Analysis of measurement results for M1 vehicles with automatic transmission

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Aim

The analysis was performed in order to give technical information with respect to the following questions/issues:

- **Can the maximum sound level of an ASEP acceleration condition be related to vehicle and engine speeds at the end of the test track (BB') or is it necessary to relate it to the actual speeds at Lmax?**
- **Can the upper engine speed limit for ASEP also be applied to vehicles with automatic transmissions?**
- **What is the appropriate slope for the propulsion noise versus engine speed function?**
- **Is there a need for additional provisions for vehicles with automatic transmissions?**

Technical data of the M1 sample

The analysis is based on results of 11 vehicles from 2 different research projects:

- **Project 1: Examination of the Noise Emission of Motor Vehicles for different Candidate Type Approval Measurement Methods, German Environment Agency R&D 2005,**
- **Project 2: In-use compliance tests for M1 and N1 petrol and Diesel vehicles, German Environment Agency R&D 2005.**

The technical data is shown in Table 1. Vehicles with numbers > 100 belong to project 2.

Technical data of vehicles with automatic transmission

project	vehicle number	veh cat	engine type	rated power in kW	engine capacity in cm³	pmr	trans-mission	number of gear ratios	v_max in km/h	rated speed in min-1	n_idle in min-1	n_max ASEP in min-1
1	9	M1	Diesel	105	2148	64.8	automatic	5	215	4200	700	3056
1	10	M1	Petrol	125	2393	75.1	automatic	6	220	6000	750	4137
1	13	M1	Petrol	141	2494	83.9	automatic	5	232	6000	750	4029
1	14	M1	Petrol	152	2946	91.0	automatic	4	232	6000	800	3972
1	17	M1	Petrol	191	3697	101.9	automatic	5	250	6000	700	3829
1	18	M1	Petrol	125	2597	76.2	automatic	5	232	5500	700	3783
1	23	M1_4w	Diesel	116	2953	46.9	automatic	5	160	3600	850	2884
1	26	M1_4w	Petrol	162	3189	68.9	automatic	5	203	6400	700	4470
2	3	M1	Petrol	170	2979	116.4	automatic	5	244	5900	800	3697
2	8	M1	Petrol	105	1796	66.5	automatic	5	203	5200	800	3741
2	18	M1	Petrol	160	3199	104.2	automatic	5	250	5700	700	3633

Table 1

Example, Vehicle 18

- Figure 1 shows the engine speed at PP’ and BB’ versus engine speed at Lmax for all measurements.
- Figure 2 shows Lmax, Lroll and Lprop versus engine speed. Lprop is only shown if Lmax – Lroll >= 3 dB(A).
- The slope of the prop. noise regression function is 4.1 dB/1000 min^{-1} (see figure 2).
- n_BB’ is below n_max_ASEP for all measurements in D-range and other measurements with v_AA’ around 20 km/h. But for entry speeds between 40 km/h and 50 km/h n_BB’ could exceed n_max_ASEP in gear selector positions 2 and 3 (see figure 3). These results are needed for the calculation of the slope.

