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Ohio Safety Congress & Expo

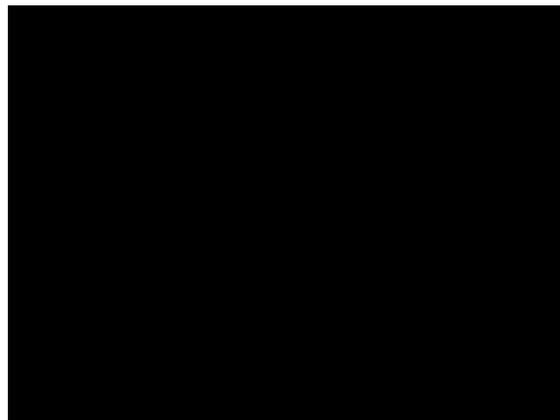


**#214 – The future of EMS transportation**

Bill Baer and Steve Cole

Wednesday, March 30, 2011  
1 to 2 p.m.

**Ohio** | Bureau of Workers' Compensation



**Future of EMS Transportation**



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**Future of EMS Transportation**

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**Future of EMS Transportation**

**Please, Feel Free to Leave the Room to Take calls!**

**Thank You!**

*PLEASE SET PHONES TO VIBRATE*



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**Future of EMS Transportation**

- **LEARNING OBJECTIVES**
- Will become familiar with research based safety improvements in process
- Will highlight significant safety hazards
- Will provide you with key issues to consider as you spec a new ambulance
- Will not suggest changes to your work tasks – you are the experts
- Will not suggest any specific product

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## Future of EMS Transportation

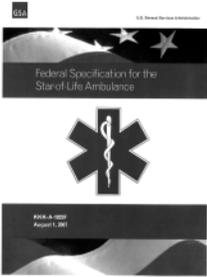
Today's Presentation

- History of Ambulance Design
- Progress to date – Standards Development
- Emissions Standards
- Patient compartment occupant injury mechanisms
- Building a strong team
- Safety Testing & Innovations
- Recommendations for near term purchases

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## Future of EMS Transportation

1971-JANUARY 1, 1975

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## Future of EMS Transportation

**ambulance design criteria**

- National Highway Traffic Safety Administration (NHTSA) undertook project to develop ambulance design and performance criteria at outset of 1968 (funeral directors wanted out of the business)
- Criteria developed from committee level of physicians, ambulance operators and specialists in fields related to ambulance use
- Great deal of information came from an ambulance exhibit held in Columbus, Ohio in 1968
- Criteria developed for 5 areas:
  - System description
  - Operational hardware/equipment
  - Vehicle standards (Chassis, design, dimensional requirements, etc)
  - Communication equipment
  - Environmental equipment

**RESULT:** *Ambulance design criteria* published in 1971

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**Federal Specification for the Star of Life Ambulance (KKK-A-1822) 1976**

- First proposed by the US General Services Administration (GSA) in 1974
  - Objective was to form a more detailed specification in *ambulance design* for purchases by GSA for Federal users of ambulances (Military, logistic centers, etc.)
- Written by personnel from GSA and **AMD**
- Developed ambulances by TYPE
  - Type 1 (Modules built on conventional cab trucks)
  - Type 2 (Van conversions)
  - Type 3 (Modules built on cut-away vans chassis)
- Expanded requirements from Ambulance Design Criteria

**RESULT:** *KKK-A-1822* published in 1976 and revised 5 times since)

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**Ambulance Manufacturers Division (AMD) formed 1976**

- Currently comprised of 16 ambulance manufacturers ar ambulance component suppliers
- Represents 90% of US ambulance production
- Purpose is to work closely with chassis vendors in developments of new models and features compatible for ambulance service
- Purpose is to work with State and Federal agencies in the development of KKK standards and development of *performance tests procedures* for ambulances



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Ambulance Manufacturers Division  
An Industry Division of the National Truck Equipment Association

