12th Australasian Injury Prevention and Safety Promotion Conference
25-27 November 2015 | Sydney

Full-face motorcycle helmet protection from facial impacts

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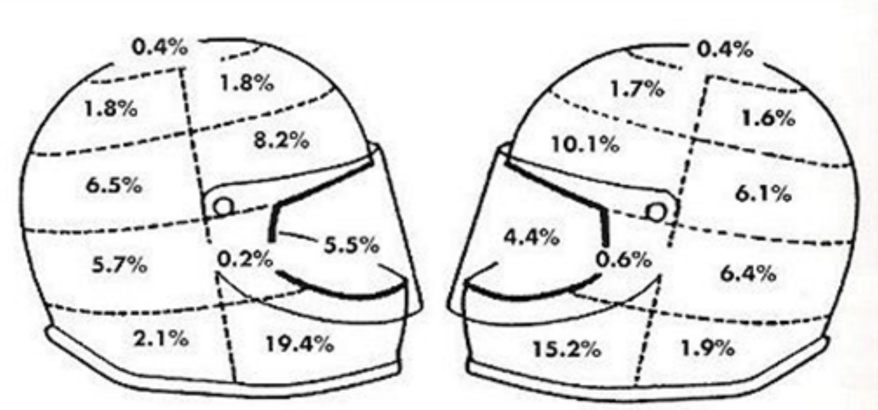
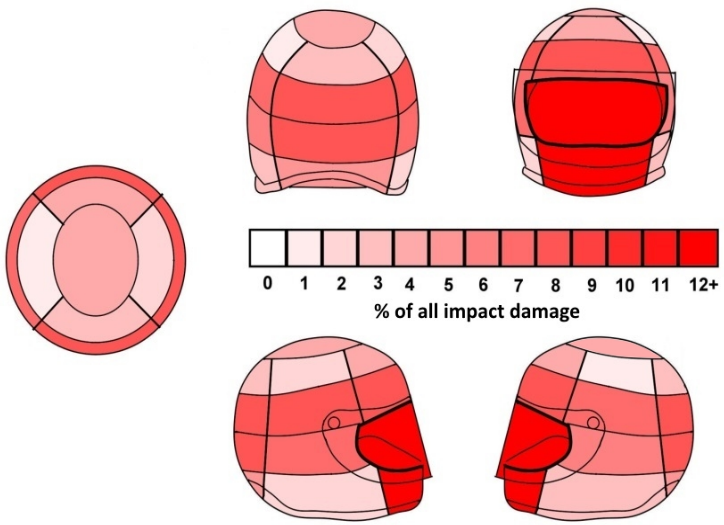
Context

- Facial impacts are common
  - 63.6% damage around facial opening (34.6% chin bar)
  - >60% cases in NSW in-depth Crash Study (2012-2014)



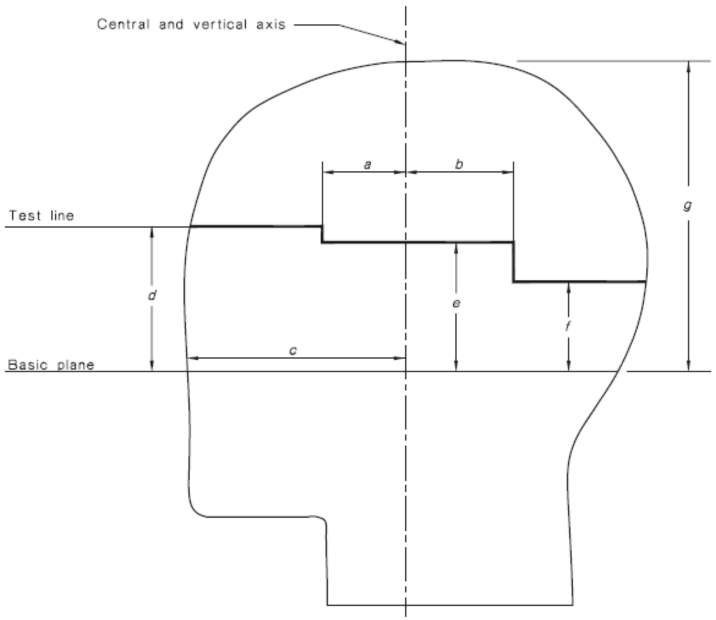
Otte 1991

- Facial impacts are particularly injurious (Otte 1991)
  - Uninjured in 37% vs 70%
  - 3 x soft tissue injuries
  - 2 x fractures
  - 2 x brain injuries

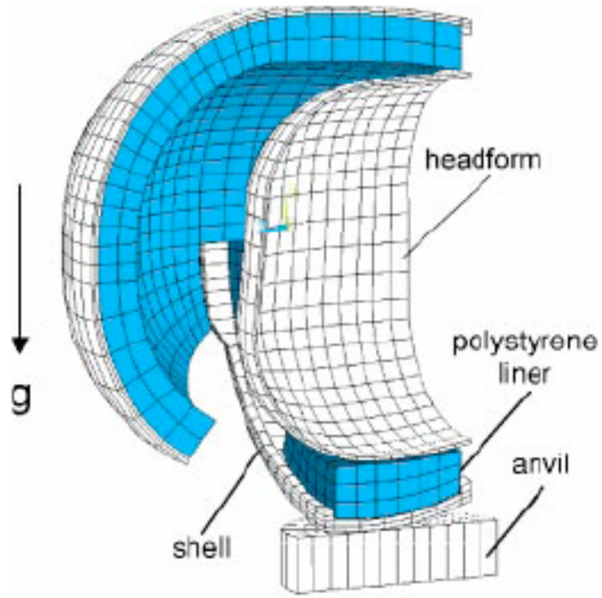


Context

- No required impact attenuation in AS/NZS or US standards.
- Some researchers suggest stiff chin bars while others recommend soft chin bars with an energy-absorbing liner.



