United States Government Accountability Office

Report to Congressional Requesters

March 2019

TRUCK UNDERRIDE GUARDS

Improved Data Collection, Inspections, and Research Needed

Accessible Version

GAO-19-264

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GAO Highlights

Highlights of GAO-19-264, a report to congressional requesters

Why GAO Did This Study

Truck underride crashes are collisions in which a car slides under the body of a truck—such as a tractor-trailer or single-unit truck—due to the height difference between the vehicles. During these crashes, the trailer or truck may intrude into the passenger compartment, leading to severe injuries or fatalities. Current federal regulations require trailers to have rear guards that can withstand the force of a crash, whereas the rear guards required for single-unit trucks do not have to be designed to withstand a crash. There are no federal side or front underride guard requirements.

GAO was asked to review data on truck underride crashes and information on underride guards. This report examines (1) the data DOT reports on underride crashes and (2) the development and use of underride guard technologies in the U.S. GAO analyzed DOT's underride crash data for 2008 through 2017; reviewed NHTSA's proposed regulations and research on new guard technologies; and interviewed stakeholders, including DOT officials, industry and safety groups, and state officials selected based on reported underride crash fatalities and other factors.

What GAO Recommends

GAO recommends that DOT take steps to provide a standardized definition of underride crashes and data fields, share information with police departments on identifying underride crashes, establish annual inspection requirements for rear guards, and conduct additional research on side underride guards. DOT concurred with GAO's recommendations.

View GAO-19-264. For more information, contact Susan Fleming at (202) 512-2834 or FlemingS@gao.gov.

What GAO Found

According to crash data collected by police and reported by the Department of Transportation's (DOT) National Highway Traffic Safety Administration (NHTSA), fatalities from "underride" crashes, such as those pictured below, represent a small percentage of all traffic fatalities.

Crash Tests of Rear Guards with (left) and without (right) Passenger Compartment Intrusion

Source: GAO and Insurance Institute for Highway Safety. | GAO-19-264

From 2008 through 2017, an average of about 219 fatalities from underride crashes involving large trucks were reported annually, representing less than 1 percent of total traffic fatalities over that time frame. However, these fatalities are likely underreported due to variability in state and local data collection. For example, police officers responding to a crash do not use a standard definition of an underride crash and states' crash report forms vary, with some not including a field for collecting underride data. Further, police officers receive limited information on how to identify and record underride crashes. As a result, NHTSA may not have accurate data to support efforts to reduce traffic fatalities.

Underride guards are in varying stages of development, and gaps exist in inspection of rear guards in current use and in research efforts for side guards.

- NHTSA has proposed strengthening *rear guard* requirements for trailers (the rear unit of a tractor-trailer) and estimates about 95 percent of all newly manufactured trailers already meet the stronger requirements. Although tractor-trailers are inspected, Federal Motor Carrier Safety Administration annual inspection regulations do not require the rear guard to be inspected, so damaged guards that could fail in a crash may be on the roadways.
- *Side underride guards* are being developed, but stakeholders GAO interviewed identified challenges to their use, such as the stress on trailer frames due to the additional weight. NHTSA has not determined the effectiveness and cost of these guards, but manufacturers told GAO they are unlikely to move forward with development without such research.
- Based on a 2009 crash investigation, the National Transportation Safety Board (NTSB) recommended that NHTSA require *front guards* on tractors. NHTSA officials stated that the agency plans to complete research to respond to this recommendation in 2019. However, stakeholders generally stated that the bumper and lower frame of tractors typically used in the U.S. may mitigate the need for front guards for underride purposes.
- Regarding *single-unit trucks*, such as dump trucks, NTSB has recommended that NHTSA develop standards for underride guards for these trucks, but the agency has concluded these standards would not be cost-effective.

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Abbreviations

ANPRM	advance notice of proposed rulemaking
CVSA	Commercial Vehicle Safety Alliance
DOT	Department of Transportation
FARS	Fatality Analysis Reporting System
FMCSA	Federal Motor Carrier Safety Administration
IIHS	Insurance Institute for Highway Safety
MMUCC	Model Minimum Uniform Crash Criteria
NHTSA	National Highway Traffic Safety Administration
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board

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March 14, 2019
The Honorable Roger Wicker
Chairman
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Richard Burr
United States Senate

The Honorable Kirsten Gillibrand
United States Senate

The Honorable Marco Rubio
United States Senate

The Honorable John Thune
United States Senate

An "underride" crash occurs when a passenger vehicle slides under the body of a tractor-trailer or "single-unit truck," such as a delivery or dump truck.[1] Due to the height difference between the vehicles, the car's safety features are bypassed because the point of impact is not the front bumper of the car. Without these safety features to absorb the force of the collision, the passenger compartment can be crushed when it contacts the truck, potentially resulting in death or severe head and neck injuries for the occupants. To help prevent or mitigate these crashes, federal regulations require that the rear end of the trailer have a guard meeting specific crashworthiness standards. With these guards in place, the front of the car will impact the guard instead of sliding under the trailer and the car's safety features will engage to offer some protection to the car's occupants. Rear guards of specific dimensions are also required for single-unit trucks, but these guards are not required to be able to withstand the force of a crash. There are no federal requirements for side or front underride guards on any type of large truck in the United States.

[1]A tractor-trailer consists of a front unit, called a tractor, and a rear unit, called a trailer. Single-unit truck types are differentiated by their weight and number of axles, and not on their height from the ground.

However, legislation aimed at, among other things, requiring the use of side and front underride guards on all large trucks was introduced in the House of Representatives and the Senate in December 2017.[2] New legislation regarding underride crashes was introduced in March 2019.[3]

You asked us to review data on truck underride crashes and information related to rear, side, and front underride guards in the United States. This report examines: (1) the data the Department of Transportation (DOT) reports on truck underride crashes and (2) the development and use of truck underride guard technologies in the United States.

To address both objectives, we conducted a literature review to identify studies regarding truck safety, in general, and underride guards, in particular; we reviewed these studies and other documentation collected from interviewees, as described below. We also interviewed a variety of stakeholders familiar with topics related to underride crashes and guards, including: officials from DOT's National Highway Traffic Safety Administration (NHTSA), as well as NHTSA's data validation and training contractor; the Federal Motor Carrier Safety Administration (FMCSA); the National Transportation Safety Board (NTSB) and representatives from the Insurance Institute for Highway Safety (IIHS). We interviewed seven trailer manufacturers, nine trucking industry organizations, four organizations representing tractor-trailer fleets, nine traffic safety groups, and four organizations involved in transportation research. Additionally, we interviewed officials of five state DOTs, five state police departments, as well as two local police departments.[4] In selecting the states and localities, we considered various factors—such as reported underride crash fatalities and highway vehicle miles traveled—to identify states that were similar in highway traffic trends and large truck-related fatality rates, but that collected underride crash data differently. The results of these interviews are not generalizable to all states and localities; however, they offer examples of the types of experiences state DOTs and state and local police have with underride crashes and inspections. We also

[2]H.R. 4622, Stop Underrides Act of 2017, 115th Cong. (2017). S. 2219, Stop Underrides Act of 2017, 115th Cong. (2017).

[3]H.R. 1511, Stop Underrides Act of 2019, 116th Cong. (2019). S. 665, Stop Underrides Act of 2019, 116th Cong. (2019).

[4]We interviewed state DOT and state police officials from the following states: California, Illinois, Indiana, Pennsylvania, and Tennessee. We interviewed local police officials from the following localities: Chicago, Illinois and Terre Haute, Indiana.

interviewed officials from transportation agencies in Canada and the European Union.

For the first objective, we also analyzed DOT data on underride crashes and fatalities from 2008 through 2017—the 10 most recent years for which these data were available—and reviewed crash report forms from all 50 states and the District of Columbia. We compared NHTSA's data collection efforts to federal internal control standards related to use of quality information.[5] For the second objective, we reviewed NHTSA's and FMCSA's regulations requiring rear guards, FMCSA's regulations on commercial vehicle inspections, DOT's documentation on underride guard technologies, and DOT's data on commercial vehicle inspections. To assess the reliability of DOT's data on underride crashes and fatalities and commercial vehicle inspections, we reviewed relevant documentation and spoke with agency officials about the data's quality control procedures. We determined that the data were sufficiently reliable for the purposes of this report, specifically to provide a high-level overview of underride crashes and fatalities, as well as commercial vehicle inspections within recent years. However, we did identify potential underreporting of underride crashes and fatalities, as discussed in this report. We compared DOT's efforts to pertinent agency regulations on commercial vehicle inspections, federal internal control standards related to use of quality information, and a statement of federal principles on regulatory planning and review.[6] See appendix I for a detailed description of our objectives, scope, and methodology, including a list of interviewees.

We conducted this performance audit from January 2018 to March 2019 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[5]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: September 2014).

[6]GAO-14-704G. Exec. Order No. 12866, 58 Fed. Reg. 51735 (Oct. 4, 1993).

Background

An underride crash can occur during a collision between a passenger vehicle and a large truck—a tractor-trailer or a single-unit truck, such as a delivery or dump truck—if the height difference between the vehicles is sufficient to allow the smaller vehicle to slide under the body of the truck.[7] The front and rear of passenger vehicles are designed to crumple in a crash and absorb the main force of an impact, while sensors detect the impact and activate safety features within the passenger compartment, such as air bags and seatbelt pretensioners.[8] However, the point of impact in an underride crash could be the hood of the passenger vehicle or—more severely—the windshield. Such impacts can result in "passenger compartment intrusion" by the large truck into the passenger area of the smaller vehicle. This intrusion can kill passengers or leave them with severe head and neck injuries. Underride guards on large trucks essentially lower the profile of the truck's body to be more compatible with that of a passenger vehicle. An underride guard designed to withstand the force of a crash can prevent the car from sliding under the truck and provide an effective point of impact that will activate the car's safety features to protect the car's occupants. Figure 1 shows images from a video depicting the difference in underride crashes with and without passenger compartment intrusion on the rear of a tractor-trailer.

[7]Of the approximately 11.5 million total registered large trucks in the U.S. in 2016, about 2.8 million (24 percent) were tractor-trailers and about 8.8 million (76 percent) were single-unit trucks. FMCSA, *2018 Pocket Guide to Large Truck and Bus Statistics*, (Washington, D.C.: August 2018).

[8]Seatbelt pretensioners retract a limited amount of webbing to help minimize the forward movement of the occupant during a crash.

