HLDI
Highway Loss Data Institute

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# Predicted availability of safety features on registered vehicles — a 2025 update

## Summary

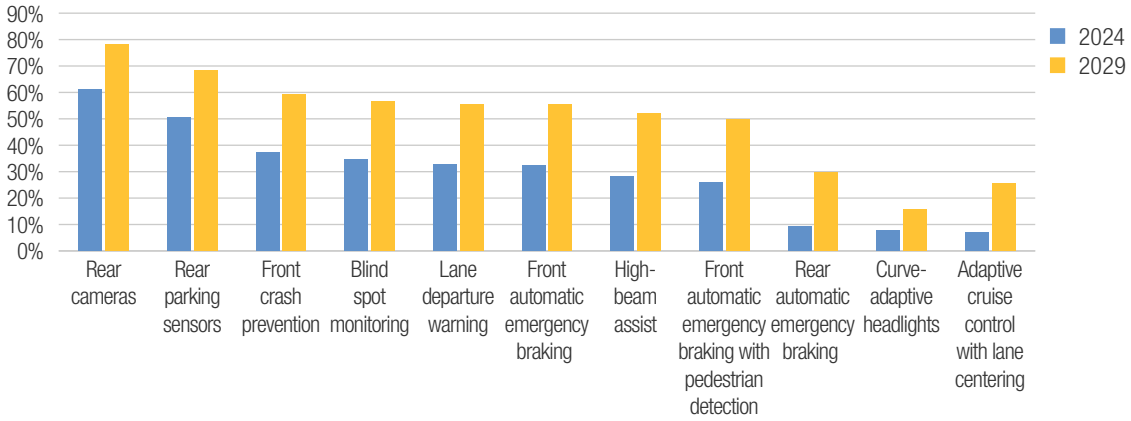
Highway Loss Data Institute (HLDI) studies have indicated that some collision avoidance systems, particularly front crash prevention systems, are reducing insurance claims. While some of the reductions are sizable, these systems were first introduced on only a small number of luxury vehicles. Consequently, the impact of these systems on all crashes has been limited.

Prior HLDI studies have shown that it typically takes decades after a feature is introduced for that feature to be installed on most vehicles on the road. This study updates the forecasted availability of collision avoidance features.

The figure below shows the percentage of registered vehicles predicted to be equipped with safety features in calendar years 2024 and 2029. The presence of most systems is predicted to increase by more than 15 percentage points by 2029. However, curve-adaptive headlights are predicted to increase by only 8 percentage points.

Eight features are predicted to be on half or more of the registered vehicle population by 2029. Rear cameras, which have been mandated on new vehicles produced since May 1, 2018, are predicted to be on 78% of the registered vehicle fleet by 2029. Front automatic emergency braking (AEB) is predicted to increase from 32% of the registered vehicle population in 2024 to 55% in 2029. This projected increase is in part due to the auto industry's voluntary commitment, brokered by the Insurance Institute for Highway Safety and the National Highway Traffic Safety Administration, to equip new vehicles with front AEB. Consequently, front crash prevention that warns and/or automatically brakes is predicted to achieve a 59% fleet penetration in 2029.

**Predicted registered vehicles equipped with collision avoidance systems, 2024 and 2029 calendar years**



## Introduction

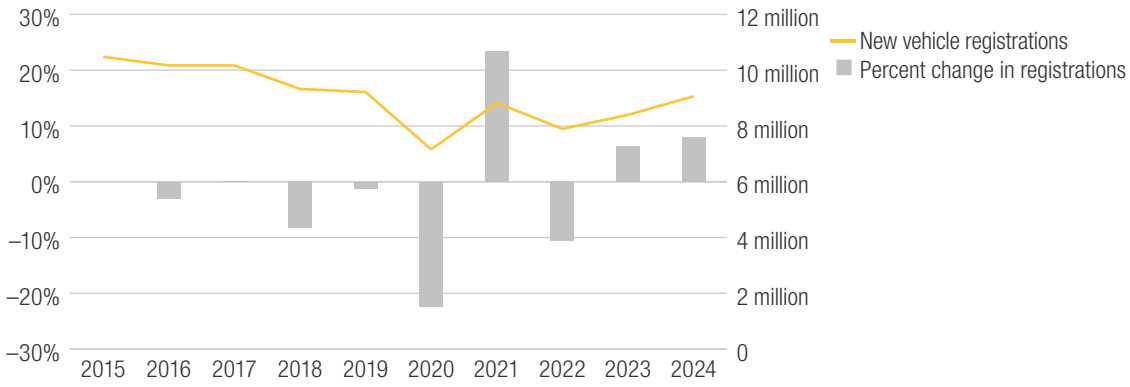
Given the potential and proven benefits of collision avoidance systems, it is almost certain that these systems will continue to reduce the number of crashes and insurance claims. While estimating the efficacy of available systems is an important part of understanding their long-term impact, it is also important to understand the prevalence of these systems in the current fleet and to estimate their growth in the fleet over time. The purpose of this study is to quantify the prevalence of vehicle safety features in the registered vehicle fleet, trace that prevalence from their introduction through the most current registration data, and then predict the prevalence of these features in the future.

The Highway Loss Data Institute (HLDI) has been forecasting safety feature availability since 2012; see the **Appendix** for a list of prior publications. These studies have shown that it typically takes decades after introduction for most vehicles on the road to have a given feature (HLDI, 2024).

## Methods

This study combines vehicle safety feature information from HLDI with vehicle registration data from S&P Global. The COVID-19 pandemic affected the economy, including new and used vehicle sales. Compared with 2019, the number of new vehicle registrations in 2020 fell by 22%, a notable difference from 2015–19 numbers. New registrations recovered after 2020, as shown in **Figure 1**. Therefore, this study estimates the number of future new vehicle registrations based on the trend of the past 30 years, excluding the exceptional 2020 data.

**Figure 1: Change in new vehicle registrations, 2015–24**



For each of the features studied, there are three figures:

- The **first figure** for each feature illustrates the percentage of new vehicle series with that feature by model year. In this figure, each new vehicle series (model year, make, series) is a single observation. The observations have not been weighted by insurance exposure or vehicle registration information.

- The **second figure** for each feature illustrates the percentage of registered vehicles with that feature by calendar year. In this figure, each observation (model year, make, series) is weighted by the number of registered vehicles. This second figure also includes an "equipped" line that estimates the percentage of the vehicle fleet with the feature installed.

- The **third figure** for each feature illustrates its predicted availability, with the actual availability displayed for comparison. One set of lines represents predicted availability with the optional take rate considered, while the other set represents the estimate without including that rate. This figure provides insight into the time required for the presence of a feature to build in the registered vehicle fleet.

The following features are included in this study: electronic stability control (ESC), front crash prevention systems that warn and those that automatically brake, front automatic emergency braking (AEB) with pedestrian detection, adaptive cruise control with lane centering, lane departure warning, blind spot monitoring, curve-adaptive headlights, high-beam assist, rear parking sensors, rear cameras, and rear AEB.

HLDI compiled the vehicle feature information by model year, make, and series and mapped these three variables to the registration data from S&P Global. For each combination of model year, make, and series, one of three possible feature values is provided: "standard," "optional," or "not available."

Registration counts belonging to either of the first two groups (standard and optional) are hereafter referred to as "available." For example, in calendar year 2024, 25.6% of registered vehicles had front AEB as standard equipment and another 15.2% had it as an option, so it is said that front AEB was available in 40.8% of the 2024 registered vehicles.

The most recent S&P Global data available to HLDI cover calendar years 1976–2024. For each calendar year, multiple recent model years are used, ranging from 10 model years for calendar year 1976 to 40 model years for calendar year 2024. The number of model years included in each calendar year has increased over time. For calendar years 2009 and later, more than 50 of the most recent model years are available, but the analysis was limited to 40 model years; this covered at least 95% of the overall fleet in calendar years during which safety features started to gain popularity. Some model years are present in earlier calendar years, age out of the data set, and then reenter when the data set is expanded. To increase the amount of usable data, missing values were extrapolated based on existing values. S&P Global has restated some of its data. In this report, original data were used from 1976 to 2008, while restated data were used for calendar years 2009–24.

**Approach used to estimate optionally equipped rates:** This study estimates the optionally equipped rates for each of the features using HLDI feature data and Vehicle Identification Number (VIN) information from a limited number of manufacturers. Using HLDI's vehicle information, vehicles registered in 2024 with optional features were identified. The equipped rates for individual features for a calendar year were estimated based on VIN data that HLDI previously received from 13 manufacturers. The equipped rate for each feature was estimated using several regression models that included some or all of the following variables: model year, size, class, and vehicle base price. Where possible, HLDI used the equipped rates from the participating manufacturers to estimate those for other vehicles of the same model year, size, class, and price. Where that level of detail was not available, the equipped rates were estimated with regression models according to the variables with known values. In the worst-case scenario, the estimated equipped rates were based exclusively on model year and vehicle price.

Once these estimated rates were assigned to the unknown values in the historical data, the optional and standard feature data from past years were used to estimate future equipped rates for each feature.

**Approach used to estimate the number of new vehicles:** New vehicles are defined as vehicles aged 0 and –1 years. For example, a 2012 model year vehicle in calendar year 2012 has a vehicle age of 0 years, while a 2013 vehicle in the same calendar year has an age of –1. Prior HLDI studies estimated the number of new vehicles in the first unknown year in the future by averaging the registrations for new vehicles for the last 5 known calendar years. However, because the COVID-19 pandemic affected new vehicle sales in 2020, the present study averaged the number of registrations for new vehicles in calendar years 2019 and 2021–24 to estimate the number of new vehicles in 2025. To predict new vehicle registrations for calendar years 2025–50, a 30-year past trend in new vehicle registrations was studied. During this period, new vehicle registrations increased by an average 0.7% per calendar year. New vehicle counts for 2025 and beyond were therefore calculated by adding 0.7% each year on a cumulative basis.

**Approach used to estimate attrition rates:** For a given model year, registration counts typically peak at age 1 and then decline over time. For example, in calendar year 2013 there were fewer registrations of model year 2008 vehicles than there were in 2012. The rate at which registrations declined as a vehicle aged 1 year (i.e., as the vehicle aged from 1 to 2 years, 2 to 3 years, 3 to 4 years, etc.) was calculated for every model year/age change combination over the past 30 years of data. The average attrition rate for a given age change was then calculated and applied to future years (2025–50) and vehicles undergoing the same age change.

Additionally, to account for changes in attrition, a 30-year past trend was studied. During this period, attrition rates declined by an average of 0.2% per model year. Based on this, the attrition rate for each subsequent model year slowed by an additional 0.2%. In other words, the attrition rate for the 2027 model year was projected to be 0.2% less than the attrition rate for the 2026 model year, which was 0.2% less than the 2025 model year, and so on. The attrition assumptions will be monitored, refined, and modified as needed for future analysis.

The estimation procedure was conducted separately for each feature in the study. The procedure involved running a logistic regression model (assuming a binomial distribution with a probit link) on the past year's data for which feature prevalence is known and then applying the model estimates to predict the feature prevalence for future years.

