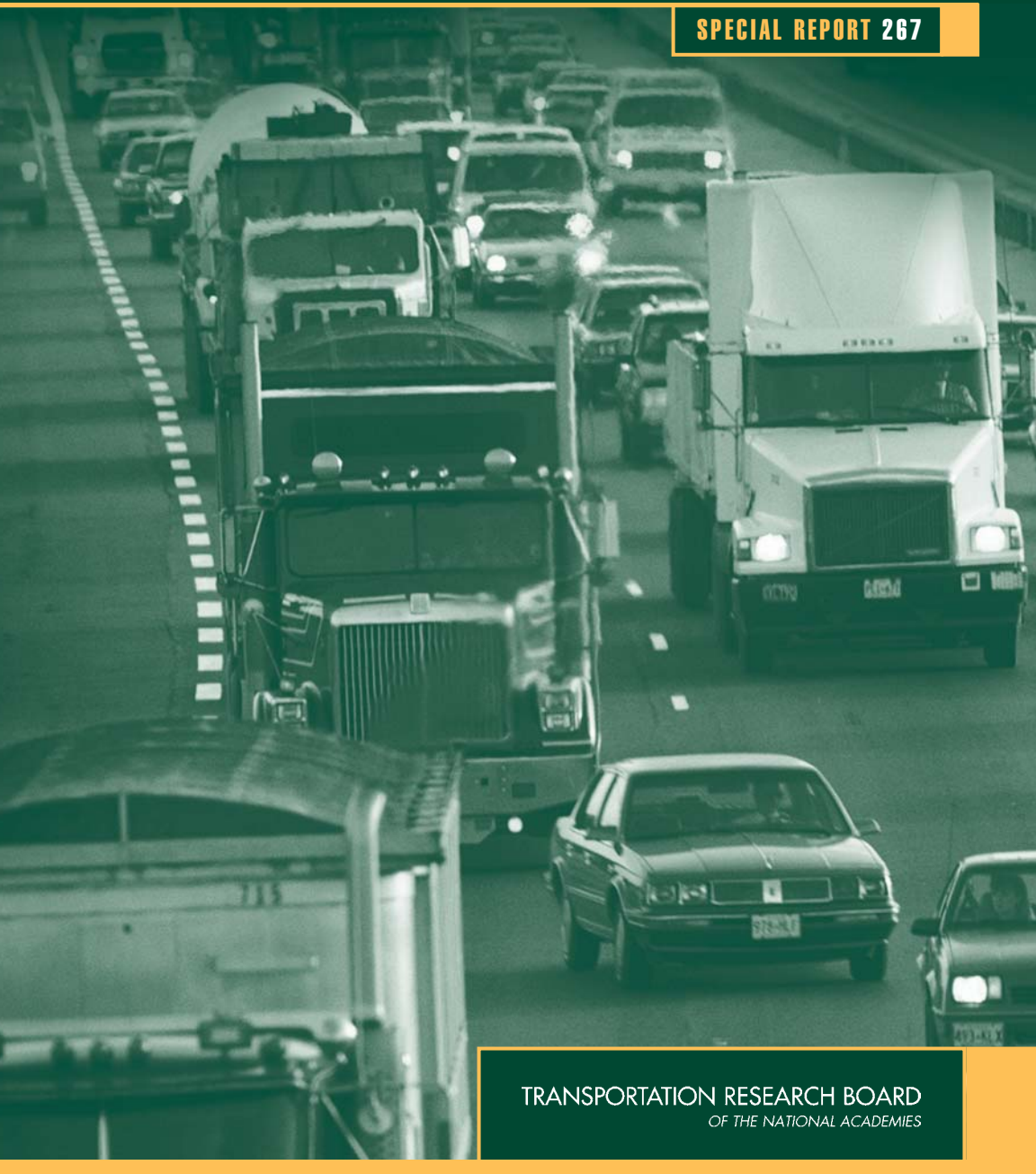
Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles

SPECIAL REPORT 267



TRANSPORTATION RESEARCH BOARD
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TRANSPORTATION RESEARCH BOARD
2002 EXECUTIVE COMMITTEE*

Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles

Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles

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Washington, D.C.
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Joseph R. Morris, Study Director

Preface

This report is the result of a provision in the 1998 Transportation Equity Act for the 21st Century (TEA-21) that instructed the Secretary of Transportation to ask the Transportation Research Board (TRB) to conduct a study of the regulations governing the weights, lengths, and widths of commercial motor vehicles operating on highways subject to federal regulation, and to recommend any revisions to the regulations deemed appropriate. These federal regulations, along with state regulations that also limit truck dimensions, have important effects on the costs of highway transportation of freight and passengers.

This study follows a series of investigations of the regulation of commercial motor vehicle size and weight conducted by the U.S. Department of Transportation (DOT) and by earlier TRB committees. The study charge in TEA-21 asked TRB to take into account the conclusions of the 1990 report *Truck Weight Limits: Issues and Options* (TRB Special Report 225), which was also produced by TRB at the request of Congress. In 2000, DOT published the final version of its *Comprehensive Truck Size and Weight Study;* the TRB committee that conducted the present study interpreted its task as complementary to the DOT study. The objective of the latter study was to develop an analytical framework that could be applied to assess a range of policy options; the study did not generate policy recommendations. In contrast, the present study provides recommendations, as Congress requested. These recommendations involve organizational arrangements designed to promote reform of the current federal regulations, as well as changes in the regulations to improve the efficiency of truck freight transportation and mitigate the costs of truck traffic to the public.

Unlike the previous TRB and DOT analyses, the present study has not produced new quantitative estimates of the impacts of changes in the regulations. The available models were fully exercised in previous studies, and it was not practical for the committee to develop new

methods. The committee based its conclusions on the evaluations in past truck size and weight studies and criticism of those studies, on other published information sources, and on the comments of interested parties solicited by the committee in accordance with its charge.

The study charge in TEA-21 was broad, encompassing in principle every aspect of a complex body of federal regulations. It was not possible for the committee to review each provision of the regulations individually. Therefore, the absence of a recommendation to change any particular regulatory provision does not represent the committee's endorsement of the provision. Nor was the objective of the study to identify an optimum set of federal size and weight limits. Rather, the committee's recommendations relate primarily to the process by which federal regulations are established and the relationship between the federal and state governments in regulating truck size and weight. As one example, the committee did not consider whether federal axle weight limits should be changed. Also, although the committee received comments from members of the motor coach industry that included proposals for regulatory changes, the committee did not evaluate provisions of the federal regulations as they affect passenger coaches in particular.

The study was managed by Joseph R. Morris, who drafted this report under the direction of the committee and under the supervision of Stephen R. Godwin, Director of TRB's Studies and Information Services Division. Thomas J. Hillegas prepared background material for the committee on enforcement of truck regulations and on methods of mitigating the effects of truck traffic. Suzanne Schneider, Associate Executive Director of TRB, managed the report review process. The report was edited and prepared for publication under the supervision of Nancy Ackerman, Director of Reports and Editorial Services. Rona Briere edited the report, and Alisa Decatur prepared the manuscript for publication. Jocelyn Sands directed project support staff. Special thanks go to Frances E. Holland for assistance with meeting arrangements, communications with committee members, and report production.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence,

and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

Appreciation is expressed to the following individuals for their review of this report: Kenneth L. Campbell, Oak Ridge National Laboratory, Oak Ridge, Tennessee; Thomas B. Deen, Stevensville, Maryland; Edward Fain, Arkansas State Highway and Transportation Department, Little Rock; Gongkang Fu, Wayne State University, Detroit, Michigan; David A. Galt, Montana Department of Transportation, Helena; Patrick McCarthy, Georgia Institute of Technology, Atlanta; Fred P. Nix, Orangeville, Ontario, Canada; and Kenneth A. Small, University of California, Irvine. Although the reviewers provided many constructive comments and suggestions, they were not asked to endorse the findings and conclusions, nor did they see the final draft before its release.

The review of this report was overseen by Christopher A. Sims, Princeton University, and Lester A. Hoel, University of Virginia, Charlottesville. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

James W. Poirot
Chair, Committee for the Study of the
Regulation of Weights, Lengths, and
Widths of Commercial Motor Vehicles

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Executive Summary

Federal and state regulations govern the weight and dimensions of trucks, buses, and trailers on U.S. highways. The regulations have important economic consequences because trucking accounts for four-fifths of expenditures on freight transportation in the United States, and trucking costs are influenced by truck size and weight. Size and weight limits also influence highway construction and maintenance costs and the convenience and safety of highway travel. The regulations affect international commerce as well because the U.S. limits differ from those of Canada and Mexico, and because containers shipped in international trade often are not consistent with U.S. regulations.

The 1998 Transportation Equity Act for the 21st Century directed the Secretary of Transportation to request that the Transportation Research Board (TRB) "conduct a study regarding the regulation of weights, lengths, and widths of commercial motor vehicles operating on Federal-aid highways to which Federal regulations apply . . . and develop recommendations regarding any revisions to law and regulations that the Board determines appropriate." TRB formed the Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles to conduct this study. The committee's conclusions, presented below, address the performance of federal size and weight regulations and the adequacy of information available for guiding regulatory decisions. These conclusions are based on a review of past evaluations conducted by the U.S. Department of Transportation (DOT), TRB, and others. The committee's recommendations involve both organizational arrangements designed to promote reform of the federal regulations and regulatory and management changes intended to improve the efficiency of freight transportation and reduce the public costs of truck traffic.

Throughout its work, the committee found that a lack of information about the costs and benefits of truck transportation and the impacts of the size and weight regulations hindered its effort to provide useful policy advice. Every past body that has examined these issues has encountered the same difficulty. Regulatory decisions on such complex matters will unavoidably entail some risk. Nevertheless, the com-

mittee believes the degree of uncertainty surrounding the question of size and weight regulation is unnecessary. This uncertainty could be alleviated if procedures were established for carrying out a program of basic research and for conducting evaluation and monitoring as a permanent component of the administration of the regulations. The committee's recommendations include a proposal for such arrangements, which would allow the federal and state governments finally to enact fact-based truck size and weight regulations.

CONCLUSIONS

1. *Opportunities exist for improving the efficiency of the highway system through reform of federal truck size and weight regulations. Such reform may entail allowing larger trucks to operate.*

Present federal standards are for the most part the outcome of a series of historical accidents instead of a clear definition of objectives and analysis of alternatives. The regulations are poorly suited to the demands of international commerce; their effectiveness is being eroded by ever-expanding numbers and types of special exemptions, generally granted without evaluation of consequences; and freight traffic is bypassing Interstate highways, the safest and most efficient roads, to use secondary roads where limits are less restrictive, but the costs generated by that traffic are higher. The greatest deficiency of the present environment may be that it discourages private- and public-sector innovation aimed at improving highway efficiency and reducing the costs of truck traffic because vehicle regulations are inflexible and because highway users are not accountable for all the costs they generate.

2. *Appropriate objectives for federal truck size and weight regulations are to facilitate safe and efficient freight transportation and interstate commerce, to establish highway design parameters, and to manage consumption of public infrastructure assets.*

The legislative history indicates that these three objectives are consistent with the intentions of Congress in enacting the regulations. These objectives are worthwhile, and truck size and weight regulation by the federal government contributes to their attainment, although the regulations ought to be complemented by other policies aimed at achieving the same goals. Evaluation of federal size and weight regulation should take into account how it affects all costs of highway transportation.

3. *Changes in truck size and weight regulations made in coordination with complementary changes in the management of the highway system offer the greatest potential to improve the functioning of the system.*

The best way to control the costs of accommodating existing and future truck traffic is by coordinating practices in all areas of highway management: design and maintenance of pavement and bridges; highway user regulations, including vehicle and driver regulations related to safety; and highway user fees. Imposition of cost-based user fees is a regulatory approach that could usefully supplement or partially replace size and weight regulation to produce more efficient control of the public and private costs of truck transportation. Whenever Congress contemplates changing policy in any one of these three areas in the federal-aid highway program, it should at the same time consider the need for complementary changes in the other two.

4. *The methods used in past studies have not produced satisfactory estimates of the effect of changes in truck weights on bridge costs.*

Past studies have not evaluated the changes in the risk of bridge failure or in useful life that would be caused by changes in truck weights. Instead, they have estimated the cost of maintaining the existing relationship of legal loads to bridge design capacity through bridge replacement. The estimated cost of these bridge replacements is the biggest component of the projected costs of accommodating larger trucks; however, many of the projected replacements would, if actually carried out, buy very little risk reduction. Past studies have not included quantitative evaluation of alternative methods of attaining the same or greater risk reduction through much less costly bridge management strategies.

5. *It is not possible to predict the outcomes of regulatory changes with high confidence.*

Development of improved models for analyzing the costs of operating trucks of different designs would be worthwhile. However, models and data will never be adequate for providing more than plausible indications of how institutions, markets, and technology will react to regulatory changes, especially in the long run. This inevitable uncertainty is not an argument for inaction, since maintaining the status quo would guarantee the loss of important opportunities for reducing the costs of

transportation. Responsible regulation is a process: the regulatory authority should do the best prior analysis possible, but once regulations have been changed, the consequences must be systematically observed and adjustments made where necessary. The chances that a regulatory change will yield a positive outcome will be enhanced if highway users have been given incentives to act in consonance with the public interest through enforcement, user fees, and application of performance standards in regulation.

6. *It is essential to examine the safety consequences of size and weight regulation. Research and monitoring needed to understand the relationship of truck characteristics and truck regulations to safety and other highway costs are not being conducted today.*

Understanding of these relationships is needed to design improved highways, vehicles, and safety management and pollution control programs, and to provide a solid basis for truck size and weight regulation. Progress toward reducing uncertainties surrounding the most critical interactions has been nearly nonexistent during the past decade. At least as important as the ability to predict the impacts of changes is to have information systems in place that allow observation of the performance of regulations and the consequences of changes once they have been made.

Promising techniques are available for improving the safety of large trucks. These techniques include vehicle designs for better control and stability, information technology applications for control and stability and collision avoidance, technology applications designed to improve enforcement, improvements in operator certification and training, and changes in highway design. However, little is known about the effectiveness of the majority of such measures that have been proposed. Because of this knowledge gap, as well as a lack of scientific understanding about the relation of safety to truck design, road features, and other factors influencing risk, it is likely that important opportunities to reduce accidents are being missed, while resources are being wasted on ineffective actions.

7. *Although violations of size and weight regulations may be an expensive problem, monitoring of compliance with the regulations is too unsystematic to allow the costs involved to be estimated.*

There is a need for direct and systematic observation of the frequency and impacts of oversize and overweight vehicles so that the costs

of violations (as well as of legally operated overweight permit vehicles) can be known and the effectiveness of enforcement methods evaluated. The technology needed for low-cost monitoring is now available.

RECOMMENDATIONS

1. Commercial Traffic Effects Institute

Congress should create an independent public organization with a charter to observe and evaluate commercial motor vehicle performance and the effects of size and weight regulation. This organization, referred to here as the Commercial Traffic Effects Institute, would be chartered to develop federal size and weight standards and related highway management practices, recommend regulatory changes, evaluate the results of the implementation of new regulations, and support state implementation of federal regulations. The Institute would be authorized to enter into agreements with private-sector entities to conduct joint programs of data collection, research, and evaluation.

Three considerations demonstrate the need for a new organizational arrangement. First, under present practices, federal size and weight policy has been deadlocked for more than a decade, in spite of general dissatisfaction with the regulations. Second, under the present system, regulatory changes that have occurred have been enacted without benefit of objective analysis or full public comment. For example, no new federal size and weight regulation has ever been subjected to a conclusive follow-up evaluation, and virtually no new information has been produced in the past decade that would help resolve the question of the safety effects of regulatory changes. Third, the committee's recommendation for a new system for federal supervision of state permitting (Recommendation 3 below) calls for federal oversight functions that are not consistent with the responsibilities and competencies of any existing federal agency.

Functions

Legislation creating the Institute should define the organization's objective as reducing the public and private costs of truck freight and passenger coach transportation by developing proposals for changes in size and weight regulations, as well as changes in related highway system management and operating practices, including user fee policy. The Institute should be charged with promoting innovation by providing a means to evaluate and implement private-sector or state

proposals for new motor vehicle or highway operating practices that would require federal regulatory accommodation.

The legislation that creates the Institute should define the scope of its activities by specifying three distinct functions:

- The conduct of pilot studies of proposed new vehicles and related operating practices, as well as research on the relationship of vehicle characteristics to highway transport costs. The Institute would solicit proposals for pilot studies and research from the private sector and the states, and would conduct studies jointly with them.
- Monitoring and program evaluation on an ongoing basis. Program evaluations would be conducted to measure whether practices intended to control accident risks and to operate highways efficiently (including size and weight regulations) were functioning as intended. Monitoring would consist of systematic observation in three areas: truck and coach traffic volumes and the distributions of vehicle dimensions and configurations; the administration of regulations, including enforcement and fees; and costs of truck traffic to highway agencies and to the public.
- Support for state implementation of federal size and weight regulations. The Institute should be responsible for reviewing state permitting practices and for developing model regulations and permitting practices as guidance for the states, as described in Recommendation 3 below.

The Institute should be required to recommend to Congress and the Secretary of Transportation changes in federal regulations when there is evidence that such changes would further the congressionally defined objective of reducing the public costs of commercial highway transport. The Institute should be authorized to make recommendations for harmonizing areas of federal highway policy related to size and weight regulation and to truck costs, including safety regulation, enforcement, infrastructure design and management, and user fees. It would not be inconsistent with the functioning of other areas of federal regulation to empower an executive agency to change federal size and weight limits, within boundaries specified by Congress, in response to needs revealed by monitoring and evaluation.

Organization

The Institute should be governed by a board with members drawn from the federal and state governments and the private sector. Funding for

core and continuing activities should be from federal highway user fees. Private sponsors of proposed new vehicles or regulations should participate in funding the evaluations of their proposals. A professional staff with diverse expertise would be essential.

The board should be required, as its first responsibility, to prepare a business plan and a technical plan for the Institute. The business plan should specify the form of cooperative relationships of the Institute with the states, the private sector, and other federal agencies. The Institute should be a resource that allows existing federal agencies to execute more successfully their established regulatory and administrative responsibilities related to truck size and weight. The technical plan would not be for a single large research project that would finally resolve all questions about the relation of truck size and weight to safety and other highway costs; no such study could be conducted. Instead, the plan would set forth a process that could be relied upon at any time as an essential part of the government's management of the highway system. The Institute should be subject to a sunset review by Congress after a specified time, possibly 6 years.

2. Evaluation of the Consequences of Changes in Truck Size and Weight Regulations Through Pilot Studies

Congress should authorize the Secretary of Transportation to approve pilot studies involving temporary exemptions from federal motor vehicle size and weight regulations for vehicles operating within alternative limits, operated by motor carriers that agree to participate in evaluation of the safety and other impacts of the alternative limits. DOT should approve pilot studies upon the recommendation of the Institute, which should be responsible for planning the studies, carrying out the evaluations, observing that carriers comply with the conditions of the studies, and recommending to DOT and Congress on the basis of the results of each study whether changes in federal regulations are warranted.

In this recommendation, a pilot study is defined as a controlled experiment designed to measure the consequences of changes in vehicle dimensions, weights, or operating practices; following a scientific design; involving the collection of data under actual operating conditions; and entailing direct observation of the primary impact of interest (e.g., frequency and severity of accidents) rather than proxies (e.g., vehicle stability or driver performance) alone. It would be necessary for vehicles participating in a pilot to be in compliance with the laws of the states in which they were operated or receive approval from the states

through established permitting processes or other state action. Congress should require that, as a policy, Institute programs promote cooperative, regional, multistate solutions to size and weight problems.

Legislation authorizing a pilot program should specify the general criteria that temporary exemptions would have to satisfy to be considered for permanent status. These criteria should include demonstration in the pilot study that an exemption is consistent with public safety and the requirement that any increases in highway agency costs be covered by user fees paid by operators of the vehicles.

3. Immediate Changes in Federal Regulations

Federal law should allow any state to participate in a federally supervised permit program for the operation of vehicles heavier than the present federal gross weight limit, provided the state satisfies the requirements outlined below. DOT should be authorized to certify, on the advice of the Institute, that a state meets these requirements. The Institute should be responsible for monitoring the consequences of the federally supervised permit program.

The federally supervised permit program provided for under this recommendation would rationalize the present, largely uncontrolled and unmonitored system of state-issued exemptions. The recommended federal oversight would be a mechanism whereby the performance of the regulations could be evaluated and adjustments made when warranted by the evaluations and by changes in external conditions. For the first time, Congress would know the consequences of changes in regulations. Improved information, together with greater facility to adjust regulations when necessary, would lead to regulations that more effectively promoted safety and controlled highway transport costs.

The permit program, implemented with federal oversight of safety, fees, and enforcement, would constitute a redefinition of the federal role in truck size and weight regulation. The federal government would have diminished involvement in defining numerical dimensional limits, but greater responsibility for ensuring that state regulations governing the use of vehicles on federal-aid highways were contributing to the attainment of national objectives. In effect, federal oversight would tend toward performance standards: states could propose solutions to problems, and the federal government would then assess whether the proposals met qualitative objectives. Federal regulation, by requiring states to justify their proposals on performance grounds, would continue to provide a buffer protecting state

highway programs from local, short-term economic pressures to depart from best management practices.

The opportunities created by the permit program would be expected to stimulate new multistate agreements on truck size and weight. Federal administration of the program should promote or require consultation among neighboring states. Expansion of regional agreements would constitute further evolution toward more rational standards and away from arbitrary state-to-state variations.

Size and Weight Provisions

Recommended size and weight provisions of the permit program are as follows:

- The states should be allowed to issue permits for operation, on any road where the use of such vehicles is now prevented by federal law, of
  - Six-axle tractor-semitrailers with maximum weight of 90,000 lb; and
  - Double-trailer configurations with each trailer up to 33 ft long; seven, eight, or nine axles; and a weight limit governed by the present federal bridge formula.
- After a transition period, all trucks operating under grandfather exemptions or state-specific exemptions from federal rules (when operating on roads where they could not be legally operated without such exemptions) should be made subject to the monitoring and evaluation requirements that would apply to trucks in the proposed new federally supervised permit program. Reliable information obtained in this way on the impacts of grandfather operation would allow Congress to decide whether the grandfather provisions should be altered or additional permitting flexibility should be extended to all states.

The recommended permit vehicle specifications are not presented as the optimum regulation. The definitions of the vehicles eligible for permitting would be subject to revision over time. Federal review of the performance of the permitting program would be permanent and ongoing, and the program's results would guide revision of the limits. Revisions would most suitably be instigated by recommendation of the Institute, following the procedures outlined in Recommendation 2.

Implementation Provisions

Enforcement A legislatively defined joint federal–state program for enforcement under the permit program should include the following four elements:

- Formal and effective performance monitoring of enforcement functions.
- Application of new enforcement tools, which may include imposition of federal penalties for violation of federal limits. Congress should consider requiring, as a precondition for state participation in the permit program, that the state enact enforcement provisions to effectively hold accountable the parties responsible for placing overweight loads on the highways and to target repeat violators. Such provisions might include information systems that would make possible identification of responsible parties and repeat offenders, as well as "relevant evidence" statutes.
- Adequate enforcement funding, including federal contributions derived from user fee revenues.
- A program to advance the application of information technology as an enforcement tool.

User Fees Legislation creating the permit program should specify a quantitative test for the revenue adequacy of the permit fees imposed by participating states. As far as possible, fees should be structured to avoid giving truck operators incentives to use truck configurations whose public costs exceed their private benefits. Fees should at least cover estimated administrative and infrastructure costs for the program when it is at its steady-state level, but proposals from states for fees that reflect other external costs or benefits, supported by well-reasoned arguments, would be acceptable. States that decide to participate in the program should be required to provide DOT with the data necessary to verify revenue adequacy.

Safety Requirements As a temporary measure, equipment requirements developed in the most rigorous existing state permit programs should be imposed on permit recipients. Requirements should be proposed by the states that apply to participate and should be reviewed by the Institute and approved by the Secretary. The requirements proposed could be more stringent than any existing requirements if the state provided a rationale for them. Their im-

plementation should be coordinated with the Institute's research on safety countermeasures.

Bridge Management A state where larger trucks come into use through the permit program will need a plan for cost-effectively alleviating constraints on the vehicles' use due to deficient bridges. The DOT responsibility for certifying that permit fees cover program costs implies the need to evaluate each participating state's management of the bridge costs of the larger trucks. The state application for participation in the permit program should include a plan for managing bridge impacts.

4. Longer Combination Vehicles

Federal law should allow operation of longer combination vehicles under the provisions of the federally supervised permit program outlined in Recommendation 3 and participation of these vehicles in pilot studies according to the procedures outlined in Recommendation 2.

5. Routes and Roads to Which Federal Standards Should Apply

The committee does not see justification at this time for any general revision of the specifications in federal laws and regulations regarding the networks of roads to which the various federal dimensional regulations are applicable. In particular, there does not appear to be justification for extending federal weight regulation to the non-Interstate portion of the National Highway System (that is, the system of principal arterial roads designated by federal law), where state regulations now govern most aspects of truck operations.

New enforcement mechanisms must be instituted and a plan for evaluating the safety effectiveness of route restrictions developed before any new federal regulations regarding truck operations on restricted networks of roads are enacted.

6. Research

The preceding recommendations call for three kinds of activities involving data analysis and research: systematic monitoring of truck traffic and truck costs to evaluate regulatory effectiveness, basic research on the relationship of truck characteristics to highway costs, and pilot studies to test new vehicles. The following are specific topics requiring research. Research on these topics should be conducted at congressional direction by the Institute (if a study topic is essentially related to

an established responsibility of a DOT agency, the study should be conducted cooperatively by the Institute and that agency):

- Evaluation of the effectiveness of the enforcement of size and weight regulations,
- Air quality impacts of changes in truck characteristics,
- Relation of truck performance to crash involvement,
- Risk-based bridge costs,
- Freight transportation market research,
- Costs of mixed automobile and truck traffic arising from nuisance and stress, and
- New infrastructure development and truck-only facilities.

Introduction

Chapter 1

Federal regulations that apply on major U.S. highways govern the weight and width of vehicles and the number of trailers that a power unit may tow. These regulations have important economic consequences because trucking accounts for four-fifths of expenditures on freight transportation in the United States, and trucking costs are influenced by truck size and weight. Size and weight limits also influence highway construction and maintenance costs and highway accident losses. The regulations affect international commerce as well because U.S. limits differ from those of Canada and Mexico and because containers shipped in international trade often are not consistent with U.S. regulations.

The most recent extensive revisions in federal truck size and weight limits were enacted in 1983. Since then there have been changes in the use and characteristics of the highway system, as well as important structural changes in the freight industries. Congress has received proposals for revisions to the federal limits from industry groups, state governments, and others. Proposals for changes in federal regulations governing vehicle size and weight have always been controversial, however, because allowing larger trucks could increase some categories of highway costs and attract freight from railroads to the highways. Trucking firms and shippers' groups typically advocate liberalization of the limits because larger trucks reduce their costs. The railroad industry, highway safety advocacy groups, some trucking firms (especially smaller ones), and some states oppose increases in federal size and weight limits.

In June 1998, Congress enacted the Transportation Equity Act for the 21st Century (TEA-21, Public Law 105-178), which provided $220 billion in highway and transit funding over 6 years. Section 1213i of the act instructs the Secretary of Transportation to request that the Transportation Research Board (TRB) "conduct a study regarding the regulation of weights, lengths, and widths of commercial motor vehicles . . . and develop recommendations regarding any revisions to law and regulations that the Board determines appropriate." The act

stipulates that the study consider regulation of commercial motor vehicles operating on federal-aid highways and that it encompass a review of laws, regulations, other studies, and practices; solicitation of input from the U.S. Department of Transportation (DOT), the states, the motor carrier industry, freight shippers, highway safety groups, air quality and natural resource management groups, and commercial motor vehicle driver representatives; and evaluation of the impact of study recommendations on the economy, the environment, safety, and service to communities. Recommendations are to be addressed to Congress and the Secretary of Transportation. Appendix A contains the text of the section of the act calling for the study.

At the request of DOT, TRB formed the Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles to conduct the study called for by Congress. This report is the committee's response to the legislation's study charge. The first section of this introductory chapter describes the purposes of truck size and weight regulations. The second section identifies the forces that have driven the evolution of these regulations in the past and that are generating calls for change today. The next three sections identify the principal directions for change that have been proposed, outline the challenges confronting reform, and describe the criteria and methods used by the committee in evaluating possible changes.

FUNCTION OF SIZE AND WEIGHT REGULATION

The first step in determining whether changes in the federal commercial motor vehicle weight, length, and width regulations would be appropriate is to define the function of the regulations. Several definitions may be given: the function the regulations are perceived to serve today, the objectives of legislators when the regulations were first enacted, a declaration of what the goals of regulation ought to be, or the actual function of the regulations as determined by the consequences of changing them. It is necessary also to distinguish the function of federal regulations from that of size and weight regulations imposed by state and local government.

Regulations Today

Motor vehicle size and weight regulations are among the most important factors determining road and bridge design and maintenance requirements and the cost of truck freight transportation. All the states regulate the weight and dimensions of vehicles on public roads. In general, these state regulations govern the following dimensions:

- The maximum weight on any single axle;
- The maximum weight on any group of axles on a vehicle (for example, the last four axles of a five-axle tractor-semitrailer) as a function of the span of the axle group and the number of axles (this limit is called a bridge formula and is intended to protect bridges from excessive flexural effects by avoiding heavy, clustered, concentrated axle loads);
- The maximum weight of the entire vehicle;
- The maximum length, width, and height; and
- The maximum number of trailers.

Some states regulate other dimensions as well, and some impose separate limits for different classes of roads. In all states, various kinds of special permits, exemptions, and grandfather rights allow some trucks to operate at dimensions exceeding the normal limits. There are also special provisions imposing more restrictive limits on certain roads and bridges. Vehicle dimensions control the applicability of other laws as well; for example, certain federal vehicle safety regulations apply to trucks over 10,000 lb, and user fees vary with weight.

The states began to regulate vehicle dimensions before World War I. Federal limits were first enacted in 1956 in the legislation that created the federal-aid highway program and were revised in 1975 and 1983. Federal law dictates the axle weight limit, gross weight limit, and bridge formula on the 46,000-mi Interstate highway system, as well as on a network of major roads that includes the Interstates and about 160,000 mi of other roads; dictates minimum trailer length and width limits that the states must permit; and requires the states to allow double trailers.

The states enforce limits through roadside inspections at permanent and portable scales. Estimates of the frequency of illegal overloads range from a few percent to 20 percent of all combination trucks on the road at any given time (TRB 1990a, 141), but definitive data on the violation rate do not exist.

The content of the regulations and the criteria applied by public agencies to evaluate proposed changes imply that the purpose of the size and weight limits in effect today is to control certain public costs associated with large trucks:

- Highway construction and reconstruction costs—The strength of pavement and bridges, lane widths, and horizontal and vertical alignment are dictated by the requirements of the largest vehicles on the road.

- Highway maintenance and rehabilitation costs—The wear on pavements, shoulders, and bridges depends on vehicle configurations and weights and traffic volumes.
- Congestion—Larger vehicles generally have less maneuverability and less acceleration capability, require longer distances to pass, and consume more road space.
- Accidents—A collision involving a large truck and an automobile is more severe on average than one involving only automobiles. Dimensions and configuration affect vehicle handling, stability, and traffic interactions and are believed to affect accident rates.
- The cost control goal has been apparent in federal as well as state actions on size and weight. The history of the regulations also indicates that the limits have been seen as a mechanism for controlling competition between trucks and other freight modes, although this end is not always made explicit.

Federal regulations specify the following vehicle dimensions:

- The maximum weight on any single axle (20,000 lb) and on any tandem axle, that is, any pair of closely spaced axles (34,000 lb), for vehicles on Interstate highways.
- The maximum weight on any group of axles on a vehicle (for example, the last four axles of a five-axle tractor-semitrailer), as a function of the span of the axle group and the number of axles, on Interstate highways (the bridge formula).
- The maximum weight of the entire vehicle (80,000 lb) on Interstate highways—States cannot impose lower weight limits than the federal limits on Interstate highways.
- The width of vehicles—Federal law requires states to allow vehicles 102 in. wide on the National Network for Large Trucks, a federally designated network that includes the Interstates and 160,000 mi of other roads.
- Trailer length and numbers—Federal law requires the states to allow single trailers at least 48 ft long and tractors pulling two 28-ft trailers on the National Network.

The other main provisions of the federal regulations are as follows:

- Grandfather exemptions—States in which vehicles exceeding a federal limit were in operation before the enactment of the federal limit may continue to allow the vehicles to operate indefinitely. The exemption applies to state permit operations as well as to general state limits.

- Statutory special exceptions—Federal law contains several exemptions applying to particular operations in specified states.
- LCV freeze—No state that did not allow operation of longer combination vehicles (LCVs, defined in general as multitrailer combinations having any trailer longer than 28 ft, having more than two trailers, or weighing more than 80,000 lb) on roads of the National Network before June 1991 may legalize operation of such vehicles on the National Network.
- Intrastate public transit buses—These vehicles are temporarily exempt from the axle weight limits.
- Enforcement—The states are required to certify that they have effective programs for enforcing weight limits on federal-aid roads as a condition for receiving federal highway aid.

Appendix B contains the text of the federal size and weight laws.

Federal statutory limits do not by themselves dictate vehicle dimensions. State regulations apply on roads where federal limits do not, and grandfather and permit operations of vehicles exceeding statutory limits are common. Many large trucks normally operate with dimensions below the limits (e.g., carriers specializing in commodities of low average density operate below the gross weight limit).

Historical Goals of Federal Regulation

Federal regulation implies that there are national goals that could not be attained by state regulation alone. The original intent of federal limits is explained in part in the report of the House Committee on Public Works on the bill that became the Federal Aid Highway Act of 1956 (H. Rept. 2022, 84th Cong., quoted in BPR 1964, 10):

> The committee recognizes that maximum weight limitations for vehicles using the highways are fundamentally a problem of State regulation, but feels that if the Federal Government is to pay 90 percent of the cost of Interstate System improvements it is entitled to protection of the investment against damage caused by heavy loads on the highway. The committee considers that such protection can best be provided by a limitation on maximum axle loadings.

The 1956 act initiated the construction of the Interstate highway system, for which the federal share of costs was to be 90 percent. The limits enacted in 1956 were taken from the recommended practices of the American Association of State Highway Officials then in effect.

The act required the Secretary of Commerce and the states to develop uniform geometric and construction standards for the Interstates. The weight limits would facilitate uniform standards for strength of pavements and bridges, while the width limit apparently was to facilitate uniformity of highway geometric design (BPR 1964, 9–11).

The circumscribed role for federal regulation apparently intended in 1956—to protect the federal investment in roads and bridges and allow uniformity of highway geometric design—was broadened in the 1983 revisions to the federal limits. Those revisions included the first requirements that states with more restrictive limits liberalize them to conform with the federal standards. Such minimum standards are not necessary for uniformity of highway design or control of maintenance costs. Their justification is that removing unjustifiably restrictive state limits reduces trucking costs. Evidently, Congress had added the federal regulatory goal of attaining a degree of uniformity in trucking regulations for the sake of the economic benefits of greater truck capacity in interstate commerce (TRB 1986, 28–29, 51–53).

The 1991 LCV freeze was the first federal law that prohibited states from allowing vehicles with larger-than-specified dimensions on roads other than Interstates. Such a rule might be imposed on grounds of infrastructure economy, as were the 1956 limits. The LCV freeze was, however, apparently the first federal rule justified in large part as a safety measure.

Appropriate Goals

The historical record does not supply a full definition of the intended function of motor vehicle size and weight regulations. It would not be inconsistent with the history of their development, however, to define their function as providing a mechanism to balance the potential public costs of truck travel—wear on public infrastructure, accident risk, and congestion—against the benefits of lower shipper and carrier costs for freight transportation. In principle, it should be possible to specify optimum regulations that strike the best balance and allow the public to derive the greatest benefit from the highway transportation system.

A comparison with railroads may be instructive in defining the goals of highway size and weight regulations. A railroad company has need of dimensional standards for locomotives and cars so it can design and maintain its rights-of-way, track beds, and equipment consistently. In contrast with a public highway agency, the railroad knows and bears all the costs of changes in the standards and has information on customers' willingness to pay for new or improved services that would re-

quire such changes. Therefore, the railroad's selection of its dimensional standards is a routine business decision, involving use of marketing and cost data to select standards that will be most profitable. The public highway agency's problem in selecting size and weight limits is more difficult than the railroad's for two reasons. First, the taxes and fees paid by highway users are not closely related to the costs users cause, so the agency has much less information than does the railroad about the market and costs. Second, the highway agency is concerned not only with deriving the greatest possible economic benefit from the public's investment in roads (analogous to the railroad's criterion of profit maximization), but also with other social values, and is accountable to multiple constituencies with sometimes conflicting interests.

Federal determination of size and weight standards as opposed to state regulation has been justified by two arguments, both of which are reflected in the history of the development of the federal standards summarized above. The first argument is that harmonization of standards reduces freight costs and that this benefit can be attained only through coordinated action. For example, nationwide standards may lower costs by reducing the need for vehicle design variations and allowing the same vehicles to operate nationwide. The federal government's responsibility for interstate commerce justifies federal regulation in such a circumstance. A minimum federal responsibility is to ensure that interstate or international commerce is not severely impeded by unduly restrictive regulations in a single state or small number of states.

This argument is prominent in the Interstate Commerce Commission's (ICC) analysis of the justification for federal intervention in size and weight regulation in its 1941 report to Congress (ICC 1941, 24–26). This first congressionally mandated study of the issue had been ordered by Congress in 1935. At the time, there was no major federal-aid highway program, so the direct federal interest in controlling highway construction and maintenance costs that was later cited by Congress to justify the 1956 federal size and weight limits did not exist. Nonetheless, the analysis remains relevant today. The ICC concluded first, regarding the powers of Congress and the possible rationales for action:

> that Congress has plenary power to remove unreasonable obstructions to interstate commerce. If State regulations governing sizes and weights of motor vehicles operate in fact to burden or obstruct interstate commerce unreasonably, Congress may enact legislation designed to secure uniformity or in other respects to protect the national interest in the commerce. . . .

> It is also concluded that under a broad policy seeking to preserve essential forms of transportation, such as those by railroad and by water, as well as by motor truck, or to promote safety in highway use, Congress could establish size and weight limits for motor vehicles, applicable to interstate traffic, lower than those now applicable to such traffic under State laws.

Regarding the actual need for federal action, the ICC concluded:

> with respect to the public highways which serve as the principal arteries of interstate commerce, State limitations may be, and to a considerable extent probably are, less liberal than is necessary for the proper protection of the highways and their appurtenances and of the public safety. . . .
>
> where such conditions exist, the limitations operate as an obstacle to the flow of interstate traffic, render motor transportation more costly, and result in an impairment of service to the public. . . .
>
> in the light of the broad public interest in the securing of as economical and efficient a motor transport service as possible, as well as in the light of the requirements of the national defense, . . . there is need for Federal regulation of the sizes and weight of motor vehicles. . . . Burdens on interstate commerce cannot be relieved through the judicial processes; only legislation can afford the needed relief. . . .
>
> considerations of safety and convenience do not, in and of themselves, require that Congress enter this field of regulation, but we do find that the evidence available justifies the conclusion, that if Federal regulation be undertaken for other reasons, there will be need for consideration of certain phases of sizes and weight in their relation to the safety and convenience of users of the highways. . . .
>
> national uniformity of standards is impracticable . . . on the contrary, Congress should enter this field only to the extent that proves necessary under the circumstances of particular situations. . . .

The second argument for federal regulation is essentially the same as the rationale for the federal-aid highway program: that the value of investments in the system of main highways from the point of view of the nation as a whole is greater than the value as seen by the individual states that would otherwise be responsible for investment decisions. For example, a sparsely populated western state whose roads carry a large volume of through traffic between the major population centers of the West Coast and the Midwest might see little need to invest in high-quality through roads to serve its own population and (as long as road use was free) would have no mechanism for capturing any of the economic benefit of the through traffic. The need for federal size and weight regulation is incidental to the need for the federal-aid program: if a local government lacks interest in constructing a road on its own, it is also likely to lack interest in managing or maintaining the road, so federal standards will be needed.

Some of the considerations that have played a part in setting size and weight restrictions in the past are questionable as goals for these regulations. Both the TRB *Truck Weight Limits* study (TRB 1990a) and the recent DOT *Comprehensive Truck Size and Weight Study* (DOT 2000) indicate that imposing nationwide uniform limits more restrictive than those previously in effect in many states would increase shipper costs by an amount greater than any compensating savings in highway operating costs. Uniformity per se is likely to be less efficient than toleration of regional variability in standards if the variability reflects actual differences in traffic and highway conditions and therefore in the costs of operating trucks of various dimensions. A second questionable goal is attempting to regulate competition among the freight modes by restricting truck dimensions.

DRIVING FORCES FOR CHANGE

Changes in motor vehicle size and weight regulations have historically been driven by external forces. The limits have changed continually throughout the development of the highway system as a consequence of the expansion of the system, improvements in vehicles and roads, and economic pressures for cost reduction in industry. Improvements in highways and freight vehicles and the resultant changes in size and weight limits, together with innovations in the management of freight and logistics, have been important sources of productivity growth. As long as the external driving forces persist, the regulations will continue to change through the political process. Planning for

change affords the public authorities responsible for the highway system an opportunity to manage this process rather than risk haphazard development.

The report of a 1990 TRB study committee that considered truck size and weight policy observes (TRB 1990b, 15):

> In the past, the regulations have been subject to nearly continuous incremental revision. The result has been trucks that are not ideal from the standpoint of highway wear, freight productivity, or safety. Highway engineers are dissatisfied with current standards because heavy truck traffic accounts for a large fraction of road wear. Throughout the country roads and structures do not stand up well to the loads they must carry, and highway agencies lack the funds to perform more frequent maintenance. At the same time, motor carriers and shippers point out that the benefits from reduced freight cost of allowing larger trucks could greatly outweigh the costs of repairing the added road wear that larger trucks would cause; and safety advocates, motorists, and the public are concerned that trucks are involved in a disproportionate share of the most severe highway accidents.
>
> Thus, the situation today is that substantial economic benefits could be gained through use of larger trucks, but chronic funding shortages in state highway maintenance programs and fears of the hazards of larger trucks stand in the way of gaining these benefits.

In the decade since this report was issued, many conditions have changed: state highway programs have received substantial funding increases; pavement and bridge design methods have advanced, and new technology for enforcing highway regulations and collecting user fees is increasingly available; technology has improved vehicle performance; and the freight and logistics sectors have experienced important technological advances and productivity gains. Federal motor vehicle size and weight limits have not undergone overall revision in this period, so it is likely that the gap between existing limits and optimum vehicle standards is greater than ever.

Changes in these three factors—highways, vehicle technology, and freight customer service demands—account for the evolution of size and weight limits throughout the century. The system of paved roads in the United States had reached 500,000 mi by the late 1930s and

1 million mi by 1956, and stands at 2.5 million mi today. The construction of a system of roads built to Interstate standards—designed for safe and efficient operation with high traffic volume, high speed, and heavy loads—has been the major highway advance of the latter half of the century. In the United States there was 1,100 mi of divided highway with full access control in 1956, 22,000 mi by 1966, and 42,000 mi by 1976; today there is 57,000 mi (FHWA 1987, Tables SM211, M203; FHWA 2000, Tables HM12, HM 35; TRB 1986, 33–36). Highway agencies also have adopted pavement and bridge designs and pavement and bridge management practices that have reduced the costs of accommodating larger vehicles, and are beginning to apply information technology for traffic management and regulatory enforcement, including systems for automatic screening and electronic identification of trucks to improve enforcement efficiency. Similar technology is used for collecting tolls, and could be applied more widely to levy user fees that would give highway users incentives to consider infrastructure costs and costs to other users in their transportation decisions.

Advances in the design of heavy trucks in the past half-century include improvements in diesel engines that resulted in their being used to replace the gasoline engine for nearly all intercity freight by the 1960s, as well as great improvements in brakes, transmissions, and suspensions. These advances have contributed significantly to the productivity of the trucking industry (Gordon 1992) and have made larger loads and long-distance operations feasible. More recently, applications of electronics and information technology have improved operating efficiency and have begun to be applied to improve vehicle control and safety.

Trucking industry operating practices are driven by customer demands. Today as in the past, customers place a premium on reliability, speed, and flexibility. Shippers appear to be aware now more than ever of the potential for cost savings through better management of logistics. However, changes in logistics management practices may not have greatly altered shippers' demands as they affect vehicle size and weight requirements. Shippers have always sought lower freight rates, which can be attained by using vehicles with greater weight and volume capacity. Changes in logistics practices and in the composition of U.S. production and consumption, however, may be altering the relative significance of increasing the volume capacity of trucks as opposed to increasing weight capacity. For example, shipments of high-value manufactured goods (e.g., processed food or electronics) have

lower average density than shipments of basic materials (e.g., grain or unfinished steel). If production and consumption are growing faster for high-value goods than for basic materials, average shipment density will decline. An additional trend in demand that has affected size and weight requirements is the growth of international trade, which has highlighted the problems of differences in size and weight limits among the United States, Canada, and Mexico, as well as differences among the United States, Europe, and Asia in practical intermodal container weights.

The result of all these developments in roads, vehicles, and management practices has been improved efficiency of freight transportation, which has benefited the public economically. The elimination of federal economic regulation of motor carriers in 1980 also contributed to improved efficiency by allowing carriers to respond to customer requirements. Total factor productivity in for-hire trucking (the ratio of the value of trucking services to the value of all inputs to the industry in constant prices) grew 2 percent annually during 1948–1978 and 1 percent annually during the 1980s (Gordon 1992). Faster growth in the earlier period is not surprising, since this was the time of the most dramatic changes in roads and vehicles. This rate of productivity growth is healthy in comparison with that of the economy as a whole (BLS 2001). If this valuable productivity trend is to continue, it will be necessary to search for additional sources of efficiency gain.

Regulatory changes stimulated by these external forces have come about through the workings of the political process. The interests and preferences of affected industries, motorists, and other constituencies have provided the motivation for changing the regulations. Decisions on the regulations are necessarily political, rather than purely technical, because they can have the effect of benefiting some parties at the expense of others. The process of change often is described as "ratcheting": industry gains a particular liberalization of limits in one jurisdiction, creating pressure for the change in neighboring jurisdictions to avoid economic disadvantage or because the new operating practice has been demonstrated to be feasible. Soon holdout jurisdictions are being labeled as barriers to uniformity, and eventually the change becomes universal. This dynamic is not an indefensible process. Innovations naturally propagate quickly through any industry. The process is undesirable only if the innovation is harmful.

Some decisions to change regulations have been well supported by engineering and economic analysis and professional evaluation.

For example, a major DOT study mandated by Congress (DOT 1981) produced results that for the most part supported the changes in federal size and weight laws contained in the 1983 highway act, and the 1956 federal standards were derived from consensus recommended practices of the American Association of State Highway Officials. Other important regulatory developments, however, have not been preceded by analysis or have been unintended consequences of legislative actions; for example (as Chapter 2 describes), widespread adoption of 53-ft semitrailers following the 1983 act was not anticipated. Moreover, no change in federal size and weight regulations has been subjected to a thorough follow-up evaluation to observe how the change in law actually affected truck traffic and highway costs.

Recently, local exemptions to federal limits (described in the next section) have been enacted without full analysis of the possible consequences. The exemptions for Maine, New Hampshire, Colorado, and Louisiana in TEA-21 required the states to study the impact of the exemption. However, the law provided no standards to guide the states in conducting the studies and no linkage between the outcomes of the studies and any regulatory action.

Recent Federal Regulatory Issues

Three recent federal size and weight issues illustrate the pressures for relaxation of federal limits faced by Congress: proposals for federal enactment of state-, route-, and industry-specific exemptions to the limits; the request of a group of governors for federal evaluation of wider use of LCVs restricted to the western region; and size and weight issues connected with international trade. These three issues also suggest inadequacies in present arrangements for responding to regulatory problems as they arise.

Exemptions

TEA-21 [Section 1212(d)] contains special provisions for four states:

- Defining loads of two or more precast concrete panels in the state of Colorado as nondivisible loads,
- Authorizing Louisiana to permit trucks hauling sugar cane during the harvest season on Interstate highways at 100,000 lb gross weight, and
- Exempting specified Interstate highway segments in Maine and New Hampshire from federal weight limits.

These are the only size and weight provisions in the legislation. Congress enacted other special provisions in the National Highway System Designation Act of 1995 (P.L. 104-49, Sec. 312) exempting specified highways in Iowa and Wisconsin from weight limits and allowing longer combination vehicles on an Iowa highway (an exemption from the 1991 LCV freeze). In all, the section of the United States Code on federal weight limits now contains special exemptions naming 15 states (23 USC 127). These are in addition to the state exemptions under the grandfather clauses in federal law. Other states have sought exemptions that have not yet been enacted.

The arguments of proponents of the Maine exemption are representative. Local government officials reported that the federal limits were forcing the largest trucks off the best roads (the Interstates) and onto lesser roads and city streets, where the heavier loads are allowed under state law (Maine Municipal Association 2000). State officials also argued that the federal limit was unjustifiable in light of grandfather exemptions that allow the heavier trucks to operate in other nearby northeastern states (Babcock 1998). In a good illustration of the ratcheting phenomenon described above, a bill was introduced in 2001 to extend the Maine exemption, which applied to I-495 and I-95 south of Augusta, to the entire length of I-95 in the state. The bill called for a 3-year trial, with the exemption made permanent if evaluation of the safety consequences of the trial was positive (Woolard 2001).

The cumulative impact of the recent special exemptions from a national perspective is slight. However, they represent a cumbersome and potentially arbitrary approach to addressing federal regulatory issues.

Western States' LCV Proposal

In 1999, after a draft of the DOT *Comprehensive Truck Size and Weight Study* (DOT 2000) had been released, the Western Governors' Association, in a letter to the Secretary of Transportation, asked that the DOT study be modified to include analysis of a regulatory scenario involving expanded use of LCVs in 14 western states and that in the new analysis, the assumed LCV dimensions be consistent with those currently used in the west. In its original study, DOT evaluated only nationwide use of LCVs, and its definitions of LCVs assumed larger dimensions than those of typical LCVs already in use. The association debated seeking federal approval for a pilot project to test western regional regulation of LCVs, but rejected the proposal after hearing objections from railroads and the American Automobile Association (AAA) (Barnes 1999).

Federal provision for a western LCV network is not a new proposal. DOT evaluated the concept in a 1986 study (FHWA 1986) at the direction of a congressional committee after a 1985 congressionally mandated DOT study of LCVs led to the following conclusion: "There is no compelling reason for designation of a federally mandated LCV network at this time. . . . There are positive aspects of LCV use, but many unresolved issues argue against their immediate widespread use" (FHWA 1985, S-8).

Also in 1999, an American Association of State Highway and Transportation Officials (AASHTO) policy resolution identified various shortcomings in the draft *Comprehensive Truck Size and Weight Study* and called on DOT to consult with the states and private parties in the course of completing the study (AASHTO 1999). Although DOT had described the purpose of its study as developing a method of analysis rather than policy proposals, the states evidently perceived the additional need for the federal government to address certain of their immediate policy concerns.

The state reactions to the DOT study, as well as the history of special state exemptions to federal law, suggest that at least some states have found federal regulatory practices inflexible and unresponsive to local needs. The states might be more satisfied with an approach to the review of federal size and weight regulations that was more open to them and that focused on the practical size and weight issues they confront. Although the history of size and weight regulation shows that demands continually arise to adapt the regulations to changing external circumstances, there is no established mechanism at the federal level for responding to such demands with timely evaluation. The replies of the states to this committee's request for comments show that they value the function of federal regulation as a buffer protecting state highway programs from the local and short-run economic pressures they face to depart from best management practices. Providing some degree of regulatory flexibility according to an established procedure might help preserve this federal role.

International Trade

The North American Free Trade Agreement (NAFTA) is an immediate impetus for review of the federal regulations governing truck size and weight. The agreement among Canada, the United States, and Mexico was signed in 1992 and became effective in January 1994. Its provisions reduce barriers to trade among the three countries. The NAFTA parties agreed to seek compatibility of standards related to

vehicle weights and dimensions, as well as safety-related vehicle standards and emission standards to facilitate cross-border movement of goods (LTSS 1997, 3). The NAFTA schedule called for agreement on compatibility of size and weight and other vehicle standards by January 1997 as a step toward full cross-border access for trucks by January 2000 (GAO 1996, 19).

Limits differ greatly among the three nations. Canada and Mexico allow heavier axle weights than those of the United States. Six-axle tractor-semitrailer combinations are common in both countries, with maximum legal weights of approximately 106,700 lb in Mexico and 95,700 to 116,600 lb (depending on the province and the axle spacings) in Canada. Multitrailer combinations are more important in Canada than in the United States or Mexico (LTSS 1997, 31, 45). However, the heaviest as well as the longest combinations in routine use in North America probably are to be found in certain states in the United States. Recently, an international working group developed a proposal for harmonization measures, under which an International Access Network of roads would be designated by the responsible road authorities within each of the three countries. On this network, trucks meeting specified criteria regarding handling and stability performance and pavement loading would be allowed to operate internationally (LTSS 1999). In principle, a solution would be to require all vehicles in cross-border traffic to comply with the most restrictive nation's size and weight standards, but presumably the goal of the negotiations is a compromise under which some vehicles closer to Mexican and Canadian standards could enter the United States. A resolution of the issue of harmonization of vehicle standards is not at hand. It should be noted that size and weight regulation is only one obstacle to realization of the objective of free cross-border trucking.

Because U.S. weight limits are lower than those enforced in most other countries, cargo containers in international commerce arriving at U.S. ports of entry are commonly loaded to weights that cannot be carried within the 80,000-lb federal limit. A ruling of the Federal Highway Administration (FHWA) allows states to issue permits for containers in international commerce as if they were nondivisible loads (DOT 2000, III-13–III-14). This ruling must be regarded as an arbitrary solution to the problem, considering that some states do require overweight container loads to be broken up and that no such allowance is made for containers in domestic commerce.

The history of efforts to reduce conflicts between international commerce and U.S. limits, together with the recent state petitions for federal

consideration of local and regional circumstances, illustrates how legitimate grounds for considering changes to the federal regulatory regime frequently arise. Also apparent is the fact that the existing regulatory machinery does not provide orderly procedures for resolving such cases.

DIRECTIONS FOR CHANGE

Because the environment is dynamic, meeting the goals of federal truck size and weight regulation requires periodic revisions to the regulations, responding to changes in conditions that have affected the use of highways and the costs of highway transportation. Evaluating the adequacy of the regulations and seeking to improve them ought to be a continuous process.

A broad range of possibilities for the form of revised federal regulations has been proposed by past studies, private-sector groups, states, and others. The options can be organized into three categories:

- Policies within the existing framework and precedents of federal truck size and weight regulation. New policies involve changes in axle weight and other dimensional limits, changes in the extent of the road system on which federal standards apply, and provisions such as the 1983 federal law regarding double trailer trucks that requires the states to allow certain configurations on certain roads. Options in this category are consistent with the critical assumptions of the DOT (2000) study that new policies entail no changes in pavement and bridge design practices, basic truck design, or highway user fees. Past size and weight studies such as those of TRB and DOT, have focused mainly on this category of options, and the evaluation methods developed in those studies are most applicable to these options.
- Approaches outside the existing framework of federal size and weight regulation. These proposals involve changing the structure of the regulations instead of simply changing the limits. There are three important kinds of proposals in this category:
  - Performance standards—regulations that directly specify required vehicle performance instead of attempting to control performance indirectly through dimensional limits. For example, a standard could require that trucks pass a test of resistance to rollover as an alternative to a gross weight limit intended to restrain rollover propensity.
  - Pricing—setting fees that induce truck operators to select equipment with lower public costs. For example, fees related more closely to costs could discourage operation of certain configurations

now in use that generate relatively high pavement wear costs (or alternatively, finance the additional maintenance these configurations necessitate). More refined pricing also would affect shippers' logistical and location decisions.

– Devolution—returning regulatory responsibilities to the states.

These approaches could complement established forms of regulation instead of wholly replacing them. However, existing data and models are inadequate for predicting some of the important conceivable effects of these kinds of policy changes.

- Options in addition to changing the size and weight regulations that would achieve the same underlying goal of controlling the costs of truck traffic while allowing for efficient freight transportation. Examples of such policies include improved enforcement of size and weight limits and safety regulations; bridge management activities targeted at reducing the effect of trucks on bridge construction, maintenance, and replacement costs and on the risk of bridge failure; changes in pavement design practices; and exclusive truck routes or lanes. Evaluation of such options along with evaluation of size and weight regulatory options could lead to better overall solutions.

Box 1-1 lists examples of each of the above three categories. The list includes options for comprehensive overhaul of regulations, as well as changes limited to specific provisions of existing regulations. It includes options that are under active discussion today and others that are receiving little or no attention. Some of the options are described more fully in Chapter 3.

CHALLENGES CONFRONTING REFORM

As described above, dissatisfaction with various aspects of present federal regulations governing truck size and weight has become widespread. Since the latest revision in 1983, several prominent evaluations of size and weight policy have led to proposals for overhaul of the regulations, supported by objective analysis. Yet these proposals have had little impact on policy because no constituency has formed to support them. Various legislative proposals during the same period have failed to win passage. Any proponent of reform must acknowledge this discouraging record and examine the sources of the difficulties Congress has confronted in dealing with the issue.

The historical alignment of opposing forces in debates over size and weight regulation was discussed above. Shippers and carriers,

Box 1-1

Options for Changes in Federal Weight, Length, and Width Regulations and Related Policies

Policies within existing framework and precedents of federal truck size and weight regulation

These do not entail changes in pavement and bridge design practices, basic truck design, or highway user fees:

DOT Comprehensive Study illustrative and policy scenarios (DOT 2000)

- Uniformity—extension of federal weight limits now applicable on Interstates to all roads on the 200,000-mi federally defined National Network; elimination of grandfather provisions
- North American trade—heavier vehicles with added axles (six-axle tractor-semitrailer, four-axle truck, eight-axle double 33-ft trailer combination) on the National Network
- Longer combination vehicles nationwide—long double- and triple-trailer combinations on restricted networks with staging areas; eight-axle double 33-ft trailer combinations on the National Network and access routes
- H.R. 551—elimination of trailers over 53 ft on Interstates and some other federal-aid roads; freezing of grandfather rights; freezing of state weight limits (including permits) on federal-aid roads
- Triples nationwide—triple-trailer combinations (seven axles, 132,000 lb) nationwide on a 65,000-mi network of Interstates and other high-quality roads nationwide and state-selected access routes

Current proposals, including industry proposals

- State option for longer combination vehicles
- Peterson-Cook bill—97,000-lb six-axle tractor-semitrailer state option
- Case-by-case legislative exemptions from federal standards; e.g., TEA-21 exemptions

(continued)

Box 1-1 *(continued)* **Options for Changes in Federal Weight, Length, and Width Regulations and Related Policies**

Recommendations of earlier TRB study committees

- New bridge formula from *Truck Weight Limits: Issues and Options* (TRB 1990a)
- Turner proposal (TRB 1990b)—state option to allow nine-axle, 111,000-lb double 33-ft trailer combinations with coordinated bridge management and fee changes

Approaches outside the existing framework of federal size and weight regulation

- Permitting program recommended for heavier trucks on Interstates (TRB 1990a)
- Performance standards defined as the basis for certification of operator-proposed vehicles
- Reform of federal user fees to align them closely with costs occasioned, coupled with optimal pavement design; e.g., *Road Work* (Small, Winston, and Evans 1989) proposal
- Devolution of regulatory responsibilities to the states

Options in addition to changing the size and weight regulations that would achieve the underlying goal of controlling the costs of truck traffic while allowing for efficient freight transportation

- Improved enforcement of size and weight limits and safety regulations
- Improved bridge management targeted at reducing the effect of trucks on bridge construction, maintenance, and replacement costs and on the risk of bridge failure
- Changes in pavement design practices
- Exclusive truck routes or lanes

Note: The above list is not exhaustive, but rather indicates the range of possible changes.

interested in reducing their costs, have supported liberalization, while parties that expect to be harmed economically by lower trucking costs have opposed it. The latter include railroads; some small trucking companies that do not want to be forced by competition to invest in new equipment; and, in some cases, truck drivers concerned about jobs and working conditions.

