FIMCAR
frontal impact and compatibility assessment research

SEVENTH FRAMEWORK PROGRAMME

FIMCAR

Frontal Impact and Compatibility Assessment Research

FIMCAR Frontal Impact Test Approach

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Content

- Accident analysis
- Strategies and priorities
- Assessment of procedures
- Selected procedures
- Outlook for assessment metrics

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Accident analysis

summary of findings

- Structural interaction still an issue
  - over/underriding
  - small overlap
- Compartment strength still an issue
  - seems to be independent from vehicle size
  - especially in crashes with HGV and objects
- High proportion of fatal and severely injured in large overlap accidents (even at relatively low speed)
- Higher injury risks for occupants in lighter car in car-to-car accidents
  - Likely caused by higher delta-v for lighter cars

FIMCAR Strategies

- Requirements for the FIMCAR assessment procedures to build FIMCAR assessment approach
  - Structural interaction
    - crash structures in common interaction zone
    - vertical / horizontal load spreading
  - Pulse
    - field relevant pulses
    - different pulses to assess RS over range of pulses
    - more severe pulse to address acceleration loading type of injuries
  - Test severity
    - maintain cabin strength for all vehicles
    - Appropriate severity level for occupant protection
  - General requirements for test procedures

Pulses from Accidents

- For comparison of test pulses with pulses from real world accidents data of CASPER accident reconstructions are used.
- For this comparison a corridor is derived from the reconstruction results

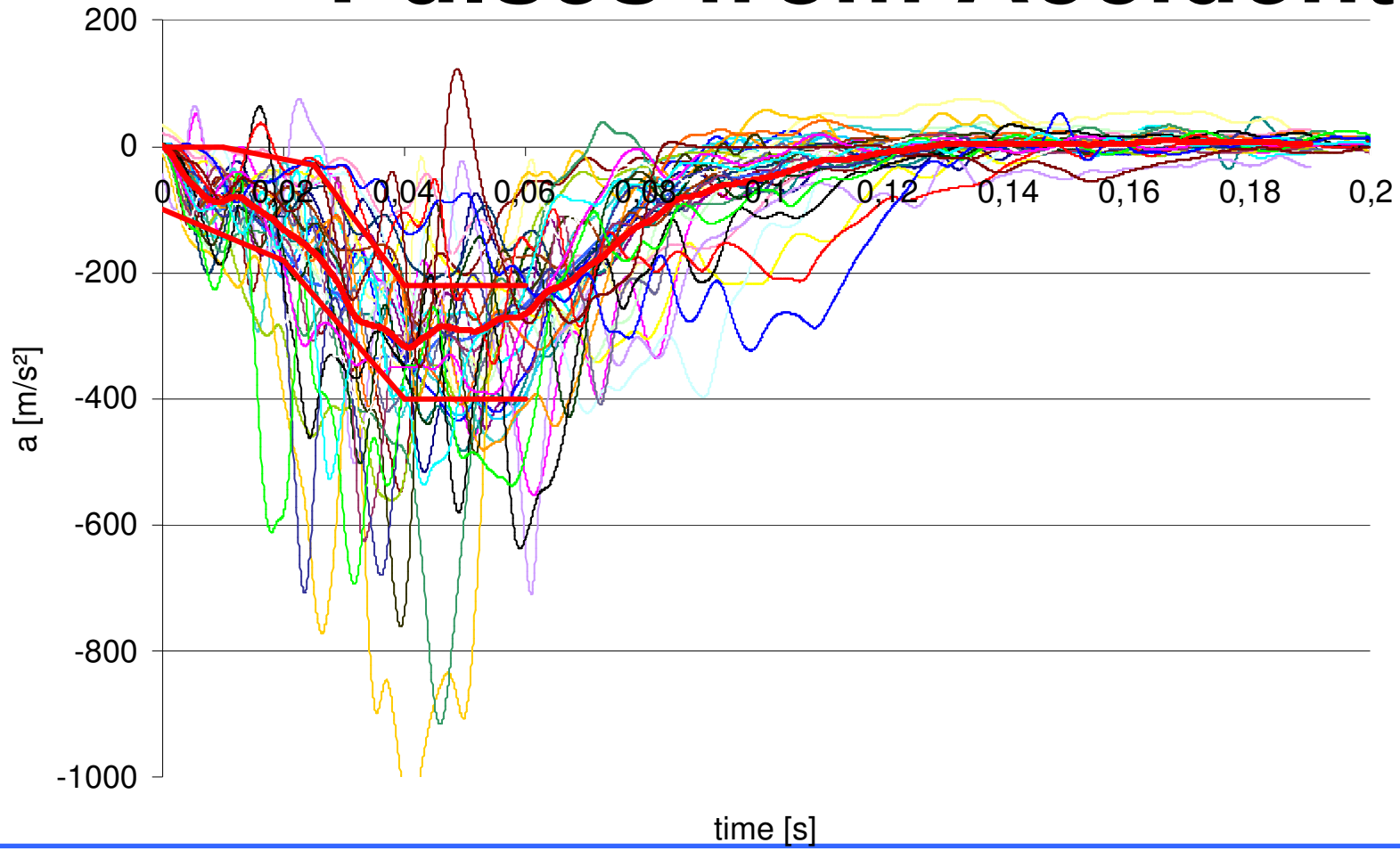
Pulses from Accidents

- Within EC funded CASPER project and previous CHILD project accidents were reconstructed in crash test facilities
- Accidents are not representative
  - selected to develop injury risk function for child dummies
    - minimum child injury severity or
    - minimum accident severity (i.e. delta-v > 40 km/h)
- Results should be considered as indication rather than evidence

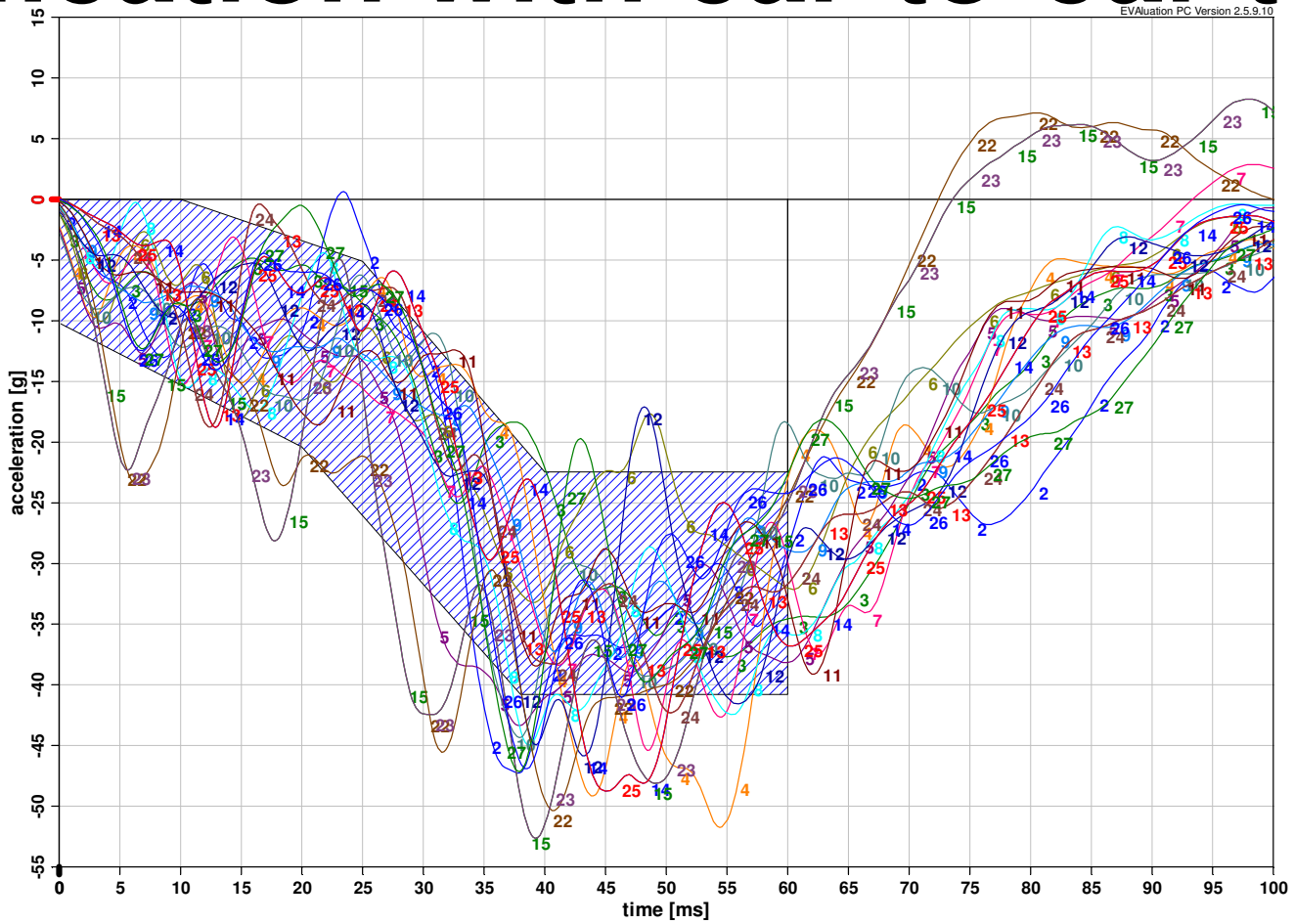
Pulses from Accidents

- Case selection for this analysis
  - Frontal impact to
    - Car front
    - Car side
    - Object
  - New cars only
    - Cars which remained on the market after October 2003
  - 40 of approx. 130 cases left

Pulses from Accidents



Verification with car-to-car tests



Analysed Test Procedures

- Off-set test procedures
  - Current ODB
  - PDB
  - MPDB
- Full width
  - FWRB
  - FWDB

