Proposal for a measurement method representing rural driving behaviour for motorcycles

By Heinz Steven

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Review of updated acceleration curves for ISO 362-2

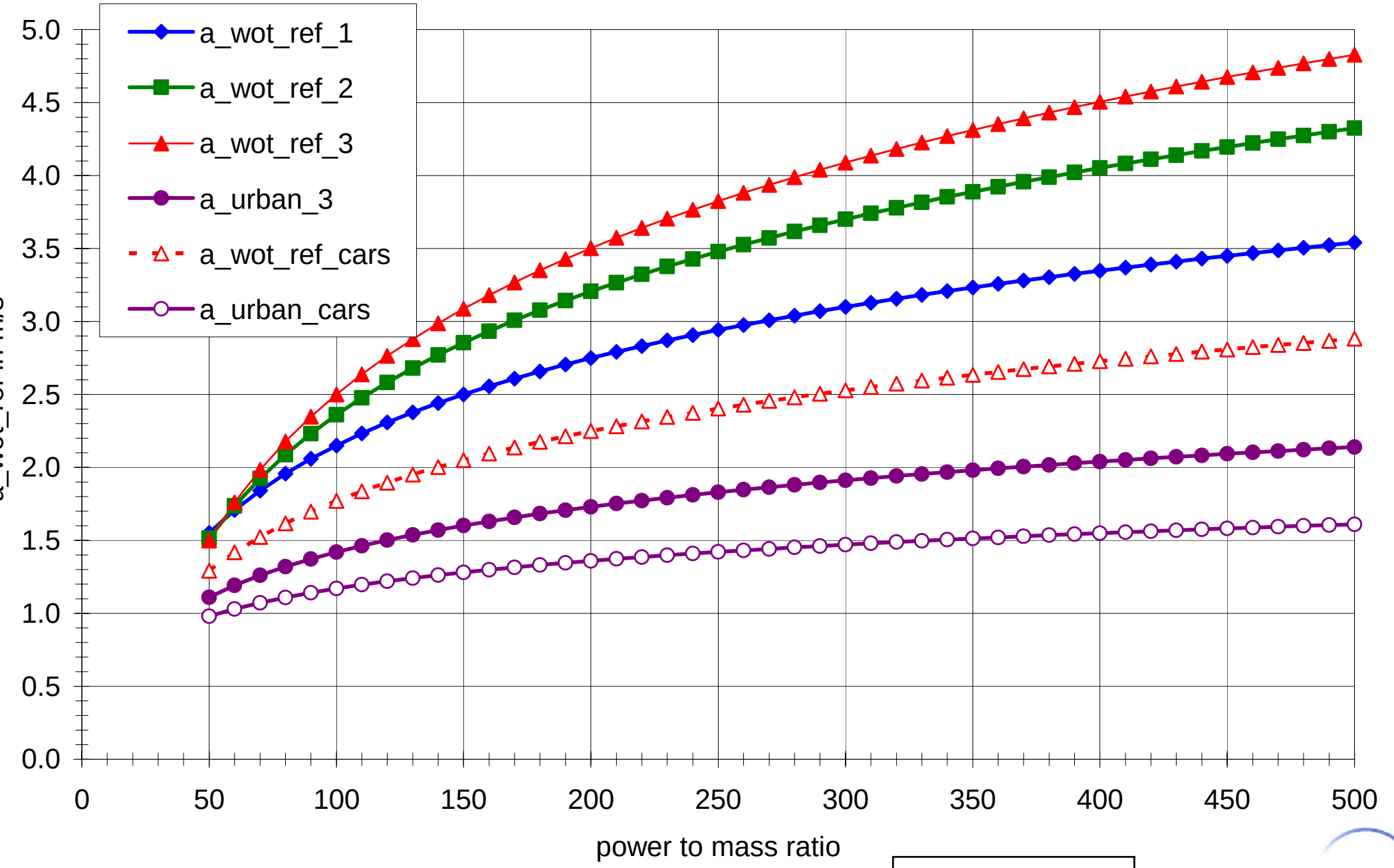


Figure 1a

Review of updated acceleration curves for ISO 362-2

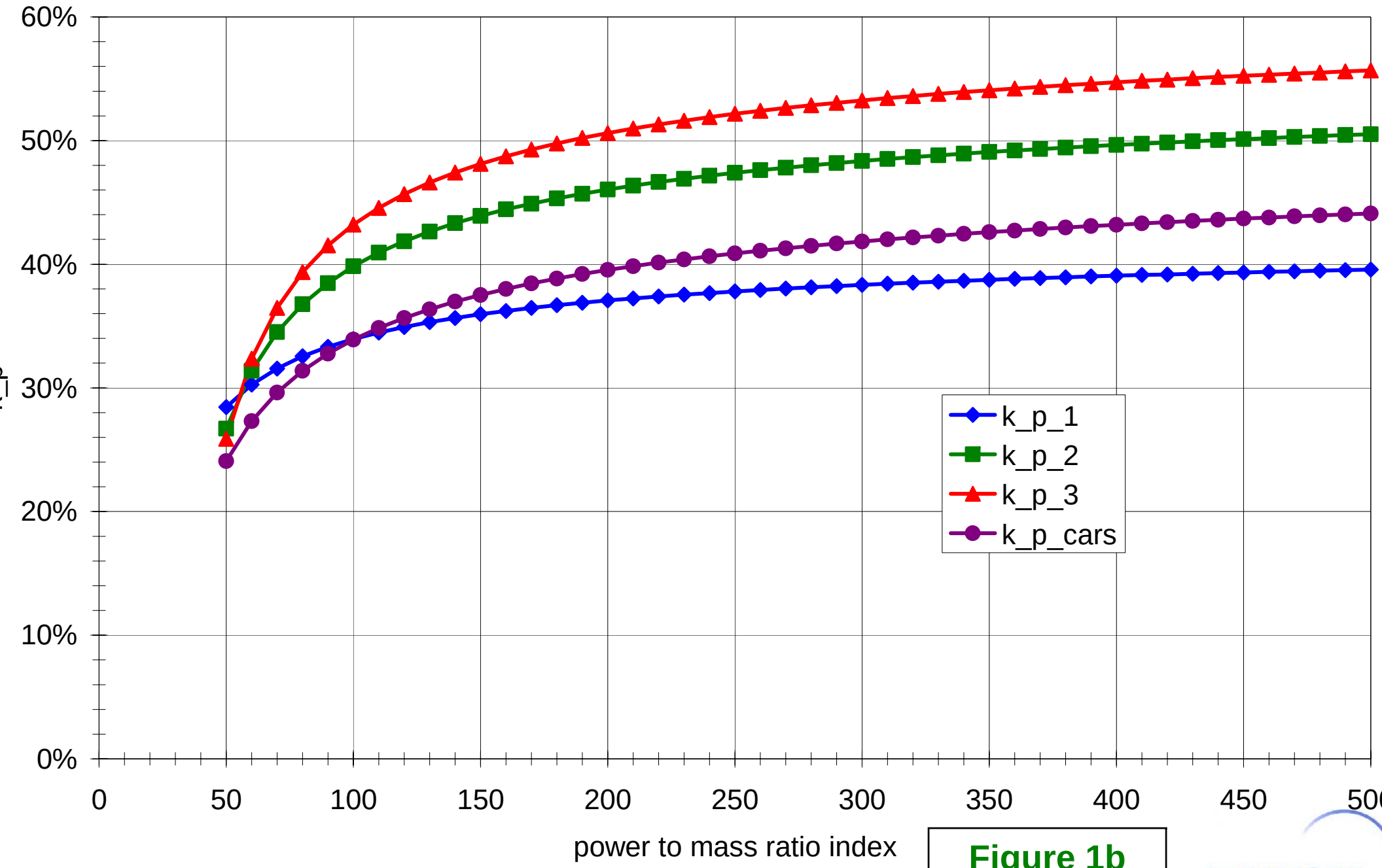


Figure 1b

Technical data of the Motorcycles

project	1	1	1	1	2	2	2	2	3	3	3	3	3	3
vehicle	1	2	3	4	1	2	3	4	1	2	3	4	6	7
engine capacity in cm^3	1085	1338	749	652	600	650	1085	1471	1157	929	1190	600	1449	992
rated power in kW	66	35	72	36	72	25	66	47	72	108	72	86	47	64
number of gears	5	5	6	5	6	5	5	5	6	6	5	6	5	5
kerb mass in kg	239	280	205	200	207	180	243	310	234	196	225	182	305	200
power to mass ratio in kW/t	210.2	98.6	257.1	130.9	255.3	98.0	207.5	122.1	233.0	398.5	240.0	334.6	123.7	232.7
maximum vehicle speed in km/h	209	145	220	155	248	140	205	175	220	278	190	260	170	230
rated speed in min-1	7250	5000	11500	6250	12000	6000	7250	4700	8500	11000	7000	13000	5450	7750
idling speed in min-1	1100	1000	1200	1100	1000	850	900	800	1200	1200	1200	1200	900	1200
n/v gear 2	73.2	57.0	83.0	70.0	94.0	86.7	68.3	57.2	65.0	64.5	69.5	101.5	58.0	73.4
n/v gear 3	48.5	40.5	66.8	52.4	75.3	65.9	50.3	46.2	49.5	53.5	55.8	80.0	41.0	55.0
n/v gear 4	39.6	31.7	57.5	41.6	62.5	53.2	40.8	34.7		46.8	45.2	68.0	32.0	44.0
n/v gear 5	33.9	25.8	51.0	35.2	53.9	43.3	33.7	26.2			39.4	60.2	26.0	38.0

Table 1

Review of updated acceleration curves for ISO 362-2

project	1	1	1	1	2	2	2	2	3	3	3	3	3	3
vehicle	1	2	3	4	1	2	3	4	1	2	3	4	6	7
