Comprehensive Truck Size and Weight (TS&W) Study

Phase 1-Synthesis

The Effects of TS&W Regulations

on

Truck Travel and Mode Share

Working Paper 9

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The Federal Highway Administration (FHWA) has recently embarked on a major study of potential changes in Federal policy relating to truck size and weight. The intention of this working paper is to provide researchers and policy analysts involved in this study, or in other studies of state or Federal size and weight policy, with as much information about estimating the effects of potential policy changes on usage of alternative truck configurations and on modal diversion as it is practical to assemble within a limited period of time.

The first section of this paper contains an extended discussion of the ways in which size and weight policy affects vehicle usage and modal diversion. The second section provides a brief discussion of several areas requiring more investigation. The concluding section contains a bibliography of material relating to issues addressed in this report. Two documents that were newly reviewed in the course of preparing this working paper are discussed at some length in Sections 1.2(a) and (c), and all other such documents are annotated briefly in the bibliography. More basic references are listed in the bibliography without annotation, and the more important of these are referenced in the text where appropriate.

1.0 Technical Relationships of Policy Consequence Concerning Truck Usage and Mode Share

This section contains four major subsections. The first three subsections provide general information for estimating how changes in transport costs for various truck configurations (discussed in Working Paper 7) are likely to affect the configurations used, modal diversion between truck and rail, and overall usage of trucks. The fourth subsection provides a brief summary of the estimated effects on truck and rail usage resulting from 18 potential truck size and weight policy changes analyzed in previous studies funded by the FHWA, the Transportation Research Board (TRB), and the Trucking Institute (TRI) (Sydec, *et al.*, 1989, 1990, 1991 and 1993).

1.1 Vehicle Configurations Used

The effect of changes in truck size and weight regulations on the vehicle configurations currently used for different hauls depends both on perceived total logistics costs for use of the affected configurations (discussed in Working Paper 7 and 8) and on whether or not the hauls are made by vehicles that are in dedicated service to a limited set of hauls (discussed below).

In the case of a set of hauls that are made by vehicles that are in dedicated service to these hauls, the vehicle configuration most likely to be used is one that minimizes perceived total logistics costs, allowing for the effect of equipment availability. These hauls frequently consist of the transport of natural resources from a small set of origins to a single destination. Since these weight-limited commodities generally are shipped in very large volumes, the most efficient vehicle usually is one that is allowed to provide reasonably direct origin-to-destination service with heavy payloads. Increases in GVW limits will result in a shift to vehicles that are best able to take advantage of the higher weight limits. In some cases, a set of related movements might be divided into two (or more) subsets to allow optimal matching of configurations with the size and weight limits on the routes to be served.

A shift in configurations for carrying such a set of natural-resource movements would be likely to occur over a period of several years, both because it would take some time to produce the larger vehicles and because it usually would be more efficient to continue using existing lower-payload vehicles until they wear out than to retire them prematurely. Equipment availability also affects the vehicles used for a set of seasonal hauls (e.g., for grain), since there may be an advantage to using conventional vehicles that are efficient for applications in the off season rather than more specialized vehicles that are more efficient for the seasonal hauls but relatively inefficient for the other hauls.

Private carriers that perform no for-hire carriage and serve only a known set of destinations are another source of dedicated hauls. Total logistics costs for carriers with exclusively cube-limited loads generally are minimized by using large vehicles (e.g., 53-foot and 57-foot semitrailers), while total logistics costs for carriers with exclusively weight-limited loads generally are minimized by using vehicles with high payload weight capacity.

From a carrier's perspective, the choice of vehicle becomes more complicated when it is to be used for a set of hauls that is not known in advance and that may have different weight/cube-limited characteristics and different length and weight restrictions on the routes to be used. Five-axle, 48-foot semitrailers are relatively efficient for carrying both weight and cube-limited loads, but other configurations frequently are more advantageous for some hauls but less advantageous for others.

Carriers that choose to include one or more of the alternative configurations in their fleet must adopt a vehicle-utilization policy that is appropriate for serving a market in which all hauls cannot be handled with equal efficiency. The benefits of using, for example, a 53-foot semi instead of a 48 exist only when cube-limited loads are carried on reasonably direct routes from origin to destination. Shippers charged by the trailerload may reject 53-foot semitrailers for weight-limited commodities unless they receive a rate reduction to compensate for the reduced load-carrying capacity of the longer trailers. On the other hand, obtaining cube-limited backhauls for such trailers may require some increase in empty mileage operated between hauls. Accordingly, when such vehicles are used to provide for-hire service to a set of shippers that has not been predetermined, some inefficiencies in utilization will result, and the overall reduction in transport costs will be somewhat less than occurs when such vehicles are used to provide dedicated service to a known set of cube-limited hauls.

The above example indicates that configurations used for shipments made by vehicles that are not in dedicated service need not always be the ones that *appear* to be most efficient for the shipment. In order to improve the efficiency of individual carriers, some weight-limited shipments may be carried by vehicles designed for cube-limited loads, and some cube-limited shipments may be carried in vehicles designed for weight-limited loads.

The issue of which vehicle configuration would be used for specific hauls becomes even more complex if non-door-to-door configurations, such as twin 48s, are allowed on a moderately extensive network of high-quality roads. A shipment with a payload maximum of about 41,000 pounds might be tendered in a 48-foot trailer to a carrier that operates turnpike doubles. However, if the shipment requires expedited service, whether or not the trailer would actually be operated in the twin-48 configuration on that part of the route on which such operation is allowed would depend on the timely availability of other trailers moving in the same general direction. Also, whether or not the shipment would even be tendered in this form depends on the rates charged for providing expedited service for such trailers (a complex subject discussed in Section 1.5(b) of Working Paper 7), as well as on the length of haul and on specific characteristics of the portion of the twin-48 network to be used. Longer trailers might prove more attractive for cube-limited shipments, while 48-foot trailers loaded to 50,000 pounds might prove more attractive for weight-limited shipments.

