FRONTAL COLLISION BUSES AND COACHES. RESEARCH AND PROBLEMS

APSN Workshop on Bus and Truck Passive Safety
TRAFIC ACCIDENTS (SPAIN 1995-2002)

APPROX. 15000 ACC.
VICTIMS (SPAIN-1995-2002)

% M + HG totales, M + HG Accid. con autobús, M + HG autobús

Porcentajes referidos al año 1995
Accidentes con autobuses

Tipo de colisión (España-1995-2002)

Datos promedio 1995-2002

- Frontal
- Frontolateral
- Lateral
- Alcance
- Múltiple
- Colisión con obstáculo
- Atropello
- Vuelco
- Salida de vía
- Otros

Totales
Urbanos
Interurbanos
TYPE OF COLISION (SPAIN 1995-2002)

Víctimas en accidentes con autobuses

Datos promedio 1995-2002

Tipo de colisión

- Frontal
- Frontalateral
- Lateral
- Alcance
- Multiple
- Colisión con obstáculo
- Atropello
- Vuelco
- Salida de vía
- Otros

M + HG totales
M + HG urbanos
M + HG interurbanos
TYPE OF COLLISION (SPAIN-1995-2002)

Datos promedio 1995-2002

Tipo de colisión

<table>
<thead>
<tr>
<th>Tipo de colisión</th>
<th>Datos promedio 1995-2002</th>
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<tbody>
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TYPE OF COLLISION (SPAIN 1995-2002)

Datos promedio 1995-2002

Víctimas por accidente

Tipo de colisión

- Accidentes totales
- Accidentes con autobuses
- Autobús

Accidentes con autobuses

Datos promedio 1995-2002
INTRODUCTION

FREQUENCY DEPENDING ON THE OPPOSITE VEHICLE IN FRONTAL COLLISIONS: REAR END-HEAD ON

- Passenger car
- Machinery
- Light truck
- Heavy truck
- Coach
- Others

0.0%  5.0%  10.0%  15.0%  20.0%  25.0%  30.0%  35.0%  40.0%  45.0%  50.0%
Collision with passengers car, vans and light trucks

Description:
A car crashes semi-frontally with the bus while finishing a wrong overtake. Finally the coach left the road and rolled over 90 degrees, standing on its right side.

Bus Deformations:
The right side of the bus damaged because of the rollover. The left front corner was badly damaged because of the impact with the car.
FRONTAL PROBLEMS: INCOMPATIBILITY

Collision with passengers car, vans and light trucks

Frontal (Bus) and Frontal (Car)

Description:

The coach was driving by a dual carriage way, in a left curve. A car crashes frontally (40% offset) into the bus, at 130kph, and reaches coach fuel tank. Coach starts burning.
Collision – Frontal (Bus) and Rear (Opponent)

**Description:**
The coach was driving by a motorway, when crashed (60% offset) against the rear part of a truck, which was driving at 40kph.

**Bus Deformations:**
The right front corner of the coach structure was badly damaged, because of the crash against the truck.
Collision – Frontal (Bus) and Rear (Opponent)

Description:
The coach was driving by a motorway, when crashed (65% offset) against the rear part of a truck.

Bus Deformations:

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>Intrusión (mm)</th>
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<tbody>
<tr>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>0.6</td>
<td>553</td>
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<tr>
<td>0.8</td>
<td>661</td>
</tr>
<tr>
<td>1</td>
<td>899</td>
</tr>
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<td>1.2</td>
<td>1164</td>
</tr>
<tr>
<td>1.4</td>
<td>1148</td>
</tr>
<tr>
<td>1.6</td>
<td>1089</td>
</tr>
<tr>
<td>1.8</td>
<td>872</td>
</tr>
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</table>
FRONTAL PROBLEMS: DRIVER AND CREW

Driver’s safety is not adequately contemplated in current regulations:

The risk can be higher than the passenger’s in many kind of accidents.

