NHTSA Side Crash Protection Research

SAE Government/Industry Meeting

May 2001

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National Highway Traffic Safety Administration

People Saving People

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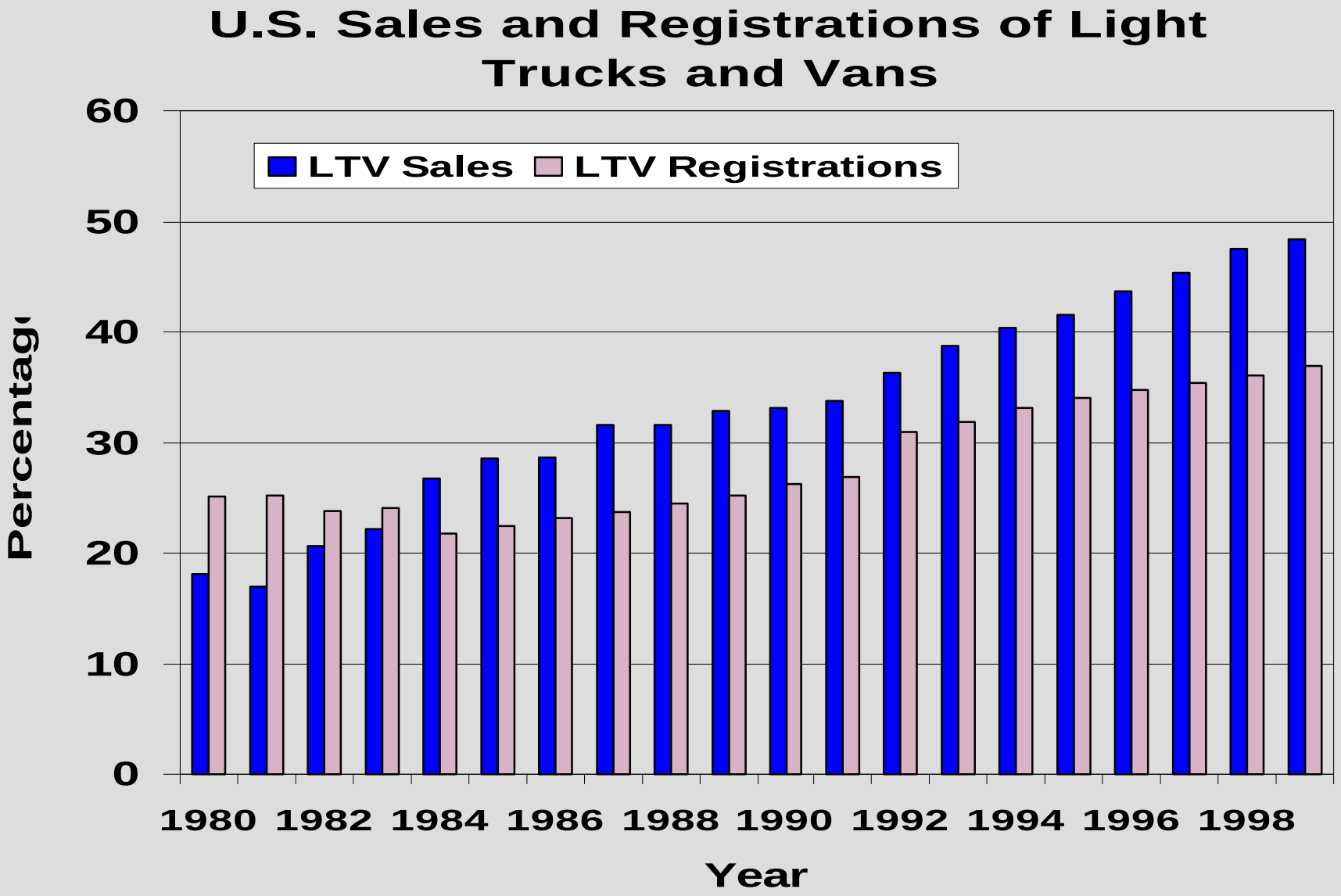
- Where are we heading?
- What is our motivation?
- Current NHTSA side crash protection research

Where Are We Heading?

