# Predicted availability and fitment of safety features on registered vehicles — a 2019 update

Highway Loss Data Institute (HLDI) studies have indicated that some collision avoidance systems are reducing insurance claims. In particular, claim frequency reductions were found across all of the crash-related coverages for most front crash prevention systems. While some of the reductions are sizable, these systems were first introduced on a small number of luxury vehicles. Consequently, the impact of these systems on the population of all crashes has been limited.

Prior HLDI studies (2012, 2014b, 2015, 2016, 2017, 2018) showed that it typically takes decades after introduction before most vehicles on the road have a given feature. Most of the prior studies examined the prevalence of the systems based on availability, meaning the feature was available as standard or optional. The percentage of vehicles equipped with an optional feature was unknown. Similar to the 2018 study, the optional-equipped rate is estimated for each feature based on known take rates from some manufacturers. Using this information, the percentage of registered vehicles equipped with a certain feature, along with future predictions, can be better estimated.

In the figure below, the fitment rate for each feature is shown for calendar years 2018 and 2023. The only feature that is estimated to be on more than half of the registered vehicle population in 2023 is rear cameras. Rear cameras also are predicted to have the largest percentage point growth (25 percentage points) between 2018 and 2023, a growth likely attributed to the mandate to equip passenger vehicles with the technology by May 1, 2018. Front automatic emergency braking (AEB), however, is estimated to increase fivefold from less than 5 percent of the registered vehicle population in 2018 to about 24 percent in 2023. This increase may be attributed to the voluntary agreement to equip vehicles with AEB by 2022.

Predicted registered vehicles equipped with advanced driver assistance systems by calendar year, 2018 and 2023
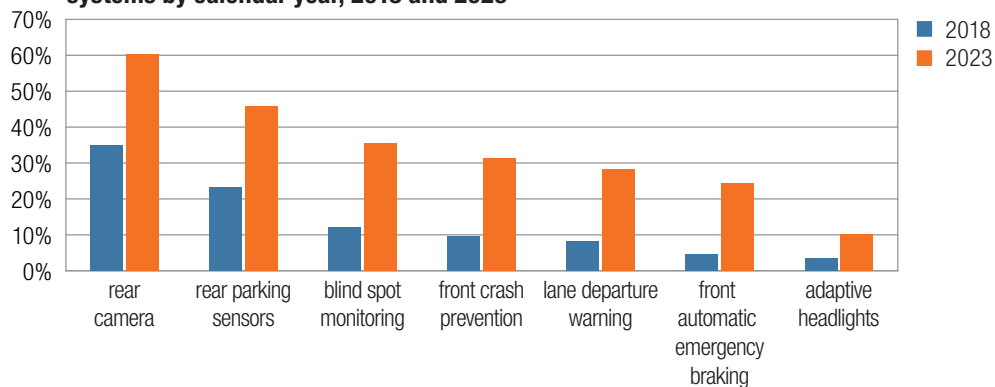
Introduction

Given the potential and proven benefits of collision avoidance systems, it is almost certain that these systems will reduce the number of crashes and insurance claims. While estimating the efficacy of available systems is an important part of understanding the long-term impact of these systems, 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 features in the registered vehicle fleet, trace that prevalence from introduction through the most current registration data, and then predict the prevalence of these features in the future. Similar to the 2018 HLDI study, this current study adjusts the vehicle fleet estimates and predictions by estimating the take rates for optional features.

Methods

This study combines vehicle feature information from HLDI with vehicle registration data from IHS Automotive (formerly R.L. Polk and Company). For each feature studied, there are three figures:

- The **first figure** illustrates the percentage of new vehicle series with a given 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. Using new vehicle series to illustrate how common a feature is can be deceiving because new safety features typically appear initially on luxury vehicles, which tend to be sold in lower volumes than nonluxury vehicles.

- The **second figure** for each feature illustrates the percentage of registered vehicles with a 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, which estimates the percentage of the vehicle fleet with the feature installed.

- The **third figure** for each feature illustrates the predicted availability for that feature. The actual availability is also displayed for comparison. One set of lines represents predicted availability with the optional take rate considered, while the other 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), rear parking sensors, front crash prevention systems that warn and those that automatically brake, rear cameras, adaptive headlights, lane departure warning, and blind spot monitoring.

Vehicle feature information was obtained by HLDI. The feature information is structured by model year, make, and series. The same three variables were mapped to the registration data from IHS Automotive. For each model year-make-series combination, one of three possible feature values are provided: "standard," "optional," and "not available."

Registration counts belonging to either of the first two groups are hereafter referred to as "available." For example, in calendar year 2018, 3.6 percent of registered vehicles had standard rear parking sensors and another 36.8 percent had it as an option, so it is said that rear parking sensors were available in 40.4 percent of the 2018 registered vehicles.

The most recent IHS Automotive data available to HLDI contain calendar years 1976–2018. For each calendar year, a number of recent model years are used, ranging from 11 model years for calendar year 1976 to 40 model years for calendar year 2018. 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 were available, but the analysis was limited to 40 model years. This covered at least 95 percent of the overall fleet in calendar years during which safety features started to gain popularity. There are model years that were present in earlier calendar years and then aged out of the dataset, but then re-entered when the dataset was expanded. To increase the amount of usable data, missing values were extrapolated based on existing values. IHS Automotive has restated some of its data. In this study, original data were used from 1976 to 2008, while restated data were used for calendar years 2009 to 2018.

Approach used to estimate optional-equipped rates: This study estimates the optional fitment rates for each of the features using HLDI feature data and Vehicle Identification Number (VIN) information from approximately a dozen manufacturers. Using HLDI's vehicle information, vehicles registered in 2018 with optional features were identified. Individual feature fitment rates for calendar year 2018 were estimated based on VIN data that HLDI previously received from a limited number of manufacturers. The fitment 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. In the ideal situation, known fitment rates at the model year, size, class, and price level were assigned to vehicles with unknown feature fitment rates of the same model year, size, class, and price. In instances where known fitment rates were not available for the variables model year, size, class, and price level, the fitment rates were estimated with regression models that used as many of these variables as possible with known values. In the worst-case scenario, the estimated fitment rates were based on models using only model year and vehicle price. Once the historical unknown feature fitment rates were assigned, the mix of the historical optional and standard feature data were used to estimate future feature-equipped rates.

Approach used to estimate the number of new vehicles: In order to estimate the number of new vehicles in 2019, registrations for new vehicles for 5 calendar years (2014–18) were averaged. New vehicles are defined as vehicles aged 0 and −1 years. For example, a 2012 model year in calendar year 2012 would have a vehicle age of 0, while a 2013 vehicle in the same calendar year would have a vehicle age of −1. To predict new vehicle registrations for calendar years 2019–50, a 30-year past trend in new vehicle registrations was studied. During this period, new vehicle registrations increased on average 0.9 percent per calendar year. New vehicle counts for 2019 and beyond were calculated by adding 0.9 percent to the prior year registration counts.

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 2013 there were fewer 2008 model year registrations 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, 2 to 3, 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 (2019–50) and vehicles undergoing the same age change.

Additionally, to account for changes in attrition, a 30-year past trend was studied. During this time period, attrition rates declined on average 0.18 percent per model year. Based on this, the attrition for each subsequent model year was slowed by an additional 0.18 percent. In other words, the attrition rate for the 2025 model year was 0.18 percent less than the attrition rate for the 2024 model year, which was 0.18 percent less than the 2023 model year, etc. The attrition assumptions will be monitored, refined, and modified as needed for future analyses.

