The Increasing Importance of Vehicle-Based Risk Assessment for the Vehicle Insurance Industry

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I. INTRODUCTION

Insurance is a data driven world of actuarial analysis. Insurance carriers rate drivers and price coverage based on past driving performance, credit score (which is highly correlated to, but obviously not causal of, driving behavior), and increasingly Usage Based Insurance (UBI).[1] Insurance carriers also factor in annual mileage, where the vehicle is garaged and

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1. GEOFF WERNER & CLAUDINE MODLIN, CAS. ACTUARIAL SOC'Y, BASIC RATEMAKING 17, 157–58, 240–41 (2010), *available at* http://www.casact.org/library/studynotes/werner_modlin_ratemaking.pdf; *see* Charles L. McClenahan, *Ratemaking*, *in* FOUNDATIONS OF CASUALTY ACTUARIAL SCIENCE 25, 34–36 (Cas. Actuarial Soc'y ed., 2d ed. 1990).

driven, and the type and value of the vehicle.[2] Modest increases in data and analysis can provide one insurance company with an important advantage over its competitors.[3]

Now a new opportunity (and challenge) awaits the insurance industry. Crash Avoidance (CA) technologies such as electronic stability control, lane departure avoidance, and forward collision avoidance are poised to revolutionize auto safety.[4] These crash avoidance technologies are fast becoming widely available and are aimed at reducing the approximately six million annual vehicle crashes on U.S. roads.[5] Each auto manufacturer is developing its own versions of CA technologies, with different capabilities and likely different degrees of efficacy.[6] This means that different makes and models of vehicles with different CA technologies, and different generations of the technologies, will perform differently.

Soon, knowing about the driver's driving behavior will be insufficient for insurance companies. It will be vital to know what type and generation of CA technology is on the driver's vehicle and how that technology performs in various driving environments.[7] It will be many decades before the entire U.S. vehicle fleet is equipped with CA technologies of one generation or another.[8] And even longer before most of the fleet is fully

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2. McClenahan, *supra* note 1, at 34.

3. *See* WERNER & MODLIN, *supra* note 1, at 154, 170.

4. Richard Bishop, *Automated Driving: For Real This Time?*, *in* AUTONOMOUS TECHNOLOGIES: APPLICATIONS THAT MATTER 15, 17–20 (William Messner ed., 2014).

5. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., U.S. DEP'T OF TRANSP., 2012 MOTOR VEHICLE CRASHES: OVERVIEW tbl.5 (2013), *available at* http://www-nrd.nhtsa.dot.gov/Pubs/811856.pdf; *Overview, Crash Avoidance Technologies*, INS. INST. FOR HIGHWAY SAFETY & HIGHWAY LOSS DATA INST., http://www.iihs.org/iihs/topics/t/crash-avoidance-technologies/topicoverview (last visited Mar. 26, 2015).

6. *See Crash Avoidance Features by Make and Model*, INS. INST. FOR HIGHWAY SAFETY & HIGHWAY LOSS DATA INST., http://www.iihs.org/iihs/ratings/crash-avoidance-features (last visited Mar. 26, 2015).

7. *See Crash Avoidance Features Reduce Insurance Claims*, INS. INST. FOR HIGHWAY SAFETY & HIGHWAY LOSS DATA INST. (July 3, 2012), http://www.iihs.org/iihs/news/desktopnews/crash-avoidance-features-reduce-crashes-insurance-claims-study-shows-autonomous-braking-and-adaptive-headlights-yield-biggest-benefits.

8. *Predicted Availability of Safety Features on Registered Vehicles–An Update*, HIGHWAY DATA LOSS INST. BULL. (Highway Loss Data Inst., Arlington, Va.), Sept. 2014, at 1, 11, *available at* http://www.iihs.org

automated.[9] This interim period provides an opportunity for insurers to move beyond just understanding drivers to also better understanding vehicles and their CA effectiveness.

