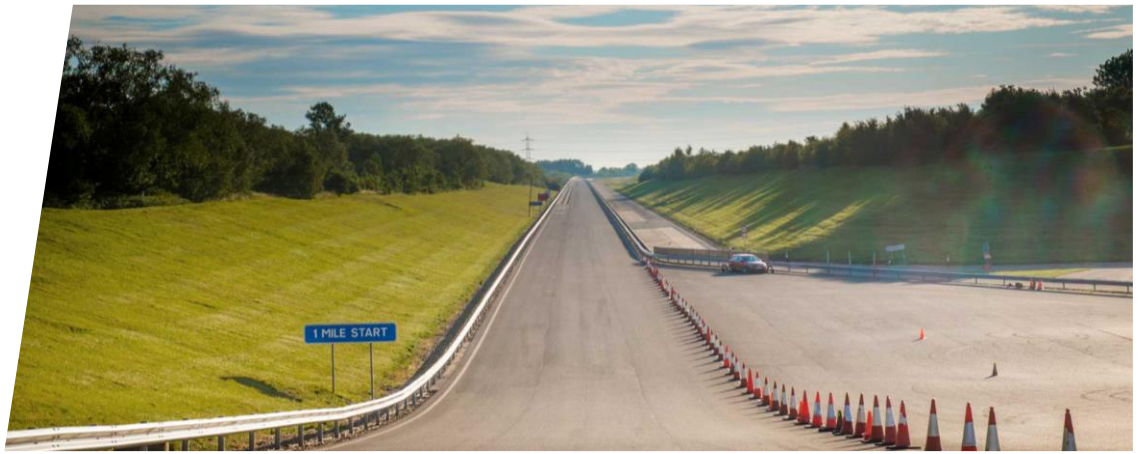
Submitted by the experts of OICA

Informal Document **GRBP-75-21 Rev.1**
75th GRBP, February 8-11, 2022
Agenda item 2

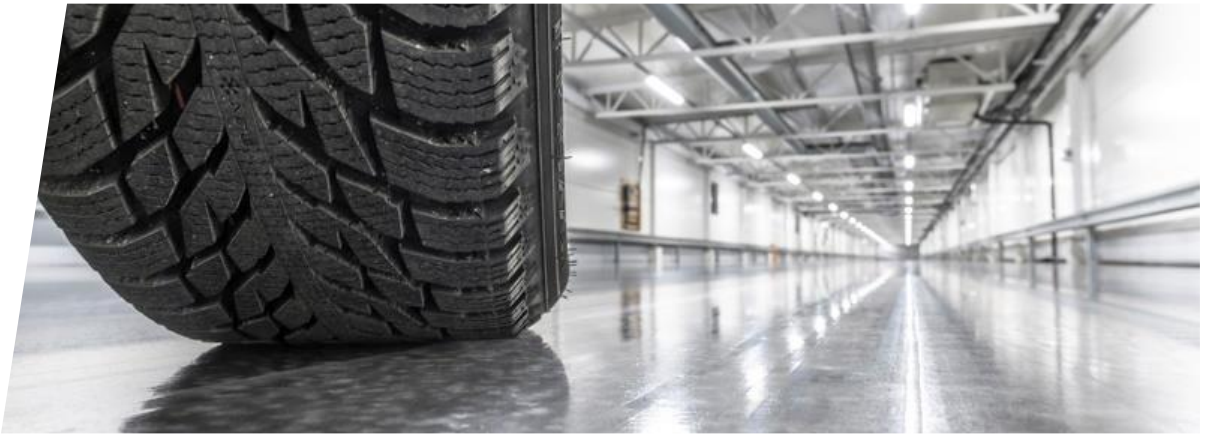


Aggregation of Tyre Studies – ACEA & ETRTO

03/02/2022

CONTENTS

EXECUTIVE SUMMARY



03/02/2022

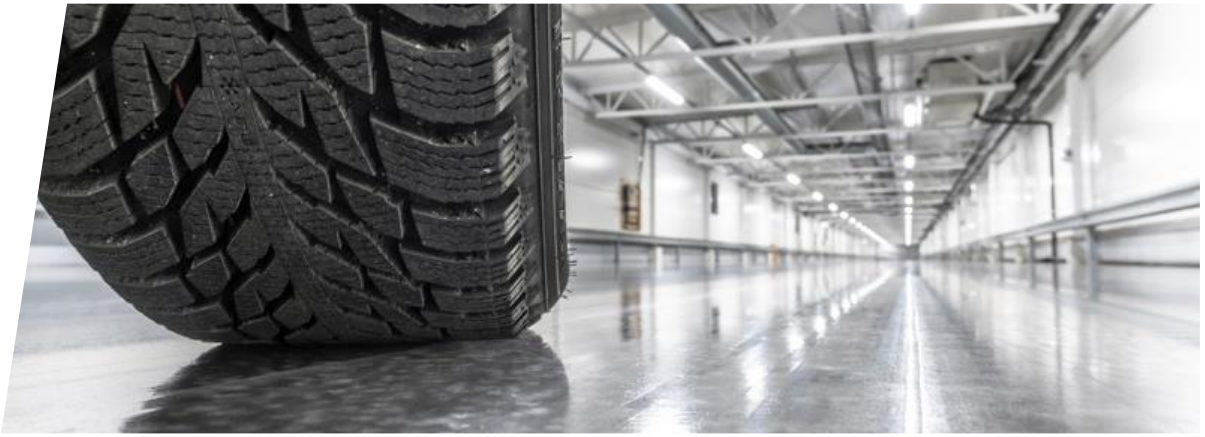
EXECUTIVE SUMMARY

- Background
  - Two studies to assess the interdependency of tyres' parameters on each other.
  - ACEA: GRBP-70-25 and GRBP-74-09,
  - ETRTO: GRBP-73-11.
  - One laboratory

- Objectives
  - Assessment of any improvement/deterioration of noise performance in regard to the other tyres' parameters
  - Rationalization of both studies as requested by the GRBP experts:
    - Larger sample of tyres
    - Confirmation of the main the conclusions

- Conclusions
  - Confirmation of ACEA and ETRTO studies conclusions:
    - Conflict between rolling sound and safety performance
    - Better Handling performance is linked to an increase of the Rolling Sound
    - Undefined relation between rolling sound and CO2-emission

