



2013–15 Honda Accord collision avoidance features

This is the fourth look at the collision avoidance features on the Honda Accord. The Honda Accord is a popular passenger car and is one of the best-selling vehicles in America. Interestingly, Honda has equipped most of the Accords with a camera-based front crash prevention system, while one Honda Accord trim is equipped with a radar-based one.

This Highway Loss Data Institute (HLDI) report updates three prior analyses of Honda Accord collision avoidance features with the addition of the 2015 model year. Forward Collision Warning (FCW) paired with Lane Departure Warning (LDW) is on most Honda Accord trims, as well as the Crosstour, and uses a single camera mounted behind the windshield for sensing. The Honda Accord four-door Touring trim is studied for only the second time in this bulletin and is equipped with FCW, LDW, and Adaptive Cruise Control (ACC). This system utilizes a radar unit mounted in the front grille, similar to most other forward collision warning systems studied by HLDI. Despite similar FCW function, these systems are evaluated separately. LaneWatch, a passenger-side blind spot information system, utilizes a camera mounted on the passenger side mirror and is equipped on some of the studied vehicles.

With the addition of time and the 2015 model year, there is almost 75 percent more exposure in this study as in the prior one. All of the estimates in this study are within the confidence bounds of the prior study. The updated results for the FCW/LDW system continue to be associated with reductions in claim frequency for all five coverage types examined. The property damage liability (PDL) claim frequency benefits for the radar-based system are slightly larger than those for the camera system, but the confidence bounds overlap. Alternative analysis for the camera-based system using data from 2012 model year vehicles to control for differences in trim levels yields similar results. This is an indication that the benefits for the camera-based system can be attributed to the feature and not variability associated with the trim level.

The camera-based system is associated with a decline in collision claim severity, while the radar based Touring system is associated with a significant increase. This is consistent with previous HLDI findings, and the increased claim severity is likely associated with the replacement cost of the radar units in crashes not avoided.

The updated claim frequency loss results for LaneWatch continue to be equivocal. Simple comparisons of trim lines with and without LaneWatch were consistent with expectations. Incursion into an occupied adjacent lane would be expected to result in a two-vehicle crash that would lead to a PDL claim against the encroaching driver. The estimated reductions in PDL claims are much larger than the reductions estimated for collision claims. This is consistent with the fact that the reductions in collision claims from such crashes would be diluted by the many single-vehicle crashes that result in collision claims and are unaffected by the LaneWatch system. However, alternative analysis using data from 2012 model year vehicles to control for differences in trim levels indicates an increase in claim frequency under three coverage types for the system. Thus, the observed benefits may not be attributable to the LaneWatch system.

Change in claim frequencies by collision avoidance feature, results summary

Vehicle damage coverage type	Forward Collision Warning & Lane Departure Warning				Forward Collision Warning, Lane Departure Warning & Adaptive Cruise Control	
	April 2014	September 2014	April 2015	Current	April 2015	Current
Collision	-3.8%	-3.6%	-1.7%	-2.3%	2.0%	4.4%
Property damage liability	-14.0%	-9.9%	-11.7%	-10.1%	-15.8%	-13.2%
Injury coverage type	April 2014	September 2014	April 2014	Current	April 2015	Current
Bodily injury liability	-39.5%	-29.2%	-26.8%	-24.2%	-39.4%	-12.5%
Medical payment	-27.3%	-29.7%	-22.3%	-21.7%	-25.7%	-26.7%
Personal injury protection	-10.7%	-16.8%	-6.3%	-6.4%	10.4%	5.6%

Introduction

This Highway Loss Data Institute (HLDI) bulletin provides an updated look at the effects of available Honda Accord collision avoidance systems on insurance losses. Earlier HLDI studies found encouraging results (HLDI, 2014a, 2014b, 2015). Prior HLDI results indicate these systems are having some benefit. This HLDI bulletin updates prior analyses with more exposure and adds the 2015 Honda Accord model year vehicles. The features included in this analysis are as follows:

Forward Collision Warning (FCW) uses a camera system located behind the windshield to assess the risk of a collision with leading traffic. The warning system has three driver-selectable range settings. When a potential crash is detected, lights flash in the heads-up display, the FCW indicator blinks, and there is continuous beeping. The system is active only at speeds more than 10 mph and can be deactivated by the driver. At each ignition cycle, the system defaults to the previous on/off setting. Vehicles with FCW also have Lane Departure Warning.

Lane Departure Warning (LDW) utilizes the same camera as forward collision warning to also identify traffic lane markings. Audio and visual warnings will indicate if the vehicle path deviates from the intended lane. The system is functional at speeds between 40 and 90 mph but does not warn if the turn signal is on or the movement is determined to be sufficiently sudden as to be evasive. The system can be deactivated by the driver. At each ignition cycle, the system defaults to the previous on/off setting.

Adaptive Cruise Control (ACC) uses radar sensors mounted in the front bumper to monitor traffic ahead and maintain the driver's selected following distance. As traffic conditions dictate, the system employs braking force to maintain the set following distance. Adaptive cruise control is active at speeds more than 10 mph. Forward Collision Warning remains active even when adaptive cruise control is turned off.

LaneWatch is Honda's term for a passenger-side-only blind spot monitor. A camera mounted behind the external passenger side rearview mirror monitors the passenger side of the vehicle and displays an 80-degree field of view on the console-mounted information screen when the turn signal indicator is activated. Reference lines are also provided to indicate proximity. Both the turn signal indicator and reference lines are driver-controllable settings and can be deactivated. An upcoming navigation system maneuver can also be given priority over the LaneWatch display. LaneWatch can be deactivated by the driver. At each ignition cycle, it will default to the previous on/off setting.

All of the vehicles in this study were equipped with rear cameras. As there are no vehicles without this feature, their effectiveness cannot be evaluated in this analysis. The vehicles in this analysis may also have been equipped with optional rear parking sensors. This feature was not controlled for in the analysis, as the availability of rear parking sensors on a vehicle was not discernible from the vehicle identification number (VIN).

► Method

Vehicles

Several trim levels are offered on the vehicles included in this study. Trim levels are bundles of vehicle options such as interior materials, engines, and comfort, convenience, and safety features. For example, the Honda Accord EX-L V6 is equipped with a 6-cylinder motor, leather seats, and several collision avoidance technologies. The less expensive LX is equipped with cloth seats, a 4-cylinder motor, and no collision avoidance technologies. For the Honda vehicles included in this study, the trim levels can be determined in the first 10 positions of the VIN. The collision avoidance features in this study are either standard or not available at the trim level. Consequently, by knowing the trim level, the presence of the collision avoidance features is known. LaneWatch and the combination of FCW and LDW are offered as standard equipment on several 2013–15 Honda Accord models (trims). LaneWatch and the combination of FCW, LDW, and ACC are offered on the Touring trim of the four-door Honda Accord. Honda Accord vehicles without these features served as the control vehicles in the analysis. **Table 1** lists total exposure, measured in insured vehicle years, and the exposure of each feature as a percentage of total exposure. Also included in **Table 1** is the exposure from the three prior HLDI reports.

Table 1: Feature exposure by vehicle series

Make	Series	Model year range	Forward Collision Warning (includes Lane Departure Warning)	Forward Collision Warning (includes Lane Departure Warning and Adaptive Cruise Control)	LaneWatch	Total exposure	April 2015 report exposure	September 2014 report exposure	April 2014 report exposure
Honda	Accord 2dr	2013–15	67%	–	67%	95,725	56,381	29,915	15,183
Honda	Accord 4dr	2013–15	37%	–	47%	985,148	569,785	283,665	157,309
Honda	Accord 4dr Touring	2013–15	–	100%	100%	20,007	11,662	–	–
Honda	Accord Crosstour 4dr	2013–15	70%	–	78%	18,692	10,767	5,750	2,408
Honda	Accord Crosstour 4dr 4WD	2013–15	100%	–	100%	15,301	8,671	4,474	1,968

Insurance Data

Automobile insurance covers damages to vehicles and property as well as injuries to people involved in crashes. Different insurance coverages pay for vehicle damage versus injuries, and different coverages may apply depending on who is at fault. The current study is based on property damage liability, collision, bodily injury liability, personal injury protection, and medical payment coverages. Exposure is measured in insured vehicle years. An insured vehicle year is one vehicle insured for 1 year, two vehicles for 6 months, etc.

Because different crash avoidance features may affect different types of insurance coverage, it can be important to understand how coverages vary among the states and how this affects inclusion in the analyses. Collision coverage insures against vehicle damage to an at-fault driver’s vehicle sustained in a crash with an object or other vehicle; this coverage is common to all 50 states. Property damage liability (PDL) coverage insures against vehicle damage that at-fault drivers cause to other people’s vehicle and property in crashes; this coverage exists in all states except Michigan, where vehicle damage is covered on a no-fault basis (each insured vehicle pays for its own damage in a crash, regardless of who is at fault).

Coverage of injuries is more complex. Bodily injury (BI) liability coverage insures against medical, hospital, and other expenses for injuries that at-fault drivers inflict on occupants of other vehicles or others on the road; although motorists in most states may have BI coverage, this information is analyzed only in states where the at-fault driver has first obligation to pay for injuries (33 states with traditional tort insurance systems). Medical payment (MedPay) coverage, also sold in the 33 states with traditional tort insurance systems, covers injuries to insured drivers and the passengers in their vehicles, but not injuries to people in other vehicles involved in the crash. Seventeen other states employ no-fault injury systems (personal injury protection coverage, or PIP) that pay up to a specified amount for injuries to occupants of involved-insured vehicles, regardless of who is at fault in a collision. The District of Columbia has a hybrid insurance system for injuries and is excluded from the injury analysis.

Statistical methods

Regression analysis was used to quantify the effect of each vehicle feature while controlling for other covariates. The covariates included calendar year, model year, garaging state, vehicle density (number of registered vehicles per square mile), rated driver age group, rated driver gender, rated driver marital status, deductible range (collision coverage only), and risk. For each safety feature studied, a variable was included.

Claim frequency was modeled using a Poisson distribution, whereas claim severity (average loss payment per claim) was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity models. Estimates for frequency, severity, and overall losses are presented for collision and property damage liability. For PIP, BI, and MedPay, three frequency estimates are presented. The first frequency is the frequency for all claims, including those that already have been paid and those for which money has been set aside for possible payment in the future, known as claims with reserves. The other two frequencies include only paid claims separated into low- and high-severity ranges. Note that the percentage of all injury claims for the Honda Accord that were paid by the date of analysis varies by coverage: 72.7 percent for PIP, 58.2 percent for BI, and 58.9 percent for MedPay. The low-severity range was <\$1,000 for PIP and MedPay, <\$5,000 for BI; high severity covered all loss payments greater than that.

A separate regression was performed for each insurance loss measure for a total of 15 regressions (5 coverages x 3 loss measures each). For space reasons, only the estimates for the individual crash avoidance features are shown on the following pages. To illustrate the analyses, however, Appendix A contains full model results for Honda Accord collision claim frequencies. To further simplify the presentation here, the exponent of the parameter estimate was calculated, 1 was subtracted, and the resultant multiplied by 100. The resulting number corresponds to the effect of the feature on that loss measure. For example, the estimate of the effect of Forward Collision Warning (including Lane Departure Warning) on collision claim frequency was -0.0228; thus, vehicles with the feature had 2.3 percent fewer collision claims than without FCW/LDW ($(\exp(-0.0228)-1)*100=-2.3$).

► Results

Results for Honda Accord's Forward Collision Warning System including Lane Departure Warning are summarized in **Table 2**. The lower and upper bounds represent the 95 percent confidence limits for the estimates. For vehicle damage losses, the frequency and severity of claims as well as overall losses are down. Half of the reductions are significant (indicated in bold in the table).

For the injury-related coverage types, bodily injury liability and medical payment claim frequencies for paid and unpaid claims show significant reductions. Among paid claims, claim frequency shows a benefit with many being significant.

Table 2: Change in insurance losses for Accords with camera-based Forward Collision Warning and Lane Departure Warning

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-4.6%	-2.3%	0.1%	-\$198	-\$80	\$43	-\$28	-\$15	-\$2
Property damage liability	-13.6%	-10.1%	-6.4%	-\$194	-\$77	\$45	-\$18	-\$13	-\$8
Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-32.6%	-24.2%	-14.7%	-43.5%	-30.5%	-14.5%	-43.6%	-29.5%	-11.9%
Medical payment	-29.5%	-21.7%	-13.2%	-50.4%	-34.3%	-13.0%	-30.8%	-19.1%	-5.4%
Personal injury protection	-13.7%	-6.4%	1.6%	-20.5%	-3.6%	16.8%	-15.4%	-5.5%	5.6%

Results for Honda Accord's LaneWatch system are summarized in **Table 3**. Again, the lower and upper bounds represent the 95 percent confidence limits for the estimates. Reductions in claim frequency are estimated for both first- and third-party vehicle damage coverages. Both collision and property damage liability claim frequency reductions are statistically significant. Losses per insured vehicle year (overall losses) declined significantly under both property damage liability and collision coverage.

Under injury coverages, the frequency of claims is lower for all three coverages. The reductions under bodily injury liability and personal injury protection are statistically significant. Among paid claims, there is a significant reduction in high severity MedPay and PIP claims, yet no clear pattern emerges.

Table 3: Change in insurance losses for LaneWatch in Accords with camera-based Forward Collision Warning

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-7.3%	-5.1%	-2.9%	-\$255	-\$140	-\$23	-\$44	-\$31	-\$18
Property damage liability	-12.8%	-9.5%	-6.0%	-\$136	-\$22	\$96	-\$16	-\$11	-\$6

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-20.8%	-11.4%	-1.2%	-21.0%	-4.2%	16.1%	-28.4%	-11.9%	8.3%
Medical payment	-14.6%	-5.8%	4.0%	-5.1%	24.1%	62.2%	-29.9%	-18.7%	-5.7%
Personal injury protection	-20.6%	-14.2%	-7.2%	-19.7%	-3.5%	15.9%	-25.1%	-16.8%	-7.6%

Table 4 shows the differences in the claim frequency estimates between the results published in April 2014, September 2014, and April 2015 and the updated results included in this report. The updated results for the combined FCW/LDW system continue to show frequency benefits for all coverage types. The PDL claim frequency reduction remains significant, although the size of the effect is between the two prior estimates. All three injury coverages continue to show reductions in claim frequency. The effect consistently dropped for bodily injury liability across the four studies. The benefits of LaneWatch under collision has increased over the four reports and is statistically significant. The frequency reduction under property damage liability is significant and similar to the prior estimate. The frequency reductions under the injury-related coverages are all larger than those of the prior report, with the estimates for bodily injury liability and personal injury protection being statistically significant.