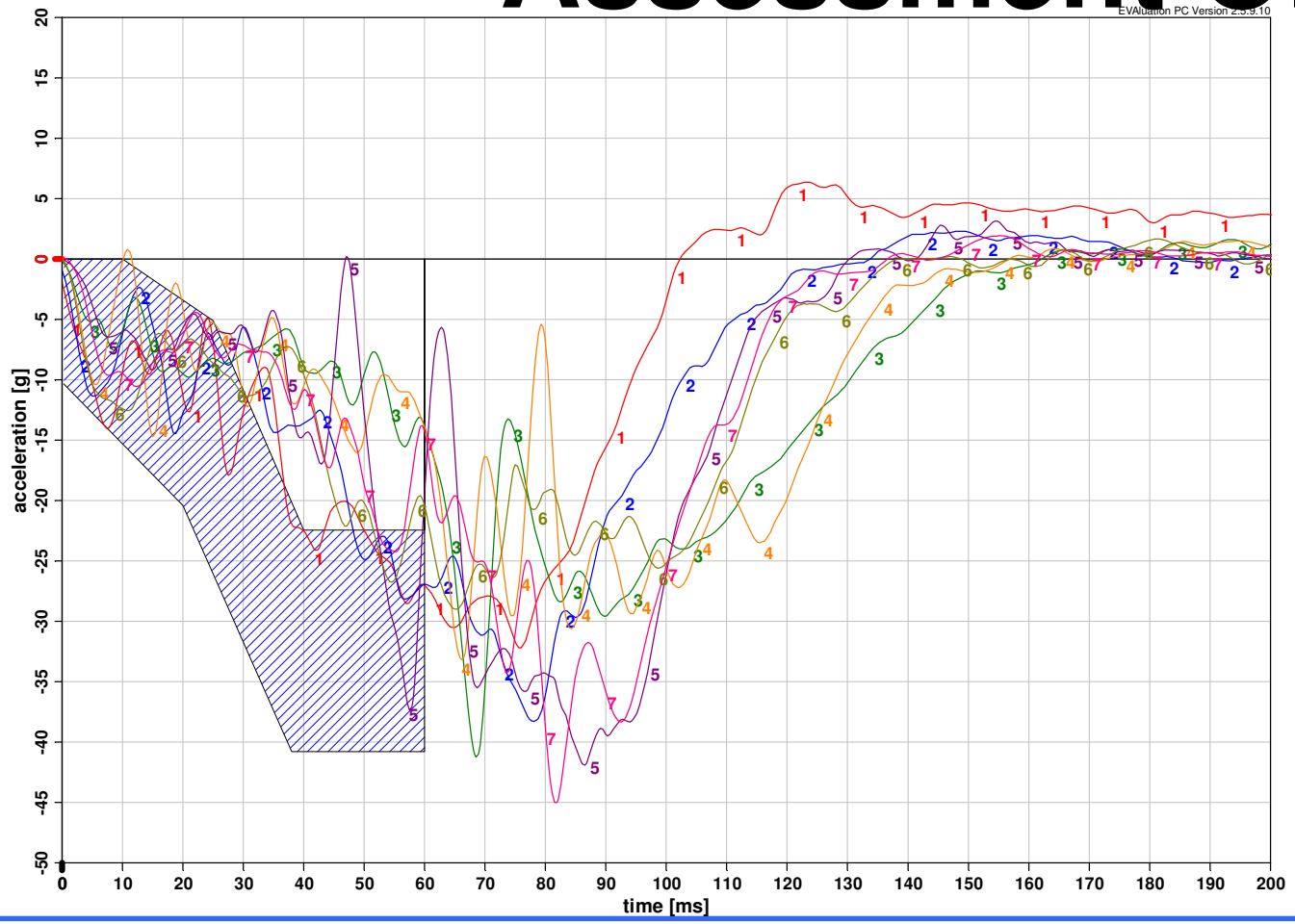
Assessment ODB

- State of the art w.r.t. cabin integrity assessment
- No compatibility assessment metrics known
- Robust compatibility assessment unlikely to be possible

Assessment ODB

- Barrier face is bottomed out by nearly every car
- Tends to cause back loaded pulse

Assessment ODB



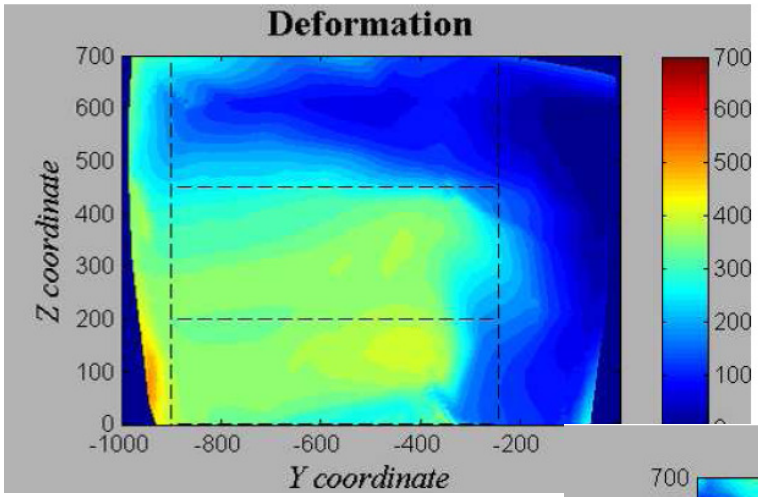
Assessment PDB

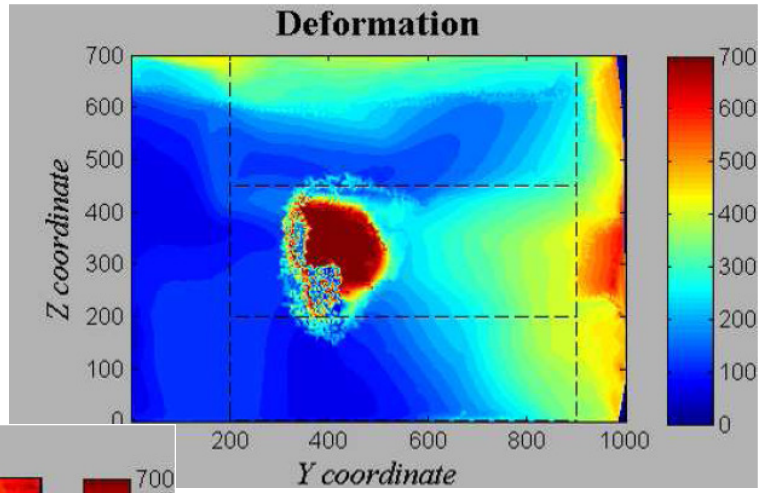
- Subjective compatibility assessment possible by analysis of barrier face deformation
  - especially load spreading (horizontally / vertically)
- Up to now no robust objective compatibility metrics developed

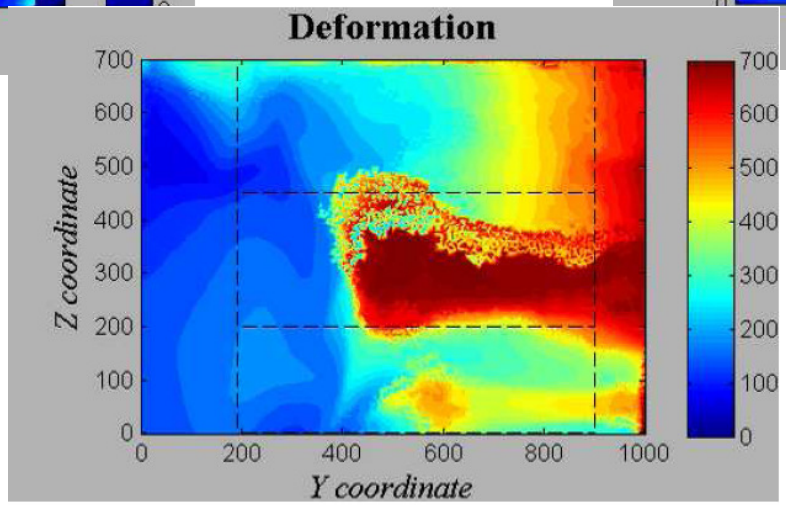
Assessment PDB

- Cabin acceleration mainly higher compared to ODB tests
- Tends to reduce requirements for cabin integrity for very heavy vehicles
- Attempts to harmonise test severity amongst vehicles of different masses

