CRS-15-3

Finite Element Analysis of Child Occupant Responses in Side Impact

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Outline

- Background
  - Literature Study of Accident Analysis
  - Full-Car Side Impact Test
  - Oblique angle
- FE Analysis Condition
- Results
- Conclusions

Background

RF and FF CRS

Rear Facing (RF) CRS

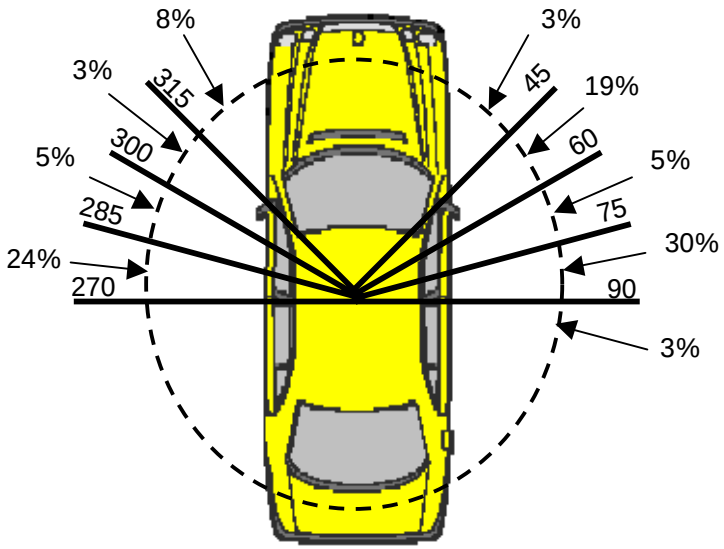
Infant

Forward Facing (FF) CRS

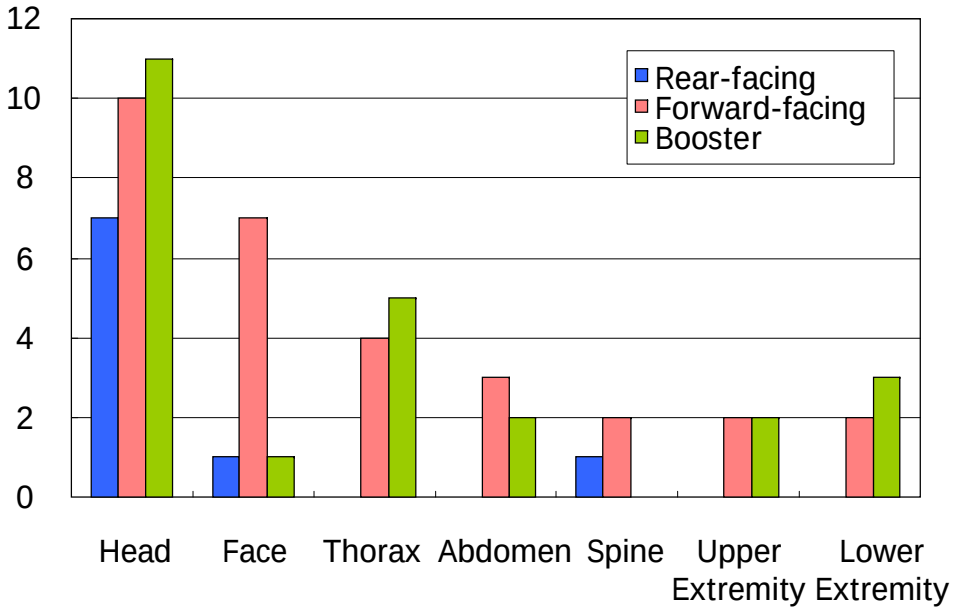
Toddler

Accident Analysis of Child Occupants using Forward Facing CRS in Side Collisions

Principal direction of force (PDOF)



Injury body region



Reference : Arbogast, JSAE Congress 2009

Injury Cause and Severity (AIS 2+) of Struck Side CRS Sitting Children

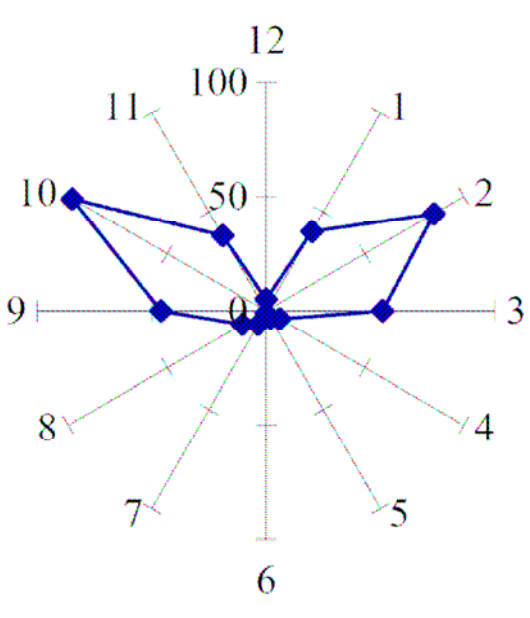
N=12

	Head	Cervical spine	Thorax	Abdomen	Pelvis
A/B pillar	AIS 5 AIS 5 AIS 5				
Door / Side interior	AIS 5 AIS 5	AIS 6			
Glass / Side window	AIS 2 AIS 2				
Intruding object	AIS 4 AIS 3				
Near by child interaction					
CRS buckle / shield	AIS 3 AIS 2				

