Summary Report

Introduction

This report presents results of a comprehensive examination of issues surrounding current Federal truck size and weight (TS&W) limits and potential impacts of changes to those limits. This is the Department of Transportation's first comprehensive study of Federal TS&W limits since 1981. However, the Department, the Transportation Research Board (TRB), and others have conducted a number of studies over the past 20 years of various aspects of Federal TS&W regulation. Those studies have highlighted the diversity of opinions among States, different segments of the trucking industry, and various other interested groups.

While these studies have generally included options to either increase or decrease Federal TS&W limits, attention has focused on options to improve productivity through various increases in TS&W limits. This follows from ad hoc changes that have been occurring in truck sizes and weights such as the gradual increases in trailer lengths over the years and the increasing numbers of overweight permits being issued by States.

Virtually all previous TS&W studies have shown large reductions in shipping costs associated with increases in TS&W limits. The magnitude of cost reductions, of course, has depended on specific assumptions concerning allowable vehicle weights and dimensions and the extent to which larger vehicles would be allowed to operate.

Past studies have also noted a variety of potential adverse impacts of increasing Federal TS&W limits including added infrastructure costs, financial impacts on competing railroads, disruption of traffic flow, and potential adverse impacts on safety. Only general estimates of these costs can be made since it is impossible to predict the extent to which States would allow larger and heavier vehicles to operate if no uniform nationwide criteria were in place.

Safety has been one of the issues of greatest concern in previous TS&W studies, yet it is difficult to quantify many safety impacts. Motorists are keenly aware of the growing volume of trucks on the road, and many express discomfort when driving in traffic with many large trucks. Particularly difficult to estimate is how safe longer combination vehicles (LCVs) would be in operating environments other than the ones in which they have been allowed to operate in the past. These multitrailer combinations currently operate at weights well above the 80,000-pound Federal gross vehicle weight limit, primarily on low-volume rural roads in western States or on turnpikes in several eastern States. In those environments their crash rates generally have been comparable to conventional tractor-semitrailer combinations, but many question their safety on more congested roads in other parts of the country. LCV's have inherent stability and control limitations because of their length and number of trailers. Short trailers tend to decrease vehicle stability and long trailers decrease vehicle control

To understand the views of the many groups with an interest in TS&W limits, extensive outreach was conducted in this study. Outreach included public meetings, regional focus groups with various interested parties, workshops to review data and analytical methods used in the study, requests for comments on study plans, working papers, and drafts of key parts of the report, and video conferences with State representatives. These outreach activities confirmed the complexity and degree of concern surrounding many TS&W issues.

Various segments of the trucking industry view TS&W regulation differently, based on their assessment of how it would affect their competitive and financial position. Not all segments of the industry believe they would benefit from increased size and weight limits. States also disagree on the appropriate Federal TS&W policy. Some States want the flexibility to set TS&W limits on all their highways including those on the Interstate System. Other States prefer stronger Federal control over TS&W limits to minimize pressures for increased weights and dimensions.

Background

1956-1975

The Federal Government did not begin regulating TS&W limits until 1956 when maximum vehicle weight and width limits were imposed on vehicles operating on the new Interstate Highway System. States historically had regulated the weights and dimensions of vehicles operating on State highways, but Congress believed that the large Federal investment in the Interstate System required more direct Federal controls on the weights of vehicles using the Interstate System. A maximum gross weight limit of 73,280 pounds was established along with maximum weights of 18,000 pounds on single axles and 32,000 pounds on tandem axles. Maximum vehicle width was set at 96 inches, but length and height limits were left to State regulation. States having greater weight or width limits in place on July 1, 1956 when Federal limits went into effect were allowed to retain those limits under a grandfather clause.

The Congress increased allowable gross weight and axle weight limits in1975, in part to provide additional cargo-carrying capacity for motor carriers faced with large fuel cost increases at the time. The gross vehicle weight limit on Interstate Highways was increased to 80,000 pounds and single and tandem-axle load limits were increased to 20,000 pounds and 34,000 pounds respectively. As in the 1956 Act, these limits were permissive and States could adopt lower limits if they chose. In the same legislation Congress required that each State annually certify that it was enforcing all State size and weight laws on all Federal-aid highways and provided for highway funding sanctions if States were found not to be adequately enforcing their TS&W laws.

1982-1991

Not all States immediately adopted the 80,000-pound weight limit. Motor carriers traveling through a State that retained the 73,280-pound limit had to restrict their loads to that weight even though most States had adopted the 80,000-pound weight limit. Carriers were most concerned about a small group of “barrier States” along the Mississippi River that retained the 73,280- pound limit and effectively limited much of the East-West traffic crossing the Mississippi River to the lower weights in those States. Carriers were also concerned that over the years State length limits and regulations on the use of short twin-trailer combinations were creating inefficiencies. A study called for in the Surface Transportation Assistance Act (STAA) of 1978 addressed these and other issues. Based in part on results of that study, Congress, in the STAA of 1982, required States to adopt the Federal weight limits on Interstate Highways and also required them to allow vehicles with certain minimum dimensions on a National Network (NN) for STAA vehicles to be designated by the Secretary of Transportation in consultation with the States. In particular, the STAA of 1982 required States to allow tractor-semitrailer combinations with 48-foot long semitrailers and twin- trailer combinations with trailers of 28 feet to operate on the NN.

Figure 1 summarizes current Federal TS&W limits. Implementation of these provisions was difficult, especially in States that previously had not allowed twin-trailer combinations. Requiring States to allow certain vehicle weights and dimensions on the Interstate System established a much stronger Federal role in the area of TS&W regulation than the Federal Government had assumed before. In addition to requiring that the STAA vehicles be allowed to operate on the NN, those vehicles were to be granted reasonable access off the NN to terminals and to facilities for food, fuel, rest, and repairs. Defining the extent of the NN and what "reasonable access" meant was a controversial process.
In addition to TS&W provisions, the STAA of 1982 also increased the Federal fuel tax by 5 cents per gallon and increased other Federal user charges on heavy trucks, based in part on work conducted for the 1982 Federal Highway Cost Allocation Study. The cost allocation study had found that Federal user taxes being paid by heavy trucks were not covering pavement, bridge, and other infrastructure costs attributable to those vehicles. Changes in user fees enacted in the STAA of 1982 resulted in heavy trucks paying a larger share of their highway cost responsibility.

Figure 1. Current Federal Truck Size and Weight Limits

Current Federal law includes the following limits:

- 20,000 pounds for single axles on the Interstate System;
- 34,000 pounds for tandem axles on the Interstate System;
- Application of the Federal Bridge Formula for other axle groups up to the maximum of 80,000 pounds gross vehicle weight on the Interstate System;
- 102 inches for vehicle width on the National Network (NN) for STAA vehicles;
- 48-foot (minimum) or longer if grandfathered, for semitrailers in a semitrailer combination on the NN; and
- 28-foot (minimum) for trailers in a twin-trailer combination on the NN.

1991 to Present

The most significant legislative action related to Federal TS&W limits since 1982 was the freeze on LCV operations imposed in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) (P.L. 102-240) and extended in the Transportation Equity Act for the 21st Century (TEA-21) (P.L. 105-85). Several studies in the 1980s by the Department of Transportation and the Transportation Research Board (TRB) had examined TS&W options involving LCVs. As noted above, such vehicles have operated in many western States and on some eastern turnpikes for a number of years, but the possibility that Federal TS&W limits might be changed to allow those vehicles to operate more widely was, and continues to be, widely debated. The "LCV freeze" enacted in the ISTEA prohibited States from allowing any expansion of LCV operations either in terms of routes upon which they may operate or the vehicle weights or dimensions that may be allowed.

Over the years special exemptions to Federal weight limits have been enacted for individual States, sometimes applying only to the transportation of specific commodities that are important to the State economy. These special exemptions along with the grandfather rights allowing States to operate vehicles exceeding Federal weight limits have created what many have characterized as a patchwork of Federal TS&W limits on Interstate Highways that overlays an even more diverse set of State TS&W limits off the Interstate System.

Since 1982, States, various segments of the trucking industry, shippers and other groups have proposed changes to Federal TS&W limits. This Comprehensive Truck Size and Weight Study has developed a framework to analyze a broad range of potential options and has used that framework to analyze several types of changes that have been recommended by others. This information and the analytical tools developed for the study provide a basis for assessing the various potential benefits and costs of alternative TS&W policy options.

Study Approach

Review Process

This study used a variety of methods to develop information concerning potential impacts of TS&W options. In addition to the extensive outreach process described above, an internal review process involving all interested elements within the Department was instituted to assure that the full range of perspectives was considered in the study. In particular, study oversight and direction was provided by a Departmental Policy Oversight Group (POG), comprised of senior policy officials from the Office of the Secretary, the Federal Highway Administration, the Federal Railroad Administration, the National Highway Traffic Safety Administration, and the Maritime Administration. In addition to the POG, a Multimodal Advisory Group (MAG) was established to ensure that major technical decisions shaping the study would be made on an intermodal basis with consideration to potential effects that changes in TS&W limits might have on the Nation's total freight transportation system. Because the rail system is both a necessary and important element of the Nation's freight transportation system, the Department considered it critical to assess potential effects on the rail industry that might be brought about by the introduction of larger, heavier trucks.

The study was closely coordinated with the 1997 Federal Highway Cost Allocation study to assure that (1) consistent assumptions were used in the two studies, (2) consistent methods were used to estimate infrastructure and other impacts of highway use by different vehicle classes, and (3) cost recovery and equitable user fee issues could be addressed if they came up in the TS&W study or legislative proposals subsequent to completion of the study.

The purpose of the Department's Comprehensive TS&W Study was to develop an information base and set of analytical tools upon which to evaluate alternative TS&W options rather than to recommend TS&W policy changes. To guide decisions concerning TS&W policy and other freight issues the

Department developed a National Freight Policy in 1997 that contains eight principles that it would use in evaluating freight-related issues. Those guiding principles are summarized in Figure 2.

An important first step in this study was to review previous studies that had been conducted by the Department, TRB, and others concerning TS&W and related truck safety issues. While safety was perhaps the most controversial issue in the study, a comprehensive analysis of truck safety issues was beyond the scope of the TS&W study. Only those safety issues directly related to truck weights and dimensions were considered in depth in this study. While broader truck safety concerns are quite important, the scope of this effort was focused on incremental effects of possible changes in TS&W limits on truck safety.

Figure 2. National Freight Transportation Policy Statement (January 1997)

The Department of Transportation established eight principles to guide freight transport policy:

- Ensure a safe transportation system;
- Use advances in transportation technology to promote transportation efficiency and safety;
- Promote economic growth by removing unwise or unnecessary regulation and through the efficient pricing of publicly financed transportation infrastructure;
- Protect the environment and conserve energy;
- Provide funding and a planning framework that establishes priorities for allocation of Federal resources to cost-effective infrastructure investments that support broad National goals;
- Effectively meet our defense and emergency transportation requirements;
- Facilitate international trade and commerce; and
- Promote effective and equitable joint utilization of transportation infrastructure for freight and passenger service.

Case Studies, Focus Groups

In addition to the literature review, a series of case studies was conducted to examine different aspects of truck transportation in detail, including competition and cooperation between trucking and other modes of freight transportation, especially rail. Specific questions were asked concerning the likely response by different types of carriers and shippers to various changes in Federal TS&W laws. Focus group meetings with auto and truck drivers in different parts of the country also were conducted to understand more clearly the perceptions of drivers in different settings, including drivers who have been exposed to LCVs and those who have not.

Impact Analyses

Through this reconnaissance process a number of factors were identified that must be considered when assessing TS&W policy options. Those factors are summarized in Figure 3.

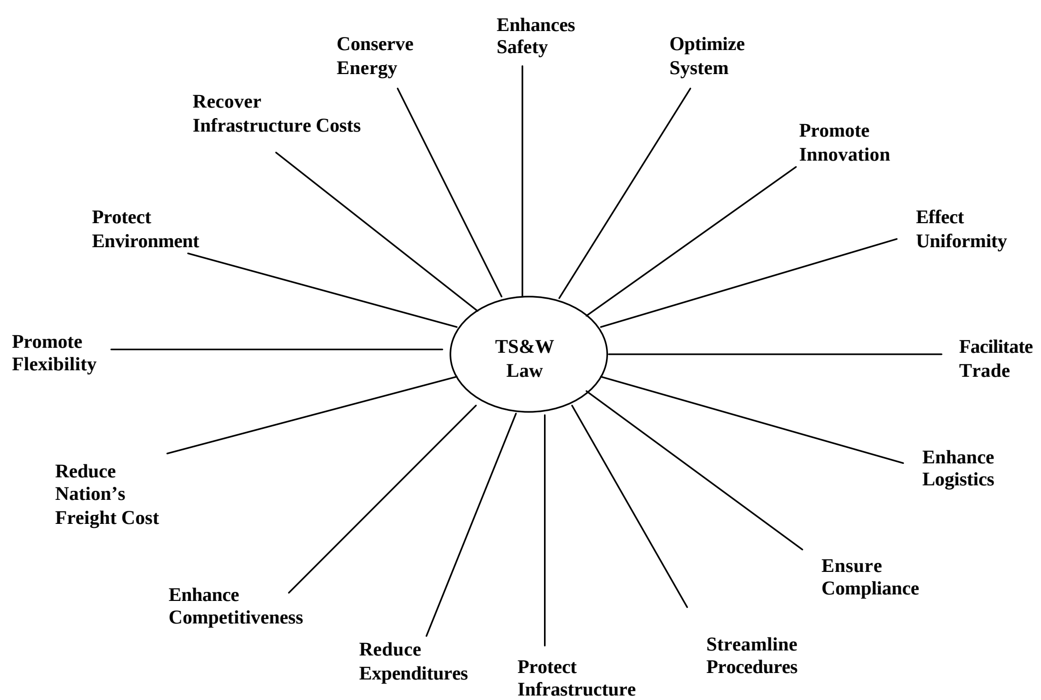
An important part of the study was to examine the state-of-the-art in assessing various impacts of TS&W options. Impacts considered most important include safety, productivity, infrastructure impacts (pavements, bridges, and geometrics), traffic congestion, environmental impacts (primarily air quality and noise), and impacts on railroads. The most important factor affecting the magnitude of most impacts is the amount of traffic that would switch to new truck configurations from existing trucks or from rail as the result of changes in Federal TS&W limits. A major part of the study involved developing and testing analytical tools to estimate this diversion.

