White Papers for: *"Toward Zero Deaths: A National Strategy on Highway Safety"*

—White Paper No. 7 —

Emergency Medical Services (EMS)

Prepared by:

Nadine Levick MD, MPH.

New York, USA

Under Subcontract to:

Vanasse Hangen Brustlin, Inc.

Prepared for:

Federal Highway Administration

Office of Safety

Under:

Contract DTFH61-05-D-00024

Task Order T-10-001

July 8, 2010

NOTICE

Distributed by the EMS Safety Foundation

EMSSafety FOUNDATION
Innovation, Collaboration & Knowledge Transfer
www.EMSSafetyFoundation.org

PREFACE

While many highway safety stakeholder organizations have their own strategic highway safety plans, there is not a singular strategy that unites all of these common efforts. FHWA began the dialogue towards creating a national strategic highway safety plan at a workshop in Savannah, Georgia, on September 2-3, 2009. The majority of participants expressed that there should be a highway safety vision to which the nation aspire, even if at that point in the process it was not clear how or when it could be realized. The Savannah group concluded that the elimination of highway deaths is the appropriate goal, as even one death is unacceptable. With this input from over 70 workshop participants and further discussions with the Steering Committee following the workshop, the name of this effort became "Toward Zero Deaths: A National Strategy on Highway Safety." The National Strategy on Highway Safety is to be data-driven and incorporate education, enforcement, engineering, and emergency medical services. It can be used as a guide and framework by safety stakeholder organizations to enhance current national, state, and local safety planning and implementation efforts.

One of the initial efforts in the process for developing a National Strategy on Highway Safety is the preparation of white papers that highlight the key issue areas that may be addressed as part of the process for developing a National Strategy on Highway Safety. Vanasse Hangen Brustlin was awarded a task order under the Office of Safety contract (DTFH61-05-D-00024) to prepare nine white papers on the following topics:

1. Future View of Transportation: Implications for Safety
2. Safety Culture
3. Safer Drivers
4. Safer Vehicles
5. Safer Vulnerable Users
6. Safer Infrastructure
7. Emergency Medical Services
8. Data Systems and Analysis Tools
9. Lessons Learned from Other Countries

Experts in these areas were retained to prepare these papers. The authors were challenged to be thought provoking and offer strategies and initiatives that, if implemented, would move the country towards zero deaths.

In this paper, Dr. Nadine Levick, noted international Emergency Medical Services (EMS) safety expert, examines strategies to enhance the effectiveness of EMS in highway safety, and what changes, technologies and innovations can guide the further development of the EMS role in highway safety. This is an initial draft that may be modified based on comments from FHWA and its partner stakeholders and a workshop to be held in Washington, D.C. on August 3-4, 2010.

Table of Contents

GLOSSARY

Many readers in the highway safety area may not be familiar with terms frequently used in discussions and writings related to Emergency Medical Services, so what follows are working definitions of terms that will be used in this paper:

Emergency Medical Services (EMS) - Emergency medical services are the responses and activities dedicated to providing out-of-hospital medical care and/or transportation to definitive medical care, to patients with illnesses and injuries.

NHTSA Office of EMS – The National Highway Traffic Safety Administration (NHTSA) DOT Office for management of EMS programs, national grants and relevant policy.

National EMS Advisory Council (NEMSAC) – NEMSAC formed in 2007, as a nationally recognized council of EMS representatives and consumers to provide advice and recommendations regarding EMS to NHTSA.

Federal Interagency Committee on Emergency Medical Services (FICEMS) – FICEMS was established by the 2005 SAFETEA-LU legislation. It is an interagency congressionally mandated committee, bridging the Secretaries of Transportation, Health and Human Services, and Homeland Security with NHTSA providing administrative support.

Ambulance – An emergency vehicle providing patient care and or transport. A spectrum of definitions depending on source.

Ambulette – A vehicle for transporting patients, either recumbent or seated, currently not part of the 911 emergency response system.

Emergency Response Mode – An emergency vehicle proceeding with emergency warning lights and within an emergency response operational protocol.

Helicopter EMS (HEMS) — Helicopter EMS, usually a dedicated rotary wing helicopter ambulance.

Basic Life Support - A level of medical care provided by prehospital emergency medical services. Basic life support consists of essential non-invasive life-saving procedures, such as CPR, bleeding control, splinting broken bones, and basic airway management.

Advanced Life Support - A level of care provided by prehospital emergency medical services. Advanced life support consists of invasive life-saving procedures including advanced airway adjuncts, intravenous infusions, manual defibrillation, electrocardiogram interpretation

National EMS Information System (NEMSIS) - A system to provide the framework for collecting, storing, and sharing standardized EMS data from States nationwide.

Public Safety Answering Point (PSAP) – 911 Call center.

Enhanced 911 (E-911) – Telecommunications based system that automatically associates a physical address with the calling party's telephone number, and routes the call to the most appropriate Public Safety Answering Point (PSAP) for that address.

Next Generation 911 (NG-911) - Initiative aimed at updating the 911 service infrastructure in the US to improve public emergency communications services in a wireless mobile society, to enable the public to transmit text, images, video and data to the 911 center.

INTRODUCTION

To quote the Honorable Robert L. Sumwalt, III, Board Member of the National Transportation Safety Board (NTSB), in his comments October 5th 2009 to the American College of Emergency Physicians Annual Convention 2009 in Boston when speaking on air medical services - "There are several standards to which every EMS operation can hold itself. 'Standard practices' are the bare minimum, embodied in the Helicopter EMS industry by mandatory compliance with the Federal Aviation Regulations, 'Best practices' go further, effectively managing recognized challenges, threats and risks. 'World class' standards are the most stringent and proactive, positioning an organization well ahead of future challenges, threats and risks. Toward which standard do you want your operation to strive?". The goal of this paper is to do exactly what that comment inspires, to strive to be ahead of future challenges, as applied to the Emergency Medical Services (EMS) system and its interaction with highway safety. The focus is to identify and manage recognized challenges threats and risks and to effectively position EMS well ahead of future challenges, threats and risks so as to achieve the most optimal outcome for highway transportation safety. As per The Safe, Accountable, Flexible and Efficient Transportation Equity Act: A legacy for Users (SAFETEA-LU), the National Strategy on Highway Safety is to be data-driven and incorporate education, enforcement, engineering, and emergency medical services. The EMS system is a key element of these highway safety 4 E's, and it is also a complex system largely outside of routine transportation realms. The recommendations made towards EMS systems and operations by the National Academies, Institute of Medicine [1] and the NTSB [2, 3, 4] in recent years outline valuable steps forwards towards advancing EMS system infrastructure and its capacity to respond optimally to highway safety. EMS bridges diverse elements of emergency health care, air and ground transportation, IT and communications, rural and urban environments, volunteer and career providers. EMS is public health, public safety, and acute and emergency medical care. This White Paper addresses the key EMS and highway safety issues of bridging Stakeholders, improving data capture and linkage, effective measures of system performance, rationalization of resources, Federal oversight, ground air integration, fleet mix and the cutting edge of technology.

The desired outcome of Towards Zero Death (TZD) is a more efficient, effective and safe EMS system, optimizing the EMS and highway safety interface, to provide better highway transport safety outcomes.

Broad strategies to pursue to achieve this vision:

- Bridging stakeholders and the involvement of EMS in highway safety platforms.
- Determine and apply outcomes based measures of EMS system performance.
- Rationalize EMS systems for optimal and appropriate provision of services based on need.
- Enhance the transportation design and oversight dimensions of EMS systems.
- Integrate and optimize communications and transportation technologies into the EMS system.

BACKGROUND - EMS AND HIGHWAY SAFETY

The EMS System is an approximately $8 billion dollar industry and currently responds to 1.6 million traffic injury crashes and 2.3 million injured people per year. These crashes result in approximately 37,000 traffic related fatalities [5], 60percent of these fatalities are in rural areas where only 20 percent of the nation's population lives[1, 6] (See Figure 1). Ambulances transport approximately 30 million patients each year to the nations Emergency Departments (EDs). However, what presents as somewhat unexpected to the transportation audience is that the vast majority of EMS transports (approximately 97percent) [7] are benign non-critical transports, and are not life threatening or critical emergency situations. Fewer than 8percent of all EMS responses are for traffic crashes (motor vehicle, motorcycle and pedestrians) according to National EMS Information Systems (NEMSIS) [8]. The nations EDs treat about 120 million patients a year in all [9], of which 30 million are injuries, and traffic injuries make up about 10percent of all injuries treated in EDs. These traffic injury patients are a very heterogeneous group. Not only are they different ages, from different geographic regions, but also, diverse acuity or severity and nature of injury. The majority of which are not critically injured. Importantly, only in less than 1 percent of traffic crash related ambulance transports to the ED is the patient identified as requiring critical care or intensive care admission in NEMSIS [8]. Furthermore, in addition to the 2.3 million traffic injury transports, EMS also responds to traffic crashes with no injury and also when there is no transport. Based on current sample data [8], estimates of rates of refusal of EMS medical aid at traffic crash scenes are greater than 20percent of all ambulance traffic crash responses.

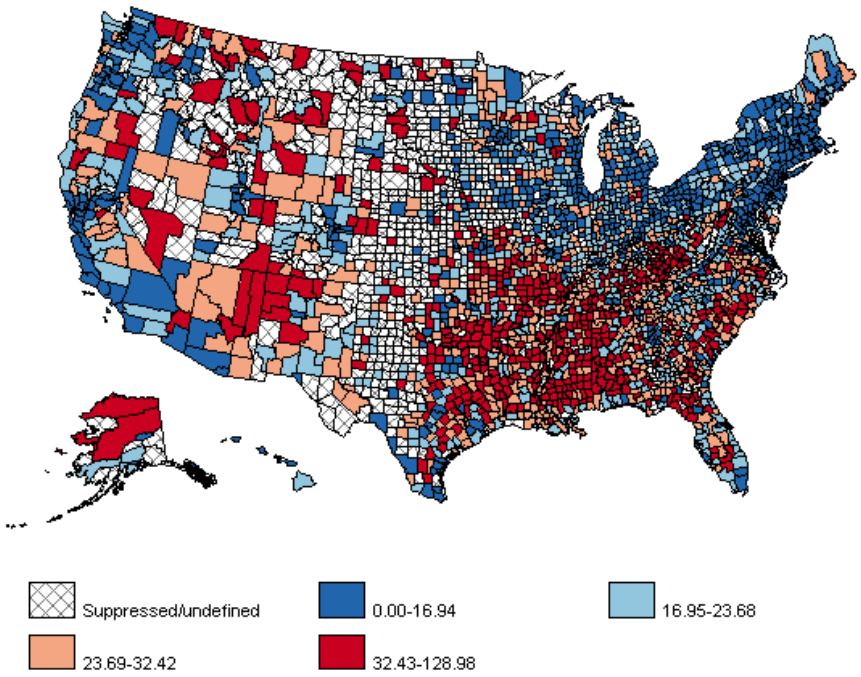


Figure 1. 2000-2006 Traffic Death Rates/100,000 population, for all ages, both sexes and all races. Source: – Produced by the Office of Statistics and Programming, National Center for Injury Prevention and Control, CDC.

There are a number of interfaces EMS has with highway safety in addition to traffic crash responses including road safety promotion and management, and the safety of the EMS response system itself.

