6th November 2018

PRESENTATION OF

OICA

INTERNATIONAL ORGANIZATION OF MOTOR VEHICLE MANUFACTURERS

Partial Load & Performance Modelling

ASEP Revision 2.0

Actual Status of the DATABASE November 2018

- **Database contains now 54 dataset (15 new vehicles since July 2018)**
  - 41 vehicles from 13 sources, PMR range 40 kW/t to 330 kW/t
  - Some vehicles with multiple dataset (full load and part load)
  - Mostly M1 vehicles, few N1
  - ICE (mostly Petrol), HEV, PEV
- **Model covers**
  - ICE, HEVs and **PEVs (via simulated engine speed)**
  - Part load **(not explained in details to IWG ASEP by now)**
  - **Performance va**
- **Various Analysis Diagrams and Tools**
  - Diagram: Sound vs Engine Speed,
  - Diagram: Sound vs Performance,
  - Diagram: Performance vs Speed,
  - **Diagram: Measured Sound vs Simulated Sound**
  - Tools: Enable/Disable Parts of the model
  - Tools: Parameter can be changed

Red highlighted items are new since July 2018

PARTIAL LOAD SIMULATION

DETAILS

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Definition for Partial Load Driving

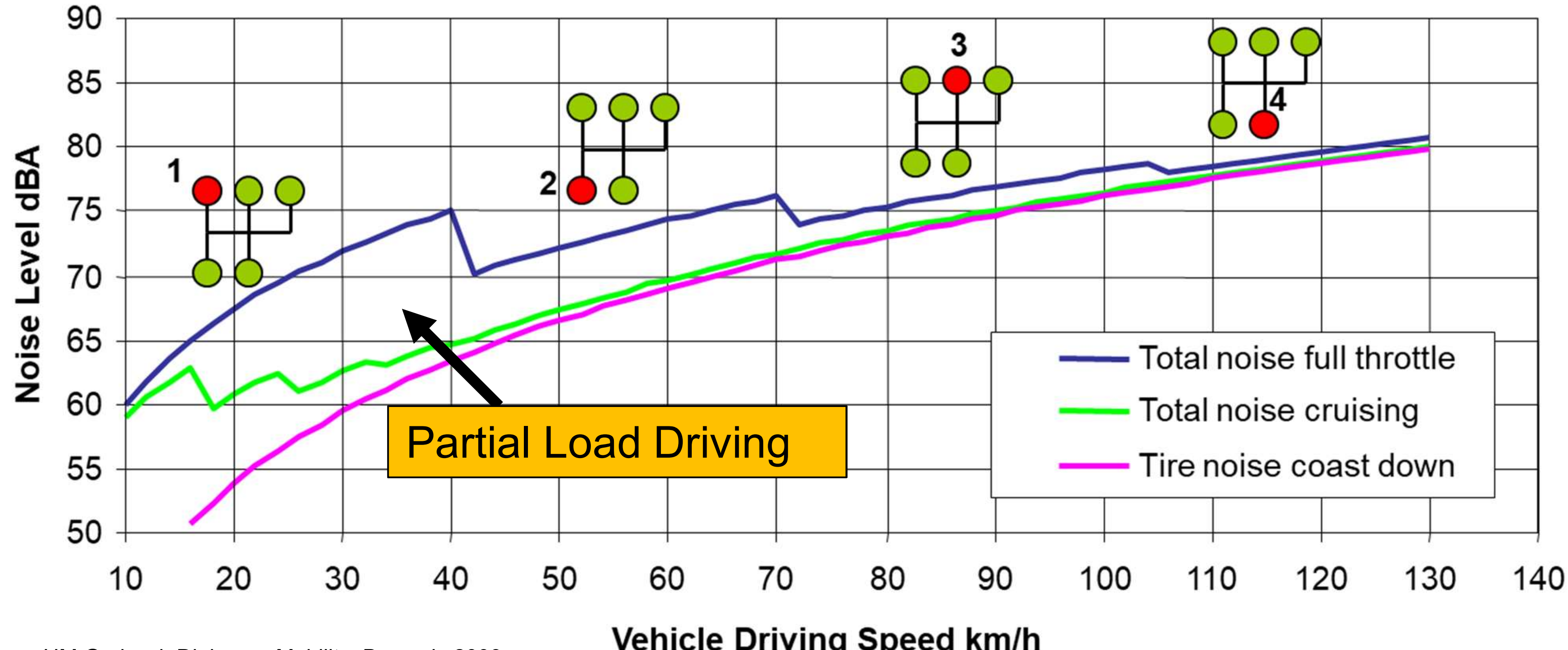
- Partial load driving means any driving condition which provides positive acceleration greater than 0.3 m/s² between cruising and maximum load driving for a specific engine condition.
- Cruising is defined as low acceleration with a variation of +/- 0.3 m/s² around zero acceleration.
  - The acceleration 0.3 m/s² is derived from the allowable tolerance of +/- 1 km/h for the steady speed test according to UN R51.03 Annex 3 paragraph 3.1.2.1.6.

    $a_{crs} = ((50^{+1km/h}/3.6)\text{\^{}}2 - (50^{-1km/h}/3.6)\text{\^{}}2) / (2*(20 + l_{veh}{}^{*)}) = 0.30\ m/s^2$

    *) L_{veh} = 5m
- Maximum load driving is the maximum achievable acceleration for a specific engine operation condition.

Definition for Partial Load Driving

mid class passenger car



Source: HM Gerhard; Dialog on Mobility; Brussels 2003

What Parameter to Chose for the Control of the Partial Load Area?