Table 4: Change in claim frequencies by collision avoidance feature, earlier vs. updated results in Accords with camera-based Forward Collision Warning

Vehicle damage coverage type	Forward Collision Warning & Lane Departure Warning				LaneWatch			
	April 2014	September 2014	April 2015	Current	April 2014	September 2014	April 2015	Current
Collision	-3.8%	-3.6%	-1.7%	-2.3%	-2.5%	-2.6%	-5.0%	-5.1%
Property damage liability	-14.0%	-9.9%	-11.7%	-10.1%	-7.8%	-12.5%	-8.8%	-9.5%

Injury coverage type	Forward Collision Warning & Lane Departure Warning				LaneWatch			
	April 2014	September 2014	April 2015	Current	April 2014	September 2014	April 2015	Current
Bodily injury liability	-39.5%	-29.2%	-26.8%	-24.2%	7.9%	-5.2%	-6.0%	-11.4%
Medical payment	-27.3%	-29.7%	-22.3%	-21.7%	-11.1%	-8.6%	-3.5%	-5.8%
Personal injury protection	-10.7%	-16.8%	-6.3%	-6.4%	-15.8%	-13.1%	-12.7%	-14.2%

Honda Accord Touring:

Results for Honda Accord Touring's Forward Collision Warning System including Lane Departure Warning and Adaptive Cruise Control are summarized in **Table 5**. The lower and upper bounds represent the 95 percent confidence limits for the estimates. For property damage liability, claim frequency (statistically significant) and overall losses are down. Under collision coverage, the Touring trim showed an increase in claim frequency, claim severity, and overall losses, with severity and overall losses being significant.

For the injury-related coverage types, bodily injury liability and medical payment claim frequencies for paid and unpaid claims show reductions. Among paid claims, claim frequency also shows a benefit under bodily injury liability and medical payment coverages.

Table 5: Change in insurance losses for Forward Collision Warning, Lane Departure Warning and Adaptive Cruise Control

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-1.1%	4.4%	10.1%	\$71	\$355	\$657	\$15	\$49	\$85
Property damage liability	-21.0%	-13.2%	-4.5%	-\$193	\$95	\$412	-\$23	-\$11	\$2
Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-32.8%	-12.5%	14.0%	-42.8%	-9.8%	42.2%	-51.0%	-18.0%	37.0%
Medical payment	-42.4%	-26.7%	-6.8%	-74.3%	-46.5%	11.7%	-45.9%	-22.8%	10.2%
Personal injury protection	-12.9%	5.6%	28.0%	-42.1%	-5.2%	55.4%	-23.0%	0.3%	30.7%

Results for Honda Accord Touring's LaneWatch system are summarized in **Table 6**. Again, the lower and upper bounds represent the 95 percent confidence limits for the estimates. Reductions in claim frequency are estimated for both first- and third-party vehicle damage coverages. Collision and property damage liability claim frequency reductions are statistically significant. Losses per insured vehicle year (overall losses) declined significantly under these two coverage types.

Under injury coverages, the frequency of claims is lower for all three coverages. The reductions under bodily injury liability and personal injury protection are statistically significant. Among paid claims, larger reductions are seen for higher severity claims.

Table 6: Change in insurance losses for Honda Accord Touring LaneWatch

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-7.1%	-4.9%	-2.6%	-\$251	-\$137	-\$20	-\$43	-\$30	-\$17
Property damage liability	-12.7%	-9.3%	-5.8%	-\$123	-\$7	\$113	-\$15	-\$10	-\$5
Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-20.8%	-11.6%	-1.3%	-20.5%	-3.6%	17.0%	-29.1%	-12.8%	7.4%
Medical payment	-15.0%	-6.1%	3.7%	-5.5%	23.7%	62.1%	-30.4%	-19.2%	-6.2%
Personal injury protection	-21.5%	-15.1%	-8.2%	-21.2%	-5.2%	14.4%	-26.1%	-17.9%	-8.8%

Table 7 shows the differences in the claim frequency estimates between the initial Touring trim results published in April 2015, and the updated results included in this report. The updated results for the combined FCW/LDW/ACC system continue to show frequency benefits for most coverage types. The PDL claim frequency reduction remains significant, although the size of the effect is smaller than the prior estimate. Bodily injury liability and medical payment continue to show reductions in claim frequency, but the significance has changed. The bodily injury liability effect dropped over 25 percentage points and is no longer significant, while the medical payment benefit remained similar but is now significant. The original estimated 39.4 percent BI reduction was the highest among FCW systems and higher than the reductions for systems with autonomous braking. The current estimate is now more in line with BI estimates for other FCW systems. While the reduction from 39.4 to 12.5 percent is large, the confidence bounds for the two estimates overlap. The benefits of LaneWatch continue across all coverage types, with nearly all reductions being significant. The frequency reductions under collision and property damage liability are significant and similar to the prior estimate. The frequency reductions under the injury-related coverages are all larger than those of the prior report, with the estimates for bodily injury liability and personal injury protection being statistically significant.

Vehicle damage coverage types	Collision Mitigation Warning, Lane Departure Warning & Adaptive Cruise		LaneWatch	
	April 2015 report	Current report	April 2015 report	Current report
Collision	2.0%	4.4%	-4.8%	-4.9%
Property damage liability	-15.8%	-13.2%	-8.8%	-9.3%
Injury coverage types	April 2015 report	Current report	April 2015 report	Current report
Bodily injury liability	-39.4%	-12.5%	-6.6%	-11.6%
Medical payment	-25.7%	-26.7%	-3.4%	-6.1%
Personal injury protection	10.4%	5.6%	-13.4%	-15.1%

Comparison results:

Table 8 shows the differences in the claim frequency estimates for the Honda Accord/Crosstour and Honda Accord Touring. The results for the FCW/LDW (ACC on Touring) system show minimal, if any, benefit under collision coverage across the vehicle series. However, under property damage liability, claim frequency is reduced significantly. Under injury coverages, reductions are seen across all vehicle series and coverages, with the exception of personal injury protection claim frequency for the Honda Accord Touring. Several of the reductions are significant.

Table 8 also shows the differences in the claim frequency estimates for LaneWatch for the Honda Accord/Crosstour and Honda Accord Touring. The estimated reductions in claim frequency for both of these vehicles are nearly identical across all coverage types. This may in part be due to the control populations being identical. Significant reductions are seen for both vehicles under collision, property damage liability, bodily injury liability, and personal injury protection coverages

Vehicle damage coverage types	Collision Mitigation Warning, Lane Departure Warning & Adaptive Cruise		LaneWatch	
	Honda Accord/Crosstour	Honda Accord Touring	Honda Accord/Crosstour	Honda Accord Touring
Collision	-2.3%	4.4%	-5.1%	-4.9%
Property damage liability	-10.1%	-13.2%	-9.5%	-9.3%
Injury coverage types	April 2015 report	Current report	April 2015 report	Current report
Bodily injury liability	-24.2%	-12.5%	-11.4%	-11.6%
Medical payment	-21.7%	-26.7%	-5.8%	-6.1%
Personal injury protection	-6.4%	5.6%	-14.2%	-15.1%

► Discussion

The loss results for the collision avoidance systems included in this study continue to be favorable and fall within the bounds of the prior studies. However, some of the point estimates have changed. While less than a year has passed from the April 2015 study, the exposure available for analysis has nearly doubled for the Honda Accord and Crosstour. The increase in exposure has resulted from the addition of the 2015 model year and the additional time insured for the vehicles included in the previous study. The results for the combined FCW/LDW system are in-line with prior findings for comparable systems. The frequency benefits are fairly similar but slightly larger than the prior bulletin. The frequency estimates for LaneWatch continue to indicate reductions, and with the exception of medical payment, the reductions are statistically significant.

Forward collision warning systems are designed to prevent or mitigate front-to-rear crashes, which typically result in PDL and BI claims if injury in the struck vehicle occurs. The updated FCW/LDW system continues to be associated with reductions in claim frequency for all five coverage types examined. The Honda Accord Touring trim with the radar based FCW/LDW/ACC system has much less exposure, but the magnitude of the property damage liability benefit is similar to the camera-based FCW/LDW system. The PDL claim frequency benefit for the radar-based system is slightly larger than for the camera system, but the confidence bounds overlap. The camera-based system resulted in a decline in collision claim severity, while the radar-based Touring system resulted in a significant increase. This is in line with previous HLDI findings, and the increased claim severity is likely associated with the replacement cost of the radar units in crashes not avoided.

The analysis of Honda's LaneWatch, a passenger side blind spot detection system, showed a reduction in claims, with significant effects for collision, PDL, bodily injury liability, and PIP. This is the first report where the reduction in bodily injury liability claim frequency is significant. Effects of LaneWatch are patterned as expected. Incursion into an occupied adjacent lane would be expected to result in a two-vehicle crash that would lead to a property damage liability claim against the encroaching driver. The PDL estimates for the Accord/Crosstour and Accord Touring are nearly identical and statistically significant, and the estimated reduction in property damage liability claims is much larger than the reduction estimated for collision claims. This is consistent with the fact that the reductions in collision claims from such crashes would be diluted by the many single-vehicle crashes that result in collision claims and are unaffected by the LaneWatch system.

As previously mentioned, the collision avoidance systems are tied to the vehicle trim levels. In order to be confident that the measured differences were attributable to the collision avoidance features and not the trim levels, a supplemental analysis was conducted including loss data for model year 2012 Honda Accord vehicles. While the Honda Accord was redesigned in 2013, the trim levels in 2012–15 were comparable. The inclusion of loss data for the 2012 model year, in which no crash avoidance features were present, allowed the supplemental analysis to include the vehicle trim level in addition to the control variables used in the primary analysis. Thus, the supplemental analysis assumes that loss differences attributable to the different trim levels were the same in both model years. The summary results of the supplemental analysis are included in **Appendix B**, and the full regression analysis results for collision claim frequencies are shown in **Appendix C**. The supplemental results for the combination FCW/LDW system is consistent with the supplemental analysis from the prior bulletins. Due to the similarity of the two analyses for FCW/LDW and uncertainty about the applicability of 2012 model trim level differences to the redesigned 2013–15 models, the analysis presented in the results section of this bulletin is expected to be the better predictor of the effects on losses of that system. However, the supplemental estimates for the LaneWatch system are showing increased claim frequencies. While the results in the main portion of this bulletin show lower losses for LaneWatch vehicles, the alternative analyses suggest that the positive results may not be due to LaneWatch but to other, uncontrolled factors that affect losses for different trim levels. Similar analysis could not be conducted for the Touring trim as the 2013 model year (included in this analysis) was the first year that trim was available.

► Limitations

There are limitations to the data used in this analysis. At the time of a crash, the status of a feature is not known. The features in this study can be deactivated by the driver, and there is no way to know how many of the drivers in these vehicles turned off a system prior to the crash. However, surveys conducted by the Insurance Institute for Highway Safety indicate that large majorities of drivers with these types of systems leave them on. If a significant number of drivers do turn these features off, any reported reductions may actually be underestimates of the true effectiveness of these systems.

Additionally, the data supplied to HLDI does not include detailed crash information. Information on point of impact and the vehicle's transmission status is not available. The technologies in this report target certain crash types. For example, LaneWatch is designed to prevent sideswipe-type collisions. All collisions, regardless of the ability of a feature to mitigate or prevent the crash, are included in the analysis.

References

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Highway Loss Data Institute. 2014b. Honda Accord collision avoidance features: an update. *Loss Bulletin* Vol. 31, No. 16. Arlington, VA.

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► Appendix A

Appendix A: Illustrative regression results — collision frequency									
Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Intercept		1	-8.6275		0.2469	-9.1115	-8.1435	1220.67	<0.0001
Calendar year	2012	1	-0.5095	-39.9%	0.0481	-0.6037	-0.4153	112.42	<0.0001
	2013	1	-0.0088	-0.9%	0.0104	-0.0291	0.0116	0.71	0.4000
	2014	1	0.0269	2.7%	0.0076	0.0119	0.0418	12.41	0.0004
	2015	0	0	0	0	0	0		
Vehicle model year and series	2013 Accord 2dr	1	-0.0361	-3.5%	0.1332	-0.2973	0.2250	0.07	0.7864
	2014 Accord 2dr	1	0.0094	0.9%	0.1342	-0.2535	0.2723	0.00	0.9442
	2015 Accord 2dr	1	-0.0175	-1.7%	0.1404	-0.2926	0.2577	0.02	0.9011
	2013 Accord 4dr	1	-0.1546	-14.3%	0.1328	-0.4148	0.1056	1.36	0.2443
	2014 Accord 4dr	1	-0.1328	-12.4%	0.1328	-0.3931	0.1274	1.00	0.3170
	2015 Accord 4dr	1	-0.1619	-14.9%	0.1333	-0.4232	0.0994	1.48	0.2245
	2013 Accord Crosstour 4dr 2WD	1	-0.1686	-15.5%	0.1361	-0.4354	0.0983	1.53	0.2157
	2014 Accord Crosstour 4dr 2WD	1	-0.0965	-9.2%	0.1462	-0.3830	0.1900	0.44	0.5092
	2015 Accord Crosstour 4dr 2WD	1	-0.2297	-20.5%	0.2063	-0.6341	0.1748	1.24	0.2657
	2013 Accord Crosstour 4dr 4WD	1	-0.1168	-11.0%	0.1370	-0.3853	0.1517	0.73	0.3939
	2014 Accord Crosstour 4dr 4WD	1	-0.1045	-9.9%	0.1450	-0.3886	0.1797	0.52	0.4711
	2015 Accord Crosstour 4dr 4WD	0	0	0	0	0	0		

Appendix A: Illustrative regression results — collision frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value	
Rated driver age group	14–24	1	0.2923	34.0%	0.0150	0.2629	0.3217	378.80	<0.0001
	25–29	1	0.1787	19.6%	0.0134	0.1525	0.2049	179.04	<0.0001
	30–39	1	0.0538	5.5%	0.0114	0.0315	0.0760	22.44	<0.0001
	50–59	1	-0.0600	-5.8%	0.0116	-0.0828	-0.0372	26.56	<0.0001
	60–64	1	-0.0877	-8.4%	0.0151	-0.1172	-0.0582	33.90	<0.0001
	65–69	1	-0.0209	-2.1%	0.0154	-0.0510	0.0093	1.84	0.1746
	70+	1	0.0972	10.2%	0.0130	0.0716	0.1227	55.53	<0.0001
	Unknown	1	0.0007	0.1%	0.0182	-0.0349	0.0364	0.00	0.9678
	40–49	0	0	0	0	0	0		
Rated driver gender	Male	1	-0.0567	-5.5%	0.0077	-0.0717	-0.0417	54.75	<0.0001
	Unknown	1	-0.2119	-19.1%	0.0302	-0.2712	-0.1527	49.22	<0.0001
	Female	0	0	0	0	0	0		
Rated driver marital status	Single	1	0.1911	21.1%	0.0084	0.1745	0.2076	514.29	<0.0001
	Unknown	1	0.2378	26.8%	0.0302	0.1786	0.2970	62.04	<0.0001
	Married	0	0	0	0	0	0		
Risk	Nonstandard	1	0.2611	29.8%	0.0145	0.2327	0.2896	324.25	<0.0001
	Standard	0	0	0	0	0	0		
State	Alabama	1	-0.0309	-3.0%	0.2108	-0.4441	0.3822	0.02	0.8833
	Arizona	1	0.0517	5.3%	0.2102	-0.3603	0.4637	0.06	0.8058
	Arkansas	1	-0.0002	0.0%	0.2143	-0.4203	0.4199	0.00	0.9992
	California	1	0.3322	39.4%	0.2088	-0.0770	0.7414	2.53	0.1116
	Colorado	1	0.0936	9.8%	0.2116	-0.3211	0.5083	0.20	0.6583
	Connecticut	1	0.0213	2.2%	0.2107	-0.3916	0.4343	0.01	0.9194
	Delaware	1	0.0270	2.7%	0.2154	-0.3951	0.4492	0.02	0.9001
	District of Columbia	1	0.4898	63.2%	0.2181	0.0622	0.9173	5.04	0.0248
	Florida	1	-0.1687	-15.5%	0.2091	-0.5784	0.2411	0.65	0.4198
	Georgia	1	-0.0491	-4.8%	0.2095	-0.4598	0.3616	0.05	0.8148
	Hawaii	1	0.1947	21.5%	0.2152	-0.2272	0.6165	0.82	0.3657
	Idaho	1	-0.1423	-13.3%	0.2259	-0.5850	0.3003	0.40	0.5286
	Illinois	1	-0.0026	-0.3%	0.2095	-0.4131	0.4080	0.00	0.9902
	Indiana	1	-0.1214	-11.4%	0.2112	-0.5353	0.2925	0.33	0.5653
	Iowa	1	-0.0646	-6.3%	0.2166	-0.4891	0.3599	0.09	0.7656
	Kansas	1	-0.0069	-0.7%	0.2140	-0.4264	0.4126	0.00	0.9744
	Kentucky	1	-0.1900	-17.3%	0.2132	-0.6077	0.2278	0.79	0.3728
	Louisiana	1	0.2488	28.2%	0.2098	-0.1624	0.6599	1.41	0.2357
	Maine	1	-0.0777	-7.5%	0.2274	-0.5233	0.3679	0.12	0.7325
	Maryland	1	0.1524	16.5%	0.2094	-0.2580	0.5628	0.53	0.4668
	Massachusetts	1	0.1644	17.9%	0.2104	-0.2479	0.5767	0.61	0.4344
	Michigan	1	0.3685	44.6%	0.2109	-0.0448	0.7818	3.05	0.0805
	Minnesota	1	-0.0695	-6.7%	0.2116	-0.4842	0.3453	0.11	0.7427
	Mississippi	1	0.1196	12.7%	0.2121	-0.2962	0.5354	0.32	0.5729
	Missouri	1	-0.1301	-12.2%	0.2116	-0.5448	0.2846	0.38	0.5386
	Montana	1	-0.2483	-22.0%	0.2460	-0.7304	0.2338	1.02	0.3127

