Beyond NCAP Dossier
BMW Assist Advanced eCall

- non confidential version -

BMW Group

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1 Innovation

1.1 Overview of BMW Assist Advanced eCall

General

BMW Assist Advanced eCall is a post-crash enhanced Automatic Collision Notification (eACN) system to alert appropriate rescue services to allow an efficient rescue promptly following a crash. After the occurrence of a serious crash, if a victim with serious injuries can survive for the first few minutes, the most important determinants of survival are the level of care received by the victim and how soon that care is received.

Vehicles equipped with an Automatic Collision Notification (ACN) System initiate a call for help in case of a moderate to severe crash. The emergency details including GPS coordinates for the vehicle along with basic vehicle identifiers are transmitted to a Telematics Service Provider (TSP). Additionally, a voice link is established between the vehicle occupants and the TSP call center so that additional information can be gathered and the casualties are immediately verbally supported. Human contact during this critical period can help reduce the likelihood and severity of post-traumatic syndromes. If necessary, the TSP operator will contact the appropriate emergency rescue coordination center (Public Safety Answering Point or PSAP) to request services like police, fire or EMS (Emergency Medical Service) as needed.
Depending on the home-country for which the BMW Assist contract was agreed, the operator will typically answer in the customer's native language, whereas the notification to the PSAP is also in an appropriate language for the PSAP.

History

- 1997 Launch of first BMW's emergency call system in US (ACN technology).
- 1999 Launch of BMW's emergency call system in Europe (ACN technology).
- 2003 Start of specification of a new telematics protocol to transfer crash data and to use enhanced service flows as part of the Automatic Crash Notification service.
- 2004 Kick-off for BMW internal Team „Advanced Automatic Crash Notification": Interdisciplinary group including surgeons, experts in accident analysis, crash verification, and airbag development, as well as telematics specialists. Continuing research in eACN.
  Key goals are to optimize triage and care of severely injured accident victims in two phases:
  - Phase 1: Support dispatching process at public answering points (PSAP) by providing a clearer indication of what rescue team capabilities are required (Start 2006).
  - Phase 2: Support trauma center diagnosis and care of injured passengers by directly providing crash analysis data (Start 2010).
- In 2007, BMW introduced the enhanced Automatic Collision Notification (eACN) technology. This system collects additional crash metrics through on-board sensors that can be used as the basis for estimating risk of severe injury to occupants with the URGENCY algorithm. An identification of an increased risk of severe injury can help rescue services provide a more appropriate and efficient response.

The safety innovation described below is the enhanced ACN system now capable of transmitting more detailed available crash attributes including

- impact direction,
- crash deltaV in the longitudinal and lateral directions for each impact event,
- number of impacts,
- safety belt status and occupancy (currently for front seat occupants),
- airbag deployment status and the
- occurrence of rollover in vehicles with rollover detection.

An algorithm, known as URGENCY has been developed to characterize injury risk based on these attributes, and the basic model has been presented during previous studies (Malliaris 1997, Champion 1999, Augenstein 2006).

The post-crash feature enhanced Automatic Collision Notification (eACN) is marketed under the name "BMW Advanced eCall" as one of many functions within "BMW Assist" which is a safety and convenience service package under BMW ConnectedDrive. Included in the whole package for example are "Roadside Assistance", if you need a tow truck, "Information plus" if you want to find a nearby chemist or "Remote Door Unlock" if you have lost your keys.

BMW Assist is available as an option in all current BMW models independent of vehicle characteristics. Customers can subscribe to BMW Assist in the following European countries: Germany, UK, Italy, France, Austria. These markets account for around 75% of all BMWs sold in Europe.
eACN is directly effective in any car that is equipped with the system. There is no need to have a special percentage of equipped cars. The system works independently of systems in other vehicles. eACN is available for all BMW models as an option.

See Annex 1 for further details about availability and Annex 2 for a sample contract.
The BMW Assist emergency call is also available in several additional markets outside Europe (USA, Canada, United Arab Emirates, Kuwait).

BMW Call Center in Europe

BMW contracted four call centers in Europe to handle the emergency calls. The decision which call center is assigned to a call depends on the home country of the customer and his current location.

Skills and training procedures

The training for each agent takes 6-8 weeks, during which the agent receives instruction on communication on the basis of BMW requirements.
The required scope of skills for all agents includes:

- Conversational competence.
- Technical competence according to BMW requirements.
- BMW competence according to BMW requirements.
- Corporate Behavior, “Premium Brand Attitude”.
- 24h a day - 7 days a week - 365 days a year native language speakers for each local market.
- English speaking back-up at any time.
- Additional soft skills, among others: psychological know-how, affinity to service delivery, experience in telematics automotive industry.

1.2 eACN System Architecture

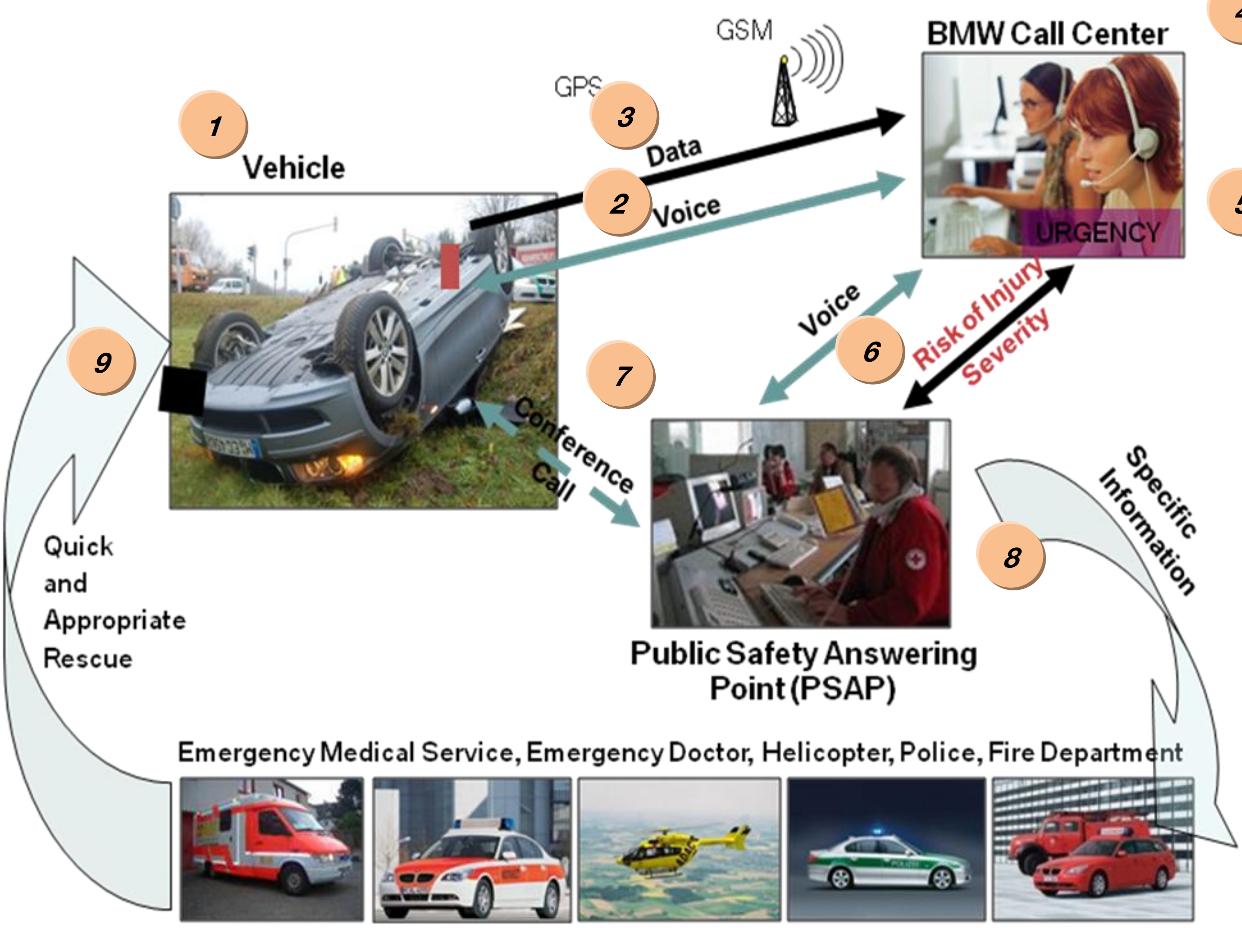


Figure 1

The time flow pertaining to Figure 1 is the following (see numbering):

1. A crash occurs.
2. The crashed car sends automatically an emergency call. A voice connection is established.
3. Parallel to the call the car sends data.
4. The URGENCY algorithm calculates the risk of injury severity.
5. In parallel the TSP is responding to the call and gets information about the crash.
6. The TSP provides risk of injury severity and other relevant information about the emergency to the PSAP.
7. If desired a conference call can be established.
8. Based on the information from the TSP the PSAP takes the decision for rescue (EMS, Helicopter, Police, Fire Department, etc.)
9. The appropriate rescue arrives quickly at the scene.

The principle in-vehicle components used by the BMW eACN system are shown in Figure 2a.

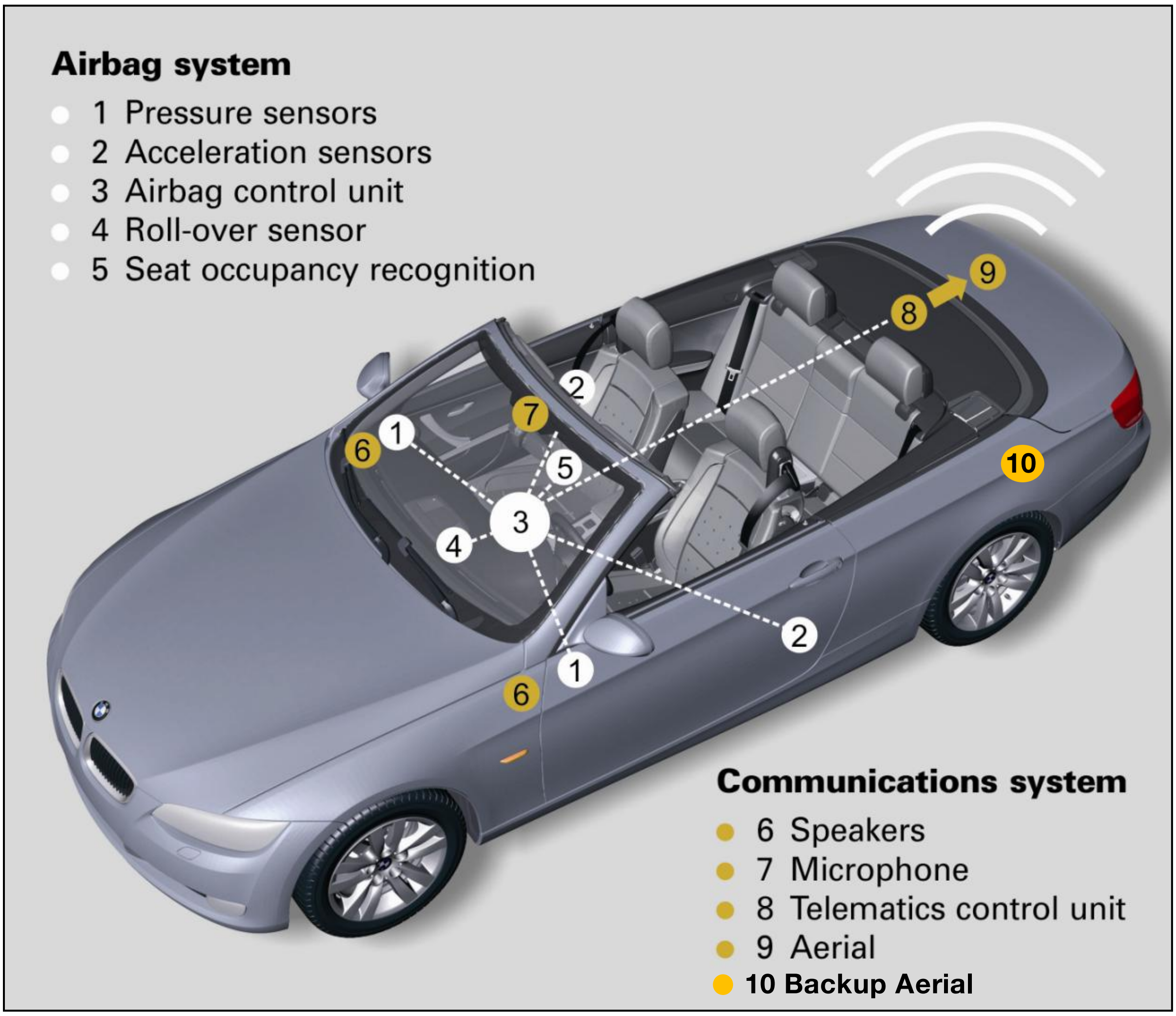


Figure 2a

The system is triggered using data from crash sensors used to deploy supplementary restraint systems, for example accelerometers, pressure sensors and gyroscopic sensors. The airbag control unit triggers the eACN in case of any airbag deployment or a heavy rear-end crash with deployment of a seat belt pretentioner.
In other emergency situations, a manual emergency call can be triggered by the customer via a dedicated SOS button. Use of the button does not interfere with an automatic emergency call .

The eACN system uses a built-in Telematics Control Unit with integrated GSM unit and SIM-card. The customer therefore does not need to have a mobile phone to use the system.
BMW is continually improving the eACN System; in 2010 a new in-vehicle system was launched.

The trigger from the airbag control unit to the Telematics Control Unit is sent via a dedicated control line and also redundantly via vehicle bus systems. A dedicated SOS button is also directly connected to the Telematics Control Unit.

The status and progress of the emergency call are displayed to the customer via the vehicle's display, as well as via a directly-connected status LED in the SOS-button, see Figure 2b and 2c.

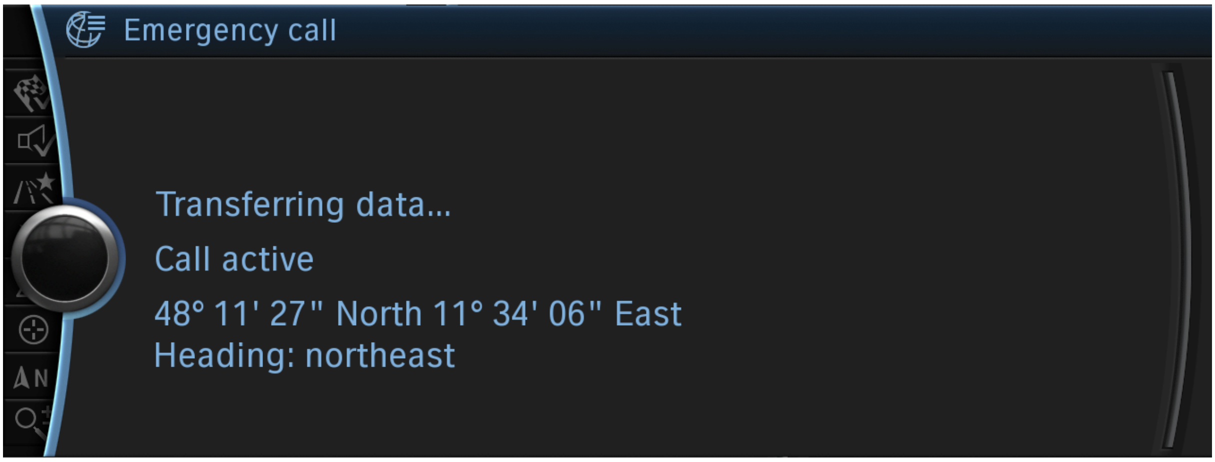


Figure 2b

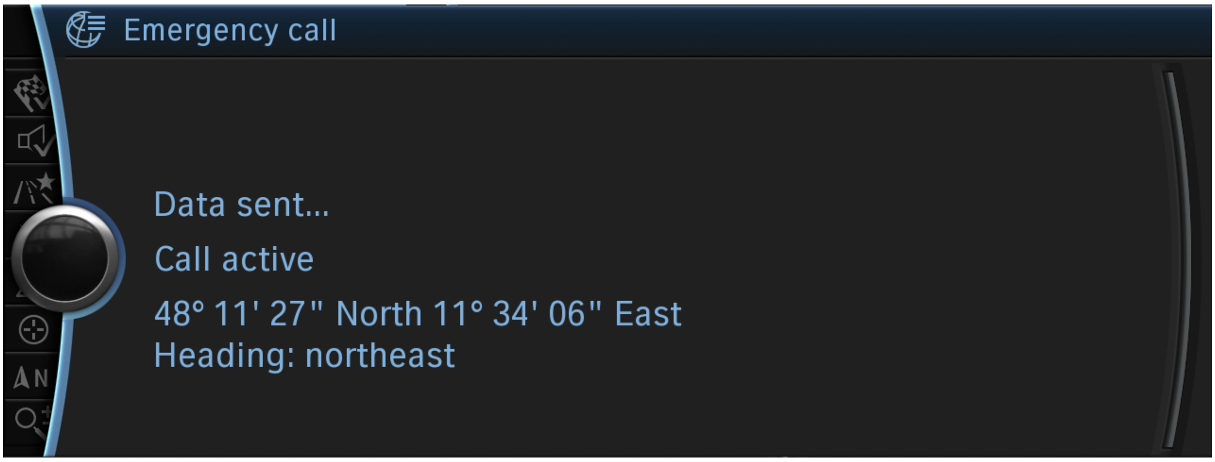


Figure 2c

The vehicle position and heading are continually calculated and monitored within the in-vehicle system. Even if GPS reception is not currently available, e.g. in tunnels, highly accurate positioning is achieved by dead reckoning and (if a navigation system is present) map-matching techniques. The system also maintains a list of recent significant waypoints, which are included in the eACN data-packet. Recent waypoints can often assist in accessing the exact vehicle location, for example in case of complex road junctions or bridges or in case of close parallel roads or motorways. In the unlikely event that the positioning system or GPS antenna is damaged during the crash, the above techniques help ensure that the in-vehicle system still has access to the last-known positions from only seconds beforehand.

