

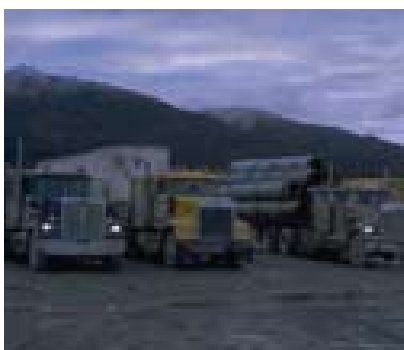
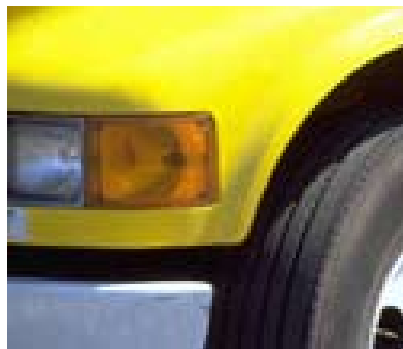


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June 2002

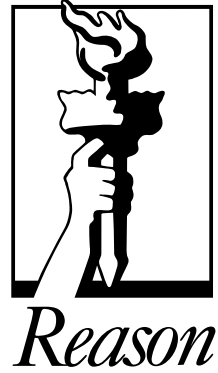
TOLL TRUCKWAYS: A NEW PATH TOWARD SAFER AND MORE EFFICIENT FREIGHT TRANSPORTATION

By Peter Samuel, Robert W. Poole, Jr., and José Holguin-Veras
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POLICY
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Toll Truckways: A New Path Toward Safer and More Efficient Freight Transportation

BY PETER SAMUEL, ROBERT W. POOLE, JR., AND JOSÉ HOLGUIN-VERAS

Executive Summary

The United States needs a fresh approach to long-distance inter-city trucking. The current system, which integrates large trucks and smaller passenger vehicles in mixed traffic lanes, leads to frequent conflicts between cars and trucks. It also unduly limits the potential productivity of long-haul trucking.

This policy study offers a viable alternative: self-financing toll truckways. These toll truckways would consist of one or more lanes in each direction for sole use by large trucks, separated from existing lanes by concrete barriers, and generally equipped with their own ingress and egress ramps. These truck “freeways-within-the-freeway” would be custom-built and designed for use by longer and heavier trucks, which would have exclusive rights to the lanes, and would keep the general motoring public free from exposure to big rigs in the mixed-traffic lanes. If permitted by the 2003 reauthorization of the federal surface transportation program, the first toll truckways could be in service by the end of the decade.

In August 2000, the U.S. Department of Transportation (DOT) published its Truck Size and Weight Study. That study documented the significant productivity gains (net savings of between \$10 billion and \$40 billion per year) which would be possible if longer combination vehicles (LCVs) were permitted on more of America’s major highways. Since those heavier LCVs can cause significantly greater wear and tear on the highways, pavement and bridges would have to be improved to accommodate heavier loads. The DOT’s Truck Size and Weight Study included an estimate of the costs of rebuilding major portions of the Interstate system to handle heavier trucks. Unfortunately, the DOT did not reach any conclusions regarding the safety implications of allowing longer and heavier trucks to use the nation’s highway system.

This report suggests a new approach. The DOT’s estimate of the cost of upgrading the infrastructure to accommodate heavier loads assumed that *all* travel lanes on the affected highways would have to be improved. This study suggests that, rather than rebuilding all lanes, federal and state governments should

authorize only specialized truck lanes which would be designed for exclusive use by large trucks. This approach would significantly reduce the amount of money it would take to improve the nation's highways in order to accommodate greater use of LCVs. Moreover, if large trucks were separated from automobiles and smaller vehicles as this study suggests, safety would actually increase along with transportation efficiency.

The quantitative analysis in this study assesses the costs of developing and operating such specialized truckways along existing Interstate rights-of-way (*e.g.*, in currently unused medians). The estimated productivity gains in this study are modeled on the assumption that LCVs and other heavy trucks would operate on such dedicated truckways and not in mixed traffic lanes. The analysis assumes that trucking firms would be willing to pay a toll of up to one-half of the cost savings that would be generated from the use of such truckways. The analysis concludes that toll truckways of the kind proposed in this study would be self-supporting and could even yield commercial rates of return. Thus, it is possible that some could be developed as private business ventures, in cooperation with state departments of transportation.

The study recommends that, since trucks using the truckways would pay tolls to cover the costs of building and operating the lanes, those trucks should not be charged ordinary state or federal fuel taxes or other truck user taxes for the miles they actually drive on the truckways. The same electronic toll-collection system used on the truckways could be used to record the miles driven and would provide the information required to rebate state and federal user taxes. After factoring in the rebate of user taxes, the net cost of using the truckways would, in many cases, be comparable to the current expenses heavy trucks incur using existing turnpikes.

Several policy changes are required before toll truckways could be implemented. The most important of these changes include: (1) providing a right-of-way along existing highway corridors on the federal-aid system; (2) easing current federal truck size and weight regulations for trucks using the truckways; and (3) providing a rebate of federal and state truck user taxes for miles driven on toll-supported truckways.

Table of Contents

- Introduction 1
- Current Truck Regulation and DOT’s Truck Size and Weight Study 3
 - A. Context 3
 - B. Brief History of Size and Weight Regulations 5
 - C. DOT’s Truck Size and Weight Study..... 7
 - D. A Better Approach 9
- Safer and More-Productive Trucking in Canada and Australia 10
 - A. Canada: Tridem Doubles Nationwide 10
 - B. Australia: B Doubles and Triples..... 12
 - C. Conclusion 14
- Toll Truckway Feasibility Analysis 15
 - A. Introduction..... 15
 - B. Pavement Design..... 16
 - C. Productivity Analysis 17
 - D. Feasibility Analysis 20
 - E. Summary..... 23
- Implementation of Toll Truckways 24
 - A. Configuration and Construction..... 24
 - B. Tolls vs. Taxes 25
 - C. Impact on Highway Trust Funds 26
 - D. Regulatory Oversight..... 28
 - E. New Technology..... 28
 - F. Toll Truckway Scenarios..... 29
- Policy Recommendations 32
 - A. Overview..... 32
 - B. Rationale 32
 - C. Specific Policy Provisions 33
- About the Authors 35
- Acknowledgments 35
- Other Relevant Reason Foundation Policy Studies 36
- Endnotes 37

Part I

Introduction

America needs a safer and more efficient freight transportation system. In 1998, the most recent year for which statistics are available, highway crashes involving trucks resulted in nearly 5,000 deaths¹. Yet safety and higher productivity need not be mutually exclusive. The current system leads to frequent conflicts between cars and trucks, due to their inherently different operational characteristics. The key to improving truck safety while increasing productivity and reducing costs is a redesigned national freight transportation system that exploits the comparative advantages of various modes of transportation.

Given the importance of safety and the need to protect the highway infrastructure, a regulatory regime that specifies vehicle sizes, weights, and configurations is appropriate. The current regulatory regime, however, is not the result of rational policymaking but is instead the byproduct of ad hoc amendments to disparate state regulations that date back to the days when the trucking industry was composed primarily of local and intrastate/short-haul trips. Today 75 percent of road freight ton-miles and more than half of the value of goods transported by truck crosses state lines.² Shipping costs comprise more than 5 percent of the cost of all goods and services produced in the United States. The bulk of those costs come from truck charges: trucks deliver 90 percent³ of the value of U.S. freight every year and truck charges now exceed \$610 billion annually.⁴ Those charges are passed through to consumers and businesses as part of the prices for everything from food, clothing, and consumer goods to construction, manufacturing, and exports. If the trucking industry is to compete in the new era of “just-in-time” deliveries, the current regulatory regime must be modernized. Deregulation was the principal source of cost reductions in the trucking industry over the past 20 years, and a highly competitive trucking industry now exists. Improvements in productivity will, therefore, have to come from some place else.

There are two diametrically opposed views with respect to regulatory reform of trucking. On the one hand, a powerful coalition including railroads, consumer groups, and environmental advocates wants to freeze, if not reduce, truck sizes and weights. On the other hand, trucking groups and many of the shippers and businesses they serve, seek lower shipping costs via larger trucks that can move greater amounts of freight more efficiently. Trucking advocates argue that safety and productivity could be improved simultaneously by concentrating freight loads in fewer but heavier vehicles.

The anti-larger-truck group draws its strength from the fact that most motorists dislike driving alongside large trucks and from concerns that large trucks are a safety hazard. Many state and federal officials also oppose liberalized truck limits on the grounds that larger trucks will cost more in terms of highway maintenance and construction. Many of those in the other camp advocate increasing the federal gross vehicle weight limit from the current 80,000 lbs. to 97,000 lbs. They would apply these new limits in mixed-traffic lanes in every state.

There is an unbridgeable chasm between these two positions. A way forward is needed which remedies each side's concerns, improving safety and productivity. The anti-larger-truck camp needs a solution that credibly offers greater protection from car-truck accidents. And the pro-larger-truck camp needs a solution that permits it to cut shipping costs by running larger, more economical rigs.

This policy study provides a way around the impasse: self-financing inter-city toll truckways. These would mostly consist of a lane in each direction (plus passing lanes) for trucks-only, separated from the existing lanes by concrete Jersey barriers, and equipped with their own access/egress ramps. These truck "freeways-within-the-freeway" would be custom-designed for longer and heavier trucks, which would be restricted to the separated truckways. On the truckways, truckers would have direct access to contiguous staging yards. In these simple truck parking lots, longer vehicles could be made up into doubles from single trailers brought in via local roads. Longer combinations ending their journey would park one of the trailers before proceeding onto local roads for a return shuttle trip with the second trailer.

The first function of toll truckways would be to extend the economies of operating Longer Combination Vehicles (LCVs) beyond the western states⁵ and the turnpike states⁶ on new routes or into adjacent states on a corridor-by-corridor basis at the discretion of states.

The second function of the toll truckways would be to encourage the development of a highway system geared toward safer, more productive trucks. These next-generation trucks would likely be designed to provide more stability and load capacity. They might also be designed for greater weight and speed. The truckways would also allow the development of advanced technologies that could be used to improve the ability of trucks to stay within lanes and to keep a safe distance from other vehicles.

This study is not an exhaustive treatment of truckways, but is intended to set the stage for reform during the 2003 reauthorization of the federal surface transportation program. The report is organized as follows:

- Part 2 reviews DOT's efforts to improve trucking regulation with its Comprehensive Truck Size and Weight Study;
- Part 3 surveys the trucking reform experience in Canada and Australia, two countries where higher-productivity trucking has been encouraged;
- Part 4 analyzes a model of inter-city toll truckways, assessing their construction and operating costs, and predicts the likely toll rates that would be needed and the productivity gains that could be expected;
- Part 5 addresses a number of implementation issues, such as design configuration and tolling issues; and
- Part 6 suggests what needs to be done to make toll truckways a reality in the United States, by explaining the specific federal policy changes that would be required.

Part 2

Current Truck Regulation and DOT's Truck Size and Weight Study

A. Context

On August 31, 2000, the U.S. DOT delivered its *Comprehensive Truck Size and Weight Study*, often referred to as the “Size and Weight Study,” to Congress.⁷ The report presented the results of a comprehensive, decade-long examination of the issues surrounding federal truck size and weight regulations and the potential impact of changes to those limits. It was the first comprehensive truck size and weight study published by the Department since 1981, though the Transportation Research Board and other agencies have since conducted smaller studies on various specific aspects of truck size and weight regulation.

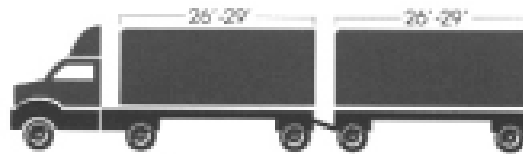
Truck configurations in the United States are a reflection of the layers of state and federal laws and regulations that govern the trucking industry. These laws and regulations are more the product of shifting political realities than the product of rational public policymaking. Figure 2-1 illustrates the principal configurations of the truck combinations currently permitted on American highways. Only the first two, the “tractor/semi-trailer” and the “short (STAA) double” are permitted throughout the entire 200,000 miles of the National Network. Types three through six are restricted to their existing routes in mountain and western states and on turnpikes, as previously noted.⁸

The term “tractor” refers to the forward unit of the vehicle—including the engine, cab, and the low rear with the attachment point for towing a trailer or semi-trailer. A “semi-trailer” is supported at the front by the tractor and at the rear by one or more axles of its own. A full “trailer” has axles front and rear. The Federal Highway Administration (FHWA) designates truck combinations by the number of axles and type of trailer. Thus, the first type shown in the figure has a three-axle cab and a semi-trailer with two axles: 3-S2. The STAA double has a two-axle tractor pulling one semi-trailer and one trailer, hence: 2-S1-T2. The other designations are self-explanatory.

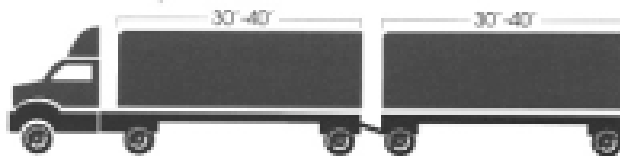
Figure 2-1: Current U.S. Truck-Trailer Combinations



Standard Tractor - Semitrailer



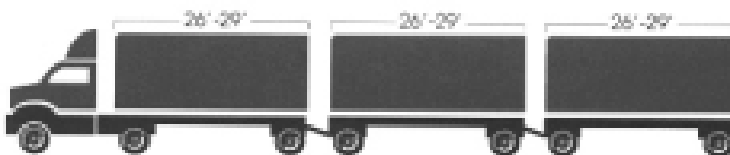
STAA Double



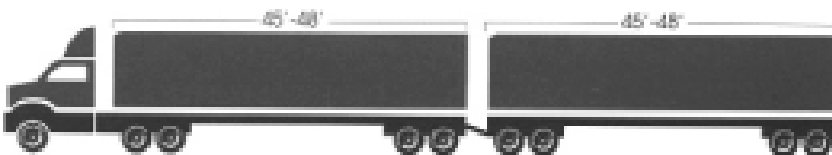
Intermediate Double



Rocky Mountain Double



Triple



Turnpike Double

Source: Western Highway Institute

B. Brief History of Size and Weight Regulations

Regulation of the trucking industry in the United States began at the state level in the 1910s. At that time, only automobiles used pneumatic tires, and trucks generally operated on solid steel wheels that ruined even the toughest pavement. By the late 1920s, every state had weight restrictions and other truck regulations designed to protect the roads. For the most part, these regulations developed piecemeal and varied from state to state.

