

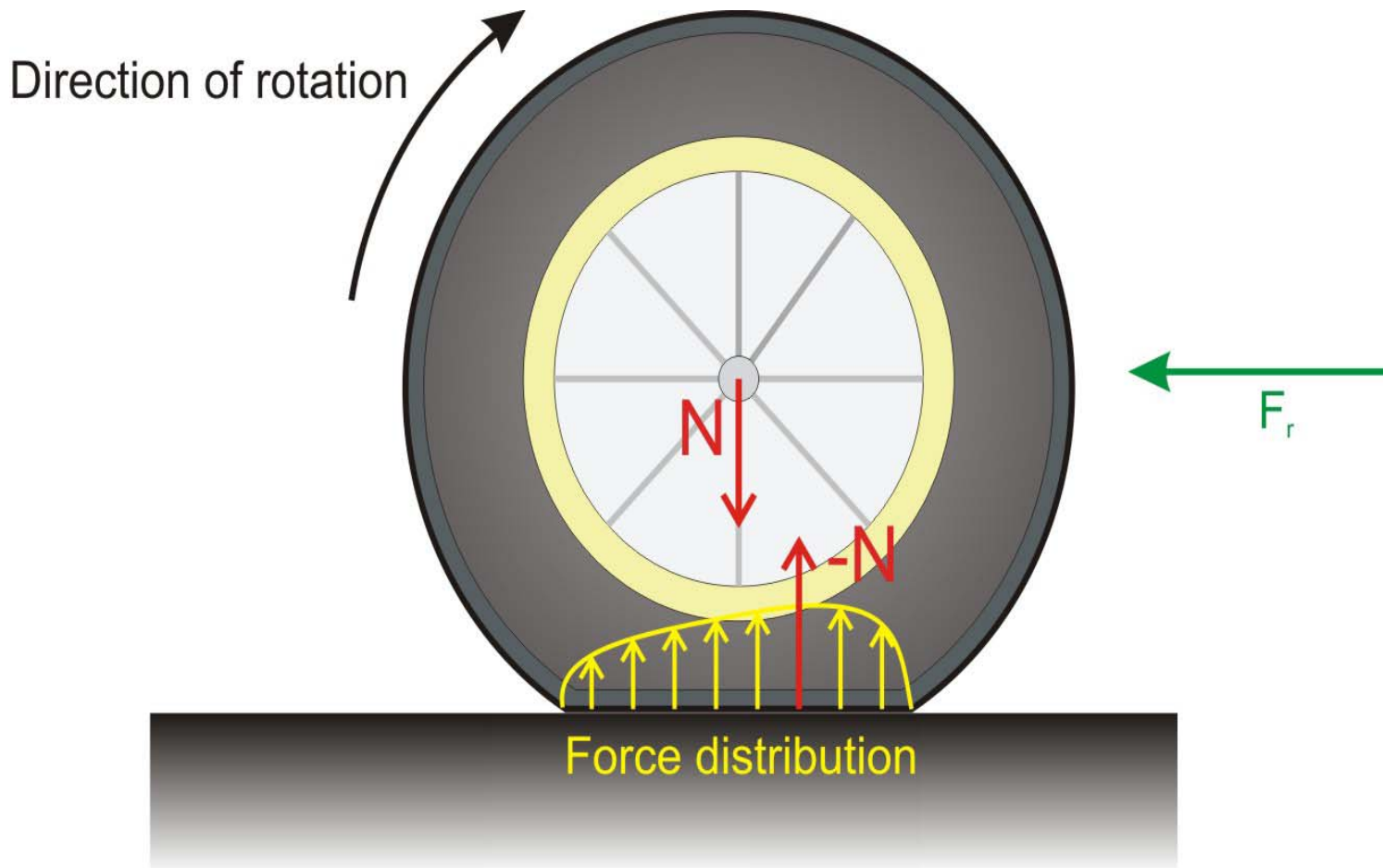
influence of road surface characteristics on rolling resistance

Authors: dr. G.J.van Blokland, M+P (NL),
 ir. W. Schwanen, M+P (NL)
 S.W. Boere, student TU/e (NL)

Tentative study on effects of different road surfaces on rolling resistance and the relation with rolling noise and wet grip

- Test program
 - test procedure
 - road surface types
 - measurement results
- Rolling resistance explained with surface characteristics
 - road surface texture
 - road surface mechanical impedance
- Relation of rolling resistance with
 - wet grip
 - rolling noise

