WHAT YOU CAN'T SEE

A Summary of The Commonwealth of Massachusetts Direct Vision Report

massDOT
Massachusetts Department of Transportation

Key Takeaways

1 Downsize the vehicle whenever possible.

On average, light-duty vehicles have the highest visibility in fleets we studied. Medium-duty vehicles have lower visibility, and heavy-duty vehicles have the lowest visibility. Picking the smallest vehicle possible affords better visibility.

2 Drivers in heavy-duty vehicles cannot easily see people on the street.

a. 50% of the heavy-duty vehicles in the study cannot see a child directly in front of the vehicle in the crosswalk.

b. Side visibility is even worse. For the heavy-duty vehicles studied, drivers in 90% of the trucks cannot see a child in the bike lane and 80% cannot see an adult in a bike lane.

3 Driver visibility is mostly getting worse.

Visibility in weight class 3 and 4 vehicles appears to be decreasing in newer generations of legacy models. In contrast, new medium-duty entrants, such as the REE P7C, appear to be designed for enhanced direct vision, and these vehicles demonstrate higher visibility, particularly forward of the driver. Of the heavy-duty vehicles measured, the cab-forward style tended to have higher forward visibility. Some of these vehicles had more passenger-side visibility, but this was not always the case.

What is Direct Vision?

Direct vision is the ability of a driver to see firsthand outside their vehicle without the aid of an indirect vision device, such as mirrors or camera displays. Direct vision enables eye contact between a driver and a vulnerable road user (VRU) near the vehicle; indirect vision generally does not.

Blind zones around a vehicle can be made visible through indirect vision, however drivers' perception and reaction time is significantly faster through direct vision. According to published research, when drivers have direct vision of a pedestrian, they can react in 0.7 seconds, or 50% faster, than when they can see the same pedestrian through indirect vision.[1]

When drivers have direct vision of a pedestrian, they can react 50% faster.

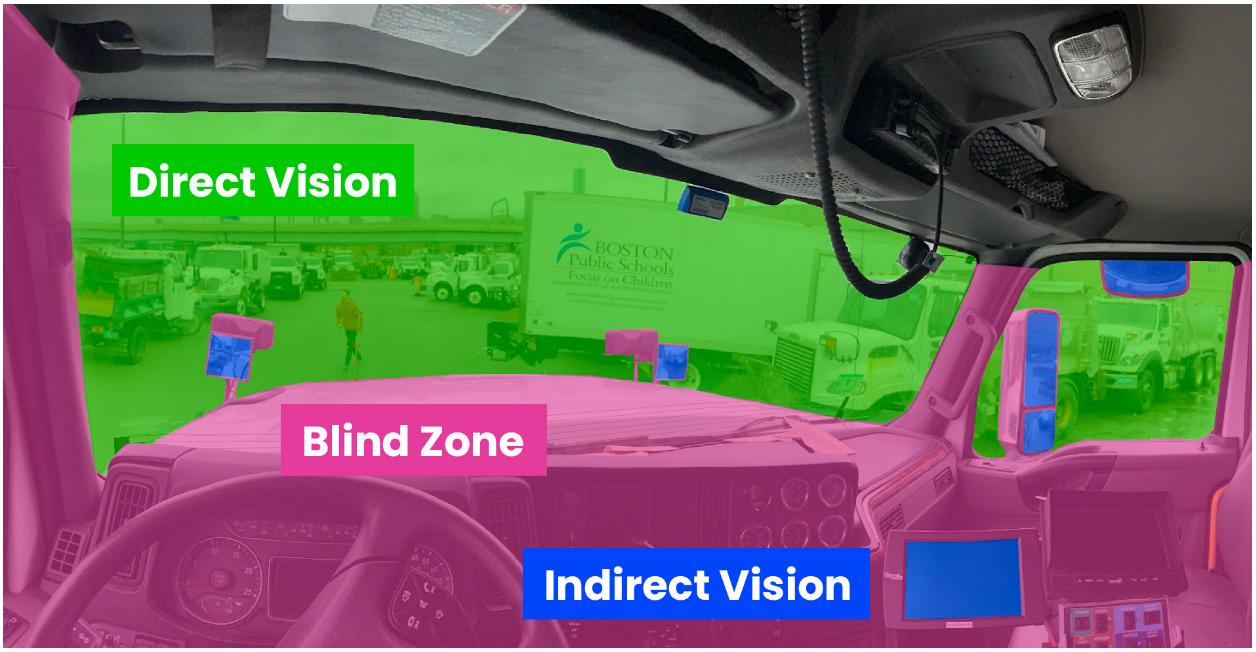

Figure 1: View from the driver's seat of an International HV 513. Direct vision of the environment is shaded green (unobstructed view through the windows), indirect vision areas are shaded blue (mirrors and camera display unit), and the blind zone areas are shaded in pink (hood, A and B pillars, and door).

