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Review of U.S. Department of Transportation Truck Size and Weight Study

First Report: Review of Desk Scans

Contents:

Transportation Research Board
National Research Council
Washington, DC
March 31, 2014

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Review of U.S. Department of Transportation Truck Size and Weight Study

First Report: Review of Desk Scans

SUMMARY

The U.S. Department of Transportation (USDOT) asked the Transportation Research Board to convene a committee to review the study of truck size and weight limits that the 2012 surface transportation authorization statute requires USDOT to carry out. This first report of the committee reviews five preliminary products of the study, called desk scans, which are surveys of past research and analysis methods for estimating the effects of changes in truck size and weight limits in each of five areas: bridges, pavements, truck and rail shares of freight traffic, safety, and enforcement of truck regulations. The principal conclusions of the committee's review are as follows:

- The desk scans were the appropriate initial task of the USDOT study in that they allow the study to build on a series of past major truck size and weight studies and to take advantage of advances in modeling of infrastructure performance and freight markets.
- The desk scans provide necessary documentation of the resources needed to support the analysis methods chosen for the USDOT study. However, in most cases the selection of methods appears not to have been a consequence of the desk scans; that is, the scans were not on the critical path of the study. The constrained schedule imposed by the congressional study charge may have precluded a more systematic approach to evaluation and selection of methods. Nevertheless, even in cases where the best practical method is evident, comparisons with alternatives are advisable in order to demonstrate the superiority of the method selected.
- To derive full value from past work, each desk scan would contain three elements: (*a*) a survey of analysis methods and synthesis of the state of the art of modeling the impact, (*b*) identification of data needs and critique of available data sources, and (*c*) a synthesis of quantitative results of past analyses.

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None of the desk scans fully provides all three of these elements.

- The comparison of alternative methods in the safety project plan (another USDOT study document) is a model of a methods synthesis, except for the absence of citations of examples of the use of each method. The enforcement desk scan is a model for systematic summary of results of past studies. The enforcement desk scan, which specifies in its introductory section the scope and objectives of the estimates and analyses in the impact area, also is a model for the organization of the other desk scans.

The committee recommends that USDOT continue the work begun in the desk scans by including two kinds of synthesis in its final report: first, a synthesis of experience in applying alternative methods of estimating each category of effect of changes in truck characteristics, leading to an assessment of the current state of understanding of the impact and needs for future research, data collection, and evaluation; and second, a critical synthesis of quantitative results of past prospective and retrospective estimates of each category of effect. The report should explain the sources of the differences between the new USDOT estimates and those of past studies. Differences in the estimates may arise from differences in the environment (e.g., traffic volumes or infrastructure conditions), in the policy options analyzed, or in data and analysis methods.

In none of the five major analysis areas of the USDOT study was the committee able to identify modeling approaches or data sources omitted from the desk scans that would be clearly superior to those selected by the USDOT study team (according to the descriptions of proposed analyses in the project plans) and that would be available for use within the congressionally imposed study deadline. 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 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 the regulatory change. For these reasons, the 2002 Transportation Research Board committee that reviewed past truck size and weight studies concluded that "it is not possible to predict the outcomes of regulatory changes with high confidence" (TRB 2002, 3).

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The desk scans do not show that this shortcoming of such studies has been greatly reduced. The recommended syntheses would be a means of conveying the uncertainties in the USDOT report.

The reviews below of each of the desk scans identify specific resources not cited in the scans that the committee recommends USDOT consult and specific topics for syntheses.

Reference

Abbreviation
TRB Transportation Research Board

TRB. 2002. *Special Report 267: Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles.* National Academies, Washington, D.C.

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INTRODUCTION

Section 32801 of the 2012 surface transportation authorization statute, Moving Ahead for Progress in the 21st Century (MAP-21), calls for the U.S. Department of Transportation (USDOT) to conduct a comprehensive truck size and weight limits (CTSW) study. The law requires the study to examine the effects of operation of large trucks in terms of impacts on bridges, pavements, safety, fuel efficiency, the environment, enforcement of truck regulations, and shares of freight traffic carried by trucks and other freight modes. The MAP-21 study charge to USDOT is included as Appendix A of this report.

USDOT asked the Transportation Research Board (TRB) to provide a peer review of the CTSW study. To conduct the review, TRB convened a committee that includes members with expertise in highway safety, vehicle dynamics, freight modal shift, bridge and structural analysis, pavement design, and highway safety enforcement. Members' biographies appear at the end of this report.

The committee is to deliver its review in two reports. This first report reviews desk scans (literature reviews) prepared by USDOT in each of the technical areas of the CTSW study with respect to their thoroughness in covering the literature, analysis of models and data for conducting the comprehensive study, and overall synthesis of the preceding body of work as it applies to the study that is to follow. Once USDOT has completed the technical analysis for the study in spring 2014, the committee will prepare its second report, which will comment on the extent to which the technical analysis and findings address the issues identified by Congress. Appendix B contains the committee's task statement.

The committee examined 10 documents provided by USDOT (USDOT 2013a–2013j): desk scans and project plans for each of five categories of impacts of changes in federal truck size and weight limits: effects on bridges, pavements, safety, enforcement of truck regulations, and shares of total freight traffic carried by trucks and other freight modes. [The modal shift desk scan (USDOT 2013c) and project plan (USDOT 2013h) address environmental impacts and energy efficiency as well as mode shift.] In addition, at a public meeting of the committee on December 5, 2013, USDOT staff presented summaries of the desk scans and project plans and responded to questions from the committee. That meeting was open to

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the public and included opportunity for public comment to the committee on its task. Appendix C acknowledges public comments received on the study. This report was subject to an independent review according to the procedures of the National Research Council, as described in Appendix D.

The desk scans describe methods and results of past studies of effects of changes in truck size and weight limits and models and data sources useful for these analyses. The project plans outline the methods to be used in the CTSW study to estimate each category of impact. As the committee's task statement specifies, this report reviews the desk scans. The committee had to understand the project plans to judge whether the desk scans were providing adequate support for the intended analyses. This report includes observations on whether the coverage of the scans is consistent with the requirements of the project plans.

USDOT faces significant time and resource constraints in completing the CTSW study. The final contractor study team was selected in 2013, technical analyses are to be completed in spring 2014, and the study report is to be delivered to Congress by November 2014. However, the USDOT study team asked that the TRB committee not refrain from noting gaps or other shortcomings in the technical analyses even if they appear justified in light of the study schedule. USDOT staff also informed the committee that, in consideration of the constraints on the present study, the USDOT report may indicate directions for improvement in future analysis of impacts of size and weight regulations. Consistent with this USDOT study goal, some of the committee's comments may propose actions that are not feasible in the present study but that might be applied in later analyses.

The next section of this report presents comments that apply to the desk scans in general. The following five sections present comments on each of the desk scans: bridges, pavement, modal shift, safety, and enforcement. The comments on each of the topical desk scans respond to the following questions, which are derived from the committee's task statement:

- Is the desk scan thorough?
- Is it missing literature, case studies, models, or data that would help achieve the study goals?

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- Does it interpret the literature reviewed correctly?
- Does it synthesize the literature and draw appropriate conclusions?

The committee intends its review to help USDOT in meeting the congressional study charge and in producing a technical analysis that is useful to the public as a source of information on the consequences of truck size and weight regulation.

References

Abbreviation
USDOT U.S. Department of Transportation

USDOT. 2013a. *Bridge Structure Comparative Analysis: Final Draft Desk Scan.* Nov.

USDOT. 2013b. *Pavement Comparative Analysis: Final Draft Desk Scan.* Nov.

USDOT. 2013c. *Modal Shift Analysis: Final Draft Desk Scan.* Nov.

USDOT. 2013d. *Highway Safety and Truck Crash Comparative Analysis: Final Draft Desk Scan.* Nov.

USDOT. 2013e. *Enforcement and Compliance Comparative Analysis: Final Draft Desk Scan.* Nov.

USDOT. 2013f. *Bridge Structure Comparative Analysis: Final Draft Project Plan/Schedule.* Nov.

USDOT. 2013g. *Pavement Comparative Analysis: Final Draft Project Plan/Schedule.* Nov.

USDOT. 2013h. *Modal Shift Analysis: Final Draft Project Plan/Schedule.* Nov.

USDOT. 2013i. *Highway Safety and Truck Crash Comparative Analysis: Final Draft Project Plan/Schedule.* Nov.

USDOT. 2013j. *Compliance Comparative Analysis: Final Draft Project Plan/Schedule.* Nov.

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GENERAL OBSERVATIONS

USDOT (2013) describes the content and purpose of the desk scans as follows:

> As part of the MAP-21 Comprehensive Truck Size & Weight Limits Study, FHWA [the Federal Highway Administration] has undertaken a series of Desk Scans focused on completed work in areas related to the Study to inform the project plans and technical analysis. These Desk Scans cover the study areas of Bridge, Compliance, Modal Shift, Pavement and Safety. The Desk Scans describe research completed, methods and techniques employed in other research initiatives, and the findings resulting from this research.

Several of the desk scans provide useful documentation of resources that will be valuable in the CTSW study. However, as a whole, the scans represent a missed opportunity. Two elements that are incomplete in most of the desk scans would have been most useful in conducting the CTSW study: (*a*) identification of alternative methods, tools, and data for estimating impacts of changes in size and weight regulations that might have been applicable in the 2014 study or in future USDOT evaluations of these regulations and (*b*) syntheses of past studies that indicate reasonable ranges of values for impact estimates and allow comparison of the 2014 study's estimates with those of past studies.

In most cases, the desk scans do not appear to have been instrumental in developing the study team's analysis plans but rather to have been prepared after the plans had been decided on. The desk scans primarily contain lists of studies and other information sources with capsule summaries. The basis for selection of sources is sometimes unclear, and as the documents acknowledge, many of the listed sources are not relevant to the CTSW study. References to the primary research literature are nearly absent in most of the desk scans, so any innovative analysis methods appearing there would have been overlooked. The description in the safety project plan of alternative methods of estimating the safety performance of the configurations considered in the study, citing methods used in past studies, could be a model for

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comparisons of methods in the desk scans for each of the impact areas.

This outcome of the desk scans may have been inevitable, given the compressed time span of the study, which would have necessitated early selection of analysis methods. If an ongoing federal program of monitoring and evaluation of trucking regulations, as recommended by the 2002 TRB truck size and weight study (TRB 2002, 6), had been in place, the priorities and analysis alternatives for the 2014 study could have been established at the outset.

