ENHANCED AUTOMATIC COLLISION NOTIFICATION SYSTEM – IMPROVED RESCUE CARE DUE TO INJURY PREDICTION – FIRST FIELD EXPERIENCE

Stefan Rauscher, Georg Messner, Peter Baur
BMW Group
Germany/USA
Jeffrey Augenstein, Kennerly Digges, Elana Perdeck
William Lehman Injury Research Center
University of Miami
United States
George Bahouth
Pacific Institute for Research and Evaluation
United States
Oliver Pieske
Ludwig-Maximilians-Universität München
Germany
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ABSTRACT

This paper summarizes the initial findings from a database of crashes that involved BMW's equipped with Automatic Crash Notification (ACN) Systems in the US and Germany. In addition, first field experiences with BMW's enhanced ACN systems are reported where vehicles not only provide an initial crash notification but also transmit data describing the nature and severity of the collision event. The benefits of such a system, including the rapid recognition of potentially injured occupants based on key characteristics of each crash, are explored.

Since 2006, nearly 14,000 BMW crashes have occurred in the US involving vehicles equipped with ACN or enhanced ACN technology. Of these, 70% of occupants indicate no injury to the TSP (Telematics Service Provider) operators, 20% indicate they are injured in some way and require help while 10% provide no verbal response to the TSP call-taker. An investigation of a subsample of crashes occurring in Florida suggests that no hospital transport was necessary for 81% of the calls where no voice response occurred. Although the majority of these cases require no further care, 19% of the no voice population was subsequently transported to a hospital or trauma center for additional care. This population of occupants could benefit from an automatic call for help to a Public Services Answering Point (PSAP- commonly known as 911) that includes an estimate of the likelihood of serious injuries.

To assist in identifying crashes with incapacitating injuries, the William Lehman Injury Research Center (WLIRC) in Miami, Florida and BMW have pioneered the development of an algorithm called URGENCY. This algorithm is based on US national crash statistics and BMW internal data. The injury prediction by URGENCY permits the transmission of the earliest and best information to the PSAP. We report early observations of injury severity and location for enhanced ACN equipped vehicle crashes occurring in the US and Germany.

INTRODUCTION

When a motor vehicle crash occurs with a potential for injuries, a notification of the event and the location of the crash are critical so that rescue can be dispatched to the scene. It is also helpful for emergency dispatch to recognize the severity of the collision and the extent of injuries so that they can adequately assign personnel and specialized equipment as needed. This paper describes Automatic Crash Notification (ACN) technology that initiates this critical call for help. In addition, this study reports first field experiences with BMW's enhanced ACN systems where vehicles not only provide an initial crash notification but also transmit data describing the nature and severity of the collision event. The benefits and potential for such a system, including the rapid recognition of potentially injured occupants even in the absence of voice, are explored.

The rapid identification of occupants involved in a crash followed by definitive care in the most appropriate facility has been shown to improve injury outcomes and prevent fatality. A study by Clark and Cushing based on US data suggests a 6% fatality reduction is possible (1,647 lives in the US in 1997) if all time delays for notification of Emergency Medical Services (EMS) were eliminated even if methods for dispatch and treatment remained the same (Clark 2002). This reduction in notification time would occur with widespread implementation of enhanced ACN technology in passenger vehicles today.

Three studies conducted by the US National Highway Traffic Safety Administration (NHTSA) have explored preventable deaths to assess the effectiveness of the current trauma care system (Esposito 1992, Maio 1995, Cunningham 1995). Two of the studies concluded that 28.5% and 27.6% of fatalities occurring in their regions were preventable with improved EMS and treatment. The third study concluded that 17% of fatalities occurring in combined urban and rural areas were preventable. Delayed treatment and improper management of the injured were cited as the factors that most frequently contributed to the avoidable death. The majority of the preventable deaths occurred after arrival at a hospital. These studies suggests that opportunities exist to prevent trauma deaths not only by reducing the time from crash to hospital, but also to aid in recognizing the nature of the most serious injuries and the most appropriate medical facility to provide definitive treatment.

A recent evaluation of the US trauma system considered the effect of trauma center care on mortality outcome of patients (MacKenzie, 2006). The study estimated mortality rates for patients arriving at hospitals with one or more Abbreviated Injury Scale Level 3 injuries (AIS 3). Overall, the findings of this study suggest that the risk of death is 25% lower when care is provided in a trauma center compared to a non-trauma center. This study underscores the importance of treatment in the most appropriate medical facility.

