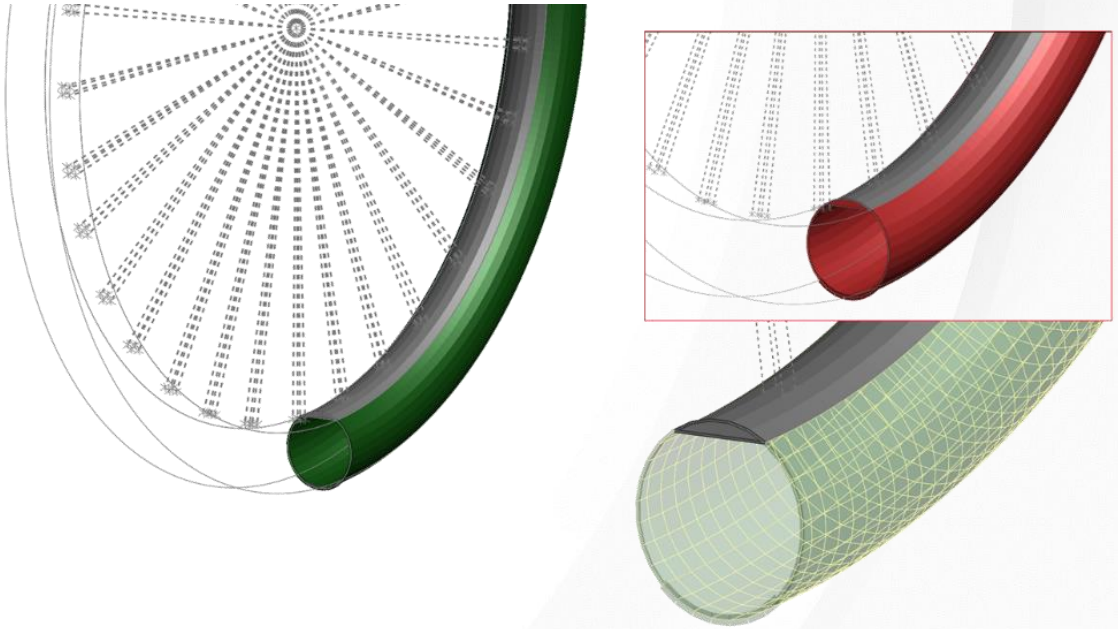
Vectayn
analysis in design

Using the Oasys LS-DYNA Environment to Simulate Pothole Impacts on Non-Automotive Road Users



Dr Kara Laing, Vectayn Ltd

© Rod Stewart, Instagram

© Pot Trumps Chelmsford

© Fill That Hole, Cycling UK

© Michelle Haywood

© Neville Daytona

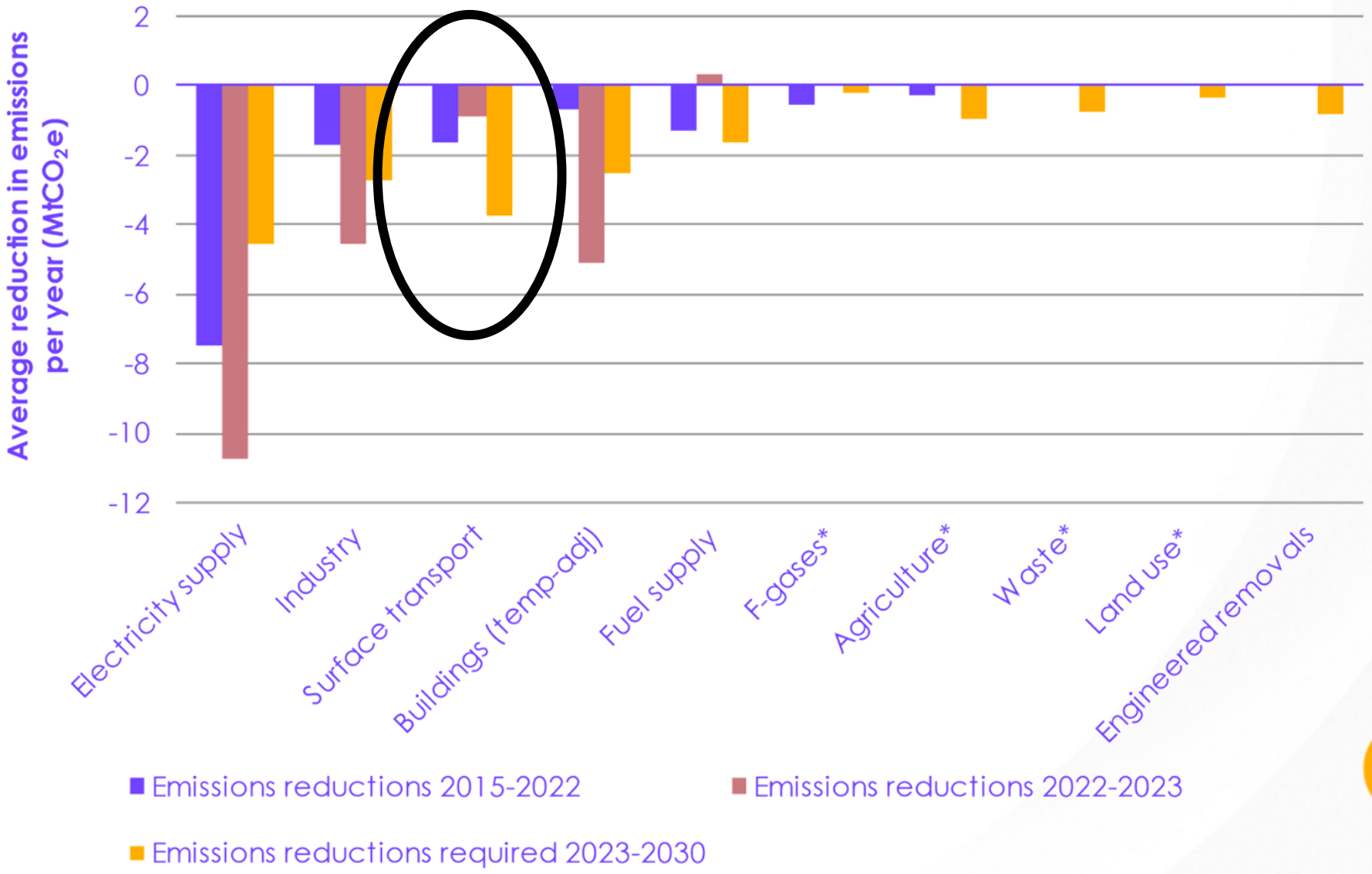
- Why?
- What?
- How?
- Validation
- Road user comparisons
- *Questions at the end*

Why? Real World Problem

- 50 cyclists a year killed or seriously injured by defects
- Assessment of potholes is subjective, and grounded in experience of car users
- These scenarios are untestable
- People don’t cycle because they feel unsafe