The power supply for the eACN system is designed to ensure functionality in the majority of crash situations without requiring a backup battery. In all of our current BMW models, the battery is located in the boot, a very secure position with respect to damage and power failure. A backup GSM antenna allows GSM reception even if the main GSM antenna is damaged (e.g. in a rollover). The exact positioning of the backup antenna (see Figure 2a, Nr.10) depends on vehicle type.

Current eACN in-vehicle systems use GSM SMS technology in Europe for data exchange. Retry mechanisms are included to improve data transmission reliability if necessary. If the system detects that a call cannot be connected, or that an active call has been dropped, then automatic retry mechanisms are incorporated.

Alongside the transmission of an eACN data-packet, verbal communication between the TSP and the occupant occurs through a directly connected in-built microphone and speaker system. In most cases, this verbal communication is in the customer's native language as described below.
The directly connected speaker allows hands-free communication even when the vehicle's entertainment system is damaged.

The BMW eACN in-vehicle system supports comprehensive configuration settings, which can also be centrally updated if necessary without any need for the customer to visit a BMW dealer. This mechanism allows, for example, the destination phone number called by the in-vehicle system to be dependent on the home country of the customer and/or the mobile network at the current location. Using this mechanism, it is possible for example to verify that a German customer generally connects to a German-speaking call-center, whilst a French customer generally connects to a French-speaking call center, but that any customers in the United Kingdom connect directly to the UK emergency authorities as regulated, and that from any locations or networks where a BMW Assist emergency call is not supported, then the local national emergency number 112 can be called.

After activation, an automatically-triggered emergency call cannot be interrupted by the driver. The BMW eACN system is therefore not influenced by the driver's behaviour or condition.
The eACN system, as with any mobile emergency notification system, relies on mobile telephone networks to connect the emergency call and to transmit the data. It is difficult to get precise data regarding mobile network availability, and the available data typically quotes the minimum expected availability and is therefore somewhat conservative. The mobile network used by the current BMW eACN system quotes an availability of >99% of the population and >96% of the area in Germany, bearing in mind that the remaining area also includes remote areas such as mountains where vehicles cannot be driven. In BMW Assist markets outside of Germany, all available GSM networks are accessible to the system.
The GSM association produces a coverage map for Europe, which is included below for reference. It can be seen that most of Europe has excellent GSM network coverage (pink and grey areas in the map Figure 3).

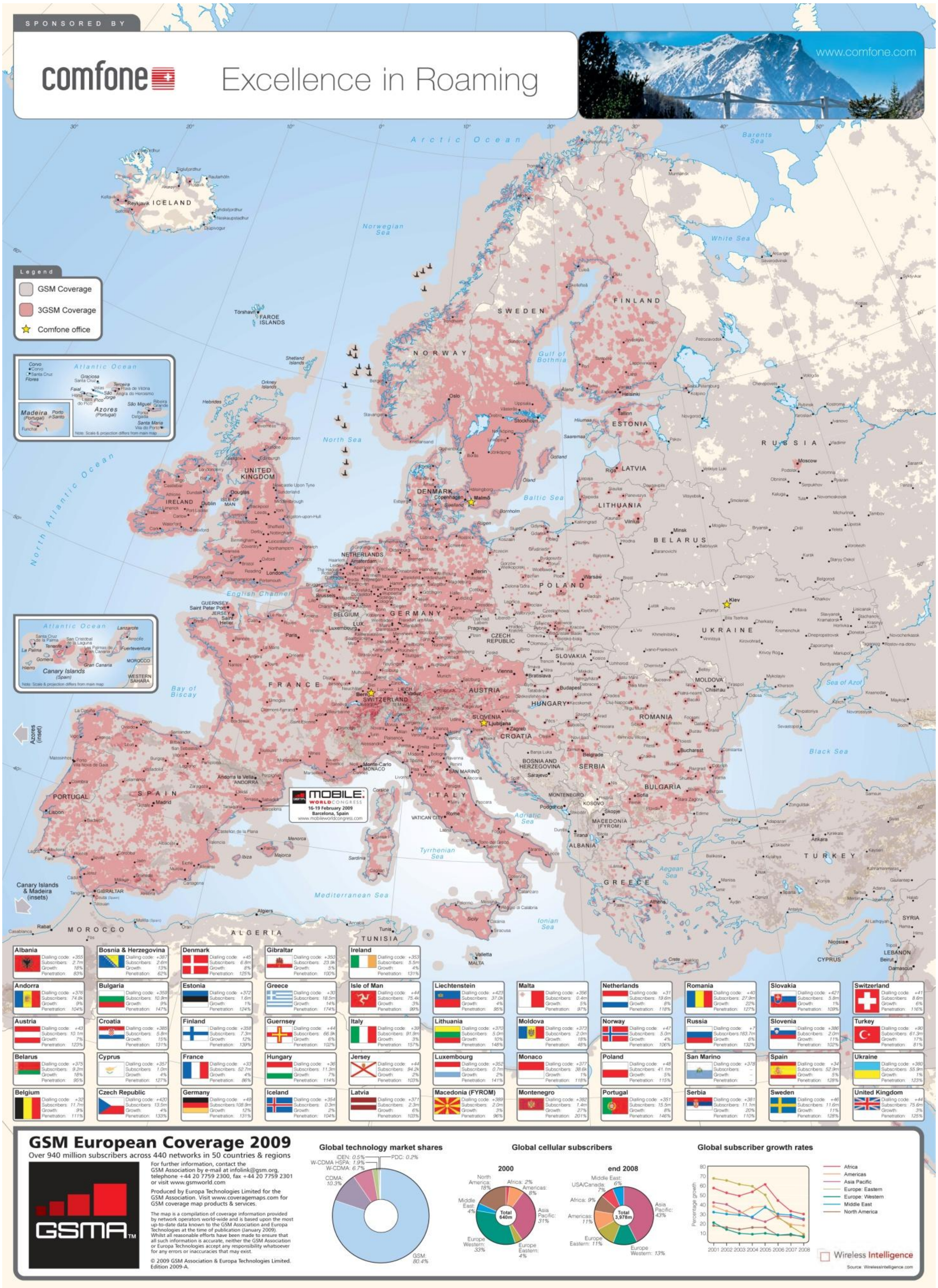


Figure 3: GSM association coverage map for Europe

The in-vehicle system is only one part in the emergency chain to ensure end-to-end functionality. The BMW Assist services infrastructure is based on the publicly available NGTP (New Generation Telematics Protocol) system architecture. Although only the latest generation in-vehicle systems also use the NGTP protocol for communication with the vehicle, a protocol conversion system allows all BMW Assist vehicles to be processed using this service infrastructure. The BMW Assist infrastructure employs fully redundant systems to help ensure 24/7 service availability.

The first part of the BMW Assist services infrastructure, called the “dispatcher”, can receive calls and/or data from the vehicles, and automatically decode information to immediately determine how best to process this “event”, including for example where the call should be routed.
This mechanism can be used to further refine the further handling of calls and data if necessary, for example based on exact location or certain vehicle settings.

The data received from the vehicle is combined with other relevant information, such as vehicle colour, and is automatically processed and displayed to the relevant operator who also receives the call.

One of the key aspects of the eACN system is that an increased risk of severe injury is automatically identified and highlighted to the BMW Assist operator.

The operator can also talk with the customer to gather further relevant information about the emergency situation if possible. The BMW Assist operators are trained how to deal with emergency situations using input from recognised bodies such as the Red Cross. It is also known from the scientific literature (Hickling, et al. 1997) that the likelihood of post traumatic stress disorder, which affects up to 1/3 of severely injured victims, depends on perception of danger and life threat at the time of the accident. Victims with a supportive eACN voice link have a chance to perceive the rescue process and thus feel less helpless. It thus seems plausible the voice link could help reduce the likelihood and severity of post-traumatic syndromes.
Thus, the operators not only quickly and efficiently gather information for the emergency services notification, but are also able to reassure and assist the vehicle occupants until the emergency services arrive at the scene.

If the call is determined to be a real emergency, then the operator will immediately ensure that the relevant emergency details are passed on to the most appropriate PSAP, automatically determined based on the vehicle’s location and type of emergency. Thus the PSAP can receive precise notification about the emergency situation with minimal delay allowing a highly efficient subsequent rescue. In case of a non-emergency situation, the PSAP is not disturbed, leaving it free to deal with other emergencies.

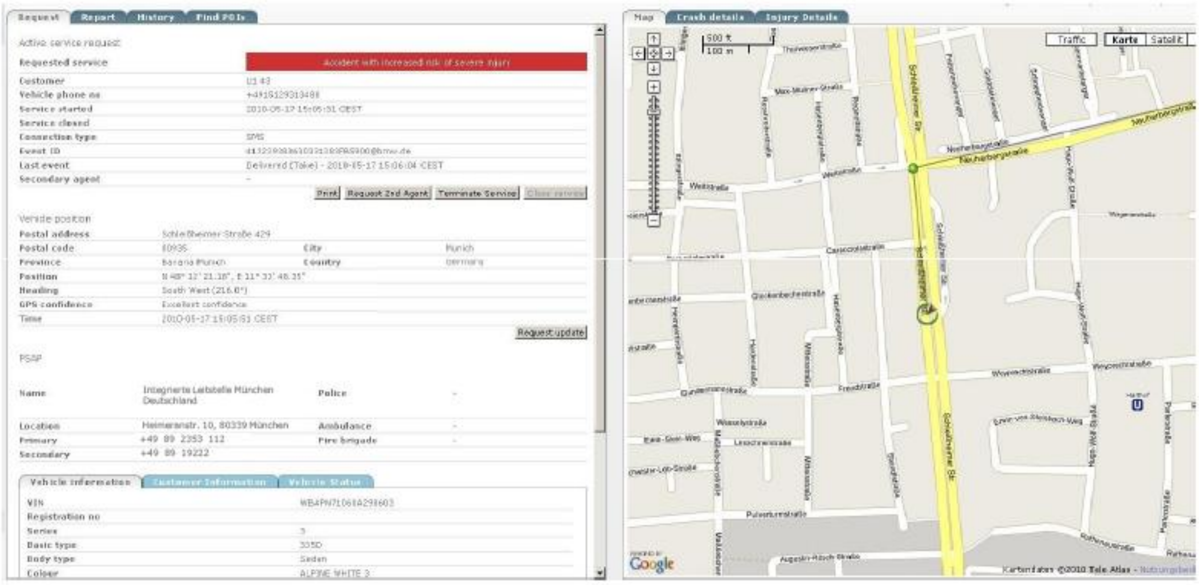
In some situations a second operator can be used to contact the most appropriate PSAP whilst the customer-facing operator continues to talk to the vehicle occupants to help reassure them and gather more information. This can be appropriate, for example, if the customer is in panic or the PSAP speaks a different language. In this case the PSAP-facing operator is presented with a similar display showing them the emergency details which need to be passed onto the PSAP. The two operators can also communicate with each other, for example, to answer specific questions from the PSAP, or a conference call can be established (rarely required) between the parties.

The emergency details are currently generally passed on verbally to the PSAP due to the available technology at PSAPs. BMW is actively contributing to international standards to help PSAPs receive and integrate such information more efficiently in the future.

The BMW Assist infrastructure and operator can determine the exact location (address and heading) of the vehicle, so precise emergency details can be passed onto PSAPs even if they only have very basic equipment. If appropriate, more hi-tech information such as GPS coordinates are also available if the subsequent rescue chain has the necessary infrastructure to use these.

A key element of the information passed to the PSAP when using the eACN system is a simple statement that an increased risk of severe injury has been automatically identifed.
Limited supporting information about the type of crash can also be supplied.
The URGENCY algorithm and presentation of results used allows the many contributory factors to be reduced to simple statements which can be quickly and efficiently passed down the rescue chain via the PSAP without any need for specific detailed vehicle knowledge for any of the parties

involved.Example screenshots of how the emergency call is presented to the BMW Assist operator are shown below in Figure 4. BMW strives to continually improve the processing and presentation used.



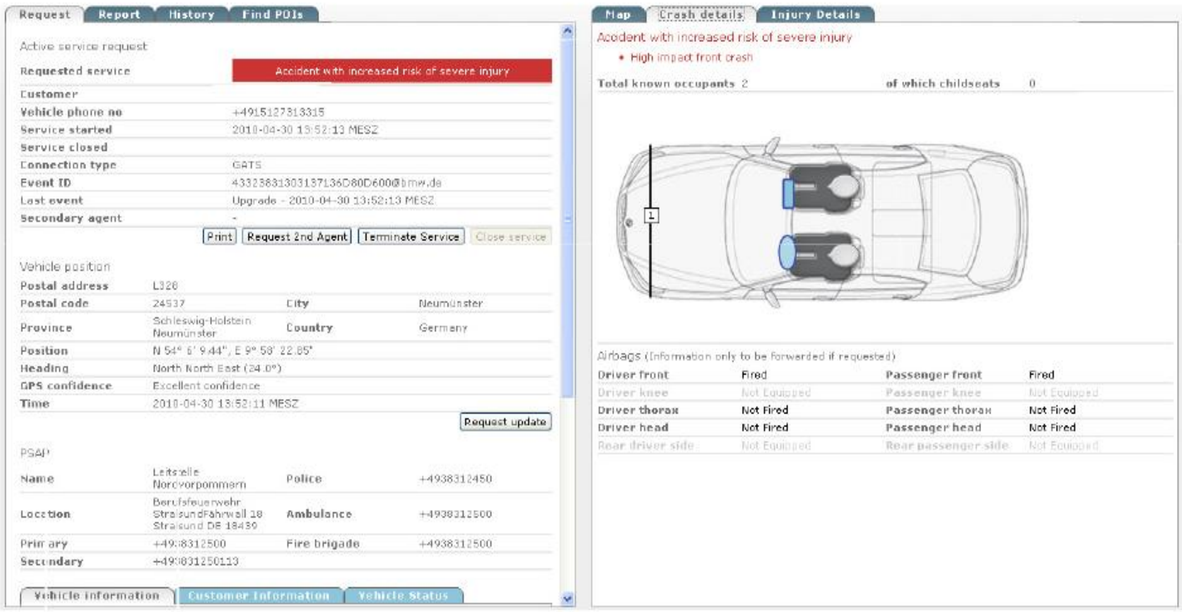


Figure 4

1.3 Regulatory Issues

There are several regulatory issues associated with the provision of the BMW Assist Advanced eCall. Some of the key issues are listed below.
In UK, as regulated, the system calls a specific phone number connecting directly to British Telecom, and a specific electronic data interface is used to provide defined information into the British Telecom systems.
BMW France received approval from the French interior ministry in 2009 for the BMW Assist Advanced eCall system.
The system has been designed to avoid use of data which might be considered to be sensitive; for example the absolute vehicle speed cannot be determined. Even though the data transmitted concerns the vehicle and is not considered as personal data, some personal data (e.g. customer name and contact number) is involved in some parts of the system, and the system is operated in

accordance with relevant european and national data protection legislation. Data received and stored is used for providing the Advanced eCall service. Unless an official specific legal order subsequently forces us to release information about a historic call to authorities, BMW will not release any data held regarding the emergency –e.g. to third parties like insurance companies.

1.4 Competition

BMW is one of only a small number of Original Equipment Manufacturers to offer a Automatic Collision Notification (ACN) System. Noteable alternative European systems include Peugeot Connect and Volvo On-Call.
In essence these other systems have similar features but also similar resitrictions to BMW Assist e.g. that the ACN feature is supported only in a limited number of countries (although there are slight differences in the countries supported by each manufacturer). PSA recently also introduced an integrated SIM-card into their newest telematics systems so that these systems, like all BMW telematics systems since 2005, do not rely on a customer SIM-card or mobile phone.

BMW is the first manufacturer to offer enhanced Automatic Collision Notification (eACN) technology, collecting additional crash metrics through on-board sensors and using this as the basis for estimating risk of severe injury to occupants with the URGENCY algorithm. An identification of an increased risk of severe injury can help rescue services provide a more appropriate and efficient response.
To our knowledge we are currently the ONLY manufacturer offering this feature in Europe.

Comparison between planned EU-Call and BMW Assist Advanced eCall

As a result of the EU's wish to reduce road traffic deaths by expanding the use of eCall systems in European Vehicles, various standardisation activities are ongoing regarding eCall systems.
BMW has actively contributed towards these technical standards, but the lengthy standardisation processes means that these standards are not yet completely fixed.
The standardisation of eCall systems via CEN foresees 2 fundamental system variants:
A Pan-European eCall system which calls the PSAP directly via 112
A Third Party Supported eCall (TPS-eCall) where the vehicle first contacts a private call center

The BMW Assist Advanced eCall can be considered as a TPS-eCall system.
As the standards are still being developed (in particular standardised interfaces for a Telematic Service Provider to pass on information to a PSAPs electronically) then it is not yet possible determine 100% compliance of any such system, but we do not currently foresee any compliance issues when the standards are finalised.

A comparison between the foreseen Pan-European eCall and the BMW Assist Advanced eCall is outlined for information below.

Foreseen Pan-European eCall

- Automatic or manually triggered.
- Vehicle to call PSAP directly via 112, prioritised within the mobile network.
- Routing to the most appropriate PSAP is achieved within the mobile network based on network cell
    - Mobile network infrastructure changes will be required to ensure that eCalls are routed to an "eCall-capable" PSAP supporting the necessary in-band modem technology.
    - Operator language based on current location, independent of occupant's home country.
    - Even unwanted/non-emergency calls must be received by the PSAP.
- A minimum Set of Data is sent over the voice connection via a specific "In-Band" modem.
    - Conversation between occupants and operator first possible after the data transmission.
    - Real-life end-to-end performance of this final in-band modem not yet demonstrated.
    - PSAP infrastructure needs to be updated to accept and process data.
    - Exact GPS-accurate location.
    - If data fails, cell-based location should still be possible (as any 112 call).
- Infrastructure and devices not yet available anywhere.
    - Necessary standardisation activities not yet complete, and necessary for launch.
    - Foreseen to be available across the EU27
    - Introduction date not yet clear.
    - All costs expected to be integrated into option and/or vehicle sales price.

