Modelling of fuel consumption and detection of driveability problems for “borderline” cars using speed caps and downscaling of sections of the extra high phase.

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Modifications made for the 3. version

- For the 3. version of the calculation tool, which is not yet distributed, the following modifications were made:
  - An additional safety margin can be applied on the wot power curve, additional to the 10% default margin.
  - The additional safety margin is fully applied at idling speed and then linearily reduced to 0 at rated speed.
  - As an example, if one chooses 10% for the additional margin, the effective safety margin at idling speed is 20% and at rated speed or higher speeds 10%.
  - In order to avoid downshifts to the 1. gear within a short trip, the choice of n_min_2 was deleted and replaced by the following requirements:

Modifications made for the 3. version

- The minimum engine speed in 2. gear during acceleration phases starting from standstill is determined by the maximum of
  - 1,15*idling_speed or
  - 0,03*(rated_speed –idling_speed) + idling_speed
- The minimum vehicle speed at which the 2. gear during deceleration phases or acceleration phases within a short trip will be kept is detemined by a theoretical corresponding engine speed of 0,9*idling_speed.
- If this is fulfilled, the 2. gear is kept and the engine speed is set to the maximum as defined in the first bullet point on this slide as long as this value exceeds the theoretical corresponding engine.
- In order to avoid engine stalling, the clutch is disengaged.

Modifications made for the 3. version

- **The application of a maximum speed cap was implemented into the tool. In cases where the original cycle speed exceeds the cap, the cycle speed is limited to the cap.**
- **In addition to that the calculation tool was further modified in that way, that it reduces the vehicle speed in cases where the required acceleration exceeds the available acceleration power and where the maximum speed of the vehicle is lower than the cycle speed.**
- **In order to enable the assessment of speed caps versus cycle downscaling, the latter was implemented as additional option for the extra high speed phases of the class 2 and class 3 cycles.**
- **But the downscaling is restricted to the time sections with high speeds within the extra high speed phases (see figures 1 and 2).**

Downscaling example for class 3 versions 5.1 and 5.3

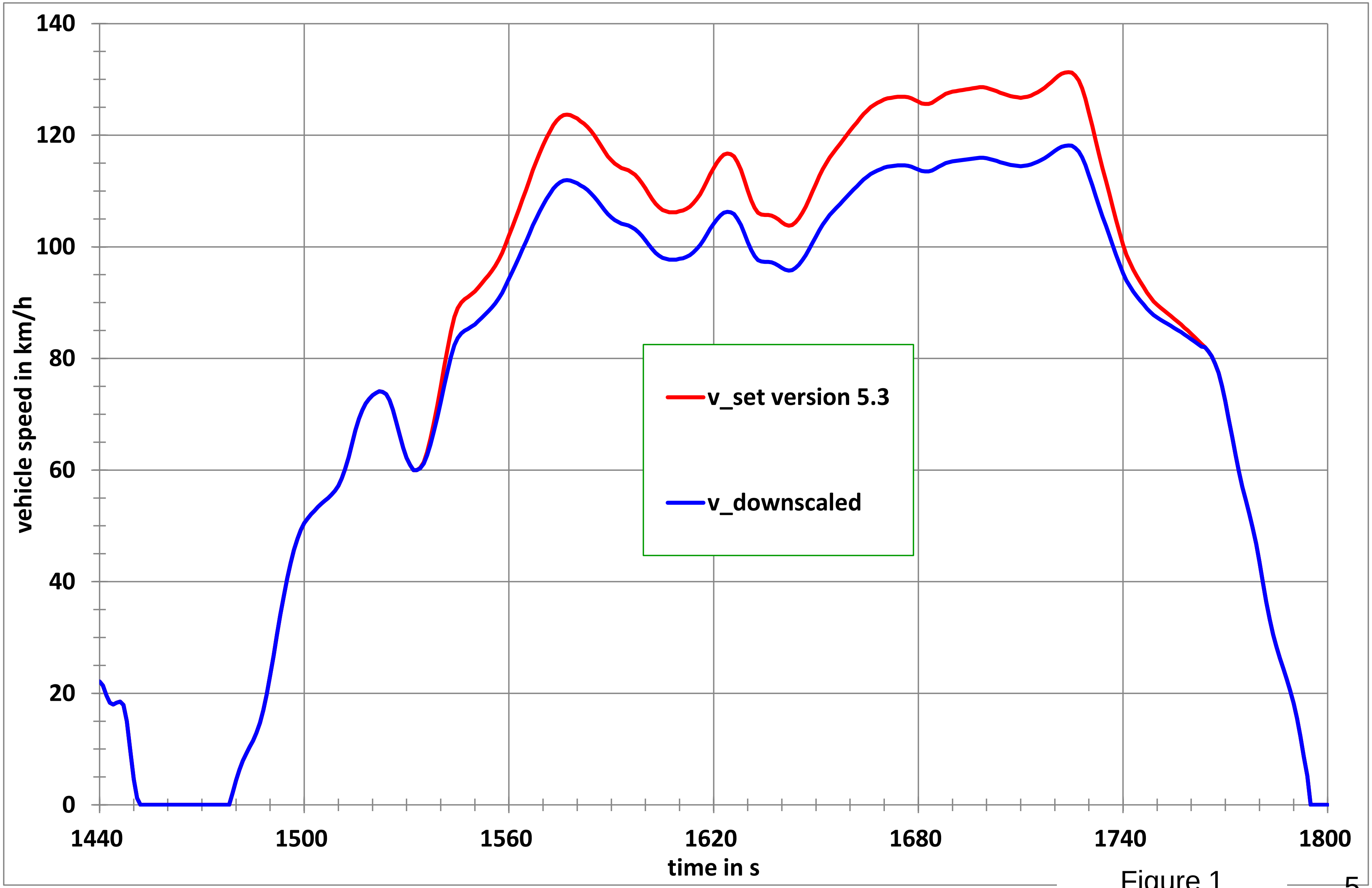

Figure 1

Downscaling example for class 2 version 2

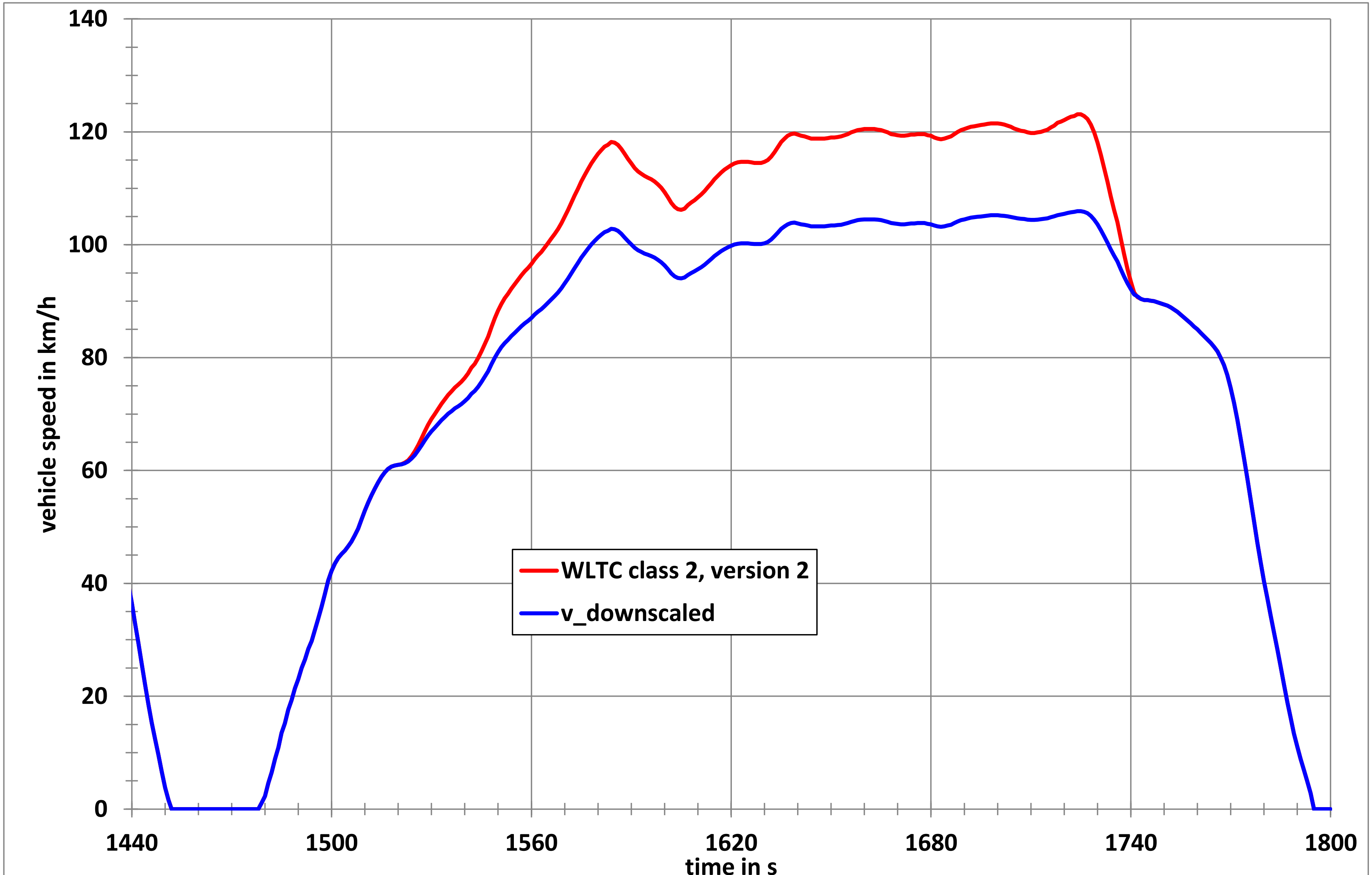

Figure 2

Calculations performed for speed cap assessments

- Calculations were performed for 427 class 3 vehicles with maximum speeds between 90 km/h and 250 km/h.
- The maximum speeds were calculated from the transmission data and the default values for the driving resistance provided by the model.
- The vehicle sample consists of
  - 154 vehicles from the WLTP in-use database,
  - 37 vehicles from the validation 2 database,
  - 152 artificial vehicle models from sensitivity analyses of the gearshift calculation tool,
  - 84 modified vehicle models designed for this study, but based on existing models.

Calculations performed for speed cap assessments

- Since it was known from a previous investigation that the driveability problems are related to the time section between 1533 s and 1724 s in the extra high speed phase, the assessment was based on a comparison of the distances between set speed and actual speed and the sum of positive accelerations over this section.
- 365 vehicles had no problems at all regarding the driveability.
- 32 vehicles had small problems, but the actual speed trace remains within the tolerance band.
- 30 vehicles had significant deviations from the set speed but for different reasons.
- These vehicles were investigated in more detail. The technical data and the fuel consumption estimations as well as the wide open throttle operation percentages are summarised in table 1.

Technical data of the investigated vehicle examples

vehicle	engine	pmr in kW/t	rated power in kW	number of gears	v_max in km/h	n_norm max	v_max cycle in km/h	v_max set in km/h	FC in g/km	p_wot	remarks
335	Petrol	34.4	28	5	106	120.1%	105.9	131.3	34.4	3.0%	modified transmission
363	Petrol	34.7	26	4	106	120.4%	105.7	131.3	30.5	2.3%	modified transmission
107	Petrol	38.8	31	5	107	120.0%	107.0	131.3	36.0	2.9%	Japanese in-use DB, veh 18
344	Diesel	38.9	55	5	107	120.5%	106.6	131.3	60.9	0.8%	modified transmission
266	Petrol	40.9	36	5	113	120.1%	113.0	131.3	38.9	3.3%	modified transmission
276	Petrol	37.5	33	5	113	120.1%	113.0	131.3	37.7	4.3%	modified transmission
286	Petrol	34.1	30	5	113	120.1%	113.0	131.3	36.5	3.9%	modified transmission
33	Petrol	38.5	37	5	117	119.8%	115.0	131.3	47.7	11.4%	provided by JAMA
265	Petrol	40.9	36	5	118	119.6%	118.0	131.3	39.0	4.1%	modified transmission
275	Petrol	37.5	33	5	118	119.6%	118.0	131.3	37.9	4.9%	modified transmission
285	Petrol	34.1	30	5	118	119.6%	118.0	131.3	36.8	6.2%	modified transmission
109	Petrol	42.0	37	5	119	119.9%	119.0	131.3	41.0	4.1%	Japanese in-use DB, veh 20
34	Petrol	35.7	35	6	120	107.7%	117.1	131.3	46.3	12.1%	provided by JAMA
331	Petrol	40.0	32	5	120	119.6%	120.0	131.3	36.9	4.8%	modified transmission
343	Diesel	38.9	55	5	120	119.7%	120.0	131.3	59.4	2.3%	modified transmission

Table 1a

Technical data of the investigated vehicle examples

vehicle	engine	pmr in kW/t	rated power in kW	number of gears	v_max in km/h	n_norm max	v_max cycle in km/h	v_max set in km/h	FC in g/km	p_wot	remarks
362	Petrol	34.7	26	4	120	119.6%	120.0	131.3	31.4	9.4%	modified transmission
274	Petrol	37.5	33	5	124	119.7%	124.0	131.3	38.4	5.2%	modified transmission
284	Petrol	34.1	30	5	124	119.7%	124.0	131.3	37.4	10.4%	modified transmission
321	Petrol	38.2	30	4	125	120.3%	124.7	131.3	34.6	8.6%	modified transmission
273	Petrol	37.5	33	5	131	120.2%	129.4	131.3	38.2	8.3%	modified transmission
283	Petrol	34.1	30	5	131	120.2%	127.6	131.3	36.8	9.8%	modified transmission
282	Petrol	34.1	30	5	133	115.0%	129.1	131.3	36.9	9.3%	modified transmission
361	Petrol	34.7	26	4	133	110.7%	128.9	131.3	31.4	10.9%	modified transmission
360	Petrol	34.7	26	4	135	93.7%	125.4	131.3	31.9	11.2%	modified transmission
281	Petrol	34.1	30	5	136	110.4%	129.8	131.3	37.0	10.5%	modified transmission
287	Petrol	34.1	30	5	136	111.2%	129.8	131.3	37.0	11.5%	modified transmission
280	Petrol	34.1	30	5	137	107.6%	130.0	131.3	37.1	9.7%	modified transmission
225	Petrol	40.9	26	4	140	99.1%	129.6	131.3	29.4	9.8%	Indian in-use DB, veh 3
412	Petrol	36.5	29	5	140	101.6%	129.8	131.3	33.5	12.8%	Validation 2, veh 37
277	Petrol	37.5	33	5	142	92.5%	131.0	131.3	38.3	9.5%	modified transmission

Table 1b

Results

- Vehicles with high wot percentages are highlighted in yellow.
- It must be noticed that the majority of these vehicles have maximum speeds above 130 km/h.
- Vehicles with maximum speeds below 106 km/h are missing, because they did not show any driveability problems.
- It must also be noticed that the major part of the vehicles consists of modified transmission versions, only 6 vehicles come from the in-use or the validation 2 database.
- The power to mass ratios vary from the borderline to class 2 (34 kW/t) to 42 kW/t, the maximum speed values range up to 148 km/h, although this value is not shown in the example table.

Results

- In all cases the calculations were performed without any speed cap or downscaling measures, with a speed cap of 10% and with different downscaling percentages ranging from 5% to 30% in steps of 5%.
- The downscaling is related to the acceleration values. 5% means a reduction of the acceleration values by 5%.
- This 5% reduction is applied from 1533 s to the top speed at 1724 s. The following decelerations are modified in that way that the original speed trace is reached again at 1762 s.
- The most „critical“ group consists of vehicles with maximum speeds above 130 km/h. They have wot percentages above 9% with on exception (vehicle 273).
- And obviously, the maximum speed is not decisive for the driveability (see vehicles 273 and 412).

Example results

- In order to demonstrate the influence of road load, the first example, which is shown in detail is vehicle 109. This vehicle is vehicle 20 in the Japanese in-use database.
- Figure 3 shows the cycle trace for the extra high speed phase in case of relatively high road load coefficients.
- The road load curve is shown in figure 4, the engine map coverage is shown in figure 5. P_norm_max is the wot power provided by the engine, reduced by the power safety margin (10%).
- The symbols for the 4 phases represent the P_norm values for eachh second of the cycle phases low to extra high. P_norm_res represents the driving resistance power for constant speed. The highest curve is related to the highest gear.
- All values are normalised to rated power.