II. UBI AND UNDERSTANDING DRIVERS

In the last several years, the vehicle insurance industry has been encouraging customers to adopt UBI, understanding that better analysis of driver behavior will yield more accurate predictions of crashes and a more accurate (and fair) rating.[10] While today less than four percent of the U.S. driving population has adopted UBI,[11] the data unequivocally supports insurers' expectations; knowing more about how drivers drive improves rating accuracy (and fairness) and may eventually lead to better profitability.[12]

But UBI also has its challenges. While at Progressive Insurance has an almost ten percent uptake of premiums are rated using UBI,[13] most other insurance companies which have rolled out UBI offerings later lag behind that share

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/media/31d3dcc6-79d5-48a8-bafb-1e93df1fb16f/324452632/HLDI%20Research/Bulletins/hldi_bulletin_31_15.pdf.

9. *See* TODD LITMAN, VICTORIA TRANSP. POLICY INST., AUTONOMOUS VEHICLE IMPLEMENTATION PREDICTIONS: IMPLICATIONS FOR TRANSPORT PLANNING 11–12, tbl.6 (2015), *available at* http://www.vtpi.org/avip.pdf (estimating fully autonomous vehicles will be available by 2020 but not widely adopted in the vehicle fleet until 2040 to 2060).

10. *See Usage-Based Insurance and Telematics*, NAT'L ASS'N INS. COMMISSIONERS & CENTER FOR INS. POL'Y & RES., http://www.naic.org/cipr_topics/topic_usage_based_insurance.htm (last updated Feb. 25, 2015).

11. *See* STUART ROSE, SAS, TELEMATICS: HOW BIG DATA IS TRANSFORMING THE AUTO INSURANCE INDUSTRY 3, fig.1 (2013), *available at* http://www.sas.com/resources/whitepaper/wp_56343.pdf.

12. *See generally* Katie DeGraaf, *Usage Based Insurance: A Revolution Is Underway*, OHIO INST. INS. (Apr. 2013), https://www.ohioinsurance.org/wp-content/uploads/2013/04/KDegraaf13.pdf.

13. *See also* PROGRESSIVE CORP., 2013 ANNUAL REPORT TO SHAREHOLDERS app.-A-53 (2014), *available at* http://media.corporate-ir.net/media_files/irol/81/81824/arInter/13_annual/assets/pdf/Progressive-2013-Financial-Review.pdf (stating a nearly ten percent increase in new and renewal applications for both personal and commercial lines of insurance in 2013, and providing that "the annual premiums from customers choosing Snapshot surpassed $2 billion"); PROGRESSIVE CORP., 2013 SECOND QUARTER REPORT 2 (2013), *available at* http://media.corporate-ir.net/media_files/irol/81/81824/qInter/2013/13Q2/assets/pdf/Progressive2013-2Q.pdf ("The base of Snapshot policies and associated premiums continues to grow and now total 1.2 million and $1.8 billion, respectively.").

considerably.[14] Then there are the costs of the On Board Diagnostic (OBD) port dongle (the device that fits in the OBD-II port of the vehicle and captures data on acceleration, braking, and speed), the costs of marketing, and the costs of operating the business model.[15] Mobile phone based application alternatives to a dedicated dongle reduce costs but suffer in terms of accuracy.[16]

The significant challenge for insurer's profitability is how the business model effects premium. UBI is voluntary and is likely to remain so.[17] As a result, the insurance carrier strategy regarding UBI is to entice customers by offering a discount to "good" drivers while not "up-charging" the base of drivers whose UBI scores are not as strong.[18] The logic goes that if a carrier can attract mostly good drivers it "sticks" its competitors with the less than average quality drivers. And since its competitors likely do not have data on the quality of the driver they may well underprice coverage; this creates a spiral of improvement for the UBI aggressive, data driven company and a cycle of challenges for the less aggressive or less data intensive carriers.[19]

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14. *See* DeGraaf, *supra* note 12, at 18–21; Susan Kuchinskas, *Usage-Based Pricing: Reality or Fantasy?*, INS. THOUGHT LEADERSHIP (July 5, 2014), http://insurancethoughtleadership.com/usage-based-pricing-reality-or-fant asy/.

15. *See* Kuchinskas, *supra* note 14.

16. *See also id.* ("[N]ot all data is equally valuable. Its utility depends on its accuracy and completeness; how frequently it's sampled; and the source—whether OBD2 outputs, GPS or accelerometers in cell phones.").

