

COMPREHENSIVE TRUCK SIZE AND WEIGHT STUDY

Summary Report

for

Phase I--Synthesis of Truck Size and Weight (TS&W) Studies and Issues

Federal Highway Administration

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EXECUTIVE SUMMARY

This is the Summary Report of Phase I of the Comprehensive Truck Size and Weight (TS&W) Study announced by the Federal Highway Administrator in June 1994. It summarizes 13 working papers prepared during Phase I. The study is to be completed in three phases:

Phase I--Synthesis of TS&W Studies and Issues--assessed past policy studies and technical research. Technical knowledge about relationships between TS&W policy controls and relevant evaluation and decision criteria was synthesized. State and Federal TS&W regulations were summarized. Research needs for later phases were identified. Thirteen working papers were prepared examining the regulations and TS&W policy controls and: truck accidents, vehicle stability and control, pavements, bridges, roadway geometry, traffic operations, truck costs, shipper logistics costs, truck travel and mode share, enforcement, environment, energy, permits and pricing mechanisms.

Based on a review of the information, FHWA has identified several policy and technical issues for consideration in Phases II and III of the study. No policy conclusions were drawn in Phase I and none are discussed in this report. Consideration of policy options is being done in the later phases. This interim report is being issued at this time to gather wide input from both the public and private sectors on the issues of importance to this study.

Phase II--a Preliminary Option Analysis--will evaluate specific policy options using existing databases and analytical tools (completion summer 1995).

Phase III--an Extended Impact Analysis--will expand the scope and depth of the policy analysis of PHASE II using new databases and analytical capabilities becoming available in late 1995 with projected completion by the end of 1996.

Based on a review of many policy and technical studies done over the last 10 to 15 years, the following are among the most important issues summarized in this Phase I report:

- There has been no significant change in Federal TS&W law since 1982 except for the 1991 freeze of State provisions for longer combination vehicles (LCV). There have been many changes in factors interrelated with TS&W laws over the past 20 years. These include growth in freight traffic, changes in freight characteristics and origin-destination patterns, global economics and trade, containerization and intermodalism, economic deregulation, enhanced safety programs, and truck equipment.
- New questions about Federal TS&W law related to the National Highway System (NHS), North American trade harmonization, and retention of the 1991 freeze of State LCV provisions should be addressed in Phases II and III.

- There are a myriad of different TS&W regulations affecting U.S. trucking emanating from local, State and Federal Governments. Many reflect considerations such as differences in economic and industrial activities, freight movements, infrastructure design characteristics and status, traffic densities, mode options and engineering philosophies. The importance of State TS&W regulations cannot be over-stated since they govern trucking on the vast majority of U.S. road mileage.
- Federal law now regulates trucks by specifying basic TS&W standards and excepting certain situations from those standards by grandfather right and provision for special permits. Thus, current Federal regulations state that the gross vehicle weight limit of a truck is 80,000 pounds on Interstate highways, but allow trucks to carry international containers at more than 80,000 pounds, an exception to the standard.

Performance-standards regulation offers an alternative approach. Specifications are made as to acceptable performance measures--in terms such as stability, turning, or acceleration--with these measures then becoming the basis of regulation either directly or indirectly surrogate measures. The performance-standard approach has been successfully applied to substantial components of trucking in Canada. While there is a growing technical interest in this method, there is also debate about details and about enforceability.

- Consideration should be given to the enforceability of policy options. Enforcement of the existing relatively simple regulations has proven difficult for many jurisdictions.
- Developments in domestic containerization will effect new demands on TS&W limits. The intermodal implications of TS&W policy options also need further study.
- The results of this study will provide a base of knowledge that can be used for the ongoing trilateral consultations on vehicle weights and dimensions required by the North American Free trade Agreement (NAFTA).

Chapter 5 identifies several research topics that will be important to carry out during Phases II and II to more definitively resolve TS&W policy options.

CHAPTER 1 - INTRODUCTION

1.1 Purpose

On June 14, 1994, during testimony before the U.S. House of Representatives Committee on Public Works and Transportation's Subcommittee on Surface Transportation, Federal Highway Administrator Rodney E. Slater made a commitment to conduct a Comprehensive TS&W Study. Stating that the FHWA had not made a "... comprehensive effort to analyze truck size and weight issues for the last 30 years ...," he added, "The time has come to revisit this issue and to do it in a way that is comprehensive, ... analytical, and well thought out ... to look at it holistically ...". Further, he said that "I believe a fundamental reexamination of all vehicle size and weight issues is necessary."

Historically, TS&W regulations have been driven by a concern for national uniformity and good highway system stewardship--matching vehicle weights and dimensions with the existing capacity of the public infrastructure and with mechanisms for cost recovery. At times, new pavement and bridge design standards have been adopted by the States to better match the weights and dimensions of the vehicles being allowed to operate on their highways. However, avoidance of premature degradation of that infrastructure with its attendant strain on public resources continues to be a major concern. More recently, as technology and shipper demand have joined to make larger and heavier trucks a reality, concerns for highway safety and loss of rail service have become increasingly important, especially with regard to longer combination vehicles (LCV).

A shift of some TS&W regulatory authority from the States to the Federal Government occurred at the start of the Interstate construction era in the 1950's, and since then, the distribution of this shared authority has shifted back and forth. Now, as the Interstate construction era draws to a close, the transportation community is again reassessing the Federal role in the context of future highway transportation needs.

The ultimate goal of the Comprehensive TS&W Study is to estimate the effects of various elements of regulatory policy on a transport system in transition as it evolves to serve a modern global economy. New capabilities and opportunities exist with new distribution and electronic systems. The impacts of changing logistics costs, production strategies, and shipping patterns must be balanced with the needs and concerns of carriers, managers of infrastructure, shippers, consumers, and the traveling public. TS&W policy touches upon public concerns such as safety, infrastructure design and wear, States' rights and national uniformity, environment, energy use, intermodal competition, and cost recovery. Finally, these issues must be evaluated at several levels--local, State, regional, national, and international.

1.2 Study Plan

The following three phase study plan was developed to address the issues related to possible changes in Federal TS&W provisions. Additional information on this study is available in a Federal Register notice published on February 2 (60 FR 6587).

Phase I, TS&W Synthesis, has assessed past policy studies and research findings. **This report describes the current knowledge of the technical relationships between TS&W policy controls and their related issues.** The history of State and Federal TS&W regulation are reviewed, State and Federal TS&W regulations are summarized, and knowledge and research gaps on TS&W issues are identified and prioritized. TS&W studies completed within the last 15 years and more recent research not covered in these studies have been synthesized in 13 working papers that cover:

- Safety
- Pavement and bridge wear
- Roadway geometry
- Traffic operations
- Truck operating costs
- Shipper logistics costs
- Truck travel
- Mode share
- Enforcement
- Environment
- Energy conservation
- Permits and pricing mechanisms
- Existing TS&W regulations

These working papers are available in FHWA Docket No, 95-5 established for this study.

Phase II, a Preliminary Option Analysis, will evaluate, on a limited basis, specific policy options using existing databases. It is preliminary because new data for a comprehensive analysis of TS&W issues, such as commodity flow information, will only become available in late 1995. Therefore, Phase II policy options will include appropriate caveats regarding the limitations of earlier studies. The analysis will be as comprehensive as possible, but at a minimum, it will include the impacts of changes in Federal TS&W provisions on safety, infrastructure, and economic productivity. This phase will be completed during the summer of 1995.

Phase III, an Extended Impact Analysis, will use the data and new tools that become available in 1995 and 1996 to prepare in-depth analyses of the Phase II policy options. It will incorporate results from a parallel cost allocation study that FHWA is undertaking to determine whether the various highway users, including heavy vehicles, are paying their fair share into the Highway Trust Fund. Specific policy options will be analyzed using improved

information on freight flows and truck use and will address the full range of costs and benefits estimated to derive from these options. The study will be completed by the end of 1996.

1.3 Federal TS&W Regulatory Development

While State and local laws govern trucking on the majority of the Nation's highways, Federal law directly governs and indirectly influences a substantial amount of total trucking activity. The milestones in Federal TS&W regulation are:

In 1956 Congress legislated maximum axle weight, gross vehicle weight, and width limits for trucks operating on Interstate highways. Congress adopted the weight limits recommended in 1946 by the American Association of State Highway Officials (AASHO), now the American Association of State Highway and Transportation Officials (AASHTO): 18,000 pounds on a single axle, 32,000 pounds on a tandem axle, and 73,280 pounds gross weight. The Federal law also authorized States to allow operation on Interstate highways beyond the specified limits, but only if such operation was legal in the State prior to July, 1 1956. This became known as a "grandfather right."

In 1975 Congress authorized higher axle and gross vehicle weights on the Interstate System. However, States were not required to adopt these higher limits. Some did not. In addition, a "Federal Bridge Formula" (Bridge Formula B) was imposed limiting the gross weight of any group of axles to the lesser of the cap or a value determined by the number of axles and the distance between them; the heavier the weight the greater the spacing required. States with "grandfathered" bridge formulas (in effect before 1975) did not have to enforce the Federal formula.

In 1982 Congress required that all States allow on their Interstate highways loads of 20,000 pounds on single axles, 34,000 pounds on tandem axles, 80,000 pounds total for a vehicle, and enforce the Federal Bridge Formula. The width limit was increased to 102 inches. States were required to allow 48-foot semitrailers and double combinations of two 28-foot trailers. The Federal length and width provisions were extended beyond the Interstate System to the designated National Network (NN) for large trucks and related access roads. States having grandfather rights were authorized to determine what vehicles and operating situations would be considered "grandfatherable".

Grandfather Rights

There are three different grandfather clauses in Section 127, Title 23, U.S.C. The first, enacted in 1956, deals principally with axle weights, gross weights, and permit practices; the second, adopted in 1975, applies to bridge formula and axle spacing tables; and the third, enacted in 1991, ratified State practices with respect to LCVs.

The vehicle weight limits--18,000 pounds on a single axle, 32,000 pounds on a tandem axle, and 73,280 pounds gross weight--enacted in 1956 were to protect Interstate System pavements and bridges from damage or premature wear caused by excessively heavy trucks. Some States, however, already allowed trucks with axle or gross weights in excess of those values. The grandfather clause was therefore enacted to avoid a rollback of vehicle weights legal in those States, while the AASHO standard set an upper limit on weights otherwise allowable.

In response to energy use concerns, the Federal-Aid Highway Amendments of 1974 increased the allowable single axle, tandem axle, and gross weight limits on the Interstate to 20,000, 34,000 and 80,000 pounds, respectively, although not all the States adopted these limits. The bridge formula and a corresponding grandfather clause were added at the same time. This second grandfather clause allows States to retain any bridge formulas or axle spacing tables in effect on January 4, 1975, which allowed greater vehicle weights at the same axle spacing than the new Federal formula.

The Surface Transportation Assistance Act of 1982 included an amendment to Section 127 introduced by Senator Symms. The language on withholding of Federal-aid funds was modified to read as follows (Symms amendment underlined):

This section shall to be construed to deny apportionment to any State allowing the operation within such State of any vehicles or combinations thereof which the State determines could be lawfully operated within such State on July 1, 1956, except in the case of the overall gross weight on any group of two or more consecutive axles (that is, the bridge formula), on the date of enactment of the Federal-Aid Highway Amendments of 1974.

Sections 1023 and 4006 of the Intermodal Surface Transportation Efficiency Act of 1991 froze the operation of LCVs, defined as a tractor and two or more trailers or semitrailers operating on the Interstate with a gross weight in excess of 80,000 pounds. More specifically, it provided that LCV combinations which were in actual and lawful operation under State law on June 1, 1991, could remain in operation, provided the State continued to enforce the weight, length, and route restrictions and any other limitations then imposed on these vehicles.

North American Free Trade Agreement (NAFTA)

Senate Report 102-351, which accompanied the 1993 Appropriations Act for the Department of Transportation and Related Agencies, requested the FHWA to report on the status of discussions relative to the NAFTA on TS&W, and to include a summary of potential highway related impacts from implementing changes to U.S. TS&W limits. In response, the FHWA reported the Agreement has no provisions that raise U.S. Federal or State limits on TS&W. It does establish a process for the United States, Canada, and Mexico to work toward compatible technical and safety standards. Truck weights and dimensions are

technical standards and a part of the NAFTA standards harmonization work plan. The NAFTA establishes the Land Transportation Standards Subcommittee (LTSS) which will have delegations from the three countries consult on TS&W and other standards. As a part of the compatibility work plan, the LTSS component on weights and dimensions is to work for 3 years to attempt to make truck weight and dimension measures and related requirements compatible.

1.4 Previous Studies

Changing concerns, circumstances and opportunities have caused numerous investigations of TS&W matters by governments, industry, interest groups, and individuals. Recent national and international research of particular significance to TS&W policy today in the United States are discussed in the following sections:

Federal Studies

Earlier, Federally-mandated studies were reported in:

- 1941 **Federal Regulation of the Sizes and Weight of Motor Vehicles:** Congress instructed the Interstate Commerce Commission to investigate the need for Federal regulation of the sizes and weight of freight-carrying motor vehicles engaged in interstate or foreign commerce. The principal findings were: (1) State limits were a costly obstacle to interstate trade, (2) Federal intervention was accordingly warranted but only in response to specific complaints regarding particular situations, and (3) considerations of safety and convenience do not unto themselves justify Federal involvement.

- 1964 **Maximum Desirable Dimensions and Weights of Vehicles Operated on the Federal-Aid Systems:** In the Federal-Aid Highway Act of 1956, Congress instructed the Secretary of Commerce to report on research and make recommendations regarding maximum desirable weights and dimensions for vehicles operated on the Federal-aid highway systems, including the Interstate System. The principal recommendations--predicated on an assumption of continued financial support--were: (1) not to make recommendations for Federal vehicle standards for Federal-aid primary and secondary systems and their respective urban extensions (because of lack of relevant information); (2) retention of the current width and axle limits, removal of the GVW cap, and adoption of a Bridge Formula A for a 3 year period; (3) introduction of maximum length limits for single and combination units, and a height limit; (4) introduction of performance standards respecting maximum weight-to-power ratio, minimum brake system performance, and linkage mechanism requirements for combinations; and (5) after 3 years, increase in the width limit and axle weight limits, and adoption of Bridge Formula B (a formula more permissive than A).