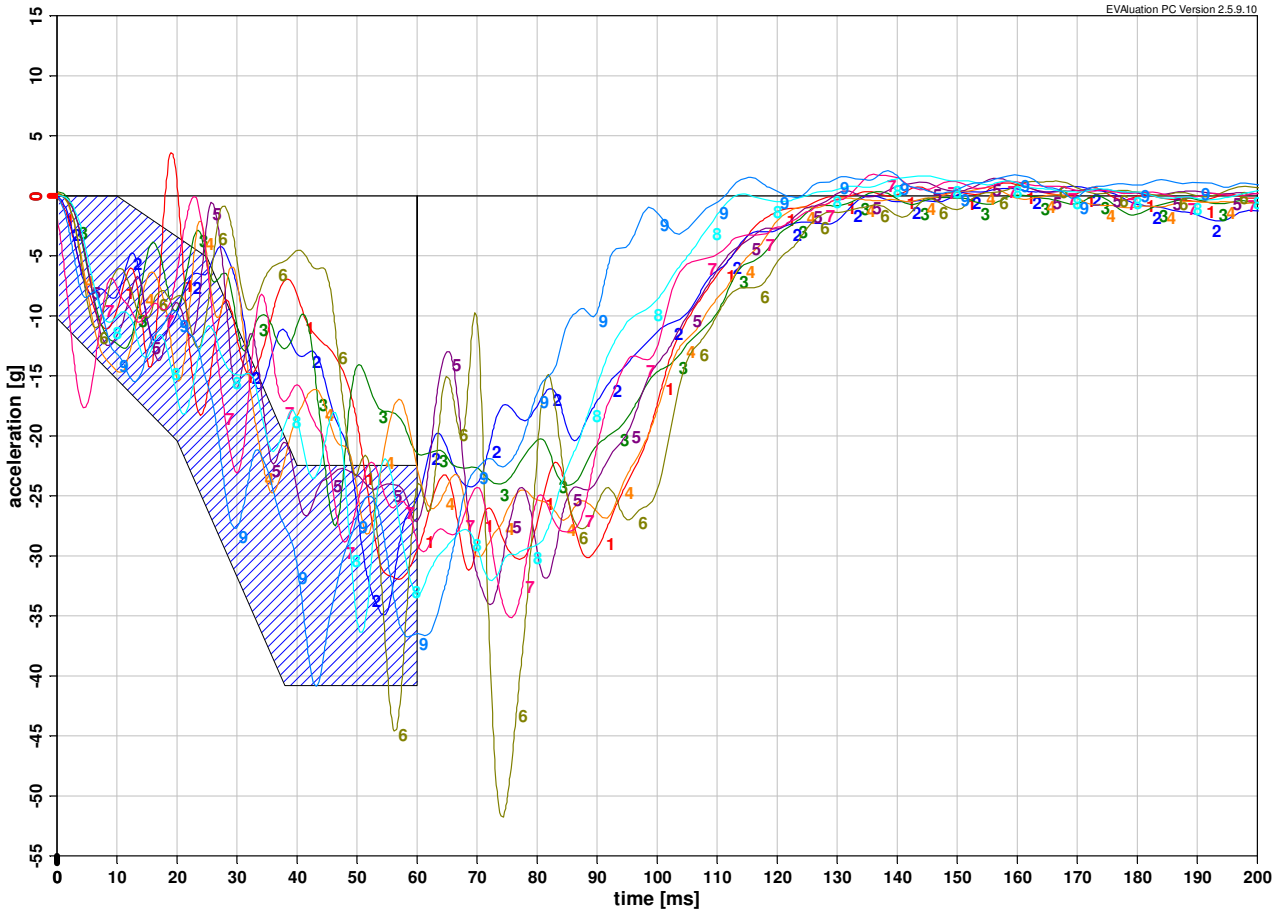
Assessment PDB







Assessment PDB



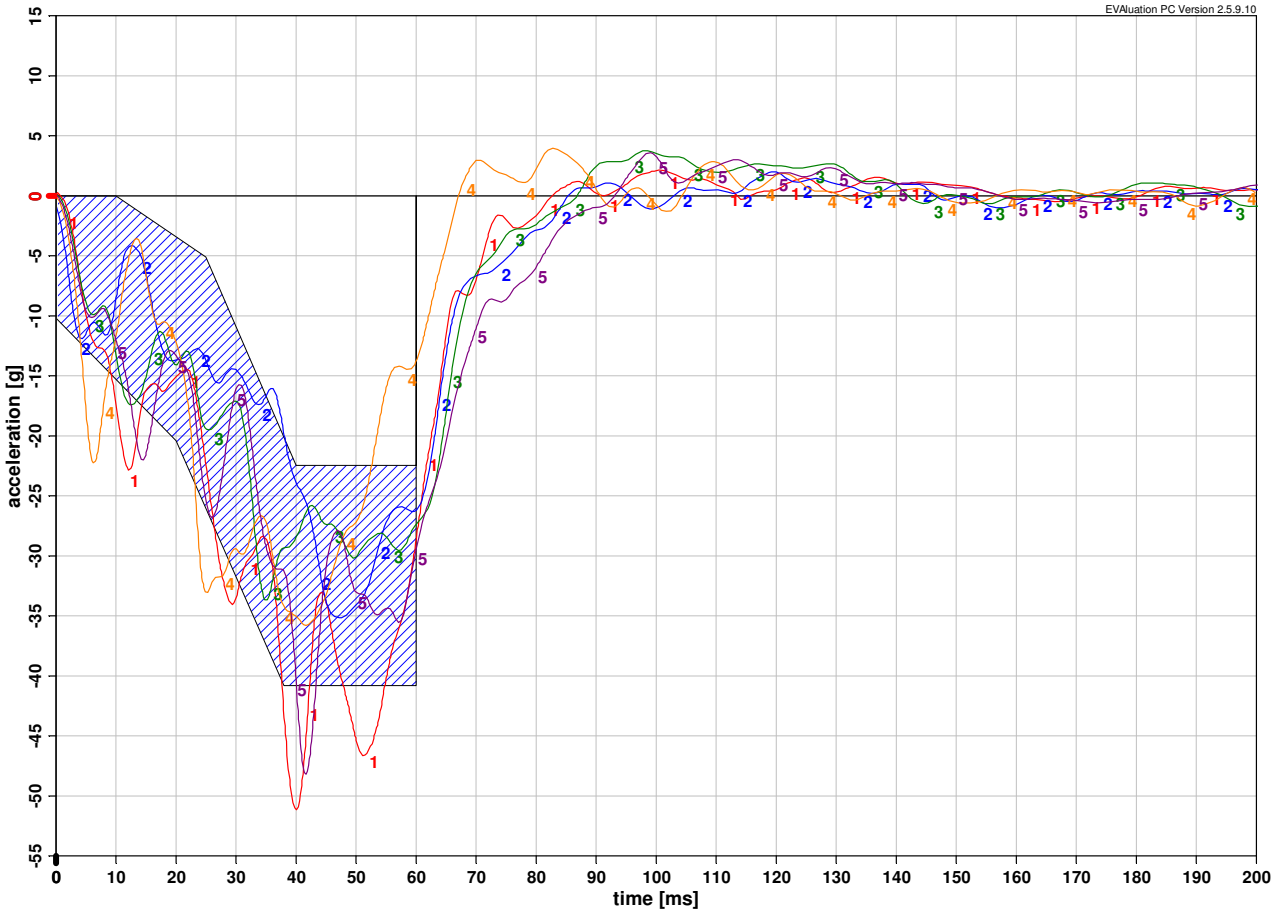
Assessment MPDB

- Subjective compatibility assessment possible by analysis of barrier face deformation
  - especially load spreading (horizontally / vertically)
- Up to now no robust objective compatibility metrics developed

Assessment MPDB

- Addresses momentum issues for smaller vehicles in car-to-car crashes

Assessment MPDB



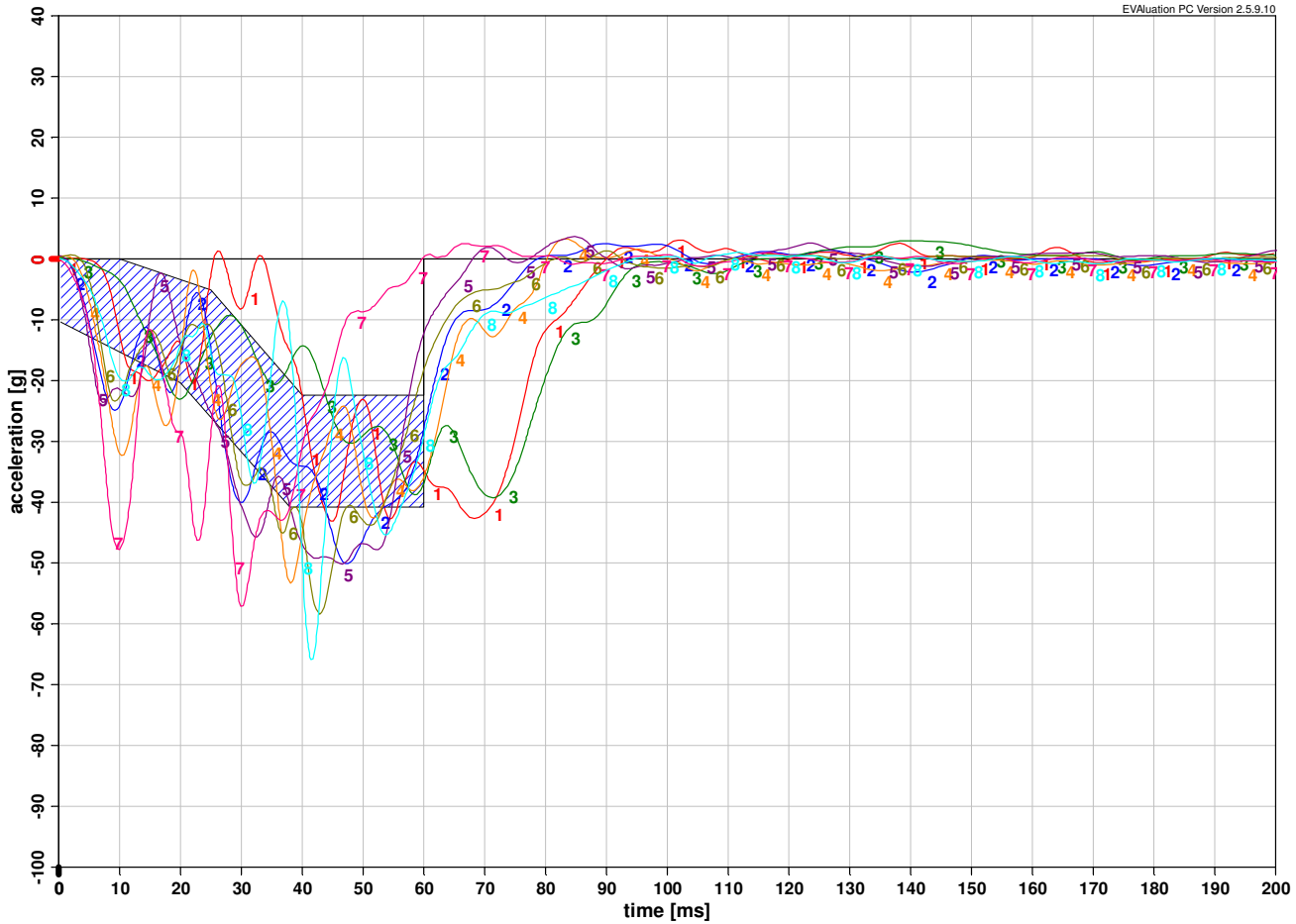
Assessment FWRB

- Defacto standard world wide
- High acceleration pulse
  - especially in the early phase
- Load cell wall based metrics for compatibility assessment
  - engine dump especially for Japanese Mini cars

Assessment FWRB

- Assessment early in the impact
- Vehicles with primary structures outside the interaction zone are likely to require an additional test to determine the compliancy of secondary structures within the zone

