Technical support for the impact assessment on Euro 5 step of L-category sound emissions level limits

Procedure nº: 841/PPGRO/IMA/20/1134/11480

TF-VS 9th , 24-05-2022

May 2022

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Task 1:
Representativeness in sound emissions

Task 1.1: Feedback gathering

Objective
Evaluate the noise emission level of the current motorcycle, tricycle and quadricycle European fleet and to analyse the potential improvement that current and future technologies may enable in this field.

- Perception on the significance of motorcycle noise emission on the global noise pollution level
- Perception on the significance of tricycle and quadricycle noise emission on the global noise pollution level
- Convergence of the existing homologation testing methods with special attention to ASEP criteria, when applicable
- Suitability of the existing test procedures to fairly evaluate all type of L-category vehicle sub-categories and configurations
- Available and detailed data on approval test results for all L-category vehicle categories
- Available and detailed data on road-side tests control results for L-category vehicles
- Availability and diversity of technologies to lower the different sources of noise on motorcycles, tricycles and quadricycles
- Impact of road-side noise level control on noise pollution caused by motorcycles.

Task 1.1: Feedback gathering

Questionnaire: 30 questions

- Effect of noise
- Effectiveness of regulation
- Tampering
- Driver’s behaviour
- Evaluation of fleet
- Noise sources
- Technological limitations
- Sound limits
- Cost/benefit
- Time to market
- Road side control

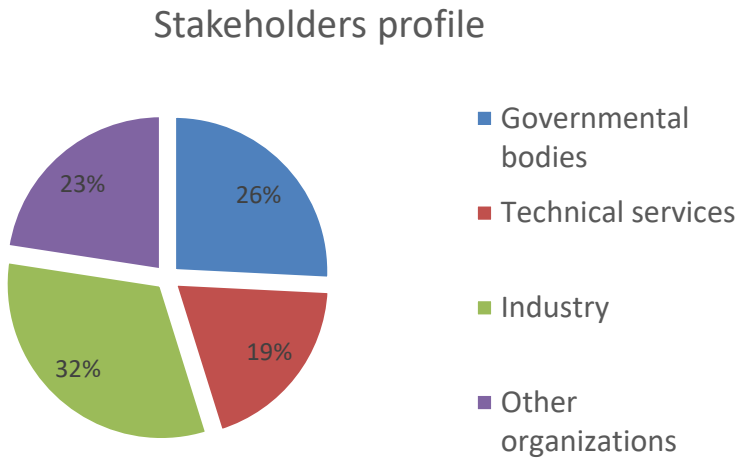
Task 1.1: Feedback gathering

Contact list:

- Industrial stakeholders: 116
- Technical services and type approval authorities: 94
- Department of transport, market surveillance and enforcement authorities: 57
- Countries, cities, citizens: 37
- Motorcycle and noise concerned associations: 18
- Environmental organizations and institutes: 14

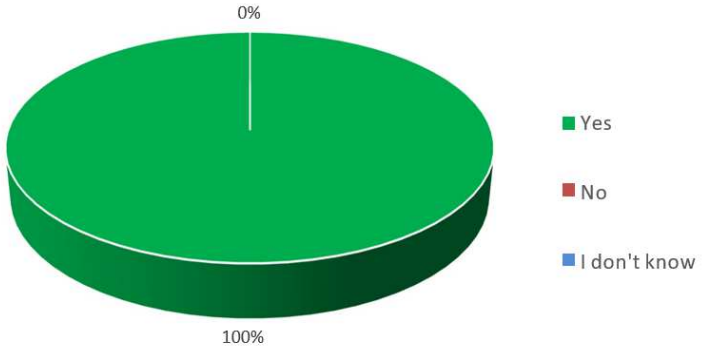
Total contacts: 336

33 answers received

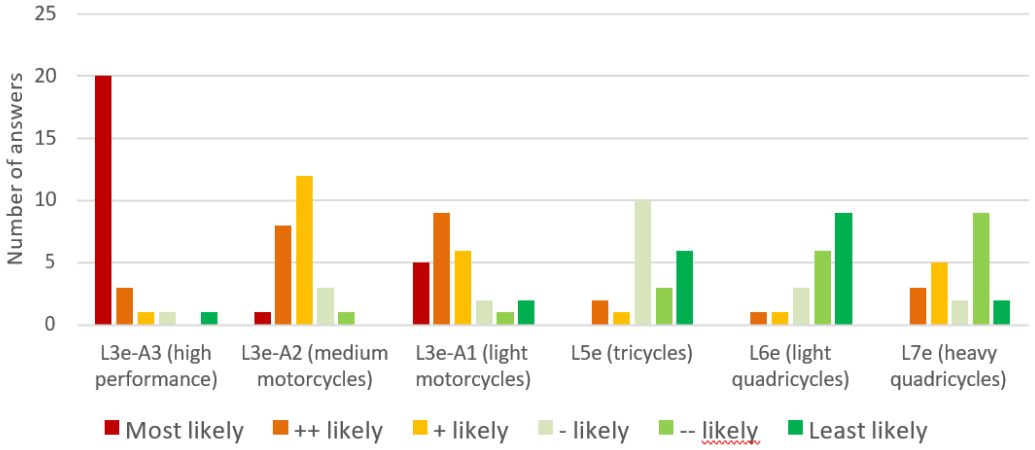


Task 1.1: Feedback gathering

- *Does tampering has a negative impact in social perception of L-cat vehicles? Q8*



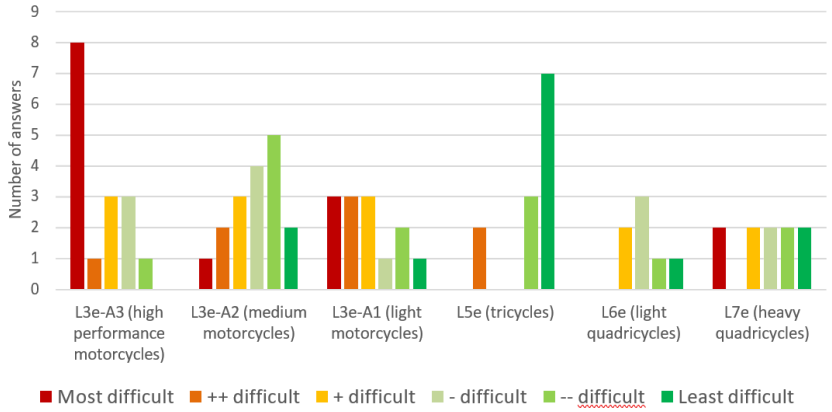
- *Which vehicles are more likely to be tampered in a way that increases its noise emission? Q9*



- Two-wheelers are understood as being likely to be modified, and among them high-performance motorbikes get the biggest percentage of answers
- Tricycles and heavy quadricycles don't seem to create big concerns regarding itspossibility to be modified.
- Light quadricycles are the sub-category perceived as having the lower potential ofmodification.

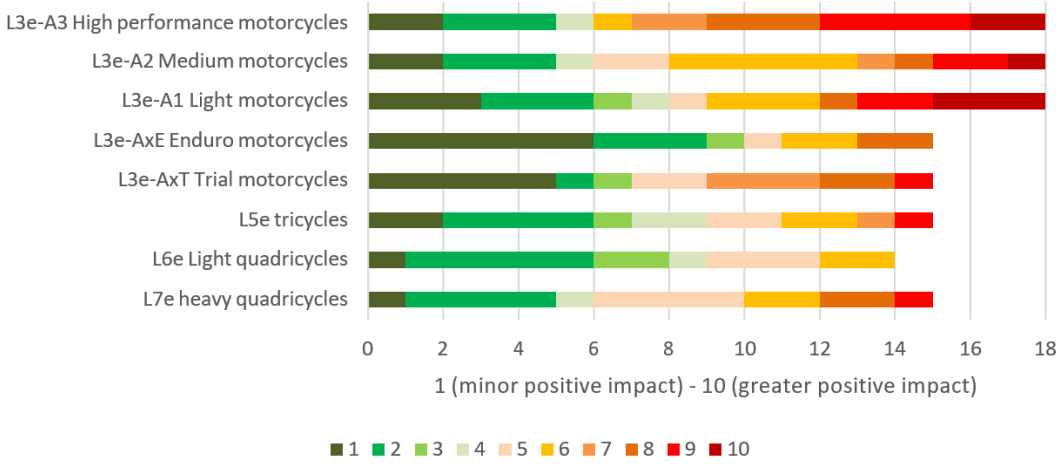
Task 1.1: Feedback gathering

- *What vehicles exhibit more difficulty to fulfil noise limits? (Q21)*



- L3e-A3 are understood as the ones having the highest difficulties, followed by L3e-A1, but for L3e-A2 results show surprisingly a perception of a lower difficulty.
- Finally, L5e tricycles are signaled by the stakeholders as the vehicles for whom the difficulty to comply with the current sound limits would be lower.

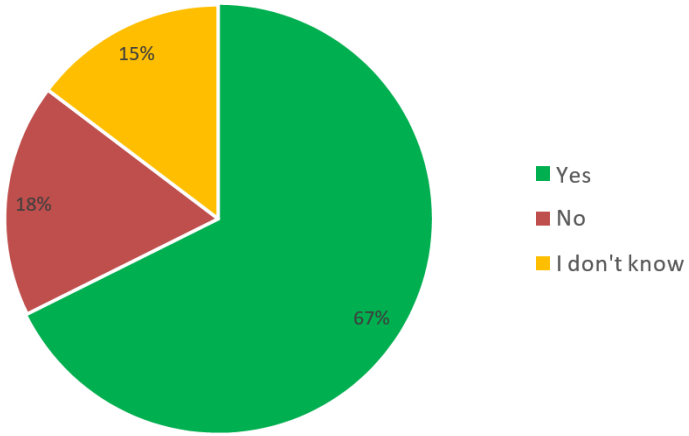
- *For which vehicle a reduction in sound limit s would have a greater positive impact on noise pollution? (Q22)*



A reduction on the approval sound limits would have a greater positive impact on road traffic noise pollution mostly when applied to two-wheelers, but without a significant difference compared to the other L-categories.

Task 1.1: Feedback gathering

If sound level limits are lowered, could this lead to an increase of tampering? Q28



There is a high percentage of answers (67 %) where stakeholders' opinion is that in the event sound level limits were substantially lowered this would lead to an increase of the tampering practices by the users of the concerned L-category vehicles.

Task 1.1: Feedback gathering: General conclusions

- L5e, L6e and L7e are categories of vehicles for which general public knowledge is lower than the knowledge on L3 category probably due to the small percentage of these units among vehicle's fleet. Many answers are focused on L3e motorcycles and express a lack of information or criteria on the rest of L-category vehicles targeted by this study.
- Motorcycles are prone to be **tampered** and thus identified as the ones producing the highest noise annoyance on public roads. This has a significant effect on noise annoyance (Tampering, rider's bevaviour, insuficient road-side control account for 70% noise disturbance)
- There are some references to improve UN Regulation no. 92 in order to ensure more comprehensive homologation procedures for replacement exhaust systems.
- Regarding the regulatory sound level test procedures there are often references to the oncoming UNECE R41.05 ASEP prescriptions as a positive move in order to make a more representative assessment of the sound level generated in a wider driving scenarios spectrum.
- When asked about a possible reduction of sound emissions level limits, most of the answers agree that **road-side controls**, such as: local traffic controls, law enforcement authorities and periodical technical inspection authorities, would be the most efficient way to detect non-conforming vehicles and thus lowering effectively the noise emission caused by motorcycles in the urban and extra-urban areas.
- L3e-A3 vehicles are ones for which it is more difficult to comply with the current sound level limits.
- Keeping the sound emission level limits unchanged for two-wheelers is a common trend among the stakeholders' answers. For tricycles and quadricycles category vehicles there are opposite opinions: a significant percentage of answers is against a change of the limits, but there is also a non-negligible part of the opinions in the sense of a reduction of the sound level limits up to over 2 dB (A).

Task 1.2:
Literature review

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Objective
To identify the full potential of the implementation of current and future technologies
Vehicle technologies addressing noise reduction
This revie will provide a list of technologies, implementation time frame and potential costs

Methodology
Literature review based on technical magazines, congress, journals and public publications

Data sources
ATZ magazines
Internoise proceedings Applied acoustics
Community noise research strategy (CALM)
ACES – Optimal Acoustic equivalent source descriptors for Automotive Noise Modelling GRD1-1999-11203, FP5
SILENCE Quieter surface transport in urban area, FP6
WHO noise guidance for the European Region
ACEM EU Market registration statistics

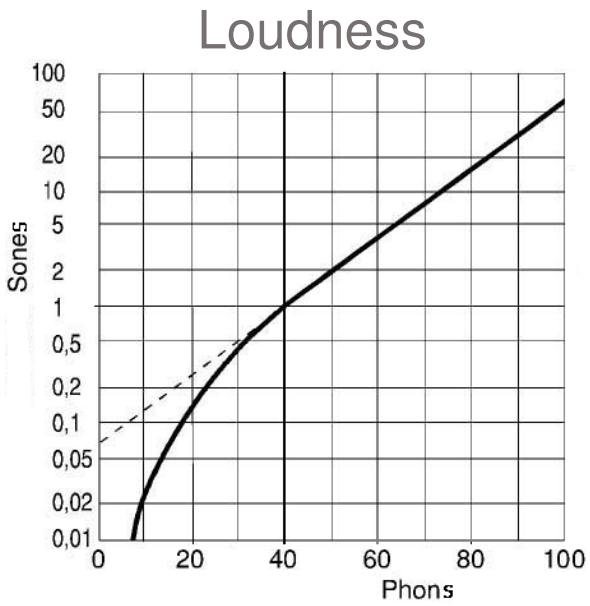
Task 1.2: Literature review: Topics covered

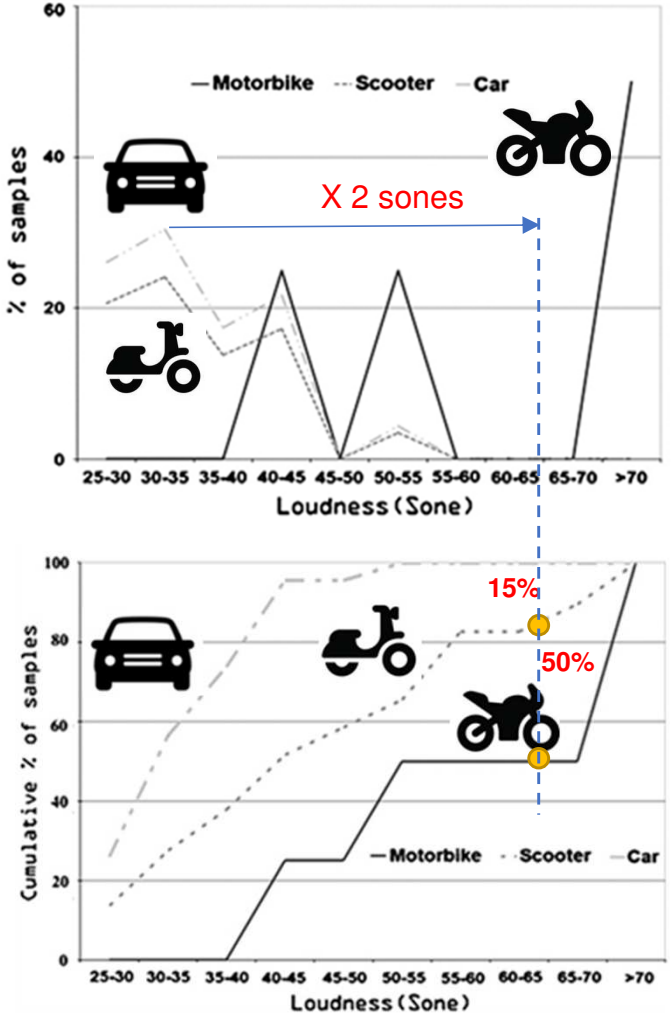
- Vehicle life expectancy (per category)
- Available technologies to reduce sound levels in L-category vehicle
- Vehicle average mileage (per category)
- EU sales of replacement exhausts
- Registration per country and per vehicle category
- Urban noise levels
- Extra urban noise levels
- Average speed in EU cities
- Number of EU cities with low-speed areas
- Health issues related to noise
- Environmental impact of road traffic noise
- UE countries with technical inspection of L-category vehicles
- Market surveillance campaigns performed
- Average approval sound level values (per category found in ETAES)

Task 1.2: Literature review: Annoyance from L-vehicles

Loudness is the perceived intensity of sound. Sound pressure level is the physical intensity of a sound. The relation between the two is complicated.