Previous TS&W studies have estimated diversion based primarily on differences in transportation costs between moving goods in vehicles operating under current Federal TS&W laws and moving goods in vehicles operating under either lower or higher limits. This study makes a significant improvement in the diversion analysis by explicitly considering inventory and other logistics costs that shippers evaluate in making real-world transportation decisions.

Another major improvement in the diversion analysis is the use of disaggregate data on observed movements from origin to destination over real transportation networks. Previous studies used aggregate data characterized by region of the country and trip length distributions rather than actual shipment data.

Like previous studies, this study analyzes several specific TS&W scenarios characterized by assumptions

Figure 3. Factors Affecting Federal Truck Size and Weight Law



about the maximum weights and dimensions of vehicles that would be allowed to operate and the networks upon which larger, heavier vehicles could travel. Many different potential scenarios were considered, but the detail at which network and access issues for each scenario were analyzed limited the number of scenarios that could be included in the study. With the limited number of scenarios that could presented in the report, scenarios were selected that showed the upper range of impacts that might be expected with various types of TS&W changes. While most scenarios assume some increase in TS&W limits, two scenarios assume reductions in allowable weights or dimensions.

Vehicle Characteristics

Many alternative vehicle configurations might be possible for a given set of TS&W limits. For analytical purposes each scenario specified one or more "scenario vehicles" into which traffic from existing trucks or from rail potentially could divert. Diversion estimates were based on truck traffic forecast for the year 2000, but it was assumed that all fleet changes and changes in shipper behavior, which in practice would occur over many years following a change in TS&W limits, would take place by 2000. The alternative would have been to try to estimate how long it would take for a new equilibrium to be achieved, and how various shippers and carriers would respond while this new equilibrium was being established. As in previous TS&W studies this was deemed to be too speculative so the assumption for analytical purposes was that a final equilibrium would be achieved instantly.

While a limited number of "scenario vehicles" were used in the diversion analysis, those vehicles represent a much larger array of vehicles that are in actual use. The highway cost allocation study analyzed 15 different truck types, based on the number of trailing units and the number of axles. Impact analyses for this study used those same vehicles classes. Figure 4 shows diagrams of many of those vehicle configurations.

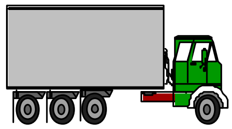
Table 1 shows the number of vehicles and the vehicle miles of travel for each of the 15 truck classes included in the study. Estimates are shown for 1994 based on actual data and forecasts for 2000. The five-axle tractor-semitrailer accounts for 43 percent of all trucks and nearly two-thirds of all truck VMT. Three-axle single units trucks are the next largest truck class with almost 25 percent of the vehicles and 8 percent of the VMT. Longer combination vehicles, which include double-trailer combinations with 7 or more axles and triples, currently account for less than 1 percent of all trucks and just over 1 percent of all truck VMT.

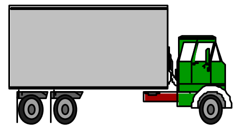
Tables 2 and 3 show State truck weight and length limits that were in effect in 1994, the base year for this analysis. Many exceptions to these limits exist for locally important commodities. Several important points regarding State weight limits can be seen in Table 2. First, several States have higher weight limits off the Interstate System than Federal law allows on the Interstate System. While some States have both higher gross weights and higher axle weight limits, other States have the same gross weight limits, but different axle weight limits or vice versa.

Overlying the gross vehicle weight and axle weight limits on Interstate and other highways are systems of overweight permits that are granted by each State. These permits are essential to allow non-divisible loads to be transported, and often come with strict conditions under which the moves can be made.

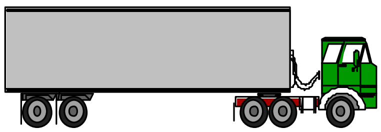
Figure 4. Illustrative Vehicle Configurations

Single Unit Trucks

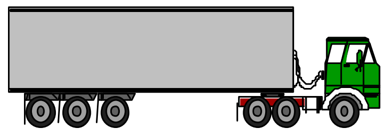




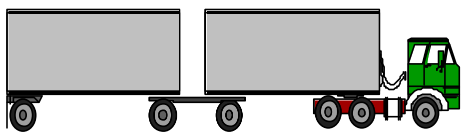
Conventional Combination Vehicles



5-Axle Tractor Semi-Trailer

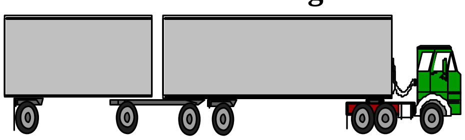


6Axle Tractor Semi-Trailer

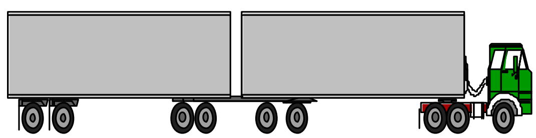


STAA or “Western” Double

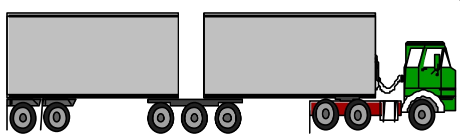
Longer Combination Vehicles (LCVs)



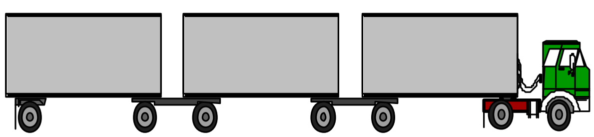
Rocky Mountain Double



Turnpike Double



8-Axle B-Train Double Trailer Combination



Triple Trailer Combination

Table 1. Existing Truck Fleet and Vehicle Miles of Travel, 1994 and 2000 Projections

Vehicle Class	Number of Vehicles			Vehicle Miles Traveled (in millions)		
	1994	2000	Percent Share of Truck Fleet	1994	2000	Percent Share of Truck Fleet
3-axle single unit truck	594,197	693,130	24.9	8,322	9,707	7.6
4-axle or more single unit truck	106,162	123,838	4.4	2,480	2,893	2.2
3-axle tractor-semitrailer	101,217	118,069	4.2	2,733	3,188	2.5
4-axle tractor-semitrailer	227,306	265,152	9.5	9,311	10,861	8.5
5-axle tractor-semitrailer	1,027,760	1,198,880	43.0	71,920	83,895	65.4
6-axle tractor-semitrailer	95,740	111,681	4.0	5,186	6,049	4.7
7-axle tractor semitrailer	8,972	10,466	0.3	468	546	0.4
3- or 4- axle truck trailer	87,384	101,934	3.6	1,098	1,280	1.0
5-axle truck-trailer	51,933	60,579	2.2	1,590	1,855	1.4
6-axle or more truck-trailer	11,635	13,572	0.5	432	503	0.4
5-axle double	51,710	60,319	2.2	4,512	5,263	4.1
6-axle double	7,609	8,876	0.3	627	731	0.6
7-axle double	7,887	9,201	0.3	542	632	0.5
8-axle or more double	9,319	10,871	0.4	650	759	0.6
Triples	1,203	1,404	0.0	108	126	0.1

Table 2 shows the weights at which "routine" overweight permits generally are issued. Fees are charged for these permits which in some cases are intended to reflect the additional infrastructure costs associated with the moves, but which in other cases only cover administrative costs of issuing the permits. Permits may be issued for moves at greater weights, but those moves often would require special equipment and special routing.

Table 3 shows State length limits for semitrailers on Interstate and other State highways. In contrast to State weight limits, where State length limits for semitrailers operating on Interstate and other highways differ, the length limit on Interstate highways is typically longer, reflecting the better geometrics of Interstate Highways. Some States do not regulate semitrailer lengths off the Interstate System, but have overall vehicle length limits instead. Also of note is the fact that many States have maximum allowable distances from the kingpin of the semitrailer to the rear axle. This controls vehicle off-tracking. Offtracking is discussed in greater detail later in this report.

Table 2. General State Weight Limits

State	Gross Vehicle		Single Axle		Tandem Axle		Federal Bridge		"Routine" Permit		
	Interstate	Other Hwys.	Interstate	Other Hwys.	Interstate	Other Hwys.	Interstate	Other Hwys.	Gross Vehicle Weight	Single Axle	Tandem Axle
Alabama	80	84	20	20	34	40	Yes	No-WT	110/150	22	44
Alaska	--	90(2)	--	20	--	38	---	Yes	88.6(2)/150	30	50
Arizona	80	80	20	20	34	34	Yes	No-WT	106.5(3)/250	28	46
Arkansas	80	80	20	20	34	34	Yes	Yes	102/134	20	40
California	80	80	20	20	34	34	Yes-mod	Yes-mod	119.8(4)/(5)	30	60
Colorado	80	85	20	20	36	40	Yes	No	127/164	27	50
Connecticut	80	80	22.4	22.4	36	36	Yes	Yes	120/160	22.4	NS
Delaware	80	80	20	20	34	40	Yes	No-WT	120/120	20	40
D.C.	80	80	22	22	38	38	Yes-mod	Yes-mod	155-248	31	62
Florida	80	80	22	22	44	44	Yes (6)	No-WT	112/172	27.5	55
Georgia	80	80	20.34	20.34	34(7)	37.34	Yes	Yes(6)	100/175	23	46
Hawaii	80.8	88	22.5	22.5	34	34	Yes	No	Case-by-case above normal limits		
Idaho	80	105.5	20	20	34	34	Yes	Yes	Case-by-case above normal limits		
Illinois	80	80(8)	20	20(9)	34	34(9)	Yes	Yes(9)	100/120	20	48
Indiana (10)	80	80	20	20	34	34	Yes	Yes	108/120	28	48
Iowa	80	80	20	20	34	34	Yes	Yes	100/160	20	40
Kansas	80	85.5	20	20	34	34	Yes	Yes	95/120	22	45
Kentucky	80	80(11)	20	20	34	34	Yes	Yes	96/140	24	48
Louisiana	80(12)	80(12)	20	22	34	37	Yes	No	108/120	24	48
Maine	80	80(13)	20(14)	22.4	34	38	Yes-mod	No	130/167	25	50
Maryland	80	80	20(15)	20(15)	34(15)	34(15)	Yes	Yes	110/110	30	60
Massachusetts	80	80	22.4	22.4	36	36	Yes	Yes	99/130	NS	NS
Michigan (16)	80	80	20	20	34	34	Yes	Yes	80/164	13	26
Minnesota	80	80(17)	20	18	34	34	Yes	Yes-mod	92/144	20	40
Mississippi	80	80	20	20	34	34	Yes	Yes	113/190	24	48
Missouri	80	80 (18)	20	20(18)	34	34(18)	Yes	Yes(18)	92/120	20	40

State	Gross Vehicle		Single Axle		Tandem Axle		Federal Bridge Formula “B”		“Routine” Permit		
	Interstate	Other Hwys.	Interstate	Other Hwys.	Interstate	Other Hwys.	Interstate	Other Hwys.	Gross Vehicle Weight	Single Axle	Tandem Axle
Montana	80	80	20	20	34	34	Yes	Yes	105.5/126	20	48
Nebraska	80	95	20	20	34	34	Yes	Yes	99/110	20	40
Nevada	80	129(19)	20	20	34	34	Yes	Yes	110(20)/(21)	28	50.4
New	80	80	20(15)	22.4	34(15)	36	Yes	No	130/150	25	50
New Jersey	80	80	22.4	22.4	34	34	Yes	No	100(22)/150(	25(22)	40(22)
New Mexico	86.4	86.4	21.6	21.6	34.32	34.32	Yes-mod	Yes-mod	104(23)/120	26	46
New York	80	80	20(24)	22.4	34(24)	36	Yes(24)	Yes(24)	100/150	25	42.5
North	80	80	20	20	38	38	Yes-mod	Yes-mod	94.5/122	25	50
North Dakota	80	105.5	20	20	34	34	Yes	Yes	103/136	20	45
Ohio	80	80	20	20	34	34	Yes	No	120/120	29	46
Oklahoma	80	90	20	20	34	34	Yes	Yes	95/140	20	40
Oregon	80	80	20	20	34	34	Yes/mod	Yes-mod	90/105.5	21.5	43
Pennsylvania	80	80	20(25)	20(25)	34(25)	34(25)	Yes(25)	Yes(25)	116/136	27	52
Rhode Island	80	80	22.4	22.4	36	36	Yes-mod	Yes-mod	104.8/(21)	22.4	44.8
South	80	80	20	22	34(26)	39.6	Yes(26)	No	90/120	20	40
South Dakota	80	129(19)	20	20	34	34	Yes	Yes	116(27)/(21)	31	52
Tennessee	80	80	20	20	34	34	Yes	Yes	100/160	20	40
Texas	80	80	20	20	34	34	Yes-mod	Yes-mod	106.1(28)/20	25	48.125
Utah	80	80	20	20	34	34	Yes	Yes	100/123.5	20	40
Vermont	80	80	20	22.4	34	36	Yes	Yes	108(29)/120	24	48
Virginia	80	80	20	20	34	34	Yes	Yes	110/150	25	50
Washington	80	105.5	20	20	34	34	Yes	Yes	103/156	22	43
West Virginia	80	80(30)	20	20	34	34	Yes	Yes	104/110	20	45
Wisconsin	80	80	20	20	34	34	Yes-mod	Yes-mod	100/191	20	60
Wyoming	117	117	20	20	36	36	Yes	No	85/135	25	55

NS...Not specified   WT...Weight table

Footnotes to table at end of Chapter.

