

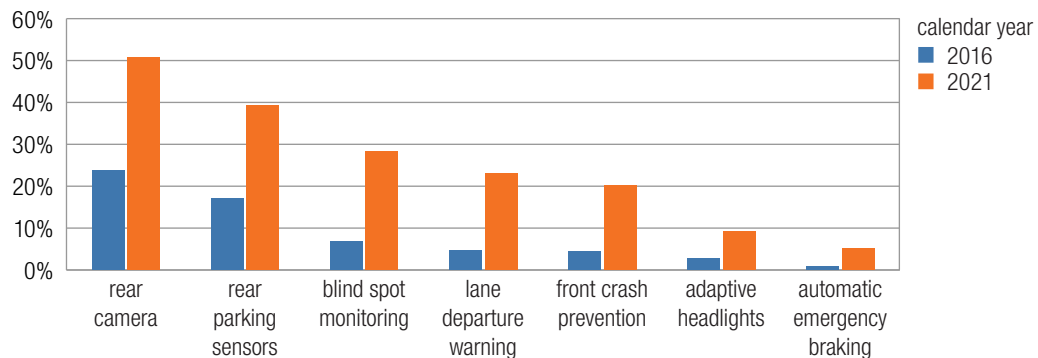


## Predicted availability and fitment of safety features on registered vehicles

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. A voluntary commitment by many manufacturers will increase the number of vehicles on the road with standard automatic braking systems.

Prior reports from HLDI (2012, 2014a, 2015, 2016) showed that it typically takes decades after introduction before most vehicles on the road have a given feature. Those reports 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. In this current report, 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 2016 and 2021. The only feature that is estimated to be on more than half of the registered vehicle population in 2021 is rear cameras. Autonomous braking, however, is estimated to have the largest growth, increasing from less than 1 percent of the registered vehicle population in 2016 to about 5 percent in 2021.

**Predicted registered vehicles equipped with Advanced Driver Assistance Systems by calendar year, 2016 and 2021**



## ► 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 bulletin 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 to predict the prevalence in the future. This bulletin differs from prior reports in that it adjusts the vehicle fleet estimates and predictions by estimating the take rates for optional features.

## ► Methods

This bulletin combines vehicle feature information from the Highway Loss Data Institute (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 bulletin: rear parking sensors, front crash prevention systems that warn and those that automatically brake, rear camera, adaptive front lighting systems, 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 2016, 2.6 percent of registered vehicles had standard rear parking sensors and another 29.9 percent had it as an option, so it is said that rear parking sensors were available in 32.5 percent of the 2016 registered vehicles.

The most recent IHS Automotive data available to HLDI contains calendar years 1976–2016. For each calendar year, a number of recent model years are used, ranging from 10 model years for calendar year 1976 to 39 model years for calendar year 2016. 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 39 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 are present in earlier calendar years, age out of the dataset, and then re-enter 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 report, original data were used from 1976 to 2008, while restated data were used for calendar years 2009–16.

**Approach used to estimate optional-equipped rates:** This report estimates the optional fitment rates for each of the features using HLDI feature data and VIN information from approximately a dozen manufacturers. Using HLDI's vehicle information, vehicles registered in 2016 with optional features were identified. Individual feature fitment rates for calendar year 2016 were estimated based on VIN data HLDI previously received from a limited number of manufacturers. The vehicle series with known optional fitment rates comprised approximately 10 percent of total optional registrations. 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 all of the following variables: model year, size, class, and price level, the fitment rates were estimated with regression models that used as many of those 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 2018, registrations for new vehicles for 5 calendar years (2012–16) were averaged. New vehicles are defined as vehicles aged 0 and -1. 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 be aged -1. To predict new vehicle registrations for calendar years 2017–50, 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 2018 and beyond were calculated by adding 0.9 percent to the prior year registration counts.

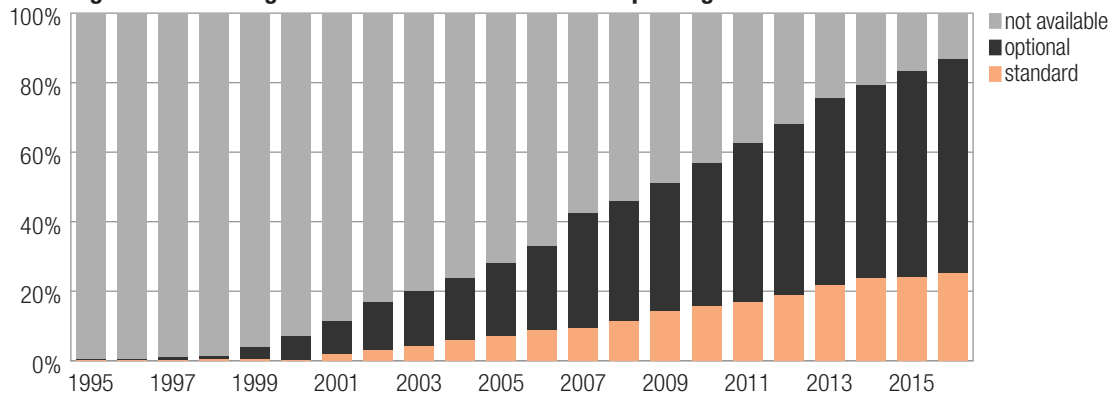
**Approach used to estimate attrition rates:** Attrition rates were calculated for each calendar/model year combination through 2016 and applied to future years (2017–50) and vehicles of the same age. Additionally, to account for changes in attrition, a 30-year past trend was studied. During this time period, attrition rates declined on average 0.2 percent per calendar year. Based on this, the attrition was estimated to be slower by 3.8 percentage points ( $0.2\% * (1+34)/2$ ) on average in the future years (2017–50). 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.

