


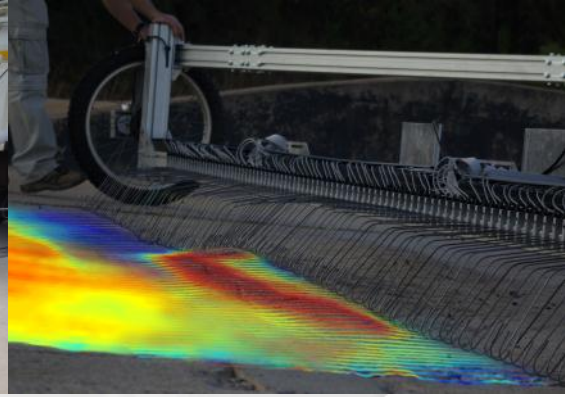

TYRE MODEL VERIFICATION OVER OFF-ROAD TERRAIN

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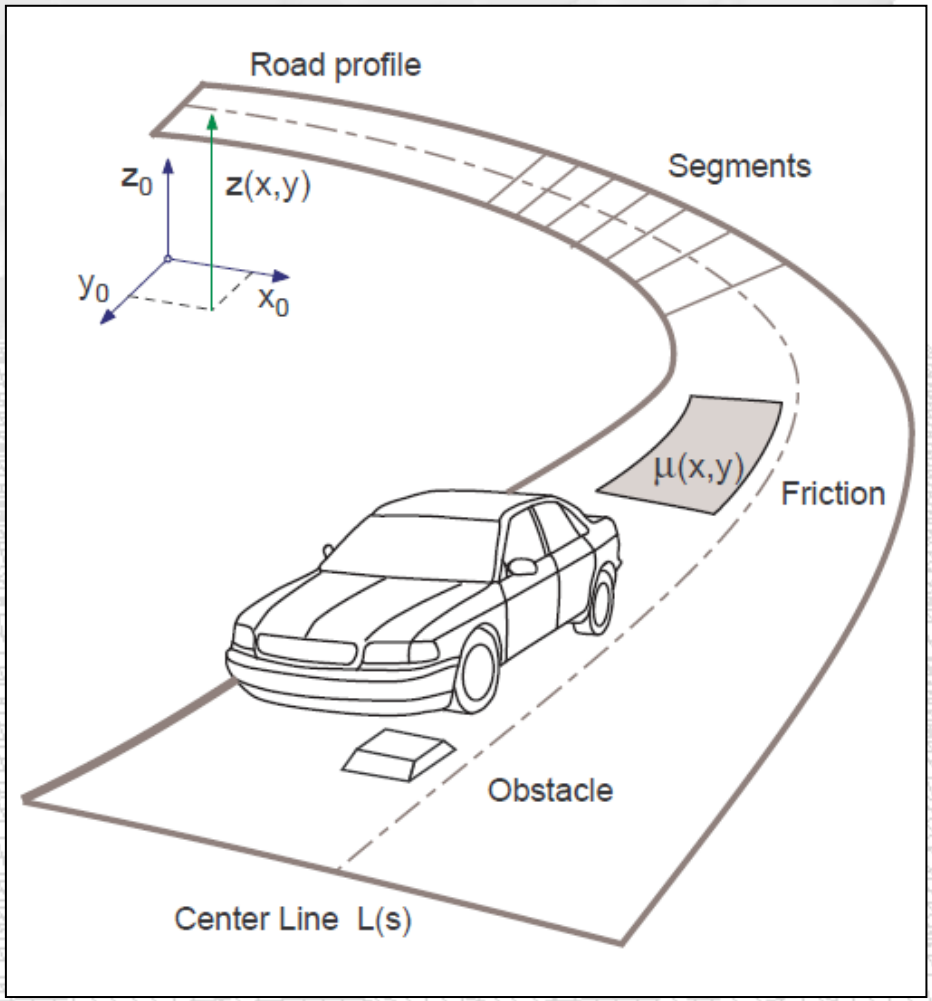
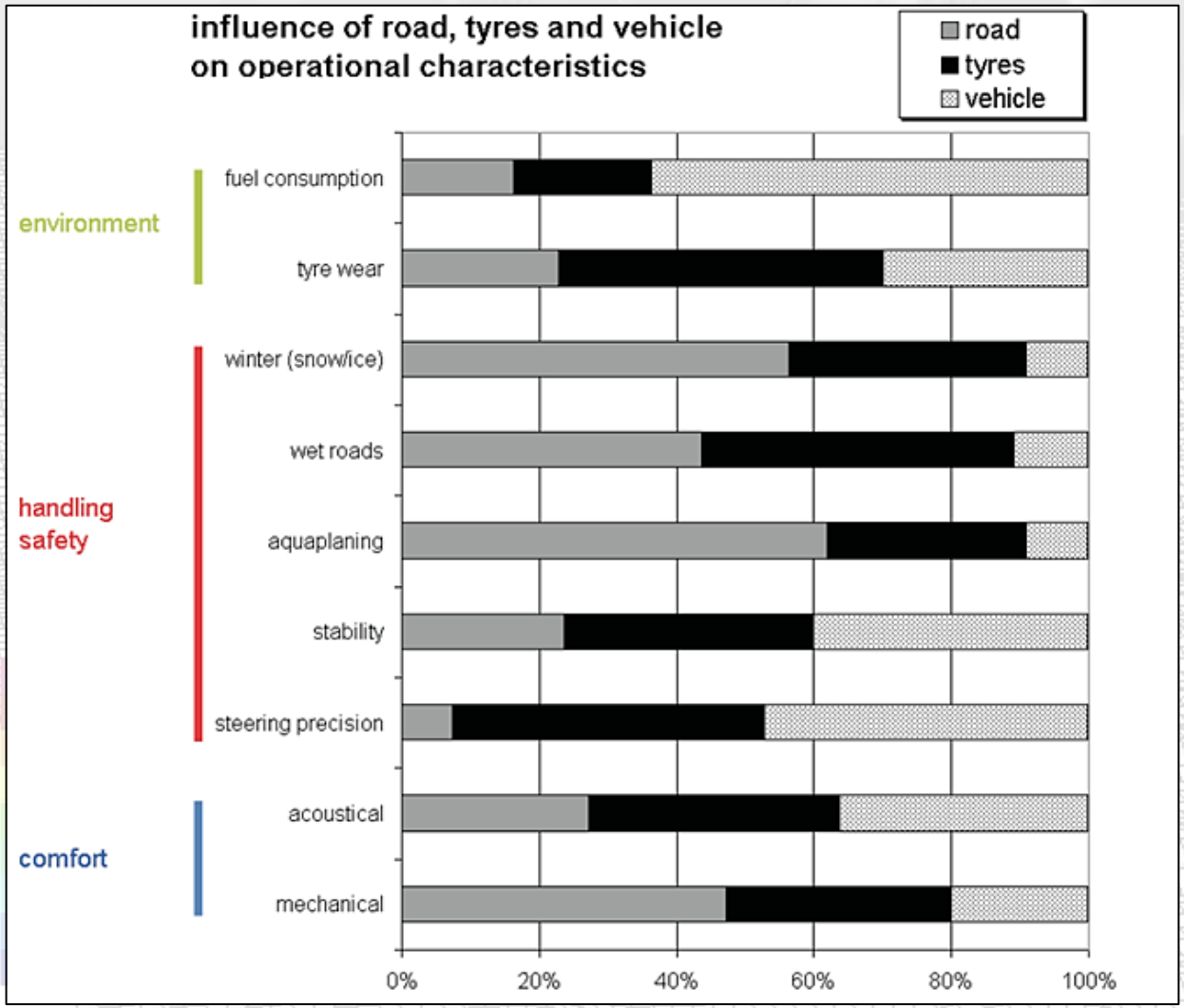
Sophisticated vehicle model

