

EMERGING COMMUNICATION TECHNOLOGIES IN EMERGENCY MEDICAL SERVICES

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ABSTRACT

Advances in communication technologies are changing the face of emergency medical services (EMS). Two communication technologies in particular—cellular-enhanced 9-1-1 service and automatic crash notification (ACN)—will have a considerable impact on EMS. Although enhanced 9-1-1 service from land-line phones is now available in nearly every EMS system across the country, enhanced 9-1-1 service from cell phones currently does not exist. With more and more emergency calls made from cell phones, the implementation of this service is a clear priority. Automatic crash notification, a quickly emerging technology, can potentially provide EMS systems with invaluable data within seconds of when a collision occurs. However, many issues with regard to ACN systems need to be addressed, including liability concerns, access to ACN data, ability of drivers to understand the ACN system, and ACN system architecture. The potential interfaces between ACN systems and EMS systems create significant opportunities to enhance EMS resource management and care of patients involved in motor vehicle crashes. With both cellular-enhanced 9-1-1 and ACN in their

infancy, EMS physicians and administrators have a valuable opportunity to provide leadership in the development of these services. **Key words:** automatic crash notification; communications; emergency medical services; enhanced 9-1-1; cellular-enhanced 9-1-1.

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Over the past 20 years, advances in communications technology have had a significant impact on everyday life. The fax machine, once the cutting edge of technology, has been supplanted by e-mail and instant messaging. In some fashion, computers are now firmly entrenched in the work and personal lives of nearly every person in the United States. Cell phones and pagers, many with nationwide and even international coverage, are becoming ubiquitous. The adoption of new communications tools has not bypassed emergency medical services (EMS) systems. Two technologies in particular—enhanced 9-1-1 service and automatic crash notification—have had or will soon have a profound effect on EMS providers.

ENHANCED 9-1-1 SERVICE

With enhanced 9-1-1 service, the caller's phone number and address are displayed for the dispatcher when the emergency call is received. This is a clear advantage over a non-enhanced 9-1-1 system, in which the dispatcher must rely on the caller to provide accurate information, which might not always be possible.

In 1976, only about 20% of land-line phone systems were equipped with enhanced 9-1-1 technology.¹ Today, nearly 100% of land-line phone systems are so equipped.

Although this is a tremendous advance in the public safety net, more and more emergency calls are received from persons using cell phones.² In 1987, only a small percentage of 9-1-1 calls were made from cell phones. By 1999, between 20% and 40% of emergency calls originated from cell phones,^{3,4} and by 2004 perhaps 75% of such calls will be made from cell phones (Scott J, personal communication, August 2001). Thus the safety net provided by the enhanced 9-1-1 land-line phone system is rapidly disappearing.

The obvious solution is to implement some means of locating a person making an emergency call from a cell phone. Such efforts are currently under way in many areas, including New York State. Through the joint efforts of the National Highway Traffic Safety Administration (NHTSA), Intelligent Transportation System (ITS), and the State University of New York Upstate Medical University, a plan for implementing cellular (wireless)-enhanced 9-1-1 throughout the state is being developed, with the goal of using the New York State experience as a model for other states. New York State was chosen for this three-year project, which began in late 1999, because of its mix of urban and rural areas, its degree of readiness to implement such a program, and the diverse range of issues that needed to be addressed in undertaking this project. The overall objectives of the cellular-enhanced 9-1-1 project in New York State are to demonstrate the need, engage the stakeholders, identify and develop resources, identify barriers to implementation, develop an implementation plan that uses resources and overcomes barriers,

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TABLE 1. Key Stakeholders in the Cellular-enhanced 9-1-1 Project in New York State

State and federal Department of Transportation
State and federal Intelligent Transportation System (ITS)
National Highway Traffic Safety Administration
New York State Police
New York State Sheriff's Association
New York State 9-1-1 Coordinators
New York State Association of Chiefs of Police
New York State Fire Chiefs Association
Emergency medical services program agencies
New York State Office for Technology
New York State Thruway Authority
National Association of Emergency Medical Technicians
Wireless Carriers Coalition
Telecommunications industry
General public
Legislators
Ethicists
Emergency physicians

and solicit endorsement by all the stakeholders (Scott J, personal communication, August 2001).