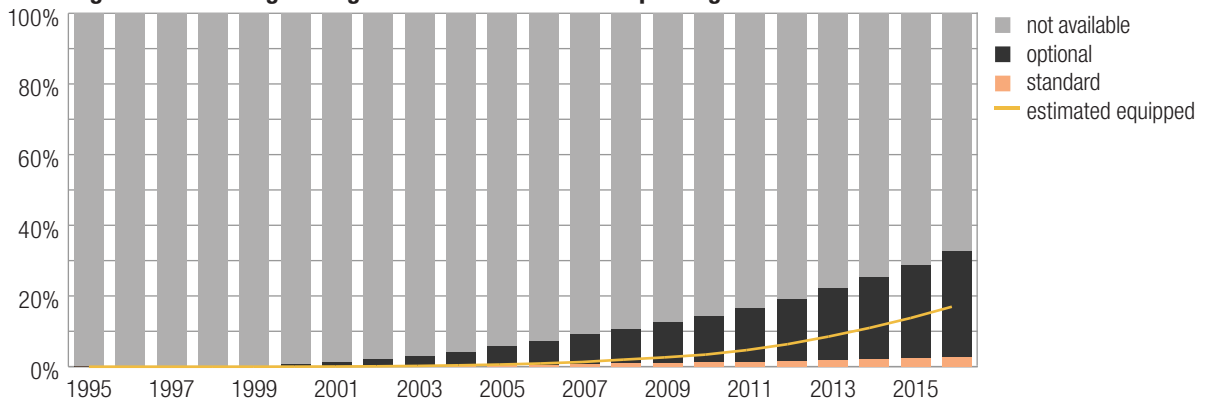
## ► Results

**Figure 1: Percentage of new vehicle series with rear parking sensors**



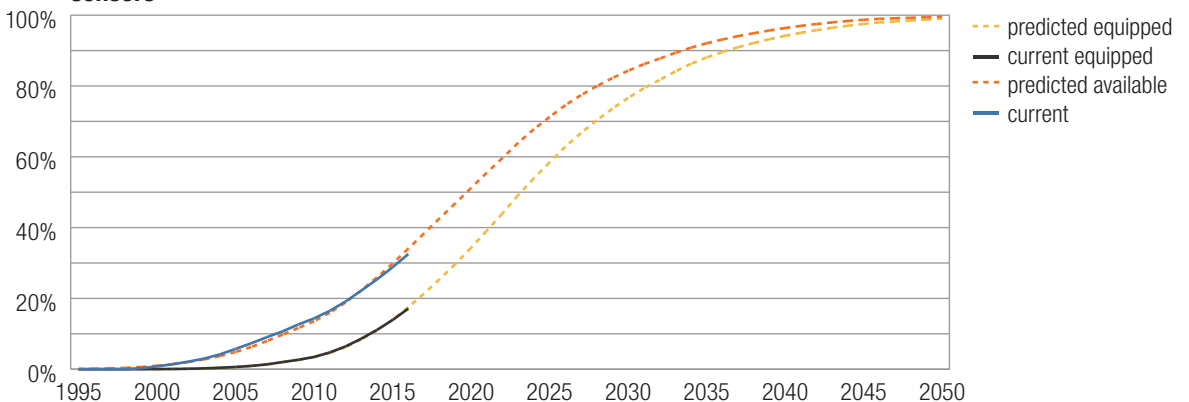
**Figure 1** shows the percentage of vehicle series by model year with either standard or optional rear parking sensors. Rear parking sensors were introduced in model year 1995 and by the 2004 model year had become standard on 6 percent and optional on 18 percent of vehicle series. For the 2016 model year, rear parking sensors were standard on 25 percent and optional on 61 percent of vehicle series.

**Figure 2: Percentage of registered vehicles with rear parking sensors**

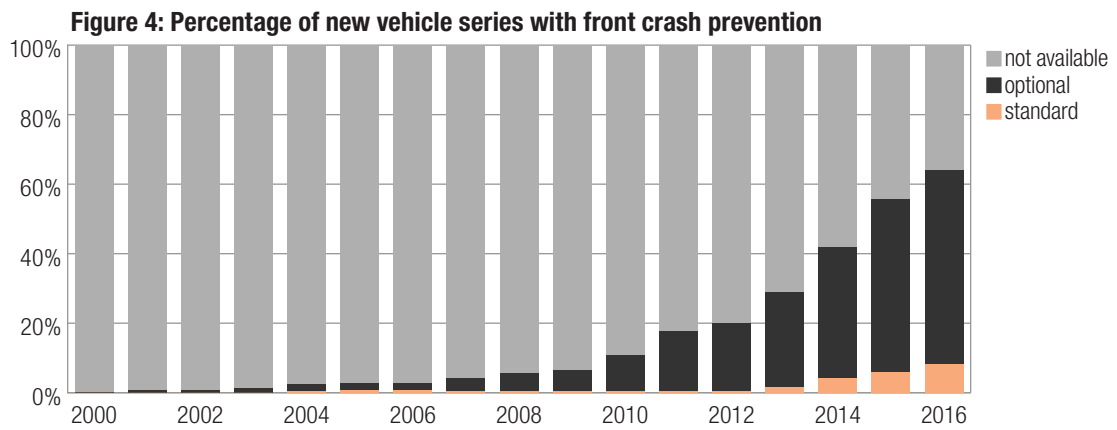


**Figure 2** shows the percentage of registered vehicles by calendar year with either standard or optional rear parking sensors. In 2004, rear parking sensors had become standard on less than 1 percent and optional on 4 percent of registered vehicles. By 2016, rear parking sensors were standard or optional on 32.5 percent of registered vehicles, but only 17 percent of registered vehicles were estimated to be equipped with the feature.

