# URGENCY for a Safer America

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At various times and places on the 4 million miles of U.S. roads, about 27 million motor vehicles are involved in about 17 million crashes each year. Of the estimated 5 million people injured in these crashes every year, approximately 250,000 people suffer serious, life-threatening injuries, and more than 42,000 die as a result of their injuries. Lifetime economic costs to society of about $100 billion are incurred each year by crash injuries.[1] The tragic human costs to individuals and families as a result of these injuries, of course, are far greater.

The U.S. Department of Transportation (DOT) projects that, by the year 2005, the annual number of crash deaths will rise to 51,000 despite its current safety programs.[2] Historically, more than 3 million Americans have been killed and 300 million injured in crashes—more than 3 times the number of Americans killed and 200 times the number wounded in all wars since 1776.

According to a recent national opinion survey,[3] 23% of people older than 16 reported they had been injured in a crash that required medical attention at some time. Thus it should not be surprising that public opinion polls and market research say personal safety and that of loved ones is high on the public's list of priorities.

Recently, a multidisciplinary team of physicians, surgeons, engineers, and crash injury statisticians studied methods to improve the triage, transport, and treatment of people injured in crashes. The team examined the latest available crash injury data and emerging technologies and conducted hundreds of statistical analyses to develop improvements in the care of seriously injured crash victims. The focus of the research was "how to identify, rapidly and automatically, those vehicles in which the 250,000 people suffer life-threatening injuries among the 27 million vehicles involved in the 17 million crashes occurring each year." The problem is how to quickly find and provide the appropriate response to all injured people, especially those critically injured in the 1 of every 100 vehicles involved in crashes.

## Results

The team concluded that significant improvements in emergency care could be achieved by using new technologies to instantly and automatically communicate to EMS providers lifesaving information on crash occurrence, location, and injury probability. Mathematical relationships were developed to compute injury severity probabilities from crash severity information.[4] In March 1997, a complex set of mathematical relationships was first produced and written into computer software, named URGENCY, to be used for computer-assisted dispatch (CAD). The team developed the URGENCY triage algorithm to predict injury severity probabilities based on vehicle, occupant, and crash parameters. All parameters for which data were available were evaluated in terms of their ability to predict the probability of serious injury. Injury probabilities were calculated for vehicle and crash severity parameters of crash force (crash Delta velocity), principal direction of crash force, rollover (number of quarter turns), vehicle weight, and safety belt use. This injury probability algorithm is being used in a small test fleet of cars equipped with automatic crash notification (ACN) technologies that sense and communicate crash data from the vehicle on impact.

Injury probabilities also were developed for the powerfully predictive occupant and crash parameters of age, gender, entrapment, and ejection—data that may be obtained by EMS dispatchers through hands-off, two-way cellular communications with the vehicle occupants and bystanders. The age parameter, for example, predicts that the probability of a serious injury for a 50-year-old person in a crash of a given Delta V is nearly double the probability of serious injury for a 25-year-old.

## New Technologies

As first described in *AIRMED* last year,[1] technologies are becoming available to make dramatic improvements in public safety through faster and smarter emergency medical care:

- Wireless telecommunications technologies now enable people to call for emergency help without having to search for a land-line telephone to make that lifesaving call, thereby saving precious minutes from crash notification times.
- Wireless location technologies and global positioning system (GPS) technologies can enable callers to be located instantly by emergency responders, thereby taking the "search" time out of search and rescue. In addition, navigation technology can automatically direct rescue workers to the crash location by the fastest route.
- Airbag crash sensor technologies aboard vehicles now enable objective and instant measurements of crash severity. These measurements can be instantly and automatically communicated to EMS providers by cellular telephone as a simple numerical probability of the presence of a serious (AIS 3) or greater injury. This information will save the time currently lost while waiting for the first responder to travel to the scene and visually evaluate the seriousness of the crash before dispatching appropriate EMS care.

