Automatic Crash Notification

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Abstract
This report discusses the ACN system and its benefits from social and financial aspects. Telematics technology that ACN system is based on is briefly introduced and some different kinds of telematics services are described.

The main advantage of ACN systems is saving time between crash occurring and medical care arrival for crash victims. This time period that ACN system saves is very precious for crash victims and the shorter the time the better. It can often decide whether or not the lives can be saved and whether or not a full recovery can be expected instead of permanent handicap.

ACN systems can be divided into two parts, in-vehicle system and response network. In-vehicle system collects the information around the vehicle and sends them to suitable departments after crash occurrence. Response system sees after the information, classifies the information and gives the right response. The functions of these two parts are all based on telematics technology which is a wireless conmmunication system. However, telematics services cover more than just those related to ACN system. Other applications of telematics technology, such as entertainment, navigation, intelligent speed control, etc, are also available from telematics service providers and make driving more comfortable and convenient.

Comparison between some different telematics service providers in North America, Europe and Asia is made, which is mainly around the applications related to ACN system. From the comparison, it can be seen that the technology that these providers use are more or less at the same level and mainly consists of GPS systems, cellular network, service centers and automatic emergency information system.

Key words: Automatic crash notification systems, telematics

Foreword

This report is the documentation of the compulsory project part in the course Active safety, 5 points. The course is given at Chalmers University of Technology in the spring term 2005. Examiner of the course is Assoc. Prof. Mats Svensson at the department of Applied Mechanics.

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1. Introduction

1.1 Background

Of the approximately 42 000 crash deaths per year in the US, nearly 20 000 die before receiving hospital care and many of the remaining 22 000 people die after reaching a hospital too late to be saved. The problem with the delay in hospital care from the crash moment can be solved with the use of Automatic Crash Notification systems (ACN). These systems uses computer and telecommunication technologies to notify rescue workers the position of the crash. Since the number of fatalities are not expected to decrease further research into how the ACN systems can help people survive serious crashes is needed.

This report looks into the problem of detecting road accidents on remote accident scenes where the alarm often is seriously delayed today. Existing ACN systems are described, the technology behind them is explained and benefits the society could expect from ACN systems are investigated.

1.2 Objective

The objective with this report is to compare the existing ACN systems with each other, combine their different features into what we think would be a good ACN system and make recommendations for further work within this area.

1.3 Methodology

Information has been collected by searching on the internet. There is a lot of information available so we recommend readers of this report to search for further details on the internet.

1.4 Delimitation

We have only looked at telematics technology available in cars, some ACN systems were studied more closely than others. It’s very hard to handle all the factors in the rescue process, that’s why we only focus on time delay and message contents in this report. Due to lack of information concerning components and their costs, we have not looked at cost when comparing the different ACN systems.

2. ACN systems and possible benefits

2.1 What is ACN?

A wireless communication system designed for the collection and sending of data is called telematics. In this report, we make a deep research only for two applications of telematics in vehicle, these are crash detecting and data collection. We define these functions as ACN, which include vehicle-based electronic systems, mobile telephony, vehicle tracking and positioning, on-line navigation, information services and emergency assistance.

What the ACN system does is to provide faster and more accurate emergency medical service (EMS) in order to save lives and reduce disabilities from injuries in car crashes. This is done with wireless communication technology. An ACN system should automatically determine that a motor vehicle has been in a collision, notify emergency response personnel of the collision and the vehicle location, provide information concerning the crash, and establish a voice link between the vehicle and emergency response personnel. Information that might be provided about the crash includes estimates of crash severity and the probability of serious injury.

2.2 Time delay

The most important feature of the ACN system is the reduction in time between a motor vehicle crash and the arrival of EMS. This reduction in time is very important as it increases the chances of crash victims to survive serious crashes.

Data collected by National Highway Traffic Safety Administration (NHTSA) show that 24 percent of crashes occur on rural roads, but nearly 59 percent of the crash deaths occur on rural roads. The time delay in delivering EMS is one of the factors contributing to the high fatality rate for crash victims in rural areas. **(1)**

About 42000 Americans die from injuries sustained in motor vehicle crashes each year. Nearly 20000 of those die before being taken to hospital for medical care. Around 13500 people die on site from injuries in crashes along rural roads and about 6500 in crashes along urban roads. The remaining 22000 people die either on the way to or after reaching hospital. **(2)**

For serious injuries time is critical when it comes to peoples chances of surviving. The Golden Hour is a concept widely used, it says that for polytrauma patients, typically serious crash victims suffering from multiple injuries, it is important to get into definitive care at a trauma center inside 60 minutes from the crash occurence. Definitive care for seriously injured crash victims includes thorough diagnoses, intensive critical care facilities and staff and readily available trauma teams with surgeons specializing in brain and spinal cord injuries, internal organ injuries and orthopedic injuries.

To get into care within the Golden Hour is crucial for the victims chances of surviving and not sustain long-term disabilities. There is also a large societal problem associated with the estimated 250 000 Americans suffering from life threatening injuries each year. Their rehabilitation process is time consuming. These victims would benefit from faster and more informed treatment. Pre-hospital care done at the crash site and on the way to the hospital is also very important and a crash victim should receive medical care within what has been called the Golden 10 Minutes, which is inside ten minutes from the crash occurrence. **(2)**

As shown in figure 1, data from 1998 shows that there is a lot of work to be done before EMS arrives at crash sites within the Golden 10 Minutes. Most of the crashes in which the reported time from crash to EMS arrival exceeded the Golden 10 Minutes were rural, 11626 compared to 2660 urban and 76 unknown roadway classification. The actual number is higher, but unknown due to the large number of fatalities, 14240, with unknown data on times, plus the 708 fatalities where the times were questionable. **(1)**

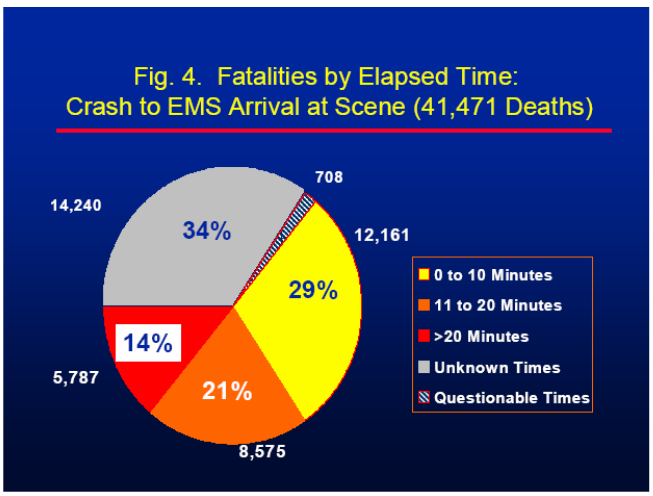


Figure 1: Fatalities by elapsed time

2.2.1 Time periods in crash

The time between crash occurrence and the delivery of the victim to a medical facility can be divided into three periods:

-Notification time
-Dispatch time
-Transit time

The notification time is the time required to notify emergency response personnel of the crash. The dispatch time is the time required to dispatch the EMS team. The transit time includes the time to travel to scene and to transport the victim to a medical facility. **(3)**

The notification time is divided into decision, contact and call periods. The decision period begins with the crash occurrence and ends when someone sees that professional medical care is required. This period is dependent on a number of factors including time of day, population density and traffic density. In rural areas this time is large due to the low traffic and population density. If the occupants of the crashed vehicle are unconscious it can result in a drastically increased decision period. This period is eliminated by the presence of an ACN system. From the time the decision is made to notify EMS to the time that a telephone, cellular telephone or other communications equipment needed can be located is called the contact period. In rural areas, locating the necessary equipment can be problematic if a cellular phone is not available. This period is also effectively eliminated by the ACN system, given that there is cellular telephone coverage at the crash site. The length of time that the actual process of contacting EMS personnel takes is known as the call period. This period is usually negligible, less than a minute, unless there is some form of miscommunication between the operator and the one making the call, either a crash survivor or a witness. Typical reasons for this would include a language barrier or if the survivor is unaware of the seriousness of the injury. The ACN eliminates the possibility of a miscommunication concerning the vehicle location and also helps establishing a voice link between the EMS dispatcher and the crash victim.