In the United States approximately 25 percent of truck-involved VRU fatalities consist of vision-related low-speed maneuvers.[2] Additionally, National Highway Traffic Safety Administration (NHTSA) data for non-traffic crashes indicate an increase from 225 apparent VRU frontover fatalities in 2012 to 543 such fatalities in 2021, in which front blind zones may be expected to be a contributing factor.[3]

Regulatory requirements for truck driver vision are minimal.

A 2021 Volpe analysis of crashes between VRUs and privately operated waste and demolition debris trucks in New York City tested the hypothesis that a tall hood would be associated with frontover crashes, which occur when the driver accelerates forward from a stop and strikes a person in front of the vehicle. Of the 43 analyzed fatal crashes, at least ten were found to be start-from-stop, visibility-related crashes. All ten involved conventional cab vehicles, whereas none involved a cabover truck.[4]

According to a 2006 study of commercial truck visibility, U.S. "regulatory requirements for truck driver vision are minimal. The only standard that bears directly on driver fields of view is Federal Motor Vehicle Safety Standard (FMVSS) 111, which regulates mirror systems. Trucks over 10,000 lb are required to have planar mirrors with an area of at least 323 cm² on each side of the cab. Direct vision is unregulated."[5] There are no direct means of blind zone comparison between vehicle makes and models in the U.S. market.

The Massachusetts Direct Vision Study

This study focused primarily on class 3 and up vehicles, with a few exceptions made for light duty vehicles that comprised high volumes in the partner fleets. MassDOT has over 2,400 vehicles in our fleet and partnered with ten municipalities and two additional Commonwealth agencies who reported at least 1,150 vehicles. Of that combined 3,500+ vehicle list, 55 were selected for measurement based upon age (2015 and newer) and their prevalence in multiple fleets. Vehicles were measured using a standardized methodology that is explained in detail in the full report.

To represent the findings we relied on the distance to where a reference height person walking or biking first becomes visible in the forward and passenger directions to a driver with a standardized eye position. This is to replicate where a person would be in a standard MUTCD crosswalk for front visibility and in a MassDOT Separated Bike Lane Planning & Design Guide protected bike lane for the passenger side visibility.

What did we find?

The following figures summarize results for the vehicles assessed in this study. Figures 3, 5, and 7 compare the forward visibility of the measured vehicles, grouped by vehicle weight category, while Figures 4, 6, and 8 compare the passenger-side visibility. Vehicles are presented in each figure in decreasing order of visibility.

To facilitate more helpful comparison between fleet vehicles that may perform similar missions and could potentially be substituted, the figures are divided into light-duty, medium-duty, and heavy-duty weight classes. Consistent with Federal Highway Administration (FHWA) classification, light-duty is defined as Class 1-2 or gross vehicle weight rating (GVWR) of 10,000 pounds or less; medium-duty is defined as Class 3-6 or 10,001 to 26,000 pounds; and heavy-duty is defined as Class 7-8 or 26,001 pounds or more.

In addition to existing fleets in the Commonwealth, we also looked at several new truck models available on the market: the Dennis Eagle ProView, Bollinger B4, REE P7C, Battle Motors LNT, and International eMV607.

The forward visibility of the study vehicles is found to range from less than 2 feet to more than 15 feet for seeing elementary school age children walking, and from 0 feet to nearly 11 feet for seeing adults walking. In the passenger side direction, visibility of the study vehicles ranges from less than 3 feet to more than 18 feet for seeing elementary school age children biking, and from 0 feet to over 14 feet for seeing adults biking. These wide ranges reflect in part the different types and sizes of vehicles included in the study, from Class 1 to Class 8. However, even within heavy, medium, and light-duty weight classes, the analysis reveals significant variation of direct vision performance across vehicles, suggesting that fleets have choices for considering best-in-class direct vision vehicles.

