The NYC School Bus Fleet: Improving Road Safety Through Technologies and Training

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Photo credit: Volpe

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Contents

List of Abbreviations

Abbreviation	Term
AEB	Automatic emergency braking
AI	Artificial intelligence
BAC	Blood alcohol Content
CFR	Code of federal regulations
DCAS	Department of Citywide Administrative Services
DOE	NYC Department of Education
DOE OPT	NYC Department of Education-Office of Pupil Transportation
EDR	Event data recorder
EU	European Union
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
G	G-force
GPS	Global positioning system
IIHS	Insurance Institute for Highway Safety
ISA	Intelligent Speed Assistance
LED	Light emitting diode
LDV	Light duty vehicle
OEM	Original equipment manufacturer
NCSL	National Conference of State Legislatures
NHTSA	National Highway Traffic Safety Administration
NPRM	Notice of proposed rulemaking
NTSB	National Transportation Safety Board
NYC	New York City
PAEB	Pedestrian automatic emergency braking
SFTP	Safe fleet transition plan
Volpe	U.S. Department of Transportation Volpe Center
VRU	Vulnerable road user

Executive Summary

In 2022, the New York City (NYC) Department of Citywide Administrative Services (DCAS) and NYC Department of Education (DOE) requested the U.S. Department of Transportation Volpe Center (Volpe) to research NYC school bus vehicle safety, with a focus on improving pupil and other vulnerable road user (VRU) safety, and to develop an analysis of prioritized countermeasures to advance the NYC Vision Zero goal of eliminating traffic deaths and injuries.

Safety context highlights include:

- School buses are widely recognized as the safest motor vehicle option for children to travel to and from school.[1]
- However, school bus transportation is not without risk, especially for the VRUs outside the bus.
- There were eleven fatalities involving a NYC school bus since 2017.[2] All fatalities reported were vulnerable road users, supporting a VRU safety lens for this SFTP.
- There were additionally 347 incidents involving NYC school buses and pedestrians and cyclists that resulted in insurance claims since 2017.
- From 2017 to 2022, there were 8,172 distinct claims relating to school transportation, resulting in payments totaling an estimated $90 million[3] with a further $249 million in unpaid claims,[4] a substantial financial outlay. As per NYC Schools, on average, $100 million is paid out annually for school bus collisions, encompassing DOE, insurance, and school bus company payouts.[5]

Based on this context, there is additional work to be done in improving school bus safety. Based on literature review, subject matter expert interviews school bus telematics data analysis, and insurance payouts for collisions involving school buses, Volpe identified safety use cases relevant to NYC's over 10,000 school buses, developed a list of applicable possible countermeasures, and assessed the countermeasures' potential safety benefit and feasibility of implementation.

Volpe conducted a literature review on safety technologies available for school buses and identified information gaps related to deployment and effectiveness data. Volpe used published evidence of effectiveness and implementation results to inform the assessment of each safety technology.

Volpe invited the school bus companies with the largest fleets operating in NYC to participate in interviews to inform the development of the NYC School Bus SFTP. NYCSBUS (929 buses), Pioneer (385),

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[1] National Highway Traffic Safety Administration. *School Bus Safety*. n.d. https://www.nhtsa.gov/road-aasafety/school-bus-safety

[2] Volpe analysis of NYC Department of Education Office of Pupil Transportation school bus insurance losses dataset spanning 6/30/17-6/30/22.

[3] Volpe analysis of NYC Department of Education Office of Pupil Transportation school bus insurance losses dataset spanning 6/30/17-6/30/22

[4] EPIC Insurance Brokers, *Auto Liability Actuarial Analysis of Unpaid Claims and Loss Forecast as of June 30, 2023* for NYC Department of Education Office of Pupil Transportation.

[5] NYC Department of Education Office of Pupil Transportation. August 2023.

Leesel/Selby (522), Hoyt (522), L&M/Quality (1,229), and Logan (1,841) participated in these interviews. These six bus companies represent 5,337 buses or nearly half of the buses operated for the City and tracked through telematics at the DCAS Fleet Office of Real Time Tracking (FORT).

The discussions revealed several themes. While companies place a high importance on safety, interviewees noted that there may be cost-related and/or other challenges associated with the implementation of one or multiple technologies across entire fleets at once. Driver attention was also a common concern among interviewees. They questioned whether too many warning systems or monitors may be detrimental for safety if they distract the driver from essential driving tasks. Multiple interviewees discussed driver behavior monitoring cameras and event-based camera systems favorably, and they emphasized the importance of driver training for successful deployment of new technologies, noting that some of the training needs may be extensive.

Volpe analyzed school bus telematics data for speeding events and harsh acceleration/deceleration events in the 2021 calendar year. On average, approximately 86 instances of speeding at 11 mph or above the speed limit were recorded per bus for 2021. Speeding alerts were analyzed by hour of the day, month, and severity. Predictably, the number of speeding alerts was highest in the early morning and midafternoon hours. In addition, most speeding events fell between 11 mph and 20 mph above the speed limit, although instances of excessive speeding (25 mph or above the speed limit) were also recorded. Volpe also analyzed the acceleration and deacceleration data from potential collision alerts. Most collision alerts occurred at the high end in each direction. The 25th and 75th percentiles of the forward acceleration were -2.51 *g* and 2.59 *g* respectively, with negative acceleration reflecting de-acceleration or braking. Research has shown that deceleration events at the 0.43 *g* threshold and acceleration events at the 0.30 *g* threshold can predict risky drivers, [6] so the g-forces of most collision alerts in the telematics data set may indicate unsafe accelerating and braking behavior. The distribution of lateral (side) acceleration patterns for each collision alert also indicated that a portion of the collision alerts could indicate unsafe driving.

Based on this four-part analysis, involving literature review, interviews, telematics, and insurance data analysis, Volpe proposes a tiered approach to aid in prioritizing among possible countermeasures. This is consistent with the approach taken in prior SFTPs developed for the NYC Fleet. The proposed tiers table organizes countermeasures by Tier 1 (Implement or Initial Pilot), Tier 2 (Best Practice), and Tier 3 (Exploratory).

[6] Mao, H., Guo, F., Deng, X., & Doerzaph, Z. R. (2021). Decision-adjusted driver risk predictive models using kinematics information. *Accident Analysis & Prevention*, *156*, 106088.

This report outlines a series of countermeasures to help avoid collisions and reduce their impact on vulnerable road users, and DCAS and DOE foresees seven new initiatives and anticipates implementing these in the near future:

- Piloting a first-in-the-nation widespread test of intelligent speed assistance (ISA) on school buses. This pilot of 50 school buses will be modeled after the New York City fleet pilot and will test ISA on buses from different manufactures, size, and powered by diesel fuel as well as electric.

- Testing audible turn alerts for pedestrians and other vulnerable road users. Statistics show that approximately twenty-eight percent of school-age pedestrians killed in crashes with school buses occurred when the vehicle was turning.[7] Systems could include LEDs as well as voice or other audible alerts. This may be modeled after the MTA NYC Transit program as well as current rollouts being organized by DCAS at NYC City fleet agencies. The pilot will start with fifty systems that will be a mix of device types and will be focused on electric buses.

- Piloting tools to provide automated enforcement, driver alert systems, and other tools to reduce incidents of vehicles passing school buses with lights flashing and stop sign extended.[8] [9] These include stop arm cameras, extended stop arms, and additional lights. This pilot program of school bus stop arm cameras will start with 30 cameras. In addition, new electric school buses are being delivered with additional lights and extended stop arms.

- Expanded use of telematics reporting, including real time alerts, speed and collision alert monitoring, and monthly safety score cards to track risk for each school bus across the school bus companies. To be modeled after the City telematics reporting including additional alerts and monthly safety reporting, with a goal of zero buses operated at high or moderate risk, as determined by the telematics system, in the new school year.

- Mitigating blind zones using technology such as surround cameras, in-cab driver alerting such as pedestrian collision warning (PCW) systems, and back up sensors, with the long-term goal of effecting school bus design that increases direct vision, especially as bus electrification offers additional opportunities for direct vision in new buses. This new pilot program will also provide near miss collision reporting and analysis. Together for Safer Roads will be working with DCAS, DOE. and a selected school bus company on this pilot of ten buses.

[7] National Highway Traffic Safety Administration. “School-Transportation-Related Crashes”. June 2022. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813327#

[8] “Ongoing Efforts to Improve School Bus Safety.” 2023. https://trafficsafety.ny.gov/ongoing-efforts-improve-school-bus-safety

[9] The City Record, Number 145. July 31, 2023. https://www.nyc.gov/assets/dcas/downloads/pdf/cityrecord/cityrecord-07-31-23.pdf

- Mandatory urban safety and defensive driver training for school bus operators as DCAS has done for City fleet operators--a new safety course for all school bus operators, reviewing Vision Zero, telematics tracking, best practices, and urban driving similar to the City fleet initiative. To be developed in conjunction with DOE OPT and school bus companies, with the goal to have all drivers complete it by the start of the 2025-2026 school year. |

- School bus of the future: DCAS to partner with DOE OPT, school bus companies, and school bus manufacturers on updated specifications for school buses looking at additional safety implementation in various areas and investigate piloting these as retrofits. As the City moves to electric school buses by 2035, DCAS and DOE will work with companies to maximize safe design in addition.

DCAS anticipates updating this report on a regular basis as additional technologies and data on their effectiveness become available. For example, there are some advanced driver assistance technologies presently available for passenger vehicle applications which may become available for school buses in the future. Further data from NYC school bus operator experience and from future federal research on school bus safety in support of the Bipartisan Infrastructure Law may also inform future SFTP updates.

Introduction

Background

In partnership with the U.S. DOT Volpe Center (Volpe), the New York City (NYC) Department of Citywide Administrative Services (DCAS) has developed industry-leading Safe Fleet Transition Plans (SFTPs) for its municipal fleet and other fleets including the private waste fleet under the purview of the City.

The first report was on truck side guards and produced in 2014. It has informed two NYC local laws, including Local Law 56 of 2015 requiring sideguards on all city-owned and private waste trucks, and Local Law 108 of 2021 which requires sideguards for trucks servicing city contracts. The NYC government has the nation's largest side guard implementation with over 4,000 trucks using side-guards daily. Building on this first safety initiative, the two published SFTPs for the City fleet from 2017 and 2018 - 2019 have resulted in over 75,000 additional safety improvements to date across over 28,500 fleet units. Each SFTP has assessed the state of the market and technology to achieve safer and more sustainable fleets The SFTP published in 2021 focused on the private trade waste fleets. It served as a model for the present NYC School Bus SFTP, which also focuses on private companies, in this case companies serving students in the five boroughs. DCAS will update again the City fleet SFTP in 2024. In 2022, DCAS and Volpe also published a first Clean Fleet Transition Plan (CFTP) focusing on electrification opportunities for the City's extensive and diverse fleet.

The NYC School Bus SFTP is intended to lay a foundation for assessing and adopting safety improvements, such as high-vision buses, intelligent speed assistance, stop arm cameras, automatic braking, turning alerts, surround cameras, telematics, backup alerts, and other potential crash countermeasures. While the city fleet SFTP created tiers of technology prioritization, the school bus SFTP takes into account various factors such as bus ownership, bus age, operations, and other factors which guided the creation of the tier descriptions used in this report.

Methods

Volpe employed four complementary methods to identify safety issues and applicable countermeasures relevant to NYC school bus operations: literature review, interviews, and analysis of telematics and insurance data.

Literature Review

In the literature review, Volpe used information on the availability, applicability, and effectiveness of safety technologies for school bus applications to inform assessment and discussion of each safety technology.

Interviews

Volpe invited the school bus companies with the largest fleets operating in NYC to participate in interviews to inform the development of the NYC School Bus SFTP. Volpe contacted fourteen companies with a fleet larger than 260 buses, 800 hours of driving duration, 8,500 miles driven, or 1,800 trips based on telematics data.

Interviews were optional and six companies representing 5,337 buses participated. NYCSBUS, Pioneer, Leesel/Selby, Hoyt, L&M/Quality, and Logan shared their insights, expertise, and knowledge. Aside from the school bus companies operating in NYC, Volpe also spoke with a few other outside districts, some manufacturers, and other industry contacts for additional insight.

Telematics

To better illuminate the current safety context and crash risks of school buses, Volpe analyzed calendar year 2021 datasets derived from Geotab fleet management telematics technologies installed on over 10,000 NYC school buses. In addition to recording metrics such as mileage, speed profile, and idling, Geotab devices record possible collision alerts. The Geotab system classifies acceleration greater than or equal to 2.5 g-force (g) (in any direction) as a potential collision event.[10] The system appears to produce an alert for any acceleration that exceeds the g-force threshold, even if it is for an extremely short duration. As part of the analysis, Volpe applied various tools to reduce non-collision events such as environmental features (potholes or other pavement conditions) or devices that seem to have alerted based on maintenance work or aspects related to other yard work.

The final, cleaned dataset for analyses consisted of 2,565 collision alerts. Collision alerts in the Geotab system are different from actual collisions, as for example potholes can generate collision alerts.

Volpe conducted analyses to identify potential patterns with the collision alerts. Volpe mapped the locations of collision alerts and created a heatmap using Leaflet (an open-source mapping program) to illustrate concentrations of collision alerts. In addition, Volpe produced descriptive statistics to analyze temporal patterns in when the collision alerts were occurring, both by month and time of day. Volpe also derived descriptive statistics regarding the distribution of forward and side acceleration levels. The results of this analysis are in the Telematics Data Analysis section of this document.

Insurance

Volpe analyzed insurance data from claims related to school buses in New York City from the years 2017-2022.[11] The insurance data set encompassed claims filed from collision, property damage, no-fault personal injury protection, and bodily injury coverage. Only data from known claimants were included in

[10] https://www.geotab.com/white-paper/collision-reconstruction-with-telematics/
[11] Volpe analysis of NYC Department of Education Office of Pupil Transportation school bus insurance losses dataset spanning 6/30/17-6/30/22

the data set (any claimant labeled as "Unknown" was excluded). Because more than one claim may be associated with the same incident (e.g., someone may file both a property damage claim and a bodily injury claim if both were relevant), Volpe filtered out duplicate claimants to obtain the estimated number of incidents to obtain a clearer picture on the prevalence of certain types of collision categories. Two outcome variables were of interest for the analysis: the total amount paid to claimants and the number of claims.

Limitations

Limitations of Literature Review

There are several limitations with the literature review. First, quantifiable research on the effectiveness of safety technology in school buses is limited. In many cases, published research on effectiveness was available for a particular technology, but not necessarily in the school bus context. Implementation of advanced safety technology does not necessarily translate into improved safety on the road, and additional future research could better illuminate the relationship between technology implemented in school buses and safety on the road. For example, the relationship between stop arm camera deployment and reduced violations is unclear and warrants further research. Second, the quality of research on safety technologies in school buses is not consistent. Much of the information specific to school bus implementation of safety technology comes from isolated case studies with limited data.

Limitations of Interviews

While insightful, the interviews with NYC school bus fleet operator had some limitations. While each company had a different perspective to share, it was not feasible to interview every school bus company operating in NYC. In addition, the scope of work that each of these companies conducts varies widely based on size of buses, routes, and areas covered. The companies Volpe did interview represent nearly 50% of school buses operated on behalf of the City.

The interviewed companies discussed safety from the context of their own fleets and operations in NYC. Each company has their own operational area resulting in different geographic characteristics and operational requirements. There are differences between companies in the mix of wheelbases in the fleet, distribution of highway and residential road driving, philosophies on the use of park outs (when the bus is kept with the driver overnight), contract types, and student populations served. These differences contributed to varied perspectives on the safety needs of school buses.

The role of the interviewees within their respective companies varied as did their familiarity with different aspects of fleet operations. Later interviews benefited from the additional context of the earlier interviews and insights from the literature review and telematics analysis.

Limitations of Telematics Data Analysis

The telematics data compiled by Geotab is a rich source of information, although like any data source, it has certain limitations. The current analysis used both Geotab “speeding alerts” (any instance of a vehicle traveling at 11 mph or above the posted speed limit for 20 seconds or more) to examine speeding patterns and “collision alerts” (any forward or side acceleration event greater than or equal to 2.5 g) to examine acceleration and deacceleration patterns. Only the maximum speed of the event is recorded. Collision alerts can include non-crash events such as driving over pot-holes. Despite efforts to clean the data, many of the alerts could still represent false positives, and thus the acceleration and deacceleration distributions may be skewed. In addition, it is possible false positives of speeding alerts may be included in the dataset (e.g., if a bus traveling on the highway temporarily picks up the signal of an adjacent side street with a lower speed limit). However, due to the 11 mph speeding threshold for inclusion in the dataset, these instances of false positives are likely rare.

Limitations of Insurance Data Analysis

Although an expansive data set, there are certain limitations of the insurance data analysis that should be factored in when interpreting the findings. First, due to the information being keyed in over the course of years, there are inconsistencies in how collisions and claims were categorized. For example, it was not possible to parse out claims where the school bus rear-ended a vehicle (was at fault) versus when a vehicle rear-ended the school bus (the school bus was not at fault). Therefore, only broad categories of collisions could be analyzed (e.g., claims involving rear-ended collisions as a whole). Related, given the potential inconsistencies in terms of how the data are categorized, the number of collision instances and payout amounts should be treated as estimates. Second, the dataset includes only one collision type classification per claim, and all the VRU injury/fatal crashes are classified as "Hit pedestrian", "Hit cyclist," etc., without providing a manner or direction of collision. The remaining collision types, which do provide information about the collision direction, such as “head-on” or “side,” only refer to school buses colliding with other vehicles. Third, the amounts reported only account for money paid out; it does not account for the possibility of future payouts. Although the results of an actuarial analysis on estimated future insurance payouts is reported, this information is not available by crash type or other detailed criteria.

School Bus Safety Context

National

School buses are widely recognized as the safest motor vehicle option for children to travel to and from school. Nationwide, students are 70 times more likely to get to school safely when taking a school bus than when traveling by car.[12]

However, school bus transportation is not without risk, especially for the VRUs outside the bus, including students. School transportation-related crashes involve, either directly or indirectly, a school bus vehicle transporting children to or from school or school-related activities. NHTSA compiles fatal school transportation-related crashes, demonstrating the relative safety of buses compared to other means of transportation, while also identifying opportunities for further improving safety. Note that NHTSA figures do not include crashes in school parking lots, driveways, private property, or other locations outside of public roads.

From 2011 to 2020, among school transportation-related crashes nationwide, there were twice as many VRU fatalities (225 deaths) than school bus occupant fatalities (113 deaths).[13] Of the 225 VRU deaths, 91 were school-age children. Slightly less than half of school-age pedestrians killed in school transportation-related crashes nationwide were struck by the school bus, while slightly more than half were struck by other motorists, including while getting on or off the bus.[14]

According to a 2019 school bus driver survey administered by the National Association of State Directors of Pupil Transportation Services, over 17 million illegal passing violations occur nationwide over the 180-day school year.[15]

As per NHTSA, from 2011 to 2020, 44% (17) of the 39 school-age pedestrians killed in a school bus-related crash nationwide were struck by the school bus or transport vehicle going straight, as seen in Table 1.[16] Fifty-seven school children in the United States died when their bus or other transport vehicle ran them over. This reality argues the importance of vision obstructions related to bus design and the need for high vision bus options.

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[12] National Highway Traffic Safety Administration. *School Bus Safety*. n.d. https://www.nhtsa.gov/road-safety/school-bus-safety

[13] National Highway Traffic Safety Administration. "School-Transportation-Related Crashes". June 2022. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813327#

[14] *Ibid.*

[15] Hannon-Ekbatani, Taylor. "NASDPTS Illegal Passive Survey Returns". April 20, 2022. *School Transportation News*. https://stnonline.com/news/nasdpts-illegal-passing-survey-returns/

[16] National Highway Traffic Safety Administration. "School-Transportation-Related Crashes". June 2022. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813327#

Table 1. School-Age (18 and Younger) Pedestrians Killed in School-Transportation-Related Crashes, by Vehicle Maneuver and Striking Vehicle Type, 2011–2020

Vehicle Maneuver	School Bus Body Type	Vehicle Used as School Bus	Other Body Type	Total
Going Straight	17	1	39	57
Slowing in Road	1	0	0	1
Accelerating in Road	2	0	1	3
Starting in Road	7	0	1	8
Passing or Overtaking Another Vehicle	0	0	1	1
Turning Right	7	0	1	8
Turning Left	4	0	0	4
Negotiating a Curve	1	0	1	2
Other/Unknown	0	0	1	1
Total	**39**	**1**	**45**	**85**

Source: FARS 2011–2019 Final File, 2020 ARF

According to the National Safety Council tabulation of school bus crashes, data for the most recent available year (2020) show that 22 percent of school bus-related crashes nationwide involved speeding, although the tabulation does not specify whether the speeding was for school buses or other involved vehicles.[17]

New York State

The New York State Department of Motor Vehicles states that the youngest students are most at risk, especially in unloading and unloading situations.[18] The smaller stature of younger children makes them more difficult for bus drivers and motorists to see, and these younger students are less able to see over or around objects such as parked cars or bushes to detect traffic hazards.