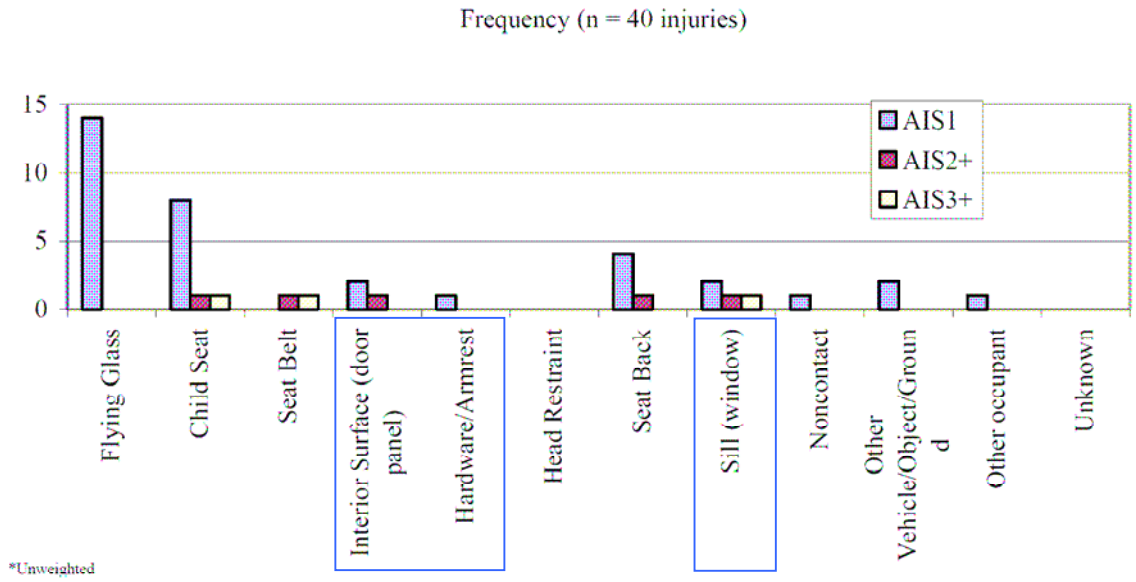
Reference : Langwider, SAE Paper 962439

Accident Analysis of Child Occupant in Side Impact (NHTSA)

Principal direction of force (PDOF)



Injury source (Forward facing CRS)

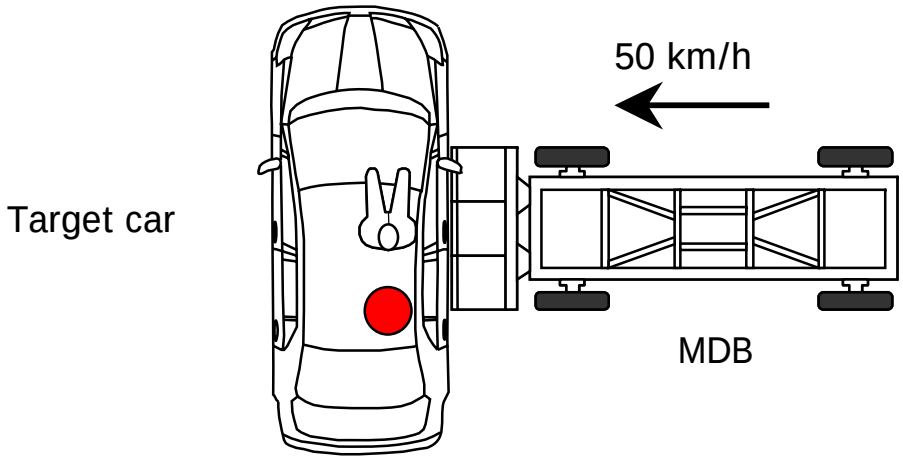


Reference : McCay, 20th ESV, 2007

Side Impact Test

Test matrix

Test No.	CRS type	Position	ATD	Target car (curb mass)	Striking vehicle (curb mass)
Test 01	Forward facing	Struck side	Q3s	Car A (1266 kg)	ECE R95 MDB (950 kg)
Test 02	Forward facing	Struck side	Q3s	Car B (1130 kg)	ECE R95 MDB (950 kg)



Kinematic Behavior

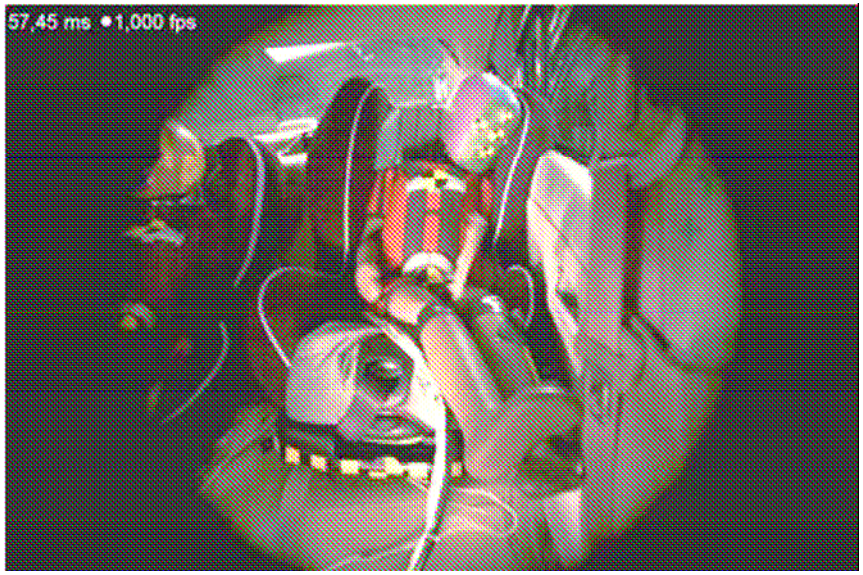
Test 01

HIC 148
Chest deflection 23.3 mm

Test 02

HIC 182
Chest deflection 20.5 mm

FMVSS214 Test Condition (NHTSA Study)



HIC 520

HIC 200

Reference：Sullivan, 21th ESV, 2009

Background (Summary)

