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MIRIAM: A ROUND ROBIN TEST TO COMPARE ROLLING RESISTANCE MEASUREMENT METHODS

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Overview

1. Introduction
2. Measurement devices
3. Test locations and surfaces
4. Test tyres
5. Repeatability
6. Reproducibility
7. Conclusions

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1. Introduction

The MIRIAM project (Models for rolling resistance in Road Infrastructure Asset Management Systems)

http://miriam-co2.net

- **Start: 2010, 12 partners Europe and USA**
- **Aim: developing methods for improved control of road transport carbon dioxide (CO_2) emissions in order to obtain sustainable and environmentally friendly road infrastructure**
- **Focus: on rolling resistance (RR) properties of pavements as these properties influence energy consumption of road traffic substantially**
- **First phase (2010-2011): measurement methods and equipment for RR were studied and round robin test to compare different RR measurement equipment was conducted**
  - **6-10 June 2011**
  - **test track Nantes, France**
  - **3 institutes participated with special trailers**

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2. Measurement devices

2. Measurement devices

Owner organization	BASt	BRRC	TUG
Test tyre size	14”-16”	14”	14”-16”
Test tyre protected from air flow?	yes	no	yes
Measurement principle	force	angle	angle
Number of supporting tyres	2	0 (test tyre also is supporting tyre)	2
Number of test tyres	1	1	1
Self-supporting construction	no	no	yes
Tyre load at testing	4000 N	2000 N	4000 N
Tyre inflation pressure	200 kPa	200 kPa	210 kPa
Exterior/Interior tyre temperature measurement	exterior	exterior/interior	exterior
Corrections made during measurement or afterwards?	afterwards	afterwards	during measurement
Measurement in wheel track or middle track?	middle track	middle track	middle track

2. Measurement devices

Texture measurements with dynamic laser profilometer BRRC to verify homogeneity of test tracks