1.2 Modal Diversion

The effect of changes in truck size and weight regulations on diversion between rail and truck depends on the effect that these changes have on total logistics costs (TLC) of rail-competitive truck movements and on how they compare with total logistics costs for rail carload and rail intermodal services. In general, changes that reduce TLC for some truck movements may result in some diversion to truck from rail carload and rail intermodal, while changes that increase TLC for some truck movements may have the opposite effect. Changes that affect the cost of draying trailers and containers to and from intermodal terminals may also result in some diversion between rail carload and intermodal service; however, this effect need only be analyzed when significant changes in drayage costs are anticipated.

Potential modal diversion can be estimated using either disaggregate data for a sample of potentially affected movements or more aggregate data in which the total volume of such movements has been summarized by one or more key variables, such as by commodity. The aggregate approach is substantially easier and less expensive to apply, though the disaggregate approach is potentially more accurate. The aggregate approach is discussed in the first subsection below. Two computer models for analyzing disaggregate data are discussed in the following two subsections and critiqued more fully in the appendix.

(a) Aggregate Data

The most relevant modal-diversion study using aggregate data that we have identified was performed by Jones, Nix and Schwier (1990). This study developed two sets of estimates of modal diversion resulting from changes in truck costs per ton-mile for three different potential changes in tax policy. Both sets of results were derived using estimates of the cross-elasticities of railroad revenue and railroad ton-miles relative to changes in truck costs.

One set of results was obtained by deriving implicit cross-elasticities from high and low estimates of modal diversion previously provided to the Roads and Transport Association of Canada (RTAC) by the Canadian National (CN) and Canadian Pacific (CP) railways (Irwin and Barton, 1987). Evidently, one set of cross-elasticities was applied to all traffic currently carried by the CN without regard to commodity, and a second set was applied to all traffic carried by the CP.

The second set of results was obtained using elasticities developed by commodity, for 18 commodity groups, by the Association of American Railroads (AAR).[1] The AAR elasticities vary with the size of the change in costs as well as with commodity group.

Jones, Nix and Schwier also make brief reference to two substantially older sources of cross-elasticities,[2] and they reproduce cross-elasticities from one

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[1] The AAR cross elasticities were developed by AAR in 1989 using the results of a run of the Intermodal Competition Model (ICM) that is not described in Jones, Nix and Schwier. The ICM is discussed in the next subsection of this paper.

[2] R.E. Turner, *Freight Mode Selection in Canada*, Canadian Institute of Guided Ground Transport, Kingston, Ontario, 1975; and T.H. Oum, *Demand for Freight Transportation with a Special Emphasis on Mode Choice in Canada*, University of British Columbia, Vancouver, 1980.

of these sources; however, they do not use data from either of these sources.

The AAR elasticities produced estimates of revenue diversion that were up to 40 percent higher than did the CN/CP elasticities, and estimates of ton-mile diversion that were about twice as large as those produced by the CN/CP elasticities. The most likely reason for these striking differences is differences in the original estimates of modal diversion from which the cross-elasticities were derived. Other possible reasons are differences in the character of the road system in the United States and Canada, and differences in the character (commodity value, length of haul, etc.) of the movements in the individual commodity groups in the two countries.

The differences in the two sets of results illustrate an important limitation in the use of this type of analysis — the results are only as good as the cross-elasticities used. A related issue is the degree to which the scenario to be analyzed is similar to the one used in developing the cross-elasticities. In particular, if the cross-elasticities are expressed relative to transport costs (rather than relative to total logistics costs), do both scenarios generate similar changes in non-transport logistics costs for truck transport? (Many size and weight policy changes affect inventory costs, but changes in transport tax policy generally do not.) Also, do both scenarios apply uniformly to all types of hauls, or does one apply primarily to relatively diversible traffic (e.g., medium and long-haul traffic) and the other primarily to less diversible traffic?

(b) The Intermodal Competition Model

The most commonly used tool for estimating modal diversion from disaggregate data is the AAR's proprietary Intermodal Competition Model (ICM) (Dennis, 1988). This model is designed to analyze a sample of actual rail movements, taken from the ICC Carload Waybill Sample,[3] and, for these movements, to estimate which will be diverted to truck, which will be retained as a result of competitive railroad rate reductions, and which will be unaffected by the reductions in truck transport costs. The most recent version of this model (with which we have very little familiarity) also is capable of analyzing the effects of increased truck costs on railroad rates charged on existing truck-competitive rail movements and

[3] The ICC Carload Waybill Sample consists of a systematic sample of waybills for railroad shipments terminating on Class I railroads in the United States.

on diversion from truck to rail (using a sample of truck movements from the North American Trucking Survey[4]).

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 (Jack Faucett Associates, 1990b). However, the comparison of cross-elasticities produced by the ICM to those produced by a CN/CP analysis presented in the preceding subsection suggests that the ICM may tend to overestimate diversion moderately and to overestimate railroad revenue reductions significantly. For this reason, extreme caution should be taken when using results produced by the model. Additional discussion of the limitations of the ICM is contained in the appendix.

(c) The T-R/R-T Diversion Model

The Truck-Rail, Rail-Truck (T-R/R-T) Diversion Model is a new model currently being developed by Transmode Consultants (1994) based on much of the same research as the ICM. The T-R/R-T Model distinguishes four types of truck transport (truckload (TL), less than truckload (LTL), longer-combination vehicle (LCV), and private); three types of intermodal transport (trailer-on-flatcar, doublestack, and RoadRailer); and conventional rail carload transport.

