Improving Patient and Worker Safety in a Moving Ambulance

Presented By: Jim Green (NIOSH)
National Association of EMS Physician,
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Biosketch – Jim Green

• 19 years with NIOSH – last 10 as a researcher
• 10 years with NAVAIRHQ in helicopter flight & crash safety
• 2 years at Boeing and 2 years with Bechtel Power Corporation
• Involved with ambulance crash safety research since 2001
• Led large research effort co-funded by NIOSH and DHS since 2010. Project also includes many commercial partners.
• Conducted 17 full vehicle crash tests and approx. 150 seating tests, 40 cot tests, 130 equipment mount and cabinet tests
• Coauthor of 10 Test Methods published or soon to be published by the Society of Automotive Engineers
• Voting member of NFPA 1917 and SME on CAAS GVS 1.0

Presentation Overview

• Background
  – Injury and fatality figures and contributing factors
  – Goals & team approach
• Review Society of Automotive Engineers (SAE) Crash Test Standard Development
  – Vehicle response, seating, patient cot, equipment mounts, and ambulance body strength
• Incorporation of SAE Standards Into Bumper-to-Bumper Standards
• Designing a safe and efficient interior
  – Creating a new layout to meet operational expectations safely
An Overview of Ground Ambulance Crashes in the US

Between 1992-2011 (20 years), there were an annual estimated average of 4,500 motor vehicle traffic crashes involving an ambulance.

Of these crashes:
- 65% resulted in property damage (only)
- 34% resulted in an injury/injuries
- <1% resulted in a fatality/fatalities

*Injuries and fatalities include occupants in all cars involved in a traffic crash involving an ambulance

Between 1992-2011 (20 years), there were an annual estimated average of 4,500 motor vehicle traffic crashes involving an ambulance. Sources: NHTSA’s Fatality Analysis Reporting System (FARS) 1992-2010 Final and 2011 Annual Report File (ARF) and National Automotive Sampling System (NASS) General Estimates System (GES), 1992-2011

Between 1992-2011 there were an estimated annual mean of 1,500 injury crashes involving an ambulance and 2,600 injured persons (includes occupants and non-occupants of all vehicles involved)

*Data represents mean number of crashes and injuries over 5 years. **Does not include data for non-occupants of vehicles (pedestrians or pedalcyclists) in injured persons. Sources: NHTSA’s Fatality Analysis Reporting System (FARS) 1992-2010 Final and 2011 Annual Report File (ARF) and National Automotive Sampling System (NASS) General Estimates System (GES), 1992-2011

Estimated Ambulance Crashes resulting in Injured Persons 1992 - 2011

Estimated Injuries in Crashes Involving an Ambulance: 1992-2011
Fatal Ambulance-Involved Crashes 1992-2011:

Between 1992-2011 there were an annual average of 29 fatal ambulance crashes and 33 fatalities (includes occupants and non-occupants of all vehicles involved).

Overarching Goals of this Research

- Provide patient compartment occupants with the same level of crash protection as is found in passenger vehicles
- Work with end users to ensure designs meet needs
- Partner with manufacturers to ensure adoption of consensus standards in the absence of a regulatory requirement to do so
- Near Term: Develop system specific test methods for publication to be referenced nationally or internationally
- Long Term: Incorporate changes into one or more bumper-to-bumper ambulance national standards

*** Most Importantly ***
Ensure all proposed standards are based on actual test data

Automotive Testing Expertise Applied

- Testing performed by three private companies at five different crash test facilities from Wisconsin to Virginia
  - Center for Advanced Product Evaluation (CAPE)
  - MGA Research
  - Transportation Research Center
- Government research support
  - National Highway Traffic Safety Administration's
    - Vehicle Research Test Center, East Liberty, Ohio
  - Office of Vehicle Crashworthiness Research, Washington, DC
  - Federal Aviation Administration's
    - Crash Dynamics, FAA Aviation Safety
    - Civil Aerospace Medical Institute
Crash Standard Development

Vehicle Response Provides Foundation for Future Work

We need to understand the loading applied to the ambulance body at impact

~30 mph – likely survivable; the basis for our auto standards in US today
~60 mph – likely not survivable


Building New Ambulance Test Methods: The Foundation is Crash Testing

Crash testing helps us understand how the vehicle reacts both internally and externally as crash energy is distributed.
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SAE Recommended Practices: NIOSH & Ambulance Builders Working Together

Using energy derived from full vehicle crash testing, the team was able to design and test new crashworthy components for use in the ambulance.