17. *See, e.g.*, Insurance Circular Letter No. 4 from N.Y. Dep't of Fin. Servs. to All Insurers Authorized to Write Property/Casualty Insurance in the State of New York (May 27, 2014), *available at* http://www.dfs.ny.gov /insurance/circltr/2014/cl2014_04.pdf ("DFS has approved UBI filings only where it is clear that the product or program is offered to the consumer solely on a voluntary basis.").

18. *See Drivewise FAQs*, ALLSTATE, https://www.allstate.com/drive-wise /faq.aspx (last visited Mar. 29, 2015); *Terms & Conditions for Snapshot*, PROGRESSIVE, https://www.progressive.com/auto/snapshot-terms-conditions/ (last updated Dec. 4, 2014).

19. *See* WERNER & MODLIN, *supra* note 1, at 154; Kuchinskas, *supra* note 14.

III. EXPANDING THE DATASET: IMPROVING VEHICLE-BASED RISK ASSESSMENT

For a given vehicle, current auto insurance ratemaking relies on a modest number of driver-specific metrics including, but not limited to, credit score, age, marital status, place of residence, and driving history.[20] The goal of this information is to determine the risk profile associated with a particular driver and calculate a competitively priced premium that will still cover losses and expenses.[21] However, in the future, early data suggests that a poor driver behind the wheel of a CA-equipped vehicle may be less likely to crash than a good driver in a non-CA-equipped vehicle.[22] As a result, our analysis indicates that understanding vehicle performance may become as important to accurately determining risk profiles as information predicting driver performance.

In order to prepare for the disruptive effects of CA and automated driving systems, insurance carriers must tap into a wealth of information that our research indicates is not currently organized in a comprehensive way. Specifically, answering the following three vehicle-focused questions is critical to preparing pricing strategies that maximize opportunities arising from this new technology:

1. Which CA technologies are present on the vehicle?
2. What are the most common types of "crash threats" the vehicle will encounter?
3. How well matched are the CA capabilities of the vehicle to those "crash threats"?

The first question is concerned with how the vehicle is equipped. Just as insurers determine if a vehicle is equipped with side airbags, an anti-theft system, or a more powerful engine and adjust risk accordingly, because CA technology will reduce crashes there is a developing need to determine what CA equipment is present on the vehicle.[23] We see the second

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20. WERNER & MODLIN, *supra* note 1, at 15–17; McClenahan, *supra* note 1, at 34.

21. McClenahan, *supra* note 1, at 33–34.

22. *See generally* Jessica S. Jermakian, *Crash Avoidance Potential of Four Passenger Vehicle Technologies*, 43 ACCIDENT ANALYSIS & PREVENTION 732, 732–35, 737–39 (2011) (estimating that certain types of crash avoidance technology could prevent or mitigate up to 1,866,000 crashes per year).

23. *See id.*

and third questions as more of a departure from conventional insurance pricing. Whereas it is largely infeasible to determine whether a driver is better at avoiding one particular type of crash versus another, it will be very possible to make that determination for vehicles.[24] In the future, our analysis indicates that knowing the type of threats most likely to be encountered by the vehicle and how it will respond to them will be an important factor in assessing risk. By answering these three questions for a given vehicle, insurers will be able to create a risk profile that is much more accurate than current driver-based pricing. The result will be more accurate and fair pricing for customers and a competitive advantage for the companies that learn to quickly seize and analyze this data.

IV. CRASH AVOIDANCE TECHNOLOGY

Answering the first question requires understanding the different types of CA technology available today, and how this technology will transition into automated driving in the future.

CA technology operates along similar principles to mandated vehicle safety technologies such as anti-lock brakes and electronic stability control.[25] In each system, sensors feed data on vehicle operation to electronic control units (ECUs), which monitor the data according to embedded software and automatically assume control of specific aspects of vehicle operation via actuators in response to an identified threat.[26] In the case of electronic stability control, a sensor detects that the turning movement of the car as indicated by driver steering inputs (in an emergency swerve, for instance) does not match the actual movement of the vehicle due to insufficient traction for one or more wheels (skidding).[27] Based on data from yaw rate, lateral acceleration, and wheel speed sensors, the ECU detects this condition and responds by activating an actuator to