# STANDARDS

- AMD STANDARD 001 — STATIC LOAD TEST FOR AMBULANCE BODY STRUCTURE
- AMD STANDARD 002 — BODY DOOR RETENTION COMPONENTS TEST
- AMD STANDARD 003 — DOOR HINGE RETENTION SYSTEM
- AMD STANDARD 004 — LITTER RETENTION SYSTEM
- AMD STANDARD 005 — AMBULANCE TO VEHICLE ELECTRICAL SYSTEM
- AMD STANDARD 006 — SOUND LEVEL TEST CODE FOR AMBULANCE COMPARTMENT INTERIOR
- AMD STANDARD 007 — CAMBION SOUNDING LEVELS FOR AMBULANCE COMPARTMENT INTERIOR
- AMD STANDARD 008 — LOAD TEST FOR AMBULANCE PATIENT COMPARTMENT STRUCTURE
- AMD STANDARD 009 — 120V AC ELECTRICAL SYSTEM
- AMD STANDARD 010 — WATER SPRAY TEST FOR AMBULANCES
- AMD STANDARD 011 — AMBULANCE EQUIPMENT TEMPERATURE TEST
- AMD STANDARD 012 — AMBIENT TEMPERATURE TEST
- AMD STANDARD 013 — WEIGHT DISTRIBUTION
- AMD STANDARD 014 — COOLING SYSTEM TEST
- AMD STANDARD 015 — AMBULANCE MAIN DRIVE/STEER SYSTEM TEST

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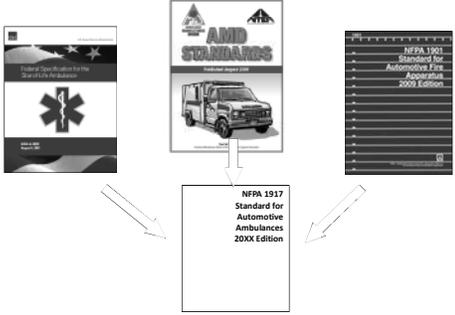
**NFPA 1917 2013??**  **National Fire Protection Association**  
The authority on fire, electrical, and building safety

**•Federal Government (GSA) wants out of the specification writing business for ambulances!!**

**RESULT:** NFPA 1917 to take effect by January 1, 2013  
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### Specs and Standards Today



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## Future of EMS Transportation

### NFPA 1917

Committee Appointed in March 2009  
Will Replace KKK  
Consensus Spec

- Fire Depts.
- Private Providers
- Test Labs
- Government (NIOSH, GSA and NHTSA)
- State EMS Agencies
- End Users
- Manufacturers (5)
- Suppliers
- Interested Parties

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## Future of EMS Transportation

### Changes From KKK Standard

#### Testing

- AMD Standards for most part
- Additional tests required
- Labs certified to ISO 17020 and 17025 (3-4 Labs)
- “Substantially different” has new definition
- Every Engine or displacement must be tested

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## Future of EMS Transportation

### Changes From KKK Standard

#### Testing

- No self testing
- Some vendor certification permitted
- Contractor must include statement of non-compliant items
- Customer must sign promise to comply before put in service

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## Future of EMS Transportation

### Chassis Items

- Vehicle data recorder has been deleted
- Operating temperature -20 to 100 degree F
- Maximum top speed is 77 MPH
- Must meet GVW and GAWR ratings

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**Future of EMS Transportation**

**Chassis Items**

- Label for height and GVW
- Engine hour meter
- Front approach angle reduced to 10 degrees
- No hubcaps or wheel covers. Wheel nuts readily observable

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**Future of EMS Transportation**

**Chassis Items**

- Stability control system has been deleted
- Mud Flaps front and rear
- Driver seat full OEM travel and 30% of range of seatback inclination or same
- As OEM angle on non-reclining seat

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**Future of EMS Transportation**

**Chassis Items**

- Cabs on ambulances over 26,000 lbs must meet SAE J2420 front strength
- and roof strength J2422
- Mirrors shall be largest OEM. Heated/Remote not required

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**Future of EMS Transportation**

**Body Requirements**

- Roof and side integrity test is same at 2.5 times GVW with 5.12" deflection
- Rear step cannot exceed 22" in kneeling position
- Walkthrough requirement deleted
- Partition does not require a window

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**Future of EMS Transportation**

**Body Requirements**

- Must be two means of escape 24" x 24". Non-traditional is OK
- Exterior stepping surfaces must meet NFPA
- Battery compartment doors do not need hold-opens

