



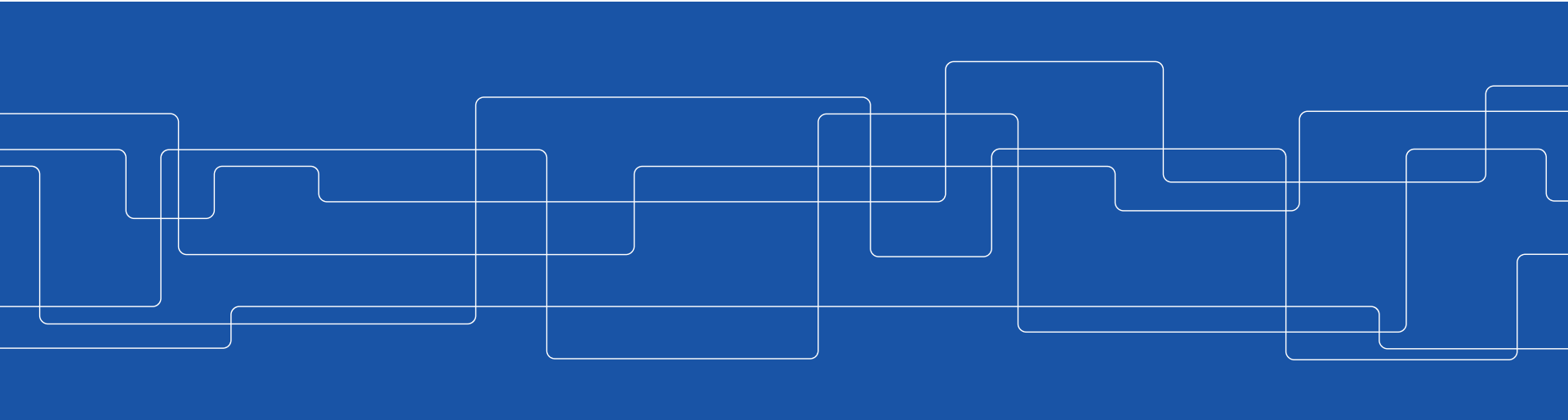
European Committee for Standardization  
Comité Européen de Normalisation  
Europäisches Komitee für Normung

# Overview of the current EU cycle helmet safety testing regime EN1078, and what is involved in changing it?

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# Conflict of interest

Funder and CTO of MIPS AB



# CEN/TC 158 – Head Protection



**TC** CEN/TC 158 "Head protection" ▾

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**Child Committees**

- CEN/TC 158/WG 01 "Industrial safety helmets" ▾  
Scope:
- CEN/TC 158/WG 03 "Firefighters helmets" ▾  
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- CEN/TC 158/WG 05 "Helmets for horse riders" ▾  
Scope:
- CEN/TC 158/WG 06 "Airborne sports helmets" ▾  
Scope:
- CEN/TC 158/WG 11 "Headforms and test methods" ▾  
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- CEN/TC 158/WG 13 "Helmets for mountaineers" ▾  
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- CEN/TC 158/WG 14 "Helmets for field sports" ▾  
Scope:
- CEN/TC 158/WG 15 "Helmets for S-EPAC users" ▾  
Scope:

No active WG for Bike helmets!

WG11 - working on new test methods that can be used for all WGs within TC158

# EN1078 – Helmets for pedal cyclists and for users of skateboards and roller skates

- Current version from 2012
- Revision and new version planed to be ready 2024
- No Convener for WG4!