AS/NZS 2512.1:2009



Chang et al. 2000

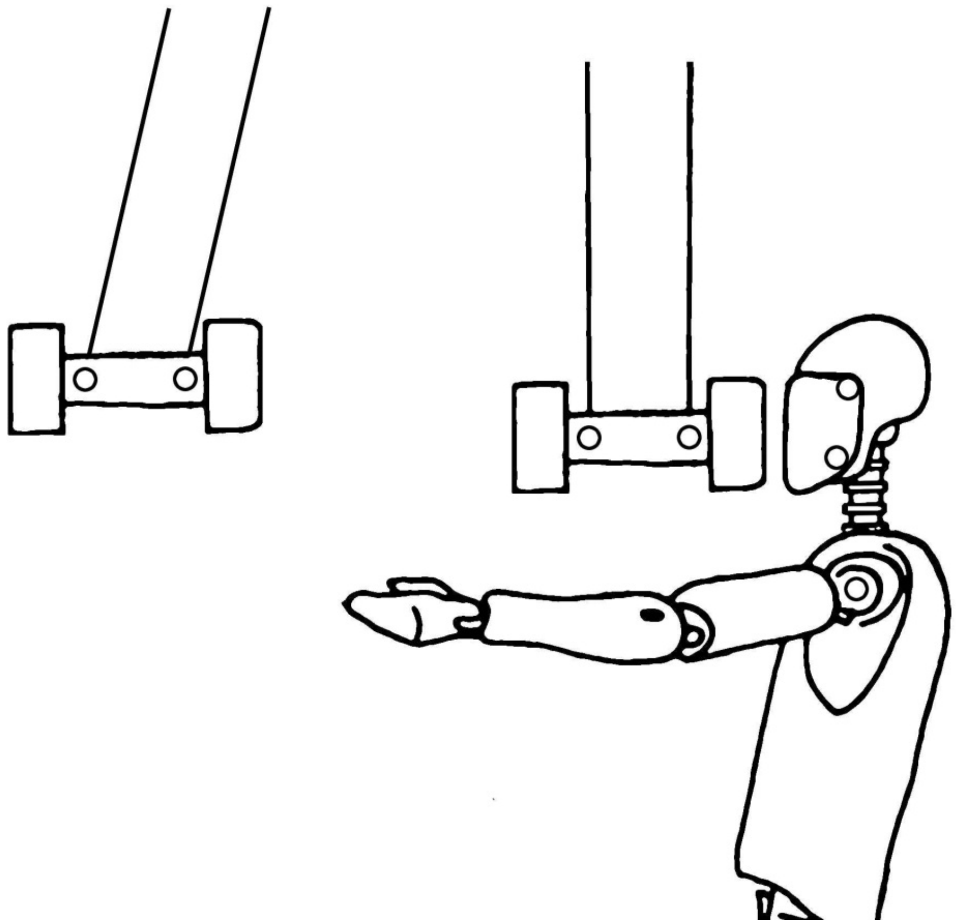
Aims

- Investigate the effect of a full-face motorcycle helmet on the risk of head injury in a facial impact.

- Investigate the effect of energy-absorbing foam placed in the chin bar of the full-face helmet.

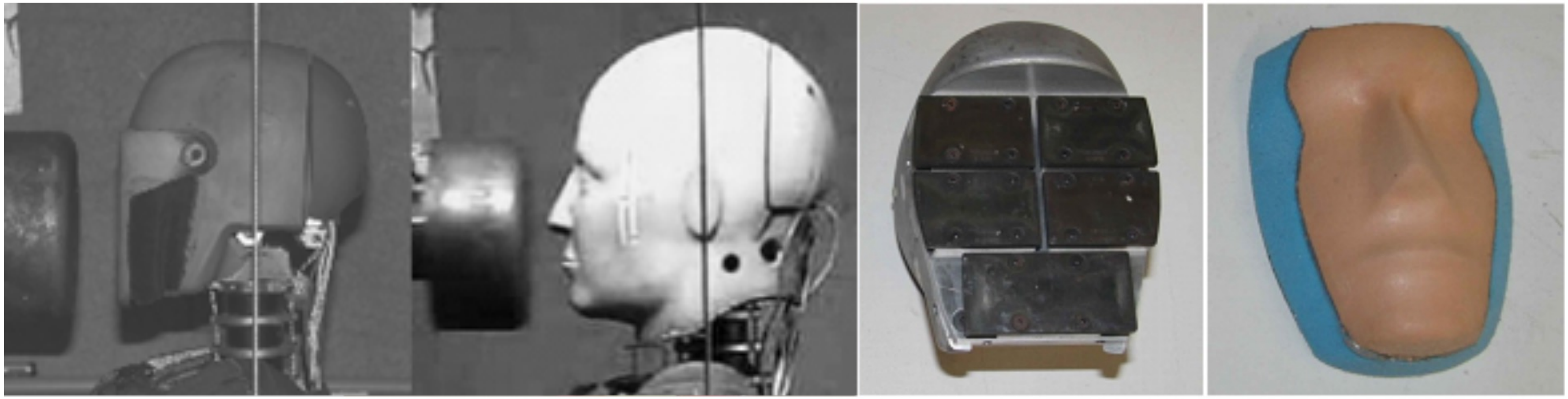
Methods

- THOR dummy
- Nine accelerometer package in headform
- 23.4 kg flat-faced pendulum impactor
- One accelerometer



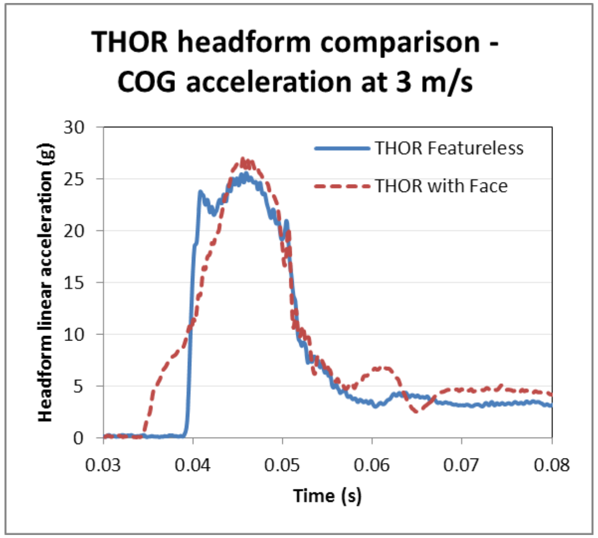
Methods

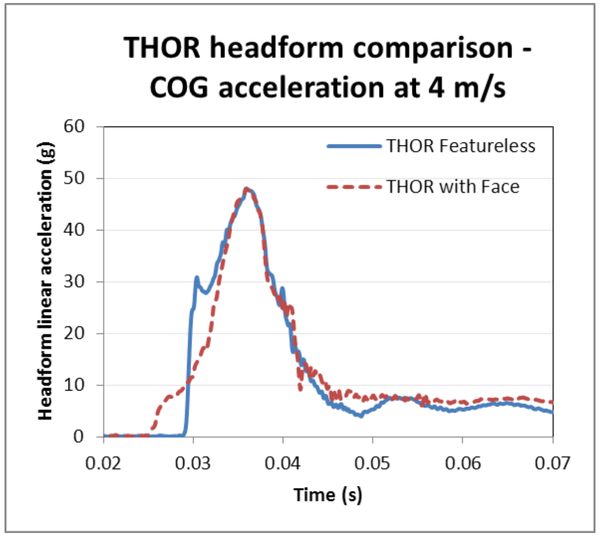
- Specialty THOR headform with face skin (GESAC 2005)
- Based on US Navy recruit data
- Facial impacts were performed at 3, 4 and 5 m/s and headform response was compared