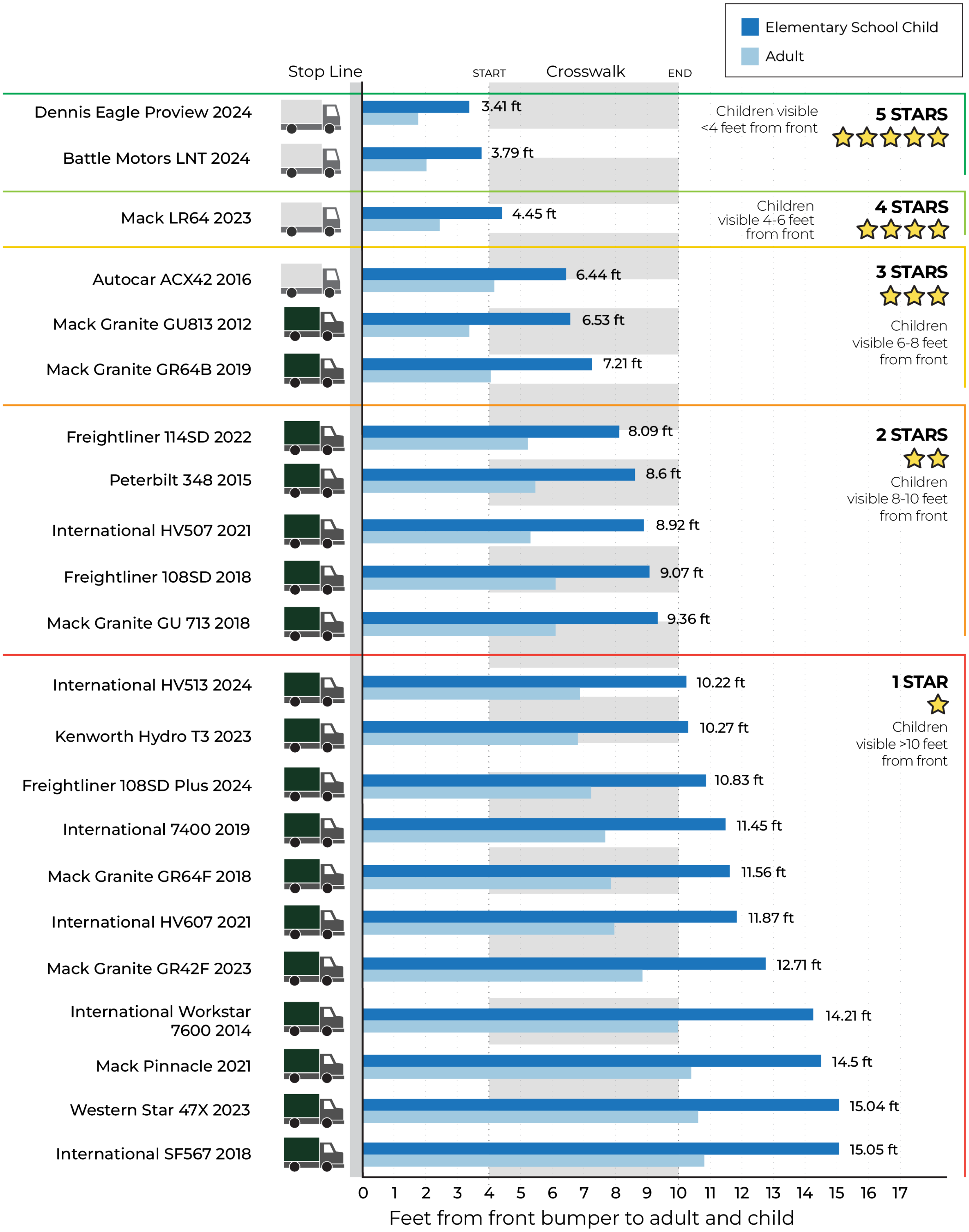

Figure 3: Nearest point at which an adult and child are visible to a driver in a standard crosswalk and stop bar overlaid with a five-star rating system for measured heavy-duty vehicles