According to the New York State Education Department:
"Fatal crashes involving students who were struck by passing motorists typically involved one or more of the following factors.

- Motorists attempted to pass the bus, claiming they did not have time to wait.
- Motorists claimed they couldn't see the flashing lights because the lights were dirty or because sun, rain, snow, or fog blinded them.
- The bus driver waved the motorist through the red flashing lights, unaware a child was crossing the road at that time.

[17] https://injuryfacts.nsc.org/motor-vehicle/road-users/school-bus/.
[18] New York State Department of Motor Vehicles. "School Bus Safety". N.d. https://dmv.ny.gov/more-info/school-bus-safety

- The motorist, demonstrating disregard for the law and children's safety, did not stop for the flashing red lights."[19]

The "Loading and Unloading" section of this report describes certain countermeasures related to the above factors.

New York City

The NYC Department of Education's Office of Pupil Transportation (OPT) moves about 150,000 students to and from home and school, along 9,000+ bus routes and about 52 bus companies.[20] As new technology and school bus designs are developed, tested, and optimized, school buses can become an even safer option for children and other VRUs. Planned electrification of the NYC school bus fleet could provide a unique opportunity to further improve safety through increased visibility and high vision trucks, advanced driver assistance systems, and other next generation fleet risk reduction technologies.[21]

Analysis Findings

Interviews Synthesis

Several themes emerged in Volpe interviews with NYC school bus operators.

Implementation challenges – While companies place a high importance on safety, interviewees noted that there may be cost-related and/or other challenges associated with the implementation of one or multiple technologies across entire fleets at once. They indicated that external support may be necessary for successful implementation of new technologies to help counteract costs and motivate manufacturers to simplify the process of adding technology to fleets.[22]

Driver attention – Driver attention was also a common concern among interviewees. They questioned whether too many warning systems or monitors may be detrimental for safety if they distract the driver from essential driving tasks. Drivers are already monitoring mirrors, the roadway ahead and crossroads, surrounding traffic, and the behavior of other drivers. Interviewees expressed concern that if drivers must additionally pay attention to other features, this may compromise their ability to operate safely.

[19] New York State Department of Motor Vehicles. "School Bus Safety". N.d. https://dmv.ny.gov/more-info/school-bus-safety#share-road

[20] https://council.nyc.gov/data/data-team/school-bus-delays-2022/

[21] Guse, Clayton. "NYC Officials Seek Tech Solution to Speeding Bus Drivers". Government Technology. September 8, 2022. https://www.govtech.com/education/k-12/nyc-officials-seek-tech-solution-to-speeding-bus-drivers

[22] See "Explanation of Technologies and Approaches" section on page 40 for a related discussion of how bus acquisition is more economical if technology standards are broad, which presents a challenge and an opportunity.

They recommended that any aftermarket equipment affixed to the dashboard be mounted securely, to avoid making drivers tend to the equipment instead of focusing on safely driving. Interviewees also praised attendants on special education routes for handling student distractions that may take drivers' attention away from the roadway.

Driver behavior monitoring and event-based camera systems – Multiple interviewees discussed driver behavior monitoring cameras and event-based camera systems favorably. One interviewee mentioned a pilot of an event-based camera system for driver monitoring and reported that driver acceptance was high; drivers did not feel constantly monitored and supervised. Interviewees expressed interest in technology to identify and address sleepiness or other forms of impaired or erratic driving behavior. Interviewees also relayed that parents have requested camera systems in school buses. One company is installing event-based camera systems across their fleet this year and is looking forward to using the real-time feedback for drivers to encourage safe driving behaviors. It should be noted that this is strictly a report of feedback from school bus companies and is not a direct reflection of current initiatives.

Driver training – Interviewees emphasized the importance of driver training for successful deployment of new technologies and noted that some of the training needs may be extensive. They also indicated that this may be especially important to mitigate the impact of any temporary glitches that may occur during rollout. According to interviewees, driver training requires a significant investment of cost, time, and other resources, and is a practical factor to consider in assessing feasible implementation pathways for technology options.

Telematics data – Interviewees consistently reported that telematics data are very useful in general and especially for improving safety. They reported that the daily speeding reports and information on braking behavior and idling illuminated driver behaviors and helped identify necessary training and retraining. They also indicated that telematics data can enable same-day conversations related to driver behavior. Interviewees noted that school bus companies would benefit from additional training on the use of the telematics data and how to report on or search through the information, as this could help them expand on the benefits.

Back-up cameras – The interviews provided conflicting viewpoints on backup cameras in school buses. Interviewees reported that, in general, drivers are not permitted to drive school buses in reverse, but this is sometime necessary for buses that provide door-to-door service and may also be necessary when parking the buses in tight lots. Some interviewees expressed interest in back-up cameras to help handle those occasions. Other interviewees questioned whether the addition of backup cameras may lead drivers to reverse when it is not necessary.

Stop arm cameras – One interviewee communicated optimism about the potential safety benefit of stop arm cameras. They noted that the cameras could generate tickets for drivers that illegally drive past a deployed stop arm, and by discouraging this behavior, create a safer environment for students when they are outside of the school bus. As discussed in the Stop Arms" section of this report, local law 10 allows NYC to create a demonstration program to use photographic evidence to impose liability on vehicle owners for passing a stopped school bus; local law 10 is set to expire December 1, 2024. NYC will be launching a pilot of stop arm cameras in the fall of 2023.

Pedestrian detection and blind zone monitoring – Multiple interviewees expressed interest in pedestrian detection and blind zone monitoring technologies. At the same time, they noted that cost remains a concern for widespread implementation of these technologies. Interviewees provided examples of challenging situations that highlight the potential benefit of these technologies; routing sometimes puts drivers in locations where maneuvering and/or visibility is difficult, due to narrow streets, double-parked cars, or other issues.

Telematics Data Analysis

Complementing literature review and operator interview-based research, Volpe also analyzed telematics data from NYC school buses to identify potential patterns of safety-relevant alerts. Volpe mapped and analyzed speeding alerts by month, time of day, , and speeding severity. A speeding alert was classified as a speeding event where the school bus was traveling 11 mph or above the posted speed limit and lasted 20 seconds or longer. In addition, Volpe analyzed collision alerts to examine harsh acceleration and deceleration patterns.

Temporal Trends

Figure 1 illustrates the average count of speeding alerts per bus by month in 2021. Speeding events of less than 11 mph over the speed limit were not captured in the telematics dataset. May was the month with the most alerts per bus (n =8.65), with the months of February (n = 3.28) and August (n = 3.54) having the least number of alerts. Although the summer months have fewer bus routes, and it would be expected to have fewer alerts compared to the rest of the year, February's relatively low number of speeding alerts is somewhat surprising. However, it is possible that early in 2021, telematics devices were still being installed and subject to ongoing commissioning. Additionally, not all schools in NYC were fully reopened in spring 2021, potentially leading to modified routes that may have reduced exposure and thus speeding.

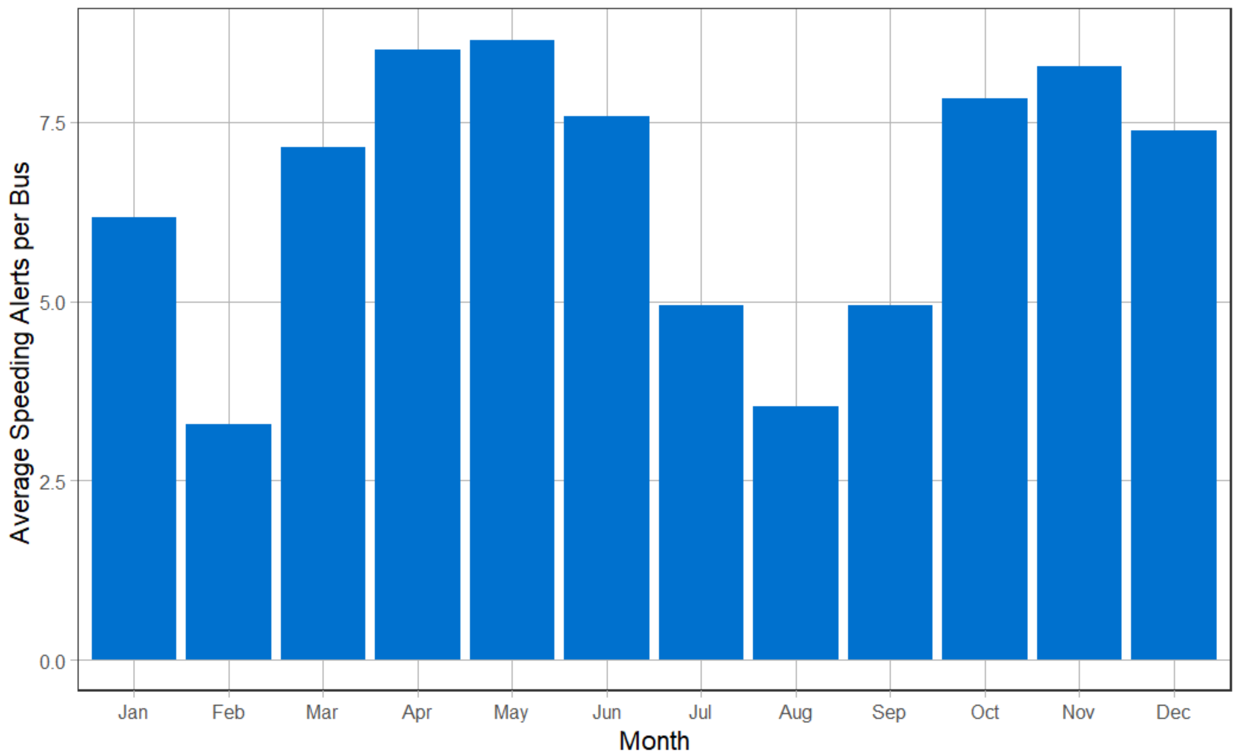

Figure 1. Average count of speeding alerts per school bus in 2021 by month

Since each school month has a different number of school days on which buses are operating, Volpe divided the number of speeding alerts per month per bus by the number of school days in each respective month for the 2021 school year (Table 2), to create a more equivalent comparison. The result was a normalized illustration of the average number of speeding alerts per school day (Figure 2). Volpe excluded July and August from this analysis due to the reduced number of school bus routes used in the summer months.

Table 2. School days for 2021 school year

Month	Jan	Feb	Mar	Apr	May	Jun	Sep	Oct	Nov	Dec
School days	19	14	20	20	19	18	13	20	18	17
Alerts per bus per school day	0.32	0.23	0.36	0.43	0.46	0.42	0.38	0.39	0.46	0.43

When normalized by school days per month, November had the most speeding alerts (average of 0.46 per bus per day). February continued to have the fewest number of speeding alerts (average of 0.23 per bus per day) in 2021.

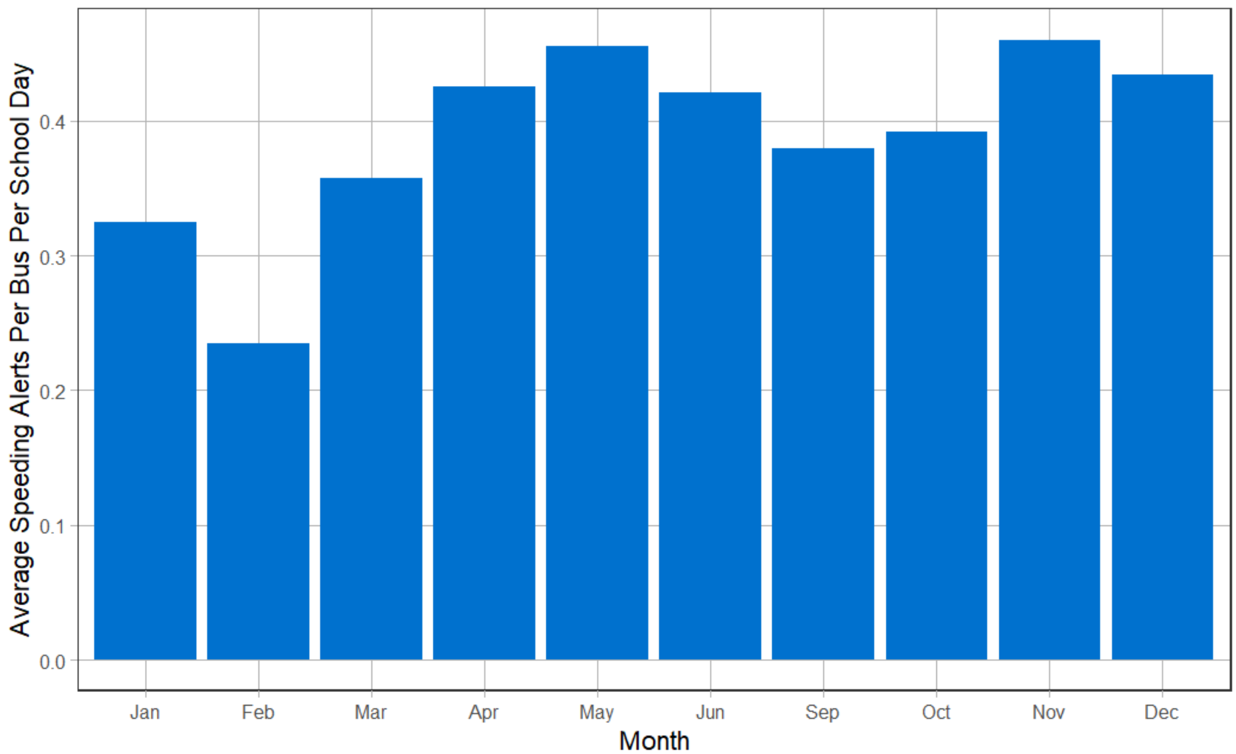

Figure 2. Average 2021 speeding alerts per school day per bus by month. Note that July and August were excluded due to reduced bus routes.

The time distribution of speeding alerts throughout the day was also examined. Figure 3 shows the number of alerts by hour of the day. The distribution was bimodal, with many alerts occurring early in the morning and mid-afternoon, coinciding with the morning and afternoon routes. There were additionally a small number of speed alerts that occurred either late at night or early in the morning.

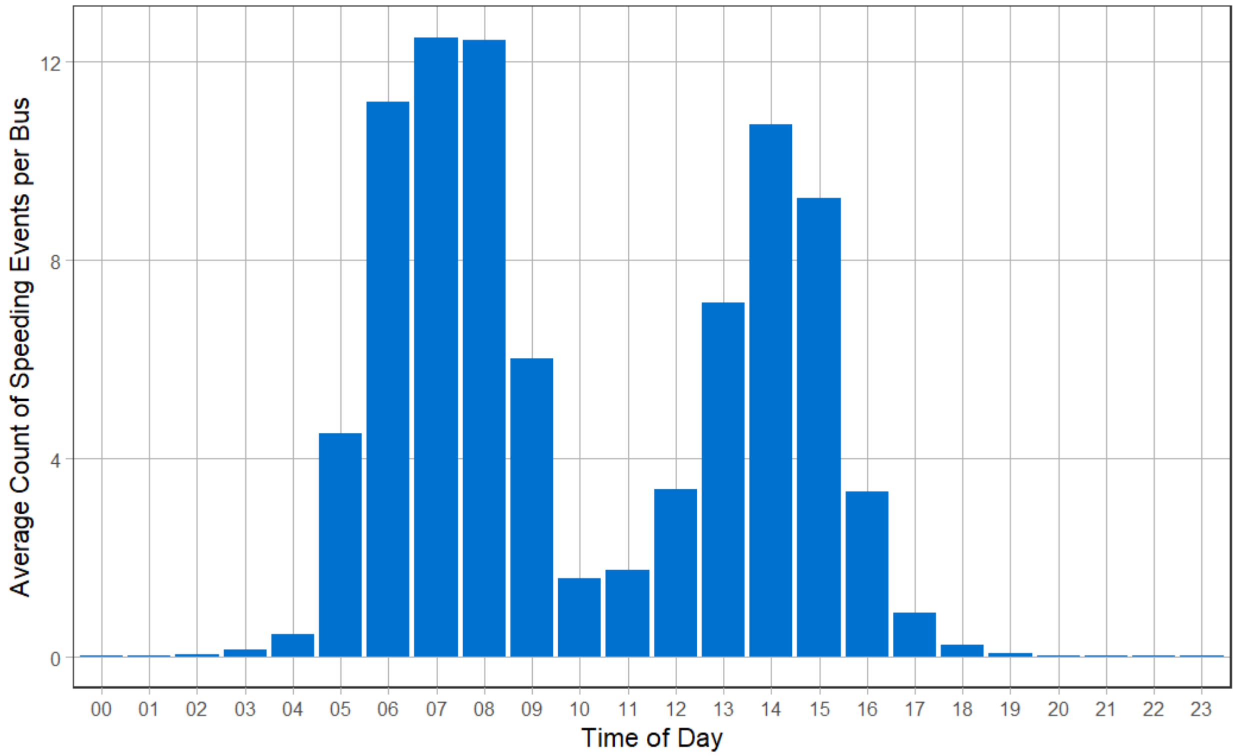

Figure 3. Average count of 2021 speeding alerts per bus by hour of the day

Speeding severity

For each speeding event, the maximum speed at which the bus travels is recorded in addition to the maximum speed limit the bus traveled through. The distribution of the difference between these two values is displayed in Figure 4. The distribution is skewed to the right, with speeding events in which school buses were operated between 11 and 20 mph over the speed limit accounting for the majority of speeding. Speeding events of less than 11 mph over the speed limit were not captured in the telematics dataset.

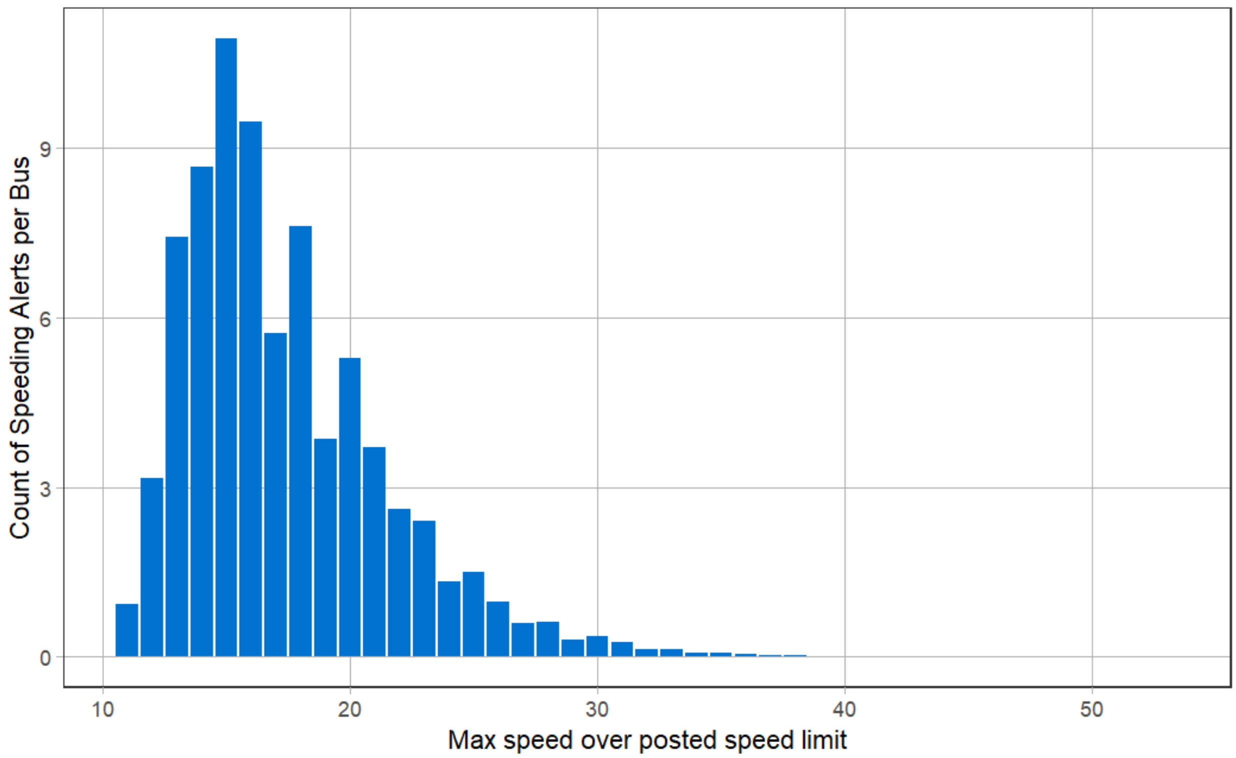

Figure 4. Distribution of speeding alerts per school bus by maximum speed over speed limit

Harsh acceleration, braking, and turning

In addition to speeding alerts, Volpe analyzed collision alerts to examine harsh acceleration and deceleration patterns. Figure 5 shows the distribution of forward acceleration patterns for collision alerts, with acceleration level mapped and reported in meters per second squared (m/s^2).[23] Acceleration with a negative sign indicates deacceleration or braking whereas a positive sign indicates acceleration. Acceleration at the time of collision alerts ranged from -30.8 to 80.1 m/s^2, and although the median is 0 m/s^2 (indicating a balance of acceleration and deacceleration events), there is a bimodal distribution where most collision alerts occurred at the high end in each direction. [24] Research has shown that deceleration events faster than -4.2 m/s^2 and acceleration events faster than 2.9 m/s^2 are strong predictors of risky drivers regardless of driver demographics and reported driving behavior characteristics.[25] These risky driving thresholds are lower than seen in most of the collision alerts in the Geotab data set. For school buses, with increased weight and more challenging handling characteristics

[23] For context, one *g* (g-force, i.e., the acceleration of gravity on Earth) is 9.81 m/s^2.

