CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this synthesis are as follows:

1. 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. These heavy vehicle types each have unique characteristics that interact with highway features. The understanding of these interactions is important to the safe operation of the highway transportation system.

2. The dimensions of heavy vehicles, particularly the spacing between axles and hitch points and the front and rear overhang distances, are primary determinants of the vehicle turning radius, off-tracking, and swept path width. These vehicle performance measures are, in turn, key factors in the design of intersections, horizontal curves, and other highway features to accommodate heavy vehicles.

3. Antilock brakes, which permit vehicles to stop in a controlled fashion without jackknifing or losing control, are now required by Federal regulation for all newly manufactured heavy vehicles. The antilock brakes used on heavy vehicles must meet a performance standard established in FMVSS 121. Braking capabilities of trucks have improved to the point that the braking distances of passenger cars and trucks on wet pavements, where braking distance is most critical to safety, are now nearly equal. Trucks have longer braking distances than passenger cars on dry pavements, however.

4. The drivers of heavy vehicles sit higher than passenger car drivers and, thus, have greater eye heights. As a result, truck and bus drivers can see farther than passenger car drivers when approaching vertical sight restrictions, such as hillcrests. This may permit truck and bus drivers to see traffic conditions or objects in the road sooner and, therefore, begin braking sooner. However, there is no comparable advantage for truck and bus drivers at horizontal sight restrictions.

5. Because of their lower acceleration rates and greater length, heavy vehicles take longer than passenger cars to accelerate and clear specific conflict zones, such as intersections and railroad-highway grade crossings. Heavy vehicle speed maintenance capabilities on upgrades are a function of the vehicle’s weight-to-power ratio and the length and steepness of the grade.

6. In combination trucks with more than one trailer, the second or third trailer may experience higher lateral acceleration than the first trailer in lane change or avoidance maneuvers. The maximum desirable lateral displacement of a trailer due to this rearward amplification is 0.8 m (2.7 ft).

7. Vehicle characteristics related to the dynamic stability of trucks, as represented by load-transfer ratio and rollover threshold, include dynamic inter-axle load transfer, height of roll center, roll stiffness, roll steer coefficient, compliance steer coefficient, center-of-gravity height, overall weight, and longitudinal and lateral weight distribution.

8. The current sight distance criteria used in highway geometric design, as presented in the AASHTO Green Book—including stopping sight distance, passing sight distance, intersection sight distance, and railroad-highway grade crossing sight distance—can reasonably accommodate the current heavy vehicle fleet.
MUTCD sight distance criteria used to mark passing and no-passing zones on two-lane highways are suitable for a passenger car passing a passenger car. While the marking criteria do not explicitly accommodate trucks, there is no indication that passing maneuvers involving trucks are made, with any frequency, in passing zones where sufficient sight distance is not available.

9. The geometrics and traffic control systems for railroad-highway grade crossings located close to highway intersections should be designed such that heavy vehicles are not forced to stop in a position where the rear of the vehicle extends onto the railroad tracks.

10. Where long, steep upgrades reduce truck speeds by 16 km/h (10 mi/h) or more, the provision of truck climbing lanes may be considered. The AASHTO Green Book presents criteria for determining where truck climbing lanes are warranted and economically justified.

11. Long, steep downgrades present a safety concern for heavy vehicles because, if the vehicle service brakes are used too often in descending the grade, they may overheat and lose their ability to decelerate the vehicle. Because of these risks, highway agencies provide warning signs and roadside brake check areas at the top of some downgrades and provide emergency escape ramps for out-of-control vehicles in the middle or lower portion of some downgrades.

12. Acceleration lanes are provided at entrance ramps to major highways to provide a location for vehicles to increase their speed before entering the highway. The AASHTO Green Book criteria for the length of acceleration lanes appear adequate to accommodate average trucks but may not accommodate the lowest performance trucks.

13. Horizontal curves designed in accordance with AASHTO Green Book criteria allow heavy vehicles to operate at the design speed of the curve with a substantial margin of safety against skidding or rolling over. Skidding or rollover should occur only when a heavy vehicle substantially exceed the design speed of the curve; the greatest risk from exceeding the design speed of a curve occurs on curves with lower design speeds.

14. Heavy vehicles are a key consideration in the design of intersections. Intersection features that must consider the presence, frequency, and characteristics of heavy vehicles include curb return radii for right turns, storage lengths for left-turn lanes, median widths on divided highways, and the offset between opposing left-turn lanes.

15. Interchange ramps are designed to provide sufficient width for other vehicles to pass a stalled heavy vehicle. The design and signing of horizontal curves on ramps is important to their safe operation because safety problems may result, as noted above, when heavy vehicles exceed the design speed of a curve. A special truck rollover warning sign for use at such locations has been used by highway agencies.

16. About 40 percent of highway agencies have used or are considering the use of differential speed limits for passenger cars and heavy vehicles. No safety benefits from differential speed limits have been demonstrated and there is concern that differential speed limits could have an adverse effect on safety due to increases in the speed variance of traffic.

17. Highway agencies have tried to improve traffic operations and safety by restricting heavy vehicle use of the left lane or restricting heavy vehicles to use only the right lane on major highways. Most evaluations of such lane restrictions have shown no effect on safety, positive or negative. A recent test in Houston for an eight-month period in one freeway corridor did find a safety benefit from left-lane restrictions for heavy vehicles.
18. Highway agencies have prohibited truck travel on selected highways for a variety of reasons unrelated to safety. Naturally, this eliminates truck-related accidents on the facility in question, but no studies for these sites have examined the safety impact of truck diversion to other routes.

19. Some highway agencies have implemented, and others are considering, exclusive truck lanes or exclusive truck roadways on selected facilities. No measures of the safety performance of such facilities are available.

20. Heavy vehicles, because of their size, can block the view of highway signs by other motorists. Highway agencies have developed specific methods for dealing with this problem where it occurs, including the use of additional advance warning signs, placement of signs on both sides of the road, and placement of overhead signs.

21. Heavy vehicles are often a consideration in selecting the length of a yellow signal phase and assessing the need for an all-red clearance interval at signalized intersections.

22. Highway agencies have used ITS technologies to improve safety for heavy vehicles at several types of sites including long, steep downgrades, sharp horizontal curves, and weigh stations. On-board collision avoidance warning systems for buses are also being tested.

The following recommendations have been developed as a result of the synthesis preparation:

1. The marking of passing and no-passing zones on two-lane highways should be evaluated to ensure that heavy vehicles use them properly. The sight distance criteria in the MUTCD used for marking passing and no-passing zones are appropriate for passenger cars, but do not explicitly consider heavy vehicles. Research to confirm that this does not lead to poor safety performance in passing zones would be desirable.