Information sources:

J. J. Keller & Associates, Vehicle Sizes and Weights Manual. July 1, 1994.

Specialized Carriers & Rigging Association (SC&RA), Permit Manual. July 19, 1994.

Western Association of State Highway and Transportation Officials (WASHTO), Guide for Uniform Laws and Regulations Governing Truck Size and Weight. June 26, 1993.

Table 3. **1994 Maximum Semitrailer Lengths by State**

	National Network (NN)		Other State Highways		
State	**Length**	**Kingpin**	**Length**	**Kingpin**	**Overall**
Alabama	57-0	41-0 KCRA(1)	53-0		
Alaska	48-0		45-0		70-0
Arizona	57-6(7)		53-0		65-0
Arkansas	53-6		53-6		
California	53-0	40-0 KCRTA(8) 38-0 KCSRA(9)	53-0	Same as NN	
Colorado	57-4		57-4		
Connecticut	53-0		48-0		
Delaware	53-0		53-0		60-0
Dist. of Col.	48-0		48-0		55-0
Florida	53-0	41-0 KCRT(2)	53-0	41-0 KCRT	
Georgia	53-0	41-0 KCRT	53-0	41-0 KCRT	67-6
Hawaii	No Limit		45-0		60-0
Idaho	53-0		48-0	39-0 KCRA	
Illinois	53-0	42-6 KCRA	53-0	42-0 KCRA	
Indiana	53-0	40-6 KCRA	53-0	40-6 KCRA	
Iowa	53-0		53-0	40-0 KCRA	60-0
Kansas	59-6		59-6		
Kentucky	53-0		No Limit		57-9
Louisiana	59-6		No Limit		65-0
Maine	53-0(3)	43-0	53-0		65-0
Maryland	53-0(4)	41-0 KCRT	53-0	41-0 KCRT	
Massachusetts	53-0(5)		53-0		
Michigan	53-0	41-0 KCRT	50-0		
Minnesota	53-0	41-0 KCRT	53-0	41-0 KCRT	
Mississippi	53-0		53-0		
Missouri	53-0(4)		No Limit		60-0
Montana	53-0		53-0		
Nebraska	53-0		53-0		
Nevada	53-0		53-0		70-0
New Hampshire	53-0(6)	41-0 KCRT	53-0	41-0 KCRT	
New Jersey	53-0	41-0 KCRT	53-0	41-0 KCRT	
New Mexico	57-6		No Limit		65-0
New York	53-0(4)	41-0 KCRT	48-0		65-0
North Carolina	53-0	41-0 KCRT	No Limit		60-0
North Dakota	53-0		53-0		
Ohio	53-0		53-0		
Oklahoma	59-6		59-6		

Table 3. 1994 Maximum Semitrailer Lengths by State (cont.)					
	National Network (NN)		Other State Highways		
State	**Length**	**Kingpin**	**Length**	**Kingpin**	**Overall**
Oregon	53-0		Varies		
Pennsylvania	53-0		No Limit		60-0
Puerto Rico	48-0				
Rhode Island	48-6		48-6		
South Carolina	53-0	41-0 KCRT	48-0		
South Dakota	53-0		53-0		
Tennessee	53-0	41-0 KCRT	53-0	41-0 KCRT	
Texas	59-0		59-0		
Utah	53-0	40-6 KCRT	53-0	40-6 KCRT	
Vermont	53-0(4)	41-0 KCRT	48-0		60-0
Virginia	53-0	37-0 Last tractor axle to first trailer axle.	No Limit		60-0
Washington	53-0		53-0		
West Virginia	53-0	Same as VA	No Limit		60-0
Wisconsin	53-0	41-0 KCRT	No Limit		60-0
Wyoming	60-0		60-0		

(1) KCRA = Kingpin to center of rear axle
(2) KCRT = Kingpin to center of rear tandem
(3) permit may be required
(4) Interstate and designated State routes
(5) Requires annual letter of authorization. Does not apply on the Massachusetts Turnpike
(6) Designated routes
(7) Only on Interstate System
(8) KCRTA = Kingpin to center of rearmost tandem axle
(9) KCSRA = Kingpin to center of single rear axle.

Figure 5 shows the States that presently allow various types of LCVs and Table 4 shows the maximum allowable weights for two and three- trailer LCVs in the various States. It is clear from this table that State LCV weight limits vary considerably. The ISTEA froze LCV weight limits at their 1991 levels; this freeze was extended in TEA-21.

Table 5 summarizes characteristics of various truck classes and how they currently are used. The table shows that the 4 main types of LCVs -- eight-axle B-trains, Rocky Mountain doubles, turnpike doubles, and triples -- are used in only a limited number of areas and currently have somewhat specialized uses.

An important assumption is that all States will adjust their TS&W limits to conform to the scenario limits and that needed infrastructure improvements to accommodate all scenario vehicles will have been completed including the construction of staging areas for certain LCVs. In practice, unless mandated to adopt Federal TS&W limits, some States could be expected to retain their current limits or adopt less permissive limits than the new Federal limits.

Table 4. Longer Combination Vehicle Weight Limits by State

Pounds	Truck Tractor and 2 Trailing Units	Truck Tractor and 3 Trailing Units
86.4	NM	
90	OK	OK
95	NE	
105.5	ID, ND, OR, WA	ID, ND,OR
110	CO	CO
111	AZ	
115		OH
117	WY	
120	KS, MO [1]	
123.5		AZ
127.4	IN, MA, OH	IN
129	NV, SD, UT	NV, SD, UT
131.06		MT
137.8	MT	
143	NY	
164	MI	

[1] From Kansas, within 20 miles of border.
Source: Final Rule on LCVs published in the Federal Register at 59 FR 30392 on June 13, 1994.

Highway Networks

Developing the networks upon which certain LCVs would be allowed to operate was difficult because most States currently do not allow LCVs and many States in the Midwest and East have indicated they do not think LCVs could operate safely on their highways, especially in and around urban areas. Resource constraints did not permit analyzing scenarios in which LCVs would be assumed to operate in certain regions of the country. For analytical purposes it was assumed that LCVs would be allowed to operate on limited nationwide networks of Interstate and other NHS routes. Figures 6 to 8 show the analytical networks assumed to be available for different vehicles under the illustrative scenarios.

The NN shown in Figure 6 was designated by the Secretary in consultation with the States pursuant to the STAA of 1982. A key factor in identifying routes to be included in this network was whether they could accommodate the 48-foot semitrailer combinations and twin-trailer combinations that States are required to allow on that network.

Figures 7 and 8 show the illustrative networks assumed to be available for long double-trailer combinations and triple-trailer combinations. The network for triples includes about 65,000 miles of highway including some low volume two-lane highways in the West and some four-lane highways in the East that are not built to Interstate standards. The longer doubles network contains about 42,500 miles of access-controlled, interconnecting segments of the Interstate System and other highways of comparable design and traffic capacity.

Both networks are more extensive than some States would find acceptable, but both also exclude roads in some States on which LCVs operate today, albeit with lower weights. In developing the analytical networks the Department did not examine potential local constraints to LCV operations on those highways, but simply selected highways that connect important markets. Resource constraints did not allow sensitivity analyses of alternative networks to estimate how variations in network extent could

Table 5. Characteristics of Typical Vehicles and How They Currently Are Used

Configuration Type	Number of Axles	Common Maximum Weight (Pounds)	Current Use
Single-Unit Truck	3	50,000 to 65,000	Single-unit trucks (SUT) are the most commonly used trucks. They are used extensively in all urban areas for short hauls. Three-axle SUTs are used to carry heavy loads of materials and goods in lieu of the far more common two-axle SUT.
	4 or more	62,000 to 70,000	SUTs with four or more axles are used to carry the heaviest of the construction and building materials in urban areas. They are also used for waste removal.
Semitrailer	5	80,000 to 99,000	Most used combination vehicle. It is used extensively for long and short hauls in all urban and rural areas to carry and distribute all types of materials, commodities, and goods.
	6 or more	80,000 to 100,000	Used to haul heavier materials, commodities, and goods for hauls longer than those of the four-axle SUT.
STAA Double	5, 6	80,000	Most common multitrailer combination. Used for less-than-truckload (LTL) freight mostly on rural freeways between LTL freight terminals.
B-Train Double	8	105,500 to 137,800	Some use in the northern plains States and the Northwest. Mostly used in flatbed trailer operations and for liquid bulk hauls.
Rocky Mountain Double	7	105,500 to 129,000	Used on turnpikes in Florida, the Northeast, and Midwest and in the Northern Plains and Northwest in all types of motor carrier operations, but most often it is used for bulk hauls.
Turnpike Double	9	105,500 to 147,000	Used on turnpikes in Florida, the Northeast, and Midwest and on freeways in the Northern Plains and Northwest for mostly truckload operations.
Triple	7	105,500 to 131,000	Used to haul LTL freight on the Indiana and Ohio Turnpikes and in many of the most western States, used on rural freeways between LTL freight terminals.