n_PP' and n_BB' versus n_Lmax

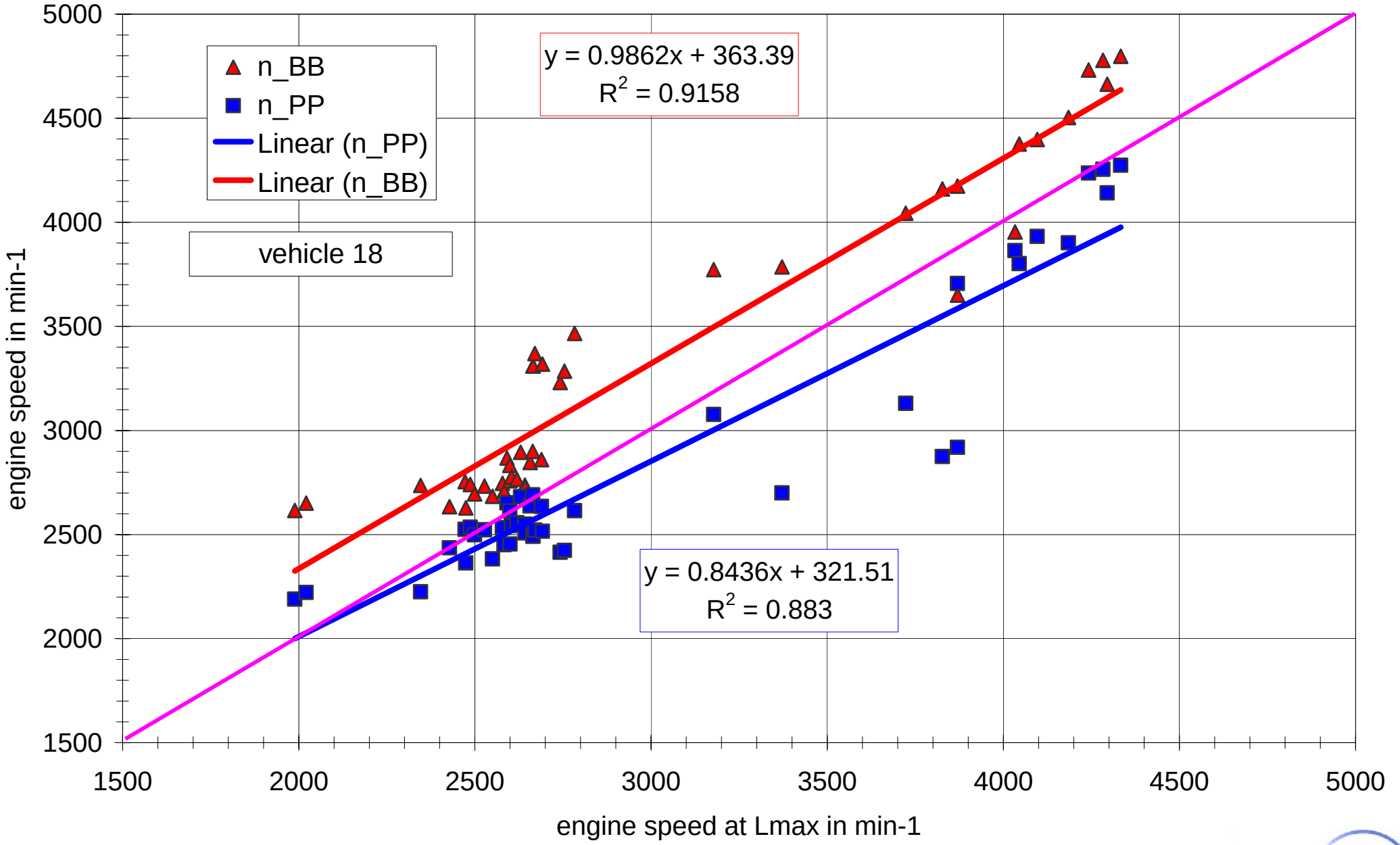


Figure 1

Lmax, Lroll and Lprop versus engine speed

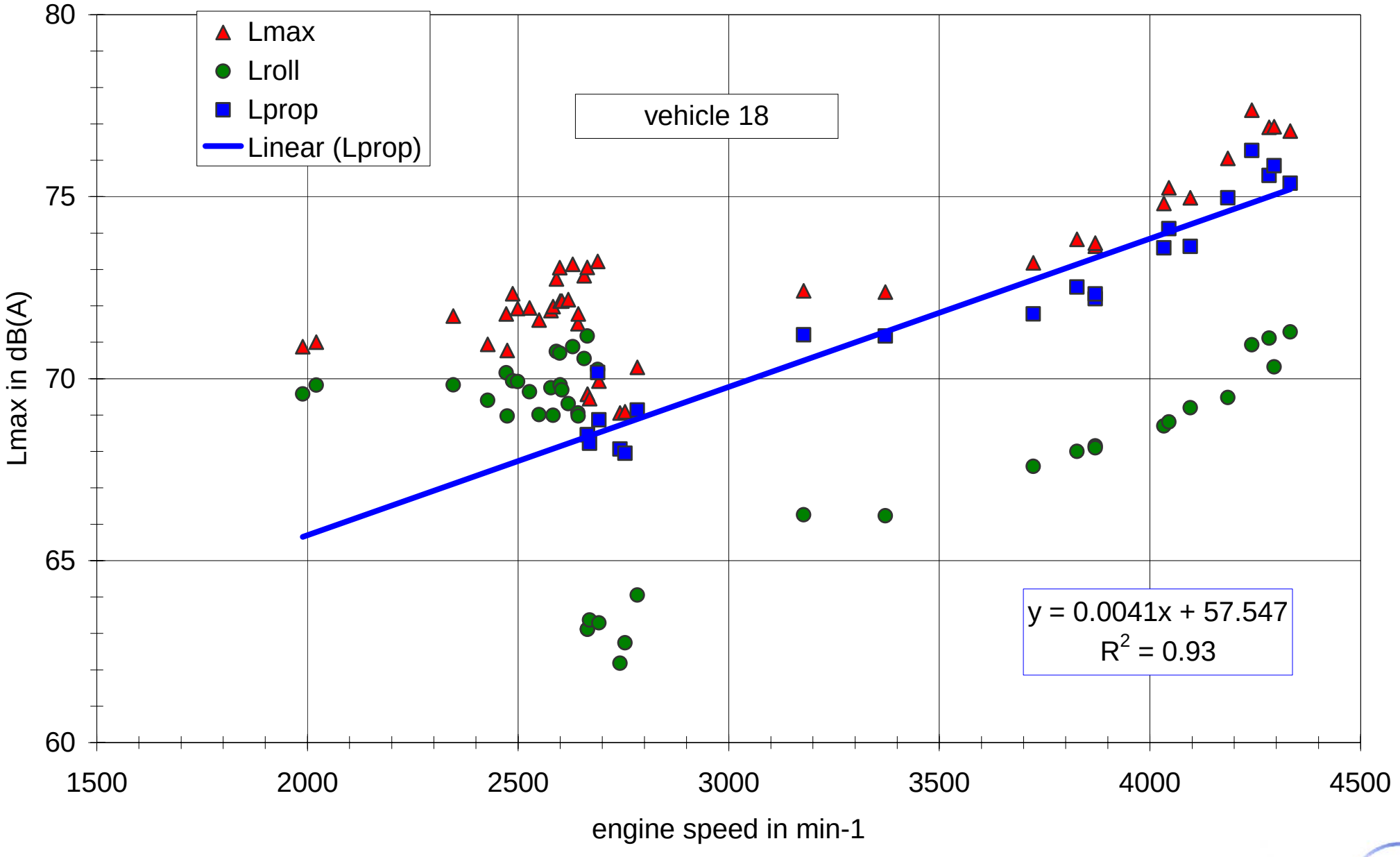


Figure 2

Lprop versus engine speed

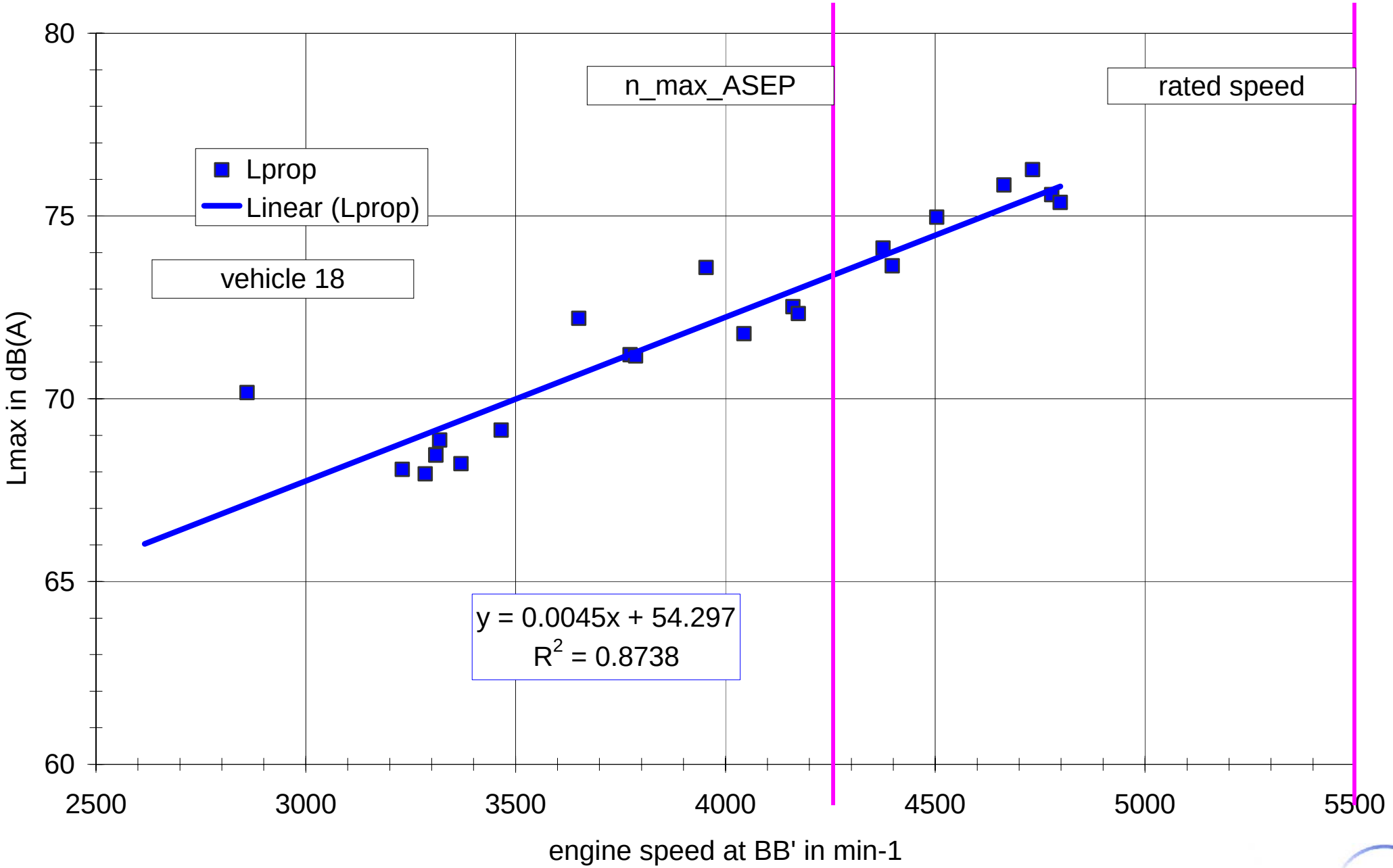


Figure 3

v, n, and L versus distance

- The following figures show examples of vehicle speed, engine speed, the ratio between engine speed and vehicle speed (ndv) and sound level versus distance along the test track.
- Gear 100 means D-range, side 1 is left side.
- The distance between the position of Lmax and BB' varies between 5 and 15 m (average 10 m).
- n_BB' could be lower than n(Lmax) (see figure 6).
- No different entry gear ratios were found but different gearshift behaviour (see figures 7 and 8).