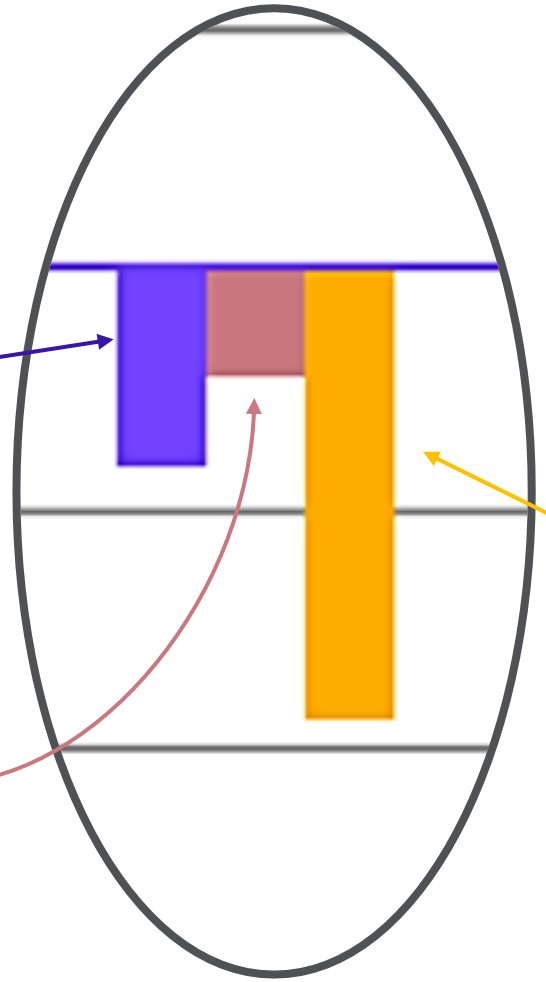
Photo credit: Simon Tippler

National Context – Untapped Opportunity



National Context – Untapped Opportunity

Average including lockdown effects



2023

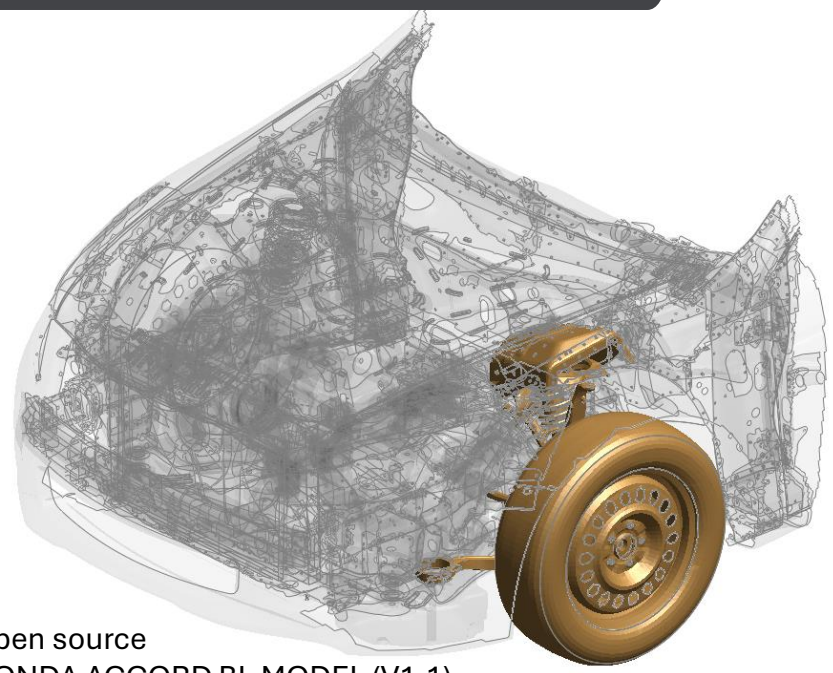
What we need to achieve for the next 5 years

What: Sources of Data

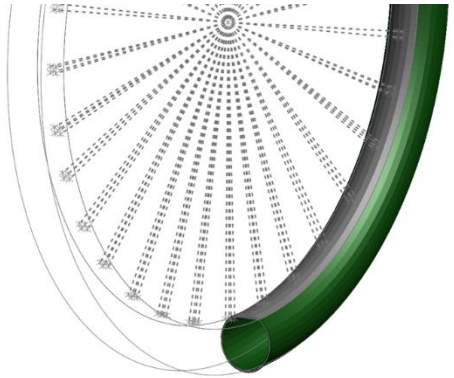
- **Corporate**: tyre companies modeling kerb strike events, some of which are published.
- **Public domain**: papers in the on heavy duty wheels traversing rough terrain.
- **Data set**: road vibration on a trail bike.
- **Single Paper**: cyclists riding over 15-16mm dowels on an instrumented road bike.

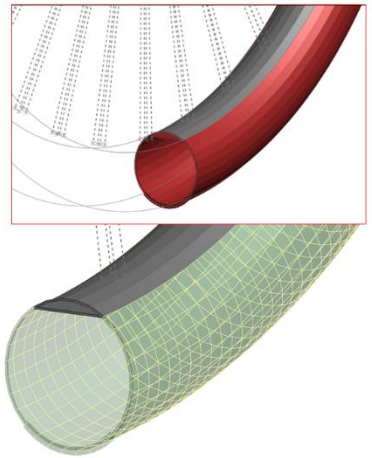
This has been an exercise in extrapolating what is available as sensibly as possible.

Models



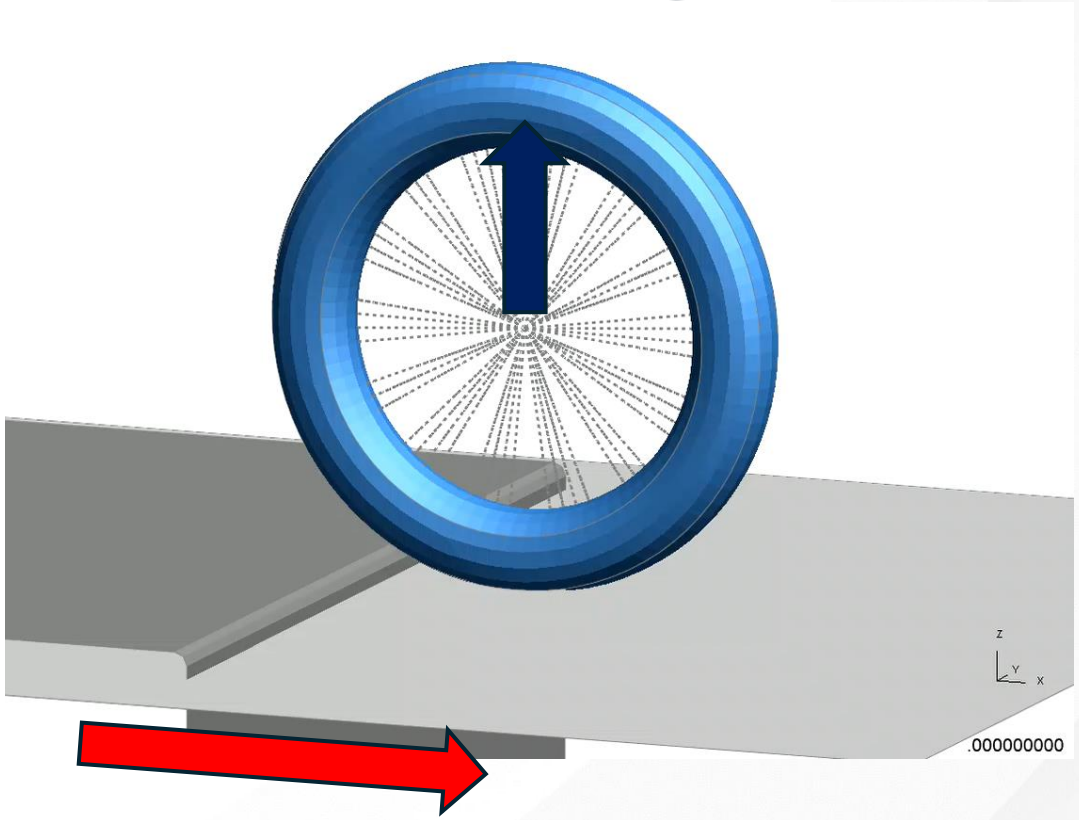
Open source
HONDA ACCORD BL MODEL (V1.1)



