

 The Annual Conference and Exhibition  
 For All Professionals Working in The Hospital and Emergency Care  
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## Ambulance Safety Issues: Hazard Analysis and Crashworthiness, Where is the State of the Art?



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## Outline

- ▶ Overview of the known hazards
- ▶ Tools that can be applied to evaluating these safety issues
- ▶ Current safety challenges
- ▶ Some of the multidisciplinary techniques for optimizing the safety of the system as a whole.

## Key Issues

- ▶ **Mythology**
  - That Emergency Medical Service personnel are safe
- ▶ **Injury Hazards**
  - Biohazard
  - Chemical/Radiation
  - Physical/Mechanical trauma – 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
    - the workplace is in a vehicle – exposure data are scant
  - Automotive Safety
    - a vehicle is the work place – 'exempt' from automotive research and regulation

## Safety oversight of what and by .... whom


- ▶ Vehicle Safety
- ▶ Vehicle Design
- ▶ Safety Equipment Design
- ▶ Vehicle and Safety Equipment Testing and Standard development
- ▶ Safety policies

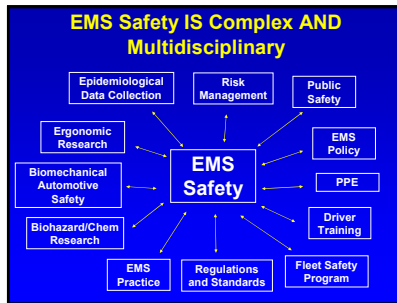
<http://www.objectivesafety.net>



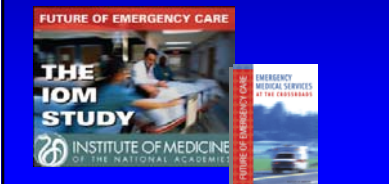
## the EMS process

- ▶ communications/dispatch
- ▶ 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





**"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)

\* Maguire, Hunting, Smith & Levick, Occupational Fatalities in Emergency Medical Services: A Hidden Crisis, *Annals of Emergency Medicine*, Dec 2002

## 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

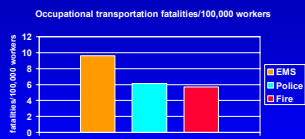
\* Maguire, Hunting, Smith & Levick, Occupational Fatalities in Emergency Medical Services: A Hidden Crisis, *Annals of Emergency Medicine*, Dec 2002.

## Predictable risks

- ▶ 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\*\*
- ▶ > 74% of EMT occupational fatalities are MVC related\*\*\*
- ▶ Serious head injury in >65% of fatal occupant injuries#
- ▶ 70% of fatal crashes EMS crashes during Emergency Use#
- ▶ More likely to crash at an intersection with traffic lights (37% vs 18% p=0.001) & more people & injuries/crash than similar sized vehicles##

\*Watts CA, Pirralo RJ, Kuhn EM. *Prehosp Emerg Care* 2001; 7(4):281-9  
 \*\*Baker, Giacomin, Landis, et. Al. *Accid Anal Prev* 2003  
 \*\*\*Maguire, Hunting, Smith, Levick, *Annals Emerg Med* Dec 2002  
 #WDCOR, 2003  
 ##Watts AM, Kuras DP. *Prehosp Emerg Care* 2005 Dec; 9:412-19  
 ##NHTSA, 49 CFR Parts 571, 572 & 589 Document No. 80-28; notice 7

## A word about occupational transportation fatalities..



▶ WE HAVE A BIG PROBLEM HERE

\* Maguire, Hunting, Smith & Levick, Occupational Fatalities in Emergency Medical Services: A Hidden Crisis, *Annals of Emergency Medicine*, Dec 2002

## EMS Injuries\*

- ▶ Higher than the injury rate for any private industry published by DOL
- ▶ 34.6 injuries/100 fulltime workers per year
- ▶ 1.5 x that of fire fighters
- ▶ 5.8 x that of health services personnel
- ▶ 7 x the national average

\* Maguire, Hunting, Guidotti & Smith, Occupational Injuries among Emergency Medical Services Personnel, *Prehospital and Emergency Care* Oct/Dec 2003

## Haddon/Baker/Runyan Phase-Factor Matrix

FACTOR	Paramedical/patient (host)	Vehicle (agent)	Environment (physical/regulatory)	Sociocultural (EMT image, scope & role), public/paramedic awareness, discrimination from S & S	Effectiveness
PHASE					Cost benefit
pre-crash (pre-event)	driving history, driver education, speeding, ending road laws	collision avoidance, anti lock brakes, vehicle weight, speed	tered dispatch, EPCS implemented, road design, markings & surface	EMS image, scope & role, public/paramedic awareness, discrimination from S & S	Ethics
crash (event)	seat belt, restraint use, child safety seat use	air bags, restraint design, bumper & crumple zone design	collision speed, road side hardware	It can and does happen	Social acceptability
post-crash (post-event)	gender, severity, age, underlying morbidity	ease of extrication, burn resistant fabrics	EMS system quality, trauma care, traffic management system	rehabilitation, documentation and data collection	Societal need

