

# The balance of vehicle and booster protection. Why ban the booster cushion?

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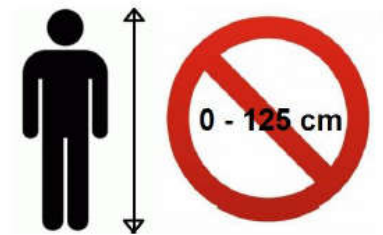
# Background

- Children of age 4-12 require a CRS to adapt to the vehicle protection systems.
- Today, CRSs are developed based on a standardized stand-alone test set-up using crash test dummies in one sitting posture.
- Children are active.
- Crashes in future vehicles are likely preceded by an evasive event.
- Increasing use of car sharing and taxis.



# European booster certification situation

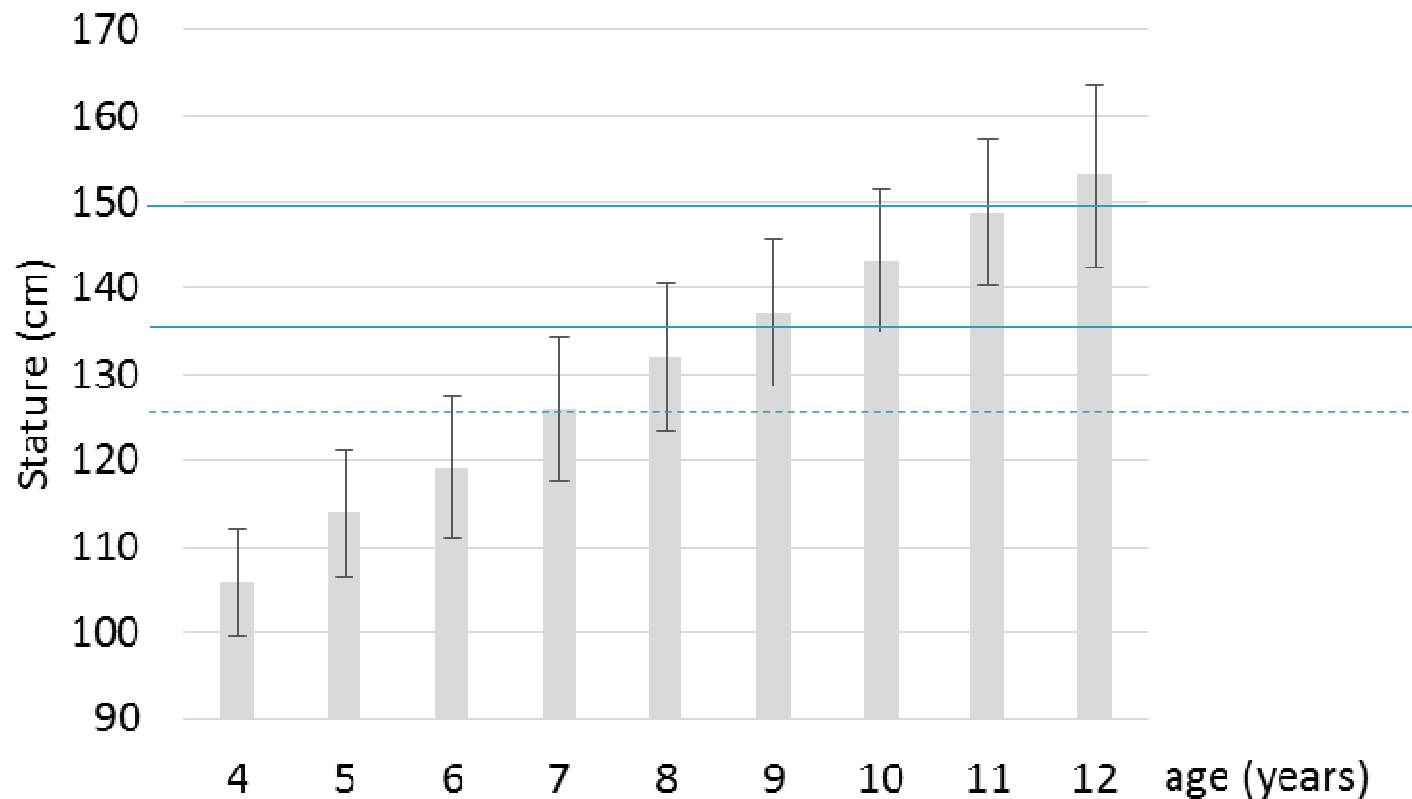
- UN ECE R129: At this stage, not possible to type approve a booster cushion due to side impact test set-up (not vehicle-like).
  - Discussions ongoing



