



Injury Criteria for Q Dummies in Frontal Impact

Analysis performed for EEVC WG12 & 18

Prepared by: Kees Waagmeester (on behalf of EEVC WG12&18)

Date: June 13, 2007

Presentation Contents

- Summary of Q dummy Injury Criteria
 - Background & definition
- Injury Criteria Evaluation
 - Application of IC's/IARVs to CRS database
 - Impact of suggested IARVs

IARVs based on Scaling

- First method is a straightforward scaling approach of adult IARVs
- Scaling Method defined for Q dummies based on masses and dimensions
 - Method similar to Mertz
- Scaling factors defined using:
 - Q dummy geometrical data provided by TNO
 - Material properties as function of age as published by Mertz, H.J.

References: Mertz, H.J.: Proposal for Dummy response Limits for FMVSS 208 Compliance Testing, ISO/TC22/SC12/WG6 doc nr. N516, and: Biomechanical and Scaling Bases for Frontal and Side Impact Injury Assessment Reference Values, Stapp 2003-22-0009

Scaling Values of Q dummies

Factors used to scale Hybrid III 50th adult values to Q dummies:

		Q0	Q1	Q1.5	Q3	Q6
Head	HIC	0.49	0.45	0.53	0.71	0.98
	Accel	0.99	0.84	0.87	0.94	1.03
Neck	Force	0.13	0.29	0.33	0.41	0.56
	Moment	0.07	0.22	0.25	0.33	0.50
Thorax	Displ (belt)	0.84	1.03	0.98	0.93	0.84

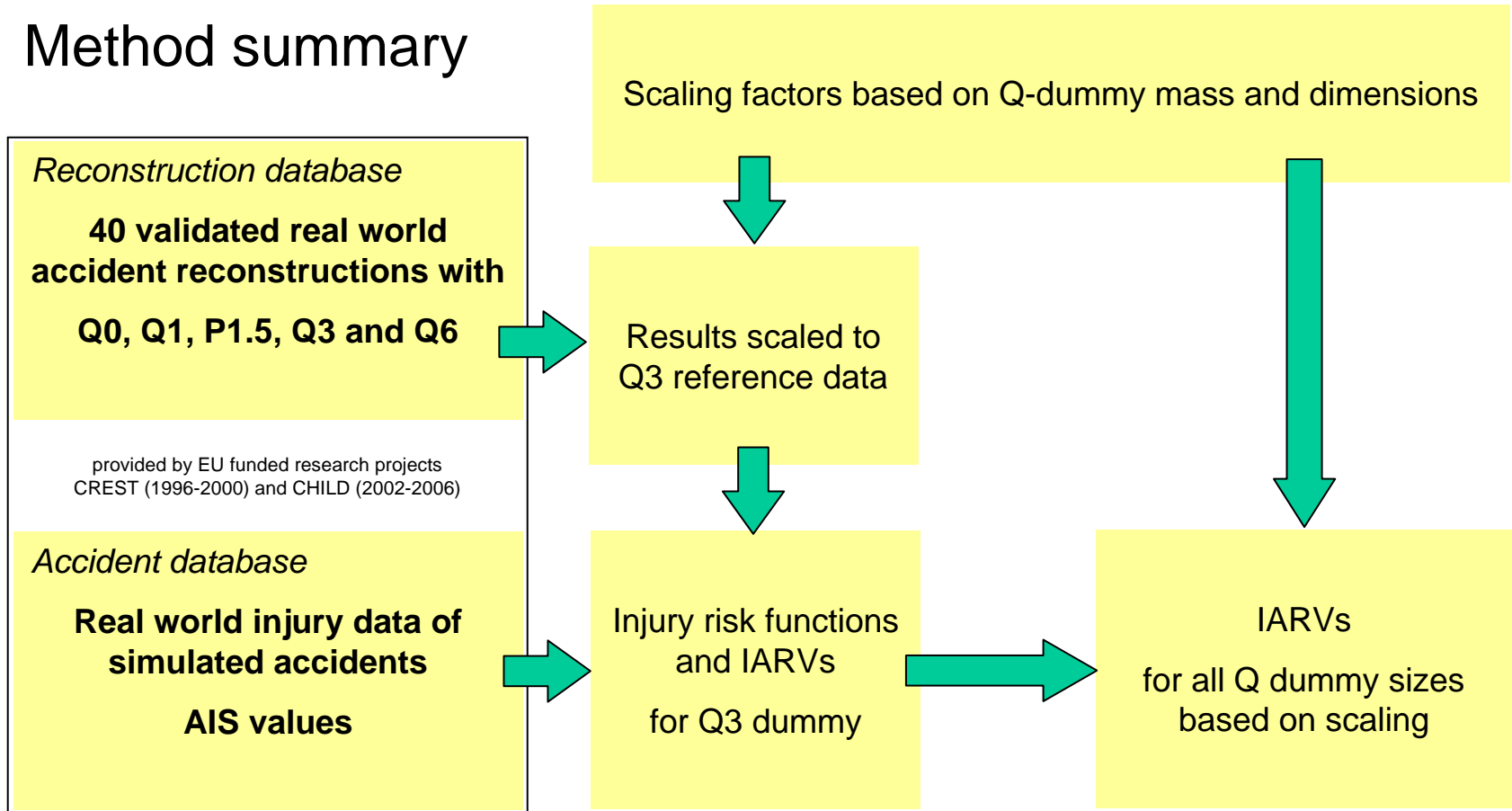
IARVs Based on Accident Reconstructions*

- Input data
 - 40 validated real world accident reconstructions with Q0, Q1, P1.5, Q3 and Q6 provided by EC funded projects CREST (1996-2000) and CHILD (2002-2006)
 - Real world injury data (AIS) of simulated accidents
- Definition method
 - Correction of test results (with all Q's and P's) with scaling factors to Q3 dummy size
 - Scaled Q-dummy test data and AIS information combined in injury risk curve and injury limits for Q3 dummy
 - Scaling of Q3 IARV's to Q0, Q1, Q1.5, Q3 and Q6 dummy size

*Note: Reference: Palisson, Cassan, Trosseille, Lesire, Alonzo, "Estimating Q3 Injury Criteria for Frontal Impacts Using the CHILD Project Results and Scaling Reference Values", IRCOBI 2007 (submitted)

Injury Criteria Definition Method

Method summary



Scaling Values of Q dummies

Factors to transfer test results from Q/P dummies to the Q3 dummy

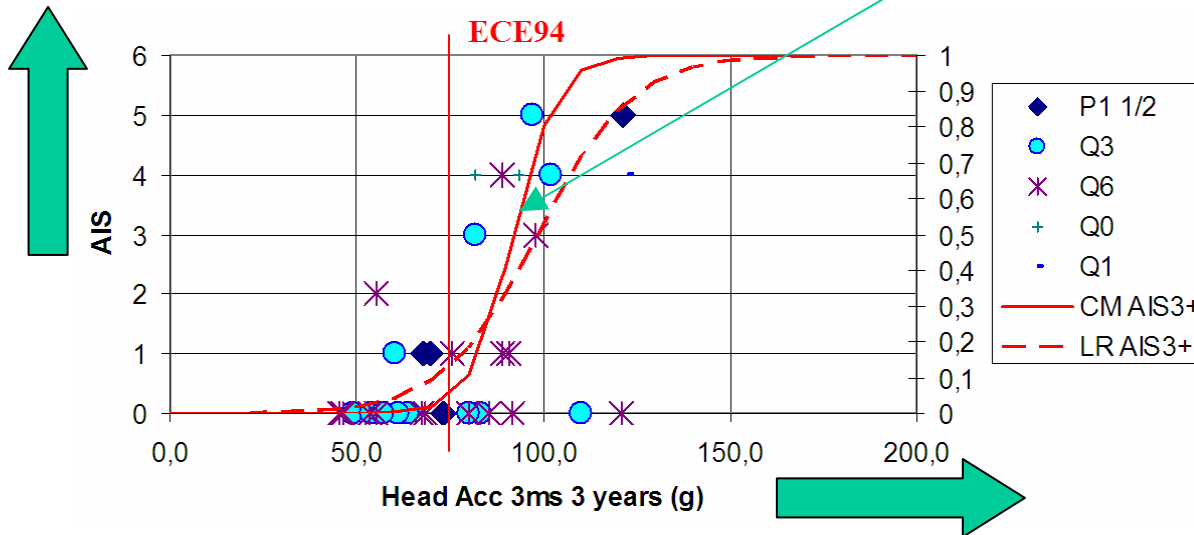
		Q0	Q1	Q1.5	Q3	Q6
Head	HIC	1.49	1.59	1.35	1.0	0.72
	Acc	0.95	1.12	1.07	1.0	0.91
Neck	Force	3.12	1.42	1.25	1.0	0.74
	Moment	4.76	1.49	1.30	1.0	0.67
Thorax	Displ (belt)	1.11	0.90	0.95	1.0	1.1

These values are used to scale up and down

Injury Risk Curves for Q3

- Input
 - Reconstruction data scaled to Q3 dummy size
 - Combined with real world injury data (AIS)

Real world injury severity data
AIS value (Abbreviated Injury Scale)

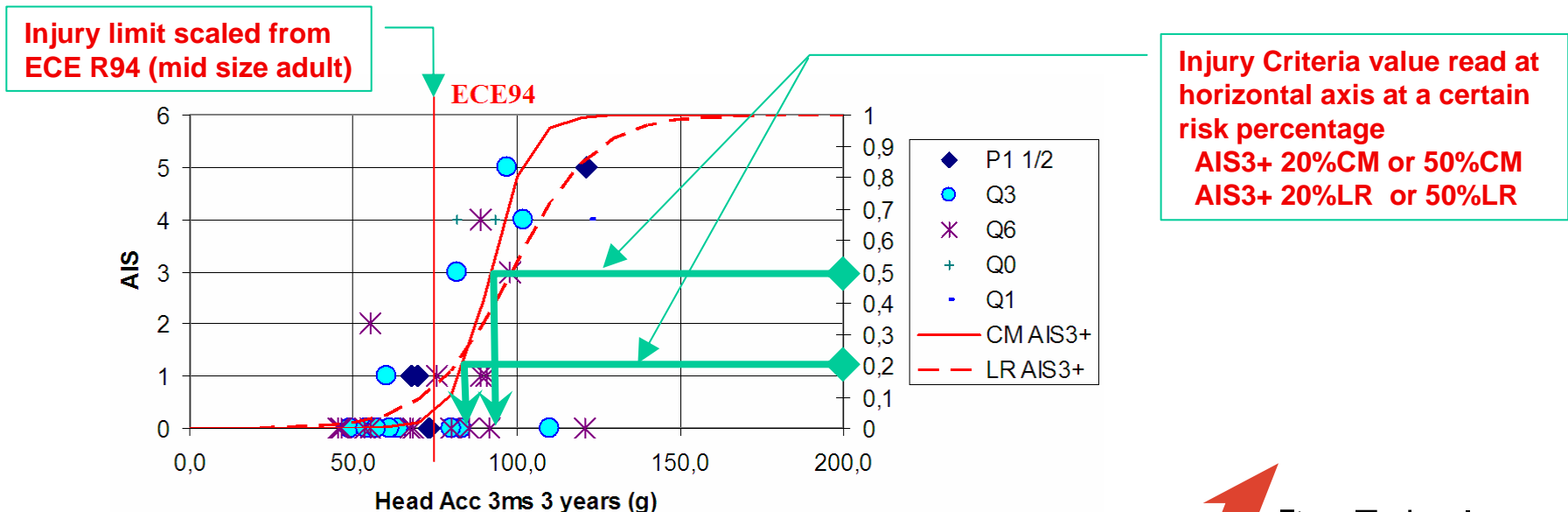


Injury Risk Curves defined
by setting AIS3+ as limit
Two methods:
CM =Certainty Method
LR =Logistic Regression