Automatic Crash Notification Systems

BMW first introduced ACN technology in their vehicles in 1997. Other vehicle manufacturers are now equipping their vehicles with ACN as well. In the event of a moderate to high severity impact, ACN systems rapidly notify authorities that a crash has occurred, transmit the location of the crash and vehicle data. The information is first screened by an intermediate TSP like ATX or OnStar and, in the case where medical care or police assistance is required, forwarded to 911 for further assistance. ACN systems allow for verbal communication between the call-taker at the TSP and crash involved occupants in order to better evaluate the overall severity of the crash event to make appropriate decisions.

The principle components used by the ACN system are listed in Figure 1. The system is triggered using data from crash sensors used to deploy front and side airbag systems including accelerometers, pressure sensors and gyroscopic sensors. If a crash event exceeds the predetermined threshold for transmission of an ACN signal, verbal communication between the TSP and occupant occurs through a fixed microphone and the vehicle audio system.

The ACN system is a stand-alone system where there is no need for an additional mobile phone. The vehicle sends an emergency call automatically, if a crash was detected or manually by pushing the SOS button if assistance is needed.

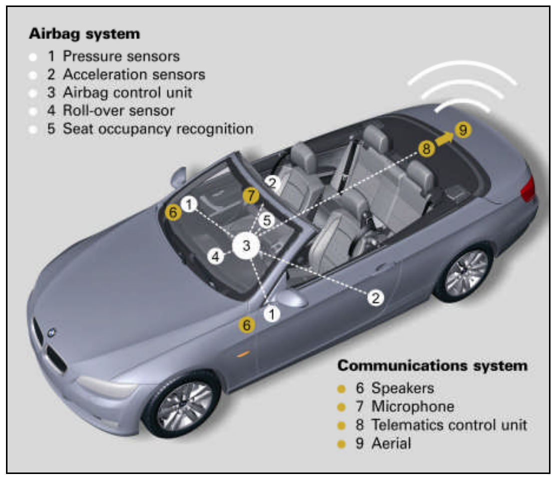

Figure 1. Airbag and communication components using the example of the 3 series convertible.

Once a call is initiated, ACN equipped vehicles transmit a notification that the crash has occurred, exact GPS position, the Vehicle Identification Number (VIN) specifying owner information and vehicle characteristics. The vehicle calls the TSP and the occupants can talk to operators with specialized training.

In 2007, BMW introduced an enhanced Automatic Crash Notification Technology. These systems collect additional crash metrics through on-board sensors that can be used as the basis for estimating crash severity and risk of injury to occupants. The additional data collected and transmitted includes the crash deltaV in the longitudinal and lateral directions for each impact event, crash type, safety belt status for front seat occupants, airbag deployment status, the occurrence of multiple impact events and the occurrence of rollover if the vehicle is equipped with rollover sensors.

Once transmitted to the BMW call center, the raw data passes through an algorithm known as URGENCY which estimates the risk of serious injuries based on crash conditions. The algorithm was first proposed in 1997 and consists of a single logistic regression model that related the risk of high severity injury to independent variables describing each crash event (Malliaris 1997). Since its initial development, URGENCY has been retrained using recent crash data, modified to more accurately treat differences in serious injury risk by crash direction and enhanced to include additional crash parameters like multiple impacts (Augenstein 2003). The algorithm estimates the risk of serious injury based on crash parameters transmitted by the enhanced ACN system. Seriously injured occupants are defined as those who have sustained one or more injuries with an Abbreviated Injury Severity (AIS) Score of 3 or higher (includes AIS 3, AIS 4, AIS 5, AIS 6 and fatally injured). This group is referred to as MAIS3+ injured and includes those who need immediate medical attention due to potentially life threatening injuries.

The URGENCY Algorithm treats crashes separately by impact type including frontal, nearside, farside, rear impacts and rollover. The algorithm was trained using 2000-2006 NASS CDS data including passenger vehicle front seat occupants over the age of 12 who are involved in planar only crashes. Model year 1998 and later vehicles only were used during model development and evaluation.

