Project STEER: Improving the EU Tyre Noise Label

Felix Schlatter[1]
Grolimund + Partner AG - environmental engineering, R&D division
Thunstrasse 101a, 3006 Bern

Ulf Sandberg[2]
Swedish National Road and Transport Research Institute (VTI)
SE-581 95 Linköping, Sweden

Erik Bühlmann[3]
Grolimund + Partner AG - environmental engineering, R&D division
Thunstrasse 101a, 3006 Bern

Truls Berge[4]
SINTEF AS
P.O. Box 4760 Torgarden, NO-7465, Trondheim, Norway

Luc Goubert[5]
Belgian Road Research Centre (BRRC)
Woluwedal 42, B-1200 Brussels, Belgium

ABSTRACT

Tyre/road noise is the dominant component of overall vehicle noise at medium and high speeds and for cars even at relatively low speeds. Consequently, road traffic noise can be reduced with the proliferation of quieter tyres. One way to achieve this is to give the tyre noise label greater attention among tyre and transportation consumers. Hence, the STEER project has evaluated the relevance and performance of the noise part of the European tyre label, looking at how it works in practice, analysing its uncertainties and suggesting how it can be improved. Its main finding is that the uncertainties in the measurement of noise level for the label are too high to be acceptable. This paper focuses on the solutions offered by STEER for an improved tyre label. With four main improvements, the overall uncertainty of the current procedure can be halved. A few possible future strategies to increase the market share of quieter tyres have been analysed and their effects quantified. If the tyre noise label is improved and the market share of quieter tyres can be increased, as project STEER proposes, area-wide reductions of up to 3 dB in road traffic noise emissions compared to the present situation are possible.

[1]felix.schlatter@grolimund-partner.ch

[2]ulf.sandberg@vti.se

[3]erik.buelmann@grolimund-partner.ch

[4]truls.berge@sintef.no

[5]l.goubert@brrc.be

1. INTRODUCTION

Low-noise tyres and road surfaces are two important solutions to the traffic noise problem that have the potential to reduce noise levels on roads at the source. Many European countries have therefore, with considerable success, invested in the construction of low-noise road surfaces as a noise abatement measure for new and existing road infrastructures. The dominating source of road traffic noise is the emission from the tyre/road interaction, which dominates even at speeds down to 20 km/h for modern cars. With the rising share of electric vehicles (EV:s), the noise problem in the future is likely to be dominated from tyre/road noise only (and possibly AVAS[6]). In the EU, tyre noise emission of individual tyres is limited, as defined in the EU Regulation 220/740, and shall be reported in the so called EU tyre noise label. However, in the past years, it has been demonstrated in several studies that the labelling system has a number of problems, for example that the noise labels in general do not correspond well with noise levels measured on market tyres by independent organisations [1, 2]. Therefore, it is of great importance to improve the tyre label and the corresponding testing procedure to further profit from the benefit of quieter tyres.

1.1. The purpose of STEER

The goal of the project STEER, which was carried out in 2019-2022 was to develop practical solutions that, firstly, improve the noise labelling for tyres with regard to its reproducibility and representativity, and, secondly, on measures that can be implemented by EU and national regulating bodies to create impact on European roads. A key objective is to encourage regulators as well as national road administrations to act on the scientific basis provided in this project.

This paper summarises the key findings of the project. Detailed reports on the project are published online[7].

2. THE EU TYRE NOISE LABEL

Label values are present for all kinds of products in our daily life. Labels help the consumer to identify the best products for their needs in an easy and understandable way. The same is true and applicable for tyres and their different performances [3]. The tyre has to fulfil various functions and thus, the tyre label includes some of the major characteristics. Since 2012, all tyres have to be labelled after a defined procedure, which was defined in EC 1222/2009.

2.1. Current label

From 1 May 2021, the tyre regulation has been changed to the new Regulation (EU) 2020/740 [4] amending the old Regulation (EU) 1222/2009. The main improvement is that the new regulation covers the fact that wet grip of winter tyres has no relevance for grip on winter roads. To correct for this problem with the old label, the major change is that there is now also a label of snow and ice friction of winter tyres (see Figure 1). Also, the new rules are extended to mandatory cover bus and truck tyres, which was only voluntary before. Furthermore, there is another important change: the previously three classes of noise emission have been changed to two only: *A* for *low noise* and *B* for normal tyres. The previous class *C*, though generally illegal, allows for the labelling of special tyres which are allowed one dB extra. Thus, in the new regulation only two classes are now possible to differentiate noise emission (see Figure 1). However, the noise level must be displayed in digits.

