FIMCAR Accident Analysis
Report to GRSP frontal impact IWG
Summary of findings

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Objectives

- Determine if previously identified compatibility issues still a problem in current vehicle fleet
  - Structural interaction
  - Frontal force matching
  - Compartment strength in particular for light cars
- Determine nature of injuries and injury mechanisms
  - Body regions injured
  - Injury mechanism
    - Contact with intrusion
    - Contact
    - Deceleration / restraint induced

Note: Current fleet means cars which have full EU type approval or have safety performance level sufficient to meet UNECE R94 requirements
Accident Databases

- CCIS UK (Cooperative Crash Injury Study)
  - TRL
- GIDAS (German In-Depth Accident Survey)
  - BASt
- PENDANT (Pan European Accident Database)
  - Chalmers
Selection Criteria

Initial selection

- Car involved in ‘significant’ frontal impact
- Car manufactured 2000 onwards
  - Registered October 2003 -> compliant with R94
  - Registered Jan 2000 to September 2003 -> may be compliant with R94
    - Assessment of possible compliance made
- Front seat adult occupants (over 12 years old)

Subsequent analysis

- Belted occupants only
- MAIS2+ injured occupants only
### Sample size*

#### CCIS

<table>
<thead>
<tr>
<th></th>
<th>Fatal</th>
<th>MAIS2+ Survived</th>
<th>MAIS 1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car - Wide object</td>
<td>28</td>
<td>76</td>
<td>163</td>
<td>267</td>
</tr>
<tr>
<td>Car - Narrow object</td>
<td>3</td>
<td>30</td>
<td>82</td>
<td>115</td>
</tr>
<tr>
<td>Car - Car</td>
<td>28</td>
<td>269</td>
<td>842</td>
<td>1139</td>
</tr>
<tr>
<td>Car - Light Goods Vehicle</td>
<td>3</td>
<td>35</td>
<td>73</td>
<td>111</td>
</tr>
<tr>
<td>Car - HGV / PSV</td>
<td>21</td>
<td>53</td>
<td>69</td>
<td>143</td>
</tr>
<tr>
<td>Car - Other</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>83</strong></td>
<td><strong>466</strong></td>
<td><strong>1236</strong></td>
<td><strong>1785</strong></td>
</tr>
</tbody>
</table>

*Includes unbelted occupants for direct sample size comparison purposes.

#### GIDAS

<table>
<thead>
<tr>
<th></th>
<th>MAIS2+</th>
<th>MAIS1</th>
<th>Uninjured</th>
<th>Unknown</th>
<th>Total</th>
<th>Fatalities (subset)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAR_CAR</td>
<td>92</td>
<td>499</td>
<td>724</td>
<td>25</td>
<td>1340</td>
<td>6</td>
</tr>
<tr>
<td>CAR_HGV</td>
<td>20</td>
<td>49</td>
<td>21</td>
<td>13</td>
<td>103</td>
<td>3</td>
</tr>
<tr>
<td>CAR_OBJ</td>
<td>57</td>
<td>142</td>
<td>276</td>
<td>14</td>
<td>489</td>
<td>7</td>
</tr>
<tr>
<td>CAR_OTH</td>
<td>2</td>
<td>11</td>
<td>657</td>
<td>2</td>
<td>672</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>171</strong></td>
<td><strong>701</strong></td>
<td><strong>1678</strong></td>
<td><strong>54</strong></td>
<td><strong>2604</strong></td>
<td>16</td>
</tr>
</tbody>
</table>
Dataset characteristics (Overlap belted occupants)

CCIS

GIDAS

Percentage of occupants in injury severity groups

Fatal
MAIS2+ survived
MAIS1

CCIS

GIDAS

Fatal (n=9)
MAIS2+ survived (n=141)
MAIS1 (n=630)
Analysis of compatibility issues

- Compartment strength
- Structural interaction
- Injury distribution / mechanisms
Compartment strength methodology

- Select belted adult front seat occupants with MAIS2+ injury
- Investigate what proportion of cases where intrusion into occupant compartment present on same side of vehicle as occupant
  - Intrusion considered to be >10cm at footwell, dashboard or A-pillar
- Assess how this relates to accident characteristics (vehicle mass, speed, overlap)
- Investigate occupant injury causation
  - Did intrusion directly cause AIS2+ injury?
**CCIS Proportion of cases with intrusion**