2. The current AASHTO Green Book criteria for acceleration lane lengths at entrance ramps to major highways appear appropriate to accommodate average trucks, but do not appear to accommodate the lowest performance trucks. Research is needed to determine whether this leads to poor safety performance and whether the design criteria for acceleration lane length can be changed in a cost-effective manner.

3. Offset left-turn lanes have been found to be effective in reducing the potential for opposing left-turn vehicles to restrict their drivers’ view of potentially conflicting traffic. Such sight restrictions are of greatest concern when one or more of the opposing left-turn vehicles is a large truck or bus. However, the frequency of accidents related to such sight restrictions and the benefits of providing offset left-turn lanes to remove such sight restrictions has not been documented. Research on this topic would be desirable.

4. More research on the issue of differential speed limits is needed. The belief that lower heavy vehicle speeds will reduce accident rates is widespread but unproven. By contrast, fundamental traffic engineering principles suggest that accident rates increase as the variance of vehicle speeds on a facility increases. Highway agencies needed better information on the safety effects of differential speed limits.

5. A recent limited test of left-lane truck restrictions in Houston showed positive results for safety. However, all previous research on truck lane restriction has found no effect on safety. Further research based on field trials would be desirable to establish whether lane restrictions have safety benefits.

6. Many highway agencies are facing decisions about whether to reduce traffic congestion by building exclusive truck lanes or exclusive truck roadways. Research is needed to provide safety performance measures to assist highway agencies in such decisions.
7. The ongoing evaluation of ITS systems that use new technology to improve heavy vehicle safety should continue. New and innovative systems should be developed and the safety effectiveness of both existing and new systems should be evaluated and documented.
REFERENCES


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46. “TTI Evaluates Lane Restrictions for Houston Demonstration Project,” Texas Transportation Researcher, Vol. 38, No. 1, Texas Transportation Institute, College Station, TX, 2002.


62. Lee, C.E., D.W. Borchardt, and Q. Fei, Truck Monitoring and Warning Systems for Freeway-To-Freeway Connections, Report TX-00/7-2915-1, Texas Department of Transportation, October 1999.


APPENDIX A

DESIGN VEHICLES

Many elements of highway geometric design are based on the consideration of specific design vehicles. These design vehicles are used to assure that highway geometric features are designed to accommodate specific classes of heavy vehicles. The truck and bus design vehicles used in the current AASHTO Green Book (1) are illustrated in this appendix, along with some additional design vehicles (2) that have been recommended in research for possible future incorporation in the Green Book, but are not currently included. The design vehicles are presented here to illustrate the various heavy vehicle types discussed in this synthesis. For comparative purposes, school buses and city transit buses have been included in this appendix even though these bus types are not within the scope of the synthesis. The dimensions of the design vehicles shown in this appendix typically represent the larger vehicles within a specific design vehicle classification, but not necessarily the largest possible vehicle.

The design vehicles presented in this appendix are:

- Single-unit truck (two axles)—Figure A-1
- Single-unit truck (three axles)—Figure A-2
- Intercity bus (BUS-12 [BUS-40])—Figure A-3
- Intercity bus (BUS-14 [BUS-45])—Figure A-4
- City transit bus—Figure A-5
- Conventional school bus—Figure A-6
- Large school bus—Figure A-7
- Articulated city transit bus—Figure A-8
- Intermediate semitrailer (WB-12 [WB-40])—Figure A-9
- Intermediate semitrailer (WB-15 [WB-50])—Figure A-10
- Interstate semitrailer (WB-19 [WB-62])—Figure A-11
- Interstate semitrailer (WB-20 [WB-67])—Figure A-12
- Double-trailer combination—Figure A-13
- Rocky Mountain double combination—Figure A-14
- Turnpike-double combination—Figure A-15
- Triple-trailer combination—Figure A-16
Figure A-1. Dimensions of single-unit (SU) truck design vehicle in current Green Book (1).

Figure A-2. Dimensions of recommended three-axle single-unit (SU-8 [SU-25]) design vehicle.
Figure A-3. Dimensions of intercity transit bus (BUS-12 [BUS-40]) design vehicle in current Green Book (1).

Figure A-4. Dimensions of intercity transit bus (BUS-14 [BUS-45]) design vehicle in current Green Book (1).
Figure A-5. Dimensions of city transit bus design vehicle in current Green Book (1).

Figure A-6. Dimensions of conventional school bus design vehicle in current Green Book (1).
Figure A-7. Dimensions of large school bus design vehicle in current Green Book (1).

Figure A-8. Dimensions of articulated city transit bus design vehicle in current Green Book (1).
Figure A-9. Dimensions of intermediate semitrailer (WB-12 [WB-40]) design vehicle in current Green Book (1).

Figure A-10. Dimensions of intermediate semitrailer (WB-15 [WB-50]) design vehicle in current Green Book (1).
Figure A-11. Recommended revision in the dimensions of interstate semitrailer (WB-19 [WB-62]) design vehicle (2).

Figure A-12. Recommended dimensions of interstate semitrailer (WB-20 [WB-67]) design vehicle (2).
Figure A-13. Dimensions of double-trailer combination (WB-20D [WB-67D]) design vehicle in current Green Book (1).

Figure A-14. Recommended dimensions of Rocky Mountain Double combination (WB-28D [WB-92D]) design vehicle.
Figure A-15. Dimensions of turnpike-double combination (WB-33D [WB-109D]) design vehicle in current Green Book (1).

Figure A-16. Dimensions of triple-trailer combination (WB-30T [WB-100T]) design vehicle in current Green Book (1).
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APPENDIX B

HIGHWAY AGENCY SURVEY

A survey of state highway agencies was conducted to determine any safety problems they have encountered related to highway/heavy vehicle interactions and mitigation measures that may have taken to address such problems.

SURVEY QUESTIONNAIRE

A copy of the survey questionnaire is presented in Figure B-1. The questionnaire includes 15 questions related to highway agency experience with highway/heavy vehicle interactions. The questionnaire included both objective questions that could be answered by placing checkmarks or completing blank spaces and descriptive questions that required a written response.

SURVEY DISTRIBUTION AND RESPONSE

The survey was sent to the chief highway design or traffic engineer of each of the 50 state highway agencies. Responses were received from 35 of the 50 agencies, for an overall response rate of 70 percent. The responses included highway agencies from all geographic areas of the United States. The responses have been tabulated and analyzed and are presented below.