Rolling resistance



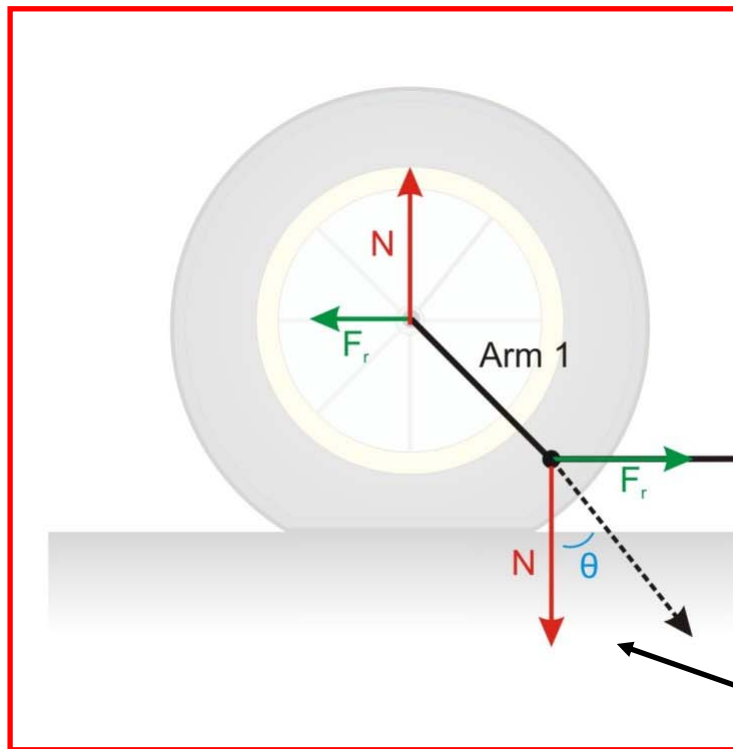
Test vehicle

- Designed and operated by TU Gdansk

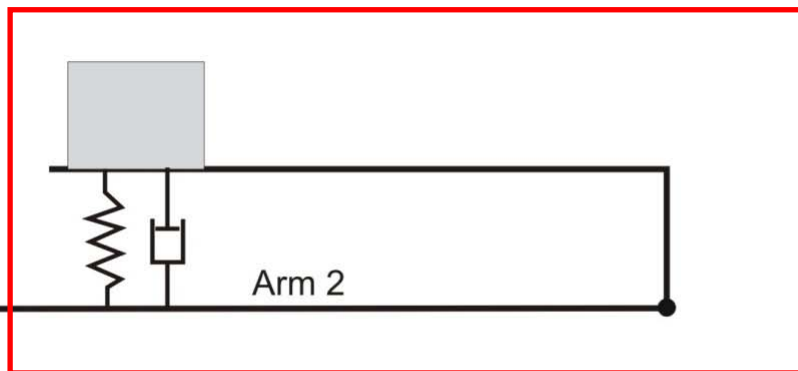


Test vehicle: Schematic representation

direct measurement system



load adjustment system



$$RRC = \frac{F_r}{N} = \tan(\theta)$$

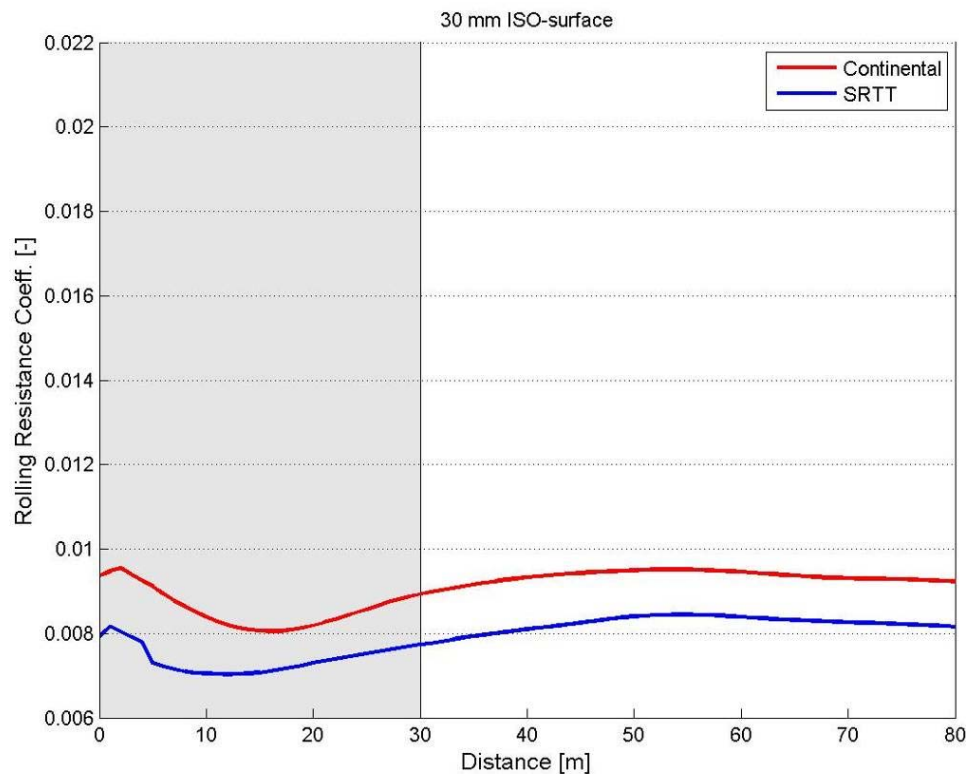
θ : orientation of Arm 1

Test surfaces

- Kloosterzande test track in the Netherlands
- 40 different test tracks
 - ISO 10844
 - SMA (0/6, 0/8, 0/11 and 0/16)
 - Dense Asphalt Concrete 0/16
 - Semi-porous thin layered surfaces
 - Porous Asphalt Concrete with various stone-sizes and layer thickness
 - two-layer Porous Asphalt Concrete with different stone-sizes and layer thickness
 - eight experimental rubberized surfaces
 - two surface dressings