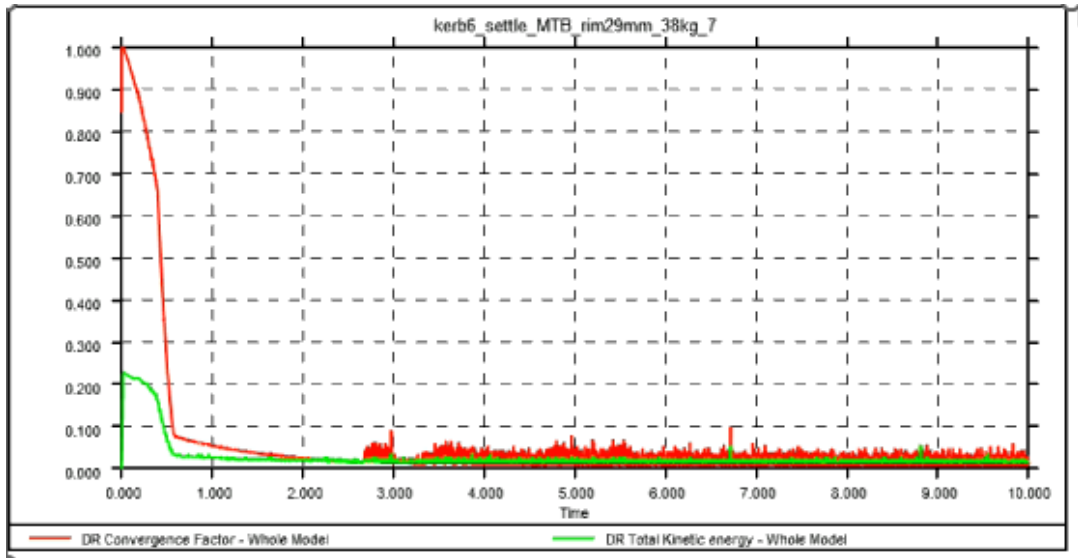


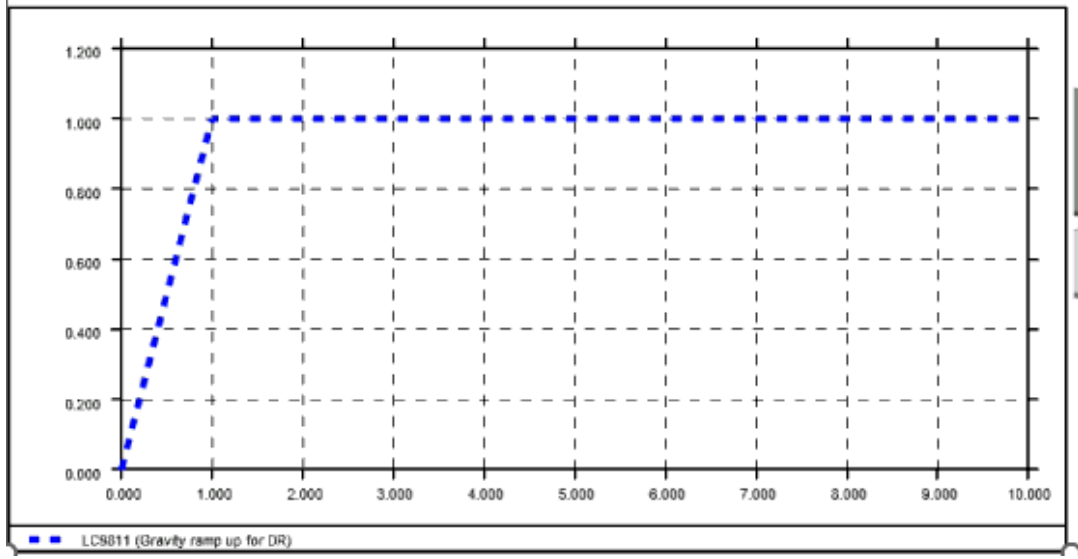
Ansys / LS-DYNA

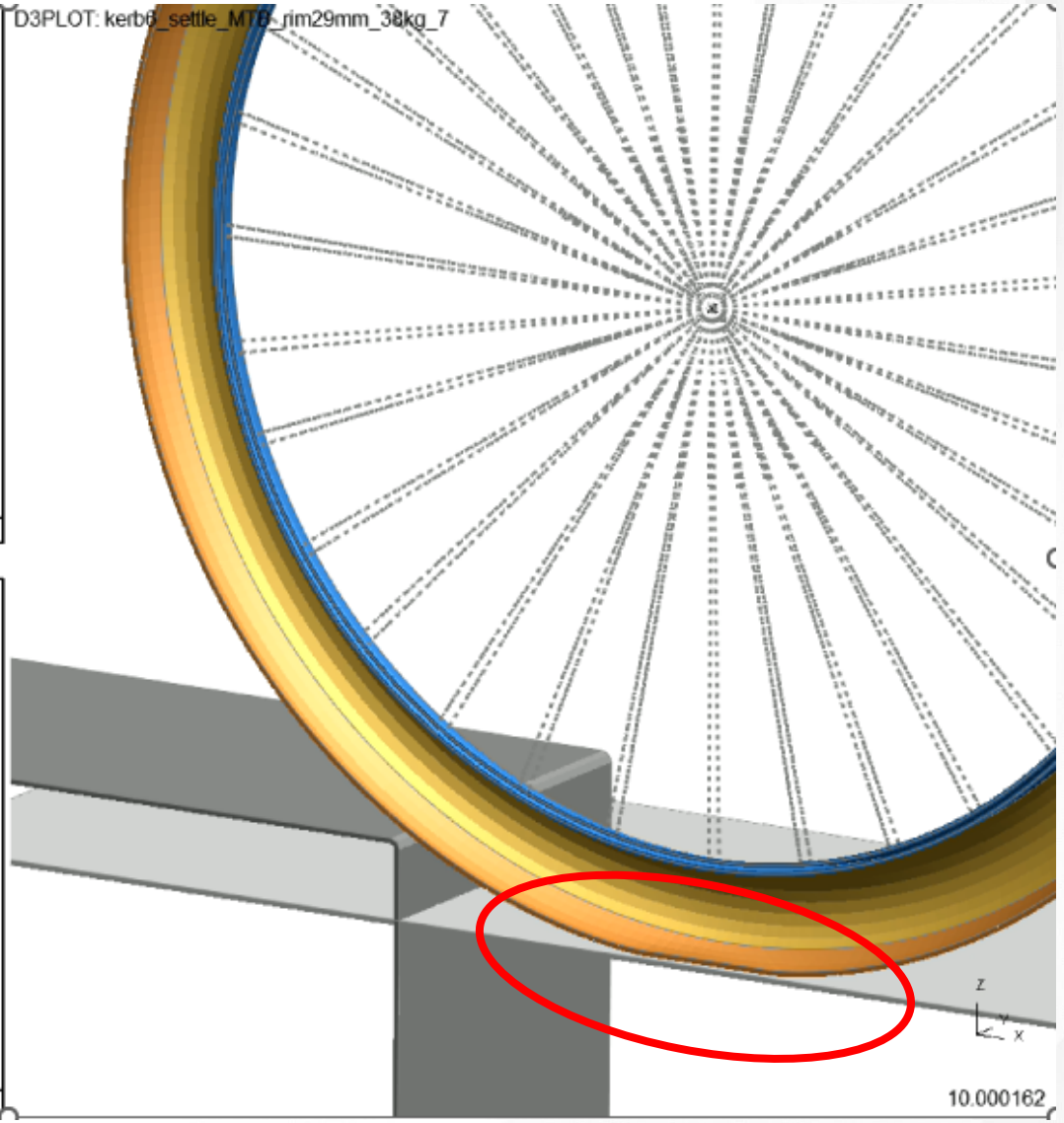
Oasys



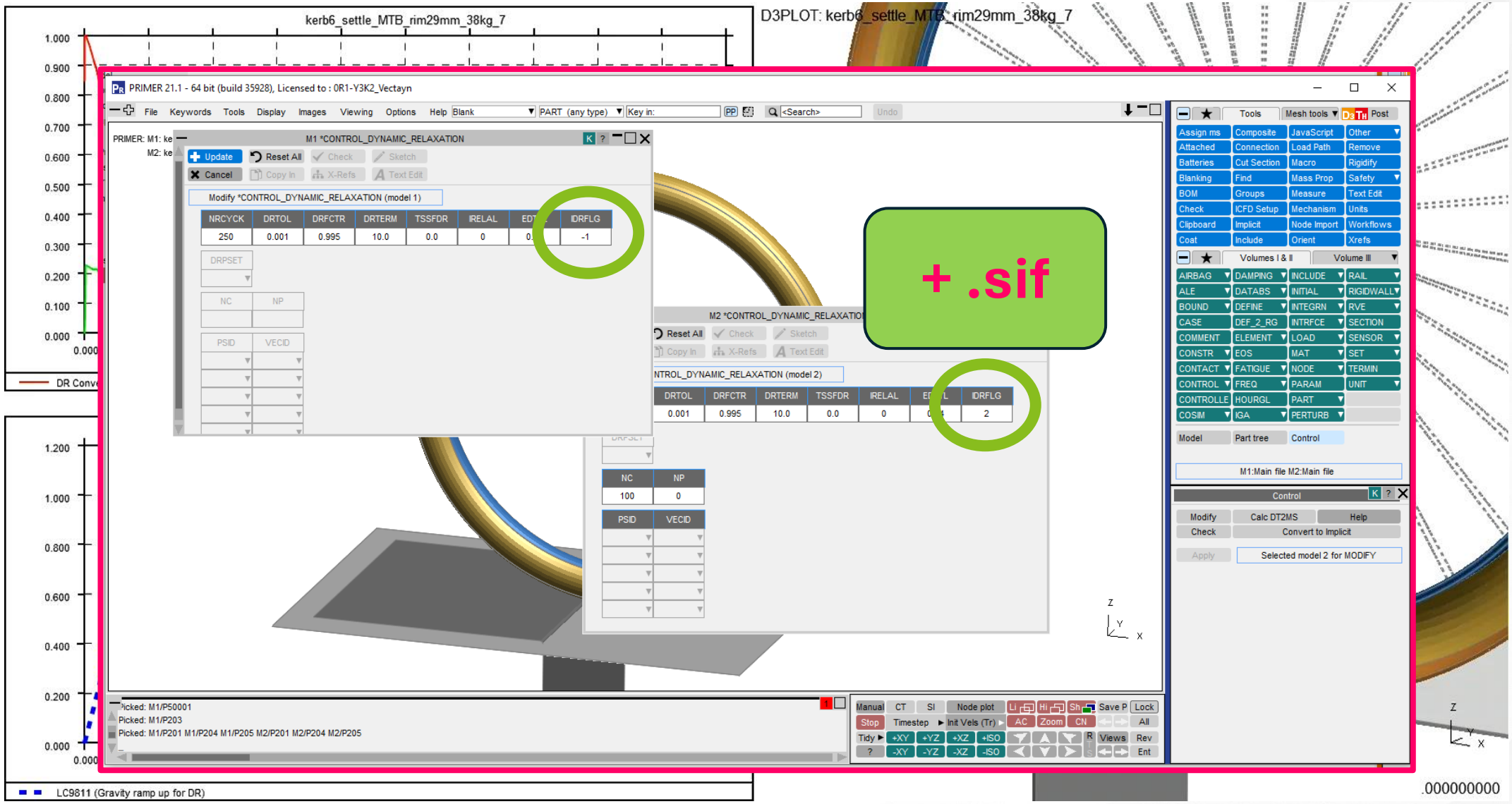
Settling - Dynamic Relaxation







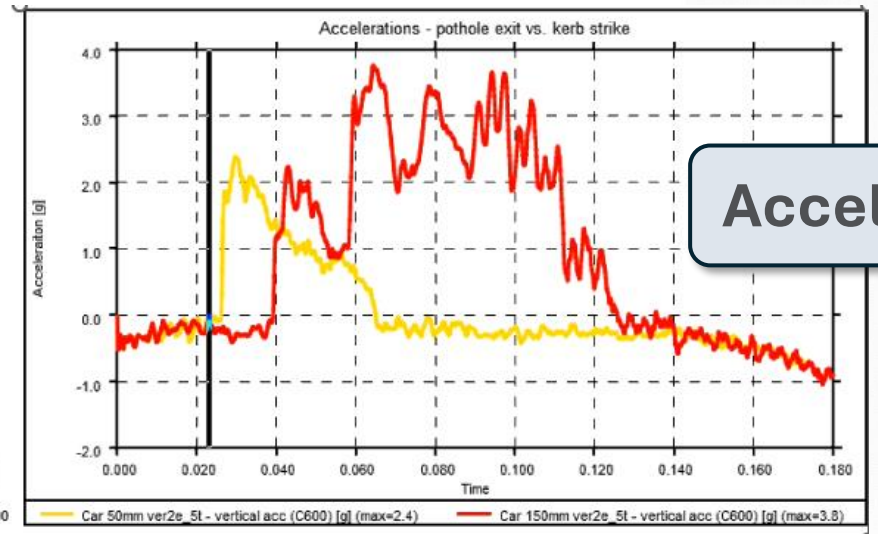
Settling - Dynamic Relaxation



- Why?
- What?
- How?
- **Validation**
- Road user comparisons