Question 1—Safety Problems Related to Highway/Heavy Vehicle Interactions

Question 1 asked highway agencies whether they had encountered safety problems related to interaction of heavy trucks and buses with specific types of highway features. The responses are presented in Table B-1. Overall, 29 of the 35 highway agencies (83 percent) reported that they had experienced at least one type of heavy vehicle safety problem related to highway geometric design. Four geometric design features were reported as being encountered most frequently; problems related to horizontal curve radius, vertical grade, intersection curb return radii for right turns, and interchange ramps had each been encountered by 51 percent of highway agencies. Other problems reported with some frequency were related to: railroad-highway grade crossings (40 percent of highway agencies); acceleration lanes (37 percent); intersection turning paths for left turns (34 percent); horizontal curve superelevation (31 percent); intersection turn lanes (29 percent); and deceleration lanes (29 percent).

States that had encountered any of the problems identified in Table B-1 were asked in Question 1b whether they consider those problems to be potentially correctable through geometric design or traffic control improvements. A total of 24 of the 29 highway agencies (83 percent) that had experienced safety problems related to highway/heavy vehicle interactions thought that those problems were potentially correctable through geometric design or traffic control improvements. The overall assessment of most highway agencies is that the problems they have encountered can be addressed with existing geometric design and traffic control criteria. Thus, addressing the problems that exist is primarily an issue of needing sufficient funding rather then needing revised geometric design or traffic control policies. In response to Question 1c, only five highway agencies indicated that they thought changes in geometric design or traffic control criteria for trucks were needed. Three of those five states explicitly cited the need to update design vehicles to match the truck fleet.

Question 2—Are Changes Needed to the Design Vehicles in the 2001 AASHTO Green Book?

In response to Question 2, three state highway agencies responded that changes to design vehicles were needed. The specific design vehicle changes
STATE HIGHWAY AGENCY SURVEY

The Commercial Truck and Bus Safety Synthesis Program is sponsored by the Federal Motor Carrier Safety Administration and is managed by the Transportation Research Board. This survey is intended to identify what types of safety problems related to interactions between heavy trucks and buses and roadway features have been encountered by state highway agencies and what types of policy changes or roadway engineering improvements have been made to address those problems. The survey should be completed by a geometric design or traffic safety engineer.

1. Has your agency encountered any safety problems related to the interaction of heavy trucks or buses with the following roadway geometric design features? (check all that apply)
   - Stopping sight distance
   - Intersection sight distance
   - Horizontal curve radius
   - Horizontal curve superelevation
   - Vertical grade
   - Intersection curb return radii (turning paths for right-turns)
   - Intersection turning paths for left-turns
   - Intersection turn lanes
   - Interchange ramps
   - Acceleration lanes
   - Deceleration lanes
   - Railroad-highway grade crossings
   - Other (please specify)

   If you answered YES to any of the preceding questions, do you consider those problems potentially correctable through geometric design or traffic control improvements?

   Is there a need for improvement in existing geometric design and traffic control criteria related to heavy trucks or buses?

---

*Figure B-1. Questionnaire used for highway agency survey.*
2. Based on the current heavy truck and bus population using the roads under your agency’s jurisdiction, do you see a need for changes in, or additions to, the design vehicles presented in the 2001 edition of the AASHTO Policy on Geometric Design of Highways and Streets (commonly known as the Green Book)? ___ YES _____ NO

If YES, what changes or additions would you recommend:

3. Does your agency have warrants for added truck climbing lanes on steep grades? _____ YES ____ NO

If YES, do these warrants differ from those presented in the AASHTO Green Book? ___ YES ____ NO

If your warrants differ from those in the AASHTO Green Book, would you please send us a copy of those warrants?

4. Has your agency installed emergency escape ramps for trucks on long, steep downgrades? ____ YES ____ NO

If YES, do you have any design criteria or warrants for emergency escape ramps that differ from those presented in the AASHTO Green Book? ___ YES ____ NO

If your criteria or warrants differ from those in the AASHTO Green Book, would you please send us a copy of those criteria or warrants?

Figure B-1. Questionnaire used for highway agency survey. (Continued)
5. Does your agency use, or are you considering, any of the following approaches to safely accommodating large trucks and buses on the highway (check all that apply)?

<table>
<thead>
<tr>
<th>Approach</th>
<th>Currently used</th>
<th>Considering for future use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different speed limits for cars and trucks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restriction of truck and bus use of left lane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restriction of all trucks and buses to right lane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision of brake check areas in advance of steep downgrades</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downgrade signing to promote proper speed and gear selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusive lanes for use by heavy trucks and buses only (no passenger cars permitted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusive lanes for use by buses only (no passenger cars or trucks permitted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusive roadways for use by heavy vehicles only (no passenger cars permitted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified traffic signal timing or longer clearance intervals for heavy vehicles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Has your agency evaluated or estimated the safety effectiveness of any of the improvement types listed in Question 5? ____ YES ____ NO

   If YES, what did the evaluation find? If possible, may we have a copy of the evaluation?

7. If your agency has used different speed limits for passenger cars and heavy vehicles on the same facility (see Question 5):

   What is the speed limit for passenger cars? ____ for heavy vehicles? _____

   On what types of facilities are these speed limits used?
8. Has your agency encountered safety problems related to truck or buses on interchange ramps (see Question 1)? ___ YES ____NO

If YES, what types of countermeasures have you used for such problems? (check all that apply):

- Advisory speed limits for trucks on specific ramps
- Advisory speed limits for all vehicles on specific ramps
- Regulatory speed limits for trucks on specific ramps
- Regulatory speed limits for all vehicles on specific ramps
- Special warning signs for trucks (e.g., truck rollover sign)
- Special warning signs for trucks accompanied by permanent flasher
- Special warning signs for trucks with flashers activated when a high-speed truck is detected
- Reconstruction of ramp to change horizontal curve radius or superelevation
- Other (please specify)

9. Does your agency have any formal criteria for deciding whether to prohibit heavy trucks and buses from using particular roadways? ___ YES ____ NO

If YES, may we have a copy of those criteria?

10. Has your agency encountered any problems related to truck or bus travel at night that are related to, or potentially correctable by, geometric design or traffic control? ___ YES ___ NO

If YES, what is the nature of those problems:

---

*Figure B-1. Questionnaire used for highway agency survey. (Continued)*
11. Does your agency use roadside safety hardware (bridge rail, guardrail, etc.) that is designed specifically to accommodate large trucks and buses?  
___ YES ___ NO

If YES, what types of hardware are used? Under what situations is such hardware used?  
Has such hardware been successfully crash tested with large trucks or buses?

