Rolling Resistance Price of Road Assets
An Environmental Retrospect

Rijkswaterstaat
Ministry of Infrastructure and Water Management

Seminar:
'Bouwen op Kennis'

Met KPE naar een klimaatneutrale weg

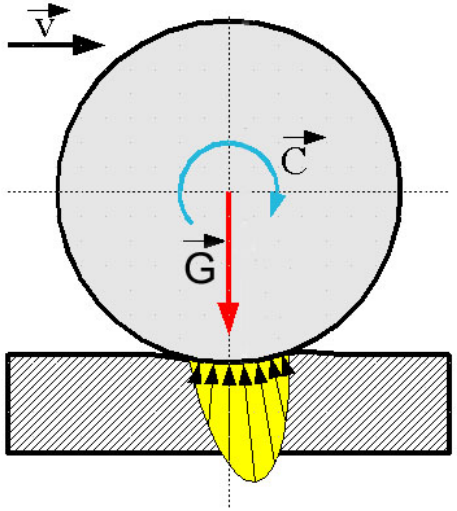
1 November 2021

Dr. Kumar Anupam
Drs. ir. Mahesh Moenielal

Knowledge-based
Pavement
Engineering
2020-2024

TNO TU Delft

1 Introduction

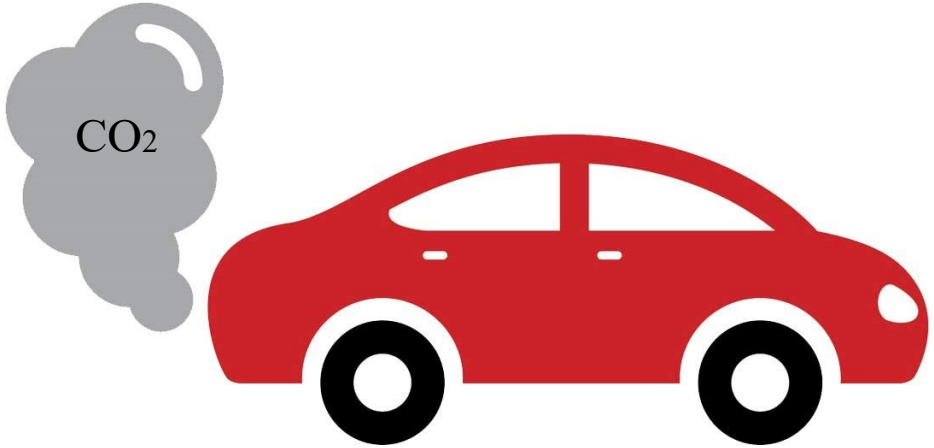


Mechanism of rolling resistance

https://nl.wikipedia.org/wiki/Rolweerstand

Additional fuel consumption

https://www.iheartradio.ca/virginradio/halifax/blogs/pumping-gas-slowly-1.3597646



CO_2 emission

https://www.amazon.com/Simple-Pollution-Cartoon-Sticker-Smoking/dp/B07K2SGRWL

2 Problem statement

- Although several literature sources address the influence of rolling resistance on CO_2 emissions, none of them focus on quantifying **the contribution of rolling resistance to the Environmental Cost Indicator (ECI)**, particularly under the Netherlands conditions.

- The knowledge of this cost could significantly change maintenance strategies, life cycle cost analysis, and the development of low rolling resistant pavement surfaces.

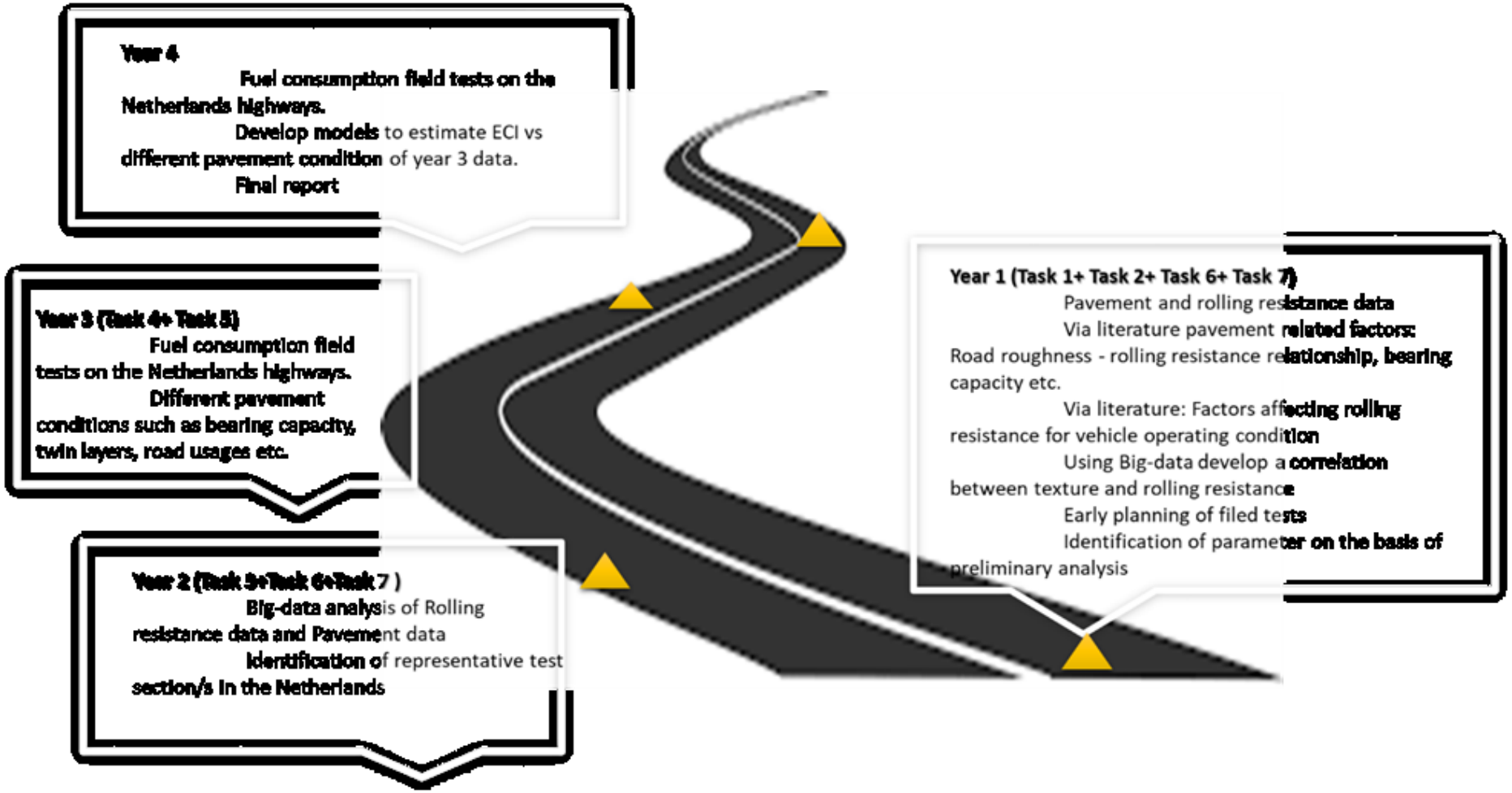
- However, **coming up with a good ECI is a complex process** since the rolling resistance is significantly affected by various factors related to traffic, environment, tire type, vehicle classes, etc. **This proposal will be a research effort to scientifically estimate ECI**.