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 was 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

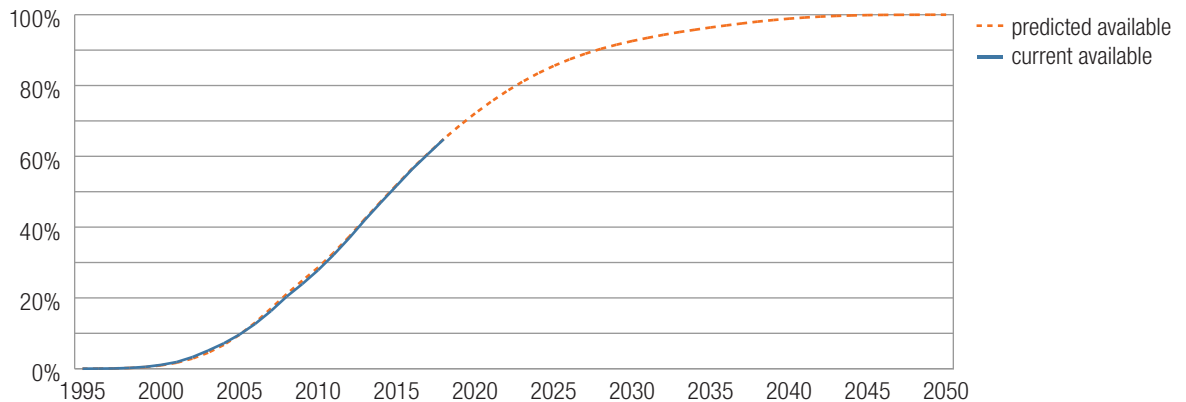**Figure 1: Percentage of new vehicle series with ESC by model year**
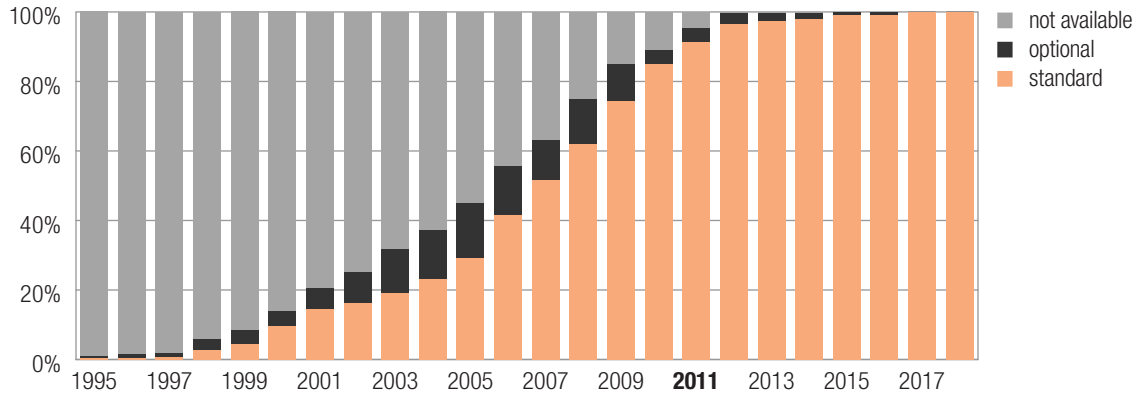
Figure 1 shows the percentage of vehicle series by model year with either standard or optional ESC. ESC was introduced in model year 1995 and by the 2004 model year had become standard on 23 percent and optional on 14 percent of vehicle series. **ESC has been required on all light-duty vehicles beginning September 1, 2011.** Starting in model year 2013, the only vehicles that do not have standard ESC are very large pickup trucks weighing more than 10,000 pounds and not subject to the regulation. By the 2017 model year, all vehicle series had standard ESC.

Figure 2: Percentage of registered vehicles with ESC by calendar year
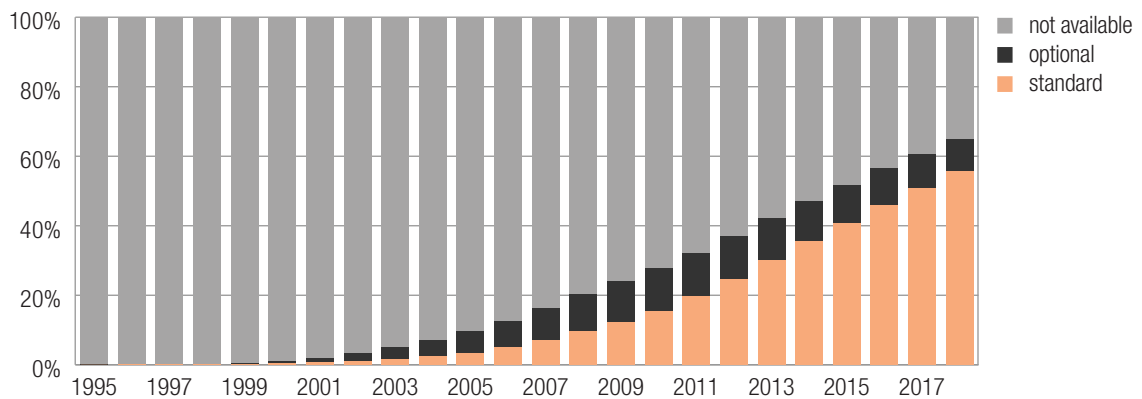
Figure 2 shows the percentage of registered vehicles by calendar year with either standard or optional ESC. By 2004, ESC had become standard on 2 percent and optional on 5 percent of registered vehicles. By 2018, ESC was standard or optional on 65 percent of registered vehicles. Data were not available on the fitment rate of vehicles with optional ESC.

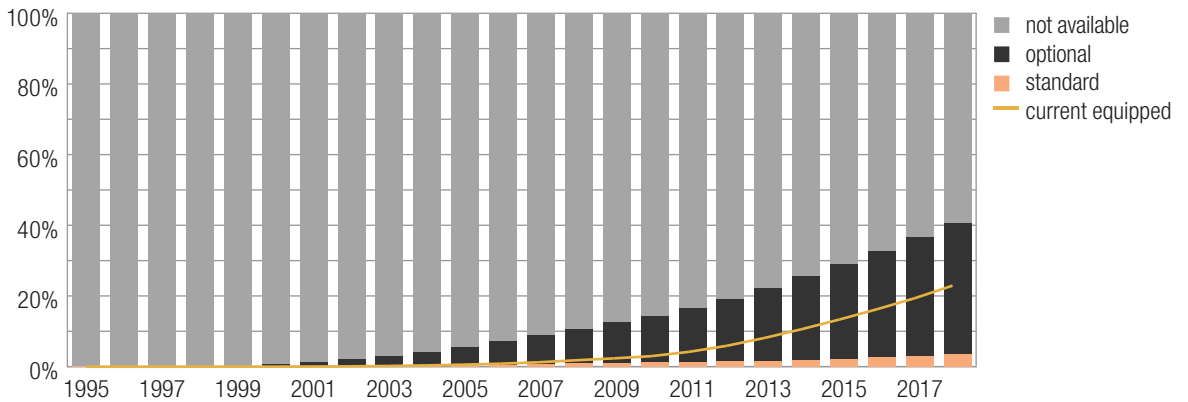**Figure 3: Predicted percentage of registered vehicles with ESC by calendar year**

Figure 3 shows the percentage of predicted registered vehicles by calendar year with either standard or optional ESC. It is predicted that ESC will be standard or optional on 95 percent of registered vehicles in 2033.