BMW Assist Advanced eCall

- Automatic or manually triggered.
- Vehicle first calls a BMW emergency call center *)
  - No mobile network infrastructure changes necessary.
  - Operator language based on customer's home country (even when roaming abroad) *).
  - Trained operators can filter out non-emergency calls avoiding unnecessary load on the PSAP.
- A comprehensive data-set is sent using tried and tested technology.
  - BMW systems automatically accept and process the data.
  - Exact GPS-accurate location.
  - Automatic crash-data analysis and determination of an increased risk of severe injury.
- In case of a real emergency, the BMW operator informs the most appropriate PSAP.
  - No specific technology required at the PSAP – key facts passed on via voice.
  - PSAP is informed in their appropriate language, even for "foreign" occupants.
  - Identification of incidents with an increased risk of severe injury allows a targeted emergency response.
- Available now, in many countries (see Annex 1).
  - Standardisation activities ongoing to allow future improvements.
  - Initial contract period (typically 3 years) included in option price, subsequently yearly subscription.
  - Part of a comprehensive services package.

*)= except in UK due to regulation, and in countries where BMW Assist is not supported.

Note that if and when the Pan-European eCall is adopted across Europe, the BMW Assist Advanced eCall can be expanded to offer the higher market-availability of Pan-European eCall alongside the advanced features described above.

Table 1 summarizes the comparism of both systems in major aspects.

	Future EU eCall	**BMW Assist Advanced eCall**
Verbal Communication	Yes	Yes
GPS coordinates	Yes	Yes
URGENCY Algorithm (Risk of Injury Severity)	No	Yes
Native language	Not guaranteed	Available (except UK)
EMS decision (targeted response:Selection of rescue strategy e.g. emergency physician, helicopter)	Only on verbal basis (assuming driver can talk)	Intelligent algorithm supported by verbal information
Selection of appropriate trauma centre	Not guaranteed	Targeted selection because of URGENCY possible
Additional Information	-	Airbag Status, Seat Occupancy, Rollover, multiple impact events
Information about accident and injured people	Only subjective information	Objective information
Manual triggering	Yes	Yes
Trained operators	-	Positiv psychological aspects
Call connection	Limited to emergency call	Not limited, duration depending on customer preference
Conference call	No	Yes

Table 1: Comparism of Future EU eCall and BMW Assist Advanced eCall

The main difference and highlight of BMW's system is that we are the first manufacturer to offer enhanced Automatic Collision Notification (eACN) technology, acquiring additional crash metrics through on-board sensors and using this as the basis for estimating risk of severe injury to occupants with the URGENCY algorithm. An identification of an increased risk of severe injury can help rescue services provide a more rapid, appropriate and intensified response when this response is really needed. To the best of our knowledge, BMW is currently the ONLY manufacturer offering this feature in Europe.

Some other manufacturers in Europe currently offer eCall systems similar to the planned PAN European eCall, meaning just a voice connection to the PSAP's and transmission of the GPS coordinates. The potential advantages of additional vehicle data and the prediction of a injury severity using a sensor-based algorithm are not realized.

Considering manufacturers worldwide, GM has followed BMW in offering an advanced eCall within ONSTAR that is similar to the BMW system. It is noteworthy and a positive development that at least one other car manufacturer is convinced of the effectiveness and the benefit of such a system in substantially reducing traffic mortality and positively influencing morbidity.

2 Safety Issue

2.1 Data base and URGENCY algorithm

General

An appropriate testing procedure for eACN is a field observational study. Due to constraints such as the requirements on security and privacy of medical and vehicle-based data and practical considerations such as the advantages of a large database, the first available field observational study data has been obtained from US sources, as described below in Chapter 7. BMW is planning corresponding tests to evaluate the real benefit of our eACN system including all relevant data of all vehicles in the field for in-depth analysis in Europe, taking into account European and/or national requirements on security and privacy of medical and consumer data.

Efficient triage (real-time injury classification) in time-critical situations requires a high-performance algorithm for detection of severe (i.e., MAIS 3+) injuries. To this end, the URGENCY algorithm was developed and evaluated using the following data sources:

- BMW internal accident research databaes (only severe crashes, analysed in Bavaria/Germany)
- BMW internal database of ACN/eACN cases in the US since 2006 (automatic emergency calls in North America)
- Trauma Register of the German Association of Trauma Surgery (Deutsche Gesellschaft für Unfallchirurgie, DGU)
- CARE database of the European Commission
- GIDAS database (German Indepth Accident Study, area of data collection Hannover and Dresden, all accidents with at least one injured person)
- DESTATIS (German national database, all accidents with police involvement)
- NASS CDS database in the US (National Automotive Sampling System, Crashworthiness Data System, all accidents with at least one vehicle towed away)
- FARS database ib the US (Fatality Analysis Reporting System, all accidents with at least one fatality).

The data bases correlate well in EU27 and US in features relevant to assessment of the post-crash systems ACN / eACN (e.g. Figure 6 “comparison of NASS and GIDAS database”, …). The studies described are based on analysis of US trauma and Emergency Room data and crash data including the Fatality Analysis Reporting System (FARS), the National Automotive Sampling System – Crashworthiness Data System (NASS CDS). The crash data is collected by the US government and publicly available. Otherwise the data used is based on the CARE database of the European Commission, the German national database DESTATIS and the GIDAS database (German Indepth Accident Study). The “Trauma Register” of the German Association of Trauma Surgery (Deutsche Gesellschaft für Unfallchirurgie, DGU) is the largest data collection of severely injured people in the world based on 21.079 severe injured people of 166 hospitals in Germany, Austria, Switzerland, Netherlands, Belgium and Slovenia (Trauma Register 2009, 2005).
Multiple studies have cited and confirmed the impact of more rapid rescue and an adequate level of medical care on morbidity and mortality reduction.

Transfer of basic data

The basis data obtained by the vehicle is very important to get a reliable prediction of the injury severity with URGENCY. Two examples of important basic data will be described here. Figure 5 shows the risk of a serious injury versus the occupant load of a rear-end collision. We can see clear differences between a front collision, a far-side collision or a near-side collision. If a person in a rear-end collision has a 20% risk of a serious injury, then in a near-side crash with the same occupant load the risk increases to 85%.

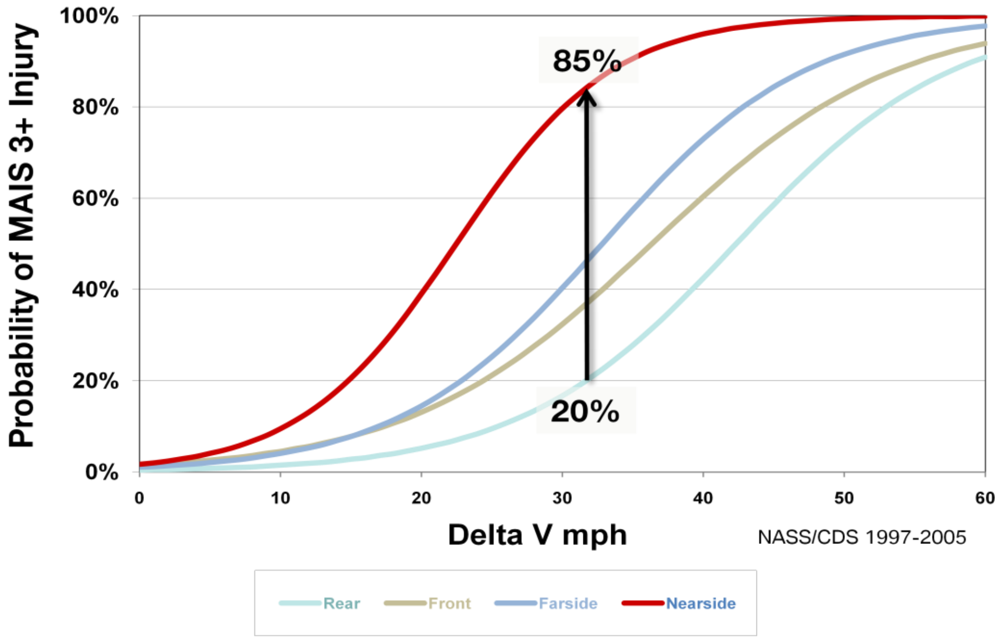


Figure 5

Seat belt use is also a very important factor. In case of a collision where the occupant is unbelted, the probability of MAIS 3+ injury[1] is more than doubled compared to a belted occupant.

Development of URGENCY algorithm

In order to identify crash events where a severe injury is likely, key characteristics describing the crash configuration, crash energy and occupant factors are important. Key crash attributes that best discriminate seriously injured occupants were identified from experience and the open literature. These attributes include the direction of impact for each event (frontal, nearside, farside and rear impact direction or rollover), the impact severity based on deltaV for each impact, the use or non-use of safety belts in front seats and the number of impact events that occurred.
The URGENCY Algorithm contains four logistic regression models which relate the risk of high severity injury to a series of independent variables describing the crash event (see Figure 5 and Chapter 7). During this evaluation, the high severity injury category was defined as occupants who sustained one or more injury with an Abbreviated Injury Severity (AIS) Score of 3 or higher during a crash due to trauma (includes AIS 3, AIS 4, AIS 5 and fatally injured). This group is referred to as MAIS3+ injured.
Data from the National Automotive Sampling System Crashworthiness Data System (NASS CDS) was used initially during model development to relate crash characteristics to the risk of serious injury for target occupants. NASS CDS is collected by the National Highway Traffic Safety Administration (NHTSA) and contains a sample of 4,500-5,000 crash cases annually. Each case involves at least one motor vehicle in transport on a public roadway where one or more vehicles were towed from the scene. Data elements recorded in NASS CDS cases are collected by professional crash investigators

[1] AIS means “Abbreviated Injury Severity score” and indicates the potential threat to life due to a single injury where an AIS 1 injury is minor and an AIS 6 injury is non-survivable. MAIS refers to multiple injuries. MAIS 3+ injuries are considered serious and life threatening.

based on an in-depth inspection of the vehicle interior, the vehicle exterior and the crash scene. Supplemental information is gathered from police accident reports, occupant interviews, and hospital records.
Each NASS CDS case is assigned a weighting factor to reflect its probability of sampling. Case weight adjustments were made to reduce the impact of outlier weights on injury rates. This process is an important step in order to reduce the variability between cases within each stratum. When weighted before and after adjustment, the sample represents the nationwide incidence of tow away crashes and resulting injuries.
SAS Software Version 9.1 was used for data handling and Stata Version 8 was used to compute parameter estimates and standard errors due sampling variability. Stata was necessary to accommodate the stratified sample of cases within NASS CDS.
This study addresses passenger vehicle front seat occupants over the age of 12 who are involved in planar only crashes from 2000-2008. Model year 1998 and later vehicles only were used during model development and evaluation.

Accuracy of URGENCY

The URGENCY Algorithm treats crashes separately by impact type including frontal, near-side, far-side, 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. The model was then evaluated on independent data (NASS CDS 2007). The detection rate on this independent data set was 75.9% (see Table 2). In other words, an automatic call for help indicating serious injury would be made for three out of four MAIS3+ injured occupants, even if occupants were unable to place a call themselves and even if their crash was not observed by someone on the scene. When URGENCY estimates are used in combination with verbal information gathered by the TSP or PSAP, occupants in need of medical attention would be rarely missed. The overall specificity of URGENCY on the independent data set was 90.8% (injuries MAIS 3+) (Rauscher S. 2008).

Crash Mode	**Model Sensitivity MAIS 3+**	**Model Specificity MAIS < 3**
Frontal	71,2 %	90,2 %
Near-side	90,6 %	85,7 %
Far-side	81,2 %	88,6 %
Rear	52,7 %	98,2 %
Overall	**75,9 %**	**90,8 %**

Table 2

In addition to the detection rate (sensitivity) and specificity of the URGENCY algorithm, it is interesting to consider the frequency of crashes that would trigger URGENCY in a realistic environment. To this end, the first two columns of Figure 7 report the percentages of real crashes with a triggered emergency call that generated URGENCY MAIS3+ reports in data from the US (26%) and Germany (27%). In the two right-hand columns, data from NASS CDS and GIDAS from 2000-2007 were considered. The measured incidence of MAIS3+ injuries was 8% in the NASS CDS data and about 5% in the GIDAS set. Note that since the enhanced ACN signal would be the first notification of a potentially serious crash and the first step of the rescue chain, it is preferable to set the threshold so that occupants with potentially serious injuries are unlikely to be missed.

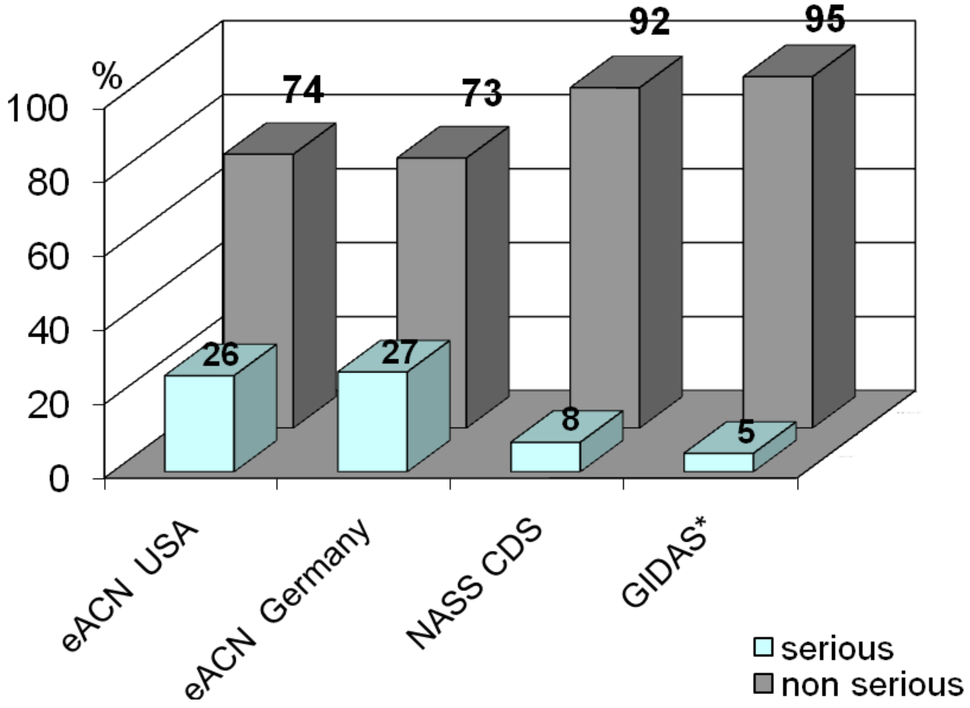


Figure 6

2.2 Safety and Rescue Factors

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 efficiently assign personnel and specialized equipment and transportation as needed. These aspects are especially important in rural areas where greater distances are involved.

Delays in the initiation of rescue calls and subsequent transport, poor recognition of injuries in the field and improper delivery of patients have all been identified as factors effecting occupant morbidity and mortality (MacKenzie 2006; Evanco 1999; Clark 2002).

According to a US study (Champion 1999), the "Golden Hour" is exceeded (elapsed time from crash to hospital > 60 minutes) in 21% of fatal crashes. In Europe (Trauma Register 2009), the average time from crash to arrival in an emergency hospital is approximately 72 minutes (30 - 114 minutes).

The technology of Automatic Collision Notification systems has the potential to positively influence post-crash care for any occupant involved in virtually any crash configuration. In the year 2007 the European Union (EU 27) counted 42.485 fatalities amongst 1.29 million crashes involving injured parties (DESTATIS 2008). More than 75% of all road fatalities in passenger cars occur in rural areas (CARE database 2008). The percentage of crashes involving injured parties with injury severity AIS 3 or higher is estimated at 5% in Germany, based on the GIDAS database, and 8% in the US, based on NASS data (Rauscher 2009).

In particular the BMW system (eACN) seeks to identify populations that may be severely injured: those with one or more AIS 3 or higher injuries.

Road accidents cost the EU economy more than €160 billion a year (European Commission 2009). The positive economic impact of equipping all cars in the EU with an ACN system has been estimated at €26 billion. BMW's eACN, including the prediction of injuries with URGENCY, could have a much larger positive economic impact.

Within this document, only severly injured people are considered. Therefore, all estimations are conservative. The real-world benefit of this system is expected to be even higher when additional aspects such as the following are considered:

- Psychological effects: As mentioned earlier, during the post-crash period, human support, the feeling of "not being alone", and the reassurance that an automatic system is in charge, can reduce immediate and post-traumatic stress.
- Positive economic factors: the duration of hospitalization and the likelihood of complications are significantly lower in severly injured patients if they are transported to a specialized trauma center.
- Intelligent traffic control: a fast emergency call and an accurate positioning of the crash scene can help to prevent secondary collisions.
- Improved triage: Improved triage of accident victims with relatively minor injuries allows public authorities to concentrate scarce resources on those who require intensive services such as helicopter transport and trauma center care.
- Manual triggering: Other accident victims can benefit from manual triggering by a driver or passenger who has observed an external crash; manual triggering provides a reliable GPS localization not subject to errors and uncertainties of a stressed caller.

2.3 Effects on Safety

ACN

The rapid identification of critically injured occupants followed by appropriate care has been shown to improve injury outcomes and prevent fatalities. A number of US studies have examined preventable deaths in detail. A study by Clark and Cushing suggests a fatality reduction between 1.5% and 6 % if all time delays for notification of EMS were eliminated, even if methods for dispatch and treatment remained the same (Clark 2002). With the current projection (Traffic Safety Facts 2010) of 33,963 fatalities in 2009 (37,261 in 2008) in the US, the resulting number of lives saved would be about 2038. The study of Champion suggest a 12% reduction of traffic deaths in rural areas (Champion 1999). According to the European Commission the potential number of saved lives would be approximately 2,500 per year in Europe, which is in line with the the US figures of 6%. Moreover, improvements in morbidity could reduce the number of persons classified as severely injured by 10 – 15% (according to the European Commission 2009).
That estimate applies to the US situation in 1997.

eACN
The figures cited for ACN do not take into account the additional benefits of applying the eACN URGENCY algorithm. In cooperation with the William Lehmann Injury Research Center (WLIRC) an analysis was performed based on the US database to estimate the potential benefit of URGENCY concerning fatalities. The result is that an additional 3.4% of the fatally injured occupants could be saved with an injury prediction algorithm like URGENCY.