v, n, and L versus distance

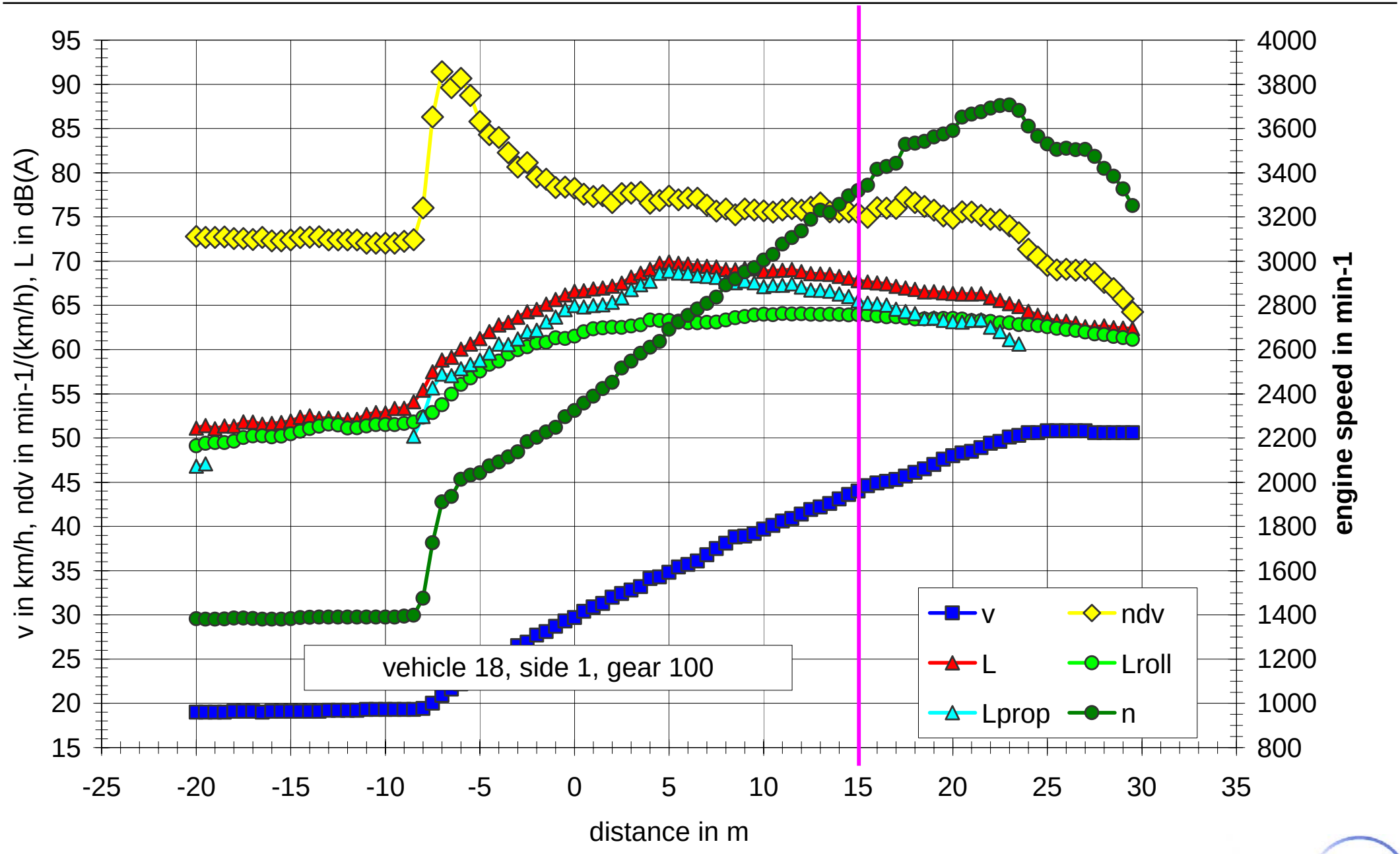


Figure 4

v, n, and L versus distance

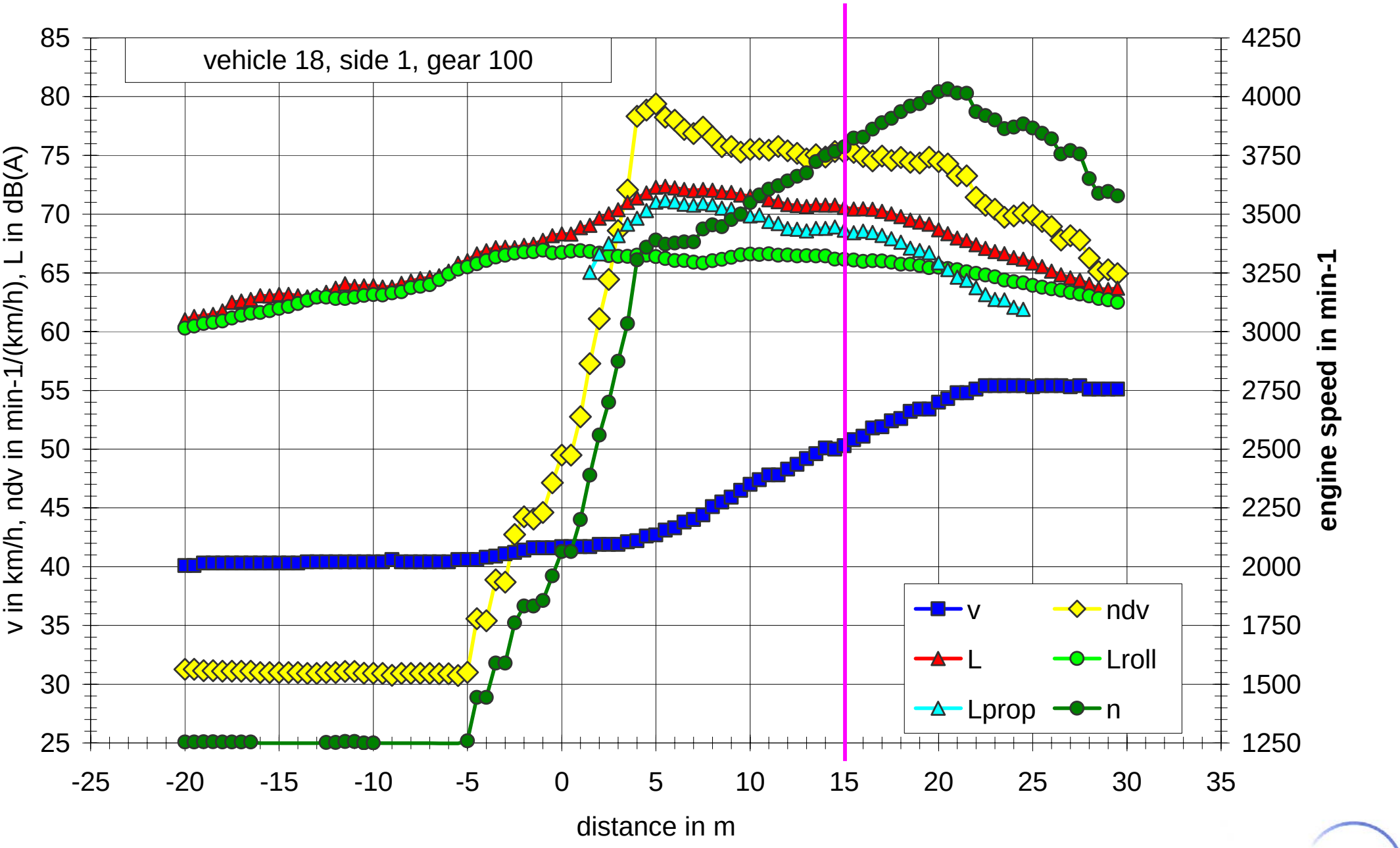


Figure 5