- The position of the throttle?
  - The throttle is a specific design of petrol engines, other technologies do not have a throttle.
  - The percentage of opening of the throttle is directly related to the achievable performance. The throttle diameter is tailored to maximum gas flow at rated engine speed.
  - This means a given percentage of opening of the throttle represents different loads at different engine speeds
- The percentage of depressing the accelerator pedal?
  - Vehicles have electronic accelerator pedals. The signal response is NOT linear to the engine. The response is mode dependent and integrates driving comfort, fuel economy and performance response.
- The achieved acceleration?
  - The achieved acceleration must be weighted against a reference value. However the reference is dependent on the operation condition of the engine and the gear/gear ratio engaged.

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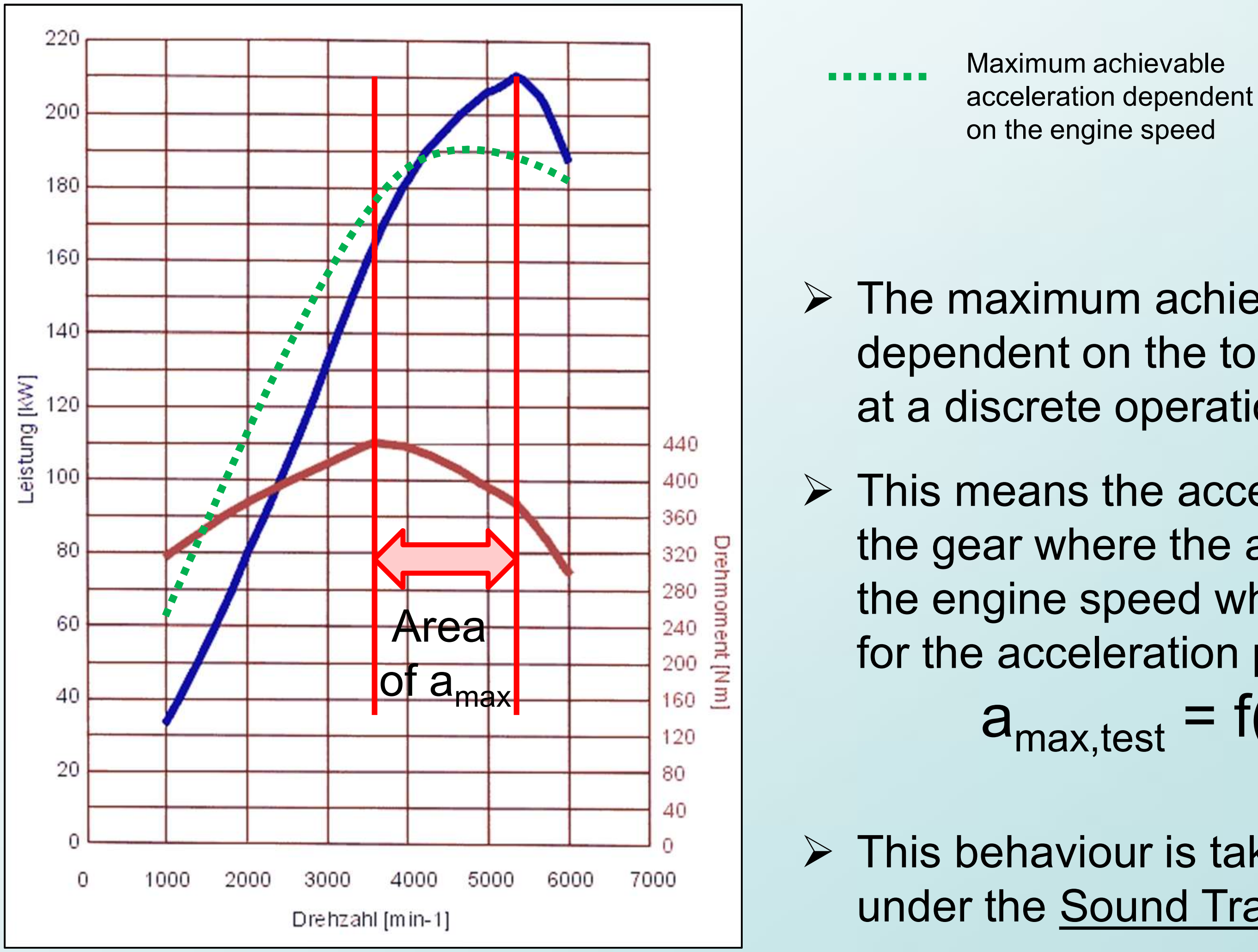
Acceleration Performance versus Engine Speed



- The maximum achievable acceleration is dependent on the torque and power available at a discrete operation condition.
- This means the acceleration is dependent on the gear where the acceleration happens and the engine speed which is taken representative for the acceleration phase:

$$a_{max,test} = f(i_{test}, n_{BB'})$$

- This behaviour is taken into consideration under the Sound Transient Function.

Simplified Approach

- The acceleration for a specific gear is assumed constant.
  - This means it is assumed that a vehicle would have always the same maximum acceleration in a given gear over the whole engine speed range.
  - The torque and power curve are considered under the Sound Tranient Function via the form factor.
- The partial load is simulated by using the acceleration performance relative to a reference acceleration in one specific gear.
  - For other gears or gear ratios, the reference acceleration is adjusted via the gear ratio.
  - Therefore it is necessary to determine once an reference acceleration, preferably in a low gear, such as 2nd gear.