12. Does your agency use any signing intended specifically for drivers of heavy trucks and buses?  
___ YES ___ NO

If YES, what types of signing are used:

13. Has your agency experienced safety problems related to obstruction of the visibility of signs or other traffic control devices by heavy trucks or buses?  
_____ YES _____ NO

If YES, has your agency implemented any specific traffic control device placement criteria or countermeasures for mitigating the effect of such obstructions to visibility?  
_____ YES _____ NO

If YES, please describe:

14. Has your agency implemented any ITS initiatives intended specifically to improve safety for heavy trucks and buses?  
___ YES ___ NO

If YES, please describe those ITS initiatives:

*Figure B-1. Questionnaire used for highway agency survey. (Continued)*
15. Has your agency encountered any other specific safety problems related to the interaction between heavy trucks or buses and roadway features that have not been mentioned previously in your response to this questionnaire?
   ___ YES ___ NO

   If YES, what is the nature of these problems?

16. May we have the name of an individual in your agency that we may contact for further information should that be necessary?

   Name _______________________________
   Agency ______________________________
   Address _____________________________
                                 _______________
                                 _______________
   Phone: _____________________________
   Fax: _____________________________
e-mail: _____________________________

   Your response to this survey prior to August 20, 2002, would be appreciated. Please mail your response to:

   Mr. Douglas W. Harwood
   Principal Traffic Engineer
   Midwest Research Institute
   425 Volker Boulevard
   Kansas City, MO 64110

Figure B-1. Questionnaire used for highway agency survey. (Continued)
Table B-1. Highway agency responses concerning safety problems encountered by heavy vehicles related to specific geometric design features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stopping sight distance</td>
<td>8</td>
<td>23%</td>
</tr>
<tr>
<td>Intersection sight distance</td>
<td>8</td>
<td>23%</td>
</tr>
<tr>
<td>Horizontal curve radius</td>
<td>18</td>
<td>51%</td>
</tr>
<tr>
<td>Horizontal curve superelevation</td>
<td>11</td>
<td>31%</td>
</tr>
<tr>
<td>Vertical grade</td>
<td>18</td>
<td>51%</td>
</tr>
<tr>
<td>Intersection curb return radii (turning paths for right-turns)</td>
<td>18</td>
<td>51%</td>
</tr>
<tr>
<td>Intersection turning paths for left-turns</td>
<td>12</td>
<td>34%</td>
</tr>
<tr>
<td>Intersection turn lanes</td>
<td>10</td>
<td>29%</td>
</tr>
<tr>
<td>Interchange ramps</td>
<td>18</td>
<td>51%</td>
</tr>
<tr>
<td>Acceleration lanes</td>
<td>13</td>
<td>37%</td>
</tr>
<tr>
<td>Deceleration lanes</td>
<td>10</td>
<td>29%</td>
</tr>
<tr>
<td>Railroad-highway grade crossings</td>
<td>14</td>
<td>40%</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>4</td>
<td>11%</td>
</tr>
</tbody>
</table>

requested were inclusion of trucks with 17.4-m (57-ft) trailers and 4.9-m (16-ft) wide mobile homes as design vehicles.

**Question 3—Warrants for Added Climbing Lanes on Steep Grades**

In response to Question 3, 23 highway agencies (66 percent) indicated that they have explicit warrants for adding climbing lanes on steep grades. In all but four states, the climbing lane warrants are identical to those presented in the AASHTO Green Book.

**Question 4—Use of Emergency Escape Ramps on Long, Steep Downgrades**

The responses to Question 4 indicated that 22 out of 35 highway agencies (63 percent) have installed emergency escape ramps on long, steep downgrades. Only one highway agency indicated that they have criteria for emergency escape ramps that differ from the AASHTO Green Book. That state uses a combination of accident experience and a model for predicting truck brake temperature to evaluate the need for escape ramps at particular locations.

**Question 5—Highway Agency Use of Specific Methods for Safely Accommodating Heavy Vehicles**

Highway agencies were asked in Question 5 whether they use specific techniques for safely accommodating large trucks and buses on the highway. The responses are presented in Table B-2. The most widely used specific methods for accommodating heavy vehicles are:

- downgrade signing to promote proper speed and gear selection (used by 74 percent of highway agencies)
- provision of brake check areas in advance of steep downgrades (49 percent)
- restriction of truck and bus use of the left lane (37 percent)
- different speed limits for cars and trucks (31 percent)

The specific methods most commonly being considered for future use are:

- restriction of all trucks and buses to the right lane (11 percent)
- different speed limits for cars and trucks (9 percent)
Table B-2. Highway agency used for specific methods for safety accommodating heavy vehicles on the highway

<table>
<thead>
<tr>
<th>Method</th>
<th>Currently used</th>
<th>Considering for future used</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of</td>
<td>Percentage of responses</td>
<td>Number of</td>
</tr>
<tr>
<td></td>
<td>responses</td>
<td></td>
<td>responses</td>
</tr>
<tr>
<td>Different speed limits for cars and trucks</td>
<td>11</td>
<td>31%</td>
<td>3</td>
</tr>
<tr>
<td>Restriction of truck and bus use of left</td>
<td>13</td>
<td>37%</td>
<td>3</td>
</tr>
<tr>
<td>lane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restriction of all trucks and buses to right</td>
<td>2</td>
<td>6%</td>
<td>4</td>
</tr>
<tr>
<td>lane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision of brake check areas in advance</td>
<td>17</td>
<td>49%</td>
<td>1</td>
</tr>
<tr>
<td>of steep downgrades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downgrade signing to promote proper speed</td>
<td>26</td>
<td>74%</td>
<td>0</td>
</tr>
<tr>
<td>and gear selection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusive lanes for use by heavy trucks</td>
<td>3</td>
<td>9%</td>
<td>3</td>
</tr>
<tr>
<td>and buses only (no passenger cars)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusive lanes for use by buses only (no</td>
<td>3</td>
<td>9%</td>
<td>3</td>
</tr>
<tr>
<td>passenger cars or trucks)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusive roadways for use by heavy vehicles</td>
<td>4</td>
<td>11%</td>
<td>3</td>
</tr>
<tr>
<td>only (no passenger cars)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified traffic signal timing or longer</td>
<td>0</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>clearance intervals for heavy vehicles</td>
<td>3</td>
<td>9%</td>
<td>1</td>
</tr>
</tbody>
</table>

- restriction of truck and bus use of the left lane (9 percent)
- exclusive lanes for use by heavy trucks and buses only (9 percent)
- exclusive lanes for use by trucks only (9 percent)

**Question 6—Evaluation of Improvement Types Identified in Question 5**

Only 3 of the 35 highway agencies (9 percent) indicated in response to Question 6 that they had conducted any formal evaluation of the improvement types identified in Question 5. Two states indicated that they had evaluated restriction of trucks to particular lanes, but in both cases the results were inconclusive. One state indicated that an evaluation was under way at the present time.