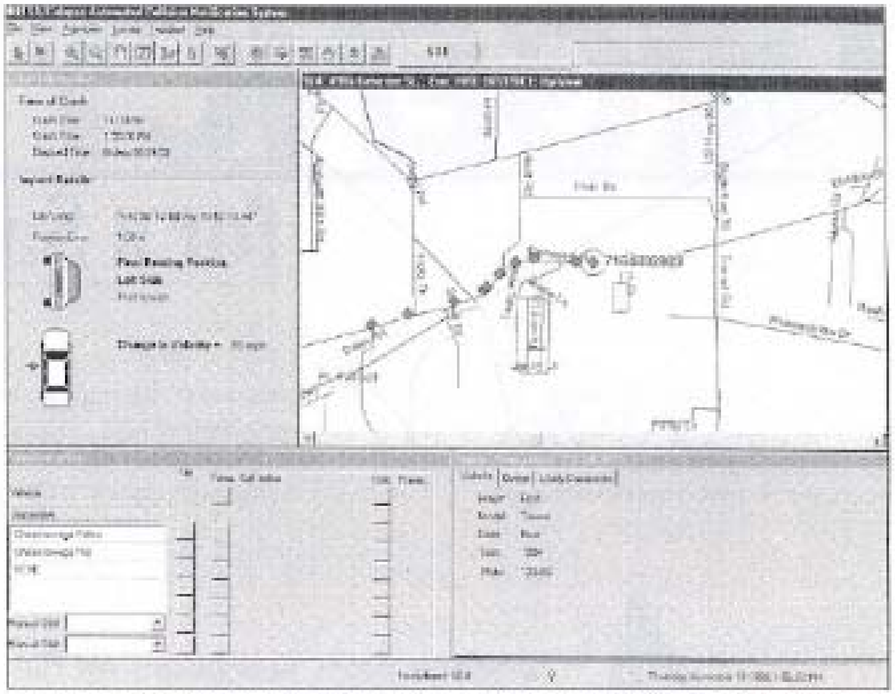

**FIGURE 1. URGENCY software pinpoints the location and other vital details of vehicle crashes.**

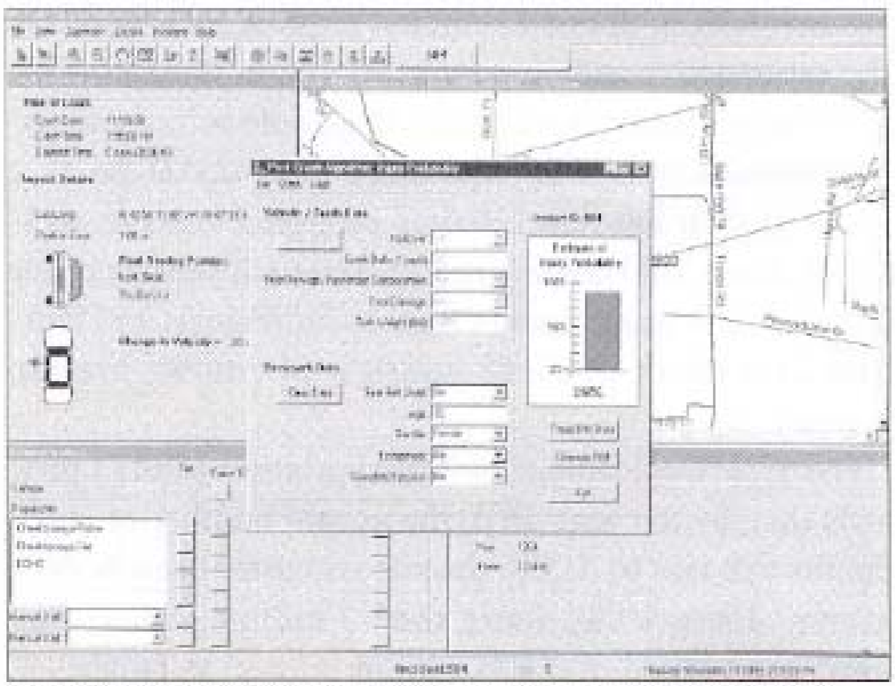

**FIGURE 2. URGENCY postcrash algorithm determines injury probability and relays necessary information.**

This constellation of technologies using crash sensors, wireless location and GPS units, and wireless telephones is called ACN. Automobile manufacturers, including GM, Ford, BMW, and Nissan, are offering first-generation versions of ACN technology in 1999 model year vehicles in the United States, and the DOT currently is installing a more advanced version of ACN technology in 1000 vehicles in the Buffalo, N.Y., area.