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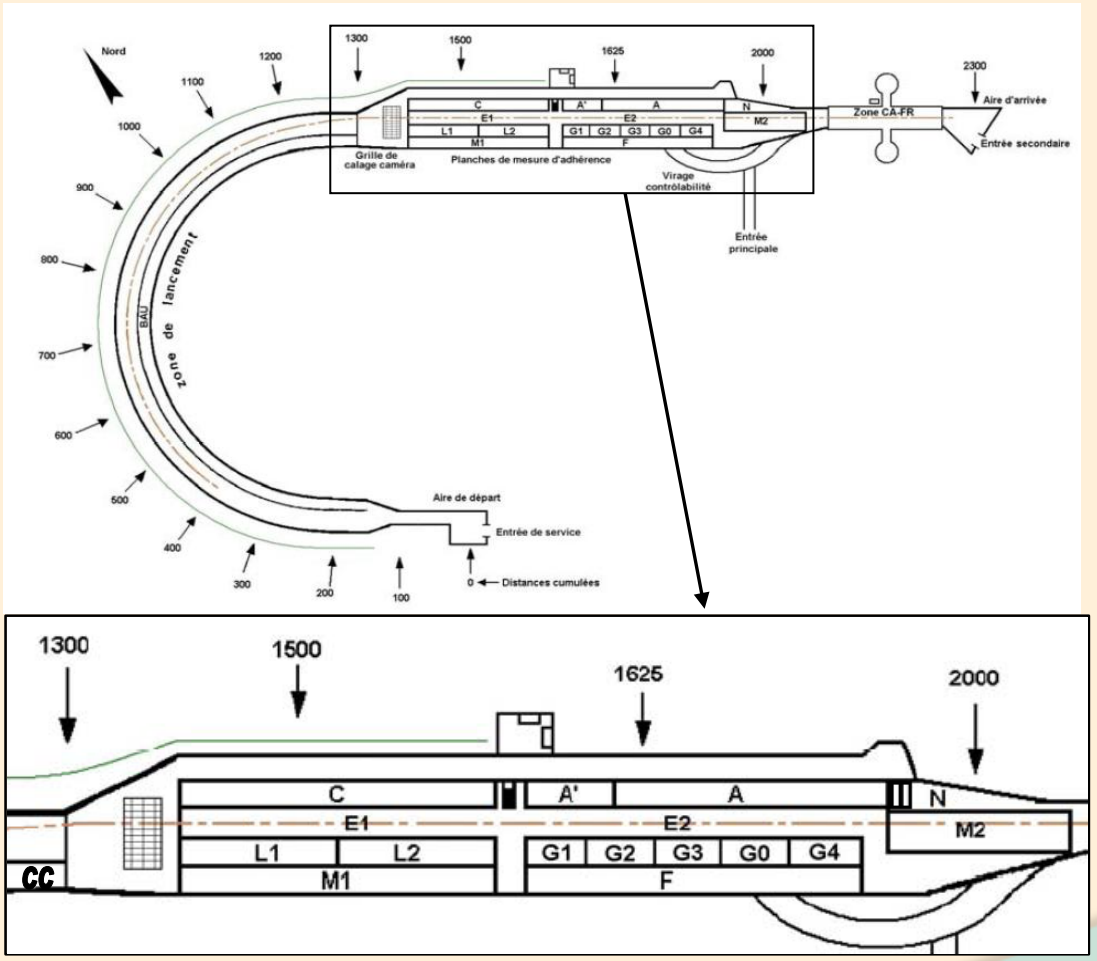
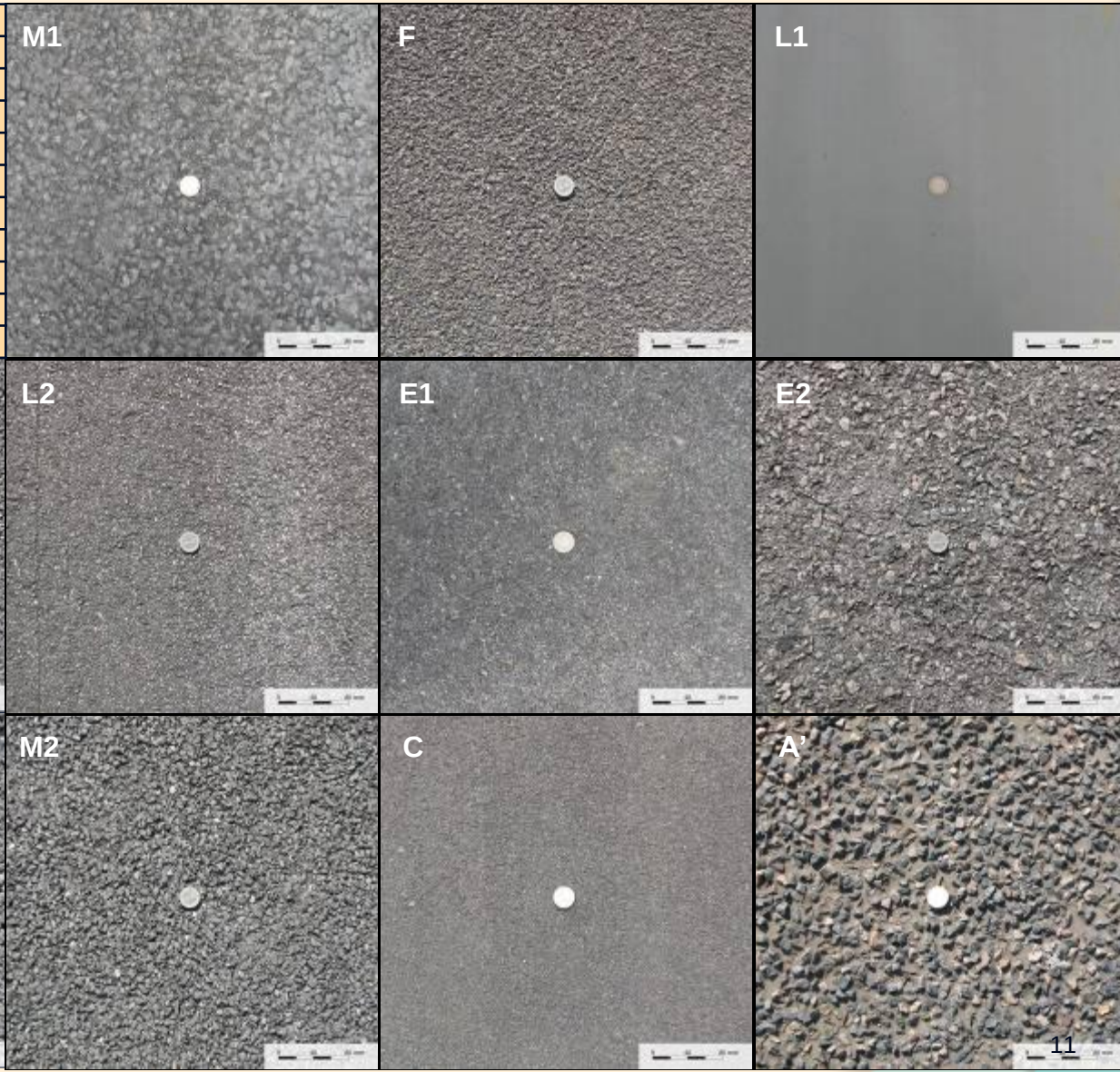
3. Test locations and surfaces



M1	Very thin asphalt concrete 0/10, class 1
F	Colgrip: Surface dressing, 1/3 bauxite
L1	Epoxy resin (smooth section)
L2	Sand asphalt 0/4
E1	Dense asphalt concrete 0/10 (new)
E2	Dense asphalt concrete (old)
M2	Very thin asphalt concrete 0/6, class 2
C	Surface dressing 0.8/1.5
A’	Surface dressing 8/10
A	Porous asphalt concrete 0/6
N	Porous cement concrete