power to mass ratio in kW/t	210.2	98.6	257.1	130.9	255.3	98.0	207.5	122.1	233.0	398.5	240.0	334.6	123.7	232.7
a in m/s², gear 2	4.87	3.29	2.30	3.89	3.70	3.90	5.10	2.60	5.07	4.92	5.77	5.20	3.81	5.80
a in m/s², gear 3	3.39	2.20	2.20	2.74	2.52	2.50	3.40	2.09	3.24	3.93	4.30	3.67	2.63	4.24
a in m/s², gear 4	2.62	1.60	2.00	1.86	1.40	1.93	2.51	1.48	2.30	2.05	3.30	2.45	2.00	3.02
a in m/s², gear 5			1.61								2.80	2.07		
a_urban in m/s²	1.8	1.4	1.8	1.5	1.8	1.4	1.7	1.5	1.8	2.0	1.8	2.0	1.5	1.8
a_wot_ref in m/s²	2.8	2.1	3.0	2.4	3.0	2.1	2.8	2.3	2.9	3.3	2.9	3.2	2.3	2.9
a_wot_ref_min in m/s²	2.51	1.92	2.67	2.14	2.66	1.92	2.50	2.09	2.59	3.01	2.62	2.87	2.10	2.59
a_wot_ref_max in m/s²	3.07	2.35	3.26	2.62	3.26	2.35	3.06	2.55	3.17	3.68	3.20	3.51	2.57	3.17
gear i	4	3	2	3	2	4	4	3	3	3	5	3	3	4
gear i+1				4	3				4	4		4	4	

project	1	1	1	1	2	2	2	2	3	3	3	3	3	3
vehicle	1	2	3	4	1	2	3	4	1	2	3	4	6	7
power to mass ratio in kW/t	210.2	98.6	257.1	130.9	255.3	98.0	207.5	122.1	233.0	398.5	240.0	334.6	123.7	232.7
a in m/s², gear 2	4.87	3.29	2.30	3.89	3.70	3.90	5.10	2.60	5.07	4.92	5.77	5.20	3.81	5.80
a in m/s², gear 3	3.39	2.20	2.20	2.74	2.52	2.50	3.40	2.09	3.24	3.93	4.30	3.67	2.63	4.24
a in m/s², gear 4	2.62	1.60	2.00	1.86	1.40	1.93	2.51	1.48	2.30	2.05	3.30	2.45	2.00	3.02
a in m/s², gear 5			1.61								2.80	2.07		
a_urban in m/s²	1.8	1.4	1.8	1.5	1.8	1.4	1.7	1.5	1.8	2.0	1.8	2.0	1.5	1.8
a_wot_ref in m/s²	3.6	2.5	3.9	2.9	3.9	2.5	3.6	2.8	3.7	4.5	3.8	4.2	2.8	3.7
a_wot_ref_min in m/s²	3.2	2.2	3.5	2.6	3.5	2.2	3.2	2.5	3.4	4.0	3.4	3.8	2.5	3.3
a_wot_ref_max in m/s²	3.9	2.7	4.3	3.2	4.2	2.7	3.9	3.1	4.1	4.9	4.1	4.7	3.1	4.1
gear i	3	3	2	3	2	3	3	2	2	2	3	2	3	3
gear i+1									3	3	4	3		4