Figure 1: Crash Tests of Rear Guards with (left) and without (right) Passenger Compartment Intrusion

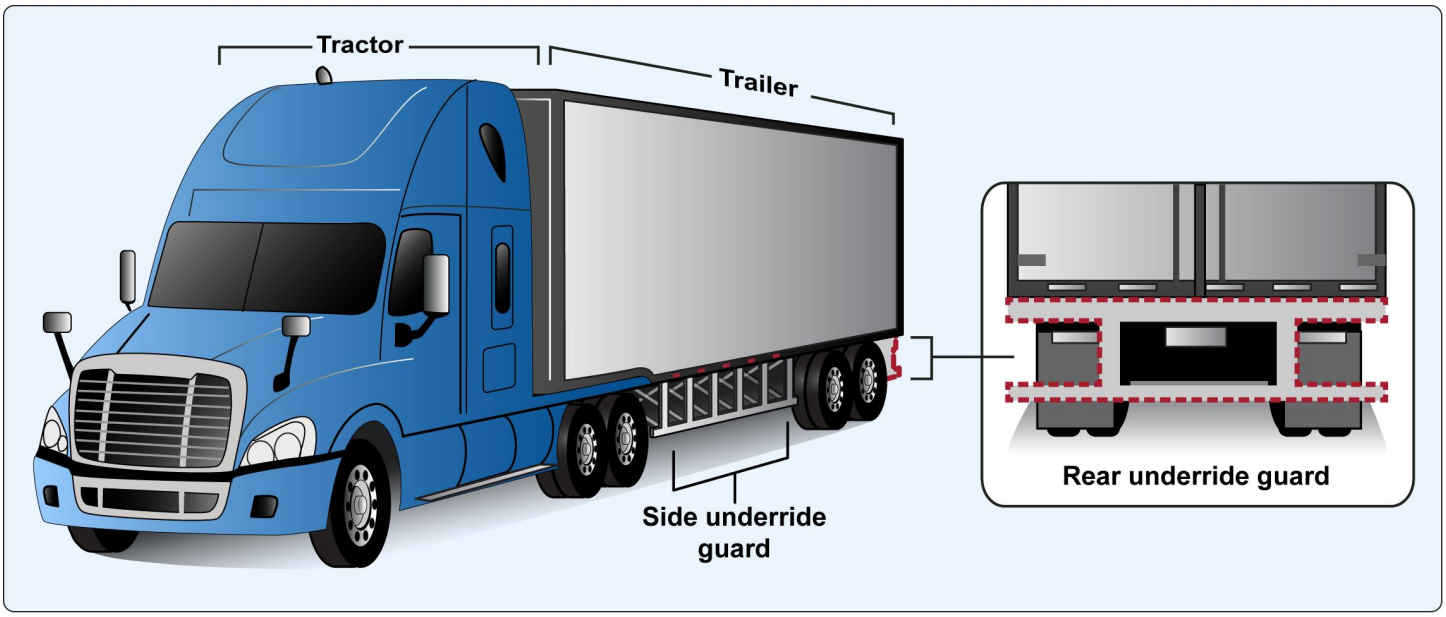
Source: GAO and Insurance Institute for Highway Safety. | GAO-19-264

Note: The images shown are from a video about the difference between underride crashes with and without passenger compartment intrusion. To view the video, go to www.gao.gov/products/GAO-19-264.

Rear and side underride guards limit a passenger vehicle's ability to go under those areas of a trailer in a crash (see fig. 2). Front guards—currently used on tractors in some other countries, such as European Union countries—can reduce the likelihood that a truck would ride over a passenger vehicle in a crash, a situation sometimes referred to as "override". In addition to saving lives and reducing serious injuries, improving traffic safety—including reducing underride crashes—may provide other benefits to society. Specifically, NHTSA has reported that preventing such crashes may result in savings in police and crash investigation resources and reduced property damage, among other things. Federal requirements, in regulations issued by NHTSA and FMCSA, exist for the installation of rear guards on most large trucks, but there are no federal requirements for side or front guards.[9]

[9]These federal requirements apply to trailers and single-unit trucks and exclude certain vehicles, including school buses. 49 C.F.R. §§ 571.223, 224, and 393.86.

Figure 2: Overview of a Tractor-Trailer and Examples of Rear and Side Underride Guards



Source: GAO. | GAO-19-264

NHTSA's mission is to "save lives, prevent injuries and reduce economic costs due to road traffic crashes through education, research, safety standards and enforcement activity." [10] As part of this mission, NHTSA requires that rear guards be installed on most trailers. Federal regulations requiring rear guards of specific dimensions date back to 1952, but the most current regulations—which set force and energy absorption standards, in addition to dimensional requirements—became effective in 1998.[11] These crashworthy rear guards must be designed and tested to protect occupants in a crash of up to 30 miles per hour.

In December 2015, NHTSA published a notice of proposed rulemaking (NPRM) that proposed to align U.S. regulations with stronger Canadian rear guard standards.[12] The Canadian standard includes a stronger

[10]NHTSA, *The Road Ahead: National Highway Traffic Safety Administration Strategic Plan 2016-2020*, DOT HS 812 343 (Washington, D.C.: October 2016).

[11]49 C.F.R. §§ 571.223 and .224. These regulations require rear guards on trailers with a gross vehicle weight rating of 10,000 pounds or more.

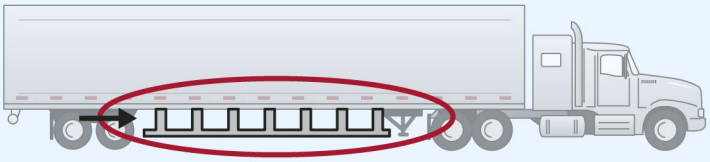
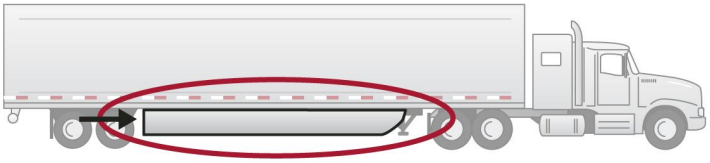
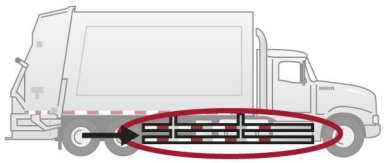
[12]80 Fed. Reg. 78418 (Dec. 16, 2015).

energy absorption requirement: 20,000 joules—a measurement of energy—as compared to 5,650 joules in the U.S. NHTSA has not taken action on this NPRM since it was proposed in December 2015. Single-unit trucks that are more than 30 inches above the ground are required to meet the dimensional specifications for rear guards set in 1952 but are not required to meet any force or energy absorption standards.[13] NHTSA introduced an advance notice of proposed rulemaking (ANPRM) in July 2015 that considered requiring rear guards with strength and energy absorption criteria for all newly built single-unit trucks. However, NHTSA has since withdrawn the ANPRM, stating that—based on the comments received as well as analysis of the petitions—the changes being considered were not justified.

Although there are no federal requirements for crashworthy side underride guards, some crashworthy side guards are being developed. For example, one aftermarket manufacturer has developed a side underride guard that was crash-tested by IIHS and successfully prevented underride crashes in tests at 35 and 40 miles per hour. Similar looking technologies—including aerodynamic side skirts and pedestrian/cyclist side guards—are installed on some trailers and single-unit trucks, but they are not meant to mitigate underride crashes (see fig. 3).

[13]49 C.F.R. § 393.86. Unlike requirements for rear guards on trailers, these regulations are not based on the truck's weight.

Figure 3: Side Guard Examples

Guard type description	Example	Designed to mitigate a passenger vehicle underride crash
Side Underride Guard To prevent a passenger vehicle from going under a large truck in a crash.		**Yes**
Aerodynamic Side Skirt To reduce drag and improve the fuel efficiency of tractor-trailers.		**No**
Pedestrian/ Cyclist Side Guard To prevent pedestrians and cyclists from being run over by a large truck's rear wheels in a side-impact collision.		**No**

Source: GAO. | GAO-19-264

FMCSA's primary mission is "to reduce crashes, injuries, and fatalities involving large trucks and buses,"[14] and it does this, in part, through developing safety regulations. These regulations include requirements for rear guards for trailers consistent with Federal Motor Vehicle Safety Standards and for single-unit trucks that are more than 30 inches above the ground, as well as for multiple types of commercial vehicle inspections that are performed by, for example, motor carriers and drivers to ensure that commercial vehicles are safely operating. Table 1 describes the types of commercial vehicle inspections.

[14]FMCSA, *Federal Motor Carrier Safety Administration Strategic Plan Fiscal Years 2015 – 2018*, (Washington, D.C.: August 2016).

Table 1: Commercial Vehicle Inspection Types

Inspection Type	Description
Annual Inspection	• Required of all trucks, trailers, and buses. Employees of the motor carrier may conduct the annual inspections if the vehicles are not subject to a mandatory state inspection program. • "Appendix G" of FMCSA's regulations lists the equipment that must be inspected as part of the annual inspection.
Roadside Inspection	• Inspectors—often certified state police officers—select commercial vehicles on the highway for roadside inspections. • A standardized set of procedures is used to determine whether large trucks are operating safely. There are eight types of roadside inspections, with some inspections examining all parts of a vehicle—including the rear guard—and others reviewing a driver's license and other administrative credentials.
Pre-Trip Inspection	• Drivers are required to check that the vehicle is in safe and proper working condition.
Driver Vehicle Inspection Reports ("Post-Trip Inspection")	• Drivers are required to prepare a post-trip inspection report at the end of each operating day to identify damaged equipment that must be repaired before the vehicle can be used again. • The motor carrier must either (1) repair or replace the defective or damaged equipment, or (2) certify that repairs are not necessary before allowing the vehicle to be driven.

Source: GAO analysis of Federal Motor Carrier Safety Administration regulations. 49 C.F.R. §§ 396.17, 396.9, 392.7, 396.11. | GAO-19-264

For fatal crashes, including fatal underride crashes, data are collected by law enforcement officials at the location of the crash, aggregated at the state level, and then transferred to NHTSA's Fatality Analysis Reporting System (FARS). FARS is a census of all fatal traffic crashes in the U.S. When a fatal crash occurs, a state or local police officer typically completes a crash report form unique to each state. These forms can include a variety of data fields, such as the time of the crash, weather conditions, and the number of killed or injured persons. In the case of an underride crash, officers may indicate an underride crash occurred in a specific field for recording this crash type or in a narrative field. FARS analysts—state employees who are trained by NHTSA's data validation and training contractor to code state crash data for input into FARS—in each state receive and analyze the data in the crash report forms in order to compile a record of the fatal crash. FARS analysts rely on the information within the crash report form in order to enter accurate data.