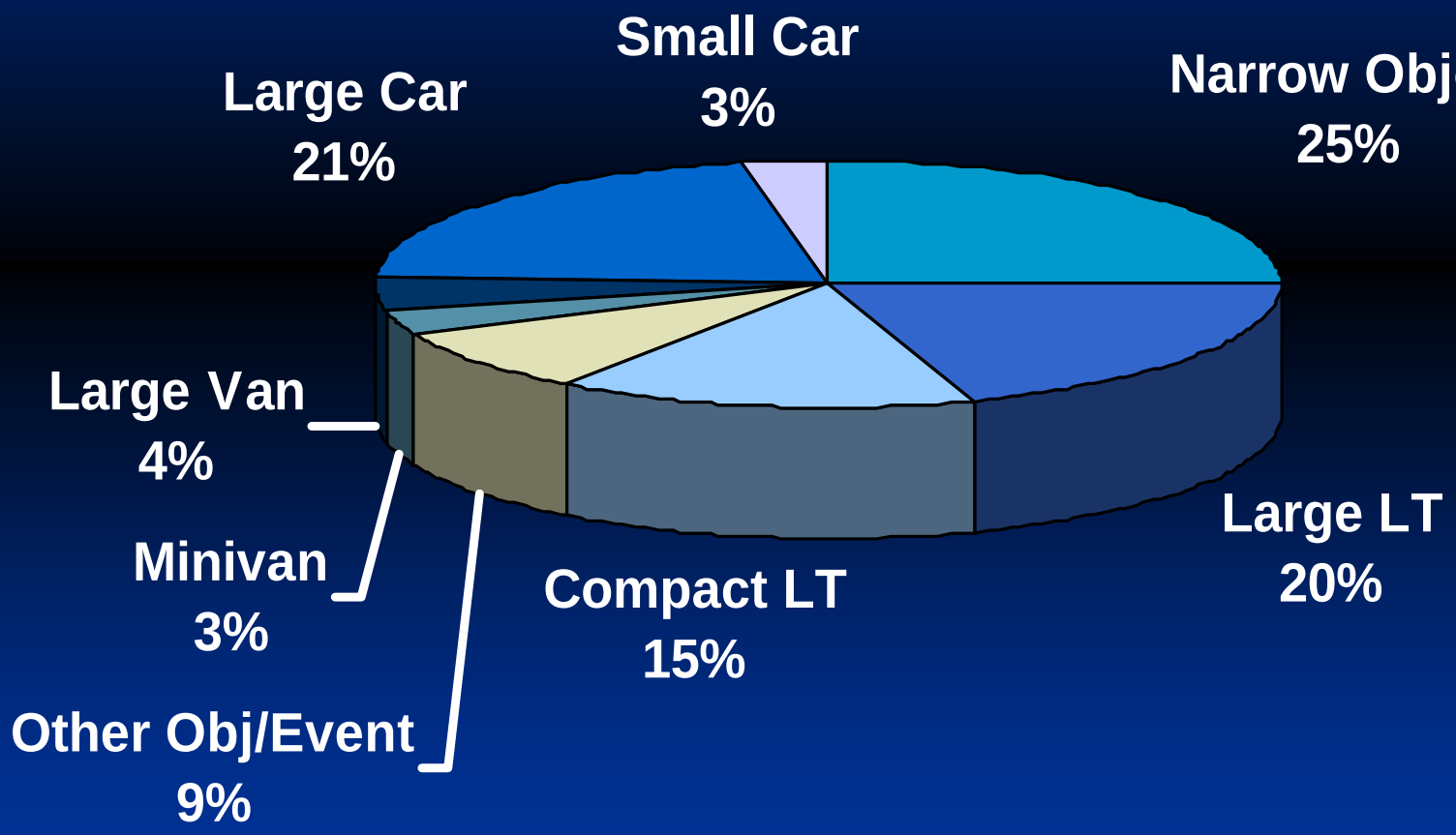
- Research to evaluate/develop procedures to assess potential risk from deploying side air bags to children/adult occupants
- Research towards FMVSS 214 upgrade: harmonized dummy, additional/new injury criteria, more representative barrier (LTV bullet), different size occupants
- Research towards a comprehensive side impact pole test

US Fleet Is Changing...