- *Questions at the end*

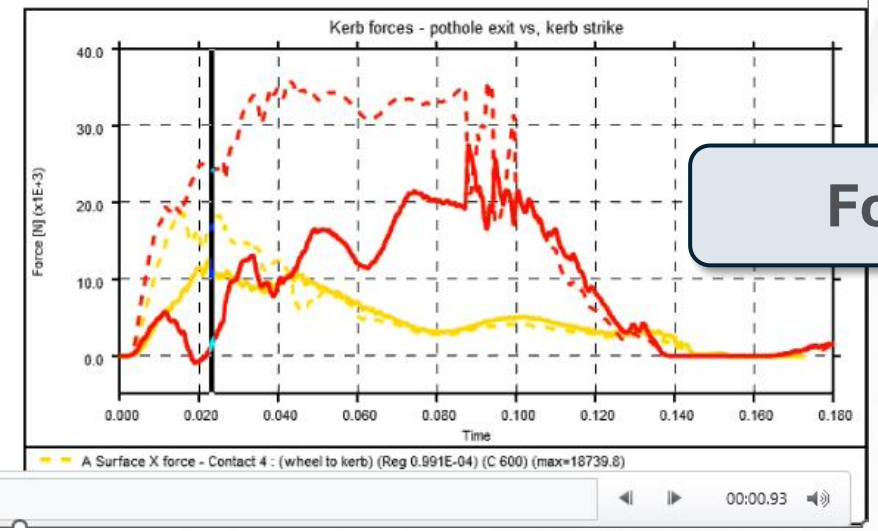
Car

Pothole exit: 2g



Acceleration

Kerb strike: 3-4g

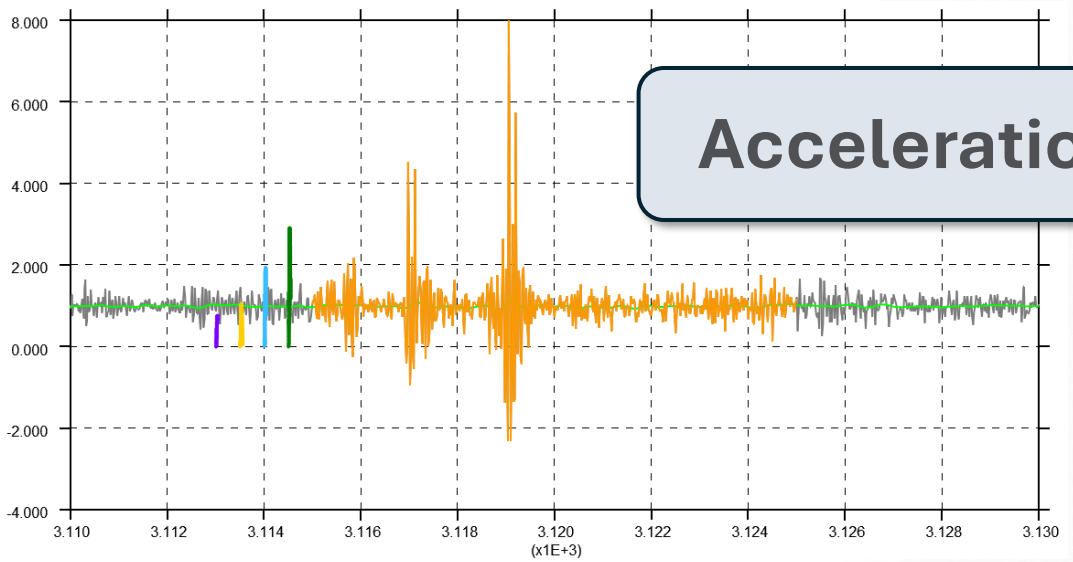


Force

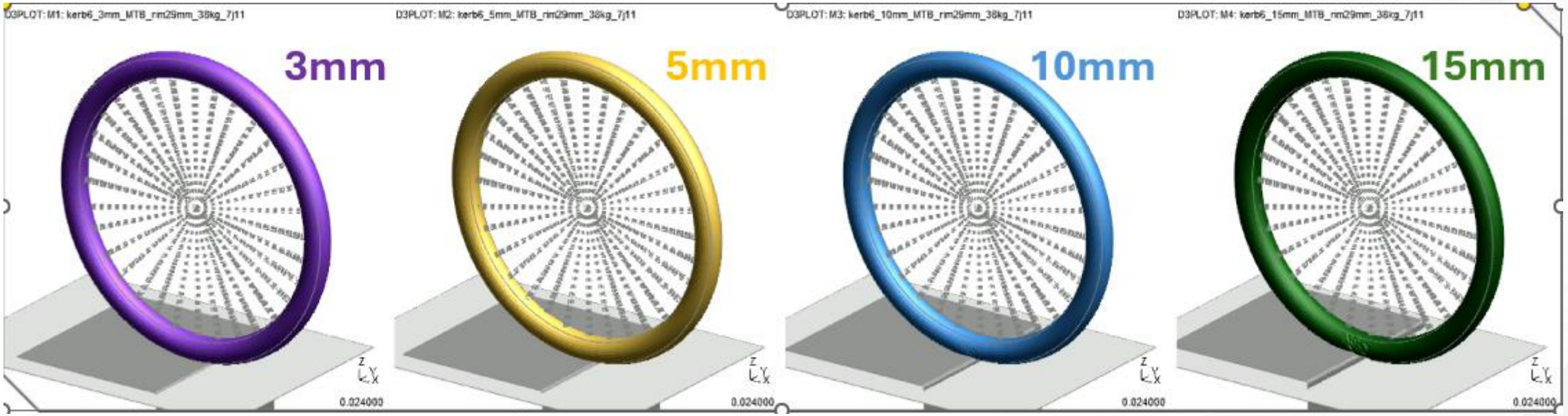
Analysis results compare well to typical data

Mountain Bike (MTB)

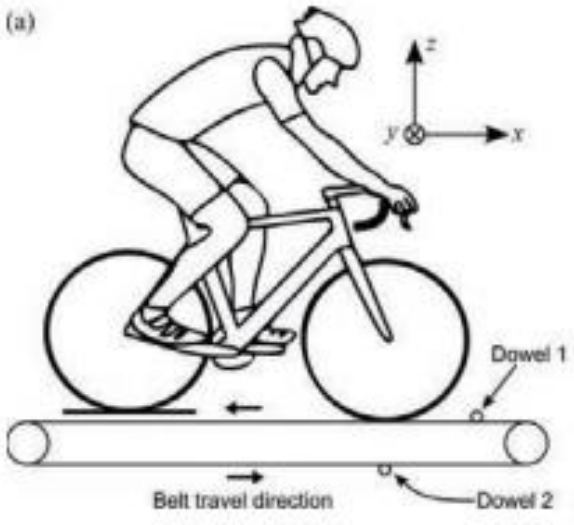
Dataset from a cycling scientist in Australia