The dispatch time is the time between the notification of a motor vehicle crash requiring medical assistance and an emergency medical team being dispatched. Recent studies have shown this delay to be approximately a minute in length.

Another delay for crash victims to receive medical assistance occurs during the transit time. The transit time is divided into response, aid, and transport periods. It includes the time it takes for the EMS team to travel to the crash scene (response period), start the initial medical aid (aid period) and then transport the patients to the emergency medical facilities (transport period).The response period could be shortened by the knowledge of the exact crash location, as provided by the ACN system. The other two time components will usually be unaffected by ACN but the information provided on crash specifics could be useful in determining the type of medical response unit to dispatch, for example a helicopter when there is a report of severe trauma at a remote location.

On rural roads, it currently takes 52 minutes to get a seriously injured patient to a hospital, which is often not a trauma center which has more resources available. On rural roads in the average fatal crash, the Golden Hour is lost. Currently, in thousands of fatal crashes each year in both rural and urban areas, victims do not obtain definitive care within the Golden Hour. **(1)**

2.3 Information needed by dispatch centre

In order to launch a suitable rescue operation for a traffic accident, the most important information needed a dispatch centre is the following:
-Number of persons in need of aid.
-If someone is trapped inside a vehicle.
-Location of the accident. (In case of accidents occurred on highway, additional information regarding heading is beneficial.)
-Type of vehicles involved. (In case of trucks, information regarding type of load carried and possible leakage.) **(4)**

2.3.1 Injury patterns and associated trauma injuries

Once the suitable number of rescue vehicles is on their way additional information is beneficial. To evaluate which type of information that is of most interest for those rescue workers who eventually will work the accident scene, different injury patterns will be presented. The following parameters can be used to determine the injury pattern.

1. Vehicle size
2. Vehicle speed
3. Type of impact
    a. Frontal
    b. Rear
    c. Lateral
    d. Roll over
4. Victim location
    a. Driver's side
    b. Passengers side
5. Proper use or deployment of restraining devices
    a. Seat belt
    b. Airbag

Vehicle size and speed will not help categorize which type of injury that can be expected. The first two parameters will however affect the severity of the injury. Regarding the third, fourth and fifth injury parameter, various assumptions can be made. If the rescue team for example receives information that a frontal collision has occurred, they can expect different injuries due to the fourth and fifth parameter.

The properly restrained driver may suffer fractures to the lumbar region of the spine or pulmonary or cardiac contusion. Injuries to the bowels such as a ruptured spleen, liver, kidney or pancreas may also be expected, all due to trauma caused by the seat belt. If the driver did not use the seat belt and/or if the airbag did not deploy, the rescue team should expect serious injuries due to collision with the steering wheel, dashboard, A-pillar and windshield. The properly restrained occupant can be expected to suffer the same injuries as the properly restrained driver. If the occupant is unrestrained, an upward rotation, due to the lack of a steering column, can be expected. A rotation as described, will increase the risk of injuries to the cranium and face.

The likelihood of each injury to actually occur can be derived, given statistics from earlier collisions of the same type, to help rescue worker prepare themselves and their equipment on their way to the accident scene. Although assumptions regarding the other impact type parameters can be made, such detailed descriptions rests beyond the scope of this report and will not be mentioned. **(3)**

2.4 Societal Benefits

In the future, with ACN, one can expect reductions in many of the longer times. In USA the benefits of an ACN system could result in a 12 % reduction in rural crash deaths. With fully deployed ACN the crash notification times will be reduced to about one minute. Reductions in crash notification times from 9 minutes to 1 minute after the crash have been estimated to save 3000 lives per year among crashes along rural roads. The

Europeans project a 15% increase in survival rates from ACN systems and the Japanese aim to cut their current emergency response times in half**. (2)**

In addition to the number of lives saved, it is reasonable to expect significant reductions in disabilities and human misery through the faster and more intelligent delivery of emergency medical care for non-fatal, but serious, injury crashes. Those people who could be saved by earlier medical intervention often die from loss of blood or breathing difficulties. If these injuries can be stabilized, many times a full recovery can be expected as opposed to an extremely expensive and permanent handicap.

Although a large percentage of the fatalities in motor vehicle crashes may not be preventable, a quicker emergency medical response time could also benefit organ transplants. Recent statistics have indicated that six people die every day in America waiting for an organ transplant.

Perhaps the most significant benefits of ACN will be result from the data generated on crashes, injuries, treatments and outcomes. This data will form the scientific basis for continuous improvements in vehicles, roadways, driver behavior and emergency care. Programs in crash injury prevention and treatment will have a new scientific resource for advances in the protection of the motoring public. **(1)**

2.5 Financial benefits

In 1988, 47000 fatalities resulted from the nearly 5 million people injured in collisions involving motor vehicles. In 1997, 42000 fatalities resulted from motor vehicle collisions. The cost of these fatalities and injuries has been calculated to be extremely high, partly due to the average years of expected life span remaining for the survivors.
In 1988, an estimate was made that the 47000 fatalities cost $112 billion dollars and the 4833 million injuries cost $178 billion dollars. By 1994 the number of fatalities had fallen to fewer than 41000 costing $116 billion dollars, while the number of injuries rose to 5278 million at a cost of $219 billion dollars. **(3)**

To compute the possible cost savings that could result due to an ACN system is extremely difficult and no real world data is available. Although there could be a substantial reduction in the number of people dying in crashes due to the ACN, the number of injured could increase by approximately the same amount. Those who have suffered neurological traumas and would have been fatalities but survive due to earlier medical intervention will as a result of surviving get severe and expensive permanent disabilities. Further research is needed for this area.

3 ACN system architecture

This section describes the architecture of an ACN system to give you a better understanding of what ACN is and how it works. As previously mentioned, ACN systems can automatically determine that a collision has taken place, notify emergency response personnel of the collision and the vehicle location, provide information concerning the crash, and establish a voice link between the vehicle and emergency response personnel. The message should provide information about the crash in two aspects, estimates of crash severity and the probability of serious injury:

1) Crash severity estimates should be based on crash data, such as the change in velocity during the crash, the direction of force and whether the vehicle has rolled over or not.

2) Estimates of the probability of serious injury may be based on the crash severity information, vehicle data (vehicle weight, fire or not, air bag deployment) and occupant-related information (age, gender and/or safety belt use).