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24. *Id.*
25. *Overview, Crash Avoidance Technologies*, *supra* note 5.
26. *See ESC Benefits Keep Adding Up as Features Become Standard*, STATUS REP. (Ins. Inst. for Highway Safety & Highway Loss Data Inst., Arlington, Va.), Sept. 28, 2011, *available at* http://www.iihs.org/iihs/sr/statusreport/article/46/8/3.
27. *Id.*

apply braking force at individual wheels.[28] In this way ESC helps to minimize loss of control.[29]

CA technology builds on the electronic stability control model by using sensors to monitor a wide range of threats in the external vehicle environment.[30] When the system determines a crash is likely based on vehicle speed, direction, relation to the lane or road edge, and relation to external objects, it can steer, brake, or accelerate the vehicle out of harm's way.[31] For example, a forward collision avoidance system uses sensors such as radar to scan in front of the vehicle for potential obstacles, and then analyzes data on speed and relative distance to calculate the likelihood of a crash.[32] The system can then apply the necessary braking force to avoid or mitigate an imminent crash with precision and reaction speed far beyond the capabilities of a human driver.[33] What was once a potentially fatal forward collision becomes the safe activation of a CA system.

Common CA systems available today include: forward collision avoidance, backup collision avoidance, blind spot warning, and lane departure avoidance.[34] CA systems act "when things go wrong" and the human driver response is inadequate to avoid a crash. When individual systems are integrated through software, the entirety of vehicle operation—steering, accelerating, and braking—can be controlled by the vehicle as opposed to the driver, leading to an automated or partially "self-driving" vehicle.[35] In such instances, the enabling technology for CA forms the foundation for automated driving, which is activated by the driver to operate the vehicle "when nothing is wrong" and the driver wants to do something other than drive.[36]

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28. *See id.*
29. *Id.*
30. *Q&As*, *Crash Avoidance Technologies*, INS. INST. FOR HIGHWAY SAFETY & HIGHWAY LOSS DATA INST. (June 2014), http://www.iihs.org/iihs/topics/t/crash-avoidance-technologies/qanda.
31. *Id.*
32. *Id.*
33. *See id.*
34. *Id.*
35. *See id.*
36. *The Road to Self-Driving Cars*, CONSUMER REP., Apr. 2014, at 16, 16–19, *available at* http://www.consumerreports.org/cro/magazine/2014/04/the-road-to-self-driving-cars/index.htm.

The development of CA technology from today's limited systems to more advanced systems and to fully automated vehicles can be characterized along two criteria: functionality and environmental complexity.

Functionality encompasses the ability of an active safety system to operate the vehicle. For example, basic forward collision avoidance systems warn the driver of oncoming obstacles but do not autonomously operate the brakes.[37] More refined systems are able to automatically apply brakes to avoid crashes under a certain speed with objects directly ahead, while cutting edge systems can steer, stop the vehicle at high speeds, and anticipate peripheral moving objects that may enter into the vehicle's path.[38] Even though all of these systems can be offered together as "forward collision avoidance," a system with higher functionality can avoid both a broader range of crash types, and do so with a higher success rate.[39]

Environmental complexity addresses the road environments in which the CA system is designed to operate. For example, BMW's "Traffic Jam Assistant" will accelerate, brake, and steer the vehicle to maintain appropriate speed, heading, and safe distance to other vehicles, but is only designed to work in dense traffic under thirty-eight miles per hour on interstate-type road conditions with no traffic signals, intersections, or sharp turns.[40] Future systems will work in increasingly complex road environments by anticipating pedestrians or animals, recognizing different speed limits and traffic signals, or tracking merging or turning vehicles.[41] Systems with high environmental complexity are able to be in operation more often, on a wider range of road types and conditions, and at higher speeds.[42]

A number of different types of CA systems are available at automotive showrooms today, and this number will only

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37. *Q&As*, *Crash Avoidance Technologies*, *supra* note 30.
38. *See id.*
39. *Id.*
40. *See Traffic Jam Assistant*, BMW, http://www.bmw.com/com/en/insights/technology/connecteddrive/2013/driver_assistance/intelligent_driving.html#trafficjam (last visited Mar. 29, 2015).
41. *The Road to Self-Driving Cars*, *supra* note 36, at 16–17, 19–20.
42. *See Q&As*, *Crash Avoidance Technologies*, *supra* note 30.

increase in the future.[43] The ability to evaluate the type of CA equipment installed on a customer's vehicle (including potential aftermarket CA technologies) in terms of functionality and environmental complexity can help insurers begin to build a risk profile for that vehicle.