REMINDER & CONTEXT

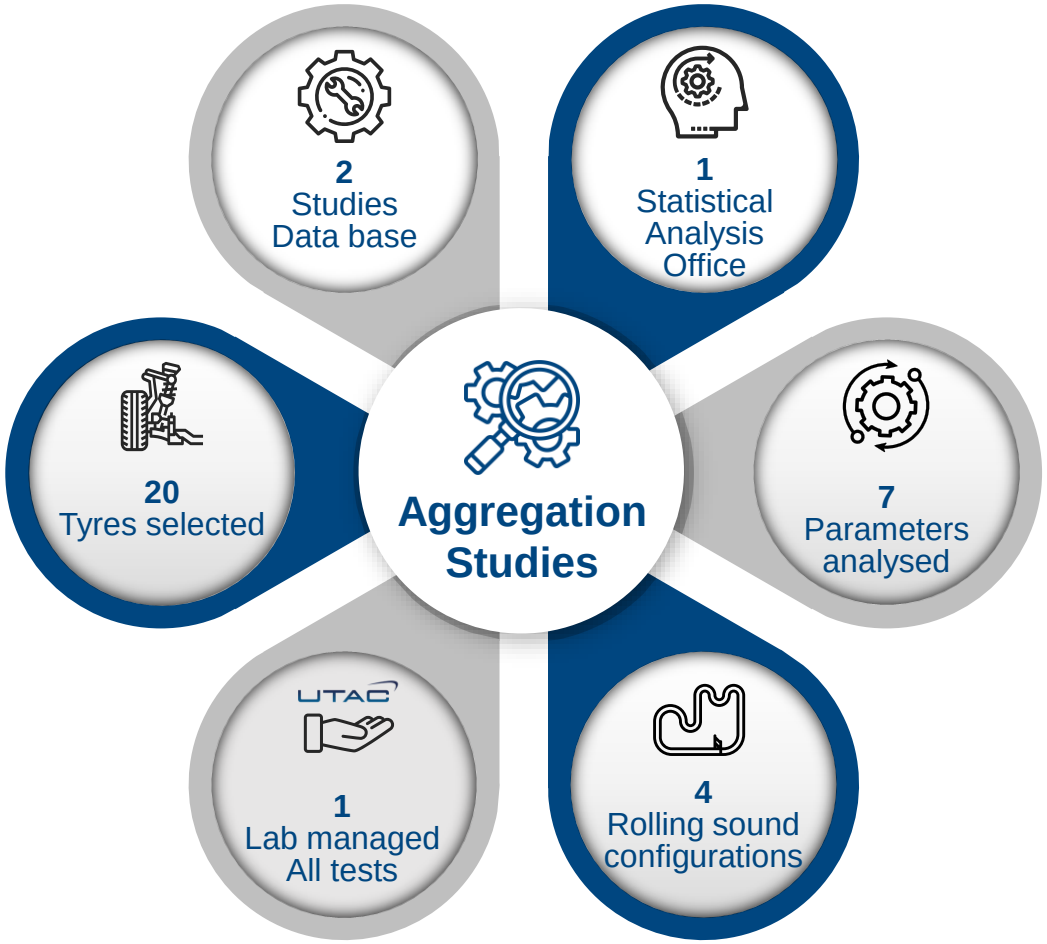


REMINDER & CONTEXT

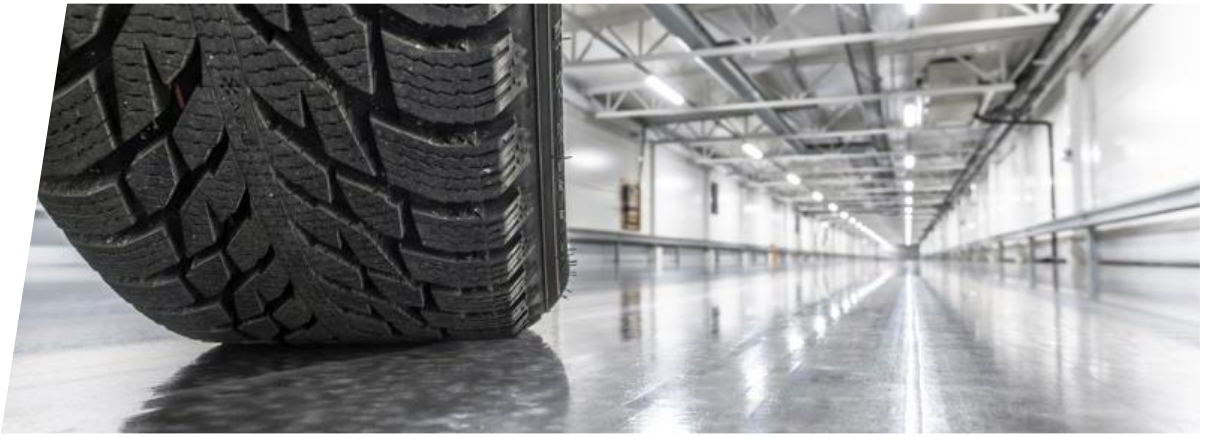
The goal of this aggregation study, is to analyse the influence of the noise reduction of the tyres regarding their essential characteristics.

- UTAC performed two separate tyre studies by the past:
  - 2019 the **ACEA** Tyre Study
  - 2020 **ETRTO** Tyre Study

- We use here only the data which can be brought in a comparable state from both studies (7 parameters)
  - Rolling Sound,
  - Rolling Resistance,
  - Wet Grip,
  - Flat Trac (80%, 50% LI)
  - Longitudinal Aquaplaning,
  - Lateral Aquaplaning,
  - Weight.



DATABASE & AGGREGATION FRAMEWORK



03/02/2022

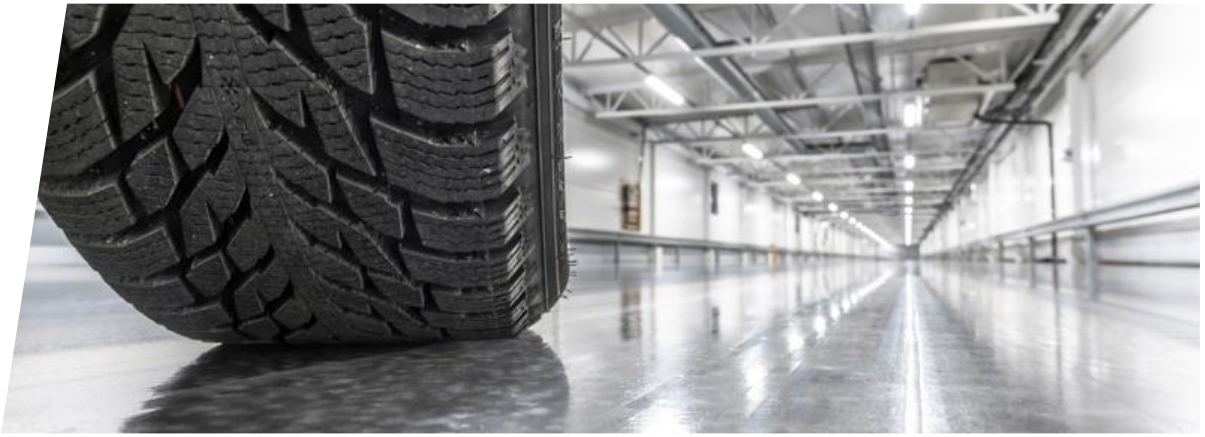
DATA BASE & AGGREGATION FRAME WORK

- Parameters retained for this aggregation study:
  - Rolling Resistance, Wet Grip, Flat Track 80%, Flat Track 50%, Longitudinal & Lateral Aquaplaning, Weight (to evaluate tyre's mass influence, if any)