- 1981 **An Investigation of Truck Size and Weight Limits:** In the Surface Transportation Assistance Act of 1978, Congress instructed the Department of Transportation to examine--among other things--the need for, and desirability of, uniformity in maximum truck size and weight limits throughout the United States. Five categories of changes in limits were assessed--namely grandfather clause elimination, barrier elimination, uniformity, rollback to pre-1974 limits, and increases in limits. The study examined the benefits and costs to the U.S. economy and society as a whole, as well as to individual interest groups associated with a series of TS&W scenarios.
- 1985 **Feasibility of a Nationwide Network for LCVs:** In the Surface Transportation Assistance Act of 1982, the Congress mandated a study on the potential benefits and costs that could be anticipated from the establishment of a nationwide network for LCVs. The study report concluded that: (1) there is no compelling evidence that LCVs are so desirable that increased Federal intrusion into State size and weight regulation authority was justified; and (2) the transportation efficiency gains were potentially substantial, but they are offset by safety concerns, losses in rail productivity, and high initial investment to realize the potential efficiencies.
- 1986 **Longer Combination Vehicle Operations in Western States:** In 1985, the Senate Appropriations Committee called for a study of LCV operations in the Western States. This study reported that the productivity benefits of allowing LCVs to operate more widely and at higher weights are unquestioned. The report noted the Department's commitment to work with the States and trucking groups to explore ways to improve the efficiency and safety of trucking. The Department would be better prepared to evaluate TS&W initiatives and enhance the productivity of LCVs, once ongoing research and congressional studies were completed.

Transportation Research Board (TRB)

The TRB published two major TS&W studies in 1990. The first, *Truck Weight Limits: Issues and Options* (Special Report 225), was requested by the Congress in the Surface Transportation and Uniform Relocation Assistance Act of 1987. It recommended: (1) establishment of a new Federal bridge formula, (2) prohibition of expanded grandfather claims for vehicles that exceed existing Federal limits, (3) establishment of State permit programs for trucks that exceed the Federal gross weight limit of 80,000 pounds (but only if accompanied by fees to cover additional public costs and restrictions to promote improved safety), (4) increased truck weight enforcement, (5) regional cooperation among States in standardizing limits and permit practices. There has been no implementation of any of these recommendations except for the last, which triggered a project undertaken cooperatively by the FHWA and AASHTO.

The second, *New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal* (Special Report 227), was requested by AASHTO. It evaluated an approach to TS&W regulation wherein motor carriers could voluntarily choose between using existing

equipment or adopting new "Turner trucks" with lower axle weights (to reduce pavement damage); higher GVW (to increase productivity); and superior stability, control and operational properties (to enhance safety). It identified a series of Turner trucks and detailed, innovative regulations for them. These proposed regulations addressed: (1) tire and axle limits, (2) a new bridge formula, (3) performance-related provisions concerning off-tracking, (4) configuration-specific regulation differences, (5) prohibition of C-trains and self-steering axles, (6) prohibition of lift axles, (7) a requirement for anti-lock braking on tractor axles, (8) a performance-related gradeability standard, (9) operating routes, and (10) special driver qualification requirements. Congress took no action on these recommendations.

General Accounting Office (GAO)

The GAO has conducted three investigations on TS&W-related matters since 1992--all dealing with LCV considerations. The observations, conclusions and recommendations from the 1994 report, Longer Combination Trucks: Potential Infrastructure Impacts, Productivity Benefits, and Safety Concerns, are:

1. Nationwide use of LCVs on interstates would require a one-time infrastructure investment of up to \$3.5 billion (FHWA estimate) and yield an annual reduction in trucking costs of \$3.4 billion (industry estimate). Principal beneficiaries would be the large, national small package and less-than-truckload (LTL) carriers.
2. Limited data show that LCVs have not been a safety problem on the western highways and eastern turnpikes where they operate.
3. "(I)dentified operational characteristics of LCVs ... could make them a greater safety risk than single-trailer combinations if allowed on more-congested highways".
4. The American Association of Railroad model used for estimating rail to truck diversions that would result from greater LCV use has significant shortcomings (insensitive to railroad productivity gains; assumes that truckload (TL) traffic will generally convert to using turnpike doubles).
5. Expanded use of LCVs should be permitted by exception to the current freeze, based on State requests and State commitments regarding suitability, cost recovery and enforcement.

The two other reports: (1) Longer Combination Trucks: Driver Controls and Equipment Inspection Should be Improved, and (2) Truck Safety: The Safety of Longer Combination Vehicles is Unknown, confirmed the difficulty of rendering a clear, definitive conclusion about the on-road safety performance of LCVs relative to other truck types. They reflect the longstanding data limitation problems that have made it impossible to definitively detect differences in on-road safety performance that can be associated with differences in TS&W

laws. This is not to say that TS&W law does not affect handling and stability performance characteristics of trucks; it does. However, acceptance of this reality may provide the basis from which useful consideration can be given to how TS&W law might be deployed to improve the inherent safety-related performance of trucks, even though these improvements may not be irrefutably detected in a statistically convincing manner on the road.

AASHTO

The AASHTO Subcommittee on TS&W has been working since July 1992 on the development of TS&W recommendations to be made to the AASHTO Joint Committee on Domestic Freight Policy, later incorporated into the AASHTO Special Committee on Intermodal and Domestic Freight Policy. The Subcommittee drafted the following "Policy Premises" to guide the development of its recommendations:

- Long term financial stability of highway infrastructure
- TS&W limits be based on full public costs and benefits
- Need to understand cost responsibility of large trucks
- Safety should continue to improve
- Insufficient safety data to justify significant expansion of large truck usage
- Need to better control incremental TS&W increases
- Retain ISTE freeze for time being
- Need national context for TS&W regulation and taxation
- Require systematic calculations of productivity gains
- Continue to reduce administrative burdens
- Support environment and energy policies

The Joint Committee will shortly release for publication the Subcommittee's report with comments and its 12 Freight Policy Principles.

The TRB and the National Cooperative Highway Research Program have two completed and several ongoing studies to support the AASHTO effort to develop new TS&W and freight policies. The completed studies are "Synthesis on the Impacts of Truck Size and Weight on the Transportation System and the Economy" and "White paper on the Feasibility of Longer Combination Vehicles." The ongoing studies include: "The Characteristics and Growth of Freight Demand," "Public Policy for Rail and Truck Competition," "Institutional Arrangements and Compatibility of Federal/State Truck Regulations," and "Corridor Analysis of Highway and Bridge Capacity."

International Studies

Canada carried out a major TS&W research project under the auspices of the Roads and Transportation Association of Canada (called the RTAC Study) in the 1980s. It was co-sponsored by the Federal and Provincial Governments and industry. The research examined infrastructure, stability and control, and economic aspects of TS&W in Canada for a wide-

range of new and innovative truck combinations. Unlike similar research efforts in most countries, this one actually culminated in a significant change of regulations agreed to and implemented by all provinces in a Memorandum of Understanding in 1988. This change in regulations has in turn spurred the broad acceptance of new, more productive, and safer trucks across the country. Unique to this regulation package is the fact that several aspects of it are founded on "performance" requirements, in particular, relating to stability and control and off-tracking. The new regulations have led to dramatic changes in the fleet mix in certain parts of the country, particularly in the west.

Mexico's Transportation Institute, in the Secretariat of Communications and Transportation, is conducting a variety of research projects in the areas of pavement management, the economics of TS&W regulations, and truck-pavement interaction.

The Organization for Economic Cooperation and Development (OECD) Dynamic Interaction Vehicle - Infrastructure Experiment (DIVINE) project, to be completed in 1996, is an international cooperative research project focusing on the interaction of live axle loads from heavy trucks with pavements and bridges. The United States is one of 14 countries involved in the research. The project will provide a scientific basis for truck suspension evaluation, and for understanding the effects of vehicle vertical response on low frequency bridges and flexible pavements.

Other Initiatives

The Trucking Research Institute of the American Trucking Association has commissioned the Iowa Motor Transportation Center to conduct a study of performance-based size and weight standards. This study commenced in November 1994.

The FHWA and National Highway Traffic Safety Administration are jointly conducting studies on the safety of LCV operations in response to the ISTEA. These studies will assess: (1) the incremental stress on fatigue that LCV drivers experience, if any, compared to drivers of standard combinations, and (2) the practicality of using antilock brakes and double drawbar dollies on multiple-trailer combinations. The reports will be delivered to Congress in December 1995.

1.5 New Pressures and New Opportunities

No significant change in Federal TS&W law has occurred since 1982, except for the freezing of LCV operating rights in 1991. Since 1982, major changes and developments have occurred in many areas of import to TS&W policy. They include: (1) changes in freight movements due to growth, new origins and destinations, increasing use of containers and double-stack trains, and just-in-time delivery requirements; (2) changes in global economics and trade patterns especially given the North American Free Trade Agreement and the General Agreement on Tariffs and Trade; (3) increasing traffic volumes; (4) fall-out from

deregulation of the transportation industry; (5) improved motor carrier safety regulation through the Commercial Vehicle Safety Alliance and the FHWA Motor Carrier Safety Assistance Program; and (6) vehicle equipment improvements such as radial tires, improved brake systems, and 53-foot semitrailers.

In addition, important new questions concerning Federal TS&W law have emerged:

- How should Federal TS&W provisions relate to the NHS?
- How should harmonization goals for NAFTA be approached?
- Should the LCV freeze imposed by ISTEA be permanent?

These changes, developments and questions need comprehensive consideration in conjunction with the issue of cost allocation and revenue generation. Particularly important to a comprehensive study are developments in the areas of truck use, commodity flow, highway condition data and truck-pavement interaction, logistics, truck travel and mode share, and highway cost allocation analytical capability.

Lastly, what future role should the Federal Government play in TS&W regulation. The question of Federal involvement was at the heart of the first Federal review of TS&W matters by the Interstate Commerce Commission in 1941. Today the Federal Government specifies certain standards, reviews State practices, and monitors State enforcement activities and exercise of grandfather rights. Possible alternatives to the existing Federal role are to: (1) gradually disengage from TS&W regulation, (2) control TS&W in different ways such as through performance regulation, (3) modify impacts or need by different investment or pricing policies, and (4) establish uniform guidelines for regional and State regulations.

CHAPTER 2 - CURRENT TS&W LAW AND REGULATIONS

Trucking in the United States is subject to TS&W regulations emanating from the local, State, and Federal governments. The importance of State and local regulations cannot be over-stated. These regulations govern trucking on the vast majority of U.S. road mileage and may indeed govern the vast majority of trucking activity itself. Some of these regulations are grandfathered exceptions to Federal law.

In Canada, the laws of the individual provinces govern, but these includes a common set of regulations on major highways as agreed upon by the Provinces. Operations into Mexico are subject to Federal law, the standards for which vary for the four different classes of Federal roads.

2.1 TS&W Regulations and Trucking

TS&W regulations are a significant determinant of what truck configurations are available to operators; and how trucks impact the infrastructure, the economy, highway safety, and the environment. Many other factors--including freight characteristics, shipment sizes, industry considerations, driver requirements--also influence the design and use of a vehicle, but none to the extent of TS&W requirements.

TS&W regulations define the envelope (maximum length, width, and height) within which trucks are to fit and the maximum weight they are to observe. Most of the time, most trucks operate well within the boundary conditions. Some trucks regularly operate at or near the boundaries. Some operate beyond the boundaries some of the time.

If a truck is operated within only one TS&W regulatory regime for example within one State, then it is optimized to that regime. A trucker confronted with multiple TS&W regimes has three choices: (1) to select a "least common denominator" vehicle and operating strategy; (2) to select a vehicle or operating practice which can be modified enroute as needed (for example, remove a trailer, reduce the load, move an axle); or (3) to attempt to circumvent the law. The complexity of the truck regulatory and operational environments continues to increase, as the role of trucking pervades nearly every aspect of the increasingly global economy.

2.2 State and Local Law

The sizes and weights of vehicles have been regulated by State and local law since the early part of the century. Over the years, these regulations have been changed many times in response to needs and circumstances. Change continues--often without Federal involvement or influence.

Working Paper 14, prepared for this study, details current State regulations. Broadly speaking: (1) many State provisions differ from Federal provisions, (2) there are many regulation differences among the States, and (3) there are more regulatory differences than ever. These differences exist because of the differences in economic and industrial activities; freight movements; infrastructure design characteristics and status; traffic densities; mode options; engineering philosophies; and choices of the different locales, States, and regions of the Nation.

The differences tend to reflect population and traffic density considerations. The dense areas in the Northeast tend to favor smaller trucks with highly concentrated loads, while low density areas, mostly in the west, favor larger trucks with less concentrated loads. These differences are apparent in the various State provisions grandfathered under the Federal law.

2.3 U.S. Federal Law

The Federal Government first became involved in TS&W regulation at the start of the Interstate era in the 1950's when maximum axle and vehicle gross weight and width limits were set trucks using that system. In 1975, the weight limits were raised, except that the bridge formula was imposed to insure that the vehicle load was distributed to avoid excessive overstressing of bridges. In 1982, minimum length limits were enacted for semitrailers and trailers in twin-trailer combinations. The width limit was also increased from 96 to 102 inches. The current U.S. Federal TS&W law has the following limits:

- 20,000 pounds for single axles.
- 34,000 pounds for tandem axles.
- Application of Bridge Formula B for other axle groups up to the maximum of 80,000 pounds for gross vehicle weight (GVW).
- 102 inches for vehicle width
- 48 feet (minimum) for semitrailers in a semitrailer combination
- 28 feet (minimum) for trailers in a twin-trailer combination

Federal truck weight law applies to the Interstate System and vehicle size law applies to the designated NN which includes the Interstate System. The NN was designated under the authority of the same 1982 Act that established the above size limits.

2.4 Canadian and Mexican Laws

In Canada, the individual provinces and territories are responsible for TS&W regulations. There is no Federal law. However, all jurisdictions have adopted a national set of "RTAC" regulations for operations on primary highways throughout the country. These regulations were developed from a research program in the mid-1980s directed at improving truck

safety, productivity and road-friendliness. Several aspects of these regulations are derived from desired performance criteria relating to such matters as off-tracking and roll stability.