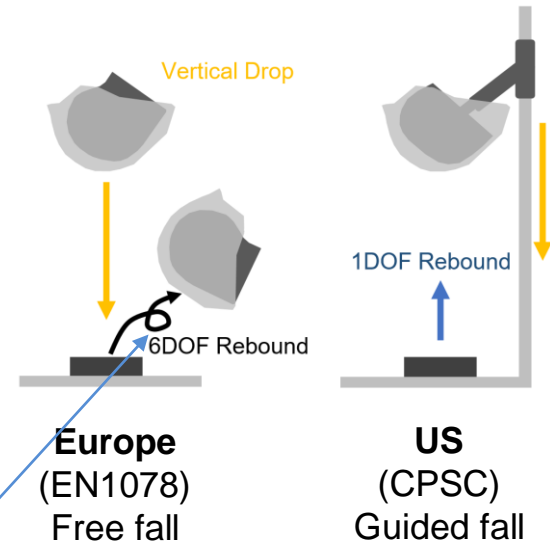


# EN1078 – In short

- Chock absorption
  - Drop from 1.5m (5.4m/s).
  - Both Flat and Kurbstone anvil
  - 3 impact locations separated 150mm
  - Pass/Fail: LinAcc < 250g (Skull fracture)

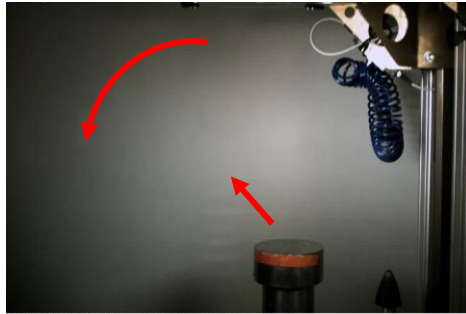
Only measuring linear acceleration!

Rotational energy can disappear!

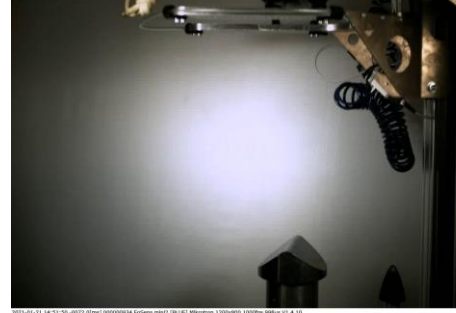


# EN1078 - Chock absorption tests

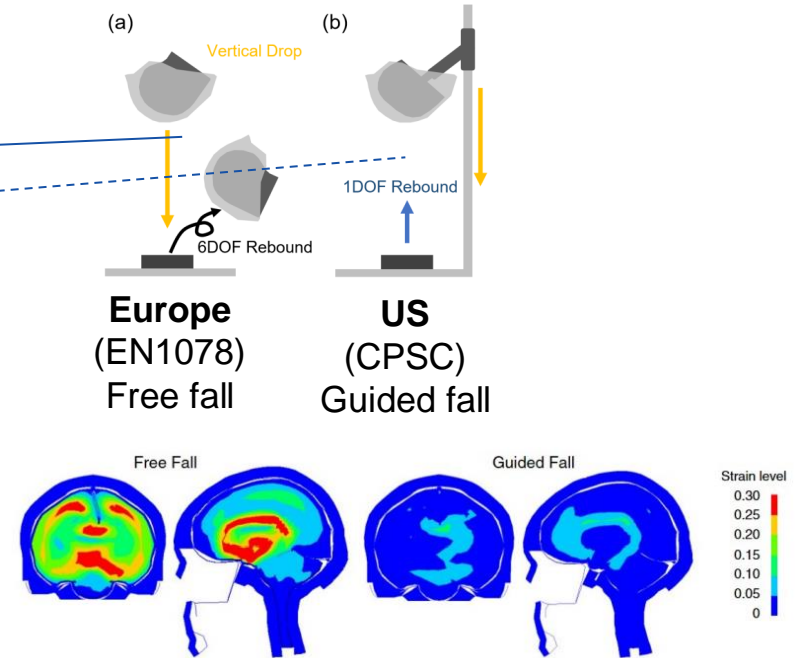
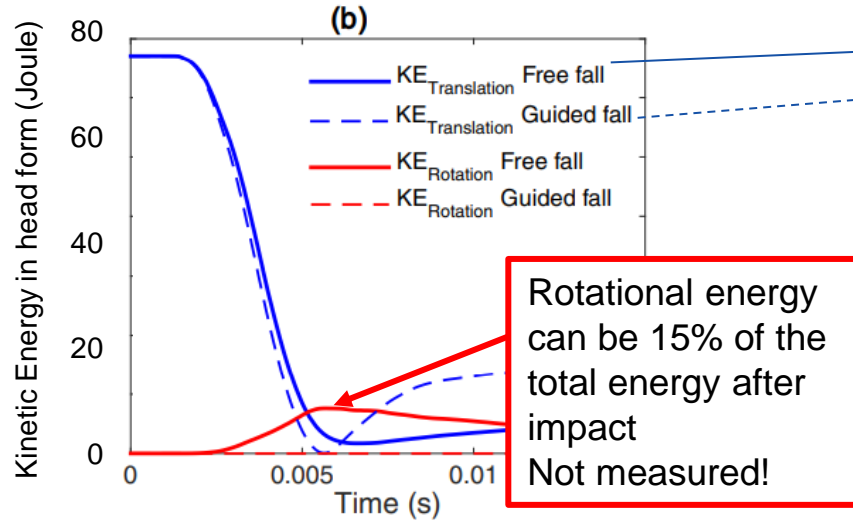
Flat anvil