Appendix A: Illustrative regression results — collision frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Nebraska	1	-0.1527	-14.2%	0.2191	-0.5822	0.2768	0.49	0.4859
Nevada	1	0.0176	1.8%	0.2130	-0.3999	0.4351	0.01	0.9342
New Hampshire	1	0.2418	27.4%	0.2136	-0.1769	0.6605	1.28	0.2578
New Jersey	1	0.0327	3.3%	0.2091	-0.3771	0.4426	0.02	0.8757
New Mexico	1	0.0265	2.7%	0.2162	-0.3973	0.4502	0.01	0.9026
New York	1	0.3229	38.1%	0.2089	-0.0865	0.7323	2.39	0.1222
North Carolina	1	-0.2700	-23.7%	0.2097	-0.6809	0.1409	1.66	0.1978
North Dakota	1	0.1987	22.0%	0.2308	-0.2536	0.6510	0.74	0.3892
Ohio	1	-0.1516	-14.1%	0.2095	-0.5622	0.2590	0.52	0.4693
Oklahoma	1	-0.0321	-3.2%	0.2124	-0.4484	0.3842	0.02	0.8800
Oregon	1	0.0282	2.9%	0.2124	-0.3882	0.4445	0.02	0.8945
Pennsylvania	1	0.1789	19.6%	0.2092	-0.2312	0.5890	0.73	0.3925
Rhode Island	1	0.2318	26.1%	0.2135	-0.1867	0.6503	1.18	0.2777
South Carolina	1	-0.1377	-12.9%	0.2105	-0.5502	0.2749	0.43	0.5131
South Dakota	1	-0.0488	-4.8%	0.2373	-0.5139	0.4163	0.04	0.8371
Tennessee	1	-0.1013	-9.6%	0.2104	-0.5138	0.3111	0.23	0.6301
Texas	1	0.0121	1.2%	0.2090	-0.3975	0.4217	0.00	0.9540
Utah	1	-0.0964	-9.2%	0.2152	-0.5182	0.3254	0.20	0.6543
Vermont	1	0.0525	5.4%	0.2297	-0.3977	0.5027	0.05	0.8192
Virginia	1	0.0724	7.5%	0.2094	-0.3379	0.4827	0.12	0.7294
Washington	1	0.0270	2.7%	0.2105	-0.3856	0.4397	0.02	0.8979
West Virginia	1	-0.2047	-18.5%	0.2205	-0.6369	0.2275	0.86	0.3533
Wisconsin	1	-0.0261	-2.6%	0.2116	-0.4409	0.3887	0.02	0.9018
Wyoming	1	-0.0309	-3.0%	0.2618	-0.5440	0.4823	0.01	0.9061
Alaska	0	0	0	0	0	0		
Deductible range								
0–250	1	0.4880	62.9%	0.0120	0.4645	0.5115	1657.24	<0.0001
1,001+	1	-0.4155	-34.0%	0.0717	-0.5561	-0.2750	33.59	<0.0001
251–500	1	0.2851	33.0%	0.0103	0.2649	0.3053	764.94	<0.0001
501–1,000	0	0	0	0	0	0		
Registered vehicle density								
0–99	1	-0.2658	-23.3%	0.0131	-0.2916	-0.2401	410.26	<0.0001
100–499	1	-0.1777	-16.3%	0.0085	-0.1944	-0.1611	438.99	<0.0001
500+	0	0	0	0	0	0		
Forward collision warning & lane departure warning	1	-0.0228	-2.3%	0.0123	-0.0469	0.0013	3.42	0.0642
LaneWatch	1	-0.0525	-5.1%	0.0118	-0.0757	-0.0293	19.69	<0.0001

► **Appendix B: Analysis results included model years 2012–15, accounting for vehicle series and model level loss differences**

Change in insurance losses for Forward Collision Warning and Lane Departure Warning									
Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-8.3%	-4.8%	-1.0%	-\$106	\$80	\$273	-\$29	-\$10	\$10
Property damage liability	-14.8%	-9.6%	-4.1%	-\$166	\$5	\$187	-\$18	-\$10	-\$2

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-28.7%	-15.6%	-0.1%	-40.8%	-20.6%	6.5%	-42.5%	-21.7%	6.6%
Medical payment	-25.4%	-12.6%	2.5%	-46.4%	-17.5%	27.2%	-29.5%	-11.0%	12.3%
Personal injury protection	-11.9%	-0.4%	12.6%	-23.5%	1.7%	35.4%	-11.2%	4.6%	23.2%

Change in insurance losses for LaneWatch									
Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-2.5%	1.1%	4.9%	-\$332	-\$164	\$11	-\$28	-\$10	\$9
Property damage liability	0.4%	6.2%	12.3%	-\$268	-\$111	\$54	-\$6	\$2	\$12

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-14.8%	-0.3%	16.8%	-20.3%	4.9%	38.0%	-24.4%	0.9%	34.6%
Medical payment	-9.8%	4.8%	21.8%	-17.1%	24.7%	87.6%	-21.7%	-2.4%	21.6%
Personal injury protection	-14.4%	-3.8%	8.0%	-22.7%	1.3%	32.7%	-20.0%	-6.7%	8.9%

► **Appendix C**

Illustrative regression results for secondary analysis — collision frequency									
Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Intercept		1	-8.6052		0.1482	-8.8957	-8.3147	3370.67	<0.0001
Calendar year	2011	1	-0.3345	-28.4%	0.0426	-0.4180	-0.2510	61.62	<0.0001
	2012	1	-0.0499	-4.9%	0.0107	-0.0710	-0.0289	21.64	<0.0001
	2013	1	0.0002	0.0%	0.0076	-0.0146	0.0150	0.00	0.9774
	2014	1	0.0241	2.4%	0.0064	0.0117	0.0366	14.44	0.0001
	2015	0	0	0	0	0	0		
Model year	2012	1	-0.0866	-8.3%	0.0151	-0.1161	-0.0570	33.01	<0.0001
	2013	1	-0.0027	-0.3%	0.0143	-0.0307	0.0253	0.04	0.8481
	2014	1	0.0297	3.0%	0.0145	0.0014	0.0581	4.22	0.0400
	2015	0	0	0	0	0	0		
Vehicle series and trim	Accord 2dr EX	1	0.0949	10.0%	0.0269	0.0422	0.1477	12.45	0.0004
	Accord 2dr EX-L	1	0.0958	10.1%	0.0225	0.0517	0.1400	18.10	<0.0001
	Accord 2dr EX-L V6	1	0.0793	8.3%	0.0219	0.0364	0.1222	13.11	0.0003
	Accord 2dr LX-S	1	0.1483	16.0%	0.0234	0.1024	0.1941	40.17	<0.0001

Illustrative regression results for secondary analysis — collision frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Accord 4dr EX	1	-0.0819	-7.9%	0.0223	-0.1256	-0.0381	13.45	0.0002
Accord 4dr EX-L	1	-0.0536	-5.2%	0.0187	-0.0902	-0.0171	8.26	0.0040
Accord 4dr EX-L V6	1	-0.0810	-7.8%	0.0191	-0.1184	-0.0435	17.96	<0.0001
Accord 4dr LX	1	-0.0146	-1.4%	0.0185	-0.0510	0.0217	0.62	0.4297
Accord 4dr Sport	1	-0.0258	-2.5%	0.0188	-0.0626	0.0110	1.89	0.1695
Accord Crosstour 4dr 2WD EX	1	-0.0546	-5.3%	0.0340	-0.1212	0.0121	2.57	0.1089
Accord Crosstour 4dr 2WD EX-L	1	0.0057	0.6%	0.0332	-0.0593	0.0707	0.03	0.8631
Accord Crosstour 4dr 2WD EX-L V6	1	0.0056	0.6%	0.0320	-0.0571	0.0683	0.03	0.8612
Accord Crosstour 4dr 4WD EX-L V6	0	0	0	0	0	0		
Rated driver age group								
14-24	1	0.2766	31.9%	0.0158	0.2456	0.3076	306.06	<0.0001
25-29	1	0.1667	18.1%	0.0148	0.1376	0.1958	126.09	<0.0001
30-39	1	0.0387	3.9%	0.0138	0.0117	0.0657	7.91	0.0049
40-49	1	-0.0191	-1.9%	0.0138	-0.0463	0.0080	1.91	0.1666
50-59	1	-0.0620	-6.0%	0.0138	-0.0891	-0.0350	20.18	<0.0001
60-64	1	-0.1110	-10.5%	0.0156	-0.1417	-0.0804	50.37	<0.0001
65-69	1	-0.0445	-4.4%	0.0159	-0.0758	-0.0133	7.79	0.0052
70+	1	0.0688	7.1%	0.0147	0.0400	0.0975	22.01	<0.0001
Unknown	0	0	0	0	0	0		
Rated driver gender								
Male	1	-0.0498	-4.9%	0.0059	-0.0613	-0.0383	72.13	<0.0001
Unknown	1	-0.2253	-20.2%	0.0206	-0.2657	-0.1849	119.31	<0.0001
Female	0	0	0	0	0	0		
Rated driver marital status								
Single	1	0.1882	20.7%	0.0064	0.1756	0.2008	854.72	<0.0001
Unknown	1	0.2498	28.4%	0.0206	0.2095	0.2902	147.26	<0.0001
Married	0	0	0	0	0	0		
Risk								
Nonstandard	1	0.2342	26.4%	0.0101	0.2144	0.2539	538.64	<0.0001
Standard	0	0	0	0	0	0		
State								
Alabama	1	-0.1562	-14.5%	0.1477	-0.4457	0.1333	1.12	0.2903
Arizona	1	-0.0789	-7.6%	0.1473	-0.3676	0.2099	0.29	0.5924
Arkansas	1	-0.0485	-4.7%	0.1503	-0.3430	0.2461	0.10	0.7470
California	1	0.1999	22.1%	0.1461	-0.0865	0.4862	1.87	0.1713
Colorado	1	-0.0286	-2.8%	0.1484	-0.3194	0.2623	0.04	0.8474
Connecticut	1	-0.0792	-7.6%	0.1475	-0.3683	0.2099	0.29	0.5912
Delaware	1	-0.0385	-3.8%	0.1512	-0.3348	0.2578	0.06	0.7989
District of Columbia	1	0.4014	49.4%	0.1535	0.1006	0.7022	6.84	0.0089
Florida	1	-0.2841	-24.7%	0.1463	-0.5709	0.0026	3.77	0.0521
Georgia	1	-0.1856	-16.9%	0.1467	-0.4732	0.1019	1.60	0.2057
Hawaii	1	0.1033	10.9%	0.1522	-0.1949	0.4015	0.46	0.4973
Idaho	1	-0.2728	-23.9%	0.1615	-0.5893	0.0438	2.85	0.0913
Illinois	1	-0.1157	-10.9%	0.1466	-0.4031	0.1717	0.62	0.4299
Indiana	1	-0.2088	-18.8%	0.1479	-0.4987	0.0811	1.99	0.1581
Iowa	1	-0.1758	-16.1%	0.1525	-0.4747	0.1231	1.33	0.2489
Kansas	1	-0.1971	-17.9%	0.1509	-0.4929	0.0987	1.71	0.1915
Kentucky	1	-0.2872	-25.0%	0.1494	-0.5800	0.0056	3.70	0.0546