In addition to these economic interests, other forces have become increasingly important in truck size and weight debates. Motorists' attitudes toward and perceptions of large trucks have played a central role. Survey data and common experience suggest that automobile travelers find large-truck traffic to be a source of stress and discomfort. In past studies, this effect has been treated as no more than a manifestation of the impacts of trucks on accident risk and congestion. However, there may be additional costs arising from motorists' antipathy toward sharing the road with large trucks that are independent of the costs of changes in accident frequency and congestion. The test to determine whether these effects are real costs is to see whether they lead to observable changes in behavior that impose costs on travelers. The volume and characteristics of truck traffic on particular roads may affect highway users' route selections, times of travel, and frequency of trips.

Regardless of how important these comfort and convenience impacts may be, however, it is possible that incremental changes to federal size and weight regulations would have little effect on their magnitude. Motorists' comfort and convenience may be insensitive to incremental changes in some truck dimensions, such as maximum gross weight. Also, although the effect of size and weight limits on the volume of truck traffic is uncertain, it is possible that in some circumstances, making limits more restrictive would increase the volume of truck traffic because each truck could carry less freight. Therefore, motorists would encounter more frequent, smaller trucks per mile of travel, and the net consequences for comfort and convenience would not necessarily be positive.

Other important bases for opposition to change in the regulations have included objections on the grounds of the environmental impacts of increased reliance on trucks, as well as concerns, especially among state officials, that any action disturbing the status quo would set in motion a process that would be difficult to control or to maintain in balance. States are wary of any change that could negatively affect highway finance.

Already noted above is the problem of the lack of established institutional mechanisms for evaluating proposals from the states, industry, or others for revisions to the regulations. Federal truck size and weight

studies, in particular, faced with a highly controversial issue and lacking a clear sense of direction from Congress, have emphasized the poor quality of the information base for supporting objective evaluation of alternative policies. More credible information about the likely impact of changes in size and weight regulations on safety and traffic might not sway some of the strongly held views on the subject, but would facilitate the task of reaching consensus on how to improve the regulations.

EVALUATING THE OPTIONS

A base of understanding about the likely effects of changes in size and weight regulations has been developed from experience with changes and the results of past evaluations. ICC's 1941 study cited above was the first analysis of the potential benefits of federal regulation of motor vehicle dimensions. Comprehensive studies of the issue were produced by the Bureau of Public Roads (BPR 1964) and DOT (DOT 1981), and DOT issued two studies of multitrailer combinations (FHWA 1985; FHWA 1986). DOT released the preliminary results of its most recent evaluation of federal limits in 1998 (DOT 1998) and the final report 2 years later (DOT 2000). State highway agencies have conducted numerous analyses of limits during the past 75 years. TRB committees conducted four policy studies on the topic between 1986 and 1990: *Twin Trailer Trucks* (TRB 1986), *Providing Access for Large Trucks* (TRB 1989), *Truck Weight Limits: Issues and Options* (TRB 1990a), and *New Trucks for Greater Productivity and Less Road Wear* (TRB 1990b).

The 2000 DOT study, the TRB studies, and most of the earlier studies employed a common analysis method in which alternative sets of size and weight limits are specified, and predictions are made regarding the truck configurations that would become attractive under the new limits and the volumes of freight these configurations would carry. Engineering and economic models are then used to predict the consequent changes in pavement and bridge construction and maintenance costs, frequency of highway accidents, congestion, freight transportation costs, and pollution.

Past studies have tended to reach similar conclusions: that incremental increases in allowable truck size can produce substantial net benefits. Predicted increases in infrastructure costs generally are smaller than predicted freight cost savings, and predicted safety effects are often positive if increasing truck capacity is predicted to reduce total truck-miles of travel. Such conclusions have been controversial. Opponents of larger trucks have argued in particular that the studies have system-

atically underestimated the safety and environmental costs of larger trucks and that the highway user tax structure would not allow highway agencies to recoup higher infrastructure costs.

ORGANIZATION OF THE REPORT

The methods used in past studies to predict the benefits and costs of changing truck size and weight regulations are reviewed in Chapter 2. The review reveals that although much is known about the likely effects of changes in size and weight on the overall performance of the highway system, limitations in the standard evaluation framework have diminished the value of past studies to decision makers. These limitations include, in particular, failure to orient the evaluation toward attaining clearly defined policy objectives and to integrate evaluation with the ongoing process of managing the highway system. Important gaps in understanding of impacts are identified, but it is noted that uncertainty about the outcomes of regulatory change is inevitable; therefore, successful reform will depend on systematic monitoring of the performance of regulation at least as much as on improved prospective evaluations of regulatory proposals.

In Chapter 3, a proposal is presented to establish a new federal capability for monitoring truck impacts and evaluating the performance of size and weight regulation, and to open up opportunities for innovation in solving size and weight problems. Three packages of possible changes to federal size and weight limits are also presented. The first is based on the recommendations of the 1990 TRB study, *Truck Weight Limits: Issues and Options,* which Congress asked the present committee to review. The second is a modified version of that earlier study's recommendations that addresses criticisms about the practicality of the original proposal, which would represent a redefinition of the federal responsibility for size and weight regulations. The third package, which is presented as an option deserving evaluation, is based on a policy of seeking to maximize highway transport productivity. Finally, a description is given of how truck user fee reforms and the concept of performance standards can reinforce traditional size and weight regulation.

A survey of new opportunities for mitigating the adverse impacts of truck traffic and the conflicts between trucks and cars on the highways, including applications of information technology, is presented in Chapter 4. A review of techniques for improving enforcement of truck regulations is included.

The committee's conclusions and recommendations on needed changes in federal size and weight regulations are given in Chapter 5.

Finally, as the legislative study charge requires, the committee solicited and considered comments on truck size and weight issues from industry, interest groups, government bodies, and others. The comments received are summarized in Appendix C.

REFERENCES

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
BLS	Bureau of Labor Statistics
BPR	Bureau of Public Roads
DOT	U.S. Department of Transportation
FHWA	Federal Highway Administration
GAO	General Accounting Office
ICC	Interstate Commerce Commission
LTSS	North American Free Trade Agreement Land Transportation Standards Subcommittee
TRB	Transportation Research Board

AASHTO. 1999. Policy Resolution PR-9-99: U.S. DOT Comprehensive Truck Size and Weight Study. Oct. 3.

Babcock, C. E. 1998. Bill's Bounty Isn't Always in Dollars. *The Washington Post,* April 6, p. A23.

Barnes, D. 1999. Western Governors Request LCV Study. *Transport Topics,* June 21.

BLS. 2001. Multifactor Productivity Trends, 1999. www.bls.gov/news.release/prod3.toc.htm. April 10.

BPR. 1964. *Maximum Desirable Dimensions and Weights of Vehicles Operating on the Federal-Aid Systems*. Doc. 354, 88th Congress, 2nd Session, U.S. Department of Commerce, Aug.

DOT. 1981. *An Investigation of Truck Size and Weight Limits: Final Report*. Aug.

DOT. 1998. *Comprehensive Truck Size and Weight Study: Draft Volume III Scenario Analysis*. Dec. 30.

DOT. 2000. *Comprehensive Truck Size and Weight Study*. Aug.

FHWA. 1985. *The Feasibility of a Nationwide Network for Longer Combination Vehicles*. U.S. Department of Transportation, May.

FHWA. 1986. L*onger Combination Vehicle Operations in Western States*. U.S. Department of Transportation, Oct.

FHWA. 1987. *Highway Statistics: Summary to 1985*. U.S. Department of Transportation.

FHWA. 2000. *Highway Statistics 1999*. U.S. Department of Transportation.

GAO. 1996. *Commercial Trucking: Safety and Infrastructure Issues Under the North American Free Trade Agreement*. Feb.

Gordon, R. J. 1992. Productivity in the Transportation Sector. In *Output Measurement in the Service Sectors* (Z. Griliches, ed.), Chicago, Ill., pp. 371–427.

ICC. 1941. *Federal Regulation of the Sizes and Weight of Motor Vehicles; Letter from the Chairman, Interstate Commerce Commission*. 77th Congress, 1st Session, House Document No. 354, Government Printing Office, Aug. 14.

LTSS. 1997. *Harmonization of Vehicle Weight and Dimension Regulations Within the NAFTA Partnership*. Working Group 2—Vehicle Weights and Dimensions, FHWA, U.S. Department of Transportation, Oct.

LTSS. 1999. *Highway Safety Performance Criteria In Support of Vehicle Weight and Dimension Regulations: Candidate Criteria & Recommended Thresholds*. Working Draft for Consultation. Nov.

Maine Municipal Association. 2000. 2000 *Federal Issues Paper*.

Small, K. A., C. Winston, and C. Evans. 1989. *Road Work: A New Highway Pricing and Investment Policy*. Brookings Institution Press, Washington, D.C.

TRB. 1986. *Special Report 211: Twin Trailer Trucks: Effects on Highways and Highway Safety*. National Research Council, Washington, D.C.

TRB. 1989. *Special Report 223: Providing Access for Large Trucks*. National Research Council, Washington, D.C.

TRB. 1990a. *Special Report 225: Truck Weight Limits: Issues and Options*. National Research Council, Washington, D.C.

TRB. 1990b. *Special Report 227: New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal*. National Research Council, Washington, D.C.

Woolard, R. 2001. Weight-Limits Increase Urged for Maine I-95. *Transport Topics,* June 25.

Past Evaluations of Changes in Truck Size and Weight Regulations

Chapter 2

In this chapter, a review of past evaluations of changes in truck size and weight regulations is presented. This review reveals that the estimates of some impacts of incremental regulatory changes provided in the studies of DOT, TRB, and others have been well founded and can help in making informed choices among alternatives. However, certain important impacts are poorly understood or have not been assessed with the most appropriate methods in these studies. For these impacts, proposals are made for obtaining the information needed for better assessments in the future. The present study has not produced new estimates of the impacts of changes in the regulations. The available models have been fully exercised in past studies, and resources were not available to the committee for the development of new methods.

The review in this chapter also points to two shortcomings common in past studies that are more fundamental than inadequacies of engineering and economic models and data. First, analyses have not started with clear definitions of the objectives of the regulations. Second, the analysis of changes in truck characteristics has not been integrated with the ongoing process of management and regulation of the highway system. As a consequence of these shortcomings, past studies, even when they have produced reasonable estimates of the consequences of changes in truck dimensions, often have not been successful in the design of improved policies or promotion of reform.

In the first section below, the evaluation framework that has become standard in past U.S. studies of truck size and weight regulation is described, and the two shortcomings identified above are examined. An overview of the evaluations of past studies is presented in the second section. In the third section, a detailed review of the estimation methods used for these evaluations is presented, including the most important needed improvements and the results obtained.

PROBLEMS IN PREDICTING IMPACTS OF CHANGES IN REGULATIONS

The DOT and TRB truck size and weight studies of the past 20 years employed a common five-step analysis method:

1. One or more alternative sets of size and weight limits are specified.
2. Projections are made of the changes in truck traffic volume and in the distribution of dimensions of vehicles in use that would result from introducing the alternative limits.
3. The magnitudes of the changes in certain costs arising from the projected traffic changes—including pavement and bridge construction and maintenance, numbers of highway accidents, highway user delay, freight transportation costs, and air and noise pollution—are predicted.
4. Certain practical issues, such as enforcement and administrative feasibility, fiscal impact on state highway programs, and effects on railroads, are given at least qualitative consideration.
5. Recommendations are made for changes in limits on the basis of predicted economic benefits and recognized practical constraints.

Within this benefit–cost framework, the DOT (2000) *Comprehensive Truck Size and Weight Study,* as well as most of its predecessors, is constrained by strong assumptions about the scope of policy changes to be considered. Specifically, the DOT study assumes:

- Constant highway user tax rates—Changes in size and weight limits would not be accompanied by any change in the user tax structure.
- Constant motor vehicle technology—New trucks would be built with off-the-shelf components.
- Constant highway design and construction practices—Highway agencies would continue to follow established practices in design of pavements, bridges, and road geometry.
- Traditional regulatory structure—The form of size and weight rules and the dimensions regulated would remain unchanged; only the numerical values of limits would change.

The specific evaluation criteria that have been applied (see Box 2-1), together with the set of regulatory options (such as those presented earlier in Box 1-1), define a matrix with criteria as rows and options

Box 2-1
Evaluation Criteria

Criteria Considered in Past DOT or TRB Studies

- Highway agency pavement costs: change in costs of maintenance and construction of pavement caused by change in vehicle dimensions
- Highway agency bridge costs: cost of bridge replacements required (or avoided) by change in dimensions; change in future bridge construction and maintenance costs
- Highway agency geometric improvement costs: cost of reconstruction to accommodate new vehicle dimensions; cost of changes in design of future highway projects necessitated by change in dimensions
- Accident costs: change in costs of accidents not borne by carriers or shippers
- Delay at construction: change in highway user delay caused by change in the amount of highway construction
- Delay from effect on traffic operations: change in delay caused by change in number and performance of trucks
- Air pollution: cost of change in emissions caused by change in traffic volume, vehicle performance, and highway construction
- Noise: cost of change in noise emissions
- Energy consumption: external costs (if any) of change in petroleum consumption, other than pollution costs
- Railroad profitability: change in welfare of railroad stockholders and employees (a distribution effect rather than a cost)
- Shipper costs: net shipper benefits

Other Criteria

- Other costs
  - Costs to road users other than accident and delay costs
  - Potential for unpredicted consequences
- Summary measures of merit
  - Benefit/cost ratio or net present value

(continued)

Box 2-1 *(continued)* **Evaluation Criteria**

- Equity
  - Regional and local distribution of costs and benefits
  - Distribution of costs and benefits among shippers, carriers, public
- Feasibility
  - Enactment feasibility
  - Implementation and enforcement feasibility
  - Provision of incentives for efficient use of highways
  - Appropriateness of federal involvement

as columns. The standard evaluation framework consists of filling in the cells of this matrix with quantitative estimates of the magnitudes of each category of impact (the criteria) for each policy option.

The past DOT and TRB studies applying this method have reached a similar conclusion: that incremental increases in allowable truck size would produce net benefits. Predicted increases in infrastructure costs (mainly for upgrading bridges) generally are smaller than predicted freight cost savings; and predicted safety, traffic, and pollution effects are often positive because increasing truck capacity is predicted to reduce total truck-miles of travel. A partial exception to this pattern of results, the DOT 2000 study estimates that the high cost of traffic delay caused by bridge construction would cancel freight productivity benefits for some changes in limits that otherwise would appear attractive.

This standard framework is a necessary starting point for evaluation of changes in size and weight regulations. However, the limitations cited above—that analyses have not been oriented toward attaining defined objectives and have not been well integrated with the processes of regulation and management—have restricted the framework's usefulness. The following two subsections examine these problems.

Defining Objectives

Truck size and weight regulations are a mechanism for balancing the potential public costs of truck travel against the benefits of lower shipper and carrier costs for freight transportation. The most useful size and

weight study would be a structured search for better means of attaining these goals. These means might entail changes in size and weight regulations coordinated with changes in safety regulations, highway design, user fees, or other areas of highway management. Studies confined solely to evaluating changes in size and weight limits will never reveal such opportunities.

Instead of serving as problem-solving exercises—asking how the size and weight regulations can be used as part of a strategy for increasing the benefits of the highway system—evaluations often have appeared directionless, asking instead what would happen if a specific limit were incrementally changed or if a particular industry proposal were put into effect. In contrast, solving the problem of maximizing highway benefits requires starting with a trial solution, discovering its shortcomings through initial evaluation, and then refining the proposal to overcome the shortcomings and come closer to a satisfactory solution. This iterative process, if not entirely lacking in past studies, has seldom been explicit or systematic.

Past studies' estimates of bridge costs illustrate the importance of aiming for objectives. The past DOT and TRB studies have identified regulatory options that appeared attractive considering freight costs, pavement wear, and truck traffic reduction, but were predicted, according to the conventional cost-estimating method, to generate high costs for replacement of deficient bridges to accommodate the new trucks. This finding usually has been the end of the analysis. In contrast, an objective-oriented approach would examine the problem to see whether there might be some means of reducing bridge costs and at the same time retaining a share of the predicted benefits of the regulatory option. Possible solutions worth exploring would include excluding bridges with high replacement costs and low freight mobility benefits from the network of roads where new trucks would be allowed; adjusting truck dimensions to reduce bridge costs (imposing minimum length requirements, for example, would reduce certain costs); making greater use of retrofit strengthening as an alternative to replacement of bridges; and performing more intensive maintenance and inspection to produce an offsetting reduction in the risk of bridge damage. A similar problem-solving approach in other elements of size and weight studies—including evaluations of safety, productivity, and traffic impacts—would likely reveal more nearly optimal truck size and weight solutions.

This not to say that such an analysis approach would necessarily reveal a basis for justifying the liberalization of regulations. The analysis could very well show (in this example) that none of the innovative

approaches to bridge management would reduce costs enough to justify the liberalization in question, or the regulatory change might be ruled out by categories of costs other than bridge costs that proved to be unavoidable.

Because of their orientation toward evaluating the impacts of changing dimensions instead of seeking means of attaining objectives, most past studies have ignored some of the most promising policy alternatives, in particular, performance standards and pricing. Performance standards are regulations that require vehicles to pass specified performance tests demonstrating that they are safe and compatible with the design of the highway system. Pricing policies that set road user fees more nearly equal to the actual costs occasioned by each truck and trip would provide incentives for operating trucks that reduced public as well as private costs. The government would calculate the proper fee to charge for any particular vehicle and trip, and the user would decide whether the benefit justified paying the fee.

Since both of these regulatory approaches depend on inducing operators to innovate in order to reduce the costs of truck transport rather than on dictating vehicle dimensions, they do not fit the assumptions of the traditional evaluation framework. Similarly, policies that would simultaneously optimize highway design and vehicle characteristics, as well as technological fixes for truck stability or enforcement problems, are neglected because seeking means to attain objectives is not part of the study design.

As an example of a definition of objectives for truck regulations, the following are the legislatively defined functions of the National Road Transport Commission (NRTC), an independent body formed by the national and state governments of Australia to coordinate road transport reform (NRTC 2000, 32):

> *Transport efficiency*
>
> - improve road transport industry efficiency and productivity
> - encourage and facilitate innovation in the industry and its regulation
> - encourage and facilitate technological advancements in the industry, e.g., ITS [intelligent transportation systems]
> - encourage and facilitate continuous improvement in the road transport regulatory environment (e.g., monitoring and updating regulation as necessary) . . .

Improve road safety
Minimize the adverse environmental impacts of road transport
Lower administration costs . . .

The NRTC's responsibilities include, in addition to truck size and weight, a broad range of safety and environmental regulations. But to the extent that these objectives are applicable to size and weight regulations, they would be appropriate in the United States as well.

As a second example, the following are the objectives set for regulatory changes recommended by the committee that authored the TRB *Truck Weight Limits* study (TRB 1990a, 228):

- To select from the various changes in truck weight regulations proposed by industry groups and others the most practical means to realize the productivity benefits of increased truck weights while reducing or eliminating possible adverse effects;
- To make changes in weight limits that would reduce truck accidents and encourage safety improvements in truck design and operation;
- To provide mechanisms to match user fees with added costs for pavements and bridges;
- To promote uniformity in the administration of truck weight regulations;
- To balance the federal interest in protecting the national investment in the Interstate system and facilitating interstate commerce with the interests of the states in serving the needs of their citizens and industries;
- To develop proposals that are realistic and feasible and would have a reasonable chance of being implemented.

Objectives for the reform of U.S. federal truck size and weight regulations must be defined by Congress. Objectives that may be inferred from past federal legislation are described in Chapter 1. If Congress had articulated clear and attainable objectives at the outset of DOT's recent *Comprehensive Truck Size and Weight Study*, it appears likely that the results would have been more valuable in congressional efforts to resolve policy issues.

Integrating Analysis with Practice

The traditional framework for size and weight studies has not fit well with the nature of decision making on size and weight limits. Experience

has shown that some outcomes of changes in regulations cannot be predicted with great certainty; that changes are political decisions often influenced only marginally by the results of rational analysis; and that the evolution of limits in the direction of allowing larger trucks has continued over many decades, in parallel with the development of the highway system. In the long run, it might be more fruitful to adopt an approach to evaluation and reform of regulations that more openly acknowledged uncertainty at the outset and more carefully monitored the consequences of changes. For example, there will be uncertainty in any prospective evaluation as to whether the safety effects of changes in regulations will be positive or negative. However, one cannot defend as erring on the side of safety a policy of doing nothing because the outcome of changes cannot be predicted if a possibility exists that liberalization of the limits would reduce accident losses. An alternative policy might be to liberalize the limits where the available information indicated a high probability of benefits and to impose positive safety requirements on carriers who chose to take advantage of the new limits. This approach would require rigorous monitoring of outcomes, as well as opportunity for review and modification of the new regulations.

The DOT 2000 study illustrates the risk of overselling the usefulness of prospective analyses of regulatory impacts. In 1994, a DOT official stated the administration position that "any decision to establish national weight standards for the entire [National Highway System] should only be undertaken after thorough safety analysis of all the benefits and costs of such an action to all highway users as well as the economy" (James 1994, 12). The *Comprehensive Truck Size and Weight Study* was begun at this time. Upon its release 6 years later, the DOT report was a careful and informative factual summary of knowledge, but did not resolve any of the quandaries facing decision makers.

Forecasting models will never be adequate for providing more than plausible indications of how markets and technology will react to changes in regulations, especially in the long run. The reliability of forecasts is limited by some irreducible sources of uncertainty:

- Changes in the environment, such as physical highway conditions and traffic, will affect costs.
- The process of writing regulations always entails risks of loopholes and unintended consequences.
- Decisions of state and local officials in hundreds of jurisdictions regarding regulation and highway management interact with federal regulations in determining outcomes.

In addition, enforcement effectiveness, an important determinant of the outcome of regulatory changes, cannot be forecast unless a systematic and substantial effort is made to collect enforcement data and to evaluate alternative enforcement strategies. As discussed in Chapter 4, monitoring and evaluation of the enforcement of federal requirements are weak today.

Because of these uncertainties, regulation is necessarily a process: the regulatory agency should do the best prior analysis possible, but once regulations have been changed, the consequences should be monitored and adjustments made where necessary. Chances for a positive outcome from a regulatory change can be enhanced by giving users incentives to act in consonance with the public interest through enforcement, user fees, and performance regulation.

Recent history provides examples of the uncertainties of regulatory impact predictions. Changes in regulatory language often elicit unanticipated responses. For example, the 1983 law revising the federal limits contained a complex set of vehicle length provisions (49 USC 3111) that proved to be instrumental in the eventual legal acceptance of 53-ft-long semitrailers on nearly all major roads nationwide. Before the law, 45 ft was the most popular length and 48 ft the greatest length commonly in use; today nearly half of all van semitrailers are 53 ft. This result was not explicitly called for in the act and apparently not the intent of the authors, nor was it foreseen by the TRB study committee that attempted to predict how the law would change vehicle usage (TRB 1986). In contrast, nationwide legalization of twin-trailer combinations, for which the act explicitly provided and which was the most controversial provision regarding truck dimensions, has had only a moderate impact on nationwide use of these vehicles. The TRB study predicted that the share of twin-trailer combinations in nationwide combination truck travel would nearly triple by 1990 as a result of the 1983 law, whereas the actual increase was only about 60 percent (Bureau of the Census 1985, Table 13; Bureau of the Census 1995, Table 13).

As a second example, a study in Ontario examined how the trucking industry had utilized the features of new provincial weight limits introduced in the 1970s to develop a great variety of vehicle configurations for specialized uses, which could not have been predicted at the time the limits were enacted. It was also observed that vehicles with undesirable handling properties had appeared among the new configurations and that most of these, though not all, had been withdrawn by their users once the problems had become known (Agarwal

and Billing 1988). This Ontario study is a rarity in being a retrospective examination of the impacts of a regulatory change. The review of past studies presented in this chapter reveals that nearly all the studies are prospective. Historically, there has been almost no systematic effort by governments to monitor the effects of changes in regulations after they occur.

It is clear from such experiences that decisions cannot be based on precise prior knowledge of consequences. In addition to prospective "paper and pencil" policy analyses, other necessary components of the process of regulatory evaluation and revision are

- Problem-solving research—especially field research to, for example, improve vehicle stability or develop more durable infrastructure designs;
- Trials or pilots—full-scale, scientifically designed tests of new equipment in commercial use before final regulations are enacted;
- Monitoring—systematic monitoring of effects on the highway system once regulations have been changed;
- Adaptation—adjustments to regulations, following orderly and straightforward procedures to improve performance when monitoring shows that objectives are not being met and to respond to changing circumstances; and
- Opportunity for innovation—incentives for truck operators, truck manufacturers, researchers, states, and others to develop proposals for more effective size and weight rules and for proposals to receive consideration.

Because of the administrative pattern of size and weight regulation that has evolved in the United States, no federal agency has the authority or resources to conduct these essential regulatory support activities. To improve the effectiveness of regulation, it will be necessary to establish an institutional home for these functions, define its objectives, and provide it with sufficient resources. Chapter 3 presents the committee's proposal for such an arrangement.

SUMMARY OF EVALUATIONS OF PAST STUDIES

This section provides a brief summary and comparison of evaluations of the costs and benefits of changes in truck size and weight regulations in prominent past studies. A strict qualitative comparison of results across studies is not possible because of differences among the studies in definitions, specific regulatory changes examined, time periods of

data and projections, and methods of reporting results. Nevertheless, comparisons indicate which categories of impacts are likely to be critical in deciding among alternative regulations. In addition, comparisons narrow the range of apparent uncertainty about the consequences of changes in size and weight regulations. For some categories of impacts, past studies have concurred about the order of magnitude of effects, whereas for other categories the results diverge, suggesting methodological problems in the estimates.

The estimates described in this section and in the remainder of the chapter are taken from evaluations of various truck regulatory options in the following studies:

- *Truck Weight Limits: Issues and Options* (TRB 1990a). The present discussion refers primarily to the "Combined TTI HS-20/Formula B" scenario evaluated in this congressionally mandated TRB study (pp. 196–204). This scenario involves changes in federal weight limits similar to those endorsed by the TRB study committee. The scenario assumes that existing state truck length and route restrictions are unchanged, as are federal axle weight limits. Truck weights are limited only by a new federal bridge formula. Under this formula, carriers are allowed to operate six-axle tractor-semitrailers of up to 89,000 lb and configurations with six axles and two 28-ft trailers of up to 96,000 lb.
- Turner Proposal study (TRB 1990b). This study predicts the consequences of changes in federal and state regulations that would allow carriers to operate trucks with higher gross weights, and moderately greater length for double trailers, on an extensive network, provided the carriers operated the trucks with lower maximum axle weights than those now allowed in federal regulations. The study predicts that the new configuration most likely to be adopted under the new regulations would be a nine-axle configuration with two 33-ft trailers and a maximum gross vehicle weight of 111,000 lb.
- *Comprehensive Truck Size and Weight Study* (DOT 2000). The estimates to which this chapter refers are from three of the regulatory scenarios evaluated in this most recent DOT study:
  - The "North American trade" scenario, in which six-axle tractor semitrailers of up to 97,000 lb and configurations with eight axles and two 33-ft trailers weighing up to 131,000 lb are allowed on the current federally defined National Network (the roads where twin 28-ft trailer combinations are allowed by federal law today).

– The "LCVs nationwide" scenario, in which double-trailer configurations with two full-sized semitrailers (i.e., turnpike doubles) and weight of up to 148,000 lb and doubles with one full-sized and one short trailer (Rocky Mountain doubles) are allowed on a limited network of roads nationwide consisting mainly of 42,000 mi of Interstate highways. No access for these configurations is allowed on lesser roads; operators are required to couple and uncouple the trailers in staging areas adjacent to major highways. Triple-trailer combinations (three 28.5-ft semitrailers) are allowed on a 65,000-mi network of Interstates and other high-quality roads nationwide with provisions for access to local destinations, and short heavy double-trailer configurations similar to that of the "North American trade" scenario are allowed on 200,000 mi of main roads plus access routes (DOT 2000, Vol. III, III-27).

– The "triples nationwide" scenario, in which triples are allowed on the 65,000-mi network, and no other new trucks are allowed.

• *Road Work* (Small et al. 1989). This Brookings Institution study is included in the comparisons in this section to illustrate a nontraditional approach to truck size and weight control. It also is an example of an objective-oriented, problem-solving approach to policy analysis. The policy options evaluated involve no changes in legal limits. Rather, highway agencies are assumed to charge fees equal to the cost of pavement wear caused by each truck, depending on the total weight of a truck's axles, the distance it travels, and the construction of the road it is using; agencies are also assumed to adopt construction designs that minimize life-cycle costs, usually building heavier pavements than are now customary. The fees provide incentives for carriers and shippers to adopt equipment and practices that reduce highway transportation costs.

The above studies contain evaluations of numerous options for truck regulations and vehicle configurations other than those listed above. However, the estimates for these options are representative and are relevant to further policy options that are discussed in Chapter 3. The truck configurations evaluated in the TRB and DOT studies include all the trucks that are commonly proposed for more widespread use in the United States: turnpike doubles, Rocky Mountain doubles, triples, short heavy double-trailer configurations (the Turner Proposal study vehicle and similar configurations), and heavy six-axle tractor-

semitrailers. All these configurations (see Figure 2-1) are in use in significant numbers in North America today. The policy options or scenarios in these studies all involve adding axles to trucks to better distribute loads or increase the total weight carried in the truck. None except the Turner Proposal study involves changing the federal weight limits for single and tandem axles. The four studies forecast the con-

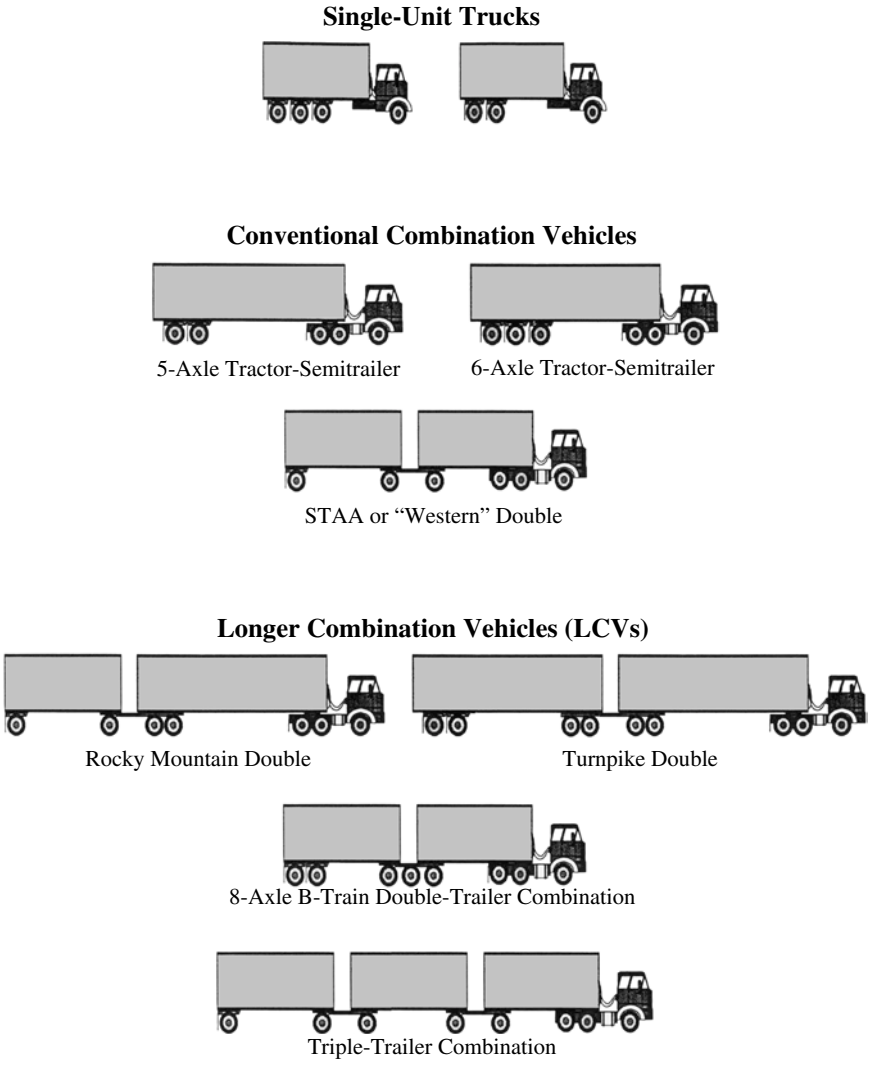

FIGURE 2-1 Illustrative truck configurations in use in the United States. Note: STAA = Surface Transportation Assistance Act. (Source: DOT 2000.)

sequences of specified changes in federal and state regulations (or, in the case of *Road Work,* user fees) in terms of changes in annual truck-vehicle-miles traveled (VMT), private freight costs, highway agency costs, safety, and delay costs. (No study estimated all of these impacts.)

The *Truck Weight Limits* study and DOT estimates agree that moderate liberalization of federal standards could yield annual cost savings to shippers on the order of 3 to 6 percent of the costs of heavy truck transportation ($7 billion to $13 billion annually at today's freight volumes and prices) and reductions in truck traffic volume of several percent as compared with costs and traffic volumes if present regulations continued. The DOT study and both TRB studies agree that even after allowing for increases in traffic that would be stimulated by cost reductions, truck traffic volume would be lower than if the regulations were not changed because the new trucks would be more productive than the ones they replaced. The three studies predict that highway agency pavement construction and maintenance costs would be unlikely to be greatly affected by a change in limits that allowed heavier trucks but did not increase axle weight limits and did not provide incentives for carriers to switch from tandem-axle to single-axle configurations. The TRB studies agree that the costs of highway accidents and congestion probably would change in the same direction as the change in total truck-VMT.

The DOT and TRB studies predict that liberalizing federal weight limits would increase the cost of constructing and maintaining highway bridges. The DOT 2000 study presents estimates showing bridge-related cost increases exceeding shipper savings in most cases analyzed, although it is acknowledged that these costs may be overstated. In fact, past studies have not used appropriate methods for estimating bridge costs, as the next section of this chapter explains.

The options to which the estimates summarized above apply are relatively moderate proposals in that they do not involve expanded geographical use of turnpike doubles, Rocky Mountain doubles, or triples. By comparison, the DOT "LCVs nationwide" scenario may approach the extreme of liberalization that would be physically feasible. The DOT 2000 report (Vol. III, 2-7) describes this scenario as a limiting case rather than as a policy proposal. It projects that nationwide use of LCVs would yield twice the freight cost savings of the "North American trade" scenario with about the same infrastructure costs, and that allowing triples nationwide without expanded use of large double-trailer configurations or any other changes in regulations would yield freight cost savings 50 percent greater than those of the "North American trade" scenario with one-fourth the infrastructure cost increase.

The two TRB committees reached consistent conclusions about safety effects for the changes in vehicle characteristics they considered. The studies evaluate changes affecting heavy single-unit trucks, tractor-semitrailers, and short double-trailer configurations. They conclude that increased use of larger trucks as a result of changes in size and weight limits would have little overall effect on highway safety because small possible increases in accident rates per truck-VMT would be approximately offset by the reduction in truck-VMT resulting from the new trucks' higher productivity. Accident rates per ton-mile of highway freight are predicted to decline. An earlier TRB study committee that projected the impacts of the twin-trailer combinations authorized by federal law in 1983 reached similar conclusions about systemwide safety impact and net change in truck traffic (TRB 1986). The DOT 2000 study does not estimate safety impacts. However, it presents estimates of accident rates and truck-VMT that are consistent with the TRB committees' conclusions.

In the estimates in *Road Work,* operators are predicted to add axles voluntarily, convert to truck configurations that generate lower highway costs, and drive more on Interstates (which have low marginal pavement costs) to reduce their payments of new user fees, which depend on axle weights and on miles and routes driven. Shippers are predicted to shift a small fraction of shipments to rail to avoid higher road user fees. The results are qualitatively similar in many respects to the projections of the effects of liberalized size and weight regulations in the TRB and DOT studies, although *Road Work* assumes the limits are unchanged. Highway agency costs decline as a result of the combined effects of carriers' reduction of axle loads and agencies' adoption of heavier pavement designs that minimize life-cycle costs. User fee revenues decline after equilibrium is reached because of the highway cost savings. Truck traffic volume and shipper costs decline slightly.

Road Work illustrates how size and weight can be controlled with user fees and how agency costs can be controlled by pricing and design optimization. The estimates indicate that it is important to consider combined strategies involving pricing and design as well as modifications in traditional size and weight regulations to find the best method of attaining these objectives.

ESTIMATION METHODS AND RESULTS

The following subsections review results for each of the principal evaluation criteria employed by the past studies:

- Truck traffic volume and freight costs;
- Highway pavement costs;
- Highway bridge and structure costs;
- Impacts on traffic operations and pollution, which are of primary significance in urban areas;
- Effects on traffic volume and land use; and
- Safety.

In summary, the review indicates that for two criteria—pavement costs and traffic impacts—the uncertainties in available estimates are not so great as to hinder evaluations of proposed regulatory changes. Regarding safety, the available information is weak on the relation of accident rates to gross weight for a given configuration. Bridge cost is a critical criterion not well estimated in past studies, but improved estimates may be possible with available information. Finally, the review reveals three criteria—change in truck traffic volume, costs that may arise from motorists stress and discomfort in mixed automobile and truck traffic, and administrative feasibility—that have been inadequately evaluated in past studies, yet may influence the desirability of policy options in practice. Motorist stress and discomfort, a potential impact of changing regulations ignored in past studies, is discussed in Chapter 1. Administrative feasibility is examined in Chapters 3 and 4.

Truck Traffic Volume and Freight Costs

Projections in the past studies of the effect of new regulations on truck traffic have proceeded according to the following steps:

1. Predict the new truck dimensions and configurations that would become attractive to carriers under the new regulations.
2. Classify the truck freight market into segments defined by features believed to influence the attractiveness of the new combinations (e.g., freight density, shipment size).
3. Estimate unit freight costs for the existing and new configurations in each segment.
4. Estimate the market penetration of the new configurations in each segment on the basis of relative costs and unquantified performance differences (e.g., route restrictiveness, operational problems presented by double trailers for some kinds of applications).
5. Estimate the change in the volume of truck freight resulting from the redistribution of freight among the modes, changes in shippers' logistics practices, or other sources caused by the change in truck costs.

6. Assign the postregulatory change in truck traffic to road classes as a function of assumed route restrictions on the new vehicles.

Some studies use quantitative, calibrated models to perform at least some of these steps; for example, *Road Work* estimates an econometric model of carriers' choices of truck configuration that is analogous to the mode choice models used in transportation planning (Small et al. 1989, 44–51). In other studies, simple cost comparisons or judgment determines assignments of freight to modes and vehicles. Information sources employed to support estimates are historical data on truck mileage by road class, region, and truck type; estimates of the operating costs of various configurations; interviews with carriers, often focusing on the more difficult-to-quantify aspects of equipment selection; analysis of historical patterns of usage of similar equipment (most vehicles evaluated for nationwide use are already in use in some states); estimates of the cost implications of differences between rail and truck transit times and reliability; and econometric estimates of freight demand elasticity (TRB 1986, 98–109; TRB 1990a, 294–303; TRB 1990b, 78–91; DOT 2000, Vol. III, IV-1–IV-34).

To provide a scale for the regulatory impact estimates, some dimensions of the trucking industry are as follows (Bureau of the Census 1998, Table 10; FHWA 1999, Table VM-1; CCJ 2000, 40–44; AAR 2000):

- Annual combination VMT (1998): 128.2 billion;
- Annual heavy (three or more axles) single-unit truck-VMT (1998): 10.4 billion;
- Average operating expenses per VMT, intercity truckload carriers (1999): $1.47;
- Annual expenditures for operation of large trucks in the United States (including carriers specializing in shipments of less-than-truckload dimensions, which account for about 15 percent of large-truck-VMT and have higher average costs than truckload carriers): $270 billion;
- Annual operating expenses of U.S. railroads: $40 billion; and
- Annual VMT of all motor vehicles on U.S. roads: 2.6 trillion.

Also for comparison, the most common configuration of combination vehicle in general use nationwide today is the five-axle tractor-semitrailer, with the semitrailer usually 42 to 53 ft in length, and weighing up to 80,000 lb. The only multitrailer configuration common nationwide is a tractor pulling two 28-ft trailers, with five axles and a maximum weight of 80,000 lb. Longer doubles, triples, and

heavier tractor-semitrailers are in use in some states (DOT 2000, Vol. II, III-7–III-9).

The various TRB and DOT projections generally agree on the following results:

- The new vehicles commonly proposed for more widespread application (LCVs, short heavy doubles, and heavier tractor-semitrailers) would serve niche markets instead of becoming the dominant vehicle type (as the five-axle tractor-semitrailer is now). Only a minority of freight is projected to be carried in new configurations. The reasons for this restricted appeal vary from vehicle to vehicle: multitrailer vehicles have operational drawbacks in many applications, and the longest multitrailer combinations would be restricted to small networks in the projections. The heavy, six-axle tractor-semitrailer would have the greatest market potential, but this combination would not be worth the added cost and tare weight in fleets that specialized in low-density freight and in locales where bridge restrictions limited access.
- In all DOT and TRB projections, allowing larger trucks causes annual truck-VMT to decline. The studies predict that reducing truck costs by liberalizing regulations would increase the volume of highway freight traffic, measured in ton-miles. The only source of increase that is estimated quantitatively is the diversion of freight traffic from rail to truck that would occur as a result of lower truck costs, although the studies address how consideration of sources of increased traffic other than intermodal diversion might influence the results (e.g., Pickrell and Lee 1998; TRB 1990a, 302–303). Diversion is insufficient to offset the reduction in truck-VMT from greater cargo capacity, according to the estimates. The section of this chapter below on effects on traffic volume and land use addresses demand effects through mechanisms other than modal diversion.
- Cost savings to shippers and carriers are significant but in most cases somewhat modest in magnitude. Savings are several percent of truck freight transportation costs—on the order of several billion dollars annually. The percentage reduction in shipper costs is smaller than the percentage reduction in truck-VMT.
- The market models used to predict how changing truck costs would affect truck traffic, although based on cost and traffic data and plausible assumptions, probably are not highly reliable. A principal difficulty is assessing the consequences of vehicle characteristics that are not easily converted into cost differences, for example, the problem that carriers report in using double trailers to serve customers' docks directly (TRB 1990b, 56–62).

Highway Pavement Costs

Most traffic-related pavement wear is caused by heavy trucks. The states spent $7.3 billion on highway resurfacing, restoration, and rehabilitation projects ("RRR projects") in 1998, 21 percent of total state highway capital expenditures (FHWA 1999, Table SF12A). This class of projects is motivated primarily by the need to repair or replace worn pavement on existing roads (although RRR projects include nonpavement improvements as well). In addition, the requirements of truck traffic affect the cost of pavement construction for new highways. In its *1997 Federal Highway Cost Allocation Study,* DOT allocated 77 percent of RRR costs to medium and heavy trucks (DOT 1997, Figure V-3). This allocation of costs depends on some arbitrary assumptions, but gives an indication of the costs of providing pavement for trucks.

If axle weights are not altered, pavement cost per ton-mile of freight will be little affected by a change in the gross vehicle weight limits. Thus, for example, the effect on the pavement of the passage of 1 million axles, each loaded to 18,000 lb, will be nearly independent of the number of axles per truck because the axles act independently of each other. The sole important exception to this rule is that two closely spaced axles (i.e., a tandem axle) cause less wear on flexible (i.e., asphalt) pavement than they would if they were widely spaced. The wear caused by the passage of one axle is quantified for purposes of pavement design and management in terms of the number of repetitions of the axle passage on a new pavement of a specified design that would cause sufficient wear to necessitate replacement or resurfacing of the pavement.

In light of these characteristics of pavement response to loads, past studies have estimated that if gross weight and vehicle length limits are changed but axle weight limits remain unchanged, pavement costs will change only slightly. Thus, for example, the DOT "North American trade" scenario and the *Truck Weight Study* permit program are predicted to reduce annual highway agency pavement costs by $120 million and $10 million, respectively. The cost impact is the result of three mechanisms that are, according to past estimates, of secondary importance: (1) a change in the limits may cause carriers to alter the distribution of freight between configurations with tandem axles (such as the five-axle tractor-semitrailer) and configurations that carry more of the load on single axles (such as the five-axle twin-trailer configuration), changing wear on flexible pavement; (2) if the proposed change varies by road class, it may alter the distribution of traffic between

roads with heavy pavements and consequently low average pavement wear costs (e.g., Interstate highways) and roads with light pavements and high average costs (typically secondary roads); and (3) the market response to the change in truck costs caused by changing limits will affect the total volume of highway freight, and pavement costs will change accordingly. The TRB and DOT studies' projections of slight declines in pavement costs reflect those studies' projections that the changes in limits they evaluated would have modest effects on the volume of truck freight transportation. However, if the increase in freight traffic in response to the reduction in truck freight rates were great enough, pavement costs would increase.

In contrast, in the two studies in which policy proposals that would more greatly alter axle weight distributions in the direction of lighter average axle loads are evaluated, pavement wear costs are predicted to be substantially reduced. The Turner Proposal study evaluates the effects of offering carriers the option of operating trucks with higher gross weights but lower axle weights than are presently allowed (TRB 1990b, 168). Annual pavement cost savings of $730 million are estimated. In *Road Work,* all gross weight, axle weight, and length limits are assumed to remain unchanged, but carriers are charged fees that depend on miles traveled, routes, gross weight, and axle configuration, and that provide a financial incentive to switch to configurations with greater numbers of axles. Also (and more significant for pavement costs in the study's estimates), highway agencies are assumed to build heavier pavements. Agency costs are predicted to decline by nearly $7 billion annually. This savings estimate appears implausibly large considering the annual rate of pavement-related highway expenditures in the study year, but the qualitative result of large pavement cost savings is conceivable. The full savings of heavier pavements probably could be realized only after a period of years, because it would not be feasible to greatly accelerate pavement reconstruction schedules.

Cost Estimation Methods

The four studies reviewed here use three different models of the relation of truck traffic to pavement costs to predict pavement cost impacts. In the DOT and TRB studies, the pavement cost of changing truck size and weight limits is estimated by assuming that the highway agency acts so as to maintain the same average pavement condition after the change by rescheduling the time of the next resurfacing of roads and by changing the design of future resurfacing treatments, following established pavement design methods, to accommodate the

new traffic mix. Under this assumption, average user costs that are related to pavement condition (e.g., speed, vehicle maintenance, comfort) do not change over the life of the road.

The TRB studies use a model of the relationship between pavement wear and traffic derived from the AASHTO (1986) pavement design method, which is based on data from the American Association of State Highway Officials (AASHO) Road Test, a test of the effect of truck traffic on pavement wear conducted in 1958. This model has two components:

- Relationships that predict, as functions of pavement structure (primarily material—asphalt or concrete—and thickness), weather, and soil condition, the expected number of passages of an axle of standard weight of 18,000 lb before the pavement surface deteriorates to a specified degree of roughness (the terminal pavement serviceability index, or PSI) as a result of cracking, rutting, and other forms of wear.
- Relationships for converting axles or axle groups of any weight into an equivalent number of standard axles. In the AASHTO model, the equivalency factor increases approximately as the fourth power of the weight: for example, a 9,000-lb axle is approximately 1/16 of an equivalent single-axle load (ESAL). That is, a pavement that could withstand 1 million passages of the 18,000-lb standard axle before reaching a specified terminal serviceability rating could withstand 16 million passages of a 9,000-lb axle before reaching the same rating.

The steps in the cost estimation in the TRB studies are as follows:

1. Compute the change in ESALs from the change in traffic.
2. Compute each road's new remaining lifetime until it reaches its terminal serviceability and requires its next resurfacing.
3. Compute the new resurfacing thickness necessary to maintain the specified pavement lifetime under the new loading instead of the previous loading.
4. Compute the cost of the traffic change: the change in present value of the cost of future resurfacings that results from changing the time and cost of each future resurfacing.

In this method, user cost (i.e., the added time, vehicle maintenance, and fuel costs of traveling on a deteriorated road) can be ignored because the consequence of the practice of always resurfacing at the

same terminal serviceability rating is that the average user cost over the life of the pavement is unaffected by a change in truck traffic.

The estimates in the DOT 2000 study and *Road Work* follow a similar logic but use different pavement wear models (that is, different relationships among vehicle traffic characteristics, pavement designs, and pavement wear). The DOT study's model, the National Pavement Cost Model (NAPCOM), predicts 11 types of pavement distress as functions of traffic and pavement design (instead of simply predicting PSI for rigid and flexible pavements as the TRB studies do), and models a highway agency's resurfacing decision as a function of all these distress types (DOT 2000, Vol. III, V-13). *Road Work* estimates new traffic versus road wear relationships using the AASHO Road Test data (instead of using the relationships AASHTO derived from the data as the TRB studies do) and concludes that the relationship between axle weight and pavement wear follows a third-power law rather than a fourth-power law as in the AASHTO model. In all three models, the pavement-wearing effect of an axle increases exponentially with weight, and the number of passages of an axle that a pavement can withstand before failing increases exponentially with pavement thickness. All three appear to yield qualitatively similar results in estimating the relative costs of various truck weights and axle configurations.

The AASHO Road Test did not measure the pavement wear effects of tridem axles (a set of three closely spaced axles). The table of tridem axle equivalency factors in the *AASHTO Pavement Design Guide,* which was used in the TRB studies to project pavement effects of increased use of tridems, was derived from less definitive sources (AASHTO 1986, MM-2). This gap in the data is important because several prominent proposals for changing size and weight regulations involve extensive use of tridem axles.

The Problem of Optimizing Vehicle and Highway Design

To discover the best combination of policies, including size and weight regulations and highway design and management practices, it is necessary to examine whether changes in prevailing pavement design and management practices coupled with changes in limits could produce greater public benefits, considering road user costs that depend on pavement condition and highway agency pavement costs, as well as other shipper costs that depend on size and weight limits. It is conceivable that a vehicle under evaluation could be predicted to generate high pavement costs given the assumed highway agency practices, but

that the high costs could be avoided with a relatively low-cost change in pavement design or resurfacing practices. Pavement durability increases exponentially with increasing thickness of pavement; thus a small increment in expenditure for construction or resurfacing can yield a large increase in pavement life.

The TRB Turner Proposal study committee evaluated the heavier pavement option and concluded that its cost-effectiveness depends strongly on the degree of influence of random and external factors (e.g., weather, materials properties, and construction practices) on pavement life. These factors are poorly understood. If they are important enough, then building pavements much heavier than current practice is unattractive economically, and present state highway pavement design practices may be about correct (TRB 1990b, 30). As noted above, *Road Work* estimates that a combination of heavier pavement designs and user fees that encouraged operators to add axles and to avoid higher-cost roads would greatly reduce pavement wear costs. A trucking industry–sponsored study also concluded that heavier pavements would reduce highway agency costs as well as user costs, although the estimated savings were smaller than in *Road Work* (TRI 1990, Appendix A).

None of the methods used in these studies to estimate pavement costs explicitly takes into account the relationship of characteristics of truck suspensions and tires to pavement wear. Tire characteristics affecting pavement are subject to regulation; much research has been devoted to the possibility of mitigating pavement wear as well as improving vehicle stability through suspension design. The TRB studies give some attention to how these factors might affect policy recommendations (TRB 1990a, 80–87; TRB 1990b, 171–176). A comprehensive approach to the problem of optimum design for the highway–vehicle system would include determining whether vehicle regulations or user fees should promote certain tire or suspension characteristics.

Finally, none of the studies described here estimates the optimum combination of axle load limits and pavement design; only existing or lower limits are considered. The optimum axle weight limit will depend on bridge as well as pavement costs.

Highway Bridge and Structure Costs

In most past studies, the greatest predicted cost of allowing larger trucks is the cost of replacing bridges deficient for carrying the new heavier loads. These estimates are summarized below. Important methodological shortcomings of the past estimates are then described.

Finally, a more useful method of estimating the bridge costs of changes in regulations is outlined.

Estimates in Past Studies

The bridge cost estimates in the TRB and DOT studies are as follows:

Regulatory Scenario	*Annual Highway Agency Bridge Costs ($ billions)*	*Annual Agency Plus User Costs ($ billions)*	*Agency Bridge Costs as % of Freight Cost Savings*	*Agency Plus User Cost as % of Freight Cost Savings*
DOT 2000 "LCVs Nationwide"	4	22	26	154
DOT 2000 "Triples Nationwide"	1	8	5	39
DOT 2000 "NA trade" scenario	5	23	31	159
Turner proposal (TRB 1990b)	0.4	Not estimated	20	–
Truck Weight Limits permit program (TRB 1990a)	0.9	Not estimated	17	–

These estimates assume amortization of capital costs at 7 percent annually. (The annualized amounts for the DOT study cases have been computed from the total cost estimates presented in the DOT report.) The estimates in the TRB studies include costs of fatigue damage and of building future bridges to higher design standards, as well as the costs of replacing existing deficient bridges.

Truck Weight Limits presents its estimate with an important qualification: "If all 35,000 additional load-deficient bridges were replaced, total bridge costs would increase by $900 million per year under this scenario. More likely, states would choose to post (rather than replace) many bridges, particularly on low-volume routes" (TRB 1990a, 203–204). Similarly, the TRB Turner Proposal study recommends bridge management practices the study committee believed would allow states to control bridge costs while avoiding route restrictions that rendered the new trucks unattractive to carriers (TRB 1990b, 206–208). Thus both studies conclude that, rather than actually incurring very high bridge replacement costs, states would or should place restrictions on truck routes and take other steps to limit costs. Similarly, the DOT report notes that in some circumstances, the states could reasonably allow loads exceeding the thresholds for bridge replacement assumed by their cost estimates, post some bridges to bar the larger trucks, and

strengthen rather than replace some structures; consequently, "certainly not all costs would have to be incurred before heavier loads could be allowed to operate" (DOT 2000, VI-11).

By comparison with the cost estimates, state highway agencies' capital expenditures for bridge construction and rehabilitation were $4.3 billion in 1998 and $3.7 billion in 1991. State costs for bridge maintenance in 1998 were roughly $1 billion (FHWA 1999, Tables SF4C and SF12A). In addition, local governments spend substantially on bridges, although less than the states.

As the table above shows, the DOT 2000 study estimates that the costs to highway users of delays due to bridge construction necessitated by increased limits would be four to six times the highway agencies' construction costs. Comparison of the studies' estimates of bridge costs with freight cost savings shows that these estimates appear to be decisive in judging whether costs exceed benefits for many proposed changes in size and weight regulations.

The method used to estimate bridge costs in the TRB and DOT studies starts with the observation that a bridge is designed to withstand the loadings of the traffic it is expected to bear, and a safety margin is incorporated into the design to allow for the possibility of multiple extreme loads traversing the bridge simultaneously, illegal overloads, uncertainties in material properties, or other unforeseen circumstances. If a bridge is exposed to a single episode of loading significantly in excess of its design load, there is unacceptable risk of irreversible or hazardous damage. Therefore, estimated bridge replacement costs, according to the method used in past studies, depend on the largest loadings to which bridges are predicted to be exposed under the new weight limits and on the load-bearing capacities assumed for the bridges, but not on the frequency of loadings.

The steps in producing the past studies' estimates are as follows:

1. Compile a database of bridges on the roads where new trucks will operate, including their load ratings, structural types, span lengths, and traffic volumes. The studies use the DOT-maintained National Bridge Inventory for this purpose.
2. Specify prototype axle loads and axle spacings of the trucks expected to come into use under the new regulations for each bridge. Also specify loadings imposed by the existing truck types.
3. Simulate the application of each prototype truck to each bridge, with assumptions about the likelihood of the presence of multiple trucks on the bridge at one time, and compare the estimated forces in

the bridge structure with some specified acceptable threshold value, expressed as a percentage of the theoretical capacity of the structure. Also, perform this simulation for the existing truck types.

4. Assign a treatment, either replacement or posting to restrict truck traffic, to each bridge for which any of the loads for existing truck types and for the proposed new trucks cause the force criterion to be exceeded. Strengthening bridges is a third possible treatment, which the TRB and DOT studies do not quantitatively evaluate. The DOT study does not evaluate posting as an option; that is, the highway agency is assumed to replace every bridge for which the load criterion is exceeded.

5. Estimate the highway agency's cost for each bridge treatment, primarily, in the TRB and DOT studies, the costs of bridge replacements. The cost of the new regulation is the difference between bridge treatment costs predicted by this method for the existing truck types and costs for the predicted truck characteristics under the new regulations.

In addition to highway agency bridge replacement costs, the DOT 2000 study estimates the cost of traffic delay due to bridge construction. The TRB studies omit this delay cost but include estimates of fatigue cost (i.e., the cost of increased maintenance and loss of useful life resulting from repeated applications of loads) and of the added cost of building new bridges to higher design standards in the future.

Shortcomings of Method of Past Studies

Three deficiencies of the above traditional method of projecting bridge costs limit the usefulness of the estimates thus derived for evaluation of truck size and weight policy. First, the method applies arbitrary criteria to determine whether bridges require replacement. The TRB and DOT studies contain no estimates of how much safety improvement would be gained (e.g., how many bridge failures would be avoided) or of how life-cycle bridge costs would be affected by applying the selected overstress criterion as compared with alternative criteria. Thus, for example, there is no evidence presented in the DOT 2000 study that the additional billions of dollars in user and highway agency costs required to replace bridges exposed to heavier trucks according to the criterion applied by that study, compared with a more lenient standard, would buy any significant public benefit.

The second failing is that past studies generally have not systematically taken into account the possibility of intelligent management of bridge investment and maintenance decisions by highway agencies.

State highway agencies evaluate bridge replacements individually and try to avoid replacements that have high costs and produce little benefit, especially when alternatives to replacement (strengthening, more intensive inspection and maintenance, or posting) are available. Alternative treatments could produce the same degree of insurance against bridge failure as the extensive bridge replacements projected in past studies at much lower cost to the highway agency and to users.

Finally, consideration of costs other than the highway agency's bridge replacement costs has been haphazard in past studies. As noted, the TRB studies ignore traffic delay due to construction, while the DOT 2000 study omits fatigue costs and the addition to costs of future bridges. No past study has taken into account the remaining useful life of bridges projected to be replaced under new size and weight regulations, although replacing a structure that would have been replaced for other reasons within a few years has lower net cost than replacing a new structure. The studies also ignore the side benefits of replacing bridges, especially older ones, since new bridges usually are safer and often have increased traffic volume capacity.

Because of these deficiencies, the past estimates are not good indicators of either economically justified expenditures or expenditures highway agencies would actually be likely to make if new trucks were introduced.

To gain a better understanding of the significance of the bridge cost estimates of past studies, the committee first examined the results of the DOT 2000 analysis for a few actual bridges and compared those results with the judgments of state bridge engineers. The committee also examined the sensitivity of the estimates to assumptions about the replacement threshold criterion. These investigations are described in the following subsections.

Comparison of Past Study Assumptions with State Practices If state DOTs were actually required to accommodate the larger trucks proposed in the TRB and DOT studies, state bridge engineers would make engineering–economic choices from a range of options including bridge replacement, retrofit reinforcement, posting, or doing nothing when examination showed a bridge had adequate load-bearing capacity. Similarly, a range of practical options is available for reducing travel delays caused by closings. Decisions would be made for each bridge individually and would depend on the volume of car and truck traffic, the remaining life of the bridge, and its functional adequacy.

Cost estimates that do not take into account practical and cost-effective means likely to be employed by the state highway agencies

to manage the bridge-related costs of accommodating new vehicles will overstate the magnitude of bridge impacts from changing limits and thereby mislead policy makers. As one check on the plausibility of the assumptions of the bridge cost model used in past studies, the committee examined cost estimates for a small number of bridges selected from one state. Results obtained with the DOT study method for determining whether each bridge would require replacement if a particular new truck came into use were then compared with the results of analyses of options for each bridge as bridge engineers of that state would carry out such analyses.

The committee obtained from DOT a list of highway structures in California identified by the bridge analysis method used in the DOT 2000 study as requiring replacement if a specified type of larger truck were to come into use. From the major structures on the list (i.e., those on Interstate highways and those more than 2,000 ft in length), four were selected for analysis, including the two with the lowest average daily traffic volume and two of the three with the highest average daily traffic. The largest is 1.4 mi long and carries 230,000 vehicles a day. Replacing these long structures would incur high construction costs, and replacing those with the greatest traffic volumes would generate high travel delay costs in the DOT estimates. Each of the four structures exceeds the threshold overstress criterion applied in the DOT study under the assumed loading by just a few percent. The four structures were examined by engineers of the state DOT, who reported to the committee that, following its normal practices, the state would not replace, strengthen, or restrict the use of any of the four structures if heavier tractor-semitrailers within the range analyzed in the DOT 2000 study came into use.