Assuming that this 3.4% reduction can be added to the upper limit of the estimate of Clark and Cushing (6%), one obtaines a 9,4% fatality reduction using an eACN system. Extrapolating this percentage to the EU27 death rate results in a potential of 4000 lives per year in Europe, based on 2007 statistics.

Obviously, there are additional factors such as penetration rates to consider, as well as differences between the US situation in 1997 and the European situation in 2010. A more detailed analysis carried out by BMW is reported, which takes the separate life-saving mechanisms into account. The effects of penetration, acceptance, and other limitations are also considered below (Quantitative illustration of impact of crash notification on traffic mortality using a calibrated Markov-chain approach).

3.0 Accident Mechanism & Injury Causation

Since BMW´s eACN system is a post crash system, it is relevant for all sorts of accidents & injuries. It is not applicable to describe any accident mechanism or injury causation.

However, the mechanism “how does the system achieve the reduction of fatalities” of eACN can be discribed as follows:
The purpose of BMW’s eACN system is to automatically detect that a collision has taken place, determine the vehicle location and to establish a voice link between the involved occupant and the TSP to gain more information about the incident and to notify the PSAP (Public Safety Answering Point) and EMS (Emergency Medical Service) about the need for rescue and any increased risk of serious injury. The eACN 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 (see Figure 7).

Figure 7

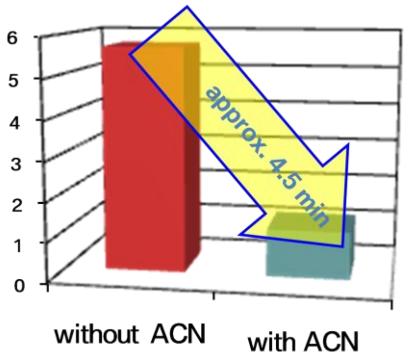
eACN helps to reduce the amount of time from the the point, when the crash occures to the point when the injured person can be treated in even the best suiting hospital/trauma center available for the exact type of injury.

4.0 Target Requirements

Casualty Benefits

Chapter 2.3 identifies a potential reduction of about 4000 fatalities per year in Europe for eACN. This potential is based on several factors:

Potential in reducing the notification time
The reduction in notification time would occur with widespread implementation of ACN/eACN technology in passenger vehicles today. In US studies, the average reported time between crash and notification is about 7 minutes in rural areas and about 4 minutes in urban areas. With ACN/eACN, the time could be reduced dramatically to just 1 minute, corresponding to a reduction of 86% in rural areas (Champion 1999). The average reduction of notification time is shown in Figure 8.



NHTSA DOT HS 809 303 (USA)

Figure 8

The European Commission estimates that the rescue time could be reduced by 50% with an automatic collision notification system (European Commission 2009).

Potential in reducing the time between crash and hospitalization (Golden Hour)

Of the crash deaths each year, nearly 48% die at the scene, while of the remaining 52% who are transported to a hospital, many die because they arrive too late to be saved. Thousands of crash deaths occur each year in which the victim did not arrive at a hospital - much less at the most appropriate one i.e. a trauma center - within the "Golden Hour" (Champion 1999).
Figure 9 indicates the time between crash and death.

If we assume that an eACN System can best address those fatalities which would occur more than 10 minutes after a crash, then as seen in the figure below, the system has a potentially benefit in about 65% of currently fatal crashes. The percentage of those fatalities that can be prevented by earlier treatment is considered in the detailed analysis reported below.

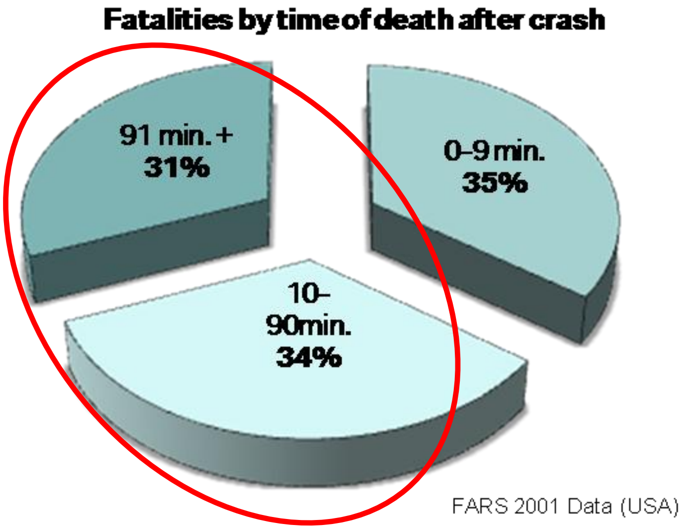


Figure 9

An evaluation of the German GIDAS database (Figure 10) confirms the similarity of the time between crash and death and therefore the comparability of crash events in Germany and the US. Figure 10 shows almost the same potential benefit with eACN in Europe of approx. 68%.

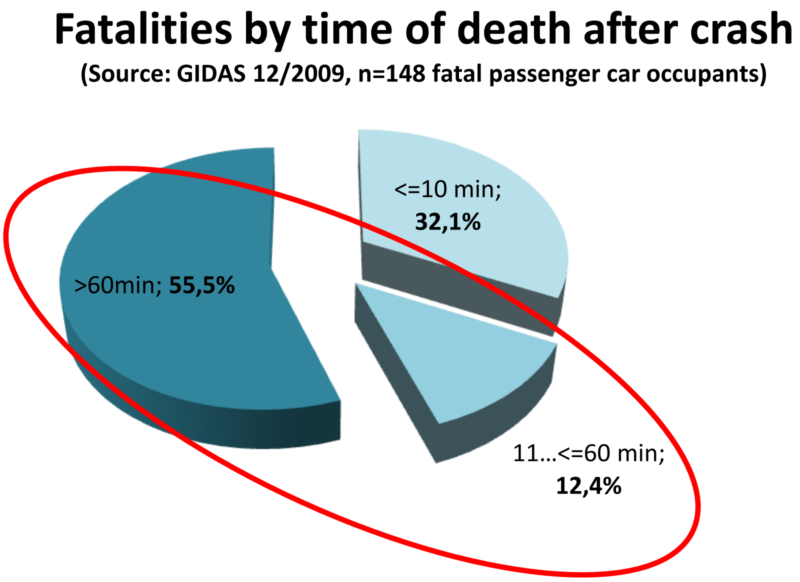


Figure 10

Potential in improved EMS and treatment – recognition of the most serious injuries

Three studies conducted by the NHTSA have explored preventable deaths to assess the effectiveness of the current trauma care system (Cunningham, 1995; Esposito, 1992; Maio 1996). 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. This study suggests that opportunities exist for preventing trauma deaths not only by reducing the time from crash to hospital, but also by aiding in the recognition of the nature of the most serious injuries.
A statement of the Trauma Register in Germany says, that every third patient arrives in the most appropriate hospital only after being first taken to a different hospital (Trauma Register, 2005).
A recent US evaluation considering the effect of trauma center care on mortality of patients arriving at hospitals with one or more AIS 3 injuries underscores the importance of treatment in the most appropriate medical facility. 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 (MacKenzie et al., 2006).
Estimating the nature and severity of injuries by the URGENCY algorithm along with transmitting the number of potentially injured persons involved enables the PSAP to dispatch exactly the most appropriate Emergency Medical Services. This means that they can be sent out only where they are needed, and other emergency service will be available for other accidents.

Potential of geographic data in combination with injury severity

To explore the benefit of geographic data (exact vehicle position including GPS coordinates and driving direction) transmitted in combination with injury severity, BMW analyzed the population of enhanced ACN crashes occurring in the US and Germany. GPS coordinates were reviewed to establish the geographically closest treatment facility to the crash. Subsequently, the distance along the roadway was calculated using a mapping application. The distribution of distances to a Level 1 trauma center (maximum treatment capability) in the US and Germany are similar with only minor differences (see Figure 11).
The percentage of crashes occurring within 20 km of a trauma center in Germany is about 50%. In the US there are just 31% of the crashes within 20 km.
About 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.
Especially these 50% of crashes have a great potential to save more lives because of the injury prediction with URGENCY - 69% in the US. (Rauscher 2008).

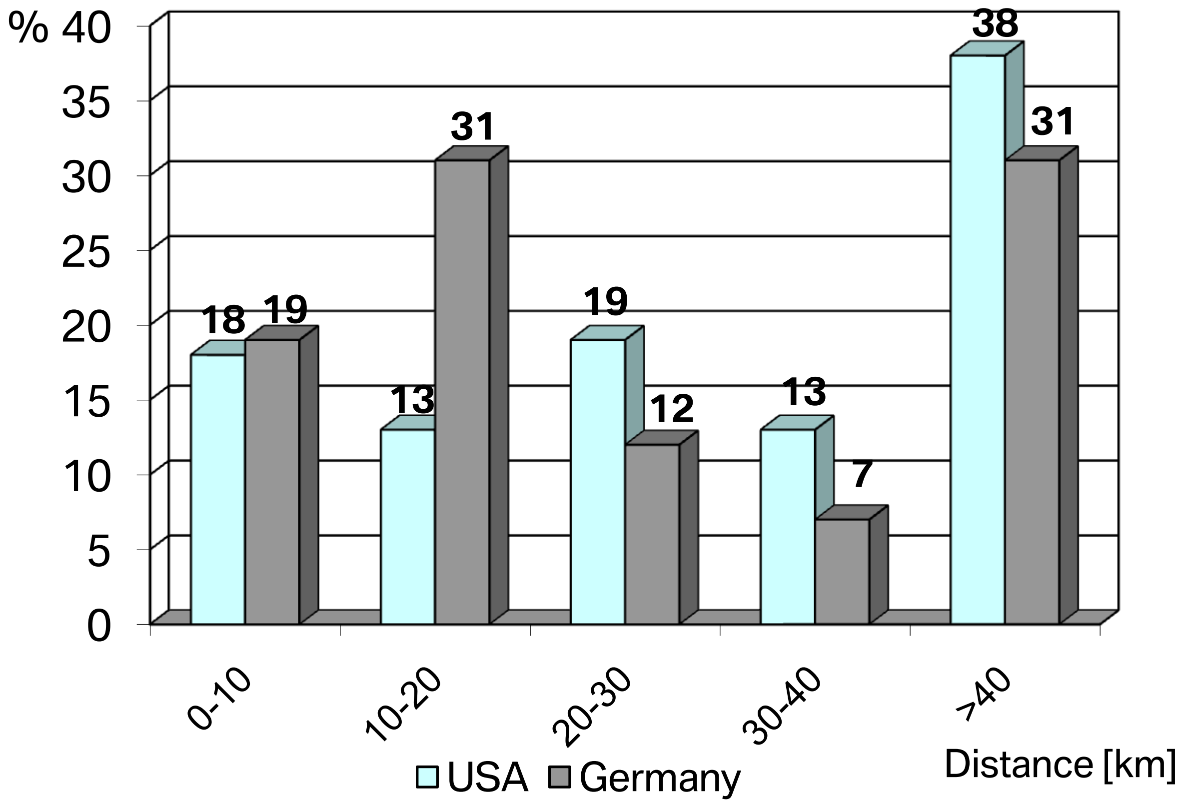


Figure 11: Distribution of distances to a Level 1 trauma center (maximum treatment capability)

Potential in reducing road accident costs

According to previous estimates (EU Commission 2009), savings in road accident costs in the European Union could amount to about € 26 billion annually with an ACN sytem. Based on the substantial improvement in mortality reduction, BMW's eACN system could save even more by including the prediction of injuries and allowing optimal care.

Although possible impacts of eACN technology on low-severity injuries have not been studied, we expect intangible benefits to providing drivers and passengers with support over the voice-link following a crash even without serious injury.

Due to the fact that this system is a post-crash system, some points in the Beyond NCAP assessment forms could not be explicitly addressed.

Detailed analysis of the influence of the rescue chain on survival

Responding to previous critique[2], we have carried out a probabilistic Markov-chain-based analysis of how the rescue chain influences survival. The aim is to demonstrate a clear link of eACN to efficacy (safety benefits) in terms of the reduction of fatalities.

Overview of Markov-chain survival approach
In this section we present a minute-by-minute probabilistic analysis of how the rescue chain influences survival. The aim is to demonstrate a clear link of eACN to efficacy (safety benefits) in terms of the most important metric, which is the reduction of fatalities.

Further benefits with regard to

- reduction of morbidity
- mitigation of suffering from injuries
- savings of medical and logistical costs
- additional economic consequences
- and “soft factors”

are expected, but they are not explicitly included in the present analysis (→ conservative approach). In line with the estimates of the European Commission 2009, reductions in morbidity could be comparable to those in mortality.

If a victim with serious injuries can survive for a few minutes following a severe crash, the most important determinants of survival are

- the level of care received by the victim and
- how soon that care is received.

The improved survival potential from our proposed eACN system results from supplying a

- higher level of care
- at an earlier time
- to a larger percentage of victims.

In order to illustrate the quantitative influence of eACN on survival, a coarse-grained, first-order sequential Markov model of crash survival was developed, programmed, and calibrated using evidence available from the medical and technical literature cited earlier. This methodology represents a first step toward a fine-grained, predictive model, which we anticipate would utilize a Monte-Carlo simulation technique and might incorporate microscopic models of particular injury sequences.[3]

The Markov modeling technique presented here was previously used by Clarke and Cushing in the context of predicting the effect of automatic emergency notification on crash mortality.

[2] Transfer Function – “This section should start to address the governing parameters for the system ... include factors relating to the whole chain - not just the first step of raising the alarm.”

[3] The methodological difference between the technique used by Clarke and Cushing or by ourselves and the microscopic Monte-Carlo method is that here we work directly with probability functions as a function of time, whereas in the Monte-Carlo technique a virtual sample of victims is explicitly generated. The two methods are theoretically equivalent.

Methodology for benefit estimation - Formalism of Markov survival model**:**

One imagines a large virtual sample of crash victims with injuries at the MAIS 3+ level of severity. At each time *t* (cycle length 1 minute), representing the duration since the crash, each victim's state is described by several binary variables.

- Survival (yes / no)
    - EMS notified
    - EMS begun (on victim)
    - Hospital care begun

In a sample of victims, each of these binary variables is associated with a time-dependent probability function. In particular, the survival probability function is denoted *S(t)* and is defined as *S(t)=1* at the beginning, although it declines quickly within the first few minutes. It is a monotonically decreasing function in the formal sense.
If a victim is still alive at time t, he has a certain probability known as the hazard function *h(t* **|** *Z)* of dying within the next minute. (Here, *Z* represents the factors influencing survival.) According to standard notation of survival theory

$$f(t \mid Z) = -\frac{dS(t \mid Z)}{dt} \qquad (1)$$

$$f(t \mid Z) = h(t \mid Z) S(t \mid Z) \qquad (2)$$

In Markov modeling, this probability *h(t* **|** *Z)* corresponds to a so-called "transition rate" or "hazard rate" for mortality, or simply the "mortality rate". The difference between *f* and *h* is that *f* represents the absolute mortality rate (compared to the original population) and *h* represents the conditional rate of mortality, given that the subject is still alive at time *t*. Basically, a Markov model boils down to a set of rules for how to compute the hazards. From these rules, all other quantities can be computed.
Clearly, the last three binary variables are only relevant if the victim survives, so we actually model the conditional probability for each of these three variables given that the victim survives to this time (see Table 3 for summary).

Binary state variable	**Abbreviation**	**Truth value**	**Associated conditional probability**	**Notation**
Survival		Alive/dead		*S(t)*
Emergency services notified	CALL	Yes/no	P(CALL|alive,t)	*N(t)*
EMS has begun to provide emergency services to victim	EMS	Yes/no	P(EMS|alive,t)	*E(t)*
Victim receives care in appropriate hospital	CARE	Yes/no	P(CARE|alive,t)	*C(t)*

Table 3: State variables.

The use of a conditional probability has the advantage that *N(t)*, *E(t)*, and *C(t)* can be assumed to be monotonically increasing functions and are relatively easy to calculate in a software application.

Definition of state variables and relevance to biological processes

Note that in our picture, it is important to model the **level of care of the victim** and **the time when this care is received**, because saving the victim is a race against pathologies (biological failure processes) that often lead to mortality after severe accidents, even if the patient receives medical care. An example of a relevant biological process is the so-called lethal triangle of acidosis, hypothermia, and coagulopathy, which have a strong influence on whether a severely hemorrhaging patient can be saved.

Hence, in our formalism, the state variables relevant to the victim are defined in terms of the time when delivery of this care begins. These times are subject to delays with respect to the arrival of an ambulance or the victim's arrival in the hospital.

Factors not included that could be important

Extrication time is not modelled in the present formalism. The eACN algorithm would be expected to provide additional positive effects if extriction time is considered. Due to the improved prediction of severe injuries, a protocol appropriate for extrication of severly injured occupants can be uniformally achieved.

Figure of merit

The virtual victims are monitored during a critical period, which in our problem consists of hours or days, and the surviving fraction is evaluated at the end[4]. In the present calculation we considered a 6 hour time period. The figure of merit evaluated here is survival. We expect additional benefit in terms of reduced hospital stays and reduction of long term disability.

Calibration, reference scenario, and treatments

Suppose we wish to compare one or more possible virtual "**treatments**" with a "**reference scenario**" (e.g., the status quo in a country of interest), and suppose that there is sufficient data available to calibrate the reference situation. "**Calibration**" means that the model constants in the reference situation are determined such that the model reproduces the reference situation to satisfactory accuracy[5]. Fortunately, many of the transition rates required for our model were calibrated in the work of Clarke and Cushing. Their survival curves were utilized in calibrating our model, with appropriate small modifications to take the difference in situation into account.