Assessment FWRB



Assessment FWDB

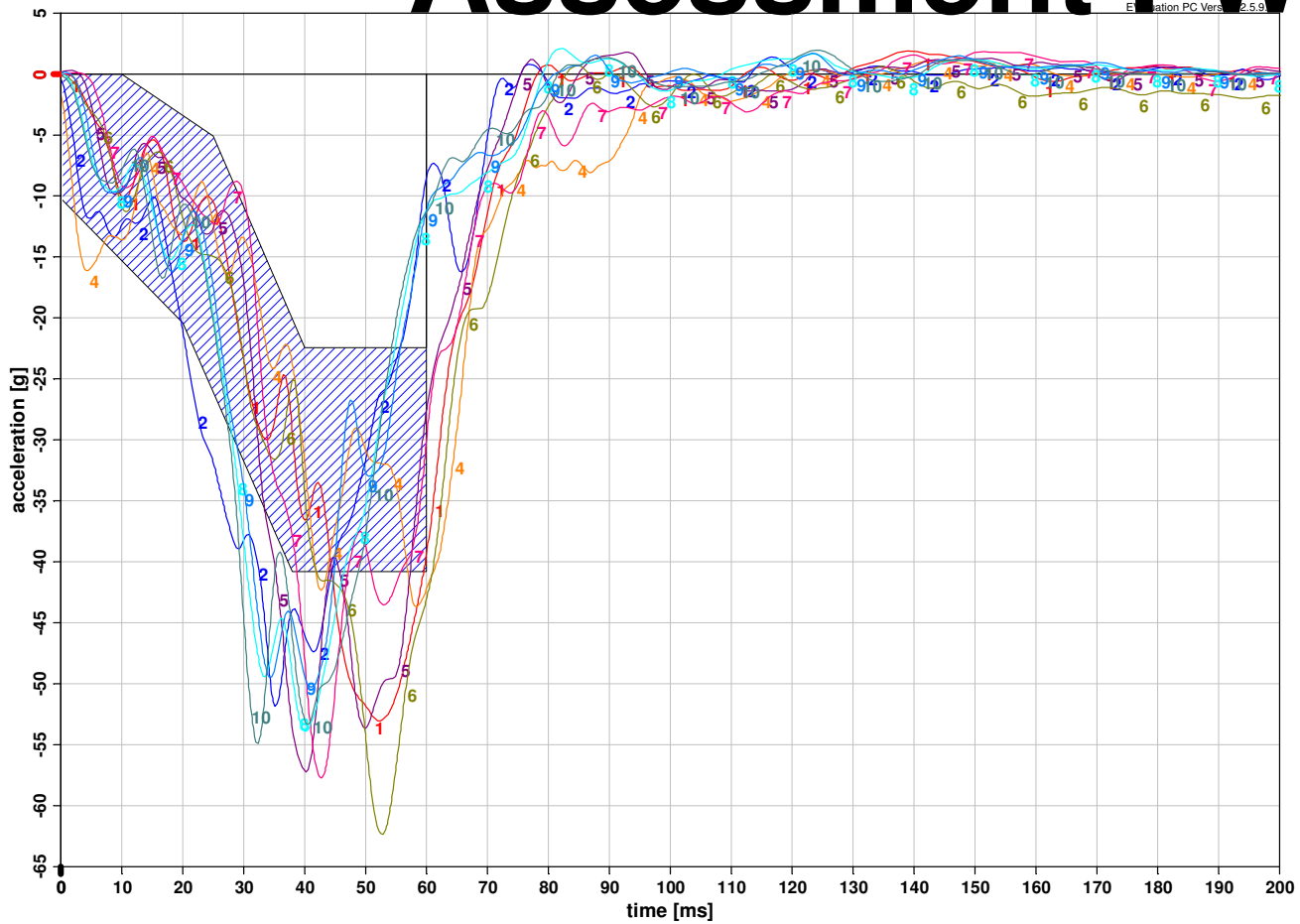
- Acceleration pulse comparable with car accident pulses
- Load cell wall based metrics for compatibility assessment
  - Less sensitive to protruding parts than FWRB
  - Engine dump attenuated

Assessment FWDB

- Assessment over the most important part of the impact duration (until 40 ms)
- Maximum acceleration appears to be higher than in FWRB → changing speed to 50 km/h
- Load spreading in the barrier face

  → Is not a problem if sum forces of rows or columns are used

Assessment FWDB



FIMCAR Test Approach

- Combination
  - Current ODB
  - FWDB

FIMCAR Test Approach

- Justification
  - ODB guarantees that current level of compartment strength will be maintained for all vehicles
  - PDB without compatibility metrics was not acceptable for a majority of FIMCAR members
  - Majority of FIMCAR members still believe in PDB as the long term approach -> research is ongoing

FIMCAR Test Approach

- Justification
  - FWDB results in more realistic pulse
  - FWDB draft metrics look later into the impact, thus is detecting more relevant structures (compared to crush cans in heavy vehicles)
  - FWDB is possibly able to detect appropriate SEAS (research ongoing)
  - FWDB possibly detects horizontal load spreading (research ongoing)

FIMCAR Test Approach

- Next steps ODB
  - Analysis ongoing if any compatibility metrics can be applied from ODB LCW readings
  - Euro NCAP compartment assessment shall be “translated” for homologation use
  - No additional changes proposed by FIMCAR

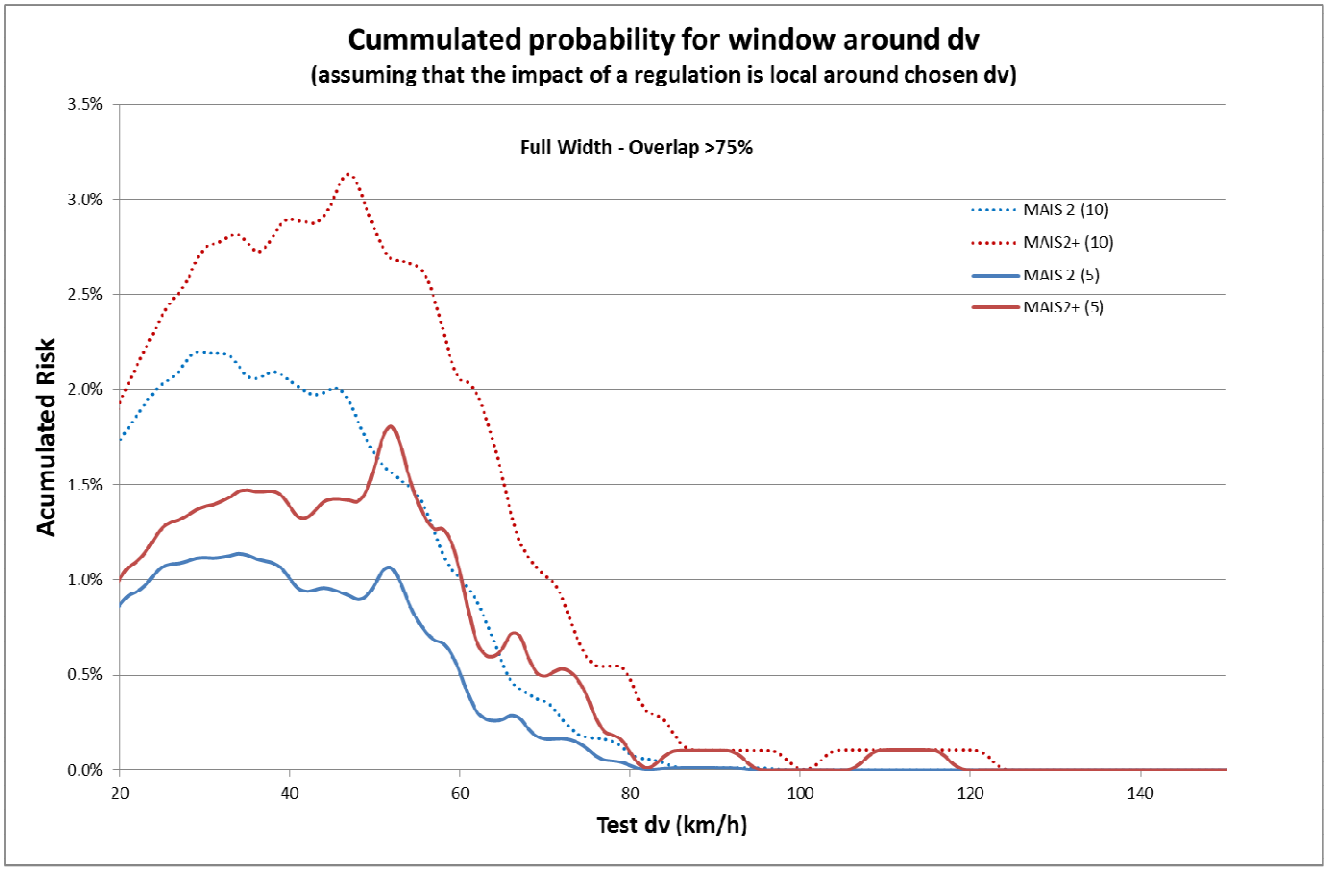
FIMCAR Test Approach

- Next steps FWDB
  - Certification procedure for load cells and LCW in progress
  - Test speed to be defined
  - Finalisation of metrics in progress
    - SEAS detection?
    - Load spreading?

FIMCAR Test Approach

- Next steps FWDB
  - can SEAS be detected?
    - car-to-barrier tests
    - car-to-car tests

FWDB Test Speed



Draft metrics for the full width test

Draft metrics for the full width test

US voluntary agreement for LTV compatibility

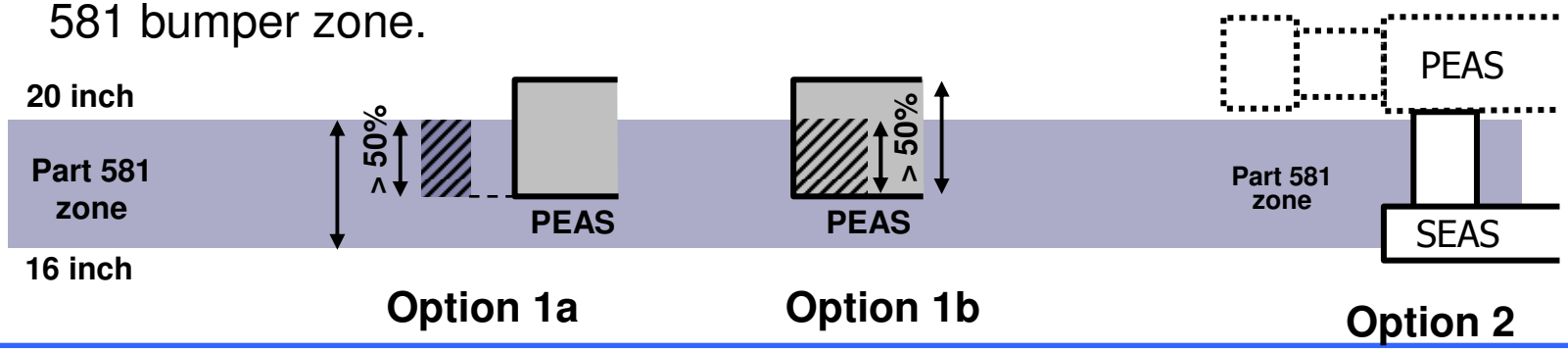
Option 1

1a The light truck's primary frontal energy absorbing structure shall overlap at least 50 percent of the Part 581 zone (Option 1a)