Illustrative regression results for secondary analysis — collision frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Louisiana	1	0.0981	10.3%	0.1470	-0.1900	0.3862	0.45	0.5047
Maine	1	-0.1286	-12.1%	0.1603	-0.4427	0.1855	0.64	0.4223
Maryland	1	0.0455	4.7%	0.1466	-0.2419	0.3328	0.10	0.7565
Massachusetts	1	0.0113	1.1%	0.1472	-0.2773	0.2999	0.01	0.9386
Michigan	1	0.2460	27.9%	0.1477	-0.0435	0.5355	2.77	0.0958
Minnesota	1	-0.2183	-19.6%	0.1484	-0.5091	0.0725	2.16	0.1412
Mississippi	1	-0.0345	-3.4%	0.1489	-0.3264	0.2575	0.05	0.8170
Missouri	1	-0.2625	-23.1%	0.1483	-0.5532	0.0283	3.13	0.0768
Montana	1	-0.1343	-12.6%	0.1693	-0.4662	0.1976	0.63	0.4277
Nebraska	1	-0.2826	-24.6%	0.1544	-0.5852	0.0200	3.35	0.0672
Nevada	1	-0.0839	-8.0%	0.1497	-0.3773	0.2095	0.31	0.5751
New Hampshire	1	0.1372	14.7%	0.1497	-0.1562	0.4307	0.84	0.3593
New Jersey	1	-0.0881	-8.4%	0.1463	-0.3749	0.1987	0.36	0.5470
New Mexico	1	-0.1001	-9.5%	0.1528	-0.3995	0.1993	0.43	0.5124
New York	1	0.1590	17.2%	0.1462	-0.1275	0.4454	1.18	0.2768
North Carolina	1	-0.3694	-30.9%	0.1468	-0.6571	-0.0817	6.33	0.0118
North Dakota	1	-0.0133	-1.3%	0.1663	-0.3392	0.3126	0.01	0.9361
Ohio	1	-0.2827	-24.6%	0.1466	-0.5701	0.0047	3.72	0.0539
Oklahoma	1	-0.1786	-16.4%	0.1492	-0.4710	0.1138	1.43	0.2313
Oregon	1	-0.1095	-10.4%	0.1494	-0.4022	0.1833	0.54	0.4636
Pennsylvania	1	0.0549	5.6%	0.1464	-0.2320	0.3419	0.14	0.7075
Rhode Island	1	0.1032	10.9%	0.1498	-0.1904	0.3969	0.47	0.4909
South Carolina	1	-0.2830	-24.6%	0.1475	-0.5722	0.0061	3.68	0.0550
South Dakota	1	-0.1783	-16.3%	0.1687	-0.5091	0.1524	1.12	0.2907
Tennessee	1	-0.2123	-19.1%	0.1474	-0.5012	0.0765	2.08	0.1496
Texas	1	-0.1158	-10.9%	0.1462	-0.4024	0.1709	0.63	0.4286
Utah	1	-0.2350	-20.9%	0.1517	-0.5323	0.0623	2.40	0.1213
Vermont	1	-0.1078	-10.2%	0.1639	-0.4291	0.2135	0.43	0.5109
Virginia	1	-0.0806	-7.7%	0.1466	-0.3679	0.2067	0.30	0.5824
Washington	1	-0.1282	-12.0%	0.1477	-0.4177	0.1613	0.75	0.3853
West Virginia	1	-0.2524	-22.3%	0.1550	-0.5562	0.0514	2.65	0.1035
Wisconsin	1	-0.1760	-16.1%	0.1484	-0.4668	0.1149	1.41	0.2357
Wyoming	1	-0.0986	-9.4%	0.1861	-0.4634	0.2663	0.28	0.5964
Alaska	0	0	0	0	0	0		
Deductible range								
0–250	1	0.4789	61.4%	0.0091	0.4611	0.4967	2784.48	<0.0001
1,001+	1	-0.4838	-38.4%	0.0583	-0.5980	-0.3696	68.94	<0.0001
251–500	1	0.2623	30.0%	0.0078	0.2470	0.2775	1131.12	<0.0001
501–1,000	0	0	0	0	0	0		
Registered vehicle density								
0–99	1	-0.2653	-23.3%	0.0101	-0.2852	-0.2454	685.02	<0.0001
100–499	1	-0.1803	-16.5%	0.0065	-0.1930	-0.1676	773.16	<0.0001
500+	0	0	0	0	0	0		
Forward Collision Warning & Lane Departure Warning	1	-0.0487	-4.8%	0.0195	-0.0869	-0.0106	6.26	0.0123
LaneWatch	1	0.0111	1.1%	0.0186	-0.0254	0.0475	0.36	0.5511



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Mazda collision avoidance features

This is the second report examining collision avoidance features offered by Mazda. In 2011, the Highway Loss Data Institute (HLDI, 2011) performed an initial look at three collision avoidance features — Adaptive Front Lighting System, Blind Spot Monitoring, and a back-up camera — offered by Mazda on model year 2007–10 vehicles. This study updates and expands the loss results for these features and examines several new features introduced on model year 2014 vehicles. These features include front crash prevention technologies such as Adaptive Cruise Control, Forward Obstruction Warning, and Mazda’s Smart City Brake Support as well as Lane Departure Warning and Rear Cross Traffic Alert.

The updated results for Adaptive Front Lighting System, Blind Spot Monitoring, and the back-up camera indicate significant reductions for property damage liability claim frequencies and some injury coverage frequencies. Results for the new systems indicate strong potential for Mazda’s Smart City Brake Support with significant reductions in property damage liability claim frequency. Bodily injury liability claim frequency was also reduced, but the result was not significant. Results for the remaining features were inconclusive, as limited loss data are available for vehicles equipped with these systems. The table below summarizes the estimated changes in claim frequency for Mazda’s collision avoidance features. Statistically significant estimates are bolded.

Summary of estimated changes in claim frequency for Mazda’s collision avoidance systems

Vehicle damage coverage type	Adaptive Front Lighting System	Blind Spot Monitoring	Back-up camera	Smart City Brake Support	Combined front crash prevention systems	Lane Departure Warning	Rear Cross Traffic Alert
Collision	-1.7%	-3.1%	0.6%	-3.4%	1.9%	-3.7%	1.5%
Property damage liability	-4.6%	-11.1%	-4.2%	-13.4%	-15.2%	-4.5%	-2.3%
Injury coverage type							
Bodily injury liability	-3.6%	-17.7%	-4.4%	-11.5%			-5.2%
Medical payment	-10.1%	-15.4%	-8.2%	12.0%			-4.4%
Personal injury protection	-7.7%	-11.1%	-8.2%	-5.2%			11.6%

► Introduction

This Highway Loss Data Institute (HLDI) bulletin updates loss results for three collision avoidance features examined in an earlier HLDI (2011) report to include additional vehicle series, model years, and exposure. These features are:

Adaptive Front Lighting System is Mazda's term for headlamps that respond to driver steering. The system uses sensors to measure vehicle speed and steering angle while small electric motors turn the headlights accordingly to facilitate vision around a curve at night. It is functional after the headlights have been turned on and at vehicle speeds above 1 mph. The adaptive lighting can be deactivated by the driver. At the next ignition cycle, it will be in the previous on/off setting.

Blind Spot Monitoring is Mazda's term for a blind spot detection system that alerts drivers to vehicles that are adjacent to them. The system uses radar sensors mounted inside the rear bumper to scan a range behind the vehicle. If a vehicle has been detected in the blind spot, a warning light on the appropriate side mirror is illuminated, and an additional auditory warning is given if a turn signal is activated. The system is functional at speeds above 6.3 mph and can be deactivated by the driver, but will reactivate at the next ignition cycle. Additionally, the driver can eliminate the audio warning but leave the visual alert.

A **back-up camera** is mounted in the rear deck lid above the license plate and shows the area behind the vehicle on the navigation screen. The camera is active when the transmission is in reverse.

New features available on model year 2014 vehicles include:

Adaptive Cruise Control (Mazda Radar Cruise Control) is a system that uses radar sensors mounted in the front grille to monitor traffic ahead and maintain the driver's selected following distance. As traffic conditions dictate, the system employs braking force to maintain the set following distance. Adaptive Cruise Control is available at speeds between 19 and 90 mph. Forward Obstruction Warning remains active even when Adaptive Cruise Control is turned off. Adaptive Cruise Control is always present on vehicles with Forward Obstruction Warning and therefore the analysis cannot separate out the individual effects of these features.

Forward Obstruction Warning uses radar to assess the risk of a rear-end collision with an obstacle in front, and warns the driver with a visual alert and a continuous warning sound. This system is functional at speeds of 6 mph and above, and when the relative speed between the driver's vehicle and the obstruction is between 6 and 90 mph. The system may be deactivated under the multi-information display settings menu, but the default setting is on. Forward Obstruction Warning is always present on vehicles with Adaptive Cruise Control, and therefore the analysis cannot separate out the individual effects of these features.

Smart City Brake Support operates the brakes if the laser sensor determines that a collision with a vehicle ahead is unavoidable. It may also be possible to avoid a collision if the relative speed between the driver's vehicle and the vehicle ahead is less than about 9.3 mph. In addition, when the driver depresses the brake pedal while the system is in the operation range at about 2–18 mph, additional brake assistance is applied. The system may be deactivated under the multi-information display settings menu, but the default setting is on.

Lane Departure Warning uses a forward facing camera mounted by the interior rearview mirror to determine if the driver's vehicle is unintentionally leaving its lane. A steady green indicator light shows when lane lines are recognizable and the vehicle speed is 40 mph or greater. The indicator light turns yellow, meaning the system is not operational, when the lane lines are not recognizable or the vehicle speed is less than 40 mph. The system indicates a flashing green indicator light and a continuous warning sound when lane lines are recognizable, the vehicle speed is 40 mph or greater, and the vehicle deviates from its lane. The system may be deactivated by using a switch to the left of the steering wheel in the dashboard area. At the next ignition cycle, it will be in the previous on/off setting.

Rear Cross Traffic Alert is a system that alerts drivers to vehicles that are adjacent to them when the vehicle is in reverse. The system uses radar sensors mounted inside the rear bumper to scan a range behind and to the sides of the vehicle. If a vehicle has been detected, a warning light on the appropriate side mirror is illuminated, and an auditory warning is given. Vehicles with a rearview monitor also receive a warning indication in the rearview monitor. The system is functional at speeds under 6 mph and can be deactivated by the driver, but will reactivate at the next ignition cycle.

► Method

Vehicles

Although some features are available as standard equipment for certain model years and trim levels, other features are offered as optional equipment. The presence or absence of these optional features is not discernible from the information encoded in the vehicle identification numbers (VINs), but rather this must be determined from build information maintained by the manufacturer. Mazda supplied HLDI with the VINs for any vehicles that were equipped with at least one of the collision avoidance features listed above. Vehicles of the same model year and series not identified by Mazda were assumed not to have these features, and thus served as the control vehicles in the analysis. Electronic stability control was standard on most vehicles but optional on one trim level of the 2010 Mazda 3, so this trim level was excluded from the analysis. No additional features are available on these vehicles. Two high-performance vehicles, the Mazda Speed3 and Speed6, were also excluded. **Table 1** lists the vehicle series and model years included in the analysis. In addition, exposure for each vehicle, measured in insured vehicle years, is listed. The exposure of each feature in a given series is shown as a percentage of total exposure.

Table 1: Feature exposure by vehicle series

Series	Model year range	Adaptive Cruise Control	Forward Obstruction Warning	Smart City Brake Support	Blind Spot Monitoring	Lane Departure Warning	Adaptive Front Lighting	Rear Cross Traffic Alert	Back-up camera	Total exposure
Mazda 3 4dr	2010–14	< 1%	< 1%	< 1%	8%	< 1%	10%	4%	3%	650,051
Mazda 3 station wagon	2010–13				8%		18%			304,010
Mazda 3 5dr	2014	5%	5%	6%	83%	6%	20%	83%	61%	27,286
Mazda 6 4dr	2009–14	2%	2%	6%	41%	< 1%	4%	10%	15%	542,363
Mazda CX-5 4dr	2013–14			11%	75%		23%		75%	121,274
Mazda CX-5 4dr 4WD	2013–14			23%	89%		41%		89%	115,241
Mazda CX-7 4dr	2010–12				4%				42%	241,643
Mazda CX-7 4dr 2WD/4WD	2007–09								19%	521,643
Mazda CX-7 4dr 4WD	2010–12				37%				63%	35,202
Mazda CX-9 4dr	2007–14				34%			1%	44%	317,778
Mazda CX-9 4WD	2007–14				40%			2%	58%	357,401
Mazda Tribute 4dr	2010–11								43%	17,590
Mazda Tribute 4dr 4WD	2010–11								63%	7,019

Insurance data

Automobile insurance covers damages to vehicles and property as well as injuries to people involved in crashes. Different insurance coverages pay for vehicle damage versus injuries, and different coverages may apply depending on who is at fault. The current study is based on property damage liability, collision, bodily injury liability, personal injury protection, and medical payment coverages. Exposure is measured in insured vehicle years. An insured vehicle year is one vehicle insured for 1 year, two vehicles for 6 months, etc.

Because different crash avoidance features may affect different types of insurance coverage, it is important to understand how coverages vary among the states and how this affects inclusion in the analyses.

Collision coverage insures against vehicle damage to an at-fault driver's vehicle sustained in a crash with an object or other vehicle; this coverage is common to all 50 states. Property damage liability (PDL) coverage insures against vehicle damage that at-fault drivers cause to other people's vehicle and property in crashes; this coverage exists in all states except Michigan, where vehicle damage is covered on a no-fault basis (each insured vehicle pays for its own damage in a crash, regardless of who's at fault).

Coverage of injuries is more complex. Bodily injury (BI) liability coverage insures against medical, hospital, and other expenses for injuries that at-fault drivers inflict on occupants of other vehicles or others on the road; although motorists in most states may have BI coverage, this information is analyzed only in states where the at-fault driver has first obligation to pay for injuries (33 states with traditional tort insurance systems). Medical payment coverage (MedPay), also sold in the 33 states with traditional tort insurance systems, covers injuries to insured drivers and the passengers in their vehicles, but not injuries to people in other vehicles involved in the crash. Seventeen other states employ no-fault injury systems (PIP coverage) that pay up to a specified amount for injuries to occupants of involved-insured vehicles, regardless of who is at fault in a collision. The District of Columbia has a hybrid insurance system for injuries and is excluded from the injury analysis.

Statistical methods

Regression analysis was used to quantify the effect of each vehicle feature while controlling for the other features and several covariates. The covariates included calendar year, model year, garaging state, vehicle density (number of registered vehicles per square mile), rated driver age group, rated driver gender, rated driver marital status, deductible range (collision coverage only), and risk. Based on the model year and vehicle series, a single variable called SERIESMY was created for inclusion in the regression model. Effectively, this variable controlled for the variation caused by vehicle design changes that occur from model year to model year.

For each safety feature supplied by the manufacturer, a binary variable was included to indicate the presence of that feature. With the exception of Adaptive Cruise Control and Forward Obstruction Warning, separate estimates for each individual feature were possible. Since those two features were always bundled together, the analysis cannot separate out the individual effects of those features. In addition, while Smart City Brake Support was available on vehicles without Adaptive Cruise Control and Forward Obstruction Warning, all vehicles with Adaptive Cruise Control and Forward Obstruction Warning also had Smart City Brake Support. Since all three features could potentially prevent or mitigate similar crash types, the effectiveness of the three features combined was estimated. The effect of Smart City Brake Support, without Adaptive Cruise Control and Forward Obstruction Warning, was still estimated separately.

Claim frequency was modeled using a Poisson distribution, whereas claim severity (average loss payment per claim) was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity models. Estimates for frequency, severity, and overall losses are presented for collision and property damage liability. For PIP, BI, and MedPay three frequency estimates are presented. The first frequency is the frequency for all claims, including those that already have been paid and those for which money has been set aside for possible payment in the future, known as claims with reserves. The other two frequencies include only paid claims separated into low and high severity ranges. Note that the percentage of all injury claims that were paid by the date of analysis varies by coverage: 75.6 percent for PIP, 70 percent for BI, and 61.3 percent for MedPay. The low severity range was <\$1,000 for PIP and MedPay, <\$5,000 for BI; high severity covered all loss payments greater than that.

A separate regression was performed for each insurance loss measure for a total of 15 regressions (5 coverages x 3 loss measures each). For space reasons, only the estimates for the individual crash avoidance features are shown on the following pages. To illustrate the analyses, however, **Appendix A** contains full model results for collision claim frequencies. To further simplify the presentation here, the exponent of the parameter estimate was calculated, 1 was subtracted, and the resultant multiplied by 100. The resulting number corresponds to the effect of the feature on that loss measure. For example, the estimate of the effect of Smart City Brake Support on collision claim frequency was -0.0349; thus, vehicles with the feature had 3.4 percent fewer collision claims than without Smart City Brake Support ($(\exp(-0.0349)-1)*100=-3.4$).

► Results

Results for Mazda's collision avoidance features are summarized in the following tables. **Tables 2–4** present the updated loss results for the three features examined in the 2011 report. **Table 5** compares the updated frequency estimates with the prior estimates. **Tables 6–9** summarize the loss results for the new features introduced on model year 2014 vehicles. For all tables, the lower and upper bounds represent the 95 percent confidence limits for the estimates. Estimates that are statistically significant at the 95 percent confidence level are bolded.