A typical ACN system is shown in figure 2 below. We can divide the whole system into two parts, in-vehicle system and response network. The goal of such a system is to improve victim care following a crash by reducing the time for providing medical assistance and increasing the information available for appropriate triage, transport, and treatment decisions.

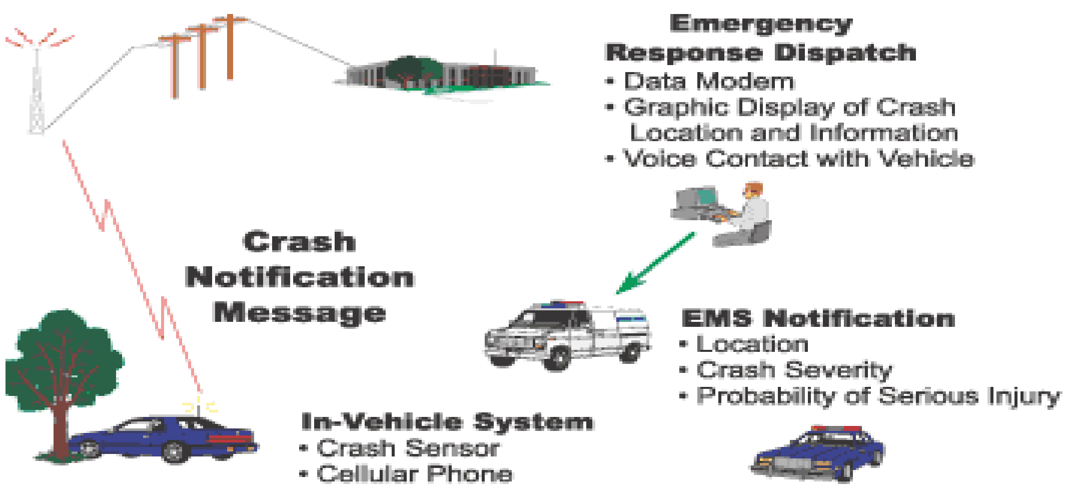


Figure 2: Typical ACN system

3.1 In-vehicle systems

The objective of in-vehicle systems is to determine the location where the crash has taken place, determination of crash severity and probability of serious injury, meanwhile communicating with an emergency centre as soon as possible. This part can carry four different functions as shown in figure 3.

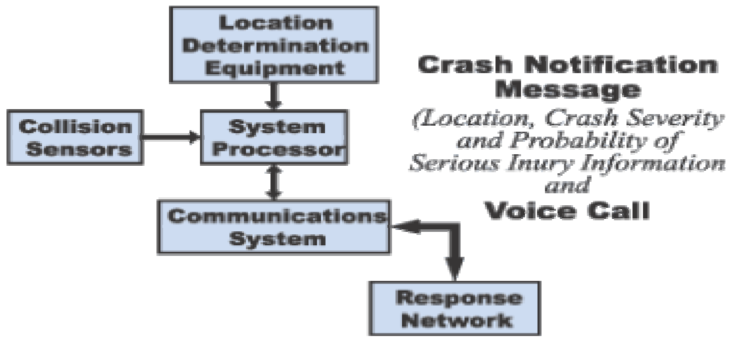


Figure 3: In-vehicle-system

1) Location determination equipment
2) Collision sensors
3) System processor
4) Communications system

The most common solution for locating is Global Positioning System (GPS), which provides two levels of point positioning accuracy, Precise Positioning Service (PPS) and Standard Positioning Service (SPS). The PPS is restricted for use by Army Force and governments and SPS is available to all the users. We can see a comparison in accuracy in the table below. **(5)**

	PPS	SPS
Horizontal Accuracy	17.8 Meters	100 Meters
Vertical Accuracy	27.7 Meters	156 Meters
Time Accuracy	100 nanoseconds	167 nanoseconds

In the U.S there is another solution to determine location using Enchanced 911 (E911). While E911 for wireline telephones can provides all caller information to the operator, if a wireless telephone is used instead, the operator does not know where the caller is. Wireless telephones will implement E911 in two steps. First, when there is a call, the E911 operator will know the number for the cell phone and the location of the nearest base station automatically. Then the system in the base station will provide an exact location of the driver to the operator. **(6)**

The primary function of collision sensors is to collect information that helps the system to detect the type of impact and to support the determination of crash severity and the probability of serious injury. The use of accelerometers as the sensors to detect crashes in ACN systems is common due to their ability to completely characterize the forces in a crash. **(7)**

Apart from this, some ACN systems are basing collision sensing on activation of air bag deployment. It should be noted that the use of air bag deployment for crash determination results in an under-reporting of non-frontal crashes (rear, side, and rollover) that may require emergency responses.

The system processing function controls the operation of the ACN system. It processes the collision sensor data to determine if a crash has occurred, assembles the crash notification message, which includes the vehicle location and crash severity and probability of serious injury information, and operates the communications system. The determination of crash occurrence involves comparing the severity of the crash to a threshold. This threshold should be set to minimize notifications when EMS response is not needed, in order to avoid overloading the emergency response system. It is believed that the driving public expects to see the majority of crashes reported, while the law enforcement and EMS community would like to minimize the number of non-injury, low-damage crashes that are automatically reported. ACN systems should also provide a backup manual-activation capability.

The current communications system for ACN systems is the use of a cellular phone, cost and service concerns have kept other communications systems, mainly satellite communications systems, from being seriously considered at this time. The limitation for such an ACN system is the lack of cell phone coverage at remote locations.

To sum up, this is how the in-vehicle system is working. When a crash is detected, the signal processor assembles a data message containing the vehicle location and information characterizing the crash. The signal processor then uses the vehicle cellular phone to deliver the crash notification message. After the data message is delivered, the system automatically switches to voice mode providing the vehicle occupants with a hands-free voice line.

3.1.1 Limitations of sensors

Nowadays, sensors are used commonly in cars for passive and active safety and car manufacturing companies campaign different safety features like air bags, ABS or ESP for their new car models. Hence functioning of most of these safety features is directly dependent on sensors working. Some safety features are directly related to life saving like airbag or ACN and sensors of these systems may have to work once in the whole life of car. But the car manufacturing companies don’t tell about the reliability of sensors which they have used and reliability of sensors is most important because environmental conditions and car vibrations directly affect the life of sensors. Therefore, car manufacturing companies should inform their customers about periodically checking of sensors fitted in the car.

3.2 Response network

The function of the response network in an ACN system is to receive the crash notification message, extract the vehicle location and any other crash information that might be important to EMS, and to dispatch the appropriate EMS response.

There are two kinds of networks, private and public. Private response networks are available to subscribers, for a fee, and are typically reached by dialing a 1-800 number. The ACN call is answered by a commercial response center, which forwards the call to a Public Safety Answering Point (PSAP) which dispatces EMS based on the vehicle location. Public response networks are envisioned as being available to all callers. The ACN system would dial the emergency number, 911, for automatic connection to the appropriate PSAP.

3.2.1 Private network

A commercial response network architecture is shown in figure 4. In-vehicle system generates a 1-800 number call to the national or regional message centre to which the owner of the vehicle subscribes. The call can carry both the crash notification data message and a voice connection to the vehicle. The crash data are displayed to a response centre operator who confirms the emergency via the voice connection.