Kerbstone



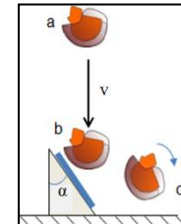
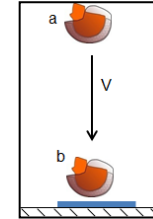
# Need for measurements of 6DOF in EN1078



Meng et al. 2018. The biomechanical differences of shock absorption test methods in the US and European helmet standards *Int J of crashworthiness*.

# Outline

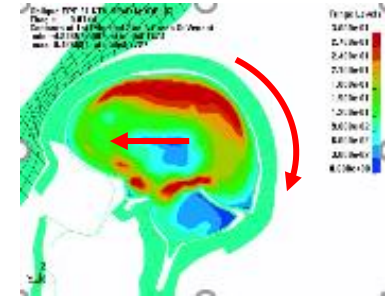
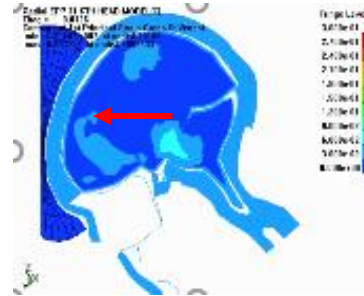
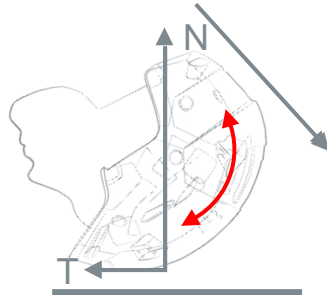
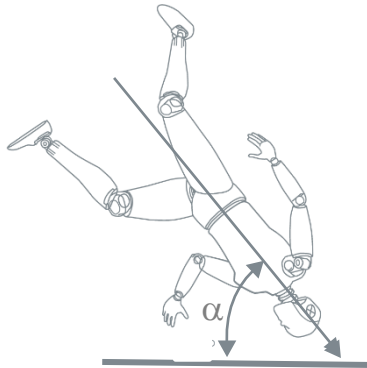
- The current test standard in Europe - EN1078
- Ongoing work towards new test standards in Europe - CEN TC158 / WG11
  - Measure 6DOF accelerations in pure linear impacts
  - **Add oblique (angled/rotation) impacts**
  - Pass/Fail criteria – are we ready for head FE models
- Discussion