So as to optimally discuss the scope, challenges and opportunities for enhancing the EMS role in highway safety, it is first important to give an overview of the EMS system as a whole, and its complexities - its operation and oversight across the nation. It is also important to understand that the EMS system is a relatively new system. This is in contrast to other arms of public safety or public health. However, what is probably the most key concept, is that EMS is an acute health care delivery system. It is there to care for illness and injury, more accurately it is there to care for people. Thus the two really key issues for this White Paper really are: Where are these people? and what is needed to provide the care to them that is essential? Over recent years there have been a number of major advances to enhancing the oversight and operation of the EMS system across the nation in many of the dimensions addressed in this White Paper. A number of the landmark documents and some of the more key infrastructure referred to here have been written or established only over the past five years. A key document that comprehensively focuses on the challenges and opportunities of the EMS system's operations is the National Academies Institute of Medicine's 2007 publication 'Emergency Medical Services: At the Crossroads'[1]. Their recommendations have far reaching insight into addressing the strengths and weaknesses of the current EMS system, though too have more emphasis on the clinical, IT, communications and workforce issues, in contrast to the transportation system and its integration.

So what is EMS? As per NHTSA EMS Office (www.EMS.gov) "EMS, is a system that provides emergency medical care. It is activated by a call for help, after an incident of serious illness or injury. The focus of EMS is emergency medical care of the patient(s). It is a system of coordinated response and emergency medical care, involving multiple people and agencies. EMS is an intricate system, with each component having an essential role as part of a coordinated and seamless system of emergency medical care. EMS includes all of the following components:

- Agencies and organizations (both private and public).
- Communication and transportation networks.
- Trauma systems, hospitals, specialty care centers and rehabilitation facilities.
- Trained professionals, including:
    - volunteer and career prehospital EMS personnel, BLS and ALS.
    - physicians, nurses, and therapists.
    - administrators and government officials.
    - an informed public that knows what to do in a medical emergency."

However, despite this organized diagram below (Figure 2), the EMS system is a complex system with disparate oversight, and many challenges and obstacles to optimal performance. As stated in the National Academies 2007 Cross Roads Report [1], "Despite the lifesaving feats performed every day by emergency departments and ambulance services, the nation's emergency medical system as a whole is overburdened, underfunded, and highly fragmented. As a result,

ambulances are turned away from emergency departments once every minute on average and patients in many areas may wait hours or even days for a hospital bed. Moreover, the system is

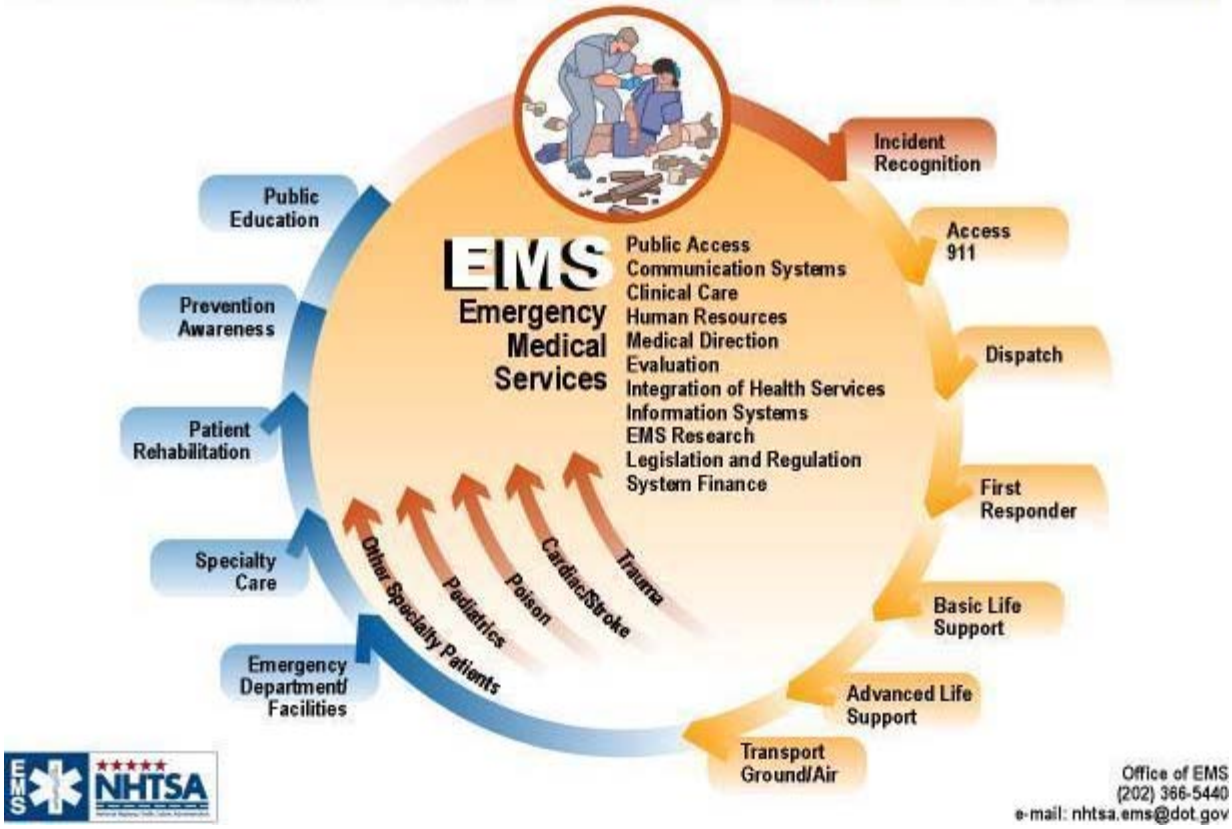


Figure 2: Diagram describing the EMS system (NHTSA EMS).

ill-prepared to handle surges from disasters…"[1]. Ambulance diversion for all ambulance arrivals is a reality for many emergency departments, and for the ambulances bringing patients to them and most importantly for the patients involved, across the US.

There is limited scientific data to support specifically the effectiveness of the EMS system in the setting of road safety, though studies have demonstrated associations with improved trauma outcomes with the establishment of regional trauma systems generally [6,10]. Disaggregating the impact of skilled and trained hospital trauma systems from the specifics of EMS response is challenging. [11] The EMS system overall is fragmented both in its oversight and its management, locally, regionally and nationally and also across agencies. The Federal Interagency Committee on Emergency Medical Services (FICEMS) established by SAFETEA-LU 2005 legislation, is a major step forwards to aligning the diverse agencies involved in EMS and highway safety. However, as well as fragmented, oversight remains complex, and it is also disparate across the nation. There is limited interstate and intrastate coordination, and often even no local coordination. The DOT NHTSA EMS Office is a compact office with limited resources for system oversight. The DOT NHTSA EMS Office has been strongly focused on programmatic approaches to addressing the key issues identified in the 'EMS Agenda for the Future' [12] with major developments in the 14 attributes identified in that blueprint. State EMS Offices oversee regional provider and service certification and have variable oversight on system performance

issues. The EMS systems are disparate in their structure, some EMS systems are under the control of the Fire Department (an increasing trend particularly in major urban areas), for others it is free standing EMS municipal or county driven, private or hospital run and some are mixed. Furthermore oversight is skewed primarily to clinical training and response times, and not directly patient outcomes or transportation systems operation. EMS has made some major advances in recent years to address these major challenges with developments to improve communications, interdisciplinary collaboration, the determination of performance measures and data capture. These include: 'enhanced 911' [13] and 'next generation 911'[14], and establishment of the National EMS Advisory Council (NEMSAC) and infrastructure such as the Transportation Safety Advancement Group (TSAG), platforms such as the National Academies Transportation Research Boards (TRB) EMS Safety Subcommittee, ANB10(5), programs addressing national data capture issues such as the comprehensive NEMSIS, and most recently the NHTSA recommended attributes and indicators for EMS system and service performance [15]. (See http://www.nasemso.org/Projects/PerformanceMeasures/documents/EMSPerformanceMeasuresDec2009.pdf for more information.) However, as outlined at the TRB Ambulance Transport Safety Summits in 2008 and 2009, nationwide fundamental systems operational and performance data for EMS are still currently lacking [16]. There is no initiative in place to identify the total number of EMS runs, a profile of the EMS fleet nationally, the nature and severity of the patients transported, the miles traveled and on which type of roads and regions throughout the nation. The NEMSIS program [8] and the recently published EMS performance measures [15] are a major step forwards towards capturing national EMS system data. Importantly, though, at present there exists no meaningful national data to address the aforementioned parameters.

It is even challenging to get precision for the data that are captured and published by the federal agencies, to try to clarify which highway traffic victims are identified as being injured, and in need of emergency care and transport. Table 1 compares 2007 and 2008 CDC traffic crash injury and fatality data captured via WISQARS[17] with , NHTSA published data from Traffic Safety Facts 2007 & 2008[5]. It is impossible, thus to have clear idea of the burden of the problem in this setting. No criticism is implied; the discrepancy below is noted to point out the challenges with our data systems to adequately identify with precision the scope of the problem, and to determine effective resource allocation, or best understand paths for alternate means of transportation. As has been well described, there are limitations with police report data, particularly in terms of injury determination. Sampling systems such used by NHTSA's NASS/CDS/GES also are stronger in some areas than others.

Table 1. A comparison of 2007 and 2008 CDC and NHTSA traffic crash injury and fatality data.,

Traffic Crash Data	CDC Traffic Injuries		CDC Traffic Fatalities	NHTSA Traffic Injuries		NHTSA Traffic Fatalities	
	2007	2008	2007	2007	2008	2007	2008
Motor Vehicle Occupant	2,661,379	2,587,242	16,560	2,264,000	2,120,000	30,527	26,698
Motorcyclist	288,379	271,102	4,889	103,000	96,000	5,174	5,290
Pedalcyclist	211,366	203,889	578	43,000	52,000	698	716
Pedestrian	122,076	196,991	4,820	70,000	69,000	4,699	4,378
Other/unknown	93,968	73,398	15,178	10,000	9,000	152	188
Total	**3,377,168**	**3,332,622**	**42,031**	**2,491,000**	**2,346,000**	**41,059**	**37,261**

It has also been demonstrated that EMS ground vehicles are hazardous in their interaction with the transport environment, with high crash rates for the EMS vehicles themselves and poor safety performance, resulting in a high rate of EMS crashes both per vehicle and miles traveled for ground ambulance vehicles [18, 19, 20, 21]. This is also in the setting of technical publications [22,23,24] and also the aforementioned TRB Summits [16] outlining strategies to improve the safety of EMS ground ambulance fleets. There has also been recent focus on the system safety of the current utilization of air medical services [3,4], as has been seen with the recent 2009 NTSB hearings, and recommendations for improving air medical transport safety [4] (See http://www.ntsb.gov/Publictn/2009/AB09-HEMS.htm for more information). These adverse EMS transport events, in addition to the direct impact on those involved, have a serious negative impact on the efficiency of the delivery of EMS care, particularly in rural settings and even also in the urban environment [25]. Furthermore, comprehensive 'risk versus benefit' analyses of such transportation safety challenges are lacking. Very recently published data strongly challenge the concept of the 'Golden Hour'. Current evidenced based science no longer supports the concept of the 'Golden Hour' for all trauma patients, and less so for patients with blunt trauma, given the inherent transport risks in emergency response mode transports [26,27,28].

