Vehicle Exterior Sound Emission Regulations

Additional Sound Emission Provisions

Application Principles for the Revision 2.0 by UN GRBP

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What are Additional Sound Emission Provisions?

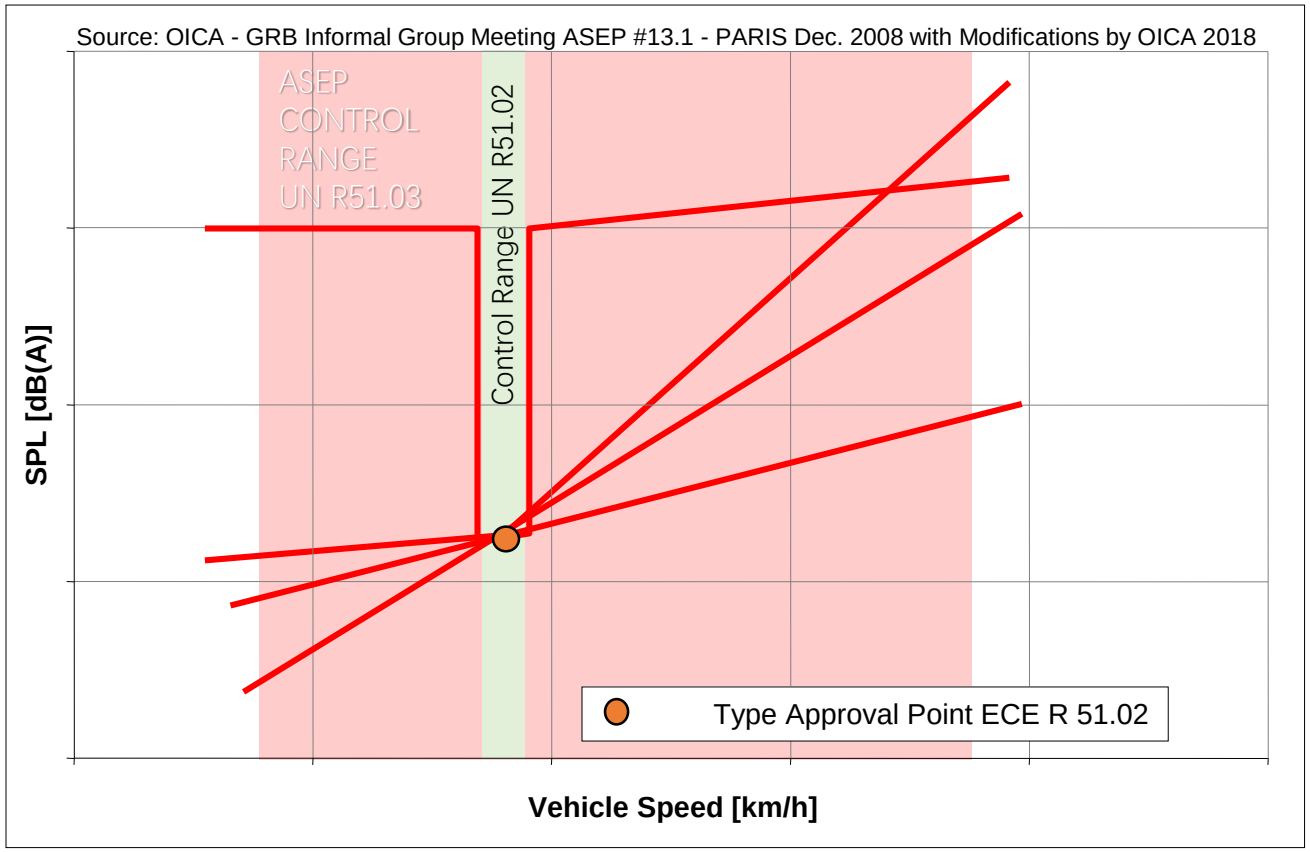
- ASEP was introduced with the lastest revision of the UN Regulation No. 51 on sound emission of vehicles.
- Modern technologies, such as active silencer systems or additional sound speaker showed that regulating the sound emission at a single operation condition cannot sufficiently control the vehicle sound behaviour.

Active Exhaust Systems

Sound Enhancement Systems

- All sound emission regulations worldwide are design neutral and verify the effect of a technology by its sound emission. No technology is prohibited, as technologies can decrease or increase the sound.
- A single point evaluation for sound is not sufficient for active controlled sound systems!

Limited Representativeness of a Single Point Sound Assessment



- UN R51.02 and GB1495-2002 regulation the sound emission at a single point (50 km/h).
- Aside of the narrow area around 50 km/h the sound emission is not evaluated and thus, no control is provided.
- Manufacturer have started to use this uncontrolled area to provide alternative sounds to their customers.
- Driven by competition, positive press reports for the „best sound“ and great customer acceptance this flexibility of Regulations is (ab)used as much as possible.

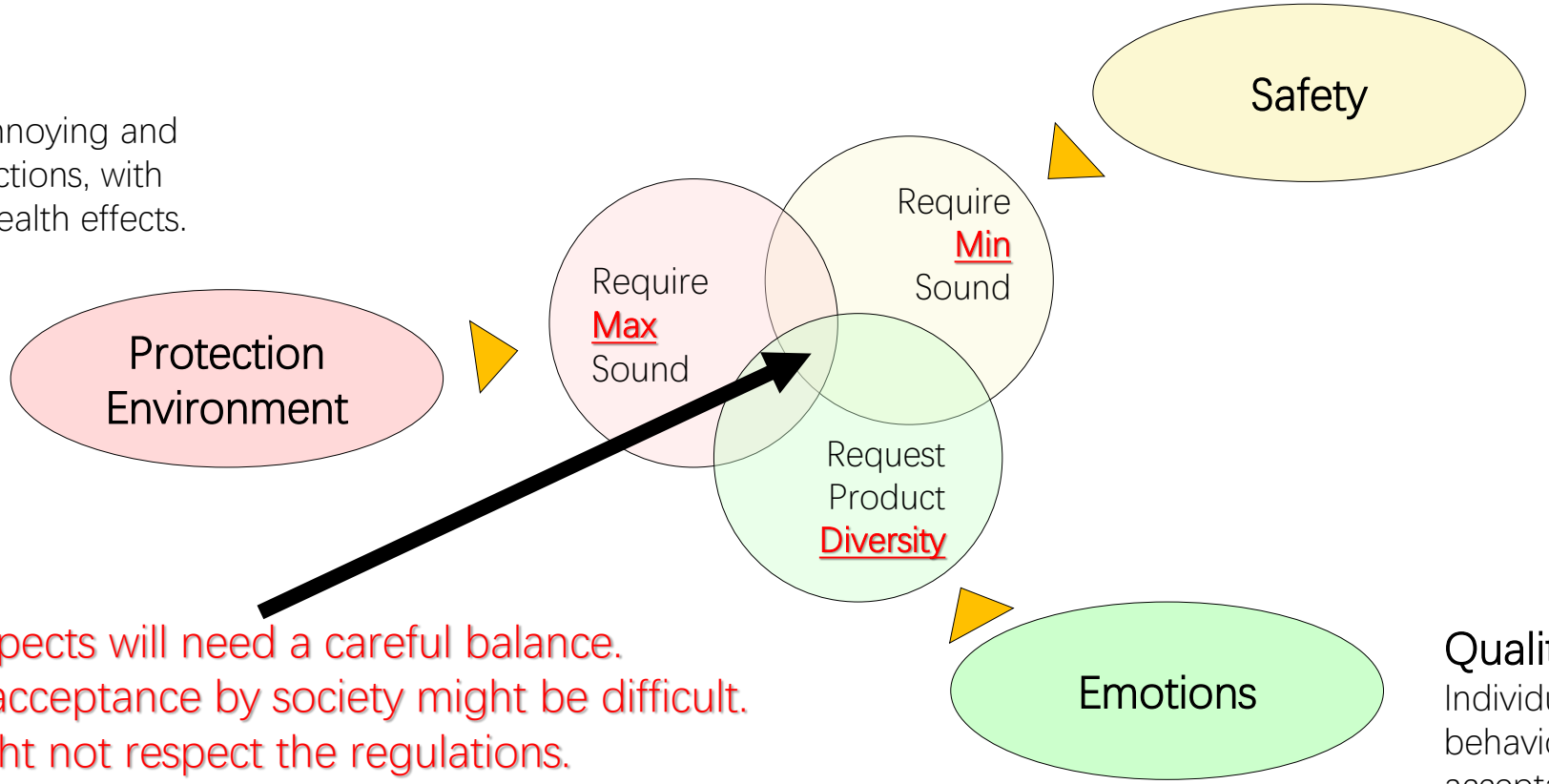
The series 3 amendments to UN R51 introduces a new sound evaluation concept ASEP which allows the control of the sound emission of the vehicle in a wider range.