Analysis results compare well to acceleration data



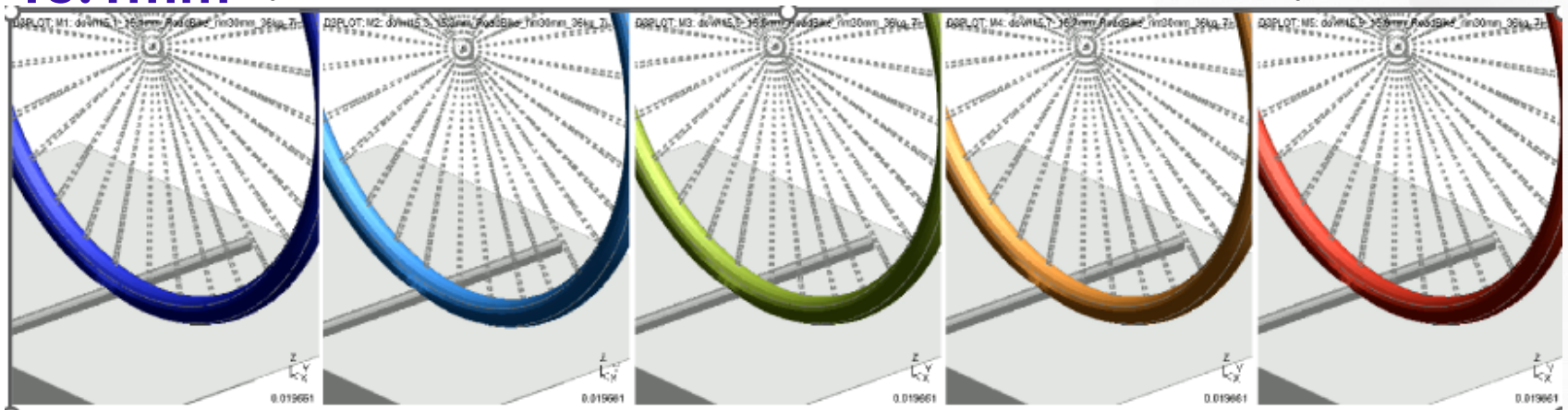
Road-type Bike

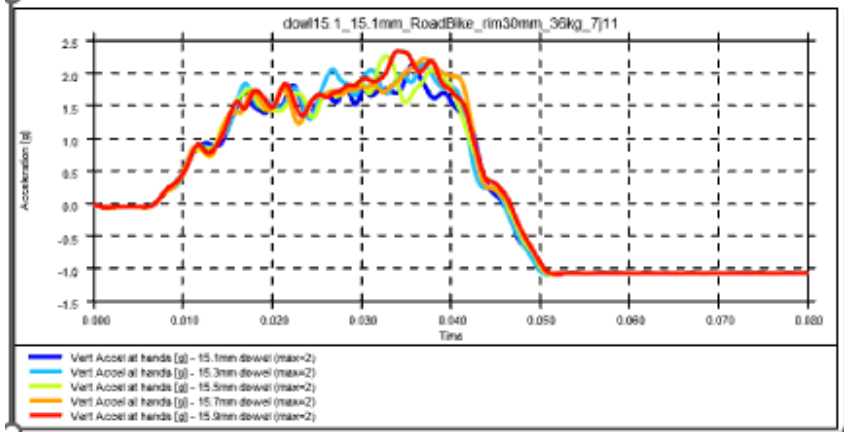


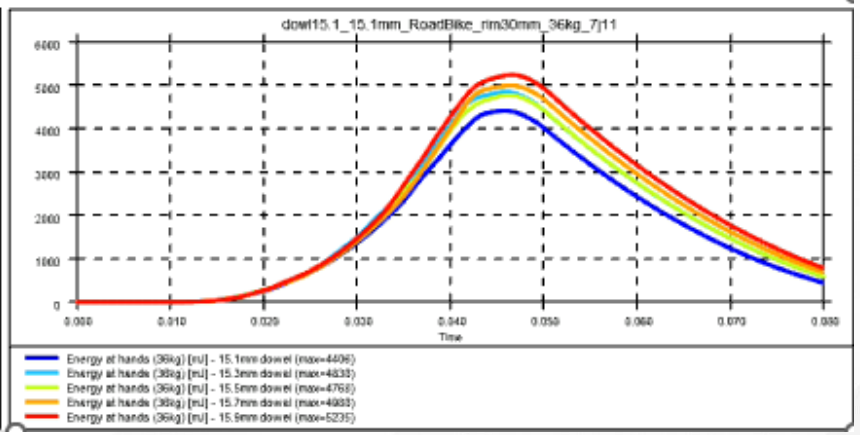
Perceptual Thresholds for Shock-Type Excitation of the Front Wheel of a Road Bicycle at the Cyclist's Hands Jean-Marc Drouet, Catherine Guastavino and Nicolas Girard

Analysis results compare well to previous research

15.1mm ⟷ 15.9mm



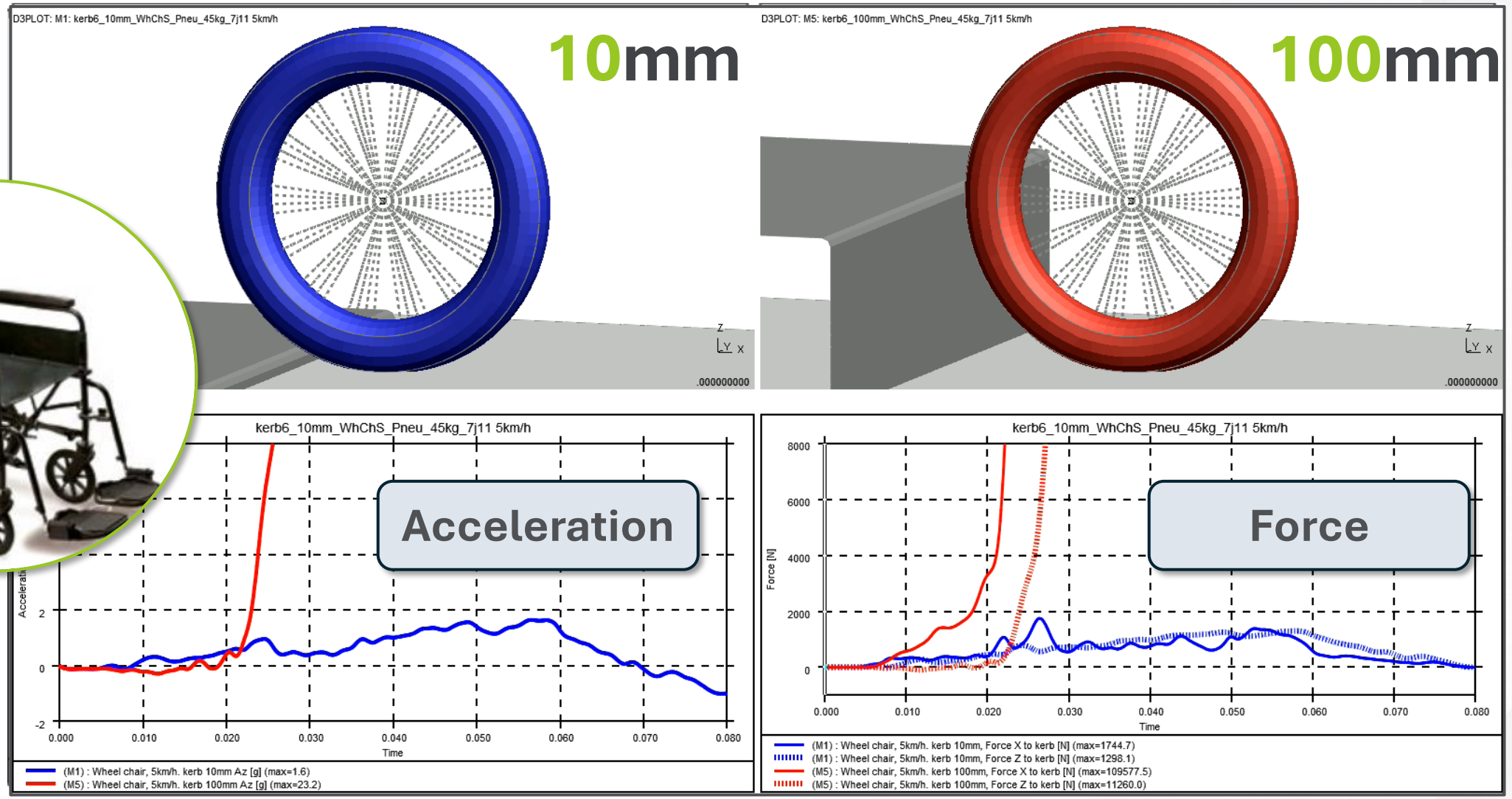




Acceleration

Energy at Hands

Wheelchair



Testing the limits of the analysis

- Why?
- What?
- How?
- Validation
- **Road user comparisons**
- *Questions at the end*