- Road profile
- Vehicle model
  - Physical properties
    - Mass, Moments of inertia …
  - Subsystems
    - Suspension, drivetrain…
  - Applied forces
    - Aerodynamic forces
    - Road contact
      - **Traction forces**
      - **Braking forces**
      - **Rolling resistance**
      - **Cornering forces**



Images taken from: Rill, G., 2006, *Vehicle Dynamics*, Lecture notes, Fachhochschule Regensburg, viewed 10 August 2013, from https://hps.hs-regensburg.de/~rig39165/.

Influence of road, tyres and the vehicle on operational characteristics



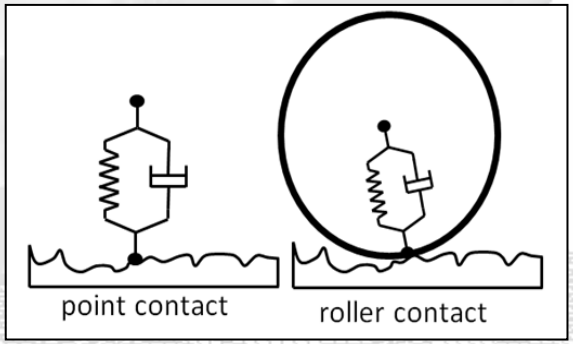
Images taken from: Mohammadi, F., 2012, *Tire Characteristics Sensitivity Study*, Master's Thesis, Chalmers University of Technology