Measured parameter value
(scaled to Q3 dummy)

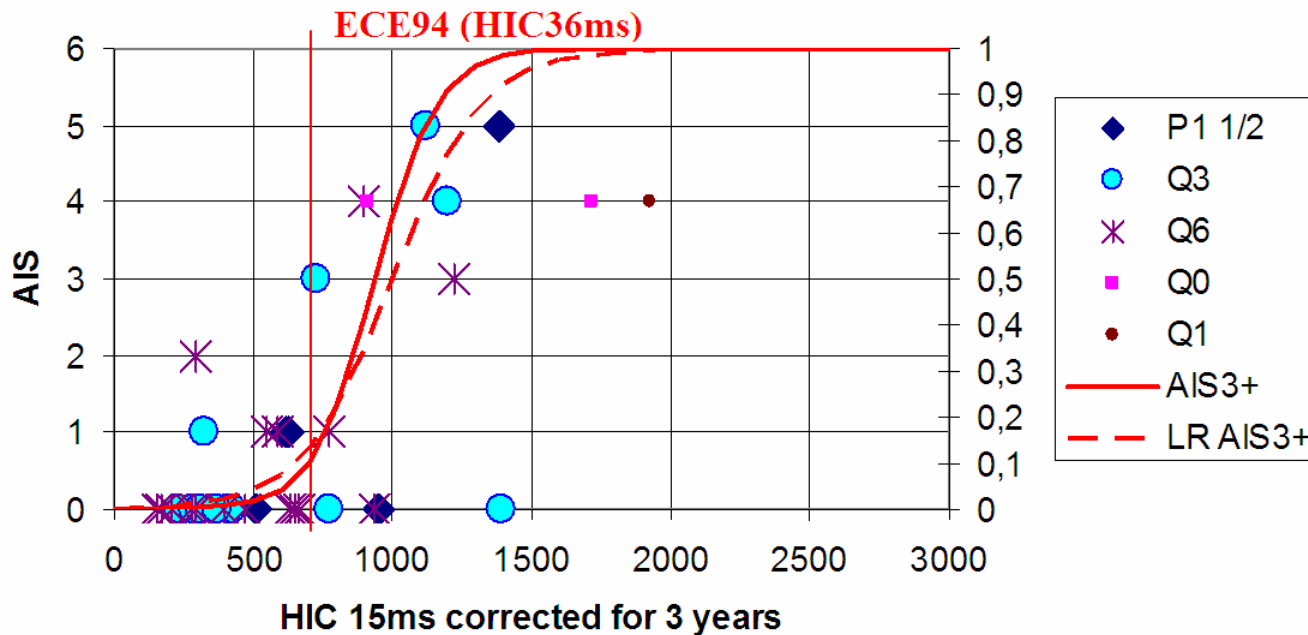
Injury Criterion Definition for Q3

- Injury Criteria Value (IARV) defined based on:
 1. Scaling of ECE R94 (adult) IARV ←
 2. AIS3+20%CM (Certainty Method) ←
 3. AIS3+20%LR (Logistic Regression)
 4. AIS3+50%CM (Certainty Method)
 5. AIS3+50%LR (Logistic Regression)



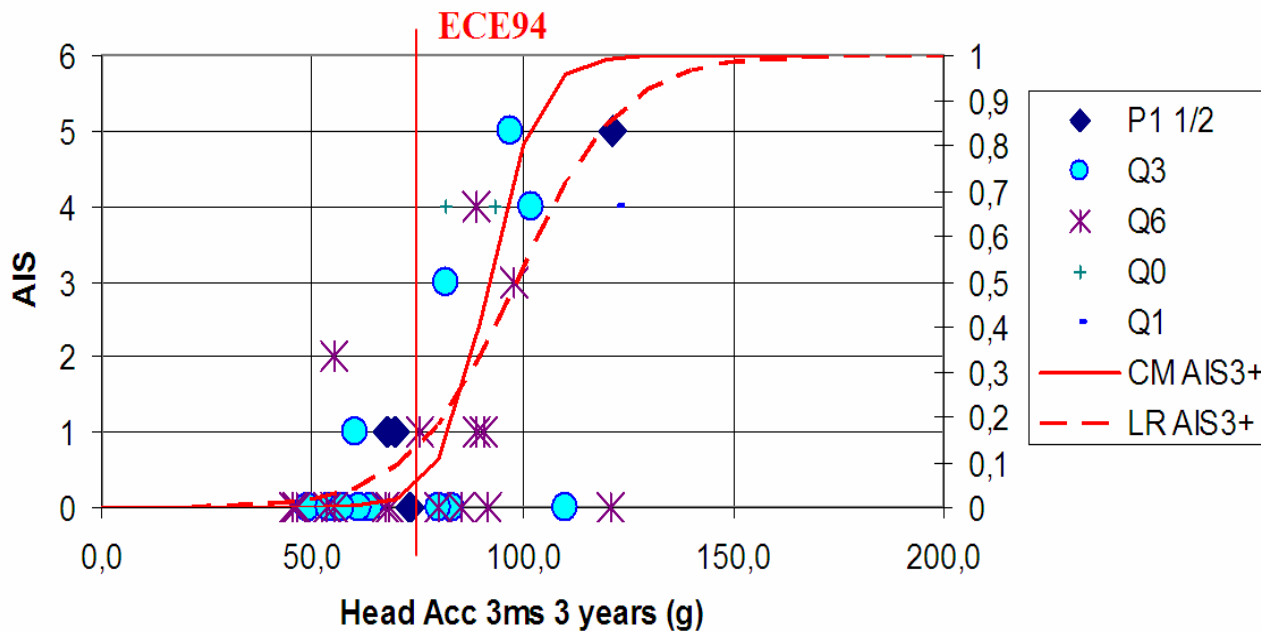
Injury Criteria Definition Q3

- Head Injury Criterion (HIC_{15ms})
 - ECE R94 scaled $HIC_{36ms} < 710$
 - Q3 AIS3+20%CM $HIC_{15ms} < 790$



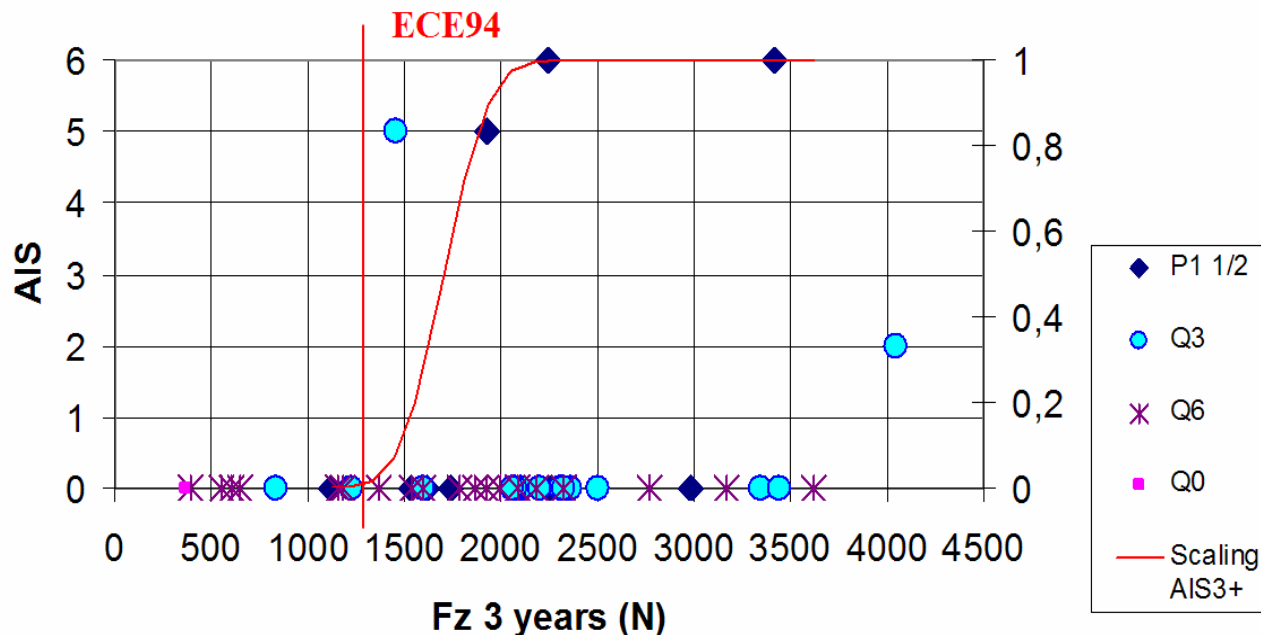
Injury Criteria Definition Q3

- Head 3 ms Acceleration Injury Criterion
 - ECE R94 scaled Head ACC 3ms < 75 g
 - Q3 AIS3+20%CM Head ACC 3ms < 84 g



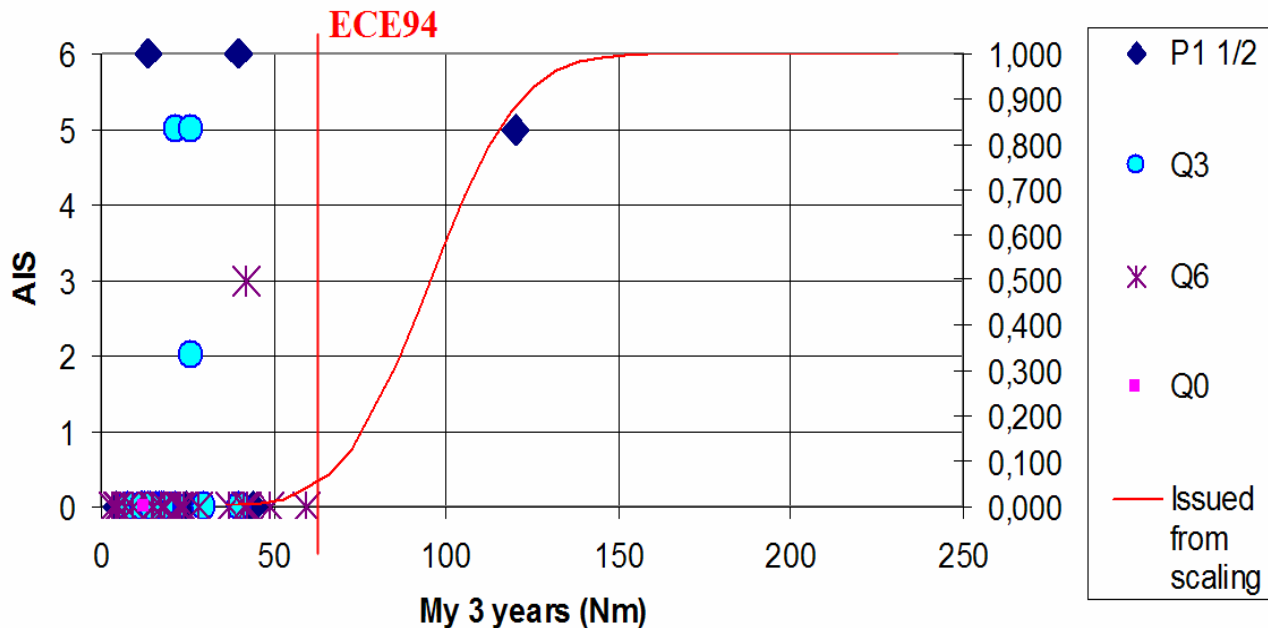
Injury Criteria Definition Q3

- Upper Neck Fz (tension) Injury Criterion
 - ECE R94 scaled Upper Neck Fz < 1350 N
 - Q3 AIS3+20% Upper Neck Fz < 1550 N



