FIMCAR
frontal impact and compatibility assessment research

Informal document GRSP-52-24
(52nd GRSP, 11-14 December 2012,
agenda item 7)

SEVENTH FRAMEWORK PROGRAMME

FIMCAR

Frontal Impact Assessment Approach

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FIMCAR

- EC funded project ended September 2012
- Partners:
  - Car manufacturers: Daimler, FIAT, Opel, PSA, Renault, Volkswagen, Volvo
  - OEM associated: CRF
  - Research institutes test houses: BASt, Chalmers, IDIADA, TNO, TRL, TTAI, TUB, UTAC
  - Suppliers: HUMANETICS, IAT
- 2/3 majority required for decision making

FIMCAR definition of compatibility

- Compatibility consists of self and partner protection.
- Improved compatibility will decrease the injury risks for occupants in single and multiple vehicle accidents.
- Compatible vehicles will deform in a stable manner allowing the deformation zones to be exploited even when different vehicle sizes and masses are involved

Accident analysis

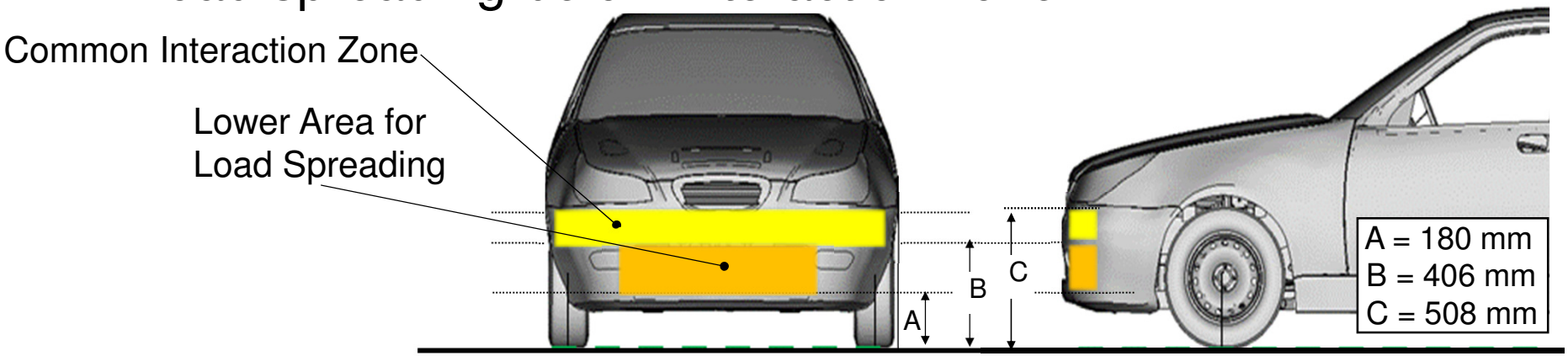
Summary of findings

- Structural interaction still an issue
  - over/underriding
  - horizontal homogeneity (small overlap / fork effect)
- 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)
- Large number of injuries are related to restraint loading without intrusion
- Higher injury risks for occupants in lighter car

FIMCAR priorities

Structural interaction

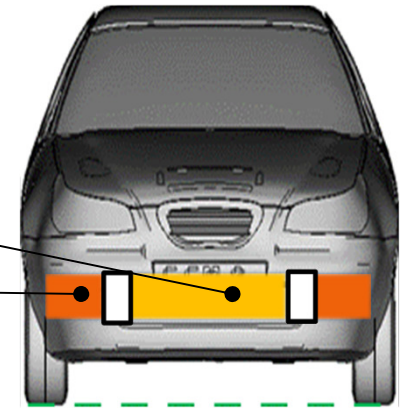
- Structural alignment
  - Common interaction zone defined based on US bumper zone
- Vertical load spreading
  - Load spreading in common interaction zone
  - Load spreading below interaction zone



FIMCAR priorities

Structural interaction

- Structural alignment
  - Common interaction zone defined based on US bumper zone
- Vertical load spreading
  - Load spreading in common interaction zone
  - Load spreading below interaction zone
- Horizontal load spreading
  - Load spreading between longmembers
  - Load spreading outside longmembers



FIMCAR priorities

Test severity and self protection

- Test severity
  - current compartment strength requirements maintained
  - appropriate severity level for occupant protection (RS)
  - (address mass dependent injury risk)
- Pulse requirements
  - field relevant pulse
  - different pulses

FIMCAR Final Decision

- Full-width deformable barrier test
  - 50 km/h
  - LCW based metrics for alignment of crash structures
- Current ODB (ECE R94)
  - Additional a-pillar displacement limits
    - 50 mm max
    - Discussion in IG FI suggests, that FIMCAR definition is not appropriate, however, the basic idea of limiting intrusion seems to be acceptable

Justification FWDB

- Accident analyses have shown the relevance of collisions with high overlap and high acceleration
- More representative loading of the front structures with the FWDB w.r.t. car-to-car tests and accidents
  - FWRB guarantees stable, ideal deformation of forward structures not observed in real accidents
  - FWDB tests produce more realistic deformation patterns compared to car-car tests
  - > more challenging for structural design

Justification FWDB

more representative deformation pattern

FWDB

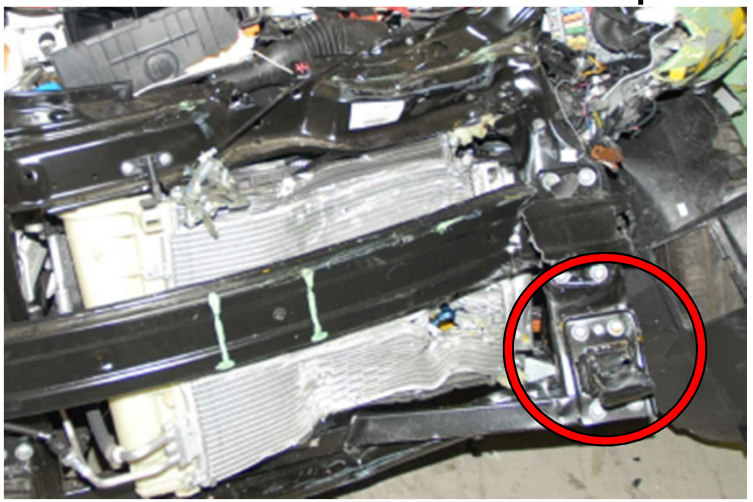
FWRB

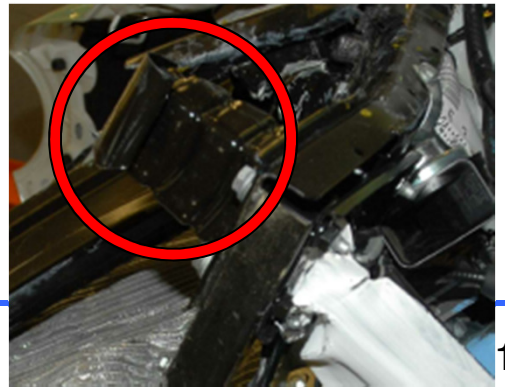
Justification FWDB

more representative deformation pattern

FWDB

car-to-car 50% overlap





Justification FWDB

more representative deformation pattern

FWDB

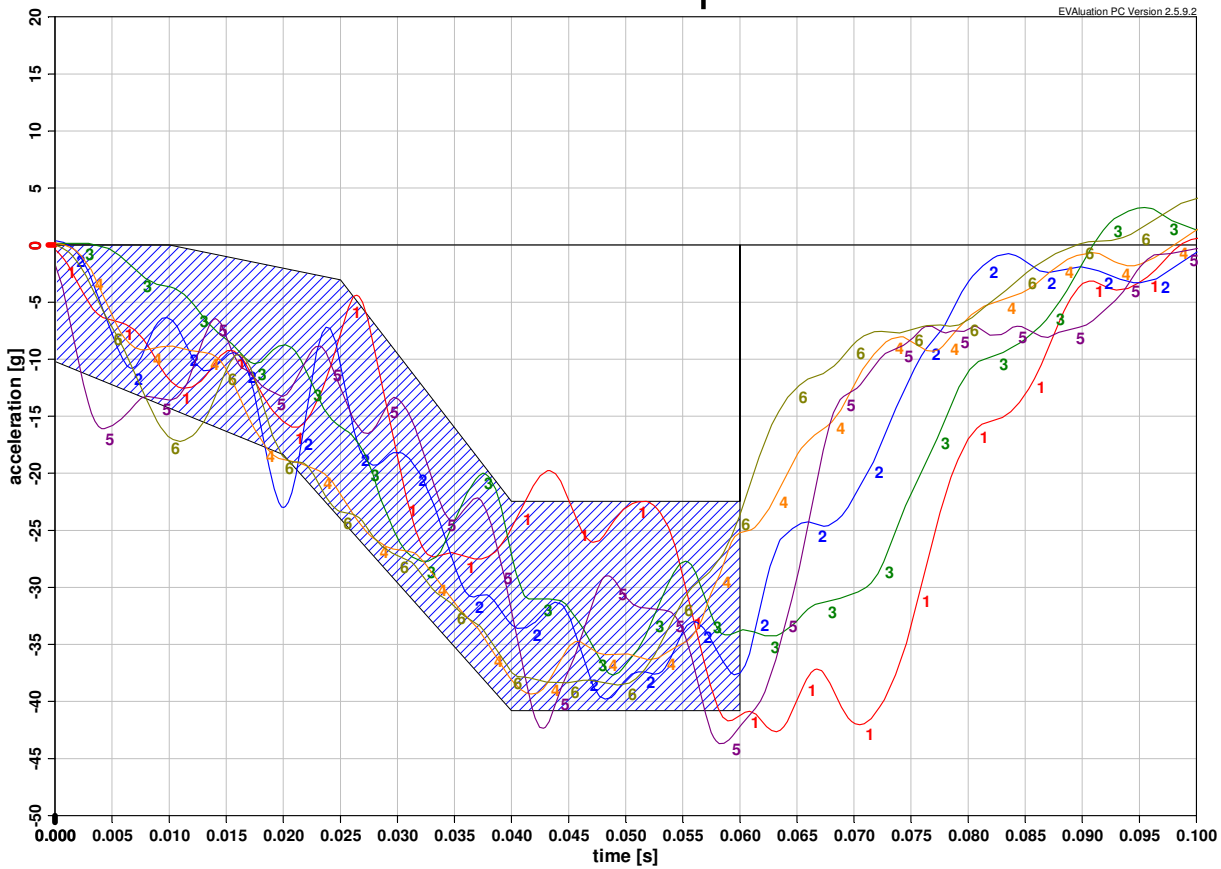
FWRB

Justification FWDB

- Higher dummy loadings with the FWDB
- Acceleration pulse more comparable with car accident pulses
  - especially in the initial phase
  - > more representative w.r.t. restraint system triggering
  - issues detected in FWDB tests
  - issues detected in EDR data
  - issues detected in accident reconstructions
- Maximum acceleration can be higher than in FWRB