3 Project information

Aims:

(1) Provide a better understanding of rolling resistance under the Dutch road conditions.

(2) Quantify the cost of rolling resistance to the Environmental Cost Indicator (ECI) under the Dutch road conditions.

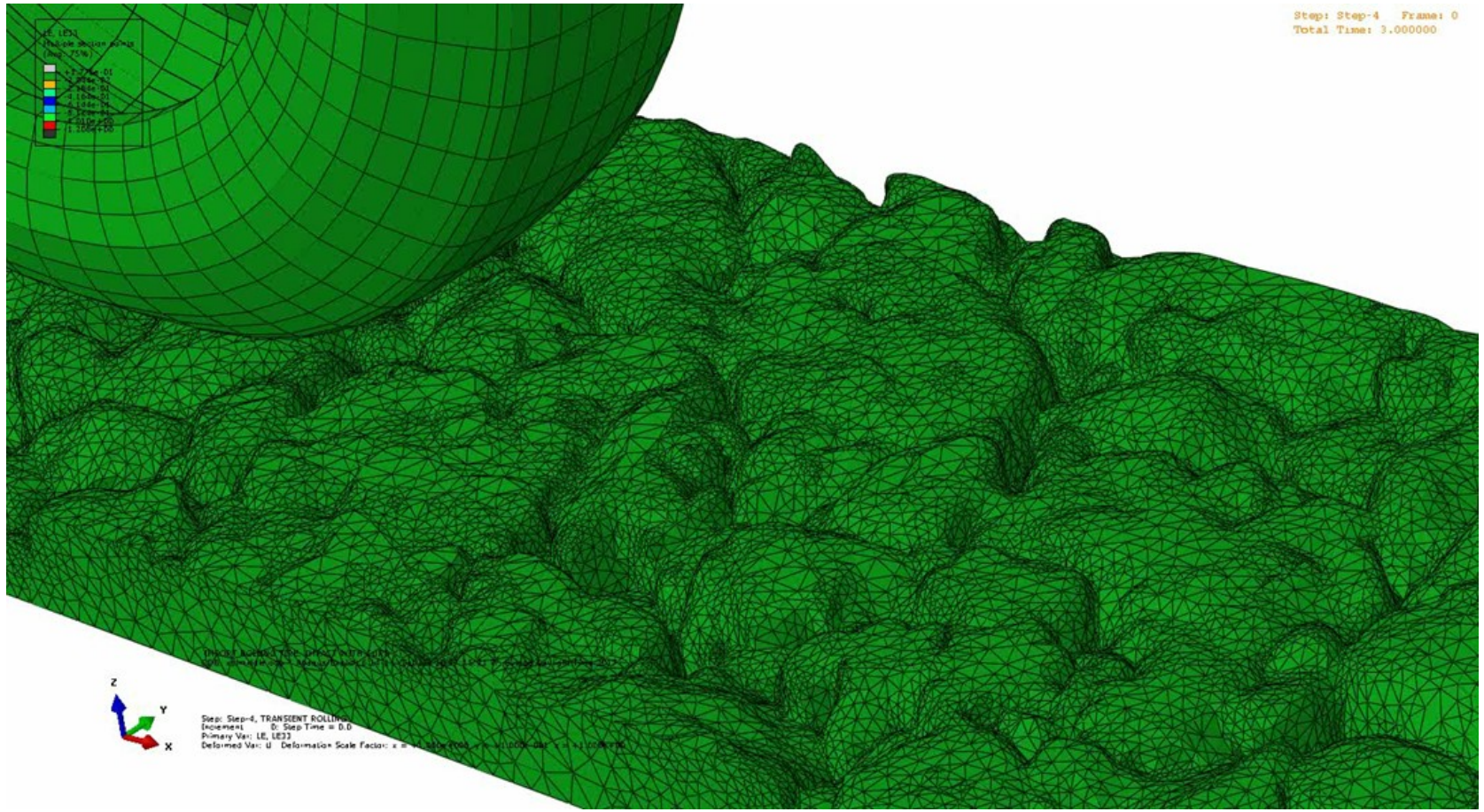


4 Time plan

Tasks and deliverables		Year 1	Year 2	Year 3	Year 4
T1	1.1 Literature reviews: Understanding existing database	PR	PR	PR	FR
	1.2 Collection, familiarity and preprocessing of rolling resistance data of M+P	FR			
	1.3 Collection, familiarity and preprocessing of pavement condition data	FR			
	1.4 Expert surveys and meetings to identify parameters affecting rolling resistance	PR	FR		
	1.5 Feasibility of field tests of Task 4.1	PR	FR		
T2	2.1 Rolling resistance data pre-processing	PR	FR		
	2.2 Pavement data pre-processing	PR	FR		
	2.3 Prelim-data analysis of Rolling resistance data and Pavement data	FR			
	2.4 Identify key factors of pavement parameter affecting rolling resistance on Task 2.4	FR			
	2.5 Organize workshop/meeting with RWS to discuss the obtained parameters and selection of key parameters	FR			
T3	3.1 Big-data analysis of Rolling resistance data and Pavement data		FR		
	3.2 Identification of representative test section/s in the Netherlands		FR		
	3.3 Identification vehicle operating condition variability		FR		
	3.4 Round table check and final feed forward		FR		
	3.5 Planning, finances for Task 4.1		PR	FR	
T4	4.1 Fuel consumption field tests on the Netherlands highways			PR	FR
	4.2 Data collection under different pavement, environmental conditions			FR	
	4.3 Field data preprocessing and preparation			FR	
	4.4 Big data analysis to obtain relationship between various parameters of Task 2.5 and fuel consumption			PR	FR
	4.5 Round table check and final feed forward for ECI parameters				FR
T5	5.1 Obtaining necessary parameters in Laboratory			PR	FR
	5.2 Analytical/Numerical/Finite element modeling of stiff vs soft pavements			PR	FR
	5.3 Carry out cost analysis to obtain ECI			PR	FR
	5.4 Assessment of results and final reporting of the project			PR	FR
Planning for the next years		YP	YP	YP	
Writing articles, attending conferences, organizing workshops/events		AS,CS,WB	AS,CS,WB	AS,CS,WB	AS,CS,WB