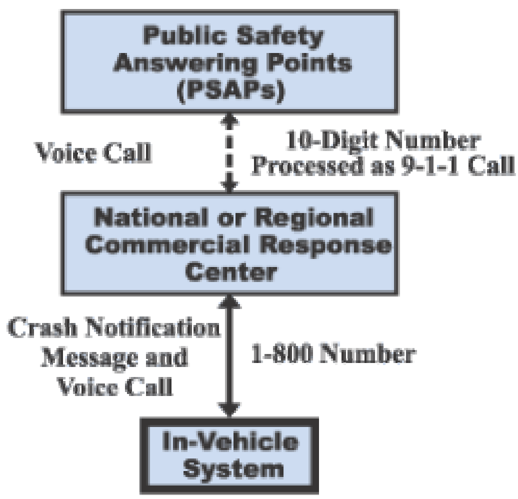


Figure 4: Commercial response network

Positive aspects of the private network include the facts that they are currently available and do not require modifications to the public emergency response infrastructure to receive ACN calls. Modifications to response dispatch equipment to receive calls and display the crash information are limited to the commercial response centres. Current negative aspects of this type of architecture are that it is not a universal service and the use of only voice lines to connect the commercial response centres to the PSAP. The concern with it not being a universal service is that the ability to use this safety service would be dependent on maintaining a paid subscription to a commercial service and an active cellular phone account. The use of voice lines to connect to the PSAP allows for the possibility of error or misunderstanding in the communication of the crash data. Additional, these systems must maintain an up-to-date database of PSAP and their respective service areas.

3.2.2 Public network

Two kinds of public system are shown in Figure 5.

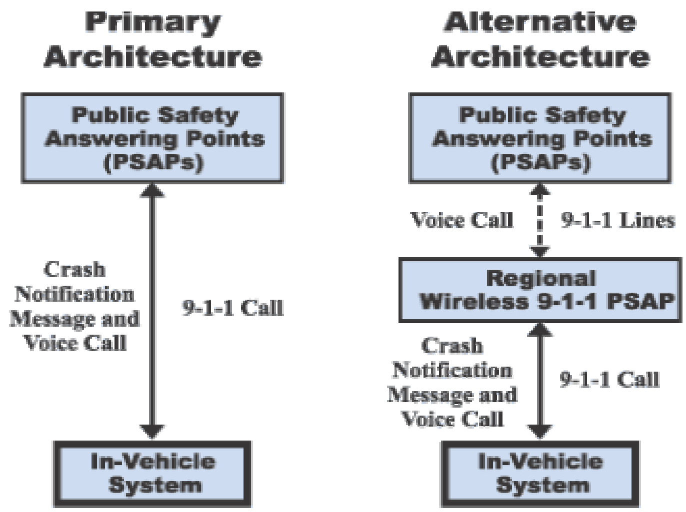


Figure 5: Public response network architecture

In the primary architecture, the in-vehicle system generates an emergency call that is routed automatically to the PSAP with responsibility for the vehicle location. It transfers both the crash notification data and a voice connection to the vehicle, with the message data automatically displayed to the PSAP operator. The routing of the call to the correct PSAP is based on the wireless 911 networks determination of the vehicle location, although the position determination by the ACN in-vehicle system would still be available in the crash notification message.

The alternative architecture means to detect the crash location where wireless system doesn't work or where there is an inability or desire not to upgrade all PSAP to handle the ACN crash notification message. In this architecture a regional wireless PSAP receives the call and displays the crash information to the operator. The regional PSAP operator confirms the emergency via the voice connection. The regional PSAP then contacts the appropriate PSAP via a special line, 911 contact, and informs the local PSAP dispatcher of the nature of the emergency and the location of the vehicle.

The positive aspect of the public network type of architecture is that it would be universally available to any vehicle that had an in-vehicle ACN system without the need to pay a fee to maintain the service. Other positive aspects are that it uses the national emergency number.

Drawbacks of this architecture are that we need some time to develop our public emergency response infrastructure to receive and display ACN calls. In America, even though 911 service was introduced in 1968 not all of the United States currently has 911 service. The National Emergency Number Association reports that currently nearly 93% of the population of the United States is covered by some type of 911 service, with 95% of that coverage being E911, which automatically provides the callers name, address, and phone number to the operator. Some type of 911 service covers approximately 50% of the geographic United States. **(8)**

An important requirement for the successful public response network architecture is the availability of standards defining the means of delivering the crash notification data message from the in-vehicle system to the PSAP. Possible methods of delivering the data message may include dividing the data portion of the call from the 911 voice call for separate delivery, either directly to the PSAP or indirectly via insertion into a database that can be accessed by the PSAP or other emergency response agency. These standards should cover both the formats of the crash notification message and the protocols used for transferring the message.

3.3 Applications in vehicle with telematics technology

Nowadays, more and more telematic solutions are used in the vehicle to make the driving more comfortable and safer.

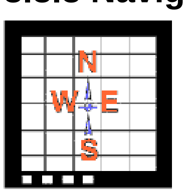
3.3.1 Entertainment

More and more motorists are talking on the phone, enjoying their music and looking for directions, all while in driving. Enjoying the ride is important, but safety is more so. Keeping hands on the steering wheel and eyes on the road insures a safe trip. The telematic solutions gives easy access to all these applications. Drivers and passengers will also enjoy digital music in the car through a USB port on the dashboard for easy connectivity to personal electronic devices. All systems will feature high-quality speech recognition. As a result, the drivers will more easily be able to make calls, access contacts, and other information stored on their own PDA or mobile phone over the car audio system handsfree simply using their voice**. (9)**

3.3.2 Electronic payment systems

Electronic payment systems employ various communication and electronic technologies to facilitate commerce between travelers and transportation agencies, typically for the purpose of paying tolls and transit fares. It has been implemented in some traffic joints, and been approved a good way to solve congestions.

3.3.3 Navigation/route guidance



In-vehicle navigation systems with GPS technology can help drivers to find the optimal route and avoid traffic jams, especially in larger cities. Together with the E-mapping, it can reduce driver error, increase safety, and save time by improving driver decision in unfamiliar areas.

3.3.4 Intelligent speed control

Intelligent cruise control, speed control, guidance/steering, and coupling/decoupling systems which help transit operators link multiple buses or train cars into trains decreasing the driver workload.

3.3.5 On-board monitoring

On-board monitoring captures relevant information and presents it to the driver or transmits it off board. There are our four main aspects we can consider:

1) Electronic monitoring of cargo areas can provide notification of changes in cargo condition such as load shifting or rising temperatures in a refrigerated area.

2) Safety and security monitoring can provide notification of tampering or contamination of cargo while en-route.

3) Vehicle diagnostic monitoring can provide advance notification of mechanical malfunctions, reducing repair costs, and aiding freight carriers with contingency planning for disabled vehicles.