Each model was subsequently evaluated using the 2007 population of NASS CDS cases meeting the same criteria used for model training. These cases are independent of those used to train the model and were analyzed to determine the predictive value of the models for crashes estimated to be at or above the threshold for triggering the ACN system. Table 1 shows the overall ability of the models to identify or capture the MAIS3+ injured within the evaluation population (i.e. model sensitivity). Further, the table presents model specificity which indicates the models ability to capture the uninjured within the evaluation population as well. These values are presented in Table 1 for planar only crashes by crash direction.

Table 1. URGENCY Algorithm capture rate within the 2007 NASS CDS crash population.

Crash Mode	Sensitivity	Specificity
Frontal	71.2%	90.2%
Nearside	90.6%	85.7%
Farside	81.2%	88.6%
Rear	52.7%	98.2%
Overall	75.9%	90.8%

The overall predictive accuracy of the model suggests that 75.9% of injured occupants would be correctly identified using data automatically collected and transmitted by vehicles alone. In other words, an automatic call for help indicating serious injury is likely would be made for three out of four MAIS3+ injured occupants even if their crash was not observed by somebody on scene or if occupants were unable to place a call themselves. When URGENCY estimates are used in combination with verbal information gathered by the TSP or 911, occupants in need of medical attention would be rarely missed. A third opportunity to assess injury severity exists before hospital transport once EMS has arrived on scene.

Figure 2 shows the sequence of events that occurs when an enhanced ACN equipped vehicle is involved in a crash severe enough to trigger the automatic call for help. In this case the vehicle automatically sends the crash descriptors described above to the BMW Assist Center (TSP). While the vehicle is sending the data, a voice communication between the BMW Call Center and the occupants is simultaneously established. In the background the URGENCY algorithm is used to calculate the risk of serious injury and the call center is able to provide all this information, shortly after the crash, directly to the nearest Public Safety Answering Point (PSAP). If desired a conference call with the vehicle is also possible. Ideally, the PSAP would then utilize the available information to arrange appropriate rescue based on the risk of serious injuries communicated by the TSP. The additional data can then aid in the decision to dispatch either a helicopter or an Emergency Doctor or the Fire Department, and to further involve the EMS and the Police, for more accurate and proper allocation of resources.

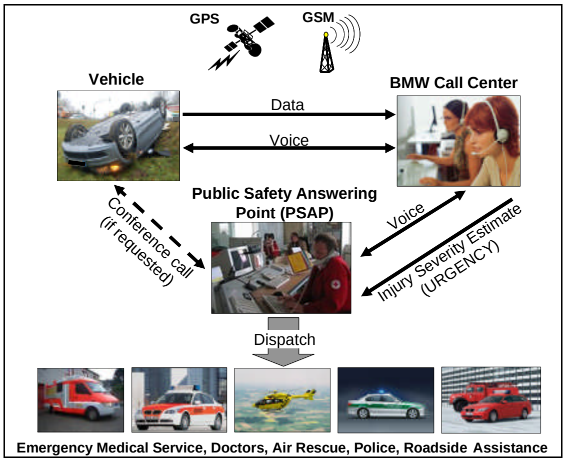

Figure 2. Flow chart of the functionality of the enhanced ACN system.

OPPORTUNITIES TO IMPROVE RESCUE USING ENHANCED ACN DATA

As discussed above, enhanced ACN systems now provide crash notification and location data along with data needed to approximate severity of the collision event. In most cases, occupants involved in crashes will respond verbally to call-taker questioning and those who require medical assistance can be easily identified. However, it is possible that occupants may not realize that they are injured shortly after a crash or they may not recognize the true extent of their injuries.

This portion of the study examined the population of BMWs in service in Florida from 2006-2008 who were involved in crashes severe enough to trigger the ACN system. The goal was to estimate: 1) the frequency of crashes where occupants suggested they were uninjured yet subsequently required hospital transport and; 2) the frequency of crashes where occupants did not respond to TSP operators yet were injured and required help. Establishing the magnitude of this population provided an indication of those who would most benefit from enhanced ACN data to be transmitted and processed remotely by the TSP and passed along to the PSAP.

Analysis of Verbal Response from Occupants

During this portion of the study, data from two primary sources were utilized. The first was the BMW Accident Research Crash database that includes a census of crashes involving ACN equipped model year 2004-2009 BMWs in service on US roadways. The dataset contains the vehicle identification number (VIN) along with GPS coordinates identifying precise crash location, and a written record of the verbal exchange between occupants and the ATX call-taker. Data is captured electronically by the communications software at the TSP. Each call-taker also enters notes documenting occupant response and information shared during the call.