In addition to the comparison of alternative methods, to take full advantage of past studies, each desk scan would need to include an analytical synthesis of quantitative results of past evaluations of size and weight regulations. Such syntheses would serve two functions:

- They would set priorities for the use of resources in the USDOT study by establishing what is already known about impacts of changes in size and weight regulation and by indicating which uncertainties critically hinder decision making on the regulations.
- They would provide context for the impact estimates of the present study by affording comparisons with estimates of past studies by USDOT, TRB, the states, and others. If USDOT's estimates differ from those of past studies, the sources of the differences will need to be explained—whether they arise from differences in the environment (e.g., traffic volumes or infrastructure conditions), in the policy options analyzed, or in data and analysis methods.

Examples of simple tabular comparisons of results of past truck size and weight studies are the summaries of estimates of bridge costs and traffic delay costs in the TRB 2002 truck size and weight study (TRB 2002, 61, 89) and comparisons of estimates of change in truck vehicle miles traveled and fuel consumption in a National Research Council study of truck fuel efficiency (NRC 2010, 156). A more analytical tabular comparison attempted to rank studies of multitrailer vehicle crash rates according to data quality and appropriateness of methodology (TRB 1986, 322–323).

In addition to the desk scans and project plans devoted to the five individual impact areas, an

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overall or crosscutting desk scan and plan for the CTSW study are needed to ensure that the work is coordinated and to allow interested parties to understand the structure of the study. The crosscutting desk scan would review how alternative vehicle types and regulatory scenarios were defined in past studies, what categories of impacts of the regulations were considered, and how the estimates of disparate impacts were integrated in a comprehensive analysis. The crosscutting desk scan also would identify and assess data sources needed in multiple analyses in the CTSW study to ensure that they are used consistently. For example, weigh-in-motion (WIM) data are needed in the bridge, pavement, modal shift, and enforcement analyses. None of the desk scans contains a complete discussion of WIM data quality issues relevant to the study or of the accuracy of weight data required for each of the study analyses. The experience of the Long-Term Pavement Performance study in the use of WIM data for research purposes (Walker and Cebon 2011) should be helpful in the CTSW study.

References

Abbreviations

NRC	National Research Council
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

NRC. 2010. *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*. National Academies, Washington, D.C.

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

TRB. 2002. *Special Report 267: Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles.* National Academies, Washington, D.C.

USDOT. 2013. Comprehensive Truck Size & Weight Limits Study Draft Desk Scans. Modified Dec. 17. http://www.ops.fhwa.dot.gov/freight/sw/map21tswstudy/deskscan/index.htm.

Walker, D., and D. Cebon. 2011. The Metamorphosis of Long-Term Pavement Performance Traffic Data. *TR News*, No. 277, Nov.–Dec., pp. 9–17.

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BRIDGE STRUCTURE

The MAP-21 Section 32801 charge to USDOT for the CTSW study contains three references to infrastructure or bridge impacts:

Sec. 32801(a)(2): [The study shall:]

(2) evaluate the impacts to the infrastructure in each State that allows a vehicle to operate with size and weight limits that are in excess of the Federal law and regulations, or to operate under a Federal exemption or grandfather right, in comparison to vehicles that do not operate in excess of Federal law and regulations (other than vehicles with exemptions or grandfather rights), including—

(A) the cost and benefits of the impacts in dollars;

(B) the percentage of trucks operating in excess of the Federal size and weight limits; and

(C) the ability of each State to recover the cost for the impacts, or the benefits incurred. . . .

Sec. 32801(a)(4): [The study shall:]

(4) assess the impacts that vehicles that operate with size and weight limits in excess of the Federal law and regulations, or that operate under a Federal exemption or grandfather right, in comparison to vehicles that do not operate in excess of Federal law and regulations (other than vehicles with exemptions or grandfather rights), have on bridges, including the impacts resulting from the number of bridge loadings. . . .

Sec. 32801(a)(6)(B): [The study shall estimate:]

(B) the effect that any such diversion [from other modes to highways if alternative configurations were allowed to operate] would have on public safety, infrastructure, cost responsibilities, fuel efficiency, freight transportation costs, and the environment. . . .

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The committee understands that the bridge desk scan was to identify resources pertaining to estimating the consequences of allowing operation of vehicles (including those already in legal operation in certain states or the alternative configurations specified in MAP-21 Section 32801) exceeding present federal size and weight limits that arise from the effect of these vehicles on bridges. Changing size and weight limits changes the loads that individual vehicles impose on bridges and changes the volume and distribution of truck traffic over the road system. Highway agencies may respond by changing practices for design, construction, retrofitting, maintenance, and posting of bridges. The ultimate consequences are changes in highway agency costs to provide highways and in highway user costs and benefits.

Is the Desk Scan Thorough?

The desk scan covers physical effects of traffic on bridges (deck deterioration and management, fatigue, bridge structure deterioration models, cost allocation methods); owners' (state and local governments') bridge management practices that determine how owners would respond to changes in truck characteristics or to observed changes in bridge conditions; highway cost allocation studies of states and other countries, with a focus on bridge costs assigned to trucks in these studies; data sources; and models of how freight mode shift and changes in truck weight limits affect axle load distributions.

The desk scan does not include a comparative evaluation of alternative methods of assessing bridge costs of changes in size and weight limits. This omission is especially unfortunate if the conclusion of the committee that conducted the 2002 TRB truck size and weight study (TRB 2002, 3) that "the methods used in past studies have not produced satisfactory estimates of the effect of changes in truck weights on bridge costs" is accepted. The references selected for inclusion in the bibliography appear to be primarily those that are necessary to support a predetermined plan of analysis for the CTSW study.

The desk scan does not review the results of past studies of the effects of changes in truck traffic on bridges. Instead, the focus is on methods of analysis and sources of data. One comparison of results

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that would be especially helpful in the CTSW bridge analysis would be a summary of how past studies have presented the financial impact of changes in size and weight limits on state highway programs over time. Changing limits creates a need for a stream of future capital spending to compensate for the change in useful life of existing bridges and the change in the cost of construction of new bridges. The financial impact would be reported as an increase in resources needed by bridge owners in the next year and in 2 years, 5 years, 10 years, and so forth. The principal risk of changes in limits is that bridge inventories will decay more rapidly than expected without a corresponding increase in funding.

The desk scan does not identify resources for carrying out each of the MAP-21 required analyses related to bridges in the CTSW study. Estimates of the costs to the public of the bridge impacts of changes in truck traffic (e.g., costs of traffic disturbance of bridge closings and bridge construction) and assessment of the owners' abilities to recover their costs are presumably being carried out in other tasks of the CTSW study; methods of conducting such estimates are not discussed in the bridge desk scan (although some of the references cited may contain estimates of these costs).

The desk scan does not identify methods or data sources to support estimates of the impacts of changes in limits on bridge barriers, median barriers, or railings. Size and weight limit changes may necessitate changes in safety hardware standards, which would affect the costs of all categories of road construction and reconstruction. On some bridges, the strength of the deck overhang limits the upgrading of safety hardware. Information sources are needed to support estimates of impacts of changes in size and weight limits on design and maintenance of barriers, railings, and other appurtenances, not only on bridges but also on all roads. (Section 7.0 of the safety desk scan cites studies of the compatibility of barriers with vehicles of larger sizes and weights.)

The desk scan describes a 2010 truck size and weight study conducted for the District of Columbia Department of Transportation (DCDOT) as (p. 18) "a basis of this study." The DCDOT study is unpublished, and the absence of a summary of it in the desk scan appears to be a significant omission.

The desk scan should cite all major data sources that may be used in the CTSW bridge analysis and describe potential shortcomings of the data. Potential data difficulties include the following:

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- According to the project plan, the CTSW study team will obtain the AASHTOWare Bridge Rating (ABrR) program files from states already using this software. Finding ABrR models of older bridges may be difficult. The pool of available bridge files may be weighted toward bridges with odd configurations, noted deterioration, or some other abnormality.
- According to the project plan, costs in the bridge analysis would be from FHWA's Financial Management Information System (FMIS). However, FMIS is based on project costs. A project may include multiple bridges and elements other than bridges. A method for extracting the bridge-related costs attributable to the change in size and weight limits from the data is required. At least, the desk scan should describe FMIS and cite previous similar applications of the data. The desk scan should identify the National Bridge Inventory database as an alternative or complementary source of cost data.
- The bridge analysis relies on WIM data. The desk scan should identify the WIM data to be used and describe the shortcomings of the data for the purposes of the bridge analysis.

Is the Desk Scan Missing Literature, Case Studies, Models, or Data That Would Help Achieve the Study Goals?

Necessary or potentially useful resources not identified in the desk scan include the following:

- The American Association of State Highway and Transportation Officials (AASHTO) load and resistance factor design (LRFD) bridge design specifications (AASHTO 2012) would be helpful.
- *Special Report 225: Truck Weight Limits: Issues and Options* (TRB 1990a) and *Special Report 227: New Trucks for Greater Productivity and Less Road Wear: An Evaluation of the Turner Proposal* (TRB 1990b) provide additional examples of methods and results of estimating the effects of changes

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in size and weight limits on bridge costs.

- Past studies of the implementation of federal Bridge Formula B (e.g., TRB 1990a) may provide useful information.
- Studies in the area of structural health monitoring of bridge decks may be useful. Estimates of the effects of limits on deck deterioration should be a major aspect of the CTSW study. The desk scan lacks in-depth review of studies of causes of deck deterioration, deck deterioration modeling, and deck deterioration quantification. The relevance to the CTSW study of some of the references on decks cited in Section 3.3 of the desk scan is unclear.
- Coverage of studies related to the service limit state in more depth would be useful [e.g., *Evaluation of Serviceability Requirements for Load Rating Prestressed Concrete Bridges* (Wood et al. 2007)].
- The review of studies of fatigue life is insufficient. A single reference is cited, from Sweden. Most of the studies cited in Section 3.6 of the desk scan appear to focus on fatigue vulnerability and not on the change in fatigue life due to increased truck loads. Potentially useful studies are those of Fisher et al. (1983), Hoadley et al. (1983), Cohen et al. (2003), Reisert and Bowman (2006), and Bowman et al. (2012).
- The attention to methods and results of past estimates of shear effects is insufficient. Article 6A.5.8 of the first reference listed in the desk scan, *Manual for Bridge Evaluation* (2nd edition, 2013), states the following: “The shear capacity of existing reinforced and prestressed concrete bridge members should be evaluated for permit loads. . . .”
- The resources cited in Section 3.8.2, Cost Allocation Study Methods and Methodology, appear insufficient for carrying out the determination of load-related cost (except in the case of decks) as described in Section 1.3.2.1 of the bridge project plan.