Obviously, the small number of bridges selected does not constitute a representative sample. Also, California bridges, which are examined in this and the following subsection, are not necessarily typical of bridge designs and conditions throughout the United States, and practices of the state's bridge engineers are not necessarily the same as those followed in other states. The purpose of this examination of the state's bridges is to illustrate some of the problems of estimating the bridge costs associated with changing limits.

The state engineers reported to the committee that, although the state would be unlikely to replace as many structures as the DOT analysis forecast, widespread use of heavier tractor-semitrailers would increase bridge costs to the state, mainly because increased loads would reduce structures' lifetimes. As noted, the DOT study omits this

bridge fatigue cost, and the TRB studies (TRB 1990a, 95, 101–102, 203; TRB 1990b, 135, 145–149) estimate that it would be small in comparison with costs related to deficient bridge load-bearing capacity; however, systematic measurements of fatigue costs are lacking. The state engineers' assessment suggests that fatigue costs are more important than past studies have indicated.

Sensitivity of Cost Estimates to Assumptions To better understand the determinants of bridge cost estimates in the past studies, the committee next asked DOT to provide tabulations of California bridges that would require replacement according to the DOT 2000 study's method of analysis, and also according to an alternative, more lenient criterion dictating the threshold stress that would trigger replacement of a bridge if a specified larger truck were introduced. The comparison that follows is a sensitivity analysis to show how the selection of this threshold criterion affects costs estimated by using the method of past studies.

AASHTO specifies two alternative criteria for application in determining the loads existing bridges should be allowed to carry. Under the inventory rating criterion, the stress on any structural member of a bridge is not to exceed 55 percent of the yield stress of the member when the bridge is traversed by one truck of the dimensions of interest in each lane simultaneously (on short spans) or multiple trucks per lane (on long spans). Under the operating rating criterion, the stress cannot exceed 75 percent of yield. AASHTO explains the two criteria as follows (AASHTO 1994, 50):

> Each highway bridge should be load rated at two levels, Inventory and Operating levels. . . .
>
> The Inventory rating level generally corresponds to the customary design level of stresses but reflects the existing bridge and material conditions with regard to deterioration and loss of section. Load ratings based on the Inventory level allow comparisons with the capacity for new structures and, therefore, result in a live load which can safely utilize an existing structure for an indefinite period of time. . . .
>
> Load ratings based on the Operating rating level generally describe the maximum permissible live load to which the structure may be subjected. Allowing unlimited numbers of vehicles to use the bridge at Operating level may shorten the life of the bridge.

In applying the rating criteria, the methods used by bridge engineers to calculate stresses on bridges caused by a given loading are conservative, so the actual measured stresses are generally much below calculated stresses (TRB 1990b, 137). States use these criteria for determining which bridges require posting (i.e., restricting use to trucks below the normal maximum weight) and for deciding whether to grant special permits allowing operation of trucks over the normal maximum weight. State practices vary widely, but few states base these decisions solely on the inventory rating (TRB 1990b, 139).

The bridge replacement threshold criteria applied in the DOT 2000 study allow stresses slightly higher than the inventory rating stress on bridges designed to accommodate the HS-20 design load (a standard vehicle defined by AASHTO for use in bridge design) and stresses slightly less than the operating rating on bridges designed to accommodate the H-15 design load. Nearly all Interstate structures were designed to the HS-20 design load or a more rigorous standard; the H-15 design load is typical of older bridges and less important roads. The bridge cost estimates of the TRB studies assume bridges would be replaced or posted if the operating rating were exceeded. DOT states it chose its criteria because they are "consistent with TS&W [truck size and weight] regulatory practice" (DOT 2000, Vol. III, II-14). The TRB committees apparently decided that the more lenient criterion they applied was reflective of state bridge posting and permitting practices and therefore appropriate for the application. None of the studies defends its chosen criterion with a quantitative argument about economic or safety consequences.

DOT provided the committee with lists of structures on California roads that fail the criterion used in the DOT study and those that fail the criterion used in the earlier TRB studies. These tabulations show a large difference in the number of bridges classified as overstressed by the specified truck according to the alternative criteria: 33 percent of bridges evaluated according to the DOT study criterion versus 6 percent applying the operating rating criterion. The difference in the replacement costs estimated by DOT is even greater: the agency and user costs of replacing the bridges failing the DOT study criterion are more than 30 times the costs of replacing bridges failing the operating rating criterion.

The largest component of replacement costs using the DOT study criterion is the cost of user delay during construction. According to the DOT study criterion, a large number of California structures with average daily traffic (ADT) above 100,000 vehicles are flagged for

replacement. These high-traffic bridges are the source of the high user costs of replacement. Using the operating rating criterion, very few structures with ADT above 100,000 are identified for replacement.

The structures that fail to meet the DOT study criterion occur throughout all highway systems in California. They include, for example, many Interstate structures. In contrast, nearly all the structures that fail the operating rating criterion are in the minor arterial, collector, and local classes.

In a 1994 congressionally mandated review of the costs and benefits of LCVs, the General Accounting Office (GAO) commented similarly on the great discrepancies in bridge cost estimates produced by differing assumptions about safety margins. In estimates produced by DOT according to GAO's instructions, agency bridge costs of nationwide use of LCVs on the Interstates ranged from $18 billion using the inventory bridge capacity rating to $1.3 billion using a capacity rating somewhat more conservative than the operating rating. GAO concluded that the latter criterion was reasonable to ensure safety, and that bridge costs could reasonably be reduced even further by judicious exclusions of Interstate segments with high bridge costs from the LCV network (GAO 1994, 24–25).

In another report, GAO comments on the fundamental shortcoming of the bridge cost estimation method used in past studies (GAO 2000, 6). In a review of DOT's biennial reports to Congress on justifiable levels of funding for the federal-aid highway program, GAO observes:

> FHWA's estimates of total highway and bridge investment requirements in the [reports to Congress] combine estimates derived from the HERS [Highway Economic Requirements System] model, a bridge model, and other types of estimates. The HERS model uses benefit-cost analyses to estimate future highway investment requirements on the basis of information about existing highways. On the other hand, the bridge model is based on engineering data and does not currently use benefit-cost analyses in estimating investment requirements for bridges.

The bridge cost estimating method used in the DOT reports relies on a method for identifying structurally deficient bridges similar to that used for the DOT *Truck Size and Weight* study. GAO notes (p. 8) that the 1994 Executive Order "Principles for Federal Infrastructure

Investments" (EO 12893) requires agencies with infrastructure responsibilities to plan for investments using a systematic analysis of expected benefits and costs, and that the bridge cost estimates in the DOT reports to Congress do not appear to be in compliance with the order. The report observes that benefit–cost analysis is superior to the application of engineering standards for determining justifiable highway investments because the latter method selects projects without regard to economic merit.

A study sponsored by the Association of American Railroads also points out the great difference between costs estimated applying the two criteria in the AASHTO standards and criticizes the TRB studies for choosing a criterion that does not reflect the preferences of most state engineers (Harrison et al., 1991). However, this dispute over the relative merits of the alternative criteria is irrelevant to the criticism stated here of the method used for the past studies.

The aim of the above comparisons is not to argue that one criterion or the other is the correct one. The large difference in the costs derived by applying the two criteria indicates that an economic analysis of risks is necessary. Neither criterion is supported by analysis of costs and risks; therefore, it is impossible to say that one or the other criterion is the correct one for evaluating alternative size and weight policies.

A More Realistic Method of Estimating Bridge Costs

As noted above, bridge cost estimates derived by the method of past studies assume replacement of bridges regardless of whether the cost of replacement is justified by the gain in safety and do not fully take into account the capabilities of highway agencies to maintain bridge safety by more cost-effective means than replacing all suspect bridges. Figure 2-2 is a diagram representing a method of estimating the bridge costs associated with changing limits that corrects these deficiencies. In each year, there are several possible outcomes for each bridge on a highway system: failure, replacement, repair, posting, or no highway agency action taken. Each of these possible outcomes has a cost and a probability that it will occur in each year. The probabilities depend on bridge characteristics, traffic, and inspection and maintenance practices. The diagram illustrates conceptually that economic analysis of truck impacts on bridges requires a model that predicts the probability of each outcome as a function of bridge condition and traffic, as well as information about the costs of each outcome. For purposes of national or state-level policy analysis of size and weight regulations,

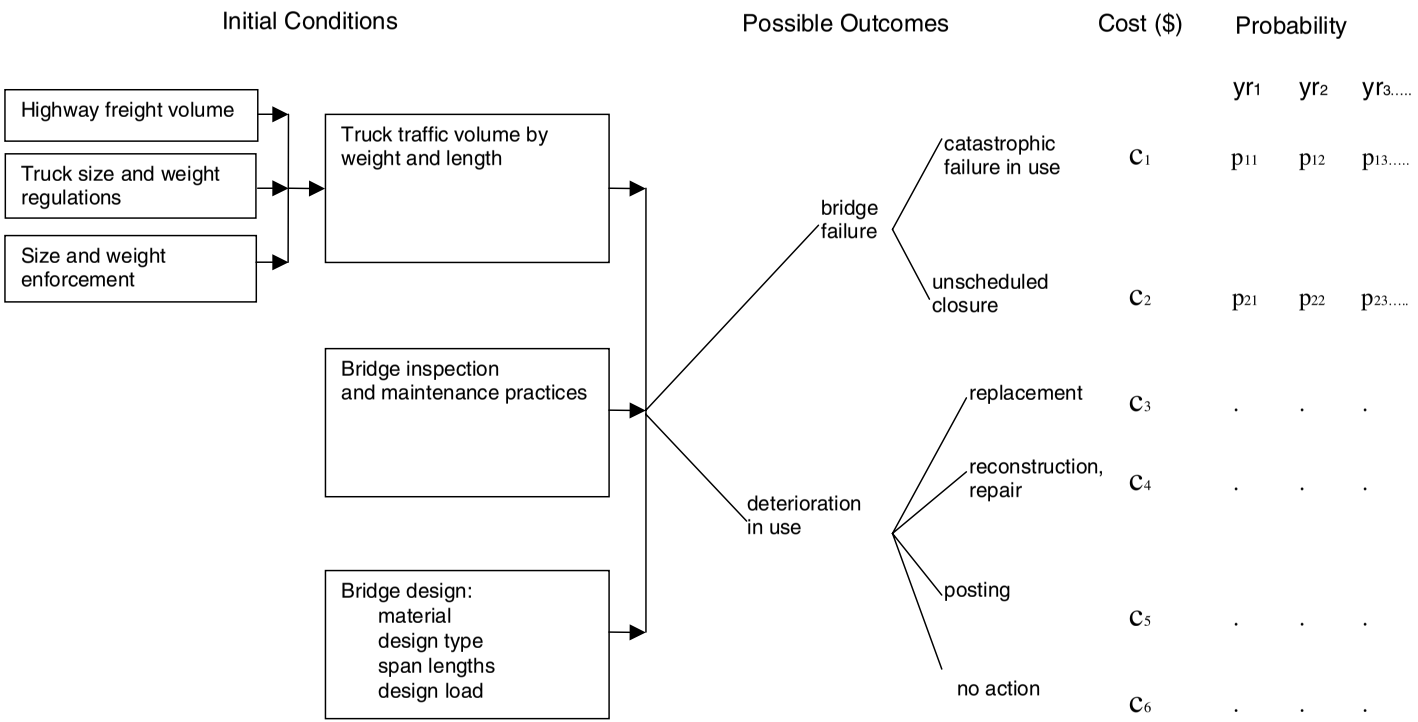

FIGURE 2-2 Determining expected bridge costs of changing truck size and weight limits.

the estimate could be carried out for a sample of manageable size drawn from the population of bridges. The estimate would proceed according to the following steps:

1. Estimate, from historical data, the expected annual rate of bridge failures on a state's system under present traffic conditions and management practices. A failure can be defined as the occurrence of damage that would necessitate closing the bridge.
2. Specify a proposed change in size and weight regulations, and project the resulting change in the distribution of truck loadings on the highway system's bridges.
3. Estimate the expected annual rate of bridge failures under the proposed new size and weight regulations.
4. With this information, estimate benefits and costs for three courses of action:
   a. Do not change the size and weight regulations.
   b. Change the regulations, and eliminate any increase in expected annual failures by replacing bridges.
   c. Change the regulations, and tolerate the new rate of failure.

   For example, if the present failure rate is 0.1 bridges per year (that is, the expected rate is 1.0 bridge every 10 years), and the rate after the change in limits (with no bridge replacements and no change in bridge management) is projected to be 1.0, the state highway agency might decide that (c) is not acceptable, that is, that the regulations could be changed only if the bridges were upgraded. On the other hand, if the present rate is 0.04 and the projected rate under the new regulations is 0.05, then a case might be made that consideration of the relevant costs (the cost of bridge upgrading, the freight cost savings of higher truck weights, and the costs of a bridge failure) would indicate that the state should decide to adopt policy (c)—accepting the increased risk—although it may be that no state would explicitly adopt such a policy. [Computations in previous truck size and weight studies are done only for policy (b)—the cost of replacing or reconstructing bridges so as to return the risk of failure to the prechange level.]
5. Knowing the risks would also allow two other possibly valuable strategies to be evaluated:
   d. Change the regulations, and replace selected bridges so that any increase in expected failure rate is partially, but not fully, eliminated.

e. Change the regulations, and reduce or eliminate the change in failure rate by means other than bridge replacement, such as more intensive bridge inspection and maintenance or more intensive enforcement of truck weight regulations.

Either strategy (d) or (e) (or a combination) might yield greater benefits than the first options. To see how policy (e) reduces risk, consider as a simple example a structural component with strength R subjected to load S (see Figure 2-3) (Moses 2001, 4–5). The strength of the component and the load to which it may be subject are uncertain, as represented by the probability distributions in Figure 2-3. Because the two distributions overlap, there is a finite probability of failure. If the component is part of a highway bridge, this probability increases over time because the component is subject to deterioration and because trucks tend historically to become heavier (see Figure 2-4). The original level of risk can be restored by either of two methods: the means of R and S can be moved apart (by posting the bridge to reduce truck weights, strengthening members, or replacing the bridge), or the uncertainties in the distributions can be reduced (see Figure 2-5). The de-

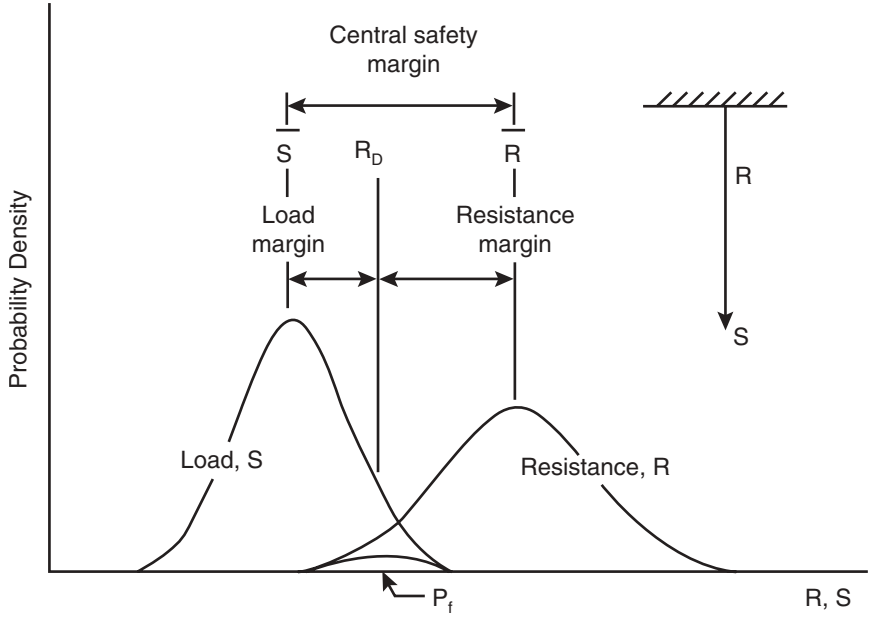

FIGURE 2-3 Basic reliability model and failure probability. (Source: Moses 2001, 5.)

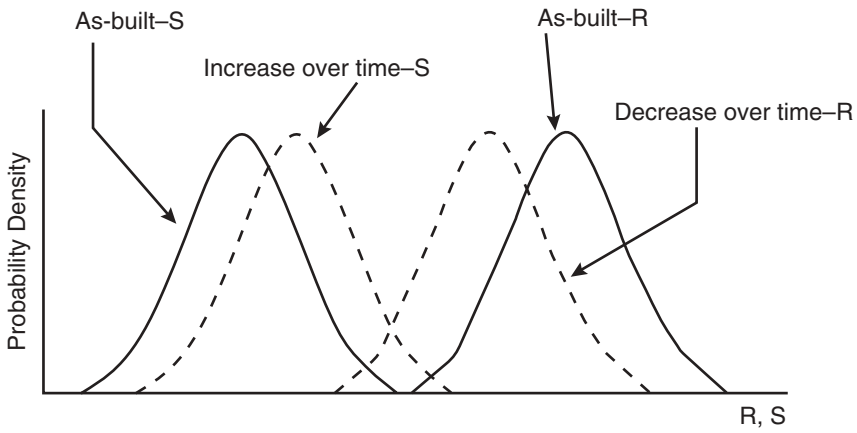

FIGURE 2-4 Illustration of changing reliabilities over time. (Source: Moses 2001, 6.)

sired level of risk can be attained by more intensive management (i.e., more frequent inspection and repair of deterioration), which reduces the uncertainty in R, or by more rigorous weight law enforcement, which reduces the uncertainty in S. If, hypothetically, a comparison were made between two highway systems—one system with a rigorous, state-of-the-art bridge inspection and maintenance program within the framework of a comprehensive bridge management system, as well as effective weight enforcement, and with liberal policies regarding allowable vehicle loadings on bridges; and the other system with underfunded and unsystematic bridge inspection and maintenance and lax weight enforcement, and with restrictive bridge loading rules—one could easily imagine that the first system might have the safer bridges and the lower long-run user and highway agency costs.

The method outlined here for estimating the costs of changing size and weight regulations assumes that highway agencies make optimal bridge management and construction decisions. An alternative approach would be to attempt to predict how state bridge engineers would be most likely to behave if the state highway systems were required to accept larger trucks, and to estimate the costs of this behavior. Both kinds of bridge cost estimates would be relevant to the federal policy decision, and with slight modification, the method outlined above could make such a plausible "behavioral" projection.

Cost estimates assuming optimal bridge program decisions would be valuable for three purposes. First, under certain of the federal policy options presented in Chapter 3, possession of minimum bridge

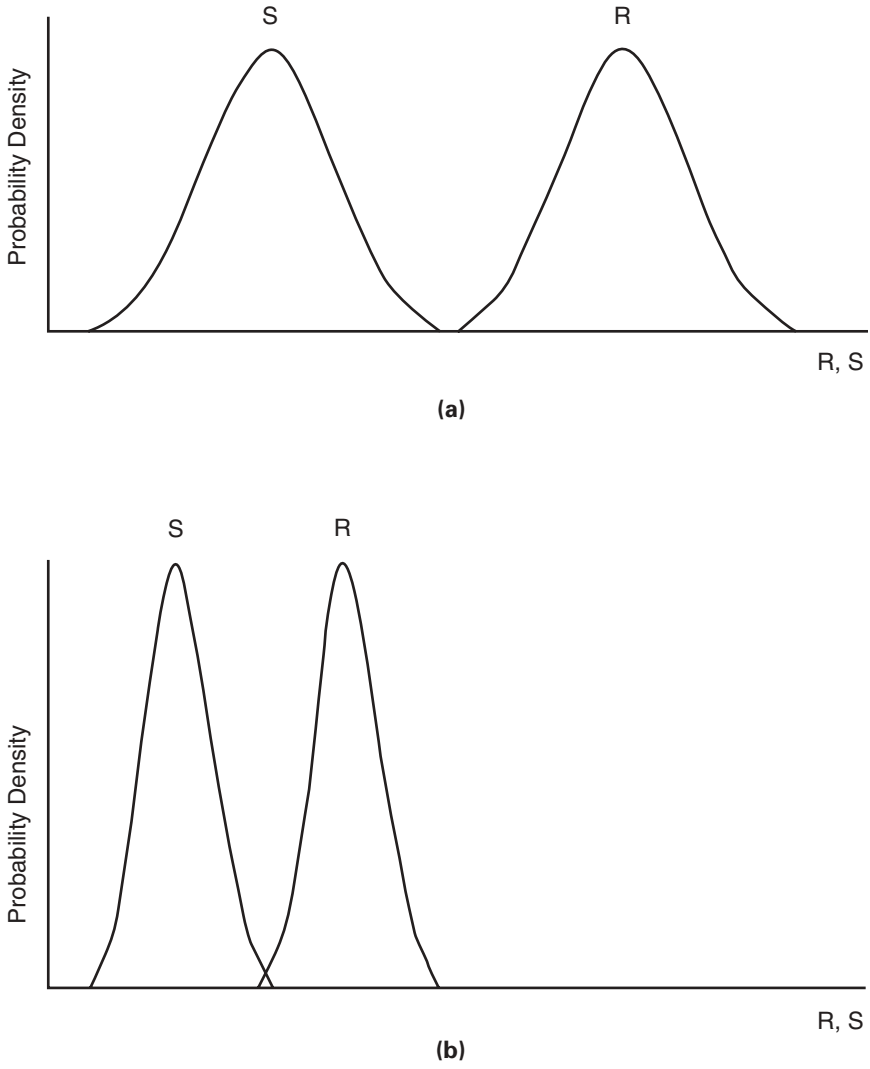

FIGURE 2-5 Relation of uncertainty to reliability: (*a*) larger safety factors; (*b*) reduced uncertainties. (Source: Moses 2001, 5.)

management capabilities would be a precondition for liberalization of federal regulations within a state. Second, state bridge management capabilities are undergoing substantial improvement, as described in the next subsection. Finally, it is vital to understand the nature of the obstacles to realizing the economic benefits of improved truck productivity. If analysis shows that the principal obstacle is inadequate highway management practices rather than physical deficiencies of the highway infrastructure, it will be possible for Congress to recognize and address this inadequacy.

Although the method of past studies sometimes has been described as a behavioral approach, that is, an estimate of how highway agencies would respond if new trucks were introduced given the agencies' established practices, the projections of the traditional method are unlikely outcomes. It is highly implausible that states would undertake bridge investments of the magnitudes predicted by the method. Instead, some mix of responses would occur: the states would post some bridges, restricting the routes on which the trucks were allowed; some critical bridges probably would be replaced earlier than otherwise; and economic and political pressures might force deviations from precedent so that trucks would be allowed to use bridges from which they might have been barred according to past practice. The consequence of the last response would be the initially invisible costs of higher risk of failure and accelerated deterioration. States with well-managed bridge programs would take action to mitigate these impacts substantially and cost-effectively within budget constraints, replacing selected bridges and rehabilitating or intensifying maintenance on others, while less capable states might do little.

Examples of Applications of Reliability and Risk Analysis

Apparently there is no example of an analysis that has carried out all of the steps in the above method either for evaluating size and weight policy or as part a of a state's bridge management activities. However, the components of the analysis have been developed and applied, so carrying out the complete analysis would be practicable.

Probabilistic analysis is increasingly recognized as the appropriate basis for bridge design and for cost-effective management of the bridges on a highway system. This approach recognizes that the consequences of highway agencies' decisions regarding bridge design and maintenance are changes in the risk of bridge failure, and quantifies these changes. The approach treats bridge management as an optimization problem: the optimum program is the schedule of construction, maintenance, and inspection activities that meets a specified objective

(e.g., a level of bridge failure risk) at lowest cost or obtains the greatest net benefit from a specified budget. Costs are the present value of the expected user and agency costs of failures plus the user and agency costs of bridge maintenance and replacement. Reflecting elements of this overall philosophy, AASHTO has developed bridge design specifications and a manual for evaluation of existing bridges that take account of the statistical variation of loads and of resistance of structural elements (AASHTO 1998; NCHRP 12-48, forthcoming 2002).

One illustration of the practical application of reliability analysis and optimization in bridge management to improve safety is a study employing condition data for a sample of New York bridges. For a fixed maintenance budget, selection of maintenance projects according to risk minimization was estimated to reduce the user costs of failures by 11 percent as compared with costs when projects were selected by traditional criteria on the basis of qualitative condition ratings (Cesare et al. 1993).

The risk-based approach to estimating the bridge costs associated with changing size and weight regulations is more consistent than the method used in past studies with the way bridges are actually affected by increased truck weights and with how highway agencies manage bridges and respond to changes in traffic loadings in practice. Highway agencies' bridge inspection data reveal how bridges deteriorate over time. Agencies must counteract the deterioration with maintenance, or the bridge will reach a state in which it is judged unfit to carry traffic. For example, a simulation model calibrated with data on New York bridges shows how the expected rate of deterioration of the steel structure of a bridge depends on the frequency of deck joint repairs to prevent water infiltration (see Figure 2-6) (Cesare et al. 1992).

The weight distribution and frequency of truck loadings affect the rate of deterioration. Agencies recognize that loadings are increasing over time and that bridge costs are rising as a result. The costs they recognize are more frequent repair of damaged decks and superstructures and the need for accelerated rehabilitation or replacement to keep structures in service. Agencies typically respond with more intensive maintenance instead of tolerating reduced reliability and increased frequency of failure. The relationship of changes in truck weights to the rate of bridge deterioration and bridge costs was measured in a recent National Cooperative Highway Research Program (NCHRP) project (NCHRP 12-51, forthcoming 2002).

The Ontario provincial highway authority has examined the relationship of repeated heavy loading to bridge fatigue and loss of useful

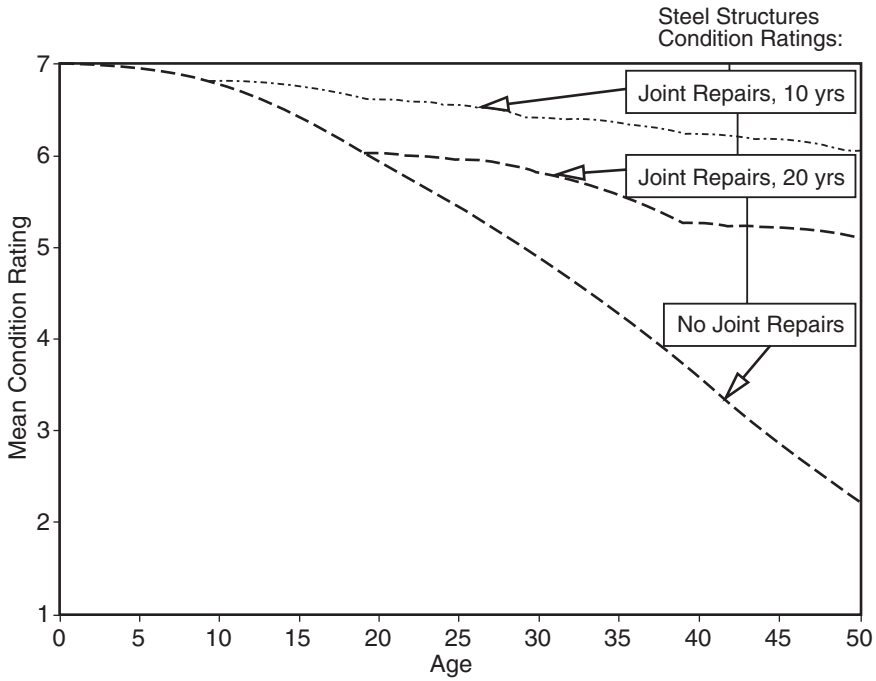

FIGURE 2-6 Effect of maintenance on bridge deterioration. (Adapted from M. A. Cesare, J. C. Santamarina, C. J. Turkstra, and E. Vanmarcke, Modeling Bridge Deterioration with Markov Chains, *Journal of Transportation Engineering,* Vol. 118, No. 6, Nov./Dec. 1992, p. 829. Reproduced with permission of the publisher, the American Society of Civil Engineers.)

life (Dicleli and Bruneau 1995). Ontario's weight regulations have been among the most liberal in North America, allowing up to 140,000 lb gross weight on eight-axle combinations. Tests of extreme permit loads (up to 290,000 lb) indicated that while typical steel bridges had adequate ultimate capacity to accommodate such overloads, they would be subject to fatigue damage from the cumulative effect of repeated overloads, which would shorten the life of bridge elements. For example, a calculation indicated that adding six passages per day of the 290,000-lb load over a particular bridge would reduce the bridge's service life by 8 percent. This study demonstrates that the cost of lost useful life of structures caused by increased loadings can be calculated and that bridge users could be assessed these charges on a per-use basis.

Ontario also has a program of bridge testing with the objective of obtaining the maximum economic use of its stock of bridges. A provincial study of bridge testing results reveals that actual load-carrying

capacities typically differ greatly from those predicted by conventional analytical methods, and that in nearly every case the capacity of the tested bridge was substantially higher than the capacity predicted. The testing program is reported to have saved the province substantial sums of money by allowing it to avoid unjustified bridge replacements. The study includes the caution that "bridges have finite capacities, and the difference between the actual and assumed capacities, however large, cannot be indiscriminately relied upon." The province regards its active bridge test program as sufficiently ensuring safety (Agarwal and Billing 1988).

A new bridge formula derived from a reliability model was recently proposed in research sponsored by FHWA (Ghosn 2000; Ghosn and Moses 2000). Traffic and bridge characteristics related to load-bearing capacity are described as probability distributions, and a target expected frequency of structural failure is specified. The research shows how to determine truck size and weight limits that meet target levels of risk of bridge failure for a system of bridges. In the study's reliability model, lifetime risk of failure of critical bridge members is estimated in terms of the principal sources of uncertainty or variability in the capacity of structural elements (for example, measured variability in the capacities of steel structural members as a function of the extent of corrosion) and in the loadings placed upon them from traffic and other sources, including actual variability in vehicle weights and the risk of multiple heavy vehicles occupying a span simultaneously. The research derives a bridge formula that would provide equal failure risk for all steel bridge span lengths, for each of a range of target levels of risk. The study also examines whether trucks satisfying the bridge formula derived for simple-span steel bridges would cause unacceptable failure risks on existing prestressed concrete and reinforced concrete bridges. It concludes that, with few exceptions, the formula would provide adequate protection for these structures as well.

The risk level embodied in the study's recommended bridge formula is justified on the basis of the consensus of engineering practice. Future extension of such an analysis, following the method outlined in the preceding subsection, should involve selecting an optimum risk level for regulating truck weights on existing bridges on the basis of economic criteria, taking into account the actions states can take to control the uncertainties in loadings and bridge conditions.

State highway agencies are making progress toward having the kinds of databases and analytical capabilities needed to control bridge failure risks through inspection and maintenance practices and to

evaluate the differences in life-cycle bridge costs for alternative strategies of maintenance, rehabilitation, and replacement. These capabilities allow a highway agency to select the lowest-cost set of practices for accommodating a change in truck weight limits. A bridge management system has two components: a database, maintained through a program of bridge inspection, describing the design characteristics, current condition, and traffic characteristics of all the state's highway structures; and a set of models or procedures to facilitate programming of bridge maintenance, rehabilitation, and replacement. The models predict next year's bridge conditions on the basis of this year's maintenance actions and allow the state to find the minimum-cost schedule of bridge work that meets specified goals relative to safety and traffic service. The models also allow the state to select designs for new structures with the lowest life-cycle costs. Today more than 40 state highway agencies subscribe to the PONTIS computer software, a bridge management system developed by FHWA and made available to the states through AASHTO. The quality of state implementations of PONTIS, in particular the quality of the databases, varies greatly, and bridge management system evaluations still are rarely a primary input to states' bridge program decisions (Marshall et al. 2000). As bridge management practice evolves, however, the states will have greater knowledge and control than previously of the condition of their bridges, allowing greater safety and reliability as well as cost savings.

The Potential of Retrofitting

Neither the TRB studies nor the DOT 2000 study quantitatively assesses the potential of bridge retrofitting as a means to accommodate greater loads. Retrofit strengthening of bridges to increase load-bearing capacity and earthquake resistance is a technique employed increasingly in state highway programs, although no state is known to have undertaken a program of retrofitting specifically to accommodate larger trucks. A study sponsored by the American Trucking Associations estimates that feasible retrofit strengthening could reduce the number of steel bridges on Interstate highways judged to be overstressed by the commonly proposed larger trucks by 70 to 100 percent, according to standard evaluation criteria, depending on the criterion applied and the truck being evaluated. The fraction of steel bridges requiring retrofit would be from 2 to 30 percent, again depending on the criterion and the truck in question. The authors assert that "retrofits would be inexpensive and would involve only a limited number of bridges but could significantly influence the allowable load capacity of the overall highway network" (Fu et al. 1992, 320–323).

Summary

If heavier trucks are introduced, highway agencies will incur costs for replacement of bridges, more intensive bridge management and maintenance, and lost useful life of some structures. Construction necessitated by bridge deficiencies will cause highway user delay costs. Competent management would make it possible to maintain bridge safety and service to users at a lower cost than that of the strategy of replacing all nominally deficient bridges.

Because of their methodological shortcomings, the bridge cost estimates of past truck size and weight studies are not very reliable guides to policy. Although the correct analysis remains to be conducted, one can conclude that the bridge cost projections in the DOT 2000 study are almost certainly overestimates of the amount of spending that would be prudent for maintaining bridge safety if truck weights were increased. The DOT study itself acknowledges this limitation. Very high estimates of bridge costs from liberalized regulations are inconsistent with the experience of jurisdictions—in particular Michigan and Ontario—that have opened their roads to use by trucks much heavier than the federal weight limits without experiencing costs of the magnitude estimated. Most important, the DOT estimates ignore the great potential for lower-cost methods of maintaining bridge safety that the states are increasingly capable of applying because of the widespread adoption of bridge management systems.

Future truck size and weight studies should produce bridge cost estimates by predicting changes in expected frequencies of bridge failure caused by changes in size and weight regulations and in highway agency management practices; estimating the costs of increased risk; and comparing alternative methods of reducing risk to find the optimum combination of size and weight limits, bridge replacements and postings, intensity of bridge inspection and maintenance, and truck weight enforcement. This analysis should include assessment of the practicability of the alternative strategies. The most important part of this evaluation would be the estimation of relationships between changes in truck traffic on bridges and changes in rates of deterioration. The same methods should be applied for computing cost-based fees for heavier trucks in state permitting programs.

Impacts on Traffic Operations and Pollution

This section describes available predictions of changes in traffic, air pollution, and noise caused by changes in truck size and weight limits. Traffic, pollution, and noise impacts are considered together be-

cause they are effects that are particularly important in urban areas and because they depend on the relationship of truck volume and performance characteristics to traffic flow.

Changing truck size and weight limits will affect traffic congestion through four mechanisms:

- Annual truck-VMT of travel will change as a result of changes in truck capacity and greater use of trucks in response to lower trucking costs.
- Truck travel will be redistributed among roads if changes in limits are different for different classes of roads.
- If new trucks are longer or less maneuverable or have less power in relation to their weight, each truck-VMT by the new trucks will cause greater perturbation of traffic than a VMT by the trucks replaced.
- Changes in truck traffic volume and any resulting changes in congestion will alter the costs of highway travel for other highway users, who in response may change the time, route, or quantity of their highway travel. Nontruck travel will also be affected if changing truck size and weight alters business location decisions.

A related chain of effects will change air pollutant emissions:

- Truck emissions per truck-VMT will change because the new, larger trucks will in general have greater fuel consumption per mile and because temporal patterns of velocity and acceleration may change, especially if the new trucks have different power-to-weight ratios than old trucks or other drive-train differences.
- The volume and distribution of truck traffic will change. Total annual truck-VMT may either increase or decrease, depending on whether the volume of freight attracted to truck transport by lower costs is great enough to offset the effect of greater capacity per truck.
- Changes in truck traffic volumes and characteristics will affect the behavior of drivers of other vehicles. Changes in truck volume and performance will change other drivers' passing or lane-changing behavior. Changes in the frequency of congested conditions also will alter other vehicles' temporal patterns of velocity and acceleration. Changes in congestion delay and in velocity and acceleration patterns will alter the emissions of all vehicles.
- Changes in nontruck travel volume and travel patterns stimulated by the changes in truck traffic characteristics and congestion will affect emissions.

The following subsections summarize methods and results of the congestion and pollution estimates in the 1981 DOT truck size and weight study, the TRB studies, and the DOT 2000 study. There is more diversity in the studies' treatment of these costs than for any of the other categories of impacts.

1981 DOT Study

The DOT (1981) truck size and weight study includes an analysis of 14 actual urban road segments, from 1.5 to 13 mi in length, located in states throughout the country. Traffic, population density, and other local data for each segment were obtained and estimates made of changes in traffic, accidents, maintenance costs, congestion, noise, and air quality for each segment for each of the nine regulatory change scenarios evaluated in the study. The case study approach was taken because the authors recognized that urban impacts will be highly variable, depending on local conditions. Presumably the authors concluded on the basis of the case study results that a nationwide urban impacts estimate would not reveal enough new information to be worthwhile.

The estimates were the result of the following computations:

- Changes in VMT for heavy trucks were predicted by truck configuration. Projections were made regionally, by urban/rural land use, and by highway class. In all the projections, allowing more productive trucks reduced total truck-VMT since the only source of induced truck traffic considered was diversion from rail, which was projected to be too small to offset the effect of increased ton-miles per truck-VMT. Increasing federal limits was projected to increase truck traffic on some roads because trucks would be diverted from state-regulated secondary roads to primary roads subject to federal regulations in response to the liberalized limits. Making limits more restrictive increased total truck-VMT.
- Passenger car equivalents (PCEs) for the new truck types were estimated. The PCE of a truck is the number of cars that would have to be added to the traffic stream to have the same effect on traffic flow as adding one truck to the stream. The report does not explain how PCE values were selected. Apparently they were assumed in most cases to be the same for new trucks as for the trucks replaced, although the study did include some direct observations of trucks in traffic.
- Peak and off-peak speeds were predicted to change as a result of the change in total PCE volume on the road segments. Thus speeds in general increased in scenarios involving the liberalization of limits.

Travel time changes were predicted on the basis of the speed changes. Speeds did not necessarily increase on every road segment in the liberalization scenarios because of diversion of trucks from secondary roads.

- The change in emissions was predicted on the basis of speed-dependent emissions factors (grams per vehicle-mile) for several classes of vehicles. The documentation available does not state how DOT derived emissions rates for larger trucks. (The study included a separate analysis of nationwide changes in emissions.)
- Change in noise exposure was predicted on the basis of models of road noise as a function of traffic volume, speed, and vehicle mix and models of truck noise as a function of configuration and speed, as well as data on highway geometry and adjacent land use for the case study segments.

The 1981 study does not include estimates of changes in emissions of particulate matter, which today are regarded as the most harmful diesel emissions (TRB 1996; McCubbin and Delucchi 1999). No economic value is placed on the projected changes in emissions.

Median values of impact estimates among the 14 urban sites in the most extreme higher-weight scenario (Scenario J, which would allow short double-trailer configurations of up to 105,000 lb and tractor-semitrailers of up to 90,000 lb) were as follows:

Impact	*Percent Change from Base Case*
Peak volume/capacity ratio	–0.15
Off-peak volume/capacity ratio	–0.25
Annual oxides of nitrogen emissions	–0.50
Annual hydrocarbon emissions	–0.30
Population with noise exposure above a specified threshold	+0.80

Thus the projected impacts are all very small and generally, with the exception of noise, are favorable. Because the traffic projections involve redistribution of truck traffic among routes in response to route-specific changes in regulations, some of the effects on the case study roads could be augmented or offset by effects on other nearby roads. Since these estimates were published in 1981, great changes have occurred in traffic, highways, vehicle emission characteristics, and population distribution. If the estimation method of the DOT study were repeated with up-to-date data, the new estimates could differ greatly from those listed above. However, updating might not alter the qualitative finding that

the percentage changes are small. The most serious deficiency in the estimates may be omission of consideration of particulate emissions.

TRB Studies

Quantitative estimates of changes in congestion delay or emissions resulting from changes in size and weight regulations were not included in the TRB studies (TRB 1986; TRB 1990a; TRB 1990b). Engineering evaluations of performance features of the new trucks and characteristics of their interactions with other vehicles, and the qualitative relation of these items to traffic flow, were involved in the studies. The features considered were as follows:

- Speed on upgrade;
- Traction ability;
- Passing (and being passed) on two-lane highways;
- Freeway merging, weaving, and lane changing;
- Freeway exiting maneuvers;
- Intersection sight distance requirements;
- Signal timing requirements;
- Downhill operations;
- Longitudinal barrier requirements;
- Splash and spray;
- Truck blind spots;
- Blockage of view; and
- Aerodynamic buffeting.

It was concluded that some of these features of the proposed new trucks would likely have adverse consequences for traffic flow in truck-for-truck comparisons with existing vehicles; that most effects would be small; but that if new trucks were underpowered compared with the vehicles replaced, the effect of poorer ability to maintain speed could be significant (TRB 1990a, 123; TRB 1990b, 110–111). It was predicted that negative effects on traffic would be approximately offset by reduced truck traffic, resulting in a negligible change in aggregate congestion delay.

DOT 2000

The methods used for producing estimates of congestion and pollution impacts in the DOT 2000 study are similar to those used for the 1981 study. Urban case studies were not conducted, but evaluations were carried out for a random sample of road segments so that total nationwide impact estimates could be produced. New estimates of

PCEs for larger trucks were produced by means of microsimulation traffic models.

Congestion The traffic models FRESIM, NETSIM, and TWOPAS were employed for the PCE estimates. The models were run for a set of road segments intended to be representative of the range of conditions on all U.S. roads, and the results were scaled to national totals using the FHWA Highway Performance Monitoring System (HPMS) sample road segment database. Inputs required for each sample segment were road geometry and traffic volumes, speed distributions, acceleration and deceleration rates, and hill-climbing speeds for each of several vehicle classes. Truck PCEs were estimated by running the models with and without trucks in the traffic stream and comparing speed-flow curves from the runs (DOT 1998).

In model runs, the various existing and proposed new truck configurations were characterized by two parameters: power-to-weight ratio and length. Power determines speed and acceleration, while length determines space requirements in the traffic stream and other vehicles' passing behavior. For the study's final estimates of congestion effects, it was assumed that newly introduced larger trucks would have the same power-to-weight ratio as existing trucks when fully loaded. This assumption is supported by examination of trends in power-to-weight ratios, which have been rising in recent years even as average truck weights have been increasing. The study report notes that the largest standard production on-road truck engine models have been getting larger and would be sufficient to maintain the prevailing power-to-weight ratio for any of the new trucks evaluated. The truck operator's selection of the optimum power-to-weight ratio is an economic decision that depends on customer service demands, safety, and driver preferences; there is no reason to expect this management calculation to change with the introduction of larger trucks. It is also noted that power requirements or minimum speed requirements can be regulated by legislative action.

Under the assumption of constant power-to-weight ratio, estimated PCEs for heavier single-trailer configurations are identical to those for existing tractor semi-trailers, and PCEs for short doubles (for example, the twin 33-ft trailer combination introduced in the DOT "North American trade" scenario) are only slightly greater. Table 2-1 shows selected PCE estimates (DOT 2000, Tables IX-1, IX-2) and ton-mi/PCE-mi (an index of traffic impact per unit of freight).

Thus in the DOT estimates, larger trucks have much greater values of ton-miles per PCE-mile than existing trucks in all conditions.

TABLE 2-1 Estimates of PCE and Traffic Impact per Unit of Freight

Vehicle	Length (ft)	Maximum Payload (1,000 lb)	PCE[a]			Traffic Impact (ton-mi per PCE-mi)		
			Congested Urban Arterial	Rural Interstate Level	Rural Interstate 3% Grade	Congested Urban Arterial	Rural Interstate Level	Rural Interstate 3% Grade
Conventional tractor-semitrailer	60	48	3.0	3.3	13.6	8.0	7.3	1.8
"North American trade" tractor-semitrailer	60	62	3.0	3.3	13.6	10.3	9.4	2.3
"North American trade" double	81	93	3.0	3.4	14.1	15.5	13.7	3.3

NOTE: PCE = passenger car equivalents.
[a] Assumes vehicle weight-to-power ratio of 250 lb/hp.
SOURCE: Derived from estimates in DOT 2000, Tables IX-1 and IX-2.

Unless introduction of the new trucks caused ton-miles of truck freight to increase substantially, traffic flow would be improved by the introduction of larger trucks. For example, if the DOT study's "North American trade" regulatory scenario (with a 51,000-lb tridem axle weight limit) were adopted, and every ton-mile of freight diverted from a conventional tractor-semitrailer to a "North American trade" double generated an additional ton-mile of truck freight, traffic flow would hardly be affected because ton-miles per PCE-mile for the "North American trade" double is nearly twice that for the tractor-semitrailers it would be replacing. Such a large volume of induced new freight would be highly improbable. It would imply that a 20 percent drop in the price of truck transportation for the cargoes for which this configuration would be suitable would cause at least a doubling of the volume of those cargoes in trucks, which is much greater than any reported estimate of price sensitivity of truck traffic.

The change in annual hours of delay was computed from the projections of changes in PCE volumes on the sample road segments for peak and off-peak periods. Delay was valued at $13/vehicle-hour. For the "North American trade" scenario, the result is an estimated annual delay cost savings of $3.4 billion.

The study used a queuing model to predict delay caused by bridge construction required to accommodate heavier trucks. The key assumptions were that construction is done on half the structure at a time and that all traffic is funneled onto the open half. (It is not clear how delay in replacing structures on two-lane roads was estimated.) No allowance for diversion to other routes was made. The report presents this cost as a lump sum; in the "North American trade" scenario, it is equivalent to $18.4 billion/year on an annualized basis (at 7 percent), for a net increase in annual congestion delay cost in the scenario of $15 billion.

Air Pollution Nearly all large trucks are powered by diesel engines. Although heavy-duty diesel engines have been subject to increasingly stringent exhaust emission regulations since 1975, emissions of oxides of nitrogen and particulate matter from these engines remain a major concern. Diesels emit other toxic organic compounds as well. These emissions contribute to violations of the National Ambient Air Quality Standards in many urban areas. Research results from the past decade suggest that particulates are a much more serious health risk than has previously been recognized and that diesel particulates may be particularly hazardous because of their size distribution and

composition. In recent DOT estimates derived from Environmental Protection Agency studies of the economic costs of air pollution, almost all costs of highway-related air pollution are attributed to health effects of particulate matter, and most particulate emissions in the fine sizes that are believed to have the greatest health effect come from heavy-duty diesel-powered vehicles (FHWA 2000). Similarly, a study of air pollution costs per mile of travel for motor vehicles operating in the Los Angeles region estimated an average cost of $0.53/mile for heavy-duty diesel trucks in 1992, 20 times the cost for gasoline cars, under the authors' baseline assumptions regarding health effects and value of life, with upper and lower bounds of $2.14 and $0.10. The baseline heavy-duty diesel estimate was projected to fall to $0.35 by 2000 as a result of new emission standards. Nearly all the estimated cost is from mortality caused by particulates. The authors observe that "charging this pollution cost would cause a significant change in trucking operations. Presumably, it would also greatly hasten the introduction of new lower-polluting vehicles, thereby lowering the appropriate charges" (Small and Kazimi 1995). Present estimates of the mortality effect of motor vehicle particulate emissions are based on a small number of studies and are controversial. Among the most important questions is the relative importance of exposure to particulates from sources other than tailpipe emissions (Small and Kazimi 1995).

Little information is available on the characteristics of emissions of heavy-duty diesel powered vehicles under actual operating conditions. Present emission models provide no information on the effect of changing weight limits on heavy-duty vehicle emissions. There are almost no data on heavy-duty diesel vehicle emissions at alternative test weights. The sole study identified as addressing this subject (Clark et al. 1999) presents data on emissions for three simulated test weights: 26,000, 36,000, and 46,400 lb. The results show a modest but inconclusive variation in emissions as a function of increasing test weight. Weights in the range of interest for evaluating weight limit changes were not studied. A substantial testing effort would be required to evaluate the emission impacts of the weight changes under consideration.

It is not surprising, considering the lack of data and models, that the DOT 2000 study does not contain pollution cost estimates. However, some of the critical factors in pollution cost projections are the same as those for the study's congestion projections: power-to-weight ratios of the new trucks and of the trucks replaced, the net change in

truck traffic volume, and the distribution of the truck traffic volume change across the road system. If new trucks have the same power-to-weight ratio as the trucks replaced, the PCE estimates indicate that traffic flow will be little affected, so it is reasonable to project that automobile emissions would not be affected. However, if, contrary to the DOT projections, the change in limits caused an increase in truck-VMT on congested roads, automobile emissions could increase. The impact on automobile emissions, however, would depend on the magnitude of the speed change caused by the change in truck traffic. If increased congestion reduced speeds to below 20 mph, emission levels for all pollutants would increase. On the other hand, if freeway speeds were reduced from 65 mph to 35 mph, EPA estimates show reduced vehicle emission rates. The increased congestion would depress automobile travel, at least partially offsetting any higher rate of emissions per vehicle-mile on the more congested roads.

Also, with the same power-to-weight ratio, the new trucks would be expected to have temporal patterns of speed and acceleration similar to those of the trucks replaced, and therefore emissions per gallon of fuel consumed would also be similar to those for the trucks replaced. DOT estimates for the 2000 study show that a 40 percent increase in payload weight, the result of increasing gross weight from 80,000 to 100,000 lb, would increase fuel consumption per VMT by about 10 percent (Cohen 1998). In interviews conducted for the TRB Turner Proposal study, carriers reported that a longer combination vehicle's fuel consumption is 10 to 25 percent greater per VMT than that of a standard tractor-semitrailer in similar operations; consequently, fuel consumption per ton-mile is lower (TRB 1990b, Tables 3-1 and 3-2).

Summary of Cost Estimates

Under the assumptions stated in the preceding section, estimates of the changes in delay and air pollution costs for one of the DOT 2000 regulatory scenarios and one of the TRB studies are as follows:

	Change in Annual Highway User Delay Costs ($ millions)	
	From Traffic Interaction Effects	*From Construction Delay*
DOT North American trade (51,000-lb tridem)	–3,400	18,400
Turner trucks	0	1,600

These estimates are presented as typical of the order of magnitude of impacts implied by the methods of past studies. Under the stated assumptions, introducing larger trucks would be expected to reduce air pollution costs even if total truck freight traffic increased substantially as a result. However, if the new trucks were underpowered or for other reasons greatly perturbed traffic flow, pollution costs could be increased instead of reduced. Congestion delay due to the traffic perturbation caused by large trucks would be little affected, but delays at bridge replacement projects would be a very large cost if such replacements actually proved necessary.

Improved Methods

The greatest shortcoming of the methods used in past studies to estimate congestion and pollution costs has been the oversimplified treatment of the complex interactions between trucks and other vehicles in the traffic stream. Changing the traffic volume, dimensions, and acceleration abilities of trucks will change how motorists drive around them, affecting other vehicles' patterns of acceleration and braking. Given the predicted changes in these three parameters, traffic and emission impacts could be estimated with a microsimulation traffic model. Such models can estimate changes in vehicles' temporal patterns of velocity and acceleration in response to a traffic perturbation. These drive-cycle profiles could be used as inputs to a modal emissions model (a model that predicts emissions for a class of vehicles as a function of second-by-second speed, acceleration, and possibly other operating conditions) to predict the change in emissions produced by all vehicles on a road caused by the perturbation.

Microsimulation models are employed regularly in traffic engineering, and the commonly used models have built-in capabilities for estimating emissions as a function of changes in traffic flow characteristics (TRB 2000). Some models have the capability to predict traffic diversion as a function of changing congestion, but any expected changes in the total volume of nontruck travel would have to be supplied as input to the models.

The emission components of existing simulation models are recognized as being in need of updating. These models might have some utility for estimating the change in emissions by automobiles in the traffic stream as a result of a change in truck traffic, but would not at present be capable of estimating changes in emissions by trucks themselves.

Effects on Traffic Volume and Land Use

Liberalizing truck size and weight limits would reduce the cost of truck freight services and hence increase the quantity of freight carried by trucks. The increase would be the result of diversion of freight from rail and other modes to truck and of the reorganization of production and logistics at existing facilities, substituting transportation for other inputs. Lower freight prices also would affect freight volume by influencing industrial and commercial facility location decisions. Long-run effects would be greater than short-run effects since shippers would have more options in the long run for taking advantage of lower truck costs (see Figure 2-7). The increase in consumption of transportation caused by a reduction in price is sometimes called *induced demand* (see Figure 2-8). Changes in business location decisions caused by changes in freight costs would eventually have some effect on residential location decisions and personal travel patterns.

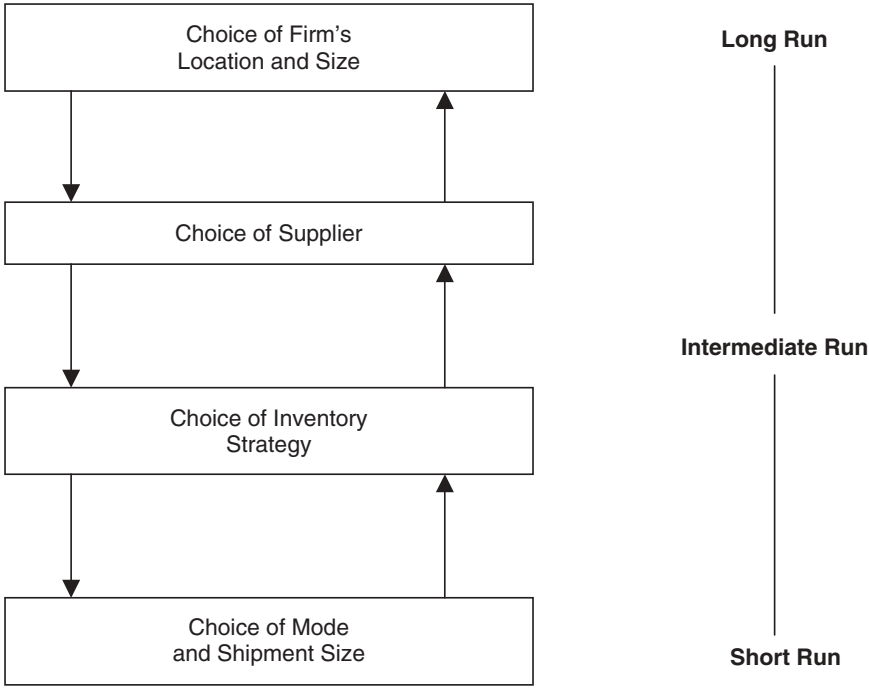

FIGURE 2-7 Freight decisions of a firm. (Adapted from Abdelwahab and Sargious 1992; used with permission of the publishers, the London School of Economics and Political Science and the University of Bath.)

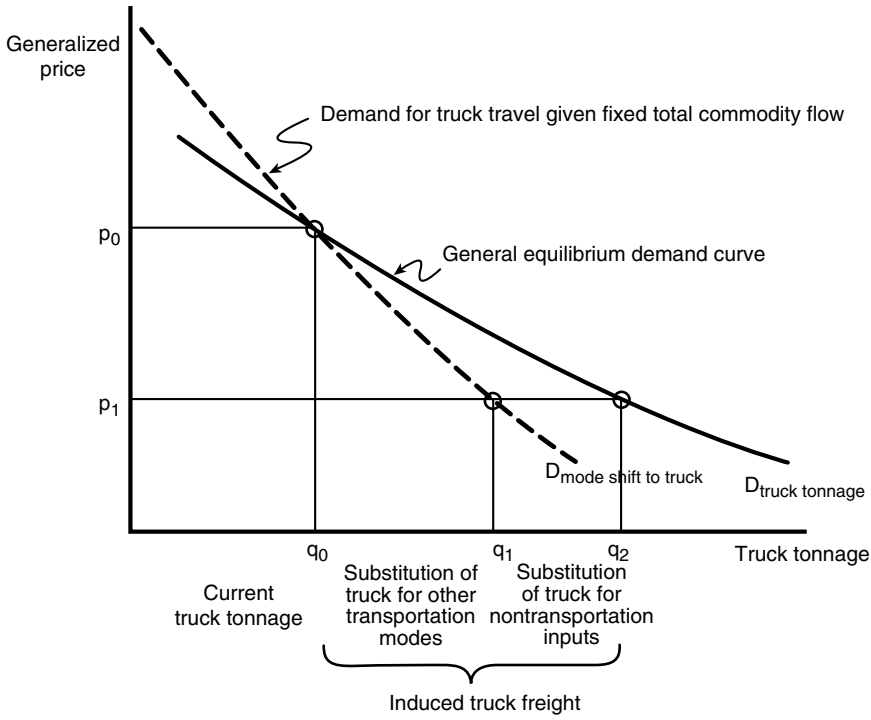

FIGURE 2-8 Induced demand. (Source: Pickrell and Lee 1998.)

Induced demand represents an initial benefit: shippers (or their customers) gain when they choose to purchase more freight services because the price of trucking falls. If highway users paid the full costs of their travel, evaluation of truck size and weight standards would not depend on the magnitude of the change in truck traffic caused by a change in standards. However, the fees a highway user pays do not always match the cost to the highway agency of providing service, and highway travel generates external costs, for example, air pollution and congestion costs that shippers do not take into account when they make freight purchasing decisions. It is only because the prices users pay do not reflect these costs that induced demand must be considered in a full accounting of the costs and benefits of changing truck regulations. If each highway user paid the cost of his or her travel, growth in travel would necessarily add to the general welfare because highway users decide to make additional trips only when the benefits they gain from the trips exceed the cost of the trips to them. However, if users do not pay all costs, and a decrease in the price of transporta-

tion causes traffic to increase, then some of the additional travel probably will represent a net waste to society because the costs users pay plus the costs they do not pay can be greater than the benefits users derive from the added travel.

In addition to the benefits they derive from the new freight services they choose to buy after the price of truck transportation falls, shippers benefit from lower costs for all freight movements that would have occurred in the absence of the price decrease. Offsetting these benefits of the price decrease are the external costs caused by the induced traffic and the portion of the added infrastructure cost from the induced traffic for which trucks do not pay. If the volume of induced traffic is large enough and external costs and subsidies are great enough, these offsetting costs will be greater than the benefits to shippers, and the net effect of the price decrease will be an economic loss. Conversely, if freight volume is not very sensitive to truck rates and external costs and subsidies are modest compared with prices, the price decrease will cause a net gain. Determining whether the net economic effect is positive or negative is an empirical question that can be answered with information about demand for truck services, external costs, and infrastructure costs.

The recent TRB and DOT truck size and weight studies predict that liberalizing truck size and weight limits would lead to a decrease in annual truck-VMT. These studies most commonly assume that the total volume of freight traffic via all modes is unchanged and that the only source of new truck traffic in response to changing the limits would be freight diverted from rail. The studies either ignore the possibility that new freight traffic will be stimulated by reduced truck costs or argue that such effects would be small.

Projections that liberalized limits would reduce total truck-VMT are important in the past studies' overall assessments of changes in the limits because they make it possible to conclude that accidents and congestion delays would decrease in total even if these costs were higher per truck-VMT for the larger trucks. Liberalizing the limits thus appears to produce a win–win outcome—lower freight costs and lower public costs of truck traffic—and the studies avoid the sensitive problem of making trade-offs between economic benefits and safety or convenience costs. It is possible that a decrease in truck transportation rates would result in a net benefit to the public even if truck-VMT increased, but if this is the forecast outcome, estimating the magnitudes of costs and benefits and assessing trade-offs becomes much more challenging.

Although it is reasonable to predict that reducing truck costs will stimulate new freight traffic, present understanding of freight markets does not support reliable prediction of the magnitude or characteristics of the new traffic. Predicting effects on residential land use and personal travel is even more difficult.

Careful consideration needs to be given to the role that should be played by evaluation of expected effects on travel volume and land use in assessments of proposed government policy changes. It is unlikely that model refinements will ever make it possible to predict the effects of transportation policy changes on travel and land use patterns with much confidence. Because of the uncertainty, regulation of freight transportation is unlikely to be a practical tool for managing urban and regional land use and development. What is more, there is no evidence that efforts to control land use, either directly through zoning or indirectly by manipulating transportation costs, are likely to be effective means of mitigating the external congestion, pollution, and accident costs of transportation.