To encourage greater uniformity of crash data, NHTSA, FMCSA, and other agencies and associations cooperatively developed the Model Minimum Uniform Crash Criteria (MMUCC) in 1998. The MMUCC guideline, currently in the fifth edition, identifies a minimum set of motor vehicle crash data elements and their definitions that states should consider collecting, but are not required to collect. The MMUCC is updated about every 4 to 5 years. Prior to publication of each edition, an expert panel from the relevant agencies and associations convenes to review all proposed changes suggested by traffic safety stakeholders to

determine what will be included in the MMUCC. According to NHTSA officials, the next updated version of the MMUCC is expected to be issued in 2022.

Underride Crash Fatalities Reported by NHTSA Data Are Relatively Low but Are Likely Undercounted

Although Reported Underride Crash Fatalities Represent a Small Percentage of Total Traffic Fatalities, Underride Crashes Present a Greater Risk of Fatalities or Serious Injuries

From 2008 through 2017, the annual number of fatalities resulting from underride crashes involving one or more trucks reported in FARS ranged between 189 and 253, resulting in an annual average of approximately 219 fatalities (see table 2).[15] Comparatively, the FARS data show an annual average of about 34,700 total traffic fatalities and approximately 4,000 fatalities involving large trucks over the same period. Therefore, reported underride crash fatalities on average accounted for less than 1 percent of total traffic fatalities and 5.5 percent of all fatalities related to large truck crashes during this time frame.

[15]To be included in FARS, a crash must have involved a motor vehicle traveling on a trafficway customarily open to the public, and must have resulted in the death of a motorist or a non-motorist within 30 days of the crash. While stakeholders we spoke with noted the factors described in this report that could lead to underreporting of fatalities related to truck underride crashes, the failure to record a fatality that occurred subsequent to—but within 30 days of—a crash could also be a factor in underreporting.

Table 2: Reported Underride Crash Fatalities, Total Traffic Fatalities, and Large Truck Fatalities, 2008 through 2017

Year	Underride Crash Fatalities[a]	Total Traffic Fatalities	Underride Crash Fatalities as a Percentage of Total Traffic Fatalities	Total Large Truck Fatalities[b]	Underride Crash Fatalities as a Percentage of Large Truck Fatalities
2008	198	37,423	0.53%	4,245	4.66%
2009	211	33,883	0.62%	3,380	6.24%
2010	221	32,999	0.67%	3,686	6.00%
2011	189	32,479	0.58%	3,781	5.00%
2012	247	33,782	0.73%	3,944	6.26%
2013	210	32,893	0.64%	3,981	5.28%
2014	213	32,744	0.65%	3,908	5.45%
2015	253	35,485	0.71%	4,094	6.18%
2016	196	37,806	0.52%	4,369	4.49%
2017	253	37,133	0.68%	4,761	5.31%
Average	219	34,663	0.63%	4,015	5.49%

Source: GAO analysis of NHTSA data. | GAO-19-264

[a]Reported underride crash fatalities include those fatalities in which a crash involved a medium or heavy truck.

[b]"Large truck" is defined as any medium or heavy truck, excluding buses and motor homes, with a gross vehicle weight rating greater than 10,000 pounds.

Although reported underride crash fatalities make up a small proportion of total traffic fatalities, NHTSA officials told us that severe underride crashes—involving passenger compartment intrusion—are more likely to result in a fatality or serious injury than crashes in which the passenger vehicle's safety features engage and are able to protect the occupants. Officials from four state DOTs we spoke to also stated that while underride crashes are not common, the consequences—fatalities or serious injuries, including head or neck injuries—are more likely to be severe. An official from one state DOT noted that their agency did not consider underride crashes to be a high priority issue. However, upon further review of the state's underride crash data, this official stated that while underride crashes may occur infrequently, they present a higher risk of fatality than the official had previously realized. An official in another state told us they do not regularly review underride crash data but, upon analysis of the data, found that underride crashes constituted a larger percentage than they anticipated—16 percent—of all fatal large truck crashes in the state in 2017.

NHTSA's FARS data show that most of the reported underride crash fatalities occurred when the crash impact was located at the rear or sides

of a trailer. From 2008 through 2017, approximately 45 percent (825 of 1836) of reported fatalities in underride crashes with a recorded point of impact on the large truck occurred when the initial impact of the crash was the rear of the trailer. About 32 percent (590 of 1836) of reported underride crash fatalities were in crashes where the side of the trailer was the point of initial impact. Approximately 21 percent (392 of 1836) of reported underride crash fatalities were in crashes with the initial impact at the front of the tractor. These 392 fatalities from crashes involving the front of a tractor could be crashes in which the tractor impacted the rear of a passenger vehicle but might also have occurred in a head-on collision between the car and the tractor. The point of impact for underride crash fatalities with passenger compartment intrusion—the most severe form of underride—had similar distributions, with most reported fatalities occurring when the initial point of impact was the rear or side of the trailer.[16]

State and local police officials we interviewed said that the underride crash fatality cases they are familiar with occurred in high speed scenarios, often exceeding 55 miles per hour. For example, officials representing a state police department described scenarios in which passenger vehicles traveling at high speeds rear-ended tractor-trailers stopped on the highway's shoulder or slowed for highway construction; similar scenarios occurred when tractor trailers failed to slow for stopped traffic and crashed into the rear of passenger vehicles. However, on average, 62 percent of fatalities from underride crashes with passenger compartment intrusion reported in 2008 through 2017 did not include a reported speed. For example, for these fatalities in 2017, 72 percent had speed coded in FARS as missing or not reported. A state and a local police official told us that determining the speed of an underride crash can be challenging due to the often severely damaged condition of the passenger vehicle following an underride crash. Officials representing state police said that they are better able to document whether or not speeding was a factor in an underride crash, rather than an exact speed. IIHS representatives also acknowledged the difficulty in documenting the speed involved in an underride crash, and further stated that this difficulty

[16]Of the reported underride crash fatalities between 2008 and 2017 in which passenger compartment intrusion occurred, approximately 46 percent (489 of 1062) occurred when the initial point of impact was the rear of the trailer. Approximately thirty percent (323 of 1062) of these fatalities occurred when the initial point of impact was the sides of the trailer, and about 23 percent (243 of 1062) when the initial point of impact was the front of the tractor.

brings into question the accuracy of the speed data that are recorded in FARS for underride crashes.

Variability in the Data Collection Process Likely Leads to Underreporting

Stakeholders we interviewed told us that underride crash fatalities are likely underreported in FARS due to several factors, such as variability across states in defining underride crashes, inconsistencies in state crash reporting forms and documentation methods, and limited information provided to state and local police on how to consistently identify and record underride crash data. These factors could contribute to police officers incorrectly and inconsistently documenting underride crash data on the crash report form. As a result, FARS analysts may not have sufficient information to properly categorize the crash as an underride, ultimately affecting the number of underride crash fatalities identified in FARS. *Standards for Internal Control in the Federal Government* notes that management should use quality information to achieve the entity's objectives.[17] Underreporting of underride crashes would affect the quality of NHTSA's data, thereby affecting the agency's ability to accurately identify the magnitude of underride-related crashes and limiting its ability to make informed decisions on rulemaking or other efforts that would help the agency meet its mission to improve traffic safety.

Other researchers and organizations have also commented on the quality of NHTSA's underride crash data. For example, IIHS representatives told us that they compared underride crash cases in FARS and in NHTSA's and FMCSA's *Large Truck Crash Causation Study*—a study of large truck crashes from 2001 through 2003—and identified some cases that involved underride crashes but that were not categorized as such in FARS. Consequently, IIHS representatives stated that they have used more general rear impact crash data as a proxy for underride crashes due to their finding that underreporting of underride crashes occurs in FARS. Additionally, the University of Michigan's Transportation Research

[17]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: September 2014).

Institute reported that it can be difficult or impossible to identify underride in available computerized crash data files, such as FARS.[18]

Variability in Underride Crash Definition

State and local police officers do not use a standard definition of an underride crash when collecting data at the scene of a crash. NHTSA officials told us that the agency's definition for an underride crash—"a vehicle sliding under another vehicle during a crash"—is found in the FARS coding and validation manual, a document primarily used by FARS analysts and researchers. The FARS coding and validation manual further distinguishes underride crashes as those with and without passenger compartment intrusion. The MMUCC, which includes definitions of various crash-related elements, does not include a definition of an underride crash. Among officials from the five state police departments we interviewed, underride crash definitions varied, even within states. For example, in one state, an official from one local police department said that a passenger vehicle would need to have over 50 percent of its hood underneath the trailer to constitute an underride crash, while other officials within the state police used a broader definition consistent with NHTSA's definition, i.e., a vehicle going underneath another vehicle by any amount. A state police official and a local police official we interviewed indicated that they would like a clearer definition of the conditions that constitute an underride crash to help them better identify these crashes. Further, representatives from NHTSA's data validation and training contractor told us that when they have identified anomalous patterns in underride crash data in FARS, the main reason for these anomalies has been varying definitions of this crash type, as reporting officers have many interpretations of what constitutes an underride crash.[19] A standard definition of an underride crash, for example in the MMUCC, would provide greater assurance that underride crashes are accurately recorded.

[18]Blower, D., Woodrooffe, J., Page, O., *Analysis of Rear Underride in Fatal Truck Crashes, 2008*. (Ann Arbor, MI: US DOT HS 811 652, 2012). The underride crash data were collected as a supplement to the 2008 Trucks Involved in Fatal Accidents survey, which in turn supplements NHTSA's FARS file.

[19]NHTSA's data validation and training contractor specializes in training and data quality control support for NHTSA. The contractor supports NHTSA's FARS data collection program, specifically in the delivery and maintenance of the FARS training program and data manuals, and assists NHTSA in quality control and review of data added by FARS analysts.

