EEVC-WG12 Update on EUROSID-2 Dummy Activities

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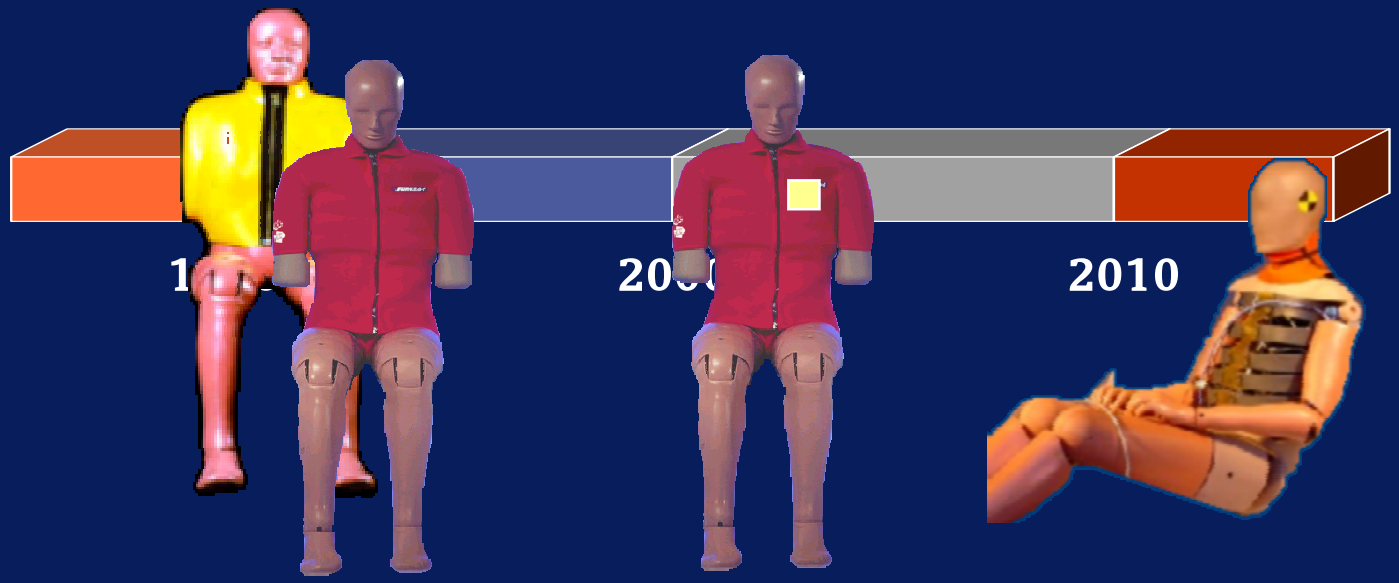
Harmonisation Goal

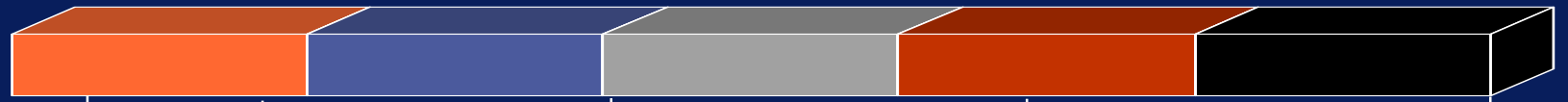
- Provide improved side impact dummy design based on EUROSID-1 that is world-wide acceptable in the interim up to the moment that a more advanced validated test device can be introduced



Motivation

- "WorldSID" dummy is being developed but harmonisation could be reached earlier based on proven design
- EUROSID-1 is most widely used regulatory side impact dummy
- EUROSID-1 deficiencies that prevent acceptance world-wide are known and solvable

ES-2 Program Timeline



- Start design work
- NHTSA petitioned to consider EUROSID for FMVSS
- Start EEVC/NHTSA evaluation testing
- EEVC recommendation
- Use of ES-2 dummy in EuroNCAP Ph-12

Status

- EECV recommendation report to GRSP and EuroNCAP in September 2001
- Proposal for amendment of ECE R95 in May 2002
- OICA concerns submitted at last GRSP meeting
  - Decision postponed to next GRSP meeting
- EEVC WG12 investigations into OICA concerns

Summary of OICA Key Points

- Variation of (biomechanical) performance criteria between EUROSID-1 and ES-2 dummy
- Directional sensitivity
- Inter rib homogeneity
- Thorax damping characteristics and stiffness (vibration)
- Interaction between body segments

Ref: Concerns regarding thoracic response of ES-2 side impact dummy LAB/PSA/Renault, March 26th 2002

Variation of Performance Criteria

OICA Concern

- **EEVC report explains that ES-2 has lower criteria than EUROSID-1 in biofidelity tests**
- **This depends on test conditions**
- **Too much data are missing to make complete analysis**
  - no maximum rib deflections in sled tests are given
  - test results at lower velocity (e.g. 8.9 m/s in ISO condition) may give more insight