- Amendment for UN ECE R44-04, Suppl 11
  - Effective date **2017-01-21**, new type approvals and extensions to existing type approvals
  - Booster cushions without backrest shall only be used by children with a stature > 125 cm
  - Requires booster cushions without a backrest to be permanently marked.

# Age vs stature (mean $\pm$ std dev)

Volvo Cars' Statistical Accident Database, Sweden



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# Swedish national research projects 2010-2017

## Aim and purpose

- Further enhance the safety of booster-seated children in the rear seat by identifying the real world needs, also taking restraint interaction and attitude aspects into account
- Establish guidelines for evaluation methods and protection principles
- Provide state-of-the art knowledge and contribute to setting the futures research and development needs




# Real world safety



Evaluation of protection beyond standardized crash testing scenarios, including child kinematics and behavior during transportation and in potential evasive braking or steering before crash.

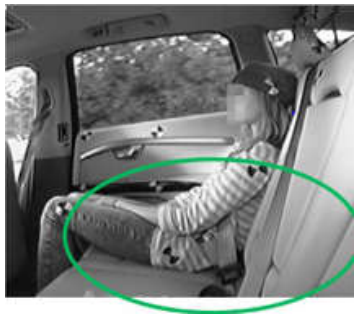
# A multi-faceted approach

## Methods

- Real world crash data
  - Driving studies with children
  - Testing and simulations
    - Crash testing and simulations
    - Low-severity / maneuver tests
  - International coordination of knowledge
- 
- Real world crash data analysis
    - Fatality trends in Sweden
    - Long-term consequences
    - Pre-crash maneuver characteristics
  - Child kinematics and behavior in cars during riding and in evasive events
  - Evaluation and development of tools
  - Evaluation of countermeasures (crash, pre-crash)
  - International dissemination

# How do children sit in cars during transportation?

## On-road driving studies



6 children aged 3-6



6 children aged 8-13



No booster

6 children aged 7-9





# Head forward position

Booster type



Activities

Visibility



Evasive braking

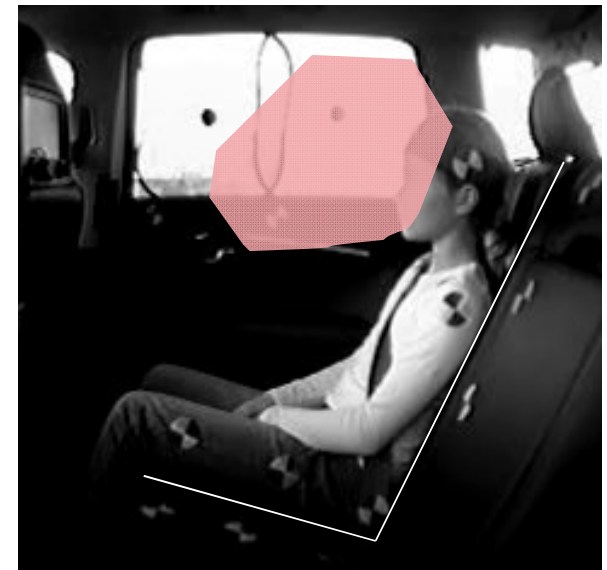


*Shoulder belt on shoulder*



*Shoulder belt slip-off*

Area of forehead positions during evasive braking, when upright initial sitting posture