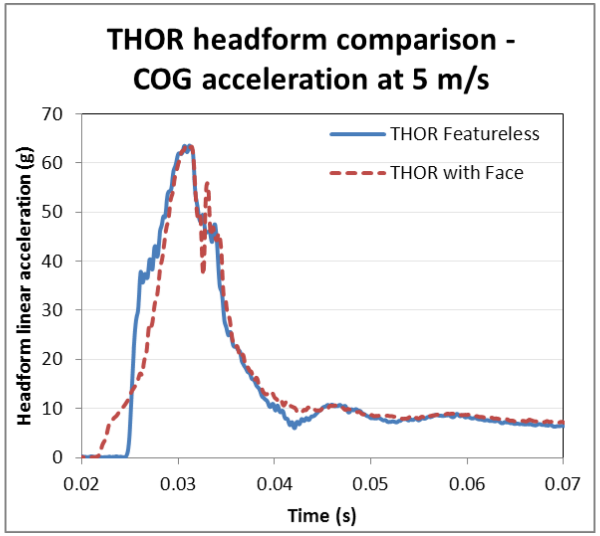


Methods

- Comparable peaks and area under acceleration pulse







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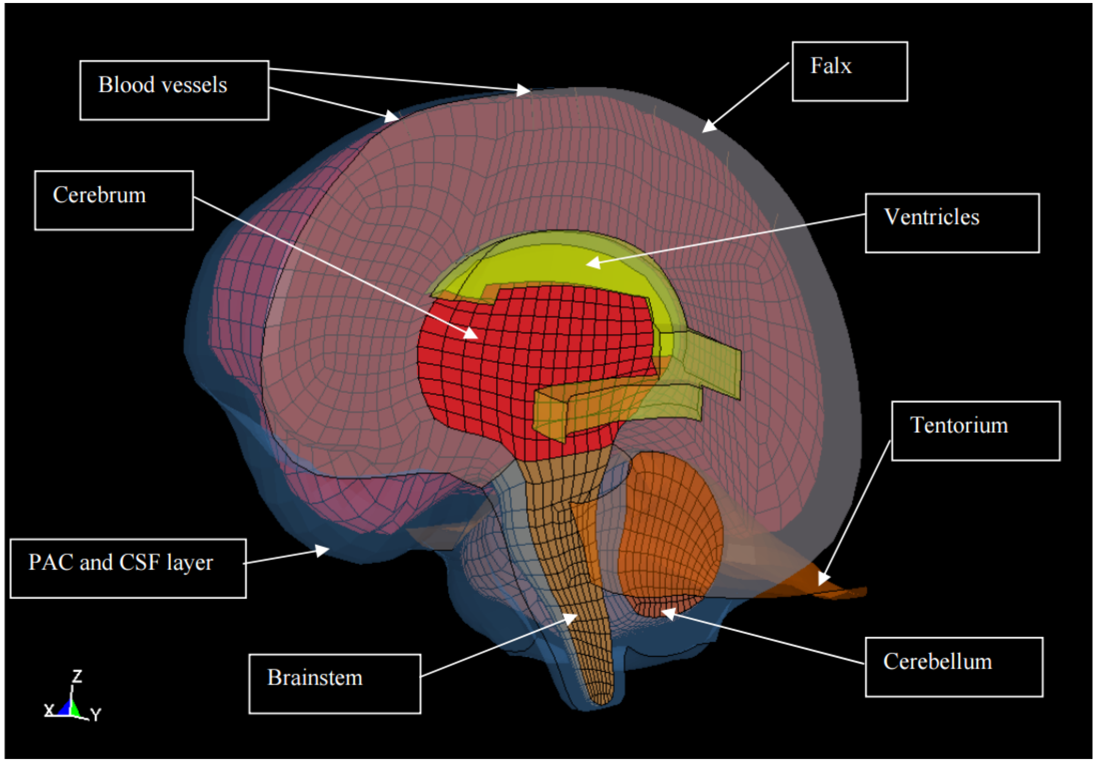
Methods

- Impacts performed unprotected, helmeted and with added EPS foam in the chin bar.
- Three impact speeds of 3, 4.3 and 5 m/s.
- Full-face helmet, X1 Moto, size L, certified to AS/NZS 1698:2006, SAI Global.
- Added 20 mm thickness Rmax Isolite EPS with nominal density of 24 kg/m^3.

Methods

- Simulated Injury Monitor (SIMon) finite element head model

- Maximum principal strain (MPS)
- Cumulative strain damage measure (CSDM)
- Correlated with brain injury risk