Figure 5. States Allowing Various Longer Combination Vehicles

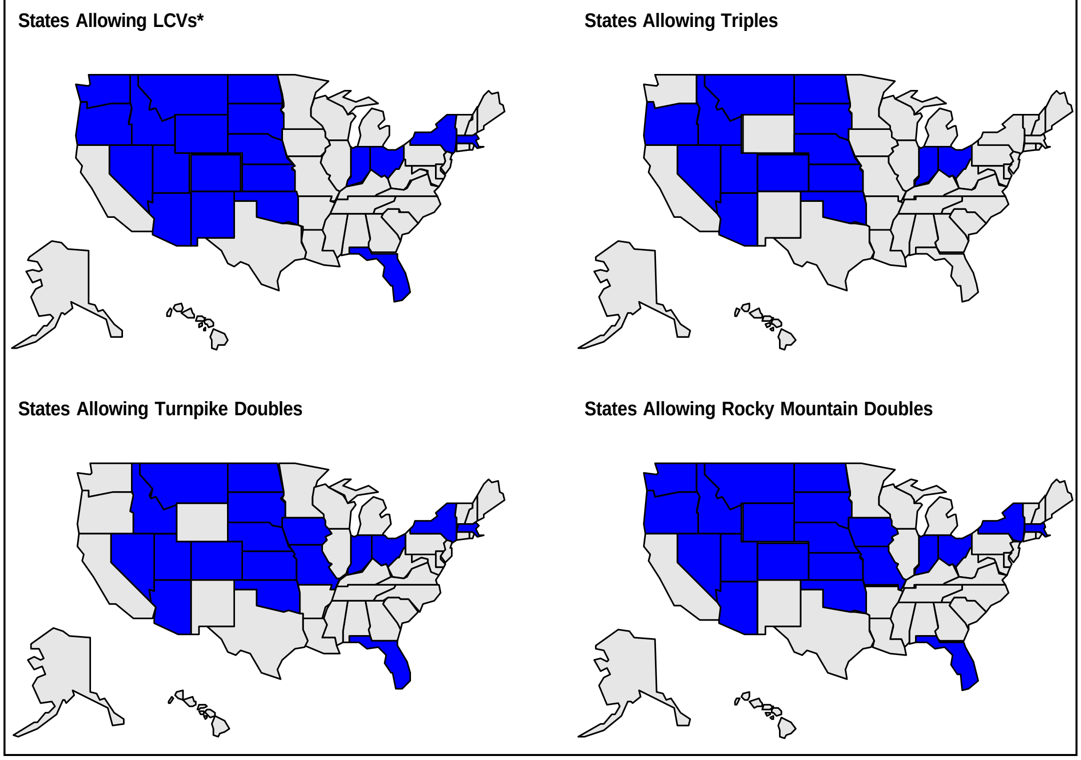


Figure 6. National Network for STAA Vehicles

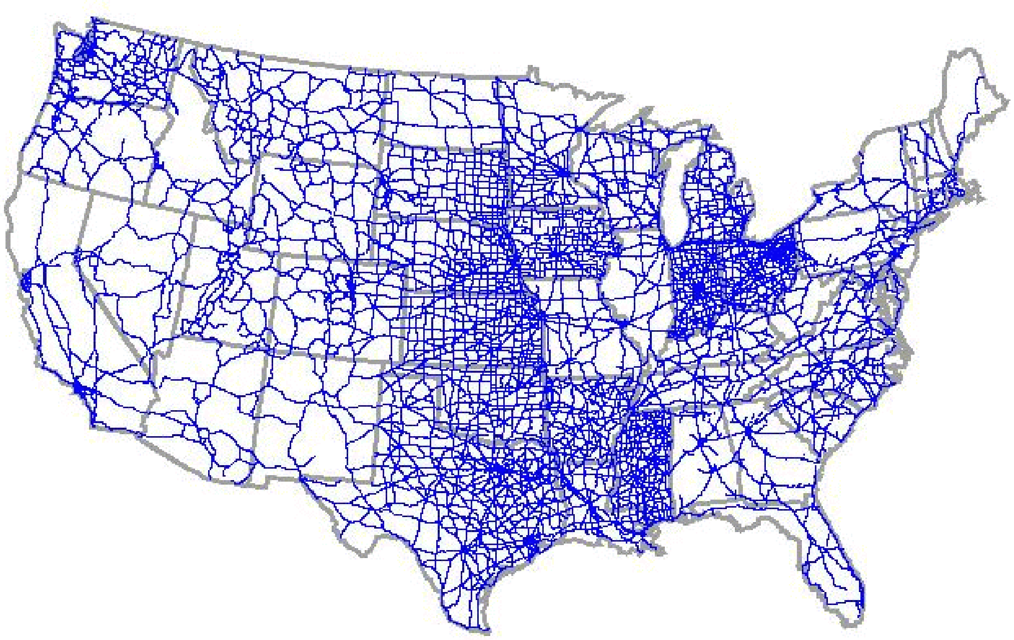
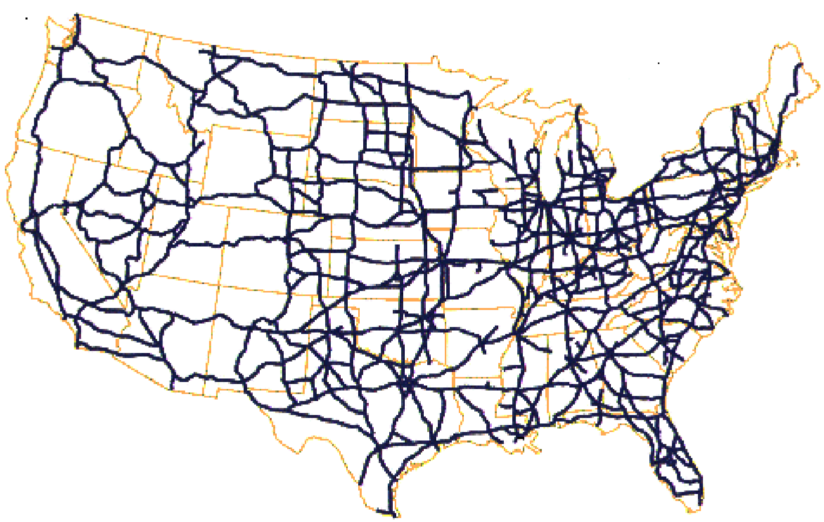


Figure 7. 1998 Comprehensive Truck Size and Weight Study Analytical Network for Longer Combination Double-Trailer Vehicles

Figure 8. 1998 Comprehensive Truck Size and Weight Study Analytical Network for Longer Combination Triple-Trailer Vehicles



affect potential LCV use. It is important to recognize that the networks developed for this study are purely for analysis purposes and do not represent networks that the Department necessarily believes should or could be used by LCVs, now or in the future.

Impact Assessment

Several factors must be considered when assessing potential TS&W options. Factors analyzed in previous Departmental and TRB studies include infrastructure costs, safety, productivity, traffic operations, and intermodal competition. These same factors are evaluated in this study, although in more detail than has been done in previous studies.

Relationships between TS&W changes and these various impacts are complex and depend on specific characteristics of vehicles anticipated to operate under various TS&W options. In general, changes in allowable weights and dimensions intended to improve trucking productivity have adverse impacts on infrastructure and most other impacts. While these impacts generally cannot be avoided, actions can be taken to reduce the adverse impacts.

Infrastructure Costs

Pavement

Potential pavement impacts associated with changes in TS&W regulations are of intense concern because of the magnitude of Federal and State investments in pavement on our Nation's highway systems. Many factors contribute to pavement impacts that might occur following TS&W policy changes including allowable axle load limits, changes in VMT by different vehicle classes, and changes in VMT and axle loads on different highway classes.

Table 6 shows the relative pavement damage caused by the different scenario vehicles analyzed in this study. Pavement damage is expressed in terms of load equivalency factors per 100,000 pounds of cargo. This measure reflects both absolute pavement damage caused by each vehicle at the maximum weight at which it can operate, as well as the benefits of moving the same volume of cargo in fewer trips. It also shows that pavement impacts vary by type of pavement. Table 6 shows that pavement damage varies depending on the specific vehicles and weights at which they are allowed to operate. Among the combination vehicles, many can haul the same quantity of cargo as the five-axle semitrailer configuration with less pavement damage, but relative damage depends on the types of axles on each vehicle (single, tandem, or tridem) and the type of pavement upon which the vehicle is operating. Among the single unit trucks, adding an axle can reduce pavement costs per unit of cargo carried for any of the configurations and weights considered in this analysis.

The analysis of impacts of each TS&W scenario on pavement costs uses the entire Highway Performance Monitoring System (HPMS) sample in estimating system-wide pavement costs. This database of over 100,000 sample pavement sections is statistically representative of highways in each State, and thus captures the effects of different pavement designs and types as well as changes in the volumes and weights of various truck configurations under each TS&W scenario. In particular, the study evaluates the

Table 6. Theoretical Load Equivalency Factors per 100,000 pounds of Payload Carried By Study Vehicle Configurations

Configuration	Gross Vehicle Weight (pounds)	Empty Weight (pounds)	Payload Weight (pounds)	No. Of Vehicles per 100,000 pounds of payload	Load Equivalency Factors***		
					Rigid Pavement Fatigue (10-inch thickness)	Flexible Pavement (5-inch wearing surface)	
						Fatigue	Rutting
Three-Axle Single Unit Truck	54,000	22,600	31,400	3.18	13.4	17.8	13.0
Four-Axle Single Unit Truck	64,000	26,400	37,600	2.66	9.6	14.4	12.2
	71,000	26,400	44,600	2.24	9.2	14.6	11.2
Five-Axle Semitrailer	80,000	30,500	49,500	2.02	5.7	9.3	10.3
Five-Axle Semitrailer (10-foot Spread)	80,000	30,500	49,500	2.02	6.3	12.2	10.9
Six-Axle Semitrailer	90,000	31,500	58,500	1.71	3.8	7.5	9.6
	97,000	31,500	65,500	1.53	4.1	8.4	9.2
STAA Double (five-axle)	80,000	29,300	50,700	1.97	8.3	9.9	9.7
B-Train Double (eight-axle)	124,000	38,700	85,300	1.17	3.9	7.0	7.6
	131,000	38,700	92,300	1.08	4.1	7.7	7.5
Rocky Mt.Double (seven-axle)	120,000	43,000	77,000	1.30	7.8	9.9	9.5
Turnpike Double (nine-axle)	148,000	46,700	101,300	0.99	5.0	7.7	7.2
Triple (seven-axle)	114,000 (LTL)*	44,500	69,500	1.44	8.6	9.8	9.6
	132,000 (TL)**	44,500	87,500	1.14	11.6	11.8	9.0

*LTL= Less-than-truckload
**TL= Truckload
***(based on 18,000-pound single axle with dual tires)

contribution of 20 vehicle classes operating at a variety of different weights to 11 separate pavement distresses based on pavement analysis methods developed for the 1997 Federal Highway Cost Allocation

Study. The distress models reflect the effects of single, tandem, and tridem axles at different weights on different types of pavement.

Bridges

Like pavement impacts, the impacts of TS&W policy changes on bridges depend on several factors including the gross weight of the vehicle, the weight on various groups of axles, the distance between axle groups, and the type and length of bridge. In previous TS&W studies by the Department and TRB, bridge impacts have been among the most significant impacts of some TS&W policy changes.

As noted above, the Federal Bridge Formula now controls vehicle weights to protect our Nation's bridges. In particular it limits the weight on groups of axles depending on the distance between those axles. The two most typical bridge designs are HS-20 which is common on higher class highways and H-15 which is typical of bridges on lower class highways. The bridge formula is intended to assure that stresses placed on HS-20 bridges do not exceed the design stress by more than five percent and stresses on H-15 bridges are no more than 30 percent greater than the design stress. Design stresses are well below stresses at which a bridge will fail, but prolonged repetitions of high stresses can cause bridge deterioration to accelerate.

The bridge formula is an approximation of the five percent and 30 percent overstress criteria discussed above. The bridge analysis conducted for this study uses those criteria directly, estimating the stresses imposed by different scenario vehicles on a sample of bridges from the National Bridge Inventory.   If stresses from scenario vehicles exceed the five percent or thirty percent criteria, those bridges are assumed to require replacement. While previous studies by the Department and TRB have used slightly different criteria to identify bridge deficiencies, they all have assumed that bridges found to be deficient would have to be replaced.

Comments to the docket for this study indicated that this assumption probably overestimates bridge costs. In practice some bridges could be strengthened and replacement of bridges on highways with low volumes of the damaging vehicles perhaps would not have to be improved at all. Also, States might decide to "post" bridges and not allow the heavier vehicles to use the bridges.

In addition to estimating costs to replace all deficient bridges, the analysis also estimates additional user delay and vehicle operating costs during the construction process. While highway agencies would not have to pay these costs to allow scenario vehicles to operate, these user costs would represent significant costs imposed on motorists. In urban areas the user costs may exceed bridge replacement costs.

Geometrics

The other major infrastructure impacts associated with TS&W changes are costs to upgrade geometric deficiencies for different scenario vehicles. Geometric deficiencies are primarily interchanges and intersections that cannot accommodate the turning radii of some scenario vehicles. The extent of geometric deficiencies for different scenario vehicles was estimated based on a survey of interchange and intersection design in nine States representing different regions of the country. For purposes of estimating improvement needs it was assumed that no encroachment on shoulders or adjacent lanes would be allowed except for at-grade interchanges where vehicles would be allowed to encroach on one lane in the same direction of travel. No costs are assumed for improvements needed to accommodate existing vehicle configurations.

Related to these geometric costs is the requirement that certain LCVs assemble and disassemble at staging areas rather than being allowed to travel off the designated networks. Based on an analysis of existing staging area operations on turnpikes and other factors, it was assumed that staging areas would be provided every 15.6 miles in rural areas and at key points at the fringes of urban areas.

In practice, staging areas could be provided in many ways with either public, private, or a combination of public and private funding. Fewer staging areas might be required in some parts of the country but if fewer staging areas were constructed, the ones that are constructed would likely have to be larger, and the average distance to haul goods between origin, destination, and the staging areas would be greater. There is considerable uncertainty concerning about exactly how staging areas would be implemented, and it is likely that the provision of staging area services would evolve over time. Regardless of who pays for staging areas, the cost of providing points where LCVs can assemble and disassemble is a cost that must be considered in assessing the extent to which those vehicles would be used and the cost of operating those vehicles.

Safety Impacts

Crash rates

The safety analysis in this study includes an extensive review of past safety studies and a synthesis of results that could be pulled from those studies. Extensive research into various aspects of truck safety has been conducted over the years, but there still are many uncertainties about the safety of certain scenario vehicles. Reasons why it has been difficult to isolate effects of vehicle weights and dimensions on highway crash rates include (1) weights and dimensions of vehicles involved in crashes often are not known or recorded on accident reports; (2) even where data on the number of crashes for certain types of vehicles are known, the VMT for those vehicles often is not known so it is difficult to develop crash rates for vehicles larger than the typical vehicles in use; and (3) crash rates for larger vehicles in use in certain regions of the country or on turnpike may not be transferrable to operations in other parts of the country where traffic volumes are higher and the operating environment is less safe. Compounding difficulties in estimating crash rates for certain scenario vehicles is the large switch to these vehicles from conventional truck configurations estimated in the diversion analysis. The sheer volume of those larger and heavier vehicles would mean that it would be much more difficult to regulate the use of those vehicles. All of these factors make predicting crash rates for widespread use of certain scenario vehicles very problematic.

Public Perception

Crash rates are perhaps the most important safety consideration, but other factors also must be factored into assessments of the safety of certain scenario vehicles. One intangible factor is the public reaction to larger and heavier trucks. While public perceptions may have little factual basis, they ultimately are important factors affecting decisions concerning whether to allow such vehicles. As noted above, focus group meetings were conducted to delve more deeply into driver perceptions of the safety of various vehicle configurations in different operating environments. Truck drivers participating in the focus groups expressed confidence that they could handle any larger trucks that might come along, but questioned the need and desirability for larger trucks and said that maintaining safety would require changes in highway conditions, training, equipment, and economic incentives. The vast majority of automobile drivers participating in the focus groups indicated that they prefer the status quo and that if changes are made they should be in the direction of greater restrictions on TS&W limits. Some indicated they could accept a role for LCVs, but only under very strict limits and conditions. While opinions expressed in the focus groups are not necessarily representative of all drivers, the focus groups do provide insights into factors underlying opinions about the truck safety held by truck and automobile drivers. A working paper prepared for this study summarizes focus groups findings in more detail.

Vehicle Stability and Control

Differences in vehicle stability and control are perhaps the most important safety-related factors directly related to differences in vehicle weights and dimensions. Where crash rates and other direct evidence of the relative safety of certain vehicles are not available, the stability and control characteristics of the vehicle provide an indication of the relative safety of the vehicle compared to vehicles currently in widespread use.

An important contribution of this study is the development of tools to evaluate stability and control properties of different vehicle configurations at different weights and dimensions. Perhaps the most important vehicle stability property is susceptibility to rollover. Approximately 60 percent of crashes fatal to heavy truck occupants involve rollovers.