- Belted adult front seat occupants in car in frontal impact; Registered 2000 on; Reg 94 compliant cars; MAIS 2+
- Vehicle sustained intrusion ≥ 10cm on occupant side

<table>
<thead>
<tr>
<th></th>
<th>Fatal</th>
<th></th>
<th></th>
<th>Overall</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of occupants</td>
<td>% of cases with intrusion</td>
<td>No. of occupants</td>
<td>% of cases with intrusion</td>
<td>No. of occupants</td>
</tr>
<tr>
<td>Car - Wide object</td>
<td>9</td>
<td>55.6%</td>
<td>50</td>
<td>20.0%</td>
<td>59</td>
</tr>
<tr>
<td>Car - Narrow object</td>
<td>1</td>
<td>100.0%</td>
<td>16</td>
<td>18.8%</td>
<td>17</td>
</tr>
<tr>
<td>Car – Car</td>
<td>23</td>
<td>56.5%</td>
<td>226</td>
<td>21.2%</td>
<td>249</td>
</tr>
<tr>
<td>Car - Light Goods Vehicle</td>
<td>2</td>
<td>50.0%</td>
<td>31</td>
<td>22.6%</td>
<td>33</td>
</tr>
<tr>
<td>Car - HGV / PSV</td>
<td>13</td>
<td>53.8%</td>
<td>39</td>
<td>23.1%</td>
<td>52</td>
</tr>
<tr>
<td>Car - Other</td>
<td>0</td>
<td>0%</td>
<td>3</td>
<td>0%</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>48</td>
<td>56.3%</td>
<td>365</td>
<td>21.1%</td>
<td>413</td>
</tr>
</tbody>
</table>
CCIS injury causation for vehicles with intrusion / no intrusion present
GIDAS intrusion

- Proportion of door opening reduction (DOR) showed 7% of drivers with MAIS 2+ injury in cars with >10cm DOR on occupant side.

![Graph showing door opening reduction and injury severity.](image-url)
GIDAS Injury causation

Occupants with injuries caused by contact with intrusion CCIS (16%), GIDAS 12% of MAIS 2+ injured occupants
Structural interaction methodology

• Investigation of structural interaction problems
  – Identify accident subset where it is possible to observe structural interaction problems
    • Cases where intrusion present
      – Only in these cases can definitely identify whether or not structural interaction has been a problem
    • Quantify in how many of these cases a structural interaction problem is seen

• Investigation of frontal force matching issues
  – Identify car to car frontal-frontal impacts where one vehicle sustained significantly more intrusion than partner vehicle

• Can only be achieved with detailed individual case analysis
CCIS Fatal case analysis

- Out of 48 fatal occupants, 28 (56%) had intrusion present on their side of the vehicle

- Structural interaction issues observed in 31% of fatal car to car cases (n=28) where intrusion present

- Frontal force mismatch observed for 1 out of 13 fatally injured occupants in car to car cases where intrusion present
CCIS MAIS2+ Survived case analysis

- 38 occupants in car to car front-front cases (both cars R94 compliant) investigated
  - 31.6% had intrusion
- 66 occupants in car to object cases (R94 compliant cars) also investigated
  - 19.7% had intrusion

- Poor structural interaction is most typical compatibility issue (64%) among car to car accidents
  - Resulting in injuries caused mainly by intrusion (low overlap and overriding)
- Fork effect rarely caused intrusion and most of injuries were result of contact with no intrusion
- Compartment strength issue without poor structural interaction seen in only two of 33 cases
- Force mismatch occurred in 7 of 33 cases (28%)
Case example – Poor structural interaction between similar cars

V1 – Ford Mondeo (2002)
- 1423kg kerb mass
- 51% overlap
- 26km/h ETS
- 19cm Facia intrusion (n/s)
- 17cm Footwell intrusion (n/s)
- Driver (Male, 32)
- MAIS2 Shoulder

V2 – Ford Mondeo (2001)
- 1384kg kerb mass
- 50% overlap
- 46km/h ETS
- 90cm Facia intrusion (n/s)
- 118cm Footwell intrusion (n/s)
- Driver (Male, 53)
- MAIS5 Chest

V1 Mondeo overrode V2 Mondeo, leading to compartment collapse in V2. V2 driver sustained MAIS5 chest injury despite most intrusion on opposite side of compartment
Case example – Frontal force mismatch