[24] *Median* = 0.00 m/s^2, *mean* = 0.62 m/s^2, and *standard deviation* = 22.55 m/s^2.

[25] Mao, H., Guo, F., Deng, X., & Doerzaph, Z. R. (2021). Decision-adjusted driver risk predictive models using kinematics information. *Accident Analysis & Prevention*, *156*, 106088.

compared to passenger vehicles, even lower thresholds might indicate unsafe driving such as speeding or tailgating.

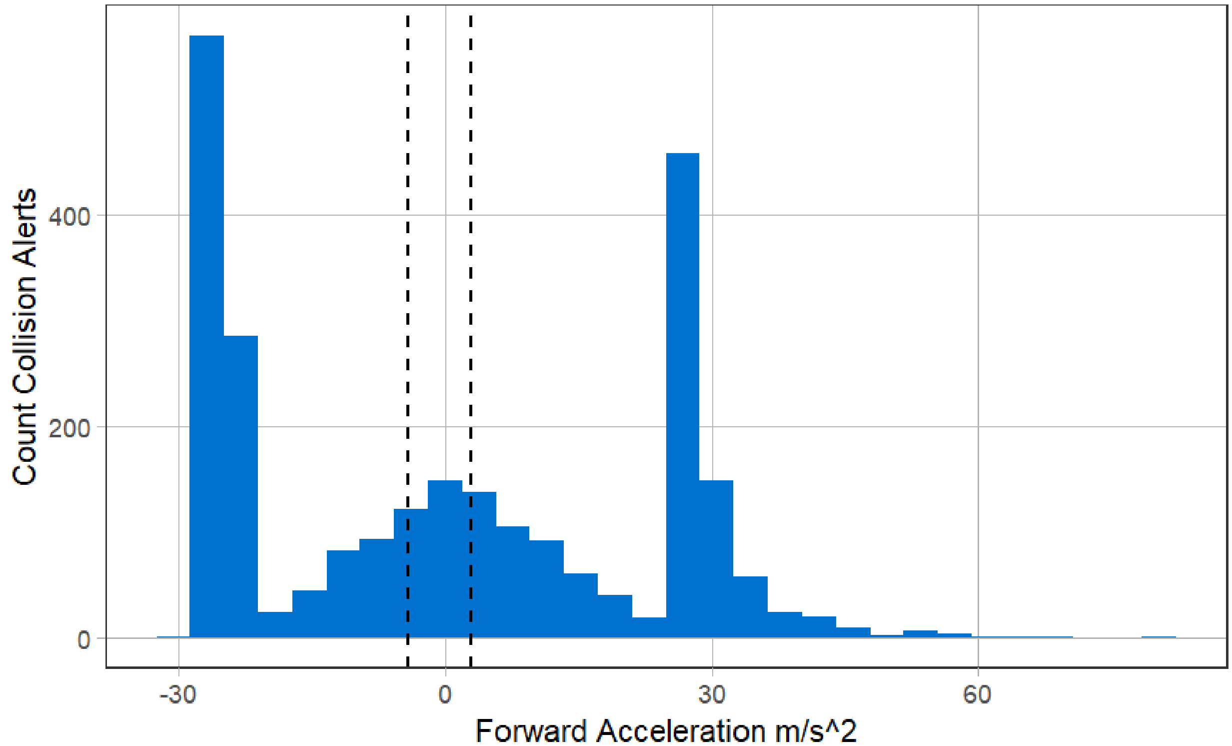

Figure 5. Distribution of forward acceleration level. Dashed lines indicate the forward deacceleration level of -4.2 m/s^2 (or -0.4 g) and acceleration level of 2.9 m/s^2 (or 0.3 g) that Mao et al., (2021) suggested predicted risky drivers.

Figure 6 shows the distribution of side acceleration patterns for collision alerts. Acceleration with a negative sign indicates the vehicle was turning right whereas a positive sign indicates the vehicle was turning left. Acceleration at the time of collision alerts ranged from -29.32 to 80.97 m/s^2, and like the forward acceleration/braking distribution, the median of side acceleration is close to zero, indicating a relatively even split between alerts that were triggered as the vehicle was moving to the right versus the left.[26] However, in the case of side acceleration, there is a spike at the left end of the distribution, suggesting that turns to the right resulted in higher acceleration measures than turns to the left. This trend is consistent with right turns typically tracking a tighter turn radius than left turns. Mao et al (2021) reported that side acceleration levels of +/- 4.9 or more predicted risky drivers regardless of driver demographics and behavior characteristics, again indicating that the Geotab data set collision alerts could indicate unsafe driving events meriting further analysis.[27]

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[26] *Median* = 0.09 m/s^2, *mean* = -1.75 m/s^2, *standard deviation* = 15.86 m/s^2

[27] Mao, H., Guo, F., Deng, X., & Doerzaph, Z. R. (2021). Decision-adjusted driver risk predictive models using kinematics information. *Accident Analysis & Prevention*, *156*, 106088.

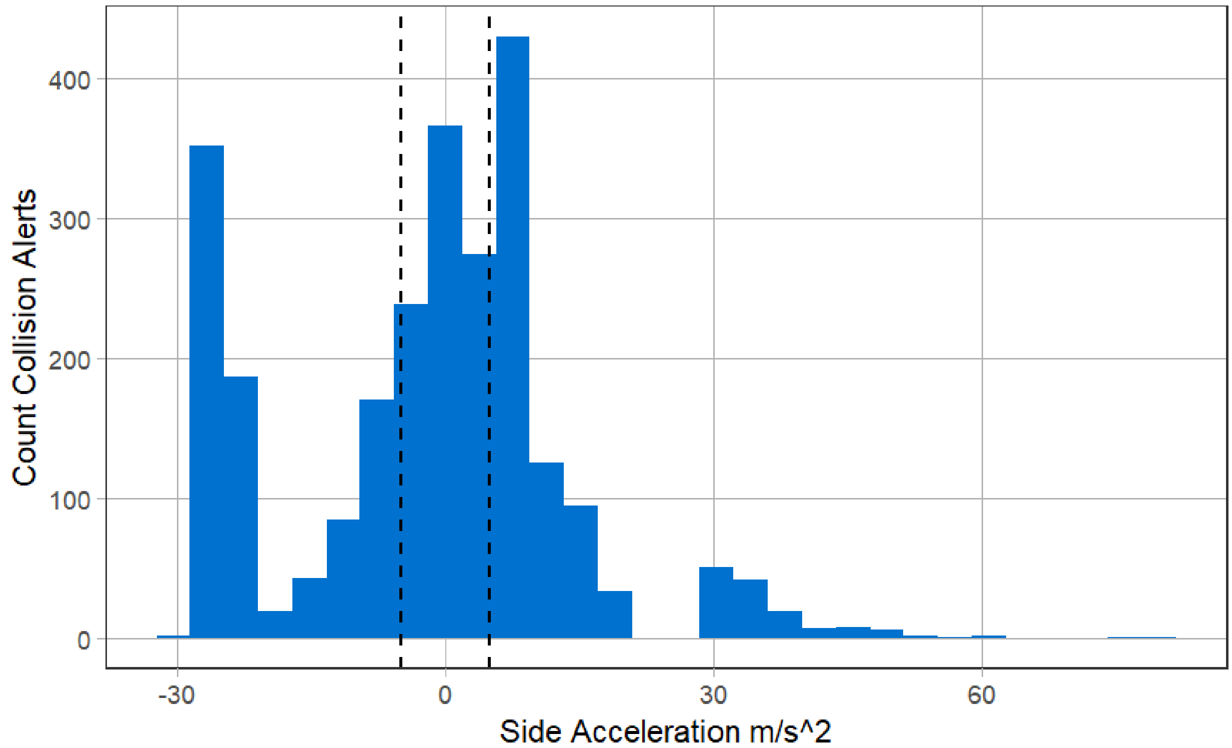


Figure 6. Distribution of side acceleration level. Dashed lines indicate the side acceleration level of +/- 4.9 m/s^2 (or +/- 0.5 g) that Mao et al., (2021) suggested predicted risky drivers.

Insurance Data Analysis

Volpe analyzed insurance data from claims related to school buses in New York City from the years 2017-2022.[28] The insurance data set encompassed claims filed from collision, property damage, no-fault personal injury protection, and bodily injury coverage. Although school bus contracts are required to have $5 million in liability insurance, the City covers the first $1.5 million of the claim. Therefore, the data set amounts account for the first $1.5 million of the claim. Only claims from named claimants were analyzed, i.e., all "Unknown" claimants were excluded. In addition, only insurance amounts that have already been paid out are reported in this analysis. The included data are only a subset of the estimated average $100 million paid out for collisions annually, encompassing DOE, insurance, and school bus company payouts.[29] An estimated $249 million in unpaid claims remained as of June 2023 with a further $82 million in ultimate claims for the coming year.[30]

[28] Volpe analysis of NYC Department of Education Office of Pupil Transportation school bus insurance losses dataset spanning 6/30/17-6/30/22.

[29] NYC Department of Education Office of Pupil Transportation. August 2023.

[30] EPIC Insurance Brokers, Auto Liability Actuarial Analysis of Unpaid Claims and Loss Forecast as of June 30, 2023 for NYC Department of Education Office of Pupil Transportation.

From 2017-2022, there were 8,172 unique claimants, with $89,720,667 paid out. The average payout per claimant was $10,979. Payouts ranged from $0 (for either minor property damage or for cases where no payout has been made yet) to $1,077,889 (for a severe spinal injury where a pedestrian was hit by a turning school bus).

Although the majority of claims were from property damage, there were eleven cases that resulted in death. All eleven of the victims were VRUs: 10 pedestrians and one bicyclist. The claims paid out for these fatal cases totaled $1,333,354.
A closer examination of cases that involved VRUs indicated that there were 335 VRU claimants that reported bodily injury. With non-fatal injury VRU cases, a total of $16,491,536 was paid out. Table 3 provides a summary of total payout amounts and average payout per claim.

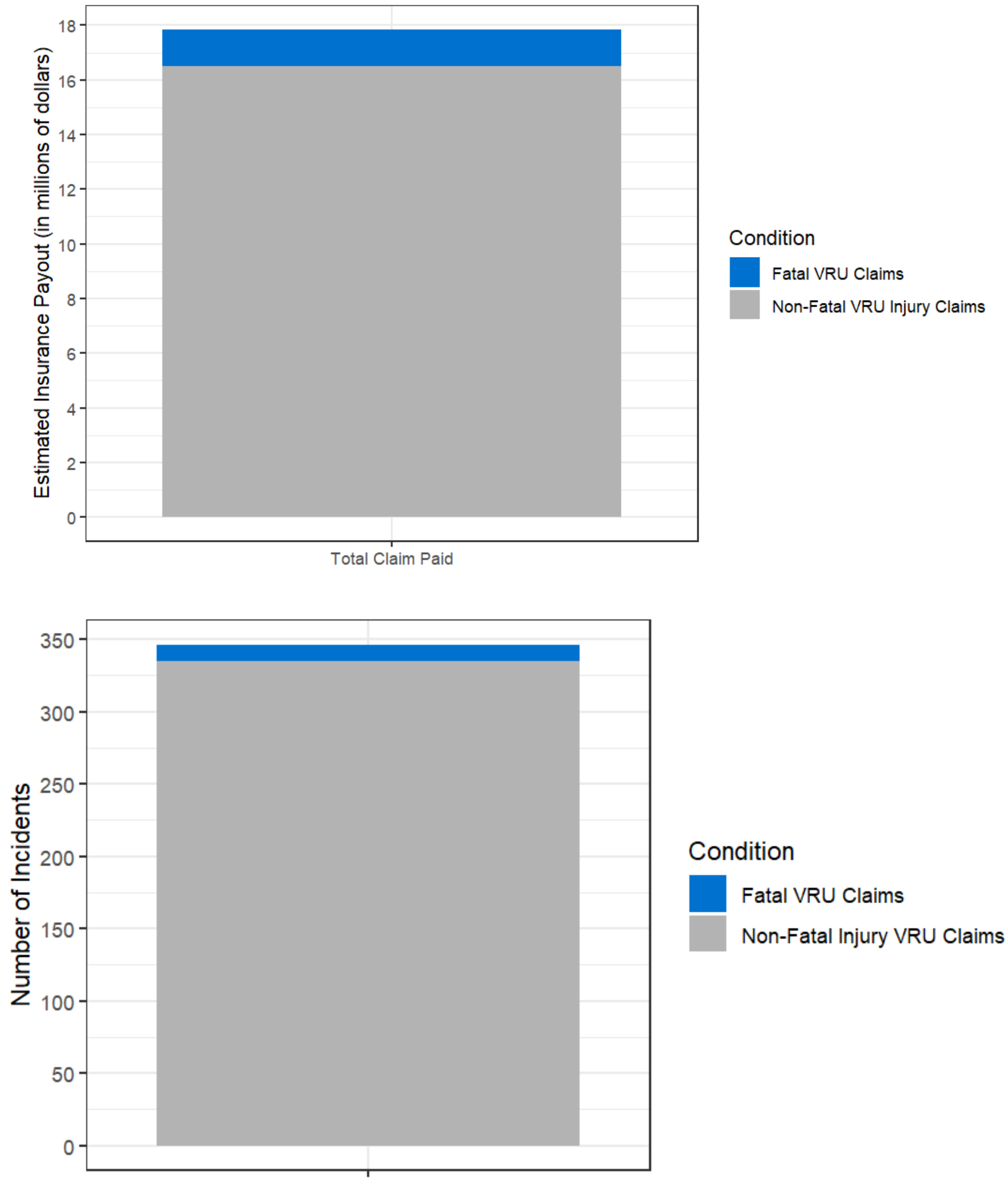


Figure 7. Insurance payout distribution of the 11 fatal and 335 nonfatal injury VRU crash claims, by paid versus reserve (top) and in total count (bottom).

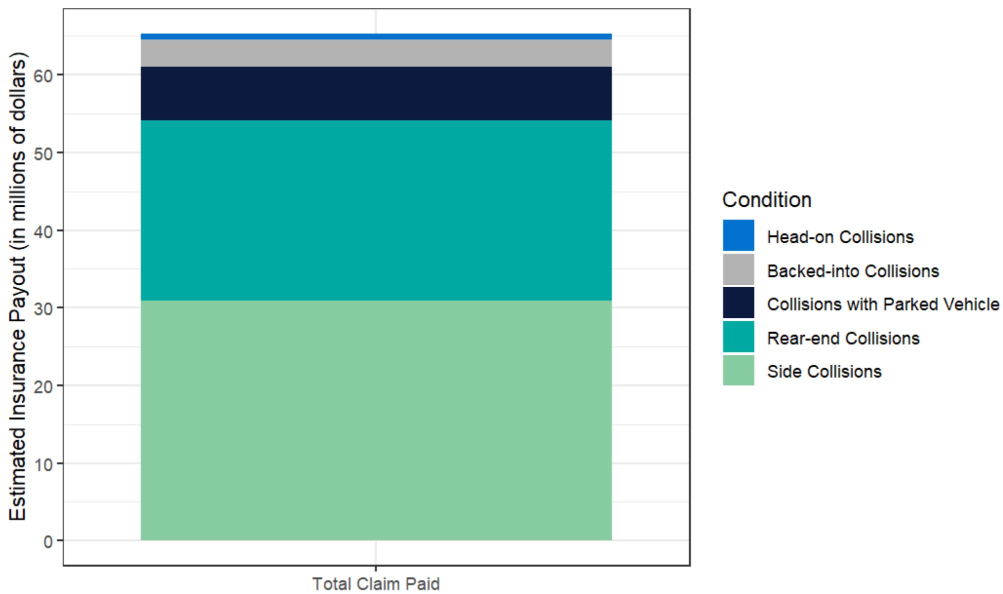
Table 3. Summary table of average payout for claims involving VRUs

Claim type	Insurance payout	Number of incidents	Average payout per incident
Fatal VRU	$1,333,354	11	$121,214.00

Non-fatal VRU	$16,491,536	335	$49,228.46

In addition to analyzing insurance claims patterns involving VRUs, Volpe examined potential patterns with a subset of collision types, combining property damage and bodily injury claims from drivers and passengers.[31] Side collisions were the most common collision type, with 3,258 unique claims, followed by rear-end collisions (1,840 claims), collisions involving parked cars (1,432 claims) and collisions where a vehicle backed into another vehicle (422 claims). In contrast, head-on collisions were rare, with only 40 claims reported.

[31] A limitation of the insurance loss dataset is that it includes only one collision type classification per claim, and that all the VRU injury/fatal crashes are classified as "Hit pedestrian", "Hit cyclist," etc. The remaining collision types, which provide information about the collision direction, such as “head-on” or “side,” therefore only refer to school buses colliding with other vehicles.



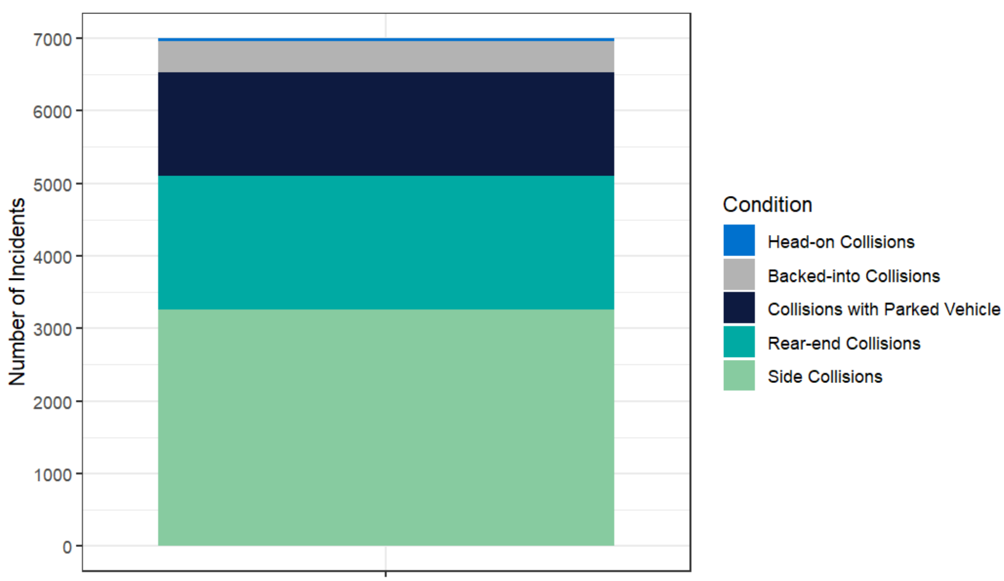


Figure 8. Insurance payout distribution of the non-VRU crashes, by amount paid (top) and total count (bottom).

For side collisions, the total claim paid out was an estimated $30,857,655; rear-end collisions resulted in $23,217,957 being paid out; collisions with parked vehicles resulted in $7,002,101 being paid out; backed-into collisions resulted in $3,413,753 paid out. Finally, head-on collisions only resulted in an estimated $747,448 being paid out. However, although head-on collisions were comparatively rare, they resulted in the largest average insurance payout, with an estimated average of $18,687 per case. Averages of payout per incident for the five collision types examined are included in Table 4.