Table 2

ISO 362-2 Test results old

project	1	1	1	1	2	2	2	2	3	3	3	3	3	3
vehicle	1	2	3	4	1	2	3	4	1	2	3	4	6	7
n_norm_PP_i	14.3%	25.6%	28.6%	29.5%	33.7%	35.2%	18.0%	38.7%	17.5%	15.1%	13.3%	23.7%	25.3%	15.3%
n_norm_PP_i+1				19.0%	25.1%				11.0%	11.6%		18.6%	15.4%	
v(Lmax)_i in km/h	53.3	52.8	52.9	53.4	54.6	52.4	53.2	52.6	54.0	54.9	53.5	54.5	53.3	53.8
v(Lmax)_i+1 in km/h				52.4	53.2				52.9	52.6		53.1	52.5	
n_norm_i at Lmax	16.4%	28.4%	31.0%	33.0%	37.6%	37.7%	20.0%	41.8%	20.2%	17.7%	15.7%	26.8%	28.2%	17.8%
v_AA_i in km/h	42.7	43.9	43.6	42.3	39.3	44.7	43.0	44.3	40.7	38.5	50.0	39.4	42.6	41.4
v_AA_i+1 in km/h				44.9	43.0				43.6	44.4		43.2	44.5	
n_norm_i+1 at Lmax				20.9%	27.3%				12.5%	12.9%		20.4%	17.2%	
n_norm, weighted_ISO 362-2_old	16.4%	28.4%	31.0%	28.1%	31.1%	37.7%	20.0%	41.8%	17.3%	16.2%	15.7%	24.3%	23.0%	17.8%
n_norm_max, urban in-use	31.7%	45.8%	28.7%	39.9%	28.8%	46.0%	31.9%	41.3%	30.1%	23.2%	29.7%	25.2%	41.0%	30.1%
delta n_norm	-15.3%	-17.4%	2.3%	-11.8%	2.3%	-8.3%	-11.9%	0.5%	-12.8%	-7.0%	-14.0%	-0.9%	-18.0%	-12.3%
Lmax_i in dB(A)	70.7	73.9	80.0	76.7	76.5	76.1	71.5	76.9	77.3	79.8	74.8	78.1	79.2	78.8
Lmax_i+1 in dB(A)				74.4	73.8				75.7	78.6		76.6	77.2	
ki	100.0%	100.0%	100.0%	59.5%	37.3%	100.0%	100.0%	100.0%	61.8%	68.9%	100.0%	61.0%	53.0%	100.0%
ki+1				40.5%	62.7%				38.2%	31.1%		39.0%	47.0%	
Lwot_rep in dB(A)	**70.7**	**73.9**	**80.0**	**75.8**	**74.8**	**76.1**	**71.5**	**76.9**	**76.7**	**79.4**	**74.8**	**77.5**	**78.3**	**78.8**
Lcst_i in dB(A)	61.5	68.6	72.6	71.7	69.6	62.8	62.6	67.0	67.6	68.8	62.4	69.7	73.0	67.2
Lcst_i+1 in dB(A)				69.1	66.9				65.2	67.6		68.0	71.1	
Lcst_rep in dB(A)	**61.5**	**68.6**	**72.6**	**70.7**	**67.9**	**62.8**	**62.6**	**67.0**	**66.7**	**68.4**	**62.4**	**69.0**	**72.1**	**67.2**
kp	33.0%	35.7%	19.9%	35.3%	37.9%	26.9%	30.4%	27.8%	37.6%	39.1%	35.3%	38.6%	35.1%	40.5%
Lurban in dB(A)	**67.7**	**72.0**	**78.6**	**74.0**	**72.2**	**72.5**	**68.8**	**74.2**	**72.9**	**75.1**	**70.4**	**74.2**	**76.1**	**74.1**

„Old“ means 1. acceleration curve,
„new“ means latest acceleration curve

Table 3a

ISO 362-2 Test results new

project	1	1	1	1	2	2	2	2	3	3	3	3	3	3
vehicle	1	2	3	4	1	2	3	4	1	2	3	4	6	7
n_norm_PP_i	21.6%	25.6%	28.6%	29.5%	33.7%	47.5%	25.4%	52.8%	28.1%	20.7%	27.4%	32.8%	25.3%	23.7%
n_norm_PP_i+1									17.5%	15.1%	18.3%	23.7%		15.3%
v(Lmax)_i in km/h	54.2	52.8	52.9	53.4	54.6	53.1	54.2	53.3	56.2	56.0	55.3	56.3	53.3	55.2
v(Lmax)_i+1 in km/h									54.0	54.9	54.1	54.5		53.8
n_norm_i at Lmax	24.9%	28.4%	31.0%	33.0%	37.6%	51.5%	28.7%	57.6%	33.6%	24.6%	32.5%	38.3%	28.2%	28.0%
v_AA_i in km/h	40.3	43.9	43.6	42.3	39.3	43.0	40.2	42.7	34.4	35.0	37.2	33.9	42.6	37.4
v_AA_i+1 in km/h									40.7	38.5	40.6	39.4		41.4
n_norm_i+1 at Lmax									20.2%	17.7%	21.5%	26.8%		17.8%
n_norm, weighted_ISO 362-2 new	24.9%	28.4%	31.0%	33.0%	37.6%	51.5%	28.7%	57.6%	23.7%	21.7%	26.6%	31.1%	28.2%	23.7%
n_norm_max, urban in-use	31.7%	45.8%	28.7%	39.9%	28.8%	46.0%	31.9%	41.3%	30.1%	23.2%	29.7%	25.2%	41.0%	30.1%
delta n_norm	-6.8%	-17.4%	2.3%	-6.9%	8.8%	5.6%	-3.1%	16.3%	-6.4%	-1.5%	-3.1%	5.9%	-12.8%	-6.4%
Lmax_i in dB(A)	72.8	73.9	80.0	76.7	76.5	78.0	73.7	79.0	80.0	81.6	77.7	81.0	79.2	80.4
Lmax_i+1 in dB(A)									77.3	79.8	75.8	78.1		78.8
ki	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	26.4%	57.5%	46.6%	37.7%	100.0%	57.5%
ki+1									73.6%	42.5%	53.4%	62.3%		42.5%
Lwot_rep in dB(A)	**72.8**	**73.9**	**80.0**	**76.7**	**76.5**	**78.0**	**73.7**	**79.0**	**78.0**	**80.9**	**76.7**	**79.2**	**79.2**	**79.7**
Lcst_i in dB(A)	64.4	68.6	72.6	71.7	69.6	66.7	64.9	71.3	71.2	70.7	67.4	72.7	73.0	69.4
Lcst_i+1 in dB(A)									67.6	68.8	64.2	69.7		67.2
Lcst_rep in dB(A)	**64.4**	**68.6**	**72.6**	**71.7**	**69.6**	**66.7**	**64.9**	**71.3**	**68.5**	**69.9**	**65.7**	**70.8**	**73.0**	**68.4**
kp	48.3%	35.7%	19.9%	43.8%	50.3%	43.6%	48.6%	41.9%	51.7%	54.7%	51.9%	53.8%	42.4%	51.7%
Lurban in dB(A)	**68.7**	**72.0**	**78.6**	**74.5**	**73.1**	**73.1**	**69.4**	**75.8**	**73.1**	**74.8**	**71.0**	**74.7**	**76.6**	**73.9**