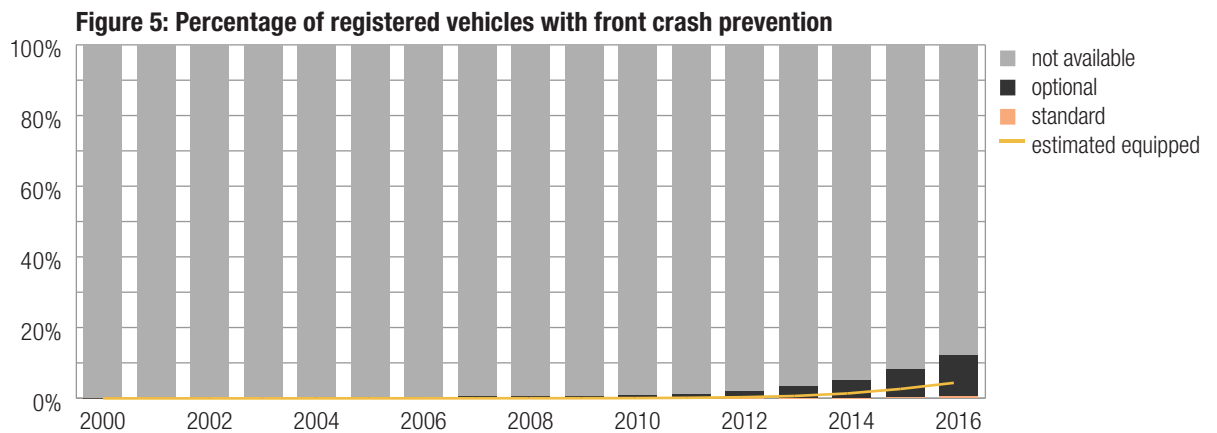
**Figure 3: Predicted percentage of registered vehicles with rear parking sensors**



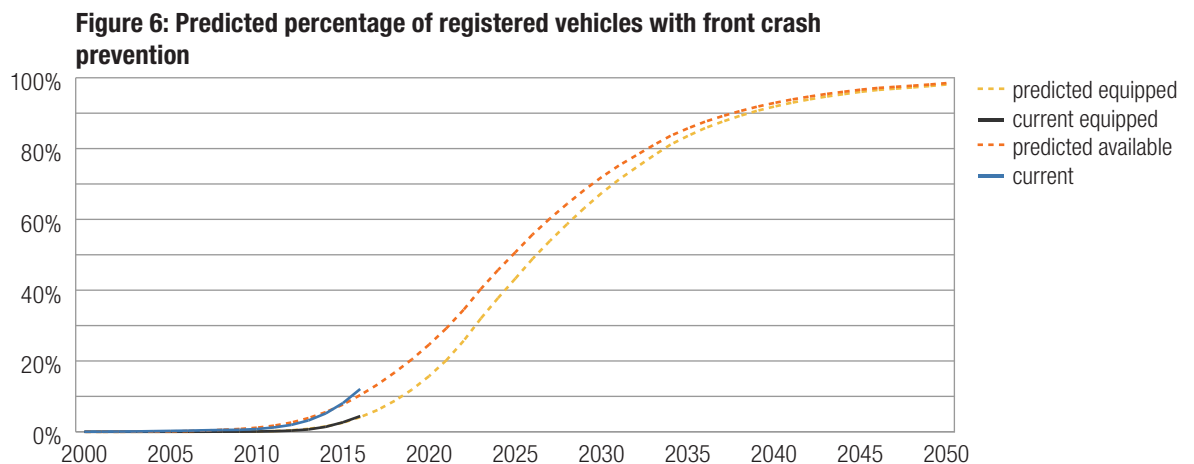
**Figure 3** shows the percentage of predicted registered vehicles by calendar year with rear parking sensors. One prediction is for vehicles with rear parking sensors available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with the sensors. It is predicted that 95 percent of registered vehicles will be equipped with rear parking sensors in 2041.



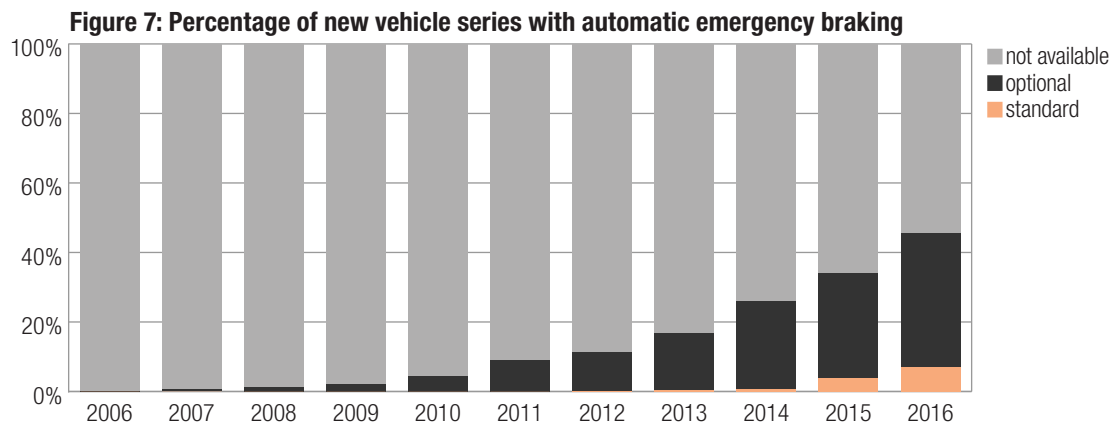
**Figure 4** shows the percentage of vehicle series by model year with either standard or optional front crash prevention. It includes vehicles that only warn and those that warn and automatically brake. Front crash prevention was introduced in model year 2000 and by the 2006 model year had become standard on 1 percent and optional on 2 percent of vehicle series. For the 2016 model year, front crash prevention was standard on 8 percent and optional on 56 percent of vehicle series.



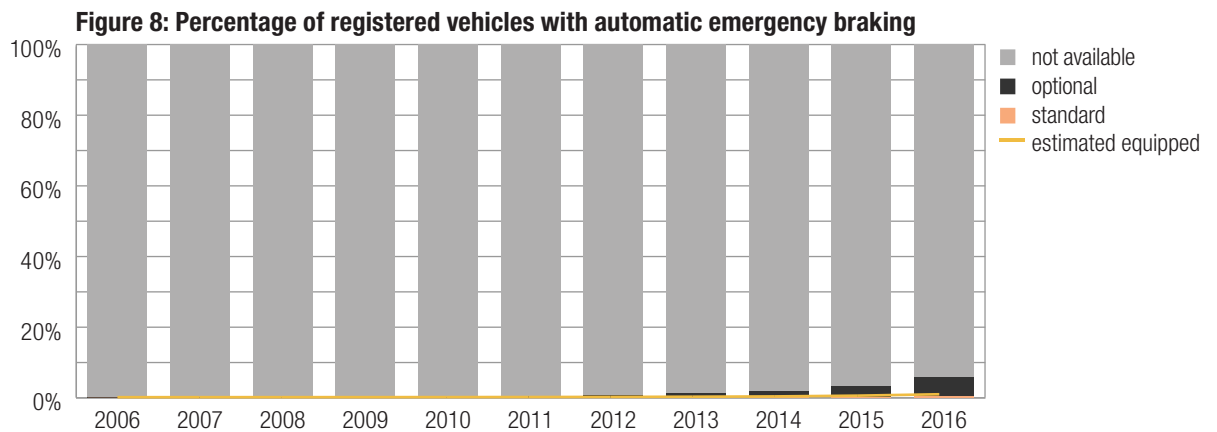
**Figure 5** shows the percentage of registered vehicles by calendar year with either standard or optional front crash prevention. In 2006, front crash prevention had become standard on less than 1 percent and optional on less than 1 percent of registered vehicles. By 2016, front crash prevention was standard or optional on 12 percent of registered vehicles, but only 4.4 percent of registered vehicles were estimated to be equipped with the feature.