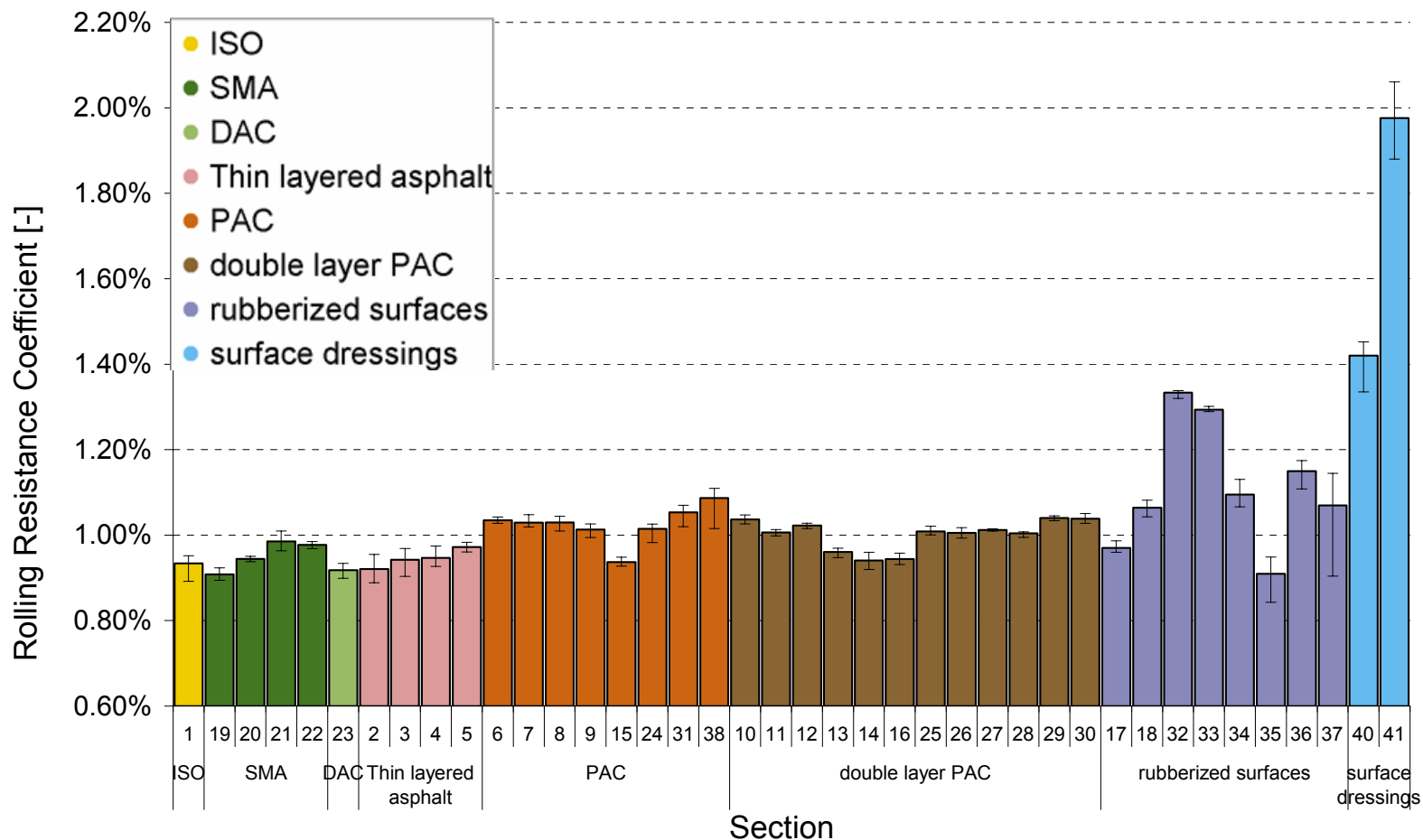
Typical result

- Rolling resistance level as function for distance
- Grey area is dominated by transient effects
- two different tyres
 - Uniroyal Tigerpaw (SRTT) 225/60 R16
 - Continental CPC2 LI98 225/60 R16



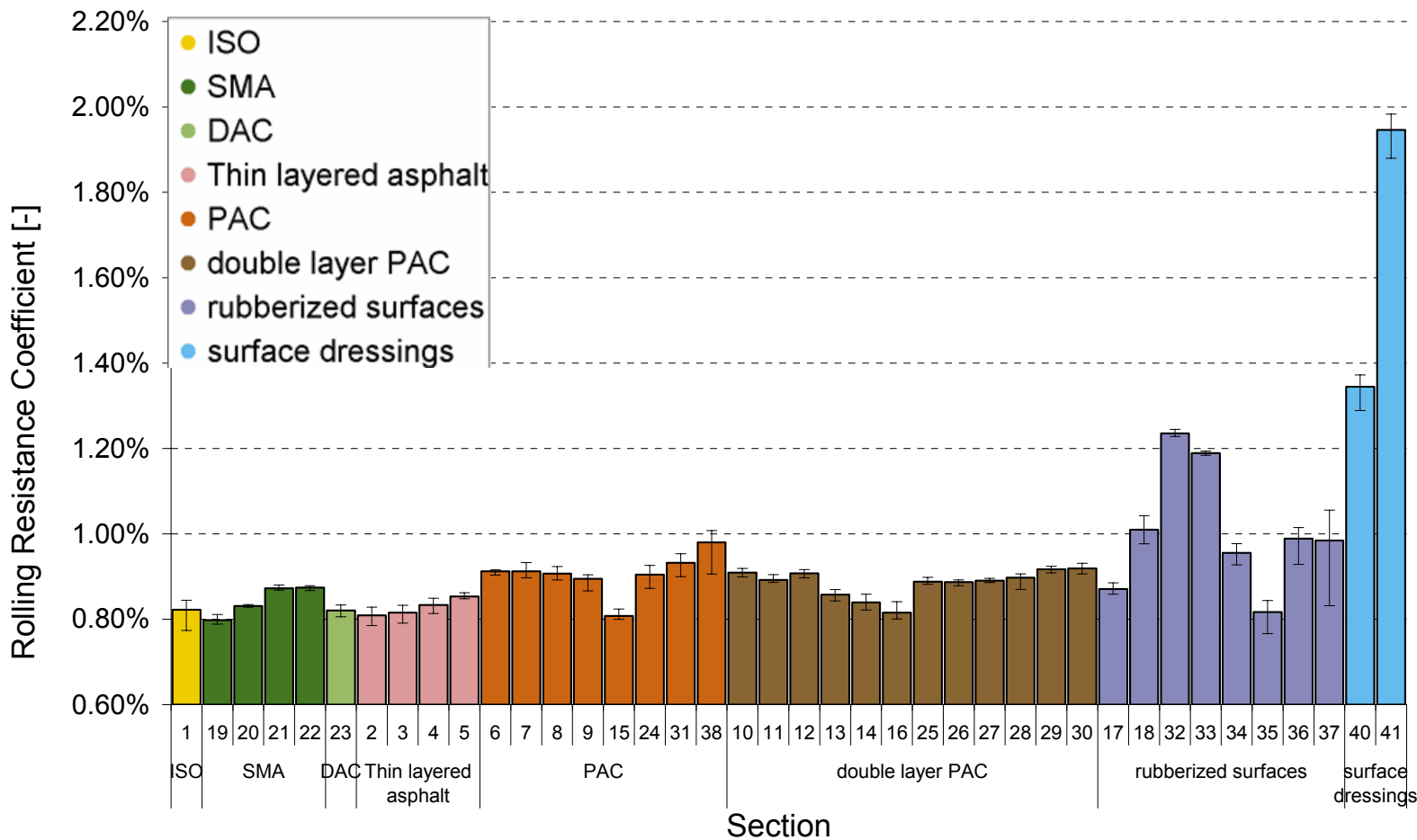
Test results: average rolling resistance

- Results for Continental tyre in categorical sequence (average over 5 measurements)
- Error bars indicate peak-to-peak levels