In general rollovers can result from one of two basic maneuvers – making a steady-state turn at too high a speed or high speed evasive maneuvers. Virtually all vehicles are susceptible to rolling over, but heavy trucks are especially susceptible. The principal attributes that affect a vehicle's rollover tendencies are the height of the center of gravity (cg) of the cargo, and the vehicle's track width, suspension, and tire properties.

A measure of a vehicle's propensity to rollover during a steady-state turn is its static roll stability (SRS). The SRS is measured in terms of the lateral acceleration (g forces) required to lift a wheel off the ground. The higher the SRS, the less susceptible the vehicle is to rollover. The typical 80,000-pound tractor-semitrailer has a SRS of about 0.3 gs compared to 0.8 gs or higher for automobiles.

Rollovers that occur as the result of evasive maneuvers are associated primarily with multitrailer combinations, but other trucks with high centers of gravity can also roll over when making quick evasive maneuvers. The number of articulation points on multitrailer combinations significantly affect this kind of rollover because they accentuate the "crack-the-whip" phenomenon where rapid steering maneuvers made in the tractor can be amplified by factors of two or three as they get to the rear trailer. Seemingly benign maneuvers by the tractor can result in the rearmost trailer skidding sideways into adjacent lanes, or worse, rolling over.

Several vehicle attributes can contribute to rollover during evasive maneuvers. As noted above, the more articulation points in the combination, the greater the susceptibility to rollover. Tractor-semitrailers have a single articulation point, doubles typically have three articulation points, and triples usually have five. Second, the shorter the wheelbase lengths of the trailers in the combination the more susceptible the vehicle is to rollover. Finally, the lower the SRS of each trailer in the combination, the more susceptible the vehicle is to rollover during evasive maneuvers.

Two measures characterize a vehicle's susceptibility to rollover during evasive maneuvers, the rearward amplification factor and the load transfer ratio. The rearward amplification factor is the ratio of the lateral acceleration of the rearmost trailer to the lateral acceleration of the tractor when making rapid steering movements. Tractor-semitrailer combinations have a factor of 1 and STAA doubles a factor of 1.7. In general a rearward amplification factor of 2 or less is considered acceptable.

The load transfer ratio is a measure of the dynamic roll stability of a truck. It measures the proportion of a vehicle's total axle load that is carried on one side of the truck relative to the other. A perfectly balanced vehicle would have a load transfer ratio of 0.5, while a vehicle with all its weight on one side of the vehicle (and the other side in the air) would have a load transfer ratio of 1.0. The Society of Automotive Engineers has developed a standard evasive maneuver for evaluating vehicle dynamic stability. Load transfer ratios for each scenario vehicle can be calculated based on this standard evasive maneuver to determine which vehicles are more likely to roll over under that maneuver.

Vehicle Comparisons

Figure 9 compares the stability and control of scenario vehicles with a reference vehicle, the conventional five-axle tractor-semitrailer combination. For each of the three measures discussed above, the percentage difference between the scenario vehicle and the reference vehicle is shown.

Only two vehicles in Figure 9 have better static roll stability than the reference vehicle, the two STAA doubles. The worst vehicles are the three single unit trucks because of their high centers of gravity. Each of the other vehicle classes is within 10 percent of the five-axle tractor-semitrailer.

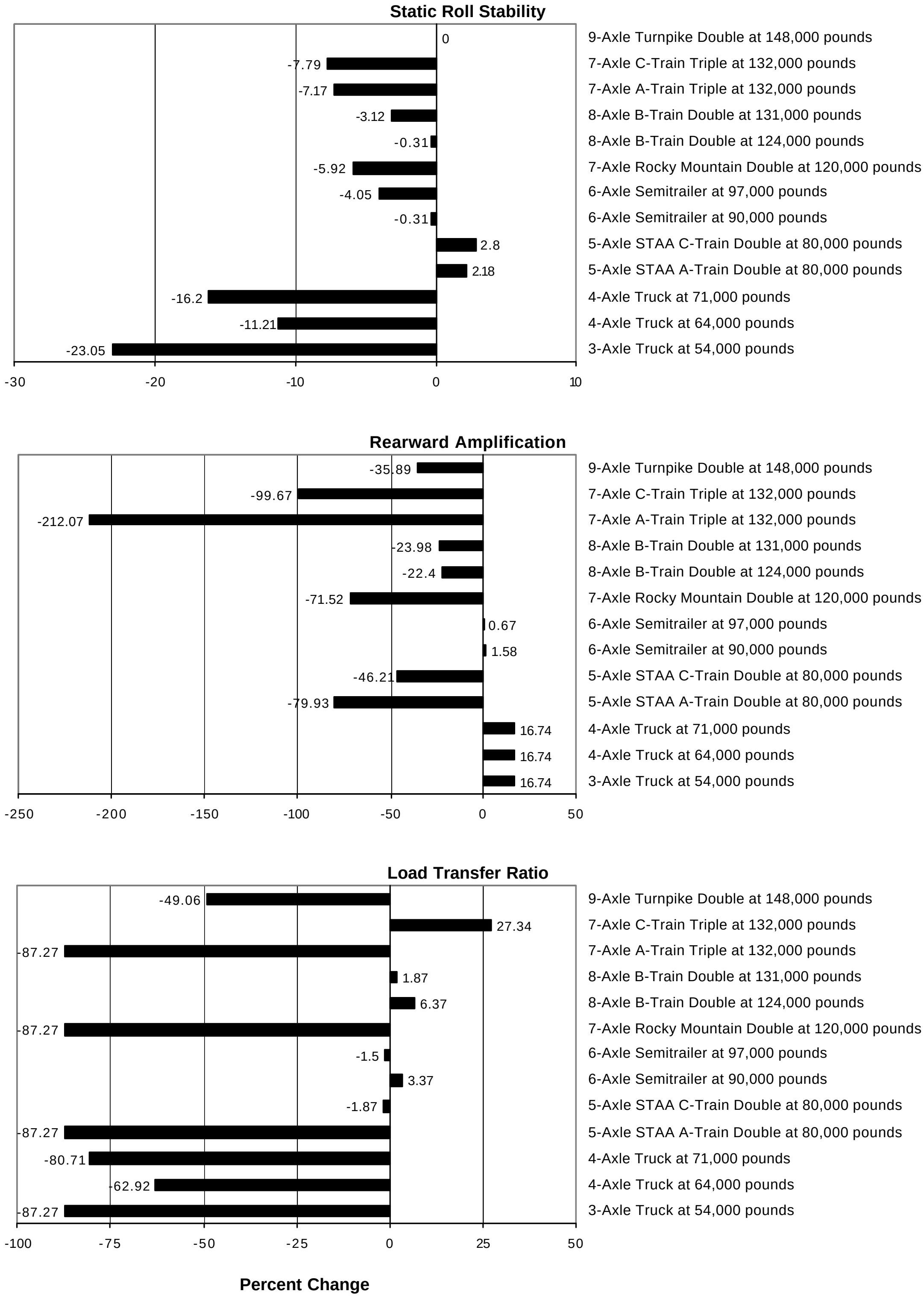
Rearward amplification shows quite different relationships among the scenario vehicles. The three single unit trucks all have less rearward amplification than the reference vehicle as do the two six-axle tractor-semitrailers. The multitrailer combinations with short trailers all have considerably worse rearward amplification than the reference vehicle with triples being the worst vehicle class. The benefits of reducing the number of articulation points can be seen by comparing the "C-train" triples and "C-train" doubles with "A-train" triples and doubles respectively. The A-train configurations use a single drawbar to connect the sets of trailers while the C-trains have double drawbar connections that reduce the number of articulation points. The "B-train" is yet another type of connection between two trailers where the front trailer has a permanently attached "fifth-wheel" connected to its frame. The eight and nine-axle doubles have more rearward amplification than the reference tractor-semitrailer, but considerably less than the other multitrailer combinations. Their longer trailer lengths and the B-train connection for the eight-axle double contribute to their better performance.

Differences in load transfer ratios between the reference tractor-semitrailer and the scenario vehicles show that many of the scenario vehicles would likely rollover under SAE's standard evasive maneuver, including the conventional STAA double and the 3-axle single unit truck. Multitrailer combinations with B and C-train connections and the six-axle tractor-semitrailer were the most stable of the scenario vehicles.

Traffic Operations

Changes in the weights, dimensions, and volumes of trucks in the traffic stream resulting from TS&W changes could affect other motorists using the highway. Among the effects that could be anticipated are

Figure 9. Comparison of Stability and Control Measures for Scenario Vehicles Relative to Five-Axle Tractor Semitrailer



changes in congestion levels, traffic interference associated with the offtracking of longer vehicles, and additional distance required to pass longer vehicles. Other impacts include potentially worse acceleration of heavier trucks unless they had more powerful engines, interference at intersections if trucks cannot stay within their lanes, and decreased visibility of traffic signs because of longer trucks. Impacts of most of these potential factors are very difficult to quantify because they are site specific.

The one operational impact that was quantified in this study is potential effects on congestion. Traffic congestion occurs when the volume of traffic using a highway at a particular time approaches or exceeds the capacity of the highway. Capacity is usually measured in terms of the maximum number of automobiles that can pass a given point on a roadway during a given period of time under existing conditions. Many factors affect highway capacity including highway design factors (access control, number of lanes, lane width, curves, grades and other factors), lateral clearance from objects at the side of the road, weather, and the presence of trucks in the traffic stream.

Impacts on Capacity

The effects of trucks on capacity depends on roadway and traffic conditions. For instance, the effect of trucks is greater in mountainous terrain with long, steep grades than it is on flat terrain because trucks typically cannot maintain their speed on such grades as well as passenger vehicles. Likewise the effect of trucks on capacity is greater on two-lane roads than freeways, especially when there is limited sight distance for passing.

The effect of trucks on capacity is measured in terms of their "passenger-car equivalents (PCEs)." On level terrain a truck may have the effect of two passenger vehicles on capacity, but in mountainous terrain the PCE may be eight. Most previous studies have used a single typical truck to evaluate highway capacity. This study and the companion 1997 Federal Highway Cost Allocation Study extended the state-of-the-art in estimating PCEs by evaluating relative effects of many different types of trucks. The primary variables affecting the relative PCEs of different trucks are their length and their weight-to-horsepower ratio, which is a measure of their ability to accelerate.

Tables 7 and 8 show PCEs for trucks with different lengths and weight-horsepower ratios in rural and urban areas. In both rural and urban areas the length of the vehicle has only a minor effect on PCEs, and that effect is little more than the fact that the longer vehicle occupies more space. On very congested roads with many closely spaced interchanges and high volumes of very long trucks it is likely that the effect of those trucks on traffic flow would be greater than shown in these tables because of they would interfere with merging movements at the on- and off-ramps. The weight-to-horsepower ratio has a greater effect on traffic flow, especially in rural areas.

Table 7 also dramatically shows the effect of grade on PCEs. On a four-lane rural Interstate PCEs for 80-foot long trucks can range from 2.6 to over 14 depending on the grade and weight-to-horsepower ratio. On two-lane highways PCEs can be even higher.

Table 9 summarizes effects of TS&W characteristics on various elements of highway and traffic operations.

Roadway Type	Grade Percent	Grade Length (miles)	Vehicle Weight to Horsepower Ratio (pounds/horsepower)	Truck Length (feet) 40	80	120
Four-Lane Interstate	0	0.50	150	2.2	2.6	3.0
			200	2.5	3.3	3.6
			250	3.1	3.4	4.0
	3	0.75	150	9.0	9.6	10.5
			200	11.3	11.8	12.4
			250	13.2	14.1	14.7
Two-Lane Highway	0	0.50	150	1.5	1.7	Not Simulated
			200	1.7	1.8	Not Simulated
			250	2.4	2.7	Not Simulated
	4	0.75	150	5.0	5.4	Not Simulated
			200	8.2	8.9	Not Simulated

Table 7. Vehicle Passenger Car Equivalents -- Rural Highways

Energy and Environment

Environmental impacts of highway travel, especially impacts on air quality and health, have been increasingly important considerations for decision makers at all levels of government. Research into detailed factors that affect emissions from different truck classes has lagged research on factors affecting automobile emissions. There are several types of emissions from trucks that contribute to health problems and other impacts on persons and property. They include nitrogen oxides, particulate matter, volatile organic compounds, and sulfur oxides. Mechanisms by which these emissions ultimately affect health are complex and in some cases poorly understood at present.

Analytical models used by the Environmental Protection Agency (EPA) and many other environmental researchers do not differentiate among the truck classes of interest in this study. Emissions from heavy trucks vary directly with VMT, but other factors such as relative fuel economy may also affect emission rates. Further research will be required to develop factors that relate emissions to vehicle weights and dimensions.

While a primary concern about the relative energy consumption under alternative TS&W policies is the connection between energy consumption and emissions, the relative energy consumption of different

Table 8. Vehicle Passenger Car Equivalents -- Urban Highways

Roadway Type	Traffic Flow Condition	Grade	Vehicle to Horsepower Ratio (pounds/horsepower)	Truck Length		
				40	80	120
Interstate	Congested	0	150	2.0	2.5	2.5
			200	2.5	3.0	3.0
			250	3.0	3.0	3.0
	Uncongested	0	150	2.5	2.5	3.0
			200	3.0	3.5	3.5
			250	3.0	3.5	4.0
Freeway and Expressway	Congested	0	150	1.5	2.5	2.5
			200	2.0	2.5	2.5
			250	2.0	3.0	3.0
	Uncongested	0	150	2.0	2.0	2.0
			200	2.5	2.5	2.5
			250	3.0	3.0	3.0
Other Principal Arterial	Congested	0	150	2.0	2.0	2.5
			200	2.0	2.0	3.0
			250	3.0	3.0	4.0
	Uncongested	0	150	3.0	3.0	3.5
			200	3.5	3.5	3.5
			250	3.5	4.0	4.0

types of trucks and alternative modes of freight transportation remains a policy issue. Table 10 shows the relative miles per gallon of fuel consumed for different truck configurations at different weights.