1b AND at least 50 percent of the light truck's primary frontal energy-absorbing structure shall overlap the Part 581 zone (Option 1b)

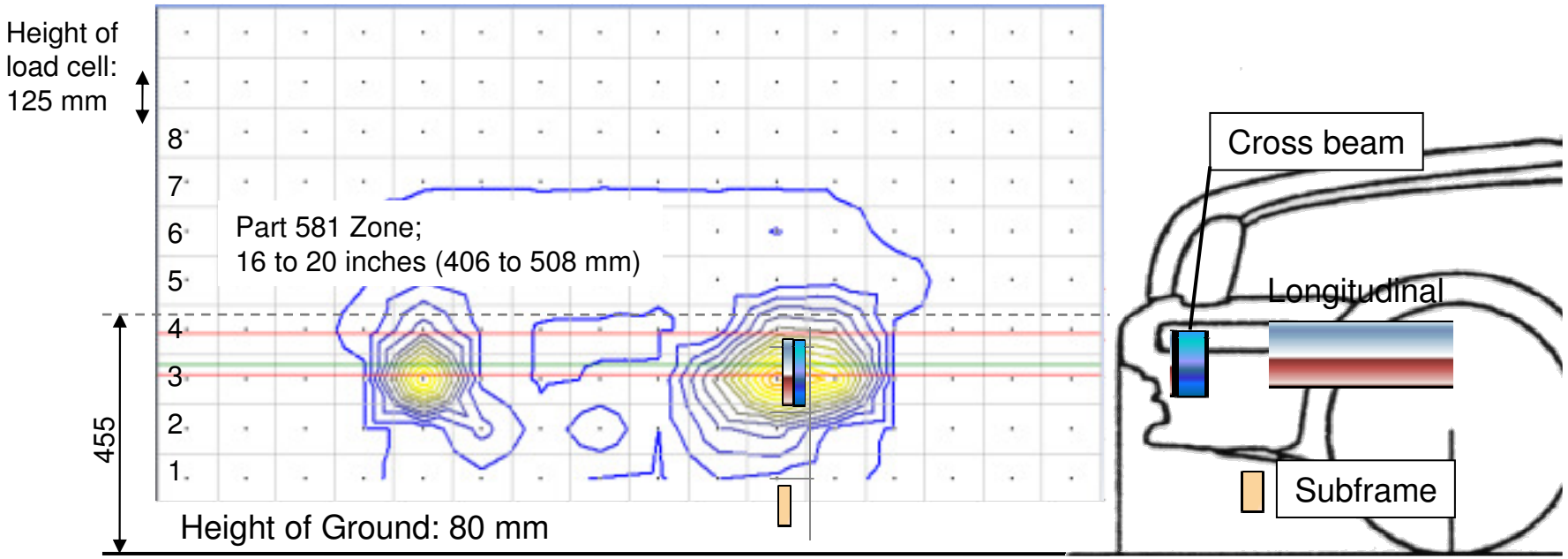
Option 2

2 If a light truck does not meet the criteria of Option 1, there must be a secondary energy absorbing structure (SEAS), connected to the primary structure, whose lower edge shall be no higher than the bottom of the Part 581 bumper zone.



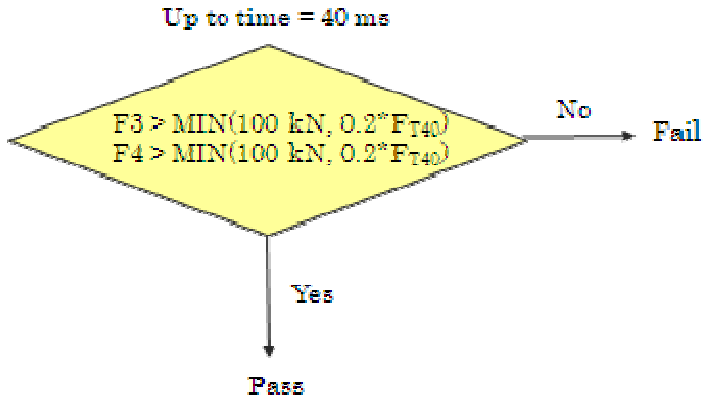
Geometric assessment of structural alignment

The part 581 zone is between row 3 and 4



Draft metrics for the full width test

FWDB



F_{T40} = Maximum of total LCW force up to 40 ms

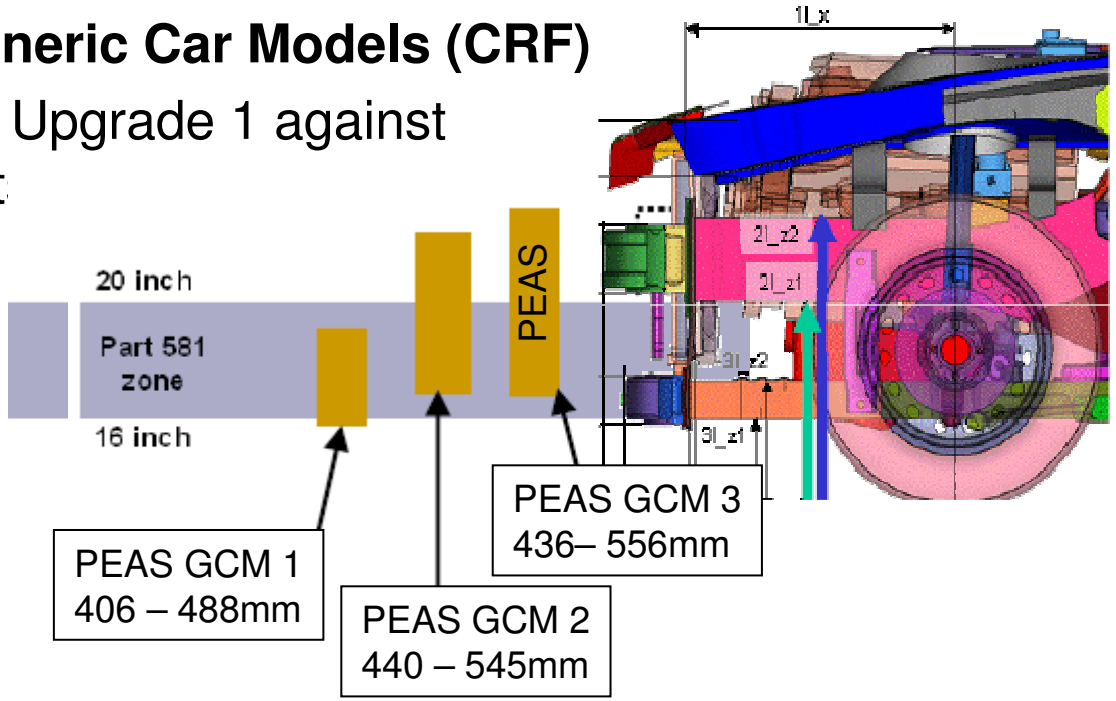
- No Stage 2 needed?
- Further tests planned

Draft metrics for the full width test

FWDB Simulations with Generic Car Models (CRF)

Comparison of FWDB Metric Upgrade 1 against geometrical measurement

- Model GCM 1 A: Pass
  (F3=114 & F4=127 > 80 kN)
- Model GCM 1 B: Pass
  (F3=160 & F4=147 > 100 kN)
- Model GCM 2 A: Pass
  (F3=124 & F4=185 > 100 kN)
- Model GCM 2 B: Pass
  F3=125 & F4=152 > 100 kN)
- Model GCM 3 A: Pass
  (F3=137 & F4=184 >100 kN)

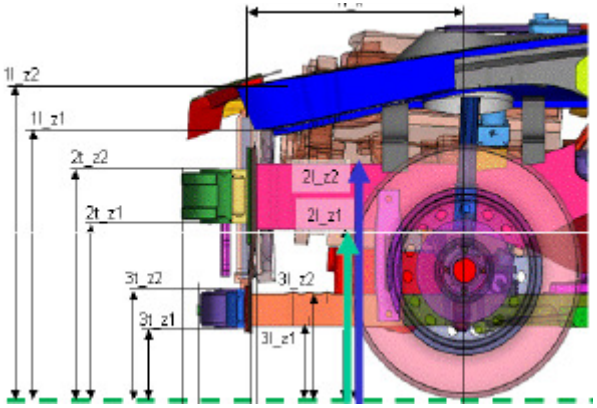


[mm]	GCM1A	GCM1B	GCM2A	GCM2B	GCM3A
Option 1a (a/b)	0.80	0.80	0.67	0.67	0.71
AND					
Option 1b (a/c)	1.00	1.00	0.65	0.65	0.60

FWDB Simulations with GCM (CRF)

Comparison of FWDB Metric Upgrade 1 against geometrical measurements

- GCM 1 A: Pass (FT40=400 kN; F3=114 & F4=127 > 80 KN)
- GCM 1 B: Pass (FT40=500 kN; F3=160 & F4=147 > 100 KN)
- GCM 2 A: Pass (FT40=625 kN; F3=124 & F4=185 > 100KN)
- GCM 2 B: Pass (FT40=537 kN; F3=125 & F4=152 > 100 KN)
- GCM 3 A: Pass (FT40=800 kN; F3=137 & F4=184 >100 KN)



