



ROSANNE Final seminar, Sterrebeek
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Validation of the measurement method for rolling resistance: the Round Robin Test in Nantes

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Objectives



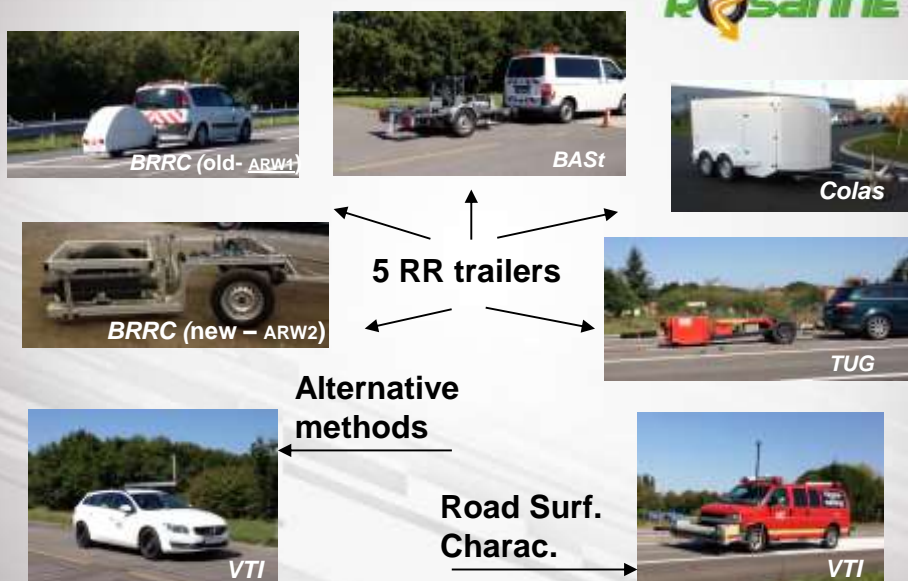
- **Validation of the draft standard** (as described in D3.5)
 - Applicability
 - Reliability and stability - short-term and day repeatability
 - Comparison of measuring devices
 - Selectivity, range and limits - road texture effect, from smooth to extremely rough
 - Robustness – influence of external parameters (temperature, speed, tyre, slope, etc;)
- **Comparison with alternative methods**
 - Coast-down and fuel consumption

Round Robin Test (RRT)



- Took place in September 2015 in Nantes, France
- **Measurements on a test track** (IFSTTAR) with 12 road surfaces, and **measurements on trafficked roads** (Effect of road **unevenness** and surface **ageing**)
- **6 teams and 7 devices in total:**
 - ✓ **5 RR trailers** (TUG, BRRC (ARW1 & ARW2), BASt, Colas)
 - ✓ 1 test vehicle for **fuel consumption** and **coast-down tests** (VTI)
 - ✓ 1 **Road Surface Tester** (texture, fuel consumption, transversal and longitudinal roughness, IRI, etc) (VTI)

Round Robin Test (RRT)



Measurement parameters



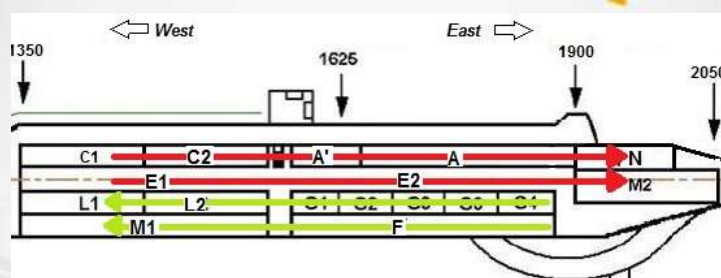
- **2 types of test tyres :**
 - P1** (ASTM SRTT F2493): P225/60 R16 97S
 - H1** (Avon AV4 Supervan): 195 R14C 106/104N
- **Tyre pressure:** 210 +/- 5 kPa
- **Tyre load:** 4 ± 0.02 kN
- **2 reference speeds:** 50 and 80 km/h