Inconsistency in State Crash Reporting Forms and Documentation of Underride Crashes

While all states have a crash report form to gather data following a crash, these state forms vary in whether and how underride crash-related information is collected. Specifically, for the most recent crash report forms we examined from the 50 states and the District of Columbia, as of October 2018:

- 17 state forms have a specific field for “Underride.” Eleven of these forms also have data fields for passenger compartment intrusion.
- 32 state forms have a point of impact or area damaged field for “undercarriage.” The point of impact field is generally intended to be used to indicate the locations of initial impact or area that was damaged for all vehicles involved in the crash. Some state police and transportation officials we spoke with noted that this field could be used to indicate that an underride crash occurred, as the initial point of impact on a large truck could be the undercarriage in such a crash.
- Two states, California and Hawaii, do not have a data element related to underride crashes or undercarriage on their state crash report forms.

The presence of an underride field in state crash report forms may affect the extent to which underride crash fatalities are captured in FARS. For example, we observed that after a state revised its form to remove the underride field, the number of reported underride crash fatalities significantly decreased, potentially indicating that underride crashes were being underreported after the change. Conversely, in another state, we observed that the number of reported underride crash fatalities significantly increased following the addition of an underride field to the crash report form, potentially indicating that underride crashes were being reported more accurately following the change.

States have their own discretion to develop crash report forms based on several factors that may be particular to each state. For example, states include or exclude certain data elements on their crash report forms based on the traffic safety priorities within that state. Officials we interviewed from two state police departments told us that they do not have an underride field on their crash report forms because underride crashes are not a traffic safety priority for them. In another state, state DOT officials told us that they chose to include an underride field on the crash report form to better align with the FARS data fields, including those

fields related to underride. States may include certain data elements on their crash report form based on the recommended data elements in the MMUCC. However, while the MMUCC was developed to encourage greater uniformity of crash data, its guidelines are voluntary, and it does not currently include references to underride or override crash data elements. In its June 15, 2017, report, the Post-Accident Report Advisory Committee—a group appointed by the FMCSA Administrator to provide input on additional data elements to be included in police accident reports involving commercial motor vehicles—suggested that MMUCC data elements be updated to include a collection of information about whether underride and override are involved in a crash. However, according to the MMUCC's standard development process and NHTSA officials, to adopt new data elements, the entire MMUCC expert panel—which is comprised of stakeholders representing NHTSA, FMCSA, the Governors Highway Safety Association, states, data collectors, data managers, data users, and safety stakeholders—must reach at least 70 percent agreement for approval of new changes to the MMUCC. Under the MMUCC's standard development process, the MMUCC expert panel will consider recommendations and proposed changes to the MMUCC guidelines, including those proposed by NHTSA in the months preceding the next MMUCC update in 2022.

In states that do not include a specific underride crash field in the state crash report form, state and local police officers we interviewed told us that officers responding to a crash may describe underride crashes in the diagram or narrative fields of the form. However, these officers said that a police officer may inappropriately document an underride crash as a rear impact crash. Similarly, officers may categorize the crash as both an underride and an override crash, which NHTSA's FARS coding and validation manual indicates would be incorrect. Selected state officials told us that unless the officer documenting the crash specifically describes an underride crash in the narrative field, FARS analysts at the state level who review the crash report forms will not have the information to know if a crash involved underride.

Police officers we interviewed in states that include "undercarriage" rather than a specific underride crash field in the crash report form told us that they may use the option as a proxy for an underride crash; however, this field may be used inconsistently. For example, in one state, state police officers said they would select "undercarriage" on the crash report form to reflect an underride crash, whereas a local police officer in the same state said that local officers would not use that field to identify an underride crash occurred and, instead, would document the underride crash in the

narrative. NHTSA's data validation and training contractor told us that it is not a recommended practice for officers to select "undercarriage" as a proxy for underride crashes, noting that this inconsistency could lead to inaccuracies in the resulting FARS data. Including underride as a recommended data field in the MMUCC would provide greater assurance that underride crashes are accurately recorded.

Limited Information Provided to Police

State and local police officials we interviewed said that they receive limited or no training on how to identify and record information for underride crashes. Officials from all five state police departments we spoke with said that they develop their own crash reporting training for police. This training emphasizes overall crash reporting with a limited focus, if any, on underride crashes. An official representing one state police office said that the state police provide training on how to complete crash reports and general traffic safety, whereas FARS analysts—often within the state DOT—are concerned with the quality of data collection for data analysis purposes, which is not a primary focus of law enforcement training. State and local police officials we interviewed said they generally have limited to no follow-up or continuous training on crash reporting beyond initial police academy training. Local police we interviewed also told us that while they develop and implement their own crash report training, they may also receive training from the state police. Some state police officers that we spoke with said that they conduct training for local police departments when requested. One local police official we spoke with said that officers have limited exposure to underride crashes in these training sessions and that the average officer would likely not know how to appropriately identify an underride crash. Officials we spoke with from three state and two local police departments stated that additional information to police departments on underride crashes could help improve data collection and overall traffic safety.

NHTSA provides training to FARS analysts on reviewing crash report forms and appropriately inputting data in FARS, but does not provide information on crash data collection to state and local police who initially collect the data. According to NHTSA's data validation and training contractor, the contractor trains FARS analysts on identifying underride crashes. Specifically, the contractor trains FARS analysts to review the crash report forms for sufficient detail to meet the definition of an underride crash and determine if a crash involved underride for entry in FARS. NHTSA officials told us that it is the responsibility of state police academies to train law enforcement officers to conduct on-site

investigations and complete crash report forms. NHTSA officials said that they do not currently provide underride identification information directly to state and local police who initially collect the crash data. However, NHTSA does provide information to state and local police on other topics, such as improving traffic safety and driver behavior, for example through DOT's Enforcement and Justice Services Division. NHTSA officials acknowledged that it would be feasible to also provide information on identifying and recording underride crashes. *Standards for Internal Control in the Federal Government* notes that management communicates quality information externally through reporting lines so that external parties can help the entity achieve its objectives and address related risks.[20] By providing information to state and local police departments—such as materials or instruction on the definition of an underride crash and how to appropriately document these crashes—NHTSA could improve the quality and completeness of underride crash data that police collect.

Underride Guards Are in Varying Stages of Development, and Gaps Exist in Inspection and Research

Underride guards for the rear, side, and front of tractor-trailers and single-unit trucks are in varying stages of development. NHTSA has issued an NPRM proposing to strengthen rear guard requirements for trailers, and estimates that about 95 percent of all newly manufactured trailers already meet the stronger requirements. While FMCSA requires commercial vehicles to be inspected to ensure they are safe, rear guards may not be regularly inspected. Side underride guards are being developed, but stakeholders identified challenges to their use, such as the stress on trailer frames due to the additional weight. NHTSA has not performed research on the overall effectiveness and cost of these guards, and manufacturers we interviewed told us that they are hesitant to invest in developing side underride guards without such research. In response to a 2009 crash investigation, the National Transportation Safety Board (NTSB) recommended that NHTSA require front guards on tractors. NHTSA officials stated that the agency plans to complete research to respond to this recommendation in 2019. However, stakeholders

[20]GAO-14-704G.

generally stated that the bumper and lower frame of tractors typically used in the U.S. may mitigate the need for front guards for underride purposes. NTSB has further recommended that NHTSA develop standards for crashworthy underride guards for single-unit trucks—such as dump trucks—but NHTSA recently concluded that these standards would not be cost effective.

Most Newly Built Trailers Are Equipped with Rear Guards That Exceed NHTSA Requirements

All seven of the eight largest trailer manufacturers—which are responsible for about 80 percent of the trailers on the road in the U.S.—we spoke with told us that they have been building to the stronger Canadian rear guard standard since those requirements became effective in 2007. Some manufacturers said that since trucking company operations may span the border between Canada and the U.S., it was easier to build to a single standard rather than manufacture trailers that comply with either the Canadian requirements or the U.S. requirements. NHTSA is considering strengthening the U.S. requirements for rear guards to align with the Canadian rear guard standards. As part of the 2015 NPRM on strengthening the U.S. requirements to the level of the Canadian standards, NHTSA estimated that 93 percent of all newly manufactured trailers in the U.S. are already equipped with a rear guard that meets the Canadian standard. In July 2018, NHTSA officials told us that figure had increased to 95 percent of all newly manufactured trailers, with the remaining 5 percent from smaller manufacturers who may not wish to incur the additional cost or weight of a Canadian-style rear guard. Trucking industry stakeholders told us that the average lifecycle of a trailer varies: one said the lifespan is 10 to 15 years and another stated a 12-year lifespan.

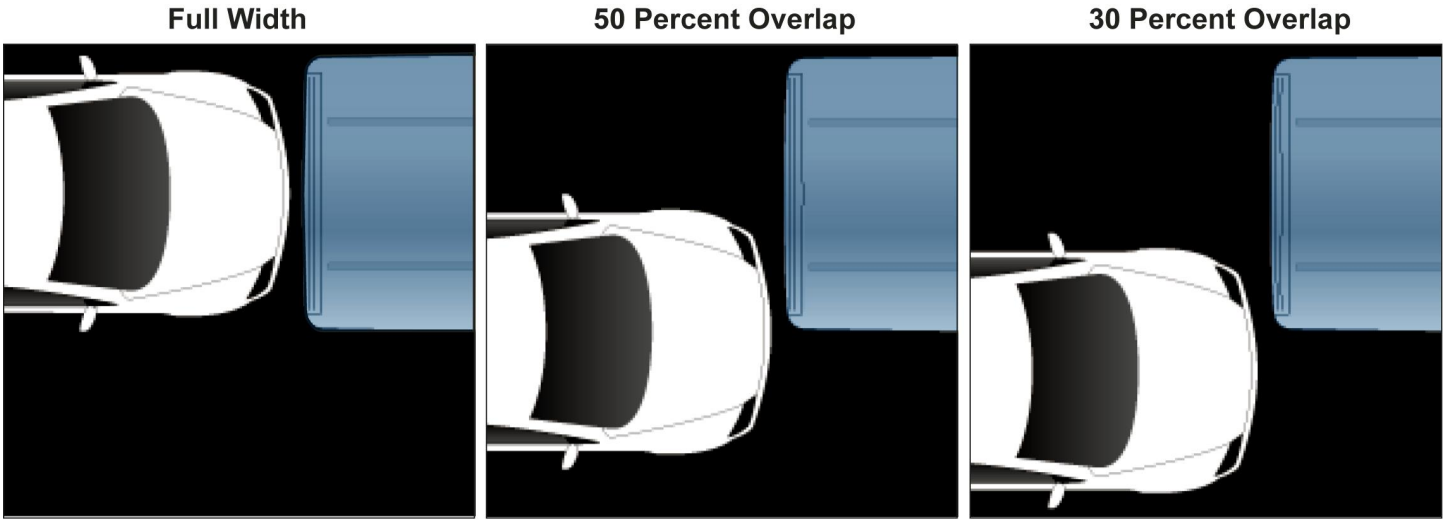
NHTSA performed a cost-benefit analysis as part of the 2015 NPRM in which it preliminarily estimated that requiring newly manufactured trailers to include rear guards built to the new standard would be cost-beneficial. Specifically, NHTSA's analysis found that the cost of a rear guard that meets the Canadian standard was approximately $500 per trailer, which was $229 more than a guard that complies with the existing U.S. requirement. NHTSA's analysis also found that a Canadian-style rear guard was heavier than its U.S. counterpart. The rear guard NHTSA studied that complies with current U.S. regulations weighed 172 pounds, whereas those meeting the Canadian standard weighed between 191 and 307 pounds. Regarding benefits, NHTSA estimated in 2015 that—

accounting for the trailers that already meet the stronger standard—adopting the Canadian standard would prevent about one fatality and three serious injuries per year. According to DOT, these estimates may have since changed, as a higher percentage of trailers are now manufactured to meet the Canadian standards. Comments on this NPRM varied. Some comments were in support of the measure, citing the safety benefits. Other comments noted that automated driver assistance technology may offer better outcomes.[21] Further, some comments called for NHTSA to take additional steps to improve the safety capabilities of rear guards, such as allowing fewer exemptions from compliance. NHTSA has not taken action on this NPRM since it was proposed in December 2015. NHTSA officials we interviewed could not provide information on when the NPRM would move forward.