Objective

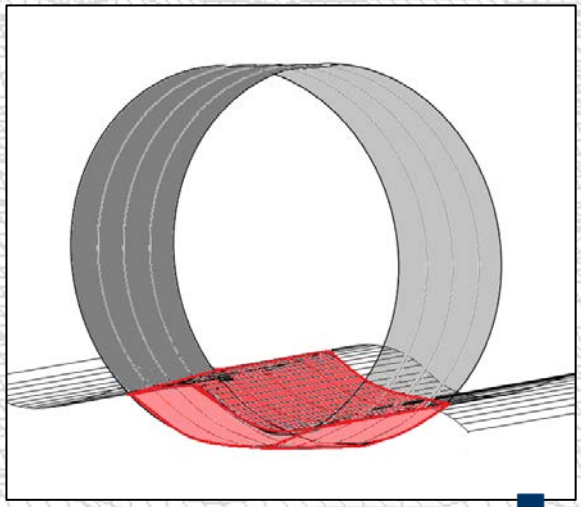
- Parameterization of large off-road tyres
- Validation of different mathematical tyre models used in Simulations
  - “one for all”
  - Road specific tyre model

Investigated Tyre/Contact models

- One Point Follower Contact model
  - Single point of contact
  - Tyre is considered as a disk
  - Contact force is normal to the road plane

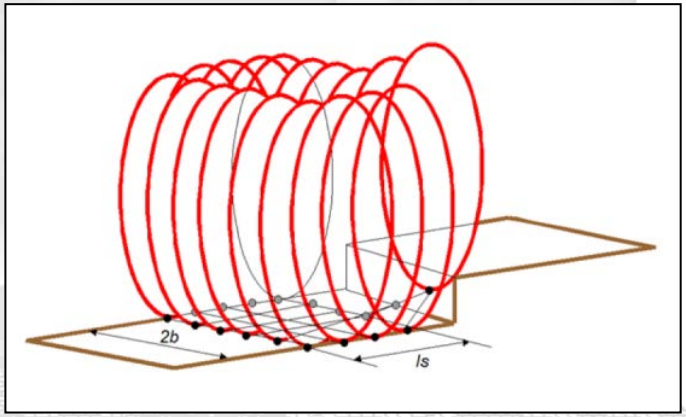


- 3D Equivalent Volume Contact model
  - Tyre –Road intersection volume is used to Calculate the effective contact point
  - Tyre is modeled as a set of disks

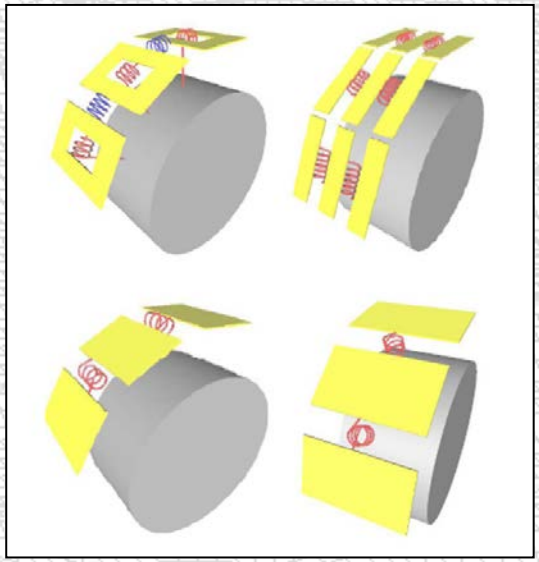


Investigated Tyre/Contact models

- 3D Enveloping Contact model
  - Elliptical cams represent the tyre
  - Contact points of the cams are used to calculate effective contact point



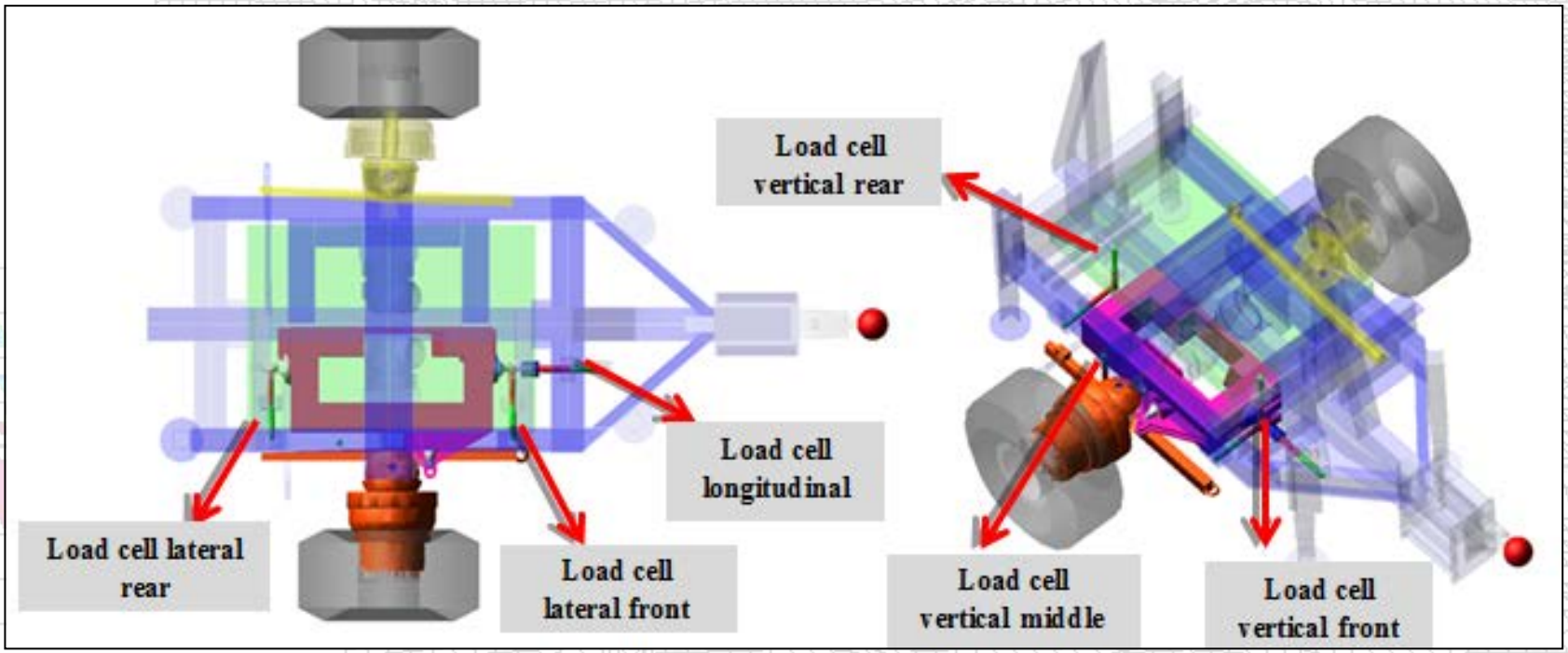
- FTire
  - Flexible-Structure-Tire-Model
  - Structural dynamics approach
  - The tyre model describes the tyre belt as a flexible ring that can flex and extend in the radial, tangential and lateral directions
  - Fully non-linear 3D model