Pass Criteria

No damage to wheel

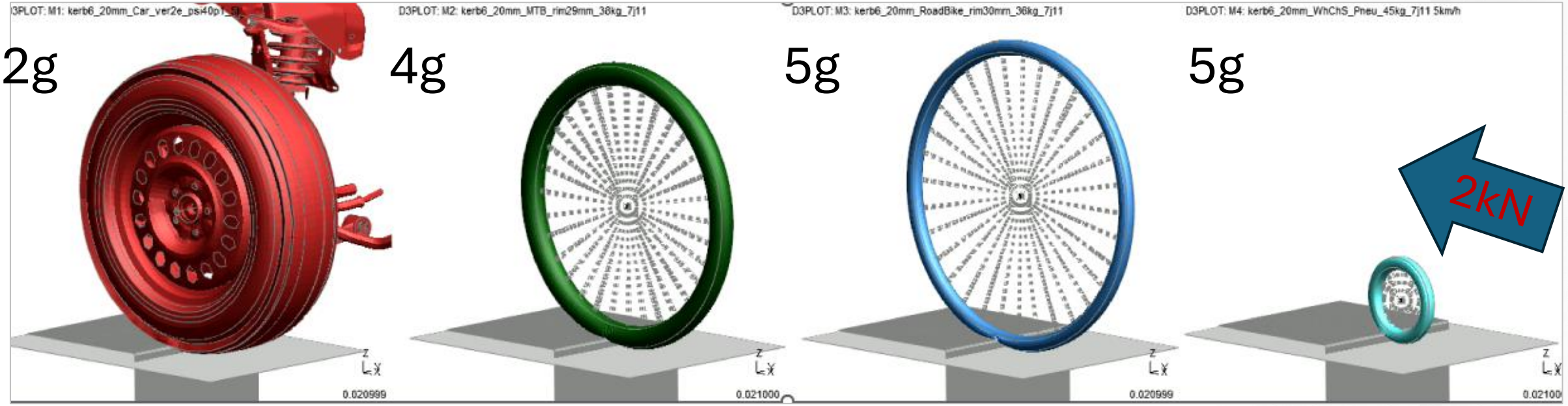
=

No ‘pinching’ of the tyre

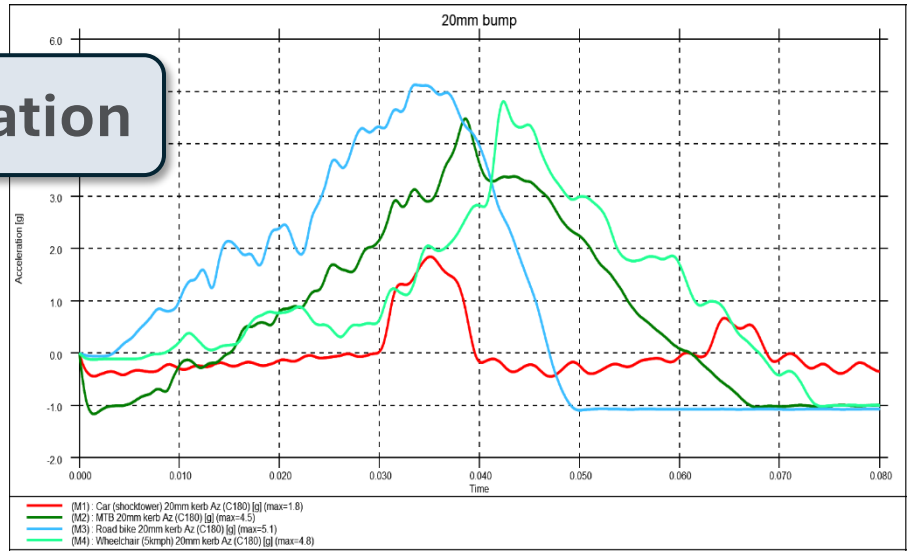
X force – too high and the subject will stop

Z loading – too large leads to risk of injury

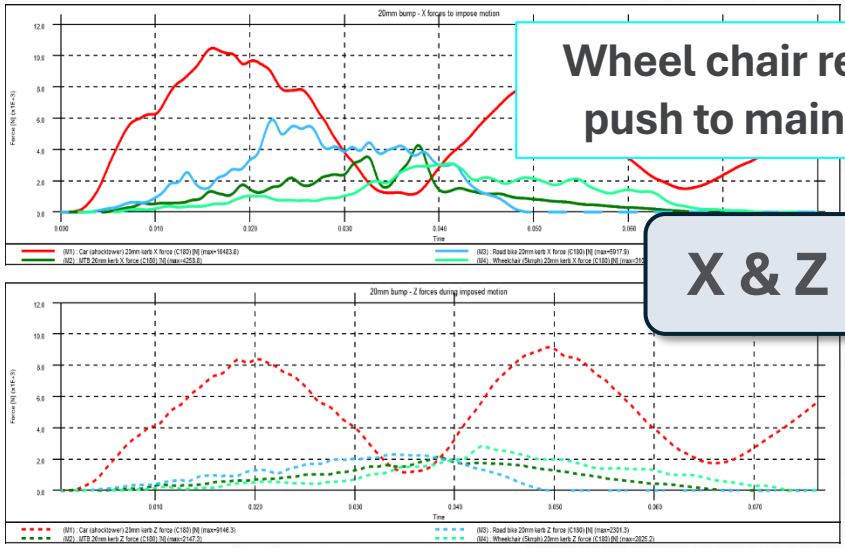
Cycles: ISO 4210-6 (bike frame strength)