The T-R/R-T Model represents nearly all 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 not. The T-R/R-T Model creates assumed origins and destinations for these shipments from their intermodal origins and destinations, County Business Pattern data, and a gravity model.

The T-R/R-T Model estimates origin/destination (O/D) distances for conventional truck movements as great-circle miles (GCMs) between county seats, adjusted for circuity. 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

[4] The North American Trucking Survey is a survey of truck drivers conducted at 46 truck stops by Arthur D. Little, Inc., under contract to the Association of American Railroads.

represent staging areas). The model currently assumes that LCVs can operate on all ramps connecting LCV network links.

For shipments that currently are not handled by conventional rail, railroad O/D distances are estimated by applying a rail/truck circuity 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 circuity factor results in consistent estimates of rail and truck O/D distances (both of which apparently are underestimated as a result of omitting any adjustment for truck/GCM circuity).

For shipments that are currently handled by conventional rail, railroad O/D distances are set to actual distances obtained from the railroad waybill. The use of actual distances for rail and GCMs with no circuity factor for truck results in overestimating the difference in length of haul between the two modes and biases the analysis toward rail-to-truck diversion.

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 most likely results in overestimating highway access miles to intermodal terminals for some shipments.

A major advantage of the T-R/R-T Model relative to the ICM is that the T-R/R-T Model is nonproprietary. The "User Manual" (Transmode Consultants, 1994) provides a better description of the model and its construction than available documentation for the ICM. However, no definitions or derivations for the many parameters incorporated in the model are provided (though some of the parameter values can be inferred from three pages of output reproduced in an appendix); and the "User Manual" provides no information about how to modify any of these parameters.

A second advantage of the T-R/R-T Model is its ability to create initial origins and final destinations for current intermodal movements. This capability enables the model to develop much better estimates of the potential for diverting current intermodal movements to alternate modes than the ICM was able to do (as discussed in Section 1.2(b)).

Despite these advantages, we have several concerns about the current version of the T-R/R-T Model as a result of our brief review. These concerns are presented in the appendix.

1.3 Effects on Truck Usage

(a) Ton-Miles

Changes in truck size and weight regulations will affect ton-miles transported by truck in three ways:

(1) Changes in the circuity of loaded vehicles will have a corresponding effect on ton-miles transported. Since localized and road-specific length and weight restrictions are most likely to affect longer and heavier vehicles, regulatory changes that allow increased use of such vehicles generally will tend to increase circuity, and those that decrease the use of such vehicles will tend to have the opposite effect.

(2) Changes in truck costs will result in diversion between rail and truck. Modal diversion (discussed in Section 1.2) usually will have a substantially greater effect on truck ton-miles than will changes in circuity. As in the case of circuity, regulatory changes that allow increased use of larger and heavier vehicles will result in increases in truck ton-miles, and those that decrease the use of such vehicles will have the opposite effect.

(3) Reduced truck costs may result in a very small amount of induced truck traffic, primarily over the long run (due to a decline in the importance of minimizing transport costs when selecting sites for industrial and commercial facilities). Increased truck costs may have the opposite effect. These effects are likely to be imperceptible and do not warrant analysis.

(b) Vehicle Miles

Changes in truck size and weight regulations will affect vehicle miles operated by truck in several ways:

1. Diversion of shipments from one configuration to another generally will affect shipment size and/or the number of shipments carried by an LTL vehicle or by a multi-trailer configuration. These changes in payload (discussed in Section 1.1) represent changes in the ratios of vehicle-miles to ton-miles, and so they have a direct effect on vehicle-miles operated by trucks.

2. Diversion of shipments from one configuration to another may also affect circuity and the percentage of miles operated empty, two effects that generally are substantially smaller than the preceding effect. As discussed in Section 1.1, to the extent that diversion to larger or heavier vehicles has any effect on circuity and percentage of miles operated empty, circuity and percentage of miles operated empty will increase, resulting in an increase in vehicle-miles operated.

3. Some changes in size and weight regulations will affect the maximum payload that can be carried by certain configurations.

4. A substantial reduction in the use of 48-foot semitrailers for truckload carriage could result in a slight increase in this configuration's percentage of miles operated empty.

5. Diversion of shipments between truck and rail (discussed in Section 1.2) has a direct effect on vehicle-miles operated by truck that usually is opposite to Effect 1 (diversion between different truck configurations) and may be comparable in magnitude.

6. As discussed in Section 1.3(a), reduced truck costs may result in a very small amount of induced truck traffic, and increased truck costs may result in a very small reduction in truck traffic. These effects are likely to be imperceptible and do not warrant analysis.

1.4 Results of Previous Studies

This section summarizes the results of recent analyses which examined the effects of various potential changes in truck size and weight limits on truck travel and mode share. These studies were performed by Sydec, Inc., with support from Jack Faucett Associates, Transmode Consultants, and the Transportation Consulting Group, for the Transportation Research Board (Sydec, *et al*., 1990), the Trucking Research Institute (Sydec, *et al*., 1989), and the Federal Highway Administration (Sydec, *et al*., 1991 and 1993).

(a) Policies Analyzed

The policies analyzed in the three studies are described briefly below. For the purpose of subsequent reference, the policies analyzed in each study are identified by the sponsoring organization, the number used in the original report, and a brief title.

Transportation Research Board (TRB):

1. Grandfather Clause Elimination. The Federal 20/34/ 80[5] weight limits and Bridge Formula B would be imposed on all roads on which higher limits are now allowed, with exceptions permitted only for the carriage of nondivisible loads.

2. Bridge Formula B. The 80,000-pound cap on GVW would be eliminated on all highway systems for vehicles with up to nine axles. Higher and lower GVW caps that exist in some states, both on and off the Interstate system, would also be eliminated. Individual bridges could continue to be posted with GVW limits. GVWs would be controlled by existing axle weight limits and by Bridge Formula B. It was assumed in this policy option, and in all other TRB policy options, that there would be no change in length limits (a significant assumption since, in the absence of a GVW limit, length becomes a significant factor in determining the maximum GVW for many combinations).

