

Report to Congress

Final Report

Comprehensive Truck Size and Weight Limits Study

April 2016



U.S. Department of Transportation
Federal Highway Administration

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Executive Summary

The U.S. Department of Transportation (DOT) has completed work on the Comprehensive Truck Size and Weight Limits Study (Study) as directed by the Moving Ahead for Progress in the 21st Century Act (MAP-21) (P.L. 112-141). The Department's task was to inform Congress, not to build a better truck or advocate for major new programs or policies. We continue to maintain that position, as further work is necessary to improve the body of information in these technical areas. There are implications for possible changes in safety, efficiency, cost, and other priorities; balancing these outcomes is not a simple calculus.

The Federal Government has researched truck size and weight matters for decades, periodically producing studies to inform congressional debate on standards to advance national interests. The analysis and technical findings of this latest Study add to this body of knowledge. What this Study did not do, due in large part to the limitations discussed in the body of this Report, is produce definitive results in all of the required study areas or yield a sound basis for any particular set of policy changes.

There will be a temptation to seek out the evidence in the results of this Study that supports a particular position: the data point, or result that would steer the policy debate on this issue in a particular direction. The universe of views and public policy goals with respect to this subject is large, diverse, and often in conflict.

With this in mind, DOT set out to conduct a study that could stand above criticism for poor procedures, bias, or conflict of interest. This Study gave much consideration to process, and focused on producing technical reports that were data-driven, transparent, and accountable. To alleviate concerns that we favored any particular goal or outcome, we maximized public input and scrutiny. We held public meetings in advance of designing the Study to get input on the data, methodology, prior work, and current models. After the public meetings, we convened webinars to share the status and interim work of the research effort, and asked for an independent peer review by the National Academy of Sciences (NAS). We posted transcripts and work, products, and schedules on a public Web site. We also made announcements through the Federal Register, logged public comments in a docket, and maintained open lines of communication for people to submit comments, offer views, and seek answers to questions about the Study structure. We required that the Study only use publicly available data so that the results could be replicated.

Predictably, in a study in which there are so many components that cover different topics, there is no single bottom-line finding. One cannot responsibly take the figures derived from the discrete study areas and come up with a summary result that would yield a clear policy decision. In fact, in each of the study areas, there are data gaps and insufficiencies in the models that make

it highly improper to extrapolate the results from each of the five technical areas across the national system.

Increases in commercial motor vehicle size (in particular, length pertaining to multiple trailing units) and weight are presumed to result in changes in highway safety, infrastructure condition, effectiveness of enforcement, the preference for utilization of certain truck types and for trucks over other modes of freight transportation, and overall productivity of the freight system. The following information summarizes the process of analyzing a set of potential size and weight impacts as part of the Study managed by the Federal Highway Administration (FHWA) on behalf of DOT. The Study was designed to be responsive to the requirements of Section 32801 of MAP-21 but did not seek to satisfy the policy question as to whether a change in allowable truck sizes or weights would yield positive impacts that could outweigh negative impacts. Instead, the research team looked at the magnitude of potential impacts if changes were implemented. This report provides the results of the assessments that were completed and a summary of this analysis.

Background

The MAP-21 directed the Secretary of Transportation, in consultation with States and other appropriate Federal agencies, to undertake the following:

- Provide and compare data on accident frequency and evaluate factors related to the accident risk of:
 - vehicles operating in excess of Federal size and weight limits in States with that authority or under other Federal exemption or right, to that of vehicles not in excess of Federal laws and regulations.
- Evaluate the impacts to infrastructure in States where vehicles are allowed to operate at a size and weight exceeding Federal limits, compared to vehicles not operating in excess, for the following characteristics:
 - Cost and benefits of the impacts in dollars;
 - Percentage of trucks operating in excess of the Federal limits; and
 - Ability of each State to recover the costs or the benefits incurred.
- Evaluate the frequency of violations in excess of Federal size and weight provisions, and the cost of enforcement and effectiveness of the enforcement methods.
- Assess and compare the impacts of vehicles in excess of Federal limits to those not in excess on bridges, including impacts from number of bridge loadings.
- Compare and contrast potential safety and infrastructure impacts of current Federal limits in relation to:
 - Six-axle and other alternative configurations of tractor-trailers;

- Where available, safety records of foreign nations with different limits and configurations.
- Estimate the extent of likely potential surface mode diversion to principal arterial routes and National Highway System (NHS) intermodal connectors by alternative truck configuration and effect on other modes;
- The effect of diversion on public safety, infrastructure, cost responsibilities, fuel efficiency, freight transportation costs and the environment,
- The effect of alternative configurations on the network;
- The increase or decrease of total trucks on principal arterial routes and NHS intermodal connectors;
- And, identify all Federal rules and regulations impacted by changes in truck size and weight laws.

To satisfy these requirements, DOT organized the study and analysis around five core technical areas:

- Highway safety and truck crash rates, vehicle performance (stability and control), and inspection and violation patterns;
- Shifts in goods movement among truck types and between modes;
- Pavement service life;
- Highway bridge performance;
- Truck size and weight enforcement programs.

To assess the impacts that a six-axle and other alternative tractor-trailer combinations would have if they were allowed to operate throughout the Nation, DOT selected six alternative truck configurations to examine. Each of these configurations was the subject of a separate scenario analysis with a related control vehicle that met current Federal size and weight standards. The total of six configurations was determined as the maximum number that could effectively be analyzed for this Study period.

Stakeholders participating in the DOT sponsored “Stakeholder Input Meeting” in May 2013 provided input on the alternative configurations to be considered in the Study. In order to make selections from the pool of configurations offered by stakeholders, DOT established criteria to consider the following vehicle characteristics:

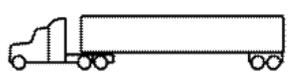
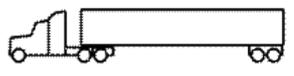
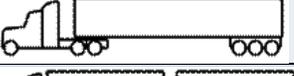
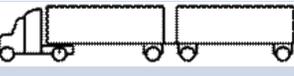
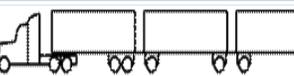
- Proposed configuration identified through stakeholder input;
- Proposed configuration serves a highway transport need;
- Proposed configuration is practical for safe operational use on U.S. roadways;
- Proposed configuration is currently in operation in the U.S. or other nations.