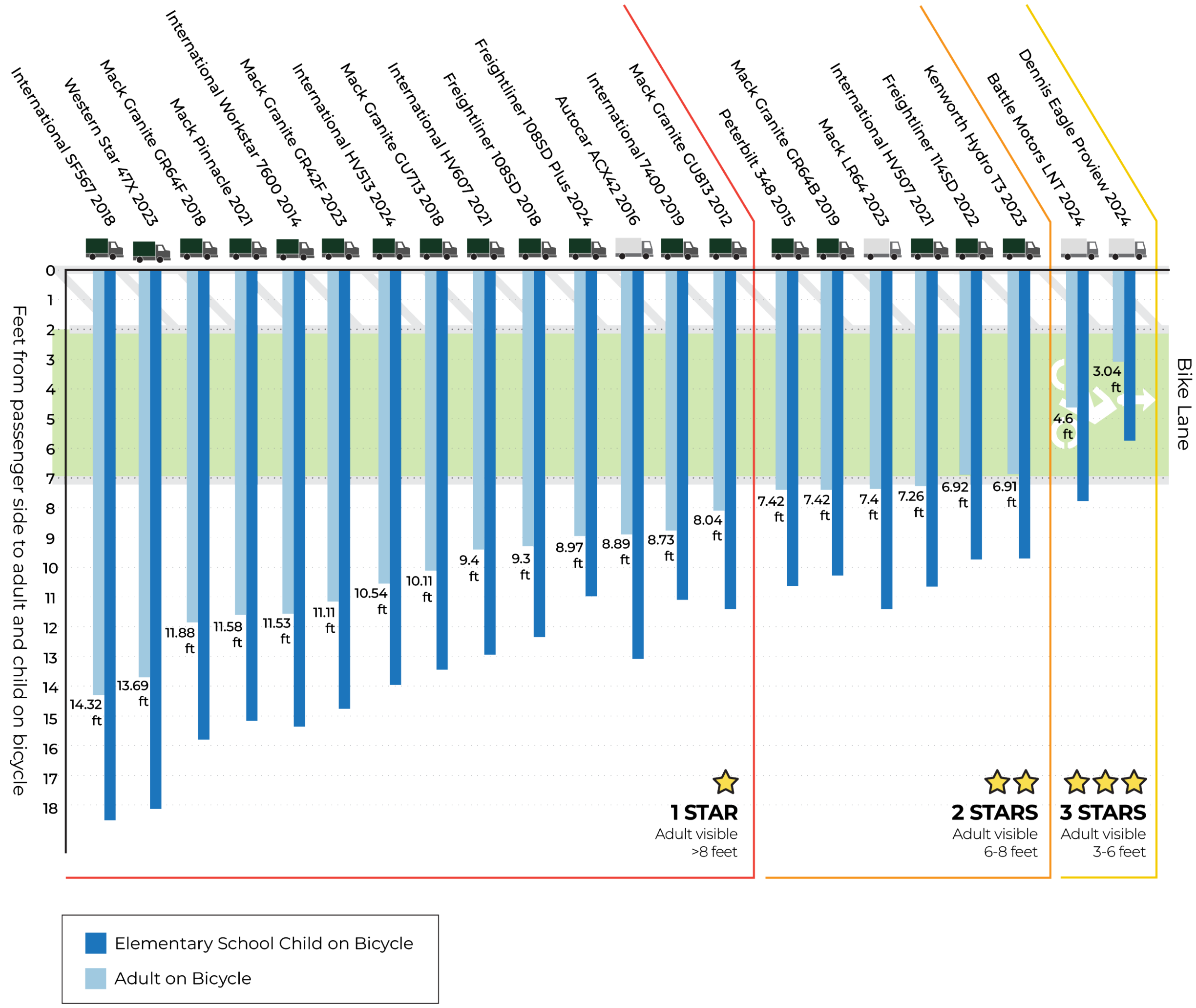

Figure 4: Nearest point at which an adult and child are visible to a driver in a buffered bike lane overlaid with a five-star rating system for measured heavy-duty vehicles