**Question 7—Different Speed Limits for Passenger Cars and Heavy Vehicles**

Table B-2 showed that 11 states have used different speed limits for passenger cars and heavy vehicles on the same facility. Table B-3 shows the speed limits that have been used in different states. In some states, the use of differential speed limits is
a statewide practice; in others, differential speed limits are used at particular sites. The maximum difference in speed limit that has been used is 16 km/h (10 mi/h). Two highway agencies stated explicitly in response to this question that they consider the use of differential speed limits to be undesirable. Another agency stated that they previously used differential speed limits, but no longer do so.

**Question 8—Safety Problems Encountered by Heavy Vehicles at Interchange Ramps**

In response to Question 8, 26 of the 35 states (74 percent) indicated that they had encountered safety problems related to heavy vehicles on interchange ramps. Table B-4 summarizes the specific types of countermeasures that have been used by highway agencies to address such problems. The most frequently used countermeasures are:

- advisory speed limits for all vehicles on specific ramps (60 percent of all responding highway agencies)
- special warning signs for trucks (e.g., truck rollover sign) (57 percent)
- reconstruction of ramp to change horizontal curve radius or superelevation (37 percent)
- advisory speed limits for trucks on specific ramps (11 percent)

**Question 9—Criteria for Prohibiting Heavy Vehicles From a Roadway**

Nine highway agencies (26 percent) indicated in response to Question 9 that they have formal criteria for deciding whether to prohibit heavy vehicles for using particular roadways. One state indicated that they have prohibited trucks on one particular 10 km (6 mi) section of Interstate highway. Another state indicated that they have had emergency regulations on truck prohibition that are currently being reevaluated and amended. A third state indicated that roadway geometric design problems are one factor in deciding whether to permit trucks. However, neither of these states cited specific criteria used in deciding these heavy vehicle prohibitions. One state indicated that they impose weather-related weight restrictions on trucks. In the remaining states, heavy vehicle prohibitions were related to bridge or pavement structural capacities.

**Question 10—Problems Related to Heavy Vehicle Travel at Night**

In response to Question 10, only 1 agency out of 35 (3 percent) indicated that they had encountered problems related to truck or bus travel at night that are related to, or potentially correctable by, geometric design or traffic control. That one agency cited a problem related to low visibility of border stations at night.

**Question 11—Roadside Safety Hardware to Accommodate Heavy Vehicles**

A total of 10 of the 35 responding highway agencies (29 percent) indicate that they use roadside safety hardware (bridge rail, guardrail, etc.) that is designed specifically to accommodate large trucks and buses. The types of roadside safety hardware used:

- concrete median barriers, including tall barriers
- bridge rail
- super heavy-duty guardrail at the bottom of a long downgrade

Respondents indicated that they have used NCHRP Report 350 (30) test levels 4 and 5 for testing of such barriers, but not all hardware currently used to accommodate trucks has been tested with trucks. Factors included in deciding where to use such hardware include high truck percentages and high truck accident experience. Tall median barriers are used for glare control, as well as to accommodate trucks.
Table B-3. Highway agency usage of different speed limits on the same facility for passenger cars and heavy vehicles

<table>
<thead>
<tr>
<th>State</th>
<th>Speed limits (mi/h)</th>
<th>Facility type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td>Idaho</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td>Illinois</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>Maine</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td>Michigan</td>
<td>70</td>
<td>55</td>
</tr>
<tr>
<td>Montana</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td>North Carolina</td>
<td>65</td>
<td>55 or 60</td>
</tr>
<tr>
<td>Ohio</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td>Texas</td>
<td>75/70/65</td>
<td>70/65/60/65/55</td>
</tr>
<tr>
<td>Virginia</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Washington</td>
<td>70</td>
<td>60</td>
</tr>
</tbody>
</table>

Table B-4. Highway agency responses concerning safety problems related to trucks or buses on interchange ramps

<table>
<thead>
<tr>
<th>Response Description</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisory speed limits for trucks on specific ramps</td>
<td>11</td>
<td>31%</td>
</tr>
<tr>
<td>Advisory speed limits for all vehicles on specific ramps</td>
<td>21</td>
<td>60%</td>
</tr>
<tr>
<td>Regulatory speed limits for trucks on specific ramps</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>Regulatory speed limits for all vehicles on specific ramps</td>
<td>2</td>
<td>6%</td>
</tr>
<tr>
<td>Special warning signs for trucks (e.g., truck rollover sign)</td>
<td>20</td>
<td>57%</td>
</tr>
<tr>
<td>Special warning signs for trucks accompanied by permanent flasher</td>
<td>9</td>
<td>26%</td>
</tr>
<tr>
<td>Special warning signs for trucks with flashers activated when a high-speed truck is detected</td>
<td>7</td>
<td>20%</td>
</tr>
<tr>
<td>Reconstruction of ramp to change horizontal curve radius or superelevation</td>
<td>13</td>
<td>37%</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>6%</td>
</tr>
</tbody>
</table>

Question 12—Signing Specifically for Drivers of Heavy Vehicles

In response to Question 12, 24 of the 35 respondents (69 percent), indicated that they have used signing intended specifically for drivers of heavy trucks and buses. This question was primarily intended to elicit comments on new or innovative types of signing, but the list of types of signing presented below obviously includes types of signing that are used by all highway agencies. The specific types of signing used are:

- steep downgrade/brake check signing
- emergency escape ramp signing
- truck rollover signing
- curve warning signs
- truck advisory speed signs
- truck speed limits
- weight restrictions
- height restrictions/vertical clearance
• other truck restrictions
• lane use signing
• truck route signing
• slow vehicles keep right
• restricted use of engine brakes
• high wind warning signs
• low ground clearance warning signs

Question 13—Obstruction of Sign Visibility by Heavy Vehicles

Seven out of the 35 highway agencies that responded to the survey (20 percent) indicated in response to Question 13 that they had experienced safety problems related to the obstruction of sign visibility by heavy trucks and buses. In one case, the state indicated that the problem was not documented, but was based on limited cases involving overweight/oversize vehicles operating under permit. The other six highway agencies indicated that they had taken actions at specific sites to alleviate the problems. These actions included:

• Placing regulatory signs on both sides of the roadway on freeways
• Using double stop signs or placing stop signs on both sides of the road
• Using overhead signs
• Placing an additional traffic signal head over the opposing through lane
• Additional use of advance warning signs

Question 14—ITS Initiatives to Improve Heavy Vehicle Safety

In response to Question 14, 13 of the 35 highway agencies (37 percent) indicated that they have implemented ITS initiatives intended specifically to improve safety for heavy truck and buses. The ITS initiatives cited include:

• Changeable message signs
• Allowing pre-approved trucks to bypass weigh scales
• Truck rollover alert system
• Downhill truck warning system
• Wind advisory warning system

Question 15—Other Safety Problems Related to Highway/Heavy Vehicle Interaction

The responding highway agencies were asked in Question 15 whether they had encountered any other safety problems, not mention in the preceding questions, that were related to the interaction between heavy trucks or buses and roadway features. The six highway agencies that responded mentioned a total of seven specific problems not addressed earlier in this appendix. These are:

• Geometric design of work zones (specifically, median crossovers)
• Failure of trucks to stop as they approach slow moving or stopped traffic from the rear
• Deer hits by heavy vehicles
• Trucks parking on interchange ramps
• Visibility problems due to dust storms
• Operation of double-trailer trucks in snow conditions
• Superelevation rates for horizontal curves on steep downgrades
APPENDIX C

INDUSTRY SURVEY

A survey of heavy vehicle operators and the national organizations that represent them was conducted to determine any safety problems they have encountered related to highway features at which they have encountered safety concerns related to highway/heavy vehicle interactions and mitigation measures that have taken or are planned to address such concerns.

SURVEY QUESTIONNAIRE

A copy of the survey questionnaire is presented in Figure C-1. The questionnaire includes eight questions related to the respondents’ experience with highway/heavy vehicle interactions. The questionnaire included both objective questions that could be answered by placing checkmarks or completing blank spaces and descriptive questions that required a written response.

SURVEY DISTRIBUTION AND RESPONSE

The survey was sent to national organizations that represent the trucking industry and through those national organizations to individual trucking companies and owner/operators. This approach was adopted so that the individual respondents would have confidence that the survey was for a worthwhile purpose and that the results would, in fact, be used to improve highway safety.

Responses were received from 33 organizations in the trucking industry. Because there is no formal industry data base from which to choose respondents systematically or randomly, the survey results should not be considered as a representative sample of the trucking industry. Nevertheless, the survey results provide valuable information on trucking industry viewpoints.

The responses represent national industry organizations and firms in all geographic areas of the United States. Responses were received from organizations and firms in 20 of the 50 states.

Question 1—Type of Commercial Trucking or Bus Operation

Question 1 asked respondents the type of commercial trucking or bus operation they represent. The responses to this questions are presented in Table C-1, which shows 12 percent of the responses were from trucking industry organizations, 46 percent were from trucking companies or fleet owners, and 42 percent were received from truck owner/operators. No responses have been received from the bus industry.

Questions 2 and 3—Industry Segment

Questions 2 and 3 asked respondent which segments of the trucking and bus industry, respectively, they represent or operate in. Table C-2 summarizes the responses from the trucking industry to Question 2. The largest number of responses represent the private truckload carriers, for-hire truckload carriers, and less-than-truckload carriers, with some responses from specialized carrier types. The tabulated responses total more than 100 percent because multiple responses to this question were permitted.

Question 4—Highway Features Considered to Be Safety Concerns

Question 4 asked about highway features considered to be safety concerns. Table C-3 summarizes the industry responses to this question. The greatest concern related to highway features identified by respondents is tight radii for right turns at intersections; this was cited as a high-priority concern by 94 percent of the survey
The Commercial Truck and Bus Safety Synthesis Program (CTBSSP) is sponsored by the Federal Motor Carrier Safety Administration and is managed by the Transportation Research Board. This survey is intended to identify the types of safety concerns related to interactions between heavy trucks and buses and roadway features that have been encountered by owners and drivers of heavy trucks and buses and the types of safety improvements might be effective in mitigating those concerns. This survey will help highway agencies to understand your views in planning future safety improvement programs. The results will be published in a CTBSSP synthesis report. All published information on this survey will be aggregated so that the responses of individual persons or organizations are not released. Your assistance in responding to the survey would be appreciated.

1. What is your connection to commercial trucking and bus operation (check one):

   Trucking industry organization
   Bus industry organization
   Trucking company/fleet owner
   Bus company/fleet owner
   Truck owner/operator
   Individual truck driver
   Individual bus driver

2. If you are associated with the trucking industry, what segment of that industry do you represent or operate in (check all that apply)?

   Less-than-truckload hauling
   Truckload hauling (for hire)
   Truckload hauling (private)
   Bulk materials hauling
   Hazardous materials trucking
   Automobile carrier
   Movers/household goods
   Other (specify):

3. If you are associated with the bus industry, what segment of that industry do you represent or operate in (check all that apply)?

   Intercity scheduled bus
   Charter bus
   Local transit bus
   School bus
   Other (specify):

Figure C-1. Questionnaire used for industry survey.
4. Which of the following highway features do you consider to be safety concerns for truck and bus operation that are most in need of improved highway design or traffic control (check one response for each item)?

<table>
<thead>
<tr>
<th>Safety Concern</th>
<th>High Priority/Major Safety Concerns at Many Locations</th>
<th>Low Priority/Safety Concerns at a Few Locations</th>
<th>Not a Concern/No Major Safety Problems Encountered</th>
<th>No Opinion/Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharp curves</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long, steep upgrades</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long, steep downgrades</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interchange ramps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceleration lanes for merging onto highway</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deceleration lanes for leaving a highway</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intersections—tight radii for right turns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intersections—insufficient storage length for turn lanes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway-railroad grade crossings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction or maintenance work zones</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Are there any other safety concerns related to highway design or traffic control that, in your opinion, are generally in need of improvement? Please describe.

6. Please rate the desirability of the following types of safety improvements, which are currently being made or being considered by highway agencies (check one response for each item):

<table>
<thead>
<tr>
<th>Safety Improvement</th>
<th>Highly Desirable/Should Be Widely Used</th>
<th>Desirable at a Few Locations Where Truly Needed</th>
<th>Undesirable/Not Needed</th>
<th>No Opinion/Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different speed limits for passenger cars and trucks/buses on the same roadway</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restriction of trucks and buses from using the left lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restriction of trucks and buses to the right lane only</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure C-1. Questionnaire used for industry survey. (Continued)
<table>
<thead>
<tr>
<th>Highly desirable/should be widely used</th>
<th>Desirable at a few locations where truly needed</th>
<th>Undesirable/not needed</th>
<th>No opinion/don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanes reserved for exclusive use by trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lanes reserved for exclusive use by buses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Separate roadways for use by trucks and buses only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck climbing lanes on long, steep upgrades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brake check areas at top of long, steep downgrades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advisory signing for speed or gear selection on long, steep downgrades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automated systems to detect high truck and bus speeds on downgrades and warn drivers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency escape ramps for trucks and buses on long, steep downgrades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advisory signing for safe speeds for trucks and buses to avoid rollover on sharp curves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automated systems to detect high truck and bus speeds on sharp curves and warn drivers</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Do you have any information or opinions about the potential effectiveness in improving safety of the improvements listed above? Please describe.