Endorsement by all stakeholders could be a challenge, considering the number of organizations with an interest in cellular-enhanced 9-1-1 (Table 1). Thus, a key to successful implementation of cellular-enhanced 9-1-1 service is early involvement of all stakeholders. At their initial meetings, stakeholders need to identify issues and tasks and seek to build a consensus. The New York State stakeholders ultimately agreed that the overriding principle on which to base their partnership was "to do what is best for current and potential victims of injury, illness, fire, and crime" (Scott J, personal communication, August 2001).

Stakeholders in New York State identified many issues that need to be resolved as the cellular-enhanced 9-1-1 system is implemented. Among these are call routing, "closest car" concept, funding, privacy and confidentiality concerns, technology limitations, systems compatibility, need for state oversight boards, and standards for staffing and training. How calls

are routed ultimately affects the number of full-time equivalents in a particular organization. Should cellular emergency calls be routed directly to the state police? Should they go to a central police operation and then be sent to a different site? Should they go to a county's public safety answering point (9-1-1 center)? Another issue is whether the police car closest to the incident should be the first to respond or whether police response should be based on jurisdiction. Funding of the cellular carriers themselves is not an issue. However, wireless companies have concerns over who should fund the activities of integrating cellular-enhanced 9-1-1 into their systems. The ability to identify the location of a cellular phone caller also raises issues of privacy, a concern of ethicists and the general public. Smooth implementation of the cellular-enhanced 9-1-1 system also requires a certain level of technology and systems compatibility between the wireless companies and 9-1-1 centers. In addition, the question of whether implementation should be phased in or put in place all at once needs to be addressed.

In their role as advocates for patient access to EMS response and care, EMS physicians have a clear leadership role in planning the implementation of any cellular-enhanced 9-1-1 system. Because EMS physicians have no financial stake in the system, they can provide an objective viewpoint and advocate for what is in the best interests of the patient and potential patients. Physicians in emergency medicine are well aware of the importance of the enhanced 9-1-1 mission and should take an active role in its implementation in cellular systems. If patients cannot be found, they cannot be helped.

AUTOMATIC CRASH NOTIFICATION

Each year in the United States, nearly 40,000 people lose their lives

in a car crash, a rate of about 112 people a day, making car crashes the leading cause of death for persons younger than age 45. About 30% of these deaths occur within minutes of the crash, and another 20% occur before the victim arrives at the hospital. Overall, nearly 70% of deaths occur within two hours of the crash. Nearly 3 million persons are injured each year in car crashes, with about 250,000 of these injuries considered to be life-threatening. The economic cost of crash injuries is estimated at a staggering \$100 billion.⁵

People involved in serious car crashes may be unsure of their location. Moreover, they may be unconscious or so severely injured that they are unable to call for help. How can communications technology be used to help these patients? A system currently being evaluated is automatic crash notification (ACN). With this system in place, the EMS system could be alerted automatically at the time a crash takes place. For the past five years, the NHTSA and Calspan Corporation have been field-testing an ACN system in Erie County, New York. The results of this test were independently evaluated by The Johns Hopkins University Applied Physics Laboratory and released in February 2001.⁵

The ultimate goal of implementing an ACN system is to provide a faster and smarter EMS response to a collision to save lives and reduce disabilities from injuries. When installed in a vehicle, the ACN system should automatically: 1) determine that a collision has taken place; 2) notify EMS personnel of the crash and the vehicle's location; 3) provide information concerning the crash (e.g., crash severity, rollover, direction of impact, probability of serious injury); and 4) establish a voice link between the vehicle and EMS personnel.