Vehicle Sound Emission - Why not Following Exhaust Emission Principles ?

In difference to the exhaust pollutants, sound has more aspects and often sound is a very essential element of quality for our daily life.

Traffic Noise

Might become annoying and lead to stress reactions, with maybe adverse health effects.



Pedestrian Protection

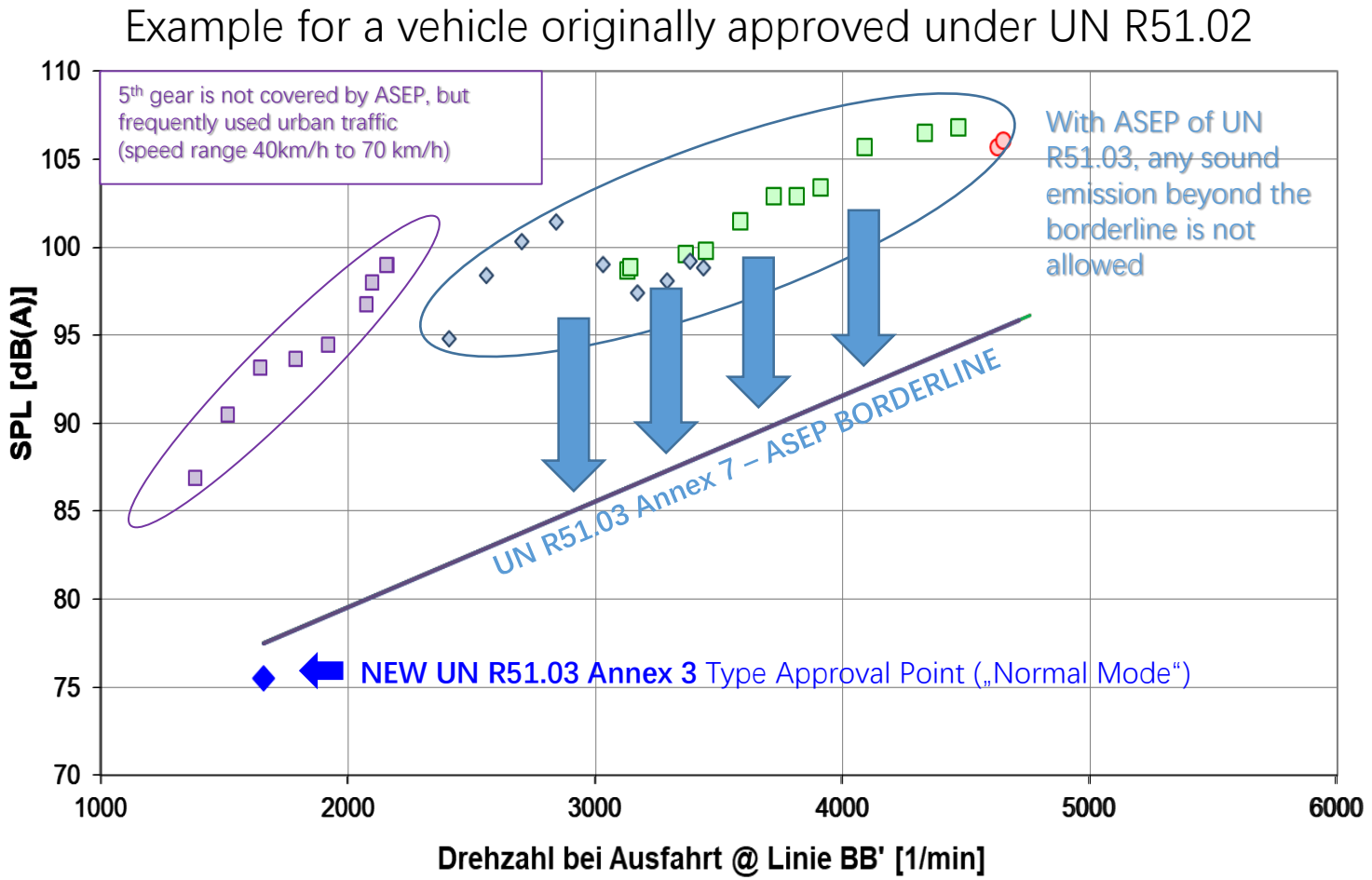
Minimum sound guarantees sufficient perception of vehicles by vulnerable road users.

All these aspects will need a careful balance.
Otherwise acceptance by society might be difficult.
People might not respect the regulations.

Quality of Life

Individuality is an essential human behavior and supports well being and acceptance.

Application of ASEP Since 2016 Provides Positive Results



- The old UN R51.02 did not define any modes, or other test conditions rather than at 50 km/h.
- New ASEP does successfully address extreme sound emission in a large range, especially at higher engine speeds
- However, the ASEP control range still has some handicaps, as it does not cover higher gears, which are more frequently used in urban traffic
- A control of the sound emission at these high gears, was not possible at the time of development of ASEP.

Although great achievements have been made with ASEP, GRB started a general revision of ASEP.

ASEP Revision 2.0 - Expectations

Stakeholder expressed different needs and expectations for the revision of ASEP.

Contracting Parties	Automotive Industry
➢ Improve efficiency of ASEP ➢ Incorporate more driving situations such as partial load ➢ ASEP be mandatory during Type Approval and not covered by a simple statement of the manufacturer ➢ Broaden the boundary conditions to enable ASEP for all major driving situations	➢ Simplify the current ASEP concept, which is confusing and ambiguous. ➢ Reduce work load, as testing for ASEP requires too much time. ➢ Safe qualification about ASEP compliance, especially with “normal” products ➢ ASEP shall follow physics, integrate performance aspects

The integration of all these diverging aspects is a challenge for the ASEP revision.

