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Benefits and Costs of Increasing Truck Load Limits: A Literature Review

The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by MnDOT and the Local Road Research Board. This TRS does not represent the conclusions of CTC & Associates, MnDOT or LRRB.

Introduction

In setting size and weight limits for large trucks, state legislatures and the U.S. Congress must balance many factors, including economic considerations, safety concerns and infrastructure impacts. Congress has considered weight limit increases periodically in recent years, but the current limit of 80,000 gross vehicle weight (GVW) on Interstates and the National Highway System has not changed since 1991. (A few states allow higher weights under grandfather clauses in the legislation.) In Minnesota, a 2009 law raised the weight limit on all paved roads to 20,000 pounds per axle (80,000 pounds GVW). The state Legislature has also periodically amended state statutes to include provisions for higher weight limits for certain industries, such as agriculture, or in specific areas of the state. When weight limits are raised, local highway agencies must address impacts to infrastructure, traffic, safety and other areas.

The Local Road Research Board would like to examine the costs and benefits of increased weight limits, and to consider how counties and cities in Minnesota can prepare for the impacts of future weight limit increases at the federal or state level. To assist in this effort, CTC & Associates prepared this Transportation Research Synthesis, which reviews recent research on infrastructure impacts, traffic and safety impacts, roadway design considerations, environmental impacts, and other considerations, with an emphasis on the effects on local highways (those highways not a part of the state or national highway system).

Summary of Findings

The impacts of truck size and weight limits have been researched extensively in recent years. Most recently, the Moving Ahead for Progress in the 21st Century Act (MAP-21) requires U.S. DOT to conduct a Comprehensive Truck Size & Weight Limits (CTSW) study. The study was scheduled to produce a Report to Congress in November 2014, but the report has not yet been published.

The MAP-21 CTSW study is using state-of-the-art analysis and modeling approaches to determine the impacts of several truck size and weight (TSW) configurations on pavements, bridges, safety and other areas. Impacts on local roads and highways as well as the National Network will be considered. The study is designed to ensure that best practices are followed in each area, with an independent Transportation Research Board (TRB) panel of experts providing critical review of each component of the report.

To provide updates on the study's progress, U.S. DOT is conducting four outreach webinars, and the study's initial draft Desk Scans (literature reviews) in each subject area were published in November 2013. The final webinar was tentatively scheduled for July 2014 but has not yet occurred, and the FHWA project contact said that technical work on the project was still being finalized.

The issue of analysis methodology emerges time and again as a critical factor in evaluating previous TSW studies. The MAP-21 CTSW study's recently published draft Desk Scans and the TRB panel's review of them repeatedly emphasize shortcomings in existing research. In some areas, such as pavement impacts, best practices in modeling approaches are evolving continuously to improve accuracy, while areas such as safety research, which has historically been hampered by a lack of detailed crash data, continue to face challenges.

In all areas, the MAP-21 CTSW study team is applying state-of-the-art models and tools to provide the most accurate estimates of TSW impacts possible. This Transportation Research Synthesis focuses on three types of research: (1) studies identified by the MAP-21 CTSW Desk Scans as using best practices in methodologies, (2) studies selected for inclusion in the 2011 NCHRP *Directory of Significant Truck Size and Weight Research*, and (3) studies and resources specific to Minnesota and neighboring states.

Report Structure and Key Documents

This report is divided into three sections:

- **General TSW Research**: Studies that address TSW impacts in a range of areas.
- **Specific Impacts:** Studies that focus on one topic, such as pavements, bridges or safety.
- **State Weight Limits:** A map of Minnesota and surrounding states' weight limits and related resources.

Two key documents are referred to frequently throughout the report:

- The MAP-21 CTSW study, especially the Desk Scans (literature reviews) on each topic.
- The 2011 NCHRP *Directory of Significant Truck Size and Weight Research*, which provides an annotated summary of selected TSW studies judged to be "relevant, significant and useful" to decision-makers involved in considering changes to TSW limits.

Selected Findings and Resources

Research

- A 2013 South Dakota DOT study found that on lower-volume roads with a thin asphalt surface, wide-base tires cause significantly more damage than standard dual-tire configurations. Legislation was passed to allow wide-base tires only on main freight routes, which are concrete or thick asphalt pavements.
- The MAP-21 CTSW study's desk scan on pavement impacts highlighted a recently developed FHWA pavement damage model called PaveDAT that can be applied to a wide range of traffic shift scenarios. The model was completed in 2011 and has been provided to a few states on a pilot basis. An application

of the model in the District of Columbia calculated that overweight trucks and buses caused $20 million in damage annually to the District's pavements and bridges.

- A 2012 Report to Congress summarized the impacts of the Vermont Pilot Program, which raised size and weight limits on Vermont Interstates for one year. For pavements, the study team used an expanded version of the PaveDAT model. During the pilot, traffic shifted primarily to 4-axle single units and 6-axle combination trucks, causing a 12 percent increase in pavement damage on the Interstate system.
- A 2007 FHWA study of a small sample of pavement sections found that raising a vehicle's GVW from 80,000 to 97,000 pounds by adding a third axle to the rear tandem group showed "no practical difference" in pavement life.
- A 2009 Michigan DOT study concluded that tridem axles had less relative effect on cracking but more relative effect on rutting than single or tandem axles of an equivalent weight per axle.

Resources

- A presentation from the MAP-21 CTSW study's third Public Input Meeting, held May 6, 2014, provides an accessible, easy-to-read summary of the project.
- The 2011 report *NCFRP Report 6: Impacts of Public Policy on the Freight Transportation System* provides a concise overview of the effects of truck size and weight limits (pages 41 and 84).
- A 2013 Michigan DOT brochure, "Michigan's Truck-Weight Law and Truck User Fees," provides a concise explanation of why Michigan chose to use maximum axle loadings rather than gross vehicle weight as the basis for its truck-weight law. Michigan's law allows a maximum of 164,000 pounds on 11 axles. See pages 4-7 of the brochure for MDOT's position on the benefits of this approach.

Detailed Findings

General TSW Research

MAP-21 Comprehensive Truck Size and Weight Limits Study, U.S. DOT and FHWA, in progress (completion was expected in November 2014).
http://www.ops.fhwa.dot.gov/freight/SW/map21tswstudy/index.htm
Presentation: Public Input Meeting #3, U.S. DOT, May 6, 2014.
http://www.ops.fhwa.dot.gov/freight/SW/map21tswstudy/outreach/session050614/presentation/public_input_mtg3.pdf
This study will produce a Report to Congress that answers two key questions:

1. What difference is there in highway safety risks (accident severity and frequency), infrastructure damage and delivery of effective enforcement between trucks operating at and below current federal size and weight limits compared to trucks that operate above those limits?
2. What would the impact be in these same areas if a change were to be made to current federal truck size and weight limits?

The study is focusing on impacts to the Interstate Highway System, the National Highway System and the National Network, but "impacts on non-NHS and non-NN roadway networks will be qualitatively addressed [by] applying results developed in the study to local roads and bridges," according to the presentation from the study's third public input meeting. The study will include both urban and rural areas, and the presentation notes that researchers are "cognizant of the differences in roadway geometrics between rural arterials and urban roadway networks." (For more detail, see Public Input Meeting #3 presentation, slides 11 and 12.)

The study is evaluating the following truck configurations:

Configuration	Trailers or Semi-Trailers	Axles	GVW (pounds)
1. 5-axle vehicle [Control Vehicle]	1	5	80,000
	1	5	88,000
2. 6-axle vehicle	1	6	91,000
	1	6	97,000
3. Tractor plus two 28- or 28½-foot trailers [Control Vehicle]	2	5	80,000
4. Tractor plus twin 33-foot trailers	2	5	80,000
5. Tractor plus three 28- or 28½-foot trailers	3	7	105,500
6. Tractor plus three 28- or 28½-foot trailers	3	9	129,000

Source: Public Input Meeting #3 presentation, U.S. DOT, May 6, 2014, slide 17.

Project plans and desk scan reports (literature reviews) are available for each of five focus areas: safety, pavements, bridges, compliance and modal shift.

- Project plans: http://www.ops.fhwa.dot.gov/freight/SW/map21tswstudy/projectplan/index.htm
- Desk scan reports: http://www.ops.fhwa.dot.gov/freight/SW/map21tswstudy/deskscan/index.htm

Key conclusions of the desk scans are summarized by topic in the "Specific Impacts" section of this report.

The MAP-21 study requirements include an independent review of the study results by a TRB panel. The panel's review of the desk scans was published in April 2014 (see http://onlinepubs.trb.org/onlinepubs/sr/TS&WDeskScans.pdf). Although the panel provided recommendations for improving the scans, the panel's overall conclusion was that the scans had not overlooked any clearly superior available modeling approaches or data sources.