„Old“ means 1. acceleration curve,
„new“ means latest acceleration curve

Table 3b

ISO 362-2 Test results comparison

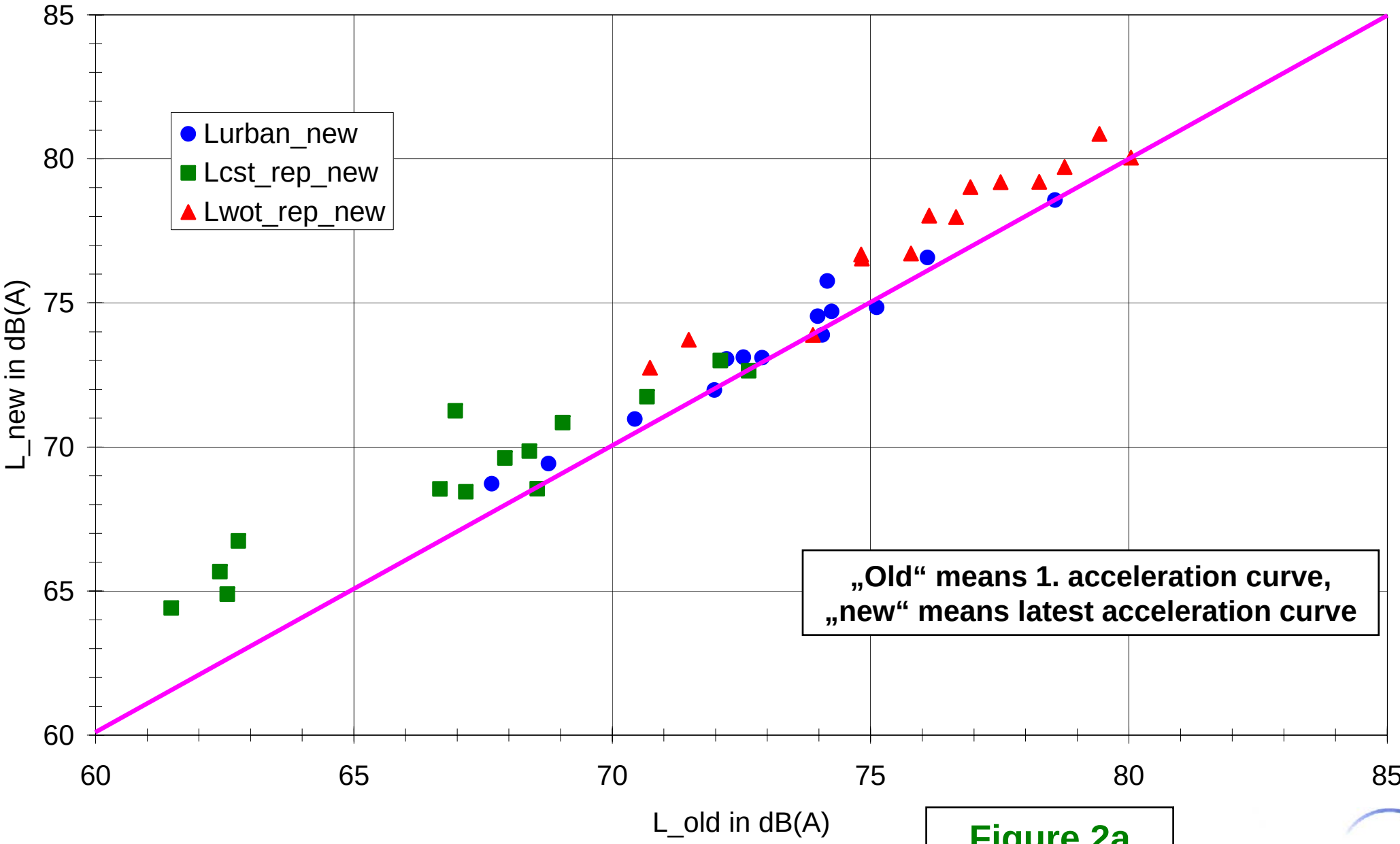


Figure 2a

ISO 362-2 Test results comparison

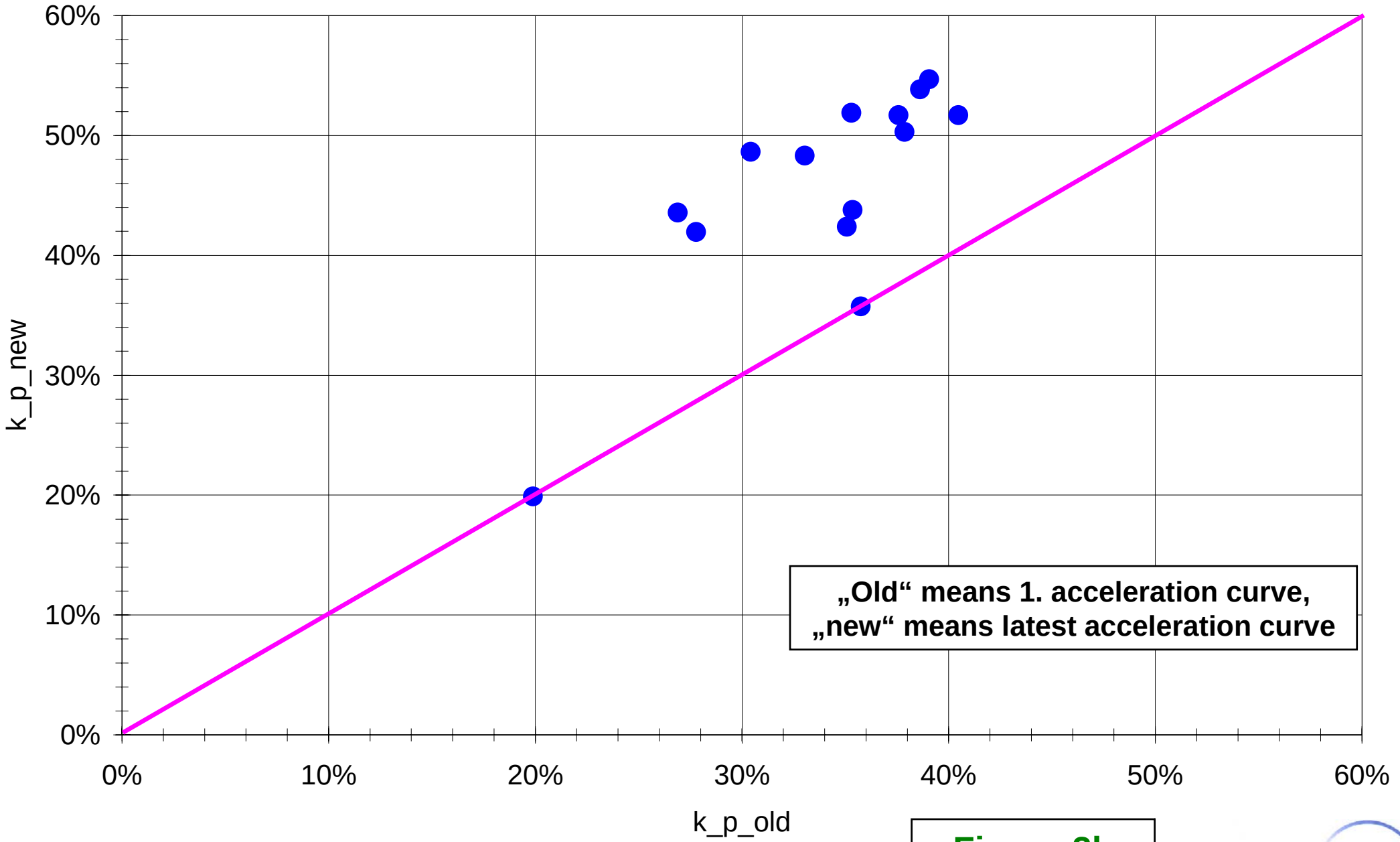
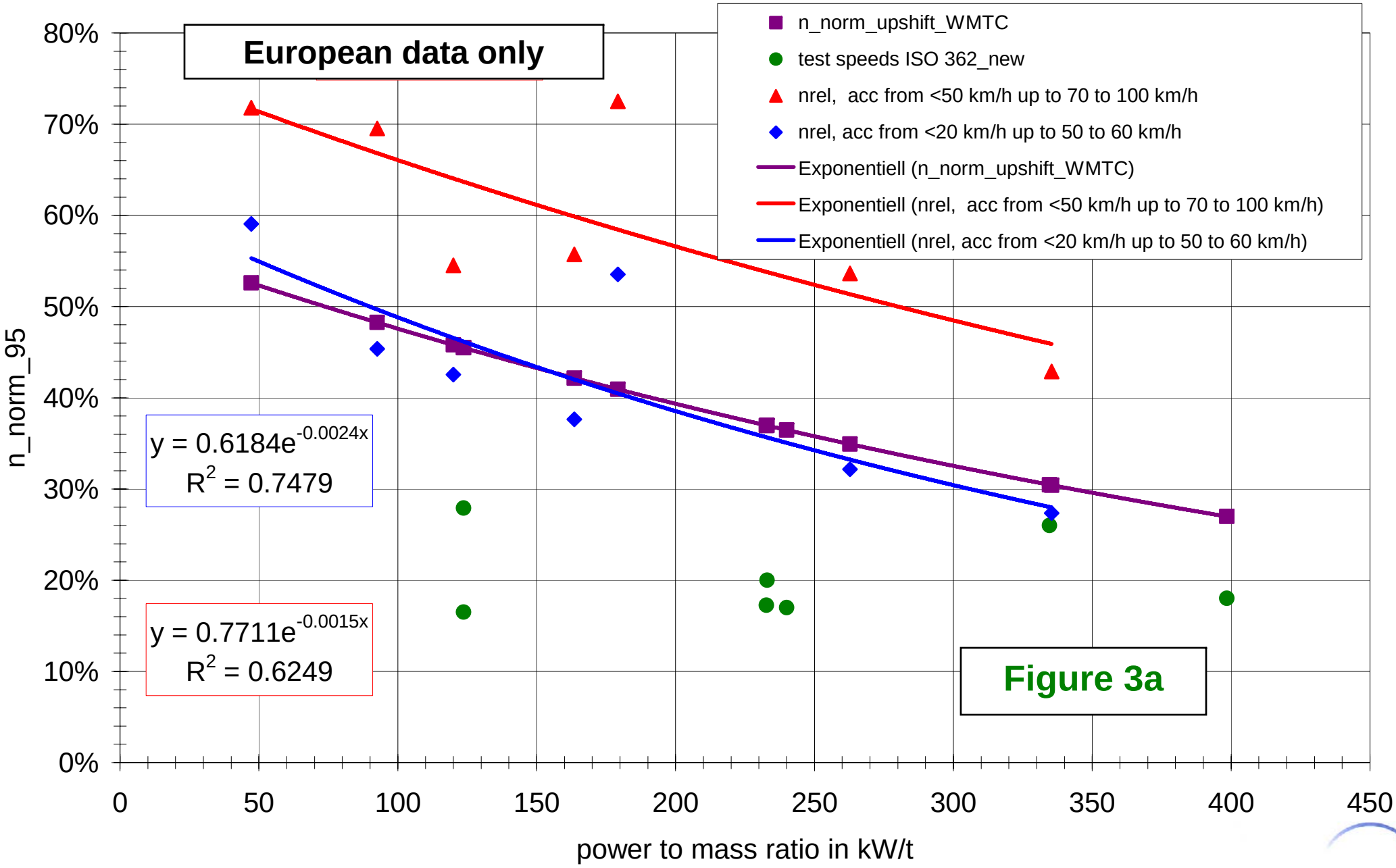


Figure 2b

Measurement method for rural driving behaviour

- At the 41st GRB meeting in February 2005 Germany presented an informal paper that showed that the driving behaviour on rural roads is characterized by significantly higher engine speeds compared to the driving behaviour on urban roads.
- Figure 3 shows a regression curve for average top engine speeds during acceleration phases at the boundaries of urban to rural roads (starting at speeds below 50 km/h and ending at speeds between 70 km/h and 100 km/h).
- This curve is based on the European part of the WMTC database.
- It was proposed to base a measurement method that represents rural driving behaviour on the ISO 362-200x method for N2 and N3 vehicles. ISO 362-200x requires a target engine speeds that must be reached at the end of the test track (BB') during a wide open throttle acceleration test. The target engine speed should be a function of power to mass ratio.
- At the Rome meeting of Informal GRB R41 (April 2005) Germany promised to deliver a more specific proposal for such measurement method.
- This proposal is presented in this informal paper.