Undesirable land use effects can arise from changes in truck operating costs primarily because shippers and carriers are not held fully responsible for all of the initial costs of truck transportation—accident, infrastructure, congestion, and pollution costs. The practical way to reduce or avoid harmful land use consequences is to eliminate subsidies in the highway program and to control the environmental, safety, and congestion costs of truck traffic through regulation or imposition of fees.

If the public were to decide that it would be desirable to limit the volume of truck freight transportation to promote environmental, safety, or other objectives, tightening truck size and weight limits might be a relatively expensive means of accomplishing this end. It would be desirable to allow trucks to operate at the dimensions that minimized their rate of consumption of resources—that is, the fuel, labor, equipment and infrastructure depreciation, accidents, and pollution costs per ton-mi—if practical means other than dimensional limits were available for restricting traffic volume.

Efficient road user fees would not necessarily lead to great shifts in land use patterns relative to those seen today. Rather, it appears likely that highway users and providers would first seek ways to reduce costs that did not entail major changes in their behavior, for example, through adjustments in trip times and routes, purchase of more fuel-efficient vehicles, and rational investments in highway capacity expansion.

User fees that internalize all costs for all road users remain a distant prospect. In certain circumstances, however, benefits could be obtained from partial reforms, including better aligning truck user fees with the highway agency's infrastructure-wear costs for each truck trip. Recent research suggests that such a reformed truck user fee scheme would not have to be sophisticated or complex in order to eliminate a large portion of the inefficiencies of the existing system (Small et al. 1989; TRB 1996). This degree of reform would reduce but not eliminate the risk that size and weight liberalization would have unjustifiable land use impacts.

Safety

The 1941 study by the Interstate Commerce Commission (ICC) of the need for federal regulation of size and weight addressed safety questions to determine whether federal regulation was needed for the sake of safety and whether allowing greater sizes and weights would be compatible with safety. The study report describes engineering analyses of maneuverability, traffic interactions, and braking of large trucks and presents results of a survey of operators' views on the relation of size and weight to safety. The report summarizes the ICC's investigation of accident statistics as follows (ICC 1941, 17–19):

> The third and potentially most productive approach is through an analysis of the relative accident experience of the various types and sizes of equipment. Analysis . . . serves, first, to indicate the need for extreme caution in the use of accident rates. Comparisons often made wholly fail to allow for the effect of important variables. . . . Sizes and weights are only two of the variables to be considered and while their relation to accidents is of primary importance in this investigation, there are other questions of probably much greater importance in the broad field of highway safety.
>
> Second, material presented in the staff report does not conclusively indicate that any greater hazard is associated with commercial vehicles of the larger sizes and weight, considering the conditions under which they are used, than with smaller commercial equipment. . . .
>
> There clearly is need for further study of the complex relations noted above. Such a study could well be made in areas with

> the more restrictive size and weight limits. However, the present analysis has indicated, at least, that there are matters to be watched carefully in the event Federal regulation is undertaken on economic grounds. It also does not clearly show the need for Federal entrance into this field merely for the sake of reducing sizes and weights in the interest of safety.

Studies of federal policy conducted since 1941 have reached conclusions generally similar to the ICC's cautiously worded statement: available evidence does not show that size and weight, within the range of existing practices, are highly significant safety factors; lack of data may have prevented observation of hazards; and therefore research and monitoring should accompany regulation. It is a source of frustration that 60 years of research has not yielded definitive conclusions on these questions.

Like the ICC study, later policy evaluations, including the DOT and TRB studies, have assembled their assessments of the likely impacts of allowing larger vehicles from multiple kinds of evidence: examinations of the relation of size and weight to vehicle handling and stability and of the relation of size and weight to the interaction of the vehicle with other vehicles in the traffic stream; reported experiences of carriers and drivers using larger vehicles; and statistical studies of accident involvement rates, accident severity, and types and characteristics of accidents. The previous TRB studies all follow the same procedure for estimating the effect of changes in size and weight regulations on accident losses:

1. Estimate a table of average accident involvement rates (accident involvements per VMT) for trucks by the following dimensions: severity, vehicle characteristics (e.g., weight, configuration), road class, and external conditions (e.g., weather, day/night).
2. Predict the change in annual VMT resulting from the change in regulations in each cell of the same matrix.
3. Predict the change in numbers of accidents by severity by summing the product of average involvement rate times change in VMT over all the cells.

The DOT 2000 study presents estimates of accident rates and changes in VMT, but does not carry out step 3 to produce estimates of changes in numbers of accidents.

The above procedure involves an oversimplification because changing truck size and weight may alter traffic conditions, congestion, and

travelers' decisions throughout the system in ways that affect accident risk but are not reflected in this standard calculation. For example, accident rates may depend on the level of congestion on a road, and the risk of accidents not directly involving a truck may depend on the density of truck traffic. The method implicitly assumes that if the volume of trucks on a road increases, the accident involvement rate of cars on the road will increase, but this relationship has not been established empirically. It is probably a reasonable approximation (provided the accident rates and changes in truck characteristics and traffic are known), but better understanding is needed of the relationship of accident risk to traffic volume and the mix of vehicles on a road (TRB 1996, 68–72).

The TRB *Truck Weight Limits* study attempts to simplify the safety risk comparisons for the trucks it considers by estimating two accident involvement rate ratios: the ratio of double-trailer to single-trailer rates and the ratio for a heavy tractor-semitrailer with respect to a conventional tractor-semitrailer. The ratios are intended to reflect the relative risk of the two vehicle types in the same applications. Following this approach, the first two subsections below summarize the evidence for the accident involvement rates, as functions of configuration and of weight, respectively, used in the calculations of changes in accident losses in past studies and the conclusions of those studies about the systemwide safety effects of changes in regulations. The third subsection reviews the conclusions of past studies about the likely safety consequences of changes in vehicle handling, stability, and performance properties that could accompany changes in size and weight regulations. The final subsection presents conclusions.

Relation of Configuration to Accident Risk

Most studies of the relation of configuration to accident risk have presented findings in the form of relative accident involvement rates for single-trailer and multitrailer combinations. Apparently, however, none of these studies incorporates a control for the effect of vehicle weight, so the results reported may reflect the combined effects of configuration and weight. In some studies, double-trailer configurations consistently have higher average weights than the tractor-semitrailers with which they are compared; in others they have lower average weights, depending on the state or region from which the data originate. In general, these studies have confronted four difficulties: the vehicles of interest sometimes represent a very small portion of the traffic stream, so sample sizes may be too small to allow actual differences in accident risk to be measured; data on accident frequency or

on miles of travel by various vehicle classes are of poor quality; data may lack detail (e.g., truck configuration and weight) required to make the comparisons of interest; and the effects of confounding factors (e.g., road geometry, driver age, time of day) on risk comparisons may be overlooked because of missing data or misspecified models.

The TRB committee that prepared the *Twin Trailer Trucks* study (TRB 1986) reviewed all available measurements through 1986 of accident rate differences between multitrailer and single-trailer combinations. Of 15 studies, 10 were eliminated because they incorporated insufficient controls, lacked documentation, or had basic methodological deficiencies. The studies reviewed include data on turnpike doubles, but the five studies that were retained all compare twin-trailer combinations with tractor-semitrailers (TRB 1986, 304–329). The TRB committee also reviewed research on relative accident severity for double-trailer and single-trailer combinations and conducted its own analysis of relative severity with a dataset of accidents reported by carriers to the DOT Bureau of Motor Carrier Safety (TRB 1986, 330–348).

In the five studies retained, the ratios of the accident involvement rate of twins to that of tractor-semitrailers (derived from data on various road classes, carrier groups, and degrees of accident severity) ranged from 0.8 to 2.3, with most in the range 0.9 to 1.1 (TRB 1986, 130). The committee concluded from its own analysis of distributions of accident involvement by severity that a lower fraction of accidents involving twins than those involving tractor-semitrailers entailed injury or death; the committee speculated that this result might be the consequence of a higher rate of single-vehicle accidents for twins than for tractor-semitrailers (TRB 1986, 337). The committee acknowledged that no single accident rate study reviewed is fully successful in controlling for the influences of all factors other than configuration that may have affected the measured accident rates (TRB 1986, 4).

Regarding the systemwide safety impact of liberalization of size and weight regulations, in the TRB studies, for the recommended changes (or in the case of *Twin Trailer Trucks,* for the regulations already enacted), accident involvement rates for combination vehicles per VMT are projected to increase, involvement rates per ton-mile of truck freight are projected to decrease, and total accidents are projected to decrease (TRB 1990a, 12–17; TRB 1990b, 5).

The TRB *Twin Trailer Trucks* study was conducted shortly after twins had been legalized for use nationwide. The study report (TRB 1986) recommends that DOT, cooperatively with the states, establish

improved programs for monitoring truck traffic, accidents, and infrastructure costs. In a 1990 report, *Data Requirements for Monitoring Truck Safety,* another TRB committee recommends a detailed plan for systematic nationwide observation of truck safety (TRB 1990c). However, data programs have not been fundamentally improved, and it is no simpler today, after 20 years of nationwide experience, to compare the accident involvement rates of double- and single-trailer combinations. Several additional special studies have been published since 1990, and their results are generally consistent with the conclusions of the *Twin Trailer Trucks* committee. The most important of these studies are described below.

The TRB *Truck Weight Limits* (TRB 1990a, 125–127) and Turner Proposal (TRB 1990b, 120–121) studies update the review of *Twin Trailer Trucks* by evaluating four more recent studies that used appropriate methodologies to isolate the effects of vehicle configuration on accident involvement rates. The *Truck Weight Limits* study committee decided to use a value of 1.1 for the ratio of double-trailer to single-trailer fatal and nonfatal accident involvement rates in its estimates of the impacts of changing size and weight regulations, citing the results of one study (Campbell et al. 1988). The *Twin Trailer Trucks* committee used the same ratio, on the basis of the totality of the research reviewed. The Turner Proposal study committee concluded that the ratio for double-trailer trucks it recommended would be 1.09 if the doubles were equipped with standard A-frame dollies (the dolly is the connector between the tow trailers), but that accident rates would be nearly equal if the doubles were equipped with a type of connector that eliminates one articulation point (the B-train configuration) (TRB 1990b, 221–223). All of the ratios used in these studies are of a magnitude that is offset by productivity gains (i.e., the increase in ton-miles of freight carried per VMT for the larger trucks), so these committees also concluded that the larger trucks they recommended would not be less safe than the trucks replaced per ton-mile of freight services provided.

A 1991 study of the relation of accident involvement rates to configuration in Michigan (Lyles et al. 1991) is noteworthy for several reasons: the state has some of the most liberal size and weight regulations in the United States (including double-trailer combinations weighing up to 164,000 lb); care was taken to collect accurate and detailed data on fatal and nonfatal accidents and truck-VMT; the population of trucks studied is diverse (all Michigan-registered tractors operating on all Michigan roads); and the analysis attempts

to control for the factors believed to be potentially important influences on accident risk, including road class, time of day, urban and rural conditions, and driver age. Accident data are from state police accident files, and travel data are based on a telephone sample survey of Michigan-registered tractors.

The study revealed no consistent difference between accident involvement rates for single- and double-trailer configurations. In contrast, rates varied greatly by road class: those for non-limited-access highways were typically 2 to 3 times higher than those for limited-access highways, and those for local streets and roads were typically 7 to 10 times higher than those for limited-access highways. Tractors operated by drivers aged 19 to 20 were found to have an accident involvement rate 5 times the average.

The Insurance Institute for Highway Safety conducted two studies in which the case control method was used to the measure the relative accident risk of single- and double-trailer combinations (Stein and Jones 1988; Braver et al. 1997). This method isolates the effects of truck configuration on accident involvement rates from the effects of other factors by comparing the characteristics of trucks involved in accidents with those of trucks observed at the same locations and times of day as the accidents. The 1988 study, with data from selected Interstate road segments in Washington, reports double-trailer involvement rates 2.5 to 3 times those of tractor-semitrailers. The committees that conducted TRB Turner Proposal and *Truck Weight Limits* studies examined traffic count data for the roads and time periods of the Washington study. They concluded that actual double-trailer traffic volumes were higher than reported in that study and that this apparent undercount was the source of the reported difference in accident rates. The 1997 case control study involved analyzing all combination-vehicle accidents on Indiana Interstates that occurred during a 15-month period. The control data collection method differed from that of the Washington study and was intended to be more reliable but less detailed. The study revealed no increased crash risk for doubles compared with tractor-semitrailers. The authors note that the study design did not allow for control by driver age, and that if drivers of doubles in the data were older or otherwise more competent on average than drivers of tractor-semitrailers, doubles might have a higher accident rate compared with tractor-semitrailers operated by similar drivers.

DOT undertook three analyses in an attempt to produce new accident risk information to support its 2000 *Comprehensive Truck Size and Weight Study:* a survey that collected accident and travel data from

carriers that operate longer combination vehicles, an analysis of DOT's national fatal accident and truck travel databases, and an evaluation of state-maintained truck accident and travel data in states that allow LCVs to operate.

Seventy-five carriers participated in the DOT survey (Ticatch et al. 1996), contributing information on 4,500 accidents during a 5-year period. Accident rates per million VMT computed from the data were 1.79 for non-LCV combinations (tractor-semitrailers and short doubles under 80,000 lb), 1.02 for turnpike doubles, 0.83 for triples, and 0.79 for Rocky Mountain doubles. The difference between the non-LCV and LCV accident rates was statistically significant; the differences among the types of LCVs were not. Fatal crash rates for LCVs and non-LCVs were found to be equal. The authors concluded that differences in patterns of use with respect to road class, time of day, or driver experience could not account for differences between LCV and non-LCV accident rates. The tabulations of usage patterns presented appear to be consistent with this conclusion, but no statistical test of the conclusion was carried out. In particular, while drivers with more experience had fewer accidents, drivers of LCVs had nearly the same professional experience as drivers of non-LCVs, so driver experience cannot account for the difference in LCV/non-LCV accident rates. Some jurisdictions are reported to impose weather restrictions on the use of certain LCVs. The DOT study did not compare accident rates by weather conditions. Differences in weather conditions during operations may explain some part of the difference in LCV/non-LCV accident involvement rates. DOT does not refer to this study in the safety impacts analysis of its 2000 report (Vol. III, Ch. VIII). The study is not conclusive because the data cannot be verified and because statistical analysis was not performed to control for factors other than configuration influencing involvement rate differences. Nonetheless, the conclusions of the carrier survey offer no support for the assertion in the DOT 2000 report (Vol. III, VIII-2) that the apparent lack of evidence of safety problems in studies of LCV accident rates is an artifact of the vehicles' restricted operating environments.

The analysis of DOT's national fatal accident and truck travel databases showed the ratio of multitrailer to single-trailer fatal accident involvement rates on all roads nationwide to be 0.97. The ratio ranged from 0.93 to 1.40, depending on road class. A weighted average ratio of 1.11 was computed, with weights assigned to the ratios by road class so as to eliminate the effect of differences between the two configurations in the distribution of travel by road class (DOT

2000, Vol. III, VIII-1–VIII-4). No measure of uncertainty or test of statistical significance of this ratio was employed. The findings of this DOT analysis contradict those of an earlier study using the national databases, sponsored by the Association of American Railroads, in which higher multitrailer accident involvement rates were reported (Mingo et al. 1991).

The DOT examination of state-maintained accident and travel databases yielded no accident rate estimates. DOT concluded that only one state (Utah) that allows LCVs also maintains the data needed to estimate accident rates by configuration, and that many years of data would be required from this state before a conclusive comparison could be made (DOT 2000, Vol. III, VIII-2).

Relation of Truck Weight to Accident Risk

The *Truck Weight Limits* study (TRB 1990a) relies on one study (Campbell et al. 1988) for estimates of the relationship between vehicle weight and accident risk for a given vehicle type. The DOT 2000 study makes no statement about the relationship of weight to accident risk. The committee is not aware of any other attempt to measure this relationship.

Truck Weight Limits presents graphs of Campbell et al.'s estimates of fatal accident involvement rates for single-unit and combination trucks by gross weight range and road class (TRB 1990a, 127–131). The conclusion offered is that "these data suggest a moderate increase in accident rates for higher gross weight, although the relatively small number of data points and the high degree of scatter make drawing conclusions from these data difficult" (p. 129). In estimating the impacts of the study's proposed regulatory changes, it was assumed that a 10 percent increase in gross weight from tractor-semitrailers would increase the accident involvement rate by 2.5 percent for all levels of severity. The mechanism proposed for this connection is that the height of the center of gravity of a truck will increase as the load on the truck increases, and that a higher center of gravity leads to a greater propensity to roll over during turning (TRB 1990a, 108–109).

The TRB report does not include a statistical test of the significance of the perceived connection of accident rate to weight in the Campbell et al. data. The graphs presented appear inconclusive: accident rates rise with weight within some weight ranges on some road classes and fall within others. The data also would not appear to pertain directly to comparison of trucks of different designs and weights, for example, comparison of five-axle tractor-semitrailers at 80,000-lb maximum

weight and six-axle tractor-semitrailers at higher maximum weight—the two tractor-semitrailers compared in the study's evaluation of recommended changes in weight regulations.

It is generally recognized that accidents involving large trucks have more severe consequences on average than those involving only smaller vehicles, and that the majority of the fatalities in large-truck crashes are persons other than the truck occupants. Past studies have expressed the concern that allowing truck weights to increase might increase the proportion of truck crashes that result in fatalities. The committees that conducted the *Truck Weight Limits* study (TRB 1990a, 132–133) and Turner Proposal study (TRB 1990b, 129) concluded that the severity of car–truck crashes would not be affected by an incremental change in truck weights. Direct observational evidence supporting this conclusion is lacking. (As noted in the preceding subsection, the TRB committees did have empirical support for their conclusion that double-trailer accidents are not more severe than single-trailer accidents.) The two study reports cite data showing that the probability that an occupant of a car involved in a crash will be killed is correlated with the change in velocity of the car during the crash. They note further that, in a collision between a car and a truck whose weight is several times that of the car, the change in velocity of the car is largely unaffected by variations in the truck's weight. Physics also dictates that the energy dissipated in a car–truck collision is insensitive to the weight of the truck if no third object is involved. The finding of Campbell et al. (1988) of a slight or no relationship between weight and fatal accident involvement rate for large trucks is indirect evidence that severity is insensitive to weight.

Relation of Handling, Stability, and Traffic Interaction Effects to Accident Risk

Most past studies, beginning with that of the ICC in 1941, have devoted considerable effort to examining how changing size and weight limits would affect certain dynamic properties and performance characteristics of trucks that are hypothesized to be related to safety. The goals of these examinations have been to understand the physical basis for any observed differences in accident rates among configurations, and to discover ways of redesigning trucks to counteract undesirable changes in dynamic properties brought about by changes in the limits.

Table 2-2, from the Turner Proposal study (TRB 1990b, 98), is an example of these analyses. The left column lists handling and stability characteristics that would be different for the proposed new truck dimensions under evaluation and that, in the committee's judgment,

TABLE 2-2 Influence of Variations in Vehicle Parameters on Handling and Stability (Estimates of Turner Study Committee)

	Parameter						
Characteristic	**Gross Combination Weight**	**Cargo Density**	**Trailer Length**	**Tires**	**Suspension**	**Dollies**	**Brakes**
Low-speed offtracking	—	—	Significant	—	—	Moderate	—
High-speed offtracking	Moderate	—	Significant	Significant	—	Moderate	—
Braking efficiency	Significant	Moderate	—	—	—	—	Moderate
Static rollover threshold	Significant	Significant	—	—	Moderate	Moderate	—
Steering sensitivity	Moderate	Moderate	—	Significant	Moderate	Moderate	—
Rearward amplification	Significant	—	Significant	Significant	—	Significant	—

NOTE: Dashes indicate little or no influence. "Significant" indicates that the committee judged variation in the parameter to have a strong effect on value of the handling and stability characteristic. "Moderate" indicates that the variation was judged to have some effect on the handling and stability characteristic.
SOURCE: TRB 1990b, p. 98.

could be related to accident risk. The other TRB studies and the DOT 2000 study identify similar properties. These characteristics are as follows:

- Low-speed offtracking—a measure of the displacement that occurs when a combination vehicle makes a turn at low speed (e.g., at an intersection), and its rear wheels follow a path to the inside of the path of the front wheels.
- High-speed offtracking—a measure of the displacement of the rear wheels to the outside of the path of the front wheels when the combination makes a high-speed turn.
- Braking efficiency—a measure of brake performance, related to the likelihood that the wheels on any axle will lock during a hard application of the brakes. Wheel lock degrades vehicle controllability during braking and may lead to jackknifing. In addition to controllability during braking, the other dimension of braking performance examined in past studies is stopping distance. The earlier TRB studies (TRB 1990a, 111–112; TRB 1990b, 101) and the DOT 2000 study (Vol. II, V-19–V-20) conclude that the stopping distance of the larger trucks evaluated would not be worse than that of existing trucks. The regulatory changes considered by these studies all involve adding axles to allow increased gross weight, with no increase in maximum axle weights. The studies conclude that the extra axles and extra brakes would allow stopping distance to be maintained. None of the studies evaluates or recommends changes in regulations that would allow existing combination vehicles to carry heavier loads.
- Rollover threshold—the level of lateral acceleration a truck can withstand before rolling over during turning, a measure of resistance to rollover. For a given truck, rollover threshold decreases (i.e., resistance to rollover is lessened) as the height of the center of gravity of the vehicle and cargo is increased. Since center of gravity will rise as load increases (if cargo density is constant), this performance characteristic often is cited as a potential source of increased accident risk from higher gross weights.
- Steering sensitivity—if low, implies that a truck requires constant attention and continual steering correction to maintain the driver's desired path.
- Rearward amplification—the ratio of the lateral acceleration of the rearmost trailer to that of the tractor during obstacle avoidance or sudden lane changes. Higher rearward amplification means the rear trailer is more likely to roll over during a sudden steering maneuver.

In addition to these handling and stability characteristics, the past studies have compared larger trucks with existing vehicles with respect to certain characteristics affecting interactions with other vehicles in traffic: performance in climbing and descending hills; performance in passing, merging, and freeway exiting maneuvers, and effect on cars performing these maneuvers; time required to cross or turn at intersections; generation of splash and spray on wet roads; truck blind spots and blockage of other drivers' views; and aerodynamic buffeting of other vehicles. These characteristics could conceivably affect safety and cause delays on congested roads.

Automotive engineers have methods for controlling these behaviors, within limits, by adjustments in vehicle design. For example, changes in suspension and dolly design, in the height of the fifth wheel connection between tractor and trailer, and in the width between the outermost tires can improve resistance to rollover. The FACT truck, a design for a tractor-semitrailer with tank body proposed by two equipment manufactures in 1989, was claimed to have a rollover threshold 25 percent higher than that of existing tankers, although its gross weight was to be 88,000 lb, 10 percent greater than the current federal maximum weight, and its cargo capacity was to be 13 percent greater than that of existing tankers (Klingenberg et al. 1989). Differences in most traffic interaction characteristics between existing and larger trucks could be minimized by properly specifying engines, tires, and brakes. Most promisingly, new technologies, such as electronic braking systems, open up possibilities for greatly reducing objectionable handling and stability behaviors. It remains for the safety benefits of any such design enhancements to be demonstrated as they are developed. These possibilities are described in Chapter 4.

The body of research on handling and stability and on traffic interaction effects that may relate to safety is reviewed in the DOT 2000 study (Vol. III, VIII-6–VIII-13, and Vol. II, V-19–V-28; Fancher and Campbell 1995; Battelle 1995a; Battelle 1995b) and in the earlier TRB studies (TRB 1990a, 103–123; TRB 1990b, 95–119; TRB 1986, 116–127, 270–303). The results of this body of research have been used appropriately to generate hypotheses about the relative accident risks of vehicles. For example, the *Truck Weight Limits* study concludes (TRB 1990a, 115–116):

> Existing five-axle doubles have a unique handling and stability characteristic, namely, rearward amplification of the motion of the lead units, that is not shared by tractor-semitrailers. This

> phenomenon constitutes a negative safety feature of doubles in obstacle-avoidance or sudden lane-changing maneuvers at highway speeds. . . .
>
> For existing five-axle doubles, increased weight would . . . downgrade the rearward amplification behavior, which may increase the probabilities of rear-trailer overturns during obstacle-avoidance or sudden lane changing maneuvers.

The relationship referred to between weight and rearward amplification has been established through physical measurements and computer simulations using engineering models. However, the relationship between rearward amplification and accident risk is a hypothesis that has not been demonstrated. Few studies have attempted to measure relationships of handling, stability, or other performance properties of trucks to accident risks, and the results of some of the studies that are available do not demonstrate the hypothesized relationship. Therefore, assessments of the physical properties of trucks affecting handling, stability, and traffic interactions cannot be used to produce quantitative estimates of the change in accident losses that would result from a change in size and weight limits. To verify judgments about the linkages among size and weight regulations, vehicle properties, and safety, two kinds of empirically derived relationships would be required: first, a model of how changes in regulations affect the handling, stability, and performance properties of trucks in use; and second, relationships, derived from observation, of accident involvement rates by level of severity as functions of these truck properties. It should be noted that the linkages between size and weight regulations and vehicle handling and stability can be weakened by optimizing vehicle designs. This outcome could be promoted through performance standards, as discussed in Chapter 3.

It is reasonable to assert that prudence dictates minimizing vehicle behaviors such as rearward amplification that appear to entail a risk. However, measurement of the magnitude of the risk related to these vehicle behaviors is essential for cost-effective regulation. If accident risk can be controlled by changes in vehicle design that affect handling and stability, it is important to fully understand and exploit this opportunity, regardless of whether size and weight limits are liberalized. Conversely, it is important to avoid restricting use of vehicles types that do not pose a risk, or attempting to control risk by requiring changes in vehicle design that prove to be ineffective.

In future studies to measure the relation of accident risk to vehicle handling and stability, it will be important to examine experience with nonfatal as well as fatal crashes. Interpretation of studies that estimate fatal rates alone [e.g., Campbell et al. 1988 and the accident rate analysis in the DOT 2000 study (Vol. III, Ch. VIII)] is complicated by a methodological difficulty. These studies confine their analyses to fatal accidents because data on fatal truck accidents are more detailed and reliable than data for other truck accidents, and because fatal crashes account for a very large share of the total costs of truck accidents. However, an analysis that considers fatal crashes alone will be unable to distinguish factors that affect the frequency of crashes from factors that affect the severity of consequences, given that a crash has occurred.

Crash frequency and crash severity are measures of two dimensions of the safety performance of a vehicle. Crash frequency is the number of trucks of a certain type involved in a crash in a time period. The crash involvement rate—the number of trucks of a certain type involved in crashes in a time period divided by the miles of travel by such trucks in the time period—reflects the chance of such trucks being involved in a crash. Crash frequency is thus equal to crash involvement rate times exposure, where exposure is the miles of travel by a category of trucks in a time period. Crash severity refers to the outcome of a crash. Severity is often described by the proportions of crashes in three categories: those causing a death, those causing injury but no death, and those causing property damage but no injury. It follows that fatal crash frequency equals crash frequency times the fraction of all crashes that are fatal. Fatal crash frequency thus mixes the two dimensions of crash frequency and crash severity. A measurement of a change in the fatal crash frequency or fatal crash rate does not tell us how the chance of being in a crash has changed. However, to evaluate the safety significance of such factors as truck stability, off-tracking, and braking, it is necessary to know how they affect the chance of being in a crash, as well as the distribution of outcomes of crashes.

Several of the vehicle performance characteristics hypothesized in past studies to be related to accident risk are correlated with gross vehicle weight. For example, rollover threshold, a vehicle property believed to increase the risk of certain accident types, tends to decrease with increasing vehicle weight for a given truck configuration. Vehicle weight, in turn, is known to be related to the likely severity of crashes in which a vehicle is involved. Therefore, a study of the relation of rollover threshold to accident risk that employed only data on fatal accidents could lead to a mistaken interpretation of the effect of

weight on severity as an effect of rollover threshold on accident risk. To avoid this confusion, research attempting to measure the relationship between vehicle performance characteristics and accident risk should employ data on accidents of a range of severities and measure the relation of the various characteristics to accident risk and expected severity.

Summary

Studies conducted over the past 20 years have not clearly shown that tractor-semitrailers are a safer means of carrying freight than multitrailer configurations. Past TRB committees that reviewed the research concluded that the safety difference is small. The body of research includes studies that use data for diverse regions, kinds of trucking operations, vehicle configurations, and road environments. The research most commonly reflects experience with the twin-trailer configuration (i.e., shorter double-trailer configurations weighing less than 80,000 lb), but results of studies that include experience for larger doubles are not inconsistent with this general conclusion. The body of past research is inadequate to provide a complete picture of the relative safety of double trailer combinations and tractor-semitrailers. Among the unanswered questions are the relative safety of different sizes of double-trailer combinations, the combined effects of weight and configuration, and the effectiveness of countermeasures. It is important to recognize that any measured differences in accident involvement rates between double trailers and tractor-semitrailers are likely to depend to some degree on specific vehicle characteristics, including the number and spacing of axles and the types of connections between trailers, and that changing these characteristics could change relative accident involvement rates. The FACT truck described above illustrates how vehicles with superficially similar configurations can differ greatly in performance characteristics.

Only one competent U.S. study directly measuring the relationship between weight and accident involvement risk for tractor-semitrailers is available (Campbell et al. 1988). There are some substantial uncertainties in that study's data, and in any case, a single study of such an important and difficult question is insufficient. The results of that study do not demonstrate a strong relationship between weight and fatal accident involvement rate. The studies on double- versus single-trailer accident rates may provide some support for the finding of the lack of a strong relationship, since the vehicles compared in those studies usually differ in average weight as well as configuration.

The past TRB studies concluded that differences in accident involvement rates among the truck types evaluated are smaller than the differences in vehicle capacity between the larger vehicles and the vehicles they would replace, so involvement rates per unit of truck freight services would decline. In these studies, therefore, the predicted change in VMT dominates the aggregate safety effect; that is, accident losses decrease in projections in which VMT decreases and vice versa.

The earlier studies' conclusion that the effect of liberalizing size and weight limits would be to reduce accident losses depends on those studies' prediction that the change would cause truck-VMT to decrease. If the effect of the change were an increase in total freight shipments (in response to lower truck freight costs) that was great enough to cause truck-VMT to increase, the regulatory change could cause truck accidents to increase even if accident losses per ton-mile of truck freight declined.

Information about the relation of risks to truck characteristics is much weaker than is desirable. The needs include carefully designed and executed statistical measurements of the relation of fatal and nonfatal accident involvement rates to vehicle configuration and dimensions; studies of the relation of vehicle dynamic properties and performance to accident risk; and a model of system-level marginal accident costs, that is, a model of how incremental changes in the volume and characteristics of truck traffic on a network of roads affect accident costs on the network, based on direct measurements of how changes in truck traffic affect the behavior of and risks to car drivers.

Little is known about the effectiveness of the majority of the safety measures recommended by past studies as accompaniments to liberalization of size and weight regulations. In particular, there is little empirical evidence for or against the effectiveness of requiring combination vehicles to meet performance standards regarding handling, stability, and performance in traffic.

REFERENCES

Abbreviations

AAR	Association of American Railroads
AASHTO	American Association of State Highway Officials
CCJ	Commercial Carrier Journal
DOT	U.S. Department of Transportation
FHWA	Federal Highway Administration
GAO	General Accounting Office
ICC	Interstate Commerce Commission

NCHRP	National Cooperative Highway Research Program
NRTC	National Road Transport Commission
TRB	Transportation Research Board
TRI	Trucking Research Institute

AAR. 2000. *Railroad Facts 2000.*

AASHTO. 1986. *Guide for Design of Pavement Structures.* Washington, D.C.

AASHTO. 1994. *Manual for Condition Evaluation of Bridges 1994.*

AASHTO. 1998. *AASHTO LRFD Bridge Design Specifications.* Second edition.

Abdelwahab, W., and M. Sargious. 1992. Modeling the Demand for Freight Transport: A New Approach. *Journal of Transport Economics and Policy,* Vol. 26, No. 1, Jan., pp. 49–70.

Agarwal, A. C., and J. R. Billing. 1988. The Effect of Ontario's Weight Regulations on Commercial Vehicle Design. *Proceedings of the International Symposium on Heavy Vehicle Weights and Dimensions,* Roads and Transportation Association of Canada, pp. 209–224.

Battelle. 1995a. *Roadway Geometry and Truck Size and Weight Regulations: Comprehensive Truck Size and Weight Study: Phase I—Synthesis: Working Paper 5.* FHWA, Feb.

Battelle. 1995b. *Traffic Operations and Truck Size and Weight Regulations: Comprehensive Truck Size and Weight Study: Phase I—Synthesis: Working Paper 6.* FHWA, Feb.

Braver, E. R., P. L. Zador, D. Thum, E. L. Mitter, H. M. Baum, and F. J. Vilardo. 1997. Tractor-Trailer Crashes in Indiana: A Case-Control Study of the Role of Truck Configuration. *Accident Analysis and Prevention,* Vol. 29, No. 1, pp. 79–96.

Bureau of the Census. 1985. *1982 Census of Transportation: Truck Inventory and Use Survey.* U.S. Department of Commerce, Sept.

Bureau of the Census. 1995. *1992 Census of Transportation: Truck Inventory and Use Survey.* U.S. Department of Commerce, May.

Bureau of the Census. 1998. *1997 Census of Transportation: Vehicle Inventory and Use Survey.* U.S. Department of Commerce.

Campbell, K. L., D. F. Blower, R. G. Gattis, and A. C. Wolfe. 1988. *Analysis of Accident Rates of Heavy-Duty Vehicles.* University of Michigan Transportation Research Institute, Ann Arbor.

Cesare, M. A., J. C. Santamarina, C. J. Turkstra, and E. Vanmarcke. 1992. Modeling Bridge Deterioration with Markov Chains. *Journal of Transportation Engineering,* Vol. 118, No. 6, Nov./Dec., pp. 820–833.

Cesare, M. A., J. C. Santamarina, C. J. Turkstra, and E. Vanmarcke. 1993. Risk-Based Bridge Management. *Journal of Transportation Engineering,* Vol. 119, No. 5, Sept./Oct., pp. 742–750.

Clark N., J. Daley, R. Nine, and C. Atkinson. 1999. Application of the New City–Suburban Heavy Vehicle Route (CSHVR) to Truck Emissions

Characterization. Society of Automotive Engineers Technical Paper 1999-01-1467.

Cohen, H. 1998. *Energy and Environmental Impacts.* Presented at DOT Comprehensive Truck Size and Weight Methodology Review Conference, Washington, D.C., July 8.

CCJ. 2000. The Top 100. *Commercial Carrier Journal,* Aug., pp. 39–56.

Dicleli, M., and M. Bruneau. 1995. Fatigue-Based Methodology for Managing Impact of Heavy-Permit Trucks on Steel Highway Bridges. *Journal of Structural Engineering,* Vol. 121, No. 11, Nov., pp. 1651–1659.

DOT. 1981. *An Investigation of Truck Size and Weight Limits: Appendices to the Final Report.* Washington, D.C., Aug.

DOT. 1997. *1997 Federal Highway Cost Allocation Study.* Aug.

DOT. 1998. *1997 Federal Highway Cost Allocation Study: Appendix I: PCE Values for Highway Cost Allocation.* Washington, D.C., May.

DOT. 2000. *Comprehensive Truck Size and Weight Study.* Aug.

Fancher, P. S., and K. L. Campbell. 1995. *Vehicle Characteristics Affecting Safety: Truck Size and Weight Study: Phase I: Working Papers 1 and 2 Combined.* FHWA, Feb. 6.

FHWA. 1999. *Highway Statistics 1998.* U.S. Department of Transportation.

FHWA. 2000. *Highway Statistics 1999.* U.S. Department of Transportation.

Fu, C. C., D. R. Schelling, B. M. Ayyub. 1992. Evaluation of Truck Configurations Based on Structural Performance of Bridges. *Journal of Advanced Transportation,* Vol. 26, No. 3, pp. 299–324.

GAO. 1994. *Longer Combination Trucks.* Aug. 9.

GAO. 2000. *Highway Infrastructure: FHWA's Model for Estimating Highway Needs Is Generally Reasonable, Despite Limitations.* June.

Ghosn, M. 2000. Development of Truck Weight Regulations Using Bridge Reliability Model. *Journal of Bridge Engineering,* Nov., pp. 293–303.

Ghosn, M., and F. Moses. 2000. Effect of Changing Truck Weight Regulations on U.S. Bridge Network. *Journal of Bridge Engineering,* Nov., pp. 304–310.

Harrison, R., J. Weissmann, and R. Barnhart. 1991. Load Rating Choice and Longer Combination Vehicle Impacts on the Rural Interstate Bridge Network. *Journal of the Transportation Research Forum,* Vol. 32, No. 1, pp. 52–60.

ICC. 1941. *Federal Regulation of the Sizes and Weight of Motor Vehicles; Letter from the Chairman, Interstate Commerce Commission.* 77th Congress, 1st Session, House Document No. 354, Government Printing Office, Aug. 14.

James, R. P. 1994. FHWA Opposes New Weight Standards for NHS Until After Study of Truck Size, Safety Relationship. *Traffic World,* June 20, pp. 12–14.

Klingenberg, B., G. Rossow, and R. Jacobsen. 1989. *FACT—The Freightliner/Heil Advanced Concept Truck.* SAE Technical Paper Series 892462.

Lyles, R. W., K. L. Campbell, D. F. Blower, and P. Stamatiadis. 1991. Differential Truck Accident Rates for Michigan. In *Transportation Research Record 1322,* TRB, National Research Council, Washington, D.C., pp. 62–69.

Marshall, A., W. Robert, K. G. Anderson, R. L. Floyd, and F. Corso, Jr. 2000. *Transportation Research Circular 498: Comparison of Pontis Bridge Project Recommendations to Programmed Work for Three U.S. Transportation Agencies.* Presentations from the 8th International Bridge Management Conference, TRB, National Research Council, Washington, D.C., June.

McCubbin, D. A., and M. A. Delucchi. 1999. The Health Costs of Motor-Vehicle-Related Air Pollution. *Journal of Transport Economics and Policy,* Sept., Vol. 33, Part 3, pp. 253–286.

Mingo, R. D., J. Esterlitz, and B. L. Mingo. 1991. Accident Rates of Multi-unit Combination Vehicles Derived from Large-Scale Data Bases. In *Transportation Research Record 1322,* TRB, National Research Council, Washington, D.C., pp. 50–61.

Moses, F. 2001. *NCHRP Report 454: Calibration of Load Factors for LRFR Bridge Evaluation.* TRB, National Research Council, Washington, D.C.

NCHRP. Forthcoming 2002. *NCHRP 12-48: Design of Highway Bridges for Extreme Events.* TRB, National Research Council, Washington, D.C.

NCHRP. Forthcoming 2002. *NCHRP 12-51: Effect of Truck Weight on Bridge Network Costs.* TRB, National Research Council, Washington, D.C.

NRTC. 2000. *2000 Annual Report.* Melbourne, Australia, Sept. 29.

Pickrell, D., and D. Lee. 1998. *Induced Demand for Truck Services from Relaxed Truck Size and Weight Restrictions: Draft.* U.S. Department of Transportation, Cambridge, Mass., Oct.

Small, K. A., and C. Kazimi. 1995. On the Costs of Air Pollution from Motor Vehicles. *Journal of Transport Economics and Policy,* Vol. 29, No. 2, Jan., pp. 7–23.

Small, K. A., C. Winston, and C. Evans. 1989. *Road Work: A New Highway Pricing and Investment Policy.* Washington, D.C., Brookings Institution Press.

Stein, H. S., and I. S. Jones. 1988. Crash Involvement of Large Trucks by Configuration: A Case Control Study. *American Journal of Public Health,* Vol. 78, No. 5.

Ticatch, J. L., M. Kraishan, G. Virostek, and L. Montella. 1996. *Accident Rates for Longer Combination Vehicles.* FHWA, Oct.

TRB. 1986. *Special Report 211: Twin Trailer Trucks.* National Research Council, Washington, D.C.

TRB. 1990a. *Special Report 225: Truck Weight Limits: Issues and Options.* National Research Council, Washington, D.C.

TRB. 1990b. *Special Report 227: New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal*. National Research Council, Washington, D.C.

TRB. 1990c. *Special Report 228: Data Requirements for Monitoring Truck Safety*. National Research Council, Washington, D.C.

TRB. 1996. *Special Report 246: Paying Our Way: Estimating Marginal Social Costs of Freight Transportation*. National Research Council, Washington, D.C.

TRB. 2000. *Transportation Research Circular E-C014: Traffic Analysis Software Tools*. National Research Council, Washington, D.C., Sept.

TRI. 1990. *Final Report: Rationalization of Procedures for Highway Cost Allocation*. Urban Institute and Sydec, Inc., Oct. 18.

Regulatory Options

Chapter 3

A description is given in Chapter 1 of how, despite widespread dissatisfaction with aspects of present federal truck size and weight regulations, recent efforts at reform have not been successful. Three impediments that may account for this difficulty are identified in Chapter 2. First, analyses have not started with clear definitions of the objectives of reform. Second, evaluation is not integrated with the management of the regulatory program, so no established mechanisms exist for measuring performance, considering proposed revisions, or establishing policy direction. Third, certain important effects of the regulations on highway costs are poorly understood or have not been assessed with the most appropriate methods. As described in Chapter 2, with present knowledge it is not possible to carry out a complete and satisfactory prospective evaluation of all the consequences of size and weight regulatory alternatives.

Proposals for improvements to the regulations should take these impediments into account. Therefore, institutional arrangements for overseeing change in federal regulation in a way that would increase the likelihood of beneficial outcomes and for remedying deficiencies in knowledge about the costs and benefits of the regulations are examined in this chapter. The need for an independent organization chartered to conduct the essential regulatory support functions of monitoring, evaluation, research, and oversight is described. With these new capabilities in place, the federal government and the states would be in a better position to manage the regulatory program, and policy options would be opened up that otherwise would be impractical.

Proposals for changes in federal truck size and weight regulations are also outlined. Implementation of any of these proposals would make use of the new evaluation and research organization's capabilities. The proposals include the recommendations of TRB Special Report 225, *Truck Weight Limits: Issues and Options* (TRB 1990a); a modified version of the *Truck Weight Limits* proposal; and a proposal for more liberal federal standards that has similarities with cer-

tain industry proposals and with practices in other countries. Finally, two methods of regulating truck use that depart from conventional federal regulatory practice are described: performance standards and greater use of pricing incentives to manage truck traffic.

In its direction for the present study, Congress asked TRB to review the merits of the *Truck Weight Limits* recommendations. The second proposal, the modified version of *Truck Weight Limits,* would share most of the objectives of the *Truck Weight Limits* proposal, but would respond to some of the criticisms the original proposal received when the study was published. The third proposal would represent a federal initiative to move U.S. size and weight policy in the direction that the evaluations of past size and weight studies imply might yield the greatest benefits. The TRB and DOT studies reach generally optimistic conclusions about the potential benefits of liberalizing the regulations, but as argued in Chapter 2, their estimates contain large uncertainties and some likely errors. The risk from these uncertainties becomes greater as the magnitude of the proposed change in regulations becomes greater. Therefore, this last proposal cannot be evaluated adequately without improved information. None of these regulatory packages is presented here as the optimal federal size and weight regulatory scheme. In Chapter 5, a description is given of how the impacts of their provisions should be subject to evaluation, making use of the organizational arrangements described in the first section of this chapter.

Performance standards and pricing are not presented as alternatives to the first three proposals. Rather, they are regulatory techniques that can be combined with any proposal to magnify its effectiveness.

INSTITUTIONAL ARRANGEMENTS TO ALLOW FACT-BASED REGULATION

Effective federal regulation of truck size and weight and effective federal oversight of state administration of federal regulations require monitoring, evaluation on an ongoing basis, and research. The federal government does not have the necessary capabilities today. Organizational arrangements that would be suited to fulfilling these requirements are outlined in this section. The committee's recommendations regarding the establishment of new arrangements are presented in Chapter 5. The four subsections below address in turn specification of the necessary federal oversight activities; the matters of funding, personnel, and legislative authorization; organizations that could serve as models for the needed arrangements; and the conduct of pilot studies, which would be a useful evaluation technique.

Essential Research, Evaluation, and Oversight Functions

In Chapter 2, it is argued that regulation ideally is an ongoing process in which research and prospective analysis form the basis for development and enactment of regulations, the effects of regulations are systematically monitored, and the results of monitoring suggest needs and opportunities for improved regulation. Historically, in the case of size and weight regulation, this cycle has not functioned. Research, evaluation, and monitoring have been sporadic and unsystematic and have not been closely linked to revision of the regulations.

Specifically, the following activities would be required to institutionalize a process of ongoing improvement of federal regulations:

- The conduct of research studies addressing fundamental questions about the relationship of vehicle characteristics to highway transport costs, and pilot studies of proposed new vehicles and related operating practices. The research agenda should be determined in a process open to proposals from the private sector, the states, and others. The following are examples of fundamental research questions, suggested by the gaps in knowledge identified in Chapter 2:
  - Effects of truck performance on traffic flow and pollutant emissions on urban roads;
  - Effects of configuration and other design features on accident involvement rates of existing trucks; and
  - Bridge costs of truck traffic and best practices for managing bridge systems, taking into account safety, bridge construction and maintenance costs, and highway transport costs.

The importance of pilot studies is described later in the chapter.

- Monitoring and program evaluation on an ongoing basis. Program evaluations would gauge whether practices intended to control accident risks and to operate highways efficiently (including size and weight regulations) were functioning as intended. Monitoring here means systematic observation to maintain up-to-date information in three areas: commercial motor vehicle traffic volumes and the distributions of dimensions and configurations of vehicles; the administration of regulations, including enforcement and fees; and costs of commercial motor vehicle traffic to highway agencies and to the public, including accidents and infrastructure costs. The design of data collection systems for monitoring depends on the specific objectives, but most needs would require data collection using scientifically designed sampling techniques. Observing the consequences of changes in federal regulations would be an important monitoring and evalua-

tion task. Monitoring activities could be joint federal–state efforts, but for purposes of federal regulation, ensuring the reliability and adequacy of information would be a federal responsibility.

- Support for state implementation of federal size and weight regulations. Oversight is a necessary function under present federal law. In addition, a federally supervised permitting program, which is an element of the regulatory options described later in this chapter, would require procedures for reviewing state permitting programs to certify that they were meeting federal requirements and for developing model regulations and model permitting programs as guidance to the states.

The scope of these activities is well beyond the current federal commitment to evaluating the performance of federal regulations and overseeing their application by the states, and does not align with the competencies of any existing federal agency. To implement the federally supervised permitting program, it would be necessary to create an organizational home for these oversight functions. The most suitable arrangement would be an independent organization with a permanent charter to evaluate commercial motor vehicle performance and the effects of size and weight regulation. This organization, which might be called the Commercial Traffic Effects Institute, would be chartered to carry out a program of development of federal size and weight regulations and related highway management practices, recommend regulatory changes, evaluate the results of implementation of new regulations, and support state implementation of federal regulations. The Institute would be authorized to enter into agreements with private-sector entities to conduct joint programs of data collection, research, and evaluation.

The Institute would use the results of pilot studies and of its research to formulate recommendations for changes in federal regulations when it had sound evidence that the changes would further congressionally defined objectives. It would recommend adjustments when its monitoring and program evaluations revealed that regulations were not working as intended or when innovations in truck or highway technology created conditions not envisioned when the regulations were enacted. The Institute also would make recommendations to harmonize areas of federal highway policy related to size and weight regulation and to truck costs, including practices and requirements regarding safety regulation, enforcement, infrastructure design and management, and user fees.

A successful organization such as that described above would come to be seen by industry, state governments, and others as a means to implement ideas about more efficient highway management and truck regulation. That such an opportunity hardly exists today is one of the most unsatisfactory aspects of the existing regulatory arrangement. Industry would be expected to bring proposals to the Institute, especially if industry were involved in the organization's structure. Numerous examples may be cited of good-faith proposals from industry and the states for modifications to federal standards that never received due consideration, in part because no mechanism existed for evaluating them. Facilitating innovation would require processes perceived to be open, objective, and scientifically sound; access to adequate resources and the authority to enter into agreements for the conduct of evaluations; and a formal, defined relationship between research and evaluation results and regulatory decisions.

Authorization, Funding, and Personnel

Congressional action would be necessary to create the Institute. Legislation would specify its charge; its powers and responsibilities; and its governance, including the nature of state and private-sector involvement.

Creation of the Institute, together with introduction of the federally supervised state permitting program discussed later in this chapter, would correct an anomaly in the manner in which federal size and weight regulation is administered. Whereas other spheres of federal regulation are overseen by executive-branch agencies with established, ongoing responsibility for regulatory development, federal size and weight regulations have been established almost exclusively by direct legislation. DOT has certain rulemaking responsibilities, but their scope is restricted (for example, to definitional questions). In other areas of regulation, the responsible executive agency routinely carries out evaluations because it has the authority to make adjustments as necessary to respond to emerging problems and changing technology. Examples are the Federal Motor Carrier Safety Administration (FMCSA), National Highway Traffic Safety Administration (NHTSA), Environmental Protection Agency (EPA), and Occupational Safety and Health Administration (OSHA). However, the limited range of executive agency responsibility has discouraged evaluation of size and weight regulations. It is worth noting that the ICC, in the first federal truck size and weight study in 1941, foresaw problems inherent in direct legislative standards setting:

> The problems to be faced in the exercise of Federal powers in this regard [size and weight regulation] do not permit of detailed statutory expression of precise standards generally and universally applicable; there obviously is need for administrative determination in the light of the facts of given situations as related to the declared standard of Congress that commerce be not unreasonably burdened (ICC 1941, 26).

The solution proposed by the ICC, that Congress give it authority to set standards administratively for particular geographic or commercial circumstances, might have proven too cumbersome, and Congress did not act at the time on the ICC's recommendations. The state permitting program discussed later, under federal supervision and with support of the Institute, is an alternative that would avoid the problems with direct legislative standards setting identified by the ICC, make use of the technical competence and local knowledge of the state governments for selection of detailed standards within a range of alternatives, and ensure that federal interests are safeguarded. Congress could retain its historical practice of establishing regulations directly by legislation rather than delegating standards setting to an executive agency, but states would have flexibility within a federally defined range, and Congress would rely on the formal mechanism it had created in the Institute for evaluating and proposing regulatory changes.

Past studies of the use of research in administering federal regulations have observed that a conflict exists between regulation and evaluation. The regulatory agency's goals are to see that rules are promulgated and defended from attacks; research may be perceived as lending credence to doubt about the aims and effectiveness of the rules and so as a source of delays and challenges. (TRB 1997, 28–29; NRC 1991, 15) One way to prevent this conflict from interfering with research would be to create an independent body charged with improving the performance of the regulations. This body's research results and recommendations would be formally linked to the regulatory process, but it would not have direct regulatory or enforcement responsibilities.

The charge to the Institute would be critical to its success. A vague charge would be a handicap; as pointed out in Chapter 2, the absence of clear, congressionally defined objectives for reform has reduced the value of past DOT truck size and weight studies and hindered progress toward better regulations. However, if the Institute's charge specified practical goals and directed it to find means of attaining them and of

overcoming any obstacles, the Institute would have the direction necessary for its success. Improved efficiency of highway transportation, considering all the important private and public costs involved, should be the fundamental goal.

It would be necessary to provide stable and adequate funding. Funding from highway user fees would be appropriate. Carrier contributions for individual projects also would be appropriate. For example, a group of carriers in one industry segment or one region might have a particular interest in having research or a pilot study conducted on a vehicle or operating practice they believed would be of value to them. In such a circumstance, the carriers should be expected to contribute a major portion of the costs of the evaluations. Legislation would be needed to provide the proper legal form for such contributions.

Estimating a budget for the Institute would not be possible until a work plan for the initial activities had been prepared. Preparation of such a work plan would be the initial task of the Institute itself, in consultation with other federal agencies, the states, and interested private-sector parties. The objective of the Institute would be to reduce the public costs (including safety costs and the cost of publicly provided infrastructure) and private costs of commercial motor vehicle transportation. Estimates of past studies suggest that savings could be on the order of several billion dollars annually. If spending of perhaps 1 percent of potential savings were required to conduct necessary oversight and evaluation through the Institute, the cost would not appear unreasonable.

The composition of the Institute's staff also would be critical. A professional staff with diverse expertise would be essential to conduct the program of research, monitoring, evaluation, and development of regulatory proposals. This staff would have to include economists and other social scientists, statisticians with skills in experimental design and program evaluation, human factors researchers, and mechanical and civil engineers. Staff knowledge of public and private administration also would be necessary.

Organizational Models

Three organizations that can provide a model for the Institute are the National Road Transport Commission (NRTC) of Australia, the arrangements established in Canada for development of the 1988 interprovincial agreement on weights and dimensions, and the U.S. Health Effects Institute (HEI). These organizations have had goals

related to those proposed above for the Institute. None of them can be copied directly, since two are in countries whose government institutions differ from those of the United States, and one is from a different sphere of regulation. However, these three organizations are evidence that the proposed arrangement could be successful and indicate some of the keys to success.

National Road Transport Commission

The Australian NRTC, formed in 1991, is making progress on regulatory issues that defied resolution for many years. Its mandate is broad, but among its most prominent projects is development of new nationwide size and weight standards. The key elements of the Australian arrangement are as follows (NRTC 2000):

- The NRTC was created by an act of the national parliament and an intergovernmental agreement among all the states and the national government.
- The national legislation was a mandate for change in a certain direction, but left the details to be resolved by the commission process. The mandate called for improved road transport productivity, encouragement of innovation, continuous monitoring and updating of regulations as necessary, facilitation of international harmonization, and improvement in the effectiveness and administrative costs of compliance enforcement.
- The NRTC's governing body is the Australian Transport Council, made up of the transport ministers of each state government and the national transport minister. The intergovernmental agreements provide, in spirit, that once the Commission has designed and evaluated a regulation on a topic within its purview and the Council has approved it, the state governments will adopt it. Most of the regulations are regarded as state rather than national responsibilities—a key difference from the U.S. situation, in which there is established precedent for federal preemption of state regulations.
- Industry participates actively, but in an advisory capacity. There are no industry seats on the governing body. Funding is entirely from the government, although industry may make in-kind contributions.
- The NRTC's approach is strongly oriented toward relying on research to develop proposals and on ongoing monitoring and evaluation of regulations. The Commission has a role in "coordinating and monitoring" actual adoption of regulations by state governments. Adoption by the states has been at least partly successful, if imperfect.

The NRTC's mandate covers, in addition to size and weight limits, motor carrier safety standards (e.g., hours of service), road user taxes, vehicle emissions, vehicle safety, and traffic regulations—matters that in the United States fall within the jurisdictions (at the federal level) of EPA, NHTSA, and FMCSA. No such broad mandate would be possible or necessary in the United States. However, there is a gap at the federal level in this country in that no agency has ongoing administrative responsibility for size and weight regulations. FHWA has limited responsibility, but the major features of federal size and weight regulations are not enacted following the same mechanisms as, for example, the rules on truck driver hours of service or motor vehicle emissions—that is, with an executive agency determining the specifics of regulations through rulemaking, following a policy directive from Congress.

Canadian Interprovincial Standards

In 1988 the Ministers of Transportation of the provinces and territories of Canada signed a Memorandum of Understanding on Interprovincial Weights and Dimensions as the culmination of a 5-year effort involving discussions, research, and regulatory development aimed at reducing unnecessary variability in regulation across Canada. As a result of this agreement, the trucking industry in Canada has been provided with minimum, nationally accepted standards for vehicle size and weight that apply to a network of highways across the country.

A major research program was conducted in support of the interprovincial discussions. Research included examination of the influence of size and weight variables on vehicle stability and on pavement performance. The results of the research program were used in developing a set of regulatory principles whereby vehicle performance and highway infrastructure were among the factors that determined the selection of size and weight limits (Pearson 1989). The Roads and Transportation Association of Canada facilitated the interprovincial discussions. The research program was conducted by a nonprofit corporation created for the purpose and funded jointly by the provinces and by industry.

The interprovincial agreement also created a permanent arrangement to monitor developments and improve standards. An appendix to the Memorandum of Understanding created the Task Force on Vehicle Weights and Dimensions Policy, reporting to the Council of Ministers of Transportation, whose members are the transportation ministers of all the provinces and territories and the federal government. The Task

Force's charge is to develop and recommend a national strategy for the evolution of vehicle weight and dimension regulations in Canada. This arrangement has maintained dialogue between government and industry on technology, regulatory harmonization priorities, and research needs, and has ensured that the national standards are monitored, expanded, and refined to reflect experience and changing circumstances. As a result, the interprovincial standards have been revised three times since 1988. Examples of issues that the Task Force is addressing at present are harmonization of conditions for oversize/overweight special permits, training and accreditation of escort vehicle drivers, and development of common standards for automobile transporters.

As in the case of the Australian NRTC, it was the need to reach agreement among all the provincial governments that provided the stimulus for the Canadian initiative. This exigency does not exist in the United States because of the established strong federal role in size and weight regulation. Nonetheless, the Canadian example shows how the process of seeking agreement among diverse public and private entities can be facilitated by information produced in a manner that is perceived as open, objective, and competent.

Health Effects Institute

HEI is an independent, nonprofit corporation formed in 1980 to provide research on the health effects of pollutants from motor vehicles and from other sources in the environment. It is funded jointly by EPA and industry (HEI n.d.).

HEI is divided into two independent committees—the Health Research Committee and the Health Review Committee—to separate the functions of planning, funding, and administration of research from the function of critical review of research. The Health Research Committee consults with HEI sponsors to determine research priorities and to develop the 5-year HEI Strategic Plan, which is reviewed annually. Once research priorities have been identified, contract proposals are solicited and reviewed with respect to scientific quality and integration with the overall research program. Studies recommended by the Research Committee are finally evaluated by the Board of Directors. The Research Committee monitors research in progress, but its involvement ends when a final report is submitted. The Health Review Committee conducts in-depth evaluation of the final reports and releases the reports, together with the committee's commentaries, to sponsors and the public.

Pilot Studies

The most credible and efficient method of addressing many evaluation questions would be a pilot study, that is, a controlled experimental trial of a vehicle specification, element of equipment, or operating practice following a scientifically designed research protocol, and involving collection of data in actual operating conditions or very close approximations thereof. In such a study, the primary impact of interest (e.g., frequency and severity of accidents) would be observed rather than proxies (e.g., vehicle stability or driver performance). A study could be limited to measuring safety effects, some other truck impact (e.g., infrastructure or traffic effects), or a set of impacts. The conduct of pilot studies would probably be the most visible function of the Institute.

A pilot study requires the participation of vehicle operators. Operator participation can allow data to be collected with greater detail, accuracy, speed, and economy than is the case with study designs that do not depend on such cooperation. However, a pilot study of a vehicle proposed for regulatory approval would have an inherent source of bias because industry participants would know they were part of an experiment whose outcome would affect them. Blind trials (the type used, for example, for drug trials conducted to gain Food and Drug Administration approval) usually would not be possible. In most evaluations, there would be no practical way to avoid this potential bias, but the problem would not prevent the pilots from producing useful information if data collection and other procedures were audited by the Institute. Insurance against misleading results would be provided by continuing to monitor the impacts of any vehicle approved for general use after the end of the pilot study.

A study conducted by Consolidated Freightways, a trucking company, that compared accident rates of tractor-semitrailers and twin trailers in the company's operations illustrates that useful evaluations can be carried out in a study of feasible scale (Glennon 1981, reviewed in TRB 1986, 310–311). The study was conducted for purposes of litigation. If a similar methodology were employed for regulatory applications, a procedure would be established for the oversight agency to verify the integrity of the data. The carrier assembled data for 300,000 trips of tractor-semitrailers and twin-trailer combinations. Each tractor-semitrailer trip was matched to a twin-trailer trip operating on the same day over the identical route. Rates of accident involvement per VMT were computed for the two configurations. The

analysis used historical records of truck trips and accidents from the company's files rather than data collected for purposes of the study. The matched-pair method allows comparison of accident experience for two vehicle types operated under nearly identical roadway and environmental conditions. The method thus overcomes the principal difficulty involved in comparing the safety of different vehicle types—that differences attributable to vehicle type can be obscured by the effects of differences in the kinds of roads and traffic conditions under which the vehicles are operated.

The pilot study approach is applicable to evaluation of the infrastructure costs and traffic impacts of new vehicles or operating practices. For example, a data collection system could be established for observing the responses of structures and pavements to new vehicles and cumulative infrastructure impacts over a period of up to a few years. The results of such a study would support good estimates of the infrastructure costs to be expected, and would allow the highway agency to plan bridge and pavement management practices that would minimize costs and to set correct user fees that would ensure cost recovery.