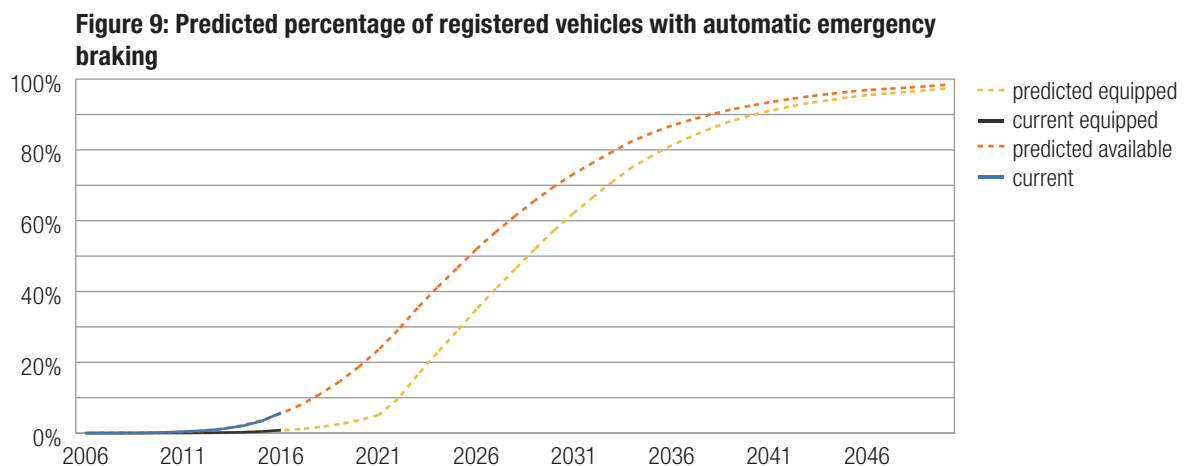
**Figure 6** takes into account a 2022 voluntary commitment by many manufacturers to make automatic emergency braking (AEB) standard on most of their vehicles by 2022. It shows the predicted registered vehicles by calendar year with front crash prevention. One prediction is for vehicles with front crash 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.



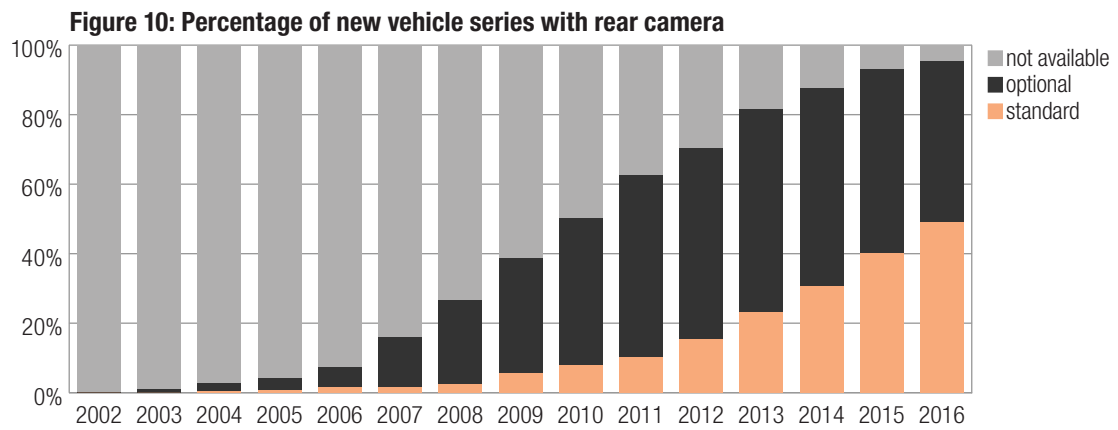
**Figure 7** shows the percentage of vehicle series by model year with either standard or optional AEB. These systems may also warn. AEB was introduced in model year 2006 and by the 2012 model year had become standard on less than 1 percent and optional on 11 percent of vehicle series. For the 2016 model year, AEB was standard on 7 percent and optional on 38.5 percent of vehicle series.



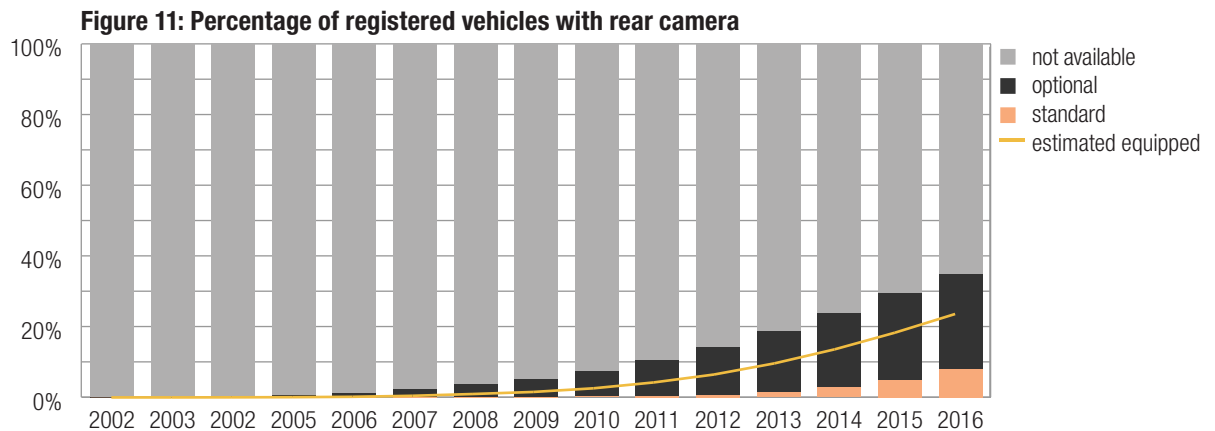
**Figure 8** shows the percentage of registered vehicles by calendar year with either standard or optional AEB. In 2012, AEB had become standard on less than 1 percent and optional on 1 percent of registered vehicles. By 2016, AEB was standard or optional on 6 percent of registered vehicles but estimated to be equipped only on 1 percent.