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[6] Acoustic Vehicle Alerting System

[7] https://www.cedr.eu/peb-research-programme-2018-noise-and-nuisance

[8] Source of the Image: https://ec.europa.eu/info/news/new-tyre-labelling-rules-apply-1-may-2021-2021-apr-29_en/

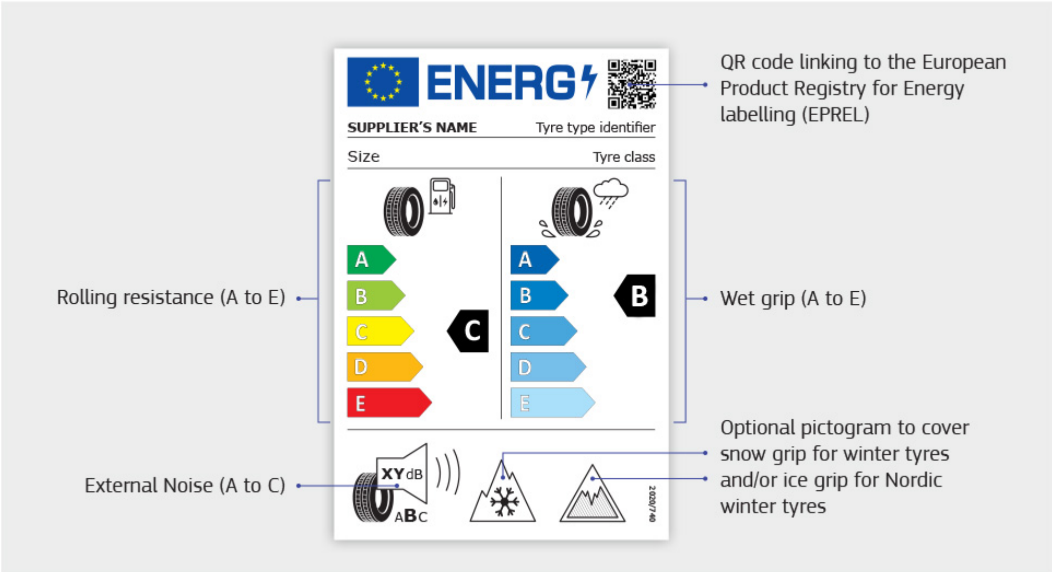


Figure 1: Description of the new tyre noise label.[8]

2.2. Label procedure & current limit values

The label procedure for the assessment of the "rolling noise" of tyres is defined in UN/ECE R117 [5]. The UN/ECE R117 foresees measurements by the means of a coast-by measurement (CB, [6]) on a defined dense asphalt concrete surface, which is specified (see section 2.3) with defined meteorologic conditions (requirements for temperature and humidity on surface apply). The resulting maximum rolling noise limit values for car tyres (C1) are defined in the following Table 1. For light trucks (C2) or heavy truck tyres (C3) different limit values apply (not shown here).

Table 1: Tyre noise limits according to EU Regulation 661/2009 for C1 tyres. [7]

Tyre class	**C1A**	**C1B**	**C1C**	**C1D**	**C1E**
Nominal section width	≤ 185	> 185 ≤ 215	> 215 ≤ 245	> 245 ≤ 275	≥ 275
Limit values in dB	70	71	71	72	74

2.3. The ISO 10844 test track

The current version of the ISO 10844 standard (version 2021, [8]) requires the surface of the test track to fulfil the following properties:

- Basic road surfaces type shall be a dense asphalt concrete
- Maximum chipping size and sieving curve are specified
- There are limitations for the Mean Profile Depth (MPD). The current version requires the MPD to be between 0.3 and 0.7 mm
- Absorption measured by *in situ* device with specification of max 8 % in each 1/3rd octave band

The test track surface, which was issued first time in the standard in 1994, was basically designed to generate minimal tyre/road noise and minimum variance. It was originally not intended to measure tyre/road noise on it but, nevertheless, the standard has been used since 1994 for tyre/road noise regulations and directives. Therefore, the surface still produces very low tyre/road emissions due to its fine-graded texture.

Practical experience with laying of test tracks in the past 5-10 years has indicated that it is difficult to construct road surfaces with closer tolerances than today at such low texture levels. Therefore, it would be better and easy to move the lower limit of MPD from 0.3 to 0.4 mm. This would reduce the admitted MPD variation (lowest to highest) from today's 133 % to 75 %. Simultaneously, test track surfaces that would be considered unsafe on highways due to wet friction concerns would not be used for noise testing. Some countries do not accept MPD values of less than 0.5 mm on highways.

3. REPRODUCIBILITY OF THE TYRE LABEL

Measurements are always bound by uncertainties. With high uncertainties, the reproducibility of a label is limited as well. Analyzing the uncertainties of the label procedure has revealed three important sources of uncertainties: (i) test tracks (ISO 10844 surface), (ii) test tyre and (iii) measurement conditions.