V. ASSESSING CRASH THREATS

Addressing the second question, imagine two drivers, both with vehicles equipped with lane keep assist. The first driver spends most of her time on state highways at night, when fatigue puts her at risk of drifting out of her lane and crashing into an object or another vehicle. Lane keep assist is perfectly suited to a common threat she might face on the road, automatically keeping the car in its lane and notifying her if she is drifting.[44] The second driver commutes across a city, negotiating busy intersections and bumper-to-bumper traffic. In his daily driving, he is rarely at risk of drifting out of his lane and much more likely to crash into the vehicle in front of him at relatively low speeds as he is checking his phone while in congested traffic. Pairing an understanding of the type of CA capabilities on a vehicle with data on the most common crash threats that vehicle will face, based on where the vehicle is operating, allows a much higher degree of insight into the risk profile of the insured.

Assessing crash threats requires data on where the vehicle most frequently drives, and what types of accidents most often occur on those roads. GPS systems can easily capture data on vehicle location, and while privacy rights will need to be accounted for, such data could be abstracted[45] to reflect the percentage of time a vehicle operates on each of three broad categories of road types: interstate/turnpike, state highways, and local roads (including urban streets).

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43. *E.g.*, *The Road to Self-Driving Cars*, *supra* note 36, at 16, 18–20 (noting CA systems with various features on cars such as Chevrolet Traverse, Ford Edge, Honda Accord, Mazda Grand Touring, Subaru Forester, Jeep Cherokee, Infiniti QX60, BMW X5, Volvo XC90, Lexus LS, Audi A7, and Mercedes-Benz S550).

44. *Q&As*, *Crash Avoidance Technologies*, *supra* note 30.

45. *See Snapshot Privacy Statement*, PROGRESSIVE, https://www.progressive.com/auto/snapshot-privacy-statement/ (last updated Nov. 18, 2014) (noting different treatment of personally-identifiable data and de-personalized data).

Table 1. Road Type Descriptions and Statistics[46]

Road Type	**Description**	Percent of Total Miles Traveled	Frequency: Crashes per 100 Million Miles Traveled	Severity: Fatalities per 1000 Crashes
Interstate/ Turnpike	• Controlled-access highway meant for high-speed vehicular traffic. • Opposite-direction traffic is usually separated with a barrier; no turns/ intersections allowed. • Access by pedestrians, cyclists, or animals is often blocked with walls or fences.	23.6%	50	10.5
State Highway	• State Highways include mostly primary and secondary roads, but can include some controlled-access highways. • Crossed by roads, railways, or pedestrian paths. • Can be controlled by traffic signals.	58.1%	138	12.3
Local Road	• Lower in volume and speed limit than other roads. • Can be controlled by traffic signals, stop signs, or yield signs depending on traffic volume.	18.3%	174	6.3
TOTAL		**100.00%**	**124**	**10.6**

See Table 1, *supra*, for a description of each road type. Given state jurisdiction, the most comprehensive data on road usage is collected at the state level.[47] We have used data from Pennsylvania as an example. Over half of all vehicle miles in Pennsylvania are traveled on state highways, which have the

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46. Data derived from PA. DEP'T OF TRANSP., 2012 PENNSYLVANIA CRASH FACTS AND STATISTICS 5, 16 (2013), *available at* ftp://ftp.dot.state.pa.us/public/Bureaus/HighwaySafety/Web%20Development/Crash%20Facts%20Book/2012_CFB_linked.pdf.