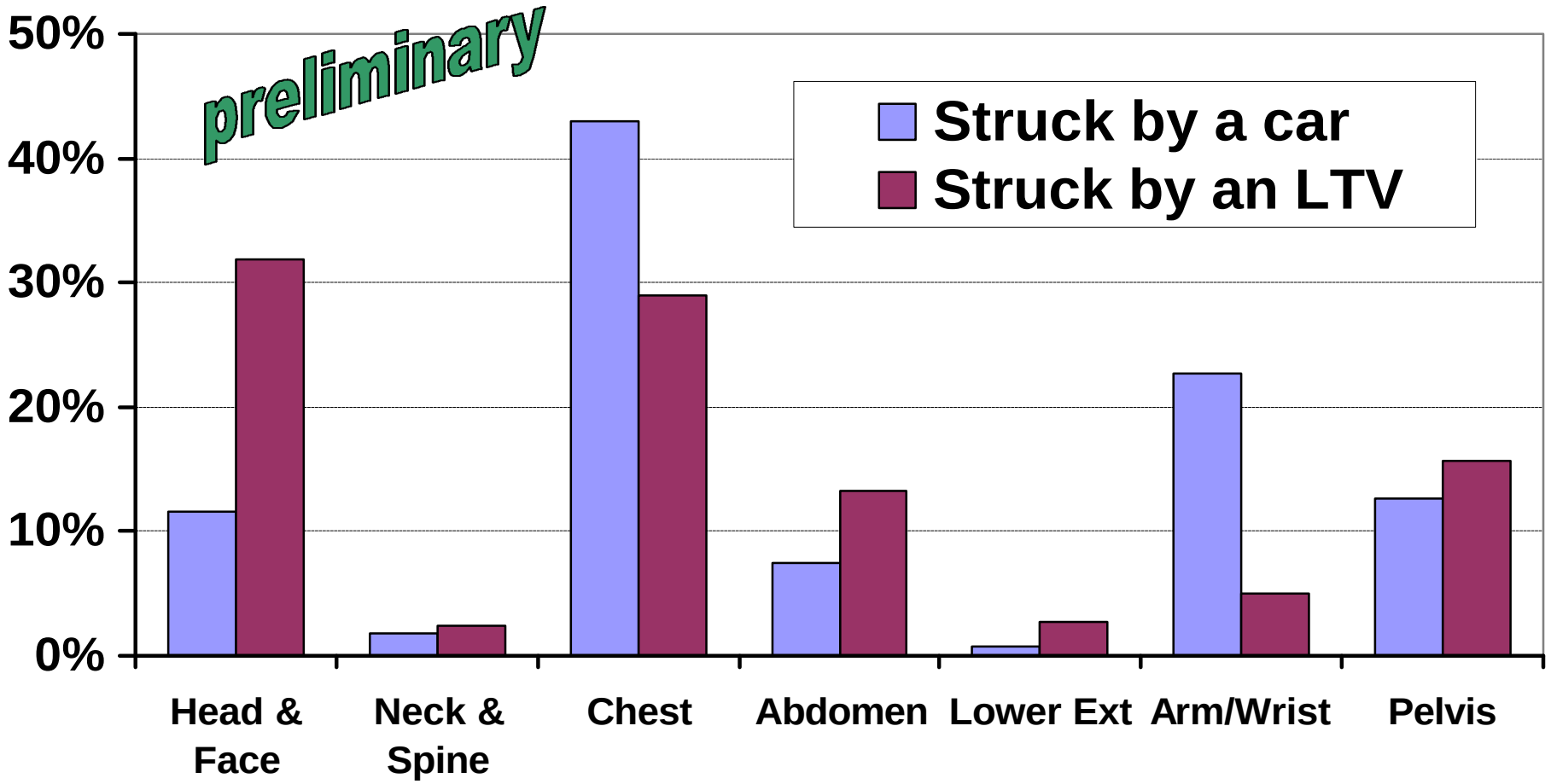
Near Side Fatalities by Crash Partner

1999 FARS Side Crashes - 1995+ MY
(light vehicles #10,000lbs, no rollover)



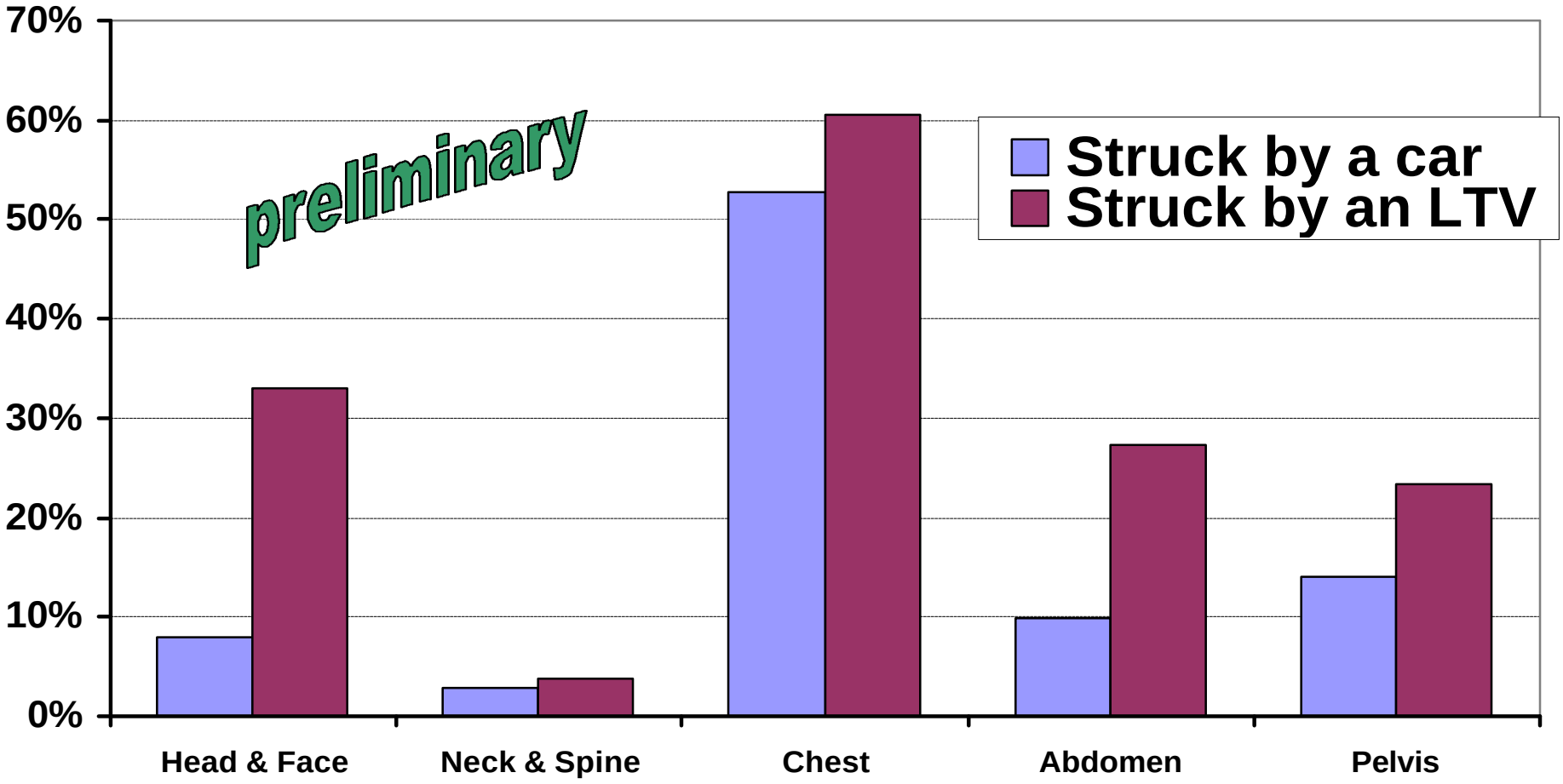
AIS 3+ Injury - Belted Occupants by Body Region

US Side Crashes
Model Year 95-2000 (NASS/CDS 95-99)



Risk of AIS 3+ Injury - Belted Occupants by Body Region

US Side Crashes
Model Year 95-2000 (NASS/CDS 95-99)