5 Our experience

TU Delft has been active in tire-pavement interactions related studies since long.



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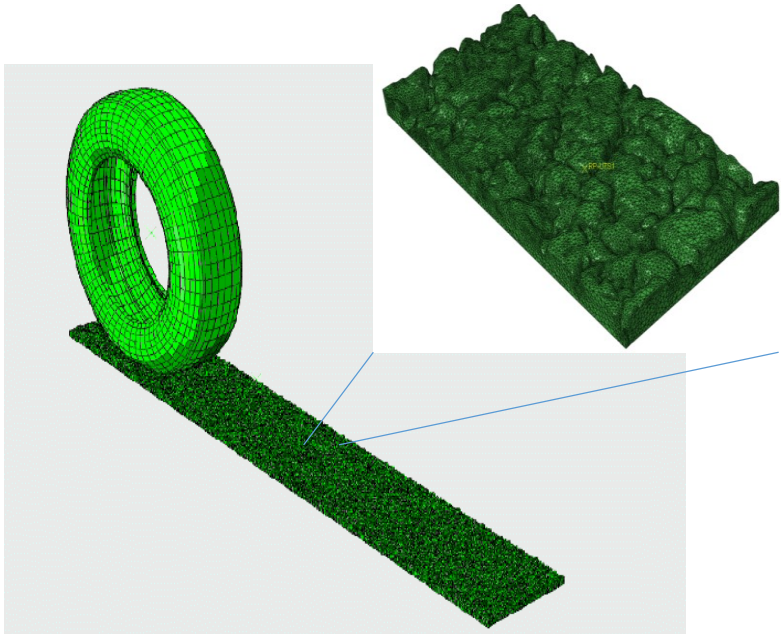
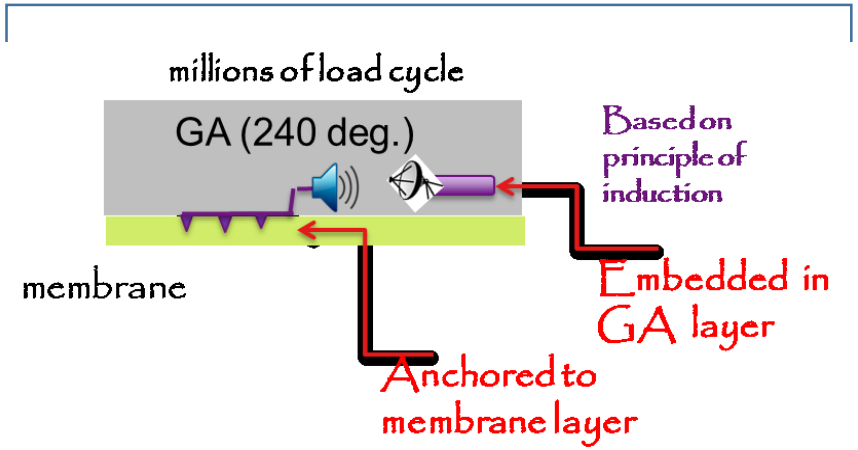


Thermo-mechanical tire-pavement interaction models



Development of shear displacement measurement device

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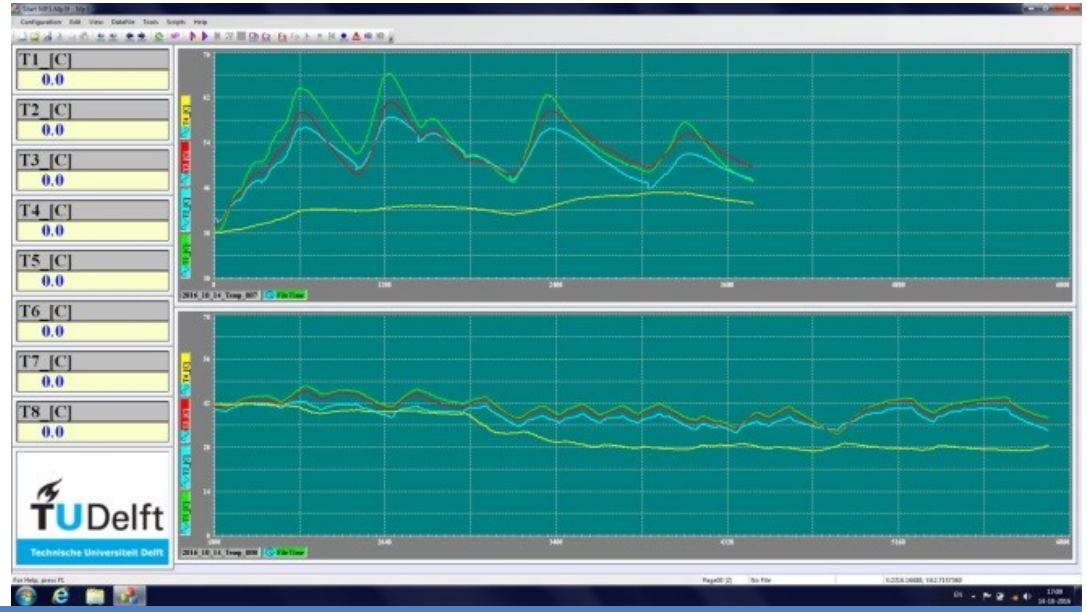

Development of device to measure temperature within tire cross during friction tests

