

Ambulance Re-design to Reduce EMS Injuries: Influencing Design through Standards Development



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NIOSH Ambulance Safety Research



- Initiated 2001
- Focus on preventing crash-related injury to EMS workers
- Provide patient compartment occupants with the same level of crash protection as passenger car occupants.

Forward Barrier Crash, 30 mph, 1999 Type III, Unrestrained and Lap Belts



Unrestrained and Lap Belted Occupants



**** Lap belts should always be used in conjunction with net ****

PCP Contacts with Assist Handle and Edge of Front Wall



Injuries:

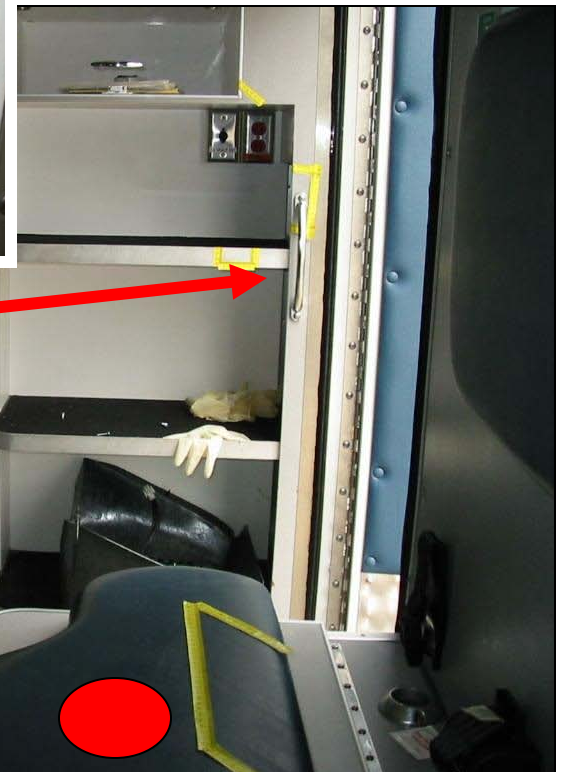
**Left Occipital
intraparenchymal
hemorrhage**

**Left occipital
contusion**

**Positive loss of
consciousness**

**20 cm laceration into
muscle on the right
parietal/occipital scalp**

**Right occipital scalp
contusion**



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



Source: Workers' Compensation Board of British Columbia, Report 1150-20 B 1999 (99FS-14)

What Safety Issues Do Emergency Medical Services Personnel Face?



-
- Patient compartment designed with patient treatment as first priority.
 - Interior configuration significantly affects worker safety
 - Interior design poses numerous crash-injury sources
 - Patient compartment is largely exempt from meeting traditional vehicle safety standards.

