Maine and Vermont Interstate Highway Heavy Truck Pilot Program

6-Month Report

Table of Contents

Executive Summary

Section 194 of the Consolidated Appropriations Act, 2010 (Public Law (P.L.) 111-117), directs the Secretary of Transportation to study the impacts of the Maine and Vermont truck pilot programs, which replace Federal commercial-vehicle weight regulations with State limits on Interstate highways in those States. Public Law 111-117 also exempts Maine and Vermont from following Federal Bridge Formula B requirements mandated by Section 127 of Title 23, United States Code.

The purpose of this initial assessment is to report "...to the House and Senate Committee on Appropriations no later than six months after the start of the pilot program on the impact to date of the pilot program on bridge safety and weight impacts." Accordingly, this report presents the findings of the U.S. Department of Transportation (DOT) analysis which focuses on bridge safety and pavement performance. It discusses truck size and weight regulations in Maine and Vermont prior to and after passage of P.L. 111-117 and provides the most recent weigh-in-motion, registration, and permit data. The report also summarizes the findings of previous truck size and weight studies and highlights methodologies used to determine bridge load and operating ratings.

The DOT organized a team comprised of several Federal and State agencies to assess the impacts of heavier truck weights on Interstate bridges and pavements in Maine and Vermont. The team includes representatives from the Federal Highway Administration (FHWA), Federal Motor Carrier Safety Administration (FMCSA), Maine Department of Transportation (MaineDOT), Maine State Police, the Maine Bureau of Motor Vehicles, Vermont Agency of Transportation (VTrans), and Vermont Department of Motor Vehicles (Vermont DMV). The team specifically examined the following highways: Vermont I-89, I-91, and I-93; Maine I-95 from the Maine-New Hampshire border; Maine I-295 beginning at the turnpike south of Portsmouth and paralleling the turnpike until I-295 reconnects with the turnpike south of Augusta; Maine I-95 from the intersection of I-295 and the Maine Turnpike to the Canadian border near Houlton.

Given the short timeframe of the study, the team concentrated on the requested topics of bridge safety and weight impacts, and utilized existing infrastructure data, engineering principles, and models that are established industry practice. There was insufficient time to acquire empirical data to accurately quantify the impacts of the pilot on bridge safety and weight impacts. To better understand bridge impacts one needs to measure the weight of actual trucks using the bridge and perform detailed load rating analysis that accounts for the bridge conditions and maintenance records. FHWA was not able to gather this information in the time frame of this study. It may take many years before any measurable impacts to the bridges and pavements could be physically observed. A subsequent report required by the Congress on the 1-year Vermont pilot program will expand this examination to include effects on "highway safety, bridge and road durability, commerce, truck volumes, and energy use within the State of Vermont."

Maine and Vermont Pilot Programs

As allowed by the statute, Maine and Vermont have chosen to apply their State commercial-vehicle weight laws to the Interstate System. Maine now allows tractors with semitrailers up to 100,000 pounds gross vehicle weight on six axles and tandem axle weights up to a maximum of 46,000 pounds for many commodities on the non-tolled Interstate highways. Tolled Interstate highways and a portion of free Interstate between the southerly terminus of the Maine Turnpike and the New Hampshire border were already exempt. Maine did not choose to allow other non-federally compliant State truck weights onto the Interstate System. Vermont allows all trucks legal on its State highway system onto its Interstate highways, including those that weigh up to a maximum gross vehicle weight of 99,000 pounds on six axles, and trucks with tandem axles that weigh up to a maximum of 36,000 pounds plus a 10 percent additional weight allowance, which allows a total of 39,600 pounds.

Bridge Impacts

The DOT analyzed available National Bridge Inventory (NBI) data and inspection records to assess the potential impacts of heavier gross vehicle and axle weights on the pilot-study-eligible Interstate highways. Bridges are inspected on a regular cycle as determined by the States in compliance with National Bridge Inspection Standards (NBIS), and calculations are based on standard simplified techniques. There was insufficient time to gather more data or conduct a more thorough analysis for this 6-month report to Congress.

The MaineDOT and Vtrans conducted more detailed analyses for a small sampling of bridges. These analyses focused on bridges that posed the highest risk as determined by their current condition and documented load rating. The State analyses took into account updated bridge inspection reports, current/future maintenance plans, and more detailed mathematical calculations.

The DOT's screening analyses found that the level of structural safety on bridges is likely to be reduced by the introduction of heavier trucks allowed under the pilot program, based on a check of the NBI reported bridge load rating and expected increase in beam stresses. In most cases, the level of safety is likely to remain above the minimum required by the American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications for the inventory threshold. The inventory rating refers to a loading for routinely operating vehicles which can travel without restriction. However, in several cases, the initial load rating screening indicates that the pilot truck will approach the operating limit, which is the absolute maximum threshold established by the AASHTO Manual for Bridge Evaluation (MBE). If this limit is breached, the State department of transportation would post lower allowable weights for the bridge and examine potential maintenance and repair options. Bridges are routinely designed for weights in excess of minimum design criteria to account for permitted non-divisible heavy loads. These findings highlight the need for further evaluation of those bridges, including more detailed stress analysis and increased monitoring and vigilance through weigh-in-motion and visual inspections.

Pavement Impacts

Axle load and the number of axles traveling over a road are the most important factors in determining pavement wear. At this time, it is unclear whether the number of axles traveling over pilot program Interstates will increase or decrease. The FHWA and Vtrans will have a more complete understanding of axle weights after the pilot program is implemented for 1 full year.

With respect to axle loads, Maine and Vermont have undertaken different approaches to Pilot Program implementation. Maine allows a 100,000 pound, six-axle truck with up to 46,000 pounds on a tandem axle unit and 54,000 pounds on a tri-axle (tridem) group to travel on its Interstates. Vermont allows several different short- and long-wheel base truck configurations that currently operate on Vermont State roads onto Interstate highways. These trucks may carry up to 39,600 pounds (36,000 pounds plus a 10 percent tolerance) on a tandem axle unit and 54,000 pounds on a tri-axle group. Both Maine and Vermont provide shippers with an opportunity to load more payload onto a truck by placing more weight over the tridem relative to the tandem axle group. Additionally both States allow more weight on the tandem axle group than is allowed currently by Federal law on the Interstate System. Accurate loading is important for the tandem-tridem trailers to minimize pavement damage.

The Maine and Vermont pilot programs have the potential to increase pavement damage by increasing the frequency of tandem axles that weigh over the federally allowable limit of 34,000 pounds. Any shift to a heavier tandem axle weight could have very significant impact on pavement performance. For example, a 4 percent shift to the 34,000 to 40,000 pound category would increase pavement damage by 10 percent. An increase in the frequency of trucks with greater than 40,000 pound axles would have an even further detrimental effect on pavement performance.

In the long term, heavier vehicles allowed under the Maine and Vermont pilot programs would cause additional pavement damage that could be managed through increased maintenance and possibly increasing pavement thickness where needed. To limit the potential pavement damage, axle loads should be tightly controlled through industry cooperation and increased enforcement. To the extent truck travel transfers from the non-Interstate system to the Interstate system, the State could manage the additional costs through potential savings on non-Interstate routes, an issue which will be further studied in the Vermont pilot program.

Summary

This 6-month study examined “the impact to date of the pilot program on bridge safety and weights,” as requested by the House and Senate Appropriations Committees. Given time constraints, DOT relied on existing data and models to assess the impacts. The collection of empirical data to directly measure and quantify pilot program impacts would take 10 to 15 years, according to FHWA bridge and highway engineers. This length of time is needed to conduct visual inspections of facilities, examine physical changes to facilities, and isolate the impact of heavier vehicles and axle loads on bridge and highway infrastructure. In addition, other important safety impacts, such as the safety improvements of moving trucks from the local roads

and State highways to the Interstate highways, are beyond the scope of this study. National analysis shows that large trucks are involved in fewer crashes on rural Interstate compared to non-Interstate rural roads. To the extent large trucks are moved from the local roads and State highways to the Interstate system there will be benefits to safety and livability since fewer trucks will pass schools, neighborhoods, and shopping centers. Definitive crash analysis of Maine and Vermont crashes is inherently difficult to analyze because the States experience relatively few truck-involved crashes per year. The DOT will provide more detailed modeling analysis and empirical data in its study of Vermont's pilot program after 1 full year of implementation.

DOT concludes:

- To maintain bridge safety Maine and Vermont will need to continue evaluation of their Interstate highways where heavier vehicles operate. The pilot program allowing trucks that weigh more than current Federal limits has reduced the margin of safety on bridges and increased the need for frequent bridge inspection, maintenance and detailed load rating analysis. Although remote, an increased possibility of overload exists, which could produce permanent damage to bridges in the form of yielding or cracking Continued monitoring of bridge conditions and further analysis should mitigate any concerns over the risk of a sudden bridge collapse for the duration of the pilot program.

- The use of heavier axle loads on Interstate highways in Maine and Vermont will reduce pavement life on the Interstate highways, but could reduce the burden on the non-Interstate system depending upon the transfer of heavy trucks. The FHWA and the State of Vermont will further quantify the long-term effects of heavier axles and heavier loads on roads and bridges in the Vermont study.

Of general concern to DOT is the shift away from bridge protection weight limits (Federal Bridge Formula B) in the pilot program States. The pilot programs allow vehicles that do not meet statutory bridge protection weight limitations to operate on Maine and Vermont Interstate highways, although Maine does have a state-based bridge formula they enforce through state statute.

Six months is not sufficient time to fully analyze and document the safety effects on bridges or the impact on pavements subjected to new truck weights as called for in the House and Senate Conference Report. These impacts may have negative connotations as they relate to bridge and pavement service life on the Interstates. They may also have positive connotations when including the non-Interstate system in the analysis of safety, economic, livability, energy and environmental issues. Further information on the results of transferring heavy trucks from the Interstate to the non-Interstate system will be provided to Congress in DOT's study of the Vermont pilot program after 1 full year of implementation.