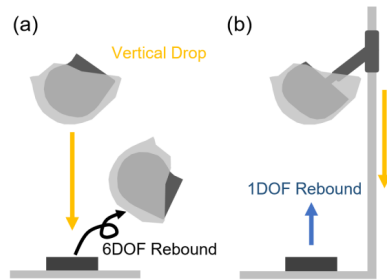
# Why the need for oblique test methods

- Oblique impacts are common in most sports (Otte et al. 1999, Verschueren 2009, Mellor and Chinn 2006)
- Oblique impacts could lead to a tangential force. Tangential force -> rotation
- The brain is more sensitive to rotation than pure translational motion (Holbourn 1943, Genarelli 1983, Marguiles and Tibault 1992, Fijalkowski et al. 2007, Kleiven 2007)



# Overview of Test standards/methods for bike, snow, MC..

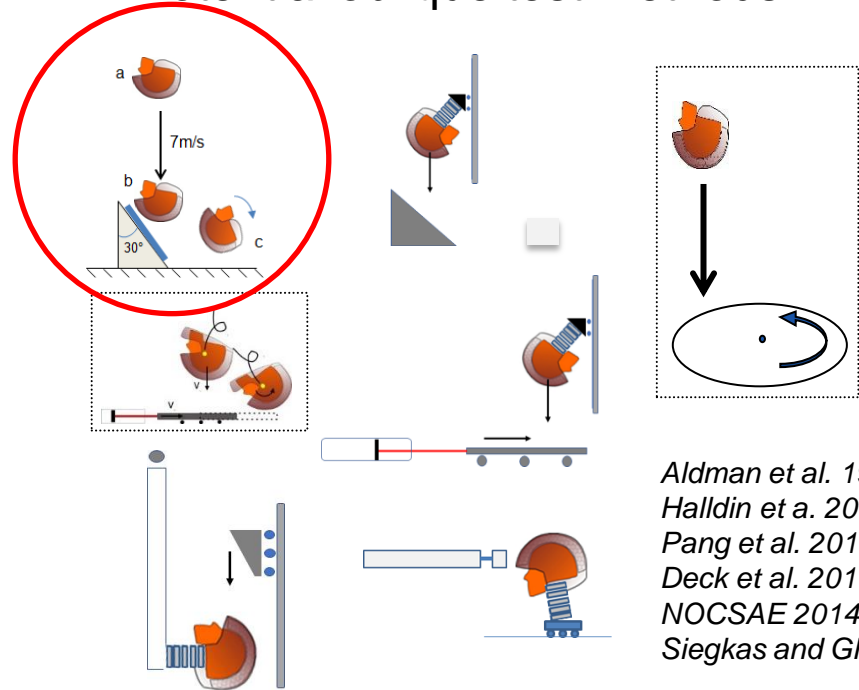
## Current test standards "Linear" impacts



**Europe**  
(EN1078)

**US**  
(CPSC)

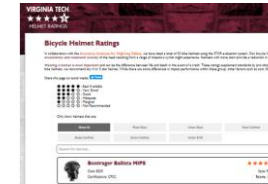
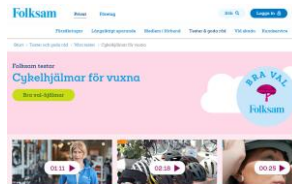
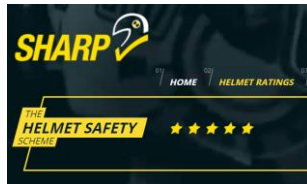
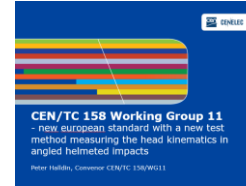
## Potential oblique test methods



*Aldman et al. 1976*  
*Halldin et a. 2001*  
*Pang et al. 2011*  
*Deck et al. 2011*  
*NOCSAE 2014*  
*Siegkas and Ghajari 2017*

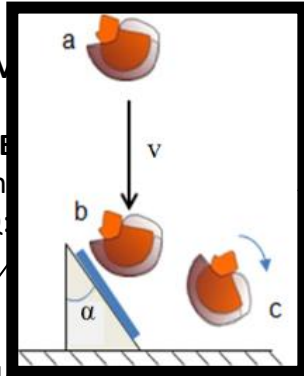
# Ongoing work towards a new sport and motorcycle helmet test standards

