EEVC Rear Impact Activities

Meeting of Experts on Rear and Side Impact Dummy Harmonization

U.S. Department of Transportation, Washington, D.C.

5-6 November, 2009

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EEVC Rear Impact Activities

EEVC WG20 Terms of Reference

- **Develop a static test of head restraint geometry**
  - **First stage in the mitigation of injuries in low-speed rear impacts**
- **Consider the development of a dynamic test of head restraint geometry as an optional alternative to the static test**
  - **Advise SC whether option should be pursued further**
  - **If so, develop a validated test procedure and cost-benefit**
- **Develop a dynamic injury risk assessment test procedure for rear impacts**
  - **Prime focus on neck injury reduction**
- **Provide EEVC contribution to the GRSP Global Technical Regulation informal WG on head restraints**

EEVC Rear Impact Activities

EEVC WG12 Terms of Reverence

- **Recommend a specific dummy design**
  - For the sled based whiplash injury assessment procedure developed by WG20
  - Based on a set of clearly defined biomechanical response requirements
- **Evaluate the repeatability and reproducibility of the selected dummy for whiplash assessment**
  - Taking account of test conditions specified by WG20 and the latest certification requirements for the dummy
- **Validate criteria for injury assessment / seat performance assessment**
  - Focus on long-term injuries

EEVC Rear Impact Activities

Static Test Procedures

- Evaluation of HRMD-based procedure
- Evaluation of CMM-based procedure
  - Recommended – just as effective and easier to implement as a standalone procedure
- Cost-benefit
  - Basis for selecting height and backset requirements
- Identification of problems with UNECE Reg17 height measurement method
  - Overestimates level of protection offered

EEVC Rear Impact Activities

Dynamic Geometric Test Procedures

- **Evaluation of several options**
  - **Hybrid III head angle**
  - **BioRID measurements (e.g. forces, moments, accelerations)**
  - **BioRID head dynamic backset**
    - **Recommended option**
- **Preliminary validation from existing data**
  - **Good reproducibility (5 labs; 5 BioRIDs; accel and decel sleds)**
  - **Validated against Kleinberger *et al.* (ESV 2007) data**
    - **Correlates with IIWPG rating for 4 seats**

Dynamic Test of HR Geometry

Dynamic Test of HR Geometry

Dynamic Test of HR Geometry

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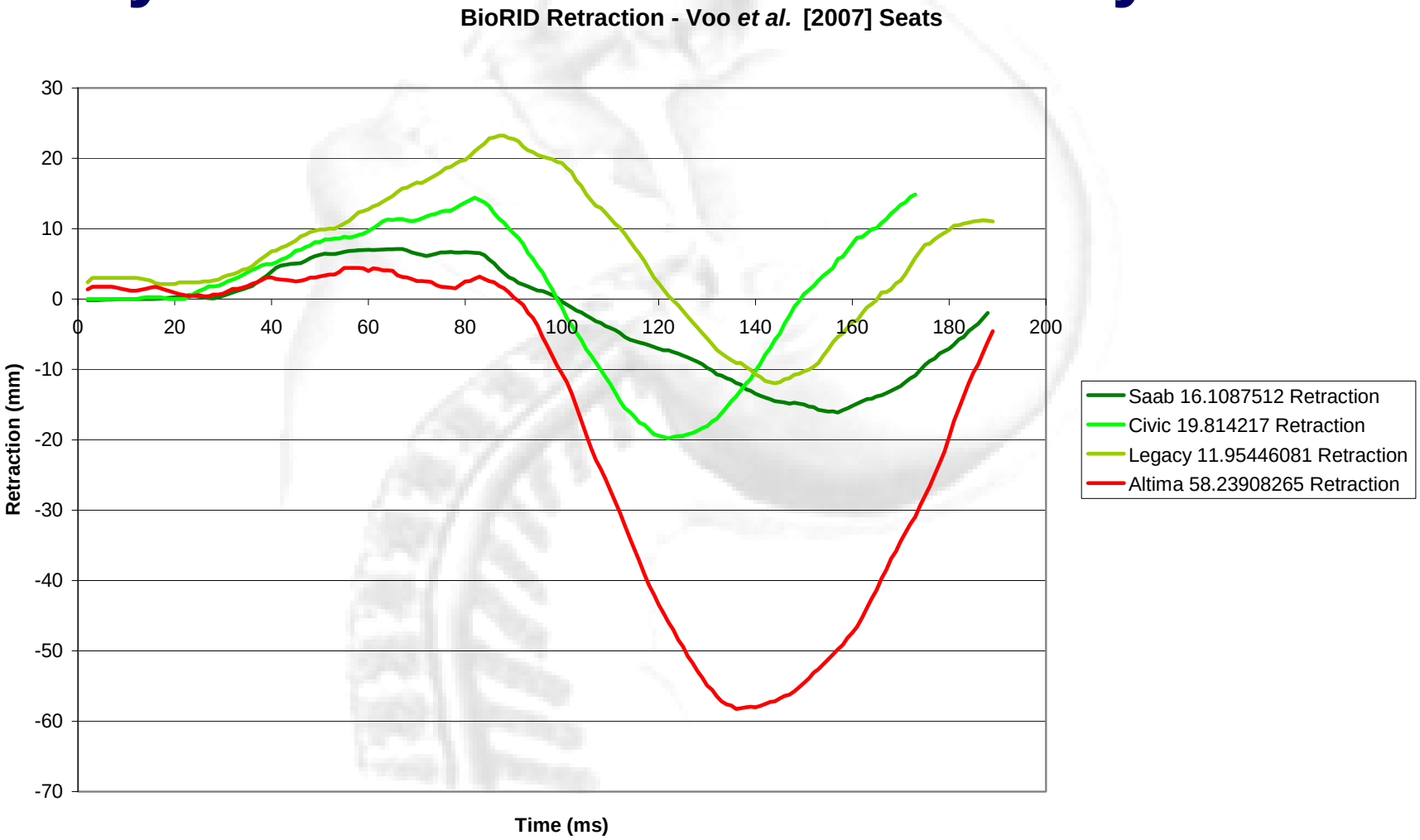
Dynamic Test of HR Geometry