Maine and Vermont Interstate Highway Heavy Truck Pilot Program 6 Month Report

Introduction

Section 194 of the Consolidated Appropriations Act, 2010 (Public Law (P.L.) 111-117), established a 1-year heavy truck pilot program that allows Maine and Vermont to apply State laws and regulations on their portions of the Interstate System. The pilot program allows trucks with a gross vehicle weight above 80,000 pounds and a tandem-axle weight above 34,000 pounds to operate on each State's Interstate highways. The legislation also exempts Maine and Vermont from following Federal Bridge Formula B regulations, mandated by Section 127 of Title 23, United States Code (see box).

Section 194(a) In General – Section 127(a)(11) of title 23, United States Code, is amended by striking "that portion of the Maine Turnpike designated Route 95 and 495, and that portion of Interstate Route 95 from the southern terminus of the Maine Turnpike to the New Hampshire State line, laws (including regulations)" and inserting "all portions of the Interstate Highway System in the State, laws (including regulations)".

(b) Period of Effectiveness – The amendment made by subsection (a) shall be in effect during the 1-year period beginning on the date of enactment of this Act.

(c) Reversion – Effective as of the date that is 366 days after the date of enactment of this Act, section 127(a)(11) of title 23, United States Code, is amended by striking "all portions of the Interstate Highway System in the State, laws (including regulations)" and inserting "that portion of the Maine Turnpike designated Route 95 and 495, and that portion of Interstate Route 95 from the southern terminus of the Maine Turnpike to the New Hampshire State line, laws (including regulations)".

(d) Vermont Pilot Program – Section 127(a) of title 23, United States Code, is amended by adding at the end the following:

(13) Vermont Pilot Program –
"(A) In General – With respect to the Interstate Routes 89, 91 and 93 in the State of Vermont, laws (including regulations) of that State concerning vehicle weight limitations apply to the State highways other than the Interstate system shall be applicable in lieu of the requirements of this subsection".

(e) Period of Effectiveness for the Vermont Pilot Program – The amendment made by subsection (d) shall be in effect during the 1-year period beginning on the date of enactment of this Act.

(f) Reversion for the Vermont Pilot Program – Effective as of the date that is 366 days after the date of enactment of this Act, Section 127(a) of title 23, United States Code, is amended by striking paragraph (13).

(g) Report on the Vermont Pilot Program – Not later than 2 years after the date of enactment of this paragraph, the Secretary shall complete and submit to Congress a report on the effects of the pilot program under this paragraph on highway safety, bridge and road durability, commerce, truck volumes, and energy use within the State of Vermont.

The House and Senate Committees on Appropriations Explanatory Statement of the Committee of Conference added:
Section 194 modifies a provision proposed by the Senate to establish a 1-year pilot program related to truck weight in the States of Maine and Vermont. The conferees direct the Secretary to report to the House and Senate Committees on Appropriations no later than 6 months after the start of the pilot program on the impact to date of the pilot program on bridge safety and weight impacts.

The statute directed the Secretary of Transportation to assess the impacts of heavier vehicles on bridges and pavements. The U.S. Department of Transportation (DOT) organized a team of several Federal and State agencies to report to Congress on pilot program impacts within 6 months of implementation. The team included representatives from:

- Federal Highway Administration (FHWA),
- Federal Motor Carrier Safety Administration (FMCSA),
- Maine Department of Transportation (MaineDOT),
- Maine State Police,
- Maine Bureau of Motor Vehicles,
- Vermont Agency of Transportation (Vtrans), and
- Vermont Department of Motor Vehicles (Vermont DMV).

As part of the 6-month assessment, the DOT team examined the following highways:

- Vermont I-89,
- Vermont I-91,
- Vermont I-93,
- Maine I-95 from the Maine-New Hampshire border,
- Maine I-295 beginning at the turnpike south of Portsmouth and paralleling the turnpike until I-295 reconnects with the turnpike south of Augusta, and
- Maine I-95 from the intersection of I-295 and the Maine Turnpike to the Canadian border near Houlton.

Given the short timeframe of the 6-month study, the team concentrated on the requested topics of bridge safety and weight impacts, and relied on existing infrastructure data and used established models and engineering practices to analyze information. There was insufficient time to collect empirical data since it takes years before bridge and pavement impacts can be quantified. Congress has required a subsequent report on the 1-year Vermont pilot program in order to expand DOT's examination of the effects on "highway safety, bridge and road durability, commerce, truck volumes, and energy use within the State of Vermont."

Maine and Vermont Pilot Program

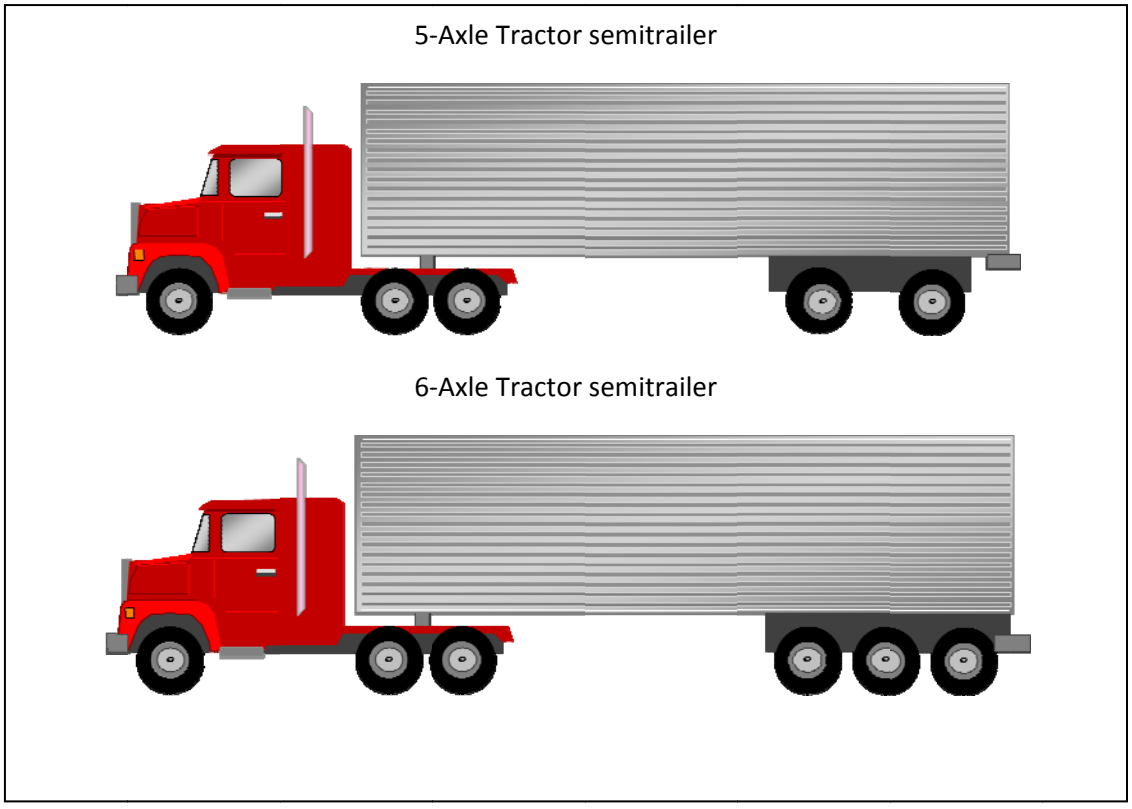
Both States chose to replace current Federal commercial-vehicle weight regulations with State laws, as allowed by P.L. 111-117. Maine now allows 6-axle tractor semitrailers that weigh up to 100,000 pounds gross vehicle weight and trucks with tandem axles that weigh up to a maximum of 46,000 pounds for hauling many commodities on non-tolled Interstate highways. Tolled Interstate highways and a portion of free Interstate highways between the southerly terminus of the Maine Turnpike and the New Hampshire border were already exempt. Maine chose not to allow other non-federally compliant State truck weights onto its Interstate System.

Vermont allows all trucks that are legal on its State highway system onto its Interstate highways, including six-axle vehicles that weigh up to a maximum gross vehicle weight of 99,000 pounds and trucks with tandem axles that weigh up to a maximum of 36,000 pounds. Vermont adds a 10 percent weight tolerance to tandem axles, bringing the total allowable weight up to 39,600 pounds.

Current Federal commercial vehicle regulations allow a maximum gross vehicle weight of 80,000 pounds and a maximum weight on axle groups, including the tandem (two-axle) group, of 34,000 pounds on the Interstate System. Federal regulations do not control the size of trucks that operate off the National Network.[1] Figure 1 shows typical five-axle and six-axle tractor-semitrailer configurations.

Federal truck size and weight regulations have important economic implications for States. They influence trucking costs, productivity, highway safety, and highway construction and maintenance requirements. Truck sizes and weights are particularly important to Maine and Vermont where trucks move more than 85 percent of the freight transported within or through their States. Forest products and other heavy commodities are major contributors to both States' economies.[2]

Figure 1. 5-axle and 6-axle Tractor-Semitrailer Configurations



[1] The National Network was authorized by the Surface Transportation Assistance Act of 1982 (P.L. 97-424) and is specified in the U.S. Code of Federal Regulations (23 CFR 658). It requires States to allow conventional combinations on "…the Interstate System and those portions of the Federal-aid Primary System..." Conventional combinations are tractors with one semitrailer up to 48 feet in length or with one 28-foot semitrailer and one 28-foot trailer, and can be up to 102 inches.

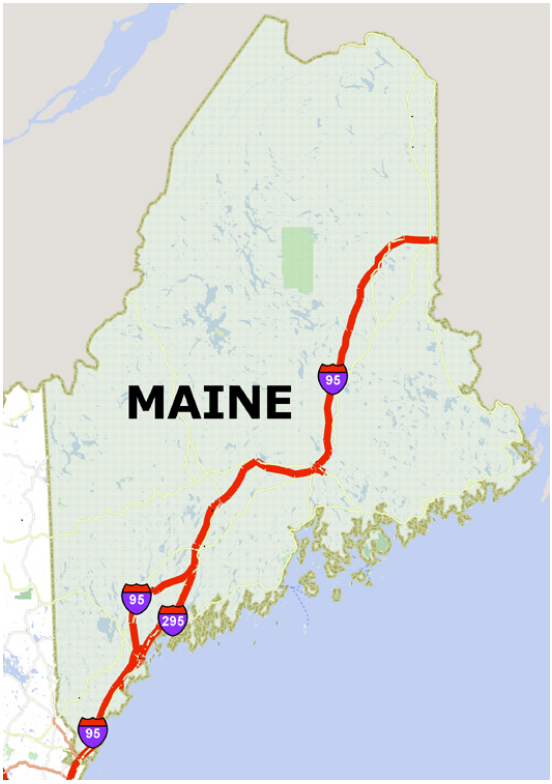
[2] Source http://ops.fhwa.dot.gov/freight/resources/frt_solutions/index.htm .