Compared to the U.S. Federal law, the Canadian regulations established as a result of the Road and Transportation Association of Canada (RTAC) study, specify:

- 12,125-pound steering axle limit
- 37,479-pound tandem-axle limit
- 46,297- to 52,911-pound tridem axle limit--depending on how far apart the axles are spread
- Substantially higher (up to 137,500 pounds) GVW limits (which vary by truck configuration to encourage the use of more stable vehicles)
- 75.5-foot overall vehicle length limit
- 53-foot maximum semitrailer length limit
- Wheelbase, kingpin and overhang limits (to control off-tracking)
- Minimum interaxle spacings (to control bridge loadings)

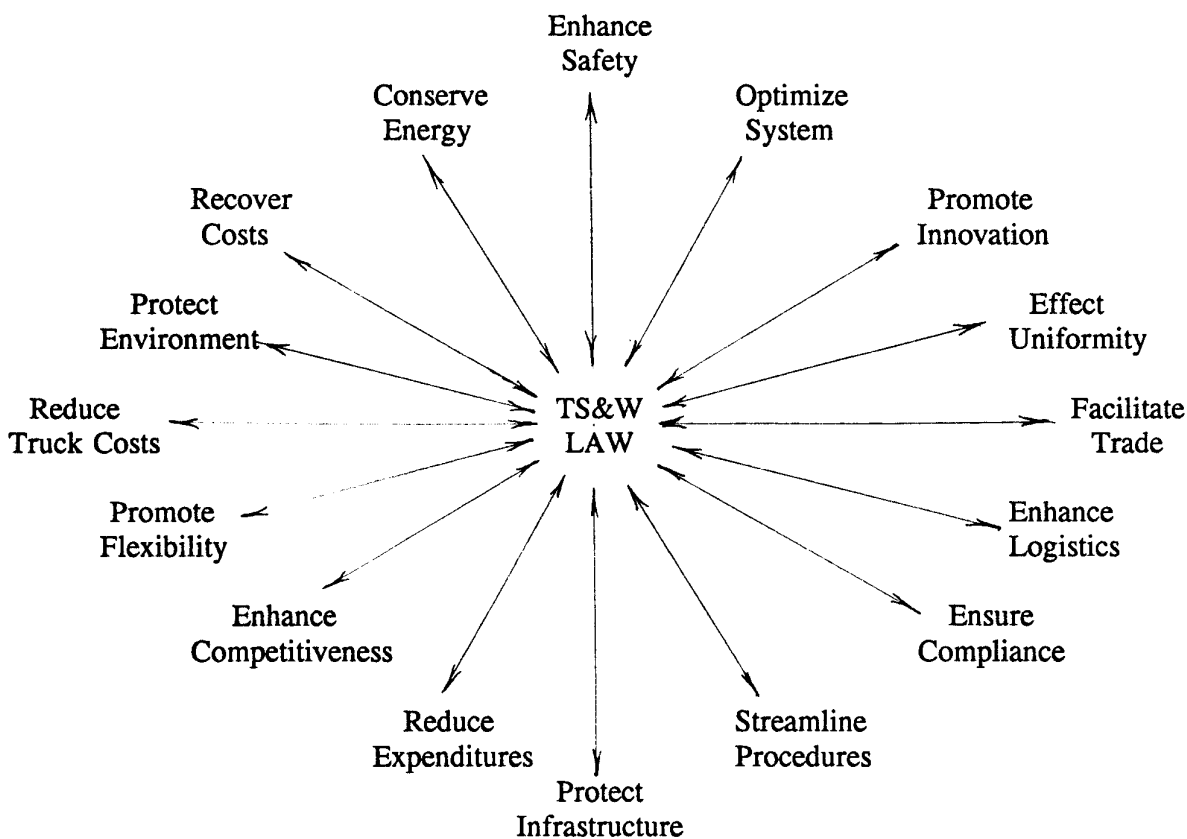
In Mexico, the regulations applicable on national highways are established by the Federal government. Compared to the U.S. Federal law, the Mexican regulations specify:

- 14,330-pound steering axle limit
- 42,990-pound tandem-axle limit
- 49,604-pound tridem axle limit
- Substantially higher (up to 136,600 pounds) GVW limits (which vary by truck configuration)
- 68.2-foot overall length limit for semitrailer combinations
- 102.7-foot overall vehicle length limit for double cargo unit combinations
- Minimum interaxle spacings (to control bridge loadings)

CHAPTER 3: - THE POLICY ENVIRONMENT

"Complex and controversial" are the words most commonly used to describe the truck size and weight "question". Figure 1 illustrates the tug-of-war on Federal TS&W law. There is no single, optimum, permanent solution.

Figure 1 - The Forces Affecting Federal TS&W Law



3.1 Policy Controls

Basic TS&W standards are the most common type of policy control used. These controls define absolute limits, specifications and restrictions on the physical attributes of trucks and their loads and operation. Table 1 lists such controls that are in use or have the potential for use if they are found to have significant policy implications.

Table 1 - Basic Standards

	Federal Law	State Law
Vehicle Weight Limits		
- <i>tire-related</i>		
number of tires	No	Some
tire load limits	No	Some
load distribution between tires	No	None
- <i>axle-related</i>		
load limits by axle type	Yes	All
load distribution between axles in a group	No	Some
suspensions	No	None
lift axles	No	Some
- <i>gross vehicle weight-related</i>		
bridge formula	Yes	All
cap	Yes	All except Mich.
Vehicle Dimension Limits		
- <i>height</i>	No	All
- <i>width</i>	Yes	All
- <i>length</i>		
single unit	No	All
semitrailer	Yes	All
trailer	Yes	All
combination	No	Some
Vehicle Specifications		
- <i>configuration</i>	No	Some
- <i>body type</i>	No	None
Equipment Specifications		
- <i>safety-related</i>		
hitching	Yes	No
weight distribution	No	Some
power/weight	No	Some
- <i>off tracking-related</i>		
kingpin	No	Many
hitching	No	None
Operational Restrictions		
- <i>area (local, state, region, routes)</i>	No	All
- <i>facility-related (bridge posting)</i>	No	All
- <i>seasonal, day-of-week, time-of-day</i>	No	Some
- <i>weather conditions</i>	No	Some

Exemptions to basic standards are the second most common type of policy control. Every jurisdiction has found it desirable in cases regarding major local industries such as coal, timber, and agriculture and necessary in others to provide exemptions, by regulation, permit, policy and tolerances.

Performance standards are a form of policy control that involves specifying minimum or maximum acceptable levels of performance (rather than absolute physical limits) regarding matters such as:

- Off-tracking envelope
- Acceleration capability
- Speedability on grades
- Speed control downgrade
- Lane change capability
- Braking capability
- Crash avoidance maneuvering
- Rollover threshold
- Load equivalency factors (LEFs) per truck
- Passenger car equivalencies (PCEs) per truck

Selected performance standards have been utilized in some countries, but have not been adopted widely in the United States. A general consensus about which performance measures are most critical is beginning to emerge in the technical community. This provides opportunities to improve the rationality of TS&W regulation. However, details on how to enforce performance standards on day-to-day trucking need to be resolved to make them possible.

3.2 Highway Investment and Pricing Considerations

An alternative way to deal with the intent of certain TS&W regulations, such as axle load limits to protect pavement, is to change investment principles and pricing. For example, additional investment increments on a new or reconstructed pavement can render the pavement less sensitive to truck loads. Similar alternatives are available for new bridges or bridge strengthening. Life cycle cost analysis often shows a benefit for higher initial design standards.

Control by pricing is a policy mechanism that entails controlling trucks, their loads and their operations by requiring them to pay for the full costs they impose. Controlling truck weights entirely by pricing is not a likely option for the near term. Technological developments may facilitate such an approach in the future. There is increasing interest in this approach, not for just controlling TS&W, but for traffic congestion and other externalities.

Even without full cost pricing, truck size and weight policy and highway user fee issues should be periodically evaluated. Pavement and bridge costs attributable to heavy vehicles

will be impacted by any changes in size and weight policy changes. Significant changes in size and weight limits should be accompanied by an assessment of appropriate changes in highway user fees.

In its June 1994 report, "Highway User Fees: Updated Data Needed to Determine Whether All Users Pay Their Fair Share," the GAO recommended that the FHWA conduct a formal cost allocation study "to determine whether all highway users are paying their fair share of Federal highway costs and to ensure that FHWA and the Congress have up-to-date information when making future decisions affecting Federal highway user fees." Other organizations including the AASHTO also have called for a new Federal highway cost allocation study. A Highway Cost Allocation Study update is being conducted in parallel with this Comprehensive TS&W Study. A notice announcing the cost allocation study was published in the February 10, 1995 Federal Register.

3.3 Enforcement and Compliance

In developing and implementing new TS&W regulatory concepts, the "enforceability" question must be addressed. Most jurisdictions today have trouble effectively enforcing even relatively simple regulatory requirements. Making requirements more technical and sophisticated without reference to their enforceability may prove counter-productive. "Without effective enforcement ... weight limit laws are meaningless," the TRB noted in Special Report 225.

3.4 Policy Options

This section describes categories of TS&W policy options available to the Federal Government. The categories are: (1) Federal role alternatives, (2) changes in scope of Federal TS&W Policy, (3) changes in limits and other standards, and (4) exceptions to Federal limits and other standards.

Federal Role Alternatives

The question of Federal involvement was at the heart of the first Federal review of TS&W matters by the Interstate Commerce Commission in 1941. At that time, major opposition to Federal involvement came first and foremost from the American Association of Railroads, and secondly the States. The report observed "that Federal intervention ... should be ... resorted to only in particular cases and upon clear proof that an unreasonable obstruction to interstate commerce exists."

Today, the Federal Government specifies certain standards, reviews State practices, and monitors State enforcement activities and exercise of grandfather rights. Possible alternatives to the existing Federal role are to: (1) gradually disengage from TS&W

regulation, (2) control TS&W in different ways such as through performance regulation, (3) modify impacts or need by different investment or pricing policies, and (4) establish uniform guidelines for regional and State regulations.

Changes in Scope of Federal TS&W Policy

Policy options in this category would deal with the scope of Federal TS&W policy in terms of vehicle types, highway systems, and Federal versus State roles. They would ensure that Federal TS&W policies are applied only to the extent necessary to achieve Federal objectives.

This study is in partial response to a proposal in the 103rd Congress to extend Federal TS&W controls to the proposed NHS established by the ISTEA of 1992 and to freeze existing State trailer length limits. There is concern that the widespread implications of such a sweeping proposal demand that any decision be made only after close examination of both public and private sector concerns and from the point of view of impacts on the safety and efficiency of the total transport system. A primary issue is whether Federal truck weight limits should apply to the NHS. Federal truck size limits already apply to most highways on the NHS as well as on the National Network for large trucks mandated by the Surface Transportation Assistance Act of 1982. Exceptions to this are in those States that have a limited set of National Network routes, which are eastern States for the most part.

Changes in Limits and Other Standards

These options would cover the weight and dimension limits and other standards for vehicles and operations needed to ensure that Federal policy objectives are met.

Exceptions to Federal Limits and Other Standards

These options would address how and under what conditions, if any, exceptions to the Federal limits and standards should be allowed. They would address grandfather rights, Federal involvement in oversize and overweight permitting, and regional exceptions to national standards.

CHAPTER 4 - CURRENT KNOWLEDGE OF POLICY ISSUES

4.1 Pavement and Bridges

PAVEMENT ISSUES

Areas of extensive recent research on pavement and TS&W regulation are:

- Changes in tire types, pressures, sizes, and loading characteristics and their implications for pavement wear.
- The relative effects of different axle configurations and loads on pavement damage.
- Truck-pavement interaction, vehicle dynamics, and the role of suspension systems.
- Long-term pavement performance.

The following issues are of particular interest to Federal policy considerations at this time.

ISSUE: **Current Axle Load Limits**

Axle limit standards and variations: Federal law specifies single- and tandem-axle weight limits, of 20,000 and 34,000 pounds respectively. The limits were formally recommended in the 1964 TS&W Report to Congress. They are the lowest axle weight limits imposed on major highways in the world (including Canada and Mexico). (Differences in design philosophy and pavement life expectations explain part of the difference in axle weight limits among jurisdictions). One or both of the Federal axle limits are surpassed by the laws of 25 States. Higher single and/or tandem axle limits are permitted on Interstates in 12 States (by grandfather rights). Permits and/or tolerance policy routinely allow Federal limits to be exceeded in most States.

The technical origin of the 34,000 pounds value of the tandem limit is uncertain. The original pavement-related research work behind the establishment of this limit dealt with a 35,000-pound limit. Pavement and productivity benefits could be realized by increasing tandem axle loads without making any other changes in the Federal law. For example, increasing the tandem load to 35,000 pounds within an 80,000 pounds GVW cap could reduce pavement damage caused by a fully loaded 5-axle tractor-semitrailer by 10 percent (by transferring load from the heavily-loaded, pavement-damaging front axle). Coincidentally, this change could increase the potential payload weight capacity of this truck by 4 percent while creating no identifiable, measurable negative effects.

Wide-spread tandem axles: There is increasing use of wide-spread (10 feet) tandem axle groups, particularly in flat-bed heavy haul operations. These axles are allowed to be loaded at single axle limits. They offer two key benefits to five-axle tractor-semitrailers usage: (1) full achievement of the 80,000 pound GVW cap, and; (2) flexibility in load

distribution. But they do so with undesirable pavement cost implication. Their expanding use could be counteracted with a higher tandem axle load to the benefit of the pavement.

ISSUE: Tridem Axle Load Limit (spreads of 8 to 12 feet)

Advantages of a unique tridem axle limit: Federal law is silent on tridem axle load limits, allowing their loads to be controlled by Bridge Formula B. Bridge Formula B is:

$$W = 500 \{ [LN/(n-1)] + 12N + 36 \}$$

- where: W = the maximum weight in pounds that can be carried on a group of two or more axles to the nearest 500 pounds.
L = the spacing in feet between the outer axles of any two or more axles.
N = the number of axles being considered.

Tridem axles could be an effective means to increase truck load capacity while reducing pavement damage. Combinations with tridem axles generally have much lower pavement cost per ton of freight carried than conventional combinations. Most countries (including Mexico, Canada, European nations) permit substantially higher weights on tridems with spreads of 8 to 10 feet (about 50,000 pounds) than is permitted in the U.S. by Bridge Formula B (42,000 to 43,500 pounds).

