

# Commercial Truck and Bus Safety

## Synthesis 3

### Highway/Heavy Vehicle Interaction

*A Synthesis of Safety Practice*

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# **Synthesis 3**

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## **Highway/Heavy Vehicle Interaction**

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## COMMERCIAL TRUCK AND BUS SAFETY SYNTHESIS PROGRAM

Safety is a principal focus of government agencies and private-sector organizations concerned with transportation. The Federal Motor Carrier Safety Administration (FMCSA) was established within the Department of Transportation on January 1, 2000, pursuant to the Motor Carrier Safety Improvement Act of 1999. Formerly a part of the Federal Highway Administration, the FMCSA's primary mission is to prevent commercial motor vehicle-related fatalities and injuries. Administration activities contribute to ensuring safety in motor carrier operations through strong enforcement of safety regulations, targeting high-risk carriers and commercial motor vehicle drivers; improving safety information systems and commercial motor vehicle technologies; strengthening commercial motor vehicle equipment and operating standards; and increasing safety awareness. To accomplish these activities, the Administration works with federal, state, and local enforcement agencies, the motor carrier industry, labor, safety interest groups, and others. In addition to safety, security-related issues are also receiving significant attention in light of the terrorist events of September 11, 2001.

Administrators, commercial truck and bus carriers, government regulators, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and undervalued. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information available on nearly every subject of concern to commercial truck and bus safety. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the commercial truck and bus industry, the Commercial Truck and Bus Safety Synthesis Program (CTBSSP) was established by the FMCSA to undertake a series of studies to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern. Reports from this endeavor constitute the CTBSSP Synthesis series, which collects and assembles the various forms of information into single concise documents pertaining to specific commercial truck and bus safety problems or sets of closely related problems.

The CTBSSP, administered by the Transportation Research Board, began in early 2002 in support of the FMCSA's safety research programs. The program initiates three to four synthesis studies annually that address concerns in the area of commercial truck and bus safety. A synthesis report is a document that summarizes existing practice in a specific technical area based typically on a literature search and a survey of relevant organizations (e.g., state DOTs, enforcement agencies, commercial truck and bus companies, or other organizations appropriate for the specific topic). The primary users of the syntheses are practitioners who work on issues or problems using diverse approaches in their individual settings. The program is modeled after the successful synthesis programs currently operated as part of the National Cooperative Highway Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP).

This synthesis series reports on various practices, making recommendations where appropriate. Each document is a compendium of the best knowledge available on measures found to be successful in resolving specific problems. To develop these syntheses in a comprehensive manner and to ensure inclusion of significant knowledge, available information assembled from numerous sources, including a large number of relevant organizations, is analyzed.

For each topic, the project objectives are (1) to locate and assemble documented information (2) to learn what practice has been used for solving or alleviating problems; (3) to identify all ongoing research; (4) to learn what problems remain largely unsolved; and (5) to organize, evaluate, and document the useful information that is acquired. Each synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation.

The CTBSSP is governed by a Program Oversight Panel consisting of individuals knowledgeable in the area of commercial truck and bus safety from a number of perspectives—commercial truck and bus carriers, key industry trade associations, state regulatory agencies, safety organizations, academia, and related federal agencies. Major responsibilities of the panel are to (1) provide general oversight of the CTBSSP and its procedures, (2) annually select synthesis topics, (3) refine synthesis scopes, (4) select researchers to prepare each synthesis, (5) review products, and (6) make publication recommendations.

Each year, potential synthesis topics are solicited through a broad industry-wide process. Based on the topics received, the Program Oversight Panel selects new synthesis topics based on the level of funding provided by the FMCSA. In late 2002, the Program Oversight Panel selected two task-order contractor teams through a competitive process to conduct syntheses for Fiscal Years 2003 through 2005.