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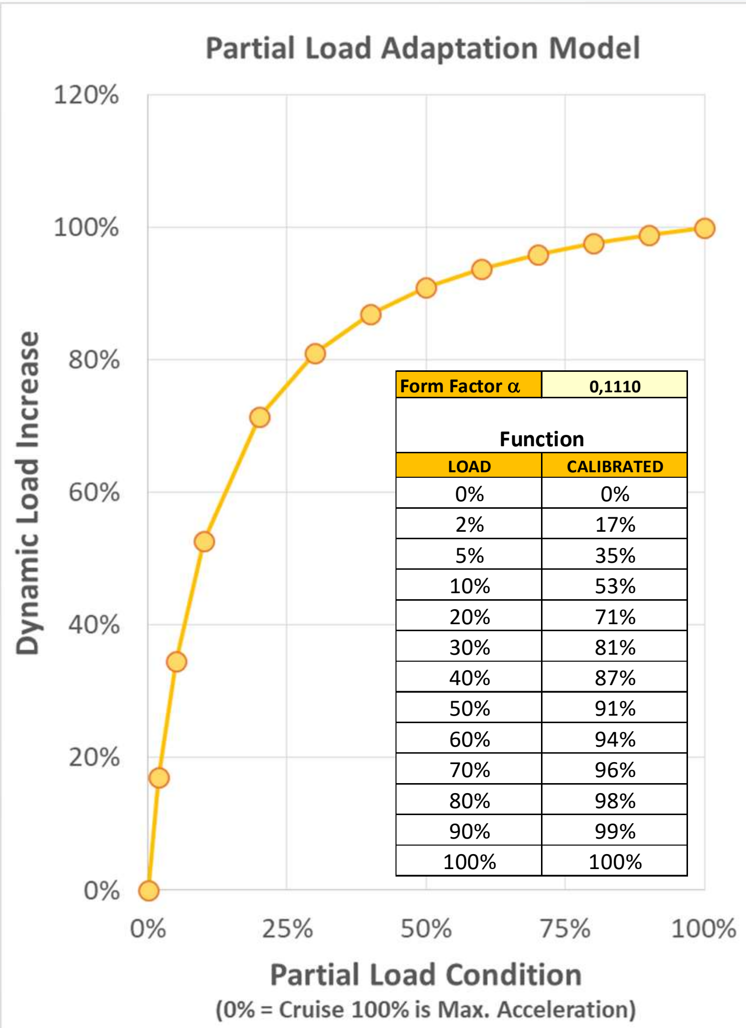
Sound Transient Function: Link Between Load and Sound



Form Factor α	0,1110
Function	
LOAD	CALIBRATED
0%	0%
2%	17%
5%	35%
10%	53%
20%	71%
30%	81%
40%	87%
50%	91%
60%	94%
70%	96%
80%	98%
90%	99%
100%	100%

The Sound Dynamic ΔL_{DYN} is the acoustic dynamic between no load and full load.

For the simulation, a hyperbolic function was chosen to adjust for engine speed dependent maximum acceleration and for the typical non-linear transient between no load and maximum load.

Formula:

$$\Delta L_{DYN,PL} = \Delta L_{DYN} \left(\left(1 - \alpha/(LOAD+\alpha)\right) / (1-\alpha)\right) / \omega$$

Calibration Part ω

$$\omega = 1/(1-\alpha) - \alpha/(1-\alpha^2)$$

The shape of this curve can be adjusted by the **form factor** α in a wide range for best fitting

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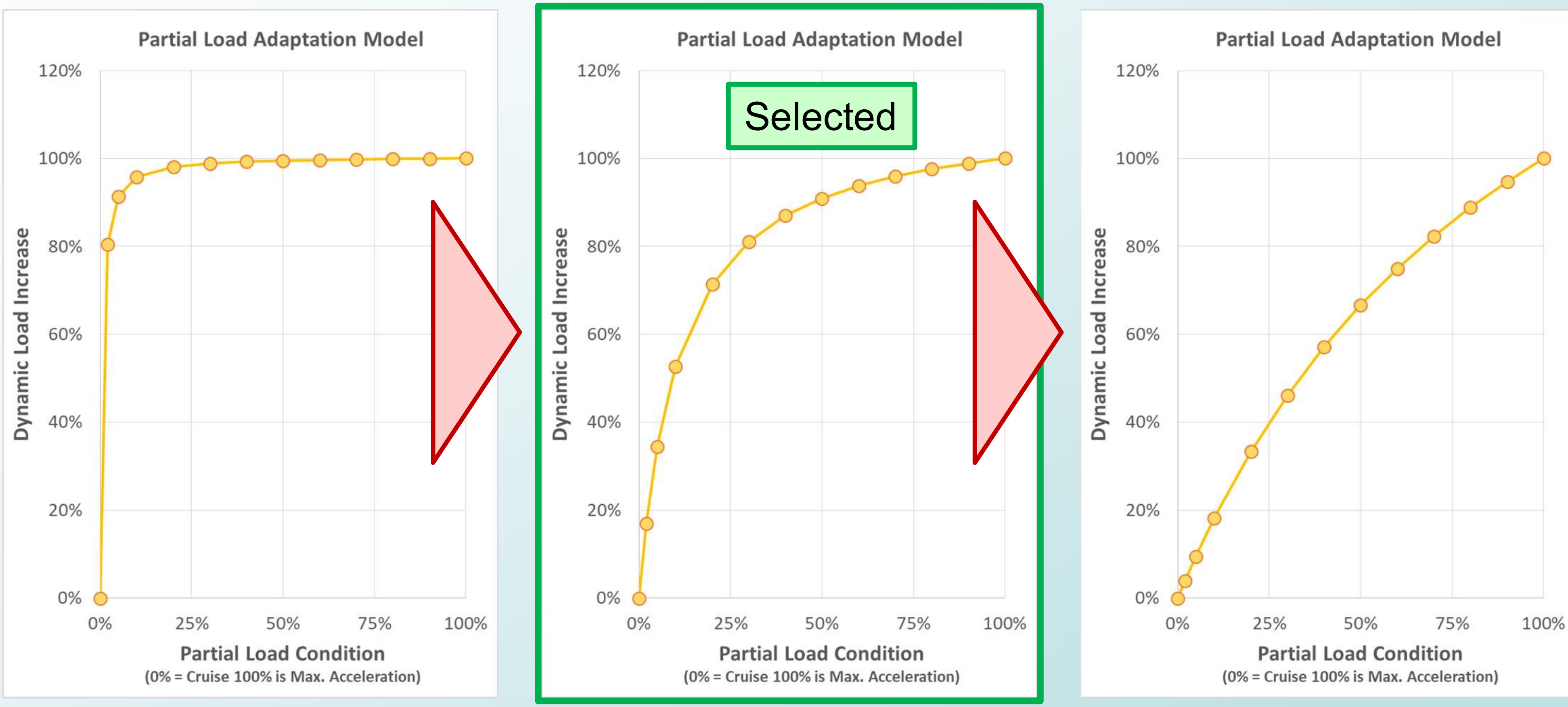
Adjustable Partial Load Transient via the Form Factor α