Table 1 shows the vehicles that were considered under each scenario as well as the existing configuration from which the most traffic would likely shift. Several configurations not selected by DOT for inclusion in the MAP-21 study were of significant interest to stakeholders. Configurations of interest to stakeholders, but not assessed in this study, include Longer Combination Vehicles (LCV) such as the Rocky Mountain doubles (48' trailer and 28' trailer) and turnpike doubles (twin 48' trailers); short-wheelbase trucks (dump trucks, concrete mixers, etc.); and specialized equipment. Some of these configurations have been examined in past studies and would be worthy of consideration in future work as the impacts are likely to vary noticeably from those of truck configurations considered in this Study.

For Table 1, it is important to note the following:

- The network addressed in the chart is the 1982 Surface Transportation Assistance Act (STAA) Network (National Network or NN) for the 3-S2, semitrailer (53'), 80,000 pound gross vehicle weight (GVW) and the 2-S1-2, semitrailer/trailer (28.5'), 80,000 pound GVW vehicles. The alternative truck configurations were presumed to be allowed to have the same access off the network as the corresponding control vehicle.
- In addition, the 80,000 pound weight reflects the applicable Federal GVW limit; a 71,700 pound GVW was used in the study based on empirical findings generated through an inspection of the Weigh-in-Motion (WIM) data used in the study.
- The triple network starts with the network used in the 2000 Comprehensive Truck Size and Weight (2000 CTSW) Study and overlays the 2004 Western Uniformity Scenario Analysis.
- And finally, the LCV frozen network for triples in the Western States was then added to the network. The triple configurations would not have the same off network access as the control vehicle, the 2-S1-2, semitrailer/trailer (28.5'), 80,000 pound GVW. Use of the triple configurations beyond the triple network would be limited to that necessary to reach terminals that are immediately adjacent to the triple network. It is assumed that the triple configurations would be used in Less-Than-Truck Load (LTL) line-haul operations (terminal to terminal). As a result, the 74,454 mile triple network used in this Study includes: 23,993 miles in the Western States (per the 2004 Western Uniformity Scenario Analysis, Triple Network), 34,802 miles in the Eastern States, and 15,659 miles in Western States that were not on the 2004 Western Uniformity Scenario Analysis, and the Triple Network used in the 2000 Comprehensive Truck Size and Weight Study (2000 CTSW Study).

Table 1: Truck Configurations and Weights Scenarios Analyzed in the MAP-21 Comprehensive Truck Size Weight Limits Study

Scenario	Configuration	Depiction of Vehicle	# Trailers or Semitrailers	# Axles	Gross Vehicle Weight (pounds)	Roadway Networks
Control Single	5-axle vehicle tractor, 53 foot semitrailer (3-S2)		1	5	80,000	Currently operating on the entire Interstate System and National Network, including most of the National Highway System
1	5-axle vehicle tractor, 53 foot semitrailer (3-S2)		1	5	88,000	Modeled to use same networks as above
2	6-axle vehicle tractor, 53 foot semitrailer (3-S3)		1	6	91,000	Modeled to use same networks as above
3	6-axle vehicle tractor, 53 foot semitrailer (3-S3)		1	6	97,000	Modeled to use same networks as above
Control Double	Tractor plus two 28 or 28 ½ foot trailers (2-S1-2)		2	5	80,000 maximum allowable weight 71,700 actual weight used for analysis ²	Modeled to use same networks as above
4	Tractor plus twin 33 foot trailers (2-S1-2)		2	5	80,000	Modeled to use same networks as above
5	Tractor plus three 28 or 28 ½ foot trailers (2-S1-2-2)		3	7	105,500	Modeled to use a 74,500 mile roadway system including the Interstate System, approved routes in 17 Western States allowing triples, and certain four-lane roads in the Eastern United States.
6	Tractor plus three 28 or 28 ½ foot trailers (3-S2-2-2)		3	9	129,000	Modeled to use same networks as above

Note: For improved clarity in the network description, this table replaces earlier versions.

Study Process

The DOT conducted the Study objectively and transparently, and used the most current, best-suited analytical methods, tools and models. Plans and procedures were established and applied across the project to address mechanisms for collecting input and providing information to the public, for peer review, for guidelines in the use of commercial or proprietary data, and for project planning. The purpose was to ensure that the Department used the best publicly available data, models, and analytical tools to answer the research questions posed by Congress.

To provide overall direction, a DOT Policy Oversight Group, with representatives from DOT operating administrations with relevant jurisdiction, was established to guide the overall process on an on-going basis from the beginning, including the technical work. The DOT managed the technical aspects of the Study through a Technical Oversight Committee (TOC), a group of subject-matter-experts with expertise directly relevant to the work being conducted. The TOC helped craft statements of work to procure contractor services. On an ongoing basis, the TOC oversaw the technical work and provided review of Study products.

The DOT procured contractor services to assist in completing the data collection and conduct the modeling and analysis required to develop the technical results supporting the Study. A request for technical proposals was issued to pre-qualified indefinite demand/indefinite quantity contract holders asking firms to specify in detail how they would conduct the work for each of the five study focus areas. The DOT study team made extensive efforts to determine that each project team member was unbiased. Project team members were asked to forego other truck size and weight work during the course of the study, and the contractor was required to demonstrate how they would manage these commitments over the course of the Study. The selected contractor established a review process to evaluate each team member for indicators of bias.

Public Involvement

Engaging stakeholders was a key part of the study process. Public outreach efforts were guided by a stakeholder outreach and engagement plan aimed at ensuring that diverse communities with a view on Federal truck size and weight limits had opportunities to express their positions at key junctures during the study. Goals stated for public involvement included:

- Interpreting and understanding critical issues and elements desired by stakeholders;
- Offering stakeholders the opportunity to recommend models and data that would beneficially contribute to the study as well as prior work relevant to the work being undertaken to complete the study;

- Providing stakeholders with opportunities to participate in the study, as appropriate, including identifying scenario configurations for evaluation and helping stakeholders understand the study areas to elicit input on the potential impacts of alternative truck types.

The DOT created a Web site to publicly share study-related materials such as schedules, documents, and presentations. The Department created a public docket for the submission and sharing of comments submitted by stakeholders and interested parties. Comments were encouraged throughout the project with an electronic mail account set up to receive input from stakeholders and interested parties at any time. Stakeholders took advantage of these opportunities to share comments as more than 100 comments were submitted to the docket and over 200 e-mail messages conveyed comments during the Study.