Truck Size and Weight on the Maine State and Interstate Highway System

Prior to P.L. 111-117

Maine allowed a maximum weight of 100,000 pounds for six-axle tractor-semitrailer combinations on non-Interstate highways. On the Interstate (Figure 2), Maine followed Federal weight limits set out in the Federal-Aid Highway Amendments of 1974. Maine State law (29-A §2355) specified Bridge Formula B for maximum weights on the Interstate and 80,000 pounds as the maximum gross vehicle weight.

Figure 2. Maine Interstate Highways



In addition, Maine applied two limited statutory exceptions to Federal truck size and weight regulations on its Interstate highways. The first exception allows DOT/FHWA to waive Federal weight requirements for the shipment of jet fuel on I-95 between Augusta and Bangor to supply the Air National Guard Base at Bangor International Airport during periods of national emergency. The second exception was granted by the 1998 Transportation Equity Act for the 21st Century (TEA-21) (P.L. 105-178, §1212), which states:

> "With respect to that portion of the Maine Turnpike designated Interstate Route 95 and 495 and that portion of Interstate Route 95 from the southern terminus of the Maine Turnpike to the New Hampshire State line, laws (including regulations) of the State of Maine concerning vehicle weight limitations that were in effect on October 1, 1995 and are applicable to the State highways other than the Interstate System…"

This exception connected the southern end of the Maine Turnpike, which is not subject to Federal size and weight regulations, with the New Hampshire border.

Table 1 shows registration activity for trucks weighing more than 80,000 pounds in Maine for the 2006 to 2010 period. While registrations in the 80,000 pound to 90,000 pound category have declined, and registrations in the 94,000 pound to 100,000 pound category have gone up, overall registrations have remained fairly steady over the past 5 years and have declined somewhat for 2010.

Table 1. Maine Truck Registrations over 80,000 pounds[1]: 2006–2010 (as of January 1)

	2006	2007	2008	2009	2010
Registered Weight (pounds)					
80,001 to 90,000	710	673	567	550	489
90,001 to 94,000	7	9	8	10	12
94,001 to 100,000	3,018	3,271	3,293	3,427	3,345
Total	**3,735**	**3,953**	**3,868**	**3,987**	**3,846**

[1] Maine charges an annual registration fee of $1,234 for trucks with registered weights greater than 94,001 but less than 100,000 pounds. Fees must be expended for the enforcement of truck weight regulations.

Maine also allows a 10 percent axle-weight tolerance for vehicles hauling specific commodities (29-A §2357). This tolerance allows 24,200 pounds on a single axle; 46,000 pounds on a tandem axle; and 54,000 pounds on a tri-axle. Regardless of any allowance on an individual axle group weight, Maine requires that six-axle tractor semitrailers may only have a maximum gross vehicle weight of 100,000 pounds (Table 2).

Tandem and tri-axle limits for the 6-axle combination vehicle exceed Federal Bridge Formula B regulations. In general, the 6-axle tractor semitrailer weight on a tandem axle may not exceed 41,000 pounds, and the tri-axle weight may not exceed 50,000 pounds. For certain commodities, there is a 10 percent weight allowance on the axle weight, but the gross vehicle weight is strictly limited to 100,000 pounds. The Federal Bridge Formula B limit is 34,000 pounds for a tandem axle and 44,000 pounds for a tri-axle.

Table 2. Truck Size and Weight Limits in Maine and on Federal Interstate Highways: Prior to P.L. 111-117 (Axle Configuration, pounds)

Axle Configuration	Maine[1]		Federal Interstate
	State Roads	State Roads, Certain Commodities[4]	
Single Axle Limit	22,400	24,200	20,000
Tandem Axle Limit	38,000	46,000	34,000
Tri-axle weight limit	48,000	54,000	n/a
4-axle combination[2]		64,000	
Gross Vehicle Weight			
5 axle combination	80,000	88,000	80,000
6-axle combination[3]	100,000	100,000	80,000

Key: n/a = not applicable

[1] Maine State road limits also apply to that portion of the Maine Turnpike designated Interstate Route 95 and 495 and that portion of Interstate Route 95 from the southern terminus of the Maine Turnpike to the New Hampshire State line [23 U.S.C. §127(a)(11)].

[2]§ 2357(2) D. On the tri-axle unit of a 4-axle single-unit vehicle hauling forest products.

[3] For the six-axle tractor semitrailer allowed a gross vehicle weight of 100,000 pounds, the weight on tandem may not exceed 41,000 pounds and the tri-axle may not exceed 50,000 pounds.

[4]§ 2357(1) A. A vehicle loaded entirely with building materials that absorb moisture during delivery originating and terminating within the State, bark, sawdust, firewood, sawed lumber, dimension lumber, pulpwood, wood chips, logs soil, unconsolidated rock material including limestone, bolts, farm produce, road salt, manufacturer's concrete products, solid waste or incinerator ash;

§ 2357(1) B. Dump trucks or transit-mix concrete trucks, carrying highway construction materials;

§ 2357(1) C. A vehicle loaded with a majority of products requiring refrigeration whether by ice or mechanical equipment; or

§ 2357(1) D. A vehicle loaded with raw ore from the mine or quarry to a place of processing.

Post P.L. 111-117

P.L. 111-117, Section 194, would have allowed all truck weights, axle spreads and commodity exemptions as specified in Maine Law Chapter 21, Subchapter I on all Maine Interstate highways, but the Maine legislature amended Chapter 21 with Section 2355. The amendment states:

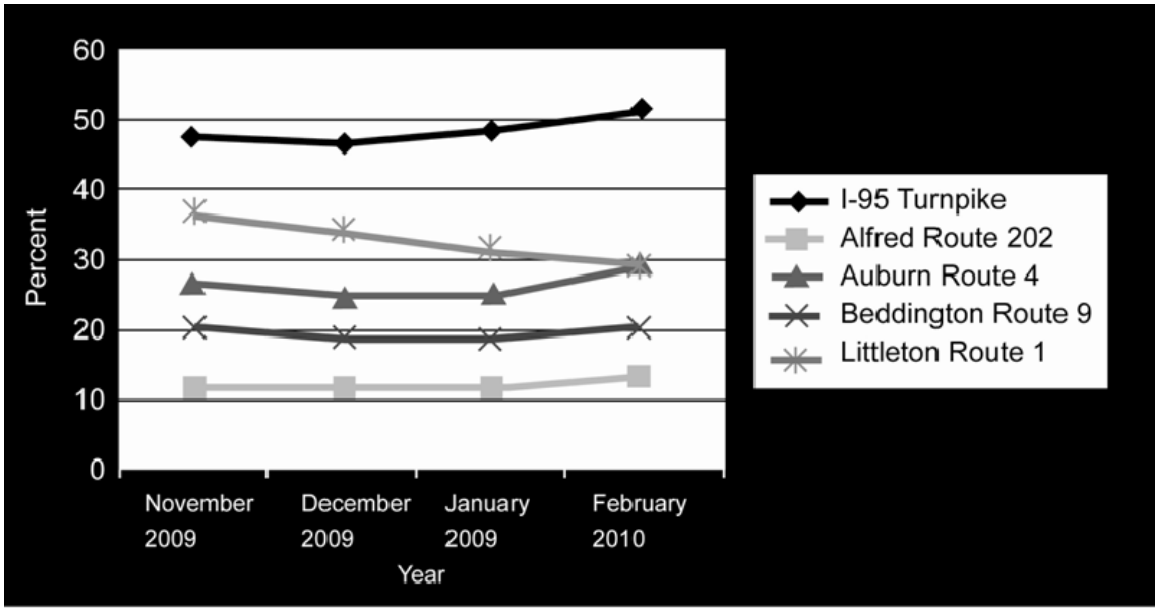
> "not withstanding any other provision of this subchapter to the contrary, for as long as the provision of 23 United States Code, Section 127(a)(11) affording an exemption from the federal vehicle weight limitations for vehicles operating on all portions of the interstate system are in effect, a 6-axle combination vehicle consisting of a 3-axle truck tractor with a tri-axle semitrailer having a maximum gross vehicle weight of 100,000 pounds may be operated on any portion of the interstate system, consistent with this subchapter as it applies to the Maine Turnpike designated Interstate 95, subject to provisions of section 2354. For purposes of this section, 'interstate system' has the same meaning as in Title 23, section 1903, subsection 3." (Section 1.29-A MRSA § 2355-A)

The change is retroactive to December 16, 2009.

Maine Weigh-in-Motion

Weigh-in-motion data show gross vehicle weight and axle weights for trucks passing weigh-in-motion stations. Figure 3 gives a snapshot of the percentage of trucks operating in Maine for the November 2009 to February 2010 period. The data show relatively high use rates for trucks weighing more than 80,000 pounds but less than 120,000 pounds. It is interesting to note that the percentage of trucks in that weight category has not declined on the I-95 Turnpike following pilot program implementation. (The non-tolled Interstate runs parallel to the Maine Turnpike.)