Speed trace of the extra high speed phase for high road load coefficients

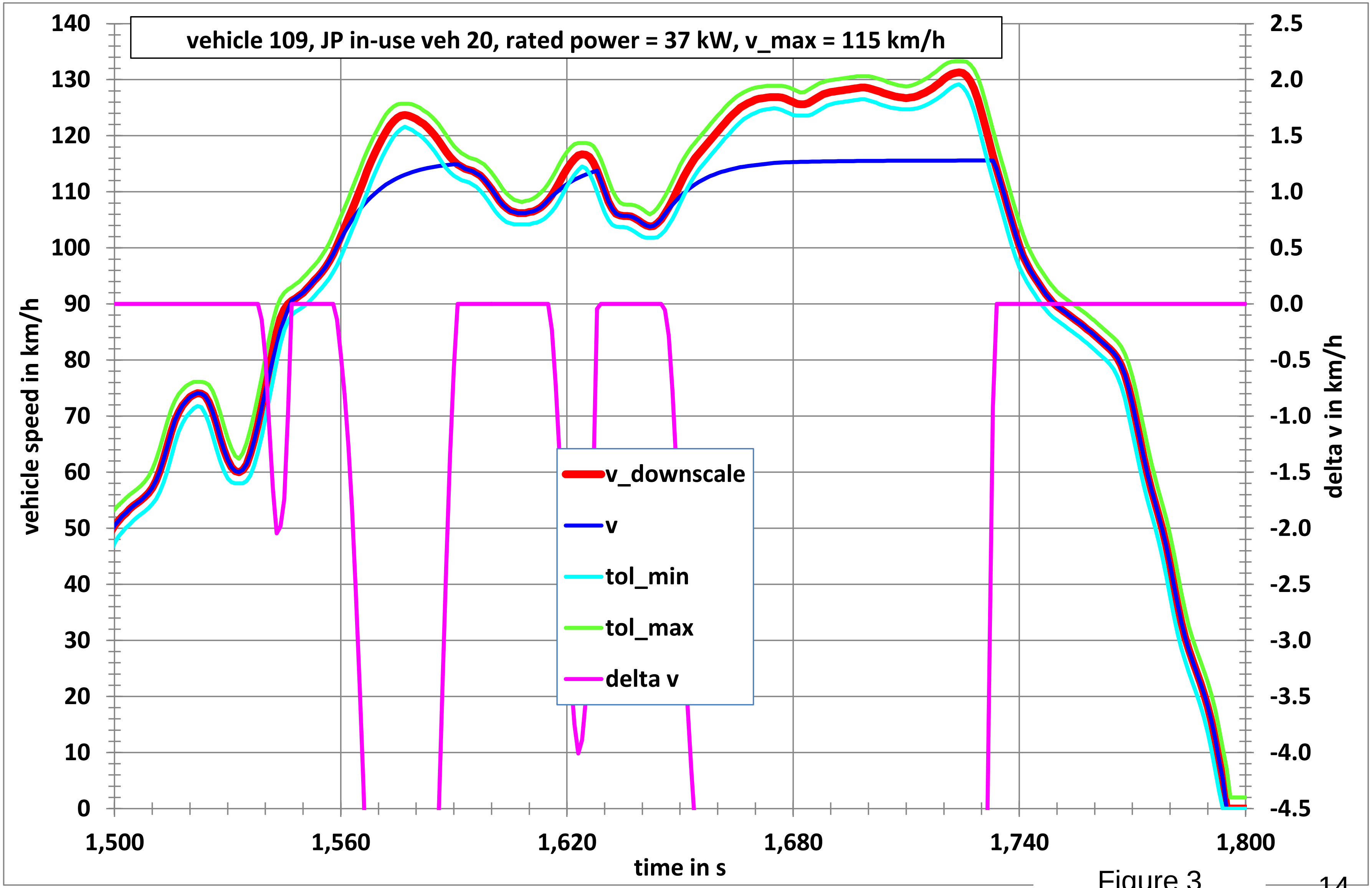

Figure 3

Driving resistance curve, high road load coefficients

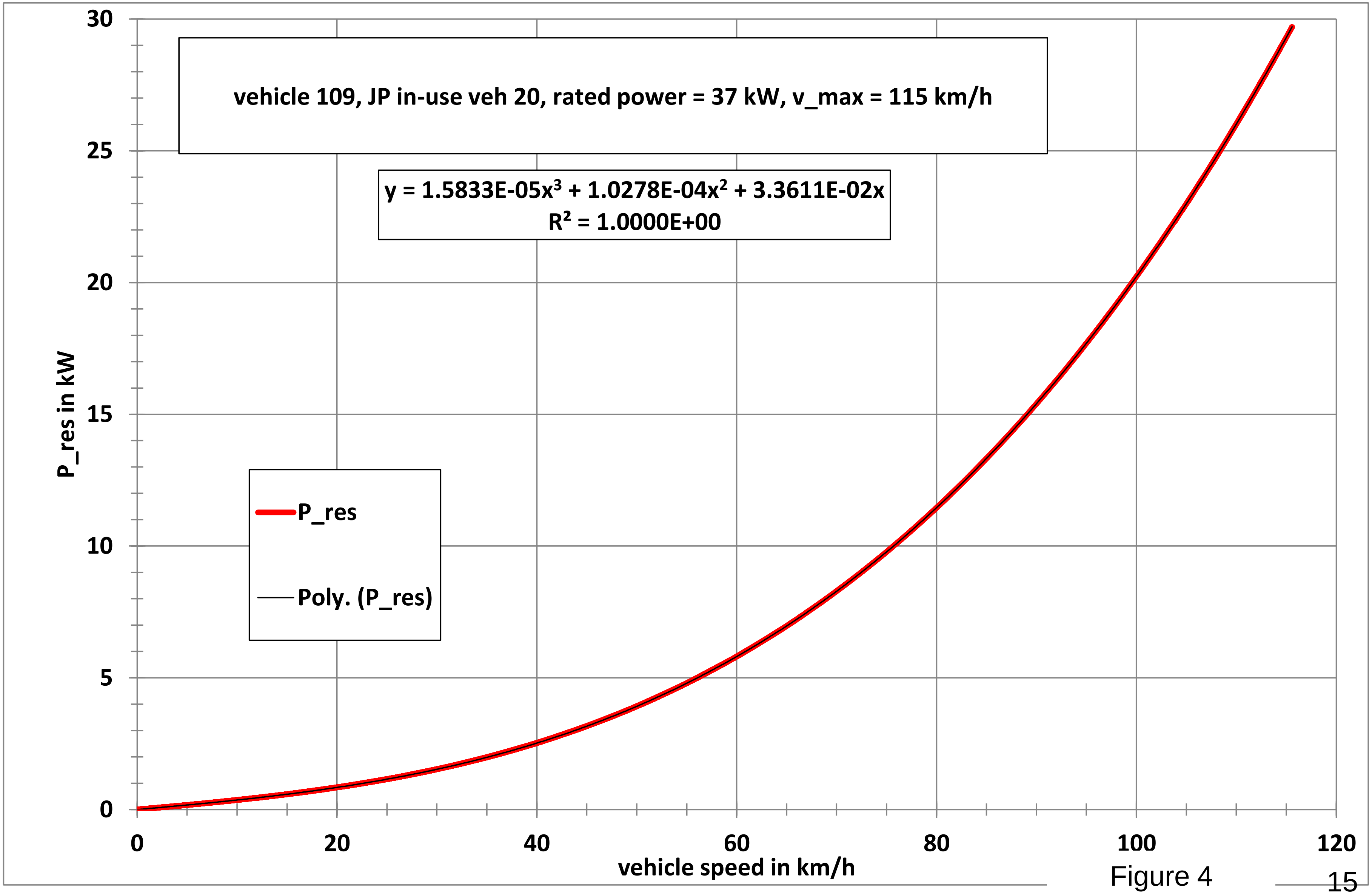

Figure 4

Engine map for high road load coefficients

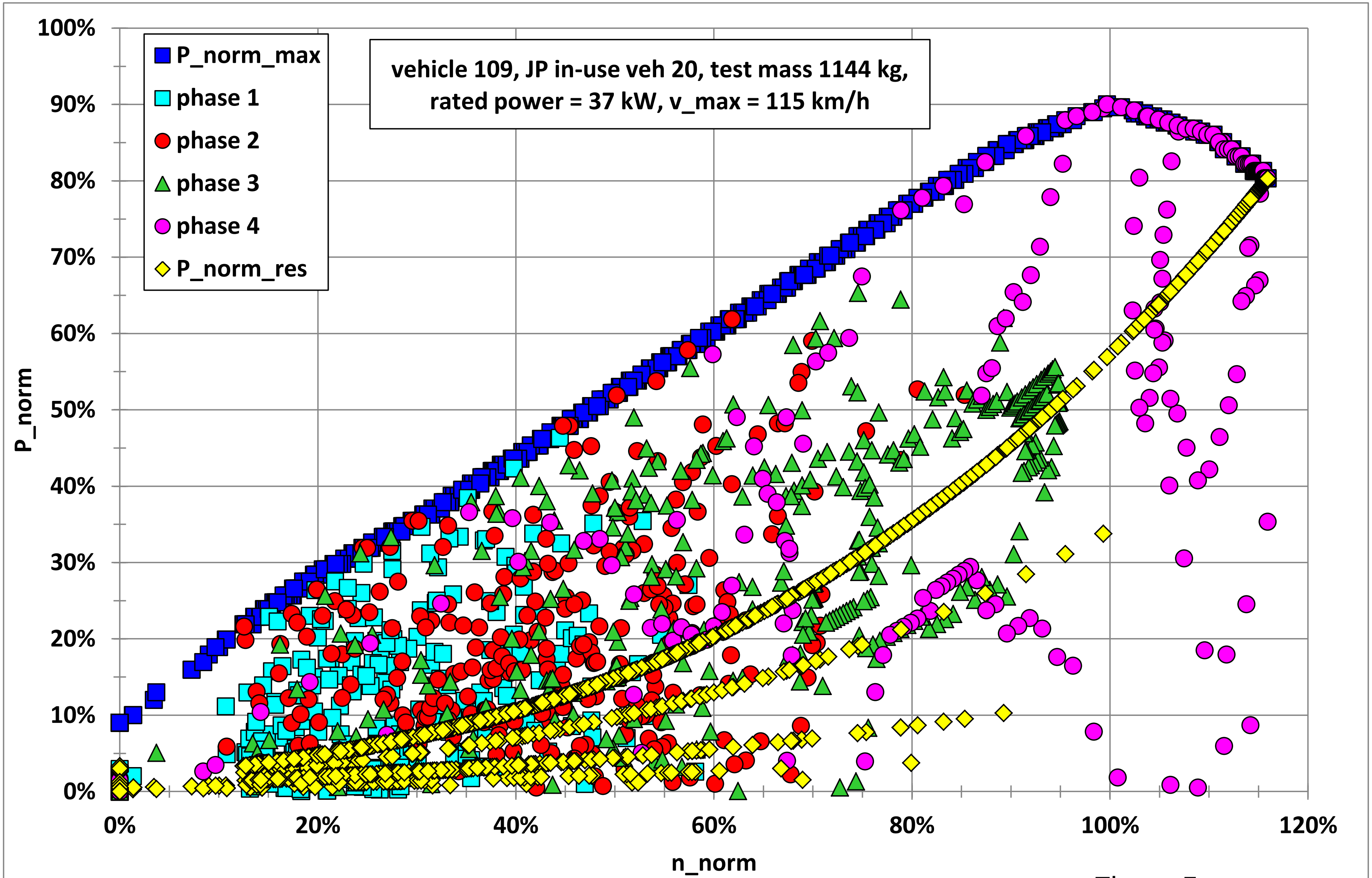

Figure 5a

Engine map coverage, normal vehicle

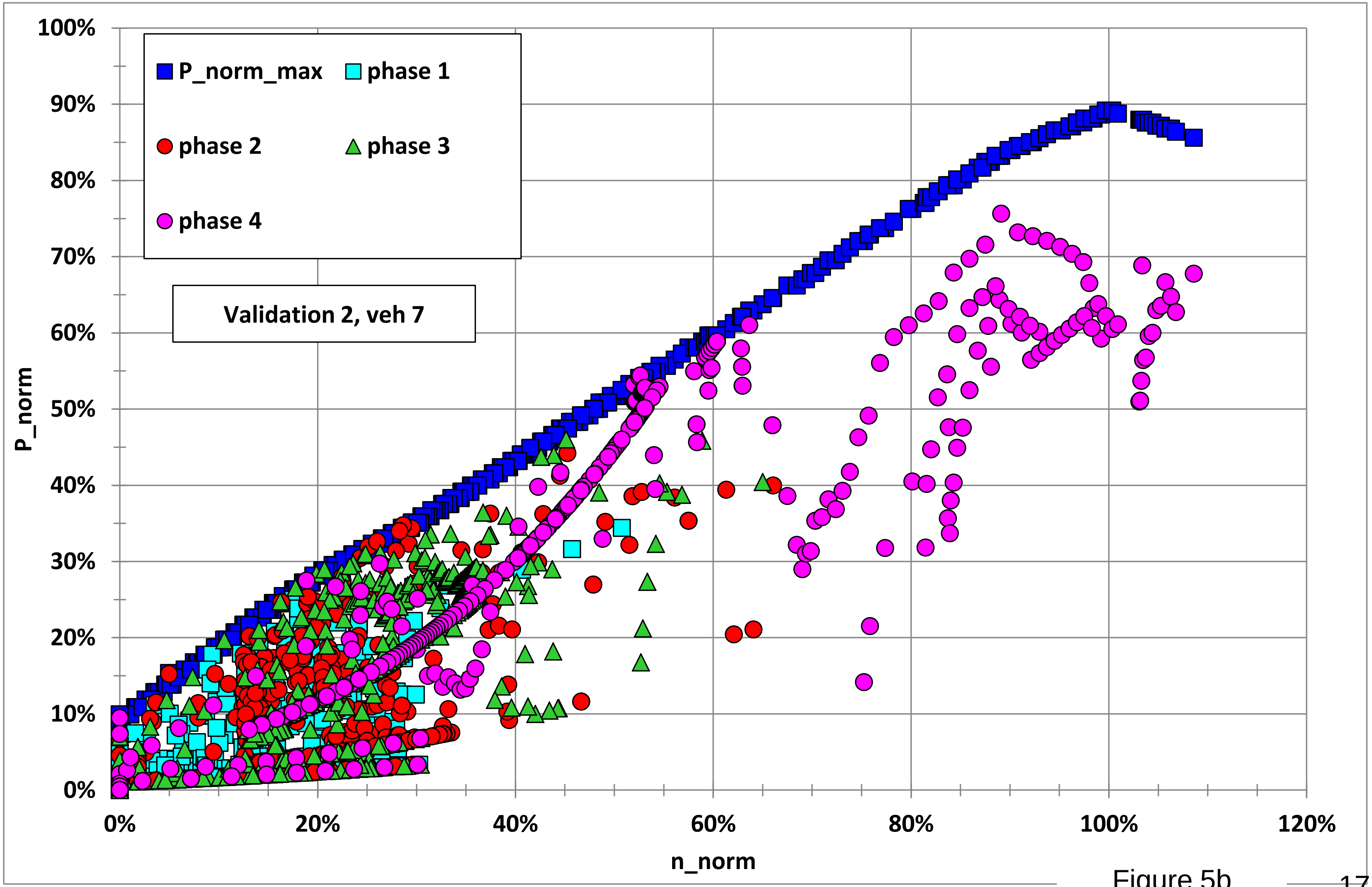

Figure 5b

Example results

- It is obvious that this configuration has driveability problems and a high percentage of wot operation at high normalised engine speeds (above rated engine speed). The maximum speed that can be reached is 115 km/h.
- Figure 5b shows the engine map of a „normal“ passenger car with rated power of 55 kW. It belongs to vehicle 7 from the validation 2 database.
- Figures 6 and 7 show the cycle trace and the engine map for a test mass of 1344 kg instead of 1144 kg. The test mass worsenes the driveability and increases the wot percentage but does not influence the maximum speed.
- For this vehicle in-use data is available.