At the heart of the ACN system tested by the NHTSA is the hardware installed in the vehicle—a collision sensor, which contains a

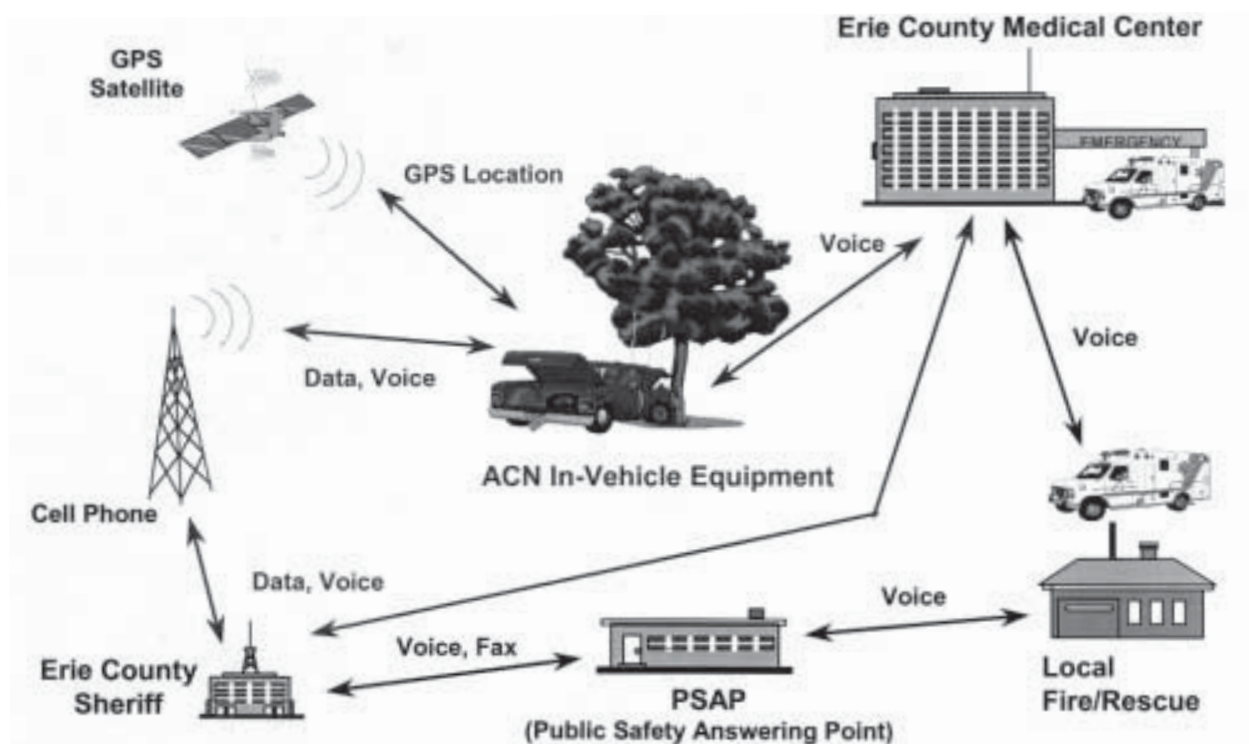


FIGURE 1. Automatic crash notification (ACN) architecture. Source: Preziotti G, Bachman L. Final Briefing for the Independent Evaluation of The Automated Collision Notification (ACN) Field Operational Test. Baltimore, MD: The Johns Hopkins University Applied Physics Laboratory, 2001. GPS □ global positioning satellite.

digital signal processor that can estimate the severity of the crash; global positioning satellite (GPS) receiver, which establishes the vehicle's location; cell phone, to transmit crash and voice data; and back-up battery. As illustrated in Figure 1, a collision above a certain threshold triggers the ACN in-vehicle system. Automatically, a data and voice transmission is sent to the nearest cell phone tower and a link with a GPS satellite is established. In the ACN field test, the crash data, voice, and location information were relayed to the Erie County Sheriff's office. From there, data about the collision were communicated via voice and fax to the public safety answering point, the local fire-rescue unit, and the Erie County Medical Center. A voice link also was automatically established between the car and the medical center, enabling a physician to speak with the patient before EMS personnel arrived.