Figure 3. Maine - Percent of Total Trucks More than 80,000 pounds and less than 120,000 pounds

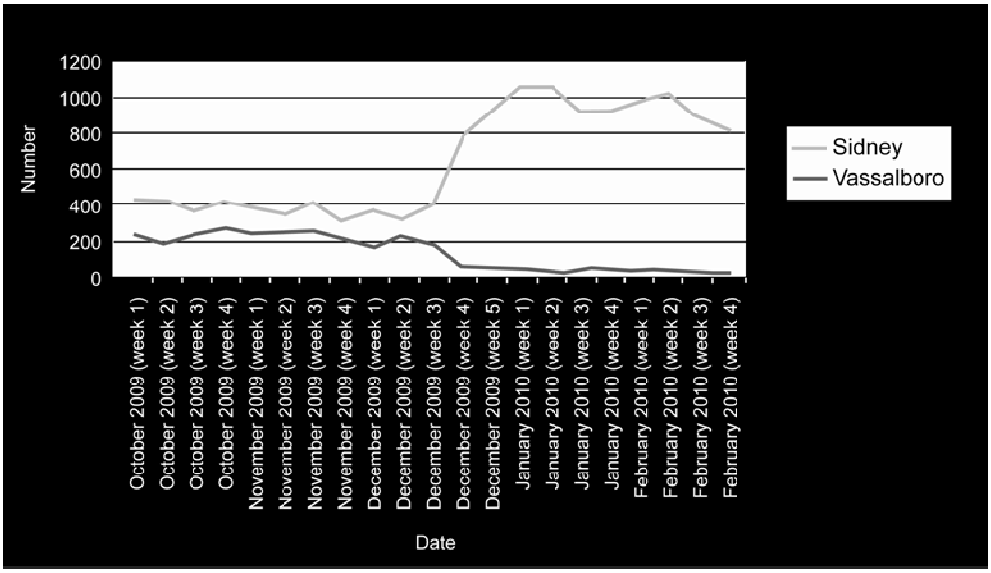


Maine Truck Count Data

Truck classification sites count the number of trucks passing in each direction by the number of axles and size, but do not weigh vehicles. Figure 4 shows truck count data for Sidney and Vassalboro, Maine. These two locations are roughly parallel. Sidney is located on Interstate 95, and Vassalboro is located on State Route 201. The figure shows a decrease in the number of six-axle tractor semitrailers on the State route and a much larger increase in the number of six-axle tractor semitrailers on the Interstate highway.

To the extent that this is representative of the shift of heavy trucks from the state highways and local roads to the Interstate system this represents an improvement in safety and livability. An additional anecdotal example comes from the study team's trip to Freeport, Maine. Freeport is a tourist shopping destination with many outlet stores located close to the state highway. To the extent that the pilot shifts heavy trucks from the state highway, with its multiple pedestrian crossings, to the parallel Interstate route there will be an improvement to Freeport's livability.

Figure 4. Six-Axle Tractor Semitrailer North Bound Truck Counts at I-95 Sidney and Route 201 Vassalboro, Maine



The weigh-in-motion and truck count data are not sufficient to conduct bridge safety or pavement analysis for the 6-month report. The data provide a snapshot of a shift from State highways to Interstate highways and an additional increase in the number of six-axle tractor semitrailers on the Interstate.

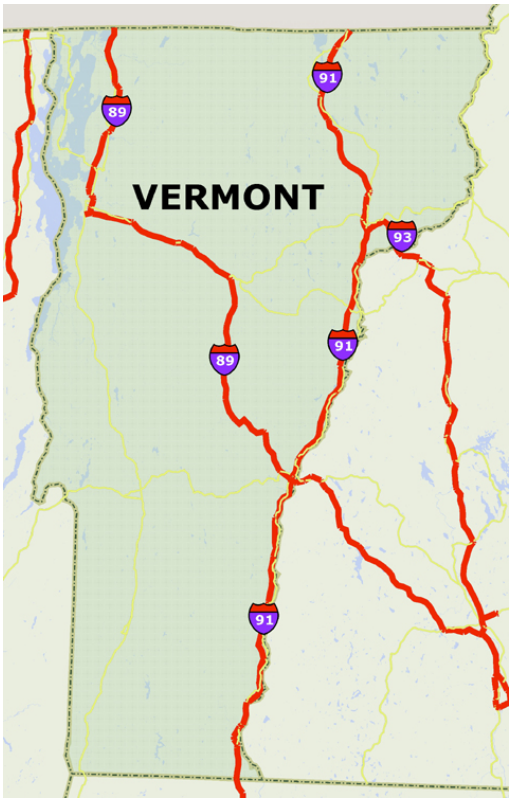
Truck Size and Weight on the Vermont State and Interstate Highway System

Prior to P.L. 111-117

Vermont State law mirrored Federal truck size and weight laws on its Interstate System (Figure 5), allowing single-axle loads of 20,000 pounds and tandem-axle loads of 34,000 pounds. Vermont's grandfather provision in Section 127 of Title 23, United States Code, allows the State to issue permits for hauling unprocessed milk up to a maximum gross weight of 90,000 pounds on a five-axle tractor-semitrailer combination or truck-trailer combination on its Interstate highways (Table 3).

On State highways, Vermont issued permits for six-axle truck tractor-semitrailer combinations with a maximum gross vehicle weight of 99,000 pounds and specially equipped for hauling unprocessed milk, unprocessed forest, or unprocessed quarry products. Vermont also allowed a 1,000 pound weight tolerance for five-axle tractor semitrailers weighing 90,000 pounds.

Figure 5. Vermont Interstate Highway



Post P.L. 111-117

The pilot program is in effect for 1 year following enactment of P.L. 111-117 on December 16, 2009. The statute requests the submission of two reports: one at the end of 6 months after pilot program implementation and one covering the full 1-year pilot program that is due 2 years after the date of enactment "on highway safety, bridge and road durability, commerce, truck volumes, and energy use within the State of Vermont." Unlike the Maine provisions in P.L. 111-117, the Vermont provisions identify specific Interstate highways for study. The legislation did not include Interstate 189, which is a 1.488-mile spur off Interstate 89 that connects to U.S. Route 7 in a principally industrial area of Burlington. The discussion below focuses on Interstate routes designated for study in P.L. 111-117.

Table 3. Vermont Vehicle Weight Regulations: Prior to P.L. 111-117

	State Roads (pounds)	State Roads, Certain Commodities (pounds)[1]	Interstate (pounds)
Single-axle Limit	22,400[2]		20,000
Tandem-axle Limit	36,000[2]		34,000
Tri-axle Limit	46,000[2]		n/a
Truck Limits			n/a
3-axle with tri-axle (registered weight of 55,000 pounds)	55,000[3]		
4-axle truck with tri-axle (registered weight of 60,000 pounds)	69,000[3]	99,000	
5-axle combination (registered weight of 80,000 pounds)	90,000[3]		80,000 (90,000 permitted unprocessed milk truck)[4]
6-axle combination	99,000		80,000

Key: n/a = not applicable.
[1] Unprocessed forest products including whole trees, parts thereof, logs, wood chips, sawdust, shavings and bark mulch, unprocessed quarry products and unprocessed milk.
[2] 10 percent weight tolerance is allowed.
[3] 5 percent weight tolerance is allowed.
[4]Sec. 23 V.S.A. § 1392 (13) 90,000 pounds is allowed on both State highways and Interstate highways when the load consists solely of unprocessed milk products.
Notes: The permit fee for hauling unprocessed milk is $10 if registered vehicle weighs 90,000 pounds or $285 if registered vehicle weighs 80,000 pounds; the fee is $310 for general commodities or unprocessed forest products if registered vehicle weighs 90,000 pounds; the permit fee is $500/year if hauling unprocessed milk, unprocessed forest or unprocessed quarry products and if the registered vehicle weighs 99,000 pounds.

Shortly after passage of P.L. 111-117, Vermont passed S.93, which allowed all State truck size and weight limits onto Interstate highways with no commodity limitations. This includes three-axle trucks with a gross vehicle weight of 55,000 pounds; four-axle trucks with a gross vehicle weight of 69,000 pounds; five-axle trucks with a gross vehicle weight of 90,000 pounds; and six-axle trucks with a gross vehicle weight of 99,000 pounds.

As shown in Table 4, Vermont issued 1,019 permits for vehicles weighing 90,000-99,000 pounds in 2009. The number of permits issued for that weight category has already reached 810 in the first 10 weeks of 2010. According to Vermont officials, this increase does not follow typical permitting activity that usually begins with the spring construction cycle. Vermont officials attribute the earlier-than-usual increase in permitting to the removal of commodity limitations.

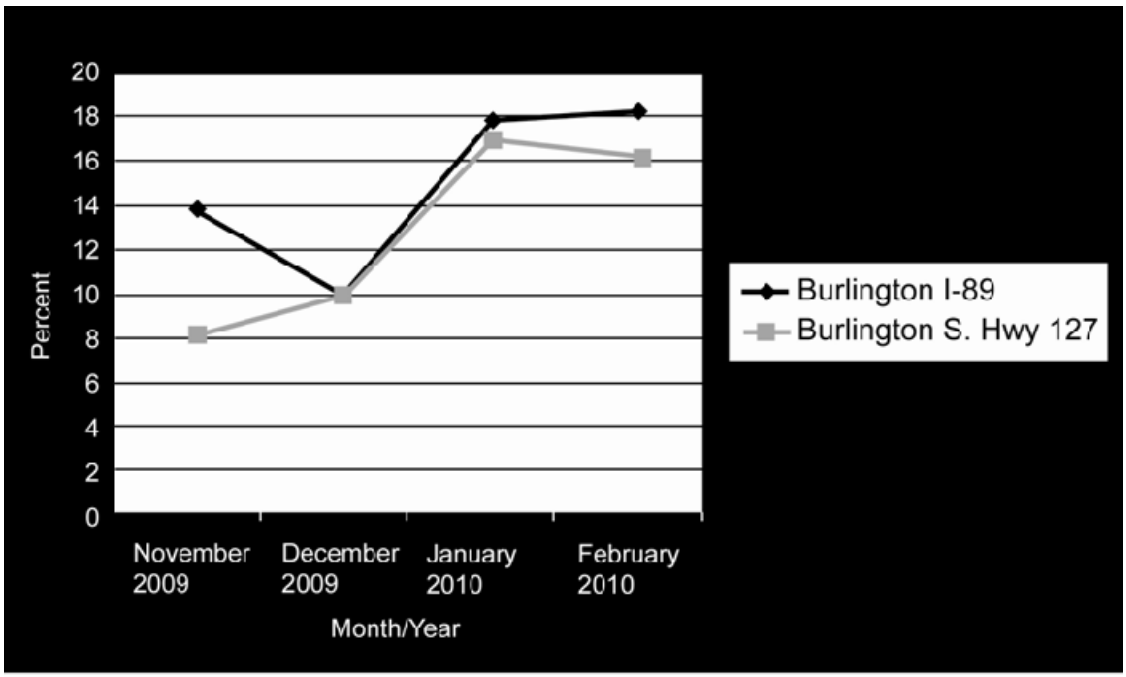
Table 4. Number of Vermont Special Excess-Weight Permits: 2007-2010