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Does the Desk Scan Interpret the Literature Reviewed Correctly?

Two interpretations of studies cited in the desk scan would be worth reconsidering. First, the desk scan states (p. 4) that *NCHRP Report 575: Legal Truck Loads and AASHTO Legal Loads for Posting* "goes to the heart of the Comprehensive Truck Size and Weight Limits Study . . . as it relates to structural impacts on bridges and load postings." Rating factors are an indication of whether a bridge needs to be posted. The outcome associated with the increased magnitude of stresses related to each alternative vehicle needs to be measured and compared with acceptable stress levels. Degradation is generally associated with the service limit state, as defined in the *AASHTO LRFD Bridge Design Specifications* (AASHTO 2012).

Second, the desk scan appears to indicate (p. 22) that the CTSW study will place little reliance on *NCHRP Report 495: Effect of Truck Weight on Bridge Network Costs*. The review characterizes it as "a 'state' tool," but apparently the methods therein could be used on any set of bridges, including local and rural bridges. The NCHRP report provides an alternative, stress-based approach to some of the analysis methods proposed in the bridge project plan. The desk scan should include a comparison of these alternatives.

Does the Desk Scan Synthesize the Literature and Draw Appropriate Conclusions?

The bridge desk scan lacks syntheses of analysis methods or of results of past estimates concerning the effects of changes in size and weight limits.

References

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
TRB	Transportation Research Board

AASHTO. 2012. *AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, 6th Edition, with*

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2013 Interim Revisions. Washington, D.C.

Bowman, M. D., G. Fu, Y. E. Zhou, R. J. Connor, and A. A. Godbole. 2012. *NCHRP Report 721: Fatigue Evaluation of Steel Bridges.* Transportation Research Board of the National Academies, Washington, D.C.

Cohen, H., G. Fu, W. Dekelbab, and F. Moses. 2003. Predicting Truck Load Spectra Under Weight Limit Changes and Its Application to Steel Bridge Fatigue Assessment. *Journal of Bridge Engineering*, Vol. 8, No. 5, pp. 312–322.

Fisher, J. W., D. R. Mertz, and A. Zhong. 1983. *Steel Bridge Members Under Variable Amplitude, Long Life Fatigue Loading.* Final report draft. Lehigh University, Bethlehem, Pa. http://preserve.lehigh.edu/engr-civil-environmental-fritz-lab-reports/2246.

Hoadley, P., K. Frank, and J. Yura. 1983. *Estimation of the Fatigue Life of a Test Bridge from Traffic Data.* Research Report 247-4. Center for Transportation Research, University of Texas at Austin.

Reisert, J. A., and M. D. Bowman. 2006. *Fatigue of Older Bridges in Northern Indiana due to Overweight and Oversized Loads, Volume 1: Bridge and Weigh-in-Motion Measurements.* Publication FHWA/IN/JTRP-2005/16-1. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University.

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

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

TRB. 2002. *Special Report 267: Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles*. National Academies, Washington, D.C.

Wood, S. L., M. J. Hagenberger, B. E. Heller, and P. J. Wagener. 2007. *Evaluation of Serviceability Requirements for Load Rating Prestressed Concrete Bridges.* Texas Department of Transportation, Jan.

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PAVEMENT

The MAP-21 [Section 32801(a)] specification for the CTSW study pavement shift analysis asks the study to

> (2) evaluate the impacts to the infrastructure in each State that allows a vehicle to operate with size and weight limits that are in excess of the Federal law and regulations, or to operate under a Federal exemption or grandfather right, in comparison to vehicles that do not operate in excess of Federal law and regulations (other than vehicles with exemptions or grandfather rights), including—
>
> (A) the cost and benefits of the impacts in dollars;
>
> (B) the percentage of trucks operating in excess of the Federal size and weight limits; and
>
> (C) the ability of each State to recover the cost for the impacts, or the benefits incurred. . . .
>
> (5) compare and contrast the potential safety and infrastructure impacts of the current Federal law and regulations regarding truck size and weight limits in relation to—
>
> (A) six-axle and other alternative configurations of tractor-trailers. . . .

The committee reviewed the pavement analysis desk scan to determine whether it identified the past evaluations, models, and data most relevant to the MAP-21 charge.

Is the Desk Scan Thorough?

More systematic reviews of the following topics would have been useful to the CTSW study in reinforcing the credibility of the study's estimates and in ensuring that more valid methods were not overlooked:

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- Alternative cost estimating methods: According to the pavement analysis project plan, the CTSW study team is using FHWA's RealCost software to relate performance measures to impacts on pavement cost. The desk scan does not cite this model. In view of the sensitivity analysis capabilities of the tool, this can be an appropriate method with the proper inputs. However, justifying this choice for use in the analysis would require a comparison of alternatives.
- Data issues: A review of sources of required data, including those to be used and any alternatives, that identifies shortcomings for the intended application is necessary for understanding the reliability of impact estimates. Long-Term Pavement Performance (LTPP study data were used to calibrate the national pavement model to be used, but state departments of transportation have performed local calibrations with local data that apparently are not being considered. The pavement analysis project plan states (p. 1) that "to the extent possible, [LTPP Program] sections will be used as a basis for each sample section" in the pavement analysis. However, many LTPP sections are more than 20 years old or were special test sections, and therefore they may not be typical of current practices.

  The pavement project plan (p. 2) cites state-conducted instrumented pavement studies in Pennsylvania and Minnesota that may be sources of data. The desk scan does not cite documentation of these studies. Also, the project plan refers (pp. 8–9) to computer programs developed in past studies for compiling WIM data in formats needed in the pavement impact analysis. The desk scan should cite and describe these programs.
- Alternative pavement models: The review should present alternative models, cite research showing the development and application of each model, and discuss the pros and cons of each model. The committee agrees that the selected model [AASHTOWare Pavement ME (Mechanistic–Empirical) Design] is the best available; however, the desk scan should identify its known drawbacks and limitations (related to how it models contact pressure, load shape, and contact stress uniformity; limitations of two-dimensional modeling; and elastic material assumptions) and should conclude with the justification for the specific model selected.

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- Grandfather states: The desk plan scan touches on the MAP-21 requirement for evaluating the "impacts to the infrastructure in each state" that allows vehicles "in excess of Federal law and regulations" in comparison with other states but does not indicate resources (data and models) for addressing it.

The desk scan does not organize the studies reviewed in a logical scheme. To be most useful, a literature review should be organized topically; alphabetical listing of references is inappropriate for the purpose. Summaries of studies judged to be irrelevant should be excluded or confined to an appendix.

Is the Desk Scan Missing Literature, Case Studies, Models, or Data That Would Help Achieve the Study Goals?

Research to improve the models to be used in the study, especially as related to rutting and cracking in asphalt, is ongoing. Results will not be available in time for the CTSW study, but the research should be cited to indicate the limitations of the present model and the prospects for improved analysis of impacts of truck size and weight limit changes in the future. Relevant research related to the limitations of the AASHTO model includes that of Lytton et al. (2010) and Schwartz et al. (2011). Research in progress includes NCHRP Project 01-51, A Model for Incorporating Slab/Underlying Layer Interaction into the MEPDG Concrete Pavement Analysis Procedures, and NCHRP Project 01-52, A Mechanistic–Empirical Model for Top–Down Cracking of Asphalt Pavement Layers.

Does the Desk Scan Interpret the Literature Reviewed Correctly?

As noted above, the committee agrees that the selected methods are the best available.

More than one-third of the scan document is related to wide-tire research. Such research could be important if the model selected captured the effect of tire size and configuration type. However, the model

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to be used is unable to quantify tire impact. Perhaps the desk scan of tire research led to a conclusion that effects related to tire characteristics could be ignored in the study; if this is the case, the desk scan should explain the rationale. The relationship between tire characteristics and pavement impact is of much interest currently.

Does the Desk Scan Synthesize the Literature and Draw Appropriate Conclusions?

The synthesis of past studies in the Concluding Summary (pp. 29–30) is cursory. Two kinds of synthesis are needed for the CTSW study: first, a synthesis of experience in applying alternative methods of estimating effects of changes in traffic on pavement condition and costs, in terms of validity and applicability, that leads to an assessment of the state of the art; and second, a synthesis of quantitative results of past prospective and retrospective estimates of the effects of changes in truck size and weight limits on pavements. A synthesis of quantitative estimates would have revealed the relative importance of pavement effects compared with other effects of changes in size and weight limits and would have indicated the degree of uncertainty in the pavement impact estimates.

The main conclusion of the desk scan is that the AASHTOWare Pavement ME Design is the most appropriate model for use in the CTSW study. This conclusion is reasonable. The model should provide satisfactory estimates of pavement impacts of projected changes in axle weights and traffic volumes, provided that the selection of sample pavements is not biased. The desk scan should provide stronger support for this choice by including consideration of other models.

The desk scan states (p. 12) that the method of studies by Timm, Turochy, and Peters and by Timm and Peters will be used as a backup approach in the CTSW study if the primary approach encounters difficulties, but the Concluding Summary (p. 29) states that "it is not yet clear that this [backup] approach will be workable in the study."

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References

Lytton, R. L., F.-L. Tsai, S. I. Lee, R. Luo, S. Hu, and F. Zhou. 2010. *NCHRP Report 669: Models for Predicting Reflection Cracking of Hot-Mix Asphalt Overlays.* Transportation Research Board of the National Academies, Washington, D.C.

Schwartz, C. W., R. Li, S. H. Kim, H. Ceylan, and K. Gopalakrishnan. 2011. *Sensitivity Evaluation of MEPDG Performance Prediction.* NCHRP Project 01-47. Dec. http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP01-47_FR.pdf.