The DOT held four outreach sessions with interactive public access available through the Internet or telephone. In May 2013, prior to the commencement of the technical analysis and modeling work activities, a “listening session” was held at the DOT Headquarters building for people wishing to attend in person. This session was also made available to the public as an interactive webinar. As indicated above, this gave participants an opportunity to share their thoughts on alternative configuration vehicles that should be considered in the Study. The input provided through this forum was important to the selection of the configurations.

Three additional public input sessions were conducted during the course of the technical work: in December 2013, May 2014, and June 2015. At the December 2013 webinar session, the public was briefed about the rationale for selecting the alternative configurations, the networks to be examined, and the methods, data and modeling approaches to be used, all of which were influenced by the public comment process. Desk Scan activities were also discussed. At the May 2014 meeting, the DOT study team provided stakeholders and the public with an update on the status of the study, focusing on issues raised in prior input sessions, and presented a review of progress in each study area. At the June 2015 meeting, the DOT study team provided an overview and answered questions regarding the final technical reports. The DOT solicited and received comments during and after each of these sessions.

Additional information about public comments can be found in the companion document, the “Stakeholder Sessions, 2013-2015: Feedback and Comments Report.” This report presents a quantitative and qualitative analysis of trends, themes, and patterns identified after a review of the comments. It also includes a disposition of significant comments.

As a quality control measure, DOT asked the NAS to seat a Peer Review Panel charged with reviewing the Study Desk Scan Reports and the Technical Reports prepared by the Department. The Panel was made up of several transportation and highway freight experts from a variety of backgrounds ensuring all aspects of the Study were adequately reviewed. The Panel met with

DOT on three occasions with an opportunity for the Panel to hear from the public at each of these meetings.

Study Documents

To fulfill the requirements of MAP-21 and document the work conducted, DOT developed a series of reports that document the technical analyses and supporting materials. These include:

Volume I - Technical Summary Report. This document gives an overview of the legislation and the Study, provides background on the scenarios selected, explains the scope and general methodology used to obtain the results, and provides a summary of the findings.

Volume II - Technical Reports. This volume comprises a set of the five comparative assessment reports that document the technical analyses required by the Study. These include:

- Bridge Structure Comparative Analysis
- Compliance Comparative Analysis
- Highway Safety and Truck Crash Comparative Analysis
- Modal Shift Comparative Analysis
- Pavement Comparative Analysis

Supplemental Documents

- Desk Scans. These documents focus on prior completed work in areas related to the Study to inform the project plans and technical analysis. The Desk Scans describe completed, methods and techniques employed in other research initiatives, and the findings resulting from this research. The Desk Scans are incorporated into each of the Technical Reports and were peer-reviewed by the NAS Panel.
- Project Plans. These documents identified the specific steps undertaken to successfully complete the technical analyses required by the Study. The Project Plans described the overall technical approach, analytical methods, data and models that were used to complete the work activities required under each study area. The Project plans were incorporated into each of the Technical Reports.
- Linkage between the Revised Desk Scans and Project Plans Report. The purpose of this report was to document how the information and understanding gained through the revised Desk Scans informed the technical methodology undertaken

in the Study. This report documents linkages between the revised desk scans and the project plans for the five technical analysis reports.

- Comparison of Results Report. The purpose of this report was to illustrate the results from the Study and compare with results from past truck size and weight studies. This analysis focuses on past studies that have findings somewhat comparable to those from the Study in terms of the types of truck size and weight limits and networks examined and the metrics used to present findings.
- Data Acquisition and Technical Analysis Plan. This report provides an outline of the types of data that were acquired and analyzed; the availability of the data and models (in the public domain or available for purchase); data custody guidelines, and the data agreement document used in the Study.
- “Stakeholder Sessions, 2013-2015: Feedback and Comments Report.” This report provides an overview of the public outreach process and summary of public input received.
- NAS Letter Report on Desk Scans. This report provides the findings of the NAS Peer Review on the Study’s Desk Scans.
- NAS Letter Report on Technical Reports. This report provides the findings of the NAS Peer Review on the Study’s Technical Reports.

Study Results and Findings

Volume I (the technical summary report) and Volume II (the technical reports) are available on the FHWA freight Web site which hosts the documents related to the MAP-21 Comprehensive Truck Size and Weight Limits Study. The link can be found here: http://ops.fhwa.dot.gov/freight/sw/map21tswstudy/technical_rpts/index.htm. Tables 2 and 3 below summarize the key technical results of the study for each of the five focus areas: 1) modal shift, 2) safety, 3) pavement, 4) bridge, and 5) compliance.

Table 2 Study Results: Scenario Configuration Compared to Control Vehicle Heavier Single Semi-Trailer Trucks

Scenarios	Modal Shift		Safety			Bridge Projected One Time Costs	Pavement Changes in Life-Cycle Cost	Enforcement Program Costs and Effectiveness
	Truck VMT	Total Logistics Costs	Crash	Vehicle Stability and Control	Violations and Citations			
Five-axle truck @ 88k pounds	-0.6%	-1.4%	No national data or results; no analysis completed.	<ul style="list-style-type: none"> Longer stopping distances No difference in vehicle path or tracking 	<ul style="list-style-type: none"> Overall slightly higher violation rate and slightly lower out-of-service and citation rates Configurations over 80k pounds had 18% more brake violations and a higher number of brake violations per inspection Vehicle weight or configuration not predominant factors in predicting a violation 	\$.4 B	+0.4% to +0.7%	-0.3%; Positive (185,000 more trucks could be weighed for the same cost)
Six-axle truck @ 91k pounds	-1%	-1.4%	No national data or results; significant crash rate increase (+47%) in the one State (WA) analyzed.	6-axle heavy truck configurations did not differ significantly from the control vehicle in any of the maneuvers.	<ul style="list-style-type: none"> Overall slightly higher violation, out-of-service and citation rates Configurations over 80k pounds had 18% more brake violations and a higher number of brake violations per inspection Vehicle weight or configuration not predominant factors in predicting a violation 	\$1.1 B	-2.4% to -4.2%	-0.4%; Positive (266,000 more trucks could be weighed for the same cost)
Six-axle truck @ 97k pounds	-2%	-3.2%	No national data or results; significant crash rate increases in the two States (ID +99%, MI +400%) analyzed.	6-axle heavy truck configurations did not differ significantly from the control vehicle in any of the maneuvers.	<ul style="list-style-type: none"> Overall slightly higher violation, out-of-service and citation rates Configurations operating over 80k pounds had 18% more brake violations and a higher number of brake violations per inspection Vehicle weight or configuration not predominant factors in predicting a violation 	\$2.2 B	-2.6% to -4.1%	-1.0%; Positive (625,000 more trucks could be weighed for the same cost)