Justification FWDB

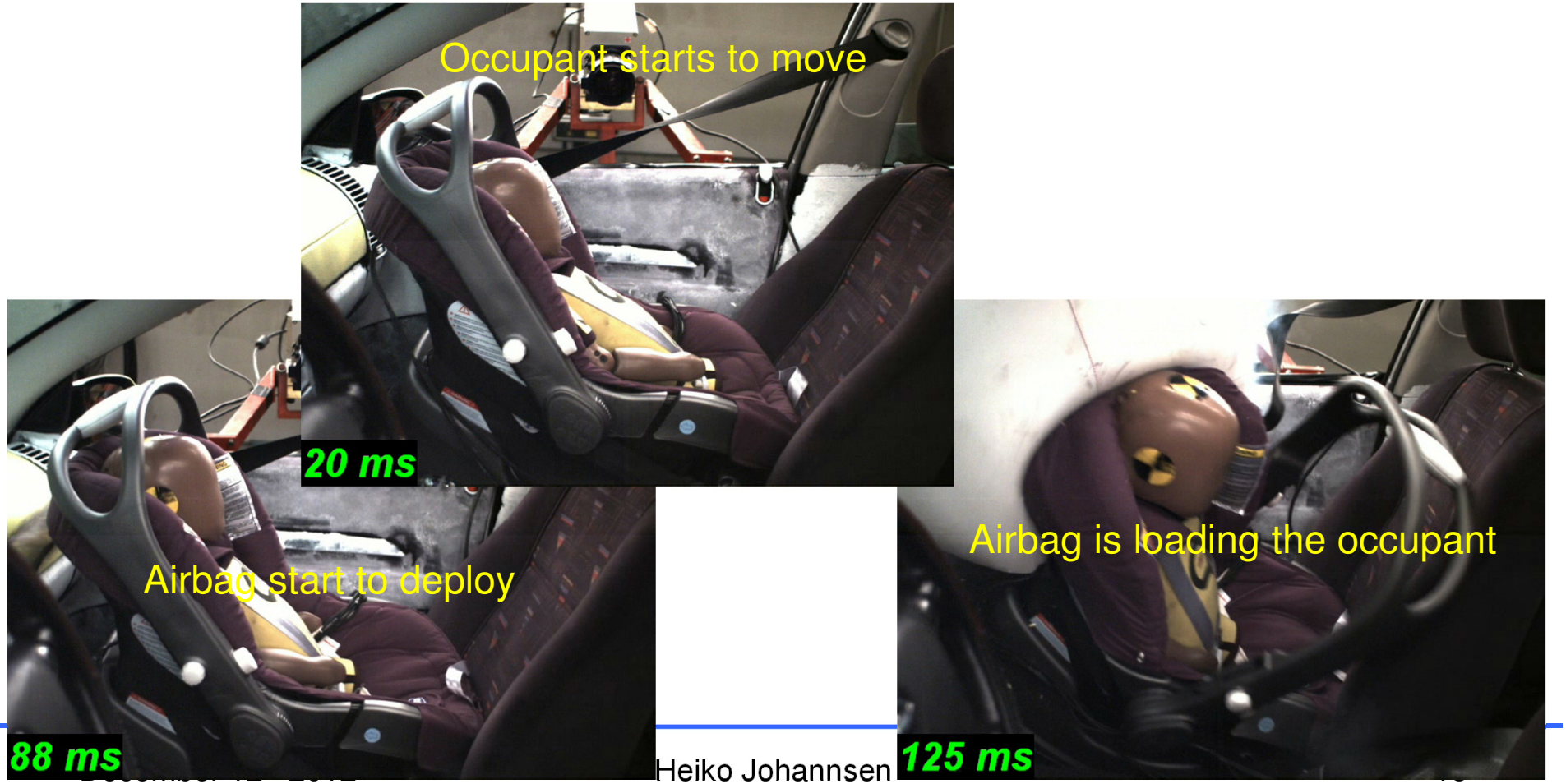
more representative pulse (in comparison to CASPER project accident reconstruction pulses of ECE R94 compliant cars)



Justification FWDB

Centered pole impact

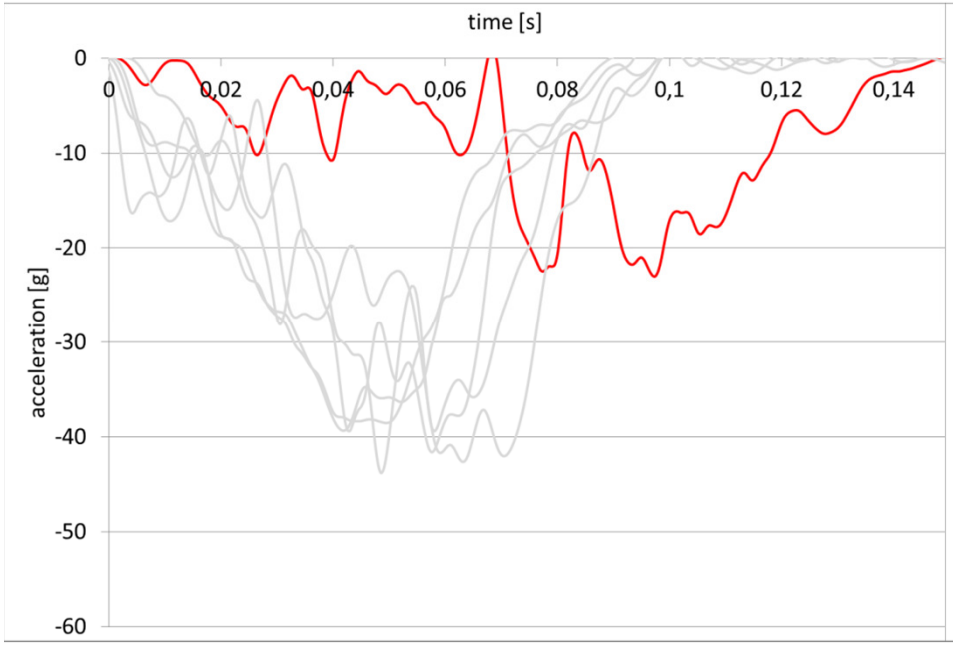
restraint system triggering (accident reconstruction)



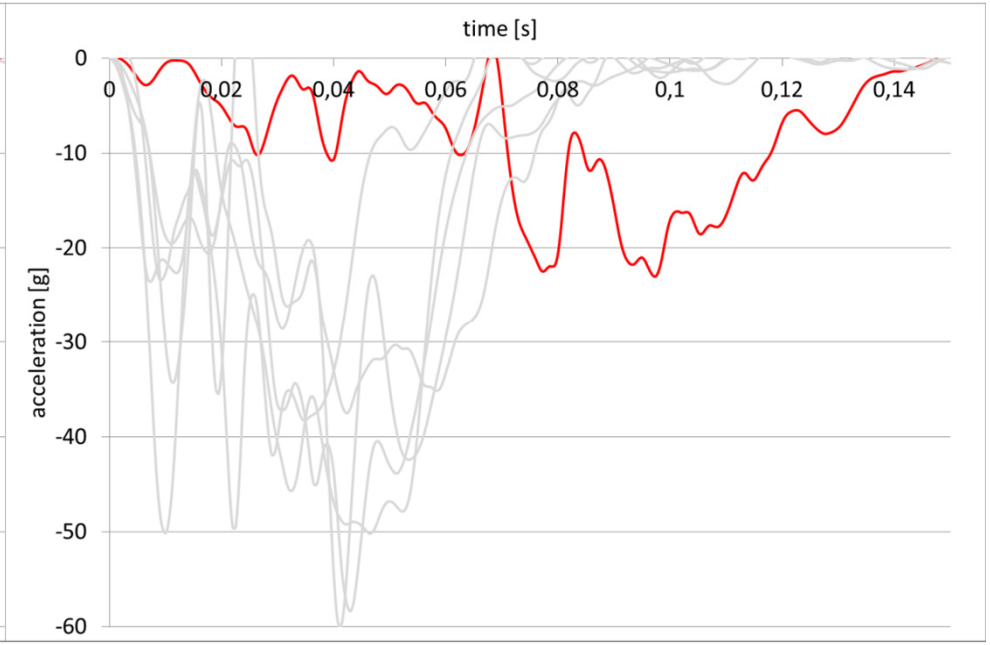
Justification FWDB

restraint system triggering (accident reconstruction)