Type of Permit (All Products)	2007	2008	2009	January 1–March 17 2010
Registered for 90,000 pounds Permitted to 99,000 must have 6 axles	1,003	1,041	1,019	810
Registered for 55,000 pounds Permitted to 60,000 must have 3 axles	1,079	1,012	918	131
Registered for 60,000 pounds Permitted to 69,000 must have 4 axles	1,201	1,190	1,152	225

Vermont Weigh-in-Motion

Figure 6 provides a snapshot of the percentage of trucks weighing more than 80,000 pounds, but less than 120,000 pounds, passing weigh-in-motion stations on Burlington I-89 and State highway 127 from November 2009 to February 2010. A preliminary analysis of Vermont weigh-in-motion data shows an 8 percent jump in volume of trucks on both the Interstate route and the corresponding State route. The volume continues to increase on the Interstate in February and starts to decline slightly on the State road during the same period. Burlington I-89 and State Highway 127 weigh-in-motion stations are located near each other in Burlington. The Burlington station on I-89 sees roughly 10 times the traffic as State Highway 127. The FHWA and Vtrans are currently increasing the number of weigh-in-motion sensors on I-91 and I-93 in Vermont to more fully estimate pilot program impacts for pavements and bridges.

Figure 6. Vermont - Percent of Total Trucks More than 80,000 pounds and less than 120,000 pounds



Bridge Analysis Results

The FHWA used the Bridge Analysis and Structural Improvement Software (BASIC) model to analyze the impacts of heavier vehicles on Maine and Vermont Interstate bridges. BASIC computes the maximum total force effects (moments) for candidate trucks against a design vehicle. It then computes the ratio of each candidate truck's force effects to that of a design vehicle for each bridge. The model can consider both dead load and live load[3] because it has estimates of bridge dead loads as a function of design type, construction material, span length and design rating. BASIC calculates the candidate trucks' live and dead load moments and compares them to the bridge inventory or operating rating. The results show which bridges may be affected by heavier trucks. Overstresses should be investigated more rigorously to determine a bridge's load bearing capabilities.

Maine Bridges

According to the 2009 National Bridge Inventory (NBI), Maine has 175 open bridges on its non-tolled Interstate Highway System.[4] Most bridges in Maine are continuous span bridges, where bridge spans are longer than a truck wheel base, and are more susceptible to the gross vehicle

[3] Live loads are temporary loads placed on a bridge, e.g., vehicles. Dead loads are permanent loads placed on a bridge before the concrete hardens, e.g., stringers and connector plates.

[4] This excludes the Maine Turnpike since it is not part of this pilot study. The number of bridges excludes small culverts. None of Maine's Interstate bridges are posted for lower weights.

weight of trucks. Ninety-six percent of the 175 bridges are constructed of steel and, therefore, have the potential for a reduced fatigue life.

The NBI shows that about one-half of Maine's bridges carry fewer than 10,000 total vehicles per day. Therefore, "truck traffic volumes in Maine are very low compared to most States and bridges will need replacement or rehabilitation due to general deterioration before they approach their fatigue life."[5]

The NBI data also show that 36 bridges are functionally obsolete, and 2 are structurally deficient. "Of the 2 that are structurally deficient, one will be repaired this year and the other one during the 2012-2013 construction season."[6] For more discussion on bridges classified as functionally obsolete and structurally deficient, please see Appendix B.

FHWA Screening Analysis

Table 5 shows the results of the BASIC screening analysis of Maine's Interstate bridges. The inventory rating[7] check indicates that the long wheel base 100,000 pound six-axle tractor semitrailer produces at least a 10 percent overstress on almost 27 percent of Maine's Interstate bridges. The operating rating[8] check indicates that Maine's non-tolled Interstate bridges can accommodate the 100,000 pound six-axle tractor semitrailer because this vehicle produces no overstresses relative to the operating rating on any bridges.

Table 5. Maine: Percentage of Bridges with Apparent Insufficient Rating for the Long-base,6 axle Truck (based on FHWA screening analysis)

	>5 percent over	>10 percent over	>20 percent over	>30 percent over	>40 percent over	>50 percent over
Inventory Rating	42%	27%	7%	0%	0%	0%
Operating Rating	0%	0%	0%	0%	0%	0%

MaineDOT Analysis

The BASIC screening analysis found that the 100,000 pound six-axle tractor semitrailer produced a negative moment ratio on several steel bridges and recommended further evaluation. MaineDOT completed a detailed Load and Resistance Factor Rating (LRFR) analysis of the four most critical steel bridges (Table 6) and concluded that Maine's non-tolled Interstate bridges "will safely carry the 6-axle tractor semitrailer at 100,000 pounds with Maine's axle and spacing requirements."[9] (See Appendix B for more discussion on LRFR)

[5] Chip Getchell, P.E., Director, Asset Services Division, MaineDOT
[6] Ibid.
[7] The inventory rating is the load that can safely use a bridge for an indefinite period of time.
[8] The operating rating is the maximum permissible live load (e.g., vehicles) that can be placed on a bridge.
[9] Chip Getchell, P.E., Director, Asset Services Division, Maine DOT – interview with Karen White, FHWA, Office of Transportation Policy Studies.

Table 6. Maine LRFR Analysis of Four Steel Bridges

Maine Bridges Stress Levels Relative to a Routine (non-permit) Load		
	BASIC Moment Ratio	LRFR Rating Factor
Bridge Number	Potential Overstress	Understress (Overstress)
5985	27.10%	(4.00%)
6075	29.60%	5.00%
5999 Northbound	25.40%	3.00%
5999 Southbound	25.40%	3.00%

Vermont Bridges

Unlike Maine, most Interstate bridges in Vermont are simple span bridges, with spans shorter than a truck wheel base, and are more susceptible to axle weights. Vermont is similar to Maine in that 67 percent of its bridges were built over 40 years ago, which is over half of the bridge life.

Vermont's implementation of the pilot program differs from that implemented by Maine. Maine chose to only allow the 100,000-pound six-axle tractor semitrailer with a long wheel base onto its non-tolled Interstate. Vermont allowed all State permitted size and weights onto its Interstate highways and expanded its previous commodity-specific size and weight provisions to include all commodities. This means that short wheel base trucks with heavy-axle loads, along with long wheel base trucks, also with heavy-axle loads, are allowed to use these bridges. Maine chose to allow only 100,000-pound six-axle tractor semitrailers with a long wheel base onto its non-tolled Interstate highways.

An examination of NBI data shows that 95 bridges are functionally obsolete and 21 are structurally deficient. Of the 21 structurally deficient bridges, 15 are included in the work plan for varying stages of repair over the next 3 years; 6 of those bridges are not included in the work plan because their deterioration is not affecting the load capacity.

FHWA Screening Analysis

The BASIC screening analysis of Vermont Interstate bridges differs from that performed for the State of Maine. In Vermont, all truck configurations currently allowed on State highways are now allowed onto its Interstate highways. Therefore, the analysis considered several different truck configurations that may overstress bridges. BASIC was able to analyze 94 percent of Vermont's Interstate bridge inventory.

Table 7 shows the results of the screening analysis. The analysis found that short wheel base, six-axle trucks used for hauling milk, quarry, and forest products produced the highest stress levels on most bridges. The 90,000-pound short wheel base five-axle truck affected only a few bridges. Relative to the inventory rating, NBI records show almost 13 percent of Vermont's bridges are potentially overstressed by at least 10 percent by short wheel base trucks and the 99,000-pound six-axle tractor semitrailer. Moreover, at least 3 percent of bridges are potentially overstressed by at least 20 percent by pilot program trucks. The operating rating check indicates that no bridge is overstressed.

Table 7. Vermont: Percentage of Bridges with Apparent Insufficient Rating for the Short Wheel Base, 6-Axle Truck used for Hauling Milk, Quarry, and Forest Products (based on FHWA screening analysis)

	>5 percent over	>10 percent over	>20 percent over	>30 percent over	>40 percent over	>50 percent over
Inventory Rating	19%	13%	3%	1%	0%	0%
Operating Rating	0%	0%	0%	0%	0%	0%

Vtrans Analysis

Vermont recently completed a 12-month Load Factor Rating (LFR) analysis on all its Interstate bridges. (See Appendix B for more discussion on LFR.) In response to preliminary analysis results, Vtrans conducted a more in-depth LFR analysis of number 58 bridges, north and south, on I-89, just south of Burlington. The agency chose these two bridges for further analysis because it expects to see an above-average loading of heavy trucks on them, and preliminary analysis identified them as potentially overstressed. Vtrans mathematically analyzed each bridge and individual members (stringers, riveted girders, and floor beams).

Bridges number 58, north and south, are constructed of A373 steel, which has a lower yield strength than steel typically required. This causes the bridge stringers to rate above an acceptable stress level. The purpose of the stringer is to support and transfer the load from the bridge deck onto the floor beams and girders. Vtrans believes that, "even without the stringers, the floor beams and girders have adequate capacity to carry the loads."[10] It is their engineering judgment that "as a unit, the bridges are showing no signs of fatigue weakening and (are) strong enough to support the increased loads."[11] These two bridges will be further analyzed, and additional findings will be available in the follow-on Vermont report.

[10] Pam Thurber, Senior Bridge Engineer, Vermont Agency of Transportation – interview with Karen White, FHWA, Office of Transportation Policy Studies.
[11] Ibid.