Table 3 Study Results: Scenario Configuration Compared to Control Vehicle - Longer Combination Trucks

Scenarios	Modal Shift 1.		Safety			Bridge Projected One Time Costs	Pavement Changes in Life-Cycle Cost	Enforcement Program Costs and Effectiveness
	Truck VMT	Total Logistics Costs	Crash	Vehicle Stability and Control	Violations and Citations			
Twin 33' trailers @ 80k pounds	-2.2%	-6.3%	N/A [Configuration not in common use]	<ul style="list-style-type: none"> Did not perform as well as the control vehicle in avoidance maneuver Slightly longer stopping distance Path deviation not affected by the ABS malfunction 	Twin trailers generally have higher vehicle inspection violation rates than five-axle 80k pound single trailers	\$1.1 B	+1.8% to +2.7%	-1.1%; Positive (653,000 more trucks could be weighed for the same cost)
Triple 28' trailers @ 105.5k pounds	-1.4%	-5.1%	No national data or results; Decrease in crash rate (-42%) in one State (ID) analyzed.	<ul style="list-style-type: none"> Did not perform as well as the control vehicle in avoidance maneuver Amplification of the third trailer's response was greater than in the control Some performance differences between the triples and twins in braking or in the ABS malfunction Off-tracking was greater than the control 	Sample size too small to conduct analysis	\$0.7 B	+0.1% to 0.2%	-0.7%; Positive (452,000 more trucks could be weighed for the same cost)
Triple 28' trailers @ 129k pounds	-1.4%	-5.3%	No national data or results; Minimal decrease in crash rate (-1%) on one roadway (KS Turnpike) analyzed.	<ul style="list-style-type: none"> Did not perform as well as the control vehicle in avoidance maneuver Amplification of the third trailer's response was greater than in the control Some performance differences between the triples and twins in braking or in the ABS malfunction Off-tracking was greater than the control 	Sample size too small to conduct analysis	\$5.4 B	+0.1% to +0.2%	-0.7%; Positive (446,000 more trucks could be weighed for the same cost)

1. Actual VMT numbers and costs for twins and triples are small but the percentages are higher.

Study Advances

The methodology used in this study reflects several changes in comparison to prior truck size and weight studies. The study took advantage of improved models in a number of areas, data sets not available to previous studies, and an analysis not previously performed.

The Study used the FHWA's Freight Analysis Framework (FAF), a more refined data set for assigning vehicles to freight corridors, more advanced models to assess truck impacts on pavements and bridges, and a careful examination of modal shift impacts on short-line and regional railroad operations caused by the introduction of the scenario vehicles. Also, a unique feature in the approach for completing highway safety and truck crash analysis was to simultaneously analyze truck safety on three tracks: State crash data analysis, corridor-based crash analysis, and fleet-based crash data analysis. The following is a summary of the key advances and methodological changes.

The data set was not available for use in prior comprehensive truck size and weight studies. The FAF integrates data from several sources to provide more detailed estimates of freight movement among States and major metropolitan areas by all modes of transportation. For the Study, the FAF information was applied at a county level, which allowed analysis of certain configurations on limited highway networks. The FAF data were used in the Intermodal Transportation and Inventory Costing (ITIC) Model to estimate modal shifts that were then used to estimate changes in truck Vehicle Miles Traveled (VMT) by configuration and weight group.

Modeling of Pavement Impacts: The pavement analysis used new pavement performance modeling software not available when prior nationwide truck size and weight studies were conducted. The software reflects an 8-year effort by the National Cooperative Highway Research Program (NCHRP) to develop a mechanistic-empirical pavement design guide. The software, available commercially as AASHTOWare™ Pavement ME Design, is considered superior to prior software because it incorporates pavement mechanics, climate effects, axle-load distributions, and other advances that allow more precise prediction of pavement performance in response to different loading scenarios.

Modeling the Impacts on Bridges: The AASHTOWare Bridge Rating® (ABrR) software was used to complete the structural analysis of load bearing capacity of 490 representative bridges on the Interstate Highway System (IHS) and non-IHS roadway systems. Bridge models previously prepared by 11 different State DOTs were used in completing the structural analysis work. The ABrR analytical software enabled a more precise estimate of the load bearing capacity of the bridges selected for analysis to be made and to evaluate the ability of the structures to accommodate the alternative scenario trucks versus the 80,000-lb control vehicles.

Modal Shift Analysis on Regional and Short-line Railroads (Class II and III): It was decided that the rail component of the modal shift analysis must include impacts on Regional and Short-line Railroads. Members of DOT and the study team met with the American Short Line and Regional Railroad Association (ASLRRA) and requested input on establishing an analytical framework for evaluating potential mode shifts in freight traffic caused by the operation of the scenario vehicles. Access to freight pricing needed by the modal shift model is highly proprietary and the importance of the confidentiality of that data is understood by DOT; as a result, this data was not used in this study. However, consultation with ASLRRA was still instrumental in developing the estimates of mode shift of short line and regional railroad freight from the introduction of heavier, six-axle trucks.

Peer Review

The DOT asked the NAS to provide an independent, objective peer review of the Desk Scan and the technical reports. The NAS was asked to prepare letter reports for each of these two areas. The peer review process was an important element in developing and completing the study. The NAS selected a well-balanced peer review panel, chaired by Dr. James Winebrake of the Rochester Institute of Technology, and over a dozen experts from the public and private sector as well as academia to conduct the reviews.

The DOT TOC met with the panel in December 2013, to brief the panel on the contents of the desk scan reports. In April 2014, the TOC presented the data, models, and approach for completing the work needed to finalize the compiled technical report. Assumptions applied in each study area and limitations imposed on the technical work due to data availability or modeling capacity were also presented to the Panel at that meeting. In July 2015, the TOC presented the results and interpretation of the results from the completed technical analysis.