3.1. ISO 10844 test surfaces

In order to compare the different test-tracks, different Round Robin Tests (RRT:s) have been performed in the past two decades:

- RRT made by M+P in 2005, in Europe (7+2 test tracks) [9]
- RRT made by JSAE in 2006, in Japan (8 test tracks) [10]
- RRT made by VDA in 2016, in Europe (13 test tracks) [11]
- RRT made by ETRTO for ISO/TC 31/WG 11 in 2018 (?), in Europe (4 test tracks) [12]
- RRT made within the project ELANORE in 2021, in Europe (3 test tracks)

From all the RRT:s, substantial noise differences between test tracks have been found no matter when the tests have been performed. The RRT:s seem to suggest that there is a high difference in noise levels between the test tracks of up to 6 dB if all test tracks are included (depending on whether some tracks are excluded due to their absorption behaviour). Nevertheless, whichever tracks are considered, it is clear that the uncertainty from the test surface is too high to be acceptable and the influence is high on the tyre noise label.

In order to reduce the uncertainty, the differences and the influences of the individual test tracks, different strategies to reduce the site-to-site variation of ISO 10844 surfaces have been elaborated:

1. **Modelling of test track noise properties:** This has already been implemented in the so called END_T-Procedure (defined in the ISO 10844:2014 standard but deleted in the current version 10844:2021). A more sophisticated approach (MBBM-Method) has been published within a VDA study [11].
2. **Round Robin Tests (SRTT):** RRT:s may be performed at regular time intervals to determine how the track noise properties differ between each other or to a defined reference.
3. **Calibration by using reference tyres:** By selecting reference tyres with very stable tyre/road noise properties and measuring noise emission from them at regular time intervals on every ISO test track, the method can provide a relatively accurate measure of the test track noise properties. These can then be used to normalise the surface to a defined reference.
4. **3D printed reference surface:** Advances in 3D printing could be used to create a durable and very accurately copied test surface for the test track wheel tracks. This would allow to use the same surface (in the wheel tracks) on all the test surfaces worldwide. Although 3D printing is already possible, trials to lay such road surface replicas on an actual test track have not yet been published, but it is technically possible

Within the STEER project, the option for the calibration using reference tyres has been applied to calibrate the tracks with each other. This calibration requires a measurement according R117 on each test track with a standardised tyre (ISO/TS 11819-3). This results in an average correction factor for

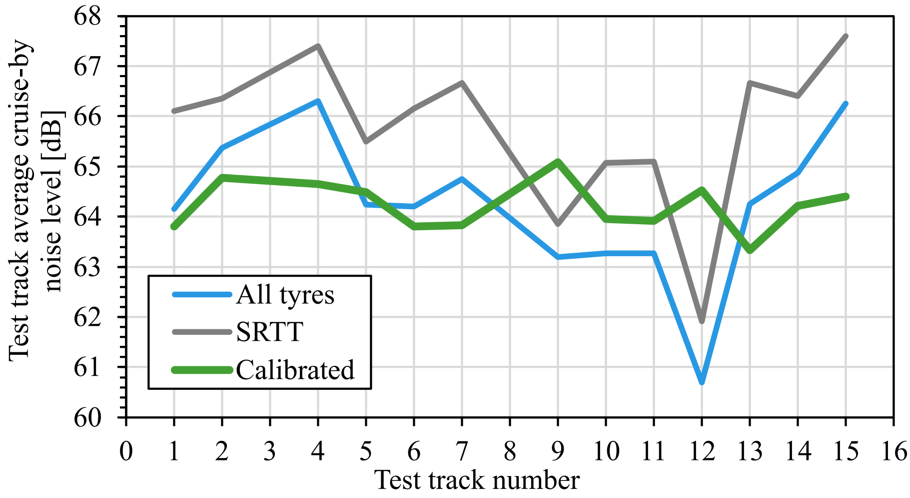


Figure 2: Proposed reference tyre calibration procedure.

the respective test track as illustrated in Figure 2, when using data from [13] as a basis and applying the calibration proposal by STEER.

As the surface properties change with time, it is suggested to repeat the calibration after a defined time interval. With the regular testing according to the *Reference Tyre Calibration procedure*, most of the variation and change in the test surface properties could be captured and taken into account. It has been estimated that the *Reference Tyre Calibration* could reduce the total uncertainty to a value of 0.55 dB (standard uncertainty). This significantly contributes to the reduction of the overall uncertainty.