Speed trace of the extra high speed phase for high road load coefficients

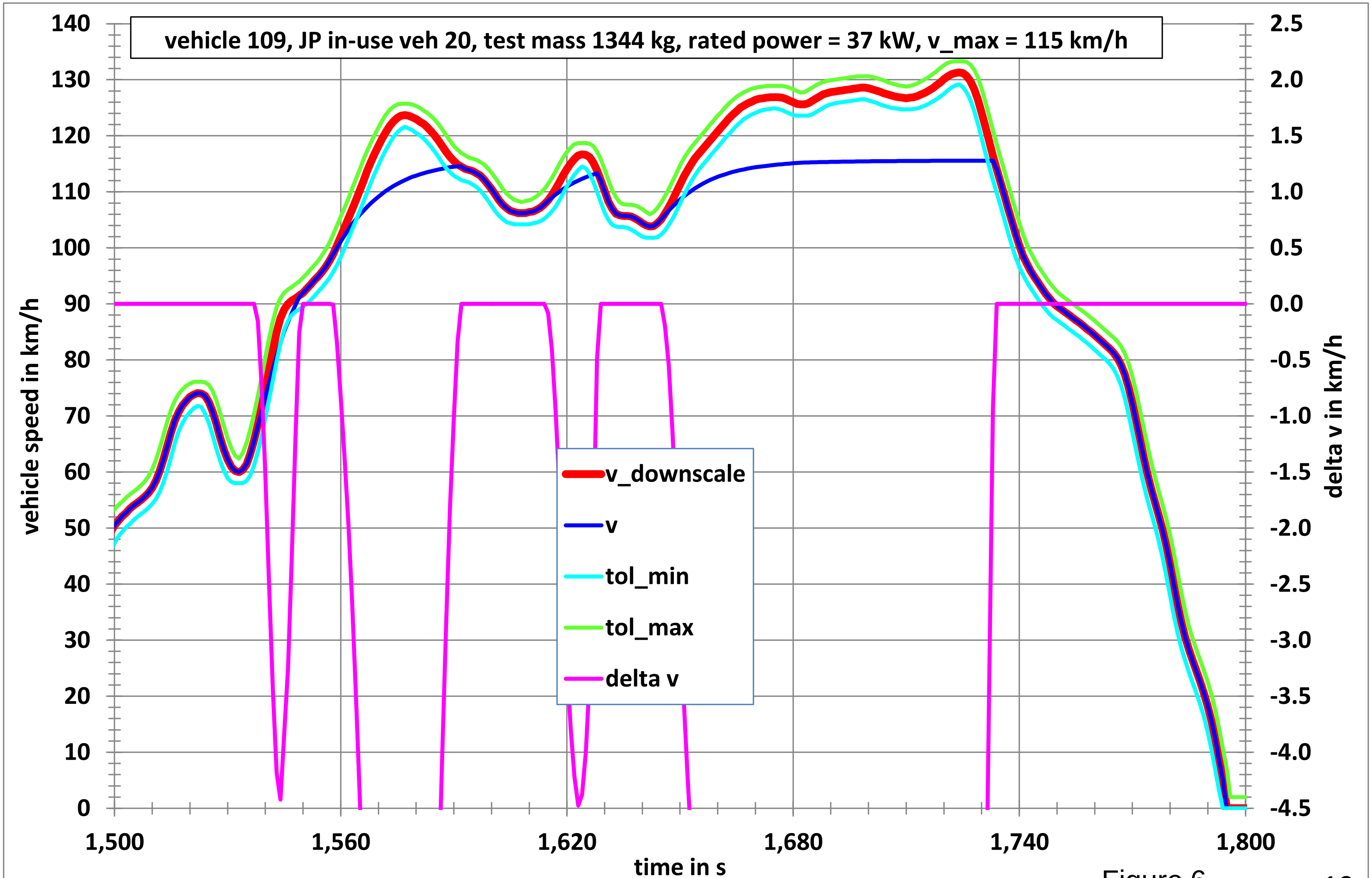

Figure 6

Engine map for high RL coefficients and 1344 kg instead of 1144 kg

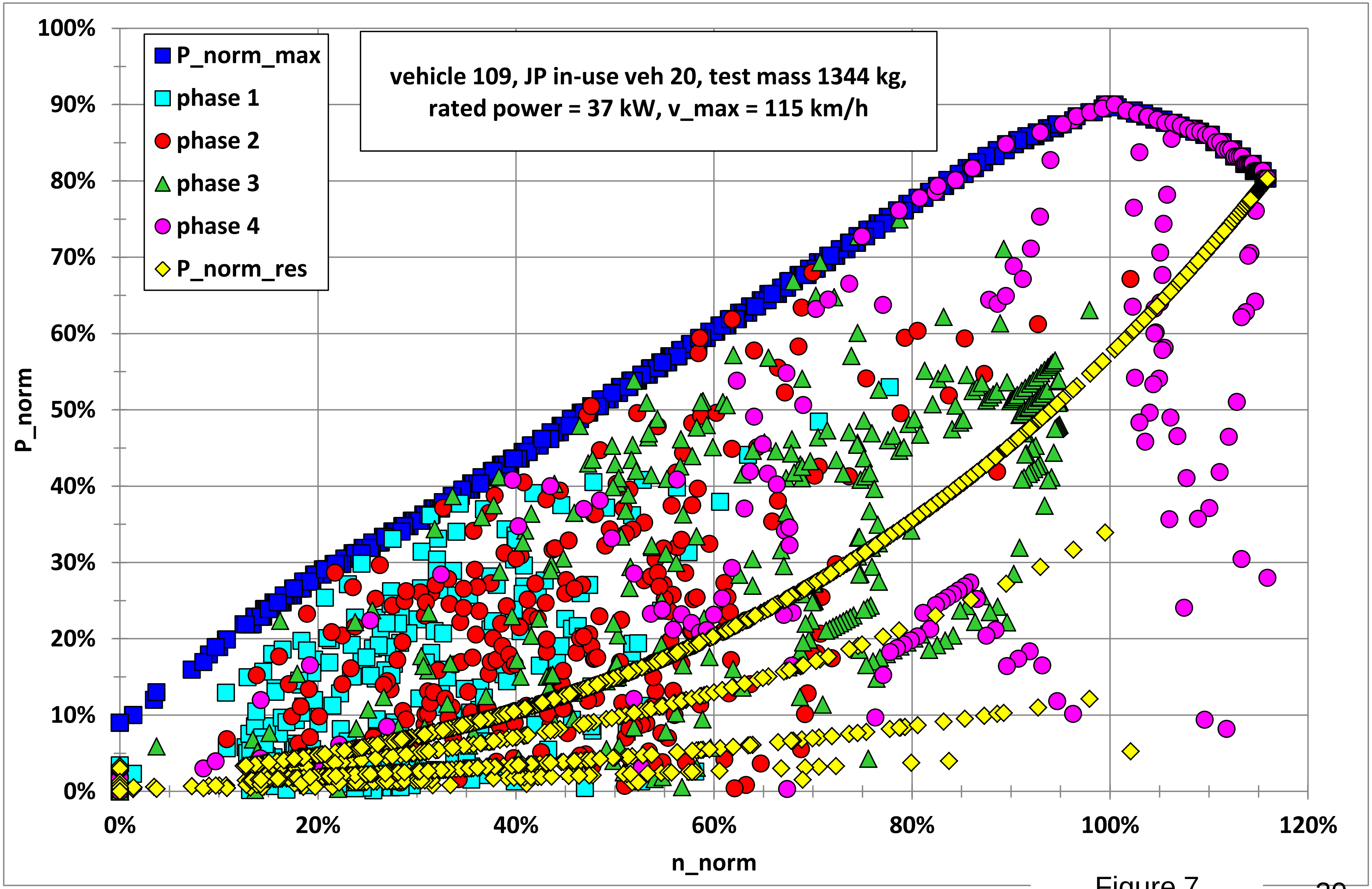

Figure 7

Example results

- Figure 8 shows the normalised engine speeds versus vehicle speed for vehicle speeds above 5 km/h. The maximum vehicle speed is in good agreement with the maximum speed of the vehicle configuration used for the calculations.
- A speed cap of 7% would solve the driveability problems completely (see figure 9), because it brings the wot operation at the maximum cycle speed to partial throttle operation (see figure 10).
- The same effect is reached by a downscaling by 25% (see figures 11 and 12), but with the advantage of a higher maximum cycle speed and a much lower drop of the cycle dynamics.
-

n_norm vs vehicle speed (in-use data)