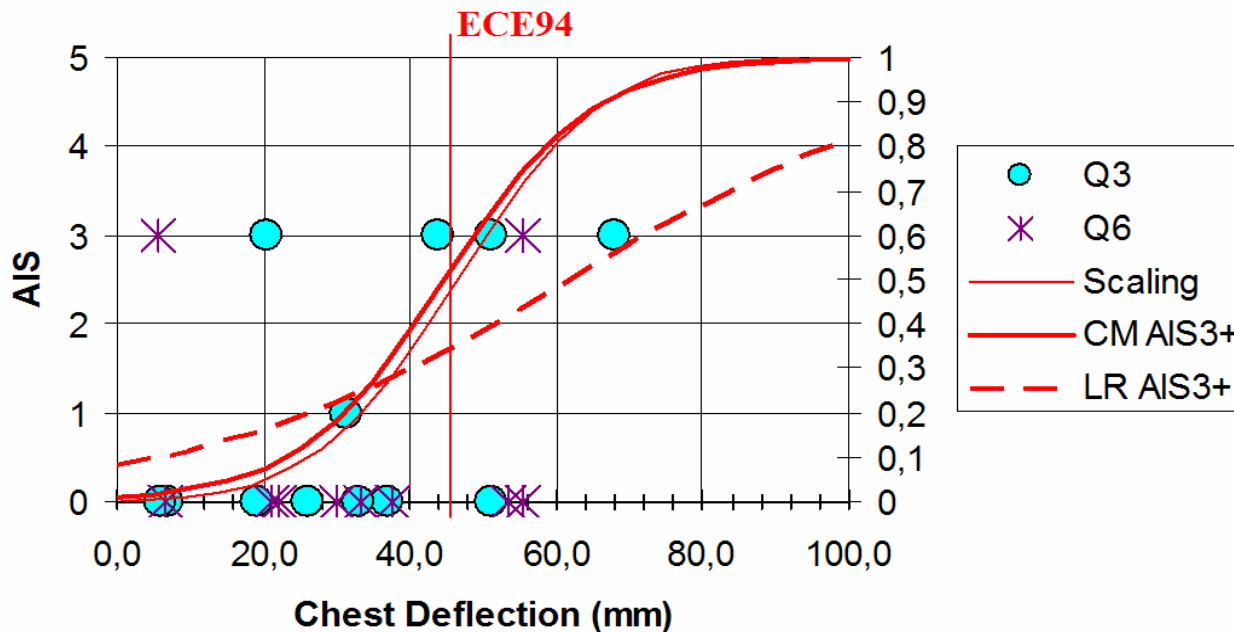
Injury Criteria Definition Q3

- Upper Neck My (flexion) Injury Criterion
 - ECE R94 scaled Upper Neck My < 63 Nm
 - Q3 AIS3+20% Upper Neck My < 79 Nm



Injury Criteria Definition Q3

- Thorax Chest Deflection Injury Criterion
 - ECE R94 scaled Chest defl. < 46.5 mm
 - Q3 AIS3+20% Chest defl. < 31.0 mm



Injury Criteria Scaled from ECER94

Injury criteria directly scaled from ECE R94 mid size male values

		Q0	Q1	Q1.5	Q3	Q6
Head	HIC ₃₆	477	447	526	710	986
	Acc	79	67	70	75	82
Neck	Force Fz	433	951	1080	1350	1824
	Moment My	13	42	48	63	94
Thorax	Displ (belt)		52	49	47	42

Injury Criteria from Accident Data

AIS3+ 20%CM - Injury criteria scaled from Q3 values base on real world accident reconstructions

		Q0	Q1	Q1.5	Q3	Q6
Head	HIC ₁₅	530	497	585	790	1097
	Acc	88	75	79	84	92
Neck	Force Fz	498	1095	1244	1555	2101
	Moment My	17	53	61	79	118
Thorax	Displ (belt)		34	33	31	28

Injury Criteria from Accident Data

AIS3+ 20%LR - Injury criteria scaled from Q3 values base on real world accident reconstructions

		Q0	Q1	Q1.5	Q3	Q6
Head	HIC ₁₅	523	491	578	780	1083
	Acc	85	72	76	81	89
Neck	Force Fz	498	1095	1244	1555	2101
	Moment My	17	53	61	79	118
Thorax	Displ (belt)		28	26	25	23

Injury Criteria from Accident Data

AIS3+ 50%CM - Injury criteria scaled from Q3 values base on real world accident reconstructions

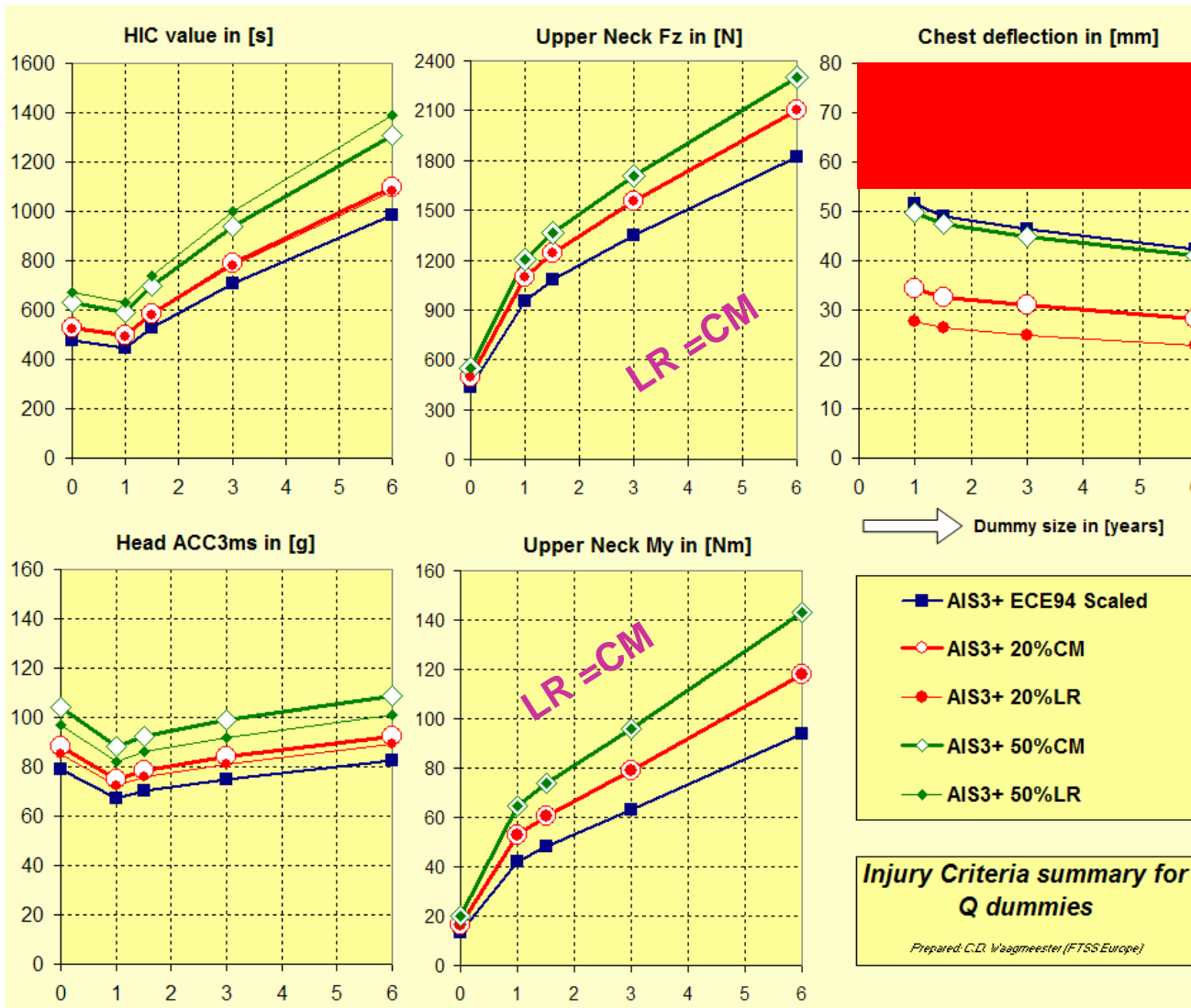
		Q0	Q1	Q1.5	Q3	Q6
Head	HIC ₁₅	631	591	696	940	1306
	Acc	97	82	86	92	101
Neck	Force	546	1201	1364	1705	2304
	Moment	20	64	74	96	143
Thorax	Displ (belt)		50	47	45	41

Injury Criteria from Accident Data

AIS3+ 50%LR - Injury criteria scaled from Q3 values base on real world accident reconstructions

		Q0	Q1	Q1.5	Q3	Q6
Head	HIC ₁₅	671	629	741	1000	1389
	Acc	104	88	93	99	109
Neck	Force Fz	546	1201	1364	1705	2304
	Moment My	20	64	74	96	143
Thorax	Displ (belt)		69	65	62	56

Injury Criteria Summary



- **HIC 15**
20% LR < CM
50% LR >> CM
 - **Head ACC 3ms**
20% LR < CM
50% LR < CM
 - **D chest**
20% LR << CM
50% LR >>> CM
- Difference LR and CM significant*

Injury Criteria Evaluation

What is the effect of application of the Injury Criteria as pass / fail criterion in CRS testing?