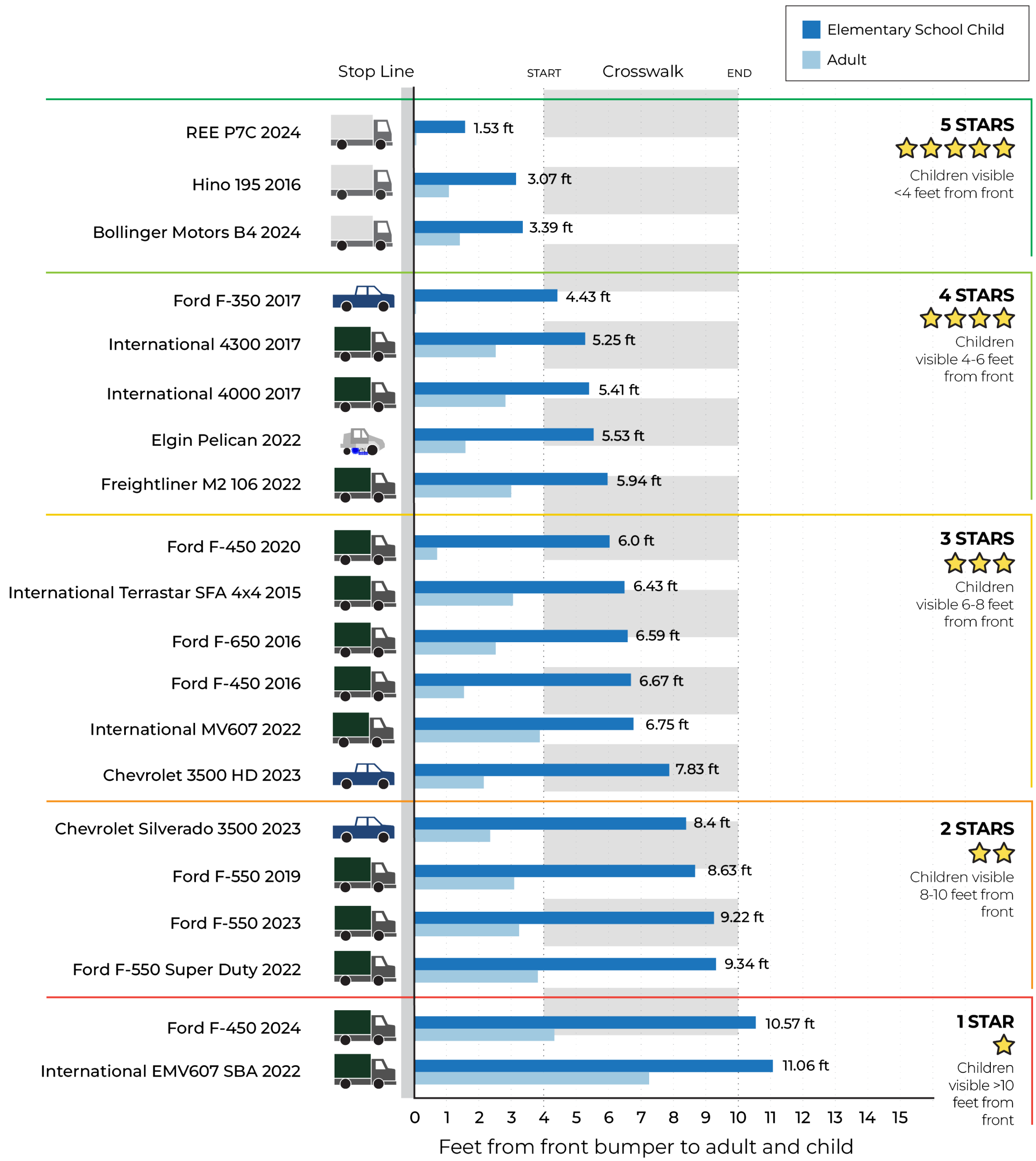

Figure 5: Nearest point at which an adult and child are visible to a driver in a standard crosswalk and stop bar overlaid with a five-star rating system for measured medium-duty vehicles

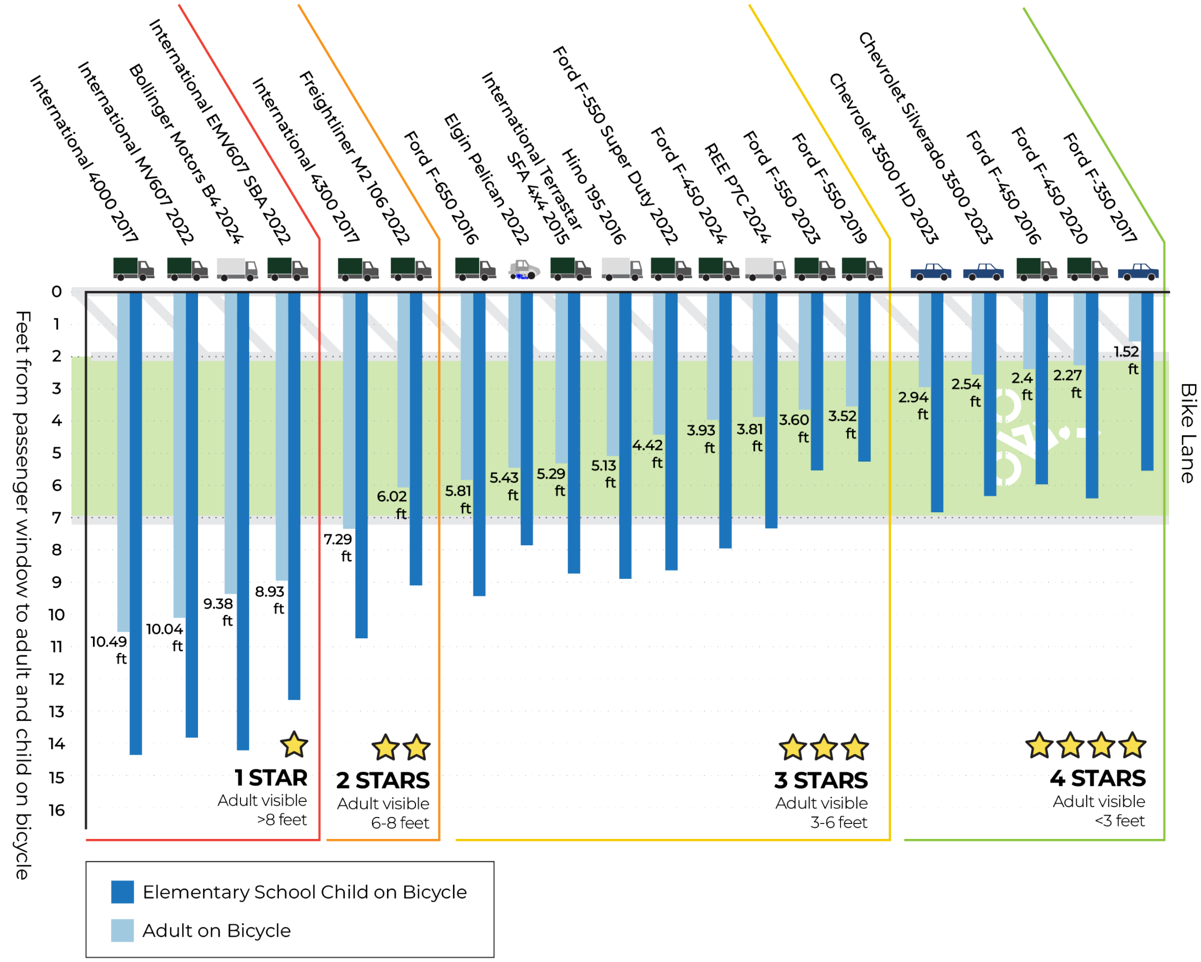

Figure 6: Nearest point at which an adult and child are visible to a driver in a buffered bike lane overlaid with a five-star rating system for measured medium-duty vehicles