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**Future of EMS Transportation**

**Cab and Body Requirements**

- Interior or exterior access handrails at each entrance to a driving or crew area and at each step or ladder position
- Exterior handrails must be non-slip material
- OEM handrails are acceptable
- Handrail test—300 lbs in any direction

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### Interior Requirements

- New test for subfloor strength
- No minimum interior storage volume
- No lips required on countertops
- Only one IV hook—no straps required

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## Future of EMS Transportation

### Interior Requirements

- Vehicles over 19,500 GVW have to have 60" seat belts
- Each seat in vehicles over 10,000 lbs shall have 24" width at shoulder
- Seat cushions must be 18" wide and 15-19" deep
- No cfm requirements for exhaust fan

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## Future of EMS Transportation

### Interior Seating

- Customer must designate the primary seating position
- If primary position is at head of cot, then the seat must be capable of being adjusted so the nearest edge of the seat bottom is no less than 6" from the nearest edge of the cot
- If primary position is at the patient torso, then seat must be able to be adjusted so the nearest edge is no less than 6" from the nearest edge of the cot
- The longitudinal centerline of the seat shall line up within 11" of the longitudinal centerline of the cot

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## Future of EMS Transportation

### Interior Seating

- Cannot orient a child safety seat in a side facing position
- Seat belt warning system was deleted
- Only one oxygen outlet is required. It must be accessible from primary care position
- All electrical controls must be accessible from primary patient position

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## Future of EMS Transportation

### Electrical Requirements

- New electrical system tests are required
- Generators over 3 KW require UL or similar outside verification
- Optical warning system is NFPA for now. May option KKK system

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## Future of EMS Transportation

### Electrical Requirements

- Only one scene light per side is required
- New ground lighting requirements. .3 foot candle 30" from edge of vehicle in entry or egress areas

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### Future of EMS Transportation Electrical Requirements

- Compartment lights-new std. 1 Foot candle at any location on floor of compartment without shelves for any compartment over 4 cu. Ft. or having an opening greater than 144 sq. in.

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### Future of EMS Transportation Electrical Requirements

- “Do Not Move Ambulance” light. Rotator, flashing light or electronic display. Operates when emergency brake is not engaged and a door is open, an equipment rack is not in stowed position or any other device is deployed that could cause damage when vehicle is in motion

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### Future of EMS Transportation Lettering

- NFPA striping 25% width of front of vehicle 50% overall length to be reflective 6.00”
- Chevrons on 50% of rear area
- Star of Life requirements were deleted

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### Future of EMS Transportation

Print Page Page 1 of 1

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### Future of EMS Transportation EMS/AMBULANCE History Buff's Website 1800's to Today

- <http://www.fl-ems.com/BEMS/EMShistory.pdf>

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### Future of EMS Transportation Emission Regulations

Year	NOx (g/bhp-hr)
1990	~0.55
1991	~0.45
1994	~0.25
1998	~0.15
2002/2004	~0.15
2007	~0.10
2010	~0.10

- 1998: Engine Manufacturers Must Comply to 4.0 NO<sub>x</sub> / .1g PM
- 2002: EPA Pulls Ahead Consent Decree Compliance to 10/1/02  
~2.5 NO<sub>x</sub> / .1g PM
- 2004: Mercedes-Benz Product Meets 2.5g NO<sub>x</sub> / .1g PM Requirements
- 2007: Engine Manufacturers Must Comply to 1.2 NO<sub>x</sub> / .01g PM
- 2010: NO<sub>x</sub> to be Reduced to .2g NO<sub>x</sub> / .01 PM  
~90% from 2007 Levels

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### Future of EMS Transportation

#### OEM Approach to 2010 emissions

Three different approaches to meet 2010 emissions:

- 1. Selective Catalytic Reduction (SCR)**

Cummins	Hino
Detroit Diesel (Freightliner)	Isuzu
Dodge chassis cabs	Paccar (DAF)
Ford	UD
Fuso	Volvo/Mack
GM	
- 2. High-rate EGR (Enhanced/Advanced EGR)**  
International (MaxxForce)
- 3. Lean NOx Trap (LNT)**  
Dodge pickups

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### Future of EMS Transportation

