Side impact protection in non-integral CRS – First feedback on 440 mm

52nd Meeting of the UN Informal Group on Child Restraint Systems
18-06-15
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• Overview of CLEPA investigation
• Implications of 440 mm and effect of CRS width in R129 test environment
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  – Simulation
  – Testing
• Summary and next steps
  – Avenues for further investigation
ISO BOOSTER VOLUME DEVELOPED IN CLOSE COLLABORATION BETWEEN OICA AND CLEPA

List of Interactions

10 worst-case vehicles selected by OICA (assessed during BASt workshop)
3 vehicles no interaction issues found

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Attachment</th>
<th>Position</th>
<th>Issue</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audi A1</td>
<td>ISO Belt</td>
<td>Outer</td>
<td>No Latch C-Pillar</td>
<td></td>
</tr>
<tr>
<td>Ford Fiesta</td>
<td>Belt</td>
<td>Middle</td>
<td>Buckling</td>
<td></td>
</tr>
<tr>
<td>Mitsubishi Space Star</td>
<td>ISO</td>
<td>Outer</td>
<td>C-Pillar 1 of 2 Fixtures</td>
<td></td>
</tr>
<tr>
<td>Suzuki SX4</td>
<td>Belt</td>
<td>Middle</td>
<td>Buckling Waiting on vehicle availability (rare car)</td>
<td></td>
</tr>
<tr>
<td>Vauxhall Adam</td>
<td>ISO</td>
<td>Outer</td>
<td>C-Pillar 1 of 2 Fixtures</td>
<td></td>
</tr>
<tr>
<td>Vauxhall Zafira</td>
<td>Belt/ISO</td>
<td>Outer</td>
<td>Door</td>
<td></td>
</tr>
<tr>
<td>Porsche Panamera</td>
<td>ISO</td>
<td>Front</td>
<td>No Latch Waiting on vehicle availability (rare car)</td>
<td></td>
</tr>
</tbody>
</table>

Summary of Interaction Investigation

5 vehicles assessed further
- 1 vehicle: the fixture fitted with no interactions – no action required
- 1 vehicle: the fixture did not fit in middle position – position not suitable
- 3 vehicles: had minor interaction – modifications proposed

<table>
<thead>
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<tbody>
<tr>
<td>Audi A1</td>
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<td>No Latch C-Pillar</td>
<td>Propose modification</td>
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<tr>
<td>Ford Fiesta</td>
<td>Belt</td>
<td>Middle</td>
<td>Buckling</td>
<td>Position not suitable</td>
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<tr>
<td>Mitsubishi Space Star</td>
<td>ISO</td>
<td>Outer</td>
<td>C-Pillar</td>
<td>Propose modification</td>
</tr>
<tr>
<td>Vauxhall Adam</td>
<td>ISO</td>
<td>Outer</td>
<td>C-Pillar</td>
<td>Fixture fits</td>
</tr>
<tr>
<td>Vauxhall Zafira</td>
<td>Belt/ISO</td>
<td>Outer</td>
<td>Door</td>
<td>Propose modification</td>
</tr>
</tbody>
</table>

Source: CRS-47-03e, Britax

- Assessment volume adapted following two joint CLEPA-OICA workshops and further assessment by Britax
- Volume fits outboard seating position of cars
CRS MANUFACTURERS ARE BEING ASKED TO REDUCE WIDTH OF BOOSTER ASSESSMENT VOLUME

Make i-Size standard across the board

- And **restrict the width to 440 mm**
  - Consistent with maximum width in Phase 1
  - Will fit 3-across larger family vehicles

- Extend i-Size seating position to 135 cm
- Justification is to ensure three (max. size) CRS will fit in “larger family cars”
  - Euro NCAP incentive to include three i-Size positions
CAR MANUFACTURERS ARE BEING ASKED TO ALIGN SEAT BELT AND ISOFIX ANCHORAGES

i-Size across the board -- way forward

• We need to think outside of the box

• Car manufacturers to install more ISOFIX when the smaller 'gabarit' facilitates this

• CRS manufacturers to make innovative products

• Requires significant change to current vehicles
We welcome 135 cm limit in R129, but booster seats accommodate larger children than integral CRS and some states adopt 150 cm