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# Child sidewise positions

## Comfort & Activities



## Evasive steering

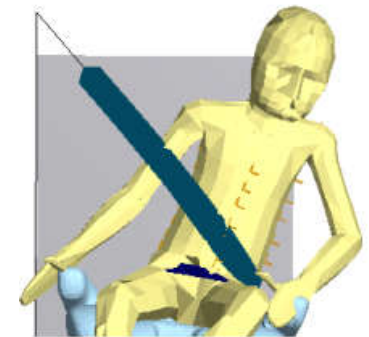


# Activation of **pre**-pretensioner in evasive steering

Starting position



No activation of pre-pretensioner



Activation of pre-pretensioner



# Activation of **pretensioner** in side **impacts**

Far-side seated occupant

No activation



Integrated booster

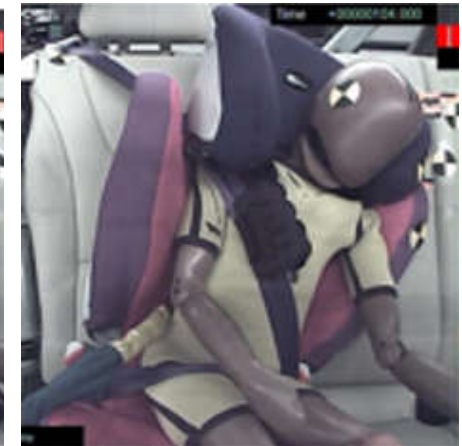
Activation of seatbelt pretensioner (pyro)



Integrated booster



Highback booster,  
no ISOFIT



Highback booster,  
ISOFIT



# Children benefit from vehicle protection systems, given they are raised in position using a booster



# Ensure good belt fit



- Vehicle and CRS should encourage “controlled” sitting postures, preferably guided by comfort, helping to restrict the variability in user positions.
- Control occupant kinematics during evasive and low severity events, which potentially precede an impact.
- Encourage designs enabling protection in real world situations for children in different user positions.

# Booster usage in Volvo cars in Sweden, 2000-2013

## Volvo Cars' Statistical Accident Database

- Children aged 4-12
- Stratified in two groups of observation (crash) years; 2000-2006 versus 2007-2013
- Type of restraints:
  - booster cushions
  - high-back-booster seats
  - integrated boosters
  - seat belt only
  - rearward facing child seat
  - unrestrained



# Data set

All children

age	Total	% front pass. seat	% outboard rear seat
4	145	13%	79%
5	134	15%	75%
6	116	13%	73%
7	112	14%	77%
8	146	23%	66%
9	139	22%	62%
10	160	27%	60%
11	129	30%	56%
12	154	31%	55%
	<b>1235</b>	<b>21%</b>	<b>66%</b>

Children of stature  $\leq 135$ cm

age	Total	% front pass. seat	% outboard rear seat
4	130	12%	81%
5	113	15%	74%
6	99	13%	72%
7	90	11%	79%
8	87	23%	68%
9	51	12%	67%
10	23	22%	65%
11	8	50%	50%
12	8	50%	50%
	<b>609</b>	<b>16%</b>	<b>73%</b>