- Standards
  - Motorcycle: **FIM 2018** (Federation Internationale de Motorcyclisme)
  - Motorcycle: **ECE22.06** 2021 (European Motorcycle helmet test standard)
  - Bike, Ski and EQ: **CEN TC158** Ongoing (European Standardisation Committee)
- Rating programs
  - EU: **SHARP, FOLKSAM, Certimoov**
  - US: **Virginia Tech**
  - Australia: **CRASH**

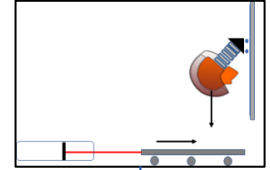
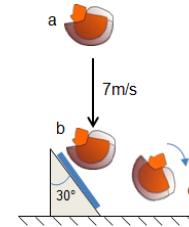
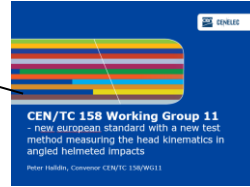


# Ongoing work towards a new sport and motorcycle helmet test standards

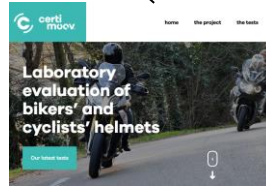
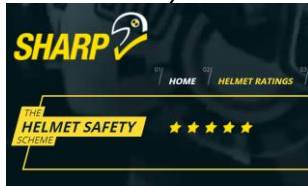
- Standards
  - Motorcycle: FIM (Fédération Internationale de Motorcyclisme)
  - Motorcycle: ECE (European Conformity) helmet test standards
  - Bike, Ski and Equestrian Standardisation
- Rating programs
  - EU: SHARP, FOLKSAM, CERTISTUDY
  - US: Virginia Tech
  - Australia: CRASH



Internationale de  
Motorcycle  
European



SHARP, FOLKSAM, CERTISTUDY  
Virginia Tech  
CRASH





# CEN/TC 158 Working Group 11

- Shock absorption including measuring  
rotational kinematics                      Since 2012

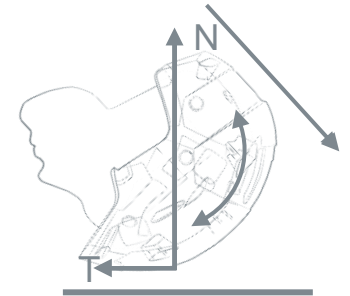
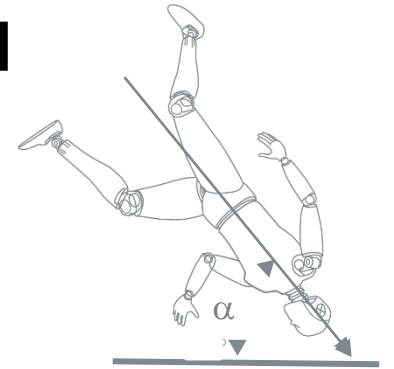
March 2021

Peter Halldin, Convenor CEN/TC 158/WG11

# The objective for CEN TC158/WG11

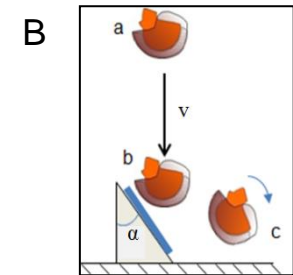
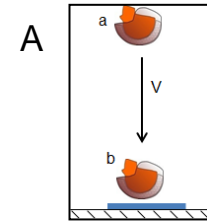
Define a test method to measure rotational energy absorption in **short duration tangential impacts**.