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MODAL SHIFT

The MAP-21 [Section 32801(a)(6)] specification for the CTSW study modal shift analysis asks the study to estimate the following:

> (A) the extent to which freight would likely be diverted from other surface transportation modes to principal arterial routes and National Highway System intermodal connectors if alternative truck configuration is allowed to operate and the effect that any such diversion would have on other modes of transportation;
> (B) the effect that any such diversion would have on public safety, infrastructure, cost responsibilities, fuel efficiency, freight transportation costs, and the environment;
> (C) the effect on the transportation network of the United States that allowing alternative truck configuration to operate would have; and
> (D) whether allowing alternative truck configuration to operate would result in an increase or decrease in the total number of trucks operating on principal arterial routes and National Highway System intermodal connectors.

The modal shift analysis may be described as the most critical element of the CTSW study, because the magnitudes of all other effects of changes in size and weight limits depend on the changes in truck traffic. The committee's review of the modal shift desk scan in light of the MAP-21 requirements led to the following observations.

Is the Desk Scan Thorough?

The desk scan is thorough in identifying past public-sector studies that included prospective estimates of the effects of changing truck size and weight limits on mode shares of freight traffic. The desk scan also

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reviews past estimates or models of impacts of changes in truck size and weight limits on fuel efficiency, the environment, traffic flow, and highway cost recovery.

Three gaps in the assessment of past studies may lead the study team to overlook resources useful in the CTSW study:

- The diversion projections of the mode shift models are not compared in terms of their utility or credibility for their intended applications. This omission is especially important in view of limitations of the Intermodal Transportation and Inventory Cost (ITIC) model chosen for use in the CTSW study.
- Alternative freight mode choice models deserve greater examination. The review covers only mode choice models used in studies of truck size and weight regulations. A broader review of freight demand modeling might have revealed other methods of analyzing the effect of changes in size and weight limits on freight flows.
- Methods of estimating the effects of mode shifts, as required in the MAP-21 study charge, are not adequately covered. Some of these effects (e.g., safety effects and highway infrastructure effects) presumably will be estimated in other parts of the CTSW study; however, the desk scans do not appear to cover methods of estimating effects on freight transportation costs, cost responsibilities, fuel efficiency, or the environment.

The committee's concerns with regard to each of these gaps are explained below.

Diversion Projections

The studies described are those produced for past prospective evaluations of proposed changes in truck size and weight regulations by USDOT, TRB, and the Government Accountability Office, together with four recent state studies and three from other sources. The mode shift methodology used in each study is identified, and the three principal methodologies (disaggregate total logistics cost models like ITIC,

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aggregate econometric models, and expert opinion) are compared qualitatively, primarily with respect to practicality of use. The review does not describe quantitative results of past model estimates, reliability of the estimates, or sources of uncertainty, and it does not compare projections with outcomes. Citation of any published critiques of ITIC or any external review of the model that the Federal Railroad Administration may have commissioned would be especially helpful. For example, the desk scan could cite the discussion of the limitations of ITIC, including the problem of all-or-nothing freight allocations, in the 2000 USDOT truck size and weight study (USDOT 2000, IV-10–IV-11).

The desk scan discusses data availability related to commodity flows. It focuses on four data sources: the Freight Analysis Framework (a synthesis of data from various sources rather than an independent source), IHS Global Transearch, the Commodity Flow Survey, and the Surface Transportation Board carload waybill sample. This focus is appropriate, since these are the major data sources available. The desk scan also should have investigated the availability of other proprietary freight flow databases.

The desk scan concludes that the ITIC model is most suitable for the CTSW study, primarily on the grounds that no other directly applicable model is available and that development of an aggregate econometric model would be impractical within the study schedule. The comparison of alternative models does not consider the suitability of the ITIC model to the aggregate analysis to be conducted in the CTSW study, as discussed in the desk scan and project plan. This problem is considered below in the section headed “Does the Desk Scan Interpret the Literature Reviewed Correctly?”

Alternative Freight Mode Choice Models

The desk scan would benefit from an overview of the fundamental concepts of modal diversion (that is, beyond studies examining solely the question of truck size and weight limits) and a review of other methodologies, in particular, econometric models of mode choice. Such a review would provide assurance to the public that the team is using the best possible methodologies given the constraints and

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would contribute to advancing USDOT's ability to analyze freight market issues in the future.

The desk scan needs a more comprehensive literature review of econometric models. The scan includes hardly any sources from the academic literature, which is unfortunate since recent studies on logistics analysis may help inform the ITIC model. These publications are essential for understanding the underlying behaviors concerning mode choice. In particular, the team should examine the following:

1. Publications that have used the Commodity Flow Survey data (Samuelson 1977; McFadden et al. 1986; Abdelwahab and Sargious 1990; Abdelwahab and Sargious 1991; Abdelwahab and Sargious 1992; Abdelwahab 1998; Abdelwahab and Sayed 1999). Although they are dated, these publications provide insight into the effect of commodity type on mode choice.
2. Publications that have studied the topic of freight vehicle choice (Holguín-Veras 2002; Cavalcante and Roorda 2010; Holguín-Veras et al. 2011), which is central to the CTSW study.
3. Publications that have used or developed supply chain models for the study of mode choice (Hall 1985; Leachman 2008).

A literature review that covers some of the academic literature related to diversion has been prepared by Winebrake et al. (2012).

On the question of whether changes in limits will induce a change in the total volume of freight traffic, the scan cites a single reference, produced for the 2000 USDOT truck size and weight study. The desk scan acknowledges that change in total traffic volume is a key question because it affects safety and infrastructure and has other consequences; therefore, citations of alternative models or newer estimates of induced freight traffic would be valuable.

The ongoing Research Project 44 of the National Cooperative Freight Research Program, Impacts of Policy-Induced Freight Modal Shifts (TRB 2013), is expected to estimate econometric models and, possibly, develop a major revision of the ITIC model. These models may enhance USDOT's capabilities of analyzing freight mode and vehicle choice. Unfortunately, the models are not likely to be ready before

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the fourth quarter of 2014.

Effects of Mode Shifts

The desk scan should identify methods of estimating the effect that diversion would have on other modes of transportation, public safety, infrastructure, cost responsibilities, fuel efficiency, freight transportation costs, and the environment, if such effects are not addressed in other parts of the CTSW study.

- Effect of diversion on infrastructure: Pavement and bridge impacts are to be covered in other parts of the CTSW study. However, infrastructure effects of diversion may include issues related to the rail system as well as consequences for rail yards and transfer facilities. Such items are not included in the desk scan.
- Effect of diversion on cost responsibilities: A number of cost responsibilities might arise from diversion and affect shippers, carriers, and consumers. Also, because diversion affects the quality of infrastructure, the cost elements of this infrastructure (and how those costs are shared between the public and private sectors) may be important to consider.
- Effect of diversion on fuel efficiency: This section of the desk scan focuses on the Environmental Protection Agency's GEM (Greenhouse Gas Emissions Model) primarily, with some discussion of other approaches to determine trade-offs between truck and rail. Hardly any nongovernmental literature is cited in this area, but much exists with respect to the energy and environmental trade-offs of truck versus rail. The challenge here is that many studies are "top–down" and do not account for the specific operations of a truck or locomotive. The "bottom–up" calculations are more accurate but are not as applicable to a wide network.[1] In the end, various energy consumption factors may need to

[1] The literature has referred to analyses that use fleet averages to estimate mode-specific energy use or emissions factors as "top–down" analyses. For example, a top–down fuel efficiency factor for trucks (BTU/ton-mile) is calculated by taking the total energy use reported for the trucking sector and dividing by the total ton-miles of freight activities for this sector. The results provide fleet averages that may "shroud the true variability that exists

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be calculated in a bottom–up fashion for a set number of truck configurations, routes, and commodities and then applied in a top–down fashion for a national network of transportation operations. Some of the problems with top–down calculations are explained by Comer et al. (2010) and Winebrake and Corbett (2010).

- Effect of diversion on the environment: The comments above related to energy consumption apply to the effect of diversion on the environment. In addition, the desk scan is relatively silent on the non–greenhouse gas emissions shifts that could occur with respect to diversion. Moving freight from rail to truck (or vice versa) could have significant impacts on particulate matter, oxides of nitrogen, and oxides of sulfur, for example.

  There is also a spatial dimension to these pollutants, and it should be recognized that both the *amount* of pollution and the *location* of that pollution (which ultimately leads to exposure to populations) are important. Some of these issues are discussed in the academic literature, particularly in analyses that examine waterborne freight as an alternative to land-based freight, since waterborne freight could reduce exposure of populations to pollution even if the overall emissions are higher.

Is the Desk Scan Missing Literature, Case Studies, Models, or Data That Would Help Achieve the Study Goals?

The preceding section identifies literature relating to alternative mode choice models and models and studies relevant to estimating the effects of changes in truck size and weight limits that may be of value to the CTSW study.

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with respect to shipping goods" (Comer et al. 2010). Another approach for estimating energy use or emissions factors in the freight sector is the "bottom–up" approach. In this approach, specific information about the route; travel speed; and vehicle, locomotive, or vessel characteristics is applied to calculate factors used in mode selection. The value of a bottom–up approach is that it creates data that are more realistically calibrated to the specific freight diversion question at hand.

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Does the Desk Scan Interpret the Literature Reviewed Correctly?

The desk scan does not adequately describe the differences between the ITIC mode choice model and the alternative models considered or potential shortcomings of ITIC for the CTSW study application. The committee understands that ITIC, a disaggregate single-shipper model, is being used in the CTSW study to determine the optimal mode and vehicle to transport nationwide freight flows, which are represented in the method as aggregate county-to-county flows by commodity. This method implicitly assumes perfect cooperation and a homogeneous level of service across shippers and perfect consolidation of the cargo.

Although these assumptions may be needed on account of the lack of readily available alternative modeling approaches, they lead to some complications that should be taken into account. The optimal mode or vehicle obtained from that process is likely to have a larger capacity than the ones that would be obtained without the assumption of perfect cooperation and consolidation; consequently, projections may overstate the rail share of traffic or the average weight or volume of truck loads. This effect should be kept in mind and accounted for when the results are interpreted. Moreover, using ITIC on the data described on pages 30–39 of the desk scan will create all-or-nothing assignments for each origin–destination–commodity pairing. This should be mentioned and addressed.

Does the Desk Scan Synthesize the Literature and Draw Appropriate Conclusions?