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## FOREWORD

*By Christopher W. Jenks  
CTBSSP Manager  
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This synthesis will be of use to state agencies, commercial truck and bus carriers, and others interested in improving commercial vehicle safety. Prepared by Midwest Research Institute, this synthesis reports on the safety interactions of commercial trucks and buses with highway features and the highway improvements that can be made to improve the safety of heavy vehicle operations. On the basis of a comprehensive literature review and surveys of state departments of transportation and the trucking industry, this synthesis presents the state of the knowledge and practice concerning the accommodation of heavy vehicles on highways. The synthesis addresses the physical and performance characteristics of heavy vehicles that interact with highways, geometric design criteria based on vehicle characteristics, traffic control devices and traffic regulations, and the use of intelligent transportation systems (ITS) to more effectively communicate with heavy vehicle drivers and provide real-time information concerning safe vehicle operation.

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Administrators, commercial truck and bus carriers, government regulators, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and underevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

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cific topic). The primary users of the syntheses are practitioners who work on issues or problems using diverse approaches in their individual settings.

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For each topic, the project objectives are (1) to locate and assemble documented information; (2) to learn what practices have been used for solving or alleviating problems; (3) to identify relevant, ongoing research; (4) to learn what problems remain largely unsolved; and (5) to organize, evaluate, and document the useful information that is acquired. Each synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation.

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# HIGHWAY/HEAVY VEHICLE INTERACTION

## SUMMARY

Trucks and buses are larger, heavier, and less maneuverable than passenger cars and make up an increasingly larger proportion of the traffic on U.S. highways. This synthesis addresses the safety interactions of commercial trucks and buses with highway features and the highway improvements that can be made to improve the safety of heavy vehicle operations. This synthesis presents the state of knowledge and the state of practice concerning the accommodation of heavy vehicles on the highway. The synthesis is based on a comprehensive literature review and a survey of highway agencies and the trucking industry.

A wide variety of heavy vehicle types—including single-unit trucks, combination trucks with one, two, or three trailers, and buses—operate on U.S. highways. The physical and performance characteristics of heavy vehicles that interact with highways include vehicle types and configurations, weights and dimensions, turning radius, offtracking and swept path width, trailer swingout, braking distance, driver eye height, truck acceleration characteristics, rearward amplification, suspension characteristics, load transfer ratio, and rollover threshold.

Many highway geometric design criteria are based on vehicle characteristics. In many cases, truck and buses are the most critical characteristics used in defining these design criteria or assessing their appropriateness. Highway geometric design features whose design is based on consideration of vehicle characteristics include sight distance, upgrades, downgrades, acceleration lanes, horizontal curves, intersection design, interchange ramps, and roadside features.

Traffic control devices and traffic regulations have an important role in safely accommodating heavy vehicles on the highway and can be used by highway agencies to better accommodate trucks at locations where safety problems have occurred or are anticipated. The traffic control device strategies that have been used, or are being considered, to better accommodate heavy vehicles on the highway include differential speed limits for passenger cars and heavy vehicles, heavy vehicle prohibitions on particular roads, lane use restrictions for heavy vehicles, exclusive lanes and exclusive roadways for heavy vehicles, signing for long downgrades, signing and marking of interchange ramps, mitigating the restriction of sign visibility by heavy vehicles, and modifying signal timing to better accommodate heavy vehicles.

Highway agencies are increasingly using intelligent transportation system (ITS) initiatives to more effectively communicate with heavy vehicle drivers and provide real-time information concerning safe vehicle operation. The types of ITS systems in current use by highway agencies include warning systems for long downgrades, dynamic curve warning systems, and improved weigh station operations. ITS initiatives related to heavy vehicle safety also include on-board vehicle technology such as collision avoidance systems for buses.

## INTRODUCTION

### BACKGROUND

Trucks and buses are larger, heavier, and less maneuverable than passenger cars and make up an increasingly larger proportion of the traffic on U.S. highways. For example, on many rural Interstate highways, commercial trucks and buses now make up more than one-third of the traffic stream. Many of the established criteria for highway design and operation used by highway agencies are based on interactions between highway features and the vehicles that use the highways. For most of these criteria, larger and heavier vehicles, such as commercial trucks and buses, have more critical interactions with highway features than passenger cars. Safe design and operation of highway facilities requires that these interactions be understood and incorporated in the formulation of highway agency policies and in the planning of safety improvements that highway agencies make to the highway system.