The largest trailer manufacturers have also taken steps to further improve the design of rear guards to prevent underride crashes in a range of scenarios. Because IIHS found that the weakest points for rear guards are generally the outer edges furthest from the center of the guard, it created a procedure to test the ability of rear guards to withstand crashes at different overlap points, starting at the center of the guard and moving closer to the endpoints. Specifically, this procedure involves three crash tests using full width, 50-percent, and 30-percent overlap of the front of the car with the rear guard, as depicted in figure 4. According to IIHS, as of September 2018, all of the top eight trailer manufacturers operating in the U.S. have successfully passed these tests. Some of these manufacturers provide the improved rear guards as a standard feature on all new trailers, while others offer them as an option for purchase.

[21]These technologies allow vehicles to perform certain driving tasks without human input and encompass a diverse range of automated technologies ranging from relatively simple driver assistance systems to fully self-driving vehicles. See GAO, *Automated Vehicles: Comprehensive Plan Could Help DOT Address Challenges*, GAO-18-132 (Washington, D.C.: Nov. 30, 2017).

Figure 4: Insurance Institute for Highway Safety Rear Guard Testing Procedure at Full Width, 50 Percent Overlap, and 30 Percent Overlap



Source: Insurance Institute for Highway Safety. | GAO-19-264

In addition to strengthening rear guards on trailers, advancements in automatic braking systems in passenger vehicles may help reduce the frequency of underride crashes. These systems, though not federally-required, have been available and installed in some passenger vehicles and tractors and are designed to detect objects or other vehicles in front of the vehicle and automatically apply the brakes to avoid or lessen the severity of an impact. According to NHTSA, twenty automakers representing more than 99 percent of the U.S. automobile market have agreed to make automatic braking systems a standard feature on newly-built passenger vehicles starting in 2022. These braking systems may help reduce the number of passenger vehicles striking the rear of tractor-trailers, potentially reducing the frequency of underride-related crashes, fatalities, and injuries.

Rear Guards in Use on Roads May Not Be Regularly Inspected

FMCSA regulations require commercial vehicles operating in interstate commerce to be inspected to ensure they are safe. However, the rules do not specifically include an inspection of the rear guard. After a rear guard has been installed on a new trailer, stakeholders told us that the guard may be damaged during normal use (see fig. 5), for example by backing

into loading docks. However, only certain roadside inspections—which are performed at random or if an officer suspects a problem—specifically require the rear guard to be inspected. Specifically, of the eight types of roadside inspections, representatives of the Commercial Vehicle Safety Alliance (CVSA)—which helps develop roadside inspection standards—told us that four require the rear guard to be inspected.[22]

Figure 5: Example of a Damaged Rear Guard

Source: GAO. | GAO-19-264

Stakeholders we interviewed told us that a trailer could go its entire lifecycle—estimated as typically 10 to 15 years—without ever being selected for a roadside inspection. FMCSA data show that although rear guard violations may be identified during roadside inspections, they constitute a small percentage of all violations. For example, out of about

[22]A fifth type of roadside inspection, known as "Level 4 – Special Inspections," is performed to review one piece of equipment, such as air brakes. Representatives from CVSA, which helps develop roadside inspection standards, stated that a special inspection could potentially be set up to solely inspect rear guards.

5.8 million violations identified during roadside inspections in 2017, approximately 2,400, or 0.042 percent, were rear guard violations. In an effort to learn more about rear guard violations, CVSA encouraged commercial vehicle inspectors to specifically focus on rear guards during their roadside inspections performed from August 27 through 31, 2018. According to these data, for the more than 10,000 trailers inspected during that 5-day time frame, about 900 violations (about 28 percent of all violations identified) for rear guard dimensional or structural requirements were identified, including almost 500 instances where the rear guard was cracked or broken, or missing altogether.[23] A CVSA representative stated there was a greater percentage of violations identified because inspectors were asked to specifically focus on the rear guard during this effort.

Inspectors performing annual inspections—which can include employees of the motor carrier—rely on a checklist established in FMCSA regulations, known as "Appendix G." This appendix specifies what equipment must be inspected, such as the brake system, lighting, and wheels. Appendix G does not list the rear guard as an item to be inspected.[24] In August 2018, CVSA petitioned FMCSA to amend Appendix G to include rear guards as an item to be inspected. According to CVSA, in September 2018, FMCSA provided acknowledgment of its intent to review CVSA's petition.

FMCSA's regulations, including those regarding commercial vehicle inspections, help the agency achieve its safety mission of reducing crashes, injuries, and fatalities. Further, *Standards for Internal Control in the Federal Government* notes that management should use quality information to achieve the entity's objectives.[25] Prior to receiving CVSA's petition to amend Appendix G, FMCSA officials told us that not including rear guards in Appendix G does not affect commercial vehicle safety, as FMCSA regulations require all parts and accessories specified within the regulations—which includes the rear guard—to be in safe and proper operating condition at all times. According to DOT, the agency does not believe that motor carriers are ignoring the application of these

[23]10,112 trailers were inspected during this time frame, including 1,072 trailers manufactured prior to January 26, 1998—the date when NHTSA's rulemaking requiring crashworthy rear guards on newly built tractor-trailers went into effect.

[24]49 C.F.R., Appendix G to subchapter B of Chapter III.

[25]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: September 2014).

regulations to rear guards. However, without explicitly including the inspection of the rear guard in Appendix G, there is no assurance that rear guards in operation will be inspected at least annually to ensure they perform as designed to prevent or mitigate an underride crash. This omission potentially affects FMCSA's safety mission to help ensure the safe operation of tractor-trailers on the nation's highways.

Side Underride Guards Are Being Developed, but Limited Information Exists to Assess Overall Effectiveness and Cost

While not currently required in the U.S., crashworthy side underride guards are being developed which could entail both costs and benefits to society. For example, there is currently one IIHS-crash-tested aftermarket manufacturer of side underride guards in North America, which has sold about 100 sets of side underride guards. According to the manufacturer, the cost of the guards starts at about $2,500 per trailer, though the price could decrease in the future as the manufacturing process becomes more efficient and greater quantities are built and sold. These side underride guards have been crash-tested by IIHS and successfully prevented underride crashes in tests at 35 and 40 miles per hour. As a result, the benefits of such guards might include a reduction in the number of fatalities in underride crashes. The manufacturer estimated that more widespread use of side underride guards would occur over the next 3 to 5 years. However, the manufacturer also said that more information on how side underride guards might affect everyday operations is needed before more widespread adoption by the industry. Additionally, some trailer manufacturers told us that they are in the process of developing side underride guards, but none are currently available for purchase. For example, a representative from one trailer manufacturer developing its own side underride guards estimated that it would be feasible to have these guards designed, tested, and available for sale within the next 2 years. However, the representative said that the manufacturer is hesitant to invest additional resources because of uncertainty about potential future regulatory requirements. Specifically, the manufacturer does not want to invest additional resources to develop a side underride guard that might later have to be redesigned to meet federal requirements, if such requirements were to be established and to differ from the manufacturer's design specifications.

Representatives from several trailer manufacturers, trucking industry organizations, and police departments we spoke with cited challenges

with the use of side underride guards that would need to be addressed prior to widespread adoption by the industry. Officials from Canada and the European Union—which also do not require the use of side underride guards that can withstand the force of a vehicle crash—noted similar challenges.

- *Weight:* According to the aftermarket side underride guard manufacturer, the side underride guards currently available for sale weigh between 575 to 800 pounds in total. Representatives from two trucking industry organizations we spoke with stated that the additional weight from side underride guards may require carriers to put more trailers on the roads to ship goods in order to stay under federal maximum weight restrictions (generally 80,000 pounds). Federal regulations allow for certain exemptions in the federal weight limits, such as for auxiliary batteries. Some stakeholders also stated that the additional weight from side underride guards would increase fuel costs (assuming all else remains the same) and could put stress on the trailer's frame, reducing its lifespan and potentially increasing maintenance costs.
- *Road clearance:* Some stakeholders we interviewed—including two trucking industry organizations, a tractor-trailer fleet operator, and a trailer manufacturer—stated that side underride guards limit a trailer's clearance from the ground, which could limit the geographic locations that could be serviced by a trailer or—if the guards drag along the ground—result in damage to the guards or even the trailer. Conditions involving limited clearance could include traveling over raised railroad crossings or navigating sloped loading docks. While aerodynamic side skirts may also drag along the ground in similar conditions, they are more flexible than side underride guards and less likely to damage the trailer.
- *Effects on under-trailer equipment and access:* Installation of a side underride guard may limit access to or displace equipment currently underneath a trailer, including spare tires, fuel tanks, and aerodynamic side skirts. Additionally, the rear axles of some trailers can be adjusted to evenly distribute the weight of the trailer's cargo. For example, trailer manufacturers told us that when the axle is moved to the furthest rear position of the trailer, a fixed-length side underride guard could leave a gap large enough for a car to still have an underride crash. Further, some police officers we interviewed told us that it could be challenging to perform roadside inspections of trailers equipped with side underride guards because the guards could limit access to the underside of the trailer.