Table 4. Summary of insurance collision types and average payout per incident

Collision type	Insurance payout	Number of incidents	Average payout per incident
Side collision	$30,857,655	3,258	$9,471.35
Rear-end collision	$23,217,957	1,840	$12,618.45
Collisions with parked vehicle	$7,002,101	1,432	$4,889.74
Backed-into collisions	$3,413,753	422	$8,089.46
Head-on collisions	$747,448	40	$18,686.20

Safety Technologies and Approaches

School buses are a unique fleet sector in several ways. The school bus industry nationwide is one of the most regulated for vehicle requirements, subject to federal as well as various state and local safety regulations.[32] School bus drivers must be aware of what is happening on the bus as well as outside the bus, meaning that some attention-demanding technologies such as driver alerts that might work on general fleet vehicles might not implement as well on school buses and may benefit from further testing.

Since school buses operate in proximity to many children, who are the smallest and most vulnerable of VRUs, more stringent performance requirements apply to school bus safety countermeasures. For example, pedestrian automatic emergency braking (PAEB) systems on four popular light-duty vehicles have been found to avoid collisions with adult-size pedestrians nearly four times more effectively than they do with child pedestrians. The systems prevented 40 percent of crashes with adults versus only 11 percent of those with children at 20 mph.[33] At higher speeds and in low light conditions, system effectiveness would be lower still. For the school bus industry, more robust performance of countermeasures may be necessary to prevent collisions with children VRUs.

Statutory and Regulatory Requirements

A direct way to promote adoption of safety technology is via regulations, whether federal, state, or local. Seatbelt installation and use, stop arm signs, drivers' minimum field of view, and external markings are examples of school bus safety features that are required in NYC, due to federal, state, and municipal regulations.

[32] In NYC, an example of local requirements is the Department of Education's vehicle safety inspection pre-trip check list.
[33] https://www.aaa.com/AAA/common/aar/files/Research-Report-Pedestrian-Detection.pdf

A number of bills have been introduced in the New York State Senate that aim to implement additional safety features on vehicles, including specifically on school buses. In August 2022, a bill was introduced that would require new vehicles registered in New York to have speed-limiting technology, in addition to other advanced safety features such as automatic emergency braking and driver monitoring systems for distraction/drowsiness recognition (Senate Bill S9528).[34] In May 2022, a bill was introduced that would require stop arms on both sides of the school bus, and not just on the driver's side (Senate Bill S9143).[35] Neighboring New Jersey enacted a law in 2017 that requires newly manufactured school buses in that state to be equipped with sensors that can detect the presence of objects in front of or behind the bus.[36] Known as Abigail's Law, this legislative action was prompted by the death of a child who was killed standing in front of a school bus, out of the line of sight of the driver.

Seatbelts

Seatbelt provision and usage are regulated at federal, state, and local levels. At the federal level, per FMVSS No. 208, only the driver's seat is required to have a lap and shoulder belt for school buses greater than 10,000 lbs.; passenger seatbelts are not required (49 CFR 571.208). However, any school buses less than 10,000 lbs. are required to have lap and shoulder belts for both drivers and passengers.

Individual states vary widely in terms of requirements regarding the presence of seatbelts on school buses, whether students must use seatbelts, and the type of seatbelts installed (lap or lap/shoulder belts). New York is one of eight states that require seatbelts to be installed on school buses.[37] New York State law stipulates that all school buses manufactured after July 1, 1987 must be equipped with passenger lap belts,[38] although it does not require passenger shoulder belts, as NTSB recommends for new, large school buses.[39] The state law does not require the *use* of passenger seatbelts and leaves that to the discretion of each school district.

Per NYC Administrative Codes Sections 19-601, 19-602 and 19-603,[40] only children in special education in NYC are required to wear a seatbelt. In addition, all school buses in NYC must be manufactured after 1988, in effect ensuring that all buses are equipped with lap seatbelts.

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[34] New bill would require speed-limiting technology in all New York vehicles (ampproject.org)
[35] https://www.nysenate.gov/legislation/bills/2021/s9143
[36] https://pub.njleg.gov/bills/2014/A1500/1455_I1.HTM#:~:text=This%20bill%2C%20designated%20%22Abigail's%20Law,or%20back%20of%20the%20bus.
[37] School Bus Safety 2020.pdf (comt.ca)
[38] NY State Vehicle and Traffic Law, Section 383
[39] https://www.ntsb.gov/news/press-releases/Pages/NR20221103.aspx
[40] https://www.schools.nyc.gov/school-life/transportation/safe-travel-tips.

Figure 9. Three-point seatbelts on a school bus. (School Transportation News)

Stop Arms

Federal Motor Vehicle Safety Standard (FMVSS) No. 131 provides standards on school bus pedestrian safety devices to improve the safety of pedestrians in the immediate surroundings of the school bus (49 CFR 571.131). All school buses are required to have a stop signal arm. A stop signal arm is a device that extends outward from the bus when it is stopped, signaling to passing motorists that the bus is unloading and loading passengers and vehicles should not pass the school bus. The stop signal arm must consist of an octagonal stop sign made of red reflective material, installed on the left side of the bus (although additional stop arms may be installed). Each side of the stop sign must have two red lamps.

New York State takes the federal requirement further and requires that a second stop arm be placed on the left-rear of the school bus for any school bus manufactured on or after January 1, 2002 (N.Y. Comp. Codes R. & Regs. tit. 15 § 46.7). According to the same regulation, a school bus may also be equipped with a stop signal arm on the right side of the bus, although this modification requires prior approval from the Commissioner of Transportation. In May 2022, a bill was introduced to NY State Senate that would require stop arms on both sides of the school bus (N.Y. Senate Bill S9143). Although it is still in committee, this bill may signal an interest in enhanced stop arm signal deployment on school buses in New York.

Figure 10. Stop arm on a school bus (Newsday)

Mirrors and Backup Cameras

Minimum standards for "rear visibility" in school buses are dictated by FMVSS No. 111 (49 CFR 571.111). It stipulates that all buses must have an inside rearview mirror and an outside rearview mirror on the driver's side. The field of view provided by the mirror must provide at least a 20-degree horizontal angle, with a view of the level road surface. New York State requires exterior mirrors on both the left and right sides to provide the driver with a view of the roadway (NY State Vehicle and Traffic Law, Section 375). In addition, any school bus with a passenger capacity of 12 or greater that has the engine in front of the driver (e.g., Type C) must have left and right front view mirrors (also known as crossover mirrors) that provide the driver with a view of the road from the bus bumper to the location where their direct vision starts. Although backup cameras are not required in most school buses, they are required in light-duty vehicles by NHTSA (including school buses with gross vehicle weight rating of 4,536 kg or less)

Figure 11. School Bus Mirror (Transalt)

Exterior Markings and Features

FVMSS No. 108 (49 CFR 571.108) specifies that school buses should have two red signal warning lamps on the front and rear of the bus that flash between 60-120 cycles per minute when activated to inform passing motorists that children are getting on or off the bus. The same regulation suggests two amber signal warning lights be placed at the front and back of the bus, but these features are not required. Although there are no federal requirements regarding the exterior markings of a school bus, NHTSA provides recommendations for states and individual jurisdictions to follow.[41] NHTSA recommends school buses be painted "national school bus glossy yellow" and that all trim and bumpers be painted black. Additionally, it states that school buses should be clearly labeled with the words "School Bus" in letters at least eight inches tall, on both the front and the rear of the vehicle.

Following federal regulations, all school buses in New York State are required to have flashing red signal lamps on the front and rear of the vehicle that are turned on whenever loading and unloading

[41] https://icsw.nhtsa.gov/nhtsa/whatsup/tea21/tea21programs/

passengers (NY State Vehicle and Traffic Law, Section 375).[42] Also, in line with NHTSA recommendations, in New York State all school buses must be clearly marked "School Bus" in black letters, at least eight inches high. School buses must be painted "national school bus chrome" (yellow).

Backup Alarms

The use and installation of a backup alarm, a device that automatically emits a noise when a vehicle is in reverse, is not required at the federal level. However, the National Congress on School Transportation states that backup alarms should be installed on school buses.[43] Additionally, New York State dictates that any school bus manufactured after April 1, 1990 that operates in the state shall have backup alarms installed (NY State Vehicle and Traffic Law, Section 375).[44]

Always-on Headlights

New York State mandates that buses always operate with headlights on: "(i) Every omnibus subject to the provisions of this subdivision shall be operated with headlights and taillights illuminated at all times of day or night."[45]

Beyond Regulatory Technologies

This section moves beyond the requirements outlined in the prior section and delves into additional technologies or approaches to improve school bus safety. It analyses current safety technologies available for school buses and examines available evidence of effectiveness.

Tiers Table

As with the SFTPs for the NYC municipal fleet, this NYC School Bus SFTP uses a three-tier scheme to bin technologies and approaches in one of three categories, in descending priority:

- Tier 1 (Priority Implementation/Initial Pilot Programs),
- Tier 2 (Best Practice Measures), and
- Tier 3 (Exploratory Measures).

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[42] https://www.nysenate.gov/legislation/laws/VAT/375
[43] Microsoft Word - NCST 2015 Specifications and Procedures 11.1.16_Pg Numbering and TOC Change.docx (nasdpts.org)
[44] https://www.nysenate.gov/legislation/laws/VAT/375; note that pending legislation in Hawaii (SB 3162) would require broadband backup alarms to be used instead of traditional tonal backup alarms https://www.capitol.hawaii.gov/sessions/session2022/bills/SB3162_.HTM; Maryland's Montgomery County has also required broadband backup alarms on vehicles servicing the Purple Line transit project.
[45] https://www.nysenate.gov/legislation/laws/VAT/375

The tier designation for each technology draws upon information gathered from multiple sources, including interviews with school bus operators, analysis of telematics data, and literature review. The designation considers multiple factors, including the following:

- Availability – whether the technology is commercially available for school buses, either as original equipment manufacturer (OEM) purchase or retrofit;
- Applicability – whether the technology or approach is relevant for mitigating a significant category of school bus safety events;
- Effectiveness – whether the technology or approach has evidence of effectiveness from research or deployment;
- Recommendations from authorities – whether authorities such as NHTSA, FMCSA, NTSB, New York State, NYC, or others have recommended the technology or approach.

Table 5 summarizes the tier designations, and the subsections that follow provide additional supporting context.
Based on the four-part analysis described above, which involved literature review, interviews, and telematics data analysis, Volpe proposes a tiered approach to aid in prioritizing among possible countermeasures. This is consistent with the approach taken in prior SFTPs developed for the NYC Fleet. The proposed tiers table organizes countermeasures by Tier 1 (Priority Implementation), Tier 2 (Best Practice), and Tier 3 (Exploratory).

Table 5. Technologies and approaches by tier

Tier 1 Priority Implementation/Initial Pilot Programs	**Tier 2 Best Practice Measures**	**Tier 3 Exploratory Measures**
Intelligent Speed Assistance (ISA)	Blind Spot Monitors (on crossover mirrors)	Passive Alcohol Impairment Detection Systems
Pedestrian External Alerts During Turns	Cell phone App/Physical Lock Box/Docking Station Interlock	Connected Vehicles or V2V Communication
Stop Arm Enforcement Cameras	Double Stop Arms	Driver Monitoring System
Telematics and Enhanced Safety Reporting	Event Data Recorder	External Public Address Systems
Improved Direct Vision†	Heated Mirrors and Power Mirrors	*Heated Windshield* or Wiper Blades
Urban safe driving training[46]	Lane Centering / Lane Keep	Downlighting on Crossover Mirrors

[46] CDL and State-mandated school bus driver training are not tailored to urban driving, and school bus operators as well as NYC DCAS noted this gap. Curriculum examples for large vehicle urban safe driving include the Safe Urban Driving course offered by FORS in the UK and the Large Vehicle Urban Safe Driving training in San Francisco. NYC DCAS has added a 90-minute Vision Zero (not specific to large vehicles) segment to the NYS-mandated defensive driving course that City Fleet drivers must complete, including these video resources: https://www.nyc.gov/assets/dcas/images/fleet/video/nyc-dot-vision-zero-your-choices-matter-turn-slowly.mp4, https://www.youtube.com/watch?v=yImrYMM4LAk, https://www.youtube.com/watch?v=ZbdcCZrHNjk&feature=youtu.be

Extended Stop Arms	LED Lighted Stop Arm	Object Detection Triggered Cameras
Minimum Bumper Height	Navigation System	Pedestrian Safety Warning Light
Minimum Body Skirt Height	*Pedestrian Automatic Emergency Braking where available†*	Predictive Stop Arm
Backup Cameras	*Automatic Emergency Braking (may only be available for Type C buses)†*	Rear Cross Traffic Collision Warning
Self-adjusting Volume and Broadband Back-up Alarms	Warning Decals	Roof-mounted Strobe Lights
Crossing Control Arm	Seatbelt Education and Use	Rear AEB for heavy-duty vehicles with air brakes
360-Degree Birds Eye View Camera (alternative: Surround Camera with separate displays)		Turn Signal Triggered Cameras
Forward and pedestrian collision warnings, internal, to warn drivers		Universal Design
Electronic Stability Control†		Wheel Guards

†*Denotes OEM-only availability of a technology*

This report outlines a series of countermeasures to help avoid collisions and reduce their impact on vulnerable road users, and DCAS and DOE foresees seven new initiatives for near-term implementation.

- Piloting a first-in-the-nation widespread test of intelligent speed assistance (ISA) on school buses. This pilot of 50 school buses will be modeled after the New York City fleet pilot and will test ISA on buses from different manufactures, size, and powered by diesel fuel as well as electric.

- Testing audible turn alerts for pedestrians and other vulnerable road users. Statistics show that approximately twenty-eight percent of school-age pedestrians killed in crashes with school buses occurred when the vehicle was turning.[47] Systems could include LEDs as well as voice or other audible alerts. This may be modeled after the MTA NYC Transit program as well as current rollouts being organized by DCAS at NYC City fleet agencies. The pilot will start with fifty systems that will be a mix of device types and will be focused on electric buses.

[47] National Highway Traffic Safety Administration. "School-Transportation-Related Crashes". June 2022. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813327#

- Piloting tools to provide automated enforcement, driver alert systems, and other tools to reduce incidents of vehicles passing school buses with lights flashing and stop sign extended.[48] [49] These include stop arm cameras, extended stop arms, and additional lights. This pilot program of school bus stop arm cameras will start with 30 cameras. In addition, new electric school buses are being delivered with additional lights and extended stop arms.

- Expanded use of telematics reporting, including real time alerts, speed and collision alert monitoring, and monthly safety score cards to track risk for each school bus across the school bus companies. To be modeled after the City telematics reporting including additional alerts and monthly safety reporting, with a goal of zero buses operated at high or moderate risk, as determined by the telematics system, in the new school year.

- Mitigating blind zones using technology such as surround cameras, in-cab driver alerting such as pedestrian collision warning (PCW) systems, and back up sensors, with the long-term goal of effecting school bus design that increases direct vision, especially as bus electrification offers additional opportunities for direct vision in new buses. This new pilot program will also provide near miss collision reporting and analysis. Together for Safer Roads will be working with DCAS, DOE. and a selected school bus company on this pilot of ten buses.

- Mandatory urban safety and defensive driver training for school bus operators as DCAS has done for City fleet operators--a new safety course for all school bus operators, reviewing Vision Zero, telematics tracking, best practices, and urban driving similar to the City fleet initiative. To be developed in conjunction with DOE OPT and school bus companies, with the goal to have all drivers complete it by the start of the 2025-2026 school year. |

- School bus of the future: DCAS to partner with DOE OPT, school bus companies, and school bus manufacturers on updated specifications for school buses looking at additional safety implementation in various areas and investigate piloting these as retrofits. As the City moves to electric school buses by 2035, DCAS and DOE will work with companies to maximize safe design in addition.

[48] "Ongoing Efforts to Improve School Bus Safety." 2023. https://trafficsafety.ny.gov/ongoing-efforts-improve-school-bus-safety
[49] The City Record, Number 145. July 31, 2023. https://www.nyc.gov/assets/dcas/downloads/pdf/cityrecord/cityrecord-07-31-23.pdf

Explanation of Technologies and Approaches

This section explains the technologies and approaches summarized above in the tiers table. It groups technologies and approaches based on the situations that they primarily address:

- **Loading and unloading**: As per NHTSA, Students are more likely to be killed while pedestrians outside the bus than as passengers onboard the bus.[50] Approximately half of these fatalities are caused by the driver of a vehicle other than a school bus.[51]
- **Blind zones**: Between 2010 to 2019, in the United States, 51% of all school-age pedestrian deaths were children between 5 and 10 years old. Children are generally shorter than adults and therefore more likely to fall within the blind zone of a vehicle. School bus blind zones vary depending on the make and model of the vehicle and can result in limited visibility of VRUs, especially children.
- **Forward collisions**: Between 2010 and 2019, one-quarter of all school-age pedestrians killed by school transportation nationally were struck by a vehicle that was going straight, highlighting the importance of preventing and mitigating front-end collisions and the potential benefits of high vision buses.
- **Side and rear collisions**: In 12 of 39 pedestrian fatalities nationally where the school bus struck the victim between 2011 and 2020, the bus was turning left, right, or "negotiating a curve." This 30-percent subset of fatalities potentially involved side impact collisions. Additionally, two fatal crashes involving underride or override between school buses and other vehicles occurred in 2017-2019.
- **Driver human factors and ergonomics**: The driver plays a pivotal role in ensuring safety, and driving a school bus is particularly demanding, given the many cognitive demands and the large size of the vehicle. Technologies in this category help to ensure that the driver can perform optimally.
- **Monitoring and evaluation**: Technologies in this category can be helpful for proactively identifying and addressing safety issues. Speeding is a common cause of crashes.

A general overarching consideration is that bus acquisition is more economical if technology standards are broad because this drives down manufacturing costs and creates a resale market. NYC-specific requirements may drive up the cost of bus acquisition to the extent that they necessitate custom vehicles for NYC streets, which are not built for a larger market and with no resale value. While the scope of this plan focuses only on New York City school buses, ultimately it may be advantageous for New York City to collaborate with other entities to work toward the creation of a state, regional, or national school bus standard, innovating and driving down costs. This could be a challenge and an opportunity. NYC Executive Order 53 of 2021 calls for DCAS to publish Safe and Clean Fleet Transition

[50] National Highway Traffic Safety Administration. *Traffic Safety Facts.* 2021. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813105
[51] National Highway Traffic Safety Administration. *Traffic Safety Facts.* 2021. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813105

Plans on a regular basis and to use these reports to promote design changes across all fleet vehicles, private, public, and non-profit.

Loading and Unloading

Students are more likely to be killed while pedestrians outside the bus than as passengers onboard the bus.[52] Approximately half of these fatalities are caused by the driver of a vehicle other than a school bus.[53] Therefore, it is important that technology countermeasures not only enhance the safe operation of the school bus, but also the safe operation of other vehicles, such as by recording and enforcing violations and unsafe behavior of other vehicle drivers. Section 24110(c) of the Bipartisan Infrastructure Law requires NHTSA to review and evaluate the effectiveness of various technologies for enhancing school bus safety, including, among other things, "the impact of advanced technologies designed to improve loading zone safety." That evaluation is due by November of 2023, so more information will be available at that time on the efficacy of technologies for improving safety at loading and unloading.[54]

Relevant loading and unloading countermeasures include:

- Five types of enhanced stop arms,
- Roof-mounted strobe lights, and
- External public address system.

Enhanced Stop Arm

This countermeasure is designated Tier 1 given its ease of implementation and relevance, recalling that half of all VRU fatalities associated with school transportation are due to another motorist colliding with the VRU.

Extended Stop Arms [Tier 1]

Extended stop arms are longer, providing an additional deterrent for vehicles to pass a stopped school bus illegally. A recent school bus safety pilot study in Virginia saw an 89% reduction in violations with the implementation of extended stop arms on a sample grouping of school buses.

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52 National Highway Traffic Safety Administration. *Traffic Safety Facts.* 2021. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813105

53 National Highway Traffic Safety Administration. *Traffic Safety Facts.* 2021. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813105

54 https://www.congress.gov/bill/117th-congress/house-bill/3684/text.

Figure 12. Extended Stop Arm (KARE 11)

A prior pilot saw a 50% reduction in violations.[55] Street widths on NYC school bus routes or the addition of a driver override to retain the extended stop arm would need to be considered to ensure that extended stop arms are possible to extend. Transport Canada required extended stop arms on school buses in Canada as part of a 2022 safety rulemaking.[56]

Crossing Control Arm [Tier 1]

A crossing control arm extends directly in front of the school bus and provides a visual cue for students so that they do not walk in the blind zone directly in front of the bus as they are crossing the road. Twenty-six states require the use of crossing control arms on school buses. New York State regulation permits but does not require the use of a crossing control arm.[57] The New York State Education Department Pupil Transportation District Safety Review Program recommended that districts consider deploying crossing control arms.[58]

Crossing control arms appear in the addendum to the National School Transportation Specification and Procedures document developed by the National Congress on School Transportation.[59] However, this feature is neither a mandatory nor advisory addition; instead, it states that school bus operators *may* use them. Figure 13 shows a picture of a crossing control arm.