This latter ACN system (Calspan, Buffalo, N.Y.) measures crash forces in all types of crashes and automatically transmits URGENCY injury severity probabilities. The DOT contract with Calspan is testing advanced ACN technology that provides an automatic, crash-activated call for help through an onboard cellular telephone to transmit voice and data. The call electronically communicates crash location and severity for all major crash modes: frontal, side, and rear impacts and rollover. The call also transmits data on precrash speed, direction of travel, and vehicle identification information, including such attributes as vehicle type. The Erie County Medical Center is participating in evaluating this system.

Our multidisciplinary research team developed the computer software, named URGENCY version 1.0, for initial use with the DOT/Calspan system. Through a series of logistic regression analyses, crash impact data have been statistically related to serious injury probabilities and programmed for CAD. On vehicle impact, URGENCY immediately reads vehicle sensor measurements of crash forces and automatically calculates the probability of a serious injury occurring in that crash. Figures 1 and 2 show a sample URGENCY bar chart that a dispatcher would see on the computer screen and a map location of the crash site. Figure 2 shows an URGENCY reading of an 89% probability of the presence of at least one serious injury of AIS 3 or greater severity. In this example, this 89% URGENCY rating was triggered in a side impact crash of 38 mph Delta V involving a rollover with a female occupant. (Age and gender can be programmed into the vehicle algorithm as the principal driver.)

Future versions of URGENCY will include other sensor data, such as airbag deployment, door openings, presence or absence of fire, and number of occupants. In addition, medical records probably will be instantly sent electronically to the emergency department that contain data on blood type, drug reactions, current medication, etc. so that this information arrives before the patient does and further improves emergency response decision-making. (A free copy of URGENCY 1.0 is available on request from *HRChampion@aol.com*.)

## Transport by Ambulance or Helicopter

URGENCY will enable responders to advance beyond current rescue practices, especially regarding helicopter dispatch. Currently when a crash occurs, regardless of how serious it may be, generally someone in authority (police, fire, or EMS agency) must travel over land to the scene, determine that the seriousness requires a helicopter response, then send a radio request for air medical assistance. If and when this request is granted, only then does the helicopter deployment process begin. In the future, CAD protocols will be developed to expedite this process with lifesaving results.

In about 1% of the 27 million vehicles in U.S. crashes each year are injuries that require immediate transport to a trauma center for treatment. In many cases, ambulances can get such injured people to a trauma center fast enough, but sometimes distances and other circumstances require helicopter rescue to transport critically injured people to trauma centers in time to save lives. These new notification technologies ultimately will increase the effective and efficient use of air medical resources.

Soon it will be possible to do a better job of delivering definitive care to those who need it in time to save lives and reduce disabilities. We can do better at finding the people who need trauma center care and deliver them to the right place within the "golden hour." We can improve the speed and accuracy of our decision-making in rescue triage, transport, and treatment. We increasingly will deploy technologies to instantly and automatically locate victims, predict injury severity, dispatch the appropriate emergency response teams, and transport victims to the right place the first time.

How big is the problem, and how "urgent" is it that we deploy these technologies soon? Emergency medical care experience has shown that, for many serious injuries, time is critical. As described by R.D. Stewart,[7] "Trauma is a time-dependent disease. The 'golden hour' of trauma care is a concept that emphasizes this time dependency; in polytrauma (typically serious crash victims suffer multiple injuries) patients, the first hour of care is crucial, and the patient must come under restorative care during that first hour. Prehospital immediate care seeks to apply supportive measures, and it must do so quickly within what has been called the 'golden 10 minutes.'"

The rule in trauma is to take a seriously injured patient to a trauma center for diagnosis, critical care, and surgical treatment within the golden hour.[8] To get the seriously injured patient into the operating room of a trauma center with an experienced team of appropriately specialized trauma surgeons within that hour requires a highly efficient and effective trauma care system. The time/life race of the golden hour to deliver definitive care consists of:

- Time between crash occurrence and EMS notification
- Travel time to the crash scene by EMS
- On-scene EMS rescue time
- Transport time to a hospital or trauma center
- Emergency department resuscitation time

Increasingly, new opportunities are opening in each category to act more rapidly and effectively to get patients to definitive care within the golden hour. These needs and opportunities are especially important on rural roads, where more than 24,000 fatalities occur in crashes each year. Data collected by the National Highway Transportation Safety Administration (NHTSA) indicate that only 24% of crashes occur on rural roads, but nearly 59% of all crash deaths occur there. "Delay in delivering EMS is one of the factors contributing to the disproportionately high fatality rate for rural crash victims," according to the NHTSA.[9]

ACN also will help in urban areas where about 17,000 fatalities occur each year. In both urban and rural areas, about 16,000 (43%) fatal crashes occur each year between the hours of 9 PM and 9 AM, times when slow discovery and notification are more likely.