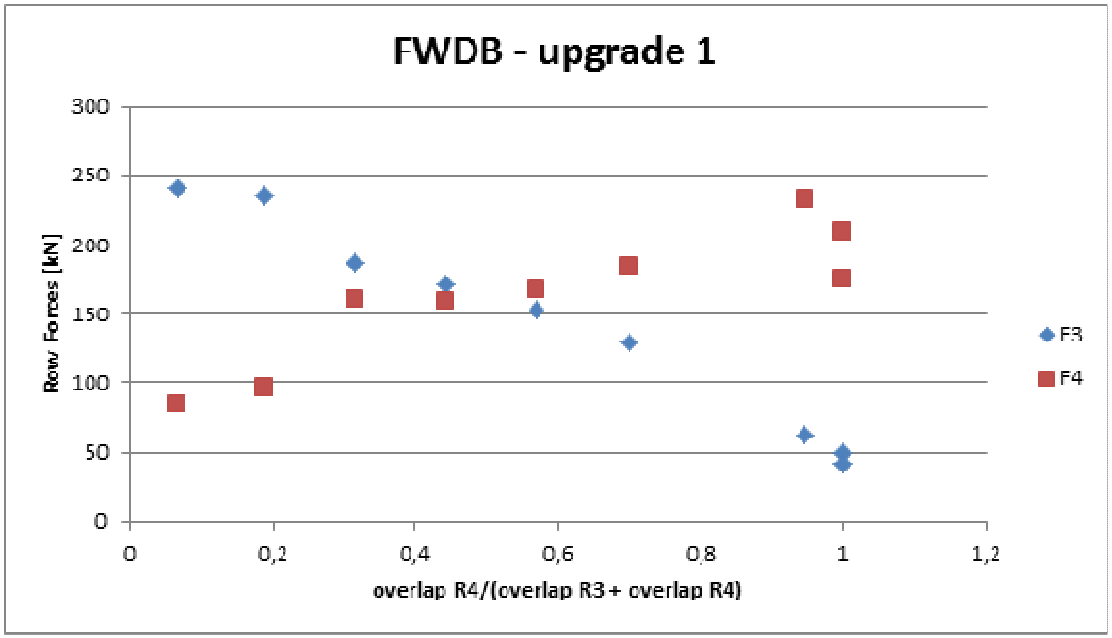
RAILS	2l-z1	2l-z2
GCM-1A	386	510
GCM-1B	386	510
GCM-2A	440	557
GCM-2B	440	557
GCM-3	416	578

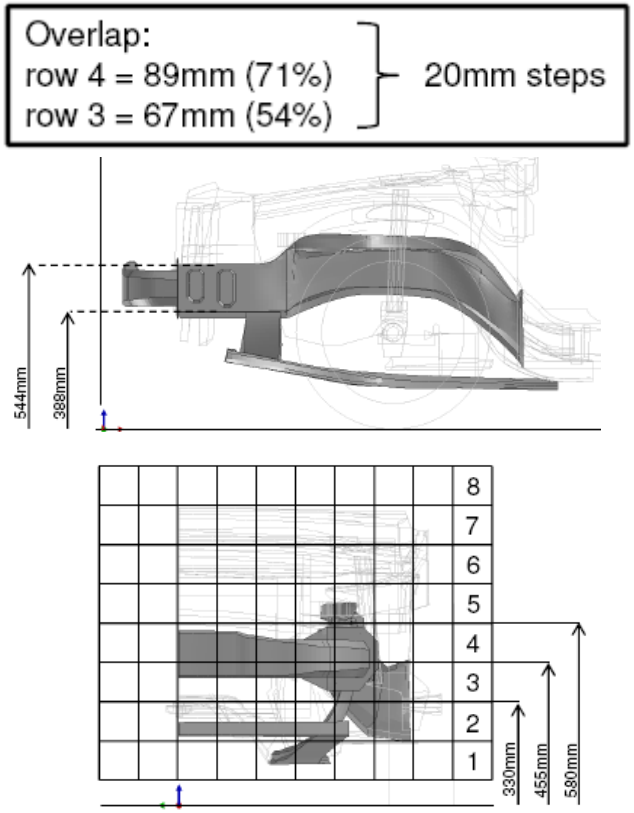
[mm]	GCM1A	GCM1B	GCM2A	GCM2B	GCM3A
Option 1a (a/b)	0.80	0.80	0.67	0.67	0.71
AND					
Option 1b (a/c)	1.00	1.00	0.65	0.65	0.60

FWDB Simulations with PCM (TUB)

Investigation of Step effects

- Raising a large family car by steps to check metrics
- Verify results by car-to-car simulationsRequest 7





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Acknowledgements

- European Commission 7th FWP GA no. 23 42 16
- CCIS
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- JAMA
- Kia/Hyundai
- CASPER Project

Questions?

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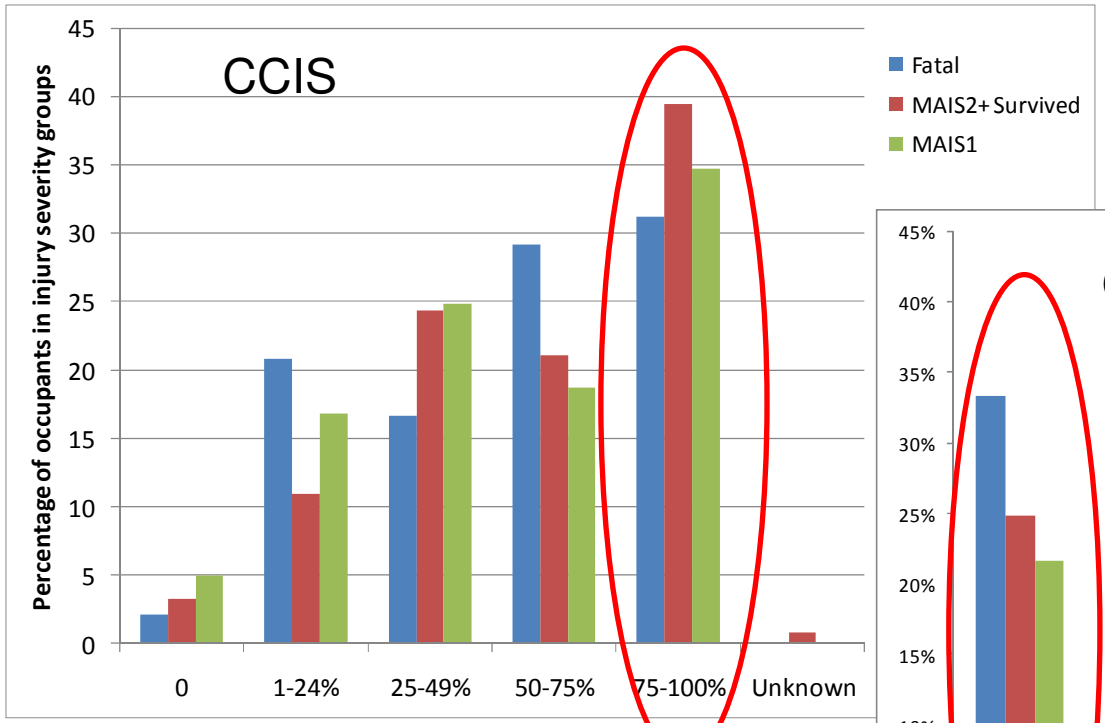
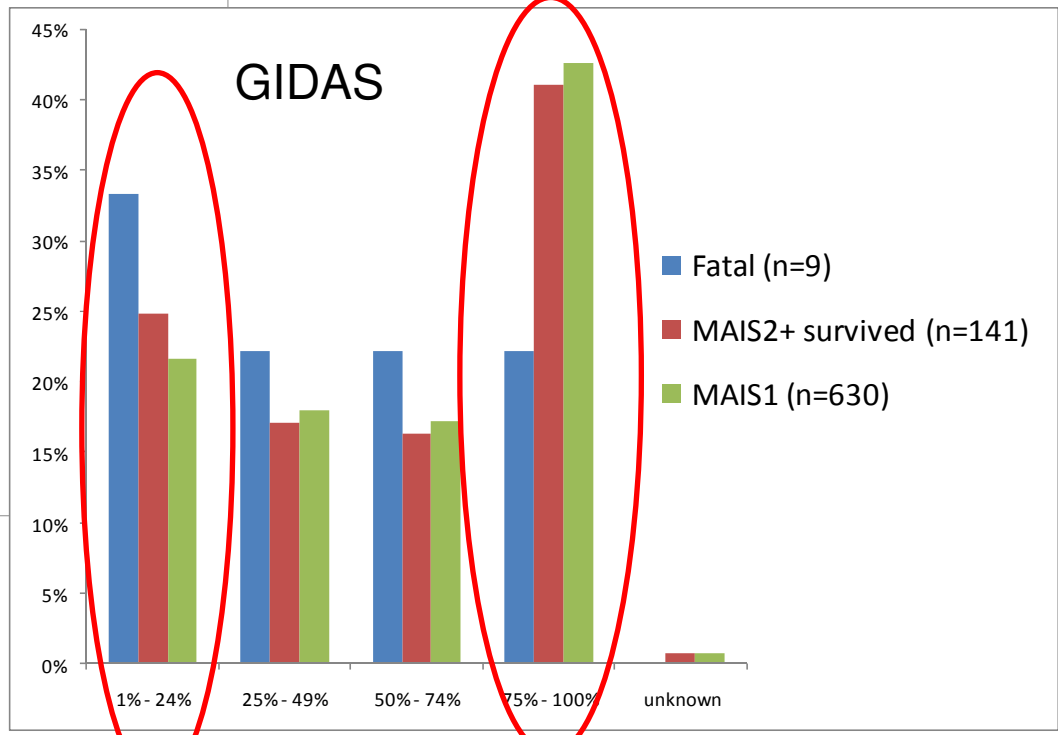
- More details and public deliverables as soon as approved by EC
  www.fimcar.eu