Principles for the New ASEP Concept Based on a Physical Expectation Model

- A compromise between an extended test area and a reduced test burden is feasible, when tests are selected randomly and when after each individual test run a direct compliance assessment is available.
- Already existing elements of the today's ASEP assessment are integrated into a new approach:

Physical Behavior
(Origin: „Slope Method“)

Direct Assessment
(Origin: „L_{urban} Method“)

Based on Type Approval Results
(Origin: „Slope & L_{urban} Method“)

Engine Speed Based
(Origin: „Slope Method“)

→ Direct assessment of single measurement based on a physical expectation model and referenced to the type approval result.

→ Test Provisions Solved as well for BEV, HEV

Sound Prediction Model Basic Considerations

1 Tyre

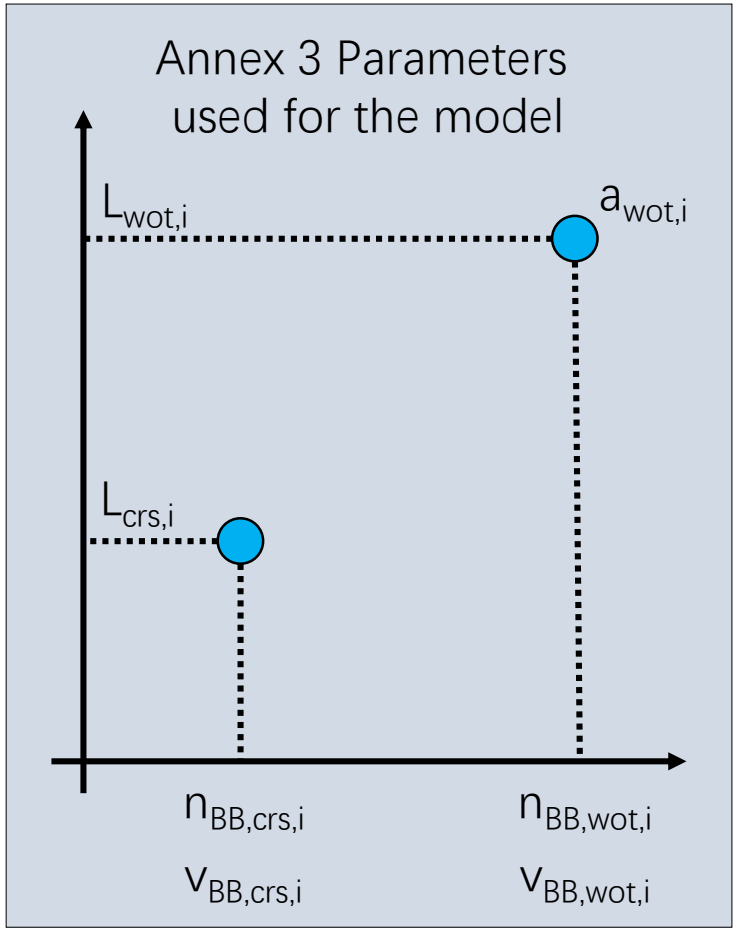
2 Base Mechanic

- The two elements together create the “physical” base model for a behavior of any internal combustion engine vehicle.
- These two models will form the minimum sound emission of a vehicle.
- This sound emission is given by physics and qualified / justified by the type approval test according to UN R51.03 Annex 3 and controlled by the limit values.

3 Dynamic

- The dynamic model covers all sound behavior, that is linked to acceleration (load) conditions
- It covers tyre torque effects, powertrain dynamics and gas flow dynamics. Since November 2018 as well performance

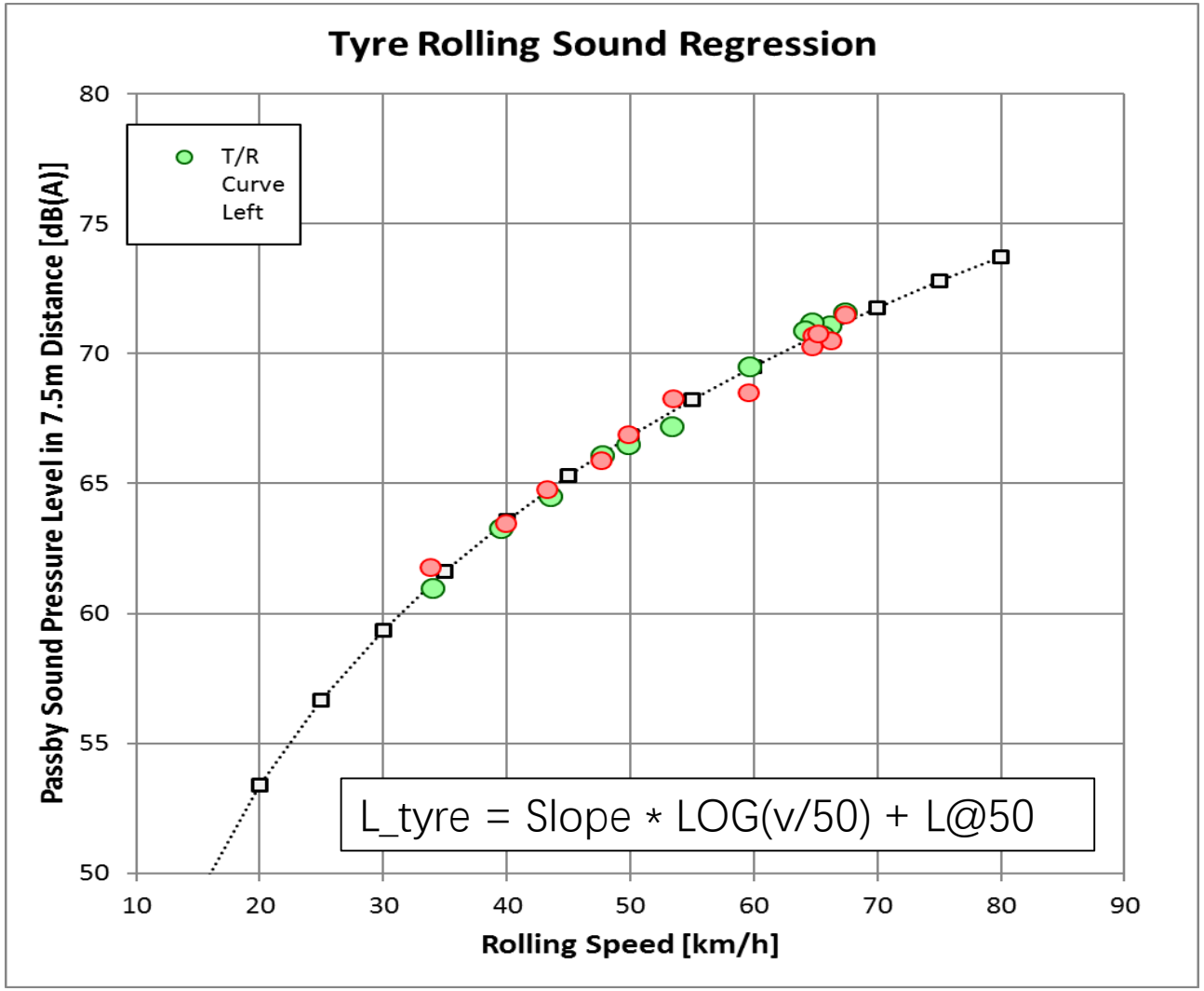
New ASEP Prediction Model is Based on Test Results of UN R51.03 Annex 3