Jané Matrix



Team Tex basic



Maxi cosi Rodi

Injury Criteria Evaluation

Evaluation for frontal impact

- 152 ECE R44 tests with Q dummies
 - 36 Child Restraint System (CRS) types
 - 74 CRS – Dummy combinations
 - 12 Q0 dummy tests all rearward facing (RF)
 - 45 Q1 dummy tests 12 RF
 - 28 Q1.5 dummy tests 14 RF
 - 48 Q3 dummy tests 2 RF
 - 19 Q6 dummy tests none RF

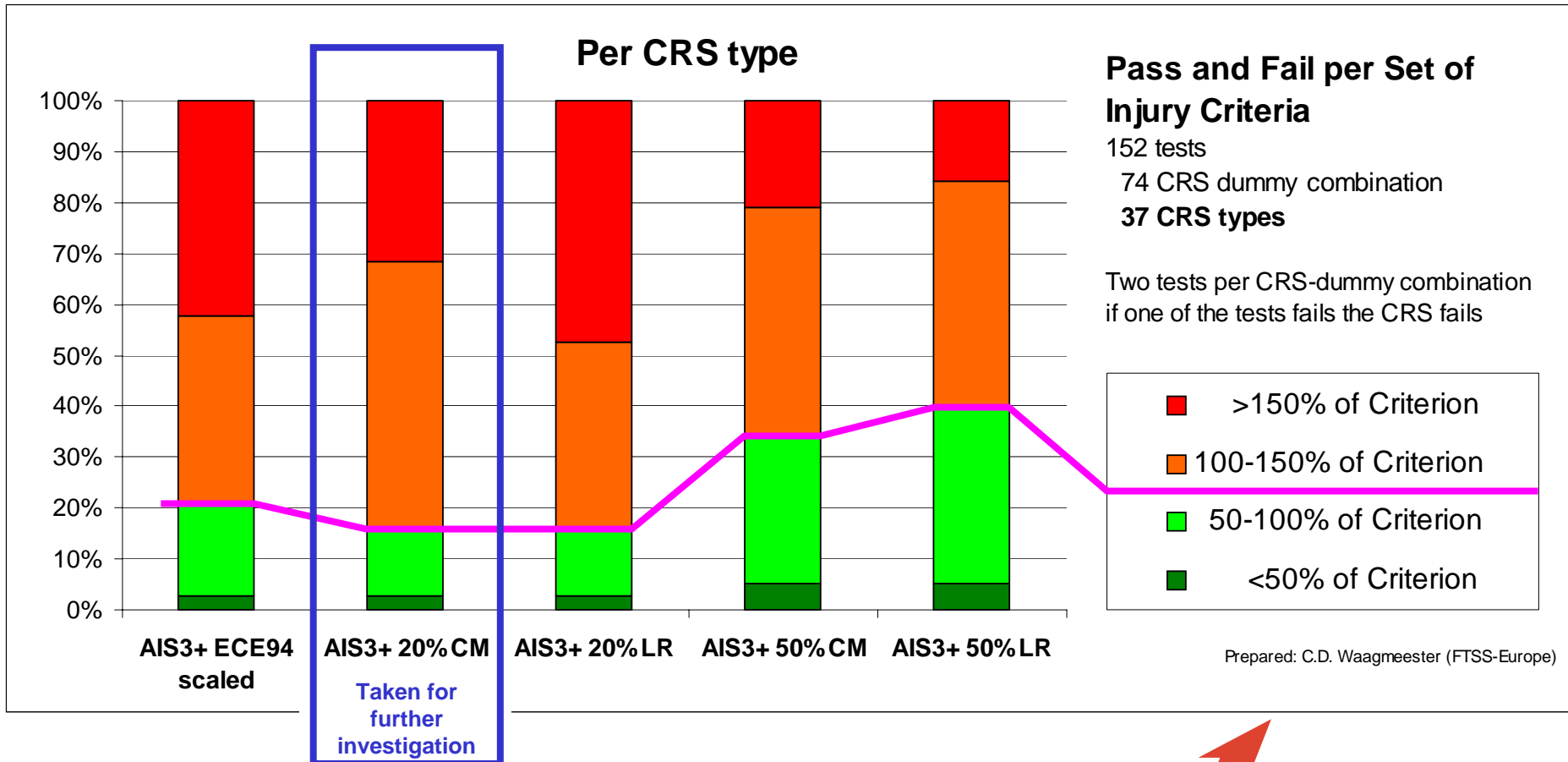
Injury Criteria Evaluation

Evaluation for frontal impact

- 152 ECE R44 tests with Q dummies
 - 36 Child Restraint System (CRS) types
 - 74 CRS – Dummy combinations
 - 34 Tests on 7 Group 0+ CRS's (all RF)
 - 85 Tests on 19 Group I CRS's (2 RF)
 - 33 Tests on 10 Group II CRS's

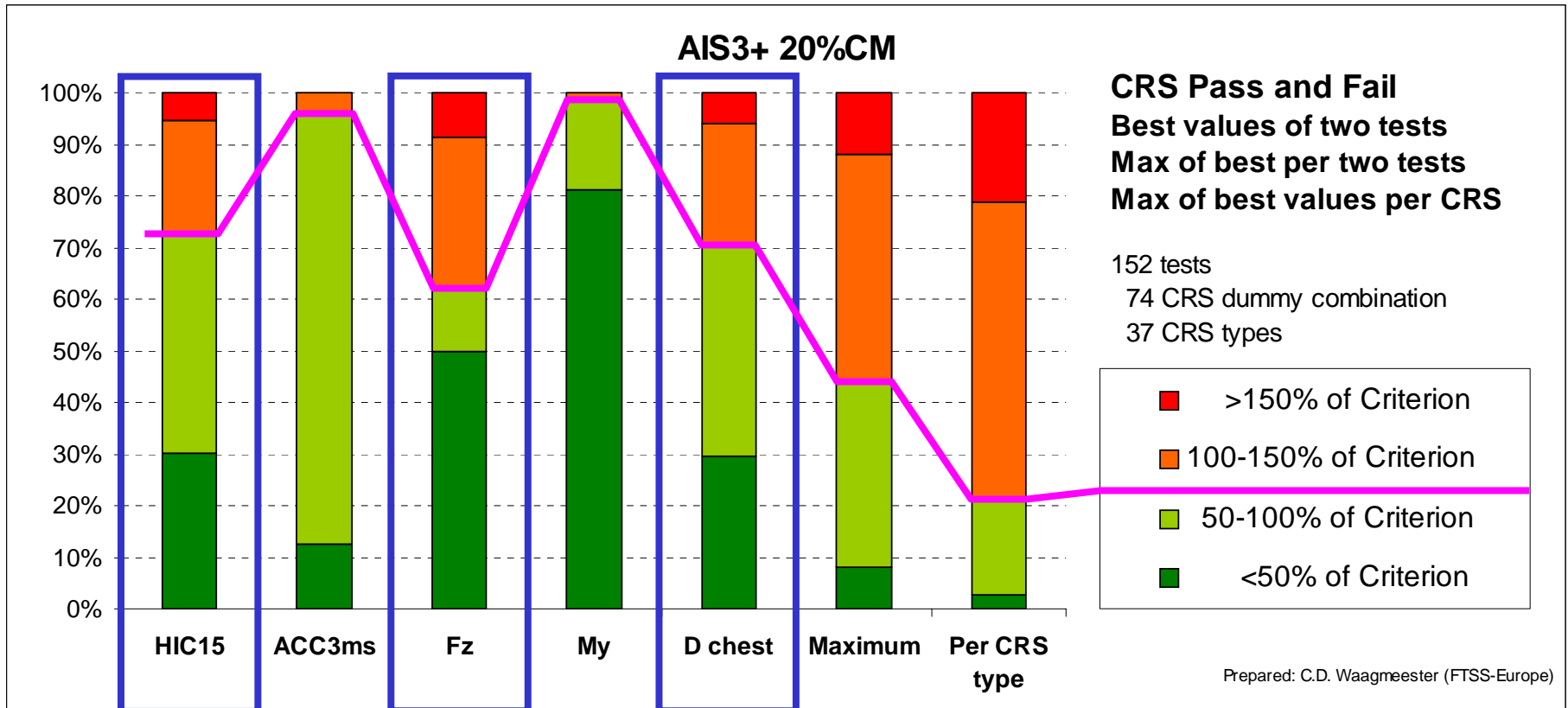
Injury Criteria Evaluation

- CRS Pass and Fail distribution per set of criteria
 - Worst test per CRS leading for pass and fail



Injury Criteria Evaluation

- AIS3+ 20%CM Injury Criteria
 - Distribution per injury criterion
 - Best test per CRS leading for pass and fail

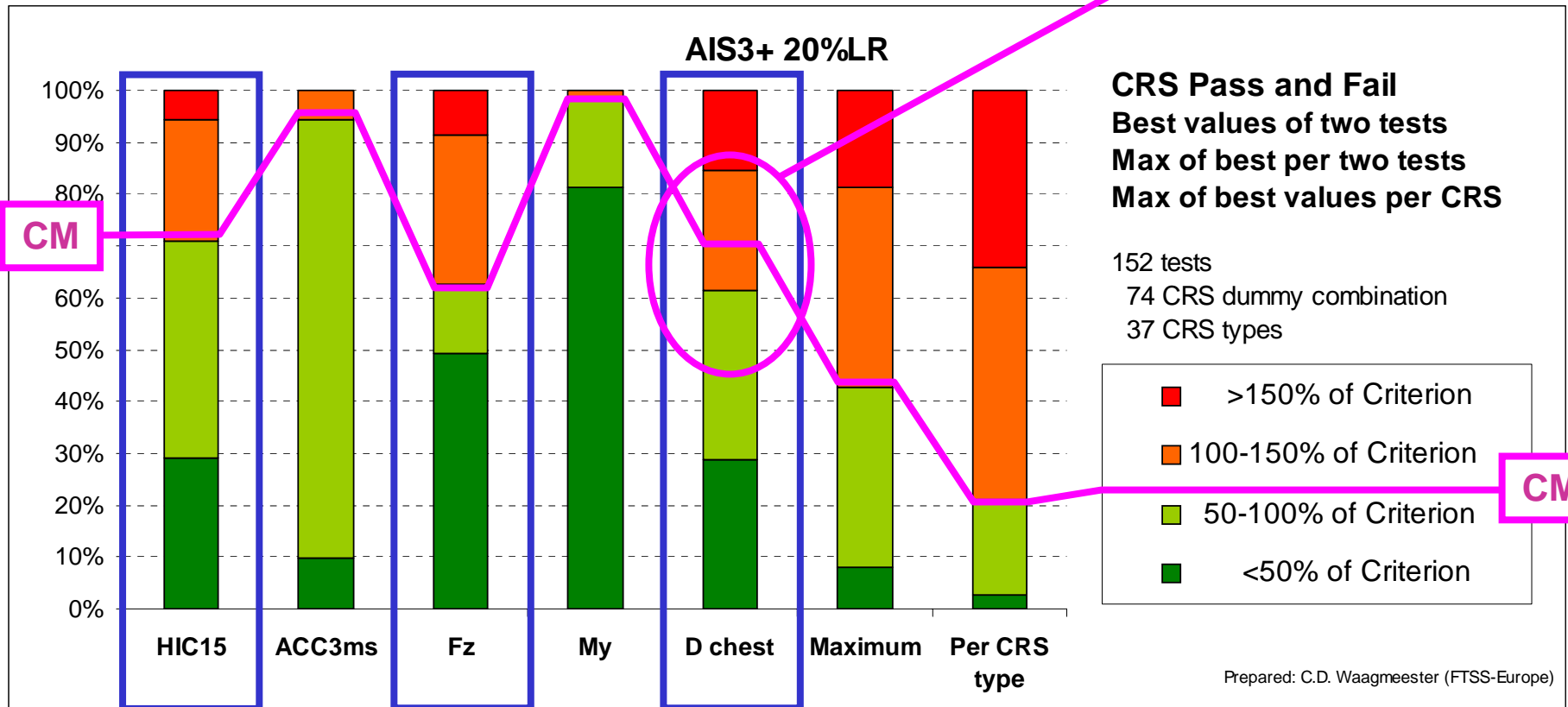


Presentation focuses on HIC15, Fz and D chest

Injury Criteria Evaluation

- AIS3+ 20%LR Injury Criteria
 - Distribution per injury criterion
 - Best test per CRS leading for pass and fail