For the present illustration, the reference scenario is intended to approximate the status quo in Germany. We certainly do not claim to have a perfect calibration of the status quo in Germany, but the calibration does contain quite a bit of empirical data and expert knowledge and should be useful for the stated purpose of illustrating a clear link of eACN to efficacy (safety benefits).

The main treatments of interest are ACN and eACN. We will evaluate the relative change in the figure of merit (survival) due to these treatments by

- Using our knowledge of the scientific literature to model how each treatment affects the transition probabilities (or hazards) and
- computing the figure of merit from the model in each case.

It is also useful to discuss a virtual "negative" treatment by imagining that that currently ubiquitous cell phones are removed, leaving us with the situation one or two decades ago. We can then check the model to see if the poorer past performance of rescue systems is consistent with the longer notification times that were typical of the days before widespread cell phone penetration.

In the present Markov survival model, the mortality rate depends explicitly on the duration t since the crash and is mitigated by the level of care the victim is currently receiving. According to Clarke and Cushing and other sources, about 20% of MAIS 3+ crash victims die within the first few minutes (this represents about 35% of the deaths). This initial mortality spike is modeled explicitly by an appropriate

[4] Those who survive the critical period are "censored" in the statistical sense, but practically speaking, most mortality occurs in the first few hours.

[5] In our problem, as pointed out by the assessment committee, there is really a spectrum of reference situations, depending on variables such as EU-27 country, region with each country, etc., so expert judgment obviously enters the selection of an "appropriate" reference model. The main criterion used here was reliability of the evidence based on publication quality.

hazard function and is seen in the figures below as a rapid survival loss (15% during the first minute and about 5% during the next three minutes). This initial mortality is assumed in the present model to be independent of treatment, that is, unaffected by rescue processes[6].

Assuming the victim survives the first few minutes, the processes of EMS notification, arrival of EMS, delivery of emergency medical services, arrival at the hospital, and delivery of appropriate hospital care occur sequentially either with a specified transition rate or with a fixed delay from the previous element in the sequence (see Table 4). The delay in appropriate hospital care takes into account the time between arrival in the hospital and effectiveness of life-saving actions in the trauma center. The delay in delivery of emergency medical services takes into account in an average way the delay between arrival and administration of first-aid or other measures before hospital care can be given.

In the absence of any care, the hazard rate $h_0(t)$ (% dying per minute relative to surviving fraction) is modeled by a decreasing Weibull function as in Clarke and Cushing.

The mortality rate in this model depends strongly on the kind of care the victim is receiving at the time. If the victim is still alive upon reaching a grade-1 trauma center (the best level) and manages to survive for the next 10 minutes (the estimated time for the trauma center to begin intensive treatment), then and only then is the mortality rate reduced dramatically.

In accordance with equation (2), the hazard rate is thus modeled as

$$h(t) = h_0(t) * [C(t) * HR(CARE) + (E(t) - C(t)) * HR(EMS) + (1 - E(t))]$$

The quantities $C(t)$, $E(t)$, and $h_0(t)$ were explained above. This equation contains quantities known as “hazard ratios” *HR*(CARE) and *HR*(EMS), which are to be calibrated from field evidence on the quality of hospital care and EMS care. We certainly can assume that *HR*(CARE)<HR(EMS)<1. This model can be understood as follows:

- The fraction of survivors who are currently receiving care in the hospital is *C*(t), and their hazard $h_0(t)$ is decreased, i.e., multiplied by a “hazard ratio” denoted *HR*(CARE).
- The fraction of survivors who are receiving EMS but not hospital care is *E*(t)-*C*(t), and their hazard is decreased too, but only by a factor HR(EMS).
- The remaining fraction of survivors (those not receiving EMS or hospital care) is $1-E(t)$. These survivors are subject to the basic hazard rate $h_0(t)$. Note that there is no difference in the assumed hazard rate due merely to notification.

[6] It is of course conceivable that with eACN, a less seriously injured vehicle occupant or a bystander might be able to render improved first aid with TSP call center support even before EMS arrive, but we have not included this possible benefit in our model.

Scenarios and sensitivity analysis - Definitions of scenarios

As stated above, we first present 4 scenarios consisting of the reference scenario (approximate status quo in Germany), two "treatments" (ACN and ideal eACN), and a past scenario (situation one or two decades ago).
Subsequently, we also summarize the results of a sensitivity analysis in which each of the three parameters characterizing the difference between eACN and ACN are separately examined.
In order to estimate constants and delays for the computations, values were obtained by combining the information from several sources [Champion (1999), Shields, L (2004), Trauma Register (2009), Clark & Cushing (2002)]. The constants and delays assumed in the scenarios considered here are as follows:

State variable in sequence	**Transition rate / fixed delay**	**Past scenario (~1985-1995)**	**Reference scenario (2010)**	**ACN**	**Ideal eACN**
EMS notification	transition rate	8.5 minutes	5.5 minutes[1]	1.0 minute	1.0 minute
arrival of EMS	transition rate	8.5 minutes	8.5 minutes	8.5 minutes	8.5 minutes
delivery of emergency medical services	fixed delay	5.0 minutes	5.0 minutes	5.0 minutes	5.0 minutes
arrival at the hospital (after EMS)	transition rate	45 minutes	45 minutes	45 minutes	15 minutes[2]
delivery of trauma care after arrival at hospital	fixed delay	10 minutes	10 minutes	10 minutes	10 minutes[3]

[1]Compromise between rural and urban USA value.
[2]Assuming helicopter use: Using data from "Bedarfsanalyse zur Luftrettung in Bayern Herausgeber: Institut für Notfallmedizin und Medizinmanagement (INM) Klinikum der Universität München" (2006), p.55.
[3]We do not model a possible decrease due to better preparation (→ conservative approach).

Table 4: Transitions

The mortality hazard ratios associated with each state variable in the sequence are summarized in Table 5

State variable in sequence	Hazard ratio associated with state	HR in Past scenario (~1985-1995)	HR in reference case (2010)	ACN	Ideal eACN
EMS notification	(Unassisted)	1.0	1.0	1.0	1.0
arrival of EMS	(Unassisted)	1.0	1.0	1.0	1.0
delivery of EMS	*HR*(EMS) [1]	0.68	0.68	0.68	0.50
arrival at the hospital	*HR*(EMS)[2]	0.68	0.68	0.68	0.50
delivery of appropriate hospital care[3]	*HR*(CARE)	0.20	0.18	0.18	0.14

[1]The hazard ratio *HR*(EMS)=0.68 for the first three scenarios was obtained from the work of Clark and Cushing by computing the ratio 0.07368 (mortality rate 'EMS arrived') to 0.10791 (mortality rate 'EMS not notified'). The rate for eACN assumes a higher level of care due to upgrading from paramedics to trained emergency physicians.

[2] Assuming standard of care in ambulance crew and on scene are similar

[3] Using relative risk from MacKenzie 2006 and assuming about ¼ of current victims are already being treated at best trauma centers

Table 5: Hazard ratios in scenarios.

In the ideal eACN scenario, we suppose that there is 100% penetration and a 100% detection rate for MAIS3+ accidents from the automatic detection algorithm. We can then rescale the results to take into account the approximately 75.9 % sensitivity of the URGENCY algorithm and / or a lower penetration.

Reference Scenario

The reference scenario is intended to model the status quo in a developed, larger European country such as Germany (average of rural and urban accident populations) without ACN or eACN. The model is intended to include the influence of mobile telephone use in achieving a reduction of about 30% in notification times within the last few decades. Figure 12 shows the state occupation functions and survival probability curves for a typical sample of MAIS 3+ accident victims.
In this case, the statistics are as follows:

Reference scenario	Percentage	Remarks
Mortality rate up to 6 hours post crash	57.3%	As percentage of all MAIS 3+ victims
Hospital mortality up to 6 hours post crash	14.2%	As percentage of all MAIS 3+ victims
Hospital death fraction	25.0%	As percentage of deaths up to 6 hours post crash (see Clark and Cushing, p. 512)

Table 6: Mortality rates in reference scenario

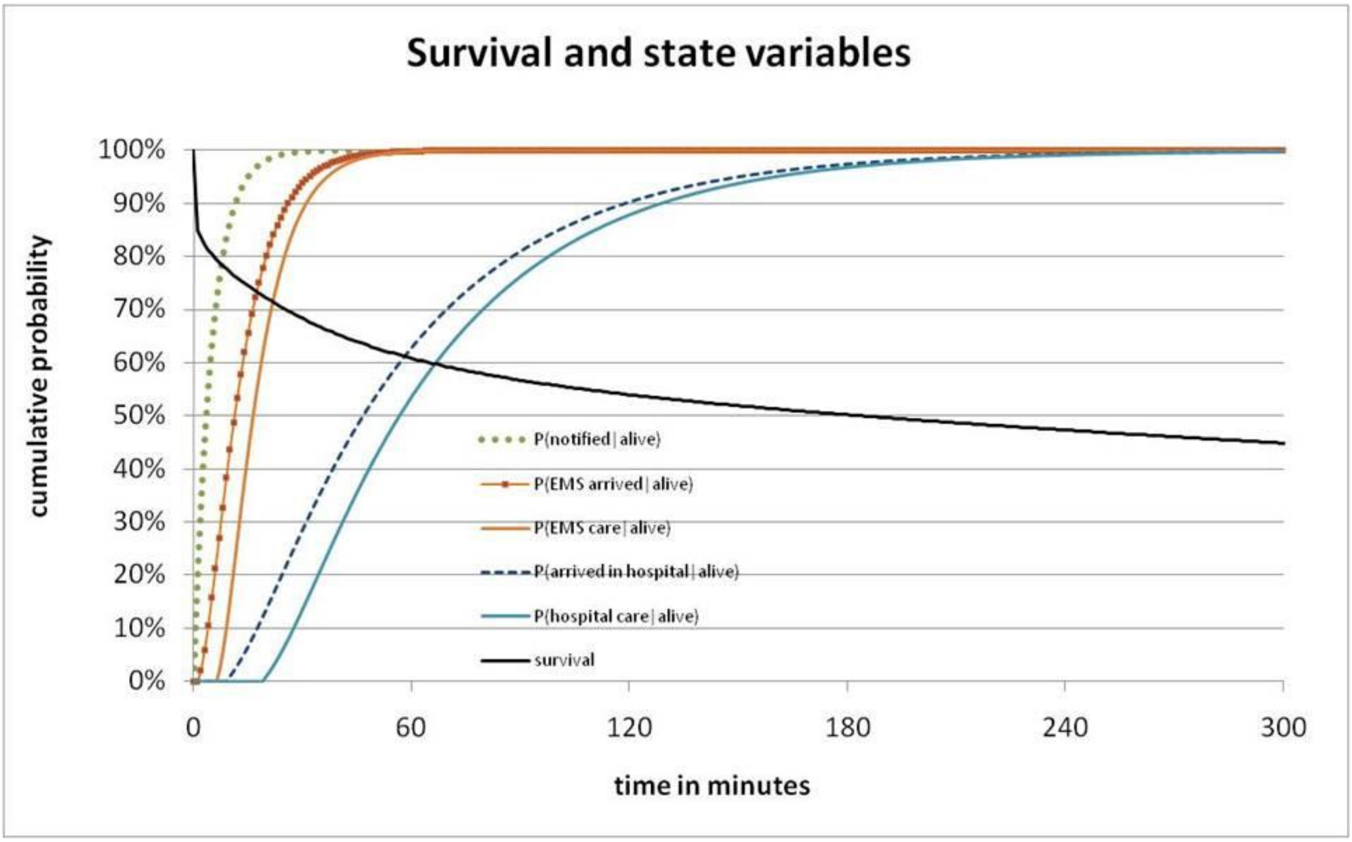


Figure 12: Reference scenario: State occupation functions and survival probability curves for a typical sample of MAIS 3+ accident victims in Germany or a similarly developed and settled European country (average of rural and urban accident populations) without ACN or eACN. Dots: fraction of those alive with notification; Dotted curve: fraction of those alive with EMS arrived; upper solid curve: fraction of those alive receiving effective EMS; dashed curve: fraction of those alive in hospital; rightmost solid increasing curve: fraction of those alive receiving effective hospital care; decreasing solid curve: surviving fraction.

ACN Scenario

The ACN scenario differs from the reference scenario only by reducing the notification time from 5.5 minutes to 1.0 minute. In this scenario, the statistics are as follows:

ACN scenario	Percentage	Remarks
Mortality rate up to 6 hours post crash	56.1%	As percentage of all MAIS 3+ victims
Hospital mortality up to 6 hours post crash	14.9%	As percentage of all MAIS 3+ victims
Hospital death fraction	25.2%	As percentage of deaths up to 6 hours post crash

Table 7: Effects of ACN scenario on mortality rates.

Figure 13 shows the state occupation functions and survival probability curves for a typical sample of MAIS 3+ accident victims. Note that the notification time now appears as a spike at t=1, and the other curves are correspondingly shifted to the left. The change in mortality is about 1.2% as a percentage of MAIS 3+ crash victims or about 2.1% as a percentage of mortality in the reference scenario.
A comparative overview of the mortality rates corresponding to the different scenarios considered here is given at the end of this section.

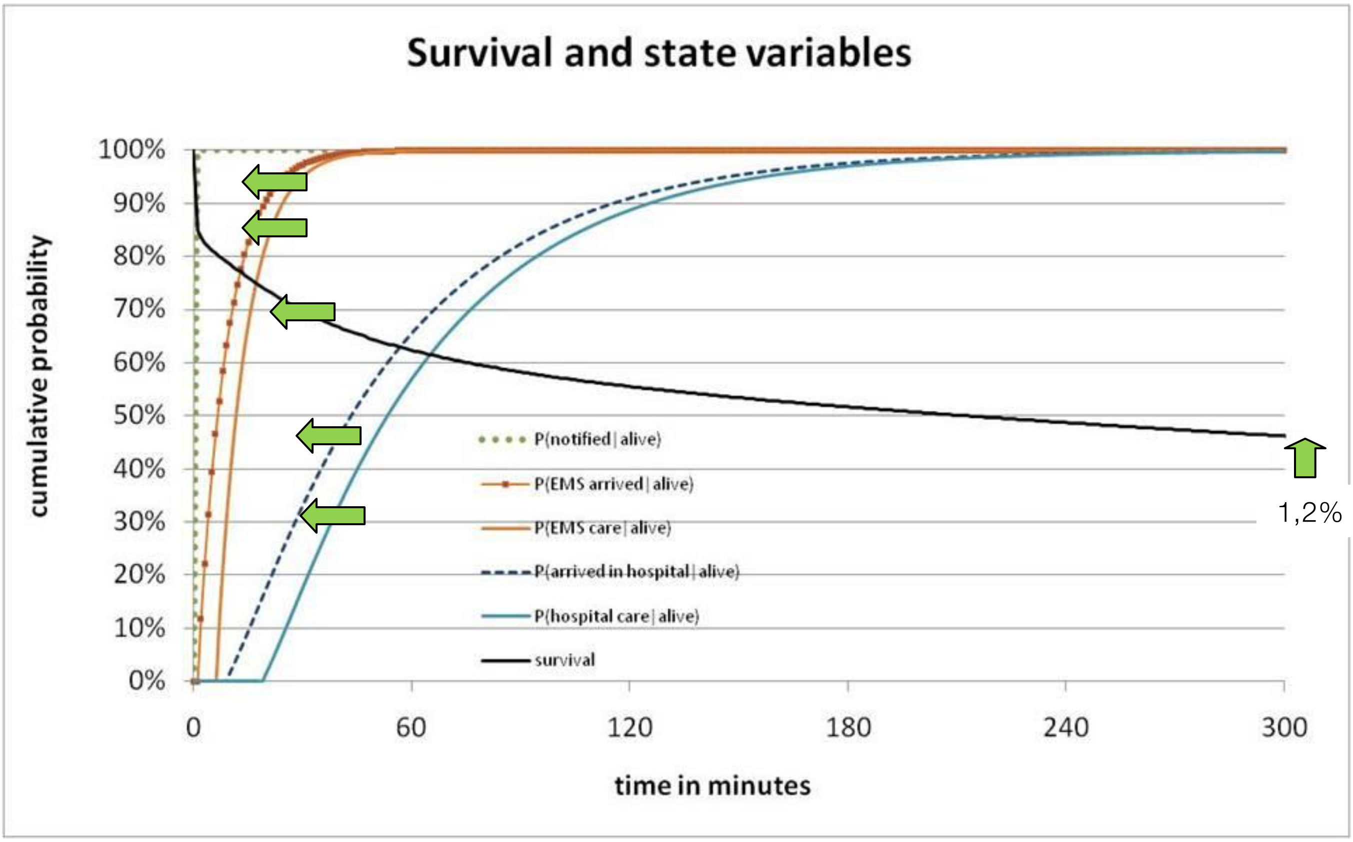


Figure 13: ACN scenario: State occupation functions and survival probability curves for a typical sample of MAIS 3+ accident victims in a developed European country as in the previous figure, but with assumed 100% ACN penetration. Curves as above.

Ideal eACN Scenario

The ideal eACN scenario differs from the reference scenario not only by reducing the notification time from 5.5 minutes to 1.0 minute, but also by assuming that a helicopter will be available to transport the victim, thus saving considerable time. Moreover, a considerably higher level of care is assumed at the scene, as well as a 22% improvement in the level of care (due to correct triage of all MAIS3+ patients to a level-I trauma center). In this scenario, the statistics are as follows:

Ideal eACN scenario	**Percentage**	**Remarks**
Mortality rate up to 6 hours post crash	45.6%	As percentage of all MAIS 3+ victims
Hospital mortality up to 6 hours post crash	15.6%	As percentage of all MAIS 3+ victims
Hospital death fraction	22.3%	As percentage of deaths up to 6 hours post crash

Table 8: Effect of ideal eACN on mortality.

The improvement in mortality is about 11.7 % as a percentage of MAIS 3+ crash victims or about 20.4% as a percentage of mortality in the reference scenario.