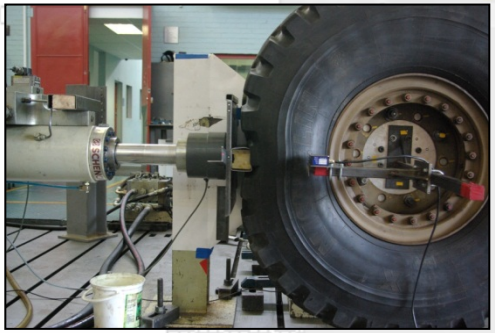
Images taken from: MSC Sotfware , n.d., DOC 10023- Help Document for Adams/Tire, viewed 2 July 2013, from http://simcompanion.mscsoftware.com/infocenter.

Truck tyre test rig

- Truck tyre test rig
  - Used to test large truck tyres
  - Real contact conditions
  - Static tyre loads of up to 5200kg
  - Measures all forces and moments that are generated in the tyre contact patch



Parameterization Tests



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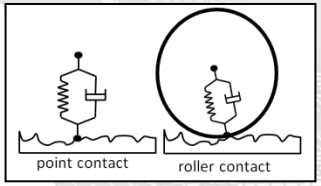
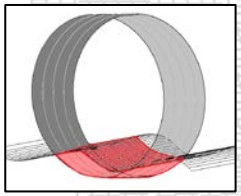
Validation Tests