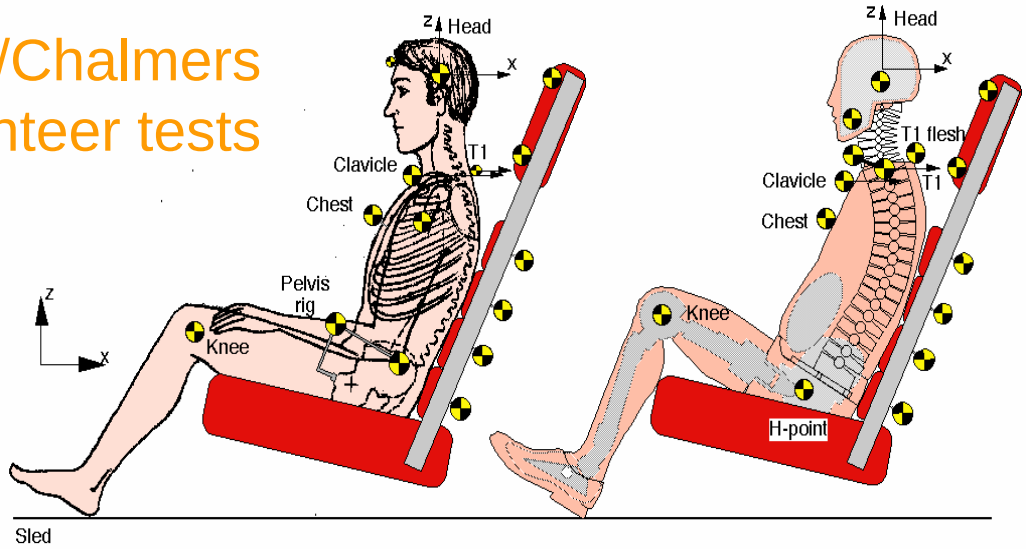
Biofidelity Evaluation - Test Conditions

