Submitted by OICA Experts

Comparison of EMISIA and ATEEL study on sound limit values for vehicle category M & N

Review study performed by ATEEL on behalf of OICA / ACEA

TFVS-10-04

Comparison of EMISIA and ATEEL study on sound level limits of M- and N-category vehicles

Interim results | 10th TF-VS

July 2022

Content

- Comparison of study approaches and findings - ATEEL vs EMISIA study
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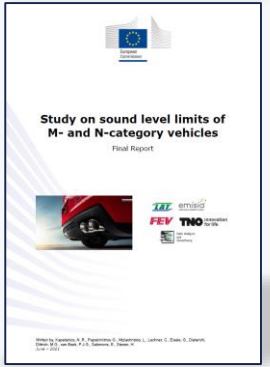
- Reflections on Benoît Fauville study (Testing the noise emission of individual motor vehicles in the Brussels-Capital Region (2022))
- Representativeness of type approval values for real traffic situations other than the type approval condition
- Conclusions and recommendations

Comparison of study approaches and findings ATEEL - EMISA

Comparison of study approaches – ATEEL vs EMISIA study

ATEEL study focus

- Analysis of survey feedback from technical entities (technical feasibility towards lower sound)
- Development of realistic vehicle sound models (powertrain and tyre) per category and limit phase
- Benefit analysis of a further limit value reduction beyond phase 3 for real traffic conditions
- Comparison of type approval limit reductions with alternative measures (tyre road interaction – speed limits)
- Sensitivity analysis vs. individual input parameters (road / weather / market penetration speed etc.)
- Determination of most efficient measures and consequences depending on driving conditions



EMISIA study focus

- Analysis of survey feedback from technical entities and social partners
- Analysis of potential to reduce limits beyond phase 3 limits based on TA (type approval) data, survey input and own measurement data
- Identification of weak points in current TA procedure (mismatch vs. real life conditions?)
- CBA (Cost Benefit Analysis) of several potential scenarios and combination of scenarios
- Proposal of new limit values and discussion about room for improvement of TA procedure to better reflect reality

- The ATEEL study mainly focuses on the benefits that can be achieved by theoretical limit value reductions (no CB analysis)
- The EMISIA study focuses on the CB analysis based on limit value reductions or changes in TA procedure

ATEEL review of EMISIA study feedback from technical entities and social partners

ATEEL understanding of feedback from technical entities

- Essence of feedback received during EMISIA study is almost identical to answers received during ATEEL study
- Technical limit for most vehicle categories already reached with Phase 3 limits*
- Lowering limits without the availability of significantly quieter tyres are not considered possible
- Even most EVs would struggle to meet limit values below phase 3 limits due to the need of wider tyres and higher tyre load indices (extra weight compared to standard IC vehicle version – battery)
- Test procedure needs to be reviewed in specific fields (measurement uncertainties, hybrid vehicles, RD ASEP)

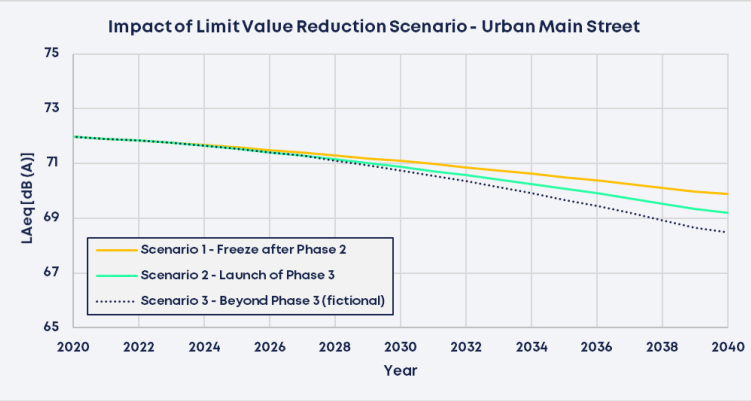
ATEEL understanding of feedback from social partners

- Responses are quite emotional and it is unclear whether the feedback addresses actual type approved products and therefor the technical progress achieved
- People are mainly disturbed by single events, manipulated or defect cars, bad driving style, over speeding etc. – besides ASEP which addresses "hectical" driving style to a certain extend, this can not be fully controlled by lower TA limits
- People appear to think that the manufacturers could compensate all traffic issues (increasing traffic, inappropriate drivers behaviour, manipulated cars etc.) by lower TA limits - TA limit value reductions will not solve the majority of the mentioned problems in most driving scenarios

* *"technical limit" means that further reduction of exterior sound creates trade-offs in other disciplines which industry is convinced, that these trade-off are not acceptable.*

- Feedback from technical entities: In line with feedback received by ATEEL – technical limit already reached with phase 3
- Feedback from social partners: Most problems mentioned in feedback are single event based and not linked to TA values or procedure – can´t be solved by reduced limit values

Scenario description – ATEEL approach



Source: ATEEL Study on future sound limit values for type approval for vehicles of category M & N (2022)

Reminder - Scenarios as used in ATEEL calculation

- Scenario 1 - Freeze limits after implementation of phase 2 (baseline)
- Scenario 2 - Launch of phase 3 limits as given by EU Regulation (status quo of the current regulation)
- Scenario 3 - Further limit reductions beyond phase 3 by -2 dB(A) - (fictional / technical feasibility not confirmed - phase 4) (4 years after phase 3)

Remarks

- To comply with the limits of scenario 2 and 3, a combination of improvements on both partial sound sources, the power train (PTR) and the tyre rolling sound (TR), is assumed in each case
- While scenario 2 is based on realistic improvements on PTR and TR, the feasibility of scenario 3 is not at all confirmed by the vehicle and tyre industry and just calculated for curiosity – “what would it bring if we could” scenario
- A market growth of e.g. 1 % was not considered during the calculations in the ATEEL study because only the difference between the scenarios (delta) was considered to be important

Scenario description – EMISIA study approach as understood by ATEEL

Scenario	Definition by EMISIA as understood by ATEEL	Comments from ATEEL	Comparability of approaches
0 - Baseline	Vehicle limits (acc. EU 540/2014 incl. phase 3) and tyre limits (acc. EU 2016/1350 stage 2)	Unclear which sound levels are assumed as baseline as contradictory information is provided (2-times 2 dB(A) benefit too high, not all vehicles on the limit)	To a certain extend comparable to ATEEL scenario 2 – no tyre contribution considered in EMISIA study
A - Available limit space	-1 dB(A) for all categories (Phase 4) (no reductions via tyres considered)	Provides a maximum benefit of 0.3 dB(A) using limits not in line with the final proposal of the study, e.g. M1-a representing 98% of M1	ATEEL study does not see a chance for lower limits beyond phase 2 without contribution of tyres (most quiet tyres required to comply with limits)
B - Targeted limit tightening	1 dB(A) for all categories but -2 dB(A) for busses, lorries and trucks (Phase 4)	Provides a maximum benefit of 0.5 dB(A) using limits far beyond the proposal	Same as A but lower values for trucks and lorries – considered by ATEEL as not feasible especially without contribution of tyres