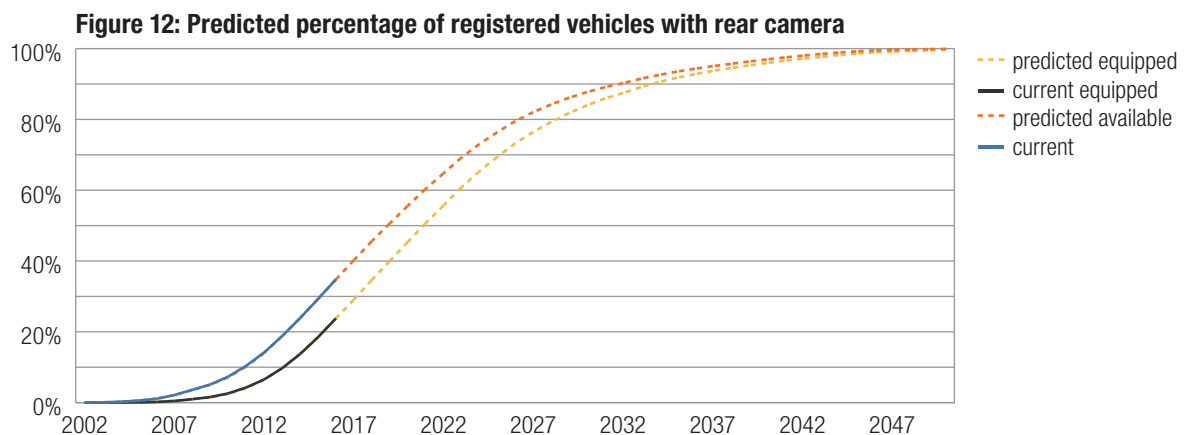
**Figure 9** takes into account the 2022 voluntary commitment and shows the predicted registered vehicles by calendar year with AEB. One prediction is for vehicles with AEB available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with AEB. It is predicted that 95 percent of registered vehicles will be equipped with AEB in 2045.



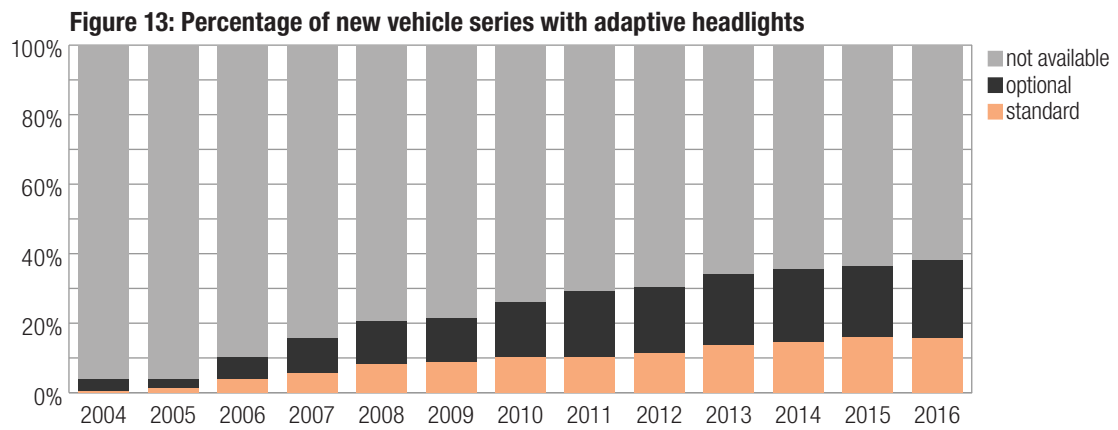
**Figure 10** shows the percentage of vehicle series by model year with either standard or optional rear cameras. Rear cameras were introduced in model year 2002 and by the 2007 model year had become standard on 2 percent and optional on 14 percent of vehicle series. For the 2016 model year, rear cameras were standard on 49 percent and optional on 46 percent of vehicle series. Rear cameras will be required on all new vehicles starting May 1, 2018.



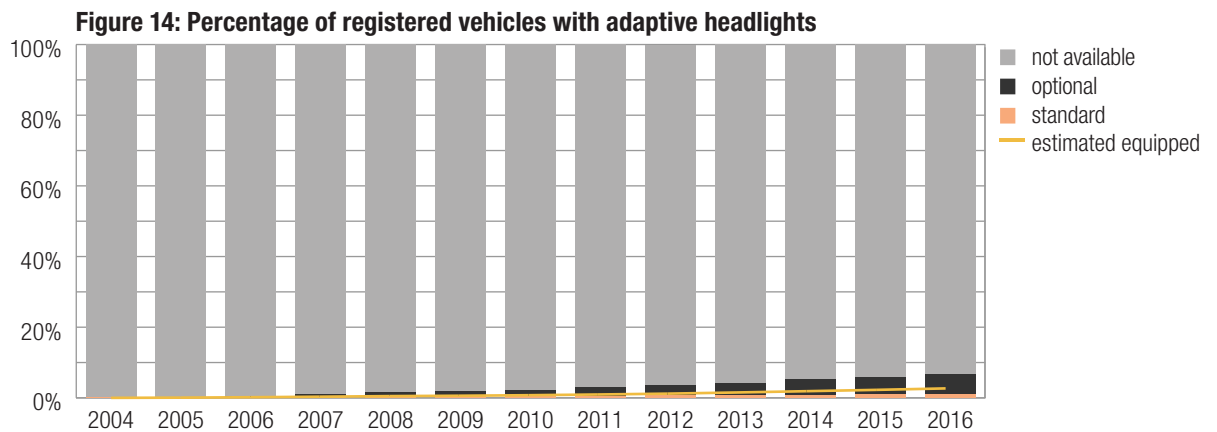
**Figure 11** shows the percentage of registered vehicles by calendar year with either standard or optional rear cameras. In 2007, rear cameras had become standard on less than 1 percent and optional on 2 percent of registered vehicles. By 2016, rear cameras were standard or optional on 35 percent of registered vehicles. It was estimated that twenty-four percent of registered vehicles were equipped with the feature.



