small.

- The transportation decisions are made by the receiver/shipper in this model.

2.4.6 Suggestions from the Discussion for the FTA Model

- Concern for how important logistics are in determining the effects that TS&W policy changes will have.

2.5 Truck-Rail/Rail-Truck Diversion Model

Raman Nanda and Bryan Smalley, Transmode Consultants

2.5.1 The Truck-Rail/Rail-Truck Diversion Model

The Truck-Rail/Rail-Truck/Truck-Truck (Rail-Truck) Model was developed for the U.S. DOT and is a statistically disaggregate model versus previous aggregate models. For this demonstration, two data bases were used. They included the 1992 ICC Rail Carload Waybill File, which contains 396,851 records with 154 fields per record, and the National Motor Truckload Data Base (NMTDB), a long-haul truckload based survey from a 1985 CSX study which contains 15 thousand records with over 20 million moves. (The NMTDB is from the AAR's truckload data base series). From this data, a policy subset needs to be extracted. The Rail-Truck Model is run two times. First, one scenario is run to produce a before-change output. Then the model is rerun with policy modifications to study the proposed policy's impacts.

The Rail-Truck Model assumes that the receiver's logistics costs will include the cost of acquiring, transporting, storing, carrying inventory, and using the product. The model also assumes the principle determinants of utility includes shipper/commodity characteristics, shipment characteristics, modal characteristics, modal performance, and logistic costs.

This model uses a Shippers Logistics Costs Model (developed originally in 1969), which aimed at maximizing the receiver's utility while minimizing the total logistic costs. This is done by calculating the receivers utility for using each alternative.

2.5.2 System Implementation

- Microsoft Excel 5.0 (spreadsheet) and Microsoft Access 2.0 (data base).
- Can calibrate the model with "pre" and "post" variables ("conceptual design").
- Diversion computations are performed through the Shippers Logistic Cost Model which is programmed in Microsoft Excel.

2.5.3 Strengths of the Rail-Truck Diversion Model

- Simple data base management system (Microsoft Access) of large data bases which allows data to be handled in relational form. No code must be learned or manipulated.
- Rapid data preparation and modification with ability to easily prepare standard reports. Diversion calculations are easy to follow and understand.
- Easy to modify the model to analyze specific policy issues.
- A long-haul model, but can accommodate other analyses.

2.5.4 Concerns of the Rail-Truck Diversion Model

- Deterministic model. A probabilistic version of the model is also available.
- The drayage is from origin to the marshaling point and from the terminating marshaling point to the final destination.
- Needs a truck commodity flow data base which is current and accurate.
- Inputs are estimates, not accurate measures.
- The model has many data needs with relatively few data bases available to feed it. Given the current truck data in the model from NMTDB, its usefulness needs to be well understood. The model's usefulness needs to reflect the quality, time frame, and industry coverage of the truck data. Understanding these limitations, the model can assist in measuring diversion issues.

- Needs careful review and testing.

2.5.5 Suggestions from the Discussion for the Rail-Truck Diversion Model

- Preference is for the use of aggregate versus disaggregate data bases.
- Preference is for stochastic models versus deterministic models.
- Careful review of costing approaches, cost parameters, and logistics-related costs.

3.0 General Discussion of Issues at Workshop

3.1 Commodity Flow Survey (CFS) and the Truck Inventory Usage Survey (TIUS)

Two brief discussions were given on the information concerning the Commodity Flow Survey (CFS), and the Truck Inventory Usage Survey (TIUS) by Wanda Dougherty and Kim Moore, respectively.

The last Commodity Flow Survey was completed in 1977. The CFS is a mandatory survey. The 1992 survey has a 76 percent response rate. There was an expressed need by the workshop members for information concerning specific commodities being shipped. However, under Title 13, some information is kept confidential to ensure a larger response rate from industry.

The 1992 TIUS survey had a 84 percent response rate. Like the CFS, specific information concerning specific commodities and other specific information obtained in the survey is kept confidential due to Title 13 and the need for larger response rates from industry.