#### Chassis Affected By Diesel Emissions

*No Diesel Exhaust Fluid (DEF)*

- 1- International will meet emissions utilizing (EGR) system.
- 2- Ford 2010 E-Series will utilize gasoline engine

*SCR System With Diesel Exhaust Fluid (DEF) Urea*

- 1- Ford F- Series will utilize urea (SCR) system
- 2- G-4500 will utilize urea (SCR) system
- 3- Dodge chassis will utilize urea (SCR) system
- 4- Freightliner chassis will utilize urea (SCR) system

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### Future of EMS Transportation

#### FORD F-SERIES CHASSIS



Urea Fill

Fuel Fill

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### Future of EMS Transportation

#### Freightliner Chassis



DEF Tank Size Refill

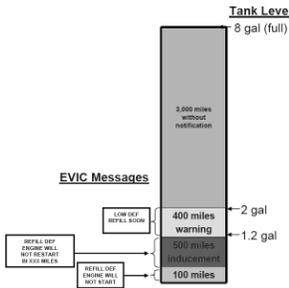
34 gallon fuel tank

6 gallon DEF tank

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### Future of EMS Transportation

#### Driver Warning System for Low DEF



**Tank Level**  
8 gal (full)

**EVIC Messages**

- REFILL DEF ENGINE WILL NOT RUN FOR 600 MILES
- REFILL DEF ENGINE WILL NOT START
- 500 miles inducement
- 400 miles warning
- Low DEF REFILL SOON
- 2 gal
- 1.2 gal
- 1,000 miles without notification

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### Future of EMS Transportation

- Provide patient compartment occupants with the same level of crash protection as passenger cars.
- Work with end users to ensure designs meet needs
- Move NIOSH research results to practice (old and new research results)
- Near Term: Develop revisions to GSA purchase specifications and AMD industry based standards –
- Long Term: Incorporate changes into second revision of new NFPA 1917 Automotive Ambulance Standards
- Ensure all proposed standards are based on actual test data not conjecture

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### Future of EMS Transportation

- Ford E-350 Type 3 vs Mitsubishi Eclipse

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### Future of EMS Transportation

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Defibrillator unit,  
restrained with seat belt –  
Right lumbar area  
contusion

Soft side medical bag

EMT's Seating  
Position

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### Future of EMS Transportation

EMT Contacts with Assist Handle and Edge of Front Wall

**Injuries:**

- Left Occipital intraparenchymal hemorrhage
- Left occipital contusion
- Positive loss of consciousness
- 20 cm laceration into muscle on the right parietal/occipital scalp
- Right occipital scalp contusion

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### Future of EMS Transportation

EMT Contact with Left Side Cabinets

EMT contact with left side cabinets results in left forearm abrasion

Two days in hospital as result of injuries

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### Future of EMS Transportation

Proper seat belt use requires occupant to be seated fully upright against seat back

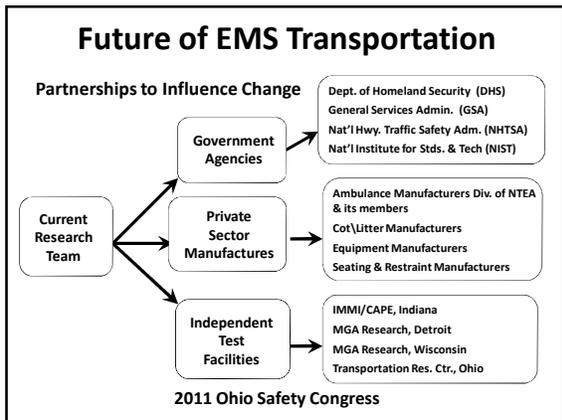
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### Future of EMS Transportation