Within seconds after a crash, an ACN system relays data about the collision and the vehicle's location to the dispatcher's screen (Fig. 2). These data include the time and date of the crash, the latitude and longitude of the vehicle's location, the final resting position of the vehicle, the change in velocity, and the track of the vehicle in the moments just before the crash.

An estimate of the probability of injury was not part of the data relayed to the dispatchers in the Erie County field test but was included in a retrospective analysis of the ACN data. However, real-time estimates of injury probability could have a substantial impact on emergency medical services systems, allowing dispatchers to more effectively manage resources by sending, for example, only a police car for probable minor injuries and reserving air or ground critical care transport for probable severe injuries.

Results of the ACN Field Test

The ACN field test in Erie County, New York, was conducted between October 1995 and August 2000. During that time, the field test team collected data on EMS response times before (baseline data) and after the ACN system was installed. To collect baseline data, crash event timers, which tracked the elapsed time since the crash, were installed in test participant vehicles. By combining data from the crash event timer with data from the public safety answering point, the field test team sought to establish baseline EMS response times.

Crash event timers were installed in approximately 2,600 vehicles, but the number of crash events was lower than expected. Over the study period, a total of 36 crashes of event-timer-equipped vehicles were reported, of which 25 were investigated. The low num-

Over the study period, a total of 70 crashes of ACN-equipped vehi-

cles occurred. Forty-eight of these crashes were below the crash severity threshold and were reported by the test participants (only one of these below-threshold crashes resulted in an injury). Twenty-two crashes were above the threshold and activated the ACN system; 12 of these crashes resulted in injury. In 16 of the 22 above-threshold crashes, the ACN system worked as intended, but in five crashes, the system failed to notify EMS responders (the remaining crash occurred outside the test area). System failure occurred for various reasons, including battery failure, inability of the ACN hardware to survive the crash, disconnection of the modem at the Erie County Sheriff's

In only three crashes were EMS units dispatched in response to ACN. Because of this small sample size, the field test team was unable to make any statistical compar-