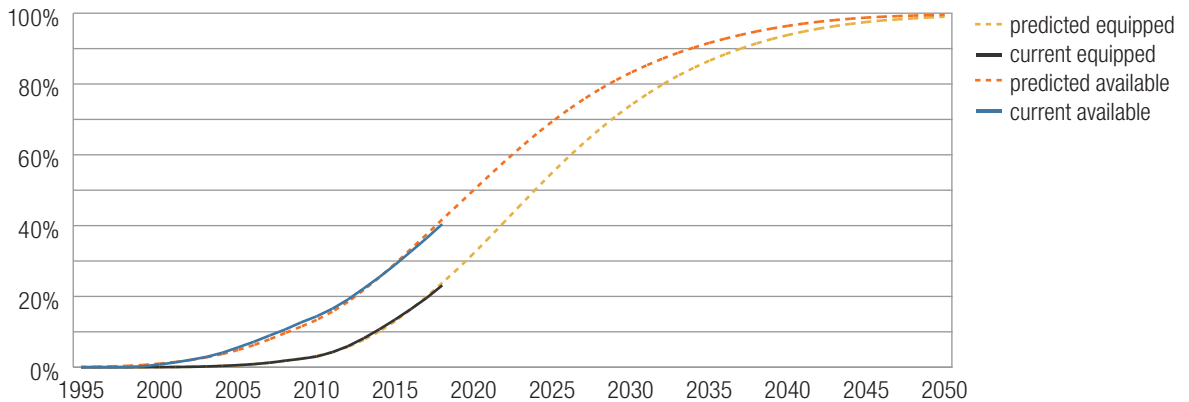**Figure 4: Percentage of new vehicle series with rear parking sensors by model year**
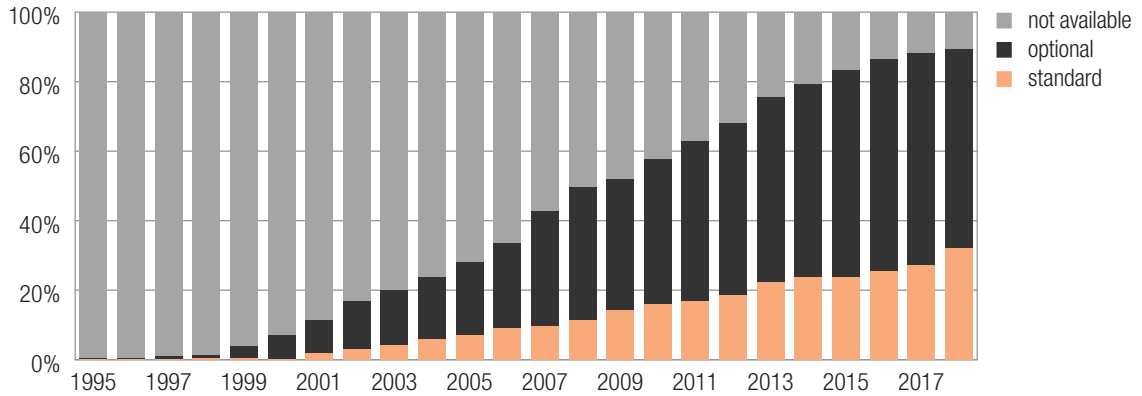
Figure 4 shows the percentage of vehicle series by model year with either standard or optional rear parking sensors. Rear parking sensors were introduced in model year 1995 and by the 2004 model year had become standard on 6 percent and optional on 18 percent of vehicle series. For the 2018 model year, rear parking sensors were standard on 32 percent and optional on 57 percent of vehicle series.

Figure 5: Percentage of registered vehicles with rear parking sensors by calendar year

Figure 5 shows the percentage of registered vehicles by calendar year with either standard or optional rear parking sensors. In 2004, rear parking sensors had become standard on less than 1 percent and optional on 4 percent of registered vehicles. By 2018, rear parking sensors were standard or optional on 40 percent of registered vehicles, but only 23 percent of registered vehicles were estimated to be equipped with the feature.

Figure 6: Predicted percentage of registered vehicles with rear parking sensors by calendar year

Figure 6 shows the percentage of predicted registered vehicles by calendar year with rear parking sensors. One prediction is for vehicles with rear parking sensors available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with the sensors. It is predicted that 95 percent of registered vehicles will be equipped with rear parking sensors in 2041.

Figure 7: Percentage of new vehicle series with front crash prevention by model year
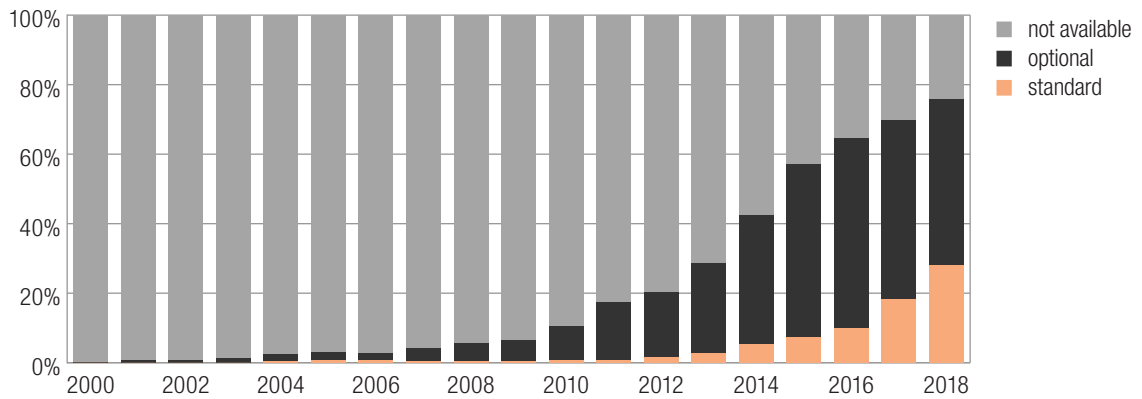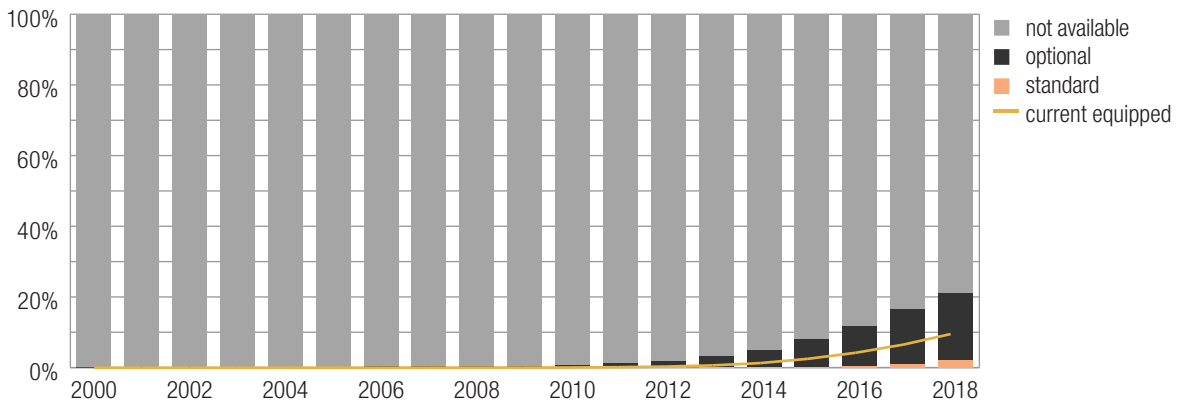

Figure 7 shows the percentage of vehicle series by model year with either standard or optional front crash prevention. It includes vehicles that warn and/or automatically brake. Front crash prevention was introduced in model year 2000 and by the 2006 model year had become standard on 1 percent and optional on 2 percent of vehicle series. For the 2018 model year, front crash prevention was standard on 28 percent and optional on 48 percent of vehicle series.