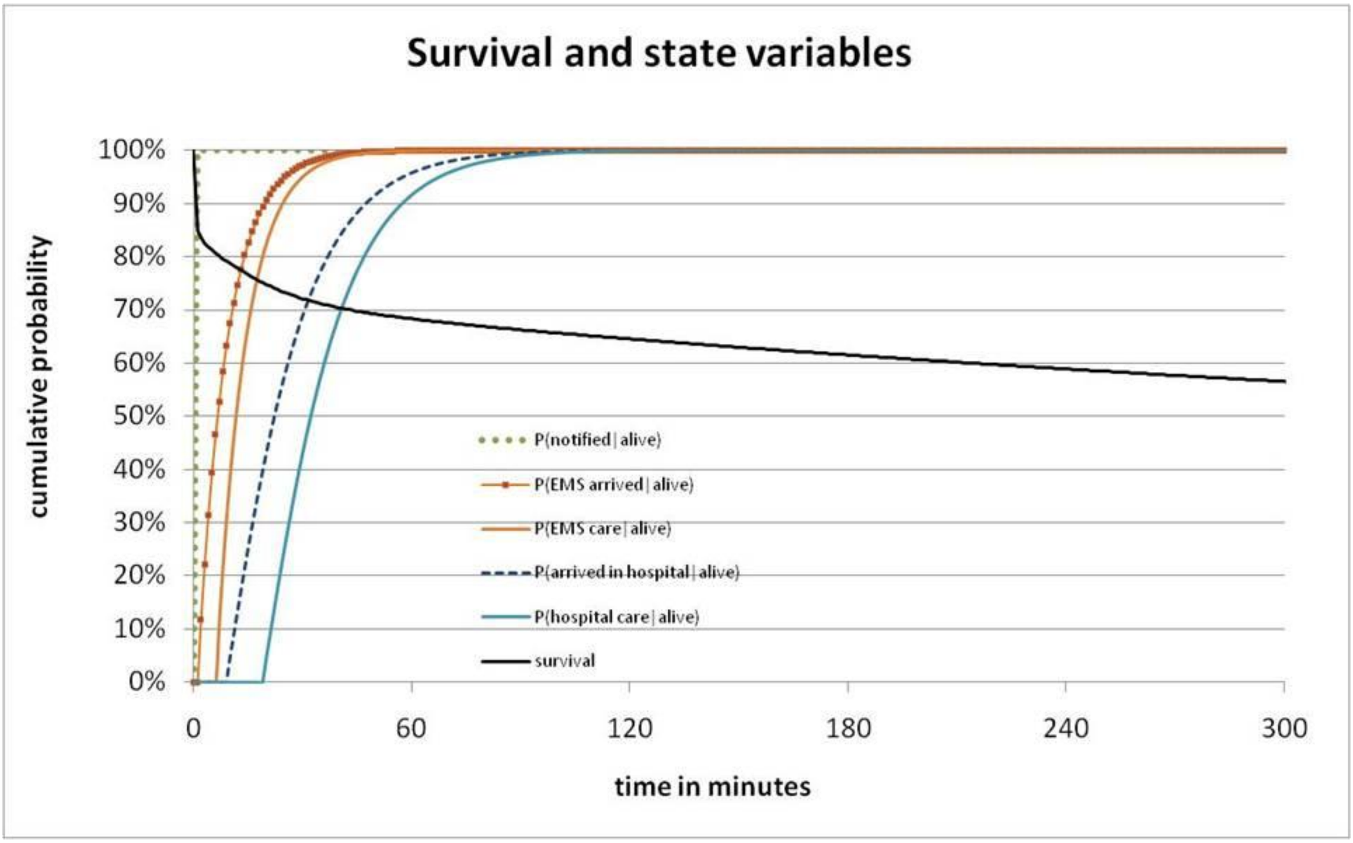


Figure14: Ideal eACN scenario: State occupation functions and survival probability curves for a typical sample of MAIS 3+ accident victims; curves as above.

Past Scenario

The past scenario is intended to model the situation about one or two decades ago, when notification times were considerably longer, especially in rural areas. Figure 15 shows the state occupation functions and survival probability curves for a typical sample of MAIS 3+ accident victims.

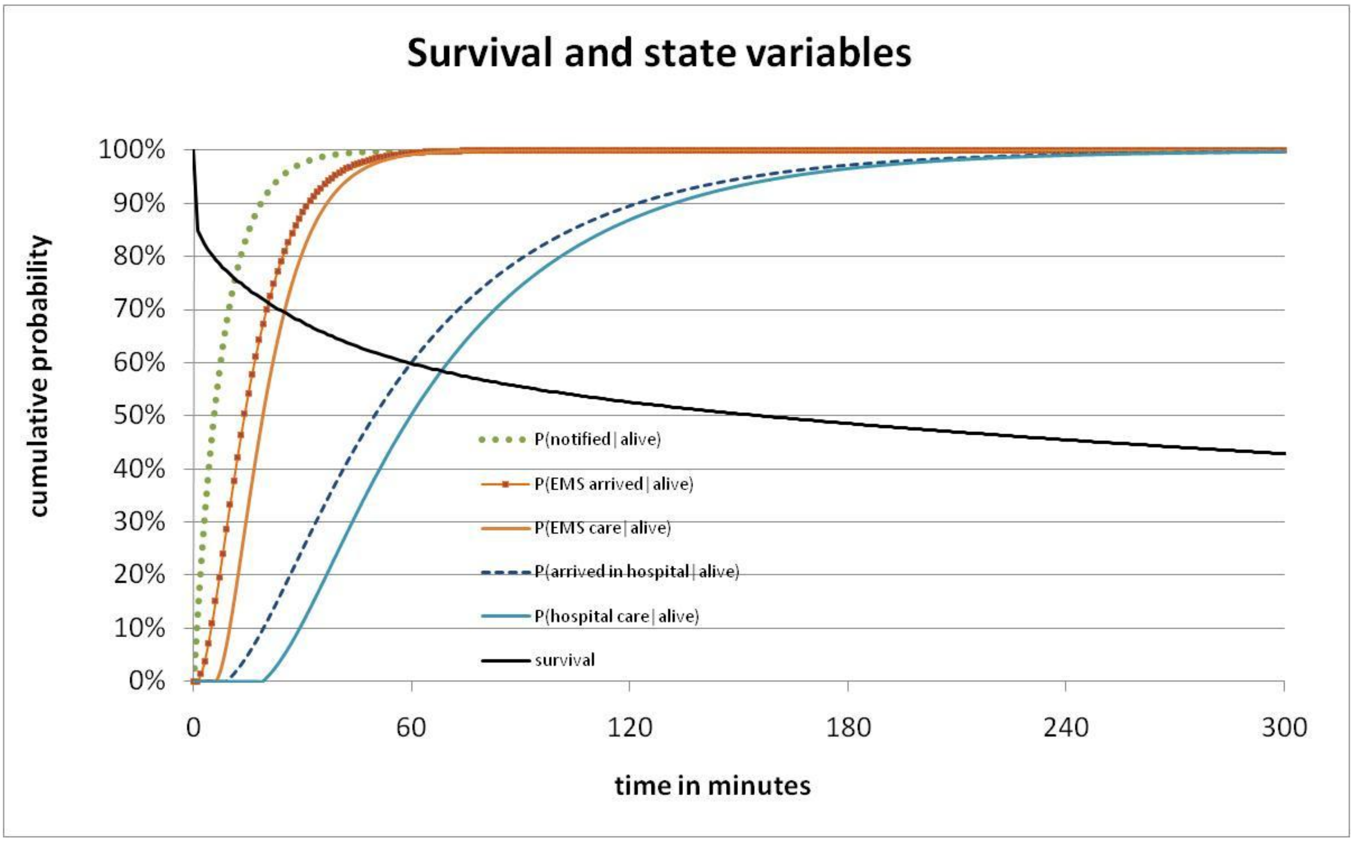


Figure15: Past scenario: State occupation functions and survival probability curves for a typical sample of MAIS 3+ accident victims; curves as above.

We note that the difference between the ACN scenario and the past scenario is about 6% as a percentage of mortality in reference case (Table 10). The past scenario could be more relevant to the situation modeled by Clark and Cushing than the reference situation, considering the data basis used by those authors.

Scope of the results and assessment of eACN in practice

This section provides a brief comparative overview of the mortality rates corresponding to the different scenarios considered above as well as a one-dimensional sensitivity analysis in which the factors contributing to mortality reduction (faster response, emergency physicians vs. paramedics, trauma center vs. normal hospital) are separately varied. In order to illustrate how these factors influence survival, Figure 16 displays the survival curves for the scenarios of Table 4.

In comparison to the reference scenario, survival in the "past scenario" is poorer primarily because of delayed EMS notification (leading to later emergency care) (Table 4, second row) ; a 10% improvement in trauma care has also been included as shown in Table 5, last row (HR(CARE): 0,20 → 0,18).

Similarly, survival in the "ACN scenario" is better than in the reference scenario primarily because of faster EMS notification (leading to earlier emergency care) (Table 4, second row); note however that the quality of care both for emergency services and for hospital treatment is assumed unchanged from the reference scenario (Table 5).

Similarly, survival in the "ACN scenario" is better than in the reference scenario primarily because of faster EMS notification (leading to earlier emergency care) (Table 4, second row); note however that the quality of care both for emergency services and for hospital treatment is assumed unchanged from the reference scenario (Table 5).

The best survival of all models considered here is seen in the "Ideal eACN scenario." As in the "ACN scenario", faster EMS notification leads to earlier emergency care (Table 4, second row) than in the "reference scenario"; moreover, helicopter rescue has a strong positive effect due to earlier hospital treatment (Table 4, row 5). In the "Ideal eACN scenario" the hazard ratios associated with quality of care both for emergency services (*HR(EMS)*) and for trauma center treatment (*HR(CARE))* (compared to ordinary hospital treatment) are modeled as signficiantly better than in the reference scenario (Table 5, rows 4 and 5, respectively). This improvement is reflected in a decreased slope of the survival curve during both EMS and trauma center care.

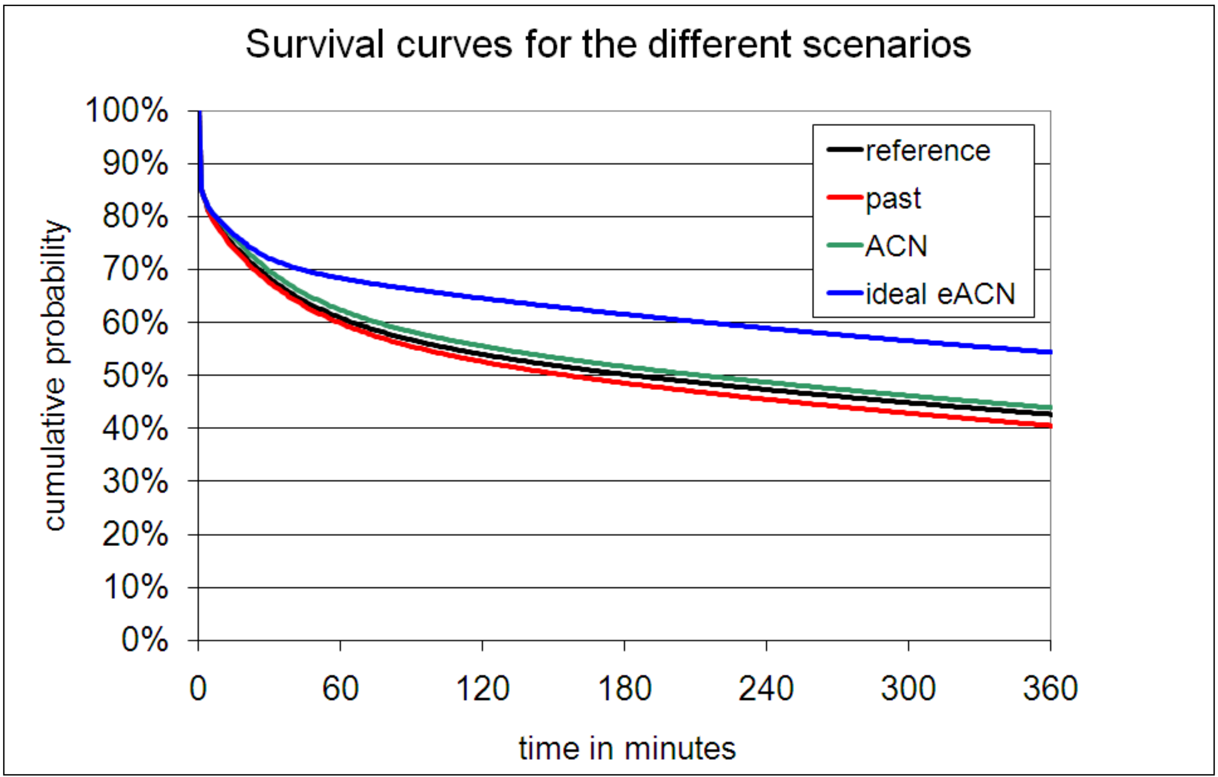


Figure 16: Comparison of survival curves corresponding to the different scenarios considered above.

Table 9 summarizes the statistics of the four scenarios considered here, together with three additional scenarios included for sensitivity analysis.

- Ideal eACN minus helicopter
- Ideal eACN minus emergency doctor
- Ideal eACN minus level-I trauma hospitals

Statistic	Scenario						
	Past (~1985 -1995)	Reference (2010)	ACN	Ideal eACN	Ideal eACN minus helicopter	Ideal eACN minus emergency doctor	Ideal eACN minus level-I trauma hospitals
Mortality rate up to 6 hours post crash	59.46%	57.30%	56.10%	45.60%	49.53%	47.61%	49.40%
Hospital mortality up to 6 hours post crash	15.06%	14.20%	14.90%	15.60%	12.78%	15.04%	19.38%
Hospital death fraction	27.09%	25.00%	25.20%	22.30%	20.17%	22.27%	27.66%
Delta mortality relative to all MAIS3+	-2.16%	0.00%	1.20%	11.70%	7.77%	9.69%	7.90%
Delta relative to mortality in reference case	**-3.78%**	**0.00%**	**2.09%**	**20.42%**	**13.56%**	**16.91%**	**13.79%**

Table 9: Summary of relative effects of scenarios on mortality.

Table 10 summarizes the scenarios discussed here with applicable modeling parameters and fatality reduction estimates ("safety benefit") as a fraction of the fatalities in the reference case/past scenario.

Scenario (Basis: 42.485 fatalities in 2007 in EU27)	EMS notification	Type of Emergency Medical Service	HR (EMS)	Time to hospital (characteristic time)	Time to delivery of trauma care after arrival at hospital	Type of hospital	HR (CARE)	Safety Benefit [percent saved lives (basis= reference scenario)]	Safety Benefit [percent saved lives (basis=past scenario)]	Delta fatalities in Europe compared to reference scenario	Delta fatalities in Europe compared to past scenario
Past	8.5 Minutes	paramedics	0,68	45 Minutes	10 Minutes	Nearest	0,20	-3,78%	0,00%	-1606	0
Reference	5.5 Minutes	paramedics	0,68	45 Minutes	10 Minutes	Nearest	0,18	0,00%	3,78%	0	1606
eCALL	1.0 Minute	paramedics	0,68	45 Minutes	10 Minutes	Nearest	0,18	2,09%	5,87%	888	2494
ACN	1.0 Minute	paramedics	0,68	45 Minutes	10 Minutes	Nearest	0,18	2,09%	5,87%	888	2494
Ideal eACN	1.0 Minute	emergency physician	0,50	15 Minutes	10 Minutes	Level I Trauma Center	0,14	20,42%	24,20%	8675	10281
Ideal eACN minus helicopter	1.0 Minute	emergency physician	0,50	45 Minutes	10 Minutes	Level I Trauma Center	0,14	13,56%	17,34%	5761	7367
Ideal eACN minus emergency doctor	1.0 Minute	paramedics	0,68	15 Minutes	10 Minutes	Level I Trauma Center	0,14	16,91%	20,69%	7184	8790
Ideal eACN minus level-I trauma hospitals	1.0 Minute	emergency physician	0,50	15 Minutes	10 Minutes	Nearest	0,18	13,79%	17,57%	5859	7465
Estimate with eACN	see chapter 2.3.1 Casualty Benefits							5,62%	9,40%	2388	3994

Table 10: Summary of the discussed scenarios

The ideal eACN scenario leads to a predicted decrease in mortality relative to the ACN scenario of about 18% (survival up to 6 hours after the crash). The column listed "ideal eACN" represents the ideal case with the following features:

1. penetration 100% (all vehicles in Europe equipped with eACN)
2. detection of MAIS3+ injuries by the vehicle-based algorithm (e.g., URGENCY) =100%
3. compliance by the authorities in the key actions =100%
   a. immediate helicopter service =100%
   b. emergency physician (not just paramedics) to the accident site =100%
   c. victims transported to a level-I trauma center=100%

Leaving out the issue (1.) of penetration for the moment, we begin with the detection rate (2.) of the URGENCY algorithm, which is not yet 100%, but currently about 75%. This effect would reduce the 18% difference by about one-fourth.

As far as compliance of authorities is concerned, one hopes that public authorities would respond positively to an algorithm with high specificity, demonstrated over an adequate period of time. However, the measures listed above require policy changes involving many regional authorities and agencies and could take years to fully implement on a voluntary basis even with proven benefits. Here, a leadership role of the EU could have an important effect.

With regard to (3a), the availability of helicopters presumably varies considerably from one country to another, even within the European Union. In Germany, it appears that there would be enough helicopters placed strategically for most required rescues of MAIS3+ injured persons within the 15 minutes assumed in our Markov models. The same is true of emergency physicians (3b) and readiness to transport victims to level-I trauma centres (3c). The situation in other EU countries requires further investigation.

Finally, the issue of market penetration (1.) enters the problem in two ways.