			TEST										
			Rolling Resistance	Rolling Sound				Flat Trac		Wet Grip	Longi. Aqua.	Lateral Aqua.	Weight
ID	Origin ID	DOT	RR (index)	R117 50 kph AVG (dB(A))	R117 80 kph Arr LR-1dB (dB(A))	R51A 50 kph (dB(A))	R51C 50 kph T° corr (dB(A))	80% LI (N/°)	50% LI (N/°)	WG (index)	Ratio LoA (%)	LaA (Integer m/s)	(Kg)
1	A-ETRTO	n/a	8,686	61,2	67,7	61,8	61,8	1530	1462	0,80	47,91	21,24	9,32
2	C-ETRTO	2418	10,084	63,3	70,6	67,2	63,4	1500	1127	1,08	74,07	38,85	11,81
3	M-ACEA	4718	8,389	66,0	71,6	69,0	66,9	1294	1126	1,67	89,76	63,39	8,43
4	B-ETRTO	n/a	6,663	62,6	69,2	63,5	63,4	1718	1613	0,93	43,83	18,97	7,54
5	D-ETRTO	0716	7,985	65,3	73,6	66,4	65,8	1576	1304	1,38	84,32	78,62	8,77
6	E-ETRTO	3218	8,011	64,1	70,9	67,0	65,2	1297	1089	1,39	96,22	90,42	8,03
7	F-ETRTO	1818	9,171	63,8	70,8	66,1	64,9	1647	1346	1,20	81,88	67,66	9,62
8	G-ETRTO	3218	8,439	62,9	69,2	66,9	64,0	1427	1134	1,25	74,92	49,33	9,34
9	H-ETRTO	3118	7,914	63,0	69,7	65,5	64,2	1519	1238	1,43	77,36	58,27	9,41
10	A-ACEA	2218	8,985	64,8	71,7	66,3	65,5	1417	1288	1,57	83,51	63,96	8,18
11	B-ACEA	4318	9,949	64,9	71,3	66,4	65,7	1387	1080	1,43	87,99	70,52	9,55
12	C-ACEA	4818	8,142	65,0	71,8	66,9	66,1	1265	1099	1,51	86,69	61,43	7,84
13	D-ACEA	1119	8,444	65,1	72,1	67,1	66,4	1470	1206	1,56	86,29	63,29	8,27
14	E-ACEA	2818	8,117	65,8	73,4	67,4	66,8	1669	1507	1,55	83,97	66,15	8,13
15	F-ACEA	3618	8,953	64,7	71,3	66,4	65,4	1500	1294	1,63	87,16	69,75	8,86
16	K-ACEA	4518	7,075	65,1	72,0	66,9	66,6	1351	1232	1,50	84,49	59,74	8,14
17	L-ACEA	4218	6,449	63,9	70,7	65,9	65,0	1326	1126	1,69	79,23	55,48	8,23
18	N-ACEA	2718	7,666	65,1	71,9	67,2	66,0	1618	1271	1,56	86,39	73,05	8,83
19	O-ACEA	4818	7,175	63,6	70,2	65,8	64,7	1382	1168	1,27	74,94	47,52	8,27
20	P-ACEA	4318	8,336	63,9	70,7	66,0	64,9	1505	1351	1,74	81,74	67,65	8,77

  - For tyres which were part of both ACEA & ETRTO studies, only one of them has been considered.
  - Tyres 1, 2 and 3 are 3PMSF, tyres 1 and 4 are plain tread, the sequence of the list is randomly chosen.
  - As the goal of the study is to analyse the influence of the noise reduction of the tyres regarding their essential characteristics, tyre were chosen for the purpose to analyse the interdependencies with a wide spread of parameters
  - *For each column the best result within the group of tyres and the worst are highlighted from green to red*