Regarding the oversight of both air and ground EMS, it is key to appreciate that there is also no national oversight of the integration of these two systems. Helicopter EMS (HEMS) are required to comply with Federal Aviation Regulations. Ground ambulances are however exempt from Federal Motor Carrier Safety Administration (FMCSA) oversight. The ground services are also a mix of paid career and volunteer services; the volunteer services are skewed to the rural settings. The rural regions are very dependent on both the volunteer services (the primary responders to rural and non urban highway road crashes), as well as air medical response for the more critical patients. Though concrete data are lacking, the EMS ground fleet nationally is made up of approximately 50,000 ground ambulance vehicles, performing approximately 30 million EMS transports annually. There is one ground patient transport fleet not currently part of the 911 EMS system, and that is the ambulette fleet. This is a very large fleet of patient transport vehicles in the US that is transporting an order of magnitude more patients than EMS transport, though non acute patients, to hospitals and clinics. There are now also approximately 1200 rotary and fixed

wing aircraft (867 Rotor wing, 309 fixed wing) [29], performing approximately 400,000 transports annually [4]. The air medical fleet is largely state of the art, paid career staffed and operated and primarily hospital or privately based, and with some HEMS within municipal services. In the current financial structure, HEMS transports are fiscally lucrative. There has been a major surge in the number of HEMS services established and rotary wing air craft deployed in recent years, as well as the aforementioned focus recently on safety issues.

In contrast to the sophistication of HEMS aircraft, the fundamental design of ground ambulances has not changed since the 1960's, even despite NTSB recommendations regarding ambulance vehicle design safety hazards in 1979 [30]. Also many ground ambulance services are volunteer operated, and operations are not lucrative. Dispatch methodology of these ground ambulance response vehicles across the USA is disparate, some sites using a standardized scientifically derived priority dispatch system, other sites, and even major sites, using a self derived system, and some other sites using virtually no system of priority dispatch. The air medical systems are disparately integrated with the overall EMS system with their dispatch approaches differing across the nation. Given this infrastructure, coordinating EMS response to reach rural regions remains a constant challenge. Identifying that the crash event has occurred, and getting EMS resources to and from the scene in sparsely populated areas have substantive challenges. These are challenges for which there has been some intensive recent focus. The Utah, Mexican Hat bus crash [2] was a rural/remote bus crash event that resulted in some sharp focus on the effectiveness of EMS systems in the non-urban regions. (See http://www.ntsb.gov/publictn/2009/HAR0901.pdf for more information). Risk factors for adverse highway safety outcomes and EMS delay that negatively impacted outcome outlined in that report highlight, some key areas relevant to the strategies outlined in this white paper:

- Rural versus Urban EMS Response.
- AASHTO Strategic Highway Safety Plan (goal #20), Enhancing Emergency Medical Capabilities to Increase Survivability.
- Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), High-Risk Rural Roads and 4 E's including EMS.
- Emergency Notification and Response.
- Enhanced 911.
- EMS Federal Oversight.
- Recommendations to FICEMS.

Additionally these rural settings are environments where driver inattention and drowsiness as well as speed are often involved. The latter increasing the energy transfer in the crash, and thus increasing the likelihood of serious injury risk. However the issues of EMS response delay are not limited to rural settings, and have also challenges in the more densely populated urban areas. Ambulance response delays specifically to traffic crashes were demonstrated to be strongly correlated to increasing urban sprawl [31].

There are also now technologies in passenger vehicles that automatically trigger an EMS response after a passenger vehicle crash, 'Advanced Automatic Crash Notification (AACN) vehicle telematics system for automatic crash notification [32]. However there remains limited

science to demonstrate that this has any true positive impact on crash survivability or minimization of the road trauma statistics. There is also currently no data to make it possible to assess if this automatic crash notification approach is resulting in further inappropriate prioritized dispatch of ambulances to crash scenes where there is either no transport, or only minor injury. Additionally it is not clear if AACN systems also skew the EMS response to the more modern (and likely safer more crashworthy) vehicles with these systems in place, and thus diverting resources away from the older and less crashworthy vehicles without AACN. Interestingly with the advent of exponentially advanced smart phone platforms which include accelerometers, it is now possible to have applications for personal cell phone devices which capture some vehicle crash data and communicate alerts with emergency services automatically. The evidence for the optimal pathway to utilize or implement these technologies is very important to collect, so that the EMS system can be most effectively triggered so as to provide the best service for those for whom rapid EMS response will have a positive impact on outcome. A real challenge that could have a major impact on enhancing the effectiveness of EMS highway response would be an understanding of exactly what acute care services were required by which highway traffic victims, and to provide those services appropriately. Clearly if >20percent of traffic victims refuse ambulance transport, and fewer than 1percent require critical care admission, and a large portion are discharged home from the emergency department – then there is a role to have a low acuity transport system in place to address these low acuity patient groups.

What is clear is that transportation and automotive expertise components of the EMS system have to date had a relatively minimal focus in contrast to the clinical aspects of EMS. To address these EMS performance issues there remain some major challenges. These include the lack of a uniform Federal oversight of EMS, data capture challenges and bridging silos to harness existing platforms to address systems issues, as well as limited legislation incentives or outcomes based tools to assist in optimizing system performance. More efficient EMS systems, reach more patients for less cost, and provide an enhanced and data driven approach to nature and quality of care. Such systems also improve both access and quality of care delivery to the more rural and non urban areas as well as to the urban sprawl, by a more equitable and resource demand driven allocation of resources.

Thus the paradigm of the majority of EMS runs being for life threatening events is a fallacy, the data demonstrate that it is quite the reverse. Furthermore, that the majority of highway trauma requires an emergent response is also far from reality, when for almost a quarter of EMS runs for traffic crashes there is a refusal of medical care and/or transport by the victims, and that fewer than one in a hundred transports require critical care hospital services. So the challenge here is how to best optimize the EMS system to address this small cohort of critical patients to provide the emergent EMS care that is needed to decrease the number of traffic related deaths.

Desired Outcome - The goal is a more efficient, effective and safe EMS system - and optimizing the EMS and highway safety interface, to provide better highway transport safety outcomes.

The objectives identified for creating a more robust and comprehensive EMS system, and to enhance highway safety outcomes are to:

- Identify the broad base of stake holders and facilitate bridging the silos of operational practice of EMS to include transportation and highway safety expertise.

- Promote the involvement of EMS decision makers in highway safety platforms.
- Improve data capture, data sharing and data analysis.
- Determine and apply meaningful measures of EMS systems performance with respect to highway safety.
- Ensure appropriate rationalization of services and resources to meet the needs of all traffic crash victims.
- Incorporate evidence based systems approaches to optimize EMS system performance.
- Seamlessly integrate ground and air EMS transport and response to highway safety.
- Encourage and facilitate the establishment of a federal office of EMS for seamless system performance oversight.
- Advance ground ambulance vehicle and fleet transport safety design and development.
- Optimize the ongoing integration of effective communications and transportation technologies into the EMS system.

STRATEGIES

The five broad strategies to pursue to achieve this vision are:

1. Bridging stakeholders and the involvement of EMS in highway safety platforms.
2. Determine and apply outcomes based measures of EMS system performance.
3. Enhance the transportation design and oversight dimensions of EMS systems.
4. Rationalize EMS systems for optimal and appropriate provision of services based on need.
5. Integrate and optimize communications and transportation technologies in EMS systems.

The following are some possible initiatives that build on current safety foundation, to achieve these 5 strategies:

- Utilize the Strategic Highway Safety Plans as a tool to facilitate integration of EMS operations with highway safety
- Strengthen interdisciplinary communication and collaboration between EMS and highway safety
- Facilitate optimal methods for effective capture of denominator data on EMS systems operations
- Remove obstacles to systems safety and performance oversight of EMS systems
- Establishment of a federal office of EMS to facilitate oversight of the EMS system
- Encourage evidenced based analysis, practices and dispatch systems to enhance EMS responses

- Structured approach and rationalization to address the regional challenges of rural highway EMS needs
- Focus on patient, provider and public safety outcomes driven EMS performance measures
- Enhancing the design of egress to hospitals and appropriate traffic and roadside design in the approach to hospitals, and on high risk highway areas
- Integrate air and ground EMS response in the highway safety setting, including structured evidence based protocols that effectively address risk versus benefit
- Rationalize the EMS fleet mix and optimize the EMS fleet to be efficient, safe vehicles that facilitate patient care and transport
- Implement incentives, grants and other benefits for the utilization of evidenced based enhancements to EMS systems, fleets or fleet operations
- Facilitate the integration of state of the art communications and transportation safety technologies

BRIDGING STAKEHOLDERS AND THE INVOLVEMENT OF EMS IN HIGHWAY SAFETY PLATFORMS

Identifying Relevant Partners

A key first step is to identify all the stakeholders relevant to bridging EMS and transportation and highway safety. Historically, though overseen by the EMS office at NHTSA, rather than under the umbrella of public health, EMS has been health care focused. The "EMS Agenda for the Future" identified 14 EMS attributes as requiring continued development in order to realize the vision established within the Agenda [12]. They are Integration of Health Services, EMS Research, Legislation and Regulation, System Finance, Human Resources, Medical Direction, Education Systems, Public Education, Prevention, Public Access, Communication Systems, Clinical Care, Information Systems, and Evaluation. Interestingly the identified key partners suggested by the EMS Agenda for the Future were the following: Managed Care Industry, Fire Service, Ambulance Industry, Academic Medical/Institution Research, Consumer, Economist, Physician, State EMS Director, Elected Leader, Public Health Agent, Education Specialist and Communications Expert. However EMS is an acute health care system on wheels, it is a transportation system in of itself, in addition to it being a key element in the highway safety system. It is important that highway safety, transportation systems and systems safety expertise be embraced as key partners in this approach, as well as a structured integration of air medical services. It is also important to appreciate that EMS might substantially benefit from functioning as a mobile system under the Public Health umbrella, rather than being limited to being part of public safety. The focus is ideally getting the right patient to the right care in the right place at the right time. There are now a number of transportation focused EMS groups both governmental and non-governmental. The Transportation Safety Advancement Group, (TSAG) [33] on behalf of The Research and Innovative Technology Administration (RITA) [34] coordinates the U.S.

Department of Transportation's (DOT) research programs and the TRB EMS Subcommittee that bridge the relevant EMS and highway safety key stakeholders. In addition there are organizations such as Advocates for EMS [35] which assist in facilitating the implementation of the activities and recommendations of such organizations.

Utilize the Strategic Highway Safety Plans as a Tool to Facilitate Integration of EMS Operations with Highway Safety

The Strategic Highway Safety Plans (SHSP) are also an excellent vehicle to facilitate bringing together the key stakeholders in EMS, highway safety, and transportation systems. Recent research identifies that this is an underutilized strategy [36]. This is a platform that could be of great value nationally for facilitating the integration for EMS with highway safety infrastructure. Ironically the physician organizations and associations that specifically represent EMS, historically and are currently largely outside of transportation infrastructure involvement and even awareness, with their primary focus being medical interventions and other systems issues. The EMT Associations in contrast are increasingly reaching out to expand their focus into transportation systems issues. SAFETEA-LU, mandates that each State have a SHSP, which is a data-driven, four to five year comprehensive plan that integrates the 4Es of highway safety: Engineering, Education, Enforcement and Emergency Medical Services (EMS). The 4th 'E' – EMS - is a relatively new player in the highway strategic arena. EMS systems and their operational design, challenges and lexicon are also new territory for highway safety professionals. Whilst the first three Es play a role in preventing or minimizing injury, once an injury occurs, EMS provides the last opportunity to improve health outcomes. As outlined on the background section, EMS are provided by a highly complex system with a goal for prompt notification of the location and severity of the crash, timely dispatch of trained providers of emergency care, use of evidence-based treatment protocols, and triage to an appropriate health care facility. EMS has historically also been less familiar and less often engaged in the SHSP process and in funding projects under the Highway Safety Improvement (HSIP) program. The SHSPs offer a unique platform to bridge this gap, to engage EMS, understand the EMS system and its key role in highway safety and also importantly to assist in funding relevant EMS projects. Counties with coordinated systems for trauma care have been shown to have crash fatality rates as much as 50percent lower than counties without trauma systems, though it is challenging to clarify all components driving such associations. Supporting a well functioning EMS system and engaging the State EMS Office and EMS systems in the SHSP process are key strategies for reducing highway fatalities and serious injuries on all public roads. Increasing the awareness and education about the importance and role of EMS in this process has now been underway at both a Highway and EMS level. The SHSP emphasizes a data-driven, strategic approach to improving highway safety that focuses on results and allows flexibility in funding projects such as EMS initiatives. Additionally, American Association of State Highway and Transportation Officials (AASHTO), Strategic Highway Safety Plan (goal #20), specifically focuses on Enhancing Emergency Medical Capabilities to Increase Survivability [36].