The dependent variable in the model was the ratio of registrations with the feature available to the total registration count. The only two independent variables were calendar year and model year.

## Results

**Figure 2: Percentage of new vehicle series with ESC by model year**

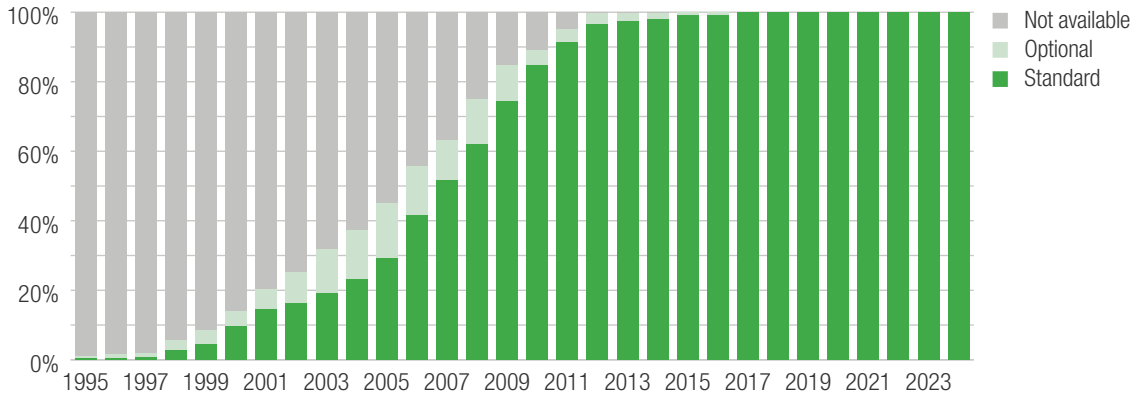



**Figure 2** shows the percentage of new vehicle series with either standard or optional ESC by model year. ESC was introduced in model year 1995 and **has been required on all light-duty vehicles beginning September 1, 2011.** From model year 2013 to 2016, the only vehicles that did not have standard ESC were very large pickup trucks weighing more than 10,000 pounds, which were not yet subject to the regulation. By the 2017 model year, all vehicle series had standard ESC.

**Figure 3: Percentage of registered vehicles with ESC by calendar year**

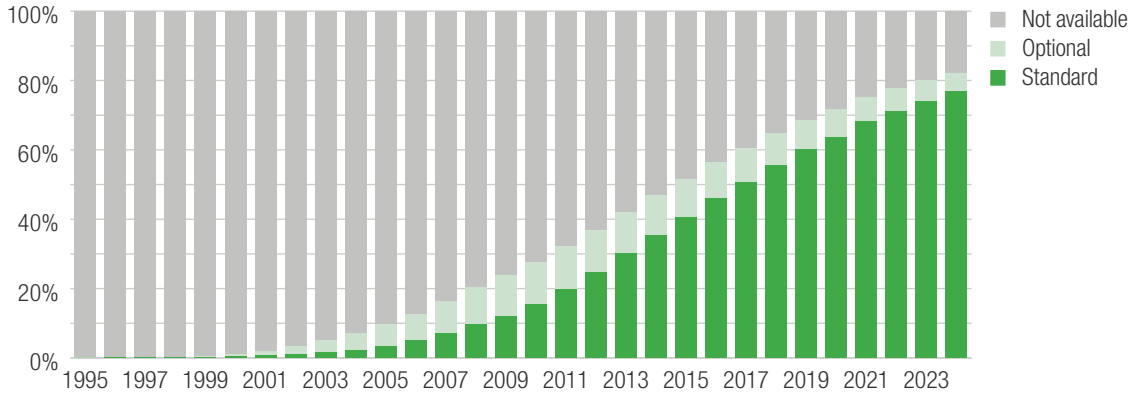



**Figure 3** shows the percentage of registered vehicles with either standard or optional ESC by calendar year. By 2024, ESC was standard or optional on 82% of registered vehicles. Data were not available to estimate the optionally equipped rate for ESC.

**Figure 4: Predicted percentage of registered vehicles with ESC by calendar year**

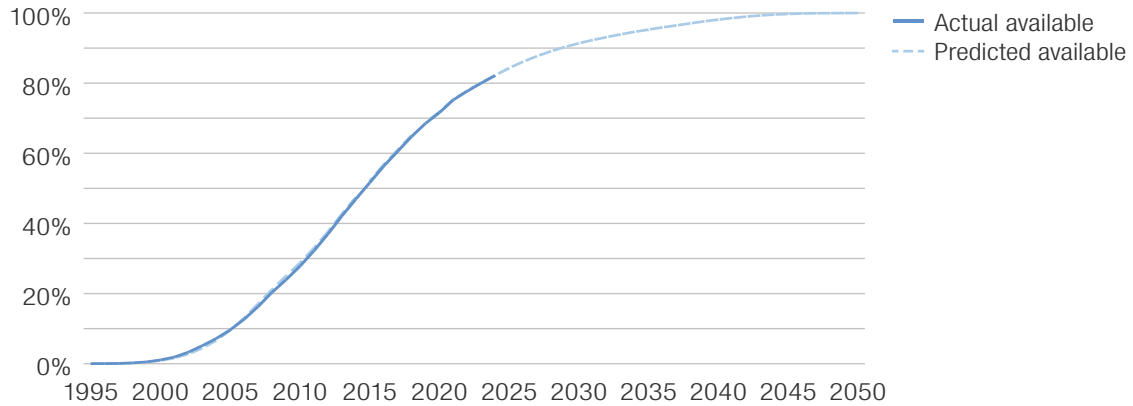



**Figure 4** shows the predicted percentage of registered vehicles with either standard or optional (i.e., available) ESC by calendar year. It is predicted that ESC will be standard or optional on 95% of registered vehicles in 2034.

**Figure 5: Percentage of new vehicle series with front crash prevention by model year**

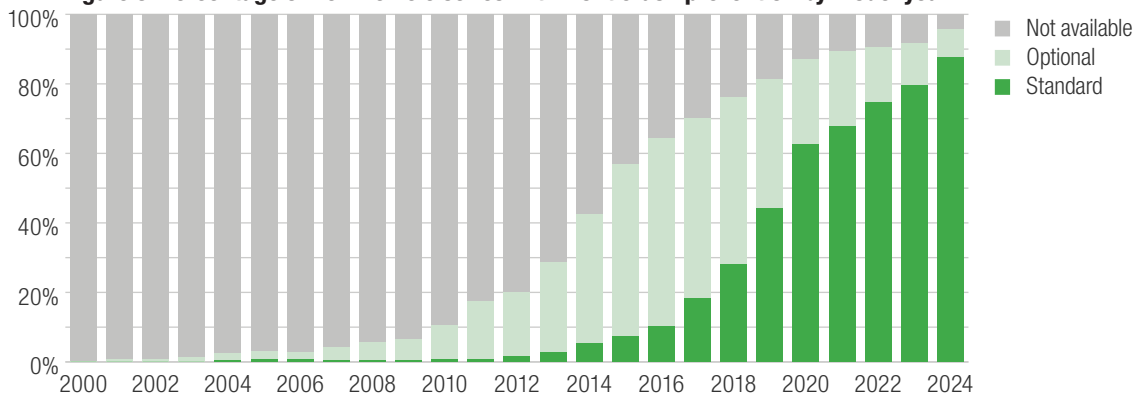



**Figure 5** shows the percentage of new vehicle series with either standard or optional front crash prevention by model year. It includes vehicles that warn and/or automatically brake. Front crash prevention was introduced in model year 2000, and by the 2010 model year, it had become standard on 1% and optional on 10% of vehicle series. For the 2024 model year, front crash prevention was standard on 88% and optional on 8% of vehicle series.

**Figure 6: Percentage of registered vehicles with front crash prevention by calendar year**

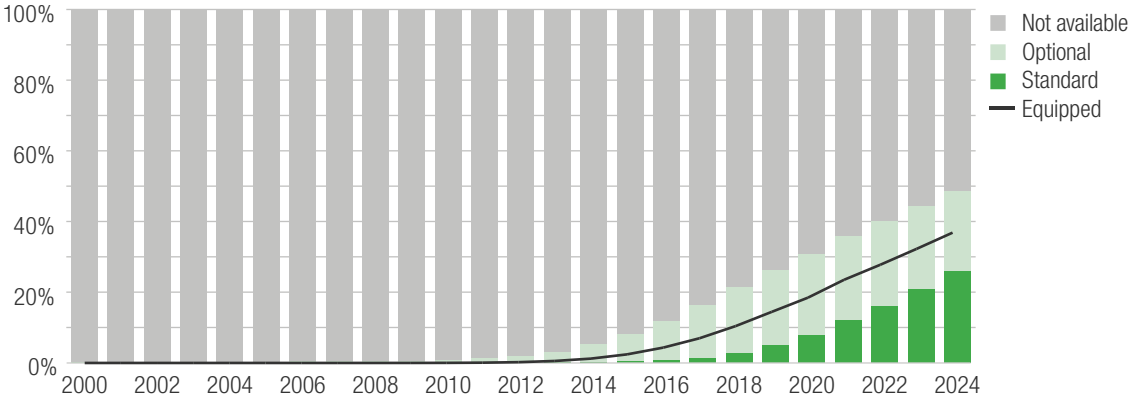



**Figure 6** shows the percentage of registered vehicles with either standard or optional front crash prevention by calendar year. In 2010, front crash prevention was available on less than 1% of registered vehicles. By 2024, front crash prevention was standard or optional on 49% of registered vehicles, with about 37% of registered vehicles estimated to be equipped with the feature.

**Figure 7: Predicted percentage of registered vehicles with front crash prevention by calendar year**

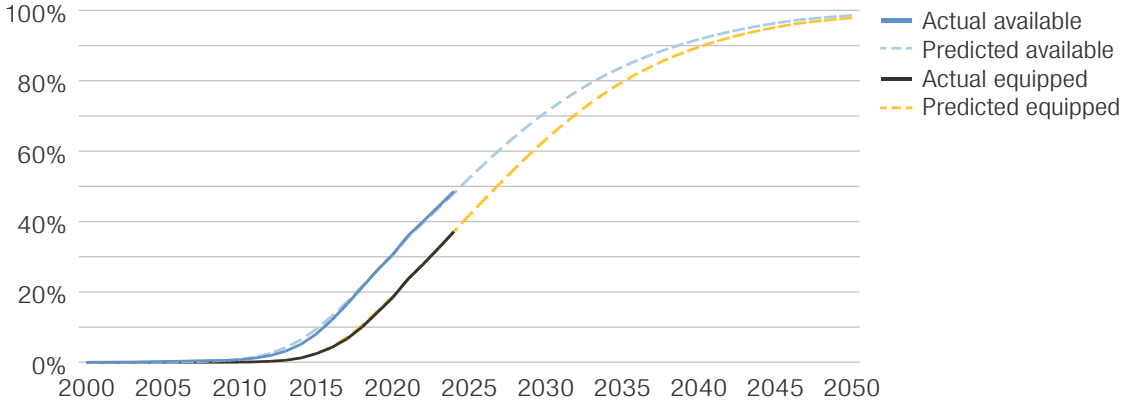



**Figure 7** shows the predicted percentage of registered vehicles with front crash prevention by calendar year. It takes into account a 2022 voluntary commitment by many manufacturers to make front AEB standard on most of their vehicles by 2022. One set of predictions is for vehicles with front crash prevention available (standard or optional), and the other set of predictions is for vehicles equipped (either standard or optionally equipped) with the system. It is predicted that 95% of registered vehicles will be equipped with front crash prevention by 2045.