Pulse comparison to FWDB

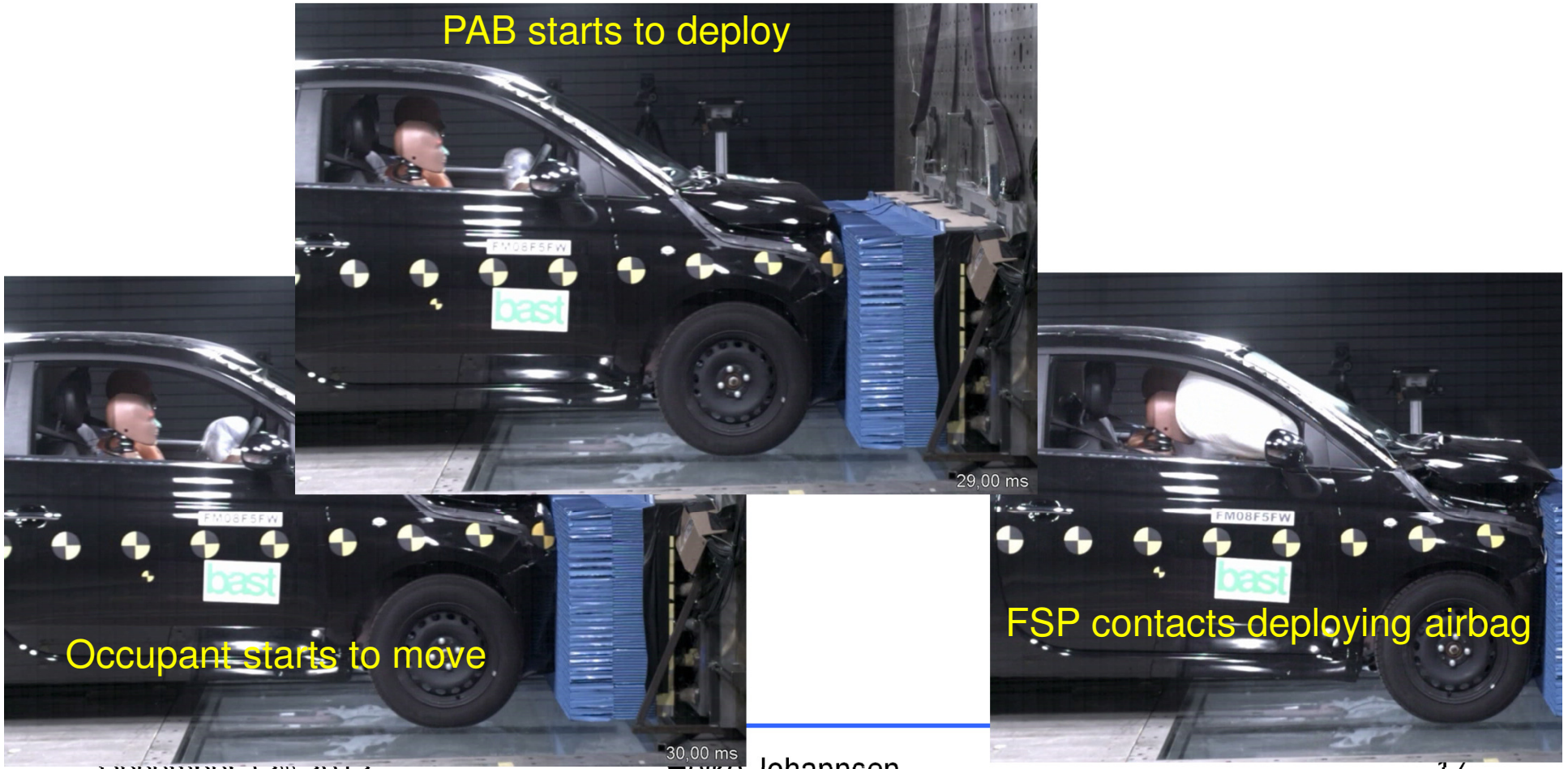


Pulse comparison to FWRB



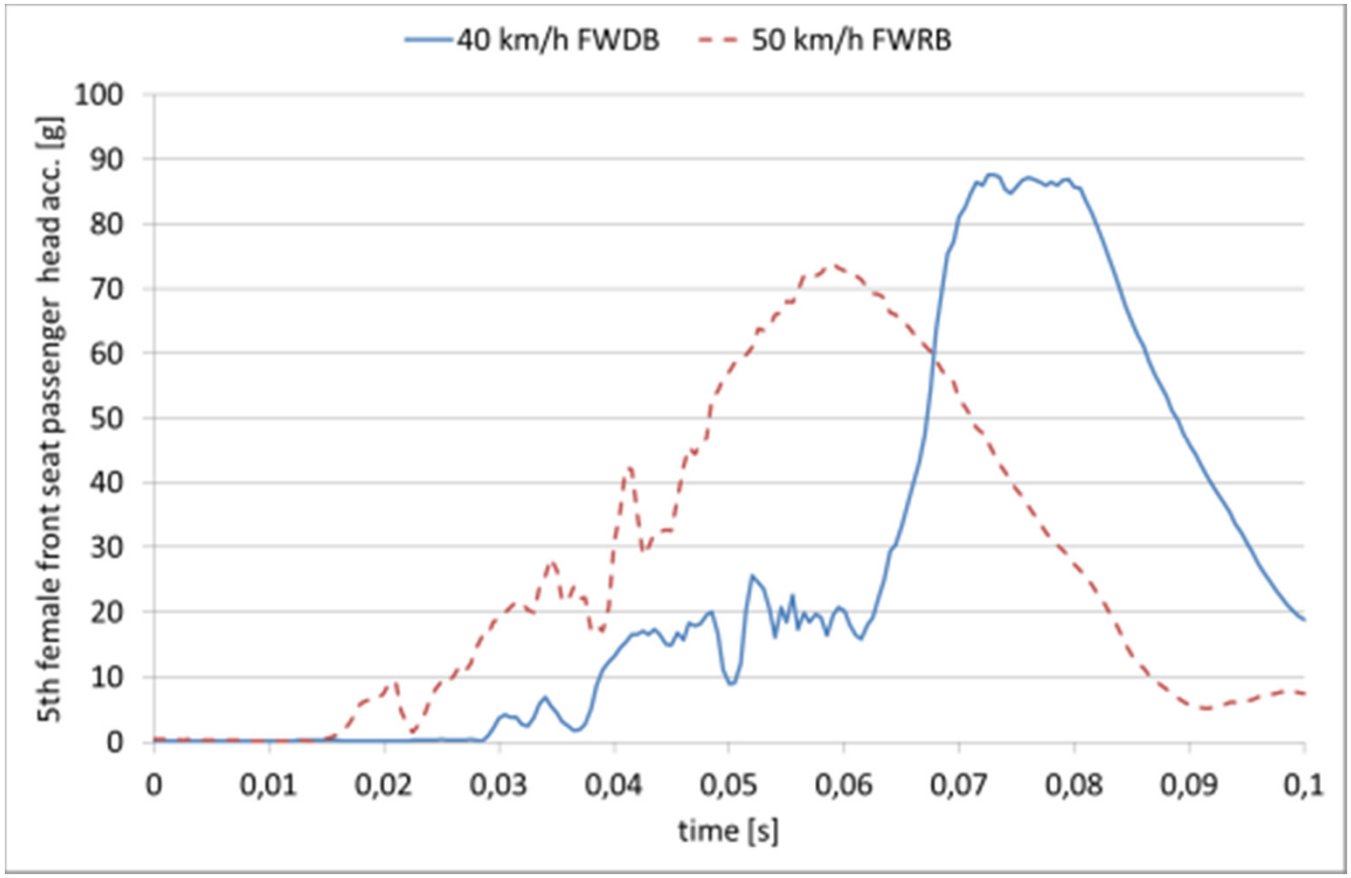
Justification FWDB

restraint system triggering (40 km/h FWDB test)



Justification FWDB

restraint system triggering (airbag delay in 40 km/h FWDB test)



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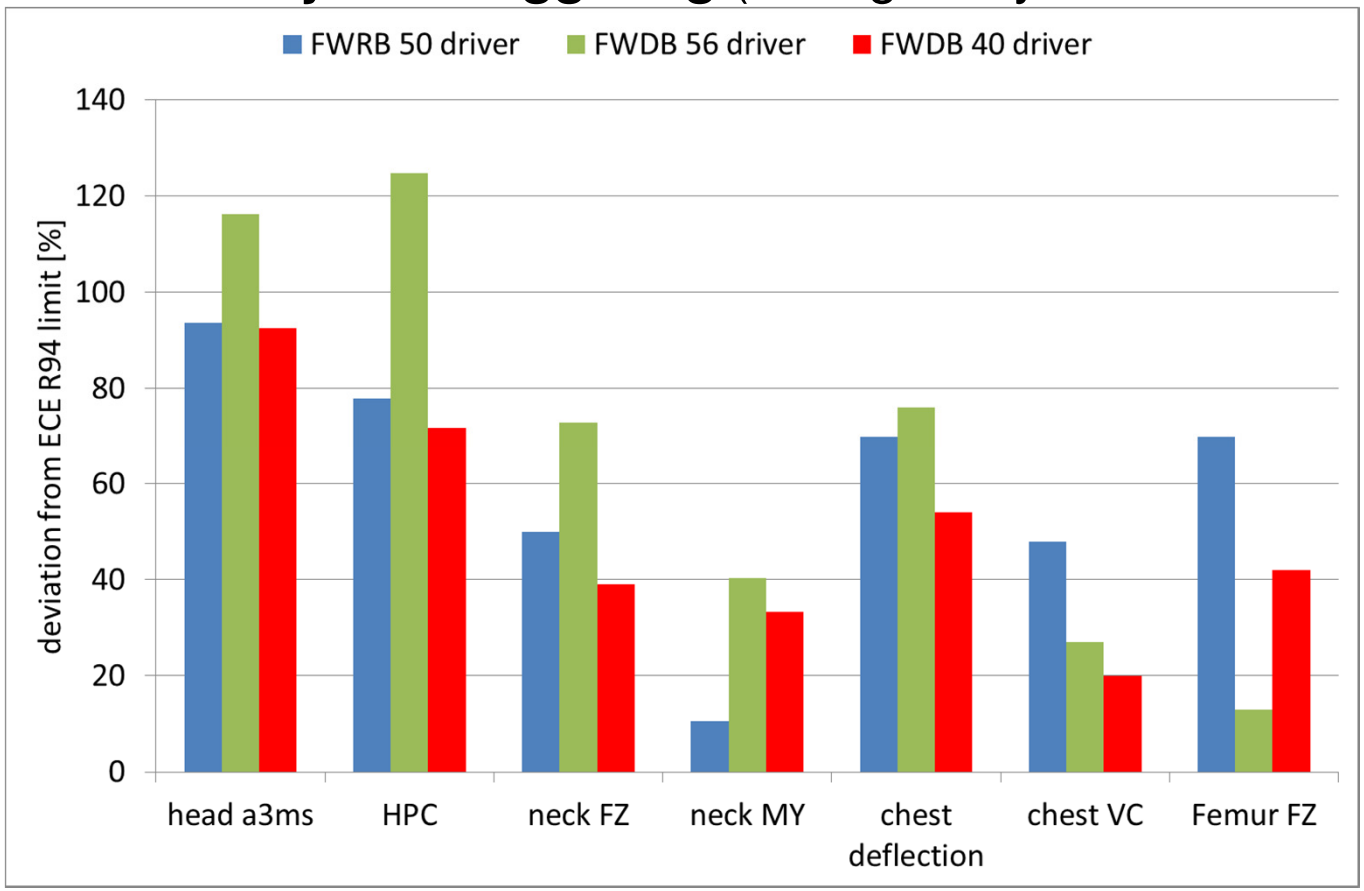

