Ambulance Transport Safety Summit

Bridging the gap between what we do and what is known

EMS Subcommittee of the TRB Ambulance Transport Safety Summit

October 29th , 2009

TRB TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

Goal of the Summit

"Enhancing ambulance transport safety through shared knowledge of technical data"

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Types of Testing and The Automotive Safety/Human Interface

Gene Lukianov

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TOPICS

- **A Comparison of Standards and Testing**
  - Automotive
  - Medium Truck
  - Ambulance
- **Automotive Safety and the Human Interface**

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AUTOMOTIVE TESTING

Multitude of INDEPENDENT Testing and Standard Setting Organizations

Act to keep each other on-track for safety

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- Internal Corporate Standards
- SAE Specs (Society of Automotive Engineers)
- ISO and CEN Specs (International and European)

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Side Impact Test

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Offset Frontal Impact Test

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INDEPENDENT ADVOCATES

Public Citizen

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THE FEDERAL GOVERNMENT

FEDERAL MOTOR VEHICLE SAFETY STANDARDS AND REGULATIONS

U.S. DEPARTMENT OF TRANSPORTATION

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

NHTSA
www.nhtsa.gov

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FEDERAL SAFETY STANDARDS

Extensive Passenger Car and Light Truck Vehicle Safety Standards apply to vehicles below 10,000 pound Gross Vehicle Weight (GVW)

VEHICLES over 10,000 GVW (Medium Trucks) have a reduced set of Federal Safety Standards

VEHICLE SELECTION impacts SAFETY

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FEDERAL SAFETY STANDARDS

THESE DO NOT APPLY to MEDIUM TRUCKS

- Standard No. 126: Electronic Stability Control
- Standard No. 201: Occupant Protection In Interior Impact
- Standard No. 202: Head Restraints
- Standard No. 203: Impact Protection for the Driver from the Steering Control System
- Standard No. 204: Steering Control Rearward Displacement
- Standard No. 208: Occupant Crash Protection
- Standard No. 212: Windshield Mounting
- Standard No. 214: Side Impact Protection
- Standard No. 216: Roof Crush Resistance
- Standard No. 219: Windshield Zone Intrusion
- Standard No. 225: Child Restraint Anchorage Systems

THESE DO APPLY to MEDIUM TRUCKS (and other vehicles)

- Standard No. 205: Glazing Materials
- Standard No. 206: Door Locks and Door Retention Components
- Standard No. 207: Seating Systems
- Standard No. 209: Seat Belt Assemblies
- Standard No. 210: Seat Belt Assembly Anchorages
- Standard No. 213: Child Restraint Systems

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ESC – A LIFE SAVER

- ESC: ELECTRONIC STABILITY CONTROL

  – **Electronic stability control** systems are second only to seat belts in terms of the potential for saving lives and reducing injuries… is a major step forward for global auto safety.

Statement by Nicole Nason, Administrator, National Highway Traffic Safety Administration, On the Adoption of Electronic Stability Control as a Global Technical Regulation

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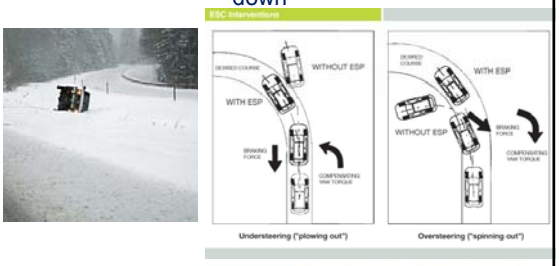
ESC – A LIFE SAVER

Works to keep you on the road and slow you down



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AMBULANCE STANDARDS and TESTING

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Ambulance Standards and Testing

- KKK A 1822F: Purchasing Guideline
  – "Minimum Specification and performance parameters"
- AMD-001-025: Manufacturing Guideline
- ASTM F2020-02a: Standard Practice