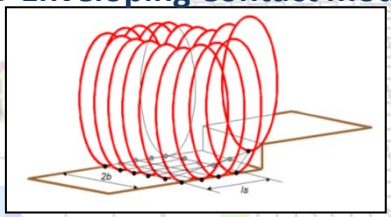
One Point Follower Contact model



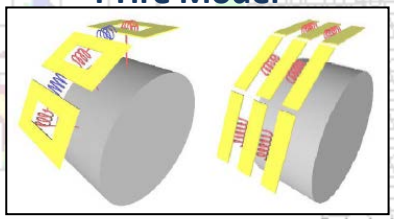
3D Equivalent Volume Contact

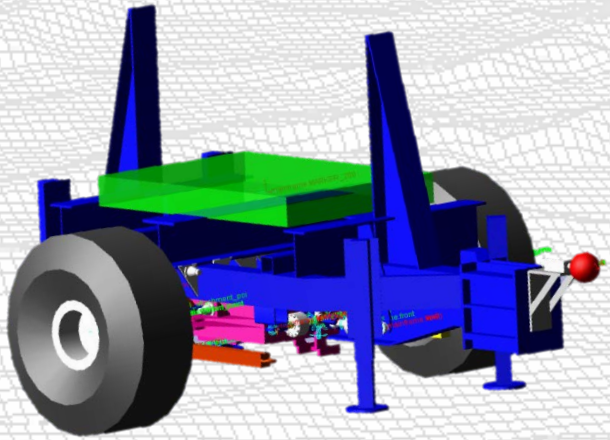


3D Enveloping Contact model



FTire Model





ADAMS Simulation

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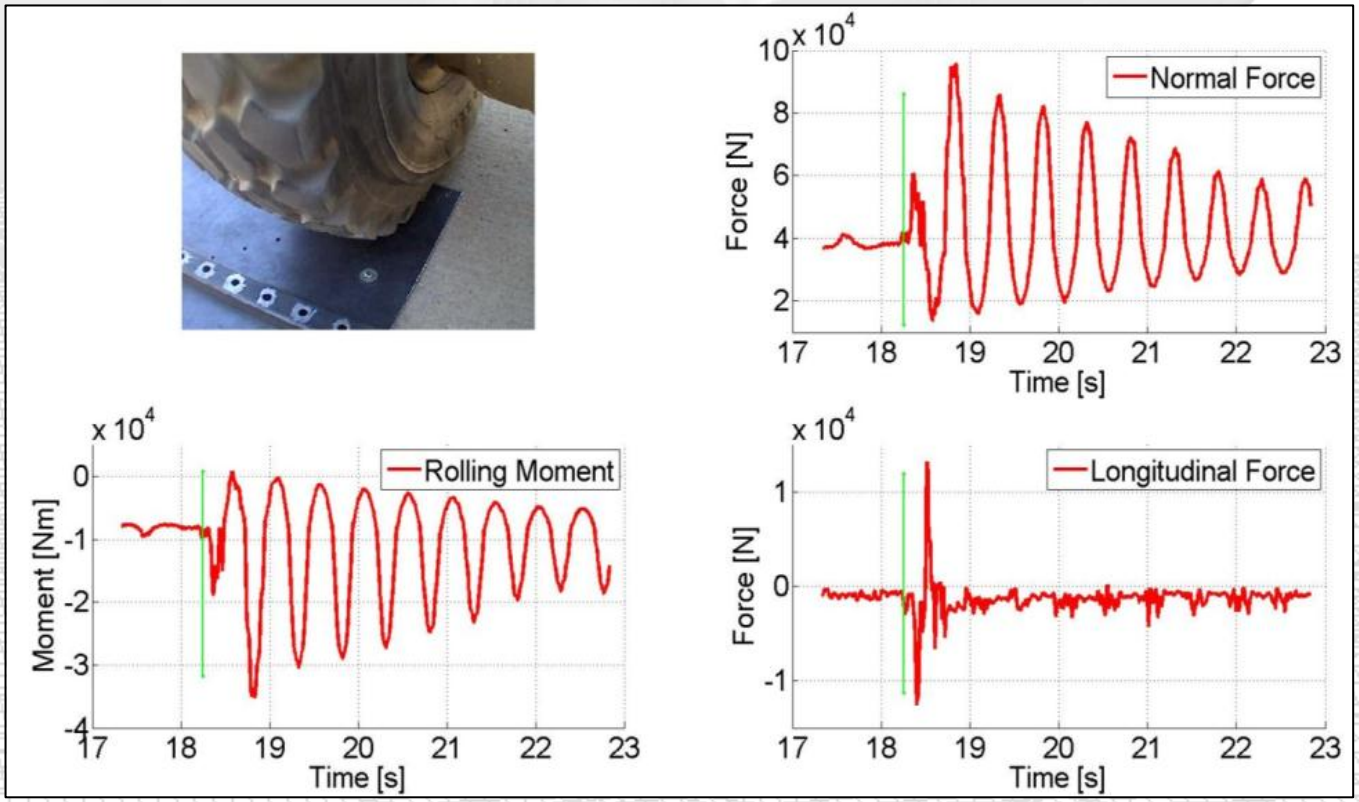
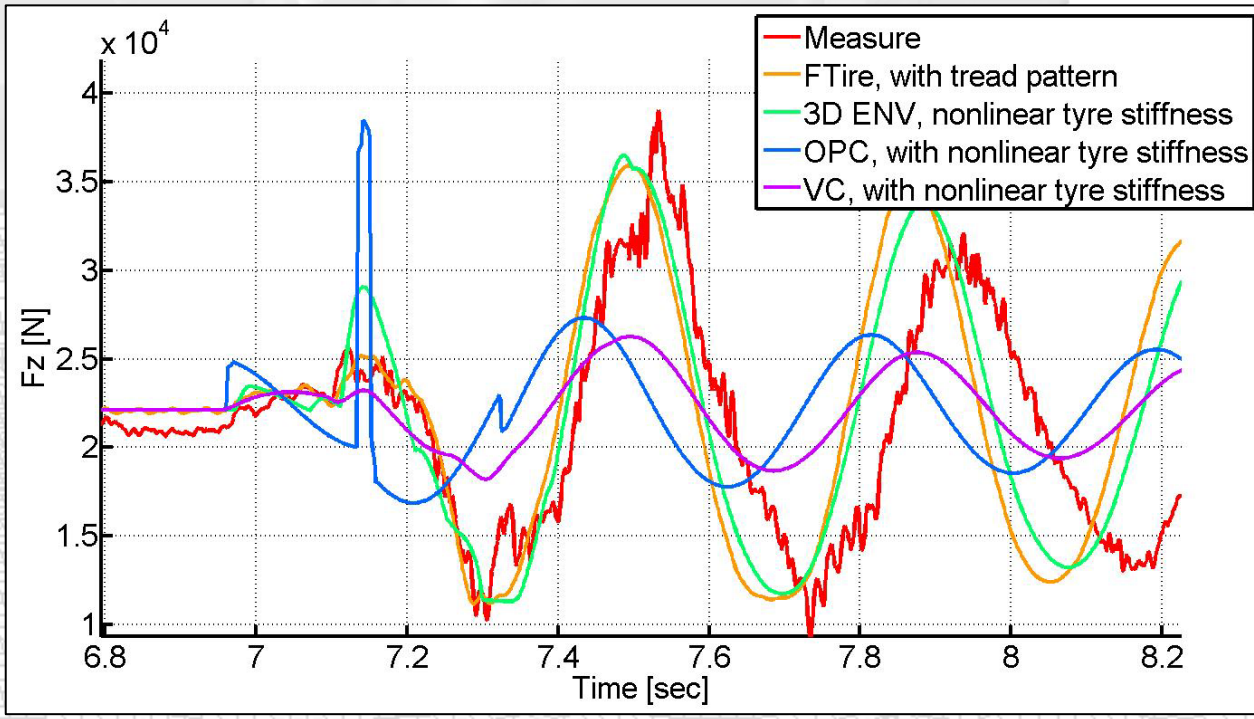
Validation of tyre models
Discrete obstacles