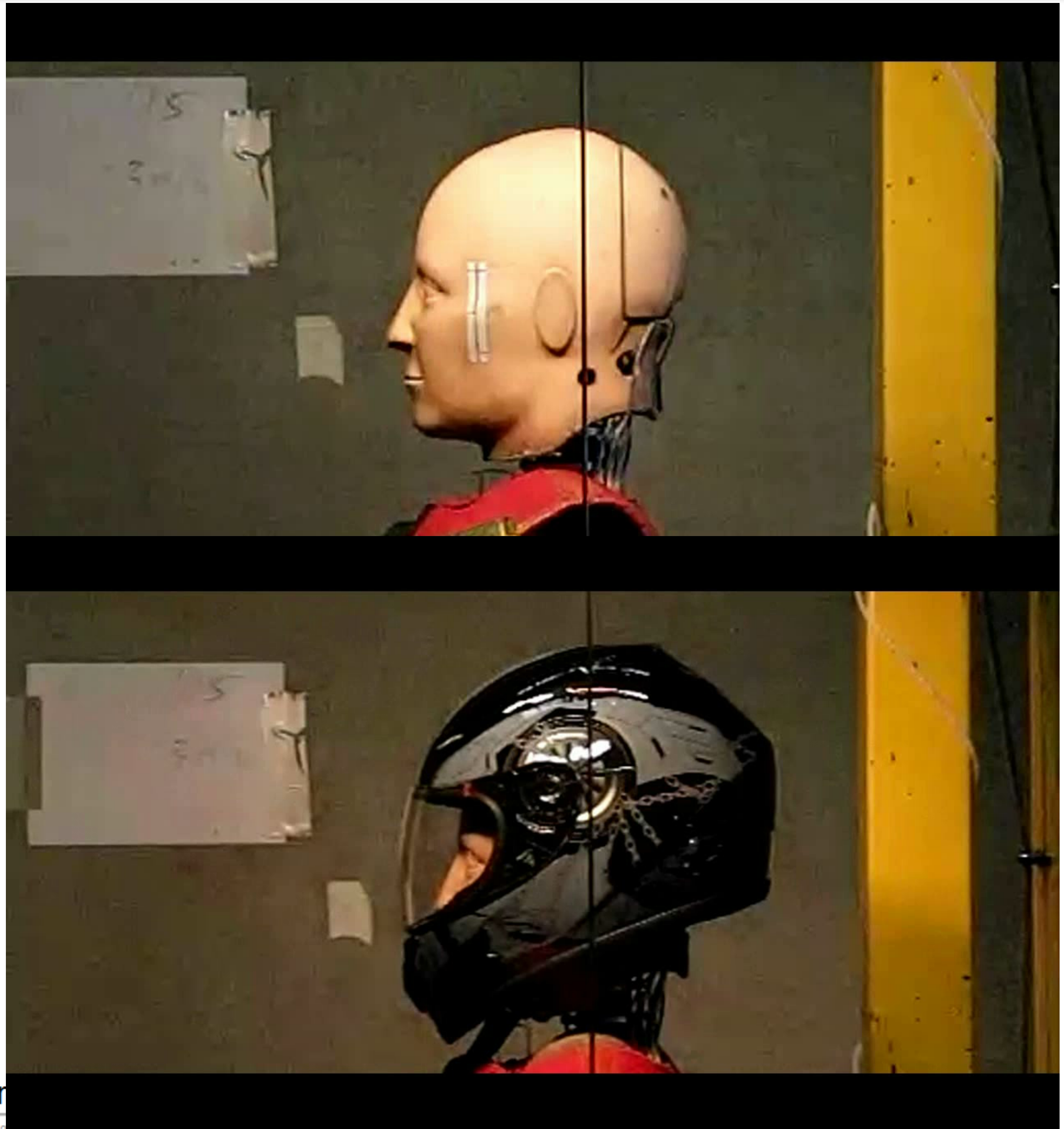
Takhounts et al. 2008

Methods

- Multiple linear regression used to investigate the effect of the helmet and of the padding on head injury risk:
  - Pendulum force
  - Headform peak accelerations and rotational velocity
  - SIMon outputs
- Dummy variables used:

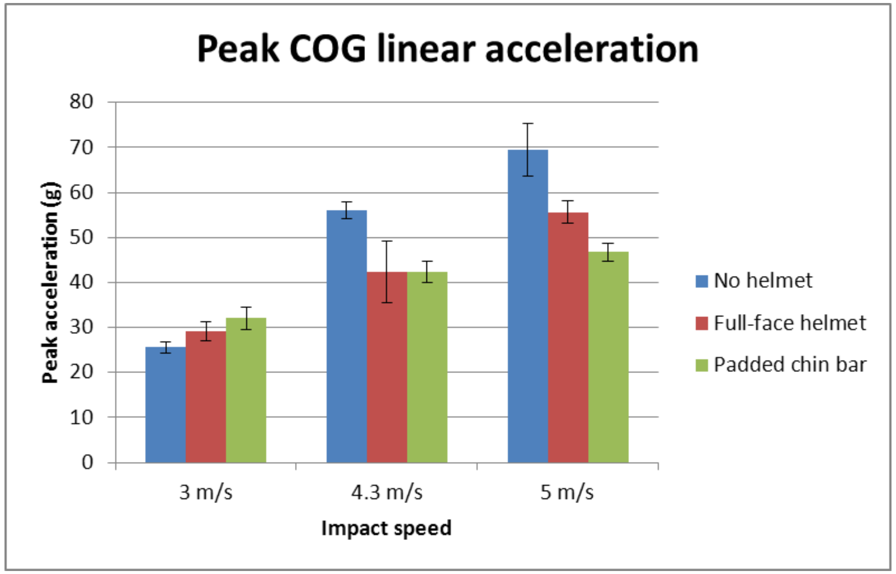
Helmet Condition	Dummy Coded Variables	
	NHvH	NPvEPS
No helmet	-2	0
Full-face helmet	1	-1
Full-face with EPS padding	1	1

