APPLICATION OF ACN DATA TO IMPROVE VEHICLE SAFETY AND OCCUPANT CARE

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ABSTRACT

In MY 2007 nearly all of the BMW's sold in the US will be equipped with an Automatic Crash Notification System (ACN) called "BMW Assist". The service is provided to the customer for a period of 4 years free of charge. This fleet of BMW's will notify the Telematics Service Provider (TSP) when they have been in moderate or severe crashes. This service will continue to be provided for a period of 4 years. The resulting body of information will be of unprecedented value for research purposes. For example, researchers will be able to determine the time between the initiation of the emergency call and the arrival of rescue. For cases with long rescue times research can focus on ways to shorten the time and improve the service. In addition, cases with injuries can be identified as candidates for in-depth investigation. This capability will resolve one of the greatest impediments to crash investigation research – how to find crashes of interest. Finally, by having a complete census of all crashes involving ACN equipped vehicles less than four years old, the crash exposure can be determined and crash involvement risks can be accurately calculated. When combined with sales exposure data, the crash involvement rates will permit the benefits of accident avoidance countermeasures to be assessed. There is no other data system that will provide the resolution or accuracy of this system – particularly for the assessment of crash avoidance countermeasures.

INTRODUCTION

The introduction of Automatic Crash Notification (ACN) technology offers new opportunities for conducting research to improve the safety of vehicles as well as the care and treatment of injured occupants. For the past five years the William Lehman Injury Research Center (WLIRC) and BMW have been conducting a pilot project to find ways to improve the service offered by the ACN system. This research also produces unique safety research opportunities. In past papers, we have reported on the benefits of using data from the crashed vehicle sensors to assess the risk of injury to occupants and the need for urgent rescue response. This paper also deals with the added benefit of using the data from ACN calls for pioneering safety research.

Existing ACN systems send a signal to emergency responders if a crash exceeding a pre-determined severity threshold occurs. This severity is roughly equivalent to that required to deploy the belt pretensioners or the airbags. The rapid notification of rescue services in the event of a crash increases the chances that an occupant who needs medical attention will receive potentially life saving care as quickly as possible. It is well established that ACN systems offer life saving benefits due to the immediate notification that a crash has occurred and the accurate description of crash location (Augenstein 2006, Donnelly 2000, Champion 2003, Evanco 1999). However, ACN data currently collected also offers a unique opportunity to analyze other aspects of pre-crash and post crash safety of drivers.

The ACN system currently offered in all BMW's are known as the BMW Assist System. This technology was optional in the past. However, in MY 2007 nearly all of the BMW's sold in the US will be equipped with an ACN system. BMW Assist currently transmits geographic coordinates of the vehicle and the vehicle identification number to a Telematics Service Providers or TSP's within seconds of a crash. As systems become more advanced in the future, additional data elements may be transmitted which characterize crash severity. The addition of crash severity data will help rescue providers to select and deploy the most appropriate type of rescue care. The transmitted data can also be used as a basis for identifying crashes of interest for in depth investigation. Such investigation would be undertaken only after gaining permission from the owner of the vehicles involved.

Since 2005, BMW and the William Lehman Injury Research Center (WLIRC), at the University of Miami School of Medicine, have conducted pilot research using ACN data. This paper presents the methodology used to improve post-crash safety to analyze the benefits of accident avoidance countermeasures.

IMPROVEMENTS IN ACN SYSTEMS AND POST-CRASH SAFETY

The automatic crash notification system offers the possibility of providing three types of data to aid in the rescue. First the geographic coordinates of the crash are provided. Second, the voice communication with the crashed vehicle occupants provides valuable information. Third, useful data from the vehicle could be provided.

The first generation of ACN systems only transmitted the geographic coordinates and voice communication. The vast majority of crashes with restraint system deployment do not result in significant injury to the vehicle occupants. Voice communications with the occupants can further verify the need for rescue. However, in a fraction of the cases there may be no voice response. In some of these cases the reason for the lack of response could be due to injuries caused by the crash. The added data from the vehicle would be particularly valuable in these cases.