Researchers reviewed each available call log to determine the nature of the crash including indications of injury, the general nature of the crash (i.e. multi-vehicle crash, rollover, etc) and the presence or absence of voice response. Cases where the ACN call log reflects no verbal response from occupants are classified as 'No voice.' In many cases, the TSP operator may hear noises in the vehicle or voices outside the vehicle yet no direct response from occupants is heard. It is suspected that some of these cases may result from occupants quickly exiting the vehicle following the crash before the TSP operator can initiate contact. In other cases, occupants may be injured such that a response is not possible or occupants may simply choose not to verbally respond. Crashes occurring in the state of Florida from 2006-2008 were retained for subsequent analysis.

The second source of data was the Florida State Crash Data from 2006-2008. This dataset contains a census of crashes where a police report was filed. In the state of Florida, the minimum criteria to file a police report include one or more fatality, any injury, alcohol involvement, or leaving scene. When a vehicle is towed from the scene, the officer uses his or her discretion in filing a report. Due to the criteria for inclusion, any crash where one or more occupant was transported to a hospital for treatment should be included within the annual file.

Findings

Table 2 shows the count of ACN crashes in the US and Florida alone in 2006-2008. The population of ACN crashes is also shown by approximate injury severity as reported verbally by occupants. A category where no voice response is provided by occupants is also included. The 'Not Reported' category includes crashes where there was verbal interaction with occupants yet no explicit statement of injury or non-injury was found in the call log. Due to the absence of this information, it was assumed that the TSP call-taker did not suspect injuries and simply neglected to enter this information into the log.

Table 2. US ACN Crash populations for 2006-2008 cases including occupant reported injury level.

Injury Level Reported Verbally	2006-2008 Crashes	
	Count	%
All Crashes	14,008	
Uninjured	6,285	45%
Low Severity Injury	2,468	18%
Moderate or Serious Injury	288	2%
No Voice	1,467	10%
Not Reported	3,500	25%
Florida Crashes	1,338	
Uninjured	565	42%
Low Severity Injury	299	22%
Moderate to Serious Injury	26	2%
No Voice	166	12%
Not Reported	283	21%

Police records from the Florida state data were merged with ACN records using the unique VIN and crash date as unique criteria for linkage. The goal in connecting the two sources is to determine the general characteristics of the crash, identify the type of information offered verbally by drivers and to characterize the type of treatment (hospital transport, trauma center transport or no transport) received by crash involved drivers. Table 3 shows the count of cases within the complete ACN dataset and the population from the Florida file.

Table 3 also shows the police reported injury severity for occupants of the BMWs involved in the crash. Injuries are coded by police using the KABCO scale. The KABCO scale was established by the National Safety Council in 1982 and is used primarily by police to classify the apparent injury severity of occupants involved in crashes. The scale includes 5 levels, where K level injuries are those where the occupant dies due to injury, A level injuries are those where the officer observed incapacitating injuries, B are non-incapacitating evident injuries, C are possible injuries and O are uninjured. The KABCO scale is a useful means to approximate injury severity yet it has been criticized as inaccurate due to the subjective assessments made by police. Data describing hospitalization was also retained, specific hospitals were identified and those where occupants were transported to a level I trauma center were flagged.

Table 3. Police reported injury severity and level of transport for 2006-2008 BMW Crash Cases.

Police Reported Injury Severity	2006-2008 Crashes	
	Count	%
Florida Crashes	1,338	
K, A	57	4%
B, C	318	24%
O*	978	73%
Hospital Transport	235	18%
Trauma Center Transport	32	2%

* includes cases where no PAR (Police Accident Report) was filed

Two populations were explored in more detail including the population where occupants did not reported injuries the TSP call-taker and the population who did not provide a verbal response to the TSP once communications were established with the vehicle. As shown in Table 4, 848 drivers were involved in crashes occurring in Florida from 2006-2008 and verbally reported that no injury was sustained. However, police coded that 194 (23%) of these drivers sustained possible (C), non-incapacitating (B), incapacitating (A) or fatal (K) injuries. A total of 108 of these were transported to a medical care facility and 23 of those receiving medical care were transported to a trauma center.