- First, independent of detection rate, the absolute number of lives saved is obviously related to market penetration in a roughly linear way, though we expect the benefit to exceed "strict proportionality", since in a multiple-vehicle, vehicle-pedestrian, or vehicle-bicycle collision, benefits accrue not only to the occupants of the equipped vehicle, but to all other injured persons at the scene.
- Secondly, if one assumes that regional authorities will implement changes (1-3) only if a threshold benefit in the population as a whole is exceeded, then increasing market penetration will obviously increase the "coverage", i.e., the fractional regional compliance in each country. As a very rough estimate, one might expect a "**coverage**" beginning at a modest current level and rising after 5 years to say **75%** in EU countries with advanced infrastructure and perhaps **30%** in less developed countries. These percentages are only very rough estimates, however.

The "coverage rate" for compliance with (3.) could also be positively affected by further improvements in specificity of the detection algorithms, or by "soft" factors such as press coverage, testimonials, and the like. As mentioned above, the mobile network used by the current BMW eACN system quotes an availability of >96% of the area in Germany, corresponding to 4% losses due to mobile network coverage. For the purposes of this discussion, we estimate a factor of 90% (10% loss) due to these and other possible gaps in coverage in most European countries.

Using these rough estimates, the percentage improvement in mortality within about 5 years due to eACN (compared to ACN) in EU countries is estimated at

Benefit ≈18% x 75% x 75% x 90% x penetration level
≈ 9% x penetration level.

In less developed countries, the corresponding benefit would be about 4% according to this estimation procedure.

Incidentally, in less developed countries, one expects that ordinary eCALL would have a stronger effect compared to the status quo than in the more advanced countries, because notification and response times are slower to begin with.

In independent analyses, the relative improvement due to eACN over ACN was estimated as stated above at about 3.4% x penetration level. The present computations imply that that estimate is quite conservative, at least in advanced EU countries.

Model Refinements

The first-order sequential Markov model of crash survival described above does not include delayed influences on survival or mortality arising from earlier treatment quality. For example as mentioned above, acidosis, hypothermia, and coagulopathy have a strong influence on whether a severely hemorrhaging patient can be saved. Hypothermia could be alleviated by optimal care at an early stage but affect mortality at a later time, e.g., after hospital treatment has already begun. In addition, microscopic models of particular injury sequences would be useful for constructing a fine-grained, predictive model, which we anticipate would utilize a Monte-Carlo simulation technique.
Following Clark and Cushing (p. 512), the present analysis considered mortality up to 6 hours subsequent to the crash. There could be additional mortality after 6 hours, of course. Although one expects the ratios of mortality reduction between the scenarios to remain relatively stable, the model could be improved by considering longer-term effects.
Incorporating delayed effects in a refined model could well lead to a somewhat higher estimate of the ACN mortality reduction percentage with respect to the reference situation than the 2.09% reported above. However, due to the time scales involved in these biological failure processes, it seems very likely that a substantial difference between eACN and ACN will persist, and that the estimate 3.4% given earlier is quite conservative.

5 Test Procedures and Criteria

Since eACN is a post-crash system, no standardized test procedure existed prior to its development. BMW has implemented a testing procedure as follows:

- General rule for crash tests: Any vehicle that potentially can be equipped with eACN should be crashed with activated emergency system for real end to end tests. BMW therefore equipped the crash facility in the research center with a GSM repeater to compensate for signal attenuation by the considerable mass of steel and concrete.
- The eACN system is validated in different crash scenarios (EuroNCAP, IIHS, ECE R94, …)

The efficacy of the system in operation is being continually monitored. To this end BMW is collaborating with German and American medical and statistical experts. Real accident experience has demonstrated functionality over several years now.

6 Expected Benefit / Side Effects

Summary of Benefits of eACN/ACN in Europe

- The potential number of saved lives is approximately 2.500 per year in Europe for ACN
- With the enhanced injury-risk identification of eACN this could be increased to almost 4000 per year in Europe
- Potential reduction of serious injury in 10 – 15% of cases for ACN
- In Europe the estimate in reducing the rescue time with ACN/eACN is about 50%
- Greatest potential in the 50% of crashes (in Germany) which occur more than 20 km from the nearest trauma center with maximum treatment capability
- The road accident costs in the European Union could save about € 26 billion annually with ACN, even more with eACN

Recommendation of eACN

The Center 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 (CDC 2008, 2009).

Testimonials

The BMW US homepage has posted testimonials from several customers.
With the following link the statements below can be found:
http://www.bmwusa.com/Standard/Content/Owner/BMWAssist/SafetyPlan/Services.aspx

"My life was saved by BMW's great engineering and the technology for the vehicle to call for help when I couldn't."

Dr. Hamnet P., Warner Robins, GA

After her airbags deployed, "BMW Assist came on immediately. He asked if I was all right and called for help. They were there in less than four minutes. I would recommend it to everybody. It's a wonderful thing for peace of mind and I plan to renew when the complimentary period is over."

Joanne O., Downingtown, PA

Sir, I wanted to inform you that your vehicle saved my life. I was involved in a serious single car accident, going over a 150' cliff, on 9/13/07. The car was totaled, I had driven it less than 500 miles when the accident occured. I swerved to avoid a deer and down I went. The cab was preserved, the seat belts held us in, and BMW assist was there to direct the rescue. They stayed with us until the search and rescue team found us, some three hours later. With out BMW, we would be dead, **with out BMW assist, we would still be down the mountain, burried in brush and dirt.** I would reccomend every auto be equipped with this fantastic safety devise. **Thank you for the engineered quality and a terrific Assist staff.**
Gary E. Walter (survivor)

By NATALIE NEFF

"BMW Assist, how may I help you today?"

I don't even think my face or chest ever made contact with the airbag, and I had no signs of neck pain or bruising from the shoulder belt in the days that followed. **But I was in no shape to act as quickly in the immediate aftermath of the crash as that voice from BMW Assist,** if only because it felt like I could barely string two coherent thoughts together, like my brain was treading through mud-which is the whole point of the service, to come to your aid in the event of an emergency, to do the thinking and acting for you.

Additionally, BMW has participated in a series of high-level medical and technical conferences in which the subject of best practice in the accident rescue chain was discussed (see pictures below).

ACEP Medical Congress, 2007
Seattle, USA
approx. 7000 participants.

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

AANS Medical Congress, 2008
Chicago, USA
approx. 7500 participants.

American Association of Neurological Surgeons
and the American Association of Neurosurgeons

Enhanced safety of vehicles (ESV) Conference, 2009
Stuttgart, Germany
approx. 1000 participants.

ESV 2009 STUTTGART

AAOS Medical Congress, 2010
New Orleans, USA
approx. 26 000 participants.

AAOS American Academy of Orthopaedic Surgeons
American Association of Orthopaedic Surgeons

Side Effects

Negative side effects of the system

- Due to the fact that the BMW Response Center is part of the rescue chain, there is a time requirement associated with the additional communication step. However, this time effect is more than compensated for by improved detection of serious injuries, patient reassurance of customers in their native language with positive psychological effects, as well as other advantages noted above.
- Some customers using this system may need to be reassured that their personal privacy is adequately safeguarded.

Positive side effects of the system

- If multiple emergency calls reach a PSAP, the eACN call is the one with the most precise event position. The location accuracy is not subject to uncertainties of a stressed caller who is not able to locate an accident position immediately and precisely.
- eACN helps the PSAP to distinguish whether there are different calls for one event or if there is another accident in the area of an earlier one.

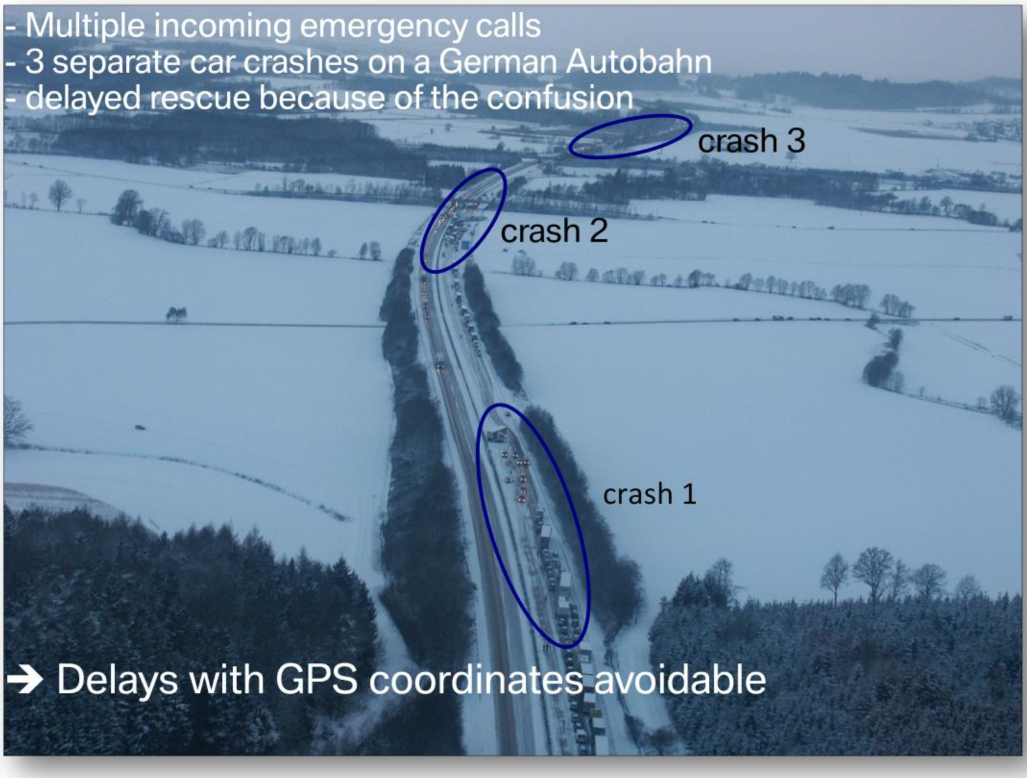


Figure 17

- eACN helps to locate the accident very accurately and enables the authorities to create the best possible traffic information and alerts. Accident warnings can be given very precisely.

- BMW's waypoint list displays the major waypoints just before the emergency call is initiated. The right lane or right ramp can be detected to guide the rescue teams to the accident in the best direct route.

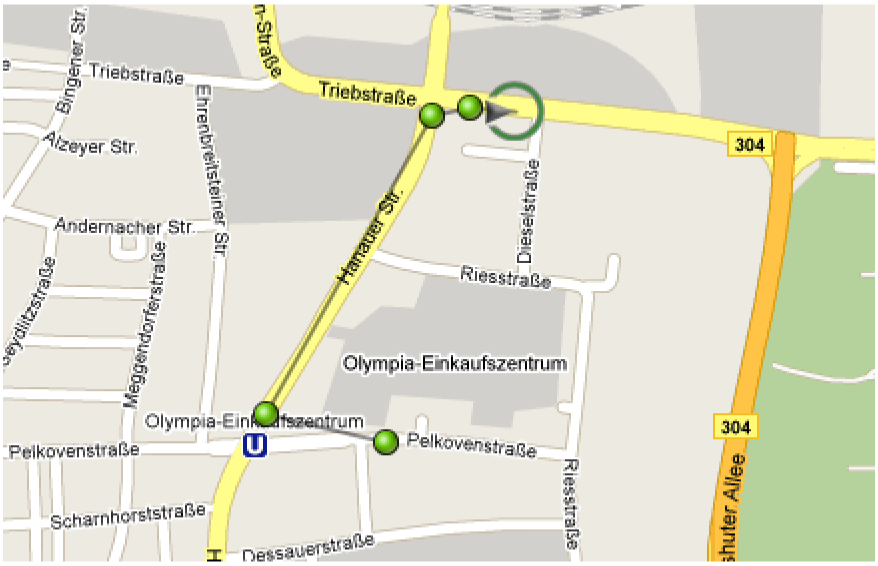


Figure 18

- Based on the vehicle identification number, the BMW call center is able to deliver additional data that helps rescue forces:
  - The exact description of the car with model, body type, color, license plate etc. makes it easier to identify the right car.
  - With the information about the model range, BMW can offer the appropriate Rescue Guidelines/Manual of this car, or the rescue crew can select it locally.
  - BMW can report the fuel type and the presence of high-voltage batteries.

Availability – market share

The BMW eACN is available on every current BMW model as standard or optional feature (see annex 1) without any restriction regarding the vehicle equipment.

The BMW Assist Advanced eCall system is basically available in all BMW cars (see annex 1) without any restriction regarding the vehicle equipment. It is either an option or standard equipment and it is offered in the following countries:

- Austria
- Canada
- France
- Germany
- Italy
- Kuwait
- UK[7]
- United Arab Emirates
- USA

The indicated European markets account for around 75% of all BMW's sold in Europe.

[7] Due to regulatory / technical restrictions, where marked with a "[1]" the enhanced features concerning injury-risk are not currently available (only ACN available).

Regarding only the European market, customers from the above mentioned European markets with an activated BMW Assist Advanced eCall system are supported with eACN when traveling in any of the following countries:

- Andorra
- Austria
- Belgium
- Canada
- France
- Germany
- Italy
- Liechtenstein
- Luxembourg
- Netherlands
- Spain
- Switzerland
- UK[1]

Outside of these markets, an activated system may attempt to call the general local emergency call number 112 where not otherwise regulated.

7 Real World Evaluation

Overview of US Field Experience

The following section summarizes recent field experience related to the BMW's enhanced Automatic Collision Notification (eACN) system. The description and data presented below includes observations only for the US market. From September 1, 2008 to May 31, 2010, there have been 2,453 distinct crashes severe enough to trigger the eACN system where an emergency call for help was initiated. Figure 19 shows the distribution of eACN crashes accross the US during this period.

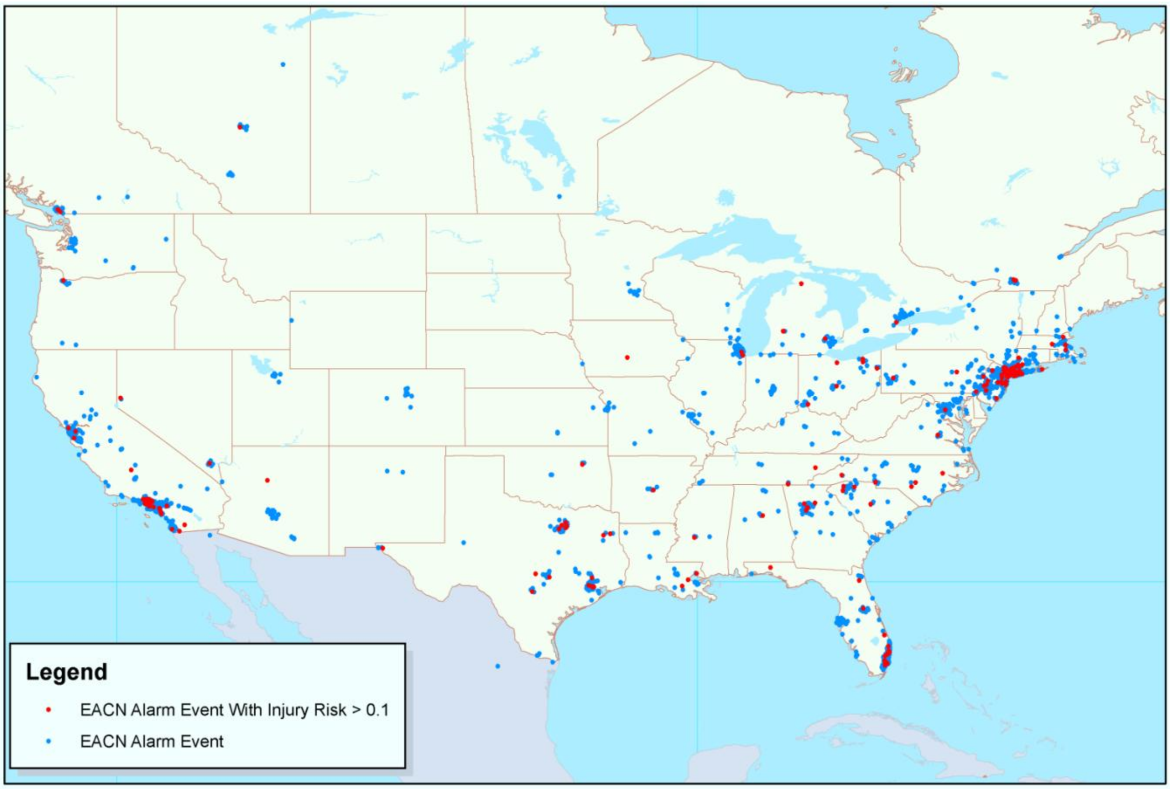


Figure 19: Location of BMW eACN Crashes in the US by Severity (September 2008-May 2010).

Combined, the red and blue dots on this graphic indicate actual crash locations. The greatest percentage of crashes, regardless of severity, occur primarily within urban and suburban areas. Shown in red in Figure 19, are the locations of crashes with a high risk of severe injury. These crashes were severe enough to trigger the eACN system and also exceeded the 10% risk of severe injury threshold based on the URGENCY algorithm.

Currently, the URGENCY algorithm takes into account crash direction for each impact event, deltaV for each event, belt use status for front seat occupants, presence of a front seat passenger, number of impact events, as well as rollover for vehicles equipped with a rollover sensor. Using MAIS3+ injury risk curves such as those shown in Figures 20 and 21, the corresponding injury risk is determined to categorize crashes. The two figures describe single-impact events for unbelted and belted front seat occupants, respectively; each curve represents the risk of injury for one of four impact directions. The corresponding risk is utilized by the TSP (Telematic Service Provider) to categorize each call as having a high risk for severe injury or a lower value. The statistical analysis used to construct the risk models included only 1998 and later model year vehicles and utilized weighted crash data. The risk curves shown in Figures 20 and 21 have been updated using the most recently available crash data (NASS CDS 1997-2007).