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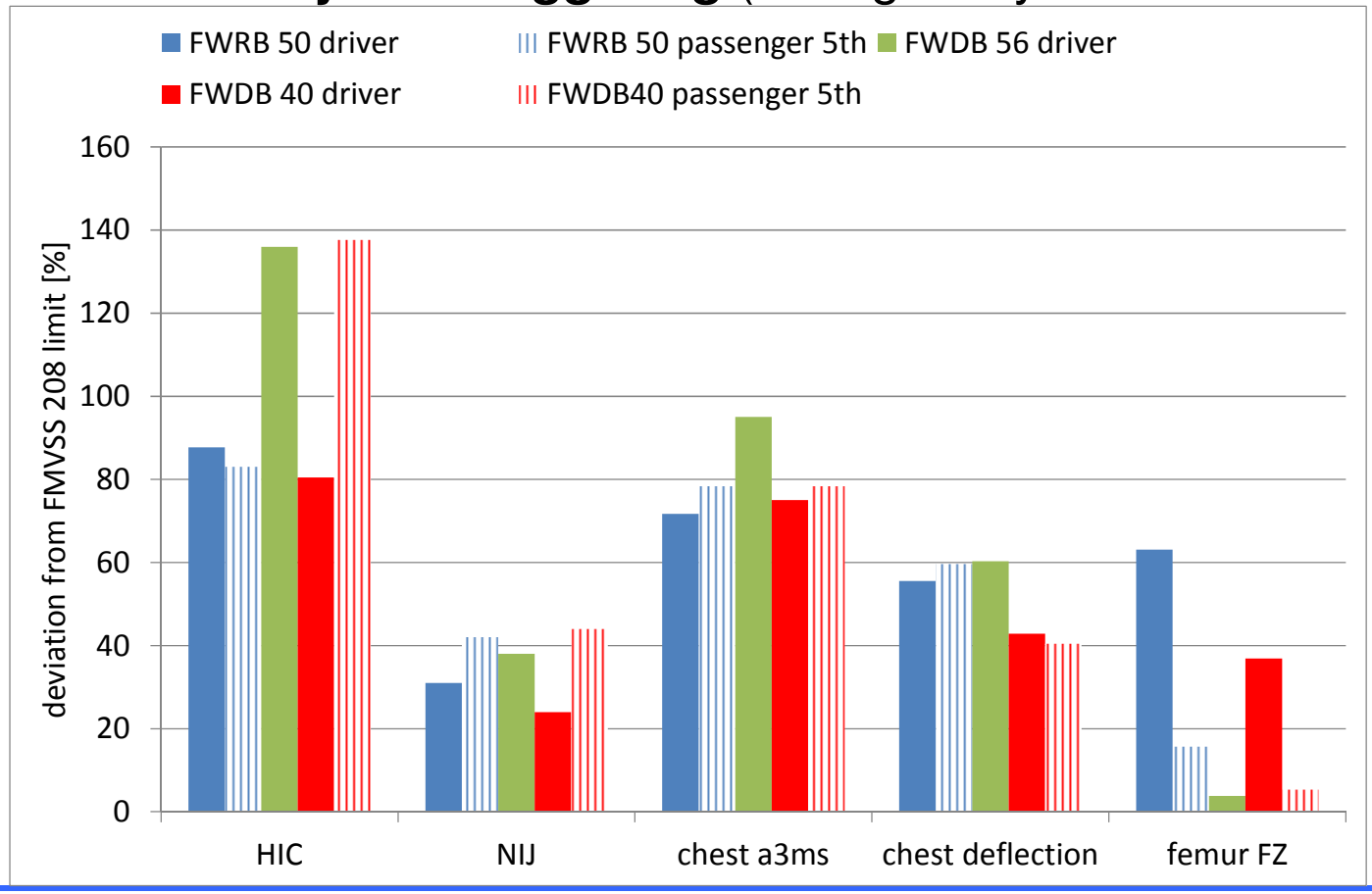
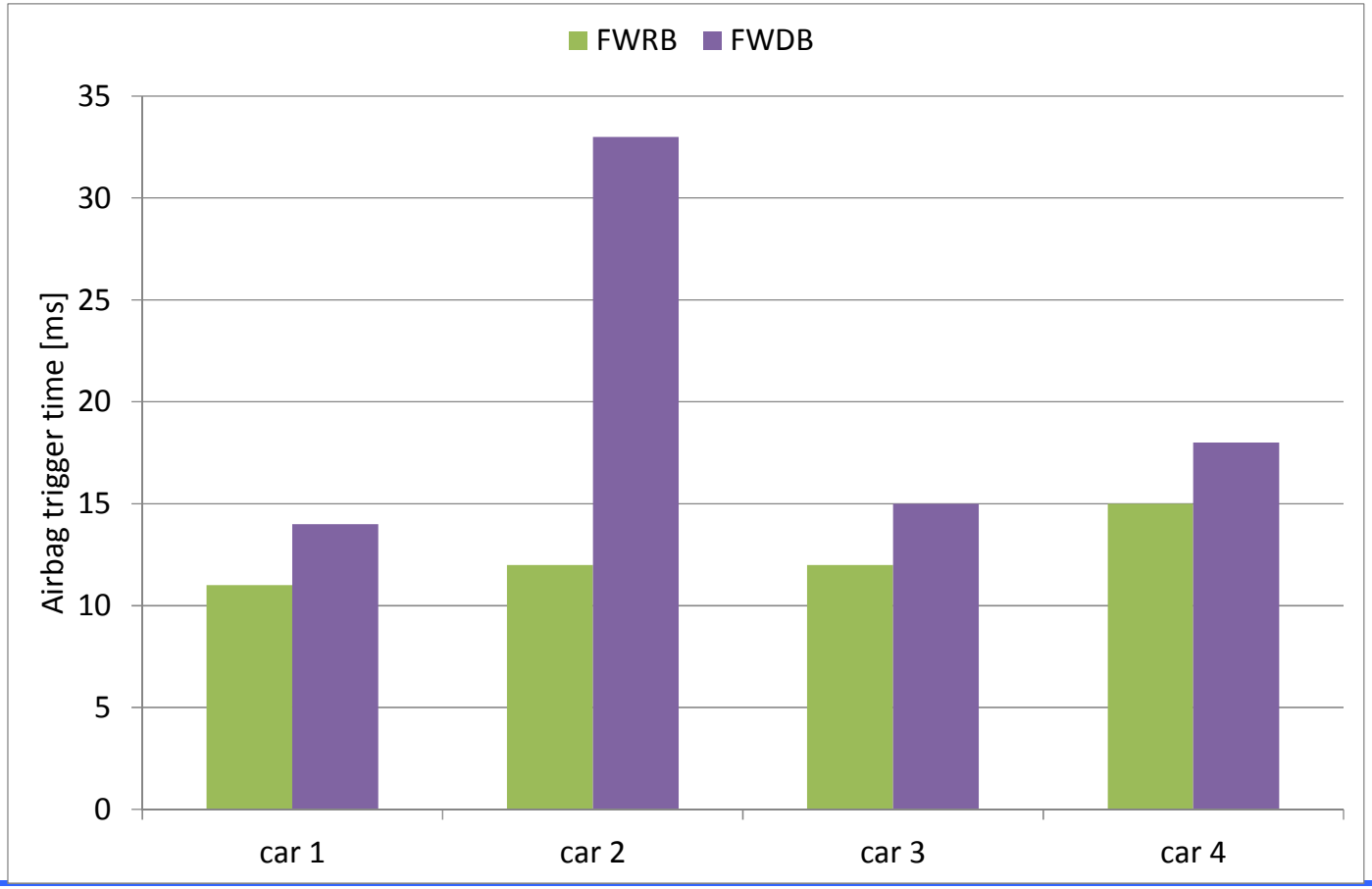