Representatives from three trucking industry organizations we spoke with indicated that crash avoidance technologies may be more effective than underride guards at minimizing underride crashes, including side underride crashes. However, while these technologies have the potential to mitigate crashes, it is unlikely that they will be available on a more widespread scale in a time frame soon enough to render underride guards unnecessary. While automatic braking systems for passenger vehicles are to become a standard feature on newly built vehicles starting in 2022, IIHS representatives told us that these systems are less effective at detecting and mitigating side crashes than rear or frontal crashes. Specifically, the representatives stated that automatic braking systems would not be effective in situations where the passenger vehicle impacts the side of a trailer at an oblique angle rather than at a perpendicular angle. According to stakeholders we interviewed, it will take a considerable amount of time for the passenger fleet to adopt automated vehicle technologies, with some stating that there will be a mix of automated and non-automated technologies on the nation's highways for decades—longer than the 3 to 5 years estimated by the side underride guard manufacturer for more widespread use of these guards.[26]

NHTSA recently issued a study on the safety performance of certain materials used for side underride guards.[27] However, NHTSA has not performed research on the overall effectiveness and costs associated with or the design of side underride guards. NHTSA's mission is to "save lives, prevent injuries and reduce economic costs due to road traffic crashes, through education, research, safety standards and enforcement activity."[28] Additionally, a statement of federal principles on regulatory planning and review indicates that in deciding whether and how to regulate, agencies should assess all costs and benefits of available alternatives, including the alternative of not regulating, and that the agency should base its decisions on the best reasonably obtainable

[26]We have previously reviewed DOT's approach to automated vehicles and recommended that the department develop a comprehensive plan for addressing associated challenges. DOT agreed with our recommendation and has begun to take actions to implement it. See GAO, *Automated Vehicles: Comprehensive Plan Could Help DOT Address Challenges*, GAO-18-132 (Washington, D.C.: Nov. 30, 2017).

[27]NHTSA, *Computer Modeling and Evaluation Of Side Underride Protective Device Designs*, DOT HS 812 522 (Washington, D.C.: April 2018).

[28]NHTSA, *The Road Ahead: National Highway Traffic Safety Administration Strategic Plan 2016-2020*, DOT HS 812 343 (Washington, D.C.: October 2016).

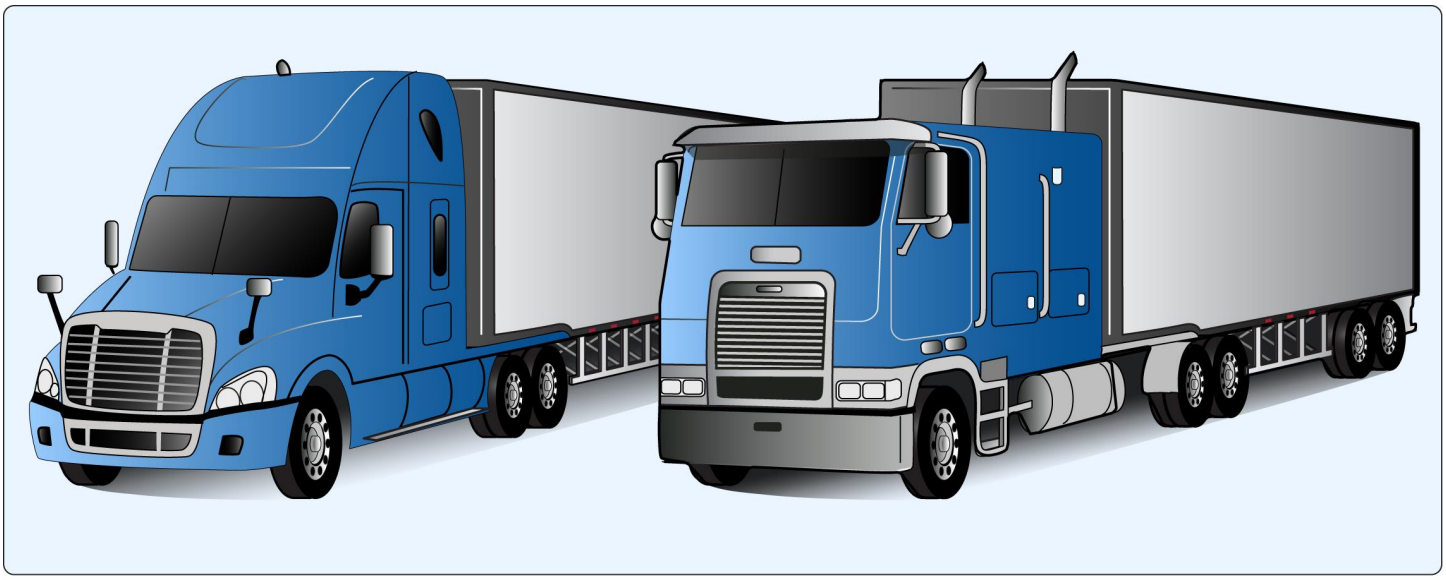
scientific, technical, economic, and other information.[29] Additional research on the effectiveness and cost associated with side underride guards could better position NHTSA to determine whether these guards should be required and, if so, appropriate standards for their implementation. Such research may also help provide information to address the challenges stakeholders cited with side underride guards.

Stakeholders Generally Agreed That North American Tractor Designs May Mitigate the Need for Front Guards for Underride or Override Purposes

In general, there are two types of tractors used in tractor-trailer combinations: conventional tractors, wherein the tractor is lower to the ground and the engine is in front of the cab where the driver sits, and "cab-over" tractors, which are designed so the driver sits atop the engine (see fig. 6). Conventional tractors are generally used in North America, whereas cab-over tractors are used more frequently in the European Union.

[29]Exec. Order No. 12866, 58 Fed. Reg. 51735 (Oct. 4, 1993).

Figure 6: Examples of a Conventional Tractor (left) and Cab-Over Tractor (right)



Source: GAO. | GAO-19-264

Since 2000, the European Union has required tractors to include front guards to improve the protection of passengers in cars involved in head-on collisions with tractors. These guards are designed to lower the front profile of a cab-over tractor to be more compatible with that of a passenger vehicle to reduce the potential for underride or override, and to help absorb the force of a collision.[30]

Some conceptual designs for front guards on conventional tractors have been proposed by researchers in the U.S., but there are no designs available for purchase or installation as there are for side underride guards. Some research organizations have developed computer models of front guards, but these guards have not been produced for U.S. tractor configurations. Representatives from three trucking associations we spoke with stated that their members were not researching, producing, or installing front guards. A government official from Canada—where the conventional tractor design is also commonly used—said that they did not know of any tractor manufacturers or truck fleets that use front guards. Representatives from a tractor manufacturer that operates in both the

[30]We focused our review of front guards on their use to prevent or mitigate underride or override crashes. Our work did not evaluate the force absorption capabilities or general crashworthiness of tractors in the U.S. or elsewhere.

U.S. and the European Union told us that front guard designs currently used in the European Union would not be compatible with conventional tractors used in the U.S., stating that these guards would need to be installed in the same space that the bumper, frame, and some equipment—including crash avoidance technologies—already occupy.

The design of conventional tractors may mitigate the need for front guards for underride or override purposes, as the lower bumpers and frame make the height of conventional tractors more compatible with passenger cars. A 2013 NHTSA study found that tractors with lower bumper heights were less likely to be involved in an override crash than those with higher bumper heights.[31] Government officials from the European Union told us that they did not see the need for conventional tractors to have front guards, since the lower bumpers essentially function as guards in frontal crashes. Officials from a state DOT, a state police department, and a local police department all stated that they do not see the need for front guards because the tractor is already so low to the ground.

Further, state and local officials we spoke with noted that the front underride crashes they have seen often occurred at higher speeds, such as when a truck fails to stop for congested traffic or in a head-on collision at higher speeds. In these cases, the speed combined with the much greater weight of the truck could cause the truck to override the car (in the first scenario) or the car to underride the tractor (in a head-on collision). According to these officials, the force of the crash at those speeds—regardless of whether there was underride or override—would very likely be unsurvivable.

Additionally, automatic braking systems in tractors and passenger vehicles may further mitigate the need for front guards for underride or override purposes. These technologies—which, according to a tractor manufacturer we interviewed, have been available and installed in some tractors—can potentially stop a tractor from, for example, overriding a passenger vehicle by automatically applying brakes in situations where a potential rear-end collision is detected. Representatives from a tractor manufacturer told us that about 70 to 80 percent of all newly manufactured tractors it produced are equipped with these braking

[31]NHTSA, *Heavy-Vehicle Crash Data Collection And Analysis to Characterize Rear and Side Underride and Front Override in Fatal Truck Crashes*, DOT HS 811 725 (Washington, D.C.: March 2013).

systems and estimated that more than 50 percent of newly built tractors sold by all manufacturers in the U.S. include these systems. Additionally, front guard researchers we spoke with told us that some front underride guard systems would be optimally effective when paired with automated technologies, such as automatic braking systems.

While stakeholders generally agreed that North American tractor designs may mitigate the need for front guards for underride or override purposes, NTSB has called for greater use of front guards. Specifically, in 2010, NTSB recommended that NHTSA, among other things, develop performance standards for front guards and, after doing so, require all newly manufactured trucks weighing more than 10,000 pounds to install these front guards. NTSB issued these recommendations based on its investigation of a June 2009 multi-car crash on an Oklahoma interstate, in which the driver of a tractor trailer failed to slow down for traffic stopped on the roadway. NTSB reported that the tractor-trailer's high impact speed and structural incompatibility with the passenger vehicles contributed to the severity of the crash. As of December 2018, NHTSA had not implemented NTSB's recommendations. NHTSA reported to NTSB in 2014 that it was in the process of conducting further examination of crash data, but that efforts in developing standards for front guards are a secondary priority to upgrading rear guard standards. NTSB stated that NHTSA's response was disappointing and that it continues to believe that NHTSA actions are needed to implement this recommendation. Additionally, NTSB recommended in 2015 that NHTSA develop performance standards and protocols for assessing forward collision avoidance systems in commercial vehicles, which could also help to stop a tractor from overriding a passenger vehicle. According to NTSB, although NHTSA has performed some research on this technology, NTSB has deemed NHTSA's responses as unacceptable. NHTSA officials told us that the agency anticipates completing relevant research and testing in 2019 that would give the agency the information it needs to make appropriate decisions on next steps related to these NTSB recommendations.