The federal government began regulating the trucking industry in 1956 to protect its investment in the Eisenhower National System of Interstate and Defense Highways (the “Interstate highway system”). The Federal Aid Highway Act of 1956 (the “1956 Act”) established the first uniform federal weight and size restrictions for interstate trucking. Trucks were limited to 18,000 lbs. gross vehicle weight per single axle and tandem axles to 32,000 lbs., with an overall limit of 73,280 lbs. gross vehicle weight. The 1956 Act included a “grandfather clause” which provided that the federal weight limits would not apply to trucks in states which permitted truck weights that exceeded the federal standards. The 1956 Act also imposed certain size restrictions on trucks using the Interstate highway system: all trucks were limited to a width of eight feet, while length and height restrictions remained subject only to state law. Height limits vary under state law, with the most common restriction being 13.5 feet in the east and 14 feet in the south and west. The 1956 Act left to the states the responsibility for enforcing these restrictions and for granting permits to those trucks exceeding the weight and length restrictions.

In response to the oil crisis of the early 1970s, Congress in 1975 increased the weight limits as a means of compensating trucking companies for soaring diesel fuel bills. The weight limit for single axles went to 20,000 lbs., for tandem axles to 34,000 lbs., and the overall weight limit to 80,000 lbs. gross vehicle weight. Congress also increased the width restriction from eight feet to 8.5 feet. These 1975 increases are the only increases in federal truck size and weight limits Congress has enacted since it launched the Interstate system in 1956.

In 1982, Congress enacted the Surface Transportation Assistance Act (“STAA”). Among other things, the STAA required states to adopt the federal weight limits on Interstate highways and required them to allow trucks with certain minimum dimensions on the National Network. Specifically, the STAA required states to allow tractor/semi-trailer combinations with a 48-foot long semi-trailer and twin-trailer combinations with 28-foot trailers to operate on the National Network.

In 1991, Congress enacted the Intermodal Surface Transportation Efficiency Act (“ISTEA”). Among other things, ISTEA froze state regulations with respect to Longer Combination Vehicles (“LCV”)⁹ as of June 1, 1991. That is, ISTEA prohibited any modification of truck size and weight limits and prohibited extension of the roads on which LCVs were permitted to operate. Although the regulatory freeze in ISTEA does not affect LCVs operating on non-interstate portions of the National Network, as a practical matter most trucking companies are affected by the freeze because most trucks use an Interstate highway for at least part of their trip.

Many regulations spring from the recognition that truck size and weight limits have a direct bearing on the costs of maintaining highway infrastructure, particularly on the costs associated with repairing and maintaining the pavement and on the costs of building and repairing bridges. Yet, gross vehicle weight is not the most important contributor to pavement deterioration. Rather, pavement deterioration is caused by a combination of factors, including, primarily, axle weight loading but also (1) axle configurations; (2) tire width; (3) tire pressure; and (4) suspension characteristics. These latter four factors are essentially unregulated. Moreover, pavement-friendly three-axle combinations, called tridems, are not taken into account in federal regulations, even though they can greatly spread loads and preserve pavement as compared to a tandem axle group.

Bridge construction and repair are also directly affected by truck weight and size regulations. Bridge stresses caused by vehicles depend on gross vehicle weight and the distances between the axles. Trucks having equal weight but different wheelbases produce different bridge stresses: the shorter the wheelbase, the greater the stress.¹⁰ The federal truck size and weight regulation designed to protect bridges is based upon a bridge formula.¹¹ Adopted in 1975; the bridge formula protects bridges by restricting the maximum weight allowed on any group of consecutive axles based upon the number of axles in the group and the distance from the first to the last axle.¹² Since the bridge formula protects bridges, and axle load limits protect pavement, gross weight restrictions are unnecessary and therefore redundant. Moreover, gross weight restriction are ineffective from a safety perspective. A 4,000 pound automobile will be destroyed in any collision with a large truck, regardless whether the truck weighs 80,000 pounds, 97,000 pounds, or 150,000 pounds. To make highways safer, policymakers should shift their focus from weight and size restrictions to policies that will actually yield safety benefits, including (1) separating automobiles and trucks wherever possible; (2) producing trucks that are more stable and which have better handling; (3) allowing more efficient combinations that will increase productivity and which provide a revenue stream that can fund improved safety; and (4) helping truck drivers become safer and more productive through high technology.

The relaxation of gross vehicle weight limits on the proposed toll truckways is essential to making highways safer while improving truck productivity. With more reasonable weight limits, freight could be moved more efficiently using fewer large trucks, which would, in turn, improve safety by reducing the number of trucks on the highways. The reduction in the number of trucks using the highways would also reduce the wear and tear on the highway infrastructure. As Table 2-1 suggests, the movement of 500,000 pounds of freight between two points would take:

- 10 regular five-axle tractor/semi-trailer trips;
- 8 trips by a Canadian-style six-axle tractor/semi-trailer (three axles on the tractor plus three axles on a tridem semi-trailer);
- 7 trips by Rocky Mountain double;
- 6 trips by a Canadian B double or a U.S. triple trailer, and
- 5 trips by a turnpike double.

| | Tractor/ semi- trailer | STAA double | Canada tridem/ semi | Rocky Mountain Double | Turnpike Double | Triple | Canada B-double |
|--|------------------------------|----------------|---------------------------|-----------------------------|--------------------|------------|--------------------|
| Configuration | 3-S2 | 2-S1-T2 | 3-S3 | 3-S2-T2 | 3-S2-T4 | 2-S1-T2-T2 | 2-S3-S2 |
| | 5-axle | 5-axle | 6-axle | 7-axle | 9-axle | 7-axle | 8-axle |
| Trailers (ft) | to 53 ft | 2x28 ft | 48 ft | 48 + 28ft | 2x48ft | 3x28ft | 2x32ft |
| Gross wt. (000lbs) | 80 | 80 | 97 | 119 | 148 | 132 | 132 |
| Empty wt. (000 lbs) | 30 | 30 | 33 | 43 | 47 | 44 | 38 |
| Payload (000 lbs) | 50 | 50 | 64 | 76 | 101 | 88 | 94 |
| Payload Ratio (relative to tractor/semi) | 1.00 | 1.00 | 1.28 | 1.52 | 2.02 | 1.76 | 1.87 |
| Trips to move 500,000-lb | 10 | 10 | 8 | 7 | 5 | 6 | 6 |

C. DOT's Truck Size and Weight Study

The Size and Weight Study contains much valuable research and useful data, but , its usefulness in the debate over trucking policy is limited, since it focuses attention on the politically charged safety issues regarding the largest trucks, but offers no solutions. At the same time, the study fails to highlight the fact that LCVs have a reasonably good safety record. For example, it fails to mention that Rocky Mountain and turnpike doubles, as well as U.S. triples operating in the mountain states and on turnpikes, have fatality and accident rates per vehicle mile which are comparable to regular tractor/semi-trailers, and they have a better safety record per ton-mile carried.¹³

The fact that these larger trucks generally operate on rural roads and turnpikes makes it difficult to predict how they would operate in more urbanized settings. There is a dearth of data regarding how these larger trucks might perform in the mixed traffic found in heavily-populated states and on more urban and congested interstates. It is true that the relatively good safety record in existing operations does not necessarily mean that they would have a good safety record in a more congested traffic environment. Although the authors of the Size and Weight Study attempted to predict performance in such an environment through modeling and computer simulations, they failed to reach any clear conclusions. The models indicated that moving freight with fewer trucks would provide a safety benefit, but the models also indicated that longer trucks with multiple attachments would have greater difficulty with handling and control. The authors reached no conclusion as to the effect those two (offsetting) factors would have on overall highway safety.

The Size and Weight Study also fails to properly identify the stakes in the debate over truck transportation and railroad transportation. Reforming trucking size and weight regulations will increase productivity and reduce transportation costs. The report suggests that, as larger trucks become more efficient, freight shippers will shift from rail to trucks and that the loss in the rail sector would constitute a “national economic loss.” This makes no sense. If the rail sector becomes less competitive, it should shrink. When a less competitive sector of the economy shrinks in favor of a more efficient sector, that represents economic advancement, not economic loss as the study’s authors suggest. All of this assumes that trucks are properly charged for their proportional use of the nation’s highways, and here there are shortcomings.

Despite the importance of truck fees to the debate between trucking and rail, the Size and Weight Study does not address the issue of truck pricing. Instead, DOT conducted a separate study, entitled the *Highway Cost Allocation Study*¹⁴ (the “Cost Allocation Study”). The Cost Allocation Study concluded that trucks do not pay their proper share of highway costs. Present federal user charges, including diesel taxes, excise taxes on truck purchases, tire taxes, and the tax on trucks over 55,000 pounds gross vehicle weight, generate roughly \$11 billion per year, or about 6.8 cents per mile for combination vehicles. That represents about 80 percent of the costs those trucks impose on the federal highway system.¹⁵ By comparison, automobiles and light vehicles pay approximately 110 percent of the costs they impose.¹⁶ In order to properly allocate resources between heavy trucks and other vehicles, trucks need to be charged rates that accurately reflect the costs they impose. Those increased charges, however, should be accompanied by regulatory reform which would allow truckers to improve productivity. Improved productivity would allow truckers to absorb the increases and to pay their fair share of highway costs without adversely affecting profits.

The Size and Weight Study does not make any recommendations or reach any definitive conclusions, despite having assembled much important new information. In the present policy study, we have extracted some of the most important data and presented it in a format more useful for drawing conclusions and making policy recommendations.

DOT developed five truck size and weight scenarios to illustrate the nature and relative magnitude of the impact on safety, productivity, infrastructure, the environment, traffic operations, and the railroads. The scenarios are characterized by specific vehicles that would likely operate in them, gross weight limits and lengths at which those vehicles would operate, the networks of highways upon which scenario vehicles would operate, and the federal truck weight and size regulations that would apply.¹⁷

Table 2-2 presents data from the five scenarios. We have extracted the estimated annual savings due to using LCVs on rebuilt highway systems. The baseline against which savings are estimated is the current National Network using regular five-axle semi-trailers and short STAA doubles weighing up to 80,000 lbs. gross vehicle weight. The data in the table represent estimated cost savings under the five scenarios, each of which would allow greater use of LCVs and which would require retrofitting *all lanes* of the specified portion of the highway to properly handle the larger and heavier trucks. The five scenarios include:

1. **Uniformity:** Under this scenario, the existing “grandfather” provisions allowing LCVs in some states would be eliminated and the existing federal size and weight limits would be extended to all 200,000 miles of the National Network. It would require that loads currently carried in long doubles and triples be carried by smaller tractor-trailer combinations.
2. **NAFTA 90K:** Under this scenario, the use of Canadian-style triple-axle (tridem) trailer configurations, with a 44,000 lb. tridem axle-loading and a total gross vehicle weight of 90,000 lbs., would be permitted on the National Network. Under this scenario, the use of B doubles of up to 124,000 lbs. gross vehicle weight would also be permitted.
3. **NAFTA 97K:** Under this scenario, the use of tridem trucks, with loads of up to 51,000 lbs. and a total weight of 97,000 lbs. gross vehicle weight, would be permitted on National Network. This would permit fully loaded international containers to be carried on tridem semi-trailers.
4. **LCVs Nationwide:** Under this scenario, the LCV freeze imposed by ISTEA would be lifted and Rocky Mountain doubles weighing up to 120,000 lbs. gross vehicle weight and turnpike doubles weighing up to 148,000 lbs. would be permitted on nearly all 42,500 miles of the Interstate highway system in the continental United States. The scenario proposes staging areas for trailers on the Interstates so that LCVs would not have to travel on local roads.
5. **Triples Nationwide:** Under this scenario, triples up to 132,000 lbs. gross vehicle weight would be permitted on a 65,000-mile network, which is about two-thirds of the Interstate highway system, plus state-designated freeways, expressways, and toll roads.

| \$billion/year | Uniformity | NAF90K | NAF97K | LCVs | Triples |
|-----------------------|------------|---------|---------|---------|-----------|
| Shipper savings | -\$6.4 | \$10.9 | \$13.3 | \$26.7 | \$19.8 |
| Congestion saving | -\$1.9 | \$3.2 | \$3.2 | \$8.6 | \$22.4 |
| Total savings | -\$8.3 | \$14.1 | \$16.5 | \$35.3 | \$42.2 |
| Pavement costs | -\$0.4 | -\$0.15 | -\$0.12 | -\$0.02 | no change |
| Bridge capital | -\$1.0 | \$2.5 | \$3.3 | \$2.6 | \$0.8 |
| Bridge u/c congestion | no change | \$2.5 | \$3.3 | \$2.6 | \$0.8 |
| Geometry costs | no change | \$0.01 | \$0.01 | \$0.36 | no change |
| Total costs | -\$1.4 | \$4.84 | \$6.49 | \$5.54 | \$1.6 |
| Net savings | -\$6.9 | \$9.26 | \$10.01 | \$29.76 | \$40.6 |

Table 2-2 presents estimated savings to shippers from the increased productivity permitted by more extensive use of larger combinations, plus savings resulting from reduced highway congestion. From the gross savings, we have subtracted the annualized costs of rebuilding highways and bridges to accommodate heavier loads. We have also estimated congestion costs while the bridges are being reconstructed and the costs of re-aligning curves and easing grades to handle the larger trucks.