Variation of Performance Criteria

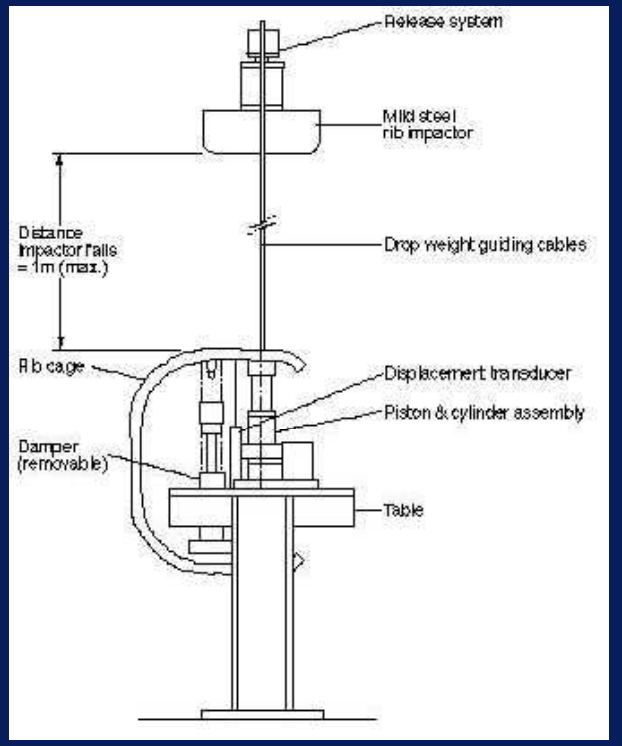
EEVC Review

- Goal of ES-2 development has been to keep same level of biofidelity to EUROSID-1 w.r.t. accepted EEVC requirements
- WG12 has checked ES-2 performance in thorax and full body (thorax/pelvis) response
- Responses of PMHS rib deflection and V*C are not available and therefore not included in the assessment

Variation of V*C

Additional tests

- Test on rib only
- Various mass impactors and velocity of impact
- Comparison of EUROSID-1 and ES-2



Speed	Mass	Energy	EUROSID-1	ES-2	Variation
m/s	kg	Nm	m/s	m/s	%
4.0	7.78	62.2	0.54	0.59	10.9
6.5	3.10	65.5	0.67	0.71	7.0
8.0	1.40	44.8	0.52	0.49	-5.5

Variation of Performance Criteria

Conclusion

- ES-2 is similar in biofidelity as EUROSID-1 in the EEVC test conditions for which it was designed (ESV 2001)
- Thorax biofidelity targets do not include displacements nor V*C, which is acknowledged in the EEVC report
- Some injury criteria may vary between the two dummies but it is not possible to say which are biomechanically more correct

Directional Sensitivity

OICA Concern

- Surprisingly higher rib deflections are observed at rearward angle impacts for ES-2
- Data to compare with production EUROSID-1 are missing in the EEVC report
- Change in position of rib displacement can have an negative effect on the measured values of the displacement when oblique loading is present