The Wide Variety of Single-Unit Truck Configurations Creates Challenges for Implementing Crashworthy Underride Guards

FMCSA regulations require rear guards for certain single-unit trucks, such as delivery or dump trucks, that are more than 30 inches above the ground. However, according to representatives of the trucking industry we

interviewed as well as NTSB, the wide variety of single-unit trucks makes it challenging to develop a one-size-fits-all requirement for underride guards. Single-unit trucks can vary widely with respect to weight, dimensions, and purpose and can include large pick-up trucks, fire trucks, and dump trucks. The FMCSA regulations exempt certain single-unit trucks—such as those already low to the ground—from the requirement to have a rear guard if the vehicle is constructed and maintained such that the body or other parts of the vehicle provide rear end protection comparable to rear guards required for other single-unit trucks.

A trucking industry representative we spoke with said that his association was not aware of any manufacturers currently designing or planning to design crashworthy rear, side, or front underride guards for single-unit trucks due to the variability of single-unit truck design. Some U.S. cities, such as Boston, require pedestrian/cyclist side guards be installed on municipally owned single-unit trucks, but these guards are not designed to mitigate a passenger vehicle underride crash.

Research shows that crashes involving single-unit trucks occur less often and are less likely to cause serious injuries and fatalities than those involving tractor-trailers. For example, a 2013 NTSB study of crash data from 2005 through 2009 found that single-unit truck crashes occurred less often, resulted in fewer fatalities, and were less likely to cause serious injuries than tractor-trailer crashes.[32] NHTSA has also acknowledged that single-unit trucks represent the majority of the registered heavy vehicle fleet, but account for a lower percentage—27 percent—of rear end fatalities.

To help address fatalities associated with underride crash fatalities involving single-unit trucks, as part of its 2013 study, NTSB recommended that NHTSA develop standards for crashworthy rear, side, and front guards for single-unit trucks, as well as devote efforts to crash

[32]NTSB, *Crashes Involving Single-Unit Trucks that Resulted in Injuries and Deaths*, NTSB/SS-13/01, PB2013-106637 (Washington, D.C.: June 17, 2013). For the crashes and fatalities information, NTSB used 2005 through 2009 data from the Trucks in Fatal Accidents database. For the serious injuries information, NTSB used 2005 through 2009 data from the Crash Outcome Data Evaluation System for the following states: Delaware, Maryland, Minnesota, Nebraska, and Utah. Additional research from IIHS using 2010 FARS data found that 75 percent of deaths in large truck crashes in 2010 were in crashes involving tractor-trailers whereas 25 percent were in crashes involving single-unit trucks. IIHS, “Fatality Facts: Large Trucks, 2010,” accessed October 24, 2018, http://www.iihs.org/iihs/topics/t/large-trucks/fatalityfacts/large-trucks/2010.

avoidance technologies and include more variables in FARS to improve data collection. NTSB also noted that, because of the variability in vehicle design and cargo body styles, safety countermeasures for single-unit trucks would need to be adapted for different truck types to address technical challenges to their implementation.

NHTSA published an ANPRM in 2015 that considered requiring rear guards with strength and energy absorption criteria for all newly built single-unit trucks. However, NHTSA subsequently found that the costs of this requirement outweighed the benefits.[33] Comments on this ANPRM varied. For example, the American Trucking Associations stated that it believed NHTSA underestimated the costs associated with installing crashworthy rear guards for single-unit trucks. In contrast, IIHS, in its comments on the ANPRM, questioned NHTSA's assumptions and stated that the agency was undervaluing the benefits and overestimating the costs. Specifically, IIHS noted that NHTSA overestimated the additional weight of the rear guards, thereby overestimating the cost by about 35 to 40 percent. IIHS also stated that due to concerns with the underlying data, NHTSA underestimated the number of crashes into the rear of single-unit trucks with passenger compartment intrusion. NHTSA officials told us that they disagreed with IIHS's assessment and stated that the data NHTSA used in the ANPRM were valid and appropriate. The ANPRM also considered requiring single-unit trucks to install red and white retroreflective tape meant to increase the visibility of these trucks, especially in the dark. NHTSA found that this requirement would be cost-effective at preventing or mitigating crashes involving single-unit trucks. However, NHTSA has since withdrawn the ANPRM, stating that—based on the comments received as well as analysis of the petitions—the changes being considered were not justified.

Conclusions

The likely underreporting of underride crashes and fatalities due to variability in the data collection process limits NHTSA's ability to accurately determine the frequency of such crashes. An underride field in

[33]NHTSA's cost-benefit analysis included in the ANPRM considered the effects of requiring rear guards with strength and energy absorption capabilities on newly built single-unit trucks for class 3 (e.g., delivery trucks) through class 8 (e.g., dump trucks). NHTSA estimated that this requirement would not be cost-effective, even if class 3 single-unit trucks were excluded from the analysis.

MMUCC and additional information from NHTSA on how to identify and record these crashes would provide greater assurance that state and local police officers are accurately reporting data on underride crashes. Such reporting would, in turn, enable NHTSA to better identify and support measures—such as rulemakings and research efforts—to help address this issue. While the stronger rear guards being voluntarily implemented by the largest trailer manufacturers show promise in mitigating the potentially devastating effects of rear underride crashes, rear guards will only be effective if they are properly maintained and replaced when damaged. The lack of specific requirements that rear guards be inspected annually for defects or damage potentially affects the safety of the traveling public and FMCSA's ability to achieve its safety mission. Finally, designs of crashworthy side underride guards show promise at mitigating underride crashes, but manufacturers may be reluctant to move forward with further development of these types of guards without information from NHTSA on the effectiveness, cost, and implementation standards for these devices. With additional research on resolving the challenges associated with side underride guards, these guards may be closer to being a feasible solution than automated driver assistance technologies designed to prevent or mitigate side impacts that could lead to an underride crash.

Recommendations for Executive Action

We are making the following four recommendations to DOT:

The Administrator of the National Highway Traffic Safety Administration should recommend to the expert panel of the Model Minimum Uniform Crash Criteria to update the Criteria to provide a standardized definition of underride crashes and to include underride as a recommended data field. (Recommendation 1)

The Administrator of the National Highway Traffic Safety Administration should provide information to state and local police departments on how to identify and record underride crashes. (Recommendation 2)

The Administrator of the Federal Motor Carrier Safety Administration should revise Appendix G of the agency's regulations to require that rear guards are inspected during commercial vehicle annual inspections. (Recommendation 3)

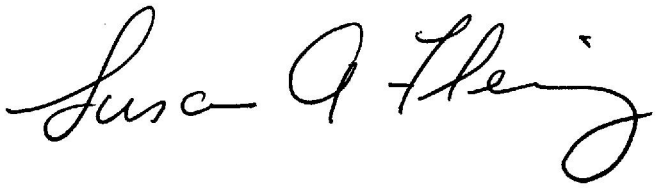
The Administrator of the National Highway Traffic Safety Administration should conduct additional research on side underride guards to better understand the overall effectiveness and cost associated with these guards and, if warranted, develop standards for their implementation. (Recommendation 4)

Agency Comments

We provided a draft of this report to DOT for comment. In its written comments, reproduced in appendix II, DOT stated that it concurred with our recommendations. DOT also provided technical comments, which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Secretary of Transportation, and other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or flemings@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.



Susan Fleming
Director, Physical Infrastructure

Appendix I: Objectives, Scope, and Methodology

Our work for this report focused on truck underride crashes, and the U.S. Department of Transportation's (DOT) efforts related to this issue. In particular, this report examines (1) the data DOT reports on underride crashes, and (2) the development and use of underride guard technologies in the U.S.

For both objectives, we conducted a literature review to identify studies regarding truck safety, in general, and underride guards, in particular, published from 1970 through 2018. We conducted a search for relevant peer-reviewed articles, government reports, trade and industry articles, and think tank publications. Key terms included various combinations of "underride," "crash," "collision," and "guard." We included those studies that were methodologically sound and covered underride crash data, guard technologies, and benefits and costs relevant to our scope. Additionally, we interviewed and analyzed the perspectives of government officials from DOT, the National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration (FMCSA), and the National Transportation Safety Board. We interviewed officials from foreign transportation agencies—Canada and the European Union—that were selected based on our review of literature identified above and recommendations from preliminary interviewees. We also interviewed a variety of relevant non-governmental organizations to gain their perspectives on topics related to underride crashes and guards. These organizations represent a variety of key players in their respective fields on underride crash-related topics. We grouped these entities into the following categories: (1) trailer manufacturers, (2) trucking industry organizations, (3) tractor-trailer fleets and related organizations, (4) traffic safety organizations, and (5) research organizations. We interviewed seven of the top eight trailer manufacturers in the United States, as identified by the Insurance Institute for Highway Safety. We requested an interview with Stoughton Trailers, but they declined to participate. The organizations we contacted as part of this work are listed at the end of this section. We also interviewed NHTSA officials and conducted semi-structured interviews with officials in five selected states, including officials in five state departments of transportation and five state and two local police departments to understand and identify limitations, if any, in

how underride crash-related data are collected and analyzed. The results of these interviews are not generalizable to all states and localities; however, they offer examples of the types of experiences state DOTs and police have with underride crashes and inspections. We selected states based on several factors to identify states that were similar in highway traffic trends and large truck-related fatality rates, but collected underride crash data differently. Selection factors included highway vehicle miles traveled per state, total underride crash fatalities by state in 2016 as reported by NHTSA, and the presence of an underride crash data field on each state's crash report form. Based on these factors, we selected and conducted interviews with state DOT and state police officials in California, Illinois, Indiana, Pennsylvania, and Tennessee. We also corresponded with officials from the Ohio DOT for clarification questions. We interviewed local police departments in Chicago, Illinois and Terre Haute, Indiana.