- EU seat belt wearing legislation specifies CRS use to 150 cm
  - Many member states choose not to take the 135 cm exemption
HEAD IS THE PRIORITY BUT BOOSTER SEATS MUST PROVIDE PROTECTION TO OTHER BODY REGIONS

Regulatory thresholds are applied to the head only, but CRS manufacturers aim to protect all body regions.
# Overview of CLEPA Investigation

<table>
<thead>
<tr>
<th></th>
<th>Q3</th>
<th>Q6</th>
<th>Q10</th>
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<tbody>
<tr>
<td></td>
<td>440 mm 520 mm</td>
<td>440 mm 520 mm</td>
<td>440 mm 520 mm</td>
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<tr>
<td>R129</td>
<td><strong>Dynamic</strong></td>
<td><strong>Dynamic</strong></td>
<td><strong>Dynamic</strong></td>
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<td><strong>Dynamic</strong></td>
<td><strong>Dynamic</strong></td>
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</table>
Implications of 440 mm and effect of CRS width in R129 test environment
- Simulation and testing
# Kiddy Numerical Simulation

## Results R129 side impact

<table>
<thead>
<tr>
<th></th>
<th>HIC</th>
<th>Head Acceleration (g)</th>
<th>Chest Acceleration (g)</th>
<th>Upper Neck force (N)</th>
<th>Upper Neck Moment (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R129 threshold</td>
<td>174%</td>
<td>129%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3 Standard seat</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Q3 Adapted seat</td>
<td>88%</td>
<td>124%</td>
<td>179%</td>
<td>100%</td>
<td>106%</td>
</tr>
</tbody>
</table>
Results R129 side impact Q3

Standard seat

Adapted seat
## Results R129 side impact

<table>
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<th>Chest Acceleration (g)</th>
<th>Upper Neck force (N)</th>
<th>Upper Neck Moment (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R129 threshold</td>
<td>254%</td>
<td>133%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6 Standard seat</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Q6 Adapted seat</td>
<td>107%</td>
<td>107%</td>
<td>144%</td>
<td>115%</td>
<td>132%</td>
</tr>
</tbody>
</table>
Results R129 side impact Q6

Standard seat

Adapted seat
Overview of Cybex Prototypes

- Internal dimensions – 95th percentile 135 cm
- Prototypes differ in shoulder / chest side wings only
  - Head wings / padding consistent across prototypes
- R129 side impact tests with Q3 and Q6
R129 PERFORMANCE REQUIREMENTS ACHIEVED WITH 440 MM – HEAD SPECIFIED ONLY
HEAD CONTAINMENT ACHIEVED WITH 400 MM, BUT HEAD IS CLOSER TO PANEL
R129 Head requirements can be met but enhanced protection offered by larger booster

- Shoulder / chest wing width influences head protection
- Step improvement in performance offered by 520 mm
CHEST PROTECTION IS SEVERELY COMPROMISED WHEN BOOSTER WIDTH IS REDUCED

• Step improvement in performance offered by 520 mm
NECK PROTECTION IS ALSO COMPROMISED WHEN BOOSTER WIDTH IS REDUCED

- Step improvement in performance offered by 520 mm
# Test Matrix - Britax

R129 side impact test method

<table>
<thead>
<tr>
<th>CRS Version</th>
<th>Q3</th>
<th>Q6</th>
<th>Q10</th>
</tr>
</thead>
<tbody>
<tr>
<td>500mm wide Booster</td>
<td>Lab 1 &amp; Lab 2</td>
<td>Lab 2</td>
<td>Lab 1</td>
</tr>
<tr>
<td>460mm wide Booster</td>
<td>Lab 1 &amp; Lab 2</td>
<td>Lab 2</td>
<td>Lab 1</td>
</tr>
<tr>
<td>440mm wide Booster</td>
<td>Lab 1 &amp; Lab 2</td>
<td>Lab 2</td>
<td>Lab 1</td>
</tr>
</tbody>
</table>

Modified Kidfix XP - Width of backrest varied
Testing Results Summary

General Trends seen from reducing the width of the booster seat:

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Q3</th>
<th>Q6</th>
<th>Q10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head Movement</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Head Resultant (3ms)</td>
<td>≈</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>HPC15</td>
<td>≈</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Neck Fz</td>
<td>↑</td>
<td>↑</td>
<td>≈↑</td>
</tr>
<tr>
<td>Neck Mx</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>≈</th>
<th>=</th>
<th>Similar</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓</td>
<td>=</td>
<td>Reduction</td>
</tr>
<tr>
<td>↑</td>
<td>=</td>
<td>Increase</td>
</tr>
</tbody>
</table>
Q3 Kinematics

Excursion increases as booster width decreases

Distance to containment plane:

- Standard: 123mm @ 45 ms
- 460mm: 113mm @ 46 ms
- 440mm: 98mm @ 49 ms
Q6 Kinematics

Distance to containment plane:

- **Standard**
  - 88mm @ 45 ms

- **460mm**
  - 67mm @ 48 ms

- **440mm**
  - 52mm @ 51 ms

Excursion and head roll increases as booster width decreases.
Q10 Kinematics

Distance to containment plane:

<table>
<thead>
<tr>
<th>Width</th>
<th>Time</th>
<th>Distance</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>65 ms</td>
<td>0 mm</td>
<td>Containment plane crossed</td>
</tr>
<tr>
<td>460 mm</td>
<td>68 ms</td>
<td>-18 mm</td>
<td>Containment plane crossed</td>
</tr>
<tr>
<td>440 mm</td>
<td>70 ms</td>
<td>-23 mm</td>
<td>Containment plane crossed</td>
</tr>
</tbody>
</table>

Excursion increases as booster width decreases
Summary – Implications of 440 mm and effect of booster width in R129 environment

1. 440mm Booster:
   a. Q3 – Passed R129 side impact requirements
   b. Q6 – Passed R129 side impact requirements
   c. Q10 – Failed R129 side impact requirements (Head not contained)

2. Q10 head not contained by any narrower booster seats

3. CRS performance degradation observed in other body regions
   a. Neck and chest loadings increased for Q3, Q6

4. Dummy kinematic affected differently by backrest width reduction:
   a. Q3 – Consistent kinematics, slight increase in neck bending
   b. Q6 – Head movement around the head pad and towards the door increases
   c. Q10 – Containment problems
Implications of 440 mm and effect of CRS width in consumer test environment
- Simulation and testing
Child Restraint System offers protection for children in cars fulfilling:

- Performance criteria in selected configurations representing car accidents
- Compatibility rules to be sure that the CRS fits properly in cars (universality)

CRS must be homologate according R44 or R129 to be sold in the Market.

Consumer Ratings distinguish products on the markets. CRS must reach a good or a very good rating to be a commercial success.
CONSUMER TESTS ARE AN IMPORTANT DESIGN CONSTRAINT – POOR PERFORMANCE CAN LEAD TO NEGATIVE PUBLICITY AND PRODUCT WITHDRAWALS
COMPARISON ETC/R129 SIDE IMPACT

Overall Setup

ETC 2015

R129
COMPARISON ETC/R129 SIDE IMPACT

Less padding in intruding door to represent door panel

ETC 2015

- Styrodur panel (20 mm)
- Rigid Structure

R129

- Styrodur panel (20 mm)
- Polychloroprene panel (35 mm)
- Rigid Structure
COMPARISON ETC/R129 SIDE IMPACT

Higher Door

ETC 2015

R129

+/− 80 mm
COMPARISON ETC/R129 SIDE IMPACT

Higher Intrusion speed
## Results ETC-2015 side impact  Q3

<table>
<thead>
<tr>
<th></th>
<th>HIC</th>
<th>Head Acceleration (g)</th>
<th>Chest Acceleration (g)</th>
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<th>Upper Neck Moment (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q3 Standard seat</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Q3 Adapted seat</td>
<td>111%</td>
<td>168%</td>
<td>196%</td>
<td>84%</td>
<td>118%</td>
</tr>
</tbody>
</table>
KIDDY NUMERICAL SIMULATION