Specifying a tridem limit: Specification of a unique weight limit for close-spaced tridem axles offers attractive technological opportunities for U.S. trucking. There is no hard and fast rule for determining what particular limit should apply to a tridem axle relative to the limits specified for other axles. From the pavement perspective, its specification need not be constrained by an arbitrary rule such as equalizing the equivalencies of single, tandem and tridem axle groups. Obviously, the selected limit should not be so large as to overstress bridges.

Opportunities for economic benefits with tridems: One group of opportunities associated with a unique tridem limit requires relaxing the existing 80,000-pound GVW cap to facilitate effective use of six-axle tractor-semitrailers. To illustrate the opportunities, a six-axle tractor-semitrailer operating at a GVW of as little as 85,000 pounds with a tridem axle of 39,000 pounds would effect less pavement damage than a five-axle tractor-semitrailer at 80,000 pounds. Because of the increased payload capacity of such a unit, the pavement damage per unit payload could decrease even more. Larger per unit payload benefits would result from an even higher GVW limit of 90,000 or more pounds on a six-axle tractor-semitrailer. Both the AASHTO TS&W Subcommittee and the TRB Special Report 225 suggest consideration of the Texas Transportation Institute (TTI) bridge formula, which would allow up to about 90,000 pounds for a six-axle, semitrailer combination.

ISSUE: Overweight containers and Tridem Axles

Container standards: The International Standards Organization (ISO) defines the weight and dimension characteristics of containers used in international trade. The prescribed maximum dimensions are compatible with U.S. truck size regulations (that is, the containers fit on U.S. trucks). Maximum allowable container weights are not compatible with U.S. truck weight regulations (that is, a loaded container, on a truck, can lead to the truck being over the Federal axle or GVW limits).

The six-axle tractor-semitrailer solution using a tridem axle: An appropriate tridem axle limit within a six-axle tractor-semitrailer combination offers an internationally-recognized solution to the "overweight container" problem. Europe specifies a unique GVW limit of 97,000 pounds for a six-axle semitrailer combination handling an international container. Mexican and Canadian general weight limits are high enough to accommodate fully-loaded ISO containers. Canada's regulations also permit configurations which can handle one-20 foot and one-40 foot fully loaded containers on the same vehicle, or three-20 foot containers nearly fully loaded.

ISSUE: Tire Regulations

Varying views about need for regulating tire pressure: Federal and State laws are silent on truck tire pressure. Tire pressure has a large effect on fatigue of flexible pavements (albeit a small to moderate effect on rigid pavements). Today's tire pressures are higher than in the 1950s--primarily the consequence of a change from bias to radial ply tires. Concern has been raised about the possibility of accelerated pavement rutting as a result of increased tire pressures. The literature gives conflicting views as to whether or not pressures should be regulated:

- 1990 Regulation could be warranted if more pessimistic analyses proved to be correct [TRB].
- 1993 Limit tire pressure to the recommended cold setting plus 15-psi [NCHRP].
- 1993 More research is required to answer all questions regarding relationships of tire size, contact pressure, and contact area with the pavement [AASHTO].

Varying views about need for regulating tire loads: Federal TS&W law is also silent on tire loads. Many State laws specify some form of tire load regulation. State regulations are applied to Interstate and designated highways at the discretion of the States. Considerable work has explored the nature and extent of unbalanced loads across dual tire sets, among sets, and across axles. There are conflicting views on whether tire loads should be regulated:

- Many States already regulate tire loads; some do not.
- Tire load limits have been proposed to control the damage effect of wide-base tires.
- The effect of tire load limits or the lack of them on pavement costs is unknown.

Varying views about need for regulating use of wide-base (super single) tires: Federal law and most State law do not discourage or prohibit the use of wide-base tires. The consensus of U.S. and international research is that these tires have substantially more adverse effects on pavements than dual tires. Wide-base tires--widely used in Europe--are being increasingly adopted by U.S. trucking operations. The benefits of wide-base tires are reduced energy use, emissions, tare weights, and truck operating costs. The trade-off between changes in Federal pavement costs and operating benefits that would result from permitting or prohibiting extensive adoption of wide-base tires in the United States has not been analyzed. The literature gives conflicting views as to the appropriateness of regulating wide-base tires:

- 1990 Regulation could be warranted if more pessimistic analyses proved to be correct. [TRB]
- 1993 Wide-base singles should be limited to loads of 650 pounds/inch of tread width (488 pounds/inch of tire section width). [NCHRP]
- 1993 More research is required. [AASHTO]
- 1993 The relative damage potential (of wide-base tires) is much less than commonly believed, and conceivably the wide base tires might be less damaging than the duals. [Midwest Research Institute]

ISSUE: Road-Friendly Suspensions

Suspension system research: Federal law is silent on suspension systems. The subject of road-friendly suspensions (within the context of the broader subject of vehicle-pavement interaction) is under intensive research in both the United States and internationally. The work is focusing on: (1) how well different suspension systems can distribute load between axles in a group (the more evenly, the better); (2) how well different suspension systems dampen vertical dynamic loads (the more, the better), and; (3) spatial repeatability of dynamic loads. Related considerations are examining how road and bridge characteristics act to excite a truck, and in turn influence the loads received by the road and bridge.

No compelling argument for suspension regulation at this time: The research has yet to produce any compelling argument to incorporate a suspension system determinant into the regulations (although Mexico and some other countries have done so). Whatever the case, the impacts of different suspension systems on pavement deterioration are of secondary importance compared to the static axle load levels themselves. This suggests that getting the static load levels right first, and enforcing them second, should take priority over suspension system regulation. Nonetheless, encouraging more use of road-friendly suspensions would be beneficial, particularly for large trucking operations with well-controlled axle loads.

ISSUE: Lift Axles

There is little research reported in the literature on the extent of the use, benefits, and pavement costs associated with lift axles. AASHTO and others have expressed concerns about enforcement problems relating to lift axles.

BRIDGE ISSUES

The following issues are of particular interest to Federal policy considerations at this time:

ISSUE: Design Considerations behind Bridge-Related Regulations

A fundamental on-going issue about bridges and TS&W regulations concerns the level of risk to accept in determining acceptable loadings for a given bridge or acceptable bridge design requirements for given loadings. Estimates of bridge cost impacts of TS&W changes are very sensitive to assumptions regarding acceptable levels of stress in bridges. The inventory rating approach, used by some States, is considerably more restrictive than the operating rating approach, used by the majority of States.

ISSUE: Bridge Formula B

The Formula: In addition to axle and maximum gross vehicle weight limits for Interstate highways in Federal law, Bridge Formula B, also specified by Federal law, restricts the maximum weight allowed on any group of consecutive axles based on the number of axles in the group and the distance from the first to the last axle. The formula concept originated in the 1956 Federal-Aid highway legislation and was developed and presented in a 1964 report to Congress from the Secretary of Commerce. Criticisms of Bridge Formula B are:

1. Bridges on Interstate highways can generally carry higher weights than those allowed under the current formula without being significantly overstressed. However, many bridges on other highways would be deficient if the maximum allowable weights for vehicles on the non-Interstate highways were increased.
2. It is overly restrictive for shorter trucks and overly permissive for short six-axle trucks and all trucks with seven or more axles.

Views that the Bridge Formula B was overly restrictive gave rise to controversy and the granting of phase-in schedules upon adoption of the formula. In those States where the formula cannot be circumvented by grandfather right, the formula can constrain the productivity of short wheelbase vehicles such as dump trucks, trash trucks and construction vehicles. In so doing, it either: (1) generates more truck movements on the Interstate System than would otherwise be necessary (that is, more smaller trucks handling a given quantity of freight)--particularly in and around major metropolitan areas (such as hauling gravel to construction sites; or garbage from residential areas), or (2) leads to the non-conforming heavier trucks operating on lower standard highways, by-passing Interstate routes.

3. If the 80,000-pound maximum gross vehicle weight cap were removed, a long nine-axle combination truck carrying the allowable load would overstress HS-20 bridges, the typical design loading for Interstate System bridges, by as much as 12 percent

depending on the bridge span length. The current Federal Bridge Formula protects HS-20 bridges from overstresses of more than 5 percent.

State practices differ in how such overstresses should be viewed. Some States prohibit routine operation at this overstress level; but in the majority of states, such overstressing would not trigger posting as the level of overstress is not considered high enough to require it. However, the structures could be unduly damaged and their design life would most likely be reduced.

4. Some have found the overstress criteria--five percent for HS-20 bridges and 30 percent for H-15 bridges--arbitrary and as having little meaning in terms of either consistent reliability or impact cost. The setting of these criteria considered the safety of the structures for the continued, long-term use by the traveling public in light of the uncertainty of bridge design, construction, maintenance, and environmental variables.

In response to these criticisms, three recent bridge formula proposals have been made:

- 1990 TRB Study Truck Weight Limits: Issues and Options: This study recommends adoption of TTI HS-20 formula (developed under contract for FHWA in 1987) to be applied together with existing Federal axle limits for vehicles with GVWs of 80,000 pounds or less, and the current bridge formula for vehicles weighing more than 80,000 pounds. This increases maximum weights for shorter vehicles, but leaves unchanged the maximum weight for longer wheelbase trucks.
- 1993 AASHTO Subcommittee on Truck Size and Weight: This study recommends that AASHTO evaluate adoption of the TTI bridge formula - subject to a limit on maximum extreme axle spacing of 73 feet, retention of existing single- and tandem-axle limits, controlling tridem weights by the bridge formula, and special permitting of vehicles with GVWs more than 80,000 pounds. The TTI formula generally allows slightly higher weights on single units trucks and short combinations. Applied to vehicles with more than six axles, the TTI formula is less permissive than the current formula. Benefits of this proposal identified by AASHTO are that it: (1) gives appropriate protection for bridges with H-15 and HS-20 ratings at higher weight levels and conforms better to the basic bridge overstress criteria than Bridge Formula B; (2) enhances productivity by allowing greater weights on short wheelbase vehicles; permitting effective use of six-axle tractor semitrailer combinations operating at a GVW of 89,900 pounds; permitting effective use of six or seven-axle doubles at a GVW of up to 98,500 pounds, with 28-foot twins; (3) achieves the above without increasing pavement and bridge damage, and; (4) achieves the above without increasing vehicle size.
- 1994 Ghosn and Moses Formula: This formula is developed from structural reliability theory. This approach more explicitly accounts for the uncertainties associated with

bridge design and load evaluation. The proposed formula is considerably more permissive than Bridge Formula B, when applied to long vehicles. The formula is:

$$W = 1000(1.64 L + 30) \quad \text{for } L < 50 \text{ feet}$$

$$W = 1000(0.80 L + 72) \quad \text{for } L > 50 \text{ feet}$$

Where: W = weight in pounds and L = distance between the outer axles in the group.

ISSUE: Bridges and the GVW "Cap"

The 80,000-pound GVW cap (maximum limit) is an arbitrary limit as the axle weight limits and bridge formula are designed to protect pavements and bridges respectively. As such it restricts the productivity of U.S. trucks and highways, although some States allow heavier combinations under grandfather rights. The equivalent limit in Europe is 96,800 pounds; Canada, 137,500 pounds; and Mexico, 146,600 pounds.

However, it is important to consider such factors as design vehicles and criteria, structural evaluation procedures, the age of the existing bridges and the extent that increased GVWs will shorten the fatigue life of U.S. bridges must be included in any consideration of lifting of the 80,000-pound cap.

Vehicle safety issues need to be addressed as well, when considering higher GVW limits. Heavier weights, for example, can contribute to increased rollover if steps are not taken to insure that the rollover potential of a vehicle is not increased to an unacceptable amount.

ISSUE: Bridges and Tridem Axles

Unique to the United States, the Bridge Formula is used as the method to determine the load to be permitted on a group of three axles connected through a common suspension system (a tridem). In Europe, Canada, Mexico and most other jurisdictions, tridem axles are given a unique load limit in the same way the United States specifies unique single- and tandem-axle limits without direct reference to a bridge formula. This is not to say that these unique tridem limits are not bridge-related. In Canada, for example, the tridem limits prescribed by RTAC, which vary as a function of spacing, are based on bridge loading limitations--not pavement limitations.

4.2 Roadway Geometry and Traffic Operations

ROADWAY GEOMETRY ISSUES

The following issues are of particular interest to Federal policy considerations at this time:

ISSUE: Length limits of semitrailers

Federal law is a minimum specification that requires States to permit the operation of a semitrailer of at least 48 feet on the National Network (NN) for large trucks. All States except Alaska and Rhode Island permit semitrailers of at least 53 feet on at least some highways. Most prohibit longer units but eleven do permit them. Canada and Mexico permit 53-foot semitrailers on national highways.

ISSUE: Federal maximum semitrailer length limit

There are two reasons to consider a Federal maximum length limit for semitrailers: (1) to control the amount of offtracking in turn or a sharp curve, and (2) to standardize the sizes of cargo units to facilitate the intermodal movement of truck trailers. Nevertheless, a Federal limit could stifle innovation and constrain productivity gains.

ISSUE: Length limits for double trailers in combination

Current regulations: Federal law is a minimum specification requiring States to permit the operation of two 28-foot trailers in combination on the NN. About one-fourth of the States prescribe 28 feet as a maximum; the others allow additional length with 28 and 1/2 feet being the most common. Canadian regulations pertaining to A and C-train doubles also permit two 28 and 1/2-foot doubles. An A-train double combination uses a dolly with one drawbar to connect the two trailers. A C-train uses a dolly with two drawbars.

Canadian B-trains are permitted two 31-foot trailers. On a B-train the second trailer connects to the "fifth wheel" on an extension of the first trailer's frame. The fifth wheel is the standard tractor semitrailer connection.

Federal law permits longer doubles but does not require States to allow them. Larger doubles (such as two 33-foot trailers) have been analyzed, as reported in TRB Special report 227, and demonstrate productivity advantages for cube-out freight (given the 80,000-pound GVW cap), and weight-out/cube-out freight (given relaxation of the cap).

ISSUE: Total length limits

Federal law prohibits States from specifying maximum combination lengths on the NN. Most States effectively control total lengths on the NN, however, by limiting semitrailer and trailer lengths. About two thirds of the States have some form of control of total

combination length for non-NN highways; one third have none. Mexico and Canada prescribe maximum combination length limits. While there are no proposals that the Federal law prescribe a total length limit at this time, offtracking standards would effectively limit overall lengths for single- and double-trailer combinations.