	1 Tyre	2 Mechanic	3 Dynamic
Acceleration	$L_{TR}(v_{BB,wot,i})$	$L_{PT}(n_{BB,wot,i})$	$L_{DYN} = L_{DYN,NL}(n_{BB,wot,i}) + dL_{DYN}$
Cruise	$L_{TR}(v_{BB,crs,i})$	$L_{PT}(n_{BB,crs,i})$	$L_{DYN,NL} = L_{PT}(n_{BB,crs,i}) - 15$ dB
	one model	**one** model	**two** models

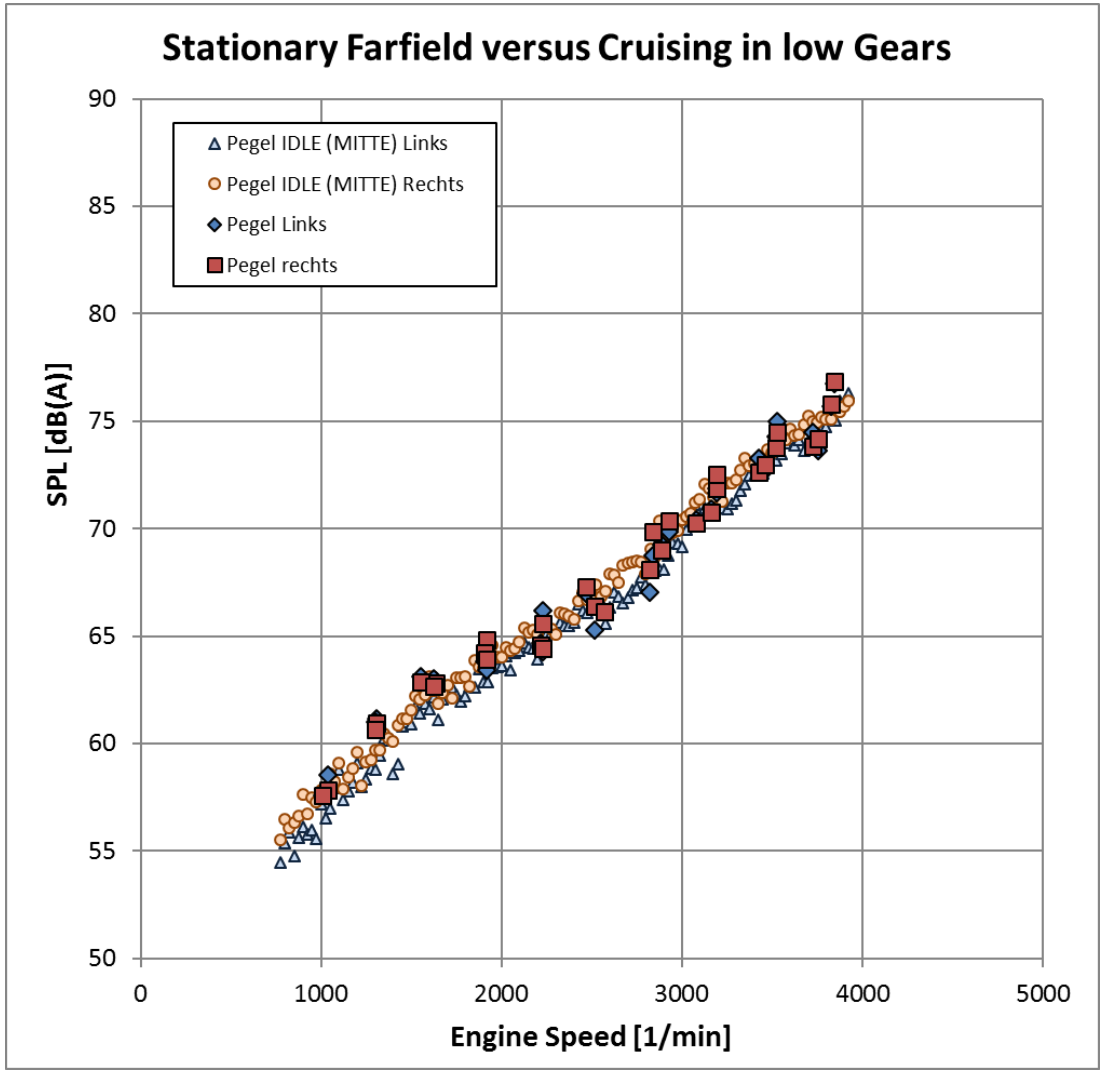
- The following slides will guide you through the model details

1 Tyre Rolling Sound - Modelling



- Tyre rolling sound can be described with good accuracy by a logarithmic regression.
- Typical regression qualities are very good with $R^2 > 0.98$

2 Base Mechanic - Modelling



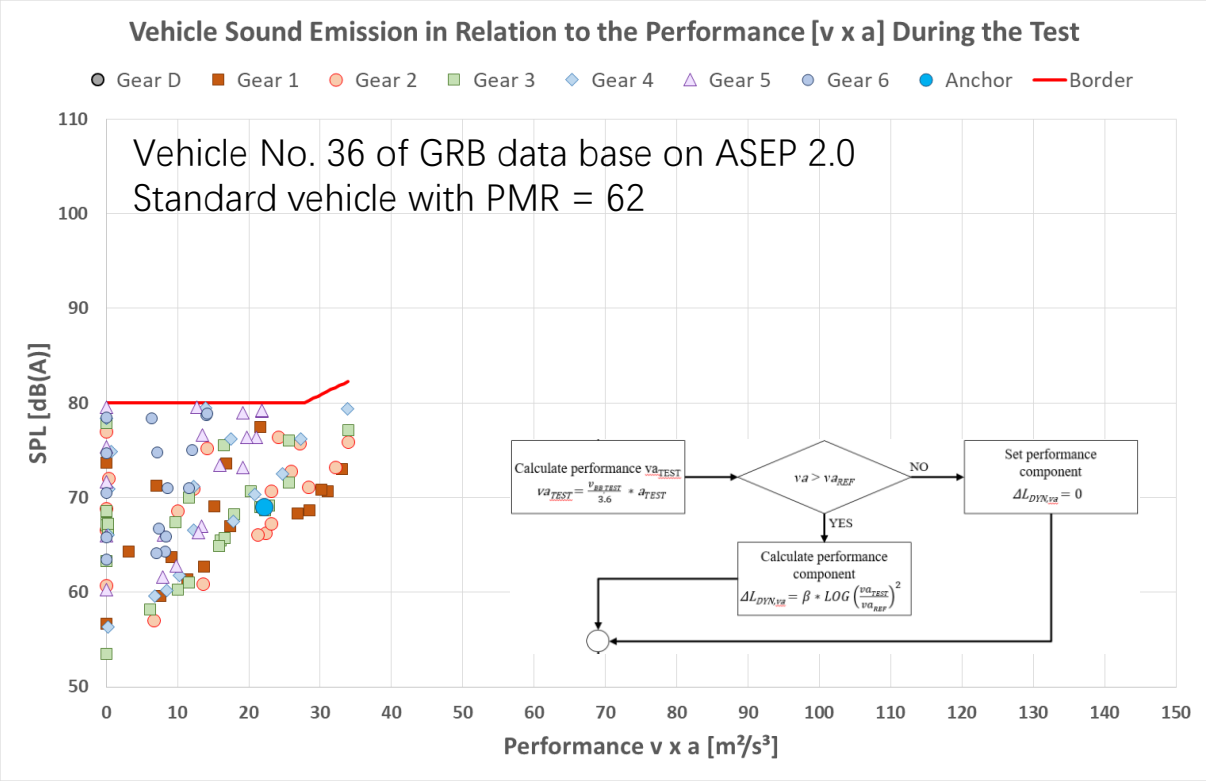
- For determination of the power train base mechanic, it is important to eliminate the influence of the tyre rolling sound and to suppress any gas flow dynamics.
- There are two possibilities:
  - stationary run-up in far field
  - cruise-by measurements at low gears, e.g. 1st gear
- Both methods provide almost the same result and can be used to elaborate the powertrain base mechanic model.