In-use engine speeds and ISO 362 test speeds



In-use engine speeds and ISO 362 test speeds

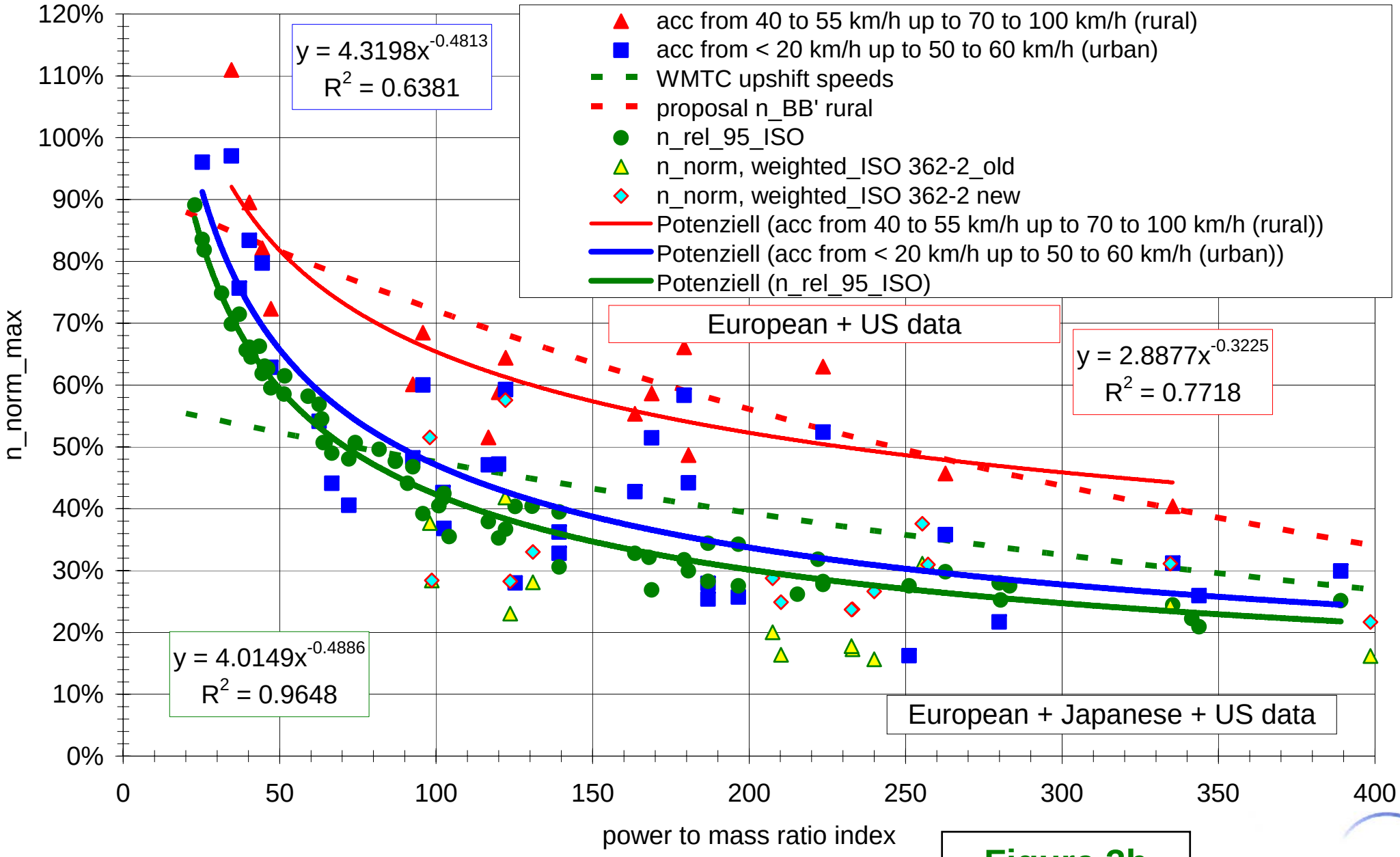


Figure 3b

Measurement method for rural driving behaviour

- At present the proposal is based on the regression curve in figure 3, because it was not possible – due to lack of time – to reanalyse the whole WMTC database with respect to rural driving behaviour.
- When this will be finalised the regression curve needs to be updated adequately.
- Since the top speed normally creates the highest noise emission, the regression curve should represent the actual engine speed where the maximum noise level (Lmax) appeares. Normally, Lmax occurs somewhere between the microphone cross section (PP') and the end of the test track (BB').
- RWTUEV has a database of 14 motorcycles with a series of pass-by measurement results that allows to calculate Lmax for wide open throttle accelerations and an engine speed corresponding to the "rural" regression curve of figure 1.
- The technical data is shown in table 1.

Measurement method for rural driving behaviour

- For these 14 vehicles the corresponding engine speeds at AA', PP' and BB' were calculated on the basis of measured acceleration values in 2. gear. In order to simplify the calculation it was assumed that the maximum noise level occurs 5 m after PP'.
- The 2. gear was chosen in order to keep the vehicle speeds driveable for test tracks.
- The calculated vehicle and normalised engine speeds at AA', PP', BB' and the calculated Lmax values are shown in table 4.
- Figure 2 shows n_norm_AA, n_norm_PP and n_norm_BB as functions of the power to mass ratio.
- The regression functions for n_norm_BB can be used as requirement for the test conditions to determine Lwot_rural.