Scenario description – EMISIA study approach as understood by ATEEL

Scenario	Definition by EMISIA as understood by ATEEL	Comments from ATEEL	Comparability of approaches
C - 75 dB(A) cap	-3 dB(A) Lwot limits for M3 & N3	Unclear what is meant in detail	No such scenario in ATEEL approach
D - Lwot restrictions	Stricter limits on Lwot for all categories by 2030	Realistic acceleration levels in real traffic need to be determined – not relevant for fluent traffic scenarios	No such scenario in ATEEL approach
E - Improved pass-by-test	Better representation of powertrain noise without changing the limits	Again question on realistic accelerations in real traffic – same acceleration for all vehicles in intermittent traffic (even ones with high PMR)	Not considered in ATEEL approach – R51.03 considered more appropriate and representative compared with R51.02
F - Quieter tyres	Tighter tyre noise limits by 3 dB(A)	Provides highest maximum benefits of 1.5 dB(A) in urban and 1.9 dB(A) in non-urban – but unrealistic reduction of tyre sound assumed (limit reduction does not lower sound level of quiet tyres – only the ones from the upper end will be excluded)	ATEEL study does not see strong improvements from tyre industry (feedback from industry) – certain benefit possible assuming that tyres are used in “real life” which are significantly louder than the ones used during TA testing

Scenario benefits calculated in EMISIA study – ATEEL comments and conclusions

Scenario	Lden		Lnight		ΔLden		ΔLnight	
	Urban	Non-urban	Urban	Non-urban	Urban	Non-urban	Urban	Non-urban
0. Baseline	59.4	67.2	50.8	58.5	-	-	-	-
A. Available limit space	59.1	67.1	50.5	58.4	-0.3	-0.1	-0.3	-0.1
B. Targeted tightening	59.0	67.0	50.4	58.4	-0.4	-0.1	-0.5	-0.2
C. 75 dB(A) cap	59.1	67.0	50.4	58.4	-0.3	-0.1	-0.4	-0.1
D. LWOT restrictions	59.2	67.1	50.5	58.4	-0.2	-0.1	-0.3	-0.1
E. Improved test	59.0	67.0	50.3	58.4	-0.5	-0.1	-0.5	-0.2
F. Quieter tyres - 3dB	57.9	65.2	49.4	56.6	-1.5	-1.9	-1.5	-1.9
Scenario A & F	57.5	65.1	48.9	56.4	-1.9	-2.1	-1.9	-2.1
Scenario B & F	57.3	65.0	48.7	56.3	-2.1	-2.2	-2.2	-2.2
Scenario A & E	59.0	67.0	50.3	58.4	-0.5	-0.1	-0.5	-0.2
Scenario B & E	58.8	67.0	50.2	58.3	-0.6	-0.2	-0.7	-0.2
Scenario D & E	59.0	67.0	50.3	58.4	-0.5	-0.1	-0.5	-0.2
Scenario E & F	57.3	65.0	48.7	56.4	-2.2	-2.2	-2.1	-2.2

Lden and Lnight values in dB(A) and reductions for the baseline and alternative scenarios (in dB) 2015 - 2045

Source: EMISIA Study on sound level limits of M- and N-category vehicles (2021) – page 220

ATEEL comments and conclusions on the calculations in CBA

- Scenarios A to E: Realised by only powertrain measures and adaptation of the test method – provide a maximum benefit of 0.5 dB(A) compared to baseline (phase 3)
- TA value reductions, reached by only PTR sound reduction appear not realistic since a PTR sound reduction of min. 3 to 5 dB(A) would be required – even higher than ATEEL scenario 3
- Lowering the type approval limits does not necessarily result in lower sound emissions in real traffic and on all street types
- Only road types with intermittent traffic (1 & 3 in CBA) have potential to benefit from lower PTR sound (27% of concerned people)
- Road types with free flowing traffic (2 & 4) and/or higher speeds (5 to 8) benefit almost exclusively from tyre noise reduction (addressed by improved tyres in scenario F)

- Highest benefits expected from quieter tyres or usage of low noise asphalts
- Progress on vehicles (powertrain) can only be expected in conjunction with quieter tyres and/or better asphalts

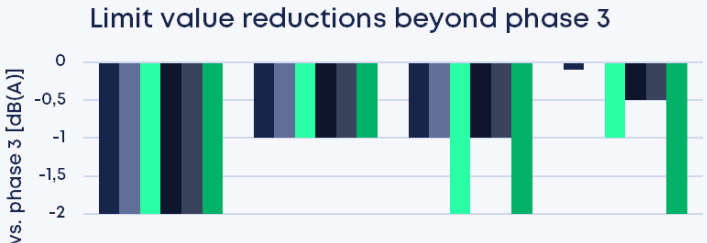
Comparison of performed calculations

General comparison of calculation models

ATEEL study	EMISIA study
Individual benefit display for each road type, driving speed, traffic condition (intermittent, free flow)	One single value calculated for a combination of 8 street types with significantly different boundary conditions
Calculations based on most realistic assumptions derived from TA databases, literature, EU registration data, etc.	Calculations based on the assumption that vehicles are all just in line with limit values? – not fully clear
Sound levels and the respectively achievable benefits calculated with an emission model with reference to the type approval microphone distance at 7.5 m	Sound levels respectively benefits calculated for facade levels (source to receiver distance differs for different streets)
Efficiency comparison of PTR/tyre measures with alternative measures (e.g. speed limits, silent asphalt)	ATEEL did not find any detailed discussion about alternative measures being included for comparison during review
Sensitivity analysis in order to understand impact of wrong assumptions in input parameters (“extreme scenarios”)	No sensitivity checks found by ATEEL during review
Individual simulations specifically for individual vehicle category (e.g. only N3) or type (e.g. only EV) possible	No individual discussions found by ATEEL during review

Impact calculations using ATEEL simulation tool

Comparison of ATEEL scenario 3, EMISIA proposal and CBA scenario A and B:



	ATEEL	EMISIA CBA Scenario A	EMISIA CBA Scenario B	EMISIA final proposal
M1	-2	-1	-1	-0,1
M2	-2	-1	-1	0
M3	-2	-1	-2	-1
N1	-2	-1	-1	-0,5
N2	-2	-1	-1	-0,5
N3	-2	-1	-2	-2

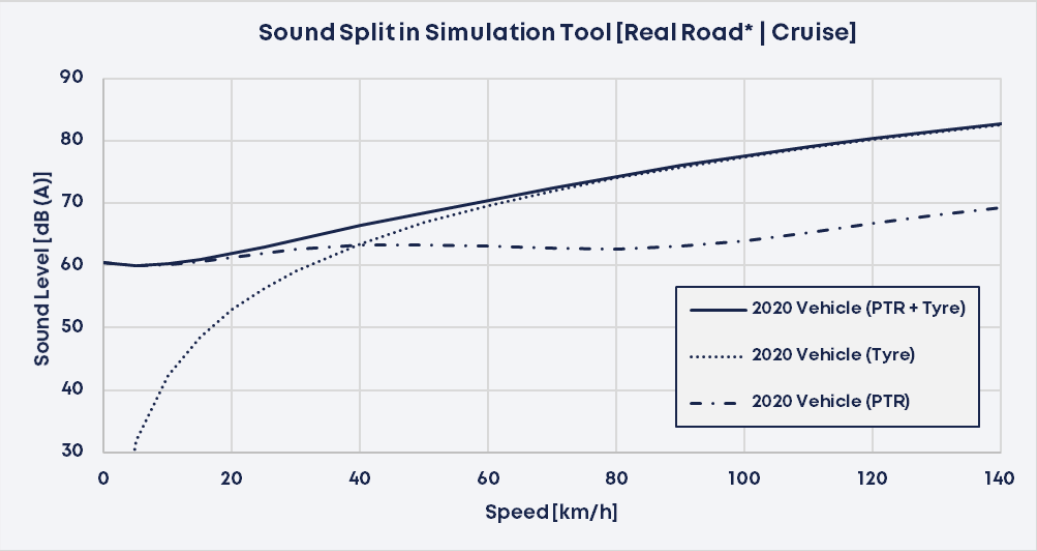
Reminder:

Vehicles of categories M1 and N1 create about 80 – 95 % of the traffic volume, dependent on traffic scenario

- ATEEL scenario 3 is the most stringent limit reduction scenario beyond phase 3 (-2 dB(A) for all categories)
- ATEEL scenario 3 is a non-confirmed fictional scenario with the assumption that PTR and TR measures are required to meet the limits
- CBA scenario A and B are understood as realised only with PTR (powertrain) improvements - according assumptions regarding ATEEL scenario 3 considered unfeasible high level of PTR reduction
- EMISIA final proposal is based on feasibility assumptions after their evaluation of TA data and their own measurement data
- Category N3 vehicle reductions appear unrealistic high since the margin in TA vs. limit is required for good reason (manufacturer feedback)
- ATEEL has aggregated EMISIA final proposal for individual sub categories to the major vehicle categories for better comparison

- Considering the minor limit reductions of the EMISIA final proposal compared to EMISIA CBA scenarios A and B, the benefit is expected to be marginal (< 0.1 dB(A)) using the EMISIA calculation approach

Impact analysis on real traffic – vehicle sound model as used in ATEEL calculation tool



Remark: The ATEEL sound emission model is aligned to the type approval procedure and the reference distance of 7,5 meter

Example M1 ICE – Real Road*

- The tyre sound in the ATEEL model is relatively low compared to the measurements in the EMISIA study:

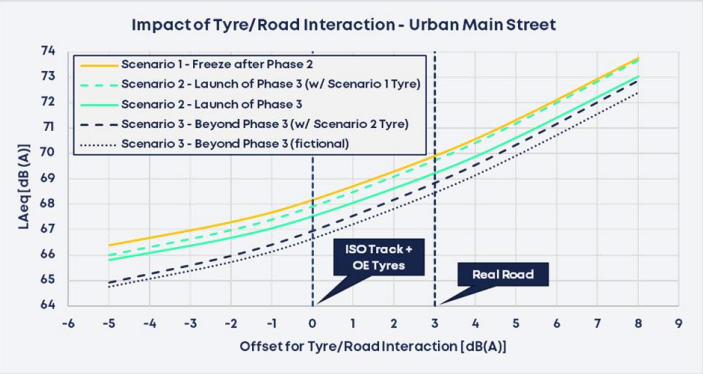
  The level of ≈ 67 dB(A) for "Real Road" TR sound is well in line with the measured values for TR sound in the EMISIA study (on ISO track)

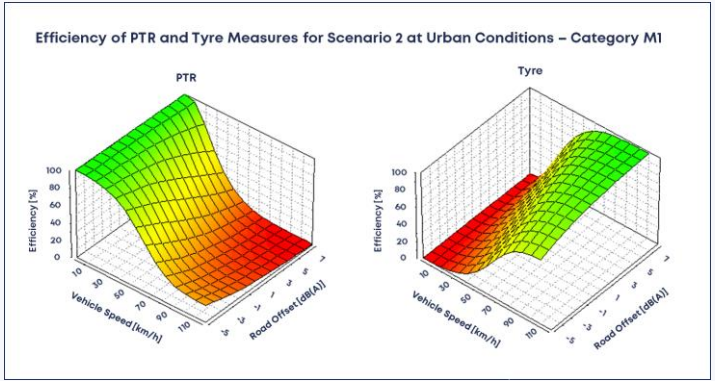
  The tyre sound level model in the ATEEL study for ISO surface at 50 km/h is about 3 dB(A) lower than the measured values for the tested vehicles in the EMISIA study
- In the EMISIA measured data, the tyre rolling noise and the cruise sound level, are almost the same level (even lower powertrain contribution than assumed in ATEEL model)

- A further reduction of only the powertrain would shift the balance further towards the tyres, even for lower driving speeds

* Real road surface is assumed to be +3 dB(A) above ISO (similar to CNOSSOS correction)

Key findings from ATEEL calculations – transfer TA values into real traffic





Improvements achieved by lower type approval values do not necessarily lead to lower vehicle sound in real traffic

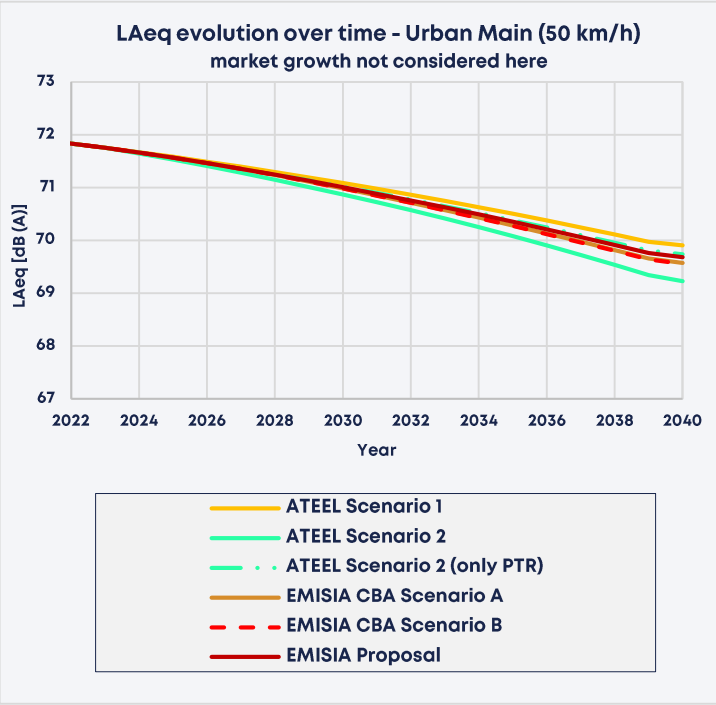
- Rolling noise typically increases under real road conditions (road surface type, louder tyres, meteorological conditions)
- Variable driving speeds in real traffic
- Only new vehicles impacted by limit value reductions
- Numerous new vehicles already show compliance towards phase 3 limits

Low efficiency from powertrain improvements

- Powertrain contribution only dominant at lower driving speeds
- Powertrain improvements only available at lower driving speeds (e.g. residential areas) and in combination with optimised tyre / road interactions
- Any reduction in TR sound is very efficient at higher vehicle speeds and especially on noisier road surfaces

- Measures on powertrain can only contribute in “real life” efficiently in combination with quite tyres and road surfaces

Comparison of proposed reductions beyond phase 2 - ATEEL calculation tool - urban 50 km/h



Simulation using the EMISIA approach (PTR only)

- Scenario 1 is representing vehicles up to phase 2 of R51.03:

  The reason for the lower sound levels over time is the exchange of older vehicles by new ones with lower sound emissions (market penetration)