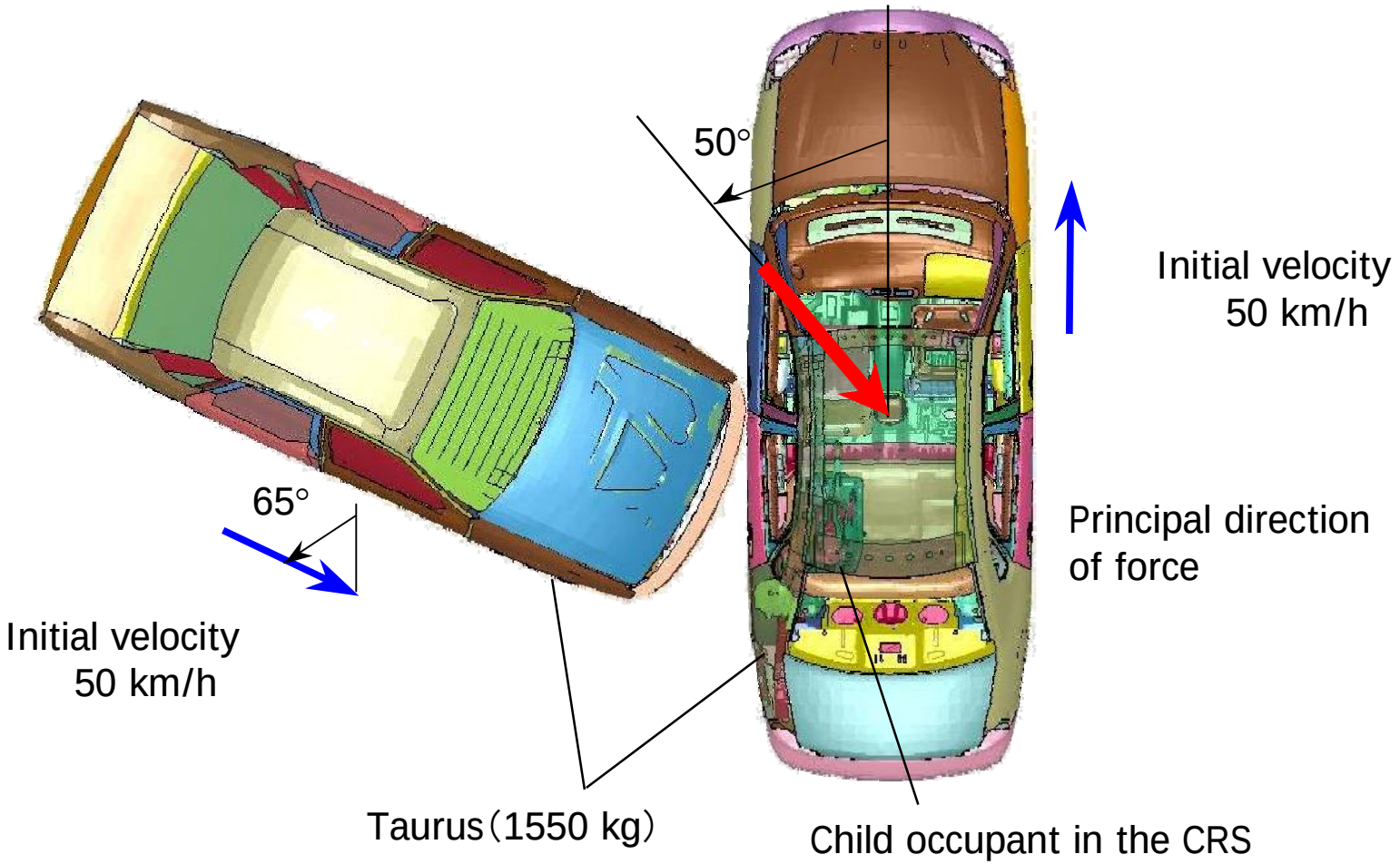
- In real-world accidents, the head is most frequently injury body region for the child seated in the FF CRS.
- The head of the child dummy was contained in the CRS shell in ECE R95 test condition.
- In angled impact (FMVSS 214), the head of the child dummy made contact with the door though the HIC was small.
- It is difficult to reproduce the head injury of child occupant in contact with the door, which occur frequently in real-world accidents.

Purpose of the current study

- In order to examine the possibilities of the head injuries in contact with car interior, a series finite element (FE) simulation of car-to-car oblique collisions was carried out by using two occupant FE models.

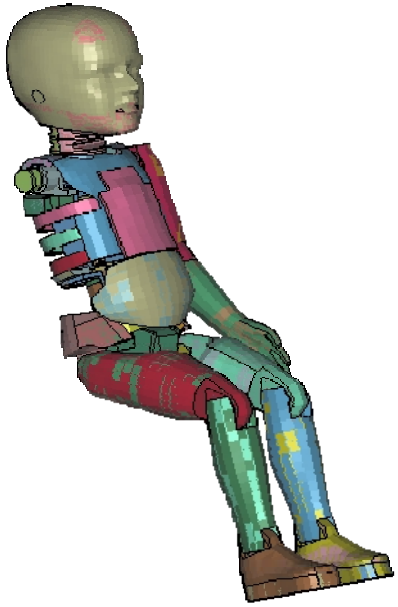
Analysis Condition

Analysis Condition

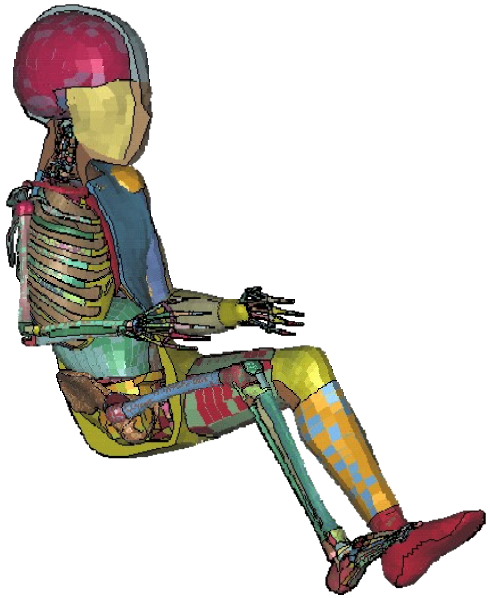


- The impact angle of the striking car was 65 degrees
- The CRS was installed on the struck side in the rear seat.
- Hybrid III 3YO FE model or the child FE model was seated in the CRS