Bridge Analysis Summary and Conclusions

The FHWA conducted a cursory screening analysis of the majority of Interstate bridges in Maine and Vermont. Maine completed detailed LRFR analysis on four bridges that had been identified as potentially overstressed by pilot-program vehicles. Vermont ran a five-axle LFR screening analysis on all its Interstate bridges to assess bridge safety after implementation of the pilot program allowing up to 99,000-pound trucks onto the Interstate System. The screening analyses indicated that the margin of safety on bridges is potentially reduced by the introduction of the pilot program. In some cases, the level of safety is still expected to remain above the minimum required by the AASHTO Bridge Design Specifications for the inventory rating. The inventory rating refers to routinely operating vehicles which can operate without restriction. However, in several cases, the pilot program trucks may approach the operating limit, which is the maximum load established by the AASHTO Manual. The possibility of an overload on several bridges exists when heavy trucks are allowed into the general traffic stream. Overloading could cause yielding or cracking, but it does not increase the risk of sudden collapse as long as bridge conditions are carefully monitored. To better understand bridge safety impacts one needs to measure the weights of actual trucks using the bridge and perform detailed load rating analysis that accounts for the bridge conditions and maintenance records. FHWA was not able to gather this information in the time frame of this study. A more refined level of safety analysis will be completed by the end of the 1-year Vermont study.

The results of this 6-month study highlight the need for further evaluation of bridges, including more detailed resistance calculations, increased monitoring through weigh-in-motion data collection, and visual inspections. State transportation agencies, in concert with FHWA, continue to actively examine bridges in Maine and Vermont.

Pavement Analysis Results

The impact of raising the allowable gross vehicle weight and axle-load limits on pavements is difficult to quantify because complex interactions of many factors govern pavement performance, including the intensity and mix of traffic, pavement design, paving material, type of soil, and climate. Pavements are designed to last a long time (20 or more years), and visible signs of distress do not appear until close to the end of a pavement's design life. In general, once a pavement begins to show distresses, it tends to deteriorate rapidly, unless steps are taken to save and preserve the pavement structure.

One of the major difficulties in assessing the impact of load limit changes is that highways carry a wide range of axle loads, from light, inconsequential loads to permitted non-divisible loads that exceed design specifications. Figure 7 shows the national average axle-load distribution for tandem axles of heavy combination trucks (Class 9 and higher[12]) on Interstate highways. It is interesting to note the lack of a prominent peak at the current Federal Bridge Formula limit for tandem axles, which is 34,000 pounds. The graph indicates the majority of axles on Interstate highways are well below the current axle-load limit, but Figure 7 also shows a significant

[12] This includes 5-axle single-trailer trucks, six or more axle single trailer trucks, and trucks with multiple trailers.

frequency of very heavy axles. The intensity and frequency of axles that weigh more than 34,000 pounds has serious impacts on pavement performance. A relatively small number of extremely heavy axles moving permitted non-divisible loads can completely overshadow the effects of changes in axle-load limits for divisible loads. The impact of changes in load limits depends on how axle-load distribution is handled in response to newly prescribed load limits.

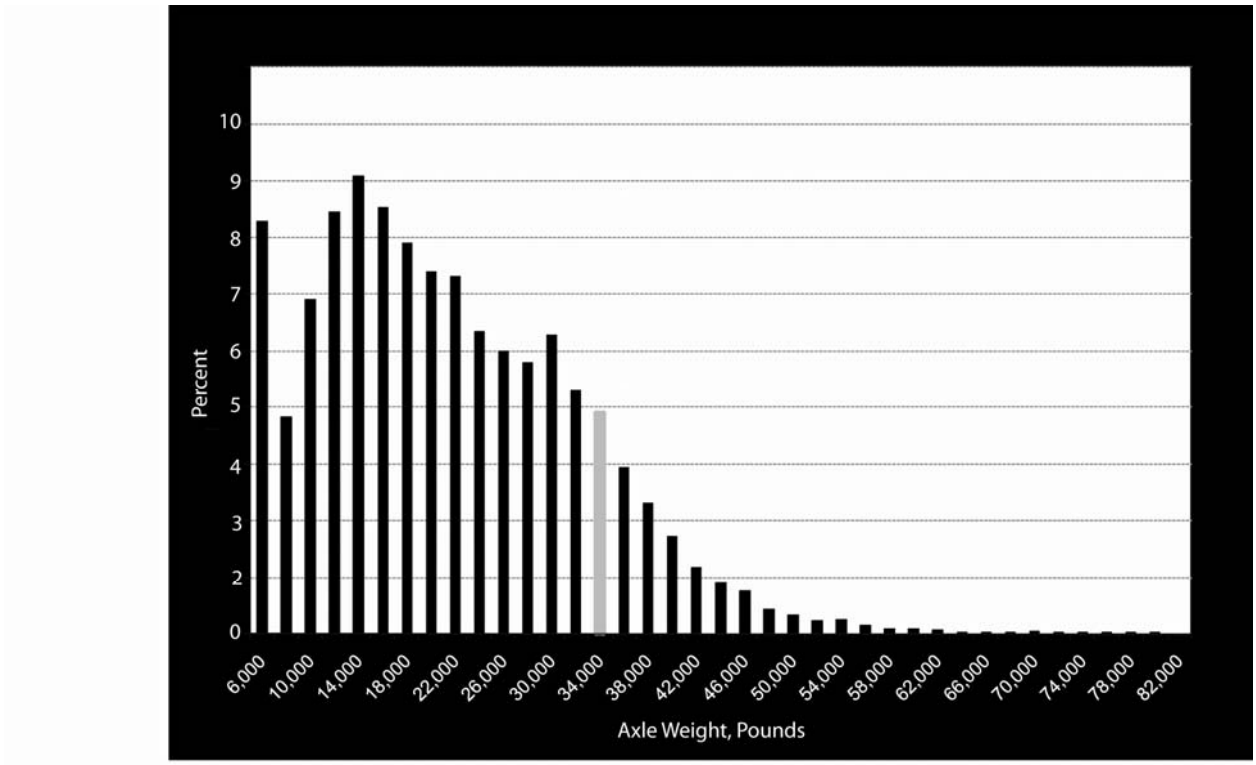
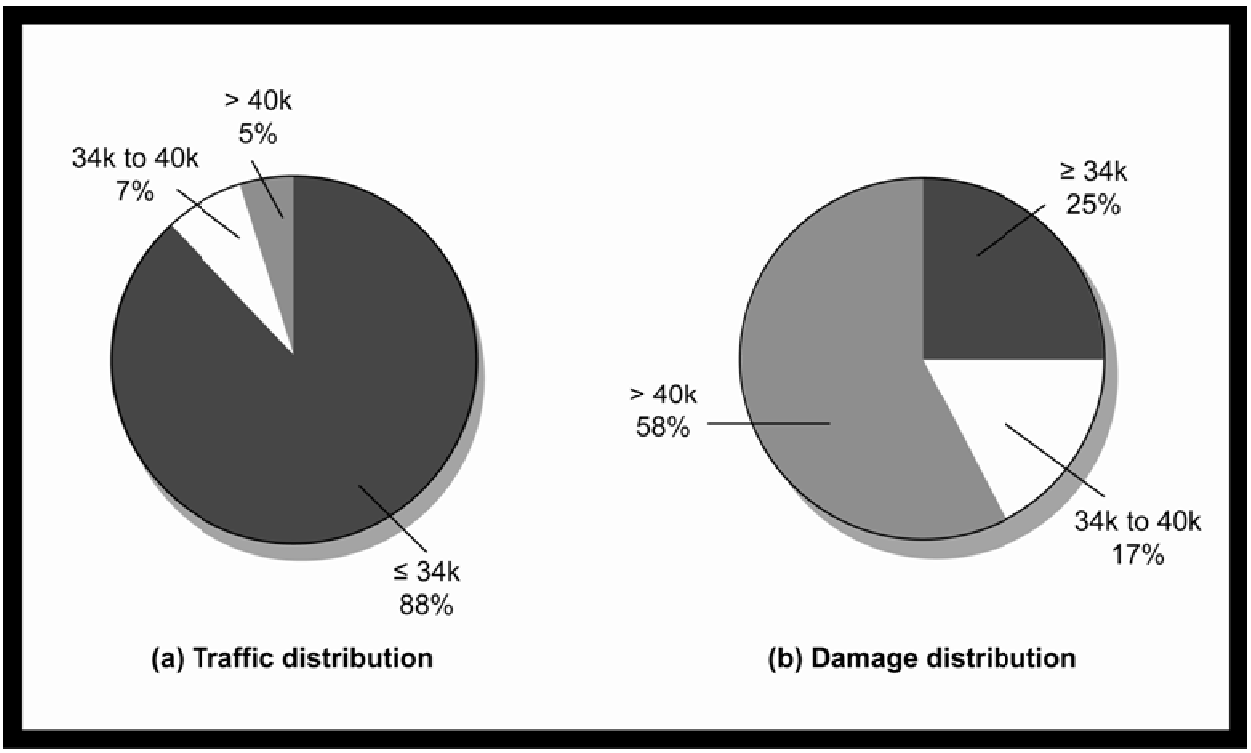


Figure 7. National average axle load distribution for tandem axles of heavy, combination trucks (Class 9 and higher)

For pavements, it is more important to control axle-load limits than gross vehicle weight because pavement performance is very sensitive to axle-loads. Figure 8 shows damage distribution by axle-weight groups. Both the effects of load intensity and frequency are included. As shown in the graph, 88 percent of tandem axles are at or below the current tandem-axle load limit of 34,000 pounds while 5 percent are heavier than 40,000 pounds. However, the 5 percent of heavy tandems cause 58 percent of the damage.

Figure 8. Traffic distribution by tandem axle weight groups and corresponding damage distribution.



Key: k = 1,000 pounds.

Pavement Analysis Summary and Conclusions

The Maine-Vermont pilot program has the potential to damage pavements by increasing the frequency of tandem axles that weigh near and above 40,000 pounds. Figure 8 shows that tandem axles in the 34,000- to 40,000-pound range cause significant damage, and any shift to this higher weight category could have a negative impact on pavement performance. For example, a 4 percent shift (from the less than or equal to 34,000-pound category to the 34,000- to 40,000-pound category) would result in a 10 percent increase in damage.