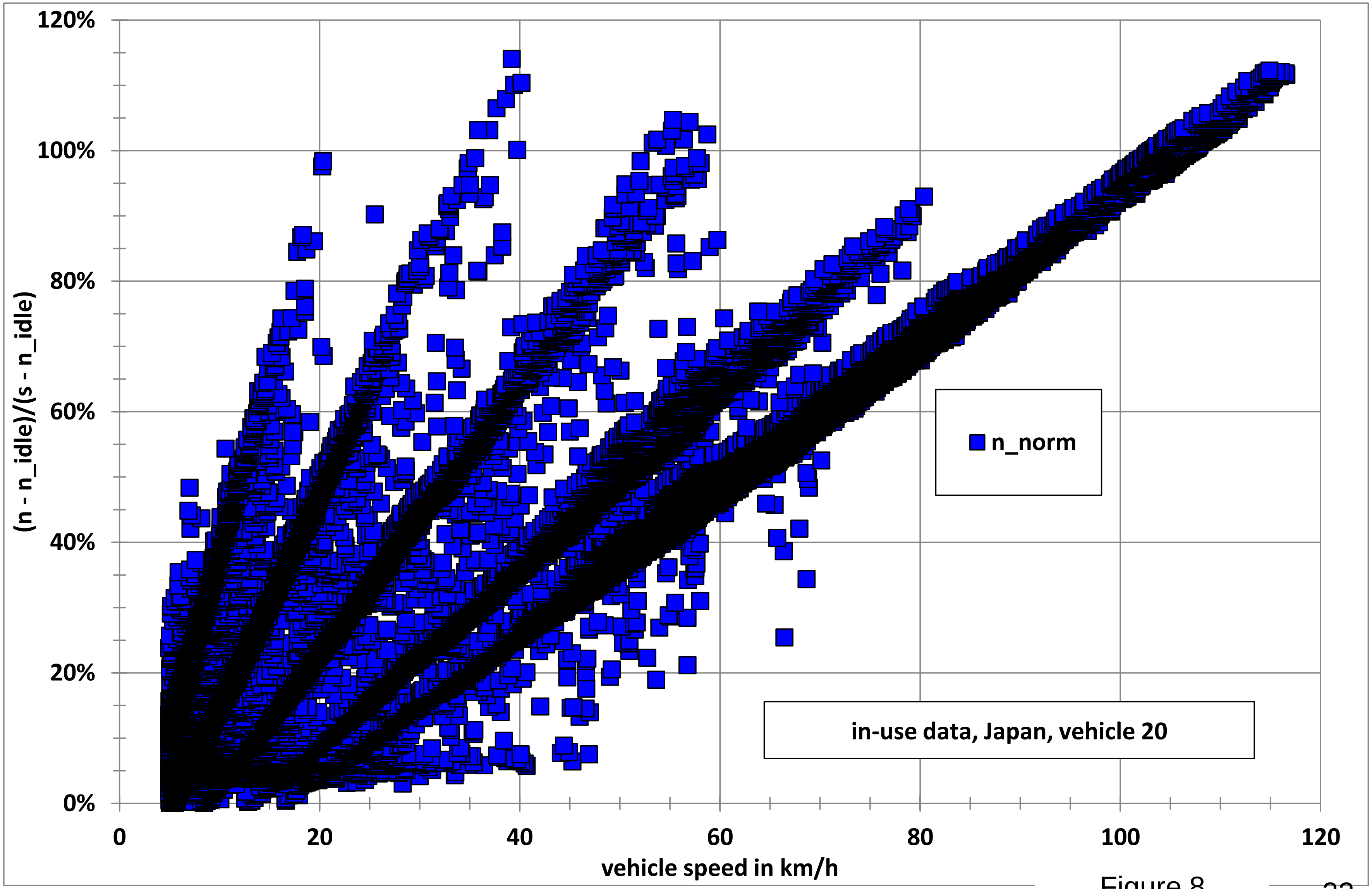

Figure 8

Speed trace of the extra high speed phase for high road load coefficients

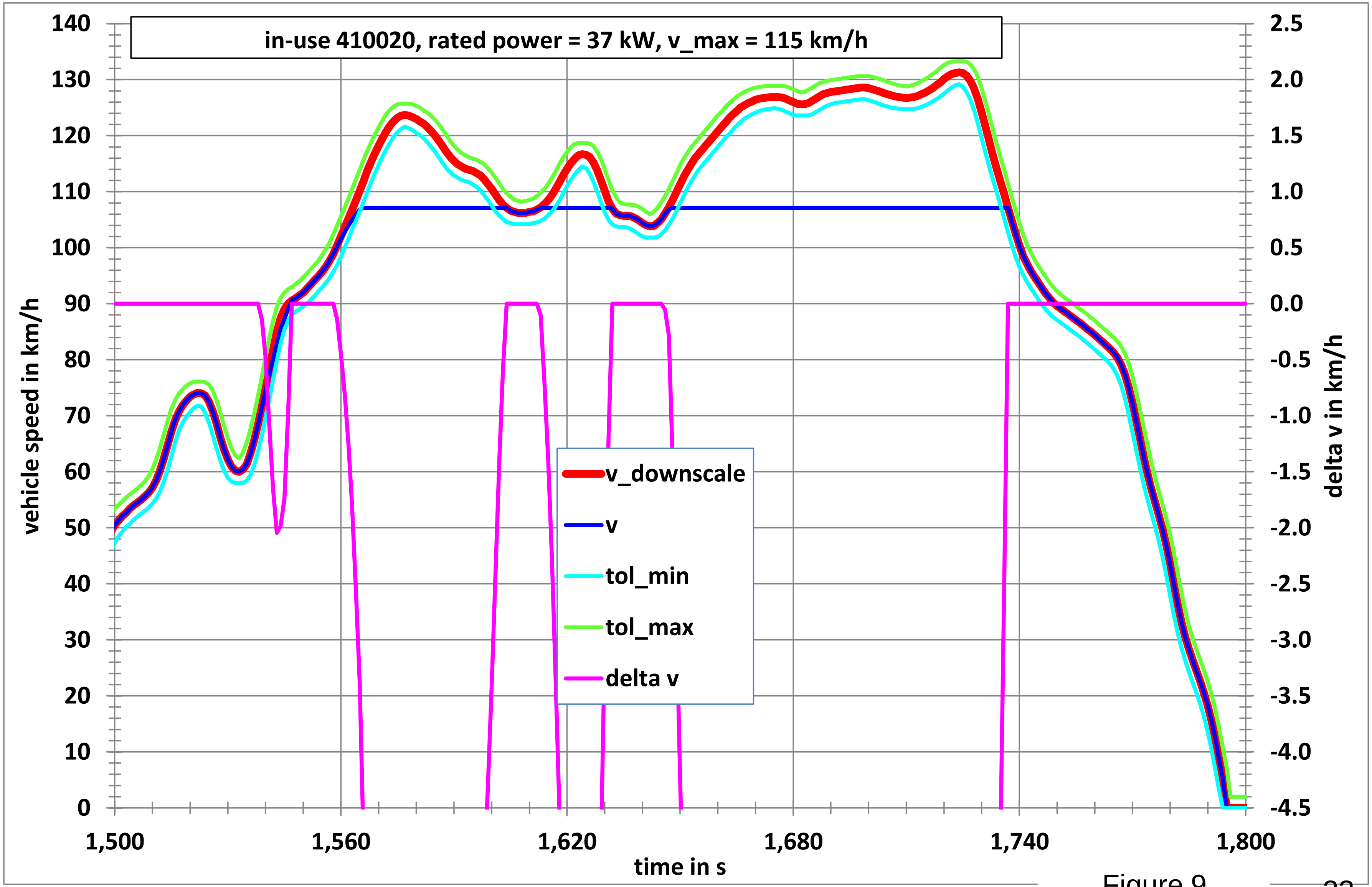

Figure 9

Engine map for high road load coefficients

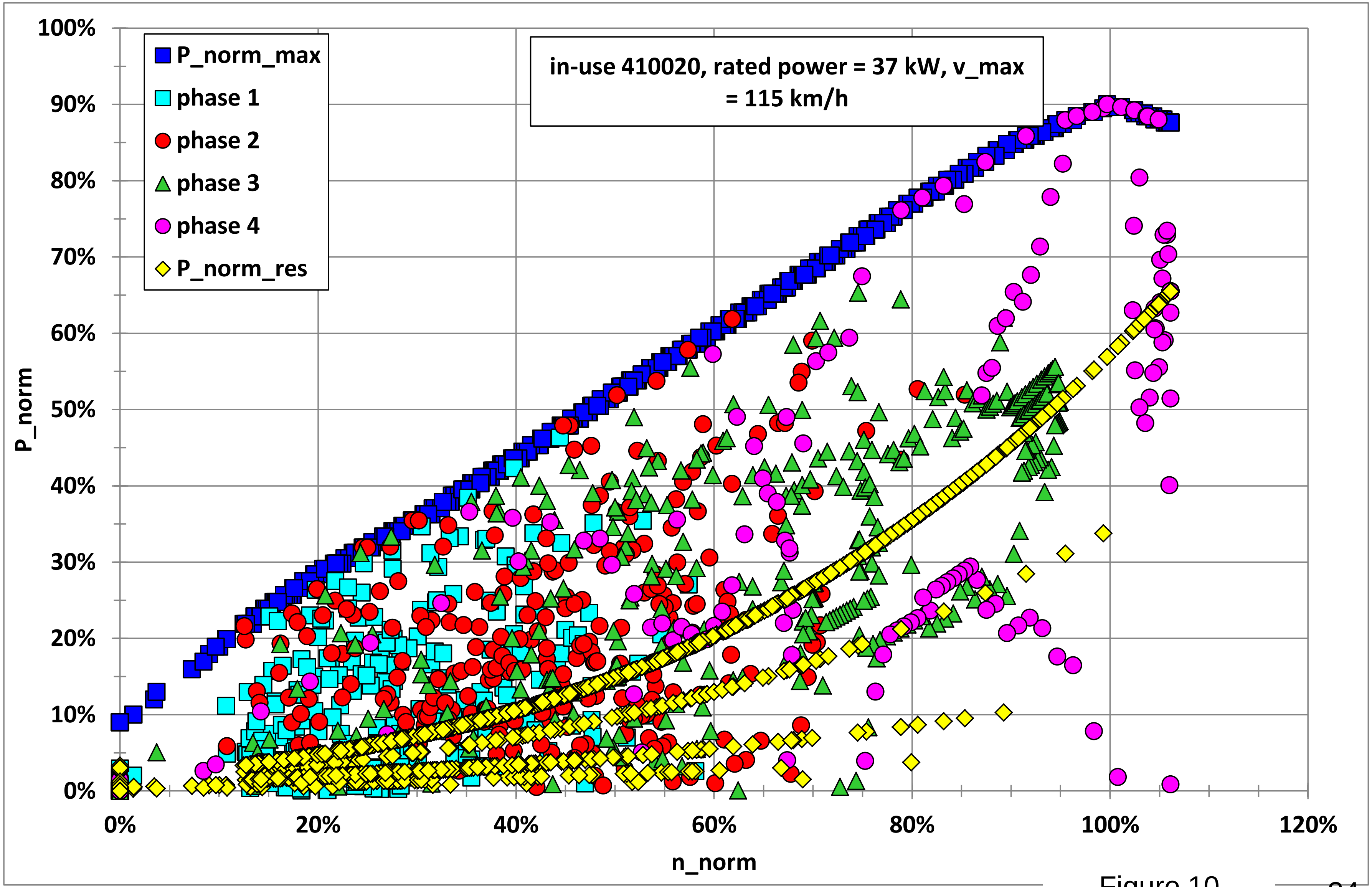

Figure 10

Speed trace of the extra high speed phase for high road load coefficients

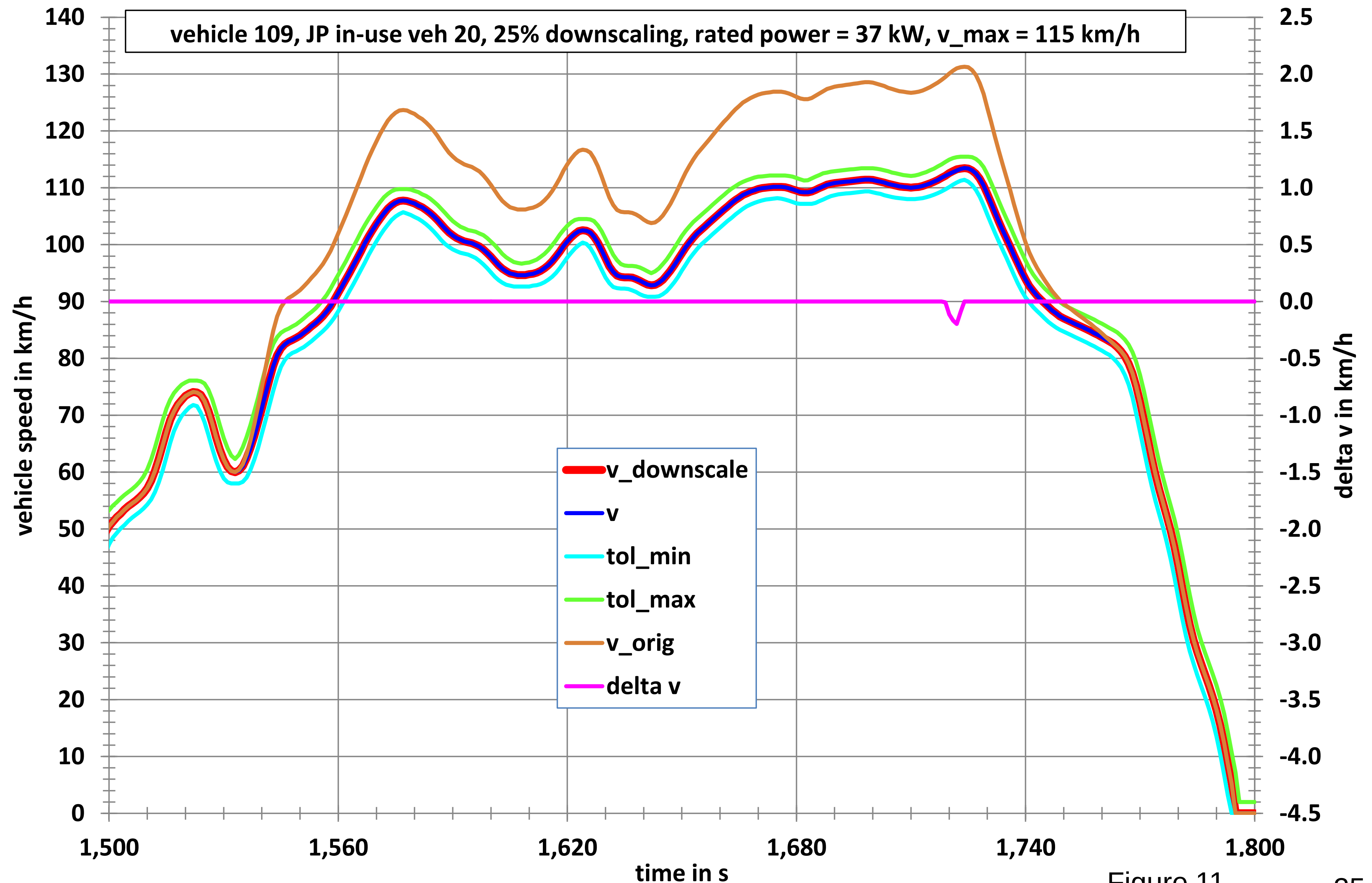

Figure 11

Engine map for high road load coefficients

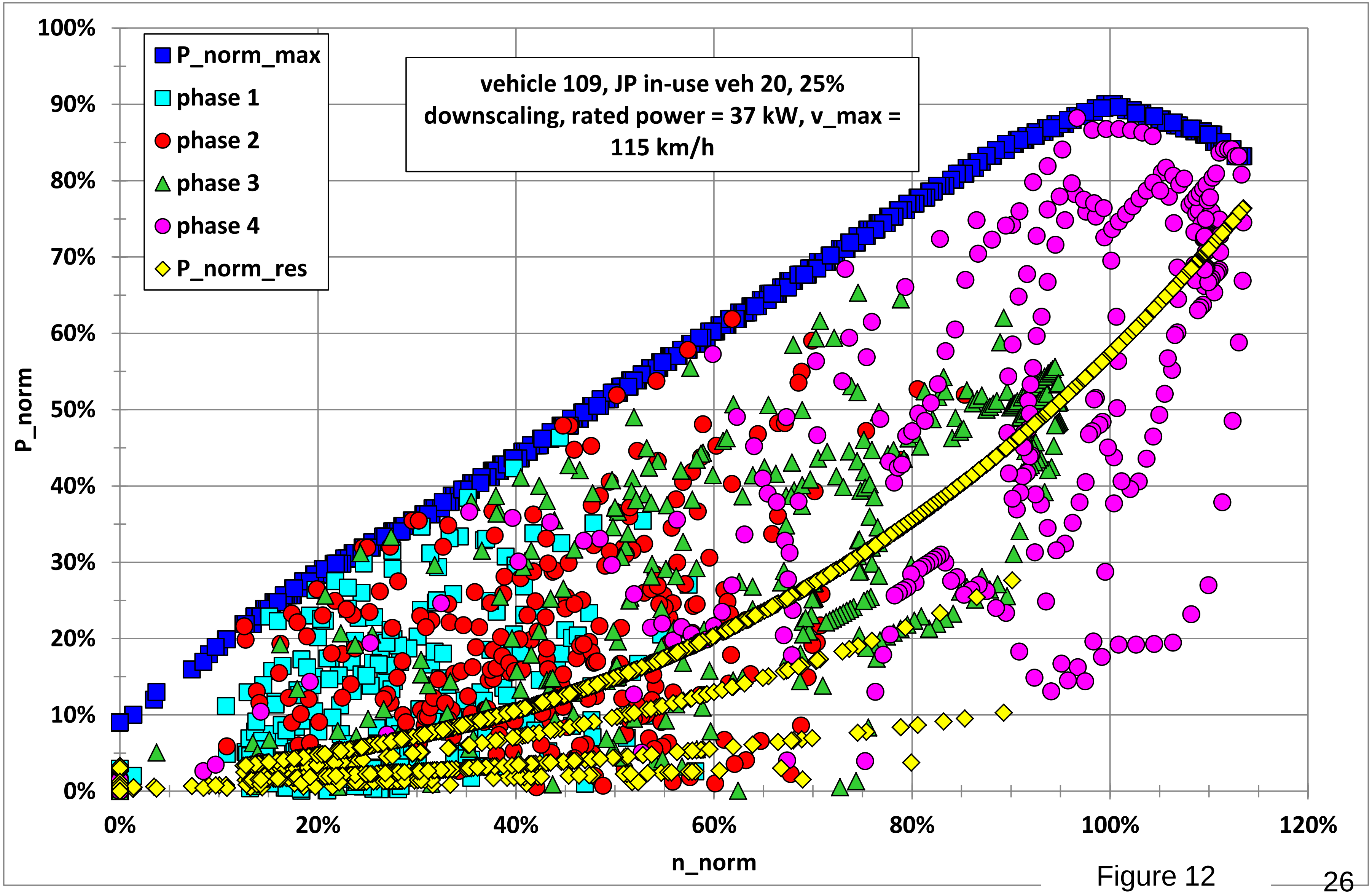

Figure 12

Example results

- The driveability problems are also reduced by lower road load coefficients (see figures 13, 14 and 15), although the maximum speed of the vehicle is increased from 115 km/h to 119 km/h.
- The remaining driveability problems can either be solved by a speed cap or by downscaling.
- A comparison of figures 16 and 17 shows, that the downscaling leads to lower reductions in the maximum cycle speed as well as in the cycle dynamics.
- And in this case the downscaling percentage is only 18% compared to 25% for the higher road load (see figures 11 and 17).