- Scenario 2 includes phase 3 and is seen as baseline, similar to EMISA approach:

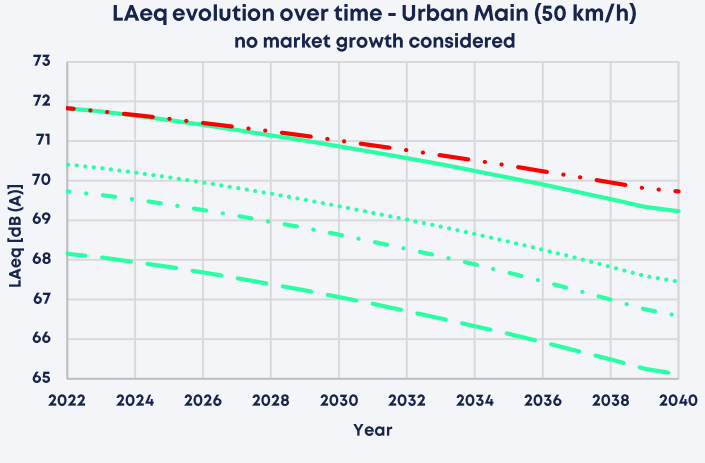
  The main benefit is achieved by tyre improvements in TA (total reduction is 0.7 dB(A) of which 0.5 dB(A) is coming from the tyre

- Achievements compared to scenario 2 via PTR only (baseline) are summarised in the following table

Year	ATEEL scenario 1	ATEEL scenario 2	ATEEL scenario 2 only PTR	EMISIA CBA scenario A only PTR	EMISIA CBA scenario B only PTR	EMISIA final proposal only PTR
2022	71.8 (0)	71.8 (0)	71.8	71.8 (0)	71.8 (0)	71.8 (0)
2040	69.9 (+0,2)	69.2 (-0.5)	69.7	69.6 (-0.1)	69.5 (-0.2)	69.7 (0)

- No significant sound level reduction by any of the calculated vehicle (PTR) measures

Comparison of proposed reductions beyond phase 2 - ATEEL calculation tool - urban 50 km/h



Simulation using alternative measures (asphalt, speed limit)

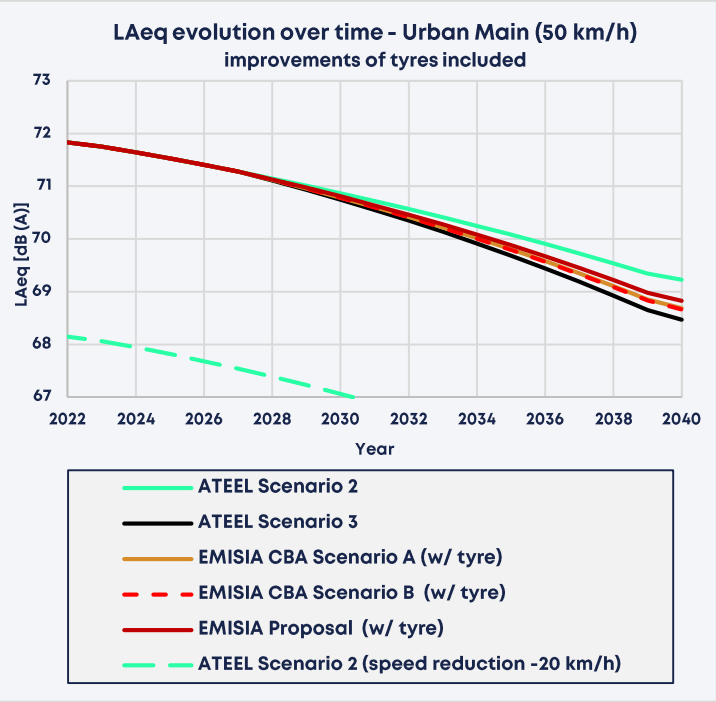
- Sensitivity of alternative measures in comparison with ATEEL scenario 2 using the original ATEEL assumption (progress on TR and PTR) and ATEEL scenario 2 using the EMISIA assumption (progress on PTR only)

Year	ATEEL scenario 2	ATEEL scenario 2 only PTR	ATEEL scenario 2 (ISO track)	ATEEL scenario 2 (low noise asphalt*)	ATEEL scenario 2 (speed reduction -20 km/h)
2022	71.8	71.8	70.4 (-1.4)	69.7 (-2.1)	68.1 (-3.7)
2040	69.2	69.7	67.4 (-1.8)	66,6 (-2.6)	65.1 (-4.1)

* -2 dB below ISO 10844 asphalt

- The calculated alternative measures provide significantly higher sound level reductions – immediately from day of implementation of measure – all vehicles concerned, not only phase 4 vehicles

Comparison of proposed reductions beyond phase 2 - ATEEL calculation tool - urban 50 km/h



Simulation using the ATEEL approach (PTR and TR)

- In difference to the EMISIA study the ATEEL calculations considered PTR and tyre measures (0.5 – 1 dB(A) depending on vehicle category per scenario step)
- The achievements by scenarios from EMISIA study show a max. reduction of 0.5 dB(A) compared to the reference scenario 2 (baseline scenario) in 2040
- A speed reduction of 20 km/h would provide a calculated sound reduction between 3.7 dB(A) in 2022 and 4.1 dB(A) in 2040

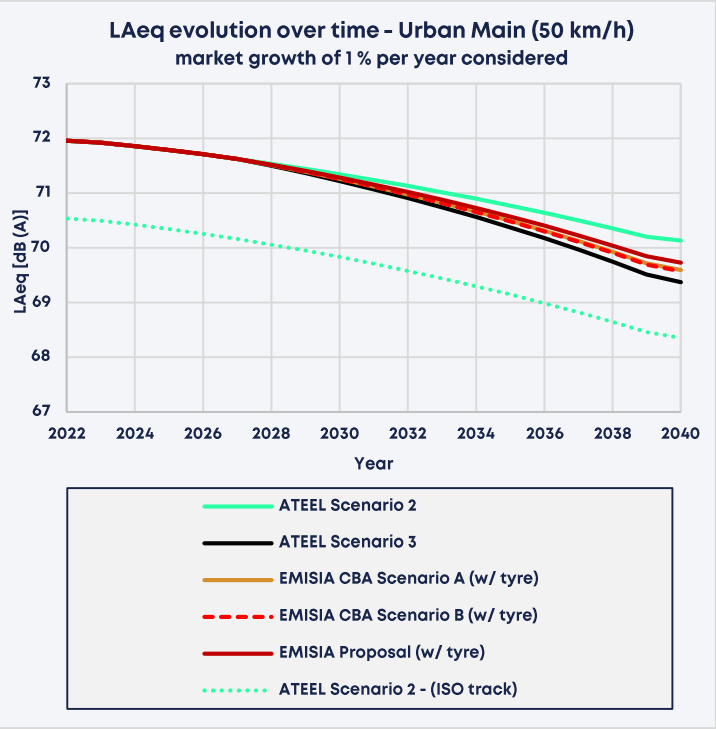
Year	ATEEL scenario 2	ATEEL scenario 3	EMISIA CBA scenario A (w/ tyre)	EMISIA CBA scenario B (w/ tyre)	EMISIA final proposal (w/ tyre)	ATEEL scenario 3 Speed reduction (-20 km/h)
2022	71.8	71.8 (0)	71.8 (0)	71.8 (0)	71.8 (0)	68.1 (-3.7)
2040	69.2	68.5 (-0.7)	68.7 (-0.5)	68.7 (-0.5)	68.8 (-0.4)	65.1 (-4.1)