Difference LR and CM significant for D chest



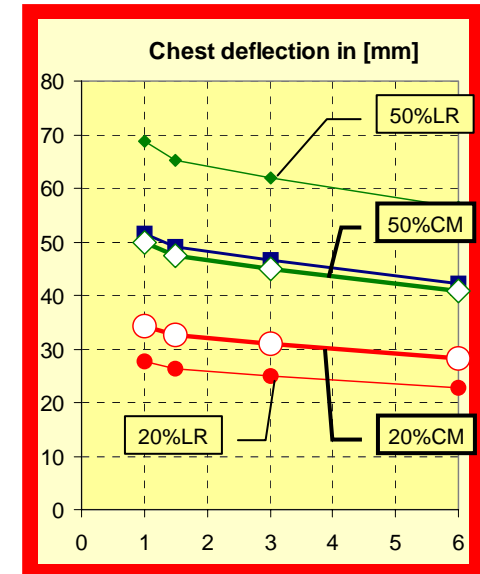
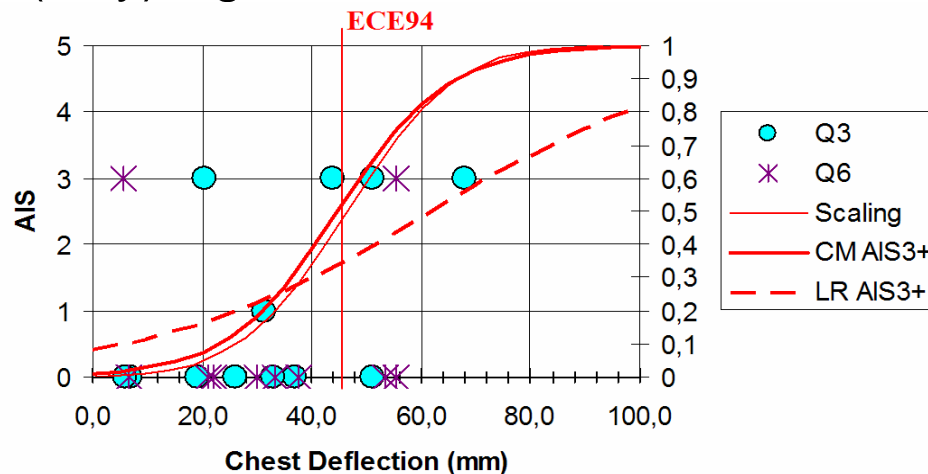
Presentation focuses on HIC15, Fz and D chest

Prepared: C.D. Waagmeester (FTSS-Europe)

Injury Criteria Evaluation

Conclusion

- Differences between CM and LR method (only) significant for D chest



- Injury Risk 20% gives best protection most challenging for CRS design
- Therefore AIS3+ 20%CM further investigated and presented
- AIS3+ 20%LR shown where significant (D chest)

Note: CM = Certainty Method, LR = Logistic Regression

Injury Criteria Evaluation

Conclusions of Kate de Jager (19ESV paper no. 05-0157):

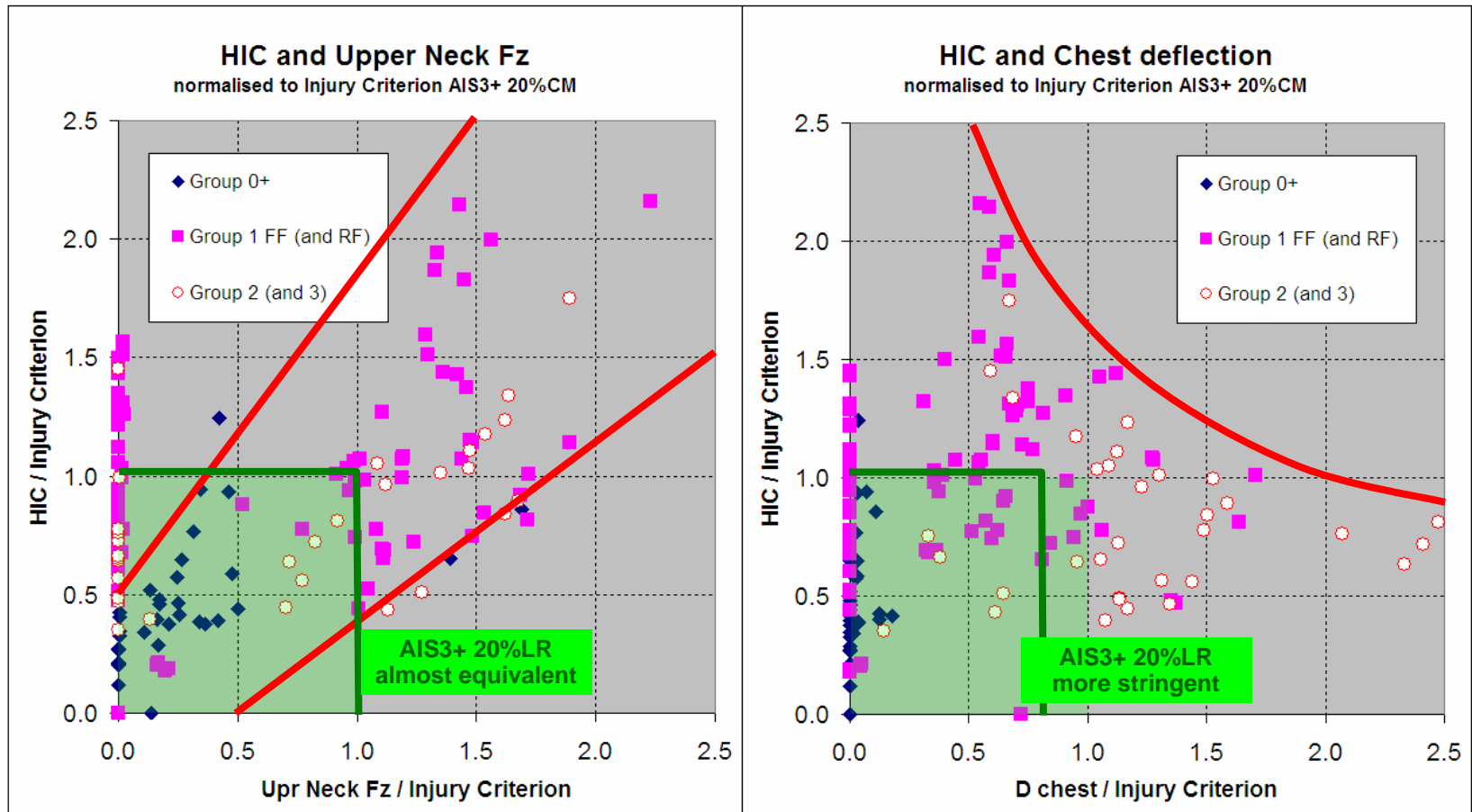
- P- and Q-dummies show similar results with respect to ECE-R44 requirements
- For CRS evaluation, potential merits of Q-dummy family lie in the extra measurement capability

Structure of presentation

- Per CRS group (Groups 0+, I and II+III)
 - Comparison of ECE-R44 requirements and AIS3+20%CM Injury Criteria
 - Injury criteria correlations
 - Dummy size related results
 - Observation and conclusions

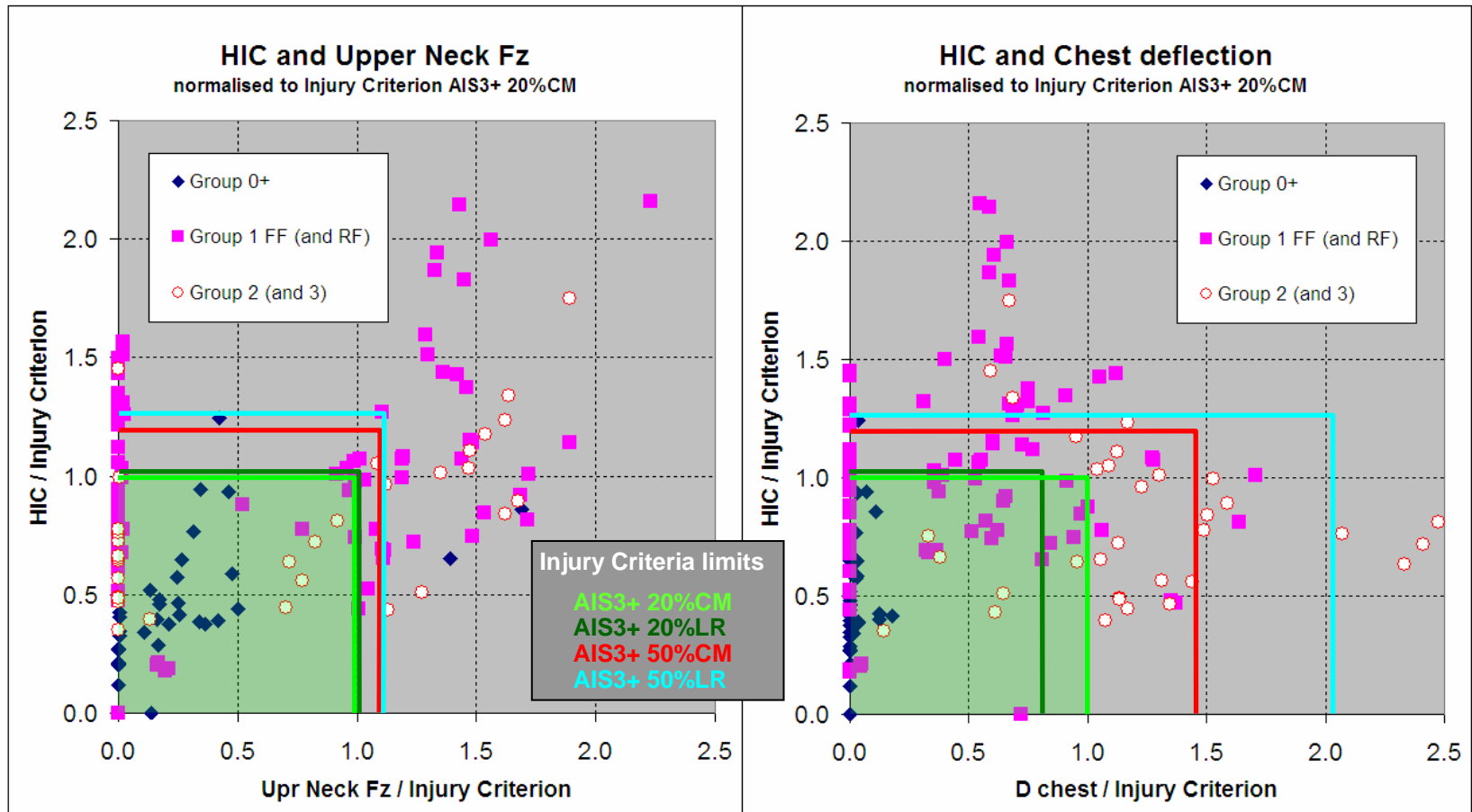
Injury Criteria Evaluation (all groups)