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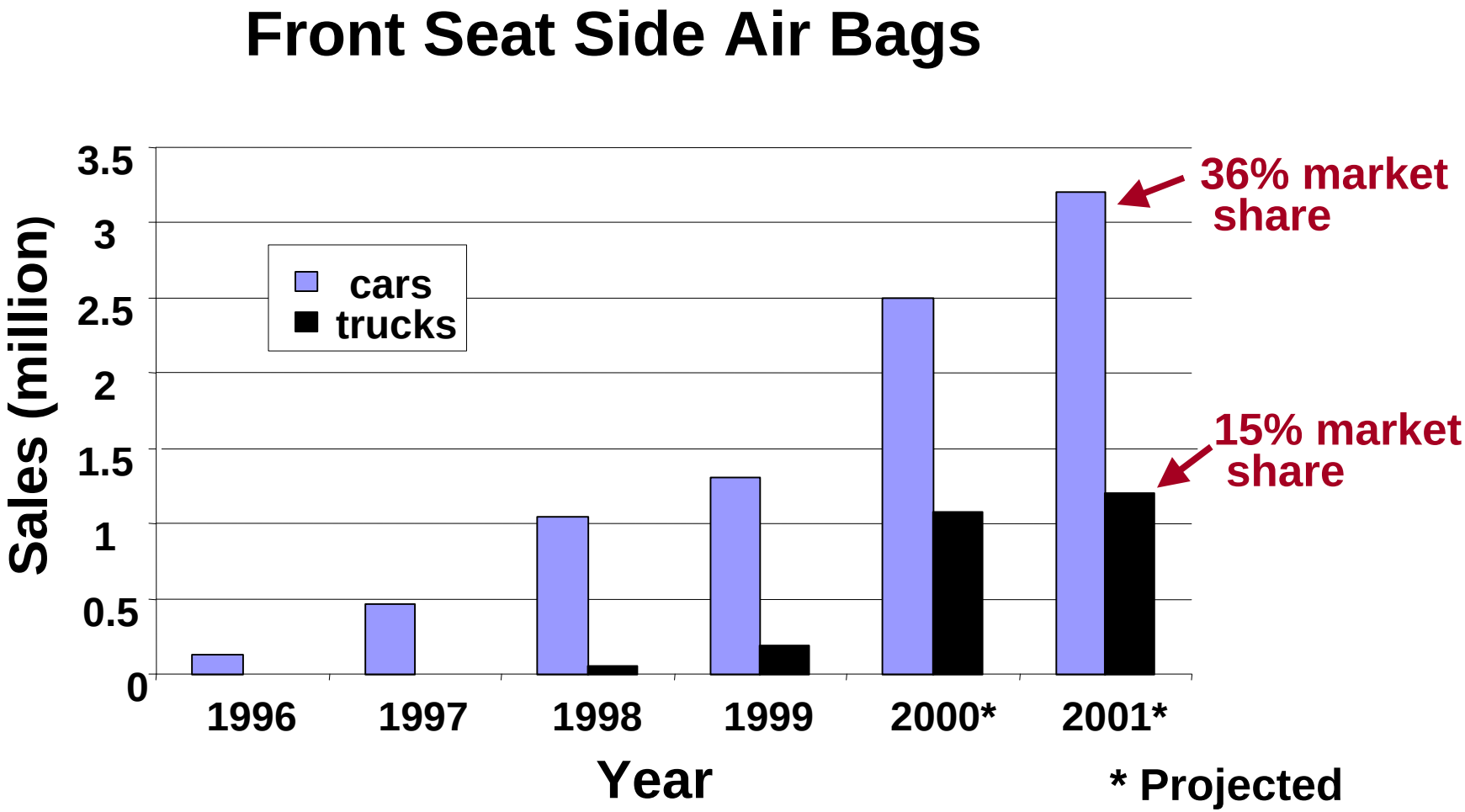

What Is Our Motivation?

- Increased risk from side impacts with LTVs/narrow objects (head injuries)
- Modern vehicle designs & countermeasures (air bags) have led to improvement in side impact protection
- Harmonization

Outline

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- Injury risk static side air bag (SAB) studies
- Interim harmonized side impact dummy (ES-2) studies
- Injury criteria studies
- SAB/advanced countermeasures effectiveness studies
- Upgrade FVMSS 214 barrier studies
- Additional side dummy research studies
- Side impact sled system

Outline

- Injury risk static side air bag (SAB) studies

Injury Risk Static SAB Studies

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NHTSA Side Impact Research

- Research is ongoing to evaluate potential risk to children and adults from current SAB systems and evaluate the corresponding industry recommended procedures**
- Evaluation of TWG 3 and 6 yr old positions for seat and door mounted systems nearly completed (6/01)
- Assessment of the proposed performance criteria is planned (summer 01)
- Research is ongoing for roof mounted bags, SID-IIs and other dummies, and repeatability aspects (8/01)

**Side Air Bag TWG (Technical Working Group), August 2000

Injury Risk Static SAB Studies – 3 & 6 YO Results*

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NHTSA Side Impact Research

- High loads are possible in current SAB systems
- TWG positions are capable of discriminating SAB systems but do not always produce the highest loads
- For seat mounted systems, variations of the TWG leaning sideways for seat mounted bags allow
  - Head to be closer to the air bag module
  - Head at a range of locations along seat back
- For door mounted systems
  - "Leaning sideways" type of position for door mounted bags not addressed by TWG

* Prasad, ESV 01

Outline

- Interim harmonized side impact dummy (ES-2) studies

Interim Harmonized Dummy Research (ES-2)