Sone is a more linear scale of perception than Phone. Increasing loudness by 10 phon increases loudness in sone by a factor of 2. The sone scale attempts to follow human perception for all sound pressure levels so that, for example, doubling the loudness of a sound doubles its value in sone.





Task 2:
Verification of sound levels

Task 2: Verification of sound levels

Objective:
Establish representative current sound levels within the L-category vehicles fleet in order to have a direct evaluation of current sound emissions and have a perception of the margin for improvement of sound level performance

Vehicle selection:

- Cover all the L categories / Sub-categories that have been defined in this study.
- Models have been chosen that we have considered to be more relevant in terms of noise impact on European roads, being common models on European roads, within each of the categories / sub-categories tested.
- A wide range of engine configurations has also been included: single-cylinder, two-cylinder, three-cylinder, and four-cylinder, in addition, we have included a motorcycle with automatic transmission.
- Faithful representation of the current fleet of category L vehicles in Europe.
- Recent approvals
- The study emphasizes L3 category vehicles because this category is dominant in the European fleet.

Task 2: tests carried out: 18 vehicles

UN-Regulation	PMR	Category / Sub-category	Engine type	Gear / Transmission	Target specifications
R.41.04	25 < PMR ≤ 50	L3e-A1	PI	Locked / Manual	Enduro
		L3e-A1	PI	Non-locked / CVT	Urban Scooter
		L3e-A1	PI	Locked / Manual	Sport
		L3e-A2T	PI	Locked / Manual	Sport TRIAL
	PMR > 50	L3e-A3	PI	Locked / Manual	Sport Naked
		L3e-A3	PI	Locked / Manual	Sport TRAIL
		L3e-A3	PI	Locked / Manual	Sport
		L3e-A3	PI	Non-locked / Automatic	Sport TRAIL
		L3e-A3	PI	Locked / Manual	Sport TRAIL
		L3e-A3	PI	Locked / Manual	Sport TRAIL
		L3e-A3	PI	Locked / Manual	Sport Naked
		L3e-A3	PI	Non-locked / CVT	Urban Scooter
		L3e-A3	PI	Locked / Manual	Touring
		L3e-A3	PI	Locked / Manual	Custom
R.09.08	PMR ≤ 50	L5e-B	PI	Locked / Manual	Bodied Tricycle
	PMR > 50	L5e-A	PI	Non-locked / CVT	Unbodied
	PMR ≤ 50	L6e-BP	PI	Non-locked / CVT	Bodied
	PMR > 50 (With ASEP)	L7e-B1	PI	Non-locked / CVT	ATV

Vehicles also selected for NSR

Task 2 tests carried out: UN Regulation № 41.04

Category and sub-category	PMR	L_{wot}	L_{crs}	L_{urban}	L_{urban} limit **	$L_{stationary}$	L_{ASEP}	Limit ASEP **
L3e-A1	38,0	78,3	69,1	74,7	74	79,6	N.A.[1]	N.A.[1]
L3e-A1	38,9	76,2	67,7	74,2	74	81,3	N.A.[1]	N.A.[1]
L3e-A2T*	48,4	76,4	70,2	74,7	74	86,7	N.A.[1]	N.A.[1]
L3e-A1	49,0	72,4	67,5	71,1	74	80	N.A.[1]	N.A.[1]
L3e-A2	76,0	76,5	68,4	71,8	77	85,8	N.A.[2]	N.A.[2]
L3e-A3	196,0	78,6	69,2	74	77	93	85,2	89,3
L3e-A3	230,8	80,7	68,9	74,7	77	91,7	84,5	89,2
L3e-A3	237,0	77,2	69,8	73,5	77	89,6	82,6	87,3
L3e-A3	238,1	81,0	68,6	74,7	77	92,4	85,7	89,6
L3e-A3	241,0	78,5	72,1	75,2	77	90,2	84,8	87,3
L3e-A3	291,0	78,6	70,3	74,7	77	91,2	83,5	88,4
L3e-A3	311,0	80,4	71,7	76,2	77	96,9	86,0	87,7
L3e-A3	331,0	80,2	72,5	76,4	77	98,3	87,6	93,9
L3e-A3	391,8	81,1	71,9	76,3	77	93,3	82,2	88,1

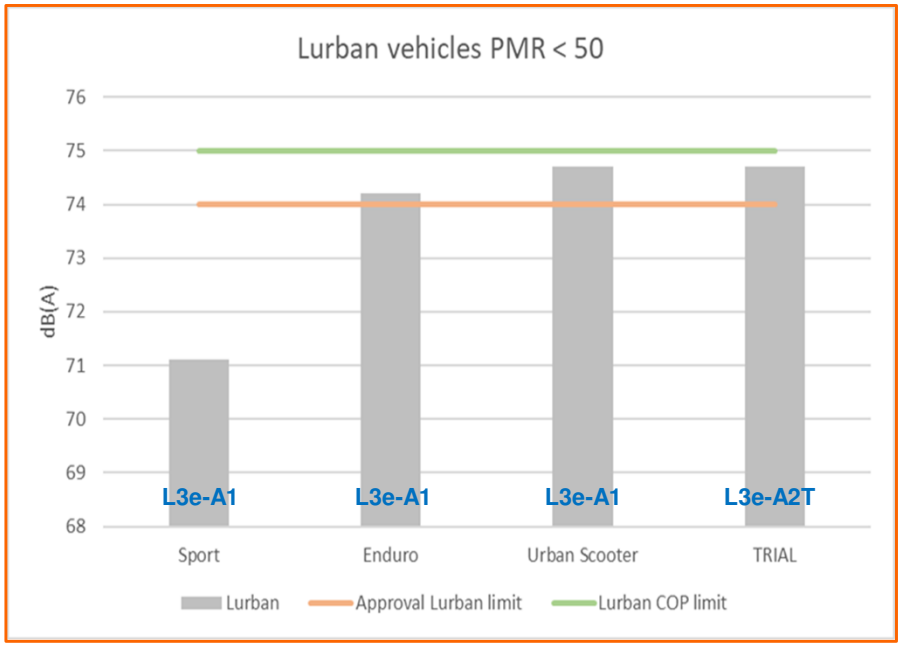
* Includes sub-category

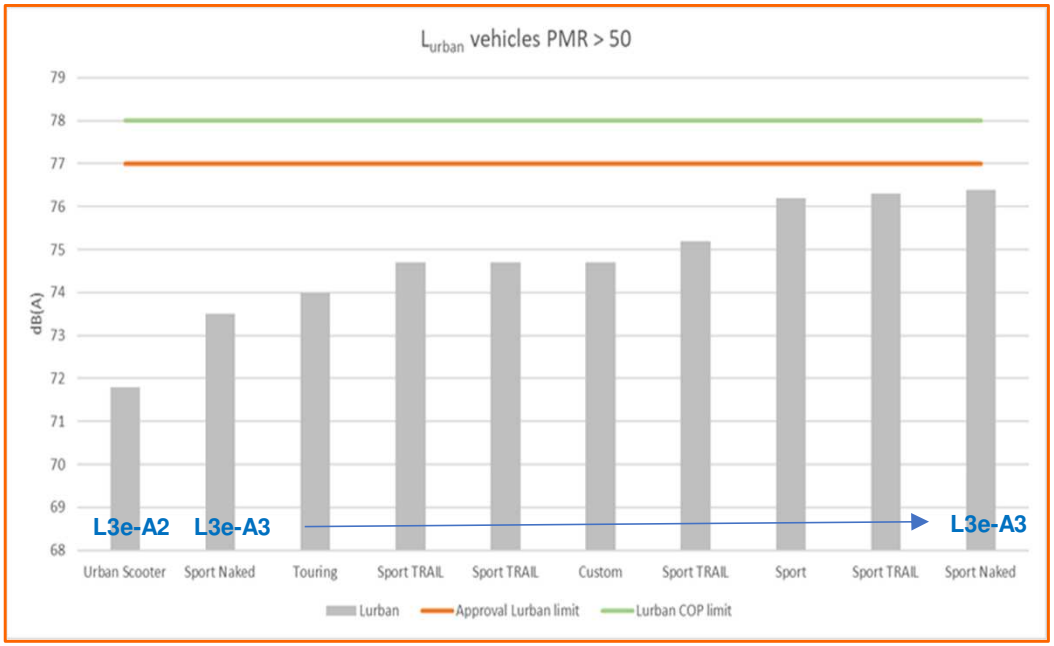
** This limit is increased in 1 dB(A) in case COP. See 8.3 of the Regulation

1 PMR < 50, ASEP does not apply. See Annex 7, item 1.1 of the regulation

CVT´s are exempted from this requirement. See Annex 7, item 1.2 of the regulation

Task 2: Tests carried out: UN Regulation Nº 41.04

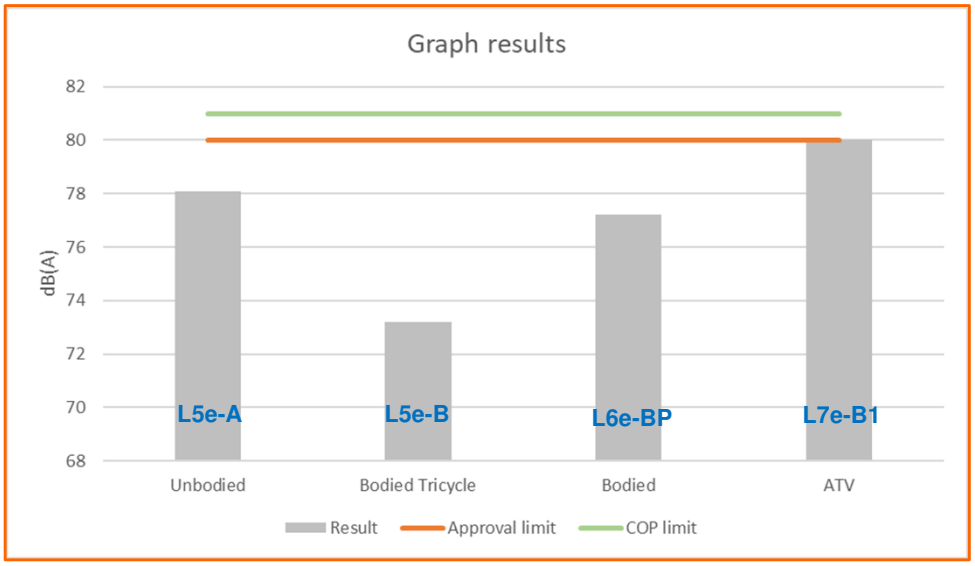




Task 2 tests carried out according to UN Regulation No. 09.08

Category and sub-category	PMR	Result	Limit **	$L_{stationary}$	L_{ASEP}
L5e-A	92,0	78,1	80	90,9	N.A.[2]
L5e-B	13,8	73,2	80	86,7	N.A.[1]
L6e-BP*	1,1	77,2	80	79,9	N.A.[1]
L7e-B1*	53,0	80	80	82,9	N.A.[2]

*Includes sub-category
** This limit is increased in 1 dB(A) in case of COP. See item 8.3 of the Regulation
1 PMR<50, ASEP does not apply. See Annex 7, item 1.1 of Regulation
2 CVT`s are exepmted from this requirement. See Annex 7, item1.2 o regulation



Task 2. Verification of sound levels: Conclusions

- The obtained sound level test results for all tested vehicles are below the existing limits
- The margin between the actual test results and the existing limits vary depending on the vehicle's subcategory
- Most of the motorcycles tested according to RD-ASEP provisions give already positive results

Task 3
Noise source ranking tests

Task 3. Noise Source Ranking tests:

Objective

Assess the influence of the different systems /subsystems of the L-cat vehicles during exterior noise testing. In order to study the potential noise reduction of the different systems, a NSR testing has been carried out on the most representative vehicles measured in task 2

Vehicle selection for NSR

- Sis of the vehicles previously tested in task 2
- According to task 1 of this study, selection of vehicles perceived as more relevant in terms of noise impact in the European roads
- Include a wide range of powertrain configurations
- Represent the current fleet in Europe (L3e and L5e subcategories)