v, n, and L versus distance

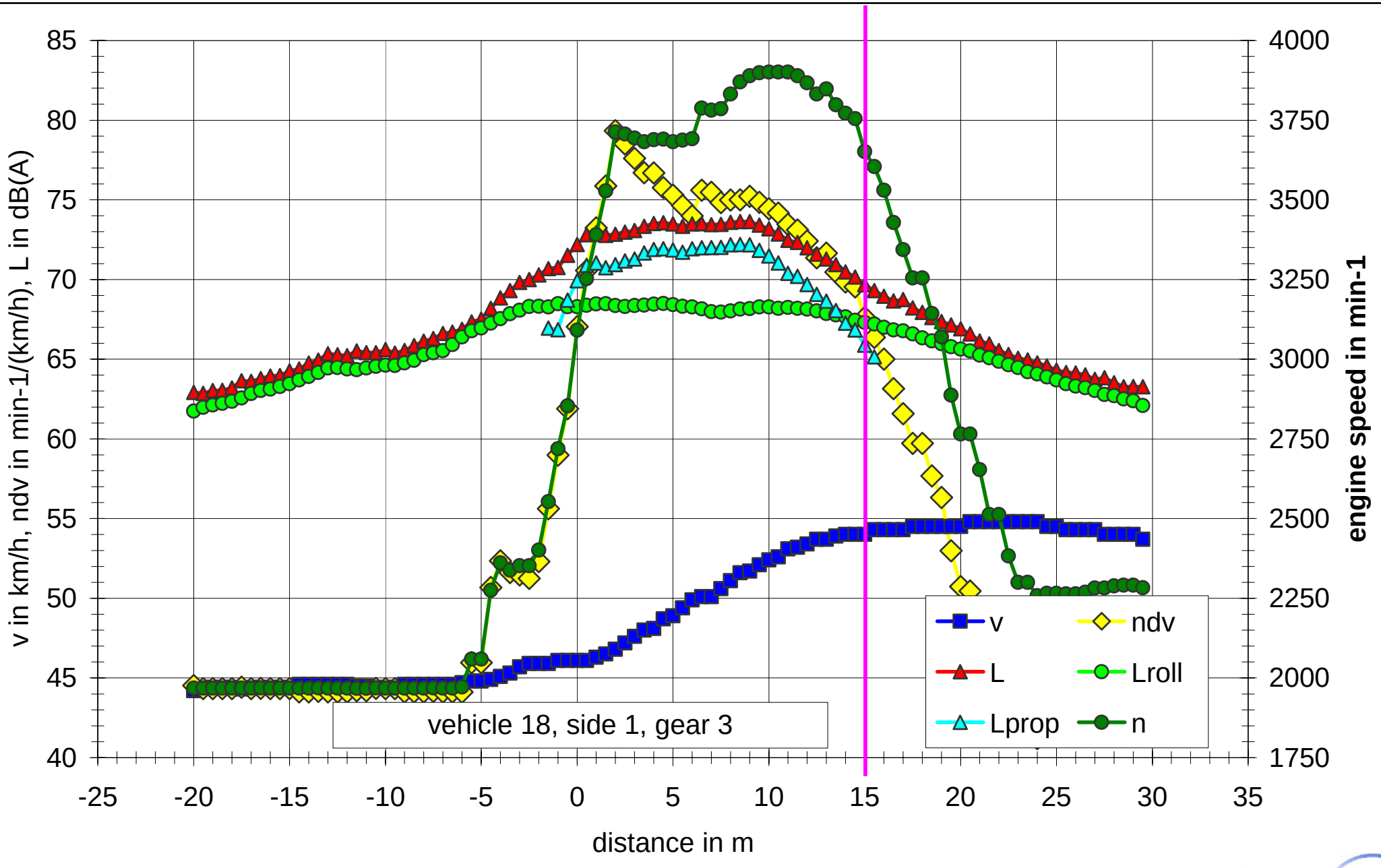


Figure 6

v, n, and L versus distance

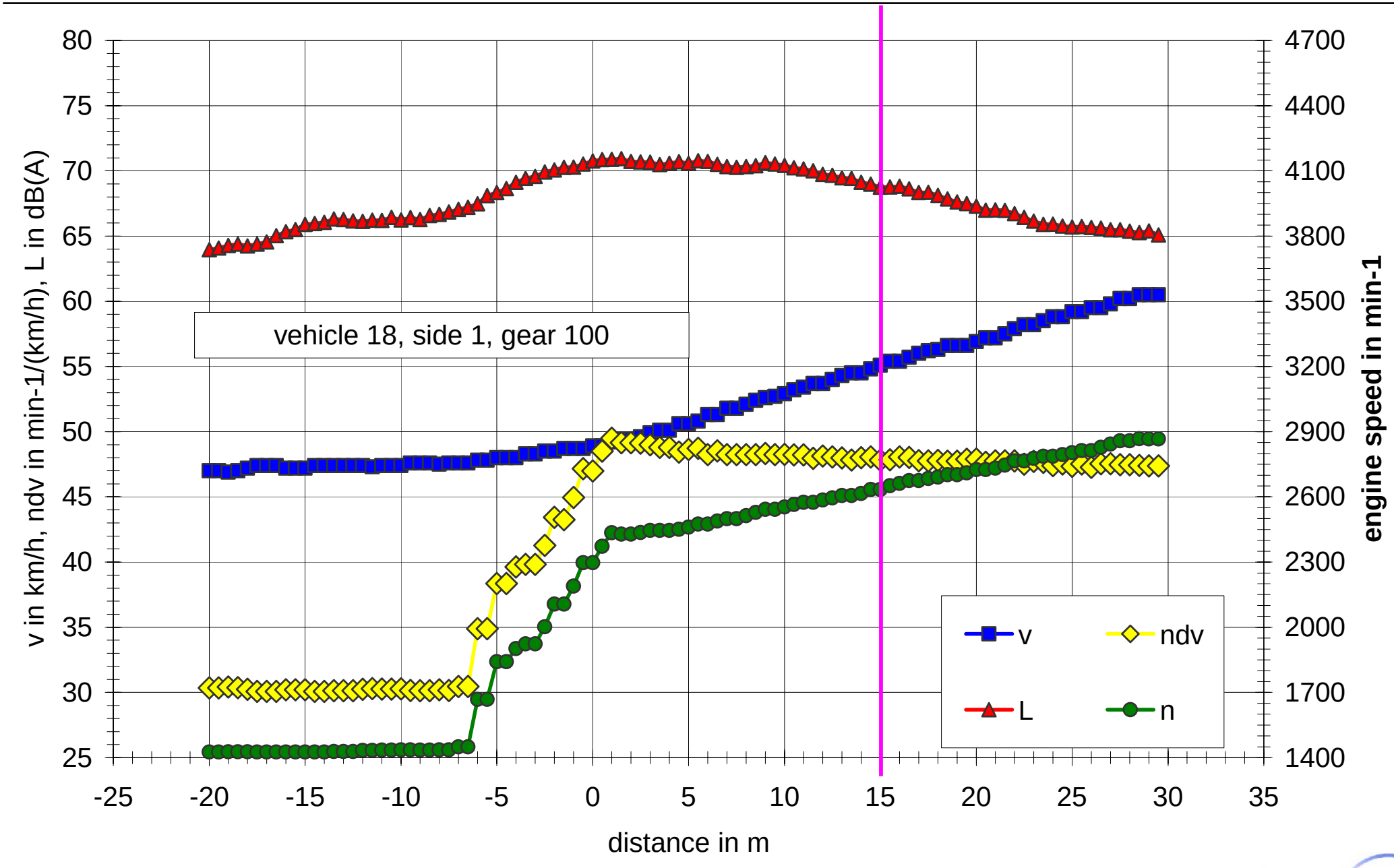


Figure 7