4) Event data recorders can monitor and record vehicle performance, speeds, steering and braking inputs, and other parameters. This information is typically stored to document activities surrounding crashes or near-crashes to aid in post-crash analysis and the identification of improvements in driver training and other operational practices to promote safety. **(10)**

4 Available ACN systems on market

4.1 OnStar

OnStar is the provider of telematics services in the United States. OnStar provides in-vehicle safety, security, and information services by using GPS satellite and cellular technology to link the vehicle and driver to the OnStar centre where the personnel, called advisors, try to make contact with the vehicle and if necessary alert EMS. **(11)**
OnStar system has been developed by General Motors Corporation (GMC) and now many other well known automotive companies has joined GMC. These companies can be seen in figure 6.

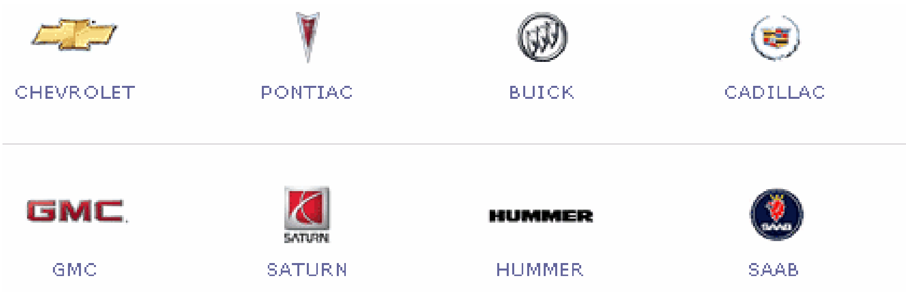


Figure 6: Different brands that have joined OnStar program

4.1.1 Ways of connection with OnStar centre

Currently the following ways to connect with a call centre are available in OnStar equipped vehicle. **(11)**

- Contact OnStar using the three-button system which establish direct voice contact with an OnStar advisor using the built-in microphone, cellular antenna in your vehicle and cellular network
- An advisor can pinpoint your location using GPS technology.
- If the vehicle air bag deploys, a message is sent to the OnStar module in your vehicle by sensors. The OnStar module then contacts the OnStar Call Centre.

4.1.2 GM Advanced Automatic Crash Notification System (AACN)

Now OnStar has developed a new ACN system for their customers which will be available in the above stated brand cars from 2005. This OnStar ACN system uses front and side sensors as well as the sensing capabilities of the Sensing and Diagnostic Module (SDM) itself. The accelerometer located within the SDM measures the crash severity. The locations of the sensors and other equipment are shown in figure 7.

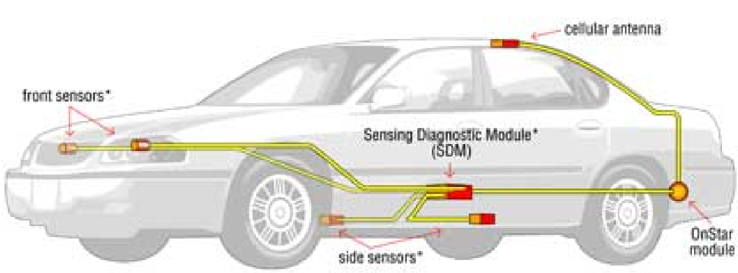


Figure 7: Locations of sensors and SDM in GM car

In the event of a moderate to severe frontal or side-impact crash, data is transmitted from the affected sensors to the SDM, see figure 8. The SDM sensor also can identify a rear impact of sufficient severity. Regardless of whether the air bag deploys or not, the SDM transmits crash information to the OnStar module of the vehicle.

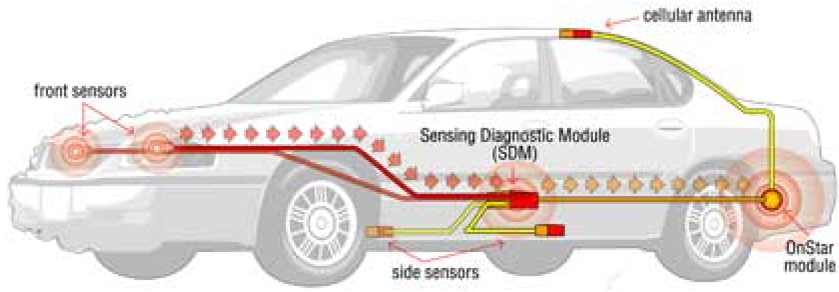


Figure 8: Sending information from sensors to SDM.

Within seconds of a moderate to severe crash, the OnStar module will send a message to the OnStar Call Centre (OCC) through a cellular connection, figure 9, informing the advisor that a crash has occurred. A voice connection between the advisor and the vehicle occupants is established. The advisor can then communicate with 911 or a PSAP, which determines if emergency services are necessary. If there is no response from the occupants, the advisor can get the emergency dispatcher with the crash information from the SDM that reveals the severity of the crash. The dispatcher can identify what kind of emergency services that is appropriate. Using the GPS satellite, OnStar advisors are able to tell emergency workers the location of the vehicle.

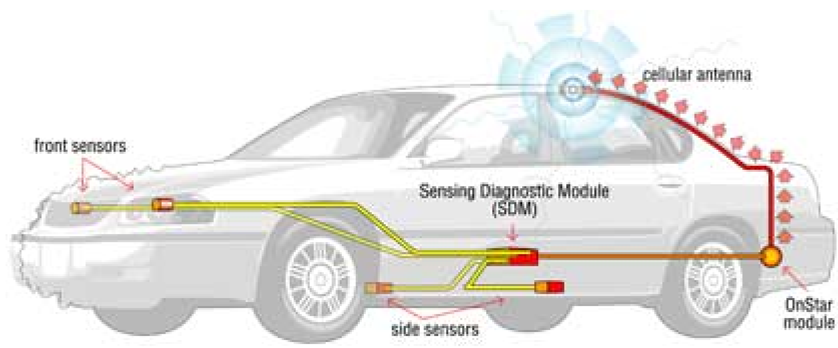


Figure 9: Information message transfer by antenna

This system operates alongside the electrical system in the vehicle and is powered by the vehicle's battery. If the battery is damaged or disconnected, the service will not function.

4.2 Toyota G-Book Alpha telematics system

Toyota has developed the G-Book telematics system to bring additional safety and entertainment benefits to the automobile. On October 1 2002, Toyota began offering G-Book services in Japan for PCs, PDAs and mobile phones. A Toyota made vehicle with onboard G-Book terminal was introduced in Japan on October 21. Building on the infrastructure of Toyota's Gazoo information service, G-Book provides the services of vehicle location/navigation, vehicle maintenance notification, music & games, emergency roadside assistance and e-commerce. Removable Secure Digital card media permits downloading of maps and entertainment content at thousands of terminals across Japan. The positioning and the design of the G-Book terminal can be seen in figure 10. In figure 11 the systems configuration of the G-book is shown.Voice recognition adds convenience and operational safety. Toyota has begun to provide the G-Book services to Daihatsu Motors, Fuji Heavy Industries, Mitsubishi Motors Corporation and Mazda in Japan. **(12)**