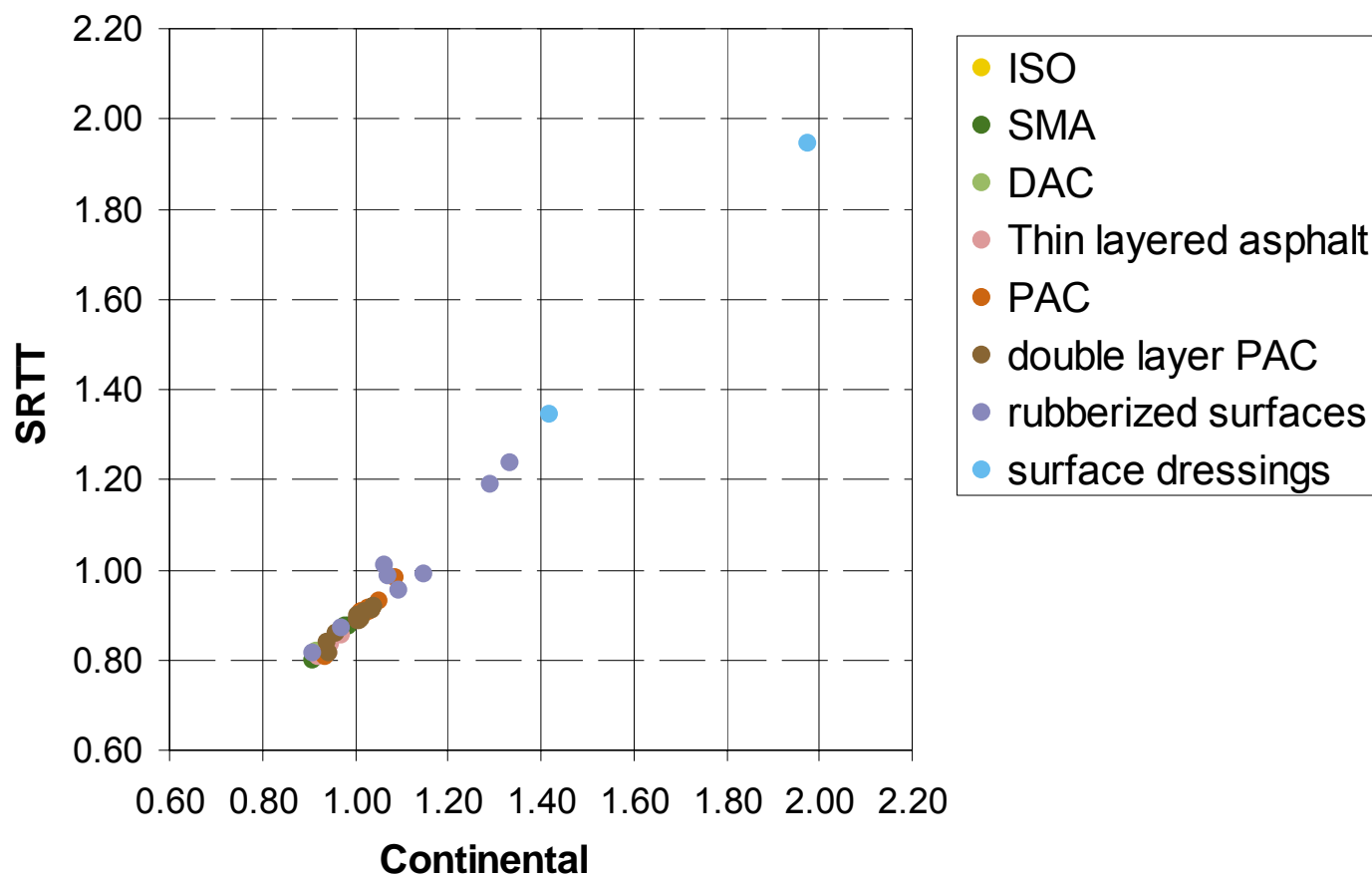
Test results: average rolling resistance

- Results for SRTT tyre in categorical sequence (average over 5 measurements)
- Error bars indicate peak-to-peak levels



Test results: comparison between tyres

- scatter diagram of rolling resistance results of both tyres
- positive correlation : $R^2 = 0.99$, slope = 1.07, residue = 0.02,



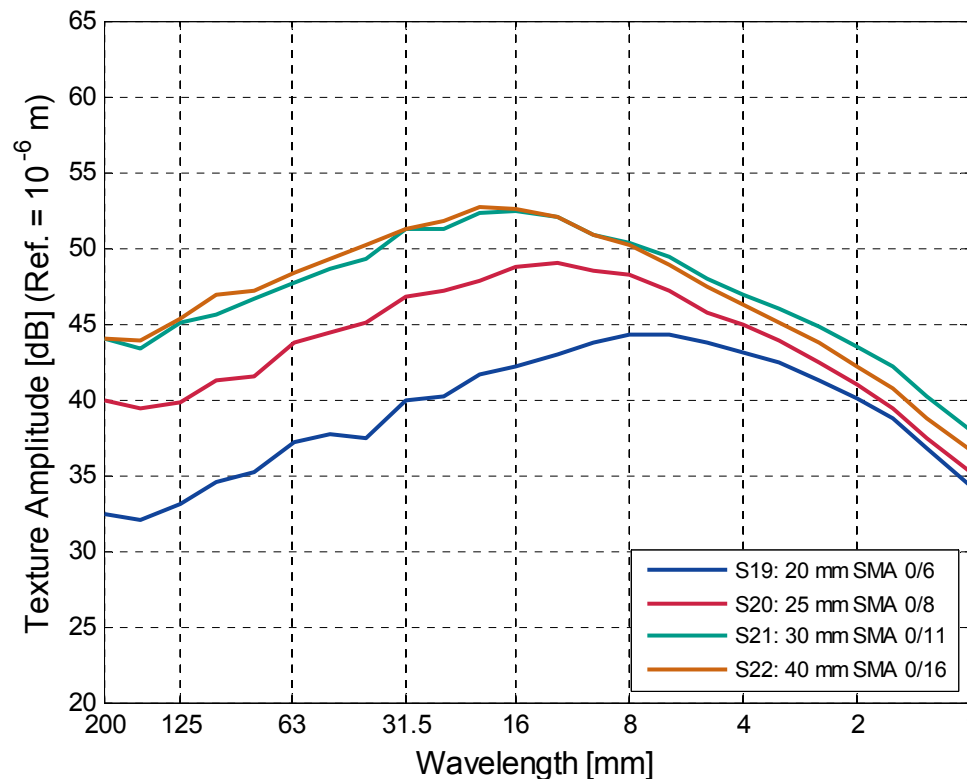
Surface texture



3-D laser profilometer:

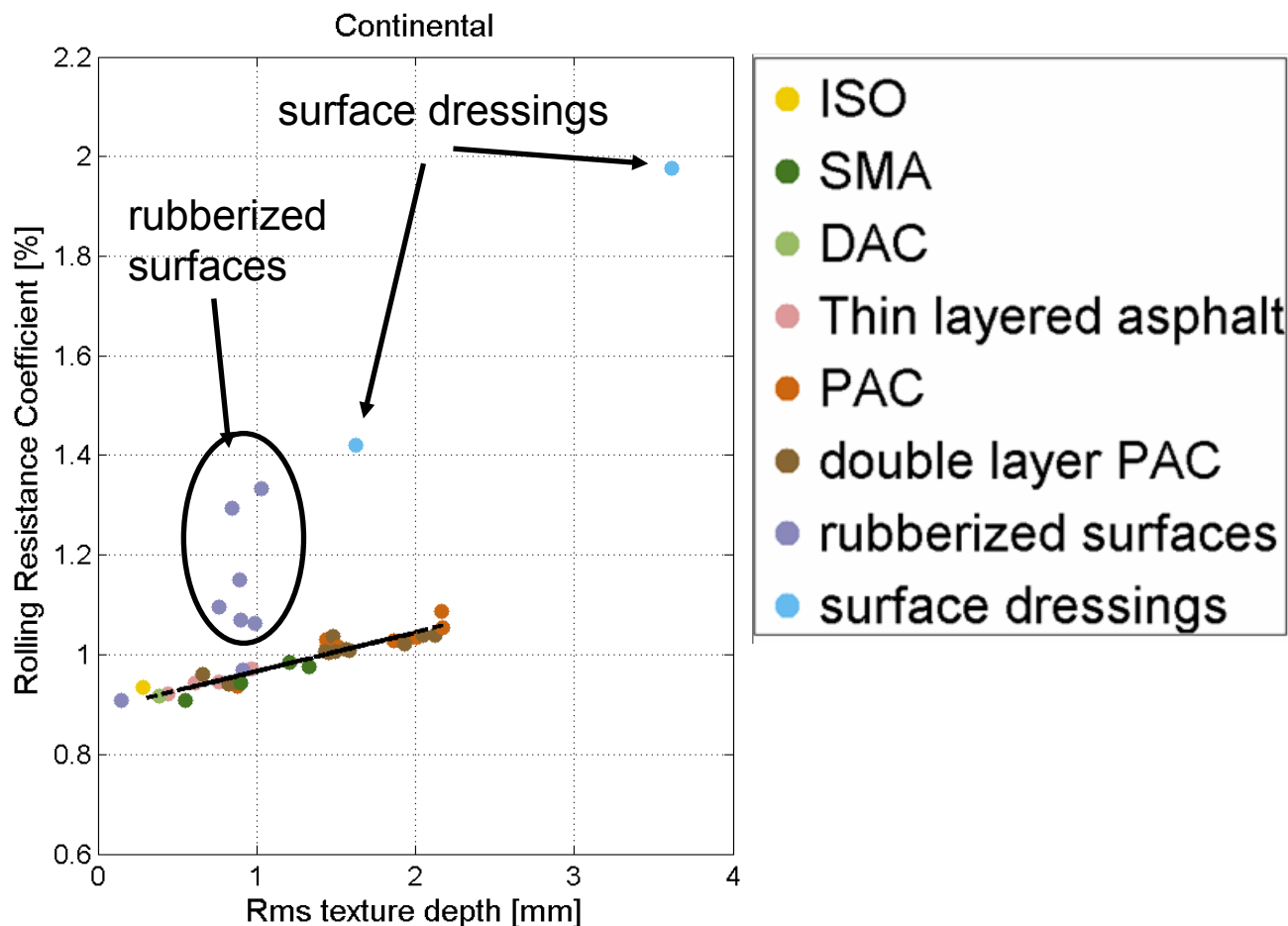
- 2.95 x 0.3 m area
- 0,3 mm step and 20 μm resolution

rms = effective amplitude of surface texture



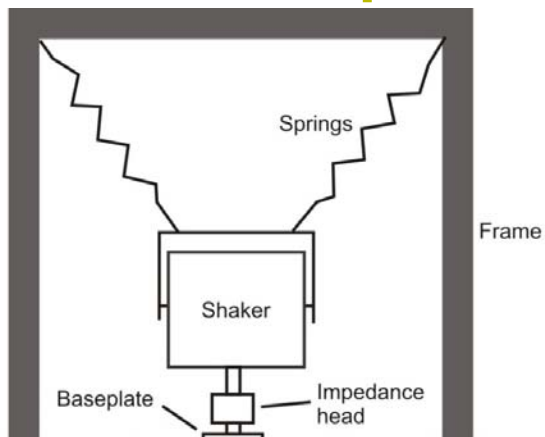
	rms
SMA 0/6	0.53
SMA 0/8	0.88
SMA 0/11	1.16
SMA 0/16	1.37

Surface texture and rolling resistance



- Correlation between rms of surface texture and rolling resistance coefficient. Various colors indicate the surface types, slope = 0.078 %/mm , $R^2 = 0.89$, residue = 0.016

Mechanical Impedance : measurement principle



- harmonic excitation :