v, n, and L versus distance

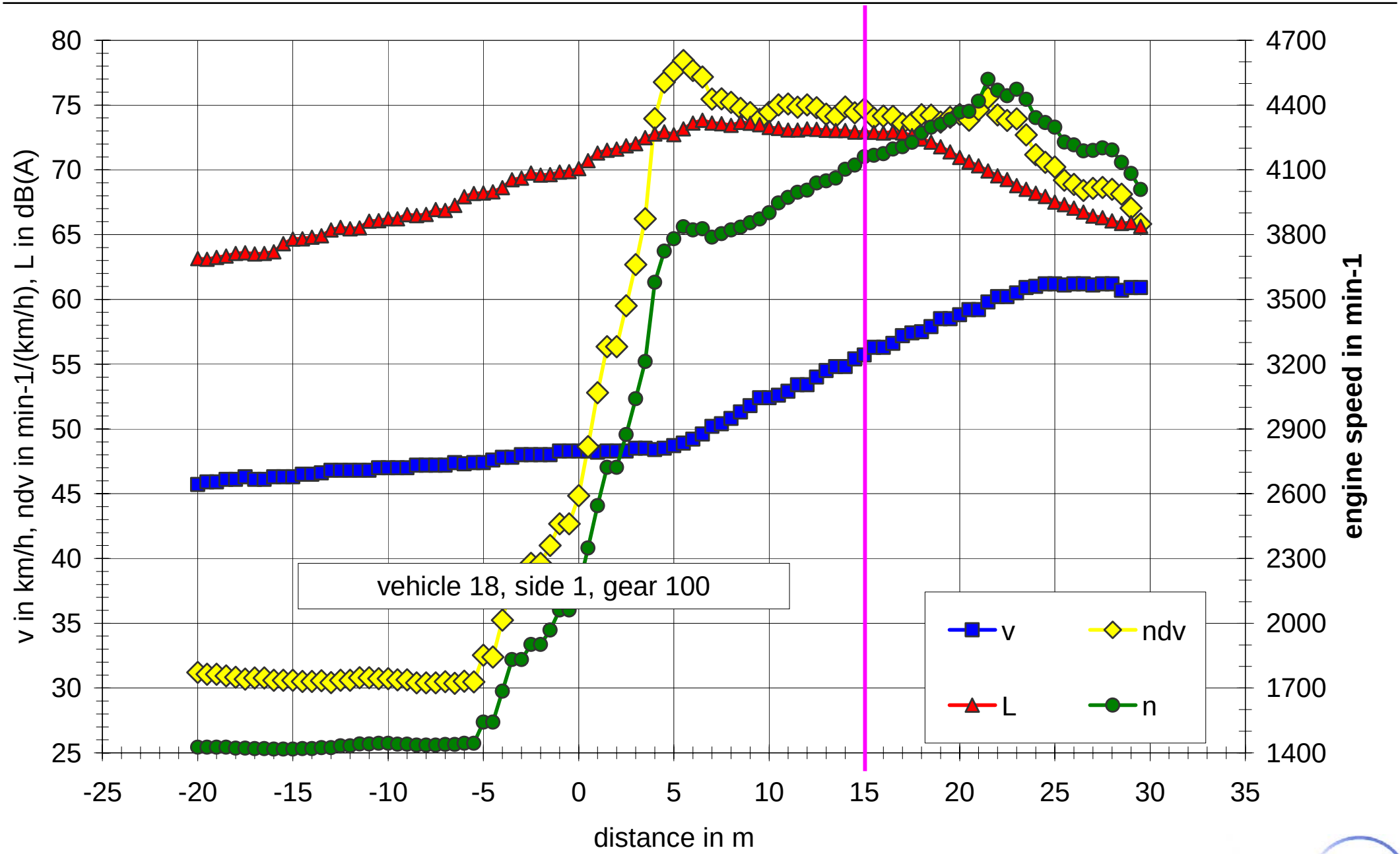


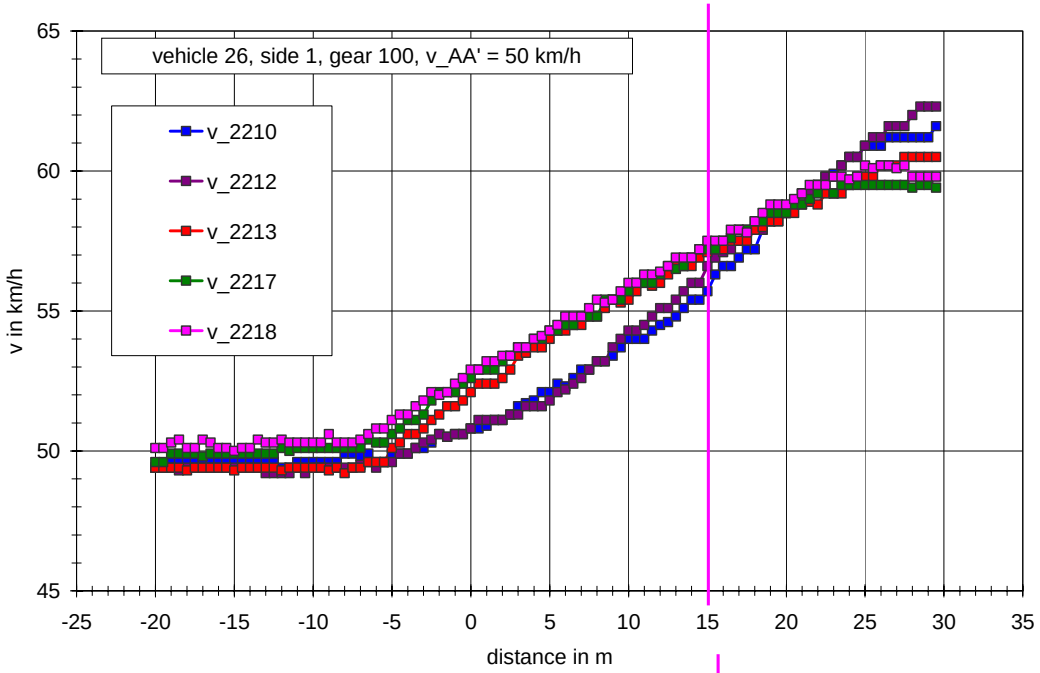
Figure 8

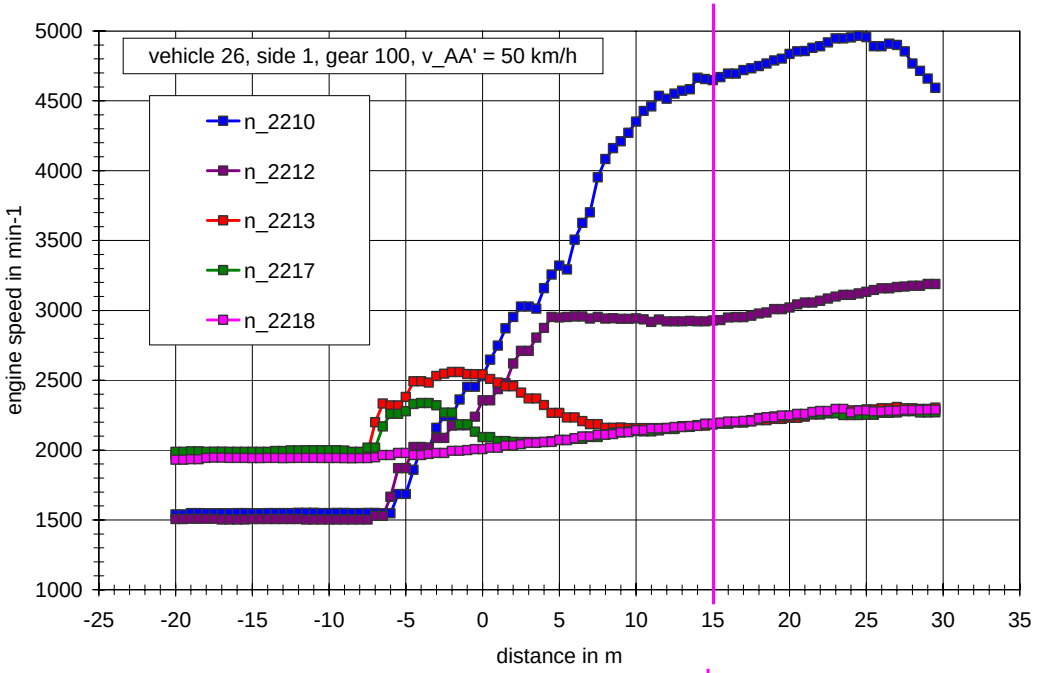