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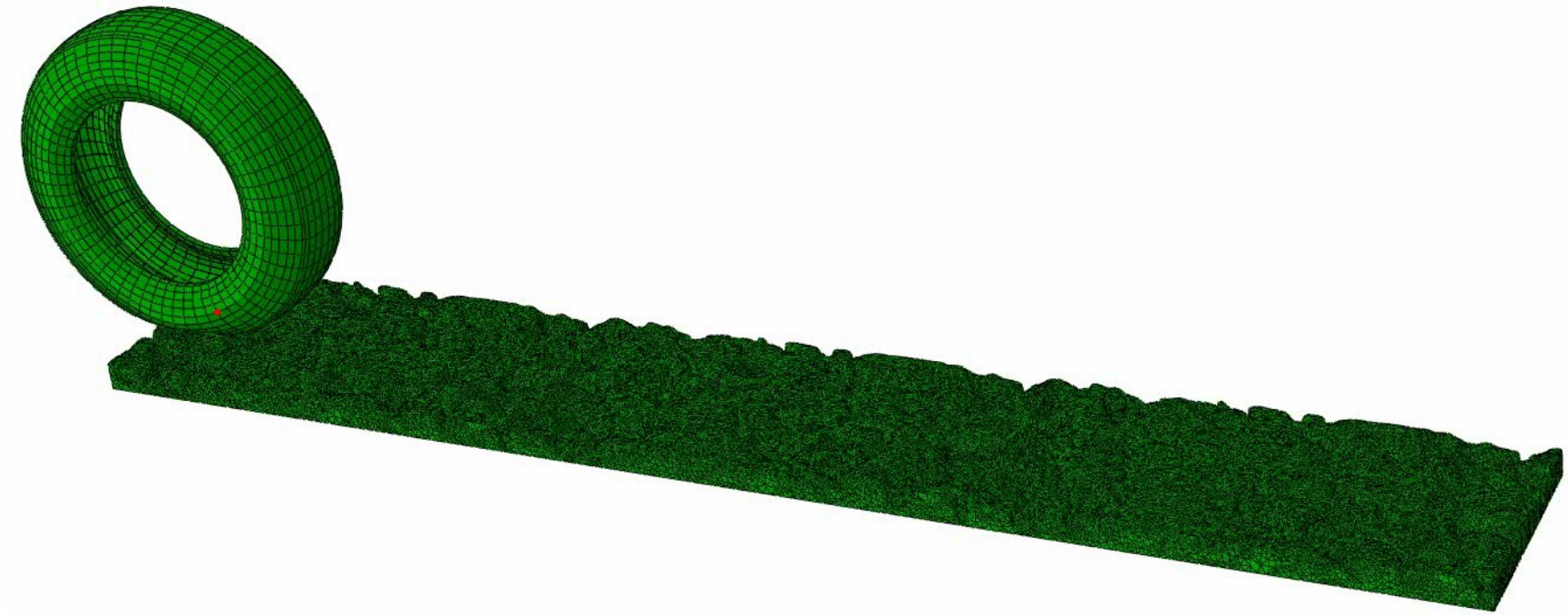

Soft-soft tire-pavement contact

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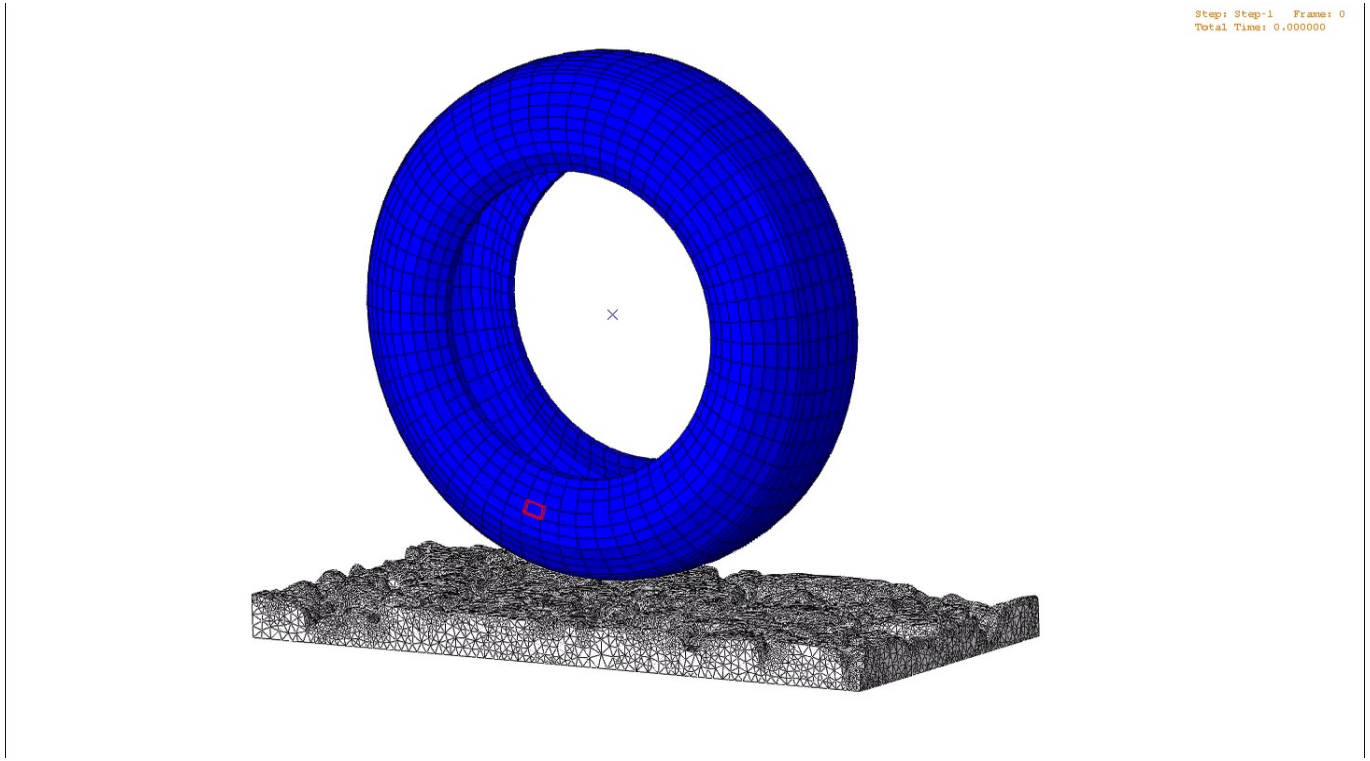