**Figure 8: Percentage of new vehicle series with front automatic emergency braking by model year**

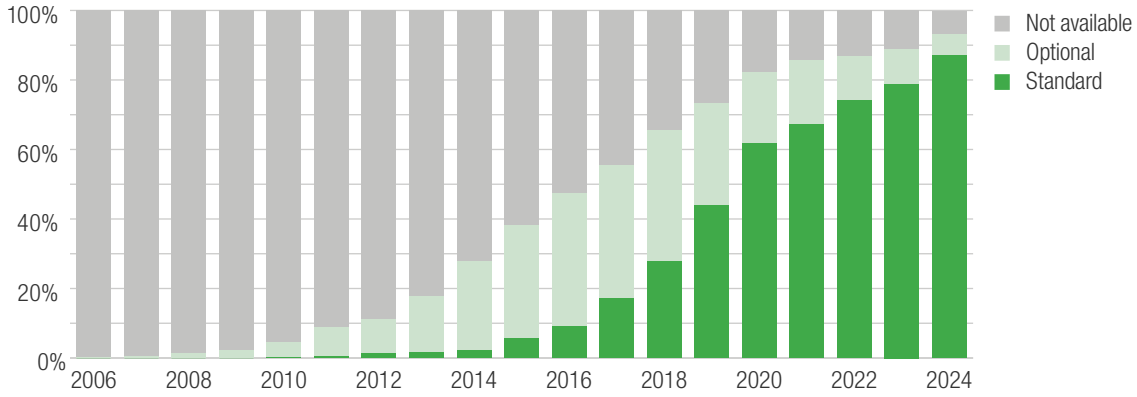



**Figure 8** shows the percentage of new vehicle series with either standard or optional front AEB by model year. This system may also issue warnings. Front AEB was introduced in model year 2006, and by the 2015 model year, it had become standard on 6% and optional on 33% of vehicle series. For the 2024 model year, front AEB was standard on 87% and optional on 6% of vehicle series.

**Figure 9: Percentage of registered vehicles with front automatic emergency braking by calendar year**

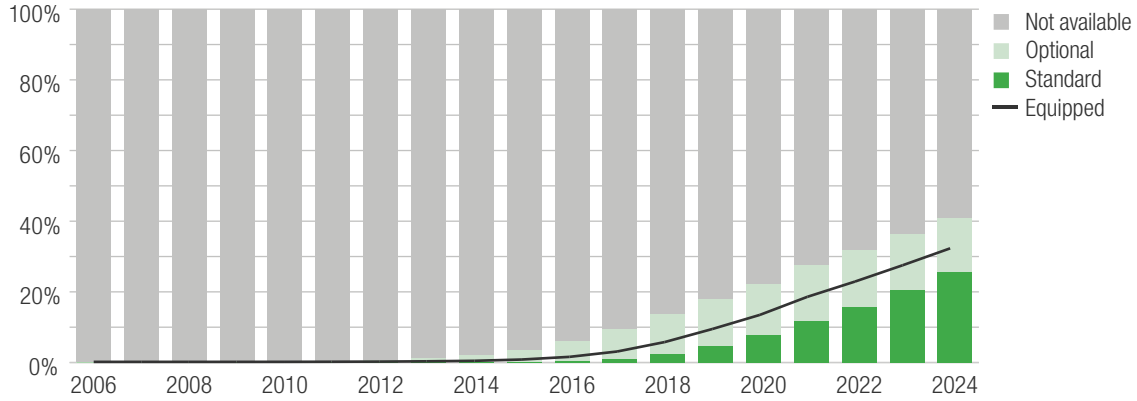



**Figure 9** shows the percentage of registered vehicles with either standard or optional front AEB by calendar year. In 2015, front AEB was available on about 4% of registered vehicles. By 2024, front AEB was standard or optional on 41% of registered vehicles and estimated to be present on 32%.

**Figure 10: Predicted percentage of registered vehicles with front automatic emergency braking by calendar year**

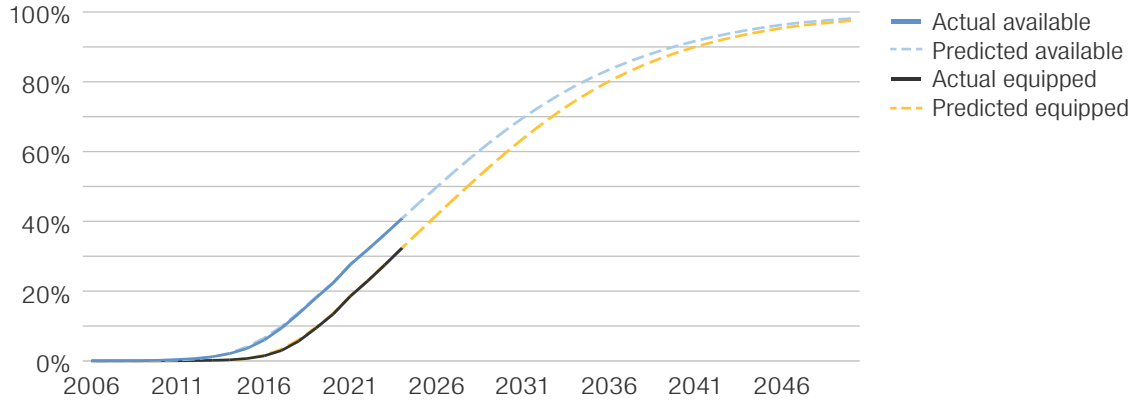



**Figure 10** takes into account the 2022 voluntary commitment. It is predicted that 95% of registered vehicles will be equipped with that feature by 2045.

**Figure 11: Percentage of new vehicle series with front automatic emergency braking with pedestrian detection by model year**

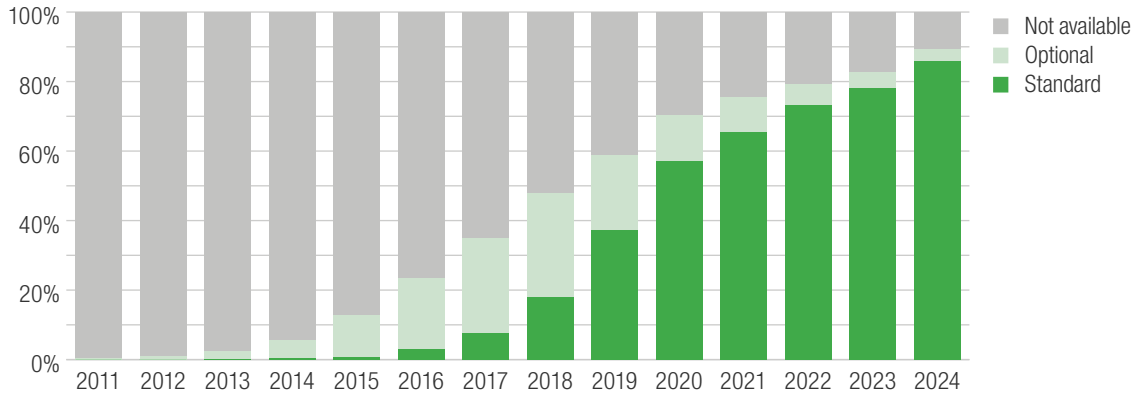



**Figure 11** shows the percentage of new vehicle series with either standard or optional front AEB with pedestrian detection by model year. This system was introduced in model year 2011, and by the 2016 model year, it had become standard on 3% and optional on 20% of vehicle series. For the 2024 model year, front AEB with pedestrian detection was standard on 86% and optional on 3% of vehicle series.

**Figure 12: Percentage of registered vehicles with front automatic emergency braking with pedestrian detection by calendar year**

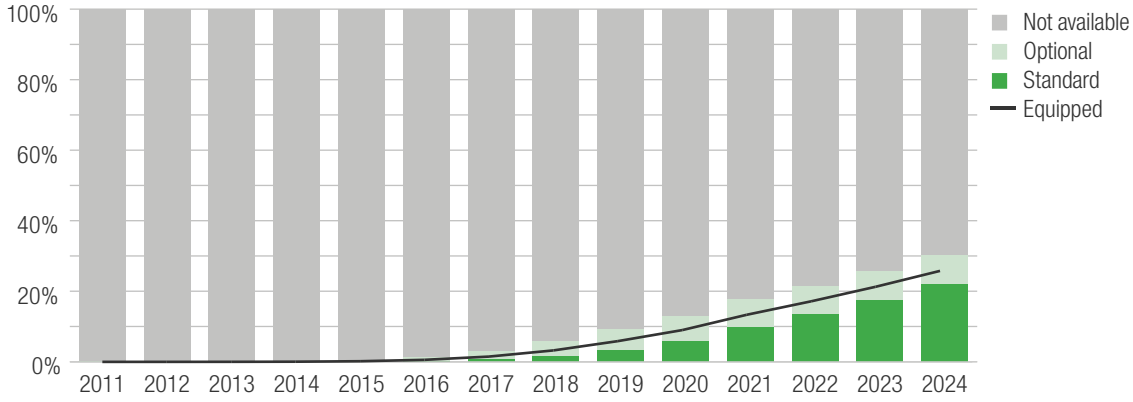



**Figure 12** shows the percentage of registered vehicles with either standard or optional front AEB with pedestrian detection by calendar year. In 2016, front AEB with pedestrian detection was available on about 1% of registered vehicles. By 2024, it was standard or optional on 30% of registered vehicles, with about 26% of registered vehicles estimated to be equipped with the feature.

**Figure 13: Predicted percentage of registered vehicles with front automatic emergency braking with pedestrian detection by calendar year**

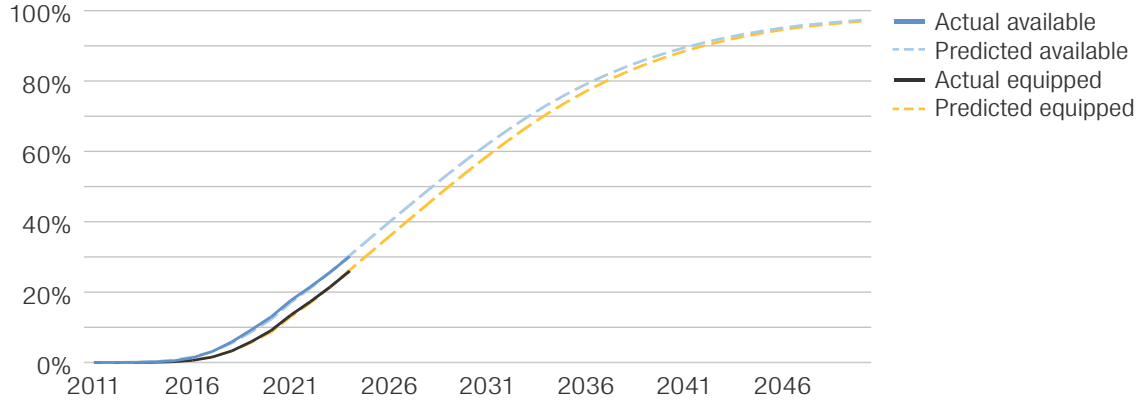



**Figure 13** shows the predicted percentage of registered vehicles with front AEB with pedestrian detection by calendar year. It is predicted that 95% of registered vehicles will be equipped with that feature by 2046.