Overview of results

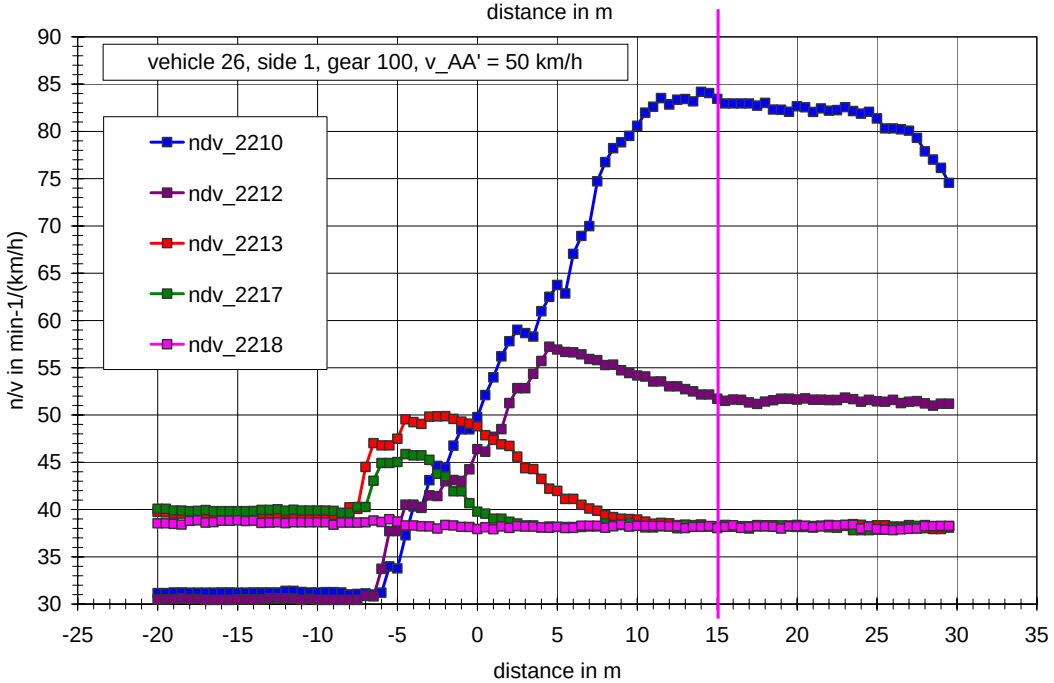
Details of the results of the analysis are shown in annex A. They can be summarised as follows:

- **The transmission behaviour of vehicles with automatic gearboxes normally show variances with respect to the entry gear ratio as well as to the gearshift behaviour. This can be demonstrated by the results for vehicle 26 where 5 different conditions were found for an entry speed v_AA' of 50 km/h (see figure 9). The transmission behaviour varied between**
  - **no gearshift and no engine speed increase caused by the torque converter,**
  - **No gearshift but different speed increase caused by the torque converter,**
  - **Downshift by 1 gear ratio,**
  - **Downshift by 2 gear ratios.**
- **There is no general correlation between the engine speed at Lmax (n(Lmax)) and at the end of the test track (n_BB'). For the major part of the measurements n(Lmax) is lower than n_BB'. But some cases were found where n(Lmax) is close to n_BB' or even lower than n_BB'.**

Overview of results







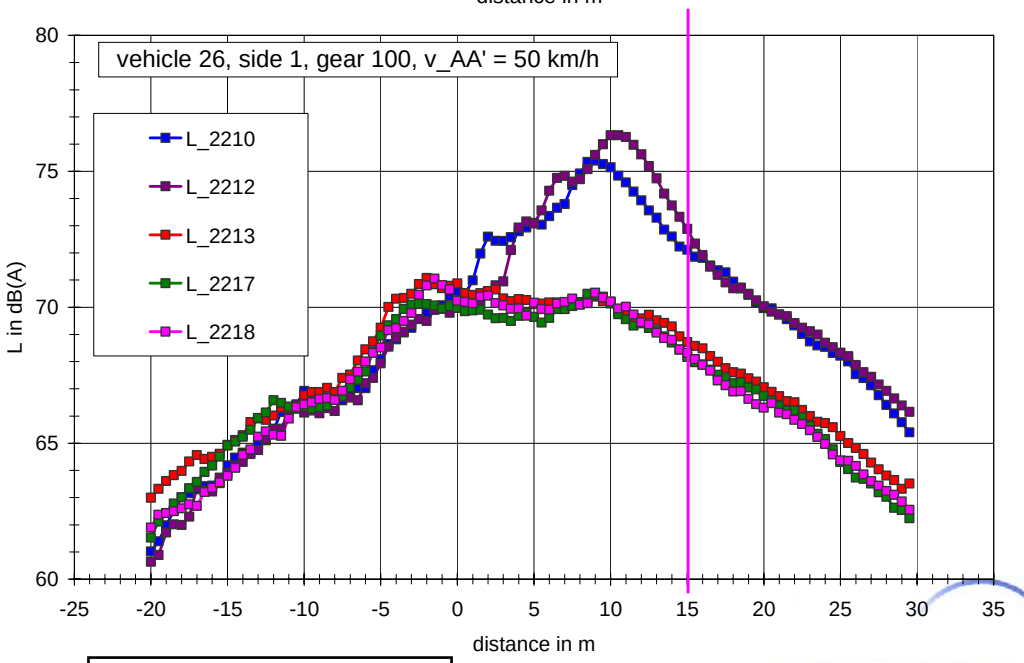


Figure 9

Overview of results

- For 6 of the 11 vehicles n_BB' was always below n_max_ASEP independent of the entry speed. For 5 vehicles n_max_ASEP was exceeded for parts of the measurement results, in 2 cases only at low entry speeds (<= 30 km/h) in the other cases not at low speeds but at speeds around 50 km/h. For 1 of these vehicles n_max_ASEP was exceeded for 73% of all measurements.
- The calculation of propulsion noise levels was possible, but sometimes driving conditions in gear selector positions other than D-range were needed and sometimes only for a limited engine speed range. Extrapolations beyond this speed range could lead to invalid results.
- Consequently the derivation of the slopes for the increase of propulsion noise levels with increasing engine speed may lead to unreliable values (see figures 10 and 11). Nevertheless the slopes were calculated. They vary from 2.6 dB/1000 min^{-1} to 8.2 dB/1000 min^{-1} (ave. 4.4 dB/1000 min^{-1}).