Figure 8: Percentage of registered vehicles with front crash prevention by calendar year

Figure 8 shows the percentage of registered vehicles by calendar year with either standard or optional front crash prevention. In 2006, front crash prevention had become standard on less than 1 percent and optional on less than 1 percent of registered vehicles. By 2018, front crash prevention was standard or optional on 21 percent of registered vehicles, with about 10 percent of registered vehicles estimated to be equipped with the feature.

Figure 9: Predicted percentage of registered vehicles with front crash prevention by calendar year
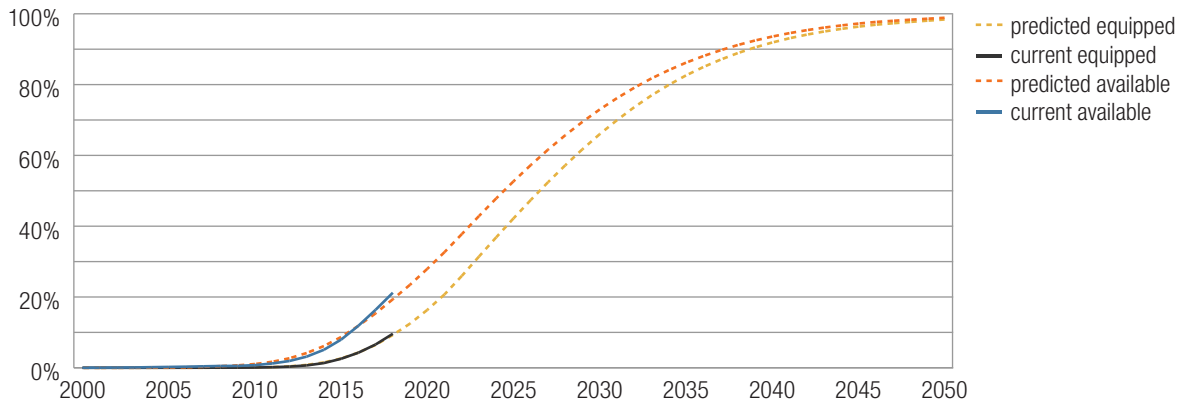

Figure 9 takes into account a voluntary commitment by many manufacturers to make front AEB standard on most of their vehicles by 2022. It shows the predicted registered vehicles by calendar year with front crash prevention. One prediction is for vehicles with front crash prevention available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with front crash prevention. It is predicted that 95 percent of registered vehicles will be equipped with the feature in 2043.

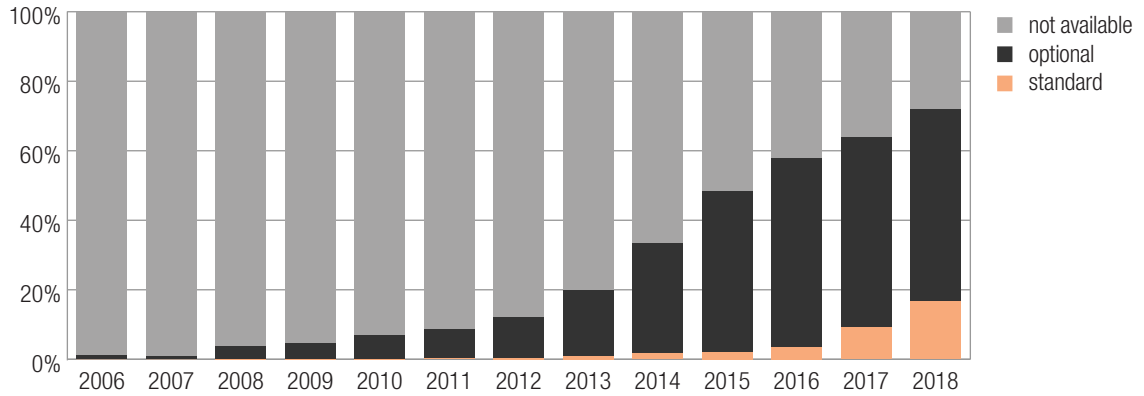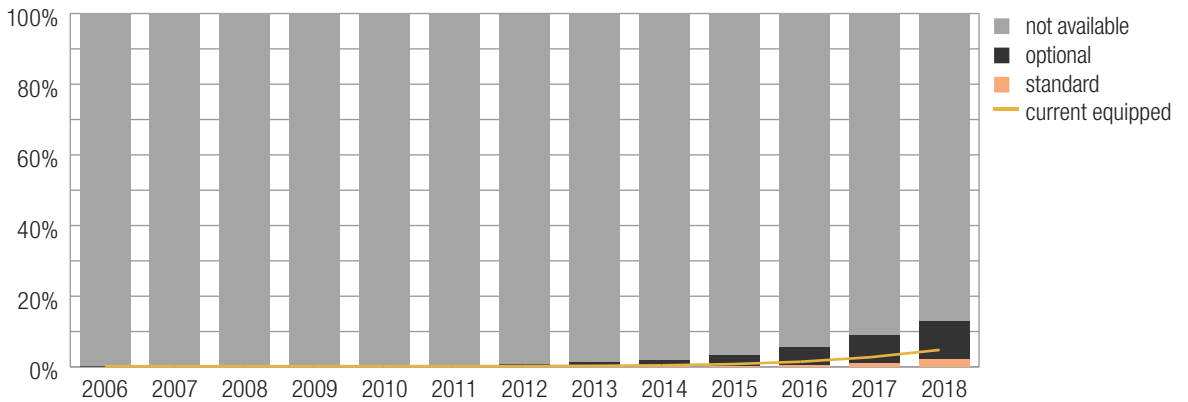**Figure 10: Percentage of new vehicle series with front automatic emergency braking by model year**

Figure 10 shows the percentage of vehicle series by model year with either standard or optional front AEB. These systems may also warn. AEB was introduced in model year 2006 and by the 2012 model year had become standard on 1 percent and optional on 10 percent of vehicle series. For the 2018 model year, AEB was standard on 28 percent and optional on 38 percent of vehicle series.

Figure 11: Percentage of registered vehicles with front automatic emergency braking by calendar year

Figure 11 shows the percentage of registered vehicles by calendar year with either standard or optional front AEB. In 2012, AEB had become standard on less than 1 percent and optional on 1 percent of registered vehicles. By 2018, AEB was standard or optional on 13 percent of registered vehicles but estimated to be equipped only on 5 percent.