Thermo-mechanical simulation
Tire rotating over the texture surface without translation

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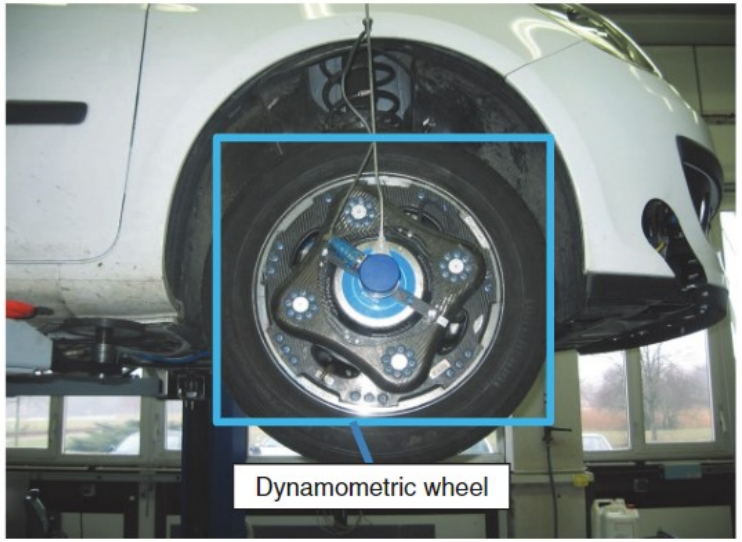