Conclusions from earlier research



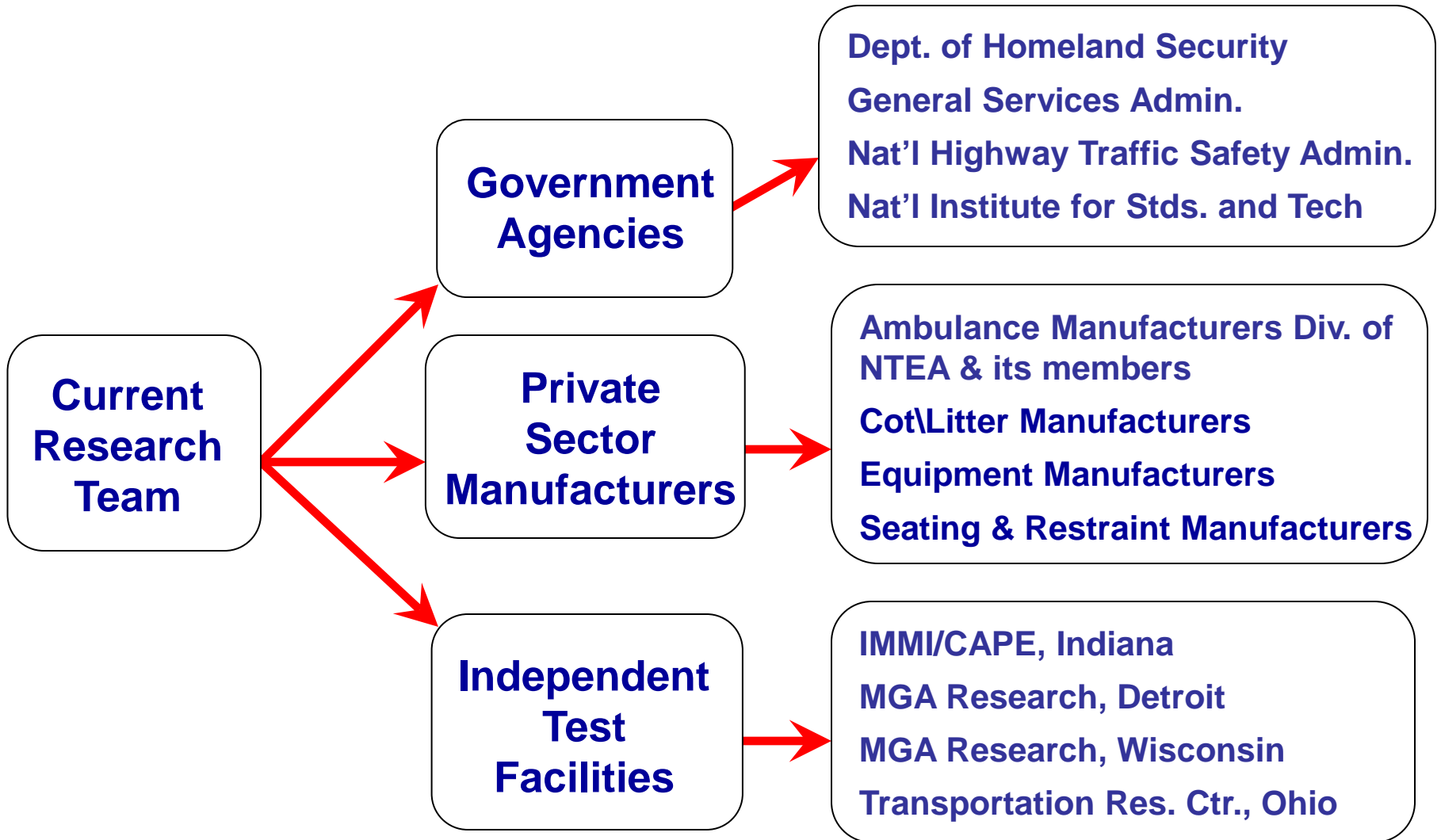
- **Most patient compartment designs force a worker to leave his/her seat to complete job tasks**
- **Our testing indicates both lap belts and multi point mobility restraints or fixed harnesses can sustain loads and reduce injury risk**
- **Patient shoulder restraints reduce travel and thus likelihood for contact with worker or surfaces**
- **Lock down equipment whenever possible, loose equipment becomes injury producing projectiles**

Current Project Objectives

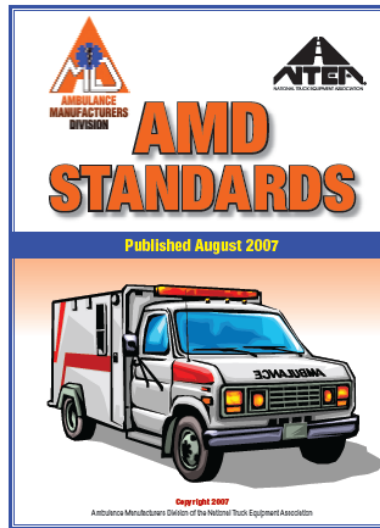
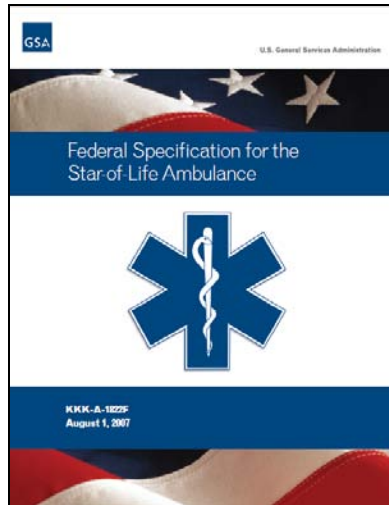


- Provide patient compartment occupants with the same level of crash protection as passenger car occupants.
- Work with end users to ensure designs meet needs
- Move NIOSH research results to practice to influence future ambulance design
- Near Term: Develop revisions to GSA purchase specifications and 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