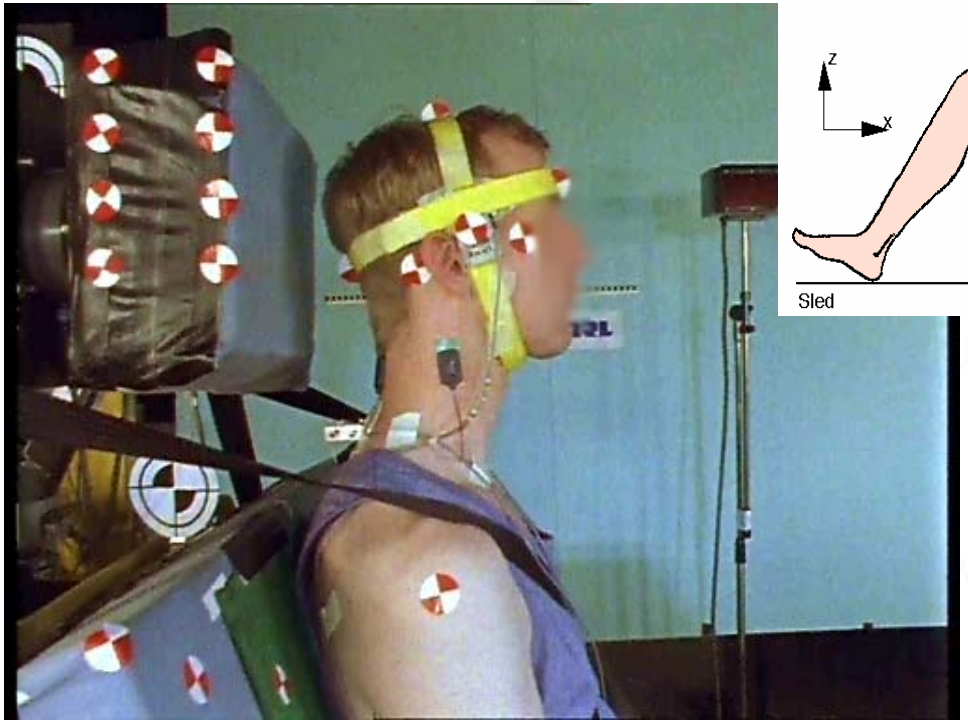
- **Rear impact biofidelity requirements chosen, based on**
  - **The availability of the full data set**
  - **Quality of the test set-up and instrumentation**
  - **Reproducibility**
  - **Relevance of the test conditions, loading condition and velocity change**
  - **Distribution of subject anthropometry, gender and age**
  - **The number of tests and test subjects**

- **Biofidelity requirements**
  - **4 based on volunteer data**
  - **1 based on PMHS data**