α = 0,005 α = 0,111 α = 1,000

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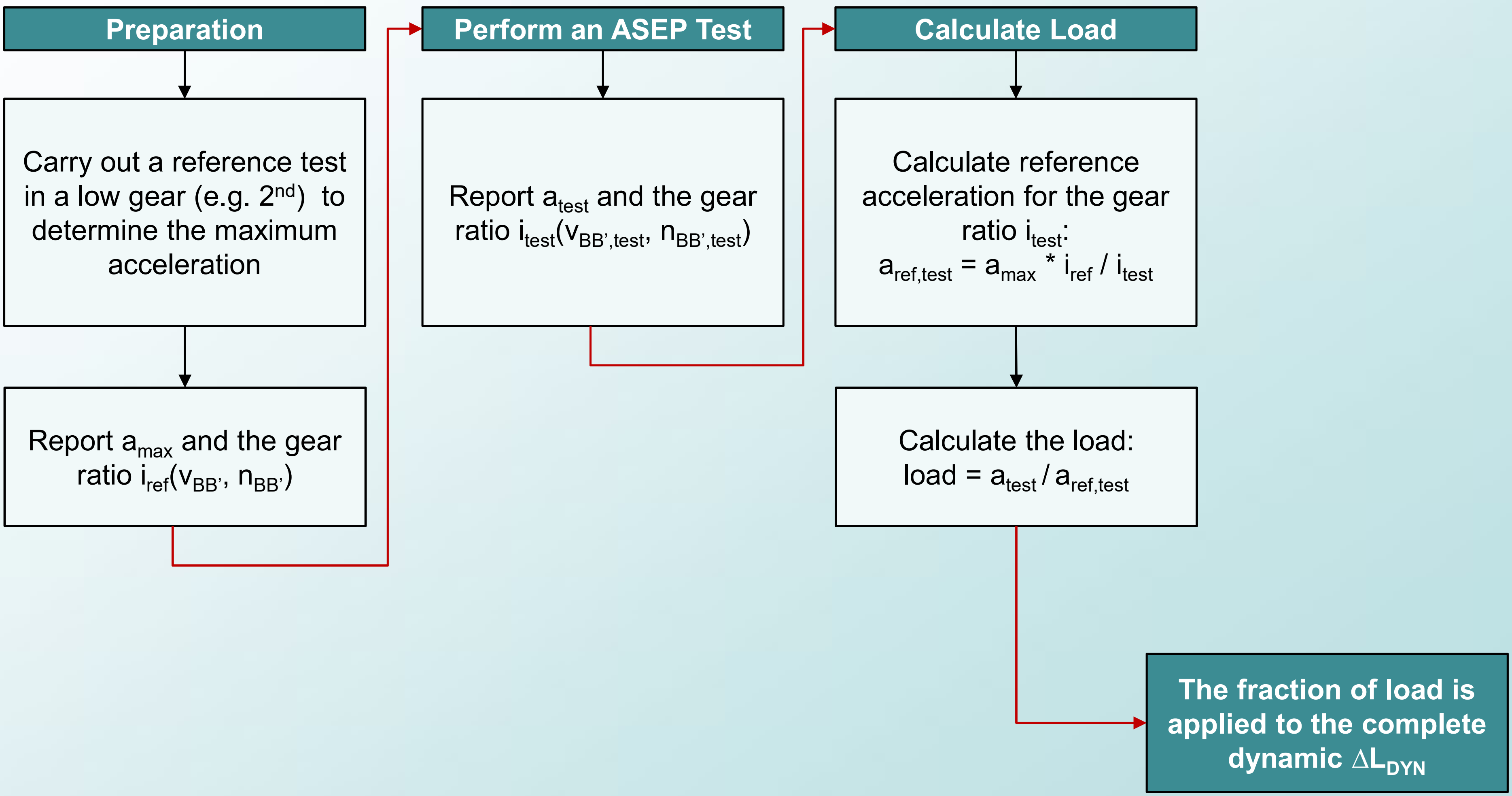
Determination of the Load for a Discrete Test