If the driver remained conscious and not seriously injured, he would keep the control of the vehicle and make easy the evacuation.
FRONTAL PROBLEMS: RESTRAIN SYSTEMS

SEATS AND SAFETY BELTS
ANCHORAGES

PARTITIONS
RETENCIÓN DE PASAJEROS

INSIA UNIVERSITY INSTITUTE FOR AUTOMOTIVE RESEARCH
CENTRO SUPERIOR DE INVESTIGACIÓN DEL AUTOMÓVIL DE LA COMUNIDAD DE MADRID
The seats and their anchorages should tolerate the more typical efforts which appear in real accidents. The use of seat belts combined with an adequate behaviour of the seats and their anchorages, would reduce drastically the severity of the injuries, especially in the case of occupants projected or ejected.
MAIN PARAMETERS AFFECTING THE DRIVER’S SAFETY (INSIA research)

- Height of the driver’s floor. (Geometric Compatibility)
  - Low driver’s floor (around 800 mm)
  - Normal driver’s floor (around 975 mm)
  - High driver’s floor (around 1060 mm)

- Distance to the front of the vehicle
MAIN PARAMETERS AFFECTING THE DRIVER’S SAFETY

Free space around the driver

Less than 100 mm

Different posture between coach and cars drivers
DEFINITION OF A SURVIVAL SPACE FOR THE DRIVER

e. From comfort and displacement allowed by safety belt

Test:
- According Regulation 80
- 50% percentile dummy
- Coach’s driver’s seat
DEFINITION OF A SURVIVAL SPACE FOR THE DRIVER

Minimum space around driver, to remain free of any intrusion in an accident

Four options could be considered:

a. The driver restrained with 3-point belt never cross it (R16 or Directive 2000/3)

INTRUSSION: So, it should not be used to define survival space
DEFINITION OF A SURVIVAL SPACE FOR THE DRIVER

b. The procedure in Regulation UN-ECE 29 (for trucks)
   A dummy of the 50th percentile cannot be in contact with any rigid part or the cabin after the tests.

c. The Spanish's standard UNE 115-204-87 which deals with rollover strength in utility vehicles. Volume free of intrusion.
d. ECBOS Work Document: Task 3.3.2 (TNO) propound a survival space after Swing-bod test (1500 kg) conform ECE/ R29.

UNE survival space seems the better
PROPOSALS: Collision with passengers car, vans and light trucks

THE PROBLEM: Incompatibility (mass, stiffness and geometries)

THE PROPOSAL:
Use a “FUP” (UN-ECE R93)
or better “eaFUP”
MAIN PARAMETERS AFFECTING THE DRIVER’S SAFETY

- Structural stiffness

The frontal frame is thought to support frontal impact but in case of low overlap, the chassis could not come in contact with the impacting vehicle or bend as a result of the impact.
PROPOSALS: Collision with heavy vehicles

SIM 1: FRONTAL LOW OVERLAP
- Speed 30 km/h
- Overlap 30%

SIM 2: REAR ON HIGH OVERLAP
- Speed 30 km/h
- Overlap 70%
PROPOSALS: Test frontal Collision with heavy vehicles
PROPOSALS: Test Frontal Collision with heavy vehicles
PROPOSALS: Test Rear-on Collision with heavy vehicles

0.2 m

0.3 m

0.5 m
PROPOSALS: Collision with heavy vehicles

A higher floor with FUP’s enhances passive safety

Current designs are not strong enough to maintain the defined survival volume for driver/crew in the two simulations
CONCLUSIONS AND FURTHER DEVELOPMENT ABOUT FRONTAL

- A survival space for the driver, free of intrusions in an accident, has been defined.
- Two crash tests have been defined (against front and rear of a truck) to specify some requirements to the frontal structure of buses and coaches.

When the geometrical incompatibility cannot be avoided:
- Increase the distance between the driver and frontal
- To use a FUP
- To elevate the driver’s floor above 1100 mm

increase the resistance of the floor, front structure, side pillars and doors to contribute to the survival space preservation
REPERCUSSIONS

R & D needed:
• Statistical data
• Definition of possible tests/simulations
• Biomechanical analysis
• ...