Except for the Uniformity scenario, which would reduce productivity by reducing the extent of LCV use, the net annual savings under each scenario are very large. Indeed, each scenario would significantly reduce trucking costs in the United States by between \$10 billion and \$40 billion per year.

There are also significant environmental benefits to be reaped from larger truck combinations, and the data in the Size and Weight Study reflect that. The bigger trucks greatly reduce vehicle miles traveled, fuel consumption, and emissions. Fuel savings are 6.2 percent for tridems, 13.8 percent for LCVs, and 12.8 percent for triples. There would likely be corresponding reductions in exhaust emissions, which would yield significant benefits in the form of cleaner air. The Size and Weight Study concludes: “The estimated reduction of 8 billion miles in heavy commercial truck travel on urban roads (from allowing triples on the postulated national network) indicates that air pollution costs would be reduced in those areas prone to significant air pollution.”¹⁹

D. A Better Approach

DOT’s scenarios assume that all lanes and many bridges on the proposed network would have to be upgraded to new and more costly standards in order to handle the heavier trucks. But it would generally be more economical to build a new truck lane or to convert and upgrade an existing lane to truck lane status than it would be to upgrade all lanes. For bridges, only the truckway lanes would need to be constructed, rather than having to reconstruct many entire bridges. Established U.S. highway tradition calls for building roads that cater to all motorized vehicles, and this is reflected in the way the Size and Weight Study approached the issue. Concentrations of heavy trucks range from a low of 2 to 3 percent of traffic to a high of 35 percent. On those inter-city highways where trucks constitute 10 percent or more of the traffic on the highway, it would make better sense to provide dedicated truck lanes.

Part 3

Safer and More-Productive Trucking in Canada and Australia

Canada and Australia, which are large and geographically dispersed countries like the United States, have reformed their truck size and weight regulations in ways that have significantly increased the productivity of trucking. In this section, we review the results of regulatory reform in those two countries. The Canadian and Australian experience suggests that the dual goals of improving highway safety and increasing trucking productivity are not mutually exclusive.

Canadian and Australian policymakers understand that, to effectively compete with the United States, they must maximize efficiencies in their trucking transportation systems. At the same time, those policymakers understand that highway safety must remain a top priority. Over the past two decades, Canada and Australia have successfully expanded the use of heavier and longer trucks while improving highway safety. Their experience should yield important lessons for American policymakers as they study options for improving trucking productivity while protecting public safety.

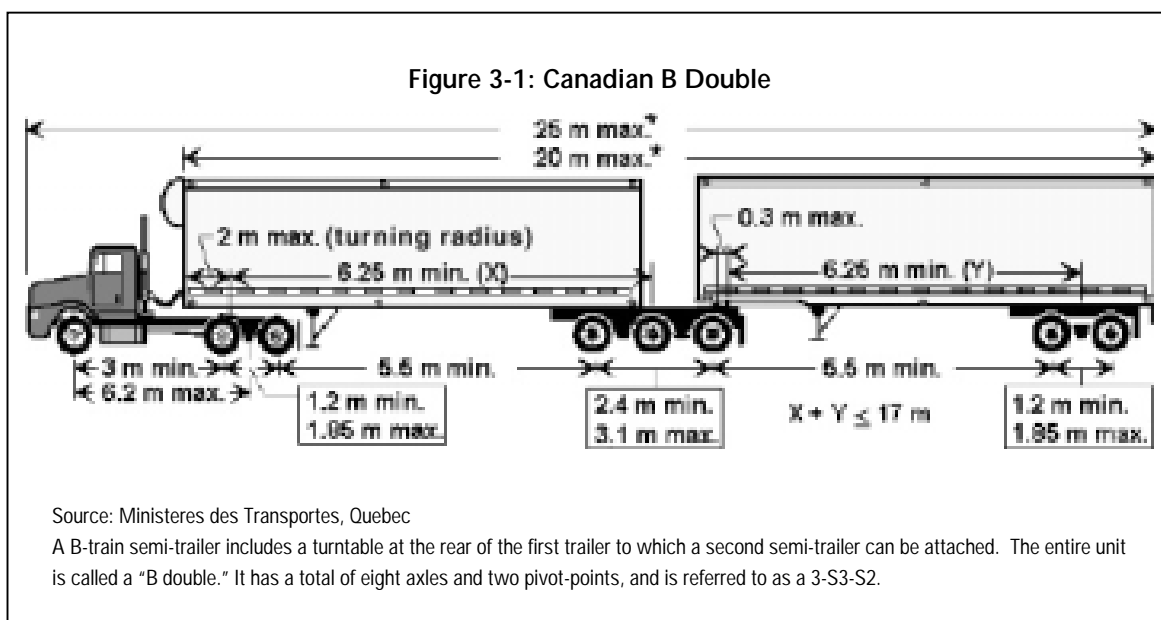
A. Canada: Tridem Doubles Nationwide

The Canadian federal government has relatively little involvement in trucking regulation. Instead, trucking regulation in Canada is left to the 10 provincial and two territorial governments. This fragmented approach to regulation has created significant differences among the provinces and territories. But in recent years, there have been both national and regional efforts to harmonize Canadian trucking regulations.

At the national level, the most significant effort to harmonize trucking regulations occurred in 1999 when a council of transportation ministers from all 12 Canadian jurisdictions reached a Memorandum of Understanding on “inter-provincial weights and dimensions.” The Memorandum of Understanding established a minimum truck size and weight configuration that would be permitted to operate on at least some portion of the highways in every province and territory. Even under the Memorandum of Understanding, however, the extent of access to the provincial highways still varies enormously. For example, Ontario, the most populated province and the most important economically, opened all of its roads and highways to inter-provincial dimensioned trucks. By contrast, Saskatchewan, New Brunswick, and Manitoba permit inter-provincial dimensioned trucks on only a few routes. Quebec used to limit such trucks to main routes, but recently agreed to simplify its permit process which will have the effect of granting inter-provisional dimensioned trucks access to most of its roads and highways. Yet, despite the Memorandum of

Understanding, regional differences remain. Some of the western provinces, for example, recently made special arrangements for oversized and overweight combination trucks which will allow them to operate on special roads with special permits. The eastern provinces, particularly those in the Atlantic region, generally allow heavier axle weights but are more restrictive with respect to truck lengths.

Many Canadian truck reforms date back to the early 1980s. At that time, the Canadian federal government, the 12 provincial and territorial governments, and four trucking organizations funded research at the University of Michigan's Transportation Research Institute and the Centre de Recherche Industrielle du Quebec on the handling properties of LCVs, including the newly-developed "B-train" or B double (see Figure 3-1). The research produced a Vehicle Weights and Dimensions Study (the "VWAD Study"), which was published in December 1986. The VWAD Study concluded (1) that tridem axle groupings were superior to the prevailing tandems and (2) that the use of B-trains was clearly preferable to the conventional full trailer or "A-train" arrangement with a drawbar or pintle hook attachment. The study concluded that the tridem grouping "introduces improved stability" both on a tractor-semi-trailer combination and as the central axle grouping between the twin semi-trailers of a B double. Specifically, the study stated: "Recognizing the safety benefits of reduced exposure which accompanies increased payload capacity plus the high performance, yet simplicity of this vehicle, the eight-axle B-train is looked upon as the closest to ideal configuration of the overall group of vehicles."²⁰ The study also recommended the use of wider trucks—eight and a half feet versus the traditional eight feet—but also recommended a tight limit on maximum truck height. Although its recommendations have not been adopted uniformly, the VWAD Study has had considerable influence on the provincial governments.



Canadian truck regulations also fluctuate with the seasons. Canadian regulations generally reduce the allowable axle weights during the spring thaw when the highways are particularly susceptible to damage. Indeed, during the spring, Canadian axle weights can be lower than they are in the adjacent U.S. states. During the other three seasons, however, Canadian axle weights for tandem axle groupings (such as those found under the rear of the tractor and under the rear of the semi-trailer on a typical 18-wheeler) are between 37,480 lbs. and 39,680 lbs. The federal limit in the United States, by contrast, is 34,000 lbs., while the limit in those states operating under the "grandfather" provisions of the 1956 Act is generally 36,000 lbs.²¹

The disparity between the United States and Canada in the treatment of tridems is striking. No allowance is made in federal size and weight regulations for the superior load-distribution characteristics of tridems. They are used in just a few of the states that operate under “grandfather” status. The tridem loading in most of Canada (as well as in Mexico and Australia) is 49,600 lbs., but in the Maritime provinces is 52,900 lbs. In its Size and Weight Study, DOT modeled a 51,000 lb. tridem axle, since it said this would allow a 40-ft. shipping container to be trucked at full ISO international loading. In some places in the United States, such containers have been exempted from existing limits, but in other places they must gain special permits—or be downloaded to remove 17,600 lbs. of their potential 67,250 lb. load. The low U.S. loading limit is cited as a source of major inefficiency in the large trade in containers between the ports of Seattle and Vancouver.

While Canadian provinces generally permit heavier vehicles than their U.S. counterparts, they impose stricter length regulations. Canadian provinces generally limit overall truck length limit to 82 feet for combination vehicles. U.S. turnpike doubles are typically 114 feet in length and thus are not permitted in Canada. Regular doubles, such as “A-train” doubles, are generally limited to 61 feet in Canada. Thus, Rocky Mountain doubles and turnpike doubles, which generally exceed 90 feet in length, are also prohibited in Canada. Canadian truck drivers favor the closely-coupled B double, which can accommodate a pair of 32 foot trailers. On the open road, the B double is more stable and resistant to turnovers. On ramps, the smaller number of pivot points of the B double reduces “off-tracking,”²² which makes them better able to negotiate narrow ramps and tighter curves. Moreover, when these large trucks are negotiating local streets rather than the open road, their shorter length makes them preferable to the longer U.S. trucks because they can clear intersections faster.

Canadian trucking has benefited from its federal government acting as a facilitator rather than as a decisionmaker about truck sizes and weights. Provincial governments take final responsibility for the difficult trade-off decisions about which roads are designated for what class of heavy vehicles, and where reasonable compromises should be made between trucking economies and infrastructure cost and safety. Reform has come through focused research into vehicle characteristics, collaboration among stakeholders, and agreements among provinces to work for harmonizing their regulatory regimes. Devising regulations to encourage tridem axle groupings and the B double rig has given Canada an edge over the United States in making its trucking safer and more efficient.

B. Australia: B Doubles and Triples

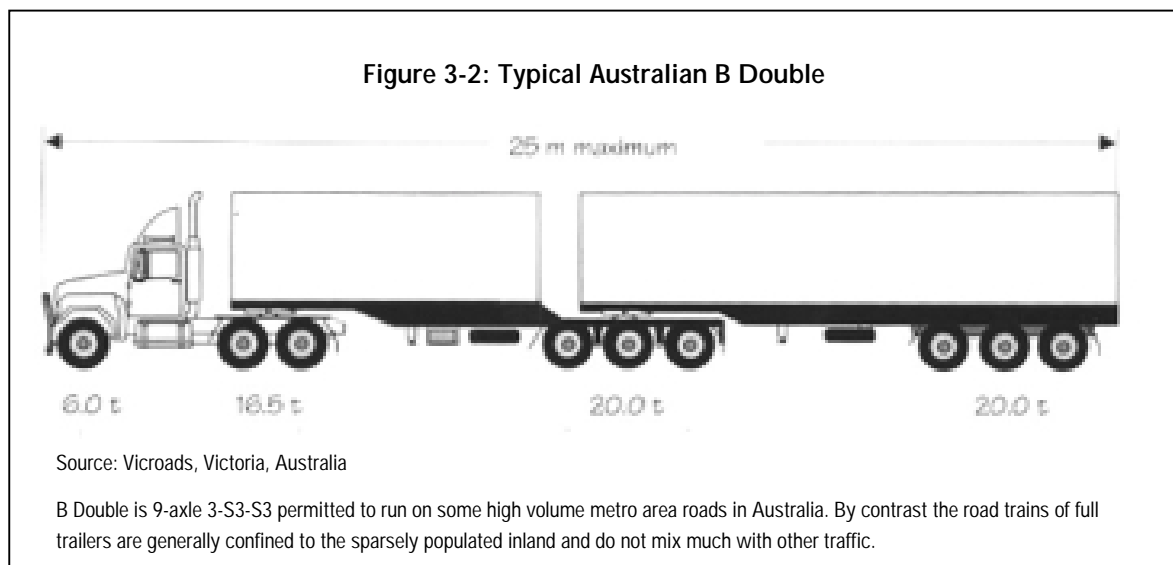
Australia has made great strides in reforming truck size and weight regulations. For more than half a century, Australia has permitted long “road trains” of up to six trailers to operate on “outback” (rural) roads. These road trains were pioneered by entrepreneurs in the outback who operated them on dirt roads in sparsely populated areas. The earliest road trains often traveled at speeds of less than 20 miles per hour. By carrying a large volume of freight with a single truck and driver, road trains played an important part in controlling the cost of wool, meat, fuel, grains, building materials, mineral ores, and other general goods, particularly in remote areas that are equipped with only primitive roads and where the cost of transportation can be significant.

As Australian roads were upgraded and modernized, faster highway speeds became possible, and government policymakers turned their attention to regulating road trains to make them safe for travel at near normal highway speeds. As a result, road trains have been modernized and subjected to the normal user-fee payment system and regulatory framework. That user-fee system and regulatory framework has, for the most part,

allowed road train operators to retain the financial advantage from their efficiencies while also generating revenue for highway maintenance. Safety has also improved. Indeed, road trains have a good safety record.