3.2 General Discussion Topics, Jim March, FHWA

Regarding the models, several comments were made by workshop participants, including:

- Need to calibrate the model, but not sure what control total should be used for the models. General consensus that the commodity flow survey may be of help with this issue.
- The models address only how the overall policy changes will effect this issue in the near future. There is no study of the long-term effects.
- Need a more comprehensive truck commodity flow data base.
- Obtaining needed data for some models will be difficult. For missing information, we may need to use expert judgement.

In addition to the models, several participants were concerned about VMT data. The following comments were made:

- Roger Mingo's VMT paper that was discussed at TRB provides a good review of VMT data issues.
- Future data collection changes that may better represent accurate truck travel includes:

- Collecting data over a 48-hour period instead of a two-hour period.

- Collecting data over a 48-hour weekday and weekend period versus just a weekday period.

- Adjust for “pairs of vehicles” that may be misinterpreted for trucks.

- Need more work investigating the intricacies of VMT, particularly as urban versus rural differences.

3.3 Further Research Topics

The following topics were listed as areas for future research:

(1) VMT. Review of VMT data collection at the state level as well as allocation to vehicle classes.

(2) Logistic costs: How do we reflect these costs (less represented in FNET, more represented in the FTA and in the Rail-Truck Model)? Do we not use these models because of data problems such as a lack of a truck commodity flow data base?

(3) Aggregate versus disaggregate models: What is the best approach?

(4) Commodity and geographic detail: We need to develop a truck commodity flow data base.

(5) Network models: How do we use such model or should we use such models?

(6) Access and drayage issues: The Rail-Truck Model simultaneously calculates the Rail-Truck/Truck-Rail shifts.

(7) LCV rates. Do we understand this issue of LCV potential use?

(8) Intermodal (Rail-Truck Model). Network framework.

4.0 Review of Models and Data Bases Available for Truck Size and Weight Study

4.1 Purpose

The purpose of this analysis is to discuss available models and data bases with recommendations about how to technically approach FHWA's TS&W study. Reflecting the workshop discussion and other analyses, this discussion will include information on the usefulness and limitations of the available models to measure the impacts of changes to Federal TS&W regulations on truck, rail, and perhaps other modes.

4.2 Available Models and New Data Bases

There are a number of models and data bases available to FHWA to measure the impacts of changes in Federal TS&W regulations. These models and data bases are at various stages of maturity and usefulness. The models and data bases discussed in this paper include:

Models	■ Rail-Truck Model, Transmode ■ Freight Network Policy Model (FNET), ORNL ■ Freight Transportation Analyzer, Penn State ■ NAPCOM, FHWA ■ BASIC (Bridge) Model, FHWA ■ Intermodal Competition Model (ICM), AAR
Data Bases	■ Truck Inventory and Use Survey, 1992 ■ Commodity Flow Survey, 1992 ■ International Fuel Plan ■ NATS and NMTDB, AAR ■ Reebie

4.3 Status and Usefulness of Models and Data Bases

The status and usefulness of the models for the TS&W study vary by model. This analysis of the individual models relates to the specific needs of the TS&W study and should not be reflective of the models' capabilities in other areas. In some cases, the models were designed for other purposes. This section is organized by analyzing individual models. Where models and data bases overlap, discussion will be provided.

In the TS&W study, we need to examine specific truck configurations (i.e., 3S3, 4 axle straights, etc.) as reported in the Phase I TS&W Report. To accomplish this task, new or revised models and data bases are needed. The models and data bases are discussed, reflecting these needs.

4.4 Models Available

4.4.1 Truck-Rail/Rail-Truck Model

The Truck-Rail/Rail-Truck Model was developed by Transmode for the U.S. DOT. The model's purpose is to determine the shifts of freight between modes and within modes from regulatory and other outside forces on the truck and rail industries. The model has been used for private clients to measure such shifts and other impacts in selected corridors with specific commodities, modes, and other factors.