The peer review panel released its Report #1 on the desk scan reports for each of the five study areas in April 2014. The Report reviewed the thoroughness of the literature search, analysis of existing models and data for conducting the study, and the overall synthesis of previous research as it relates to the present Study. The report noted:

- Desk scans are a logical step in conducting a study where significant prior work has been completed
- No superior models and data sets were omitted
- A synthesis of models and data used in previous research needs to be prepared to strengthen the case for models and data used in the study
- The linkage between the desk scan reports and the project plans needs to be strengthened
- The primary difficulties in projecting the consequences of changes in truck size and weight limits are that the available methods have significant weaknesses and that even uncertainties that are small in absolute terms (e.g., with regard to changes in truck traffic

volume and distribution resulting from a change in regulations) can have large consequences for the net impact of a regulatory change

As a result of the findings, a Comparison of Results Report and a Linkage Report were prepared. The Comparison of Results Report identifies models, data, and results produced in prior related studies and evaluate the relevancy of the results to the results produced under this Study. The Linkage Report shows how previously completed similar work was considered and, in some cases, used at a starting point for the work conducted under this Study. Also, the Desk Scan Reports were updated to show how studies not included in the original Reports were considered during the operation of this Study. The Peer Review Panel's recommendations on studies that should be included in the various Desk Scans are included in the revised Reports.

The peer review panel released its Report #2 on the technical analysis for each of the five study areas in September 2015. The Report considered:

- How the DOT study addressed the questions identified by Congress;
- The appropriateness of the methods and data used to produce the estimates; and
- Recommendations to increase the value of any future truck size and weight studies.

The Peer Review Panel Report noted that the Technical Reports lacked a consistent and complete quantitative summary of the evaluations of the alternative configuration scenarios. In particular,

- Lack of cost estimates for major categories (local roads, bridge structural costs, user costs from detours, crashes);
- Inconsistency in the way in which units of measure for impacts estimates are presented;
- Missing or inaccurate assessments of the uncertainty of estimates.

The Department has summarized all of the Study results into Tables 2 and 3 of this Report. The Department acknowledges that the results are not comparable across subject areas or able to be summed into one number. The Department believes this is beyond the charge in MAP-21. Converting the various analyses into common units of measurements for comparison across all subject areas could be done as a future project. However, with data limitations in key areas of the Study we believe such an effort would present incomplete and misleading results that would lead to misinterpretation and potential misuse by the reader of this complex topic of truck size and weight.

The NAS Report noted that the evaluation of consequences of grandfathered provisions is required but the study does not provide an overall assessment where the exemptions are in effect. Within the current data and modeling limitations, the Department believes it has met the intent of the statutory requirements regarding the consequences of grandfathering provisions. We recognize that with complete and accurate data, a more robust analysis could be completed.

The NAS Report provided conclusions on the methods and data used in the Study. The Department holds that there are multiple methods of conducting a study of this nature and there

are tradeoffs in the approaches used. We used the most appropriate and best-suited data and models for this study and included those considerations that could be reasonably analyzed with the current state of the practice and available time.

The Report provides a series of recommendations by subject area. These validate the Department's conclusion that the topic of truck size and weight has numerous areas where the development of additional data, methodologies, models and research would strengthen and expand our understanding of the impacts of trucks. We concur with the recommendations and suggest the need for a research program framework to address these issues.

More detailed information on the NAS Peer Review Panel and its work is available at <http://www8.nationalacademies.org/cp/projectview.aspx?key=49568>

Stakeholder Comments

On June 5, 2015, the Volume I Summary Report and five Technical Reports were made available to the public. Following the release of these documents, the Department conducted its 4th Web-based public meeting to share the Study findings. The proceedings from this event are documented in the "Stakeholder Sessions, 2013-2015: Feedback and Comments Report" that was referenced earlier. In addition, stakeholders submitted comments to the public docket. These respondents represent a variety of stakeholders including ten different national organizations and associations, seven State DOTs, a national trucking firm and a State association. A summary of the responses are highlighted below.

As one might expect from a polarized issue, the comments ranged across a spectrum of views:

- Several respondents provided feedback on the overall Study findings, and discrete comments were offered on the findings in the pavement, bridge, compliance and safety Study areas. Comments on the modal shift safety, pavement and bridge areas of the Study stated that sufficient assessments have been developed in the Study for States to choose as to whether larger and heavier trucks could operate safely on their highways.
- Some commended DOT for citing the lack of reliable, accurate data as a justification for not changing size and weight laws. Among the respondents who opposed an increase in the Federal truck size and weight limits were a law enforcement organization, safety advocates and 19 individuals. The comments cited an adverse impact on safe highway operations and adverse impacts on highway infrastructure already in a state of less than ideal conditions.

- Another respondent cited a need for uniformity in truck size and weight limits as a priority, with several respondents supporting an increase in the limits, including two national associations, a national trucking firm, and seven individuals.
- Included in the statements of support for new configurations were comments on the benefits of implementing twin 33 foot semitrailer-trailer configurations and input as to how demand currently exists in the industry toward their use.
- Comments from seven individuals were based on higher weight limits in other countries, accommodating equipment needed to implement alternative fuel (for example, compressed natural gas) and productivity needs of the private sector.
- Several respondents submitted comments on the study methodology. Some questioned the methodology used to model modal shift assessments performed between rail and truck others commented on the projections for use of the twin 33 foot semitrailer-trailer combination.
- Some State DOTs commented that configurations included in the Study do not reflect what is on the road today and whether adequate consideration was given to the current roadway network with respect to the accommodation of longer trucks given current geometrics on ramps and local roads accessing terminals.
- Public entities expressed concern that impacts on local roadways were not included in the Study and an individual shared concerns that passenger car and heavy truck interactions should have been studied closely in light of their contributions to truck crashes. Several respondents provided comments on the truck configurations that were evaluated, and a need to look at special hauling, sample axle arrays and weight distributions.
- Finally, miscellaneous comments included one expression of concern about the burden to the trucking industry due to the patchwork of State limits.

The DOT response to the above comments as well as the many other comments is included in the companion document, “Stakeholder Sessions, 2013-2015: Feedback and Comments Report,” a compilation of public input related to the stakeholder input sessions for the Study.

Limitations and Issues

Although FHWA's technical work was able to employ the latest modeling techniques in a number of areas, the analytical work revealed very significant data limitations that severely hampered efforts to conclusively study the effects of the size and weight of various truck configurations. These limitations are discussed below.