Strengthen Interdisciplinary Communication and Collaboration between EMS and Highway Safety

There has been a major move towards interdisciplinary communication and collaboration in the past five years, to bridge the EMS and highway safety communities. The SAFETEA-LU mandated establishment of FICEMS in 2005, which created a structured interdisciplinary interface for emergency services and other public and highway safety infrastructure. FICEMS has become a most valuable platform for enhancing the communication between EMS and highway safety, and it has become a formal pathway for recommendations from NTSB to be addressed [2]. TSAG, an assembly of multi-discipline professionals sharing a common concern for transportation and public safety, serves as a forum for providing technologies for public safety input and guidance to the US Department of Transportation, ITS Joint Program Office. TSAG's focus is to enhance traveler safety on our nation's roadways through the application of advanced technologies and the promotion of inter-discipline and inter-agency cooperation. TSAG identifies surface transportation-based technologies and applications and promotes a national dialogue on public safety practitioners' first hand experiences and corresponding best practices and lessons learned, and performs a knowledge transfer function on behalf of the ITS Joint Program Office. Increased awareness of programs such as TSAG within both the EMS and highway safety communities is of value so that there is optimal utilization of that infrastructure. The (TRB) which has a longstanding history of promoting and supporting interdisciplinary collaboration and knowledge transfer has provided impressive focus and resources toward strengthening the bridges and collaboration between EMS and highway safety. The TRB has created a subcommittee within ANB10, Transportation Safety Management, EMS Safety Subcommittee, ANB10(5), to address EMS and transport safety issues, and has held two interdisciplinary Summits, 2008 and 2009 [16] integrating these disciplines and exploring these highway safety and EMS issues.

Determine and Apply Outcomes Based Measures of EMS System Performance

Facilitate Optimal Methods for Effective Capture of Denominator Data on EMS Systems Operations

National data capture and sharing for EMS at many levels has challenges, with limited denominator and numerator data, and approximately 15,000 EMS services, ranging from urban to rural/remote, volunteer to paid, municipal to private, air and ground, and large to very small. Currently, highway safety data is captured via databases that do not capture effective EMS systems data, even the number of EMS vehicles, personnel and number of patients and runs nationally is not known with any precision. It is key that the databases that capture this information be developed in a manner where it is possible for there to be fluid data communication and effective database linkages. There have been a number of innovative developments in the past five years that have the potential to have substantial impact on this somewhat hazy issue of EMS system data capture and performance measures. The platforms that have been developed and established to address these areas are: the Crash Outcomes Data

Evaluation System (CODES) data linkage program [37], National EMS Information System (NEMSIS) [8] and the Emergency Medical Services Performance Measures [15]. These DOT NHTSA projects have opened a new era for capturing and managing data on EMS systems performance. The latter two projects are relatively new, and still at early stages of implementation and thus are still not yet implemented nationwide. The NEMSIS is the national repository that will be used to potentially store EMS data from every state in the nation. The need for EMS systems and patient information has been well established, and many statewide data systems have been created. However, these EMS systems vary in the structure and content of the information collected, making it difficult to compare information across agencies or states or aggregate at the national level. For this reason, the NEMSIS project was developed to help states collect more standardized elements and eventually submit the data to a national EMS database, and at the very least already provides a uniform data set of data elements that should be collected. NEMSIS NHTSA Version 2.2.1 Data Dictionary [38], is being used by the currently participating States. NEMSIS now has a public access data processing interface – so that the data that has been collected to date by NEMSIS can be sorted and analyzed by the public via the Cube online software [http://www.nemsis.org/dataCenter/dataReporting/nationalReports/dataQuerySystem.html.]. There is an extensive range of fields captured in that data set regarding EMS operational parameters. The Cube software provides filters to identify traffic accident, motorcycle, pedestrian and bicycle fields, and also levels of care and disposition, thus as this database expands and captures more representative data it will be a most valuable tool in better understanding the role of EMS and its interface with traffic crashes across the nation. The recent development of the 'Emergency Medical Services Performance Measures Recommended Attributes and Indicators for System and Service Performance' [15], is another recently developed and valuable tool, based on the healthcare performance indicator format developed by the Joint Commission on the Accreditation of Healthcare Organizations and utilizing the NHTSA EMS Prehospital Dataset (NHTSA E09-13). Indicators include fields such as:

- *"What are the mean (10.1) and 90th percentile (10.2) emergency patient response time intervals?*
- *What are the Rate of Injuries (16.3) and Deaths (16.4) because of EMS Crashes per 100,000 Fleet Miles?"*

The National EMS Assessment Project [39] is currently underway to conduct a preliminary assessment of the state of the nation's EMS systems using currently available data, and to identify key areas for which existing EMS data are insufficient for a meaningful analysis. The results of the assessment, gap analysis and recommendations for ongoing EMS assessment will be used by NHTSA to prepare a Report to Congress on the state of the Nation's EMS systems, on behalf of FICEMS, and to facilitate an eventual gap analysis. "NHTSA's National EMS Assessment Project objectives are to:

- understand what data are being collected at the state, regional, and national levels that pertain to EMS systems, EMS emergency preparedness, and 9-1-1 communications.
- assess the quality, availability, and comprehensiveness of the data on EMS systems that are currently being collected,
- identify significant areas for which assessment is not possible at this time, due to limitations in existing data,
- develop recommendations for a sustainable process to assess the nation's EMS system, and
- obtain a written report summarizing the current state of the nation's EMS system, including recommendations for future assessment efforts." [39]

The project allows for collection of data on all aspects of EMS systems from by-stander care and 911/emergency dispatch through prehospital care and transport to definitive care, and including EMS emergency preparedness. There also exist in the public domain some new and innovative models to address EMS system performance for which these data would be of great value.

Encourage Evidenced Based Analysis, Practices and Dispatch Systems to Enhance Effectiveness of EMS Responses

"Although it is acknowledged that timely transport is necessary for some patients, many have questioned the value of the range of prehospital care services currently provided. In the broader health care community, there is a persistent concern about the lack of proof of effectiveness related to most prehospital care. Most experts on both sides of the argument agree that methodologically sound outcomes research that identifies "what works" in prehospital care is long overdue" (NHTSA 2003) [40]. There exists evidence in the scientific and operational literature that there are measurable benefits in the effectiveness of an EMS system with the implementation of a structured tiered dispatch system. The recently published EMS Makes a Difference: Improved clinical outcomes and downstream health care savings', A Position Statement of the National EMS Advisory Council refers to these issues specifically [10]. This document specifically refers to the benefits of Regionalized Systems of Care: Trauma and Pediatric Shock, and qualifies that the success of regionalization is dependent on a well functioning EMS System to deliver the appropriate patients to the regional tertiary care centers. A recent study identified that the risk of death is considerably lower among trauma patients requiring early operative intervention if they are treated at a designated Level I trauma center. However, it also qualified that these outcomes are not a result of more rapid assessment and intervention alone, and emphasized the complex factors that contribute to the survival benefit of trauma center care which include experience [11].

Regarding dispatch systems, there are a number of proprietary systems that have been extensively evaluated in the field, based on resource utilization, patient outcomes and response times, with compelling findings for system efficiency and benefit. APCO, Medical Priority Dispatch System and Power Phone are the three dispatch systems identified specifically in the

Performance Measures document [15]. These dispatch systems, are in place in many parts of the USA and throughout the world. However, the use of such priority dispatch systems is not yet uniform across the USA, and there still remain many EMS services in the USA that have not yet adopted a validated dispatch systems and protocols. Facilitating the national adoption of the optimal and validated priority dispatch systems could enhance the effectiveness of EMS performance nationally.

Additionally, there is compelling data on the effectiveness of the implementation of operational fleet safety and performance technologies in EMS. Particularly, the in-vehicle telematics devices, which are increasing in their availability and application to EMS operations [22,23,24]. Such systems have the added benefit of augmenting system wide denominator data and can be applied to optimizing system performance for EMS systems. There are States that have incentivized the implementation of such systems in their EMS fleets given the evidenced based improvement on system performance and safety [22,24]. Also the development of networked touch screen technologies is rapidly accelerating, and data input in real time is becoming as simple as tapping the screen on an electronic touch tablet device connected to a network. The balance between quality national data and the challenges of privacy rights is a real issue in the US that to some degree compounds implementation.

Additionally, there are some traffic management technologies that have shown some initial possible benefit, such as the intersection signal technologies that give right of way to emergency vehicles. However it is difficult to ascertain from the studies if the effect demonstrated in the studies was specifically related to the device or some other system wide confounder [41]. And importantly, there is a very real concern that such devices 'train' emergency responders to anticipate that the light will change for them – which may be hazardous should the system not be in place uniformly. Of even greater concern, emergency vehicles, police fire and ambulances are often approaching an emergency scene from a number of different directions. Thus it is possible that this type of technology could result in an increase in emergency vehicle to emergency vehicle intersection crashes. This effect has been noted in recent circumstances in regions with this type of technology implemented. This is an important concern, as not only does it result in a direct negative impact on the specific emergency situation involved, it also creates a substantial negative impact on the emergency response system as a whole given the indirect impacts of such a crash. There are a number of validated tools that exist to address performance measurement for EMS systems, in addition to the existing evidenced based practices utilized currently in EMS, that have sound scientific bases to drive operational practice. There are also some promising newer models to measure the effectiveness of EMS system performance and the others can be applied to enhance the system performance of EMS. Data Envelopment Analysis methodology has recently been demonstrated to be a valuable tool in Europe for analysis of the effectiveness of EMS Trauma Systems. In their 2010 paper, Evaluating Trauma Management Performance in Europe [42]- a methodology is described to evaluate the performance of trauma systems and EMS Resource allocation. The Data Envelopment Analysis approach, utilizes parameters such as

the number of EMS Stations/10,000 citizens, 100 km rural road length and 1000 km2 area, number of Staff/number of EMS Transportation Units, 10,000 citizens and 100 km rural road length and 1000 km2 area and EMS response times related to similar parameters as outlined in Figure 3) Application of a system such as this would support the appropriate rationalization of the scarce resource of EMS to ensure that areas of need have essential services and optimal trauma outcomes. Application of models such as this, to the USA environment is now increasingly feasible given the advancement of the NEMSIS and other data platforms.