Regarding the study's progress toward completion, Tom Kearney of FHWA's Freight Operations Program said the researchers are now completing their technical work, which U.S. DOT will review and incorporate into a final draft report. He did not have an update on the timing of the report completion or the scheduling of the fourth stakeholder outreach meeting and webinar, which was originally scheduled for July 2014; he said leadership at FHWA and U.S. DOT would determine the timing for those events.

The MAP-21 CTSW study follows a 2000 U.S. DOT study and a follow-up 2004 study:

> **Comprehensive Truck Size and Weight Study,** U.S. DOT, 2000.
> http://www.fhwa.dot.gov/reports/tswstudy/TSWfinal.htm
> Executive Summary: http://www.fhwa.dot.gov/reports/tswstudy/Vol1-ExecSum.pdf
>
> **Western Uniformity Scenario Analysis: A Regional Truck Size and Weight Scenario Requested by the Western Governors' Association,** U.S. DOT, April 2004.
> http://www.fhwa.dot.gov/policy/otps/truck/wusr/wusr.pdf

U.S. DOT's 2000 CTSW study compared five scenarios of possible revisions to federal size and weight limits, evaluating their impacts on safety, infrastructure, the environment, traffic and other factors. The follow-up 2004 study evaluated the impacts of an additional scenario: harmonizing weight limits among the western states at 129,000 pounds GVW for longer-combination vehicles. *NCFRP Report 6* (2011) compared the impacts of two scenarios at the low end and high end of the proposed weight limits: harmonizing weight limits at 80,000 pounds

GVW (all states) and at 129,000 pounds GVW for longer-combination vehicles (western states only). The following table summarizes those impacts.

Summary of Impacts of Harmonization of State Truck Size and Weight Rules

Type of Impact	Metrics	Impacts in Federal Uniformity Scenario (80,000 lbs max GVW)	Impacts in Western Uniformity Scenario (129,000 lbs max GVW)
Freight distribution by type of truck	VMT by truck configuration	Significant decrease in VMT traveled by doubles, triples, and 6-axle single trailers. Increase in VMT by 5-axle single trailers.	Significant shift of VMT from single trailers to double- and triple-trailers
Mode share	Percentage	Mode shift not analyzed	Little or no shift from rail to truck
Safety	Crash rate involving trucks per million truck VMT; rate of fatal truck crash per million truck VMT	Net impact is unclear: reduced VMT by longer, heavier trucks would reduce crash severity and possibly number of accidents, but increase in total truck VMT would likely increase number of accidents	Net impact is unclear: decrease in total truck VMT would likely reduce number of accidents; but more VMT by longer, heavier trucks would increase crash severity and possibly number of accidents
Fuel consumption	Gallons of diesel	Higher due to increase in truck VMT	Lower due to decrease in truck VMT, but partially offset by reduced fuel economy of heavier trucks
Air quality	Tons of emissions	Higher due to increase in fuel consumption	Lower due to decrease in fuel consumption
Traffic operations	Vehicle-hours of delay; cost of congestion	Slight increase in number of vehicle-hours of delay due to increase in truck VMT	Slight decrease in delay due to fewer truck VMT, but offset somewhat by effect of longer, heavier trucks on traffic flow
Shipper costs	Dollars	Higher due to increase in cost-per-ton-mile	Lower due to decrease in cost-per-ton-mile
Railroad revenues	Dollars	Higher due to decreased competition from longer, heavier trucks	Lower due to increased competition from longer, heavier trucks

Source: *NCFRP Report 6 (Revised)*, 2011; Table 4-4, page 43.

Impacts of Public Policy on the Freight Transportation System, NCFRP Report 6 (Revised), 2011.
http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_006.pdf
This report provides a concise overview of the effects of truck size and weight limits in two sections:

- "Truck Size and Weight Limits," page 41.
- Appendix B, also under the subhead "Truck Size and Weight Limits," page 84.

Directory of Significant Truck Size and Weight Research, NCHRP Project 20-07, Task 303, October 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_FR.pdf
This directory provides an annotated summary of selected TSW studies judged to be "relevant, significant and useful" to decision-makers involved in considering changes to TSW limits. Relevant sections include:

- Infrastructure Preservation: Pavements (page 8)
- Infrastructure Preservation: Bridges (page 20)
- Highway Safety (page 48)
- Highway Geometrics (page 60)
- Infrastructure Financing (page 74)
- Highway Congestion (page 84)
- Environment (page 91)

A summary PowerPoint presentation of the directory's key findings is available at http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_Presentation.ppt.

Minnesota Truck Size and Weight Project, Minnesota DOT, 2006.
http://www.dot.state.mn.us/information/truckstudy/
This project's objective was to evaluate proposed changes to Minnesota's TSW laws that would benefit the Minnesota economy while protecting roadway infrastructure and safety. The study recommended a package of weight limit increases that included several vehicle configurations under special permit, as well as various changes to spring load restrictions. In 2009, the Legislature followed through on another of the study's recommendations, raising weight limits on all paved state roads to 80,000 pounds GVW (20,000 pounds per axle).

Table 5 of the report (see page 21), reproduced below, provides a summary of the costs and benefits of allowing each proposed configuration. The study identified the following impacts of the proposed vehicle configurations:

- **Industry costs:** Increased payloads and fewer truck trips will lower transport costs significantly.
- **Pavements:** Additional axles and fewer truck trips will result in less pavement wear.
- **Bridges:** There will be a modest increase in bridge postings and future design costs.
- **Safety:**
    - Proposed trucks have slightly higher crash rates but, given fewer overall truck miles (due to increased payloads) than would be experienced otherwise under existing weight limits, safety would improve slightly.
    - The proposed vehicle configurations for operations above 80,000 pounds GVW meet internationally accepted heavy vehicle safety performance standards.
    - The surplus brake capacity available for all of the proposed vehicle configurations is greater than the surplus brake capacity of a standard five-axle tractor semitrailer and therefore the stopping distance for all of these vehicles should be better than the existing 80,000-pound tractor semitrailer.

Truck Size and Weight Proposal Benefits
(Benefits in millions of dollars per year; negative values represent increased costs)

Truck Size and Weight Package Elements	Transport Savings	Pavements	Bridge Inspection, Rating and Posting	Bridge Fatigue and Decks	Increased Bridge Design Loads	Safety	Congestion	Total Net Benefits
Proposed Vehicle Configurations								
6-Axle 90,000 lb. Semi	$3.68	$1.27	$-0.05	$0.15	$-0.96	$0.15	$0.18	$4.43
7-Axle 97,000 lb. Semi	4.00	2.24	-0.01	0.22	-0.64	0.23	0.23	6.27
8-Axle Twin 108,000 lb.	2.01	1.25	-0.01	0.14	-0.72	0.05	0.08	2.79
Single Unit up to 80,000 lbs.	6.27	0.55	0.00	0.10	-0.13	0.06	0.05	6.90
Subtotal	***$15.96***	***$5.31***	***$-0.07***	***$0.61***	***$-2.45***	***$0.49***	***$0.54***	***$20.39***
Spring Load Restrictions and Other Legislative Policy Issues								
Change SLR	$8.82	$-2.34	$0.00	$0.04	$0.00	$0.44	$0.17	$7.12
80,000 lb. GVW on 9-Ton System	24.82	-8.49	0.00	-0.83	0.00	1.65	0.72	17.87
Subtotal	***$33.64***	***$-10.83***	***$0.00***	***$-0.79***	***$0.00***	***$2.09***	***$0.89***	***$24.99***
Total Package	**$49.60**	**$-5.52**	**$-0.07**	**$-0.18**	**$-2.45**	**$2.57**	**$1.43**	**$45.38**

Source: Minnesota Truck Size and Weight Project, Minnesota DOT, 2006; Table 5, page 21.

"Michigan's Truck-Weight Law and Truck User Fees," Michigan DOT, March 2013.
http://www.michigan.gov/documents/mdot/MDOT_013-4-16TruckWeightsMichigan_418609_7.pdf?20141021154145
This brochure provides a concise explanation of why Michigan chose to use maximum axle loadings rather than gross vehicle weight as the basis for its truck-weight law. Michigan's law allows a maximum of 164,000 pounds on 11 axles. See pages 4 to 7 of the brochure for MDOT's position on the law's benefits.

Specific Impacts

Pavements

MAP-21 CTSW Study: Pavement Comparative Analysis, Final Draft Desk Scan, U.S. DOT and FHWA, November 2013.
http://www.ops.fhwa.dot.gov/freight/SW/map21tswstudy/deskscan/pavement_dksn.pdf
This literature review focused on identifying best practices in methods for pavement cost analysis related to heavy vehicles. The researchers selected methodology that uses the *AASHTOWare Pavement ME Design* software for the analysis they will be performing for the MAP-21 study. They noted that in 1979, concerns about accuracy led FHWA to discontinue use of ESAL-based methods derived from the AASHO Road Test, but many states continue to use these methods for TSW studies.

The desk scan highlights recent state, federal and international research, describing for each study whether the methods used to model pavement damage are considered to be best practices. The following studies are among those cited as using promising methodologies for estimating pavement damage and costs.