Task 3. Noise Source Ranking tests: Selected vehicles

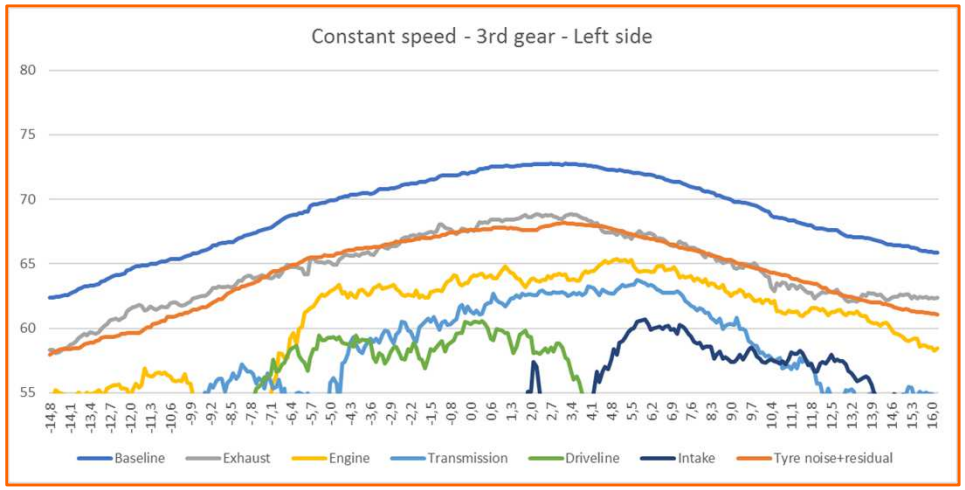
UN-Regulation	PMR	Category / Sub-category	Engine type	Gear / Transmission	Target specifications	Name in this report *
R.41.04	PMR > 50	L3e-A3	PI	Locked / Manual	Sport Naked	***Sport Naked***
		L3e-A3	PI	Locked / Manual	Sport TRAIL	***Sport TRAIL***
		L3e-A3	PI	Non-locked / Automatic	Sport TRAIL (Automatic)	***Sport TRAIL_Auto***
		L3e-A3	PI	Locked / Manual	Sport TRAIL (Manual)	***Sport TRAIL_Manual***
R.09.08	PMR ≤ 50	L5e-B	PI	Locked / Manual	Bodied Tricycle	***Bodied Tricycle***
	PMR > 50	L5e-A	PI	Non-locked / CVT	Unbodied Tricycle	***Unbodied Tricycle***

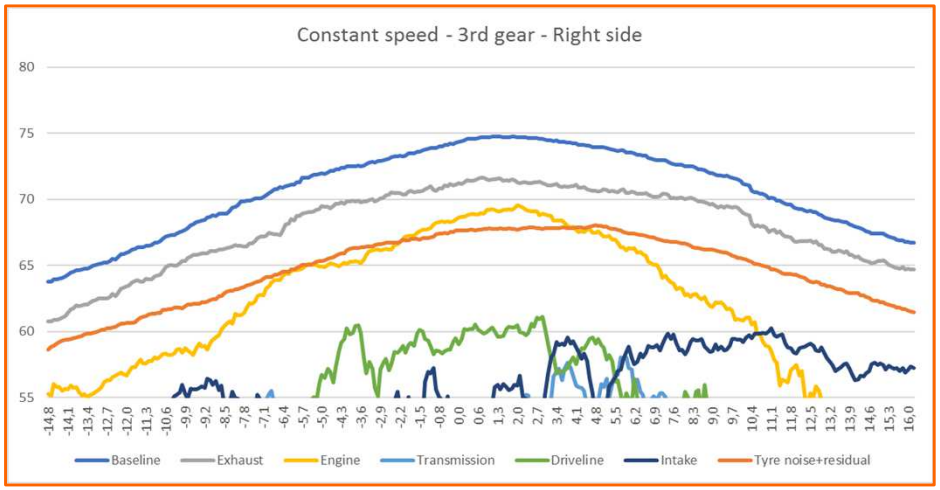
Task 3. Noise Source Ranking tests: Acoustic shielding

Task 3. Noise Source Ranking tests:

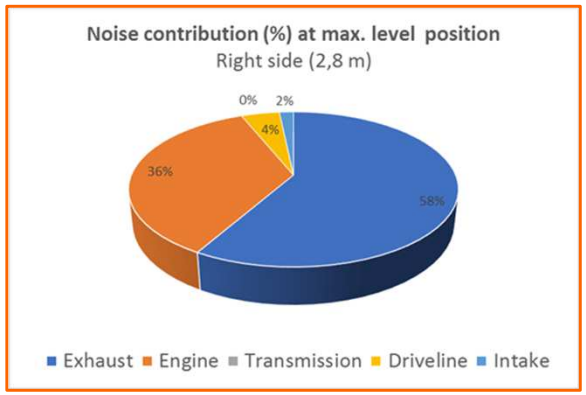
Example of noise source ranking results: Sport Naked

Constant speed test (3rd gear)





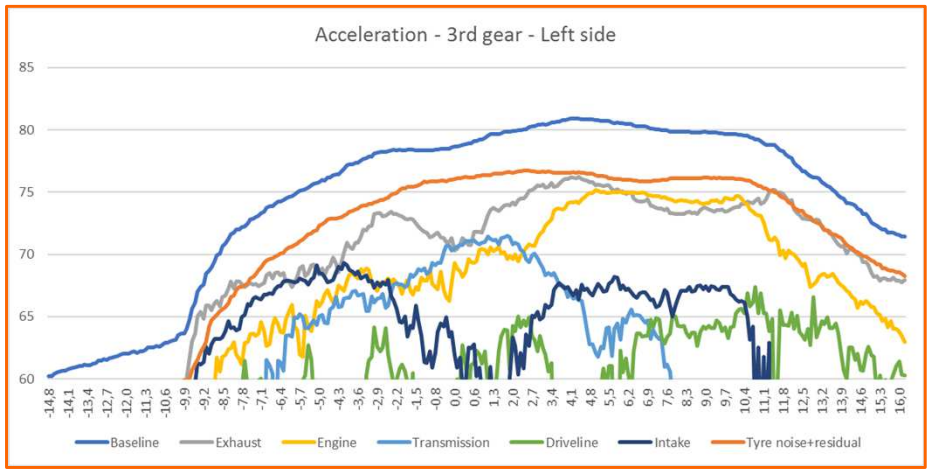
Source contribution to maximum noise level value. Position: 2.8 m after PP'

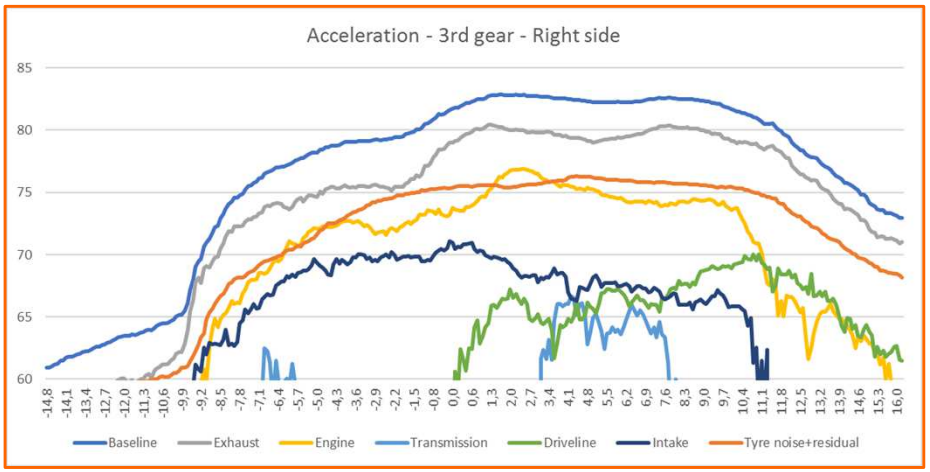


Task 3. Noise Source Ranking tests:

Example of noise source ranking results: Sport Naked

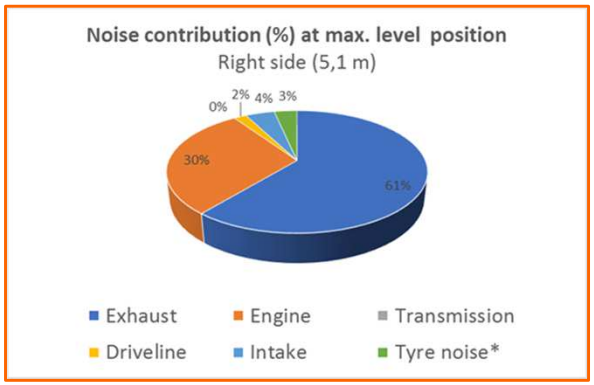
Acceleration test (3rd gear)

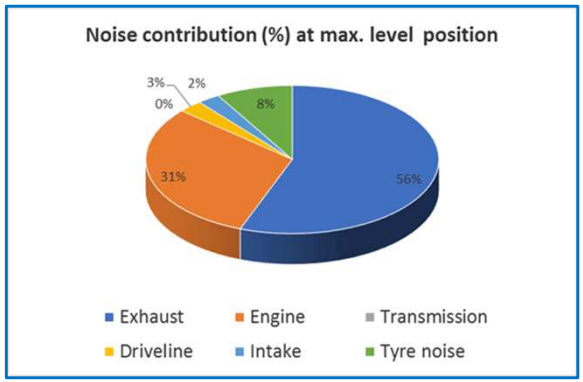




Source contribution to maximum noise level value. Position: 5.1 m after PP'

*Tyre noise calculated from constant speed test

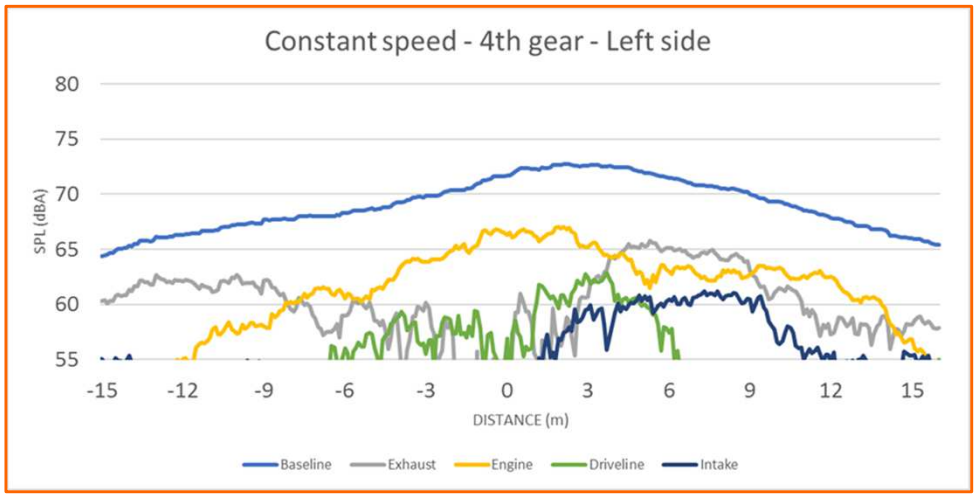


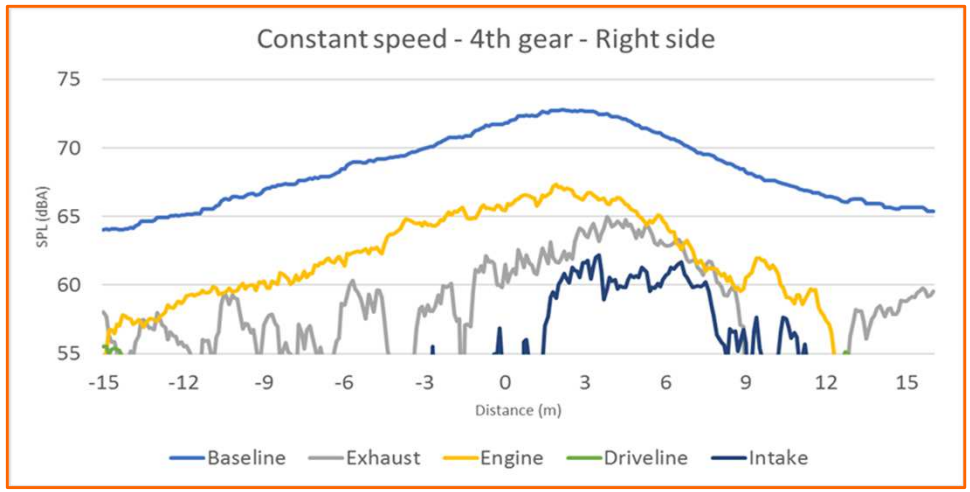


Task 3. Noise Source Ranking tests:

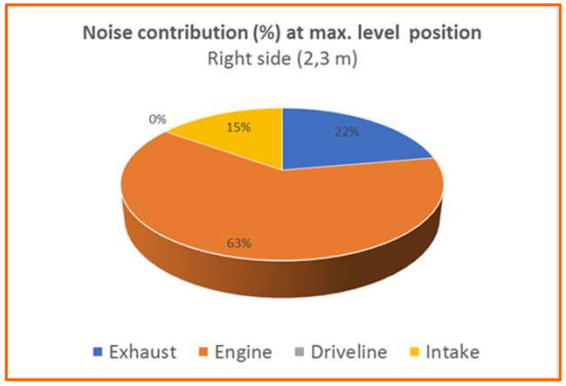
Example of noise source ranking results: Sport TRAIL

Constant speed test (4rd gear)





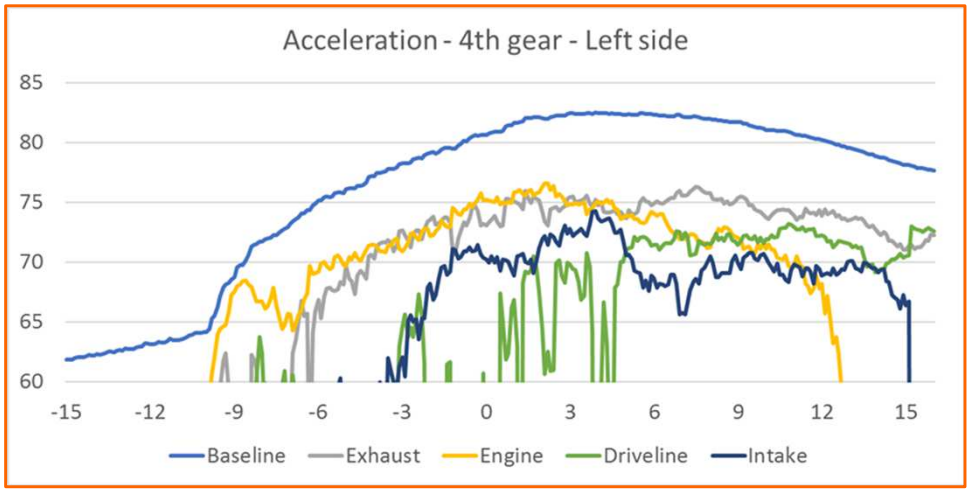
Source contribution to maximum noise level value. Position: 2.3 m after PP'