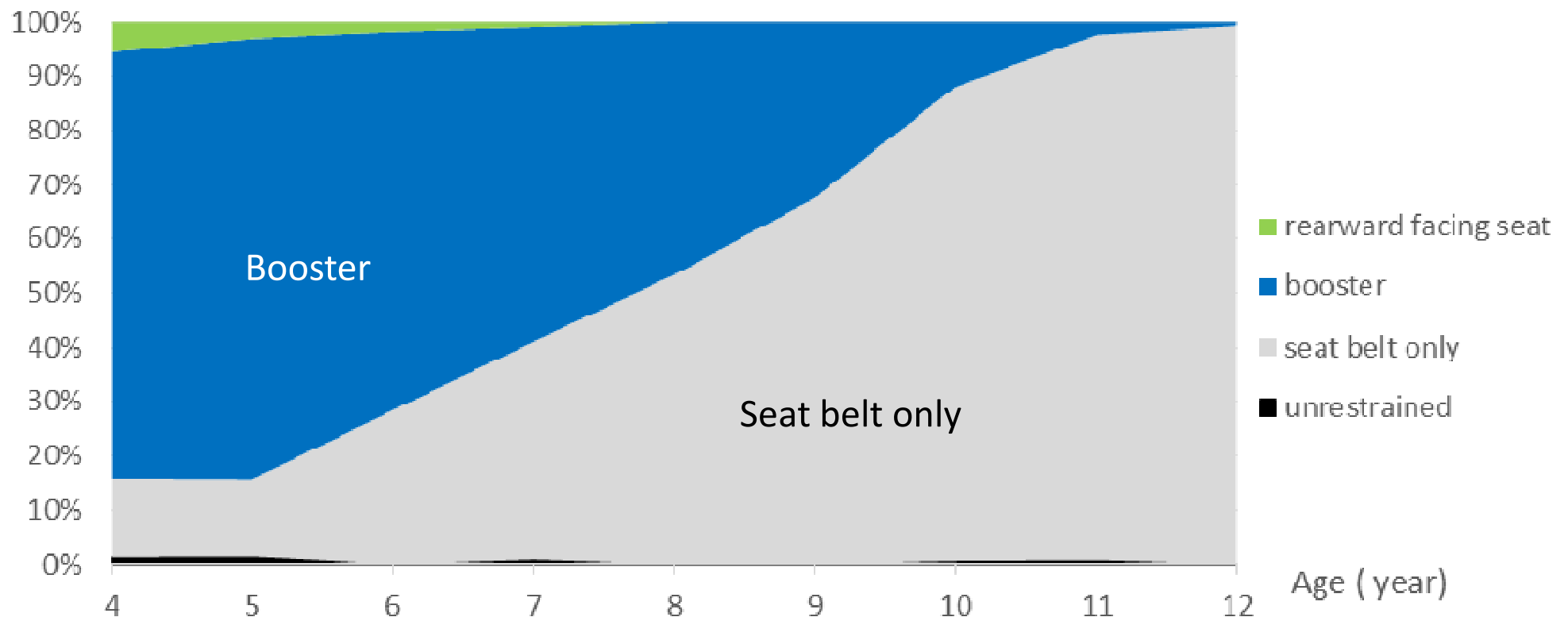
57%  $\leq 135$ cm

Missing data due to lack of stature information, N= 157

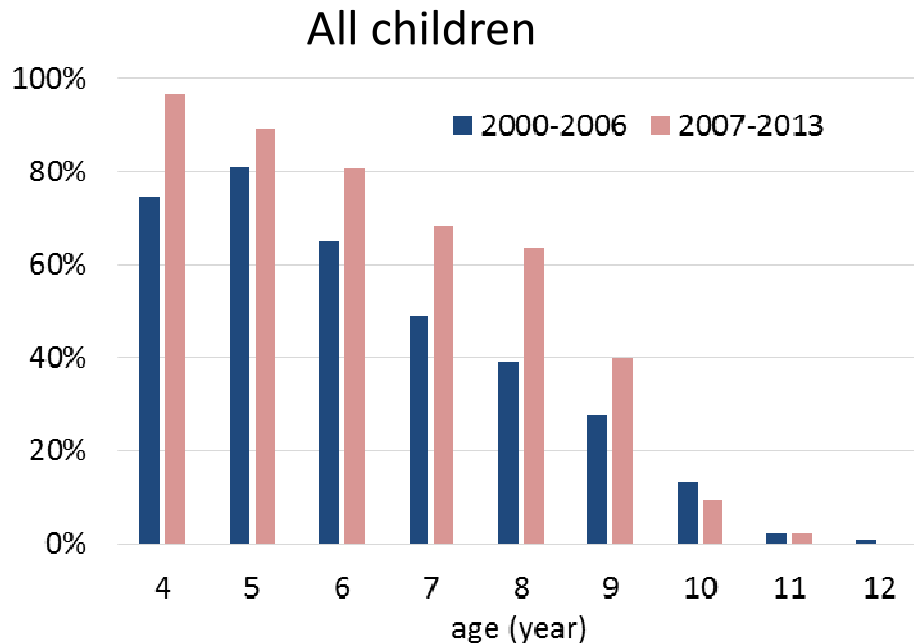




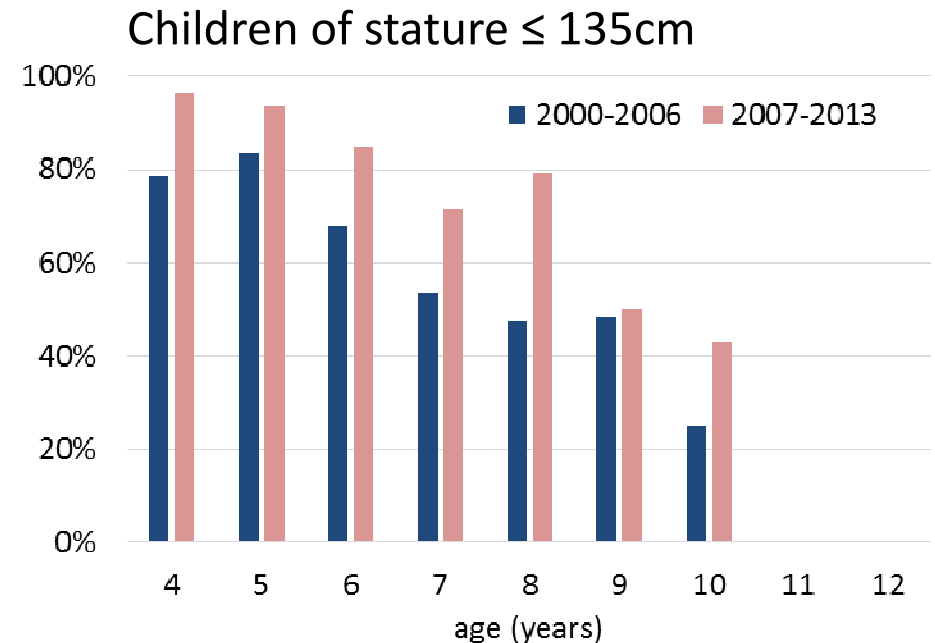
# Restraint usage all 4-12yo, 2000-2013



# Booster (incl RFCRS) usage rate per age



- Increase over time; 37% → 51% (+39%)
- Decrease with increased age



- Increase over time; 63% → 79% (+26%)
- **21% are not following the law!**

# Boosters

- Children using boosters are well protected, irrespective of type of booster
  - no real world evidence of different level of protection when using booster cushion vs booster seat.
- The car provides protection to the child!
- Although law requires booster usage up to 135cm in Sweden, one of five children aged 4 and above are using seat belt only. Those are:
  - The majority of the 9+ year-olds
  - Approximately 20% of the 6-8 year olds
- Child occupant protection strategies should consider higher degree of car sharing / taxis and car automation.

# Protection strategies?



?



Comfort cover  
when needed

Back to basics?



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# Conclusions



- For total child safety, a priority is to increase overall booster usage rate.
- Regulation forcing children up to 135cm stature to use CRS contributes only to a limited extent.
- Necessary to understand and address the needs for the specific travel to reach high usage.
- Booster designs are important measures to encourage increased usage over the whole age range.
  - Integrated boosters and booster cushions increase relative usage among the older age group.
- The car provides protection to the child. The booster is essential to ensure good belt-fit.
- The balance of vehicle and booster protection should be in focus, not the banning of the booster cushion.

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