Partnerships to Influence Change



Specs and Standards Today



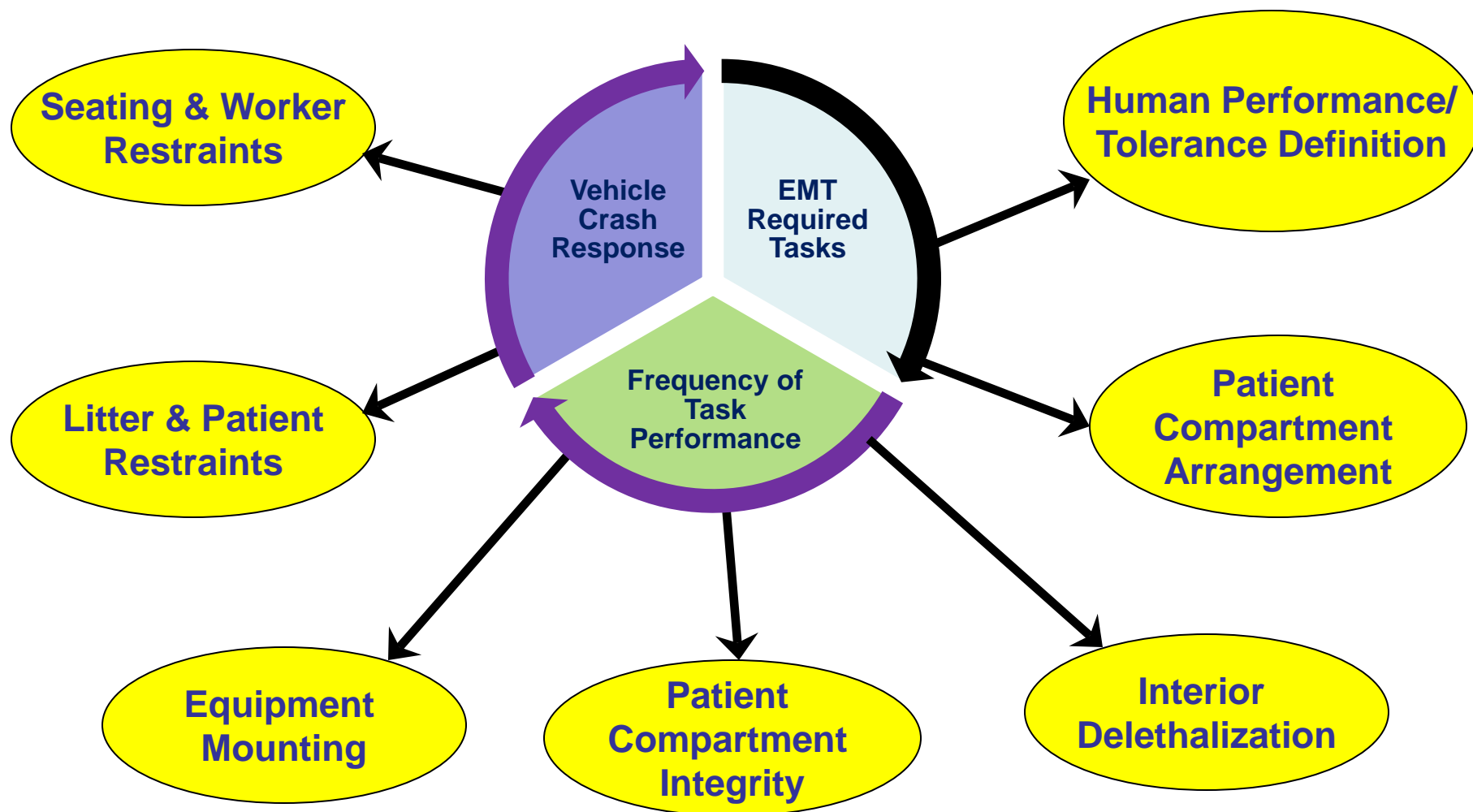
**NFPA 1917
Standard for
Automotive
Ambulances
20XX Edition**

Strategy for Impact



- **With funding support from Dept. of Homeland Security and partnerships with industry we 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 – 2nd revision