It should be noted that the criteria for transport to a trauma center can be met in a number of ways that are assessed and established on scene by first responders. These criteria include: 1) physiologic criteria like obvious signs of injury, reduced awareness (based on Glasgow Coma Scale), low blood pressure or head injury with neurologic deficit; 2) mechanism criteria including fatality of another occupant in the vehicle, ejection or evidence of a high energy event or; 3) First responder high suspicion of injury. If a first responder permits EMS personnel to override tangible criteria and decide that trauma center is in the best interest of crash involved occupants.

Although 108 occupants were transported to some type of medical care facility based on decisions made by EMS personnel on scene, this does not necessarily prove that an injury has occurred.

Table 4. Police reported injury severity and level of transport for cases where no injury was reported by drivers (2006-2008 cases in Florida only).

Police Reported Injury Severity	2006-2008 Crashes Count	%
Crashes with Voice Response but No Injury Reported	848	
K, A	23	3%
B, C	171	20%
O*	654	77%
Hospital Transport	108	13%
Trauma Center Transport	23	3%

* includes cases where no PAR was filed

Table 5 indicates that, during 166 crashes, there was no verbal response from any occupant in the vehicle following the crash. Of these, police reported that 8 (5%) drivers sustained incapacitating or fatal injuries based on their judgment. A total of 34 (20%) were coded as having non-incapacitating or possible injuries and 111 (67%) were coded as having no injury at all. Thirty one (31) crashes or 19% of no voice cases resulted in one or more hospital transports and 5 (3%) resulted in trauma center transport.

Table 5. Police reported injury severity and level of transport for no voice cases (2006-2008 cases in Florida only).

Police Reported Injury Severity	2006-2008 Crashes Count	%
Crashes With No Voice Response	166	
K, A	8	5%
B, C	34	20%
O*	111	67%
Hospital Transport	31	19%
Trauma Center Transport	5	3%

* includes cases where no PAR was filed

Opportunities to Improve Rescue Decisions

Since their first introduction in the fall of 2007 in Germany, 116 enhanced ACN crash calls have occurred. In the US, 449 enhanced ACN crashes have occurred since the spring of 2008.

To further explore the benefit of geographic data (GPS coordinates) transmitted in combination with injury severity, we analyzed the population of enhanced ACN crashes occurring in the US and Germany to date. Each crash was classified as low to moderate or serious based on their crash characteristics. GPS coordinates were reviewed to establish the geographically closest treatment facility to the crash. Subsequently, the distance along the roadway was calculated using the Google Earth mapping application. Figure 3 shows the driving distances along the roadway separating enhanced ACN vehicle crashes and Trauma Centers in Germany and the US. This plot is limited to those classified as serious based on transmitted crash data processed by the URGENCY Algorithm.

In general, the distribution of distances to a Level 1 trauma center in the US and Germany are similar with only minor differences. The percentage of crashes occurring within 20 km of a trauma center is higher in Germany compared with the US. While a larger percentage of US crashes appear to occur more than 20 km from the nearest level 1 trauma center.

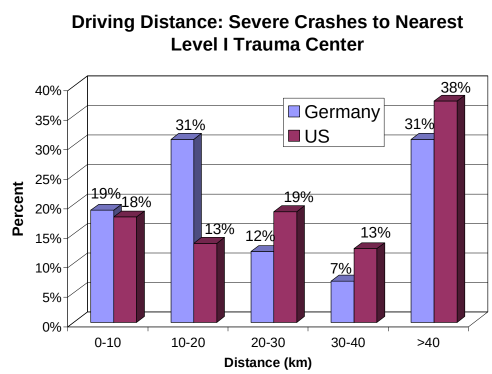

Figure 3. Driving distances from enhanced ACN vehicle crash locations to nearest Level I trauma center- US and Germany compared.

The transfer of geographic information from the TSP to the PSAP is currently done verbally. In the future, transmission of this data, accompanied by estimates of injury severity from the URGENCY algorithm, could be done electronically. Once received, the PSAP could utilize the data according to their established dispatch protocols to best select and deploy rescue resources.

Analysis of Enhanced ACN Data- First Experiences

Figures 4 and 5 compare the overall estimated injury severity for enhanced ACN equipped vehicle crashes occurring in the US and Germany with the percentage of crashes where one or more MAIS3+ injuries occurred in a vehicle. Data from NASS CDS and GIDAS from 2000-2007 were considered and the subset of crashes expected to exceed the enhanced ACN Trigger threshold were retained. These crashes include those severe enough to deploy airbags in the frontal and side direction.