Justification FWDB

restraint system triggering



Justification FWDB

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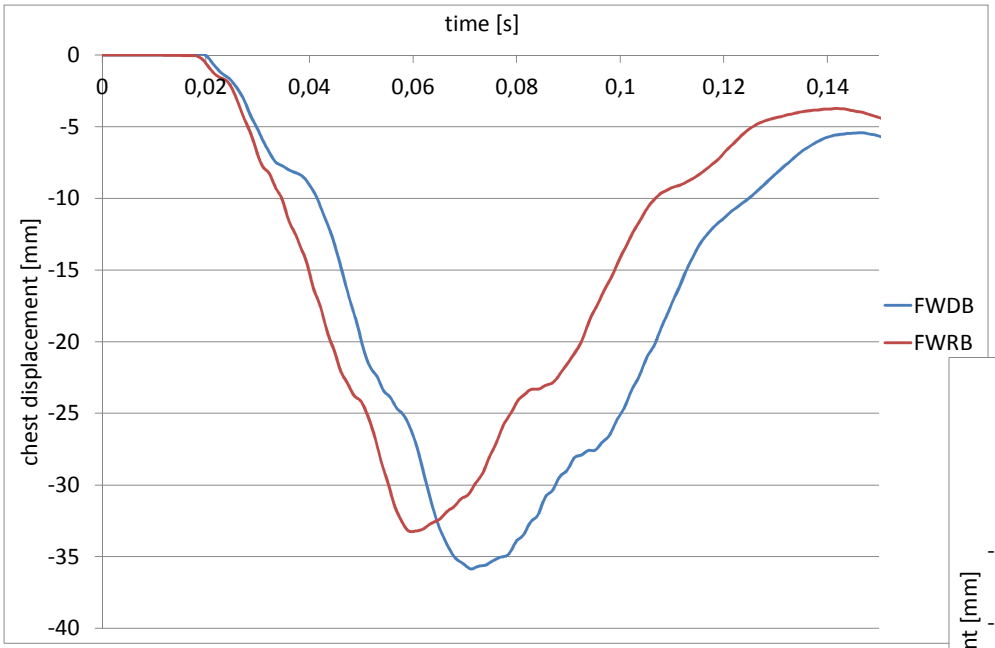
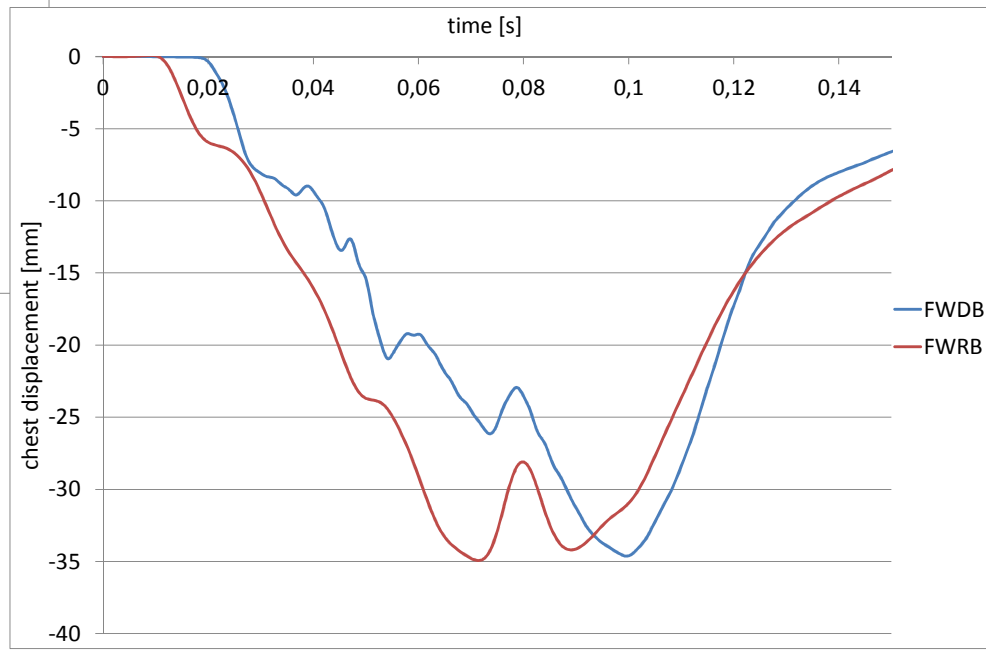
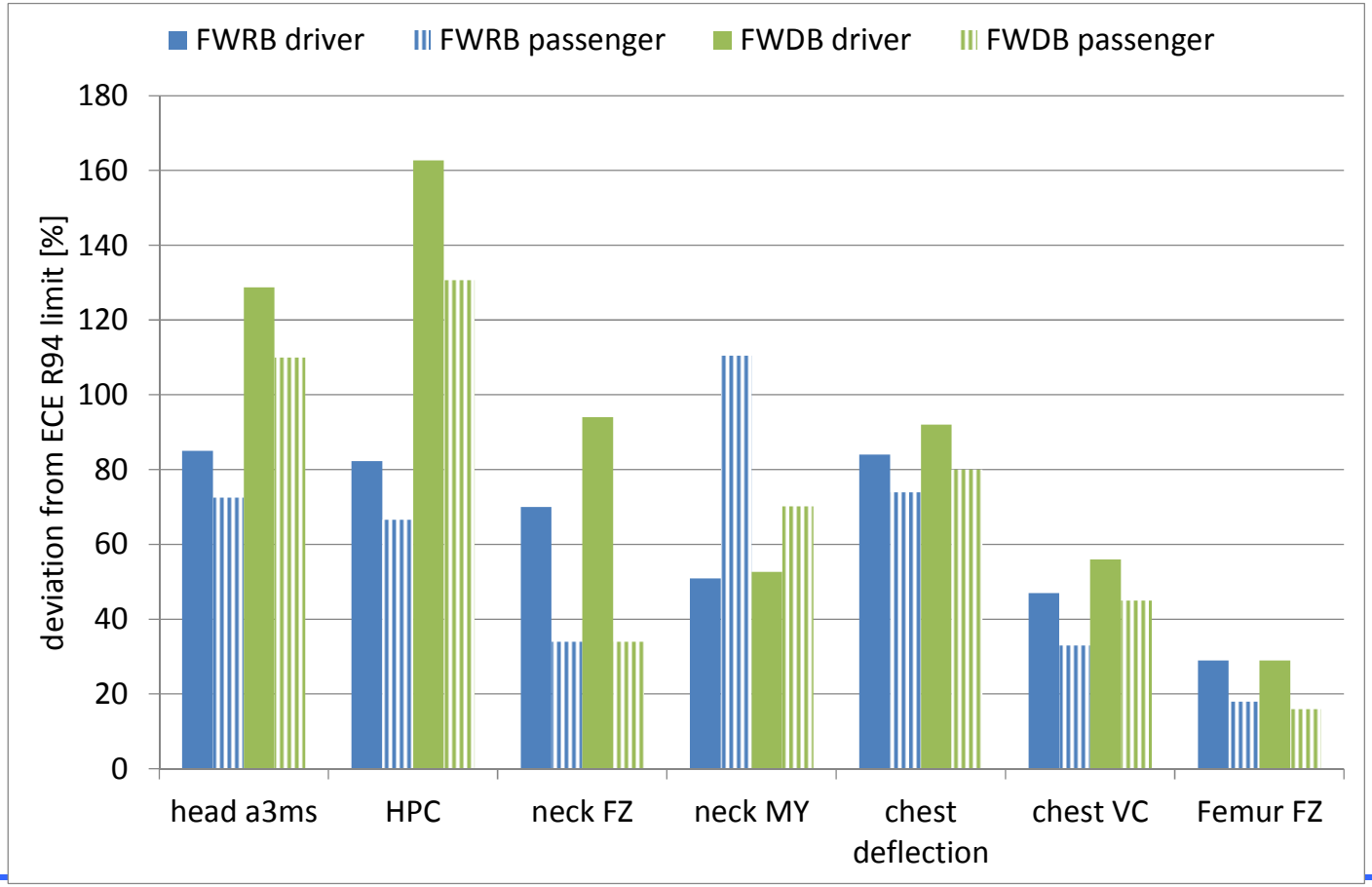




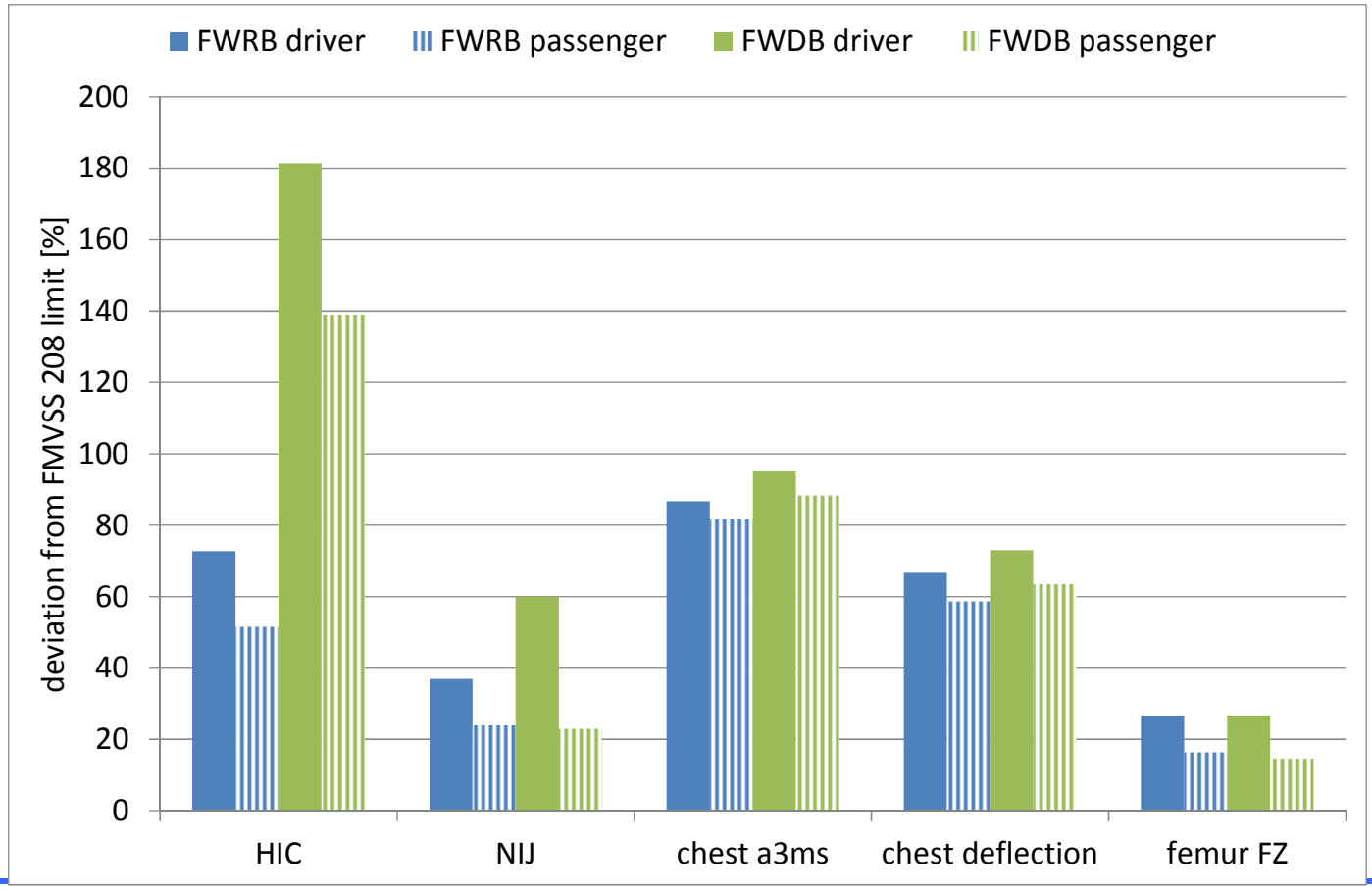
Justification FWDB

restraint system triggering (airbag delay in car 2)