Important:

- Air (and tyre and road surface) **temperature**
- **Warming up procedure** (15 min at test speed with no stop as possible)

Measurements on test track

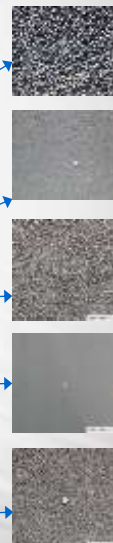


- 12 surfaces in 4 lines
 - broad set of textures (MPD ranging from 0.12 to >3)
 - 50 m to 250 m long
 - Straight, no unevenness
- **Measurement of C_{RR}** : 1 "standard" test + 2 short term repetition + 1 day-repetition
- Optional tests (other direction, other tyres, other surfaces, etc.)

Pavements on test track



Code	Line	Type of surface	Length (m)	MPD (mm)	IRI
C1	L1	Fine surface dressing	140	0.33	1.83
C2	L1	Coarse surface dressing 0/14	100	3.96	2.21
A'	L1	Coarse surface dressing 8/10	50	3.08	2.15
A	L1	Porous AC 0/6	220	1.23	1.02
N	L1	ISO „type“ – DAC 0/6	186	0.36	1.94
E1	L2	DAC 0/10 (new)	252	0.87	1.87
E2	L2	DAC 0/10 (old)	250	1.12	1.59
M2	L2	VTAC 0/6, class 2	150	1.30	1.69
L1	L3	Epoxy Resin (smooth)	128	0.11	1.15
L2	L3	Sand asphalt 0/4	116	0.71	1.68
M1	L4	VTAC 0/10, class 1	244	1.42	1.59
F	L4	High friction surface dressing 1/3	250	1.41	



Measurements on road



- 11 km long circuit
- 6 sections in DAC
- Performed by 2 trailers + energy vehicle + RST
- Measurements repeated 3 times

	Length	Speed	IRI	
# 1	~ 300 m	50 km/h	~ 6	Urban road - Old
# 2	~ 700 m	80 km/h	~ 5	Rural road - Old
# 3	~ 400 m	50 km/h	~ 3	Rural road - Old
# 4	~ 500 m	80 km/h	~ 1	Highway - New
# 5	~ 700 m	80 km/h	~ 1	Rural road - New, slopes up and down
# 6	~ 350 m	50 km/h	~ 4	Semi-urban road - Old

Repeatability

Short term repeatability



Standard deviation of repeatability % average value

%	TYRE P1		TYRE H1		Avg
	50 km/h	80 km/h	50 km/h	80 km/h	
ARW1			2.0	2.4	2.2 %
BASt	6.0	5.6	1.3	1.3	3.5 %
TUG	3.0	2.5	2.4	2.4	2.6 %
COLAS	13.6	6.8	6.8	9.2	9.1 %

- ✓ Depends on the device
- ✓ Relatively independant of speed (less clear for tyre)
- ✓ TUG and BRRC trailers: between 2% and 3% repeatability (similar to RRT 2011)
- ✓ BASt trailer: 1.3% with tyre H1, around 6% with tyre P1
- ✓ Colas trailer: unsteady results leading to high standard dev.
- ✓ Application of ISO 5725 gave an overall standard deviation of repeatability (tyre H1, both speeds, 3 trailers): $\sigma_r = 0.025$

Repeatability

Day repeatability

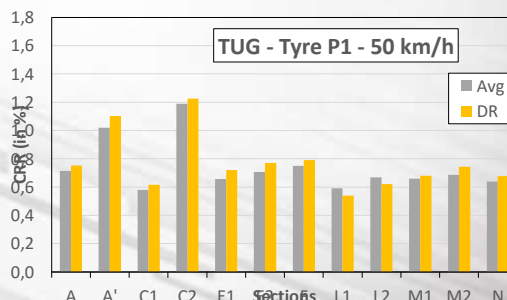
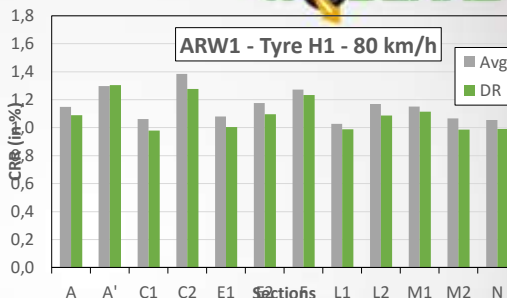