The ability to identify injured occupants has become more difficult as vehicle safety systems have improved (Augenstein, 2003, Champion, 2003). As restraint systems have improved, the residual injuries have become more subtle and difficult to identify at a crash scene. Occupants may not display the physiological cues to assist first care providers in recognizing injuries, and injured occupants may “feel fine”. Improved technology from the ACN system might help in identifying these injuries.

BMW and WLIRC have pioneered the development of methods to identify crashes in which there is a high probability of injury and a need for rapid post-crash response. This research has included the development and continued improvement of an algorithm called URGENCY. The URGENCY algorithm uses the restraint deployment data from the crashed vehicle to predict the risk of injury to the occupants involved in the crash.

Previous papers have discussed the difficulty in identifying crashes with injuries and the application of URGENCY to improve the injury recognition (Augenstein 2003, 2006). The single most valuable data element is the change of velocity of the crash (deltaV). However, the injury risk is also highly dependent on the direction of the crash. This dependenct is shown in Figure 1. The Figure shows the injury risk vs crash severity for different crash modes, based on data from NASS/CDS 1997-2003 (Augenstein, 2006). It is evident from Figure 1 that for a given deltaV (30 mph for example), the probability of injury varies with crash direction. Consequently, crash direction is an important variable for accurately determining injury risk.

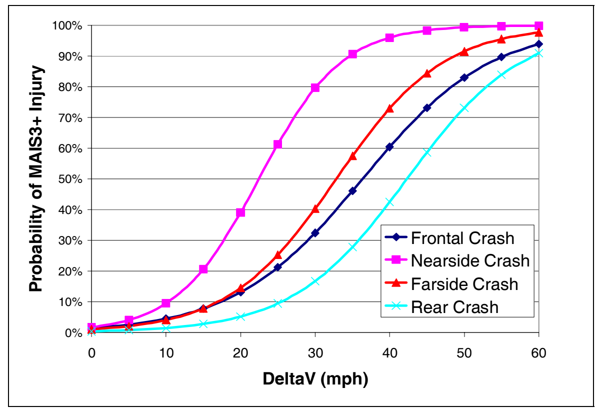

Figure 1. MAIS3+ Injury Probability by Delta-V and Crash Direction

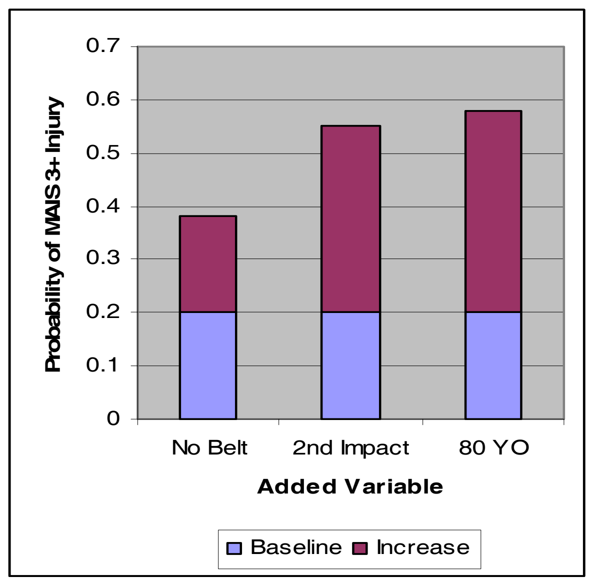

Figure 2. MAIS3+ Injury Probability Increase for Added Variables in Frontal Crashes

There are other important variables that are measured before or during the crash that are also useful. In addition, the ages of the occupants would be useful, when available. The benefits of these added variables are illustrated in Figure 2. This figure shows how different variables influence the injury probability for a 25 mph frontal crash with a baseline injury risk of 20%. For example, the absence of safety belts increases the risk from 20% to 38% (Augenstein 2003).

The influence of the variables shown in Figure 2 varies with crash direction. In addition, other variables become important in non-frontal crashes. To simplify the presentation of the complex relationships, the URGENCY algorithm can be used. A typical presentation from the algorithm is shown in Figure 3.