Correlation Between Truck Weight, Highway Infrastructure Damage and Cost, David H. Timm, Rod E. Turochy and Kendra D. Peters, Auburn College of Engineering for FHWA, October 2007.
http://www.eng.auburn.edu/files/centers/hrc/DTFH61-05-P-00301.pdf
Using the Mechanistic-Empirical Pavement Design Guide (MEPDG) for a small sample of pavement sections, the study team determined the time until terminal pavement distress under three different loading scenarios: shifting entire weight distributions toward heavier axles, adding specific heavier axles, and increasing the GVW from 80,000 to 97,000 pounds by adding an axle to the rear tandem group. The first scenario showed very large decreases in pavement life (and increases in cost), the second showed significant cost increases when the number of added heavy axles exceeded 10 percent of the number of legally loaded axles, and the third showed "no practical difference." Mechanistic analysis outside the MEPDG showed only a slight difference in pavement response, confirming the finding of insignificant changes in pavement costs.

FHWA initiated a follow-up project that systematically varied axle loadings for a larger number of pavement sections and derived a general set of findings that could apply to any set of traffic shift scenarios. For more information on this follow-up effort, the desk scan notes that the following webinar offers a good introduction to the FHWA pavement damage model PaveDAT, a simplified version of the more complex, nationally representative NAPCOM model.

"Pavement Damage Analysis Tool (PaveDAT) for Overweight Truck Permit Calculation," FHWA *Talking Freight* seminar, June 12, 2012.
Transcript: http://www.fhwa.dot.gov/planning/freight_planning/talking_freight/june202012.cfm
http://www.fhwa.dot.gov/planning/freight_planning/talking_freight/talkingfreight06_20_12ecmb.pptx
This seminar transcript describes a successful application of FHWA's PaveDAT model in the District of Columbia in an assessment of the costs associated with overweight vehicles. The analysis determined that overweight trucks and buses in the district caused $20 million in damage to pavements and bridges annually. The presenters noted that much of this damage was allocated to single-unit, 2- and 3-axle trucks such as dump trucks and trash compactors.

The transcript notes that FHWA has made the PaveDAT model available to a few states on a pilot basis. An accompanying PowerPoint presentation, "Pavement Damage Assessment Tool," states that PaveDAT was completed in 2011 and has been used in some form in the District of Columbia, Wisconsin and Oregon, and that Texas was adapting the model for its use. Documentation of these states' use of the model does not appear to be available online. See
http://www.fhwa.dot.gov/planning/freight_planning/talking_freight/talkingfreight06_20_12rm.pptx.

Vermont Pilot Program Report, U.S. DOT, Report to Congress, 2012.
http://www.ops.fhwa.dot.gov/freight/sw/reports/vt_pilot_2012/vt_pilot.pdf
Summary from the MAP-21 CTSW study Pavement desk scan: Vermont raised size and weight limits on its Interstate highways for one year beginning in December 2009. This study estimated traffic and infrastructure impacts and energy consumption and compared them to the pre-pilot (control) case. For pavements, the study team used an expanded version of the PaveDAT model, with its newly derived, distress-specific load equivalence factors (LEFs). Since traffic shifted mostly to 4-axle single units and 6-axle combination trucks as a result of the temporary allowance of 51-kip tridems on the Interstate system, pavement damage attributable to these vehicle classes increased considerably. Pavement damage on the Vermont Interstate system increased by 12 percent, which translates to significant increases in pavement maintenance and repair costs and more frequent work zones. There was a negligible decrease (less than 0.5 percent) in pavement damage off the Interstate system.

Effect of Michigan Multi-Axle Trucks on Pavement Distress, Michigan DOT, Project RC-1504, February 2009.
http://www.michigan.gov/documents/mdot/MDOT_Research_Report_RC-1504__ExecSum_272183_7.pdf
This study concluded that tridem axles had less relative effect on cracking but more relative effect on rutting than single or tandem axles of an equivalent weight per axle.

Directory of Significant Truck Size and Weight Research, NCHRP Project 20-07, Task 303, October 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_FR.pdf
This report draws several conclusions from the body of literature related to trucks' impacts on pavement damage, which includes studies using multiple methodologies. Four of these points are excerpted below (see page 8 of the report):

- Axle weight is a more significant determinant in pavement damage and subsequent pavement costs than gross vehicle weight (GVW). Truck weight limits that allow higher axle weights can significantly increase pavement costs. Truck weight limits that allow higher GVWs distributed over more axles (e.g., 6 instead of 5 axles) do not necessarily lead to higher pavement costs and can even produce cost savings.
- An increase in axle weight generally causes an exponential increase in pavement damage. For flexible pavements, the relationship between axle load and pavement deterioration has an exponent power of 4 (recent research suggests it may be closer to 3). For semi-rigid and rigid pavements, this same relationship has an exponent power of between 11 and 33.
- For flexible pavements, tandem axles are generally less damaging to pavements than single axles, tridem axles are less damaging to pavements than tandem axles, and so on. For rigid pavements, the evidence on the relationship between axle grouping and pavement damage is mixed.
- The effects of axle spacing on pavement damage are complex and variable. Increasing the spread of axles within an axle group reduces damage to rigid pavements, but increases fatigue damage to flexible pavements.

Assessing the Effects of Heavy Vehicles on Local Roadways, Minnesota DOT, Report #2014-32, August 2014.
http://www.dot.state.mn.us/research/TS/2014/201432.pdf
This project developed an analysis method and associated tool for estimating the impacts of heavy vehicles on pavement structures on local roads such as county highways and city streets. It is designed for estimating site-specific impacts of new construction that will increase truck traffic (warehouses, distribution centers, etc.).

Effects of Implements of Husbandry (Farm Equipment) on Pavement Performance, Minnesota DOT, Report #2012-08, April 2012.
http://www.lrrb.org/media/reports/201208.pdf
Pooled fund project page: http://www.pooledfund.org/Details/Study/375
This MnROAD pooled fund study analyzed pavement damage caused by heavy farm equipment as compared with a typical 5-axle, 80,000-pound truck.

Wide-Base Tires

MAP-21 CTSW Study: Pavement Comparative Analysis, Final Draft Desk Scan, U.S. DOT and FHWA, November 2013.
http://www.ops.fhwa.dot.gov/freight/sw/map21tswstudy/deskscan/pavement_dksn.pdf
This desk scan includes a section on wide-base tire research (Section 1.4, "Wide-Tire Studies," pages 19 to 29). However, the researchers concluded that wide-base tires (WBT) could not be included as a factor in the MAP-21 study's analysis because the *Pavement ME-Design* model currently cannot incorporate this tire configuration, and separate modeling could not be conducted within the study time frame. They also noted that "there is not enough evidence that the larger trucks we are considering in this study would make greater or less use of WBT than current vehicles."

Effects of Wide Base Super-Single Tires on Pavements, South Dakota DOT, 2013.
Summary presentation:
http://www.sdmunicipalleague.org/vertical/Sites/%7B2540DC39-A742-459F-8CAF-7839ECF21E89%7D/uploads/David_Huft-_SDDOT_Pavement_Research_SDML(1).pdf
This study was selected as one of the AASHTO Research Advisory Committee's "Sweet 16" high-value research projects for 2014. The study was initiated in response to proposed legislation to allow wide-base (445 mm and 455 mm) super-single tires to carry the same legal load as standard dual tire configurations in South Dakota.

The study determined that on portland cement concrete pavement and thick asphalt pavements, allowing the same load on super-single tires would impose no additional damage; in some cases, less damage would be expected. However, on thin asphalt pavements, the super-single tires would cause significantly more damage than standard dual tire configurations. Based on these results, the legislation (which was passed in 2013) allows super-single tires to carry equivalent loads on main freight routes, which are concrete or thick asphalt pavements. The legislation excludes other state routes and essentially all local roads, which are typically surfaced with thin asphalt or gravel. The Sweet 16 project summary notes that the research "reduced hauling cost, fuel consumption and exhaust emissions on competent freight routes, while avoiding extra damage to state and local pavements."

"Impact Quantification of Wide-Base Tire Loading on Secondary Road Flexible Pavements," H. Wang and I. Al-Qadi, *Journal of Transportation Engineering,* Vol. 137(9), pages 630–639, 2011.
Abstract at http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29TE.1943-5436.0000245
This study modeled the damage caused by the new generation of wide-base tires on low-volume secondary roads. Researchers analyzed a 76-mm HMA layer and an aggregate base layer with various thicknesses (203, 305 and 457 mm). They found that the new wide-base tire (455/55R22.5) caused greater fatigue damage, subgrade rutting, and HMA rutting (densification) but less HMA rutting (shear) and base shear failure compared to a conventional dual-tire assembly when carrying the same load. The findings indicate that wide-base tires' impact on secondary road pavements depend on the roads' predominant failure mechanisms.