Table 2 summarizes the results for Mazda's Adaptive Front Lighting System. For vehicle damage losses, collision claim frequency was down 1.7 percent and property damage liability claim frequency was down 4.6 percent. Only the PDL estimate was statistically significant. Collision claim severity was up \$167 while property damage liability severity was down \$146. Both results were statistically significant. This resulted in an increase to collision overall losses of \$7 and a statistically significant reduction to property damage liability overall losses of \$11.

For injury losses, the overall frequency of claims (paid plus reserve) decreased for all coverages, with the decreases for medical payment and personal injury protection being significant. Among paid claims, reductions are seen for all coverage types at both low and high severity.

Table 2: Change in insurance losses for Adaptive Front Lighting System

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-3.7%	-1.7%	0.4%	\$72	\$167	\$265	-\$3	\$7	\$17
Property damage liability	-7.4%	-4.6%	-1.6%	-\$224	-\$146	-\$66	-\$15	-\$11	-\$6
Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-11.8%	-3.6%	5.4%	-30.3%	-18.5%	-4.7%	-15.3%	-1.2%	15.3%
Medical payment	-18.5%	-10.1%	-0.7%	-47.2%	-30.0%	-7.1%	-20.9%	-8.5%	5.7%
Personal injury protection	-14.1%	-7.7%	-0.8%	-20.4%	-7.3%	8.0%	-18.7%	-10.3%	-0.9%

Results for Mazda's Blind Spot Monitoring are summarized in **Table 3**. Claim frequencies for all coverage types, both vehicle damage and injury, are down and statistically significant. Collision and PDL severities are also down but not significant.

Table 3: Change in insurance losses for Blind Spot Monitoring System

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-4.4%	-3.1%	-1.7%	-\$72	-\$9	\$55	-\$17	-\$10	-\$4
Property damage liability	-12.8%	-11.1%	-9.4%	-\$64	-\$12	\$41	-\$16	-\$14	-\$11
Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-22.4%	-17.7%	-12.6%	-25.0%	-17.1%	-8.5%	-30.6%	-23.1%	-14.8%
Medical payment	-20.7%	-15.4%	-9.7%	-30.9%	-17.7%	-1.9%	-26.1%	-18.7%	-10.6%
Personal injury protection	-15.1%	-11.1%	-6.9%	-26.2%	-18.2%	-9.4%	-14.2%	-8.7%	-2.9%

Table 4 summarizes results for Mazda’s back-up camera. For vehicle damage losses, claim frequency is down 4.2 percent for property damage liability and significant. The frequency for collision coverage is up slightly but not significant. Claim severities for collision coverage are up \$84 and significant. This results in a statistically significant increase to overall losses for collision of \$8. Claim severities for property damage liability are down \$21 although not significant. Consequently, overall losses for property damage liability were down \$6 and significant.

For injury losses, the overall frequency of claims (both paid and reserved) is lower for all coverage types, with medical payment and personal injury protection being statistically significant. Frequencies were also down among paid claims for both low and high severity claims. However, only the high severity personal injury protection frequency was significant.

Table 4: Change in insurance losses for back-up camera									
Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-0.8%	0.6%	1.9%	\$23	\$84	\$145	\$2	\$8	\$14
Property damage liability	-5.9%	-4.2%	-2.5%	-\$70	-\$21	\$28	-\$9	-\$6	-\$3

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-9.6%	-4.4%	1.1%	-14.1%	-5.6%	3.6%	-12.4%	-3.7%	5.9%
Medical payment	-13.7%	-8.2%	-2.3%	-22.4%	-8.3%	8.5%	-13.3%	-5.2%	3.6%
Personal injury protection	-12.0%	-8.2%	-4.3%	-6.7%	2.6%	12.8%	-14.3%	-9.4%	-4.2%

Table 5 compares the estimated changes in claim frequency published in December 2011 for Mazda’s Adaptive Front Lighting System, Blind Spot Monitoring, and back-up camera with the updated results included in this report. It is important to note that the updated results include new model years and vehicles not included in the original study. For example, in the original study, the Adaptive Front Lighting System was only available on the 2010 Mazda 3. In this study, the Adaptive Front Lighting System is also available on the 2011–2014 Mazda 3, the 2014 Mazda 6, and the 2013–14 Mazda CX-5.

The updated results show smaller benefits for the Adaptive Front Lighting System than previously estimated. Collision claim frequency went from a statistically significant 6.4 percent reduction to a non-significant 1.7 percent reduction. Similarly, property damage liability claim frequency went from a 10.1 percent reduction to a 4.6 percent reduction, although this result remained statistically significant. The injury benefits for all three coverages are also smaller now than previously estimated.

Vehicle damage coverages show larger benefits for Blind Spot Monitoring than previously estimated. Collision claim frequency now shows a statistically significant 3.1 percent reduction compared to no benefit from the initial results. The property damage liability benefit also increased from a 7.5 percent reduction to an 11.1 percent reduction. Injury coverages for Blind Spot monitoring show slightly smaller benefits than previously estimated, although all results are still statistically significant.

The updated results for Mazda’s back-up camera show increased claim frequency benefits for all coverages. Collision claim frequency originally showed a statistically significant 3.1 percent disbenefit. The updated results show only a 0.6 percent disbenefit that is not significant. The benefit for property damage claim frequency increased from a 2.3 percent reduction to a significant 4.2 percent reduction. Injury coverages also show larger reductions in claim frequency, with medical payment and personal injury protection being statistically significant.

Table 5: Change in claim frequencies by collision avoidance feature, initial vs. updated results

Vehicle damage coverage type	Adaptive Front Lighting System		Blind Spot Monitoring		back-up camera	
	Initial results	Updated results	Initial results	Updated results	Initial results	Updated results
Collision	-6.4%	-1.7%	0.0%	-3.1%	3.1%	0.6%
Property damage liability	-10.1%	-4.6%	-7.5%	-11.1%	-2.3%	-4.2%

Injury coverage type	Initial results	Updated results	Initial results	Updated results	Initial results	Updated results
	Bodily injury liability	-12.5%	-3.6%	-20.9%	-17.7%	-3.1%
Medical payment	-28.9%	-10.1%	-23.9%	-15.4%	0.6%	-8.2%
Personal injury protection	-28.8%	-7.7%	-14.5%	-11.1%	-2.1%	-8.2%

The remaining features evaluated in this study were introduced on model year 2014 vehicles. Consequently, claims data for vehicles equipped with some of these features are sparse. This is especially true for injury claims. In such instances, the estimates for these features can vary wildly with extremely large confidence bounds. As a result of sparse data, injury estimates for vehicles with Mazda’s Lane Departure Warning as well as vehicles equipped with the combination of Forward Obstruction Warning, Adaptive Cruise Control, and Smart City Brake Support are not presented here. The effect of these features was still controlled for when computing injury estimates for the other features.

Table 6 summarizes the loss results for Mazda’s Smart City Brake Support. Collision claim frequencies are down 3.4 percent, though this result is not significant. Property damage claim frequencies are down a significant 13.4 percent. Collision claim severity remained essentially unchanged while property damage claim severity rose \$237. This results in slightly lower overall losses for both collision and property damage liability coverages, though neither result is significant.

Under injury coverages, the overall frequency of claims (paid plus reserved) decreases for bodily injury liability and personal injury protection but increases for medical payment. Among paid claims, the high severity frequency was lower for all three coverages. The low severity frequency was higher for medical payment and personal injury protection but lower for bodily injury liability.

Table 6: Change in Insurance losses for Smart City Brake Support

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
	Collision	-7.3%	-3.4%	0.6%	-\$196	-\$14	\$176	-\$29	-\$12
Property damage liability	-19.0%	-13.4%	-7.3%	\$45	\$237	\$442	-\$17	-\$7	\$3

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
	Bodily injury liability	-28.5%	-11.5%	9.5%	-40.6%	-11.9%	30.7%	-40.3%	-10.3%
Medical payment	-8.7%	12.0%	37.4%	-9.0%	55.8%	166.7%	-29.4%	-3.5%	31.8%
Personal injury protection	-18.6%	-5.2%	10.4%	-18.1%	14.3%	59.4%	-27.4%	-10.4%	10.6%

Results for the combined front crash prevention systems — Adaptive Cruise Control, Forward Obstruction Warning, and Smart City Brake Support — are summarized in **Table 7**. These estimates indicate the change in insurance losses for vehicles equipped with all three features, compared with vehicles without any of the three features. Collision coverage shows a slight increase in claim frequency of 1.9 percent with severity down \$89. This results in a \$1 decline in overall losses. None of the collision results were significant. Property damage claim frequency was down 15.2 percent with severity up \$725. Both results were statistically significant. This results in a nonsignificant increase to overall losses of \$7. Injury results are not shown due to the small number of injury claims and exposure for vehicles equipped with these features.

**Table 7: Change in insurance losses for combined front crash prevention systems
(Adaptive Cruise Control, Forward Obstruction Warning, and Smart City Brake Support)**

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-5.8%	1.9%	10.2%	-\$416	-\$89	\$267	-\$34	-\$1	\$37
Property damage liability	-26.4%	-15.2%	-2.3%	\$261	\$725	\$1,257	-\$15	\$7	\$33

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability									
Medical payment	Injury results not shown due to insufficient data								
Personal injury protection									

Table 8 summarizes the results for Lane Departure Warning. Vehicle damage coverages show reductions to collision and property damage claim frequencies but increases in severities. As a result, overall losses increase for both coverages as well. None of the results were statistically significant. Injury results are not shown due to insufficient data.

Table 8: Change in insurance losses for Lane Departure Warning

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-13.1%	-3.7%	6.8%	-\$118	\$351	\$875	-\$32	\$14	\$66
Property damage liability	-21.2%	-4.5%	15.9%	-\$276	\$263	\$913	-\$23	\$5	\$41

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability									
Medical payment	Injury results not shown due to insufficient data								
Personal injury protection									

Table 9 summarizes the results for Rear Cross Traffic Alert. No clear pattern emerges with no estimates being statistically significant. Collision coverage shows a slight increase to claim frequency but reduced severity. Property damage claim frequencies are slightly reduced but severity is higher. For the injury coverages, overall frequency of claims (paid plus reserved) is down for bodily injury and medical payment but up for personal injury protection. Among paid claims, frequencies are up for both low and high severities with the exception of high-severity bodily injury claims.

Table 9: Change in insurance losses for Rear Cross Traffic Alert

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-2.8%	1.5%	6.0%	-\$297	-\$110	\$86	-\$22	-\$4	\$17
Property damage liability	-8.6%	-2.3%	4.5%	-\$71	\$114	\$311	-\$8	\$2	\$13

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-24.3%	-5.2%	18.9%	-15.0%	35.5%	115.8%	-55.9%	-30.2%	10.6%
Medical payment	-24.2%	-4.4%	20.4%	-45.0%	10.0%	120.2%	-13.9%	25.6%	83.1%
Personal injury protection	-5.1%	11.6%	31.2%	-28.0%	5.1%	53.3%	-1.6%	22.7%	53.0%

Discussion

Although the inclusion of additional model years and vehicles series have changed the point estimates for Mazda's Adaptive Front Lighting System, Blind Spot Monitoring, and back-up camera, loss results for these features continue to be favorable. The benefits for Mazda's Adaptive Front Lighting system are reduced compared with the initial estimates. However, the new, reduced estimates are consistent with results from other manufacturers. It is still unclear why, to the extent that adaptive lighting is effective, there are greater reductions to property damage claims than collision claims. However, this trend is consistent with other manufacturers' adaptive lighting systems.

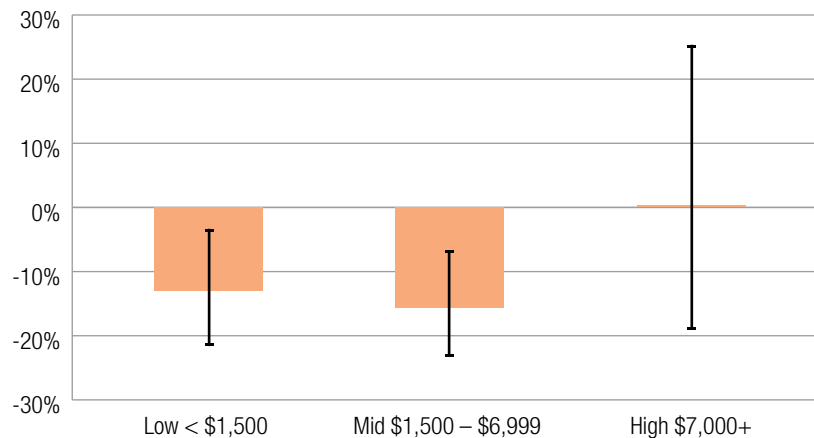
Claim frequency benefits for Mazda's Blind Spot Monitoring are improved for the vehicle damage coverages and reduced for the injury coverages. However, the new estimates are within the confidence bounds of the original study. These results are generally consistent with expectations. Incursion into occupied adjacent lanes would be expected to result in two-vehicle crashes that lead to property damage claims against the encroaching driver. The estimated reduction in property damage claims is much larger than that estimated for collision claims. That is consistent with the fact that any reduction in collision claims from such crashes would be diluted by the many single-vehicle crashes that result in collision claims and are unaffected by blind spot information. Given that Blind Spot Monitoring is intended to assist with lane changes that typically occur on multi-lane roads, many of which are higher speed roads, it is expected that the system would help prevent high-speed crashes and the injuries involved. All of the injury coverages have statistically significant reductions in claim frequency.

Mazda's back-up cameras show improved results compared with initial estimates. Back-up cameras would be expected to reduce impacts with other vehicles, objects, and some nonoccupants when operating the vehicle in reverse. This would be expected to yield reductions in collision and PDL losses and, perhaps, in BI losses. Contrary to expectations, collision claims show no real change in frequency for vehicles with Mazda's back-up camera, although property damage claims did decrease significantly. There was a reduction to bodily injury claims as well, although this was not statistically significant but it could be an indication that cameras are reducing some nonoccupant crashes. Surprisingly, there were significant reductions to medical payment and personal injury protection claims.

The new collision avoidance features introduced on some 2014 Mazda vehicles include front crash prevention systems that are designed to prevent front-to-rear crashes, which are the type of crashes that result in property damage and bodily injury claims. Mazda's Smart City Brake Support, which is a low-speed braking system similar to Volvo's City Safety system, appears to be effective at reducing these types of claims. The reduction to property damage claims was statistically significant and consistent with other manufacturers, including the estimate for Volvo's City Safety. The estimated reduction in bodily injury claims was not significant. However, the system is still new and more loss data are needed to be confident in the injury coverage results.

Property damage liability claim severity was also higher for Mazda's Smart City Brake Support. An examination of PDL claim frequency by claim size explains this result. The figure below shows the estimated change in PDL claim frequency for vehicles equipped with Smart City Brake Support by size of claim. The estimated effects indicate that the frequency of low-and mid-severity claims was much lower for vehicles with Smart City Brake Support. However, the frequency of high-severity claims was about the same. This finding is consistent with the expectations for a low-speed autonomous emergency braking system. It is designed to eliminate, or at least mitigate, low-speed and low-severity front-to-rear crashes. By removing many of the lowest cost claims, Smart City Brake Support shifted the distribution of claim severity to a higher mean.