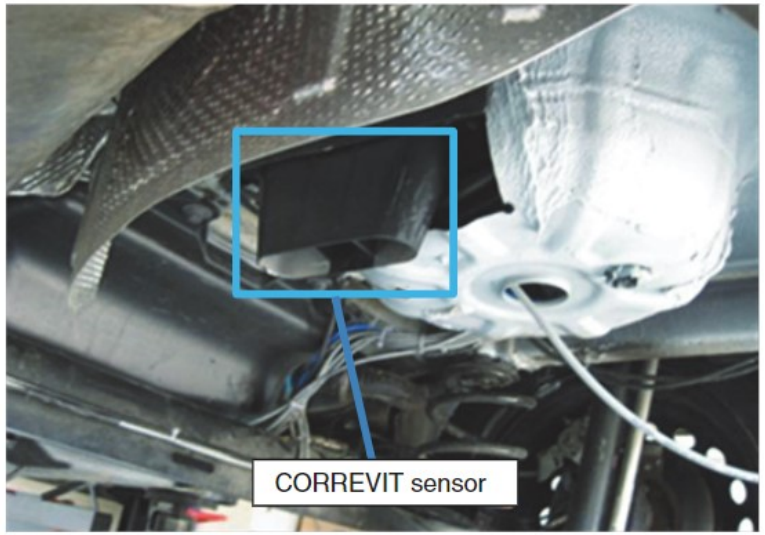

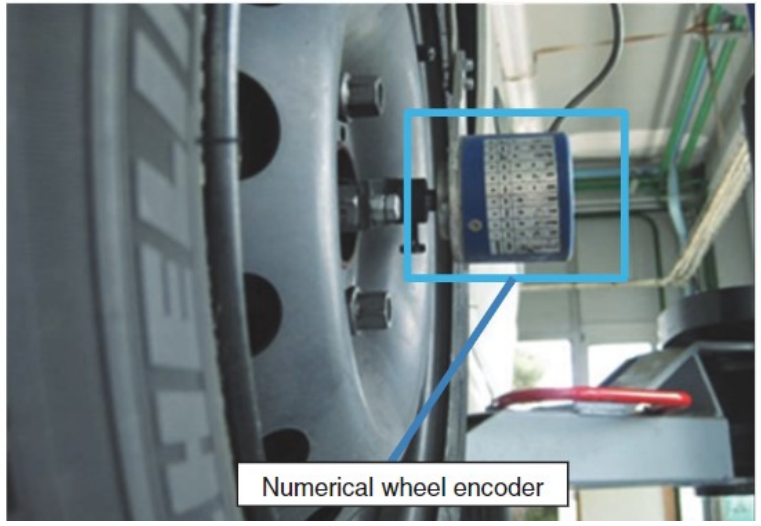

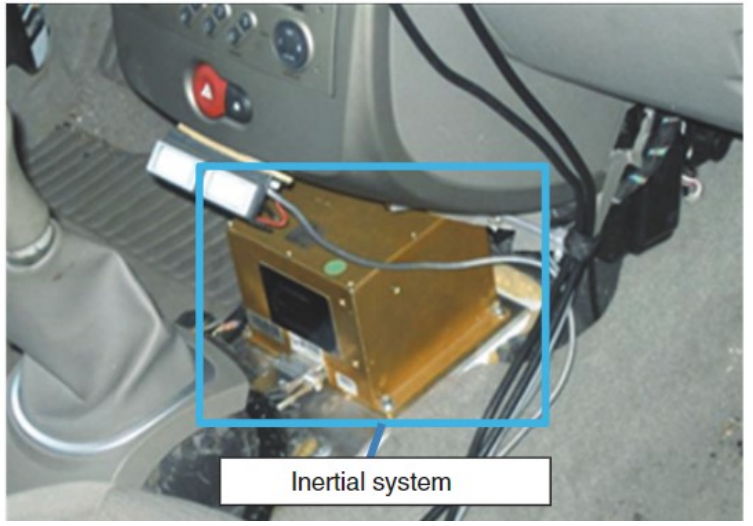

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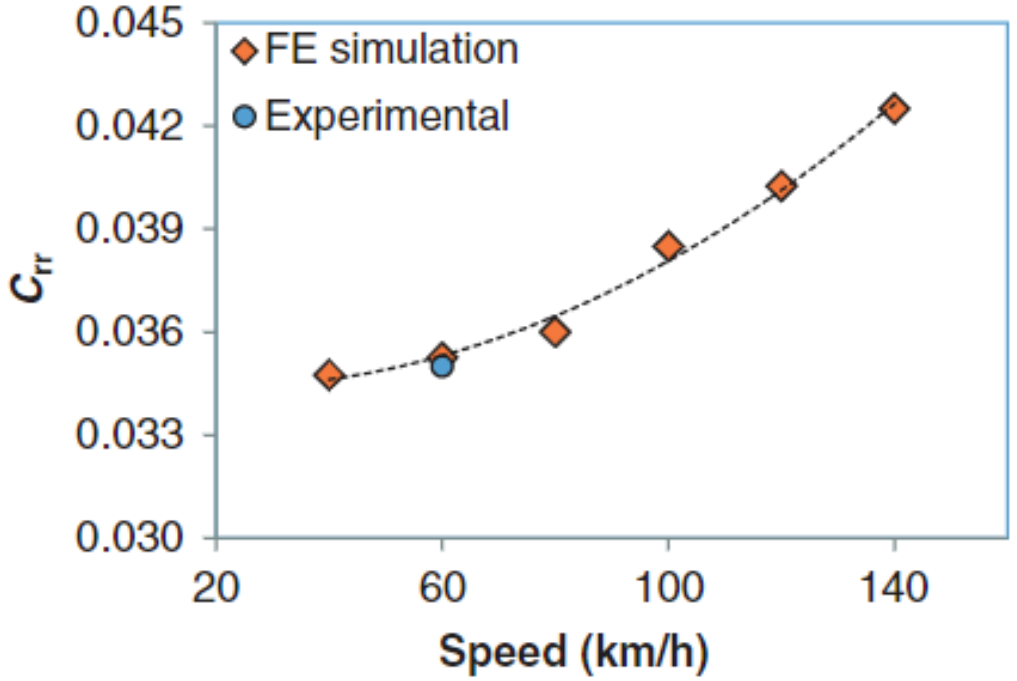

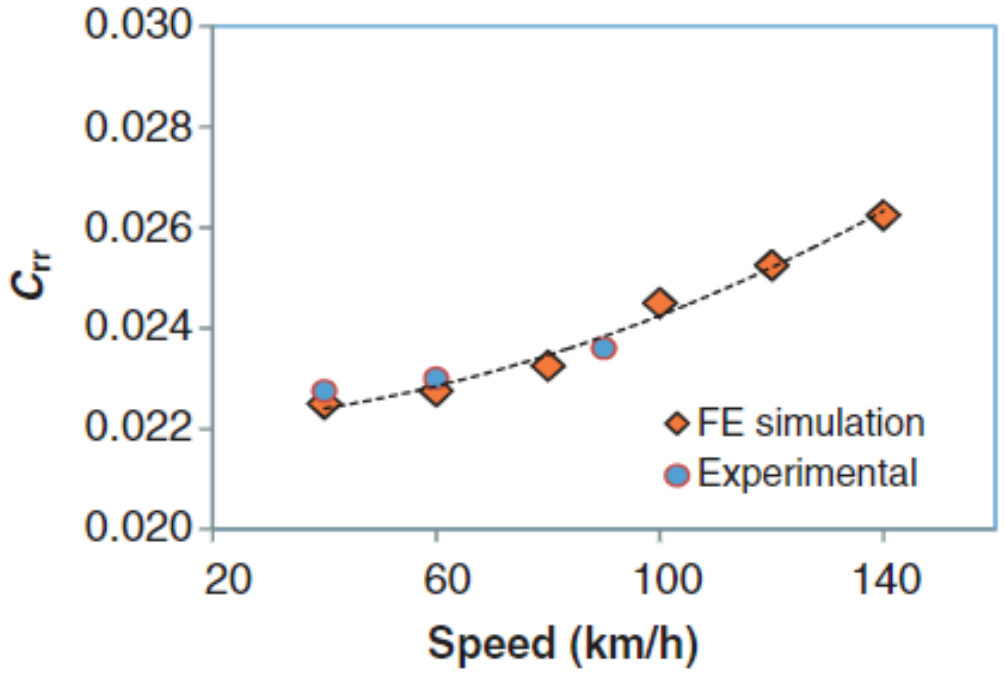

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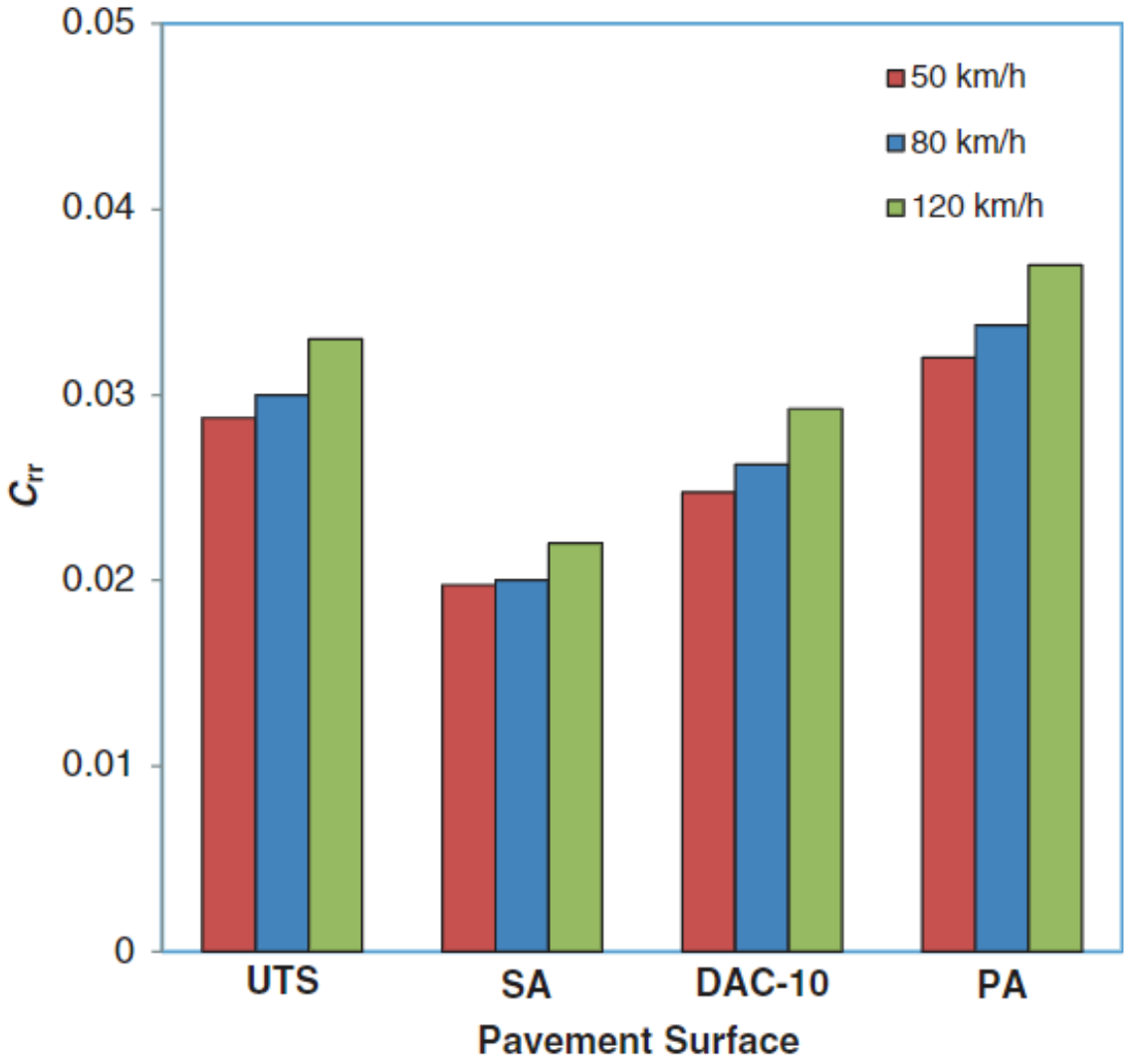