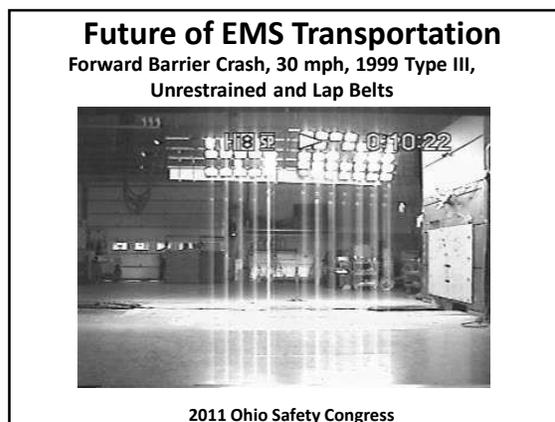
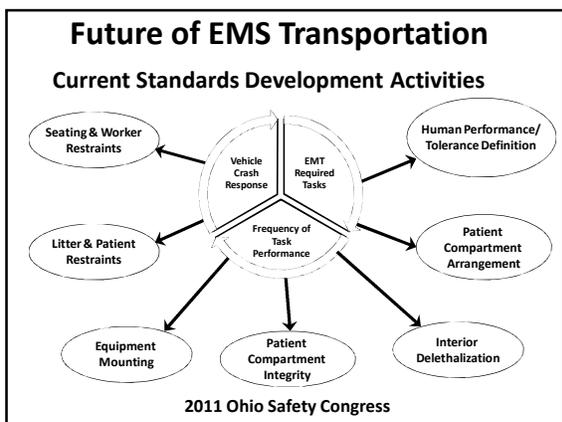
Some procedures require more mobility than provided when using seat belts properly

Source: Workers' Compensation Board of British Columbia, Report 11/01/20, B 1999 (99FS-14)

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- ### Future of EMS Transportation
- #### Strategy for Impact
- With funding support from Dept. of Homeland Security and partnerships with industry NIOSH will:
    - Validate proposed AMD standards through full scale testing
    - Design, manufacture and qualify new seats, restraints, gurneys, patient restraints and equipment mounts to the proposed AMD standards
    - Quantify the price impact of change to the industry and end user
    - Address human factors/interior layout concerns (NIST)
  - Use data from development of AMD standards to influence change in NFPA national consensus standard – 2<sup>nd</sup> revision
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### Future of EMS Transportation

#### Testing Criteria – Frontal Impact

(Society of Automotive Engineers Approved)

- Based on NIOSH Testing
- Reviewed by Ford, GM, NHTSA, and 3 independent test labs

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## Future of EMS Transportation

### Seat and Worker Restraint Team

Key Elements:

- Seat should remain attached to vehicle without structural failure using new crash pulses
- Reduce worker excursion to eliminate impacts
- Do so without driving patient loading in head, neck, chest beyond accepted human tolerance limits

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## Future of EMS Transportation

### Reducing Lethality of Interior Structure

FIGURE C:  
(Forward Facing seat)

Stay Away Zone  
Head Path  
Maximum Travel Distance  
Foremost Seat Plane  
FRONT OF VEHICLE

FIGURE D:  
(Side Facing seat)

Stay Away Zone  
Head Path  
Maximum Travel Distance  
Foremost Seat Plane  
FRONT OF VEHICLE

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## Future of EMS Transportation

### Lap Belt vs. Mobile Restraint, at 25 mph Front Impact, Bench Seat Occupant

Impact Direction

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## Future of EMS Transportation

### CPR Seat Frontal Impact

Impact Direction

Lap Belt  
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## Future of EMS Transportation

### The Problem -- Case Investigations Show

- Regardless of seating location, non-use of seat belts is the primary injury risk.
- EMS workers routinely work unrestrained in the patient compartment.
- EMS workers need mobility to reach equipment and access the patient in ambulances as currently built.
- Occupant protection systems allowing mobility offer the opportunity for improved outcomes

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## Future of EMS Transportation

### Existing Mobile Restraint Systems

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### Future of EMS Transportation Improved Ergonomics (Patient Access)



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### Future of EMS Transportation Forward Barrier Crash, 30 mph, 1993 Type III



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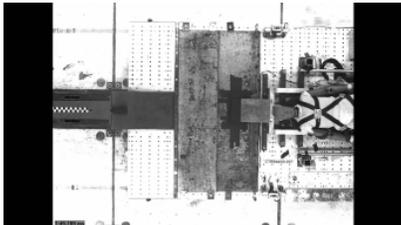
### Future of EMS Transportation Patient Restraint Issues: Current Production Configuration



- ▶ Data from this test used to develop new SAE Crash Pulse
- ▶ Excursion distance greater than 30 inches
- ▶ Head, neck, chest, and pelvis loading within published limits