This model is designed to reflect six sectors of the trucking industry (private, LTL, etc.) and to measure the shift between modes (rail-truck) and within a mode (truck). This latter capability makes it more versatile than the AAR's Intermodal Competitive Model (ICM) which is primarily designed to measure freight shifts from rail to truck. The Rail-Truck Model requires commodity flow data bases for truck and rail. The rail commodity flow data are available via the Rail Waybill for the nation. A truck equivalent to the Rail Waybill does not exist for the nation. However, a relatively large sample of disaggregate movements for long-haul truckload carriers could be assembled from the NATS and the NMTDB data developed by the AAR. Therefore, the model has limited capability to measure nationwide impacts of truck to rail and truck to truck shifts without such a national data base. The likelihood of creating such a data base (Truck Waybill-type data base) from the new and existing data bases, such as the CFS and the new TIUS, is difficult in the timeframe of this TS&W study because of the release timing of the electronic nationwide CFS data base. (This project has a delivery date of Fall 1996.)

The CFS data base will require extensive review by analysts before it is well understood and a wide range of acceptance is given. Such Truck Waybill data could be produced for a region or specific corridor/commodity(s) analysis where a very specific problem/scope of analysis is identified. For example, an individual corridor analysis for selected commodities could be analyzed if the truck data were supplied via case studies or other means. This model has been used in such cases. However, a complete truck commodity flow data base does not exist at the regional/corridor level, as is the case for the nation.

The Rail-Truck Model treats intermodal and truck movements as originating and terminating at county seats. The actual origins and destinations of shipments currently being made by truck or conventional rail are contained in the data sources used, but those of intermodal shipments are missing. The Rail-Truck Model creates assumed origins and destinations for these shipments from their intermodal origins and destinations, County Business Pattern data, and a gravity model.[2]

The Rail-Truck Model estimates origin/destination (O/D) distances for truck movements as great-circle miles (GCMs) between county seats, adjusted for circuitry. For LCV movements, the model estimates mileages of LCV operation from a node-link representation of an LCV network and from mileages of access hauls using GCMs between origins and destinations and nearby LCV network nodes (assumed to represent staging areas). The model currently assumes that LCVs can enter the LCV network at any node in the highway network, but this is easily changed to enter only at legitimate LCV marshaling points connecting LCV network links.[2]

For shipments that currently are not handled by conventional rail, railroad O/D distances are estimated by applying a rail/truck circuitry factor to GCMs. It is not clear what assumptions are made about the availability of rail service at the origin and destination. The use of a rail/truck circuitry factor results in consistent estimates of rail and truck O/D distances.[2]

For shipments that are currently handled by conventional rail, railroad O/D distances are set to actual distances obtained from the railroad waybill. If actual distances for rail and GCMs with no circuitry factor for trucks were used, it would result in overestimating the difference in length of haul between the two modes and bias the analysis toward rail-to-truck diversion.[2] However, truck circuity is included in the analysis.

All intermodal shipments are assumed to be made through one of 32 major intermodal rail terminals at each end of their rail haul. Rail distances between each pair of these terminals are actual rail distances and are maintained in a matrix used by the model. The use of a restricted set of intermodal terminals probably results in overestimating highway access miles to intermodal terminals for some shipments.[2] A more complete intermodal network is currently being implemented.

This model has an innovative way to understand relative freight movements between regions of the nation by containing a data base of published truck freight rates (contract freight rates are not available) by specific regions (county level) of the nation. Such a data base could help us better understand corridor and regional freight balances.

This model assumes that all shipments fill vehicles to capability (cube or wt). The LTL shipment, of course, is an exception, where the shipment size is assumed to be 10,000 lb (or perhaps, some cubic equivalent). Analysis from a study by Lowland and others for the Council of Logistics

[2]Phase I TS&W Working Paper #9 material, with slight modifications.

Management shows, however, order quantities (in lb) are often less than a full load.[3] The entire truck movement is paid for, however.