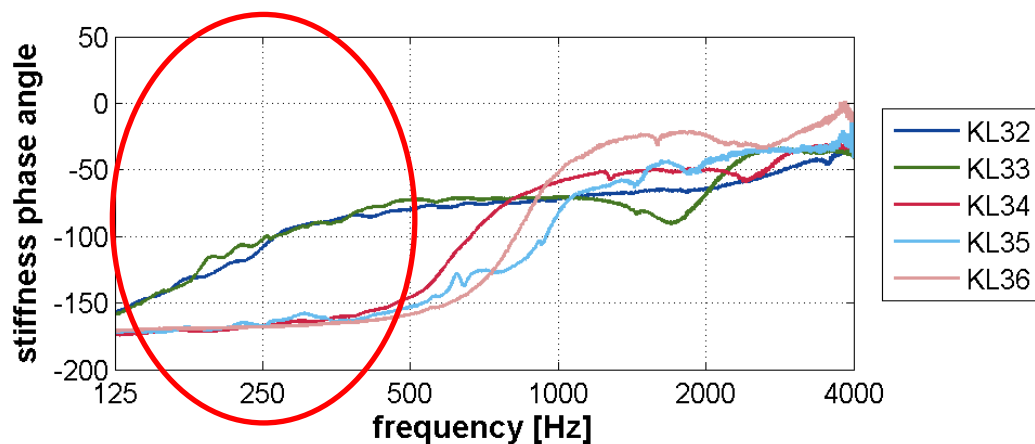
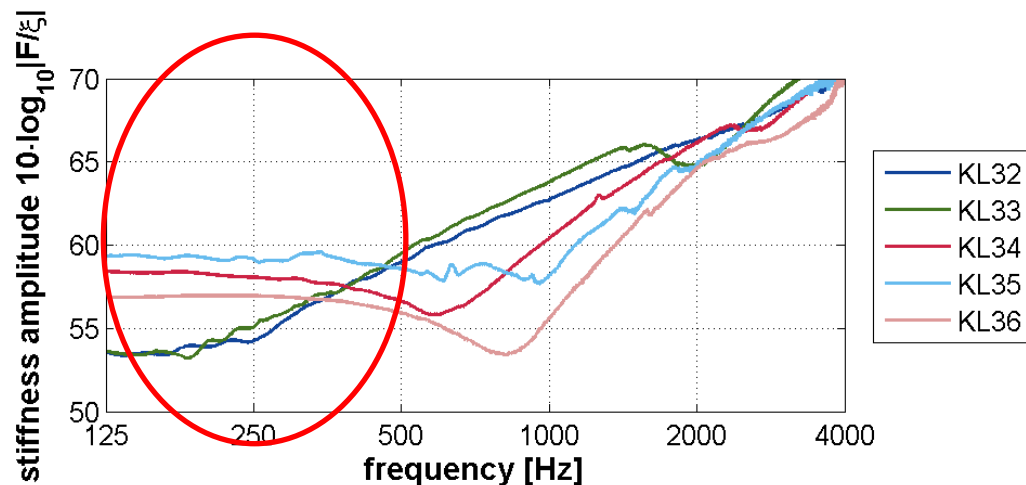
$$F(t) = F_0 \cdot \sin(2\pi f \cdot t)$$
- result
 - stiffness of road surface
 - admittance

- measurement in lab
- frequency range 125 – 4 kHz
- presented result is an average over 20 excitations

- rolling resistance:
 frequency range of interest :
 250 – 400 Hz

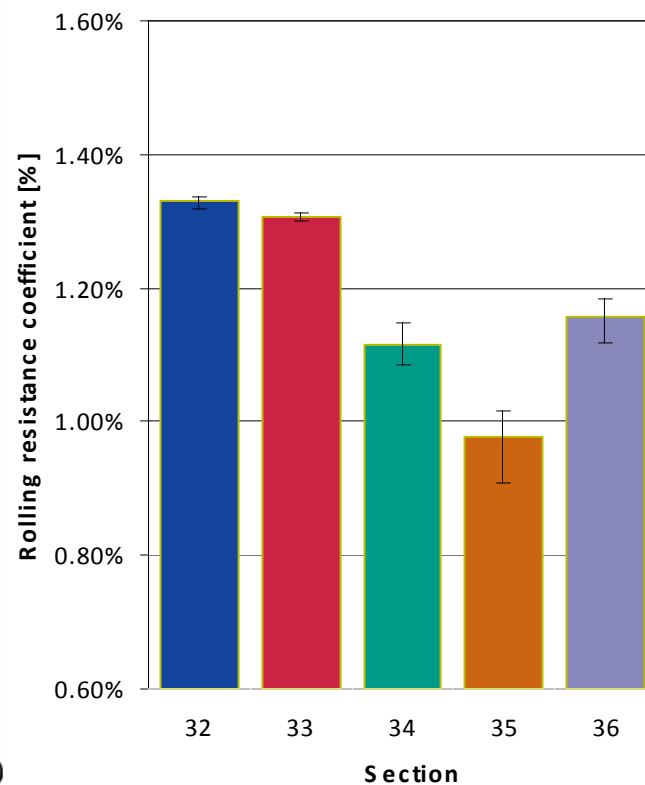
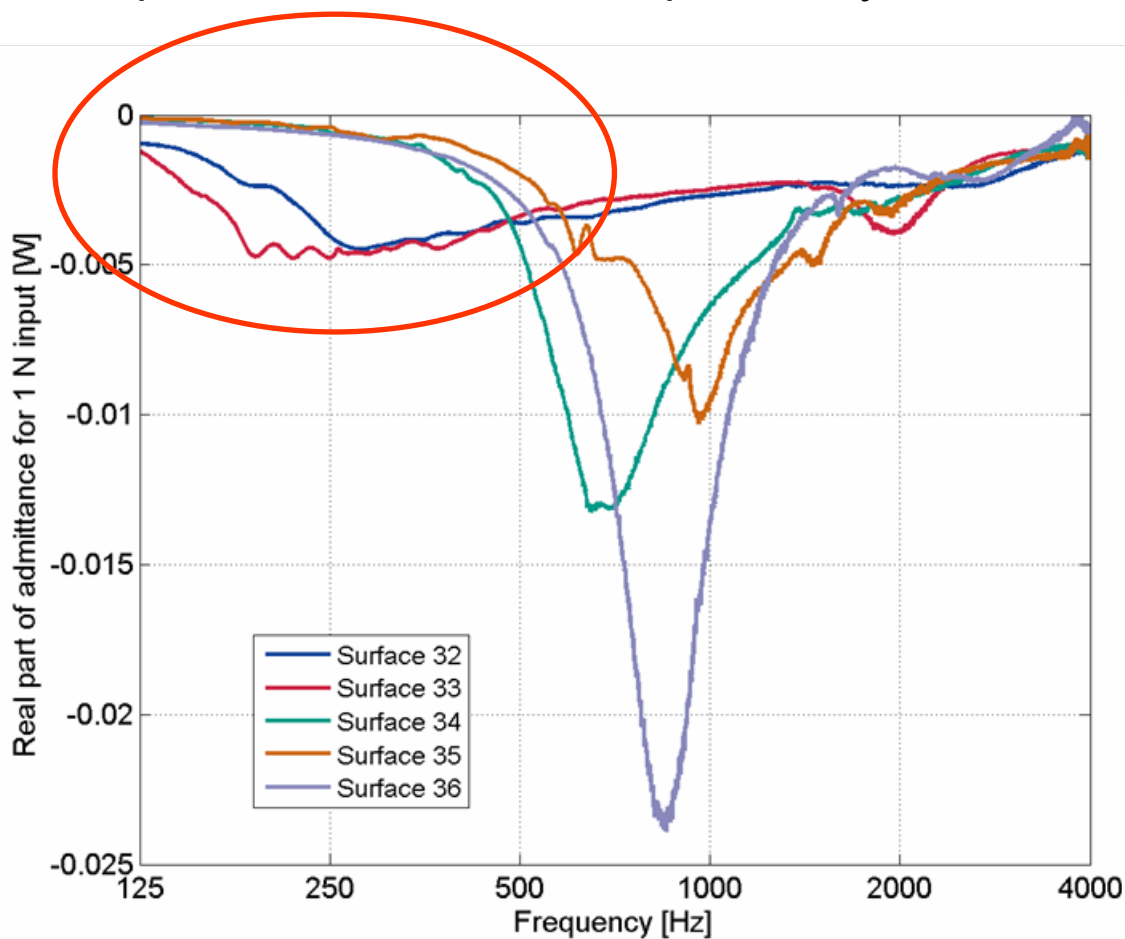
Mechanical impedance