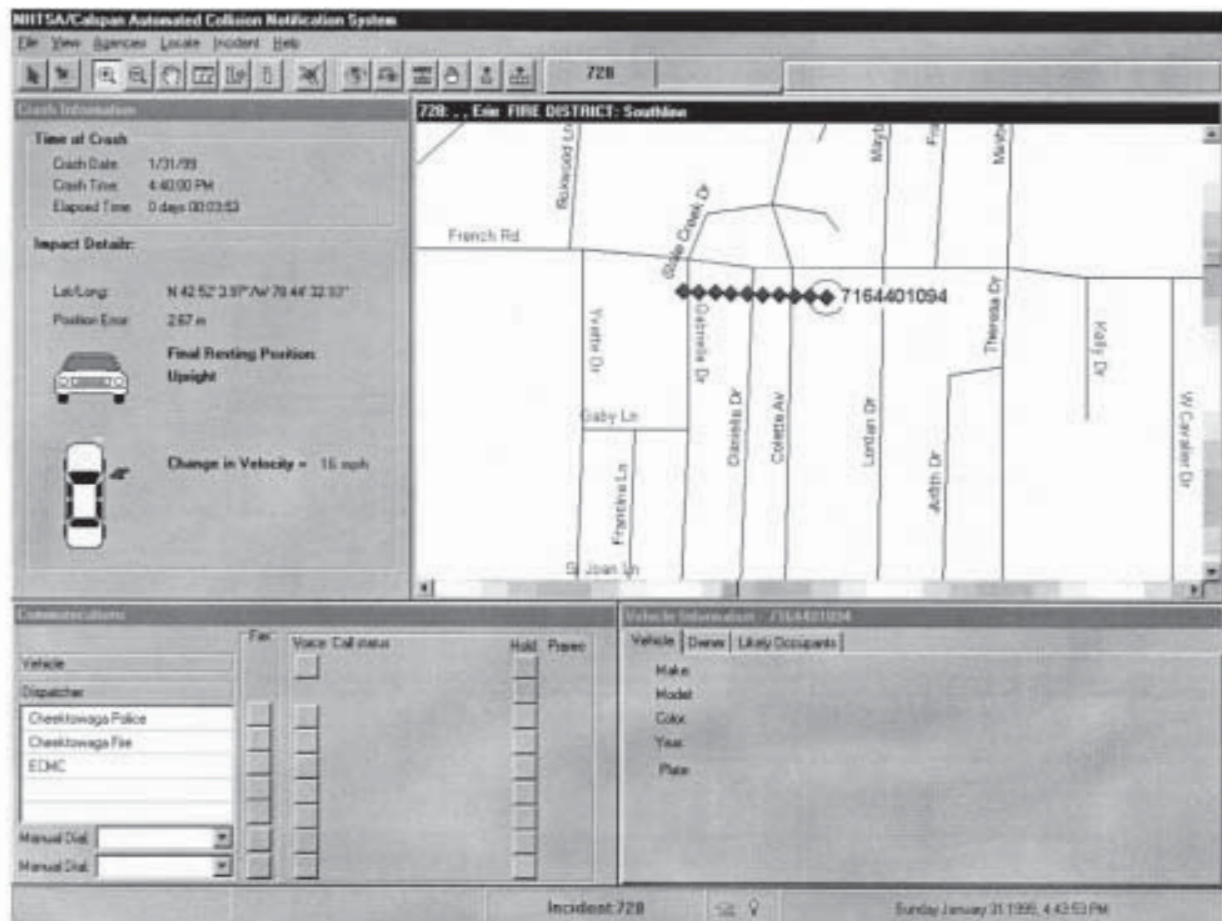


FIGURE 2. Dispatcher screen in automatic crash notification system. Source: Preziotti G, Bachman L. Final Briefing for the Independent Evaluation of The Automated Collision Notification (ACN) Field Operational Test. Baltimore, MD: The Johns Hopkins University Applied Physics Laboratory, 2001.

TABLE 2. Automatic Crash Notification (ACN) System Capabilities*

	OnStar	Mercedes-Benz TeleAid	Lincoln RESCU	Erie County Field Test ACN System
How is the system triggered?	• Airbag deployment • Manual button	• Airbag deployment or emergency tensioning retractor • Manual button	• Airbag deployment • Manual button	• Independent array of accelerometers and 3-D crash detection threshold • Manual button
What data are sent from the vehicle?	• GPS position • Car cell phone number	• GPS position • Car cell phone number	• GPS position • GPS heading and speed • VIN number	• GPS position heading and speed • Crash delta V • Crash PDOF • Final resting position • Entire acceleration crash pulse • GPS history • Car cell phone number • Number and location of vehicle occupants • Seat belt use • Photograph of interior

*Source: Preziotti G, Bachman L. Final Briefing for the Independent Evaluation of The Automated Collision Notification (ACN) Field Operational Test. Baltimore, MD: The Johns Hopkins University Applied Physics Laboratory, 2001. GPS □ global positioning satellite; PDOF □ principal direction of force; VIN □ vehicle identification number; delta V = change in velocity.

isons in EMS response times between vehicles equipped and those not equipped with the ACN system. Thus, further work needs to be done to determine how much ACN can decrease EMS response times.

Issues in Implementing an ACN System

The ACN field test in Erie County clearly demonstrated the feasibility of automatic notification of EMS responders after a serious collision. However, before such systems can be implemented nationwide, a number of issues must be considered and resolved.