Additionally, the diversion results are likely to be sensitive to the assumptions about safety stock in the Rail-Truck Model. The underlying assumptions about safety stock (1.5 times the average transit time) should be refined in several ways. First, use estimates of the mean and variance of lead time for industry groups (e.g., from studies like Lowland's). Second, use lead-time demand (not transit-time) to determine safety stock. Third, use the gamma function (available in Excel) to approximate lead-time demand and evaluate the safety stock required to meet a receiver's service target. Fourth, use industry-group estimates of the service targets, which again, may be found in studies like Lowland's. The FTA model (or more sophisticated efforts that can be easily programmed in Excel) can address these concerns for micro/case analyses.[3]

Lastly, the Rail-Truck Model needs to be examined for its market pricing approach, rather than a cost approach, and its cost data for logistics and other related costs. The market approach is useful to reflect real world conditions.

Summary. The Rail-Truck Model could be used for nationwide rail to truck diversion analysis and could be used for case studies (corridor and commodity specific). However, the model needs to be reviewed per a few of the suggested improvements. This model has been used for corridor/commodity analysis for the private sector.

4.4.2 Freight Transportation Analyzer

The Freight Transportation Analyzer (FTA) was developed by Penn State University. This model has been used in several studies for the Federal government, but is used more often by private industry traffic managers. The purpose of the model is to provide information about logistics and other related transport costs to assist in decisionmaking by traffic managers, shippers, and receivers. The FTA was used in a LCV Study for FHWA to measure and identify potential corridor characteristics (length of haul, commodity, corridor) that would encourage as well as discourage LCV use. The FTA does not necessarily contain commodity flow data bases to draw on but does offer data related to logistics and other costs that could be used to improve the Rail-Truck Model for nationwide diversion (rail to truck) estimates. Most of the commodity flow data needed for an analysis are gathered and customized for the specific project.

Summary. The FTA could be useful in case studies (corridor, modal(s), and commodity specific) where the commodity flow data can be generated. But the FTA is not useful in measuring nationwide impacts of TS&W regulation changes. The FTA could improve the logistic-related costs in a simple spreadsheet model and Rail-Truck Model.

[3]Input from G. Tyworth, Penn State.

4.4.3 FNET

The Freight Network Policy Model (FNET) was developed by Oak Ridge National Laboratory. This model is designed to estimate impacts of changes in TS&W regulations, and highway use charges on truck and rail characteristics. The specific impacts are measured in changes to vehicle miles of travel (VMT) and payload ton-miles (PTM) by various truck operating weight classes and truck types, rail operating costs, and truck-rail modal split. The model uses a PC (Pentium) in MS-DOS and interfaces with TransCAD and GisPlus. The model network includes the Interstate System, Federal Primary and other highways (i.e., triple, turnpike double, and Rocky Mountain Double networks) from the ORNL National Highway Planning Network, and covers 181 BEA regions and tonnage for 23 commodity types. The model uses Reebie commodity data which has a base from the 1977 Commodity Flow Survey.

Very simply, the FNET model uses the following logic flow. The model sets the commodity supply and demand as well as TS&W limits (Federal and state), and truck and highway level limitations. Next, it finds the path (commodity supply/demand OD pairs) and uses modal split (truck-rail) model, then follows the spatial interaction (trip distribution) model and truck class competition model. Lastly, traffic is assigned and impacts are measured (VMT, PMT, and costs).

The FNET is attractive because of its stated ability to measure impacts from TS&W regulation changes on truck VMT and PMT as well as truck-rail modal split and costs. This assumes the FNET is able to reflect the complex operating and competitive environment of the trucking industry with regard to commodities, regional operations, local operations, national operations, intermodal operations, freight balance impacts, fuel cost fluxes, non-TS&W regulations, and service quality needs by shippers. However, the model depends on extensive amounts of data, some of which may be questionable. However, the lack of good solid data, the complexity of the trucking industry with regard to operations and competitive environment, the complexity of service quality as a determinant on modal use by shippers, and the need to measure specific TS&W policy options focusing on selected industry sectors and commodities by region of the nation and performance-based regulations suggest the inability to satisfy the data needs of the FNET.

Lastly, the FNET has had limited use by the community but has had some testing by ORNL. The FNET will be used for measuring the benefits of the Alameda Corridor on national freight. This activity is just starting and will provide valuable feedback on the model's data needs and ability to measure this issue as well as determine the ease of using it.

