Introduction

Emergency Medical Services – (EMS)
> Important interface between public health, transportation, public safety and emergency and acute care and the community
> Unique challenges - patient, provider and public safety and transportation safety
> Unique needs of this important part of our health care and transportation system

EMS Definition

> An Emergency Medical Services system is –
  ◦ A coordinated arrangement of resources (including personnel, equipment, and facilities) which are organized to respond to medical emergencies, regardless of cause. (ASTM, 1988).
> EMS –
  ◦ The services provided to accident victims and patients suffering from severe acute illness and psychiatric emergencies.
  ◦ Detection and reporting of medical emergencies, initial care in transportation and care for patients en route to health care facilities, medical treatment for the acutely ill and severely injured within emergency departments, and the provision of linkages to continued care or rehabilitation services. (EMS Research Agenda 2001)

What is the scope of EMS?

> Emergency care, public health, public safety and patient transport
> Bridge between the community and the hospital
> Volunteer – professional
> Urban – rural
> Disaster response
> Majority of transports NOT critical or life threatening

USA EMS

> EMS Systems - >15,000
> Personnel - ~1 million
  (150% F/T professional & 70% volunteer)
> Vehicles - ~50,000
  (Type I, Type II, Type III, Freightliners, ?motorcycles)
> Transports - ~50 million
  (to Emergency Depts - 50%, < 1/3 emergent)
> Cost - ~$8 Billion annually
> Safety Oversight - ? Disparate

An important and unique system

> Public safety, public health and emergency service
> Is there to save lives
> A more recent service compared to Fire and Police
Transport related aspects of EMS
- dispatch of EMS vehicles
- transport policies and protocols
- vehicle fleets and vehicle design
- vehicle purchase standards
- Intelligent Transportation Systems technology
- driver training
- training simulation
- driver performance monitoring
- roadside and road design
- integrated traffic safety technologies
- scene safety and visibility
- safety data capture
- safety oversight

A tragic emergency health care intervention outcome
- It does happen….

Transport oversight?
- In contrast to the bus and truck industries, which have comprehensive safety oversight, and transportation safety interventions, as well as transportation safety data capture via the Federal Motor Carrier Safety Administration (FMCSA) - EMS has been focused more as an acute health care delivery and emergency service and largely outside of much of the other transportation oversight infrastructure that exists.
- This is an opportunity for transportation planners, engineers, and system operators to see a comprehensive overview some of the multidisciplinary transportation challenges faced by Emergency Medical Services.

Some odd facts
- Ambulances are generally not built by the automotive industry
- Intelligent Transportation Systems (ITS), transportation safety engineering and transport systems engineering are not generally integrated into EMS systems
- Although all EMS systems have medical direction and oversight, it is rare for there to be transportation expertise oversight

What happened??
- Why is it that Emergency Medical Services have developed outside the umbrella of transportation safety infrastructure??

Emergency Medical Service (EMS) Transport
- What are the transport safety issues that pertain to this important public service and public safety industry?
- What do we know of the risks and hazards and how can we measure these?
- How can the safety of this transport system be optimized?

Some challenges
- No accepted national safety standards for -
  - EMS fleet management or safety practice
  - Ambulance vehicle rear compartment design and performance
  - Provider occupational injury protective equipment
  - Yet convincing data for injury risk and hazard
  - Need for patient, provider and public safety focus

A very serious gap in data, performance and oversight
- FMCSA Truck safety goals – to decrease the fatality rate of 2.8 per 100 million truck-miles in 1996 to 1.65 by 2001
- EMS crash fatality estimates are - 7.66 - 41.93 fatalities per 100 million ambulance-miles

History of EMS
- EMS is a relatively new industry
- An unusual history of beginnings within the mortician industry.
  - Early ambulances were hearses, once motorized usually a Cadillac, a vehicle in which an occupant could be transported in the recumbent position
  - Over the past 100 years, the sophistication of EMS medical care has advanced dramatically
- EMS communications and transportation technology have not kept up with that pace
Scope

- Safety data on EMS transport and its oversight
- EMS vehicle crash rates are in excess of similar sized vehicles
- EMS worker transport fatality rates are above other emergency services
- Is a part of the transportation system that is largely exempt from most of the Federal Motor Vehicle Safety Standards (FMVSS), and not covered by other national transportation system safety oversight (e.g. FMCSA)
- The findings of limited research conducted to date suggest EMS transportation safety is in need of urgent focus and has been left behind commercial truck and bus safety.

Scope

- A synthesis of the TRB research truck and bus conducted to date that applies to or could be applied to this field – has potential for substantially enhancing EMS transport safety.
  - Intelligent Transportation Systems (ITS), interactive traffic signal technologies, in vehicle and in system driver performance improvement technology (IDP)
  - Simulators for training and competencies;
  - Vehicle design and safety;
  - Safety and practice policies (Dispatch, shift length, safety oversight);
  - Interaction with other road users (wake effect and high density EMS traffic and hospital access road design – may benefit EMS);
- EMS transport safety is a unique gap in the standards, oversight and coordination of the transport system.