Modal Shift

- Breaking the FAF's freight flow estimates below the regional level used in the Framework to the county level affects the confidence associated with the data set produced for the Study. A breakdown at the county level was required to gain the fidelity needed to model freight flow shifts from rail to truck and among truck configurations.
- The precise origins and destinations of shipments are unknown from the FAF. Origins and destinations are assumed to be county centroids (the center-most point in a county) for inter-county shipments.
- The precise routes used to ship commodities between origins and destinations are not known. Shortest path routes between each origin and destination pair are calculated for purposes of estimating transportation costs.
- Characteristics of specific commodities within broad commodity groups may vary significantly.
- Shipment sizes and annual usage rates for freight flows between individual origins and destinations cannot be discerned from the FAF and must be estimated from the old Vehicle Inventory and Use Survey (VIUS) and other sources. This affects non-transportation logistics costs.
- The VIUS was last conducted 13 years ago; the validity and accuracy of the information representing current trucking industry characteristics and operation is not known.
- Truck/rail intermodal origins and destinations are unavailable from the Carload Waybill Sample and have been estimated consistent with the process in the 2000 CTSW Study.
- Comprehensive and accurate (and now deregulated) truck rates were difficult to obtain.
- Multi-stop truck moves to accumulate and/or distribute freight from/to multiple establishments are not captured in the FAF.
- Modal shift analysis for Regional and Short-line (Class II and III) railroads was accomplished using information from the ARSLRRA, which led to the determination that 90 percent of this traffic interchanges with Class I railroads and is reflected on the Confidential Way

Bill. The study lacked sufficient Regional and Short-line data for more precise modal shift modeling due to data confidentiality concerns.

Highway Safety/Crash Analysis

- A lack of truck weight data for individual trucks in crash databases resulted in the State crash analyses comparing groups of control and alternative scenario trucks operating within State-specified maximum allowable GVW limits. As a result, the study team completed its comparison based on the number of axles on the vehicle rather than a comparison of vehicles at specific weights.
- Limitations in Annual Average Daily Traffic and Weigh-In-Motion (WIM) data restricted the crash analysis to rural and urban Interstates.
- The lack of data elements in most State crash databases that would identify the configuration of a truck (count of trailers, a count of total axles, and the length of each trailer for combination vehicles involved in crashes) limited the State crash analysis and the development of crash estimates to one State for Scenarios 2 (Six-axle truck @ 91,000 pounds), 5 (Triple 28 foot trailers @ 105,500 pounds) and 6 (Triple 28 foot trailers @ 129,000 pounds) and two States for Scenario 3 (Six-axle truck @ 97,000 pounds). Scenario 1 (Five-axle truck @ 88,000 pounds) could not be analyzed due to the lack of truck weight records in the crash records. Scenario 4 (Twin 33 foot trailers @ 80,000 pounds) could not be analyzed due to its very limited operation in the U.S. at this time.
- Due to the limited number of States with suitable data, the analysis of crash rates cannot be extended to other States or used to draw meaningful conclusions on a national basis. This lack of weight data on State crash reports also made it impossible to complete a comparative assessment between trucks operating at and below current Federal size and weight limits and trucks that operate above those limits.
- Vehicle weight information is not consistently reported by the States in the Federal Motor Carrier Safety Administration's Motor Carrier Management Information System (MCMIS), affecting the ability to categorize vehicles appropriately for the study.

Pavement Analysis

- This Study considers only initial service lives predicted by AASHTOWare® Pavement ME Design software, version 2.0, and only for the distresses and pavement types that the software could suitably model. The relative performance of overlaid pavements, which represent a notable portion of pavements, was assumed to be similar to that of newly constructed pavements, because current AASHTOWare® Pavement ME Design software does not accommodate consideration of axle load impacts on overlaid pavement performance.

- Deterioration caused by the interaction of loads and construction deficiencies or decreased materials durability (e.g., deterioration of Hot Mix Asphalt transverse cracks caused by low temperatures, deterioration of concrete pavement “D” cracking) are outside the scope of this study, although these elements can significantly impact the overall performance of pavements.
- The impacts of truck tire types (e.g., wide-based radial) and tire-pavement interaction (e.g., braking, torqueing, and other physical responses) are not considered.
- Local roads were not considered due to general lack of pavement layer and traffic information required as inputs to AASHTO Pavement ME Design ®. There is generally little quantitative information available regarding travel, by facility, on the non-NHS roadway network and on how pavements on the local road system are designed, built, and maintained. These data limitations make it impossible to develop sampling-based approaches that would produce results with adequate statistical confidence.

Bridge Analysis

- Despite literature investigations that were completed, DOT and NAS could not identify a nationally accepted model for analyzing heavy truck/bridge deck interaction and deterioration. No analytical approach or tool quantifying the magnitude of the impact of heavy trucks on bridge decks as a function of axle weight is currently available.
- An extensive literature search was conducted, followed by the identification of a representative sample of bridges. The 490 bridges selected include the 11 most common bridge types from the National Bridge Inventory (NBI) from 11 different States. The sampling size provides a sufficient confidence level for broad conclusions about the overall NBI but not sufficient enough to draw conclusions below the national level.
- Bridge costs are calculated based on assuming strengthening or replacement of all bridges with insufficient load carrying capacity. These are monetized as a one-time total cost to upgrade the entire national inventory for each scenario truck. Loss of service life due to stress and fatigue were only considered qualitatively. One weakness in the research was the inability to account for detour mileage and costs: to do so, it would be necessary to know how the States would prioritize bridge replacement or repairs.
- Local bridges were not considered as the design, construction, and management of local bridges vary greatly given that there are thousands of independent local owners across the Nation with differing practices. Consequently, it is difficult to draw detailed conclusions about the impacts of truck size and weight increases on these facilities.

Compliance and Enforcement Analysis

- The base analysis year for the study was 2011. To capture annual trends in enforcement program costs, the analysis examined data reflecting program resources and activities from 2008 through 2012 inclusive, using the most current and reliable data available.
- While the work focused on truck size and weight enforcement costs, much of the available cost data reflects the allocation of resources for both truck size and weight and commercial vehicle safety enforcement. The costs reported by States reflected resources (e.g., personnel, facilities) directed at truck size and weight enforcement and truck safety enforcement. No attempt has been made to disaggregate costs allocated to these separate programs.
- Definitions of certain data elements may be inconsistently interpreted by States submitting the data.
- Any differences arising from State-to-State comparisons cannot be solely attributed to differences in truck size and weight limits.
- This study analyzed resources directed at enforcing truck size and weight. However, to support the purpose of some study elements, certain aspects of the analysis focused solely on truck weight.
- Vehicles operating under a State-issued permit, including all divisible or non-divisible load movements, were all treated in the same manner.