Remark:

The assumption is made that customers continue to use the OE tyres over the whole life cycle of the vehicle

- The theoretical benefit achievable by powertrain/vehicle measures is still very limited (even considering quieter tyres over time) compared to alternative measures like speed reductions through speed limits

Comparison of proposed reductions applied to ATEEL calculation tool- urban 50 km/h



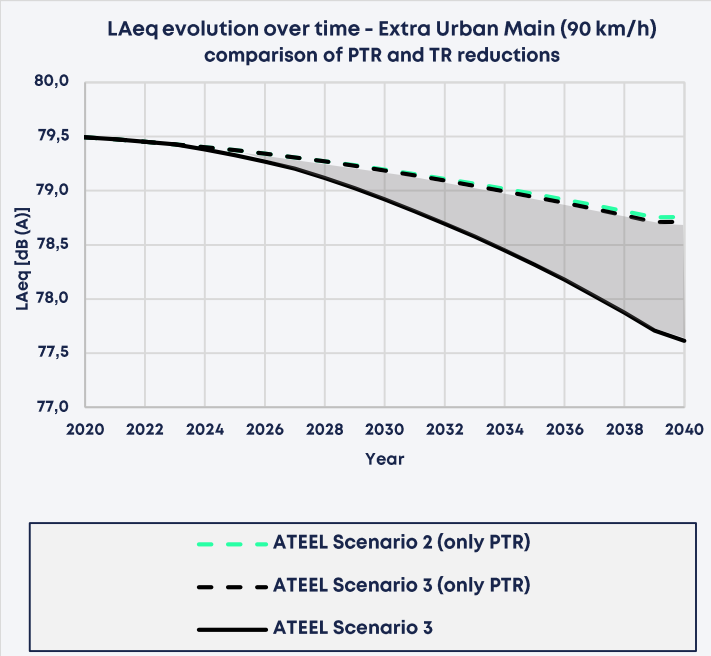
Consideration of 1 % market growth per year (EMISIA assumption)

- The implementation of the parameter market growth into the calculation is changing the shape of the curves and lifts up the level by ≈ 0.9 dB(A) in 2040 without impacting the differences between the calculated scenarios
- All other findings from previous slides remain valid
- A reduction of the TR sound by 3 dB(A) would lead to an immediate reduction of at least 1.5 dB(A) (when applied in 2022) up to 1.7 dB(A) in 2040 where tyre contribution is becoming more dominant

Year	ATEEL scenario 2	ATEEL scenario 3	EMISIA CBA scenario A (w/ tyre)	EMISIA CBA scenario B (w/ tyre)	EMISIA proposal (w/ tyre)	ATEEL scenario 2 ISO track
2022	72	72 (0)	72 (0)	72 (0)	72 (0)	70.5 (-1.5)
2040	70.1	69.4 (-0.7)	69.6 (-0.5)	69.6 (-0.5)	69.7 (-0.4)	68.4 (-1.7)

- Still the same level of relative reductions per scenario vs. ATEEL scenario 2, here with market growth 1% per year considered

Comparison of proposed reductions applied to ATEEL calculationtool – extra urban 90 km/h



Consequence of usage of quieter OE tyres for TA testing only (potentially not used over entire vehicle life cycle)

- In ATEEL scenario 3 less than 5 % of the calculated improvement was caused by the powertrain – more than 95 % by the tyre at 90 km/h
- The shaded area between scenario 3 (PTR only) and scenario 3 (PTR and TR) is the uncertainty considering that customers might replace tyres with less quiet ones than the OE tyres

Year	ATEEL scenario 2 (only PTR)	ATEEL scenario 3 (only PTR)	ATEEL scenario 3
2022	79.45	79.45 (0)	79.45 (0)
2040	78.76	78.71 (-0.05)	77.61 (-1.65)

- Benefits from sound improved vehicles via tyre optimisation will only lead to the expected progress for environmental noise provided that customers will replace worn tyres with equivalent quiet tyres

Reflection on Benoît Fauville study

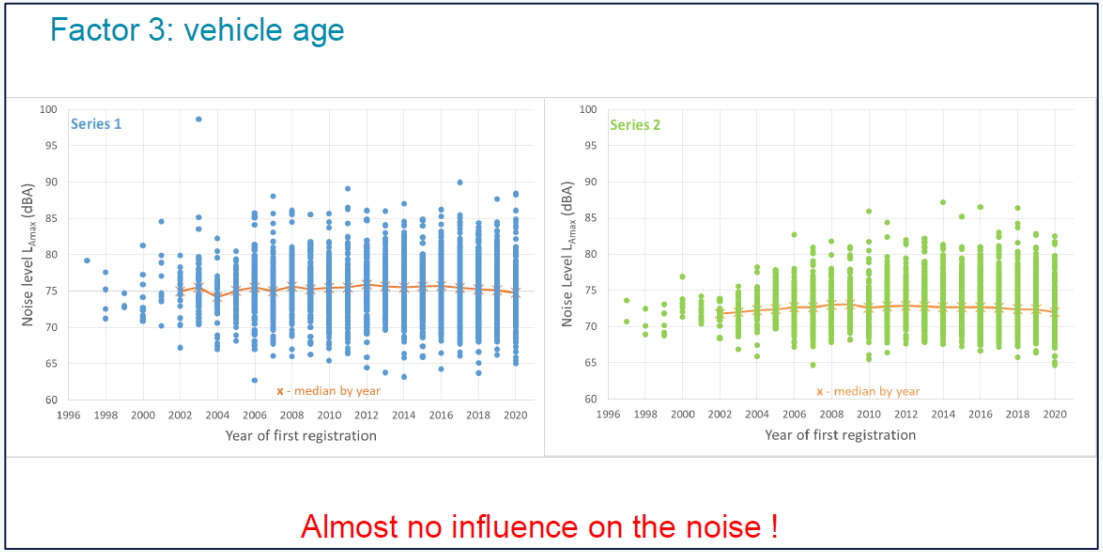
(Testing the noise emission of individual motor vehicles in the Brussels-Capital Region (2022))

Real traffic investigation (Brussels-Capital region (2022))

Content and focus of the study

- Analysis of noise situation in Brussels-Capital Region
- Testing the noise emission of individual vehicles in the Brussels-Capital Region - the remote sensing campaign– Autumn 2020
- Measurement of random vehicles in real traffic situations with access to car data - speed, acceleration, category, power, age,...
- 2 measurement locations (series 1 and 2) close to a roundabout – random weather conditions (representing “real life” conditions)
- Data processing and statistics about age, weight, power, propulsion type...
- Summary of findings
- Proposals for next steps

Real traffic investigation (Brussels-Capital region (2022))