Another promising (long-term) perspective vision of STEER is to mitigate the problem of different surfaces by the means of performing the measurements on a laboratory drum with a (defined and controlled) replica of a test surface. This is already performed for rolling resistance measurements [5]. With this approach, the two most serious uncertainty factors can be eliminated, namely the influence of the measurement conditions (outdoor climate) and the track surfaces variation. Further information about the STEER future vision is discussed in detail the final report from STEER.

3.2. Measurement conditions (Temperature correction)

The influence of temperature at the tyre type approval and label noise measurements may influence the measurements by up to 2 dB. Therefore, the measurement conditions have a huge impact on the noise label itself and the measurement conditions have to be controlled. ECE R117 (tyre labelling) requires that the measurements are corrected by the road surface temperature according to the Equation 1 to a reference temperature ($\vartheta_{ref} = 20°C$)

$$L_R(\vartheta_{ref}) = L_R(\vartheta) + K \cdot (\vartheta_{ref} - \vartheta) \tag{1}$$

STEER has identified that the correction factor K, as defined in ECE R117, is too low. STEER suggests the application of the following correction factors:

$$K_{\text{STEER}} = \begin{cases} 0.07, & \text{if } \vartheta < 20°\text{C} \\ 0.05, & \text{otherwise} \end{cases} \qquad K_{\text{R117}} = \begin{cases} 0.06, & \text{if } \vartheta < 20°\text{C} \\ 0.03, & \text{otherwise} \end{cases}$$

The suggested temperature conversion factors lead to slightly higher corrections. However, STEER has identified several topics for further research. Most important is to develop a new correction model which is based on both air and road temperatures combined, as it seems that the most important tyre temperature is influenced by both air and road surface temperatures. As recent data show, the current generic correction procedures provided in the current standards may not be suitable for application in different climatic regions and lead to significant errors that have not yet been taken into account [14].

4. REPRESENTATIVITY OF THE TYRE LABEL

The representativity of the tyre label includes the aspects of how the label compares to the real world. Several aspects could be identified that could be improved with regard to the representativeness of the label:

4.1. Differences between tyre variants within a tyre line

A *tyre line* refers to the same trade description, but its tyres have different dimensions, load indices or speed ratings. The labelling regulation does not require that all tyres are tested individually. Thus, it is current practice, that only the noisiest tyres within a so called tyre line are tested and the labels are applied to all the other tyres within this line. Within a popular tyre line there may be many different tyre variants (> 50), in the most extreme case all having the same noise label assigned. As often only the noisiest tyres within a tyre line are measured, the noise label tends to be overestimated within a tyre line; sometimes by more than 2 dB. For one of three tyre lines tested, all tyres had the same noise label although in measurements they were up to 6 dB different. This strongly limits the meaningfulness of a tyre label.

The problem was studied in a Swedish project, related to STEER, which is reported in another paper at this conference [15] and in more detail in [13]. To solve the problem,three different options for improving the labelling procedure were considered in the Swedish project and by STEER, where the two last ones have been designed to reduce the actual measurement efforts:

1. Measure all tyres using the current procedure acc. R117 (coast-by-method)
2. Use a simplified laboratory drum method to determine differences between tyre variants within a *tyre line* and use this difference to the type approval level, or another level measured according to R117, to assign the noise labels.
3. Use noise modelling to determine differences between tyre variants within a *tyre line*. Due to limitations of current noise modelling, this can be used to determine differences between tyres which are not so different in dimension or load or speed ratings, but when dimensions are very different, one would have to combine the method with some R117 measurements.

4.2. Regional distribution of surfaces and their representation by the ISO track

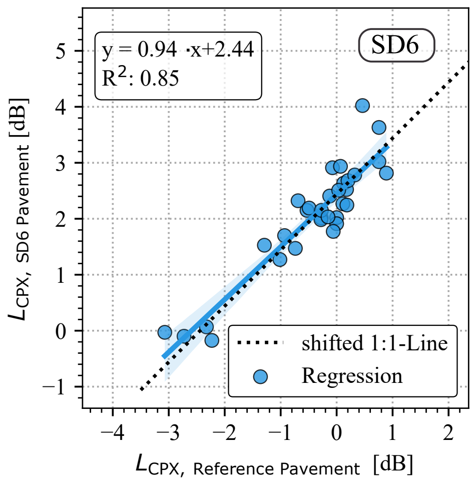
The ISO surface, which is used for tyre noise labelling has a quite smooth surface texture as already indicated in section 2.3. An analysis of the distribution of texture levels of the road network has shown that mostly secondary and local roads in the European countries with moderate traffic have smooth textured surfaces somewhat similar to the ISO 10844 surface. These road surfaces tend to offer favourable conditions in terms of the tyre/noise, as well as rolling resistance. The smooth textured road surfaces are reasonably well represented by the ISO surface, but only in the range of MPD values between 0.5 and 0.7 mm. Road surfaces on the high-speed network are in most countries of larger aggregate size (SMA 11 or SMA 14 or exposed aggregate cement concrete road surfaces). They belong to a medium texture range which offer required safety properties (good wet grip). Consequently, the ISO surface in the MPD range under 0.5 mm has no resemblance to common road surfaces and the range of 0.5 to 0.7 mm is uncommon on high-speed and heavily trafficked roads, but common on low-speed roads.