High vision buses are another way to address this blind spot issue.

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[55] https://www.cvilletomorrow.org/new-school-bus-safety-pilot-program-study-finds-89/.
[56] https://gazette.gc.ca/rp-pr/p1/2022/2022-07-02/html/reg2-eng.html
[57] https://casetext.com/regulation/new-york-codes-rules-and-regulations/title-15-department-of-motor-vehicles/chapter-i-regulations-of-the-commissioner/subchapter-d-equipment/part-56-safety-equipment-exemptions/section-569-front-crossing-control-arms-on-certain-school-buses.
[58] https://www.p12.nysed.gov/schoolbus/documents/pdf/2006_NYSED_DSR_final.pdf.
[59] https://www.nasdpts.org/resources/Documents/amendmentsto2015/Editorial Edits for 2015 NSTSP 11.2021.pdf

Figure 13. Crossing control arm (SafeFleet)

Stop Arm Enforcement Cameras [Tier 1]

Stop arm enforcement cameras are cameras located on the stop sign of a bus. They collect vehicle information from those who fail to stop as required by law. Although they are useful in reporting violations, they may not immediately reduce the number of violations.[60] Public messaging to promote awareness of automated stop arm cameras may reduce violations sooner and reduce the number of motorists that must be cited before overall violations decrease. Policies that allow stop arm enforcement cameras have been adopted by numerous states, including New York.[61] In December 2021 the NYC City Council passed local law 10 that allowed NYC to create a demonstration program to use photographic evidence to impose liability on vehicle owners for passing a stopped school bus; local law 10 is set to expire December 1, 2024. A pilot initiative will be launched by NYC in fall, 2023.

Figure 14. Stop Arm Enforcement Camera (PRNewswire)

Double Stop Arms [Tier 2]

"Double stop arms" are features in which there is a stop arm signal attached to both the driver's and passenger's side of the bus. As noted above, New York State does not currently require stop arms on the right side of school buses. However, a bill was introduced in the New York State legislature in May 2022 that would require school buses to have stop arm attachments both on the right and left sides. The additional right side stop arm will have an override switch to allow drivers to disable the equipment if

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[60] National Transportation Safety Board. *Vehicle Collision with Student Pedestrian Crossing High Speed Roadway to Board School Bus.* 2020. https://www.ntsb.gov/news/events/Pages/2020-HWY19MH003-webinar.aspx
[61] National Conference of State Legislatures. *State School Bus Stop-Arm Camera Laws.* 2022. https://www.ncsl.org/research/transportation/state-school-bus-stop-arm-camera-laws.aspx

necessary based on the street scape.[62] Although there is currently no available research on whether double stop arms on school buses reduce violations, an additional stop signal could be more conspicuous to drivers and prompt them to wait until passengers have boarded or disembarked the bus before passing. The New York State Education Department Pupil Transportation District Safety Review Program recommended the installation of stop arms on the passenger side of the bus, and especially emphasized their importance in areas where stop arm violations are common or where there is heavy traffic.[63]

LED-Lighted Stop Arm [Tier 2]

Current New York State regulations do not dictate whether the lights on stop arms are illuminated using LEDs. However, given that LEDs are brighter and sharper compared to traditional incandescent light bulbs, in 2006 the New York State Education Department Pupil Transportation District Safety Review Program recommended that stop arms be lit with LEDs. [64]

Figure 15. LED-Lighted Stop Arm (SeekingAlpha)

In 2017, Marietta City Schools in Colorado piloted LED lights on some of their buses, including adding LEDs to the stop arm. They reported that school buses with the LEDs resulted in fewer stop arm violations than buses without the LEDs. Although these positive, preliminary results may not be entirely attributable to the LEDs on the stop arm, it suggests that adding LEDs to stop arms may help drivers notice the stop signs and stop for the school bus.

Predictive Stop Arm [Tier 3]

A combination of a blind spot monitoring system and stop arm, this novel technology detects when a vehicle is passing the school bus when the stop arm signal is deployed (a stop arm violation) and

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[62] Cornell Law School Legal Information Institute. *N.Y. Comp. Codes R. & Regs. Tit. 15 § 46.7 – Use of school bus stop arm. Current through Register Vol. 45, No. 8, February 22, 2023*. https://www.law.cornell.edu/regulations/new-york/15-NYCRR-46.7
[63] [2006 NYSED District Safety Review](#)
[64] [2006 NYSED District Safety Review](#)

provides an auditory and visual alert to the driver and an auditory voice alert to passengers and pedestrians outside the bus.[65] If a stop arm violation is detected, the system will broadcast via external loudspeakers "Stop, do not cross." The system can monitor up to three lanes of traffic and aims to proactively protect children from drivers who violate stop arm signals.[66] The technology has been deployed in at least three school districts in the United States, although the effectiveness of predictive stop arms at improving safety remains unclear. Specifically, details regarding the system's lag time to detect a stop arm signal violator and the typical time it takes for a pedestrian to listen and respond to the warning message would need to be more closely examined.

Roof-Mounted Strobe Lights [Tier 3]

Roof-mounted strobe lights alert motorists that a school bus is in the vicinity. This may be especially helpful in limited visibility conditions, such as rain, fog, smog, and snow, where the vision of approaching motorists is compromised. New York State regulations at title 15 part 56.12 permit but do not require this technology on school buses.[67] The New York State Education Department Pupil Transportation District Safety Review Program recommended that school districts consider equipping buses with roof-mounted strobe lights.[68] This technology appears in the National School Transportation Specification and Procedures document developed by the National Congress on School Transportation.[69] However, this feature is neither a mandatory nor advisory addition in that document; instead, it is listed as optional. One outstanding research question is whether the available strobe light products may pose a risk of seizures for those with epilepsy. Volpe was not able to identify any definitive research on this topic.

Figure 16. Roof-Mounted Strobe Light (Durham Radio News)

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[65] www.wthr.com/article/news/local/new-school-bus-safety-system-designed-prevent-tragedies/531-57e260a0-2ae5-413c-9515-1848cbcd15ed
[66] https://www.gsacrd.ab.ca/download/343385
[67] https://casetext.com/regulation/new-york-codes-rules-and-regulations/title-15-department-of-motor-vehicles/chapter-i-regulations-of-the-commissioner/subchapter-d-equipment/part-56-safety-equipment-exemptions/section-5612-school-bus-strobe-light.
[68] https://www.p12.nysed.gov/schoolbus/documents/pdf/2006_NYSED_DSR_final.pdf.
[69] https://www.nasdpts.org/resources/Documents/amendmentsto2015/Editorial Edits for 2015 NSTSP 11.2021.pdf

External Public Address Systems [Tier 3]

External public address systems can help the driver communicate safety issues to students and other VRUs outside the bus during loading and unloading. The New York State Education Department Pupil Transportation District Safety Review Program recommended that school districts consider deploying this on school buses.[70] The National School Transportation Specification and Procedures document identified this as an optional technology.[71]

Blind Zones

Between 2010 to 2019, 51% of all school-age pedestrian deaths involving school buses nationwide were children between 5 and 10 years old.[72] On average, children are shorter than adults and therefore more likely to fall within the blind zone of a vehicle; this is particularly true for large vehicles. School bus blind zones vary depending on the make and model of the vehicle and can result in limited visibility of VRUs, especially children.

Crossover mirrors installed to comply with Federal Motor Vehicle Safety Standard 111 are intended to mitigate obstructed frontal views. However, the addition of these mirrors introduces new obstructions, and the minification of the view through these mirrors as well as sun glare or misalignment may reduce their effectiveness as compared to improving direct vison through optimal vehicle hood and cab design.

Camera systems and automatic emergency front and rear braking can help mitigate the risks to VRUs that existing school bus blind zones pose, including the rear blind zone, where direct vision is generally not possible.

Relevant countermeasures include:

- Visibility improvements,
- Cameras,
- Mirror enhancements,
- External alerts,
- Rear cross traffic collision warning,
- Rear automatic emergency braking (AEB), and
- Warning decals

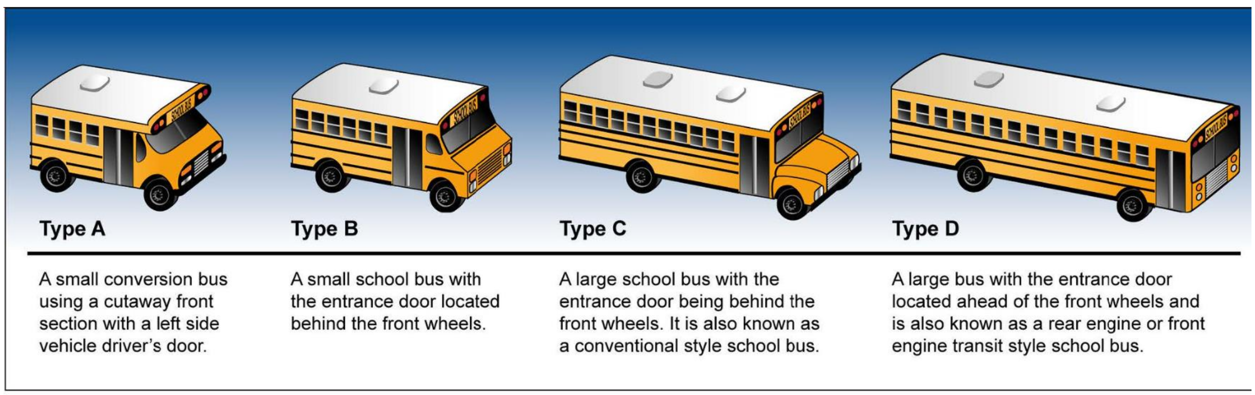
[70] https://www.p12.nysed.gov/schoolbus/documents/pdf/2006_NYSED_DSR_final.pdf.
[71] https://www.nasdpts.org/resources/Documents/amendmentsto2015/Editorial Edits for 2015 NSTSP 11.2021.pdf.
[72] National Highway Traffic Safety Administration. *Traffic Safety Facts.* 2021. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813105

Visibility Improvements

Improved Direct Vision [Tier 1]

Children and school bus attendants routinely cross in front of school buses, making it critical for the driver to see them and for child pedestrians to establish eye contact with the driver. Direct vision, or line-of-sight between the driver and people outside the bus, is necessary for establishing this eye contact and situational awareness.

Type A-D school buses can have significantly different levels of direct vision. Figure 17 shows these types. In Type C (engine forward) buses, the most common type, a key consideration is the downslope of the engine hood, specifically ensuring that it does not block the driver's line of sight to the ground ahead. The dashboard design as well as the side and crossover mirror configuration can also affect the blind zone size. In Type D (transit style) buses, the interior cab design is key, specifically a low dashboard design that permits direct vision very close to the front of the bus. Ideally, the direct vision for a Type D bus would exceed the APTA bus procurement standard of allowing the driver to see a 3.5-foot-tall person standing two feet in front of the bus.[73]



Source: GAO presentation of 2015 National School Transportation Specifications and Procedures. | GAO-17-209

Figure 17. Common school bus types (GAO)

Some bus manufacturers report, at least qualitatively, on their blind zone performance. However, quantitative direct vision assessments of the most common Type C and D makes and models in the NYC school bus fleets could help to identify the best direct vision options on the market.[74]

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[73] "TS 51. Windshield: The windshield shall permit an operator's field of view as referenced in SAE J1050. The vertically upward view shall be a minimum of 14 deg, measured above the horizontal and excluding any shaded band. The vertically downward view shall permit detection of an object 3½ ft high no more than 2 ft in front of the bus." From APTA BTS-BPG-GL-001-13 https://www.apta.com/research-technical-resources/standards/procurement/apta-bts-bpg-gl-001-13/

[74] For example, either using the VIEW blind zone calculator tool (https://blindzonecalculator.herokuapp.com/) or using a simplified physical method, such as measuring the minimum distance forward and to the passenger side at which a specified vulnerable road user (e.g., 5th percentile height female adult) can be seen by the driver.

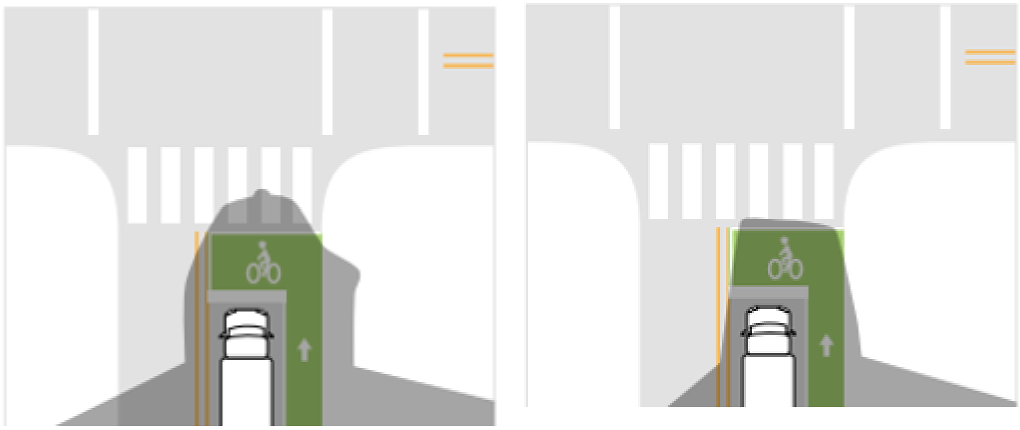

Figure 18. Example of qualitative blind zone comparison at 900 mm above ground level between two conventional cab truck models. (Adapted from NACTO)

Notably, electrification could play a role in expanding direct vision in school buses. By NYC Local Law, all school buses will be electric models by 2035. When there is no longer an engine block in an electric school bus, this presents a unique opportunity to redesign Type A, B, and C buses with a low, rounded extension that tapers down to the bumper, optimized for guiding VRUs around the front of the bus while not obstructing line-of-sight for any height driver. Such a design could draw on the "soft nose" enhanced front end concept for truck design intended to help sweep aside VRUs in a forward collision and reduce the risk of front overs.[75] In crash simulations testing the impact on human models (male, female, child), front overs were avoided in all cases for a rounded truck front end, as compared to 70% risk of front over with a flat-front truck.

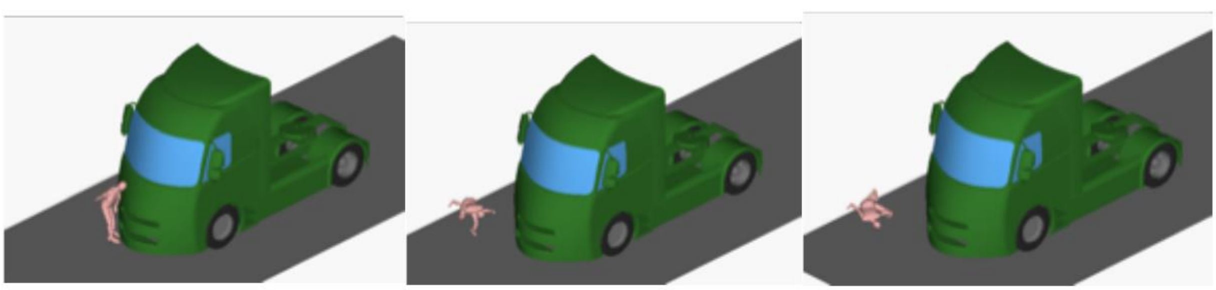

Figure 19. Frontal collision between a rounded front vehicle end and a struck pedestrian, demonstrating front over protection. (TRL)

Heated Windshield or Wiper Blades [Tier 3]

Heated windshield wiper blades help prevent visibility problems from ice and snow. The New York State Education Department Pupil Transportation District Safety Review Program recommended that school districts consider deploying this on school buses.[76]

[75] https://trl.co.uk/projects/enhanced-truck-front-end-designs--tfed--in-europe-from-sept-2020; https://trl.co.uk/publications/enhanced-truck-front-end-designs--tfed-
[76] https://www.p12.nysed.gov/schoolbus/documents/pdf/2006_NYSED_DSR_final.pdf.

Heated windshields use a similar technology as the heated rear windows found in light duty passenger vehicles. The difference is that the heating elements must not be visible or otherwise restrict driver visibility. Heavy duty OEMs are developing practically invisible systems that could work efficiently on the large windshields of heavy-duty vehicles.

Cameras

Several types of camera systems can aid in providing drivers with additional visibility where direct vision is not possible. Cameras do not provide the driver additional warnings.

Back Up Cameras [Tier 1]

A back up camera provides a driver with a video of the rear view while in reverse.[77] While fixed-route school buses generally do not back-up, door-to-door school buses do, since they are driven into dead-end streets where turning around is not possible. Door-to-door buses also have an attendant on the bus who can help spot the driver when backing up. In the absence of a spotter, back up cameras have been proven to be effective at preventing rear crashes in automobiles and to be more effective than parking sensors to help drivers avoid crashes with objects or people.[78] It is important to note that although back up cameras can help prevent rear crashes, detection of a vehicle, pedestrian, or object is not guaranteed, and drivers must not become over reliant on the camera display.[79] Backup cameras are now commercially available on school buses, as both an aftermarket device[80] and a standard OEM feature,[81] but research on the effectiveness of such devices specifically in school buses is scarce. Although backup cameras are not required in most school buses, they are required in light-duty vehicles by NHTSA (including school buses with gross vehicle weight rating of 4,536 kg or less) and have become required or best practice equipment, based on vehicle size and type, on all DCAS fleet units based on the municipal fleet SFTP.[82]

[77] National Highway Traffic Safety Administration. *Driver Assistance Technologies*. n.d. https://www.nhtsa.gov/equipment/driver-assistance-technologies#other-systems-30696

[78] Consumer Reports. *Report Finds Backup Cameras can Help Prevent Needless Tragedies.* 2014. https://www.consumerreports.org/cro/news/2014/03/report-finds-backup-cameras-can-help-prevent-needless-tragedies/index.htm

[79] Consumer Reports. *Report Finds Backup Cameras can Help Prevent Needless Tragedies.* 2014. https://www.consumerreports.org/cro/news/2014/03/report-finds-backup-cameras-can-help-prevent-needless-tragedies/index.htm

[80] https://www.rearviewsafety.com/backup-camera/bus-backup-camera-systems/school-bus-backup-camera.html

[81] https://www.blue-bird.com/about-us/press-releases/119-blue-bird-buses-now-equipped-with-electronic-stability-control-and-backup-cameras-as-standard-equipment

[82] Government Fleet. *NHTSA Releases Final Rule Requiring Back Up Cameras.* N.d. https://www.government-fleet.com/117271/nhtsa-releases-final-rule-requiring-backup-cameras

Figure 20. Bus Backup Camera (JCBL)

Birds Eye View Camera System [Tier 1]

A bird's eye view camera system (also known as 360° camera systems) provides a top-down, 360-degree view of a vehicle and its immediate surroundings, stitched together from four separate camera feeds on the front, rear, and sides of the vehicle and shown on a single in-cab display. The stitched image includes views of areas that are in the blind zones and typically displays areas within a close range of the vehicle. This type of camera system is currently available as both an OEM and an aftermarket option in school buses. Examples include the PerimeterView 360 Camera Package (PV360) from Thomas Built Buses, the Rosco Vision Systems Safe-T-Scope (also referenced above), and the REI 360° Surround View Camera System.[83]

[83] Thomas Built Buses. *360 Degree Camera Provides Unmatched Visibility and Safety*. 2018. https://thomasbuiltbuses.com/resources/articles/360-degree-camera/; https://www.radioeng.com/driver-assistance-safety/#360

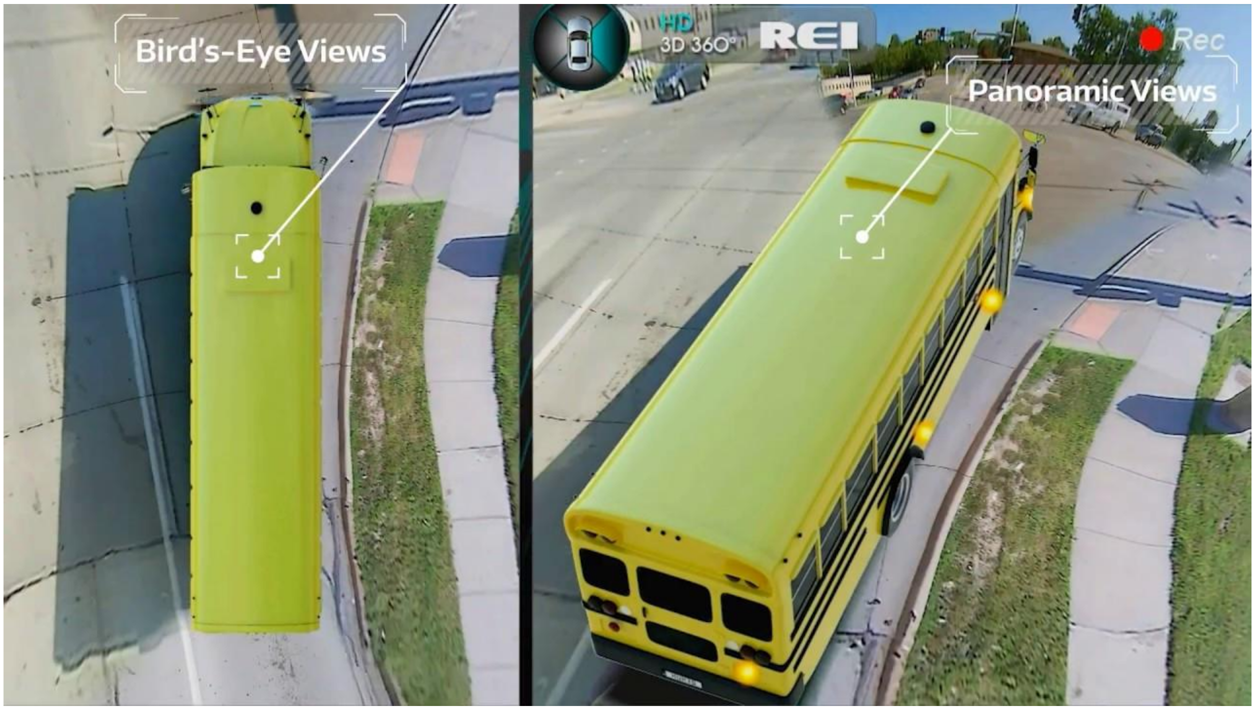

Figure 21. Bird's Eye View Camera System (REI)

While birds-eye view cameras in light-duty vehicles are typically displayed only at low speeds (such as while parking), the REI and potentially other school bus implementations also display during normal driving. The birds eye view camera system appears to be a recognized countermeasure to the issue of blind spot monitoring in school buses: the Task Force on School Bus Safety, chaired by Transport Canada, recently recommended the installation of birds eye view cameras on school buses to improve pedestrian safety.[84] However, it is unclear to what extent this decision was based on empirical research on the effectiveness of these camera systems; research on birds eye view camera systems' efficacy is scarce both in the context of school buses and automobiles. As described in the Interviews Synthesis section, some of the interviewees expressed concerns that too many displays may even be distracting.