PERFORMANCE MODELLING

MERGED WITH THE SOUND MODEL

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Integration of v x a – Concept for the Sound Model

- The actual sound model simulates the general sound sources tyre/road, power train mechanics and dynamics based on type approval test results.
  - This model is based on engine speed and vehicle speed and does not consider performance aspects of a vehicle.
  - However, behind a tested operation condition the acceleration can be very different and thus as well the sound emission of vehicles.
- In 2018 a separate assessment model for performance was developed.
  - This models helps to differentiate between normal and extreme driving conditions.
  - However, this model cannot adequately assess partial load and cruising, as acceleration close to zero will lead to very low although the vehicle speed and thus the tyre/rolling sound could be very high.

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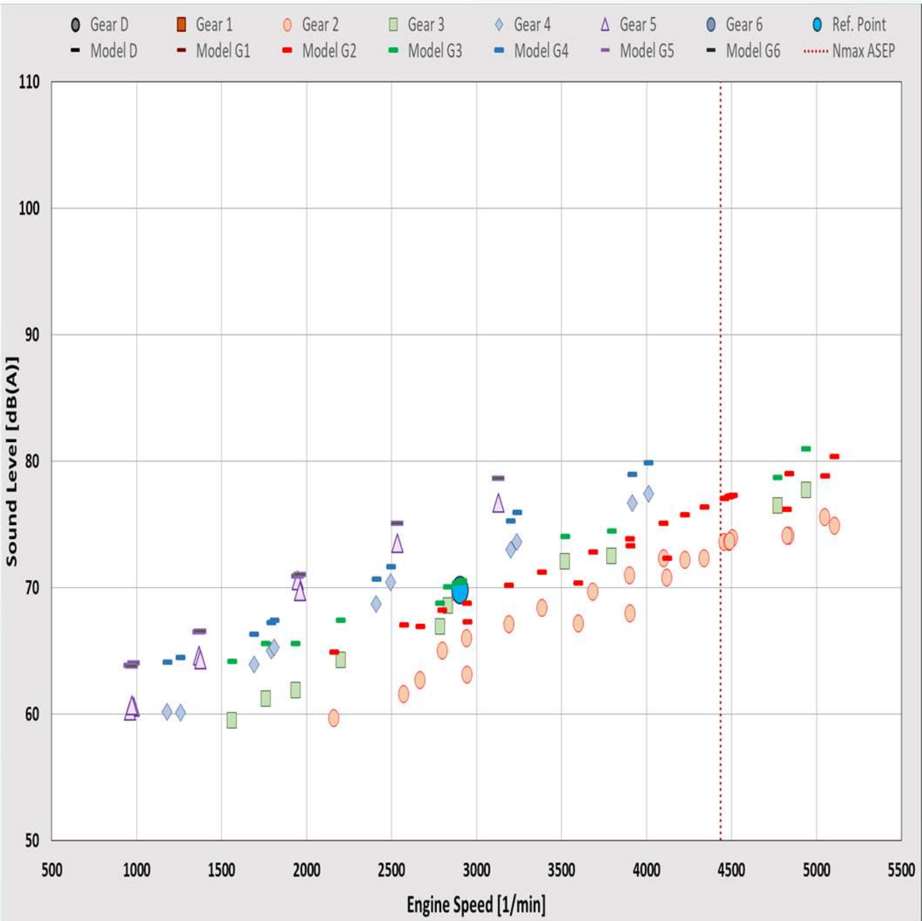
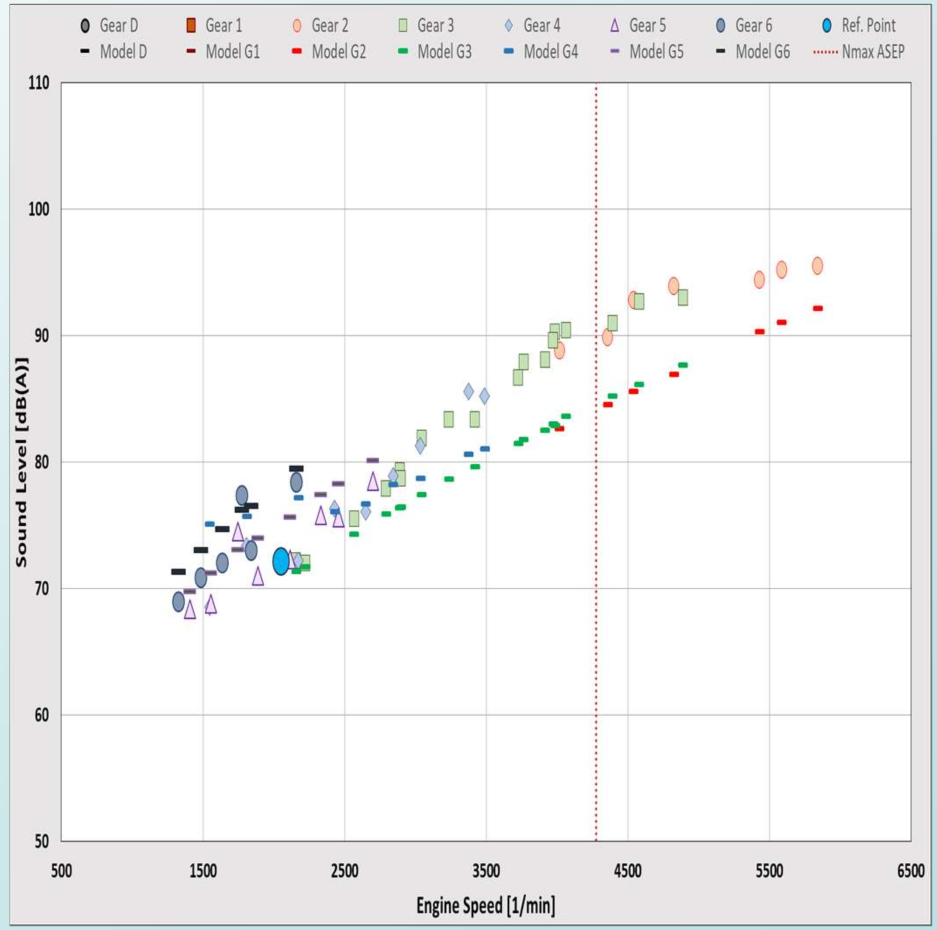
Actual Sound Model – Based on IWG ASEP Presentation Tokyo 2017