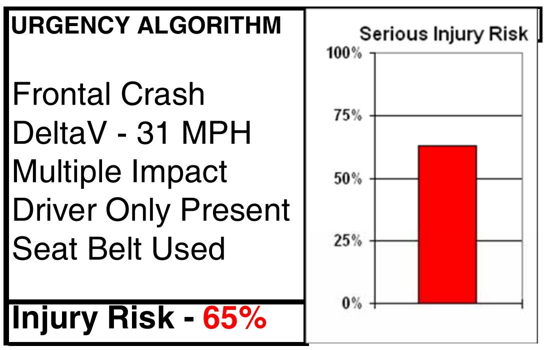

Figure 3. Typical Presentation of the URGENCY Algorithm

The presentation shown in Figure 3 permits the rapid identification of the combination of crash events that could increase injury risk. It could assist in rapidly identifying crashes that may need rapid response from rescue.

There are several types of crashes that URGENCY could be particularly helpful to the occupants of the crash. The first type is the severe crash with no response from the occupants. Heightened concern over the need for rapid response could be transmitted to the emergency responders. Reducing the rescue time for these rare cases could have life-saving benefits. Another potential benefit is for people with injuries that are not immediately recognized. The algorithm could raise the suspicion of an injury so that immediate care could be sought. In some cases, unrecognized and untreated injuries can lead to subsequent disabilities and even death.

BMW and WLIRC are continuing to evaluate ways to improve the post-crash safety environment. One of the impediments is the novelty of using crash data from the vehicle to assist in recognizing crashes with high probability of injuries. Continuing efforts are underway to develop publications and training materials to advise emergency responders and care givers of the technology available that could assist in post-crash safety.

ASSESSMENT OF THE BENEFITS OF CRASH AVOIDANCE COUNTERMEASURES

ACN data can provide a wealth of information to analyze the pre-crash safety of vehicles. Unlike other available datasets, ACN data includes a census of crashes involving a know population of vehicles where the criteria for inclusion within the dataset are consistent and well defined. Only those that exceed the deployment threshold of the ACN system are automatically included. Manual transmissions are also possible if a driver or other occupant manually activates the system. Figure 4 below shows the population of BMWs equipped with ACN technology in use on US roadways. Using this data in combination with crash counts, crashes per vehicle in service can be accurately calculated for any population of interest.

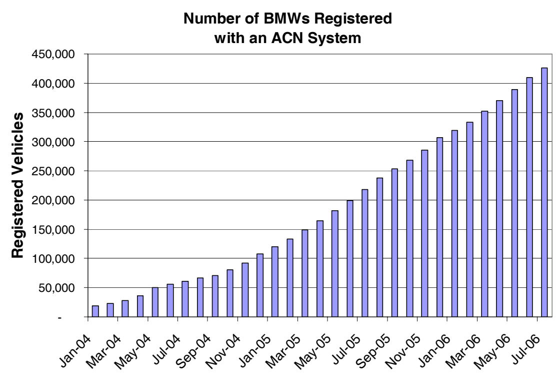

Figure 4. Registration Count by Month for BMWs with Active ACN Systems

For vehicles equipped with an ACN system, a notification that a crash has occurred is transmitted to the telematics service provider for all crashes exceeding the deployment threshold. For this reason, a wealth of data is available to analyze crash involvement rates for the population of vehicles deployed. Sales data exists which defines the exact size of the exposed population. The impact of crash avoidance technologies can be assessed by comparing crash involvement rate before and after the introduction of a safety feature or through direct comparison of crash rates for populations with and without an optional feature.

Using ACN data, exact vehicle specifications, including the presence of optional features, can be determined using the available vehicle identification number (VIN). In the future, this data will allow for the evaluation of the safety improvement of emerging active safety systems. Some examples include Adaptive Cruise Control, Heads-Up Displays, Lane Departure Warning Systems, Active Steering Systems and Blind Spot Warning Systems. In addition, it is possible to compare user interfaces and communication strategies for crash warning systems and for driver assistance systems like in-dash Navigation devices.