3. National Truck Weight Advisory Committee (NTWAC) Proposal. Annual permits could be purchased for

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[5] 20/34/80 represents in sequence, the single-axle, tandem-axle, and GVW limits in thousands of pounds (kips).

"specialized hauling vehicles" carrying divisible loads at GVWs of up to:

- 80,000 pounds for three-axle trucks
- 85,000 pounds for four-axle trucks
- 110,000 pounds for five-axle tractor-semitrailers

A specialized hauling vehicle was defined to be a single-unit or combination truck with at least three load-bearing axles carrying construction materials, building supplies, mining products, forest products, solid or hazardous waste, or scrap metal or other recyclable scrap materials.

4. Canadian Limits. The bridge formula would be replaced by minimum axle spacings; 51,000 pounds would be allowed on tridem axles; and maximum GVWs for several configurations would be derived from the Canadian Interprovincial Limits and from the Federal 20,000- and 34,000-pound limits for single and tandem axles. GVW limits specified under this scenario are shown in Table 1.1.

5. TTI HS-20 Bridge Formula. The 80,000-pound cap on GVW (as well as all existing higher and lower caps) would be removed and Bridge Formula B would be replaced by a modified version of the bridge formula developed by the Texas Transportation Institute (TTI) under contract with FHWA.

   Under this bridge formula, three-axle single-unit trucks with a conventional tandem axle and a wheelbase of at least 14 feet would have a maximum GVW of 54,000 pounds. Four-axle trucks with 8-foot overall spacing for the tridem axle would have a maximum GVW of 62,000 pounds; with a 10-foot tridem it would be 66,000 pounds; and with a 12.5-foot tridem it would be 71,000 pounds.

   Effective GVW limits for many combinations would be slightly higher than under Policy Option 2, particularly for six-axle semitrailers (typically 89,000 pounds), and five and six-axle twin 28s (91,500 and 96,000 pounds, but with no further increase for more than six axles).

Table 1.1. Maximum GVWs Allowed Under TRB 4 (Canadian Limits)

	GVW Limit (pounds)
Single Unit Trucks	
3 Axles	54,000
4 Axles	71,000
Tractor-Semitrailers	
5 Axles	80,000
6 Axles	97,000
Doubles	
5 Axles	87,000
6 Axles	101,000
A-Train with 7 or more axles	115,000
8 Axle B-Train	131,000

6. Combined Bridge Formulas. The 80,000-pound cap would be removed, the TTI bridge formula would be applied to all axle groups with two to six axles, and Bridge Formula B would be applied to all axle groups with seven to nine axles.

Trucking Research Institute (TRI):

All TRI policy options consisted of allowing certain longer-combination vehicles (LCVs) to operate on the entire mainline Interstate System (IS), all IS ramps on which the vehicles would not offtrack excessively, all turnpikes, and some other primary roads. These vehicles would be subject to specified GVW limits that generally would be slightly below the Bridge Formula B limits (but higher than 80,000 pounds). Also, in several major metropolitan areas, LCVs would not be allowed to operate during rush hours on congested Interstates inside beltways or beltway equivalents. The four TRI policies analyzed were:

1. Triples. Seven-axle triple 28s would be allowed to operate at GVWs up to 116,000 pounds on an appropriate system of roads that would include the entire mainline IS and access roads off the IS. Offtracking restrictions would exclude triples from about 50 percent of the IS ramps in New England and 5 to 40 percent of these ramps in other regions. It was assumed that all major LTL terminals are at or would be moved to locations that could be accessed directly by triples.

2. Turnpike Doubles. Nine-axle combinations with two 42 to 48-foot trailers would be allowed to operate at GVWs up to 127,400 pounds on the IS, all turnpikes, and a few other roads, but they would be excluded from 40 to 75 percent of IS ramps (varying by region). Twin 40-foot doubles and doubles with fewer than nine axles would also be allowed to use these roads, but, because of Bridge Formula B, their maximum GVWs would be lower than 127,400 pounds.

3. Intermediate-Length Doubles (ILDs). A variety of ILDs would be allowed to operate on the IS, all turnpikes, and most other primary roads. ILDs explicitly analyzed were: nine-axle twin 33 tanks, flatbeds and hoppers, with a maximum GVW of 116,000 pounds; and seven-axle Rocky Mountain double (RMD) vans, consisting of a 48-foot lead

trailer and a 28-foot pup, with a maximum GVW of 105,500 pounds. Twin 33s would be excluded from about 25 percent of IS ramps in New England and smaller percentages of IS ramps in other regions, while these vehicles would be allowed on 50 to 95 percent of non-IS, non-turnpike primary roads (varying by region). The 40' + 28' RMDs would encounter slightly greater restrictions than the twin 33s.

4. All LCVs. This policy would combine TRI Policies 1, 2 and 3.

Federal Highway Administration (FHWA):

1. Grandfather Clause Elimination. The Federal 20/34/80 weight limits and Bridge Formula B would be imposed on the entire IS, with exceptions allowed only for the carriage of nondivisible loads. This policy is a more limited version of TRB 1 (which would apply to all roads).

2a. Bridge Formula B on the IS. The 80,000-pound cap on GVW would be eliminated on the IS plus a relatively modest set of access roads. On these roads GVWs would be limited by Bridge Formula B. This policy is a much more limited version of TRB 2.

2b. Bridge Formula B on an Expanded Truck Network (ETN). FHWA 2(a) would be extended to include all rural Principal Arterials (PAs), plus all urban PAs on the National Network for trucks, and greater access to origins and destinations would be allowed. This policy is a moderately more limited version of TRB 2.