In order to reduce the difference between the smooth ISO tracks and the medium textured high speed road network, it would be favourable to reduce the extremely large range of MPD allowed for the construction of ISO surfaces to the range of 0.5-0.7 mm, or for practical reasons at least not below 0.4 mm.

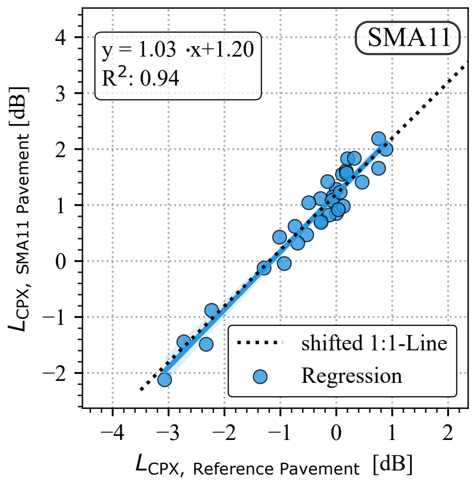
4.3. Performance of tyre labels on different surfaces

Surfaces with textures comparable to the ISO test track tend to rank tyres in a similar way. For rough textured surfaces, the ranking of the C1 tyres starts to deviate if one compares the labelled values to the measured values [2]. This is not the case for truck tyres as has been demonstrated in the NordTyre project [1]. The comparison of labelled values vs. measured values leads thus to low correlations. This is however mostly due to the reproducibility and representativity issues of the labelled value itself as discussed in this paper (see sections 3.1, 3.2, 4.1).

Figure 3 shows measurements on two different surfaces with a set of 15 different tyres using the CPX system (re-evaluation of data presented in [16]). The measured values were related to a fine textured reference surface (in analogy to the ISO test surface), which was also measured with the CPX system.



(a) Surface dressing w. 6mm aggregate size



(b) SMA11

Figure 3: Comparison of normalised measured noise level (Using CPX system) compared to the noise level of a reference road surfaces (CPX system). Data from [16]

Figure 3 shows rather good correlations for both surfaces, suggesting that the tyres (also C1 tyres) basically also work on medium textured surfaces (3b) with regard to rolling noise (loud tyres are loud as well on other surfaces and vice versa). It also illustrates that the labelled values are subject to the problem of reproducibility and representativeness. Thus, with an own reference (measured with the same device, for each tyre separately, with very comparable temperatures) clearly differentiable results can be achieved.

5. SCENARIOS AND PROLIFERATION OF QUIETER TYRES

In 2016, a study revealed that the consumers are aware of the tyre label [17]. But it was also shown that noise is currently not a decisive purchase criterion. The most important decision criterion is still the safety aspect (wet grip), followed by the price of the tyre. However, other studies have shown that quiet tyres do not necessarily have to be expensive. [3].

5.1. Impact of quiet tyres on the European Road network

Within the project an estimation has been performed, how different measures could increase the proliferation of quieter tyres. A total set of three different scenarios has been investigated regarding their impact on the road network of the EU and the annoyance of the population. These scenarios are shortly described below:

1. **Scenario 1, ECE proposal**[9]: Proposal for the reduction of tyre noise limit values according a proposal to ECE.
2. **Scenario 2, Industry agreement**: Output oriented noise reduction. Total fleet value of sold tyres must not exceed a certain threshold. Mechanism comparable to Regulation (EU) 2019/63 on maximum CO_2 emissions for passenger cars
3. **Scenario 3: Consumer incentives**: Financial incentives for consumers to buy tyres having the best label values .

The estimation showed that with the proliferation of the quieter tyres using the scenarios, substantial noise reductions of up to 1.5 dB in 2030 and up to 2.5 dB in 2040 could be achieved. Regarding the health and annoyance costs, the following annual benefits for selected countries could emerge (Figure 4). The analysis of the benefits shows that the scenario 2 *Industry agreement* as well as the scenario 3 *Consumer incentives* provide slightly higher benefits than the simple adjustment of noise limits.