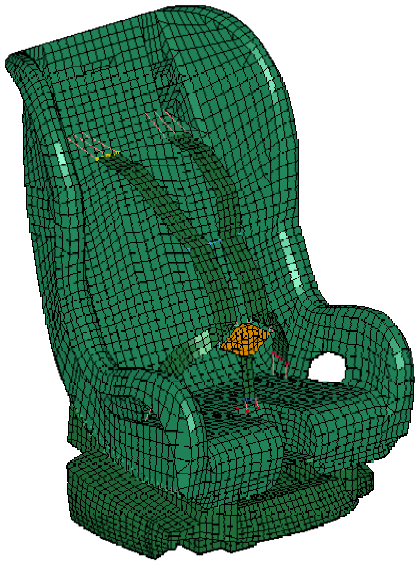
FE models



Hybrid III 3YO



Child FE



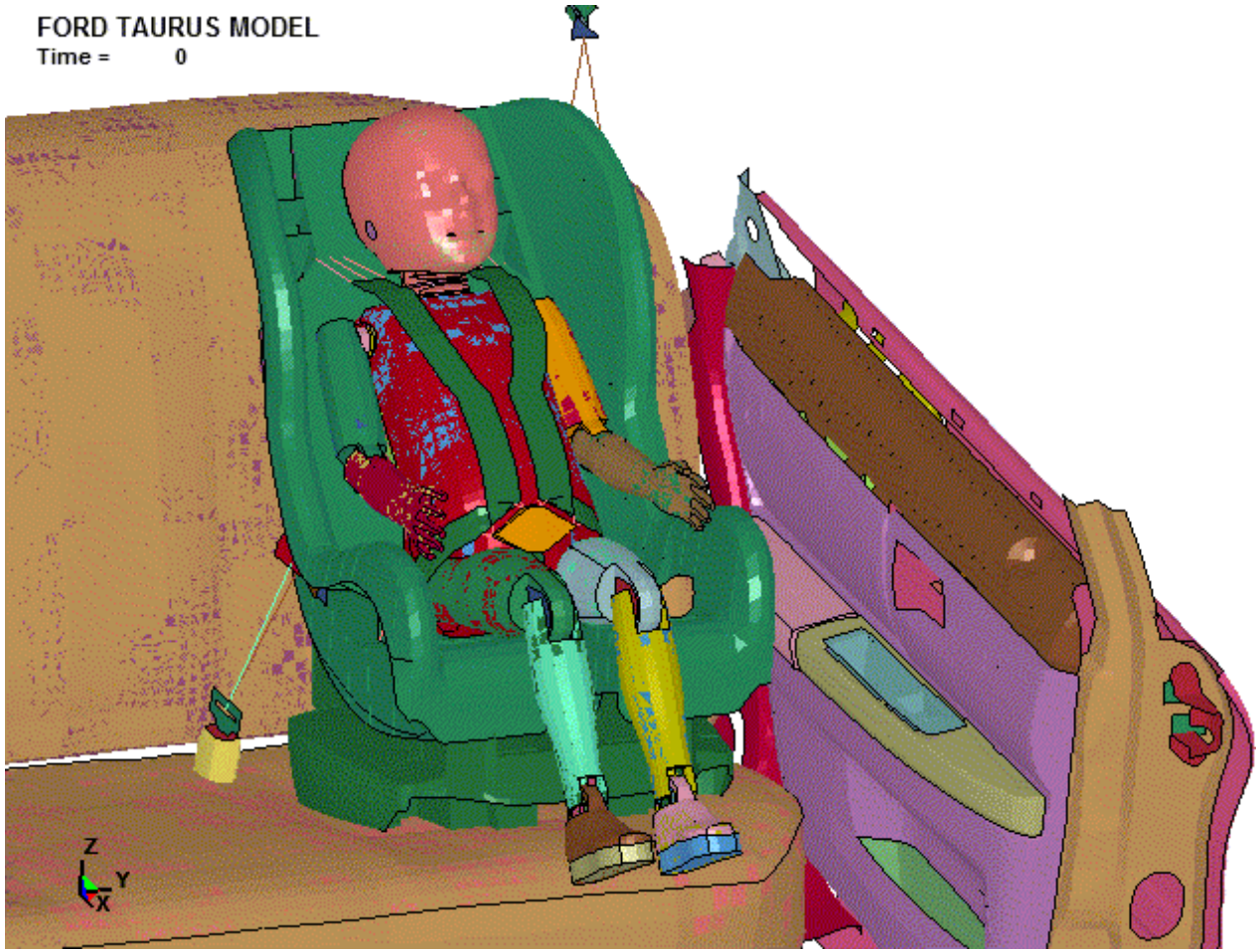
CRS FE model

Analysis Matrix

Analysis No.	CRS type	Position	Model	Shoulder harness slack (mm)
01	Forward facing	Struck side	Hybrid III 3YO	0
02	Forward facing	Struck side	Child FE	0
03	Forward facing	Struck side	Child FE	70