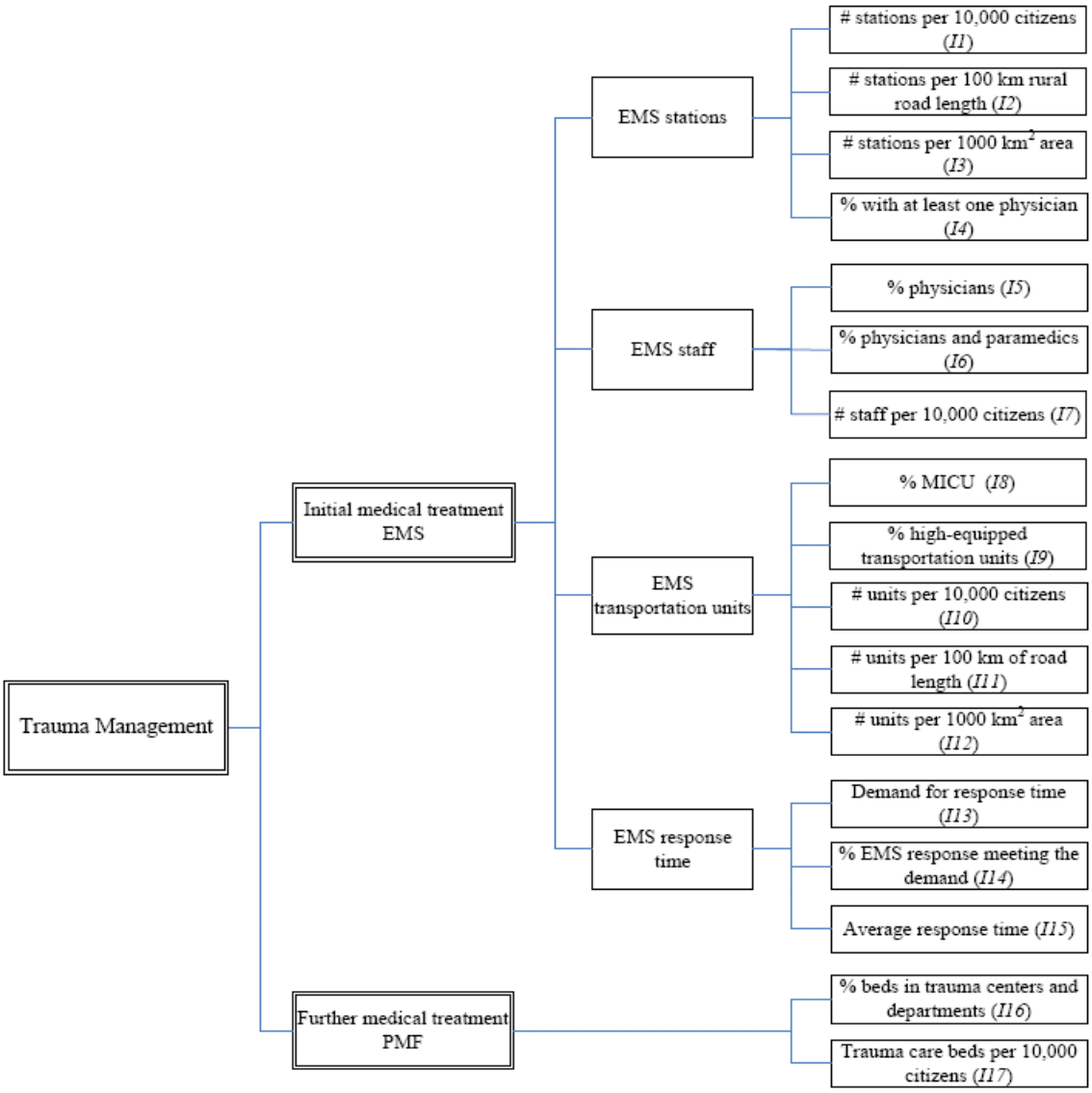


Figure 3. Hierarchical framework of trauma management performance indicators.
Source: Brijs, TRB 2010 [43].

Focus on Patient, Provider and Public Safety Outcomes Driven EMS Performance Measures

In stark contrast to hospital emergency care, EMS responses are an acute health care delivery environment where the safety of the patient, the provider and the public all need to be considered as part of the one system of safety. Much of health care is focused primarily solely on patient safety. In the realm of automotive and transport safety, and providers and patients sharing an operational environment occurring as part of transportation are somewhat unique. Thus EMS has a special balance of risk to consider that is unique to EMS operations. Ground ambulances are involved in approximately 10,000 crashes annually, with high crash, injury and fatality rates both per vehicle and per mile traveled. Two thirds of the fatalities were not in the ambulance vehicle and involved another vehicle or pedestrian unrelated to the EMS transport [16,20.21]. Fatal Analysis Reporting System (FARS) data show that intersections are over represented in the urban setting for fatal ambulance crashes, as is emergency response mode driving [43,44,45]. Published reports identify the rear compartment of the ambulance vehicle as a hazardous occupant environment, exempt from many FMVSS standards, are built outside of the accepted automotive safety and occupant protection infrastructure, and are not currently required to undergo occupant protection safety testing [46-50]. Decisions to drive with emergency response mode driving, to traverse intersections against traffic signals and to be unrestrained or inadequately restrained as a patient and/or provider clearly have identifiable hazardous consequences. In the light of the data presented in the background section, where in > 20percent of ambulance runs for traffic crashes, the victims refuse medical assistance and or transport, and where the vast majority of the remaining ambulance runs are not for life threatening or critical situations, it is key that polices and ambulance vehicle operations reflect the safety of all three parties who are involved in those decisions, the patient, the provider and the public. Getting to the scene two minutes faster has not been demonstrated to have a survival advantage or positive impact on outcomes [27], however the increased risk of that emergency response mode driving has been demonstrated to be hazardous [43,44]. There are very limited clinical circumstances where emergency response mode driving from the scene to the hospital is warranted, and increasingly EMS services aware of these risks are decreasing the number of “lights and Sirens’ emergency runs from the scene to the hospital. In fact recent studies have shown that emergency response mode driving negatively impacts the operational emergency health care delivery to the patient [51]. The FEMA document ‘Traffic Incident Management Systems’, 2008, provides specific safety guidance to emergency response vehicles involved in highway crash and other emergency scenes. There is extensive information regarding known hazards to emergency response vehicles providing emergency assistance on the highways, and how to optimize scene safety [52].

RATIONALIZE EMS SYSTEMS FOR OPTIMAL AND APPROPRIATE PROVISION OF SERVICES BASED ON NEED

Structured Approach and Rationalization to Address the Regional Challenges of Rural Highway EMS Needs, and the Issues of Urban Sprawl

The EMS system is clearly not an unlimited resource, and as outlined in the background section. Almost a quarter of EMS highway traffic crash responses result in a refusal of medical aid by the traffic victim and no transport, and that less than 1percent of patients who are transported actually require critical care services. It is not known what the impact of AACN is on triggering responses such as these. It is clear though that the vast bulk of the responses of the EMS system generally, and in the setting of traffic crashes, are to relatively benign events, where outcome is unlikely to be a time critical issue. Thus it is clear that in order to have time critical EMS responses to the small number of truly emergency calls, and to aim to decrease the number of highway deaths it is important to rationalize this limited resource appropriately. It is also key that this resource be effectively coordinated across all elements of the EMS system of acute care. No point in racing to the scene, and then racing back to the hospital, to find that it is on bypass, or that the level of care that the patient requires is not available. EMS is a public health enterprise, linkages must be in place that permit rural health providers, hospitals, EMS agencies, doctors, nurses and EMTs to come together. A system that identifies the highway trauma EMS needs by acuity and severity of injury burden, and ensures that appropriate resources are directed toward the high acuity road trauma cases is key. What is known is that it is possible to identify the areas of traffic crash events and to use mapping technologies and IT with – 'Visual Information Systems for Traffic Safety and EMS', as outlined in Safer Road maps project, and the interactive web site [53], Figure 4.

Figure. 4. Visual information systems for traffic safety and EMS [53].

This project was developed with the support of the University of Minnesota and the Center for Excellence in Rural Safety (CERS), and the EMS applications are discussed at length in the ITS publication, "ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment", by Horan and Schooley [53]. These mapping technologies can locate traffic crash patterns and assist in effective EMS deployment (Figure 4). There are also a number of commercial EMS vehicle positioning and dispatch technologies that are linked to frequency and density of call volumes that are sporadically in use in some EMS services.

"To perform effectively there is a need for integrated systems in EMS – seamlessly interrelating operational, organizational and governance aspects." Horan 2009, The Crash Trauma information network outlines this plan (Figure 5). These approaches are based on the fundamental need to track a patient from end-to-end – from the time of 911 notification through to being discharged from a hospital (and rehabilitation). To achieve this there is a need to integrate data systems across traditional "silos" (pre-hospital, hospital/trauma, crash data systems). It is key to investigate better use of information technology to address time lag in emergency response, and to investigate better use of IT to address information hand-offs for "point of care" decision making [54].

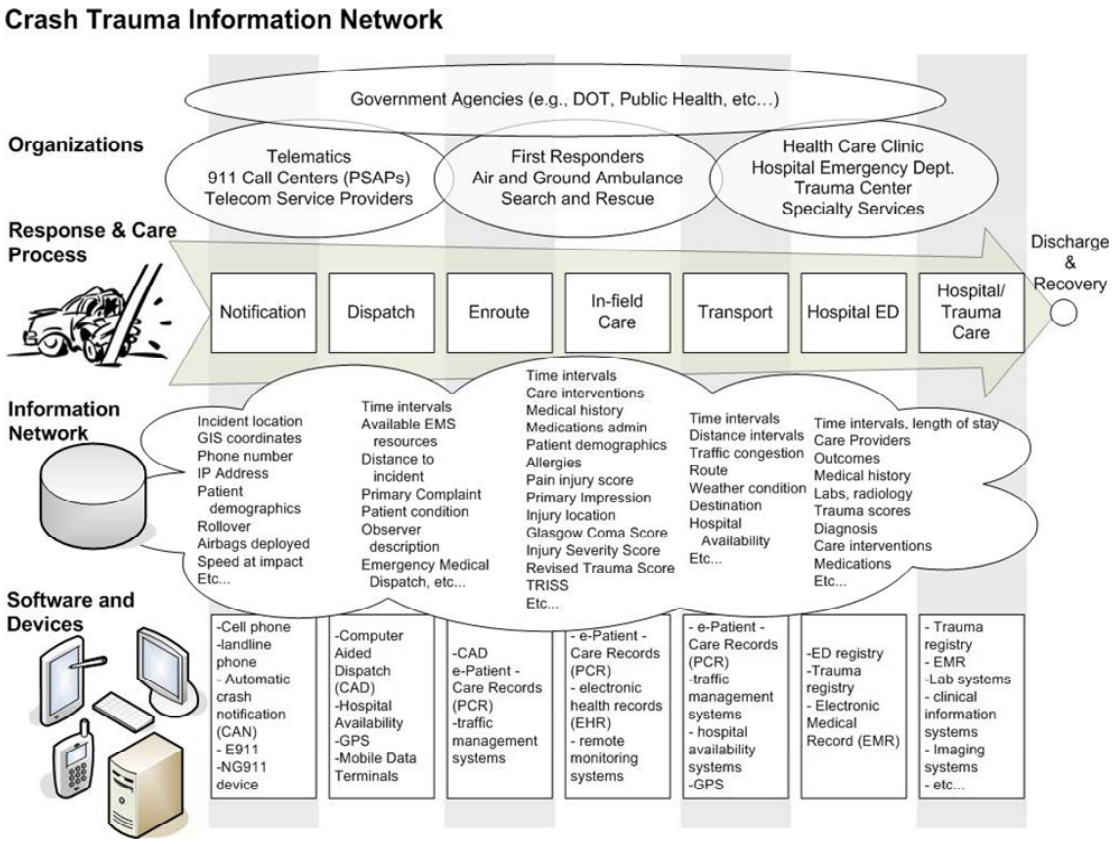


Figure 5. The crash trauma information network. Source: Horan 2009 [54].