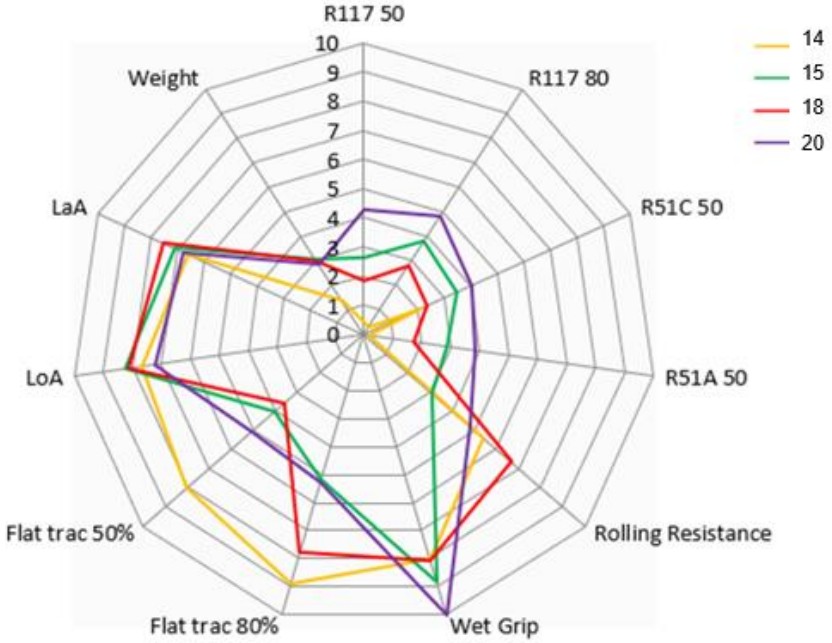
STATISTICAL ANALYSIS



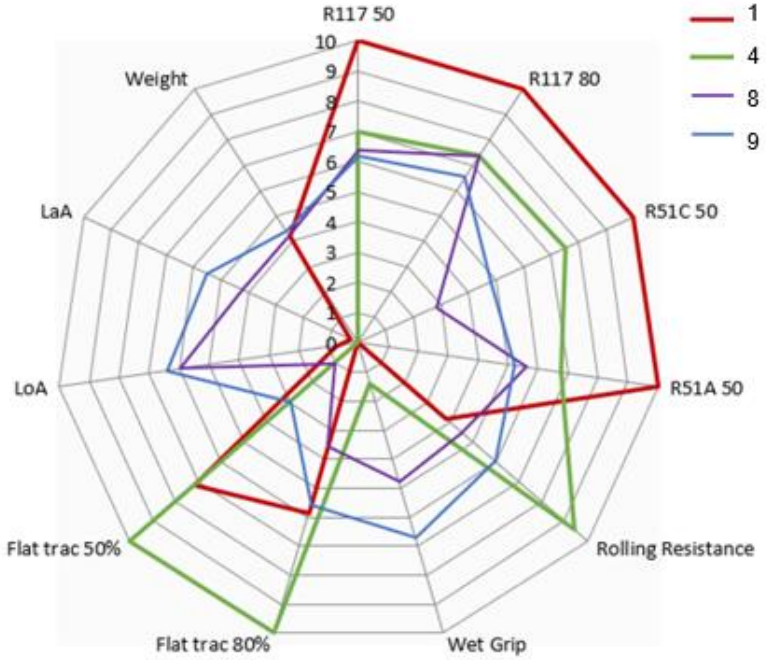
03/02/2022

STATISTICAL ANALYSIS – Radar Chart

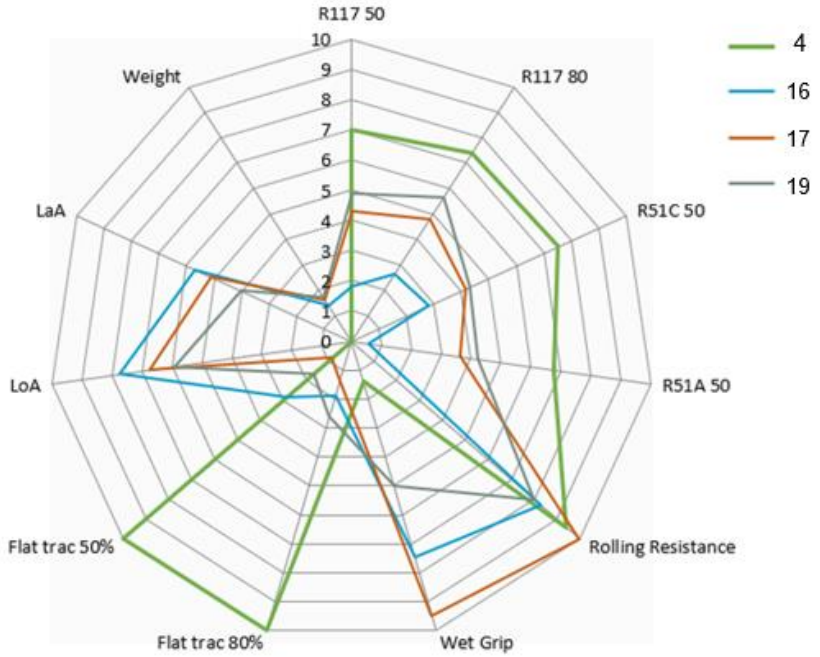
The 4 Best for Safety
Those 4 tyres are good on Safety Performance and also quite noisy



The 4 Best for Noise
Those 4 tyres are good on Rolling Sound but have poor Aquaplaning and Wet Grip scores



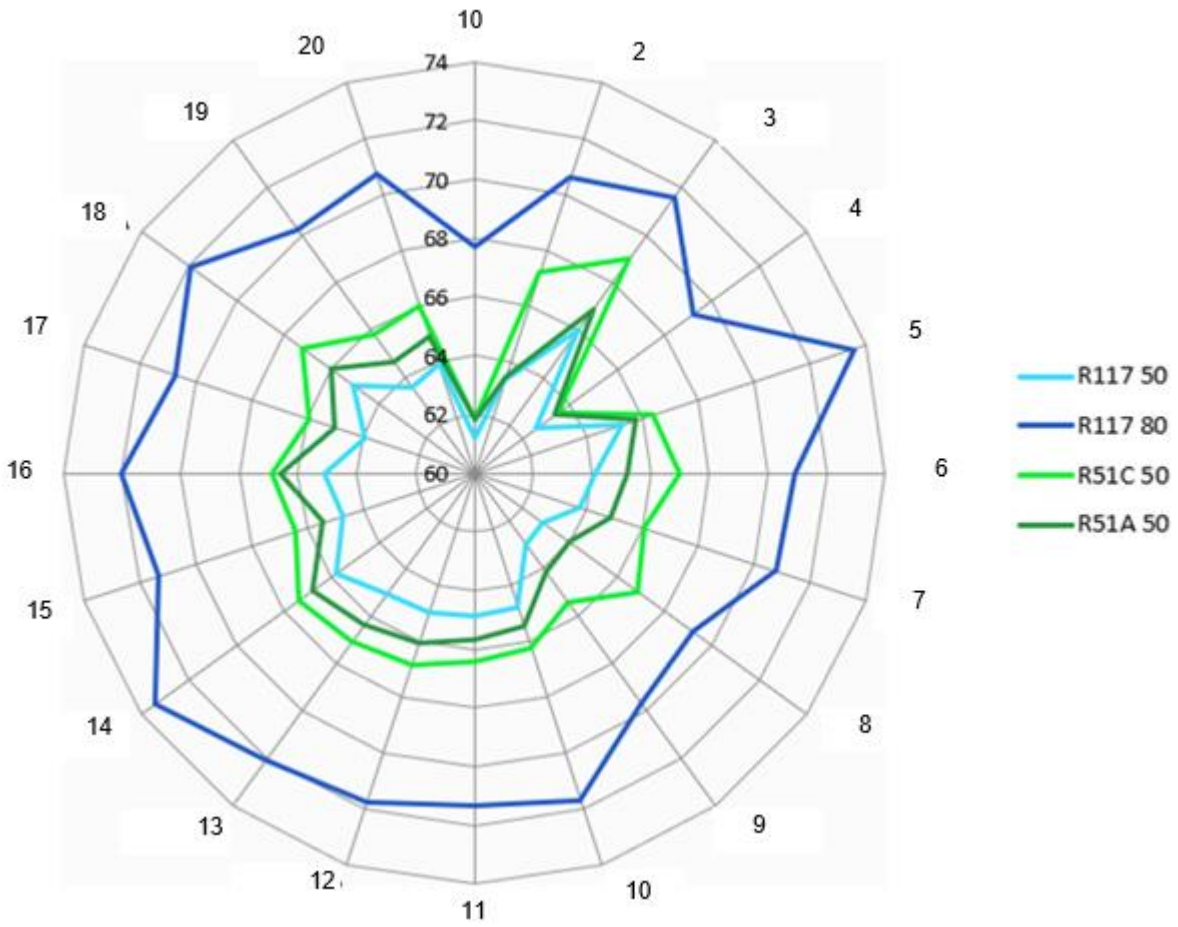
The 4 Best for CO_2 Emissions
The 4 tyres are good in Rolling Resistance, but 3 are poor in flat trac



- The radar charts provide a vision for a given performance a potential correlation with any other characteristics
- No correlation highlighted
- Reminder: tyres 1 and 4 are plain tread tyres