## Crucial Time Elements

For fatal U.S. crashes in 1996, the average reported time of crash notification was 7.36 minutes (35% unknown) in rural areas and 3.87 minutes (49% unknown) in urban areas. Although this average varies greatly by state, ACN and URGENCY will dramatically reduce many of the longer times. With ACN, all crash notification times instantly and automatically would be reduced to 1 minute. For time between EMS notification and arrival at the scene, the average reported elapsed time was 11.39 minutes (35% unknown) in rural areas and 6.23 minutes (51% unknown) in urban areas.[12]

For time between EMS arrival at the scene to arrival at the hospital, the average reported time was 36.19 minutes (68% unknown) in rural areas and 26.17 minutes (72.5% unknown) in urban areas. Ultimately, the average reported time between the crash and arrival at the hospital was 52.85 minutes (69% unknown) in rural areas and 35.45 minutes (72.6% unknown) in urban areas.[11,12] Nationwide, data (where both times are reported) show that in nearly 2300 fatal crashes each year, this time from crash to hospital (not necessarily trauma center) arrival exceeds 60 minutes. The actual number is much greater considering the large number of crashes for which times were unknown. ACN technology will help dispatchers immediately decide to send extrication equipment in severe crashes, thereby saving precious minutes.

Current medical references allocate 15 minutes to ED resuscitation times for the steps of diagnosis, decision-making on treatment strategies, and required pre-operating room procedures before surgical care.[7] Add 15 minutes for ED resuscitation to the average reported time of 53 minutes on rural roads that it takes to get a seriously injured patient to a hospital (often not a trauma center), and clearly the time/life budget of 60 minutes probably is exceeded in many thousands of fatal crashes each year.

In 1996, for example, the average reported time from crash to arrival at a hospital (without time measured for ED resuscitation) in rural fatal crashes exceeded 60 minutes in five states. The states with the worst reported times were:[11,12]

- Arizona (71.67 minutes, 99.3% unknown times, 426 fatal crashes)
- Montana (62.32 minutes, 31.3% unknown, 163 fatal crashes)
- Nevada (61.76 minutes, 36.2% unknown, 141 fatal crashes)
- North Dakota (62.14 minutes, 28.2% unknown, 71 fatal crashes)
- Texas (60.63 minutes, 47.9% unknown, 1785 fatal crashes)

In 1996, 37,351 fatal crashes occurred in the United States. Data from time of crash to time of hospital arrival are available for only 11,003 (29%) of these crashes. In the 6655 rural fatal crashes with both times available, the elapsed time to hospital arrival exceeded 60 minutes for 1995 (30%). In the 4348 urban fatal crashes for which both times are known, 323 (7%) occurred in which the elapsed time exceeded 60 minutes. Thus in 1996, 2318 of the 11,003 fatal crashes for which both times are reported had an elapsed time to hospital arrival in excess of 60 minutes.[11,12] If both times were reported in all cases, the number of fatal crashes exceeding 60 minutes would be much higher. Table 1 provides data showing that these numbers have been fairly constant from 1993-1996.

**TABLE 1. FATAL CRASHES WITH REPORTED ELAPSED TIMES GREATER THAN 60 MINUTES FROM CRASH TO HOSPITAL ARRIVAL**

| 1993 | | 1994 | | 1995 | | 1996 | |
|---|---|---|---|---|---|---|---|
| Urban | Rural | Urban | Rural | Urban | Rural | Urban | Rural |
| 301 | 1817 | 346 | 1934 | 314 | 1897 | 323 | 1995 |
| 7.4% | 29.2% | 7.7% | 30.9% | 7.5% | 30.8% | 7.4% | 30% |

## Patient Destination

In too many cases, especially in rural areas, people die without having obtained definitive care at a trauma center within the golden hour. Definitive care includes thorough, timely, and accurate diagnoses; intensive critical care; and trauma teams with surgeons specialized in treating brain, internal organ, and orthopedic injuries.