8. Are there any other types of improvements related to highway design or traffic control that you believe should be used to improve the safety of the roadway system? Please describe.

---

*Figure C-1. Questionnaire used for industry survey. (Continued)*
9. (Optional) May we have the your name as a point of contact for further information should that be necessary?

Name ________________________________________
Agency ________________________________________
Address ________________________________________
Phone: ________________________________________
Fax: ________________________________________
e-mail: ________________________________________

Please return this survey within two weeks to:

Mr. Douglas W. Harwood  
Principal Traffic Engineer  
Midwest Research Institute  
425 Volker Boulevard  
Kansas City, MO 64110

If you received the survey electronically, you are welcome to e-mail your response to dharwood@mriresearch.org.

Thank you for your cooperation.

*Figure C-1. Questionnaire used for industry survey. (Continued)*
Table C-1. Type of operation represented by respondents to the industry survey

<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucking industry organization</td>
<td>4</td>
<td>12.1</td>
</tr>
<tr>
<td>Trucking company/fleet owner</td>
<td>15</td>
<td>45.5</td>
</tr>
<tr>
<td>Truck owner/operator</td>
<td>14</td>
<td>42.4</td>
</tr>
<tr>
<td>Bus industry organization</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Bus company/fleet owner</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>33</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Table C-2. Trucking industry segment represented by respondents to the industry survey

<table>
<thead>
<tr>
<th>Industry segment</th>
<th>Number of responses</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less-than-truckload hauling</td>
<td>9</td>
<td>27.3</td>
</tr>
<tr>
<td>Truckload hauling (for hire)</td>
<td>16</td>
<td>48.5</td>
</tr>
<tr>
<td>Truckload hauling (private)</td>
<td>13</td>
<td>39.4</td>
</tr>
<tr>
<td>Bulk materials hauling</td>
<td>7</td>
<td>21.2</td>
</tr>
<tr>
<td>Hazardous materials trucking</td>
<td>7</td>
<td>21.2</td>
</tr>
<tr>
<td>Automobile carriers</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>Movers/household goods</td>
<td>4</td>
<td>12.1</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>12.1</td>
</tr>
</tbody>
</table>

*a Because of multiple responses, the columns total to more than 100%.

respondents. Other concerns identified as high priorities by a majority of survey respondents include acceleration lanes for merging onto a highway, insufficient storage length for left turns at intersections, interchange ramps, sharp curves, construction or maintenance work zones, and highway-railroad grade crossings.

Question 5—Other Safety Concerns Related to Highway Design or Traffic Control

Question 5 asked respondents to comment on other safety concerns related to highway design or traffic control. The responses received were as follows:

- Post uniform speed limits for all vehicle types (5 responses)
- Provide sufficient maneuvering room for large trucks that use facilities including ramps, surface streets, and intersections (4 responses)
- Use advance or overhead flashers to warn drivers that the green phase of a signal is about to end (4 responses)
- Eliminate truck lane restrictions (3 responses)
- Provide more rest areas and pull offs (2 responses)
- Need wider and stronger shoulders to accommodate disabled vehicles (2 responses)
- Need lane lines that are more visible at night and in adverse weather (2 responses)
- Provide more median barriers on freeways (1 response)
<table>
<thead>
<tr>
<th>Highway features</th>
<th>High priority/ major safety concerns at many locations</th>
<th>Low priority/ safety concerns at a few locations</th>
<th>Not a concern/ no major safety problems encountered</th>
<th>No opinion/ don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of responses</td>
<td>Percentage of responses</td>
<td>Number of responses</td>
<td>Percentage of responses</td>
</tr>
<tr>
<td>Sharp curves</td>
<td>20</td>
<td>66.6</td>
<td>9</td>
<td>30.0</td>
</tr>
<tr>
<td>Long, steep upgrades</td>
<td>7</td>
<td>22.6</td>
<td>19</td>
<td>61.2</td>
</tr>
<tr>
<td>Long, steep downgrades</td>
<td>12</td>
<td>40.0</td>
<td>16</td>
<td>53.3</td>
</tr>
<tr>
<td>Interchange ramps</td>
<td>21</td>
<td>67.7</td>
<td>9</td>
<td>29.0</td>
</tr>
<tr>
<td>Acceleration lanes for merging onto highway</td>
<td>24</td>
<td>75.0</td>
<td>6</td>
<td>18.8</td>
</tr>
<tr>
<td>Deceleration lanes for leaving a highway</td>
<td>14</td>
<td>45.2</td>
<td>13</td>
<td>41.9</td>
</tr>
<tr>
<td>Intersections—tight radii for right turns</td>
<td>30</td>
<td>93.8</td>
<td>2</td>
<td>6.3</td>
</tr>
<tr>
<td>Intersections—insufficient steerage length for left turns</td>
<td>22</td>
<td>68.8</td>
<td>7</td>
<td>21.9</td>
</tr>
<tr>
<td>Highway-railroad grade crossings</td>
<td>16</td>
<td>50.0</td>
<td>13</td>
<td>40.6</td>
</tr>
<tr>
<td>Construction or maintenance zones</td>
<td>19</td>
<td>61.3</td>
<td>10</td>
<td>32.3</td>
</tr>
</tbody>
</table>
- Provide flatter roadside slopes on ramps (1 response)
- Improve poorly designed islands at intersections (1 response)
- Provide more shoulder rumble strips (1 response)
- Redesign interchanges to eliminate weaving areas (1 response)
- Provide wider lanes—3.6 to 4.3 m (12 to 14 ft) preferred (1 response)
- Provide appropriate superelevation on horizontal curves (1 response)
- Reduce congestion at entry to weigh scales (1 response)
- Eliminate situations where trucks must turn left into weigh scales where no left-turn lane is provided (1 response)
- Find some effective way to improve work zone safety (1 response)
- Reduce the brightness of flashing arrow panels in work zones (1 response)
- Improve pavement surfaces/fill potholes (1 response)
- Use longer yellow signal-change intervals (1 response)
- Provide more guide signs in advance of interchanges (three signs per interchange) (1 response)
- Need more uniformity in signage (1 response)