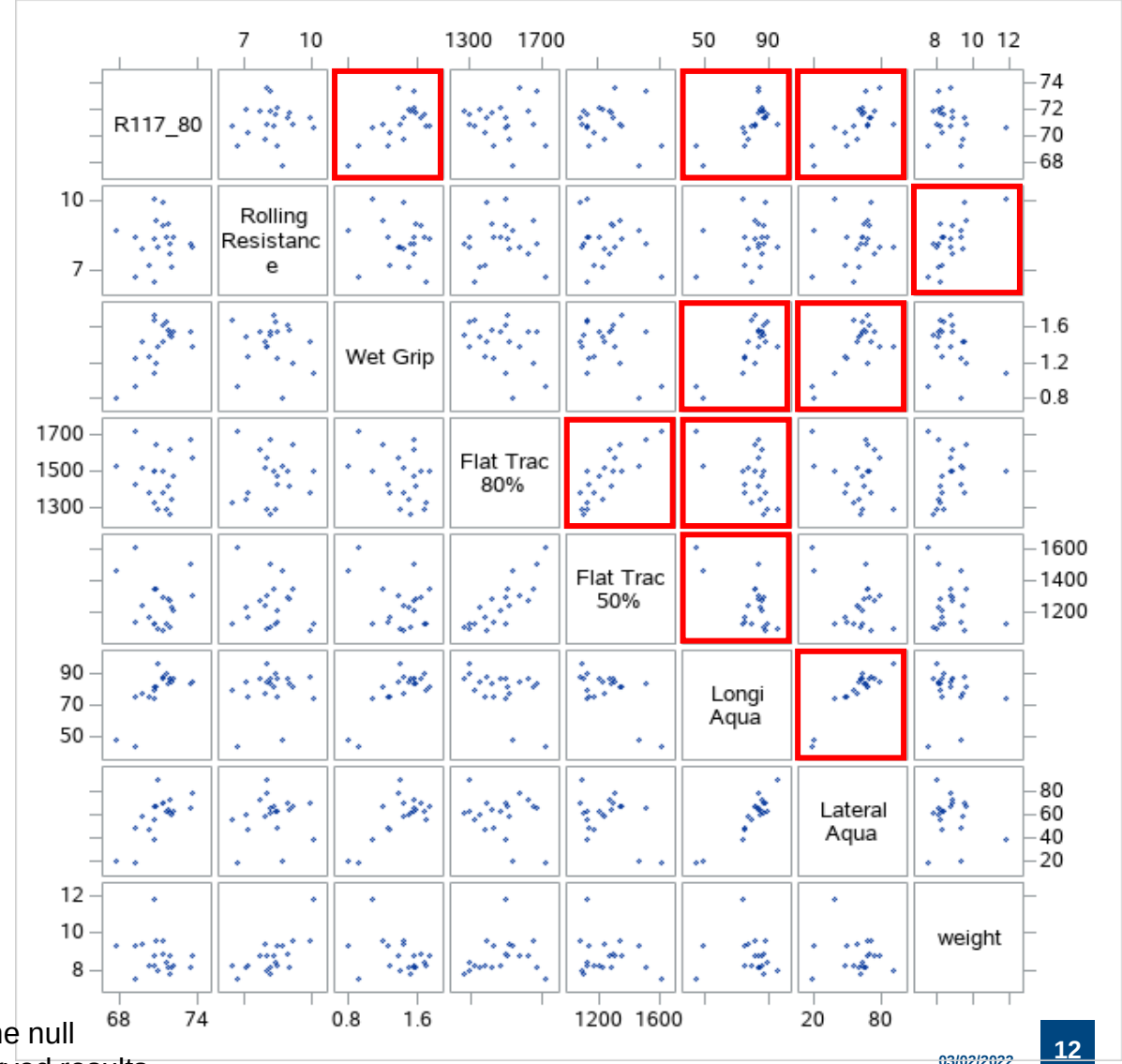
STATISTICAL ANALYSIS - Focus on Rolling Sound

- Rolling Sound Correlation
  - Radar chart of all rolling sound tests according to each tyre.
  - The majority of the tests follow the same trend for the entire batch.
    → the shape of each « circle » shows a good correlation between noise performances
  - To be noted that this correlation is a linear statistical correlation and not deterministic rule.
  - Only one representative characteristic among them is kept for the next steps of the study.



STATISTICAL ANALYSIS – 2D Charts & Scatterplots

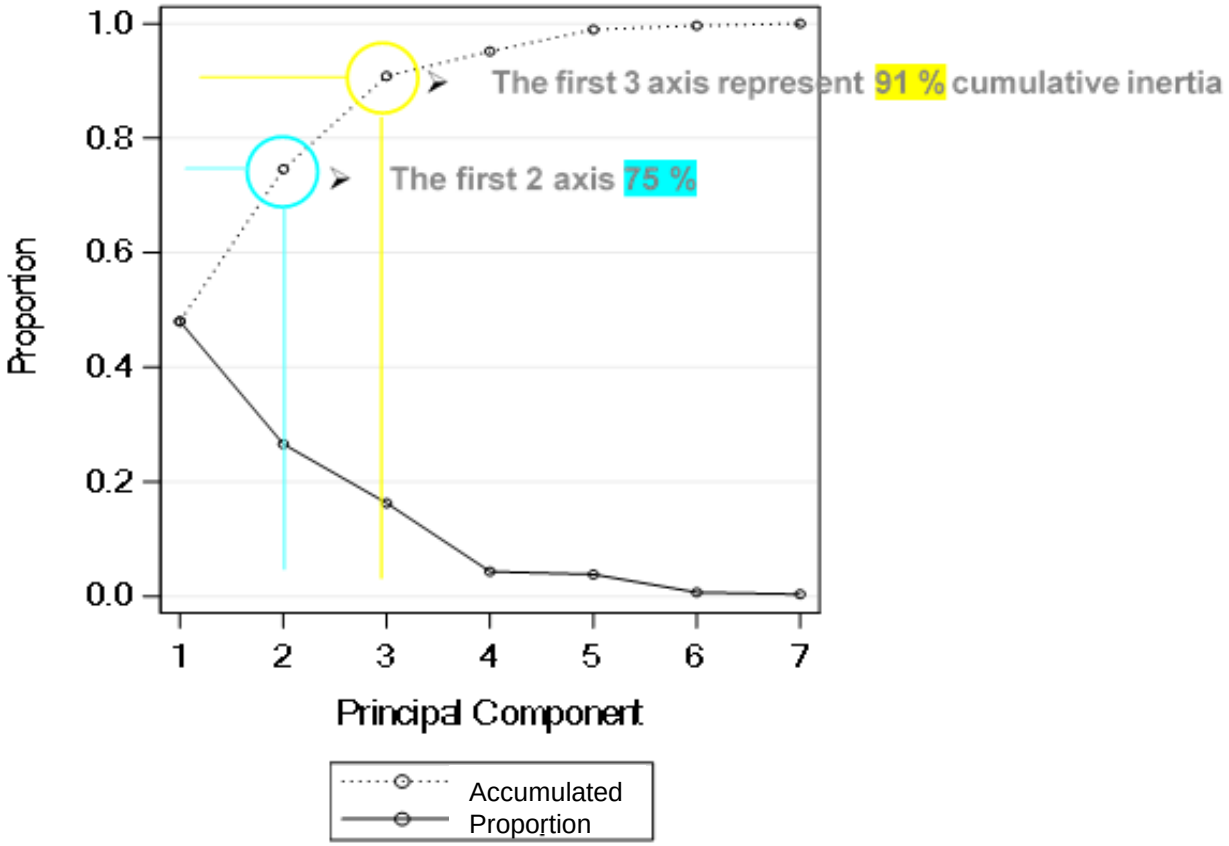
- Further analysis to find correlation between parameters: bivariate analysis
- Red boxes enlighten significant correlation between two characteristics (p-value* <0.05).