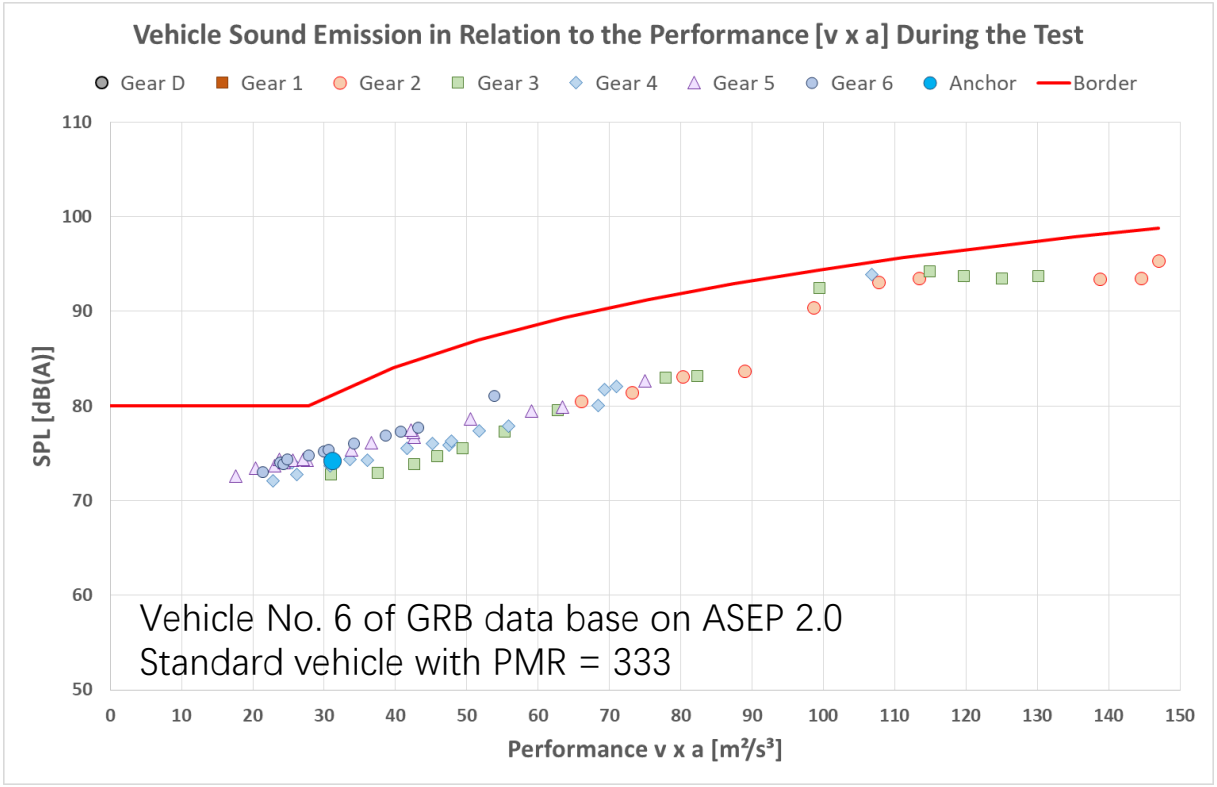
3 The Dynamic Model (Status November 2018)

- The dynamic model covers all energy generated under load, respectively acceleration:
  a) All gas flow components (intake and exhaust), no load and load
  b) Change of the power train mechanic sound with the load
  c) Tyre torque effects
- The load response from the power train and the torque effect are relatively small compared to the gas flow components from intake and exhaust.
- The dynamic model of late 2018 introduces as well the aspect of performance on a basis of a (v x a)-Model.

3 The Performance Model V x A

- The performance if defined by the product of vehicle speed $v_{BB'}$ and achieved acceleration $a_{AA'-BB'}$



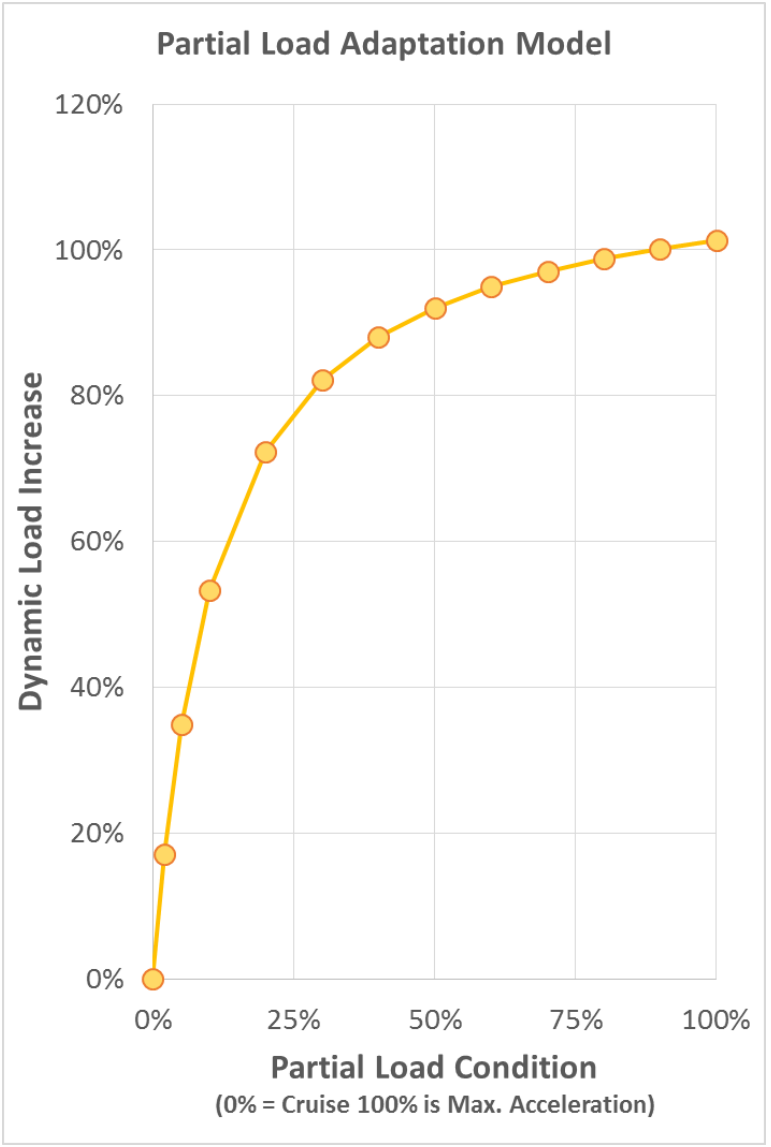


- By using the performance criteria (VxA), differences in performance can be accounted for.