6 TU Delft team

Prof. Sandra Erkens

s.m.j.g.erkens@tudelft.nl

Dr. Kumar Anupam

k.anupam@tudelft.nl

Ir. Cor Kasbergen

c.kasbergen@tudelft.nl

MSc. Zhaojie Sun

zhaojie.sun@tudelft.nl

Data analysis - measurement campaign 2013

- 69 road sections together with Prov. Gelderland:
  different top layers, age and condition for passenger cars
  - Trailer TU Gdansk and M+P
  - Set-up database rolling resistance (per 1m), texture and other parameters (GPS, temperature, tyre pressure, etc.)

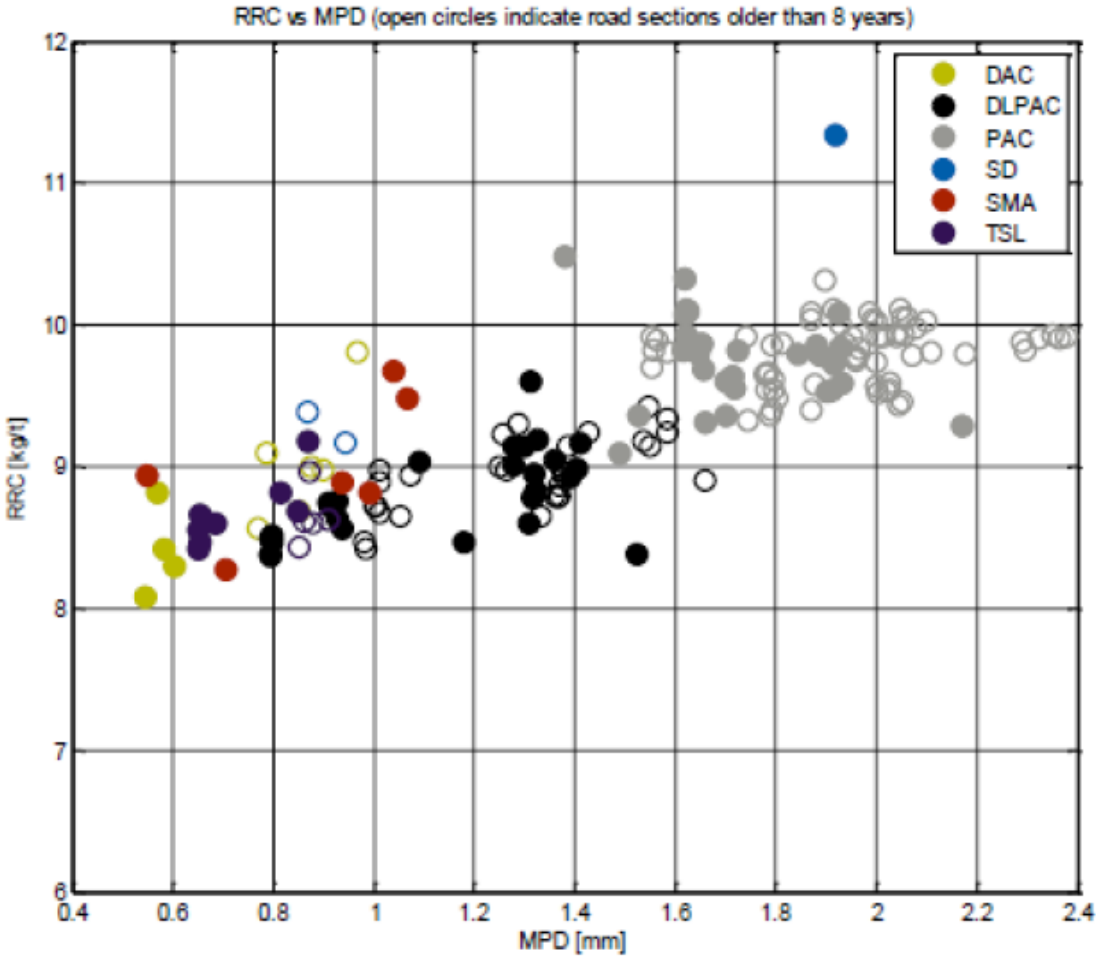
- Temperature significant effect

- Tyre wall side temperature best correlation

- Modelling RR and texture depth: regression analysis

Conclusions (2013)

- Age effect for all surface types not significant, except DAC/AC Surf
- Fine graded top-layers (0/5, 0/6) have average 9-11 ± 2% lower RR than PA16
- Thin surface layers (DGD) reduce RR with 7 ± 5% than 0/11 grading
- <u>Estimation passenger cars:</u>
  10 % lower RR by varying surface type gives reduction potential in fuel consumption and CO_2 emission of 3%