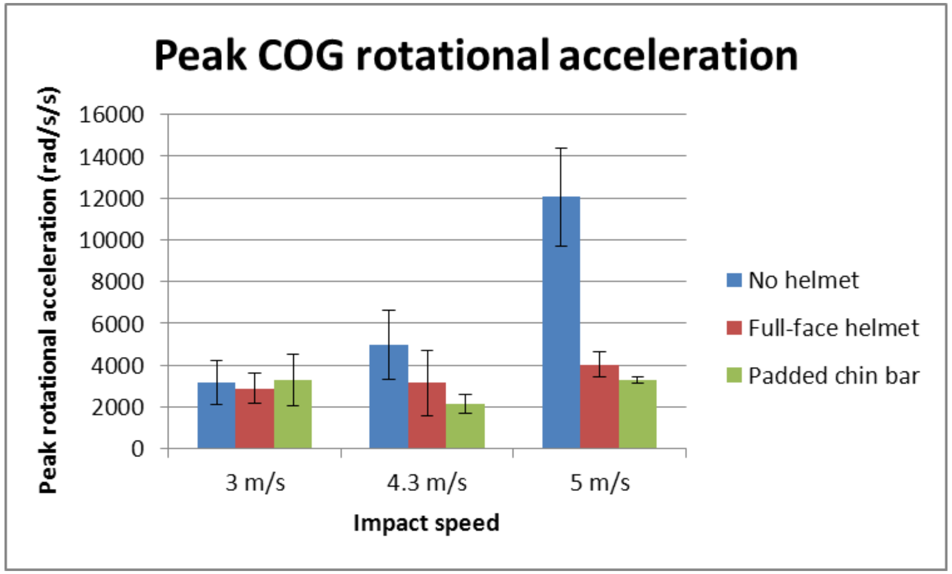
Results



Results

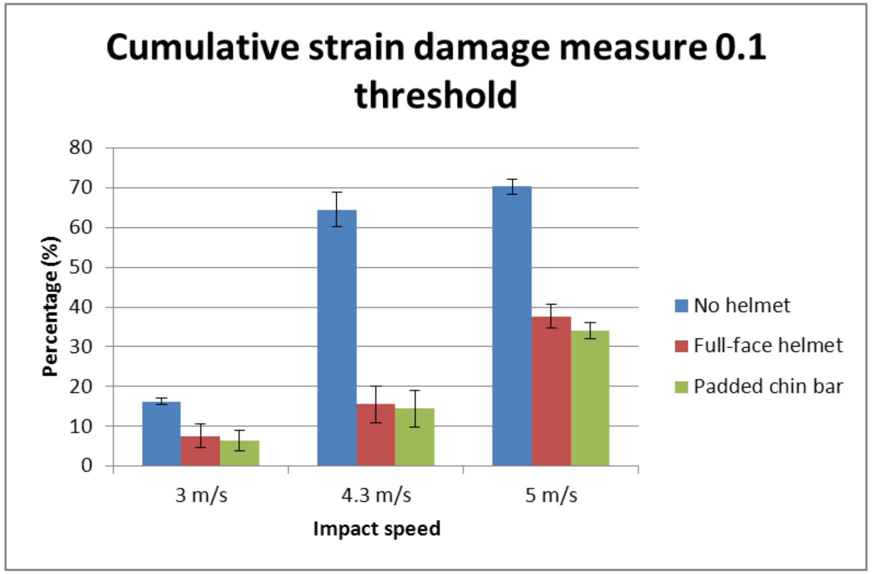
- Headform responses

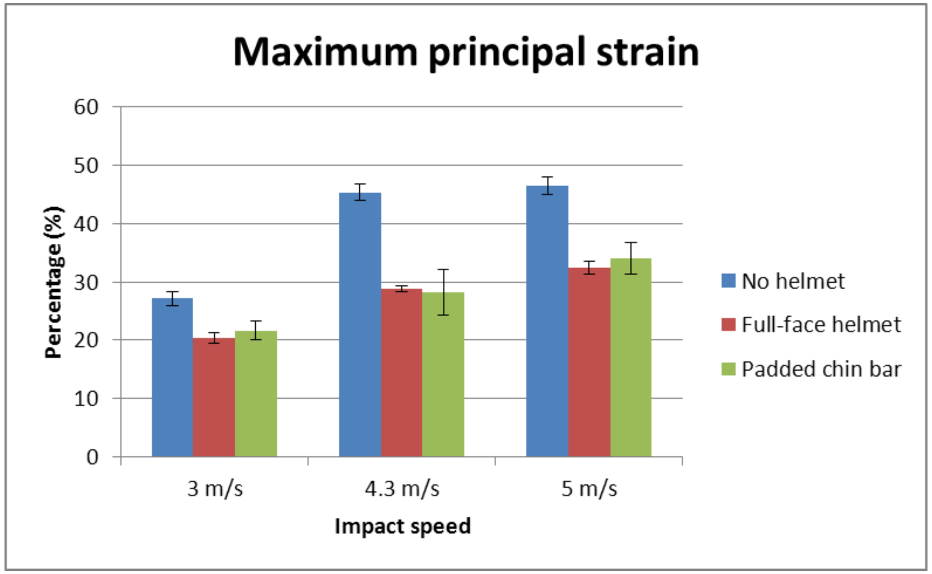




Results

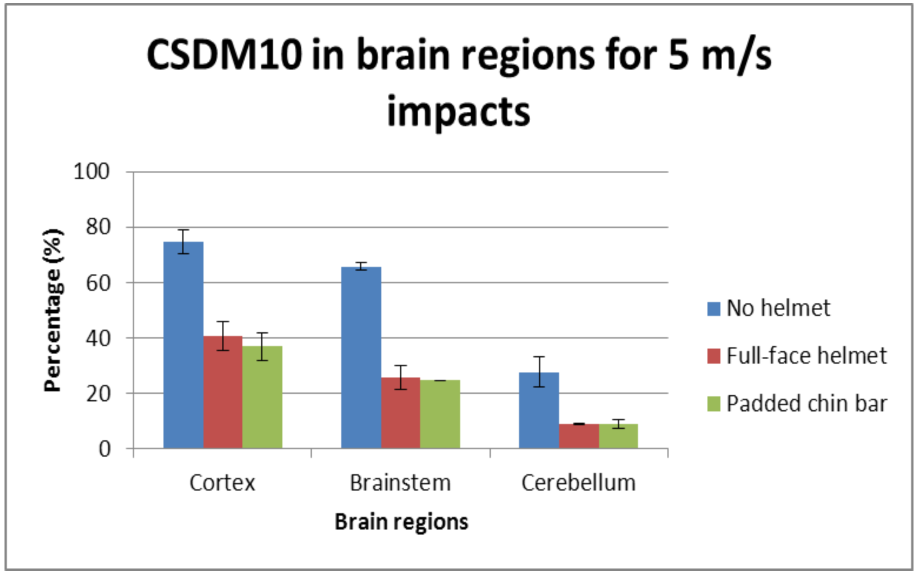
- SIMon outputs

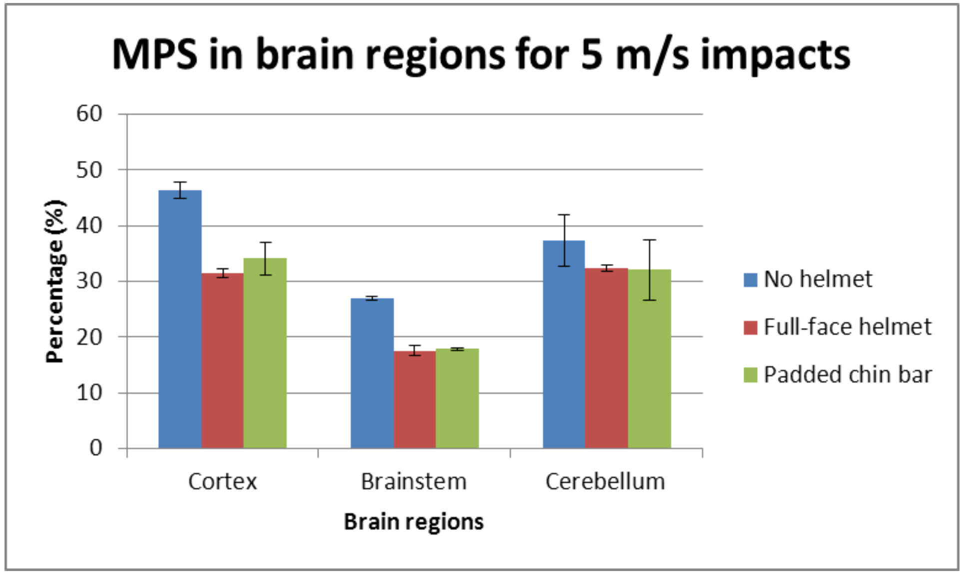




Results

- Specific brain regions

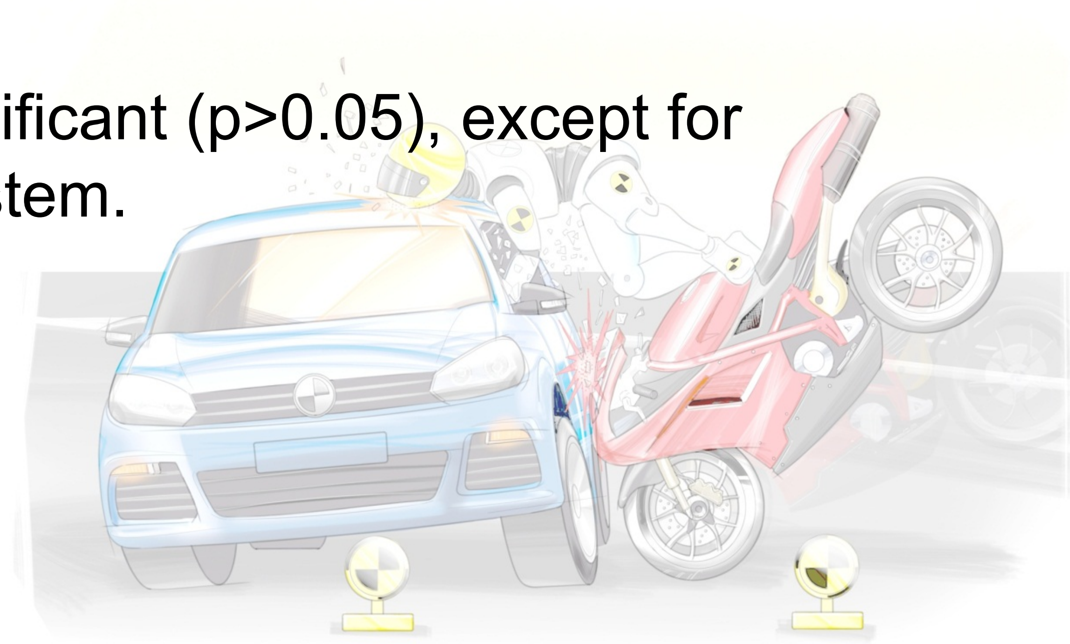




Results