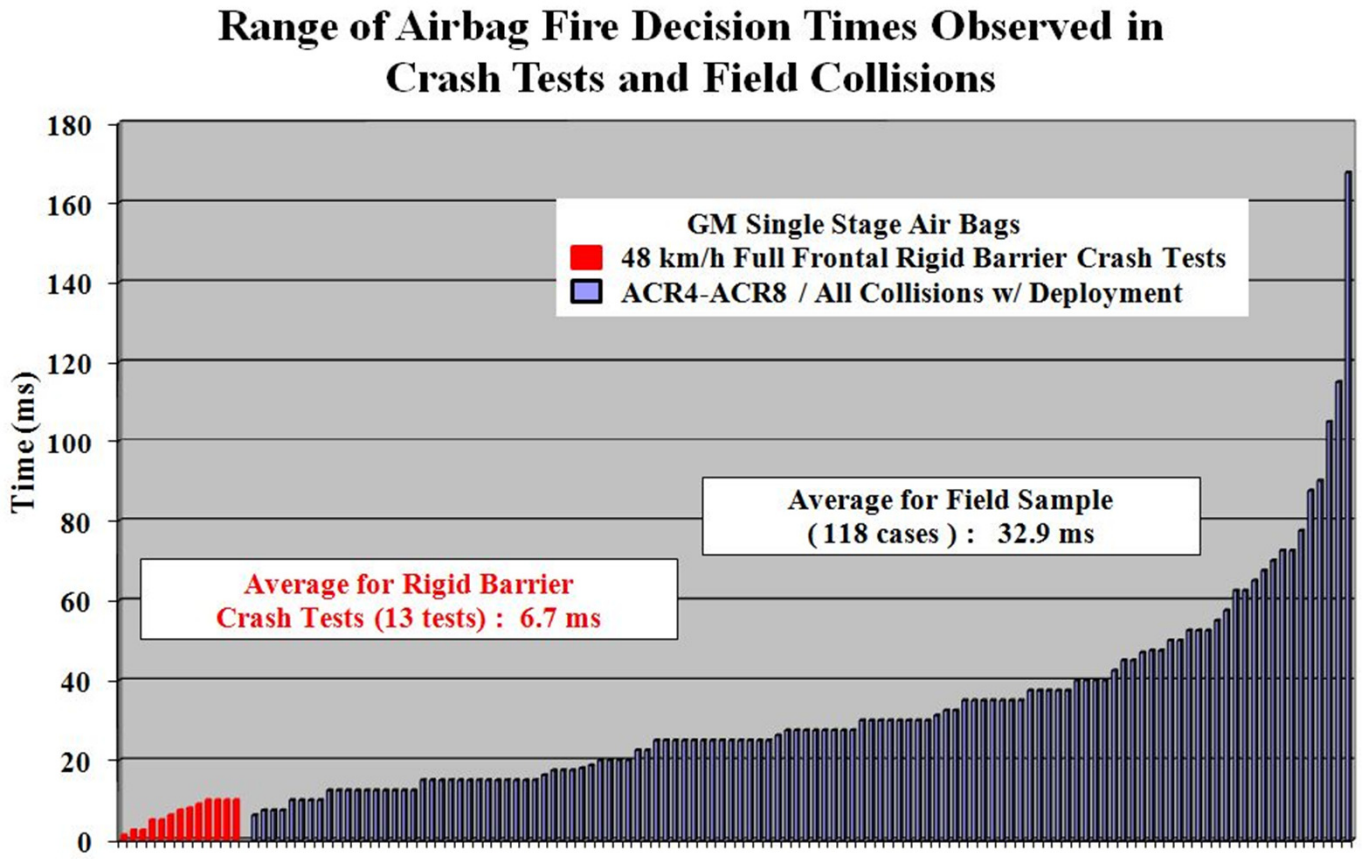
Justification FWDB

restraint system triggering (airbag delay in car 2)



Justification FWDB

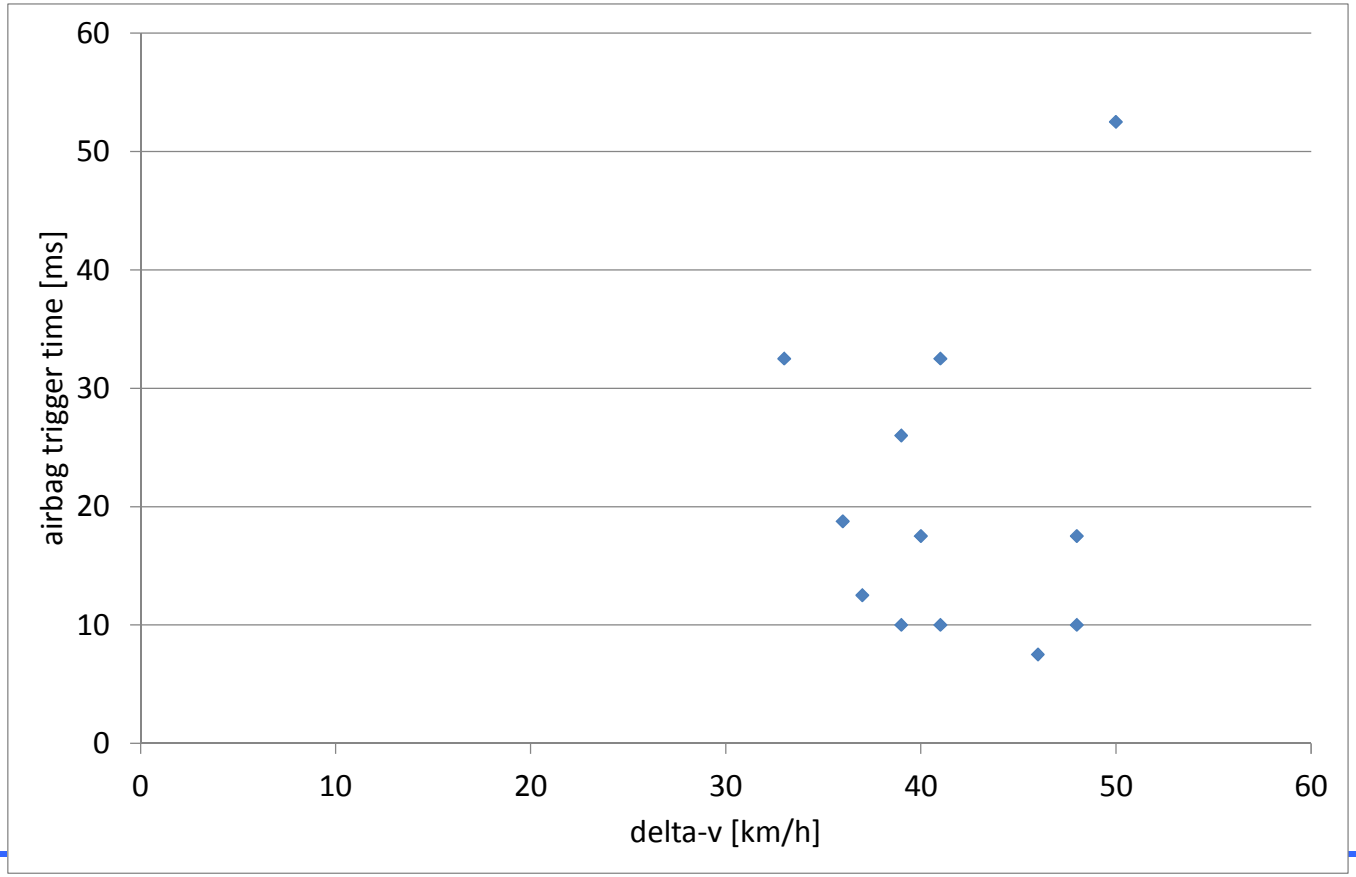
restraint system triggering (EDR data and FWRB data)



Dalmotas DJ, German A and Comeau J-L; Crash Pulse Analysis using Event Data Recorders; Proceedings of the 19th Canadian Multidisciplinary Road Safety Conference, Saskatoon, Saskatchewan, June 8-10, 2009.

Justification FWDB

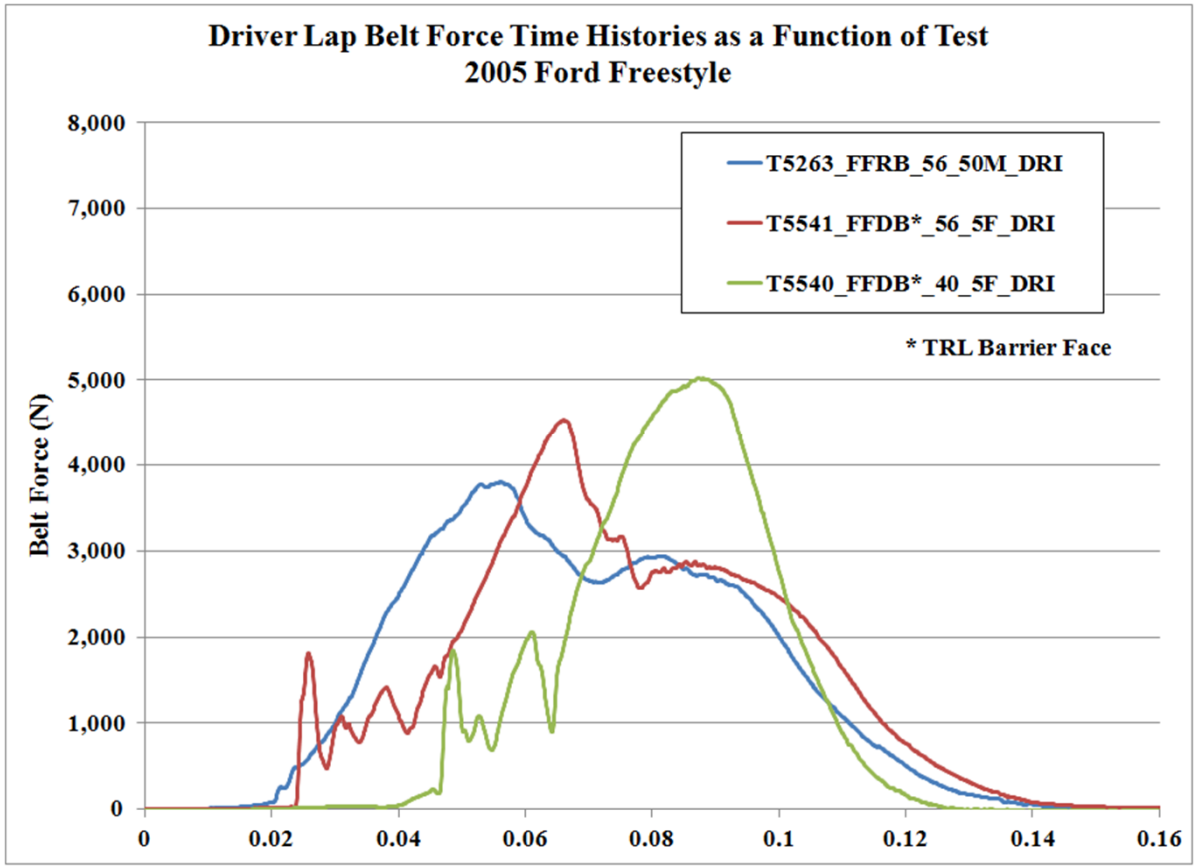
restraint system triggering (NASS EDR data with good representation of FW test, only 12 o'clock impacts GM volume cars)



Pre analysed data made available by Dainius Dalmotas, D. J. Dalmotas Consulting, Inc