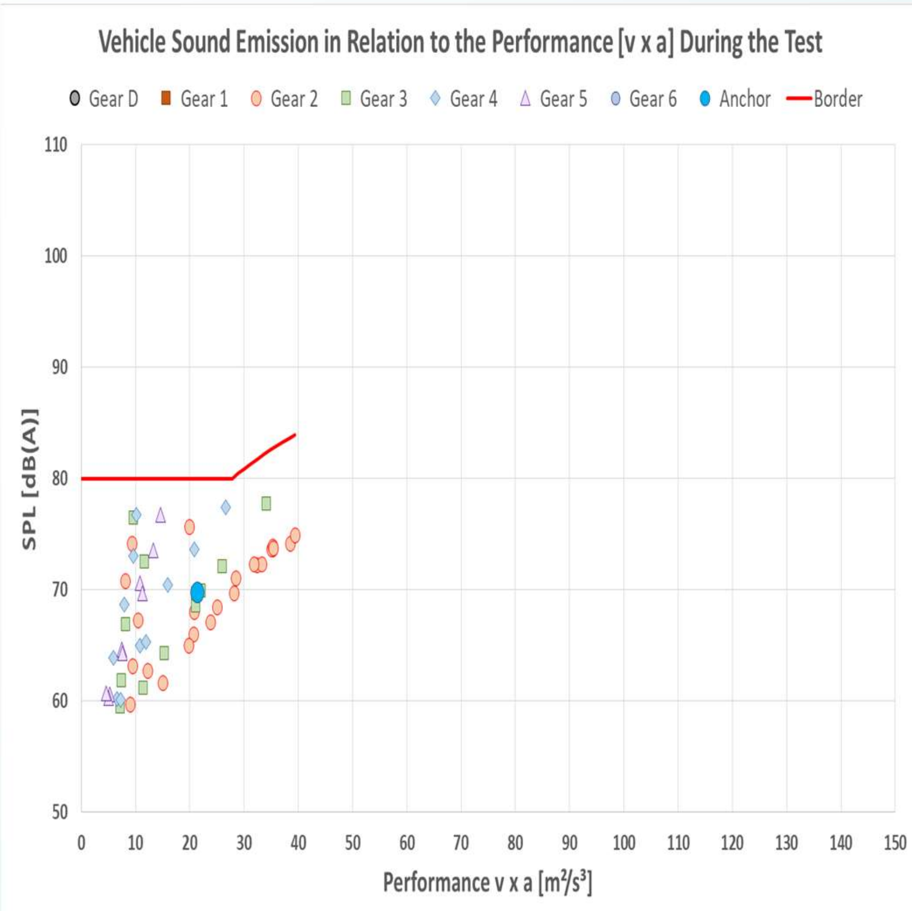


Example 1 (normal vehicle)