Current Standards Development Activities



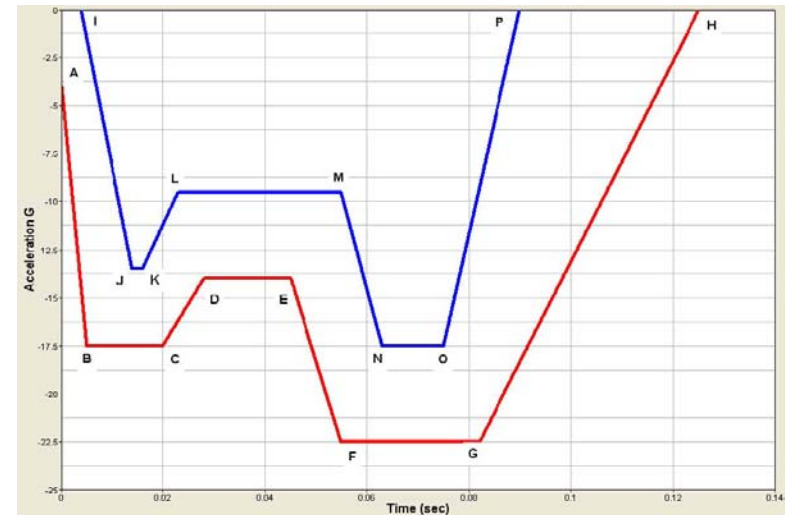
SAE Recommended Practice – Crash Pulse Envelope for Frontal and Side Impact Testing (Society of Automotive Engineers Approved)



➤ Based on NIOSH Testing

➤ Reviewed by Ford, GM, NHTSA, and 3 independent test labs

	SURFACE VEHICLE RECOMMENDED PRACTICE	SAE J2917 MAY2010
		Issued 2010-05
Occupant Restraint and Equipment Mounting Integrity – Frontal Impact System-Level Ambulance Patient Compartment		
RATIONALE		
Not applicable.		
1. SCOPE		
This SAE Recommended Practice describes the test procedures for conducting frontal impact occupant restraint and equipment mounting integrity tests for ambulance patient compartment applications. Its purpose is to describe crash pulse characteristics and establish recommended test procedures that will standardize restraint system and equipment mounting testing for ambulances. Descriptions of the test set-up, test instrumentation, photographic/video coverage, and the test fixtures are included.		
2. REFERENCES		
2.1 Applicable Publications		
The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.		
2.1.1 SAE Publications		
Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org		
SAE J211-1	Instrumentation for Impact Test—Part 1: Electronic Instrumentation	
SAE J211-2	Instrumentation for Impact Test—Part 2: Photographic Instrumentation	
SAE Engineering Aid 23	"Users' Manual for the 50th-Percentile Hybrid-III Test Dummy," June 1985	
Current, R.S., Moors, P.H., Green, J.D., Yannaccone, J.R. et al., "Crash Testing of Ambulance Chassis Cab Vehicles," SAE Technical Paper 2007-01-4267, 2007		
2.2 Other Publications		
Code of Federal Regulations, Title 49, Part 571.208.		
Code of Federal Regulations, Title 49, Part 571.214.		
Code of Federal Regulations, Title 49, Part 572.		
<small>SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user." SAE reserves each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions. Copyright © 2010 SAE International. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE. TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada) Tel: +1 724-776-4970 (outside USA) Fax: 724-776-0799 Email: CustomerService@sae.org http://www.sae.org</small>		
SAE values your input. To provide feedback on this Technical Report, please visit http://www.sae.org/technicalstandards/J2917_201008		



Seat and Worker Restraint Team



Language completed for AMD 026

Key Elements:

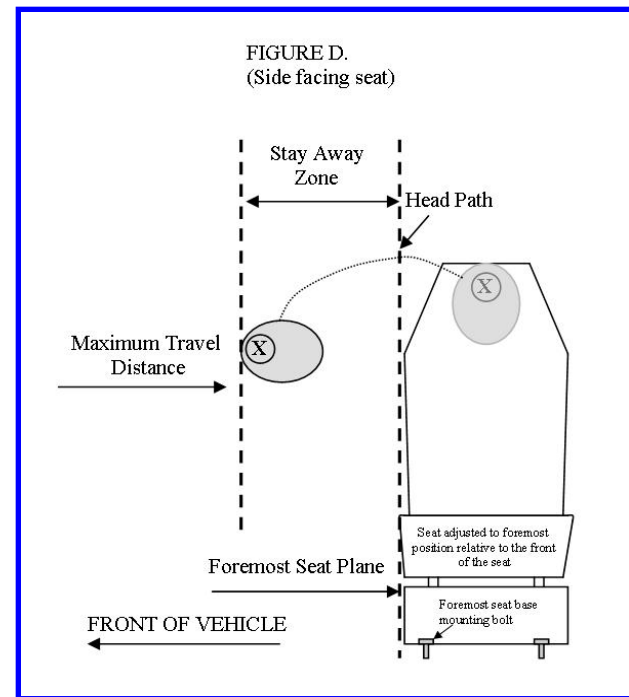
- **Seat should remain attached to vehicle without structural failure using new crash pulses**
- **Reduce worker excursion to eliminate impacts**
- **Do so without driving patient loading in head, neck, chest beyond accepted human tolerance limits**

* Reducing Lethality of Interior Structure *

Impact Direction 



Lap Belt



Existing Mobile Restraint Systems



Forward Barrier Crash, 30 mph, 1993 Type III



**Impact
Direction**



Litter Design – Patient Restraint Team



Language completed for AMD 004

Key Elements:

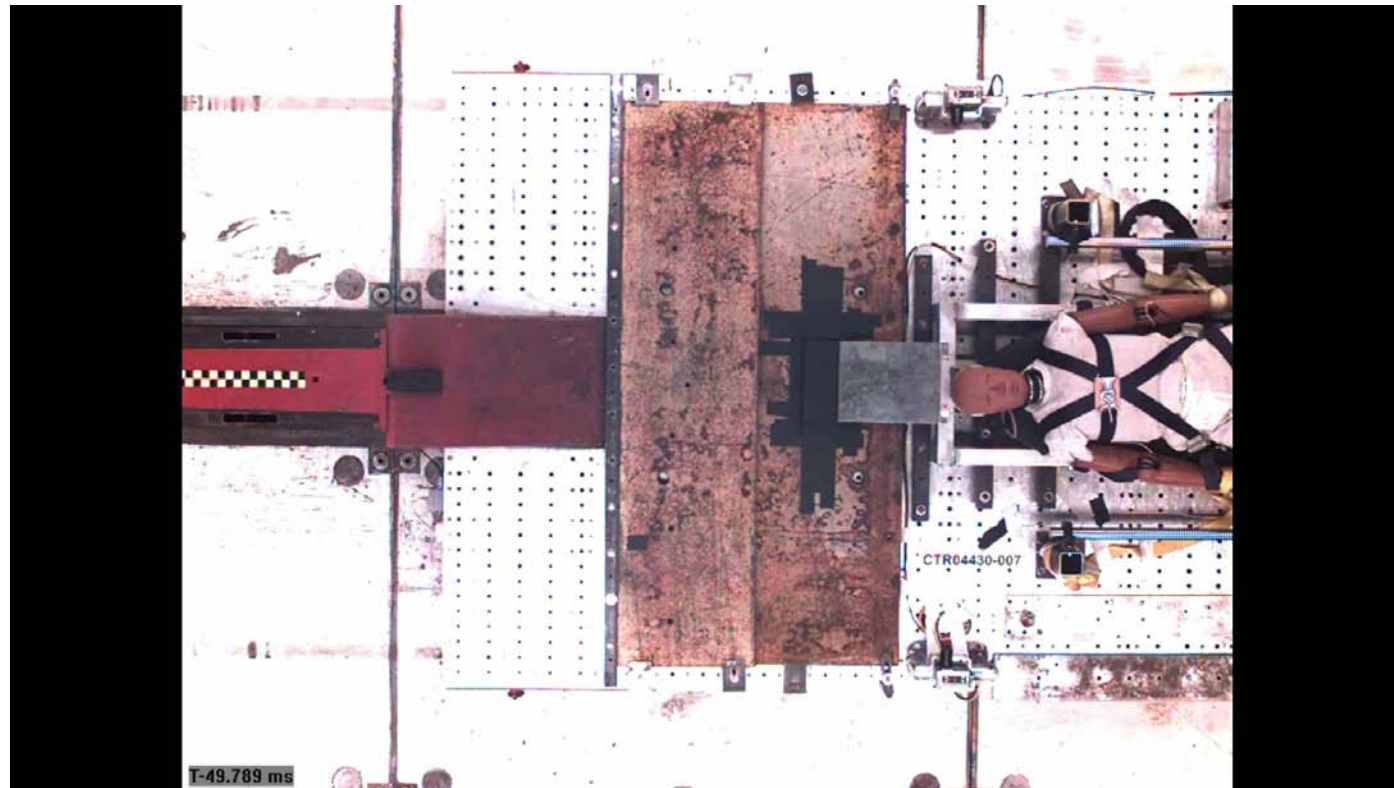
- Remain attached to vehicle without structural failure using new crash pulses
- Reduce patient excursion to eliminate impacts
- Do so without driving patient loading in head, neck, chest beyond accepted human tolerance limits