- The test shall be
  - simple,
  - robust and
  - cost effective
- Impact conditions **based on science and real accident data**



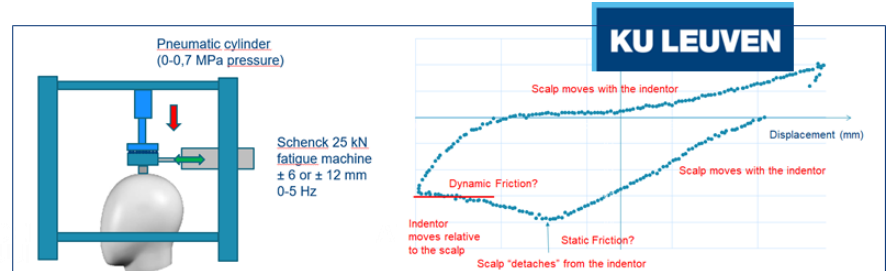
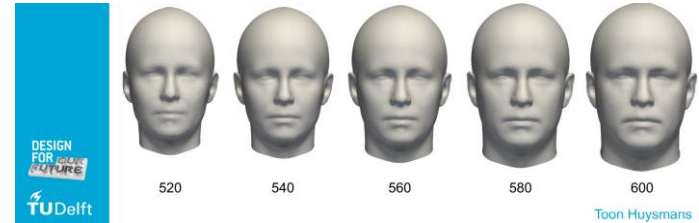
# Proposal from CEN TC158-WG11

- Test method A – Keep pure vertical drop against flat anvil or curbstone (EN1078, EN1384, EN1077) but add measurement of angular kinematics (6DOF).
- Test method B – Vertical drop towards an 45degree impact angle.
  - No neck (free falling head)
  - New head form (mass, MOI, CoF)
  - Head instrumentation: 9-acc-array or ARS
  - Impact surface: Rough grinding paper



# The New WG11 head form will have improved specification of:

- Mass and Moment of Inertia properties ( $I_{xx}$ ,  $I_{yy}$ ,  $I_{zz}$ )
- Head shape
- Coefficient of friction between helmet and head form: 0.3 (Trotta et al. 2018)
- Final head form ready during 2021





# Movies from the different impact locations



Xrot

Yrot

Zrot

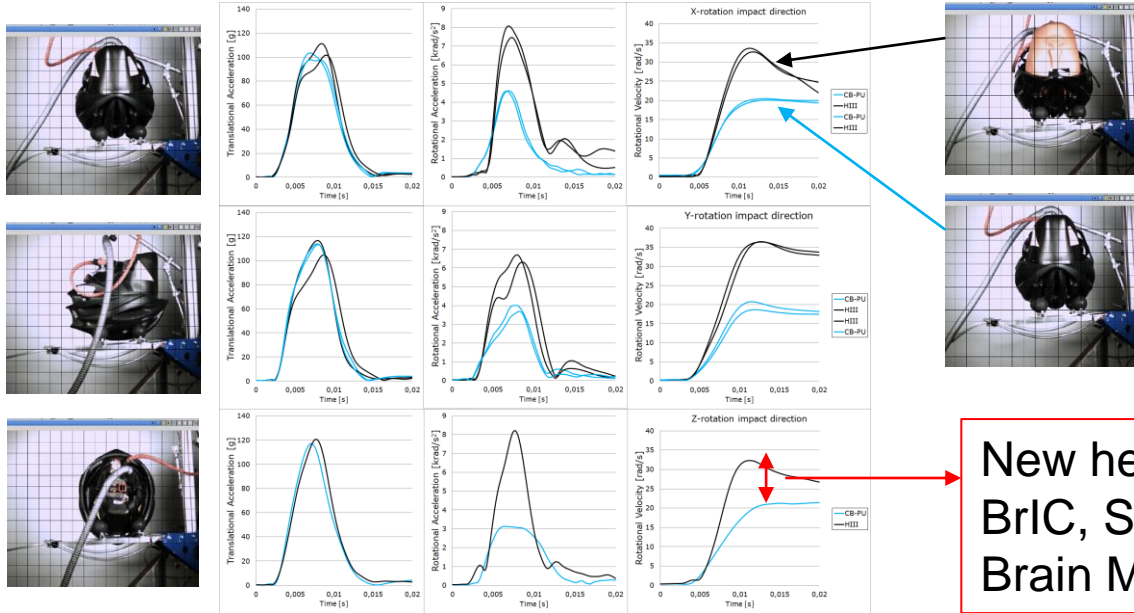
Hill head form



New WG11  
head form  
*Version 2018*



# Preliminary results comparing the HIII head with the New WG11 head form



Note: These results are from the first version of the WG head form dated 2018. The final version of the head form will have a bit different properties that will give in a bit different results.