ISSUE: Offtracking and dimensional regulations

Low-speed offtracking: When a combination-unit vehicle makes a low-speed turn--for example a 90 degree turn at an intersection--the wheels of the rearmost trailer axle follows a path several feet inside the path of the tractor steer axle. This is called low-speed offtracking. Excessive low-speed offtracking may make it necessary for the driver to swing wide into adjacent lanes in order to execute the turn (that is, to avoid climbing inside curbs or striking curbside fixed objects or other vehicles). Also, when negotiating exit ramps, excessive offtracking can result in the truck tracking inboard onto the shoulder or up over inside curbs. This performance attribute is affected primarily by the tractor kingpin to center of trailer rear axle dimension, which is its effective wheelbase in the case of semitrailers. In the case of multiple trailer combinations, the effective wheelbase(s) of all the trailers in the combination, along with the tracking characteristics of the converter dollies, dictate this property. In general, longer wheelbases worsen low-speed offtracking.

Standard "Western" doubles (two 28-foot trailers) and triple combinations (three 28-foot trailers) exhibit better low speed offtracking performance compared to a standard tractor and 53-foot semitrailer combination. This is because they have more articulation points in the vehicle combination, and use trailers with shorter wheelbases than semitrailers.

High-speed offtracking: When a combination-unit vehicle negotiates a large radius, high speed curve--for example at some interchanges between freeways--the rearmost trailer axle can track outside the path of the tractor steer axle. This is called high-speed offtracking. For most configurations that have been analytically compared in this regard, the amount of such offtracking is one foot or less at 55 mph. The effect is reduced on superelevated curves.

Current regulations: Federal law is silent on offtracking related characteristics of vehicles. In particular, it specifies no requirements on kingpin setting, kingpin setback, and rear overhang. Nearly one half of the States specify a kingpin setting for semitrailers--with the most common value being 41 feet. This kingpin setting effectively caps single trailer lengths.

Regulation alternatives: Control of offtracking can be done in two ways. The first requires considering the length limit(s) of the semitrailer(s) within the context of total combination length limit, restrictions on the kingpin setback, wheelbase, and effective rear overhang (per the Canadian regulations). A more straightforward alternative is with a performance specification requiring that a truck be able to turn through a given angle, at a given speed, within a defined swept path (per the European regulations).

ISSUE: Safe passing--passing or being passed on two-lane roads

Cars passing longer combination vehicles on two lane roads could need up to 8 percent longer passing sight distances, compared to passing existing tractor semitrailers. Longer and/or heavier trucks would require incrementally longer passing sight distances to safely pass cars on two-lane roads. In practice, safety conscious truck operators currently find it impractical to pass cars now in these situations, except under the most ideal conditions. Operators of longer/heavier vehicles would likely be inclined to follow this practice even more often.

TRAFFIC OPERATIONS

This Section discusses current knowledge about TS&W considerations relating to traffic operations (capacity, level of service, public perceptions about flow quality, costs) of potential consequence to Federal policy.

The following issues are of particular interest to Federal policy considerations at this time.

ISSUE: Passenger car equivalencies, capacity, level of service, traffic stream costs

TS&W-sensitive passenger car equivalencies: Traffic engineers use the concept of passenger car equivalencies (PCE) of trucks for analysis and design relating to highway capacity and level of service. PCE represents the number of passenger cars that would consume the same percentage of a highway's capacity as the trucks(s) under consideration. The Highway Capacity Manual (HCM) prescribes PCE values which vary as a function of road class, geometry, types of trucks, and percent trucks in the traffic stream. The values are not explicitly sensitive to parameters considered in TS&W investigations (such as truck weight, length, configuration). Recent work conducted for the American Association of Railroads suggests higher PCE values for certain five- or more-axle trucks. This work, however, has not been subject to substantial peer review by traffic engineering experts. Microscopic simulation programs such as FRESIM could be calibrated to provide reasonable estimates of the PCE and capacity effects of a wide variety of feasible combinations of trucks, performance characteristics, volume:capacity ratios, and percent trucks as a function of grades, roadway section lengths, and other critical geometric conditions.

PCEs on downgrades: Some believe that the HCM makes some questionable assumptions about the PCEs of trucks on downgrades. Recent Canadian work identified recurring platooning problems behind large trucks on relatively high volume downgrades on two-lane primary highways in western Canada. While most upgrades in such circumstances have climbing lanes, most downgrades have long no-passing zones.

Effects of trucks on traffic stream costs: Changing the numbers and types of trucks in a traffic stream can alter the cost of operation of the total traffic stream. In particular, changes in mean speeds, speed distributions, and speed changes can occur--particularly on higher

volume routes. All of these factors affect both vehicle operating costs and travel time. Such cost effects have never been directly evaluated in any objective manner.

ISSUE: Trucks in merging, weaving and lane changing

TS&W considerations can have important effects on these maneuvers because of their effects on gap size requirements and acceleration performance. Little is known about the effects of different percentages of trucks with variable size and weight on the ability to merge and change lanes in traffic streams of varying speed and density. Ramp junctions and weaving areas are so site-specific as to their geometric design and operating speeds that simulation of those specific intersections is probably the only analytical method that will give reasonable precision.

Experience with the use of longer vehicles indicates that skilled drivers compensate for these facts by minimizing the number of lane changes they make and using extra caution when merging.

ISSUE: Trucks in hill climbing

As a vehicle's weight increases, its ability to climb hills at prevailing traffic speeds and to accelerate quickly can be compromised if larger engines and/or different gearing arrangements are not used. When speed differentials between vehicles in flowing traffic streams exceed 20 mph, crash risks increase significantly. On routes with steep grades, that are frequently travelled by trucks, special truck climbing lanes have been built. However, these lanes are not always available, making it important that trucks be able to maintain reasonable performance in this regard.

In the case of multiple trailer combinations, if single drive axle tractors are used, a situation can arise where the tractor cannot generate enough tractive effort, under slippery road conditions, to pull the weight of the entire vehicle up the hill. However, past experience has shown that it is unlikely that competent carriers who use routes susceptible to this problem, would experience repeated incidents of this type without taking corrective actions.

ISSUE: Truck operations at intersections

Larger and/or heavier vehicles can affect traffic operations at intersections in many ways including: (1) requiring extra time to accelerate up to the posted speed limit; (2) altering sight lines; (3) increasing sight distance requirements; (4) altering signal timing requirements. Many of these traffic disruption effects can be mitigated with the use of powertrains that ensure acceleration performance equivalent to or better than current vehicles.

ISSUE: Trucks at terminals, ports and border crossings

Trucking activities concentrate at terminals, ports and border crossings, at particular times--often in or at the edge of seriously congested metropolitan areas. The implications of TS&W changes in these areas has not been extensively examined. The 1992 GAO Report on Intermodal Freight Transportation indicates that the success of intermodal trains between Chicago and the West Coast has increased truck traffic around Chicago's intermodal terminals, adding to the city's congestion. Similar problems are evident in Los Angeles, New York and other port cities. Better understanding of the effects of change--or the lack of change--of Federal TS&W regulations on highly congested freight traffic concentration areas is needed.

ISSUE: Public perceptions about large trucks

The literature is not extensive on the effects of TS&W changes on public perceptions about traffic flow quality and traffic impacts. While the perception issue is not one which can be easily dealt with, it requires consideration in the evaluation of regulatory options.

European studies: European research on public attitudes about trucks indicates that:

- Medium sized goods vehicles are often preferred to either fewer large goods vehicles or more small goods vehicles.
- People think that trucks with more axles are longer than they actually are.
- People cannot detect weight differences directly, except to some extent through noise level differences.

Perceptions vary by volumes and size of change: In relatively high volume situations, public perceptions about the effects of trucks on traffic flow quality and safety are not positive. While relatively small increases in vehicle size have gone by largely unnoticed (for example, the broad and rapid adoption of 53-foot semitrailers), large changes (for example, wide-scale adoption of turnpike doubles) would probably be less well-received. Anecdotal experience in areas of Canada where significant changes in truck characteristics have occurred in response to regulation changes suggests that the public either did not perceive the changes, or did not care about them. The relatively low traffic volumes of the highways most affected explains part of this, as does the fact that most changes took place without much fanfare.

4.3 Safety

TRUCK ACCIDENTS

Truck accident rates have been steadily falling over the past 10 years, more rapidly than the accident rates for passenger vehicles. Medium and heavy trucks accounted for 3.1 percent of all motor vehicles in use, 3.5 percent of all motor vehicles involved in

crashes, and 6.8 percent of all vehicle miles travelled, in the U.S in 1992. The truck fleet consists of 4.3 million single unit straight trucks and 1.6 million combinations. Of the 52,227 vehicles involved in fatal crashes in 1992, 3,957 (7.6 percent) were trucks with three of four being a combination. Of the 4,462 persons killed in crashes involving trucks, 85 percent were occupants of cars and light trucks. The following issues are of particular interest to Federal policy considerations at this time.

ISSUE: Data limitation problem

Accidents are relatively rare events; heavy truck accidents are even rarer. But when they happen, they are seldom caused by a single event or factor. Detailed information about them is often elusive. It has been impossible to reach any firm conclusions about the role of existing TS&W regulations in accidents, let alone the effects of possible future changes in those regulations. The following quotations illustrate the difficulties with attempting to hinge decisions upon the availability of definitive accident data:

- 1941 "(I)n a field so burdened with opinions and so fraught with variables it is not surprising that conclusive proof is lacking as to the effects of the large or heavy vehicle on safety. When the problem is further narrowed to the possible effects of changes ... the difficulties of analysis mount up".
- 1968 "(T)he analysis of ... highway traffic accidents offers practically no help in determining what effects on highway safety would result from increasing the limits of dimensions and weight of motor vehicles ... (U)ntil accident analyses can be afforded a better factual basis, judgement must rest upon logical reasoning from meager facts".
- 1981 "(T)he data that can be used to address this issue (of the ... impacts of changes in TS&W on safety) are inconclusive".
- 1990 "(D)etermining the effects of truck weight and configuration on accident rates is very difficult because these rates are also highly sensitive to driver and environmental factors".
- 1992 "(E)xisting studies ... have reached widely different conclusions concerning the safety of LCVs ... weaknesses in the data used and different study approaches contributed to the different results ... thus, the safety of LCVs is largely unknown".
- 1994 "(I)t is unlikely that statistical analysis would be able to detect statistically significant differences in the safety performance of A versus C-trains".

Commentary: It is difficult to envision a systematic analysis of the on-road safety implications of any feasible TS&W change that would not require qualifications because of insufficient data and/or statistical validity. It is unlikely that such analyses will be able to yield compelling, undisputable conclusions.

ISSUE: Predicting the accident future from the accident past

Accident data provide retrospective insights: Attempts are often made to use accident data prospectively to forecast future trends in accident patterns if TS&W policies are modified. Doing so is problematic, primarily because the conditions under which crashes occurred in the past are likely not to be the same as future conditions.

Inability to predict the decline of truck accident rates: The decline in truck accident rates over the past 15 years occurred during a period when TS&W limits were relaxed, operations under grandfather rights expanded, trucking deregulation coupled with increased competition came to pass, and highway traffic volumes doubled. However, none of these factors is particularly conducive to reducing accidents.

Understanding double versus single trailer accident rates: Many studies have investigated the relative crash involvement rates of various configurations and sizes of trucks, but most are based on limited data. The University of Michigan Transportation Research Institute, however, compared the safety record of double- and single-trailer operations, controlling for differences in the time of day and roadway types under which the two kinds of vehicles operated. They found that doubles have a slightly higher (5 to 10 percent) crash involvement rate than singles. The probable reason cited for this difference is that doubles have been shown, on the basis of engineering tests, to have a slightly higher rollover and jackknifing propensity than singles.

Predicting accidents involving LCVs: There have been many attempts to forecast LCV accident frequencies and patterns if their use were expanded. Because the extent of LCV use has been limited, very little historical crash data are available. Further, a statistically reliable data set could not be assembled even with a large resource commitment. Most statistics are derived from motor carrier files and primarily reflect experience in the West. These data generally show LCVs to be safe. This is attributable to a number of factors that could change including strict control on equipment standards, drivers, and operating conditions. Additionally, the reporting carriers are typically large, well-established, safety-conscious fleets, operating in sparsely populated regions over limited access roads with light traffic densities.

Despite these tendencies, if fewer truck trips are made because of productivity gains, the number of crashes might not increase, assuming freight diversion from rail is not significantly offsetting. Additional vehicle design changes, such as antilock braking systems, could offset these tendencies.

ISSUE: Engineering for better safety

Safety equipment is available which can make the braking, handling, and stability performance of LCVs and other larger trucks equal to or somewhat better than vehicle configurations they might replace. This equipment includes: antilock braking systems that

control all the vehicles' axles, steerable double drawbar converter dollies, and suspension design and cargo body shapes that minimize rollover tendencies. The Canadian Provinces have used the approach of allowing certain TS&W changes--particularly for vehicles with inherently advantageous safety performance characteristics. These issues are further discussed in the next section.

VEHICLE STABILITY AND CONTROL

Changes in truck size and weight policies can affect the safety characteristics of combination vehicles because they precipitate changes in basic vehicle design (such as wheelbase, track width, center of gravity height, suspension properties, and axle weights). These design changes can in turn affect vehicle braking, handling, stability, and maneuverability properties. If these factors are degraded, accidents and traffic disruption can increase unless changes in driver performance or environmental demands counteract the effects of vehicle changes. The following issues are of particular interest for Federal policy consideration at this time.

ISSUE: Static rollover threshold

The static rollover threshold is the level of lateral (sideward) acceleration that a truck can achieve during turning, without rolling over. Vehicles with low rollover thresholds are prone to rolling over when negotiating exit ramps from freeways, when making severe accident avoidance lane change maneuvers, or when they run off road. The principal determinant of rollover threshold is the ratio of the center of gravity height of the vehicle's mass and cargo to one-half the vehicle's track width. Suspension and tire properties also influence this property, but to a lesser degree.

Rollovers account for 8 to 12 percent of all combination truck crashes, but are involved in approximately 60 percent of crashes fatal to heavy truck occupants. They greatly disrupt traffic when they occur in urban environments.

