NHTSA Side Impact Research

- 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...

U.S. Sales and Registrations of Light Trucks and Vans

Year

Percentage (%)
Near Side Fatalities by Crash Partner

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

- Narrow Object: 25%
- Large LT: 20%
- Compact LT: 15%
- Large Car: 21%
- Small Car: 3%
- Other Obj/Event: 9%
- Minivan: 3%
- Large Van: 4%

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)

Struck by a car
Struck by an LTV

Head & Face
Neck & Spine
Chest
Abdomen
Lower Ext
Arm/Wrist
Pelvis

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

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

- Struck by a car
- Struck by an LTV

- Preliminary

图表显示了不同身体部位在不同类型的车祸中受伤的风险。

- 头部和面部
- 颈部和脊椎
- 胸部
- 腹部
- 骨盆

模型年份：1995-2000年
(NASS/CDS 95-99)
US Fleet Is Changing...

Front Seat Side Air Bags

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>0.5</td>
</tr>
<tr>
<td>1997</td>
<td>1</td>
</tr>
<tr>
<td>1998</td>
<td>1.5</td>
</tr>
<tr>
<td>1999</td>
<td>2</td>
</tr>
<tr>
<td>2000*</td>
<td>3</td>
</tr>
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</tr>
</tbody>
</table>

* Projected

- 36% market share
- 15% market share
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

- 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

NHTSA Side Impact Research

- Injury risk static side air bag (SAB) studies
Injury Risk Static SAB Studies

- 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
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
Interim harmonized side impact dummy (ES-2) studies
Interim Harmonized Dummy Research (ES-2)

- **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

<table>
<thead>
<tr>
<th>3-5/00</th>
<th>7/00</th>
<th>8/00-4/01</th>
<th>5-7/01</th>
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**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
## ES-2 Phase I Full Scale Tests

<table>
<thead>
<tr>
<th>VEHICLE</th>
<th>DUMMY</th>
<th>TEST CONFIGURATION</th>
<th>SPEED (km/h)</th>
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</thead>
<tbody>
<tr>
<td>96 Taurus- 4dr*</td>
<td>Eurosid-1</td>
<td>EU Side</td>
<td>48.3</td>
</tr>
<tr>
<td>96 Taurus- 4dr</td>
<td>ES-2</td>
<td>EU Side</td>
<td>49.2</td>
</tr>
<tr>
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<td>Eurosid-1</td>
<td>EU Side</td>
<td>50.3</td>
</tr>
<tr>
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<td>EU Side</td>
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<td>53.3</td>
</tr>
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<td>ES-2</td>
<td>FMVSS 214</td>
<td>52.3</td>
</tr>
<tr>
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<td>ES-2</td>
<td>US Side NCAP</td>
<td>61.6</td>
</tr>
<tr>
<td>2000 Grand Am- 2dr</td>
<td>ES-2</td>
<td>US Side NCAP</td>
<td>62.1</td>
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*Baseline Tests in 1997*
# ES-2 Phase I Full Scale Tests

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*Baseline Tests in 1997*
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 the dummy during vehicle crash tests, however the significance of these loads on overall dummy responses has not been assessed.

* Samaha, ESV 01
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
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
### Planned

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<tr>
<th>3-5/00</th>
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- **Second ES-2 Available**

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

- **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
- 1999 Prism (no SAB)
- 2000 Maxima (no SAB)
- 1999 Cadillac Deville (std SAB)

### Test Information
- 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

<table>
<thead>
<tr>
<th>Test Vehicles</th>
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<tbody>
<tr>
<td>1999 Cougar (no combo SAB)</td>
</tr>
<tr>
<td>1999 Cougar (with SAB)</td>
</tr>
<tr>
<td>1999 Volvo S80 (with Curtain)</td>
</tr>
<tr>
<td>1999 Volvo S80 (no Curtain)</td>
</tr>
</tbody>
</table>

### Test Configuration

- 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

<table>
<thead>
<tr>
<th>Test Vehicles</th>
<th>Test Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 8 vehicles</td>
<td>• Current FMVSS 214 test and side NCAP conditions and barrier</td>
</tr>
<tr>
<td>• Matrix of current models-TBD</td>
<td>• Provide data on current US fleet performance with the ES-2 dummy</td>
</tr>
<tr>
<td></td>
<td>• Provide data for benefits analysis of ES-2 versus SID in FMVSS 214</td>
</tr>
</tbody>
</table>
Outline

- Injury criteria studies

NHTSA Side Impact Research
Side Injury Criteria Studies

- 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

- 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
**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

- Striking bullet: 1999 Ford 150 pickup
- 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
<table>
<thead>
<tr>
<th>Test Vehicle</th>
<th>Seat Mounted SAB Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 Audi A6</td>
<td>Curtain + Torso (SM)</td>
</tr>
<tr>
<td>1999 Chevrolet Prism</td>
<td>Torso (SM)</td>
</tr>
<tr>
<td>1999 Ford Windstar</td>
<td>Combo (SM)</td>
</tr>
<tr>
<td>1999 Mercury Cougar</td>
<td>Combo (SM)</td>
</tr>
<tr>
<td>2000 Nissan Maxima</td>
<td>Combo (SM)</td>
</tr>
<tr>
<td>1999 Saab 9-5</td>
<td>Combo (SM)</td>
</tr>
<tr>
<td>1999 Toyota Camry</td>
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</tr>
<tr>
<td>1999 Volvo S80</td>
<td>Curtain + Torso (SM)</td>
</tr>
<tr>
<td>1999 VW Jetta</td>
<td>Torso (SM)</td>
</tr>
<tr>
<td>2001 Saturn</td>
<td>Curtain + Torso (SM)</td>
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SM = Seat Mounted
DM = Door Mounted
Combo = Head & Torso
# F150 Tests Vehicle Matrix (Continued)

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<thead>
<tr>
<th>Test Vehicle</th>
<th>Door Mounted SAB</th>
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<tbody>
<tr>
<td>2000 BMW 5</td>
<td>Head Tube + Torso (DM)</td>
</tr>
<tr>
<td>1999 Cadillac Deville</td>
<td>Torso (DM)</td>
</tr>
<tr>
<td>2000 Mercedes S-Series</td>
<td>Curtain + Torso (DM)</td>
</tr>
</tbody>
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SM = Seat Mounted  
DM = Door Mounted  
Combo= Head & Torso
Vehicle to Pole Crash Tests

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 90° expected

Dummies: TBD driver; Restrained Q3/HIIlc (if side-ready child dummy available) and SIDIIIs in rear

Status: 6/01 → completion Fall 2001
<table>
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Combo = Head & Torso
Upgrade FMVSS 214 barrier studies
Upgrade FMVSS 214 Barrier Studies

- **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

NHTSA Side Impact Research

- Additional side dummy research studies
5th %tile Side Dummy Evaluation & Testing

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

SID-IIs

SAE Gov/Industry Meeting, May 2001
SID-IIIs 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

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

NHTSA Side Impact Research

Photo from www.worldsid.org
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)
Outline

- Side impact sled system
NHTSA Dynamic Side Impact Sled System

- **Goals**: offer a more realistic door intrusion profile than 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
Thank you!