Figure 12: Predicted percentage of registered vehicles with front automatic emergency braking by calendar year
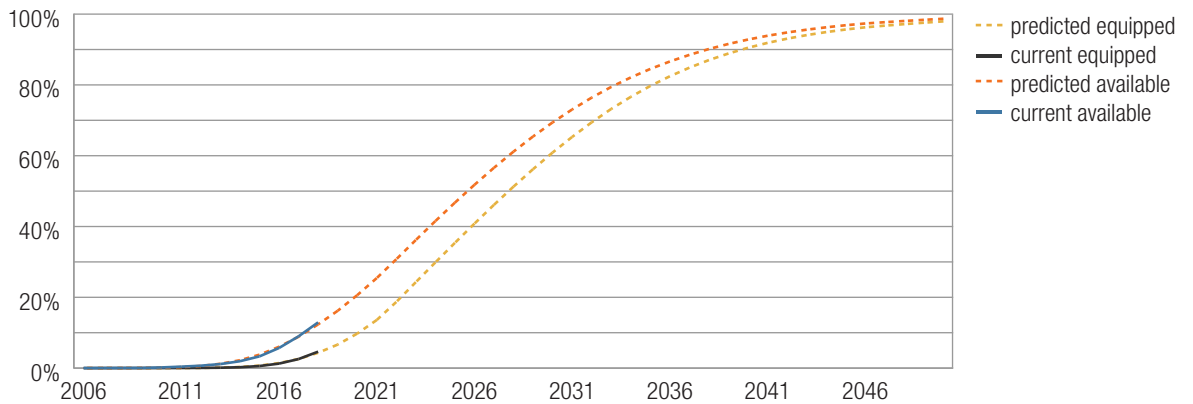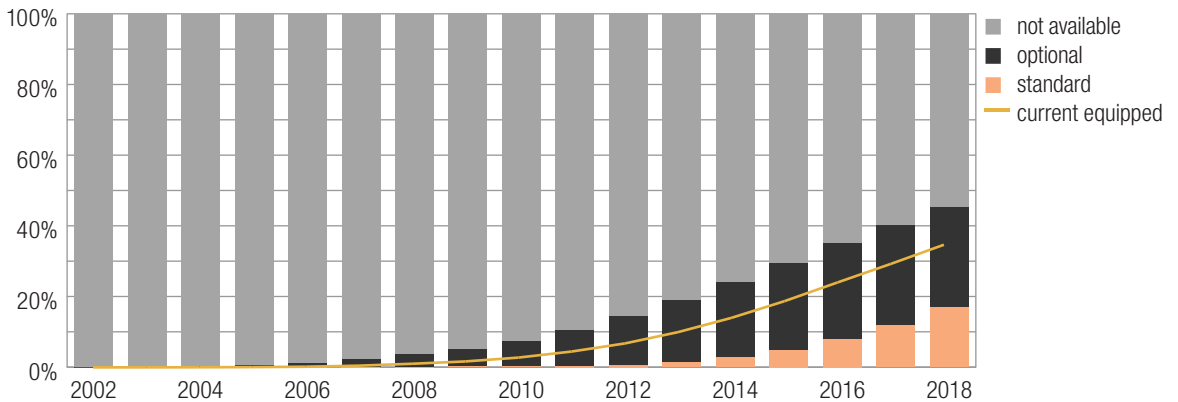

Figure 12 takes into account the 2022 voluntary commitment and shows the predicted registered vehicles by calendar year with front AEB. One prediction is for vehicles with AEB available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with AEB. It is predicted that 95 percent of registered vehicles will be equipped with AEB in 2044.

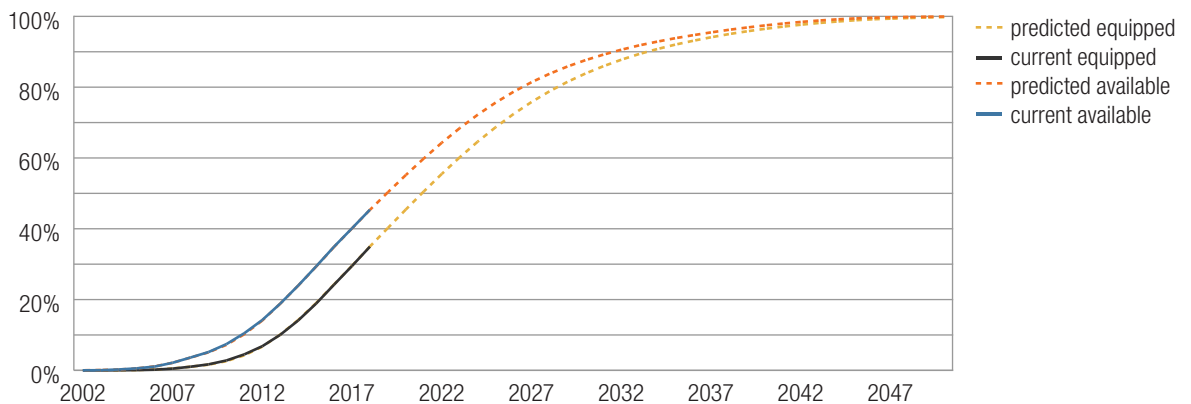**Figure 13: Percentage of new vehicle series with rear cameras by model year**
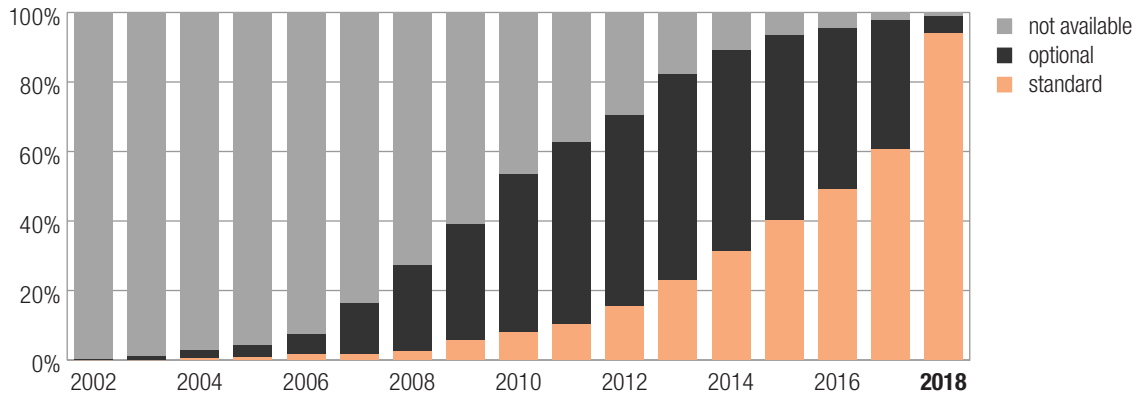
Figure 13 shows the percentage of vehicle series by model year with either standard or optional rear cameras. Rear cameras were introduced in model year 2002 and by the 2007 model year had become standard on 2 percent and optional on 15 percent of vehicle series. **Rear cameras are required on all new vehicles with a gross vehicle weight rating under 10,000 lbs produced after May 1, 2018**. For the 2018 model year, rear cameras were standard on 94 percent and optional on 5 percent of vehicle series.

Figure 14: Percentage of registered vehicles with rear cameras by calendar year

Figure 14 shows the percentage of registered vehicles by calendar year with either standard or optional rear cameras. In 2007, rear cameras had become standard on less than 1 percent and optional on 2 percent of registered vehicles. By 2018, rear cameras were standard or optional on 45 percent of registered vehicles. It was estimated that 35 percent of registered vehicles were equipped with the feature.

Figure 15: Predicted percentage of registered vehicles with rear cameras by calendar year

Figure 15 takes into account the 2018 mandate and shows the predicted registered vehicles by calendar year with rear cameras. One prediction is for vehicles with rear cameras available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with rear cameras. It is predicted that 95 percent of registered vehicles will be equipped with rear cameras in 2038.