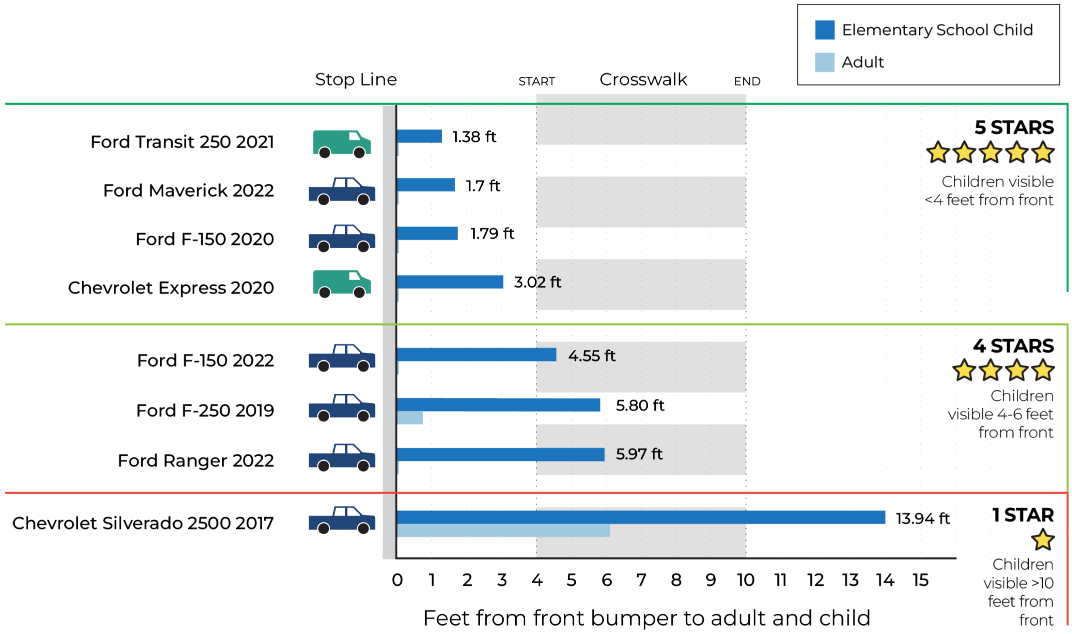

Figure 7: Nearest point at which an adult and child are visible to a driver in a standard crosswalk and stop bar overlaid with a five-star rating system for measured light-duty vehicles

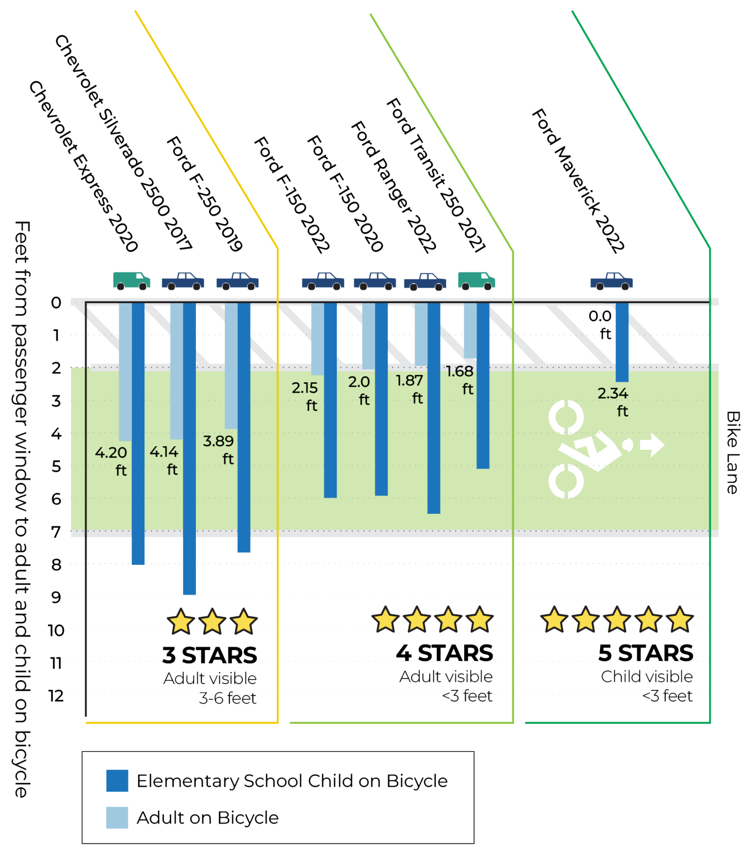

Figure 8: Nearest point at which an adult and child are visible to a driver in a buffered bike lane overlaid with a five-star rating system for measured light-duty vehicles