Component Specific Test Methods

SAE J3027 – Patient Cot
SAE J3102 – Subfloor – Under Cot
Structural Concerns with Existing Litter Retention Devices & Seating Systems

Occupant Excursion Issue:
Existing Restraint Type and Location

Pre-crash event: standard cot, restraint and antler floor fastener

Mid-crash event: patient excursion exceeds 30 inches or 76 cm

Ambulance Crash Investigations:
Patient Restraint System Use and Ejection from Cot

Litter Design – Patient Restraint Team

Key Elements in RP
- Dynamic, crash testing is required using front, side and soon rear impact pulses
- Litter, litter mounting and restraints structurally sound
- Occupant excursion reduced to less than 14 inches
- A 2nd edition to be published this fall

Production Cot – Successfully Meets SAE J3027 Recommend Practice Criteria

SAE J3027: Patient Litter & Restraint
(14 inch Excursion Limit – The Goal Line View)
Ramp & Cart Roll Tests with Cots: 30 MPH

A new prototype cot and instrumented crash test dummy installed in each ambulance – one from Stryker and one from Ferno.

Both cots and their floor fixtures remained structurally sound, with the patient securely restrained. Dummy parameters fell below NHTSA limits.

What is the impact when adopting new crashworthy cot requirement?

- The existing antler system will not meet the new standard.
- Future ambulances will need to be outfitted with new, crashworthy floor fixtures or cot mounts.
- Very few existing cots will work in the new mounts (please see each manufacturer for specific details).
- New, complete cot and floor retention systems range from about $7,000 to $40,000.
- You don’t have to purchase a high end powered cot: Ferno and Stryker both offer manual load cots at a far lower cost than the powered options.

SAE J3102 Sub-Floor Structural Integrity Test Methodology

Key Elements in this Recommended Practice:
- Testing must be completed for front, side, and rear crash loading.
- Static testing requires a pull test of > 18,000 lbs.
- Dynamic testing uses published crash pulses.
- Validates design for both modular body and van style bodies.

SAE J3102 - Dynamic Test Option

This test also provided positive test results for SAE J3027 – patient cot for structural integrity and excursion.

Meet floor strength requirements in SAE J3102

Component Specific Test Methods

SAE J3026: Seating and Occupant Restraints

SAE J3059: Occupant Excursion

Seat Belt Use by EMS Providers

84% of EMS providers in the patient compartment were not restrained.

Injury Severity and Use of Safety Restraints by EMS Providers

SAE J3026: Seat and Worker Restraint

Key Elements in Recommended Practice
- Dynamic, crash testing is required
- Bench seats are included
- Seat and restraint systems must protect occupants to same crash standard as automotive seating
- Utilizes HIII and ES3-re 50th male ATD as appropriate.

Demo: Frontal Impact, Forward and Rear Facing Seating
Mapping Occupant Excursion

Head path information helps ambulance builders AND buyers create safer work environments collaboratively!

Component Specific Test Methods

SAE J3043 - Equipment Mount Test

SAE J3058 – Cabinet Content Retention
Equipment Mount & Cabinet Integrity:
SAE J3043 and SAE J3058

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

Final crash (rollover) equipment and gurney positions drastically changed.

An avoidable fatality – neonatal transport team

Dr. Stanley Phillips III
(32 at time of death in 2013)

Dr. Phillips' severe brain injury likely occurred when a laptop in the back of the ambulance hit him during the crash.