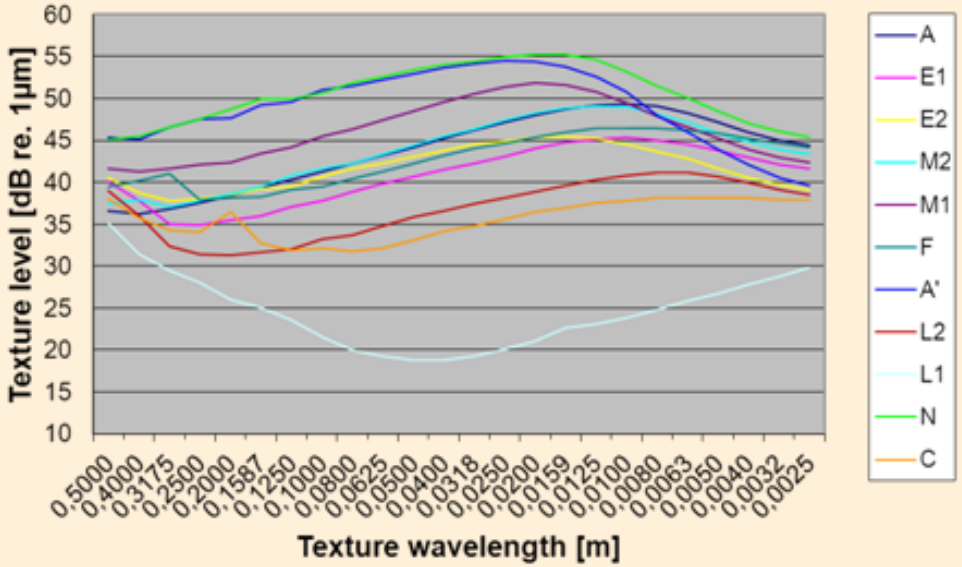
the coin has a diameter of 23 mm



3. Test locations and surfaces

Texture spectra

- **Width test sections: 2.5 - 3.9 m -> various trailers measured in different wheel tracks?**
- **Transversal homogeneity was verified by texture measurements (middle, left and right wheel tracks)**
- **Only N and L1 minor variation between wheel tracks >< negligible in relation to other errors**



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4. Test tyres

Symbol	Manufacturer	Tyre type	Tyre size	Load index
AAV4	Avon	Supervan AV4	195 R14 C	106/104N
ES16	Michelin	Energy Saver	225/60 R16	98V
ES14	Michelin	Energy Saver	195/70 R14	91T
SRTT	Uniroyal	Tiger paw M+S	P225/60 R16	97S

SRTT **AAV4** **ES14** **ES16**

4. Test tyres

- Each institute own set of tyres
- To minimize differences due to tyres, tyres from same batch (defined by DOT markings) -> only SRTT from different batch
- Additional measurements on laboratory drums TUG to detect differences between tyres same type
- Tyre inflation (after warm-up by driving 15 min. at 80 km/h):
  - BASt and BRRC: 200 kPa
  - TUG: 210 kPa (after warm-up)
  - Artesis project: difference of 10 kPa = C_r difference of 1.6 %
- Tyre load: BASt and TUG 4000 N, BRRC 2000 N (restrictions trailer suspension)
- Rims/wheels: SRTT and ES16 wheels with rim width of 6.5”, ES14 and AAV4 wheels with rim width 6 and 5.5”

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5. Repeatability

Short term repeatability:

- Measurement runs one after the other on same test section
- Calculation average and standard deviation, standard deviation divided by mean value and expressed as percentage
- BASt trailer 2.6 %; independent of tyre and surface
- BRRC trailer 2.7 %; some speed and direction dependency < wind?
- TUG trailer 1.1 %; no significant influence due to speed, test section or direction, tyre type seems to influence repeatability

5. Repeatability

Day-to-day repeatability:

BASt:

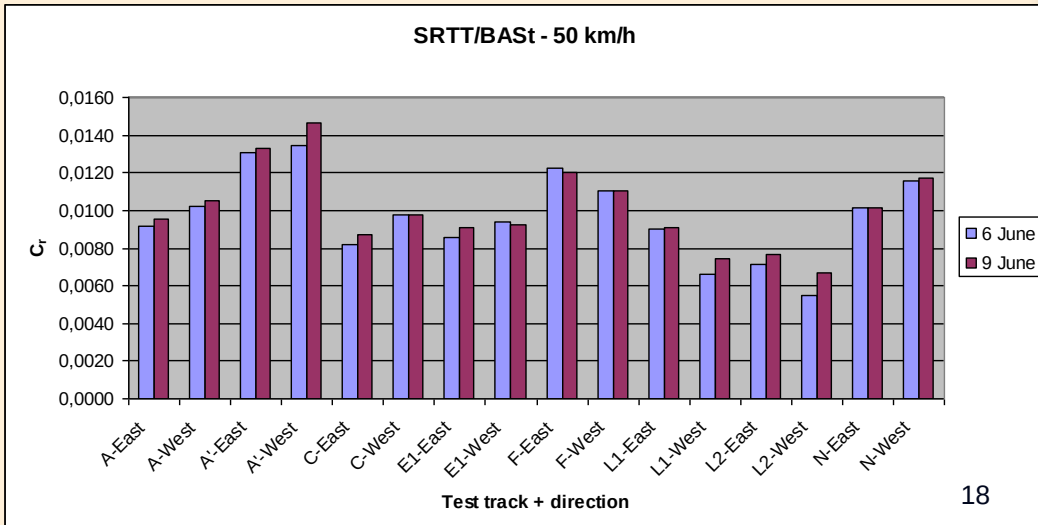
- **Measurements on various test sections with SRTT at 50 and 80 km/h on 6 and 9 June 2011**
- **Overall relative RMS variation σ 7 % both speeds:**

$$\sigma^2 = \sum \left[(C_{r,i,6\ June} - C_{r,i,9\ June}) / C_{r,i,6\ June} \right]^2 / N$$

for all tracks i, where

N is the number of test tracks

$C_{r,i,x}$ is C_r measured on track i on day x



5. Repeatability

Day-to-day repeatability:

BRRC:

- **BRRC measurements on several test sections on 6 and 9 June 2011**
- **Since trailer hit object on the 9th, partly damaging the device, only part of results relevant**
- **Systematic increase of 10 up to 25 %, probably due to calibration error**

TUG:

No measurements several days

Test track	Direction	Date	C_r	Change between 6 and 9 June
F	E	6 June	0.0197	
F	W	6 June	0.0205	
F	E	9 June	0.0232	17.8 %
F	W	9 June	0.0242	18.0 %
L1	E	6 June	0.0160	
L1	W	6 June	0.0169	
L1	E	9 June	0.0188	17.5 %
L1	W	9 June	0.0196	16.0 %
L2	E	6 June	0.0169	
L2	W	6 June	0.0183	
L2	E	9 June	0.0189	11.8 %
L2	W	9 June	0.0202	10,4 %
A	E	6 June	0.0170	
A	E	9 June	0.0206	21.2 %
C	E	6 June	0.0174	
C	E	9 June	0.0217	24.7 %
A'	E	6 June	0.0203	
A'	E	9 June	0.0240	18.2 %

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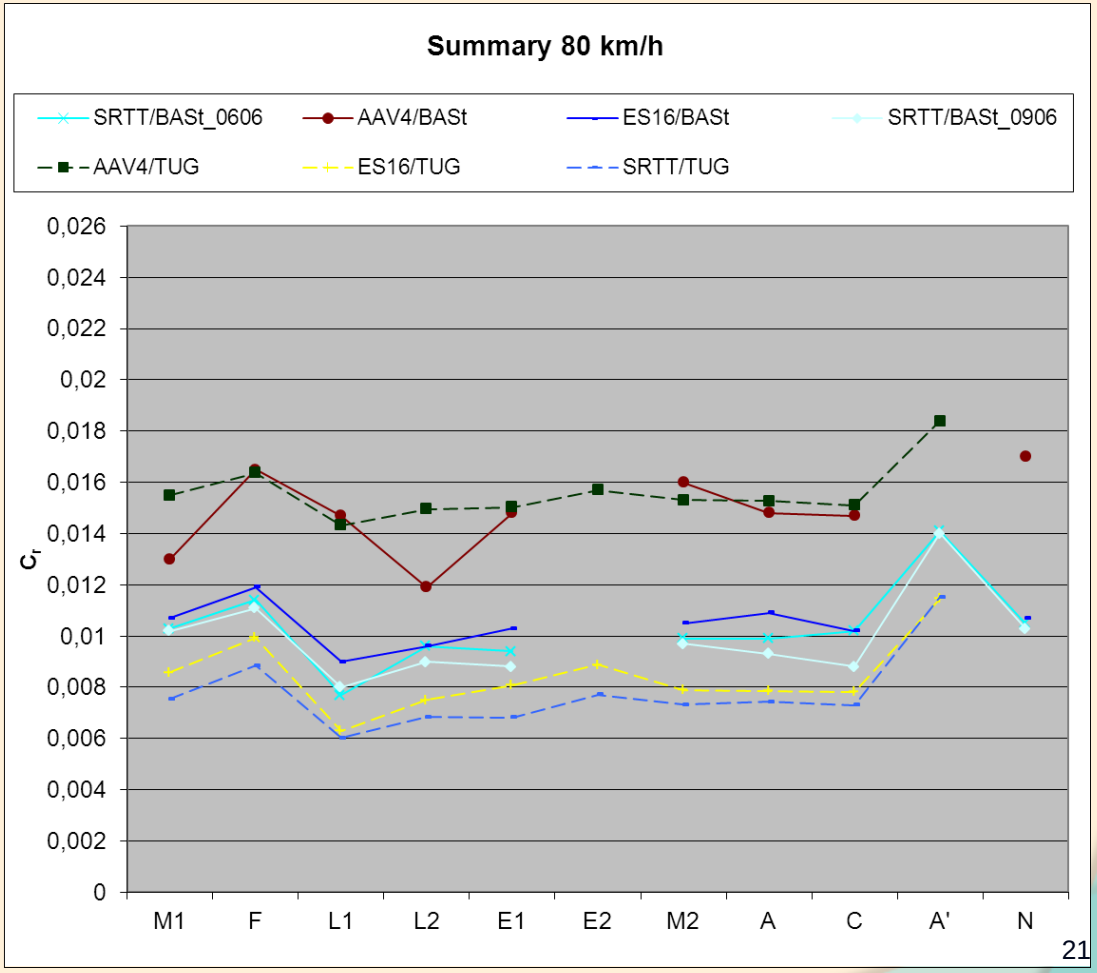
6. Reproducibility