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### Future of EMS Transportation Patient Restraint Issues: Reduced Excursion Testing



- ▶ Used new SAE Published Frontal Crash Pulse
- ▶ Excursion distance of 8.42 inches
- ▶ Head, neck, chest, and pelvis loading within published limits

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### Future of EMS Transportation Equipment Mounting and Cabinet Standards Development Team

Key Elements:

- Equipment weighing 3 lbs or greater must be mounted or be located in an enclosed cabinet
- Mount should retain equipment under frontal and side impact pulses (working on a translation to static load test)
- Equipment in cabinets must remain in cabinets
- Cabinet doors and latches must remain latched

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### Future of EMS Transportation Equipment Mounting Cabinet Latching Issues



Prior to crash equipment and gurney either mounted or stowed in cabinets

Post crash (rollover) equipment and gurney positions drastically changed

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**Example of Possible Change: Defibrillator Mount With Sliding Tray**




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### Future of EMS Transportation

**Body Integrity and Mounting Standards Development Team**

Key questions currently under discussion:

- Can we devise a test to ensure patient compartment structural integrity – especially during side impact or under rollover conditions?
- Can testing be conducted in a quasi static fashion versus full vehicle crash test?
- Goal – meet or exceed US automotive testing requirements and international ambulance standards

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### Future of EMS Transportation

**Body Integrity and Mounting Standards**

- Frontal edge of patient compartment took hit
- Side sheared off
- Very different from pure side impact




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### Future of EMS Transportation

**Human Factors Research - NIST & DHS**

\*\* New to Research Team this year \*\*

- Both organizations possess engineers and scientists with expertise in human factors and work station design
- Understand the tasks EMS worker tasks must perform
- Understand the context in which they perform their tasks
- Identify and analyze worker and performance risks associated with task performance
- Identify emerging technologies and products that may be incorporated into future ambulance patient compartments

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### Future of EMS Transportation

**Human Factors Research - NIST & DHS**

- Identify user interface design requirements for key medical and communication systems to reduce injury risks and enhance patient care
- Develop User Interface design concepts for patient compartments that address compartment/equipment configurations and identified design requirements
- Evaluate concepts through modeling and/or mockups and perform design tradeoffs
- Document final design concepts and criteria in a preliminary design guidance document

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### Future of EMS Transportation

**Completed NIOSH Modeling Work**

- Compared “standard” design to the “custom” design using digital human modeling
- Developed representative models of ambulance interiors
- Created accurate human reach envelopes using different sized workers
- Identified and evaluated opportunities for design improvement

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### Future of EMS Transportation

Digital Human Modeling – Improvements to Compartment and Seating Design

Typical

Modified

Modeled and Evaluated

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Simulations – 95<sup>th</sup> Male, “Standard”

“Traditional Environment:  
95<sup>th</sup> Male by Stature”

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### Future of EMS Transportation

Simulations – 95<sup>th</sup> Male, “Custom”

“Modified Environment:  
95<sup>th</sup> Male by Stature”

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### Future of EMS Transportation

#### Conclusions

- Interior configuration significantly affects worker safety
- Most patient compartment designs force a worker to leave his/her seat to complete job tasks
- Data analysis indicates both lap belts and multi point mobility restraints or fixed harnesses can sustain loads and reduce injury risk
- Patient shoulder restraints reduce travel and thus likelihood for contact with worker or surfaces
- Lock down equipment whenever possible

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### Future of EMS Transportation

#### What could be improved?

- Develop list of required tasks, equipment used, & frequency
- Think about compartment layout based on task frequency
- Work closely with ambulance builder to locate equipment
- Consider improved seating and worker restraints