Results ETC-2015 side impact  Q3

Standard seat

Adapted seat
# Kiddy Numerical Simulation

## Results R129 side impact – Q6

<table>
<thead>
<tr>
<th></th>
<th>HIC</th>
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<th>Upper Neck Moment (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q6 Standard seat</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Q6 Adapted seat</td>
<td>153%</td>
<td>158%</td>
<td>225%</td>
<td>157%</td>
<td>120%</td>
</tr>
</tbody>
</table>
KIDDY NUMERICAL SIMULATION

Results R129 side impact

Q6

Standard seat

Adapted seat
COMPARISON ETC/R129 SIDE IMPACT – DOREL TESTING

Tests with 440 mm wide prototype
COMPARISON ETC/R129 SIDE IMPACT – DOREL TESTING

Tests with 440 mm wide prototype – Comparison with ETC side impact criteria

Severity Increase
59 % for Q3
69 % for Q6
COMPARISON ETC/R129 SIDE IMPACT – DOREL TESTING

ETC Side impact – Influence of product width with Q3

440 mm

500 mm
COMPARISON ETC/R129 SIDE IMPACT – DOREL TESTING

Side Impact ETC - Effect of width Increase Q3

(references 100 for 440 mm width)

Improvement 17% with 500 mm

Important improvement for chest and neck
COMPARISON ETC/R129 SIDE IMPACT – DOREL TESTING

ETC Side impact – Influence of product width with Q6

440 mm  500 mm
COMPARISON ETC/R129 SIDE IMPACT – DOREL TESTING

Side Impact ADAC - Effect of width Increase Q6

(refERENCE 100 FOR 440 MM WIDTH)

Improvement 16 % WITH 500 MM

Important improvement for head and chest
SUMMARY - IMPLICATIONS OF 440 MM AND EFFECT OF BOOSTER WIDTH IN CONSUMER TEST ENVIRONMENT

- ETC and Regulation side impact differ substantially:
  - Less door padding
  - More important intrusion speed
- ETC is much more severe compared to Reg 129.
- Increased product width offers possibility to reach better results.
- ETC seems to favor performance results in side impact when GRSP would like to favor car compatibility. These 2 requirements may be contradictory.
- Unintended consequences:
  - CRS manufacturers may be unable to produce i-Size boosters that achieve reasonable performance in consumer tests
  - CRS manufacturers may produce specific to vehicle boosters only, with potentially better ratings compared to i-Size universal products
  - Few i-Size boosters may come to the market
OVERALL SUMMARY

• R129 performance thresholds can be met with 440 mm with Q3 and Q6
• R129 performance thresholds cannot be met with 440 mm with Q10
• Reducing width of CRS leads to significant performance degradation in non-regulated body regions
• Acceptable consumer test performance cannot be achieved with 440 mm for all dummy sizes
  – CRS manufacturers reluctant to bring products to the market with such a risk
  – This may limit the penetration of i-Size booster seats
AVENUES FOR FURTHER INVESTIGATION - INTERNAL DIMENSIONS
INTRODUCTION

In order to be sure that ECRS accept children of a certain stature, 95th centile dimensions are checked in the ECRS.

This requirement is very demanding for the higher stature:

<table>
<thead>
<tr>
<th></th>
<th>HIII 5th</th>
<th>Q6</th>
<th>Q10</th>
<th>135 cm 95th</th>
<th>150 95th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip Breadth (mm)</td>
<td>307</td>
<td>200</td>
<td>270</td>
<td>330</td>
<td>379</td>
</tr>
<tr>
<td>Shoulder Breadth (mm)</td>
<td>358</td>
<td>259</td>
<td>338</td>
<td>369</td>
<td>415</td>
</tr>
</tbody>
</table>
INTRODUCTION

Since design space is also limited by ISO envelope, available lateral space to offer side protection is very limited.

440 mm booster envelope

Available volume for 135 cm size in 440 mm envelope
POSSIBLE CONCEPT

Shoulder Breadth (cm)

Stature (cm)

- 50%ile
- 95%ile
- Proposal
AVENUES FOR FURTHER INVESTIGATION – F4 DEPTH
F4 DEPTH MODIFICATION REQUEST

Why?

More cushion depth needed for the comfort of older children:

More lateral protection needed with side wing

Concept
Align F4 fixture depth with F2X
F4 DEPTH MODIFICATION REQUEST