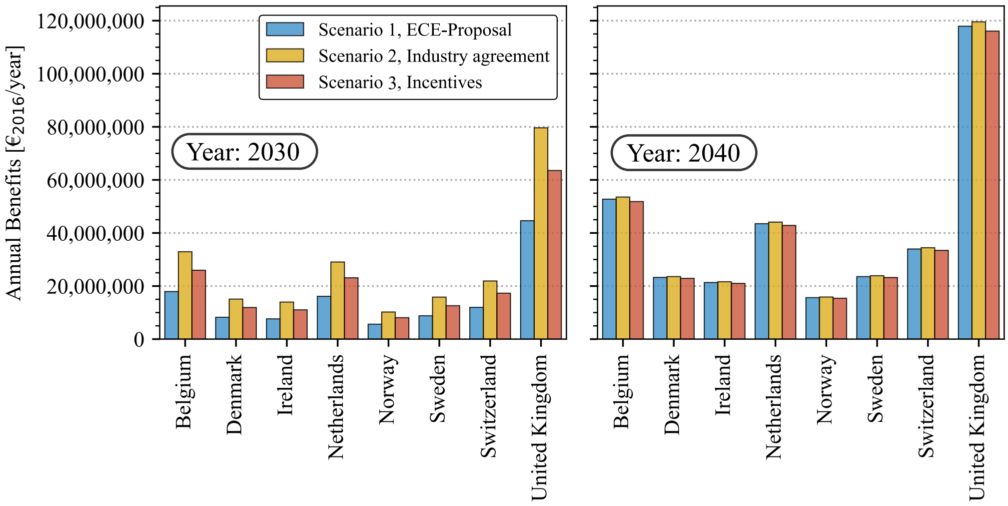


Figure 4: Relative annual benefits for selected countries and different scenarios for two different target years.

5.2. Available Tyres on the market

A tyre has to fulfil various functions, as it is one part in the tyre/road interaction for the moving vehicle. Therefore, various functions have to be fulfilled. First of all, it shall ensure the safety of the drivers, but also the environment is an important aspect to consider. Furthermore, rolling resistance should be as low as possible and the tyre construction has to be optimised also in terms of wear and noise emission. The optimisation of tyres for all parameters is subject to different trade-offs between important tyre properties, which have to be balanced. As for all products, this is the common case in the product development cycle.

Within the project STEER, it was possible to analyse a database of all approved C1 tyres for Switzerland for the year 2021. The analysis was done to evaluate, if there are quiet tyres on the market that have at the same time good rolling resistance *and* wet grip characteristics. The results are shown in Figure 5, the different colours show the combined ratings of wet-grip and rolling resistance index. Each pie chart indicates the share of the rated tyres in the respective noise-class (hypothetical Y axis) and tyre width (hypothetical X axis).

[9]Informal document GRB-62-11-Rev.1, 64th GRB, 5-7 September 2016, agenda item 7