ISSUE: Braking performance

The most straightforward measure of brake system performance is the distance required to stop the vehicle when fully loaded. Obviously, shorter distances are considered better in this regard. However, brakes must also be able to absorb and dissipate large amounts of kinetic energy when a fully loaded truck descends a grade. Also, trucks need to be able to stop stably, without jackknifing or otherwise losing directional control due to wheels locking and skidding. Brake system performance could play a contributing role in approximately one-third of all medium/heavy truck crashes.

The ability to stop in short distances is primarily dependent upon the size and number of brakes on the vehicle, their state of maintenance, and tire properties. If the vehicle's brakes are adequately sized, which virtually all trucks are as a result of Federal regulatory

requirements, they are capable of generating enough torque to lock most wheels on the vehicle when it is fully loaded. However, inadequately maintained or maladjusted brakes cannot generate needed braking power, which leads to longer stopping distances and poor brake balance. Improper brake balance can cause downhill runaways and braking instability.

None of these problems are attributable to a truck's size or weight, they are generic truck safety issues. However, because larger trucks tend to have more axles and, therefore brakes, to carry the heavier loads for which they are designed, these problems can be exacerbated if brake maintenance is lax.

Antilock braking systems are especially beneficial for heavier multiple trailer combinations because they have more axles/brakes which can be unevenly loaded or balanced, leading to incrementally increased risks of braking-induced instability and loss-of-control.

ISSUE: Rearward amplification

When a multiple trailer combination is travelling at highway speeds (55 mph), it is susceptible to rolling over its rear trailer if an unexpected abrupt lane change accident avoidance maneuver becomes necessary. This phenomenon (rearward amplification) is reduced primarily with increased trailer lengths and fewer articulation points. Other design factors, as well as the vehicle's weight, influence this characteristic to a lesser degree. Instances of these occurrences are rare, primarily because these type vehicles (doubles and triples) accumulate less than 5 percent of the total truck mileage and, therefore, experience comparatively little exposure to crash risk. The number of incidents could be expected to increase, however, if larger numbers of these vehicles were used, particularly in denser traffic environments that give rise to more frequent traffic conflicts.

ISSUE: Aerodynamic Buffeting of Adjacent Vehicles

Air turbulence around trucks does not increase if they are longer or heavier than currently used trucks. However, the gap between the tractor and the semitrailer it tows can be the source of a transient disturbance to adjacent vehicles, if they are operating in substantial crosswinds. Doubles combinations have two of these gaps, while triples have three. To the extent that motorists now find these occurrences disconcerting, they would experience that feeling incrementally more often if multiple trailer combinations were more widely used.

Truck generated splash and spray is primarily an aerodynamic phenomenon. Thus the incremental concerns that arise relative to buffeting and multiple trailer combinations, would be similar relative to incremental splash and spray concerns.

Efforts to improve truck aerodynamics are continual, since the fuel economy benefits they can yield are substantial. Both buffeting and splash and spray effects will be reduced as these market-driven product development efforts proceed.

4.4 Permits, Pricing and Enforcement

PERMITS AND PRICING

The subject is important because (1) much trucking takes place under such permits and (2) improved permit systems with FHWA involvement have been proposed as a means of enhancing productivity and safety of trucking in a cost-responsible manner. The following issues are of particular interest to Federal TS&W policy considerations at this time.

ISSUE: Significant differences among State permit programs

Significant differences exist among the States in terms of oversize and overweight permit policies, programs, practices, details and fee schedules. These differences reflect the needs (commodities), circumstances (geometry, traffic volumes), and priorities (promoting economic development) of the States. They also reflect State differences in interpretations of the law, tolerance policies, and enforcement practices. To facilitate interstate movement, State efforts have helped to standardize some permit practices at the regional level. Recent examples include:

- 1994 Southern Association of State Highway and Transportation Official (SASHTO): envelope vehicle of length = 100 feet, height = 13.5 ft, width = 14 feet, 120,000 pound GVW, 20,000 pound single axle limit, 40,000 pound tandem axle limit, 60,000 pound limit on 3 or more axles
- 1993 Western Association of State Highway and Transportation Officials (WASHTO): "Guide for Uniform Laws and Regulation Governing Truck Size and Weight Among the WASHTO States"

ISSUE: Current Federal involvement in permitting

ISTEA freeze: The ISTEA prohibits States from allowing expanded operation of double or triple trailer combinations operating at GVWs greater than 80,000 pound on the National Network beyond that permitted on or before June 1 1991. FHWA rule-making concerning this freeze was recently completed. The freeze is not a long-term solution and will have to be reviewed before the next reauthorization.

Containers and divisible/non-divisible loads: In 1984 FHWA made an administrative decision to allow states to define containers used in international trade as a non-divisible load. In doing so, all states (and not just those ones having related grandfather rights) were authorized to issue permits for container movements at weight levels beyond that allowed by Federal law. FHWA is considering a rulemaking on the divisibility of containers used in maritime trade.

ISSUE: Proposals to change Federal involvement in permitting

TRB Truck Weight Study (1990): This study recommends that: (1) States be allowed to establish permit programs for heavier vehicles in place of States having to claim grandfather rights, and; (2) FHWA work with States and industry to establish a review and approval process for State permit programs. Significant segments of the trucking industry have generally endorsed this proposal. Part of this endorsement probably comes from a belief that this is one practical means by which the constraints imposed by the apparent entrenchment of the 80,000 pound GVW cap could be circumvented.

House Bill # H.R. 4496 (1994)--Revocation of the Symms Amendment: Revocation of the Symms Amendment of the Surface Transportation Assistance Act of 1982 that allows States to define the scope of their grandfathering authority is proposed. This would require FHWA to re-assume more active involvement in overweight permitting.

House Bill # H.R. 4496 (1994)--Extend freeze to NHS: This bill proposes to extend Federal TS&W controls to the NHS, and to freeze permitting on that system. This study will address the implications of these proposed actions.

ISSUE: Cost recovery and equitable truck taxes

Productivity and cost effectiveness studies performed to date generally indicate larger productivity benefits than negative or offsetting highway infrastructure cost impacts for most larger and/or heavier trucks. Whether such units are to be authorized pursuant to a modified Federal law and/or special permits, their incremental infrastructure costs--and more specifically, recovery of these costs--are of concern to both Federal and State authorities. Typically, permit fees do not recover the incremental costs of overweight truck operations, especially those under multiple-trip permits.

The last comprehensive Federal cost allocation study was completed in 1982. In concert with this TS&W study, the FHWA Office of Policy is undertaking an updated cost allocation study to determine current and projected equity of the Federal user fee structure. Several States are also conducting similar studies.

ENFORCEMENT

Because of its economic importance, most of the recent research has concentrated on the extent and implications of overweight trucking operations and enforcement strategies. The issues of particular interest to Federal TS&W policy considerations at this time are:

ISSUE: Lack of knowledge about non-compliance with regulations

Current compliance: While many believe that there is much overweight trucking, the literature provides no systematic appreciation for the extent and nature of the problem

(that is, what highways, vehicles, commodities, regulations are involved). Nor are the implications of overweight trucking for pavement costs well-understood.

Effects of growth in intermodal container traffic: Some believe that growth in international container traffic exacerbated the overweight problem because certain of the permitted container weights cannot be accommodated on trucks in the U.S. when operated pursuant to Federal TS&W provisions. The Intermodal Safe Container Act of 1992 (ISCA) required a comparative study of truck-related overweight problems with container versus non-container traffic. The draft report of that study (conducted for FHWA) observes that there is no solid evidence that container traffic is more of a problem than general truck traffic.

ISSUE: Lack of knowledge about use of multiple-trip permits

Because of the increasing use of multiple-trip permits, the States are less able to determine how much use is being made of them. This makes it more difficult to determine the appropriate cost responsibility for overweight vehicles using these permits.

ISSUE: Need for simple and reasonable regulations

Pervasive through the enforcement literature is the need for TS&W regulations to be: (1) simple to comprehend and apply, and (2) reasonable from the standpoint of the trucking industry and the enforcement community. An overweight axle is relatively easy to explain in court. Being overweight on a group of axles because of too short a distance between axles is not. Add to this tire weight limits, and the situation becomes extremely complex from an enforcement perspective.

ISSUE: Limitations of existing enforcement techniques

Skepticism of permanent scales: There is much skepticism about the effectiveness of permanent weigh scales in detecting overweight trucks as generally the scales are easily by-passed. Portable scales are generally considered more effective.

Some help from weigh-in-motion (WIM) and other Intelligent Transportation System technology: WIM equipment can serve three useful enforcement purposes: (1) monitoring truck traffic to identify problem areas and help focus on- and off-road enforcement efforts, (2) preclear and bypass at weigh scales and points of entry when used in consort with automatic vehicle identification equipment (AVI), and (3) screening trucks for portable enforcement. WIM cannot be used to record evidence of violations. Potential violators must be weighed at static scales to support citations.

Limited use of relevant evidence: A few jurisdictions apply relevant evidence laws in TS&W enforcement. The use of relevant evidence (such as bills of lading) has been declining in Minnesota. Relevant evidence can only be applied to GVW provisions, thereby missing the most common and costly violations with axle weights.

Audits: Off-road, office audits provide another means of assessing compliance with TS&W regulations. Audits are more feasible with the larger carriers because these carriers generally maintain better records. But it is these same carriers that are more apt to control their operations and their compliance.

ISSUE: Enforceability of performance regulations

The literature is silent on how to enforce performance regulations. One approach is to convert the performance requirements (such as a desired offtracking performance) to measurable surrogates (for example, kingpin setback, wheelbase, overhang). This method is used to deliver the performance aspects of Canada's RTAC regulations.

ISSUE: Enforceability of specially-permitted operations

Several proposals for regulation change envision special-permitting to supplement basic specifications in the law on a broader scale than now exists. The idea of these proposals is that State-issued and controlled special permits authorizing operation beyond the governing limits could be issued using nationally uniform guidelines to vehicles and/or operations considered safer and/or more road friendly. The fees for such permits need to be set to recover the occasioned costs. The permits would be revocable if their conditions are abused. This type of permit can be much more self-enforcing. It is in the carrier's and shipper's interests to keep the permits; revocation for non-compliance reasons could prove costly.

4.5 TRUCK COSTS AND LOGISTICS

TRUCK COSTS

TS&W provisions affect the types and characteristics of trucks permitted, the cost of operating individual trucks, the payloads carried by trucks, and resultant truck operating costs (TOCs) per unit payload. The following factors in truck costs are influenced by changes in TS&W standards:

- Vehicle dimensions (height, width, truck and trailer lengths, and number of trailers)
- Gross vehicle weight (effect of bridge formula and GVW cap)
- Axle characteristics (number of axles, axle loads, suspensions, and load distribution among axles in a group)
- Tire characteristics (number, type, size, tire pressure, and load distribution between tires)
- Other vehicle characteristics (type of trailer or body, engine horsepower, brakes, and hitch design)
- User fees (heavy-vehicle permit fees, graduated weight-distance taxes, and fuel taxes)
- Enforcement activities (weight checks and safety inspections)
- Route restrictions (circuitry and access to origins and destinations)

- Other operational factors (availability of backhauls, density of loads, availability of full loads, and speed)
- Driver costs (pay differentials for driving certain configurations).

Number and Length of Trailers: Relaxation of TS&W standards may result in the increased use of vehicle configurations that are designed primarily for carrying either cube-limited or weight-limited freight. Utilization rates for these trucks may be lower than the trucks they replace because of higher empty mileage, lower annual mileage, and certain payloads that do not take advantage of their increased capacity, cube or weight. Such reduction will reduce the truck cost savings resulting from the increased TS&W standards.

If a specific TS&W standard change permitted more trailers to be used in selected vehicle configurations, there are costs related to adding the extra trailer. These costs could include: assembling and disassembling multi-trailer configurations, cleaning costs, the non-door-to-door operation, and drayage. In general, the cost to assemble and disassemble twin 28-foot trailer combination is about \$30 per trip or about 5 cents per vehicle-mile (assuming a 500 mile trip). The cost to cleaning tank trailers is between \$30 to \$150, depending on the commodity. The cost of draying the extra trailer ranges from \$85 to \$230 per trailer.

Additional Axle: The negative capital cost and weight impacts of adding an extra axle on trailers (tandem versus tridem axles) are about \$3,000 and about 1,500 pounds of tare weight.

Fuel: In general, fuel cost per vehicle mile increases by about 0.1 cents per mile for each 1,000-pound increase in GVW for a five-axle semitrailer combination with fuel costs of \$1.25 per gallon and 5.8 miles per gallon fuel efficiency (Knapton, 1981). The fuel consumption coefficients to measure the impact of weight vary by trailer type .

Tires: For a five-axle semitrailer combination, tire consumption is estimated to be about 3 cents per vehicle mile with a GVW of 63,000 pounds. Tire costs for multi-trailer combinations are not as well documented at this time. This cost is estimated to increase by 0.7 percent for each 1 percent increase in weight. For a six-axle semitrailer combination, the extra axle is subject to significant tire consumption and a cost increase of about 67 percent.

Routes and Circuitry: Relaxation of TS&W standards on a limited highway system could result in some increase in circuitry when current vehicles are replaced with larger or heavier vehicles. Also, route restrictions for heavier or larger vehicles require less direct routing and increase transit times which can increase costs and decrease the advantage of these vehicles.

Length of Haul: Length of haul is relatively unimportant in the analyses of changing configurations or weight limits on transport costs. Peat, Marwick, Stevenson & Kellogg (1993) found that, for cube-limited truckload shipments, reducing length of haul only resulted

in changing the cost advantage of 53-foot relative to 48-foot semitrailer combinations from 8.4 percent to 8.1 percent. Length of haul does become important when comparing the costs of operating configurations with different numbers of trailers that require cleaning after each haul—an important consideration for trailers used to carry chemicals or liquid food products.

Repair and Servicing: The cost related to truck repair and servicing is affected by increased GVW. This cost is estimated to change by about .097 cents per vehicle mile for each thousand pounds.

In summary, there are trade-offs between changing TS&W standards and their costs and benefits. For example, permitting or encouraging the use of an extra trailer axle without lifting the GVW cap increases the TOC by about 3 percent for a typical truck load operation. However, lifting the GVW cap from 80,000 to 86,500 pounds (permitted by Bridge Formula B) decreases the cost per payload ton-mile for six-axle semitrailer combinations costs by about 8 percent.