SAE J3043 - Equipment Mount Test Options
SAE J3058 – Cabinet Dynamic Testing

Basic Parameters of Testing
- Manufacturer to determine cabinet loading capacity
- Utilized front, side and rear impact pulses
- Weights placed 4 inches from each door face
- Have now tested more than 30 cabinets from 9 manufacturers
- Weights were directed at door surfaces and cabinets ends

Cabinet Testing: Aluminum Cabinet - 20 lbs. in bags
(Prototype Design)

Cabinet Testing: Aluminum Cabinet - 20 lbs. in bags
(Upgraded Design)
Modular Body Structural Integrity: Test Methodology

Key Elements in 2 Phase Recommended Practice
- Phase 1 is a dynamic test where patient compartment is impacted by 28,000 ft-lbf
- Phase 2 is a quasi-static test which evaluating roof strength at loading at 2.5 x curb weight
- Doors must open after each test

SAE J3057: Should be published in February 2017

Patient Compartment Integrity – SAE J3057
Phase 1: Slowed Video Clip

Impact loading of 26,000 ft-lb – twice the requirement for the cab of large trucks
All doors must open after impact
Intended to simulate side roll with roof line impacting ground

SAE Documents

SAE J3057
SAE J3056
SAE J3058
SAE J3059
SAE J3043
SAE J3044
SAE J3045
SAE J3026
SAE J3027
SAE J3028
SAE J3029
SAE J3030
SAE J3031
SAE J3032
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SAE J3049
SAE J3050
SAE J3051
SAE J3052
SAE J3053
SAE J3054
SAE J3055
SAE J3056
SAE J3057
Understanding the Changing Ambulance Standards Landscape

Incorporation of GSA Purchase Specification

Specs and Standards Tomorrow

- Society of Automotive Engineers (SAE) Test Methods:
  - Crash Test Pulses, Seats, Head Excursion, Cots, Equipment Mounts, Cabinets, Body Structure, Floor Structure

Slide provided by National Association of State EMS Officials
Why should NAEMSP advocate for the inclusion of a specific standard in regulatory language?

- Real opportunity to improve safety for workers and patients
- Ensures vehicles meet new industry minimums
- Likely to reduce the cost of doing business for builders and purchasers
- Development of new crashworthy products offers opportunity to reduce risk of injury and perhaps insurance premiums

QUESTION: Is there a liability risk to operators if they don’t adopt new crashworthy standards modeled and tested in accordance with automotive crash testing practices?

Patient Compartment Layout

To download your free copy visit:
www.cdc.gov/publications/ambulance-patient-guidebook

EMS Agency Uses Run History to Drive Design

The Echo Haliburton County:
County ambulance purchase made with paramedic safety in mind
By Chad Ingram
Dec. 20, 2016

“The ministry ambulance dispatch reporting system indicates that since Jan. 1, 2014, to Nov. 28, 2016, Haliburton County paramedic service has responded to 7,529 emergency calls,” the report reads.

“Through an audit ambulance call reports it was noted that 46 rescue calls or 0.61 per cent were emergency calls that presented more than one patient. Thirty-five of those calls transported more than one patient and of those 35, only 10, or 0.01 per cent were calls where two stretchers were required.”

Quoting EMS Director and Paramedic Chief Craig Jones
Patient compartment design with worker efficiency and safety in mind

Model with Mannequins

Closing Thoughts

- Require seat belt use in the patient compartment
- Require the use of patient shoulder restraints at all times
- Advocate for the purchase of new cot and cot retention systems that meet new testing requirements in all new ambulance purchases
- Advocate for policy or regulatory changes in your state to adopt the NFPA or CAAS ambulance standards
- Revisit medical protocols – Identify those procedures that can and should be done in a moving ambulance and those that shouldn’t.
- Advocate for thoughtful patient compartment designs with worker safety and efficiency in mind.
Contact Information

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