Justification FWDB

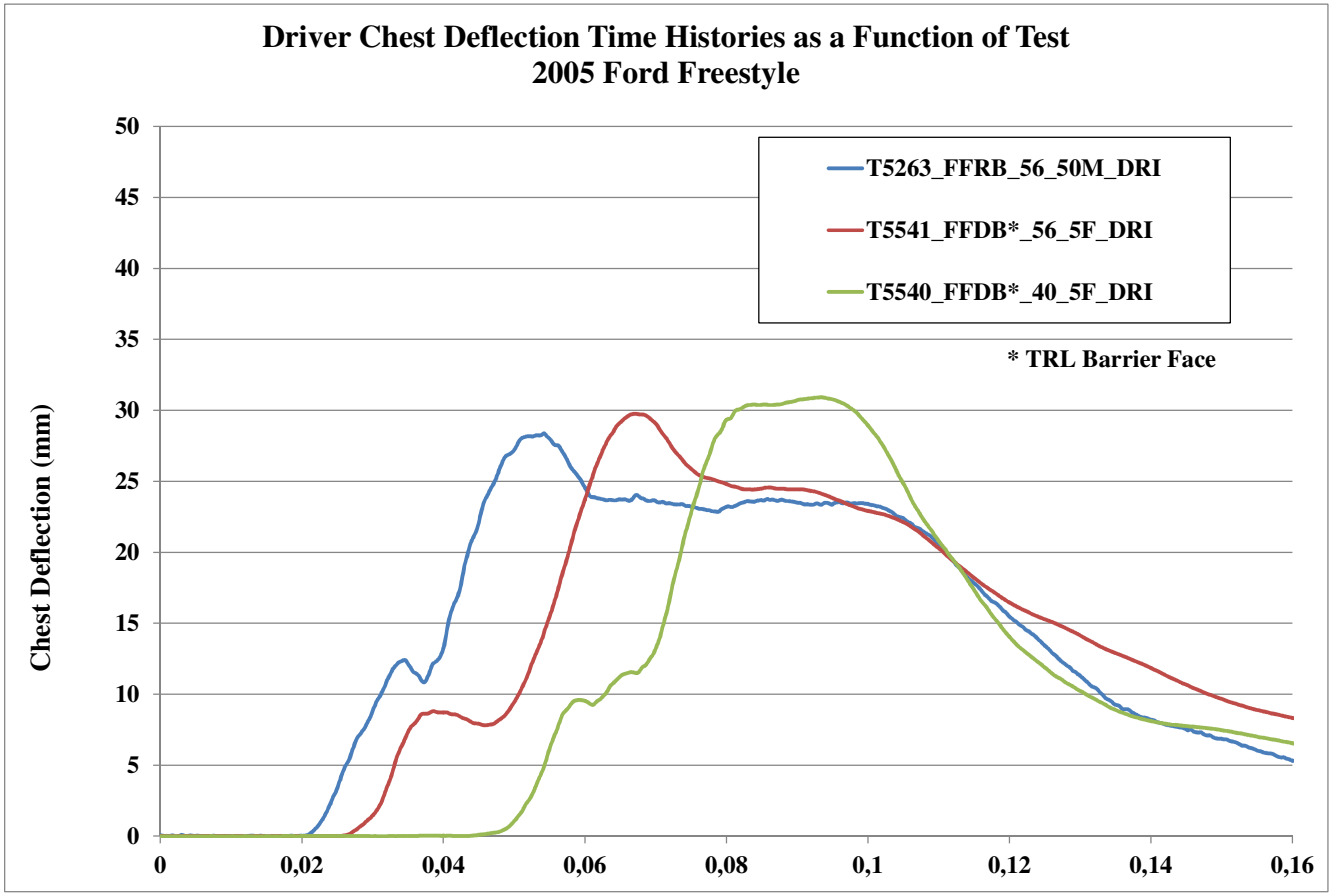
restraint system triggering (belt forces dependent on test type)



Pre analysed data made available by Dainius Dalmotas, D. J. Dalmotas Consulting, Inc

Justification FWDB

restraint system triggering (chest deflection dependent on test type)



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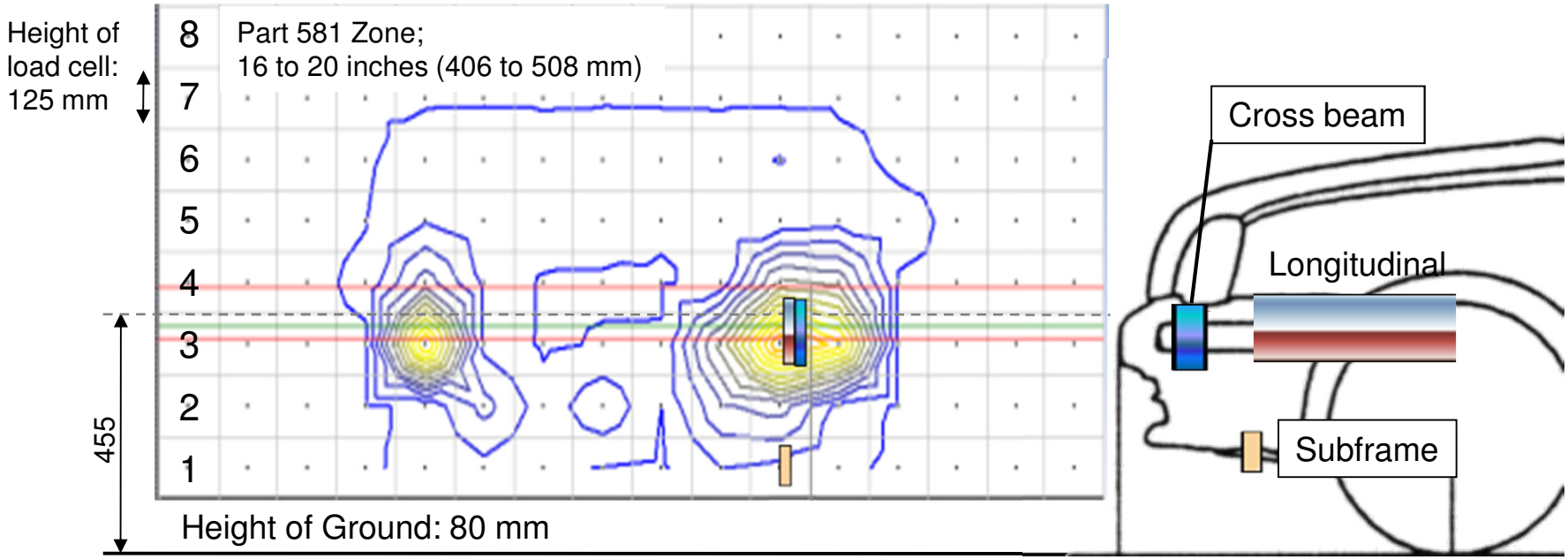
Justification FWDB

- Better assessment of structure alignment capabilities possible
  - Engine dump attenuated
- Detection of lower structures possible that were proved to beneficial for
  - Car-to-car frontal impact
  - Car-to-car lateral impact

FWDB metrics

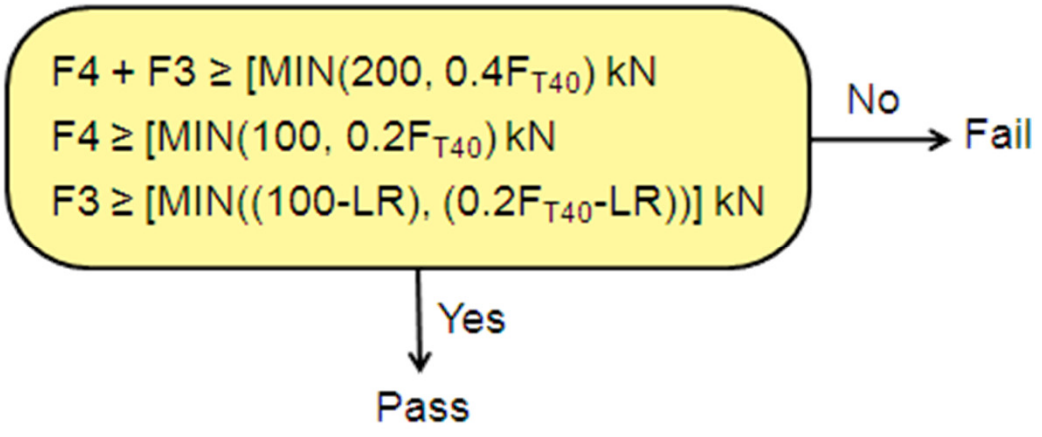
Concept:

- Assess structural alignment from measurement of forces in rows 3 and 4



FWDB Metric

Up to time of 40 msec



with:

F_{T40} = Maximum of total LCW force up to time of 40 msec
Limit Reduction (LR) = [F2-70] kN and 0 kN ≤ LR ≤ 50 kN

– Note: metric was developed based on FWDB 56 km/h tests, metric needs to be adjusted to proposed impact velocity of 50 km/h (especially LR)

FWDB Metric

SEAS detection

- FWRB would require stage 2 approach for correct assessment of cars applying SEAS in common interaction zone
  - Likely additional test
- Test and simulation results available for FIMCAR suggests
  - SEAS structures that are beneficial in car-to-car impacts can be detected
  - ORB as proposed for FWRB SEAS detection also credits SEAS that are expected not to be beneficial

FWDB R&R

- R&R analysis includes
  - 2 barrier test with same car in different TNO labs
  - 4 barrier tests with same car (2 each at FIAT and IDIADA)
    - IDIADA tests with different dummy use than at FIAT
    - Ride height seems to be different
  - Several impactor tests
  - 3 barrier test with same car (1 at FIAT and 2 at BASt)
    - BASt LCW does not meet FIMCAR LCW requirements

FWDB R&R

- R&R analysis conclusion
  - R&R is acceptable
    - I.e. in line with other crash tests, for cars with a stable front structure in this test mode.
    - For further analysis of R&R the use of a car with a stable front structure and sum forces above 500 kN is recommended.
    - Furthermore the LCW requirements as developed by FIMCAR should be met for the LCWs used.
  - One of the three FIMCAR test (i.e., the one at BASt) resulted in different metric outcome compared to the other two. This was attributed to insufficient front structure stability and issues of the LCW

Disadvantages FWRB

- FWRB results in a pulse that is not representative in the initial stage
- FWRB may results in simple restraint system trigger algorithms that may cause too late airbag triggering in other crash configurations (e.g., car-to-car, pole, lower speed …
- FWRB causes unrealistic low requirements for the front structure energy absorption capabilities, especially by low requirements concerning load path stability against bending ...