Biofidelity Evaluation - Test Conditions

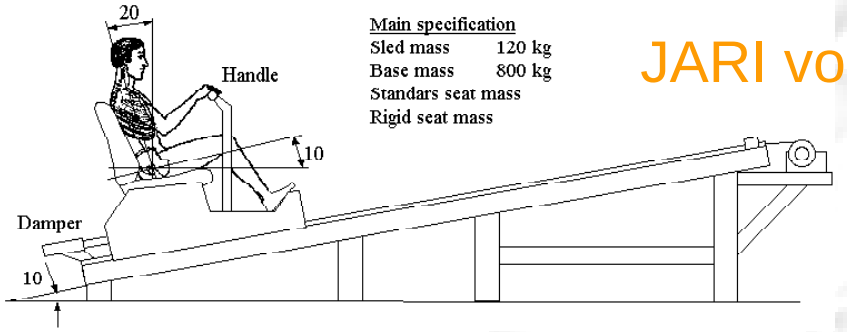
AZT/Chalmers volunteer tests



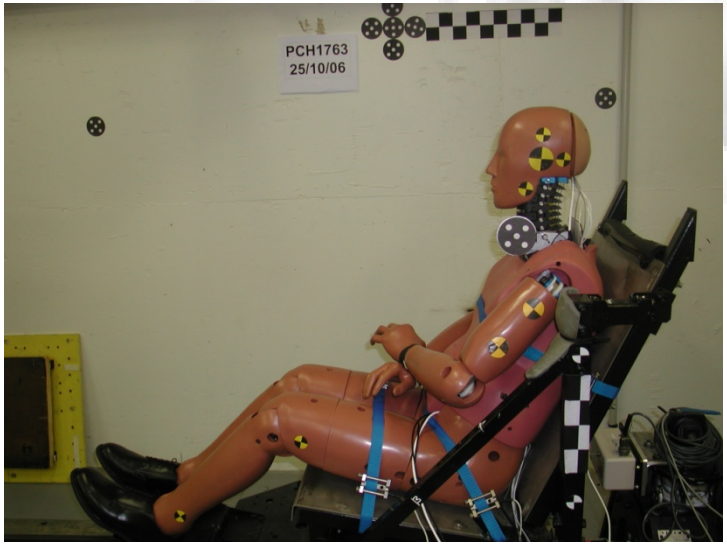


TRL volunteer tests

Biofidelity Evaluation - Test Conditions



JARI volunteer tests

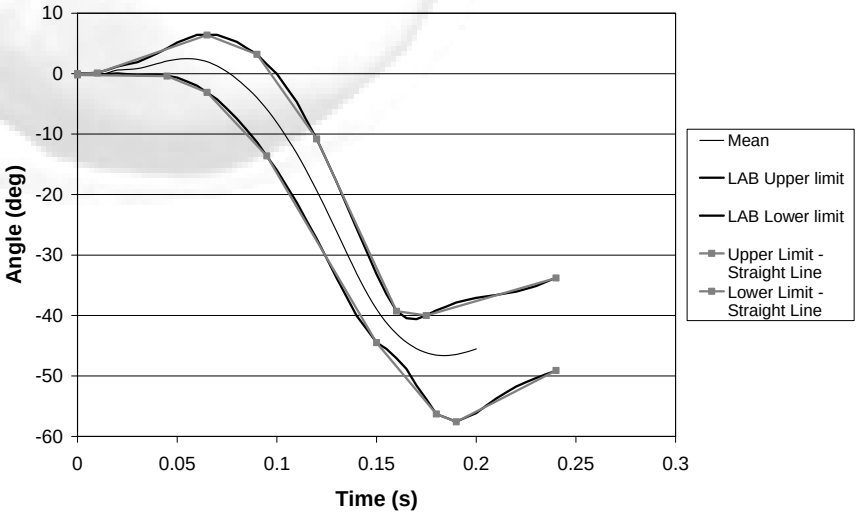


LAB PMHS tests

GDV/Allianz volunteer tests

Biofidelity Requirements

- **Most relevant criteria prioritised**
  - **E.g. head angle, T1 angle, head CoG displacement…**
- **New target corridors developed using a standardised method**
  - **EEVC WG9 method**
  - **Mean ± 1 std dev**
  - **Straight line approximation for tabulation**



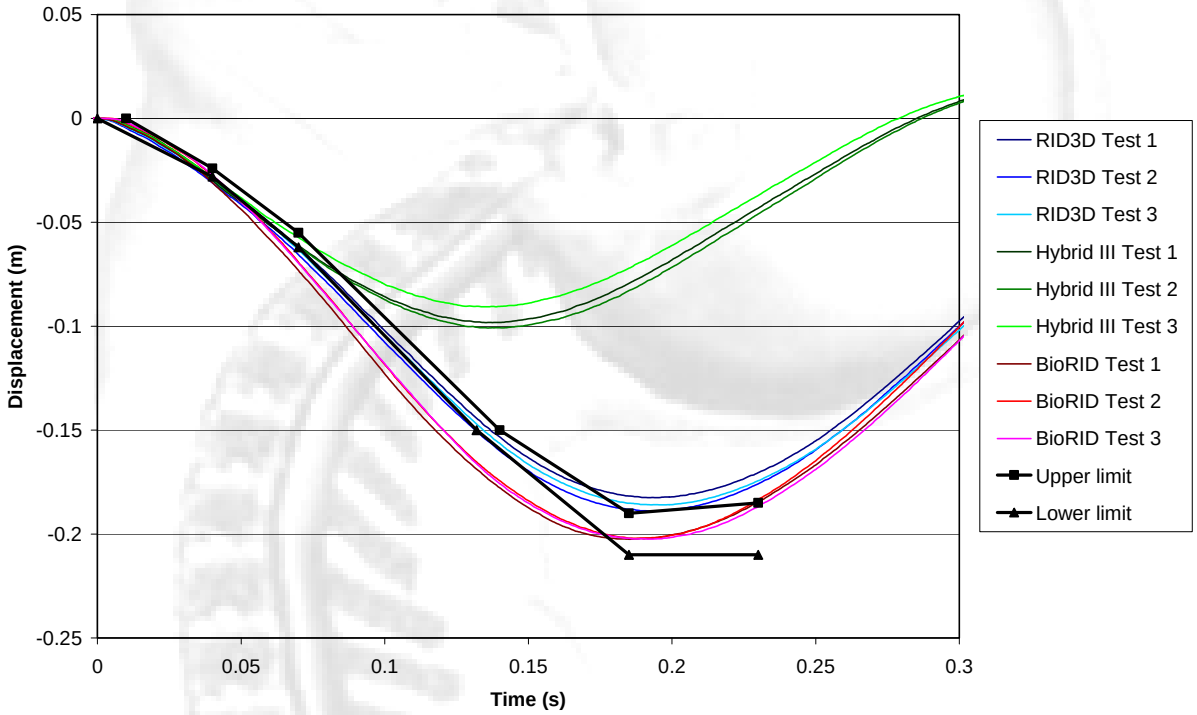
LAB - head angle wrt T1 co-ordinate system