- Cleats
  - 38 x 38mm
  - 50 x 50mm
  - 76.3 x 76.3mm
  - 100 x 100mm



Validation of tyre models
Discrete obstacles – 50mm cleat

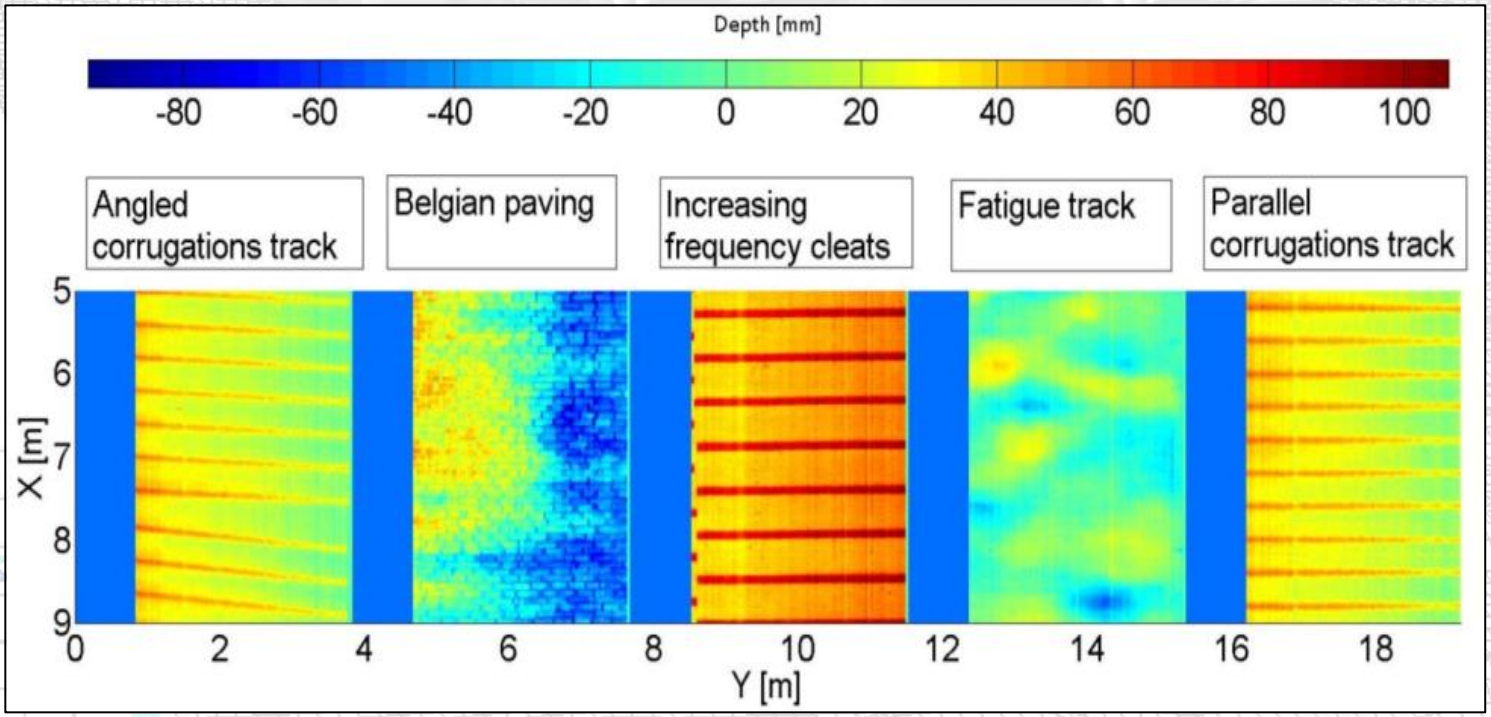
- One Point Follower Contact
  - Peak load when tyre clears the cleat
  - Impulse response
- 3D Equivalent Volume Contact
  - No peak load
- 3D Enveloping Contact
  - Good representation
  - Mimics tyre response while clearing the cleat
- F-Tire
  - Best representation
  - Mimics tyre response while clearing the cleat well