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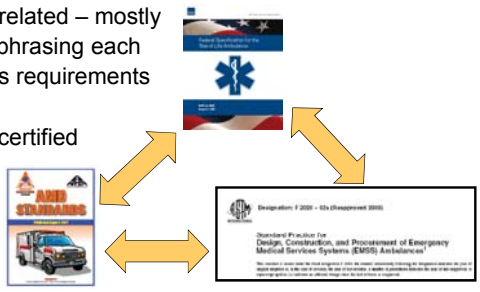
Ambulance Standards and Testing

- Interrelated – mostly paraphrasing each other's requirements
- Self certified



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Ambulance Standards and Testing

What is not Referenced

- Electronic Stability Control
- DYNAMIC Occupant Crash Protection Considerations
  – Occupant Protection in Interior Impact
  – Occupant Crash Protection
  – Side Impact Protection

What is New for Safety

- ASTM F2020-02a
  – Requires patient shoulder straps on litter (6.11.8.1)

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AUTOMOTIVE-AMBULANCE SAFETY and the HUMAN INTERFACE

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AMBULANCE ACCIDENTS

Ambulances have a significant incidence of:

- INTERSECTION COLLISIONS in Urban Areas
  - Frontal Impact
  - Side Impact
  - Rear Impact
- LOSS OF CONTROL and ROAD DEPARTURES in Rural Areas

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DRIVER RESPONSIBILITY

SHARED RESPONSIBILITY

- Ambulance Driver Behavior and Operation Rules
- Public Driver Behavior

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AMBULANCE CONSPICUITY

- Do Public Drivers observe the Ambulance EARLY ENOUGH to react safely?
- Can they SEE, HEAR AND IDENTIFY the Ambulance early enough to react?

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THE POTENTIAL for Ambulance Accident AVOIDANCE is hardly MAXIMIZED

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THE AMBULANCE SAFETY/HUMAN INTERFACE DESIGN CHALLENGE

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THE AMBULANCE CHALLENGE

ROAD ACCIDENT SCENARIOS
- Frontal, Side, Rear Impacts
- Roadway Departures and Rollovers

ATTENDENT POSITION SCENARIOS
- Seated (in position), belted
- "Out of Position" attending Patient

PATIENT SCENARIOS
- Pediatric to Bariatric size and weight
- Various levels of injury and medical need

ALL COMBINATIONS MUST BE CONSIDERED

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THE AMBULANCE CHALLENGE

Front or Rear Facing Seat → Side Impact Challenge: hard cabinet and hard edges on the side

Squad Seat → Frontal Impact Challenge: Attendants will crush each other and impact hard cabinets

Out of Position, unbelted Attendant becomes a projectile during accident → impacts patient, compartment interior, other attendants or is ejected from the compartment

Patient Gurney straps support laterally but NOT fore/aft → Patient becomes a projectile during a frontal accident impacting head first into compartment interior or into attendant in rear facing seat.

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ROBUST
Rear Compartment Occupant Protection and Crashworthiness Design Solutions are Needed !

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SUMMARY

- Automobile Vehicle Safety has made great strides in knowledge and application of technology for Accident Avoidance and Crash Safety
- Ambulance Safety can utilize many advances from the Automotive sector but also pose unique challenges
- Ambulance Accident Avoidance and Rear Compartment Safety improvements are two key areas for Ambulance Safety progress

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Questions??

- Please raise your hand
- or type in the message box
- or send your questions via this link
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Principles of Automotive Occupant Protection: Methods and Considerations for Application to the Ambulance Case

Jeff Welch
Automotive-Occupant Protection Engineer

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Passenger Cars Compared with Ambulances

- Passenger Cars – Extensive understanding and technical data on structural deformation modes for all vehicle types and models
- Ambulances - Inadequate understanding of typical rear compartment deformation modes (twisting, e.g.) for any box/chassis models to anticipate movement/deformation of energy absorbers and other features

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Some Passenger Car Occupant Protection Methods "After Structure"

- "Front" Impacts:
  - Seat Belt Systems
  - Airbags: Driver, Passenger, Knee
  - Seat Structure
  - Energy Absorbing Dash/Pillar Components
  - Energy Absorbing Steering Wheel/Column
- "Side" Impacts:
  - Energy Absorbing Surfaces
  - Side Airbags (Seat or Door Mounted)
  - Inflatable Curtains
  - Seat Structure
- "Rear" Impacts:
  - Seat Structure
  - Seat Belt Systems
- "Rollovers":
  - Seat Belt Systems
  - Inflatable Curtains