**Figure 14: Percentage of new vehicle series with adaptive cruise control with lane centering by model year**

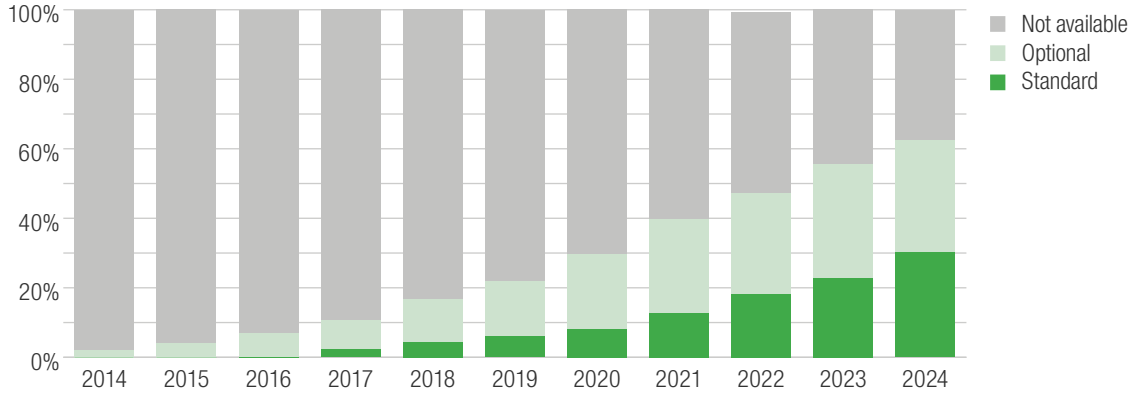



**Figure 14** shows the percentage of new vehicle series with either standard or optional adaptive cruise control with lane centering by model year. This system includes adaptive cruise control with some form of steering-based lane keeping and with complete stop capability. Adaptive cruise control with lane centering was introduced in model year 2014, and by the 2017 model year, this feature had become standard on 2% and optional on 9% of vehicle series. For the 2024 model year, adaptive cruise control with lane centering was standard on 30% and optional on 32% of vehicle series.

**Figure 15: Percentage of registered vehicles with adaptive cruise control with lane centering by calendar year**

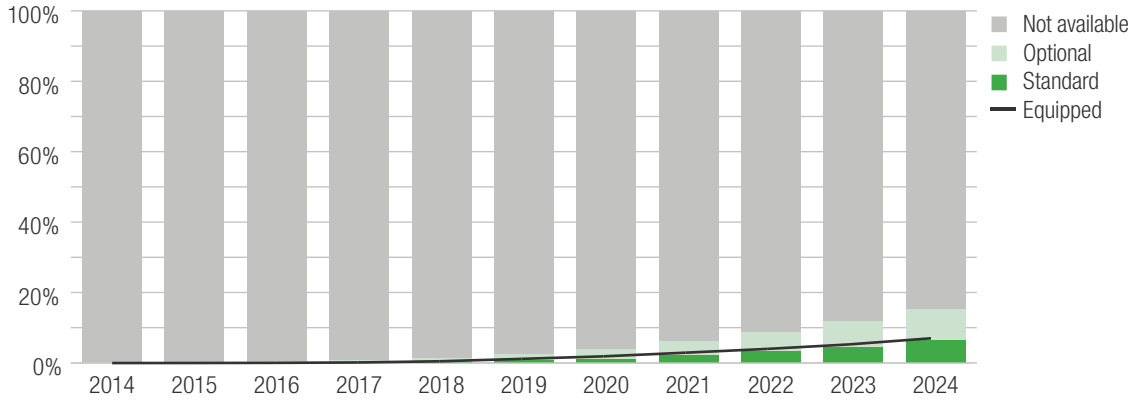



**Figure 15** shows the percentage of registered vehicles with either standard or optional adaptive cruise control with lane centering by calendar year. In 2016, adaptive cruise control with lane centering was available on less than 1% of registered vehicles. By 2024, adaptive cruise control with lane centering was standard or optional on 15% of registered vehicles, and 7% of them were estimated to be equipped with the feature.

**Figure 16: Predicted percentage of registered vehicles with adaptive cruise control with lane centering by calendar year**

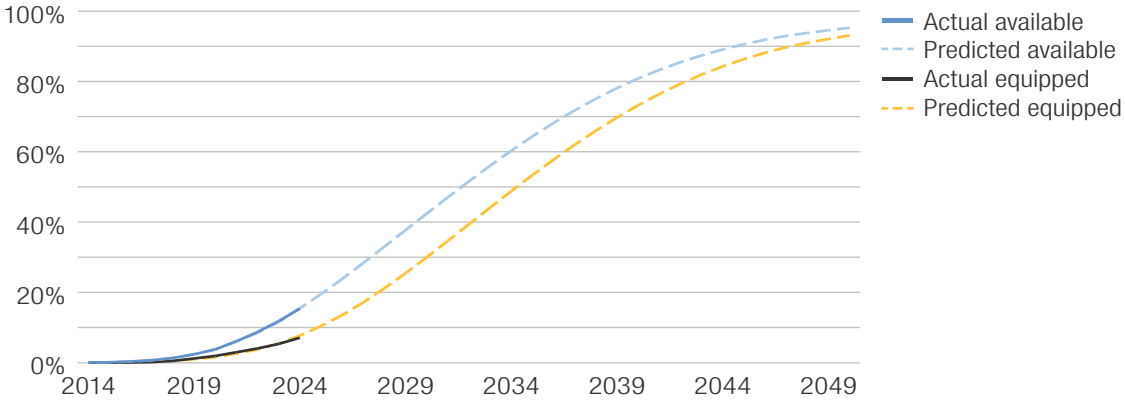



**Figure 16** shows the predicted percentage of registered vehicles with adaptive cruise control with lane centering by calendar year. It is predicted that 95% of registered vehicles will be equipped with this feature sometime after 2050.

## Side-assist systems

**Figure 17: Percentage of new vehicle series with lane departure warning by model year**

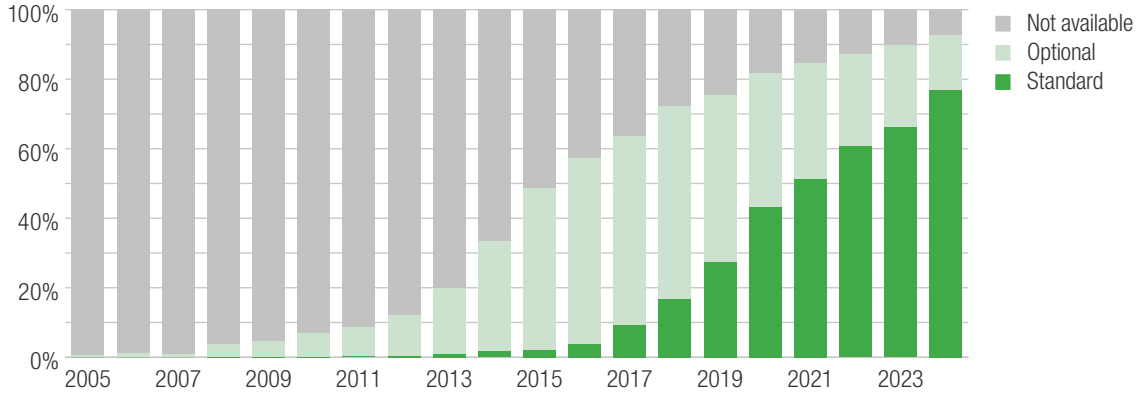



**Figure 17** shows the percentage of new vehicle series with either standard or optional lane departure warning by model year. Both vehicles with systems that only warn drivers when they depart from a lane and those with systems that both warn and provide lane keeping are included. Lane departure warning was introduced in model year 2005, and by the 2014 model year, it had become standard on about 2% and optional on 32% of vehicle series. For the 2024 model year, lane departure warning was standard on 77% and optional on 16% of vehicle series.

**Figure 18: Percentage of registered vehicles with lane departure warning by calendar year**

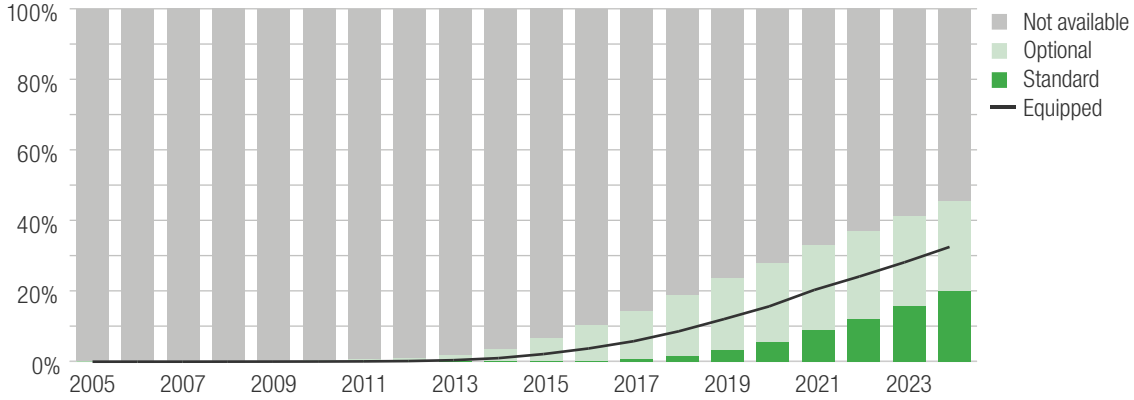



**Figure 18** shows the percentage of registered vehicles with either standard or optional lane departure warning by calendar year. In 2014, lane departure warning was available on 4% of registered vehicles. By 2024, lane departure warning was standard or optional on 45% of registered vehicles, but only 33% of registered vehicles were estimated to be equipped with that feature.