Validation of tyre models
Hard Terrain

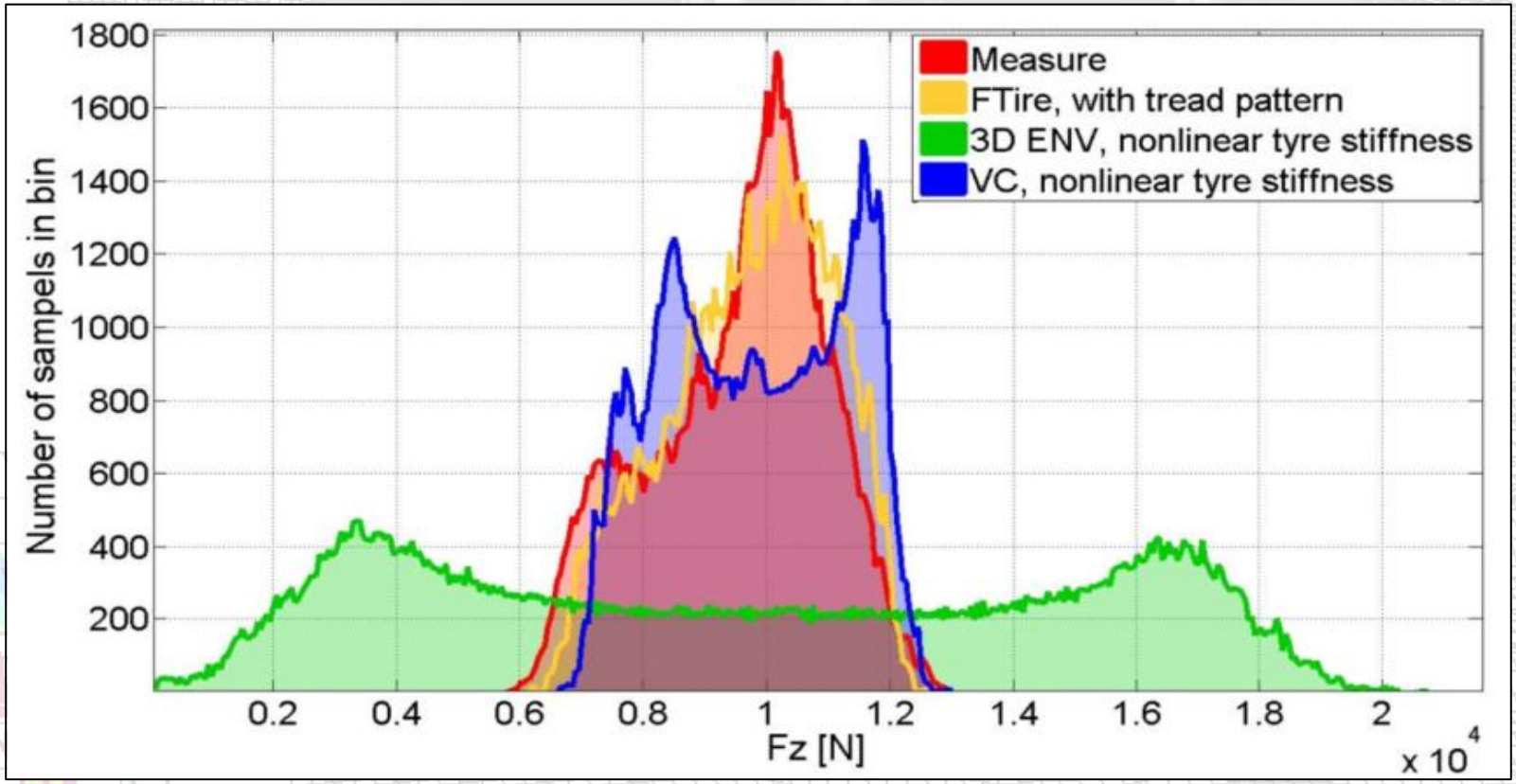
Gerotek Suspension Track

- Belgian paving
- Fatigue track
- Parallel corrugation track
- Angled corrugation track
- Increasing frequency cleats



Tyre model validation – Angled Corrugations

- FTire is capable of predicting the tyre forces
- 3D Equivalent Volume Contact shows acceptable performance
  - Not able to capture the peak loads
- Poor performance of the 3D Enveloping Contact and One Point Follower Contact