- ✓ Depends on the device
- ✓ Calculation of the average of

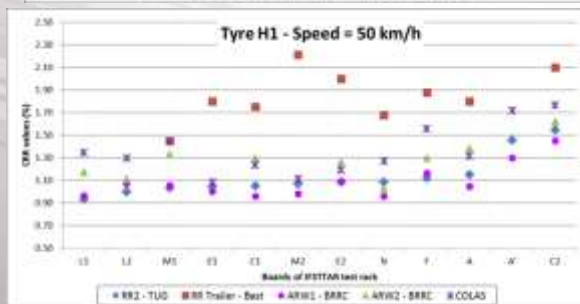
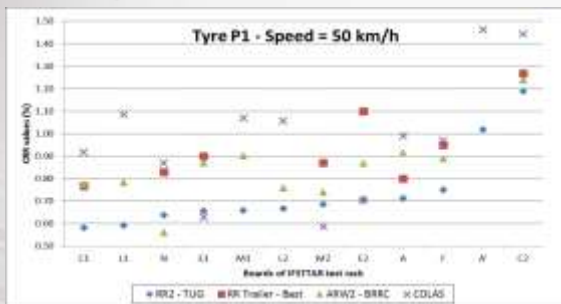
$$100 \times \frac{|C_{RR,D1} - C_{RR,D2}|}{C_{RR,D1}}$$

TUG: 4%
 ARW1: 7%
 BASt: 10% (pb with tyre P1)

Improvement since RRT 2011 (except for BASt)

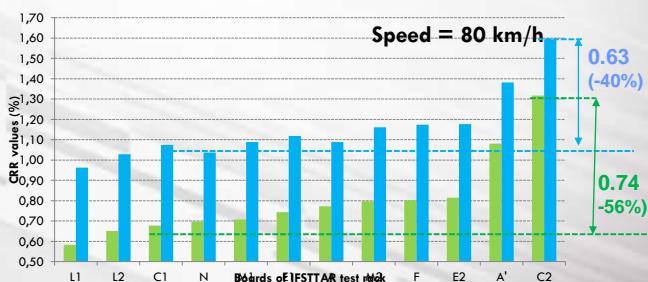
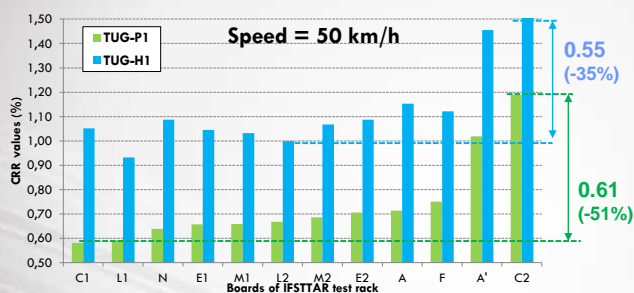


Comparison of devices



- Clear outliers: BAsT and COLAS trailers
- For the others, similar trends
- close results for ARW1 and TUG (tyre H1)