Beyond the qualitative comparisons in Tables 1 and 2, the desk scan does not attempt to synthesize the literature. Two kinds of synthesis are needed for the study:

- A synthesis of experience in the use of alternative methods of estimating mode shares, in terms of reliability and applicability, that leads to an assessment of the current state of the art. (That is, are reliable predictions of the effect of policy changes on mode shares feasible with available models?)

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- A synthesis of quantitative results of past estimates of mode shift effects of changing truck size and weight limits. Readers assessing the credibility of the CTSW study final report will need to compare the mode shift estimates with those of earlier studies and to understand the sources of differences, which may arise from real-world changes over time (e.g., changes over time in freight markets), differences in modeling assumptions, or differences in the policies simulated in the various studies.

The committee's overall impression of the desk scan is that its intent is to justify a prior decision about the method to be used in the CTSW study. There is not a logical flow from literature review to synthesis to conclusion. The desk scan represents more a listing of reports and literature, followed by a conclusion that is likely based on availability of models, time to complete the study, familiarity with the methods, and budget.

References

Abbreviations

TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

Abdelwahab, W. M. 1998. Elasticities of Mode Choice Probabilities and Market Elasticities of Demand: Evidence from a Simultaneous Mode Choice/Shipment-Size Freight Transport Model. *Transportation Research Part E: Logistics and Transportation Review*, Vol. 34, No. 4, pp. 257–266.

Abdelwahab, W. M., and M. Sargious. 1990. Freight Rate Structure and Optimal Shipment Size in Freight Transportation. *Logistics and Transportation Review*, Vol. 26, No. 3, pp. 271–292.

Abdelwahab, W. M., and M. A. Sargious. 1991. A Simultaneous Decision-Making Approach to Model the Demand for Freight Transportation. *Canadian Journal of Civil Engineering*, Vol. 18, No. 3, pp. 515–520.

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

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Abdelwahab, W., and T. Sayed. 1999. Freight Mode Choice Models Using Artificial Neural Networks. *Civil Engineering and Environmental Systems*, Vol. 16, No. 4, pp. 267–286.

Cavalcante, R., and M. J. Roorda. 2010. A Disaggregate Urban Shipment Size/Vehicle-Type Choice Model. Presented at 89th Annual Meeting of the Transportation Research Board, Washington, D.C.

Comer, B., J. J. Corbett, J. S. Hawker, K. Korfmacher, E. E. Lee, C. Prokop, and J. J. Winebrake. 2010. Marine Vessels as Substitutes for Heavy-Duty Trucks in Great Lakes Freight Transportation. *Journal of the Air and Waste Management Association*, Vol. 60, July, pp. 884–890.

Hall, R. 1985. Dependence Between Shipment Size and Mode in Freight Transportation. *Transportation Science*, Vol. 19, No. 4, pp. 436–444.

Holguín-Veras, J. 2002. Revealed Preference Analysis of Commercial Vehicle Choice Process. *Journal of Transportation Engineering*, Vol. 128, No. 4, pp. 336–346.

Holguín-Veras, J., N. Xu, G. de Jong, and H. Maurer. 2011. An Experimental Economics Investigation of Shipper–Carrier Interactions on the Choice of Mode and Shipment Size in Freight Transport. *Networks and Spatial Economics*, Vol. 11, No. 3, pp. 509–532.

Leachman, R. C. 2008. Port and Modal Allocation of Waterborne Containerized Imports from Asia to the United States. *Transportation Research Part E: Logistics and Transportation Review*, Vol. 44, No. 2, pp. 313–331.

McFadden, D., C. Winston, and A. Boersch-Supan. 1986. Joint Estimation of Freight Transportation Decisions Under Non-Random Sampling. Discussion paper, Harvard University.

Samuelson, R. D. 1977. *Modeling the Freight Rate Structure*. Center for Transportation Studies, Massachusetts Institute of Technology.

TRB. 2013. NCFRP 44 [Active]: Impacts of Policy-Induced Freight Modal Shifts. http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3534.

USDOT. 2000. *The U.S. Department of Transportation's Comprehensive Truck Size and Weight Study: Volume III: Scenario Analysis.* Aug.

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Winebrake, J. J., and J. J. Corbett. 2010. Improving the Energy Efficiency and Environmental Performance of Goods Movement. In *Climate and Transportation Solutions: Findings from the 2009 Asilomar Conference on Transportation and Energy Policy* (D. Sperling and J. S. Cannon, eds.), University of California, Davis.

Winebrake, J. J., E. H. Green, B. Comer, J. J. Corbett, and S. Froman. 2012. Estimating the Direct Rebound Effect for On-Road Freight Transportation. *Energy Policy*, Vol. 48, Sept., pp. 252–259.

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HIGHWAY SAFETY AND TRUCK CRASH

The MAP-21 Section 32801 charge to USDOT for the CTSW study contains three references to safety impacts:

Sec. 32801(a)(1): [The study shall:]

(1) provide data on accident frequency and evaluate factors related to accident risk of vehicles that operate with size and weight limits that are in excess of the Federal law and regulations in each State that allows vehicles to operate with size and weight limits that are in excess of the Federal law and regulations, or to operate under a Federal exemption or grandfather right, in comparison to vehicles that do not operate in excess of Federal law and regulations (other than vehicles with exemptions or grandfather rights). . . .

Sec. 32801(a)(5): [The study shall:]

(5) compare and contrast the potential safety and infrastructure impacts of the current Federal law and regulations regarding truck size and weight limits in relation to—

(A) six-axle and other alternative configurations of tractor-trailers; and

(B) where available, safety records of foreign nations with truck size and weight limits and tractor-trailer configurations that differ from the Federal law and regulations. . . .

Sec. 32801(a)(6)(B): [The study shall estimate:]

(B) the effect that any such diversion [from other modes to highways if alternative configurations were allowed to operate] would have on public safety, infrastructure, cost responsibilities, fuel efficiency, freight transportation costs, and the environment. . . .

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Is the Desk Scan Thorough?

The comparison of alternative safety analysis methods in the safety project plan appears to be a valuable first step in carrying out the safety analysis, because it shows the range of methods available and identifies the pros and cons of each method for application in the CTSW study. These alternative methods should be documented in the desk scan, with references to studies that used each of the methods. Especially valuable would be comparison of the route-based approach, which in effect treats crash risk as a property of the vehicle–road system rather than of the characteristics of individual vehicles, with the more common approaches that project the effect of a change in truck traffic on the basis of vehicle-specific average crash involvement rates. The committee that wrote TRB Special Report 246, *Paying Our Way* (TRB 1996, 68–72), concluded that the road system perspective is preferable. Changes in the characteristics and volume of truck traffic on a road network may change traffic flow and driving behavior in ways that affect rates of crashes that do not involve trucks.

The desk scan includes an extensive and useful summary of regulations concerning equipment, drivers, and operating practices that govern longer combination vehicle (LCV) operation in Canada, Australia, and the Netherlands. However, the review of safety research does not cover studies of the effectiveness of such regulations in mitigating hazards associated with larger trucks. The committee that prepared the TRB 2002 truck size and weight study devoted a chapter to mitigation measures, including vehicle design, enforcement, and separation of car and truck traffic (TRB 2002, 154–188), and the committee that wrote the TRB Turner truck study proposed special regulations concerning equipment and drivers (TRB 1990, 202–206). Such safety mitigation measures could be imposed regardless of whether size and weight limits are changed; therefore, the safety of alternative vehicles with special safety rules contrasted with present trucks without such rules would not be the appropriate comparison for policy analysis. However, the practice of coupling liberalization of limits with special mitigation requirements is common in the United States and other countries. Thus, the audiences of the CTSW report have an interest in whether the mitigation measures can be effective.

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The desk scan notes (e.g., pp. 10, 17) the effect of driver experience and skill level on the safety of LCVs. To the references cited on this point in the desk scan may be added the results of the *Large Truck Crash Causation Study* (LTCCS), which indicate driver-related factors coded as "critical factors" in a substantial fraction of all large truck–involved crashes (FMCSA 2007). Research has found that trailer configuration affects drivers' experiences of stress and fatigue (FMCSA 2000). Consequently, the CTSW study safety analysis will need to account for the driver's influence on crash risk. The project plan notes (p. 27) that controlling for driver characteristics would not be possible in the Method 3 safety analysis, State Crash Rate Analysis. However, driver-related factors could be explored with Method 2, Fleet-Based Method. The desk scan should describe the design of past studies that have measured the effect of driver characteristics on truck crash rates.

The safety analysis project plan states that vehicle stability and control will be examined as part of the safety analysis and identifies simulation models to be used in this examination. The safety desk scan reviews past studies that evaluated large truck stability and control but does not cite the models identified in the project plan or identify sources for input data for the models.

A gap in the desk scans is omission of studies of the safety and environmental costs of increasing the extent or duration of work zones. Safety risks include both vehicle crashes and occupational injuries [see, e.g., FHWA (2013)]. Introduction of the alternative vehicles may increase the frequency of pavement and bridge repair and renovation projects, and the associated construction zones would impose safety hazards on all road users. The construction zones may also pose special safety risks for larger vehicles or force them to divert to less safe routes, where their presence might impose further safety risks on other drivers. The desk scan should identify resources to support estimates of these safety effects in the CTSW study (e.g., studies of risk of crashes in work zones and in congestion caused by work zones compared with risk in segments without nearby work zones, delay associated with work zones, and effects of such delay on fuel consumption and emissions), although the effects would be difficult to determine precisely.

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Is the Desk Scan Missing Literature, Case Studies, Models, or Data That Would Help Achieve the Study Goals?

