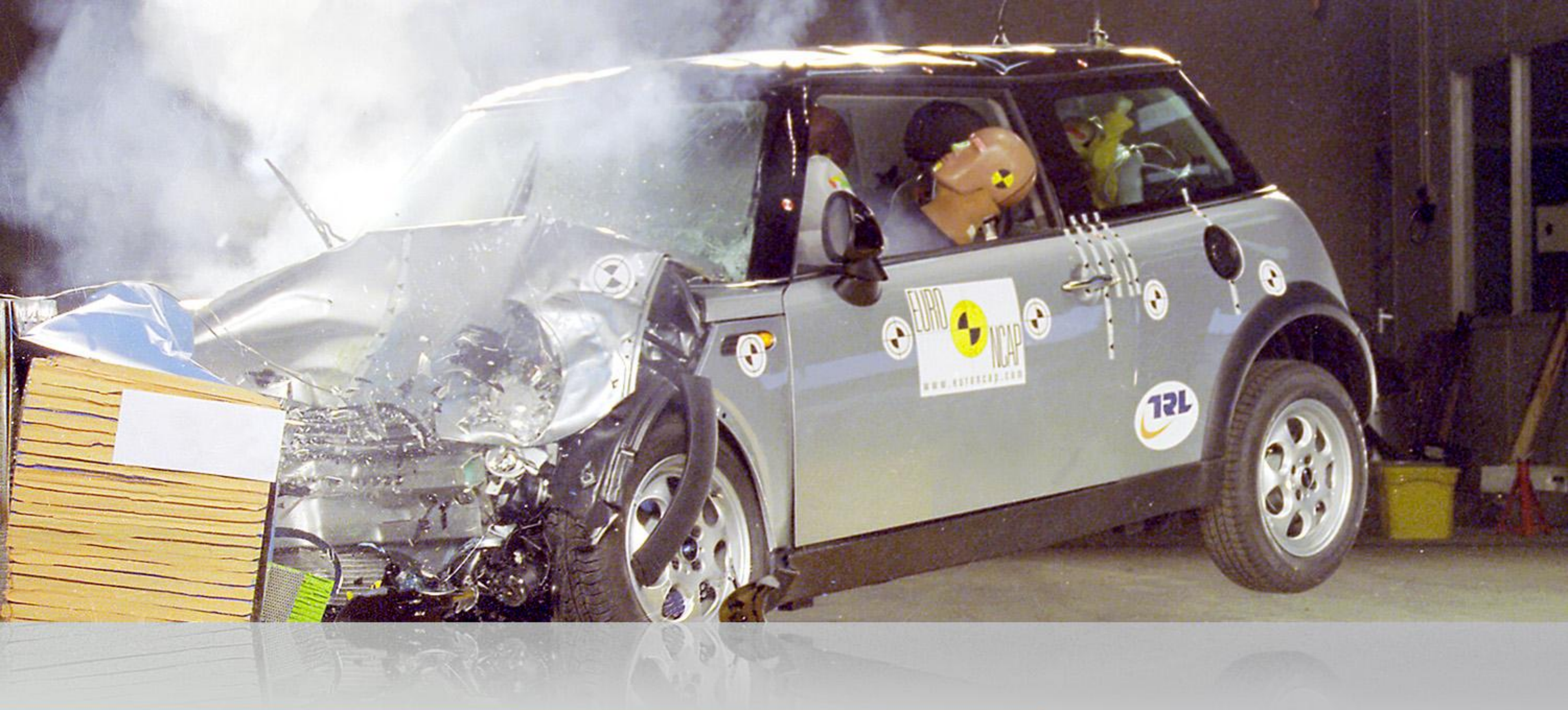

Validation of proposed chest deflection thresholds

Presented by Dinos Visvikis
Child Safety Centre Team Leader

UN Informal Group on CRS 14th Oct 2014

Background

- UN Regulation 129 (Phase 1) specifies **chest acceleration** limit
  - Same threshold as UN Regulation 44 (55g)
  - Measure of how well CRS allows occupant to ‘ride down’ impact
  - Does not detect concentrated loading to chest
- **Chest deflection** is a better predictor of chest injury than acceleration
  - Informal Group on CRS is agreed on specifying deflection
  - Evidence-based limits are needed (and should be validated)
  - Outputs from chest and abdomen injury criteria task force expected after Phase 2 deadlines