Relationship of Cost Responsibility to Total Truck Cost

TS&W considerations can impact pavement and bridge consumption patterns for trucks. Such changes can be measured in a traditional cost responsibility exercise. The 1988 Heavy Vehicle Cost Responsibility Study, concluded that: (1) for any configuration, the greater the weight, the lower the share of highway costs that are covered by user revenues; (2) in any weight category, the greater the number of axles, the higher the ratio of revenues to costs; (3) six-axle tractor-semi-trailer and multi-unit combination vehicles with seven or more axles may pay a fair share of highway costs at weights somewhat above 80,000 pounds; and (4) twin-trailer combinations with nine or more axles may bear a fair share of highway costs at gross weights up to about 120,000 pounds, depending on their axle loads. Proposed changes in TS&W regulations must include the analysis of cost responsibility and equitable payment of user fees. Changes in user fees obviously affect truck operating costs.

LOGISTICS

Generally, TS&W provisions are given in the minds of logisticians, who try to optimize the movement of freight in the entire picture of getting commodities to market. This task is getting more complex with involvement by parties not typically perceived in receiver/shipper decisionmaking process. Some of the factors influencing change in the logistics environment are:

- **Time Sensitive Delivery:** As just-in-time (JIT) delivery becomes more prevalent, transit time may not be as important as having accurate and reliable delivery times. Transit time is still important, however, for perishable products.
- **Inventory Costs:** Logisticians are beginning to look at the cost of inventory throughout the entire production system from raw materials to finished products.

- **Supply Chain Management:** Manufacturers are starting to align themselves vertically with suppliers farther up the supply chain, having each member focus on the activities they do best.
- **Global Economy:** The European Union and NAFTA are removing some of the previous barriers to moving goods expeditiously between countries.
- **Information Management Systems:** Using computer systems, manufacturers are sharing production schedules and sales forecasts with the other members of the supply chain in order to allow them to plan production and delivery better to decrease inventory and logistics costs throughout the entire system.

In general, there are no laws regulating the type of logistics and/or distribution manufacturers and suppliers must use. Since transportation cost is an inherent cost of delivering products to market, the free market generally determines the most feasible and economical forms of distribution and transportation. While TS&W standards are factored into logistics decisions, in general TS&W regulations will not have a direct impact on the global distribution patterns of manufacturers.

High-Value, Time Sensitive Products

The major focus for high-value, time sensitive commodities has been reducing inventory and transportation costs through integrated production planning between manufacturers and the entire supply chain. This has led to a trend of smaller shipment sizes and more frequent deliveries, which tends to increase transport costs (Whitford, 1987¹). With transportation costs comprising a relatively small portion of total product costs, the incentive to reduce inventory generally surpasses the cost savings associated with increased productivity from bigger, heavier trucks.

No literature was available that directly relates the TS&W issues with shipper decisions on size of shipments. Some modeling work has been done on optimal shipment size that incorporates transportation costs. However, many models treat transport costs as a single cost regardless of shipment size, and all assume no uncertainty in transportation.

Truck-Load Shipment (TL) of Low-Value, Non-Time-Sensitive Products

For TL shipments there is potential for benefit from longer and bigger trucks. A study for FHWA found that "... an excellent indicator of whether or not a truckload shipper would

¹Whitford, R.K., "Aspects of Freight Service Quality for Just-in-time Transportation Serving the U.S. Automobile Industry," Presented at "Just-in-Time Transport: New Road Freight Transport Strategies and Management: Adapting to the New Requirements of Transport Services," research Seminar, June 22-24, 1987, Gothenburg, Sweden.

benefit from switching to LCVs is the ratio of the shipper's current annual single trailer freight costs to annual inventory carrying costs"². This study suggests that single trailer freight costs are two or more times greater than the inventory carrying costs, therefore, switching from single trailers to LCVs will in all likelihood greatly reduce the shipper's annual total logistics costs. This scenario would also apply to the terminal-to-terminal leg of LTL carriers as well.

While no quantifiable research has been found, there is definitely a relationship between products that would benefit from increased truck size and weight and the product's value and transportation costs. For relatively low-value items and many regional products like coal, grain, and many petroleum products, transportation costs are a significant portion of total costs. Thus, these products are more likely to benefit from scenarios that would reduce transportation costs since the added inventory carrying costs would likely be small.

ISSUE: How Shippers react to Federal And State TS&W limitations and resultant benefits

Within the logistics community, those most concerned about the Federal and State TS&W limitations will be the carrier industry. Shippers are most concerned about optimizing their shipments to reduce total costs—balancing inventory carrying costs against transportation costs. The shippers most likely to benefit from changes in the TS&W regulations will be those shipping goods that are low-value and non-time-sensitive where the transportation costs makes up a significant portion of the total final product cost.

Carriers, however, will be more likely to take advantage of the changes in TS&W limitations. LTL carriers would likely take advantage of bigger and/or longer trucks on the TL portion of their shipments between terminals, while TL carriers would use the most economic configuration available to move the desired freight with the least amount of cost.

The TRB Study, "Truck Weight Limit: Issues and Options" examined seven TS&W policy scenarios: (1) Grandfather Clause Elimination, (2) Uncapped Formula B, (3) NTWAC Proposal, (4) Canadian Interprovincial Limits, (5) TTI HS-20 Bridge Formula, (6) Uncapped TTI HS-20 Bridge Formula, and (7) Combined TTI HS-20/Formula B. Among the impacts evaluated were changes in total logistics costs, which primarily includes transportation and inventory carrying costs. The total logistics costs estimates ranged from additional costs to shippers of \$7.76 billion for the Grandfather Elimination Clause Scenario to a savings to shippers of \$11.69 billion for the Canadian Interprovincial Limits Scenario. The median value was a savings to shippers of \$5.11 billion for the Uncapped TTI HS-20 Bridge Formula Scenario.

²"Effect of Truck Size and Weight Policy Options on Carrier and Shipper Productivity," Center for Transportation Analysis, Oak Ridge National Laboratory, prepared for FHWA, April 1994.

Use of Containers in International Trade

Although having origins in the maritime trade, the use of containers continues to expand in international trade, and more recently in domestic commerce. While overall growth in intermodal traffic on railroads has been double digit, no attempt has been made to bifurcate that statistic into its domestic and international components as this can no longer be made on equipment type alone.

Sizes of intermodal containers moving in maritime trade continue to focus on 20 and 40-foot lengths as dictated by the design of vessels in the world cellular containership fleet. Where carriers deviate, a notable example being American President Lines' (APL) use of 45, 48, and 53-foot units, utilization is limited to specific high-density trade lanes. Moreover, many, if not most, foreign port and highway infrastructures impose their own limitations with a notable example being the exclusion of many high cube units from the European trades because of bridge and tunnel clearances. International trade has been growing at some multiple to the growth of gross domestic product (GDP), thereby suggesting the presence of a disproportionately larger number of containers on future highways.³

Historically, international containers have moved as TOFC (trailer or container with chassis on flatcar), COFC (container without chassis on flatcar), and double stack. Most railroad equipment has been configured for 20 and 40-foot containers and 45-foot trailers, although newer equipment is providing for longer vehicles.

ISSUE: Impacts of Heavy International Containers

A container used in international trade, often loaded to gross weights up to that allowed by the International Standards Organization (ISO), may cause axle weight violations if loaded onto a tractor-chassis combination that has single axles rather than tandem axles; bridge formula violations if carried on a chassis too short for its weight; and, in cases, gross weight violations. A 20-foot container loaded to the ISO weight limit of 24 metric tonnes on a five-axle semitrailer requires a minimum of 36 feet between the first drive axle and last tag axle to comply with the U.S. Federal bridge formula. A 20-foot container loaded to the old ISO weight limit of 20 metric tonnes on a five-axle semitrailer requires a minimum of 23 feet between the first drive axle and last tag axle. A 40-foot container loaded to the ISO weight limit of 30.48 metric tonnes is too heavy under the U.S. 80,000-pound (36.287 metric tonnes) gross vehicle weight limit. However some States, port States in particular, may issue overweight permits if they find that sealed containers are loads that cannot be easily divided.

The fact that many international shippers are unfamiliar with U.S. weight limits results in many containers being loaded to heavily to ensure compliance with the U.S. limits. This results in an enforcement problem, although probably no worse than overweight trucks in

³Young, R., Penn State University.

general. Many factors contribute to the use of illegally overweight container-carrying combinations. Such factors include:

1. The international nature of much intermodal transportation;
2. Tight competition among ports for international trade;
3. The use of per-container shipping charges;
4. The competitive nature of the freight industry;
5. Limited exposure to enforcement because of the shortness of pick-up or delivery trips;
6. Uncertainty on the part of motor carriers as to how the distribution of container weight will affect axle loading or compliance with the bridge formula.

The Intermodal Safe Container Transportation Act of 1992 was enacted to address this problem. It requires prior written notification and certification of the gross cargo weight and a reasonable description contents by the person tendering a loaded container or trailer having a gross cargo weight over 10,000 pounds. The Act stipulates that such certification be passed to subsequent carriers of the container or trailer, and makes it unlawful to transport such a container or trailer without certification, or to coerce a motor carrier to move a container or trailer without certification or with a weight in excess of that permitted by State law.

Section 3 of the Act required the Secretary of Transportation to report to the Congress on the results of a study on data collection and recommendations for improving the collection of data related to movements of containers in violation of the Act.

Use of Containers in Domestic Commerce

Originally proposed as a means of utilizing empty APL containers needing to move from east to west coast ports, the addition of double stack technology suggested that real economies were also present for domestic commerce. The most significant development has been within the past 2 to 3 years with the adoption of 53-foot container/chassis combinations by both J.B. Hunt and Schneider National.

The advent of 28-foot containers for potential adoption by the LTL carriers is also noteworthy. Pairs of 28-foot containers, as well as single 48 and 53-foot containers, are most easily accommodated as upper tiers on double stack railcars, although longer well units are being introduced.

Domestic ISO bulk liquid containers, first introduced for maritime use, now show some growth potential for domestic commerce. Union Pacific, as well as bulk haulers Matlack and

Chemical Leaman, continue to participate. Equipment is identical to its international analog with 20-foot lengths being standard.

4.6 TRUCK TRAVEL AND MODE SHARE

TS&W provisions affect truck travel (vehicle miles of travel--VMT) as well as the split of traffic between modes and use of intermodalism. TS&W regulations influence payload size and weight, truck and trailer usage, truck costs by truck configuration, and other truck operating factors that affect the decision-making of traffic managers and carriers when deciding how and how much freight to carry.

Table 1 presents the distribution of truck VMT by commodity and truck and trailer type for selected commodities. The commodities presented were selected to give a representative sample of high- and low-value, bulk and non-bulk, and time-sensitive and non-time-sensitive products. The VMT is broken down by trailer type: van, refrigeration, flat bed, and other.

Table 1. Distribution of Truck VMT by Selected Commodities

Configuration & Commodity	Trailer Type			
	Van	Reefer	Flat Bed	Other
Five or More Axle, Semitrailer Combination				
Lumber and Wood	15.6%	0.2%	75.7%	8.5%
Processed Foods	32.9%	58.5%	2.1%	6.5%
Textiles	96.1%	2.3%	1.5%	0.1%
Petroleum	5.6%	0.3%	0.7%	93.4%
Plastics	66.8%	1.3%	21.1%	10.8%
Fabricated Metals	58.0%	0.6%	38.5%	2.9%
Three or More Axle, Straight Truck				
Lumber and Wood	8.2%	0.0%	69.4%	22.4%
Processed Foods	20.7%	65.6%	5.9%	7.8%
Textiles	94.8%	0.0%	5.2%	0%
Petroleum	1.0%	0.0%	4.1%	94.9%
Plastics	25.4%	0.0%	24.5%	50.1%
Fabricated Metals	24.8%	0.0%	66.7%	8.5%

(Source: Truck Costs Working Paper, 1995.)

Impacts of Federal TS&W Law on Truck Travel

Increases in TS&W provisions will result in larger payloads especially for bulk commodities such as construction materials, agricultural and forestry products, and natural resources such as coal and potash. The effect is not nearly as great on finished goods. Increased payloads reduce the number of trucks required to transport a given amount of freight. This reduces the amount of truck VMT.

However, larger trucks are subject to more operational restrictions particularly on lower types of roadways. Heavier trucks may have to use circuitous routes to get around posted bridges. These effects increase truck mileage or VMT as well as costs.

For those commodities for which truck payloads can be increased, typically the TOCs per unit of payload decrease even with an overall cost increase. This effect will increase the demand for transporting freight by truck. Some of this increase may be new demand, but most of it would be from another mode. Consequently, truck VMT will increase.

The net effect of increases in TS&W limits on the truck travel for truck-rail competitive commodities is not well understood. Most past studies have found that the net effect will be a decrease in truck VMT, but the lack of understanding of the factors considered in a shipper's choice between competing modes reduces the confidence in the results of those studies. For transport markets where there is not competition between truck and rail, such as relatively short hauls of bulk commodities, the impacts of TS&W changes on truck VMT can be made with confidence.

ISSUE: TS&W changes can have significant impact on shipper choice of mode

Past TS&W analyses provide information to group general trends with regard to rail market share, truck costs, truck VMT, and overall shipper costs. Note, that recent TS&W scenario analyses are very specific with regard to TS&W policy changes, therefore, caution is needed when generalizing or grouping broad TS&W policy scenarios.

Based on the TRB truck studies, the rail market share (both ton-miles and revenue), particularly with respect to intermodal freight, transportation equipment, and bulk commodities moved long distances, appears to be sensitive to TS&W policies that would allow:

- Triple 28-foot trailer combinations to have GVWs up to 116,000 pounds on the Interstate System with appropriate access roads.
- Turnpike doubles, two 45- to 53-foot trailers with a total of nine axles, to have GVWs up to 129,000 pounds on the Interstate System.
- Other LCVs.
- Use of Canadian weight limits: The bridge formula would be replaced by minimum axle spacings; 51,000 pounds would be allowed on tridem axles; and maximum

GVWs for several configurations would be derived from the Canadian interprovincial limits. (The U.S. Federal weight limits for single and tandem axles would remain).

Such TS&W policy scenarios have been estimated to negatively impact rail ton-miles and revenue ranging between 4 to 10 percent, depending on the specific TS&W Policy. However, the most recent GAO study of LCVs addressed the limitations of current models for estimating such modal impacts and questioned assumptions that do not reflect today's intermodal markets and large gains in productivity made by the railroads in recent years (page 33, GAO/RCED-94-106).