The Impact of Wide-Base Tires on Pavement Damage: A National Study, pooled fund project TPF-5(197), ongoing.
http://www.pooledfund.org/Details/Study/423
Minnesota is a member of this pooled fund study, which aims to quantify the impact of vehicle-tire interaction on asphalt pavement damage using advanced theoretical modeling that will be validated via full-scale pavement testing. The study will determine the relative effects of wide-base tires (445/50R22.5 and 455/55R22.5) and dual-tire assemblies on pavement performance. The study will also analyze the economic, safety and environmental effects of using wide-base tires and develop methodology that allows states to assess the impact of wide-base tires on the pavement network.

- MnDOT technical liaison: Shongtao Dai, Research Operations Engineer, 651-366-5407, Shongtao.Dai@state.mn.us.

Spring Load Restrictions

North Dakota Strategic Freight Analysis: Truck Size and Weight Issues in North Dakota, North Dakota DOT, July 2007.
http://www.ugpti.org/pubs/pdf/DP185.pdf
This study focused on the impact of seasonal load restrictions and annual load limits on industry costs. Researchers analyzed costs under various GVW limit scenarios for both farm and commercial operations. They concluded that eliminating seasonal restrictions on routes with higher truck traffic could significantly reduce trucking costs and increase companies' profitability, which could have positive effects on the regional economy. Based on case studies of other areas, they identified an alternative strategy: designing key corridors to handle heavier loads and reducing the time period of restrictions, as most damage occurs during the maximum thaw period that lasts approximately 30 days.

Bridges

Compared with the body of research related to the effects of heavy trucks on low-volume roads, fewer studies have quantified how local agencies' bridge management practices have been affected by heavier trucks. Although studies can model the typical costs of bridge replacement and reinforcement, each highway agency that faces an increase in weight limits will have a unique approach that may involve posting some bridges to prohibit heavier trucks, strengthening some bridges, and replacing others. Each agency's approach will be affected by the makeup of its current bridge inventory as well as the availability of alternate routes.

MAP-21 CTSW Study: Bridge Structure Comparative Analysis, Final Draft Desk Scan, U.S. DOT and FHWA, November 2013.
http://www.ops.fhwa.dot.gov/freight/SW/map21tswstudy/deskscan/bridge_dksn.pdf
The independent TRB panel review of the five desk scans notes that the desk scan on bridge research "lacks syntheses of analysis methods or of results of past estimates concerning the effects of changes in size and weight limits." As such, it was not possible to draw meaningful conclusions from this scan regarding which past studies are considered to be the strongest and most accurate.

Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles, TRB Special Report 267, 2002.
http://www.trb.org/publications/sr/sr267.pdf
The 2011 NCHRP *Directory of Significant Truck Size & Weight Research* (page 27) summarizes several key points from pages 63-64 of *TRB Special Report 267*. The directory notes that the 2002 report identified a number of shortcomings in prior research methodologies that limit the usefulness of the resulting cost estimates:

- Many previous studies have relied on a single conservative parameter to determine whether bridges require replacement.

- Prior research has not accounted for alternative treatments (such as strengthening, more intensive inspection and maintenance, or posting) that could produce the same degree of insurance against bridge failure as costly replacement.
- Consideration of costs other than the highway agency's bridge replacement costs has been haphazard. Direct costs related to bridge fatigue, new bridge designs, and remaining useful life of existing bridges, as well as associated costs such as traffic delays and fuel consumption attributable to construction of the new bridge, are not consistent components in bridge infrastructure cost estimates.

Directory of Significant Truck Size and Weight Research, NCHRP Project 20-07, Task 303, October 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_FR.pdf
Research on bridge impacts appears on pages 20 to 32 of the directory. Themes identified from the bridge research cited (see page 20) include:

- Studies consistently predict that increases to truck size and weight limits will increase bridge-related infrastructure costs. Bridge-related costs far exceed pavement-related costs.
- Bridge-related infrastructure cost estimates may be exaggerated, assuming full replacement of bridges rather than considering cost-effective alternatives that offer the same margin of safety, such as strengthening the bridge or restricting select truck configurations for bridges along nonessential routes. (Note that strengthening is not a viable option for many bridge types such as reinforced or prestressed concrete spans; the cost of strengthening these bridge types approaches the cost of full replacement.)
- The number of axles on a truck has little impact on bridges; bridge stress is affected more by the total amount of load than by the number of axles. Bridge stress generally increases with axle group weight and, except on some continuous bridges with long spans, generally decreases with the separating distance. It is possible to have GVWs greater than 80,000 pounds without introducing excessive stress.

Effect of Truck Weight on Bridge Network Costs, NCHRP Report 495, 2003.
http://trb.org/publications/nchrp/nchrp_rpt_495.pdf
From the Foreword: The objective of this project was to develop a methodology for estimating the bridge network costs associated with changes in legal and permit gross weight, axle weights, or axle configurations. This objective has been achieved with a recommended methodology for estimating changes in truck-weight histograms and for calculating the cost of fatigue and overstress in bridge components. To automate the recommended methodology, a software module that can be integrated with AASHTOWare BridgeWare was also developed.

Appendix A of the report describes the recommended methodology, and Appendix B gives two case studies illustrating how to apply the methodology. For more information, including a link to Appendix A, see http://www.trb.org/main/blurbs/153582.aspx.

The Influence of Vehicular Live Loads on Bridge Performance, pooled fund project TPF-5(283), ongoing.
http://www.pooledfund.org/Details/Study/519
Excerpt: The objective of this study is to assess the effect of truck traffic on bridge performance. This multi-year study will collect quality truck traffic and loads data (volumes, classifications, size, weights, and other relevant data) by installing, maintaining, calibrating, and utilizing instrumentation at selected bridge sites nationally, for the purpose of calibrating bridge specifications and quantifying load-induced deterioration of bridge elements and systems to establish bridge performance and serviceability criteria for improved long-term bridge performance, management and operations.

Minnesota is a member of this pooled fund study. For more information, see this project update presented at the January 2014 TRB Annual Meeting:
http://www.fhwa.dot.gov/multimedia/research/infrastructure/bridges/ltbp/trb2014_pooledfund_update.cfm

Contact: Thomas Saad, FHWA Structures Resource Center, 708-283-3521, thomas.saad@dot.gov.

Minnesota Truck Size and Weight Project, Minnesota DOT, 2006.
http://www.dot.state.mn.us/information/truckstudy/
Table 5 of this report gives the bridge-related impacts of several proposed modifications to truck configurations and restrictions (see page 21; the table is also reproduced on page 6 of this Transportation Research Synthesis). The changes were predicted to create "a modest increase in bridge postings and future design costs."

The MnDOT Bridge Office analyzed the number of state and local bridges that would need to be posted under a range of loadings. Table F.3 (see page 169 of the PDF), which shows the analysis results, is reproduced below.

Table F.3 Bridge Posting Analysis

Vehicles Analyzed			Number of Posted Bridges		
Gross Vehicle Weight (kips)	Length (Feet)	Number of Axles	State	Local	Total
80	51	5	0	63	63
88	51	5	2	219	221
90	60	6	0	117	117
99	60	6	4	284	288
97	63	7	1	98	99
99	63	7	4	111	115
108	73	9	0	76	76
129	92	10	0	79	79
90	51	6	2	352	354
98	51	6	15	523	538

Source: Minnesota Truck Size and Weight Project, Minnesota DOT, 2006; Table F.3, page F-8.

Excerpt (see pages 169-170):

> For each scenario, bridges were identified that would need to be posted under the scenario, but would not have to be posted with no change under current limits. The added cost associated with inspecting, rating, and posting these bridges was estimated assuming that the average cost to inspect, rate, and post a bridge is $3,400 and that the bridge must be re-inspected, rerated and (if necessary) reposted every 10 years.
>
> The benefits and costs of replacing the bridges that would have to be posted under each scenario were estimated. These estimates were prepared using data from the Minnesota bridge inventory on traffic volumes, bridge deck area, and detour distance. In these analyses, the added transport costs associated with scenario trucks having to detour around a posted bridge was compared with the cost of replacing the bridge to accommodate scenario trucks. In all cases, the benefits associated with replacing the bridges to accommodate scenario trucks were found to be less than the cost of replacing the bridges.

Effects of Increasing Truck Weight on Steel and Prestressed Bridges, Minnesota DOT, Report 2003-16, 2003.
http://www.dot.state.mn.us/ofrw/PDF/200316.pdf
This study concluded that "any increase in legal truck weight would shorten the time for repair or replacement of many bridges." Researchers also noted that "decks with thickness less than 9 inches or with girder spacing greater than 10 ft may be susceptible to longitudinal flexural cracking, which could decrease life."

The MAP-21 CTSW study researchers included this report in their Bridge Structure Comparative Analysis Desk Scan. In their summary of the report, the CTSW researchers put in bold type the Minnesota study's conclusion that "bridge decks are affected by axle weights rather than overall truck weights," and noted that "This is an important finding for the current CTSW study in general and as it relates to fatigue in bridge decks."