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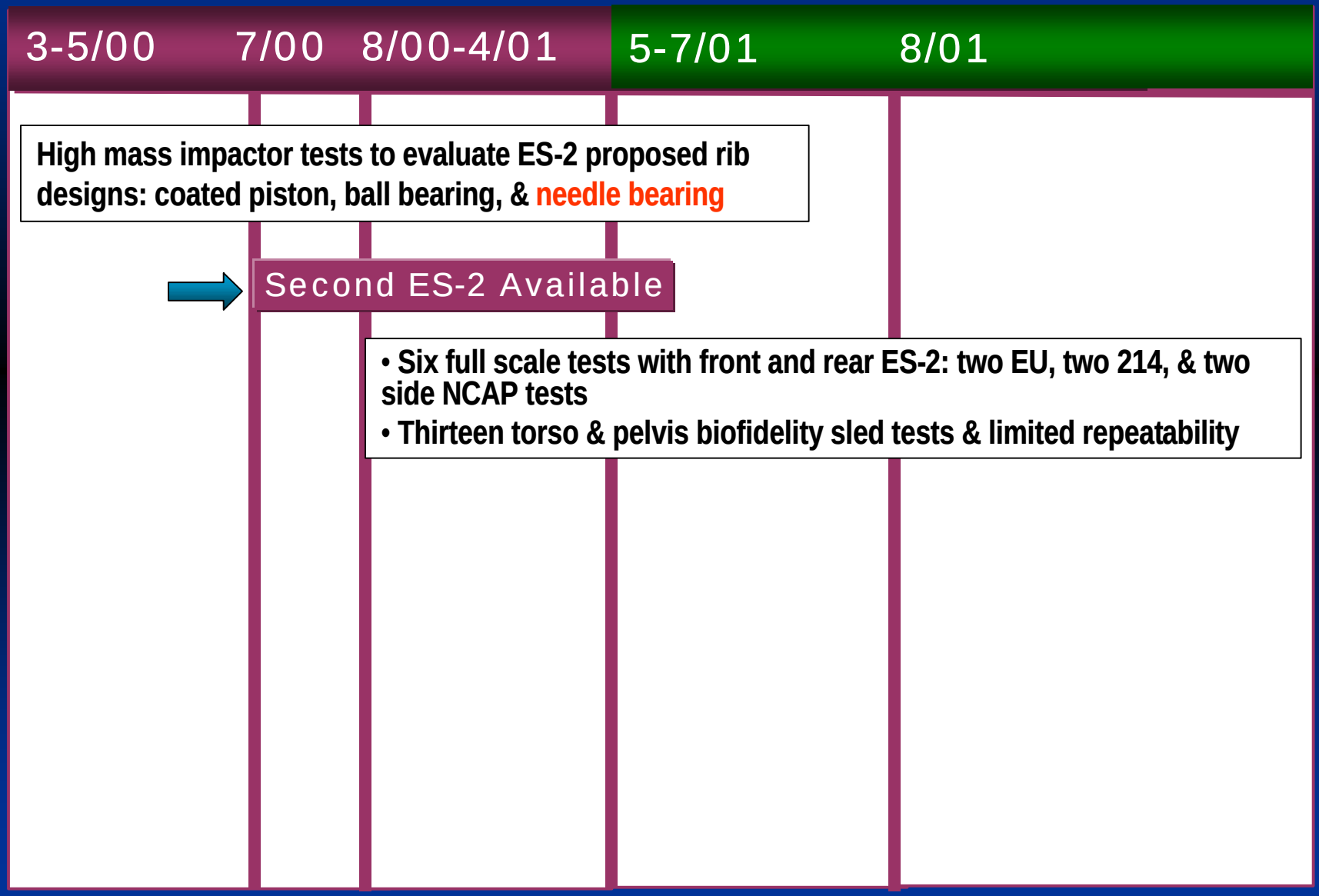
NHTSA Side Impact Research

- **Motivation:** improve injury measurement capabilities in FMVSS 214 (thorax, abdomen, & pelvis) & harmonization
- **Goal:** assess use of ES-2 in FMVSS 214 and subsequent testing by the agency as the proposed interim harmonized dummy
- **Approach:** perform series of component, high mass impactor, sled (biofidelity), and full vehicle testing

ES-2 Research Testing



ES-2 Phase I Full Scale Tests

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NHTSA Side Impact Research

VEHICLE	DUMMY	TEST CONFIGURATION	SPEED (km/h)
96 Taurus- 4dr*	Eurosid-1	EU Side	48.3
96 Taurus- 4dr	ES-2	EU Side	49.2
96 Metro- 3 dr*	Eurosid-1	EU Side	50.8
96 Metro- 3 dr	ES-2	EU Side	50.5
96 Taurus- 4dr	ES-2	FMVSS 214	53.3
96 Taurus- 4dr	ES-2	FMVSS 214	52.3
98 Chevy Cavalier- 4dr	ES-2	US Side NCAP	61.6
2000 Grand Am- 2dr	ES-2	US Side NCAP	62.1

**** Baseline Tests in 1997***

ES-2 Phase I Full Scale Tests

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96 Metro- 3 dr	ES-2	EU Side	50.5
96 Taurus- 4dr	ES-2	FMVSS 214	53.3
96 Taurus- 4dr	ES-2	FMVSS 214	52.3
98 Chevy Cavalier- 4dr	ES-2	US Side NCAP	61.6
2000 Grand Am- 2dr	ES-2	US Side NCAP	62.1

** Baseline Tests in 1997*

ES-2 Phase I Full Scale/Sled Test Results*

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- ES-2 modifications appear to have addressed rib binding which is one mechanism of rib deflection flat top
- Rib deflection flat top response was not present in the FMVSS 214 tests with ES-2 but may need to be investigated further in the US side NCAP tests
- ES-2 back plate loads are roughly 10-20% of the total impulse applied to to the dummy during vehicle crash tests, however the significance of these loads on overall dummy responses has not been assessed

* Samaha, ESV 01

ES-2 Phase I Full Scale/Sled Test Results*...