*The P-value or probability value is, for a given statistical model, the probability that, when the null hypothesis is true, the statistical summary would be greater than or equal to the actual observed results

STATISTICAL ANALYSIS - Principal Component Analysis

- How:
  - factor analysis method that allows multivariate analyses between quantitative variables
- Purpose:
  - to reduce the number of 7 parameters
- The first 3 axes represent 91% of cumulative inertia.



STATISTICAL ANALYSIS - Principal Component Analysis

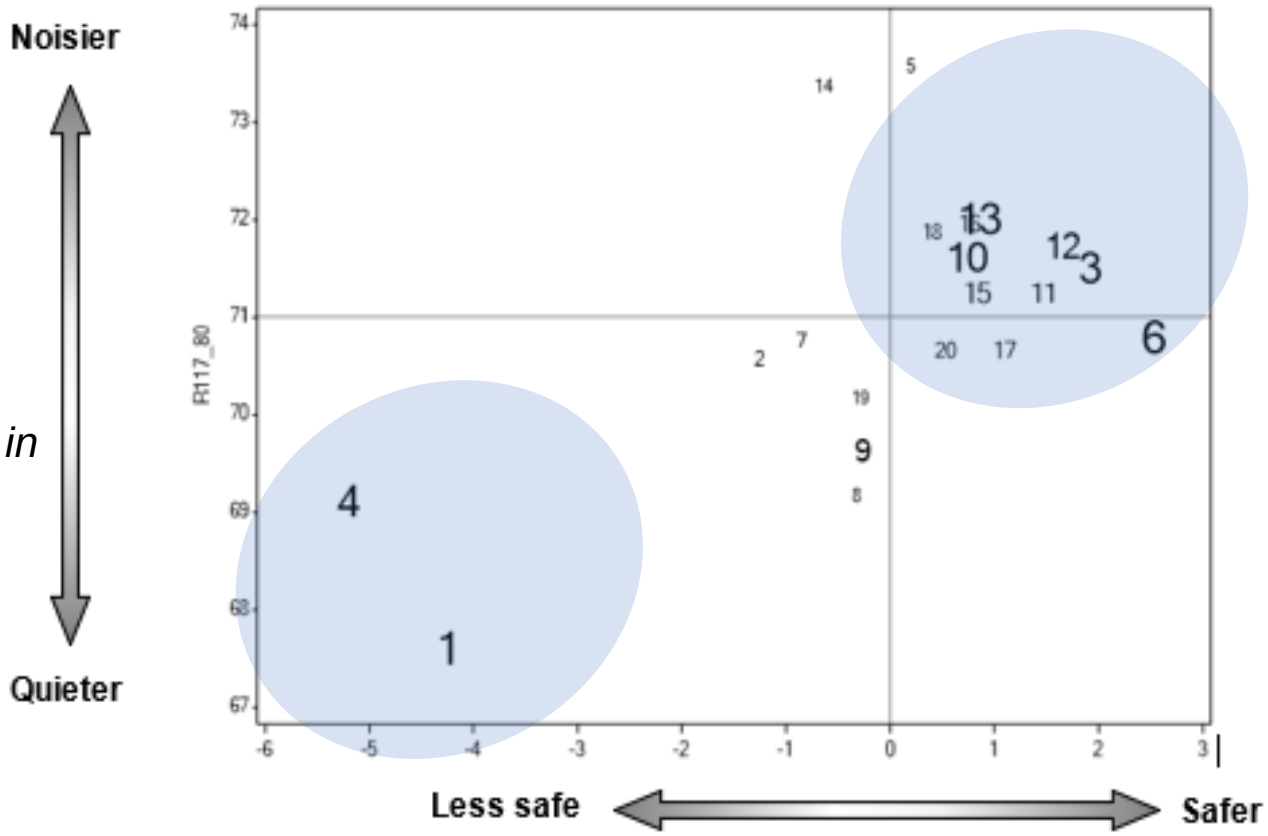
- **Axis 1**
  - Wet Grip, Lateral and Longitudial Aquaplaning and Flat Trac (negative).
  - This axis is the most representative for **Safety**
- **Axis 2**
  - **Rolling Resistance** & **Weight.**
  - This axis is representative for **CO2 Emissions**.
- **Axis 3**
  - Flat Trac (positive)
  - This axis is representative for **Handling**
- These axes are slightly different from the 2 previous studies (due to other settings of parameters)

Part of inertia	48%	27%	16%
	Axis 1	**Axis 2**	**Axis 3**
Rolling resistance	0.11447	0.88298	0.25046
Wet Grip	0.81409	-0.30913	0.25639
Flat Trac 80%	-0.68436	-0.00475	0.69410
Flat Trac 50%	-0.75908	-0.34619	0.50409
Longi aquaplaning	0.95221	0.06517	0.25576
Lateral aquaplaning	0.84282	-0.04567	0.45466
Weight	-0.14998	0.92685	0.04316

STATISTICAL ANALYSIS - Principal Component Analysis

- Axis 1 representative for **Safety**

the larger the size (quality score), the more the tyre is in line with the performance axis. axis characterises



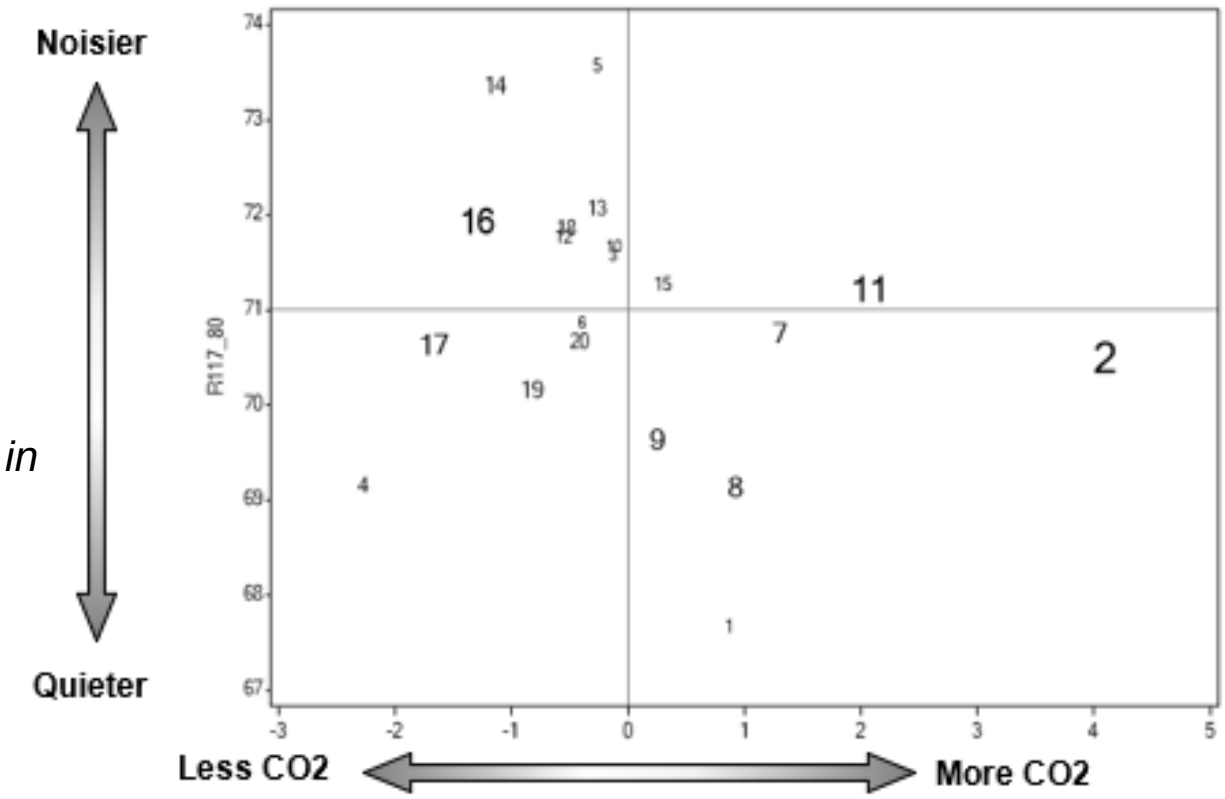
R117_80 vs Axis 1 "Safety"