Acceleration

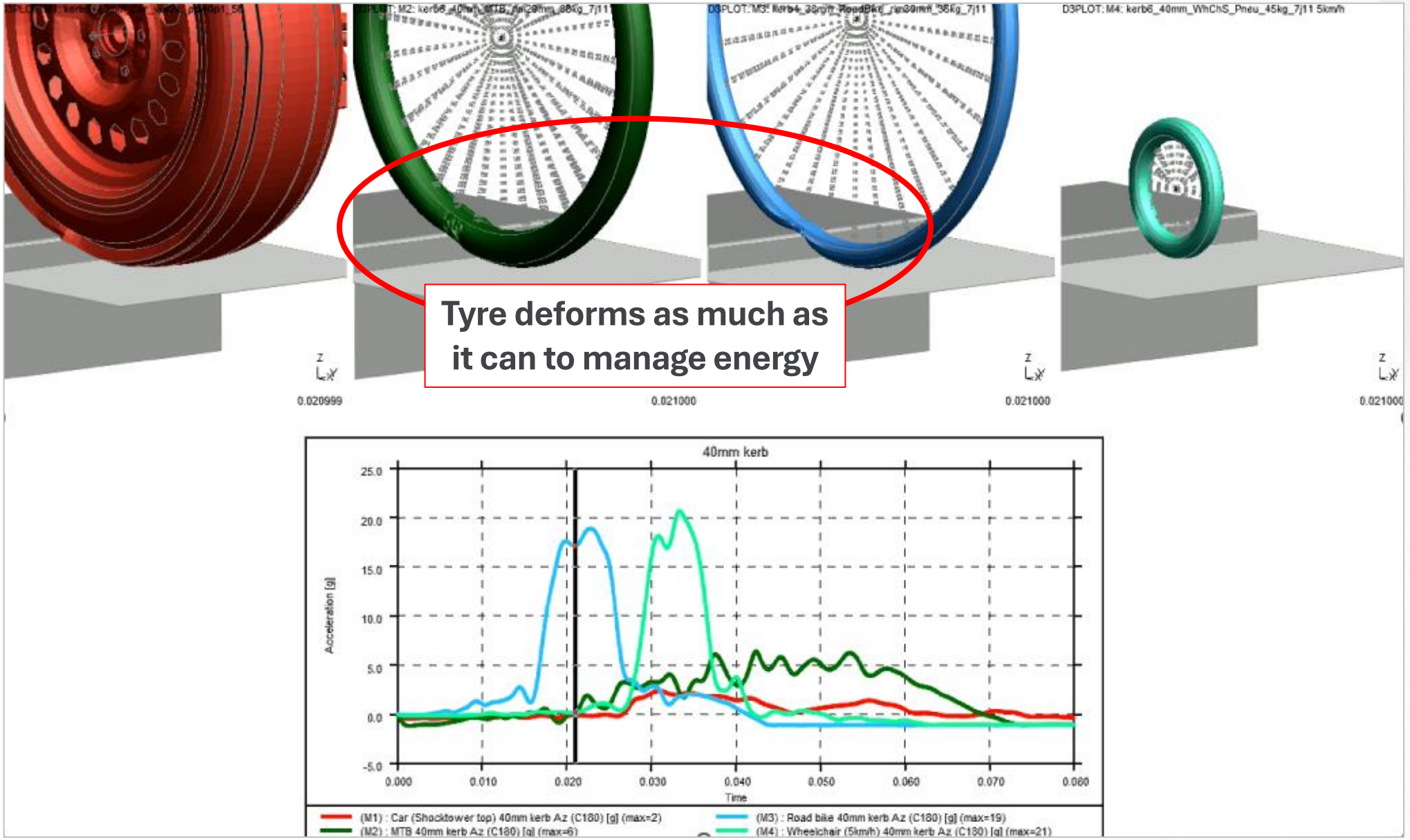


Wheel chair requires 2kN push to maintain speed

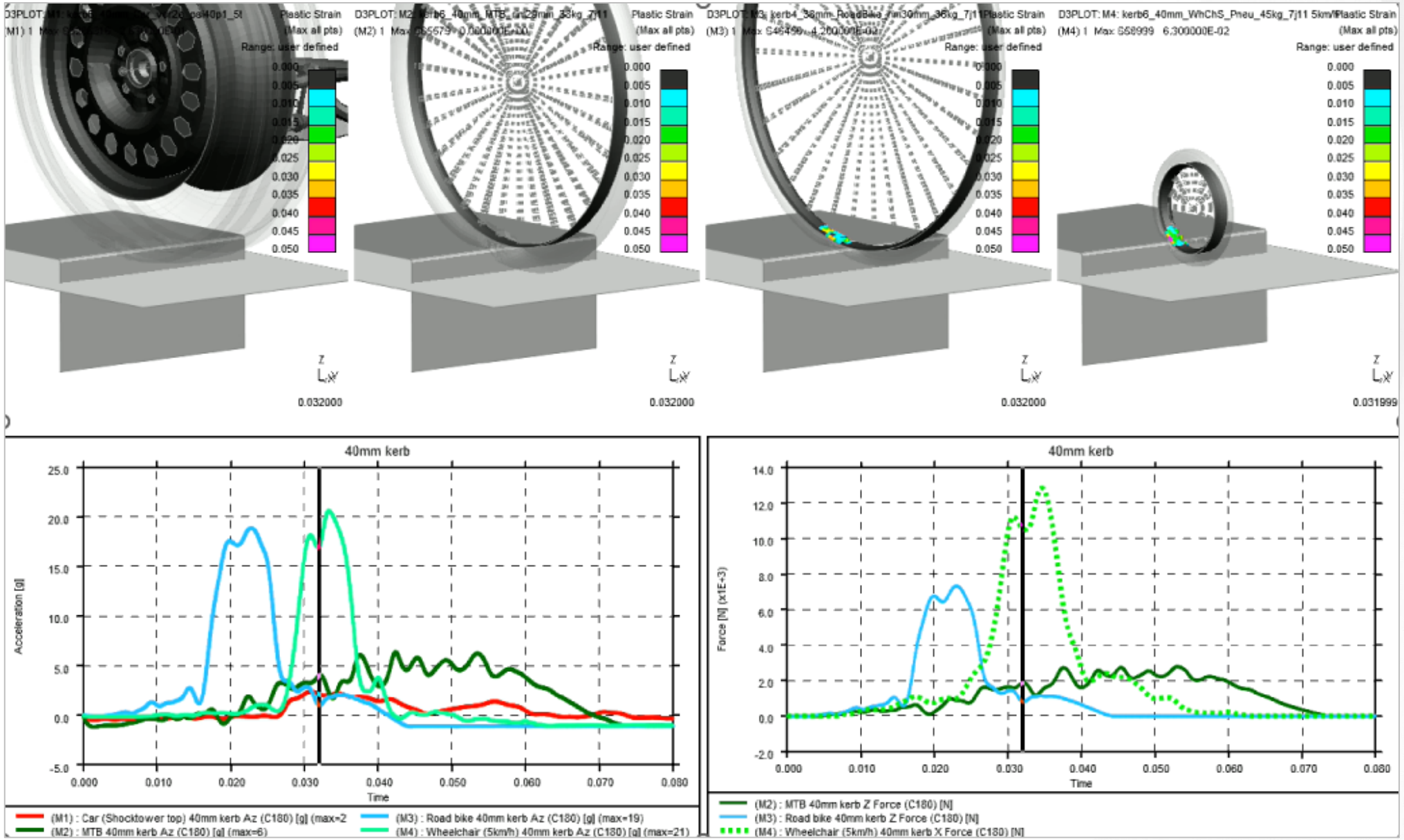


X & Z Forces

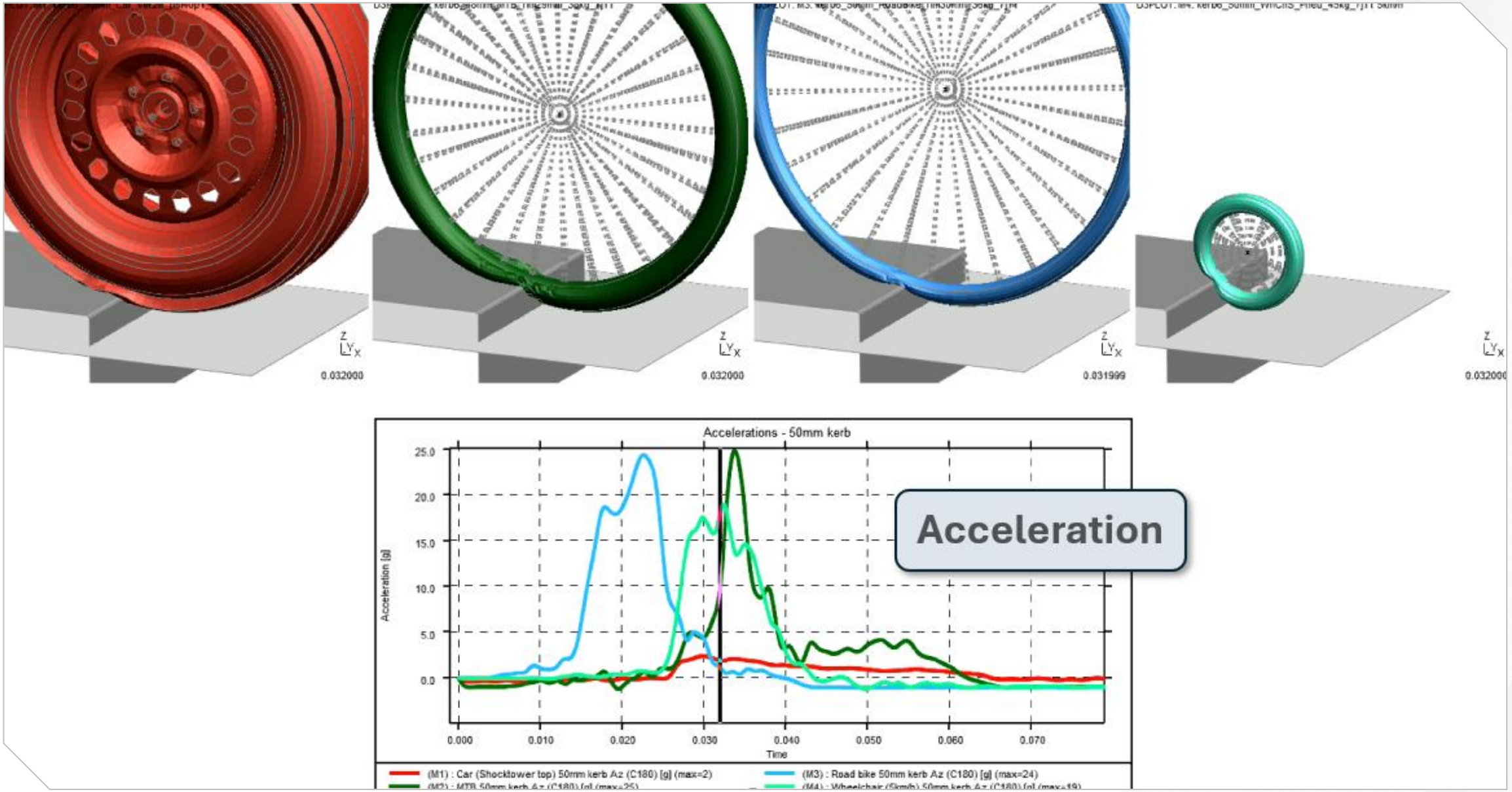
20mm bump



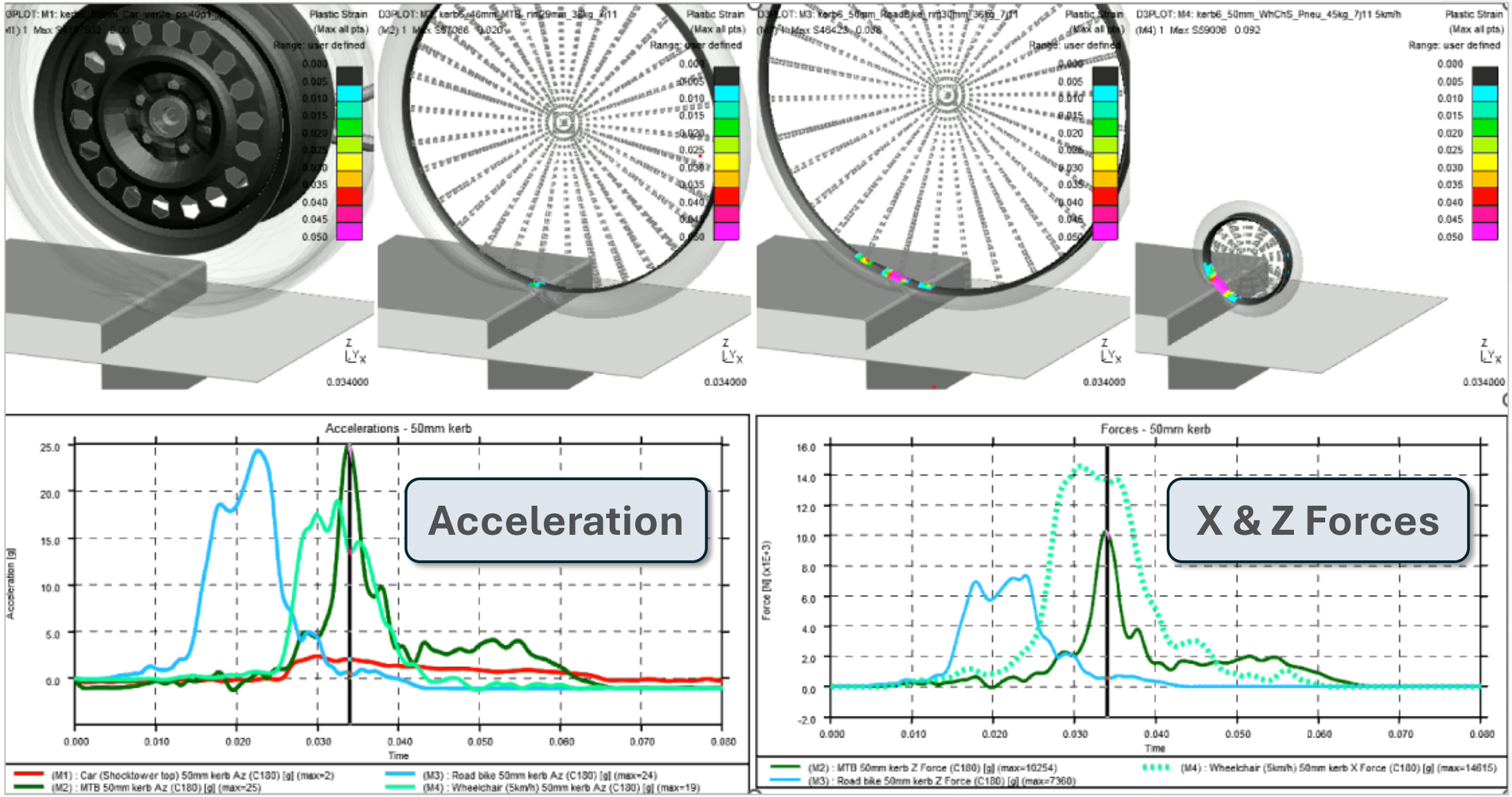
40mm bump



40mm bump: plastic strain = damage



50mm bump



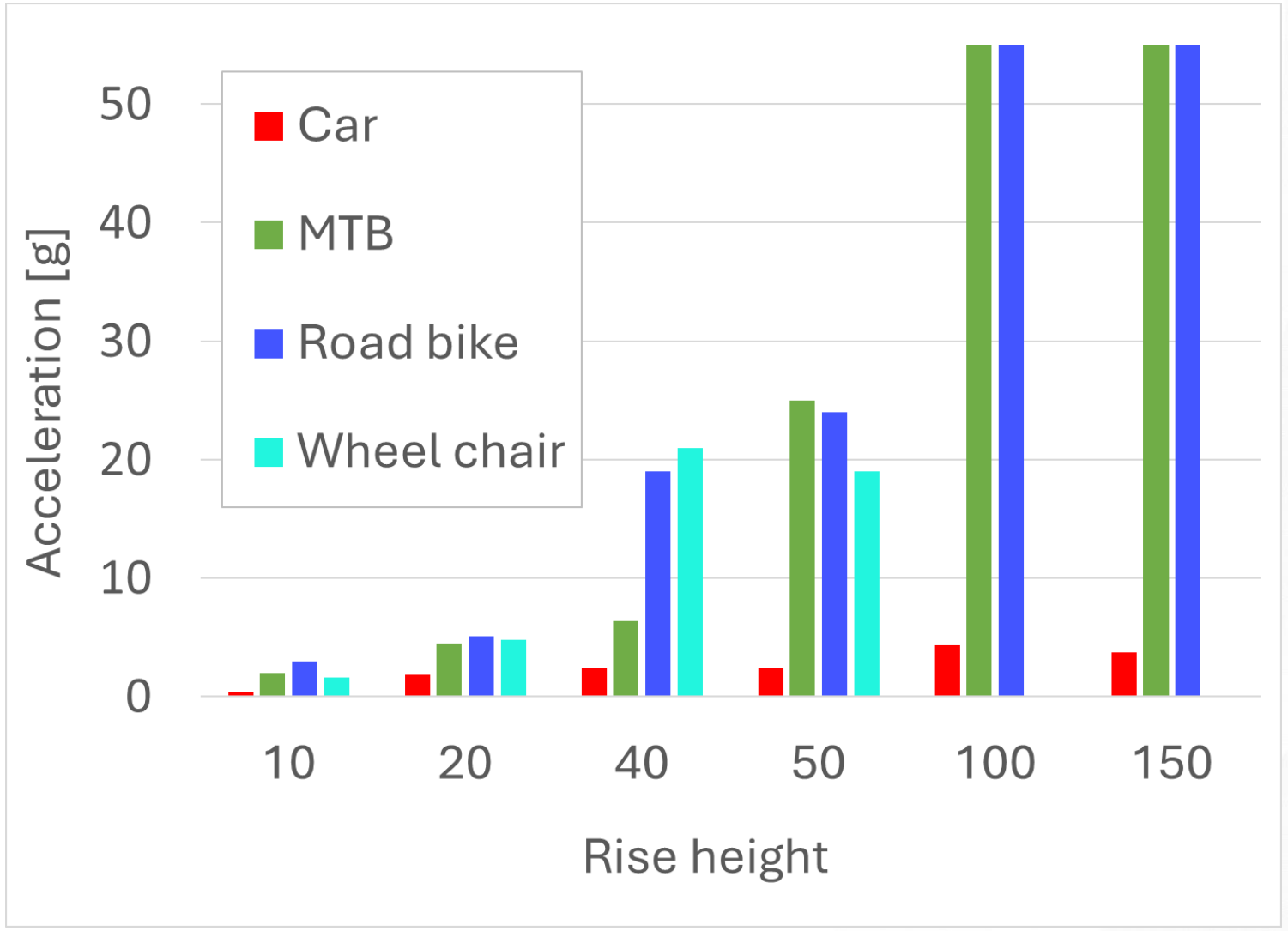
50mm bump: plastic strain = damage

Results Summary

Peak g / wheel damage

Kerb height [mm]	3	5	10	15	20	40	50	100	150
Car			0.4		1.8	2.4	2.4	4.3	3.7
MTB	0.8	1	2	2.9	4.5	6.4	**25**	**117**	**177**
Road bike			3		5.1	***19***	**24**	**69**	**132**
WhCh (5km/h)			1.6		4.8	**21**	**19**	>~~23~~	

Results Summary



Findings

- Risk of a flat tyre and risk of wheel structure damage are paired
- Noting that most councils repair carriageway defects that are 50mm deep and large enough to fit a car wheel, or pavement defects that are 20mm deep:
  - → In this analysis, at 15km/h, the car was able to withstand this BUT not necessarily representative (perfect tyre etc.).
  - → A pothole 50mm deep would damage a cyclist's wheel or cause them to fall off.
  - → A wheeler rolling over a 20mm pavement defect at 5km/h would not necessarily do so easily.

“All models are wrong, but some are useful.”

George Box

A finite element model has been used to objectively compare the effects of potholes and surface defects on different road users.

The model suggests that the risk of harm is far higher for cyclists and wheelchair users than for cars. This is consistent with real world data.

Current maintenance practice is not aligned with the need to promote active travel.

Vectayn
analysis in design

Contact Information:

10 Atlantic Square
Station Road
Witham
Essex
CM8 2TL
England

Phone +44 (0)1376 501068

Or contact
Kara Laing klaing@vectayn.com

BS EN ISO 9001:2015
No. FS34183