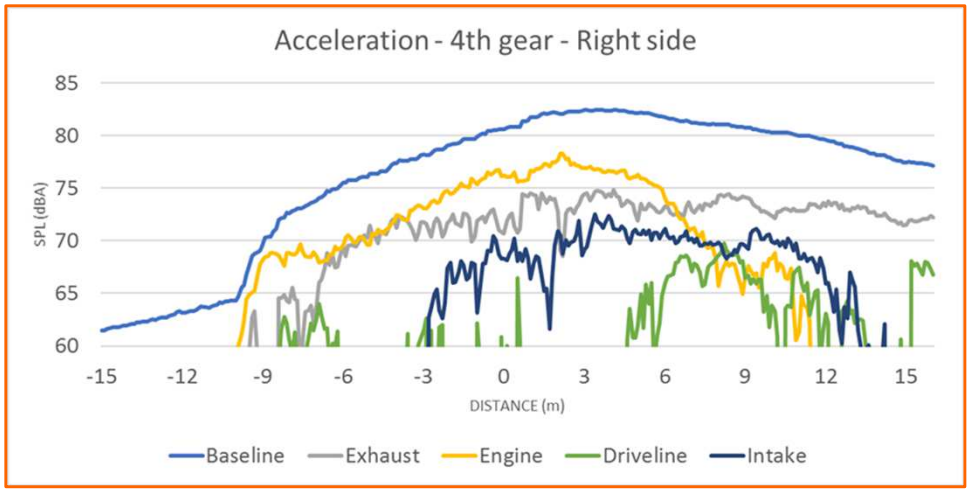


Task 3. Noise Source Ranking tests:

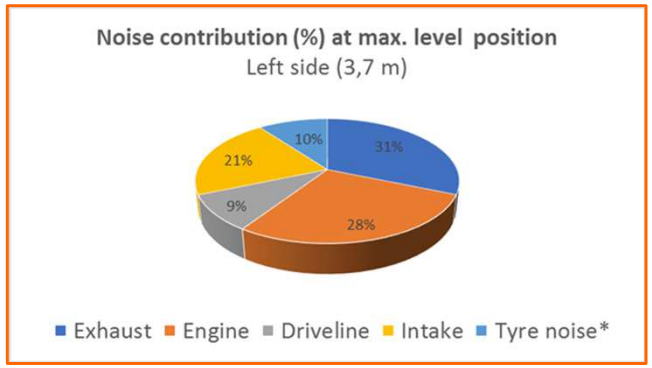
Example of noise source ranking results: Sport TRAIL

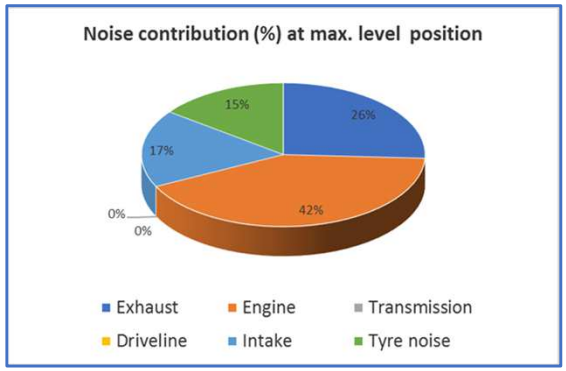
Acceleration test (4rd gear)





Source contribution to maximum noise level value.
Position: 3.7 m after PP'

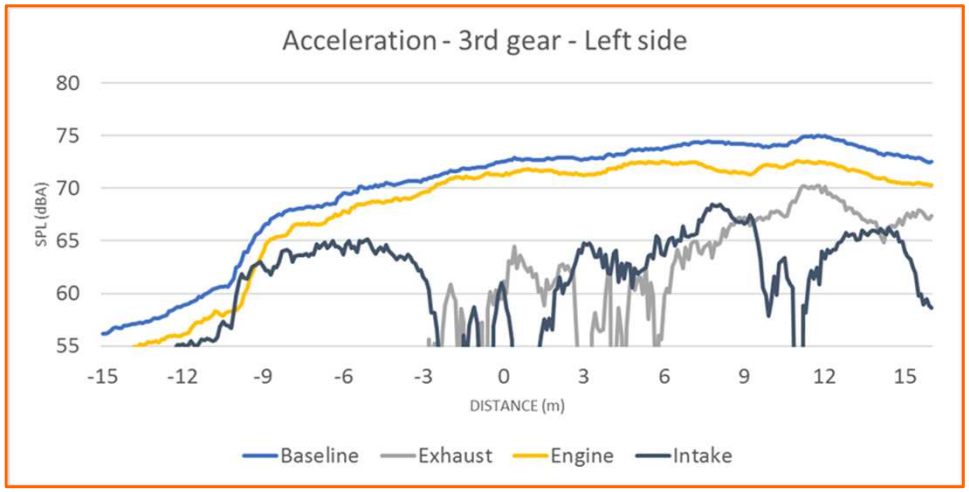


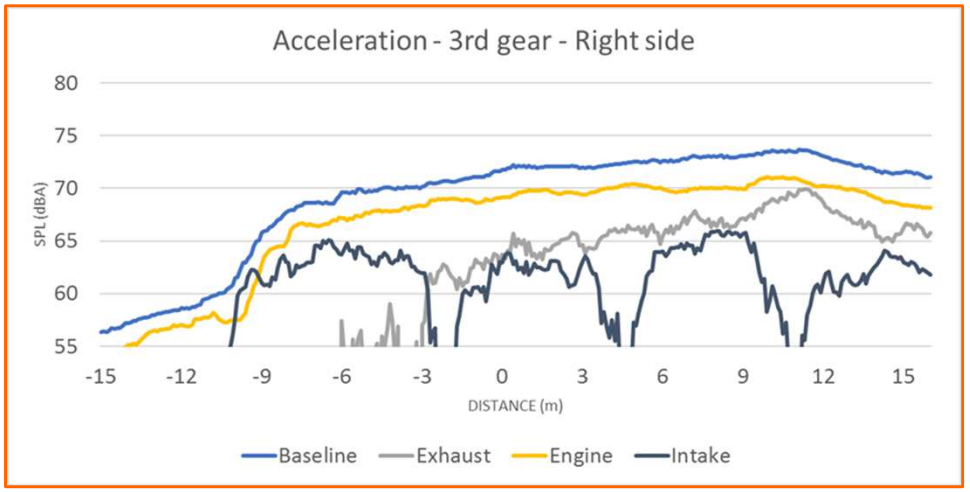


Task 3. Noise Source Ranking tests:

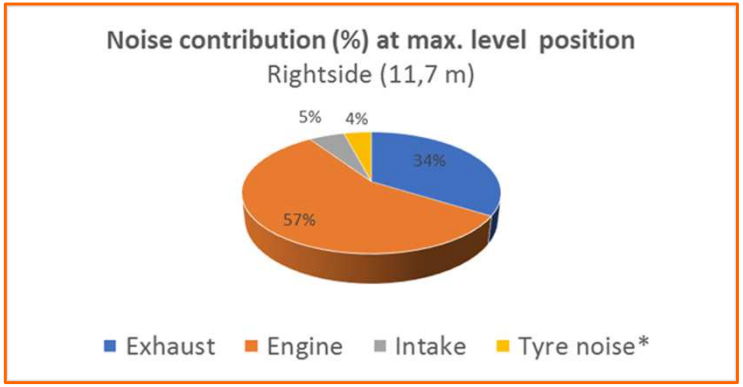
Example of noise source ranking results: Bodied tricycle

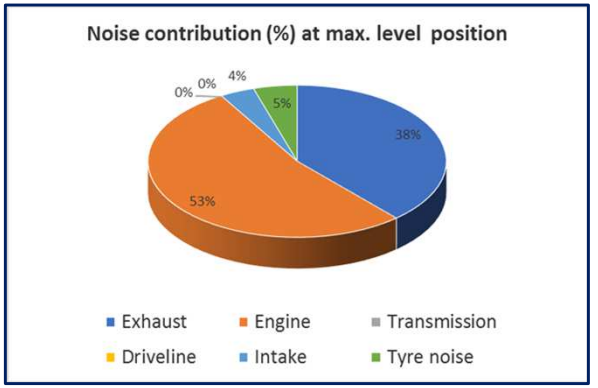
Acceleration test (3rd gear)





Source contribution to maximum noise level value.
Position: 11.7 m after PP'

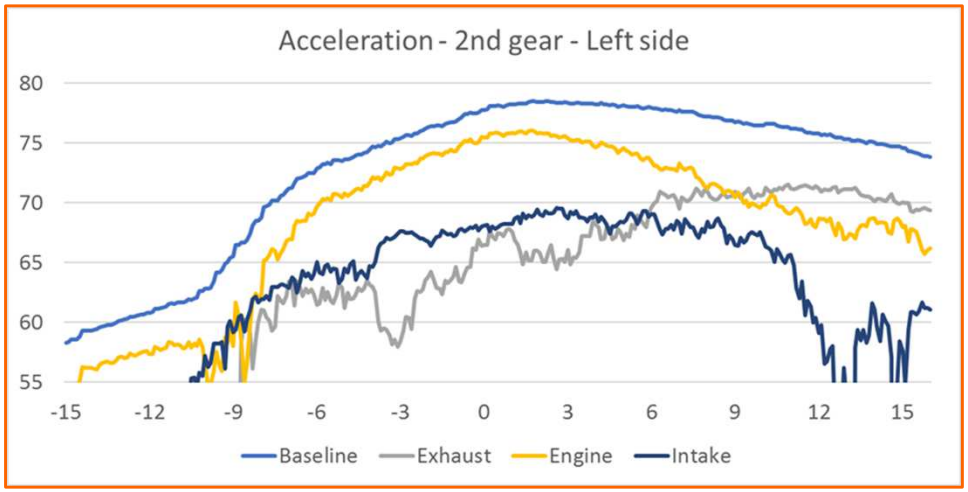


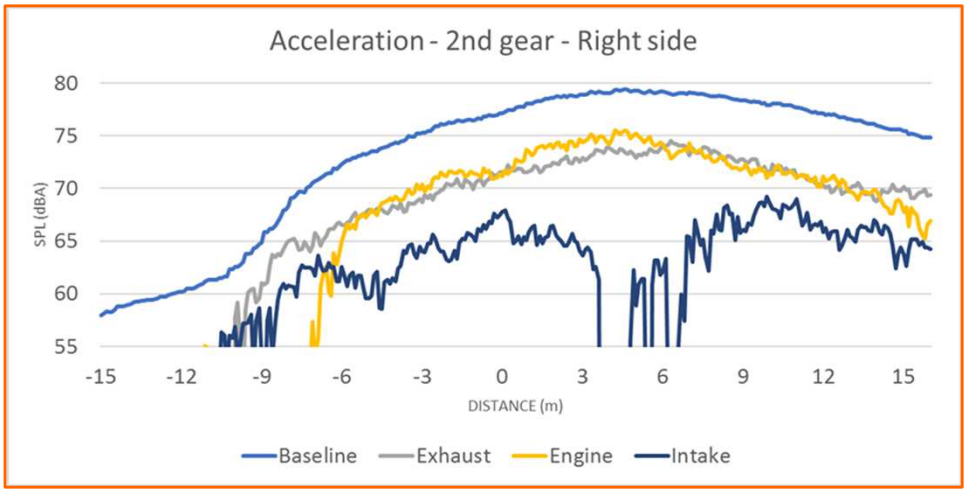


Task 3. Noise Source Ranking tests:

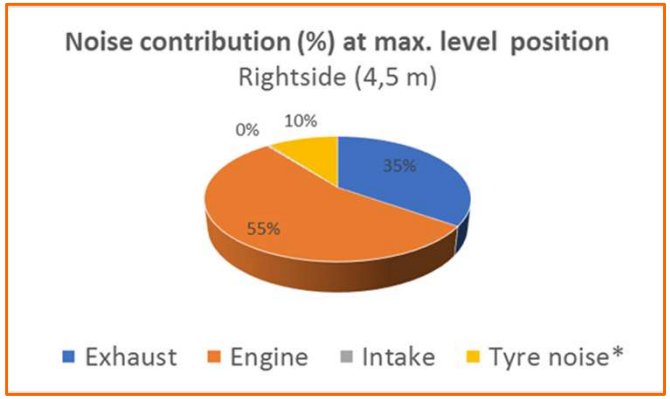
Example of noise source ranking results: Unbodied tricycle

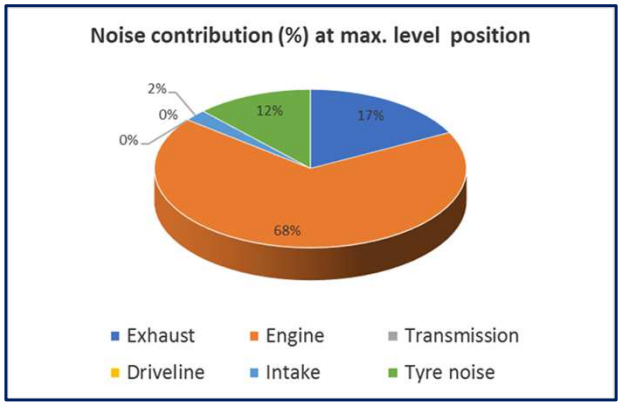
Acceleration test (2rd gear)





Source contribution to maximum noise level value. Position: 4.5 m after PP'

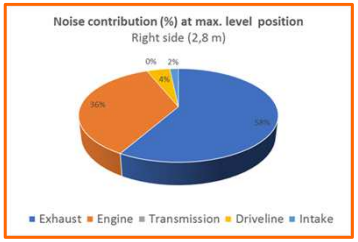




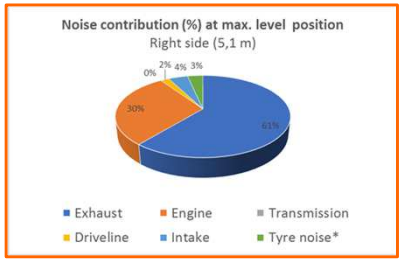
Task 3. Noise Source Ranking tests:

Noise source ranking v.s. driving conditions

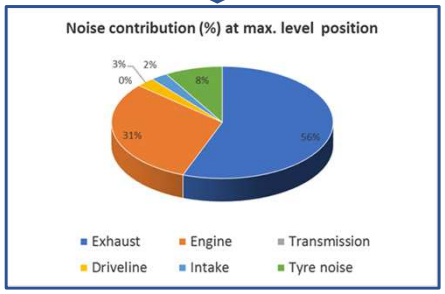
Sport Naked



CRS – 3rd

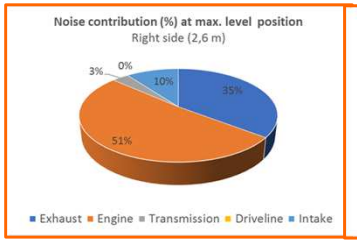


WOT – 3rd

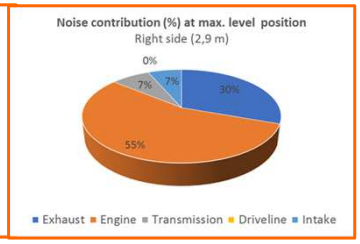


Lurban

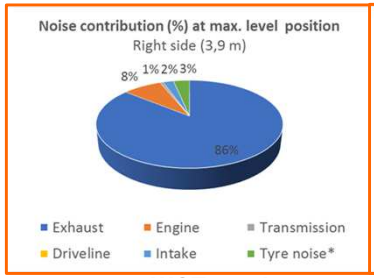
Sport TRAIL (Manual))