3(b)1. Twin-28 B and C Trains. This policy is derived from FHWA 2(b) (and lettered to emphasize the correspondence) by adding a restriction that, except where already allowed, doubles could operate at GVWs over 80,000 pounds only in B Train or C Train configurations and only if they have at least three axles under each trailer.

3(b)2. Twin-33 B and C Trains. This policy is identical to FHWA 3(b)1 except that length limits would be extended to allow twin 33 B and C Trains on the entire National Network for trucks plus access roads.

4. Combined Policy. All provisions of FHWA 1 and 3(b)2 would be implemented.

5. Expanded National Network. The National Network of roads open to 48-foot semitrailers and twin 28s would be expanded to include all rural PAs.

6. LCVs. This policy is similar to TRI 4 except that:

   - The GVW limit for nine-axle twin 48s would be 129,000 pounds (instead of 127,400 pounds);

   - The GVW limit for nine axle twin 33s would be 113,500 pounds (instead of 116,000 pounds); and

   - Six- and seven-axle semitrailers would be allowed to operate at Bridge Formula B GVWs (instead of being limited to 80,000 pounds).

   Although the policy described by FHWA 6 is quite similar to TRI 4, the analyses performed were very different, leading to substantially different estimates of the effects. Differences in the way these analyses were performed include:

   - A preliminary version of the T-R/R-T Model (described in Section 1.2(c)) and data for a sample of actual truck movements were used to develop estimates of usage of turnpike doubles (twin 48s and similar configurations), but not usage of the other truck configurations;

   - Separate estimates were developed of low and high usage of turnpike doubles ("low TD" and "high TD");

   - An additional set of slightly higher diversion estimates were developed for the year 2010 to reflect the effect of improvements to some National

Highway System roads that would enable them to be opened to turnpike doubles;

- The analysis incorporated relatively optimistic assumptions about the efficiency attainable for turn-pike-double and drayage operations — accordingly we believe the "high TD" results to reflect unreal-istically high estimates of turnpike-double usage.

- The FHWA 6 analysis was the only one to be based on the improved estimates of truck costs developed in Jack Faucett Associates, 1991 (instead of Jack Faucett Associates, 1990a); and

- The cost estimates in Jack Faucett Associates, 1991, (unlike those in the earlier document) incorporate extra user charges that Sydec (1993) estimated would be imposed on vehicles operating at GVWs above 80,000 pounds.

(b) Results Produced

The results of the Sydec policy analyses are summarized in Table 1.2, which is described below.

The first three columns of Table 1.2 summarize the effects resulting solely from changes in vehicle utilization. The results in these three columns exclude the effects of modal diversion. All results in these three columns are expressed as a percentage of total vehicle-miles of travel (VMT) of combination trucks or, for policies affecting usage of both combinations and single-unit trucks, as a percentage of total VMT of trucks with three or more axles. For each policy option, the first column in the table shows the estimated extent to which VMT would be diverted from one axle/trailer configuration to another, the second column shows the estimated percentage change in VMT, and the third column shows the estimated percentage change in transport costs. The affected configurations vary with the policy option.

The next five columns of Table 1.2 summarize the results of the modal diversion analyses. Columns 4 and 5 summarize estimated percentage effects that modal diversion would have on VMT of combination trucks and on railroad traffic (measured in ton-miles); and Column 6 summarizes the estimated percentage effects that modal diversion and

Table 1.2. Results of Previous Studies

	Changes in Vehicle Utilization			Modal Diversion					
	(1) VMT Diverted[a] (%)	(2) Change in VMT[a] (%)	(3) Transport Costs[a] (%)	(4) Truck VMT[a] (%)	(5) Rail Ton-Miles (%)	(6) Rail Revenue (%)	Cross Elasticities (7) Rail TM	Cross Elasticities (8) Rail Rev.	(9) Overall Shipper Costs (Bil. of 1988 $)
TRB									
1. Grandfather Clause	1.4[b]	+3.2[b]	+3.7[b]	-0.4	+0.7	+0.9	0.2	0.2	+$7.8
2. Bridge Formula B	31	-3.3	-1.6	+0.9	-2.3	-3.2	1.4	2.0	-2.3
3. NTWAC Proposal	1.3[b]	-1.5[b]	-2.6[b]	+0.4	-0.9	-1.3	0.4	0.5	-5.5
4. Canadian Limits	41 [b]	-8.4[b]	-5.3[b]	+2.5	-6.7	-9.5	1.3	1.8	-12.3
5. TTI HS-20 Br. Formula	30 [b]	-3.1[b]	-1.7[b]	+1.0	-2.6	-3.6	1.5	2.1	-5.4
6. Combine Bridge Formulas	30 [b]	-3.7[b]	-2.5[b]	+0.9	-2.6	-3.7	1.0	1.5	-5.5
TRI									
1. Triples	30	-4.0	-2.4	+1.5	-3.6	-3.9	1.5	1.6	-3.3
2. Turnpike Doubles	27	-3.7	-1.8	+1.9	-4.5	-4.7	2.4	2.5	-2.6
3. ILDS	29	-4.1	-1.9	+1.9	-4.5	-4.7	2.3	2.4	-2.7
4. All LCVs	31	-5.4	-3.2	+2.1	-5.8	-6.3	1.8	2.0	-4.4
FHWA									
1. Grandfather Clause	NE	+0.5[b]	+1.1[b]	-0.1	+0.3	+0.4	0.3	0.4	+2.3
2(a) Formula B - IS	2.3	-0.2	-0.1	+0.0	-0.1	-0.1	1.0	1.0	-0.1
2(b) Formula B - ETN	23	-2.2	-1.0	+0.4	-1.1	-1.6	1.1	1.6	-1.4
3(b)1 B&C Trains	21	-1.7	-0.8	+0.4	-0.9	-1.4	1.1	1.8	-1.1
3(b)2 Twin-33 B&C Trains	26	-3.0	-1.1	+0.7	-1.7	-2.6	1.5	2.4	-1.6
4. FHWA 1 & 3(b)2	23 [b]	-2.5[b]	+0.1[b]	+0.7	-1.6	-2.4	NM	NM	-0.5
5. Expand Truck Network	1.4	-0.03	-0.0	NE	NE	NE	NE	NE	-0.03
6. All LCVs									
Low TD Use	30	-5.4	-3.0	+2.5	-6.3	-7.3	2.1	2.4	-4.4
High TD Use	33	-6.5	-3.4	+2.8	-7.8	-9.9	2.3	2.9	-5.0