These limitations were anticipated. The NAS's April 2014 peer review report acknowledged weaknesses in the available methods and data. However, the NAS panel was not able to identify better modeling approaches or data sets that FHWA could use. In addition, the 2000 CTSW Study identified similar insufficiencies. The Department sought the input of the public and subject matter experts, including members of academia in an effort to overcome these limitations and provide expertise and objective analysis. The DOT held several public meetings and webinars to solicit feedback on the data, methodology, and prior work, as well as to share the status of the study effort. In addition, the Department made information on the project plans available on our Web site, and invited comments from the public. Despite these efforts, the researchers could not overcome the data and analytical weaknesses as the study progressed.

Recommendations

At the conclusion of the Technical Reports, the Department believed that the current model and data limitations were so profound that the results could not accurately be extrapolated to confidently predict national impacts. Subsequent public input and peer review has not altered that view. As such, the Department stresses that no changes in the relevant Federal truck size and weight laws and regulations should be made until these limitations are overcome. Despite recent Congressional action approving additional size and weight exceptions and waivers on a piecemeal and nationwide basis, DOT recommends a thoughtful approach to future policy making.

To make a genuine, measurable improvement in the knowledge needed for these study areas, a more robust study effort should start with the design of a research program that can identify the areas, mechanisms, and practices needed to establish new data sets and models to advance the state of practice. This research plan could be developed by an expert panel, perhaps convened by the NAS, and should include a realistic estimation of timelines and costs. Recommended areas of research include the following:

Safety

Truck Weight Data in Crash Databases - A consistent theme in past research on size and weight issues has been the limitations of crash and exposure data. Most crash data systems are inadequate in terms of allowing precise identification of longer or heavier trucks. No State crash data system includes the operating weight of trucks at the time of the crash. The difficulty in studying actual truck weight in crash-based analyses was noted in a Transportation Research Board study (TRB, 2002), which indicated that the safety implications of GVW had been studied in only one prior research effort (Campbell, et al., 1988). The current study also does not analyze individual truck GVWs due to the lack of such data on State crash forms. Protocols and requirements for weight data for individual trucks in crash databases are needed for comparison of trucks at specific weights.

Truck Configuration Data in Crash Data Bases - The lack of data elements in most State crash databases that would identify the configuration of a truck limits crash analysis and the development of crash estimates. Data elements in State crash databases to identify the truck configuration are needed (count of trailers, a count of total axles, and the length of each trailer for combination vehicles involved in crashes).

Weigh-In-Motion (WIM) Coverage – The WIM equipment can be used to collect data on such factors as vehicle and axle weights, axle spacing, speed, and vehicle class. The WIM data was essential for conducting an assessment of crash information among trucks by type and various gross vehicle weights. The WIM data was predominately available for the Interstate System but was very limited for other NHS roadways. The locations of WIM constrained the crash analysis

to rural and urban Interstates. An increase in geographic coverage of vehicle classification count and WIM data are needed.

Longitudinal Barriers - Longitudinal barriers for use in federally funded projects are currently evaluated based on a series of crash tests where the maximum GVW is 80,000 pounds for a tractor-semitrailer combination. An analytical framework and related tools are needed to measure the impacts heavy trucks (trucks weighing more than 80,000 pounds) would have on roadway barriers.

Motor Carrier Management Information System - The truck configurations examined in this study were limited to those available within the MCMIS inspection file. Each inspection included information about the type and number of vehicle units as well as the GVW. Note that the gross combined vehicle weight field is filled in by the field inspector and may include the gross vehicle manufacturers' weight rating, the weight of the load per the bill-of-lading, or an actual measured weight if the truck was weighed at time of inspection. Quality control and assurance of data input by field inspectors in Gross Vehicle/Combination Weight field in the MCMIS is needed.

Compliance and Enforcement

Annual Certifications and State Enforcement Plans - Much of the available cost data reflects the allocation of resources for both truck size and weight and commercial vehicle safety enforcement. The costs reported by States reflect resources (e.g., personnel, facilities) directed at truck size and weight enforcement and truck safety enforcement. Approaches and protocols are needed to identify truck weight enforcement program costs separately from overall truck safety enforcement costs. In addition, requiring data submitted by the States in Annual Certifications and State Enforcement Plans to separate the person-hours or program costs attributed specifically to weighing trucks would be beneficial to future analysis.

Modal Shift

Vehicle Inventory and Use Survey (VIUS) - The VIUS was last conducted in 2002 and was an important source of data on characteristics of the trucking industry and how the trucking fleet was used by different segments of the trucking industry. Key data inputs for truck size and weight policy analysis from the VIUS include average payloads for different commodities and vehicle types, the distribution of vehicle configurations by body type, and the use of different body types to haul specific commodities. Updating and restoring the VIUS should be considered as a Federal initiative. The DOT has attracted the support of multiple Federal agencies to work toward the development and release of a modern VIUS; however, conducting a new VIUS is estimated to cost more than \$10 million. This is currently challenging to program given the numerous data and research needs at the Department. Future efforts to revive VIUS will require the identification of new funding sources.

Intermodal Transportation and Inventory Costing Model - Even with robust data, actual market responses to changes in truck size and weight are difficult to predict. However, a review of the cost minimization logic of modal choice in the ITIC model should be undertaken to determine whether additional variables and/or alternative approaches would better reflect real world mode choice decisions.

Passenger Car Equivalents- The Study uses research findings from previous simulation studies on calculating Passenger Car Equivalents (PCE). Since the previous research was done before the publication of a systematic framework on simulation applications as included in the FHWA Traffic Analysis Toolbox series, more research on truck PCE is desired to model different truck combinations in a systematic manner consistent with the new guidance. Systematic research assessing PCE values for different truck configurations should be conducted.

Short Line Railroads - There are around 560 Short Line Railroads operating in the U.S. Together these railroads originate or terminate about 18 percent of Class I carload freight (around 6.5 million carloads) annually and generate around \$4 billion in revenues. While commodity makeup on these carriers is diverse, they principally serve rural communities and provide the rail link for these areas to the Class I railroad network. Certain alternative truck configurations could have noticeable impact on Short Line Railroads. Research is recommended to construct a framework for modeling modal shift impacts of changes in truck size and weight on Regional and Short Line Railroads.