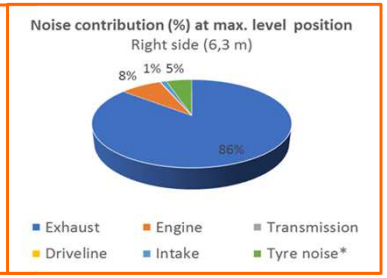
CRS – 3rd



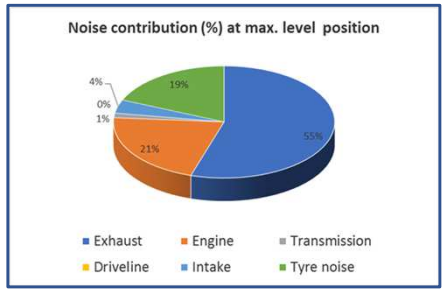
CRS – 4rd



WOT – 3rd

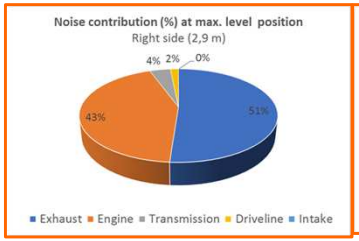


WOT – 4rd

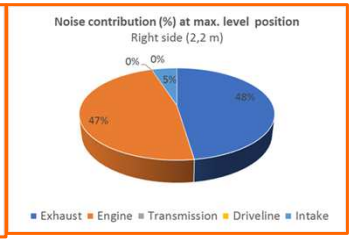


Lurban

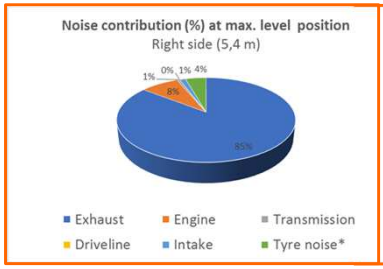
Sport TRAIL (Automatic)



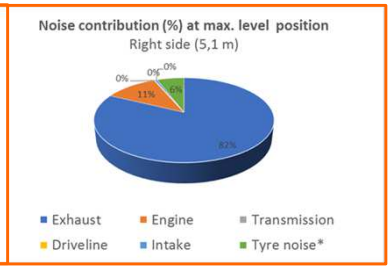
CRS – 3rd



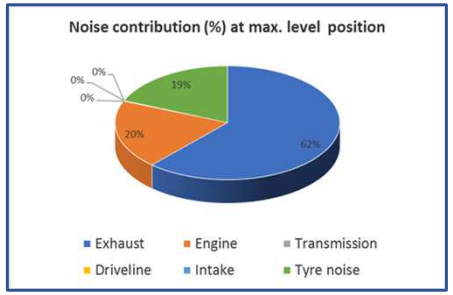
CRS – 4rd



WOT – 3rd



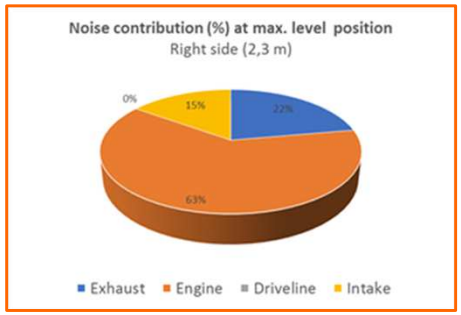
WOT – 4rd



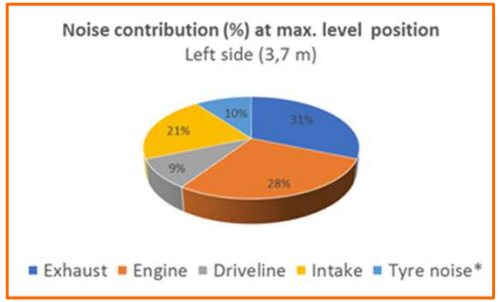
Lurban

Task 3 tests: noise source ranking v.s. driving conditions

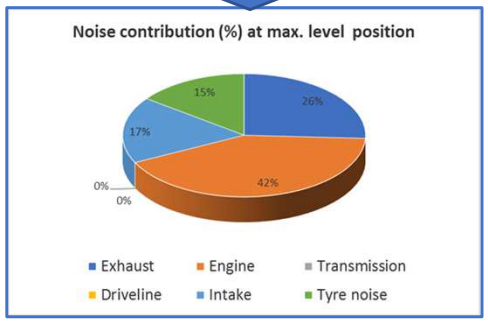
Sport TRAIL



CRS – 4th

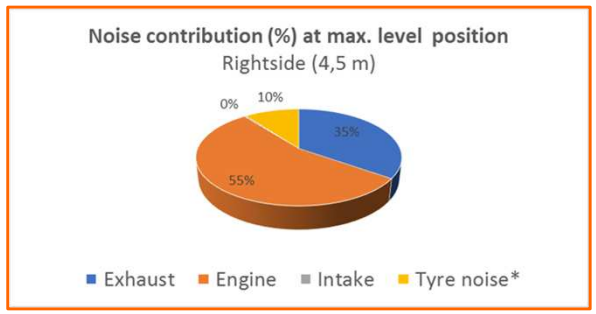


WOT – 4nd

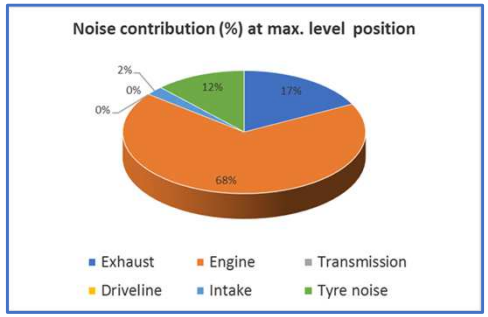


Lurban

Unbodied tricycle

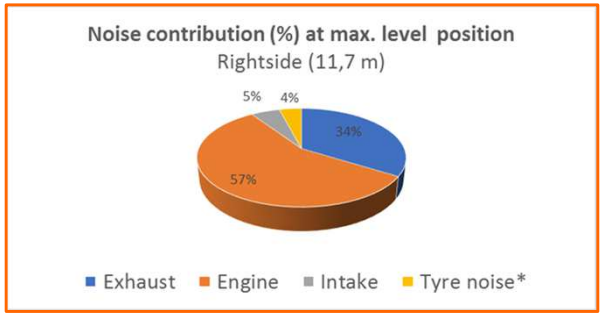


WOT – 2nd

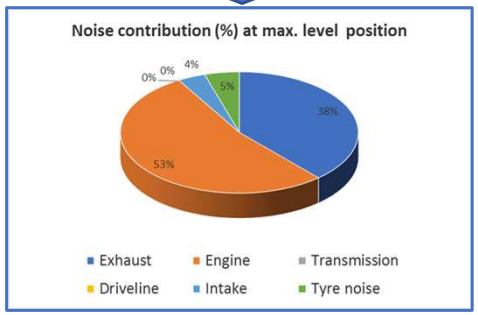


Lurban

Bodied tricycle



WOT – 3rd



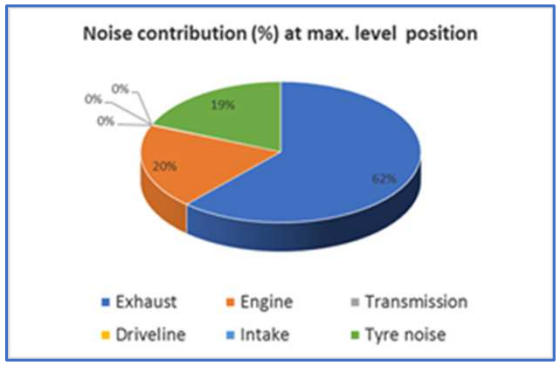
Lurban

Task 3. Noise Source Ranking tests:

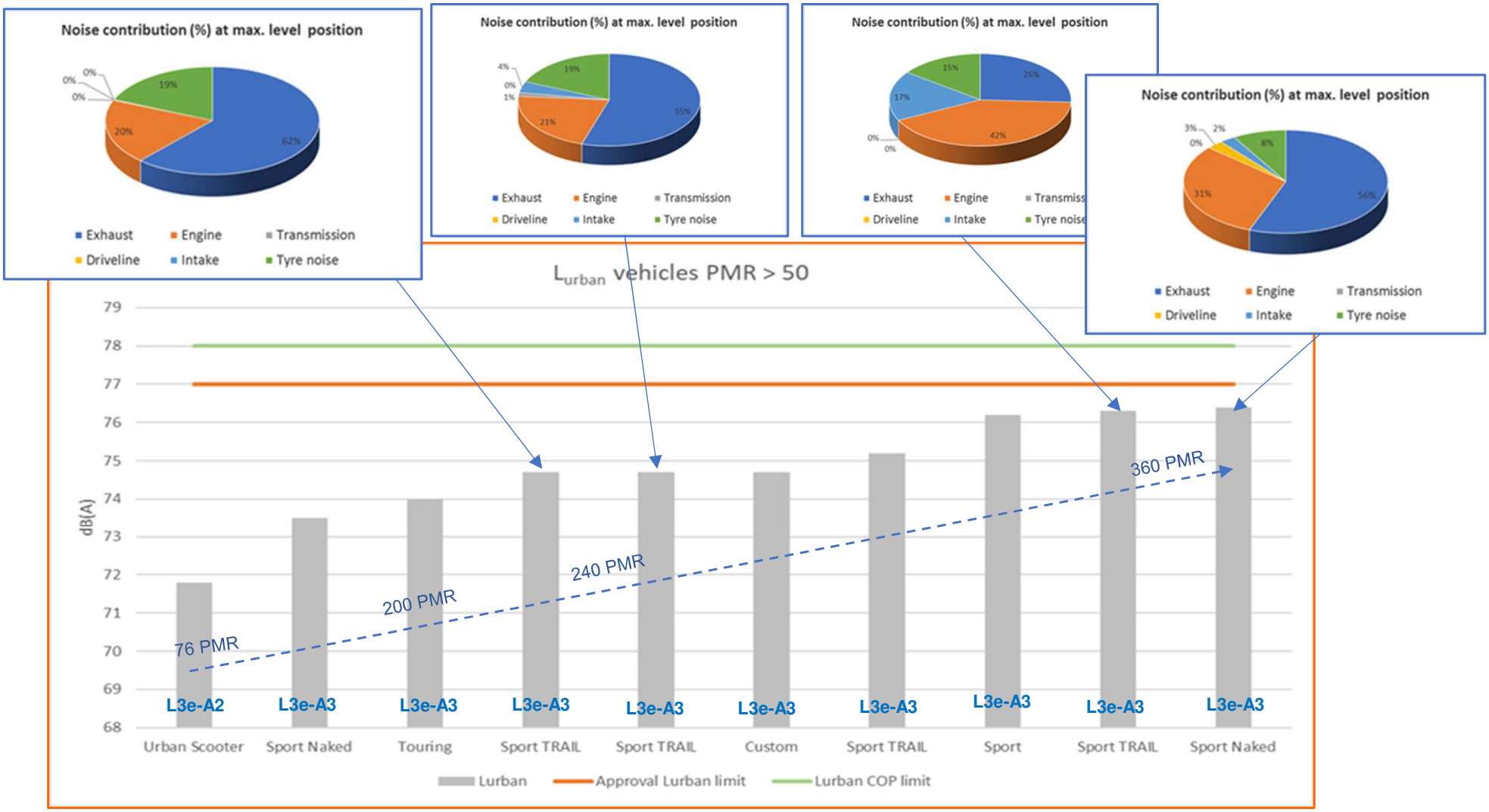
Noise source ranking: Sound structure for L-veh. categories

			Lcrs (3rd)						Lcrs (4th)						Lwot (2nd)						Lwot (3rd)						Lwot (4th)						Lurban					
UN-Reg.	PMR	Name in this report *	Lex %	Leng %	Lt %	Ld %	Li %	Lty* %	Lex %	Leng %	Lt %	Ld %	Li %	Lty* %	Lex %	Leng %	Lt %	Ld %	Li %	Lty* %	Lex %	Leng %	Lt %	Ld %	Li %	Lty* %	Lex %	Leng %	Lt %	Ld %	Li %	Lty* %	Lex %	Leng %	Lt %	Ld %	Li %	Lty* %
R.41.04	PMR > 30	*Sport Naked*	58	36	0	4	2	0													61	30	0	2	4	3							56	31	0	3	2	8
		Sport TRAIL							22	63	0	0	15	0													31	28	1	9	21	10	26	42	0	0	17	15
		Sport TRAIL_Auto	51	43	4	2	0	0	48	47	0	0	5	0							85	8	1	1	1	4	82	11	1	0	0	6	62	20	0	0	0	19
		Sport TRAIL_Manual	35	51	3	1	10	0	30	55	7	1	7	0							86	8	0	1	2	3	86	8	0	0	1	5	55	21	1	0	4	19
R.09.08	PMR ≤ 30	*Bodied Tricycle*																			34	57	N/A	N/A	5	4							38	53	0	0	4	5
	PMR > 30	*Unbodied Tricycle*													35	55	N/A	N/A	0	10													17	68	0	0	2	12