Direct Vision Ratings for Heavy-Duty Vehicles

Make/Model/Year	Front DV Rating	Side DV Rating
Dennis Eagle Proview 2024	★★★★★	★★★☆☆
Battle Motors LNT 2024	★★★★★	★★★☆☆
Mack LR64 2023	★★★★☆	★★☆☆☆
Mack Granite GR64B 2019	★★★☆☆	★★☆☆☆
Autocar ACX42 2016	★★★☆☆	★☆☆☆☆
Mack Granite GU813 2012	★★☆☆☆	★★☆☆☆
Freightliner 114SD 2022	★★★☆☆	★☆☆☆☆
Peterbilt 348 2015	★★☆☆☆	★★☆☆☆
International HV507	★★☆☆☆	★★☆☆☆
Freightliner 108SD 2018	★★☆☆☆	★☆☆☆☆
Mack Granite GU 713 2018	★★☆☆☆	★☆☆☆☆
Kenworth Hydro T3 2023	★☆☆☆☆	★★☆☆☆
International HV513 2024	★☆☆☆☆	★☆☆☆☆
Freightliner 108SD Plus 2024	★☆☆☆☆	★☆☆☆☆
International 7400 2019	★☆☆☆☆	★☆☆☆☆
Mack Granite GR64F 2018	★☆☆☆☆	★☆☆☆☆
International HV607 2021	★☆☆☆☆	★☆☆☆☆
Mack Granite GR42F 2023	★☆☆☆☆	★☆☆☆☆
International Workstar 7600 2014	★☆☆☆☆	★☆☆☆☆
Mack Pinnacle 2021	★☆☆☆☆	★☆☆☆☆
Western Star 47X 2023	★☆☆☆☆	★☆☆☆☆
International SF567 2018	★☆☆☆☆	★☆☆☆☆

Direct Vision Ratings for Medium-Duty Vehicles

Make/Model/Year	Front DV Rating	Side DV Rating
Ford F-350 2017	★★★★☆	★★★★☆
Hino 195 2016	★★★★★	★★★☆☆
REE P7C 2024	★★★★★	★★★☆☆
Ford F-450 2020	★★★☆☆	★★★★☆
Ford F-450 2016	★★★☆☆	★★★★☆
Chevrolet 3500 HD 2023	★★★☆☆	★★★★☆
Elgin Pelican 2022	★★★★☆	★★★☆☆
Chevrolet Silverado 3500 2023	★★☆☆☆	★★★★☆
International Terrastar SFA 4x4 2015	★★★☆☆	★★★☆☆
Ford F-650 2016	★★★☆☆	★★★☆☆
International 4300 2017	★★★★☆	★★☆☆☆
Freightliner M2 106 2022	★★★★☆	★★☆☆☆
Bollinger Motors B4 2024	★★★★★	★☆☆☆☆
Ford F-550 2019	★★☆☆☆	★★★☆☆
Ford F-550 2023	★★☆☆☆	★★★☆☆
Ford F-550 Super Duty 2022	★★☆☆☆	★★★☆☆
International 4000 2017	★★★★☆	★☆☆☆☆
Ford F-450 2024	★☆☆☆☆	★★★☆☆
International MV607 2022	★★★☆☆	★☆☆☆☆
International EMV607 SBA 2022	★☆☆☆☆	★☆☆☆☆

Direct Vision Ratings for Light-Duty Vehicles

Make/Model/Year	Front DV Rating	Side DV Rating
Ford Maverick 2022	★★★★★	★★★★★
Ford Transit 250 2021	★★★★★	★★★★☆
Ford F-150 2020	★★★★★	★★★★☆
Chevrolet Express 2020	★★★★★	★★★☆☆
Ford Ranger 2022	★★★★☆	★★★★☆
Ford F-150 2020	★★★★☆	★★★★☆
Ford F-250 2019	★★★★☆	★★★☆☆
Chevrolet Silverado 2500 2017	★☆☆☆☆	★★★☆☆

So What’s Next?

Purchase More High Vision Vehicles

High vision vehicles are only helpful to advancing a Safe System to the extent that they are deployed on the road. The Commonwealth of Massachusetts is positioned to potentially leverage its buying power to ensure that agencies, municipalities, and contractors prioritize procuring high vision vehicles.

There are several options for increasing the adoption of high vision vehicles across the Commonwealth. For example, language could be included in the VEH111 state contract for Heavy Duty Vehicles, Road Maintenance, and Construction Equipment. In the current iteration of VEH111, the contract allows for departments to purchase Environmentally Preferable Products. A similar section on direct vision (or more broadly, safer design) could be included, prompting relevant parties to purchase high vision vehicles whenever possible. Relatedly, there is also a unique opportunity to combine the priorities of electrification and direct vision. Trucks without an engine block (i.e., electric batteries are integrated into the bottom of a vehicle) can have improved direct vision compared to conventional cab diesel trucks, meaning that road safety and electrification are linked.