EEVC thresholds (2008 & 2014 report)

	Q1	Q1.5	Q3	Q6	Q10
20% risk of AIS≥3 injury	40	38	36	33	23
50% risk of AIS≥3 injury	59	56	53	49	37

EEVC WG12/18 (2008). Q-dummies report: advanced child dummies and injury criteria for frontal impact. Retrieved November 8, 2012 from: http://eevc.org/publicdocs/publicdocs.htm

EEVC WG12 (2014). Q10 dummy report – Advanced child dummies and injury criteria for frontal impact. Draft report not currently published.

Greatest tolerance for smallest child size – plausible for rib fracture only (not meaningful for organ injury)

$$\lambda_\delta = \frac{\lambda_y \lambda_{\sigma t}}{\lambda_{Eb}}$$

Bone modulus ratio as denominator causes trend mentioned above

Where:

λy is the ratio of rib length (usually making use of the chest depth as an approximation)

λσt is the ratio of calcaneal tendon failure stress (as a proxy for a more relevant scaling factor for the failure stress of thoracic tissues) and

λEb is the ratio of bone modulus (usually taking values from skull bone samples, rather than bone from the ribs)

Thresholds derived from CHILD project accident reconstruction data using logistic regression (survival analysis now preferred)

Pragmatic thresholds – Draft 01 Series R129

Table 5

Criterion	*Abbreviation*	*Unit*	*Q0*	*Q1*	*Q1,5*	*Q3*	*Q6*	***Q10***
Head performance criterion (only in case of contact during in-vehicle testing)	HPC* (15)		600	600	600	800	800	**800**
Head acceleration 3 ms	A head 3 ms	g	75	75	75	80	80	**80**
Upper neck tension Force	Fz	N	For monitoring purpose only**					
[Upper neck flexion moment EEVC report 2008]	My Nl proposal	Nm 20% risk	For monitoring purpose only*** 17	53	61	79	118	**157**
[Chest acceleration 3 ms]	A chest 3 ms	g	55	55	55	55	55	**55**
[Chest deflection]	**TBC**	**mm**	**NA**	**40**	**40**	**40**	**56**	**56**
[Abdominal pressure]		**Bar**	**NA**	**NA**	**1.2**	**1.2**	**1.2**	**1.2**

* HPC: see Annex 17.

** To be reviewed within 3 years following entry into force of this Regulation.

*** To be reviewed within 3 years following entry into force of this Regulation.

Can IWG share data (anonymously) to validate pragmatic thresholds?

Proposed template

Dummy	Child restraint system		Test bench	Pulse	Upper Neck		Chest deflection	Chin / chest contact?	Chest deflection pre-contact	Comment
	Type	Attachment			+Fz (N)	+My (Nm)				
Q0	RF Integral	ISOFIX	R129	R129 / R44	165	0.8	n/a	n/a	n/a	
Q0	RF Integral	ISOFIX	R129	R129 / R44	173	0.7	n/a	n/a	n/a	
Q0	RF Integral	ISOFIX	R129	R129 / R44	99	0.8	n/a	n/a	n/a	
Q1	RF Integral	ISOFIX	R129	R129 / R44	650	9	5			
Q1	RF Integral	ISOFIX	R129	R129 / R44	390	7	3			
Q1	RF Integral	ISOFIX	R129	R129 / R44	189	7	3			
Q1	FF Integral	ISOFIX	R129	R129 / R44	1,636	18	20			
Q1	FF Integral	ISOFIX	R129	R129 / R44	1,391	15	17			
Q1	FF Integral	ISOFIX	R129	R129 / R44	1,750	22	19			
Q1.5	RF Integral	ISOFIX	R129	R129 / R44	728	11	4			
Q1.5	RF Integral	ISOFIX	R129	R129 / R44	426	6	2			
Q1.5	RF Integral	ISOFIX	R129	R129 / R44	350	6	2			
Q3	FF Integral	ISOFIX	R129	R129 / R44	2,540	10	28			
Q3	FF Integral	ISOFIX	R129	R129 / R44	1,713	9	24			
Q3	FF Integral	ISOFIX	R129	R129 / R44	2,485	21	fault			
Q3	FF Non-integral	ISOFIX	R129	R129 / R44	2,460	21	28			
Q3	FF Non-integral	ISOFIX	R129	R129 / R44	2,375	15	31			
Q3	FF Non-integral	ISOFIX	R129	R129 / R44	2,174	19	32			
Q3	FF Non-integral	ISOFIX	R129	R129 / R44	2,768	12	34			
Q6	FF Non-integral	ISOFIX	R129	R129 / R44	2,128	55	35			
Q6	FF Non-integral	ISOFIX	R129	R129 / R44	1,487	38	35			
Q6	FF Non-integral	ISOFIX	R129	R129 / R44	2,090	44	37			
Q6	FF Non-integral	ISOFIX	R129	R129 / R44	1,720	50	26	Yes	20	Abdomen sensors fitted
Q6	FF Non-integral	ISOFIX	R129	R129 / R44						
Q10 (Prototype)	FF Non-integral	ISOFIX	R129	R129 / R44	3,630		49 and 47			