- Impact speed and NHvH added significantly ($p<0.05$) to the prediction of all headform responses and SIMon outputs.

- NPvEPS was not significant ($p>0.05$), except for CSDM05 in the brainstem.



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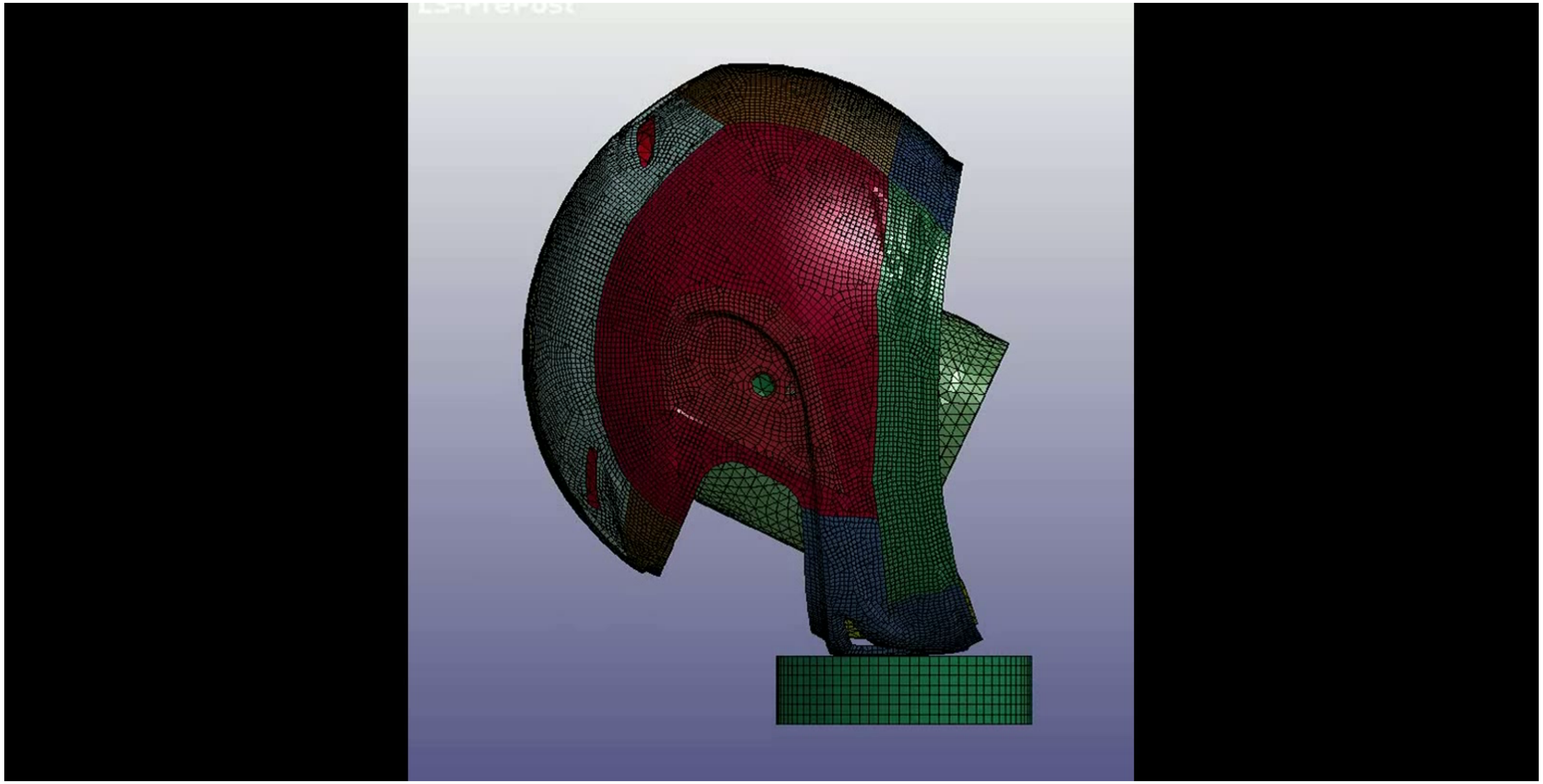
Discussion

- Low risk of head injury when compared to injury risk thresholds.
- Related to the face structure of THOR.
- Minimal crushing of the low density EPS foam.