## EMS 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

## Goals

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

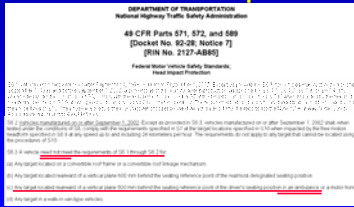
## General Concerns

- ▶ 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) 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

## Background: USA Problems

- ▶ No reporting system or database specifically for identifying ambulance crash related injury
- ▶ Rear passenger compartment, > 60cm behind driver - exempt from Federal Motor Vehicle Safety Standards (FMVSS)

## USA Ambulances: FMVSS Exempt



## “Are our policies killing people?”

- ▶ 1991-2000, 302,969 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\*:
  - 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)

\*Comparison of Crashes Involving Ambulances with those of similar sized vehicles – Adam Ray, Douglas Kupas, PEC Dec 2005;9-412-415

## Daily American Republic

### Ambulance driver in fatal crash is charged

REDDOTT, Mo. (AP) — An ambulance driver from the Missouri border town charged Friday with two counts of involuntary manslaughter for an accident that killed a patient in the ambulance and the driver of the other vehicle.

The accident happened Sunday on Missouri 164 near Kennett in Dunklin County.

Patrick White, 23, of Poplar Bluff, was driving an ambulance for Poplar Bluff Regional Medical Center. The Missouri State Highway Patrol said White failed to stop at a stop sign and struck a 1993 Buick driven by Dorothy Winstead, 64, of Homeville.

The ambulance's siren and emergency lights were not on, the patrol report said.

Winstead and a patient in the ambulance, William Bradley, 66, of Wappapetola, were killed.

White suffered minor injuries. His co-worker in the ambulance, James Simpson, 41, of Potosi, Mo., was taken to a hospital in Memphis, Tenn., with serious injuries.

Bond for White was set at \$10,000.

## Crash Prevention

- ▶ EVOC
- ▶ Tiered Dispatch
- ▶ The “Black Box”
- ▶ Intelligent vehicle design
- ▶ Appropriate policy

## What do we know now??

- ▶ Intersection crashes are the most lethal
- ▶ There are documented hazards, some which can be avoided
- ▶ Occupant and equipment restraint with standard belts is effective. (Over the shoulder harnesses for patients should be used, with the gurney in the upright position where medically feasible)
- ▶ Some vehicle design features are beneficial - automotive grade padding in head strike areas, seats that can slide toward the patient
- ▶ Electronic Driver monitoring/feedback systems appear to be highly effective
- ▶ Head protection??

## A number of potential interventions to enhance safety have been identified:

- ▶ Safety Policy
- ▶ Safety performance standards
- ▶ Vehicle crashworthiness
- ▶ Vehicle interior ergonomics
- ▶ Personal Protective Equipment design
- ▶ Driver training and simulation
- ▶ Safety and risk awareness modification
- ▶ Risk behavior modification
- ▶ Intelligent Transportation Systems (ITS)

## The ‘workplace’ IS a vehicle

- ▶ Providers often in vulnerable positions during transport.
  - Bench seat
  - Captains chair
  - Standing or kneeling



View of Ambulance interior from Rear



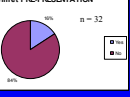
It does happen....

## But what about head protection?



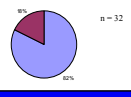
## Preliminary Study: Attitudes to Head Protection in EMS

Would You Consider Wearing a Helm at PRE-PRESENTATION



n = 32

Would you consider wearing a helmet POST



n = 32

## Automotive Safety World

SAE Future book  
A collection of 140+ Chapters in 2007, industry overview. Focus: the future of mobility technology.

### The future of vehicle safety



...discussing effort by the auto industry and government has produced a tremendous reduction in the number of traffic fatalities in the United States. In fact, the number of traffic fatalities in the United States in 2006 was 42,000 people, an 80% reduction from 1982. The industry and government are working together to reduce the number of traffic fatalities even further. One program called 'Active Safety' will reduce the number of traffic fatalities by an additional 10%. At Continental, we are committed to the safety of our customers and we are working to reduce the number of traffic fatalities by an additional 10%.