Aligning Oversize/Overweight Fees with Agency Costs: Critical Issues, Wisconsin DOT, August 2013.
http://wisdotresearch.wi.gov/wp-content/uploads/WisDOT-CFIRE-project-0092-10-21-final-report.pdf
Summary commentary from the MAP-21 CTSW study's Bridge Structure Comparative Analysis Desk Scan: "This document attempts to address a number of issues regarding OSOW trucks in Wisconsin. Of relevance to the current CTSW Study is the attempt to allocate bridge cost to vehicles using the load based allocator—ESAL miles. This is one of the few states that have deviated from the Federal Cost Allocation method as outlined in this document."

Wisconsin Truck Size and Weight Study, Wisconsin DOT, June 2009.
http://www.topslab.wisc.edu/workgroups/tsws/deliverables/FR1_WisDOT_TSWStudy_R1.pdf
Section 7.5, "Bridge Reconstruction, Rehabilitation, and Posting Costs" (see page 169 of the PDF), analyzes how various truck size and weight increases would require bridge reconstruction, rehabilitation or reinforcement, or posting, and identifies associated costs.

Table 7.2 (page 179 of the PDF), showing estimated annual bridge replacement costs, is reproduced below.

Table 7.2 Estimated Annual Bridge Replacement Costs

Special Vehicle Configuration	State Route Bridge Replacement Costs	Local Route Bridge Replacement Cost
Six-Axle Tractor-Trailer, 90,000-Pound GVW (6-90)	$0.04M	$2.14M
Seven-Axle Tractor-Trailer, 97,000-Pound GVW (7-97)	$0.28M	$2.80M
Eight-Axle Tractor-Trailer, 108,000-Pound GVW (8-108)	$0.04M	$2.22M
Seven-Axle Single Unit, 80,000-Pound GVW (7-80)	$0.78M	$5.24M
Six-Axle Tractor-Trailer, 98,000-Pound GVW (6-98)	$1.54M	$6.94M
Six-Axle Tractor-Trailer and Pup, 98,000-Pound GVW (6-98 Pup)	$0.72M	$3.5M

Source: Wisconsin Truck Size and Weight Project, Wisconsin DOT, 2009; Table 7.2, page 7-17.

Excerpt (see pages 179-180 of the PDF):

> The respective costs assume an estimated bridge deck area and average unit costs. All bridge replacement costs shown are in millions of dollars per year annualized over a 10-year period using a 5 percent interest rate. …
>
> The study team did not complete a detailed evaluation of the locally maintained bridges because HSIS does not include specific rating information. Instead, the team used the results of the State route evaluation to extrapolate replacement costs for local bridges. The review criteria included age, design rating, sufficiency rating, inventory rating, and type of structure. The replacement cost used bridge area and unit prices to determine an order of magnitude cost to address bridges not capable of carrying the

respective TSW special vehicle load. It is important to note that **Table 7.2 does not account for the entire magnitude of the state and local bridge replacement cost.** The above cost only accounts for the bridge replacement cost associated with allowing the specific special vehicle across the bridge. The total cost to replace all statewide deficient bridges on both the state and local route far exceeds the amount shown above. Historically the Wisconsin bridge program replaces about 100 structures annually with an **estimated construction cost in the range of $80 million to $100 million (structure only cost).** The total construction cost including the bridge and approach roadway is in the range of $150 million to $160 million per year. This amount includes replacement of deficient bridges as well as bridge improvements to the state highway and local network of roads. The estimated total cost to repair or replace all deficient bridges, both state and local, is in the range of $450 million to $525 million. Over a 10-year period assuming 5 percent interest, the range of annual cost is $58 million to $68 million. Deficient state bridges account for approximately 25 percent of this cost while deficient local bridges account for the remaining 75 percent.

The team did not identify specific bridges requiring posting under each special vehicle configuration. The added cost associated with inspecting, rating, and posting a bridge is $3,000 per structure. This inspection-related cost is an annual expense for a State route bridge. For a locally maintained bridge, the $3,000 per structure is conservative. There is additional cost associated with posting a structure. These annual costs include additional mileage, additional time, and lost revenue of the user.

An exact number of bridges requiring posting is difficult to estimate. The team assumes 25 bridges require posting for the State route. Posting of locally maintained bridges is more likely because the bridge capacity is too low. Many local bridges are not structurally adequate to carry the legal load or the proposed TSW loading.

Safety

The MAP-21 CTSW study desk scan on safety and the 2011 NCHRP *Directory of Significant Truck Size and Weight* both concluded that limitations in crash and exposure data make it difficult to definitively relate truck size and weight to highway safety. This was repeatedly cited as a caveat along with specific findings.

MAP-21 CTSW Study: Highway Safety and Truck Crash Comparative Analysis, Final Draft Desk Scan, U.S. DOT and FHWA, November 2013.
http://www.ops.fhwa.dot.gov/freight/SW/map21tswstudy/deskscan/safety_dksn.pdf
This desk scan's conclusions included the following (see pages 45-46):

- Recent studies based on observing the effect of larger and heavier trucks on the total system crash rate or the total truck rate have been inconclusive.
- Gross vehicle weight appears to be associated with higher crash rates (based on changes in vehicle operating characteristics and limited crash studies).
- Different studies have found crash rates for double-trailer trucks were either the same, lower or slightly higher than rates for single-trailer trucks. Also, different studies have found crash severity to be lower, higher or about the same for longer-combination vehicles (LCVs) and tractor semitrailers.
- Operating environment, including road type and time of day, has a larger effect on crash rates than truck configuration. (The 2011 NCHRP Directory reiterates this finding, adding that turnpikes and Interstates have been shown to be safer irrespective of truck size or weight.)
- Older crash rate studies have shown that roll threshold, rearward amplification, load transfer ratio, braking efficiency and steering sensitivity are associated with changes in crash risk. Low-speed and high-speed offtracking have not yet been shown to be associated with crash risk.
- Time-limited pilot studies in small states do not generate sufficient data to assess safety performance.

Directory of Significant Truck Size and Weight Research, NCHRP Project 20-07, Task 303, October 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_FR.pdf
Research on safety impacts appears on pages 48 to 59 of the directory. Themes identified from the safety research cited (see page 49) include:

- Changes in truck size and weight limits can affect highway safety by: (1) increasing or decreasing truck traffic; (2) causing or requiring changes in vehicle design and performance that may affect crash rates and severity; or (3) causing trucks to shift to highways with higher or lower crash rates.
- With some consistency, heavier trucks (with higher GVWs) were associated with lower crash rates (attributable to fewer required truck trips to haul a given amount of freight) but higher crash severities.
- With some consistency, larger, heavier trucks were observed to have the same or slightly higher crash risk based on vehicle handling and stability characteristics:
    - Double trailer trucks are prone to rearward amplification that can have a detrimental safety effect.
    - Higher centers of gravity increase potential for rollover or ramp-related crashes.
- Changes in driver qualifications and vehicle/roadway design can potentially offset the safety drawbacks of some larger, heavier vehicles.
- International efforts have defined safety performance measures—based on vehicle stability and control characteristics—to help assess the safety-related impacts of changes in truck size and weight limits.

Traffic and Congestion

Directory of Significant Truck Size and Weight Research, NCHRP Project 20-07, Task 303, October 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_FR.pdf
Research on traffic and congestion impacts appears on pages 84 to 90 of the directory. Themes identified from the research cited (see page 85) include:

- Increases in allowable truck size and weight could impact highway congestion through resultant changes in either truck volumes or highway capacity:
    - Heavy truck VMT may either decrease as a result of increased truck capacity or increase in response to lower trucking transport costs.
    - Larger, heavier trucks may be less maneuverable and have less horsepower in relation to their weight, effectively reducing highway capacity.
- With some consistency, increases in allowable truck size and weight were predicted to result in a modest degradation in traffic flow and associated capacity. However, anticipated corresponding reductions in heavy truck VMT were predicted to offset these negative impacts in the broader context of highway congestion.
    - Larger, heavier trucks would have inferior capabilities related to traction; speed maintenance on upgrades; and freeway merging, weaving, and lane changing. They would also require increased intersection and passing sight distance.
- Prior studies have been criticized for oversimplifying the complex interactions between trucks and other vehicles in the traffic stream. Changing truck volumes, dimensions and acceleration abilities will affect other vehicles' driving, acceleration and braking patterns.

Geometric Design

Directory of Significant Truck Size and Weight Research, NCHRP Project 20-07, Task 303, October 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_FR.pdf
Research on geometric design impacts appears on pages 60 to 64 of the directory. Themes identified from the geometric design research cited (see page 60) include:

- Geometric design features most affected by increased truck size and weight include horizontal curves, intersection turning radii, passing sight distance, sight distance at intersections and railroad grade crossings, and ramp interchanges.
- Increases in trailer lengths are most problematic in terms of current highway geometric designs—the longer the trailer, the greater the vehicle's off-tracking.
- Estimated costs to upgrade existing geometric features to accommodate larger, heavier trucks are significant but highly variable depending on truck configuration and the extent of roadway network to be redesigned.
- Wider trucks operating on rural two-lane highways have been observed to elicit undesirable/unsafe actions by oncoming drivers.