Biofidelity Analysis

- **Subjective analysis**
  - Performance with respect to target corridors
  - Influence of seat type and relevance to real-world seat testing
- **Objective analysis**
  - CORA analysis - goodness of fit of each dummy response to each mean PMHS or volunteer response
    - Algorithm developed by PDB
    - Score 1 if entirely within inner corridor (mean human ±1 std dev)
    - Score 0 if entirely outside outer corridor (mean ±2 std dev)
    - Linear aggregation between these limits

Biofidelity Results

- **Some typical results…**



LAB test results - head CoG x-axis displacement w.r.t. the sled - PMHS, no head restraint

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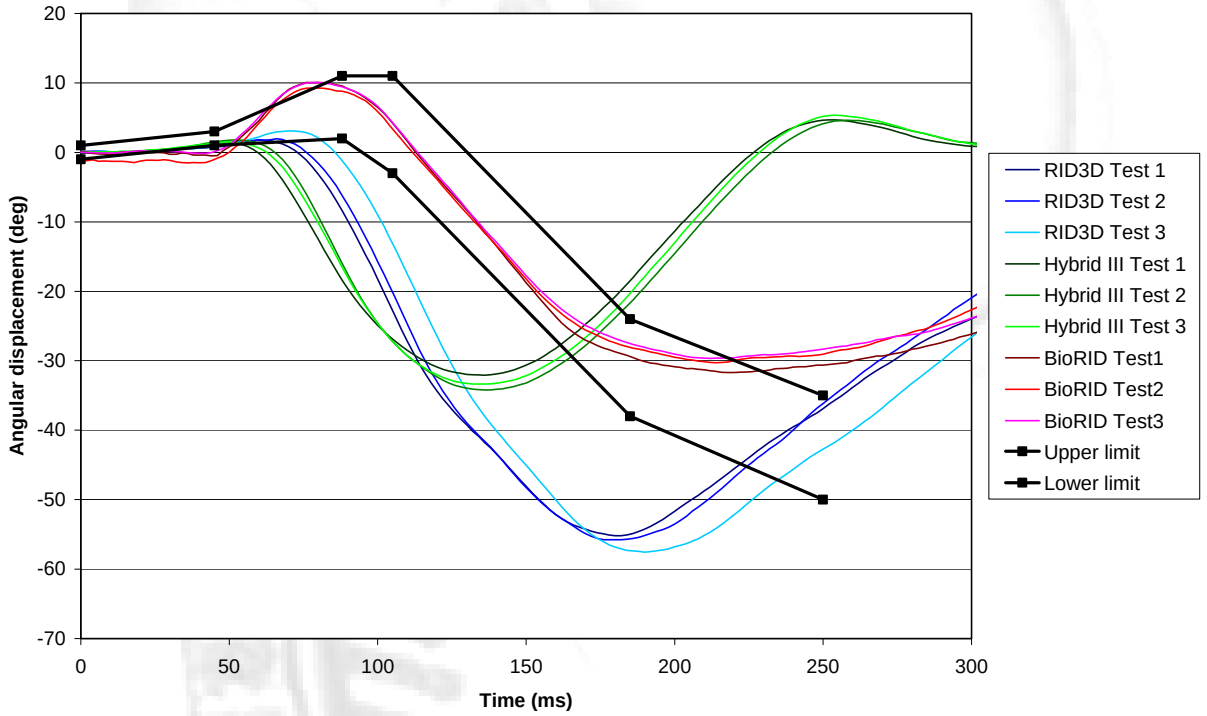