Accident analysis

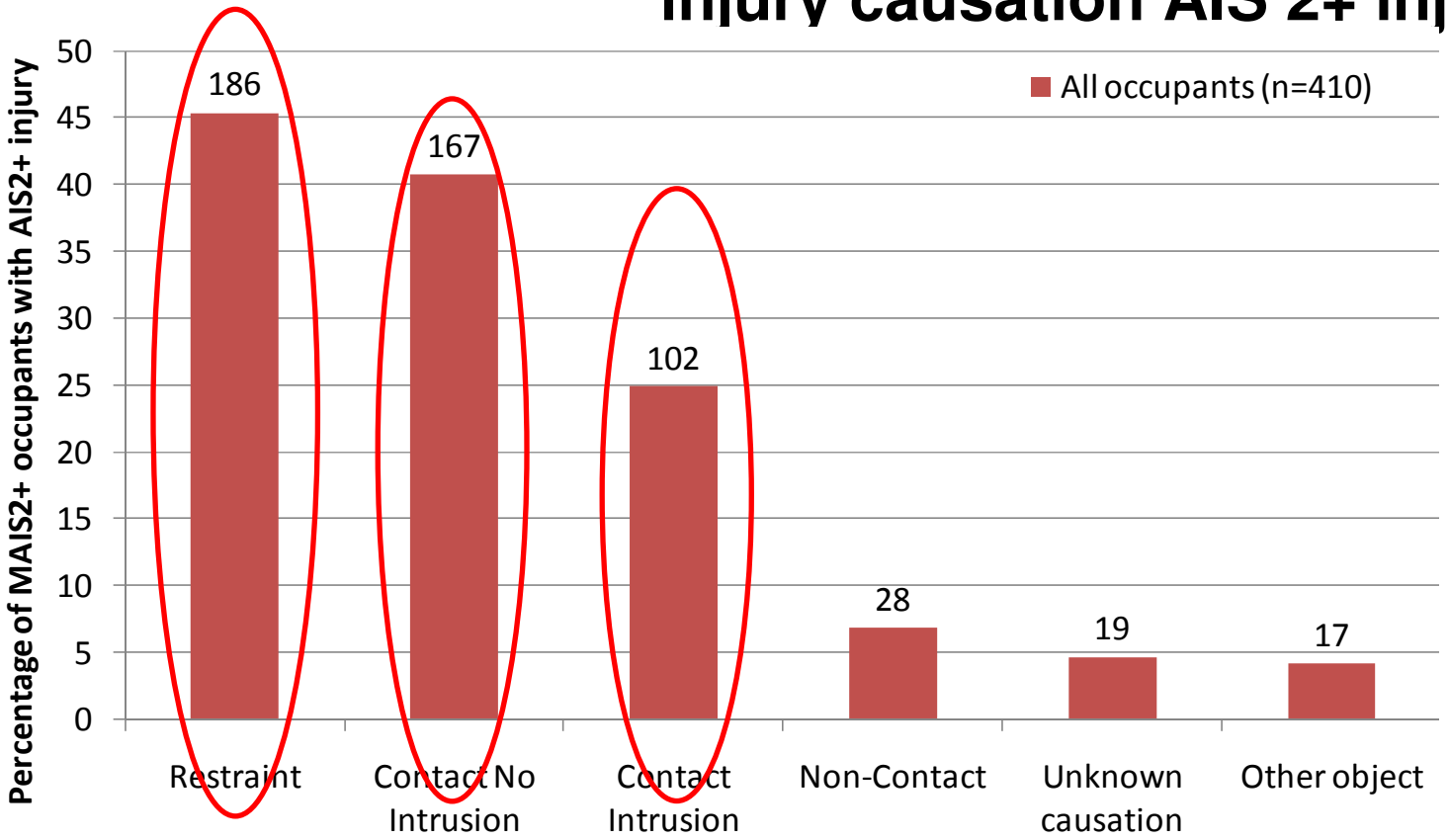
overlap





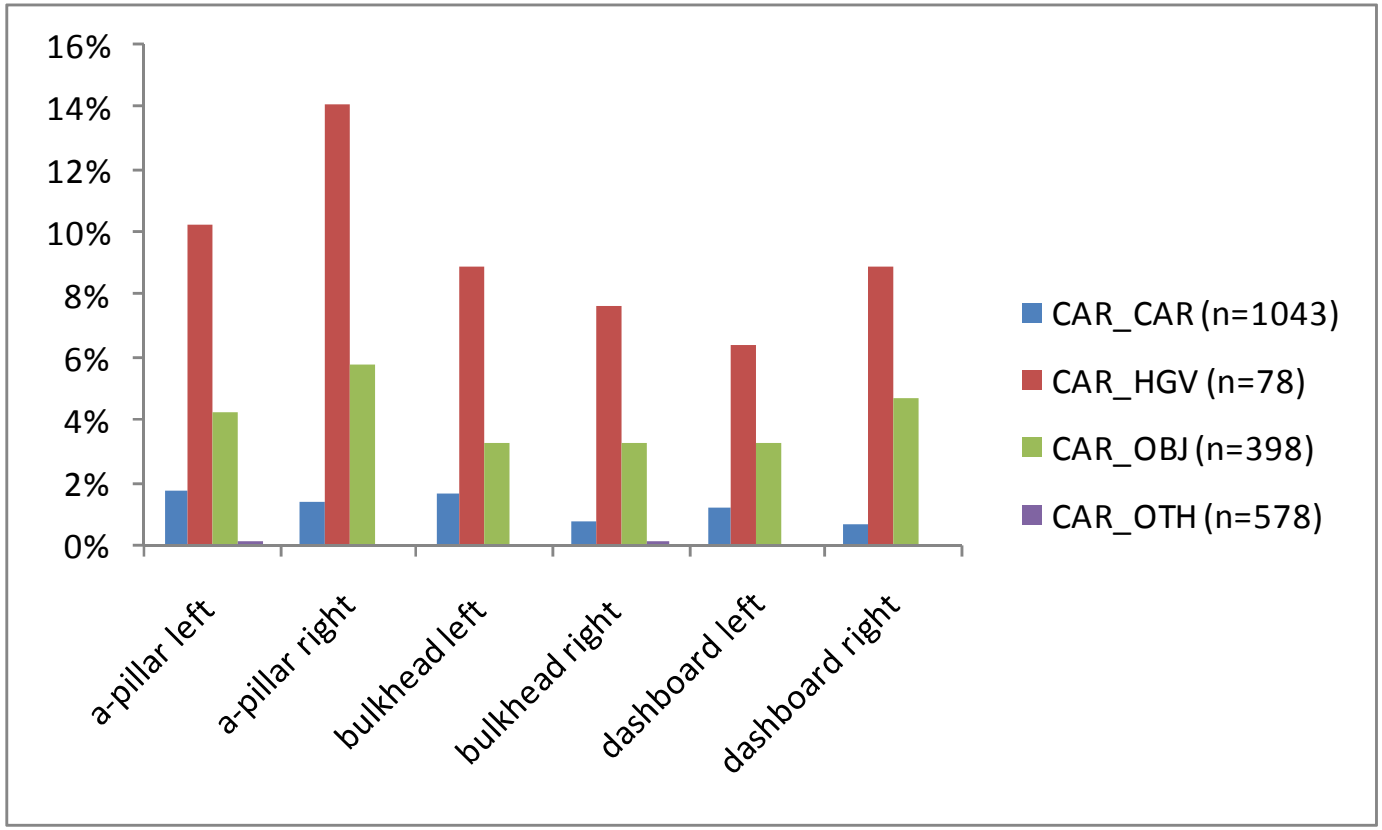
Accident analysis

injury causation AIS 2+ injuries



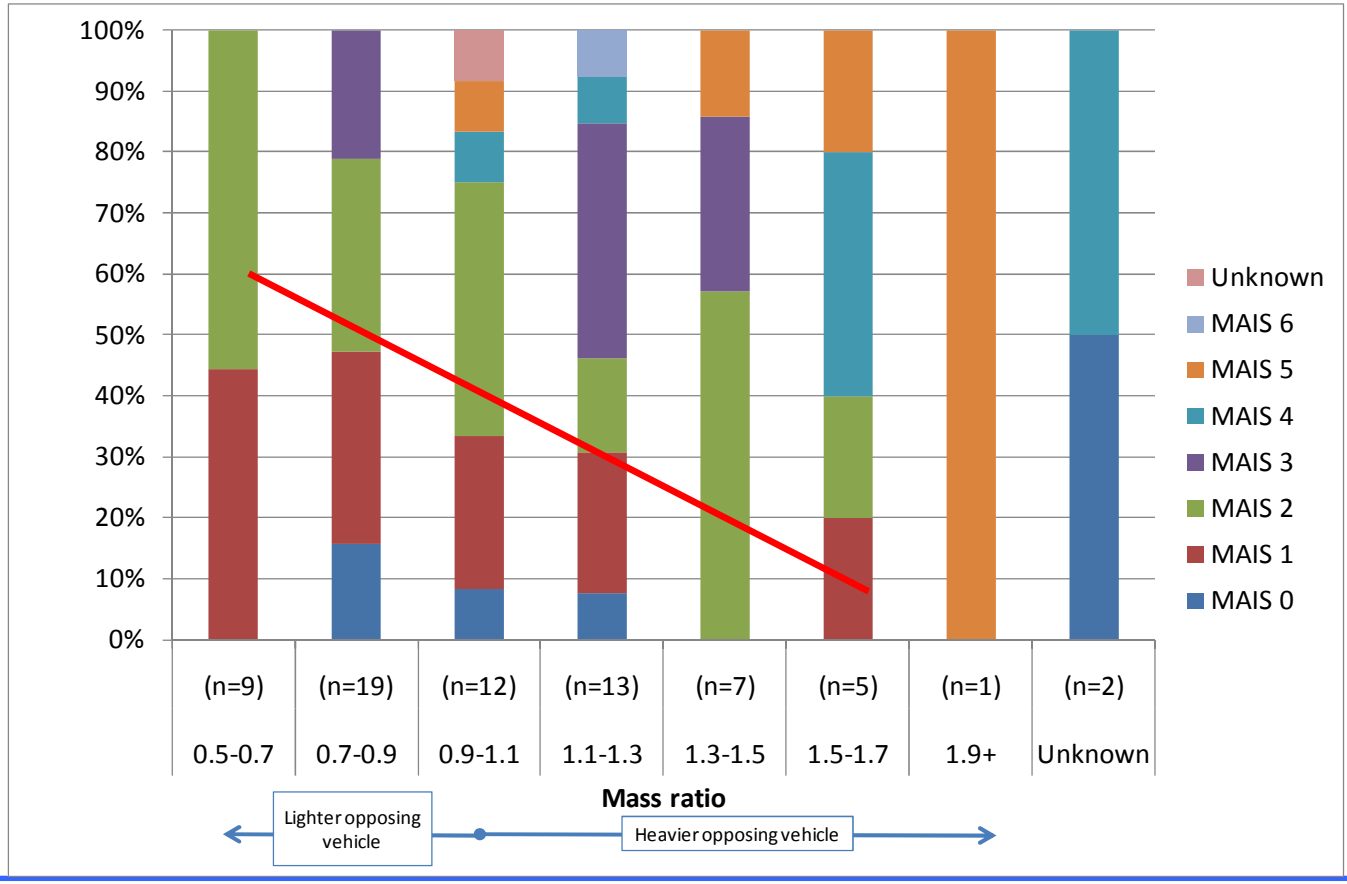
Accident analysis

intrusion in frontal impact accidents



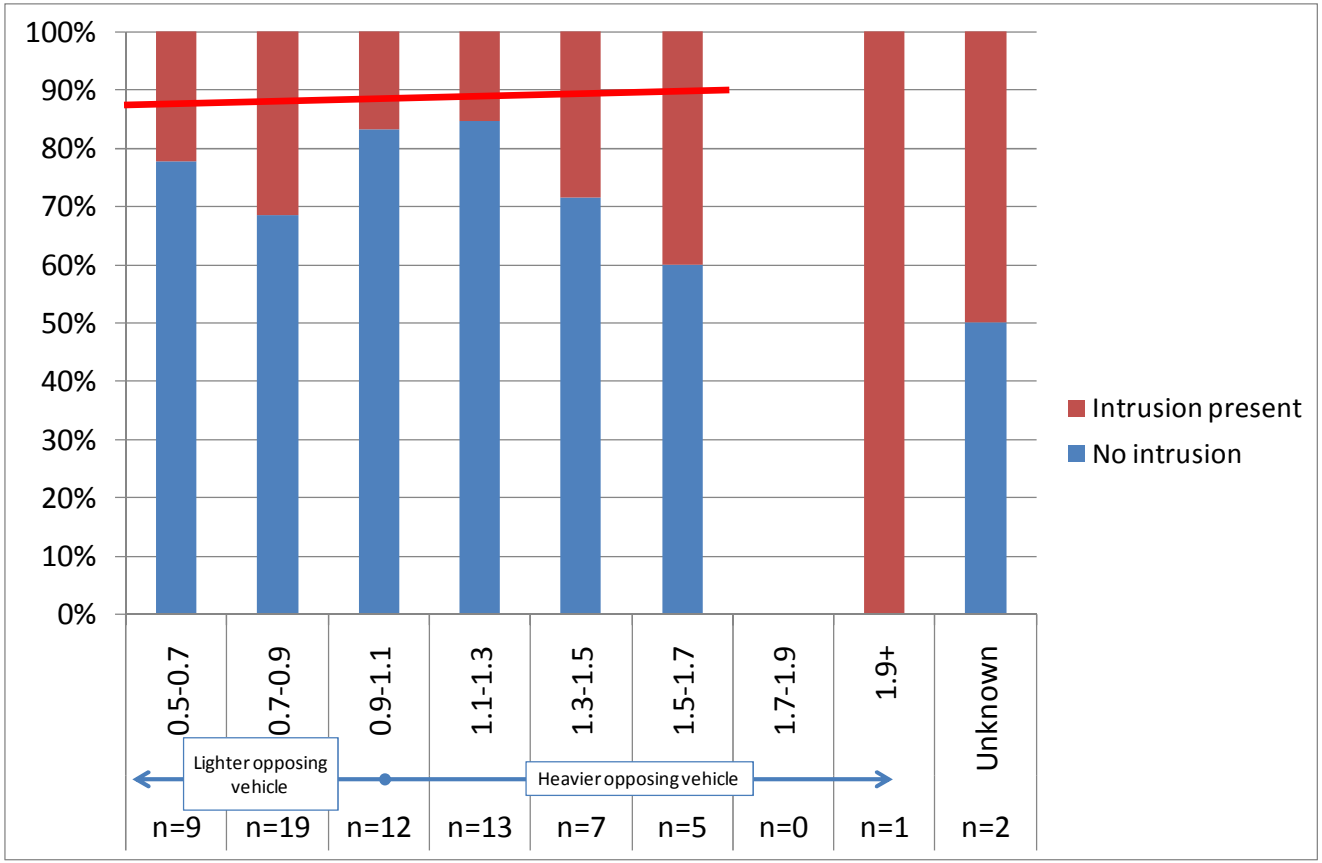
Accident analysis

influence of mass ration on injury risk – UK data



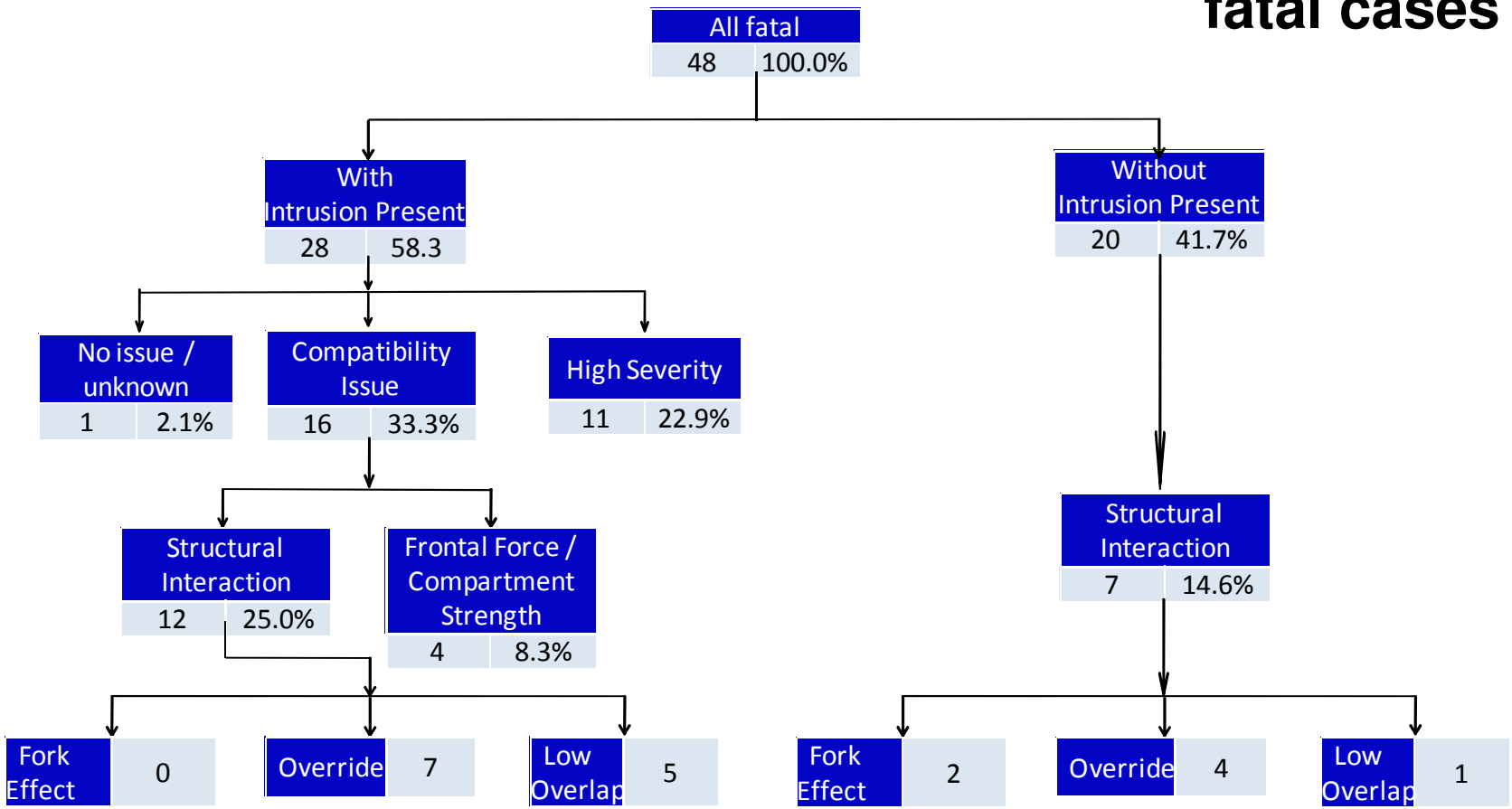
Accident analysis

Influence of mass ratio on intrusion – UK data



Accident analysis

fatal cases



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Structural Interaction

Alignment

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Common interaction zone • Relevant, initial crash loads applied in common interaction zone, Part 581 (406-508mm) • Mandatory to apply loads above and below 581 centerline (457mm), further load balance covered in load spreading	Priority 1

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Structural Interaction

Load spreading - Vertical

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Vertical load spreading (or load balance) in common interaction zone (Part 581)	**Priority 1**
Vertical load spreading assessed below common interaction zone – assess lower loadpath, above 180 mm	**Priority 1**
Vertical load spreading assessed above common interaction zone – primarily for side impact considerations	**Priority 2**

Structural Interaction

Load spreading - Horizontal

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Horizontal load spreading between longitudinal members - prevent fork effect	**Priority 1**
Horizontal load spreading outside longitudinal members - reduce intrusion in small overlap at edge	**Priority 2**

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Pulse Requirements

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Field relevant pulse – reconstructions, car-car tests, and possibly EDR data	**Priority 1**
Two different pulses are desired for assessing restraint systems – expected to be fulfilled with 2 assessment procedures	**Priority 2/3**