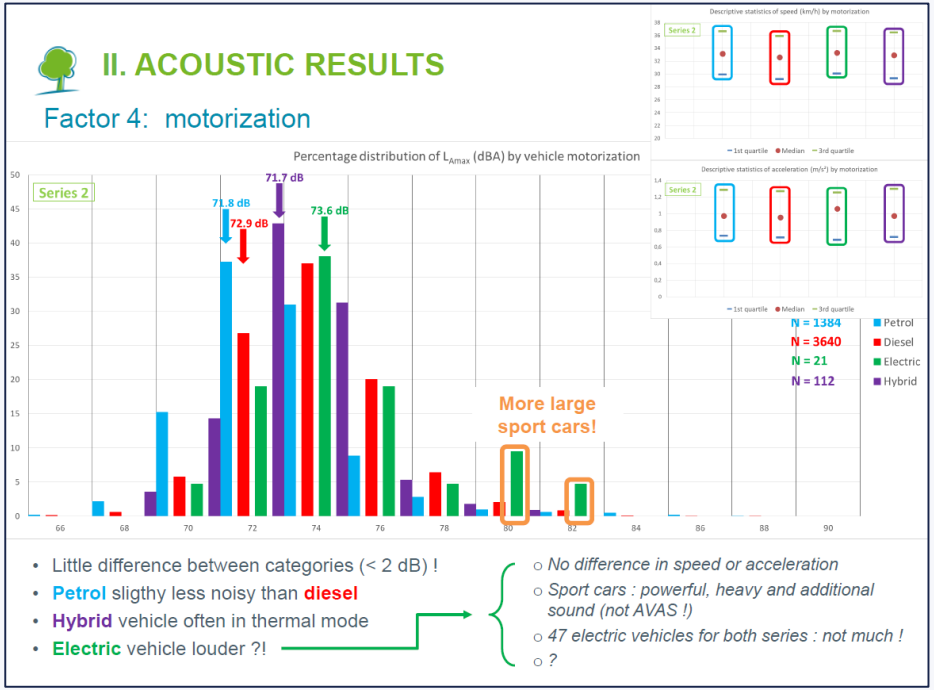
Source: BENOÎT FAUVILLE - Testing the noise emission of individual motor vehicles in the Brussels-Capital Region (2022)

Comparison of random vehicles of different ages and types under real traffic conditions

- The test conditions at the measurement locations should perfectly be able to reflect the technical progress to lower TA sound levels
- Almost no improvement visible for cars built during the last 20 years
- The bandwidth of sound emission levels in chart increases over time (poor number of older vehicles?)
- The driving style appears to be more important than the vehicle age (TA limit)

- Vehicle registration date (limit value) does not contribute significantly to sound level reduction in real life situations

Real traffic investigation (Brussels-Capital region (2022))



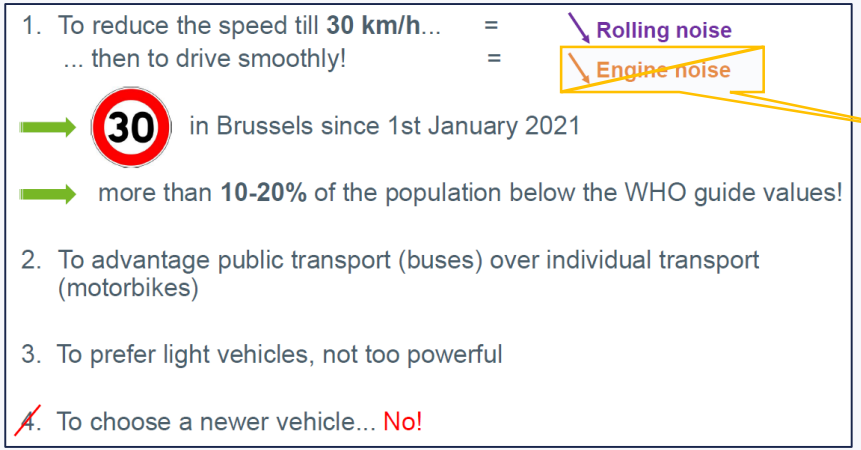
Source: BENOÎT FAUVILLE - Testing the noise emission of individual motor vehicles in the Brussels-Capital Region (2022)

Comparison of vehicles of different ages and types under real traffic conditions

- Within category the engine type is not making big differences in real life
- Electric vehicles do not show the expected benefit
- Some electric vehicles seem to be equipped with additional "sound generators" – not linked to AVAS requirements!
- A potential abuse of sound generators not linked to safety needs to be covered and prevented by adaptation of type approval procedure – already foreseen in future RD-ASEP supplements

- The motorisation does not play a significant role, unless driven recklessly or vehicles are manipulated
- Electric vehicles do not provide any benefit compared to ICE driven vehicles in "real life" scenarios

Real traffic investigation (Brussels-Capital region (2022))



Source: BENOÎT FAUVILLE - Testing the noise emission of individual motor vehicles in the Brussels-Capital Region (2022)

Conclusions taken from study

- Speed limit considered most efficient – in line with findings from ATEEL (typically engine (PTR) sound level at 30 km/h is at least on the same level than at 50 km/h – benefit mainly driven by reduced TR sound level)
- Promote public transportation – reduction of traffic flow
- Promotion of smaller / lighter vehicles (exact opposite of trends to bigger cars with more power)
- New vehicles (with lower limits during type approval) are not considered to be beneficial for noise reduction, at least as long as new vehicles still tend to be bigger and heavier than the ones being replaced
- Analysing the study results, no obvious benefit of TA limit adaptations can be concluded

- The efficiency of alternative measures is considered higher than the ones on vehicle side
- Powertrain sound level of modern vehicles is already so low that the speed reduction is already very efficient at low vehicle speeds – sound level decrease mainly by reduction of TR sound level

Representativeness of type approval values for real traffic situations

Representativeness of type approval values for real traffic situations

Reminder 75th GRBP in February 2022

- **Comment from Germany**
  Since 2010, the number of vehicles with variable sound adjustment technologies has immensely increased – how representative are type approval values for real traffic conditions?
- **Context of the question**
  Type Approval data gathered under R51.02 and R51.03 has been used in the ATEEL study to display the progress in terms of vehicle sound between 2010 and 2020 as well as to predict the impact of further limit reductions for real traffic
- **The difficulty**
  UN R51.02 has been identified as not representative for real traffic driving (unrealistic combination of engine speed and load) and the M1 testing only represented by one specific operating condition. No provisions available for other operating conditions

  UN R51.03 is testing under more operation conditions for which Annex 3 operation conditions are deemed representative for 90% of the sound events in urban traffic. ASEP with Annex7 is covering a wider area, but the effect of ASEP has not been validated by any study up to now
- **The approach to adequately reflect on the comment from Germany**
  It is important to understand where differences between the different type approval conditions and the different real driving conditions are and how they can be considered for example in a calculation model
  - Comparison of both regulations UN R51.02 and UN R51.03
  - Analysis of representativeness of each regulation for real traffic

Representativeness of type approval values for real traffic situations (M1 and N1)

Main differences between UN R51.02 and R51.03

UN R51.02	UN R51.03
Only full load acceleration (not realistic for real driving)	Combination of full load acceleration and constant speed with 2/3 share of full acceleration
No acceleration requirements (high performance vehicles criteria - $\Delta v > 11$ km/h)	Acceleration requirements in dependency to PMR with a maximum of 2 m/s^2
Test gears only 3rd (or 2nd & 3rd) (MT) respectivley D (AT)	Test gears defined by their acceleration performance relative to the mandated acceleration performance $a_{wot\ ref}$
Combined results only in case of 2nd and 3rd gear via average	Weighted results regarding gears (k) and load (k_p)
Correction of result by -1 dB(A) and round off (down)	Mathematically rounded to the nearest integer and no correction.
No off cycle provisions	ASEP to avoid “noise defeat devices” beside TA point