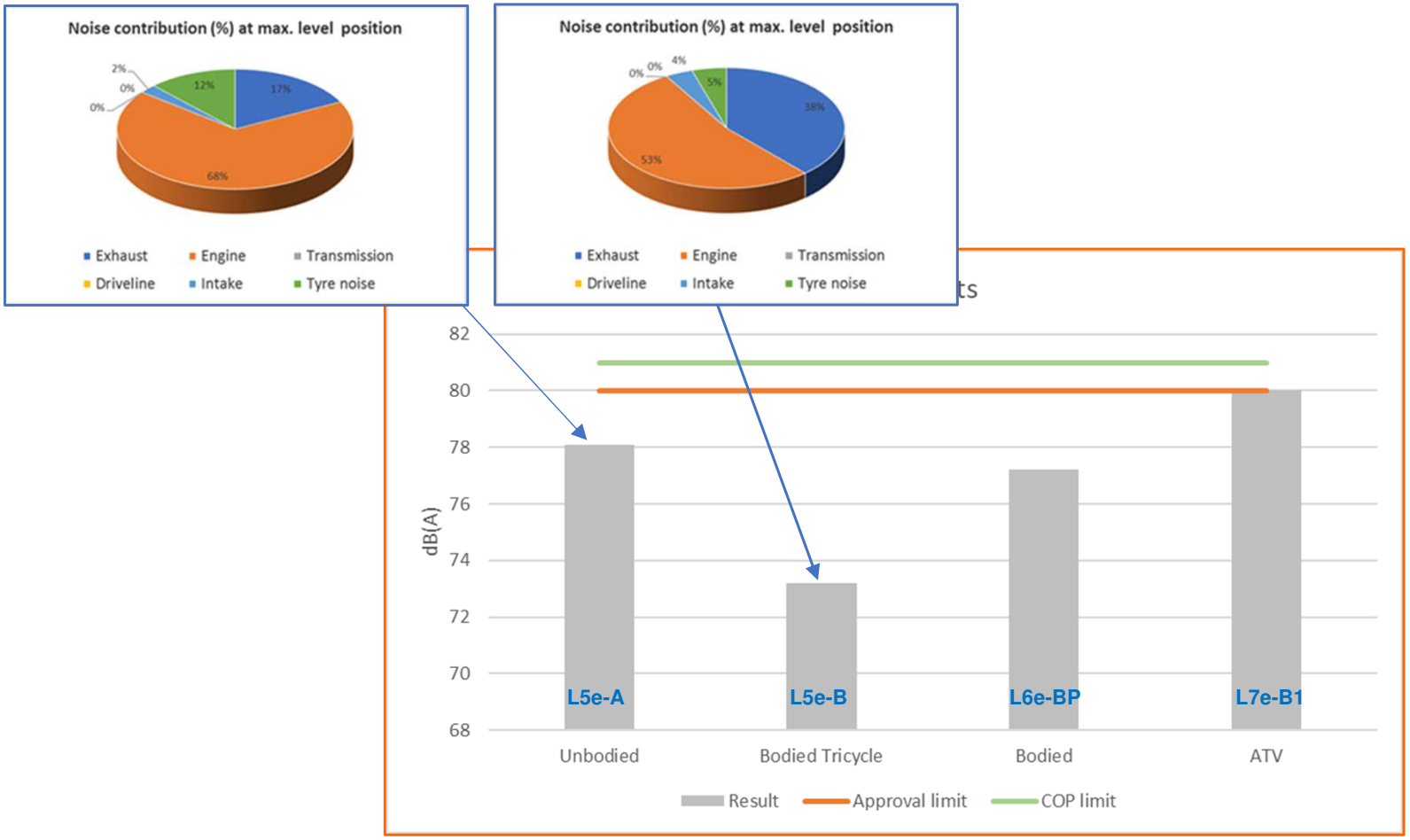
- L_{ex}: Acoustic energy contribution due to the exhaust system (%)
- L_{eng}: Acoustic energy contribution due to the engine (%)
- L_t: Acoustic energy contribution due to the transmission (%)
- L_d : Acoustic energy contribution due to the drive line (%)
- L_i : Acoustic energy contribution due to the intake (%)
- L_{ty} : Acoustic energy contribution due to the tyres (%)



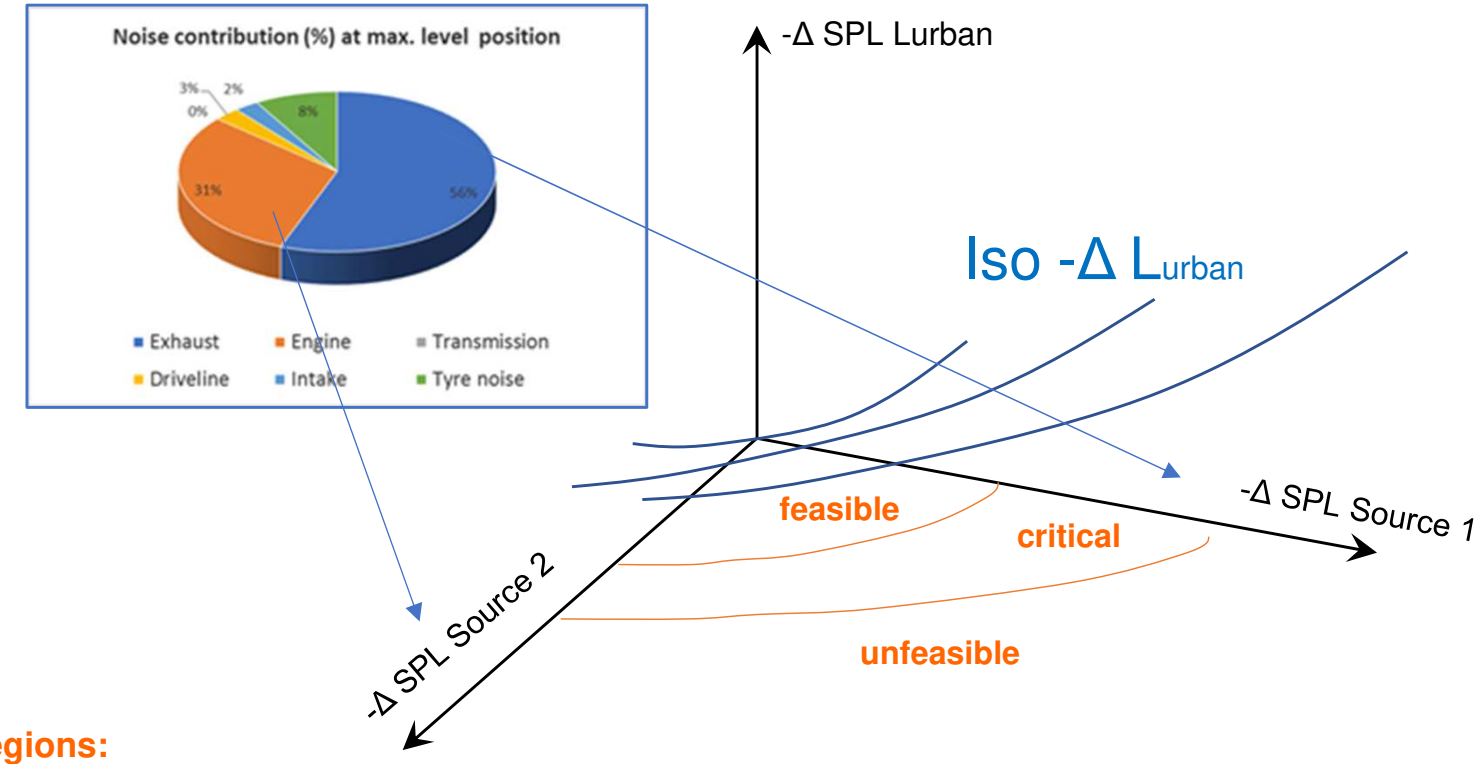
Task 3. Noise Source Ranking tests: L_{urban} and NSR (Regulation Nº 41.04)



Task 3. Noise Source Ranking tests: Lurban and NSR (Regulation № 09.08)



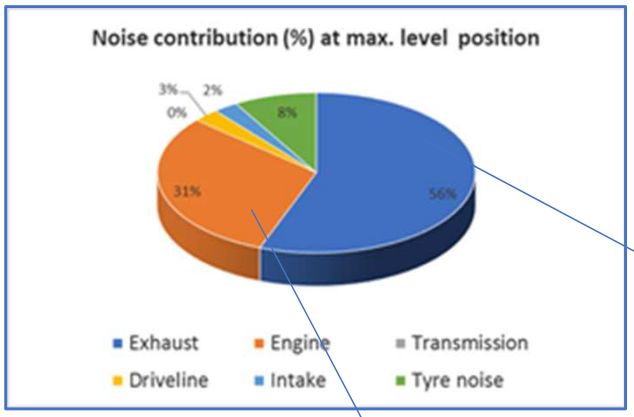
Task 3. Noise Source Ranking tests: Iso Δ Lurban curves

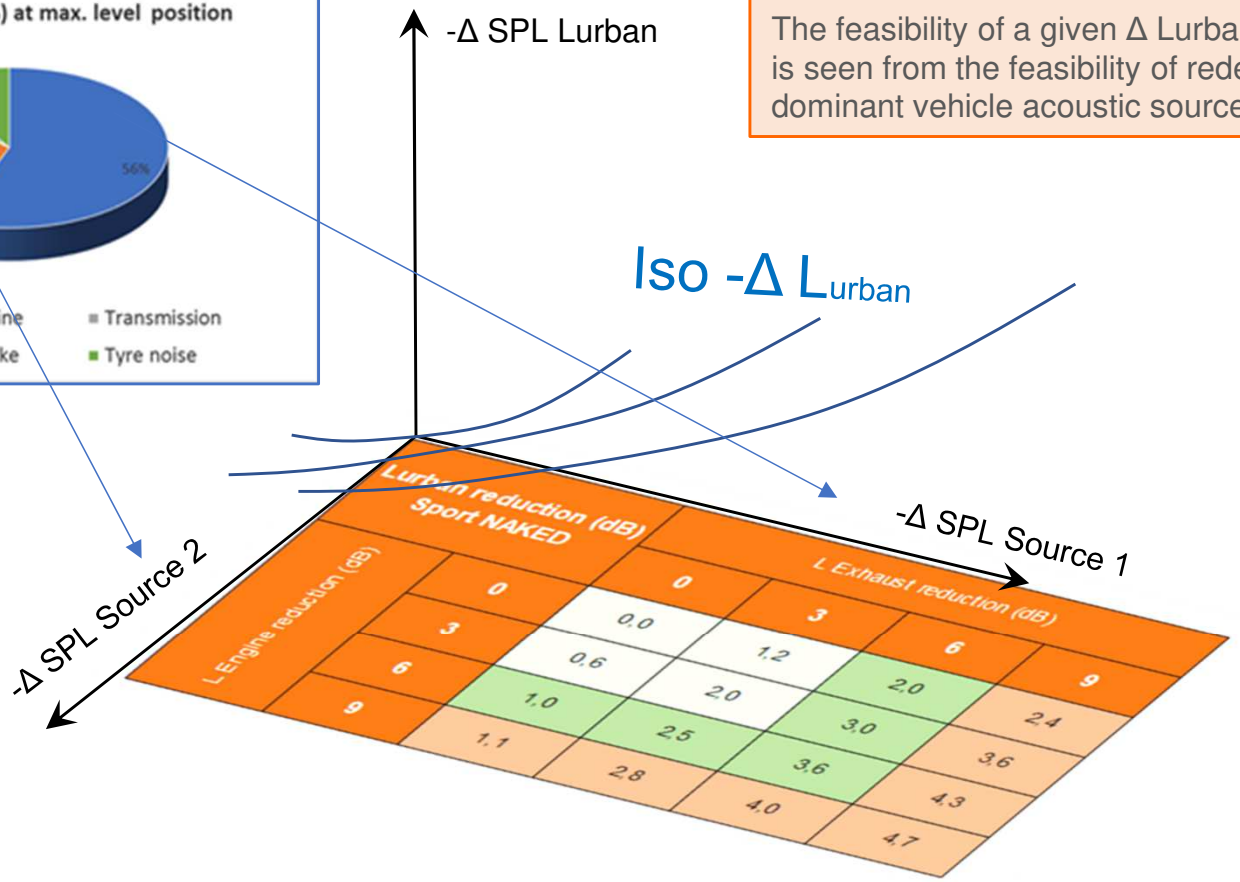


Feasibility regions:

Feasible: Reductions in the vehicle components can be achieved through an evolutive design process keeping the same basic technology concept in the vehicle parts.
Critical: Noise reductions can imply technology changes whose cost or technical sophistication could prevent its practical materialization
Unfeasible: Noise reductions might imply technology changes whose cost or technical sophistication could prevent its practical materialisation involving disruptive technical changes in the corresponding component design concept. Therefore, the technological uncertainty associated with these levels of noise reductions tends to be very high in both, the required design effort and the potential degree of achievement and ability to implement.

Task 3. Noise Source Ranking tests: Iso Δ Lurban curves & feasibility areas





The feasibility of a given Δ Lurban reduction is seen from the feasibility of redesigning the dominant vehicle acoustic sources.

Task 3. Noise Source Ranking tests:

Feasible L_{urban} reductions v.s vehicle

Lurban reduction (dB) Sport NAKED		L Exhaust reduction (dB)			
		0	3	6	9
L Engine reduction (dB)	0	0,0	1,2	2,0	2,4
	3	0,6	2,0	3,0	3,6
	6	1,0	2,5	3,6	4,3
	9	1,1	2,8	4,0	4,7

Lurban reduction (dBA) Sport TRAIL MANUAL		L Exhaust reduction (dBA)			
		0	3	6	9
L Engine reduction (dBA)	0	0,0	1,3	2,3	2,9
	3	0,4	1,8	2,9	3,7
	6	0,7	2,1	3,2	4,1
	9	0,8	2,3	3,4	4,3

Lurban reduction (dBA) Sport TRAIL AUTO		L Exhaust reduction (dBA)			
		0	3	6	9
L Engine reduction (dBA)	0	0,0	1,3	2,3	3,0
	3	0,4	1,8	2,9	3,6
	6	0,5	2,0	3,2	3,9
	9	0,6	2,2	3,3	4,1

Lurban reduction (dBA) Sport TRAIL		L Exhaust reduction (dBA)			
		0	3	6	9
L Engine reduction (dBA)	0	0,0	0,3	0,4	0,5
	3	0,5	0,8	1,0	1,1
	6	0,7	1,1	1,3	1,4
	9	0,9	1,2	1,4	1,5

Feasible

Limited feasibility

Unfeasible

Task 3. Noise Source Ranking tests:

Feasible L_{urban} reductions v.s vehicle

Lurban reduction (dBA) Unbodied Tricycle		L Exhaust reduction (dBA)			
		0	3	6	9
L Engine reduction (dBA)	0	0,0	0,4	0,6	0,6
	3	1,2	1,6	1,8	2,0
	6	1,9	2,4	2,6	2,8
	9	2,3	2,8	3,1	3,3

Lurban reduction (dBA) Bodied Tricycle		L Exhaust reduction (dBA)			
		0	3	6	9
L Engine reduction (dBA)	0	0,0	0,9	1,5	1,8
	3	1,3	2,6	3,4	3,9
	6	2,2	3,8	4,9	5,6
	9	2,7	4,5	5,9	6,8

Feasible

Limited feasibility

Unfeasible

Task 4
COST BENEFIT ANALYSIS

Task 4: Cost Benefit Analysis: Scenarios

0dB

- Scenario a): No limit change, only enforcement

-2dB

- Scenario b):start of type approval (TA) with Euro 5 step and 2dB noise limits reduction mid 2024, two more years (mid 2026) for the compliance of all vehicles

-4dB

- Scenario c):Start of type approval (TA) with 4dB noise limits reduction mid 2026, 2-3 more years (i.e. mid 2028 or mid 2029) for the compliance of all vehicles

-2dB -4dB

- Scenario d): (mix of a and b) start of TA with Euro 5 step and 2dB noise limits reduction mid 2024, two more years (mid 2026) for the compliance of all vehicles with simultaneous start of TA with more 2dB noise limits reduction and finally 2-3 more years (i.e. mid 2028 or mid 2029) for all vehicles compliance

Task 4: Cost Benefit Analysis: General remarks

- We know there are many uncertainties around most of the assumptions in individual elements of the methodology, including:
  - level of illegally modified vehicles;
  - cost of bringing down (to zero) level of illegally modified vehicles;
  - impact of single events on health;
  - evolution of fleet;
  - cost for manufacturers (based on small sample biased by company size and model type).