Such large-scale studies are not the only research design that would be useful in answering questions about truck impacts. Pilot studies might be relevant primarily to evaluation of new truck configurations preparatory to changes in regulations. Other, smaller-scale studies exemplifying a variety of research designs that could be used to obtain information applicable to regulatory development are identified in Chapter 2.

Sample Size Limitations

In pilot studies involving a small number of vehicles, it would not be possible within a reasonable time span to measure small differences in relative accident risks (Sparks et al. 1988). For example, if the involvement rate in all accidents for one vehicle type were half the rate for the comparison vehicle type, this difference could be detected after a few million truck-VMT of experience, but if the involvement rate difference were 5 percent, hundreds of millions of miles of experience might be necessary to confirm the difference. When pilot studies involved only a small number of vehicles, it would be reasonable to continue operation of the vehicles provided the pilot study results were sufficiently accurate to rule out serious deficiencies, and procedures were in place for continued close observation of the new vehicles' performance.

A discussion of accident rate measurement problems presented in the DOT 2000 *Truck Size and Weight Study* implies that direct mea-

surement of accident rate differences among vehicle configurations in the present truck fleet would be nearly impossible because traffic volumes of larger configurations are so low that decades might be required to collect data sufficient for statistically meaningful comparisons (DOT 2000, VIII-2). However, the study that is the basis for the DOT discussion reveals that useful comparisons of the accident involvement rate for all longer combination vehicles with the rate for conventional tractor-semitrailers could be made with 4 years of data from the one state (Utah) for which the necessary accident and traffic information is available (Council and Stewart n.d., 15). This is the period required to measure an accident rate difference of 15 percent; a very large difference would be detected much more quickly, and if more states could be induced to report the necessary data, it might be possible to begin to make comparisons in a matter of months. Moreover, the experimental design of a pilot study, together with required carrier cooperation in reporting accident and travel data, could be expected to allow more efficient measurement of rates than is possible with the passive observation method assumed in the Council and Stewart estimates.

Relation of Pilot Studies to Regulation

A pilot study would constitute an integral step in the regulatory process. An analogy can be drawn between pilot studies and the process by which new drugs are approved by the Food and Drug Administration. When a firm has a new drug it wishes to produce, it approaches the regulatory agency with a plan for demonstrating the product's safety and effectiveness. The drug evaluations are conducted by private parties under government oversight. Similarly, before a pilot study of a new truck was conducted, the criteria by which the study results were to be judged would be specified. If the evaluation showed that the new vehicles (or new operating practice) failed to satisfy the criteria, it would be necessary to modify the proposal and conduct new trials.

Federal Motor Carrier Safety Pilot Program as a Model

TEA-21 authorized DOT to conduct pilot studies for the purpose of evaluating alternatives to existing federal motor carrier safety regulations or innovative approaches to motor carrier safety (Public Law 105-178, Section 4007). This program provides a model for the pilot study concept, but initial experience also suggests pitfalls to be avoided in the conduct of monitoring and evaluation, thus highlighting the critical importance of the kind of technical oversight the Institute would provide.

TEA-21 allows the Secretary of Transportation to initiate a proposal for a pilot study involving exemption from an existing motor carrier safety regulation and also provides that a carrier can petition for an exemption to be evaluated through a pilot study. Presumably if DOT wished to initiate a pilot study on its own, it would solicit carriers to apply for the associated exemption. The legislation specifies that safety measures in any pilot program must be designed to achieve a level of safety equivalent to or greater than that which would be attained through compliance with existing regulations. DOT is required to have a pilot program plan with the following elements:

- A duration for the pilot program of not more than 3 years,
- A data collection and safety analysis plan that identifies a method for making comparisons,
- A number of participants sufficient to yield statistically valid findings,
- Oversight to ensure that participants comply with all terms of the program,
- Adequate measures to protect the health and safety of study participants and the public, and
- Means of disseminating information to states and the public about the program.

DOT can cancel the pilot or remove a participant if there is a failure to comply with the terms of the program or its continuation would not be consistent with safety. The law explicitly preempts any conflicting state regulations for the duration of a pilot program. (One difference between the structure of the TEA-21 safety regulation pilot program and the size and weight pilot study program described here is that the latter would not involve federal preemption of state regulations; rather, the states would be voluntary participants.) At the end of a pilot program, the law requires the Secretary of Transportation to report the findings to Congress and to recommend any amendments to regulations that would improve safety.

A federal pilot study program that included these general provisions would be suitable for evaluating the consequences of changes in federal size and weight regulations. However, conducting a successful pilot study of changes in size and weight regulations would require scientifically competent data collection and analysis to measure impacts. The first DOT proposal for a pilot program to evaluate changes in motor carrier safety regulations [for a training program to allow drivers under

the regulatory minimum age of 21 years to work as truck drivers after undergoing screening and training (66 FR 10935, February 20, 2001)] did not in its originally published form contain adequate provision for evaluation of safety impacts. The shortcomings of this proposal suggest that Congress must make stronger and more explicit provision for evaluation in enabling legislation for such programs. This need would be the rationale for creation of the Institute.

The DOT proposal for a pilot program to allow commercial drivers under 21 years of age was initiated by petition of a motor carrier association. The association's proposal includes a plan for a training curriculum and procedures for supervision of drivers, as well as support for a consortium of motor carriers and driver training schools expressing willingness to participate. However, the DOT proposal contains no provision for data collection and analysis to evaluate the safety effect of the pilot program. Under the heading "Monitoring and Evaluation," the *Federal Register* notice (p. 10938) states: "Under the [industry association] proposal, each carrier participating in the program would provide monitoring of each younger driver from the day the driver began team driving operations until the driver's 21st birthday. To satisfy the monitoring requirements, monitoring would, at a minimum, include: face-to-face meetings with the younger driver every 3 months; monthly reviews of the younger driver's service logs. . . ."

The younger-driver pilot as proposed does not entail any industry reporting of safety-related data to DOT, and would not allow DOT to determine the effect on safety of a change in driver age requirements or of any of the specific training practices and other measures of the pilot program. Thus the evaluation is not in any way analogous to the evaluations in the size and weight pilots described in this chapter. The missing element is an experimental design that would allow DOT to test statistically the effect of the younger-driver program on safety. One such design might be to set up two or three alternative programs involving different kinds and levels of driver screening, training, and apprenticeship and compare their results.

DOT's proposal for conducting the younger-driver pilot also fails to describe how the program will be judged to have succeeded or failed or how DOT will decide what recommendation to make to Congress at its conclusion. Congress has specified that regulatory changes evaluated in the pilots must not allow any degradation of safety. The pilot study plan should explain how the information collected in the study will allow this congressional criterion to be applied. As noted above, credibility of pilots and private-sector willingness to participate will

depend on establishment of a clear linkage between results and regulatory actions.

TRUCK WEIGHT LIMITS RECOMMENDATIONS

The recommendations for changes in federal regulations of the 1990 TRB study *Truck Weight Limits: Issues and Options* (TRB 1990a) are presented here primarily as the point of departure for the modified version of these recommendations presented in the next section. In addition, the congressional charge for the present study called for a review of the 1990 study's recommendations. This section summarizes the recommendations and their rationale and describes the objections that were raised when the study was published. The next section of this chapter describes how the capabilities of the Institute as outlined above could help overcome these objections.

Truck Weight Limits was the product of a study conducted by TRB in response to a provision in the 1987 federal highway act. Federal truck weight regulations and numerous alternatives were evaluated, using the best available engineering and cost information. Federal weight standards have not changed since the study was conducted [with the exception of the weight provisions of the LCV freeze imposed in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991], nor, regrettably, has scientific understanding of the impacts of changing truck dimensions greatly advanced. Highway conditions have changed with the growth of traffic and continuing investment in the system, but the study's findings remain relevant nonetheless.

The TRB committee made the following recommendations regarding federal limits (TRB 1990a, 229–232):

- New bridge formula—The bridge formula in federal law should be replaced with a new one that is less restrictive for short, heavy single-unit trucks (e.g., dump trucks) and for tractor-semitrailers with more than five axles.
- Special permit program—Federal law should be changed to authorize any state to issue permits allowing vehicles to exceed the federal gross weight limit (dropping the requirement that a state must show a grandfather right to issue such permits), subject to the new bridge formula and to requirements regarding routes, fees, and safety restrictions.
- Grandfather rights—No new rights should be recognized, but existing rights should not be eliminated. Grandfathered operations that exceed federal axle weight limits or certain specified gross weight

limits should be required to comply with the requirements (other than weight limits) of the new permit program.

In addition, the committee recommended more spending and more effective program design for weight enforcement, and called upon the states to cooperate in standardizing limits and permit practices regionally.

Weights of permitted vehicles would be limited by the new bridge formula. A tridem axle would be limited to about 44,000 lb; a six-axle tractor-semitrailer with a 48-ft semitrailer would be practically limited to 86,000 lb; and an eight-axle double-trailer configuration with 33-ft trailers would be limited to 113,000 lb. The exact limits would depend on the axle spacings of the vehicles. Appendix D contains the complete text of the study's recommendations.

The distinguishing characteristics of this proposal are as follows:

- It allows increases in gross weight beyond the present federal 80,000-lb limit on the Interstates in states that do not have grandfather rights, and for nongrandfathered vehicle types in grandfather states. The significance of the grandfather provisions of federal law as a source of arbitrary differences in state practices is thus diminished.
- States have the option of not allowing the increased weights by not participating in the permitting program. (The alternative approach would be a mandatory liberalization of state limits, as the Surface Transportation Assistance Act of 1983 accomplished.)
- The federal government would oversee state permitting practices and be more involved in enforcement to ensure that application of the new limits was consistent with safety and economy. Aspects of this oversight would be new federal responsibilities.
- The recommendations do not explicitly address LCVs, although certain LCVs would be able to take advantage of the permitting program. The committee's charge was to evaluate federal weight limits only. Consequently, it made no recommendations regarding vehicle length. In evaluating the proposed new regulations, the committee assumed that each state would retain its length limits unchanged, although the committee anticipated that the federal permit program would be an incentive for some states to increase their length limits so they could operate larger double-trailer configurations on the Interstates.

Objectives and Benefits

The TRB committee stated the objectives with respect to which it evaluated regulatory alternatives as follows:

- To select from the various changes in truck weight regulations proposed by industry groups and others the most practical means to realize the productivity benefits of increased truck weights while reducing or eliminating possible adverse effects;
- To make changes in weight limits that would reduce truck accidents and encourage safety improvements in truck design and operation;
- To provide mechanisms to match user fees with added costs for pavements and bridges;
- To promote uniformity in the administration of truck weight regulations;
- To balance the federal interest in protecting the national investment in the Interstate system and facilitating interstate commerce with the interests of the states in serving the needs of their citizens and industries;
- To develop proposals that are realistic and feasible and would have a reasonable chance of being implemented. (TRB 1990a, 228)

The TRB study committee estimated that if all states chose to participate in the permit program, about a third of the mileage of all large trucks (that is, heavy single-unit trucks as well as combination vehicles) would adopt new configurations. The vehicle experiencing the greatest growth in popularity would be the six-axle tractor-semitrailer. Users of heavy single-unit trucks, such as dump trucks and garbage trucks, would benefit, primarily by replacing three-axle with four-axle trucks. A small amount of freight was predicted to shift from tractor-semitrailers to short, heavy double-trailer combinations. Traffic equivalent to 1 percent of annual large-truck-VMT would be diverted from railroads to the highways, but the total annual mileage of large trucks would decline by more than 3 percent compared with traffic volume if the federal limits were not changed.

With these projected levels of use, annual freight transportation costs were projected to decline by $5.2 billion (in 1995 prices and freight volumes) or 2.6 percent of the prior total cost of truck freight transportation. Highway agency pavement costs would be nearly unchanged, but annual bridge construction and maintenance costs were projected to increase by $900 million, primarily for replacement of bridges deficient for carrying the heavier vehicles. Accident losses were projected to decline because the reduction in truck-VMT would more than offset any greater risk per mile of travel of the new trucks com-

pared with the vehicles replaced. The TRB committee concluded that these projected outcomes matched the defined objectives better than any of the range of alternatives within the scope of the study and so recommended adoption of the new regulations.

Objections and Obstacles

The *Truck Weight Limits* proposal continues to be worthy of consideration. Freight productivity benefits would exceed highway agency costs of accommodating the larger trucks, according to the evaluation in the study. Moreover, as argued in Chapter 2, the analysis method used in the study tends to overestimate bridge costs because it does not take into account bridge management techniques for reducing those costs. Finally, it may be argued in the proposal's favor that it would provide a mechanism for adjustment of federal regulations with some degree of planning and control and would therefore be preferable to the stop-gap measures and haphazard erosion of existing standards that appears to have been the pattern of recent years. Before judging whether implementing the proposal today would be advisable, it is necessary to consider changes in the environment since the study was conducted and the criticisms aimed at the study when it was released.

Changes Since 1990 in the Highway Transport Environment

Since the TRB committee issued its recommendations in 1990, some factors in the environment have changed that would affect the consequences of adopting those recommendations. Truck and automobile traffic has grown, and more time is lost to congestion today than in 1990. However, with federal leadership beginning with the 1983 STAA and continuing with the ISTEA (1991) and TEA-21 (1998) highway programs, spending on roads has increased significantly, and progress has been made toward improving the physical condition of bridges and pavements (DOT 1999).

Traffic of containerized freight, much of it in international trade, grew rapidly in the 1990s. U.S. weight limits are lower than the limits of most of the nation's trading partners, and heavier six-axle semitrailers operating under the *Truck Weight Limits* permit program would be well suited to carrying international containers. Indeed, the benefits of increased truck productivity may appear more attractive today because of emergent concerns over capacity constraints throughout the freight transportation system.

Average fatal accident involvement rates for trucks have declined since 1990, possibly rendering any relative differences in accident rates among vehicle types somewhat less significant. Some data indicate that

average loaded truck weights may be decreasing (DOT 2000, Vol. II, III.8), a trend that could affect the productivity benefit of adopting the TRB recommendations. Resources devoted to truck regulatory enforcement have increased, although measurement of the effectiveness of regulation remains poor, as discussed in Chapter 4.

The significant federal regulatory change since 1990 has been enactment of the LCV freeze in 1991, which prevents states from claiming any expansion of grandfather rights to operate heavier multitrailer configurations on the Interstates and blocks changes in state regulations that would expand use of multitrailer configurations on the National Network for Large Trucks (which includes 160,000 mi of roads in addition to the Interstates) (DOT 2000, Vol. III, III.17). The LCV freeze would restrict states' options for taking advantage of the proposed permitting program.

Criticisms of the Truck Weight Limits *Proposal*

The most serious objections raised to the original *Truck Weight Limits* proposal upon its release concerned implementation. The proposal incorporated requirements regarding routes where permit vehicles would operate, user fees for permit vehicles, enforcement, and safety practices. These requirements were stated in general language and left to the discretion of the states or as regulatory details to be worked out by FHWA in promulgating regulations to govern the permit program. Some state officials and others argued that technical expertise, institutional arrangements, financial and human resources, and political support that would be essential for putting these safeguards in place were all lacking. State officials were concerned that the end result of attempting to implement the study's recommendations would be that the states would be forced to accommodate larger trucks and to incur added infrastructure costs without the needed additional revenue (which according to the proposal should come from permit fees and other user fees) and without the strengthened enforcement and safety checks the study said would also be necessary.

These concerns find support in past experience. Truck permit fees often are insufficient for covering the costs of administration and enforcement of the permit programs, let alone for recouping added infrastructure costs generated by permit vehicles (see Chapter 4). At the federal level, truck excise taxes were increased on a graduated scale with respect to weight in STAA, the 1983 law that required all states to allow 80,000-lb trucks, but the graduated fee schedule was repealed 2 years later.

On enforcement, the *Truck Weight Limits* proposal contained a partially dissenting statement by a committee member who was a state enforcement official, presenting two objections. First, the study's evaluations did not include sensitivity analysis of how the projected benefits and costs of the options would change if differing assumptions about the effectiveness of enforcement were made. The statement's author believed that under the permit program, the average infrastructure damage cost of violations would rise and that the added complexity of the permit program would make it more difficult to enforce than existing regulations. Higher cost per violation and greater frequency of violations might annul the projected benefits, the statement argued. Second, the author of the statement noted that although the report listed possible federal actions to strengthen state enforcement, the recommendations did not call for any specific new federal initiative regarding enforcement.

As discussed in Chapter 4, federal oversight of state enforcement programs has historically been weak. Implementation of the *Truck Weight Limits* proposal would heighten the importance of the federal oversight role.

Finally, regarding the proposal's recommendation that permits issued under its recommended procedures include provisions requiring special equipment or operating practices to ensure safety, the results of the review of safety evaluations of size and weight limits presented in Chapter 2 indicate that the effectiveness of most such measures is largely unknown. Therefore, this part of the proposal's recommendations, by itself, would not provide strong assurance of safe operation of permit vehicles, even if it were vigorously implemented.

MODIFIED VERSION OF *TRUCK WEIGHT LIMITS* RECOMMENDATIONS

In this section, a proposal for reform of federal size and weight regulations is outlined that retains the core concept and most of the objectives of the *Truck Weight Limits* recommendations, but includes provisions intended to overcome some of the problems identified in criticisms of that study. The specific size and weight provisions outlined below are presented as an interim arrangement rather than as a permanent resolution. Implementing the proposal would create a mechanism whereby the performance of the regulations and the states' administration of them could be monitored and evaluated, and adjustments made when warranted by the evaluations and by changes in external conditions. The Institute proposed earlier in this chapter would be a suitable

organizational arrangement to provide technical support for these functions. Recommendation 3 in Chapter 5 specifies in greater detail the necessary oversight functions and the proposed responsibilities of the Institute.

Two modifications to the *Truck Weight Limits* proposal are described below: changes in the earlier study's size and weight limit recommendations, and stronger and more specific provisions to ensure that implementation is effective in furthering the objectives of the regulations. The modified proposal retains the central feature of the original: a federally supervised, state-implemented permitting program, adopted at state option, to allow operation of certain trucks larger than those now allowed under federal law on the Interstates and other roads where federal restrictions currently apply.

Size and Weight Provisions

In this modified regulatory proposal, specific size and weight provisions that differ from the original *Truck Weight Limits* recommendations are as follows:

- An immediate change in the federal bridge formula is not proposed. How the new bridge formula would influence equipment selection in actual practice is difficult to predict and an important source of uncertainty in the original study's impact estimates. Also, since 1990 other proposals for modifications to the bridge formula have been made, so reassessment probably will continue in the future.
- Instead of defining the trucks that would be eligible for the new permit program solely by a bridge formula, specific eligible configurations are identified: a six-axle tractor-semitrailer with maximum weight of 90,000 lb (regardless of the bridge formula restriction) and double-trailer configurations with each trailer up to 33 ft long, seven to nine axles, and weight limit governed by the present bridge formula, implying a maximum weight of about 111,000 lb. These would be the maximum weights and dimensions allowed, but a state could apply to participate in the program and to impose more restrictive limits on its permitted trucks. For example, a state could propose to impose a bridge formula on the six-axle tractor-semitrailer. The specificity of this approach might be attractive to state officials, in contrast to the uncertain outcome of application of the new bridge formula proposed in *Truck Weight Limits*. On the other hand, specificity curtails operator flexibility and innovation. Federal permission to use heavy doubles would constitute a limited relaxation of the present federal LCV freeze.

• After a specified transition period, all trucks operating under grandfather exemptions or state-specific exemptions from federal regulations would be made subject to the requirements for monitoring and evaluation that would apply to trucks in the proposed new state permitting programs. Information from monitoring would allow Congress to decide whether the grandfather provisions should be altered. Alternatively, grandfather rights could simply be sunset after a period of time. When the permit program and the needed federal oversight capabilities were in effect, carriers and states would have the opportunity through these mechanisms to use almost any economically justifiable vehicle, and with more effective controls to prevent abuse than now exist in grandfather rights operations.

The six-axle 90,000-lb tractor-semitrailer, one of the vehicles that would be eligible for the permit program, is evaluated as carefully as existing information allows in the DOT 2000 size and weight study and in *Truck Weight Limits*. This vehicle is considered in the DOT and TRB studies because (1) it offers a modest productivity gain over the current standard five-axle tractor semitrailer (the TRB study estimates about a 5 percent savings per ton-mile for high-density cargo); (2) it would reduce pavement wear costs per ton-mile of truck freight because it provides carriers an incentive to adopt trucks with lower average axle weights; and (3) the total weight and weight distribution would be consistent with criteria for acceptable levels of bridge stress that are the basis of current federal regulations. The desire to limit the extent of potential bridge overstress is the principle constraint on the weight of the vehicle in the two earlier analyses.

The DOT study further notes that allowing use of the heavier six-axle tractor-semitrailer would reduce the discrepancies between U.S. limits and those of Canada and Mexico and between U.S. limits and the weights of standard containers in international commerce. The six-axle tractor-semitrailer is similar to trucks used widely today in many other countries.

Double-trailer combinations with 28-ft trailers and gross weight of up to 80,000 lb operate legally in every state by federal law, and 22 states allow operation of longer and heavier multitrailer combinations. Short, heavy double-trailer combinations are evaluated in the DOT 2000 study, in *Truck Weight Limits,* and in the Turner Proposal study (TRB 1990b). The proposed 33-ft trailer length limit on the double-trailer permit vehicles would allow this configuration to make turns at intersections without encroaching farther into the

opposing lane than do common existing tractor-semitrailers. The evaluations in past studies indicate also that the 33-ft trailer length would offer some advantages with respect to stability as compared with 28-ft trailers.

There is no basis for claiming that these weight limits are optimum. They would be expected to be subject to revision over time. The federal review of state permit programs would be permanent and ongoing, and as its effectiveness was strengthened through experience, the review process would yield results that would provide the needed guidance on revision of the limits.

Implementation Provisions

As explained in the preceding section, serious objections to the *Truck Weight Limits* proposal concerned implementation problems: How could the study's recommendations regarding adequate fees; adequate enforcement; and assurance of safe operation through imposition of vehicle, operational, and routing restrictions be made to work in practice, considering the history of federal and state failings in these areas? Outlined below are proposals aimed at increasing the likelihood of successful implementation of the permitting program by putting teeth into the federal oversight of enforcement, fees, and safety requirements. The key to improved results in each of these areas is effective evaluation and monitoring. If regulatory agencies cannot observe how the programs they administer are performing with respect to their objectives, the chance of success is small.

User Fees

The federal legislation creating the program would contain a quantitative test for revenue adequacy of the permit fees imposed by states that wished to participate in the new permit program. Fees should be sufficient to cover all costs of administering and enforcing the permits, as well as any increase in infrastructure cost caused by the permits. The ability of the permit program to cover its costs is a necessary test that it is economically justified. States that decide to participate in the program should be required to provide DOT with the data necessary to verify revenue adequacy.

Enforcement

An effective joint federal–state program for enforcement under the permit program would include the three elements listed below. The federal legislation creating the new federal truck size and weight reg-

ulatory program would have to contain specific requirements regarding each of these elements:

- Performance benchmarking—A state participating in the program would be required to have in place a data collection program that allowed it to know the actual distribution of axle weights and gross weights on significant truck routes and the frequency of extreme overloads, and that allowed it to observe the effect of enforcement efforts on the frequency and severity of violations.
- Application of new enforcement tools—The list in *Truck Weight Limits* of possible federal measures to strengthen enforcement remains valid (pp. 142–143). That study recommends a federal evaluation of these measures but does not explicitly recommend any federal action regarding enforcement. The measures identified are as follows:
  - Imposition of federal penalties for violation of federal limits. Penalties might include fines and other penalties, such as forced offloading of trucks and revocation of the driver's commercial driver's license for serious violations within the driver's control, such as ignoring a bridge posting. Federal penalties could also be imposed on carriers and on shippers, depending on where responsibility lay for placing the overload on the highway.
  - Federal programs to educate judges, prosecutors, and state law enforcement officials about the importance of the problem.

A strong federal action would be to make enactment of a "relevant evidence" statute a precondition for state participation in the permit program. A few states authorize enforcement officials to conduct terminal and office inspections of shippers and receivers to find evidence of haulage of illegal loads and to utilize the records in prosecuting weight violations (TRB 1990a, 275).

- Adequate and stable funding—One of the possible federal actions listed in *Truck Weight Limits* is direct federal funding of state enforcement, possibly by amending the federal Motor Carrier Safety Assistance Program. If federally funded enforcement were financed through federal truck user fees, this approach might be the most direct way to overcome state objections on enforcement grounds and to stimulate improvements.
- A program to substantially advance the application of information technology as an enforcement tool—Information technology applications that are available today could, with the proper institutional support, dramatically improve the effectiveness of enforcement.

Safety Requirements

Truck Weight Limits recommends that FHWA, the states, and industry jointly develop standards that would improve the safety of the vehicles operating under the new permit program in the areas of power requirements; driver qualifications; accident reporting; brakes; couplings; and axle, tire, and rim specifications. States would be required to impose these standards on permit vehicles. The problem with this recommendation is that little is known about the relationship of the vehicle characteristics cited, or of driver qualifications, to on-the-road accident risk. Therefore such standards, derived from present knowledge, could not be relied upon to ensure safe operation. A substantial commitment to research would be needed to establish the efficacy of such a requirement. As a temporary measure, equipment requirements developed in established state permit programs could be imposed. For example, some states require that a permitted truck's components carry manufacturers' ratings consistent with the loads the truck is allowed to carry. As an accompaniment to enactment of the permit program, federal legislation could provide resources and an institutional structure for the research program on the relationship of vehicle design and performance characteristics to accident risk. An arrangement for this purpose was described in the first section of this chapter.

As described in Chapter 2, knowledge about the relation of truck size and weight to safety is weak. This uncertainty leaves room for a substantial probability that safety effects of changes in regulations would be large, even if best available estimates indicated that they would not be. Nonetheless, it would be reasonable to hope that implementing the regulatory changes described in this section, in conjunction with the permanent data collection and research arrangements outlined in the first section of this chapter, would contribute to safety. Such a program would be a first step toward imposing effective oversight and performance monitoring on a regulatory system that today is haphazard and poorly monitored, as Chapter 4 will describe. In addition, the research and evaluation activities could greatly strengthen the scientific basis of truck and highway safety programs.

Redefinition of Federal and State Responsibilities

The permit program, implemented with effective federal oversight of safety, fees, and enforcement, would constitute a redefinition of the federal role in size and weight regulation. The federal government would have diminished involvement in defining numerical dimensional limits on the Interstates and other federal-aid highways, since the states would

have more discretion with respect to limits on these roads. However, the federal government would take on greater responsibility for ensuring that state rules governing the use of vehicles on federal-aid highways were contributing to meeting national objectives.

Historically, the central provision of federal size and weight regulations has been the numerical limits on weights and dimensions, either maximum limits (for weight and width) or rules forbidding the states to impose limits below certain values (for trailer length and number of trailers). Policy debates have focused on setting these numerical values. However, the federal government has paid little attention to how its numerical limits affect the performance of the highway transportation system. It does not systematically monitor how federal and state regulations, exemptions, permits, and regulatory violations combine to determine the characteristics of trucks in operation; federal oversight of state enforcement of the federal limits has been imperfect; and evaluations of the regulations' impacts in the federal truck size and weight studies have been infrequent and have been weakened by methodological flaws and data gaps.

The committee envisions that the structure of the recommended permit program, together with the capabilities for monitoring, oversight, and research provided by the Institute, would eventually lead to a regulatory regime in which federal numerical limits would have much less importance because states would have greater flexibility to set their own limits. However, federal monitoring of the performance of the regulations would play a much stronger role than it does now in determining how trucks are regulated. In effect, federal oversight would tend toward performance standards: states could propose solutions to problems, and the federal government would have to assess whether the proposals met qualitative objectives. The redefined federal role, by requiring states to justify their proposals on performance grounds, would allow the federal government to continue to provide a buffer between state highway programs and local, short-term economic pressures to depart from best management practices, as federal standards do now.

The opportunities created by the permit program would be expected to stimulate new multistate agreements on size and weight. Federal administration of the program could promote or require consultation among neighboring states. Expansion of multistate agreements would be consistent with evolution away from reliance on federal numerical standards. Some regional multistate agreements on matters related to size and weight matters already exist. Multistate

agreements could improve regulation if they promoted best practices and reduced needless variability in regulations. They could be useful in situations in which several adjacent states have similar road conditions that differ from those of surrounding states (e.g., a group of states having relatively new Interstates with relatively light traffic), or in which a regional industry that extends across state lines requires a special provision in the regulations.

The federally supervised permit program would be expected to promote multistate agreements for two reasons. First, states would have more flexibility to change regulations than they now have. Second, the federal oversight function would provide a formal mechanism for states with similar needs to develop common regulatory responses. As a hypothetical example, if each of a group of neighboring states saw a need to provide in its size and weight regulations for special requirements of a regional industry (and the changes were not possible under present federal rules), each state would be required to apply to the federal government for review and approval of a permitting program. The federal review would examine infrastructure compatibility, provisions for safety, and user fees. It often would be preferable from the point of view of the affected industry, the state governments, and the federal program administrators if the states devised a common solution to the regulatory problem rather than multiple, arbitrarily differing solutions.

The program would also foster innovation. States, shippers, carriers, and equipment manufacturers would have opportunities for presenting new ideas and demonstrating their effectiveness.

At least one North American jurisdiction, the Province of Saskatchewan, today operates a permit program with several of the essential features of this proposal. The Saskatchewan program illustrates the concept and gives some indication of practical administrative requirements. The province authorizes use of vehicles exceeding statutory dimensional limits under the terms of contractual agreements negotiated with individual operators. The program has antecedents dating back to 1977. Under present procedures, an operator seeking permission to use larger trucks first pays for a feasibility study conducted by the provincial highway department. If the study results are favorable, an agreement is drawn up specifying allowable vehicle dimensions, equipment specifications and maintenance procedures, allowable routes, and driver qualifications. The agreement also specifies fees to be paid, which are calculated to cover all incremental road and bridge costs incurred by the province plus half the estimated remaining cost savings to the operator from use of the larger trucks. The fee

is deposited in a special fund that may be drawn upon for highway improvements mutually agreed upon by the province and the private-sector participants, as well as for research, truck safety activities, and program administration. Some agreements call for the private-sector operator to deliver the road improvements necessary for operation of its vehicles.

The program has been used primarily to allow operation on secondary roads of trucks that meet the state's normal primary road dimensional standards, but some larger configurations also are operating. The number of participants is small at present. The province would like to see participation expand, but recognizes that a larger program would require more streamlined administrative procedures (Lang et al. 2001; Saskatchewan n.d.).

PROGRAM FOR LARGE REDUCTIONS IN SHIPPER COSTS

The TRB and DOT size and weight policy studies described in Chapter 2 considered regulatory alternatives involving liberalization of limits beyond the *Truck Weight Limits* recommendations. The methods and assumptions used by those studies imply that liberalization would yield benefits up to a point where trucks substantially larger than those now in use were allowed in those regions where road and traffic conditions were suitable. The proposal outlined in this section indicates the kinds of limits that would be closer to efficient practice, that is, to limits that would allow the public road system to yield the greatest public benefits according to the results of those earlier evaluations. Efficient use of the nation's highways means extracting the greatest economic benefit from the existing highway system and from future highway investments, taking into account the costs imposed by vehicles on other highway users and on the public. Efficient use of the public road system requires the right government policies regarding highway design, operating practices, and user fees. Size and weight regulations can contribute to efficiency if they are combined with appropriate policies in all these areas.

The proposal is not presented as a package to be considered for early implementation. Because of the uncertainties and flaws in the projections of the past studies, the risk of unanticipated harmful consequences arising from radical change in the limits would be great. However, the past studies' results raise the possibility that worthwhile public benefits could be gained from regulations such as those outlined below. The Institute proposed earlier in this chapter would be a suitable organization to conduct the research and evaluation that would be

needed before decisions were made on implementation. The recommendations in Chapter 5 regarding pilot studies and research indicate some of the necessary activities.

The size and weight provisions in the proposal are as follows:

- Replacement of existing federal weight regulations with a new federal bridge formula without a weight maximum, but retaining the present federal single- and tandem-axle weight limits. Candidates for the formula would include the "Uncapped TTI HS-20" formula or the "Combined TTI-HS-20/Formula B" defined in *Truck Weight Limits* (pp. 189–204).
- Introduction of a new federal tridem-axle weight limit of 51,000 lb.
- Federal authorization of operation of six-axle tractor-semitrailers of up to 97,000 lb, eight-axle B-train double-trailer configurations of up to a specified weight, and eight-axle twin 33-ft trailer combinations of up to a specified weight on a specified system of roads (this provision could be either a federal requirement, like the 1983 federal law requiring the states to accept twin trailers and 80,000-lb semis, or a state option).
- A provision allowing limited expansion, as a state option, of use of turnpike doubles and of triple-trailers in rural areas.

This package would be consistent with proposals from some segments of industry, including the Peterson-Cook bill first introduced in Congress in 1999, which would allow 97,000-lb trucks at the option of each state and which are supported by a group of shippers and carriers. The package would be similar in effect to the present Canadian interprovincial limits, which were adopted by all the provinces in 1988 after completion of a government–industry research program (RTAC 1988). The Canadian limits make no provision for turnpike doubles or triples.

Although NAFTA requires the United States, Canada, and Mexico to seek harmonization of standards related to vehicle weights and dimensions, progress has been slow to date, and great disparities exist in limits among the three nations. By allowing U.S. operation of trucks with dimensions closer to those employed in Canada and Mexico, the proposal would largely accomplish harmonization.

The proposal outlined here embodies a continued strong federal role in direct regulation of truck dimensions (in contrast to the proposal in the preceding section), as well as in finance of needed infrastructure

and in monitoring of program performance. Similar outcomes probably would be attainable through a more flexible regulatory regime or with greater devolution of responsibility to the states. The strong federal role might be justified because leadership would be important in making such a large change in regulatory practice and also perhaps because funding needs might be very unevenly distributed among the states.

Potential Benefits

Truck Weight Limits evaluates application of the Canadian interprovincial limits to the United States. The "North American trade" regulatory scenario (in the version that assumes establishment of a 51,000-lb federal tridem axle weight limit) in the 2000 DOT study also envisions use of similar configurations (DOT 2000, Vol. III, III.10–III.17). The key vehicles in both these evaluations are the 97,000 tractor-semitrailer and the 131,000 short, heavy double-trailer combination; neither evaluation addresses expanded use of turnpike doubles or triples. The estimates in these two studies suggest the potential for impressive public benefits.

Truck Weight Limits estimates that nationwide application of the Canadian interprovincial limits would yield annual shipper cost savings (at 1995 prices and traffic volumes) of nearly $12 billion, equal to 6 percent of the prior costs of all truck freight transportation. The negative aspect of the evaluation in *Truck Weight Limits* is the estimate of infrastructure costs. Annual bridge costs are predicted to increase by $2.4 billion and pavement costs by $500 million. If bridges were replaced to accommodate the larger trucks only on principal highways, bridge costs would be $1 billion annually.

The DOT 2000 study estimates similar freight cost savings for its "North American trade" scenario (with a 51,000-lb tridem-axle weight limit). Projected annual private freight cost savings are $14.5 billion (at present-day traffic volumes and prices). Savings to prior truck users are estimated to be 6 percent of prior expenditures on truck freight (DOT 2000, Vol. 3, p. XII.4). As in the TRB study, the major drawback, according to the estimates, is the cost of replacing bridges judged inadequate to carry the heavier trucks. Estimated bridge replacement costs total $65 billion, or $4.5 billion annually if amortized at 7 percent as assumed in the TRB study. Even more problematic is the estimate of $329 billion (or $23 billion/year) in the costs of delay to highway users due to bridge construction projects (DOT 2000, VI-12).

Obstacles and Uncertainties

Among the most apparent problems in implementing such a proposal would be managing bridge costs, financing highway improvements, and maintaining safety.

Bridge Costs

Although the Canadian interprovincial limits showed the greatest net benefits among all options evaluated, the *Truck Weight Limits* committee presumably did not recommend adoption of those limits in part because of the magnitude of the estimated bridge costs, especially the up-front expenditures that would be needed in the first few years after the limits were changed, according to the study's cost estimation methodology, to accommodate the new trucks on a useful network of major roads. In the DOT evaluation, the addition of delay costs due to bridge construction (a cost ignored in the TRB study) boosts the costs of its "North American trade" scenario (but not of all the LCV scenarios evaluated) above the benefits.

Chapter 2 explains why the method used to derive bridge cost estimates in the past studies is inaccurate. It is likely that if the trucks evaluated in these studies came into use, it would be feasible to maintain or reduce the risk of bridge failures at lower cost than these studies' estimates through more intensive inspection and maintenance of bridges, routing restrictions, and more effective enforcement. Some states with older bridge stocks, lower historical design standards, or less adequate maintenance programs would face the need for substantial bridge replacement expenditures. States would also encounter costs for early replacement of bridges because of accelerated fatigue deterioration. Providing the necessary institutional and financial support for improved bridge management and for justified bridge replacements would be a challenge for the state highway agencies.

Finance

Even though there are grounds for regarding past studies' bridge cost estimates as misleading, states would face initial and continuing costs for accommodating trucks of the dimensions provided for under this proposal. Therefore, a financing plan would be essential for implementation. The keys would be raising the necessary funds from users of the new equipment, and implementing a program for prioritizing and staging bridge replacements that took into account the importance of routes to freight traffic. The most reliable test of the economic justification of the new regulations would be carriers' and shippers'

willingness to finance genuinely necessary infrastructure upgrades through user fees or other financial arrangements with states.

Safety

Historical experience with similar vehicles, including experience in other countries, together with the available research results, although imperfect and fragmentary, provides sufficient justification for the conduct of trials to demonstrate the safety of the vehicles this proposal would bring into common use. The trials would have to be large enough to generate data sufficient to calculate differences among vehicle configurations in accident involvement rates and to assess the effectiveness of mitigation measures. Careful experimental design of the trials would be essential. Conduct of large-scale trials would be the only means of putting to rest doubts about safety impacts.

INCREASING THE EFFECTIVENESS OF REGULATION: PERFORMANCE STANDARDS AND PRICING

Opportunities exist to establish a direction for reform of size and weight regulations and related highway management practices that would lead to a more efficient and safer highway system in future decades. Incremental regulatory changes, as they occurred, could be made in such a way that progress would be maintained toward an eventual transformation of size and weight regulation into a highway management mechanism fundamentally different from present practice. The principles underlying the new scheme would be regulation by performance standards and pricing to provide truck operators with financial incentives to choose efficient equipment and operating practices.

Performance Standards

Performance standards would directly limit the behavior of vehicles instead of limiting dimensions or requiring specific equipment or appurtenances. For example, one source of the concern that increasing the gross weight limit might degrade safety is that if gross weight is increased for a vehicle of a specified length, the vehicle's center of gravity is likely to be elevated. Therefore, it will have a greater propensity to roll over in use, and hence will be at greater risk of involvement in accidents. The performance standards approach would involve first verifying that this causal chain is valid and then regulating some direct measure of propensity to roll over, instead of attempting to regulate the rollover hazard indirectly (and probably ineffectively) by means of the gross weight limit. All vehicles that had high rollover risk would be

affected by the application of such a standard (rather than just those vehicles operating at the gross weight limit), and operators would have an incentive to find ways of reducing the rollover propensity of their trucks without sacrificing productivity.

The term *performance-based standards* denotes an approach to vehicle regulation that is intended to yield some of the benefits while avoiding the implementation difficulties of pure performance standards. A performance-based standard is a dimensional limit on vehicles that is derived from and justified by an explicitly defined performance standard. For example, the performance standard might be ability to perform a specified turning movement without encroaching more than a specified distance into the opposing lane. Dimensional limits (e.g., on spacing between articulation points) derived from this standard would be promulgated as performance-based standards.

The performance-based standards approach has the advantages that each dimensional limit has a clear rationale. If more is learned through research about the relation of safety (or other vehicle operating costs) to the performance in question, or if innovation leads to new techniques for satisfying the performance standard, the dimensional standard can readily be revised. In contrast, some dimensional limits in effect today are fossils, justified originally on the basis of highway conditions that have not been relevant for decades. The performance-based standards approach is being explored as a basis for harmonization of international limits under the NAFTA accords (LTSS 1999) and is the basis for national standards under development in Australia (NRTC 2000, 11–14).

The success of performance standards depends on empirically establishing the links between performance measures and accident risks and bridge and pavement impacts, and on designing a practical certification process. The performance–risk linkages are not known and must be established by research.

Pricing

The benefits of any of the standards described above would be increased if they were adopted along with a system of user fees more closely aligned with the public costs generated by each truck trip. Although *Truck Weight Limits* recommends that fees related to costs be adopted to accompany the proposed new size and weight limits, that study's evaluations of regulatory alternatives assumes that no changes in the structure of user fees would occur. As a consequence, even in regulatory options that show large net benefits in the evaluations, changing

the regulations would stimulate some truck operations of questionable economic value. For example, several of the options outlined in the study would encourage use of five-axle twin trailers with weights of more than 90,000 lb, a vehicle that generates relatively very high pavement wear costs (TRB 1990a, 195–196). Charging these vehicles for the costs they incurred would eliminate this problem by stimulating most operators to choose more road-friendly configurations and by providing the revenue needed to repair wear caused by users who did use the high-cost vehicles. Proper user fees would in this way separate the beneficial uses from the uneconomical ones, magnifying the net economic benefits of the new limits. Metering road use would not be fundamentally more difficult technically than metering the use of other public utilities—telephone, electricity, or water.

Matching fees to costs would greatly facilitate the implementation of any new standards that promised net benefits but required investment in upgrading infrastructure. The new user fees would provide the revenue the state highway agencies needed to carry out the upgrades. The state would take on a risk in making the initial, most essential upgrades, but over time the state could defer upgrades until revenues for the new truck fees began to materialize, to reduce the risk of overinvestment.

In the proposal outlined above for a federally supervised state permitting program, states would impose fees on permit operators related to the costs of operating the permit trucks. The estimates of past studies summarized in Chapter 2 indicate that costs arising from the new trucks' impacts on bridges would be the largest category of highway agency costs of the program. Even if the highway agency understands its bridge costs well, charging trucks for bridge impacts of the federally supervised permit program outlined above would present difficulties.

As described in Chapter 2, the cost of a passage of a permit truck would vary greatly from bridge to bridge, and therefore fees truly reflective of costs would have to depend on the routes each permit vehicle used. Some states already have procedures for evaluating bridge capacities on individual routes as part of their procedures for reviewing permit operations. However, levying route-specific fees and enforcing route restrictions for large numbers of permit vehicles would be a formidable administrative undertaking; therefore simpler fee schemes would be acceptable in some circumstances, particularly where bridge impacts were expected to be small for a particular vehicle class in a particular state. It would be technically feasible today to automate

route monitoring with the automatic vehicle identification technology described in Chapter 4.

As also described in Chapter 2, it is likely that there are many bridges that could safely bear the loads of larger trucks but which would require greater expenditure for maintenance and inspection and would have reduced useful lifespans. Methods of estimating these costs exist and have been applied, although present models do not lead to very precise cost estimates. These added costs might be proportional to the volume of permit traffic up to some traffic level but increase at an accelerating rate at higher volumes. Therefore the appropriate fee to charge a permit truck could depend on the volume of permit traffic on the routes the truck used. If accelerating costs were not detected, the state would face the risk of financial loss and possibly of degraded safety. Also in such a circumstance, bridge fees equal to the average cost per truck of use of the bridge would be too low to cover the marginal cost of additional permit traffic and would therefore encourage uneconomic permit operations.

A state adopting the permit system might determine that some of its bridges would be inadequate to carry the larger trucks safely. The state would have to decide whether to bar the use of these bridges by the permit trucks or to replace or strengthen them, and also how to finance any replacements or strengthening. Borrowing on expected revenues from future permit users of the bridge would entail financial risk for the state but might be the best compromise solution to this problem. There would be some cases where most of the benefits of replacing a bridge would be gained by a small number of shippers or carriers (for example, a bridge on a lightly traveled road that is the access route to a mine). It would be reasonable for the state to seek direct financial participation of these beneficiaries before replacing the bridge.

Finally, estimates for the DOT 2000 truck size and weight study presented in Chapter 2 indicate that the cost to highway users of traffic delays caused by bridge construction is significant, sometimes exceeding the highway agency's construction cost for bridge replacements or improvements. One purpose of charging fees to permit trucks would be to ensure that the costs to the public of operating the trucks did not exceed their benefits, and the fees should on this principle reflect the delay costs as well. At least, the states should measure delay costs at construction sites, employ all cost-effective measures for reducing them (for example, by accelerating construction schedules and through traffic management), and, if construction is undertaken to accommodate

permit trucks, cover the cost of these delay-reducing measures with fees imposed on the permit trucks.

The 1989 economic study *Road Work,* described in Chapter 2, presents evidence that even if no change were made in truck size and weight limits or in highway agency design practices, and if a very simplified form of road pricing for trucks were introduced, pricing would yield substantial economic benefits by providing operators with incentives to select equipment and routes that reduced pavement wear (Small et al. 1989). Benefits could be much greater than estimated in that study if operators also were allowed to carry heavier loads when they were willing to pay any added infrastructure costs or to adopt equipment that mitigated those costs.

SUMMARY

The failure under existing institutional arrangements to adequately evaluate the performance of size and weight regulations and the lack of progress on improving understanding of many aspects of the costs and benefits of truck transportation point to the need for creating a new organization authorized to conduct research in support of development of federal size and weight standards, to recommend regulatory changes, and to monitor and evaluate the results of regulation. Strong federal oversight of state permitting, a component of two of the regulatory proposals outlined in this chapter, also would require new organizational arrangements since it would be a function not matching the responsibilities and competence of any existing federal agency.

Valid concerns have been raised that the *Truck Weight Limits* study underestimates the difficulty of putting into effect the enforcement, safety, and fee provisions recommended to accompany new federal weight limits. A modified version of the *Truck Weight Limits* permit program might constitute a package of reforms with greater credibility. This modified version would include simpler weight limit provisions initially and stronger legislatively defined federal oversight responsibilities, including effective monitoring of performance. It also incorporates ongoing research and evaluation with competent independent oversight that would reduce uncertainties about costs and benefits of regulatory alternatives, leading to continuing improvement in the regulations and reduction of the public and private costs of commercial motor vehicle transportation.

The modified version of the *Truck Weight Limits* recommendations outlined in this chapter involves modest changes in the federal limits. However, evaluations in past studies and experience in some regions

of the United States and abroad suggest the possibility that greater increases in truck productivity would ultimately be possible that would yield greater public benefits. The results of the past studies regarding the more radical liberalization proposals are too uncertain to provide a basis for action, but the proposals deserve adequate evaluation.

Incorporating performance standards and rational pricing would magnify the effectiveness of any of these regulatory reforms. The federal oversight of state permit programs could evolve toward regulation based on performance standards, but research is essential to link measurable vehicle performance indices to actual on-the-road safety and economy. Although past studies often have recommended that truck user fees match costs, they usually have overlooked how pricing could enhance the benefits of their size and weight regulatory proposals. Performance standards and pricing could help filter out undesirable trucks that might manage to comply with the dimensional limits but would be inconsistent with the principles of economy and safety that are supposed to justify the limits.

REFERENCES

Abbreviations

DOT	U.S. Department of Transportation
HEI	Health Effects Institute
ICC	Interstate Commerce Commission
LTSS	North American Free Trade Agreement Land Transportation Standards Subcommittee
NRC	National Research Council
NRTC	National Road Transport Commission
RTAC	Roads and Transportation Association of Canada
TRB	Transportation Research Board

Council, F. M., and J. R. Stewart. n.d. *Potential Use of HSIS Data and the Examination of Safety of Longer Combination Vehicles.* University of North Carolina Highway Safety Research Center.

DOT. 1999. *Conditions and Performance of the Nation's Highways and Transit Systems.*

DOT. 2000. *Comprehensive Truck Size and Weight Study.* Washington, D.C., Aug.

Glennon, J. C. 1981. *Consolidated Freightways Corporation v. Larson et al.* Matched Pair Analysis, 81-1230, U.S. District Court, Middle District of Pennsylvania, Aug. 12.

HEI. n.d. *Health Effects Institute: Two Decades of Trusted Science: 2000–2001 Annual Report.* www.healtheffects.org/news.htm.

ICC. 1941. *Federal Regulation of the Sizes and Weight of Motor Vehicles; Letter from the Chairman, Interstate Commerce Commission.* 77th Congress, 1st Session, House Document No. 354, Government Printing Office, Aug. 14.

Lang, A., C. Berthelot, N. Burns, and R. Hanson. 2001. *Saskatchewan Rural Partnership Haul Program.* Proceedings, International Road Federation.

LTSS. 1999. *Highway Safety Performance Criteria in Support of Vehicle Weight and Dimension Regulations:* Candidate Criteria & Recommended Thresholds. Working Draft, Nov.

NRC. 1991. *Rethinking the Ozone Problem in Urban and Regional Air Pollution.* National Academy Press, Washington, D.C.

NRTC. 2000. *2000 Annual Report.* Melbourne, Australia, Sept. 29.

Pearson, J. 1989. From Research to Regulation: The Canadian Agreement on Vehicle Weights and Dimensions. Presented at Second International Symposium on Heavy Vehicle Weights and Dimensions, June.

RTAC. 1988. *The Memorandum of Understanding on Interprovincial Vehicle Weights and Dimensions: Summary Information.* Feb.

Saskatchewan Highways and Transportation. n.d. The Saskatchewan Transportation Partnership Policy: Trucking in the 21st Century. www.comt.ca/english/programs/trucking/Sask.htm.

Small, K. A., C. Winston, and C. Evans. 1989. *Road Work: A New Highway Pricing and Investment Policy,* Vol. 29, No. 2, Jan., pp. 7–23.

Sparks, G. A., A. T. Horosko, and A. Smith. 1988. Safety Experience of Large Trucks: An Analysis of Sample Size Requirements. *Journal of the Transportation Research Forum, Vol. 29, No. 1, pp. 24–27.*

TRB. 1986. *Special Report 211: Twin Trailer Trucks.* National Research Council, Washington, D.C.

TRB. 1990a. *Special Report 225: Truck Weight Limits: Issues and Options.* National Research Council, Washington, D.C.

TRB. 1990b. *Special Report 227: New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal.* National Research Council, Washington, D.C.

TRB. 1997. *Clean Air and Highway Transportation: Mandates, Challenges, and Research Opportunities.* National Research Council, Washington, D.C.

Mitigation

Chapter 4

Opportunities for mitigating the harmful effects of truck traffic and conflicts between trucks and cars on the nation's highways are surveyed in this chapter. The committee considered mitigation relevant to its charge because evaluation of size and weight regulations must encompass consideration of alternative or complementary means of accomplishing the regulatory objective—to control the costs of truck traffic while allowing for efficient freight transportation.

The term *mitigation* is used here to refer to practices or policies designed to accommodate large trucks, either those already on the road or new trucks allowed by future changes in regulations. This definition is extremely broad, since it includes any action taken by public or private parties to improve efficiency or control the costs of truck transportation. Government road authorities employ an array of regulations and practices for this purpose that apply to each component of the highway transportation system: drivers (for example, commercial driver licensing requirements); vehicles (for example, size and weight regulations, motor vehicle safety standards, and pollutant emission standards); and roads (for example, design standards governing pavement and bridge strength and geometric layout, and bridge and pavement management systems that monitor truck-induced wear).

The review in this chapter is not comprehensive. It is limited to three categories of measures that are closely linked to size and weight issues:

- *Changes made in vehicle design to reduce accident risk or highway infrastructure wear*—Size and weight policy proposals, including those of past TRB studies, often have included recommendations that changes in size and weight limits be accompanied by vehicle design requirements intended to offset potentially harmful consequences of the changes. The rules of state overweight permit programs sometimes incorporate such requirements. Research is active on design improvements that could overcome certain of the undesirable properties associated with greater size and weight.

• *Separation of car and truck traffic*—This direct approach to counteracting the conflicts between car and truck traffic recently has received greater consideration and limited application.

• *Enforcement of size and weight regulations*—Effective enforcement is among the most important government activities mitigating the costs of truck traffic. If vehicles exceeding the limits (either illegally or legally with permits) are common, the characteristics of this traffic will be a major determinant of costs, and the nominal statutory limits will have reduced significance. Evaluation of changes in size and weight regulations should include consideration of the practicality of enforcing the new rules.

Certain mitigation actions not discussed in this chapter are described in Chapters 2 and 3:

• More intensive bridge management, inspection, and maintenance as an alternative to bridge posting or replacement to accommodate heavier loads;

• Construction of heavier, more durable pavements, which conceivably could reduce the total cost of truck traffic; and

• Close matching of highway user fees to the costs caused by each user, a potentially highly effective means of controlling costs by giving truck owners economic incentives to manage their operations in ways that reduce costs to the highway agency and other road users.

Other important categories of measures, such as truck driver regulations, were not considered by the committee.

The review in this chapter shows that a number of recent developments, including new technologies and new administrative arrangements, hold promise for reducing the costs and risks of truck operation and improving the effectiveness of regulatory enforcement and monitoring. Efforts in other countries to reduce truck costs and reform regulations, in particular the program of the National Road Transport Commission (NRTC) in Australia described in Chapter 3, may provide useful models for the United States. While enforcement of size and weight regulations in the United States has been imperfect, a proliferation of special permit operations and exemptions, where these privileges are not adequately monitored, may be as significant for the effectiveness of the regulations as are illegal operations. Nonetheless, the diversity of operating environments across U.S. roads implies that some flexibility in the regulations is necessary to derive the greatest benefit

from the road system. One way of providing such flexibility would be to move toward the performance-based standards approach to regulations, reinforced by user fees that reflect the costs that each vehicle generates (see Chapter 3). The vehicle identification technology described later in this chapter would provide some of the capabilities needed to manage such a regulatory system.

Vehicle design improvements, separation of car and truck traffic, and enforcement as means of mitigating the impacts of truck traffic are addressed in the first three sections below. In each case, policy recommendations of others, current research, and recent innovations are described. A summary is presented in the final section.

VEHICLE DESIGN

How truck dimensions are related to handling and stability is described in Chapter 2. As an example, adding payload to a truck will generally raise its center of gravity, reducing the truck's rollover threshold (the lateral acceleration the truck can withstand without rolling over). In past studies, it has been argued that such linkages between truck dimensions and performance imply a connection between dimensions and safety. The TRB *Twin Trailer Trucks* study committee, for example, concluded:

> Studies of the performance and handling characteristics of large trucks show that compared with tractor-semitrailers, twins are prone to experiencing rear trailer rollover in response to abrupt steering maneuvers, provide less sensory feedback to the driver about trailer stability, tend slightly more to encroach on outside lanes or shoulders on curves at highway speeds, and undergo greater rear-end sway during routine operations. . . . Taken together, these special handling characteristics are mechanisms that could lead to a higher accident rate for twins operating at highway speeds. However, it is not possible to tell from vehicle handling observations alone how differences in handling affect the frequency of accidents in on-the-road experience. (TRB 1986, 3–4)

The relationship between accident risk and truck handling and stability has not been established by research, as also noted in Chapter 2. Only a few studies have attempted to measure the relationship directly. Studies comparing the accident involvement rates of double- and single-trailer configurations—the most extensive body of research

on the safety effects of a particular vehicle feature linked to handling and stability—also fail to provide strong support for the existence of such a relationship.

If truck handling and stability are related to accident risk, they are relevant to the safety of all large trucks operating under existing size and weight regulations, not just to the matter of mitigating the consequences of increasing the limits. A recent review of truck rollover research concludes that "the rollover threshold of loaded heavy trucks extends well into the 'emergency' maneuvering capability of the vehicle and sometimes into the 'normal' maneuvering range" (Winkler 2000, 2). This conclusion implies that for some types of trucks, there is a risk of rollover in the course of maneuvers that must be performed routinely.

Other potential costs of increasing truck size and weight can be mitigated or avoided by attention to truck design. For example, engine size determines acceleration capability, one of the factors influencing how trucks affect traffic congestion; likewise, suspension and tire characteristics and the spacings of axles affect pavement and bridge costs. Some of these relationships are described in Chapter 2 as well.

The first subsection below summarizes past proposals for combining changes in size and weight limits with requirements for vehicle-based mitigation measures. The second subsection describes evaluations and demonstrations of such measures.

Mitigation Recommendations of Past Studies

Proposals for reform of truck size and weight standards in the United States, Canada, and Australia have included provisions that would fit the definition of mitigation measures stated above. These studies have followed two different lines of reasoning in arriving at their recommendations. In the TRB *Truck Weight Limits* study (TRB 1990a, 231–232), special safety requirements are presented as a quid pro quo arrangement. That is, issuance of the vehicle permits recommended in the study would be used as an incentive to induce carriers to adopt safer practices: "The states should use the permit process to aggressively promote safety by establishing restrictions and by revoking the permits of carriers with serious or repeated safety violations." The *Truck Weight Limits* study committee recommended that standards be imposed on permit vehicle designs regarding power requirements for acceleration and hill climbing, brakes, connecting equipment between the tractor and semitrailer and between the two trailing units in a double-trailer configuration, axle width, and tires and rims. It also

recommended that there be special requirements regarding driver qualifications and reporting of accidents involving permit vehicles.

The Roads and Transport Association of Canada (RTAC 1986) developed standards defining common vehicles to be employed in interprovincial trucking throughout Canada. It adopted the performance standards philosophy: that liberalization of limits is acceptable provided certain fundamental safety and road compatibility conditions are maintained. The results of a program of vehicle testing and simulation modeling of vehicle dynamics supported RTAC's recommendations.

The Canadian study's recommendation for weight limits for double-trailer configurations illustrates how RTAC applied the performance standards concept. The study evaluated three alternative forms of coupling between the two trailers, called the A-, B-, and C-train configurations. The B-train has a fifth-wheel coupling device permanently affixed at the rear of the frame of the first trailer; in the A-train and C-train configurations, the coupling device is a detachable dolly between the trailers. The study's maximum weight recommendation for the B-train is higher than for the A-train and C-train configurations. Research showed that the B-train configuration is less susceptible to high-speed offtracking (that is, the rear trailer's wheels follow the path of the tractor axles more closely during a high-speed turn) and more resistant to rollover than the other double-trailer configurations, and that its performance according to these measures is equal to that of existing tractor-semitrailers (RTAC 1986, 13). Regarding the safety significance of such differences, RTAC concludes: "Many of the differences in performance are seen as implicating higher or lower safety risks. Although it is not generally possible to quantify the magnitude of the safety risks, there is good reason to believe that the probability of involvement in certain kinds of accidents is significantly higher with some types of vehicles than others . . ." (p. 11).

For a specified double-trailer configuration, high-speed offtracking and rollover susceptibility tend to increase with weight (RTAC 1986, 34; TRB 1990b, 100–103); therefore, allowing greater weight in the B-train, as RTAC recommends, offsets some portion of that configuration's advantage over the other double-trailer designs. The apparent rationale for the recommendation is that B-trains can operate at a greater maximum weight than the other double-trailer configurations without exhibiting a higher rate of stability-related accidents (RTAC 1986, 17). The intended effect of the B-train weight limit recommendation is to promote use of this vehicle design and consequently to mit-

igate the possibly hazardous consequences of expanded use of double trailers.

NRTC is developing a proposal for comprehensive reform of vehicle dimension standards in Australia that also applies the performance standards concept (ARRB 2000). Initial plans called for considering the development of vehicle performance standards organized into five categories:

- Safety,
- Access (i.e., compatibility with the roadway and with other traffic),
- Infrastructure impact,
- Truck freight productivity, and
- Environmental impact.

The safety category includes 19 safety-related performance measures regarding stability, braking performance, mechanical integrity, and speed and acceleration capabilities (Stevenson 1999).

The NRTC uses a diagram that it calls a "performance map" to illustrate its performance standards concept (NRTC 2000a, 54–55). The diagram shows the trade-off between two performance measures for a class of vehicles. For example, in Figure 4-1 (Stevenson 1999), the points at the vertices of the triangle plot the load transfer ratio (a safety performance measure) on the vertical axis with respect to gross weight (a productivity performance measure) on the horizontal axis for three truck-trailers. The load transfer ratio is a measure of the fraction of a vehicle's weight that shifts to the outer wheels during a specified turning maneuver and is related to the likelihood of rollover. The oval represents the range of variability in these two performance measures among the population of truck-trailers; the horizontal band is the range within which the minimum acceptable load transfer ratio value is judged to lie. The lower left vertex is a truck-trailer with conventional steel spring suspension. The upper left point is a vehicle of the same configuration and weight, but equipped with air suspension, which improves the vehicle's load transfer ratio. The lower right point is a truck-trailer with air suspension and a higher gross weight. Its load transfer ratio is no worse than that of the vehicle with conventional suspension and lower gross weight. The diagram is intended to convey the performance standards philosophy that it is acceptable to allow productivity measures (in this example, gross weight) to increase as long as the vehicle remains within the performance measure thresholds.