Figure 16: Percentage of new vehicle series with adaptive headlights by model year
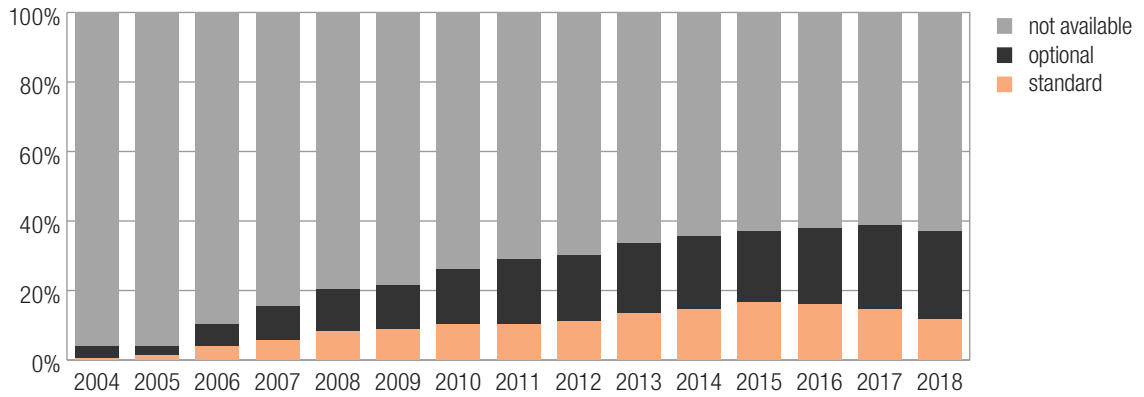

Figure 16 shows the percentage of vehicle series by model year with either standard or optional adaptive headlights. Adaptive headlights were introduced in model year 2004 and by the 2008 model year had become standard on 8 percent and optional on 12 percent of vehicle series. The percentage of vehicle series with adaptive headlights as standard has decreased from 17 percent for the 2015 model year to 12 percent for the 2018 model year. Adaptive headlights were optional on 25 percent of vehicle series for the 2018 model year.

Figure 17: Percentage of registered vehicles with adaptive headlights by calendar year
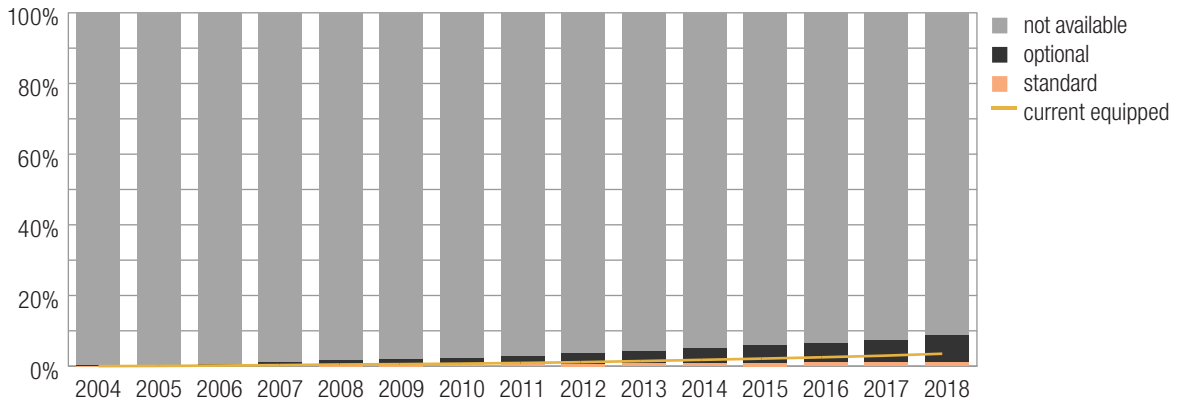

Figure 17 shows the percentage of registered vehicles by calendar year with either standard or optional adaptive headlights. In 2008, adaptive headlights had become standard on less than 1 percent and optional on 1 percent of registered vehicles. By 2018, adaptive headlights were standard or optional on 9 percent of registered vehicles, but only 4 percent of registered vehicles were estimated to be equipped with the feature.

Figure 18: Predicted percentage of registered vehicles with adaptive headlights by calendar year
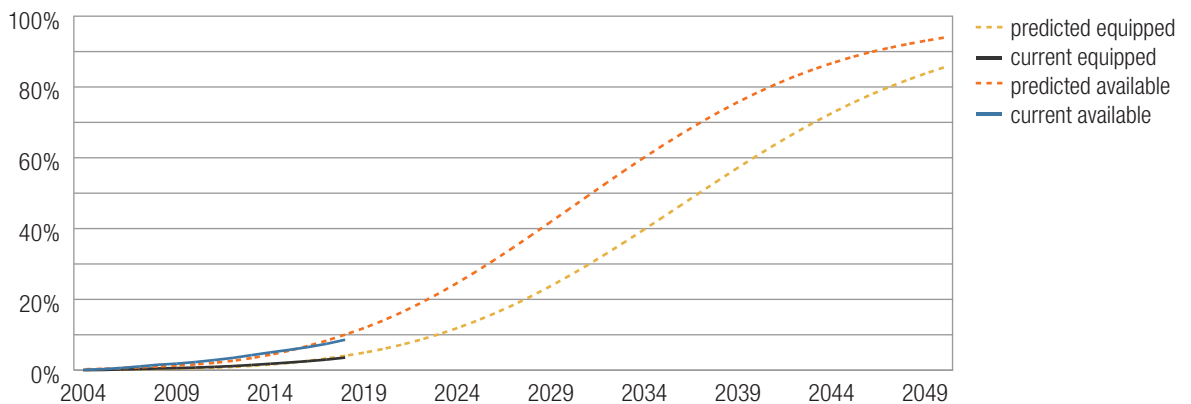

Figure 18 shows the predicted registered vehicles by calendar year with adaptive headlights. One prediction is for vehicles with adaptive headlights available (standard or optional), and the other prediction is for vehicles equipped (standard or optionally equipped) with adaptive headlights. It is predicted that 95 percent of registered vehicles will be equipped with adaptive headlights sometime after 2050.

Figure 19: Percentage of new vehicle series with lane departure warning by model year
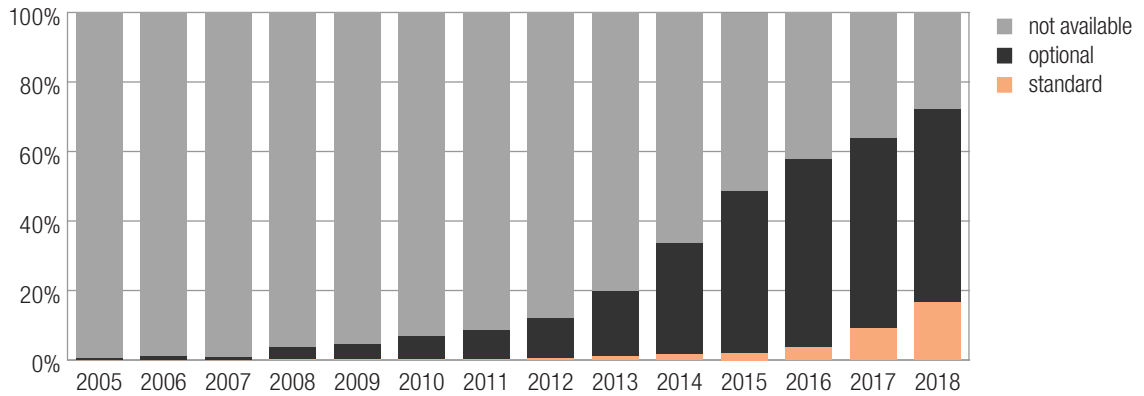

Figure 19 shows the percentage of vehicle series by model year with either standard or optional lane departure warning. Vehicles with systems that only warn drivers when they depart a lane and those with systems that both warn and provide active lane keeping are included. Lane departure warning was introduced in model year 2005 and by the 2009 model year had become standard on less than 1 percent and optional on 4 percent of vehicle series. For the 2018 model year, lane departure warning was standard on 17 percent and optional on 55 percent of vehicle series.