Citation of the following studies in the desk scan would be appropriate:

- Stein and Jones (1988). The study was not as carefully designed for studying truck configuration as that of Braver et al. (1997; cited on p. 13 of the desk scan) but may still provide insights. The TRB Turner truck study (TRB 1990, 120–121) discusses Stein and Jones (1988).
- Jones and Stein (1989). The study examined defective equipment in tractor-trailer crashes and had a strong design. Table 2 of the study showed that more than half of crash-involved trucks had brake defects and that the odds of being in a crash were 60 percent higher with at least one brake defect. Brake defects may be a more serious issue with increased weight.
- Blower et al. (1990). The study contains travel estimates by truck weight and by configuration, as well as crash rates. Such data may be useful for setting priorities or estimating expected costs and benefits.
- Zaloshnja et al. (2006), the most recent Federal Motor Carrier Safety Administration (FMCSA) report on unit costs of large-truck crashes. Drawing on LTCCS data, Tables 2 to 4 in that report show that crash injury severity is higher in double- or triple-trailer than in single-trailer crashes, both overall and at each police-reported severity level. (These U.S. findings from a national sample differ from the Alberta study findings.) This study demonstrates that a key outcome measure of crash severity is total crash harm, not just crash rate.
- Hagemann et al. (2013), a Volpe Center report to FMCSA. That report provides useful analytic input for the CTSW study on delay and environmental costs of truck crashes.
- A research needs statement on large-truck safety prepared by a TRB standing committee (TRB 2010). The statement cites several relevant studies not cited in the desk scan.

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The desk scan does not appear to have made use of information from the publications of the expert witness community or any engineering or expert reports (about, e.g., vehicle stability) that are openly accessible as exhibits in trial records. Inquiries to the crash reconstruction firms that are engaged in crash litigation involving trucks would uncover such reports. Any use of expert witness testimony, however, must recognize the inherent bias of the source.

Does the Desk Scan Interpret the Literature Reviewed Correctly?

The findings of the studies cited in the desk scan appear to be summarized and interpreted accurately.

Does the Desk Scan Synthesize the Literature and Draw Appropriate Conclusions?

Section 6.0, Findings, is a worthwhile attempt at a synthesis, although it fails to address some critical methodological issues, and some of the observations in the section are open to debate. Separation of findings concerning methods (models and data) from those concerning results of safety studies would be helpful.

Citing the basis of the findings would help the reader judge the strength of findings concerning results of safety studies. For example, the finding (p. 46) that "gross vehicle weight would appear to be associated with higher crash rates based on changes in vehicle operating characteristics and limited crash studies" seems to be supported by only one study cited [Fancher and Campbell (1995), cited on p. 10].

A synthesis of alternative methods of estimating the relationship of truck size and weight to crash risk, parallel to descriptions of alternative methods in the safety project plan and with citations where possible of studies that illustrate each of the methods, would be valuable. Although two case-control studies exist [Stein and Jones (1988) and Braver et al. (1997)] and this method is capable of controlling well for driver experience and driving record in analyzing crash risk by vehicle type, the desk scan does

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not provide a critique of the method that would support the decision not to include it among those selected in the study plan.

A synthesis of methods used in past studies for estimating the systemwide safety consequences of changes in truck size and weight regulations would also be an aid to the CTSW study. Responding to the MAP-21 study charge will require an estimate of the likely systemwide safety effects of changing the regulations to allow introduction of the alternative configurations. Systemwide safety impacts will depend on the effect of changes in the regulations on traffic volume and distribution, enforcement, work zone hazards, and other factors beyond any differences among the alternative configurations in average crash involvement rates.

The number of relevant crash studies is sufficient to support a systematic synthesis of results, rather than selective observations. The summary of multitrailer crash rate studies in TRB Special Report 211, *Twin Trailer Trucks* (TRB 1986, 322–323), could serve as a model.

References

Abbreviations

FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
TRB	Transportation Research Board

Blower, D., R. Lyles, K. Campbell, and P. Stamatiadis. 1990. *The Michigan Heavy Truck Study*. Michigan Office of Highway Safety Planning, Lansing.

FHWA. 2013. Facts and Statistics—Work Zone Injuries and Fatalities. Last modified Sept. 19. http://www.ops.fhwa.dot.gov/wz/resources/facts_stats/injuries_fatalities.htm.

FMCSA. 2000. *Stress and Fatigue Effects of Driving Longer-Combination Vehicles.* http://www.fmcsa.dot.gov/documents/tb00-012.pdf.

FMCSA. 2007. *Analysis Brief: The Large Truck Crash Causation Study: LTCCS Summary*. July.

Hagemann, G., K. Hymel, A. Klauber, D. Lee, G. Noel, D. Pace, and C. Taylor. 2013. *Delay and Environmental Costs of Truck Crashes.* Federal Motor Carrier Safety Administration, March.

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Jones, I., and H. Stein. 1989. Defective Equipment and Tractor-Trailer Crash Involvement. *Accident Analysis and Prevention*, Vol. 21, No. 5, pp. 469–481.

Stein, H., and I. Jones. 1988. Crash Involvement of Large Trucks by Configuration: A Case-Control Study. *American Journal of Public Health*, Vol. 78, No. 5, pp. 491–498.

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

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

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

TRB. 2002. *Special Report 267: Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles.* National Academies, Washington, D.C.

TRB. 2010. Crash Harm per Freight Ton-Mile for Different Large Truck Configurations: ANB70 Research Needs Statement. Aug. http://rns.trb.org/dproject.asp?n=27486.

Zaloshnja, E., T. Miller, and R. Spicer. 2006. *Revised Costs of Large Truck– and Bus-Involved Crashes*. Federal Motor Carrier Safety Administration.

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ENFORCEMENT AND COMPLIANCE

The MAP-21 [Section 32801(a)(3)] specification for the CTSW study enforcement analysis asks the study to:

> (3) evaluate the frequency of violations in excess of the Federal size and weight law and regulations, the cost of the enforcement of the law and regulations, and the effectiveness of the enforcement methods.

The enforcement desk scan and project plan indicate that the USDOT study team interprets this part of the MAP-21 study charge as requiring two assessments: (*a*) evaluating the violation frequency and enforcement cost and effectiveness for the current fleet of trucks operating in the United States and (*b*) making similar estimates for the alternative configurations considered in the CTSW study.

Is the Desk Scan Thorough?

The enforcement desk scan presents the material reviewed in a logical and useful topical organization, defines the scope and criteria of its review, and systematically summarizes the results of the past studies. These features of the desk scan could serve as a model for the desk scans in the other study areas.

The desk scan reviews 76 studies and other documents published since approximately 2000, organized into eight topic areas: extent of the compliance problem, traditional approaches to enforcement, effect of regulatory changes on enforcement, enforcement costs, enforcement benefits, effectiveness of enforcement, application of enforcement and compliance technologies, and alternative approaches for achieving compliance. The summaries provide a thorough consideration of the topic areas. The committee has identified a few missing studies, as discussed below.

One area to which the desk scan pays little attention is the prospect for more rigorous

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enforcement using new technologies. Examples of the increased possibilities for technology in truck size and weight enforcement include USDOT's Smart Roadside Initiative (SAIC n.d.), which aims to connect and share data among vehicles, motor carriers, enforcement resources, highway facilities, intermodal facilities, toll facilities, and other nodes on the transportation system to improve motor carrier safety, security, operational efficiency, and freight mobility.

Is the Desk Scan Missing Literature, Case Studies, Models, or Data That Would Help Achieve the Study Goals?

Overall, the information available from the sources reviewed is insufficient for measuring the cost and effectiveness of enforcement. The authors acknowledge this difficulty in the introduction to the desk scan (p. 1): "The review emphasizes the enforcement of truck size and weight limits; however, distinguishing enforcement activities concerning truck size and weight from those directed at safety or credentials regulations is not always possible." The lack of necessary data is the consequence of long-standing problems associated with weight enforcement programs. Adequate performance metrics for the success of state enforcement programs are not available. Analyzing state data that are likely influenced by inconsistent state laws will be difficult. As a consequence, at best, only broad estimates of the effectiveness of enforcement efforts may be possible in the CTSW study.

More detailed documentation of the limitations of the data sources to be used in the CTSW study would have been appropriate in the desk scan. In particular, accurate depiction of the true level of compliance through use of WIM data is challenging. The project plan makes apparent that the CTSW study team recognizes this difficulty, but how the analyses proposed will compensate for the data problems is not evident. It will be necessary to analyze weight distributions from WIM stations where no enforcement occurs and compare them with distributions from stations at locations with vigorous enforcement. This will provide insight into the frequency and weight distribution of trucks diverting to secondary routes to avoid enforcement. For best results, selected WIM sites should use the same WIM

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technology and be of approximately the same age, or calibrated similarly, to provide comparable data.

The desk scan does not cite data sources for potentially important categories of enforcement costs, in particular, costs of increased inspection times that may be required for new vehicle configurations and costs of expansion or replacement of existing scales and inspection areas that may be needed for handling larger and heavier trucks.

The review does not cover economic research on optimal fine levels. For example, Kenkel (1993) shows that optimal fines should recover the full costs of harm and enforcement. Similar reasoning suggests that permit fees should recover the full costs of accelerated rehabilitation and repair projects, including construction, congestion, safety, and environmental costs.

Does the Desk Scan Interpret the Literature Reviewed Correctly?

The overall interpretation of the literature in the desk scan is reasonable. In general, a more critical appraisal of all studies cited would provide a stronger basis for selecting approaches in the study plan. The desk scan uncritically reports a statement of the 2002 TRB truck size and weight study (TRB 2002) that rigorous weight enforcement could increase overall truck shipping costs. The proceeds of illegal activities should not be regarded as benefits to society in benefit–cost analysis of enforcement programs (Trumbull 1990).

Does the Desk Scan Synthesize the Literature and Draw Appropriate Conclusions?

The organization of the literature into topical areas and the summaries in Tables 1–4 and 6–9 that identify the key documents in each topic area and the contribution of each to the CTSW study are useful first steps toward a synthesis and conclusions. However, syntheses of quantitative results (e.g., statements about the likely range values of metrics of enforcement effectiveness and enforcement costs, derived from the estimates in the sources reviewed) are not presented.

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References

Kenkel, D. S. 1993. Do Drunk Drivers Pay Their Way? A Note on Optimal Penalties for Drunk Driving. *Journal of Health Economics*, Vol. 12, No. 2, pp. 137–149.

SAIC. n.d. Smart Roadside Initiative (SRI). http://www.smartroadsideinitiative.com/.

TRB. 2002. *Special Report 267: Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles*. National Academies, Washington, D.C.

Trumbull, W. N. 1990. Who Has Standing in Cost–Benefit Analysis? *Journal of Policy Analysis and Management*, Vol. 9, No. 2, pp. 201–218.