Changes to property damage liability claim frequencies by claim severity range for Smart City Brake Support



The addition of Adaptive Cruise Control and Forward Obstruction Warning to vehicles equipped with Smart City Brake Support do not appear to substantively affect claim frequency results compared with vehicles with just Smart City Brake Support. This could be an indication that most of the benefit from these front crash prevention systems comes at low speeds. Similar to the vehicles equipped with just Smart City Brake Support, property damage liability claim severity was also higher for vehicles equipped with all three of these systems. However, an analysis of PDL claim frequency by claim size was inconclusive as the data are still very limited for vehicles equipped with all three of these features. More data are needed before drawing any conclusions.

Although physical damage coverages show a reduction in claim frequencies for Mazda’s Lane Departure Warning system, a lack of data prevents drawing a meaningful conclusion as to the effectiveness of this system.

Rear Cross Traffic Alert is designed to detect vehicles that might be crossing your rearward path, such as when you are backing out of a parking space. Similar to the back-up camera, this system operates when the vehicle is in reverse. This would be expected to yield reductions in property damage and bodily injury claims. While frequencies are down for both of these coverage types, the estimates are not significant and have wide confidence bounds.

Overall, Mazda’s Adaptive Front Lighting System, Blind Spot Monitoring System, and back-up camera are reducing insurance losses. Initial results for Mazda’s Smart City Brake Support are also promising. However, conclusions regarding Mazda’s Adaptive Cruise Control, Forward Obstruction Warning, Lane Departure Warning, and Rear Cross Traffic Alert systems must wait for additional data.

► Limitations

There are limitations to the data used in this analysis. At the time of a crash, the status of a feature is not known. The features in this study can be deactivated by the driver, and there is no way to know how many of the drivers in these vehicles turned off a system prior to the crash. However, surveys conducted by the Insurance Institute for Highway Safety indicate that large majorities of drivers with these types of systems leave them on. If a significant number of drivers do turn these features off, any reported reductions may actually be underestimates of the true effectiveness of these systems.

Additionally, the data supplied to HLDI does not include detailed crash information. Information on point of impact and the vehicle’s transmission status is not available. The technologies in this report target certain crash types. For example, the back-up camera is designed to prevent collisions when a vehicle is backing up. All collisions, regardless of the ability of a feature to mitigate or prevent the crash, are included in the analysis.

All of these features are optional or tied to higher trim levels and associated with increased costs. The type of person who selects these options or trim levels may be different from the person who declines. While the analysis controls for several driver characteristics, there may be other uncontrolled attributes with people who select these features.

References

Highway Loss Data Institute. 2011. Mazda collision avoidance features: initial results. *Loss Bulletin*. Vol. 28, No 13. Arlington, VA.

► Appendix A

Appendix A: Illustrative regression results — collision frequency								
Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits	Chi-square	P-value
Intercept		1	-9.1296		0.0982	-9.3220 -8.9372	8652.02	<0.0001
Calendar year	2006	1	0.0653	6.7%	0.0643	-0.0608 0.1914	1.03	0.3101
	2007	1	0.1665	18.1%	0.0207	0.1259 0.2072	64.52	<0.0001
	2008	1	0.1042	11.0%	0.0153	0.0742 0.1342	46.21	<0.0001
	2009	1	0.0669	6.9%	0.0128	0.0419 0.0919	27.49	<0.0001
	2010	1	0.0477	4.9%	0.0109	0.0264 0.0690	19.32	<0.0001
	2011	1	0.0377	3.8%	0.0096	0.0189 0.0564	15.53	<0.0001
	2012	1	-0.0131	-1.3%	0.0088	-0.0303 0.0041	2.22	0.1358
	2013	1	0.0027	0.3%	0.0081	-0.0132 0.0186	0.11	0.7354
	2014	1	0.0165	1.7%	0.0077	0.0015 0.0315	4.66	0.0308
	2015	0	0	0	0	0	0	
Vehicle model year and series	2010 3 4dr	1	0.3822	46.6%	0.0860	0.2138 0.5507	19.77	<0.0001
	2011 3 4dr	1	0.4730	60.5%	0.0854	0.3056 0.6405	30.65	<0.0001
	2012 3 4dr	1	0.4574	58.0%	0.0855	0.2899 0.6250	28.64	<0.0001
	2013 3 4dr	1	0.4969	64.4%	0.0861	0.3282 0.6656	33.34	<0.0001
	2014 3 4dr	1	0.6284	87.5%	0.0877	0.4565 0.8002	51.36	<0.0001
	2010 3 station wagon	1	0.2806	32.4%	0.0859	0.1123 0.4489	10.68	0.0011
	2011 3 station wagon	1	0.3762	45.7%	0.0865	0.2066 0.5459	18.90	<0.0001
	2012 3 station wagon	1	0.3121	36.6%	0.0862	0.1432 0.4810	13.12	0.0003
	2013 3 station wagon	1	0.3504	42.0%	0.0874	0.1791 0.5217	16.08	<0.0001
	2014 Mazda 3 5dr	1	0.5904	80.5%	0.0892	0.4156 0.7651	43.85	<0.0001
	2009 6 4dr	1	0.3581	43.1%	0.0858	0.1900 0.5262	17.43	<0.0001
	2010 6 4dr	1	0.3817	46.5%	0.0857	0.2137 0.5497	19.83	<0.0001
	2011 6 4dr	1	0.4416	55.5%	0.0863	0.2724 0.6107	26.18	<0.0001
	2012 6 4dr	1	0.5403	71.7%	0.0862	0.3713 0.7094	39.25	<0.0001
	2013 6 4dr	1	0.4857	62.5%	0.0889	0.3114 0.6600	29.83	<0.0001
	2014 6 4dr	1	0.6537	92.3%	0.0876	0.4821 0.8253	55.74	<0.0001
	2013 Mazda CX-5 4dr	1	0.3543	42.5%	0.0866	0.1846 0.5240	16.74	<0.0001
	2014 Mazda CX-5 4dr	1	0.3395	40.4%	0.0867	0.1697 0.5094	15.35	<0.0001
	2013 Mazda CX-5 4dr 4WD	1	0.3464	41.4%	0.0868	0.1762 0.5165	15.92	<0.0001
	2014 Mazda CX-5 4dr 4WD	1	0.3739	45.3%	0.0868	0.2038 0.5439	18.57	<0.0001
	2010 Mazda CX-7 4dr	1	0.4141	51.3%	0.0856	0.2463 0.5819	23.40	<0.0001
	2011 Mazda CX-7 4dr	1	0.4569	57.9%	0.0857	0.2888 0.6250	28.39	<0.0001
2012 Mazda CX-7 4dr	1	0.4898	63.2%	0.0892	0.3149 0.6648	30.13	<0.0001	
2007 Mazda CX-7 4dr 2WD/4WD	1	0.3794	46.1%	0.0854	0.2121 0.5467	19.75	<0.0001	

Appendix A: Illustrative regression results — collision frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
2008 Mazda CX-7 4dr 2WD/4WD	1	0.3827	46.6%	0.0856	0.2150	0.5504	20.00	<0.0001
2009 Mazda CX-7 4dr 2WD/4WD	1	0.4016	49.4%	0.0864	0.2322	0.5710	21.60	<0.0001
2010 Mazda CX-7 4dr 4WD	1	0.5015	65.1%	0.0878	0.3295	0.6736	32.64	<0.0001
2011 Mazda CX-7 4dr 4WD	1	0.5627	75.5%	0.0916	0.3831	0.7423	37.72	<0.0001
2012 Mazda CX-7 4dr 4WD	1	0.6349	88.7%	0.1851	0.2722	0.9977	11.77	0.0006
2007 Mazda CX-9 4dr	1	0.2867	33.2%	0.0869	0.1164	0.4569	10.89	0.0010
2008 Mazda CX-9 4dr	1	0.2660	30.5%	0.0862	0.0970	0.4350	9.52	0.0020
2009 Mazda CX-9 4dr	1	0.2668	30.6%	0.0886	0.0930	0.4405	9.06	0.0026
2010 Mazda CX-9 4dr	1	0.3565	42.8%	0.0866	0.1868	0.5262	16.95	<0.0001
2011 Mazda CX-9 4dr	1	0.4028	49.6%	0.0874	0.2314	0.5742	21.22	<0.0001
2012 Mazda CX-9 4dr	1	0.3892	47.6%	0.0878	0.2171	0.5613	19.64	<0.0001
2013 Mazda CX-9 4dr	1	0.4829	62.1%	0.0913	0.3040	0.6617	27.99	<0.0001
2014 Mazda CX-9 4dr	1	0.5725	77.3%	0.0999	0.3766	0.7683	32.81	<0.0001
2007 Mazda CX-9 4dr 4WD	1	0.3827	46.6%	0.0868	0.2126	0.5528	19.44	<0.0001
2008 Mazda CX-9 4dr 4WD	1	0.3885	47.5%	0.0859	0.2201	0.5569	20.45	<0.0001
2009 Mazda CX-9 4dr 4WD	1	0.3940	48.3%	0.0874	0.2226	0.5653	20.31	<0.0001
2010 Mazda CX-9 4dr 4WD	1	0.4974	64.4%	0.0860	0.3288	0.6660	33.44	<0.0001
2011 Mazda CX-9 4dr 4WD	1	0.5073	66.1%	0.0864	0.3379	0.6767	34.45	<0.0001
2012 Mazda CX-9 4dr 4WD	1	0.5488	73.1%	0.0867	0.3788	0.7188	40.04	<0.0001
2013 Mazda CX-9 4dr 4WD	1	0.6303	87.8%	0.0897	0.4545	0.8060	49.41	<0.0001
2014 Mazda CX-9 4dr 4WD	1	0.5567	74.5%	0.0969	0.3667	0.7467	32.98	<0.0001
2010 Mazda Tribute 4dr	1	0.1578	17.1%	0.0939	-0.0263	0.3419	2.82	0.0930
2011 Mazda Tribute 4dr	1	0.0594	6.1%	0.1022	-0.1410	0.2597	0.34	0.5616
2010 Mazda Tribute 4dr 4WD	1	-0.0418	-4.1%	0.1106	-0.2587	0.1750	0.14	0.7053
2011 Mazda Tribute 4dr 4WD	0	0	0	0	0	0		
Rated driver age group								
14–24	1	0.2739	31.5%	0.0083	0.2576	0.2901	1089.18	<0.0001
25–29	1	0.0873	9.1%	0.0076	0.0724	0.1023	131.03	<0.0001
30–39	1	0.0135	1.4%	0.0064	0.0010	0.0260	4.49	0.0341
50–59	1	-0.0337	-3.3%	0.0070	-0.0474	-0.0200	23.37	<0.0001
60–64	1	-0.0344	-3.4%	0.0103	-0.0546	-0.0142	11.12	0.0009
65–69	1	0.0057	0.6%	0.0120	-0.0178	0.0293	0.23	0.6330
70+	1	0.1189	12.6%	0.0116	0.0961	0.1417	104.58	<0.0001
Unknown	1	0.0910	9.5%	0.0112	0.0690	0.1130	65.88	<0.0001
40–49	0	0	0	0	0	0		
Rated driver gender								
Male	1	-0.0519	-5.1%	0.0049	-0.0615	-0.0424	113.95	<0.0001
Unknown	1	-0.2147	-19.3%	0.0140	-0.2421	-0.1874	236.86	<0.0001
Female	0	0	0	0	0	0		

Appendix A: Illustrative regression results — collision frequency

Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Rated driver marital status	Single	1	0.1786	19.6%	0.0055	0.1679	0.1893	1073.39	<0.0001
	Unknown	1	0.1855	20.4%	0.0138	0.1584	0.2127	179.83	<0.0001
	Married	0	0		0	0	0		
Risk	Nonstandard	1	0.1529	16.5%	0.0068	0.1396	0.1662	507.61	<0.0001
	Standard	0	0	0	0	0	0		
State	Alabama	1	-0.1345	-12.6%	0.0518	-0.2360	-0.0330	6.74	0.0094
	Arizona	1	-0.1825	-16.7%	0.0502	-0.2808	-0.0841	13.23	0.0003
	Arkansas	1	-0.1279	-12.0%	0.0568	-0.2392	-0.0166	5.07	0.0244
	California	1	0.0378	3.9%	0.0482	-0.0567	0.1323	0.61	0.4330
	Colorado	1	-0.0954	-9.1%	0.0500	-0.1934	0.0025	3.65	0.0561
	Connecticut	1	-0.1290	-12.1%	0.0503	-0.2276	-0.0304	6.58	0.0103
	Delaware	1	-0.0894	-8.6%	0.0546	-0.1964	0.0175	2.69	0.1011
	Dist of Columbia	1	0.2212	24.8%	0.0613	0.1011	0.3413	13.03	0.0003
	Florida	1	-0.3249	-27.7%	0.0484	-0.4197	-0.2301	45.14	<0.0001
	Georgia	1	-0.2148	-19.3%	0.0497	-0.3122	-0.1173	18.65	<0.0001
	Idaho	1	-0.3043	-26.2%	0.0644	-0.4305	-0.1782	22.36	<0.0001
	Illinois	1	-0.1058	-10.0%	0.0488	-0.2014	-0.0102	4.70	0.0301
	Indiana	1	-0.1925	-17.5%	0.0511	-0.2926	-0.0923	14.20	0.0002
	Iowa	1	-0.2107	-19.0%	0.0561	-0.3206	-0.1007	14.10	0.0002
	Kansas	1	-0.2139	-19.3%	0.0528	-0.3174	-0.1104	16.41	<0.0001
	Kentucky	1	-0.2758	-24.1%	0.0518	-0.3773	-0.1742	28.34	<0.0001
	Louisiana	1	0.0409	4.2%	0.0500	-0.0572	0.1389	0.67	0.4143
	Maine	1	-0.0934	-8.9%	0.0636	-0.2180	0.0312	2.16	0.1418
	Maryland	1	-0.0585	-5.7%	0.0491	-0.1548	0.0378	1.42	0.2337
	Massachusetts	1	-0.0880	-8.4%	0.0503	-0.1865	0.0106	3.06	0.0803
	Michigan	1	0.2217	24.8%	0.0498	0.1240	0.3193	19.80	<0.0001
	Minnesota	1	-0.2068	-18.7%	0.0502	-0.3051	-0.1084	16.99	<0.0001
	Mississippi	1	-0.0406	-4.0%	0.0581	-0.1545	0.0732	0.49	0.4844
	Missouri	1	-0.2311	-20.6%	0.0504	-0.3299	-0.1323	21.02	<0.0001
	Montana	1	-0.1151	-10.9%	0.0847	-0.2810	0.0509	1.85	0.1741
	Nebraska	1	-0.2918	-25.3%	0.0553	-0.4002	-0.1833	27.80	<0.0001
	Nevada	1	-0.1889	-17.2%	0.0546	-0.2959	-0.0819	11.98	0.0005
	New Hampshire	1	0.0276	2.8%	0.0549	-0.0799	0.1351	0.25	0.6146
	New Jersey	1	-0.1422	-13.3%	0.0486	-0.2376	-0.0469	8.55	0.0035
	New Mexico	1	-0.1570	-14.5%	0.0562	-0.2671	-0.0470	7.82	0.0052
	New York	1	0.0078	0.8%	0.0483	-0.0869	0.1026	0.03	0.8716
	North Carolina	1	-0.3360	-28.5%	0.0497	-0.4334	-0.2387	45.77	<0.0001
North Dakota	1	0.0266	2.7%	0.0772	-0.1246	0.1778	0.12	0.7303	
Ohio	1	-0.2426	-21.5%	0.0490	-0.3386	-0.1466	24.55	<0.0001	
Oklahoma	1	-0.2084	-18.8%	0.0529	-0.3121	-0.1048	15.53	<0.0001	
Oregon	1	-0.2862	-24.9%	0.0515	-0.3871	-0.1853	30.90	<0.0001	
Pennsylvania	1	0.0167	1.7%	0.0484	-0.0781	0.1116	0.12	0.7294	
Rhode Island	1	-0.0144	-1.4%	0.0559	-0.1239	0.0951	0.07	0.7965	