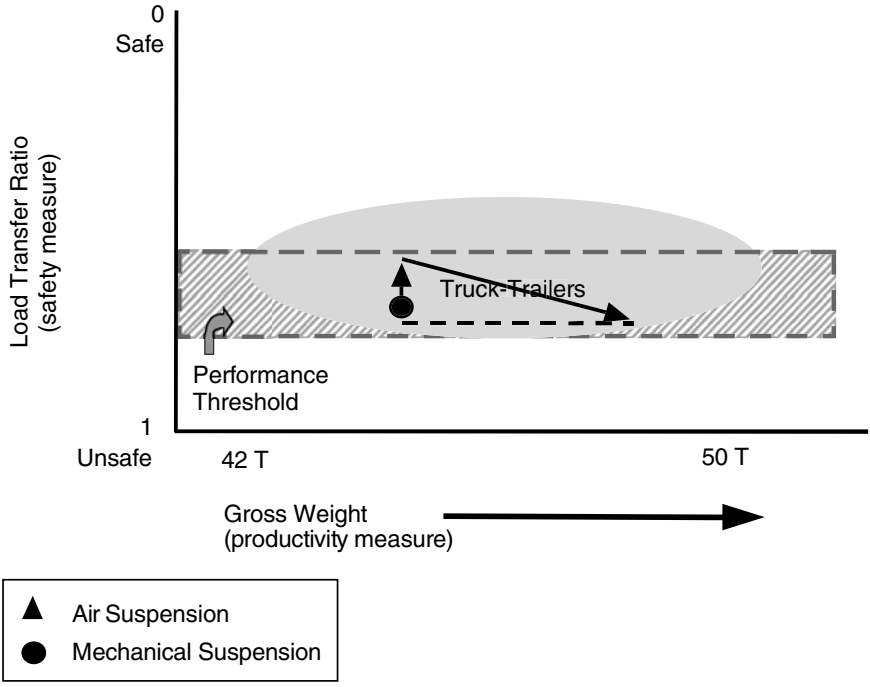

FIGURE 4-1 Application of performance standards. (Adapted from Stevenson 1999; used with permission.)

A similar performance standards framework has been put forth as the basis for international harmonization of size and weight regulations under NAFTA (LTSS 1999). A minimum allowable rollover threshold regulation was recently proposed by the government in New Zealand (Land Transport Safety Authority 2001).

The goal of programs for the development of performance standards is not enactment of regulations setting standards for each performance measure, to be enforced on vehicles in use. There would be no practical way, for example, to measure a truck's load transfer ratio during a roadside inspection. Instead, performance standards would be implemented through approval of packages of standard vehicle specifications on the basis of tests showing that the standard vehicles could meet specified threshold values of the performance measures. The vehicle specifications would address length, width, coupling design, suspension design, tire characteristics, power requirements, and other features. The performance measures would provide the justification for these specifications. The specifications thus would be

performance-based standards as defined in Chapter 3. Presumably, operators or manufacturers could devise and seek approval for new vehicle specifications that met the performance measure thresholds.

All of the above proposals involve linking size and weight liberalization to vehicle redesign in order to maintain acceptable levels of performance with respect to accident risk and other costs of truck traffic. This approach appears promising, but the credibility of the proposals suffers from the lack of quantitative estimates of the costs and benefits of the vehicle design features and other mitigation measures contemplated. Consideration of Figure 4-1 reveals the necessity of cost and benefit estimates. Even if it is assumed that a high load transfer ratio value increases accident risk (a relationship that has not been established empirically), there is no way to tell from the diagram which of the three truck types is superior from the standpoint of overall public welfare. If the safety gains of a low load transfer ratio are large, the truck with lower gross weight and superior load transfer ratio may be best instead of the vehicle with high productivity and safety no worse than that of the baseline vehicle, which is the preferred choice according to the performance threshold approach.

Research and Evaluation Programs

The development of methods for improving the stability of tractor-semitrailers and double-trailer combinations has been an active area of research since at least the 1970s. In the past decade, one focus of this research has been the application of electronics and information technology to improve vehicle performance. Research has been active as well on the relationship of vehicle dynamics, as influenced by suspension and tire characteristics, to infrastructure costs.

One major objective of the safety research in this area has been to reduce the risk of rollover accidents. The susceptibility of a large truck to rollover is affected by its weight and configuration. The relationship among load, center-of-gravity height, and rollover threshold was noted above. In a multitrailer combination, the rearmost trailer may roll over as a consequence of rearward amplification, a "crack-the-whip" phenomenon in which the rear trailer sways laterally in response to a steering maneuver. It is because of these relationships that all of the regulatory recommendations reviewed in the preceding subsection include some provision for reducing susceptibility to rollover.

Although much effort has been devoted to studying the relationship of vehicle design to dynamic behavior, few efforts have been made to

measure the relationship of dynamic properties to accident risk. As described in Chapter 2, research has shown a correlation between rollover threshold (the lateral acceleration a truck can withstand without rolling over) and accident rate (Ervin and Mathew 1988; Mueller et al. 1999), although the relationship appears to be weakly supported by the available data, so that the magnitude of the risk is not well known.

Some examples of vehicle design research are described below. These examples indicate the promise of technological advances in vehicle design for mitigating truck impacts, as well as the obstacles to be overcome.

Industry Concept Vehicles

The FACT experimental vehicle, a specification for a six-axle tractor-semitrailer with tank body proposed by two manufacturers in 1989, is described in Chapter 2. According to its designers, the vehicle would show at least a 25 percent improvement in rollover threshold compared with then-standard tankers [0.45 to 0.50 *g* (acceleration of gravity) compared with 0.36 *g*]. Thus the FACT vehicle would be substantially more resistant to rollover, even though its gross weight would be 88,000 lb, 10 percent above the federal maximum weight, and its cargo capacity would be 13 percent greater than that of existing tankers (Klingenberg et al. 1989). The improved rollover threshold is achieved primarily by lowering the height of the fifth-wheel connection between tractor and trailer and increasing the width of the axles from 96 to 102 inches. The lower fifth-wheel height is made possible by the use of air suspension on the tractor. The proposal represents an adaptation to U.S. conditions of TOPAS, a concept vehicle developed in Europe by Daimler-Benz with German government support (Weatherly 1988).

The FACT proposal did not lead to widespread changes in vehicle design. Attracting both market support and government regulatory sanction for the proposal would have been a complex undertaking. More recently, one of the developers of the FACT vehicle proposed another concept vehicle called Argosy, a six-axle tractor-semitrailer designed for low-density freight, with a 58-ft semitrailer (longer than any in common use today) and 90,000 lb maximum gross weight. The vehicle is reported by the manufacturer to have improved rollover resistance and an electronic suspension control feature that gives it acceptable cornering maneuverability during low-speed turns in spite of its trailer length (Moore 1998). Once again, the proposal has apparently failed to attract strong public or private interest.

DOT Evaluations of Information Technology Applications

DOT, as part of its Intelligent Vehicle Initiative, has under way three field tests of information technology and electronics applications designed to improve truck safety, described in the following subsections. The tests are organized as partnerships between DOT and the private participants and are intended to facilitate the transition of the applications from research and development to commercial deployment. They are thus a critical step in a nearly two-decades-long development program involving vehicle and equipment manufacturers, researchers, and the government.

In their organizational aspects, these tests provide possible models for pilot studies for evaluation of new truck types and alternative size and weight limits as proposed in Chapter 3. An important distinction, however, is that the pilot studies described in Chapter 3 would constitute a formal, established element of a regulatory process. That is, states, carriers, or others seeking federal authorization of the use of new vehicles or of other changes in size and weight regulations could instigate pilot studies under the control of the Commercial Traffic Effects Institute described in Chapter 3. The Institute would be then be required to recommend to the Secretary of Transportation or to the Congress, on the basis of the outcome of a pilot study, whether the associated change in the regulations would be justified.

The total cost of the three tests will be $14 million. The larger tests are designed as controlled experiments and will generate sufficient experience to support direct estimates of safety benefits. Results are to be available by 2003 (DOT n.d.).

Electronic Braking Systems and Collision Avoidance Electronic braking systems (EBS) represent a potential breakthrough technology for mitigating the stability problems of combination vehicles. In conventional brake systems, pedal pressure is transmitted pneumatically to the brakes. In EBS, pedal pressure is translated into an electronic signal that is sent to the brakes on each wheel. Present EBS translate this signal into pneumatic pressure at the wheel to activate the brakes. In future systems, an electric motor at each wheel may be activated to apply the brakes, eliminating any fluid pressure in the operation.

Two forms of potential benefits are being evaluated. First, the technology is intended to improve the ability of the driver to slow and stop the truck quickly and without loss of control. One source of improved stopping ability is that the brakes on the rearmost axles are activated more rapidly than is the case with present pneumatic-only

systems, resulting in greater control and shorter stopping distance. Second, EBS can be employed to apply brakes automatically and selectively to maintain vehicle control during maneuvering. Microprocessors can receive data from each wheel regarding load, instantaneous tire traction, and other factors and compute the optimal braking force for each wheel. Systems in development are designed to use this capability not only to improve stability when the driver is braking, but also to avoid rollover and dampen rearward amplification during turning, lane changing, or evasive maneuvering, regardless of whether the driver is applying the brakes.

U.S. manufacturers now offer EBS as an option on their newest trucks (to improve performance during driver-initiated braking) (Cullen 1999), and EBS for trailers may be offered soon. Present federal vehicle regulations pose some deterrents to the technology's adoption; however, revisions to the standards in question are under consideration. The technology also is in commercial use in Europe.

In the Intelligent Vehicle Initiative trial, the ability of EBS to avoid or mitigate the severity of crashes by reducing stopping distance and improving stability during braking is being evaluated. EBS is combined with disc brakes on the test trucks in an effort to further improve braking performance. Drum brakes are standard on U.S. trucks today. Trucks in the trial also are equipped with a collision warning system that uses radar to detect impending collisions and warn the driver, and a system that automatically slows the truck to avert a collision, provided the truck's cruise control is activated. There are 97 trucks in regular revenue service involved in the trial, including control vehicles with conventional brakes and conventional cruise control. The private-sector participants include a carrier and a truck manufacturer.

Rollover Avoidance Systems A field trial of two related systems intended to reduce the risk of rollover is being conducted. The Rollover Stability Advisor system senses when the lateral acceleration of the vehicle is approaching the vehicle's rollover threshold and issues a warning to the driver (Winkler 2000, 14). The Rollover Stability Controller system extends this capability by automatically intervening to slow engine speed when the threshold is approached. In future trucks with EBS (not included in these tests), such a system could control the application of the brakes differentially at each wheel to avert rollover. The study team includes a truck manufacturer, a truck components manufacturer, a carrier, and the University of Michigan Transportation Research Institute. Six trucks in commercial use are fitted with the devices.

Advisory Systems Three diverse systems for providing timely information intended to reduce accident losses are being evaluated. The Trucker Safety Advisory system warns the driver when the truck approaches a location that historically has experienced frequent heavy-vehicle crashes. The Lane Departure Warning system observes the driver's performance in keeping the truck within the lane and warns the driver if the truck strays near or over the lane edge. The Automatic Collision Notification system detects the occurrence of a crash and sends a message identifying the truck and its location to a dispatcher or other agent of the carrier that operates the vehicle. The system is intended as an aid to emergency response. Thirty-six trucks are to be equipped with the devices for the trial. Participants include a truck manufacturer, the companies that developed the safety devices, and a carrier.

Other Truck Technology Programs

Two other programs in the United States are aimed at making systematic improvements in large-truck performance, including safety. The federal 21st Century Truck Initiative originated as a program of the U.S. Army to reduce acquisition and operating costs and improve the safety of military trucks, but was expanded to involve civilian agencies, including the Department of Energy and DOT (Skalny 2001). Future funding for this program is reported to be uncertain (Whitten 2001). The American Trucking Associations' Future Truck Program, in operation since 1984, is an industry effort to communicate the needs of carriers to truck and equipment manufacturers, set priorities for product development, and facilitate trials and demonstrations. The program's focuses have included cab design, engine durability, and brake performance (Whitten 2001).

Mitigation of Highway Costs Through Vehicle Design

Truck design improvements can reduce infrastructure costs as well as safety hazards. The characteristics of truck suspensions and tires affect pavement and bridge wear. Increasing tire pressure or substituting single tires for dual tires on truck axles will accelerate some forms of pavement wear. Suspension and tire attributes influence the dynamic loads to which pavements and bridges are exposed, that is, the magnitude and frequency of peak forces that occur as a vehicle travels over a road. The distribution of load among the axles in a tandem- or tridem-axle group also depends on the suspension. Maintaining even load distribution tends to reduce pavement wear. Study of these relationships has

been an active area of research in the United States and internationally. The goals have been to understand how the dynamic characteristics of loads affect pavement and bridge wear and to test whether changes in vehicle suspension and tire designs can reduce infrastructure costs (Gillespie et al. 1993; Sharp et al. 1998).

As a result of research findings linking the dynamic characteristics of loads to pavement wear, at least 11 jurisdictions outside the United States allow greater maximum weights for vehicles equipped with air suspension, which is regarded as the most road-friendly design, or with suspension meeting other criteria related to dynamic loading characteristics (York and Maze 1996). These regulations have been viewed as prototypes of the performance standards approach to truck regulation. An alternative form of incentive would be to charge lower highway user fees to trucks equipped with suspensions and tires of designs that demonstrably cause less road wear.

The benefits of road-friendly suspension are not well established. They will depend on maintenance and enforcement, as well as on the performance of new vehicles and on careful specification of performance standards. The TRB Turner Proposal study estimates that improved suspensions could reduce the cost of pavement wear by about 5 percent (TRB 1990b, 176). The maximum gross weight allowances for road-friendly suspensions recently enacted in Australia range from 3 to 9 percent for combination vehicles with five or more axles, suggesting that authorities there may be expecting a reduction in pavement wear somewhat greater than that estimated in the TRB study (NRTC n.d.).

SEPARATION OF CAR AND TRUCK TRAFFIC

Size and weight regulation is an aspect of the problem of provision of adequate freight system capacity. Trends in the growth of freight demand, especially in certain high-density corridors, imply that substantial expansion of truck capacity, as well as improved capacity management, will be required to maintain present service levels. Exclusive truck facilities have been proposed as one design option for future additions to capacity.

Constructing dual facilities would require duplication of some features, adding to costs. The quantities of median strips, shoulders, and interchange ramps would increase. In most designs that have been proposed, it is assumed that the minimum size for the truck-only facility is two lanes in each direction to allow for safe passing. Under this assumption, separating traffic on a four-lane highway would require

construction of four additional lanes, although in a road network, it might be possible to close more than 1 mile of highway to trucks for every mile of truck-only lanes built. In operation, separation of traffic causes the loss of some economies; in particular, a lane strictly dedicated to one vehicle type that happens to be uncongested cannot be used by other vehicle types.

Offsetting these costs would be possible savings from two sources. First, mixing traffic affects road construction and operating costs. An expressway carrying 200,000 cars a day and no large trucks would cost appreciably less to build than one carrying 190,000 cars and 10,000 large trucks because truck characteristics determine requirements for pavement durability, bridge strength, specifications for guardrail and other safety appurtenances, and horizontal and vertical alignments. According to one estimate, nearly a quarter of the cost of building a typical urban expressway would be saved if the road were restricted to automobiles (Small et al. 1989, 111). If trucks could be restricted to two lanes on a new eight-lane expressway, the cost of constructing pavement and bridges for the six car lanes would be lower than if the lanes had to carry trucks, and the pavement and bridge construction costs of the two truck lanes would be no greater than those for building two mixed-traffic lanes. One consideration in evaluating such a proposal would be the practicality of excluding trucks from the car lanes for all purposes, including maintenance and emergencies.

The second and perhaps more significant source of savings would be a reduction in traffic conflicts. Cars and trucks differ greatly in dimensions, weight, acceleration, speed, braking distance, sight distance requirements, and driver skills. Mixing these very different vehicles creates operational problems and hazards that would not exist in a traffic stream of uniform vehicles. A high volume of truck traffic appears to be a source of stress and anxiety for car drivers. On urban expressways, accidents involving large trucks sometimes cause widespread and protracted delay. Therefore, separation of cars and trucks might mitigate the impacts of truck traffic by reducing accident losses, congestion, and nuisance to car travelers.

Segregation of traffic according to vehicle size can take several forms, including provision of lanes reserved exclusively for trucks, exclusive car lanes, or rules barring the largest trucks from all but a restricted network of the highest-quality roads. All of these arrangements are in use and have been subject to evaluation, although experience and information on their impacts are still limited. The restriction of larger trucks to designated networks is evaluated in the past DOT

and TRB truck size and weight studies, and a TRB policy study committee has considered the problem of providing access for large trucks from a designated network to final destinations (TRB 1989). The remainder of this section describes evaluations of exclusive truck facilities.

There has been virtually no experience with exclusive truck facilities in the United States or internationally. Apparently, the only such facility in operation in the United States in 1997 was a segment of Interstate 5 near Los Angeles, where a reconstruction project created two separate roadways through three major interchanges. The truck lanes bypassed the intersections. A few other roads have lanes designed primarily to serve trucks but allow cars as well (Jasek et al. 1997, 12–13). One substantial exclusive facility is in development in the United States; as part of its Portway project, New Jersey is planning to construct a truck-only tolled highway connecting the Newark–Elizabeth air and seaport complex to the region's main highways (NJDOT 2000).

A number of prospective evaluations of exclusive truck lanes at particular sites have been conducted. In Virginia, the state is planning to widen Interstate 81 in stages over a period of 20 years to accommodate expected traffic growth. I-81, running from Tennessee to New York, is a major eastern U.S. truck route (VDOT 1999a; VDOT 1999b). The state studied construction of exclusive truck lanes as part of the project. The Virginia Department of Transportation's analysis, conducted at the direction of the state legislature, questioned whether a separate facility would be justifiable, although the state is still considering the option. The design considered was for two truck-only lanes in each direction (because provision for passing would be essential) and separate truck lanes on some interchanges. The facility would have required more right-of-way acquisition than widening following a conventional design, increasing the potential for environmental damage and community disruption. Most important, if a separate truck facility were constructed and automobiles were left with the four lanes of the present highway, automobile travelers would still experience significantly degraded levels of service by 2020. That is, the truck-only lanes would not solve the underlying problem. Finally, it was concluded that the recommended design would be safer than the separate truck facility option. The analysis apparently did not include estimation of cost savings from not having to accommodate large trucks in the automobile-only lanes or any service improvements perceived by car travelers as a result of the absence of trucks, other than reduced congestion delay.

The states have recently undertaken several detailed planning studies of regional freight and passenger corridors. These studies have considered special provisions for trucks, but no firm plan for an exclusive interstate truck facility has emerged. An example is the I-35 Trade Corridor Study, which considered future development of the interstate corridor from Laredo, Texas, to Duluth, Minnesota. Further evaluation of special truck features for the most heavily traveled segment of the route was recommended, including provisions for trucks larger than current limits and truck-only lanes (TXDOT 1999).

The Southern California Association of Governments has evaluated a proposal to develop exclusive truck lanes with tolls on 37 miles of US 60 (the Pomona Freeway) in Los Angeles. The proposed design is for two lanes in each direction. A market analysis revealed that truck tolls could finance only 20 percent of the cost of constructing the truck lanes. The limit on toll revenue is competition from free roads. Most trucks are predicted to divert from the toll facility at higher toll rates (SCAG 2000). As in the Virginia I-81 study, the traffic projections indicate that if exclusive truck facilities were constructed, the adjacent car lanes would be highly congested in the forecast year of 2020. Therefore, as in Virginia, the most beneficial use of the lanes once built might be to open them to all vehicles instead of restricting them to trucks. These two studies suggest that if building truck-only lanes precludes expanding car capacity on a route, the truck-only lanes will be difficult to justify unless trucks represent a very large share of total traffic, or car travelers place a high value on truck-free traffic as an amenity.

A Washington State study produced results somewhat more favorable to traffic separation. The proposal evaluated was for trucks and buses to use existing high-occupancy vehicle (HOV) lanes in the Puget Sound region, along with high-occupancy cars. This strategy was projected to save travel time for trucks and to decrease the variability of truck trip times. The major beneficiaries in the projections were low-occupancy autos, which would save travel time because of the removal of trucks and buses from the general traffic stream. The option of designating or constructing exclusive truck lanes was estimated to have no greater benefits and much higher costs (Trowbridge et al. 1996).

The limited results of past analyses, together with evidence from the projects that are being pursued most seriously (that is, those in Southern California and New Jersey), tend to support the conclusion that exclusive truck facilities would most likely be justifiable on very-high-volume routes within urban areas rather than on long intercity

routes. Yet certain factors not adequately considered in past evaluations may have a large influence on whether exclusive facilities appear attractive. For example, no study has considered the possibility that car occupants using truck-free lanes would derive benefits beyond conventionally defined user cost savings in the form of reduced discomfort or stress. Few studies have considered the possibility of cost savings from lighter construction of bridges, pavements, and other road features on car-only lanes, and most studies have not considered how finance arrangements, in particular the use of tolls on exclusive facilities and on competing routes, would affect feasibility.

ENFORCEMENT

The federal government is not directly engaged in enforcing size and weight limits. Rather, federal truck size and weight laws include provisions imposing requirements on the states for enforcement of weight regulations. State enforcement of size and weight laws traditionally has concentrated on checking gross vehicle weights and axle weights at fixed stations and with portable scales. Enforcement of dimensional limits was complicated by the 1983 revisions to the federal regulations, which required the states to allow, on a limited network of major roads, semitrailers that were longer and wider than the dimensions then common. In many jurisdictions, the problem of enforcing this federal rule has diminished with time as the larger trailers have become accepted on most roads. Enforcement of special permits, which allow operation of vehicles larger and heavier than the statutory maximums and often specify route restrictions, presents special challenges.

This section addresses only enforcement of size and weight regulations. However, other areas of legal enforcement are relevant to the control of truck costs and to the effectiveness of size and weight regulation. These include enforcement of tax payment, carrier qualifications, vehicle standards regarding safety and pollution control, and driver qualifications.

As noted in the introduction to this chapter, enforcement has a large effect on the cost of truck transportation because the heaviest loads (which may include illegal overloads and trucks operating with legal permits) account for a disproportionate share of infrastructure costs attributable to trucks. It is generally believed that effective enforcement of size and weight laws can reduce truck accident losses, although this benefit has not been not established empirically. Therefore, enforcement is an important consideration in evaluating proposals for reform

of size and weight regulations. If enforcement is lax in general, reforms are less likely to produce the intended results. Furthermore, changing the regulations may affect the frequency and severity of violations. For example, new regulations might be more difficult to enforce because of complexity or might promote use of trucks with characteristics that make them easier to overload.

When evaluation and oversight are insufficient, proliferation of permit operations, grandfather exceptions, and other special exceptions for trucks with dimensions exceeding nominal limits has consequences similar to those of lax enforcement. Although data are incomplete, the incidence of permit operations and exceptions appears to be growing nationwide. It is important for legislators and policy makers planning reforms to recognize that the statutory limits do not dictate truck dimensions. Rather, they interact with many other factors to influence the diversity of the dimensions of trucks commonly operated in the United States today.

The extent and costs of overweight/oversize operation are first described below. Proposals from past evaluations for improvements in enforcement practice are then summarized. Finally, some emerging new approaches, including applications of information technology that have the potential to revolutionize enforcement in the future, are reviewed.

Extent of Oversize/Overweight Operations and Enforcement Effectiveness

Data on the actual weights of trucks in use are fragmentary and inconsistent. A meaningful estimate would require surreptitious weighing and an appropriate sample design for selection of vehicles or weighing sites. Large-scale studies meeting these requirements have not been carried out. The following subsections summarize the available information on the extent of illegal overloads, the scope of permit operations, the cost of overweight/oversize operations, and the effectiveness of enforcement.

Illegal Overloads

A 1988 National Cooperative Highway Research Program study synthesized available truck weight data. The study yielded a "conservative" estimate that 15 percent of large trucks would exceed axle weight or gross vehicle weight limits on a segment of Interstate highway where enforcement was not taking place and that the minimum rate of violations would be 6 percent (the frequency of axle weight violations at fixed scales in the data examined for the study) (Grenzeback et al.

1988, 23). Only 0.6 percent of trucks exceed gross vehicle weight limits at weigh stations (FHWA 1993), but overweight trucks routinely avoid the stations.

Installation of automatic weigh-in-motion (WIM) devices in recent years has provided some new information about the frequency of overloads, although uncertainties are introduced in converting the devices' readings to equivalent static load distributions, and data collection and analysis have not been designed for the purpose of assessing compliance with weight regulations. In WIM data from several hundred sites on all road systems in 18 states collected for the DOT Long-Term Pavement Performance program, roughly 12 percent of tandem axles exceeded 34,000 lb (the federal maximum) (Hajek and Selsneva 2000, Figure 11). This rate for all trucks (loaded and unloaded) implies a rate for loaded trucks of 15 percent of tandem axles exceeding the federal maximum. An appreciable share of the trucks exceeding the federal limit in these data would be operating legally under higher state limits or permits.

Unpublished DOT estimates, compiled from various sources, attribute 10 percent of all miles of travel by trucks with three or more axles to vehicles weighing more than 80,000 lb (the federal Interstate highway weight limit), including both legal and illegal operations. This estimate appears roughly consistent with the rate of overloaded axles from WIM data cited above. It should be recognized that the majority of large trucks on the road at any given time weigh less than the legal maximum. Trucks under the weight limit include those that are partially loaded or empty and those carrying low-density commodities.

State officials perceive the problem of illegal overloads to be concentrated in certain segments of the trucking industry. Vehicles carrying dense bulk commodities (for example, agricultural and mining products and construction materials) usually are constrained by the weight limits and therefore have a strong economic incentive to exceed them. Compared with all truck traffic, these trucks tend to be found more often on secondary roads traveling short distances and to be operated by local businesses. This segment also appears most likely to be favored with special legislative exemptions. Other categories of truck operations, such as van trailers operated by Interstate carriers hauling merchandise over long distances on main roads, are regarded as less likely violators. These trucks often are not constrained by the weight limits because their cargo is of low density, and their routes are subject to the most intense enforcement. A lack of data makes such generalizations difficult to verify, however.

Grandfather and Permit Operations

According to DOT tabulations, four states have grandfathered statutory gross weight limits over 80,000 lb on the Interstates (DOT 2000, Vol. II, II-13–II-14). In addition, an unpublished DOT tabulation shows that 27 states exercise grandfather rights (or possibly other special legislative exemptions) to issue divisible-load permits for vehicles over 80,000 lb on the Interstates. Divisible loads are cargoes that could practicably be divided and carried in more than one vehicle, such as bulk commodities or goods loaded on pallets. (Under federal law, states may issue permits allowing trucks carrying nondivisible loads, such as structural members or heavy equipment, to exceed federal weight limits on the Interstates.) Of these 27 states, 5 issue the permits only on toll road sections of the Interstates, and 5 others issue permits on other limited segments of their Interstates. Of the states allowing trucks over 80,000 lb on the Interstates, 12 are east of the Mississippi. An industry tabulation (ATA 2001) shows four more states than appear on the FHWA list with weight limits over 80,000 lb.

Since enactment of the federal Interstate weight limits, federal law has exempted certain roads and kinds of truck operations. TEA-21 [Section 1212(d)] contains special provisions for trucks hauling concrete panels in Colorado and sugar cane in Louisiana and for exemption of specified Interstate highway segments in Maine and New Hampshire from federal weight limits. Congress enacted other special provisions in the National Highway System Designation Act of 1995 (P.L. 104-49, Sec. 312) exempting specified highways in Iowa and Wisconsin from certain federal limits.

Most of the states holding grandfather rights and other exceptions use them extensively. According to DOT data, 212,000 multiple-trip divisible-load permits were issued in the United States in 1995. Nearly 90 percent of these permits were issued in states with grandfather rights to allow overweight trucks on the Interstates. According to DOT, "multitrip permits essentially allow unlimited operation with no accounting for mileage or routes for a greater length of time, generally one year" (DOT 2000, Vol. II, II-19–II-20).

Multiple-trip divisible-load permitting has been growing rapidly. According to FHWA surveys of the states, the number of such permits issued annually increased 180 percent between 1983 and 1995, from 54,000 to 212,000 (DOT 2000, Vol. II, II-21). No data are collected on miles traveled by trucks operating under these permits.

Sixteen states have statutory gross vehicle weight limits greater than 80,000 lb for highways other than the Interstates. Four additional

states that do not have grandfather rights to operate trucks over 80,000 lb on the Interstates issue substantial numbers of divisible-load permits, presumably for operation of heavier trucks on other roads. Double-trailer combinations with twin 28-ft trailers and gross weight of up to 80,000 lb operate legally in every state by federal law. In addition, 22 states allow operation of longer and heavier multitrailer combinations (DOT 2000, Vol. II, II-13–II-14, II-21, II-19).

Representative nationwide data do not exist on the frequency of legal loads (i.e., trucks operating under higher state limits or permits) over 80,000 lb gross vehicle weight. In the 1997 Vehicle Inventory and Use Survey (U.S. Bureau of the Census 1999, Table 10), vehicles that reported operating with an average loaded weight of more than 80,000 lb accounted for 3.3 percent of all combination VMT. Since these weights were self-reported, this fraction may indicate the extent of legal loads over 80,000 lb. In the 1992 survey, this share was 2.9 percent (U.S. Bureau of the Census 1995, Table 13).

Costs of Overweight/Oversize Operations

Since the extent of overweight and oversize truck operations on U.S. roads is poorly known, only rough estimates can be made of the costs of these operations (compared with the costs of truck operations and highways if all vehicles complied with statutory limits). According to the TRB *Truck Weight Limits* study, if all illegally overweight axle loads were eliminated and the volume of truck freight carried remained unchanged, highway agency pavement costs would decrease by $160 million to $670 million annually (TRB 1990a, 254–255). This range reflects uncertainty over the rate of violations. At today's prices and traffic volumes, the savings would be somewhat greater. The study does not estimate bridge cost savings or the effect on shippers' costs of eliminating illegal overloads. Under the assumption that the quantity of truck freight would be unchanged, and using other assumptions consistent with those in the *Truck Weight Limits* study, rigorous enforcement would cause an increase in annual VMT by large trucks of 0.5 to 2.5 percent, at a cost to shippers of $500 million to $2.5 billion annually. In other words, shippers might prefer to pay the added pavement costs generated by their overloaded trucks instead of reducing their loads.

Truck Weight Limits and the DOT (2000) *Comprehensive Truck Size and Weight Study* estimate the effects of eliminating the states' exemptions from federal limits as provided for by the grandfather clauses in the federal size and weight laws. Both studies conclude that

the cost of lost productivity in truck freight transportation would be greater than the savings in highway agency costs. (TRB 1990a, 158; DOT 2000, Vol. III, V-14, VI-12, IX-9, XII-4). The uncertainties in these studies' projections of freight traffic and infrastructure costs are described in Chapter 2. If the studies underestimate the responsiveness of the demand for truck transportation to changes in costs, then they overestimate the cost in lost productivity of elimination of grandfather rights. However, their estimates do suggest that the larger trucks operating under grandfather exemptions would be willing to pay user fees adequate to cover additional costs to highway agencies in return for the privilege of continuing operation.

Effectiveness of State Enforcement Programs

Few evaluations have been performed of the relationship between the level of effort or strategy of state enforcement and the rate of size and weight violations. A 1998 review for NCHRP led to the following conclusion:

> Wide divergence in enforcement practice across that United States confounds the problem of assessing [compliance] trends. It is impossible to gauge the impact of enforcement activity without a systematic data-sampling approach. . . . At present, the effects of truck weight enforcement programs are generally not known in terms of (1) actual impact on weight-law compliance, (2) effect on safety of truck operations, (3) pavement service life effects, or (4) cost-effectiveness of enforcement activity. (NCHRP 1998, 2)

FHWA is responsible for certifying that states are complying with the federal requirement that they enforce weight limits on the Interstates. In 1991 the DOT Office of Inspector General (OIG) evaluated FHWA's oversight on the basis of investigations of a sample of eight states. OIG concluded that a lack of data was preventing FHWA from assessing the effectiveness of state weight enforcement programs (OIG 1991). A need was identified for the development of automatic weight monitoring systems and statistically valid sampling plans for use in determining actual distributions of weights and changes over time. Other findings highlighted in the OIG report include an imbalance between enforcement effort on the Interstates and on other highways and the problem of repeat violators. None of the eight states audited imposed progressively higher fines for repeated violations.

Proposals for Reform of Size and Weight Enforcement

Both the 1991 OIG report and the 1990 *Truck Weight Limits* study propose enforcement reforms that are similar on essential points. The same reform principles underlie the enforcement program being developed by Australia's NRTC. These three proposals are summarized below. All three call for institutional or procedural reforms with three goals: strengthening incentives for compliance (for example, by imposing higher fines and by holding shippers accountable); targeting enforcement efforts (e.g., at repeat offenders and on roads with high violation rates); and developing information systems to monitor compliance, evaluate effectiveness, and direct resources.

Office of Inspector General Report

The OIG recommendations are for changes in FHWA oversight, but would have a profound effect on state practices if implemented. It is recommended that FHWA undertake the following measures (OIG 1991, 23):

- Develop a program to produce the data needed to quantify the extent of overweight traffic, for use in state enforcement and federal oversight.
- Require that the states formulate annual enforcement plans based on valid monitoring data and that they demonstrate the effect of enforcement on violations in order to receive certification of their enforcement programs.
- Develop standards and technological improvements for automatic WIM systems used to monitor weights and compliance.
- Request Congress to restrict state use of divisible-load permits and multiple-trip nondivisible load permits on the Interstate system.
- Work with the states to evaluate fine structures and demonstrate that they deter violations.
- Promote nontraditional enforcement techniques, including the Relevant Evidence Audit Program introduced in Minnesota. Under this program (Monson 1990, 275; DOT 2000, Vol. II, VII-12), the state legislature gave state enforcement officials authority to inspect the terminals and offices of shippers and receivers for evidence that illegal loads had been dispatched or received.

In 1993, in response to the OIG recommendations, FHWA published a proposal to revise its oversight functions. Action on these reg-

ulatory revisions was postponed, and the proposal was republished in 2000.

Truck Weight Limits *Study*

Truck Weight Limits diagnoses the states' poor enforcement record as primarily an institutional problem. Political pressures frequently work against vigorous enforcement when local industries and agriculture are the likely targets, and police and judges often are ignorant of the need for the regulations and the consequences of violations. Generally the defendant in adjudication is the truck driver, but decision-making power regarding loading rests with the carrier or the shipper (TRB 1990a, 135–143).

As a component of the permit program proposed in the study, a portion of the revenues from fees paid by carriers for permits would be dedicated to increasing the resources devoted to enforcement; the level of enforcement effort would be increased, especially on roads other than Interstates; and greater use would be made of portable scales and of WIM installations for screening trucks to increase enforcement efficiency. The study also recommends that fines be increased. It is estimated that in a typical case, the cost savings to a carrier from operating overweight would be several times the carrier's expected liability for fines (p. 140). In fact, the appropriate fine to protect the public from loss would be equal to the added cost for infrastructure wear caused by the overload divided by the probability that a violator will be caught.

The *Truck Weight Limits* study committee recommended that Congress consider the following measures to strengthen enforcement:

- Direct federal funding of state enforcement, possibly by amending the federal Motor Carrier Safety Assistance Program, which provides funding to states for enforcement of federal truck safety regulations;
- Imposition of federal penalties for violations of federal weight limits on Interstate highways, or alternatively, mandating of minimum state penalties;
- Federal provision for assessing penalties against the parties responsible for placing overweight shipments into commerce, that is, enforcement targeted at shippers as well as carriers and drivers;
- Federal support for state measures to place overweight trucks out of service until they are offloaded;
- Development of educational programs for judges and prosecutors regarding the overweight problem; and

- Creation of a federally managed program for systematic collection of data on violators that would identify the responsible carrier or other operator so repeat offenders could be targeted.

It is acknowledged in the report that evaluation of these proposals would be necessary before they would be ready for implementation. Although one member of the *Truck Weight Limits* study committee dissented from the report on matters concerning analysis of enforcement issues, that member endorsed this list of possible reform measures (p. 278).

National Road Transport Commission

NRTC is developing model legislation for the reform of enforcement of truck regulations in Australia. (The function of NRTC is described in Chapter 3.) Despite the institutional differences between the two countries, the principles of the NRTC proposal might be taken as a model for U.S. reforms as well. The elements of the proposal are as follows (NRTC 1999; NRTC 2000b):

- Unified and consistent procedures for enforcement of size and weight regulations, as well as vehicle and driver safety regulations.
- Procedures for targeting enforcement to operators and locations where violations are most likely.
- Introduction of schemes for self-enforcement, which NRTC calls "alternative compliance." In the case of weight enforcement, operators would seek accreditation by showing that they had their own auditable load-control systems. Accredited operators would be subject to periodic audits of their weight records, but would experience reduced frequency of stops for weighing on the road. Roadside enforcement would be focused on nonaccredited operators.
- Use of privilege-based strategies, such as making eligibility for special permits dependent on a low rate of violations.
- New training programs for enforcement officers and for industry.
- Systematic monitoring of enforcement effectiveness.
- Provisions to hold accountable the parties responsible for the offenses. In the case of weight laws, the shipper might be a responsible party.
- Appropriate severity of fines and other penalties.
- Nationally consistent practices among the jurisdictions responsible for enforcement to facilitate investigation and court proceedings.

This proposal is awaiting action by the national and state legislatures. Some jurisdictions have adopted certain of its elements.

Information Technology Applications for Enforcement

The *Truck Weight Limit*s and OIG recommendations call for expanded use of WIM, which was the only prominent technological enforcement aid available at the time the two reports were written. In the past decade, information and communications technologies with the potential to revolutionize the enforcement of highway regulations have been applied in trucking. Technology applications could greatly facilitate the administration of more complex size and weight regulatory approaches and enforcement schemes—including the permit programs that exist today, as well as the federally supervised permitting proposed in *Truck Weight Limits,* self-enforcement such as the NRTC alternative compliance scheme, and performance standards.

The purpose of the following discussion is not to suggest that technology is the solution to the enforcement problem. The information technology applications described below can be valuable enforcement tools, but will not by themselves overcome institutional obstacles to effective enforcement. The three enforcement reform proposals described in the preceding section emphasize the development of political support and legal mechanisms as the fundamental needs.

The first subsection below describes existing automated clearance systems, which approve vehicles for bypassing of enforcement stops. These systems illustrate the value and present state of development of the relevant technologies. The second subsection lists some possible future extensions of these applications, and the third identifies the need to improve the databases that serve as the foundation of any automated enforcement system.

Clearance Systems

Automatic clearance systems, which screen trucks on the road and allow those that meet certain criteria to bypass enforcement stops, can increase enforcement efficiency in three ways: officers can concentrate their efforts on trucks that are more likely to be in violation; some enforcement functions are automated, reducing their cost; and the cost of enforcement to carriers who obey regulations is reduced. The most extensive such system in the United States is PrePass, which allows certified commercial vehicles to bypass designated weigh stations and port-of-entry facilities (where states, in addition to weighing, check that trucks entering the state comply with registration, fuel tax reporting,

and other state requirements). As a truck that is enrolled in the program approaches a PrePass-equipped station, a transponder in the vehicle communicates with a terminal at the station, and the truck's weight is checked automatically as it traverses a WIM installation. If the computer verifies that the truck's credentials are in order and its weight is legal, the transponder in the truck displays a green light to the driver and sounds a tone. A red light alerts the driver to pull in to the station.

The PrePass program is administered by a nonprofit corporation governed jointly by motor carriers and the states. It is funded by transaction fees paid by the participating carriers. PrePass began operation in 1995 and has 170,000 vehicles enrolled. It is deployed at 181 sites in 21 states and continues to expand (PrePass n.d.). Another multistate program, Norpass, is in operation in other states, and some states have their own independent systems.

PrePass's voluntary public–private structure places certain limits on its application. It is not used to collect tolls, and if a carrier found that information in such a system was causing enforcement officials to single it out for greater scrutiny, it could respond by dropping its enrollment.

Possible Extensions of Applications

PrePass is one example of a technology with broad potential applications. Similar automatic vehicle identification (AVI) technology is already being used for toll collection. Extended applications would require enhancement of technical capabilities, greater investment in hardware by industry and public agencies, and probably new organizational arrangements. Conceivable extensions include the following:

- Permit enforcement—AVI could be employed to verify that the conditions of a truck's permit matched operations with respect to weight, dimensions, or route restrictions without requiring the truck to stop. Use of a transponder could be made a requirement for certain types of permits. PrePass may in the future have some capability to check permits, but the states do not presently enter permit information in the database of credentials against which vehicles are checked. A dense network of sensors would be required for effective enforcement of route restrictions, while PrePass installations are located mainly along major Interstate corridors.
- Repeat offenders—Studies of weight enforcement have revealed the high proportion of violations accounted for by repeat offenders, but the states lack effective means of targeting enforcement at these

offenders. Requiring repeat offenders to employ transponders on their vehicles would allow states to intensify observation of this population and would in itself serve as a deterrent.

- Automated enforcement—With existing technology, it is possible for systems on board a truck to monitor the truck's weight, routes, and hours of operation continuously. This information could be recorded and made available to enforcement officials or transmitted by the truck to roadside stations. Mandatory automatic recording of driver hours of service has been proposed as a regulatory requirement by the National Transportation Safety Board. On-board weighing devices are commercially available, and vehicle tracking with the Global Positioning System (GPS) is widely used in the industry, so trucks could similarly record weights and locations to demonstrate compliance with permit requirements.

Evaluating the cost-effectiveness of such schemes would require planning studies and pilot implementations. Capabilities that could be added to existing systems would be the most immediately practical; for some applications, however, such as tagging of repeat offenders, the voluntary public–private organizational model would not be applicable.

Databases and Information Systems

Enforcement officials recognize that databases and information systems are the key to improving enforcement efficiency. The needs include data on the histories of inspections and violations of size and weight, safety, and other truck regulations; a database showing the connections among vehicles, drivers, and carriers; and records of credentials, including registrations and special permits with their restrictions. Data must be accessible in the field, comprehensive, and current. Some examples illustrate the limitations of present information systems:

- As noted above, the states today cannot automatically check for compliance with special permits at PrePass sites or other WIM installations. Some states are beginning tests of this capability.
- States do not routinely check the safety records of permit applicants. Until recently, no database existed that would have allowed a state to perform such a check. DOT has now created a national database of carrier safety information, although its coverage remains incomplete.

- The majority of states do not track drivers or carriers who are repeat weight violators, nor do they routinely check for past weight violations when issuing overweight permits. When a citation for a weight violation is issued at the roadside, the driver is named, and the citation in general does not record carrier or shipper identity. Therefore, it is nearly impossible in most states to identify repeat offenders (either drivers or carriers) for increased scrutiny or to impose graduated penalties.

Although the remaining limitations are important, progress has been made in recent years toward developing information systems for enforcement. The assembly and updating of the safety and credentials databases needed to perform real-time clearance of vehicles in systems such as PrePass are the product of a national undertaking. Through the Commercial Vehicle Information Systems and Networks (CVISN) program of the DOT's Intelligent Transportation Systems initiative, the federal government, the states, and industry have cooperated in designing and maintaining the database (FMCSA 2000). Progress on information systems can build on these existing organizational relationships.

An integrated data system that recorded size and weight enforcement history as well as safety enforcement history by carrier would provide support for new enforcement strategies. DOT maintains and publishes safety ratings for interstate motor carriers. The ratings are derived from carrier accident experience and the results of safety inspections that check compliance with vehicle, driver, and safety management regulatory requirements (FMCSA n.d.; 49 CFR 385). Inclusion of weight violations in the determination of a carrier's safety rating has been proposed. The rationale is that a correlation is believed to exist between a carrier's size and weight violations and accident risk. DOT can require carriers with poor safety ratings to suspend operations. The ratings also affect the intensity of the enforcement effort directed at carriers and presumably have some competitive significance since they are published. Therefore, carriers would have strong incentives to avoid reducing their ratings through overweight violations and might be less inclined to view overweight fines as a cost of doing business. It would be necessary to evaluate such a combined rating to ensure that the practice did not detract from the utility of the rating as an indicator of accident risk.

SUMMARY

Promising new techniques for reducing the costs of truck travel, including safety costs, are becoming available. If these techniques prove

to be effective, substantial cost reductions may be possible, regardless of whether size and weight limits are liberalized. Conceivably, these techniques also could substantially alter the costs and benefits of liberalizing the regulations, for example, by reducing concerns about the possible hazards associated with the handling and stability properties of larger trucks. The techniques now emerging include improved vehicle designs for better control and stability, information technology applications for control and stability and collision avoidance, streamlining the implementation of technology applications to improve enforcement, and changes in highway design.

The benefits of most of these techniques in practice have not been measured, however. More effective research, monitoring, and evaluation will be essential to progress in reducing the costs and increasing the efficiency of truck transportation. The new mitigation techniques can be expected to yield benefits only if they are properly evaluated during development and implementation.

Progress on mitigating truck costs will depend on the provision of incentives for innovation. Ways to strengthen such incentives include the provision of opportunities for trials of innovative vehicles and devices, streamlining the implementation of regulatory revisions that are demonstrated to be beneficial, use of performance standards, and closer linkage of user fees to costs.

Construction of exclusive truck roads to eliminate car–truck conflicts may be justifiable under special circumstances. The mixing of cars and trucks in the traffic stream generates costs that would be avoided if the two kinds of vehicles did not share the same roads. In addition to the potential traffic and safety benefits of separation, savings would occur if car-only lanes could have more lightly constructed pavement and bridges. Evaluations of proposals for exclusive facilities should include examination of how user fee policies on exclusive truck roads and on competing unrestricted routes would affect feasibility. Better understanding is needed of the value car travelers would place on access to truck-free roads.

The application of information technology to enforcement has made a promising start, but substantial development work is needed before this technology can achieve its full potential for improving enforcement efficiency and facilitating the enforcement of permit operations. The immediate priorities are as follows:

- Development of databases and information systems needed to give enforcement officials access to the full enforcement history and credentials of vehicles, drivers, and carriers;

- Expansion of established automated clearance systems by enhancing the value of the systems to industry and the states; and
- Planning and pilot studies of new technologies and applications, such as permit enforcement systems, repeat offender tracking and monitoring, self-enforcement, and GPS applications.

Because evaluation and monitoring of enforcement are lacking, the magnitude of the compliance problem and the effectiveness of alternative enforcement strategies are unknown. Information technology is a valuable enforcement tool, but will not by itself overcome institutional and political obstacles to effective enforcement of truck regulations.

The reviews in this chapter of mitigation and enforcement proposals have consistently revealed that evaluations essential to progress on reducing the costs of truck traffic have not been performed. In summary, these evaluations include the following:

- Measurement of the relationships between truck handling and stability properties (for example, rollover threshold) and accident risk;
- Examination of whether essential trade-offs exist between safety costs and other truck operating costs per unit of freight services (for example, trade-offs between safety and cargo-carrying capacity);
- Development of certification and monitoring procedures that would provide the opportunity for innovative vehicles to be demonstrated and evaluated;
- Measurement of the relationship of vehicle characteristics other than static axle weights and spacing, in particular suspension and tire properties, to pavement and bridge costs;
- Measurement of the relationship of size and weight law enforcement and size and weight violations to accident risk;
- Monitoring of rates of violation of size and weight regulations by road class, type of trucking operation, and other characteristics that would allow enforcement to be effectively targeted;
- Evaluation of alternative enforcement strategies, including applications of information technology for vehicle identification and automated enforcement, through planning studies and pilot implementations.

Because all these topics are closely related to the effectiveness of size and weight regulations and to the capability of the federal government and state highway agencies to control the costs of truck traffic, conducting the evaluations would be suitable tasks for the independent

Commercial Traffic Effects Institute proposed in Chapter 3. The scope of the list of unfulfilled information requirements is an indication of the value such an Institute could have if it were well supported in federal law and by the interested parties. Some of the topics on this list are related to established functions of existing federal agencies; these evaluations could be conducted through cooperative arrangements overseen by the Secretary of Transportation and involving the Institute and the responsible DOT agency.

REFERENCES

Abbreviations

ARRB	Australian Road Research Board
ATA	American Trucking Associations
DOT	U.S. Department of Transportation
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
LTSS	North American Free Trade Agreement Land Transportation Standards Subcommittee
NCHRP	National Cooperative Highway Research Program
NJDOT	New Jersey Department of Transportation
NRTC	National Road Transport Commission
OIG	Office of the Inspector General, U.S. Department of Transportation
RTAC	Roads and Transportation Association of Canada
SCAG	Southern California Association of Governments
TRB	Transportation Research Board
TXDOT	Texas Department of Transportation
VDOT	Virginia Department of Transportation

ARRB. 2000. *Specification of Performance Standards and Performance of the Heavy Vehicle Fleet: Discussion Paper.* National Road Transport Commission, Melbourne, Australia, Aug.

ATA. 2001. *Transport Topics; Supplement.*

Bureau of the Census. 1995. 1992 *Census of Transportation: Truck Inventory and Use Survey: United States.* May.

Bureau of the Census. 1999. *1997 Economic Census: Vehicle Inventory and Use Survey: United States.* Oct.

Cullen, D. 1999. Smart Brakes: Electronic Braking Systems Will Soon Be Fact, Not Fantasy. *Fleet Owner,* Aug., pp. 58–62.

DOT. n.d. IVI Generation 0 Field Operational Test Program. www.its.dot.gov/ivi/ivifot.html.

DOT. 2000. *Comprehensive Truck Size and Weight Study.* Aug.

Ervin, R. D., and A. Mathew. 1988. *Reducing the Risk of Spillage in the Transportation of Chemical Wastes by Truck.* UMTRI.

FHWA. 1993. *Overweight Vehicles—Permits and Penalties.* Cited in Titus, M. J. Benefits of Electronic Clearance for Enforcement of Motor Carrier Regulations. In *Transportation Research Record 1522,* TRB, National Research Council, Washington, D.C., pp. 64–68.

FMCSA. n.d. Safety and Fitness Electronic Records System. www.safersys.org.

FMCSA. 2000. *Commercial Vehicle Information Systems and Networks.* U.S. DOT, Washington, D.C. www.jhuapl.edu/cvisn.

Gillespie, T. D., S. M. Karamihas, M. W. Sayers, M. A. Nasim, W. Hansen, N. Ehsan, and D. Cebon. 1993. *NCHRP Report 353: Effects of Heavy-Vehicle Characteristics on Pavement Response and Performance.* TRB, National Research Council, Washington, D.C.

Grenzeback, L. R., J. R. Stowers, and A. B. Boghani. 1988. *NCHRP Report 303: Feasibility of a National Heavy-Vehicle Monitoring System.* TRB, National Research Council, Washington, D.C.

Hajek, J. J., and O. I. Selsneva. 2000. *Estimating Cumulative Traffic Loads, Final Report for Phase 1.* FHWA, July.

Jasek, D., M. A. Shafer, D. L. Picha, and T. Urbanik II. 1997. *Guidelines for Truck Lane Restrictions in Texas.* Research Report 1726-S, Texas Transportation Institute.

Klingenberg, B., G. Rossow, and R. Jacobson. 1989. FACT—*The Freightliner/Heil Advanced Concept Truck.* SAE Technical Paper Series 892462.

Land Transport Safety Authority. 2001. Truck Stability Scrutinized. *Road Safety New Zealand,* Aug. www.ltsa.govt.nz/publications/rsnz.

LTSS. 1999. *Highway Safety Performance Criteria in Support of Vehicle Weight and Dimension Regulations: Candidate Criteria & Recommended Thresholds.* Working Draft, Nov.

March, J. W. 2001. DOT's Comprehensive Truck Size and Weight Study. *Public Roads,* Vol. 64, No. 5, March–April, pp. 2–9.

Monson, S. H. 1990. Statement of Stephen H. Monson on Enforcement. In *Special Report 225: Truck Weight Limits: Issues and Options,* TRB, National Research Council, Washington, D.C.

Moore, T. 1998. Fleet Managers Figure It Out: New Holistic Approach to Driver Retention. *Fleet Owner,* April.

Mueller, T. H., J. J. De Pont, and P. H. Baas. 1999. *Heavy Vehicle Stability Versus Crash Rates.* New Zealand Land Transport Safety Authority, July 9.

NCHRP. 1998. *NCHRP Research Results Digest 229: Developing Measures of Effectiveness for Truck Weight Enforcement Activities.* TRB, National Research Council, Washington, D.C.

NJDOT. 2000. *NJ Transportation Fact Book 2000: Goods Movement.* www.state.nj.us/transportation/publicat/Facts/goods.htm, Sept. 6.

NRTC. n.d. *National Heavy Vehicle Dimensions, Mass Limits & Registration Charges.* www.nrtc.gov.au/place/index.asp.

NRTC. 1999. *Alternative Compliance (Heavy Vehicle Accreditation Scheme): Information Bulletin.* Melbourne, Australia, April.

NRTC. 2000a. *2000 Annual Report.* Melbourne, Australia, Sept. 29.
NRTC. 2000b. *Compliance Outcomes (Smart Compliance): Information Bulletin.* Melbourne, Australia, March.
OIG. 1991. *Report on the Audit of the Vehicle Weight Enforcement Program.* U.S. Department of Transportation, Washington, D.C., Nov. 21.
PrePass. n.d. *PrePass, A Nationwide Weigh Station Bypass Service.* www.prepass.com.
RTAC. 1986. *Vehicle Weights and Dimensions Study: Technical Steering Committee Report.* Ottawa, Canroad Transportation Research Corporation, Dec.
RTAC. 1988. *The Memorandum of Understanding on Interprovincial Vehicle Weights and Dimensions: Summary Information.* Feb.
SCAG. 2000. *Truck Lane Feasibility Study, Task Report, Task 5, Conceptual Designs: Operational Assessments and Financial Analysis.* June.
Sharp, K. G., P. F. Sweatman, and R. R. Addis. 1998. OECD Cooperative International Research into Vehicle-Road Interaction—DIVINE Project. *Road & Transport Research,* Vol. 7, No. 1, March, pp. 48–55.
Skalny, P. 2001. 21st Century Truck Initiative: Developing Technologies for 21st Century Trucks. U.S. Army Tank-Automotive and Armaments Command, tacom.army.mil/tardec/nac/21ctruck/cong329.htm, June 29.
Small, K., C. Winston, and C. Evans. 1989. *Road Work: A New Highway Pricing and Investment Policy.* Washington, D.C., Brookings.
Stevenson, J. 1999. Performance Standards and Transport Reform. Presentation at ICM Intermodal Logistics Conference, National Road Transport Commission, Nov. 4.
TRB. 1986. *Twin Trailer Trucks.* National Research Council, Washington, D.C.
TRB. 1989. *Special Report 223: Providing Access for Large Trucks.* National Research Council, Washington, D.C.
TRB. 1990a. *Special Report 225: Truck Weight Limits: Issues and Options.* National Research Council, Washington, D.C.
TRB. 1990b. *Special Report 227: New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal.* National Research Council, Washington, D.C.
Trowbridge, A., D. Nam, F. L. Mannering, and J. Carson. 1996. *The Potential for Freight Productivity Improvements Along Urban Corridors.* Report WA-RD 415.1, Washington State Department of Transportation, Dec.
TXDOT. 1999. *I-35 Trade Corridor Study-Recommended Corridor Investment Strategies.* I-35 Steering Committee, Sept. 30.
VDOT. 1999a. *Route 81 Traffic Data.* Oct. 4.
VDOT. 1999b. *I-81 Update.* Spring.
Weatherly, B. 1988. Steady as She Goes. *Commercial Motor,* June 2–8, pp. 50–51.

Whitten, D. L. 2001. Trucking Research Hampered by Fund Cuts, But U.S. Agencies, Industry Continue Efforts. *Transport Topics,* Aug. 27, pp. 14–15.

Winkler, C. 2000. Rollover of Heavy Commercial Vehicles. *UMTRI Research Review,* Oct.–Dec., pp. 1–17.

York, J., and T. H. Maze. 1996. Applicability of Performance-Based Standards for U.S. Truck Size and Weight Regulations. *1996 Semisesquicentennial Transportation Conference Proceedings,* Center for Transportation Research and Education, Iowa State University.

Conclusions and Recommendations

Chapter 5

The conclusions presented below address the performance of federal motor vehicle size and weight regulations and the adequacy of the information available for guiding regulatory decisions. These conclusions are based on the evaluations in past truck size and weight studies and criticisms of those studies, the comments of interested parties, and the other information sources described in the preceding chapters. The committee's recommendations involve organizational arrangements designed to promote reform of the federal regulations, as well as changes in the regulations intended to improve the efficiency of truck freight transportation and mitigate the costs of truck traffic to the public.

CONCLUSIONS

1. *Opportunities exist for improving the efficiency of the highway system through reform of federal truck size and weight regulations. Such reform may entail allowing larger trucks to operate.*

Present federal standards are for the most part the outcome of a series of historical accidents instead of a clear definition of objectives and analysis of alternatives. A TRB committee concluded in 1990 that "the result [of past regulation] has been trucks that are not ideal from the standpoint of highway wear, freight productivity, or safety" (TRB 1990b, 15). After another decade of policy deadlock on size and weight, the unsatisfactory performance of these regulations is more acutely evident. The regulations are poorly suited to the demands of international commerce; their effectiveness is being eroded by ever-expanding numbers and types of special exemptions, generally granted without evaluation of consequences; and freight traffic is bypassing Interstate highways, the safest and most efficient roads, to use secondary roads where limits are less restrictive, but the costs generated by that traffic are higher. The greatest deficiency of the present environment may be that it discourages private- and public-sector

innovation aimed at improving highway efficiency and reducing the costs of truck traffic because vehicle regulations are inflexible and because highway users are not accountable for all costs they generate.

2. *Appropriate objectives for federal truck size and weight regulations are to facilitate safe and efficient freight transportation and interstate commerce, to establish highway design parameters, and to manage consumption of public infrastructure assets.*

The legislative history indicates that these three objectives are consistent with the intentions of Congress in enacting the federal regulations. To fulfill the desire of Congress when it created the Interstate highway system in 1956 that the system be designed to uniform nationwide geometric and construction standards, it was necessary to define standard vehicles so that specifications for pavement and bridge strength and for roadway geometric layout could be developed. The federal responsibility for interstate commerce eventually led, in 1983, to federal legislation establishing minimum vehicle dimensions that all states were required to allow on principal highways, preempting state regulations judged by Congress to be more restrictive than necessary for economy or safety and thus to constitute obstacles to interstate transportation. These objectives are worthwhile, and truck size and weight regulation by the federal government contributes to their attainment, although the regulations ought to be complemented by other policies aimed at achieving the same goals. Evaluation of federal size and weight regulation should take into account how it affects all costs of highway transportation, including environmental, safety, and congestion costs, as well as infrastructure costs and costs to shippers and carriers.

3. *Changes in truck size and weight regulations made in coordination with complementary changes in the management of the highway system offer the greatest potential to improve the functioning of the system.*

The best way to control all the costs of accommodating existing and future truck traffic is by coordinating practices in each of the following areas of public-sector highway management:

- Engineering practices—pavement and bridge design and maintenance, and highway geometric design;

- Highway user regulations—size and weight regulation, related areas of vehicle and operator regulation (in particular, vehicular safety regulation and regulation of driver qualifications related to safety), and enforcement of regulations; and
- Highway user fees. Imposition of cost-based user fees is a regulatory approach that could usefully supplement or partially replace size and weight regulation to produce more efficient control of the public and private costs of truck transportation.

The federal and state governments should recognize the range of measures at their disposal, including size and weight limits, for meeting highway program goals of cost control and service quality. Whenever Congress contemplates changing policy in any one of these three areas in the federal-aid highway program, it should at the same time consider the need for complementary changes in the other two. It is not possible to change some of these aspects of the highway system quickly to accommodate a change in truck size and weight regulations. For example, systemwide changes in geometric design features occur only over periods of decades. Historically, however, systemwide evolution of standards has been continuous, and it is necessary to plan the direction for these changes.