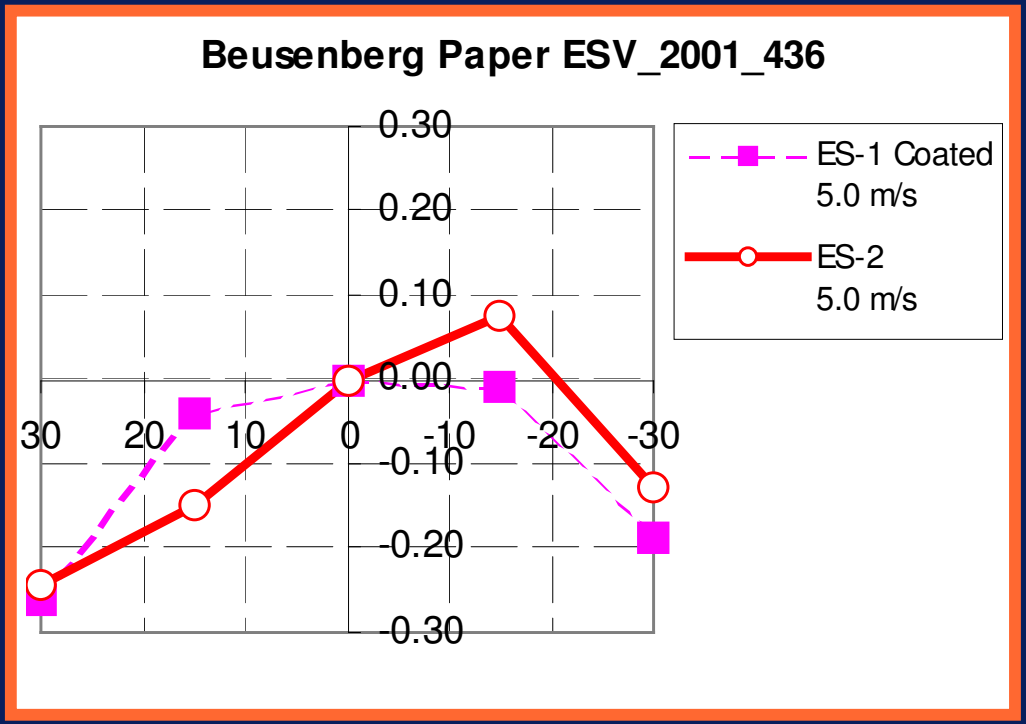
Directional Sensitivity

EEVC Review

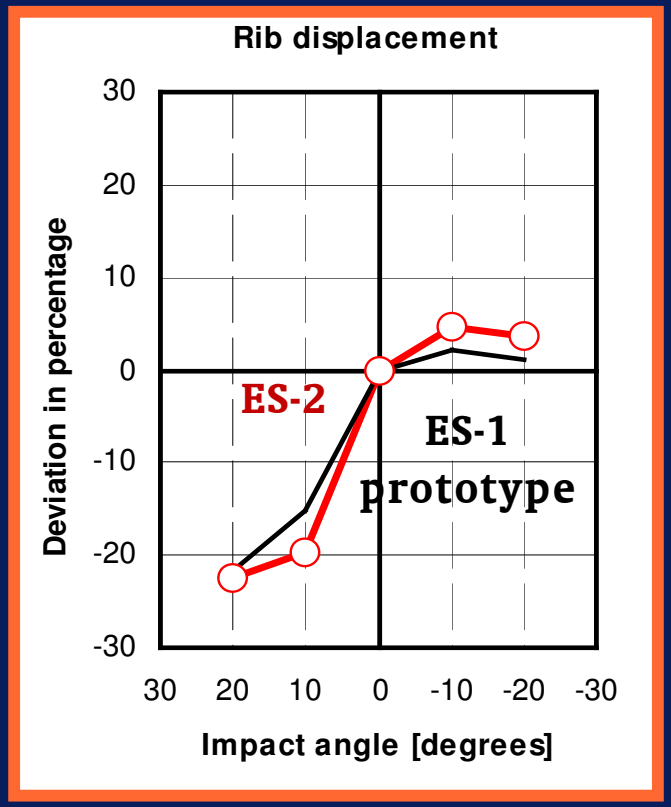
- **Conclusion in EEVC report based on impactor data**
- **Additional directional impact data available on EUROSID-1 and ES-2 include:**
  - Biokinetics study, 23.4 pendulum impact tests on EUROSID-1 (coated piston) and ES-2 @ +30, +15, 0, -15 and -30 deg
  - NHTSA study, 907 bumper pendulum impact tests on EUROSID-1 (coated piston) and ES-2
  - TNO biofidelity tests 23.4 kg pendulum tests on EUROSID-1 EUROSID-1(coated piston) and ES-2 @ +30 and 0 deg
  - TNO rib only drop tests (+20, +10, 0, -10, -20 deg)

Directional Sensitivity

Biokinetics

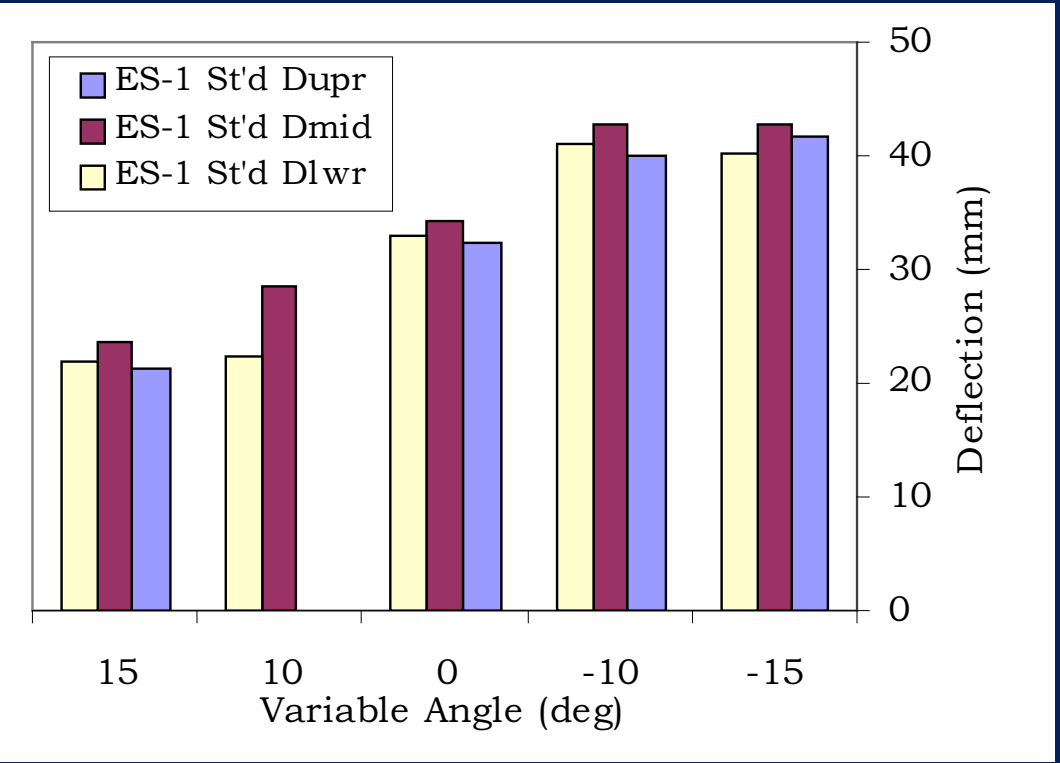


TRL/EEVC



Directional Sensitivity

- NHTSA data on EUROSID-1 also show higher values for rearward oblique impacts



Directional Sensitivity

Conclusion

- EUROSID-1 and ES-2 show a similar trend regarding oblique loading i.e. lower readings in fwd oblique and higher readings in rwd oblique impacts
- This is explained by the design of the rib structure and location of actual measurement point
- Changes in directional sensitivity between EUROSID-1 and ES-2 are caused by changes in rib friction and a small shift in point of measurement as explained in the EEVC report