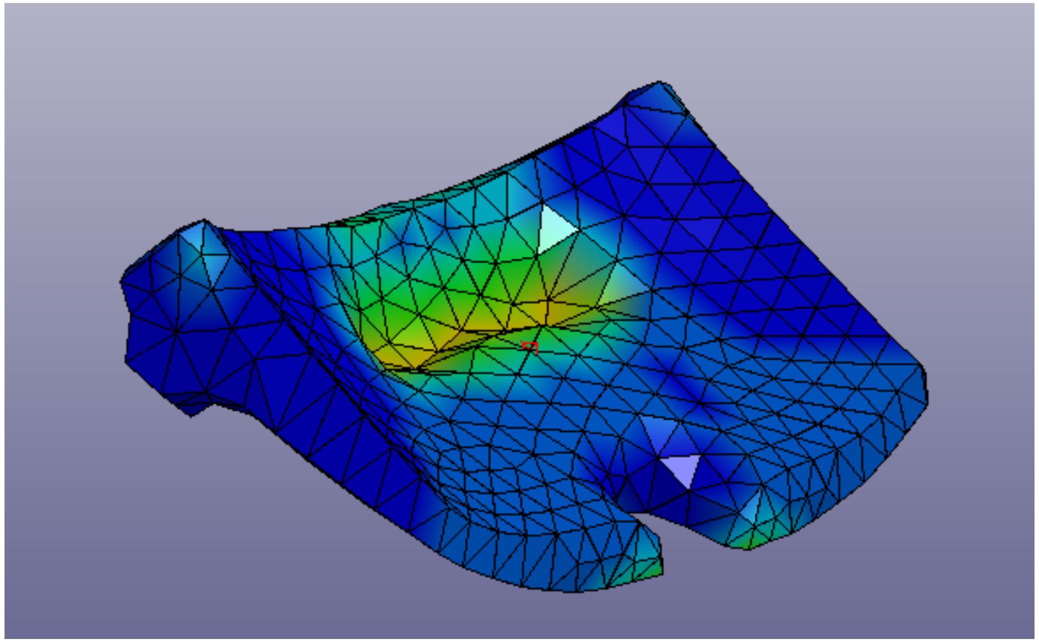
Discussion

- European Regulation chin bar test simulation



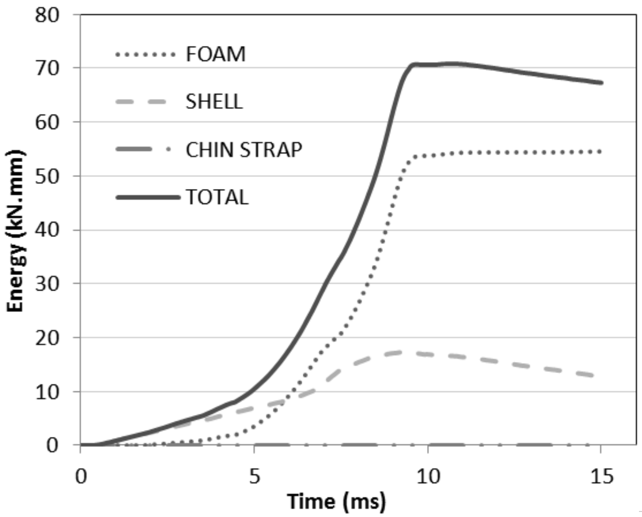
Discussion

- Limited area of foam being fully crushed.

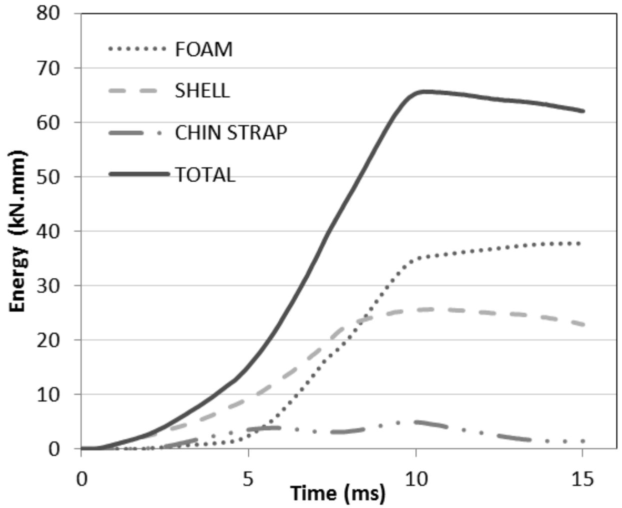


Discussion

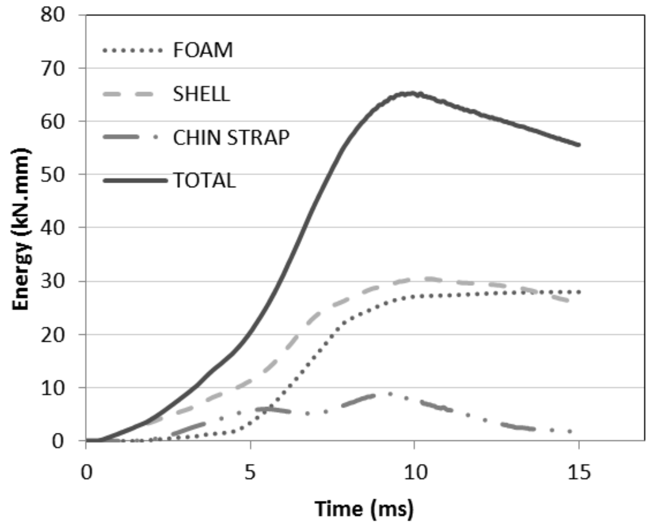
- Importance of other components.
- Chin bar impacts different to cranial impacts.