ACN System Liability

With an ACN system in place, who might be liable if the system does not work or help is not provided in time? In the field test, vehicle owners signed statements noting that the ACN system was experimental and might fail or not perform to expectations.

Access to ACN Data

The ACN system collects and transmits a considerable amount of real-time data related to each crash.

Who should be allowed access to these collision data? Would the availability of crash records affect the public's acceptance of ACN? In the field test, vehicle owners signed statements granting the right to use data gathered during the field test and noting that the ACN system could create an official record of a crash.

Ability of Drivers to Understand ACN Technology

Will drivers understand how the ACN system works? In the field test, some drivers involved in below-threshold crashes were upset that the ACN system was not triggered, even though they knew at the outset the system would be activated only in serious collisions. To address this issue, the field test team recommended improved operating instructions, better education of the public on the capabilities of the ACN system, installation of an indicator of a below-threshold crash, and installation of a single-button means of manually reporting a crash.

ACN System Architecture

Should the ACN system architecture be part of the public 9-1-1

service? Should it be a private subscription service? Or should it be a hybrid of the two?

Vehicle Location Reporting

In the field test, the vehicle's location was established using GPS. Another option is triangulation, using the timing and strength of the cell phone signal sent to at least three cell phone towers. This raises the question of whether there should be nationwide uniform standards for reporting vehicle location.

Commercial ACN Services

Since 1996, owners of certain vehicles, such as those made by General Motors, Ford, and Mercedes-Benz, have had the option of installing a system with ACN capabilities. How these systems compare with the ACN system used in the Erie County field test is shown in Table 2. Unlike the field-test ACN system, the commercial systems typically are activated by airbag deployment or a manual button. In most commercial systems, the data transmitted consist of the vehicle's location via GPS and the cell phone number in the car.⁵

At present, the most widespread commercial system is OnStar, which has 1 million subscribers. This system offers not only crash notification but also convenience services, such as providing directions, remotely unlocking the car, and tracking a stolen vehicle. In 2001, OnStar received about 125 airbag notifications per month. When the airbag is deployed, the OnStar service center receives information on the vehicle's location and a voice line to the vehicle is established. The private OnStar service then identifies and calls the local 9-1-1 center to alert them of the collision. Dispatchers are not necessarily accustomed to receiving reports of a local crash from a center located in Michigan and may not believe it is a legitimate call. OnStar, however, has made considerable efforts to educate local public safety answering points about its system (Huber C, personal communication, November 2001).

ACN Summary

Overall, the Erie County field test demonstrated that ACN systems are technically feasible and can provide potential benefits to crash victims through decreased crash notification times, improved knowledge of the vehicle's location, and, eventually, estimates of crash severity and the probability of serious injury. Commercial sys-

tems already being deployed are providing real-world proof of some of these benefits. The response of trauma systems to victims of motor vehicles crashes may be revolutionized if ACN becomes standard equipment in vehicles in the United States.

CONCLUSION

New communication technologies have changed many aspects of life in the United States, and EMS is no exception. Nearly all EMS systems now have land-line-based enhanced 9-1-1 systems in place, which allow the dispatcher to identify the location of the call, whether or not the caller is able to do so. Yet, this enhanced 9-1-1 service is available only for calls made from land-line phones, which is becoming increasingly less common as the use of cell phones increases. So the challenge for EMS physicians and administrators is to provide a leadership role, working with various public, private, and governmental organizations to implement enhanced 9-1-1 service for calls from cell phones.

Another challenge for which EMS physicians should be taking an active leadership role is the implementation of ACN systems. With ACN systems, EMS providers will be notified of a collision within seconds after it occurs and provided with accurate injury severity predictions, something that has

never been possible before. These systems are still in their infancy but have the potential to have a significant positive impact on EMS response to victims of motor vehicle crashes. However, without input from EMS leaders, their potential as lifesaving tools may not be fully realized.

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