- Opposition between Rolling Sound and Safety performances.

STATISTICAL ANALYSIS - Principal Component Analysis

- Axis 2 representative for **CO2 emission**

the larger the size (quality score), the more the tyre is in line with the performance axis. axis characterises



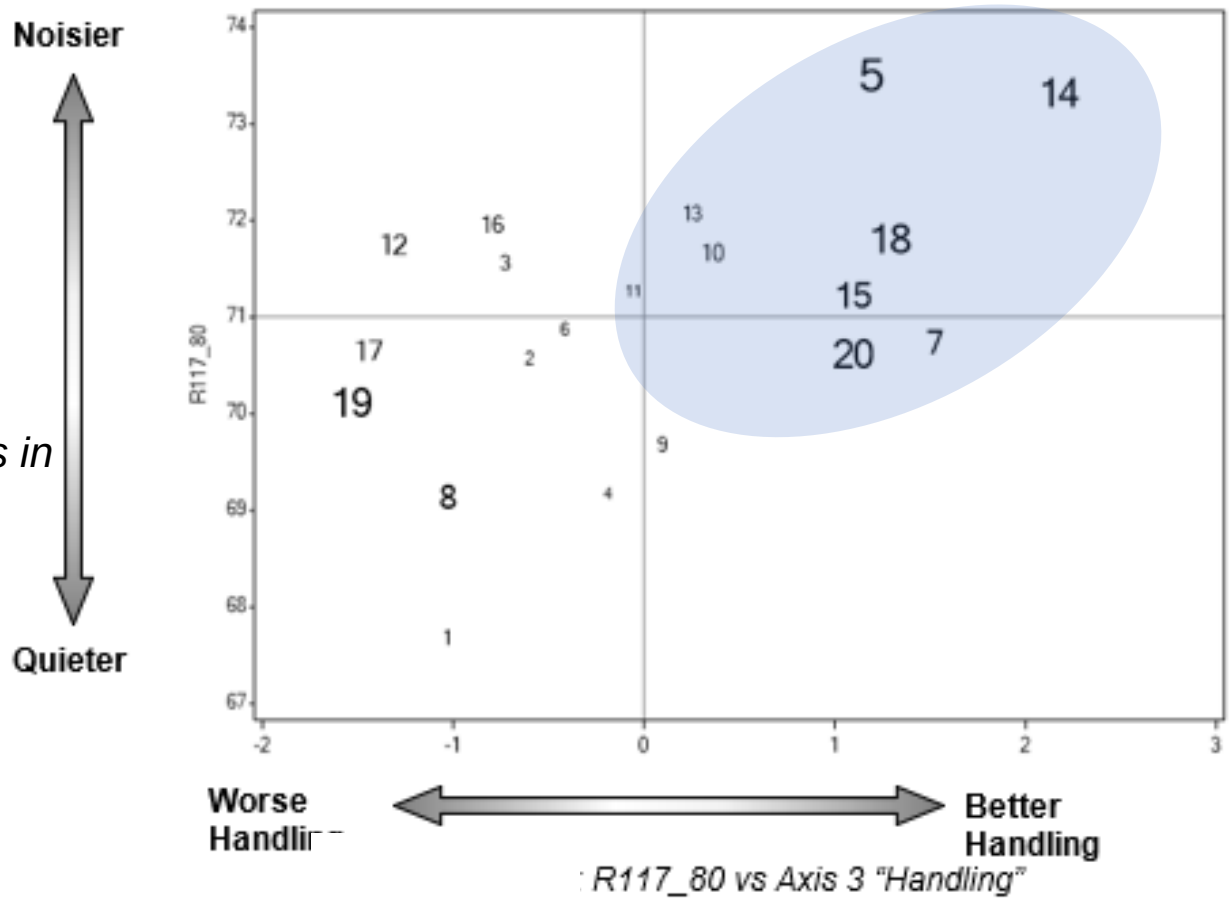
: R117_80 vs Axis 2 "Rolling Resistance & Weight"

- No clear correlation

STATISTICAL ANALYSIS - Principal Component Analysis

- Axis 3 representative for **Handling**

the larger the size (quality score), the more the tyre is in line with the performance axis. axis characterises