Driving resistance curve, high road load coefficients

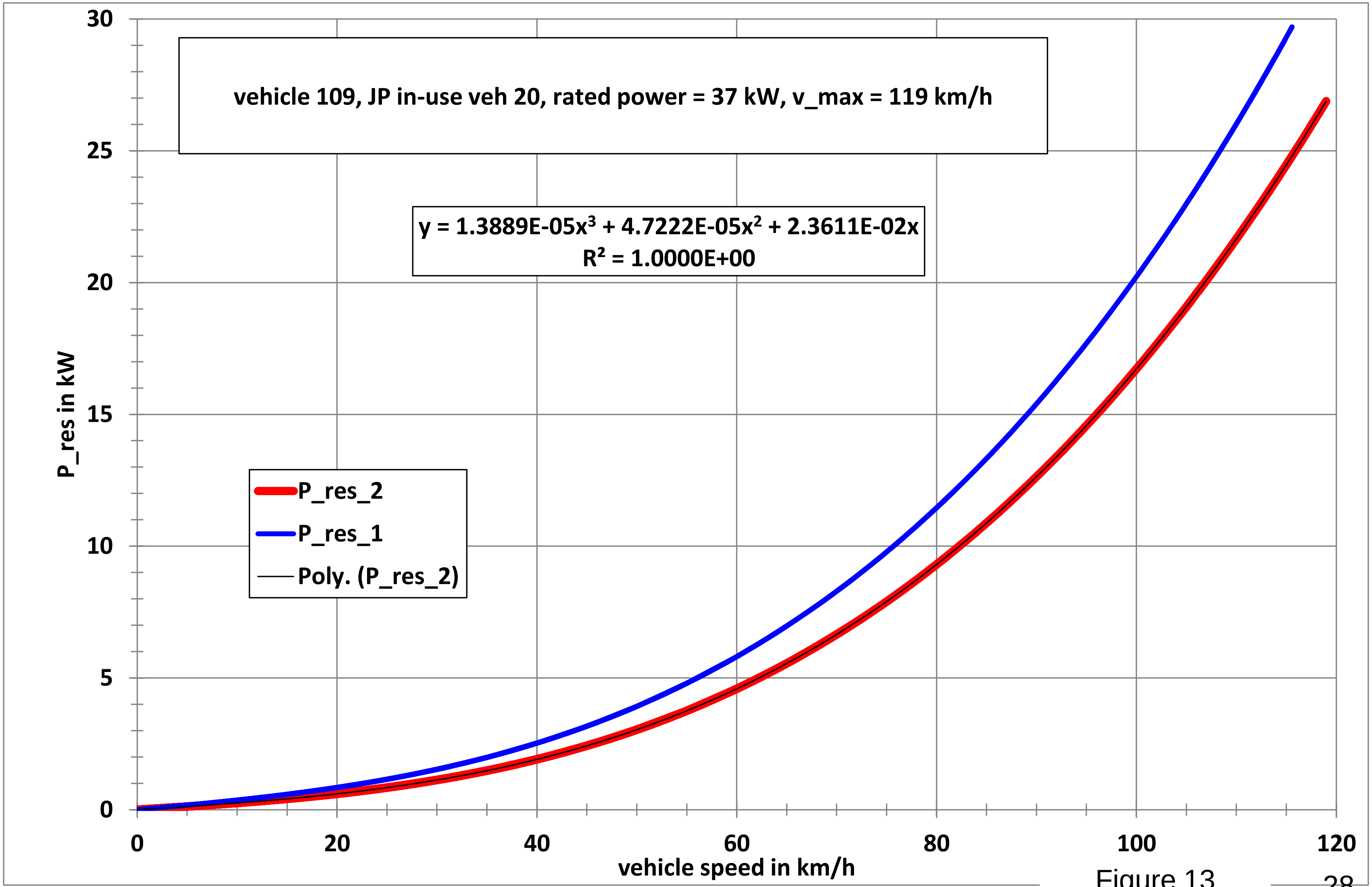

Figure 13

Speed trace of the extra high speed phase for high road load coefficients

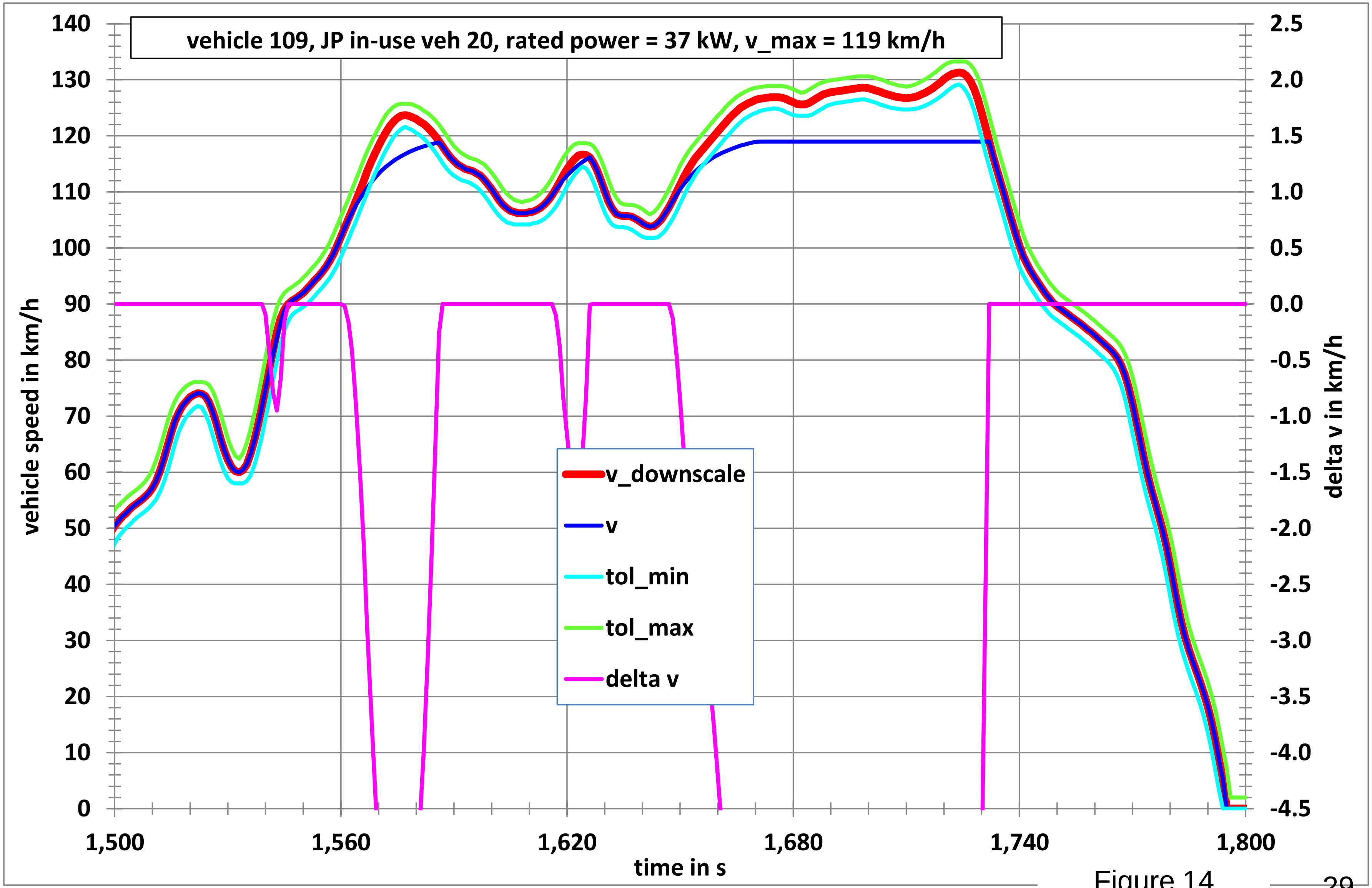

Figure 14

Engine map for high road load coefficients

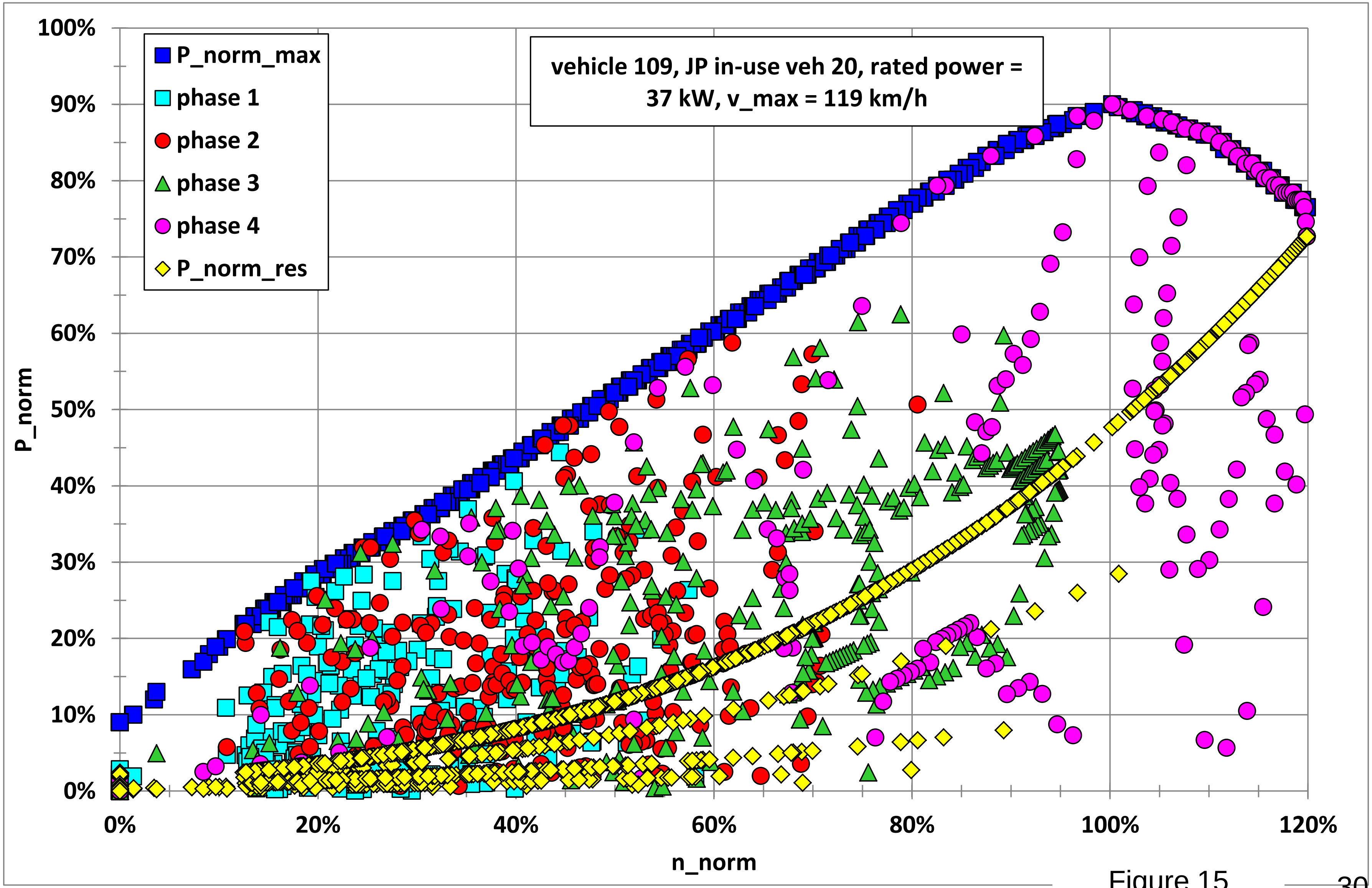

Figure 15

Speed trace of the extra high speed phase for high road load coefficients

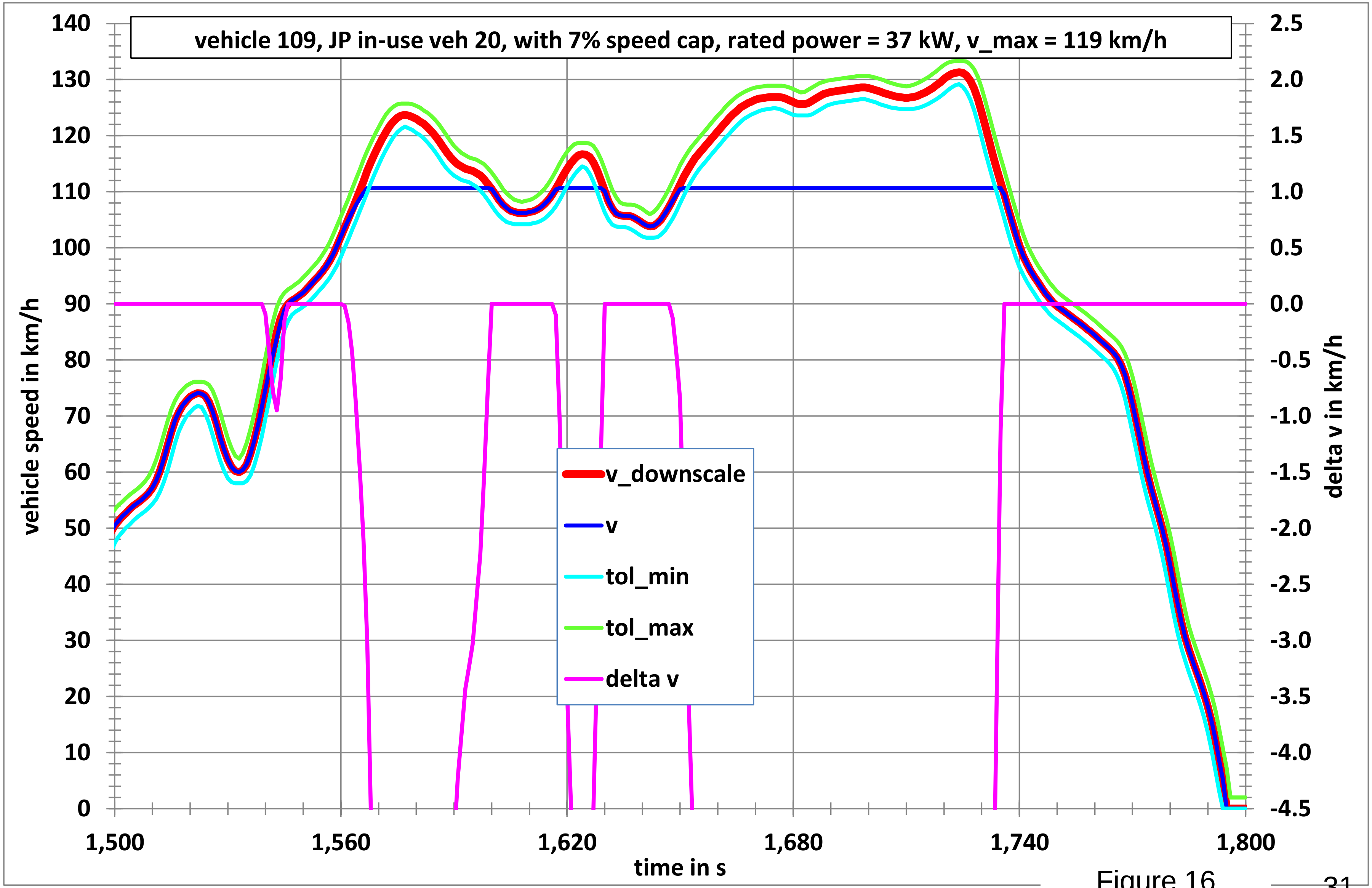

Figure 16

Speed trace of the extra high speed phase for high road load coefficients

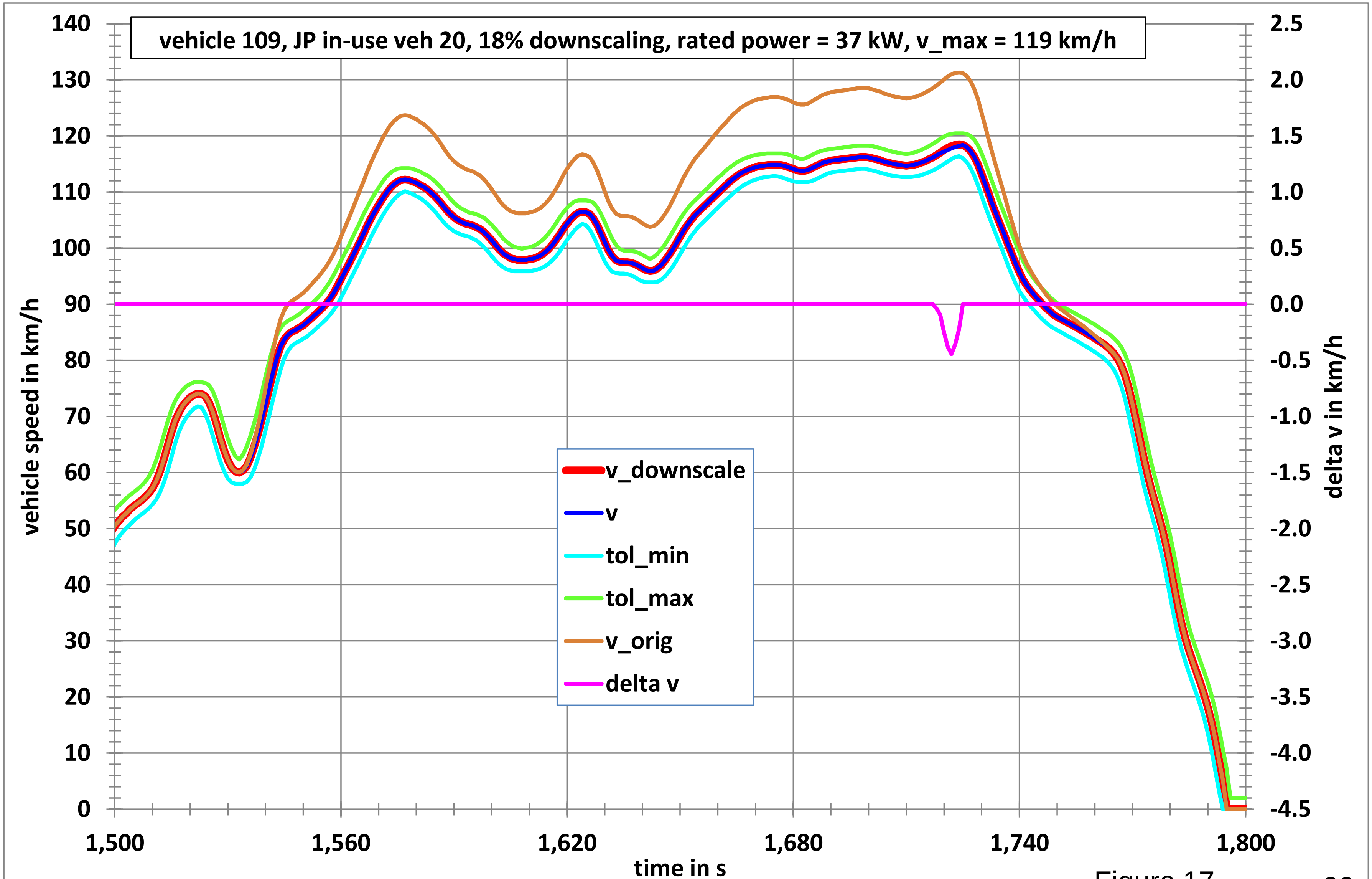

Figure 17

Example results

- A further decrease of the road load can even lead to the situation that no driveability problems occur and thus no further measures are necessary in order to improve driveability and reduce the wot percentage (see figures 18 to 20).
- This is typically the case, when the speed limit is achieved by electronical measures and the vehicle with the given transmission design would be able to achieve a higher maximum speed.
- In such a case the maximum speed is reached under partial throttle operation (see figure 20).
- Similar results were obtained for road load variations of vehicle 107 (lower maximum speed than vehicle 109) and vehicle 225 (higher maximum speed than vehicle 109).