Appendix A: Illustrative regression results — collision frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
South Carolina	1	-0.2555	-22.5%	0.0527	-0.3588	-0.1522	23.52	<0.0001
South Dakota	1	-0.1884	-17.2%	0.0794	-0.3440	-0.0328	5.63	0.0176
Tennessee	1	-0.1663	-15.3%	0.0505	-0.2652	-0.0673	10.84	0.0010
Texas	1	-0.1347	-12.6%	0.0482	-0.2292	-0.0402	7.80	0.0052
Utah	1	-0.2784	-24.3%	0.0524	-0.3812	-0.1756	28.18	<0.0001
Vermont	1	-0.1058	-10.0%	0.0761	-0.2549	0.0434	1.93	0.1646
Virginia	1	-0.1215	-11.4%	0.0490	-0.2175	-0.0255	6.15	0.0131
Washington	1	-0.1681	-15.5%	0.0494	-0.2649	-0.0712	11.56	0.0007
West Virginia	1	-0.2332	-20.8%	0.0619	-0.3546	-0.1118	14.18	0.0002
Wisconsin	1	-0.1713	-15.7%	0.0509	-0.2711	-0.0714	11.3	0.0008
Wyoming	1	-0.0158	-1.6%	0.0889	-0.1901	0.1585	0.03	0.8593
Hawaii	1	0.0185	1.9%	0.0540	-0.0873	0.1244	0.12	0.7312
Alaska	0	0	0	0	0	0		
Deductible range								
0–250	1	0.4963	64.3%	0.0078	0.4810	0.5115	4065.97	<0.0001
1,001+	1	-0.3997	-32.9%	0.0403	-0.4787	-0.3208	98.45	<0.0001
251–500	1	0.2966	34.5%	0.0066	0.2836	0.3096	2002.65	<0.0001
501–1,000	0	0	0	0	0	0		
Registered vehicle density								
0–99	1	-0.1872	-17.1%	0.0078	-0.2025	-0.1719	575.21	<0.0001
100–499	1	-0.1316	-12.3%	0.0050	-0.1414	-0.1217	683.44	<0.0001
500+	0	0	0	0	0	0		
Adaptive Cruise Control, Forward Obstruction Warning and Smart City Brake Support	1	0.0186	1.9%	0.0399	-0.0597	0.0969	0.22	0.6413
Smart City Brake Support	1	-0.0349	-3.4%	0.0211	-0.0762	0.0064	2.75	0.0973
Blind Spot Monitoring	1	-0.0313	-3.1%	0.0071	-0.0453	-0.0173	19.33	<0.0001
Lane Departure Warning	1	-0.0374	-3.7%	0.0524	-0.1402	0.0654	0.51	0.4756
Adaptive Front Lighting System	1	-0.0172	-1.7%	0.0106	-0.0379	0.0036	2.63	0.1045
Rear Cross Traffic Alert	1	0.0152	1.5%	0.0222	-0.0283	0.0586	0.47	0.4940
Back-up camera	1	0.0055	0.6%	0.0067	-0.0075	0.0185	0.68	0.4086



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The Highway Loss Data Institute is a nonprofit public service organization that gathers, processes, and publishes insurance data on the human and economic losses associated with owning and operating motor vehicles. DW201509 NB Runs 244 & 245

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Acura collision avoidance features: initial results

This analysis examines three Acura collision avoidance features — Collision Mitigation Braking System, Active Front Lighting System, and Blind Spot Information. Vehicles with Collision Mitigation Braking show significant reductions in property damage liability claims, as would be expected from a forward collision warning system. Results for the other two features are not significant, nor are they patterned as expected. Additional data is needed before conclusions can be drawn.

▶ Introduction

Collision avoidance technologies are becoming popular in U.S. motor vehicles, and more and more automakers are touting the potential safety benefits. However, the actual benefits in terms of crash reductions still are being measured. This Highway Loss Data Institute bulletin examines the early insurance claims experience for Acura vehicles fitted with three features:

Collision Mitigation Braking System is Acura's term for a forward collision warning system that includes some autonomous emergency braking. The system is an enhancement of Acura's Adaptive Cruise Control system, which uses a radar sensor behind the front grille to maintain a particular speed and distance interval from traffic ahead, both of which are set by the driver. With collision mitigation, the system will also provide visual and auditory warnings when speed and distance indicates risk of a crash with the leading traffic and, if the driver does not respond by reducing speed, the system will tug at the seat belt to get the driver's attention and begin braking to mitigate — but probably not prevent — the crash. Collision mitigation becomes functional at speeds over 10 mph and deactivates when speed drops below 10 mph. The system operates whether or not Adaptive Cruise Control is activated. Collision mitigation can be deactivated by the driver but will reactivate at the next ignition cycle. Adaptive Cruise Control is always present on vehicles with Collision Mitigation Braking, and therefore the analysis cannot separate out the individual effects of these features. Adaptive Cruise Control is available at speeds over 25 mph and must be activated by the driver during each ignition cycle. Adaptive Cruise Control cannot bring the vehicle to a complete stop. Once activated, it continues until the driver deactivates it or until vehicle speed falls below 25 mph.

Active Front Lighting System is Acura's term for headlamps that respond to driver steering input. It uses sensors to measure vehicle speed, steering angle and vehicle yaw while small electric motors turn the headlights accordingly, up to 20 degrees, to facilitate vision around a curve at night. At a stop, the right headlight turns right when you turn the steering wheel to the right. However, the left headlight does not turn left when you turn the steering wheel to the left to prevent the light from pointing at oncoming traffic. Once the headlights are turned on by the driver, Active Front Lighting goes on after the vehicle has been driven a short distance. The system can be deactivated by the driver but will reactivate the next time the headlights are turned on.

Blind Spot Information is Acura's term for a side view assist system that alerts drivers to vehicles that are adjacent to them. There are two radar sensors, one in each corner of the rear bumper to scan a range behind and to the side of the vehicle, areas commonly known as driver blind spots. If a vehicle is detected in a blind spot, a warning light on the appropriate A-pillar is illuminated. If the driver activates a turn signal in the direction a vehicle has been detected, the warning light will flash. The system is functional at speeds over 6 mph and can be deactivated by the driver. At the next ignition cycle Blind Spot Information will be in the previous on/off setting.

► Method

Vehicles

Collision Mitigation Braking (with Adaptive Cruise Control), Active Front Lighting, and Blind Spot Information are offered as optional equipment on various Acura models. The presence or absence of some of these features is not always discernible from the information encoded in the vehicle identification numbers (VINs), but rather, this must be determined from build information maintained by the manufacturer. Acura supplied HLDI with the VINs for any vehicles that were equipped with at least one of the collision avoidance features listed above. Vehicles of the same model year and series identified by Acura as not having these features served as the control vehicles in the analysis. It should be noted that some of these vehicles may have been equipped also with Rear Parking Sensors or Rear View Camera (MDX and RL), but no VIN-level information was supplied about rear sensors or cameras. Therefore, it must be assumed that these features — which can affect some insurance losses — were equally distributed among the controls and the study vehicles. Certain features are always bundled together on a vehicle and cannot be standalone features. The MDX and ZDX vehicles that have collision mitigation also have Blind Spot Information. **Table 1** lists the vehicle series and model years included in the analysis and the exposure for each vehicle, measured in insured vehicle years. The exposure of each feature in a given series is shown as a percentage of total exposure.

Table 1 : Feature exposure by vehicle series

Make	Series	Model year range	Active Front Lighting System	Collision Mitigation Braking System (includes Adaptive Cruise Control)	Blind Spot Information	Total exposure
Acura	MDX 4dr 4WD	2010-11		12%	12%	42,123
Acura	RL 4dr 4WD	2005-11	97%	4%		174,044
Acura	ZDX 4dr 4WD	2010-11		28%	28%	2,034

Insurance data

Automobile insurance covers damages to vehicles and property as well as injuries to people involved in crashes. Different insurance coverages pay for vehicle damage versus injuries, and different coverages may apply depending on who is at fault. The current study is based on property damage liability, collision, bodily injury liability, personal injury protection and medical payment coverages. Exposure is measured in insured vehicle years. An insured vehicle year is one vehicle insured for one year, two for six months, etc.

Because different crash avoidance features may affect different types of insurance coverage, it can be important to understand how coverages vary among the states and how this affects inclusion in the analyses. Collision coverage insures against vehicle damage to an at-fault driver's vehicle sustained in a crash with an object or other vehicle; this coverage is common to all 50 states. Property damage liability (PDL) coverage insures against vehicle damage that at-fault drivers cause to other people's vehicle and property in crashes; this coverage exists in all states except Michigan, where vehicle damage is covered on a no-fault basis (each insured vehicle pays for its own damage in a crash, regardless of who's at fault). Coverage of injuries is more complex. Bodily injury (BI) liability coverage insures against medical, hospital, and other expenses for injuries that at-fault drivers inflict on occupants of other vehicles or others on the road; although motorists in most states may have BI coverage, this information is analyzed only in states where the at-fault driver has first obligation to pay for injuries (33 states with traditional tort insurance systems). Medical payment coverage (MedPay), also sold in the 33 states with traditional tort insurance systems, covers injuries to insured drivers and the passengers in their vehicles, but not injuries to people in other vehicles involved in the crash. Seventeen other states employ no-fault injury systems (personal injury protection coverage, or PIP) that pay up to a specified amount for injuries to occupants of involved-insured vehicles, regardless of who's at fault in a collision. The District of Columbia has a hybrid insurance system for injuries and is excluded from the injury analysis.

Statistical methods

Regression analysis was used to quantify the effect of vehicle feature while controlling for other covariates. The covariates included calendar year, model year, garaging state, vehicle density (number of registered vehicles per square mile), rated driver age group, rated driver gender, rated driver marital status, deductible range (collision coverage only), and risk. For each safety feature supplied by the manufacturer a binary variable was included. Based on the model year and series a single variable called SERIESMY was created for inclusion in the regression model. Statistically, including such a variable in the regression model is equivalent to including the interaction of series and model year. Effectively, this variable restricted the estimation of the effect of each feature within vehicle series and model year, preventing the confounding of the collision avoidance feature effects with other vehicle design changes that could occur from model year to model year.

Claim frequency was modeled using a Poisson distribution, whereas claim severity (average loss payment per claim) was modeled using a Gamma distribution. Both models used a logarithmic link function. Estimates for overall losses were derived from the claim frequency and claim severity models. Estimates for frequency, severity, and overall losses are presented for collision and property damage liability. For PIP, BI and MedPay three frequency estimates are presented. The first frequency is the frequency for all claims, including those that already have been paid and those for which money has been set aside for possible payment in the future, known as claims with reserves. The other two frequencies include only paid claims separated into low and high severity ranges. Note that the percentage of all injury claims that were paid by the date of analysis varies by coverage: 78.9 percent for PIP, 67.8 percent for BI, and 61.6 percent for MedPay. The low severity range was <\$1,000 for PIP and MedPay, <\$5,000 for BI; high severity covered all loss payments greater than that.

A separate regression was performed for each insurance loss measure for a total of 15 regressions (5 coverages x 3 loss measures each). For space reasons, only the estimates for the individual crash avoidance features are shown on the following pages. To illustrate the analyses, however, the Appendix contains full model results for collision claim frequencies. To further simplify the presentation here, the exponent of the parameter estimate was calculated, 1 was subtracted, and the resultant multiplied by 100. The resulting number corresponds to the effect of the feature on that loss measure. For example, the estimate of the effect of Collision Mitigation Braking System on PDL claim frequency was -0.15293; thus, vehicles with the feature had 14.2 percent fewer PDL claims than expected $((\exp(-0.15293)-1)*100=-14.2)$.

► Results

Results for Acura's Collision Mitigation Braking System are summarized in [Table 2](#). The lower and upper bounds represent the 95 percent confidence limits for the estimates. For vehicle damage losses, frequency of claims are generally down while the average cost of the remaining claims is slightly higher and overall losses are slightly lower. Only the reduction in frequency of property damage liability claims, 14.2 percent, is statistically significant (indicated in blue in the table).

For injury losses, overall frequency of claims (paid plus reserved) decrease for all coverages, but none of the decreases is significant, and the confidence bounds are quite wide. Among paid claims, those of higher severity tend to show larger reductions in frequency, but still the reductions are not statistically significant, and the confidence bounds are even larger due to the reduced sample size.

Table 2 : Change in insurance losses for Collision Mitigation Braking System (includes Adaptive Cruise Control)

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower Bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-11.2%	-3.1%	5.7%	-\$452	\$31	\$567	-\$52	-\$9	\$41
Property damage liability	-25.9%	-14.2%	-0.6%	-\$323	\$69	\$523	-\$24	-\$10	\$7

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower Bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-46.5%	-15.0%	35.0%	-45.5%	9.8%	121.1%	-78.8%	-41.3%	62.5%
Medical payments	-40.8%	-3%	58.8%	-12.9%	119.5%	453.4%	-67.7%	-25%	74%
Personal injury protection	-40.1%	-16.5%	16.4%	-74.3%	-36%	59.4%	-42.7%	-13.1%	31.8%

Results for Acura’s Active Front Lighting System are summarized in **Table 3**. Again, the lower and upper bounds represent the 95 percent confidence limits for the estimates. Reductions in loss claims are estimated for both first- and third-party vehicle damage coverages, resulting in somewhat lower losses per insured vehicle year (overall losses). However, none of the estimated effects for active lighting on collision or PDL losses is statistically significant.

Under injury coverages, the frequency of claims is lower for both MedPay and PIP, but not for BI, and none of the differences is statistically significant. Among paid claims, there appears to be a reduction in high severity injury claims under all coverages, though still not statistically significant and the confidence bounds are quite large. No pattern is observed for low severity claims and the confidence bounds are even larger.

Table 3 : Change in insurance losses for Active Front Lighting System

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower Bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-11.9%	-2%	9%	-\$466	\$12	\$556	-\$40	-\$4	\$38
Property damage liability	-20.3%	-6.3%	10.3%	-\$418	-\$9	\$473	-\$20	-\$5	\$14

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower Bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-38.2%	8.7%	91%	-51.9%	39.4%	304.1%	-68%	-23.6%	82.7%
Medical payments	-59.7%	-28.2%	27.8%	-92.1%	-25.9%	597.1%	-65.5%	-24.9%	63.3%
Personal injury protection	-38.6%	-7.9%	38.1%	-43.9%	88.7%	535.2%	-50.1%	-16.7%	39.3%

Results for Acura’s Blind Spot Information system are summarized in **Table 4**. The lower and upper bounds represent the 95 percent confidence limits for the estimates. Both vehicle damage loss frequencies are lower with the blind spot information feature, with larger reductions for PDL than collision; however, neither reduction is statistically significant and, in the case of collision, the small reduction in frequency is more than offset by an increase in average cost of the remaining claims. The \$19 reduction in loss payments per insured vehicle year for PDL coverage is encouraging but still not statistically significant.