Review of Truck Characteristics as Factors in Roadway Design, NCHRP Report 505, 2003.
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_505.pdf
This report provides guidance for roadway geometric designers on how best to accommodate large trucks on the U.S. highway system.

Energy and Emissions

MAP-21 CTSW Study: Modal Shift Analysis, Final Draft Desk Scan, U.S. DOT and FHWA, November 2013.
http://www.ops.fhwa.dot.gov/freight/sw/map21tswstudy/deskscan/modal_shift_dksn.pdf
The Modal Shift desk scan addresses environmental issues, primarily from the perspective of comparing rail vs. trucks. See the subsection "Energy and Environment," pages 42 to 46. An excerpt from page 46:

> [The] U.S. EPA is part of a SmartWay Transport Partnership whose goal is to encourage shippers and fleets to reduce air pollution and greenhouse gas emissions through lower fuel consumption. One strategy that is part of the SmartWay program is the use of longer combination vehicles. The U.S. EPA says that "LCVs are more fuel-efficient, on a ton-mile basis, than typical combination trucks. For example, a Rocky Mountain Double consumes 13 percent less fuel per ton-mile of freight, compared to a typical combination truck. This saves over $8,000 in fuel costs per year. Turnpike Doubles and Triples reduce fuel use per ton-mile by 21 percent, saving over $13,000 in annual fuel costs."

The U.S. EPA document cited is a two-page brochure:

> **"Longer Combination Vehicles: A Glance at Clean Freight Strategies,"** U.S. EPA, undated.
> http://www.epa.gov/smartway/forpartners/documents/trucks/techsheets-truck/420f10053.pdf

Directory of Significant Truck Size and Weight Research, NCHRP Project 20-07, Task 303, October 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(303)_FR.pdf
Research on environmental impacts appears on pages 91 to 98 of the directory. Themes identified from the research cited (see pages 91-92) include:

- The impacts of increased truck size and weight limits on the environment are typically characterized in terms of energy consumption, harmful emissions and noise levels.
  - Estimates are often derived from anticipated reductions in heavy truck VMT and do not directly differentiate between truck configurations or size and weight classes.

- With some consistency, fuel consumption is estimated to decrease with increased truck size and weight limits, attributable to anticipated reductions in heavy truck VMT.
- Harmful emissions impacts are largely inestimable for specific truck configurations or size and weight classes using contemporary models, with the exception of CO_2—CO_2 production is directly proportional to diesel fuel use. As such, CO_2 production is also consistently estimated to decrease with increased truck size and weight limits, attributable to anticipated reductions in heavy truck VMT.
- Results relating increased truck size and weight limits and noise levels are inconsistent—noise levels have been shown to both increase and decrease with increases in allowed truck size and weight.

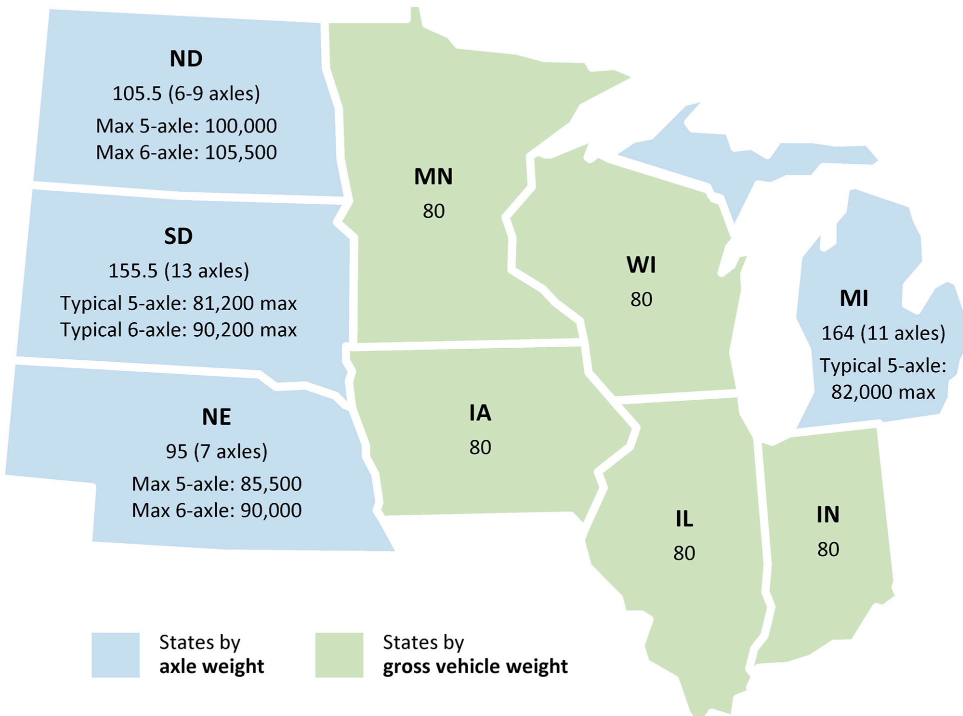
Estimating Truck-Related Fuel Consumption and Emissions in Maine: A Comparative Analysis for a 6-Axle, 100,000 Pound Vehicle Configuration, American Transportation Research Institute, September 2009.
http://www.maine.gov/mdot/ofbs/documents/pdf/atrimainereport.pdf
This ATRI report examined the potential emissions and energy impact of increasing the federal gross vehicle weight exemption to more sections of Maine's Interstate highway system. The study evaluated the performance of a 6-axle configuration that operated at 100,000 pounds. Two different travel scenarios were developed using a simulation model, one assuming uninterrupted travel requiring no deceleration and one incorporating stops at each traffic light along Route 9. An extrapolation found that expanding the weight exemption to allow 6-axle, 100,000 pound GVW trucks on more segments of I-95 would result in fuel savings and reduced emissions.

(Note: ATRI is a research organization representing the trucking industry. This report was cited in the MAP-21 CTSW study's desk scan on pavements.)

State Weight Limits

The following map was created by CTC & Associates based on review and interpretation of neighboring states' statutes and websites.

Maximum Gross Vehicle Weight Allowed without Permit
(thousands of pounds)



Note: Many states issue routine permits exempting specific commodities from the maximum weight limits. This map does not reflect these exemptions. See Appendix A for a table of states' exemptions compiled by the American Trucking Associations.

Minnesota Weight Limits

A 2009 legislative change raised weight limits so that all paved highways in Minnesota are now 10-ton highways (referring to the weight limit of 20,000 pounds, or 10 tons, per axle).

- 80,000 pounds GVW limit; 20,000 pounds per axle limit.
- On state and federal highways, permits allow 88,000 pounds GVW on 5 axles during harvest season.
- Higher GVWs are allowed in some circumstances on certain 10-ton local roads that are not part of the National Highway System.
    - Raw, unprocessed agricultural products: Up to 97,000 pounds on 7 axles (requires permits from each road authority).

Resources on Minnesota's current weight limits and laws:

- Two-page fact sheet, "Minnesota Weight Laws & Limits," Minnesota Department of Public Safety, 2012. https://dps.mn.gov/divisions/msp/commercial-vehicles/Documents/Pamphlets/2012%20Weight%20Limits.pdf

- Minnesota Truck-Weight Education Program
  http://www.mnltap.umn.edu/training/topic/customized/truck-weight/
  Funded through 2016, this program "addresses concerns from state, county, city, and township transportation authorities regarding damage from heavy trucks."

Other States' Weight Limits

Many studies and organizations have compiled tables of states' weight limits. The tables differ slightly depending on what data is being presented, and each table reflects current state laws at the time it was created. A few recent compilations are noted below.

Wisconsin Truck Size and Weight Study, Wisconsin DOT, June 2009.
http://www.topslab.wisc.edu/workgroups/tsws/deliverables/FR1_WisDOT_TSWStudy_R1.pdf
See the following tables:

- Table 2.2, "Summary of Maximum Commercial Vehicle Weights in Wisconsin and Neighboring States," pages 2-4 and 2-5.
- Table 2.3, "Summary of Permitting Practices for Commercial Vehicle Weights in Wisconsin and Neighboring States," page 2-6.
- Table 2.4, "Load-Specific Exceptions by State," page 2-7.

Minnesota Truck Size and Weight Project, 2006.
http://www.dot.state.mn.us/information/truckstudy/
See Table 2, "Summary of Maximum Truck Weights in Minnesota and Neighboring States and Provinces," page 9 of the report.

State Weight Exemptions, American Trucking Associations, March 2013.
Dan Murray of the American Transportation Research Institute (ATRI) provided us with a table of state weight exemptions compiled by the American Trucking Associations (see Appendix A).

Contact: Dan Murray, Vice President, Research, ATRI, 651-641-6162, dmurray@trucking.org.