No chin strap
300 g



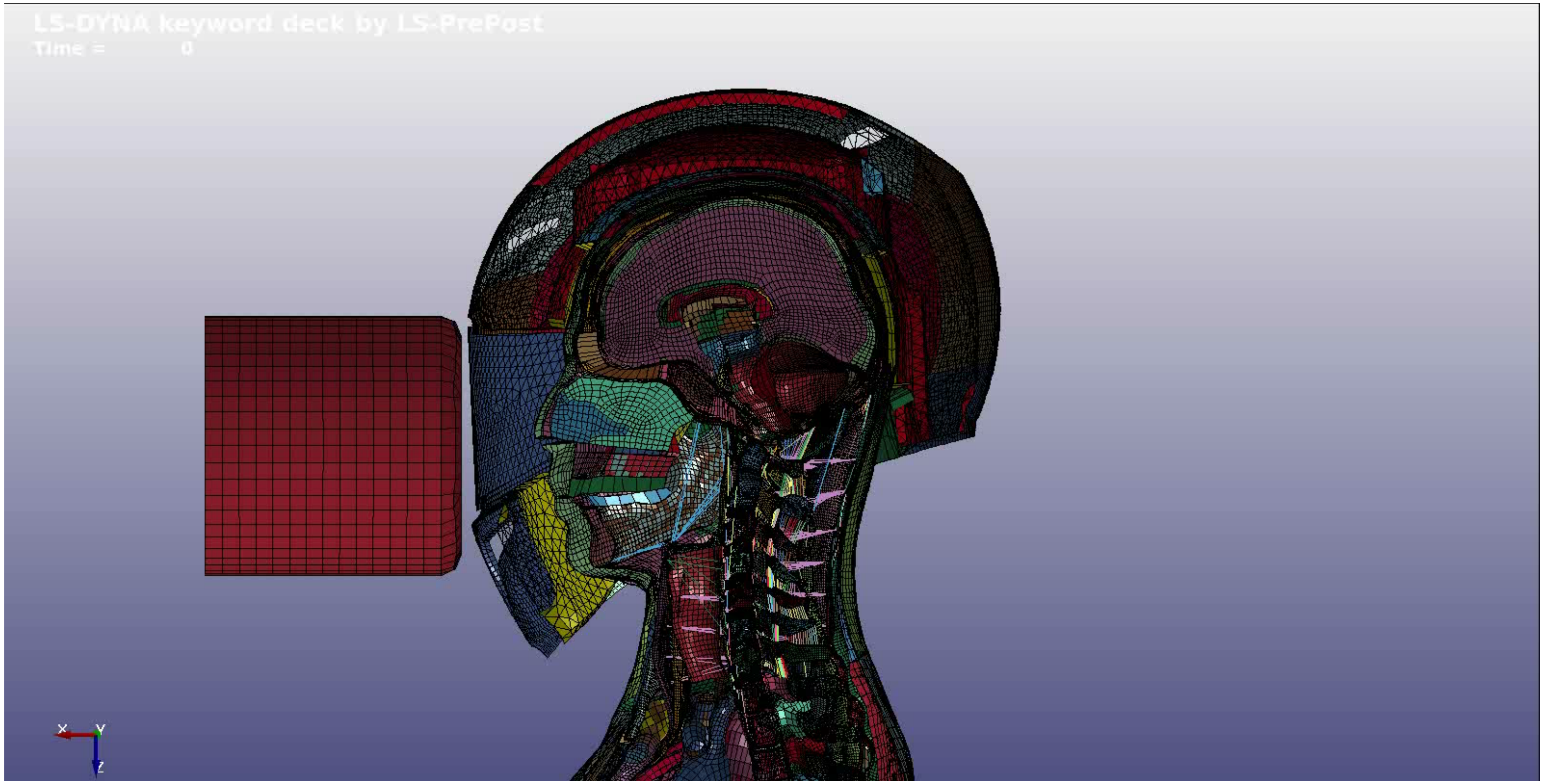
Tight chin strap
155 g



Stiffer shell
108 g

Discussion

- Full picture of head and neck injury



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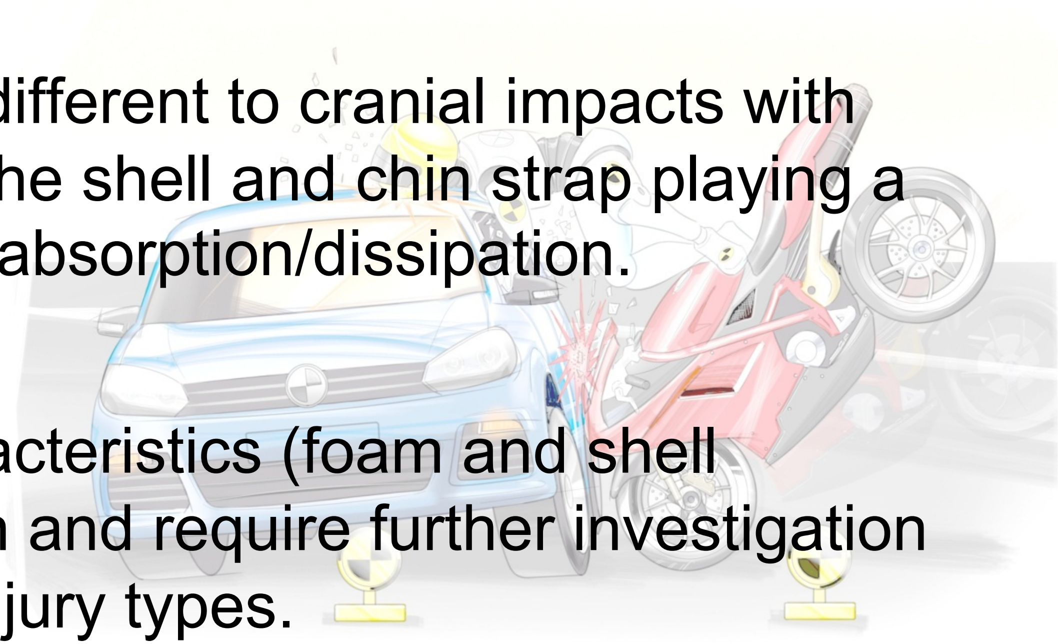
Summary

- Despite no required impact attenuation, full-face motorcycle helmets provide head injury protection from facial impacts.

- Chin bar impacts are different to cranial impacts with components such as the shell and chin strap playing a greater role in energy absorption/dissipation.



- Optimal chin bar characteristics (foam and shell stiffness) are unknown and require further investigation considering multiple injury types.

Acknowledgements

- NRMA Motoring and Services
- Department of Infrastructure

Thank You