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Appendix A
MAP-21 Section 32801. Comprehensive Truck Size and Weight Study

[112th Congress Public Law 141]
[From the U.S. Government Printing Office]

[[Page 126 STAT. 405]]

Public Law 112-141
112th Congress

An Act

To authorize funds for Federal-aid highways, highway safety programs, and transit programs, and for other purposes. <<NOTE: July 6, 2012 - [H.R. 4348]>>

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, <<NOTE: Moving Ahead for Progress in the 21st Century Act. State and local governments.>>

SECTION 1. SHORT TITLE; ORGANIZATION OF ACT INTO DIVISIONS; TABLE OF CONTENTS.

(a) <<NOTE: 23 USC 101 note.>> Short Title.--This Act may be cited as the “Moving Ahead for Progress in the 21st Century Act” or the “MAP-21”.

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SEC. 32801. COMPREHENSIVE TRUCK SIZE AND WEIGHT LIMITS STUDY.

(a) <<NOTE: Deadline.>> Truck Size and Weight Limits Study.—Not later than 45 days after the date of enactment of this Act, the Secretary, in consultation with each relevant State and other applicable Federal agencies, shall commence a comprehensive truck size and weight limits study. The study shall—

(1) provide data on accident frequency and evaluate factors related to accident risk of vehicles that operate with size and weight limits that are in excess of the Federal law and regulations in each State that allows vehicles to operate with size and weight limits that are in excess of the Federal law and regulations, or to operate under a Federal exemption or grandfather right, in comparison to vehicles that do not operate in excess of Federal law and regulations (other than vehicles with exemptions or grandfather rights);

(2) evaluate the impacts to the infrastructure in each State that allows a vehicle to operate with size and weight limits that are in excess of the Federal law and regulations, or to operate under a Federal exemption or grandfather right, in comparison to vehicles that do not operate in excess of Federal law and regulations (other than vehicles with exemptions or grandfather rights), including—

(A) the cost and benefits of the impacts in dollars;

(B) the percentage of trucks operating in excess of the Federal size and weight limits; and

(C) the ability of each State to recover the cost

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for the impacts, or the benefits incurred;

(3) evaluate the frequency of violations in excess of the Federal size and weight law and regulations, the cost of the enforcement of the law and regulations, and the effectiveness of the enforcement methods;

(4) assess the impacts that vehicles that operate with size and weight limits in excess of the Federal law and regulations, or that operate under a Federal exemption or grandfather right, in comparison to vehicles that do not operate in excess of Federal law and regulations (other than vehicles with exemptions or grandfather rights), have on bridges, including the impacts resulting from the number of bridge loadings;

(5) compare and contrast the potential safety and infrastructure impacts of the current Federal law and regulations regarding truck size and weight limits in relation to—

(A) six-axle and other alternative configurations of tractor-trailers; and

(B) where available, safety records of foreign nations with truck size and weight limits and tractor-trailer configurations that differ from the Federal law and regulations; and

(6) estimate—

(A) the extent to which freight would likely be diverted from other surface transportation modes to principal arterial routes and National Highway System intermodal connectors if alternative truck configuration is allowed to operate and the effect that any such diversion would have on other modes of transportation;

(B) the effect that any such diversion would have on public safety, infrastructure, cost responsibilities, fuel efficiency, freight transportation costs, and the environment;

(C) the effect on the transportation network of the United States that allowing alternative truck configuration to operate would have; and

(D) whether allowing alternative truck configuration to operate would result in an increase or decrease in the total number of trucks operating on principal arterial routes and National Highway System intermodal connectors; and

(7) identify all Federal rules and regulations impacted by changes in truck size and weight limits.

(b) Report.—Not later than 2 years after the date that the study is commenced under subsection (a), the Secretary shall submit a final report on the study, including all findings and recommendations, to the Committee on Commerce, Science, and Transportation and the Committee on Environment and Public Works of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives.

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Appendix B
Committee for Review of USDOT Truck Size and Weight Study
Statement of Task

An ad hoc committee will provide a peer review of a comprehensive truck size and weight study that Congress required the U.S. Department of Transportation (USDOT) to conduct. The review will include two letter reports. The first will review "desk scan reports" (literature reviews) prepared by the Federal Highway Administration (FHWA) based on their thoroughness in reviewing the existing literature, analysis of existing models and data for conducting the comprehensive study, and overall synthesis of the preceding body of work as it applies to the study that is to follow. The desk scans are expected to be available for committee review in August–September 2013. Once FHWA has completed the technical analysis for the study in March 2014, the committee will prepare and issue its second and final report, commenting on the extent to which the technical analysis and findings address the issues identified by Congress. The committee's second letter report will be due by May 1, 2014.

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Appendix C
Parties Submitting Comments to the Committee

The following persons submitted comments on the committee's task, either in writing or in remarks at the December 5, 2013, public meeting:

Steve Carter, Board of County Commissioners, Sequoyah County, Oklahoma
James and Marge Freeman
Steve Howard, Terex Advance Mixer, Charleston, South Carolina
Henry Jasny, Advocates for Highway and Auto Safety, Washington, D.C.
Donald J. Kaleta, Rome, Ohio
Shaun Kildare, Advocates for Highway and Auto Safety, Washington, D.C.
John Lannen, Truck Safety Coalition, Arlington, Virginia
John Runyan, Coalition for Transportation Productivity, Washington, D.C.
Ed Slattery, Parents Against Tired Truckers, Arlington, Virginia
Curtis Sloan, GoRail, Alexandria, Virginia
Tami Friedrich Trakh, Citizens for Reliable and Safe Highways, Arlington, Virginia
Peter J. Vanderzee, LifeSpan Technologies, Alpharetta, Georgia

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Appendix D
Review Of The Document

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that assist the authors and NRC in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The contents of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The following individuals participated in the review of this report: R. Stephen Berry, University of Chicago; Judith Corley-Lay, North Carolina Department of Transportation; Norman Dofflemyer, Maryland Department of State Police; Gongkang Fu, Illinois Institute of Technology; Ronald Knipling, Independent Consultant; Gerard McCullough, University of Minnesota; Bernard Robertson, BIR1, LLC; and C. Michael Walton, University of Texas at Austin. Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the committee's conclusions or recommendations, nor did they see the final draft of the report before its release.

The review of this report was overseen by National Academy of Sciences member Susan Hanson, Clark University (emerita) and National Academy of Engineering member Maxine Savitz, Honeywell Inc. (retired). Appointed by NRC, they were responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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STUDY COMMITTEE BIOGRAPHICAL INFORMATION

James Winebrake (Chair) is Professor and Dean of the College of Liberal Arts at Rochester Institute of Technology (RIT) and Co-Director of the RIT Laboratory for Environmental Computing and Decision Making. Previously, he was chair of the Department of Science, Technology, and Society/Public Policy, directing a BS program in public policy and an MS program in science, technology, and public policy. Dr. Winebrake has published on a wide variety of transportation, energy, and environmental topics. Over the past decade, he has been involved in evaluating the environmental impacts of freight transportation, with emphasis on air quality, health, climate change, and regulations. He has served or is serving on a number of professional committees related to freight transportation, including the U.S. Department of Energy Transportation Energy Futures Steering Committee, the National Academies Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles, and the National Academies Committee for a Study of Potential Energy Savings and Greenhouse Gas Reductions from Transportation. Before joining RIT, Dr. Winebrake served as an associate professor of integrated science and technology at James Madison University. He received a BS in physics from Lafayette College, an MS in technology and policy from Massachusetts Institute of Technology (MIT), and a PhD in energy management and policy from the University of Pennsylvania.

Imad L. Al-Qadi, a pavement engineer, is the Founder Professor of Engineering at the University of Illinois at Urbana–Champaign. He is also the Director of the Advanced Transportation Research and Engineering Laboratory and the founding Director of the Illinois Center for Transportation. Before that, he was the Charles E. Via, Jr., Professor at Virginia Tech. He is a registered professional engineer. His work has resulted in the development of new pavement modeling methods, techniques, and testing standards. He is the President of the American Society of Civil Engineers (ASCE) Transportation and Development Institute Board of Governors and the editor-in-chief of the *International Journal of Pavement Engineering*. Professor Al-Qadi has received the National Science Foundation’s Young Investigator Award, the quadrennial International Geosynthetics Society Award, the ASCE James Laurel Prize, the American Road and Transportation Builders Association Steinberg Award, the ASCE Turner Award, and the French Limoges Medal. He is a Chapter Honorary Member of Chi Epsilon, the Civil Engineering Honor Society, at the University of Illinois; an Honorary Member of the Società Italiana di Infrastrutture Viarie; and an Honorary Professor at Southeast University in China and at KTH Royal Institute of Technology in Sweden. In 2010 he was elected as an ASCE Distinguished Member. Dr. Al-Qadi holds a BS from Yarmouk University and an MEng and a PhD from Pennsylvania State University, all in civil engineering.

Sean Brennan is an Associate Professor of Mechanical Engineering at Pennsylvania State University, where he has been since 2003. He shares a joint faculty appointment with the Pennsylvania Transportation Institute. Since 1998, he has published more than a dozen papers on topics such as systems dynamics, modeling, identification, and control; robust control; and vehicle chassis dynamics. His current areas of study include modeling and experimental validation of vehicle dynamics, hardware and human-in-the-loop experimental testing, and fault-tolerant sensing and control. In addition to being the secretary of the International Forum for Road Transport Technology, he is an associate editor for the Automotive Control special issue in the Institute of Electrical and Electronics Engineers *Transactions on Control Systems Technology* and is the Vice Chair of the American Society of Mechanical Engineers Dynamic Systems and Control Technical Committee on Automotive and Transportation Systems. In 2006 he was selected for Pennsylvania State University’s Premier Service Award for his involvement in starting a summer camp focused on advanced vehicle technologies. He holds BS degrees in physics and mechanical engineering from New Mexico State University and an MS and a PhD in mechanical engineering from the University of Illinois at Urbana–Champaign.

Christopher Caplice is Executive Director of the Center for Transportation and Logistics at MIT. He is

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also the founder of the MIT FreightLab—a research initiative that focuses on improving the way freight transportation is designed, procured, and managed. His primary research is in the design, procurement, and management of freight transportation systems to include combinatorial auctions, robust planning, and performance metrics. He has presented and published in numerous business and academic conferences and journals. Before joining MIT, Dr. Caplice held senior management positions in supply chain consulting, product development, and professional services at several companies, including Logistics.com, Sabre, and Princeton Transportation Consulting Group. He is also the Chief Scientist for Chainalytics, the leading analytical supply chain consulting firm. In this role, he pioneered and leads the Chainalytics Model Based Benchmarking Consortium. Dr. Caplice served 5 years in the Army Corps of Engineers, achieving the rank of captain. He received a PhD from MIT in 1996 in transportation and logistics systems, an MS in civil engineering from the University of Texas at Austin, and a BS in civil engineering from the Virginia Military Institute.