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

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

Equipment Mounting and Cabinet Development Team



Draft language completed

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**

Equipment Mounting Cabinet Latching Issues



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



Post crash equipment and gurney positions drastically changed

Body Integrity and Mounting Standards Development Team



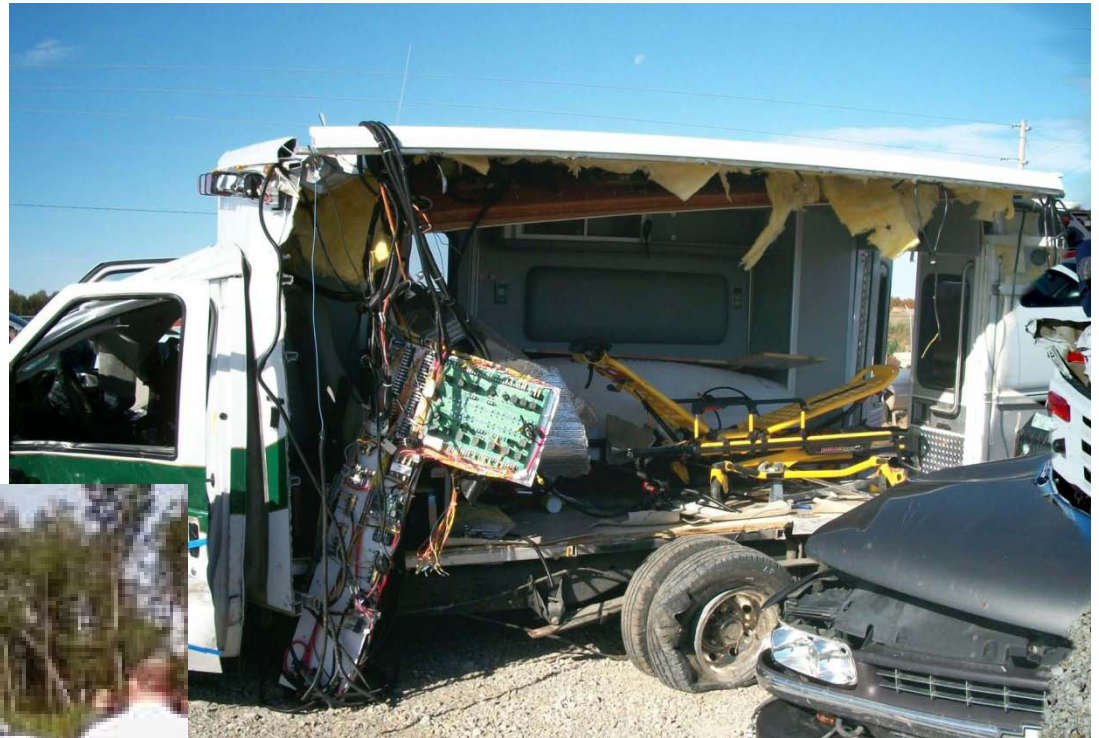
Key questions currently under discussion:

- **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**

Body Integrity and Mounting Standards



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



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 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

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 HMI/UI 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

Completed NIOSH Modeling Work



- Compared the standard GSA layout to the City of Winter Park FD 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

Digital Human Modeling – Improvements to Compartment and Seating Design



Typical



Modified



Modeled and
Evaluated



Communications Access Current vs. New Designs



Current Design



New Design

Closing Thoughts: 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

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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