3 The Dynamic Model Partial Throttle

- For a full dynamic model it is necessary to consider a partial throttle model.
- One difficulty is, that for many situations an already partially opened throttle means already full throttle.
- The partial load function applies to ΔL_{DYN}

$$\Delta_{LDYN,EXP} = (\Delta L_{DYN} + \Delta L_{DYN,va}) * \left(1 - \frac{\alpha}{(LOAD_{TEST} + \alpha)}\right) / (1 - \alpha)$$



Integration of all Modules

- Before the ASEP evaluation, it is necessary to carry out the Annex 3 type approval test
  - The parameter to be reported are: L_{wot} and L_{crs} from the lower or single gear, the acceleration (actually PP-BB), the vehicle speed v_{BB}, the engine speed n_{BB}.
  - For each gear ratio, the maximum acceleration must be known to determine the load condition.

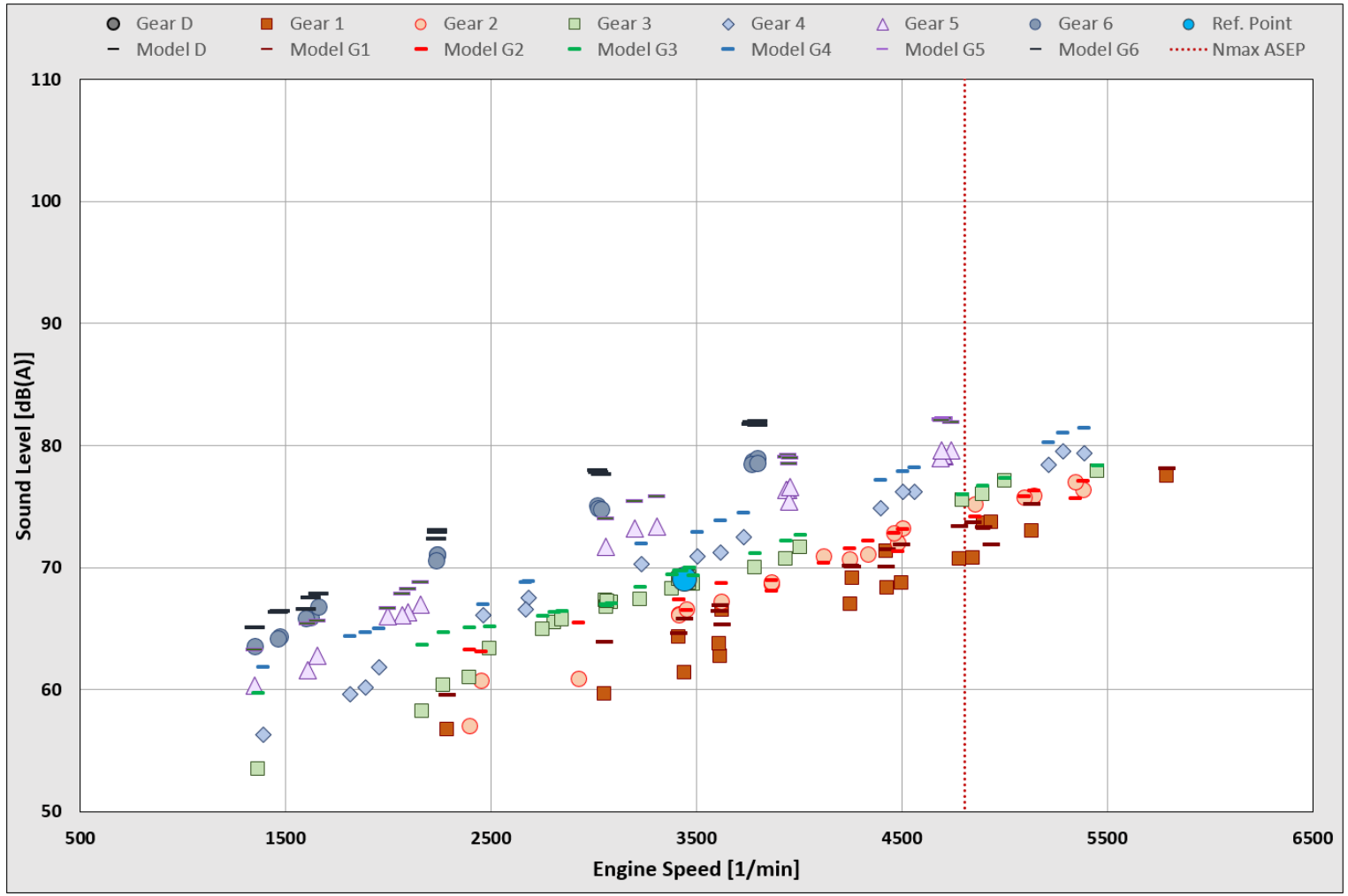
- The expectation level is then calculated

$$L_{exp} = 10 * LOG\left(10^{0,1*L_{TR,NL}} + 10^{0,1*L_{PT,NL}} + 10^{0,1*(L_{DYN,NL} + \Delta L_{DYN})}\right) + \Delta L_{MARGIN}$$

- Compliance is achieved when

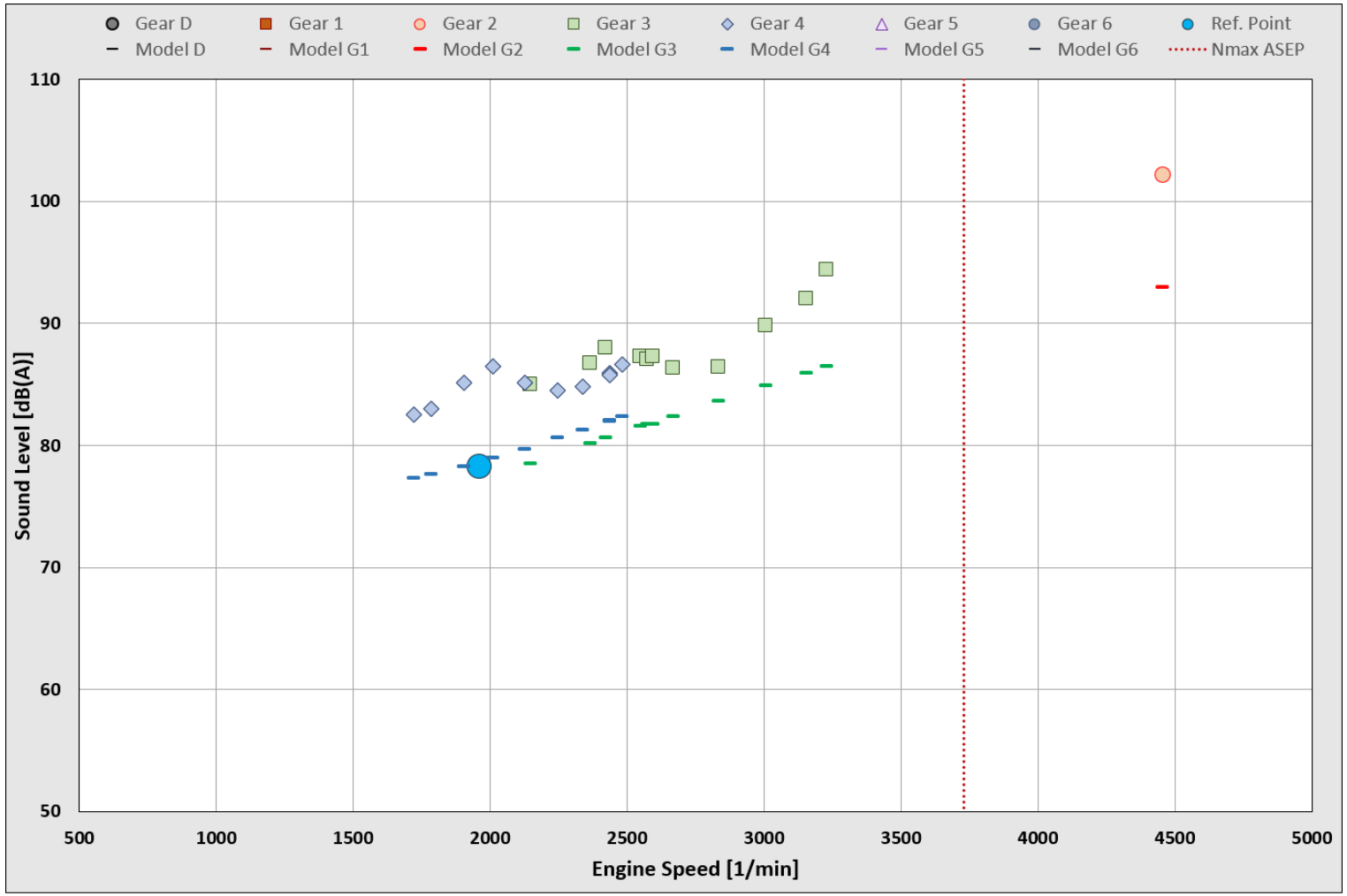
$$L_{test}(v_{test}, a_{test}, n_{test}) \leq L_{exp}(v_{test}, a_{test}, n_{test})$$