The Australian development of an extensive network of public roads to accommodate B doubles and triple-trailer road trains is of particular relevance to North American policymakers. Although the B-train form is actually a U.S. and Canadian invention, Australia has over the past 15 years actually put it to much greater use. The Australians have favored the B-train because it connects the trailer closer to the tractor, reducing trailer wander, which provides important safety advantages in heavy and mixed traffic. Indeed, B-trains are much more stable in lateral maneuvers than conventional A-train trailer combinations because a U.S.-type A-train triple will have five pivot points compared with just three on a B-triple. Consequently, B-trains produce much less of what the vehicle engineers call rearward amplification of tractor movement, a kind of whiplash effect on the rear trailer which is caused by a sideways movement such as an abrupt lane change or a maneuver to avoid an obstacle.²³

The Australian B double also has payload capacity advantages over the U.S. turnpike double. An Australian B double, with up to 69 feet of cargo space, has roughly the payload weight capacity of the U.S. turnpike double. The Australian national road network is built to accommodate B doubles, and thus they may be loaded to a gross vehicle weight of 150,000 lbs. The comparable American truck is limited to 80,000 lbs. Australian axle loading limits are also generous. Australian axle-loading limits are 14,800 lbs. for the steering axle, 37,500 lbs. for a tandem axle grouping, and 49,600 lbs. for a tridem grouping. These axle loading limits are only for certified road-friendly suspension systems which are estimated to do 10 to 20 percent less pavement wear than an equivalent amount of weight on a regular suspension.



B doubles have extensive networks available to them in all six Australian states and two territories, including all freeways, tollways, and expressways, and many of the principal arterials in the major metropolitan areas such as Sydney, Melbourne, Brisbane, Adelaide and Perth. B triples were successfully tried out in the state of Victoria (Melbourne) and are now in regular use there. The double and triple road trains also have an extensive network of roads available to them in the Australian outback. Road trains are not allowed many places in the smaller area states such as Victoria and Tasmania, or in the more heavily populated coastal third of New South Wales (NSW) and they are excluded from the major metropolitan areas. Road trains of more than three trailers are operated only on specially designated roads, often quasi-private roads.

Although not without problems, the Australian reforms have been a remarkable accomplishment. Truck accidents have been reduced and safety has improved.²⁴ Costs of maintaining the roads are comparable to the levels they had been prior to the introduction of larger and heavier truck combinations because payloads are distributed over extra axles and truck suspensions have been improved to reduce shock effects. The heavier combinations do increase stress on many bridges, and there is a program to upgrade these to cope with the higher axle group weights. The extra bridge costs, however, are more than offset by lower freight costs.

These advances have all been achieved, surprisingly, without federal legislation or rulemaking. The Australian federal government has delegated truck legislation and regulation to the six state and two territory governments. The National Road Transport Commission (the “NRTC”) oversees truck regulation and has devoted substantial attention to issues such as truck safety, clean air, noise reduction, driver fatigue, and improved trucking productivity.

The NRTC has taken a new approach to its regulatory mission. It has replaced traditional prescriptive standards with performance-based standards. Instead of issuing top-down mandates, regulators have set performance standards that the industry must meet, and the industry decides how best to meet them. Those standards include:

- minimizing trailer “off-tracking” on curves;
- minimum rollover thresholds;
- braking efficiency; and
- stability in evasive maneuvers.

The NRTC estimates that the 1999 increases in truck weights have resulted in economic benefits that far outweigh the costs associated with heavier trucks. The NRTC estimates that the benefits of more liberal weight limits have resulted in economic benefits to the trucking industry of approximately (U.S.) \$279 million per year, plus \$6 million in lower pavement costs for total savings of \$285 million per year. Costs include \$6 million annually for road-friendly suspensions, \$13 million for bridge upgrades, and \$5 million in extra compliance costs for total costs of \$24 million. Net benefits are therefore \$261 million annually, and the benefit/cost ratio is 11.9.²⁵ The more liberal standards are also accompanied by new road user charges to recoup the road wear and improvement costs to the roads, and those costs typically have been recouped in one to two years. Moreover, the more generous weight limits have also been accompanied by requirements to install independently certified road-friendly suspensions and a requirement to provide independent verification of regulatory compliance.

C. Conclusion

The Canadian and Australian reforms suggest the following points:

- 1) The B-train combination vehicle is particularly attractive because it brings improved handling and safety which make it more acceptable to the public than full-trailer combinations.
- 2) A special national network of roads should be dedicated for use by long combination trucks.
- 3) The economic gains from more liberal size and weight restrictions far outpace the costs.
- 4) The public, and even certain special interest groups, will support truck reform efforts provided issues such as safety and the environment are not sacrificed for commercial productivity.

Part 4

Toll Truckway Feasibility Analysis

A. Introduction

How much of a difference in productivity could be realized by making use of longer and heavier combination vehicles on specialized lanes designed for such vehicles? What would it cost to build and operate such truckways? If truckers were charged tolls to cover the costs, how much would they be, and would those tolls be worth truckers' while to pay? And would the economics of such toll truckways be robust enough to entice private capital to finance, build, and operate them? These are the kinds of questions investigated in this section.

One of the coauthors and his colleagues at the City College of New York conducted an estimation of the most relevant economic impact attributed to the implementation of an inter-city toll truckway system. The analysis quantified: (1) costs of developing and operating the truckway (i.e., highway construction, rehabilitation and maintenance); (2) road user costs savings (i.e., fuel savings, wear and tear); and (3) travel time savings. Constraints of limited time and budget prevented the quantification of: (1) changes in environmental emissions resulting from a shift of trucks to the truckway; and (2) changes in the demand patterns.

In general terms, the analysis consisted of three main components:

- 1) **Pavement Design.** In this section of the analysis, pavements were designed for the various scenarios of truckway usage. This enabled the research team to produce a realistic estimation of initial investment, as well as to provide a critical input to the pavement deterioration models.
- 2) **Productivity Analysis.** This part focused on the quantification of the impact that the truckway system would have upon the productivity of truck fleets, measured by the resulting changes in operating costs. This analysis provided critical information about the range of tolls that could be levied from trucks using the truckway system.
- 3) **Feasibility Analyses.** The final stage of the analysis involved estimating the likely feasibility of the proposed toll truckway concept. These analyses relied upon modeling pavement deterioration and estimating the corresponding road user costs. The feasibility analyses considered two major facets: the overall economic feasibility of the project from the systemwide point of view, and the private (financial) feasibility of the project from the standpoint of a private toll truckway developer/operator.

B. Pavement Design

Although the detailed geometric design of the proposed toll truckway is beyond the scope of this exploratory research, the project team conceptualized the key features of the implementation. The analyses modeled an inter-city truckway added to the median of the right-of-way of an existing Interstate highway. The project team assumed the truckways would consist of 24-foot full-depth pavement in each direction allowing the striping of one 12-foot travel lane and 6-foot shoulders on either side. There would be a concrete Jersey barrier in the median to divide the two directions of truck travel and side barriers to separate the truckway traffic from mixed-flow lanes. This provides considerable flexibility and room for a disabled vehicle to be parked while other traffic passes by.

In order to determine the strength requirements for the truckway pavement, the potential heavy truck traffic using the special lanes had to be estimated. The team, therefore, modeled the pavement impacts (as measured by equivalent single axle loadings or ESALs) for five different distributions of the same traffic stream among the total set of lanes on the Interstate (mixed-flow and truckway). The baseline traffic modeled was 40,000 vehicles per day, with 20 percent of them being heavy trucks. This is the kind of traffic that is observed on a major trucking route such as I-35 outside the major metro areas between Dallas and Laredo, Texas. A base case assumed the traffic was all in three mixed-flow lanes on each side, and then examined increasing proportions shifted over to the truckway. Concentrating the heavy traffic in the truckway, as expected, increases the pavement impact substantially. The truckway would receive 193 million ESALs versus 135 million for the mixed lanes in the base case. If all heavy trucks moved out of the mixed traffic lanes, those mixed lanes would be subjected to only 6 million ESALs, dramatically reducing the wear and increasing their useful life.

| Table 4-1: Pavement Designs for the Different Scenarios | | | | | | | | | | |
|---|---------------------|---------------------------------|---------------------|-------------------------------------|-----------------------------|--------------------------|---------------------------------|---------------------|-------------------------------------|-----------------------------|
| Layer properties | | | | | | | | | | |
| Mr = | 7000 Psi | Layer | | | | Structural Coefficient | | | Drainage Coefficient | |
| R = | 90% | Asphalt Concrete | | | | 0.42 | | | 1 | |
| S ₀ = | 0.45 | Asphalt-Treated Permeable Base | | | | 0.23 | | | 1 | |
| P ₀ = | 4.5 | Subbase | | | | 0.12 | | | 0.9 | |
| P ₁ = | 2.5 | Select Granular Subgrade | | | | 0.10 | | | 0.9 | |
| Layer thicknesses | | | | | | | | | | |
| Scenario | <i>One TTW LANE</i> | | | | | <i>Three Mixed Lanes</i> | | | | |
| | ESAL (Millions) | Selected Granular Subgrade (in) | Subbase Course (in) | Asphalt-Treated Permeable Base (in) | Asphalt Concrete Layer (in) | ESAL (Millions) | Selected Granular Subgrade (in) | Subbase Course (in) | Asphalt-Treated Permeable Base (in) | Asphalt Concrete Layer (in) |
| I (base case) | 0 | 0 | 0 | 0 | 0 | 135 | 6 | 12 | 4 | 10 |
| II (25% trucks) | 48 | 0 | 12 | 4 | 9 | 101 | 6 | 12 | 4 | 10 |
| III (50% trucks) | 96 | 6 | 12 | 4 | 10 | 67 | 0 | 12 | 4 | 10 |
| IV (75% trucks) | 145 | 6 | 12 | 4 | 10 | 34 | 0 | 12 | 4 | 9 |
| V (100% trucks) | 193 | 12 | 12 | 4 | 10 | 6 | 0 | 12 | 4 | 6 |

1. Computation of ESAL's is based on NYSDOT "simplified procedure" 1994 manual.

2. FHWA class 1-4 vehicles (motorcycle, cars, SUVs and buses) are ignored. Design is based on class 5-13.

The next step was to come up with a pavement design capable of handling the heavy load. This was done using the DARWIN Pavement Design Computer Software. Table 4-1 shows the basic design features of the pavement designs selected for the four different truckway scenarios—representing the cases in which the truckway attracts 25 percent, 50 percent, 75 percent, or 100 percent of heavy truck traffic. These pavement designs were costed out using current highway construction cost data.

C. Productivity Analysis

The team looked at the productivity changes associated with the revised axle weight for the toll truckways. These productivity analyses focused on assessing the impact that the revised axle load limits would have upon operating costs. These productivity changes, in addition to being a function of the revised axle load limits, are also a function of:

- 1) the current levels of axle load limits, which vary from state to state and determine the baseline condition of operating costs; and
- 2) the type of vehicle.

Since the analytical study of productivity changes for all the resulting combinations is beyond the scope of the project (there are potentially 50 different axle load limits and 15 different basic types of commercial vehicles), the research team decided to focus on a selected set of cases. The productivity increases were calculated for each of the resulting combinations. More specifically, the cases considered were:

- 1) two different levels of current axle load limits (base cases); and,
- 2) two different types of vehicles: the tractor/semi-trailer (3-S2) and the long double--a tractor/semi-trailer/trailer (3-S2-T4) combination.

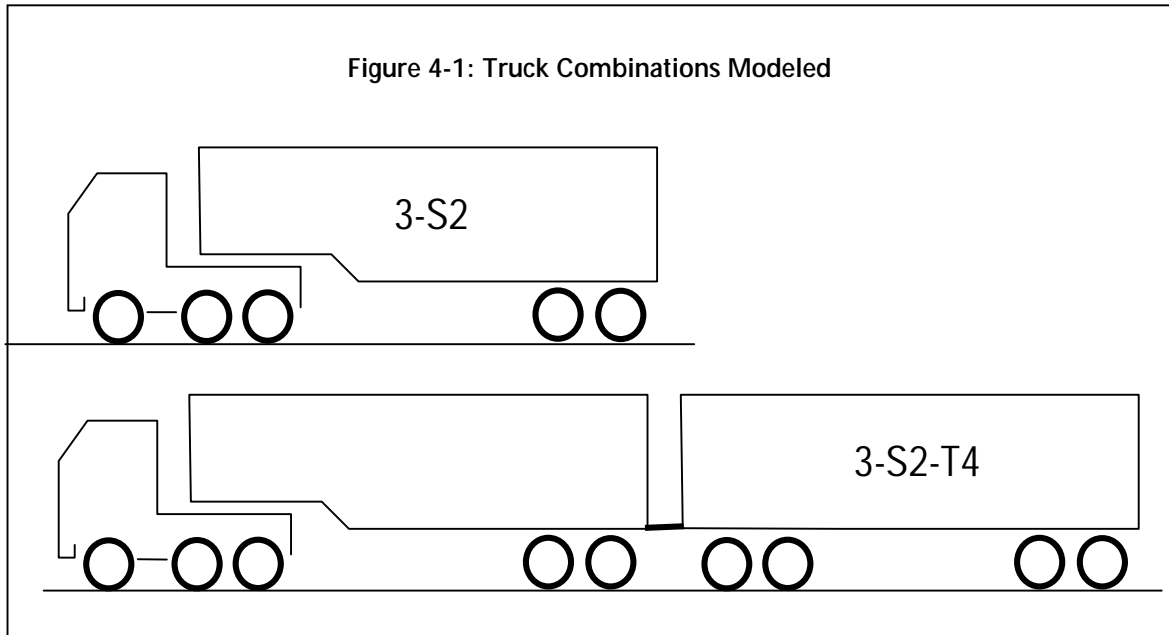
Two base cases were considered: Base Case A (BCA) represents the cases where “tight” gross weight limits have been implemented; Base Case B (BCB) represents the cases where “high” gross weight limits have been enacted. And the case we designate TTW represents the toll truckway scenario. The axle load limits considered in the analyses are shown in Table 4-2. As seen the axle load limits associated with the TTW case are, in essence, 50 percent higher than the higher axle loads allowed in the United States.

| Axle type | Base case A (BCA) | Base case B (BCB) | TTW |
|---------------------------|--------------------|-------------------|--------|
| Single axles - dual tires | 17,680 | 22,100 | 33,160 |
| Tandem axle | 33,160 | 39,780 | 59,680 |
| Tridem axle | (no allowance for) | 53,040 | 79,560 |

Note: Base Case A has a maximum Gross Weight Limit of 80,000 pounds

The project team focused on two important types of vehicles: the 3-S2 and the 3-S2-T4 (see Figure 4-1). The 3-S2 is probably the most widely used truck combination in the United States. For that reason, it is important to examine how it would be affected by the implementation of a toll truckway system. The second combination, 3-S2-T4, was selected because it is one with the largest carrying capacity among the current combinations. By focusing on these two combinations, insights could be gained into the productivity implications of the toll truckway system. In states with “tight” (low) gross weight limits, the availability of a

toll truckway would permit the standard (3-S2) tractor/trailer to carry 115 percent more payload; for states where gross weights are already higher, the truckway would permit that truck to carry 62 percent more payload. For the long double (3-S2-T4), the payload increase in “tight” states would be 492 percent, while in higher gross-weight states, it would increase by 57 percent. Moreover, implementation of the toll truckway concept would likely lead to other truck combinations with capacity larger than the 3-S2-T4.