Under injury coverages, the pattern is unclear, and the confidence bounds for all estimated effects are quite large. The central finding is that the data are insufficient.

Table 4 : Change in insurance losses for Blind Spot Information

Vehicle damage coverage type	Lower bound	FREQUENCY	Upper bound	Lower Bound	SEVERITY	Upper bound	Lower bound	OVERALL LOSSES	Upper bound
Collision	-18.5%	-5.4%	9.7%	-\$523	\$315	\$1,315	-\$70	\$3	\$94
Property damage liability	-34%	-16.2%	6.3%	-\$739	-\$187	\$512	-\$38	-\$19	\$8

Injury coverage type	Lower bound	FREQUENCY	Upper bound	Lower Bound	LOW SEVERITY FREQUENCY	Upper bound	Lower bound	HIGH SEVERITY FREQUENCY	Upper bound
Bodily injury liability	-47%	24.1%	190.6%	-37.9%	116%	651.6%	-43.5%	197.3%	1463.9%
Medical payments	-60%	-5%	125.7%	-89.6%	-37.8%	272.4%	-60.7%	41.8%	411.3%
Personal injury protection	-21.5%	43.1%	161%	-81.8%	-0.2%	446.5%	-26.8%	58.5%	243.3%

► Discussion

The results for these three Acura collision avoidance features — Collision Mitigation Braking System (with Adaptive Cruise Control), Blind Spot Information, and Active Front Lighting System — are encouraging. Collision mitigation, in particular, shows reductions in claim frequencies across all coverages. Additionally, the pattern of findings for vehicle damage coverages is consistent with the expected benefits; that is, the reduction in claims is greater for PDL coverage than for collision coverage. Collision Mitigation Braking is operative in following traffic and intended to reduce the occurrence and/or severity of front-to-rear collisions, and those types of crashes are more common among PDL claims than among collision claims, which include many single vehicle crashes. Adaptive Cruise Control, which is always bundled with Collision Mitigation Braking, if used, could reduce the likelihood that drivers get into situations that lead to a crash.

Analyses of Active Front Lighting indicate a benefit in claims reductions, but the effects are not significant, and the pattern is not consistent with expectations. For example, the prevalence of single-vehicle crashes at night suggests that active lighting would have a greater effect on collision coverage than PDL. However, to the extent that this feature is effective, it appears to reduce PDL claims more than collision claims. Making the pattern even more perplexing is the fact just 7 percent of police-reported crashes occur between 9 p.m. and 6 a.m. and involve more than one vehicle. Given the reduction in PDL claim frequency (6.3 percent), this would mean that over 70 percent of night time PDL claims were prevented. This raises questions about the exact source of the estimated benefits: Does active lighting work because the lamps are steerable or is there something else about cars with active lighting that has not been adequately accounted for in the current analyses?

Although not statistically significant, results for Blind Spot Information are patterned as expected. Incursion into occupied adjacent lanes would be expected to result in two-vehicle crashes that lead to PDL claims against the encroaching driver. Again, although neither estimate is statistically significant, the estimated reduction in PDL claims is much larger than that estimated for collision claims. This is consistent with the fact that the reduction in collision claims from such crashes would be diluted by the many single-vehicle crashes that result in collision claims and are unaffected by blind spot information.

Taken alone, these data leave much uncertainty about the real-world effectiveness of Acura’s collision-avoidance features. The benefits seen for Collision Mitigation Braking are consistent with those identified for Volvo City Safety (HLDI, 2011) — another system intended to prevent front-to-rear crashes — and indicate that the warning system probably is having some benefit. It’s still too early to tell if the autonomous emergency braking feature is having additional benefit, as this is not expected to reduce the frequency of crashes but only the resulting severity. In that regard, the increase in average cost of the remaining vehicle damage claims is not encouraging, but the confidence bounds are quite wide. Conclusions about the other features examined — even tentative conclusions — must wait for additional data, both from additional experience with Acuras and also from other vehicle makes fitted with similar technology.

► Limitations

There are limitations to the data used in this analysis. At the time of a crash, the status of a feature is not known. The features in this study can be deactivated by the driver and there is no way to know how many of the drivers in these vehicles turned off a system prior to the crash. If a significant number of drivers do turn these features off, any reported reductions may actually be underestimates of the true effectiveness of these systems.

Additionally, the data supplied to HLDI does not include detailed crash information. Information on point of impact and the vehicle's transmission status is not available. The technologies in this report target certain crash types. For example, Blind Spot Information is designed to prevent sideswipe type collisions. All collisions, regardless of the ability of a feature to mitigate or prevent the crash, are included in the analysis.

All of these features are optional and are associated with increased costs. The type of person who selects this additional cost may be different from the person declining. While the analysis controls for several driver characteristics, there may be other uncontrolled attributes associated with people who select these features that are different among people who do not.

References

Highway Loss Data Institute. 2011. Volvo City Safety loss experience — initial results. Loss bulletin Vol. 28, No. 6. Arlington, VA.

Appendix : Illustrative regression results — collision frequency									
Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Intercept		1	-8.3515		0.3931	-9.1220	-7.5811	451.37	<0.0001
Calendar year	2004	1	-0.4270	-34.8%	0.2364	-0.8904	0.0364	3.26	0.0709
	2005	1	0.0435	4.4%	0.0445	-0.0438	0.1308	0.95	0.3286
	2006	1	-0.0116	-1.2%	0.0335	-0.0773	0.0541	0.12	0.7286
	2007	1	0.0917	9.6%	0.0292	0.0345	0.1490	9.87	0.0017
	2008	1	0.0395	4%	0.0282	-0.0158	0.0947	1.96	0.1614
	2009	1	0.0348	3.5%	0.0272	-0.0186	0.0882	1.63	0.2015
	2011	1	0.0094	0.9%	0.0259	-0.0413	0.0601	0.13	0.7172
	2010	0	0		0	0	0		
Vehicle model year and series	2010 MDX 4dr 4WD	1	-0.6334	-46.9%	0.3175	-1.2556	-0.0112	3.98	0.0460
	2011 MDX 4dr 4WD	1	-0.7472	-52.6%	0.3187	-1.3720	-0.1225	5.50	0.0191
	2005 RL 4dr 4WD	1	-0.3810	-31.7%	0.3220	-1.0121	0.2501	1.40	0.2367
	2006 RL 4dr 4WD	1	-0.3603	-30.3%	0.3222	-0.9917	0.2712	1.25	0.2635
	2007 RL 4dr 4WD	1	-0.4246	-34.6%	0.3211	-1.0540	0.2048	1.75	0.1861
	2008 RL 4dr 4WD	1	-0.3579	-30.1%	0.3222	-0.9893	0.2735	1.23	0.2666
	2009 RL 4dr 4WD	1	-0.4388	-35.5%	0.3262	-1.0781	0.2006	1.81	0.1786
	2010 RL 4dr 4WD	1	-0.2985	-25.8%	0.3300	-0.9452	0.3483	0.82	0.3657
	2011 RL 4dr 4WD	1	-0.2076	-18.7%	0.4119	-1.0148	0.5997	0.25	0.6143
	2010 ZDX 4dr 4WD	1	-0.1332	-12.5%	0.3249	-0.7700	0.5036	0.17	0.6818
	2011 ZDX 4dr 4WD	0	0		0	0	0		

Appendix : Illustrative regression results — collision frequency

Parameter		Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value
Rated driver age group	14-20	1	-0.0135	-1.3%	0.0792	-0.1687	0.1417	0.03	0.8649
	21-24	1	0.3072	36.0%	0.0646	0.1806	0.4338	22.61	<0.0001
	25-39	1	0.1906	21.0%	0.0220	0.1474	0.2337	74.93	<0.0001
	65+	1	0.0982	10.3%	0.0230	0.0531	0.1433	18.23	<0.0001
	Unknown	1	-0.0480	-4.7%	0.0398	-0.1260	0.0301	1.45	0.2284
	40-64	0	0		0	0	0		
Rated driver gender	Male	1	-0.0071	-0.7%	0.0202	-0.0466	0.0324	0.12	0.7256
	Unknown	1	-0.1748	-16.0%	0.0439	-0.2608	-0.0887	15.85	<0.0001
	Female	0	0		0	0	0		
Rated driver marital status	Single	1	0.2463	27.9%	0.0240	0.1992	0.2934	105.19	<0.0001
	Unknown	1	0.2633	30.1%	0.0427	0.1796	0.3469	38.04	<0.0001
	Married	0	0		0	0	0		
Risk	Nonstandard	1	0.2267	25.4%	0.0282	0.1714	0.2820	64.50	<0.0001
	Standard	0	0		0	0	0		
State	Alabama	1	-0.1181	-11.1%	0.2429	-0.5942	0.3580	0.24	0.6269
	Arizona	1	-0.3956	-32.7%	0.2415	-0.8690	0.0778	2.68	0.1015
	Arkansas	1	-0.4271	-34.8%	0.2697	-0.9556	0.1014	2.51	0.1132
	California	1	-0.1291	-12.1%	0.2311	-0.5821	0.3239	0.31	0.5764
	Colorado	1	-0.1853	-16.9%	0.2370	-0.6497	0.2792	0.61	0.4343
	Connecticut	1	-0.2477	-21.9%	0.2359	-0.7101	0.2147	1.10	0.2937
	Delaware	1	-0.1446	-13.5%	0.2574	-0.6490	0.3599	0.32	0.5744
	District of Columbia	1	0.3615	43.5%	0.2510	-0.1305	0.8535	2.07	0.1498
	Florida	1	-0.4921	-38.9%	0.2319	-0.9466	-0.0376	4.50	0.0338
	Georgia	1	-0.3481	-29.4%	0.2347	-0.8081	0.1120	2.20	0.1381
	Hawaii	1	-0.1277	-12.0%	0.2640	-0.6452	0.3898	0.23	0.6286
	Idaho	1	-0.4292	-34.9%	0.3206	-1.0575	0.1992	1.79	0.1807
	Illinois	1	-0.2105	-19.0%	0.2326	-0.6664	0.2454	0.82	0.3656
	Indiana	1	-0.3830	-31.8%	0.2518	-0.8765	0.1104	2.31	0.1281
	Iowa	1	-0.3286	-28.0%	0.3103	-0.9368	0.2796	1.12	0.2896
	Kansas	1	-0.4180	-34.2%	0.2469	-0.9019	0.0659	2.87	0.0904
	Kentucky	1	-0.5863	-44.4%	0.2740	-1.1234	-0.0493	4.58	0.0324
	Louisiana	1	0.0222	2.2%	0.2447	-0.4573	0.5018	0.01	0.9276
	Maine	1	-0.3658	-30.6%	0.4049	-1.1593	0.4278	0.82	0.3663
	Maryland	1	-0.1215	-11.4%	0.2325	-0.5773	0.3342	0.27	0.6013
	Massachusetts	1	0.0366	3.7%	0.2371	-0.4281	0.5012	0.02	0.8774
	Michigan	1	0.2192	24.5%	0.2428	-0.2568	0.6952	0.81	0.3667
	Minnesota	1	-0.2572	-22.7%	0.2414	-0.7303	0.2158	1.14	0.2866
	Mississippi	1	-0.2945	-25.5%	0.2678	-0.8194	0.2305	1.21	0.2715
	Missouri	1	-0.3255	-27.8%	0.2415	-0.7987	0.1478	1.82	0.1777
	Montana	1	0.0376	3.8%	0.3470	-0.6426	0.7177	0.01	0.9138
	Nebraska	1	-0.3995	-32.9%	0.2884	-0.9646	0.1657	1.92	0.1659

Appendix : Illustrative regression results — collision frequency

Parameter	Degrees of freedom	Estimate	Effect	Standard error	Wald 95% confidence limits		Chi-square	P-value	
Nevada	1	-0.3395	-28.8%	0.2551	-0.8394	0.1604	1.77	0.1831	
New Hampshire	1	-0.0394	-3.9%	0.2560	-0.5412	0.4625	0.02	0.8778	
New Jersey	1	-0.1780	-16.3%	0.2326	-0.6339	0.2779	0.59	0.4441	
New Mexico	1	-0.2699	-23.7%	0.2723	-0.8035	0.2638	0.98	0.3216	
New York	1	-0.0509	-5.0%	0.2315	-0.5047	0.4028	0.05	0.8259	
North Carolina	1	-0.5858	-44.3%	0.2369	-1.0501	-0.1215	6.12	0.0134	
North Dakota	1	-0.1745	-16.0%	0.5511	-1.2548	0.9057	0.10	0.7515	
Ohio	1	-0.3258	-27.8%	0.2361	-0.7885	0.1370	1.90	0.1677	
Oklahoma	1	-0.1432	-13.3%	0.2515	-0.6361	0.3498	0.32	0.5692	
Oregon	1	-0.2525	-22.3%	0.2423	-0.7274	0.2225	1.09	0.2975	
Pennsylvania	1	-0.0947	-9.0%	0.2320	-0.5494	0.3600	0.17	0.6831	
Rhode Island	1	-0.0351	-3.4%	0.2573	-0.5395	0.4693	0.02	0.8916	
South Carolina	1	-0.4679	-37.4%	0.2486	-0.9552	0.0194	3.54	0.0598	
South Dakota	1	-0.4356	-35.3%	0.5031	-1.4217	0.5504	0.75	0.3866	
Tennessee	1	-0.3693	-30.9%	0.2402	-0.8400	0.1015	2.36	0.1242	
Texas	1	-0.3717	-31.0%	0.2327	-0.8278	0.0844	2.55	0.1102	
Utah	1	-0.7246	-51.5%	0.2614	-1.2369	-0.2122	7.68	0.0056	
Vermont	1	-0.3147	-27.0%	0.3689	-1.0377	0.4084	0.73	0.3937	
Virginia	1	-0.2223	-19.9%	0.2328	-0.6785	0.2339	0.91	0.3396	
Washington	1	-0.3025	-26.1%	0.2356	-0.7642	0.1593	1.65	0.1992	
West Virginia	1	-0.9880	-62.8%	0.3601	-1.6937	-0.2823	7.53	0.0061	
Wisconsin	1	-0.2542	-22.4%	0.2462	-0.7367	0.2283	1.07	0.3019	
Wyoming	1	-1.3263	-73.5%	0.7440	-2.7844	0.1318	3.18	0.0746	
Alaska	0	0		0	0	0			
Deductible range	0-250	1	0.6052	83.2%	0.0276	0.5511	0.6593	481.07	<0.0001
	251-500	1	0.3616	43.6%	0.0241	0.3144	0.4088	225.51	<0.0001
	1001+	1	-0.3644	-30.5%	0.1461	-0.6507	-0.0780	6.22	0.0126
	501-1000	0	0		0	0			
Registered vehicle density	0-99	1	-0.2368	-21.1%	0.0374	-0.3102	-0.1634	39.99	<0.0001
	100-499	1	-0.1157	-10.9%	0.0202	-0.1554	-0.0760	32.67	<0.0001
	500+	0	0		0	0			
Active Front Lighting System		1	-0.0203	-2.0%	0.0544	-0.1268	0.0863	0.14	0.7093
Collision Mitigation Braking System		1	-0.0318	-3.1%	0.0446	-0.1191	0.0556	0.51	0.4759
Blind Spot Information		1	-0.0559	-5.4%	0.0757	-0.2043	0.0926	0.54	0.4608

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