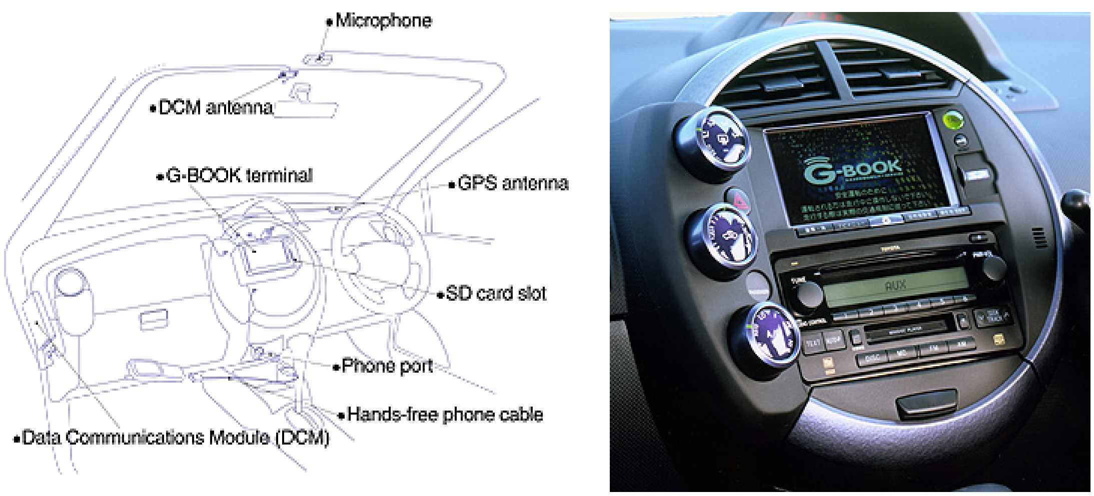


Figure 10: Locations of G-Book parts in vehicle and design of terminal.

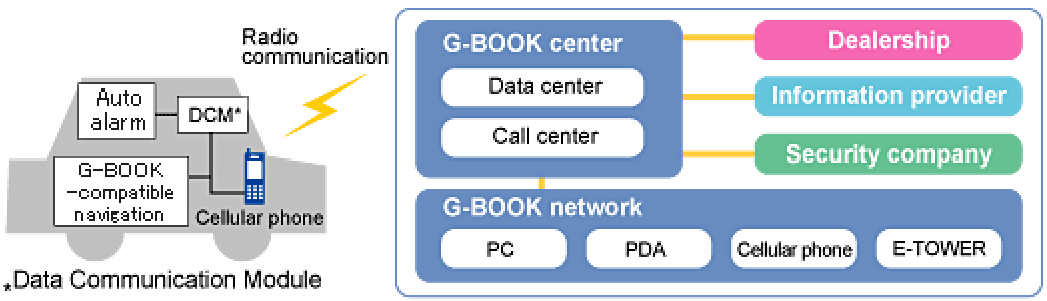


Figure 11: System configuration of G-Book

G-Book Alpha is a newly developed telematic service that takes more safety, security and comfort into account. This updated G-Book will be installed from June 2005 in some cars. In addition to offering the services of the G-Book, a new service is the emergency call service known as Helpnet which is activated by driver or airbag deployment and it can alert the police or fire department to dispatch emergency vehicles in the event of a traffic accident. In addition, the G-Book Alpha has got DCM, a data communication module which improves data communication speed and enables voice communication with mobile phone quality. **(13)**

In the event of a traffic accident or medical emergency Helpnet connects users to a operator through the touch of a button or airbag deployment and allows the dispatch of an ambulance or other assistance using an onboard microphone. The system automatically transmits the vehicle location, and after confirming the situation, the operator transfers the call to the appropriate police station or fire department, thus ensuring a quick and effective response. The way Helpnet works can be seen in figure 12. **(14)**

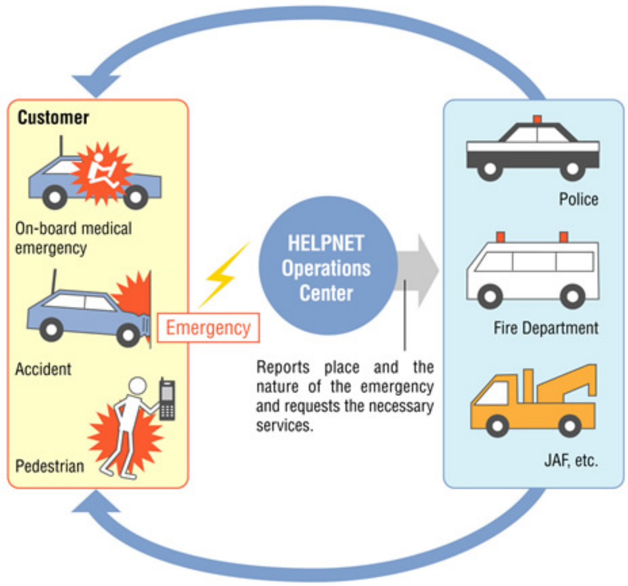


Figure 12: Working of Helpnet system

4.3 Ford Wingcast system

Ford has published a study of their ACN system efficiency. By this system, critical safety information from crashed vehicles can now be delivered automatically to 911 operators in less than 60 seconds from the moment of impact, equipping EMS personnel to provide a more informed and quicker response. Crashes are reported in an average time of 5.2 minutes after the impact without ACN system so the improvement is good.

Ford's ACN technology can send vital details of a crash to operators, including whether the air bags were deployed or not, which seats throughout the vehicle that were occupied and whether the occupants were wearing seat belts or not. Sensors and GPS satellites determine vehicle orientation and location. **(15)**

When a crash occurs, this valuable information is automatically sent to the Ford telematics response centre. The response centre, in turn, electronically transmits the data to the appropriate PSAP and establishes a voice link between the vehicle and the operator. The data is also received on a screen at the 911 call centre, to inform operators of the situation whether the driver can respond verbally or not.

The ACN system, developed by Veridian, is activated by extreme changes in g-forces on the vehicle in three directions. Sensors measure deceleration and direction such as front, rear or side, all of which are important factors in determining injuries.

This enhanced telematics technology was installed into 500 police cars in 23 cities in the suburban Houston area during the summer of 2002 for a two-year pilot project in partnership with Greater Harris County 911 Emergency Network. The information is routed to 911 operators with the help of Intrado, a leader in delivering public safety data. **(15)**

4.4 Volvo On Call

This is an ACN system with a driver assistance system that has the following features:

- Automatic alarm in the event of an accident. The alarm activates in case of airbag or pre-tensioner is deployed.
- Help in an emergency, SOS button for direct Emergency contact.
- Roadside assistance, on call button for direct contact with Volvo On Call.
- Theft alert, automatic alert in case of alarm going off for 15 seconds or more.
- Tracking, in case of the car has been stolen it can be tracked down.
- Remote door unlocking via the telephone, in case of keys being lost doors can be opened by an operator.

Volvo On Call is a GPS-based communication system that provides immediate access to 24-hour personal emergency and roadside assistance, see figure 13. The system has a Short Message Service (SMS) and in case of one of the two buttons, SOS or On Call, is being used a SMS is sent to the call centre and they call back to the car. The system has a backup system so if the battery does not work the system still does. The system can only be used in countries where there is a Volvo On Call centre. Initially the Volvo On Call system is only available in Britain, Sweden and Netherlands, but it is expanding throughout the rest of Western Europe. The system is available on all the new car models. **(16)**

Figure13: Working of Volvo On Call system

4.5 Mercedes-Benz TeleAid

The TeleAid system is similar to the Volvo On Call system. It is also a GPS based system. There is an emergency button and two other buttons for non-emergency use.