Driving resistance curve, high road load coefficients

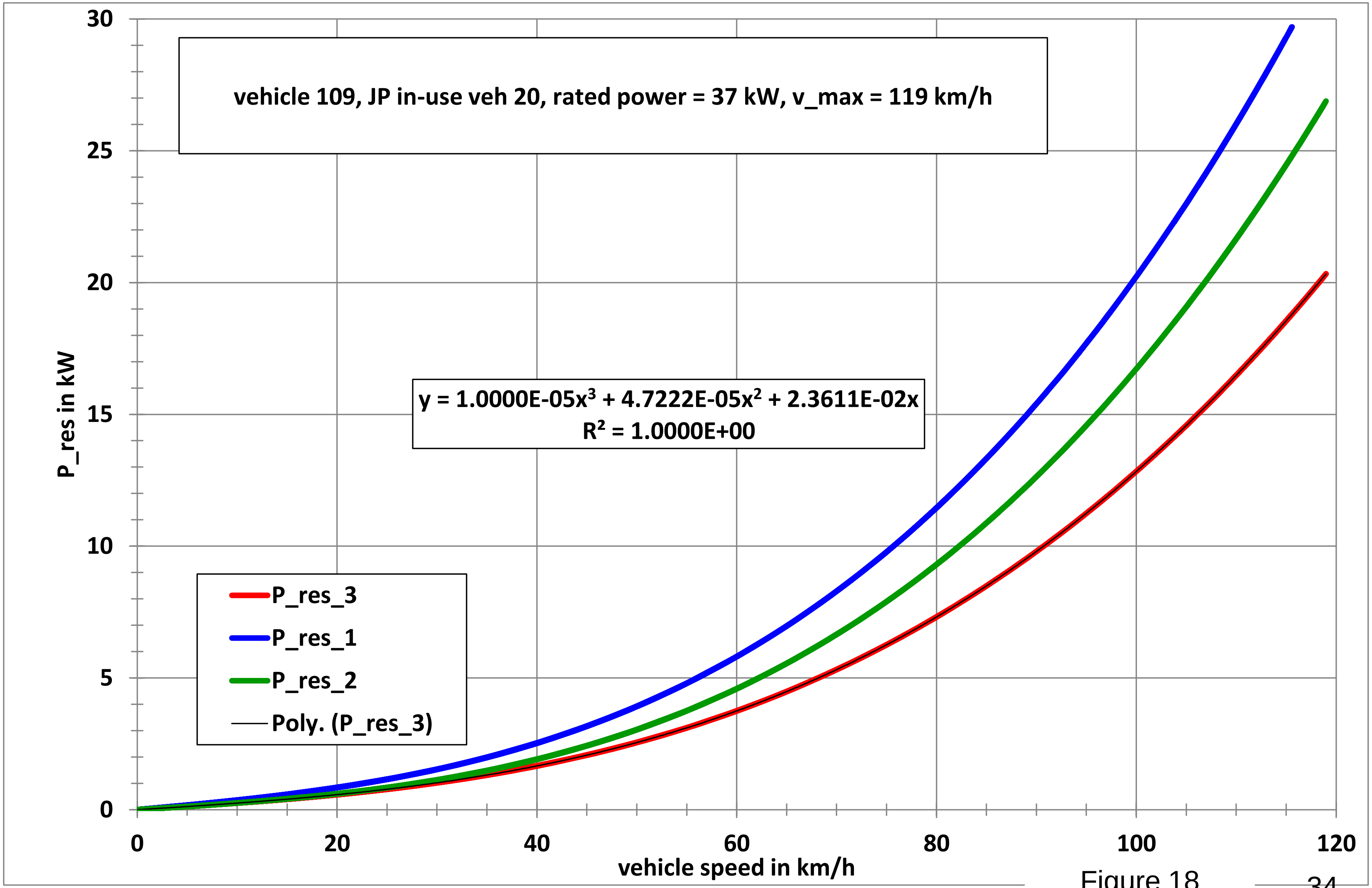

Figure 18

Speed trace of the extra high speed phase for high road load coefficients

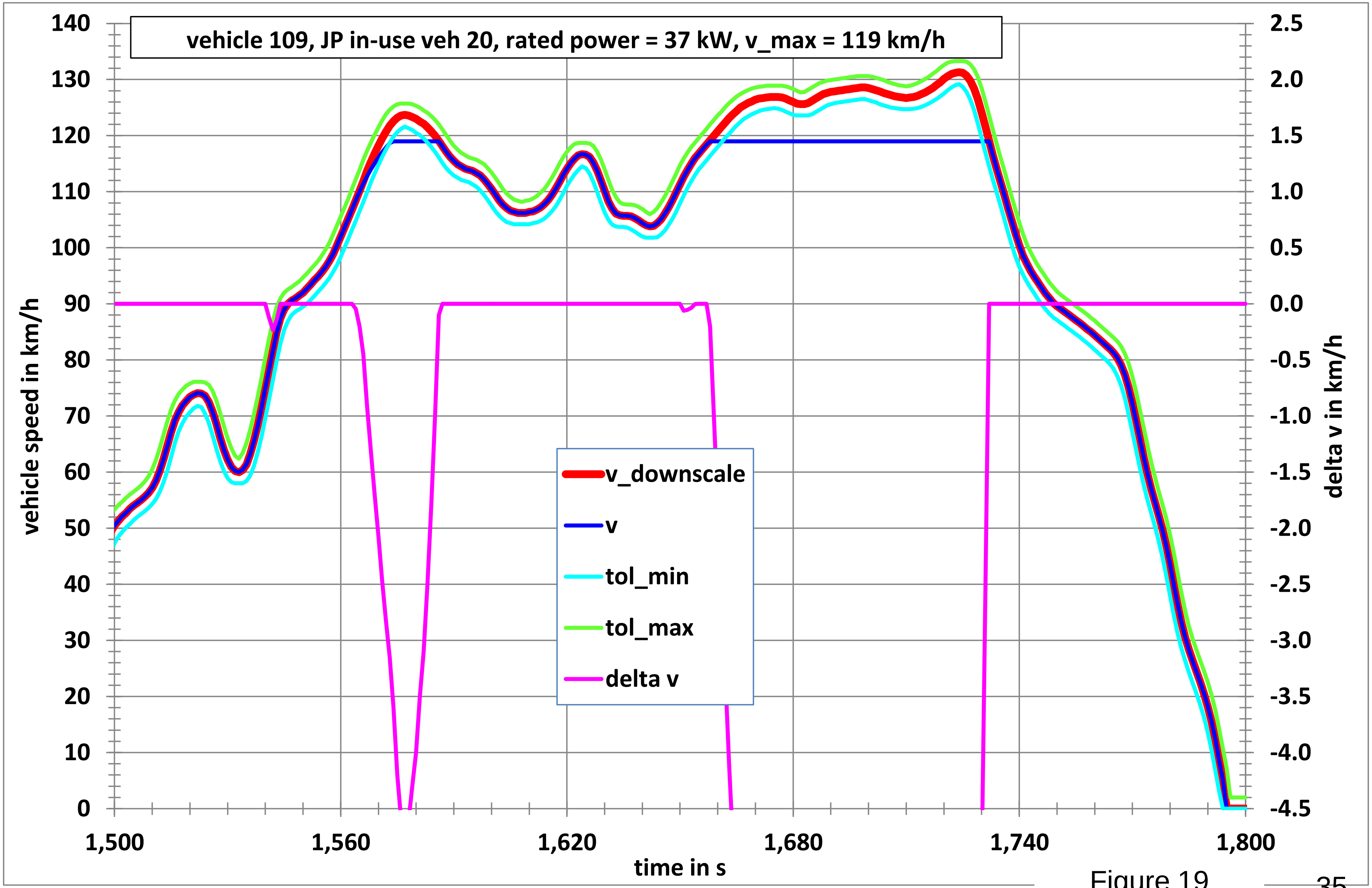

Figure 19

Engine map for high road load coefficients

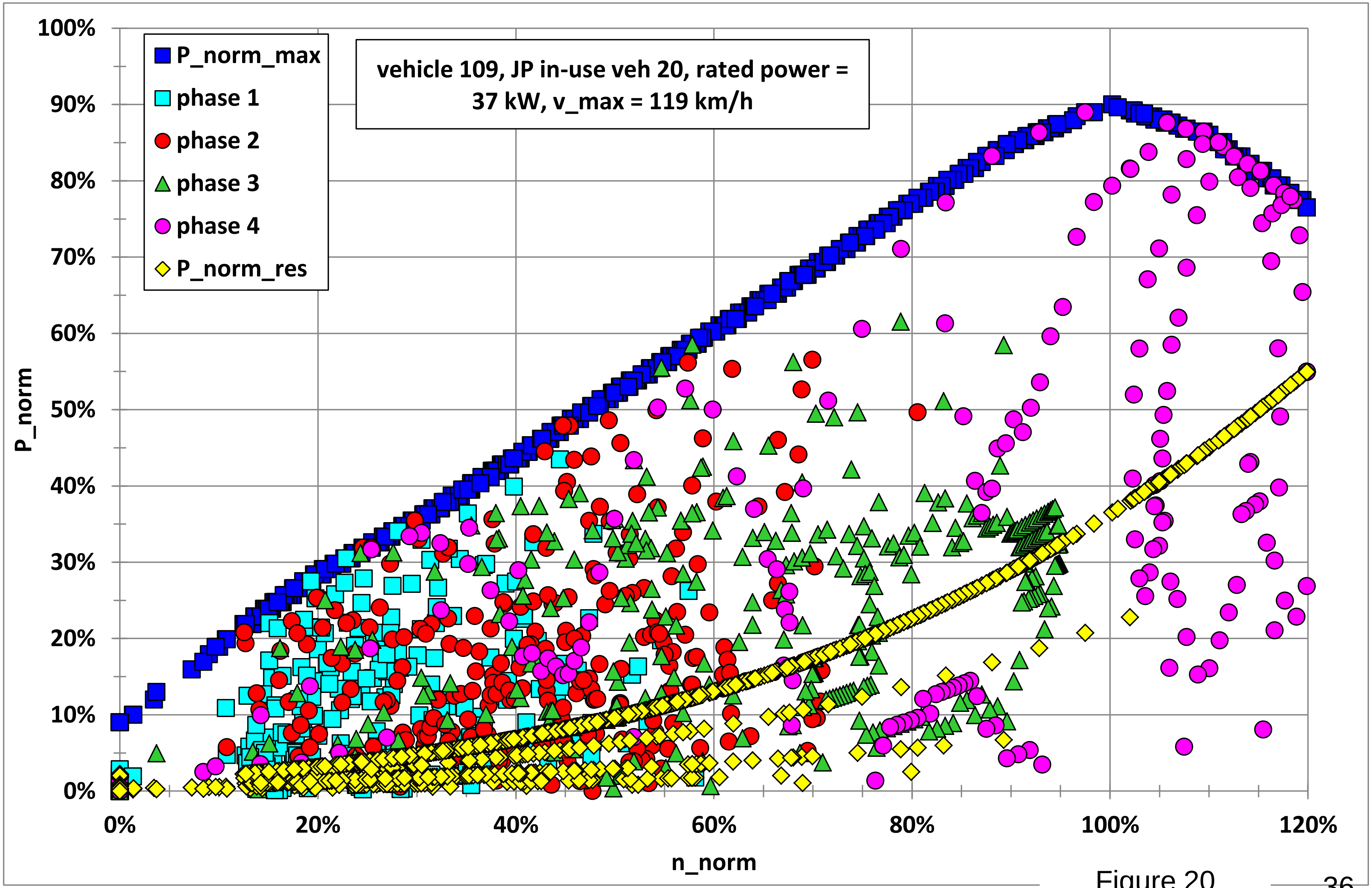

Figure 20

Example results

- Further examples of the cycle trace for the extra high speed phase for vehicles with driveability problems are shown in figures 21 to 33.
- Vehicle 412 (figures 24 to 26) is vehicle 37 from the validation 2 exercise. It must be noted that this vehicle had much higher driveability problems in validation 2 than forecasted by the gearshift calculation model.
- This might be related to differences in the road load and the full load power curve of the vehicle within the validation tests and the road load coefficients and average wot power curve used for these calculations.
- The figures demonstrate that a speed cap does not solve the driveability problems sufficiently and that downscaling would be a better solution.