Raymond Cook is a Lieutenant with the Pennsylvania State Police and the Director of the Commercial Vehicle Safety Division, a position he has held since 2008. He oversees the department's Motor Carrier Safety Assistance Program and Pennsylvania's Size and Weight Enforcement Program. In this role, he has facilitated a 36 percent increase in truck inspections since 2009. Previously, he has served as a station commander, a supervisor in the Bureau of Criminal Investigation's Intelligence Division, a trooper in a patrol unit, and a special investigator for the Pennsylvania Office of the Inspector General. He holds a BS in administration of justice from Pennsylvania State University.

Georgene Geary is the State Research Engineer with the Georgia Department of Transportation (GDOT). She has worked for the department for nearly three decades, first as a geotechnical engineer in Materials. She has also worked in Construction as a field liaison to roadway and bridges, as the Assistant State Utilities Engineer, and as the Office Head of the Information Services Office, which managed the Geographic Information System and Highway Performance Monitoring System efforts in GDOT. Most recently she spent almost 12 years as the State Materials and Research Engineer, creating the first Pavement Management Branch in GDOT in 2001. She began her current position in 2012, when the Office of Research was created. Ms. Geary is responsible for overall management of the $6 million GDOT research program, including Strategic Highway Research Program 2 products implementation, and implementation of AASHTO Pavement Design ME (pavement design software from AASHTO). She is Vice Chair for the AASHTO Subcommittee on Materials and is a member of both the AASHTO Joint Technical Committee on Pavements and the AASHTO Research Advisory Committee. Ms. Geary is a member of the TRB Rigid Pavement Design Committee and the Chair of the TRB Nanotechnology in Concrete Task Force. She holds a BS in civil engineering from the University of Illinois (Urbana–Champaign) and an MS in civil engineering from Georgia Institute of Technology and is a licensed engineer in Georgia.

Douglas W. Harwood is Program Director in the Transportation Research Center at MRIGlobal, a not-for-profit research institute located in Kansas City, Missouri. Mr. Harwood has more than 40 years of research experience for federal, state, and local agencies, and he has served as principal investigator of numerous Federal Highway Administration and NCHRP research projects concerning traffic safety, highway geometric design, and traffic operations. He has led research projects that have addressed the relationship of truck characteristics to highway geometric design and traffic safety. Mr. Harwood is a licensed professional engineer in Missouri, Kansas, and Montana. He is a member of the Transportation Research Board's Committee on Highway Safety Performance and served as chair of the TRB Committee on Operational Effects of Geometrics. He holds a B.S. degree in civil engineering from Clarkson College and an M.S. degree in transportation engineering from Purdue University.

Susan Hida is the Assistant State Bridge Engineer for the California Department of Transportation (Caltrans) in Sacramento. Her professional experience includes the design and analysis of bridges, as well

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as structural reliability and probability-based design methods. She is a member of the AASHTO Subcommittee on Bridges and Structures, serving on the Load and Resistance Factor Design Executive and T10 Concrete Committees, and chairing the T5 Loads/Load Distribution Committee. At Caltrans, she is the technical focal point within the Office of Structure Design and is a member of the Caltrans Bridge Issues Steering Committee. Previously, she was a Technical Specialist for LRFD and Chair of the Caltrans Loads Committee, Project Engineer for the Bayshore Viaduct Seismic Retrofit, Grass Valley–Yuba City Seismic Retrofit, and New River Bridge redesign, among others. She also served as an instructor for a bridge design loads course and was a designer for strengthening of steel I-girder and of new post-tensioned reinforced concrete box girder and prestressed concrete I-girder bridges. Ms. Hida is a licensed professional engineer in California and Oregon. She has authored many publications and received numerous awards, including the James E. Roberts Award for Outstanding Structures Engineering in Transportation. She holds a BS and an MS in civil engineering (structural emphasis) from Purdue University and an MS in civil engineering (emphasis on structural mechanics) from Princeton University.

José Holguín-Veras is the William H. Hart Professor and Director of the Center for Infrastructure, Transportation, and the Environment at Rensselaer Polytechnic Institute and is Director of the Volvo Research and Educational Foundations' Center of Excellence on Sustainable Urban Freight Systems at the institute. He was previously a faculty member at California Polytechnic State University at San Luis Obispo and the City College of New York. He has served as Vice President for Logistics of the Pan-American Conferences of Traffic and Transportation Engineering, Elected Member of the Council for the Association for European Transport, member of the International Organizing Committee of the City Logistics Conferences, and member of three technical committees and invitational task forces on freight modeling at TRB. He is a member of a number of editorial boards, Review Chair for freight transportation at TRB, and Transportation Editor at *Networks and Spatial Economics*. His work has received numerous awards, including the 2013 White House Champion of Change Award for his contributions to freight transportation and disaster response research. He is the author of numerous articles on transportation modeling and economics. He has a BS from the Universidad Autónoma de Santo Domingo, an MS from the Universidad Central de Venezuela, and a PhD from the University of Texas at Austin, all in civil engineering.

Brenda Lantz has been a researcher at the Upper Great Plains Transportation Institute since 1990, first as a graduate student and professionally since 1994. She specializes in the areas of intelligent transportation systems for commercial vehicle operations, business logistics and supply chain management, statistical modeling and diagnostics, and commercial vehicle safety; she has authored numerous articles and presented many times on these subjects. She is the Chair of the TRB Committee on Truck and Bus Safety and is a member of the TRB Committee on Trucking Industry Research. She is also a member of the Commercial Vehicle Safety Alliance Intelligent Transportation Systems and Information Systems committees. She holds a BS in sociology and an MS in applied statistics, both from North Dakota State University, and a PhD in business administration from Pennsylvania State University.

Sandra Q. Larson is the Systems Operations Bureau Director at the Iowa Department of Transportation, where she has served since 1988. She has also served as Research and Technology Bureau Director, Engineering Bureau Director, Bridges and Structures Office Director/State Bridge Engineer, a Resident Construction Engineer, and a Bridge Design Engineer. She is the Chair of the NCHRP Ideas Deserving Exploratory Analysis panel, is a member of the TRB Long-Term Bridge Performance Program Committee, and serves on the TRB General Structures Committee. She served on the Committee for the Strategic Highway Research Program 2 Implementation and National Research Council–appointed Committee for Pavement Technology Review and Evaluation. Ms. Larson is the past TRB and AASHTO Research Advisory Committee state representative for the Iowa Department of Transportation; past AASHTO Research Advisory Committee Chair, past AASHTO Standing Committee on Research Vice Chair, and past AASHTO Highway Subcommittee on Bridges and Structures Vice Chair. She has bachelor's degrees

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in civil engineering and general science and biology from Iowa State University and is a licensed civil and structural engineer in Iowa.

Ted R. Miller has been a Senior Research Scientist and program director at the Pacific Institute for Research and Evaluation for 20 years. He previously served on the senior staff of the Urban Institute and the Granville Corporation. His publications primarily analyze the incidence and costs of societal problems, evaluate programs, or analyze policies. He has led studies for USDOT on crash costs to society, employers, and government, as well as studies of property and casualty insurance issues. He has published extensively on the costs of occupational injury. His crash cost estimates have been used in safety planning or regulatory analysis by USDOT, state transportation departments, foreign transport departments, and vehicle manufacturers. He has estimated costs of heavy truck crashes and rail crashes and has evaluated related safety programs. Dr. Miller has estimated benefit–cost ratios for health and safety measures, highway safety laws, and enforcement efforts. He is a Fellow of the Association for the Advancement of Automotive Medicine. He was the 1999 recipient of the Excellence in Science Award from the American Public Health Association’s Injury Control and Emergency Health Services Section and received the Vision Award from the State and Territorial Injury Prevention Directors Association in 2005. He serves on the editorial boards of *Accident Analysis and Prevention*, *Injury Prevention*, the *Journal of Safety Research*, the *Ergonomics Open Journal*, and the *Journal of Forensic Economics*. Dr. Miller holds a BS in engineering from Case Western Reserve University and an MS in operations research, a master’s in city planning, and a PhD in regional science, all from the University of Pennsylvania.

Eric Teoh is a Senior Statistician with the Insurance Institute for Highway Safety. He was previously a Mathematical Statistician at the National Institute of Environmental Health Sciences. He has published more than 20 papers and is a member of the American Statistical Association, the Washington Statistical Society, the Association for the Advancement of Automotive Medicine, and TRB’s Committee on Motorcycles and Mopeds. He holds a BS and an MS in mathematics from the University of Alabama at Birmingham.

Michael Tooley is the Director of the Montana Department of Transportation, a position he has held since January 2013. Before that, he served in the Montana Highway Patrol for 28 years, including 4 years as colonel. He is also President of Tooley and Associates, which provides consulting services to the public safety community and has extensive experience in highway safety project management and research. He has a BS in biology from Carroll College and a BS in public safety administration from Grand Canyon University, and he has attended the Federal Bureau of Investigation National Academy at the University of Virginia and the Senior Executives in State and Local Government program at Harvard University’s John F. Kennedy School of Government.

Sharon L. Wood is the interim Dean of the Cockrell School of Engineering at the University of Texas at Austin and holds the Cockrell Family Chair in Engineering No. 14. She previously served as Chair of the Department of Civil, Architectural, and Environmental Engineering and Director of the Phil M. Ferguson Structural Engineering Laboratory, one of the nation’s leading research centers for the large-scale study of the behavior of bridges, buildings, and structural components. Dr. Wood is a Member of the National Academy of Engineering and a Fellow of the American Concrete Institute (ACI). She currently serves as Vice President of ACI. Her research interests include developing passive sensors to monitor the condition of civil infrastructure systems, investigating the fatigue performance of bridges, and improving the seismic response of reinforced concrete buildings. She holds a BS in civil engineering from the University of Virginia and an MS and a PhD in civil engineering from the University of Illinois at Urbana–Champaign. She is a licensed professional engineer in Texas.

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