> **There is a unique opportunity to combine the priorities of electrification and direct vision.**

Install Countermeasures on Low Vision Vehicles

Although there are safety benefits to procuring and maintaining high vision vehicles, practical and fiscal limitations can sometimes mean that it is not realistic to have only high vision vehicles in the fleet. Fortunately, there are certain strategies and additions that can be employed to mitigate the risk of low vision vehicles.

As a potential model, Transport for London established seven requirements for countermeasures in their Progressive Safe System model. This includes camera monitoring systems fitted at the passenger side of a vehicle, cross-over mirrors fitted to the front of the vehicle, side guards, audible warnings when turning right, and external warning signs that signal to other road users the hazards around the vehicle.

Figure 9: Example of crossover mirrors on a truck in New York City.

Future Research on Roadway Design and Visibility

Given that the vehicles on the roads have the direct vision levels they currently have, complementary Safe System Approach strategies through safe road design that could mitigate the presence of large vehicle blind zones at key locations could be explored. Separating vulnerable road users (VRUs) far enough apart to be positioned out of any vehicle's blind zones can be a design solution, but it is not always possible to widen rights-of-way, and there are tradeoffs of doing so. However, there is a significant toolkit of potential geometric, design, and operational strategies that could potentially mitigate blind zone risk of low-vision vehicles.

Potential strategies to position road users in space and time to help keep VRUs safely out of blind zones include:

Geometric Design

- Protected intersections
- Offsets
- Raised crosswalks, bike lanes, and tables

Pavement Markings

- Advance stop lines
- Two-stage left boxes
- Daylighting

Traffic Control Devices

- Near-side traffic signals
- No Turn On Red (NTOR) policy
- Leading Pedestrian Intervals or exclusive pedestrian phase

Modal Priority Networks

- Safe Routes to School
- Bike networks

Acknowledgements

The work that is at the heart of this report is focused on safety. At MassDOT, transportation is not about roads and bridges, or trains and buses – it is about people. We partner with cities and towns, public agencies, and private sector businesses. This report upholds both of those principles. We look forward to continuing to partner with all sectors and actors to ensuring the safety of people traveling in Massachusetts. Thank you to the US DOT Volpe Center for being our research partner and much gratitude for our alumni from The Lab @ MassDOT who worked to bring this research to life. Lastly, we are grateful for the collaboration with ten municipal partners who opened up their fleet lists, garages, and cab doors for this study.

Full Report Available Here: www.mass.gov/doc/commonwealth-of-massachusetts-direct-vision-study/download

Additional Resources

Commonwealth of Massachusetts Direct Vision Study

This is the full study done in collaboration with US DOT Volpe Center summarized in this document.

https://tinyurl.com/MA-dv-study

City of Boston Direct Vision Study

This was the first study in Massachusetts with US DOT Volpe Center that investigates direct vision. It took its measurements from the City of Boston municipal fleet.

https://rosap.ntl.bts.gov/view/dot/68730

Optimizing Large Vehicles for Urban Environments

US DOT Volpe Center Studies

Learn more about the differences in safety (or lack thereof) between cab-overs and conventional trucks in Appendix B of the 'Downsizing' report.

https://nacto.org/optimizing-large-vehicles/

Exploring the Road Safety Benefits of Direct vs Indirect Vision in Heavy Goods Vehicle (HGV) Cabs

Transport for London Study

A study investigating benefits of direct vision over indirect vision.

https://tinyurl.com/tfl-direct-vs-indirect

The Lab @ MassDOT Direct Vision

Landing page for the Direct Vision project at The Lab @ MassDOT. Find more information and resources regarding our work on direct vision in large vehicles here.

https://www.mass.gov/info-details/direct-vision-study

End Notes

1: “Exploring the Road Safety Benefits of Direct vs Indirect Vision in HGV Cabs: Direct Vision vs Indirect Vision: A study exploring the potential improvements to road safety through expanding the HGV cab field of vision” https://content.tfl.gov.uk/road-safety-benefits-of-direct-vs-indirect-vision-in-hgv-cabs-summary.pdf

2: “Prioritizing improvements to truck driver vision” https://rosap.ntl.bts.gov/view/dot/20427/Share

3: Based on “forward moving vehicles” in “non-traffic crashes, ” i.e., crashes in parking lots, driveways, and other locations not on public roadways. https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812311, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813539

4: “Safe Fleets Transition Plan: Private Vehicle Crashes and Safety Technology” https://www.nyc.gov/assets/dcas/downloads/pdf/fleet/Safe-Fleet-Transition-Plan-Private-Vehicle-Crashes-and-Safety-Technology-December-2021.pdf

5: “Prioritizing improvements to truck driver vision.” https://rosap.ntl.bts.gov/view/dot/20427/Share