Summary. The FNET is a complex model that is programmed to measure the impacts of TS&W regulation changes on truck/rail VMT and PMT as well as truck/rail modal split and costs. The model has extensive data needs, and because of the lack of good truck data may have limited ability to measure impacts from specific TS&W regulation changes (focused on parts of the trucking industry (not a generic trucking industry). Also, the truck networks in the model (i.e., triples and others) may be useful for GIS purposes of illustrating the varying truck networks and potential networks.

4.4.4 Intermodal Competition Model

The most commonly used tool for estimating rail-truck modal diversion from disaggregate data is the AAR's proprietary Intermodal Competition Model (ICM). This model is designed to analyze a sample of actual rail movements, taken from the ICC Carload Waybill Sample (Rail Waybill). The Rail Waybill Sample consists of a systematic sample of waybills for railroad shipments terminating on Class I railroads in the United States. For these movements, the model estimates shipments to be diverted to truck, to be retained as a result of competitive railroad rate reductions, and to be unaffected by the reductions in truck transport costs. The most recent version of the model which is limited, also is capable of analyzing the effects of increased truck costs on railroad rates charged on existing truck-competitive rail movements and on diversion from truck to rail (using a sample of truck movements from the North American Trucking Survey).[2]

The proprietary nature of the ICM makes a careful evaluation of the accuracy of its estimates difficult. We have reviewed output produced by the previous version of the model and concluded that the cross-elasticities of rail demand relative to changes in truck costs that are implicit in these results appear to be reasonable (Source: Jack Faucett Associates Report, 1990). However, the comparison of cross-elasticities produced by the ICM to those produced by a Canadian National and Canadian Pacific railways analysis (presented in the TS&W Phase I Working Paper #9) suggests that the ICM may tend to overestimate diversion moderately and to overestimate railroad revenue reductions significantly. For this reason, caution should be taken when using results produced by the model.[2]

4.4.5 NAPCOM

NAPCOM is a pavement model which can allocate pavement consumption or deterioration to highway users and non-users. This model is currently undergoing revision per FHWA direction. The model can be used, as currently written, to allocate pavement costs to highway users but with limited capability to measure pavement impacts for changing Federal TS&W regulations for specific truck configurations. However, planned improvements in the model will permit for better measuring of TS&W regulation changes impacts on pavement.

NAPCOM planned improvements do not include the need to revise the model to measure the impacts on pavement from tire pressures, studded tires, super single tires and other trucking industry equipment trends. The NAPCOM could be revised to reflect these industry trends. Also, this model needs to include the data being generated by Turner Fairbanks for the Finite Element Model project in regard to improved regression models for pavement damage.

[2]Phase I TS&W Working Paper #9 material with slight modifications.

Summary. The NAPCOM model could be used to measure the pavement impacts from proposed truck configurations and weights. The planned revisions to the NAPCOM will permit this analysis. However, several other revisions to the model need to be done to make it more useful. Such revisions include: tire pressures, super single tires, and studded tires impact on pavement as well as other industry equipment trends discovered in the TS&W Case Studies.

4.4.6 BASIC

The BASIC model was developed by Transtec, Inc. for FHWA. The purpose of the model is to provide bridge improvement costs for a specific corridor, regional, or the nation. This model can handle various truck configurations and weights and the overstress limits can be changed for sensitivity analysis. The model has two parts: Moanstr and BITI. The model can calculate the delay times and dollars, pollution impact, and bridge cost but not accidents related to imposing a truck configuration on bridges. This model can be used as a policy tool for case studies and the nation, but cannot be used for permitting trucks at the state level.

Summary. The BASIC model can be used for calculating the bridge impacts of introducing various truck configurations and weights at the case study and national levels.

4.5 New Data Bases

There are several data bases that could assist the TS&W analysis. These data bases range from not previously available to updating existing data bases. With these data bases, coordination of planned efforts to analyze and review the data bases needs to take place.

4.5.1 Truck Inventory and Use Survey (TIUS)

The 1992 TIUS is available. The updated data base is useful in several models. Also, the new TIUS offers several new data points, such as better disaggregation of length of haul. Coordination and sharing of experiences with the updated data base needs to happen so as to avoid duplicative efforts.