Integrate Air and Ground EMS Response in the Highway Safety Setting, Including Structured Evidence Based Protocols that Effectively Address Risk Versus Benefit

The scope, effectiveness and safety of air medical services and their integration with ground EMS have had much recent attention [4]. In fact, far more attention than these issues as applied to ground EMS transport, which involves an order of magnitude higher volume of patients. The Atlas and Database of Air Medical Services (ADAMS) project has made a major step forwards in identifying a national perspective on the air medical system. ADAMS was originally conceived as part of an effort to improve delivery of emergency medical care to car crash victims in order to reduce the deaths and serious injuries occurring each year along U.S. roads [29]. There are now 307 air medical services in operation [29] (Figure 6), and there has been a large increase in the number of operators and the fleet of air medical aircraft over the past 10 years, with currently approximately 1200 rotary and fixed wing aircraft performing approximately (867 Rotor , 309 fixed wing), [29], 400,000 transports annually [4].

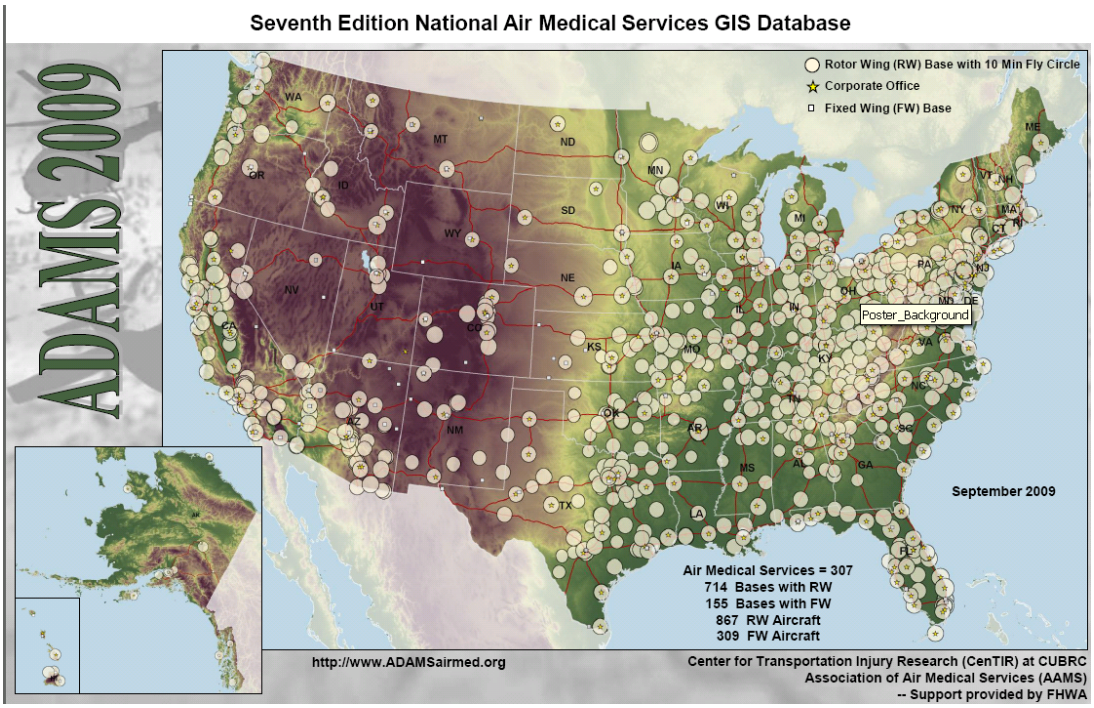
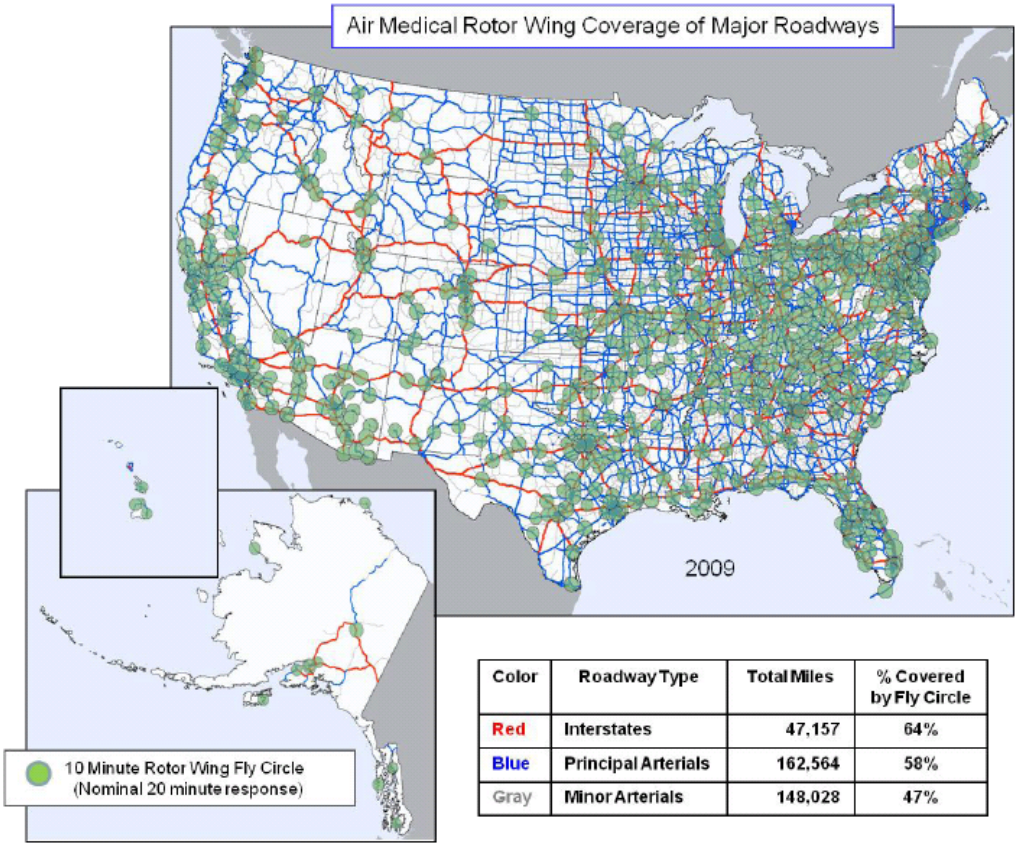


Figure 6. Location of air medical services. Source: ADAMS 2009 [29].

Though the NTSB and independent researchers have identified this exponential increase in the number of air medical services and aircraft being deployed [55], the distribution of the air medical systems deployment however, is also not driven by a need for resource allocation determinant. Calculations from the ADAMS Project indicate that across the 50 states and the District of Columbia, 64percent of interstate, 58percent of principal arterial and 47percent of minor arterial miles are within a nominal 20 minute air medical rotor wing response (Figure 7.) . There exist also large variations in the dispatching and response protocols for air and ground

EMS response across the nation, and even within one region, and also with many regions without structured integration of the ground and air systems.



Color	Roadway Type	Total Miles	% Covered by Fly Circle
Red	Interstates	47,157	64%
Blue	Principal Arterials	162,564	58%
Gray	Minor Arterials	148,028	47%

Figure 7. Air Medical rotor wing coverage of the nation's Highway System – nominal 20 minute response. Source: ADAMS 2009 [29].

Furthermore there are some serious issues being explored currently regards air EMS safety and the commercial pressures to fly via air EMS [55]. As a result of an escalation in adverse HEMS events, and an exponential increase in the number of HEMS operations there has been extensive public focus and increasing professional scrutiny of HEMS operations [3,4]. Also as a result of some of this activity, there is some increasing focus on helicopter EMS and ground EMS becoming more integrated by EMS regions so that scene responses are well coordinated with emphasis on patient care and safety - not on competition.

In addition to the dispatch issues and the integration of ground and air emergency medical services responses, there is also an area of need for facilitating the coordination of helicopter EMS with highway safety, and the public and private officials responsible for setting up landing sites for accident victims, especially during night operations.

Remove Obstacles to Systems Safety and Performance Oversight of EMS Systems

Whilst fiscal limitations are frequently cited as being key obstacles, much positive ground can be claimed in systems safety and performance oversight by addressing awareness and an understanding of the key challenges and opportunities of the effectiveness of EMS and highway safety. In fact it is quite likely that with a more integrated system, with more seamless coordination and – one driven by need and outcomes, in contrast to meeting a predetermined 'response time', that the system maybe more cost and resource utilization effective.

There are some creative solutions to consider, such as to use federal dollars to link EMS with Governors Highway Safety Committee funds, with funding awards linked to specific outcomes measures. Another strategy is to consider reactivating Public Health and Health Services block grants to EMS Regions, and to insist upon regional planning for routine EMS and disaster responses. Additionally to consider linking EMS to the comparative effectiveness and electronic medical record initiatives of the Obama Administration

ENHANCE THE TRANSPORTATION DESIGN AND OVERSIGHT DIMENSIONS OF EMS SYSTEMS

Establishment of a Federal Office of EMS to Facilitate Oversight of the EMS System

There exist federal offices of oversight for other emergency and public safety services. However, EMS does not have that infrastructure at this time and there exist obstacles, political and other to that being achieved. According to the National Academy of Sciences, "government leadership in emergency care is fragmented and inconsistent" with "a regulatory vacuum at the Federal level." [1]. The NTSB states in the Mexican Hat report in 2009, "A host of departments, divisions, and agencies play a role in the various aspects of EMS: the Federal Communications Commission regulates carriers, State and local jurisdictions control PSAPs, National Telecommunications and Information Administration (NTIA) funds some infrastructure development, the U.S. Department of Homeland Security provides equipment grants, and a Federal committee coordinates policy. In addition, many other agencies have a vested interest in emergency notification systems, including the U.S. Department of Health and Human Services, the Centers for Disease Control, the U.S. Department of Commerce, and FEMA". The congressionally mandated FICEMS was established by the 2005 SAFETEA-LU legislation. The law required the Secretaries of Transportation, Health and Human Services, and Homeland Security to establish FICEMS and required NHTSA to provide administrative support. As a result, FICEMS was established to identify EMS services and 911 needs; ensure coordination among Federal, State, and local entities; and recommend new or expanded programs, such as enhanced 911 (E-911) [13] and next generation 911 (NG-911) [14].