Example for an ASEP 2.0 Evaluation of a Vehicle



- This example shows a vehicle which is perfectly in line with the expectation model.
- The model is created in a way, to basically overestimate the sound level.
- But still some points may not be exactly in line with the model expectation.
- Therefore further considerations are needed to determine, how the vehicle will comply with the ASEP 2.0 provisions.

Example for an ASEP 2.0 Evaluation of a Vehicle

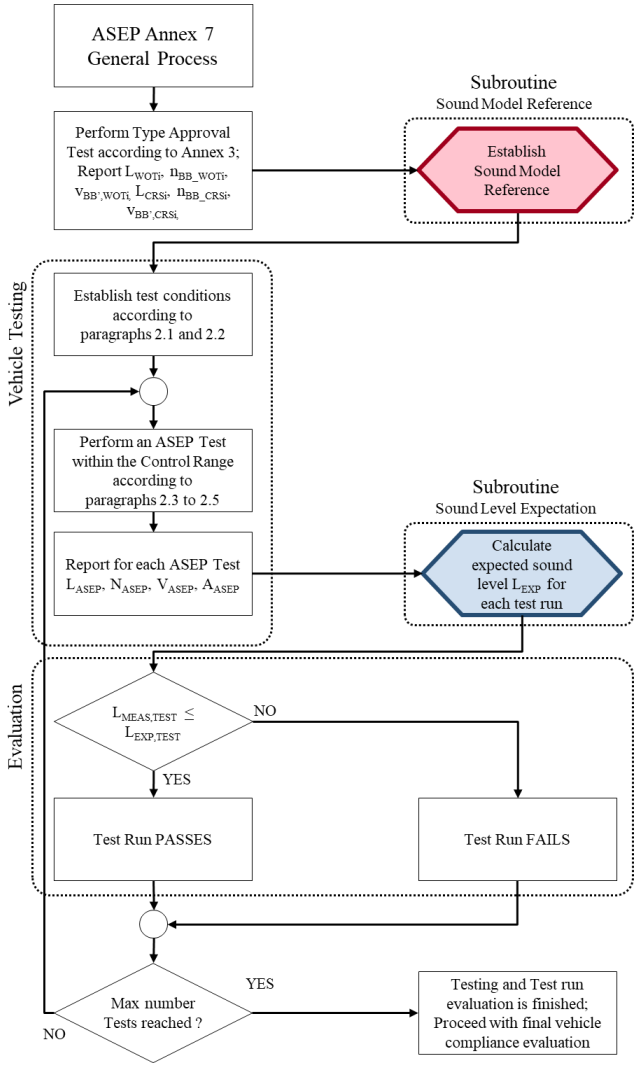


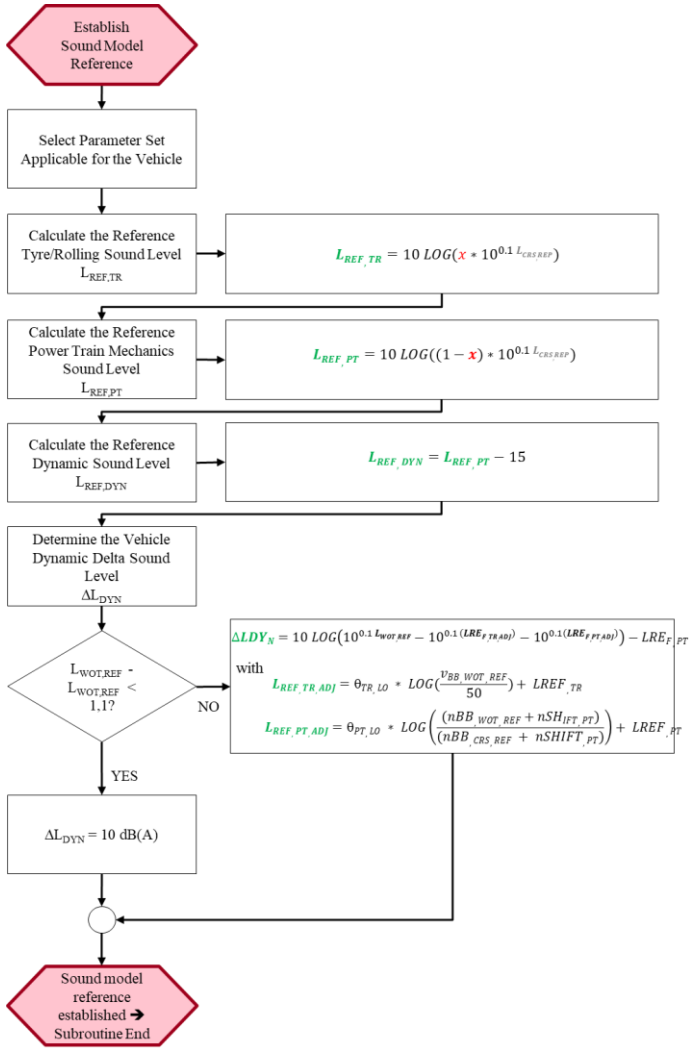
- Vehicles that are tailored to just comply with the type approval test of UN R51.03 Annex 3 cannot comply with the expectation model.