- R51.02 type approval results are higher than R51.03, especially for manual transmission (for trucks the other way around)
- R51.03 changes are aiming for a better representation of vehicle behavior in real traffic conditions

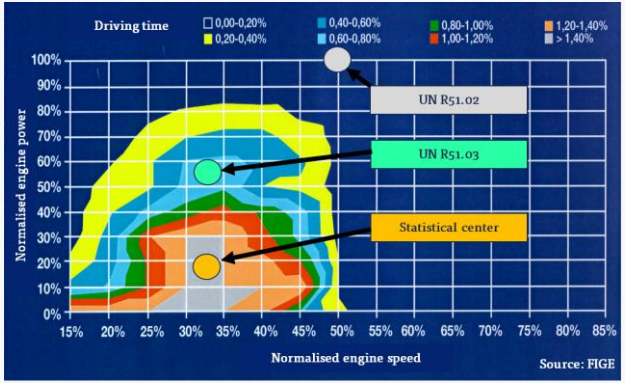
Representativeness of type approval values for real traffic situations (M2, M3, N2 and N3)

Main differences between UN R51.02 and R51.03

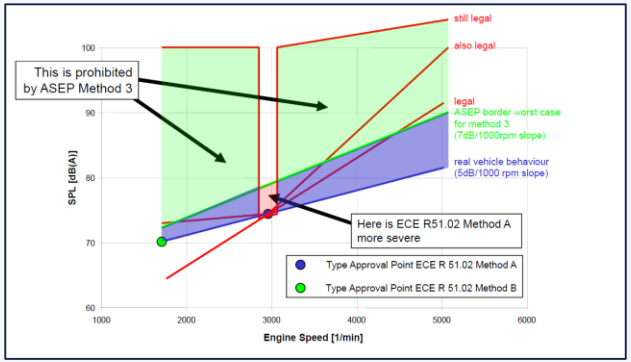
UN R51.02	UN R51.03
Test speed approx. 50 km/h (AA‘) (or 75% Vmax)	Test speed approx. 35 km/h (BB’)
Tested unladen without trailer	Tested with extra load of 50 kg per kW Pn (only N2 and N3)
Test engine speed above S (rated engine speed) (at BB‘)	Test engine speed 85% to 89% of S (at BB’) (M3 and N3) – 70% to 74% of S (M2 and N2)
Test gear only first gear that reaches S (dependent on x/n) (MT)	One or two test gears (fulfilling the requirements for driving speed and engine speed)
Maximum result of measurements per vehicle side	Averaging of measurement results per vehicle side (also per gear)
Correction of result by -1 dB(A) and round off (down)	Mathematically rounded to the nearest integer and no correction

- For heavy commercials R51.02 type approval results are lower than R51.03 due to the extra loading
- R51.03 changes are aiming for a better representation of vehicle behavior in real traffic conditions

Representativeness of type approval values for real traffic situations (M1 and N1)



Source: OICA GRB 32 (2000) (modified for simplicity)



Source: GRB Informal Group ASEP 13.1 (2008)

Category M1 – passenger cars:

- R51.03 TA points better aligned to typical urban driving conditions – covering a significant part of realistic operating conditions
- R51.02 is only covering a small engine speed range (no off-cycle critera) - no variable sound designs were available when entered into force – risk for uncontrolled behavior outside of test area
- R51.03 is more restrictive due to ASEP, resulting in vehicle sound, better aligned to driving dynamic (acceleration)
- Future UNR51.04 (RD-ASEP) is aiming to assess more accurately the sound behaviour of a vehicle and to define tighter tolerances

→ Due to the dominance of tyre rolling sound to the overall vehicle sound emission at higher vehicle speeds outside urban agglomerations, type approval data can provide in combination with tyre rolling sound curves, a fair guess for vehicle sound levels, even outside urban areas

Representativeness of type approval values for real traffic situations (M1 and N1)

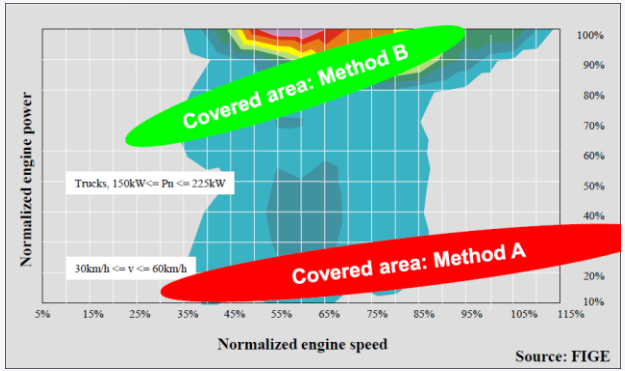
Development of UN R51 to make sure, that the sound emission of a vehicle is in context with the type approval value and that real world scenarios are covered appropriately

	UN R51.02	UN R51.03 ASEP	UN R51.03 & GRB68-03	UN R51.04 RD-ASEP
Covered Gears	MAX 2 GEARS	UP TO GEAR i	ALL	ALL
Covered Modes	DEFAULT ONLY	ALL	ALL	ALL
Speed Range	50 km/h to 61 km/h	20 km/h to 80 km/h	10 km/h to 100 km/h	> 0 km/h to 100 km/h
Full load	YES	YES	YES	YES
Part Load	NO	NO	YES	YES
Cruise	NO	ONLY 50 km/h	YES	YES
Covered Environment Condition	UNCLEAR	URBAN + HIGH REV	URBAN + SUBURBAN + HIGH REV	REAL DRIVING W/O HIGHWAY
Model Precision	N.A.	FAIR	FAIR; ext AREA LOOSE	PRECISE
Tolerances	N.A.	2 dB(A) + (Limit - Lurban)	2 dB(A) + (Limit - Lurban) extended area + 6 dB(A)	t.b.d.
Backfire	NOT REGULATED	WITH SUPPLEMENT 3	YES	YES
Sound Enhancement	NOT REGULATED	WITH SUPPLEMENT 3	YES	YES
"Grey Areas"	HIGH	RESTRICTED	VERY RESTRICTED	VERY LIMITED

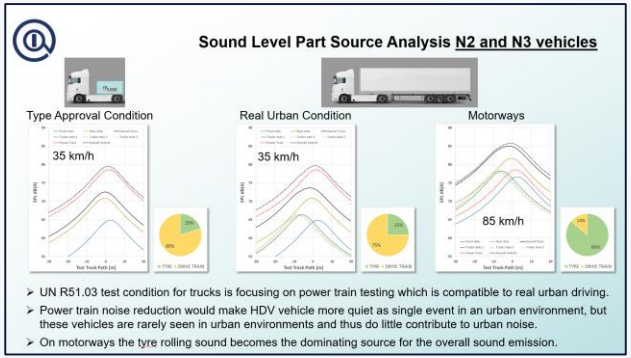
Source: OICA TF-VS (2021)

Status 2022

Representativeness of type approval values for real traffic situations (N2 and N3)



Source: OICA GRB 33-17 (2011)



Source: OICA TF-VS (2021)