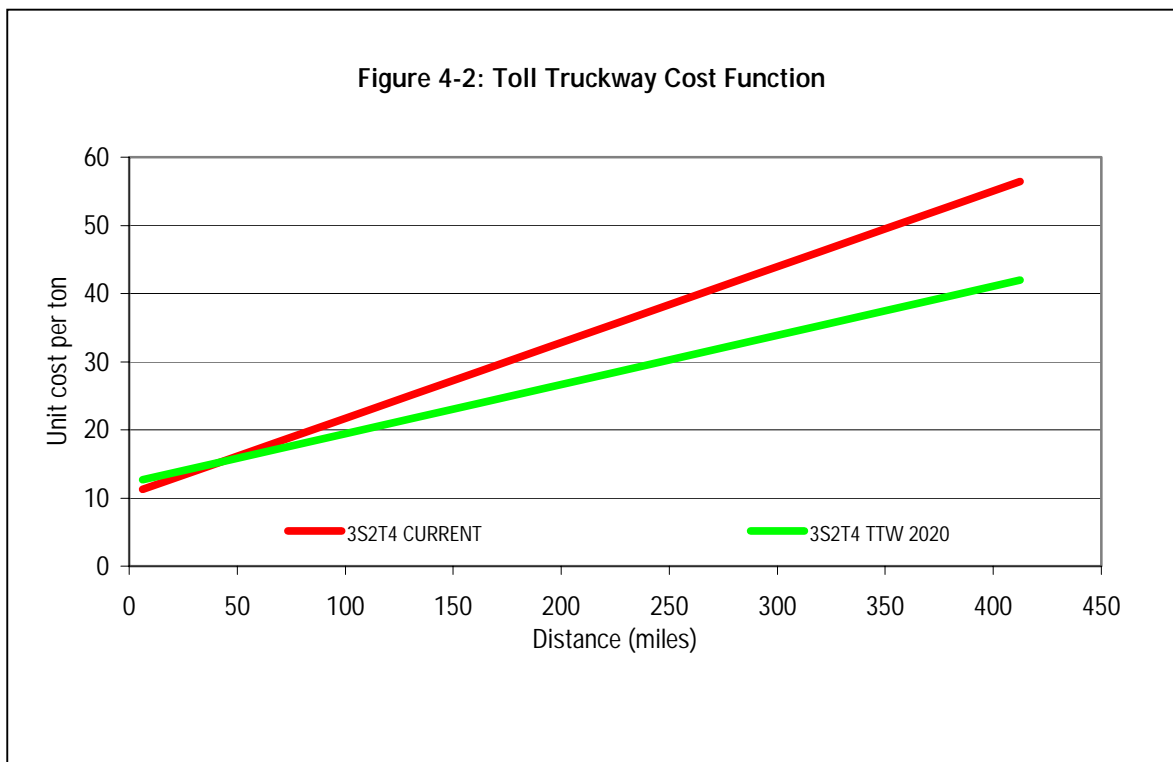


Statistical cost functions calibrated with proprietary data from trucking companies were used to analyze the productivity gains. Representative current data were obtained on driver cost, insurance, cargo values, speeds, fuel, fuel mileage, equipment costs and depreciation, maintenance, operational hours/day, payload, and productivity. From these the team produced cost functions. Driver wages and benefits represent a significant share of the total operating costs. The team assumed 20 percent higher pay and benefits for the heaviest trucks. The shaded variables are the ones that were subject to sensitivity analysis. Assumptions about the extra cost of the more productive equipment were also kept very conservative (see Table 4-3).

The analysis found that, for very short distances and with loads less than 44,000 lbs., the higher capacity trucks are not the most economical alternative. But with trips over 25 miles and heavier loads, the productivity gains increase considerably. In general terms, if the amount of cargoes to be transported on a per trip basis is less than 33,000 lbs. (which is the current capacity of the 3-S2-T4 combination), the toll truckways are not the most economical alternative. However, once the amount of cargoes exceed 33,000 lbs. (which necessitates the use of two of the current vehicles) the toll truckways become the most efficient alternative. For comparative purposes, Figure 4-2 shows the cost function for transporting just over 66,000 lbs (though the capacity of the 3-S2-T4 in the toll truckway would be over 175,000 lbs.), as well as the current costs from Base Case A. The fixed costs (the cost at distance equal to zero) are nearly the same in both cases. However, the variable costs (the slope of the cost function) are lower for the toll truckway alternative. As can be seen, the breakeven point (the point at which the costs for each alternative are equal) occurs at a very short distance trip.

| Table 4-3: Truck Operating Parameters | | | | |
|--|----------|---------|----------|---------|
| | 3-S2 | | 3-S2-T4 | |
| Input data | Current | TTW | Current | TTW |
| Driver wages and benefits | \$25.00 | \$30.00 | \$25.00 | \$30.00 |
| Other crew members | \$0.00 | \$0.00 | \$0.00 | \$0.00 |
| Crew insurance | \$1.00 | \$1.00 | \$1.00 | \$1.00 |
| Cargo value (\$/hr-ton) | \$1.82 | \$1.82 | \$1.82 | \$1.82 |
| Operational speed (mi/hr) | 65.00 | 65.00 | 65.00 | 65.00 |
| Cost of diesel (gallon) | \$1.40 | \$1.40 | \$1.40 | \$1.40 |
| Fuel mileage (mi/gallon) | 3.98 | 2.35 | 3.98 | 2.35 |
| Fixed cost per stop (\$/stop) | \$10.00 | \$10.00 | \$10.00 | \$25.00 |
| Ratio of equipment investment costs | 1.00 | 1.50 | 1.00 | 2.00 |
| Daily depreciation of tractor (\$/day) | \$14.41 | \$21.62 | \$14.41 | \$28.82 |
| Daily depreciation of trailer (\$/day) | \$3.94 | \$5.91 | \$3.94 | \$7.88 |
| Daily interest of tractor (\$/day) | \$12.00 | \$18.00 | \$12.00 | \$24.00 |
| Daily interest of trailer (\$/day) | \$3.20 | \$4.80 | \$3.20 | \$6.40 |
| Maintenance (\$/mi) | \$0.07 | \$0.07 | \$0.07 | \$0.16 |
| Max Payload (tons) * | 22, 27.5 | 44 | 16.5, 55 | 88 |
| Number of hours per day | 10 | 10 | 10 | 10 |
| Handling productivity (tons/hr) | 3.30 | 3.30 | 3.30 | 3.30 |
| Load being transported (tons) | 44.00 | 44.00 | 33.00 | 33.00 |

* the first number in "Current" refers to BCA and the second to BCB



Next, the team looked into the toll potential of the truckways. In this very preliminary analysis, lacking the resources to either do demand modeling or to survey trucking companies as to willingness to pay, the simplifying assumption was made that trucking companies would be prepared to pay tolls equal to as much as 50 percent of their cost savings from operating on the toll truckway. The team ran 164 different scenarios to estimate the average (mean) toll that would deliver direct operational savings to truckers twice as large as the toll.

The analyses indicated that toll truckways implemented in states with the most restrictive axle load limits (Base Case A) would translate into the most significant productivity increases and, as expected, the larger tolls. The mean toll resulting from the different cost scenarios are: \$0.43/mile for the 3-S2 combination and \$1.86/mile for the 3-S2-T4. The average breakeven distance is 14 miles, which means that toll truckways are economical beyond that distance.

The implementation of toll truckways in states with more liberal axle load limits (Base Case B) also results in productivity gains. However, due to the higher existing axle load limits, the expected productivity increases are less than the previous case, though the productivity increases are still significant. The mean tolls range from \$0.48/mi to \$0.83/mi for the 3-S2, and from \$0.88/mi to \$1.52/mi for the 3-S2-T4 combinations. The mean breakeven distance becomes 14 miles for the 3-S2 and 49 miles for the 3-S2-T4.

The difference in the amount of the viable tolls reflects the potential cost savings. In cases in which the cost savings is very high, viable tolls increase accordingly. Conversely, small or negligible cost savings leads to small or negligible values of the tolls. Viable tolls increased with trip distance as a consequence of the above. Breakeven trip distances were an average 14 miles.

D. Feasibility Analysis

The next step was to explore the economic and financial feasibility of toll truckways. First, the capital costs were estimated using the various pavement configurations, varying the extent of truck traffic attracted to the truckway. Separate calculations tested the sensitivity of the results to variations in capital costs, over a three-fold range. The baseline capital cost was \$1 million per lane-mile, appropriate for rural routes where a wide median is available and the amount of bridge work and climbing lanes is modest. The \$2 to \$3 million per lane-mile scenarios represent more typical inter-city conditions.

Data from the Federal Highway Administration's HPMS database show new highway costs averaging \$1.5 to \$3.7 million per lane-mile.²⁶ What the report calls "high-cost" additions, generally in urban areas, average \$5.1 million per lane-mile. The privately developed 91 Express Lanes, added to the wide median of SR 91 in high-cost Orange County, California, cost \$3.2 million per lane-mile, including Jersey barrier. A proposed set of tolled express lanes to be added to the median of U.S. 101 in suburban Sonoma County, California were costed out at \$2.6 million per lane-mile, again including a central Jersey barrier.²⁷ The cost of such barriers ranges from about \$120,000/mi. (prefab) to \$250,000/mi. (slipform, cast in place).²⁸

Next, the team used the World Bank's Highway Design and Maintenance (HDM) model that relates usage to maintenance needs to analyze the relationship between pavement deterioration and operating and maintenance costs. This made it possible to quantify such factors as reduced wear and tear on the mixed-flow lanes (which postpones the need to repave them) due to the shift of high-impact vehicles to the truckway. The

model calculates pavement conditions for each lane for each year in the planning horizon (in this case 50 years), and uses those conditions (along with assumed maintenance and repaving) to estimate road user costs and travel time savings. Finally, it calculates the net present value (NPV) and internal rate of return (IRR) for the highway.

This analysis looked at the overall economic effects of the highway (including the added truckway) from the standpoint of the state highway agency. It concluded that the agency's net present value would be positive for a wide range of values of the percentage of trucks using the truckway. The NPV of travel time savings would be very high and would increase with the percentage of trucks using the truckway (due to the additional capacity made available to passenger cars and other vehicles). Overall, both the NPV and the IRR indicate a solid economic performance—i.e., adding toll truckways to such an Interstate highway would produce net benefits for society.

The next analysis looked at private return on investment, examining the toll truckways as a possible investor-financed project. Two different truckway toll rates were tested in this analysis: 40cents/mile and 80cents/mile. (A toll of 8cents/mile was initially considered but was rejected because it did not yield an adequate return on investment.) This analysis did not consider the maximum value tolls (which, as indicated previously, could reach in excess of \$1.50/mile, if based strictly on 50 percent of overall savings) because of the lack of real demand data. Using a lower range of toll values also makes this analysis more conservative.

| Table 4-4: Private Return on Investment (1 to 1 truck shift) at 40,000 ADT | | |
|--|--------------|--------------|
| a) \$1 million/mile capital cost | | |
| TRAFFIC | Toll= \$0.40 | Toll= \$0.80 |
| 25% Trucks (1000) | 8.60% | 17.26% |
| 50% Trucks (2000) | 16.85% | 33.12% |
| 75% Trucks (3000) | 23.92% | 48.46% |
| 100% Trucks (4000) | 32.72% | 64.52% |
| b) \$2 million/mile capital cost | | |
| TRAFFIC | Toll= \$0.40 | Toll= \$0.80 |
| 25% Trucks (1000) | 4.12% | 9.17% |
| 50% Trucks (2000) | 8.85% | 17.34% |
| 75% Trucks (3000) | 13.04% | 25.31% |
| 100% Trucks (4000) | 16.97% | 33.19% |
| c) \$3 million/mile capital cost | | |
| TRAFFIC | Toll= \$0.40 | Toll= \$0.80 |
| 25% Trucks (1000) | 2.26% | 6.23% |
| 50% Trucks (2000) | 5.97% | 12.02% |
| 75% Trucks (3000) | 9.03% | 17.40% |
| 100% Trucks (4000) | 11.76% | 22.66% |

The 40cents/mile toll yielded positive returns across a wide range of truck usage of the toll truckway. Table 4-4 shows the estimated return on investment (ROI) corresponding to the three different assumptions about initial capital investment cost to add the truckways. The estimates are also broken down by the percentage of

traffic using the truckway and the assumed toll. While the ROI is positive for all of the cases shown, indicating that a truckway in each case would recover its costs, its ability to attract private developers is more limited. Toll road projects developed privately have generally needed ROIs in the double-digit range in order to attract private-sector investment. Still, these generally positive returns are encouraging. Although significant uncertainty remains about both the magnitude of the initial investment and the tolls that could be actually implemented, the results of the sensitivity analyses suggest that toll truckways could be self-supporting projects in a wide range of scenarios.