Speed trace of the extra high speed phase

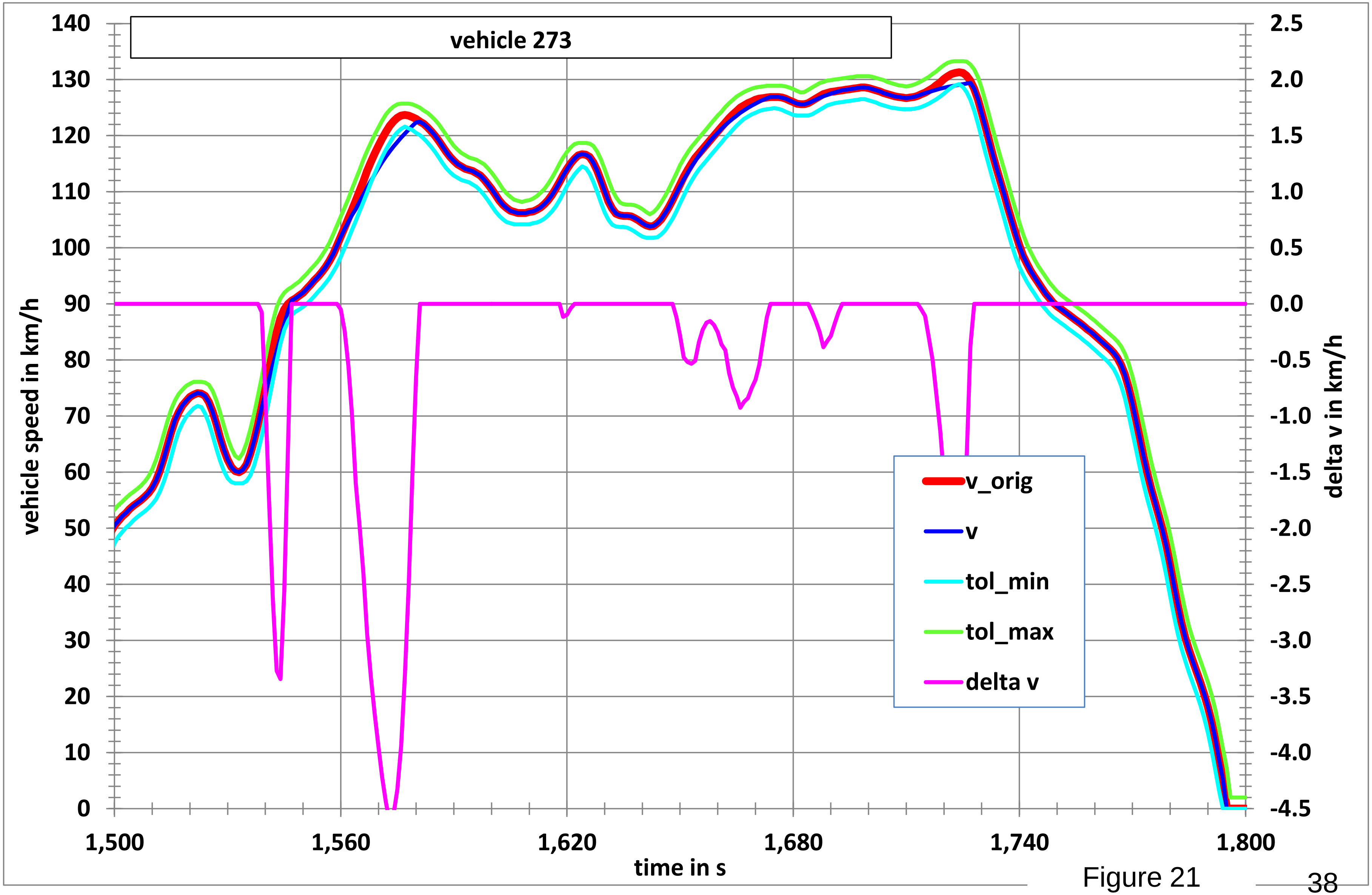

Figure 21

Speed trace of the extra high speed phase

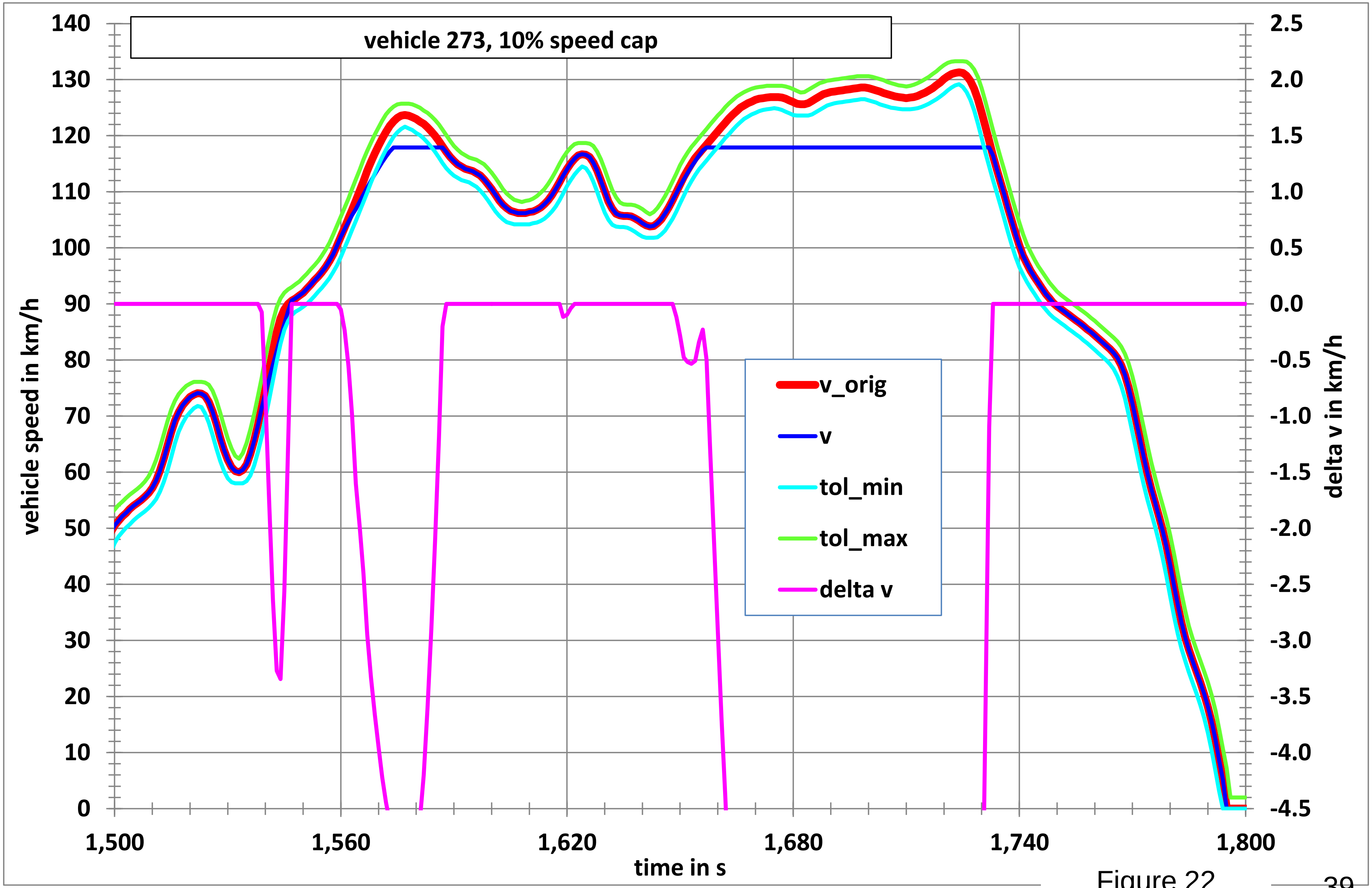

Figure 22

Speed trace of the extra high speed phase

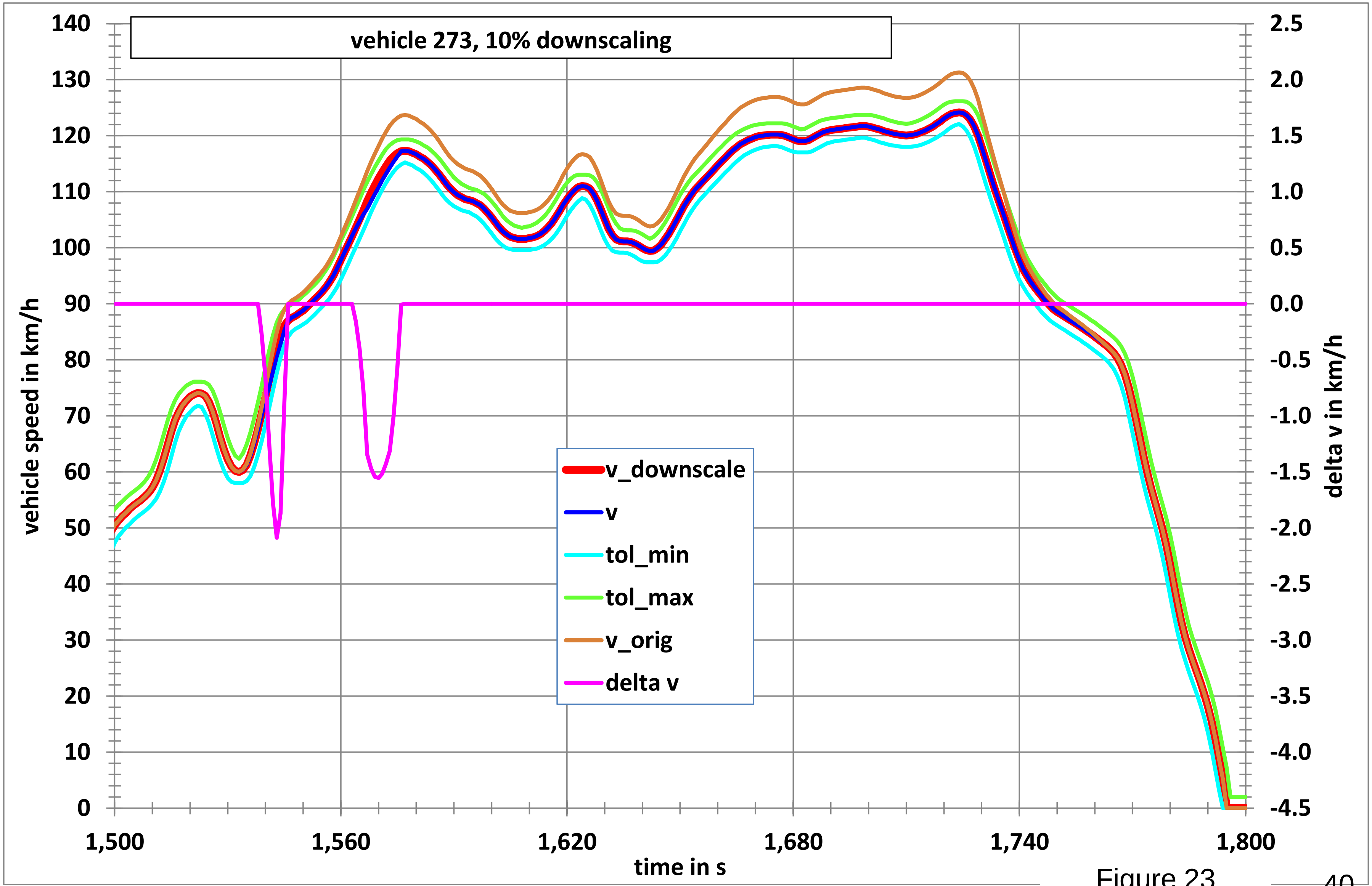

Figure 23

Speed trace of the extra high speed phase

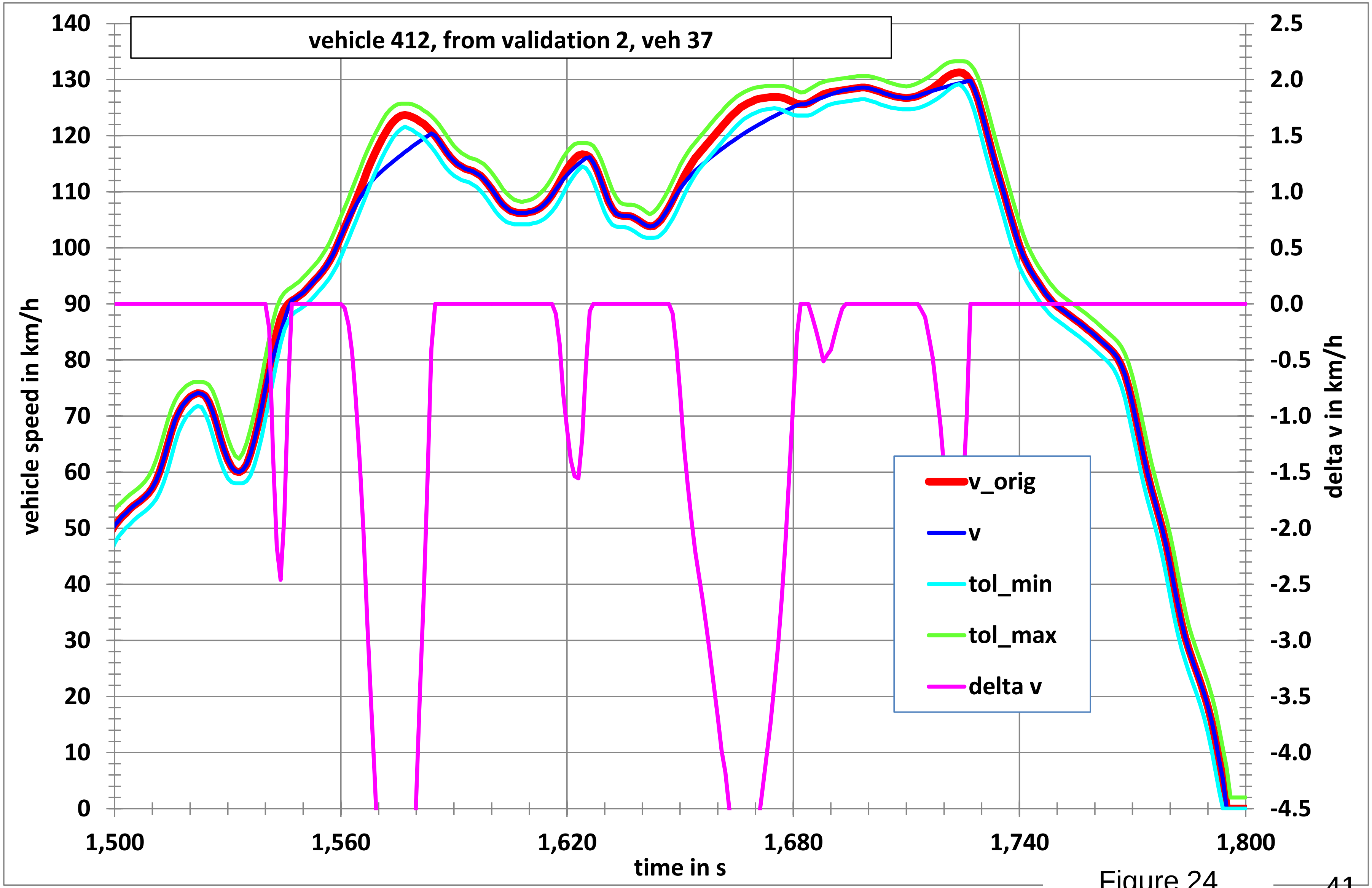

Figure 24

Speed trace of the extra high speed phase

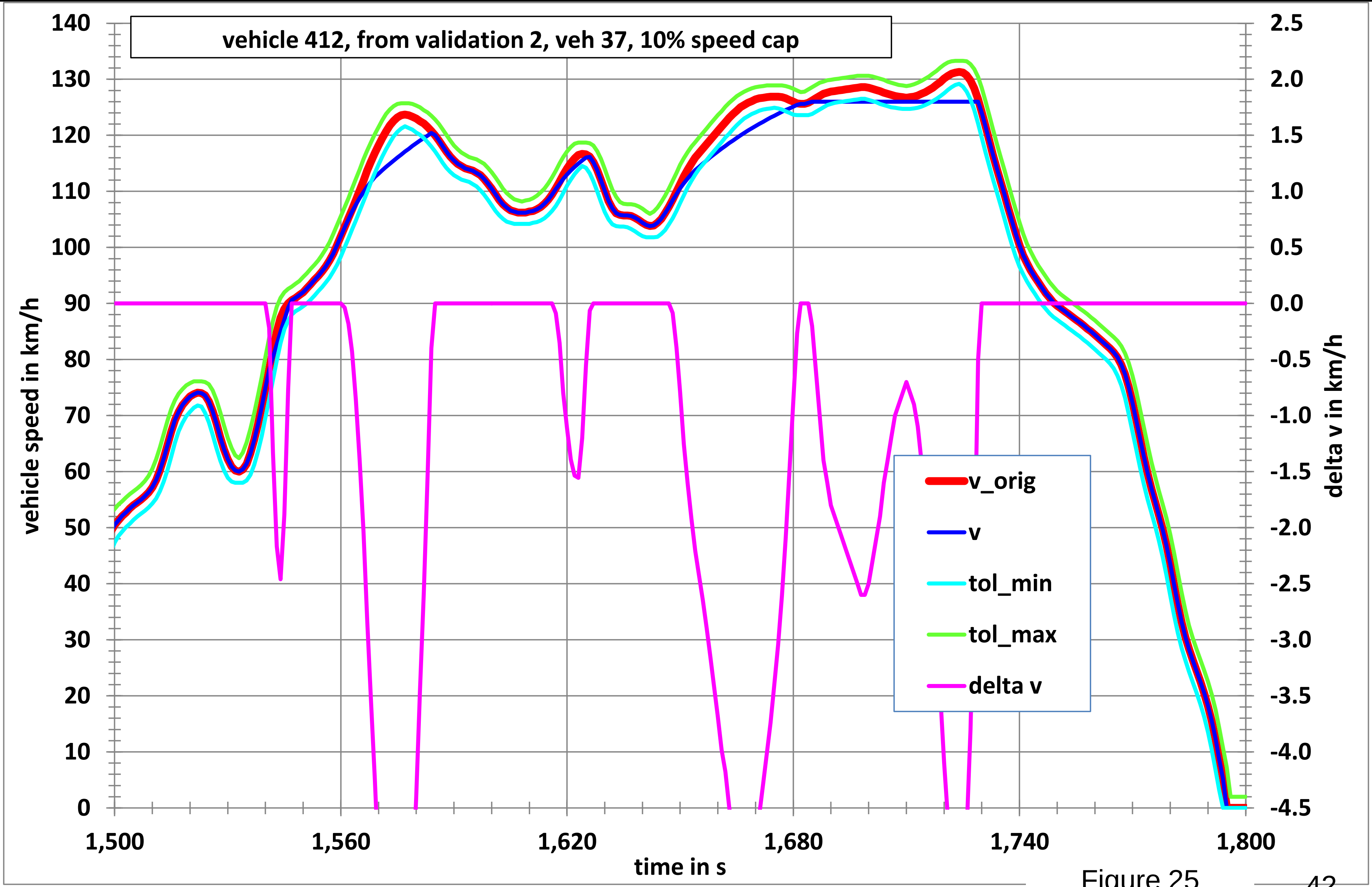

Figure 25

Speed trace of the extra high speed phase

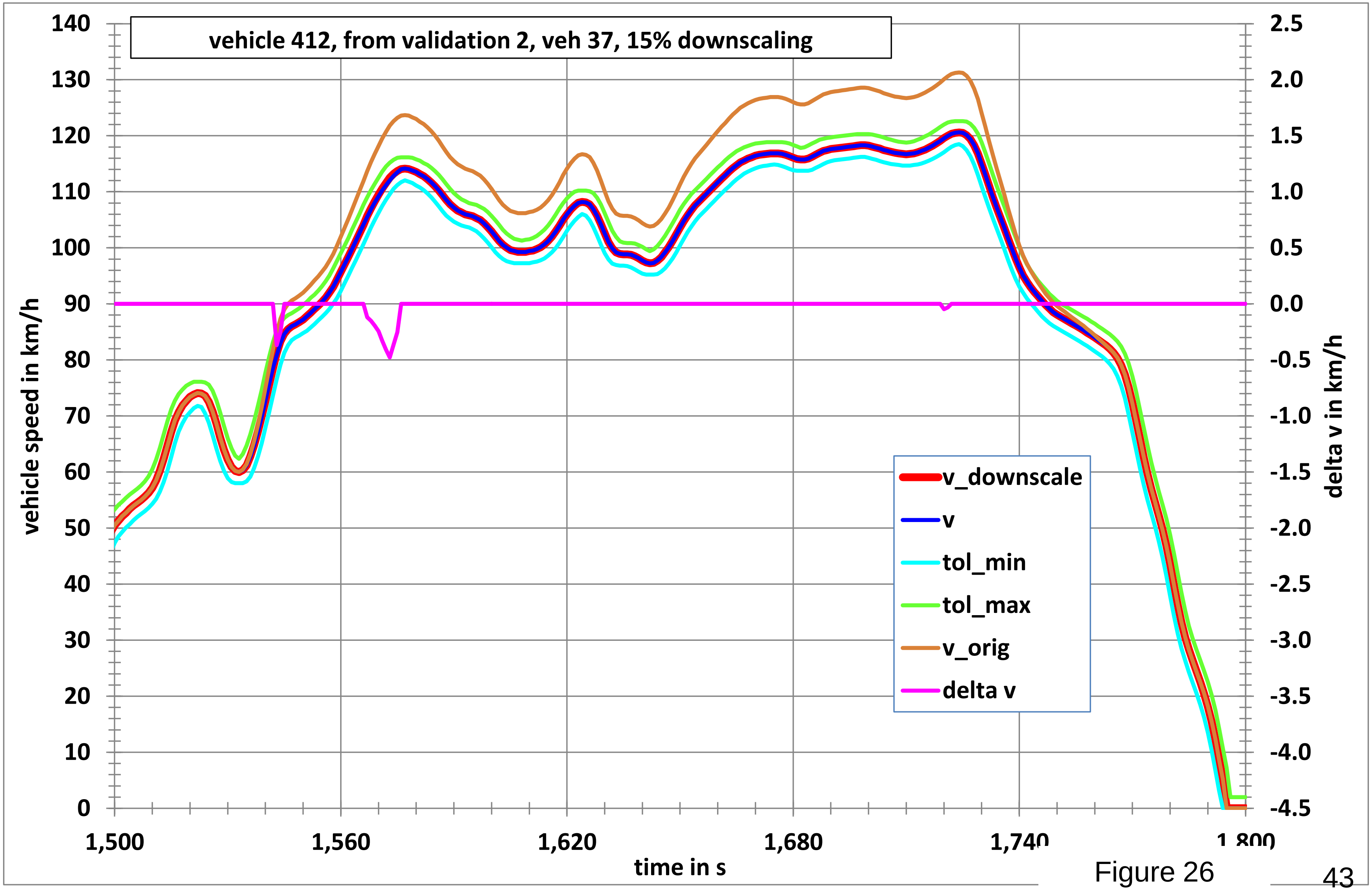

Figure 26

Speed trace of the extra high speed phase

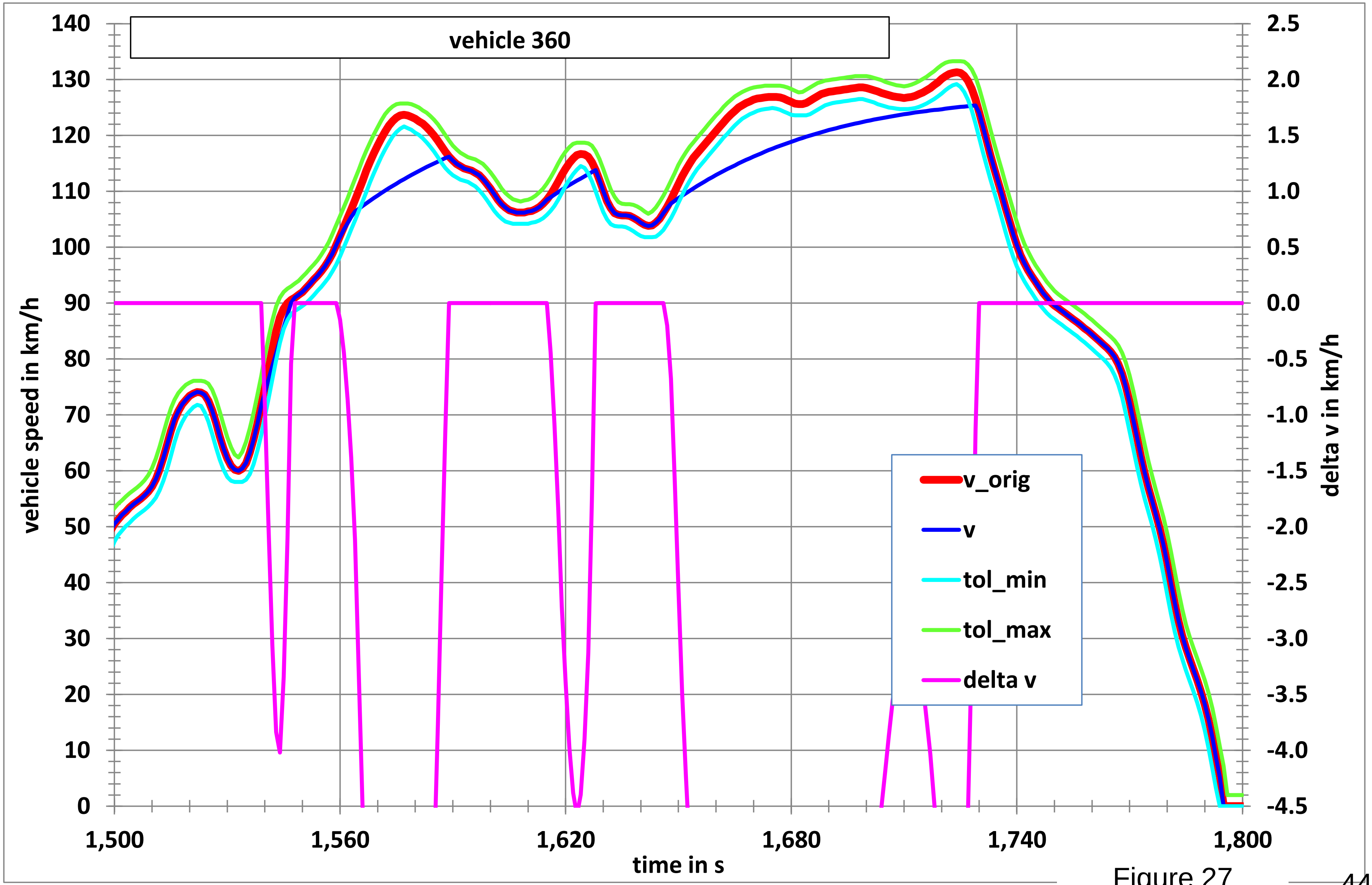

Figure 27

Engine map coverage

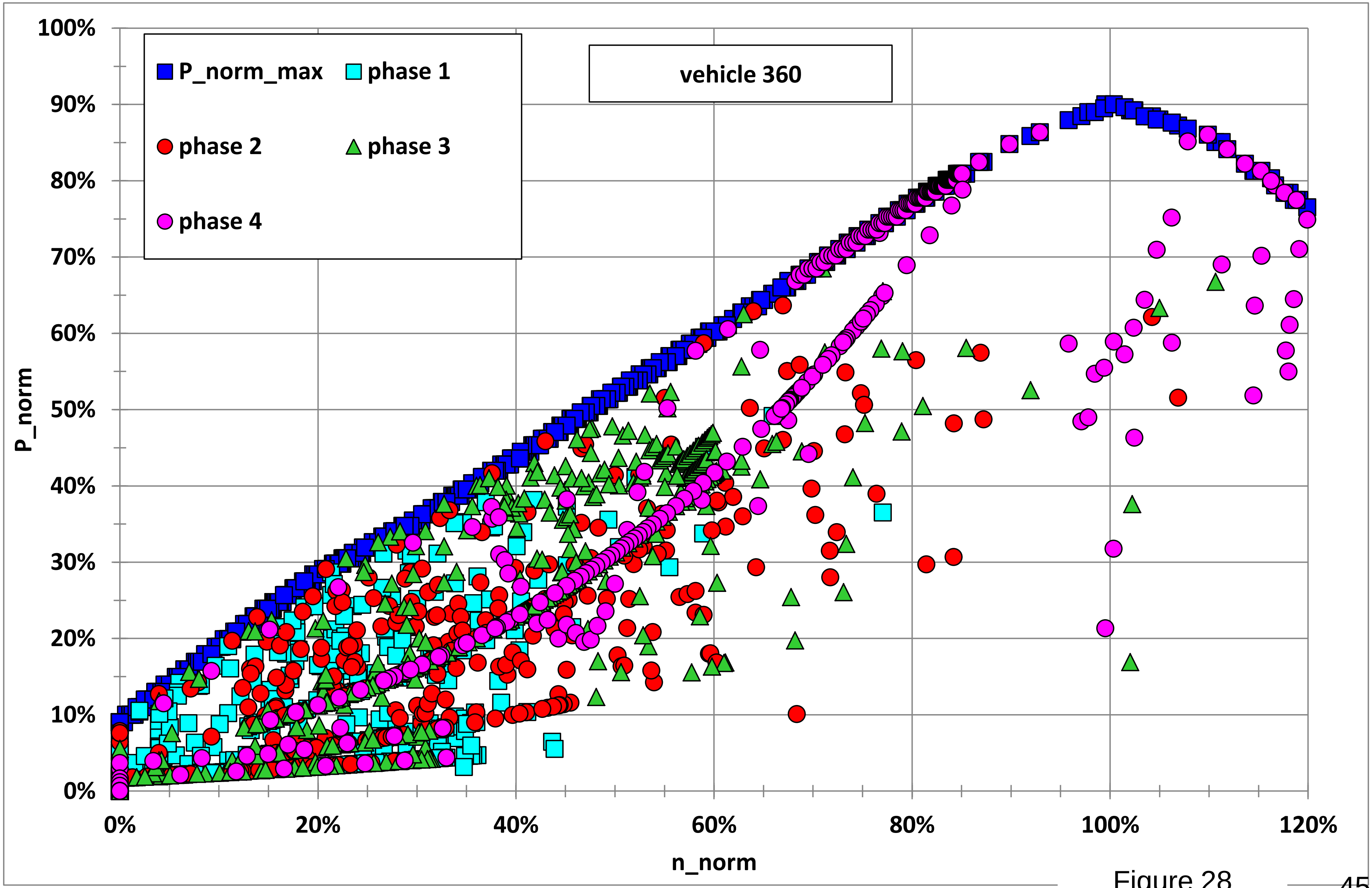

Figure 28

Speed trace of the extra high speed phase

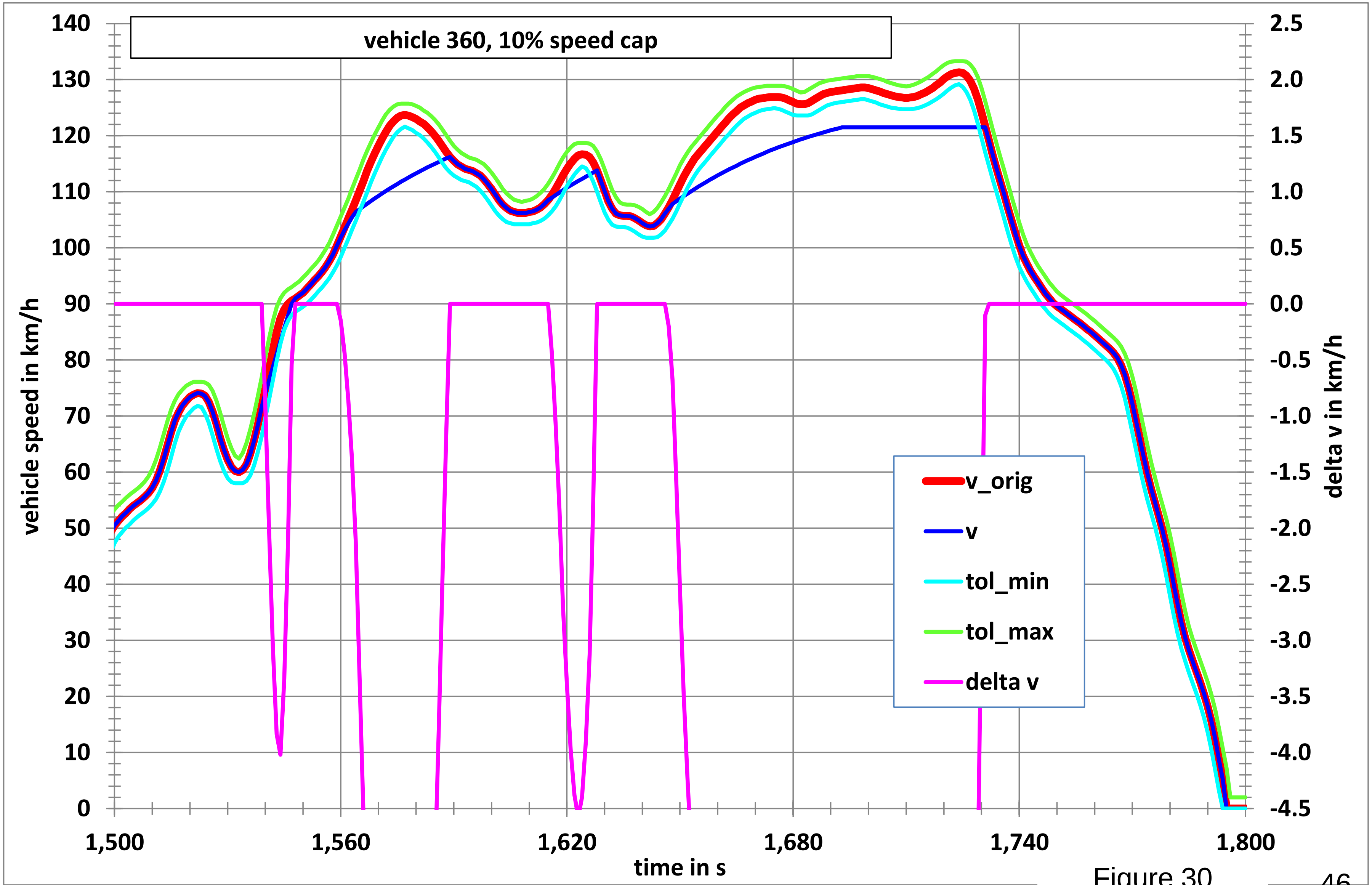

Figure 30

Speed trace of the extra high speed phase

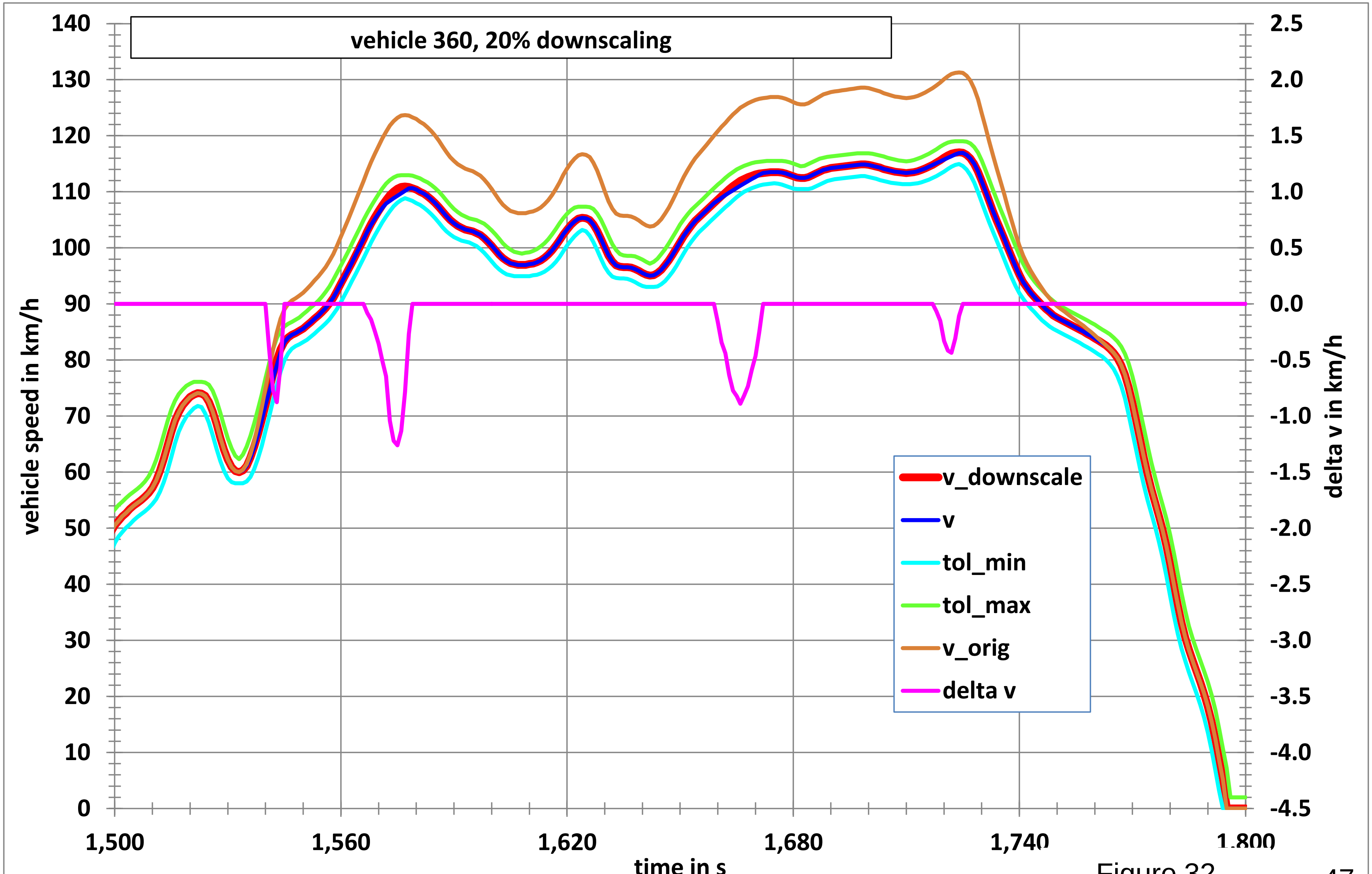

Figure 32

Results

- Depending on the degree of deviation from the set speed different degrees of downscaling have to be applied.
- But it can already be concluded from the previous figures that the downscaling method is more appropriate than the speed cap method.
- Table 2 summarises the results for the fuel consumption and the wot percentage for all 30 vehicles.
- Downscaling is also shown in cases, where no driveability problems occur in order to allow a comparison with the 10% speed cap results.
- 25% downscaling means that the accelerations between 1533 s and 1723 s are multiplied by 0.75.

Results

- Table 3 lists the differences compared to the base case without any downscaling or speed cap. v_max / v_max without means the ratio of the maximum speeds achieved within the extra high speed phase with and without the cap or the downscaling.
- The downscaling leads to reductions of the fuel consumption between 0.5% and 3% compared to the base case. The 10% cap would lead to higher reductions in most cases.
- It must be mentioned that most vehicles in table 3 without driveability problems are model vehicles. It is most likely that the number of vehicle models in the markets with such transmission design is limited compared to the number of vehicle models that would need measures to improve the driveability.

Results

							10% speed cap			downscaling				
vehicle	pmr in kW/t	v_max in km/h	n_norm max	v_max cycle in km/h	FC in g/km	p_wot	v_max cycle in km/h	FC in g/km	p_wot	percen-tage of acc	v_max cycle in km/h	FC in g/km	p_wot	remarks
335	34.4	106	120.1%	105.9	34.4	3.0%	95.4	32.5	2.4%	30%	105.9	34.0	2.4%	no cap or downscaling necessary
363	34.7	106	120.4%	105.7	30.5	2.3%	95.4	28.8	2.1%	30%	105.7	30.1	1.8%	no cap or downscaling necessary
107	38.8	107	120.0%	107.0	36.0	2.9%	96.3	34.1	2.4%	30%	107.0	35.5	2.3%	no cap or downscaling necessary
344	38.9	107	120.5%	106.6	60.9	0.8%	96.3	59.6	0.6%	30%	106.6	60.6	0.4%	no cap or downscaling necessary
266	40.9	113	120.1%	113.0	38.9	3.3%	101.7	36.8	2.4%	25%	113.0	38.1	2.3%	no cap or downscaling necessary
276	37.5	113	120.1%	113.0	37.7	4.3%	101.7	35.6	3.1%	25%	113.0	36.9	2.6%	no cap or downscaling necessary
286	34.1	113	120.1%	113.0	36.5	3.9%	101.7	34.3	2.3%	25%	113.0	35.7	2.5%	
33	38.5	117	119.8%	115.0	47.7	11.4%	105.3	45.4	3.6%	25%	113.2	46.2	5.5%	
265	40.9	118	119.6%	118.0	39.0	4.1%	106.2	37.0	2.6%	15%	118.0	38.6	2.5%	
275	37.5	118	119.6%	118.0	37.9	4.9%	106.2	35.8	3.0%	15%	118.0	37.5	3.3%	
285	34.1	118	119.6%	118.0	36.8	6.2%	106.2	35.0	3.6%	15%	118.0	36.5	5.6%	
109	42.0	119	119.9%	119.0	41.0	4.1%	107.1	38.8	2.6%	15%	119.0	40.4	2.4%	
34	35.7	120	107.7%	117.1	46.3	12.1%	108.0	45.5	5.2%	25%	113.3	45.5	7.3%	
331	40.0	120	119.6%	120.0	36.9	4.8%	108.0	35.1	2.8%	15%	120.0	36.5	3.0%	
343	38.9	120	119.7%	120.0	59.4	2.3%	108.0	56.9	1.0%	15%	120.0	58.5	0.8%	no cap or downscaling necessary

Table 2a

Results

							10% speed cap			downscaling				
vehicle	pmr in kW/t	v_max in km/h	n_norm max	v_max cycle in km/h	FC in g/km	p_wot	v_max cycle in km/h	FC in g/km	p_wot	percen-tage of acc	v_max cycle in km/h	FC in g/km	p_wot	remarks
362	34.7	120	119.6%	120.0	31.4	9.4%	108.0	29.6	2.9%	15%	120.0	30.7	4.9%	
274	37.5	124	119.7%	124.0	38.4	5.2%	111.6	36.8	3.1%	10%	124.0	37.9	4.3%	
284	34.1	124	119.7%	124.0	37.4	10.4%	111.6	35.6	4.7%	15%	120.6	36.3	5.7%	
321	38.2	125	120.3%	124.7	34.6	8.6%	112.5	32.9	3.2%	5%	124.7	34.4	7.2%	
273	37.5	131	120.2%	129.4	38.2	8.3%	117.9	37.0	4.7%	10%	124.2	37.4	4.5%	
283	34.1	131	120.2%	127.6	36.8	9.8%	117.9	35.9	5.6%	15%	120.6	35.9	4.9%	
282	34.1	133	115.0%	129.1	36.9	9.3%	119.7	36.2	5.8%	15%	120.6	36.3	5.0%	
361	34.7	133	110.7%	128.9	31.4	10.9%	119.7	31.1	7.3%	20%	117.0	31.2	5.8%	
360	34.7	135	93.7%	125.4	31.9	11.2%	121.5	32.0	11.2%	20%	117.0	31.3	6.4%	
281	34.1	136	110.4%	129.8	37.0	10.5%	122.4	36.7	7.9%	15%	120.6	36.7	6.9%	