**Figure 19: Predicted percentage of registered vehicles with lane departure warning by calendar year**

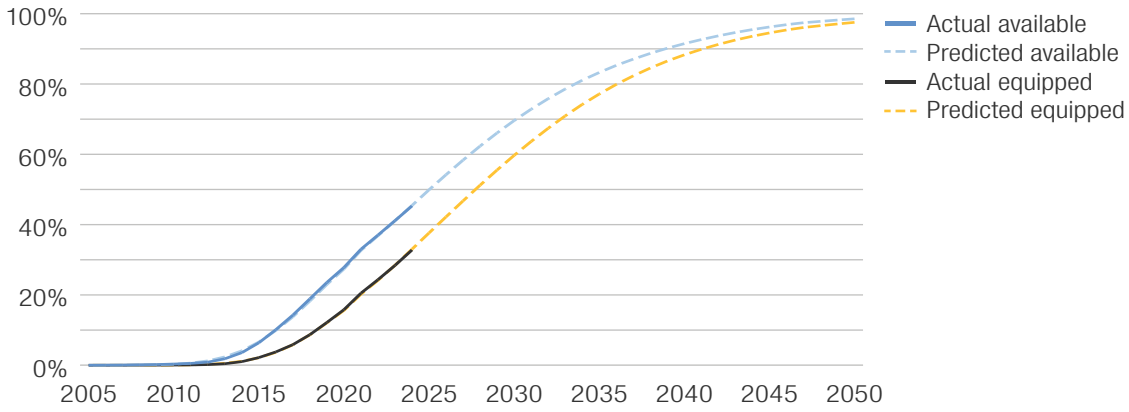



**Figure 19** shows the predicted percentage of registered vehicles with lane departure warning by calendar year. It is predicted that 95% of registered vehicles will be equipped with lane departure warning in 2045.

**Figure 20: Percentage of new vehicle series with blind spot monitoring by model year**

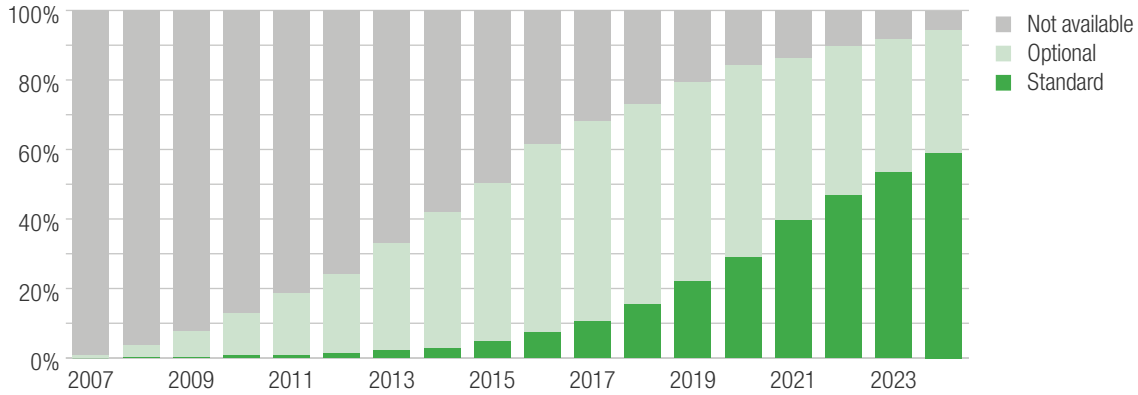



**Figure 20** shows the percentage of new vehicle series with either standard or optional blind spot monitoring by model year. Blind spot monitoring was introduced in model year 2007, and by the 2016 model year, it had become standard on 7% and optional on 54% of vehicle series. For the 2024 model year, blind spot monitoring was standard on 59% and optional on 35% of vehicle series.

**Figure 21: Percentage of registered vehicles with blind spot monitoring by calendar year**

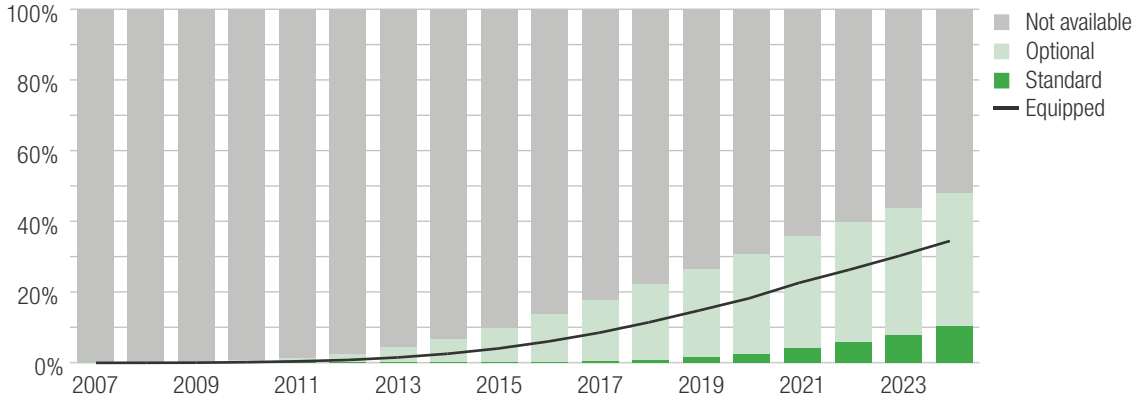



**Figure 21** shows the percentage of registered vehicles with either standard or optional blind spot monitoring by calendar year. In 2016, blind spot monitoring was available on 14% of registered vehicles. By 2024, blind spot monitoring was standard or optional on 48% of registered vehicles, but only 35% of registered vehicles were estimated to be equipped with that feature.

**Figure 22: Predicted percentage of registered vehicles with blind spot monitoring by calendar year**

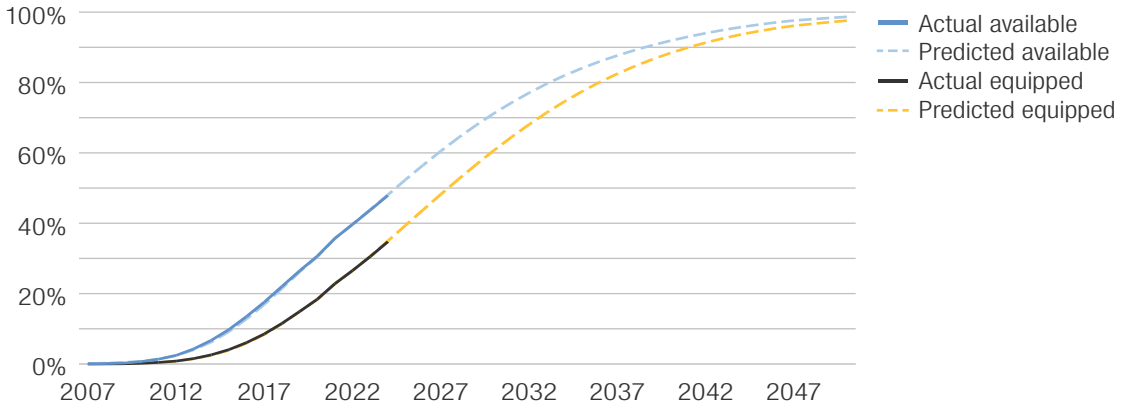



**Figure 22** shows the predicted percentage of registered vehicles with blind spot monitoring by calendar year. It is predicted that 95% of registered vehicles will be equipped with blind spot monitoring in 2045.

## Night-assist systems

**Figure 23: Percentage of new vehicle series with curve-adaptive headlights by model year**

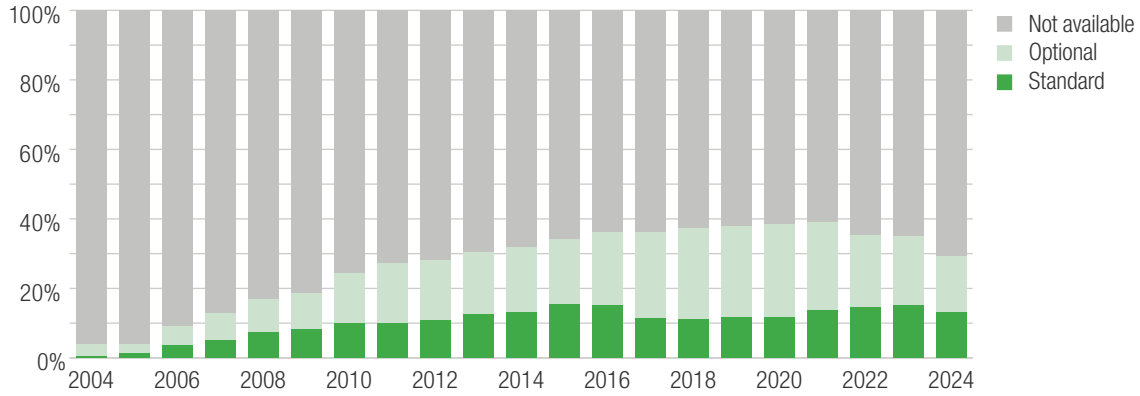



**Figure 23** shows the percentage of new vehicle series with either standard or optional curve-adaptive headlights by model year. Curve-adaptive headlights were introduced in model year 2004, and by the 2013 model year, they had become standard on 13% and optional on 18% of vehicle series. The percentage of vehicle series with standard curve-adaptive headlights reached 15% in the 2015 model year, and the adoption rate fluctuated in the following model years. In model year 2024, curve-adaptive headlights were installed on 13% of vehicle series as standard equipment and on 16% of vehicle series as optional equipment.

**Figure 24: Percentage of registered vehicles with curve-adaptive headlights by calendar year**

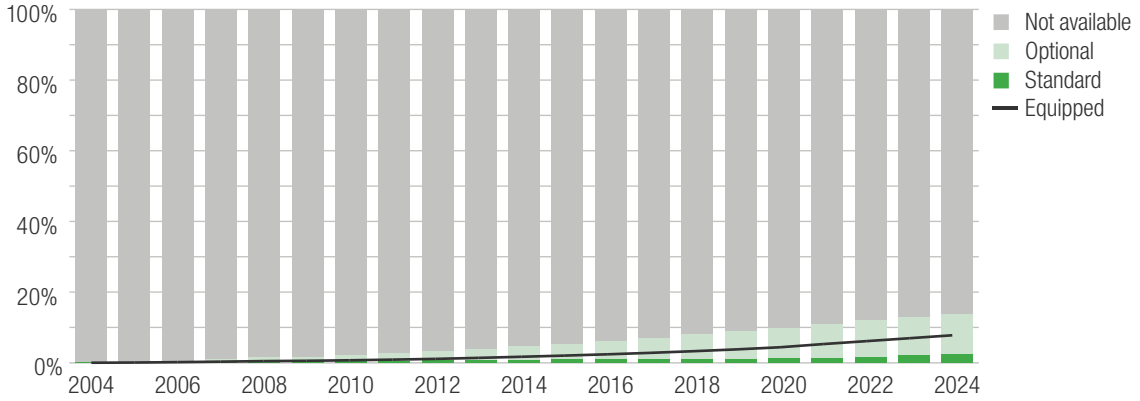



**Figure 24** shows the percentage of registered vehicles with either standard or optional curve-adaptive headlights by calendar year. In 2013, curve-adaptive headlights were available on 4% of registered vehicles. By 2024, curve-adaptive headlights were standard or optional on 14% of registered vehicles, but only 8% of registered vehicles were estimated to be equipped with the feature.