Figure 20: Percentage of registered vehicles with lane departure warning by calendar year
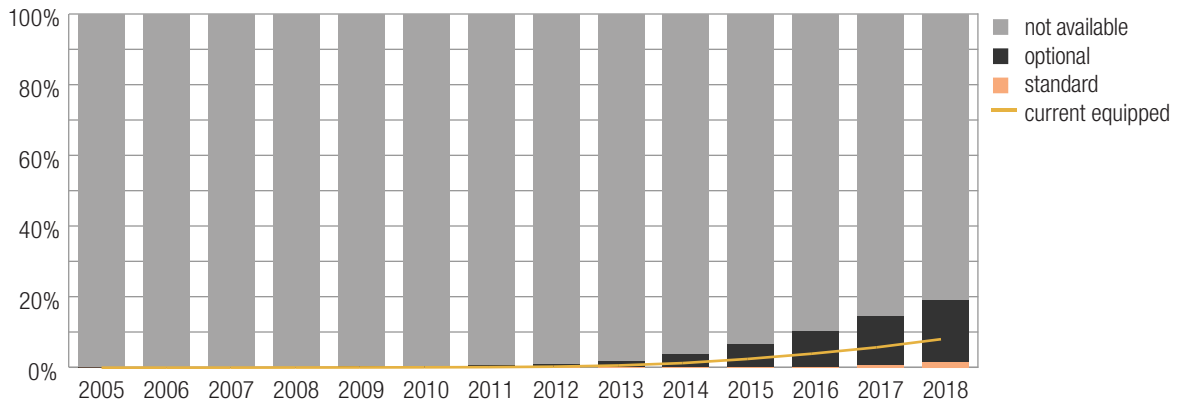

Figure 20 shows the percentage of registered vehicles by calendar year with either standard or optional lane departure warning. In 2009, lane departure warning had become standard on less than 1 percent and optional on less than 1 percent of registered vehicles. By 2018, lane departure warning was standard or optional on 19 percent of registered vehicles, but only 8 percent of registered vehicles were estimated to be equipped with the feature.

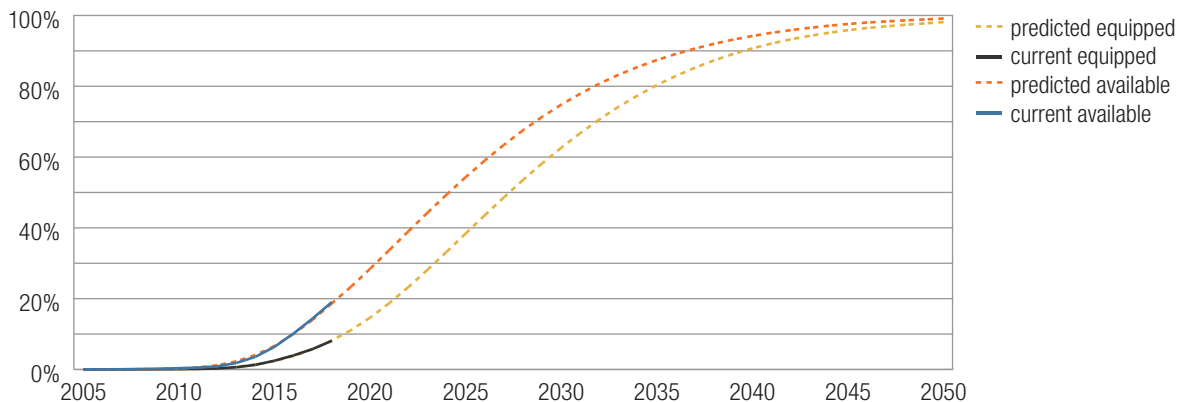**Figure 21: Predicted percentage of vehicles with lane departure warning by calendar year**

Figure 21 shows the predicted registered vehicles by calendar year with lane departure warning. One prediction is for vehicles with lane departure warning available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with lane departure warning. It is predicted that 95 percent of registered vehicles will be equipped with lane departure warning in 2044.

Figure 22: Percentage of new vehicle series with blind spot monitoring by model year
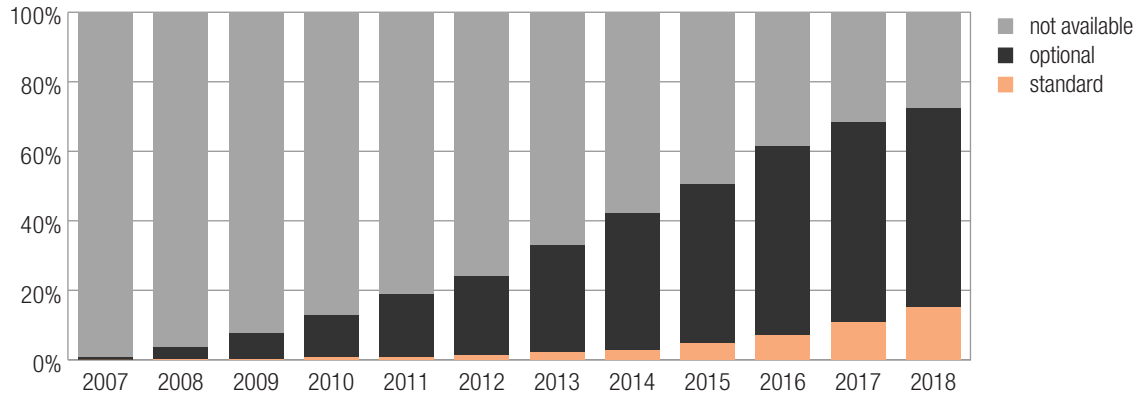

Figure 22 shows the percentage of vehicle series by model year with either standard or optional blind spot monitoring. Blind spot monitoring was introduced in model year 2007 and by the 2009 model year had become standard on less than 1 percent and optional on 8 percent of vehicle series. For the 2018 model year, blind spot monitoring was standard on 15 percent and optional on 57 percent of vehicle series.

Figure 23: Percentage of registered vehicles with blind spot monitoring by calendar year
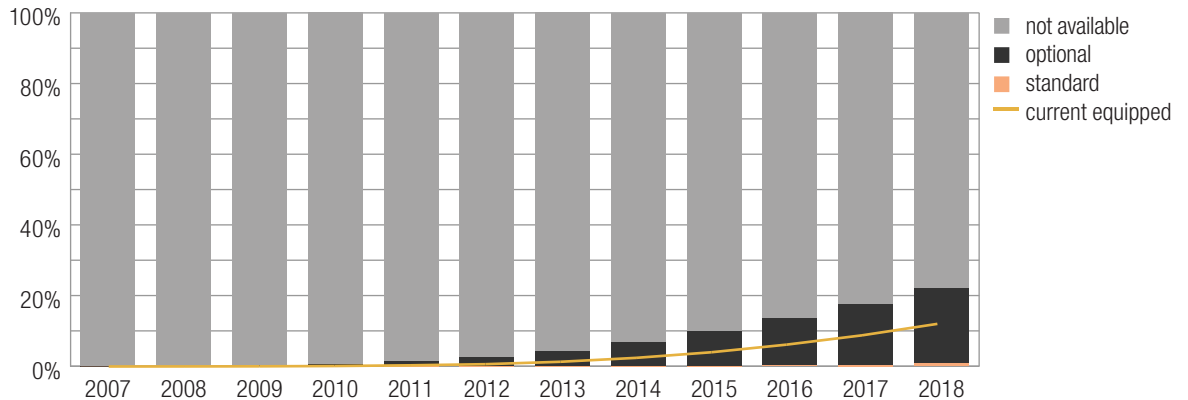

Figure 23 shows the percentage of registered vehicles by calendar year with either standard or optional blind spot monitoring. In 2009, blind spot monitoring had become standard on less than 1 percent and optional on less than 1 percent of registered vehicles. By 2018, blind spot monitoring was standard or optional on 22 percent of registered vehicles, but only 12 percent of registered vehicles were estimated to be equipped with the feature.