NE Not estimated
NM Not meaningful
[a] Except as noted, relative to total use of combination trucks
[b] Relative to all trucks with three or more axles.

Source: Sydec *et al.* (1989, 1990, 1991 and 1993).

competitive rate reductions would have on railroad revenue. (Several of the FHWA analyses also estimated the effects of reduced rail traffic on railroad costs. The estimated effects on costs, not shown, generally were about 60 percent of the effects on railroad revenue.)

Columns 7 and 8 show implicit cross elasticities for percentage changes in railroad ton-miles and railroad revenue relative to percentage changes in truck transport costs. These cross elasticities were obtained by dividing values in Columns 5 and 6 by those in Column 3.[6]

The final column of Table 1.2 summarizes the estimates of the effects of each policy option on overall shipper costs in billions of 1988 dollars. These estimates include the change in other logistics costs resulting from modal diversion, but they exclude the appreciably smaller changes in other logistics costs that may result from changes in vehicle configurations used.

The results summarized in Table 1.2 are aggregate results that sometimes obscure the estimates for usage of individual configurations. For example, Column 1 shows estimates of the overall percentage of current VMT diverted in the three "All LCV" analyses (TRI 4, FHWA 6 - Low TD, and FHWA 6 - High TD) to be relatively similar (31, 30 and 33 percent, respectively[7]). However, the three analyses actually produce appreciable differences in the estimates of the percentage of current traffic diverted to turnpike doubles (1.8, 2.3 and 5.5 percent, respectively). For additional detail on the results of these analyses, the source documents (Sydec, *et al.*, 1989, 1990, 1991 and 1993) should be consulted.

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[6] Except for the two Grandfather Clause policies, the estimates of percentage changes in railroad ton-miles and railroad revenue were, in turn, partly or completely derived from cross elasticities produced by two runs of the ICM (Jack Faucett Associates, 1990b, p. 18). The ICM runs produced rail ton-mile cross elasticities of 0.99 under conditions approximating policy FHWA 2(b) and 1.50 under conditions approximating policy FHWA 3(b)2. (The differences between these values and those shown in Table 1.2 result from the use of rounded data in deriving all elasticities shown in Table 1.2.) The corresponding rail-revenue cross elasticities produced by the ICM were 1.43 and 2.30, respectively.

[7] The second of these figures is lower than the first primarily because the cost assumptions used in FHWA 6 (Jack Faucett Associates, 1991), but not in any of the other analyses, incorporate increased user charges that were assumed to apply to vehicles registered at GVWs over 80,000 pounds.

2.0 Knowledge Gaps and Research Needs

The largest gap in the transportation research community's current understanding of the effects of truck size and weight regulations on truck travel and mode share is in the estimation of the modal diversion caused by policy changes. The substantial differences between the results produced using the CN/CP elasticities and those produced using the AAR elasticities indicates a relatively wide disparity between informed rail-industry analysts in the extent of diversion that would be expected for any given change in truck costs (see Section 1.2(a)). Unfortunately, the proprietary nature of most rail industry analyses makes it unlikely that one can obtain enough details about the CN, CP and AAR analyses to be able to identify the sources of the differences.

The T-R/R-D Diversion Model, now being developed (see Section 1.2(c)), has the important advantage of being nonproprietary and eventually should be very useful for performing these diversion analyses. However, this model still requires a substantial amount of additional development, refinement, review and testing. Accordingly, in the near term, the practical options for analyzing modal-diversion effects are either to use multiple sources and to produce a range of diversion estimates, or to choose one source as particularly appropriate for a given purpose and to accept the estimates it produces as the best available.

Another issue relating to the performance of any modal-diversion analysis relates to the level of effort to be budgeted, and, in particular, whether to use published cross-elasticities or new model runs. Also, regardless of the source and type of analysis used, some effort should be planned to minimize the effects of any identifiable weaknesses in the source (such as those discussed in Section 1.2).

A second area warranting further investigation relates to the use of aggregate data in the estimation of the effects of regulatory changes on vehicle configurations used. Data sources that attempt to represent the universe of all truck transport (e.g., the Truck Inventory and Use Survey, and the forthcoming Commodity Flow Survey (CFS)) do not provide data on individual shipments (though it might be possible to request the Census Bureau to perform specified analyses of CFS data at the individual shipment level). However, aggregate data may not provide sufficient detail to permit ready distinctions to be made between shipments that can be transported most efficiently using one configuration from those that can be transported most efficiently using another configuration.

3.0 References for Truck Travel and Mode Share Working Paper

Forthcoming

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<u>1989</u>

Sydec, Inc. and Jack Faucett Associates, *Productivity Analysis for Truck Weight Study*, Final Report, prepared for Trucking Research Institute, Alexandria, VA, October 25, 1989.

<u>1988</u>

Dennis, Scott M., *The Intermodal Competition Model*, Washington, D.C., September 1988.

<u>1986</u>

U.S. Department of Transportation, Transportation Systems Center, *The Feasibility of a Nationwide Network for Longer Combination Vehicles*, Working Paper: Effects on Truck Traffic and Transportation Costs, Cambridge, MA, May 1986.