**Figure 25: Predicted percentage of registered vehicles with curve-adaptive headlights by calendar year**

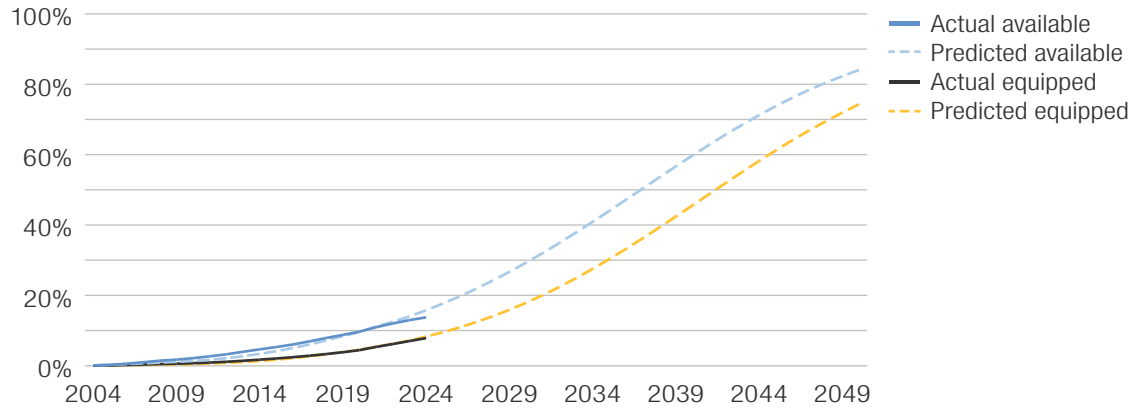



**Figure 25** shows the predicted percentage of registered vehicles with curve-adaptive headlights by calendar year. It is predicted that 95% of registered vehicles will be equipped with curve-adaptive headlights sometime after 2050.

**Figure 26: Percentage of new vehicle series with high-beam assist by model year**

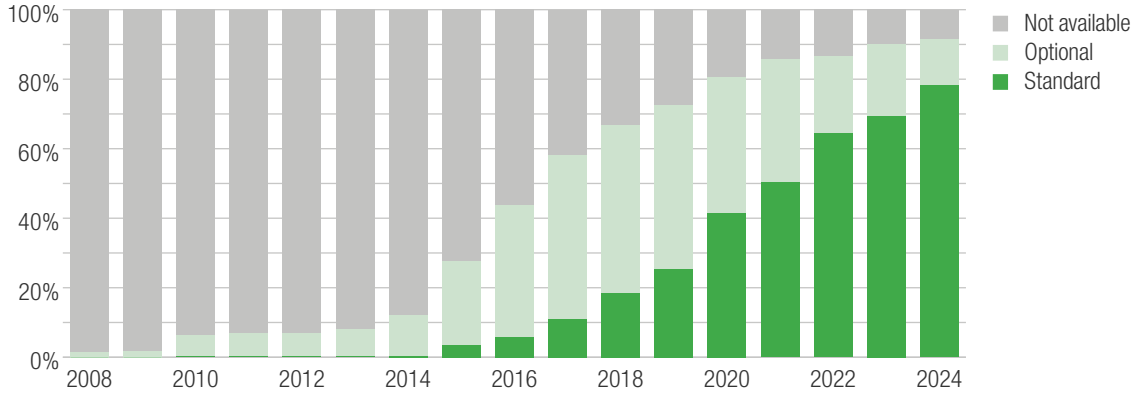



**Figure 26** shows the percentage of new vehicle series with either standard or optional high-beam assist by model year. High-beam assist was introduced in model year 2008, and by the 2016 model year, it had become standard on 6% and optional on 38% of vehicle series. In model year 2024, high-beam assist was installed on 78% of vehicle series as standard equipment and 13% of vehicle series as optional equipment.

**Figure 27: Percentage of registered vehicles with high-beam assist by calendar year**

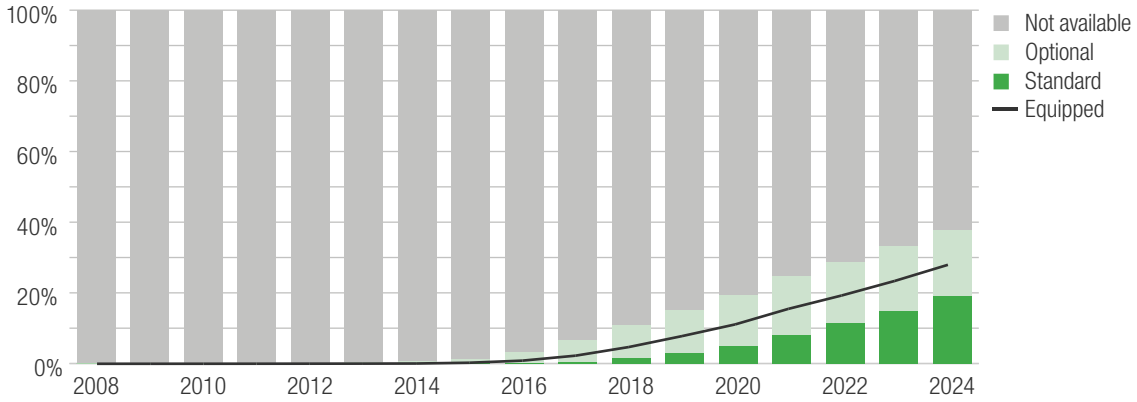



**Figure 27** shows the percentage of registered vehicles with either standard or optional high-beam assist by calendar year. In 2015, high-beam assist was available on about 1% of registered vehicles. By 2024, high-beam assist was standard or optional on 38% of registered vehicles, and about 28% of registered vehicles were estimated to be equipped with the feature.

**Figure 28: Predicted percentage of registered vehicles with high-beam assist by calendar year**

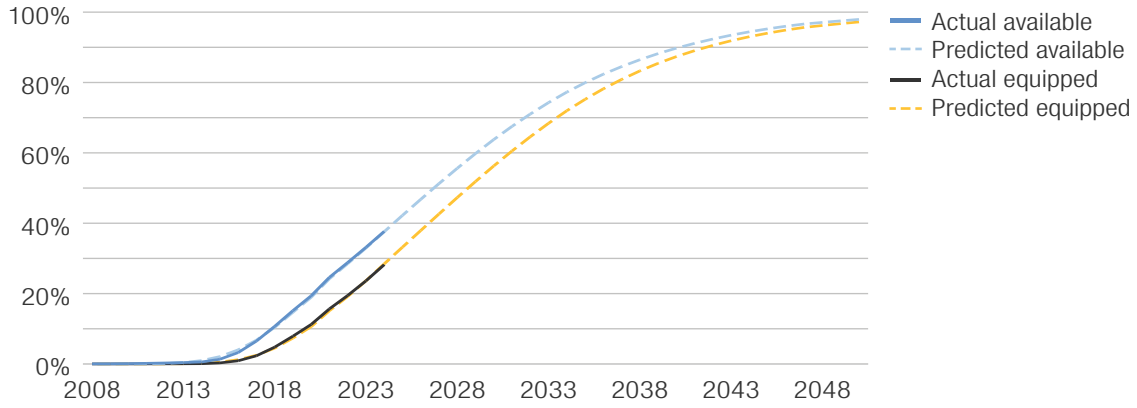



**Figure 28** shows the predicted percentage of registered vehicles with high-beam assist by calendar year. It is predicted that 95% of registered vehicles will be equipped with high-beam assist in 2046.

**Figure 29: Percentage of new vehicle series with rear parking sensors by model year**

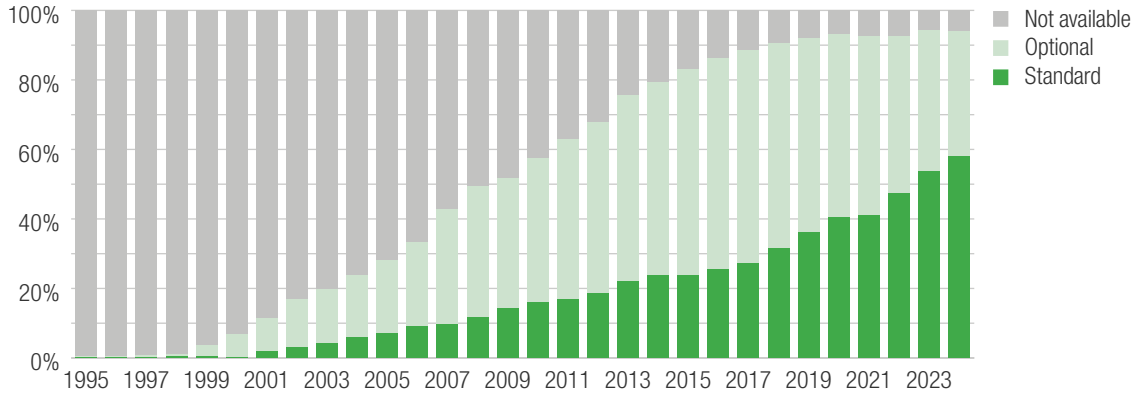



Figure 29 shows the percentage of new vehicle series with either standard or optional rear parking sensors by model year. Rear parking sensors were introduced in model year 1995, and by the 2004 model year, they had become standard on 6% and optional on 18% of vehicle series. For the 2024 model year, rear parking sensors were standard on 58% and optional on 36% of vehicle series.

**Figure 30: Percentage of registered vehicles with rear parking sensors by calendar year**

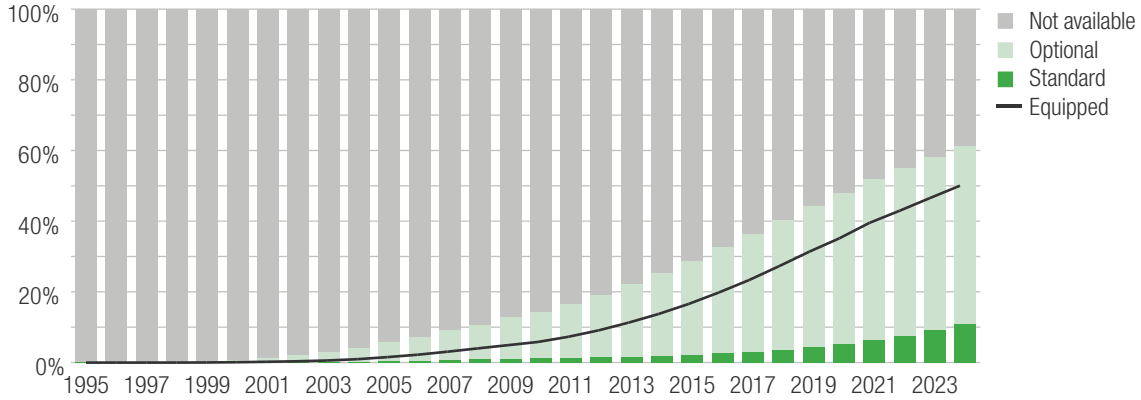



Figure 30 shows the percentage of registered vehicles with either standard or optional rear parking sensors by calendar year. In 2004, rear parking sensors had become standard on less than 1% and optional on 4% of registered vehicles. By 2024, rear parking sensors were standard or optional on 61% of registered vehicles, but only 50% of registered vehicles were estimated to be equipped with the feature.