Today's Focus

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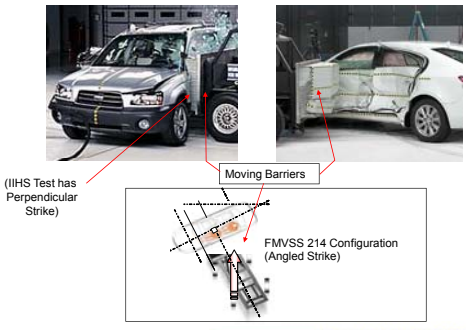
Passenger Car Side Impact Testing
(Pictures in this Presentation from the Insurance Institute for Highway Safety Website)



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Passenger Vehicle Airbag Development

- The safety of airbag systems is based on extensive real world injury mechanism and crash mechanics data
- However even in that data rich setting – life threatening hazards in passenger vehicle production airbag devices were demonstrated in the real world
- Absent this real world development data and post implementation crash data capture data, serious safety hazards are not easily identified.

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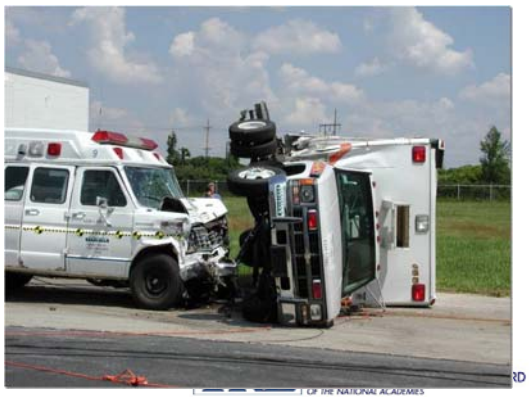
Occupant Safety: Ambulance rear compartment issues

For the ambulance case

- Absent or very limited ambulance impact biomechanics and occupant injury mechanics data
- Large vehicle compartments with wide ranges of occupant impact angle/velocity
- Challenges to safely design active occupant protection systems in this setting



Differences between a passenger vehicle rollover and an ambulance rollover

- There are many differences between the mechanisms and predicted resultant forces on occupants between a passenger vehicle rollover and an ambulance vehicle rollover

Side Impact Protection: Energy Absorbing Surfaces

- "Padding" for interior head impacts – established materials and designs for given head trajectories and velocities (regulated under FMVSS 201U)
- Collapsible/energy absorbing structures for torso impacts (e.g., deformable armrests in passenger cars)
  - May be a good option for large vehicle compartments with wide ranges of occupant impact angle/velocity and wanting to minimize padding "bulk"

Side Impact Protection: Side Airbags

- Available in passenger vehicles for over 10 years now (well established). Torso-only, torso-pelvis and head-torso versions exist
- Provide additional energy absorption for occupant
- Defined out-of-position tests (TWG) for child and small female dummies
- Typically quick deployment and venting to avoid over-loading

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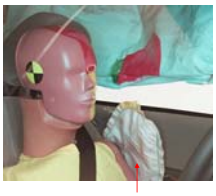
Side Airbags:



Seat Mount Airbag

TWG Test

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Side Airbags: Ambulance rear compartment issues

For the ambulance large compartment case

- Lack of data on structural performance of compartment
- Challenges with respect to effective design
  - need to balance the coverage and longer duration pressure probably needed versus cushion stability
- Out-of-position safety concerns, with hazards to out-of-position occupants

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Side Impact and Rollover Protection: Inflatable Curtains

- Available in production vehicles for over 10 years
- Function:
  - head protection from intruding objects (poles, other vehicle hoods, etc.) FMVSS 214 now has an angled pole impact test
  - establishing a cushion and containment device across window openings for rollover safety
- Defined out-of-position tests (TWG) for child and small female dummies