Inter Rib Homogeneity

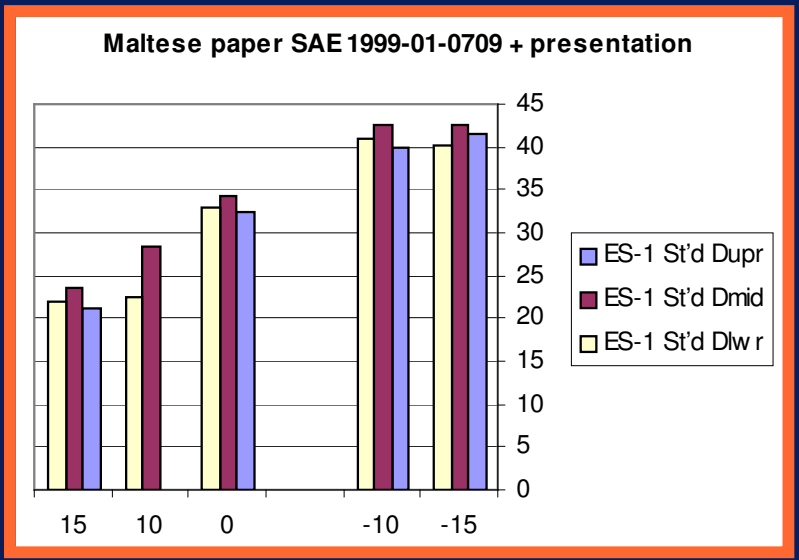
OICA Concern

- **Evolution of rib responses between EUROSID-1 and ES-2 is not continuous**
  - Reference is made to EUROSID-1 prototype data by Friedel et al.
- **Effect on maximum deflection and/or V*C may be greater for the individual ribs than indicated by the average given in the EEVC report**

Inter Rib Homogeneity

EEVC Review

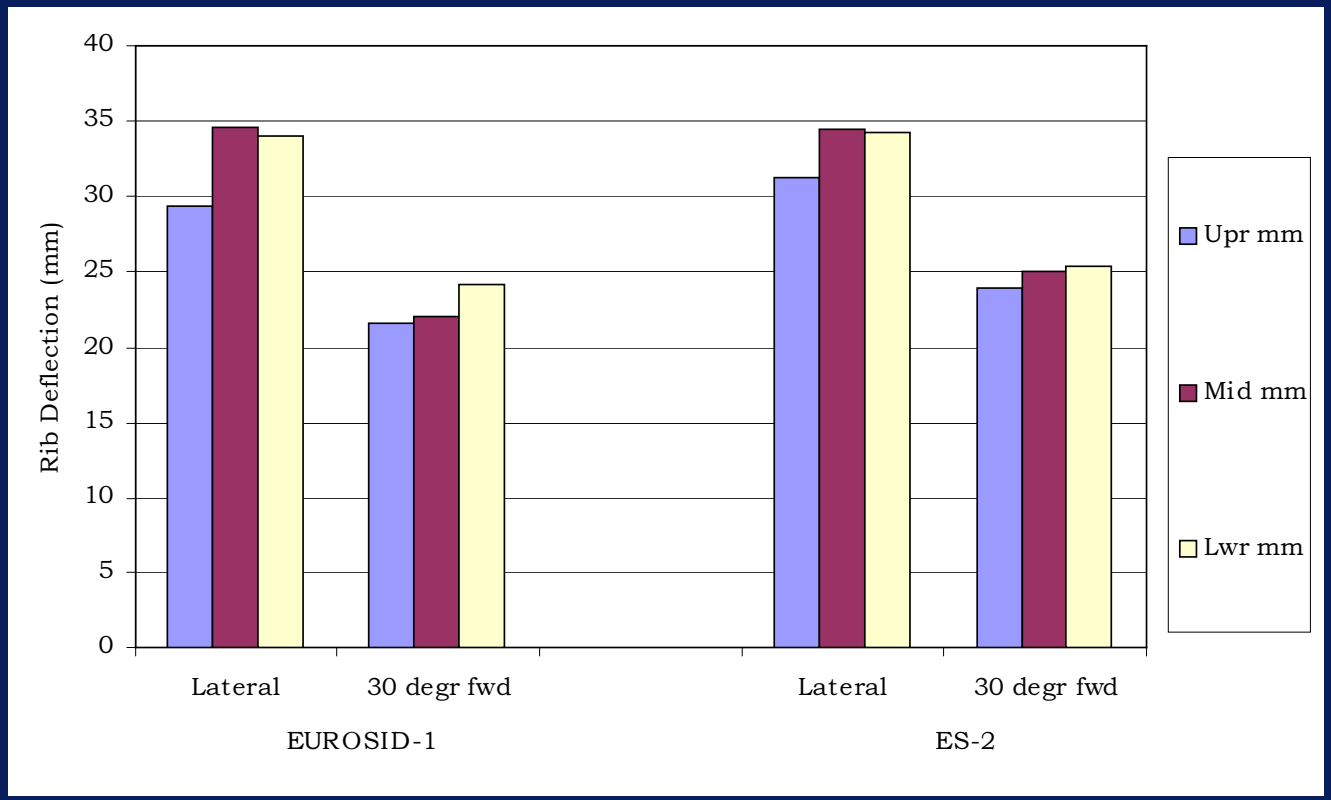
- **Friedel et al. data shows evidence of flat-tops at angled impacts, suggesting rib binding for EUROSID-1**
  - The European side impact dummy EUROSID, Proceedings of the seminar held in Brussels, December 1996, Fig 6, page 96
- **NHTSA bumper pendulum data on EUROSID-1 does not show continuous response**



Inter Rib Homogeneity

EEVC Review

- New full body pendulum tests were performed (4.3 m/s)