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Newly Reviewed Literature

<u>1994</u>

Morlok, Edward K., and Lazar N. Spasovic, "Redesigning Rail-Truck Intermodal Drayage Operations for Enhanced Service and Cost Performance," *Journal of the Transportation Research Forum*, Vol. 34, No. 1, 1994, pp. 16-31. (Presents estimated costs for several alternative systems for providing drayage to a Conrail intermodal yard.)

Norris, Bahar, *Intermodal Freight: An Industry Overview*, Volpe National Transportation Systems Center, prepared for the Federal Highway Administration, Washington, D.C., March 1994. (Contains an extensive overview of rail-truck intermodal operations, but no information relating to how changes in truck costs would affect intermodal traffic.)

Oak Ridge National Laboratory, Center for Transportation Analysis, *Effect of Truck Size and Weight Policy Options on Carrier and Shipper Productivity*, Draft Final Report, prepared for the Federal Highway Administration, Washington, D.C., April 1, 1994. (Develops estimates of truck freight that might be diverted to Rocky Mountain doubles or turnpike doubles as a function of annual volume of freight shipped from a particular origin to a particular destination and relative rates for LCVs and semis. Assumes that carriers will not match trailers from different shippers in order to form LCVs. Does not consider costs of accessing an LCV network. Using Jack Faucett Associates (1991) costs and assuming increased GVW limits, estimated 23 to 35 percent of weight-limited traffic would be diverted to LCVs and 31 to 50 percent of cube-limited traffic.)

Transmode Consultants, Inc., *Truck-Rail, Rail-Truck Diversion Model*, User Manual, Draft, Washington, D.C., April, 1994. (See Section 1.2(c).)

Transportation Association of Canada and Canadian Trucking Research Institute, *Impacts of Canada's Heavy/Vehicle Weights and Dimensions Research and Interprovincial Agreement*, June 1994. (Estimates that, because of increased weight limits adopted for B Trains, there has been a significant shift from the use of A and C Trains to B Trains (primarily eight-axle B Trains) and that this shift is likely to continue over the next decade. A slight increase (of about 5 percent) has also been observed in the use of six-axle semis, and this increase also is expected to grow.)

U.S. General Accounting Office, *Longer Combination Trucks: Potential Infrastructure Impacts, Productivity Benefits, and Safety Concerns*, GAO/ RCED-94-105, Washington, D.C., August 1994. (Based on an extensive review of the literature (but not Sydec, *et al.*, 1993, which was not released in time to be reviewed) and discussions with shippers, trucking companies, and truck and railroad associations, GAO concluded that use of LCVs would be modest. Diversion estimates of 4 to 11 percent of railroad traffic are quoted but not considered to be significant, partly because of GAO's concerns that the ICM (used for deriving all but one of the estimates) overestimates diversion.)

<u>1993</u>

Peat Marwick Stevenson & Kellogg, *Economic Impact of Introducing 53' Semi-Trailers and 25 Metre B-Trains in Ontario*, prepared for the Ontario Ministry of Transportation, Downsview, Ontario, January 11, 1993. (PMS&K quote CN and CP estimates that indicate that allowing semi-trailer lengths in Ontario to be increased from 48 to 53 feet would reduce rail revenue attributable to traffic to, from and within Ontario by about 1.4 percent. A survey of 65 shippers suggests that actual diversion would be only about 0.35 percent, and PMS&K's own estimate of revenue loss is 0.1 to 0.7 percent. All sources agreed that increasing B-Train lengths from 23 to 25 meters would have little impact on rail revenues.)

<u>1992</u>

Abdelwahab, Walid and Michel Sargious, "Modeling the Demand for Freight Transport: A New Approach," *Journal of Transportation Economics and Policy*, January 1992, pp. 49-70. (A three-equation model for estimating truck/rail mode share and shipment size for each of the two modes is developed and estimated using a quasi-maximum likelihood procedure.)

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Oum, Tae Hoon, W.G. Waters, II, and Jong-Say Yong," Concepts of Price Elasticities of Transport Demand and Recent Empirical Estimates," *Journal of Transport Economics and Policy*, May 1992, pp. 139-154. (Presents estimates of own-price elasticities of demand for rail and truck transport, by commodity, from 11 studies using log-linear, aggregate logit, translog, and discrete-choice models. For a given mode and commodity, elasticity estimates frequently vary by a factor of two to four.)

<u>1990</u>

Jones, J., F. Nix, and C. Schwier, *The Impact of Changes in Road User Charges on Canadian Railways*, Final Report, prepared for Transport Canada, revised September 1990. (See Section 1.2(a).)

<u>1987</u>

Irwin, N.A. and R.A. Barton, *Economics of Truck Sizes and Weights in Canada*, Final Report, Council on Highway and Transportation Research and Development and the Roads and Transportation Association of Canada, Ottawa, July 1987. (Four alternative scenarios for increased size and weight limits in Canada were estimated by the CN and CP to reduce their annual net contribution by $108 to $192 million and to reduce gross revenue by four to nine percent. The portion of the report containing additional details about these estimates has not yet been received.)

Appendix. Further Critique of the Two Modal-Diversion Models

Brief descriptions of two modal-diversion models, AAR's Intermodal Competition Model (ICM) (Dennis, 1988) and Transmode Consultants' Truck-Rail, Rail-Truck (T-R/R-T) Diversion Model (Transmode Consultants, 1994), are presented in Section 1.2(b) and (c). As stated in those sections, we have a number of concerns about each of these models. These concerns are presented below.