- This gives importance to weighting assumptions against each other, i.e. when assuming upper limit in benefits, then also upper limit in costs. Gaining an understanding of the proportions of one to another.

Task 4: Cost Benefit Analysis: Assessment of TNO'17

- TNO '17 study appears to have a reasonable balance.
- We understand both, benefits and costs to be on the conservative side.
- Our analysis aims at considering most recent research in benefits of noise reduction, geographical split in North/South, Urban/Rural, consideration of single events, and industry costs based on most recent consultation, and at the same time broadly maintaining the methodology developed by TNO.
- Individual elements discussed on next slides.

Task 4: Cost Benefit Analysis: Benefits - Noise reduction and unit costs

- Main factors of benefits are noise reduction, marginal unit costs and affected population

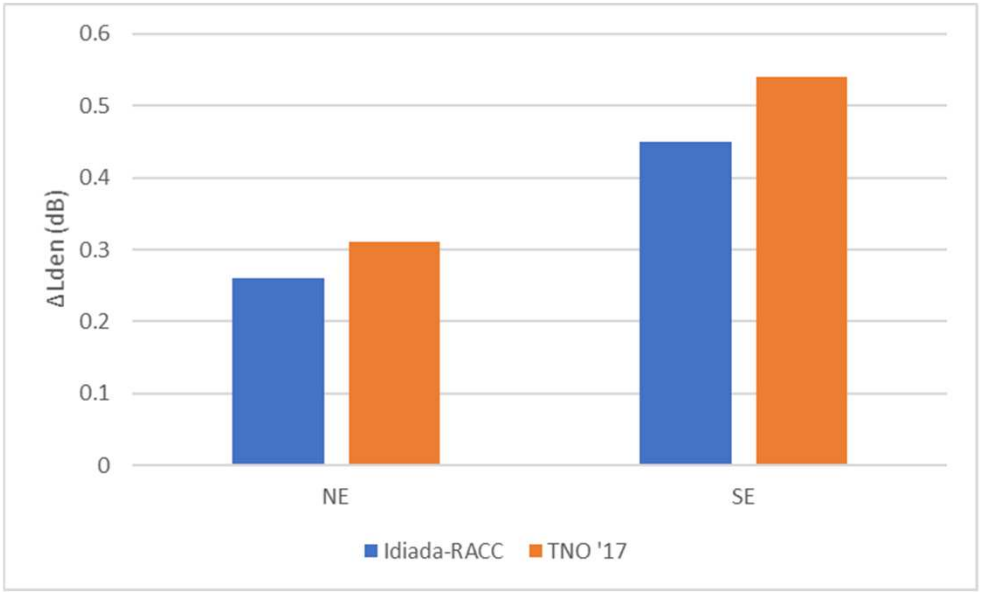


Fig. 1: Noise reduction in urban environment [-2dB scenario]

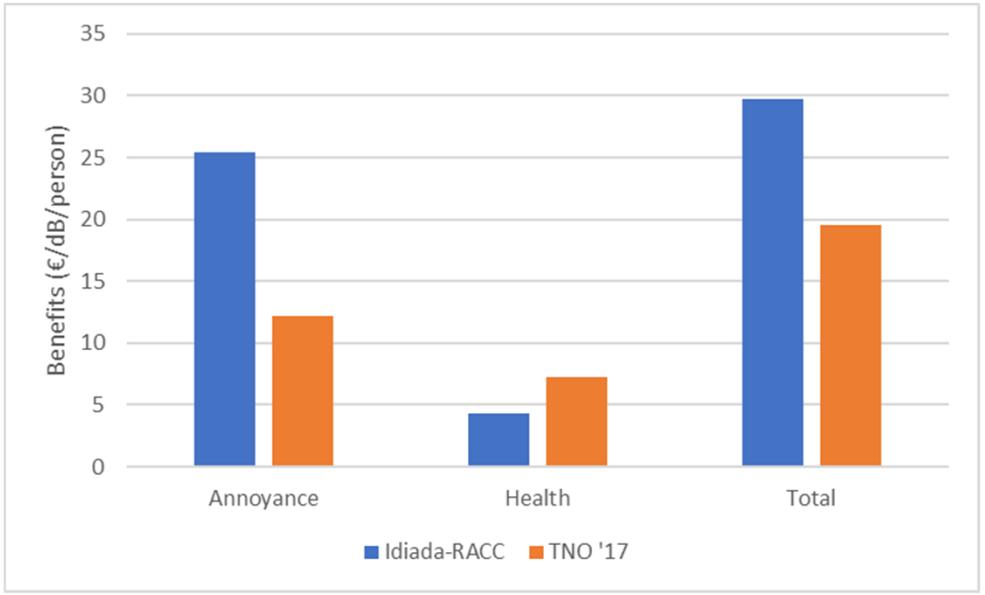


Fig. 2: Valuation of noise reduction per unit

Task 4: Cost Benefit Analysis: *Benefits*. Comparison of total benefits with TNO'17 and IAI'21

- Differences due to higher valuation of noise reduction, higher noise reduction in rural areas and the North
- Partly offset by shorter analysis period (15y instead of 20y)

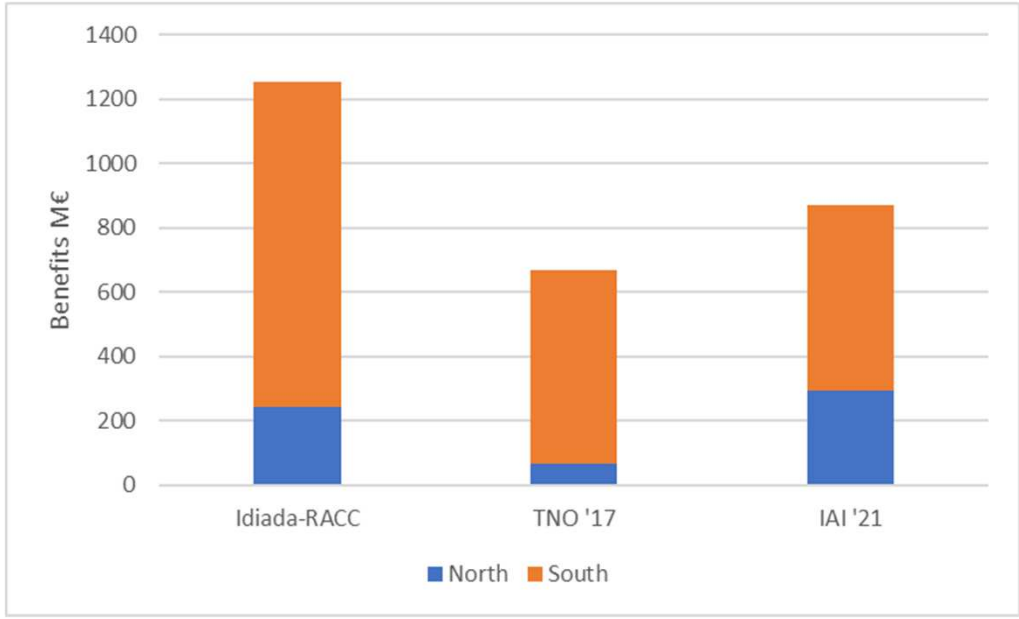


Fig. Comparison of total benefits for -2dB scenario

Task 4: Cost Benefit Analysis: *Costs*- Comparison of total benefits with TNO`17 and IAI'21

- Industry costs equal to these of IAI´s assessment, based on recent industry consultation
- However, sample based on small sample biased by company size and model type
- more than 3 times those presented in TNO '17

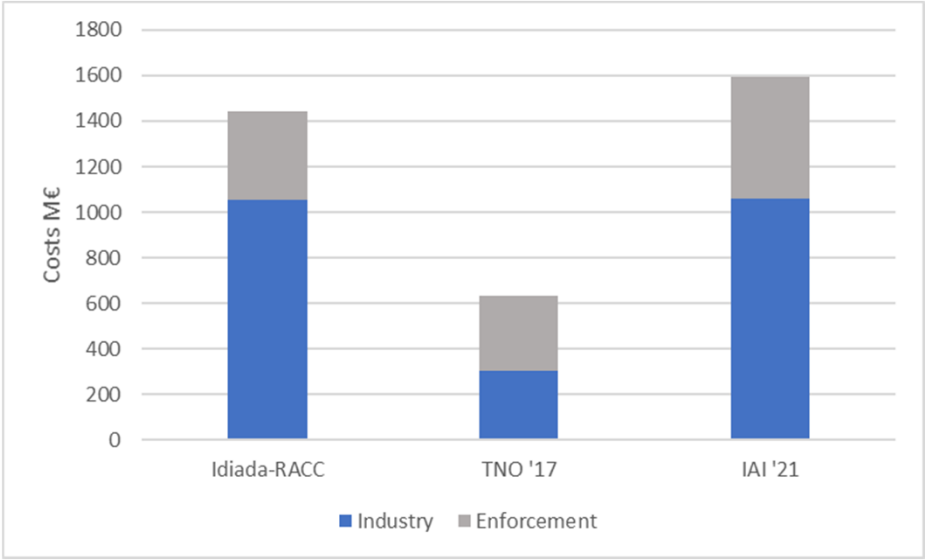


Fig. Comparison of total benefits for -2dB scenario

Task 4: Cost Benefit Analysis: Resulting ratios

- Comparison of total costs with TNO ‘17 and IAI ’21 [for -2dB scenario]
- Our estimates conservative, with upside potential in shape of lower than expected costs, and additional benefits through elimination of single-events in urban areas

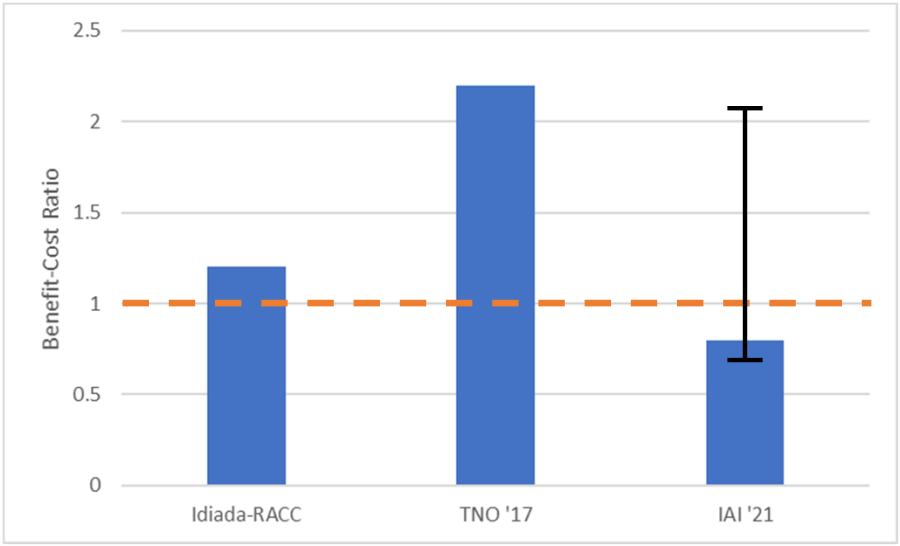


Fig.: Benefit-Cost ratios for -2dB scenario

Task 4: Cost Benefit Analysis: Summary of all scenarios

[A: only-enforcement; B: -2dB reduction; C: -4dB reduction; D: stepwise -2/-4dB reduction]

- Highest B/C ratio in enforcement only
- However, benefits higher in those scenarios including limit reduction
- -4dB scenarios include high uncertainty around industry cost/feasibility

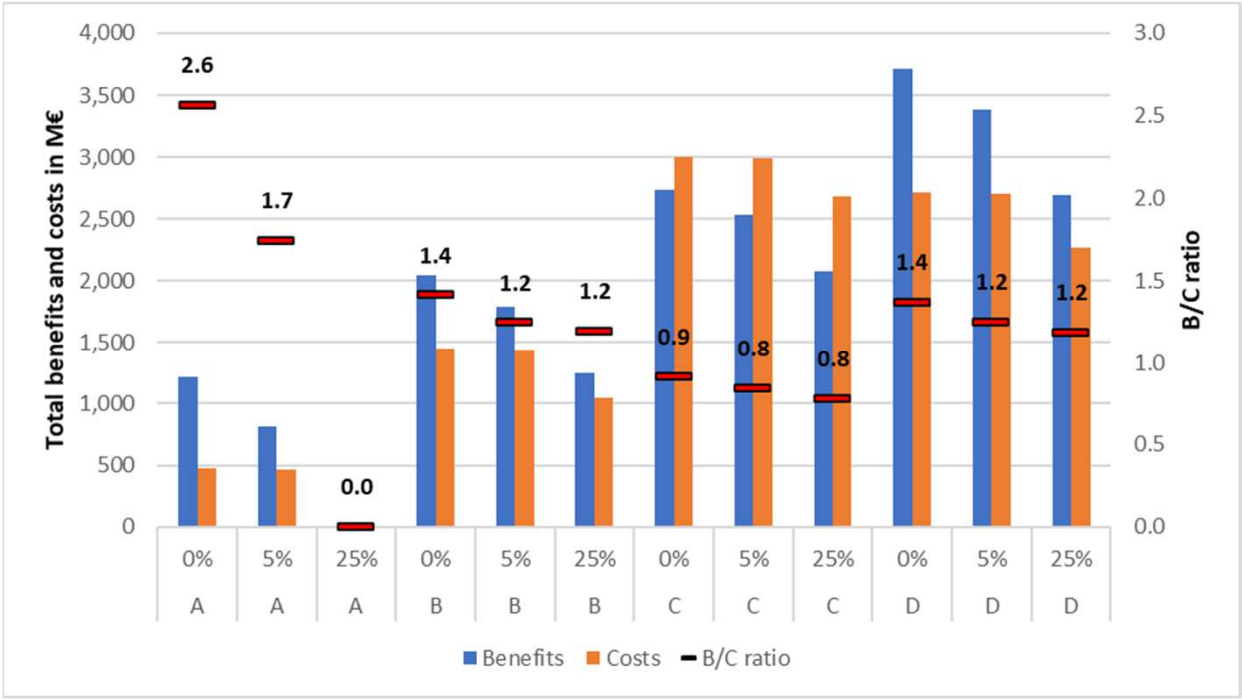


Fig.: Benefit-Cost ratios, total benefits, total costs for all scenarios

Task 5
Proposal sound emissions limits

Task 5. Proposal sound emissions limits: Scenarios

0dB

- Scenario a): No limit change, only enforcement

-2dB

- Scenario b):start of type approval (TA) with Euro 5 step and 2dB noise limits reduction mid 2024, two more years (mid 2026) for the compliance of all vehicles