Inter Rib Homogeneity

Conclusion

- Inter rib homogeneity in angled impacts should not be assumed for EUROSID-1 or ES-2
- Continuous response between upper, mid and lower ribs in angled impacts may be related to rib binding, and therefore is less likely observed for the ES-2 dummy than for EUROSID-1
- In pendulum impact tests, ES-2 and EUROSID-1 show identical behaviour

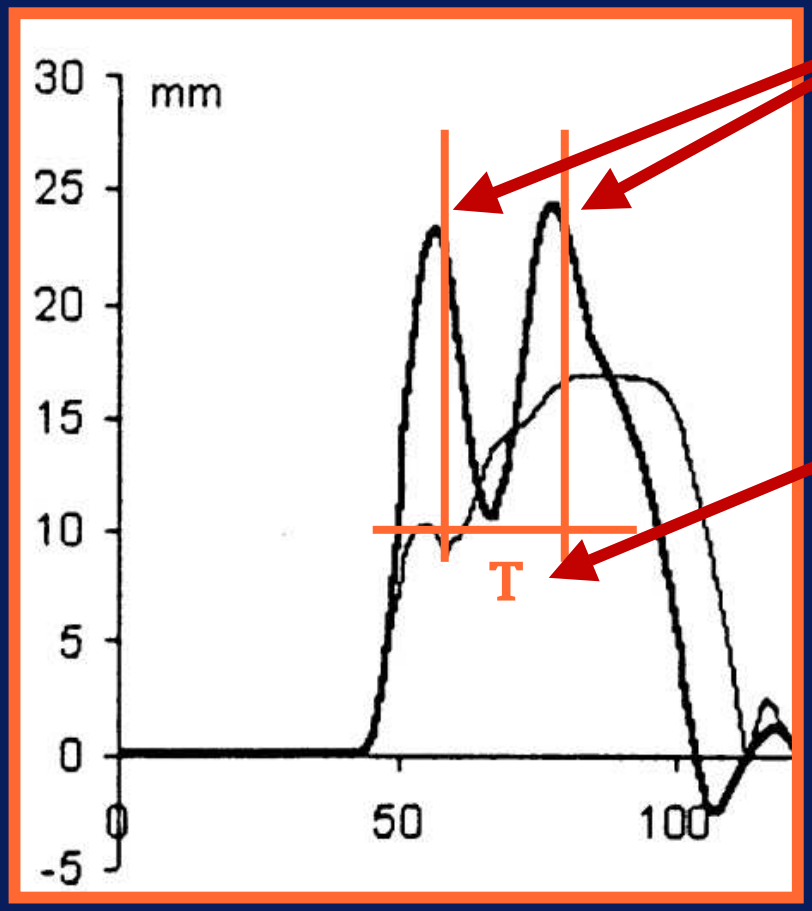
Thorax Damping Characteristics

OICA Concern

- Friction is eliminated in ES-2 and compensated by increasing tuning spring stiffness
- This leads to stiffer thorax with less overall damping which is not appropriate

Thorax Damping Characteristics

Concern



Double peak of same magnitude at small deflection

Oscillations (~50 Hz) observed on three ribs

Thorax Damping Characteristics

Review

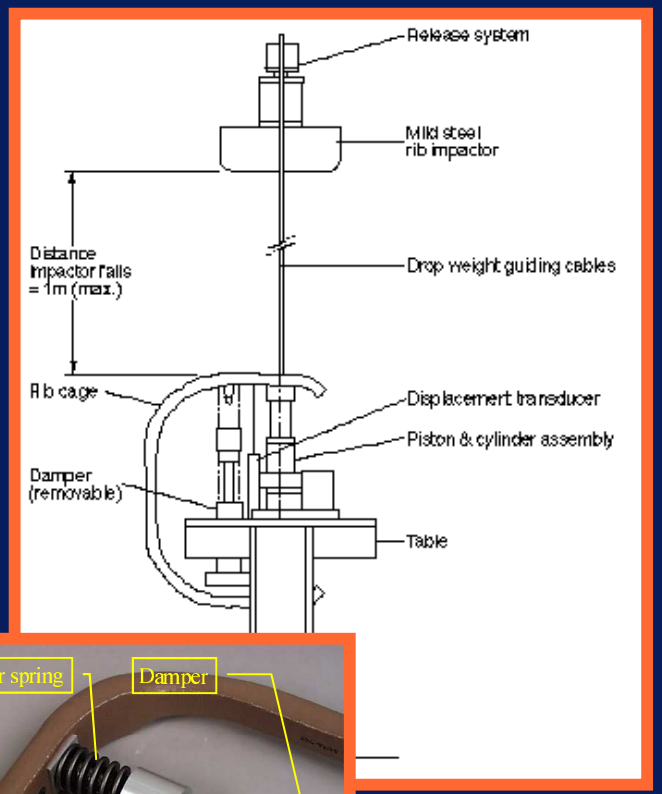
- Theoretical calculation of eigenfrequency shows differences are small between EUROSID-1 and ES-2

- New series of rib only tests performed at TNO/FTSS to further vibration behaviour of EUROSID-1 and ES-2