Proposal for a method to determine L_rural

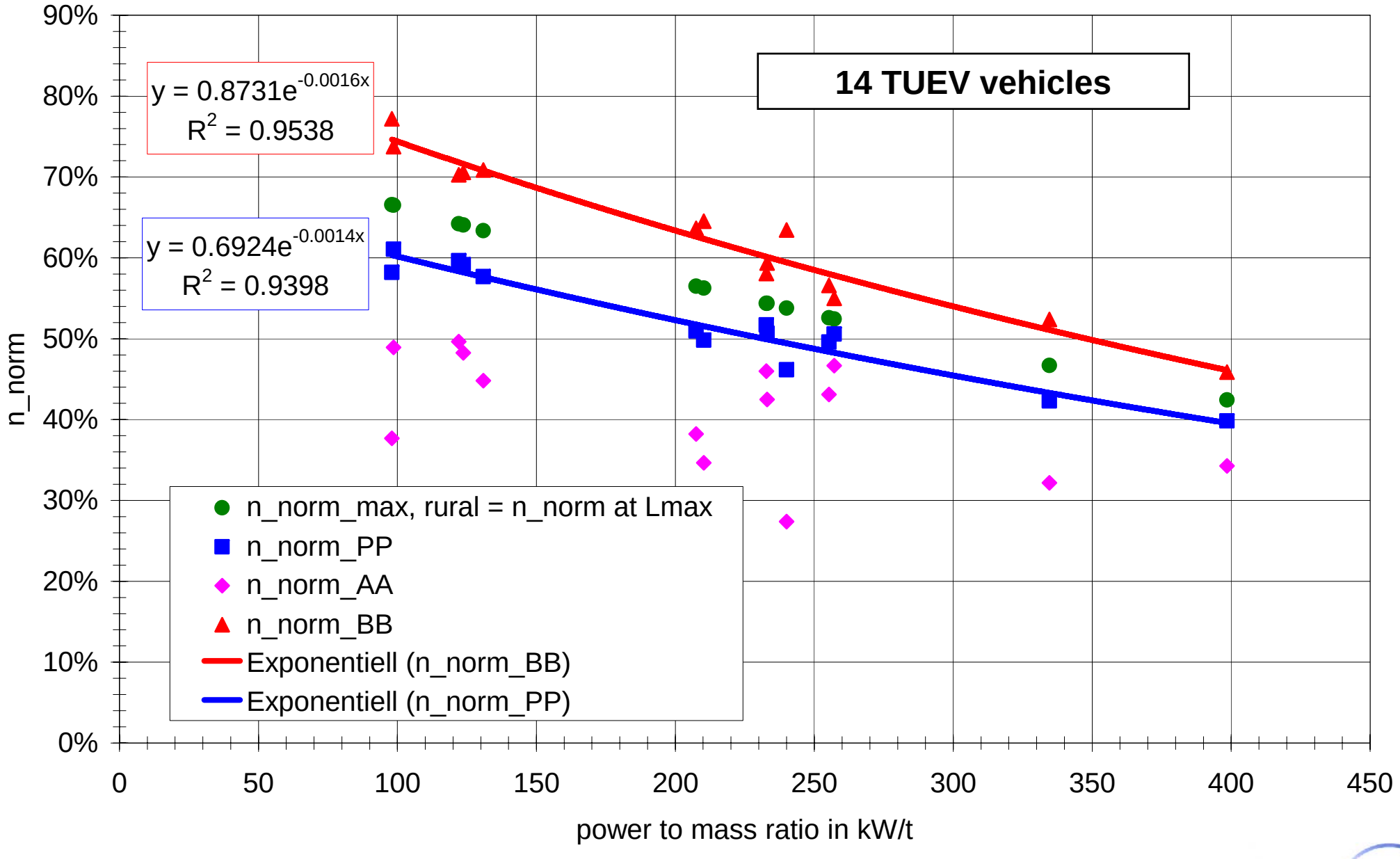


Figure 3a

Proposal for a method to determine L_rural

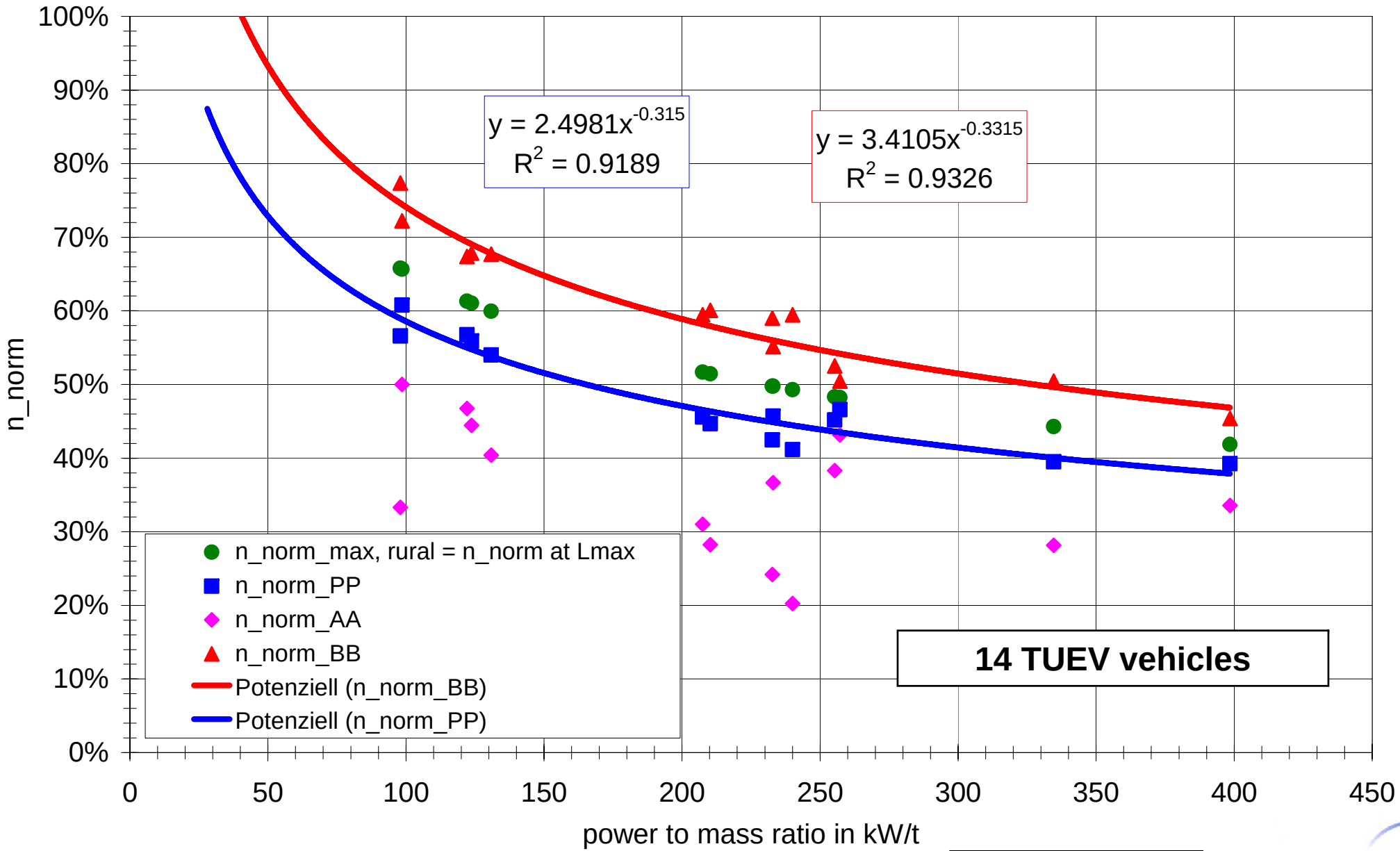


Figure 3b

Proposal for a method to determine L_rural

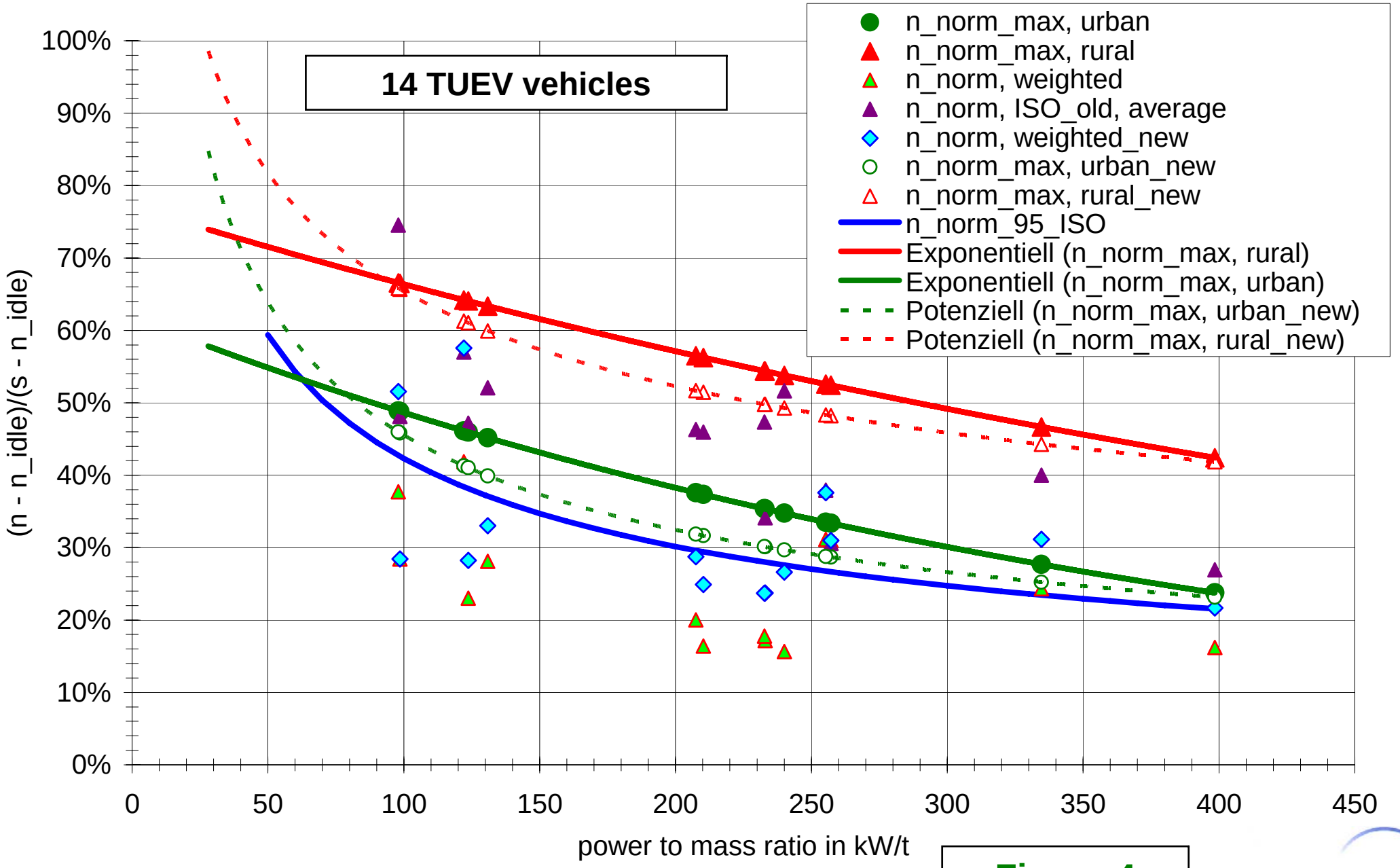


Figure 4

Proposal for a method to determine L_rural

project	1	1	1	1	2	2	2	2	3	3	3	3	3	3
vehicle	1	2	3	4	1	2	3	4	1	2	3	4	6	7
gear	2	2	2	2	2	2	2	2	2	2	2	2	2	2
n_norm_max, rural = n_norm at Lmax	56.3%	66.5%	52.4%	63.4%	52.6%	66.6%	56.5%	64.2%	54.4%	42.4%	53.8%	46.7%	64.1%	54.4%
v(Lmax) in km/h	62.3	64.2	79.5	62.3	72.1	49.4	65.7	57.8	79.5	83.0	62.2	66.1	65.8	64.9
vPP in km/h	56.9	60.4	77.2	58.1	68.6	44.4	60.5	54.7	75.3	79.1	55.8	61.0	61.9	58.8
v_AA in km/h	44.1	51.9	72.4	48.7	61.0	32.2	48.7	47.9	66.2	70.7	40.1	49.2	53.4	44.2
v_BB in km/h	69.2	69.3	82.7	67.8	76.8	55.7	72.3	61.9	85.1	88.3	70.2	72.7	70.9	72.6
n_norm_PP	49.8%	61.0%	50.6%	57.7%	49.6%	58.2%	51.0%	59.6%	50.6%	39.8%	46.2%	42.3%	59.1%	47.6%
n_norm_AA	34.6%	48.9%	46.7%	44.8%	43.1%	37.7%	38.2%	49.6%	42.5%	34.3%	27.4%	32.2%	48.2%	31.2%
n_norm_BB	64.5%	73.7%	55.0%	70.8%	56.6%	77.2%	63.7%	70.3%	59.3%	45.9%	63.5%	52.4%	70.6%	63.1%
Lwot_rural in dB(A)	**80.2**	**82.6**	**83.5**	**82.5**	**80.5**	**80.1**	**80.8**	**79.9**	**84.2**	**86.3**	**81.3**	**83.0**	**85.7**	**84.7**

Table 4a, $n\_norm = 0.8731e^{-0.0016*pmr}$

project	1	1	1	1	2	2	2	2	3	3	3	3	3	3
vehicle	1	2	3	4	1	2	3	4	1	2	3	4	6	7
gear	2	2	2	2	2	2	2	2	2	2	2	2	2	2
n_norm_max, rural = n_norm at Lmax	51.5%	65.7%	48.2%	59.9%	48.3%	65.8%	51.7%	61.3%	49.8%	41.9%	49.3%	44.3%	61.0%	49.8%
v(Lmax) in km/h	58.3	63.6	74.3	59.8	67.2	48.9	61.2	55.8	74.4	82.2	58.4	63.3	63.4	60.8
vPP in km/h	52.6	60.2	72.3	55.4	63.5	43.4	55.5	52.7	69.8	78.2	51.6	57.7	59.4	54.2
v_AA in km/h	38.7	52.6	68.0	45.4	55.4	29.6	42.0	45.9	59.6	69.6	34.2	44.6	50.4	37.9