## Protective devices/concepts

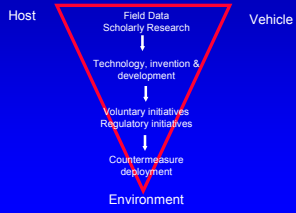
**To prevent a crash**

- ▶ Driver feedback
- ▶ Driver monitoring
- ▶ Driver training
- ▶ Vehicle ITS technologies
- ▶ Tiered dispatch
- ▶ Appropriate policies

**In the event of a crash**

- ▶ Vehicle crashworthiness
- ▶ Seat/seat belt systems
- ▶ Equipment lock downs
- ▶ Padding
- ▶ Head protection

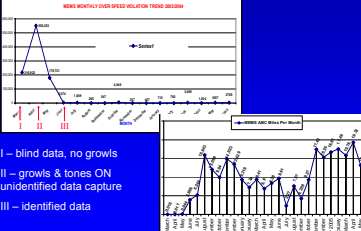
## Automotive Injury Triangle and Safety Development



## Purpose of 'Black box' Program

- ▶ Enhance Safety
- ▶ Improve Driver Performance
- ▶ Save Maintenance Dollars
- ▶ Aid Accident / Incident Investigation

## Demonstrated Effectiveness



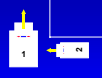
I – blind data, no grows  
II – grows & tones ON unidentified data capture  
III – identified data

## Other monitoring devices

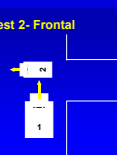
- ▶ Primarily to record events during and immediately preceding a crash
- ▶ Give no driver crash prevention feedback
- ▶ Administratively burdensome
- ▶ Intrusive
- ▶ Not demonstrated to be as effective in improving vehicle maintenance costs or as effective in modifying driver behavior long term

## Full Vehicle Crash Tests - 2000

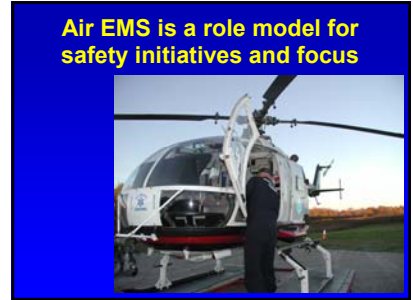
Test 1 – Right side impact



Test 2 – Frontal



1 – Target vehicle  
2 – Buffer vehicle  
Type II ambulance  
Closing speed: 44 mph



**Air EMS is a role model for safety initiatives and focus**

### Global EMS Vehicle Safety Standards v Specifications and Guidelines

- ▶ **EMS Safety and Performance Standards**
  - Australia & New Zealand 4535
  - Common European Community (CEN) EN1789
- ▶ **Non EMS Specific USA Standards**
  - [Aviation - FAA/CAA/JAA]
  - Z15 – Fleet vehicles safety management
- ▶ **USA EMS Specification & Guidelines**
  - Purchase Specification: KKK & NTEA – AMD
  - Guideline: EMSC Dos and Donts CAAS and CAMTS

### 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

### Z15 Incident Rates

- ▶ Incident rate based on number of vehicles operated:  

$$\text{Incident rate} = \frac{\text{Number of incidents} \times 100}{\text{Number of vehicles}}$$
- ▶ Incident rate based on vehicle mileage:  

$$\text{Incident rate} = \frac{\text{Number of incidents} \times 1,000,000}{\text{Vehicle mileage}}$$
- ▶ Injury incident rate based on vehicle mileage:
  - Injury incident rates, the most frequently used indicator of incident severity, are useful for tracking events that have the potential to affect financial or operational performance of the operating unit.
  - Injury incident rate =  $\frac{\text{Number of incidents with injury} \times 1,000,000}{\text{Vehicle mileage}}$
- ▶ Incident rates based on service activity:
  - Motor vehicle operations that pose injury risks other than those associated with driving should also use the service activity as the basis of a safety performance rate. The number of deliveries, stops, or loads should be considered as appropriate indicators of performance.
  - Incidents per 10,000 transports =  $\frac{\text{Number of incidents} \times 10,000}{\text{Number of transports}}$
- ▶ Vehicle injury rates based on work hours:  

$$\text{Vehicle incidents per 200,000 hours} = \frac{\text{Number of incidents} \times 200,000}{\text{Number of hours worked}}$$

### Safety Management

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

### EMS Risk/Hazards

- ▶ Predictable risks
- ▶ Predictable fatal injuries
- ▶ Serious occupational hazard
- ▶ Public safety hazards

## Safety Enhancements Being Implemented

- ▶ EVOC
- ▶ Tiered dispatch
- ▶ Monitoring & Feedback devices
- ▶ Helmets
- ▶ Optimized ambulance vehicle design
- ▶ New Standards

## Future

- ▶ Meaningful Goals
- ▶ 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

**PREDICTABLE  
PREVENTABLE  
and  
NO ACCIDENT**

## Conclusion

- ▶ Major advances in EMS safety research, infrastructure and practice over the past 5 years
- ▶ There are clear and very serious safety risks and hazards in ambulance transport now documented
- ▶ Technologies for safe vehicle design, occupant PPE and equipment restraint and driver performance are available
- ▶ Development of substantive EMS 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 vehicle safety and occupant protection

## And....

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



Thank you! Any Questions?

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[www.objectivesafety.net](http://www.objectivesafety.net)