differences in mechanical behavior of flexible surfaces in frequency area relevant for rolling resistance



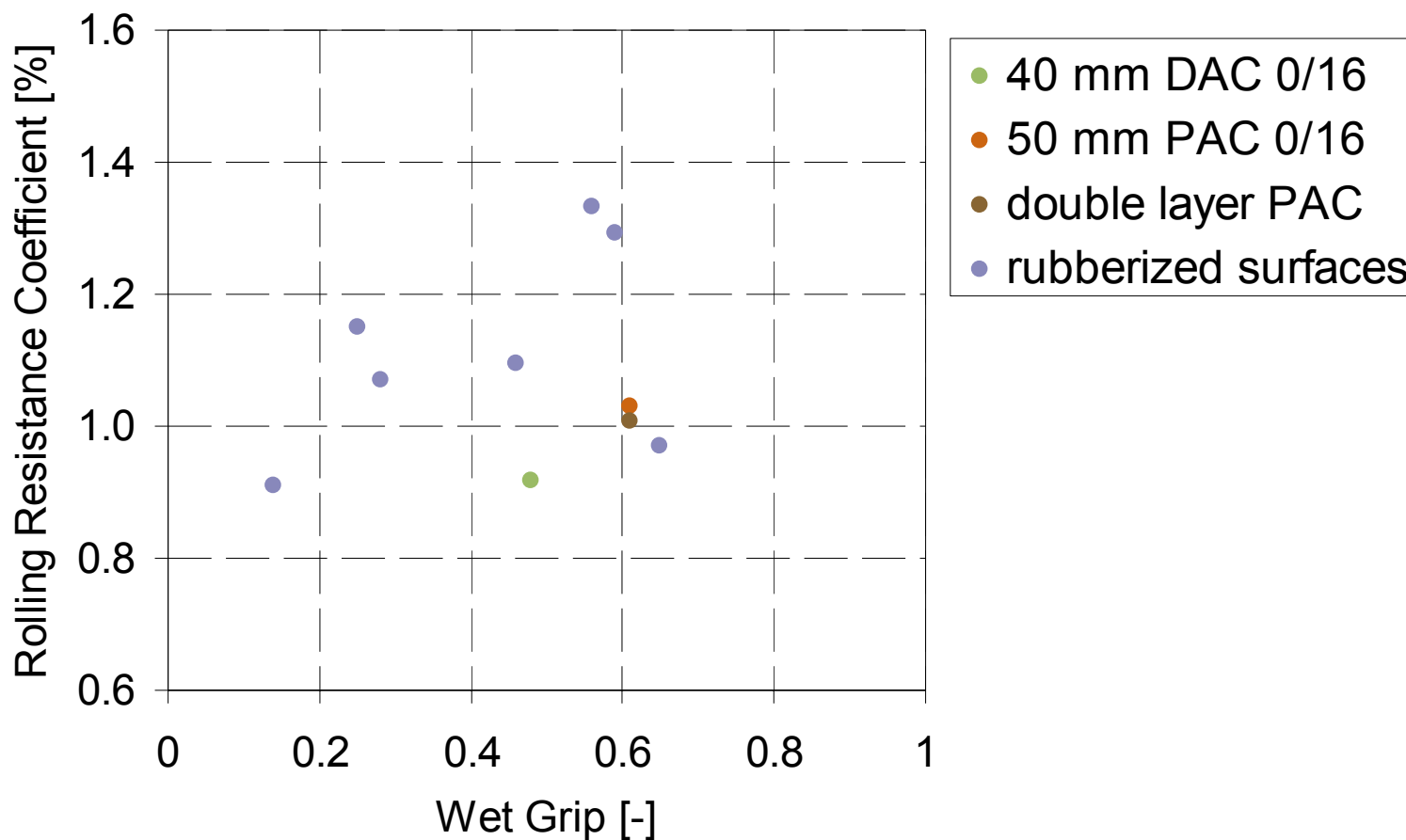
Rolling resistance and mechanical impedance

- influence of damping on rolling resistance ?
- part of the differences explained by difference in damping