47. *See* FED. HIGHWAY ADMIN., U.S. DEP'T OF TRANSP., A GUIDE TO REPORTING HIGHWAY STATISTICS 1-1 (2000), *available at* http://www.fhwa.dot.gov/policyinformation/hss/guide/guide.pdf (noting that responsibility for collecting highway statistics falls on the states even when there is federal cost-sharing).

second highest frequency of accidents per mile and the highest severity.[48] Data shown in Table 1 supports the logical assumption that crashes are generally rare on interstates given the relatively simple driving environment, but more severe when they do occur, due to the high speeds involved.[49] Similarly, local road crashes are more frequent due to the complexity of the environment, including more cars operating closer together through intersections and among pedestrians, but less severe due to lower speeds.[50] State highways present a dangerous mix of higher environmental complexity than interstates with higher driving speeds than local roads.[51] These relationships are represented in Figure 1, *infra*.

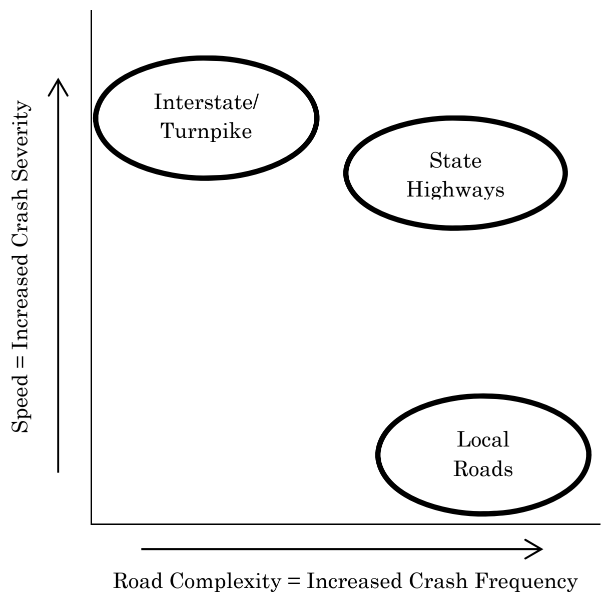

Figure 1. Road Speed vs. Complexity[52]

48. PA. DEP'T OF TRANSP., *supra* note 46, at 16.

49. *See* FED. HIGHWAY ADMIN., U.S. DEP'T TRANSP., SPEED CONCEPTS: INFORMATIONAL GUIDE 1 (2009), *available at* http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa10001/fhwasa10001.pdf (noting that high speed interstates have fewer crashes than other roads, but higher risk of crashes resulting in injuries and fatalities).

50. *See also supra* Table 1 (showing more frequent crashes but lower severity on local roads versus state highways).

51. *See also supra* Table 1 (showing that state highways have higher severity crashes than interstates or local roads).

52. Data derived from PA. DEP'T OF TRANSP., *supra* note 46, at 16.

While the above data provides a general framework of the frequency and severity of threats on each road type, it is necessary to understand the types of threats specific to each road type as well. There is a need for cross-tabulated data on crash type and road type to generate an accurate analysis, and while this data may be available for some states, our research indicates it is not easily accessible.[53] Still, simple logic can begin to give us some idea of how types of crash threats correspond with road type. For example, a vehicle on state highways is vulnerable to a wide range of threats, including drifting from its lane into oncoming traffic or off the road. Vehicles on interstates rarely face front-to-front collisions as oncoming traffic lanes are separated by barriers or medians, nor do they face crossing path collisions since there are no intersections. Lane-change accidents and front-to-rear collisions are much more prominent threats on interstate roads. Our analysis indicates that pairing GPS data with a comprehensive understanding of road and crash data will allow insurers to answer question two, generating a much more nuanced understanding of which types of crash threats a vehicle is most likely to encounter based on where it spends most of its time in operation.

VI. MATCHING THREATS TO CAPABILITIES

Having captured data on the type of CA system in the vehicle and the types of threats the vehicle is most likely to face, addressing the third question involves determining how likely a specific CA system is to successfully avoid a potential crash.