Thorax Damping Characteristics

Review

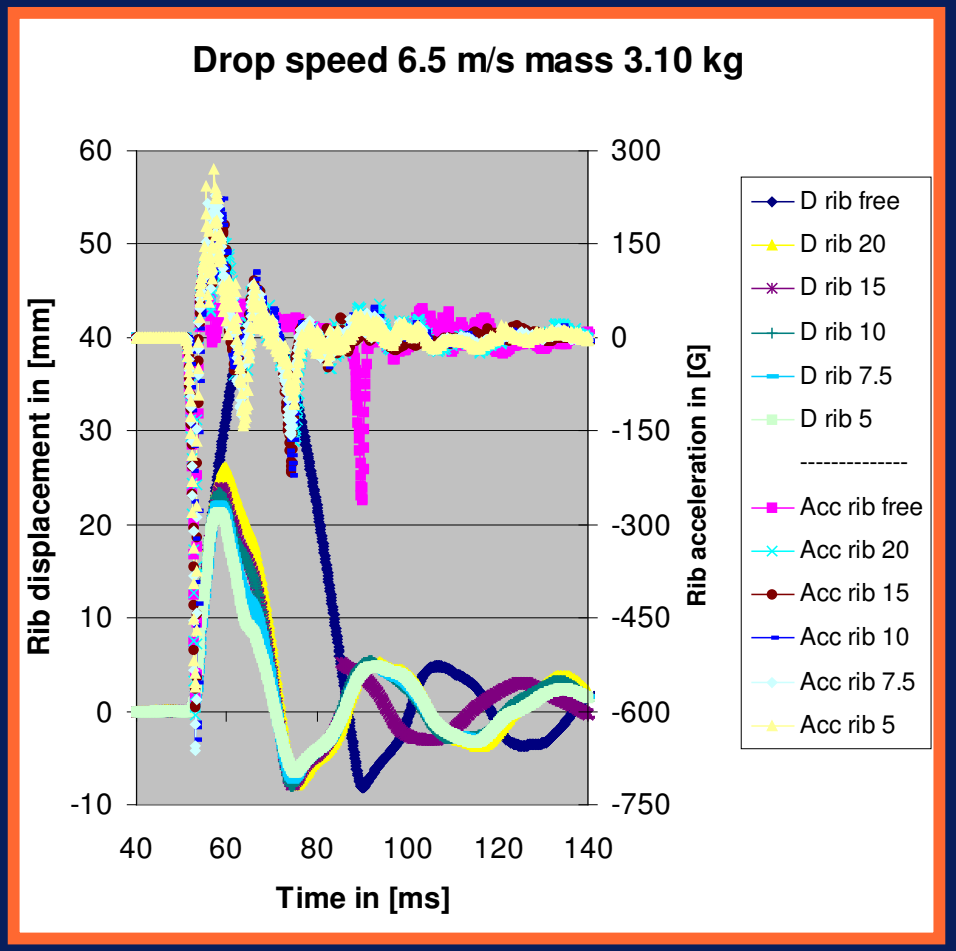
- Certification-type rib drop
- Impactor mass stopped after 5, (7.5), 10, 15, 20 mm (w.r.t. compressed foam) to study potential vibration
- Velocities 2.0, 3.0, 4.0, 6.5 and 8.0 m/s
- Mass 7.78, 3.1, 1.43 kg
- EUROSID-1 and ES-2



Thorax Damping Characteristics

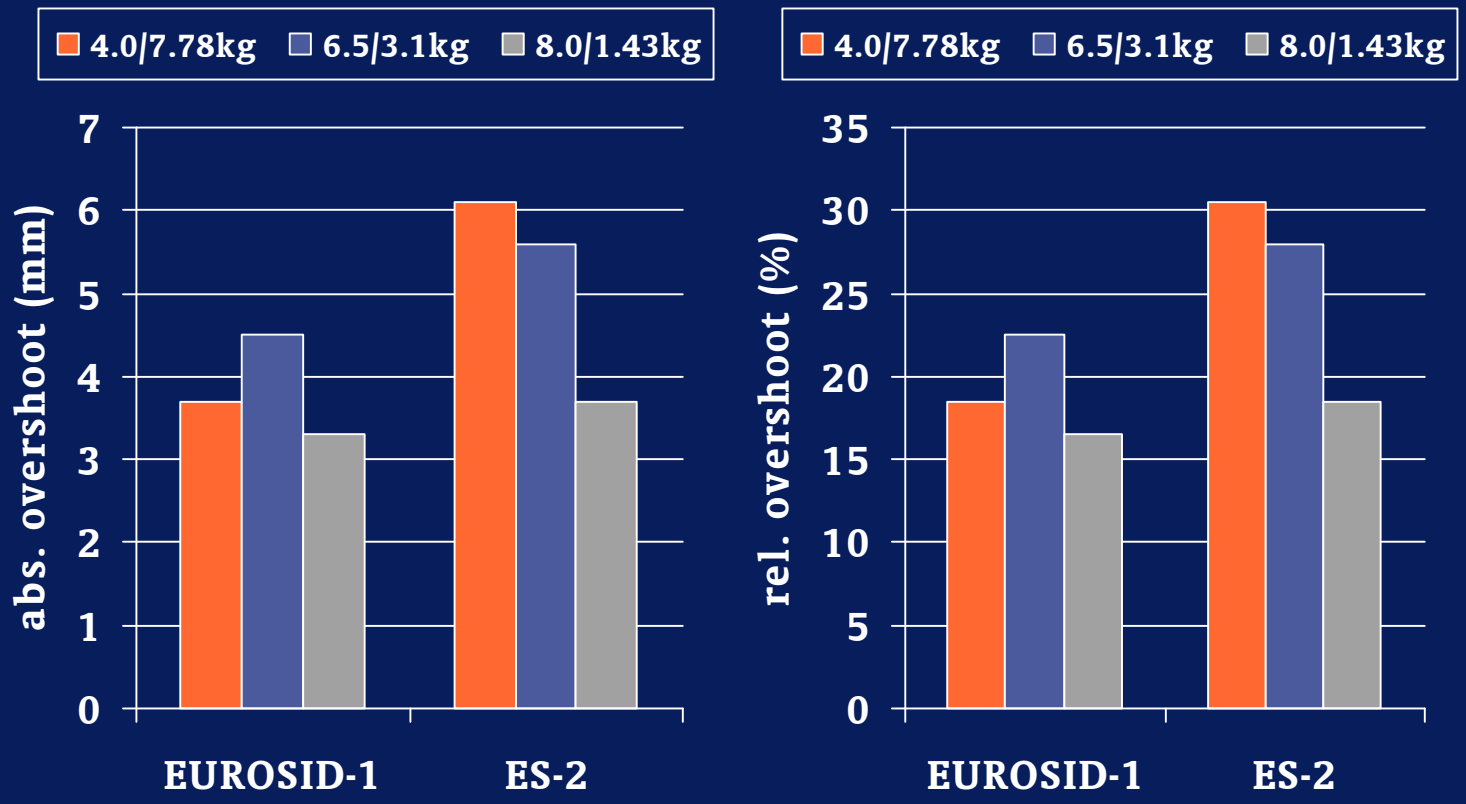
Review (cont'd)