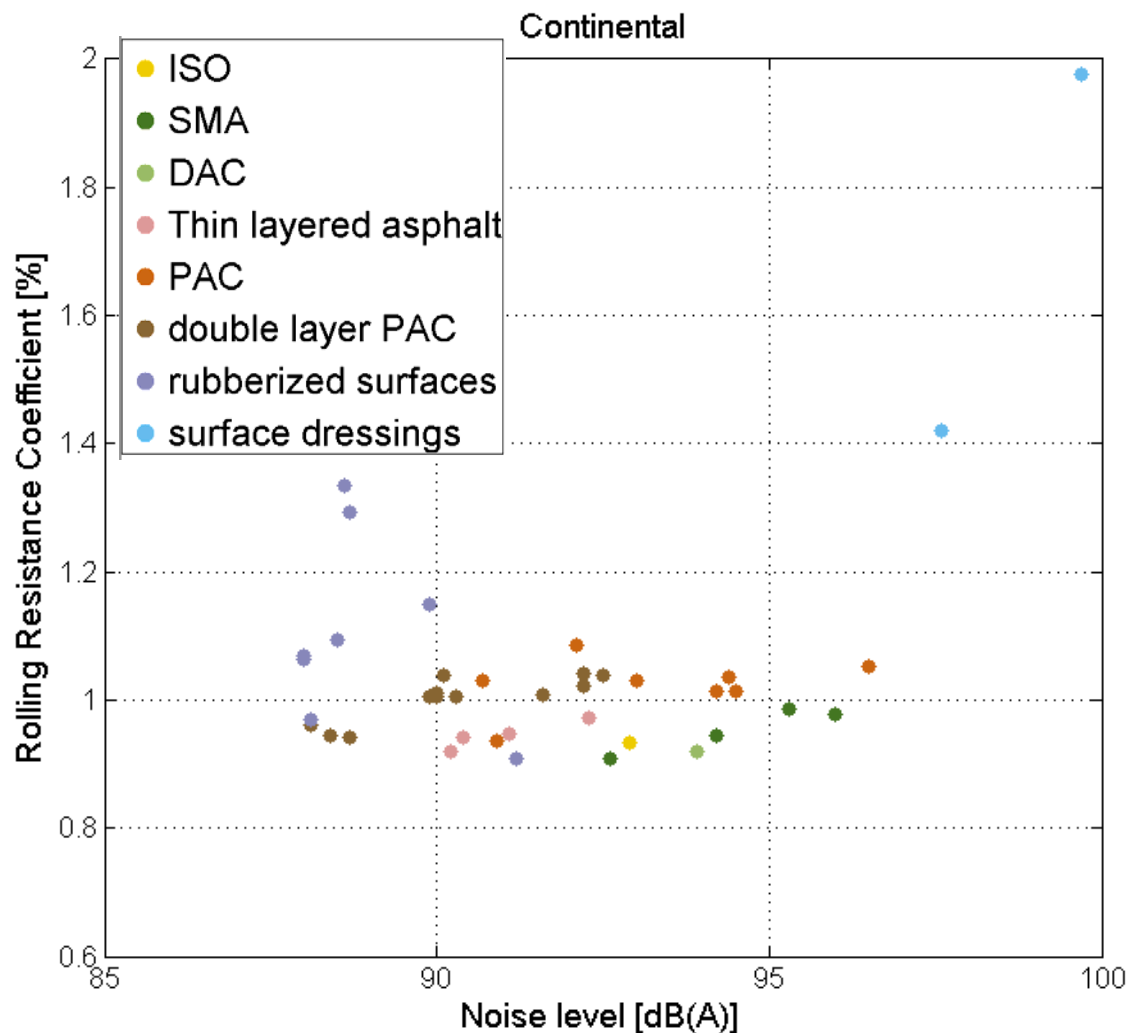


Rolling resistance and wet grip

results of ten surfaces including rubberized surfaces



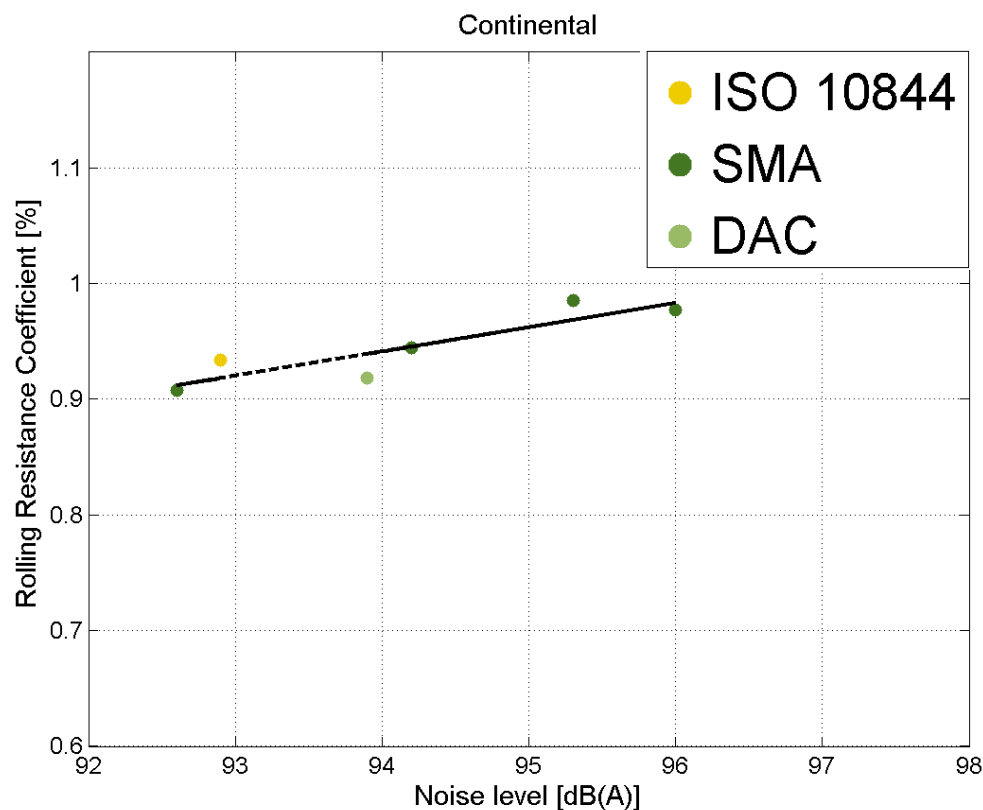
Rolling resistance and tyre/road noise



rolling resistance and tyre/road noise

subset of dense surfaces

- relation on previous sheet spoiled by effect of acoustic absorption and elasticity
- subset of test sections with no absorption and high mechanical impedance



slope = 0.21 [%/dB]

R² = 0.79

residue = 0.14

Conclusions

- Road Surface Characteristics
 - good correlation between rms of texture profile and rolling resistance
 - outliers are surface dressings and elastic rubberized surfaces

- Rubberized surfaces
 - the real part of the admittance measure for energy dissipation
 - in relevant frequency range (250 – 400 Hz) higher energy dissipation corresponds to higher rolling resistance

- Effect of rolling resistance of road surfaces
 - In this study we found no correlation between wet grip and rolling resistance for road surfaces
 - For dense surfaces a positive correlation between rolling noise and rolling resistance was found

Recommendations

- It shall be generally acknowledged that road surface characteristics have a significant effect on the rolling resistance of tyres
- Improving sustainability of road transport shall therefore incorporate both acoustic and fuel efficiency properties of road surfaces
- Measurement methods, test procedures and evaluation criteria are required for large-scale implementation
- Integrated study's on the basic interaction process between tyre and road incorporating safety effects, shall be initiated on short notice