FAF – The FAF provides a comprehensive national picture of freight flows and a baseline forecast to support policy studies. The FAF indicates to States and regions their major trading partners and the volumes and sources of through traffic at the corridor level. Policy analysis requires supplemental models to make forecasts sensitive to cost and other variables. In the case of truck size and weight studies, disaggregation to a more granular level than originally intended, such as the county level, and the ability to flow goods across a multimodal network is required. Research should be conducted on how to enhance the capabilities of the FAF while maintaining data integrity and confidence.

Truck Rate Survey – Understanding truck rates and costs across various trade lanes and commodities is a fundamental input to modal shift analysis. The lack of comprehensive and current rates inhibits some aspects of analysis. Developing a framework and process for frequent collection of truck rate data should be undertaken.

Bridge

Bridge Damage Cost Allocation Methodology - There is no generally accepted and applied approach for measuring the cost effects of heavy vehicles on bridges on a national scale. Bridge Decks are the most visible component of the bridge to the traveling public and one of the most important elements of bridges in terms of maintenance repairs, rehabilitation, and replacement. A methodology for bridge damage cost allocation and bridge deterioration by truck class is

needed. Research is needed to develop an approach or tool to assess the impact of truck configuration and weight limit changes on concrete bridge decks based on an analytical approach described in Technical Report.

Long-Term Bridge Performance Program (LTBPP) - The importance of FHWA's LTBPP Long-Term Bridge Performance Program (LTBP) in developing the data needed to build a bridge deck deterioration modeling capacity is evident. The LTBPP is in the process of collecting a significant amount of data useful in understanding bridge deck performance and heavy vehicle interactions. Over time, FHWA's data-driven LTBPP will generate the data and establish a stronger understanding of relationship between heavy truck/concrete bridge deck interactions. Such knowledge and data are essential in developing the modeling framework for estimating bridge annual maintenance costs and the relationship to loads. An example of advancements developed under the LTBPP to understand bridge deck performance is the RABIT™ bridge deck assessment tool. The tool collects a wide range of data simultaneously—high-resolution photographic, electromagnetic, seismic, and electrical—on external and internal bridge deck conditions. Continuing efforts like this as part of the LTBPP bridge deck performance data collection is recommended.

In its second Peer Report, TRB suggested that the accuracy of impact assessment on bridge load carrying capacity evaluation could be improved if an expanded sampling of bridges were selected and analyzed to consider all 50 State DOTs, Puerto Rico and the District of Columbia with sufficient sampling size in each bridge type. For its Long Term Bridge Performance Program, the Department had already selected 14 bridge clusters and 4 separate corridors to collect performance data; these clusters and corridors were selected with input from its independent external advisory panel, to be representative of the most common bridge types and climatic conditions and represent a sound sampling framework for this Study.

Local Bridges - An assessment of structural impacts that the alternative configuration vehicles would have on bridges located on non-Interstate System or non-NHS roadways would not likely differ from the results produced and presented in this Report. Generally, local bridges feature shorter span lengths than bridges located on higher functionally classified roadway networks. However, the design, construction, and management of local bridges are highly variable considering that there are thousands of independent local owners across the Nation with differing practices, making it difficult to draw detailed conclusions about impacts. Development of methodology and an analysis of the impacts that changes in Federal truck size and weight limits would have on local bridges are needed.

Pavement

Pavement Performance Prediction Methodology Design - American Association of State Highway and Transportation Officials (AASHTO) AASHTOWare Pavement ME Design® software was used for pavement analysis in this study. The Pavement ME Design® software is

the tool based on the M-EPDG procedure that was adopted by AASHTO in 2007. The M-EPDG directly applies an axle load spectra to calculate the amount of damage produced by the estimated range of traffic loads. Further development and refinement of AASHTOWare Pavement ME Design® is needed to enhance pavement performance modeling capability.

Composite (Overlay) Pavement Analysis - The current AASHTOWare Pavement ME Design® models only allow for analysis of load impacts on pavements without overlays. For this reason, the Study could not do scenario impacts on overlaid pavements. Development of more advanced modeling capability suited to estimate the impact of varying axle loads on performance of composite (overlay) pavement types is needed.

Local Roads - The Study focused on Interstate and NHS highways, since they carry the most truck traffic. However, there is a higher percentage of county-, city-, and municipal-owned roads in the United States than the higher classification roadway networks where most of the truck VMT occurs. Yet in most cases there is little quantitative information on how these local road pavements are designed, built, and maintained. There is minimal to no history of Highway Performance Monitoring System data from local roads and hard data on how many trucks and how often they are using the lower-order facilities is in many cases not readily available.

In order to better investigate, at a minimum, the qualitative impacts that changes in federal truck size and weight limits would have on local roadway networks could start by gathering information on existing pavement sections located on reasonable access routes used by commercial motor vehicles to access terminals, fuel, food, and rest. The information could include pavement design standards, construction specification details, maintenance frequency and treatment types, materials properties of the pavements and underlying soils, and the traffic volume and distribution on lower-order facilities. It would be particularly beneficial to quantify the truck traffic volumes, truck type distributions (classes), and truck traffic variations (seasonally, hourly, monthly, etc.) as a basis for comparison of the effects of introducing any of the six alternative configuration scenarios that were part of the Study.

Conclusion

In many ways, this study produced more questions than it sought to answer. Another study effort, with more time and more money, would not at this point yield more reliable results. To make a genuine, measurable improvement in the knowledge needed for these study areas, a more robust study effort should start with the design of a research program that can establish data sources and models to advance the state of practice. Not all of this is within the purview or capacity of DOT. Even recent gains in long term reauthorization of transportation programs does not sufficiently advance the state of research and data to enable us to say when or even whether

we will be in a position to collect and analyze better data and apply it to improved policy determinations and regulatory strategies.

Changes made by Congress regarding the size and weight of vehicles allowed on the Nation's Interstate System are matters of policy. The work performed and the findings produced in this study can inform the debate on these matters but do not provide definitive evidence or direction to support any specific new change of direction in the areas of truck size and weight limitations. This work has helped identify the areas in which we are reminded that we need to know more, and that new technologies for data collection and sharing can offer us improved mechanisms for growing that knowledge.