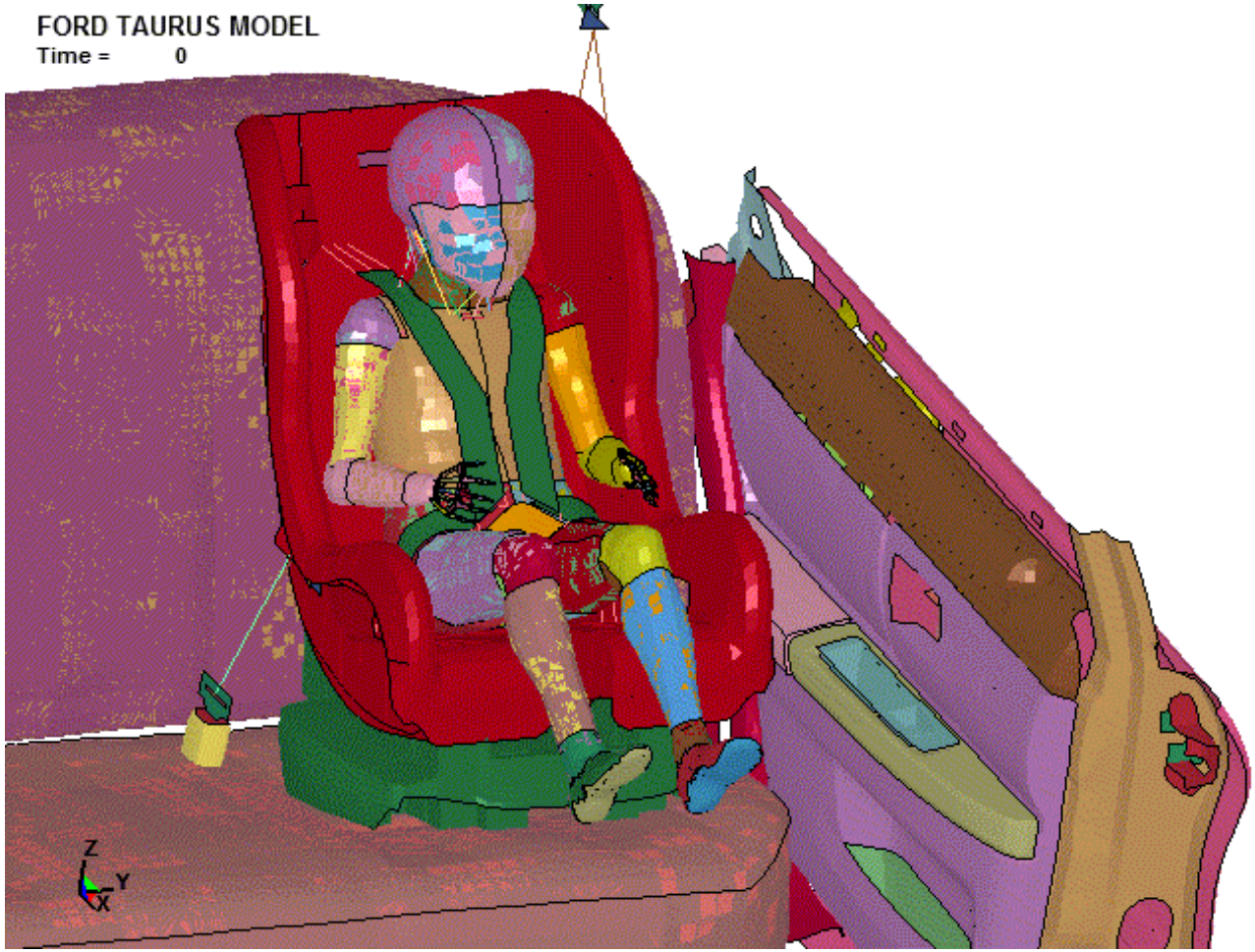
Results

Kinematic Behavior of Hybrid III 3YO

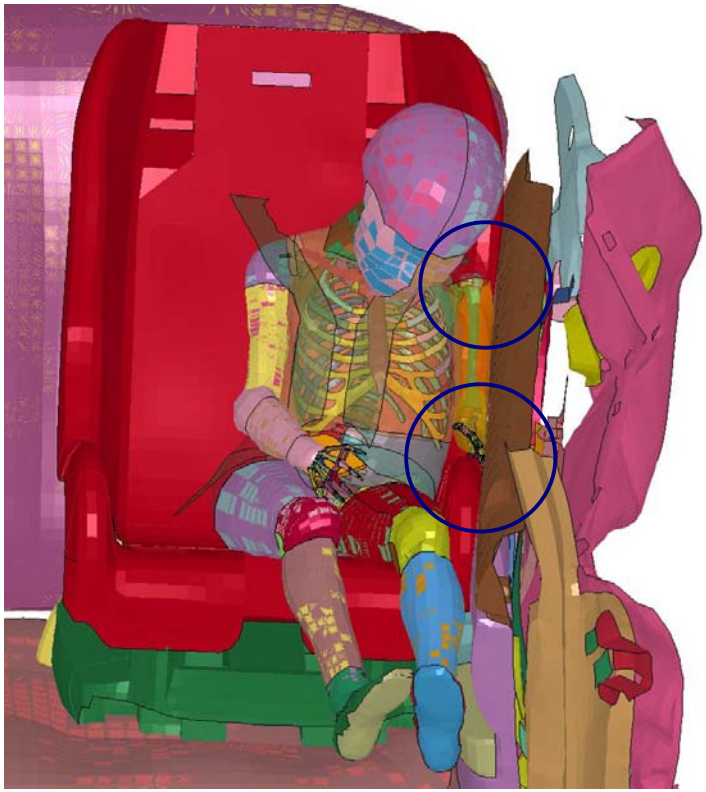


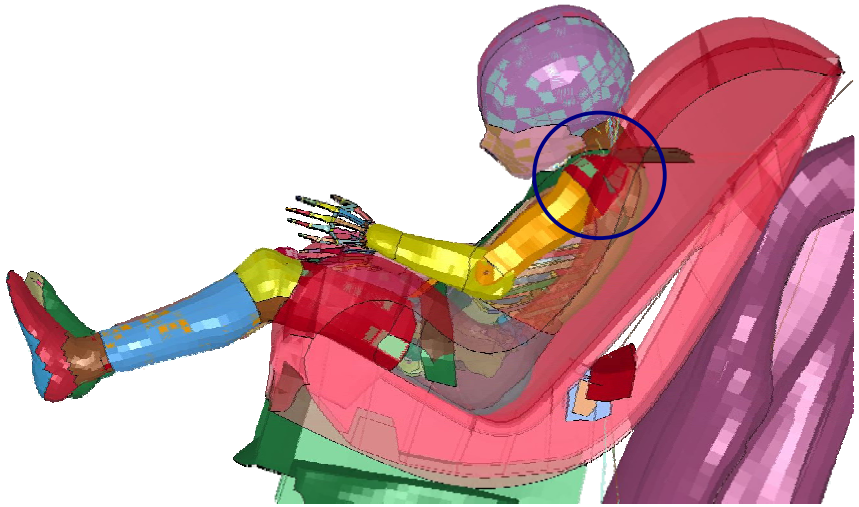
Kinematic Behavior of Child FE

Child FE (no slack)