New head will result in lower BrIC, STAR and Strain in FE Brain Models!

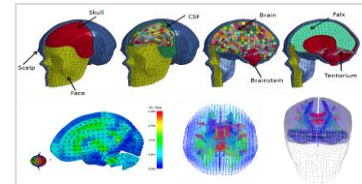
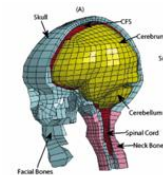
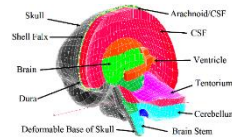
# Pass/Fail criteria – Ongoing discussions within WG11

A pass/fail criteria shall include all 6DOF accelerations over time, either by:

- I. 6DOF (3 linear and 3 rotational) acceleration based pass fail criteria (HIP, HIC+BrIC or similar)
- II. An injury risk assessment tool based on the computed strain from an FE head model

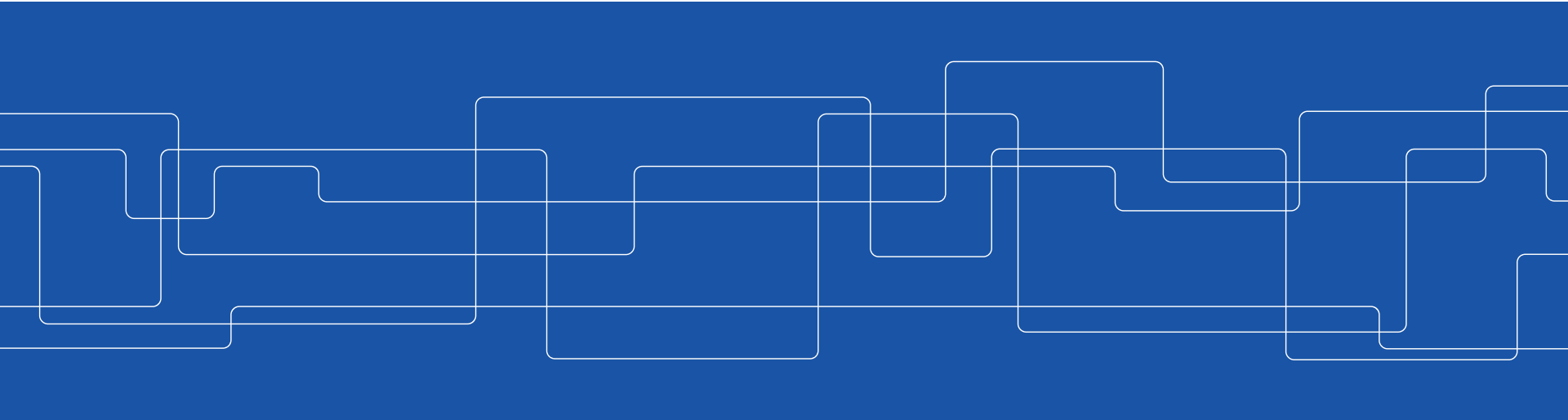
$$HIC = \left\{ \left[ \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t) dt \right]^{2.5} (t_2 - t_1) \right\}_{\max}$$

$$BrIC = \sqrt{\left(\frac{\omega_x}{\omega_{xC}}\right)^2 + \left(\frac{\omega_y}{\omega_{yC}}\right)^2 + \left(\frac{\omega_z}{\omega_{zC}}\right)^2}$$