To identify the data DOT reports on truck underride crashes, we analyzed existing DOT data on underride crashes and fatalities from 2008 through 2017, the 10 most recent years for which these data are available. We reviewed DOT documentation for policies and procedures on data collection and data reliability assessments for underride crash-related data. NHTSA fatality data came from the Fatality Analysis Reporting System (FARS). FARS is a census of all fatal traffic crashes in the United States that provides uniformly coded, national data on police-reported fatalities. We analyzed these data to determine the reported number of fatalities involving underride crashes. To assess the reliability of the FARS data, we reviewed relevant documentation and spoke with agency officials about the data's quality control procedures. We determined that the data were sufficiently reliable for the purposes of this report, specifically to provide a high-level overview of underride crash fatalities within recent years. However, we did identify potential underreporting of underride crashes and fatalities, as discussed in this report. We also reviewed NHTSA's annual *Traffic Safety Facts* reports—which use FARS data—to determine the annual number of traffic and large truck crash fatalities from 2008 to 2017, the 10 most recent years for which these data are available. We reviewed state crash report forms from all 50 states and the District of Columbia to understand the variability of underride crash-related data elements and how such variability could affect DOT's data collection and analysis efforts. We compared NHTSA's data collection efforts to federal internal control standards related to use of quality information.

To describe the development and use of truck underride guard technologies in the United States, we reviewed research and documentation on underride guards. Primarily, we reviewed documents relating to underride guards from NHTSA and FMCSA, as well as information from traffic safety groups, trucking industry organizations, research organizations, and selected foreign transportation agencies. We reviewed NHTSA's regulations requiring rear guards, FMCSA's regulations requiring commercial vehicle inspections, DOT's documentation on underride guard technologies, and DOT data on commercial vehicle inspections. To assess the reliability of DOT's commercial vehicle inspection data, we reviewed relevant documentation and spoke with agency officials about the data's quality control procedures. We determined that the data were sufficiently reliable for the purposes of this report, specifically to provide a high-level overview of commercial vehicle inspections within recent years. We compared DOT's efforts to pertinent agency regulations on commercial vehicle inspections, federal internal control standards related to use of quality information, and a statement of federal principles on regulatory planning and review. We spoke with relevant non-governmental organizations to obtain their perspectives on the perceived benefits and costs of rear, side, and front underride guards, and the potential factors that may influence the benefits and costs.

We conducted this performance audit from January 2018 to March 2019 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Organizations Contacted

We interviewed representatives from the following entities:

Federal Government Entities

- U.S. Department of Transportation
  - National Highway Traffic Safety Administration (NHTSA)
  - National Institute for Safety Research (NHTSA's data validation and training contractor)

- Federal Motor Carrier Safety Administration
- National Transportation Safety Board

State Government Entities

- California Department of Transportation
- California Highway Patrol
- Illinois Department of Transportation
- Illinois State Police
- Indiana Department of Transportation
- Indiana State Police
- Pennsylvania Department of Transportation
- Pennsylvania State Police
- Tennessee Department of Transportation
- Tennessee Highway Patrol

Local Police Departments

- Chicago, Illinois Police Department
- Terre Haute, Indiana Police Department

Foreign Government Entities

- European Commission for Growth—Internal Market, Industry, Entrepreneurship and SMEs
- European Commission for Mobility and Transport
- Transport Canada

Trailer Manufacturers

- Great Dane Trailers
- Hyundai Translead
- Manac Inc.
- Strick Trailers
- Utility Trailer Manufacturing Company

- Vanguard National Trailer Corp.
- Wabash National

Trucking Industry Organizations

- AirFlow Deflector
- American Trucking Associations
- Arconic
- Hydro
- Motor and Equipment Manufacturers Association
- Owner Operator Independent Drivers Association
- Truck and Engine Manufacturers Association
- Truck Trailer Manufacturers Association
- Volvo

Tractor-Trailer Fleets and Related Organizations

- Association for the Work Truck Industry
- M&J Intermodal/Eagle Intermodal
- National Association of Fleet Administrators
- US Foods

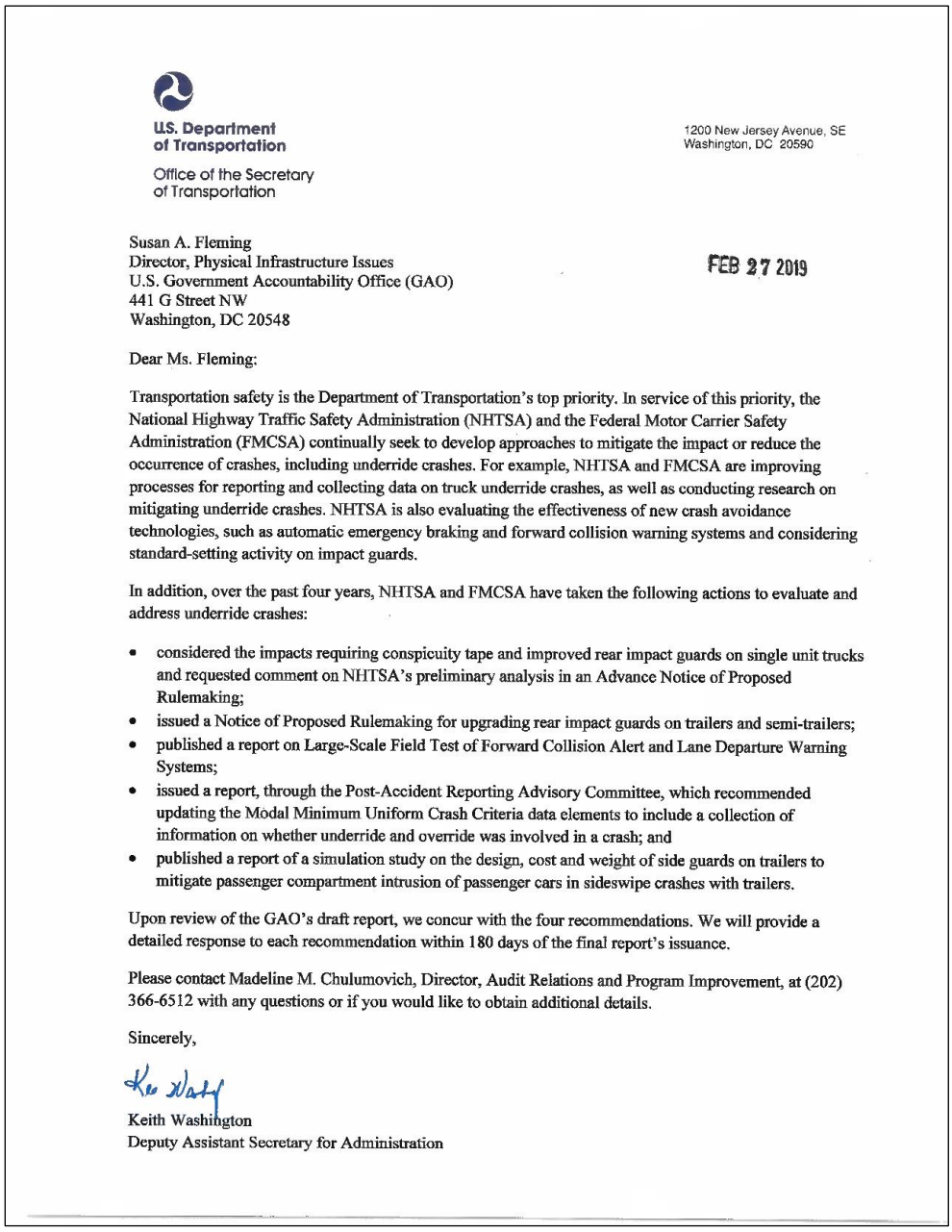
Traffic Safety Organizations

- Advocates for Highway and Auto Safety
- AnnaLeah & Mary for Truck Safety
- Commercial Vehicle Safety Alliance
- Governors Highway Safety Association
- Insurance Institute for Highway Safety
- National Sheriffs' Association
- Property Casualty Insurers Association of America
- Stopunderrides.org
- Truck Safety Coalition

Research Organizations

- Collision Safety Consulting
- Friedman Research Corporation
- Texas A&M Transportation Institute, Center for Transportation Safety
- University of North Carolina, Gillings School of Global Public Health

Appendix II: Comments from the Department of Transportation



U.S. Department of Transportation

Office of the Secretary of Transportation

1200 New Jersey Avenue, SE
Washington, DC 20590

Susan A. Fleming
Director, Physical Infrastructure Issues
U.S. Government Accountability Office (GAO)
441 G Street NW
Washington, DC 20548

FEB 27 2019

Dear Ms. Fleming:

Transportation safety is the Department of Transportation's top priority. In service of this priority, the National Highway Traffic Safety Administration (NHTSA) and the Federal Motor Carrier Safety Administration (FMCSA) continually seek to develop approaches to mitigate the impact or reduce the occurrence of crashes, including underride crashes. For example, NHTSA and FMCSA are improving processes for reporting and collecting data on truck underride crashes, as well as conducting research on mitigating underride crashes. NHTSA is also evaluating the effectiveness of new crash avoidance technologies, such as automatic emergency braking and forward collision warning systems and considering standard-setting activity on impact guards.

In addition, over the past four years, NHTSA and FMCSA have taken the following actions to evaluate and address underride crashes:

- considered the impacts requiring conspicuity tape and improved rear impact guards on single unit trucks and requested comment on NHTSA's preliminary analysis in an Advance Notice of Proposed Rulemaking;
- issued a Notice of Proposed Rulemaking for upgrading rear impact guards on trailers and semi-trailers;
- published a report on Large-Scale Field Test of Forward Collision Alert and Lane Departure Warning Systems;
- issued a report, through the Post-Accident Reporting Advisory Committee, which recommended updating the Modal Minimum Uniform Crash Criteria data elements to include a collection of information on whether underride and override was involved in a crash; and
- published a report of a simulation study on the design, cost and weight of side guards on trailers to mitigate passenger compartment intrusion of passenger cars in sideswipe crashes with trailers.

Upon review of the GAO's draft report, we concur with the four recommendations. We will provide a detailed response to each recommendation within 180 days of the final report's issuance.

Please contact Madeline M. Chulumovich, Director, Audit Relations and Program Improvement, at (202) 366-6512 with any questions or if you would like to obtain additional details.

Sincerely,

Keith Washington
Deputy Assistant Secretary for Administration

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Susan Fleming, (202) 512-2834 or flemings@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Sara Vermillion (Assistant Director); Daniel Paepke (Analyst in Charge); Carl Barden; Jessica Du; Mary Edgerton; Timothy Guinane; David Hooper; Gina Hoover; Madhav Panwar; Joshua Parr; Malika Rice; Oliver Richard; Matthew Rosenberg; Pamela Snedden; and Michelle Weathers made key contributions to this report.

Appendix IV: Accessible Data

Agency Comment Letter

Text of Appendix II: Comments from the Department of Transportation

Page 1

February 27, 2019

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Director, Physical Infrastructure Issues
U.S. Government Accountability Office (GAO)
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