Rationalize the EMS Fleet Mix and Optimize the EMS Fleet to be Efficient, Safe Vehicles that Facilitate Patient Care and Transport

Furthermore, there are a number of other strategies that need to be addressed, beyond the data capture and systems strategies. Fleet mix is a key issue. Ambulance vehicles have generally not changed much in the USA since they transitioned from the Cadillac to the box style ambulance in the 1960's. The operational safety and utility of the box style ambulance has not passed independent scrutiny [46,48]. There have been vast advances in both general vehicle and fleet safety, and in efficiency, since that time also. Ambulance vehicles in Europe and Asia are smaller, sleeker, safer more vehicles, within which it is possible to safely provide essential patient care. These vehicles also have Enhanced Stability Control (ESC), as well as other proven safety features and greater economy. Identification of the optimal fleet mix for region or locality is key. Demographics, terrain and weather are all important factors to consider in fleet selection and operations. We need to be focused on what the realities are – and ask the awkward questions of 'why are our ambulance fleets being designed by health care providers and vehicle drivers and not by the technical automotive occupant protection engineering expertise of the transportation arena? Hospitals are not designed without the input from specialized technical architectural expertise, safety codes, systems design, ergonomics etc. Also, there exist fleet safety management standards now, i.e. American National Standards Institute (ANSI) - Z.15, that offer general safety, efficiency and fleet operational guidelines. An enhanced EMS fleet could have a positive impact on the efficiency and the safety of EMS. The use of motorcycles for rapid response in an urban setting has been demonstrated to be effective in a number of large urban cities globally. They provide for early patient assessment and emergent stabilizing care so that the transport vehicle can load and go on arrival. Generally, the sleeker more maneuverable and safer vehicles, utilizing the latest safety technologies such as Enhanced Stability Control (ESC) are of great benefit to optimizing the system performance of EMS, and such vehicles are less likely to be involved in a crash, and more likely to protect the occupants in such a circumstance, and also provide, particularly the trauma patient, with a smoother ride and with better fuel economy.

Enhancing the Design of Egress to Hospitals and Appropriate Traffic and Roadside Design in the Approach to Hospitals, and on High Risk Highway Areas

The road and surrounding street architecture in the access paths to the hospital are areas where it is important to have an understanding of the interaction with ambulance traffic and flow. Due to the high exposure of ambulance vehicles in the vicinity of hospitals, it is no surprise that the frequency of ambulance crashes is higher in the access and egress roads and streets leading to hospitals and nearby intersections. In one of the major USA cities, a 2 year map plotting the location of ambulance vehicle crashes, neatly identifies crash clusters coinciding around each of the major hospital sites. Whilst these crashes may not result in fatalities directly, the scientific data clearly point to the negative impact an ambulance crash has on the care of the patient involved (their transport is interrupted and they also may suffer additional injury), and furthermore this event has a cascade of negative impact on the EMS response system as a whole. The crashed vehicle generates an EMS response for itself, and it also is likely to be out of service as a result of its crash, taking at least two vehicles and respective staff away from the EMS response system. In addition to the road architecture surrounding hospitals, some consideration for the safety of EMS highway response crews should be involved in highway design. One in five medics killed in a traffic crash, were struck and killed at a rescue scene.

INTEGRATE AND OPTIMIZE COMMUNICATIONS AND TRANSPORTATION TECHNOLOGIES INTO THE EMS SYSTEM

Facilitate the Integration of State of the Art Communications and Transportation Safety Technologies

The NTSB states that "A pervasive wireless capability throughout our nation's highway system will undoubtedly improve rural highway accident notification for EMS response and coordination of prehospital transport and offer substantial collateral benefit to rural citizens". [2] NTSB recommends that FICEMS should develop a plan that can be used by the States and PSAPs to pursue funding for enhancements of wireless coverage that can facilitate emergency notification and response along high-risk rural roads, as identified under SAFETEA-LU criteria. These plans could include State HSIP projects to develop cellular communication for transportation accident notification. Federal initiatives such as the Enhanced (E-911) [13] and Next Generation 911 project (NG-911) (see Figure 6), and the focus on developing ITS to enhance the effectiveness of EMS are key projects to optimize the integration of ITS into EMS 14]. The stated goal of the USDOT NG-911 project is to: "To enable the general public to make a 9-1-1 'call' (any real-time communication – voice, text, or video) from any wired, wireless, or IP-based device, and allow the emergency services community to take advantage of advanced call delivery and other functions through new internetworking technologies based on open standards." [14].

The Enhanced 911 system is a telecommunications based system that automatically associates a physical address with the calling party's telephone number, and routes the call to the most appropriate PSAP for that address. This provides emergency responders with the location of the emergency without the person calling for help having to provide it. However there remain challenges in regions with poor cell reception. Additionally, integration of ambulance vehicle safety design technologies, electronic fleet management safety technologies, and interfacing the EMS operations and practice data capture with real time data capture devices, have been discussed previously.

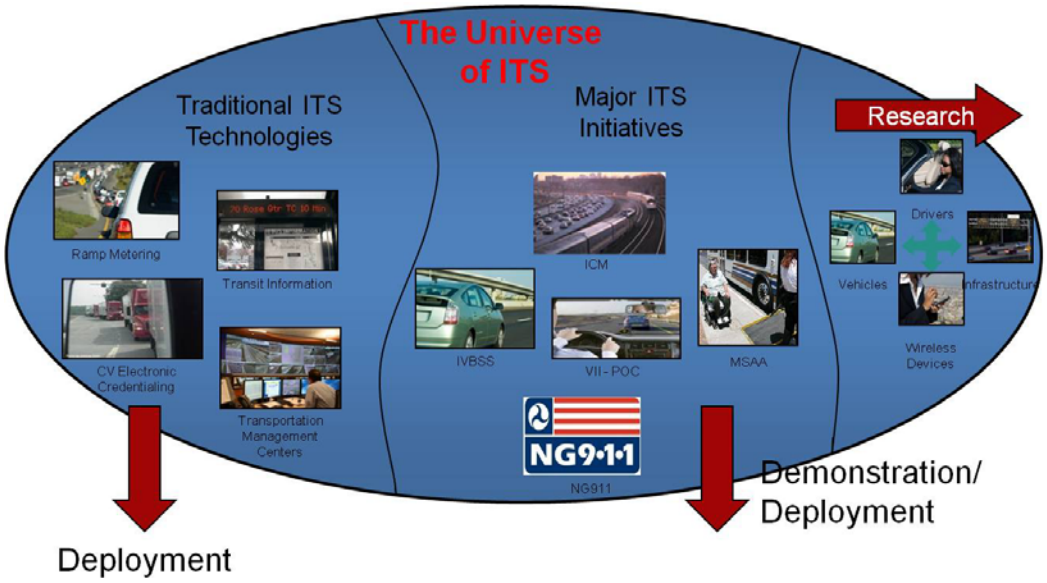


Figure 6. ITS Next Generation 911. Source: Linda Dodge DOT/RITA, from TRB 2009 Summit presentation, Washington DC.

Implement Incentives, Grants and Other Benefits for the Utilization of Evidenced Based Enhancements to EMS systems, Fleets or Fleet Operations

Currently there are few structured incentives, grants or other benefits for the utilization of evidenced based enhancements to EMS systems, fleets or fleet operations. Implementation of such incentives has been achieved sporadically, at a State level, in some regions. State grant funding to support a fleet management and ambulance driver feedback safety system is one such example from the Colorado State EMS Office's Emergency Medical and Trauma Service Provider Grant Program. This program, which addresses data collection and also vehicle innovation, equipment and other initiatives, preferentially supports project proposals that are strongly evidence based. Recently this program awarded a grant for a vehicle design innovation that was supported by input from automotive safety technical expertise. It should also be considered that the insurance companies may be supportive of incentives for integration of evidence based practices to augment system safety. There is scope also for linking these strategies with Governor's Highway Traffic Safety infrastructure, and to provide performance measures and benchmarks that must be met to secure those funds: i.e. that by 2010, X percent of EMS services will have implemented dispatch systems that are evidenced based; that X percent of agencies must have X percent of ambulances fitted with vehicle real time feedback telematics, within X years; that within X years, all ambulance purchases within a State must have electronic enhanced stability control; that by 2020 all new ambulances purchased must meet new safety design and performance standards, developed by independent automotive occupant protection safety engineers; and by 2020 dispatch standards must be in place nationally integrating, ground, air, volunteer and other regional services. Ensure that new technologies are adequately evidences based, use existing assessment tools [56].

Identify International Lessons Learned as They Apply to EMS and Road Safety

A key issue that is a theme in this White Paper series is that learning from our international colleagues can be achieved with relative ease in this increasingly global community. There are many diverse systems for integration of traffic safety and EMS systems globally, and equally as many paths available to explore those realms. And just as our colleagues around the globe have novel and potentially translatable approaches to the other themes in this White Paper series, whether it be traffic calming approaches, driver focused technologies or enhanced vehicle safety features – our international colleagues have much for us to learn from them in the realm of EMS and road safety. EMS data capture systems in Australia are able to capture a profile of the nations EMS system activity and its performance, dispatch of air and ground transport is integrated, and with far fewer HEMS vehicles per capita than the USA. Ambulance ground vehicles have a focus on both vehicle safety and vehicle visibility and conspicuity. This is very similar to the approaches in Europe. Another model that is a valuable arena for bridging the EMS and highway communities is the Road Safety Research, Education and Policing Conference held in Australia. This creates a structured platform where EMS professionals and highway safety operational, educational and policy expertise can share in common themes, issues and solutions. There are also innovative practices to learn from our international Scandinavian colleagues, as regards EMS road side emergency operations, such as complex vehicle extrication [57]... A platform for a coordinated and structured international knowledge transfer of EMS practice innovation is the applied Innovation Consortium of the EMS Safety Foundation. This platform provides for a virtual interface via interactive Webinar with international expertise in both EMS and also transportation and road safety science, and has provided a technical and applied knowledge and practice conduit from some of these global best practices into the USA EMS community.

CLOSURE

An appreciation of the EMS system as a whole, its current role in road safety, the challenges, threats and risks and above all opportunities that exist to enhance system performance in this realm are outlined in this paper. It is also important to appreciate that advancing EMS system infrastructure and its capacity to respond optimally to highway safety involves bridging diverse elements of emergency health care, air and ground transportation, IT and communications, rural and urban environments, and volunteer and career providers. EMS is public health, public safety, and acute and emergency medical care mobile infrastructure. Key issues that have arisen to augment the effectiveness of EMS in highway safety relate to the prevalence cell reception to interfacing with EMS systems in rural areas, the integration of air and ground response systems and ensuring that the appropriate EMS resources are in the right places and for the people in most need of those resources, i.e. getting the right patient to the right care in the right place at the right time. And most importantly to ensure that there are incentives, fiscal and other approaches implemented so as to strengthen and to support the most effective system performance.

The seven (7) action items that can drive the above strategies and initiatives are:

1) Conduct a nationwide practice analysis of what EMTs/Paramedics are actually doing and ensure that they are trained based on what they need to do to enhance patient outcomes.
2) Design a fleet of ground and air vehicles based on both clinical and regional conditions with input from appropriate automotive occupant protection and safety technical expertise.

3) Determine which patients should be matched to which modality of vehicle or response.
4) Link all activities, clinical and transportation, air and ground, with electronic communications.
5) Continue refinements in engineering, education, and communication.
6) Use federal dollars to force collaboration, and make federal dollars accountable to performance measures.
7) Refine and link all databases and monitor outcomes so that it can be demonstrated what is and isn't working.

Whilst it is not known exactly how many lives could be saved or serious injuries could be prevented with an optimized EMS system, the sample existing data suggest that optimizing the EMS and trauma response system can have a substantial improvement on morbidity and mortality figures [10]. Given the data challenges outlined in this paper, estimates of predicted fatality reduction nationally are currently difficult to gauge. Improving data capture and database linkages would be of major benefit to address this. However, appreciation that EMS is not an unlimited resource, that careful focusing and integration of that resource based on highway safety needs is key. Road safety is one element of the larger scope of activity of the EMS system as a part of the public health and public safety net. The strategies outlined here are focused on an understanding of the EMS systems key role in enhancing highway safety in that context, and the primary focus being integration, rationalization and innovation. It is essential that this scarce and valuable resource is deployed and utilized in the most optimal manner, so as to best save lives on the highways and roads of the nation.