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Side Impact and Rollover Protection: Inflatable Curtains

A TWG Test

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Inflatable Curtains: Issues in the Ambulance rear compartment

Large compartments need to consider -

- What are the mechanics of rollover in this vehicle environment
- Hazards of damage/movement of curtain attachments
- Hazards of deployment in complex events
- Hazards regarding out-of-position occupants

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Seat Structure and Seat Belts

- Seat structure can be used to maintain occupant position as well as contribute to intrusion resistance in side impacts
- Seat belts are known to be effective in passenger vehicle rollover ejection mitigation as well as preventing excessive interior impacts
- For large compartments, these features can be used to improve occupant protection and do not have the potential hazards of active airbag systems

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Summary

- Passenger car occupant protection methods and considerations are well known and are based on extensive crash and occupant injury biomechanics
- Large compartment dynamics present different hazards than the typical passenger car
- Airbags are hazardous to out-of-position occupants
- Key to research and development of ambulance occupant protection:
  - Population based detailed injury data
  - As much occupant information as possible from field data
  - A good understanding of typical rear compartment deformation modes (twisting, e.g.) to anticipate movement/deformation of energy absorbers and other features

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Walther F Bloch
Manager Sprinter Engineering Support
Mercedes-Benz USA
Charleston, SC

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Outline to cover

- Sprinter Features
- Sprinter Active Safety
- Sprinter Passive Safety
- Sprinter Customer Assurance Program
- Sprinter Engineering Contacts

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Accessibility

Unique interior compartment accessibility of any full size van

- 20 inch side step (lowest height in the segment)
- 27 inch load floor (lowest height in the segment)
- 18 3/4 inch rear bumper step pad height

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Unique Doors

Rear Door Opening:

- 270 degree opening standard all models
- On Standard roof height
  62" w x 61" h
  (53.9 w x 49.5 h)
- On High roof height
  62" w x 72" h
  (NA)

LH & RH Side Sliding Door Opening:

- On Standard roof height:
  51" w x 60" h
  (39.6 w x 48.2 h)
- On High roof heights:
  51" w x 72" h
  (NA)

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Sprinter Features Summary

Market Exclusives

- **Available left side sliding door**
- **Premium CDI turbo Diesel engine with SCR technology to meet the EPA / CARB 2010 emission standards.**
- **Best in class cargo capacity**
- **Best in class wall-to-wall turning diameter**
- **Best in class available payload capability**
- **Superior safety standard with ABS, ASR, BAS, ESP and 3-point seat belts on all passenger seats**
- **Most versatile commercial van on the market**

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Load adaptive Electronic Stability Program (ESP)

ADAPTIVE ESP uses the steering angle and the wheel speed to calculate the direction in which the driver intents to steer.

If ESP detects wheelspin, severe understeer (plowing), or oversteer (fishtailing), ESP stops individual wheels and reduces engine power to correct the aforementioned driving conditions and stabilizes the vehicle.

If the vehicle is determined to be moving in a different direction, ADAPTIVE ESP reacts immediately.

By selective braking of each wheel, ADAPTIVE ESP "steers" the vehicle in the desired direction. ADAPTIVE ESP is able to increase directional stability under extreme driving situations.

A warning light in the instrument cluster lights when ADAPTIVE ESP and ASR interventions are in progress.

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Load Adaptive Electronic Stability Program (ESP)

Summary:

- Enhances active safety under severe driving situations
- Improves track-holding and directional stability by automatically adjusting for load weight.
- Adaptive ESP is standard on all Sprinter models.

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Load adaptive Electronic Stability Program (ESP)

Details and Technology

- The Electronic Stability Program (ESP®) comprises the following functions:

- **EBD** (electronic brake force distribution) – This system prevents the rear wheels from locking under braking.
- **ABS** (anti-lock braking system) – Prevents the wheels from locking and ensures steering control while severe braking.

- **ASR** (acceleration skid control) – Regulates wheel spin by intervening in the engine management and by braking the spinning wheels. A deactivation switch allows engine intervention to be switched off at lower speeds to raise the slip threshold and tighten snow chains.
- **BAS** (Brake Assist) – If an emergency braking situation is detected, this system actively increases braking pressure up to the slip threshold.