Front impact data | Rear impact data | Sheet2 | Sheet3

Thank you

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The following additional slides were not presented during the meeting but illustrate thresholds derived previously by TRL using alternative scaling formulae and factors.

They are presented here to illustrate how scaling assumptions and approaches can influence the final thresholds.

From a pragmatic viewpoint, the following thresholds seem to be more useful than the EEVC biomechanical thresholds because:
i. The threshold gets larger as the dummy size increases, which seems to be more plausible for a given risk of chest injury (i.e. all injuries, not just rib fracture);
ii. All of the dummies are physically capable of measuring deflection up to the threshold.

These thresholds appear stringent, but have some biomechanical basis and are offered here as a further means of commenting on the findings of the data sharing exercise (and on the pragmatic thresholds in UN Regulation 129)

For more detailed explanation of the hresholds, see Annex 7 of:
Visvikis, C., Pitcher, M., Carroll, J., Cuerden, R., Barrow, A. (2014). New UN regulation on child restraint systems - assessment of amendments to the new regulation, front and side impact procedures and Q-Series dummy family injury criteria (Client Project Report 1801). Report to be published on-line here: http://ec.europa.eu/enterprise/sectors/automotive/documents/calls-for-tender-and-studies/index_en.htm

Alternative biomechanical thresholds #1

Mertz et al. (2003) – Scaled adult threshold (50 mm)

	Q1	Q1.5	Q3	Q6	Q10
50% risk of AIS≥3 injury	23.7	24.6	26.5	29.3	33.5

Mertz, H. J., Irwin, A. L. and Prasad, P. (2003). Biomechanical and scaling basis for frontal and side impact injury assessment reference values (Paper No. 2003-22-0009). In: Stapp Car Crash Journal Volume 47: Papers Presented at the 47th Stapp Car Crash Conference. Warrendale, PA: SAE International.

Threshold increases with dummy size - plausible for all chest injury (i.e. not just rib fracture)

$$\lambda_\sigma = \lambda_x$$

Where:

λx is the ratio of chest depth

Material properties <u>not</u> taken into account

Alternative biomechanical thresholds #2

Scaling factors proposed by EEVC for air bag loading (not used to develop thresholds in 2008 report)

	Q1	Q1.5	Q3	Q6	Q10
50% risk of AIS≥3 injury	16.6	18.4	22.5	28.2	32.7

Threshold increases with dummy size – intended for distributed loading

$$\lambda_\sigma = \lambda_y \lambda_{\sigma t}$$

Soft tissue properties only; bone modulus not taken into account

Where:

λy is the ratio of rib length (usually making use of the chest depth as an approximation)

$\lambda \sigma t$ is the ratio of calcaneal tendon failure stress (as a proxy for a more relevant scaling factor for the failure stress of thoracic tissues) and