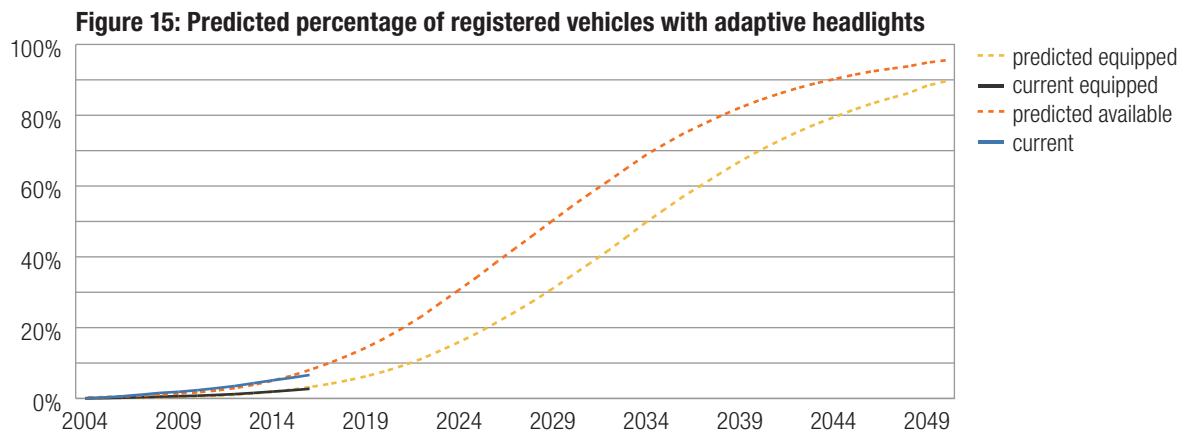
**Figure 12** takes into account the 2018 mandate and shows the predicted registered vehicles by calendar year with rear cameras. One prediction is for vehicles with rear cameras available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with rear cameras. It is predicted that 95 percent of registered vehicles will be equipped with rear cameras in 2039.



**Figure 13** 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. For the 2016 model year, adaptive headlights were standard on 16 percent and optional on 22 percent of vehicle series.

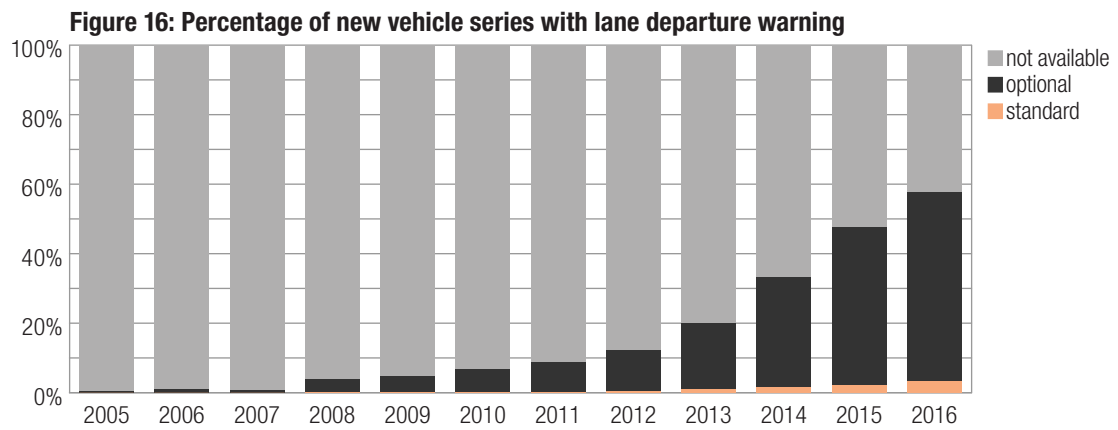


**Figure 14** shows the percentage of registered vehicles by calendar year with either standard or optional adaptive headlights. In 2008, adaptive headlights had become standard on less than 1 percent and optional on 1 percent of registered vehicles. By 2016, adaptive headlights were standard or optional on 6.6 percent of registered vehicles, but only 2.7 percent of registered vehicles were estimated to be equipped with the feature.

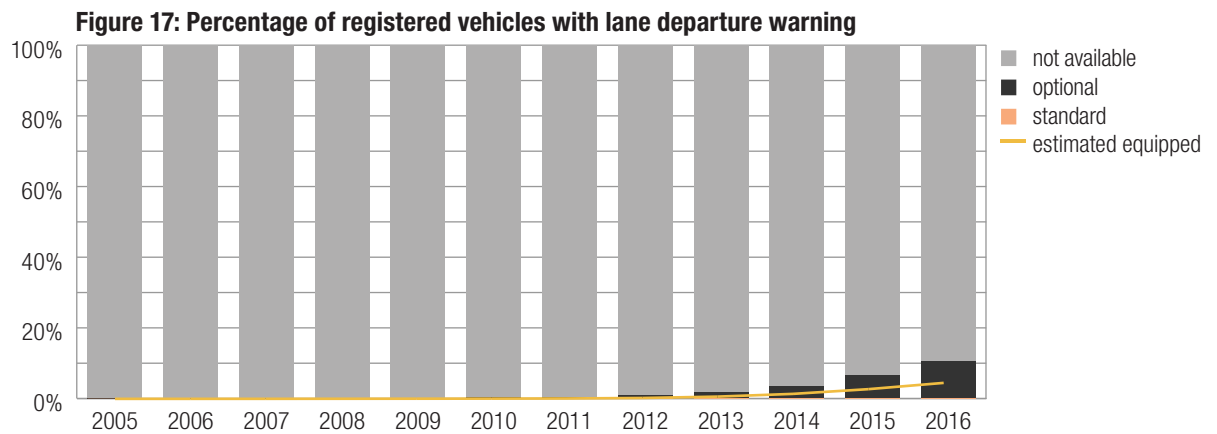


**Figure 15** shows the predicted registered vehicles by calendar year with adaptive headlights. One prediction is for vehicles with adaptive headlights available (standard or optional), and the other prediction is for vehicles equipped (standard or optionally equipped) with adaptive headlights. It is predicted that 95 percent of registered vehicles will be equipped with adaptive headlights sometime after 2050.