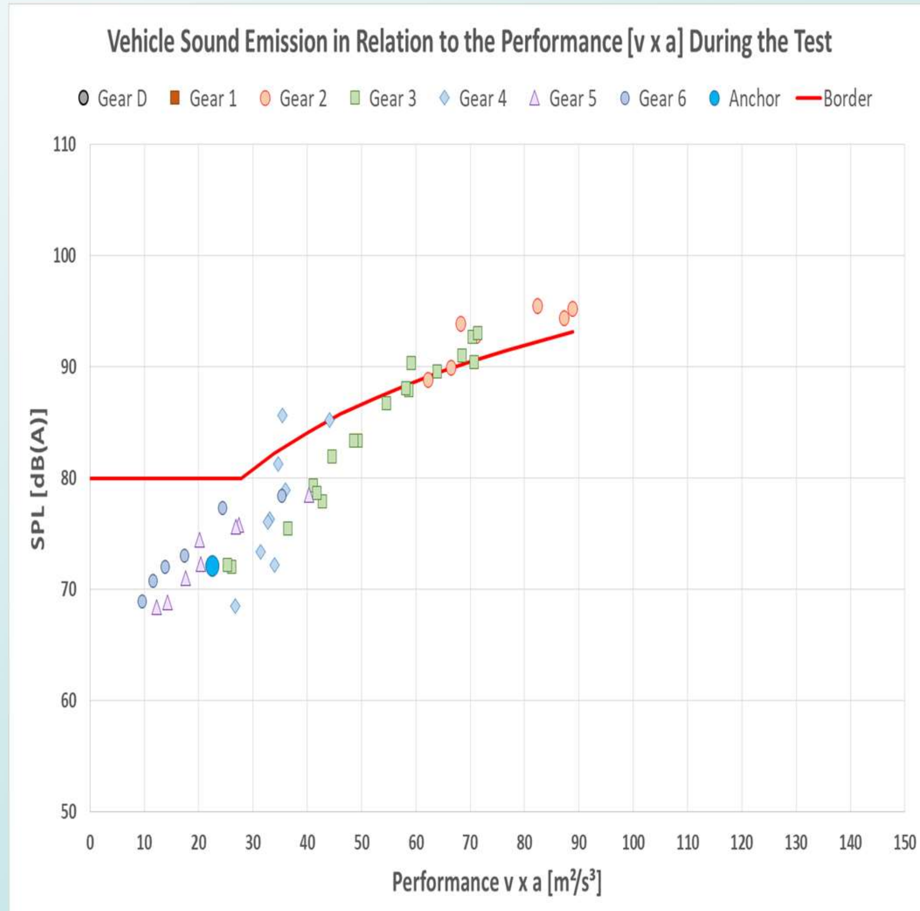


Example 2 (high performance vehicle)

Performance Model - Based on IWG ASEP Presentation Brussel 2018

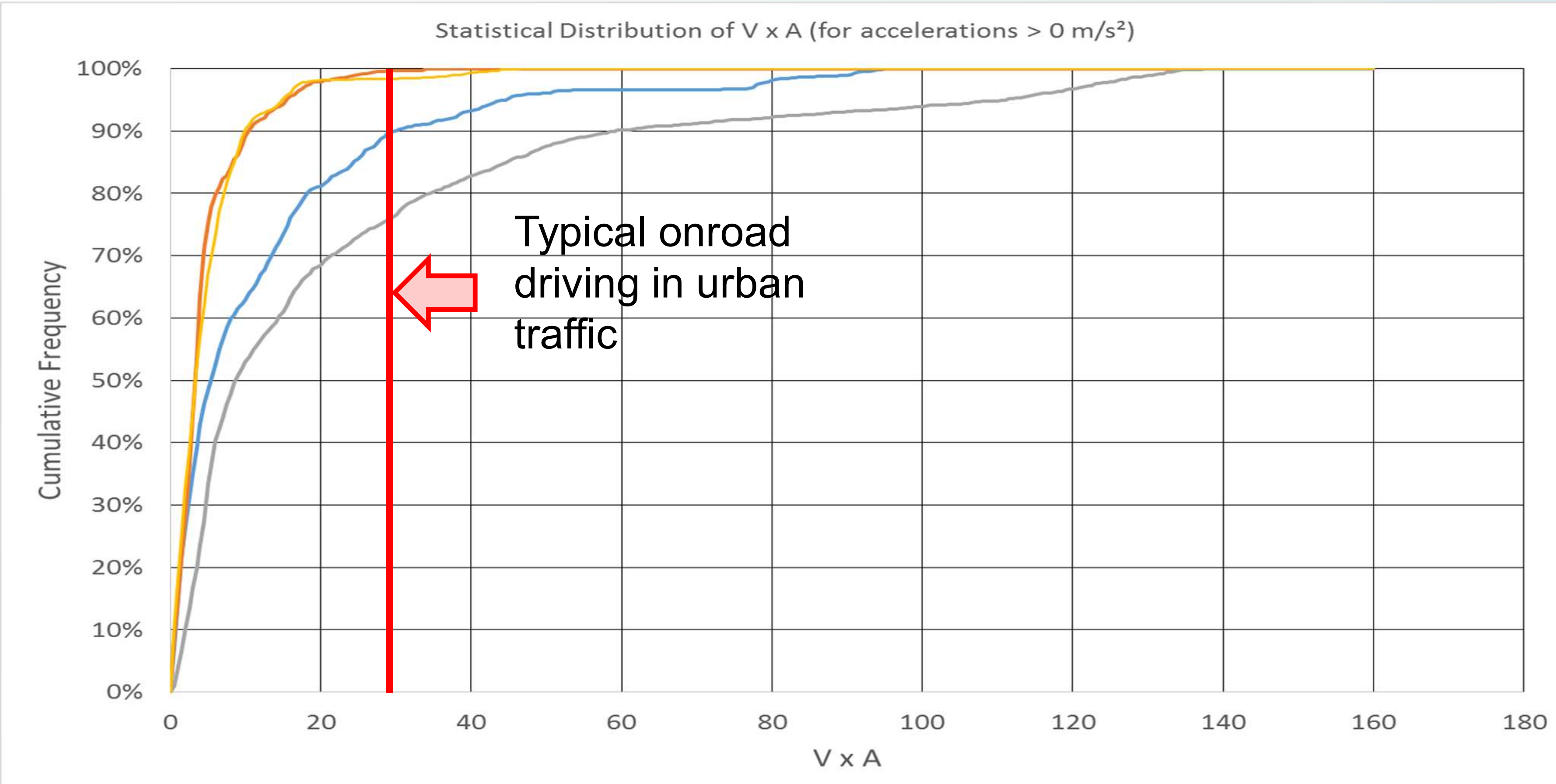


Example 1 (normal vehicle)



Example 2 (high performance vehicle)

Real Driving Performance (OICA Presentation February 2017)



- For driving within the typical onroad driving, performance cannot be added, as UN R51.03 Annex 3 is considered to be almost design neutral.
- ASEP Annex 7 and especially the revision 2.0 goes beyong that neutral area.