The feasibility analysis also considered a possible operational change by trucking firms in response to the availability of toll truckways: what we call a truck shift. This “substitution of trucks” effect considers the hypothetical case in which the higher weight limits available on the truckway lead trucking firms to use a smaller number of trucks to transport a given set of commodities (rather than, as implicitly assumed in the previous analysis, that trucking volume expands to take advantage of the increased capabilities made available). Although there is no way to predict which industry response is more likely, the research team decided to include the estimates of private return on investment for this case as well, for the sake of completeness. The estimated ROIs are in Table 4-5. As shown, a significant “truck shift,” reduces the number of paying trucks and, consequently, the private profitability of the project (though higher unit tolls could be levied, up to the 50 percent of trucker cost-savings level discussed previously).

| Table 4-5: Private Return on Investment (1.5 to 1 truck shift) at 40,000 ADT | | |
|--|---------------|---------------|
| a) \$1 million/mile capital cost | | |
| TRAFFIC | Toll = \$0.40 | Toll = \$0.80 |
| 25% Trucks (1000) | 5.43% | 11.81% |
| 50% Trucks (2000) | 11.49% | 22.61% |
| 75% Trucks (3000) | 23.92% | 48.46% |
| 100% Trucks (4000) | 22.67% | 43.72% |
| b) \$2 million/mile capital cost | | |
| TRAFFIC | Toll = \$0.40 | Toll = \$0.80 |
| 25% Trucks (1000) | 1.96% | 6.10% |
| 50% Trucks (2000) | 5.89% | 11.99% |
| 75% Trucks (3000) | 8.70% | 17.20% |
| 100% Trucks (4000) | 12.06% | 22.88% |
| c) \$3 million/mile capital cost | | |
| TRAFFIC | Toll = \$0.40 | Toll = \$0.80 |
| 25% Trucks (1000) | --- | 3.84% |
| 50% Trucks (2000) | 3.70% | 8.30% |
| 75% Trucks (3000) | 5.88% | 11.91% |
| 100% Trucks (4000) | 8.35% | 15.84% |

For toll truckways added to much higher-traffic highways (e.g., with double the 40,000 ADT previously assumed), more robust rates of return are projected for a wide range of scenarios, even assuming the 1.5 to 1 truck shift to the truckway. Table 4-6 indicates significantly higher rates of return than the previous two tables due to the assumed higher traffic levels.

| Table 4-6: Private Return on Investment (1.5 to 1 truck shift) at 80,000 ADT | | |
|--|---------------|---------------|
| a) \$1 million/mile capital cost | | |
| TRAFFIC | Toll = \$0.40 | Toll = \$0.80 |
| 25% Trucks (1000) | 11.49% | 22.61% |
| 50% Trucks (2000) | 22.13% | 43.59% |
| 75% Trucks (3000) | 23.92% | 48.46% |
| 100% Trucks (4000) | 43.74% | 85.48% |
| b) \$2 million/mile capital cost | | |
| TRAFFIC | Toll = \$0.40 | Toll = \$0.80 |
| 25% Trucks (1000) | 5.89% | 11.99% |
| 50% Trucks (2000) | 11.63% | 22.63% |
| 75% Trucks (3000) | 16.97% | 33.19% |
| 100% Trucks (4000) | 22.98% | 43.97% |
| c) \$3 million/mile capital cost | | |
| TRAFFIC | Toll = \$0.40 | Toll = \$0.80 |
| 25% Trucks (1000) | 3.70% | 8.30% |
| 50% Trucks (2000) | 8.03% | 15.59% |
| 75% Trucks (3000) | 11.76% | 22.66% |
| 100% Trucks (4000) | 15.98% | 30.03% |

E. Summary

To summarize, this analysis estimates that inter-city toll truckways would be economically and financially feasible across a wide range of possible scenarios. Specifically, under most scenarios, the addition of toll truckways to inter-city routes would be economically beneficial with strong positive net present value. Similarly, realistic toll rates would produce positive and often commercial rates of return on investment over a wide range of scenarios, which suggests that toll truckways could be self-funding enterprises.

This analysis should be considered conservative in that:

- It is based only on the types of LCVs currently in use in western states, and not on larger and more productive combinations that might be developed to take better advantage of the toll truckways' capabilities. With significantly higher productivity gains, there should be willingness to pay higher tolls to obtain those gains.
- Its financial feasibility analysis relied on toll levels in many cases equivalent to far less than half the cost saving that would be realized by trucking firms using the toll truckways.

Part 5

Implementation of Toll Truckways

The previous section modeled a generic toll truckway in order to assess the basic economic and financial feasibility of the concept. In this section, we turn to some of the principal issues that must be addressed in actually implementing such truckways on the National Network. Such issues include the physical configuration of the truckways, the relationship between tolls and existing highway user taxes, and the potential of new technology (in particular, that of Intelligent Transportation Systems—ITS) to improve the utility of toll truckways. Finally, we suggest two scenarios for the introduction and expansion of toll truckways.

A. Configuration and Construction

As proposed and modeled in this study, long-distance inter-city toll truckways would normally be a single lane in each direction, with a passing lane at intervals of every few miles and on hills. The truckways would be separated from mixed-flow lanes by continuous concrete Jersey barriers. They would have their own entrance and exit ramps, to avoid mixing heavy truck traffic with autos and light trucks in the mixed-flow lanes. And combinations would be assembled and disassembled in staging yards adjacent to the truckways, enabling conventional combinations (usually a regular tractor/trailer) to make use of local freeways and arterials at existing weight and length limits.

A key feature of the truckways would be a stronger and more durable pavement design, better-suited to handling heavy trucks than standard U.S. pavements. The Washington, D.C.-based body of the state highway departments, AASHTO²⁹, has set many of the standards by which U.S. highways were built, but those long-accepted standards have recently been re-examined by a number of researchers. In general, the conclusion of this research is that U.S. highways are built to inadequate durability standards, such that they cannot properly bear up under the weight of extensive mixed traffic, especially from heavy trucks. Hence, they need to be rebuilt far sooner than if they had been built to a higher standard in the first instance.³⁰ Small and Winston, for example, estimated that current state highway practice produces maintenance costs three to four times the optimal level. Optimal pavement for mixed traffic, they suggest, would be 13.5 inches of concrete versus 10 inches with a corresponding beefing up of asphalt.³¹

The Federal Highway Administration and the National Asphalt Pavement Association conducted a six-nation study tour researching pavement design in Europe in 1991. The tour was led by Wayne Muri, chief engineer of the Missouri Highway & Transportation Department and chair of the TRB Executive Committee. In reporting on the tour's findings, Muri discussed the use of stone mastic, using a greater ratio of stone to sand than typical U.S. practice, as well as greater pavement thickness. Design life was typically 40 years compared

with 20 years in this country. Muri also praised the contractor warranties on pavement quality commonly provided in Europe. The combination of these practices allowed the use of 20 percent heavier trucks but markedly less pavement damage, he said. “The time has come to incorporate proven European methods into this country’s advances,” he said.³²

Much additional research has been done over the past decade on stronger and longer-lived pavements. A good summary can be found on the Web site of the Transportation Research Board, particularly the sections on Strategic Highway Research Program (SHRP), Long Term Pavement Performance (LTPP), Research on Improved Concrete Pavement (RICP), and Superpave.³³

Drawing on such findings, investors are likely to build toll truckways to a heavier standard at somewhat greater initial cost but with much longer life and much lower repaving costs than are typical of today’s Interstates and expressways. In fact, the standards already used by American turnpikes and toll roads are far closer to the Small/Winston estimates of optimal pavement than they are to the AASHTO standards.³⁴ It seems likely that toll truckway investors would use innovative methods for designing their pavement. They should have the independence to set their toll rates and truck standards such that a much better match is made between shipper productivity and highway costs. They may contract for both construction and long-term maintenance as a package. Or they will set performance specifications for their pavement and bridges with penalties for any downtime and loss of toll revenues.

B. Tolls vs. Taxes

The feasibility analysis in Section 4 found that dedicated toll truckways would be a viable investment over a range of scenarios with tolls in the 40-80cents/mile range, based solely on their promise of allowing existing Rocky Mountain and turnpike doubles in states where they are currently barred. The lower end of this toll range is not out of the ordinary for trucks on present state toll roads. For comparison the Ohio Turnpike is presently charging 38 cents/mi. for doubles weighing in the range 115,000 to 127,400 lbs.³⁵ The Ohio Turnpike and the adjoining Indiana Toll Road are the closest thing this country presently has to toll truckways, in that they carry very heavy volumes of trucks relative to cars. They both earn the bulk of their revenue from trucks and provide special staging areas for the big doubles and triples that we envisage running on toll truckways in the first stage. Each of these state toll roads is a successful commercial operation that competes very effectively at quite significant toll rates with nearby free roads by giving truckers extra speed of travel, special truck-oriented facilities along the way, and the ability to operate at greater sizes and weights—precisely the characteristics envisaged for the toll truckways.

But what if it should turn out that actual toll truckways, in order to provide a commercial return on investment and thereby attract the needed capital, must charge tolls somewhere near 80 cents/mi., as indicated in the previous analysis? Would truckers be willing to pay rates higher than what they now pay on the Ohio Turnpike? To answer this question, we must first look at truckers’ total cost of using such current toll roads. Heavy trucks (combination vehicles) currently pay diesel fuel taxes and other taxes and fees equal to around 16 cents/mi, split about 7 cents/mi. federal and 9 cents/mi. state/local.³⁶ FHWA data suggest that longer combination vehicles pay about one-third more than average combinations, so they are paying approximately 21 cents/mi. in federal and state/local user taxes. Thus, a big rig on the Ohio Turnpike today is paying a total of between 54 and 59 cents/mi. This gives us a ballpark estimate of the willingness to pay of the largest big rigs currently allowed on U.S. highways.

Because trucks using the proposed toll truckways would in many states be able to operate *only* on the toll truckways, and because the diesel tax and other truck excise taxes are supposed to be user taxes, a strong case exists for not charging those user taxes on toll truckways. The toll truckways would be analogous to the tracks and roadbed used by the railroads: infrastructure provided by the operators themselves, for their own exclusive use, and paid for solely by them.

One practical way to implement this policy would be to provide rebates to trucking companies for the user taxes paid for all recorded miles they drive on the toll truckways. This mileage would be recorded by the electronic toll collection system used by the toll truckway operator, in which a transponder would be required in each tractor in order to use the truckway. Company-specific mileage records would be provided periodically (e.g., monthly) to the relevant state taxing authority, which would issue the rebates to the trucking companies. Precursors of such rebate programs for trucks already exist on the Massachusetts Turnpike and the New York Thruway.³⁷ A toll of 80 cents/mi. less a rebate of 21 cents/mi. yields a net price of 59 cents/mi. to use the toll truckway, quite competitive with what truckers now pay on such toll roads as the Ohio Turnpike.

An alternative approach to resolving the “double taxation” issue would be for the truckway operator to receive the rebates, rather than individual trucking companies. The trucking companies would set up accounts with the truckway operator, depositing funds to cover projected toll costs. The truckway would charge each user a net toll (i.e., toll rate per mile minus fuel taxes per mile, for that class of truck). The truckway operator would keep records of miles driven by type of truck and would transmit that information periodically to a state agency. That agency would remit to the truckway operator the appropriate amount of federal and state fuel tax revenue, which would help to cover its operating costs. Thus, rather than having to deal with numerous trucking firms, the state agency would deal only with the truckway operator.

Charging truckway users only tolls, rather than tolls plus fuel taxes, would respond to the historic concern of the trucking industry over “double taxation.” It would also serve to make the federal authorization of toll truckways along routes of the National Network less vulnerable to political opposition from the railroad industry. Since this new infrastructure would be developed and operated without the use of federal or state funding, it would not be subject to arguments over whether or not the trucks involved were somehow receiving unfair federal subsidies (vis-à-vis the railroads) or were not paying their way. With toll truckways fully and solely supported by tolls, that objection would be removed from the debate.

C. Impact on Highway Trust Funds

While granting fuel-tax rebates to trucking firms that use the toll truckways will address that industry’s concern about “double taxation,” the prospect of losing fuel-tax revenues is likely to cause concern within state transportation departments (DOTs). Would the implementation of the toll truckway concept, as outlined here, cause harm to state highway trust funds, making them less able to meet their states’ highway needs?

To answer this question, we must keep in mind the circumstances under which a toll truckway would actually be implemented along an existing Interstate right of way. Since each such truckway must, by definition, be able to be self-supporting from its toll revenues (it would not be using federal or state fuel tax revenues to be built or operated), there would be a limited number of such truckways. They would be able to be financed only in those inter-city corridors with heavy truck traffic and limited existing highway capacity. It is precisely those inter-city routes which would be the most likely candidates for toll truckways.