Configurations Benefiting from Liberalized Truck Weight Standards

The current Federal truck weight regulations constrain the use of some combinations--four-axle straight trucks and six-axle semitrailer combinations--that could be more productive without any increase in size, which reduces safety and operational concerns. Further, they would have less of an impact on pavements, but they would increase bridge stresses, although for most bridges, these stresses would not exceed the overstress criteria used to establish the Federal bridge formula.

Four-Axle Trucks: For States without grandfather authority, the bridge formula and axle weight limits typically restricts the GVWs of three-axle straight trucks to a range of 51,000 to 54,000 pounds and four-axle trucks to a range of 55,000 to 58,000 pounds, depending on the truck wheelbase. Further the bridge formula restricts the maximum weight on a tridem-axle to a range from 42,000 to 43,500 pounds for axle spreads of 8 feet to 10 feet. The TRB Special Report 225 noted in its discussion of the Texas TTI bridge formula that the formula would allow up to 65,000 pounds for a four-axle single unit truck.

The types of trucks that would be affected by these limits are fuel trucks, dump trucks, transit mixers, trucks carrying other building and construction materials, and trash removal trucks. Given the unusually heavy empty weights for these trucks, these limits seriously constrain their productivity. Consequently, the industries that use these trucks are always looking for increases in truck weight limits as even small increases in weight mean much larger increases in payload.

In the 1995 DOT Appropriations Act, Maryland was given a new grandfather date of June 1, 1994, which allows a 70,000-pound, four-axle dump truck to operate on its Interstate highways. This change is intended ultimately to result in Maryland's dump truck fleet converting from 3-axle dump trucks operating with weight up to 65,000 pounds to four-axle dump trucks operating at weights up to 70,000 pounds. The Maryland provision allows a lift axle in front of the two rear axles. Broader application of this provision would be controversial as lift axles are generally found to be underloaded, if they are carrying any load at all.

Six-Axle Semitrailer Combinations: Allowing the States to permit the operation of six-axle semitrailer combinations at GVWs of up to 90,000 or more pounds, as discussed in Section 4.1, would make these combinations about 13 percent more efficient than five-axle, 48-foot semitrailer combinations operating at 78,000 pounds. With an actual GVW cap of 90,000 pounds, the 90,000-pound GVW becomes slightly less attainable, and a slightly smaller average efficiency advantage for the six-axle semitrailer combination results—probably about 12 percent. With a GVW cap of 94,000 pounds and a tridem limit of 50,000 pounds, an 18 percent efficiency advantage for the six-axle semitrailer combination, though the above discussion suggests that, on average, the practical advantage for weight-limited operation is likely to be about 17 percent.

The average 12 or 17 percent efficiency advantage for six-axle semitrailer combinations suggested in the preceding paragraph holds for weight-limited operation on routes that can be served at 90,000 or 94,000 pound GVWs. For cube-limited operation, six-axle semitrailer combinations are typically about 3.5 percent more expensive than five-axle semitrailer combinations.

Relative to five-axle, six-axle semitrailer combinations have very clear cost advantages (10 percent or more) for carrying weight-limited loads when they are allowed to operate at 90,000 or 94,000 pounds, but they are disadvantageous when they are limited to 80,000 pounds or when they are carrying loads that are not weight-limited. Accordingly, allowing six-axle semitrailer combinations to operate at 90,000 or 94,000 pounds would result in an eventual switch from five-axle to six-axle semitrailer combinations for vehicles used exclusively or primarily to carry weight-limited loads on routes that allow operation at the higher weights.

4.7 ENVIRONMENT AND ENERGY CONSERVATION

Federal (i.e. Congress) and State policymakers can alter existing truck size and weight policy and thereby affect energy conservation and environmental quality through basic standards, performance, and pricing controls. Limits on gross vehicle weights (GVW) and dimensions directly affect energy conservation and environmental quality, but they also indirectly affect energy and the environment as the trucking industry responds to these new or modified regulations. For instance, modifications in existing GVW and/or dimension limits may result in the modal diversion of certain types of freight movement (that is, truck to rail or vice versa). This modal shift (including intermodal shipments) impacts energy conservation and the environment through changes in vehicles' fuel consumption, emissions, and noise.

Direct Impacts

Gross Vehicle Weight

Federal and State set GVW limits determine the amount of freight that can be carried by a single truck. Increased GVW limits would allow more freight to be shipped in fewer trucks, resulting in reduced truck VMT, truck trips, which would lead to reduced energy consumption, vehicular emissions, and total vehicular noise.

The literature is quite old, but generally agrees that increased GVW limits could contribute to energy conservation and environmental objectives. Several studies have found that increased cargo weights of 50 percent can be transported by a single truck with less than a 10 percent increase in fuel consumption.

Vehicle Dimensions

Federal and State laws set various vehicle length, width, and height limits that determine the amount of freight which can be shipped by truck. Changes in dimension limits can affect the operational efficiency of trucks and thereby affect the energy consumption and environmental quality because of changes in fuel use and emissions per ton-mile shipped, but generally, only in limited ways. For instance, liberalization of dimension limits with no corresponding GVW changes improves operational efficiency only for cube-limited, or low density cargo, which fills the volume capacity before reaching the GVW or axle weight limits. From the data available, it would appear that dimension limits would have a relatively minor impact on energy conservation and air quality objectives.

The number of axles and/or tires follows a similar logic. As the number increases, the expected GVW as well as tire friction with the road increase, causing an increase in fuel consumption and emissions. Limited data have shown these hypotheses to hold true, although no specific estimates of differences in fuel consumption and emissions are available.

Indirect Impacts

Modal Diversion and Intermodal Shipments

Changes in TS&W can increase or decrease the capacity of trucks which could affect fuel consumption and operating costs. Changes in operating costs could increase/decrease the modal share of all freight transported by truck. This can impact energy conservation and emissions due to differences in the energy efficiency between the modes.

The consensus in the literature is that rail is more fuel efficient (ton-miles/gallon) than trucking for long haul shipments. However, trucking is better than rail for drayage operations and for shipments where rail transport would be highly circuitous. Regarding emissions, in general, trucks emit more pollutants (pounds/ton-mile) than rail shipments.

Regarding intermodal shipments, deregulation allows greater cooperation between truckers, railroads, and intermodal carriers. No literature discusses the energy and emissions impacts of multimodal freight shipments. This is a significant research gap.

Vehicle Performance, Condition, and Technology Improvements

The literature is limited, but generally shows that vehicle performance significantly impacts trucks fuel consumption. One study reported a fuel savings of 10 percent from reduced truck speeds from 60 to 55 miles per hour (1975 DOT). Other issues which could affect energy conservation, such as individual driver habits (acceleration/deceleration) and volume-to-capacity ratio have not been addressed in the literature. More research is needed to answer all questions regarding the relationships of vehicle performance with energy conservation.

Federal and State laws deal extensively with vehicle condition from a safety perspective. However, laws relating to engine condition and fuel efficiency typically apply to new engines and are less imposing as the engines age. Newer engines are more fuel efficient, but without proper maintenance, engine performance and fuel efficiency significantly declines. Recent Federal and State environmental laws set emissions and miles per gallon requirements for engines (not vehicle configurations), but the applicability of these laws vary. The literature agrees that deteriorating engine condition from age and neglect increases emissions and reduces fuel efficiency. However, this relationship has not been quantified in the research identified for this study.

Another aspect of vehicle condition is tires. Federal and State laws are generally silent on tires. The literature gives conflicting views on tire condition. Wide-base (super single) tires are believed to reduce energy consumption and vehicular emissions. More research is needed to determine the energy conservation potential of improved tire technology.

Fuel consumption represents an operating cost for trucks and there is a financial incentive to reduce fuel consumption. This results in technology that contributes to energy conservation and emissions objectives. The literature does not address all recent improvements to fuel efficiency and emissions. All the literature agrees that technological improvements in equipment and materials, such as aerodynamic cabs and lightweight body designs, and engine performance have significantly improved trucks environmental and energy efficiency over the last 20 years. Also, new Intelligent Transportation System technology with better communication and information exchange can decrease energy consumption and emissions.

CHAPTER 5 - KNOWLEDGE GAPS AND RESEARCH NEEDS

This Chapter identifies knowledge gaps and research needs concerning TS&W options and their impacts. There are many research issues identified in the working papers prepared for this study. The items listed below are judged to be the most important to be addressed for this Comprehensive TS&W Study.

5.1 PAVEMENTS AND BRIDGES

AXLE LOAD

Research the feasible range and relative merits of alternative unique Federal tridem axle load limits on Federal bridges and pavements. Options to consider include 42,000/43,500 pounds (Bridge Formula B), 46,200 pounds (21 metric tonnes), 48,400 pounds (22 metric tonnes), 50,600 pounds (23 metric tonnes), and 52,800 pounds (24 metric tonnes). Consider the merits of a unique tridem limit relative to the increasing use of wide-spread tandem axles.

Research the feasible range and relative merits of alternative increased Federal tandem axle load limits on bridges and pavements. Options to consider include 35,000 pounds, 36,000 pounds, 37,400 pounds (17 metric tonnes), 39,600 pounds (18 metric tonnes), and 40,000 pounds. Consider the merits of alternative tandem limits relative to the increasing use of wide-spread tandem axles.

Research methods and criteria that Federal law might use to encourage and reward the use of road-friendly equipment and practices respecting such matters as suspension systems, tire load balancing, and tire pressure control.

Research whether or not, and if so how, the Federal law should discourage use of wide-base tires and lift axles.

BRIDGE FORMULA

Analyze the feasible range and relative merits of alternative risk criteria that FHWA could use in determining bridge load limits.

Analyze the need for change and relative merits of outstanding and proposed bridge formula alternatives. The analysis should consider alternative risk criteria, unique tridem axle loads, alternative tandem axle loads, and alternative GVW caps. Vehicles of interest include:

1. Short wheelbase four-axle straight trucks with GVWs from 64,000 to 70,000 pounds
2. Six-axle tractor semitrailers with GVWs from 90,000 to 97,000 pounds

GROSS VEHICLE WEIGHT CAP

Analyze the direct pavement, bridge, and safety implications of allowing vehicles to operate at weights above the 80,000 pound GVW cap. Options will include:

1. The effective use of six-axle tractor-semitrailer combinations with GVWs ranging from 86,000 to 97,000 pounds in terms of transporting bulk commodities in regional trade and intermodal containers in international commerce.
2. Use of a bridge formula for multiple-trailer combinations at weights above 80,000 pounds.

5.2 ROADWAY GEOMETRY AND TRAFFIC

TRAFFIC OPERATIONS

Research enhanced analytical means for evaluating the effects of feasible TS&W options and truck volumes on traffic operations--including capacity, level of service, and traffic stream operating costs. The impacts of trucks on downgrades as well as upgrades in medium to high volume-to-capacity ratios are of particular interest. The enhanced capability should facilitate route assessment for specially-permitted operations.

5.3 SAFETY

PERFORMANCE CRITERIA

Define the safety-related vehicle performance test procedures, acceptability criteria, and implementation approach required for Federal truck regulation. Identify minimum and desirable TS&W specifications and/or performance regulations which would ensure compliance with these criteria and be enforceable and research the implications of adoption of such regulations.

Research technological innovations that would improve the safety operations of commercial vehicles and evaluate possible incentives through higher limits, to encourage the purchase of those technologies.

Determine the maximum acceptable limit for off-tracking performance with which trucks should comply. Define the minimum and desirable TS&W specifications and/or performance regulations which would ensure compliance with these criteria and be enforceable and research the implications of adoption of such regulations.

5.4 PERMITS, PRICING, AND ENFORCEMENT

PERMITS

Research alternative technical, management, and pricing aspects of Federal/State special permit approaches that could be used to oversee trucking operations on the NHS. These could supplement the basic provisions of Federal law in a way similar to proposal in TRB Special Report 225.

One potentially innovative permitting scheme is to have the Federal and/or State Government specify criteria that permitted vehicles are to satisfy, and require licensed professionals (such as professional engineers) to assess, certify, and assume responsibility for whether or not given vehicle configurations and/or operations are in compliance with the requirements. Without certification, the permit would not be granted. The concept mirrors the building codes within which structural engineers work and assume professional responsibility for their designs.

Analyze the importance of exempt and specially-permitted U.S. trucking operations relative to Federal TS&W law to facilitate evaluation of the likely impacts of potential TS&W options.

PRICING

Reevaluate user fee equity through an updated cost allocation study. Assess marginal cost pricing concepts and the extent to which social costs externalities, for example environmental concerns, should be considered in the TS&W and user fee analyses.

ENFORCEMENT

Evaluate with the States, the effectiveness and adequacy of current enforcement methods. Assess how new technologies and communication methods might improve enforcement effectiveness, both in detecting weight limit violators and reducing avoidance of inspection facilities.

5.5 TRUCK COST AND LOGISTICS

TRUCK COSTS

Assess and enhance truck costing methods for evaluating vehicle and TS&W policy scenario options.

LOGISTICS

Analyze the constraints that current Federal axle limits, bridge formula and the GVW cap place on enhancing productivity and logistics. Develop a practical understanding of the effects of the constraints and how they can be changed to facilitate productivity and logistics opportunities for key commodity movements, traffic lanes, industries, regional development objectives, and international trade. The research will address the full range of trucking activity impacted by the Federal law--remembering that there is probably as much or more to be gained by enhancing the operations of local and regional commodity haulers (and the like) than turnpike doubles (and the like).

Research on-going and expected developments in domestic and international containers and their implications for Federal TS&W law. Examples of areas of interest include: the advent of 28-foot domestic container for potential adoption by the LTL carriers; development of domestic ISO bulk liquid containers. The implications of these developments for GVW caps, axle load distributions, and divisible/non-divisible load interpretations are of interest.

Analyze the opportunities foregone by the LCV freeze imposed by the Intermodal Surface Transportation Assistance Act.

5.6 TRUCK TRAVEL AND MODE SHARE

TRUCK TRAVEL

Analyze the fleet mix effects of adjustments to Federal law that would permit the effective use of truck, single-trailer, and multi-trailer combinations.

MODE SHARE

Analyze the rail to truck mode share effects of adjustments to Federal TS&W law such as permitting the effective use of rail competitive configurations.

Develop improved methods for estimating mode shares.