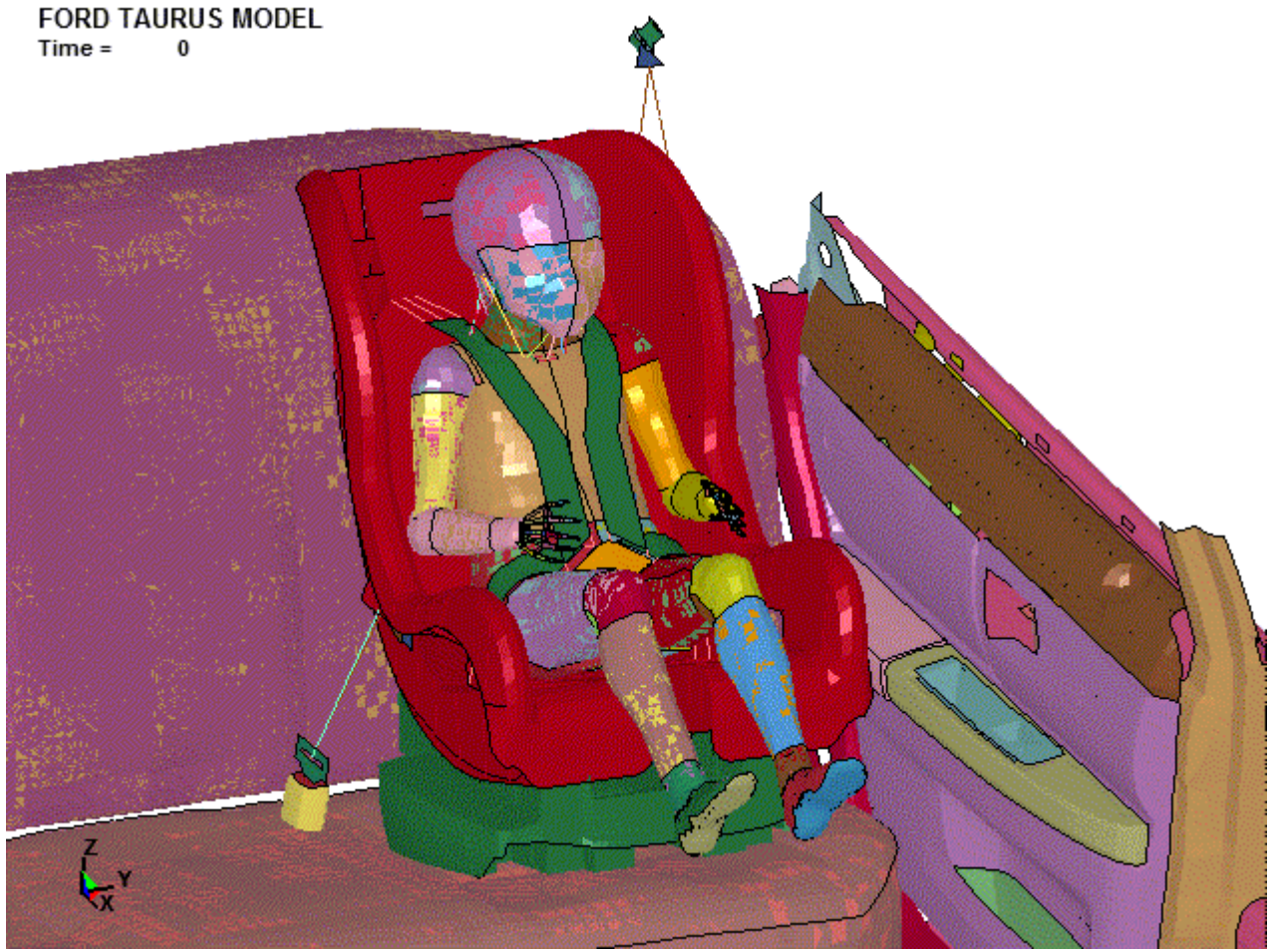
Child FE (No slack)