Ad Hoc Expert Groups/ EEVC/European Projects / …

MANUFACTURES:
• FUP: Not difficult to adopt (little structural changes)
• Seats-safety belts anchorages: Not much more difficult than nowadays
• Partitions: New requirements
• Structural strength: New designs and/or new vehicle concept
INTRODUCTION

Accidents data collected by Spanish Traffic Authorities, since 1995 to 1999.

Only accidents with two vehicles with implication of almost one bus.

<table>
<thead>
<tr>
<th></th>
<th>SUCCESS</th>
<th>PERCENT</th>
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<tbody>
<tr>
<td>FRONTAL IMPACT</td>
<td>415</td>
<td>22.29%</td>
</tr>
<tr>
<td>FRONT-LATERAL</td>
<td>508</td>
<td>27.28%</td>
</tr>
<tr>
<td>SIDE IMPACT</td>
<td>189</td>
<td>10.15%</td>
</tr>
<tr>
<td>REAR-END</td>
<td>344</td>
<td>18.47%</td>
</tr>
<tr>
<td>FIXED OBJECT</td>
<td>121</td>
<td>6.50%</td>
</tr>
<tr>
<td>PEDESTRIAN IMP.</td>
<td>200</td>
<td>10.74%</td>
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<tr>
<td>ROLLOVER</td>
<td>85</td>
<td>4.56%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1862</td>
<td>100%</td>
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1º Head on collisions
2º Rear end collisions
3º Side impacts
Consequences to the driver.

- Head on causes the 50% of the deaths
- Rear end impact the 15% of the deaths

<table>
<thead>
<tr>
<th>TYPE OF</th>
<th>DIED</th>
<th>SERIOUS INJURES</th>
<th>SLIGHT INJURY</th>
<th>NO INJURY</th>
<th>NOT KNOWN</th>
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<tbody>
<tr>
<td>FRONTAL</td>
<td>1.67%</td>
<td>2.39%</td>
<td>8.13%</td>
<td>87.32%</td>
<td>0.48%</td>
</tr>
<tr>
<td>FRONTAL-SIDE</td>
<td>0.59%</td>
<td>2.94%</td>
<td>8.22%</td>
<td>86.89%</td>
<td>1.37%</td>
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<tr>
<td>SIDE</td>
<td>1.57%</td>
<td>3.15%</td>
<td>7.45%</td>
<td>88.25%</td>
<td>0.29%</td>
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<tr>
<td>REAR END</td>
<td>0.86%</td>
<td>3.15%</td>
<td>7.45%</td>
<td>88.25%</td>
<td>0.29%</td>
</tr>
<tr>
<td>FIXED OBJECT</td>
<td>1.64%</td>
<td>14.75%</td>
<td>80.33%</td>
<td>98.29%</td>
<td>3.28%</td>
</tr>
<tr>
<td>PEDESTRIAN IMP.</td>
<td></td>
<td>1.71%</td>
<td></td>
<td>98.29%</td>
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<tr>
<td>ROLLOVER</td>
<td></td>
<td>27.27%</td>
<td></td>
<td>72.73%</td>
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<tr>
<td>RUNNING OUT</td>
<td>3.31%</td>
<td>12.71%</td>
<td>27.62%</td>
<td>55.25%</td>
<td>1.10%</td>
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<tr>
<td>OTHERS</td>
<td></td>
<td>13.33%</td>
<td></td>
<td>86.67%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>1.07%</td>
<td>3.32%</td>
<td>9.68%</td>
<td>85.19%</td>
<td>0.75%</td>
</tr>
</tbody>
</table>
DEFINITION OF A SURVIVAL SPACE FOR THE DRIVER

From comfort and displacement allowed by safety belt: extrapolation to other percentiles

- Comfort position: Percentil 50% male
- Proposed Survival space: Displacement of 200 mm