287	34.1	136	111.2%	129.8	37.0	11.5%	122.4	37.0	10.2%	25%	113.5	36.5	6.3%	
280	34.1	137	107.6%	130.0	37.1	9.7%	123.3	37.0	8.2%	15%	120.6	36.9	6.3%	
225	40.9	140	99.1%	129.6	29.4	9.8%	126.0	29.4	9.8%	15%	120.6	28.9	5.5%	
412	36.5	140	101.6%	129.8	33.5	12.8%	126.0	33.5	10.6%	15%	120.6	33.3	9.2%	
277	37.5	142	92.5%	131.0	38.3	9.5%	127.8	38.3	9.1%	15%	120.6	38.1	5.3%	

Table 2b

Results

							10% speed cap			downscaling				
vehicle	pmr in kW/t	v_max in km/h	n_norm max	v_max cycle / v_max veh	FC in g/km	p_wot	v_max / v_max without	Delta FC in g/km	Delta p_wot	percen-tage of acc	v_max / v_max without	Delta FC in g/km	Delta p_wot	remarks
335	34.4	106	120.1%	99.9%	34.4	3.0%	90.1%	-5.5%	-18.5%	30%	100.0%	-1.3%	-20.3%	no cap or downscaling necessary
363	34.7	106	120.4%	99.7%	30.5	2.3%	90.2%	-5.6%	-11.9%	30%	100.0%	-1.3%	-21.5%	no cap or downscaling necessary
107	38.8	107	120.0%	100.0%	36.0	2.9%	90.0%	-5.3%	-15.4%	30%	100.0%	-1.3%	-19.3%	no cap or downscaling necessary
344	38.9	107	120.5%	99.7%	60.9	0.8%	90.3%	-2.1%	-26.7%	30%	100.0%	-0.5%	-53.2%	no cap or downscaling necessary
266	40.9	113	120.1%	100.0%	38.9	3.3%	90.0%	-5.4%	-28.3%	25%	100.0%	-2.2%	-30.1%	no cap or downscaling necessary
276	37.5	113	120.1%	100.0%	37.7	4.3%	90.0%	-5.6%	-28.6%	25%	100.0%	-2.1%	-40.4%	no cap or downscaling necessary
286	34.1	113	120.1%	100.0%	36.5	3.9%	90.0%	-5.8%	-41.4%	25%	100.0%	-1.9%	-35.7%	
33	38.5	117	119.8%	98.3%	47.7	11.4%	91.5%	-4.9%	-68.8%	25%	98.4%	-3.2%	-51.7%	
265	40.9	118	119.6%	100.0%	39.0	4.1%	90.0%	-5.3%	-35.6%	15%	100.0%	-1.2%	-38.4%	
275	37.5	118	119.6%	100.0%	37.9	4.9%	90.0%	-5.5%	-38.6%	15%	100.0%	-1.2%	-33.0%	
285	34.1	118	119.6%	100.0%	36.8	6.2%	90.0%	-4.9%	-42.3%	15%	100.0%	-0.9%	-9.0%	
109	42.0	119	119.9%	100.0%	41.0	4.1%	90.0%	-5.3%	-37.0%	15%	100.0%	-1.3%	-41.1%	
34	35.7	120	107.7%	97.6%	46.3	12.1%	92.2%	-1.8%	-56.9%	25%	96.8%	-1.7%	-39.4%	
331	40.0	120	119.6%	100.0%	36.9	4.8%	90.0%	-4.9%	-41.9%	15%	100.0%	-1.3%	-37.2%	
343	38.9	120	119.7%	100.0%	59.4	2.3%	90.0%	-4.2%	-57.1%	15%	100.0%	-1.6%	-64.3%	no cap or downscaling necessary

Table 3a

Results

							10% speed cap			downscaling				
vehicle	pmr in kW/t	v_max in km/h	n_norm max	v_max cycle / v_max veh	FC in g/km	p_wot	v_max / v_max without	Delta FC in g/km	Delta p_wot	percen-tage of acc	v_max / v_max without	Delta FC in g/km	Delta p_wot	remarks
362	34.7	120	119.6%	100.0%	31.4	9.4%	90.0%	-5.9%	-69.2%	15%	100.0%	-2.2%	-47.9%	
274	37.5	124	119.7%	100.0%	38.4	5.2%	90.0%	-4.2%	-41.5%	10%	100.0%	-1.2%	-17.0%	
284	34.1	124	119.7%	100.0%	37.4	10.4%	90.0%	-4.8%	-54.5%	15%	97.3%	-3.0%	-45.5%	
321	38.2	125	120.3%	99.8%	34.6	8.6%	90.2%	-4.9%	-63.0%	5%	100.0%	-0.6%	-16.2%	
273	37.5	131	120.2%	98.8%	38.2	8.3%	91.1%	-3.0%	-43.6%	10%	95.9%	-2.0%	-45.6%	
283	34.1	131	120.2%	97.4%	36.8	9.8%	92.4%	-2.4%	-43.2%	15%	94.5%	-2.4%	-50.0%	
282	34.1	133	115.0%	97.1%	36.9	9.3%	92.7%	-1.9%	-37.1%	15%	93.4%	-1.7%	-46.1%	
361	34.7	133	110.7%	96.9%	31.4	10.9%	92.9%	-0.9%	-32.7%	20%	90.8%	-0.6%	-46.9%	
360	34.7	135	93.7%	92.9%	31.9	11.2%	96.9%	0.3%	0.0%	20%	93.3%	-2.1%	-42.6%	
281	34.1	136	110.4%	95.4%	37.0	10.5%	94.3%	-0.7%	-24.3%	15%	92.9%	-0.8%	-34.4%	
287	34.1	136	111.2%	95.4%	37.0	11.5%	94.3%	0.0%	-11.6%	25%	87.4%	-1.4%	-45.4%	
280	34.1	137	107.6%	94.9%	37.1	9.7%	94.8%	-0.4%	-16.0%	15%	92.8%	-0.6%	-34.9%	
225	40.9	140	99.1%	92.6%	29.4	9.8%	97.2%	0.0%	0.0%	15%	93.0%	-1.7%	-43.8%	
412	36.5	140	101.6%	92.7%	33.5	12.8%	97.1%	-0.2%	-17.3%	15%	92.9%	-0.7%	-28.6%	
277	37.5	142	92.5%	92.3%	38.3	9.5%	97.5%	-0.2%	-4.7%	15%	92.0%	-0.6%	-44.4%	

Table 3b

Conclusions/Proposals

- The model calculations showed that for most of the class 3 vehicles from the in-use database (and especially from the EU market) no driveability problems with the WLTC version 5.3 can be expected.
- However, driveability problems can occur for vehicles with rated power to kerb mass values between 34 kW/t and 42 kW/t and maximum speeds up to 148 km/h.
- In such cases the downscaling method provides more appropriate solutions than the application of a speed cap.
- Unfortunately, the occurance of such driveability problems cannot (yet) be forecasted by technical vehicle parameters.
- Therefore it is proposed to perform pretests in order to verify driveability problems and then use the downscaling method to eliminate/reduce them.

Conclusions/proposals

- **It is further proposed to extend the analysis to class 2 for consistency reasons. Preliminary calculations showed that driveability improving measures would not be necessary for class 1 vehicles.**
- **It is proposed to get more information and collect more data about road load coefficients and continue the analysis in order to enable the forecast of the downscaling percentage from the cycle trace violations.**