Appendix A: State Weight Exemptions (Source: ATA)

State Weight Exemptions (As of March 2013)

NOTE: The information in this document was compiled by the American Transportation Associations (ATA) and is accurate to the best of ATA's knowledge. However, additional requirements and restrictions may apply. Please consult with official documents when determining the legal status of a delivery.

Bolded items: Non-Interstate operations only.

Alabama*	• **10% weight tolerance, 40,000 pound tandem axle limit, 84,000 lbs GVW (6 axles) limit on state highways other than Interstates for all vehicles.** • **Vehicles hauling milk products are exempt from weight restrictions.**
Alaska	• 38,000 pound tandem axle limit for all trucks. • GVW is uncapped and governed by axle weight and bridge formula limits. • Traction weight shifting to the drive axle up to 2,000 pounds during winter. • 1,500 lbs gross and axle weight tolerance for snow and ice build-up Oct. 1 – April 30.
Arizona	• LCVs up to 123,500 lbs
Arkansas	• 50,000 lbs tridem, all highways. • **Weight exception for vehicles hauling cotton seed (8,000 lbs).** • **Vehicles hauling animal feed or solid waste allowed 8% weight increases above bridge formula without exceeding 80,000 lbs GVW; tandem axle limited to 36,500 lbs. Tandem axle limits don't apply if bridge formula limits are met. Applies only to non-Interstates.** • **5-axle trucks hauling sand, gravel rock, crushed stone, unprocessed farm or forest products are exempt from the bridge formula on non-Interstates.** • **5-axle trucks hauling unprocessed farm or forest products allowed 36,500 lbs tandem axle limit and 85,000 lbs GVW limit on non-Interstates.**
California	• **Logging trucks on non-Interstates allowed 35,500 lbs on tandem axles.** • **Cotton module movers off National Network allowed 40,000 lbs on tandem axles.** • **DOT may allow 25% weight tolerance on non-Interstate highways for trips up to 75 miles.**
Colorado	• Tandem axle weight limit of 36,000 pounds on the Interstate System, 40,000 pounds on non-Interstates. • 54,000 lbs tridem all highways. • **Maximum gross weight of 85,000 pounds for non-Interstate operations.** • **Vehicles equipped with a self-compactor and used solely for hauling trash are exempt from a single-axle weight limit.** • **Bridge formula for non-Interstate Highways: W = 1,000(L plus 40), where W = the gross weight in pounds, L = the length in feet between the centers of the first and last axles of such vehicle or combination of vehicles. No GVW shall exceed 85,000 lbs.** • **Additional 1,000 lbs allowed for alternatively fueled or hybrid vehicles off the Interstate System.** • LCVs up to 110,000 lbs.
Connecticut	• Bridge formula exemptions, 22,400 lbs single axle, 45,000 lbs tandem axle, single unit vehicles, all highways • 99,000 lbs GVW for bulk milk trucks • Various bridge formula exemptions for trucks hauling bulk materials and raw products.

Delaware	• **Bridge formula exemptions off Interstate –**
	    o **2 axle: 40,000 lbs GVW**
	    o **3 axle: 65,000 lbs GVW; 70,000 lbs GVW for construction and agricultural vehicles**
	    o **4 axle: 73,280 lbs GVW**
	• **22,400 lbs single axle, 36,000 lbs tandem axle off Interstate**

* See state statute for additional information.

Appendix A: State Weight Exemptions (Source: ATA)

Florida*	• Single axle weight limit of 22,000 pounds, tandem axle limit of 44,000 pounds, tridem axle limit of 66,000 pounds on all highways. • **88,000 lbs maximum GVW on non-Interstates.** • **LCVs up to 105,500 lbs on Turnpike.**
Georgia	• 20,340 on single axle • 40,680 lbs. on tandem axle if GVW is less than 73,280 lbs and length is less than 55'. • **Weight limits may be exceeded on non-Interstate routes, provided single axle weight do not exceed 23,000 lbs and GVW does not exceed 80,000 lbs. Applies to trucks hauling forest products, cotton, live poultry, feed, granite, solid waste or unhardened poultry.**
Hawaii	• 22,500 lbs single axle limit on all highways • **88,000 GVW limit on non-Interstate highways** • **Non-Interstate bridge formula: W = 900(L + 40)**
Idaho*	• 37,800 lbs tandem axle limit on Interstate Highways if GVW does not exceed 79,000 lbs for trucks carrying logs, pulpwood, stull, poles or piling, ores, concentrates, sand and gravel, and unprocessed agricultural products, including live animals. • All trucks may operate on all highways at up to 105,500 lbs. Permit required above 80,000 lbs for Interstate Highways. • **37,800 lbs limit on tandem axles for non-Interstates when GVW does not exceed 80,000 lbs.**
Illinois	• **Cities may allow 2-axle vehicles up to 40,000 lbs GVW regardless of bridge formula limits** • **Collection of rendering materials on non-Interstates: 22,000 lbs single axle, 40,000 lbs tandem axle** • **Refuse trucks on non-Interstates: 22,000 pounds on a single axle; 40,000 pounds on a tandem axle; 40,000 pounds gross weight on a 2-axle vehicle; 54,000 pounds gross weight on a 3-axle vehicle. This vehicle is not subject to the bridge formula.** • **Axle weight tolerance for agricultural commodities on non-Interstates: 35% 2 axle; 20% 3,4 axle; 10% 5 axle** • **Raw milk on non-Interstates exempt from bridge formula provided no single axle exceeds 20,000 lbs and GVW does not exceed 80,000 lbs.**
Indiana	• **Maximum GVW up to 134,000 lbs on certain non-Interstate highways** • **Laden garbage trucks on non-Interstate highways may operate at 24,000 lbs on a single axle and 42,000 lbs on a tandem axle** • LCVs up to 127,400 lbs on Toll Road.
Iowa*	• **GVW on non-Interstate highways:** o **5-axle – 86,000 lbs (livestock only)** o **6-axle – 90,000 lbs** o **7-axle – 96,000 lbs** • LCVs up to 129,000 lbs
Kansas	• **GVW limit of 85,500 lbs off Interstate system.** • **Exempts vehicles from bridge formula limits if they are carrying sand, salt for highway maintenance operations, gravel, slag stone, limestone, crushed stone, cinders, coal, blacktop, dirt or fill material; vehicles must comply with limits on triple and quad axles.** • LCVs up to 120,000 lbs
Kentucky	• **Steel haulers may operate at up to 120,000 lbs off Interstates up to 35 miles.** • Tridem axles 48,000 lbs all highways. • **Farm and forest product haulers not subject to axle weight limits off Interstates.** • **Forest product haulers allowed 10% axle and GVW increase off Interstates.** • **Refuse haulers not subject to axle weight limits off Interstates.** • **10% axle weight tolerance for vehicles hauling crushed stone, fill dirt and rock, soil, bulk sand, coal, phosphate muck, asphalt, concrete, solid waste, tankage or animal residues, livestock, and agricultural products off Interstates.**

* See state statute for additional information.

Appendix A: State Weight Exemptions (Source: ATA)

Louisiana	• 83,400 lbs on Interstates with tridem or quadrum • **On all non-Interstates 88,000 lbs GVW with tridem or quadrum, 22,000 lbs single axle, 37,000 lbs tandem axle, 45,000 lbs tridem, 53,000 lbs quadrem.** • **Permit loads (non-Interstate)** o **Agronomic/horticultural crops: 100,000 lbs GVW; 48,000 lbs tandem; 60,000 lbs tridem.** o **Farm, forest products, grass sod, seed cotton modules, cotton: 86,600 lbs GVW; 22,000 lbs single axle; 37,000 lbs (40,000 lbs forest products) tandem axle.** o **Refuse ($1,000 permit): 48,000 lbs tandem axle; 60,000 lbs tridem axle; 108,000 lbs GVW (5 axles); 120,000 lbs GVW (6 axles).** o **Refuse/waste ($10 permit): 37,000 lbs tandem axle; 45,000 lbs tridem axle; 86,600 lbs GVW.** o **Solid waste ($50 permit): 48,000 lbs tandem axle; 60,000 lbs tridem axle.** o **Timber-cutting, logging: 105,000 lbs GVW; 48,000 lbs tandem.** • On all highways, 100,000 lbs GVW on 6 axles for vehicles hauling sugarcane under permit.
Maine*	• 6-axle: 100,000 lbs GVW; 22,400 lbs single; 41,000 lbs tandem; 50,000 lbs tridem. • 5 axles or less: 22,400 lbs single; 38,000 lbs tandem; 48,000 lbs tridem. • 4-axle single unit hauling forest products: 64,000 lbs GVW.
Maryland	• **22,400 lbs single axle limit for single unit trucks and combination trucks with GVW under 73,000 lbs.** • **On non-Interstates, forest and milk (in certain counties) products permit for 6-axle vehicle: 87,000 lbs GVW; 1,000 lbs GVW tolerance; 15% axle weight tolerance.** • **10% weight tolerance for farm vehicles off Interstate; 15% tolerance under certain circumstances**
Massachusetts	• On all highways 22,400 lbs on single axle, 36,000 lbs on tandem axle • Reducible Load Permit: • 73,000 lbs 3 axles • 87,000 lbs 4 axles • 99,000 lbs 5 axles • 2-axle construction or refuse vehicle: 46,000 lbs GVW, regardless of axle weight or bridge formula limits. • 3-axle construction, refuse, bulk feed, liquid petroleum: 60,000 lbs GVW, regardless of axle weight or bridge formula limits. • LCVs up to 127,400 lbs on Turnpike.
Michigan	• No GVW limit for vehicles with more than 5 axles; vehicles must comply with bridge formula and axle weight limits up to 164,000 lbs.
Minnesota	• **88,000 lbs GVW on non-Interstate trunk roads for livestock haulers under permit.** • **12.5% GVW increase up to 90,000 lbs for forest products on 6 axles on non-Interstates under permit (higher seasonal increases up to 98,000 lbs).** • **82,000 lbs GVW on 6 axles for vehicles hauling pulpwood on non-Interstates under permit.**
Mississippi	• **Axle, bridge formula and tire weight exemptions for concrete, raw cotton and solid waste on non-Interstates if GVW is 60,000 lbs or less.**
Missouri	• **36,000 lbs tandem axle weight limit, 22,000 lbs single axle weight limit on all non-Interstate highways.** • **GVW on non-Interstates may exceed bridge formula limits by 2,000 lbs provided GVW does not exceed 80,000 lbs.** • **Vehicles hauling solid waste on non-Interstates: 22,400 lbs single axle; 44,800 lbs tandem axle, regardless of GVW and bridge formula limits.** • LCVs up to 120,000 lbs.
Montana	• 131,060 lbs GVW limit on all highways, provided they comply with Bridge Formula B.