Overview of all tests for HIC, Upper Neck Fz and Chest deflection



Injury Criteria Evaluation (all groups)

Injury criteria set influence for HIC, Upper Neck Fz and Chest deflection



Injury Criteria Evaluation - Group 0+ CRS's

Sample:

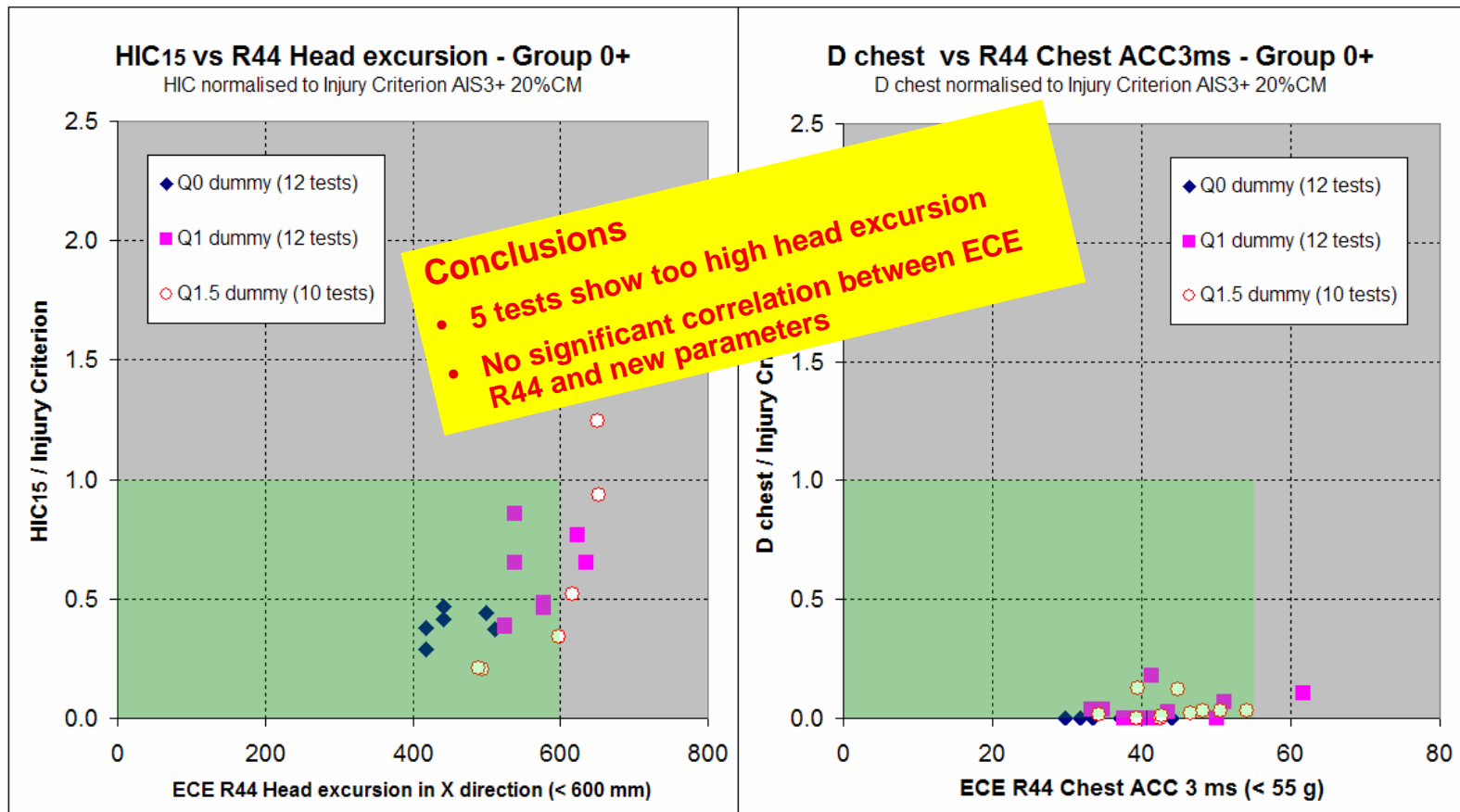
- 34 tests (frontal ECE R44 sled tests)
- Dummies: Q0, Q1 and Q1.5
(in general 2 tests per CRS per dummy)
- 7 types of CRS's
- all rearward facing (RF)



Maxicosi Citi

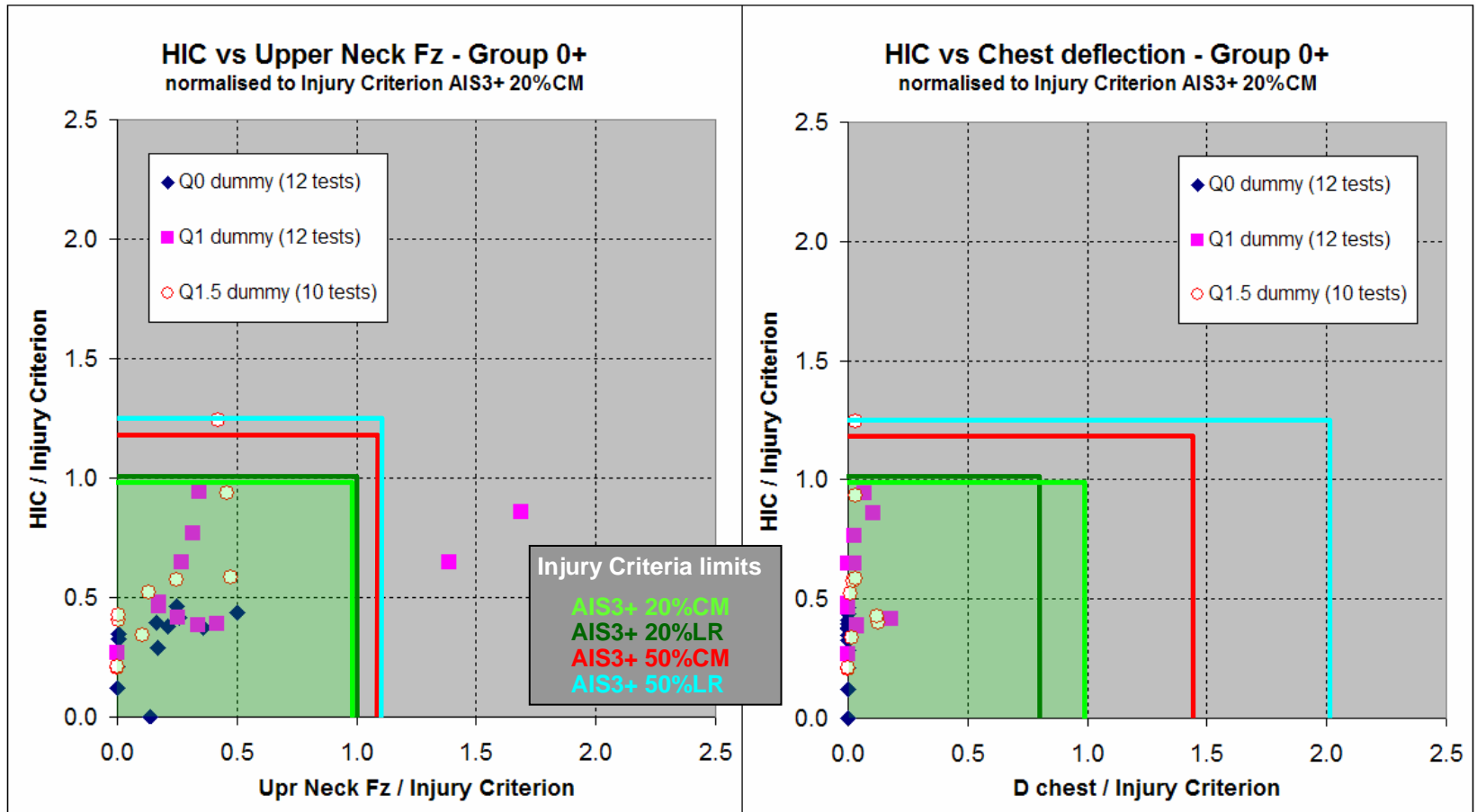
Injury Criteria Evaluation - Group 0+ CRS's

New parameters versus ECE R44 results



Injury Criteria Evaluation - Group 0+ CRS's

Overview of Group 0+ tests for HIC, Upper Neck Fz and Chest deflection



Injury Criteria Evaluation - Group 0+ CRS's

34 tests on 7 Group 0+ CRS's, all Rearward facing (RF)

Pass/ Fail result per CRS (based on best case result)

- Maximum of Value / Injury Criterion
- Normalized against AIS3+ 20%CM
- Number of parameters Failed – Pass

with AIS3+ 50%CM



• Bébéconfort Elios + basifix	0.52	0 - 6	0.47
• Volvo	0.57	0 - 5	0.48
• Maxicosi Citi	0.67	0 - 12	0.55
• Britax First class	0.68	0 - 6	0.56
• Jané Matrix	0.72	0 - 12	0.66
• Team Tex Babyone	0.96	0 - 14	0.88
• Kiddy Easyfix	1.39	2 - 6	1.27

ADAC or ÖAMTC rating stars



*

Bébéconfort Elios



Jané Matrix



Maxicosi Citi

Injury Criteria Evaluation - Group 0+ CRS's

- Conclusions:
 - No significant correlation between ECE R44 and the new parameters for this group of seats/dummies
 - With AIS3+ 20%CM only 1 of the 7 CRS's failed on neck loads (Kiddy Easyfix)
 - With AIS3+ 50%CM this failure also remains
 - Group 0+ rearward facing seats provide good protection in compliance with the newly suggested injury criteria

Injury Criteria Evaluation - Group I CRS's

Sample:

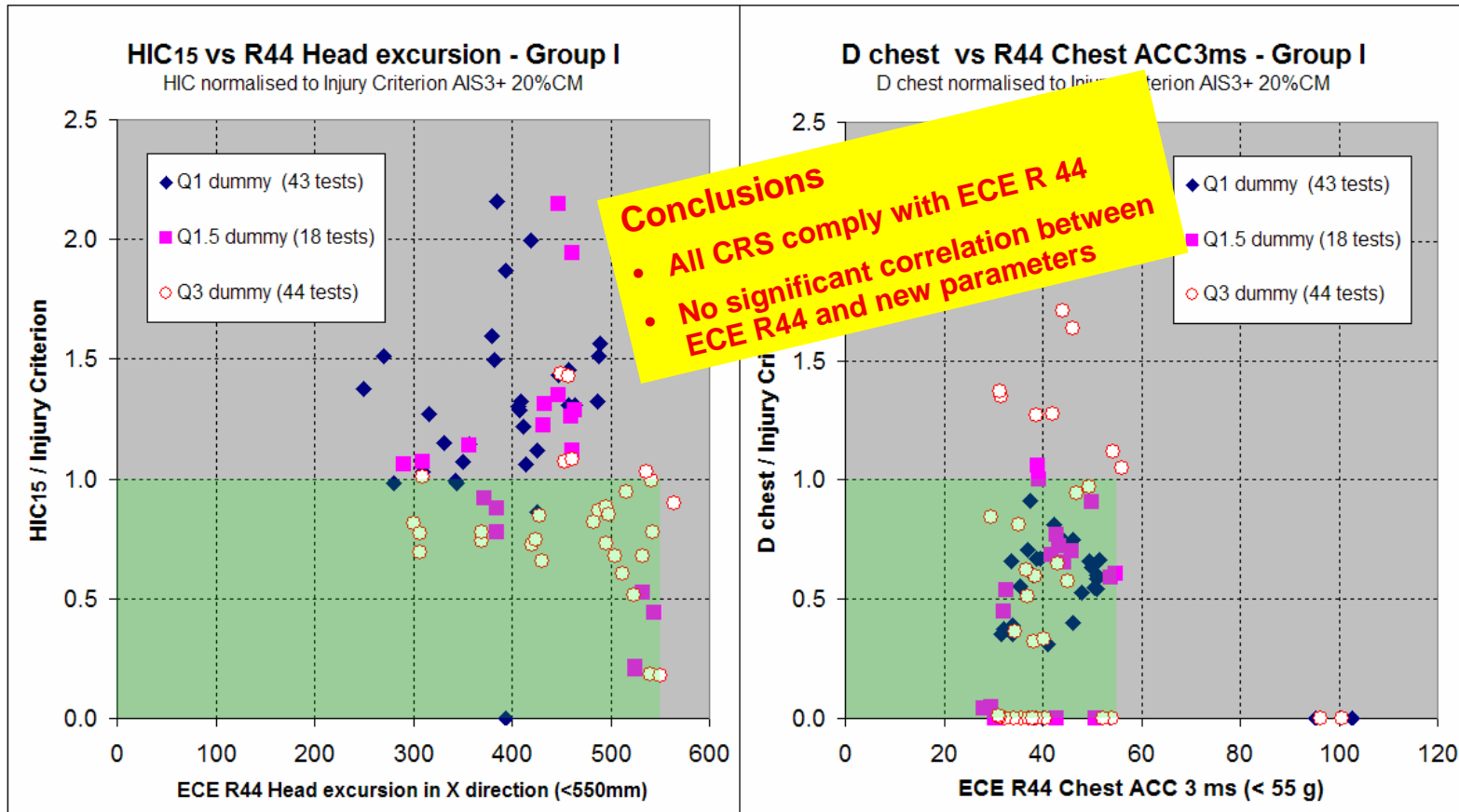
- 85 tests (frontal ECE R44 sled tests)
- Dummies: Q1, Q1.5 and Q3
(in general 2 tests per CRS per dummy)
- 19 types of CRS's
- 1 rearward facing (RF)
- 1 used in forward and rearward mode



Maxi Cosi Priori

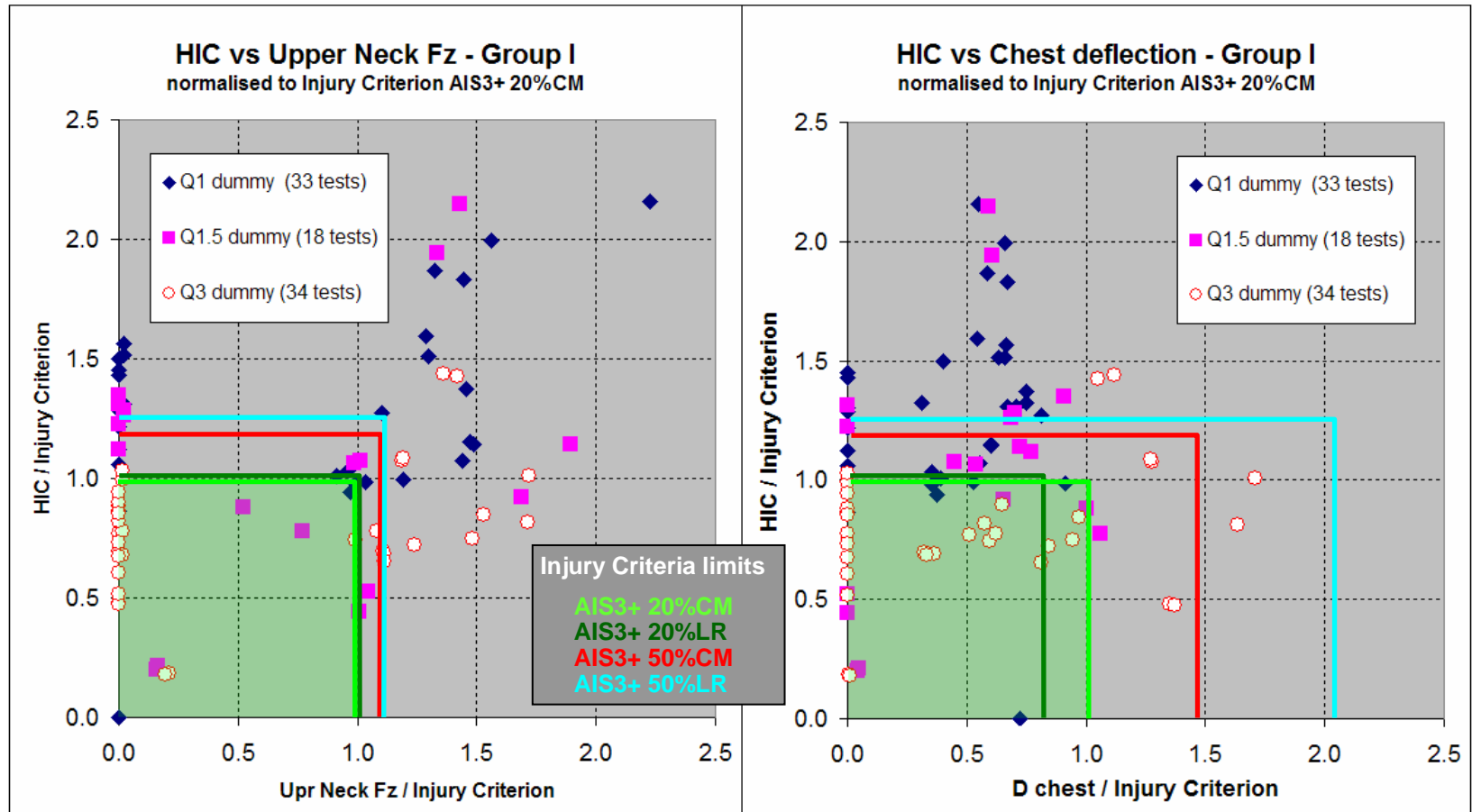
Injury Criteria Evaluation - Group I CRS's

New parameters versus ECE R44 results



Injury Criteria Evaluation - Group I CRS's

Overview of Group I tests for HIC, Upper Neck Fz and Chest deflection



Injury Criteria Evaluation - Group I CRS's

85 tests on 19 Group 1 CRS's (2 RF)

Pass/ Fail result per CRS (based on best case)

Maximum of Value / Injury Criterion
with AIS3+ 20%CM and

Number of parameters Failed – Pass
with AIS3+ 50%CM

•	Volvo (RF)	0.43	0 - 10	0.39
•	Team Tex basic	0.86	0 - 6	0.73
•	Kiddy Easyfix (RF)	1.00	1 - 3	0.92
•	Kiddy Easyfix (FF)	1.03	2 - 8	0.94
•	Fair	1.06	1 - 14	0.91
•	Chicco	1.11	1 - 9	1.01
•	Concord Maxus	1.12	1 - 9	0.94
•	Team Tex Speedway – GI	1.12	1 - 5	0.94
•	Britax Kid	1.27	3 - 2	1.08
•	Maxi Cosi Priori	1.29	2 - 4	1.08
•	Britax First class	1.31	2 - 11	1.10
•	Bébéconfort Trianos	1.32	1 - 7	1.11
•	Kiddy Life - G I	1.35	1 - 3	0.93
•	Bébéconfort Iseos	1.43	1 - 3	1.20
•	Jane Racing	1.44	3 - 7	1.31
•	Britax Eclipse plus	1.51	2 - 6	1.27
•	Team Tex Topper	1.59	5 - 5	1.34
•	Romer Duo	1.69	3 - 12	1.54
•	Autoplay Beat	1.71	4 - 6	1.56
•	HTS 123	2.00	6 - 4	1.68

ADAC or ÖAMTC rating stars

*

Kiddy Easyfix Renault system
often used in EuroNCAP

**



Team Tex basic



HTS 1-2-3



Maxi Cosi Priori

Injury Criteria Evaluation - Group I CRS's

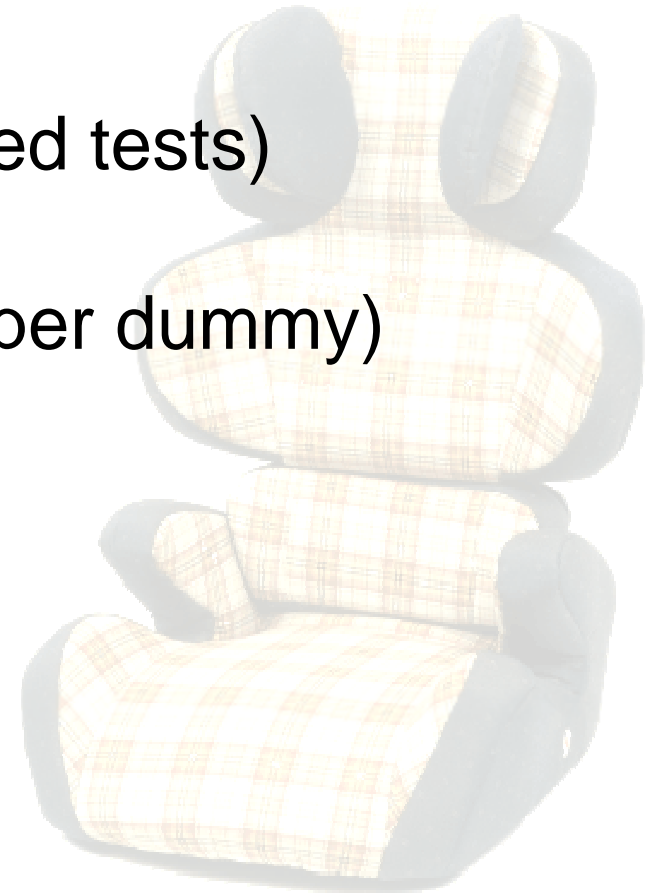
Conclusions:

- No significant correlation between ECE R44 and the new parameters
- With AIS3+ 20%CM only 2 of the 20 CRS configurations passed
 - Failures mainly on HIC and/or Upper Neck Fz
 - Several failed on Q3 chest deflection
- With AIS3+ 50%CM 8 of the 20 CRS configurations passed (one additional boarder line case)
 - Failures mainly on HIC and/or Upper Neck Fz
 - One failed on Q3 chest deflection
- Group I provides poor protection based on the new injury criteria (**significant challenge for improvement**)

Injury Criteria Evaluation - Group II CRS's

Sample:

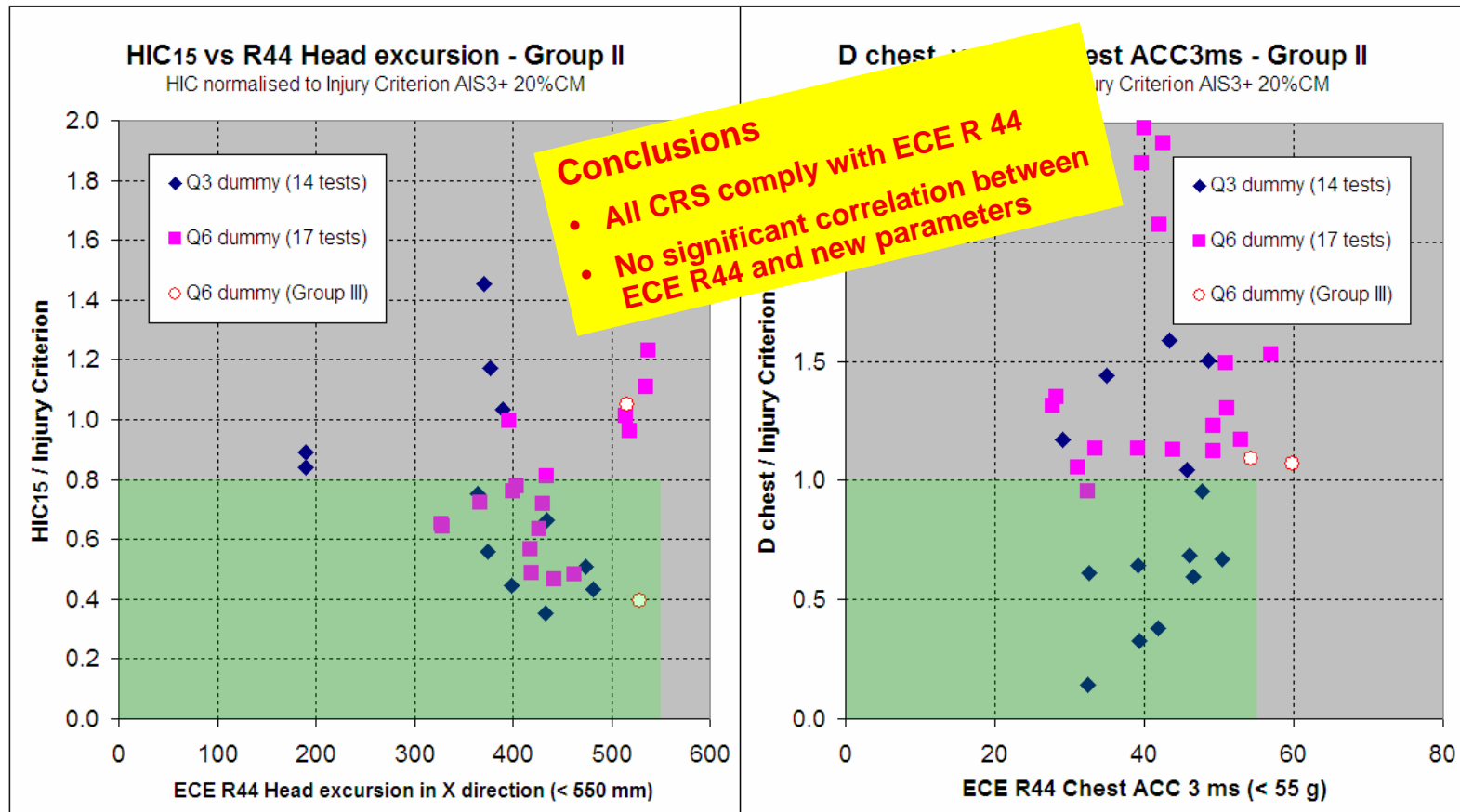
- 33 tests (frontal ECE R44 sled tests)
- Dummies: Q3 and Q6
(in general 2 tests per CRS per dummy)
- 10 types of CRS's



HTS 1-2-3

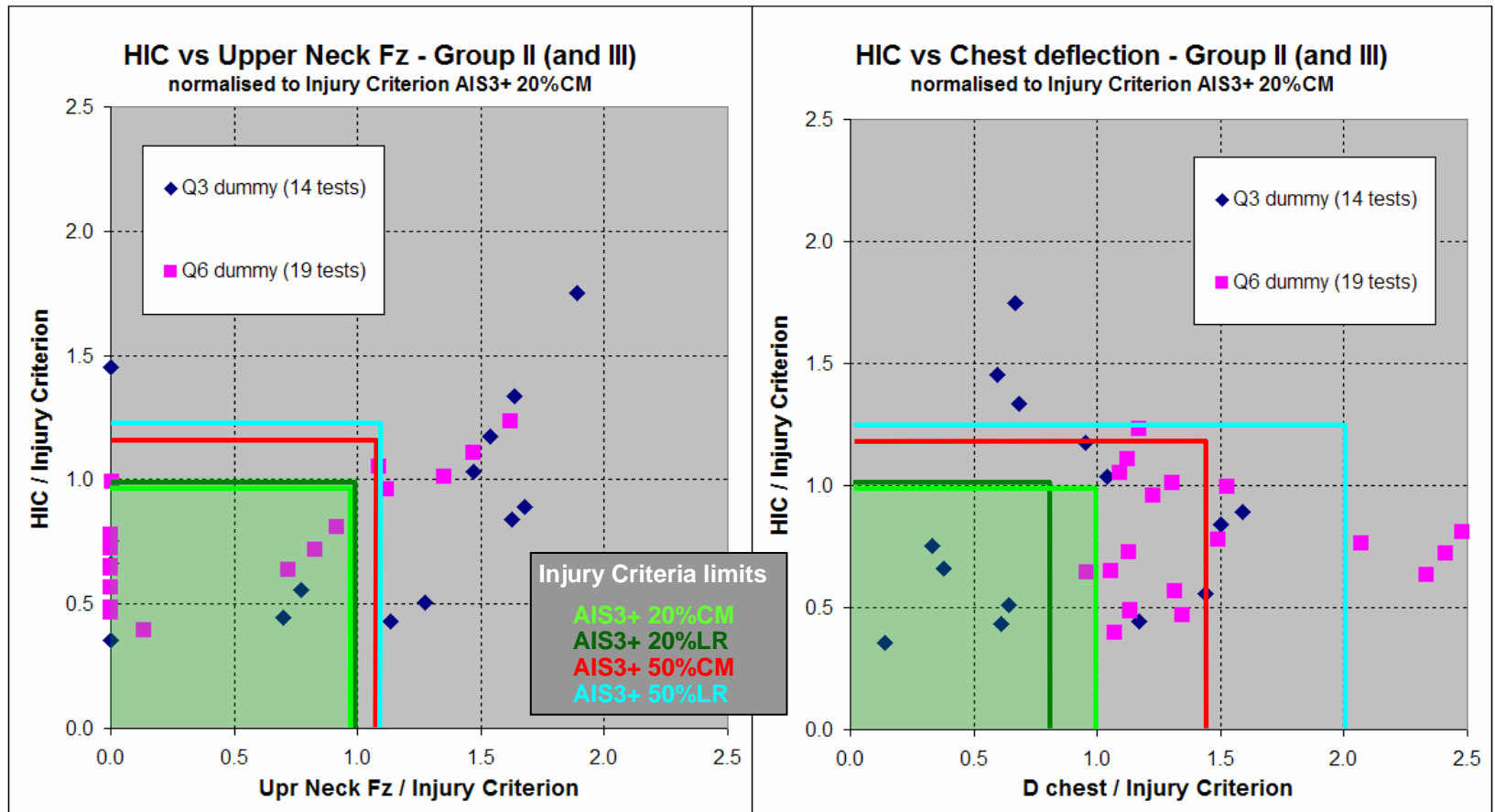
Injury Criteria Evaluation - Group II CRS's

New parameters versus ECE R44 results



Injury Criteria Evaluation - Group II CRS's

Overview of Group II tests for HIC, Upper Neck Fz and Chest deflection



Injury Criteria Evaluation - Group II CRS's

33 tests on 10 Group II CRS's

Pass/ Fail result per CRS (based on best case)

Maximum of Value / Injury Criterion
with AIS3+ 20%CM and

Number of parameters Failed – Pass

with AIS3+ 50%CM

ADAC or ÖAMTC rating stars

•	Bébéconfort Trianos- G II	1.13	1	-	7	0.96
•	Kiddy Easyfix	1.13	1	-	4	1.03
•	Play – disney	1.17	2	-	6	0.81
•	Britax Kid	1.23	2	-	3	1.02
•	Autoplay Beat	1.31	1	-	2	0.90
•	Team Tex Topper	1.47	2	-	3	1.34
•	Maxi cosi Rodi Safe Side	1.49	1	-	7	1.03
•	Concord Lift	1.62	2	-	6	1.48
•	HTS 123	1.63	7	-	3	1.49
•	Team Tex Speedway – GII	2.33	3	-	7	1.61

Kiddy Easyfix Renault system
often used in EuroNCAP

**



Maxi cosi Rodi

Injury Criteria Evaluation - Group II CRS's

Conclusions:

- No significant correlation between ECE R44 and the new parameters
- With AIS3+ 20%CM none of the 10 CRS configurations passed
 - Failures mainly on Chest deflection of Q6
 - Several failure are on HIC and Upper Neck Fz
- With AIS3+ 50%CM 3 of the 10 CRS configurations passed (additional 3 almost passed)
 - Failures mainly on HIC and/or Upper Neck Fz
- Group II provides poor protection based on the new injury criteria (**significant challenge for improvement**)

Injury Criteria Evaluation

Overall conclusions:

- **No significant correlation between ECE R44 and the new parameters found**
 - ECE R44: Excursion envelope and Chest acceleration
 - New parameters: HIC, Head acc3ms, Upper Neck Fz and My and Chest deflection
- **New Injury Criteria provides significant design challenge:**
 - AIS3+ 20%CM
 - Group 0+ (7 CRS's) 6 passed 1 failed
 - Group I (20 CRS's) 2 passed 18 failed (2 almost passed)
 - Group II (11 CRS's) no passed 10 failed
 - AIS3+ 50%CM
 - Group 0+ (7 CRS's) 6 passed 1 failed
 - Group I (20 CRS's) 8 passed 12 failed (1 almost passed)
 - Group II (11 CRS's) 3 passed 7 failed (3 almost passed)