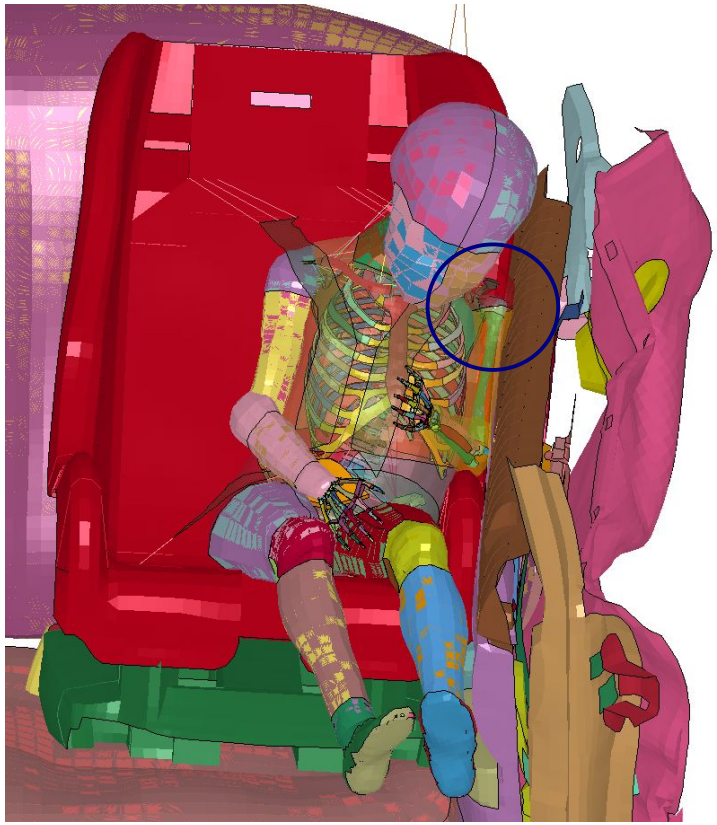


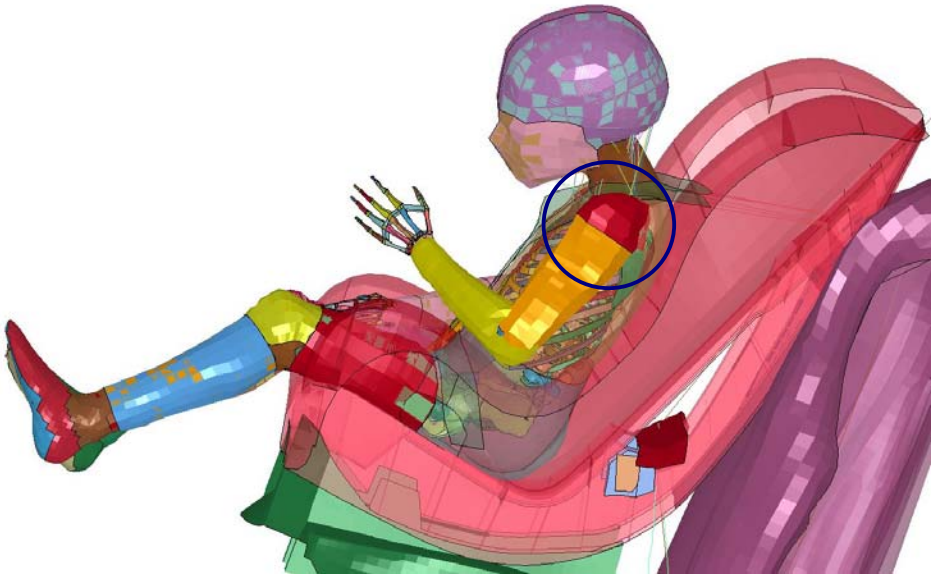
Kinematic Behavior of Child FE

Child FE (70mm harness slack)



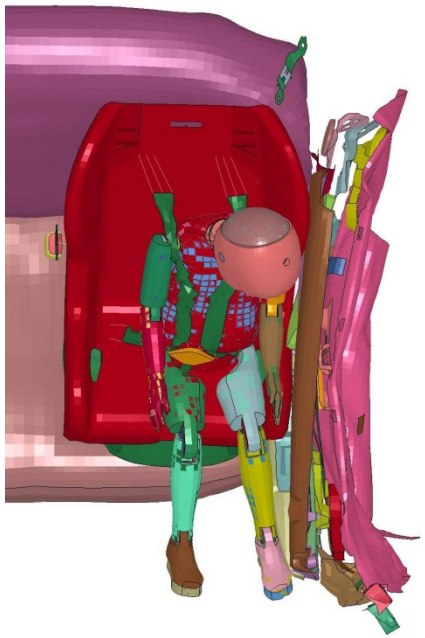
Child FE (70 mm harness slack)