Surround Camera Systems [Tier I alternate]

Distinct from birds-eye view camera systems, surround camera systems display four independent video images from the four camera feeds. The system provides regular and zoomed views of the front and rear. Sometimes the front and rear horizontal field of views are expanded up to 180 degrees by stitching the front or rear camera with the side cameras. The views provided aid the driver in seeing the objects and VRUs around the vehicle and may support safer vehicle maneuvers. This camera system has so far been deployed in 1,500 of NYC DCAS Fleet units including heavy duty trucks. Additional implementation is planned for DSNY garbage trucks.

[84] https://tc.canada.ca/en/binder/school-bus-safety; https://comt.ca/Reports/School%20Bus%20Safety%202020.pdf

Object Detection Triggered Cameras [Tier 3]

Object detection triggered cameras are devices that use ultrasonic sensors to detect objects that are close to the vehicle and use the input from the ultrasonic sensors to turn on the camera system view on the object; they also provide an audible or haptic warning to the driver. This feature operates at low speed, e.g., when backing out of a parking space. Object detection triggered cameras could help reduce crashes when the vehicle is surrounded by VRUs, in addition to helping the vehicle maneuver in tight places. Object detection triggered cameras have been implemented in passenger vehicle models,[85] but no research to examine their effectiveness in improving safety could be identified. This review also did not identify any commercially available offerings for school bus applications.

Turn Signal Triggered Cameras [Tier 3]

Turn signal triggered cameras (also referred to as blind spot cameras) turn on the camera system side view when the turn signal is activated; this feature helps drivers of long vehicles and vehicles with trailers see objects that usually are in the blind spot and make safer turns. Rosco Vision Systems Safe-T-Scope is an example of a system that allows custom triggers, such as for turn signals, to activate specific views; it also provides a bird's eye view (see below). Driving simulator research on turn signal triggered cameras in automobiles suggests that using the blind spot camera systems can lead to improved safety, lessen the need for head and eye movements, and reduce the mental workload of driving.[86]

Mirror Enhancements

As discussed above in the Statutory and Regulatory Requirements section, mirrors are already extensively regulated for school buses in New York. However, there may still be some enhancements that could improve the usability of mirrors.

Heated Mirrors and Power Mirrors [Tier 2]

The addition of heated mirrors and power-adjustable mirrors to school buses has been recommended by the New York State Education Department Pupil Transportation District Safety Review Program[87] and are deemed permissible by the National Congress on School Transportation.[88] Heated mirrors would help the driver maintain visibility in poor weather such as snow and rain. Although school bus drivers conduct bus checks before each trip (thus ensuring that their mirrors are clear of debris such as snow), heated mirrors can maintain visibility during the trip in the case of ongoing adverse weather. Heated mirrors also offer improved visibility during rainy conditions, meaning that they can offer benefits year-round.

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85 https://www.nissan-global.com/EN/INNOVATION/TECHNOLOGY/ARCHIVE/MOD/
86 https://ieeexplore.ieee.org/abstract/document/6318516
87 https://www.p12.nysed.gov/schoolbus/documents/pdf/2006_NYSED_DSR_final.pdf
88 https://www.nasdpts.org/resources/Documents/amendmentsto2015/Editorial Edits for 2015 NSTSP 11.2021.pdf

Power-adjustable mirrors allow drivers to alter the school bus's mirror position without getting out of the vehicle. This feature can be useful if a mirror was moved out of adjustment while driving a route, if a driver changes vehicles, or when encountering a situation where the driver needs to quickly change their view of the surrounding roadway.

Warning Decals [Tier 2]

Safety decals are intended to increase awareness and avoidance of truck blind zones among VRUs. These may be positioned with one on the left side, one on the right side, and one on the rear of the vehicle. They are typically a conspicuous color and should be designed to be easily seen by someone near the vehicle. However, decals should generally not be diamond-shaped, as this denotes hazardous materials. There are a variety of companies that can produce premade or custom decals. Transport for London places safety decals at the rear of each fleet vehicle over 3.5 metric tons (7,716 lbs.). Figure 28 shows an example of the current decal and model language.

Figure 22. Transport for London places safety decals at the rear of each fleet vehicle over 3.5 metric tons. (Road.cc)

External Alerts

External alarms are intended to warn VRUs of the presence and motion of a vehicle so that they can avoid potentially dangerous positions in relation to the vehicle. This may include back-up alarms or audible turning systems. There is evidence to suggest that traditional tonal alarms may not prompt sufficient action from VRUs. However, there are newer alarm technologies that are more effective and produce less noise pollution. These use self-adjusting volume and/or broadband alarms.[89] One study suggests external alarms may be ineffective warnings for very young children.[90] As noted previously, section 24110(c) of the Bipartisan Infrastructure Law requires NHTSA to evaluate school bus safety technologies by November 2023, and the law specifically mentions “audible warning systems” as one of the technology types that NHTSA must evaluate.[91]

Self-adjusting Volume and Broadband Back-up Alarms [Tier 1]

Self-adjusting volume and broadband back-up alarms aim to reduce noise pollution and make auditory alerts more efficient. While “self-adjusting volume” and “broadband” are independent features that could be combined in a single device, they could also be implemented separately; in other words, a back-up alarm could have one of these features, none of these features, or both. The 2019 update to the NYC municipal fleets SFTP designated self-adjusting volume back-up alarms as Tier 1 and broadband back-up alarms as Tier 2. More detail is available in that report.[92]

In noisy urban environments, pedestrians are exposed to a constant stream of auditory alerts and alarms, meaning that alerts may be ignored over time. Self-adjusting volume back-up alarms adjust the volume of the alert depending on the volume of surrounding ambient noise.[93] This technology ensures that alerts remain audible to those at risk, while also reducing noise pollution and harmful exposure levels.

Broadband (or tonal) back-up alarms use a variety of tones to improve people’s perception and response to the sound. Most back-up alarms consist of a single tone, which means that they can be masked by competing tones in the environment.[94] Broadband alarms are easier for a VRU to locate in space while also using lower decibel levels, which in turn can reduce noise pollution and decrease exposure to unsafe volume levels.[95]

Although this review did not find effectiveness research on these devices from a school bus passenger or pedestrian safety perspective, both potential safety benefits as well as a reduction in noise pollution and volume levels may be expected from the “self-adjusting volume” and “broadband” features.

Audible turning warning systems [Tier 1]

Audible turning warnings are auditory (and sometimes visual) exterior alerts that aim to notify pedestrians and other road users when the bus is about to turn or leave a bus stop. These systems have

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[89] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3018517/.
[90] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1730927/.
[91] https://www.congress.gov/bill/117th-congress/house-bill/3684/text.
[92] https://www1.nyc.gov/assets/dcas/downloads/pdf/fleet/Safe-Fleet-Transition-Plan-Update-2018.pdf.
[93] https://www.grainger.com/product/SMART-Back-Up-Alarm-3WRT4
[94] https://www.rallylights.com/asa-bbs-brigade-smart-self-adjusting-white-sound-backup-alarm.html
[95] https://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2013;volume=15;issue=67;spage=420;epage=436;aulast=Vaillancourt

already been implemented on transit buses,[96] but could also be applied to school buses. Although a long-term evaluation of turning alert systems has not yet been conducted, research suggests that the alarms have high levels of acceptability, at least from pedestrians. In an evaluation of transit bus turn warning systems, researchers found that there was a disconnect between bus operators and pedestrians when it came to opinions regarding the safety system.[97] When transit bus operators were surveyed, fewer than half thought that that alarm systems were effective at warning pedestrians. Further, fewer than a third of surveyed operators thought that system reduced close calls with pedestrians. However, pedestrians generally had a more favorable view of audible turning systems, with most respondents reporting they thought audible turning systems increased pedestrian safety. Pedestrians reported that the spoken warnings were more intrusive than the beeping warnings. In addition, the same report estimated the total benefit of each warning system installed on a transit bus to be $65,300, based on the reduction in close calls observed during the evaluation period.

In New York City, audible turning warning systems are being deployed on 250 city fleet vehicles as an initial evaluation project in summer 2023. Although no studies could be identified for school buses, once deployment of the system in NYC is complete, more research could be conducted on whether these systems would be suitable for widespread use on NYC school buses.

Rear Cross Traffic Collision Warning [Tier 3]

This technology provides warnings to the driver in rear cross traffic scenarios. It uses radar to detect objects including vehicles and bicycles that are invisible to the driver, visually, through the vehicle mirrors, and through surround camera systems (for equipped vehicles). The radars are placed on the rear side of the vehicle where their field of view can detect cross traffic. The primary use case for this feature is for a vehicle backing out of a parking space; as the vehicle is backing up, if a cross traffic vehicle is detected, the feature provides an audible warning to the driver with arrows on the display indicating the side of the incoming traffic. The feature's detection distance depends on the range of the radar used; these are usually short-range radar; it operates at low speed. While regular bus application rarely involves backing maneuvers during road operation, door-to-door school bus applications may benefit from this feature. However, this feature is not commercially available for school bus applications at this time.

Rear Automatic Emergency Braking (AEB) [Tier 3]

Rear Autonomous Emergency Braking (AEB) activates when a driver is in proximity with a person or object as they are going in reverse.[98] While these systems are not required in vehicles, NHTSA believes

[96] https://www.bostonmagazine.com/news/2014/05/06/mbta-testing-new-turn-alert-system-select-buses/.
[97] https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA_Report_No._0084.pdf.
[98] National Highway Traffic Safety Administration. Collision Intervention. n.d. https://www.nhtsa.gov/equipment/driver-assistance-technologies#technologies-explained-collision-intervention

AEB systems will be able to mitigate common rear-end crashes.[99] Rear AEB systems that interlock with air brakes, such as those commonly found on Type C and D school buses, are available as aftermarket systems. However, Volpe was unable to identify such a system that has been implemented on school buses. Implementing rear AEB in a school bus would require installation of sensors at the rear most surface of the vehicle and at a height that will have a sensing field that encompasses areas closer to the ground. Since positioning and calibration is important to the functioning of the system, the support structure for the positioning must be rigid while keeping departure angle in mind.

Forward Collisions

Between 2010 and 2019, one-quarter of all school-age pedestrians killed by school transportation were struck by a vehicle that was going straight,[100] highlighting the importance of preventing and mitigating front-end collisions. This pattern reinforces the important of high vision truck options as discussed above.

Additional relevant forward collision countermeasures include:

- Illumination
- Collision Avoidance
- Safe Speed Management
- Vehicle handling and
- Occupant countermeasures.

Illumination

Downlighting on Crossover Mirrors [Tier 3]

Adding downlighting to safety mirrors can increase the visibility of areas that would otherwise not be seen by drivers in poor lighting. This works by adding LEDs to the bottom of the mirror, illuminating critical areas where students may be walking around the school bus. The lights can turn on automatically whenever headlights or turn signals are activated, ensuring maximum visibility to the driver, and a speed control may be suitable due to possible glare issues when the vehicle is traveling on the road. This technology is commercially available.[101] For example, each Rosco Eye-Max LED cross view mirror offers four LED lights to illuminate the area around the mirror.

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[99] National Highway Traffic Safety Administration. Collision Intervention. n.d. https://www.nhtsa.gov/equipment/driver-assistance-technologies#technologies-explained-collision-intervention

[100] National Highway Traffic Safety Administration. *Traffic Safety Facts.* 2021. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813105

[101] https://www.roscomirrors.com/downloads/02_EYEMAX_LED_TRUCK_11022020_1.pdf

Figure 23. Downlighting on Crossover Mirror (Rosco)

Collision Avoidance

Collision avoidance systems can be either active, such as automatic emergency braking (AEB), or passive, such collision warning systems that warn the driver but do not include any automated physical intervention.

Pedestrian Collision Warning [Tier 1]

A pedestrian collision warning system generates a warning to the driver when a pedestrian is detected near a vehicle. The warning can be audible, visual, haptic, or a combination. The Saf-T-Zone Pedestrian Detection System offered by Thomas Built Buses, and the Safety Vision/Mobileye option from Blue Bird are two examples of a pedestrian collision warning system offered by a school bus OEM.[102] When a pedestrian is detected, the system provides an auditory alert to an in-cabin tablet and through caution lights on the crossover mirrors (for Thomas Built Bus) or to a small dashboard-mounted display (Blue Bird).[103]

Abigail's Law in New Jersey requires that all newly manufactured school buses operating in the state use front and rear detection systems for avoiding collisions with pedestrians.[104] Section 24110(c) of the Bipartisan Infrastructure Law requires NHTSA to evaluate school bus safety technologies by November 2023, and among those, it explicitly includes "motion-activated detection systems capable of detecting pedestrians, cyclists, and other road users located near the exterior of the school bus and alerting the operator of the school bus of those road users.[105] Pedestrian collision warning is readily available for

[102] https://www.blue-bird.com/mobileye; https://www.blue-bird.com/about-us/press-releases/194-collision-avoidance-solution-now-available-on-blue-bird-school-buses

[103] Thomas Built Buses. *Thomas Built Buses Introduces New Saf-T-Zone Pedestrian Detection System*. 2021. https://thomasbuiltbuses.com/resources/news/thomas-built-buses-introduces-new-saf-t-zone-2021-11-01/

[104] https://pub.njleg.gov/bills/2014/A1500/1455_I1.HTM#:~:text=This%20bill%2C%20designated%20%22Abigail's%20Law,or%20back%20of%20the%20bus.

[105] https://www.congress.gov/bill/117th-congress/house-bill/3684/text.

Type C buses from at least two major school bus manufacturers (Thomas Built Buses and Blue Bird). However, it is unclear whether this technology is readily available for other school bus types.

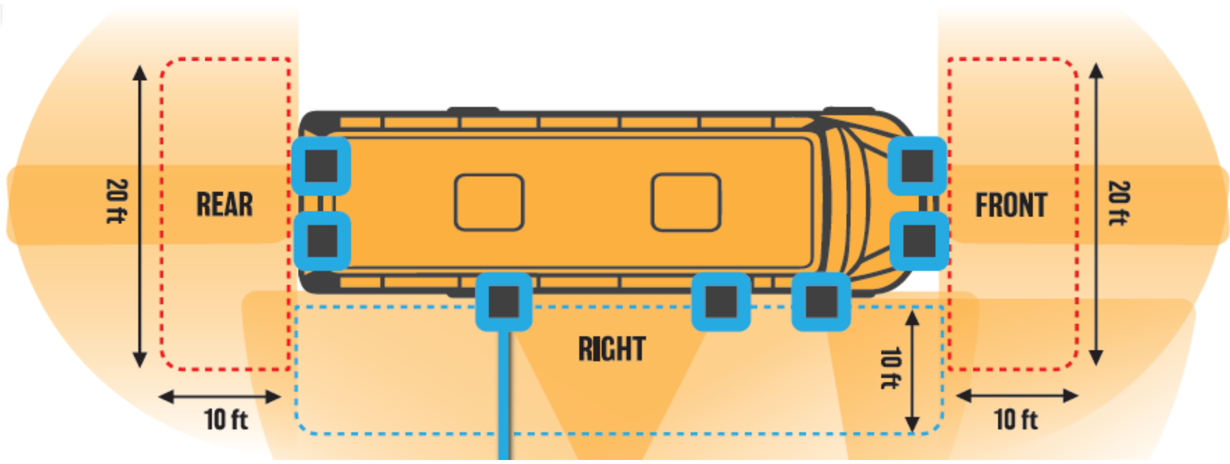

Figure 24. Coverage zones of school bus pedestrian collision warning system. (TBB Saf-T-Zone)

Figure 25. Illustration of pedestrian detection indicator in blind spot mirror (Thomas Built Buses)

Forward Collision Warning [Tier 1]

Forward collision warning detects a potential collision with a vehicle ahead and provides a warning to the driver.[106] Although not required in school buses, National Highway Traffic Safety Administration

[106]National Highway Traffic Safety Administration. *Technologies Explained.* n.d. https://www.nhtsa.gov/equipment/driver-assistance-technologies#technologies-explained-collision-warning

(NHTSA) recommends them in all vehicles.[107] The Seman-Tov school bus company in Central New Jersey reports having reduced front-end collisions by approximately 50 percent by installing Mobileye forward collision warning systems, a system offered OEM or aftermarket by Blue Bird.[108] The Bendix Wingman system offered by IC Bus also provides forward collision warnings,[109] while BYD states that its Type D bus includes a collision avoidance system but does not specify what type.[110]

Automatic Emergency Braking (AEB) [Tier 2]

Automatic emergency braking (AEB) assists the driver by intervening and applying the vehicle brakes when an imminent forward crash is detected but the driver has not taken any preventative action. An AEB system is paired with a collision avoidance system, which typically detects moving, stopped or stationary vehicles ahead. Additionally, the National Transportation Safety Board (NTSB) has found that AEB should be paired with electronic stability control (see related report section) to be most effective in school buses. The NTSB school bus crash investigations and research have found that collision avoidance systems with AEB and electronic stability control are effective in preventing or mitigating the severity of crashes and in reducing the frequency of rear-end or loss-of-control crashes. Although collision avoidance systems, AEB, and electronic stability control are not required in school buses, the NTSB has recommended that NHTSA require all new school buses to be equipped with them.[111] AEB is readily available for Type C buses from at least two manufacturers (Saf-T-liner C2 vehicles from Thomas Built Buses, in the form of Wabco Active Onguard, and Bendix Wingman from IC Bus[112]) and for Type D buses from at least one manufacturer (IC Bus). It is unclear whether this technology is readily available for other school bus types.

Figure 26. Illustration of Automatic Emergency Braking Sensor (Thomas Built Buses)

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[107] National Highway Traffic Safety Administration. *Technologies Explained.* n.d. https://www.nhtsa.gov/equipment/driver-assistance-technologies#technologies-explained-collision-warning

[108] Mobileye. *Mobileye in The Field.* 2020. https://www.mobileye.com/us/fleets/case-study/seman-tov-bus-company-lowers-collision-rate-with-mobileye/

[109] https://www.icbus.com/why-icbus/safety/safety-collision-mitigation

[110] https://en.byd.com/news/byd-to-revolutionize-electric-school-buses/

[111] National Transportation Safety Board. *Selected Issues in School Bus Transportation Safety: Crashes in Baltimore, Maryland, and Chattanooga, Tennessee*. 2018. https://www.ntsb.gov/safety/safety-studies/Documents/SIR1802.pdf; additionally, the School Bus Safety Act of 2021 (bill not passed) would have required AEB for all school buses.