Category N3 – heavy duty trucks

- R51.03 TA points are better aligned to typical urban driving conditions - medium engine speed range and high loads are more representative for urban and sub-urban driving of these vehicles (even with trailer in reality)
- Still tested without trailer, trucks are at least tested with some weight in R51.03 - unladen vehicle in R51.02 resulted in lower TA value
- TA testing under R51.03 procedure is performed without trailer to minimise the impact of the tyres during type approval testing and to avoid excessive wear of the test track
- The powertrain contribution to the overall vehicle sound in TA procedure is highlighted by purpose
- Similar to M1 cars but stronger pronounced, the high increasing rolling sound at higher speeds (where long haul vehicles are driven most time!) and reduced sound values in TA testing does not necessarily lead to reduced sound in real life

- Partial sound source splits and load conditions of R51.03 TA results are more representative for real urban driving (analogous M1 cars)
- Sound reduction at higher vehicle speeds (typical field of operation) may be significantly lower than progress under TA conditions may indicate

Representativeness of type approval values for real traffic situations

Conclusions:

- TA results according UN R51.03 tend to be lower than UN R51.02 and generally overestimate the real sound emissions of real urban driving (especially MT) (the other way around for heavy commercial vehicles)
- UN R51.03 rates the vehicles according to their performance at a condition which is within the real driving conditions map
- In contrast to UN R51.02, the type approval point of UN R51.03 is located inside the area of most frequently used operating conditions. UN R51.02 only covers a very small and non-representative part of the engine operation map
- Off cycle provisions such as ASEP do not exist in UN R51.02
- Even the ASEP concept does not prevent certain vehicles producing high sound levels under extreme driving conditions – statically almost irrelevant and to be considered as single events with very small impact on LAeq. By using the border curves of ASEP, UN R51.03 allows to consider a "worst case" behaviour for each type approved vehicle
- Although more vehicles with “variable sound technology” are on the market, these vehicles follow in a reliable way the principles as desired by the regulator – this enables prognoses of the vehicle sound for conditions beside TA points
- Commercial vehicles are tested under UN R51.03 within the typical driving map, and the vehicle is loaded to engage the relevant sound sources at the targeted traffic conditions. Therefore, the real world sound emission was underestimated with previous UN R51.02 for trucks

- The estimation of real sound emissions based on UN R51.03 TA data is possible and reliable
- UN R51.03 is much better suited to real driving situations, since cruising conditions and realistic acceleration levels are considered, compared to pure full load testing of UN R51.02

Conclusions and recommendations

Conclusions after peer review of EMISIA study

Conclusion regarding benefits

- Both studies showed that all benefits by further limit reductions are highly limited and may not lead to significant improvement in real traffic and of course go along with a significant time delay
- Benefits calculated in the CBA appear significantly too high according to recalculation with ATEEL tool (difficult to compare precisely due to differences in approach and boundary conditions)

Conclusion regarding measures

- Both studies show that all powertrain measures that would be required to comply with type approval limit reductions can only contribute to improvements in conjunction with quite road surfaces and / or tyres
- Both studies conclude that a reduction of tyre rolling sound provides the highest benefit
- Regarding the TR sound, the EMISIA study is only focused on reducing tyre sound while ATEEL has extended the effect to quieter roads and shown the effect of bad road surfaces and e.g. weather conditions
- Good road building practice in areas with high population density AND high traffic volume in combination with a certain progress on tyre technology provide outstanding sound reduction without significant time delay
- In the EMISIA study, it appears to ATEEL that the efficiency of quite road surfaces is assumed to be almost zero for urban street types (road type 1 to 4) (figure 72 – p. 214) which is not in line with the ATEEL findings, showing the significant impact of reducing tyre/road interaction

Conclusions after peer review of EMISIA study

Conclusion regarding results and final limit value proposals

- According to the EMISIA study the space for tighter limits is highly restricted and some limit reductions are recommended for subcategories with a minor share rate in real traffic (e.g. M1-b, M1-d) – therefore only a minor impact can be expected
- The final proposal for category N3 does not reflect the needs and conflicts where the gap between TA limits and TA values exists for good reason. The limit cannot simply be reduced by 2 dB(A) as concluded in the EMISIA study since the tested vehicles need to represent an entire vehicle family with plenty of different variants (see GRB-51-13, GRB-51-20, GRB-53-17)
- The recommendations for improved test procedure (scenarios C to E) need to be reviewed carefully and balanced – acceleration levels in test procedure should be representative for real traffic (not maximum acceleration capability) since full load accelerations of high powered vehicles mostly are not possible and also violating the law in most situations
- The proposal to consider higher accelerations is a step back towards UN R51.02, for which enough studies have shown the inefficiency of "worst case" type approval testing method
- Most cases of single event noise peaks are more a problem of bad (illegal!) driving style or manipulated (illegal!) vehicles what could be handled more effectively by traffic monitoring since type approval has less influence on this topic

Recommendations for next Steps

Legislation side – limit value adaptations beyond phase 3

- Waiting for new exhaust emission legislation before considering stricter sound emission limits for vehicles
- Wait for phase 3 vehicles (actually representing the technical limit for most categories) to enter the market for a few years and observe the impact on sound level
- The issue that lower type approval values do not necessarily lead to lower sound levels in real life can not be fixed by simply further tightening the limit values – will be the same result
- All vehicle categories proposed for limit tightening should be examined more closely and a cost, risk, benefit analysis considering other disciplines such as safety and pollutant emissions should be carefully conducted, taking also into account the desired/efficient movement of goods and people. e.g. payload or packaging issues
- Even if a reduction of the limit values seems feasible, the possible consequences and trade offs must be weighted against the expected result when analysing the current type-approval values (can the measure really reduce the noise or only on paper?)
- Review of legislation and test procedures regarding potential acoustic problems caused by electric / hybrid electric vehicle (definition of AVAS – sound level, frequencies etc. to be more harmonised to make identification as vehicle easier for pedestrians, how to deal with “sound generators”, how to test hybrid vehicles most realistic etc.)

Recommendations for next Steps

Additional tasks that could help to get a better understanding on real traffic issues

- Perform additional measurement campaigns similar to the recent study from Brussels to identify realistic conditions for calculations or even type approval procedure (real vehicle speed during 24h, acceleration levels, sound level of vehicle types, distribution of vehicle categories during day / week)
- Would it be possible to get access the raw data of study performed in Brussels, of course raw data without any brand information, just car, van,.....whatever can be shared?
- Tests could ideally include different weather conditions (wet street, snow etc.) and tests with speed limits (test wise) or special road surfaces on parts of investigated road (same conditions but different road surface types)
- A discrete study could be performed about the impact of weather condition that do occur very often in Europe (the impact of wet conditions would be of interest, especially in conjunction with different road surface qualities)
- Alternatively the output of related investigations should be collected and investigated to get an overall and most realistic view on the current situation and the potential of vehicle measures compared to alternative measures
- Performing additional measurements of “real N3 vehicles” under real driving scenarios (correct load, axle configuration, higher speed, realistic acceleration etc.) to get a better understanding about the sound sources under “real conditions” in the frame of a research project (not necessarily on ISO track)

technology experts

Thank you for your attention!

In case of questions or comments,
please do not hesitate to contact us

ATEEL S.à r.l.
14, Op Huefdréisch
L-6871 Wecker
+352 28335 0
info@ateel.com
www.ateel.com