JARI test results - head rotation w.r.t. T1 - volunteer, no head restraint

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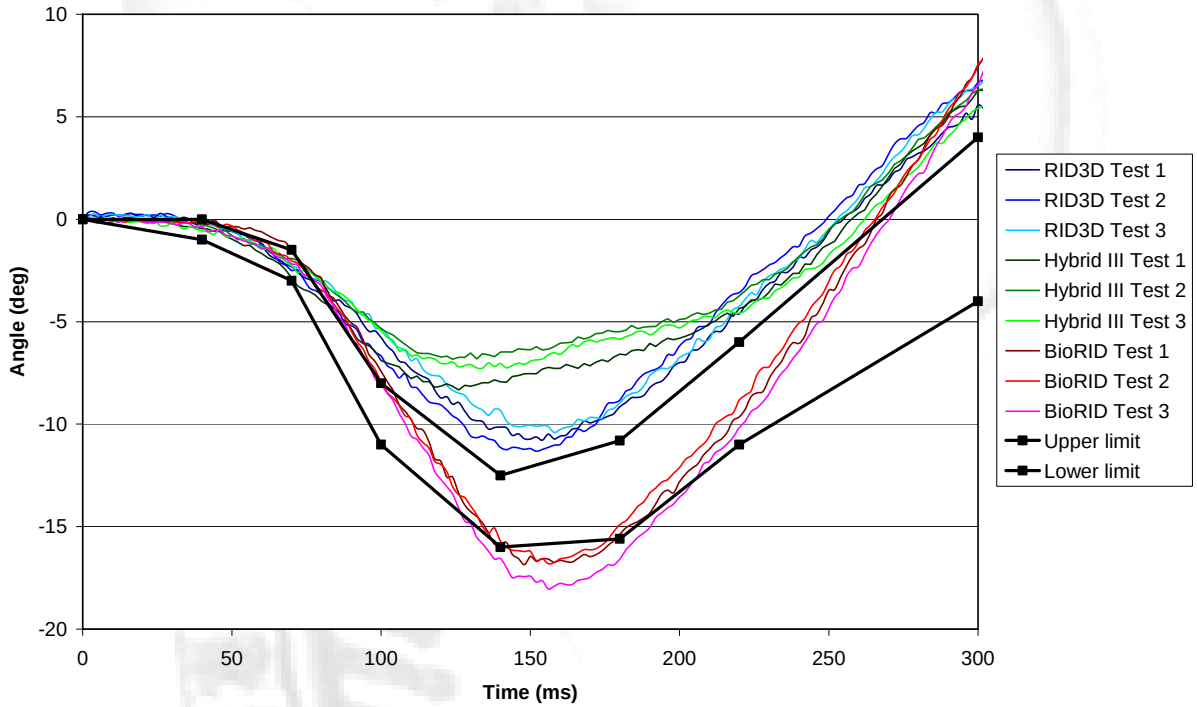