V1 – Peugeot 206

- 910kg kerb mass
- 67% overlap
- 59km/h ETS
- 29cm Facia intrusion (o/s)
- 19cm Knee Contact intrusion (o/s)
- Driver (Female, 68)
- MAIS5 Thorax & AIS4 Head

V2 – Mercedes

- 1925kg kerb mass
- 57% overlap
- 28km/h ETS
- No intrusion
- Driver (Female, 40)
- MAIS1 Thorax

V1 overcrushed by V2 resulting in compartment collapse in V1
Injury distributions

- Select MAIS2+ injured occupants
- Investigate distribution of AIS2+ injuries by body region
- Investigate factors such as age, gender, accident type and seating position to identify any correlations with injuries to body regions
CCIS AIS2+ Body injury distribution

% of occupants with AIS2+ injury in body region

- Head
- Neck
- Arms
- Thorax
- Abdomen
- Pelvis
- Legs
- Surface

Fatal (n=44)
MAIS2+ Survived (n=365)
GIDAS AIS2+ Body injury distribution

- Head: 50%
- Neck: 20%
- Arm: 30%
- Thorax: 50%
- Abdomen: 20%
- Pelvis: 10%
- Leg: 30%

N = 182
Final Conclusions – Compatibility Issues (1)

- Poor structural interaction between vehicles, in particular low overlap and over/underriding of car fronts, has been identified as an issue in the current vehicle fleet.
  - In CCIS, poor structural interaction observed in 64% of MAIS2+ Survived car to car cases and 31% of fatal car to car cases where intrusion was present

- Frontal force mismatch between cars in the current fleet has also been identified, although this appears to be less of an issue than poor structural interaction.
  - Force mismatch identified in 28% of MAIS2+ Survived car to car cases and 8% of fatal car to car cases where intrusion present
Final Conclusions – Compatibility Issues (2)

- Compartment strength of vehicles is still an issue in the current vehicle fleet. However, further work is required to investigate if it is more of a problem for small cars than it is for larger cars.
  - Occupants with injuries caused by contact with intrusion CCIS 16%, GIDAS 12% of MAIS 2+ injured occupants
- Compartment strength is a particular problem in collisions with HGVs and objects, with these collisions having a high proportion of fatal and MAIS2+ injuries
  - In CCIS, 31% of car-HGV cases resulted in intrusion in the car, compared to 25% for car to car cases
  - In GIDAS, 20% of Car-HGV cases had MAIS2+ injury severity for the car occupant, compared with 7% for car to car cases
Final Conclusions – Injury Patterns (1)

- AIS2+ injuries resulting from deceleration loading of the occupant by the restraint system are present in a significant proportion of frontal crashes, regardless of whether intrusion was present or not
  - Over 40% MAIS2+ occupants sustained AIS2+ injury attributed to restraint loading in both CCIS and GIDAS datasets

- AIS2+ injuries to the Thorax are the most prevalent. AIS2+ injuries are also frequently sustained by the Head, Legs and Arms
  - Over 80% fatally injured occupants and 35% MAIS2+ Survived occupants sustained AIS2+ Thorax injuries in CCIS

- AIS2+ injuries resulting from contact with the intrusion occur in a large proportion of cases where compartment intrusion is present
  - 65% of MAIS2+ occupants in cars with intrusion sustained AIS2+ injury attributed to contact with intrusion (CCIS)
Final Conclusions – Injury Patterns (2)

• High proportion of fatal and MAIS2+ injuries in cases with high overlap (>75%)
  – In GIDAS, 41% of MAIS2+ Survived were in high overlap cases
  – In CCIS, 40% of MAIS2+ Survived and 31% of fatal occupants were in crashes with high overlap
  – In GIDAS, 25% of MAIS2+ Survived were in low overlap cases indicating possible low overlap issue. However, much lower percentage seen in CCIS.

• Greater proportion of fatal and MAIS2+ injuries for elderly occupants compared with other age groups
  – Occupants over 60 years old represent 18% of injured occupants in CCIS dataset
  – However, over 60s account for 52% of fatalities and 25% of MAIS2+ Survived occupants in CCIS dataset
Way Forward

• Additional restraint injury investigation
  – When do restraint injuries occur?

• ‘Matched pair’ analysis (compartment strength) with detailed and national accident databases
  – Is compartment intrusion a bigger issue for light vehicles compared to heavier vehicles?