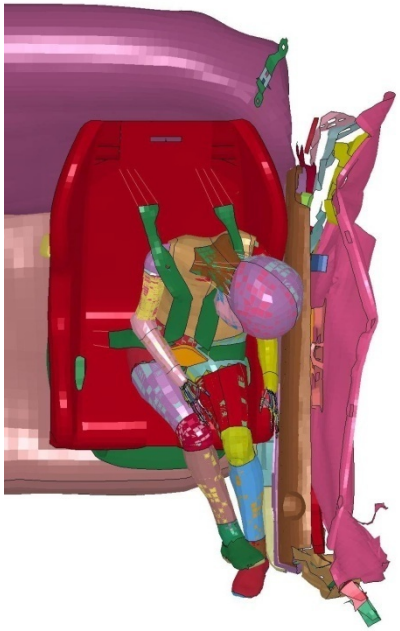


Head Excursion

Hybrid III 3YO



Child FE
No slack

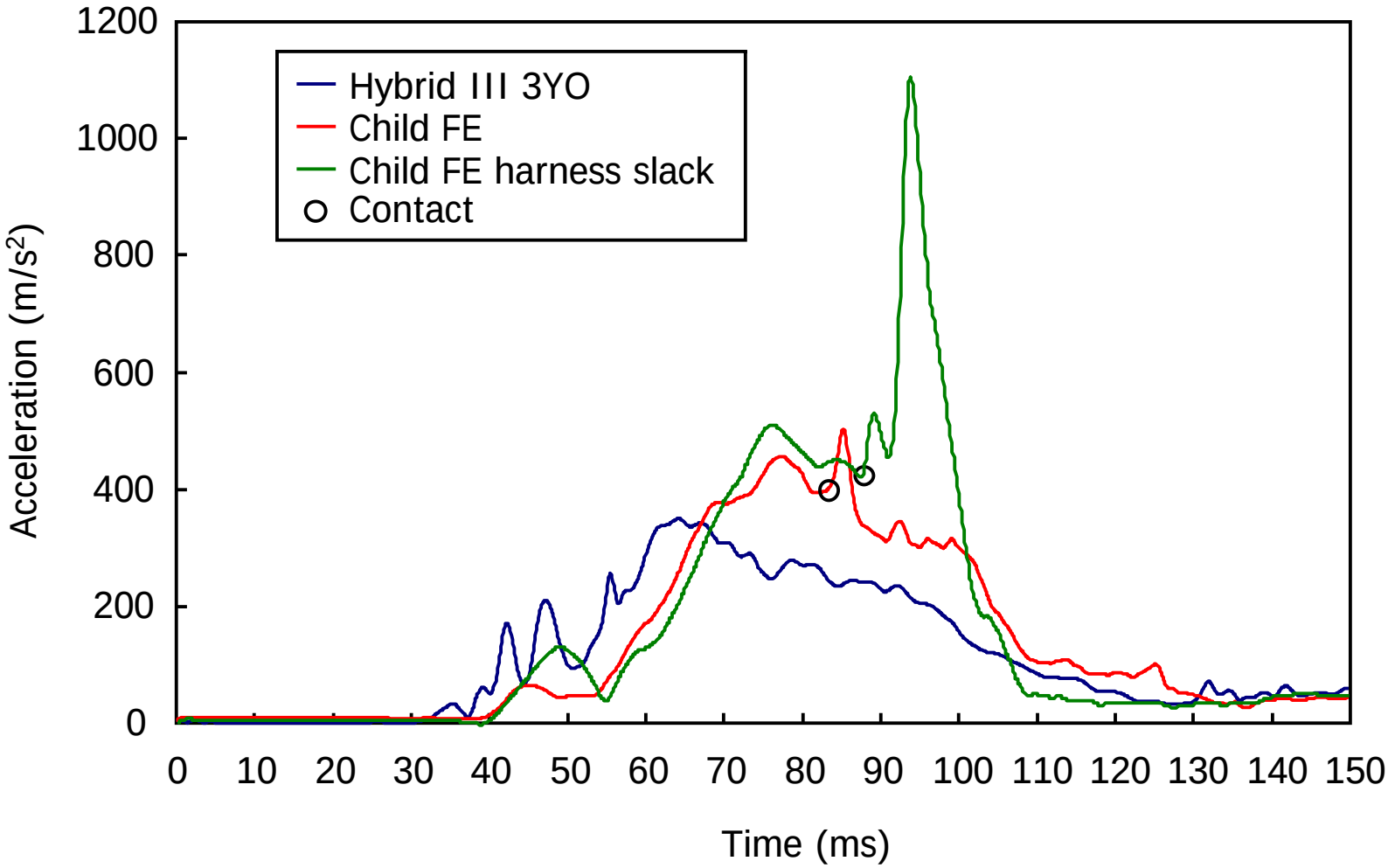


Head impact velocity
3.7 m/s

Child FE
70mm harness slack

Head impact velocity
6.3 m/s

Head Acceleration



Injury Measures

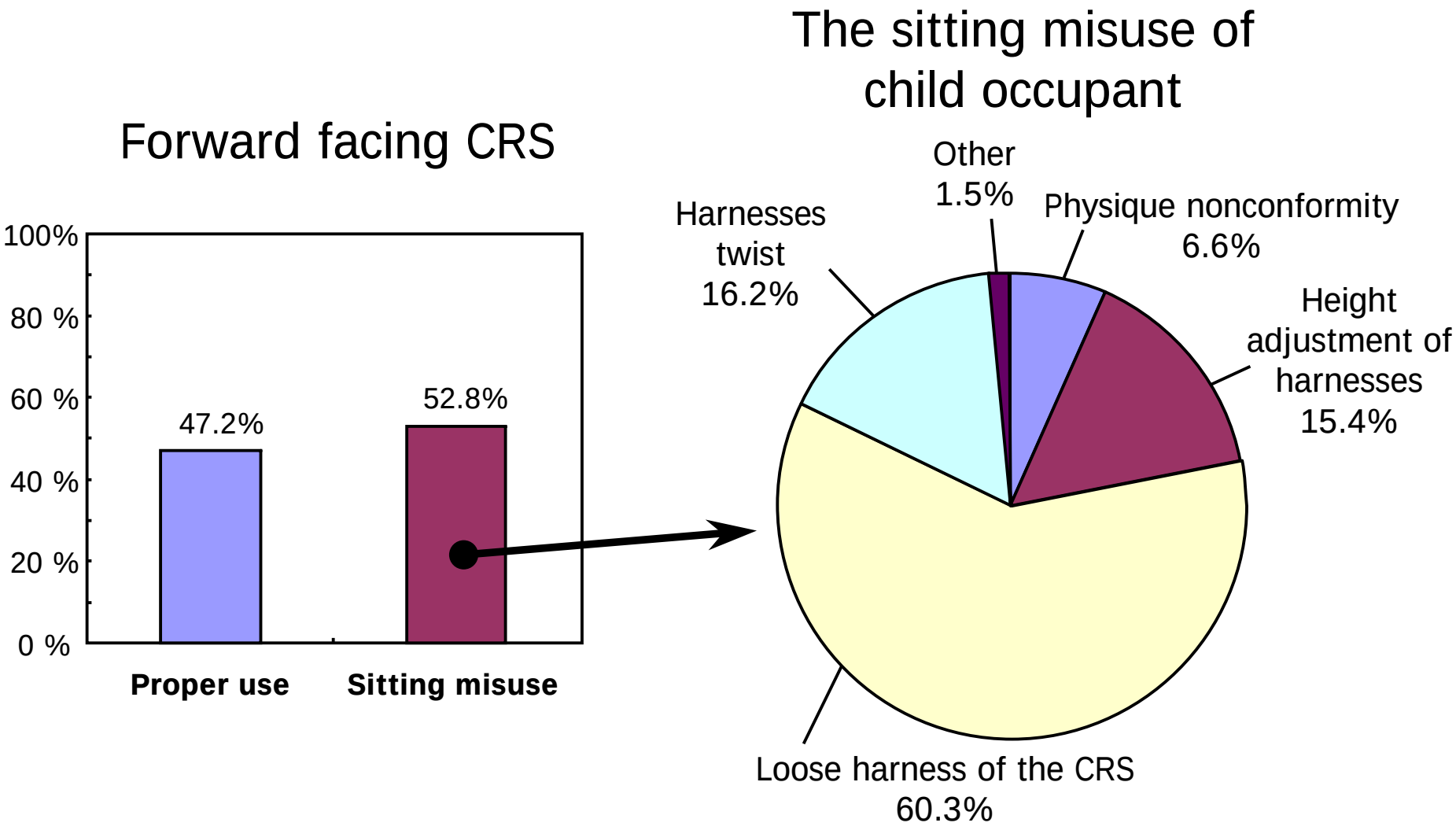
Model	HIC15	Chest deflection Dy (mm)
IARV (3YO)	568	23.0
Hybrid III 3YO FE	90	8.2
Child FE （no slack）	185	10.6
Child FE （harness slack 70 mm)	481	11.0

Conclusions

- In the car-to-car oblique side collision, the head of the Hybrid III 3YO flexed but it did not make contact with the door.
- The head of child FE made contact with the stationary door. The head impact velocity and HIC was small（HIC 185）
- When the slack was added in the shoulder harness of the CRS, the head displacement of the child FE model was substantially large. The head made contact with the door beltline（HIC 481）
- It is probable that the misuse of the CRS could be one of the causes of the head contact with car interior in real world side collisions.

Thank you for your attention

Forward Facing CRS Misuse



Reference :Japan Automotive Federation (JAF) 2009