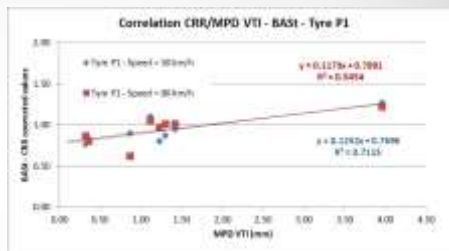
Pavement vs. tyre effect



Effect of pavement texture



Correlations between C_{RR} and texture indicator MPD

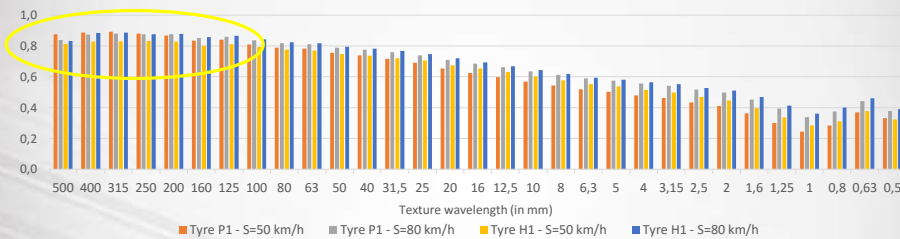


- Clear trend of a linear relationship for all tyres and devices
- The quality of the correlation is device dependant

Effect of pavement texture 2



Coefficient of correlation between C_{RR} and texture spectral bands

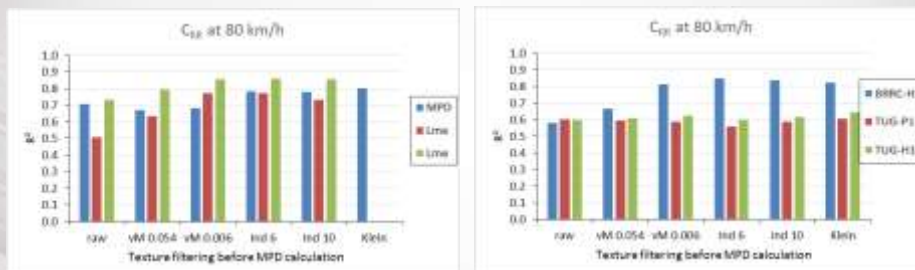


- Clear correlation between C_{RR} and megatexture (~ 50 to 500 mm wavelength) for all tyre and speed configurations

Effect of pavement texture

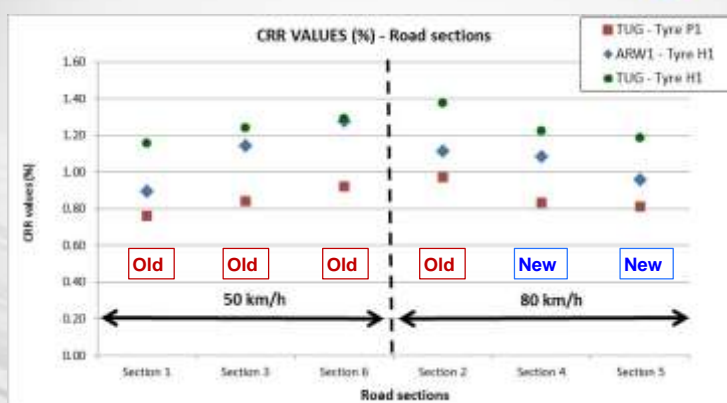


Correlation between C_{RR} and MPD calculated after filtering the texture profile with different envelopment procedures



- Good correlation with MPD and L_{Me} (megatexture level)
- better correlation when envelopment procedure is applied
- Envelopment methods by Green function [Klein et al.] (advanced) and indentor (simple) perform well

C_{RR} on road loop



- ✓ Condition (age) and speed effect are mixed
- ✓ Surface/speed effect of about 0.2 %
- ✓ Tyre effect (P1-H1) for a same trailer (TUG) of about $C_{RR}=0.4\%$

Conclusions



- Large amount of data have been collected and will be of interest beyond the project
- Two trailers showed close results with
 - Short-term repeatability 2 %– 3%
 - Day to day repeatability 4% - 7%
 - Similar trends for pavement ranking
- Comparability between devices still needs progress: discrepancies are higher than pavement effect on RR
- Road surfaces tested showed a potential of 35% to 56% reduction in rolling resistance (depending on the tyre)
- C_{RR} is well correlated with MPD and megatexture of pavements.
- RR measurements on site are very complex and need further investigation



Thank you !



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<http://rosanne-project.eu/>
Look for deliverable D3.6