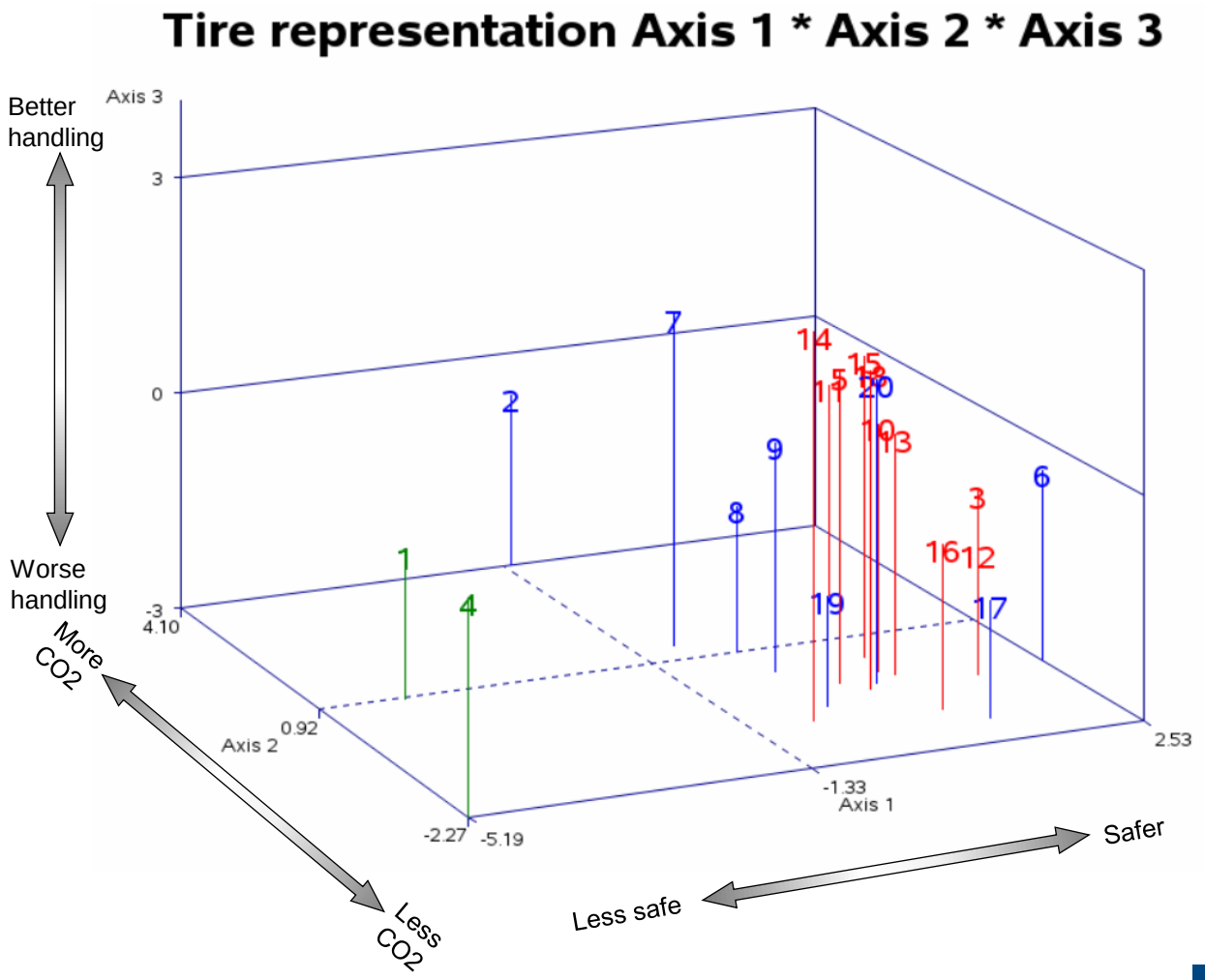


- Better Handling performance is linked to an increase of the Rolling Sound

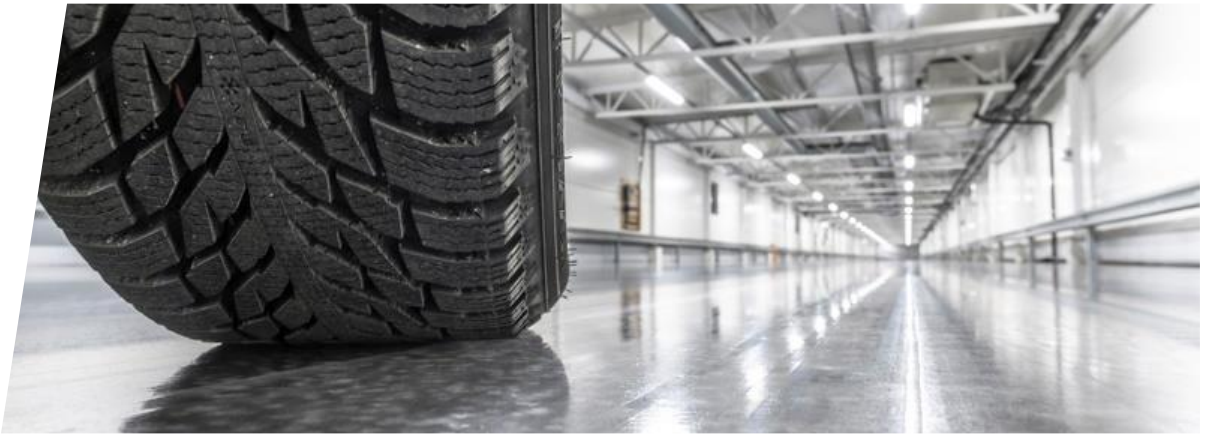
STATISTICAL ANALYSIS – Global overview

- Letters correspond to the 20 tyres tested:
  - **Red** letters are **noisy** tyres,
  - **Green** are **quiet** tyres,
  - **Blue** are **middle** noise tyres.

- Reminder: tyres 1 and 4 are plain tread tyres



CONCLUSIONS



CONCLUSIONS

- Test program conclusion
  - It gives **a comprehensive toolbox to evaluate the relationship and interdependency between Rolling Sound and other tyre's performances using standard or regulatory measurement protocols**.
  - Correlation of the four acoustic parameters regarding UN-R51.03 (Vehicle measurement) and UN-R117 (Tyre measurement) is good and can be chosen only one in this study (To be noted that this correlation is a linear statistical correlation and not deterministic rule).

		ACEA study	ETRTO study	Aggregation Study
Tyres tested	set/size	16 x 205/55 R16 91 H/ T/ V/W	10 x 205/55 R16 91/94 H/V/W	20 x 205/55 R16 91 H/V/W
Safety Related Tests	dry grip	ECE13H Type 0	Similar to ECE R117 wet grip	-
	dry handling	Flat trac bench	Flat trac bench	Flat trac bench
	wet grip	ECE R117	ECE R117	ECE R117
	aquaplaning	VDA methods (E08, E05)	VDA methods (E08, E05)	VDA methods (E08, E05)
Emission Related Tests	vehicle noise	ECE R51 cruises and acceleration -	ECE R51 cruises and acceleration Ditto (2nd vehicle)	ECE R51 cruises and acceleration -
	tyre noise	ECE R117 – rolling sound	ECE R117 – rolling sound	ECE R117 – rolling sound
	CO2	ECE R117 – RR weight, tread depth, void ratio	ECE R117 - RR weight	ECE R117 - RR weight

CONCLUSIONS

- Statistical analysis
  - The 7 parameters summarize in 3 axes with a good level of representativeness (part of inertia is 91%).
  - The radar charts and the Principal Components Analysis show **a conflict between rolling sound** (R117) **and safety performances** (wet grip, lateral aquaplaning).
  - **Simple conclusions regarding rolling sound, and other parameters**: rolling resistance, weight and safety performance (longitudinal aquaplaning) **cannot be drawn**.

ACEA study	ETRTO study	Aggregation Study
summarize 8 characteristics to “safety”, “handling” and “CO2-emissions”: - conflict between rolling sound and safety performance - handling performance supports good rolling sound - undefined relation between sound and CO2-emission	summarize 7 characteristics to “wet safety”, “dry grip/ CO2-emissions” and “flat trac 80% / dry grip”: - conflict between rolling sound and wet safety - plain tread tyres represent an asymptote for rolling sound at a forbidden stage of wet safety	summarize 7 characteristics to “safety”, “CO2-emissions” and “handling”: **Confirmation of both conclusions**

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