**Figure 31: Predicted percentage of registered vehicles with rear parking sensors by calendar year**

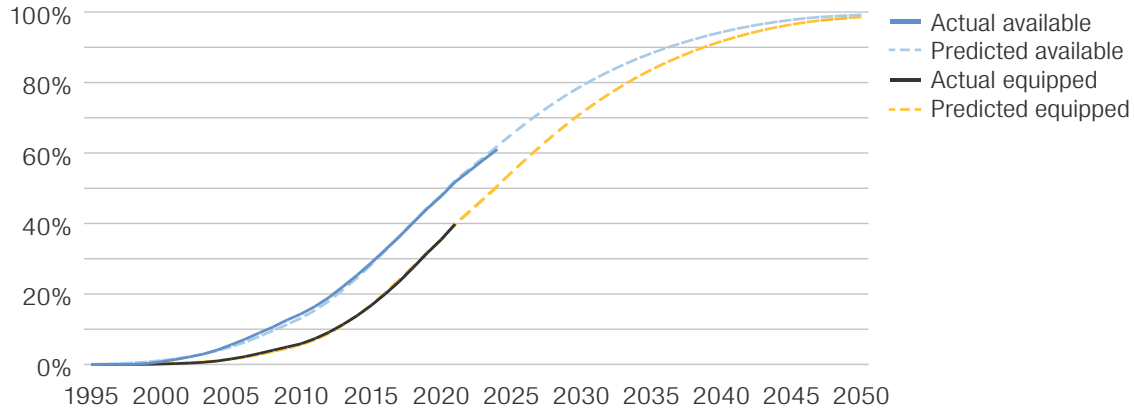



Figure 31 shows the predicted percentage of registered vehicles with rear parking sensors by calendar year. It is predicted that 95% of registered vehicles will be equipped with rear parking sensors in 2043.

**Figure 32: Percentage of new vehicle series with rear cameras by model year**

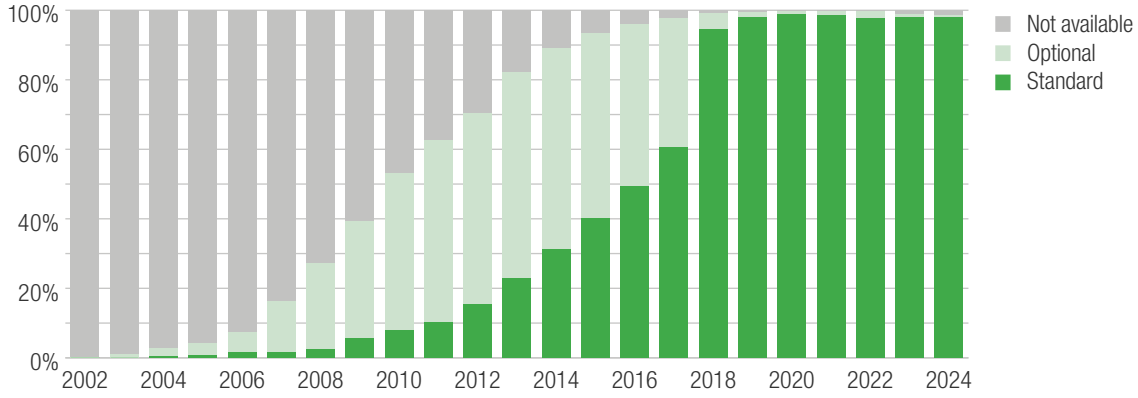



**Figure 32** shows the percentage of new vehicle series with either standard or optional rear cameras by model year. Rear cameras were introduced in model year 2002, and by the 2011 model year, they had become standard on 10% and optional on 53% of vehicle series. **Rear cameras have been required on all new vehicles with a gross vehicle weight rating under 10,000 pounds produced since May 1, 2018.** For the 2024 model year, rear cameras were standard on 98% and optional on less than 1% of vehicle series.

**Figure 33: Percentage of registered vehicles with rear cameras by calendar year**

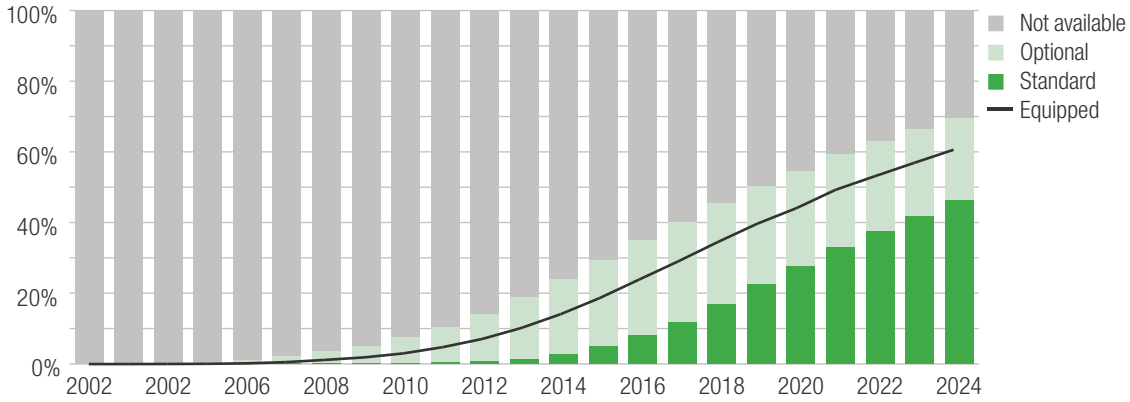



**Figure 33** shows the percentage of registered vehicles with either standard or optional rear cameras by calendar year. In 2012, rear cameras were available on 14% of registered vehicles. By 2024, rear cameras were standard or optional on 70% of registered vehicles. It was estimated that 61% of registered vehicles were equipped with that feature.

**Figure 34: Predicted percentage of registered vehicles with rear cameras by calendar year**

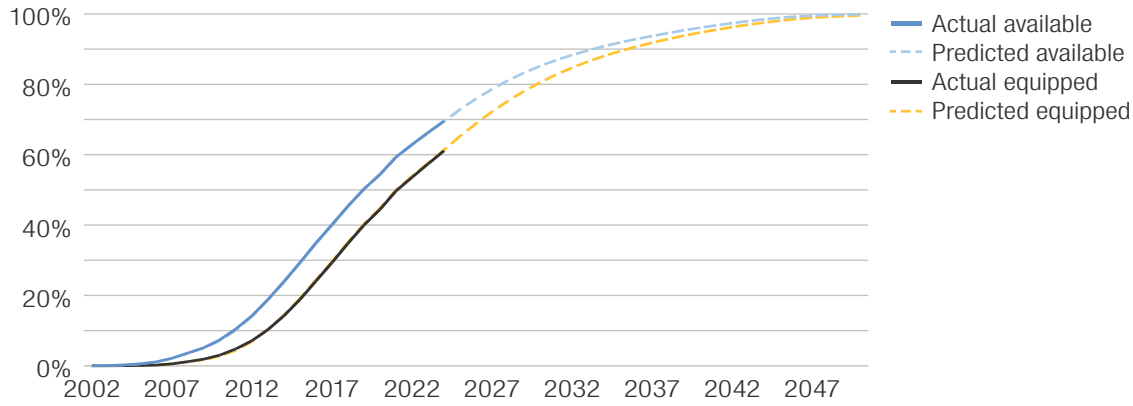



**Figure 34**, which takes into account the 2018 mandate, shows the predicted percentage of registered vehicles with rear cameras by calendar year. It is predicted that 95% of registered vehicles will be equipped with rear cameras in 2040.

**Figure 35: Percentage of new vehicle series with rear automatic emergency braking by model year**

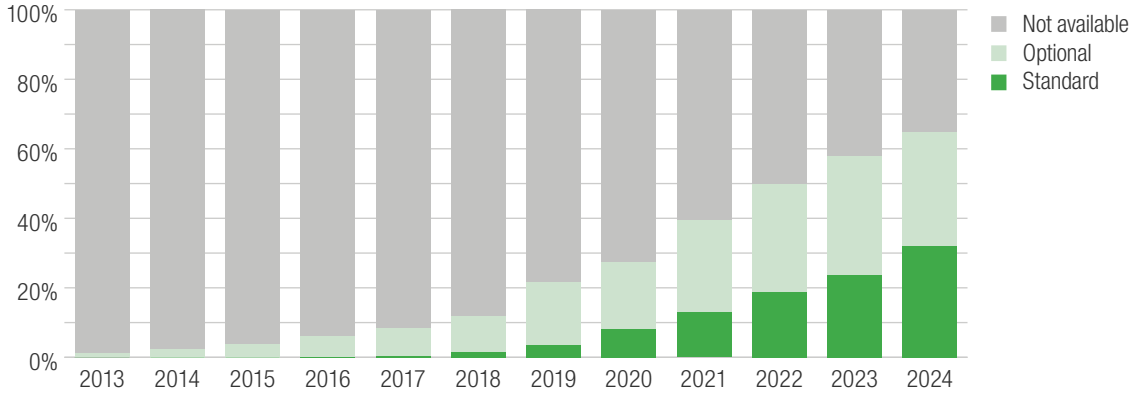



**Figure 35** shows the percentage of new vehicle series with either standard or optional rear AEB by model year. Rear AEB was introduced in model year 2013, and by the 2018 model year, it had become standard on 2% and optional on 10% of vehicle series. For the 2024 model year, rear AEB was standard on 32% and optional on 33% of vehicle series.

**Figure 36: Percentage of registered vehicles with rear automatic emergency braking by calendar year**

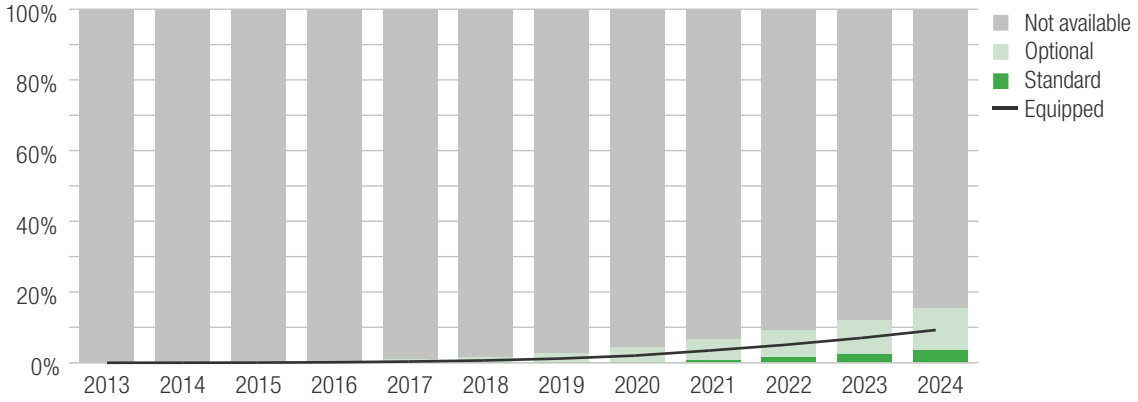



**Figure 36** shows the percentage of registered vehicles with either standard or optional rear AEB by calendar year. In 2017, rear AEB had become available on 1% of registered vehicles. By 2024, rear AEB was standard or optional on 15% of registered vehicles, and 9% of registered vehicles were predicted to be equipped with the feature.