While future testing and on-road experience may generate performance data as CA systems become more common, our research indicates that there is currently little data on the performance of CA systems available today. The Highway Loss Data Institute has begun to compare real world data on insurance claim rates of forward collision avoidance-equipped Volvos versus similar non-equipped vehicles, however results

53. *See, e.g.*, IOWA DEP'T TRANSP., CRASH RATES AND CRASH DENSITIES IN IOWA BY ROAD SYSTEM 2003-2012 (2013), *available at* http://www.iowadot.gov/crashanalysis/pdfs/crash_rate-density_comparables_segments_2003-2012_20131113_statewide.pdf (providing statistics on crashes, fatalities, and property damage by road type, but no specific information on type of crash).

are preliminary.[54] Some of the most comprehensive analysis of the potential of CA technology to reduce different types of crashes comes from the Insurance Institute of Highway Safety (IIHS), which matched data on crash types and conditions from the National Automotive Sampling System General Estimates System (NASS GES) and Fatality Analysis Reporting System (FARS) to the types of crashes targeted by the current suite of CA technologies.[55] The IIHS analysis suggests forward collision warning systems could prevent 70% of front-to-rear crashes, which translates to 20% of passenger vehicle crashes overall.[56] Current blind spot assist systems, on the other hand, could only prevent 24% of all lane-changing accidents, reducing overall accidents by 7%.[57] While this study only presents potential accident reduction based on crash statistics, it provides a starting point to understand what kind of data the industry will need to complete the vehicle-based risk assessment picture. Knowing that one manufacturer's forward collision warning is 60 to 80% effective at reducing forward collisions, while a competitor's is only 30 to 50% effective (based on speed of travel, sensing range, and a multitude of other factors), will provide a basis for increased pricing accuracy, especially when combined with data on common crash threats.

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54. *Volvo City Safety Loss Experience – An Update*, HIGHWAY DATA LOSS INST. BULL. (Highway Loss Data Inst., Arlington, Va.), Dec. 2012, at 1, *available at* http://www.iihs.org/media/48c6e9ae-d60b-4cc7-9bf6-a330ef1d177e/-808307776/HLDI%20Research/Bulletins/hldi_bulletin_29.23.pdf (calculating CA-equipped Volvos at 15%–16% lower property damage claim amounts, 9%–20% lower collision frequencies, and 18%–33% lower bodily injury claim amounts).

55. *See* Jermakian, *supra* note 22.

56. *See id*. at 734–36, tbl.3A.

57. *See id*. at 734–35, tbl.2.

Table 2. California Systems and Targeted Crash Types[58]

Crash Avoidance System	Crash Type Targeted
Forward Collision Avoidance (FCA)	• Front-rear • Frontal collision with object
Lane Departure Warning (LDW)	• Single vehicle off roadway • Head-on collision • Sideswipe (same direction) • Sideswipe (opposite direction)
Blind Spot Assist (BSA)	• Intentional lane change
N/A	• Angle (without lane change) • Front-to-front other (without lane change) • Other (atypical crashes)

VII. IMPLICATIONS FOR THE INSURANCE INDUSTRY

More data and analysis is better than less, especially in the insurance industry where pricing occurs before experience is generated. Recall the three key questions outlined in the introduction:

1. Which CA technologies are present on the vehicle?
2. What are the most common types of "crash threats" the vehicle will encounter?
3. How well matched are the CA capabilities of the vehicle to those "crash threats"?

The answer to question three is a matter of future analysis. As more data is generated on CA system effectiveness this analysis can be undertaken. And the insurance company that first implements a system to gather answers to questions one and two for their customers, and combines it with insights into question three, will have a significant advantage in increasing market share by undercutting competitors using conventional ratemaking.

While it will take decades to reach a 100% penetration rate of CA technology in the vehicle population,[59] our analysis

58. *See generally* Jermakian, *supra* note 22.

indicates that data on vehicles, not just on drivers, will become essential very soon. The insurance industry has done an excellent job at determining what kinds of driver data correlate with safer driving, and in leveraging this data to create competitive pricing. The industry must now create new models to determine what kinds of vehicle data correlate with safer driving, such as the type of CA systems on board, and leverage this data to develop a new and better generation of pricing. In the coming years, the vehicle population will include a mix of CA-enabled and non-CA-enabled vehicles, which are likely to have very different crash risk profiles independent of the driver. In an industry facing declining premiums due to crash reduction technology, the first mover advantage this data affords is critical to capturing increased market share over the next several decades.

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59. *See generally Predicted Availability of Safety Features on Registered Vehicles–An Update*, *supra* note 8.

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