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Development of Proposed Crash Test Procedures for Ambulance Vehicles

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Some recent USA ambulance crash outcomes

Background: USA Problems

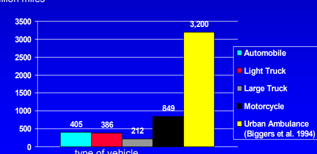
- In USA ~8,500 ambulance and fire vehicle crashes/year[+]
  - ~ One fatality each week#
  - Fatal crashes more often at intersections ($p < 0.001$)*
  - 82% of fatally injured EMS rear occupants were unrestrained**
  - > 74% of all occupational fatalities for EMTs are MVC related***
  - ~10 x as lethal per mile traveled than large trucks##
  - USA ambulance crash fatality rate/capita 35x higher than in Australia
- Cost estimates > $500 million annually

[+]FARS/GES BTS, 2000-2005
* Kahn CA, Pirrallo RG, Kuhn EM, Prehosp Emerg Care 2001 Jul-Sep;5(3):261-9
**Becker, Zaloshnja, Levick, Li, Miller, Acc Anal Prev 2003
***Maguire, Hunting, Smith, Levick, Annals Emerg Med Dec 2002
Pirallo, Swor, Prehospital and Disaster Med, 1994
##FMCSA 2006

USA Vehicle Crash Rates

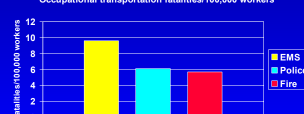
Crashes per 100 million miles

FARS 2003 DATA & Biggers et al 1994



USA EMS occupational transportation fatalities..

Occupational transportation fatalities/100,000 workers



- 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*

Occupant Hazards

Rollover Crash Kills Medical Technician

Ambulance Runs Off I-66 and Rolls Over, Injuring Two Employees and a Patient

Global snapshot

- A unique 'passenger vehicle – workplace' environment
- Recent history of safety testing standards in Australia and Europe - 1999
- USA ambulance vehicle changed from intact automotive vehicle – the Cadillac, to truck or van cutaway chassis with non automotive engineered after market box, and now sporadic OEM van vehicles

USA 1960's

1960 to 2007

Unique aspect of vehicle safety infrastructure

- Ambulance retrofit - small market
- <u>These are the very vehicles that are there to respond to passenger vehicle safety failures</u>
- Important that testing requirements and standards be designed to address real world risks and hazards for occupants of these vehicles

Current 2007 ambulance 'safety testing' practices in the USA..!?

Objective

- To determine a testing procedure that reflects the real world environment of ambulance vehicle crashworthiness

Methods

- Review of available ambulance crash information
- Review of existing standards and designs for ambulance vehicles

Methods

- Analysis and integration of existing test profiles with USA real world data by multidisciplinary team

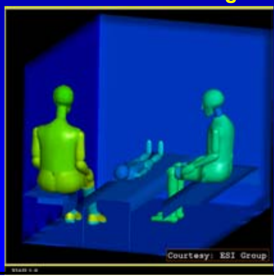
Real World Issues for safety testing of ambulances

- Occupants are oriented in a range of seating and lying positions
- Medics are trying to perform clinical and emergency care during transport
- Often heavy equipment in close proximity to occupants
- Real world injury data on ambulance crashes is at best limited – testing not driven by real world injury data and NCAP
- Unusual environment where occupant protection is impacted by realms of vehicle and interior design AND also practice policy

USA full vehicle crash research

Using real world practice research model

Outcome Modeling



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Real world crash data

High speed crash, rolled and the occupants (patient and medics) only minor scratches

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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
  - Z15 – Fleet vehicles safety management
- USA EMS Specification & Guidelines
  - Purchase Specification: KKK & NTEA – AMD
  - Guideline: ASTM

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2007 CEN Safety Testing

Squad bench concerns

- A challenge is the right hand side 'squad bench' – a structure that has minimal if any automotive safety features
- Described in previous military vehicle crash testing to be a hazardous mode of occupant transport in a forward traveling vehicle (Richardson et al 1999, Zou et al 1999).