4. *The methods used in past studies have not produced satisfactory estimates of the effect of changes in truck weights on bridge costs.*

Bridge costs appear to be the critical impact in past DOT and TRB evaluations of proposed changes in regulations. Bridge costs of introducing larger trucks include the costs of necessary strengthening or replacement of bridges, as well as changes in the useful lives of structures, in the cost to construct new bridges in the future, in maintenance costs, and in the risk of bridge failure. Past studies have not evaluated the changes in the risk of bridge failure or in useful life that would be caused by changes in truck weights. Instead, they have estimated the cost of maintaining the existing relationship of legal loads to bridge design capacity through bridge replacement. The estimated cost of these bridge replacements is the biggest component of the projected costs of accommodating larger trucks; however, many of the projected replacements would, if actually carried out, buy very little risk reduction. Past studies have not included quantitative evaluation of alternative methods of attaining the same or greater risk reduction through much less costly bridge management strategies.

5. *It is not possible to predict the outcomes of regulatory changes with high confidence.*

Development of improved models for analyzing the costs of operating trucks of different designs would be worthwhile. However, models and data will never be adequate for providing more than plausible indications of how institutions, markets, and technology will react to regulatory changes, especially in the long run. More difficult to predict than the physical properties of vehicles and highways are the reactions of institutions: how federal executive agencies, courts, state legislatures, highway administrators, and enforcement officials will interpret and react to changes in federal law; and how carriers and equipment designers will take advantage of new vehicle options to reduce transport costs. The outcome of a regulatory change will depend on numerous dynamic factors in the environment that cannot be controlled or forecast. This inevitable uncertainty is not an argument for inaction, since maintaining the status quo would guarantee the loss of important opportunities for reducing the costs of transportation. Responsible regulation is a process: the regulatory authority should do the best prior analysis possible, but once regulations have been changed, the consequences must be systematically observed and adjustments made where necessary. The chances that a regulatory change will yield a positive outcome will be enhanced if highway users have been given incentives to act in consonance with the public interest through enforcement, user fees, and application of performance standards in regulation. Performance standards are regulations that directly specify required vehicle performance instead of attempting to control performance indirectly through dimensional limits.

6. *It is essential to examine the safety consequences of size and weight regulation. Research and monitoring needed to understand the relationship of truck characteristics and truck regulations to safety and other highway costs are not being conducted today.*

Understanding of these relationships is needed to design improved highways, vehicles, and safety management and pollution control programs, and to provide a solid basis for truck size and weight regulation. Progress toward resolving uncertainties surrounding the most critical interactions has been nearly nonexistent during the past decade. In particular, little productive safety research has been undertaken. Although the inevitable uncertainties from the sources de-

scribed in the previous conclusion make highly accurate predictions of the consequences of regulatory changes impossible, the present degree of uncertainty about the relationship of truck dimensions to safety and other highway costs is unnecessary. Research can improve predictions. At least as important as the ability to predict the impacts of changes is to have information systems in place that allow observation of the performance of existing regulations and the consequences of changes once they have been made.

Efforts to meet federal goals for reducing truck accidents can be successful only if they are supported by scientific understanding of the relation of safety to truck design and performance, road features, driver characteristics, and other factors influencing risk, and by knowledge of the effectiveness of alternative measures for reducing risk. Because this understanding generally is absent today, we are probably missing important opportunities to reduce accidents on the one hand, and wasting resources on ineffective programs on the other.

Truck safety studies using valid research methods have in the past produced results useful for evaluating regulatory proposals. The kind of research most needed entails the collection of data on accident frequency and factors believed to be related to accident risk, using study designs devised for statistically testing hypotheses about the effectiveness of particular interventions in improving safety. Research involving the analysis of existing general-purpose databases or the collection of anecdotal information will be less valuable guides to policy. Some past analyses of size and weight issues using general-purpose accident and travel databases have been worthwhile; however, improvements in the design of these data programs and research to develop improved analysis methods are required before these sources will be able to contribute much more to the formulation of size and weight policy.

Promising techniques are available for improving the safety of large trucks. These techniques include improved vehicle designs for better control and stability, information technology applications for control and stability and collision avoidance, technology applications designed to improve enforcement, improvements in operator certification and training, and changes in highway design. Some stability-enhancing measures would counteract the mechanisms that are suspected to be sources of differing accident rates among different truck configurations. Some of these approaches may greatly improve truck safety in the future. Past studies have recommended packages comprising changes in size and weight regulations coupled with vehicle design and operating requirements intended to offset any adverse

consequences of the size and weight changes. However, little is known about the effectiveness of the majority of the safety measures recommended by these studies. In particular, there is no empirical evidence for the effectiveness of requiring combination vehicles to meet performance standards regarding stability and controllability. Because such strategies do hold promise, the recommendations provided below involve arrangements for research and for evaluations in trial implementations to develop effective techniques of applying them.

Policy research has also lagged in the area of the relation of truck characteristics to bridge costs. The states are applying new methods of evaluating bridge improvement needs and management practices, but these methods have not been used in assessing size and weight policy.

In addition, data are almost entirely lacking on in-use emissions of diesel-powered large trucks and the relationship of emissions to weight and other vehicle characteristics. Consequently, no highway emissions model is capable of estimating how changes in traffic affect emissions of these vehicles.

Well-defined procedures must be in place for applying the results of research and evaluation to adjust regulations when opportunities to improve performance are discovered. Because of the administrative pattern of size and weight regulation that has evolved in the United States, no federal agency has the direction, authority, or resources needed to conduct this essential regulatory support activity. Moreover, present arrangements weaken incentives for truck operators, manufacturers, and the states to develop improved technologies and management practices because regulation is inflexible, and little opportunity exists to test the effectiveness of alternative approaches.

7. *Although violations of size and weight regulations may be an expensive problem, monitoring of compliance with the regulations is too unsystematic to allow the costs involved to be estimated.*

There is a need for direct and systematic observation of the frequency and impacts of oversize and overweight vehicles and of the identities of responsible carriers and shippers so that the costs of violations (as well as of legally operated overweight permit vehicles) can be known and the effectiveness of enforcement methods evaluated. The technology needed for low-cost monitoring is now available. The relevant technologies include automatic vehicle identification and weigh-in-motion devices, and the automated vehicle clearance systems that

integrate these devices, as well as systems for on-board monitoring and recording of vehicle characteristics and performance. Extensions of existing applications of these technologies could improve the effectiveness of enforcement, including enforcement of permit schemes that allow differing dimensional limits for different vehicles. Information on the frequency of extreme overloads is essential. The effect of changing federal size and weight limits on the costs of illegal overloads is unknown.

RECOMMENDATIONS

1. Commercial Traffic Effects Institute

Congress should create an independent public organization with a charter to observe and evaluate commercial motor vehicle performance and the effects of size and weight regulation. This organization, referred to here as the Commercial Traffic Effects Institute, would be chartered to develop federal size and weight standards and related highway management practices, recommend regulatory changes, evaluate the results of the implementation of new regulations, and support state implementation of federal regulations. The Institute would be authorized to enter into agreements with private-sector entities to conduct joint programs of data collection, research, and evaluation.

Three considerations demonstrate the need for a new organizational arrangement. First, under present practices, federal size and weight policy has been deadlocked for more than a decade, in spite of general dissatisfaction with the regulations. The current procedure for establishing size and weight regulations is incompatible with the dynamic nature of the size and weight problem. Federal regulations have undergone significant revision just twice in 45 years. Meanwhile, enormous changes have occurred in traffic and highway conditions and technology that call for regulatory responses.

Second, under the present system, regulatory changes that have occurred have been enacted without benefit of objective analysis or full public comment. As a result, some federal regulations have had far-reaching consequences that were not contemplated by their framers, but that might have been foreseeable with adequate prior analysis. DOT has produced a series of comprehensive studies of size and weight issues over the years, but its evaluations have had indirect influence at best. The inherent complexity of regulation in this area, which involves numerous details of motor vehicle and highway technology, argues in favor of a more formal deliberative process to direct necessary reforms.

The present arrangement has not been conducive to serious evaluation of the outcomes of regulation. No new federal size and weight regulation has ever been subjected to a conclusive follow-up evaluation. With the exception of a few nonfederal studies, virtually no new information has been produced in the past decade that would help resolve the question of the safety effects of regulatory changes. Although the deadlock over federal size and weight policy has several sources, one of the important causes has been the inadequacy of information on the impacts of existing regulations and the potential impacts of changes. Information that is perceived as having been produced objectively and openly using scientifically rigorous methods will be required for reform of the regulations.

Third, the committee's recommendation for a new system for federal supervision of state permitting (Recommendation 3 below) calls for federal oversight functions that are not consistent with the responsibilities and competencies of any existing federal agency. This recommendation involves joint public–private activities that may not be compatible with the organization and functions of existing federal agencies.

The inadequacies of federal truck size and weight regulation are attributable in part to procedural shortcomings. Whereas other spheres of federal regulation are overseen by executive branch agencies with established, ongoing responsibility for regulatory development, federal size and weight regulations have been promulgated almost exclusively by direct legislation. DOT has certain rulemaking responsibilities, but their scope is restricted (for example, to definitional questions). In other areas of regulation, the responsible executive agency routinely carries out evaluations because it has the authority to make adjustments as necessary to respond to emerging problems and changing technology; however, the limited range of executive agency responsibility has discouraged evaluation of size and weight regulations.

Functions

Legislation creating the Institute should define the organization's objective as reducing the public and private costs of truck freight and passenger coach transportation by developing proposals for changes in size and weight regulations, as well as changes in related highway system management and operating practices. Related practices include user fee policy, which is a complementary means of attaining the Institute's objective. The relevant costs include those borne by carriers and their customers, highway infrastructure costs, accident costs,

and pollution and other environmental costs. The Institute should be charged with promoting innovation by providing a means to evaluate and implement private-sector or state proposals for new motor vehicle or highway operating practices that would require federal regulatory accommodation.

The legislation that creates the Institute should define the scope of its activities by specifying three distinct functions:

- The conduct of pilot studies of proposed new vehicles and related operating practices, as well as research addressing fundamental questions about the relationship of vehicle characteristics to highway transport costs, including safety and infrastructure costs. The Institute would solicit proposals for pilot studies and research from the private sector and the states, and would conduct studies jointly with them.
- Monitoring and program evaluation on an ongoing basis. Program evaluations would be conducted to measure whether practices intended to control accident risks and to operate highways efficiently (including size and weight regulations) were functioning as intended. Monitoring would consist of systematic observation designed to maintain up-to-date information in three areas: truck and coach traffic volumes and the distributions of vehicle dimensions and configurations; administration of regulations, including enforcement and fees; and costs of commercial motor vehicle traffic to highway agencies and to the public, including accidents and infrastructure costs. The design of data collection systems for monitoring depends on the specific objectives involved, but most needs will require data collection using scientifically designed sampling techniques. Observing the consequences of any changes in federal regulations would be an important monitoring and evaluation task.
- Support for state implementation of federal size and weight regulations. Recommendation 3 below calls for giving states new authority to issue permits for truck operations exceeding present federal limits, provided state permitting practices meet certain criteria. The Institute should be responsible for reviewing state permitting practices and determining whether they merit certification as meeting federal requirements. In addition, the Institute would be responsible for developing model regulations and permitting practices as guidance for the states.

The Institute should be required to use the results of its pilot studies and research to formulate recommendations to Congress and the Secretary of Transportation regarding changes in federal regulations

when there is sound evidence that such changes would further the congressionally defined objective of reducing the public costs of commercial highway transport. The Institute would also recommend adjustments when its monitoring and program evaluations revealed that regulations were not working as intended or when innovations in truck or highway technology created conditions not envisioned when the regulations were enacted. It would not be inconsistent with the functioning of other areas of federal regulation to empower an executive agency to change federal size and weight limits, within boundaries specified by Congress, in response to such events. The Institute should be authorized to make recommendations for harmonizing areas of federal highway policy related to size and weight regulation and to truck costs, including practices and requirements regarding safety regulation, enforcement, infrastructure design and management, and user fees.

Organization

The Institute should be governed by an independent board of directors with members drawn from the federal government, the states, and the private sector. The board should be appointed by Congress or by public officials designated by Congress. Funding for core and continuing activities should be from the federal government; authorizing the needed amounts from highway user fees would be appropriate. Private sponsors of proposed new vehicles or regulations should participate in funding the evaluations of their proposals. The board should report periodically on all its activities to the Secretary of Transportation and to Congress, and recommend changes in federal regulations to the Secretary and Congress as warranted by the results of the Institute's pilot studies, research, and monitoring. A professional staff with diverse expertise would be essential to the Institute's program.

The board should be required, as its first responsibility, to prepare a business plan and a technical plan for the Institute. These plans would be submitted as a proposal to the Secretary and Congress. The business plan should specify arrangements for joint public and private involvement in research and pilots, arrangements for international liaison, and initial funding and staffing requirements. Arrangements for coordinating activities with the states would be necessary for success because regulation is a joint federal and state activity.

The technical plan should describe the framework the Institute will employ to produce defensible information about the effects of changes in size and weight regulations through pilot studies, research,

and monitoring, and propose initial specific technical activities. The technical plan the committee envisions is not for a single large research project that would finally resolve all questions about the relation of truck size and weight to safety and other highway costs; no such study could be conducted. Instead, the plan would set forth a process that could be relied upon at any time as an essential part of the government's management of the highway system. As traffic conditions and highway and vehicle technologies change, new regulatory questions will continue to arise.

The technical plan should define how the Institute's future program of research and evaluation will be determined and revised. This program would include initiatives from four sources: congressional directives; commissions from the Secretary of Transportation for specific research studies or evaluations; proposals from the states, industry, university researchers, safety organizations, or others; and activities identified by the board.

The Institute should be subject to a sunset review by Congress after a specified time, possibly 6 years. The board should be required to report to Congress and the Secretary at the end of the specified time on its past performance and plans for future activities as a basis for Congress's decision on whether to continue the Institute.

Relation to Existing Agencies

The business plan should also specify relations of the Institute with existing federal agencies. Certain functions proposed for the Institute would be new federal activities, but others would fall within the sphere of present activities of the existing administrations within DOT and possibly of other federal agencies. The proposal for the Institute does not entail transfer of regulatory authority from existing agencies. The Institute should be a resource that allows existing federal agencies to execute their regulatory and administrative responsibilities related to truck size and weight more successfully. To this end, coordination of activities under the direction of the Secretary would be required. At the same time the Institute would need to have a high degree of independence in establishing its program and issuing recommendations.

Development of the Institute's business plan and technical plan, in consultation with the related agencies and interested parties, would be a substantial undertaking. It would therefore be premature for the committee to make detailed organizational recommendations. However, consideration of two of the Institute's major activities—the pilot studies proposed under Recommendation 2 and the federally supervised

permitting program detailed under Recommendation 3—indicates some of the areas in which coordination with existing executive agency programs will be necessary.

Pilot studies to evaluate and produce specific recommendations on proposals of states, industry, or others for changes in federal size and weight regulations would constitute a new regulatory support practice. No federal agency now has a permanent charge to conduct such activities. FHWA, NHTSA, and FMCSA have used pilot studies for other purposes and so might be able to contribute expertise. However, practices evaluated in the Institute's pilot studies and the ensuing recommendations could relate to multiple DOT programs. For example, a pilot study of a new truck configuration might include trucks that were equipped with new braking systems or might involve monitoring of bridge impacts or an evaluation of a bridge retrofit. NHTSA is responsible for truck brake regulations, and FHWA has responsibilities related to bridge design and maintenance on federal-aid roads. Because of these connections, it would be necessary for these agencies to participate in the design of the evaluation. The Institute would remain responsible for recommendations at the conclusion of the pilot study. The recommendations, addressed to the Secretary or to the Congress as appropriate, might call for changes in regulations or practices regarding bridges and brakes, as well as changes in size and weight regulations.

The federally supervised permitting program would also be a new activity. However, the Institute's oversight functions under the program could overlap with the present responsibilities of other agencies. For example, one function of the Institute's oversight would be to verify periodically that states participating in the program were enforcing permitting restrictions effectively. At present, FHWA has responsibility for supervising state enforcement of federal size and weight regulations. One possible assignment of responsibilities would be for FHWA to continue with its enforcement oversight responsibilities and for the Institute and FHWA to cooperate in developing the additional procedures needed to verify state enforcement under the permit program. Certainly other arrangements would be possible. The Institute's business plan would identify such potential overlaps of responsibility and propose resolutions.

2. Evaluation of the Consequences of Changes in Truck Size and Weight Regulations Through Pilot Studies

Congress should authorize the Secretary of Transportation to approve pilot studies involving temporary exemptions from federal motor vehi-

cle size and weight regulations for vehicles operating within alternative limits, operated by motor carriers that agree to participate in evaluation of the safety and other impacts of the alternative limits. DOT should approve pilot studies upon the recommendation of the Institute, which should be responsible for planning the studies, carrying out the evaluations, observing that carriers comply with the conditions of the studies, and recommending to DOT and Congress on the basis of the results of each study whether changes in federal regulations are warranted.

It would be necessary for vehicles participating in a pilot to be in compliance with the laws of the states in which they were operated or receive approval from the states through established permitting processes or other state action. Congress should require that as a policy, Institute programs promote cooperative, regional, multistate solutions to size and weight problems.

In this recommendation, a pilot study is defined as a controlled experiment designed to measure the consequences of changes in vehicle dimensions, weights, or operating practices; following a scientific design; involving the collection of data under actual operating conditions; and entailing direct observation of the primary impact of interest (e.g., frequency and severity of accidents) rather than proxies (e.g., vehicle stability or driver performance) alone. The design of pilot studies should not place primary reliance on existing government-maintained accident and travel data programs for the evaluation of outcomes.

The most successful past studies of the relative accident rates of trucks of differing dimensions have used data obtained from truck operators that include records of large numbers of trips made by different kinds of trucks operating between the same origins and destinations. Pilot studies should encompass this general methodological approach whenever it is feasible and appropriate. A carrier wishing to operate a new vehicle configuration (or a vehicle not complying with existing weight or dimensional regulations) would receive temporary approval to do so as part of the pilot study on the condition that it provide data to be used in the evaluation.

The most appropriate organizational arrangements and the best study design in each case would depend on the specific potential regulatory change being evaluated and on the participants. However, the following would be one possible set of procedures:

1. A proposal for a pilot study would be presented to the Institute by states or private parties or would be originated by the Institute.

2. The Institute would make an initial determination, based on all available information, as to whether the proposed pilot study could be conducted without harm to public safety. If the study were judged to be acceptable on this basis, the Institute would develop a plan specifying the objectives of the study (i.e., what impacts were to be measured and for what purposes), the methods to be used for collecting and analyzing data, and criteria for carrier participation.

3. The Institute would make a recommendation to the Secretary on the conduct of the pilot study and on necessary exemptions from federal regulations.

4. If the pilot were approved, the Institute would solicit participation from states and from motor vehicle operators, consistent with its study plan. Carrier participants would be responsible for all or part of the direct costs of conducting the pilot study. Carriers might have to agree to some departures from their normal procedures regarding dispatching, routing, and equipment and driver assignments as required by the evaluation protocol.

5. During the course of the pilot study, the Institute would ensure that participants were complying with the study's data reporting and operating requirements and watch for indications that the pilot was compromising safety. The Institute could terminate the pilot or remove participants at any time if it determined that the pilot was unlikely to meet its objectives.

6. The Institute would report pilot study results, regulatory recommendations, and the justification for its recommendations to the Secretary and Congress.

The Institute could recommend to the Secretary any general limitations it believed were advisable for reasons of safety or practicality with regard to the kinds of vehicles that would be eligible for pilot studies and the numbers of carriers or vehicles that could participate.

The proposed course of action poses certain risks and difficulties. Challenges include the uncertain transferability of the results of pilot studies to the whole population of truck operators, the inherent difficulty of designing and applying truck accident rate measures, the potential competitive inequity of allowing only certain carriers to operate more productive trucks, and concerns about liability. It may be argued that a temporary exemption would be used as a foot in the door and would inevitably become permanent; however, the committee believes that with information available about the actual consequences of the exemptions, making necessary adjustments to the regulations over time would be feasible.

In pilot studies involving a small number of vehicles, it would not be possible within a reasonable time span to measure small differences in relative accident risks. In these cases, it should be acceptable for the Institute to recommend continued operation of vehicles provided the pilot study results were sufficiently accurate to rule out serious deficiencies, and procedures were in place for continued close observation of the performance of the new vehicles.

The legislation authorizing the pilot program should specify the general criteria that temporary exemptions would have to satisfy to be considered for permanent status. These criteria should include demonstration in the pilot study that an exemption is consistent with public safety and the requirement that any increases in highway agency costs be covered by user fees paid by operators of the vehicles involved.

The committee anticipates that the primary objective of most pilot studies would be to estimate the effect of changing regulations on accident risk. However, the pilot study approach could also provide information of value in estimating the infrastructure cost impacts of new regulations.

3. Immediate Changes in Federal Regulations

Federal law should allow any state to participate in a federally supervised permit program for the operation of vehicles heavier than the present federal gross weight limit, provided the state satisfies the requirements outlined below. DOT should be authorized to certify, on the advice of the Institute, that a state meets these requirements and to review certifications periodically. The Institute should be given permanent oversight responsibility for monitoring the performance and consequences of the federally supervised permit program.

By introducing a degree of flexibility together with stronger federal oversight, this change in law would reinforce an essential federal regulatory function that is in the process of eroding. Through grandfather rights or special statutory exemptions, 31 states allow vehicles weighing more than 80,000 lb to operate on the Interstates under divisible-load permits or with no permit required. (Divisible loads are cargoes that practicably could be divided and carried in more than one vehicle.) Of these 31 states, 15 are east of the Mississippi. Most states make extensive use of their grandfather rights, increasingly through issuance of multiple trip permits. According to DOT, "multi-trip permits essentially allow unlimited operation with no accounting for mileage or routes for a greater length of time, generally one year" (DOT 2000, Vol. II, II-19–II-20). In addition, 22 states allow operation

of multitrailer combinations of more than 80,000 lb. Actual legal operation of trucks over 80,000 lb remains limited; vehicles that usually operate with a loaded weight of more than 80,000 lb accounted for 3.3 percent of all combination-VMT reported in a 1997 survey of truck operators (U.S. Bureau of the Census 1999, 70).

The federally supervised permit program provided for under this recommendation would be a step toward rationalization of the present, largely uncontrolled and unmonitored system of exemptions. The recommended federal oversight functions would create a mechanism whereby the performance of the regulations could be evaluated, and adjustments made when warranted by the evaluations and by changes in external conditions. For the first time, Congress would know the consequences of changes in regulations and would be able to modify practices in response. Improved information, together with greater facility to adjust regulations when necessary, ultimately would lead to regulations that more effectively promoted safety and controlled highway transport costs, including costs to shippers, other highway users, and the public.

The permit program, implemented with effective federal oversight of safety, fees, and enforcement, would constitute a redefinition of the federal role in truck size and weight regulation. The federal government would have diminished involvement in defining numerical dimensional limits on the Interstates and other federal-aid highways, but greater responsibility for ensuring that state regulations governing the use of vehicles on federal-aid highways were contributing to the attainment of national objectives. In effect, federal oversight would tend toward performance standards: states could propose solutions to problems, and the federal government would have to assess whether the proposals met qualitative objectives. Federal regulation, by requiring states to justify their proposals on performance grounds, would continue to provide a buffer protecting state highway programs from local, short-term economic pressures to depart from best management practices.

The opportunities created by the permit program would be expected to stimulate new multistate agreements on truck size and weight. Federal administration of the program should promote or require consultation among neighboring states. Expansion of regional agreements would constitute further evolution toward more rational standards and away from arbitrary state-to-state variations.

This recommendation incorporates the core elements of the permit program recommendation in TRB's report to Congress entitled *Truck Weight Limits: Issues and Options* (TRB 1990a): a federally

supervised, state-implemented permit program, adopted at state option, to allow operation of certain trucks larger than those currently allowed under federal law on the Interstates and other roads where some federal restrictions now apply, with permit fees covering all administrative and infrastructure costs of the program. The differences between the present proposal and that of the earlier committee are intended to address objections raised to the *Truck Weight Limits* proposal on grounds of practicality: first, the 1990 study's recommended change in the bridge formula is forgone; second, only a limited set of vehicles of certain specified configurations and dimensional limits would be eligible for permit operation; and third, more concrete actions are proposed to ensure that implementation would be effective in furthering the objectives of the regulations.

Size and Weight Provisions

Recommended size and weight provisions of the permit program are as follows:

- The states should be allowed to issue permits for operation, on any road where the use of such vehicles is now prevented by federal law, of
  - Six-axle tractor-semitrailers with maximum weight of 90,000 lb; and
  - Double-trailer configurations with each trailer up to 33 ft long; seven, eight, or nine axles; and a weight limit governed by the present federal bridge formula.
- After a specified transition period, all trucks operating under grandfather exemptions or state-specific exemptions from federal regulations (when operating on roads where they could not be legally operated without such exemptions) should be made subject to the requirements for monitoring and evaluation that would apply to trucks in the proposed new federally supervised permit program. Reliable information obtained in this way on the impacts of grandfather operation would allow Congress to decide whether the grandfather provisions should be altered or additional permitting flexibility should be extended to all states.

Trucks of the dimensions specified above should be allowed to operate through the mechanism of special permits, rather than through a change in the federal gross vehicle weight limit, in order to avoid possible undesirable impacts of weight increases for configurations other than those specified.

The recommended permit vehicle specifications are not presented as the optimum regulation. The definitions of the vehicles eligible for permitting would be subject to revision over time. Federal review of the performance of the permitting program would be permanent and ongoing, and as the program's effectiveness was strengthened through experience, the results of the review process would provide the needed guidance on revision of the limits. Revisions would most suitably be instigated by recommendation of the Institute, following the procedures outlined in the preceding recommendation.

Implementation Provisions

The recommended actions outlined below are designed to ensure successful implementation of the permit program through federal oversight of enforcement, fees, safety measures, and bridge management.

Enforcement A joint federal–state enforcement effort under the permit program should include the following four elements. The legislation creating the permit program should contain specific requirements regarding each of these elements:

- Formal and effective performance monitoring of enforcement functions.
- Application of new enforcement tools, which may include imposition of federal penalties for violation of federal limits. Congress should consider requiring, as a precondition for state participation in the permit program, that the state enact enforcement provisions to effectively hold accountable the parties responsible for placing overweight loads on the highways and to target repeat violators. Such provisions might include information systems that would make possible identification of responsible parties and repeat offenders, as well as "relevant evidence" statutes.
- Adequate and stable funding for enforcement, including federal contributions derived from user fee revenues.
- A program to substantially advance the application of information technology as an enforcement tool. Information technology applications available today could, with the proper institutional support, dramatically improve the effectiveness of enforcement.

User Fees The federal legislation creating the permit program should specify a quantitative test for the revenue adequacy of the permit fees imposed by states that wish to participate. As far as possible, fees

should be structured to avoid giving truck operators incentives to use truck configurations whose public costs exceed their private benefits. Fees should at least cover estimated administrative and infrastructure costs for the program when it is at its steady-state level, but proposals from states for fees that reflect other external costs or benefits, supported by well-reasoned arguments, would be acceptable. States that decide to participate in the program should be required to provide DOT with the data necessary to verify revenue adequacy.

The committee recognizes that administration of this requirement will be challenging. Costs and demand for permits will be imperfectly known at the outset of the program. Fees should be set initially according to the best available information, and the appropriateness of fees should be subject to ongoing review by the Institute. It is possible that some permit vehicles on some road systems would generate costs lower than those of the trucks they replaced. User fees should reflect the cost savings in such cases.

Safety Requirements As a temporary measure, equipment requirements developed in the most rigorous existing state permit programs should be imposed on permit recipients. These should include the requirement that truck components carry manufacturers' ratings consistent with the loads they are permitted to carry. Requirements should be proposed by the states that apply to participate in the federally supervised permit program, and should be reviewed by the Institute and subject to approval by the Secretary. The requirements proposed could be more stringent than any existing requirements if the state provided a rationale for them. As noted earlier in this chapter, evidence is lacking to demonstrate that any particular vehicle performance requirements, equipment specifications, or operating practices would reduce overall accident risk. Implementation of such requirements should be coordinated with the program of research on the effectiveness of these measures to be undertaken by the Institute.

Bridge Management A state where larger trucks come into use through the permit program will need a plan for cost-effectively alleviating constraints on the vehicles' use due to deficient bridges. The DOT responsibility for certifying that permit fees cover program costs implies the need to evaluate each participating state's management of the bridge costs of the larger trucks. A state that wishes to participate in the permit program should be expected to submit its plan for managing bridge impacts as part of its application. Specification of the contents

of an adequate plan should be a matter for mutual agreement between the federal and state governments. An adequate plan would be likely to include the following elements:

- A priority ranking of truck routes in need of bridge upgrades based on the expected volume of permit truck traffic and the presence of bridges that are inadequate for larger vehicles.
- A program of bridge capital improvements and noncapital measures necessary to accommodate the larger trucks.
- A program of bridge inspection and evaluation. There are opportunities for reducing the costs of bridge replacements or upgrades by undertaking more intensive inspection. Also, the cooperation of states in supplying data will be required for federal monitoring of the effect of larger trucks on bridge costs.
- A cost estimate and finance plan. Required bridge improvements and added costs of bridge management and maintenance should be financed with permit fee proceeds. In addition, states should be encouraged to seek arrangements for direct private-sector financial support of specific projects aimed at correcting deficiencies in order to open routes to larger trucks. Such arrangements would be suitable on routes where only a small number of shippers or carriers would take advantage of the larger permissible truck loads.

4. Longer Combination Vehicles

Federal law should allow operation of longer combination vehicles under the provisions of the federally supervised permit program outlined in Recommendation 3 and participation of these vehicles in pilot studies according to the procedures outlined in Recommendation 2.

Specifically, federal vehicle weight limitations should not prevent the double-trailer configuration described in Recommendation 3 above from operating in any state under the rules of the proposed federally supervised permit program and should not prevent the conduct of pilot studies involving operation of any longer combination vehicle according to the procedures described in Recommendation 2. "Longer combination vehicle" is defined here as in federal law: "any combination of a truck tractor and 2 or more trailers or semitrailers which operates on the Interstate System at a gross vehicle weight greater than 80,000 lb" [23 USC Section 127(d)(4)].

5. Routes and Roads to Which Federal Standards Should Apply

The committee does not see justification at this time for any general revision of the specifications in federal laws and regulations regarding

the networks of roads to which the various federal dimensional regulations are applicable. In particular, there does not appear to be justification for extending federal weight regulation to the non-Interstate portion of the National Highway System (that is, the system of principal arterial roads designated by federal law), where state regulations now govern most aspects of truck operations.

New enforcement mechanisms must be instituted and a plan for evaluating the safety effectiveness of route restrictions developed before any new federal regulations regarding truck operations on restricted networks of roads are enacted. However, the designated network concept, as it has been applied in past federal size and weight laws, is a reasonable regulatory approach in principle. If restrictions are effective and enforceable and if user fees are in line with costs, it makes good economic and safety sense to have more liberal standards that apply to the best roads. The principle of federalism underlying the highway program dictates that states have a role in such designations.

6. Research

The preceding recommendations call for three general kinds of activities involving data analysis and research: systematic monitoring of truck traffic and truck costs to evaluate regulatory effectiveness, basic research on the relationship of truck characteristics to highway costs, and pilot studies to test new vehicles. The following are specific topics requiring research. Research on these topics should be conducted at congressional direction by the Institute. If a study topic is essentially related to an established responsibility of an existing DOT agency, the study should be conducted cooperatively by the Institute and that agency.

Evaluation of Enforcement Effectiveness

The TRB *Truck Weight Limits* committee recommended that Congress direct DOT to conduct research on methods of improving the enforcement of truck weight laws. The recommended study was to "identify specific techniques for improved enforcement and assess these techniques in terms of their impact on the . . . frequency of overweight trucks, . . . costs to enforcement agencies, and possible burdens on the trucking industry" (TRB 1990a, 24–25). This recommendation was not acted upon. Today, little more is known about enforcement effectiveness than at the time of the earlier TRB report. The study should be conducted and should include evaluation of the effectiveness of applications of automatic electronic vehicle identification and screening technology for enforcement.

Air Quality Impacts of Changes in Truck Characteristics

Basic data on in-use emissions of heavy trucks are extremely limited. Research is needed to develop and apply methods of measuring the in-use emissions of trucks as a function of vehicle dimensions and other relevant characteristics. Of equal importance, research is needed on how truck traffic volume, the performance characteristics of trucks, and the effect of trucks on the behavior of other drivers affect emissions of all vehicles on a road. The Institute should coordinate with the Environmental Protection Agency, state environmental agencies, and engine and truck manufacturers to develop a program that will provide the data needed to evaluate the effect of changes in size and weight regulations on emissions.

Relation of Truck Performance to Crash Involvement

A data collection and research program should be conducted to establish the links between crash involvement rates and the physical and dynamic characteristics of trucks, such as weight, braking, offtracking, and rearward amplification in double-trailer combinations. Truck manufacturers and carriers have a stake in the results of such research. Since only a well-funded effort with access to industry data would have a good chance of succeeding, a government–industry consortium should undertake the initiative and underwrite its cost.

Risk-Based Bridge Costs

Correct methods should be developed for estimating the highway agency and user costs of impacts on bridges and structures caused by changes in the size and weight composition of the truck traffic stream. The methods developed should be based directly on risk assessment instead of on cost to comply with previously established engineering standards. The methods should incorporate estimates of changes in fatigue costs and in the useful lives of structures, derived from survey data collected according to a scientifically valid sampling plan. The methods should be capable of comparing the cost-effectiveness of alternative mitigation measures, including bridge replacement, bridge strengthening, and changes in bridge monitoring and weight enforcement practices. Congress should specify that the pilot studies and program evaluations conducted by the Institute include monitoring of bridge impacts.

Freight Transportation Market Research

A program of research should be carried out to develop predictive models of the effects of changes in truck costs on the volume of truck

traffic in the short and long run. To be successful, the research program will need to develop new databases on freight market transactions and shippers' logistical decisions. As stated above, attempting to use truck size and weight regulation to manipulate truck traffic volumes or shippers' industrial location decisions is not practical or desirable. However, better understanding of freight markets would be useful in evaluating proposed changes in regulations or in highway user fees.

Costs of Mixed Automobile and Truck Traffic Arising from Nuisance and Stress

Some costs of truck traffic have been overlooked in past studies. Motorists evidently often regard large trucks as a nuisance or a cause of stress. This reaction, one apparent source of public antipathy toward large trucks, may be independent of the effect of large trucks on accident risk and may constitute a cost of trucks that should be taken into account in policy evaluations, analogous to the environmental cost of highway noise.

The test to determine whether these possible effects are real costs that should be considered in evaluations of highway regulations is whether they lead to observable changes in travelers' behavior. Therefore, research should be conducted to determine whether changes in the volume and characteristics of truck traffic on particular roads affect highway users' route selection, time of travel, and frequency of trips, and to quantify the costs to travelers of any such impacts on behavior. If it is documented that such costs are significant, the research should investigate how their magnitude is affected by changes in truck size and weight regulations. Finally, the research should examine alternative measures for reducing these costs of car–truck conflicts through demand management, expansion of highway capacity, and applications of vehicle and road technology.

New Infrastructure Development and Truck-Only Facilities

Size and weight regulation is one aspect of the long-run problem of provision of adequate freight system capacity. Present trends in the growth of freight demand relative to capacity expansion, especially in certain high-density corridors, are not sustainable. Other modes will be part of the solution to this problem, but substantial expansion of truck capacity and better management of capacity will be needed.

One potentially important form of new infrastructure development is exclusive truck facilities. Such facilities are already being planned in

a few locations, but experience and analysis have been insufficient to indicate the scope of their practical application. A planning and research program should be conducted to determine what conditions would render exclusive truck facilities economically feasible. The research should include examination of alternative forms of private-sector participation in the development of such facilities and of how their feasibility would be affected by changes in user fee policy for the highway system as a whole.

A related and more general problem is provision of infrastructure required for goods movement in the urban environment, especially in older cities. Research is needed to identify the full range of best practices and innovative techniques available for retrofitting and upgrading facilities and to understand the costs and benefits of the growth of urban freight traffic.

REFERENCES

Abbreviations

DOT U.S. Department of Transportation
TRB Transportation Research Board

Bureau of the Census. 1999. *1997 Economic Census: Vehicle Inventory and Use Survey: United States*. Oct.

DOT. 2000. *Comprehensive Truck Size and Weight Study*. Aug.

TRB. 1990a. *Special Report 225: Truck Weight Limits: Issues and Options*. National Research Council, Washington, D.C.

TRB. 1990b. *Special Report 227: New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal*. National Research Council, Washington, D.C.

Study Charge

Appendix A

[Public Law 105-178, 105th Congress, June 9, 1998 (H.R. 2400).]

An Act

To authorize funds for Federal-aid highways, highway safety programs, and transit programs, and for other purposes.
. . . [E]nacted by the Senate and House of Representatives of the United States of America in Congress assembled . . .

SECTION 1. SHORT TITLE . . .
(a) Short Title.—This Act may be cited as the "Transportation Equity Act for the 21st Century." . . .

Sec. 1213. Studies and Reports. . . .
(i) Commercial Motor Vehicle Study.
(1) In General.—The Secretary shall request the Transportation Research Board of the National Academy of Sciences to conduct a study regarding the regulation of weights, lengths, and widths of commercial motor vehicles operating on Federal-aid highways to which Federal regulations apply on the date of enactment of this Act. In conducting the study, the Board shall review law, regulations, studies (including Transportation Research Board *Special Report 225: Truck Weight Limits: Issues and Options)* and practices and develop recommendations regarding any revisions to law and regulations that the Board determines appropriate.
(2) Factors to Consider and Evaluate.—In developing recommendations under paragraph (1), the Board shall consider and evaluate the impact of the recommendations described in paragraph (1) on the economy, the environment, safety, and service to communities.
(3) Consultation.—In carrying out the study, the Board shall consult with the Department of Transportation, States, the motor carrier industry, freight shippers, highway safety groups, air quality and

natural resource management groups, commercial motor vehicle driver representatives, and other appropriate entities.

(4) Report.—Not later than 2 years after the date of enactment of this Act, the Board shall transmit to Congress and the Secretary a report on the results of the study conducted under this subsection.

(5) Recommendations.—Not later than 180 days after the date of receipt of the report under paragraph (4), the Secretary may transmit to Congress a report containing comments or recommendations of the Secretary regarding the Board's report.

(6) Funding.—There is authorized to be appropriated out of the Highway Trust Fund (other than the Mass Transit Account) $250,000 for each of fiscal years 1999 and 2000 to carry out this subsection.

(7) Applicability of Title 23.—Funds made available to carry out this subsection shall be available for obligation in the same manner as if such funds were apportioned under chapter 1 of title 23, United States Code; except that the Federal share of the cost of the study under this subsection shall be 100 percent and such funds shall remain available until expended.

Federal Truck Size and Weight Laws

Appendix B

UNITED STATES CODE

TITLE 23—HIGHWAYS
Chapter 1—Federal-Aid Highways
Subchapter I—General Provisions[1]

Sec. 127. Vehicle Weight Limitations—Interstate System

(a) In General.—No funds shall be apportioned in any fiscal year under section 104(b)(1) of this title to any state which does not permit the use of The Dwight D. Eisenhower System of Interstate and Defense Highways within its boundaries by vehicles with a weight of 20,000 lb carried on any one axle, including enforcement tolerances, or with a tandem axle weight of 34,000 lb, including enforcement tolerances, or a gross weight of at least 80,000 lb for vehicle combinations of five axles or more. However, the maximum gross weight to be allowed by any state for vehicles using The Dwight D. Eisenhower System of Interstate and Defense Highways shall be 20,0000 lb carried on one axle, including enforcement tolerances, and a tandem axle weight of 34,000 lb, including enforcement tolerances and with an overall maximum gross weight, including enforcement tolerances, on a group of two or more consecutive axles produced by application of the following formula:

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

where W equals overall gross weight on any group of two or more consecutive axles to the nearest 500 lb, L equals distance in feet between the extreme of any group of two or more consecutive axles, and N equals number of axles in group under consideration, except that two consecutive sets of tandem axles may carry a gross load of 34,000 lb each providing the overall distance between the first and last axles of such consecutive sets of tandem axles (1) is 36 ft or more, or (2) in the case of a motor vehicle hauling any tank trailer, dump trailer, or ocean transport container

before September 1, 1989, is 30 ft or more: Provided, That such overall gross weight may not exceed 80,000 lb, including all enforcement tolerances, except for vehicles using Interstate 29 between Sioux City, Iowa, and the border between Iowa and South Dakota or vehicles using Interstate 129 between Sioux City, Iowa, and the border between Iowa and Nebraska, and except for those vehicles and loads which cannot be easily dismantled or divided and which have been issued special permits in accordance with applicable state laws, or the corresponding maximum weights permitted for vehicles using the public highways of such state under laws or regulations established by appropriate state authority in effect on July 1, 1956, except in the case of the overall gross weight of any group of two or more consecutive axles on any vehicle (other than a vehicle comprised of a motor vehicle hauling any tank trailer, dump trailer, or ocean transport container on or after September 1, 1989), on the date of enactment of the Federal-Aid Highway Amendments of 1974, whichever is the greater. Any amount which is withheld from apportionment to any state pursuant to the foregoing provisions shall lapse if not released and obligated within the availability period specified in section 118(b)(1) of this title. This section shall not be construed to deny apportionment to any state allowing the operation within such state of any vehicles or combinations thereof, other than vehicles or combinations subject to subsection (d) of this section, which the state determines could be lawfully operated within such state on July 1, 1956, except in the case of the overall gross weight of any group of two or more consecutive axles, on the date of enactment of the Federal-Aid Highway Amendments of 1974. With respect to the state of Hawaii, laws or regulations in effect on February 1, 1960, shall be applicable for the purposes of this section in lieu of those in effect on July 1, 1956. With respect to the state of Colorado, vehicles designed to carry two or more precast concrete panels shall be considered a nondivisible load. With respect to the state of Michigan, laws or regulations in effect on May 1, 1982, shall be applicable for the purposes of this subsection. With respect to the state of Maryland, laws and regulations in effect on June 1, 1993, shall be applicable for the purposes of this subsection. The state of Louisiana may allow, by special permit, the operation of vehicles with a gross vehicle weight (GVW) of up to 100,000 lb for the hauling of sugarcane during the harvest season, not to exceed 100 days annually. With respect to

Interstate 95 in the state of New Hampshire, state laws (including regulations) concerning vehicle weight limitations that were in effect on January 1, 1987, and are applicable to state highways other than the Interstate System, shall be applicable in lieu of the requirements of this subsection. With respect to that portion of the Maine Turnpike designated Interstate 95 and 495, and that portion of Interstate 95 from the southern terminus of the Maine Turnpike to the New Hampshire state line, laws (including regulations) of the state of Maine concerning vehicle weight limitations that were in effect on October 1, 1995, and are applicable to state highways other than the Interstate System, shall be applicable in lieu of the requirements of this subsection.

(b) Reasonable Access.—No state may enact or enforce any law denying reasonable access to motor vehicles subject to this title to and from the Interstate Highway System to terminals and facilities for food, fuel, repairs, and rest.

(c) Ocean Transport Container Defined.—For purposes of this section, the term "ocean transport container" has the meaning given the term "freight container" by the International Standards Organization (ISO) in Series 1, Freight Containers, 3rd Edition [reference number IS0668-1979(E)] as in effect on the date of the enactment of this subsection.

(d) Longer Combination Vehicles.—

(1) Prohibition.—

(A) General continuation rule.—A longer combination vehicle may continue to operate only if the longer combination vehicle configuration type was authorized by state officials pursuant to state statute or regulation conforming to this section and in actual lawful operation on a regular or periodic basis (including seasonal operations) on or before June 1, 1991, or pursuant to section 335 of the Department of Transportation and Related Agencies Appropriations Act, 1991 (104 Stat. 2186).

(B) Applicability of state laws and regulations.—All such operations shall continue to be subject to, at the minimum, all state statutes, regulations, limitations and conditions, including, but not limited to, routing-specific and configuration-specific designations and all other restrictions, in force on June 1, 1991; except that subject to such regulations as may be issued by the Secretary pursuant to paragraph (5) of this subsection, the state may make minor adjustments of a temporary and emergency nature to route designations and vehicle operating restrictions

in effect on June 1, 1991, for specific safety purposes and road construction.

(C) Wyoming.—In addition to those vehicles allowed under subparagraph (A), the state of Wyoming may allow the operation of additional vehicle configurations not in actual operation on June 1, 1991, but authorized by state law not later than November 3, 1992, if such vehicle configurations comply with the single axle, tandem axle, and bridge formula limits set forth in subsection (a) and do not exceed 117,000 pounds GVW.

(D) Ohio.—In addition to vehicles which the state of Ohio may continue to allow to be operated under subparagraph (A), such state may allow longer combination vehicles with three cargo carrying units of 28½ ft each (not including the truck tractor) not in actual operation on June 1, 1991, to be operated within its boundaries on the 1-mi segment of Ohio State Route (SR)7 which begins at and is south of exit 16 of the Ohio Turnpike.

(E) Alaska.—In addition to vehicles which the state of Alaska may continue to allow to be operated under subparagraph (A), such state may allow the operation of longer combination vehicles which were not in actual operation on June 1, 1991, but which were in actual operation prior to July 5, 1991.

(F) Iowa.—In addition to vehicles that the state of Iowa may continue to allow to be operated under subparagraph (A), the state may allow longer combination vehicles that were not in actual operation on June 1, 1991, to be operated on Interstate 29 between Sioux City, Iowa, and the border between Iowa and South Dakota or Interstate 129 between Sioux City, Iowa, and the border between Iowa and Nebraska.

(2) Additional state restrictions.—

(A) In general.—Nothing in this subsection shall prevent any state from further restricting in any manner or prohibiting the operation of longer combination vehicles otherwise authorized under this subsection; except that such restrictions or prohibitions shall be consistent with the requirements of sections 31111-31114 of title 49.

(B) Minor adjustments.—Any state further restricting or prohibiting the operations of longer combination vehicles or making minor adjustments of a temporary and emergency nature as may be allowed pursuant to regulations issued by the Secretary pursuant to paragraph (5) of this subsection, shall, within

30 days, advise the Secretary of such action, and the Secretary shall publish a notice of such action in the Federal Register.

(3) Publication of list.—

(A) Submission to Secretary.—Within 60 days of the date of the enactment of this subsection, each state

(i) Shall submit to the Secretary for publication in the Federal Register a complete list of

(I) All operations of longer combination vehicles being conducted as of June 1, 1991, pursuant to state statutes and regulations;

(II) All limitations and conditions, including, but not limited to, routing-specific and configuration-specific designations and all other restrictions, governing the operation of longer combination vehicles otherwise prohibited under this subsection; and

(III) Such statutes, regulations, limitations, and conditions; and

(ii) Shall submit to the Secretary copies of such statutes, regulations, limitations, and conditions.

(B) Interim list.—Not later than 90 days after the date of the enactment of this subsection, the Secretary shall publish an interim list in the Federal Register, consisting of all information submitted pursuant to subparagraph (A). The Secretary shall review for accuracy all information submitted by the states pursuant to subparagraph (A) and shall solicit and consider public comment on the accuracy of all such information.

(C) Limitation.—No statute or regulation shall be included on the list submitted by a state or published by the Secretary merely on the grounds that it authorized, or could have authorized, by permit or otherwise, the operation of longer combination vehicles, not in actual operation on a regular or periodic basis on or before June 1, 1991.

(D) Final list.—Except as modified pursuant to paragraph (1) (C) of this subsection, the list shall be published as final in the Federal Register not later than 180 days after the date of the enactment of this subsection. In publishing the final list, the Secretary shall make any revisions necessary to correct inaccuracies identified under subparagraph (B). After publication of the final list, longer combination vehicles may not operate on the Interstate System except as provided in the list.

(E) Review and correction procedure.—The Secretary, on his or her own motion or upon a request by any person (including a state), shall review the list issued by the Secretary pursuant to subparagraph (D). If the Secretary determines there is cause to believe that a mistake was made in the accuracy of the final list, the Secretary shall commence a proceeding to determine whether the list published pursuant to subparagraph (D) should be corrected. If the Secretary determines that there is a mistake in the accuracy of the list the Secretary shall correct the publication under subparagraph (D) to reflect the determination of the Secretary.

(4) Longer combination vehicle defined.—For purposes of this section, the term "longer combination vehicle" means any combination of a truck tractor and two or more trailers or semitrailers which operates on the Interstate System at a GVW greater than 80,000 lb.

(5) Regulations regarding minor adjustments.—Not later than 180 days after the date of the enactment of this subsection, the Secretary shall issue regulations establishing criteria for the states to follow in making minor adjustments under paragraph (1)(B).

(e) Operation of Certain Specialized Hauling Vehicles on Interstate 68.—The single axle, tandem axle, and bridge formula limits set forth in subsection (a) shall not apply to the operation on Interstate 68 in Garrett and Allegany counties, Maryland, of any specialized vehicle equipped with a steering axle and a tridem axle and used for hauling coal, logs, and pulpwood if such vehicle is of a type of vehicle as was operating in such counties on United States Route (US) 40 or 48 for such purpose on August 1, 1991.

(f) Operation of Certain Specialized Hauling Vehicles on Certain Wisconsin Highways.—If the 104-mi portion of Wisconsin SR 78 and US51 between Interstate 94 near Portage, Wisconsin, and Wisconsin SR 29 south of Wausau, Wisconsin, is designated as part of the Interstate System under section 103(c)(4)(A), the single axle weight, tandem axle weight, GVW, and bridge formula limits set forth in subsection (a) shall not apply to the 104-mi portion with respect to the operation of any vehicle that could legally operate on the 104-mi portion before the date of the enactment of this subsection.

(g) Operation of Certain Specialized Hauling Vehicles on Certain Pennsylvania Highways.—If the segment of US 220 between Bedford and Bald Eagle, Pennsylvania, is designated as part of the Interstate System, the single axle weight, tandem axle weight,

GVW, and bridge formula limits set forth in subsection (a) shall not apply to that segment with respect to the operation of any vehicle which could have legally operated on that segment before the date of the enactment of this subsection.

Sec. 141. Enforcement of Requirements

(a) Each State shall certify to the Secretary before January 1 of each year that it is enforcing all State laws respecting maximum vehicle size and weights permitted on the Federal-aid primary system, the Federal-aid urban system, and the Federal-aid secondary system, including the Interstate System in accordance with section 127 of this title. Each State shall also certify that it is enforcing and complying with the provisions of section 127(d) of this title and section 31112 of title 49.

(b) (1) Each State shall submit to the Secretary such information as the Secretary shall, by regulation, require as necessary, in his opinion, to verify the certification of such State under subsection (b) of this section.

(2) If a State fails to certify as required by subsection (b) of this section or if the Secretary determines that a State is not adequately enforcing all State laws respecting such maximum vehicle size and weights, notwithstanding such a certification, then Federal-aid highway funds apportioned to such State for such fiscal year shall be reduced by amounts equal to 10 per centum of the amount which would otherwise be apportioned to such State under section 104 of this title.

(3) If within one year from the date that the apportionment for any State is reduced in accordance with paragraph (2) of this subsection the Secretary determines that such State is enforcing all State laws respecting maximum size and weights, the apportionment of such State shall be increased by an amount equal to such reduction. If the Secretary does not make such a determination within such one-year period, the amounts so withheld shall be reapportioned to all other eligible States.

(c) The Secretary shall reduce the State's apportionment of Federal-aid highway funds under section 104(b)(4) in an amount up to 25 per centum of the amount to be apportioned in any fiscal year beginning after September 30, 1984, during which heavy vehicles, subject to the use tax imposed by section 4481 of the Internal Revenue Code of 1986, may be lawfully registered in the State without having presented proof of payment, in such form as may be prescribed

by the Secretary of the Treasury, of the use tax imposed by section 4481 of such Code. Amounts withheld from apportionment to a State under this subsection shall be apportioned to the other States pursuant to the formulas of section 104(b)(4) and shall be available in the same manner and to the same extent as other Interstate funds apportioned at the same time to other States.

TITLE 49—TRANSPORTATION
Subtitle VI—Motor Vehicle and Driver Programs
Part B—Commercial
Chapter 311—Commercial Motor Vehicle Safety
Subchapter II—Length and Width Limitations[2]

Sec. 31111. Length limitations

(a) Definitions.—In this section, the following definitions apply:

(1) Automobile transporter.—The term "automobile transporter" means any vehicle combination designed and used specifically for the transport of assembled highway vehicles, including truck camper units.

(2) Maxi-cube vehicle.—The term "maxi-cube vehicle" means a truck tractor combined with a semitrailer and a separable property-carrying unit designed to be loaded and unloaded through the semitrailer, with the length of the separable property-carrying unit being not more than 34 ft and the length of the vehicle combination being not more than 65 ft.

(3) Truck tractor.—The term "truck tractor" means—

(A) A non-property-carrying power unit that operates in combination with a semitrailer or trailer; or

(B) A power unit that carries as property only motor vehicles when operating in combination with a semitrailer in transporting motor vehicles.

(b) General Limitations.—

(1) Except as provided in this section, a state may not prescribe or enforce a regulation of commerce that—

(A) Imposes a vehicle length limitation of less than 45 ft on a bus, of less than 48 ft on a semitrailer operating in a truck tractor-semitrailer combination, or of less than 28 ft on a semitrailer or trailer operating in a truck tractor-semitrailer-trailer combination, on any segment of the Dwight D. Eisenhower System of Interstate and Defense Highways [except a segment exempted under subsection (f) of this section] and those classes of qualifying Federal-aid Primary System high-

ways designated by the Secretary of Transportation under subsection (e) of this section;

(B) Imposes an overall length limitation on a commercial motor vehicle operating in a truck tractor-semitrailer or truck tractor-semitrailer-trailer combination;

(C) Has the effect of prohibiting the use of a semitrailer or trailer of the same dimensions as those that were in actual and lawful use in that state on December 1, 1982;

(D) Has the effect of prohibiting the use of an existing semitrailer or trailer, of not more than 28.5 ft in length, in a truck tractor-semitrailer-trailer combination if the semitrailer or trailer was operating lawfully on December 1, 1982, within a 65-ft overall length limit in any state; or

(E) Imposes a limitation of less than 46 ft on the distance from the kingpin to the center of the rear axle on trailers used exclusively or primarily in connection with motorsports competition events.

(2) A length limitation prescribed or enforced by a state under paragraph (1)(A) of this subsection applies only to a semitrailer or trailer and not to a truck tractor.

(c) Maxi-Cube and Vehicle Combination Limitations.—A state may not prohibit a maxi-cube vehicle or a commercial motor vehicle combination consisting of a truck tractor and two trailing units on any segment of the Dwight D. Eisenhower System of Interstate and Defense Highways [except a segment exempted under subsection (f) of this section] and those classes of qualifying Federal-aid Primary System highways designated by the Secretary under subsection (e) of this section.

(d) Exclusion of Safety and Energy Conservation Devices.—Length calculated under this section does not include a safety or energy conservation device the Secretary decides is necessary for safe and efficient operation of a commercial motor vehicle. However, such a device may not have by its design or use the ability to carry cargo.

(e) Qualifying Highways.—The Secretary by regulation shall designate as qualifying Federal-aid Primary System highways those highways of the Federal-aid Primary System in existence on June 1, 1991, that can accommodate safely the applicable vehicle lengths provided in this section.

(f) Exemptions.—

(1) If the chief executive officer of a state, after consulting under paragraph (2) of this subsection, decides a segment of the

Dwight D. Eisenhower System of Interstate and Defense Highways is not capable of safely accommodating a commercial motor vehicle having a length described in subsection (b)(1)(A) of this section or the motor vehicle combination described in subsection (c) of this section, the chief executive officer may notify the Secretary of that decision and request the Secretary to exempt that segment from either or both provisions.

(2) Before making a decision under paragraph (1) of this subsection, the chief executive officer shall consult with units of local government in the state in which the segment of the Dwight D. Eisenhower System of Interstate and Defense Highways is located and with the chief executive officer of any adjacent state that may be directly affected by the exemption. As part of the consultations, consideration shall be given to any potential alternative route that serves the area in which the segment is located and can safely accommodate a commercial motor vehicle having a length described in subsection (b)(1)(A) of this section or the motor vehicle combination described in subsection (c) of this section.

(3) A chief executive officer's notification under this subsection must include specific evidence of safety problems supporting the officer's decision and the results of consultations about alternative routes.

(4)

(A) If the Secretary decides, on request of a chief executive officer or on the Secretary's own initiative, a segment of the Dwight D. Eisenhower System of Interstate and Defense Highways is not capable of safely accommodating a commercial motor vehicle having a length described in subsection (b)(1)(A) of this section or the motor vehicle combination described in subsection (c) of this section, the Secretary shall exempt the segment from either or both of those provisions. Before making a decision under this paragraph, the Secretary shall consider any possible alternative route that serves the area in which the segment is located.

(B) The Secretary shall make a decision about a specific segment not later than 120 days after the date of receipt of notification from a chief executive officer under paragraph (1) of this subsection or the date on which the Secretary initiates action under subparagraph (A) of this paragraph, whichever is applicable. If the Secretary finds the decision will not be made in time, the Secretary immediately shall notify Congress, giv-

ing the reasons for the delay, information about the resources assigned, and the projected date for the decision.

(C) Before making a decision, the Secretary shall give an interested person notice and an opportunity for comment. If the Secretary exempts a segment under this subsection before the final regulations under subsection (e) of this section are prescribed, the Secretary shall include the exemption as part of the final regulations. If the Secretary exempts the segment after the final regulations are prescribed, the Secretary shall publish the exemption as an amendment to the final regulations.

(g) Accommodating Specialized Equipment.—In prescribing regulations to carry out this section, the Secretary may make decisions necessary to accommodate specialized equipment, including automobile and vessel transporters and maxi-cube vehicles.

Sec. 31112. Property-carrying unit limitation

(a) Definitions.—In this section—

(1) "Property-carrying unit" means any part of a commercial motor vehicle combination (except the truck tractor) used to carry property, including a trailer, a semitrailer, or the property-carrying section of a single unit truck.

(2) The length of the property-carrying units of a commercial motor vehicle combination is the length measured from the front of the first property-carrying unit to the rear of the last property-carrying unit.

(b) General Limitations.—A state may not allow by any means the operation, on any segment of the Dwight D. Eisenhower System of Interstate and Defense Highways and those classes of qualifying Federal-aid Primary System highways designated by the Secretary of Transportation under section 31111(e) of this title, of any commercial motor vehicle combination (except a vehicle or load that cannot be dismantled easily or divided easily and that has been issued a special permit under applicable state law) with more than one property-carrying unit (not including the truck tractor) whose property-carrying units are more than—

(1) The maximum combination trailer, semitrailer, or other type of length limitation allowed by law or regulation of that state before June 2, 1991; or

(2) The length of the property-carrying units of those commercial motor vehicle combinations, by specific configuration, in actual, lawful operation on a regular or periodic basis (including continuing seasonal operation) in that state before June 2, 1991.

(c) Special Rules for Wyoming, Ohio, Alaska, and Iowa.—In addition to the vehicles allowed under subsection (b) of this section—

(1) Wyoming may allow the operation of additional vehicle configurations not in actual operation on June 1, 1991, but authorized by state law not later than November 3, 1992, if the vehicle configurations comply with the single axle, tandem axle, and bridge formula limits in section 127(a) of title 23 and are not more than 117,000 lb GVW;

(2) Ohio may allow the operation of commercial motor vehicle combinations with three property-carrying units of 28.5 ft each (not including the truck tractor) not in actual operation on June 1, 1991, to be operated in Ohio on the 1-mi segment of Ohio SR 7 that begins at and is south of exit 16 of the Ohio Turnpike;

(3) Alaska may allow the operation of commercial motor vehicle combinations that were not in actual operation on June 1, 1991, but were in actual operation before July 6, 1991; and

(4) Iowa may allow the operation on Interstate 29 between Sioux City, Iowa, and the border between Iowa and South Dakota or on Interstate 129 between Sioux City, Iowa, and the border between Iowa and Nebraska of commercial motor vehicle combinations with trailer length, semitrailer length, and property-carrying unit length allowed by law or regulation and in actual lawful operation on a regular or periodic basis (including continued seasonal operation) in South Dakota or Nebraska, respectively, before June 2, 1991.