During the past 10 years, nearly 400,000 Americans died from crash injuries, and nearly 50% were not taken to a hospital for treatment.[11] Currently 20,000 people die at the scene annually—about 6500 people in urban areas and 13,500 people in rural areas. Although the number of crash deaths of people taken to a hospital for treatment are about equal in rural and urban areas at 10,500 per year, the number not taken in rural areas is more than twice the number in urban areas. (Historical data by state, as well as a ranking of crash deaths and death rates, are available on request from HRC.)

These data raise the question: How many of the 42,000 crash deaths each year could be saved if the victims obtained the appropriate level of medical care—and obtained it faster? Preliminary estimates indicate thousands of lives could be saved each year if average crash notification times could be reduced to 1 minute.[13-15] Rural EMS notification times (from time of crash) reported in fatal crashes in 1996 averaged 7 minutes (down from 9 minutes in 1990, probably as a result of increased cellular telephone use and incident management technologies). Reductions in rural average notification times from 9 minutes to 1 minute have been estimated to potentially save 3000 lives per year in rural crashes.[13]

Both notification times and response times will improve with ACN technologies. Helicopter and other emergency response vehicles will be able to reach the scene faster using onboard navigation systems that will use the ACN location coordinates. Furthermore, rescuers increasingly will have onboard guidance to the scene by the "fastest route." With instant URGENCY information on the probability of serious crash injury, we should be able to do a better job of saving lives and preventing disabilities by taking people to the right place the first time.[16,17]

## What Needs to Happen Next

Currently, in the race to produce a national automatic lifesaving system (ALS), Japan is ahead of the United States and the rest of the world. Toyota, Nissan, and other auto manufacturers have planned a national ACN program in Japan in cooperation with the National Police Agency, the Fire Defense Agency, and telecommunications companies. On September 1, 1998, E Call Japan was set up jointly by Daimler-Benz, Nippon Telegraph and Telephone Corp., Tokio Marine and Fire Insurance Co., and others. The auto manufacturers expect these ACN services to halve the current average emergency response time of 30 minutes in Japan.[9]

In America, a group of physicians, nurses, surgeons, law enforcement organizations, wireless communications companies, and others have worked together to organize the ComCARE (Communications for Coordinated Assistance and Response to Emergencies) Alliance, which supports legislation to use antennae-siting fees to further ACN development and deployment. Legislation was introduced in Congress but not enacted in the 1998 session.

An urgent need exists for a national program, under medical direction, to improve the U.S. emergency medical infrastructure. Leadership, time, people, and money are needed to deliver the lifesaving benefits now possible with these technologies. Systems will have to be improved at all trauma centers to apply this technology, an undertaking that will involve systems integration of hardware and software, development of new protocols, and training to deliver the benefits of improved triage, transport, and treatment to people in need of urgent care.

To create an ALS nationwide, we need to expand the research, development, testing, and evaluation (RDT&E) program of the 1000 cars in Erie County, N.Y. One problem is that this fleet is too small to experience enough serious injury crashes. Statistically, we can expect less than one serious injury crash during the 1-year test. The test needs to increase the number of vehicles and the length of the test period and be conducted at a larger number of trauma centers geographically located across the nation—at least one in each state. The ALS must be nationally compatible so that motorists can be similarly protected as they travel across state lines.

## What Is Happening Now

Congress already has funded DOT research on crashes at trauma centers in California, the District of Columbia, Florida, Maryland, Michigan, New Jersey, New York, and Washington. However, this research needs to be expanded to all states. Congress has authorized $2 million per year for the next 6 years to perform such research at a new Calspan research center at the State University of New York at Buffalo. Similar RDT&E programs in each of the 50 states are needed for trauma care systems to develop the necessary medical infrastructure to deliver the full lifesaving potential of these technologies as soon as possible. This commitment may seem costly, but, in fact, it is far more costly *not* to conduct such a program when compared with the more than $100 million in new economic costs incurred by the 115 crash deaths and 500 serious injuries that occur on U.S. roads every day.

The DOT is spending only about 1.5% of its $200 million per year intelligent transportation system (ITS) budget on ACN, a figure less than 0.01% of the $38 billion annual DOT budget, yet motor vehicle crashes account for more than 90% of the nation's transportation safety problems. And DOT regularly states that safety is its highest priority. A substantial increase in funding and leadership are needed to build a national ALS that will result in a safer America.