Pushing the SOS button will immediately establish voice contact with T-Mobile Control Centre which is a provider contracted by Mercedes-Benz. If an airbag deploys or the front, side or turnover sensors detect an impact data for the damages transfers to the T-Mobile Control Centre. There this data is supplemented with individual details about the service user like medical data and details about the family doctor and is forwarded immediately to the emergency call centre. This reduces the aid time by almost 50%. The transmitter is crash-secure and has access to a redundant antenna. The second button puts the costumer in contact with the Mercedes-Benz Roadside Assistance, which gives you access to help along the road. The third button connects the costumer with the Mercedes-Benz Client Assistance centre which can answer customer questions about the car. Like the Volvo On Call system this system can also help the costumer with theft tracking. The TeleAid system is workable in Germany, Austria, Belgium, Luxemburg, Italy, France, the Netherlands, Switzerland, Japan and USA. The system is available in the E-Class, S-Class and the CL-Coupe. **(17) (18)**

4.6 BMW Assist

BMW also has an ACN system with a driver assistance system. BMW Assist is standard in the 5, 6 and 7 Series and optional on all other models. The system works in about the same way as the above mentioned. The system combines an integrated wireless phone for communication and a GPS satellite receiver to determine the vehicle’s location. The system enables the driver to call up information on their car’s on-board computer monitor about information for restaurants as well as opening hours on museums. The driver can get information about traffic conditions and help in case of a breakdown. In case of an impact the airbag sensors automatically send an emergency call which contains the automobile’s location to the relevant rescue service. **(19) (20)**

4.7 Citroen NaviDrive and the Peugeot RT3

The Citroen and Peugeot system are the same but with different names, offers a GPS navigation system, a GSM dual band hands-free telephone with access to the address book and audio system. The main functions can easily be used from the steering wheel controls, which can also be used for the voice recognition and synthesis functions the system also has an on board monitor. The NaviDrive systems and RT3 services are:

- Citroen/Peugeot emergency service: In emergency situations the user presses the SOS button like in the other systems. In case of an impact this system also makes an emergency call automatically, if an airbag is deployed.
- Citroen/Peugeot Assistance: If another button is pressed service can be provided in case of a breakdown.
- Citroen/Peugeot on line: an online service that provides answers to the telemetric system.

This system works in the same way and has the same functions as the Volvo, BMW & Mercedes Benz systems and is available in the Citroen models C8, C5, C3 and C2 (depending on the country). The system works in all of Europe. For Peugeot the RT3 system is available in most models. **(21) (22) (23)**

4.8 Alpha Romeo and Fiat

These auto companies have a system called bConnect. This system is an European solution developed by Targa Infomobility and Alpha Romeo and Fiat are using its services. This system works in all of Europe but is mainly a driver's assistance service system and not an emergency system. **(24)**

4.9 Renault

Renault has a system called Carminat Navigation & Communication System. This system is similar to the Alpha Romeo and Fiat system. These systems do not have a connection to the emergency centre, only help for traffic and navigation information for driver assistance. This system has made its entrance in the Laguna model. **(25)**

4.10 Hyundai-KIA Mozen System

In Korea, Hyundai and KIA are developing a combined telematic system called Mozen with the help of KTF. KTF is a Korean mobile telecom company and this system will start to work from the mid of 2005. **(26)**

The structure of this system consists of CCD cameras and other monitoring devices which are installed along roadways to gather traffic flow data, which is processed at a Data Centre and distributed via a wireless network, see figure 14. Individual drivers use wireless modems to receive the processed data, which appears on the display in their cars. Current road conditions are conveyed to the driver in the form of text and colour codes. This system only works for information and has no service for ACN. **(27)**

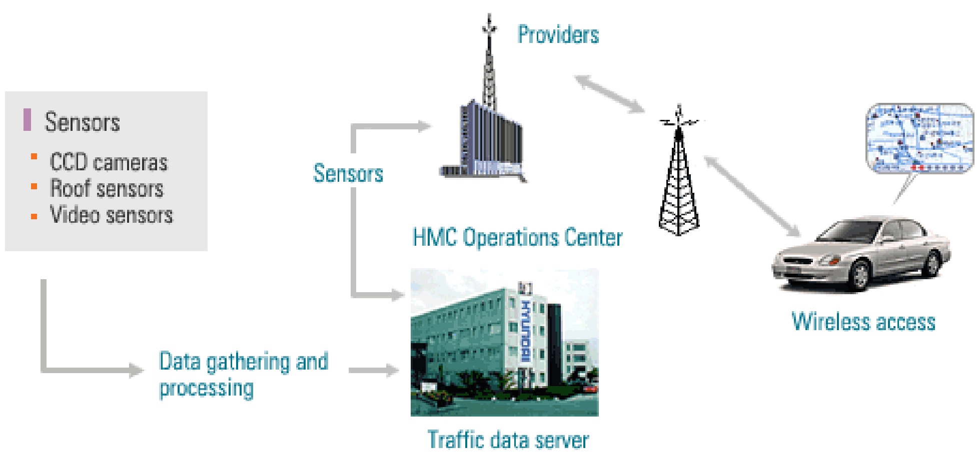


Figure 14: Working of Mozen system

4.11 Nissan Carwings System

Carwings is a service that allows the driver to obtain various information, receive e-mail, use hands-free phones and road guidance by connecting a cell phone to the vehicle. Compass Link is the service developed by Nissan. This system uses a navigation system and a digital cell phone to call and receive the services of an operator at the touch of a button. Suzuki and Nissan had agreed to begin providing Carwings telematic services to

Suzuki car owners from end of 2003. An overview of the system is illustrated in figure15. **(28) (29)**

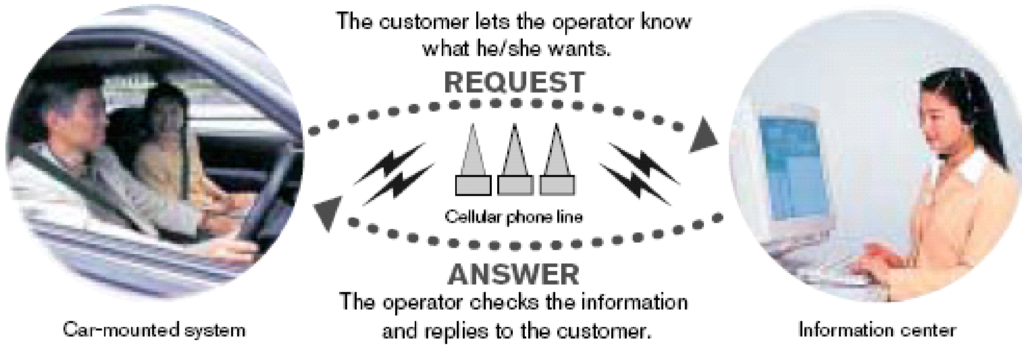


Figure 15: Overview of Carwings system

Nissan Carwings system is a driver assisted system and there is no ACN related system.