Compared to currently available crash data collected by NHTSA and US states, ACN data provides a significantly larger number of observations from which conclusions can be drawn. Some publicly available US crash data systems provide only a small sample of crash cases including all makes upon which general safety conclusions can be drawn. The National Automotive Sampling System, Crashworthiness Data System (NASS CDS) is an example of a database that contains very detailed information for a very small sample of crashes. Since the data is only a sample of 4,500 crashes per year, few conclusions regarding specific vehicle platforms and the impact of newly introduced technologies can be drawn unless the technology is deployed nearly fleet wide. Further, since NASS CDS collects crashes involving both new and older vehicle models such that it may be necessary to compile multiple years of observations before any meaningful changes can be detected. Alternatively, US state crash data systems include a census of police reported crashes occurring in a particular state. Each state data file contains a large number of records however; the quality of data collect by police is questionable. Further, state files are compiled by state and made available for analysis long after a safety device first enters the vehicle fleet. As not all states report crash counts, national level analysis of data is not possible.

In the past, several researchers have analyzed the effectiveness of safety devices including Anti-lock Brake Systems (ABS) and Electronic Stability Control (ESC) technology using US state crash data (Evans 2000, Farmer 2004, Bahouth 2005, Green 2006). State data files were the only available crash data source with a sufficient number of observations required to draw statistically significant conclusions. Such evaluations have lead to important and noteworthy findings, however the use of police reported crash data from multiple states is problematic and could be biased in some cases. With regard to the evaluation of ESC, the first such evaluation was possible only 2004 even though the technology emerged in some vehicles in 1999. It was necessary to pool data from as many as 10 US state files in order to estimate statistically significant effects. Similarly, it is difficult to pool data from multiple files due to inconsistencies in case inclusion criteria from state to state. As the ACN data is collected in real time across the entire US and collected using consistent inclusion criteria, it offers a significantly better alternative to the use of state crash files.

The ACN dataset available for analysis contains a large sample of crashes and is expected to grow significantly based on expected sales of new ACN equipped vehicles. Figure 5 shows the projected number of crashes expected for the coming 4 year period. This plot was created using current ACN equipped vehicle crash rate (approximately 0.008 crashes per month per registered vehicle in service) times the projected number of vehicle registrations based on 2005 and 2006 new vehicle sales estimates. The sales estimates assume equivalent sales for 2007-2010 where 100% of the vehicles sold are equipped with an ACN system. By June, 2010, these estimates indicate that more than 1,000 vehicles will be involved in crashes per month exceeding the deployment threshold of the ACN systems. Currently, the ACN dataset includes over 8,000 crash events and is expected to exceed 44,000 crashes by December 2010.

The ACN dataset provides a unique resource to study newly emerging active safety technologies. If we were to conduct an analysis of a technology with 25% penetration into the vehicle fleet, with the current crash population as shown in Figure 5, we have 71.1% power to detect a presumed effect size of 5% or greater. As the population grows over the next 4 years as shown in the figure, this power to detect 5% difference in crash involvement will increase to over 99%.

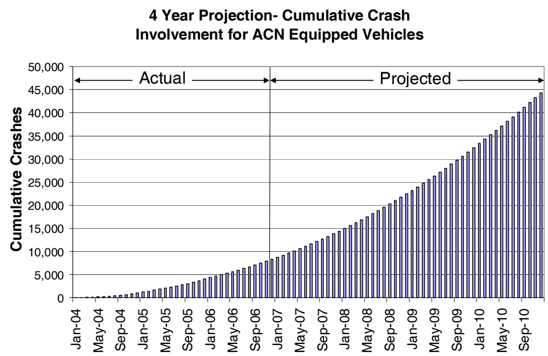

Figure 5. Projected Number of Vehicle Crashes Involving BMWs with and ACN System (sales rates and crash rates based on 2005 and 2006 data).

CONCLUSIONS

The ACN system on BMW vehicles provides unique opportunities for studying pre-crash and post-crash safety. Our studies of factors that influence injury risks in vehicles is providing guidance in how to best use the information from the vehicle to improve post-crash safety.

The decision by BMW to offer 'BMW Assist" free of charge for four years will create a unique database for evaluation accident avoidance countermeasures. It will be possible to develop a database of all BMW's that crash in the US and the crash avoidance features on each of those each of those vehicles. Such a database, in conjunction with the vehicle sales database will permit an unprecedented capability to evaluate accident avoidance countermeasures such as active cruise control, lane departure warning, blind spot warning, heads-up displays and many other features associated with communicating information to the driver. BMW and the William Lehman Injury Research Center are working together to continue to improve the safety of motor vehicle occupants, focusing on new technology.

ACKNOWLEDGMENTS

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