- Knee-to-knee contact, when present, in the ES-2 had little or no effect on pubic symphysis loads in the 214 and side NCAP tests performed
- Overall, ES-2 responses showed good repeatability in component level and limited sled tests

* Samaha, ESV 01

ES-2/SIDH3 Biofidelity & Injury Assessment*

- The ES-2 thorax is less biofidelic than the SID while the ES-2 abdomen and pelvis biofidelity are roughly equivalent
- ES-2 detects abdominal injuries that the SID misses
- ES-2 has the potential to better detect serious pelvic injuries
- More research is necessary to understand the biofidelity of the head/neck complex

* Samaha, ESV 01

ES-2 Research Testing

Planned

3-5/00 | 7/00 | 8/00-4/01 | 5-7/01 | 8/01

High mass impactor tests to evaluate ES-2 proposed rib designs: coated piston, ball bearing, & needle bearing

Second ES-2 Available

- Six full scale tests with front and rear ES-2: two EU, two 214, & two side NCAP tests
- Thirteen torso & pelvis biofidelity sled tests & limited repeatability

- Three 214 tests/IIHS barrier
- Eight 201P pole comparison tests: ES-2 versus SIDH3
- Component tests: back plate interaction, flat top
- Sled tests: head/neck/shoulder biofidelity & kinematics

- TBD- Eight 214/NCAP tests with current vehicles for fleet performance

ES-2 IIHS Barrier Tests
Planned 5/01

Test Vehicles	Test Information
1999 Prism (no SAB) 2000 Maxima (no SAB) 1999 Cadillac Deville (std SAB)	• 214 test conditions • 1770 kg IIHS side impact barrier • Front & rear ES-2 dummies • Provide data on ES-2 head & neck responses • Provide data on ES-2 in high severity loading

ES-2/SIDH3 Pole Tests
Planned 7/01

Test Vehicles	Test Configuration
1999 Cougar (no combo SAB) 1999 Cougar (with SAB) 1999 Volvo S80 (with Curtain) 1999 Volvo S80 (no Curtain)	• 201 pole test conditions • Provide data on ES-2 head & neck responses • Provide comparison of SIDH3/ES-2 responses in side impact pole test

ES-2 Fleet Performance Tests - TBD

Test Vehicles	Test Configuration
• 8 vehicles • Matrix of current models-TBD	• Current FMVSS 214 test and side NCAP conditions and barrier • Provide data on current US fleet performance with the ES-2 dummy •Provide data for benefits analysis of ES-2 versus SID in FMVSS 214

Outline

- Injury criteria studies

Side Injury Criteria Studies

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- Head: SIMon (Simulated Injury Monitor), finite element based brain injury assessment algorithm driven by dummy kinematics to address brain injury and also provide HIC (initiated)
- Thorax, abdomen, & pelvis: analyzing most recent data to determine best predictor of trauma. Deflection, force and acceleration based measures under consideration (ongoing, summer 01)
  - Application of injury criteria for the ES-2 dummy

Side Injury Criteria Studies
Adult/Pediatric Head-Neck Research

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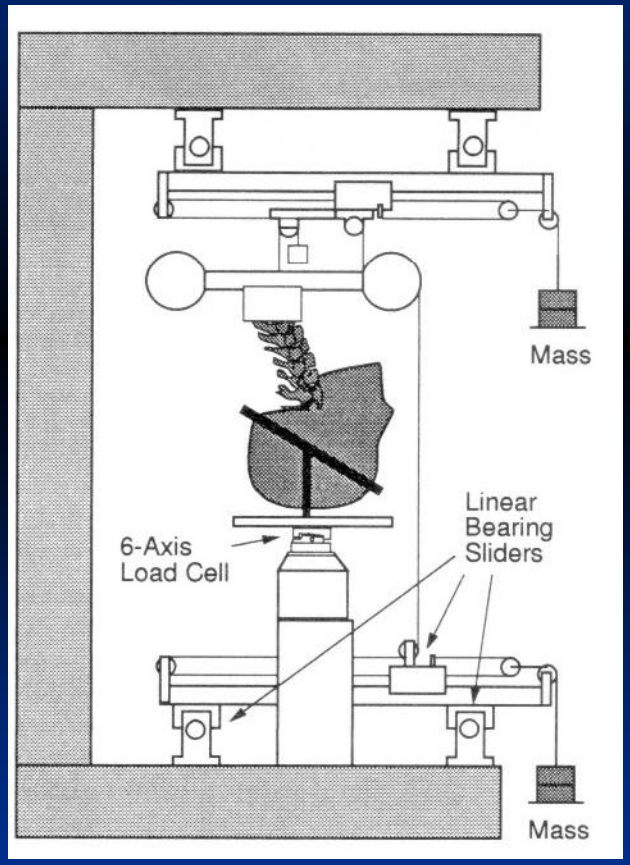
NHTSA Side Impact Research



- Determine tolerance to loading in all directions
- Develop Nij-like injury criteria for lateral loads and twist
- STATUS: tensile, compressive, and flexion/extension (ongoing); lateral bending (initiated) and torsion (planned)
- Initial tension results presented in 2000 STAPP

Outline

- SAB and advanced countermeasures effectiveness studies

Side Air Bag Effectiveness Research Testing

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- **Goal:**
  - Assess the protection effectiveness of SAB & other advanced countermeasures in side impacts representative of current and future side crashes in the U. S. Fleet
  - Develop research foundation to upgrade FMVSS 214 & 201P
- **Approach:** perform vehicle to vehicle and vehicle to pole side crash tests using SAB equipped vehicles

Vehicle to Vehicle Tests

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NHTSA Side Impact Research

- Striking bullet: 1999 Ford 150 pickup
- Target vehicles: matrix of 13 1999/2000 MY vehicles equipped with SABs.
- Baseline tests: F150 into pre-SAB or inactive SAB models
- Test conditions: TBD by crash data analysis; Speed & angle expected similar to FMVSS 214
- Dummies in struck vehicle: SID-IIs driver & in rear; Restrained Q3/HIIIc (if side-ready child dummy available) and SID-IIs in rear for some tests
- Status: 7/01 →, completion spring 2002