BASt (full line) - TUG (dashed line):

SRTT, AAV4, ES16 at 80 km/h

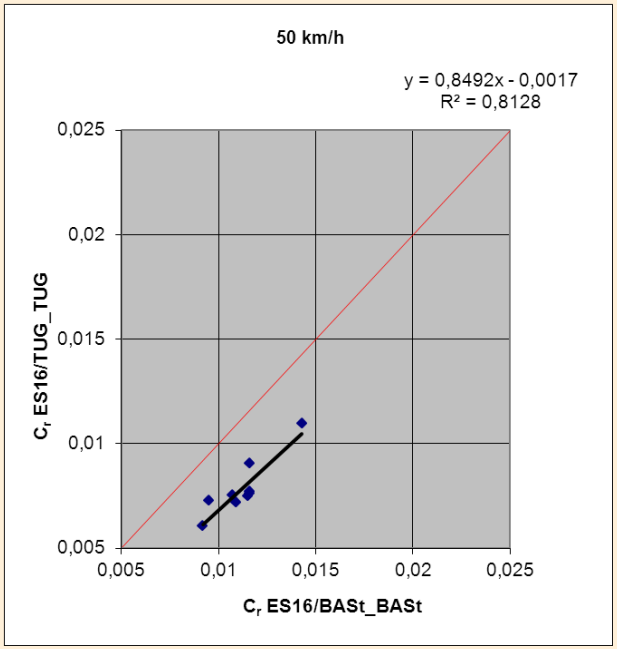
1. **All graphs similar pattern with respect to effect road surface**
2. **Except for 2 inconsistent BASt values, AAV4/BASt and AAV4/TUG rather close together at 80 km/h (approx. 10 % difference) >< not at 50 km/h, speed dependency difficult to explain**
3. **C_r values ES16 and SRTT much higher for BASt than TUG at both speeds**

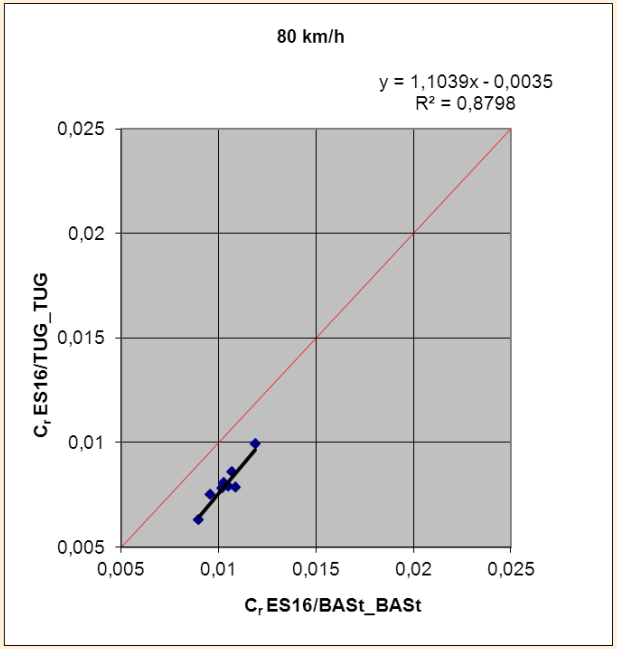


6. Reproducibility

BASt – TUG:

- **Very good correlations between ES16/BASt and ES16/TUG at both speeds**
- **Some difference between regression line and an assumed 1:1 relation (red colour), indicating poor reproducibility**