[112] https://www.icbus.com/why-icbus/safety/safety-collision-mitigation

Pedestrian AEB [Tier 2]

Pedestrian AEB (PAEB) assists the driver by intervening and applying brakes when the vehicle is in forward motion and an imminent collision is detected with pedestrians. Some PAEB systems are designed to work in scenarios where the vehicle is moving forward at speeds up to 25 mph and a pedestrian is moving in a direction perpendicular to the vehicle and up to 37 mph when a pedestrian is moving parallel to the path of the vehicle. Standard testing protocols[113] are updated to reflect PAEB system capabilities. PAEB systems are currently available on medium and heavy-duty trucks, including certain Freightliner and Isuzu models,[114] but Volpe did not identify any commercially available PAEB for school buses.

Safe Speed Management

Speeding is a common cause of crashes. According to the National Safety Council tabulation of school bus crashes, data for the most recent available year (2020) show that 22 percent of school bus-related crashes nationwide involved speeding, although the tabulation does not specify whether the speeding was for school buses or other involved vehicles.[115] A Daily News investigation in NYC reported that roughly two-thirds of NYC school buses had been ticketed by speed and red light cameras, and added that thousands of those tickets were issued in zones near schools.[116] As discussed in the Geotab speeding alert analysis section above, NYC school buses traveled at 11 mph or higher over the speed limit on average between 0.23 and 0.46 times per bus, per day, depending on the month, and most commonly by about 15 mph over the speed limit.

Speed Governor [Tier 2]

Fixed-speed governors limit the revolutions per minute or top speed of the vehicle to reduce the risk of loss of control in highway driving. According to New York State Department of Transportation Bus and Passenger Vehicle Regulations, each school bus engine may be provided with a governor set at the revolutions per minute of the engine that represents the recommended maximum performance within the safety range of the engine speed or a speed-regulated governor to control the maximum speed of the engine.[117] Federally, a speed limiting device requirement for vehicles with gross vehicle weight

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[113] IIHS. Pedestrian Autonomous Emergency Braking Test Protocol Version III. August 2022 https://www.iihs.org/media/f6a24355-fe4b-4d71-bd19-0aab8b39aa7e/TfEBAA/Ratings/Protocols/current/test_protocol_pedestrian_aeb.pdf

[114] https://www.dovellandwilliams.com/isuzu-advanced-safety-technology/; https://demanddetroit.com/our-company/community/blog/automated-safety-a-vital-element-of-working-smart/

[115] https://injuryfacts.nsc.org/motor-vehicle/road-users/school-bus/.

[116] https://www.govtech.com/education/k-12/nyc-officials-seek-tech-solution-to-speeding-bus-drivers.

[117] https://www.dot.ny.gov/divisions/operating/osss/bus-repository/busregs1.pdf

rating over 26,000 pounds, including school buses, remains listed as a "long-term action,"[118] although FMCSA has proposed a more near-term speed governor requirement for interstate motor carriers.[119] NYC school buses most commonly operate on city streets at speeds below the range addressed by speed governors.

Intelligent Speed Assistance (ISA) [Tier 2]

An intelligent speed assistance (ISA) system monitors the vehicle speed and compares it to a target speed; the target speed is usually the speed limit or the speed limit plus a threshold. If the vehicle speed exceeds the target speed, ISA provides a warning to the driver that the target speed is exceeded. The warning may be visual, audible, haptic, or a combination. The speed limit is provided via on-board maps or GPS. Some applications of ISA intervene and prevent or inhibit the vehicle speed from crossing the target speed, such as by disengaging the throttle. Fleet operators can use ISA to monitor the vehicle speed and provide training to the drivers to maintain the target speed. New York City commenced a 50-vehicle ISA pilot on municipal vehicles in summer 2022, and the lessons learned will inform future tier assignment of this technology for school bus use. Volpe is supporting DCAS in 2023 is evaluating the ISA pilot on City Fleet vehicles as it expands to 250 vehicles. Based on Volpe's review and consultation with industry, ISA does not appear to have been implemented yet on school buses in the United States.[120] DCAS and NYC Fleet executed a test of ISA on school buses in conjunction with the drafting of this report. Preliminary results on the first nine-bus pilot indicate that installing ISA on school buses decreased excessive speeding (11+ mph above the speed limit) from 4.21% to 0.03% of overall driving time, representing a 99.29% decrease in excessive speeding time. These initial findings suggest that ISA is a feasible intervention to decrease speeding behaviors in school bus drivers. DCAS along with DOE has added ten more buses to this pilot and as part of the release of this report will increase the number of ISA equipped school buses to 50.

Figure 27. Intelligent Speed Assistance Illustration (DCAS)

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118 "Fall 2021 Unified Agenda of Regulatory and Deregulatory Actions." *Current Unified Agenda of Regulatory and Deregulatory Actions,* https://www.reginfo.gov/public/do/eAgendaMain?operation=OPERATION_GET_AGENCY_RULE_LIST

119 https://www.fmcsa.dot.gov/regulations/docket-no-fmcsa-2022-0004-parts-and-accessories-necessary-safe-operations-speed

120 Email correspondence with National Association of Pupil Transportation and National Student Transportation Association, February 23, 2023.

Vehicle Handling

Electronic Stability Control [Tier 1]

Electronic stability control systems monitor vehicle movement and steering and use automatic computer-controlled braking to address severe under-steer or over-steer conditions that can lead to loss of control, including rollover incidents. 49 CFR § 571.136 provides a more detailed definition.[121] Electronic stability control has been required on all new passenger vehicles under 10,000 pounds in the U.S. since 2012, and as of 2015, 49 CFR § 571.136 has required electronic stability control systems on heavy trucks and some large buses, such as motorcoaches, but not school buses. Although not yet mandated in the U.S., electronic stability control is becoming increasingly common from school bus OEMs. Additionally, the NTSB concluded that the full benefits of AEB for commercial vehicles can only be achieved when it is installed on vehicles also equipped with electronic stability control.[122,123] See related report section on AEB.

Lane Centering and Lane Keep [Tier 2]

Lane centering and lane keep are driver safety features that help maintain the vehicle in its lane and reduce the possibility of collisions. Lane keep is a passive feature that helps maintain the vehicle between the lane lines; if the vehicle starts to depart from the lane, the system provides a warning to the driver. The warning may be audible, visual, haptic, or a combination. The system also provides a warning if the driver attempts to change lanes without the turn signal activated. This feature uses a vehicle front-mounted camera to detect the lane lines, and it operates above a certain speed threshold (e.g., 35 MPH). Lane centering is the same as lane keep, but it also applies a steering torque (torque overlay) when required to maintain the vehicle at the center of the lane; the torque overlay can be overcome easily by the driver.

This technology is available for school bus applications (e.g., through Thomas Built Bus/Blue Bird). Lane centering and lane keep are mature automotive application features, and they are available in most driver assistance / driver safety packages offered by OEMs. The features' full functionality and performance are easily transferable to bus applications with electro-hydraulic or electric steering systems.

A study by IIHS concluded "Lane-departure warning systems lower the rates of three types of passenger car crashes—single-vehicle, side-swipes, and head-on—by 11 percent and cut injuries in those same types of crashes by 21 percent, the study found." This study did not uncover any similar studies on the effectiveness of these technologies for school bus applications. NTSB has recommended requiring lane

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[121] https://www.ecfr.gov/current/title-49/subtitle-B/chapter-V/part-571/subpart-B.
[122] Page 78 of https://www.ntsb.gov/investigations/AccidentReports/Reports/SIR1802.pdf.
[123] Page 24 of https://www.ntsb.gov/safety/safety-studies/Documents/SIR1501.pdf.

departure prevention systems on new vehicles with gross weight ratings greater than 10,000 pounds since 2010.[124]

Occupant Countermeasures

Seat Belt Education and Use [Tier 2]

As described in the Statutory and Regulatory Requirements section, in NYC school buses must be equipped with seat belts for all occupants, but only children in special education are required to wear a seatbelt. NHTSA indicates that "the best way to provide crash protection to passengers of large school buses is through a concept called 'compartmentalization.' This requires that the interior of large buses protect children without them needing to buckle up. Through compartmentalization, children are protected from crashes by strong, closely-spaced seats that have energy-absorbing seat backs."[125] However, according to the NTSB,[126] NHTSA, Transport Canada,[127] and others, evidence shows that seatbelt use could provide an additional layer of safety to the existing bus design, especially for rare severe collisions such as a rollover or side impact event. Crash testing by NHTSA found that three-point seatbelts may reduce the risk of moderate to serious injury by an estimated 30-35% in collision types with a high probability of ejection and could lower the risk of serious to severe injury in frontal impacts by approximately 4-10%. A NHTSA cost-effectiveness analysis estimates that three-point seatbelts on school buses could save 2 lives per year across the U.S., assuming 100% seatbelt usage nationwide.[128] Transport Canada developed draft Task Force Guidelines for the Use of Seatbelts on School Buses to help address operational concerns and highlight additional training needs for students, drivers, parents, and schools.[129] A summary on school bus seat belt research is available from the NCSL.[130]

Side and Rear Collisions

Nationally, in 12 of the 39 pedestrian fatalities between 2011 and 2020 in which a school bus struck the victim, the bus was turning left, right, or "negotiating a curve."[131] This 30-percent subset of fatalities potentially involved side impact collisions. Additionally, at least two fatal crashes involving underride or override between school buses and other vehicles occurred in 2017-2019.[132]

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[124] https://www.ntsb.gov/news/press-releases/Pages/NR20221103.aspx
[125] https://www.nhtsa.gov/road-safety/school-bus-safety.
[126] https://www.ntsb.gov/Advocacy/safety-topics/Pages/schoolbuses.aspx.
[127] https://comt.ca/Reports/School%20Bus%20Safety%202020.pdf.
[128] 2008 NHTSA Final Rule to Upgrade School Bus Passenger Crash Protection in FMVSS Nos. 207, 208, 210, and 222 (https://www.nhtsa.gov/document/final-rule-seating-systems-occupant-crash-protection-seat-belt-assembly-anchorages-0) and 2010 NHTSA Response to Petition. Federal Register, 75(209), 66686-66698 (https://www.govinfo.gov/content/pkg/FR-2010-10-29/pdf/2010-27312.pdf).
[129] https://comt.ca/Reports/School%20Bus%20Safety%202020.pdf.
[130] https://www.ncsl.org/research/transportation/should-school-buses-have-seat-belts.aspx.
[131] https://crashstats.nhtsa.gov/Api/Public/ViewPublication/813327
[132] [1]Fatality Analysis Reporting System (FARS): 2006-2019 Final File and 2020 Annual Report File (ARF) Report Generated: Monday, October 24, 2022 (4:33:54 PM) on https://cdan.dot.gov/query Additionally, there were three fatal crashes during this period marked, "Unknown if Underride or Override."

Relevant forward collision countermeasures include:

- Wheel guards,
- Minimum Body Skirt Height, and
- Minimum Bumper Height.

Minimal Body Skirt Height [Tier 1]

According to New York State Department of Education's District Safety Review, "section III.D.15 Body skirts," school districts and bus companies should consider equipping buses with lowered body skirts to reduce the possibility of a student or other child falling or crawling under the bus. This State guidance designates such body skirts or side guards as a "Best practice."[133] As with wheel guards, both going-ahead and turning collisions between the school bus and VRUs represent the use case for this safety countermeasures. Both aim to prevent the VRU from being run over by the rear wheels, as occurred for example in a fatal January 2022 right-turn crash in Brooklyn.[134]

Aftermarket adjustment of sidewall height may be feasible, if there is access to the frame rails on these buses for support. As a consideration, there may be packaging difficulty if a school bus with a long wheelbase travels a route with breakover angle concerns (e.g., hilly routes).

Figure 28. School Bus Equipped with Lower Body Sidewall (Sky-HiNews)

[133] https://www.p12.nysed.gov/schoolbus/documents/pdf/2006_NYSED_DSR_final.pdf
[134] https://nypost.com/2022/01/18/shocking-video-shows-nyc-school-bus-fatally-striking-teen/

Minimal Bumper Height [Tier 1]

Rear underride occurs when a following vehicle impacts and slides underneath a larger vehicle with higher ride height. As of July 2022, NHTSA has addressed rear underride protection for occupants of compact and subcompact passenger cars into trailers and semitrailers by adopting similar requirements to Transport Canada's standard for rear impact guards. The guards are required to provide sufficient strength and energy absorption to protect occupants when impacting the rear of trailers at up to 35 mph. However, school buses and single unit trucks remain exempt from the requirement.[135] A best practice recommended by Fairfax County (Va.) Public Schools is to specify the lowest rear bumper height that will work for routes. New York State law requires that bumpers must be at least sixteen and not more than thirty inches above the ground with the vehicle empty.[136]

Bumper heights are adjustable aftermarket if there is access to support structure. Considerations include potential packaging difficulty with the decrease in approach and departure angles for the bus, especially for one with a longer overhang. When the approach and departure angles are decreased on a bus, the working envelope for emergency tow retrieval is also reduced and should be considered.

Wheel Guards [Tier 3]

Wheel guards mount to the cross members of the bus and project down to about five inches above the ground. The device aims to reduce the number of fatalities by making a pedestrian who has fallen to the ground less likely to be caught under the rear wheel as the bus rolls forward. While wheel guards can be installed on both the left and right sides, an interviewed major school bus fleet indicated that in their experience most fatalities occur on the right rear side.[137] The MDZ Shield by Public Transportation Safety International Corp is an example of a wheel guard.[138]

Figure 29. Wheel Guards on a School Bus (PRWeb)

Driver Human Factors and Ergonomics

[135] https://stnonline.com/news/traffic-safety-experts-push-for-under-ride-guard-mandate-on-school-buses/
[136] https://www.nysenate.gov/legislation/laws/VAT/375.
[137] Interview with Charlie Bruce, Senior VP at Durham School Services, conducted by Volpe staff on July 13, 2022.
[138] Public Transportation Safety Int'l Corp. *Public Transportation Safety Int'l Corp. n.d.* https://www.s1gard.com/

Relevant countermeasures include:

- Passive alcohol impairment detection,
- Cell phone interlock,
- Navigation system,
- Universal design,
- Training in use of technologies, and
- Driver monitoring system.

Training in Use of Technologies and Urban Safe Driving [Tier 1]

There is risk in incorporating new technologies into buses without training drivers on their uses and limitations. For example, research into the use of partially automated systems has shown that the longer drivers used the systems the more likely they were to take both hands off the steering wheel or use a cell phone relative to drivers who did not have the technology.[139] However, research also found that with a partially automated driver assistance system drivers who were given a brief intensive hands-on training session had a stronger grasp of the technology, the system limitations, and its safety implications.[140]

Training programs to familiarize school bus drivers with new technology may be necessary to realize their full safety benefits. Training programs may be useful in helping drivers prepare for unexpected events with the technology or for better situational awareness while using new systems. DCAS requires a day long safety training every three years for full time fleet operators. This training reviews crash trends, general safety practices, and also new technologies.

Cell Phone App/Docking Station Interlock [Tier 2]

New York State law prohibits all drivers from using a hand-held mobile telephone or portable electronic device while driving.[141] NY State Senate Bill S2259, introduced in 2021, would prohibit drivers of school buses from using hands-free cell phones while operating.[142] DCAS has barred use of hands-free devices by drivers of City fleet vehicles. Many companies offer smartphone apps that either monitor driver behavior or block use of the phone partially or entirely. Research on the effectiveness of these technologies is limited and shows generally mixed results.[143]

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[139] Insurance Institute for Highway Safety. "Disengagement from driving when using automation during a 4-week field trial." October 2021. https://www.iihs.org/topics/bibliography/ref/2231

[140] AAA Foundation for Traffic Safety. "Longer Term Exposure and Drivers' Mental Models of ADAS Technology." April 2022. https://newsroom.aaa.com/wp-content/uploads/2022/04/Full-Report-Longer-Term-Exposure-and-Drivers-Mental-Models-of-ADAS-Technology.pdf

[141] "Cell Phone Use and Texting". New York State Department of Motor Vehicles. https://dmv.ny.gov/tickets/cell-phone-use-texting

[142] SSB2259. January 20, 2021. https://legislation.nysenate.gov/pdf/bills/2021/S2259

[143] AAA Foundation for Traffic Safety. "Effectiveness of Distracted Driving Countermeasures: An Expanded and Updated Review of the Scientific and Gray Literatures". March 2022. https://aaafoundation.org/wp-content/uploads/2022/03/22-1066-AAAFTS-Distracted-Driving-Research-Brief_v2.pdf

Other "lockbox" devices are meant to replace traditional land mobile radio systems often used for communication between school bus drivers and dispatchers. These systems require the bus driver to connect their cell phone to the lockbox hardware, which can include a traditional push-to-talk radio handset or button on the cell phone screen to allow communication between driver and dispatcher while complying with hands free and distracted driving rules. These devices can also allow the drivers to use navigation features while blocking other applications depending on the product specifications and settings.[144]

Navigation System [Tier 2]

A key takeaway from the original NYC SFTP for municipal fleets was that offering standardized navigation systems may be more effective than cell phone lockbox technologies in enabling drivers to commit to hands-free operation.[145] School bus navigation needs differ from those of many drivers as their routes require traveling to multiple points of interest rather than a single destination. School bus routes are planned and delivered to the drivers in advance of departure, and drivers perform dry runs of the routes. The relevance of navigation systems as a safety feature will also depend on the operating context of each school bus operator. For operators that infrequently alter their routes, this may be less important. For other operators, where routes change frequently,[146] a navigation system would be more relevant. School bus navigation systems would also need to consider height clearances and their exemption to travel on parkways.

If navigation systems are used, their programming should be done while stopped and not while traveling to avoid increasing driver workload. A 2017 study from the AAA Foundation for Traffic Safety reported that entering navigation was the most attention-demanding task using in-vehicle infotainment systems and had very high visual and cognitive demand of drivers.[147] Additionally, the sturdiness of the mount for the navigation system is an important consideration; an insecure mount could be detrimental for safety.

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[144] GPS Lockbox. "School Bus Transportation Services Need to Meet High Safety Standards". *n.d.* *https://gpslockbox.com/school-bus/*

[145] https://www1.nyc.gov/assets/dcas/downloads/pdf/fleet/VOLPE_Recommendations_for_Safe_Fleet_Transition_Plan_SFTP.pdf.

[146] For example, NYCSBUS reports that 11% of their stops are not the same day-to-day.