Some recent adverse outcomes

- UPS and Laundry trucks have very similar design and even more stringent safety requirements to EMS vehicles
- BUT very different cargo......

Fatalities and funerals

- Last week....

Fatalities and funerals

- A devastating tragedy...
- Medical care error may kill the patient and be a terrible burden for the pts family and for the medic involved
- BUT an EMS crash can kill all involved AND wipe out an EMS systems response capacity......

Last week....

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- BUT very different cargo......

People are passengers and NOT laundry or packages

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A few weeks ago in New York

- A few weeks ago in New York
- Medical care error may kill the patient and be a terrible burden for the pts family and for the medic involved
- BUT an EMS crash can kill all involved AND wipe out an EMS systems response capacity......

Major deal...

- Major deal...
Firstly!

An accident?

or a predictable and preventable event

What are the solutions?

Training?
Practice Policy?
Transportation Systems Engineering?
Automotive Engineering?
Education of other road users???

What’s missing

1. What data is collected nationally?
   - We have no denominator data
   - We have incomplete numerator data
2. Absent population based national injury data or injury mechanics data
3. Absent structured transportation safety engineering input
   - 1+2+3 = resultant inability to design and evaluate efficacy of injury interventions
4. What oversight is there?
5. Which organizations would determine policy?

This IS a transportation safety issue

- Systems engineering
  - Where do ambulance crashes occur?
  - What transportation safety engineering interventions
  - ITS - Does opticom work effectively in this environment given the traffic density and emergency vehicle density?
  - Frontal design of emergency vehicle traffic flow
  - Frontal mix to match anticipated transport environmental challenges (e police model – bicycle, motorcycle, horse, three-wheeled, cruiser, van, truck)?

Balance of concerns and risk during transport

- Response and transport time
- Clinical care provision
- Occupant safety/protection
- Public Safety

Goals

- Standards for safety
- Policy based on Science
- Databases to demonstrate outcome

911 Call to Hospital/ED Definitive Care Time Intervals*

*Not drawn to scale

Vehicle related transport time

Challenges to Optimizing EMS Transport Safety

- Disparate and fragmented safety infrastructure
- Lack of a centralized EMS Safety oversight or data
- A large number of small groups of end users, with a mix of volunteers and professionals
- Ambulances are hybrid non-standard vehicles, a truck chassis and an after market box or a modified van
- EMS vehicle safety is not integrated as a part of the transport safety industry

the EMS transport process

- communications/dispach
- the patient
- restraining device/seat
- transporting device/gurney
- paramedics/transport nurses, doctors & family
- patient monitoring equipment
- clinical care & interventions
- protective equipment
- the vehicle
- the driver/driving skill
- other road users
- the road

911 Call to Hospital/ED Definitive Care Time Intervals*

- Emergency Response Time
- EMS call to hospital
- EMS leaves hospital
- EMS EMS bay (X)
- Hospital/ED Definitive care (Y)

Vehicle related transport time

*Not drawn to scale
Challenges to Optimizing EMS Transport Safety

- Rear compartment exempt from FMVSS
- Complex automotive safety area bridging acute clinical care, public health, public safety and automotive safety
- Very recent history as a research issue
- Limited fiscal support for cross-disciplinary EMS transport safety research

Benefit of Safety

- Any cost of addressing these issues is dwarfed in contrast to the huge burden of not doing so - in financial costs let alone the personal, societal, ethical and litigation costs

EMS Transport Safety IS Complex AND Multidisciplinary

- Epidemiological Data Collection
- Ergonomic Research
- Biomechanical Automotive Safety
- Driver Research
- EMS Safety
- Public Safety
- Fleet Safety Program
- Risk Management
- EMS Policy
- PPE
- Regulations and Standards
- Fleet Safety Program

This is not acceptable

In the USA
- ~ 5,000 crashes a year
- ~ One fatality each week
- ~ 2/3 pedestrians or occupants of other car
- ~ Approximately 4 child fatalities per year
- ~10 serious injuries each day
- Cost estimates > $500 million annually
- USA crash fatality rate/capita 35x higher than in Australia

Key Issues

- Mythology: That Emergency Medical Service personnel are safe
- Injury Hazards
  - Violence
  - Chemical/Radiation
  - Physical/Mechanical Issues - THE BIG PROBLEM
- Motor Vehicle Crashes are the highest cause of death at work - EMS has > 2X the mean national rate
- An R & D and Regulatory Gap
  - Occupational Health and Safety
  - Safety policies
  - Vehicle and Safety Equipment Testing and Standard development
  - Safety oversight of what and by whom