4.12 Comparison

Case studies of different companies show that most of the European and Asian companies are more or less at a similar level and are using the same technology that consists of a GPS system, cellular network, a service centre and an automatic emergency information system which is operated by airbag deployment or driver call. There may be a situation in which the driver cannot call due to being unconscious after a severe crash or airbags dont deploy becaue of a roll over of car then OnStar, Ford Wingcast and Mercedes-Benz TeleAid systems have sensors on the car which activates by high impact and automatically connects to a call centre. Alfa Romeo, Fiat and Renault are taking telematic services for their customers by other communication companies who are working in Europe. Moreover the telematic systems from Alfa Romeo, Fiat, Hyundai, KIA, Nissan and Renault are only driver assisted systems and doesn´t have ACN related systems.

5 Conclusions and recommendations

In our opinion, OnStars system AACN has the potential to sufficiently cover the need of information sought after in a crash situation. Therefore, AACN will be the base of which the proposed system rests on.

Activation of an ACN system should be based on signals from impact sensors and accelerometers rather than deployment of restraining devices. This will, not only secure activation of the ACN system in case of malfunctioning restraining systems, but also provide the opportunity of determining impact type and impact severity. Since AACN uses front and side sensors in addition to an accelerometer, it will be able to detect the four main impact types, assuming sufficient severity. Although AACN lacks rollover and rear sensors, these impact types will be detected using the response, or lack of, from the front and side impact sensors in addition to the accelerometer. AACN is not able to detect the number of passengers, their location or if seat belts were used during the crash. In order to fill this need a function similar to the existing Wingcast system by Ford will be added to the proposed system.

In order to locate the crashed vehicle we propose GPS. The technique has proven its ability throughout recent years and has been tested in various applications. In order to transmit additional information, a built in cell phone is the most cost efficient alternative. The cell phone enables the collected information to be transmitted, whilst establishing voice link and visual connection. This will help the PSAP to discard from false alarms and gather more information. Sound and picture will of course demand the presence of appropriate components. Use of cell phone service is unfortunately limited to certain areas why a satellite phone should be considered although they are more expensive.

Volvo on call ACN system uses a backup system with a separate battery, which enables the ANC system to function properly even if the main car battery has been damaged in the crash. A backup system similar to Volvos will be implemented in our proposed system.

The cost for the in vehicle system described above is hard to estimate, although since all of our components, except the satellite phone, already exists in production the cost can be expected to be feasible.

In chapter 3.2.2 a response network called the public alternative architecture were described. This architecture has several advantages, it provides a buffer for false alarms, allows for a smooth transfer from the existing emergency response centre to one that is ACN compatible in order to further shorten response time.

One can imagine possible spin off features of an ACN system. Traffic situations, as for example traffic jams, could be monitored. Law enforcement agencies could use the location function to track suspects or stolen cars. Recreation of accidents could more easily be done using collected data from the accelerometer and other sensors. This available data could help interpreting different vehicle responses into injury patterns, according to chapter 2.3.1. In some sense the ACN system will help perfect itself.

If an ACN system is implemented in a large scale, an issue concerning privacy is unavoidable. We therefore believe it to be necessary that a uniform ACN system is implemented by legislation.

Furthermore we recommend that personnel for the PSAPs are chosen with care, certainly if the proposed video link is implemented.

Reference list

1. Howard R. Champion, et al. *Reducing Highway Deaths and Disabilities with AutomaticWireless Transmission of Serious Injury Probability Ratings from Vehicles in Crashes to EMS*. ESV Paper 406. (2005-05-12). http://www-nrd.nhtsa.dot.gov/pdf/nrd-01/esv/esv18/cd/files/18esv-000406.pdf

2. Howard R. Champion, et al. *Reducing Highway Deaths and Disabilities with Automatic Wireless Transmission of Serious Injury Probability Ratings from Crash Recorders to Emergency Medical Services Providers*. International Symposium of Transportation Recorders, 3-5 May 1999, Arlington, VA. (2005-05-12). http://www-nrd.nhtsa.dot.gov/edr-site/uploads/Reducing_Hwy_Deaths_and_Disabilities_w-_Auto_Wireless_Trans-.pdf

3. *ACN field operational test*. (2005-05-12). http://www-nrd.nhtsa.dot.gov/departments/nrd-12/ACNEvaluation/index.htm#toc

4. *SOS Alarm.* (2005-05-12). http://www.sosalarm.se/112/forbereda.asp

5. *Phrack: a hacker magazine by the community, for the community* (2005-05-12). http://www.phrack.org/

6. *E911 Third Report and Order*, Federal Communications Commission, FCC 99-245, October 1999.

7. *Technology Alternatives for an Automated Collision Notification System*, The Johns Hopkins University Applied Physics Laboratory, FS-94-080, August 1994.

8. *National Highway Traffic Safety Administration.* (2005-05-12). http://www.nhtsa.com

9. *FIAT.* (2005-05-12). http://www.fiat.com

10. *ITS deployment tracking*. (2005-05-12) http://itsdeployment2.ed.ornl.gov

11. *OnStar.* (2005-05-12). http://www.onstar.com/us_english/jsp/explore/onstar_basics/technology.jsp#connected

12. *Toyota to Initiate Full Rollout of G-BOOK.* (2005-05-12). http://www.toyota.co.jp/en/news/03/0729.html

13. *Toyota's approaches to ITS.* (2005-05-12). http://www.toyota.co.jp/en/tech/its/program/function/g_book.html

14. *Toyota's approaches to ITS.* (2005-05-12). http://www.toyota.co.jp/en/tech/its/program/function/help_net.html

15. *Greater Harris County 9-1-1 Emergency Network.* (2005-05-12). http://www.911.org/news/release13.asp

16. *Volvo On Call.* (2005-05-12). http://www.volvocars.co.uk/NR/rdonlyres/1ACF5A24-FD93-450B-AA38-977A639ACE83/0/VolvoOnCall.pdf

17. *Mercedes-Benz reaches drivers via satellite with all-new TeleAid system.* (2005-05-12). http://www.autoworld.com/news/Mercedes/TeleAid.htm

18. *T-traffic.* (2005-05-12). http://www.t-traffic.de/en/t_traffic/safety/mercedesbenzteleaid/index.html

19. *How BMW Assist works.* (2005-05-12). http://www.bmwtransact.com/bmwassist/howitworks.htm

20. *BMW technology and innovations.* (2005-05-12). http://www.bmw.com/generic/com/en/fascination/technology

21. *Citroen NaviDrive system.* (2005-05-12). http://www.citroen.com/CWW/en-US/TECHNOLOGIES/COMFORT/NAVIDRIVE/

22. *Safe and legal with Peugot.* (2005-05-12). http://www.tiscali.co.uk/motoring/roadtests/roadtests_newcarnet/type/news/2003/11/13/story_2.html

23. *Peugeot.* (2005-05-12). http://www.peugeot.com/en/default.htm

24. *bCONNECT.* (2005-05-12). http://www.bconnect.biz/Eng/Index2.htm

25. *Renault Laguna sport tourer.* (2005-05-12). http://www.renault.com/gb/produits/laguna2break.htm

26. *KTF.* (2005-05-12). http://www.ktf.com

27. *KIA Vehicle information system (ATIS).* (2005-05-12). http://www.kiamotors.com/Common/html/innovation/its/atis05.html

28. *Nissan motor co.* (2005-05-12). http://www.nissan-global.com/EN/index.html

29. *Japan's corporate news network.* (2005-05-12). http://www.japancorp.net/default.asp?sec=3&P_SecName=Automotive