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Determining Test Procedure

- USA ambulances are most frequently involved in frontal high speed and rear low speed impacts
- ASA for frontal impact of 24 G and a rear impact of 10 G as in the CEN could be considered appropriate
- ATDs for each position, should reflect real world practice (50th and 95th percentile ATDs, as described in the ASA standards), Side impact ATDs for side impact locations
- The restraint configuration used should be the restraint configuration to be implemented in the real world vehicle, for:
  - medics, patient, and other occupants, key equipment such as oxygen tanks, cardiac monitors as well as medication bags and communications equipment

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Vehicle Type

- The vehicle type selected here for this study was the automotive industry manufactured intact, structurally unmodified van and not the combined box and chassis vehicle, and also not a van that has undergone any structural after market modification

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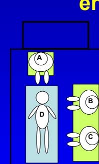
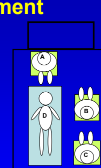
Occupant layout for ambulance environment



Standard rear occupant compartment layout (USA)



Standard rear occupant compartment layout (Europe/Australia)

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Frontal

- For Test plan 2 – ATD's in forward or rearward seating positions A, B, C, D.
- Velocity change of 49 km/h in forward direction
- 50th percentile ATD:
  - Deceleration of 24g - 34g within 30 millisecs, and remain within the range of 24g to 34g for not less than 20 milliseconds
- 95th percentile ATD:
  - Deceleration 18.2g - 26g within 30 millisecs and remain within the range of 18.2g to 26g for not less than 20 milliseconds.
- If vehicle layout as per test plan 1 then side impact ATD should be used for position B & C

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Rear

- For Test plan 2 – ATD's in forward or rearward seating positions A, B, C, D.
- Velocity change of 32 km/h in the rear direction
- 50th percentile ATD:
  - Deceleration of 12g and 22g within 30 millisecs, and remain within the range of 10g to 17g for not less than 20 milliseconds
- 95th percentile ATD:
  - Deceleration 9g and 19g within 30 millisecs and remain within the range of 10g to 17g for not less than 20 milliseconds.
- If vehicle layout as per Test Plan 1 then side impact ATD should be used for position B & C

Right side impact

- For the squad bench layout Test Plan 1, the 50th and 95th percentile manikins could be utilized for this test in that seating position. However, for the Test Plan 2 layout, in the side impact test – the side impact ATD should be utilized.
- Velocity change of 32 km/h in the lateral direction
- For the 50th percentile ATD
  - Deceleration of 12g - 22g within 30 milliseconds and remain within the range of 10g to 17g for not less than 20 milliseconds
- For the 95th percentile ATD
  - Deceleration of 9g - 19g within 30 milliseconds and remain within the range of 10g to 17g for not less than 20 milliseconds

Vertical

- CEN includes a vertical test component, ASA 4535 does not. Given the nature of ambulance crashes – is felt by the authors that this test should be included in this test profile.
- Velocity change of 32 km/h in the vertical direction
- For the 50th percentile ATD
  - Deceleration of 12g - 22g within 30 milliseconds and remain within the range of 10g to 17g for not less than 20 milliseconds
- For the 95th percentile ATD
  - Deceleration of 9g - 19g within 30 milliseconds and remain within the range of 10g to 17g for not less than 20 milliseconds

Real world applicability of existing testing profiles of ambulance vehicles

- Difference between acceleration/deceleration testing of the retro fit separately from full crash and deformation testing of the full vehicle with the retrofit in place
- The use of a side impact ATDs for crash scenario where occupants would be seated sideways
- The limitation of absent real world injury and crash data for guiding design and testing profiles

Further confounding issues

- Impact of practice policies on the potential for specific risks and hazards
- Broad spectrum of ambulance vehicle configurations in the USA
- Currently ambulance designs are strongly being driven by end users, with no automotive safety or crashworthiness background

Limitations

- Refinement of crash pulses to specifically meet these vehicle's design and performance has not taken place
- Simple deceleration /acceleration testing of an intact vehicle shell may not provide meaningful results – particularly at 10G - as deformation of the structure of the shell via intrusion is not able to be modeled

Discussion

- Standards such as the CEN and the ASA are likely inadequate for demonstrating the occupant safety for combination or structurally modified vehicles such as the chassis and box design or retrofits of vans that involve any structural modifications
- Evidence from real world crash ambulance crashes, even relatively low speed intersection collisions or collisions involving fixed objects suggests serious occupant hazards and failures
- It remains an irony that occupant protection for ambulance vehicles is unsafe and lacking in crashworthiness safety testing or features

Conclusion

- A first step and in no way regarded as adequate from an automotive safety engineering perspective
- True vehicle performance and crashworthiness safety standards should include comprehensive real world crash data, full vehicle crash test data, include formal injury data and address known injury criteria, and involve the automotive safety engineering industry
- These profiles could ensure ambulance vehicle design and system safety be ascertained and optimized, and also support safety enhancements for ambulance vehicle development

Thank you! Any Questions?? http://www.objectivesafety.net