As shown in Figure 4 and Figure 5, the percent of cases in the enhanced ACN crash populations in the US and Germany were more frequently classified as serious when compared with the NASS and GIDAS populations of crashes.

Since the enhanced ACN signal would be the first notification of a potentially serious crash and the first step of the rescue chain, a rather broad criteria has been established so that occupants with potentially serious injuries are unlikely to be missed. Once EMS arrives at the scene, they will conduct a more detailed, in-person assessment of crash involved occupants to make subsequent triage decisions. It should be noted that the threshold applied to these first enhanced ACN crashes is purposely set lower than that used to identify the performance of URGENCY as shown in Table 1 to avoid missed serious injuries as the system is first introduced.

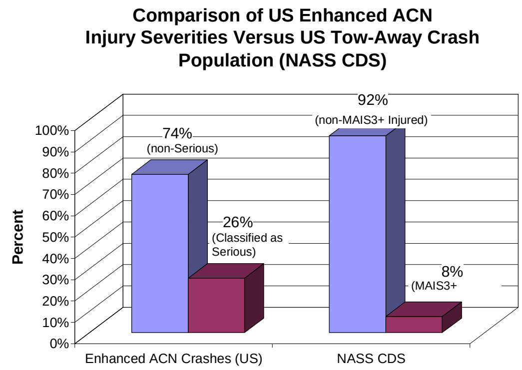

Figure 4. Comparison of injury severity from enhanced ACN data and MAIS3+ Injury Rate based on US Tow Away Crash Population

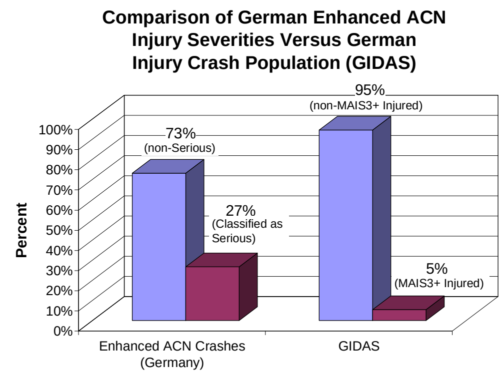

Figure 5. Comparison of injury severity from enhanced ACN data and MAIS3+ Injury Rate based on German Crash Populations

A second reason for the disparity in percentage of serious crashes between the enhanced ACN data and the US and German data, may result from differences in severity between the two populations. It is likely that the enhanced ACN crashes are more severe than the distribution of crashes in the general population. While the data shown in Figures 4 and 5 include only crashes severe enough to trigger the ACN system, it is possible that those in the enhanced ACN dataset occur at higher speeds or under more severe conditions.

DISCUSSION

This paper reports first field experiences with BMW's enhanced ACN systems where vehicles not only provide an initial notification of a crash but also transmit data describing the nature and severity of the collision event. We present an analysis of populations who could benefit from enhanced data now transmitted and identify how the application of URGENCY to estimate likelihood of serious injuries could help improve rescue care.

Usefulness of verbal data- A review of BMW ACN crash call logs suggests that verbal interactions between drivers and TSP call-takers often provides valuable information needed to make remote dispatch decisions. However, a review of logs for BMW crashes occurring in Florida from 2006-2008, in combination with a review of corresponding police reported data, revealed that some occupants who verbally indicated to the TSP they were uninjured were, in fact, transported to hospitals following on scene assessment by EMS. As shown in Table 4, 13% of drivers who initially provided no definite indication of injury indeed required hospital transport. Twenty-three of these 108 (3% of those who reported no injury) even met current criteria for trauma center transport. This suggests that serious injuries were sustained by one or more occupants in the BMW or the crash event was severe enough that EMS decided trauma center care was needed due to a high suspicion of injury.

Past research has shown that occupants who sustain the most serious internal injuries, including those to the liver and thoracic aorta, are often unaware of their injuries until diagnosed in a hospital or before treatment is too late (Augenstein 1994, 1995, 2000; Lombardo 1993). For those where occupants report no injury, the injury severity could also be applied to confirm a lower severity crash has occurred or suggest follow-up by rescue when in fact a higher severity event is detected.