[147] AAA Foundation for Traffic Safety. "Visual and Cognitive Demands of Using In-Vehicle Infotainment Systems." October 2017. http://publicaffairsresources.aaa.biz/wp-content/uploads/2017/09/CDST_Final_Report.pdf

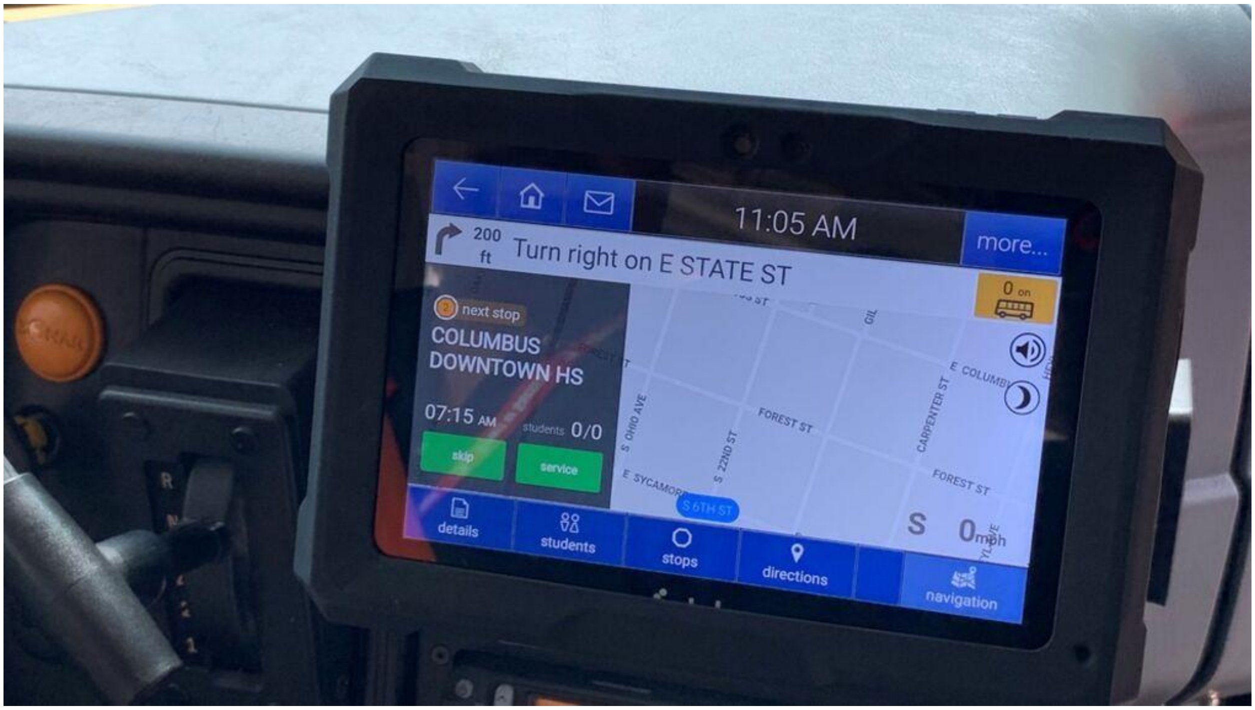

Figure 30. School Bus Navigation System (ABC6)

Passive Alcohol Impairment Detection Systems [Tier 3]

A 2020 Stateline investigation identified 118 cases in 38 states in which police arrested or cited school bus drivers since 2015 for allegedly driving a bus while impaired by alcohol or drugs.[148] In New York, at least four school bus drivers have been arrested since 2012 for operating a school bus while allegedly intoxicated.[149]

France and Spain currently mandate the installation of traditional breathalyzer alcohol ignition interlocks.[150] In 2018 the European Transport Safety Council recommended mandatory "alcohol interlock" installation on all new professional cars in the EU.[151]

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[148] Risky Ride: How Impaired School Bus Drivers Endanger Children. Pew Charitable Trusts. January 22, 2020. https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2020/01/22/risky-ride-how-impaired-school-bus-drivers-endanger-children

[149] Bergal, Jenni. 'Every State Should Be Passing a Law to Deal with This': The Danger of Impaired School Bus Drivers. January 23, 2020. Pew Charitable Trusts. https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2020/01/23/every-state-should-be-passing-a-law-to-deal-with-this-the-danger-of-impaired-school-bus-drivers

[150] European Transport Safety Council. "Spain: major changes to road safety rules will see alcohol interlocks in new passenger transport vehicles and mandatory helmets for e-scooter riders." ETSC. December 3, 2021. https://etsc.eu/spain-major-changes-to-road-safety-rules-will-see-alcohol-interlocks-in-new-passenger-transport-vehicles-and-mandatory-helmets-for-e-scooter-riders/

[151] https://etsc.eu/call-for-mandatory-alcohol-interlocks-in-vans-lorries-and-buses-across-the-eu/.

Traditional breathalyzer-style alcohol interlocks are currently used in the United States to monitor drinking and driving behaviors of those convicted of DWI to prevent reoffending and as part of probation requirements.[152] These devices require the driver to blow into a device attached to the vehicle in order to unlock the ignition system. Recent advances in technology, however, have included the development of so-called passive impairment detection systems that are seen as less invasive than the traditional breathalyzer devices. The Insurance Institute for Highway Safety reported an estimate of the benefits that could be expected if passive alcohol impairment detection were standard equipment in all new vehicles.[153] The US National Transportation Safety Board (NTSB) issued a report on September 20, 2022 recommending that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems or a combination of the two that would be capable of preventing or limiting vehicle operation if it detects driver impairment by alcohol.[154]

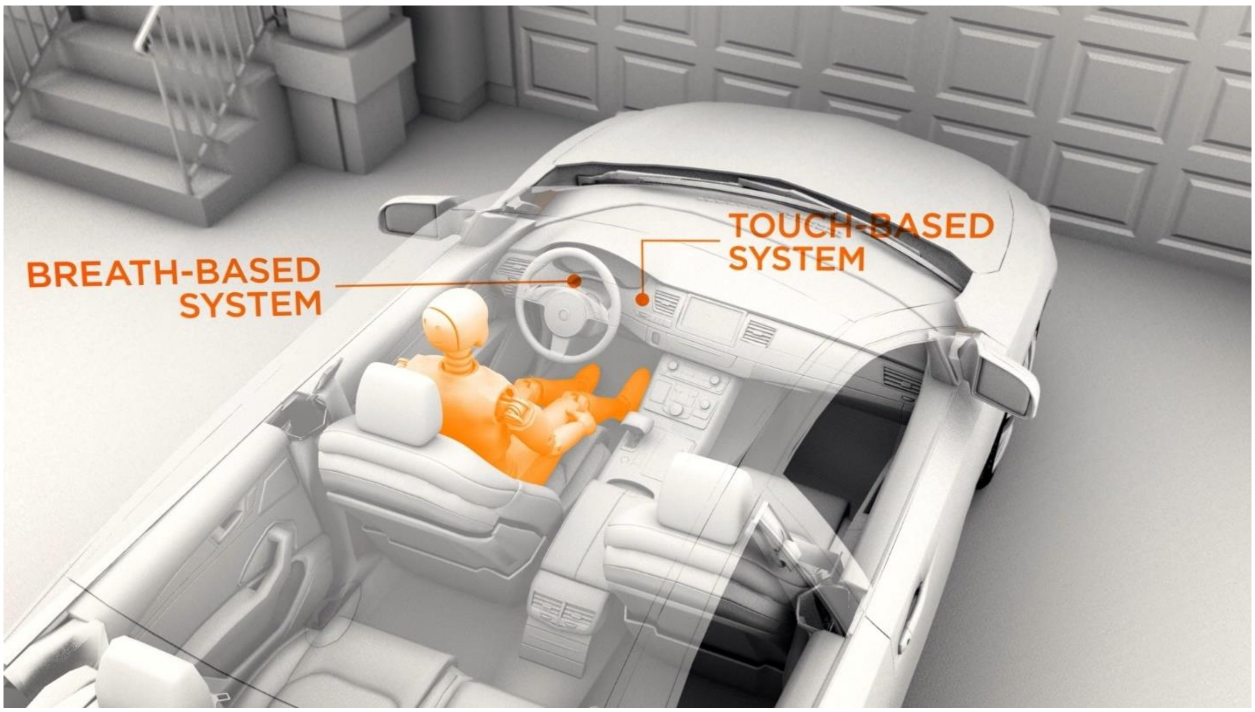

Figure 31. Passive Impaired Driving Detection Technologies (NPR)

In 2020, NHTSA released a Request for Information on technologies in these four categories:

- "Technologies that can monitor driver action, activity, behavior or responses, such as vehicle movements during lane keeping, erratic control, or sudden maneuvers;

[152] Centers for Disease Control and Prevention. "Alcohol Ignition Interlocks". February 22, 2022. https://www.cdc.gov/transportationsafety/calculator/factsheet/interlocks.html
[153] Insurance Institute for Highway Safety. "Alcohol-detection systems could prevent more than a fourth of U.S. road fatalities". July 23, 2020. https://www.iihs.org/news/detail/alcohol-detection-systems-could-prevent-more-than-a-fourth-of-u-s-road-fatalities
[154] National Transportation Safety Board. "NTSB Calls for Alcohol Detection Systems in All New Vehicles". September 20, 2022. https://www.ntsb.gov/news/press-releases/Pages/NR20220920.aspx

- Technologies that can directly monitor driver impairment (e.g., breath, touch-based detection through skin);
- Technologies that can monitor a driver's physical characteristics, such as eye tracking or other measures of impairment; and,
- Technologies or sensors that directly measure a driver's physiological indicators that are already linked to forms of impaired driving (e.g., BAC level)."[155]

A report submitted in response to the RFI by the nonprofit Mothers Against Drunk Driving identified 35 existing or proposed technologies related to Passive Breath or Touch Alcohol Detection. Passive alcohol detection systems can potentially use an array of sensor technologies, including biometric sensors and cameras. [156] One company has expressed plans to offer a touch-based alcohol detection interlock device designed specifically for school bus applications, although this company was not one of the ones listed in the Mothers Against Drunk Driving response to the 2020 NHTSA RFI described above.[157]

The 2021 Infrastructure Investment and Jobs Act required NHTSA to begin a rulemaking process to evaluate technologies and set standards for impaired driving prevention technologies on all new vehicles by 2024.[158]

Universal Design [Tier 3]

The seven principles of Universal Design are equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use.[159] These guiding principles can be considered when making decisions about the incorporation of safety technologies.

Applied to school bus drivers, the physical space of the vehicle cab and orientation of technologies around the driver's seat should be compatible with all body sizes and types. There may be a safety risk to the driver, students, or other road users if the driver is operating a vehicle with a poorly fitting seat belt, non-ergonomically placed pedals, and limited seat adjustment options that create larger blind

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[155] https://www.federalregister.gov/documents/2020/11/12/2020-24951/request-for-information-impaired-driving-technologies.

[156] Mothers Against Drunk Driving. "10 Things to Know About the Impaired Driving Prevention Technology Provision in the Infrastructure Law". August 6, 2021. https://madd.org/press-release/10-things-to-know-about-the-drunk-driving-prevention-technology-provision-in-the-infrastructure-bill/

[157] Tackett, Richard. "SOBRsafe Pioneers Alcohol Detection for Bus Drivers". *School Bus Ride*. National Association for Pupil Transportation. February 9, 2021. https://school-busride.com/sobrsafe-pioneers-alcohol-detection-for-bus-drivers/

[158] https://www.nhtsa.gov/bipartisan-infrastructure-law#:~:text=Advanced%20Drunk%20Driving%20Prevention%20Technology,and%20impaired%2Ddriving%20prevention%20technology.

[159] NC State University College of Design. "The Principles for Universal Design". April 1, 1997. https://projects.ncsu.edu/ncsu/design/cud/pubs_p/docs/poster.pdf

spots. New safety technology should be intuitive for driver, allowing for few errors in their use, and not add a physical burden to their job.

The addition of left-side doors (also referred to as dual-door design), as required in NYC on all buses transporting children with disabilities is a universal design choice that encourages flexibility in use: allowing students to unload closer to the curb and without interacting with traffic on one-way roads.[160] Reduced traffic exposure especially benefits students with poor eyesight, hearing, or situational awareness, and also benefits all students who do not have to cross in front of the bus or a travel lane by using the additional door.

Driver Monitoring System [Tier 3]

As artificial intelligence (AI) has advanced, researchers and transportation stakeholders alike have identified automatic detection of distracted driving as an important technology for reducing a common cause of crashes. While deep learning algorithms for detecting distracted and drowsy behaviors continue to mature, private companies have already brought automated driver detection and alert systems to market. These technologies use cameras/sensors and algorithms to detect a variety of distracted driving behaviors and create an audio, visual, or combined alert to warn the driver. In many cases, these technologies are paired with telematics so that data on distracted driving can be collected at the enterprise level.

Monitoring and Evaluation

Telematics [Tier 1]

Telematic devices (like the Geotab devices installed on NYC school buses) record driving behavior such as speed, acceleration, steering, idling, fuel consumption, and geographic location. Telematics devices can use sensors, engine data, and GPS to capture a holistic picture of how the operator is driving and the vehicle is performing, generating driver safety scorecards. This information can be monitored by a fleet manager to ensure that both drivers and vehicles are operating safely. If a manager notices that an operator is driving in an unsafe manner, they can intervene and remedy the issue via training or disciplineThese preliminary results suggest that telematics devices could enhance safety for drivers, passengers, and VRUs.

As one model, the NYC municipal fleet has implemented a series of initiatives related to telematic reporting. The initiatives includes monthly safety scorecard reporting (see Figure 32), real-time safety alerting to driver supervisors, and daily and weekly reporting on harsh driving and seat belt use by

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[160] NYC Administrative Code § 19-604 Dual opening doors. “All buses transporting handicapped children in the city, after September first, nineteen hundred seventy-five, shall be equipped with dual opening doors so that said doors shall open from no less than two sides of the motor vehicle.” https://nycadmincode.readthedocs.io/t19/c06/index.html#section-19-604

drivers. In addition, the City fleet has used telematics for safety campaigns related to speeding and seat belt use. NYC Fleet reports regularly on vehicles that operate at high to moderate safety risk and works to reduce those instances. In tandem with expanding telematics to the school bus contracted fleet, safety alerting and safety risk reporting would be best practices to expand to these fleet operations as well.

Based on current reporting, up to 90% of fleet operators for NYC operate within low or mild risk. A Vision Zero goal is for all operators to operate within low or mild risk.

Figure 32. Example driver safety scorecard based on telematics reporting on NYC municipal fleet (NYC DCAS)

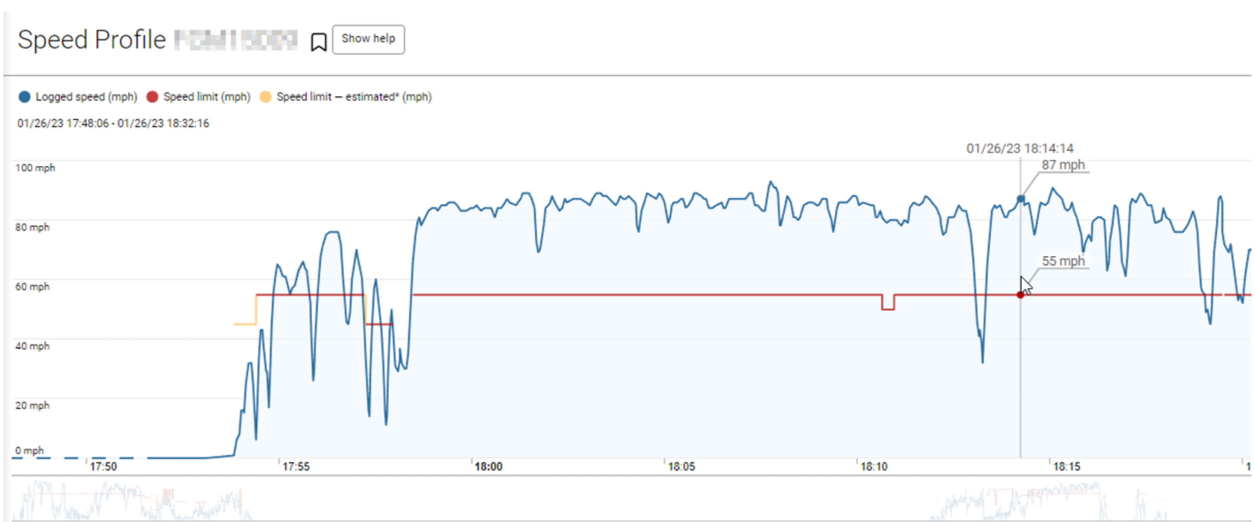

Figure 33. Example telematics alert for supervisor showing a driver traveling 87 mph in a 55-mph zone (NYC DCAS)

Event Data Recorder (EDRs), including Camera based EDRs [Tier 2]

An event data recorder is a device installed in a vehicle to record technical vehicle and occupant information for a brief period (seconds) before, during and after a crash. For instance, event data recorders may record pre-crash vehicle dynamics and system status, driver inputs, and restraint usage/deployment status. In addition, dashboard cameras (dashcam) have been used as event data recorders to record collisions events especially with pedestrians; dashcams record the events immediately after the collision.

Some event data recorders continuously record data and override it after a specified time duration, until an event (e.g., crash) stops the re-write. The most common automotive event data recorders are triggered and start recording by a vehicle sensor that detects a collision (impact acceleration); pre-determined data is recorded and retained. In some heavy truck applications, the event data recorder is part of the engine control system; the recording is triggered by an engine event like sudden stop or loss of oil pressure. For camera-based event data recorder systems including external cameras and dashcam, the system records and stores a video of the event; the video can be viewed in vehicle or downloaded into an external medium.

Camera-based event data recorders are available for school bus applications. In addition to potential safety training, and coaching applications, external camera recording has been documented to save significant liability costs to the City when processing collision claims. Non-camera-based event data recorders can be retrofitted into school buses.

The School Bus Safety Act of 2021 (bill not passed) would have required event data recorders for all school buses.[161]

NHTSA has established requirements for voluntarily installed event data recorders in light passenger vehicles with United States Regulation CFR Part 563 since August 2006. In December 2012, NHTSA published a notice of proposed rulemaking (NPRM) proposing to convert Part 563's “if-installed” requirements for event data recorders into a new Federal Motor Vehicle Safety Standard (FMVSS) installation of event data recorders in most light vehicles. In February 2019, NHTSA withdrew the December 2012 NPRM because the agency determined that a mandate is not necessary at this time to achieve the nearly universal installation of event data recorders on new light vehicles. Telematics devices like those implemented by DCAS can perform many to most of the data functions of an EDR.

Next Steps

This is a living document and DCAS, working with DOE, plans to update it at regular intervals in the future to reflect new developments related to technology availability and evidence of effectiveness. For example, section 24110(c) of the Bipartisan Infrastructure Law requires NHTSA to review and evaluate the effectiveness of various technologies for enhancing school bus safety by November of 2023, and the new information resulting from that review might warrant an update to this document. Many of the best practices in this report may be best achieved through specifications for new OEM purchased school

161 https://www.congress.gov/bill/117th-congress/senate-bill/2539

buses as opposed to more expensive and less or not commercially available retrofits. Moving forward, DCAS plans to work closely with the DOE and school bus companies to:

- Develop short-term retrofit proposals,
- Reevaluate and develop bus specifications and requirements for future school bus contracts, and
- Work with school bus suppliers to invest in electric vehicles with enhanced safety features.

This report applies countermeasure evidence from general light, medium, and heavy-duty fleet use cases since school bus use case evidence remains relatively limited for certain countermeasures. Future research to identify school bus specific effectiveness data for countermeasures will be needed to refine current findings and continuously evolve the SFTP tier assignments based on best available data.

Appendix: Estimated Purchase Costs of Technologies

The following summary of estimated costs reflects the subset of technologies shown in the Tiers Table for which information could be identified. The approximate costs shown below represent cost of purchase but not installation, where applicable.

Low (<$500)	**Medium ($500-1,500)**	**High ($1,500 +)**
Crossing Control Arm ($130-$160)[162]	Backup Cameras ($400-1,000)[163] [164]	360-Degree Birds Eye View Camera (alternative: Surround Camera with separate displays) ($2,300-2,500)[165]
Self-adjusting Volume and Broadband Back-up Alarms ($140-200)	Electronic Stability Control ($700-1,400)[166]	Extended Stop Arms ($2,800-3,000)[167]
Cell phone App/Physical Lock Box/Docking Station Interlock ($450-470)[168]	Forward Collision Warning ($1,000+)[169]	Stop Arm Enforcement Cameras ($2,200-2,400[170])
Double Stop Arms ($250+)	Event Data Recorder ($1,000+)[171]	Speed Governor or Intelligent Speed Assistance (ISA) ($1,500)[172]
Heated Mirrors and Power Mirrors ($120-550)[173]	LED Lighted Stop Arm ($450-1,000 per arm)[174]	Audible Turning Systems ($1,600-1,900)[175]
Warning Decals	Downlighting on Crossover Mirrors ($650+)[176]	Predictive Stop Arm ($2,000+)[177]

162 https://www.unityparts.com/crossing-arm-blades-rods/
163 https://www.tadibrothers.com/products/school-bus-backup-camera-system-9-monitor-with-wireless-ccd-mounted-rv-backup-camera
164 https://www.roscovision.com/our-products/view/stsk6630
165 Email correspondance with Safe Fleet on 11/10/2022
166 https://www.fldoe.org/core/fileparse.php/7585/urlt/2020-16PriceOrderingGuide.pdf
167 https://extendedstoparm.com/faq
168 https://gpslockbox.com/?s=+atmos+ptt&post_type=product
169 https://www.wirelessaircard.com/mobileye-630-collision-avoidance-system-with-eyewatch/
170 Email correspondance with Safe Fleet on 11/10/2022
171 https://www.roscovision.com/our-products/view/dv440
172 https://www.nyc.gov/office-of-the-mayor/news/589-22/mayor-adams-dcas-commissioner-pinnock-implement-new-technology-city-fleet-cars-reduce-speeds#/0
173 https://www.everblades.com/heated-windshield-wiper-kit/
174 Email correspondance with Safe Fleet on 11/10/2022
175 https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA_Report_No._0084.pdf
176 https://midwestbusparts.com/product/heated-eyemax-mirror-with-led-downlight-kit/
177 Email correspondance with Safe Fleet on 11/10/2022

Seatbelt Education and Use		Automatic Emergency Braking (may only be available for Type C buses) ($2,200)[178]
Heated Windshield or Wiper Blades ($150+)[179]		
Roof-mounted Strobe Lights ($100-300)[180]		

[178] https://www.fldoe.org/core/fileparse.php/7585/urlt/2020-16PriceOrderingGuide.pdf
[179] https://www.everblades.com/heated-windshield-wiper-kit/
[180] https://www.fldoe.org/core/fileparse.php/7585/urlt/2020-16PriceOrderingGuide.pdf

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