Truck noise comes from three sources, the engine, the exhaust, and the tires. Truck noise begins to dominate noise from other vehicles in the traffic stream once trucks account for more than three percent of the traffic stream.

Table 9. Summary of Effects of Truck Size and Weight Characteristics on Highway and Traffic Operations

Vehicle Features		Traffic Congestion	Vehicle Offtracking		Traffic Operations			
			Low Speed	High Speed	Passing	Acceleration (merging and hill climbing)	Lane Changing	Intersection Requirements
Size	Length	- e	- E	+ e	- E	—	- E	- E
	Width	—	- e	+ e	- e	—	- e	—
	Height	—	—	- e	—	—	—	—
Design	Number of units	—	+ E	- E	—	—	- e	—
	Type of hitching	—	+ e	+ E	—	—	+ E	—
	Number of Axles	—	+ e	+ e	—	—	+ e	—
Loading	Gross vehicle weight	- e	—	- E	- E	- E	- e	- E
	Center of gravity height	—	—	- e	—	—	- e	—
Operation	Speed	+ E	+ E	- E	- E	—	+ e	+ E
	Steering input	—	- E	- E	—	—	- E	—

+/- As parameter increases, the effect is positive or negative.
E = Relatively large effect. e = relatively small effect. -- = no effect.

Noise passenger car equivalency factors were developed for this study based on FHWA noise prediction models. Those models do not differentiate among truck types so a generalized factor for all heavy trucks was developed.

The measure that traditionally has been used to estimate the economic costs associated with transportation-related noise is the effect of that noise on residential property values. A synthesis of property value studies was conducted for the 1997 Federal Highway Cost Allocation Study and results are used to estimate noise related costs associated with TS&W scenarios. Because there currently are no

Table 10. Noise Passenger Car Equivalents for Trucks

Vehicle type	Speed (miles per hour)				
	20	30	40	50	60
Auto	1.0	1.0	1.0	1.0	1.0
Truck	85	44	27	19	14
Source: FHWA					

data on the relative differences in noise for different types of trucks, changes in truck volumes and speeds are the most significant factors affecting noise impact estimates.

Table 11 shows that equivalency factors are much greater at low speeds than at high speeds, varying from 85 at 20 miles per hour to 14 at 60 miles per hour.

Rail Impacts

Motor carriers, railroads, barges, and pipelines are the principal transportation modes for moving intercity freight, with motor carriers and railroads having the largest market shares in both revenues and tonnage. Railroads have a competitive advantage over motor carriers in hauling bulk commodities, and trucks have an advantage in hauling low density, high-value commodities. But railroads and trucks compete for many movements, especially the increasing volume of intermodal traffic.

Since the Staggers Rail Act was passed in 1980 the railroads have been reorganizing to make their operations more efficient and profitable. There is concern that, if changes in TS&W regulations allowed larger trucks, those trucks would draw freight from the railroads and adversely affect their profitability.

Table 11. Diesel Fuel Use Rates for Illustrative Vehicle at Different Weights
(miles per gallon)

Configurations	Gross Vehicle Weight (pounds)					
	40,000	60,000	80,000	100,000	120,000	140,000
Three-axle Single-Unit Truck	5.11	4.42				
Four-axle Single-Unit Truck	4.80	4.15				
Five-axle Tractor-Semitrailer		5.44	4.81	4.31		
Six-axle Tractor-Semitrailer		5.39	4.76	4.27		
Five-axle STAA Double		5.95	5.29	4.76		
Seven-axle Rocky Mountain Double			5.08	4.58	4.36	4.16
Eight-axle (or more) Double			5.08	4.82	4.58	4.36
Triple-Trailer Combination			5.29	5.01	4.76	4.54
Source: FHWA						

A shrinking volume of traffic is of particular concern to railroads because railroads are a decreasing cost industry. They have high fixed and common costs, and per-unit costs decline as production increases to capacity. If production (traffic volume) decreases, however, the high fixed costs must be spread over the lower volume, resulting in higher per-unit costs. The railroads could price some shipments below average total cost, but above variable cost, to retain traffic, but any such discounts would have to be made up through higher costs to captive shippers, increasing total freight costs for those shippers.

Impacts of the various illustrative TS&W scenarios are estimated using the Department's Intermodal Transportation and Inventory Cost (ITIC) model and an Integrated Financial Model. Data limitations prevented analyzing potential truck-to-rail diversion under the two scenarios that would have rolled back Federal TS&W limits, but potential rail-to-truck diversion resulting from scenarios that assumed increases in allowable vehicle weights and dimensions are estimated.

The ITIC model uses the Surface Transportation Board Carload Waybill Sample of rail freight shipments and estimates total shipper transportation and logistics costs for each record in that database. Comparable transportation and logistics costs to move the same shipments by truck operating under the TS&W limits assumed in each illustrative scenario are estimated and compared with the rail costs. If trucks costs are lower, the shipment is assumed to shift from rail to truck. A more detailed description of the diversion model is contained in Volume III of this report.

In addition to estimating the total diversion of rail traffic to trucks under the illustrative TS&W scenarios, the ITIC model can estimate (1) remaining rail revenues after accounting for losses due to diversion and discounting to hold traffic and (2) the car miles remaining on the railroads.

Using these ITIC outputs as inputs, the Integrated Financial Model uses the change in revenues and the estimated change in railroad freight service expense for remaining car miles to measure the impact on the rail industry's financial condition following changes in TS&W regulation. Post-diversion return on investment is calculated along with the increase in rail rates that would be required to return the rail industry to its pre-diversion financial condition. These estimates are made for the rail industry as a whole and for four individual railroads

Shipper Costs

Previous TS&W studies by the Department and TRB have concluded that certain increases in allowable vehicle weights and dimensions could reduce the costs of shipping freight, thereby increasing productivity. Not every shipment would benefit from increases in either the allowable weight or cubic capacity of a truck. Time sensitive shipments that are becoming increasingly important with just-in-time and other advanced logistics systems might not benefit from larger trucks. Likewise, short-distance moves that have either an origin or destination away from roads on which larger vehicles are allowed to operate might not benefit. But studies have shown that many freight transportation markets potentially could benefit from increases in allowable truck weights and dimensions. The extent of the benefit would depend on details of changes in TS&W regulations and responses by States, different segments of the trucking industry, and shippers to such changes.

Shippers are concerned about more than just the cost of moving goods between origin and destination when they make transportation-related decisions. They and their customers also consider other logistics costs including inventory, product packaging, plant location, production processing requirements. For instance if a shipper wants to reduce transportation costs by using larger trucks, it might incur higher inventory costs to store the larger quantities of goods that can be shipped in the larger trucks, and the shipper's customers might also incur higher inventory costs to store goods at the destination. Just-in-time inventory systems work with little or no inventories so larger shipments in larger trucks might not suit firms that use such inventory systems, depending on the nature of the product.

The ITIC model estimates both transportation and key inventory costs associated with moving goods by rail or by various truck configurations. For a given change in TS&W limits, the model predicts whether changes in transportation and inventory costs would cause a given shipment to be transported by an alternative mode or truck configuration. As noted above the Carload Waybill Sample is used for rail shipments. The database of truck shipments comes from surveys of shipments at truck stops. If total transportation and logistics costs are estimated to be lower for an alternative mode or truck configuration, the shipment is assumed to divert to that alternative.

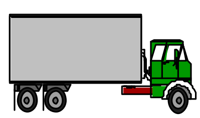
Illustrative Truck Size and Weight Scenarios

Five TS&W scenarios were developed for this study to illustrate the nature and relative magnitude of impacts on safety, productivity, infrastructure, the environment, traffic operations, and the railroads. Scenarios are characterized by specific vehicles that would likely operate under the scenarios, gross weight limits and lengths at which those vehicles could operate, and the networks of highways upon which scenario vehicles could operate. Those illustrative scenarios are briefly described below.

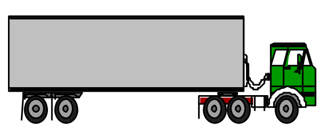
Uniformity Scenario

Figure 10 shows the major scenario vehicles for the Uniformity Scenario and key analytical assumptions underlying the scenario. Tables 2, 3,and 4 showed

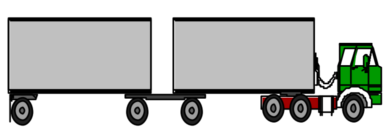
Figure 10. Uniformity Scenario



Three-axle single unit truck
Maximum weight – 51,000 pounds



Five-axle tractor-semitrailer
Maximum weight – 80,000 pounds



Five-axle STAA double
Maximum weight – 80,000 pounds

<u>Main Features</u>

- **Extend Federal gross vehicle weight and axle weight limits to the National Network for STAA vehicles.**
- **Grandfather provisions removed.**

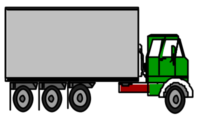
<u>Available Highways</u>

- **National Network for STAA vehicles**

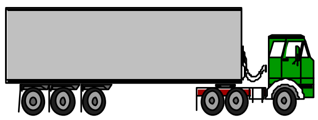
Access Provisions

- **Current Federal and State provisions**

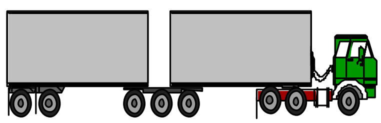
Figure 11. North American Trade Scenarios



Four-axle single unit truck
64,000 pounds or 71,000
pounds maximum weight



Six-axle tractor-semitrailer
90,000 pounds or 97,000



pounds maximum weight

Eight-axle B-train double
124,000 pounds or 131,000
pounds maximum weight

<u>Main Features</u>

- **Combination vehicles widely used in Canada and Mexico**
- **Introduces tridem-axle weight limits**

<u>Available Highways</u>

- **Current National Network for STAA vehicles**

<u>Access Provisions</u>

- **Current Federal and State provisions**

the large variation in State TS&W limits off the Interstate System and the many States that have grandfathered weight limits on the Interstate System. This scenario assumes that grandfather provisions in current Federal law would be removed and that States would be required to adopt Federal weight limits on all NN highways. States now exercising grandfather rights to allow heavier vehicles on the Interstate System would have to roll those weights back to the current Federal limits. They also would have to roll back higher limits they may have on other NN highways. With an 80,000- pound weight limit, LCVs would be impractical for all but the lightest loads.

The STAA of 1982 was intended to improve the uniformity of TS&W regulations and to extend regulations beyond the Interstate System. However, it did not require any rollback of State TS&W limits. Rather it established minimum weights and dimensions that would have to be allowed on certain highways.

Several States currently have weight limits below Federal limits on non-Interstate portions of the NN. Those States would be required to bring weight limits up to Federal limits on those NN highways. Non-divisible load permits would continue. Off the NN, vehicles would continue to operate at current State-regulated weights.

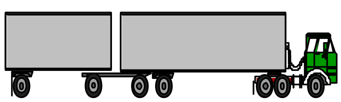
North American Trade Scenarios

The North American Trade Scenarios assume heavier gross vehicle weights on certain configurations by increasing allowable tridem-axle loads to be more consistent with tridem-axle loads in Canada and Mexico. Two alternative tridem-axle load limits are tested, one at 44,000 pounds and the second at 51,000 pounds. Figure 11 shows key assumptions for these scenarios. The 51,000-pound limit would allow six-axle tractor-semitrailers to operate at 97,000 pounds which would permit transportation of international containers loaded to the International Standards Organization (ISO) limit. Other vehicles considered in this scenario are a four-axle single unit truck weighing up to 71,000 pounds and an eight-axle B-train double weighing up to 131,000 pounds with trailer lengths of 33 feet. Because they corner as well as current tractor-semitrailers and are relatively stable vehicles, the eight-axle B-train double is assumed to be allowed the same access. Eight-axle doubles are operated in some Canadian Provinces and in States along the U.S.-Canadian border, but not in Mexico. Current grandfathered weight limits would stay in effect in these scenarios.