(d) Additional Limitations.—

(1) A commercial motor vehicle combination whose operation in a state is not prohibited under subsections (b) and (c) of this section may continue to operate in the state on highways described in subsection (b) only if at least in compliance with all state laws, regulations, limitations, and conditions, including routing-specific and configuration-specific designations and all other restrictions in force in the state on June 1, 1991. However, subject to regulations prescribed by the Secretary under subsection (g)(2) of this section, the state may make minor adjustments of a temporary and emergency nature to route designations and vehicle operating restrictions in effect on June 1, 1991, for specific safety purposes and road construction.

(2) This section does not prevent a state from further restricting in any way or prohibiting the operation of any commercial motor vehicle combination subject to this section, except that a restric-

tion or prohibition shall be consistent with this section and sections 31113(a) and (b) and 31114 of this title.

(3) A state making a minor adjustment of a temporary and emergency nature as authorized by paragraph (1) of this subsection or further restricting or prohibiting the operation of a commercial motor vehicle combination as authorized by paragraph (2) of this subsection shall advise the Secretary not later than 30 days after the action. The Secretary shall publish a notice of the action in the Federal Register.

(4) Nebraska may continue to allow to be operated under paragraphs (b)(1) and (b)(2) of this section, the state of Nebraska may allow longer combination vehicles that were not in actual operation on June 1, 1991 to be operated within its boundaries to transport sugar beets from the field where such sugar beets are harvested to storage, market, factory or stockpile or from stockpile to storage, market or factory. This provision shall expire on February 28, 1998.

(e) List of State Length Limitations.—

(1) Not later than February 16, 1992, each state shall submit to the Secretary for publication a complete list of state length limitations applicable to commercial motor vehicle combinations operating in the state on the highways described in subsection (b) of this section. The list shall indicate the applicable state laws and regulations associated with the length limitations. If a state does not submit the information as required, the Secretary shall complete and file the information for the state.

(2) Not later than March 17, 1992, the Secretary shall publish an interim list in the Federal Register consisting of all information submitted under paragraph (1) of this subsection. The Secretary shall review for accuracy all information submitted by a state under paragraph (1) and shall solicit and consider public comment on the accuracy of the information.

(3) A law or regulation may not be included on the list submitted by a state or published by the Secretary merely because it authorized, or could have authorized, by permit or otherwise, the operation of commercial motor vehicle combinations not in actual operation on a regular or periodic basis before June 2, 1991.

(4) Except as revised under this paragraph or paragraph (5) of this subsection, the list shall be published as final in the Federal Register not later than June 15, 1992. In publishing the final list, the Secretary shall make any revisions necessary to correct inaccuracies identified under paragraph (2) of this subsection. After

publication of the final list, commercial motor vehicle combinations prohibited under subsection (b) of this section may not operate on the Dwight D. Eisenhower System of Interstate and Defense Highways and other Federal-aid Primary System highways designated by the Secretary except as published on the list. The list may be combined by the Secretary with the list required under section 127(d) of title 23.

(5) On the Secretary's own motion or on request by any person (including a state), the Secretary shall review the list published under paragraph (4) of this subsection. If the Secretary decides there is reason to believe a mistake was made in the accuracy of the list, the Secretary shall begin a proceeding to decide whether a mistake was made. If the Secretary decides there was a mistake, the Secretary shall publish the correction.

(f) Limitations on Statutory Construction.—This section may not be construed—

(1) To allow the operation on any segment of the Dwight D. Eisenhower System of Interstate and Defense Highways of a longer combination vehicle prohibited under section 127(d) of title 23;

(2) To affect in any way the operation of a commercial motor vehicle having only one property-carrying unit; or

(3) To affect in any way the operation in a state of a commercial motor vehicle with more than one property-carrying unit if the vehicle was in actual operation on a regular or periodic basis (including seasonal operation) in that state before June 2, 1991, that was authorized under state law or regulation or lawful state permit.

(g) Regulations.—

(1) In carrying out this section only, the Secretary shall define by regulation loads that cannot be dismantled easily or divided easily.

(2) Not later than June 15, 1992, the Secretary shall prescribe regulations establishing criteria for a state to follow in making minor adjustments under subsection (d) of this section.

Sec. 31113. Width limitations

(a) General Limitations.—

(1) Except as provided in subsection (e) of this section, a state (except Hawaii) may not prescribe or enforce a regulation of commerce that imposes a vehicle width limitation of more or less than 102 in, on a commercial motor vehicle operating on—

(A) A segment of the Dwight D. Eisenhower System of Interstate and Defense Highways (except a segment exempted under subsection (e) of this section);

(B) A qualifying Federal-aid highway designated by the Secretary of Transportation, with traffic lanes designed to be at least 12 ft wide; or

(C) A qualifying Federal-aid Primary System highway designated by the Secretary if the Secretary decides the designation is consistent with highway safety.

(2) Notwithstanding paragraph (1) of this subsection, a state may continue to enforce a regulation of commerce in effect on April 6, 1983, that applies to a commercial motor vehicle of more than 102 in. in width, until the date on which the state prescribes a regulation of commerce that complies with this subsection.

(3) A Federal-aid highway (except an interstate highway) not designated under this subsection on June 5, 1984, may be designated under this subsection only with the agreement of the chief executive officer of the state in which the highway is located.

(b) Exclusion of Safety and Energy Conservation Devices.—Width calculated under this section does not include a safety or energy conservation device the Secretary decides is necessary for safe and efficient operation of a commercial motor vehicle.

(c) Special Use Permits.—A state may grant a special use permit to a commercial motor vehicle that is more than 102 in. in width.

(d) State Enforcement.—Consistent with this section, a state may enforce a commercial motor vehicle width limitation of 102 in. on a segment of the Dwight D. Eisenhower System of Interstate and Defense Highways (except a segment exempted under subsection (e) of this section) or other qualifying Federal-aid highway designated by the Secretary.

(e) Exemptions.—

(1) If the chief executive officer of a state, after consulting under paragraph (2) of this subsection, decides a segment of the Dwight D. Eisenhower System of Interstate and Defense Highways is not capable of safely accommodating a commercial motor vehicle having the width provided in subsection (a) of this section, the chief executive officer may notify the Secretary of that decision and request the Secretary to exempt that segment from subsection (a) to allow the state to impose a width limitation of less than 102 in. for a vehicle (except a bus) on that segment.

(2) Before making a decision under paragraph (1) of this subsection, the chief executive officer shall consult with units of local government in the state in which the segment of the Dwight D. Eisenhower System of Interstate and Defense Highways is located and with the chief executive officer of any adjacent state that may be directly affected by the exemption. As part of the consultations, consideration shall be given to any potential alternative route that serves the area in which the segment is located and can safely accommodate a commercial motor vehicle having the width provided for in subsection (a) of this section.

(3) A chief executive officer's notification under this subsection must include specific evidence of safety problems supporting the officer's decision and the results of consultations about alternative routes.

(4)

(A) If the Secretary decides, on request of a chief executive officer or on the Secretary's own initiative, a segment of the Dwight D. Eisenhower System of Interstate and Defense Highways is not capable of safely accommodating a commercial motor vehicle having a width provided in subsection (a) of this section, the Secretary shall exempt the segment from subsection (a) to allow the state to impose a width limitation of less than 102 in. for a vehicle (except a bus) on that segment. Before making a decision under this paragraph, the Secretary shall consider any possible alternative route that serves the area in which the segment is located.

(B) The Secretary shall make a decision about a specific segment not later than 120 days after the date of receipt of notification from a chief executive officer under paragraph (1) of this subsection or the date on which the Secretary initiates action under subparagraph (A) of this paragraph, whichever is applicable. If the Secretary finds the decision will not be made in time, the Secretary immediately shall notify Congress, giving the reasons for the delay, information about the resources assigned, and the projected date for the decision.

(C) Before making a decision, the Secretary shall give an interested person notice and an opportunity for comment. If the Secretary exempts a segment under this subsection be-

fore the final regulations under subsection (a) of this section are prescribed, the Secretary shall include the exemption as part of the final regulations. If the Secretary exempts the segment after the final regulations are prescribed, the Secretary shall publish the exemption as an amendment to the final regulations.

Sec. 31114. Access to the Interstate System

(a) Prohibition on Denying Access.—A state may not enact or enforce a law denying to a commercial motor vehicle subject to this subchapter or subchapter I of this chapter reasonable access between—

(1) The Dwight D. Eisenhower System of Interstate and Defense Highways (except a segment exempted under section 31111(f) or 31113(e) of this title) and other qualifying Federal-aid Primary System highways designated by the Secretary of Transportation; and

(2) Terminals, facilities for food, fuel, repairs, and rest, and points of loading and unloading for household goods carriers, motor carriers of passengers, or any truck tractor-semitrailer combination in which the semitrailer has a length of not more than 28.5 ft and that generally operates as part of a vehicle combination described in section 31111(c) of this title.

(b) Exception.—This section does not prevent a state or local government from imposing reasonable restrictions, based on safety considerations, on a truck tractor-semitrailer combination in which the semitrailer has a length of not more than 28.5 ft and that generally operates as part of a vehicle combination described in section 31111(c) of this title.

Sec. 31115. Enforcement

On the request of the Secretary of Transportation, the Attorney General shall bring a civil action for appropriate injunctive relief to ensure compliance with this subchapter or subchapter I of this chapter. The action may be brought in a district court of the United States in any state in which the relief is required. On a proper showing, the court shall issue a temporary restraining order or preliminary or permanent injunction. An injunction under this section may order a state or person to comply with this subchapter, subchapter I, or a regulation prescribed under this subchapter or subchapter I.

NOTES

1. From the U.S. Code Online via GPO Access (wais.access.gpo.gov). Laws in effect as of January 2, 2001.
2. From the U.S. Code Online via GPO Access (wais.access.gpo.gov). Laws in effect as of January 6, 1999.

Comments Received by the Committee

Appendix C

At the committee's direction, TRB sent letters to 45 parties identified by the committee as having an interest in truck size and weight regulations. The letters asked for the parties' views on what changes in federal regulations, if any, the committee should consider, what recommendations the committee should make, and what factors it should consider in evaluating proposals. Twenty-five organizations responded (Box C-1).

No attempt was made to have equal numbers of responses from each of the various categories of interested parties. The intent of the requests for comments was not to conduct a poll to determine which changes in regulations would be most popular, but rather to obtain information that would be useful to the committee in its evaluations. More responses were received from trucking industry groups than from any other category of organization, reflecting in part the specialized interests of segments of the trucking industry in particular features of the regulations that most affect their operations.

In addition to indicating the views of the respondents on particular options for changes in federal regulations, the responses read as a whole point out three general issues regarding federal truck size and weight regulation that are sources of concern:

1. The complexity of the regulations: The detailed and specialized nature of many of the responses demonstrates the complexity of federal and state motor vehicle size and weight regulations. This complexity has several causes: the inherent complexity of the engineering and economic system subject to the regulations (i.e., the highway transportation system); the multiple, often competing, interests and objectives of the interested parties; and the accumulated legacy of 85 years of state and federal rulemaking.

As explained in the Preface, the committee was not able to evaluate all the specific provisions of the existing federal law and regulations. Hence, issues of significant concern to some of the respondents were not addressed.

Box C-1
Organizations Asked for Comments

Italics indicate that the party did not respond.

Motor carrier industry and private carrier associations
- American Bus Association (membership includes carriers and manufacturers)
- American Trucking Associations
- Distribution & LTL Carriers Association
- Motor Freight Carriers Association
- National Automobile Transporters Association
- National Solid Wastes Management Association
- Western Highway Institute
- *Association of Waste Hazardous Materials Transportation*
- *National Private Truck Council*

Construction industry associations
- *American Road and Transportation Builders Association*
- *Associated General Contractors of America*

Independent driver association and labor union
- Owner-Operator Independent Drivers Association, Inc.
- *International Brotherhood of Teamsters, AFL-CIO*

Vehicle and equipment manufacturer associations
- Truck Manufacturers Association
- Truck Trailer Manufacturers Association

Transportation companies
- Federal Express Corporation
- *J B Hunt Transport*
- *Schneider National Carriers*
- *United Parcel Service*

Vehicle manufacturers
- Motor Coach Industries, Inc.
- *Freightliner Corporation*

(continued)

Box C-1 *(continued)* **Organizations Asked for Comments**

Shipper associations
- National Industrial Transportation League
- *Intermodal Association of North America*
- *National Small Shipments Traffic Conference*

Railroad industry association
- Association of American Railroads

Motorist or safety advocacy organizations
- American Automobile Association
- Coalition Against Bigger Trucks
- Insurance Institute for Highway Safety
- *Advocates for Highway and Auto Safety*
- *Surface Transportation Policy Project*

State transportation departments
- Connecticut Department of Transportation
- Florida Department of Transportation
- Georgia Department of Transportation
- Idaho Transportation Department
- Indiana Department of Transportation
- Michigan Department of Transportation
- New York State Department of Transportation
- Texas Department of Transportation
- *Minnesota Department of Transportation*
- *New Jersey Department of Transportation*

Other government
- *American Association of Port Authorities*
- *American Association of State Highway and Transportation Officials*
- *Commercial Vehicle Safety Alliance*
- *International Bridge, Tunnel and Turnpike Association*
- *National Governors Association*

2. Goals of regulation: Chapter 2 argues that evaluation of possible changes in federal regulations ought to start with a stated philosophy of the purpose of size and weight regulation. There is great variety in the views of the respondents on this question. Some responses argue that the only justifiable purposes of any revisions would be to improve safety and passenger mobility and reduce infrastructure costs, while other responses refer primarily to shipper costs of freight transportation.

3. Definition of federal responsibility: The evolution of federal involvement in size and weight regulation is described in Chapter 1. Several alternative philosophies of federal responsibility for size and weight regulation are advocated in the responses. At one extreme, one respondent calls for a "minimal" federal role. A federally supervised permitting program would constitute a middle-of-the-road proposal: it would give states greater flexibility to decide their own limits on all roads but would retain federal oversight of the terms of permits. Proposals for federally planned national systems—specifying size and weight limits, road networks, and other requirements nationwide—embody a dominant federal role.

This summary of the responses is organized by grouping responses under the options for change in federal regulations listed in Box C-2. The options listed in Chapter 1 are included, and several more were added to accommodate the responses. Many of the recommendations in the responses did not match the listed options exactly, and often a single proposal in a response pertains to several of the listed options, so the categorization of responses is somewhat arbitrary. This summary does not reflect every comment contained in the responses. Each summary of a response is a paraphrase, unless a quotation is indicated. Following the summary of the respondent's position, the respondent's arguments in support of that position are listed.

I. POLICIES WITHIN EXISTING FRAMEWORK AND PRECEDENTS OF FEDERAL TRUCK SIZE AND WEIGHT REGULATION

These do not entail changes in pavement and bridge design practices, basic truck design, or highway user fees.

DOT 1998 Study Illustrative and Policy Scenarios (DOT 1998)

1. Uniformity: extend federal weight limits now applicable on Interstates to all roads on the 200,000-mi federally defined national network; eliminate grandfather provisions.

Box C-2

Options for Changes in Federal Weight, Length, and Width Regulations and Related Policies

I. Policies Within Existing Framework and Precedents of Federal Regulation: these do not entail changes in pavement or bridge design practices, basic truck design, or highway user fees.

DOT comprehensive study illustrative and policy scenarios (DOT 1998)

1. Uniformity: extend federal weight limits now applicable on Interstates to all roads on the 200,000-mi federally defined national network; eliminate grandfather provisions.
2. North American trade: heavier vehicles with added axles (six-axle tractor-semitrailer, four-axle truck, eight-axle double-33-ft-trailer combination) on national network.
3. Longer combination vehicles nationwide: long double- and triple-trailer combinations on restricted networks with staging areas; eight-axle double-33-ft-trailer combinations on national network and access routes.
4. H.R. 551: eliminate trailers over 53 ft on Interstates and some other federal-aid roads; freeze grandfather rights; freeze state weight limits (including permits) on federal-aid roads.
5. Triples nationwide: triple-trailer combinations (seven axles; 132,000 lb) nationwide on 65,000-mi network and state-selected access routes.

Current proposals, including industry proposals

6. State option for longer combination vehicles.
7. Peterson-Cook bill: 97,000-lb six-axle tractor-semitrailer as state option.
8. Case-by-case legislative exemptions from federal standards (e.g., TEA-21 exemptions).
9. Changes in weight limits [other than DOT scenarios, Peterson-Cook, or *Truck Weight Limits* (TRB 1990a)].
10. Increased vehicle width limits.
11. Changes in federal length regulations.
12. Changes in current federal size and weight law or regulations in general.

(continued)

Box C-2 *(continued)* **Options for Changes in Federal Weight, Length, and Width Regulations and Related Policies**

Recommendations of earlier TRB study committees

13. New bridge formula from *Truck Weight Limits*.

14. Turner Proposal (TRB 1990b): state option to allow nine-axle, 111,000-lb double-33-ft-trailer combinations with coordinated bridge management and fee changes.

II. Approaches to Federal Size and Weight Regulation Outside the Existing Framework

15. Permitting program recommended in *Truck Weight Limits* for heavier trucks on Interstates.

16. Performance standards as the basis for certification of operator-proposed vehicles.

17. Federal user fee reform to closely align fees with costs occasioned (possibly coupled with optimal pavement design).

18. Devolution of regulatory responsibilities to the states.

III. Policies to Mitigate the Effects of Large Trucks: such policies would provide a broader range of options for controlling the costs of truck traffic while allowing efficient freight transportation.

19. Improved enforcement of size and weight limits and safety regulations.

20. Improved bridge management targeted at reducing bridge costs of trucks.

21. Changes in pavement design practices.

22. Exclusive truck routes or lanes.

23. Mitigation policies in general.

Owner-Operator Independent Drivers Association, Inc.

The committee should recommend that federal law be changed to eliminate all state grandfather exemptions from federal size and weight standards. Federal standards should apply uniformly across the country. No other change in federal standards should be enacted.

Arguments:

- Nonuniformity impedes the free flow of interstate and foreign commerce.

• Uniformity would promote healthy competition in trucking [presumably by eliminating the short-term advantage that large trucking companies are alleged to gain when standards are changed and by allowing all truckers to operate in all parts of the country unimpeded by regional equipment differences].

• Larger trucks would uneconomically increase infrastructure costs.

• "The introduction of heavier and longer trucks would greatly compromise highway safety. Drivers simply have less control over heavier and longer trucks. . . . it is intolerable to consider creating circumstances that give drivers less ability to safely operate commercial motor vehicles." If use of larger trucks were expanded, the trucks would be operated by drivers of all skill levels on all roads; limiting use to the best drivers and roads would be impractical.

Michigan Department of Transportation
The committee should not recommend abolition of existing state grandfather rights under federal size and weight laws.

American Trucking Associations
The committee should recommend provision of "a set of minimum truck size and weight standards for vehicles operating on the National Highway System." Existing grandfather provisions should be retained. Provision should be made for access to points of loading.

[See also ATA responses under Options 6 (LCV state option), 9 (gross weight limit), and 11 (length limits) below.]

Argument: The ATA size and weight policy "supports reasonable size and weight standards consistent with highway capability and the need for an efficient, intelligent, productive transportation system that meets national, regional and local economic needs."

2. North American trade: heavier vehicles with added axles (six-axle tractor-semitrailer, four-axle truck, eight-axle double-33-ft-trailer combination) on national network.

Truck Trailer Manufacturers Association
Recommends that "efforts be made to harmonize size and weight regulations throughout North America and especially within the U.S."

[See also TTMA response under Option 7 (97,000-lb tractor-semitrailers) below.]

National Automobile Transporters Association
Committee should consider elimination of the federal 80,000-lb weight limit "without instituting a permit program or a regionalization

concept." [That is, presumably, a federally mandated nationwide rule establishing a higher gross weight limit or specifying that gross weight be limited only by the bridge formula and length limits. The outcome would be similar to the DOT study NAFTA scenario.] Heavier vehicles would pay appropriate taxes and would be required to be equipped with "the most modern and practical safety devices available."

Arguments:

- The experience of the automobile transporters industry shows that liberalizing limits leads to increased productivity and less truck traffic. Since federal law and regulation established nationwide minimum length standards for automobile haulers, the automobile hauler fleet size has decreased as the number of vehicles hauled has increased. Liberalizing limits will reduce congestion, pollution, and accidents while increasing productivity.
- Because of the shift in consumer demand toward SUVs, vans, and pickups, standard automobile hauling configurations today have space to carry an additional vehicle but are prevented from doing so by weight restrictions.
- Federal allowance for regional variation in application of the higher weight limits would result in inequitable variations in the limits.

Western Highway Institute

The committee should recommend changes such that federal law would provide a framework for promoting the efficient movement of freight, giving consideration to the effects of NAFTA and to the overall growth in freight. Present federal law sometimes is a barrier to efficiency.

3. Longer combination vehicles nationwide: long double- and triple-trailer combinations on restricted networks with staging areas; eight-axle double-33-ft-trailer combinations on national network and access routes.

Truck Trailer Manufacturers Association

The committee should consider recommending that LCVs be allowed as described in the DOT study.

Arguments: The main freight problem of the future will be to maintain efficiency in spite of greatly increased traffic. Allowing larger trucks will reduce the number of trucks on the road and thereby reduce congestion, ease the driver shortage, reduce accidents, and reduce the need to build additional highway lanes.

National Industrial Transportation League
The committee should consider changes to limits allowing more liberal use of LCVs "if they can clearly be operated in a safe manner." In general, limits should be relaxed in a way that does not compromise safety.

Arguments:

- Relaxing size and weight limits would increase the productivity of the trucking industry.
- Relaxing limits would allow freight to be carried with fewer miles of truck travel, tending to reduce the number of accidents. The volume of rail traffic will for some years be constrained mainly by rail capacity [and hence, presumably, restricting truck sizes will be unlikely to affect rail's share of traffic].
- The effect of regulatory changes on rail and truck market shares is not in itself a relevant consideration in evaluating the changes unless the larger trucks would not be paying their fair share of highway infrastructure costs.
- The driver shortage increases the importance of truck productivity.
- Productivity growth can be attained without loss of safety by placing special requirements on the operation of larger trucks and on the qualifications of their operators.

4. H.R. 551: eliminate trailers over 53 ft on Interstates and some other federal-aid roads; freeze grandfather rights; freeze state weight limits (including permits) on federal-aid roads.

Coalition Against Bigger Trucks
Proposes consideration of enactment of H.R. 551 as one component of a package of changes in federal law to prevent further liberalizations of state size and weight limits, including repeal of the Symms amendment defining grandfather rights, and defining nondivisible loads in such a way as to close a present loophole in federal weight limits.

Arguments:

- The 1998 DOT *Comprehensive Truck Size and Weight Study* found that allowing larger trucks would generate large costs for bridge improvements, for example, $300 billion in the case of extensive use of longer combination vehicles.
- The federal study concluded that longer combinations have fatal accident rates 11 percent higher than conventional combinations.

- The long-term consequences of adoption of larger trucks for land use and total highway traffic volume are potentially significant and have not been assessed. Larger trucks would likely lead to lower-density land use patterns and increased environmental costs of transportation.
- The stress and discomfort to automobile drivers from sharing the road with large trucks is a real cost that drivers are sensitive to and that has never been evaluated.
- The systemwide safety cost of changing truck operations on a road network has never been evaluated. Changes in the size, performance, or numbers of trucks change the behavior of drivers and probably affect the safety of the road system in ways that are not reflected in average truck accident rates.
- Proposals to counteract increased risk of larger trucks by new requirements concerning vehicle design, route restrictions, or driver qualification are of unproven effectiveness.
- The 1997 federal highway cost allocation study concluded that user fees collected from heavier trucks would be substantially less than their cost responsibilities. No practical tax change to eliminate the underpayment has been proposed.
- In light of the uncertainties, recommending an increase in limits would be unreasonable. Recommending a freeze until uncertainties are reduced would be prudent.

5. Triples nationwide: triple-trailer combinations (seven axles; 132,000 lb) nationwide on 65,000-mi network and state-selected access routes.

Distribution and LTL Carriers Association
The DOT study triples scenario uses a maximum weight (132,000 lb) that is above the optimum. Triples with 120,000-lb maximum weight have substantial productivity benefits and much lower pavement and bridge costs.

[See DLTLCA response under Option 6 (state option for LCVs) below.]

Motor Freight Carriers Association
The committee should consider proposals for operations of triples on highways that can safely accommodate them and under conditions that foster safe operations. Such proposals would entail a more limited network of roads and lower maximum weight than the assumptions of the DOT study triples scenario. One contribution that the committee could make would be to develop criteria defining the high-

ways that can safely accommodate triples and conditions that foster safe operations of triples.

Current Proposals, Including Industry Proposals

6. State option for longer combination vehicles.

Distribution and LTL Carriers Association
The committee should recommend federal legislation allowing states to create permit programs for operation of longer combination vehicles. The permit program option should be available to all states regardless of grandfather rights. Such legislation would have the effect of repealing the current federal LCV freeze. Vehicles allowed under the permit program should include seven-axle triple-trailer combinations up to 120,000 lb, as well as other LCVs with maximum weight limited by a federal bridge formula. The federal law should compel the state permit programs to have features similar to those of the permit program recommended in *Truck Weight Limits* (TRB 1990a) [which referred only to vehicle weights and not lengths or configurations], including safety requirements for vehicles, drivers, and carriers, and accident and mileage data reporting for safety monitoring.

Arguments:

- The existing federal LCV freeze increases shipper costs, truck traffic volumes, pollution, and congestion, and does not enhance safety.
- The effect of size and weight limits on railroads is not a legitimate public policy issue. Protecting railroads' market share and profits from competition is bad for the economy.

Western Highway Institute
The committee should recommend repeal of the LCV freeze.

Arguments: See WHI arguments under Option 9 (weight limits) below.

Federal Express Corporation
The committee should consider recommending allowance of broader use of longer combination vehicles.

Georgia Department of Transportation
The committee should consider the importance of regional differences in traffic and terrain in its evaluation of larger and longer vehicles.

Vehicles that are safe in rural and less populated areas may be a safety risk in East Coast states.

Idaho Transportation Department
The committee should recommend lifting the current federal freeze on longer combination vehicles.

Arguments: See Idaho Transportation Department arguments under Option 18 (devolution) below.

Michigan Department of Transportation
The committee should consider allowing regional variation in legal vehicle configurations. Vehicles acceptable in western states may be inappropriate in the East.

American Trucking Associations
LCVs and/or other more productive vehicles should be allowed at the option of the states.

[See Also ATA response under Option 11 (length limits) below.]

7. Peterson-Cook bill: 97,000-lb six-axle tractor-semitrailer as state option.

Truck Trailer Manufacturers Association
Consideration should be given to allowing 97,000-lb six-axle tractor-semitrailers.

Arguments: See TTMA arguments under Option 3 (LCVs nationwide) above.

National Industrial Transportation League
The committee should consider a change in limits that would allow such trucks, "as long as they are safe and operated in a safe manner."

Arguments: See NITL arguments under Option 3 (LCVs nationwide) above.

8. Case-by-case legislative exemptions from federal standards (e.g., TEA-21 exemptions).
No comments were received for this option.

9. Changes in federal weight limits [other than DOT scenarios, Peterson-Cook bill, or *Truck Weight Limits* (TRB 1990a) recommendations].

National Solid Wastes Management Association
The committee should consider recommending increased tandem and tridem axle weight limits, as an alternative to revising the bridge formula. [It is unclear whether the proposed limits would supersede bridge formula limits.]

Arguments: See NSWMA arguments under Option 13 (bridge formula) below.

Western Highway Institute
The committee should recommend repeal of the federal 80,000-lb weight limit now in effect on Interstate highways. States should be allowed to set higher (but not lower) maximums or to leave weight governed only by the federal axle weight limits and the federal bridge formula.

Arguments:

- The outcome of existing federal law [including the 80,000-lb weight limit as well as the LCV freeze, which WHI also advocates repealing] is arbitrary. Often, vehicles that are in compliance with the federal axle limits and the bridge formula and that can operate legally in a state cannot operate in adjacent states.
- The 80,000-lb limit is artificial [that is, presumably, there is no scientific or economic basis for the limit].
- States are in the best position to decide on the suitability of gross weight limits and LCVs. In the western states in particular, government-industry organizations have been established to work cooperatively on size and weight matters.
- Present law results in substantial excess transportation costs, particularly in the western states; the money could be spent elsewhere in a productive fashion.

Federal Express Corporation
The committee should consider an increase in maximum gross vehicle weight.

Connecticut Department of Transportation
The committee should recommend that 23 CFR Part 658 (the federal regulations on truck size and weight) be changed to include a definition of trunion axles.

Georgia Department of Transportation
The committee should consider recommending changing federal law to give states the option of imposing tandem axle weight limits

greater than the current federal maximum of 34,000 lb on the Interstates.

The committee should recommend that federal law or regulation impose uniform state permitting practices for overweight intermodal containers. AASHTO Policy Resolution 9-96 in 1996 called for the same action.

Argument: Georgia allows 40,680-lb tandem axles on roads other than Interstates. States with grandfather rights can allow similar weights on their Interstates, but Georgia does not have the right to do so because it cannot claim a grandfather exemption. In such circumstances, states ought to have some leeway to judge appropriate limits.

American Bus Association

The committee should recommend that federal law specify weight limits for intercity motor coaches independent of those applying to trucks or exempt motor coaches from federal weight limits. The legal maximum weight for the tandem axle pair of a motor coach should be no less than 36,000 lb, and for the drive axle of the tandem axle pair, 22,400 lb. A tolerance of 15 percent above these limits should be considered.

Arguments:

- Motor vehicle size and weight limits have been established with trucks in mind and are incompatible with the design and operation of motor coaches.
- There is no practical way for motor coach operators to monitor their weight or to adjust loading to balance axle weights, as trucks can do.
- Weight has no effect on motor coach safety because coaches are designed to be safely operated at higher weights than the legal maximum.
- The design of the air suspension of a motor coach results in far less infrastructure wear than that caused by typical truck suspensions for a given weight.
- Federally mandated wheelchair lifts and emission control equipment have added to the weight of motor coaches.
- Transit buses have received a temporary exclusion from federal weight limits.

Motor Coach Industries, Inc.
The committee should recommend that intercity motor coaches be exempt from federal axle weight restrictions or given a 15 percent allowance over the current limits.

Arguments: Similar to those of ABA above.

National Automobile Transporters Association
The committee should consider recommending weight tolerances for commodity-specific truck equipment such as car haulers.

Argument: The combined effect of current weight and length restrictions often prevents car haulers from optimizing loads. Consequently, they must often travel with empty spaces where additional vehicles could be hauled.

American Trucking Associations
The committee should recommend elimination of the federal 80,000-lb weight limit on Interstate highways. Gross weight should be governed by appropriate axle weight limits and the bridge formula.

The committee should consider weight tolerances for automobile haulers.

10. Changes in federal vehicle width limits.

National Solid Wastes Management Association
The committee should recommend redefinition of the federal vehicle width limit to exclude ladders, mirrors, and controls from the definition of width to which the limit applies.

Argument: Steps are already excluded from the width definition; the same justification would apply to other appurtenances.

Truck Trailer Manufacturers Association
The committee should recommend federal action to allow 102-in.-wide vehicles on all highways.

Arguments: Trailers 102 in. wide probably are already operating on all highways. Removal of 96-in. limits would allow construction of 102-in.-wide tractors and tank trailers, which would have improved rollover resistance.

Idaho Transportation Department
The committee should recommend that the definition of nondivisible loads in federal regulations be made consistent with the definition

adopted by the Western Association of State Highway and Transportation Officials, in particular as it applies to wide loads and the hauling of equipment.

11. Changes in federal length regulations.

Federal Express Corporation
The committee should consider recommending that federal law prevent states from establishing maximum trailer length limits of less than 53 ft for a semitrailer in a tractor-semitrailer combination.

Connecticut Department of Transportation
The committee should recommend that certain ambiguities in federal trailer length regulations (23 CFR Section 658.13) be clarified. First, the regulations "should be revised to include a maximum semitrailer length. As written, any length semitrailer would be allowable for motorsports competition." Second, the regulations "should be revised to include a definition of those automobile transporters not considered specialized equipment."

The committee should recommend that a uniform nationwide federal standard for the kingpin-to-rear-axle dimension of 53-ft semitrailers be adopted.

The committee should recommend that a federal standard be adopted for the dimensions and location of markings indicating the length of 53-ft semitrailers.

American Bus Association
The committee should consider recommending that the federal maximum length of motor coaches be increased from the present 45 ft to 50 ft. Motor coach bumpers should be excluded in measurement of length.

Arguments:

- Trailers 53 ft long are legal on nearly all roads.
- Motor coaches 50 ft long are in use in Europe.
- Bumpers should qualify as safety devices, which are already excluded in the application of federal dimensional limits.

Motor Coach Industries, Inc.
Bumpers should be excluded in the definition of motor coach length for regulatory purposes.

Arguments:

- Bumpers are safety devices.
- Federal action would preempt inconsistent state length requirements.

American Trucking Associations
The committee should consider a federal minimum trailer length law for combinations that include tractors with dromedary boxes.

"The committee should consider changes to the federally grandfathered longer combination vehicle . . . laws that allow for the measurement of combined trailer length . . . rather than the overall length of the combination."

12. Changes in current federal size and weight law or regulations in general.

Texas Department of Transportation
The committee should not recommend changes in existing federal law or regulations governing vehicle weight, length, and width.

Arguments: "Normally, demand drives the need for change and thus far in Texas we are hearing neither public nor business requests for any changes in the status quo. The economy is thriving within current guidelines, manufacturers are building cleaner and more fuel efficient trucks, truck safety is on everyone's agenda, . . . and our communities appear well served by existing transportation modes."

Motor Freight Carriers Association
The committee should consider the range of reasonable proposals that have been made in recent years for liberalizing limits to provide increased productivity, including the recommendations of earlier TRB committees on size and weight issues, including *Truck Weight Limits* and the Turner Proposal study (TRB 1990b).

Arguments:

- The decision embodied in the 1991 LCV freeze to "freeze productivity improvements on a mode of transportation that is vital to a growing and diverse economy" was an irrational one.
- "With a growing economy—and its attendant increases in freight and truck traffic—we eventually must confront the reality that trucks are a large part of the equation. We will have to decide if we want more trucks of the same or smaller size or do we want to rationally consider sensible increases in sizes and weights."

Truck Manufacturers Association
Truck size and weight regulation is of interest to members of the association, but the views of members are diverse and the association has not developed a consensus position on the issue.

New York State Department of Transportation
Increases in length, width, and height limits should only be considered and agreed to by states within geographical regions. The federal government can consider revisions to weight limits, but on Interstate highways only.

Recommendations of Earlier TRB Study Committees

13. New bridge formula from *Truck Weight Limits*.

National Solid Wastes Management Association
The committee should recommend a new bridge formula similar to the one recommended in *Truck Weight Limits,* either as a state option or as a federal mandate.

Arguments:

- Waste-hauling costs would be reduced.
- Fewer truck trips would be required to remove waste, reducing traffic congestion, pollutant emissions, and accidents.
- Increasing the length of waste-hauling trucks to allow increased weight under the existing bridge formula is impractical and unsafe.
- Most states already have special limits for waste-hauling trucks off the Interstates, forcing heavier trucks onto the less-well-designed roads.

Western Highway Institute
Consideration should be given to a new bridge formula, although the present formula is adequate for the majority of industry's needs. Provision should be made for large-scale testing of proposed new bridge formulas.

14. Turner Proposal (TRB 1990b): state option to allow nine-axle, 111,000-lb double-33-ft-trailer combinations with coordinated bridge management and fee changes.

Michigan Department of Transportation
The committee should consider changing regulations to encourage adding axles to vehicles to lessen pavement wear.

II. APPROACHES TO FEDERAL SIZE AND WEIGHT REGULATION OUTSIDE THE EXISTING FRAMEWORK

15. Permitting program recommended in *Truck Weight Limits* for heavier trucks on Interstates.

National Solid Wastes Management Association
The committee should recommend a permitting program with features similar to the recommendation of *Truck Weight Limits* as a state option.

Arguments: See NSWMA arguments under Option 13 (bridge formula) above.

16. Performance standards defined as the basis for certification of operator-proposed vehicles.

Truck Trailer Manufacturers Association
The committee should recommend creation of a federal special permit program for testing and demonstration of new industry-developed vehicle technologies.

The committee should recommend that the federal government develop performance requirements (presumably for use at least as the basis for the permit program).

Argument: State size and weight regulations today prevent testing and demonstration of industry-developed concept vehicles. The federal permit program would allow experience to be gained with such vehicles and would encourage innovation. The research base for defining performance requirements exists.

National Automobile Transporters Association
NATA is sponsoring research for design of automobile hauler configurations based on performance standards.

Western Highway Institute
The committee should recommend creation of a mechanism for testing of new types of operations, including new bridge formulas, the Argosy concept vehicle, and performance standards.

17. Federal user fee reform to closely align fees with costs occasioned (possibly coupled with optimal pavement design).

Association of American Railroads
Conclusions on appropriate changes in the regulations must include consideration of how costs are to be recovered from the parties involved.

"[A]n efficient cost recovery system would eliminate the cross subsidization between highway users, ensuring that each category of highway user pays only for the costs it imposes on the highway system, thus providing the basis for an economically efficient allocation of freight among all freight transportation modes." The relevant costs are direct infrastructure costs; social costs including safety impacts; and the full effects on shippers' costs, including disadvantages of larger trucks to shippers (e.g., higher inventory costs) and the effect of higher rail rates that would result if rails lost traffic to larger trucks.

National Automobile Transporters Association
"The privilege of hauling additional weight should be indexed into the current heavy vehicle use tax."

Michigan Department of Transportation
The committee should consider mechanisms to fund pavement, bridge, freeway interchange, and local road upgrades necessitated by any changes in commercial vehicle weights, lengths, and widths.

New York State Department of Transportation
If federal weight limits on the Interstates are increased, the trucking industry should pay for any improvements necessary to accept heavier loads on roads giving access to the Interstate system. A truck operating at a higher weight by permit should pay fees depending on its equivalent single-axle load (ESAL) rating.

18. Devolution of regulatory responsibilities to the states.

Idaho Transportation Department
The committee should recommend changes so that laws and regulations on the federal level concerning vehicle dimensions "should be minimal and more general." Specific laws and regulations should be the responsibility of individual states, working in cooperation with other states.

Arguments:

- The states differ greatly in the conditions that are relevant to selecting size and weight limits. These include population density, terrain, climate, and infrastructure condition.
- The federal government is not capable of assessing local conditions in setting size and weight limits. Examples of unintended and illogical consequences of federal divisible load regulations are cited.

New York State Department of Transportation
If federal weight limits on the Interstates are increased, the states must have total control of provisions giving the larger trucks access to and from the Interstates, without federal influence.

III. POLICIES TO MITIGATE THE EFFECTS OF LARGE TRUCKS
Such policies would provide a broader range of options for achieving the underlying goal of controlling the costs of truck traffic while allowing efficient freight transportation.

19. Improved enforcement of size and weight limits and safety regulations.

New York State Department of Transportation
Heavier trucks operating under permit should be required to display a plate showing the weight rating and horsepower of the power unit and other specifications.

20. Improved bridge management targeted at reducing bridge costs of trucks.

Western Highway Institute
Consideration should be given to use of a field diagnostic system to ensure that posted limits reflect bridges' true carrying capacity.

21. Changes in pavement design practices.
No comments were received for this option.

22. Exclusive truck routes or lanes.

Truck Trailer Manufacturers Association
"New intelligent highway construction should be planned" for major freight lanes to accommodate larger combinations.

23. Mitigation policies in general.

Indiana Department of Transportation
The committee should recommend revisions in federal law and regulations that will provide a safer infrastructure system for the traveling public. The committee should not recommend changes that would

increase vehicle weights, lengths, or widths. In evaluating alternatives, the committee should consider safety, costs, alternatives to trucking, and freight diversion.

Insurance Institute for Highway Safety

"Revisions to federal law and regulations regarding commercial vehicle weights, lengths, and widths should not be considered if they could worsen the current level of truck safety on U.S. roads. Reducing the losses associated with large truck crashes should be the primary concern of any revisions to federal laws and regulations concerning truck size and weight."

"Design changes to heavier trucks that may improve one aspect of performance can have a negative effect on another. For example, increasing the number of axles can reduce pavement damage from heavier trucks and their tendency to roll over; but this also degrades braking efficiency and the ability of a truck to evade obstacles."

Several studies indicate that multitrailer accident rates are higher than those of single-trailer configurations when confounding factors are controlled for.

American Automobile Association

The committee should evaluate vehicle weight, length, and width limits and related regulations that affect safety, infrastructure, and mobility. Examples of such regulations are truck driver licensing including requirements for particular vehicle configurations; enforcement of licensing requirements and other safety regulations and of size and weight limits; state permitting practices as they affect safety, infrastructure, and mobility; U.S. and foreign regulations that govern the dimensions of trucks entering the United States from Canada and Mexico; and the efficacy of hours of service regulations for various truck configurations.

The committee should attempt to identify changes in regulations that would improve safety, mobility, and the economy of use of the infrastructure.

New York State Department of Transportation

In addition to weight, new regulations changing the federal weight limits would have to address suspension characteristics and performance, tire characteristics, maximum weights for axle groups, horsepower-to-weight ratio, and state permitting and fee requirements.

REFERENCES

Abbreviations

DOT U.S. Department of Transportation
TRB Transportation Research Board

TRB. 1990a. *Special Report 225: Truck Weight Limits: Issues and Options*. National Research Council, Washington, D.C.

TRB. 1990b. *Special Report 227: New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal*. National Research Council, Washington, D.C.

DOT. 1998. *Comprehensive Truck Size and Weight Study: Draft Volume III Scenario Analysis*. Dec. 30.

Recommendations from *Truck Weight Limits* Study (1990)

Appendix D

[Transportation Research Board Committee for the Truck Weight Study. *Special Report 225: Truck Weight Limits: Issues and Options*. TRB, National Research Council, Washington, D.C., 1990, pp. 14–25.]

STUDY RECOMMENDATIONS

The impact analyses conducted for this study support findings from previous truck size and weight studies mandated by Congress. It has been found that increasing truck weights can significantly reduce the cost of goods movement and that cost savings due to more efficient trucks generally exceed the additional pavement and bridge costs incurred by highway agencies. At the same time, other study findings suggest the need for caution in implementing increases in truck weights. Unless the revenues required to cover additional pavement and bridge costs are provided to highway agencies, the condition of the highway system will deteriorate, thereby increasing vehicle repair costs, lowering fuel economy, increasing travel delays and accidents, and adversely affecting driver and passenger comfort. Also, increasing truck weights has both positive and negative effects on safety and traffic operations. On one hand, reduced truck traffic serves to decrease truck-related accidents and congestion. On the other, simply allowing more weight on existing trucks could adversely affect truck operating characteristics and increase accident rates. Further, if user charges do not increase in step with truck costs, inefficient levels of rail diversion might occur. This new truck traffic could cause net losses for the transportation system as a whole if added pavement and bridge costs resulting form diversion exceed savings in transport costs.

In formulating the major recommendations for this study, the committee was guided by the following objectives:

- To select, from the various proposed changes in truck, weight regulations from industry groups and others, the most practical means

to realize the productivity benefits of increased truck weights while reducing or eliminating possible adverse effects;

- To make changes in weight limits that would reduce truck accidents and encourage safety improvements in truck design and operation;
- To provide mechanisms to match user fees with added costs for pavements and bridges;
- To promote uniformity in the administration of truck weight regulations;
- To balance the federal interest in protecting the national investment in the Interstate system and facilitating interstate commerce with the interests of states in serving the needs of their citizens and industries; and
- To develop proposals that are realistic and feasible, and would have a reasonable chance of being implemented.

The following are five recommendations that the committee believes to be consistent with these objectives.

Recommendation 1: New Bridge Formula

Congress should replace the current federal bridge formula on Interstate highways with the following formula:

$$W = 1{,}000\ (2L + 26) \qquad \textit{for } L \leq 24$$
$$W = 1{,}000\ (L/2 + 62) \qquad \textit{for } L > 24$$

where W *is the maximum weight in pounds that can be carried on any group of three or more axles and* L *is the length in feet of the axle group rounded to the nearest whole foot. States adopting the new bridge formula on Interstates and other roads should identify all bridges that must be posted or replaced as a consequence of the heavier loadings and estimate all additional costs associated with the increase in limits. Taxes on heavy vehicles should then be increased as necessary to cover these additional costs.*

The recommended bridge formula is the TTI HS-20 formula. This formula, together with federal axle-weight limits, would be applied to vehicles with gross weights of 80,000 lb or less. Recommendation 2 deals with a permit program for vehicles over 80,000 lb and describes how the formula would be extended for these vehicles.

Truck costs would decrease by $2.4 billion per year ($2.7 billion per year in transport cost savings less $0.3 billion in higher taxes to cover pavement and bridge cost increases) if all states adopted the recom-

mended bridge formula on all their highways. Operators of specialized hauling vehicles (SHVs) such as dump trucks, concrete mixers, and solid-waste disposal trucks would be the principal beneficiaries of this change. Operators of relatively short tractor-semitrailers (such as haulers of tank trailers, dump trailers, and containers) would also benefit.

Many states currently have more permissive limits on non-Interstate highways than on Interstates. In these states, increasing the bridge formula on Interstates should serve to attract heavy-truck traffic from other roads. The shift of heavy trucks from non-Interstate to Interstate highways would reduce pavement costs to highway agencies, because on a per-vehicle-mile basis, the pavement wear effects of heavy trucks are much less on thicker pavements.

The recommended formula would also cause some operators of heavy three-axle trucks to use four-axle trucks instead. The shift from three-axle trucks to four-axle trucks would be beneficial to pavements, because four-axle trucks cause less pavement wear per ton of freight carried. This shift would occur because the recommended formula provides a greater incentive to add an axle than the current formula. For example, under the current bride formula, 22-ft-long, three-axle trucks can operate at 52,500 lb and 22-ft-long, four-axle trucks can operate at 56,500 lb, a difference of 4,000 lb. Under the recommended bridge formula, the three-axle truck would be controlled by axle weight limits to 54,000 lb (20,000 lb on the single axle and 34,000 lb on the tandem axle) and the four-axle truck could operate at up to 70,000 lb (depending on its axle spacings), a difference of 16,000 lb.

Replacing the current bridge formula with the recommended formula would increase the number of bridges that must be posted or replaced. Currently, about 120,000 of the nation's 600,000 bridges are posted. If all states adopted the recommended bridge formula on all their highways, the number of posted bridges would increase by about 22,000—4,000 on primary highways and 18,000 on nonprimary highways. On an annual basis, the cost to reconstruct all 22,000 bridges would be about $350 million a year.

As a practical matter, many states would choose to post rather than reconstruct some of these bridges (particularly those on low-volume nonprimary highways). Whereas posting results in lower bridge costs to highway agencies, it also increases the circuitry of travel for heavy trucks and might make the use of certain heavy trucks impractical because they cannot conveniently reach their destinations. Thus, if highway agencies posted rather than reconstructed many bridges, both truck cost savings and the added costs for bridges should be reduced.

In summary, the committee found that, even with a cautiously high estimate of the added bridge costs, adoption of the recommended bridge formula by all states would result in a new savings of over $2 billion per year and would reduce congestion and accidents involving heavy trucks.

The impact analyses conducted for this study indicate that increases in weight limits beyond the recommended formula would, more likely than not, result in additional savings; however, the committee's ability to anticipate all the important consequences of such increases is limited. The bridge formula recommended here is the result of striking a balance between the objectives of maximizing net savings and minimizing uncertainty about the consequences of changes in limits.

Recommendation 2: Special Permit Programs

Congress should broaden the process for exemptions so that it would not be necessary for states to claim grandfather exemptions in order to permit vehicles to operate over the federal gross weight limit of 80,000 lb. Rather, all states should be allowed to establish permit programs for heavier vehicles, provided that such programs included provisions to control the characteristics and operations of permit vehicles. Key features of the special permit programs would be designated routes, maximum weights, fee structures, and safety restrictions for permit vehicles.

- ***Designated Routes.*** States should designate routes over which permit vehicles may operate, and all bridges on proposed routes should be checked to ensure that they can accommodate permit vehicles.
- ***Maximum Weights.*** The maximum weight for permit vehicles over 80,000 lb should be no greater than that given by the current federal bridge formula for vehicles with up to nine axles. How the new bridge formula given in Recommendation 1 could be combined with the current formula for vehicles over 80,000 lb is shown in . . . Table ES-3. States with grandfather exemptions that currently allow vehicles to operate over federal axle limits or at weights greater than those shown in Table ES-3 should be allowed to continue to do so only if they meet other requirements of the special permit process.
- ***Fee Structures.*** States should establish fee structures for permits that are adequate to cover any increase in highway agency costs resulting from permit vehicles and all costs associated with administration and enforcement of permit programs.

TABLE ES-3 Recommended Bridge Formula Limits for Axle Groups

Axle-Group Length (ft)	Maximum Weight (kips), 3 or More Axles	Axle-Group Length (ft)	Maximum Weight (kips)		
			5–6 Axles	7 Axles	8 Axles
8	42.0	37	80.5	81.5	87.0
9	44.0	38	81.0	82.0	87.5
10	46.0	39	81.5	83.0	88.5
11	48.0	40	82.0	83.5	89.0
12	50.0	41	82.5	84.0	89.5
13	52.0	42	83.0	84.5	90.0
14	54.0	43	83.5	85.0	90.5
15	56.0	44	84.0	85.5	91.0
16	58.0	45	84.5	86.5	91.5
17	60.0	46	85.0	87.0	92.5
18	62.0	47	85.5	87.5	93.0
19	64.0	48	86.0	88.0	93.5
20	66.0	49	86.5	88.5	94.0
21	68.0	50	87.0	89.0	94.5
22	70.0	51	87.5	90.0	95.0
23	72.0	52	88.0	90.5	95.5
24	74.0	53	88.5	91.0	96.5
25	74.5	54	89.0	91.5	97.0
26	75.0	55	89.5	92.0	97.5
27	75.5	56	90.0	92.5	98.0
28	76.0	57	90.5	93.5	98.5
29	76.5	58	91.0	94.0	99.0
30	77.0	59	91.5	94.5	99.5
31	77.5	60	92.0	95.0	100.5
32	78.0	61	92.5	95.5	101.0
33	78.5	62	93.0	96.0	101.5
34	79.0	63	93.5	97.0	102.0
35	79.5	64	94.0	97.5	102.5
36	80.0	65	94.5	98.0	103.0
		66	95.0	98.5	103.5
		67	95.5	99.0	104.5
		68	96.0	99.5	105.0
		69	96.5	100.5	105.5
		70	97.0	101.0	106.0
		71	97.5	101.5	106.5

NOTE: Axle Group Length is the distance between the extremes of any group of three or more consecutive axles. Maximum weights over 80,000 lb are permitted only under special permit on designated routes. All vehicles are also subject to a single-axle limit of 20 kips and a tandem-axle limit of 34 kips. (1 kip = 1,000 lb.)

		Maximum Weight (kips)			
9 or More Axles	Axle-Group Length (ft)	5–6 Axles	7 Axles	8 Axles	9 or More Axles
93.0	72	98.0	102.0	107.0	112.5
93.5	73	98.5	102.5	107.5	113.0
94.0	74	99.0	103.0	108.5	113.5
94.5	75	99.5	104.0	109.0	114.0
95.0	76	100.0	104.5	109.5	115.0
95.5	77	100.5	105.0	110.0	115.5
96.0	78	101.0	105.5	110.5	116.0
97.0	79	101.5	106.0	111.0	116.5
97.5	80	102.0	106.5	111.5	117.0
98.0	81	102.5	107.5	112.5	117.5
98.5	82	103.0	108.0	113.0	118.0
99.0	83	103.5	108.5	113.5	118.5
99.5	84	104.0	109.0	114.0	119.5
100.0	85	104.5	109.5	114.5	120.0
100.5	86	105.0	110.0	115.0	120.5
101.5	87	105.5	111.0	115.5	121.0
102.0	88	106.0	111.5	116.5	121.5
102.5	89	106.5	112.0	117.0	122.0
103.0	90	107.0	112.5	117.5	122.5
103.5	91	107.5	113.0	118.0	123.0
104.0	92	108.0	113.5	118.5	124.0
104.5	93	108.5	114.5	119.0	124.5
105.0	94	109.0	115.0	119.5	125.0
106.0	95	109.5	115.5	120.5	125.5
106.5	96	110.0	116.0	121.0	126.0
107.0	97	110.5	116.5	121.5	126.5
107.5	98	111.0	117.0	122.0	127.0
108.0	99	111.5	118.0	122.5	127.5
108.5	100	112.0	118.5	123.0	128.5
109.0	101	112.5	119.0	123.5	129.0
109.5	102	113.0	119.5	124.5	129.5
110.5	103	113.5	120.0	125.0	130.0
111.0	104	114.0	120.5	125.5	130.5
111.5	105	114.5	121.5	126.0	131.0
112.0					

• ***Safety Restrictions.*** States should use the permit process aggressively to promote safety by establishing restrictions on permit vehicles and vehicle components and by revoking the permits of carriers with serious or repeated safety violations. FHWA and the National Highway Traffic Safety Administration should review their current regulations and establish additional regulations as necessary to ensure that vehicles operating under the permit programs would contribute to improved highway safety. Specific topics to be considered in establishing special safety regulations for permit operations include the following:

– Power requirements for acceleration and hill climbing;
– Driver qualifications;
– Accident reporting and insurance requirements;
– Braking systems;
– Connecting equipment such as fifth wheels, pick-up plates, kingpins, and hitch connections; and
– Axle width, tires, and rims.

FHWA should work with states and the trucking industry to establish a review and approval process for state permit programs to ensure that (a) permit fees are commensurate with added highway costs, (b) safety regulations for permit vehicles are implemented, and (c) strict revocation procedures are in effect for permit holders who violate the terms of their permits. Congress should enact legislation to authorize this expanded role for FHWA.

One of the key findings of this study is that, although grandfather exemptions provide substantial benefits to the economy of a state through the use of more productive vehicles, the grandfather test itself is an arbitrary and inequitable means for determining such exemptions. This recommendation would allow states that cannot claim grandfather exemptions to establish permit programs for these more productive vehicles operating over the 80,000-lb federal limit on gross weight.

The committee recommends a permit process rather than simply the elimination of the 80,000-lb limit for several reasons:

• Most states that currently allow vehicles over 80,000 lb under grandfather exemptions do so only under special permit programs, with designated networks for permit vehicles.
• A permit process with a carefully designed fee structure provides a mechanism for covering possible increases in pavement or bridge costs caused by heavier vehicles.

• Permit processes strengthen the hand of the state in enforcing weight and safety regulations. They give states considerable latitude to impose special conditions to make enforcement easier (e.g., special markings on vehicle) and permits can be revoked for repeated or severe violations.

• Permit processes allow states to require safety-related improvements to vehicle components as a condition for using more productive trucks.

• If the 80,000-lb limit were eliminated, five-axle doubles could operate at up to 92,000 lb, depending on their length. Such vehicles are undesirable at weights over 80,000 lb, because they cause relatively high pavement wear per unit of freight hauled. Under a permit program, these vehicles could be banned or charged higher permit fees commensurate with the damage they add to pavements.

There is a substantial body of experience with permit programs for vehicles over 80,000 lb, with limits very similar to those called for by the committee. Currently, 13 western states have permit programs for vehicles over 80,000 lb, with weights controlled by the federal bridge formula and axle limits. Several other states in the East and Midwest allow such vehicles to operate on turnpikes.

To ensure that permit revenues cover added costs, states wishing to establish new permit programs should compile the following information: (a) all routes over which permit vehicles would be allowed to operate, (b) bridge replacements and any other improvements necessary to accommodate permit vehicles on these routes, (c) a schedule and cost estimates for making these improvements, (d) estimates of increases in administrative and enforcement costs due to the program, (e) a fee schedule for permits to be issued under the program by vehicle configuration and operating weight, (f) estimates of permit revenue by year, (g) other changes in highway user revenues expected to result from the permit program (e.g., increases or decreases in fuel tax revenues or registration fees), and (h) a comparison of estimated costs and revenues by year.

Special permit operations for heavier vehicles will have implications for federal highway program costs as well as state costs. Since it is proposed that state permit fees be collected to cover the full costs of added pavement and bridge improvements necessitated by special permit operations, the issue of federal costs must be considered. If the improvements to accommodate permit vehicles continue to be eligible for federal participation, some adjustment to federal cost responsibility

assessments and program apportionments may be necessary to maintain equity.

States with many deficient bridges might face a large up-front cost if they wished to open many routes to permit vehicles. This problem might be addressed in the following ways:

- Initially restrict permit vehicles to routes without deficient bridges and then apply permit revenues as they become available to expand the routes open to permit vehicles.
- Restrict weights for permit vehicles based on an analysis of the load-bearing capacity of individual bridges.
- Institute a temporary increase in existing highway user taxes for heavy trucks (e.g., diesel fuel, registration fees) to build up revenues that could then be used to make improvements necessary to open routes to permit vehicles. Once the improvements have been made and permit revenues have become available, the increase in existing taxes could be rolled back.
- Develop innovative public-private arrangements for funding improvements. For example, carriers might be given a discount on permit fees paid several years in advance. States would then not have to draw on existing revenue sources to advance the money for making the improvements.

Recommendation 3: Grandfather Rights

Congress should take no action to restrict grandfather rights that have already been claimed by states, but should prevent future expansion of these claims.

Many vehicles that can now be operated on Interstates only under grandfather exemptions could, if Recommendations 1 and 2 are adopted by Congress, be operated in all states. For example, the longer combination vehicles (LCVs) that now operate at weights over 80,000 lb in those western states with grandfather exemptions to the federal gross weight limit could operate in any state that chose to establish a permit program for such vehicles. Nonetheless, the implementation of Recommendations 1 and 2 would not completely render moot the issue of grandfather exemptions. Currently, 19 states have axle-weight limits that are exempt under the grandfather clause. Also, several states exempt certain types of vehicles from the bridge formula. For example, Michigan allows vehicles over 80,000 lb that exceed Formula B by a considerable amount, and Arkansas and Pennsylvania apply

Formula B only to vehicles over 73,230 lb. Further, the 1982 Surface Transportation Assistance Act (STAA) increased the latitude of states regarding grandfather claims based on legislation that was effective in 1956 or 1974.

The committee believes that Congress should put a halt to new claims of grandfather rights for weights in excess of federal axle limits and the recommended weights presented in Table D-1. However, a decision by Congress to eliminate grandfather rights that have already been claimed by states could present a hardship to truckers who have purchased equipment to take advantage of these rights and could adversely affect transport costs for commodities that are important to the economies of states. In such cases, the committee believes that the question of whether grandfather clauses should remain in place is best left up to the states themselves.

Recommendation 4: Increased Enforcement

A portion of the revenues from overweight permits should be used to increase efforts to enforce truck weight laws, particularly on non-Interstate highways, which are more susceptible to damage by illegally overweight trucks. These efforts should include more weight enforcement personnel in the field, more use of portable scales, use of weigh-in-motion scales to screen potentially overweight trucks, and higher fines and penalties for repeated offenses.

Congress should ask FHWA to conduct a study directed toward improved enforcement of truck weight laws. The study should address (a) direct enforcement (apprehension and arrest), (b) adjudication and penalties, (c) education of judges and prosecutors, and (d) research and management of enforcement activities. The study should identify specific techniques for improved enforcement and assess these techniques in terms of their impact on the magnitude and frequency of overweight trucks, personnel requirements and other costs to enforcement agencies, and possible burdens on the trucking industry.

Increased enforcement would benefit highway agencies and highway users by decreasing the cost required to repair damaged pavements and bridges. Increased enforcement would also benefit truckers and shippers who operate within weight limits by eliminating the competitive advantage of those who operate illegally. Finally, increased enforcement would reduce the number of accidents caused by dangerously overweight trucks.

Recommendation 5: Regional Cooperation in Standardizing Limits and Permit Practices

States should pursue opportunities for standardizing limits and permit practices at the regional level.

More uniform weight limits and permit practices would simplify the problem of designing, selecting, and loading trucks for use in interstate commerce. Total uniformity is probably not practical, given regional variations in commodities carried, terrain, density, and highway and bridge design. Nonetheless, there are important opportunities for standardizing limits and permit practices at the regional level.

Good examples of past efforts along these lines include (a) ongoing efforts in western states to standardize aspects of the special permits allowing operation of LCVs and (b) an agreement by New England states to implement a common set of procedures for issuing oversize and overweight permits for trucks engaged in interstate transport of nondivisible loads.

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