- Similar behaviour for ES-2
- Relative overshoot at 20 mm clearance: (25.6-20)/20=28%
- No second peak in same order
- Different wave length from car test



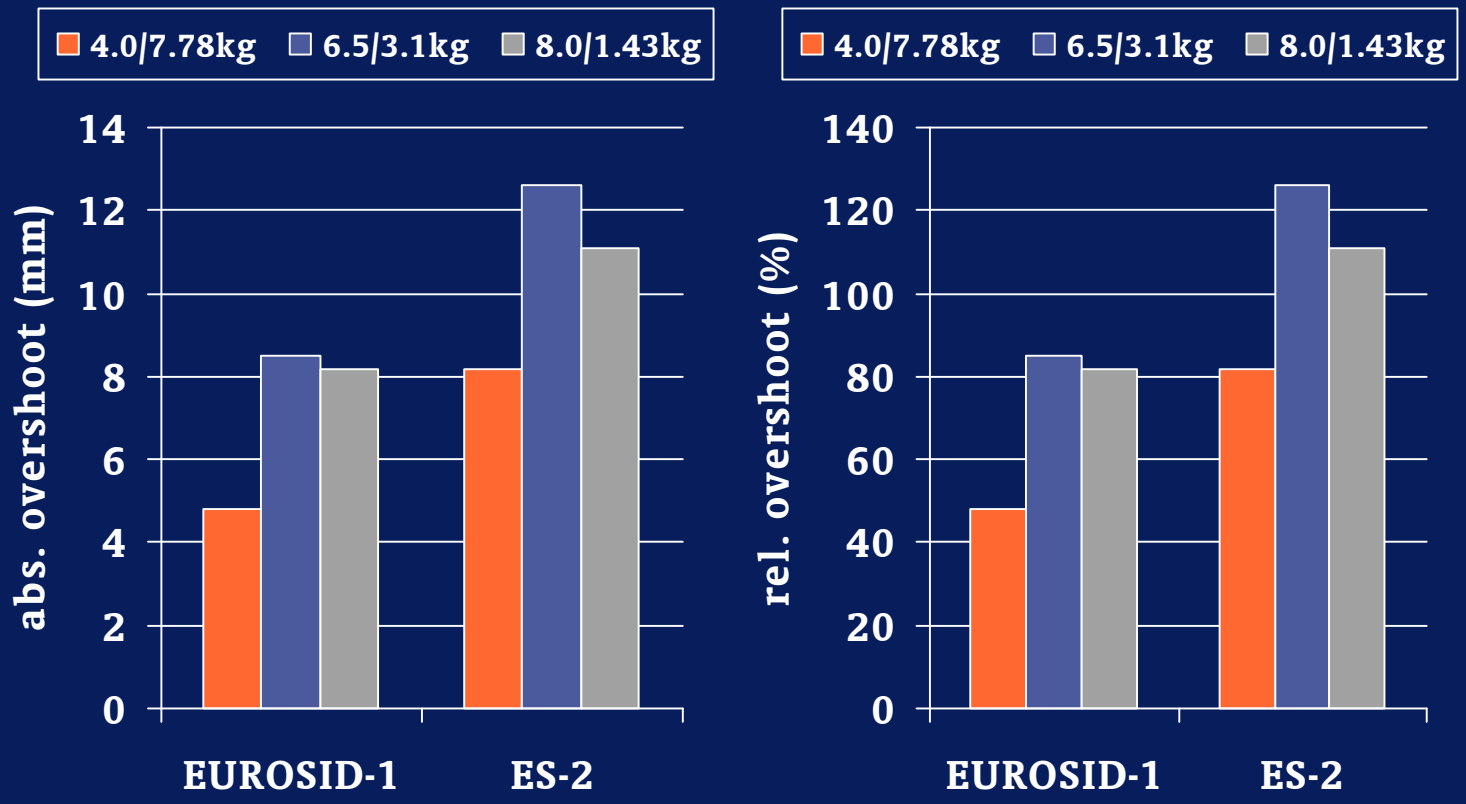
Thorax Damping Characteristics

- Comparison of overshoot in rib displacement, impactor stopped after 20 mm deflection