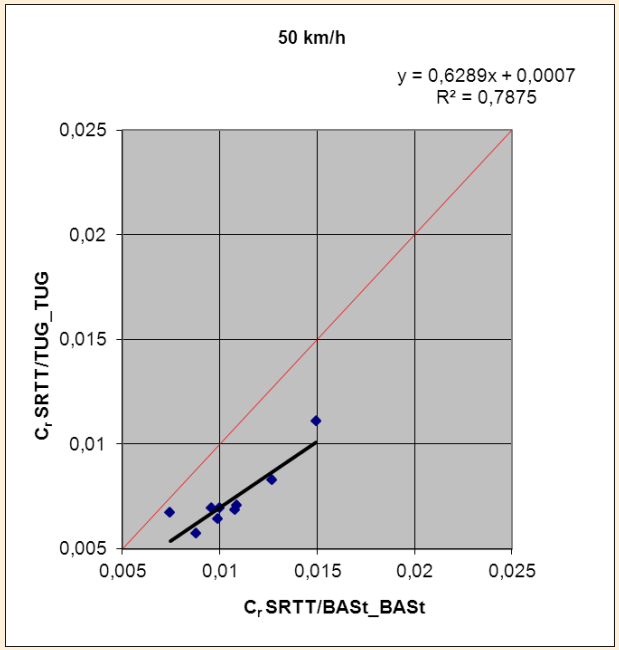


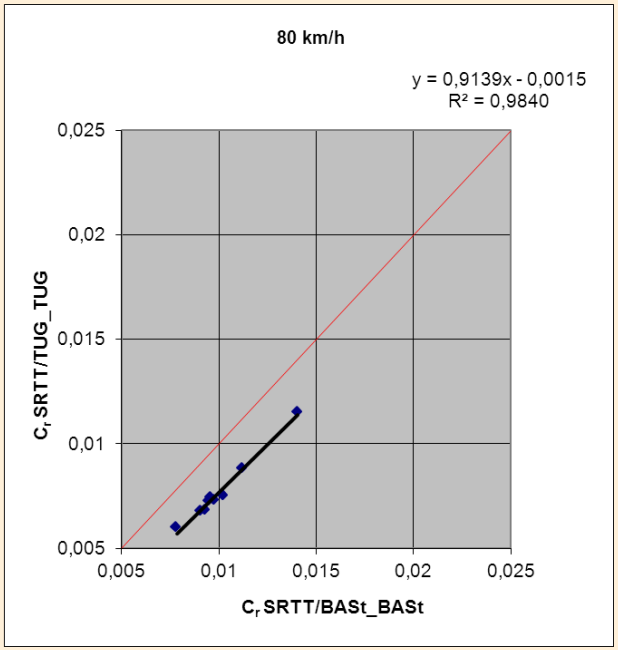


6. Reproducibility

BASt – TUG:

- **Very good correlations between SRTT/BASt and SRTT/TUG for both speeds; correlation at 80 km/h excellent (0.984)**
- **Difference to 1:1 line (red colour) is again substantial, especially at 50 km/h, indicating poor reproducibility**

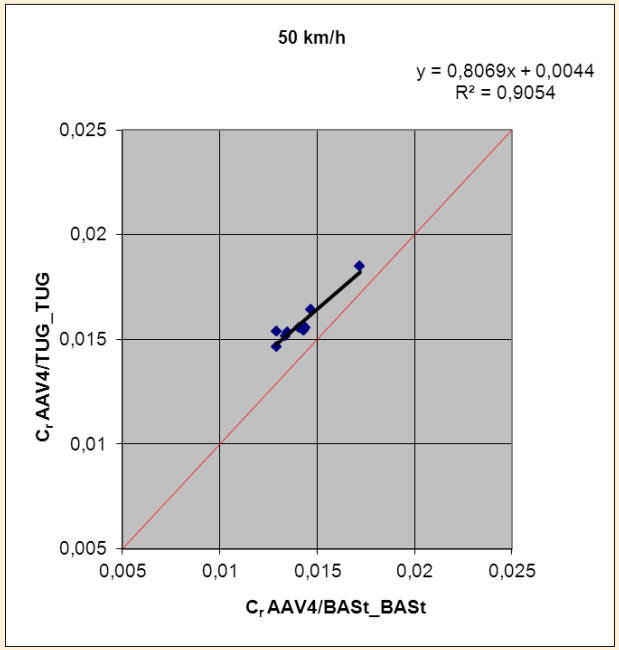


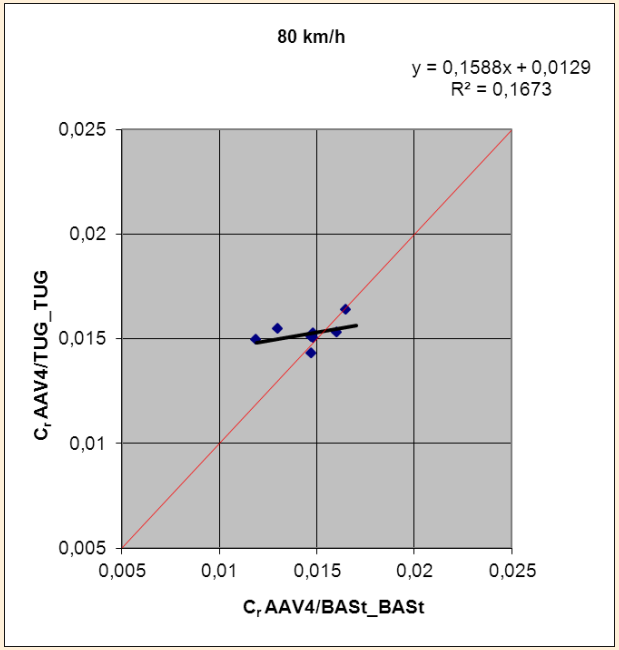


6. Reproducibility

BASt – TUG:

- **Measurements with AAV4/TUG and AAV4/BASt at 50 km/h very good correlation >< at 80 km/h no correlation -> mainly due to 2 inconsistent BASt values**
- **Poor reproducibility**