Cases with no voice response- Table 2 indicates that, in 10% of all cases and 12% in Florida, there is no verbal response from the vehicle occupants, even though there is voice communication within the vehicle by the TSP. For most, the lack of response suggests that the crash is minor and vehicle occupants have perhaps exited the vehicle to examine damage or for other reasons. In some cases, the lack of response is due to an incapacitating injury. It is particularly important to apply an injury risk algorithm to these events with no-voice response so that those in most need of care are identified and receive prompt rescue response.

Data presented here shows that, in the state of Florida from 2006-2008, 31 out of 166 cases or 19% of occupants who did not respond verbally to the TSP subsequently required hospital transport and medical attention (see Table 5). Five of these occupants ultimately received care at a trauma center. It is these occupants who may not be able to communicate the need for care who would best benefit from enhanced ACN technology. For them the vehicle based data could provide an automatic indication to the PSAP that the risk of serious injury is high and immediate rescue care is required.

Although findings are based on preliminary data with relatively low crash counts, the implications are clear. Looking at the complete US, 10% of all BMW ACN crashes had no voice response (i.e. 569 out of 5,689 in 2008). Applying findings from Florida we project that a total of 114 BMW occupants across the US each year could require subsequent medical attention although they may not provide a verbal response to TSP call-takers. Imagining such a system implemented in all passenger vehicles in the US, this automatic call for help could improve outcomes in the same way for over 15,200 drivers each year involved in moderate to high severity crashes. This estimate was derived from NASS CDS 2007 data, where 800,000 passenger vehicles were reported to be involved in a tow-away crash severe enough to trigger an ACN system if the system were available.

Utility of crash location data- Knowledge of crash location by dispatch in combination with the likelihood of serious injuries also presents opportunities to improve care for crash involved occupants. Figure 3 suggests that in 31% of BMW enhanced ACN crashes in Germany and 38% in the US occur further than 40 km from the nearest Level 1 trauma center. Even under ideal rescue conditions, it is unlikely that the total time from crash occurrence to definitive trauma center care (including EMS to travel to the scene, on scene care and transport) would occur within the "Golden Hour" of trauma. The "Golden Hour" of trauma care is a concept that emphasizes the time dependency of many injuries where the patient must come under restorative care during that first hour following the trauma.

For the most severe crashes, delayed deployment of additional rescue resources like extrication equipment or air transport could also significantly impact outcomes. If the automated assessment of injury severity occurred just moments after the crash using enhanced data transmitted by vehicles, deployment of such resources could occur much more rapidly than in the present system. Based on traffic conditions and location data, the decision to deploy air rescue may also be considered if appropriate conditions exist.

Development of a working system- Although manufacturers like BMW are now equipping vehicles with technology capable of transmitting valuable crash information to TSPs, the remaining rescue system must be enhanced to most effectively utilize the data. Mechanisms for the transfer of telematics data from one entity to another along the rescue chain are needed. This transfer may occur verbally or in electronic form as the system develops. Protocols must be enhanced so that the injury severity data is consistently treated by all involved and actionable. Currently, no criteria exists within dispatch or trauma triage protocols to process specific data elements known to effect the risk of serious injury including crash (deltaV), impact direction, number of impacts, restraint status (i.e. airbag deployment regime and belt use) and occupant age. In our opinion and those of others, a synthesized estimate of injury severity would be most useful. Finally, education is required so that 911 operators, EMS and treating physicians understand the value and correctly interpret the information to allow for real improvements in patient care.

The Centers for Disease Control (CDC) in the US has established a new triage protocol that allows for the telematics data like those transmitted by enhanced ACN Systems as criteria for increasing the level of urgent care provided to occupants exposed to a crash. Although no formal definitions have been specified for the treatment of telematics data, a medical committee established by CDC has recommended the use of an algorithm like URGENCY as the basis for recognizing crashes with high risks of serious injury and accelerating the rescue for those crashes. BMW and WLIRC will continue work with the CDC, EMS and dispatch community to define best practices to apply when this enhanced data is transmitted from the vehicle.

CONCLUSIONS

Enhanced Automatic Crash Notification Systems are now available and in service in many countries around the world and provide near instantaneous data on crash occurrence, location and severity. This data should be used by PSAPs to identify when the dispatch of rescue services is needed and the most appropriate assets to send. Enhanced ACN data, now transmitted by a growing population of BMW vehicles, can be used to optimize rescue response particularly in the absence of voice from occupants of the car.