### PROBLEM STATEMENT

The objective of this synthesis is to summarize and present information concerning the safety interaction of highways with commercial trucks and buses and the highway improvements that can be made to improve the safety of heavy vehicle operations. This synthesis presents the state of knowledge and the state of practice concerning the accommodation of heavy vehicles on the highway. The synthesis describes current highway design features, operational practices, and other initiatives of importance to commercial truck and bus safety. The synthesis includes issues such as roadway type and design, ramp design, exclusive roadways or lanes for commercial trucks and buses, restrictions on commercial truck and bus roadway/lane use, differential speed limits for commercial trucks and buses, roadside devices to minimize road departures and crashes, and signage for drivers. It also identifies the key physical characteristics of commercial vehicles (such as length, width, roll

stability, low- and high-speed offtracking, and braking) and the ability of these vehicles to operate within existing highway designs. The synthesis also discusses intelligent transportation system (ITS) impacts and identifies needed research relevant to commercial truck and bus safety.

This synthesis is based on a comprehensive review of relevant literature as well as surveys of and interviews with representatives of state departments of transportation and the commercial truck and bus industry. The synthesis has been prepared as part of the Commercial Truck and Bus Safety Synthesis Program (CTBSSP), sponsored by the Federal Motor Carrier Safety Administration (FMCSA) and managed by the Transportation Research Board (TRB). The FMCSA will likely use information collected to identify collaborative safety research and technology transfer activities, as well as initiatives that FMCSA could undertake on its own to better inform the commercial motor vehicle industry about highway-related safety factors. The information will also be of interest to a variety of other organizations involved in the design of highway facilities and the manufacture and operation of vehicles.

### SCOPE OF SYNTHESIS

The synthesis addresses the safety interactions between highways and heavy vehicles. For purposes of this synthesis, heavy vehicles are defined to include commercial trucks and buses. Commercial trucks are defined to include motor vehicles with gross vehicle weight ratings in excess of 4,550 kg (10,000 lb). Commercial buses are defined to include any vehicle designed and used to transport 15 or more passengers (including the driver). Only intercity and charter buses are considered. School buses and local transit buses are not addressed by this synthesis, although many of the issues discussed may also apply to these vehicles.

The issues considered in the synthesis are those that (1) have a direct relationship to interactions between heavy vehicles and roadway features, roadside design features, traffic control devices, or traffic regulations and (2) have a direct relationship to safety. The scope of the synthesis does not include issues related exclusively to driver behavior or human factors, except when those issues also involve interaction with the roadway. For example, hours-of-service regulations or in-vehicle alarms to rouse drowsy drivers are considered to be outside the scope of the synthesis. ITS initiatives intended to improve safety are addressed in the synthesis, but commercial vehicle operations initiatives that are related exclusively to reducing delays or minimizing costs are not. Issues related to structural design of bridges, pavement design, and pavement wear are outside the scope of the synthesis, even though they involve interactions with heavy vehicles, because they are primarily cost issues rather than safety issues.

## **ORGANIZATION OF THIS SYNTHESIS**

The remainder of this synthesis is organized as follows. Chapter Two presents the physical and performance characteristics of heavy vehicles that are related to their interactions with highways. Chapter Three reviews the role of roadway geometric design in safely accommodating heavy vehicles on the highway. The role of traffic control devices and traffic regulations in safely accommodating heavy vehicles on the highway is reviewed in Chapter Four. Chapter Five describes ITS initiatives intended to improve the safety of highway/heavy vehicle interactions. The conclusions and recommendations of the synthesis are presented in Chapter Six.

Appendix A presents drawings of typical heavy vehicle types that are considered in the design of highways. The drawings in Appendix A illustrate the various vehicle types that are mentioned throughout the synthesis. Appendix B present the results of the survey of highway agencies conducted for this synthesis and Appendix C presents the results of the survey of the commercial trucking industry.