Figure 24: Predicted percentage of registered vehicles with blind spot monitoring by calendar year
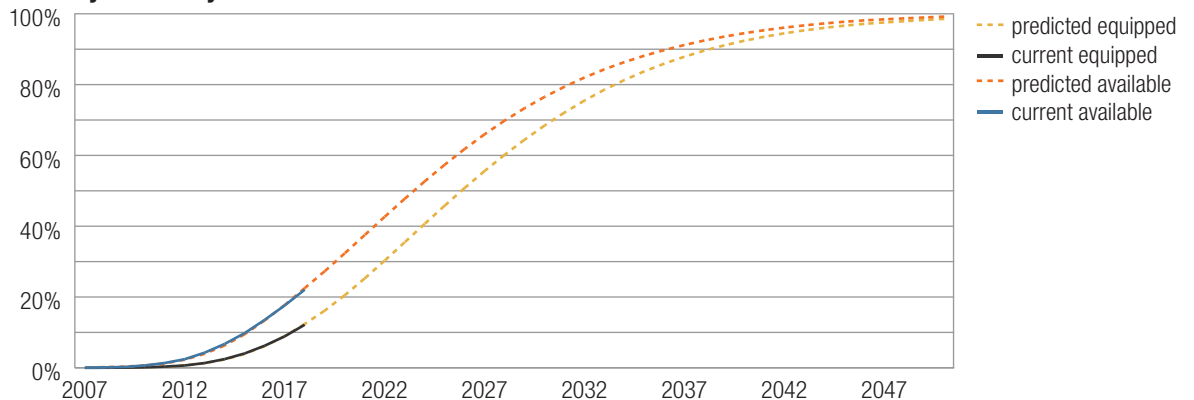

Figure 24 shows the predicted registered vehicles by calendar year with blind spot monitoring. One prediction is for vehicles with blind spot monitoring available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with blind spot monitoring. It is predicted that 95 percent of registered vehicles will be equipped with blind spot monitoring in 2043.

Figure 25: Predicted registered vehicles equipped with advanced driver assistance systems by calendar year, 2018 and 2023
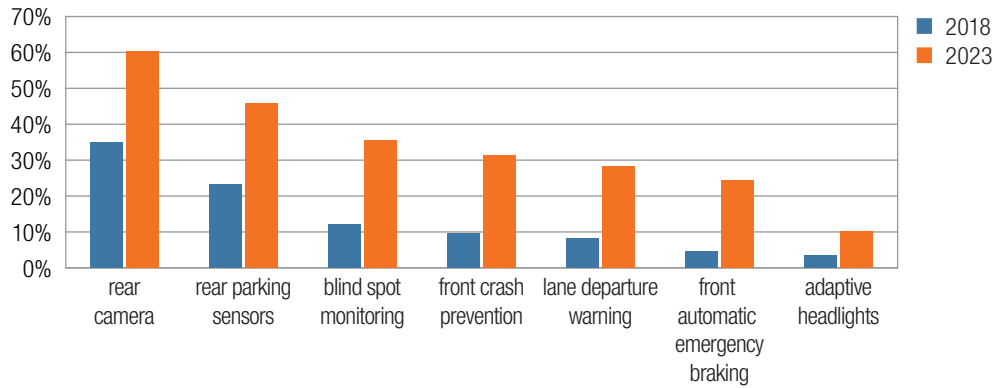

Figure 25 shows the percentage of registered vehicles fitted with a feature in 2018 and 2023. The only feature that is estimated to be fitted on more than half of the registered vehicle population in 2023 is rear cameras. Rear cameras also are predicted to have the largest percentage point growth (25 percentage points) between 2018 and 2023, a growth likely attributed to the mandate to equip passenger vehicles with the technology by May 1, 2018. Front automatic emergency braking (AEB), however, is estimated to increase fivefold from less than 5 percent of the registered vehicle population in 2018 to about 24 percent in 2023. This increase may be attributed to the voluntary agreement to equip vehicles with AEB by 2022.

‣ Discussion

It takes a long time for new vehicle features to spread through the registered vehicle fleet. Even when features are required by the government, it takes many years for features to be available on all vehicles. Many collision avoidance features have been recently introduced to the fleet, though of the ones in this study, only rear cameras have been mandated. Manufacturers have agreed to voluntarily equip vehicles with AEB by 2022.

With the exception of ESC, estimated take rates have been included for optional features. Although it isn't known with absolute certainty how many of the optional features were purchased, estimates were made from VIN data supplied from several manufacturers. This provides a better estimate of the actual penetration of collision avoidance features in the vehicle fleet. Equipped rates varied considerably by feature. Less than 5 percent of the fleet was estimated to be equipped with AEB even though it was available on 13 percent of vehicles in the 2018 fleet (2 percent standard and 11 percent optional). Rear cameras, however, were estimated to be present on 35 percent of the 2018 registered vehicle fleet, with 17 percent having it standard and 29 percent having it available as an option.

Accounting for the optionally equipped vehicles in the analysis also slowed down the projected penetration rates. Features will reach half of the registered vehicle fleet 1 to 5 years later than projected without considering optional fitment rates.

Vehicles equipped with effective collision avoidance features could also allow vehicles to persist longer in the vehicle fleet, slowing fleet turnover. A prior HLDI report on ESC found that ESC-equipped vehicles last longer in the vehicle fleet than non-ESC equipped vehicles (HLDI, 2014a). This could lead to a slowdown in the change of the fleet from one with few collision avoidance features to one with more features. 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 percent, which it approaches slowly toward the end of the distribution. When a given feature's prevalence reaches 95 percent, its growth substantially slows and it takes a number of years to capture the remaining 5 percent. It is not known how this remaining small percentage will be captured because no feature has reached 100 percent prevalence yet. 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 describe the future data. It may be the case that 100 percent prevalence is never reached, as some people tend to keep old cars as collectable vehicles. Even if so, the goal of the study was to estimate when each feature will be available for the vast majority of the fleet, not 100 percent of the fleet.

Additionally, the work presented here was based on data from a limited number of vehicle manufacturers. The estimates for the optional fitment rates were the best estimates possible with the available data. Sensitivity analysis was conducted by excluding an individual manufacturer from the dataset and using the remaining data for the analysis. For most safety features, the elimination resulted in only minimal changes of the fitment 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/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 reflected in the graphs, the model fits the existing data well, and consequently it is reasonable to believe that the predictions for the future fleet are the best possible.

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HLDI

Highway Loss Data Institute

4121 Wilson Blvd., 6th floor
Arlington, VA 22203

+1 703 247 1500

iihs-hldi.org