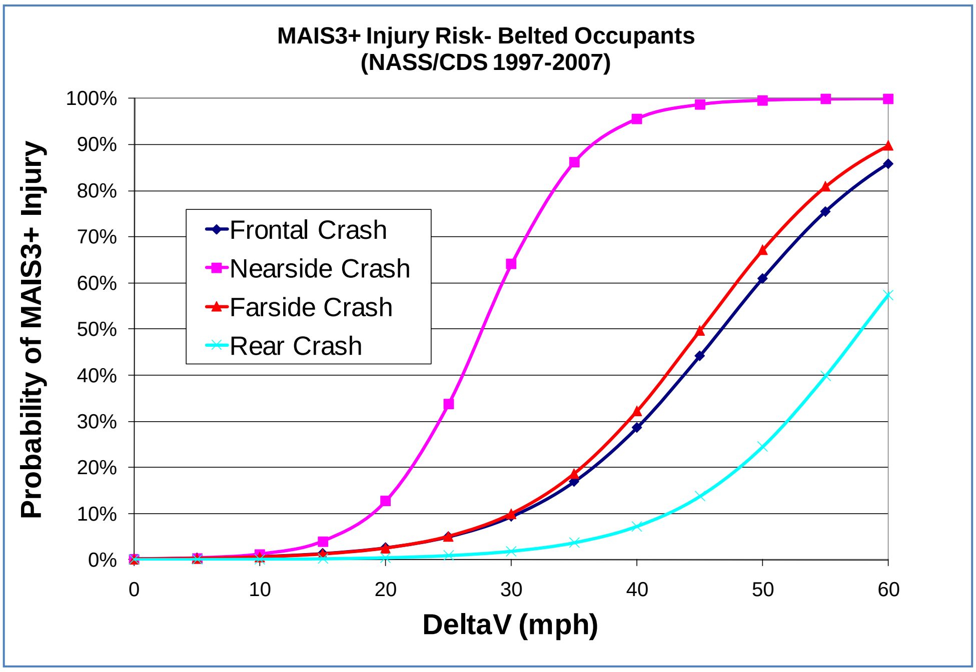


Figure 20: MAIS3+ Injury Risk by Crash Direction for Belted Occupants.

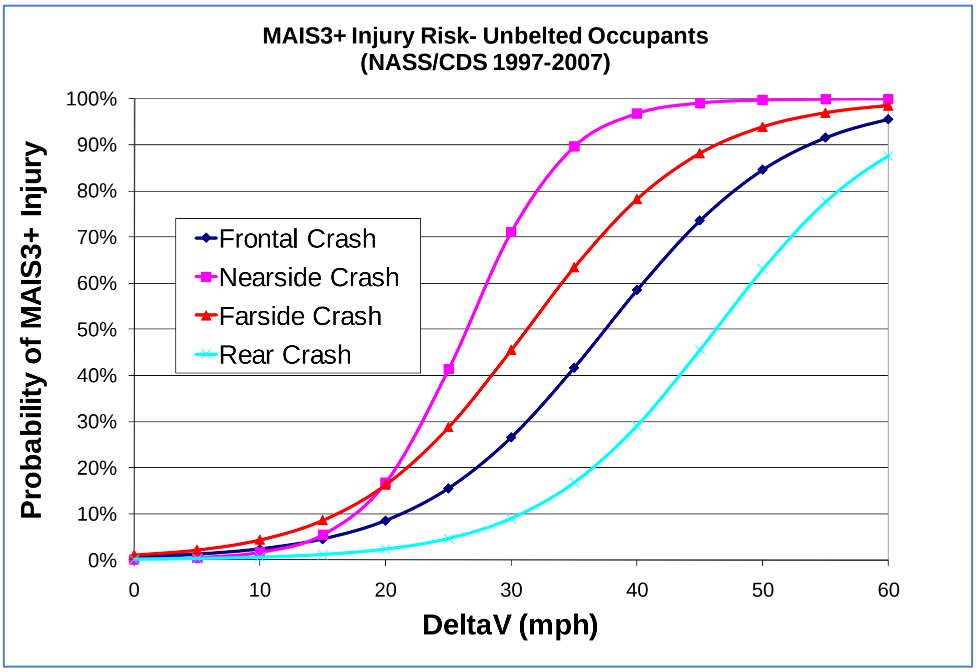


Figure 21: MAIS3+ Injury Risk by Crash Direction for Unbelted Occupants.

The distribution of crashes observed in the field to date largely represents field experience within the German In-Depth Accident Study (GIDAS) as well as the US National Automotive Sampling System (NASS CDS) database. Overall, approximately 73% of eACN events were categorized as primarily frontal, 13% were near-side (driver's side) crashes, 9% were far-side (passenger's side) crashes and 5% were rear impacts. It is noteworthy, as seen in Figures 20 and 21, that the threshold for the automatic call for help depends not only on DeltaV, but also varies significantly by crash direction; for example, rear-end collisions are far less dangerous than all others at a given DeltaV. In 24% of the crashes analyzed, a right front seat occupant was present. Over 8% of the crashes contained more than one event activating the system trigger level detected by the system. 13% of the vehicles equiped with sensors to recognize rollovers were involved in rollover events. Incidentally, safety belt use for drivers was approximately 92%, surprisingly low considering the presence of safety belt reminder systems through the fleet.

Table 13 below lists the distribution of injury risks for the crashes observed in the US to date. As seen in the right-hand column, less than 10% of the crashes are categorized as having an “elevated” (i.e. 10 - 100%) risk for MAIS3+ injury. According to a detailed case analysis of a small sample of the total eACN crash population, fewer than 5% of crashes where an occupant sustained a severe injury were incorrectly classified as “low risk” (i.e. 0 - 10%) for MAIS3+ injury using vehicle-based data alone. Within the working system, verbal information exchanged between the BMW Call Center and vehicle occupants could permit identification of severely injured occupants even within this group. Information concerning occupants of a second vehicle in multiple-car crashes could also be used in this way. These possibilities highlight the usefulness of the voice link in further characterizing the severity of the crash.

Because detailed case analysis has considered only a small subset of crashes to identify true injury outcomes based on EMS and hospital data, further field investigation is needed. The US Agency “Centers for Disease Control” has awarded a grant to the William Lehman Injury Research Center at the University of Miami in the US to further compare injury risk predictions made using URGENCY with actual injury outcomes for a larger sample of the BMW crash population. This study is currently ongoing; final results are expected in October 2011.

MAIS3+ Injury Risk	Number	Percent	Summary
0-10%	2,536	90.31%	**>90%**
10-20%	118	4.20%	**<10%**
20-30%	55	1.96%	
30-40%	22	0.78%	
40-50%	25	0.89%	
50-60%	15	0.53%	
60-70%	6	0.21%	
70-80%	5	0.18%	
80-90%	8	0.28%	
90-100%	18	0.64%	

Table13: Distribution of BMW Front Seat Occupant Injury Risks in the US (Drivers and Right Front Passengers, September 2008-May 2010).About 200 crashes severe enough to trigger the system occur per month in the US involving eACN vehicles. We are starting to build up a data base in Europe to evaluate the statistics there as well, taking into account the data protection requirements in Europe, which are in some cases more restrictive than in the USA. As the number of available cases with informed consent is still low due to the short sampling period, reliable statistics for Europe are not yet available.

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9 Acronyms & Abbreviations

ACN	Automatic Collision Notification
AIS	Abbreviated Injury Score
CARE	Community database on Accidents on the Roads in Europe
DESTATIS	Statistische Bundesamt Deutschland
eACN	enhanced Automatic Collision Notification
EMS	Emergency Medical Service
GPS	Global Positioning System
GIDAS	German Indepth Accident Study
FARS	Fatality Analysis Reporting System
HMI	Human Machine Interface
M2M	Machine to machine
MAIS	Maximum Abbreviated Injury Score
NASS	National Automotive Sampling System
NASS CDS	National Automotive Sampling System / Crash Worthiness Data System
NHTSA	National Highway Traffic Safety Agency
PSAP	Public Safety Answering Point
SIM	Subscriber Identity Module (GSM)
SMS	Short Message Service
TSP	Telematics Service Provider
URGENCY	Name of the injury prediction algorithm

Annex 1 –
Availability of BMW Assist™ Advanced eCall in Europe

The current detailed model availability for BMW Assist™ including BMW Advanced eCall in Europe is shown in the table below. These markets account for around 75% of all BMWs sold in Europe. BMW Assist™ is also available in USA, Canada, United Arab Emirates, and Kuwait.

Model Series	Germany	United Kingdom	Italy	France	Austria
1 Series 3-door	o	o	o	-	o
1 Series 5-door	o	o	o	-	o
1 Series Coupé	o	o	o	-	o
1 Series Cabrio	o	o	o	-	o
3 Series Saloon	o	o	o	-	o
3 Series Touring	o	o	o	-	o
3 Series Coupé	o	o	o	-	o
3 Series Cabrio	o	o	o	-	o
5 Series Saloon	o	o	o	o	o
5 Series Touring	o	o	o	o	o
5 Series GT	o	o	o	o	o
6 Series Coupé	o	■	o	o	o
6 Series Convertable	o	■	o	o	o
7 Series	o	■	o	o	o
X1	o	o	o	-	o
X3 *)	o	o	o	-	o
X5	o	o	o	o	o
X6	o	o	o	o	o
Z4	o	o	o	o	o
M3 Saloon	o	o	o	-	o
M3 Coupé	o	o	o	-	o
M3 Convertable	o	o	o	-	o
M5 Saloon	o	o	o	o	o
M5 Touring	o	o	o	o	o
M6 Coupé	o	■	o	o	o
M6 Convertable	o	■	o	o	o
X5M	o	o	o	o	o
X6M	o	o	o	o	o
Rolls Royce Ghost (Rolls Royce Assist starting 09/2010)	■	■	■	■	■

Key : o optional equipment, ■ standard equipment, * ACN without eACN (no injury risk assessment)

Customers from the above European markets with an activated BMW Assist™ Advanced eCall system are supported with eACN when traveling in any of the following countries; Germany, UK*, Italy, France, Austria, Spain, Switzerland, Belgium, Netherlands, Luxembourg, Andorra, Liechtenstein. Outside of these markets, an activated system may attempt to call the general local emergency call number 112.
*) Due to regulatory / technical restrictions, where marked with a * the enhanced features concerning injury-risk are not currently available (only ACN available).
**) X3 model change in Sept. 2010. Old model with ACN, new model with eACN.

Annex 2 – Sample Contract Page 1

Application for BMW ConnectedDrive

Please complete this application form in full, noting the General Terms of Business and General Notes overleaf. Please fax the completed form to 0870 505 0207 prior to vehicle delivery to allow the set-up to be completed. If you have any questions, please call 0800 561 0555.

New Account

I herewith apply for BMW ConnectedDrive

Main user

BMW Customer number (if known)	
Mr/Mrs/Ms/Other title	
Forename	
Surname	
Address	
	Postcode
Home telephone	
Mobile number	

Important: Please note we will not be able to process your application form without a valid mobile telephone number. Your mobile telephone number is required to enable us to send you your account password by text message. You will need this password to access www.bmwconnecteddrive.co.uk

Work telephone	
Fax	
Email (see below)	

Please provide your email address if you wish to hear from BMW Group companies, authorised BMW Dealers and other suppliers of BMW branded products and services about the latest news on our vehicles and other products and services by email.

Vehicle

Vehicle registration number (if known)	
Chassis number (last 7 digits)	
Model	Colour
Vehicle delivery date	

Declaration of agreement under the Data Protection Act. We would like to keep you informed of our latest vehicles and other products and services that may be of interest, and we may occasionally ask for your assistance in market research to help improve our services to customers. Your personal data may be shared for these purposes with other BMW Group companies, authorised BMW Group Dealers and other suppliers of BMW branded products or services. Further details are available in our privacy policy at www.bmw.co.uk/privacy You can tell us at any time if you would prefer NOT to receive this information: please call us on freefone 0800 561 0666, or write to us at: BMW Customer Information Service, Europa House, Bartley Way, Hook RG27 9UF.

Customer's signature	Date
Signed on behalf of BMW (UK) Ltd.	Richard Hudson Marketing Director

Important: If this form is signed and returned to BMW (UK) Ltd. less than 72 hours before vehicle delivery, we cannot guarantee that the services will be available at the time of vehicle delivery. The completed form should be faxed to 0870 505 0207.
Registered Office: BMW (UK) Ltd. Ellesfield Avenue, Bracknell, Berkshire RG12 8TA. Registered in England and Wales 1378137.

Annex 3 – Sample Contract Page 2

BMW ConnectedDrive – General Terms of Business

1 Validity of General Terms of Business
BMW (UK) Limited ("BMW") of Ellesfield Avenue, Bracknell, Berkshire, RG12 8TA, provides to you ("Customer") telematic and online services under the name "BMW ConnectedDrive" ("Services") in accordance with these General Terms of Business ("Agreement").

2 Commencement of Agreement
The Agreement shall be effective upon the sooner of BMW's acceptance of this Agreement duly signed by the Customer or when the Services are accessible for the Customer ("Commencement"). The Services shall be made accessible to the Customer when the technical requirements for the access to the Services by the Customer have been met.

3 Scope of Services, interruptions in Service
3.1 BMW shall provide the Services listed in its specification as agreed with the Customer. 3.2 The Services are partly restricted in spatial terms to the reception and transmission of the radio stations operated by the relevant network operator. They may be adversely affected by atmospheric conditions and topographical factors or obstacles (e.g. bridges and buildings). 3.3 The Customer's call number must be displayed in order for the Services to be properly provided. For this reason, any exclusion of the call number display is automatically cancelled. In individual cases, it is possible that the network operator/ Service switchboard may not support this function. Any failure to display the call number may lead to a deterioration in function, especially for the BMW ConnectedDrive breakdown and Emergency Service. The simultaneous use of identical mobile phone subscriptions (mobile phone cards – SIM) may also adversely affect the Services. 3.4 Interruptions in Service may be caused by force majeure, or by technical and other measures, which must be carried out in the systems of BMW, the suppliers or network operators in order to ensure proper operation or to improve the Services, e.g. maintenance, repairs, system-related updates, expansions. They may also result from short-term capacity bottlenecks caused by loading peaks in the Services or by malfunction in areas where telecommunication assets of third-parties are located. BMW will make every reasonable effort to reinstate the Service immediately or to assist with their reinstatement. 3.5 BMW reserves the right to change the agreed Services, if these are of a minor nature or if these are deemed reasonable. 3.6 Where a mobile phone SIM card is provided by BMW as part of the in-car hardware, the Customer may only use this SIM card for the purposes of BMW ConnectedDrive.

4 Obligations of the Customer
4.1 The Customer may not and shall not permit others to use the Services in violation of the Agreement or for illegal purposes. The Customer is not entitled to forward the data and information obtained from using the Services to third parties on a commercial basis or to process them further. 4.2 The Customer must report faults in the Services immediately to BMW. 4.3 The Customer must inform BMW immediately of any change in the data communicated under this Agreement. 4.4 The Customer must inform the BMW Customer Service department immediately in writing of the sale, loss, theft, destruction or unauthorised third-party use of the telematic device assigned to him. In the event that the car is sold, Services may be provided to the new owner of the vehicle on the basis of the agreed terms and conditions subject to BMW being informed in writing of the details of the new user. In all other aforementioned cases, BMW will immediately block access authorisation to the Services. 4.5 The Customer shall bear the costs of any misuse of the Emergency Service.

5 Charges
The Customer will receive the Services free of charge for a three year period from the Commencement. BMW will inform the Customer of the charges for the use of Services ("Charges") at least six weeks before the third anniversary of this Agreement. BMW reserves the right to amend the Charges upon giving not less than six weeks' notice. The Customer is entitled to terminate the Agreement upon giving not less than one months notice, if BMW increases the Charges, with effect from the date, on which the increase shall take effect.

6 Duration of Agreement
6.1 The Agreement shall continue until terminated by either party with not less than one month's prior written notice with effect from the next anniversary of the Agreement. 6.2 Either party is entitled to terminate the Agreement without notice for a material breach of the Agreement on the part of the other party. This includes, but is not limited to, the use of the Services by the Customer for illegal purposes, BMW's decision to stop providing the Services for any reason, and the Customer and/ or BMW becoming bankrupt or insolvent, being in liquidation or administration or entering into an arrangement with their creditors.
6.3 Notice of termination must be given in writing and sent by first class post or facsimile and addressed to the Company Secretary of BMW and in the case of the Customer to the residential address of the Customer.

7 Liability
7.1 BMW will only accept liability arising from a failure to observe and perform its obligations under this Agreement and/or liability attributable to negligence limited to £40,000.00 per claim or series of claims arising from one incident. 7.2 BMW is not liable for loss of profit, indirect or consequential loss or damage. 7.3 BMW is not liable for any inaccuracy in the data or information provided to the Customer as part of the Services. BMW does not warrant the timeliness of the transmission of any data or information provided to the Customer as part of the Services.
7.4 BMW's liability for death or personal injury shall remain unaffected by the aforementioned limitations of liability.

8 Storage of data
BMW hereby confirms that personal data of the Customer shall be stored and processed in accordance with all mandatory Data Protection legislation.

9 Assignment
Either BMW or the Customer may assign the benefit of this Agreement to a third party with the consent of the other party, such consent is not to be unreasonably withheld.

10 Customer's right to cancel
10.1 This Clause applies if: (i) The Customer enters into this Agreement wholly at a distance, meaning the Customer does not have any face-to-face contact with BMW, or any other intermediary, for the purpose of this Agreement before the Customer signs this Agreement, and (ii) In relation to this agreement, the Customer is acting for purposes which are outside any business the Customer may carry on and the Customer is not a limited company. 10.2 If this Clause applies, the Customer has the right to cancel this Agreement during a period of seven working days from the day after the Customer signs it. 10.3 The Customer can contact BMW to cancel this Agreement in accordance with this Clause by emailing BMW at bmwconnecteddrive@bmwfin.com or writing to BMW ConnectedDrive Services, Europa House, Bartley Way, Hook, Hampshire RG27 9UF or by calling BMW on 0800 561 0555 or faxing BMW on 0870 505 0207. BMW will refund any sum that the Customer has paid under this agreement within 30 days.

11 Jurisdiction and applicable law
This Agreement shall be governed by English Law and both parties hereby submit to the jurisdiction of English Courts.

General Notes
This Agreement must be completed and processed before the Services can be activated for use. Please ensure that the form is completed in full, as incomplete information could delay the availability of the Services. If you have any questions, please contact your local BMW Dealer or call 0800 561 0555.