Disadvantages FWRB

- Engine dump results wrong assessment of location of energy absorbing structures
  - Metrics need to assess before engine dump occurs
  - Most advanced proposal results in assessment of crash cans in some vehicles and not of the energy absorbing structures
  - SEAS detection is impossible

Advantages and disadvantages ODB

+ ODB guarantees that current level of compartment strength will be maintained for all vehicles
+ Used in legislated and consumer tests in many countries
+ Provides a softer pulse compared to the full width test
+ Harmonization potential
– Load spreading not covered

Justification ODB Modification

- Additional compartment strength requirement will likely not affect recent cars
  - They are Euro NCAP driven are designed for more challenging requirements
- Legal requirement required to ensure minimum safety levels even if cars are not designed for good ratings
- FIMCAR to maintain compartment strength at least at level of today requires compulsory target

Achievement of FIMCAR priorities

- Structural alignment
  - Addressed with FWDB metric
- Vertical load spreading
  - Addressed at basic level
    - Requirements for row 3 and 4
    - Limit reduction on Row 3 for load spreading down to row 2
    - Minimum section size required for SEAS to be detectable
- Horizontal load spreading
  - Not addressed

Achievement of FIMCAR priorities

- Current compartment strength requirements maintained
  - Addressed by definition
- Appropriate severity level for occupant protection (RS)
  - Addressed (metrics are expected to be consistent even at lower speeds, dummy performance?)
- Pulse requirements
  - Addressed

Benefit Analysis

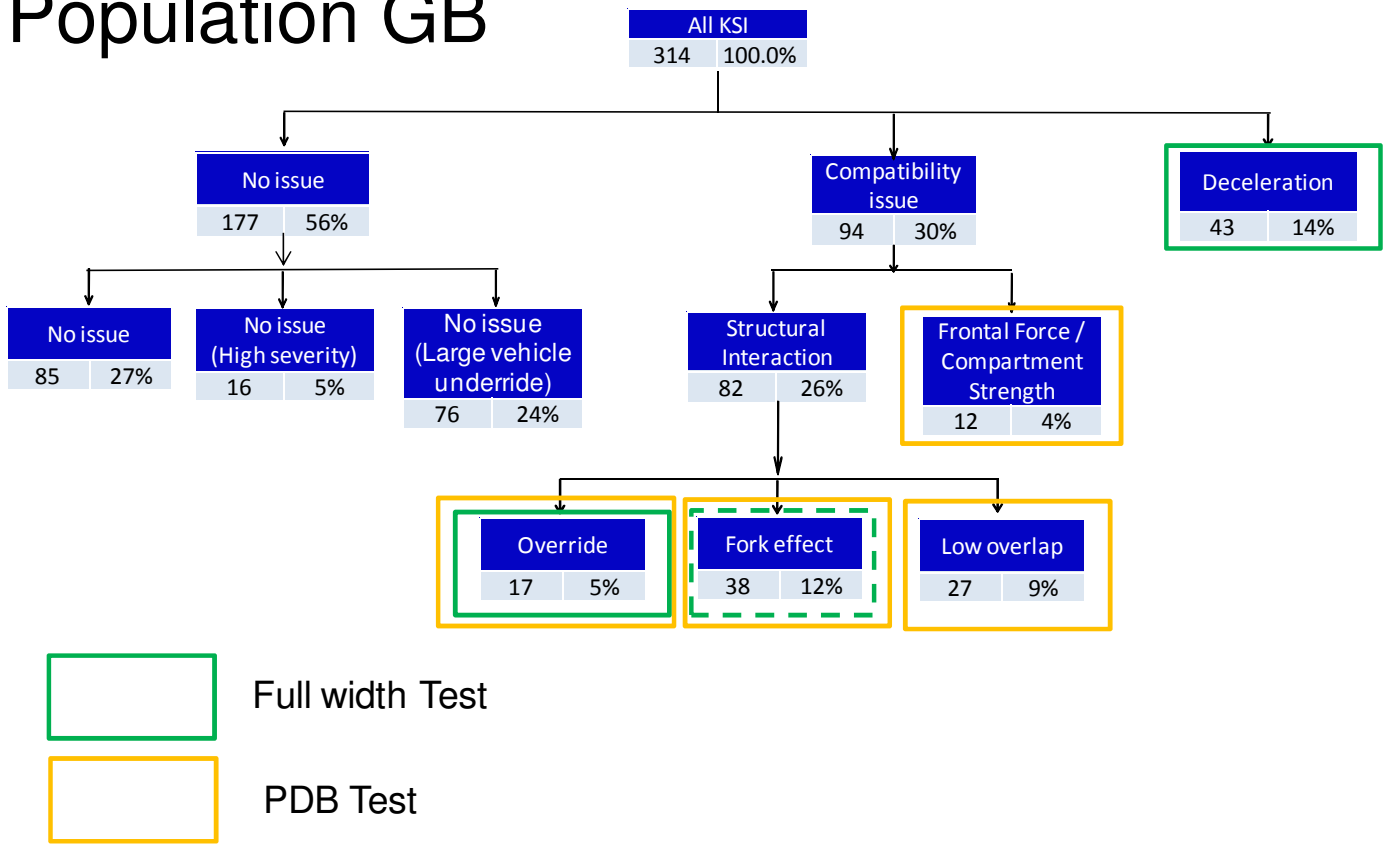
- Assumptions
  - Occupants suffering from high acceleration injuries would benefit from the introduction of FWB
  - Occupants suffering from under/override accidents caused by structural misalignment would benefit from the introduction of FWB

Benefit Analysis

- Assumptions (continued)
  - Occupants suffering force mismatch issues would benefit from additional introduction of PDB
  - Occupants suffering from fork effect issues would benefit from additional introduction of PDB
  - Occupants suffering from low overlap would benefit from additional introduction of PDB

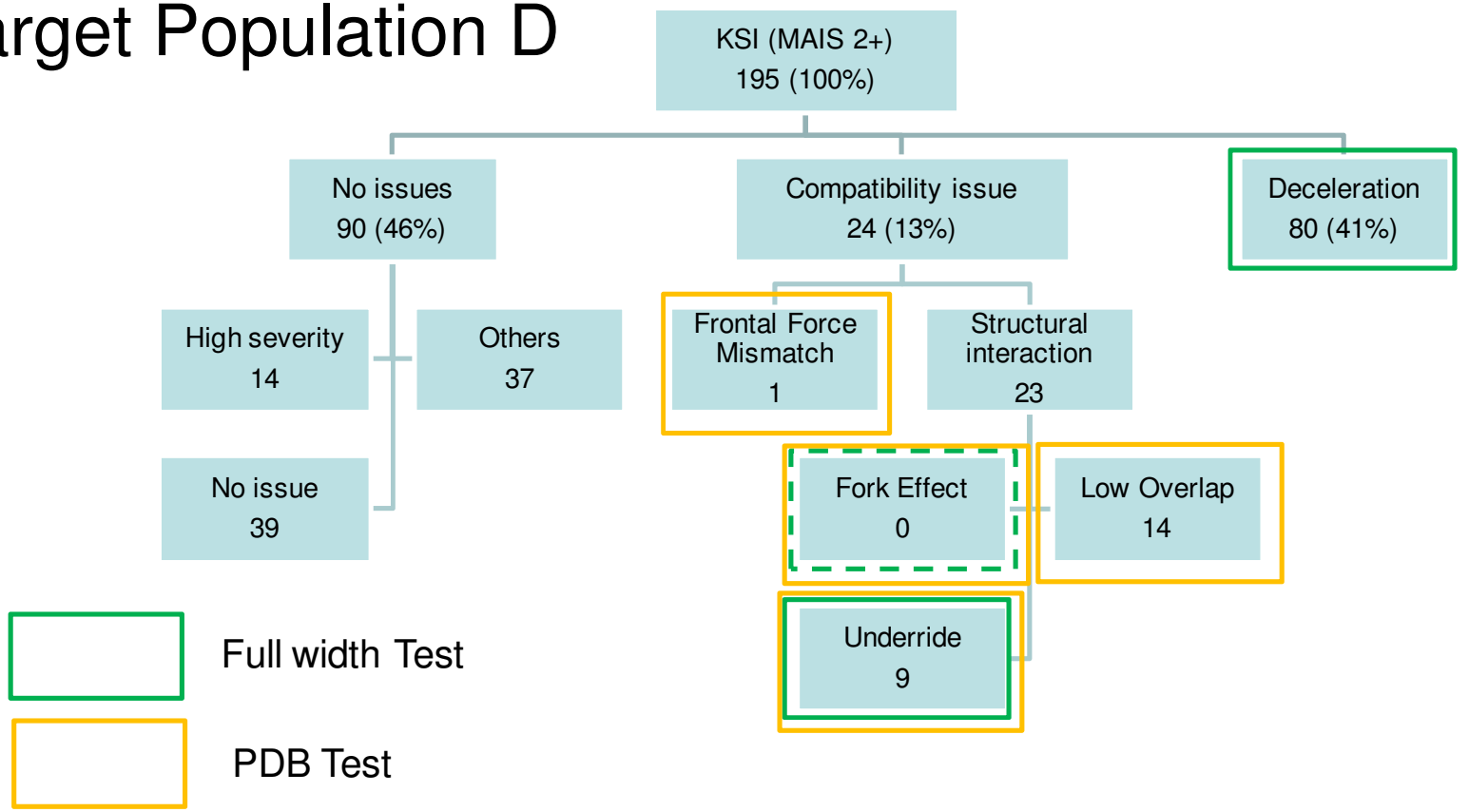
Benefit Analysis

- Target Population GB



Benefit Analysis

- Target Population D



Benefit Analysis

- Estimation of break even costs per car scaled for Europe
  - For introduction of FWB with compatibility metrics
    - 104 – 294 Euro
  - For introduction of FWB with compatibility metrics and PDB with compatibility metrics
    - 158 – 415 Euro

Summary

FIMCAR proposal for updated frontal impact protocol

- FWDB with 50 km/h (lower impact speed acceptable if in line with dummy capabilities)
- ODB

Expected improvements

- Alignment of structures
- Improved restraint system performance

Disadvantages of FWRB

- Undesirable single point optimisation in wrong direction