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Load adaptive Electronic Stability Program (ESP)

Details and Technology (cont.)

- **ROM** (Roll Over Mitigation) – This system helps to detect rollover tendencies during maneuvers with low road speed and high lateral acceleration.
- **RMI** (Roll Movement Intervention) – This system helps to detect rollover tendencies in dynamic maneuvers and in high-speed evasive maneuvers with a high lateral acceleration.

- **LAC** (Load Adaptive Control) – is an adaptive algorithm which calculates the vehicle mass and center of gravity using various parameters such as acceleration, speed and the accelerator position.
- **EUC** (Enhanced Understeering Control) – provides enhanced stability under heavy under steer, for example when driving quickly through tight-radius corners.

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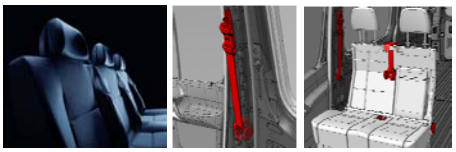
Passive Safety – SRS Systems



Seat belt technology (our most important passive safety feature)

- The Sprinter is equipped with a 3 point seat belt on every seat.
- Driver and front passenger seats are equipped with Emergency Tensioning Devices (ETDs) and belt force limiters.

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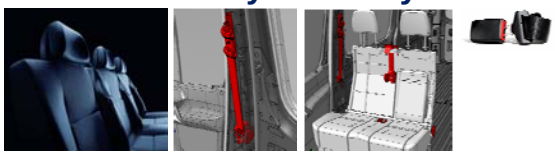
Passive Safety – SRS Systems



- If a collision exceeds a preset threshold, the ETDs instantly remove slack from the seat belt. Belt force limiters reduce the peak seat belt forces on the occupants.
- Depending on the crash severity in a collision, the following actions occur:

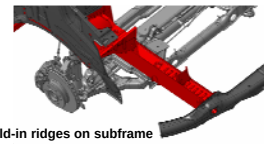
✓The electrical fuel pump and fuel fired heater are switched off.

✓The driver and passenger doors are unlocked, the windows are opened 2 inches and the hazard warning system is switched on automatically.

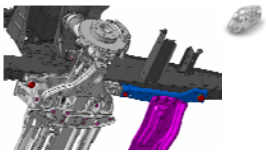
Airbag – SRS Systems

- Airbags standard for driver and front passenger on all models
- Thorax airbags and side curtain airbags available as option for driver and passenger side

Safety First – Passive Safety

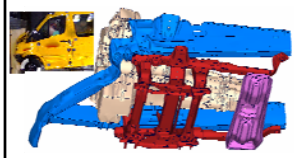


Fold-in ridges on subframe



Front axle module

- **A main feature in a front-end crash is the "disconnectable" front axle, which releases additional deformation zones in the longitudinal frame member when a particular force level is reached.**
- **On a frontal crash, transmission and engine will be pushed underneath front occupants.**



Front axle module after crash

Sprinter Customer Assurance Program

American Emergency Vehicles (AEV)	165 American Way, Jefferson, NC 28640	800.374.9749	Randy Hanson	Approved
Leader Industries	10941 Weaver Ave South El Monte, CA 91733	626.575.0880	Gary Hunter	Approved
Medix specialty Vehicles	3008 Mobile Dr. Elkhart, IN 46515	574.266.0911	Tom Moleski	Approved

Sprinter Engineering Contacts

- Walther F. Bloch, Engineering Support Manager
  E-mail: walther.bloch@Daimler.com
  Phone: (843) 695-5053
- Andreas J. Brockmann, Support Engineer
  E-mail: andreas.j.brockmann@Daimler.com
  Phone: (843) 695-5052
- Jochen Hornikel, Test Engineer
  E-mail: jochen.hornikel@Daimler.com
  Phone: (843) 695-5064

Sprinter Body Builder Information Book and Drawings:

www.sprinter-engineeringcompliance.com

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