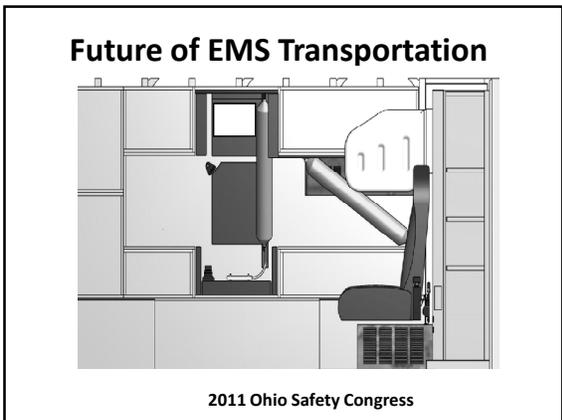
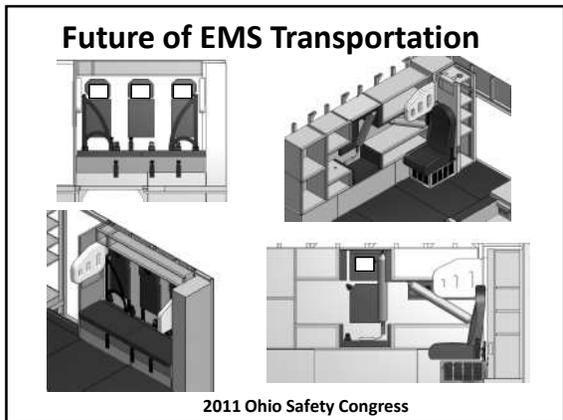
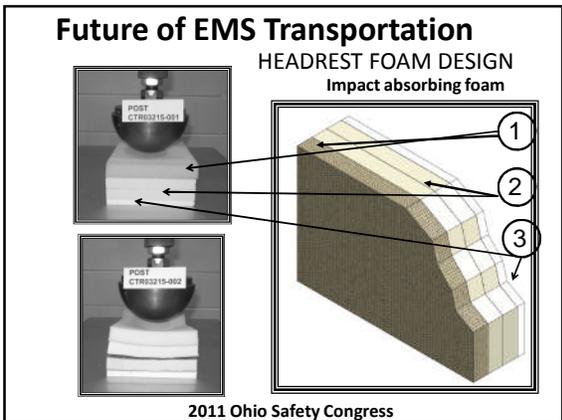
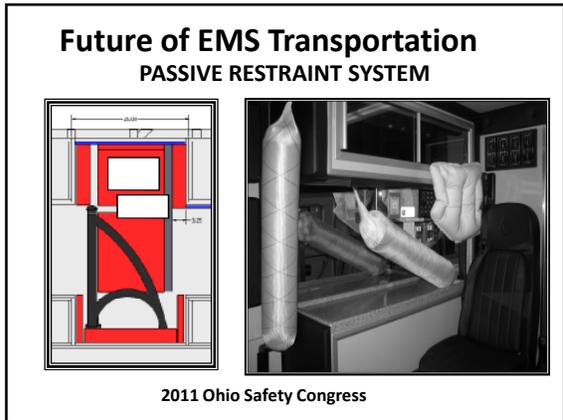
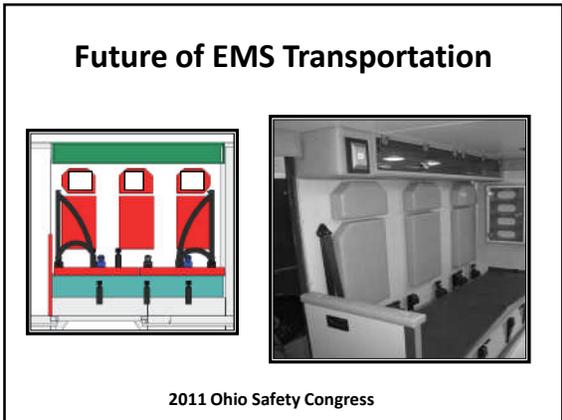
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### Future of EMS Transportation

#### Other Thoughts to Consider

- New patient compartment configurations, seating and restraint types are coming on the market that improve a worker’s ability to remain restrained while performing job tasks

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### Future of EMS Transportation

Cross mount Cot      Forward/Rear Facing Seating Only



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### Future of EMS Transportation

Decreased Vehicle Profile on Roadway      Increased Conspicuity



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### Future of EMS Transportation

## THANK YOU!



**CREDITS**

- NIOSH – Jim Green
- NHTSA
- NFPA
- NIST
- GSA
- AEV Ambulances
- Braun Ambulances
- Horton Emergency Vehicles
- McCoy-Miller Ambulances

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