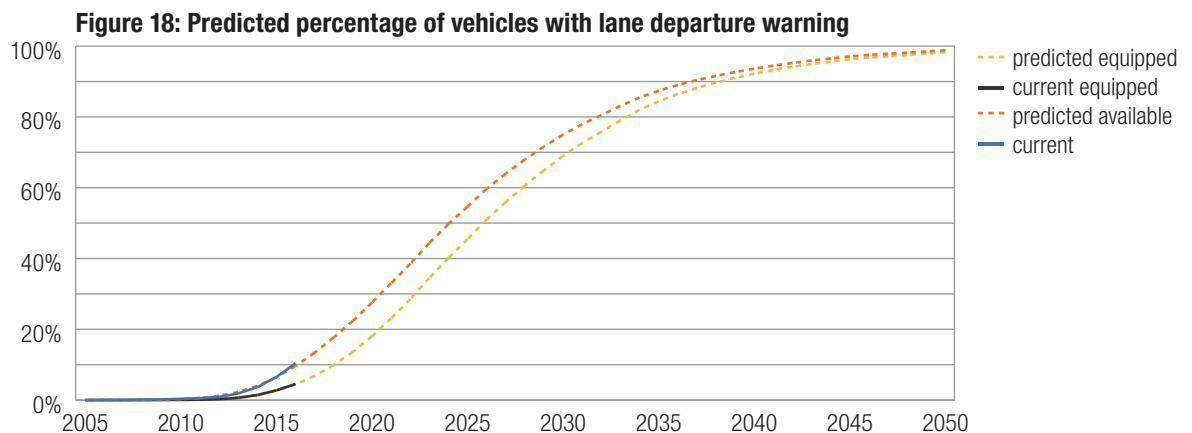




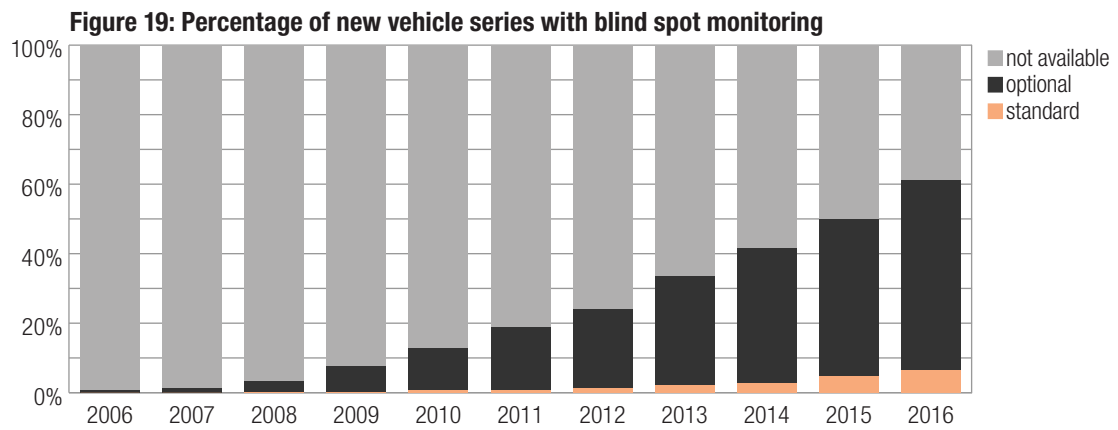
**Figure 16** shows the percentage of vehicle series by model year with either standard or optional lane departure warning. Vehicles with systems that only warn drivers when they depart a lane and those with systems that both warn and provide active lane keeping are included. Lane departure warning was introduced in model year 2005 and by the 2009 model year had become standard on less than 1 percent and optional on 4.5 percent of vehicle series. For the 2016 model year, lane departure warning was standard on 3 percent and optional on 54 percent of vehicle series.



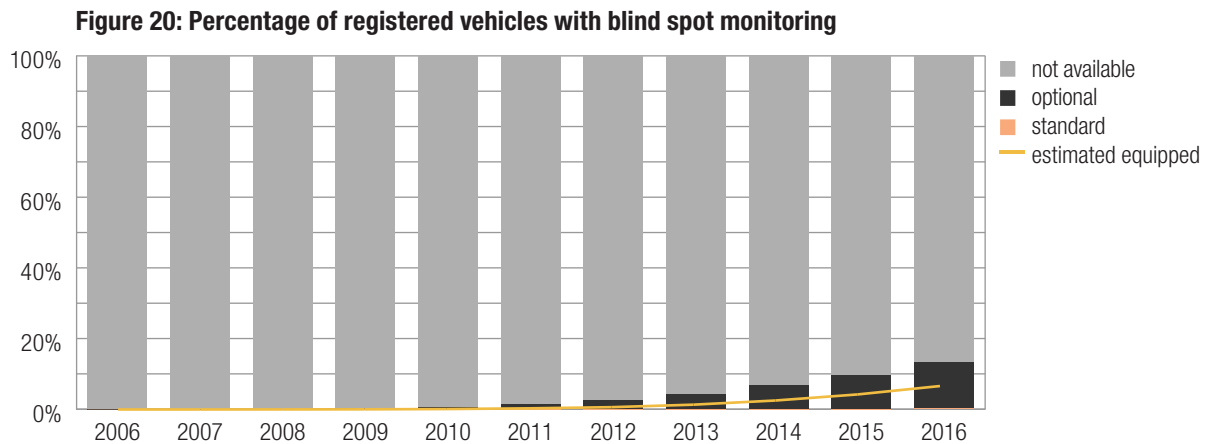
**Figure 17** shows the percentage of registered vehicles by calendar year with either standard or optional lane departure warning. In 2009, lane departure warning had become standard on less than 1 percent and optional on less than 1 percent of registered vehicles. By 2016, lane departure warning was standard or optional on 10 percent of registered vehicles, but only 4.6 percent of registered vehicles were estimated to be equipped with the feature.