**Figure 37: Predicted percentage of registered vehicles with rear automatic emergency braking by calendar year**

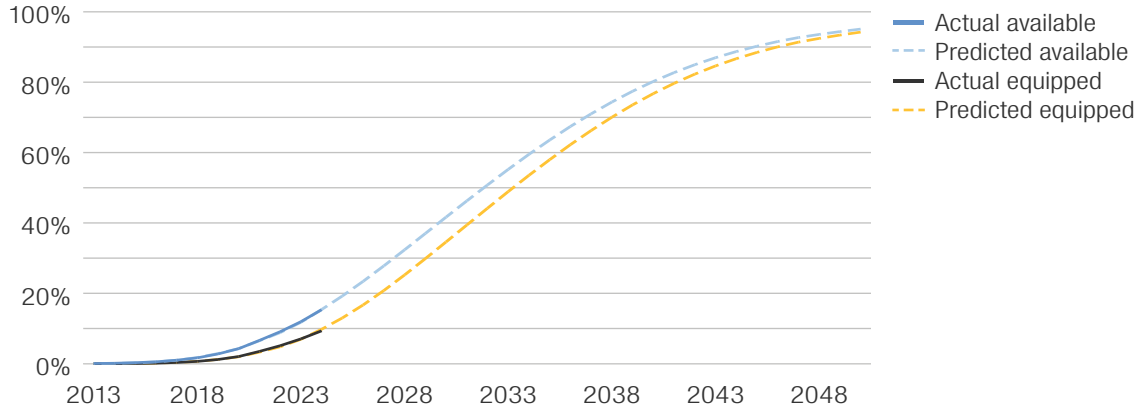



**Figure 37** shows the predicted percentage of registered vehicles with rear AEB by calendar year. It is predicted that 95% of registered vehicles will be equipped with rear AEB around 2050.

**Figure 38: Predicted registered vehicles equipped with collision avoidance systems, 2024 and 2029 calendar years**

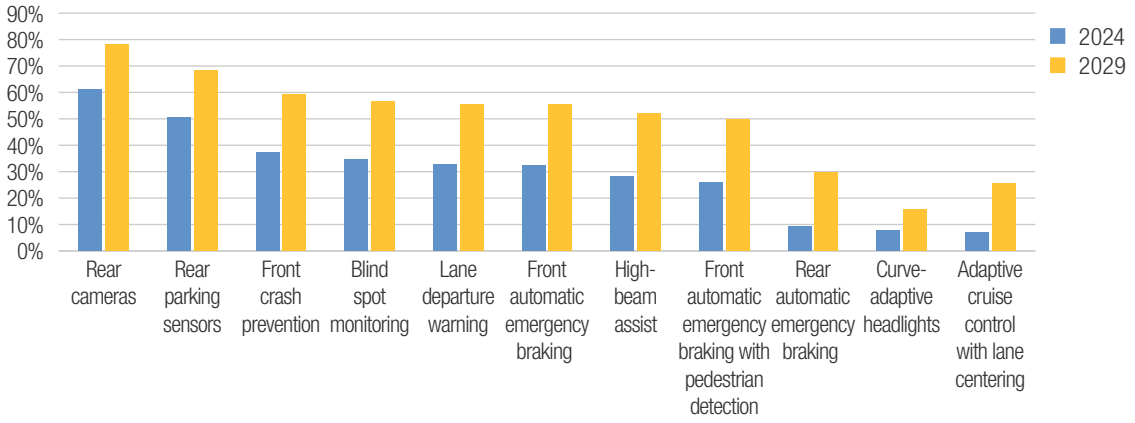



Figure 38 shows the percentage of registered vehicles estimated to be equipped with the features covered by this report in 2024 and 2029. The presence of all systems is estimated to increase by about 17 to 24 percentage points by 2029, except curve-adaptive headlights, which are estimated to increase by only 8 percentage points. Rear cameras and rear parking sensors are estimated to be equipped on 78% and 68%, respectively, of the registered vehicle population by 2029. Front AEB is estimated to increase from 32% of the registered vehicle population in 2024 to 55% in 2029. This projected increase can be attributed to a voluntary industry commitment brokered by the Insurance Institute for Highway Safety (IIHS) and the National Highway Traffic Safety Administration. Twenty automakers agreed to equip nearly all their vehicles with front AEB no later than the production year beginning September 1, 2022. Consequently, front crash prevention systems that warn or/and automatically brake are estimated to achieve a 59% fleet penetration by 2029.

## Discussion

It takes many years for new vehicle features to spread through the registered vehicle fleet, even when they are required by the government. Among the collision avoidance features discussed in this report, only rear cameras have been mandated, while many manufacturers agreed to voluntarily equip vehicles with front AEB by September 1, 2022.

With the exception of ESC, estimated take rates were included for optional features. Because it is not known with absolute certainty how many of the optional features were purchased, VIN data supplied to HLDI from 13 manufacturers were used to estimate the actual penetration of collision avoidance features in the vehicle fleet. Equipped rates varied considerably by feature. About 32.4% of the fleet was estimated to be equipped with front AEB, even though it was available on 40.8% of vehicles in the 2024 fleet (25.6% standard and 15.2% optional). Rear cameras, however, were estimated to be installed on 61.1% of the 2024 registered vehicle fleet; they were available on 69.6% of vehicles in the 2024 fleet (46.2% standard and 23.4% optional).

The percentage of new vehicle series with a given feature as standard has increased steadily since the introduction of the feature, except for curve-adaptive headlights, which were standard on fewer and fewer vehicles from model year 2015 to 2020. Consequently, curve-adaptive headlights may not reach 95% availability in the fleet as soon as the other features, if they ever become so prevalent. The headlight evaluation program from IIHS has found that headlights can provide sufficient levels of lighting without adaptive technology. For example, many vehicles with headlights that earn the highest rating of good from the IIHS evaluation, such as the 2022 Honda Insight and the 2022 Genesis G90, have LED headlights that are not curve adaptive. This might have slowed the growth of adaptive headlights in the fleet.

Another feature predicted to reach 95% fleet penetration after 2050 is adaptive cruise control with lane centering, which provides some Level 2 driving automation capability. When introduced in the model year 2014, adaptive cruise control with lane centering was available on only a small number of vehicles. For the 2024 fleet, adaptive cruise control with lane centering was estimated to be available on 15% of vehicles, with 7% equipped with it. Although the percentage of new vehicle series with adaptive cruise control with lane centering as standard has increased since the feature's introduction, it will still take decades until a majority of vehicles on the road are equipped with it.

Front AEB with pedestrian detection was analyzed separately from regular front AEB because of increased concern about pedestrian safety. Front AEB with pedestrian detection was introduced in model year 2011 and was initially available only as optional equipment. In the 2014 fleet, the feature was available on only about 0.2% of registered vehicles. After a decade, about 30% of the 2024 registered vehicles had front AEB with pedestrian detection available, and 26% were estimated to be equipped with the feature. Based on the growth rate, it is predicted that 95% of registered vehicles will be equipped with front AEB with pedestrian detection by 2046.

Accounting for the optionally equipped vehicles in the analysis, we predict that features will reach half of the registered vehicle fleet 1 to 5 years later than estimates from projections that assume all vehicles with an optional system were actually equipped with that system.

A prior HLDI study (2019) found that Honda and Subaru vehicles equipped with effective collision avoidance systems persisted longer in the vehicle fleet. Another HLDI report (2014) found that ESC-equipped vehicles also lasted longer in the vehicle fleet than non-ESC-equipped vehicles. This could lead to a slowdown in the turnover of the fleet, as vehicles are lasting longer. However, a sensitivity analysis on changes in the rate of attrition found that small changes in the rate of attrition over time had minimal impact on results. Consequently, the potential longer life span for collision avoidance-equipped vehicles was not accounted for in the predictions.

## Limitations

One limitation of the logistic model with a probit link is that it assumes a distribution with an asymptote of 100%, which it approaches slowly toward the end of the distribution. When a given feature's prevalence reaches 95%, the feature's growth substantially slows, and it takes a number of years to capture the remaining 5%. It is not known how this remaining small percentage will be captured because no feature has yet reached 100% prevalence. The model was carefully chosen to fit the existing (past year) data well, and there is no reason to believe that it does not adequately project future data. It may be the case that 100% prevalence is never reached, as some people tend to keep old cars as collectable vehicles. The goal of this study was to estimate when each feature will be available for the vast majority of the fleet, not 100% of the fleet.

Additionally, the work presented here was based on data from a limited number of vehicle manufacturers. The estimates for the optionally equipped rates were the best estimates possible with the available data. Sensitivity analysis was conducted by excluding an individual manufacturer from the data set and using the remaining data for the analysis. For most safety features, the elimination resulted in only minimal changes in our feature-equipped estimates. However, for a few manufacturers, larger changes were observed. Additional data from manufacturers would likely result in better estimates.

Another limitation is that the prediction was based on the coarse calendar year/model year registration counts rather than stratified by make and series. However, the stratified approach would be difficult, if not impossible, to accomplish. The future is uncertain, and so is the future new model fleet. Even with the present approach, a bold assumption of stalled vehicle sales had to be made. Making assumptions of which makes and series will be popular in the future or which manufacturers will introduce safety features more aggressively is beyond the scope of this analysis. However, as mentioned previously and as reflected in the graphs, the model fits the existing data well, and therefore it is reasonable to believe that our predictions for the future fleet are the best possible given the limitations.

## References


Highway Loss Data Institute. (2014). Electronic stability control and the vehicle fleet. *Loss Bulletin*, *31*(13).

Highway Loss Data Institute. (2019). Attrition of vehicles with collision avoidance technologies in the vehicle fleet. *Loss Bulletin*, *36*(36).

Highway Loss Data Institute. (2024). Predicted availability of safety features on registered vehicles — a 2024 update. *Loss Bulletin*, *41*(6).


## Appendix

**Prior HLDI studies of predicted safety feature availability**

| Publication year | HLDI *Loss Bulletin* issue |
|---|---|
| 2012 | Vol. 28, No. 26 |
| 2014 | Vol. 31, No. 15 |
| 2015 | Vol. 32, No. 16 |
| 2016 | Vol. 33, No. 15 |
| 2017 | Vol. 34, No. 28 |
| 2018 | Vol. 35, No. 27 |
| 2019 | Vol. 36, No. 23 |
| 2020 | Vol. 37, No. 11 |
| 2021 | Vol. 38, No. 19 |
| 2022 | Vol. 39, No. 2 |
| 2023 | Vol. 40, No. 2 |
| 2024 | Vol. 41, No. 6 |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