A Simple Question…
EMS Transport General Concerns

- Consequences can be predictable & likely preventable
- Costs of these adverse events are high in loss of life, financial burden and negative impact on delivery of EMS care
- Other high speed vehicles (eg. racing cars) and also passenger carriers such as trucks and buses have a different safety paradigm
- Design of interventions to mitigate injury is predicated on a valid testing model
- Complex both engineering and public health issues

USA Ambulances: FMVSS Exempt

USA Ambulance purchase specifications
- Static Pull test
- 2200 lbs. (8G’s) in Longitudinal and Lateral
- No dynamic test
- No definition to manikin mass
- No restraint for equipment
- Voluntary

Global EMS Vehicle Safety Standards v Specifications and Guidelines
- EMS Safety and Performance Standards
  - Australia & New Zealand 4555
  - Common European Community (CEN) EN1789
- Non EMS Specific USA Standards
  - FAA/CAA/JAA
  - Z15 – Fleet vehicles safety management
- USA EMS Specification & Guidelines
  - Purchase Specification: KKK & NTEA, AMD
  - Guideline: EMSC Dos and Don’ts

American National Standard
ANSI/ASSE Z15.1-2006
Safe Practices for Fleet Motor Vehicle Operations

What Z15 encompasses
- Safety Program
- Safety Policy
- Responsibilities and Accountabilities
- Driver Recruitment, Selection and Assessment
- Organizational Safety Rules
- Orientation and Training
- Reporting Rates and Major Incidents to Executives
- Oversight

NASCAR, Car of tomorrow ready to go
USA Today – March 23rd, 2007

and who’s life was he racing to save?

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The truck and bus industry is on the right track.... Where is EMS??

Transportation Research Board is an excellent resource... we should be using it!!!
EMS RESPONDER CRASH PREVENTION

- Undertake a systematic review of other state actions and protocols to identify those that may contribute to injuries resulting from the impact of ambulance crashes
- Develop and implement ambulance traffic safety protocols at state, regional and service level
- Increase education and involvement of EMS providers in principles of appropriate traffic safety techniques

Unique workplace

- In vehicles
- At roadside and other emergency scenes

The ‘workplace’ IS a vehicle

- EMT’s often in vulnerable positions during transport
  - Bench seat
  - Captains chair
  - Standing or kneeling

The ‘workplace’ is also a crash scene

News we don’t want to see

Caught On Video: EMT Struck By Car

Very Predictable…

- Intersections are lethal environments

“Are our policies killing people?”

- 1991-2000, 202,969 Emergency vehicles were involved in MVCs - 1,565 involving fatalities*
- In PA 1997-2001, ambulances were more likely than similar sized vehicles to be involved in MVCs:
  - 4 way intersection crashes (43% vs 23%, p<0.001)
  - Collisions at traffic signals (37% vs 18%, p<0.001)
  - MVCs with more people injured (76% vs 61%, p<0.001)


So.. The real world for an EMS vehicle approaching a red light

- You think they heard you...
- You know they must have seen you...
- And maybe they did
- ...... But...
- There is NO way humanly possible that they could stop.....
The real world
Intersection passenger car stopping distance* at 40 mph dry and wet

Automotive Injury Triangle and Safety Development

Intelligent Transport Safety Systems

Is this a strategy that can work?

EMS Best Practice, Sept 2006
Best Practice.....? The technology described in your junk mail is far more advanced than that used in EMS

Data
- What national statistics are there for EMS transport safety
- What is known about 'wake effect'

* Stopping distance: Perception time + Reaction time + Vehicle braking time (varies with age, skill, agility, distance, vehicle type, tire pressure, road etc)
Ambulance Safety Research: A New Field

- Sociocultural engineering
- Epidemiology
- Ergonomic

Highnett

Medical Services: A Hidden Crisis, Annals of Emergency Medicine, Dec 2002

* Maguire, Hunting, Smith & Levick, Occupational Fatalities in Emergency National EMS Information System

Ambulance Safety Research / Data Vacuum

- ? total no. of ambulances
- ? total no. of medics
- ? total no. of runs (per age & severity)
- ? total pt. miles (per age & severity)
- ? true crash fatality rate per mile
- ? crash injury rate
- ? adverse events

EMS Research / Data Vacuum

- More often at intersections, & with another vehicle (p < 0.001)
- Most serious & fatal injuries occurred in rear (OR 2.7 vs front) & to improperly restrained occupants (OR 2.5 vs restrained)
- 82% of fatally injured EMS rear occupants unrestrained
- 34% of EMT, occupational fatalities are MVC related
- Serious head injury in 45% of fatal occupant injuries
- 72% of fatal EMS crashes during Emergency Use
- More likely to crash at an intersection with traffic lights
- Serious & fatal injuries occurred in rear (OR 2.7 vs front)
- More often at intersections, & with another vehicle (p < 0.001)

Predictable risks

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National EMS Information System

“Nation’s Emergency Care System is fragmented, unable to respond to disasters”, says Institute of Medicine, June 14, 2006

EMS Provider Fatalities

- 12.7 fatalities/100,000 EMS workers
- Greater than 2 X the national average (5.0 fatalities/100,000)
- Similar to Police (14.2/100,000) and Fire Fighters (16.5/100,000)

and what is killing EMS?