Monitor pulses in the test procedure development	**Priority 1**

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Test Severity (1)

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Appropriate severity level for occupant protection for relevant accidents (full frontal) – trade off between fatal and serious injury, 50-56 km/h test speed current option	**Priority 1**
Address mass dependent injury risk – higher injury risk in lighter vehicles reported in accident analysis	**Priority 2**

Test Severity (2)

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Compartment strength requirements maintained for off-set configuration - R94 is reference, acceleration and intrusion data used	**Priority 1**

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Test Procedure General

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Repeatibility/Reproducibility – minimum requirement is for 3 tests at 2 labs using 1 car model, additional data processing at other labs	**Priority 1**
Appropriate pass/fail thresholds – database of test data, vehicles grouped into known performance categories	**Priority 1**
Check step effects in metrics – theoretical analysis of metrics	**Priority 1**

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Test Procedure General

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Assessment results reflect real world performance – limited to older vehicle data	**Priority 1**
• good car is rated good	**Priority 1**
• poor car is rated poor	**Priority 1**
• borderline car rating improves when car is improved – simulation approach	**Priority 2**
• borderline car rating gets worse when car is worsened – simulation approach	**Priority 2**

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Test Procedure General

Priority 1- Must do
Priority 2 – should do
Priority 3 – not required

Description	FIMCAR
Detection of architectures/loadpaths - vehicles grouped into known performance categories	**Priority 1**