The addition of a self-supporting toll truckway in such a corridor would benefit the state DOT in two fundamental ways. First, it would provide new lane capacity in a place where it was needed, and where the DOT would presumably otherwise have to spend its own funds to create that capacity. Thus, the DOT would avoid the cost of adding that lane capacity. Second, as discussed in Section 4, by attracting between 25 and 100 percent of existing heavy truck traffic off the existing lanes, the toll truckway would lead to significant reductions in wear and tear on those lanes, which would reduce the DOT's maintenance and rehabilitation expenditures. Against these two positives must be weighed the loss of fuel-tax revenue from those trucks that shift to the toll truckway.

The analysis done for Section 4 permits us to quantify these various effects. Table 5-1 illustrates the results of this quantification. We return to the standard case modeled in Section 4, of an existing Interstate with three mixed-flow lanes in each direction, to which a single toll truckway lane is added in each direction. The table uses the same four scenarios, in which the truckway attracts 25, 50, 75, or 100 percent of the heavy trucks away from the mixed-flow lanes, and shows the resulting fuel-tax loss and maintenance savings to the DOT. (We use 16 cents/mile for the federal plus state fuel tax paid by heavy trucks.) The difference between the fuel-tax loss and the operations and maintenance (O&M) savings is the net cost to the DOT of having the toll truckway added to the Interstate.

But that's not the end of the story. What must also be factored in is the cost which the DOT has avoided, by virtue of the fact that a third party—a state toll authority or a private firm under a long-term franchise—has taken upon itself the task of financing, building, operating, and maintaining the new truckway, which is a task the state DOT would eventually have had to take on, using its scarce highway trust fund (fuel tax) monies. The economic analysis of Section 4 yields the annualized cost of building and operating the toll truckway lane, for various scenarios. As can be seen, the annual cost *avoided* by the DOT is greater than the net cost of its fuel tax loss. The DOT comes out significantly ahead. For Table 5-1, we have used the mid-range investment case of \$2 million/lane-mile, but the same conclusion holds true for the other cases studied.

In short, the addition of toll truckways paid for solely by tolls would be a positive-sum game for state DOTs. More needed highway capacity would be made available thanks to this policy innovation, by supplementing limited fuel tax revenues with tolls paid by willing customers. Those trucking customers would willingly pay the tolls because they would be gaining large increases in productivity.

Table 5-1: Annualized Impact on State DOT (\$ per lane-mile of TTW)

| Truck % in TTW | Truck ADT in TTW | Fuel tax loss to DOT | O&M savings to DOT | Net cost to DOT | Avoided cost of new lane (1:1 case)* | Avoided cost of new lane (1:1.5 case)* |
|----------------|------------------|----------------------|--------------------|-----------------|--------------------------------------|--|
| 25% | 1,000 | \$58,400 | \$6,090 | \$52,310 | \$352,428 | \$340,468 |
| 50% | 2,000 | \$116,800 | \$13,298 | \$103,502 | \$366,250 | \$358,132 |
| 75% | 3,000 | \$175,200 | \$37,558 | \$137,642 | \$381,478 | \$366,252 |
| 100% | 4,000 | \$233,600 | \$47,101 | \$186,499 | \$389,788 | \$376,198 |

*Annualized TTW costs were calculated in detail for the baseline capital cost case of \$1 million per lane-mile and extrapolated to the \$2 million/lane-mile and \$3 million/lane-mile cases. The figures shown in the table are for the \$2 million/lane-mile case.

D. Regulatory Oversight

There is understandable concern within the trucking industry over a new era of tolled highways. If toll truckways are introduced, and truckers see the potential for very large gains in productivity, they will want to invest in new trucks designed to take maximum advantage of this new infrastructure. But since that equipment will often not be usable elsewhere, the trucking companies will hesitate to make the investment if they are uncertain what future toll levels will be.

Whether a particular truckway is franchised out to the private sector or is developed and operated by a state toll agency, the entity that develops and operates it will be granted essentially a monopoly franchise using a valuable public asset—the right of way of an existing highway corridor. Global experience with long-term highway franchises (called “concessions” overseas) offers some guidelines for addressing this potential problem. Such agreements range in duration from 20 to 99 years, and given that long duration, they obviously need to address issues of pricing and profits.

The long-term concession agreement provides the legal basis under which the state and the tollway developer/operator (either state-owned or privately owned) negotiate terms and conditions that protect both investor interests and the public interest. When it comes to toll rates, there are two general models. One, adopted in California’s pioneering private toll road law of 1989, calls for setting a ceiling on the rate of return which can be earned over the life of the agreement. This approach, which does not directly control the prices which can be charged, is advantageous for urban tollways where variable pricing can be a powerful tool for traffic management. The other approach, as used for Toronto’s Highway 407 Electronic Toll Route, negotiates a future rate schedule based on factors such as a recognized inflation index and traffic levels. This approach generally provides greater predictability of future toll levels, for both users and the tollway operator.

E. New Technology

Toll truckways would be designed from the outset to make use of state-of-the-art electronic toll collection technology, the largest and most successful of today’s suite of ITS technologies. There would be no toll booths or toll plazas at all. Each truck would be required to have a transponder encoded with its size and weight category. Each participating trucking firm would maintain a prepaid account with the truckway operator, from which tolls would be deducted based on recorded miles driven, from entry point to exit point on the truckway. That same system would calculate the approximate fuel used for each trip, and would provide that information to the appropriate state agency for calculation of the periodic fuel tax rebates due to each company.

But toll truckways will also provide an environment in which more advanced ITS technologies can be applied for more efficient, safer trucking. Jacob Tsao, an engineer previously with the Automated Highway System project at University of California, Berkeley and Jan Botha, a colleague at San José State University, have recently made a detailed proposal along these lines.³⁸ With very much a California perspective, Tsao and Botha note the inefficiencies of trucking in California with no LCVs at all allowed in the state, merely the federal minimum 5-axle units—tractor/semitrailers (3-S2) and the light doubles (3-S1-T2). Tsao and Botha say increased productivity needs relaxation of weight, size, and configuration limits, and to this end they propose dedicated truck lanes equipped with a variety of high-tech driver aids. Driving manually in mixed

traffic, they note, is a major workload for a driver who has to continuously monitor and anticipate the behavior of other motorists driving a variety of vehicles with different handling characteristics.

Tsao and Botha propose a number of steps toward Segregated Electronic Road Trains (SERTs). This would begin with deployment of sensors for warning of rear-end collisions and straying from the lane. These involve range-sensors, usually some kind of frontal radar or laser that tracks the distance to the vehicle ahead and closing speed, and camera systems that sense any significant divergence from the marked lane such as a movement across an edge line marking. At first these systems would merely provide a warning beep or visual indication to alert the driver. In a later stage, similar sensing systems together with “servomechanisms” on the brakes, accelerator, and steering would allow some hands-off or feet-off driving. These have already been demonstrated in the joint Detroit/USDOT Automated Highway System demonstration project in 1997. In Europe, Daimler-Chrysler demonstrated a similar “electronic towbar” for trucks under a research program called CHAUFFEUR.³⁹

At first the systems might be organized to keep the driver at work at the wheel. They would allow system steering but manual control of brake and accelerator, or system control of headway but manual steering. A third stage would see both steering and accelerator/brake functions of trucks controlled simultaneously in some physically separated lane. Then LCVs could be operated in such lanes together with dedicated entry and exit and associated staging areas.

Tsao and Botha foresee a number of possible further developments to improve the productivity and safety of automated trucking. They say that with lanes engineered with systems to control the path of vehicles, there will be less wander in the lane. With repeated loads concentrated in a predictable track it will be possible to design much longer lasting pavement. The staging areas for LCVs will act as intermodal centers for transfers between automated electronic road trains and more conventional trucks used on local streets for the trip ends of many journeys. But unlike rail/road intermodal centers, no elaborate and costly equipment will be needed to move loads between tires and flanged wheels, just hitch or unhitch the trailers and drive away.

The main points emerging from the Tsao/Botha paper are that separated lanes will be needed to pursue a variety of promising applications of advanced sensing and control technologies.

F. Toll Truckway Scenarios

Toll truckways could be implemented to various degrees. The most likely initial step would be as a way to extend the territory through which today’s LCVs (long doubles and short triples) can operate. A more comprehensive approach would be to use such truckways to harmonize U.S. and Canadian best-practice standards, consistent with NAFTA. Longer-term, toll truckways could be the avenue for introducing new forms of LCVs, which would be more stable (and therefore safer) as well as being more productive—but that is beyond the scope of this study.

1. *Present LCVs Extended Scenario (2001 LCV+)*

This scenario involves toll truckways as “bridges” across states that are presently barriers to LCV movement. It also involves extensions of LCV operations into restrictive coastal states. This would allow truckers to operate existing LCVs in the states from which they are presently barred. Under this scenario there would be bridge truckways through Pennsylvania, Minnesota, Missouri, Iowa, Illinois, and there would be spur

truckways from this central base of LCV operations into the east and west coast ports and into key border states such as Texas. In addition, major trucking routes presently denied to LCVs such as I-95 Maine to Florida, I-5 San Diego to Seattle, I-10 Los Angeles to Jacksonville, Florida, could be equipped with toll truckways to provide a completely new level of productive LCV use outside traditional LCV states.

Under the 2001 LCV+ scenario there would be Rocky Mountain/turnpike double regulations on the toll truckways, so they would allow the same axle loadings as now (20,000 lbs. single axle, 34,000 lbs. on a standard tandem axle). The 2001 LCV+ scenario would allow 9-axle turnpike doubles with a pair of 48 ft. trailers or box length of about 100 ft. and 7-axle short triples with 28 ft. trailers, box length about 90 ft. This would accommodate common Canadian style B doubles easily with box length of 66 ft. and also an Australian style 12-axle B triple of 98 ft. box length. This 2001 LCV+ standard is what is already allowed on the Ohio Turnpike and Colorado's Interstates⁴⁰ and is a small variation from limits prevailing on toll roads in New York, Florida, Oklahoma and Kansas, and on major Interstate routes in Arizona, the Dakotas, Idaho, Montana, Nebraska, Nevada and Utah.

2. Harmonization with Canada and Mexico

A second scenario would employ toll truckways to help meet U.S. trucking obligations under NAFTA. Under that 1994 agreement, the United States must pursue harmonization of truck size and weight limits with those of Canada and Mexico. This also makes economic sense because it will reduce costs and enhance trade. Given the political difficulties of doing this for the U.S. road system as a whole, it would be helpful to NAFTA to do it at least on toll truckways. This would involve, in essence, adoption by the United States on toll truckways of U.S. lengths and Canadian weight limits. The Canadians in turn could be pressed by our negotiators to adopt U.S. lengths on their major highways. The Canadians also have a slightly lower steering axle weight limit. So the toll truckways would have a U.S. steering axle limit of 13,000 lbs. versus 12,100 lbs. steering axle common in Canada and allow at least 14 ft. high vehicles versus the 13.5 ft. common in Canada. The most important increase would be adoption of the Canadian tandem limit of 37,500 lbs. compared to the U.S. 34,000 lbs—a 10 percent increase. A number of U.S. states operate tandem limits about midway between the U.S. federal limit and the Canadian limit. Mexico allows 39,700 lb. tandems. Mexico could be pressed as part of its end of the deal to police a new NAFTA 37,500 lb. tandem axle limit.

The U.S. bridge formula effectively sets the limit on a tridem (triple axle) grouping at 43,400 lbs. for a spread (first to third axle) of 10 feet. At the moment that federal calculation is an almost purely academic number because three-axle semi-trailers are effectively ruled out many places by the federal standard since the 80,000 lb. gross vehicle weight limit prevents truckers from making use of the triple axle grouping limit. Canada, Australia and Mexico all have tridem limits of about 49,700 lbs. The Atlantic provinces of Canada have 53,000 lb. tridems, which we recommend for this scenario. This 52,900 lbs. would not bring loadings up to the level of some of the Rocky Mountains, where some tridems already operate up to 58,400 lbs.

On the toll truckways with these limits, American truckers with a 6-axle tractor/semi-trailer could transport a common 40-ft. shipping container loaded to the international (ISO) weight limits of 67,200 lbs. Federal regulations presently only allow a gross vehicle weight of 80,000 lbs. Since an empty tractor/semi-trailer weighs 30,500 lbs., so there is only 49,500 lbs. payload capacity, a shortfall of 17,600 lbs. unless a special permit is obtained. Efficient intermodal ship/truck transfers require lanes that can carry at least a 97,000 lb. 6-axle semi-trailer so we can move the standard ISO shipping container more freely on the land-side of U.S. ports. On toll truckways freed from the highly restrictive federal 80,000 lb. limit, using a 52,900 lb. tridem B double of eight or nine axles at 124,000 to 132,000 lbs. gross weight becomes possible. These limits would

also allow more productive use of traditional U.S. long combinations such as Rocky Mountain and turnpike doubles, and traditional U.S. short 28 ft. triples.

They would also allow 12-axle Australian B triples with three 32 ft. tridem-supported semi-trailers with a GVW of about 176,000 lbs. and a payload of 127,000 lbs., far larger than the turnpike double's 101,000 lb. load limit. A transition to B triples on the toll truckways would therefore probably occur, since B triples would enhance freight productivity by upwards of 25 percent over turnpike doubles using the combination of Canadian axle loadings and U.S. length allowances. The B triples would also handle better, be more stable, and off-track much less on curves.

Part 6

Policy Recommendations

A. Overview

While toll truckways have been presented in this policy study as new infrastructure capable of being self-supporting solely by toll revenues, their development will not be possible without policy changes by the federal government. The National Network for Large Trucks, though it consists of highways owned and operated by state DOTs, is significantly funded and regulated by the federal government. Since toll truckways involve both the use of right of way along these existing highway corridors and significant exemptions from the current federal tolling and truck size and weight regulations, it is important to spell out the federal policy changes needed to make toll truckways possible. The coming reauthorization of the federal surface transportation program in 2003 is an obvious opportunity to address these policy changes.