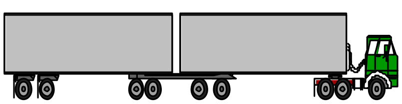
Longer Combination Vehicles Nationwide Scenario

Longer combination vehicles currently operate in 16 States west of the Mississippi River and on turnpikes in 5 States east of the Mississippi River. The ISTEA froze LCV operations, preventing their use in States where they were not permitted on June 1, 1991. This freeze was extended in TEA-21. As indicated in Figure 12, the LCVs Nationwide Scenario assumes LCV operations on a nationwide network. Limited networks would be designated upon which LCVs could operate. Turnpike doubles (twin 53-foot trailer combinations weighing up to 148,000 pounds) and Rocky Mountain Doubles (combinations with one 53-foot trailer and one 28.5-foot trailer weighing up to 120,000 pounds) would not be allowed to leave the network because of their relatively poor maneuverability. They would have to use staging areas to assemble and disassemble; travel off the network would be in single trailer combinations. Triple-trailer combinations (combinations with three 28.5-foot trailers weighing up to 132,000 pounds) and eight-axle twin-trailer combinations with two 33-foot trailers weighing up to 124,000 pounds would be allowed to travel off their networks to get to origins and destinations under current access rules because they can negotiate curves as well as current tractor-semitrailer combinations. In practice triple trailers and the eight-axle twin trailers might not be allowed this degree of access off their designated networks, but there was no way to estimate the extent to which access might be granted. To the extent that diversion to those two vehicles

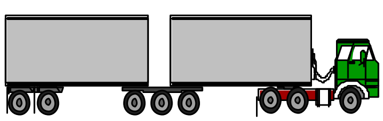
Figure 12. Longer Combination Vehicles Nationwide Scenario



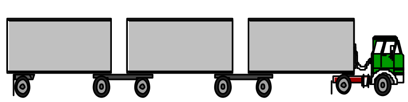
7-axle Rocky Mountain Double
Maximum weight – 120,000 pounds



9-axle Turnpike Double
Maximum Weight – 148,000 pounds



8-axle B-train double
Maximum weight – 124,000 pounds (33-foot trailers)



Triple-trailer combination
Maximum weight – 132,000 pounds

Main Feature

- **Broad national LCV operations**

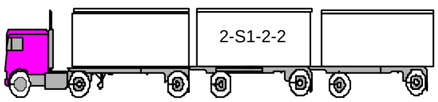
Available Highways

- **RMDs and TPDs – 42,000 mile analysis network**
- **Triples – 60,000 mile analysis network**
- **8-axle B-train double – National Network for STAA vehicles**

Access Provisions

- **RMDS and TPDs – none off the analysis network**
- **Triples – State issued permits**
- **8-axle B-train doubles – current Federal and State provisions**

Figure 13. Triples Nationwide Scenario



Seven-axle triple-trailer combination
132,000 pounds (maximum)

Main Feature

- **Broad national operation of triple-trailer combinations and new weight limits for triple-trailer combinations**

Available Highways

- **65,000-mile system**

Access Provisions

- **State issued permits**

may be overestimated, all of the impact measures, both positive and negative, are also overestimated. The scenario assumes that all States would uniformly adopt the new limits, and therefore captures the maximum impact. All other Federal size and weight controls would remain.

H.R. 551 Scenario

H.R. 551, "The Safe Highways and Infrastructure Preservation Act," was introduced in 1994 during the 103rd Session of Congress, and again in 1997 during the 105th Session. The bill would federalize certain areas of truck regulation that are now State responsibilities. Specifically, H.R. 551 contains three provisions related to Federal TS&W limits: (1) it would phase out trailers longer than 53 feet, (2) it would freeze State grandfather rights, and (3) it would freeze weight limits (including divisible load permits) on non-Interstate portions of the NHS.

Triples Nationwide Scenario

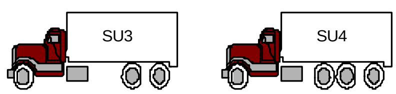
This scenario assumes the operation of triple-trailer combinations across the country at the same weights and dimensions as are assumed under the Scenario. Figure 14 gives key assumptions of this Scenario.

Illustrative Scenario Impacts

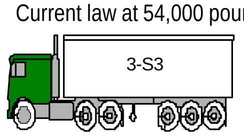
Diversion

Table 12 shows estimates of traffic diversion from existing trucks and from rail to selected vehicles for each of the scenarios. Total vehicle miles of travel

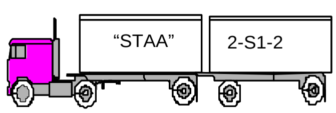
Figure 14. H.R. 551 Scenario



Two- to four-axle single unit truck
Current law at 54,000 pounds to 70,000 pounds



Five- to six-axle semitrailer
Current law at 80,000 pounds to 100,000 pounds



Five to six-axle STAA double trailer combination
Current law at 80,000 pounds

Main Features

- **Phases in elimination of semitrailers over 53 feet long**
- **Assumes status quo weights**

Available Highways

- **National Highway System**

Access Provisions

- **Current Federal and State provisions**

(VMT) do not equal the sum of VMTs for individual vehicle classes because not all vehicle classes are shown. It should be noted that base case VMT exceeds current VMT because the analysis year is 2000; growth in the economy through 2000 will increase truck VMT.

The two illustrative scenarios involving some rollback of State TS&W limits show small increases in truck VMT. The Uniformity Scenario would reduce travel by six-axle tractor-semitrailers and LCVs because those vehicles would not be able to travel at weights above 80,000 pounds on the NN. The H.R. 551 Scenario has very small changes in VMT for those two vehicle classes.

The four scenarios that assume heavier vehicle weights all show large (greater than 70%) reductions in travel by five-axle tractor-semitrailers and very large increases in LCV travel. Total VMT estimated under the North American Trade Scenarios is about ten percent less than total base case VMT. Most VMT that shifts from five-axle tractor-semitrailers diverts to eight-axle twin-trailer combinations rather than six-axle tractor-semitrailers in the North American Trade Scenarios since the twins are assumed to have virtually unlimited access off the NN and have significantly greater cubic capacity and payload. In fact much of the diversion to the eight-axle twins is lower density traffic that takes advantage of the additional cubic capacity of the vehicle rather than the additional gross weight it can carry compared to the six-axle tractor-semitrailer. The relative diversion to eight-axle twins compared to six-axle tractor-semitrailers is larger than has been experienced in Canadian Provinces where similar configurations are allowed. Several comments to the docket expressed concern that estimated diversion to the eight-axle twins is too high in these scenarios. Certainly it would take time for shippers and carriers to learn how to efficiently use such a vehicle and to manage fleets with multiple trailer types, but with the widespread access assumed for eight-axle twins in this scenario and the large cubic capacity, substantial transportation cost savings could be possible. If States did not provide the liberal access assumed in this study, or if cargo handling and other logistics costs associated with using the eight-axle twins were larger than assumed, diversion would be lower. The various assumptions in these scenarios are discussed in detail in Volume III of the report.

Estimated reductions in total VMT under the two LCV scenarios are about twice as great as under the North American Trade Scenarios. In addition to diverting large volumes of traffic currently shipped in five-axle tractor-semitrailers, LCVs could also divert less-than-truckload traffic currently being shipped in STAA doubles. Even in the Triples Nationwide Scenario, considerable truckload traffic is diverted from five-axle tractor-semitrailers because of the greater cubic capacity and gross weight of the triple. While little truckload traffic currently moves in triples, the liberal access and high gross weight limit assumptions in the scenario result in a vehicle that has relatively low costs per payload ton-mile. If access were more restricted, as would be likely in many States, the allowable gross weight lower, and the handling and other logistics costs associated with using triples higher than are assumed in this scenario, the diversion to triples would be lower than shown in Table 12. Assumptions in these scenarios are discussed in detail in Volume III.

Costs

Impacts of the various TS&W scenarios on infrastructure, shipper and rail costs, and the environment are all related to the traffic diversion estimates summarized above. Table 13 shows estimated changes from base case levels for key impact areas. Changes are expressed in terms of cost changes for each of the impact areas except rail contribution. The change in rail contribution is a measure of the amount of revenue available to cover rail fixed costs after variable costs have been covered.

Table 13 indicates that bridge replacement costs change significantly under all scenarios, including those that would reduce certain vehicle weights and dimensions. The assumption in this study is that all bridges that would be stressed beyond the overstress criteria underlying the Federal bridge formula ultimately would be replaced to accommodate vehicles allowed under the various scenarios. This is similar to assumptions in previous TS&W studies by the Department and TRB, but it may overestimate bridge-related costs based on comments by several States. In practice, depending on the degree of overstress, the volume of vehicles expected to utilize the bridge, and the type of bridge, States might postpone replacement for a number of years or perhaps be able to strengthen the bridge rather than replace it. Lightly traveled bridges that were significantly overstressed might simply be posted to prevent the most damaging vehicles from using the bridges. Posting significant numbers of bridges, however, would affect the level of utilization of prohibited vehicle classes. Impacts of heavy trucks on fatigue and bridge deck deterioration are not estimated. An on-going study under the National Cooperative Highway Research Program is examining fatigue and deck deterioration issues in more detail.

While bridge costs are primarily a function of weight, geometric costs are strongly influenced by trailer length. In general, the longer the trailer, the greater the vehicle's offtracking, especially in multitrailer combinations. Freeway interchanges and at-grade intersections would have to be modified to accommodate some longer vehicles. In scenarios analyzed for this study, turnpike doubles and Rocky Mountain doubles are assumed to be restricted to the limited networks upon which they can operate because of their long turning radii. Staging areas are assumed to be required to allow those vehicles to assemble and disassemble. In some Western States those vehicles can travel more widely than is assumed in the illustrative scenarios, but the vehicles operating in those States are shorter and have lower weight limits than the configurations examined in this study. The additional length would make the scenario vehicles less maneuverable than the vehicles in use today.

As in other TS&W studies by the Department and TRB, this study estimates that certain scenarios could produce significant reductions in shipping costs. Changes in shipping costs shown in Table ES-2 are all smaller in percentage terms than changes in some other impacts, but the base for these changes is much larger. Assumptions about allowable vehicle weights and dimensions and the extent of the network available for LCVs result in estimates of shipper cost savings that are higher than estimates in most previous studies. If lower weights, shorter lengths, and smaller networks were analyzed, shipper cost savings would be lower, but so too would most of the other impacts.

The analysis of scenario impacts on rail revenues indicates that several scenarios could significantly reduce revenues available to cover railroad fixed costs, known as "contribution." Because contribution is closely linked to return on investment, contribution is an important measure of a railroad's ability to cover its fixed cost and sustain necessary ongoing investment. Industry-wide estimates showed that contribution could be reduced by over 50 percent under the LCVs Nationwide Scenario and by somewhat lesser amounts under the North American Trade and Triples Nationwide Scenarios, which also allow nationwide LCV operation. Volume III contains estimates of changes in rail contribution for several individual railroads for each scenario. If allowable vehicle weights and dimensions were reduced, as assumed in the Uniformity Scenario impacts on rail contribution would be smaller.

Safety impacts are not shown on this table because there are so many dimensions to the safety issue that no one adequately captures safety considerations surrounding the illustrative scenarios. Previous TS&W studies have estimated changes in crashes and crash costs that might result from TS&W changes, but in this study the Department determined that changes in crash rates could not reliably be estimated for the

Table 12. Estimated Diversion for Selected Vehicle Configurations for Illustrative Truck Size and Weight Scenarios

Vehicle Class	5-axle tractor-semitrailer		6-axle tractor-semitrailer		LCVs		Total Truck [2]		Rail	
Illustrative Scenario	VMT	% change	VMT	% change	VMT	% change	VMT	% change	Car-miles	% change
Base Case	83,895	na	6,059	na	1,517	na	128,288	na	25,555	na
Uniformity	91,205	8.7	3,519	-41.9	542	-64.3	132,351	3.2	na	na[3]
N.A. Trade (1)	22,274	-73.5	6,209	2.5	49,837	3185.2	114,671	-10.6	24,354	-4.7
N.A. Trade (2)	24,997	-70.2	6,246	3.1	47,453	3028.1	114,632	-10.6	24,073	-5.8
LCV nationwide	19,611	-76.6	na[1]	na[1]	40,980	2601.4	98,562	-23.2	20,546	-19.6
H.R. 551	83,915	0.0	6,051	-0.1	1,517	0.0	128,311	0.0	na	na
Triples	23,405	-72.1	na[1]	na[1]	39,647	2513.5	102,400	-20.2	24,533	-4.0

N.A. Trade (1) – 44,000 pound tridem axles; N.A. Trade (2) – 51,000 pound tridem axles.

[1] To facilitate the diversion analysis, six-axle tractor-semitrailers were not included in the analysis for the two scenarios involving LCVs.

[2] The Total does not equal the sum of the three vehicle classes shown in the table because other vehicle classes included in the Total are not shown in the table.

[3] Potential diversion from truck to rail under the Uniformity and H.R. 551 Scenarios could not be estimated because of lack of data on rail pricing.

Table 13. Estimated Impacts of Illustrative Truck Size and Weight Scenarios (Percent Change from Base Case)

	Uniformity	N.A. Trade (1)	N.A. Trade (2)	LCV Nationwide	H.R. 551	Triples
Pavement Costs	-0.3	-1.6	-1.2	-0.2	0	0
Bridge Costs	-13.0	+33.1	+42.2	+34.4	0	+10.4
Geometric Costs	0	+13.3	+13.3	+965.0	0	0
Congestion Costs	+0.6	-1.2	-1.2	-2.9	0	-7.6
Energy Costs	+2.1	-6.2	-6.3	-13.8	0	-12.8
Shipper Costs	+3.0	-5.1	-7.0	-11.4	0	-8.65
Rail Contribution[1]	na	-42.8	-49.7	-55.8	na	-38.2

N.A. Trade (1) – 44,000 pound tridem axles; N.A. Trade (2) – 51,000 pound tridem axles.
[1] The amount of rail revenue available to pay fixed costs after freight service (variable) costs have been covered.

LCV scenarios. The small body of evidence on LCV crash rates in Western States are based on such different operating conditions and vehicles than those evaluated in this study that they do not provide a credible basis for estimating crash rates for vehicles with the dimensions and weights analyzed in this study, especially on congested highways on eastern portions of the illustrative LCV networks. Other factors considered in assessing safety impacts of possible TS&W changes are stability and control properties of different configurations, and perceptions of drivers concerning the safety of longer and heavier vehicles.