Outlook for ASEP 2.0

- The GRB Informal Working Group on ASEP 2.0 has its last meeting in Liuzhou (China) in April 2019.
- The next meeting will be in July in Berlin (Germany)
- The drafting of the future regulation text has started already. A first complete draft is expected by September 2020 for the UN working group GRBP 72.
  A revised ASEP 2.0 will create a new series of amendments ➔ UN R51.04
- The revised ASEP 2.0 will as well introduce provisions against manipulation, especially of software.
- Documents are available on the UN website:
  https://wiki.unece.org/pages/viewpage.action?pageId=2523476

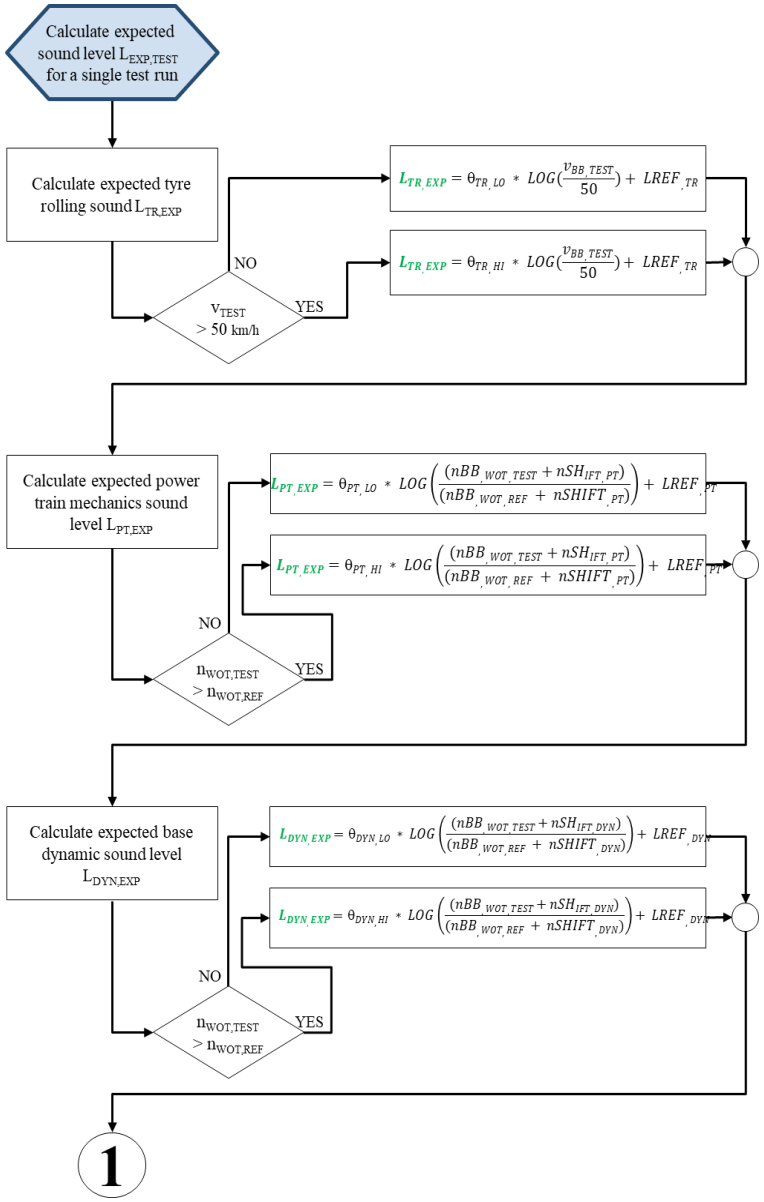
DRAFT Flowcharts for ASEP 2.0

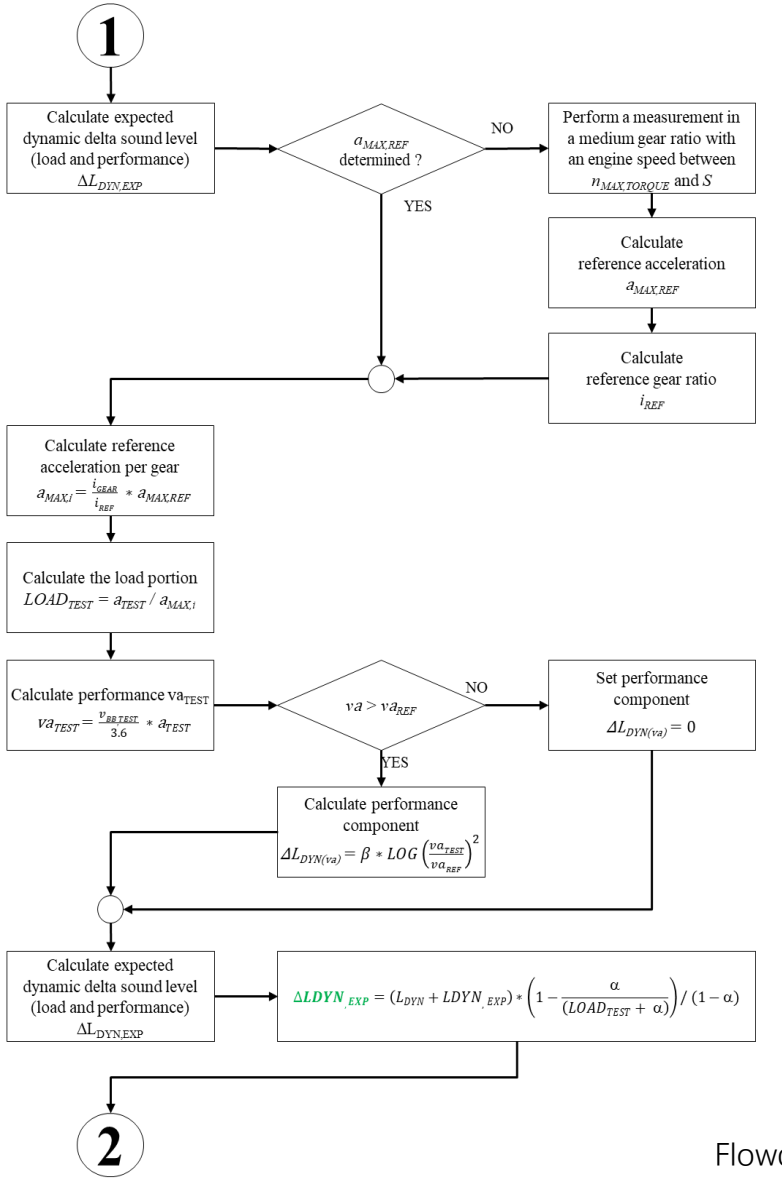


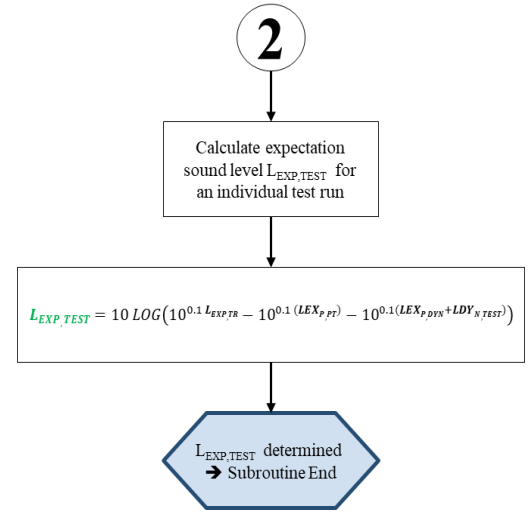


Flowchart only indicative, revised flowchart available

DRAFT Flowcharts for ASEP 2.0







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