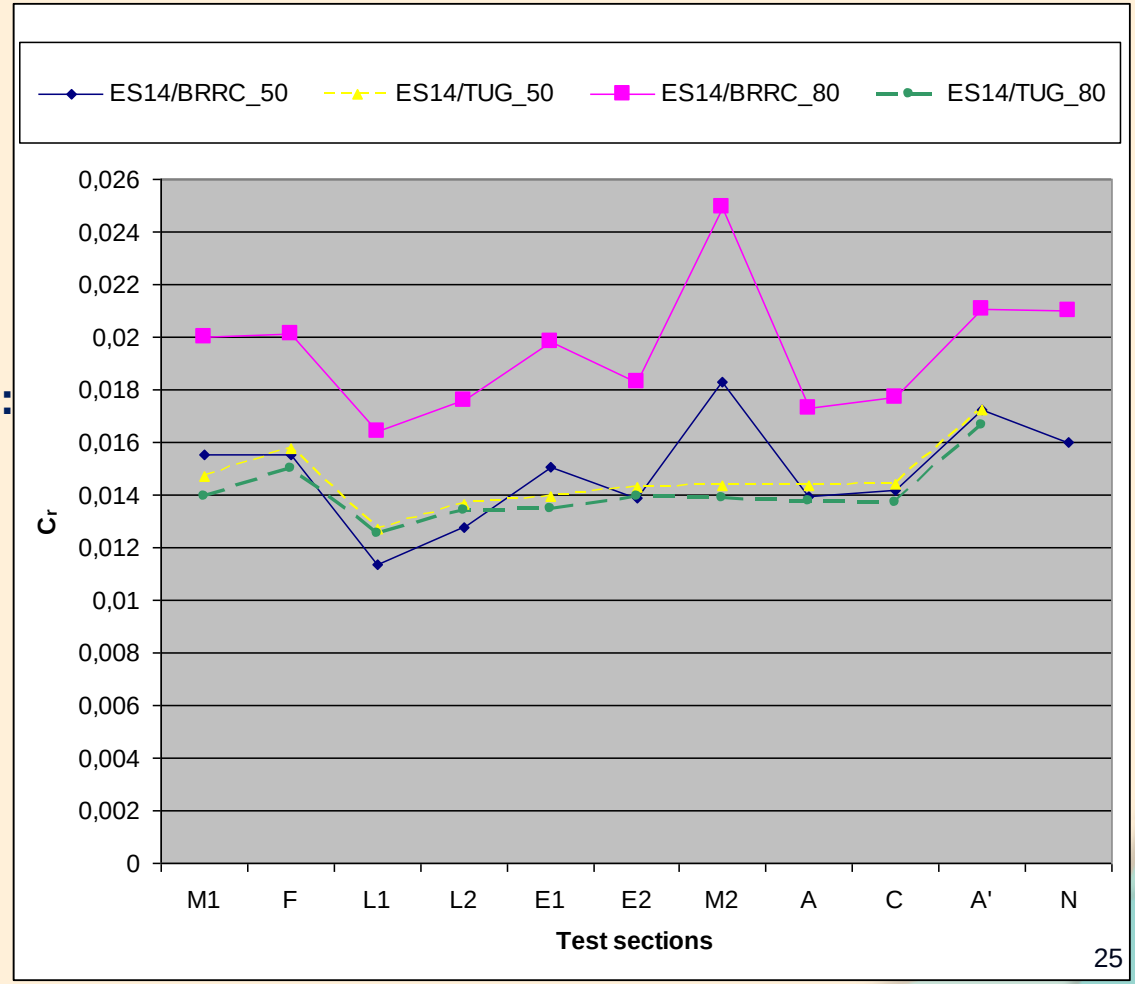


6. Reproducibility

BRRC (full line) - TUG (dashed line):

ES14 tyre at 50 and 80 km/h

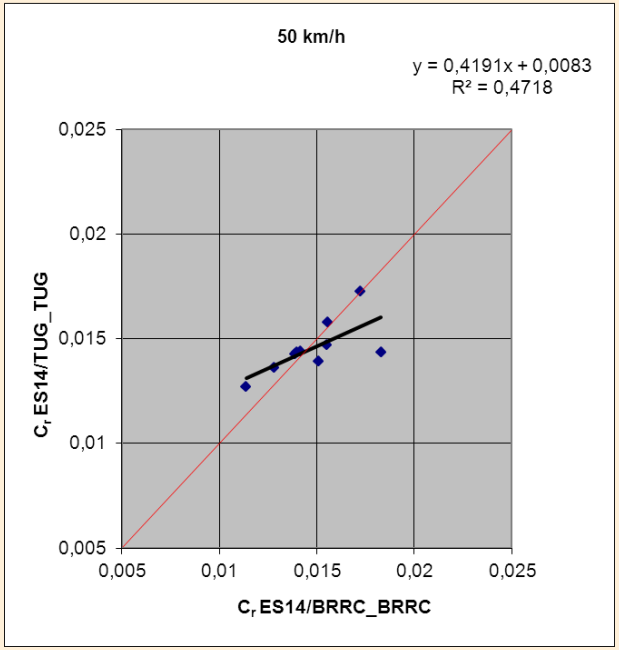
- **Large difference TUG – BRRC at 80 km/h: lack of wind shielding BRRC trailer**
- **BRRC C_r values M2 too high: high acceleration over short distance**
- **When discarding outlier M2, all graphs similar shape; results at 50 km/h are situated closely together, although larger difference was expected, as TUG uses higher load (4000 N)**