A.1 The Intermodal Competition Model

Our most important concern about the use of the ICM relates to the truck cost analysis performed by the model. This analysis presumes that the utilization rates of larger and heavier vehicles generally would be the same as current utilization of 48-foot semitrailers; i.e., that all loads carried would be loads for which the vehicles are designed and that there would be no increase in empty mileage and no decrease in annual mileage. As discussed in Section 1.1 above and in Section 1.5 of Working Paper 7, these assumptions about utilization are optimistic, especially with respect to non-door-to-door configurations such as twin 48s. ICM's estimates of cost savings resulting from the use of larger and heavier trucks are overstated, and, accordingly, modal-diversion estimates derived using these cost estimates are too high. This problem is not insurmountable. The model has been run in the past using exogenously specified estimates of the effects of regulatory changes on truck transport costs (Jack Faucett Associates, 1990b, and Sydec, 1991); and adjustments also can be made to ICM results (with some loss of accuracy) to compensate for any known tendency of the model to over or underestimate diversion.

Several other factors have affected ICM results that have been produced in the past, although some of these may have been corrected in the latest version of the model. These factors are listed below, along with estimates that we previously made of the effect of these factors on the model's estimates of overall diversion to twin 48s (Sydec, 1993, pp. V-4 - V-5).

- Fuel taxes were assumed to be zero on truck movements originating in Canada, increasing overall diversion by an estimated 8.0 percent.

- The costs of reconfiguring twin 48s and the costs of access hauls to the twin-48 network were not adequately reflected for short hauls (particularly those under 800 miles) while they were overestimated for long hauls (particularly those over 1,800 miles), increasing overall diversion by about 23 percent.

- Because the ICC waybill sample does not identify the true origin and true destination of intermodal movements (but only the rail origin and rail destination), the ICM underestimates the cost of intermodal movements and significantly underestimates diversion of these movements. Overall diversion was estimated to be reduced by 3 percent, but the magnitude of this underestimate can be expected to grow as intermodal traffic grows.

- The use of waybill data for a recent historic year tends to understate the portion of rail traffic that is intermodal or will be in the future. Since intermodal traffic is the traffic most readily divertible to twin 48s, overall diversion to twin 48s tends to be underestimated.

- ICM estimates of other logistics costs (OLCs) (which have been printed in the past but are no longer printed) do not appear to represent realistic relationships between OLCs for rail movements and OLCs for truck movements. (However, the model appears to have been calibrated to compensate for this effect.)

It should be emphasized that some of these problems may have been corrected in the latest version of this model.

Finally, although we have not reviewed the construction of the North American Trucking Survey (NATS) or the way the ICM uses this data to represent the universe of rail-competitive truck shipments, the National Motor Truck Data Base (the predecessor to the NATS) had an inherent, but easily correctable, bias toward over-representing long-haul movements (Sydec, 1993, p. C-7). If the ICM is used with NATS for estimating truck-to-rail diversion resulting from policy changes that *increase* truck costs, a failure to adjust for this bias will result in a significant overrepresentation of long-haul truck movements, which are relatively divertible, and therefore truck-to-rail diversion will be overestimated.

A.2 The T-R/R-T Diversion Model

Our concerns about the current version of the T-R/R-T Diversion Model are based on a brief review of the model description and of the three pages of output produced in an appendix for a single shipment (of a weight-limited sodium compound).

The most significant of our concerns relate to the analysis of LCVs. Data contained in the appendix indicates that transit times for LCVs are assumed to be one-third shorter than those of for-hire TL transport, and that reliability is assumed to be 20 percent better. Although not discussed anywhere in the User Manual, the shorter transit times reflect an assumption that around-the-clock relay operation would be used for LCVs but not for conventional trucks. However, the cost structures used for LCVs and for conventional trucks apparently do not reflect any cost difference between relay operation and the single-driver operation assumed for conventional trucks. (If the costs actually are similar, conventional TL operators would choose to provide the better service attainable with relay operation.)

The transit time assumption for LCVs apparently also ignores the delays that can be expected at staging areas in order to match pairs of trailers moving in the same general direction. Also, because of the need for such delays (without which the economies of LCV operation are unattainable), it seems that, for most shippers, transit-time reliability of LCVs would be *poorer* than that of conventional truckload service (though some shippers might be willing to pay a premium to guarantee expedited handling of their trailers).

Other concerns include:

- The procedures used for estimating length of haul for shipments currently handled by rail (discussed above) apparently overstate somewhat the lower circuity of truck, thus biasing the analysis somewhat toward diversion to truck.

- A load ratio (loaded miles per total mile) of 1.0 is assumed for all modes except rail (for which it is 0.6) and private truck (for which it is 0.5). An overall load ratio of 1.0 is unattainable for any mode. (There might be some analytic justification for treating loaded backhauls as if they had load ratios of 1.0, or even higher; but the movement in question — from Barstow, California to Swansea, Illinois — is unlikely to represent a backhaul.)

- The assumptions used for LCV access costs (roughly half to two-thirds of those for intermodal access costs) may be somewhat optimistic.

- Rail costs appear to be modeled as being directly proportional to distance, with no additional costs for pickup and delivery.

- A negative charge for pickup and delivery appears to be incorporated into the rate structure of truckload carriers (actually, a $162 charge per shipment for pickup and a $332 credit for delivery).

- The costs for LCVs appear either to exclude or to underrepresent the cost of reconfiguring LCVs en route and the inefficiency resulting from an inability to pair all trailers operating on the LCV network. Also, the apparent assumption that efficient interconnections will exist between all intersecting LCV roads without any added circuity will result in underestimating the lengths of LCV hauls.

It is likely that most of all of these concerns will be addressed in the course of further development and refinement of the model. However, we do not believe the model will be ready to be used for analyzing the effects of possible changes in TS&W policy until these concerns have been addressed, the data incorporated in the model is more clearly presented and reviewed, and the model itself has been more thoroughly tested.