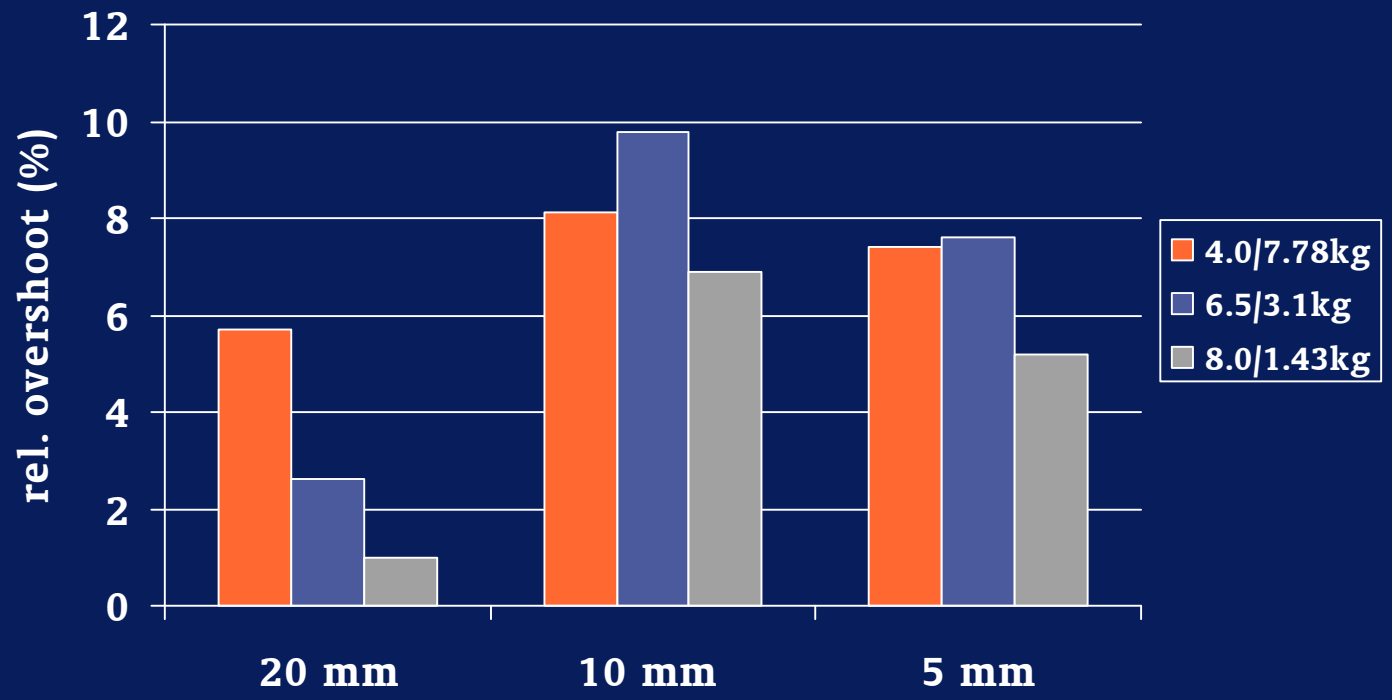
Thorax Damping Characteristics

- Comparison of overshoot in rib displacement, impactor stopped after 10 mm deflection



Thorax Damping Characteristics

- EUROSID-1/ES-2 comparison, normalised to injury criterion (42 mm), impactor stopped after 20, 10 and 5 mm deflection



Thorax Damping Characteristics

Conclusion

- Overshoot occurs in rib deflection for EUROSID-1 and ES-2
- This effect is (relatively) largest for small deflections
- This is explained by the design of the EUROSID-1/ES-2 rib module, in particular the combination of spring and damper
- No evidence for natural vibration found

Thorax Damping Characteristics

Conclusion (cont'd)

- Reduced friction and angular sensitivity has lead to increase of overshoot in ES-2 compared to EUROSID-1
- This increase is the same magnitude as observed in overall rib readings from vehicle tests, but relatively small compared the injury criterion
- For higher velocities, the difference between EUROSID-1 and ES-2 overshoot becomes smaller

Interaction Between Body Segments

OICA Concern

- Besides thorax, changes were made to other body part, in particular pelvis
- Their effect on thorax loading needs to be investigated
- Biomechanical reasons have to be given before applying them in regulation

Interaction Between Body Segments

EEVC Review

- Most significant change in the lower body region is the change of mass distribution in the upper leg
- The new distribution of mass better corresponds to the actual human and addresses the “unrealistic” high peaks in pubic responses
- Pelvis and lumbar spine stiffness have not been changed
- Full body Heidelberg tests show unaffected performance for ES-2 (see point 1)

Interaction Between Body Segments

Conclusion

- Changes in ES-2 lower body are sufficiently biomechanically supported and have been implemented to solve a EUROSID-1 deficiency
- Further points made by OICA are not valid as the Heidelberg test results demonstrate comparable behaviour between the two dummies

Overall conclusions

- EEVC WG12 has addressed the issues put forward by OICA
- Review of evidence and new component test results further confirm the conclusions in the EEVC report
- Contact has been sought with representatives of industry to discuss these findings
- No immediate design change is prompted by the comments received by OICA