EMS personnel fatalities

- 74% transportation related
  - 1/5 of ground transport fatalities were struck by moving vehicles
  - 11% were cardiovascular
  - 9% were homicide
  - 4% needle sticks, electrocution, drowning and other

So does it make sense?

- Gloves and universal precautions... ... good biohazard protection BUT aren’t going to give much protection in an ambulance crash


**Becker, Zaloshnja, Levick, Li, Miller, Acc Anal Prev 2003


#NIOSH, 2003

##NHTSA, 49 CFR Parts 571, 572 & 589 Docket no. 92-28; notice 7
A word about occupational transportation fatalities.

\[ \text{Occupational transportation fatalities/100,000 workers} \]

\[ \text{EMS} \quad \text{Police} \quad \text{Fire} \]

WE HAVE A BIG PROBLEM HERE


**Fleet Mix?**

Johns Hopkins University

Test 1 – Right side impact

- Target vehicle, Type I ambulance
- Bullet vehicle, Type II ambulance
- Closing speed 44 mph

Test 2 – Frontal

- Bullet vehicle, Type III ambulance
- Target vehicle, Type II ambulance
- Closing speed 34 mph

**Full Vehicle Crash Tests**

Air EMS is a role model for safety initiatives and focus

**Safety Management**

- A Safety Culture
- Protective Policies
- Protective Devices
  - In the event of a crash
  - To prevent a crash
  - Continuous Education and Evaluation

**Protective devices/concepts**

To prevent a crash
- Driver feedback
- Driver monitoring
- Driver training
- Vehicle Intelligent Transportation System (ITS) technologies
- Tiered dispatch
- Appropriate policies

In the event of a crash
- Vehicle crashworthiness
- Seatbelt systems
- Equipment lock downs
- Padding
- Head protection

**Tiered Dispatch**
Back up Camera…. Shouldn’t all vehicles have one of these?

The “Black Box”
Driver behavior monitoring and feedback device

Purpose of ‘Black box’ Program
- Enhance Safety
- Improve Driver Performance
- Save Maintenance Dollars
- Aid Accident / Incident Investigation

Demonstrated Effectiveness

Other monitoring devices
- Primarily to record events during and immediately preceding a crash
- Give no driver crash prevention feedback
- Administratively burdensome
- Intrusive
- Not demonstrated to be as effective in improving vehicle maintenance costs or as effective in modifying driver behavior long term

Data, but is it generalizable

EMS is emerging in the transport safety arena
- First and only presentation of ambulance safety research at ESV Congress was 2001
- SAE Toptech on Military and Emergency Vehicles, USA, September 2001
- Emergency Vehicle Symposium, Australia, Melbourne, May 2003
- Sporadic Ambulance safety research presented at peer reviewed AAAM, ITMA, SAEEM, Safe America, World Injury, Asia Pacific Injury Conferences 1999-2005
- Next week at inaugural meeting at 2007 TRB Congress in DC

EMS Risk/Hazards
- Predictable risks
- Predictable fatal injuries
- Serious occupational hazard
- Public safety hazards

What’s new
- New automotive safety technologies
  - EVS
  - ITS
- Monitoring and feedback enhancements
- New expertise
  - TRB
  - A3SE
  - SAE
  - UTRC
  - Ergonomics
  - Industrial Design
Regional University Transportation Research Centers

FDNY a leader in safety

Future
- Meaningful Goals
- New collaborations
- New policies
- New practices
- New standards
- New vehicles
- New technologies

Very Important Principle

Ambulance transport safety is part of a SYSTEM, the overall balance of risk involves the safety of all occupants and the public

Conclusion
- Major advances in EMS safety research, infrastructure and practice over the past 5 years
- New technologies for vehicle design, occupant PPE and equipment restrained and driver performance are now available
- Development of substantive EMS transport safety standards is a necessity and a reality
- Enhanced cross disciplinary collaboration in development of safety initiatives now exist
- EMS is still way behind the state of the art in transport and vehicle safety and occupant protection

And….
- It is no longer acceptable for EMS to be functioning outside of transportation, automotive and PPE safety standards for prevention of and protection of EMS providers and the public from injury and death

Any Questions??
Electronic handout available online
http://www.objectivesafety.net