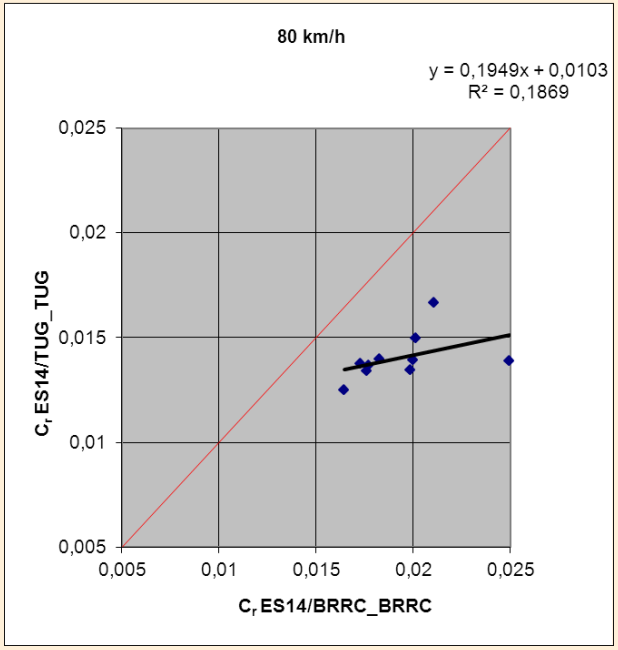


6. Reproducibility

BRRC – TUG:

- **Fair correlation at 50 km/h while almost no correlation at 80 km/h (probably due to influence of wind)**
- **Outlier M2 included**

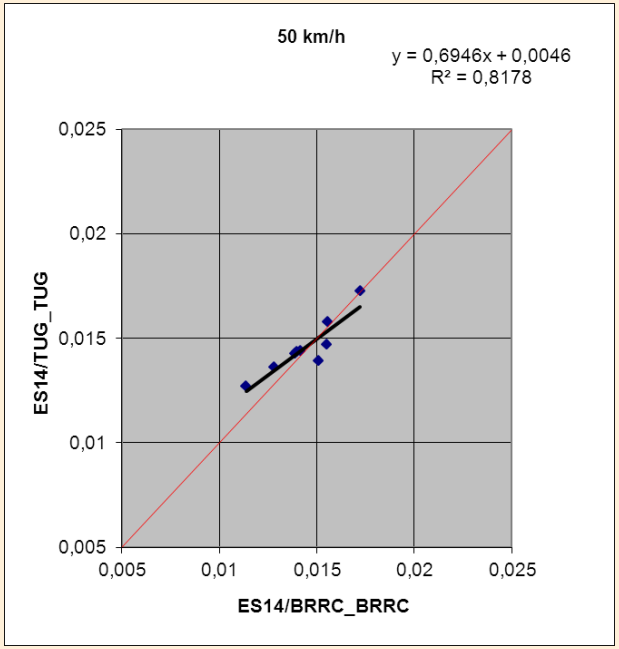


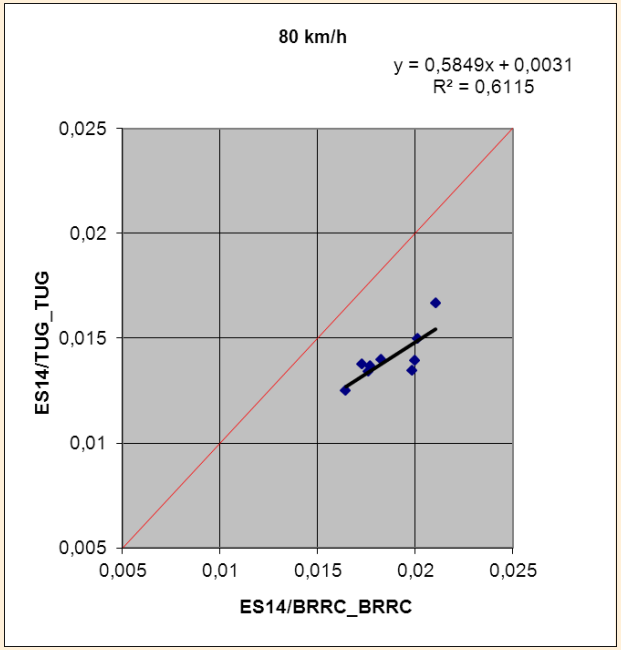


6. Reproducibility

BRRC – TUG:

- **If M2 discarded, better correlations**
- **Poor reproducibility as BRRC values consistently higher, especially at 80 km/h**





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- **Short term repeatability BRRC and BASt approx. 3 % of average C_r values, which is just acceptable; short term repeatability TUG as low as 1 %, which is excellent.**
- **Day-to-day variability approx. 7 % for BASt, which is as high as differences one wishes to detect. For BRRC even higher, indicating calibration problem which needs follow up. Corresponding tests for TUG trailer were not made.**
- **Correlation between values of C_r measured by trailers BASt and TUG, using different samples of tyres of same type, generally very good. In general, reproducibility rather poor.**

Thank you for your attention!

The full report about the round robin test may be downloaded on:
http://miriam-co2.net/

Bergiers, A., Goubert, L., Anfosso-Lédée, F., Dujardin, N., Ejsmont, J. A., Sandberg, U., Zöller, M. (2011). Comparison of Rolling Resistance Measuring Equipment – Pilot Study. MIRIAM SP1 Deliverable No. 3.