Summary

Group	Obstacle	Tyre model/ Contact model			
		FTire	3D ENV	3D VC	OPC
Discrete Obstacles	Cleats	Comparable, best	Comparable	Not representative	Not representative
	Trapezoidal bump	Comparable, best	Not representative	Comparable	Not representative
Rough tracks	Belgian paving	Comparable, best	Not representative	Comparable, under certain conditions	Not representative
	Fatigue track	Comparable, best	Not representative	Comparable	Not representative
	Parallel corrugations	Comparable, best	Not representative	Comparable	Not representative
	Angled corrugations	Comparable, best	Not representative	Comparable	Not representative

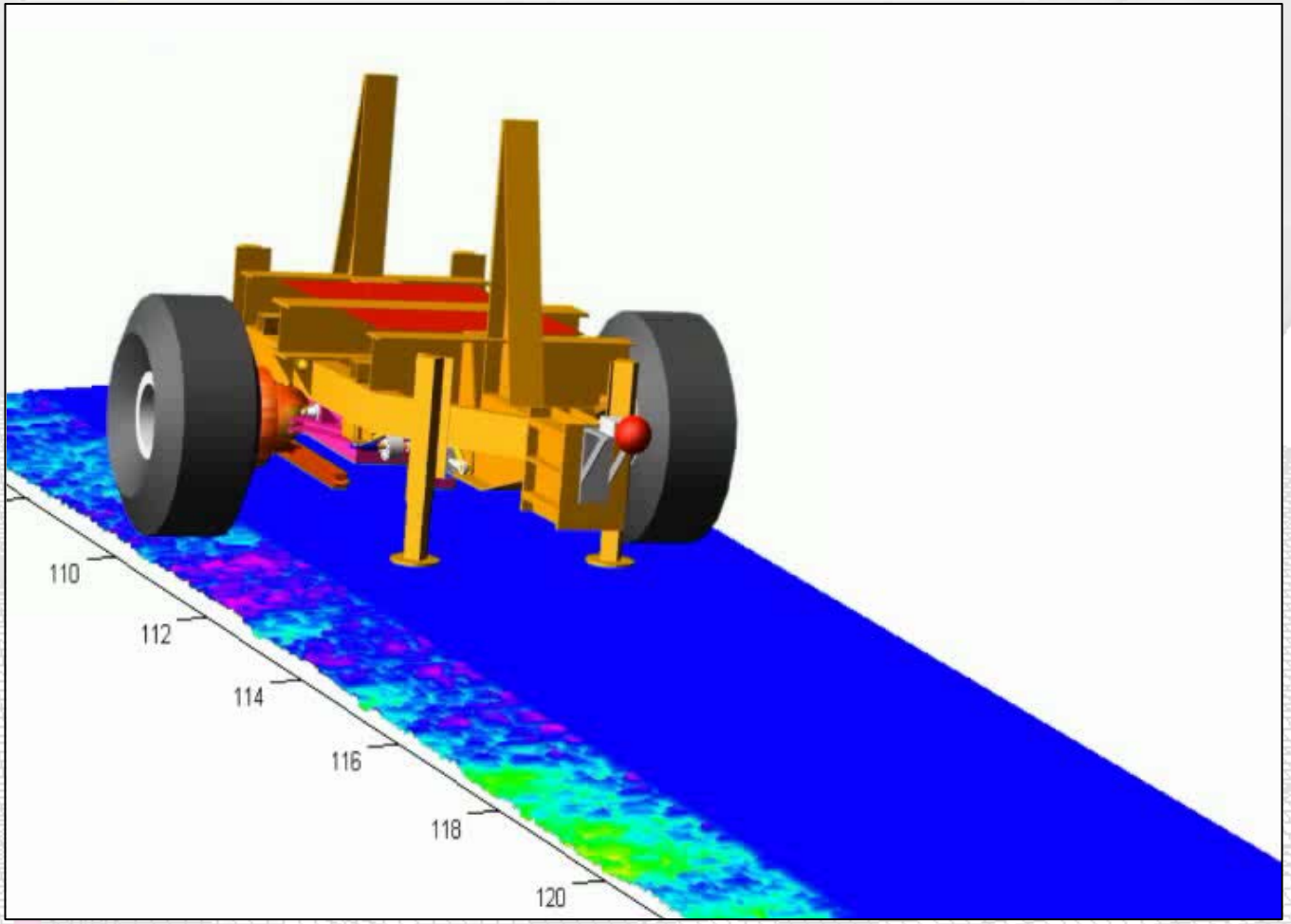
Future Work

I. Develop test equipment that can be used to determine dynamic tyre behaviour in a laboratory.

II. Include lateral and longitudinal test data in the parameterization process. These tests can be used to further improve the FTire model.

III. Develop test equipment that can be used to investigate camber effects. Static and dynamic test should include camber test data.

IV. Investigate the poor tyre model performance for simulations over the Fatigue track.



Thank you