In most cases, verbal data provided to the TSP and PSAP through the on-board communication system are valuable to dispatch in order to make rescue decisions. However, some occupants who provide a verbal response to TSP call-takers may not always accurately recognize or communicate that they are injured. A lack of voice response from occupants does not necessarily indicate a high risk of serious injury; however some occupants who may be unable to respond do require immediate medical assistance.

The data analyzed during this study represents a census of crashes involving ACN and enhanced ACN equipped vehicles in service in the US and Germany. With more than 700,000 BMW vehicles worldwide currently in service equipped with the technology, the resulting information transmitted in the event of a crash is of unprecedented value for research purposes. True population based estimates are possible using this data. When linked with other records like police reports, the information serves as a valuable resource for studying the performance of enhanced ACN systems or other safety technologies introduced within the fleet.

REFERENCES

Augenstein, J., Digges, K., Lombardo, L., Perdeck, E., Stratton, J., Malliaris, A., et al. (1994). “Airbag protected crash victims: The challenge of identifying occult injuries.” SAE Transactions, 103(6), 866-875.

Augenstein, J., Digges, K., Lombardo, L., Perdeck, E., Stratton, J., Malliaris, A., et al. (1995). “Occult Abdominal Injuries to Airbag-Protected Crash Victims: A Challenge to Trauma Systems.: The Journal of Trauma: Injury, Infection, and Critical Care, 38(4), 502.

Augenstein, J., Perdeck, E., Martin, P., Bowen, J., Stratton, J., Horton, T., et al. (2000). “Injuries to restrained occupants in far-side crashes.” Annual Proceedings of the Association for the Advancement of Automotive Medicine, 44, 57-66.

Augenstein, J, Digges, K., Bahouth, G. and others, “Characteristics of Crashes that Increase the Risk of Injury.” 47th Annual Proceedings of the Association for the Advancement of Automotive Medicine, p. 561-576, September, 2003.

CDC 2008. “Guidelines for Field Triage of Injured Patients: Recommendations of the National Expert Panel on Field Triage.” Morbidity and Mortality Weekly Report Recommendations and Reports, Centers for Disease Control, February 2009 / 58(07);172.

Champion HR, Augenstein JS, Cushing B, Digges KH, Hunt RC, Larkin R, Malliaris AC, Sacco WJ, Siegel JH. “Urgency for a Safer America.” AirMed, March/April 1999, pp.18-23.

Champion HR, Augenstein JS, Cushing B, Digges KH, Hunt RC, Larkin R, Malliaris AC, Sacco WJ, Siegel JH. “Reducing Highway Deaths and Disabilities with Automatic Wireless Transmission of Serious Injury Probability Ratings from Crash Recorders to Emergency Medical Services Providers.” Proceedings of the National Transportation Safety Board (NTSB) International Symposium on Transportation Recorders, May 3-5, 1999, pp. 67- 84.

Clark DE, Cushing BM. “Predicted effect of automatic crash notification on traffic mortality.” Accident Analysis & Prevention, Volume 34, Issue 4, July 2002, Pages 507-513.

Cunningham PRG. “North Carolina Preventable Mortality Study with Inter-Rater Reliability Modifications.” NHTSA Report DOT HS 808 345, Washington, DC, July 31, 1995.

Esposito TJ, Reynolds SA, Sanddal ND, Hansen JD, Rinker CF, Dale G, Maningas PJ, O’Reilly PJ, Bleicher J, Petrashek B. “Rural Preventable Mortality Study.” NHTSA Report DOT HS 807 973, Washington, DC, Dec. 7, 1992.

Lombardo, L., & Ryan, S. “Detection of Internal Injuries in Drivers Protected by Air Bags.” NHTSA: Research Note, August 1993.

MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL et. al. “A National Evaluation of the Effect of Trauma-Center Care on Mortality.” New England Journal of Medicine 2006; l354:366-78.

Maio RF, Burney RE, Gregor MA, Baranski M, Welch KB, Rothman ED. “Michigan Rural Preventable Mortality Study.” NHTSA Report DOT HS 808 341, Washington, DC, June 1995.

Malliaris AC, Digges KH, DeBlois JH. “Relationships Between Crash Casualties and Crash Attributes.” Society of Automotive Engineers SAE 970393, February 1997.

NHTSA 2006. “National Automotive Sampling System (NASS) Crashworthiness Data System Analytical User's Manual, 2006.” U.S. Department of Transportation; National Highway Traffic Safety Administration, Washington, DC 2006.