REFERENCES

1. Emergency Medical Services: At the Crossroads, Committee on the Future of Emergency Care in the United States Health Care System, National Academy of Science, 2007
2. Motorcoach Run-Off-the-Road and Rollover U.S. Route 163 Mexican Hat, Utah January 6, 2008 http://www.ntsb.gov/publictn/2009/HAR0901.pdf - Report 2009
3. National Transportation Safety Board Annual Report to Congress, 2009 ANNUAL REPORT NTSB/SPC-10/01 http://www.ntsb.gov/Publictn/2010/SPC1001.pdf
4. NTSB Helicopter EMS Report – (NTSB Sept 2009 - A-09-102 and -103)
5. Traffic Safety Facts 2008 DOT, NHTSA 2008
6. U.S. Department of Transportation, National Highway Traffic Safety Administration, Contrasting Attributes Between Rural and Urban Fatal Crashes, 1994–2003, Technical Report DOT HS 809 896 (Washington, DC: NHTSA, 2005)
7. Clawson JJ. Running "hot" and the case of Sharron Rose. JEMS. 1991;16:11–13
8. National EMS Information System - NEMSIS – (http://www.NEMSIS.org), EMS Data Cube https://www.nemsis.org/reportportal/design/view.aspx accessed July 1-25, 2010
9. Health United States, 2009, CDC http://www.cdc.gov/nchs/data/hus/hus09.pdf
10. National EMS Advisory Council (NEMSAC) – "EMS Makes a Difference" paper http://www.ems.gov/pdf/nemsac-dec2009.pdf, December 2009
11. Haas B, Jurkovich GJ, Wang J, Rivara FP, Mackenzie EJ, Nathens AB. Survival advantage in trauma centers: expeditious intervention or experience? J Am Coll Surg. 2009 Jan;208(1):28-36. Epub 2008 Oct 31.
12. EMS Agenda for the Future – 1996, http://www.dphhs.mt.gov/ems/publications/agendas/agenda_for_future.pdf , Implementation Guide - http://www.nhtsa.gov/people/injury/ems/agenda/index.html and Summary of Recommendations http://www.nhtsa.gov/people/injury/ems/agenda/apenc.html
13. Enhanced 911, Federal Communications Commission, Consumer Facts, Wireless 911 Services http://www.fcc.gov/cgb/consumerfacts/wireless911srvc.html
14. Next Generation 911 Report, September 2008
15. http://www.its.dot.gov/ng911/pdf/NG911_POCTesTReport091708.pdf
16. Emergency Medical Services Performance Measures: Recommended Attributes and indicators for system and service performance, December 2009, DOT HS 811211 http://www.ems.gov/pdf/811211.pdf
17. National Academies Transportation Research Board Ambulance Safety Summit, Washington DC, 2008, http://www.objectivesafety.net/TRBSummit2008.htm and 2009 http://www.objectivesafety.net/TRBSummit2009.htm, and www.trb.org

18. Center for Disease Control WISQARS, Centers for Disease Control and Prevention, National Centers for Injury Prevention and Control. (CDC) Web-based Injury Statistics Query and Reporting System (WISQARS) [online]. (2005) {cited 2010 June-July}. Available from: www.cdc.gov/ncipc/wisqars
19. Saunders G, Gough A. Emergency ambulances on the public highway linked with inconvenience and potential danger to road users. Emerg Med J. 2003 May;20(3):277-80.
20. Clawson JJ, Martin RL, Cady GA, Maio RF.The wake-effect--emergency vehicle-related collisions. Prehosp Disaster Med. 1997 Oct-Dec;12(4):274-7.
21. Levick NR, Emergency Medical Services: Unique Transportation Safety Challenge, Report No. 08-3010, Transportation Research Board, January 2008, www.trb.org or http://www.objectivesafety.net/LevickTRB08-3010CD.pdf
22. Levick NR, USA Ambulance Transport Safety Challenges – what are we really measuring? Poster Presentation, Jun 2010, Singapore International Congress for Emergency Medicine
23. Levick NR, Swanson J, An Optimal Solution for Enhancing Ambulance Safety: Implementing a Driver Performance Feedback and Monitoring Device in Ground Ambulances. Proceedings - 49th Annual Conference of the Association for the Advancement of Automotive Medicine, September 2005, http://www.objectivesafety.net/LevickAAAM2005.pdf
24. Levick NR, Hazard Analysis and Vehicle Safety Issues for Emergency Medical Service Vehicles: Where is the State of the Art? American Society of Safety Engineers, PDC Proceedings, No. 732, June 2006, http://www.objectivesafety.net/LevickASSEPDC2006.pdf
25. Levick NR, MD MPH, Wiersch L, , Nagel ME, Real World Application Of An Aftermarket Driver Human Factors Real Time Auditory Monitoring And Feedback Device: An Emergency Service Perspective Vehicles, International Enhanced Safety of Vehicles Technical Paper 07-0254, Lyon, France June 2007 http://www.objectivesafety.net/LevickESVDriverFeedbackpaper07-0254-O.pdf
26. Auerbach PS, Morris JA, Phillips JB, Redlinger SR, Vaughn WK, An analysis of ambulance accidents in Tennessee. JAMA 1987 Sept; 258(11):1487-90
27. Newgard CD et al , Emergency Medical Services Intervals and Survival in Trauma: Assessment of the “Golden Hour” in a North American Prospective Cohort, Ann Emerg Med. 2010 Mar;55(3):235-246
28. Brown LH, Whitney CL, Hunt RC, Addario M, Hogue T. Do warning lights and sirens reduce ambulance response times? Prehosp Emerg Care. 2000 Jan-Mar;4(1):70-4.
29. Kupas DF, Dula DJ, Pino BJ. Patient outcome using medical protocol to limit "lights and siren" transport. Prehosp Disaster Med. 1994 Oct-Dec;9(4):226-9.
30. Atlas and Database of Airmedical Services (ADAM) , ADAMS Annual Public Atlas (7th Edition, Sept 2009) http://www.adamsairmed.org/public_site.html
31. The 1979 NTSB Ground Ambulance Crash Report - NTSB Number: HAR-79/04, NTIS Number: PB-296889/ASNTSB - http://www.ntsb.gov/publictn/1979/har7904.htm NTSB - Ground EMS Safety Recommendation Doc:H79_27_28,

http://www.ntsb.gov/recs/letters/1979/h79_27_28.pdf NTSB - Ground EMS Safety Recommendation Doc: H79_29, http://www.ntsb.gov/recs/letters/1979/h79_29.pdf NTSB - Ground EMS Safety Recommendation Doc: H79_30 http://www.ntsb.gov/recs/letters/1979/h79_30.pdf

32. Trowbridge MJ, Gurka MJ, O'Connor RE., Am J Prev Med. 2009 Nov;37(5):428-32 Urban sprawl and delayed ambulance arrival in the U.S
33. Advanced Automatic Collision Notification and Triage of the Injured Patient, 99-9460, http://www.cdc.gov/injuryresponse/pdf/AACN Report_FINAL-a.pdf
34. Transportation Safety Advancement Group (TSAG) - http://www.tsag-its.org/
35. The Research and Innovative Technology Administration (RITA) RITA, http://www.rita.dot.gov/about_rita/
36. Advocates for EMS, http://www.advocatesforems.org/
37. Levick NR, Cordi HP, Comparative Analysis of EMS Components of State Strategic Highway Safety Plans: Where is EMS? http://apha.confex.com/apha/136am/webprogram/Paper173867.html
38. The Crash Outcome Data Evaluation System (CODES) and Applications to Improve Traffic Safety Decision-Making, NHTSA , DOT HS 811 181, April 2010, http://www-nrd.nhtsa.dot.gov/Pubs/811181.pdf
39. NHTSA NEMSIS Data Dictionary 2.2 http://www.nemsis.org/media/pdf/NEMSIS_Data_Dictionary_v2.2.1_05042010.pdf
40. National EMS Assessment Study (NHTSA Solicitation Number: 2009-0032 – underway)
41. Emergency Medical Services Outcomes Evaluation, 2003, http://www.nhtsa.gov/people/injury/ems/EMSOE/exec_summary.htm
42. Intelligent Transport Systems (ITS):Traffic Signal Preemption for Emergency Vehicles,: A Cross-Cutting Study, NHTSA January 2006, US Department of Transportation, http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//14097.htm
43. Evaluating Trauma Management Performance in Europe Evaluating Trauma Management Performance in Europe: A Multiple- Layer Data Envelopment Analysis Model, Shen Y, Hermans E, Ruan D, Wets G, Brijs T, Vanhoof K, 89th TRB Paper #10-2080, Jan 2010,
44. Kahn CA, Pirrallo RG, Kuhn EM, Characteristics of fatal ambulance crashes in the United States: an 11-year retrospective analysis. Prehosp Emerg Care 2001 Jul-Sep;5(3):261-9
45. Ray A, Kupas D, Comparison Of Crashes Involving Ambulances With Those Of Similar Sized Vehicles – Pre-hospital and Emergency Care Dec 2005;9:412-415
46. Levick NR, MD MPH, Transportation safety performance – how does EMS compare to commercial fleets, Poster Presentation - NAEMSP, January 2009, http://www.objectivesafety.net/NAEMSP2009TransportComparisons.pdf
47. Levick NR, MD MPH, Grzebieta R, BE MEngSci PhD, Crashworthiness Analysis of Three Prototype Ambulance Vehicles, International Enhanced Safety of Vehicles Technical Paper

07-0249, Lyon, France June 2007 http://www-nrd.nhtsa.dot.gov/pdf/esv/esv20/07-0249-W.pdf

48. Levick NR, MD MPH, Grzebieta R, BE MEngSci PhD, Engineering analysis of 'safety concept' ambulances: Poster Presentation - NAEMSP, January 2009, http://www.objectivesafety.net/NAEMSP2009SafetyConcept.pdf
49. Levick NR, MD MPH, Grzebieta R, BE MEngSci PhD, Ambulance vehicle crashworthiness and passive safety design: A comparative vehicle evaluation, Society of Automotive Engineering, ComVec Technical paper, October, 2008, 2008-01-2695, www.sae.org
50. Levick NR, MD MPH, Grzebieta R, BE MEngSci PhD, USA Ambulance Crashworthiness Frontal Impact Testing, International Enhanced Safety of Vehicles Technical Paper, 09-0471, Stuttgart, Germany June 2009, http://www-nrd.nhtsa.dot.gov/pdf/esv/esv21/09-0471.pdf
51. Chung TN, Kim SW, Cho YS, Chung SP, Park I, Kim SH. Effect of vehicle speed on the quality of closed-chest compression during ambulance transport, Resuscitation. 2010 Jul;81(7):841-7. Epub 2010 Apr 7.
52. Traffic Incident Management Systems: FEMA, April 2008 https://www.usfa.dhs.gov/downloads/pdf/publications/tims_0408.pdf
53. SafeRoadMaps Interactive Website - http://saferoadmaps.org/home/
54. ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment, Jan 2009, http://www.tsag-its.org/resources/media/ITS&TranspSafety-EMSDataIntegration.pdf
55. HEMS Update, Tom Judge, Presentation NAEMSP, January 2010
56. EMS Technology Assessment, DOT HS 810 87, Jan 2008 http://www.ems.gov/pdf/810873.pdf
57. Wike, Lars; Trond Boye Hansenb; Kjell Kjenslic; and Petter Andreas Steenb. Rapid Extrication from a Car Wreck. International Journal of the Care of the Injured, 2004.