* See state statute for additional information.

Appendix A: State Weight Exemptions (Source: ATA)

Nebraska	• **95,000 lbs GVW limit on non-Interstates.** • **Overweight permits for non-Interstates:** o **15% axle and GVW for beans.** o **20% axle for refuse or garbage.** • LCVs up to 95,000 lbs.
Nevada	• 129,000 lbs GVW on all highways. Permit required for loads over 80,000 lbs. • **Refuse haulers on non-Interstates allowed 22,000 lbs GVW on single axle, 40,000 lbs GVW on tandem axle.**
New Hampshire*	• 99,000 lbs GVW limit; 22,400 lbs single; 36,000 lbs tandem; 54,000 lbs tridem – see table. • Tandem axle weight limit of 36,000 lbs, single axle weight limit of 22,400 lbs, provided GVW does not exceed 73,280 lbs.
New Jersey	• Single axle weight limit of 22,400 lbs on all highways. • **Solid waste vehicles exempted from axle weight limits on non-Interstates.**
New Mexico	• On all roads, 21,600 lbs single axle limit, 34,320 lbs tandem axle limit • **On non-Interstates, 86,400 lbs GVW limit.** • **25% axle weight increase for single unit liquid hauling tank trucks under permit.**
New York*	• Single axle weight limit of 22,400 lbs and tandem axle weight limit of 36,000 lbs on all highways. • Issues divisible load permits for various operations on state highways – see table. • LCVs up to 143,000 lbs on Thruway.
North Carolina	• Tandem axle limit of 38,000 lbs on all highways. • **90,000 lbs GVW limit on agricultural haulers on non-Interstates.** • **23,500 lbs steering axle for refuse trucks equipped with a front boom or rear axle if loaded from the rear; non-Interstates only.** • **Vehicles hauling aggregates on non-Interstates exempted from axle-weight limits.** • **Vehicles hauling crops, bulk soil, bulk rock, sand, sand rock or millings on non-Interstates: 4,000 lbs GVW over bridge formula, 22,000 lbs single, 42,000 lbs tandem.**
North Dakota	• 105,500 lbs GVW on all highways (over 80,000 lbs on Interstates requires permit). • **On non-Interstates, 48,000 lbs tridem.** • **On non-Interstates, only exterior bridge formula calculation is applied.**
Ohio	• Trucks hauling farm products and equipment, and logging trucks, may exceed Interstate weight limits by 5% • **Higher axle weights allowed for trucks on non-Interstate highways. These higher weights are generally utilized by trucks hauling sand, gravel, coal and agricultural products.** • LCVs up to 115,000 lbs on Turnpike.
Oklahoma	• **90,000 lbs GVW limit on all non-Interstate highways. Most of these loads are used by trucks hauling construction supplies such as sand, gravel and rocks.** • **Utility and refuse trucks allowed 15% greater weight on all non-Interstate highways** • **Vehicles carrying timber, pulpwood, chips or grain allowed 5% greater weight on all non-Interstate highways,** • LCVs up to 90,000 lbs.
Oregon	• GVW regulated by Bridge Formula up to 105,500 lbs

* See state statute for additional information.

Appendix A: State Weight Exemptions (Source: ATA)

Pennsylvania	• On Interstate and other designated highways, single axle weight of 22,400 lbs, tandem axle weight of 36,000 lbs if GVW is 73,280 lbs or less • **Non-Interstate permits (limited mileage and/or origin-destination) –** o **Loads of steel coils, 100,000 lbs GVW** o **Raw milk, waste tires 95,000 lbs GVW** o **Hot ingots or hot box, 150,000 lbs GVW** o **Raw coal, waste coal, beneficial combustion ash, 95,000 lbs GVW** o **Raw water, 96,900 lbs GVW, 6 axles** o **Pulpwood wood chips, 95,000 lbs GVW, 5 axles; 107,000 lbs GVW 6 axles (53,000 lbs tridem)** o **Particleboard or fiberboard; bulk refined oil, 107,000 lbs GVW 6 axles (53,000 lbs tridem)** o **Limestone, 95,000 lbs GVW on 6 axles** o **Nonhazardous liquid glue, 105,000 lbs GVW** • **Non-Interstate permits (unlimited mileage, no O-D specified) –** o **Domestic animal feed or grain, 95,000 lbs GVW** o **Live domestic animals, 95,000 lbs GVW**
Rhode Island	• 22,400 lbs on single axles and 36,000 lbs on tandem axles on all highways • 104,800 lbs GVW for 5-axle trucks, 76,650 lbs GVW for 4-axle trucks.
South Carolina	• **Bridge formula exemption for dump trucks, dump trailers, trucks carrying agricultural products, concrete mixing trucks, fuel oil trucks, line trucks, and trucks designated and constructed for special type work on non-Interstates.** • **Concrete mixers exempted from axle weight and bridge formula limits within 15 miles of home base on non-Interstates.** • **15% tolerance on non-Interstates for vehicles hauling unprocessed forest products and sod.**
South Dakota	• **Various exemptions for trucks hauling farm products, refuse and aggregates on non-Interstates.** • LCVs up to 129,000 lbs.
Tennessee	• **Bridge formula exemption for trucks hauling crushed stone, fill dirt and rock, soil, bulk sand, coal, clay, shale, phosphate muck, asphalt, concrete, other building materials, solid waste, tankage or animal residues, livestock and agricultural products, or agricultural limestone on non-Interstates**
Texas	• **Trucks may operate at 10% over state limits (12% for agricultural movements) off the Interstate system**
Utah	• Weight may exceed normal limits provided they comply with modified bridge formula limits
Vermont	• 22,400 pounds on single axles and 36,000 pounds for tandem axles, with a 10% tolerance on axles and 5% on GVW. • Haulers of forest, milk and quarry products may operate at up to 99,000 pounds GVW. • Other trucks may operate with a GVW of 90,000 pounds.
Virginia	• **Trucks hauling coal on any non-Interstate highway can operate at up to 90,000 pounds GVW, and can have a single axle weight limit of 24,000 pounds and a tandem axle limit of 45,000 pounds** • **Concrete mixers and trucks hauling solid waste allowed a 40,000 pound tandem limit.** • **Trucks may operate at up to 84,000 pounds GVW on any non-Interstate highway.**
Washington	• GVW governed by federal bridge formula up to 105,500 lbs
West Virginia	• **Coal trucks may operate at up to 120,000 lbs GVW on non-Interstates**
Wisconsin	• **Milk haulers single axle limit of 21,000 lbs, tandem axle limit of 37,000 lbs on non-Interstates** • **Haulers of forest products, scrap metal and municipal sewage allowed 21,500 lbs single axle, 37,000 lbs tandem axle on non-Interstates** • **Forest products 98,000 lbs on 6 axles on non-Interstates** • **Certain agricultural products on non-Interstates up to 90,000 lbs** • Weight exemptions for certain agricultural products and scrap for a segment of I-39

* See state statute for additional information.

Appendix A: State Weight Exemptions (Source: ATA)

Wyoming	• 36,000 lbs on tandem axles on all highways • 117,000 pounds GVW on all highways • **Trucks hauling agricultural, forest and gravel products on non-Interstate highways may operate at 10% above regular limits**

* See state statute for additional information.