Integration of v x a – Modelling Approach (1)

- For the modelling the performance is calculated by using the vehicle speed $v_{BB'}$ and the acceleration a_{test}.
- The performance is calculated by:

$$va_{test} = v_{BB'} / 3.6 * a_{test}$$

- For normal onroad driving in urban areas the reference performance is determined by:

$$va_{ref} = v_{BB',Annex3} / 3.6 * a_{max,Annex\,3} \quad \text{with} \quad v_{BB',Annex\,3} = 50\ km/h$$

$$a_{max,Annex\,3} = 2.0\ m/s^2$$

- The reference performance is $va_{ref} = 27.8\ m^2/s^3$

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Integration of v x a – Modelling Approach (2)

- For performances lower than the reference acceleration, there will be no effect to the actual model.
- For performances greater than the reference acceleration, additional sound quotation is applied:

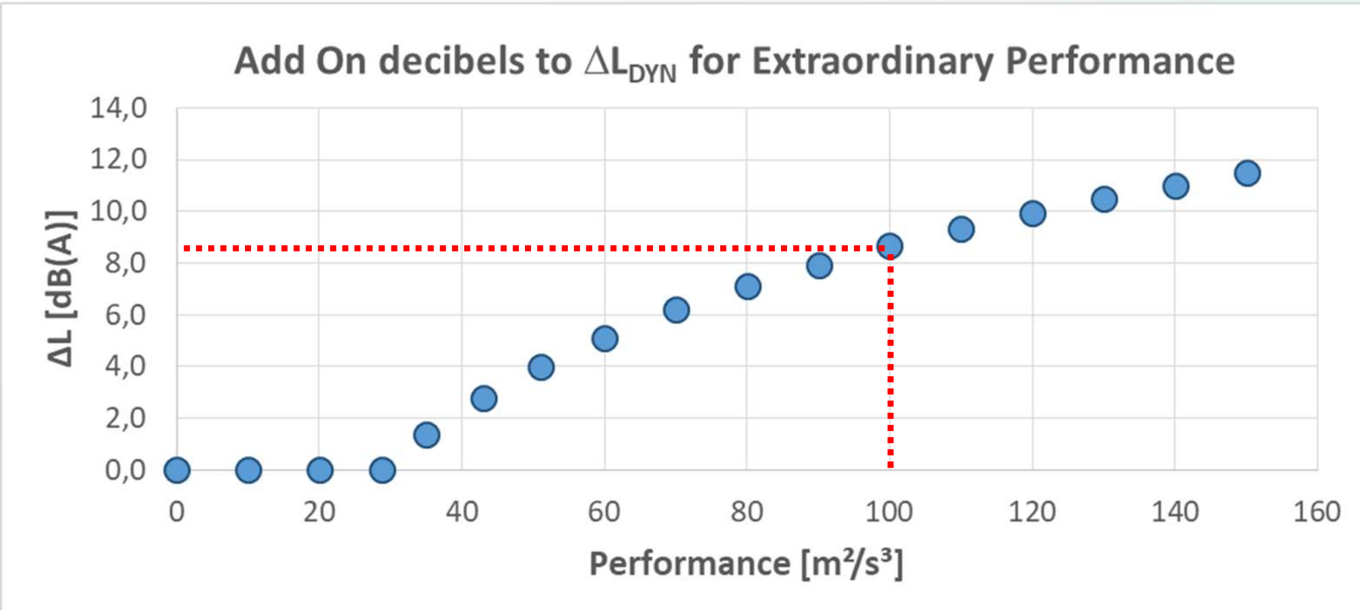
$$\Delta L_{DYN(va)} = \beta * \log(va_{test} / va_{ref})^2 \qquad \text{with } \beta \text{ as adjustable factor}$$

- For the actual model, the factor β was set to 8.
- The total dynamic of the vehicle is the set to:

$$\Delta L_{DYN(tot)} = \Delta L_{DYN} + \Delta L_{DYN(va)}$$

- The total dynamic $\Delta L_{DYN(tot)}$ is subject to the partial load model.

The Effect of the v x a in the Sound Model



The Add On is only applied, when the vehicle truly provides this performance.

For "typical on-road driving" nothing is added for performance.

Acceleration m/s^2	Vehicle Speed km/h: 10	20	30	40	50	60	70	80	90	100
0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,5	1,4	2,8	4,2	5,6	6,9	8,3	9,7	11,1	12,5	13,9
1,0	2,8	5,6	8,3	11,1	13,9	16,7	19,4	22,2	25,0	27,8
1,5	4,2	8,3	12,5	16,7	20,8	25,0	29,2	33,3	37,5	41,7
2,0	5,6	11,1	16,7	22,2	27,8	33,3	38,9	44,4	50,0	55,6
2,5	6,9	13,9	20,8	27,8	34,7	41,7	48,6	55,6	62,5	69,4
3,0	8,3	16,7	25,0	33,3	41,7	50,0	58,3	66,7	75,0	83,3
3,5	9,7	19,4	29,2	38,9	48,6	58,3	68,1	77,8	87,5	97,2
4,0	11,1	22,2	33,3	44,4	55,6	66,7	77,8	88,9	100,0	111,1
4,5	12,5	25,0	37,5	50,0	62,5	75,0	87,5	100,0	112,5	125,0
5,0	13,9	27,8	41,7	55,6	69,4	83,3	97,2	111,1	125,0	138,9

For a performance of 100 m^2/s^3 at 80 km/h an acceleration of 4,5 m/s^2 is needed.