Meanwhile, the emergency medical community must continuously improve its ability to deliver care. ACN technology provides an opportunity and a mechanism to make a quantum leap forward in this arena, but we need the emergency medical and scientific infrastructure to produce the fullest lifesaving potential of this technology. With a medically directed national program of RDT&E, we can improve the nation's emergency medical infrastructure to use these technologies to deliver definitive care. As we do so, we will create a research mechanism for continuous improvement of emergency medical care in its broadest sense.

## Potential Benefits

The European community's ITS organization, ERTICO, in its "Twenty-year Vision for Europe," estimates that in-vehicle automatic emergency call systems will result in a 15% increase in survival rates.[13] The U.S. Highway Administration cites a study[14] performed by a European consortium (including Mercedes-Benz) that estimated a 43% reduction in response times and a 12% increase in the chance of survival for a crash occupant using ACN technologies.

Furthermore, the benefits of ACN technology to the public will be much broader and greater than just improving care for crash victims. This technology also offers the opportunity to provide better emergency medical care for all health problems that arise away from home. For example, when cars are so equipped, citizens (for themselves or as Good Samaritans) will be able to make emergency calls for such incidents as heart attacks, strokes, and injuries from falls and other causes—even crimes.

## Wireless Communications Advances

The wireless communications industry currently transmits more than 83,000 emergency 9-1-1 calls each day without automatic location information embedded in the call. This flood is creating a problem for emergency responders who do not know where the callers are. This problem, too, will be reduced as cellular call location technologies are deployed during the next few years as part of the process of building a safer America.[15]

The ability to make instantaneous wireless calls for emergency help with automatic location has been identified in market research, both by the auto industry and the cellular industry, as products and services the public is willing to pay for as consumers. One market research study found that 48% of car buyers said that automatic dial 9-1-1 safety equipment would be important or very important in their purchase decisions.[16] More recently, a Louis Harris poll[17] for Advocates for Auto and Highway Safety found 68% of respondents would like to have such safety equipment in their cars.

GM now offers OnStar equipment ($1300 value) and installation at no extra charge on every new Buick model under the advertisement headline: "You can't put a price tag on security. So we didn't." However, GM does require a 1-year prepaid OnStar subscription and cellular service.[18] However, GM's OnStar currently provides ACN only to a third party, private call center that then calls for public 9-1-1 rescue service and is limited to only those crashes in which an airbag deploys (primarily frontal, not rollovers, side, or rear impacts).

The more advanced ACN safety equipment provided by Calspan that covers all crash modes currently costs about $400 installed in low volume production. This technology would cost much less in high volume production. According to Calspan and government estimates, the cost of the system is estimated at between $200 and $300.[19] Moreover, the cost of electronics equipment is dropping fast as the technologies develop and production volumes increase.

Government is beginning to become involved. The National Transportation Safety Board (NTSB) has made three particular recommendations that will help build the ALS and a safer America:

- To the NHTSA:

  H-97-18: "Develop and implement, in conjunction with the domestic and international automobile manufacturers, a plan to gather better information on crash pulses and other crash parameters in actual crashes, utilizing current or augmented crash sensing and recording devices"[24]

- To domestic and international automobile manufacturers:

  H-97-21: "Develop and implement, in conjunction with the NHTSA, a plan to gather better information on crash pulses and other crash parameters in actual crashes, utilizing current or augmented crash sensing and recording devices"[24]

- To the governors and legislative leaders of the 50 states and U.S. territories and the mayor and chairperson of the Council of the District of Columbia:

  H-96-13: "Emphasize the importance of transporting children in the back seat of passenger vehicles through educational materials disseminated by the state. Consider setting aside 1-10th of 1% from all motor vehicle insurance premiums for policies written to establish a highway safety fund to be used for this and other safety efforts (urgent)"[24]

The first two are on the NTSB's list of "Most Wanted Transportation Safety Improvements," the third recommendation, if and when implemented, would generate about $100 million per year for state highway safety efforts. These funds could be used to organize the ALS in each state.

Time may be of the essence, but it's not just a matter of time before we have the safety benefits of these new technologies. It's also a matter of how many avoidable tragedies the nation must experience before the ALS is built and working. Building a safer America is a matter of time, money, public policy, political leadership, and, most importantly, people's lives.

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