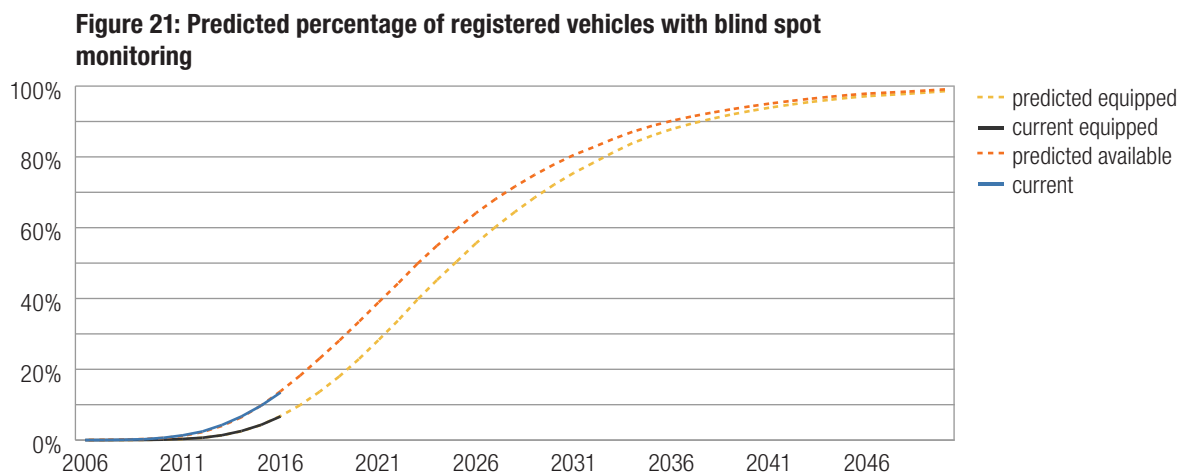
**Figure 18** shows the predicted registered vehicles by calendar year with lane departure warning. One prediction is for vehicles with lane departure warning available (standard or optional) and the other prediction is for vehicles equipped (standard or optionally equipped) with lane departure warning. It is predicted that 95 percent of registered vehicles will be equipped with lane departure warning in 2043.



**Figure 19** 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 2006 and by the 2009 model year had become standard on less than 1 percent and optional on 7.5 percent of vehicle series. For the 2016 model year, blind spot monitoring was standard on 7 percent and optional on 55 percent of vehicle series.



**Figure 20** 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 2016, blind spot monitoring was standard or optional on 13 percent of registered vehicles, but only 7 percent of registered vehicles were estimated to be equipped with the feature.



**Figure 21** 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 22: Predicted registered vehicles equipped with Advanced Driver Assistance Systems by calendar year, 2016 and 2021**

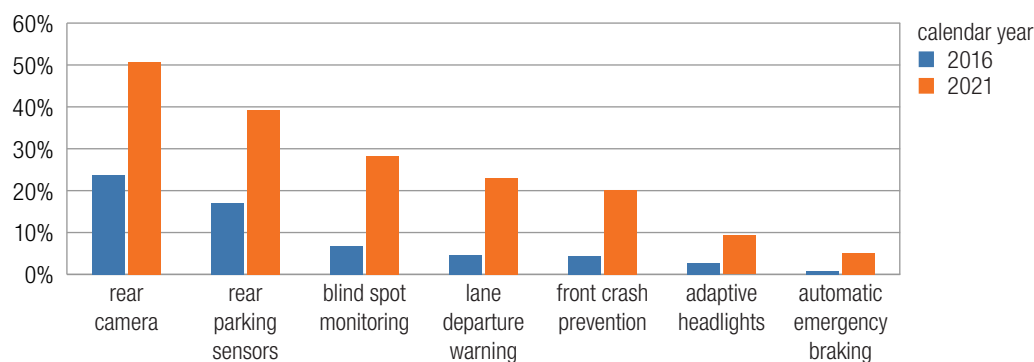


Figure 22 shows the percentage of registered vehicles fitted with a feature in 2016 and 2021. The only feature that is estimated to be fitted on more than half of the registered vehicle population in 2021 is rear cameras. Autonomous braking, however, is estimated to have the largest growth, increasing from less than 1 percent of the registered vehicle population in 2016 to about 5 percent in 2021.

## ► 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 report only rear cameras have been mandated. Manufacturers have agreed to voluntarily equip vehicles with automatic emergency braking by 2022.

For the first time since HLDI began conducting this type of analysis, 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. Only 1 percent of the fleet was estimated to be equipped with automatic emergency braking even though it was available on 5.7 percent of vehicles in the 2016 fleet (0.3 percent standard and 5.4 percent optional). Rear cameras, however, were estimated to be present on 24 percent of the 2016 registered vehicle fleet, with 8 percent having it standard and 27 percent having it 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 2-5 years later than projected without considering optional fitment rates.

Comparisons can be made between this report and earlier ones. For most features, the current estimated date when a feature would be available (standard or optional) on 95 percent of the vehicle population is within 1-2 years of initial estimates published by HLDI in 2014. Front crash prevention and adaptive headlights are the exceptions. Given the 2022 mandate, front crash prevention is expected to reach 95 percent of the fleet 5 years sooner than the original estimate. Adaptive headlights, however, for reasons that aren't clear, could reach 95 percent 5 years later than originally estimated.

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 electronic stability control (ESC) found that ESC-equipped vehicles last longer in the vehicle fleet than non-ESC equipped vehicles (HLDI, 2014b). 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 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 since 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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