The most basic changes, as suggested above, are the provision of right of way for toll truckways along existing Interstate and other National Network corridors, the easing of current federal size and weight regulations for toll truckways, and the rebates of federal and state truck user taxes for miles driven on toll truckways.

A few words are in order about the propriety of the federal government requiring states to provide rebates of state truck user taxes for users of toll truckways. Even though the corridors in question are owned by the states (via their DOTs), federal highway user taxes have paid for the majority of their capital costs, and they must be operated in accordance with federal regulations. The proposed policy change simply offers states a new option: permitting some of this federally supported right of way to be used for a new type of infrastructure. Should they wish to take advantage of this new option, one of the conditions is to grant rebates of state truck user fees to those trucking firms making use of the new infrastructure. But no state would be required to participate.

B. Rationale

The federal government should support the introduction of toll truckways on the National Network for large trucks for the following reasons:

- To improve trucking safety by taking larger trucks out of mixed traffic lanes in which cars and trucks mingle, putting many of those heavy vehicles in separate roadways behind safety walls;
- To allow major increases in trucking productivity by encouraging consolidation of freight into longer combination vehicles, initially the long-doubles and short triples presently operating in some 18 states

and on many state turnpikes as well as Canadian-style B doubles, but envisioning more productive and more stable specialized truckway trucks that will be produced in the future as a result of the development of an increasingly nationwide truckway system;

- To provide environmental benefits thanks to reduced vehicle miles traveled, fuel consumption, and emissions, thanks to transporting more freight in fewer trucks;
- To provide an environment in which various intelligent transportation systems (ITS) can be designed for progressive deployment to improve the trucking system;
- To provide extra heavy-duty roadway capacity that can be turned over for use by emergency services in times of natural disaster, major accidents or terrorist attack;
- To provide extra weight and clearance dimensions for homeland security and defense requirements;
- To encourage investment in self-financing infrastructure via tolls, consistent with existing FHWA policies that encourage innovative finance and public-private partnerships;
- To further the objectives of NAFTA, as a significant U.S. contribution to hemispheric harmonization of truck size and weight standards, and to encourage Canada and Mexico to adopt similar rules and policies for truckways.

C. Specific Policy Provisions

1. *Definition*

A toll truckway is a toll-financed roadway dedicated to heavy trucks which is located either in its own right of way separate from any other roadway or located within the right of way of a limited-access highway, but which is completely separated from the mixed traffic lanes by continuous concrete safety barrier(s) and is equipped with its own dedicated ingress and egress ramps and staging areas. Toll truckways will be fully grade separated and access controlled and may be one or two lanes in each direction.

2. *Eligibility*

Toll truckways would be open to use by commercial vehicles of from 10,000 to 150,000 lbs. gross vehicle weight, including long doubles and short triples which operate in western states and on many turnpikes, Canadian style B doubles, and other combinations deemed safe and productive by a toll truckway advisory commission.

3. *Policy Changes*

- The “LCV freeze” on truck size and weights will not apply to toll truckways, which will allow at least the heavier of turnpike or Canadian axle loadings and dimensions, namely 22,000 pounds single axle, 37,500 pounds tandem axle, and 53,000 pounds per tridem axle, lengths to 108 feet, widths 8.5 feet, height to 14 feet.
- Present restrictions on tolling on Interstates will not apply to toll truckways.
- Trucks using toll truckways will be exempt from federal fuel taxes and other federal user charges for miles traveled on a toll truckway. The IRS will be required to accept certified and audited toll truckway account data as evidence of truck miles traveled when exempt from federal charges and will rebate these

to truckers or the toll truckway operator as arranged between the two. States will be required to make similar arrangements as a condition of receiving federal approval to implement toll truckways along Interstate or other federally aided rights-of-way.

4. Other Provisions

- Tolls will be collected entirely by non-stop technology such as the use of a truck transponder, camera recognition, GPS tracking, or other automatic identification device.
- Tolling on truckways could use the existing 915MHz ASTMv6 transponders in wide use at truck weigh stations under the HELP (Heavy Vehicle Electronic License Plate) program, but envisage a possible transition to the 5.9GHz standard currently in development.
- Use of the toll truckways will be optional for trucks already permitted to operate in the mixed-traffic environment, but Longer Combination Vehicles will be strictly limited to toll truckways in states and on routes where they are presently not permitted
- Ownership and operation of toll truckways could be by traditional state highway agencies, cities, counties, metropolitan planning organizations, toll agencies, special purpose not-for-profit entities, or for-profit road corporations.
- FHWA could sponsor an Operators and Shippers Forum on toll truckway standards and interoperability and a Truckway Advisory Commission in charge of policy research and development;
- When developed by investors, toll truckways should be capable of being sold, consolidated, and spun off in order to provide maximum flexibility and to encourage responsiveness to trucker needs and a return on investment.
- Commercial truck-stop activities and warehousing development associated with staging areas should be specifically permitted on the right of way of truckways and as part of toll truckway development.
- Truckway staging areas for make-up and break-up of LCVs should be located alongside the right of way, or truckway spur ramps to staging areas off the mainline should be provided.
- In case of natural or terrorist emergency, truckways would come under the control of local emergency services.

5. Research

The FHWA should finance a program of research into:

- Optimum truck/roadway specifications (axle weights, pavement design etc);
- Truckway ITS;
- B-train versus traditional doubles and triples; and
- Safety rules for LCVs.

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Acknowledgments

This research project benefited from the hard work of a group of outstanding graduate students from the City College of New York who undertook various aspects of the work. The work done by Mr. David Sackey (economic analyses), Mr. Victor Ochieng (productivity analyses), Mr. David Sackey, and Mr. Sajjad Hussain (pavement design) is both acknowledged and appreciated.

Other Relevant Reason Foundation Policy Studies

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Endnotes

- ¹ U.S. Dept. of Commerce, Bureau of the Census, *Statistical Abstract of the United States: 2000*, Table 1039, at 635.
- ² U.S. Department of Transportation, Bureau of Transportation Statistics, “Truck Movements in America: Shipments From, To, Within, and Through States,” BTS/97-TS/1, May 1997, p. 1.
- ³ Railroads deliver five percent of the value of freight moved in the United States, while air transportation moves three percent and the remainder is moved by barge and pipeline. “Our Nation’s Highways” Office of Highway Information Systems, Federal Highway Administration, 1998, p. 3. The version downloadable from www.fhwa.dot.gov/ohim says 89 percent but the printed version of the same publication says 93 percent, so 90 percent seems a fair approximation.
- ⁴ “U.S. Freight Transportation Forecast to 2013,” DRI-WEFA, 2002, p. 11 (for American Trucking Associations).
- ⁵ Alaska, Colorado, Idaho, Nebraska, North Dakota, Nevada, Oregon, South Dakota, and Utah permit the operation of “turnpike doubles,” while Washington and Montana permit “Rocky Mountain doubles” and triples and Wyoming permits only “Rocky Mountain doubles.” These truck types are described in greater detail in Part 2 and in Figure 2-1.
- ⁶ Florida, Indiana, Kansas, Massachusetts, New York, and Ohio all permit “turnpike doubles” on their turnpikes.
- ⁷ U.S. Department of Transportation, *The U.S. Department of Transportation’s Comprehensive Truck Size and Weight Study* (Washington, DC: U.S. Department of Transportation, August 2000) .
- ⁸ See footnotes 5 and 6.
- ⁹ LCVs are tractor/trailer combinations of two or more cargo units and more than 80,000 lbs. gross weight operating on Interstate highways. Conventional combination vehicles (CCVs) include 5-axle and 6-axle tractor/semi-trailers and short or STAA doubles operating at less than the 80,000 lbs. gross weight limit—the first two types shown in Fig. 2-1.
- ¹⁰ *The U.S. Department of Transportation’s Comprehensive Truck Size and Weight Study*, Chapter 6, page VI-7.
- ¹¹ *Ibid.* page VI-7.
- ¹² *Ibid.*, VI-9.
- ¹³ *Longer Combination Vehicles: Guide to Operation & Regulation* (Casper, WY: Western Highway Institute, 1992), p. 7
- ¹⁴ U.S. Department of Transportation, *1997 Federal Highway Cost Allocation Study* (Washington, DC: U.S. Department of Transportation, August 1997) and U.S. Department of Transportation, *Addendum to Federal Highway Cost Allocation Study* (Washington D.C.: USDOT, May 2000).
- ¹⁵ The study concluded that federal user charges collect roughly the right amount from trucks in the 50,000 to 70,000 lb. gross vehicle weight class relative to the cost they impose, but trucks in the 80,000 to 100,000 lb. gross vehicle weight class pay only 50 percent of the costs they impose, while trucks in the over 100,000 lb. gross vehicle weight class pay about 40 percent of their costs.
- ¹⁶ U.S. Department of Transportation, *Addendum to Federal Highway Cost Allocation Study*, Table 7, Ratios of 2000 Federal User Charges to Allocated Costs by Vehicle Class.
- ¹⁷ U.S. Department of Transportation, *The U.S. Department of Transportation’s Comprehensive Truck Size and Weight Study*, Executive Summary p. 3.
- ¹⁸ Notes to Table 2-2: Shipper savings are “truck-to-truck” annual savings from Table XII-1, p. XII-4. Congestion savings are from Tables IX-6 through IX-10. Pavement costs are 20-year costs from Table V-4, p. V-14, divided by 20 to annualize. Bridge costs are 20-year capital costs from Table VI-2 divided by 20 to annualize. Bridge under construction (u/c) congestion costs are put equal to bridge capital costs since USDOT figures at five to seven times capital costs are completely implausible. Geometry costs (realigning curves and grades) are from Table 3, p.VII-12, divided by 20 to annualize.

- ¹⁹ U.S. Department of Transportation, *The U.S. Department of Transportation's Comprehensive Truck Size and Weight Study*, Volume III, p.X-6.
- ²⁰ "A Vehicle Weights and Dimensions (VWAD) Study" Technical Steering Committee Report, VWAD, Ottawa, 1986, p. 14.
- ²¹ One notable exception is Florida, which allows axle weights up to 44,000 pounds.
- ²² Off-tracking is the extent to which the track of the rear of a combination diverges from the track of the tractor on curves. The problem increases with the length of the trailers and the number of pivot points. Triples and B doubles experience lower rates of off-tracking.
- ²³ "The B-train configuration eliminates rollover due to rearward amplification and may be a means of improving stability of double-tank trucks which would often haul gasoline or other hazardous goods." From "New Trucks for Greater Productivity and Less Road Wear," Transportation Research Board, National Research Council, Special Report 227, 1990, p. 185 in the conclusions and recommendations chapter.
- ²⁴ *Motoring Facts*, Australian Automobile Association, June 2000, p. 4, reports that Australian road fatalities have declined more than 50 percent between the mid-1970s and 2000, to 90 deaths per million population per year. That compares with the current U.S. rate of 150 per million per year, even though miles traveled per capita are slightly higher in Australia. The U.S. rate declined only 25 percent over the same period. While many factors are responsible, the decline coincides with the shift to B-train combinations and tridem-equipped semitrailers. In any event, it seems clear that the growing use of B doubles has not led to increased fatalities on Australian highways.
- ²⁵ Economic Associates Pty. Ltd., *Proposed Second Hurdle for HigherMass Limits: Regulatory Impact Statement* (Melbourne: National Road Transport Commission, December 1999), p. 24.
- ²⁶ U.S. Department of Transportation, Federal Highway Administration, *Status of the Nation's Surface Transportation System: Condition and Performance* (Washington, DC: U.S. Department of Transportation, 1997), p. 289.
- ²⁷ "Sonoma-101 CA Go for Dynamic Priced HOT Lane—Parsons Brinckerhoff," *Toll Roads Newsletter*, #28, June 1998, p. 1.
- ²⁸ Author (Samuel) interviews with Smith Midland and Tavares Concrete, March 2002.
- ²⁹ AASHTO is the American Association of State Highway and Transportation Officials.
- ³⁰ Kenneth A. Small and Clifford Winston "Optimal Highway Durability," *American Economic Review*, Vol. 78, June 1988, pp. 560-569.
- ³¹ Kenneth A. Small, Clifford Winston and Carol A. Evans, *Road Work: a New Highway Pricing and Investment Policy* (Washington, D.C.: The Brookings Institution, 1989), p. 42.
- ³² Wayne Muri, "Paving the Way," *TR News* 154, May-June 1991, pp. 2-9.
- ³³ www4.trb.org/trb/dive.nsf/web/homepage?OpenDocument.
- ³⁴ Author (Samuel) interviews with turnpike engineers, 2001.
- ³⁵ www/ohioturnpike.org/class11.html
- ³⁶ Derived from 1997 *Federal Highway Cost Allocation Study* (op. cit.), Table IV-11, p. IV-21 plus Addendum, May 2000, Table 6, p. 8, assuming non-toll user fees are 94 percent of total user-fees of combinations as for all vehicles, and that state and local fees are over 1997 projections for 2000 by the same proportion (9 percent) as reported for federal fees in the May 2000 Addendum. Arithmetic is \$18.2 billion x 7.8/7.2 x 0.94/116 billion miles traveled = 16cents/combo mile.
- ³⁷ Peter Samuel, *Putting Customers in the Driver's Seat*, Policy Study No. 274 (Los Angeles: Reason Public Policy Institute, November 2000), pp. 33-35.
- ³⁸ Hsiao Shen Jacob Tsao and Jan Louis Botha, "An Automated Highway System Dedicated to Inter-City Trucking: Operating Concepts and Deployment," San Jose State University, paper 2-2857, Transportation Research Board Annual Meeting, January 2002.
- ³⁹ See www.cordis.lu/telematics/tap_transport/research/projects/chauffeur.html.
- ⁴⁰ Excluding the segment of I-70 through the Rocky Mountains, Lakewood to Glenwood Springs.



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