-4dB

- Scenario c):Start of type approval (TA) with 4dB noise limits reduction mid 2026, 2-3 more years (i.e. mid 2028 or mid 2029) for the compliance of all vehicles

-2dB
-4dB

- Scenario d): (mix of a and b) start of TA with Euro 5 step and 2dB noise limits reduction mid 2024, two more years (mid 2026) for the compliance of all vehicles with simultaneous start of TA with more 2dB noise limits reduction and finally 2-3 more years (i.e. mid 2028 or mid 2029) for all vehicles compliance

Task 5. Proposal sound emissions limits: New limit values

[A: only-enforcement; B: -2dB reduction; C: -4dB reduction; D: stepwise -2/-4dB reduction]

UN Regulation	Category	Scenario A - 0 dB(A) reduction	Scenario B - 2 dB(A) reduction	Scenario C - 4 dB(A) reduction	Scenario D - 2 dB(A) reduction in 2024 (Step 1)	Scenario D - 4 dB(A) reduction in 2026 (Step 2)
41.04	L3e PMR ≤ 25	73	71	69	71	69
	L3e 25 < PMR ≤ 50	74	72	70	72	70
	L3e > 50	77	75	73	75	73
9.08	L2e	76	74	72	74	72
	L4e, L5e-A, L5e-B, L6e-A, L6e-B, L7e-A, L7e-B, L7e-C	80	78	76	78	76

Task 5. Proposal sound emissions limits: Feasibility for new limit values

[A: only-enforcement; B: -2dB reduction; C: -4dB reduction; D: stepwise -2/-4dB reduction]

Feasible: Reductions in the vehicle components can be achieved through an evolutive design process keeping the same basic technology concept in the vehicle parts.
Critical: Noise reductions can imply technology changes whose cost or technical sophistication could prevent its practical materialization
Unfeasible: Noise reductions might imply technology changes whose cost or technical sophistication could prevent its practical materialisation involving disruptive technical changes in the corresponding component design concept. Therefore, the technological uncertainty associated with these levels of noise reductions tends to be very high in both, the required design effort and the potential degree of achievement and ability to implement.

UN Regulation	Category	Scenario A - 0 dB(A) reduction	Scenario B - 2 dB(A) reduction	Scenario C - 4 dB(A) reduction	Scenario D - 2 dB(A) reduction in 2024 (Step 1)	Scenario D - 4 dB(A) reduction in 2026 (Step 2)
41.04	L3e PMR ≤ 50					
	L3e PMR > 50					
	High performance L3e > 50					
9.08	L2e					
	L4e, L6e-A, L6e-B, L7e-A, L7e-C					
	L5e-A					
	L5e-B					
	L7e-B					

Feasible	
Limited feasible	
Unfeasible	

Table.: Feasibility for new sound limit values

Task 5. Proposal sound emissions limits: Feasibility for new limit values

[A: only-enforcement]

Feasible: Reductions in the vehicle components can be achieved through an evolutive design process keeping the same basic technology concept in the vehicle parts.
Critical: Noise reductions can imply technology changes whose cost or technical sophistication could prevent its practical materialization
Unfeasible: Noise reductions might imply technology changes whose cost or technical sophistication could prevent its practical materialisation involving disruptive technical changes in the corresponding component design concept. Therefore, the technological uncertainty associated with these levels of noise reductions tends to be very high in both, the required design effort and the potential degree of achievement and ability to implement.

UN Regulation	Category	Scenario A - 0 dB(A) reduction
41.04	L3e PMR ≤ 50	
	L3e PMR > 50	
	High performance L3e > 50	
9.08	L2e	
	L4e, L6e-A, L6e-B, L7e-A, L7e-C	
	L5e-A	
	L5e-B	
	L7e-B	

Feasible	
Limited feasible	
Unfeasible	

Table.: Feasibility for new sound limit values. Scenario A

- The stakeholders' feedback gathering, highlighted factors such as tampering vehicles, illegal NORESS and reckless driving as the main reasons of producing the highest noise annoyance on public roads.
- The new RD-ASEP procedure on UN-R41.05 adds new real driving conditions to be tested on a higher control boundary range.
- Highest B/C ratio scenario
- Feasible for all L-category vehicles evaluated within this study.

Task 5. Proposal sound emissions limits : Feasibility for new limit values
[B: -2dB reduction]

Feasible: Reductions in the vehicle components can be achieved through an evolutive design process keeping the same basic technology concept in the vehicle parts.
Critical: Noise reductions can imply technology changes whose cost or technical sophistication could prevent its practical materialization
Unfeasible: Noise reductions might imply technology changes whose cost or technical sophistication could prevent its practical materialisation involving disruptive technical changes in the corresponding component design concept. Therefore, the technological uncertainty associated with these levels of noise reductions tends to be very high in both, the required design effort and the potential degree of achievement and ability to implement.

UN Regulation	Category	Scenario B - 2 dB(A) reduction
41.04	L3e PMR ≤ 50	
	L3e PMR > 50	
	High performance L3e > 50	
9.08	L2e	
	L4e, L6e-A, L6e-B, L7e-A, L7e-C	
	L5e-A	
	L5e-B	
	L7e-B	

Feasible	
Limited feasible	
Unfeasible	

Table.: Feasibility for new sound limit values. Scenario B

- The stakeholders' feedback gathering highlights that the reduction up to 2 dB(A) is not desired for L3e-A3, however is more feasible for tricycles and quadricycles L- category vehicles.
- B/C ratio of 1.4 is lower than in scenario A but provides around 70% more total benefits. However, these benefits come at a higher cost.
- For L5e-A,L5e-B, L6e-BU, L6e-BP and L7e-CP category vehicles, excluding L7e-B1 and L7e-B2 (ATVs), will be feasible to reduce 2 dB(A).
- Some tested L3e vehicles with PMR > 50 depending on the engine configuration and power-torque curve are below the approval limits. (More than 2 dB(A) difference). It is feasible.
- A reduction of 2 dB(A) in the Lurban limit, for a high performance L3e-A3 with PMR > 50, estimates a required sub-category worst-case reduction* of 6 dB(A) of engine and 6 dB(A) in exhaust system contributions respectively. A limited feasibility could be considered on this scenario.
- A reduction of 2 dB(A) in the Lurban limit for L3e category vehicles with PMR ≤ 50 is unfeasible. Most of this category vehicles are within the thresholds of the actual sound approval limit (74 dB(A)). Assuming this vehicle configuration is usually low-cost, this level of noise reduction in vehicle components normally involves disruptive technical changes in the corresponding component design concept. Therefore, the technological uncertainty associated to these levels of noise reductions is very high in both, the required effort and the potential degree of achievement.

Task 5. Proposal sound emissions limits: Feasibility for new limit values

[C: -4dB reduction]

Feasible: Reductions in the vehicle components can be achieved through an evolutive design process keeping the same basic technology concept in the vehicle parts.
Critical: Noise reductions can imply technology changes whose cost or technical sophistication could prevent its practical materialization
Unfeasible: Noise reductions might imply technology changes whose cost or technical sophistication could prevent its practical materialisation involving disruptive technical changes in the corresponding component design concept. Therefore, the technological uncertainty associated with these levels of noise reductions tends to be very high in both, the required design effort and the potential degree of achievement and ability to implement.

UN Regulation	Category	Scenario C - 4 dB(A) reduction
41.04	L3e PMR ≤ 50	
	L3e PMR > 50	
	High performance L3e > 50	
9.08	L2e	
	L4e, L6e-A, L6e-B, L7e-A, L7e-C	
	L5e-A	
	L5e-B	
	L7e-B	

Feasible	
Limited feasible	
Unfeasible	

Table.: Feasibility for new sound limit values. Scenario C

- The stakeholders' feedback gathering, does not consider a reduction of 4 dB(A).
- A reduction of 4 dB(A) in the Lurban limit, for a high performance L3e-A3 with PMR > 50, estimates a required sub-category reduction 9 dB(A) in the engine and 9 dB(A) in exhaust system contributions, respectively. It is considered as an unfeasible scenario.
- B/C ratio below 1. There are more costs than benefits mainly due to costs for R&D and manufacturing to be assumed in first years while benefits start to kick in only after 5 years.
- A reduction of 4 dB(A) in the Lurban limit, for unbodied tricycles (L5e-A), estimates a required sub-category average reduction of 6 dB(A) in the engine and 0 dB(A) in exhaust system contributions. It is limited feasible to achieve this scenario. These noise level reductions might imply technology changes whose cost or technical difficulty could prevent its practical materialisation.

Task 5. Proposal sound emissions limits: Feasibility for new limit values

[D: stepwise -2/-4dB reduction]

Feasible: Reductions in the vehicle components can be achieved through an evolutive design process keeping the same basic technology concept in the vehicle parts.
Critical: Noise reductions can imply technology changes whose cost or technical sophistication could prevent its practical materialization
Unfeasible: Noise reductions might imply technology changes whose cost or technical sophistication could prevent its practical materialisation involving disruptive technical changes in the corresponding component design concept. Therefore, the technological uncertainty associated with these levels of noise reductions tends to be very high in both, the required design effort and the potential degree of achievement and ability to implement.

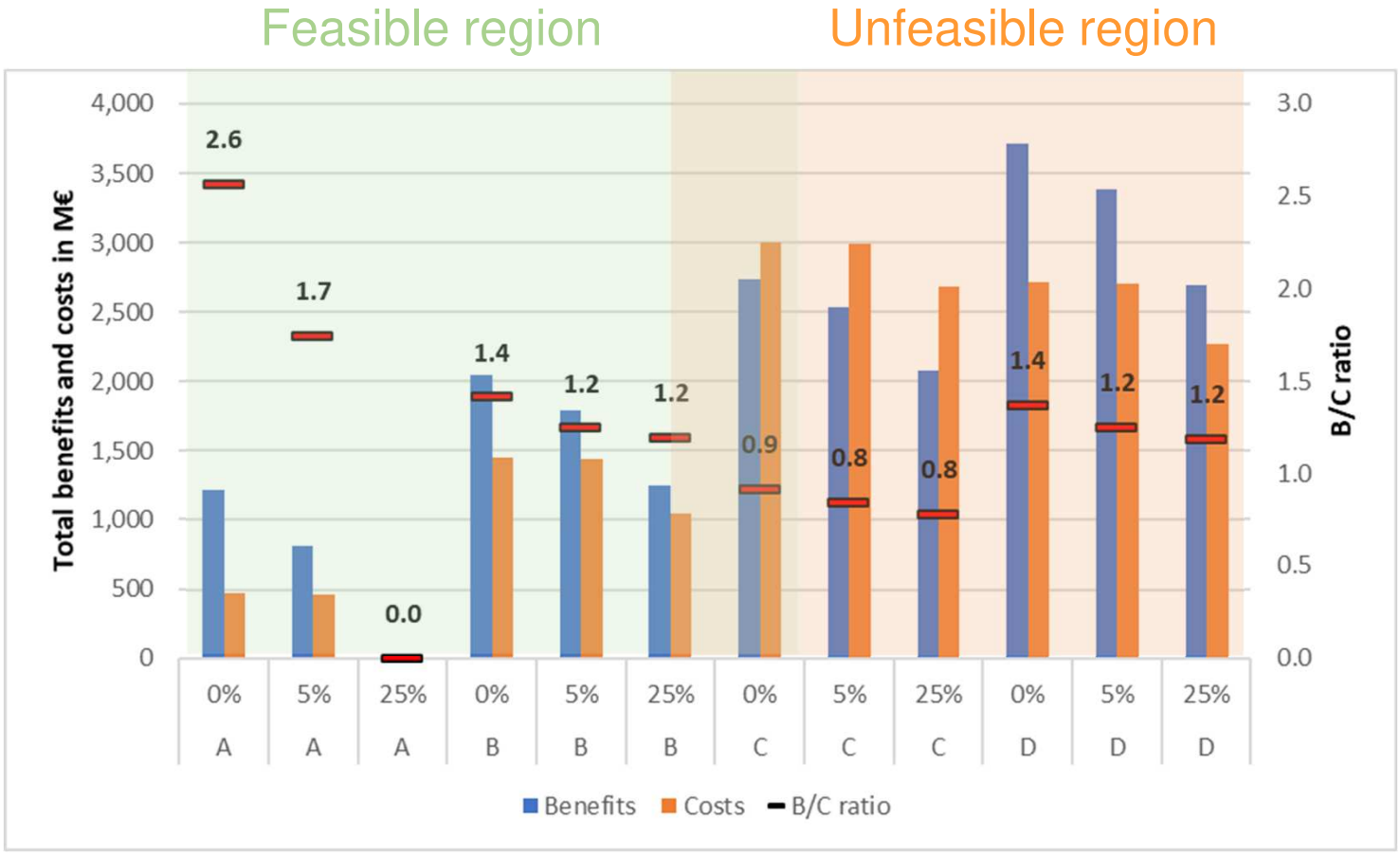
UN Regulation	Category	Scenario D - 2 dB(A) reduction in 2024 (Step 1)	Scenario D - 4 dB(A) reduction in 2026 (Step 2)
41.04	L3e PMR ≤ 50		
	L3e PMR > 50		
	High performance L3e > 50		
9.08	L2e		
	L4e, L6e-A, L6e-B, L7e-A, L7e-C		
	L5e-A		
	L5e-B		
	L7e-B		

Feasible	
Limited feasible	
Unfeasible	

Table.: Feasibility for new sound limit values. Scenario D

- In terms of technical feasibility, the Scenario D is identical as the Scenario B for the Step 1 and identical as the Scenario C for Step 2.
- The B/C ratio is the same as in the Scenario B. However in this case the costs are almost the double.

Task 5. Proposal sound emissions limits: CBA & Feasibility



Benefit-Cost ratios, total benefits, total costs for all scenarios