Chalmers/AZT test - T1 angle w.r.t. the sled

Biofidelity Results

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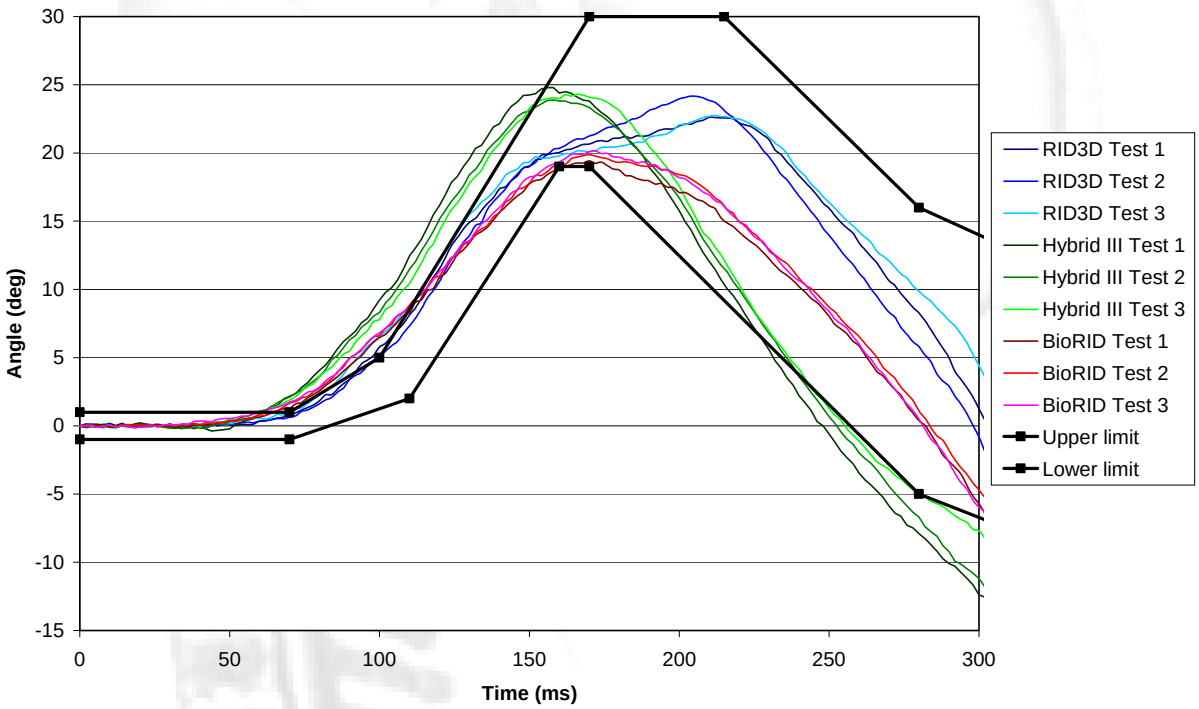

Chalmers/AZT test - Head rotation w.r.t. the sled

Biofidelity Results

- **Biofidelity - Hybrid III**
  - **Head motion w.r.t. T1 not biofidelic**
  - **Head rotation good in some seats, poor in others - biofidelity seat dependent**
  - **T1 rotation generally not biofidelic**
  - **Head acceleration poor**
  - **Seat back interaction least humanlike**
  - **Head restraint interaction least humanlike - contact force too low**

Biofidelity Results

- **Biofidelity - RID^{3D}**
  - Biofidelity better at higher test severity
  - Not as able to accommodate different seat structures as BioRID and seat back interaction not as good as BioRID
  - Head restraint interaction comparable to BioRID II
- **Biofidelity - BioRID II**
  - Best overall biofidelity, although z displacements not good (nor for Hybrid III nor RID^{3D})
  - Head restraint interaction comparable to RID^{3D}
  - Seat back interaction most humanlike

Biofidelity Results

- **Objective CORA analysis**

Parameter	RID^{3D}	Hybrid III	BioRID II
T1 angle w.r.t. the sled	0.55	0.38	0.77
T1 x-axis displacement	0.53	0.50	0.47
T1 x-axis acceleration	0.56	0.48	0.60
Head rotation w.r.t. T1	0.45	0.28	0.59
Head C of G x-axis displacement w.r.t. T1	0.49	0.50	0.60
Head rotation w.r.t. the sled	0.49	0.29	0.62
Head C of G x-axis displacement w.r.t. the sled	0.62	0.43	0.46
Overall	**0.53**	**0.41**	**0.59**

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Conclusions

- Hybrid III, RID^{3D} and BioRID II successfully evaluated in five biofidelity test conditions
- Hybrid III had insufficient biofidelity to be considered further as a test tool for low-speed rear impact
- For many parameters, RID^{3D} and BioRID II were similarly biofidelic wrt target corridors
  - Subjectively, BioRID slightly better
  - Objectively (CORA analysis) BioRID scored higher (0.59) than RID^{3D} (0.53) - average of seven parameters from five test conditions
- BioRID showed better seat back and head restraint interaction

Conclusions

- **Overall, recommend that based on the currently available biofidelity data, BioRID II is the most suitable dummy for use in a low-speed rear impact test procedure**
  - **Scope for improvement of T1 vertical motion**

End of Presentation

Presented by David Hynd, TRL Limited

Chairman, EEVC WG20

Tel: +44 1344 770310 Email: wg20chair@eevc.org