v_BB in km/h	65.5	68.2	77.1	65.5	72.1	55.8	68.4	59.9	80.4	87.5	66.9	70.5	68.7	69.0
n_norm_PP	44.7%	60.8%	46.6%	54.0%	45.2%	56.6%	45.6%	56.8%	45.7%	39.2%	41.2%	39.5%	55.9%	42.5%
n_norm_AA	28.2%	50.0%	43.1%	40.4%	38.3%	33.3%	31.0%	46.7%	36.7%	33.6%	20.3%	28.2%	44.5%	24.2%
n_norm_BB	60.1%	72.2%	50.5%	67.7%	52.5%	77.3%	59.5%	67.4%	55.1%	45.4%	59.5%	50.4%	67.8%	59.0%
Lwot_rural in dB(A)	**79.0**	**82.4**	**82.8**	**81.9**	**79.4**	**80.0**	**79.6**	**79.5**	**83.3**	**86.2**	**80.5**	**82.4**	**85.1**	**84.0**

Table 4b, $n\_norm = 3.4105*pmr^{-0.3315}$

Proposal for a method to determine L_rural

This results in the following proposal with respect to a method to determine Lwot_rural:

- **The normalised engine speed at BB is defined by the following equation:**
  - **n_norm_BB = 0,8731*exp(-0.0016*pmr) old,**
  - **$n\_norm\_BB = 3{,}4105 * pmr^{-0{,}3315}$ new**
  - **pmr is the power to mass ratio index as defined in the new ISO standard (the value in kW/t without the dimension).**
- **This engine speed must be reached within a tolerance band of 0,95*n_norm_BB and 1,05*n_norm_BB (+/- 5%).**
- **The engine speed at BB is calculated by:**
  - **n_BB' = n_norm_BB'*(s – n_idle) + n_idle,**

    where s is the engine speed where the engine develops its maximum power and n_idle is idling speed
- **The test has to be performed in 2. gear.**
- **The test results of 4 valid runs shall be averaged for each side of the vehicle.**
- **Lwot_rural is the maximum of these averages.**

Proposal for a method to determine Lwot_rural

- It must be pointed out that the equations mentioned in this presentation need to be confirmed or modified by applying this method to a representative motorcycle sample including also less powerful vehicles.
- The intention of this paper is to outline the concept and the design of the method.