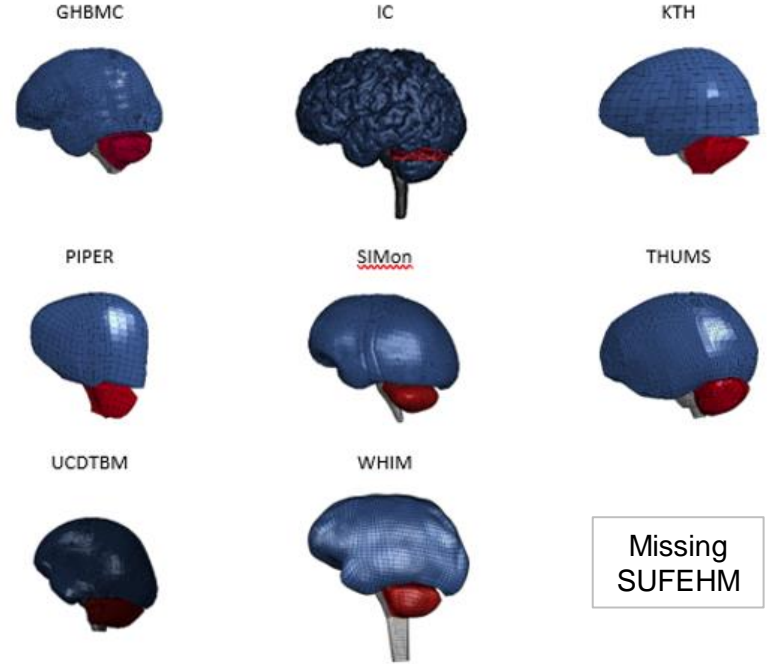
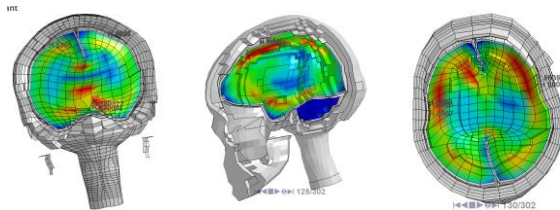


# Are helmet standards ready for FE based pass/fail criteria?





# Comparing 8 FE models

- Eight FE models of the human head
- Simulating 17 bike helmet tests (Folksam 2015)



Original Article

## Ranking and Rating Bicycle Helmet Safety Performance in Oblique Impacts Using Eight Different Brain Injury Models

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ANTONIA TROTTA,<sup>5</sup> WEI ZHAO,<sup>6</sup> MAZDAK GHAJARI,<sup>2</sup> MICHAEL D. GILCHRIST,<sup>5</sup>  
SONGBAI JI,<sup>6,7</sup> SVEIN KLEIVEN,<sup>1</sup> XIAOGAI LI,<sup>1</sup> AISLING NÍ ANNAIDH,<sup>5,8</sup>  
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Associate Editor Joel D. Stitzel oversaw the review of this article.

*Original Article*

## Ranking and Rating Bicycle Helmet Safety Performance in Oblique Impacts Using Eight Different Brain Injury Models

**From Abstract:** One specific helmet was rated as 2- star when using one brain model but as 4-star by another model. This could cause confusion for consumers rather than inform them of the relative safety performance of a helmet. **Therefore, we suggest that the biomechanics community should create a norm or recommendation for future ranking and rating methods.**

**From Discussion:** At present, depending on which model or injury metric that is chosen to evaluate the helmet performance, the ranking and rating can differ. **We suggest that all rating organizations should provide clear information regarding the uncertainty in the rating depending on the metric used.**



# Summary

- EN1078 and other EN standards needs improvements to become state-of-the art such as:
  - Measure 6DOF accelerations over time for all impacts
  - Add oblique impact
  - New head form
  - Pass/Fail criteria:
    - 6DOF accelerations over time like BrIC, STAR
    - Metric based on validated FE model(s)
    - Not decided yet!
- Planned to be ready 2024





# THANK YOU

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