Question 6—Assessment of Specific Improvement Types

Question 6 asked respondents for their assessment of potential mitigation measures for heavy vehicle safety concerns. The primary focus of this question was to obtain an industry assessment of traffic control and regulatory strategies that have been used or are being considered by highway agencies to improve safety for heavy vehicles. The responses to Question 6 are presented in Table C-4. The mitigation measures that were most frequently rated by the survey respondents as highly desirable and appropriate for widespread use included truck climbing lanes on long, steep upgrades (66 percent); advisory signing for speed or gear selection on long, steep downgrades (59 percent); emergency escape ramps for trucks and buses on long, steep downgrades (58 percent); brake check areas at the top of long, steep downgrades (47 percent); and automated systems to detect high truck and bus speeds on sharp curves and warn drivers (46 percent). An additional mitigation measure that was rated by many survey respondents as desirable at a few locations where truly needed was the use of lanes reserved for exclusive use by trucks (50 percent). Mitigation measures considered as undesirable or not needed included different speed limits for passenger cars and heavy vehicles on the same roadway (81 percent); restriction of trucks and buses to the right lane only (79 percent); restriction of trucks and buses from using the left lane (64 percent); and separate roadways for use by trucks and buses only (58 percent).

Question 7—Potential Effectiveness of Measures for Improving Safety

Question 7 asked drivers for information or opinions about the effectiveness of potential mitigation measures like those shown in Table C-4. The following comments were received:

- Differential speed limits have an adverse effect on safety (10 responses)
- Lane restrictions cause congestion and disrupt smooth traffic flow (8 responses)
- Separate truck/bus lanes will work only if passenger cars are not allowed to use them; stiff fines are needed (1 response)
- Automated signing may not work because too few drivers pay attention to signs (1 response)

Question 8—Other Safety Improvements

Question 8 asked respondents to suggest other types of safety improvements, not mentioned in previous questions, that should be considered to

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Table C-4. Assessment of mitigation measures for heavy vehicle safety concerns by respondents to industry survey

<table>
<thead>
<tr>
<th>Mitigating measures</th>
<th>Highly desirable/should be used widely</th>
<th>Desirable at a few locations where truly needed</th>
<th>Undesirable/not needed</th>
<th>No opinion/don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of responses</td>
<td>Percentage of responses</td>
<td>Number of responses</td>
<td>Percentage of responses</td>
</tr>
<tr>
<td>Different speed limits for passenger cars and truck/buses on the same roadway</td>
<td>2</td>
<td>6.3</td>
<td>4</td>
<td>12.5</td>
</tr>
<tr>
<td>Restriction of trucks and buses from using the left lane</td>
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<td>Restriction of trucks and buses to the right lane only</td>
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<tr>
<td>Separate roadways for use by trucks and buses only</td>
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<td>19.4</td>
<td>7</td>
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<tr>
<td>Truck climbing lanes on long, steep upgrades</td>
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<td>65.6</td>
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<td>Brake check areas at the top of long, steep downgrades</td>
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<td>46.9</td>
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<td>Advisory signing for speed or gear selection on long, steep downgrades</td>
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<td>59.4</td>
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<tr>
<td>Automated systems to detect high truck and bus speeds on downgrades and warn drivers</td>
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<td>37.5</td>
<td>13</td>
<td>40.6</td>
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<tr>
<td>Emergency escape ramps for trucks and buses on long, steep downgrades</td>
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<td>57.6</td>
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<tr>
<td>Advisory signing for safe speeds for trucks and buses to avoid rollover on sharp curves</td>
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<td>45.5</td>
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</tbody>
</table>
improve the safety of the highway system. The responses included:

- Need improved driver training for both heavy vehicle and passenger car drivers (4 responses; one respondent mentioned the need to teach good road manners and one stated that driver training should use the “share the road” concept)
- Increase aggressive driving enforcement (lane changing, tailgating, etc.) (2 responses)
- Reduce state-to-state variation in traffic laws and fines (2 responses)
- Provide more rest area parking spaces; improve lighting and enforcement at rest areas (2 responses)
- Need better curve design (2 responses)
- Provide appropriate superelevation on horizontal curves; eliminate curves with reverse superelevation (2 responses)
- Provide longer acceleration lanes (1 response)
- Use yield signs rather than merging signs at entrance ramps (1 response)
- Eliminate cloverleaf designs (1 response)
- Eliminate entrance ramps on curves (1 response)
- Redesign sites where several roadways merge into a single lane (1 response)
- Reduce need for work zones by building better roads in the first place (1 response)
- Provide detours around work zones (1 response)
- Make sure road construction keeps up with increases in traffic (1 response)
- Improve pavement friction for wet pavements (1 response)
- Provide more automated warning systems for sharp curves (1 response)
- Provide automated warning signs for speeding vehicles (1 response)
- Flashing lights at highway-railroad grade crossings should begin soon enough that vehicles are not trapped by the gates (1 response)
- Clear brush in front of road signs (1 response)
- Provide advance street names signs; use larger letters on street name signs (1 response)
- Require all through traffic (heavy vehicles and passenger cars) to use the left lane in urban areas (1 response)
- Make truck and bus routes truck friendly (1 response)
- Encourage graduated licensing for heavy vehicle drivers as well as for passenger car drivers (1 response)
- Need more enforcement of failure to dim high-beam headlights (1 response)
- Provide better fog lights for vehicles (1 response)
### Abbreviations used without definitions in TRB publications:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AASHO</td>
<td>American Association of State Highway Officials</td>
</tr>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transportation Officials</td>
</tr>
<tr>
<td>APTA</td>
<td>American Public Transportation Association</td>
</tr>
<tr>
<td>ASCE</td>
<td>American Society of Civil Engineers</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>ATA</td>
<td>American Trucking Associations</td>
</tr>
<tr>
<td>CTAA</td>
<td>Community Transportation Association of America</td>
</tr>
<tr>
<td>CTBSSP</td>
<td>Commercial Truck and Bus Safety Synthesis Program</td>
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<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<td>FMCSA</td>
<td>Federal Motor Carrier Safety Administration</td>
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<td>Federal Railroad Administration</td>
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<tr>
<td>FTA</td>
<td>Federal Transit Administration</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>ITE</td>
<td>Institute of Transportation Engineers</td>
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<td>NCHRP</td>
<td>National Cooperative Highway Research Program</td>
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