Moreover, any increase in the frequency of the greater than 40,000-pound tandem axles would have a detrimental effect on pavement performance. To limit the potential pavement damage, axle loads should be tightly controlled either through industry cooperation and/or increased enforcement. To the extent truck travel transfers from the non-Interstate system to the Interstate system, the State could manage the additional costs through potential targeted savings on non-Interstate routes, an issue which will be further studied in the Vermont pilot program.

The most direct and objective means of assessing the effects of increased gross vehicle weight on pavement performance is to conduct a direct comparison of damage caused by proposed truck configurations, on a constant payload basis, relative to damage caused by an 80,000-pound five-axle tractor semitrailer. The associated damage can be assessed, and an additional pavement

thickness can be calculated. An increase in pavement thickness can limit damage and retain a roadway's current performance level. The cost of the additional pavement thickness is, then, the cost of accommodating heavier trucks. In addition, a nominal increase in pavement thickness can accommodate a fairly significant increase in axle loads. It is more economical to build a pavement structure that can handle the load rather than allowing heavier loads to cause premature pavement failures.

The FHWA and Vtrans are currently expanding the use of weigh-in-motion sensors on the Vermont Interstate System to more fully estimate pilot program impacts on pavements.

Conclusion

This 6-month study examined "the impact to date of the pilot program on bridge safety and weights," as requested by the House and Senate Appropriations Committees. Given the short timeframe of the study, DOT used available data and modeling techniques to analyze pilot program impacts. There was insufficient time to acquire empirical data for this study as it takes years before there would be any measurable impacts on pavements and bridges.

This study does not examine the operational safety impacts, as that is beyond the scope of the study. Operational safety takes into account the road conditions, driver training, and roadway environment. National data[13] show that large trucks are involved in fewer crashes on rural Interstate compared to non-Interstate rural roads. To the extent that large trucks are moved from the Vermont and Maine rural non-Interstate to the rural Interstate system one can expect there will be benefits to both safety and livability. Analysis of the Maine and Vermont large truck crashes is inherently difficult because the States experience relatively few truck-involved crashes per year.

A subsequent report required by Congress on the 1-year Vermont pilot program will expand the examination to include the effects on "highway safety, bridge and road durability, commerce, truck volumes, and energy use within the State of Vermont."

DOT concludes:

- To maintain bridge safety Maine and Vermont will need to continue evaluation of their Interstate highways where heavier vehicles operate. The pilot program allowing trucks that weigh more than current Federal limits has reduced the margin of safety on bridges and increased the need for frequent bridge inspection and maintenance and detailed load rating analysis. Although remote, an increased possibility of overload exists, this could produce permanent damage to bridges in the form of yielding or cracking. Continued monitoring of bridge conditions and further analysis should mitigate any concerns over the risk of a sudden bridge collapse for the duration of the pilot program.

- The use of heavier axle loads on Interstate highways in Maine and Vermont will reduce pavement life on the Interstate highways but could reduce the burden on the non-Interstate system depending upon the transfer of heavy trucks. The FHWA and the State of Vermont will further quantify the long-term effects of heavier axles and heavier loads on roads and bridges in the Vermont study.

Of general concern to DOT is the shift away from bridge protection weight limits (Federal Bridge Formula B) in the pilot program States. The pilot programs allow vehicles that do not meet statutory bridge protection weight limitations to operate on Maine and Vermont Interstate highways, although Maine does have a State-based bridge formula they enforce through State statute.

[13] Source Large Truck Crash Facts 2005-February 2007, http://www.fmcsa.dot.gov/facts-research/research-technology/report/large-truck-crash-facts-2005/index-2005largetruckcrashfacts.htm

Six months is not sufficient time to fully analyze and document the safety effects on bridges or the impact on pavements subjected to new truck weights as called for in the House and Senate Conference Report. Although engineering models have been used in this analysis, those same engineering models, using thoroughly vetted data, can predict potential impacts in more detail. These impacts may have negative connotations as they relate to bridge and pavement service life on the Interstates. They may also have positive connotations when including the non-Interstate system in the analysis of safety, economic, livability, energy and environmental issues. Further information on the results of transferring heavy trucks from the Interstate to the non-Interstate system will be provided to Congress in DOT's study of the Vermont pilot program after 1 full year of implementation.

Appendix A. The History of Federal Truck Size and Weight Regulations

The Federal Government became involved in truck size and weight regulations in 1956 when truck axle weight, vehicle gross weight, and vehicle width limits were established for the Interstate System. They were based on recommendations from the American Association of State Highway Officials, the predecessor to the AASHTO. The Federal-Aid Highway Act of 1956 (P.L. 84-627) placed limits on the weight of vehicles operating on the Interstate System to protect the substantial Federal investment in its construction. The limits were 18,000 pounds for single axles, and 32,000 pounds for tandem axles. The allowable gross weight of each vehicle was determined as the sum of the allowable axle weights up to a maximum allowable gross vehicle weight of 73,280 pounds.

In 1975, Congress raised the weight limits and codified Bridge Formula B into law to ensure that divisible vehicle loads are distributed so as to avoid excessive overstressing of bridges. The Federal-Aid Highway Amendments of 1974 (P.L. 93-643) also increased the allowable maximums on the Interstate System to 20,000 pounds for single axles, 34,000 pounds on tandem axles, and 80,000 pounds for the gross vehicle weight. The maximum weight is limited to 80,000 pounds under Bridge Formula B to take into account the distance between and within each axle group for a five-axle tractor semitrailer pulling a 48- or 53-foot trailer.

All truck size and weight legislation, including the Federal-Aid Highway Act of 1956, includes provisions that allowed States to retain vehicle size and weight limits exceeding Federal limits if the State's weight laws or regulations were in effect in 1956. This legislative provision is called a grandfather clause. Most States that have grandfather clauses use the Federal exemptions because the transportation savings afforded to their industries are important to their State economies.

The Federal Government does not exercise jurisdiction over truck weight limits on non-Interstate roads. Each State is able to set size and weight limits it deems appropriate on non-Interstate roads, either through commodity exceptions/permits or overall higher limits. In addition, States issue permits for the movement of non-divisible loads on both the State and Interstate roadways.

Appendix B. Weight Impacts on Bridge Safety and Pavement Performance

Three aspects of a vehicle's weight interact with the highway infrastructure: 1) axle weight (loading), 2) axle spacing, and 3) gross vehicle weight. Each affects pavements and bridges differently.

The Federal Bridge Formula B (codified in 23 CFR §658.17 and currently enforced on the Interstate System, where it is not specifically exempted) takes into account both the number of axles and axle spacing in determining allowable gross vehicle weight in order to maintain bridge safety. Axle weight is an important factor in determining impacts to short-span bridges (those with spans shorter than a truck wheel base), and gross vehicle weight is more significant to medium- and long-span bridges (those with spans longer than a truck wheel base).

Bridge safety and serviceability are directly related to the maximum permitted truck gross vehicle weight, axle weight, vehicle configuration, and the number of other heavy trucks allowed in the traffic stream. Any changes to heavy truck maximum gross vehicle weight limits will affect safety and serviceability. Bridges must maintain the minimum safety requirements as established by the AASHTO's Load and Resistance Factor Design (LRFD) specifications and the MBE. This section summarizes the methodology and results of bridge safety assessment as it relates to the pilot program in Maine and Vermont.

For pavements, the weight of an axle or axle group, such as tandems (a group of two axles) or tridems (a group of three axles), are the most important factors in determining pavement impacts. Axle groups distribute the vehicle's load on the pavement. More axles allow a greater distribution, which increases the weight a vehicle can carry. This principle holds as long as the weight is properly spread across the axles so as not to concentrate the weight on any one axle or axle group. For example, a spread of 9 to 10 feet between two axles results in no apparent interaction of one axle with the other, and each axle is considered a separate loading for pavement impact analysis or design purposes. Conversely, the closer the axles are in a group, the greater the weight they may carry without increasing pavement damage beyond that caused by a single axle, depending on the number of axles in the group. The benefit to pavements of adding axles to a group decreases rapidly beyond four axles.

Load Rating

Load rating is the process of quantifying the live-load carrying capacity of existing bridges -- the LRFR approach -- which is recognized by FHWA as the preferred method for load rating of existing bridges, and the only one acceptable for new bridges after October 1, 2010. Bridge load ratings are performed for different purposes, with different truck models and configurations and levels of safety. Load rating can be done at one or more of three distinct levels: 1) design load rating, 2) legal load rating, and 3) permit load rating. The results of each rating level serve a specific purpose and guide the need for further bridge evaluations. Some of the purposes of load rating include NBI reporting, assessing the need for strengthening load restriction, or evaluating the ability to carry overload permit trucks. For example, the design (or inventory) load rating can serve as a first-level assessment of bridges based on a combination of a notional (or fictitious) truck and lane loading. It provides a measure of current bridge performance against

the performance of newly designed bridges. Evaluation at a second, lower-reliability level (or operating) also can be done to determine the maximum notional design load a structure can carry.

The design load rating serves as a screening process to identify bridges that should be evaluated further against national or local legal loads and are used for NBI reporting. Bridges that do not pass the design level rating require further evaluation at the legal load rating level. The legal load rating level provides a safe-load capacity for a given legal truck configuration. At this level, bridges are evaluated against structural failure and selectively-applied serviceability performance criteria (such as restrictions on stress, deformation, and crack opening). Bridges with an inadequate safe load capacity for a given truck need to be strengthened or load restricted. If the maximum weight limit for heavy trucks is raised, as in the case of this pilot program, then bridges with inadequate safety reserve may not be able to safely support the new increased loading.

Ideally, the Maine and Vermont Interstate bridges would be load rated with LRFR to assess their ability to safely carry the new pilot trucks. Due to time limitations, the NBI data can be used instead to identify those bridges at risk of safety failure under the new loading. Detailed LRFR load rating analysis is then needed for those at-risk bridges to better assess their true truck carrying capability in the as-is condition.