F150 Tests Vehicle Matrix

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Test Vehicle	Seat Mounted SAB Configuration
2000 Audi A6	Curtain +Torso (SM)
1999 Chevrolet Prism	Torso (SM)
1999 Ford Windstar	Combo (SM)
1999 Mercury Cougar	Combo (SM)
2000 Nissan Maxima	Combo (SM)
1999 Saab 9-5	Combo (SM)
1999 Toyota Camry	Torso (SM)
1999 Volvo S80	Curtain +Torso (SM)
1999 VW Jetta	Torso (SM)
2001 Saturn	Curtain + Torso(SM)

SM = Seat Mounted
DM = Door Mounted
Combo= Head & Torso

F150 Tests Vehicle Matrix (Continued)

Test Vehicle	Door Mounted SAB
2000 BMW 5	Head Tube +Torso (DM)
1999 Cadillac Deville	Torso (DM)
2000 Mercedes S-Series	Curtain +Torso (DM)

SM = Seat Mounted
DM = Door Mounted
Combo= Head & Torso

Vehicle to Pole Crash Tests

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NHTSA Side Impact Research

- Baseline tests: pre-SAB or inactive SAB vehicle models into pole
- Target vehicles: matrix of eight vehicles with head protection SABs
- Rigid pole: 250 or 350 mm diameter
- Test conditions: TBD by crash data analysis; 29 kph and 90º expected
- Dummies: TBD driver; Restrained Q3/HIIIc (if side-ready child dummy available) and SIDIIs in rear
- Status: 6/01 →, completion Fall 2001

Pole Test Vehicle Matrix (Highlighted)

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Test Vehicle	SAB Configuration
2000 Audi A6	Curtain + Torso (SM)
2000 BMW 5	Head Tube+Torso (DM)
1999 Cadillac Deville	Torso (DM)
1999 Chevrolet Prism	Torso (SM)
1999 Ford Windstar	Combo (SM)
1999 Mercury Cougar	Combo (SM)
2000 Mercedes S-Series	Curtain + Torso (DM)
2000 Nissan Maxima	Combo (SM)
1999 Saab 9-5	Combo (SM)
1999 Toyota Camry	Torso (SM)
1999 Volvo S80	Curtain+Torso (SM)
1999 VW Jetta	Torso (SM)

SM = Seat Mounted
DM = Door Mounted
Combo= Head & Torso

Outline

- Upgrade FMVSS 214 barrier studies

Upgrade FMVSS 214 Barrier Studies

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NHTSA Side Impact Research

- **F150-to-vehicle tests**
  - Provide baseline data for upper limit of current countermeasures effectiveness
  - Provide insight for feasibility and practicality of an LTV-like 214 movable deformable barrier (MDB)
- **IIHS MDB tests**
  - Provide data to indicate how representative the IIHS side impact barrier is
- **New MDB development (Fall 2002)**
  - Design/develop an advanced MDB with LTV geometry and variable lateral stiffness
  - Force-time history based on both frontal NCAP and crabbed NCAP test data for the F150

Outline

- Additional side dummy research studies

5th %tile Side Dummy Evaluation & Testing

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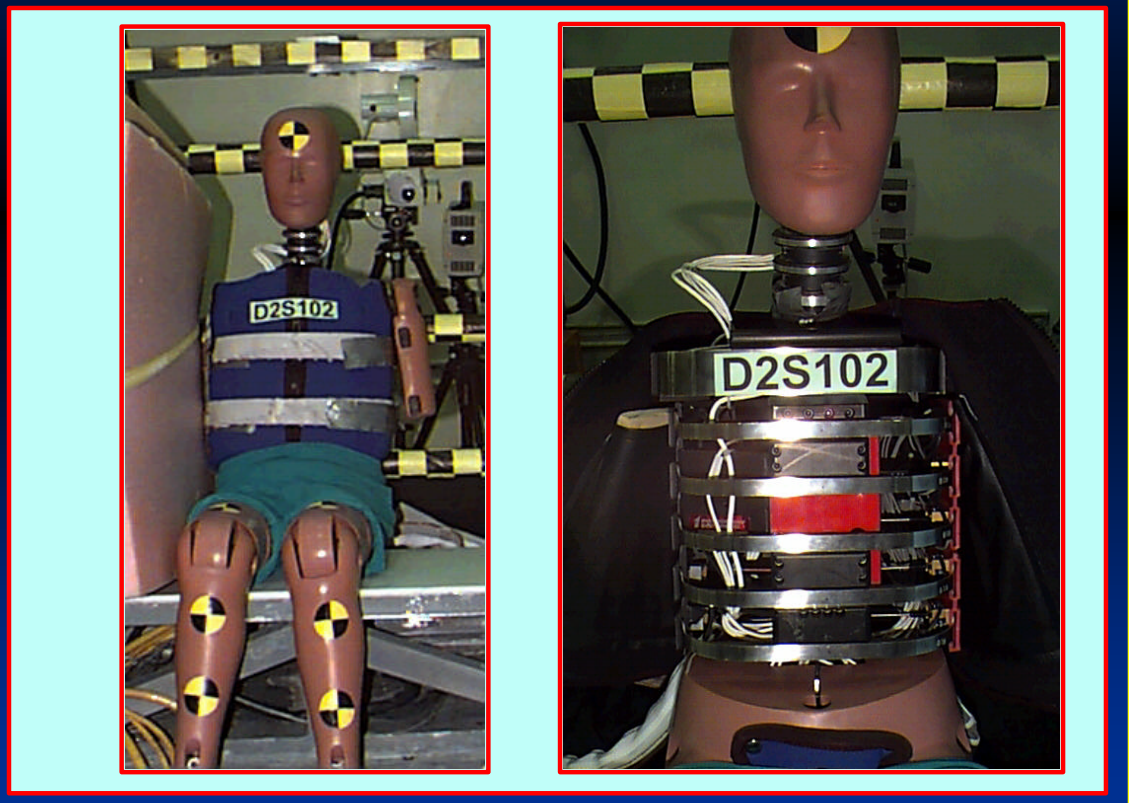
NHTSA Side Impact Research