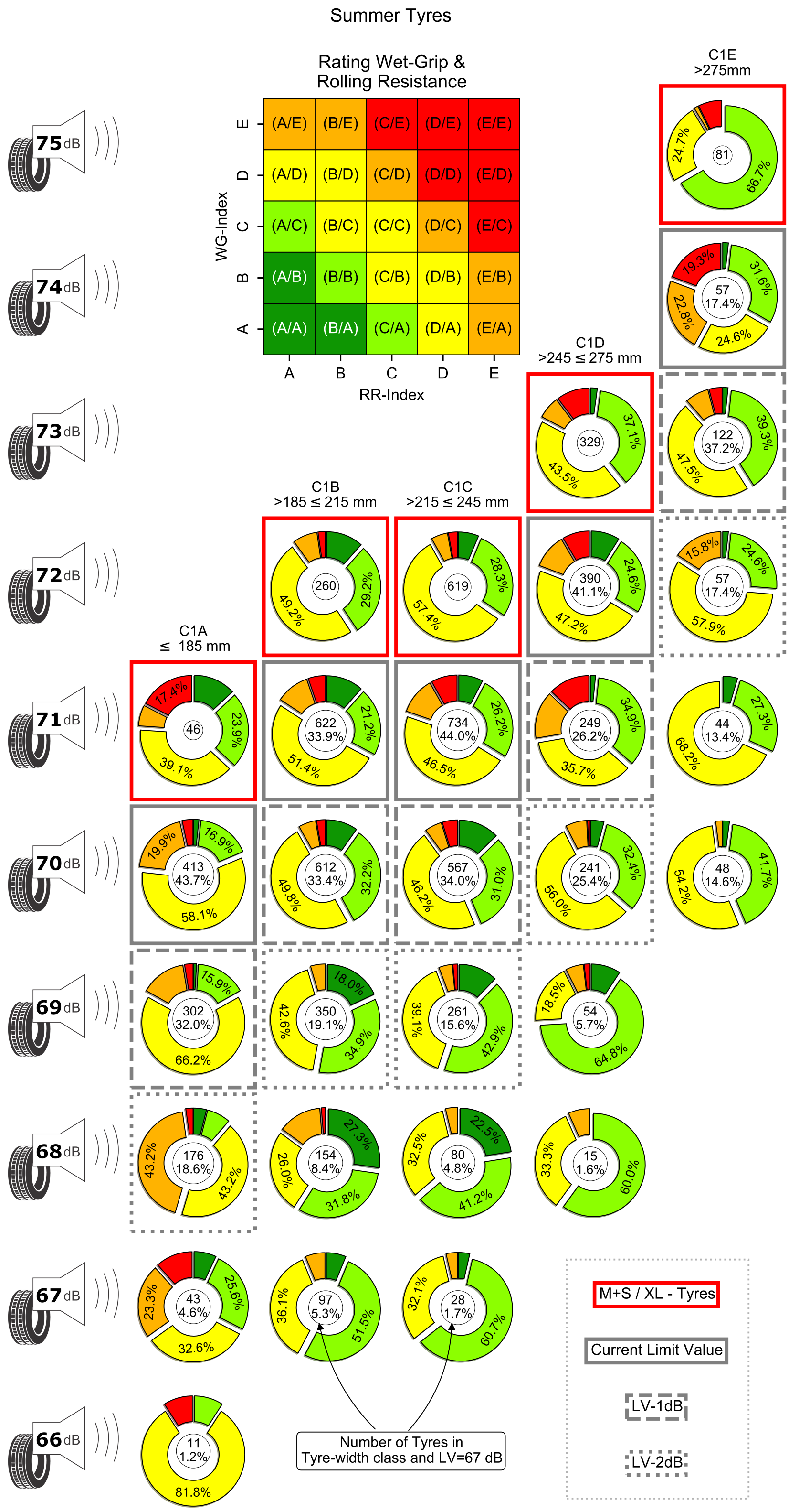


Figure 5: Distribution of available tyres according to their combined rating of noise, rolling resistance and wet grip.

The analysis illustrates that, according to the database, there is a reasonable number of tyres that have excellent labelled values in terms of all three analysed categories (noise, wet grip and rolling resistance combined). From the analysis, it is furthermore evident that the share of available tyres with good characteristics in all three labels is not decreasing with lower noise values. For most of the analysed tyre widths, the share of well performing tyres (green colours) is even increasing with lower noise levels. This is especially true for the tyre widths C1B, C1C, C1D and to some degree also the widest tyres C1E. Regarding the absolute number of tyres, the analysis shows that the majority of the tyres are located close to the allowed limit values. With lower noise values, the number of available tyre models is decreasing.

This kind of analysis strongly depends on the reported label values, but it shows that it is generally possible to find a tyre option that is quiet, low in rolling resistance *and* good in terms of wet grip performance.

5.3. Consideration of future trends

Following the ongoing shift from fossil-fuel-driven vehicles (ICE:s) towards electric driven vehicles (EV:s), total vehicle noise is expected to decrease. At first sight, this is a favourable trend for noise emission in urban driving situations but the popularity of the heavier SUV:s as well as the increased weight of electric vehicles needing larger tyres may increase tyre/road noise. Generally, a trend of wider tyres has been observed in the past decades. With the planned ban on ICE-driven vehicles by 2035, noise emissions will be increasingly dominated by the tyre/road interactions, increasing the overall importance of tyres

6. CONCLUSIONS AND RECOMMENDATIONS

The STEER project showed that the European tyre label system is an important tool for the consumers to find their most suitable tyre on a big market. It is absolutely unquestionable, that the labelling strategy should be pursued also in the future. Within the project STEER several aspects regarding the tyre label itself or the testing procedure have been identified, which should be addressed. These aspects are discussed in this section. The resulting (reduced) uncertainty, after implementation of the measures are discussed in the chapter 6.2

6.1. Urgent need for improvements of the current noise labelling procedure

- Implement a *Reference Tyre Calibration* procedure to compensate for the acoustic variability of ISO test tracks. (see section 3.1)
- All tyre variants within a tyre line shall be labelled on the basis of individual measurements (or calculations) and not only by testing one or a few tyres within a line.
- To simplify the testing requirements, STEER suggests two options where labelling is based on determining differences between noise levels within a tyre line in relation to one or more tyres measured in the current way.
- Such differences can be determined either by measurements with a laboratory drum method, or by simulation or modelling tyre noise differences.
- Implement stricter requirements for test vehicles (focus on ground clearance and wheelbase) to limit the vehicle influence on the label value.
- Improve the temperature correction procedure according to the solution offered in Section 3.2.
- Clarify the noise label better: The noise label should again have three legal classes, as it had before 2021. However, each class may have a range of 2 dB instead of 3. The labelled noise level shall still be stated, in addition to the class.