4.5.2 Commodity Flow Survey

This data base is new (since 1977) and will provide a wealth of information to better understand commodity movements, commodity volumes, and related data. The timing of the data release to analysts is an important issue for its usefulness to the TS&W effort. Once determined, we need to organize and coordinate our efforts with other U.S. DOT offices and other efforts to better understand the data.

Longer term opportunities for the data include a review of its usefulness in developing a Truck Waybill. Given such a data base and other existing data bases, the use of the Rail-Truck Model could include freight shift impacts of truck to truck and truck to rail and better capture the intermodal aspects of the freight business.

4.5.3 State Fuel and Registration Plans

The States have a continuing program to better coordinate truck fuel and registration taxes for interstate vehicles. The fuel and registration plans require data to be collected and shared by trucking firms to states. We need to examine these data bases and determine their usefulness in the TS&W project.

4.5.4 NATS and NMTDB

The Association of American Railroads (AAR) has funded two truck surveys -- North American Trucking Survey (NATS) and the National Motor Truck Data Base (NMTDB). The focus of the data bases was to gather long-haul truck operating data via surveys and other means. The data collected (in general) included:

- Monthly Truck Passing Counts by
  - Location
  - Trailer Type
  - Truck Operation (RRCC, IRCC, Private)

- Truck Equipment and Operating Characteristics for Dry Van, Reefer, Flatbed by Driver Type (Union, Non-Union, O-O, etc.)

  - Tractor Type
  - Trailer Length
  - Trailer Width
  - Tractor Age
  - Driver Wages (Cents/Mile)
  - Driver Work Experience
  - Truck Fuel Economy
  - Tractor Ownership
  - Driver Daily Driving Hours
  - Driver Distribution
  - Length of Haul
  - Cargo Weight
  - Empty to Total Mileage
  - Average Loading Time
  - Diner Layover
  - Average Layover
  - Truck Speed
  - Driver Annual Mileage
  - Diesel Fuel Price
  - Cubic Capacity
  - Number of Drops
  - Number of Pickups
  - Type of Packaging
  - Loading Cargo
  - Unloading Cargo

This type of data was collected for about 10 years at varying sites. The goal of the data base was to reflect the long-haul trucking industry hauling rail-competitive commodities over rail-competitive corridors.

Currently, the data are no longer being collected by the AAR. The cost to collect the data was about $150,000 (rough estimate) per year. Consideration should be given to continuing the data collection for data not collected by other data bases such as TIUS and CFS. Also, we need to explore how to examine and determine the usefulness of the NATS and NMTDB data bases for the TS&W project.

5.0 Recommendations

(1) The Rail-Truck Model should be reviewed extensively and improved to be ready to measure nationwide rail to truck diversion and rail revenue contribution impacts from changes in Federal TS&W regulations. FHWA needs to have an independent estimate of diversion potential and avoid being in a situation of solely depending on the AAR's ICM for diversion estimates. Also supporting this recommendation is the availability of a long-haul/rail-competitive truck data from AAR's NATS and NMTDB data bases as well as the CFS.

(2) The FHWA should investigate the likelihood of using NATS and NMTDB data bases from the AAR. Also, the FHWA should address the value of continuing a NATS/NMTDB-type data base collection project. Perhaps, these data could be collected every two years or be combined with other current truck data collection efforts (i.e., TIUS). Related to this decision should be a review of the Reebie data base and a data collection method where the trucking industry would provide data at no cost and obtain national truck flow data for marketing purposes.

(3) The planned improvements to the NAPCOM need to be completed. Also, future changes to the model should include tire pressure, super single tire, and studded tire impacts on pavement.

(4) Coordinate the review of the CFS and TIUS with other U.S. DOT offices and other efforts. This data base will be valuable to the TS&W effort.

(5) The FNET needs to be reviewed for the data bases containing the different highway networks and the GIS interface capability. Also, we need to better the state regulation data base and its usefulness in the TS&W study. Currently, the FNET is being used to estimate the benefits of completing the Alameda Corridor in the L.A. Basin. This exercise should be a good test case of the ease of use and completeness of the model.