Engineering Criteria

Bridge rating requires many assumptions to be made and involves several unknowns and variables. Bridges are affected by the probability of side-by-side truck presence, illegally loaded trucks, truck speeds, and surface roughness. Safety margins are used to provide a means to cover the various uncertainties that exist in the calculation of bridge design and rating.

The LRFD method applies statistically determined factors to bridge design parameters by using a series of load and resistance factors to account for variability in loads and material resistance. Statistical methods and probability theory are used to define the variations in loading and material properties, and the likelihood that various load combinations will occur simultaneously.

The nationwide implementation of LRFD specifications for bridges has resulted in the LRFR system for bridge evaluation. The FHWA adopted a policy on October 1, 2007, that new bridges will be designed using the LRFD specifications. After October 1, 2010, FHWA's policy stated that bridges designed with LRFD will be load rated with LRFR. The FHWA considers LRFR to be the preferred load-rating methodology for existing bridges as well. Several States have transitioned to LRFR for the existing bridges; however, Vermont and Maine have not. It is expected that LRFR analysis will be performed on several bridges in Vermont to better understand the impact of lifting the weight limit on the bridge capacity and safety margin. Maine identified four bridges for LRFR analysis.

The LRFD and LRFR provide a target level of safety (safety index), which is established so that there is a sufficiently small probability that a loading condition could exceed the structural resistance during the bridge's design life. Providing for a margin of safety is necessary to bridge design because:

- The materials used in construction are not always completely consistent in size, shape, and quality;
- The effects of weather and the environment are not always predictable;
- Highway users on occasion violate vehicle weight laws;
- Legally allowed loads may increase during the design life of a structure; and
- Overweight loading is allowed by permit.

Bridge Inventory and Operating Ratings

The MBE allows the use of three different methodologies for bridge load ratings: Allowable Stress Rating (ASR), LFR, and LRFR.

AASHTO has established two limits for rating bridges within ASR and LFR: inventory and operating. These limits are generally taken to represent the upper and lower bounds of safe load capacity. Most States will allow a vehicle that has a gross vehicle weight that exceeds the inventory rating but is less than the operating rating to operate as an infrequent or permit vehicle. In general, vehicles with a gross vehicle weight greater than the operating rating are not allowed to cross the bridge, except under carefully controlled conditions with special escort and after a thorough analysis. The operating rating can be used as the limit for load posting of bridges due to the economic implications of restricting commercial traffic and the cost of bridge strengthening.

When using ASR and LFR**,** States have the option to use either level for posting purposes. Thus, both ratings have been used in past studies to assess bridge impacts for evaluating truck size and weight policy scenarios. Use of the more conservative level (inventory rating) results in the identification of more bridges that need upgrades.[14] Following the reviews of the Transportation Research Board (TRB) Special Report 225, FHWA determined that the stress level representative of many State bridge posting practices was the inventory rating plus 25 percent.[15]

Inventory and operating limits for LRFR indicate the level comparable to a newly designed bridge at two levels of safety: 1) identical to the level of safety of a new design, and 2) a reduced level of safety. Neither of the two rating limits is applicable to the pilot trucks in assessing the existing bridges. Instead, the legal load level rating is used to assess the safe carrying capacity of the bridges (for the given pilot truck configuration) along with the MBE legal load factors. If needed, a more refined level of analysis can be done using site-specific traffic data. If the pilot trucks cannot pass the safe load carrying capacity rating with the calibrated legal load factor, site-specific reliability analysis can be conducted to determine the safety index using weigh-in-motion data obtained from the affected highways. Additional weigh-in-motion data will be collected and used in the Vermont 2-year study. The legal load factors used by the MBE or obtained from site-specific calibration would take into account the multiple presence probability of side-by-side heavy pilot trucks.

[14] The TRB Special Report 225, *Truck Weight Limits: Issues and Options,* estimated the bridge costs of the TS&W changes under study based on the operating rating of 75 percent of yield stress, whereas reviewers of those reports found much higher bridge costs resulting from the use of the inventory rating of 55 percent of yield stress.
[15] Comprehensive Truck Size and Weight Report, Volume II, Chapter 6, page VI-7.

Bridge Conditions

Bridges are considered *structurally deficient* if: 1) significant load-carrying elements are in poor condition or worse due to deterioration and/or damage, or 2) the adequacy of the waterway opening provided by the bridge is insufficient to the point of causing bridge flooding that results in intolerable traffic interruptions. A deficient bridge, when left open to traffic, typically requires significant maintenance and repair to remain in service, and it will need eventual rehabilitation or replacement to address the deficiencies. This may be done through weight limits that restrict the gross weight of vehicles using the bridges to less than the maximum weight typically allowed by statute.

Functional obsolescence is a function of the geometrics, waterway adequacy, and load-carrying capacity of the bridge in relation to the requirements of current design standards. While structural deficiencies are generally the result of bridge component deterioration, functional obsolescence results from changing traffic and waterway demands on the structure. Facilities, including bridges, are designed to conform to the design standards in place at the time they are designed. However, current design standards are based on different criteria and require wider bridge shoulders to meet current safety standards. The magnitude of these types of deficiencies determines whether a bridge is classified as functionally obsolete.

Appendix C. Previous Truck Size and Weight Studies

Several studies have examined the implications of changing truck size and weight policy at both the national and State levels. The DOT and TRB have conducted two prominent examinations of U.S. truck size and weight policy. Each highlights the difficulties in properly assessing the impact of truck weight on bridges and holds different views on the replacement of deficient bridges. Below is a brief summary of these and other important State studies.

Comprehensive Truck Size and Weight Study (U. S. Department of Transportation, 2000)
This study assessed the potential impacts of changing truck size and weight limits on bridge and pavement performance, safety, productivity, geometrics, traffic congestion, air quality and noise, and railroads. A major part of the study involved developing and testing analytical tools to estimate the potential diversion of traffic from one type of truck to another and between rail and truck if truck size and weight limits were changed. It made several significant improvements over previous studies by implicitly modeling inventory and logistics costs, roadway geometry, pavement performance, bridge safety, and traffic operations. Like previous studies, this study analyzed several specific truck size and weight scenarios, including a few that assumed some increase in truck size and weight limits and two that assumed reductions in allowable weights or dimensions.

In order to estimate bridge-related costs, the study assumed the replacement of bridges showing overstress, even though States might postpone replacement for several years or perhaps strengthen the bridge rather than replace it. This simplified assumption was used because of the complexity of analyzing each individual bridge structure.

Truck Weight Limits: Issues and Options, Special Issue 225 (Transportation Research Board, 1990)
This study focused on four issues: 1) elimination of existing grandfather provisions; 2) alternative methods for determining gross vehicle weight and axle loadings; 3) adequacy of and alternatives to the current Federal Bridge Formula; and 4) treatment of specialized hauling vehicles, such as garbage trucks, dump trucks, and other trucks with short wheelbases that have difficulty complying with current Federal regulations.

The Board recommended: 1) a new bridge formula is needed, 2) Congress should enact a special permit program to allow States to examine changes in truck sizes and weights with oversight from a board authorized to issue/remove permits, 3) Congress should not restrict current grandfather rights but should prevent future expansion of these provisions, 4) a portion of overweight permit fees should be used to increase enforcement of truck weight laws, and (5) Congress should create pilot programs that allow States to pursue opportunities for standardizing limits and permit practices at the regional level.

Wisconsin Truck Size and Weight Study (Wisconsin Department of Transportation and University of Wisconsin, 2009)
This study examined the impacts of several truck configurations on safety, congestion, pavements, and bridges. Four of the vehicles examined do not operate on Wisconsin highways: six-axle 90,000-pound tractor semitrailer; seven-axle 97,000-pound tractor semitrailer; seven-

axle 80,000-pound single-unit truck; and eight-axle 108,000-pound tractor with double trailers. Two of the vehicles examined are allowed only on Wisconsin State highways: six-axle 98,000-pound tractor semitrailer and straight truck-trailer. The study reports positive net benefits for operating the following trucks on both State and Interstate highways: the six-axle 90,000-pound tractor semitrailer; seven-axle 97,000-pound tractor semitrailer; and the six-axle 98,000-pound tractor semitrailer. The net benefits analysis did not consider the cost of State and local bridge replacement.

New Hampshire Weight Limit Impact Study for I-89 and I-93 (New Hampshire Department of Transportation, 2006)
The 1998 Transportation Equity Act for the 21st Century (TEA-21) provided an exception to the Federal 80,000 pound weight limit on I-95 in New Hampshire. It allowed six-axle tractor semitrailers weighing up to 99,000 pounds gross vehicle weight to operate on that highway. Permission to extend the I-95 vehicle weights to I-89 and I-93 was granted in the Omnibus Appropriations Act, 2005 (Public Law 108-447). The maximum gross vehicle weights allowed on New Hampshire Interstates are 37,400 pounds on a two-axle single-unit truck; 65,000 pounds on a three-axle single-unit truck; 73,000 pounds on a four-axle single-unit truck; 84,000 pounds on a five-axle tractor semitrailer; and 99,000 pounds on a six-axle tractor semitrailer. New Hampshire allows a 5 percent weight tolerance, bringing the actual limit to 88,200 pounds on a five-axle tractor semitrailer and 103,950 pounds on a six-axle tractor semitrailer.

The study also examined New Hampshire's enforcement system, pavement performance, truck-route selection, and shipper benefits. The study does not include bridge costs beyond maintaining and monitoring the structures. It recommended additional evaluation of the State's 231 bridges, but no cost is estimated for their replacement or rehabilitation.

Study of Impacts Caused By Exempting Currently Non-Exempt Maine Interstate Highways from Federal Truck Weights (Maine Department of Transportation, 2004)
This study analyzed the safety consequences, infrastructure costs, and related social and economic impacts resulting from an exemption of Federal truck weight regulations to all non-exempt Interstate highways in Maine. The study reported net savings to the State by allowing 100,000-pound trucks on Interstates where they could not travel at the time of the study. The bridge analysis only reviewed the savings to bridges on the Maine Turnpike and State routes. It did not analyze potential bridge costs related to allowing 100,000-pound trucks on the then non-exempt Interstate highways.