The LCV configurations generally show poorer stability or control properties than the base tractor-semitrailer configuration. Short multitrailer combinations have poor lateral stability that can result in the rearmost trailers traveling outside their lane or, at the extreme, rolling over if rapid steering maneuvers are required. In general the shorter the trailers, the worse the lateral instability, although certain types of trailer connections can reduce this instability. Thus while shorter trailers on triple trailer combinations reduce offtracking, they also reduce lateral stability. Reducing allowable weights and dimensions of scenario vehicles would improve stability and control, but would also reduce productivity benefits. Volume III presents detailed results of safety-related analyses conducted for this study.

Future Research

A review by TRB of data and methods used in this study was initiated but put on hold while TRB conducts the TS&W study called for in TEA-21. The intent of this review is to help develop a long-term research agenda to continuously improve the Department's ability to estimate impacts of alternative TS&W policy options. The TRB review is expected to get underway again in 2000.

Future research needs identified in conducting this study include (1) incorporating improved truck origin-destination data by commodity from the Commodity Flow Survey and other sources into the ITIC freight diversion model;
(2) improving other essential logistics data in the ITIC model; (3) improving our understanding of relationships between TS&W variables and truck safety risks; (4) examining the potential for new technology to reduce adverse safety and operational characteristics of current vehicles; (5) improving information on impacts of heavier vehicles on bridges and strategies to mitigate those impacts; and (6) improving our understanding of ways to reduce traffic conflicts between large trucks and the rest of the traffic stream.

Work to address some of these research issues can begin immediately, but even after the research has been conducted, uncertainties about potential impacts of TS&W options will remain. It is extremely difficult to accurately predict how the market might respond over time to changes in allowable TS&W limits or how States might respond, particularly if longer multitrailer vehicles were to be an option. However, many impacts are interrelated; if one impact is known others can more readily be estimated.

While future research may allow more informed decisions about impacts of various TS&W policy options, many TS&W decisions are fundamentally political and involve tradeoffs among equally worthy goals.

Conclusions

State Perspectives

Significant productivity benefits were estimated for each illustrative scenario that allowed heavier vehicle weights, but these benefits were derived primarily from the use of LCVs, even for the North American Trade Scenarios. Nationwide use of LCVs would entail significant infrastructure costs, adverse impacts on railroads, and potentially negative safety impacts. Furthermore, officials in many States that currently do not allow LCVs oppose policies that would relax restrictions on LCV use. In addition to concerns about infrastructure costs and safety risks, their opposition likely reflects apprehension about larger trucks by motorist and other interest groups in their States.

States differ markedly on their positions regarding changes in Federal TS&W limits. Some States oppose changes in Federal TS&W laws that would give States either the flexibility to allow higher gross weights or to allow LCVs. Even if Federal law did not require States to allow larger or heavier vehicles, some States fear that if neighboring States allow LCVs, they will face irresistible pressure to also allow LCVs to keep their businesses competitive. Federal TS&W limits thus act as buffers which protect States from industry pressure to raise their TS&W limits.

States that presently allow LCVs on their State highways generally favor removing the LCV freeze and liberalizing rules under which LCVs may operate. They argue that grandfathered operations in most States are based on laws in effect in 1956 and that highways have become safer since that time. They also maintain that LCVs have had good safety records in their jurisdictions, that LCVs improve productivity, that LCVs can operate without staging areas or interchange improvements, and that current grandfather laws often result in LCVs having to operate off the Interstate System rather than on the safer Interstate Highways.

Still other States would like increases in gross weights allowed for six-axle tractor-semitrailers and single unit trucks like dump trucks, garbage trucks, and other specialized hauling vehicles. These States want additional truck productivity without the infrastructure costs and potential safety concerns associated with LCVs. No separate analysis was conducted in this study to estimate effects of allowing only those shorter vehicles. In general, allowing such vehicles at the weights analyzed in this study would not be expected to cause additional pavement damage on Interstate Highways, nor would they increase costs to improve roadway geometrics. Bridge impacts would be mixed depending on the gross weights allowed. The heavier vehicles allowed under the North American Trade Scenario would require substantial bridge improvements. Heavier six-axle tractor-semitrailers, such as the 97,000 pound vehicle that would be allowed to operate under H.R. 1667 introduced in 1999, generally would exceed bridge formula limits and would cause stresses exceeding bridge design stresses. Many bridges would have to be replaced, strengthened, or posted to prevent vehicles operating at the proposed weight limits.

Truck Size and Weight Trends

While basic Federal TS&W limits have not changed since 1982 with the exception of the LCV freeze, this does not mean that the status quo has been maintained. Several States have been granted legislative exceptions to Federal gross weight or axle-weight limits, including four States that received such exemptions in TEA-21. States are granting increasing numbers of oversize and overweight permits, especially for international containers, but also for many other commodities. In many cases such permits allow unlimited use over a year's period

While Federal laws have constrained increases in vehicle weights, the cubic capacity of vehicles has been increasing, primarily as the result of increasing trailer lengths. For example, at the time of the last Departmental report on TS&W limits in 1981, the standard trailer length was 45 feet with 48-foot semitrailers being used in increasing numbers. Fifty-three foot long semitrailers are becoming a standard for many carriers, and some States allow trailers up to 60 feet in length. Average operating weights of tractor-semitrailers have actually gone down slightly in recent years with decreases in cargo density and pressures to provide smaller, more frequent deliveries to support just-in-time and other advanced logistics operations. There are several implications of these ad hoc trends that are occurring while basic Federal TS&W limits remain unchanged. With the increasing weights being allowed under permit, pavements and bridges will deteriorate faster. Increasing trailer lengths probably have not had as significant an effect because carriers are operating those vehicles with the rear axles pushed forward so that their offtracking is not significantly worse than 48-foot trailers. As trailer lengths have moved beyond 53 feet in some States, however, geometric deficiencies have increased because there is a limit to how far forward the rear axles can be pushed to minimize offtracking. The sum of these ad hoc changes at the State level has been to create an ever more diverse patchwork of TS&W limits nationwide. Increasing trade with Mexico and Canada which have higher allowable gross weight and axle weight limits than the U.S. will cause even greater pressures to increase weight limits, especially in major trade corridors in this country.

One scenario evaluated in this study, the Uniformity Scenario, would have virtually eliminated variations in State TS&W limits, but little sentiment to roll back Federal TS&W limits to the extent assumed in this scenario was expressed in docket comments. The H.R. 551 Scenario would phase out trailers longer than 53-feet and freeze weight limits on the National Highway System, but would retain existing grandfather and other legislative exemptions to the basic Federal weight laws.

Cost Recovery

Cost recovery is an issue that several States mentioned in comments to the docket, and is an issue for the Federal Government as well. Most increases in TS&W limits would require some infrastructure improvements. Even if more incremental changes in TS&W limits were implemented than those included in the illustrative scenarios, bridge, geometric, and perhaps pavement costs could increase. Some States capture a large share of the additional infrastructure costs associated with operations of oversize and overweight vehicles through permit fees, but other States charge fees that cover little more than costs to administer the permit program. At the Federal level, there is no mechanism for capturing added costs of larger, heavier trucks through user taxes. Weaknesses of the current Federal user fee structure to reflect the cost responsibility of different vehicle classes were discussed in detail in the 1997 Federal Highway Cost Allocation Study.

Next Steps

The TRB has a study underway of Federal TS&W regulations as requested in TEA-21. That study will consider whether changes in Federal TS&W limits are advisable and evaluate how changes might affect the economy, the environment, safety, and services to communities.

The Department will continue to improve this analytical framework during the next several years. Comments submitted to the docket provided valuable recommendations for additional research in several areas. In May 2000 the Federal Highway Administration sponsored a nationwide truck size and weight policy workshop to discuss specific improvements that can be made in data and analytical methods used in assessing impacts of truck size and weight policy options. The workshop also was intended to provide solicit perspectives from a variety of stakeholders on future directions for Federal truck size and weight policy.

The Department will be prepared to update this TS&W study before the next surface transportation reauthorization using updated data and analytical tools and building on other on-going research by TRB, the National Cooperative Highway Research Program and other institutions. In the meantime, if requested by Congress, the Department is prepared to examine additional TS&W options that may be of interest. An analysis is already underway of a “Western Uniformity Scenario” as requested by the Western Governors Association.

The analytical framework developed for this study is flexible and many assumptions can be varied to assess specific proposals. While the illustrative scenarios analyzed in this study covered most basic TS&W alternatives, many variations are possible. An option might be identified that could improve shipper and carrier productivity, improve safety, have acceptable infrastructure costs, and cause little serious impacts to railroads or other modes. Identifying such an option would require close coordination with States, shippers, carriers, and other industry groups. If consensus could be developed that the benefits clearly outweighed potential costs, it might be possible to rationalize national TS&W policy, reduce or eliminate the need for the kinds of State exemptions to Federal TS&W laws that recently have been enacted, and improve productivity, safety, and international competitiveness.

Notes to Table 2

(1) "Routine" Permit Gross Vehicle Weight: the first number (left) is the highest weight a five-axle unit can gross before special (other than routine) review and analysis of an individual movement is required. The second number (right) is the highest gross weight any unit with sufficient axles can gross before special review is required.

(2) State rules allow the more restrictive of the Federal Bridge Formula or the sum of axle weight limits. The five-axle "routine" permit value is estimated using a truck tractor-semitrailer with a 65-foot outer bridge (based on a 48-foot semitrailer).

(3) The five-axle "routine" permit value is estimated using a truck tractor-semitrailer with two tandem axles at 47,250 pounds each and a 12,000 pound steering axle.

(4) Estimate based on State weight table values for a' tandem drive axle at 46,200 pounds, a rear tandem at the 60,000 pound maximum, and a 12,500 pound steering axle.

(5) Maximum based on the number of axles in the combination.

(6) Federal bridge formula applies if gross vehicle weight exceeds 73,280 pounds.

(7) If gross vehicle weight is less than 73,280 pounds, the tandem axle maximum is 40,680 pounds.

(8) On class III and non-designated highways the maximum is 73,280 pounds.

(9) On non-designated highways the single axle maximum is 18,000 pounds, the tandem axle maximum is 32,000 pounds, and the bridge formula does not apply.

(10) On the Indiana Toll Road the single axle maximum is 22,400 pounds, the tandem axle maximum is 36,000 pounds, and the maximum practical gross is 90,000 pounds.

(11) The maximum gross weight on class AA highways is 62,000 pounds, and on class A highways, 44,000 pounds.

(12) Six or seven-axle combinations are allowed 83,400 pounds on the Interstate System, and 88,000 pounds on other State highways.

(13) A three axle tractor hauling a tri-axle semitrailer has a maximum gross vehicle weight of 90,000 pounds.

(14) If the gross vehicle weight is less than 73,280 pounds, the single axle maximum is 22,000 pounds.

(15) If the gross vehicle weight is 73,000 pounds or less, the single axle maximum is 22,400 pounds, and the tandem axle maximum 36,000 pounds.

(16) Federal axle, gross and bridge formula limits apply to five-axle combinations if the gross vehicle weight is 80,000 pounds or less. For other vehicles and gross vehicle weights over 80,000 pounds other limits apply. State law sets axle weight controls which allow vehicles of legal overall length to gross a maximum of 164,000 pounds.

(17) Most city, county and township roads are considered "9-Ton Routes" with a maximum gross vehicle of 73,280 pounds.

(18) On highways other than Interstate, Primary, or other designated, the single axle maximum is 18,000 pounds, the tandem axle maximum 32,000 pounds, the bridge formula is modified, and the gross vehicle weight maximum is 73,280 pounds.

(19) The maximum is directly controlled by the Federal bridge formula. Given the State's length laws, the maximum practical gross is 129,000 pounds.

(20) The five-axle "routine" permit value is estimated using a truck tractor-semitrailer with a 12,500 pound steering axle, a 47,250 pound drive tandem (5-foot spacing from State weight table), and a 50,400 pound spread tandem (8-foot spacing from the State weight table).

(21) A determination is made on a case-by-case basis.

(22) All "routine" permit values are calculated using 10-inch wide tires and a maximum 800 pounds/inch of tire width loading value.

(23) The five-axle "routine" permit value is estimated using a truck tractor-semitrailer with two 46,000 pound tandem axles and a 12,000 pound steering axle.

(24) If the gross vehicle weight is less than 71,000 pounds, the single axle maximum is 22,400 pounds, the tandem axle maximum 36,000 pounds, and a modified bridge formula applies.

(25) If the gross vehicle weight is 73,280 pounds or less, the single axle maximum is 22,400 pounds, the tandem axle maximum 36,000 pounds, and the bridge formula does not apply.

(26) If the gross vehicle weight is 75,185 pounds or less, the tandem axle maximum is 35,200 pounds, and the bridge formula does not apply.

(27) The five-axle "routine" permit value is estimated using a truck tractor-semitrailer with two 52,000 pound tandem axles and a 12,000 pound steering axle.

(28) The five-axle "routine" permit value is estimated using a truck tractor-semitrailer with a 13,000 pound steering axle, a 45,000 pound drive tandem, and a 48,125 pound spread tandem. Both tandem weight values are from the State weight chart.

(29) The five-axle "routine" permit value is estimated using a truck tractor-semitrailer with two 48,000 pound tandem axles and a 12,000 pound steering axle.

(30) The maximum gross vehicle weight on non-designated State highways is 73,500 pounds, and on county roads 65,000 pounds.