6.2. Updated uncertainty of the tyre noise label after implementation of the proposals by STEER

Within STEER different uncertainty sources have been evaluated in terms of the minimum and the maximum uncertainty contribution (standard deviation) [18]. Figure 6 illustrates the mean uncertainty (with min/max contributions) for the different groups. From the Figure it is evident, that the overall uncertainty of the tyre labels amounts to 1.4 - 2.0 dB. The main contribution is assigned to the uncertainty of the test track, followed by the uncertainty of the test tyres. The test vehicle, as well as the measurement conditions have also important contributions to the total uncertainty.

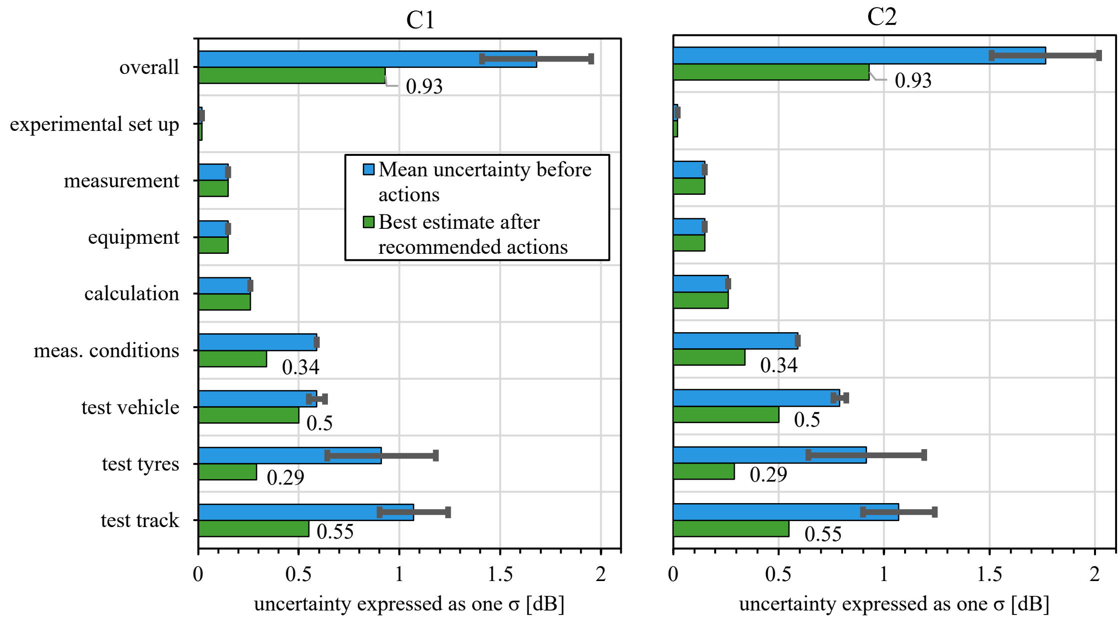


Figure 6: Uncertainty contributions per uncertainty group – expressed as standard deviations – for the current tyre noise label procedure (minimum and maximum estimation) and for the situation after implementation of the STEER actions in the procedure, calculation for the C1 tyres (left) and for the C2 tyres (right)

ISO test track: Within the STEER project, the analysis of various existing RRT:s has shown that the variation of the acoustic quality on the test tracks is too large and thus introduces a high uncertainty into the labelling procedure, as can be seen in Figure. 6. With the proposed acoustic calibration of the test tracks, the uncertainty of the test track can be almost halved.

Improvement on test tyres: As the analysis has shown, a big improvement can be achieved in the test method of tyre lines.

Improvement on measurement conditions (temperature correction): As indicated in the previous section 3.2, temperature correction has a big influence. It is expected that with the updated temperature correction, the uncertainty can be improved.

Improvement on test vehicle: As indicated in Figure 6, the test vehicle has a certain influence on the total uncertainty. If the other uncertainties (test track and test tyres) are lowered, then this factor gains more importance. Therefore, it is advisable to implement stricter requirements for test vehicles. Thereby the focus should be laid on ground clearance and the wheelbase as well as the specification of the car underbody. STEER has identified that the influence of the test vehicle should be minimized in order to influence the label as little as possible. It is estimated that the influence of the vehicle is higher for C2 tyres than for C1 tyres.

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