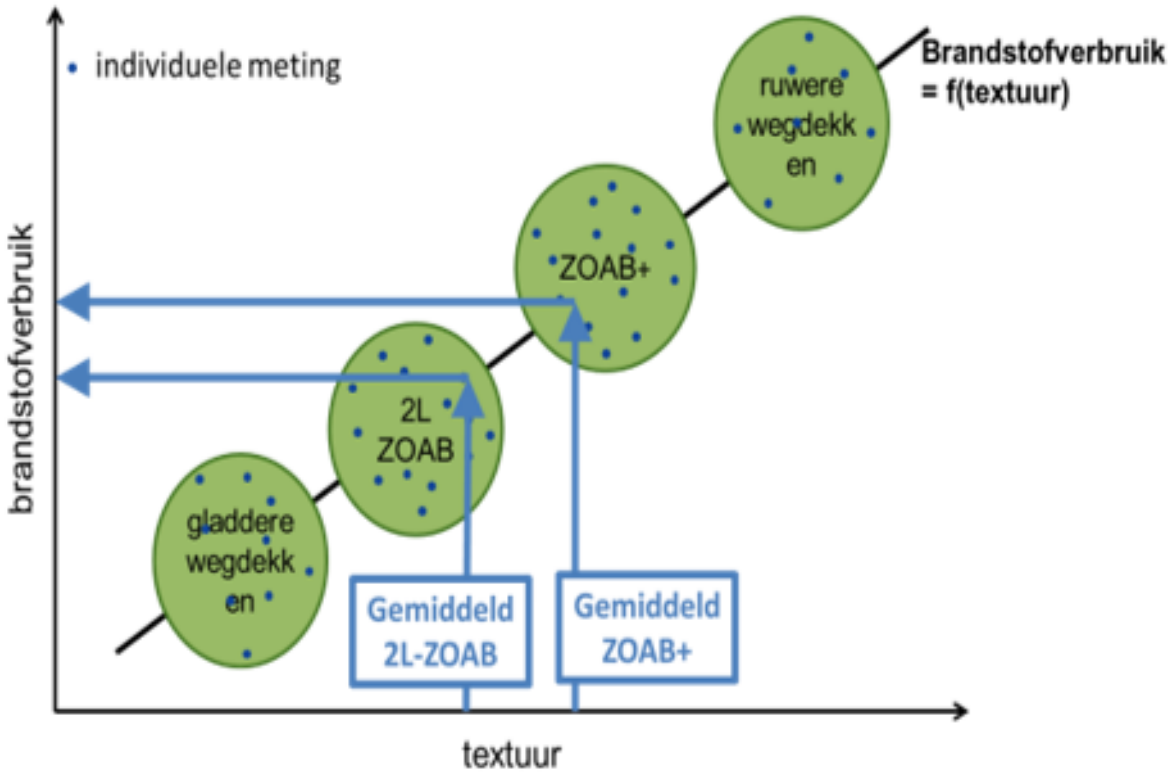
Data analysis - measurement campaign 2017

- 1000 km on 6 road sections (2017) and test track:
  innovative full-scale measurement method M+P by truck
  - Fuel Consumption 2-axle loaded truck (13,5 ton)
  - Road surface parameters: Texture depth (MPD), IRI
  - Disruptive parameters: slope, temperature, wind (head/cross)
  - Effective: good preparation and good weather conditions (LUCK)

- Developed Model Fuel Consumption -
  difference texture depth average PA16 and 2LPA8/2LPA6

- Multi regression explanatory (disruptive) variables
  - Correction factors for cross-wind, spinneys and slopes (viaduct)

Conclusions (2017)



Difference fuel consumption PA16:

- 0.9 ± 0.2% lower for average 2LPA8
- 1.7 ± 0.2% lower for average 2LPA6 (fine)

- <u>Estimation fuel consumption total truck mix NL</u>

  Transition from PA16 to 2LPA6 by varying surface type gives reduction potential in fuel consumption and CO_2 emission of 3%

Research questions KPE-RR (1)

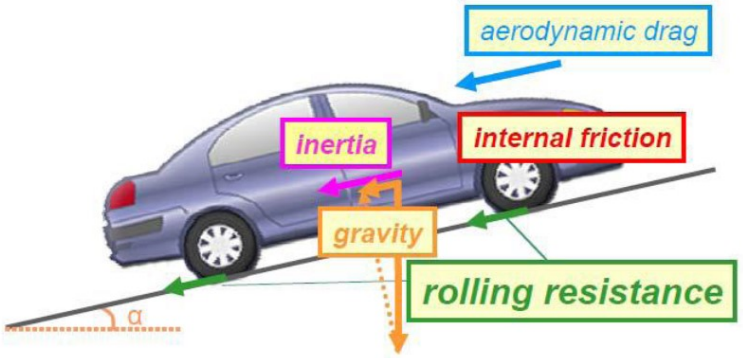
- Fresh look on collected data and developed database
  - Advanced texture model by several combinations MPD, texture spectra, IRI, time-series.
  - Correlation pavement condition data
  - Identify key pavement parameters affecting RR

- Suitability measurement method
  - Representative vehicles: different trucks (aerodynamic/RR), tyre profile, truck/trailer, cars, etc
  - Verification of DAF truck by trailer

- Research on key factors Fuel Consumption
  - More measurements (incl. texture, pavement condition) for PA16 and 2LPA8/2LPA6
  - Effect wind: trucks at high wind speeds and influence of cross wind

Research questions KPE-RR (2)

- Improve reliability regression model to predict Fuel Consumption (FC)
  - FC affected by many different parameters (crosswind/spinneys/slopes)
  - Quantify impact road surface characteristics



- Sound basis for calculation CO_2 reduction shifting from PA16 to 2LPA8/2LPA6
  - Conversion of test truck to total truck mix (type vehicle and tyres/ tyre profile)
  - Impact on life-time top-layer (ravelling)
  - Relation with noise properties and skid resistance

Exchange knowledge rolling resistance and CO_2 reductions

- Climate targets 2030 and 2050 give common grounds!

- Expert surveys: state-of-the-art knowledge
  - Plan ‘on the way’
  - Measurement equipment and method (NL/Europe)
  - Road contractors, Engineering firms (NL/Europe)
  - National and foreign road authorities

- Preparation field testing
  - Selection suitable road sections with different top-layers (PA16/2LPA8/2LPA6)
    - Texture data (LCMS) and pavement condition
    - Road geometry (slopes, viaducts), bearing capacity, traffic intensity
  - Selection measurement method

Thanks !