- Calibration type tests (11/00 & 5/01)
- Rigid, padded wall, & offset impact sled tests (11/00 & 5/01)

SID-IIs



SID-IIs Planned Testing

- TWG OOP positions for seat, door, and roof mounted side air bags (6/01→)
- Driver dummy in F150-to-vehicle side impact tests (7/01→)
- Rear dummy in some F150-to-vehicle (7/01→) and vehicle-to-pole side impact tests (6/01→)

New "SID" on the Block!
WorldSID Evaluation

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NHTSA Side Impact Research

- NHTSA/Transport Canada alpha prototype testing (ongoing)
- WorldSID prototype biofidelity evaluation (per ISO TR9790 and proposed IHRA tests)

Photo from www.worldsid.org

HIII 3yo/Q3 (Side Adapted) Evaluation & Testing

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NHTSA Side Impact Research

- Calibration/sled tests (when available)
- "Piggy back" as restrained child rear occupant in some F150-to-vehicle and vehicle-to-pole side crash tests (planned)

Q3

Photo from www.ftss.com

Outline

- Side impact sled system

NHTSA Dynamic Side Impact Sled System

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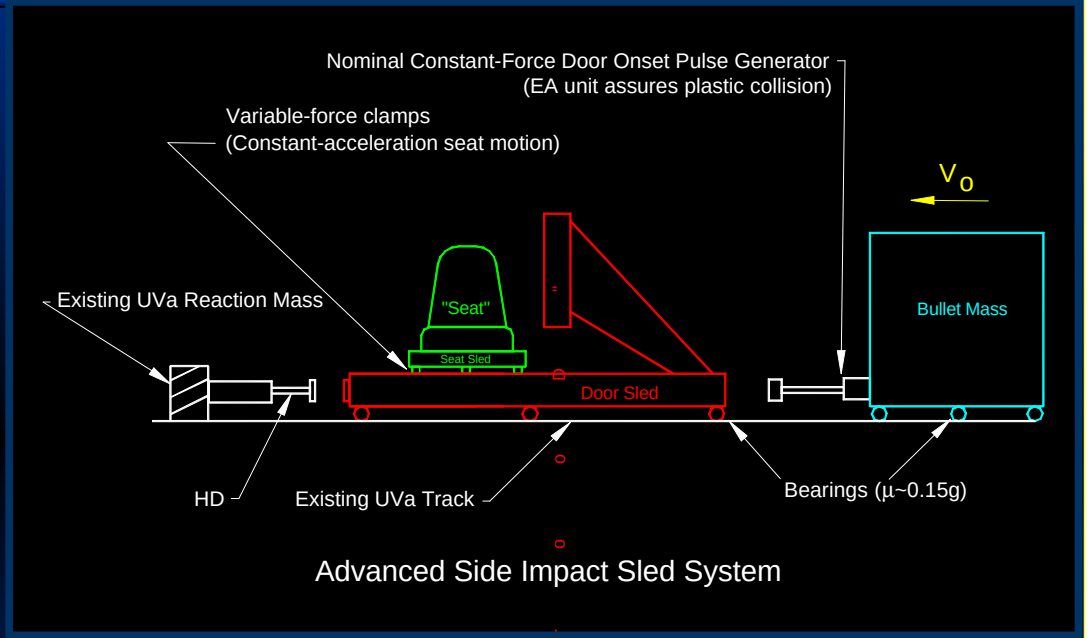
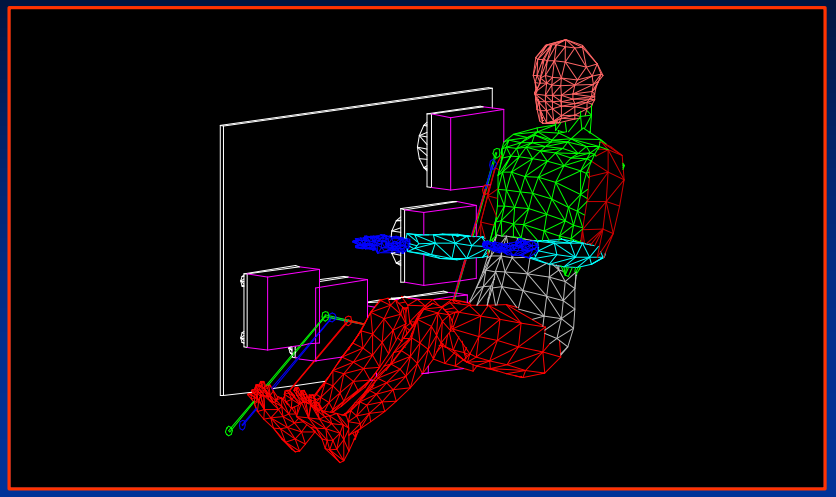
- Goals: offer a more realistic door intrusion profile then existing systems, allow the study both in-position and OOP dynamic deployments of side airbags
- Approach: simulate force-area-time characteristic of real vehicle crash
- Status: built - currently



Advanced Side Impact Sled System



Thank you!