Lmax, Lroll and Lprop versus engine speed

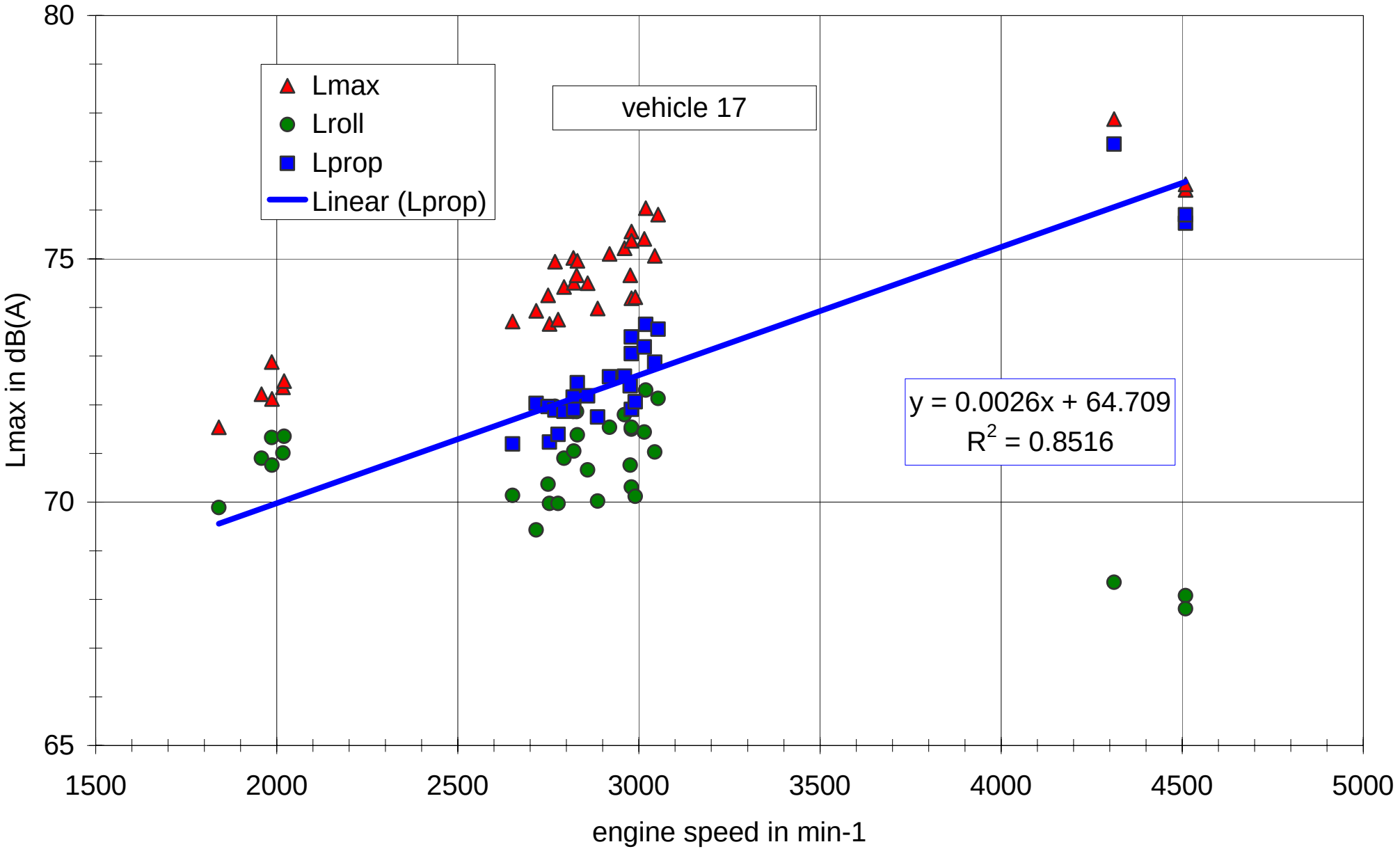


Figure 10

Lmax, Lroll and Lprop versus engine speed

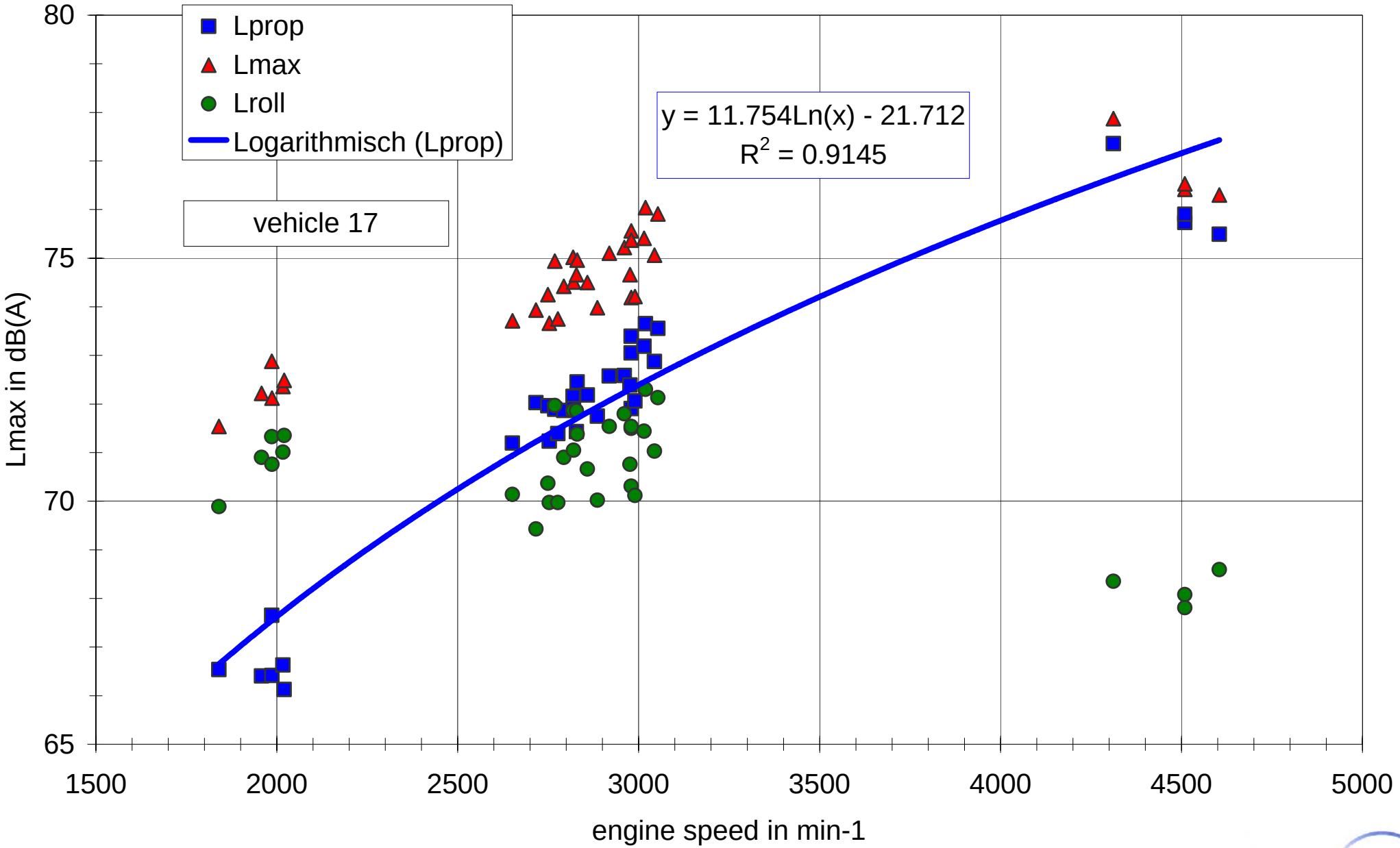


Figure 11

Conclusions and further remarks

- **The results show clearly that maximum noise levels cannot be related to the engine speed values at BB' but should be related to the values at Lmax, even if this requires more advanced measurement technique as for annex 3.**
- **The high variations in entry gear ratio and gearshift behaviour might even require to include noise and speed pattern (engine speed as well as vehicle speed) along the test track.**
- **There is a risk for vehicles with automatic gearboxes that ASEP provisions can be bypassed by a design of the transmission in that way that the engine speeds at BB' are higher than n_max_ASEP and thus outside the ASEP control area. That means the engine speed boundary needs to be rediscussed at least for automatic and CVT transmissions but may be also for manual transmissions (see figure 12).**
- **The propulsion noise calculation as well as values for the slopes for the increase of propulsion noise levels with increasing engine speed need to be further investigated. This is related to the French/German proposal.**

v_max_ASEP, 2. gear

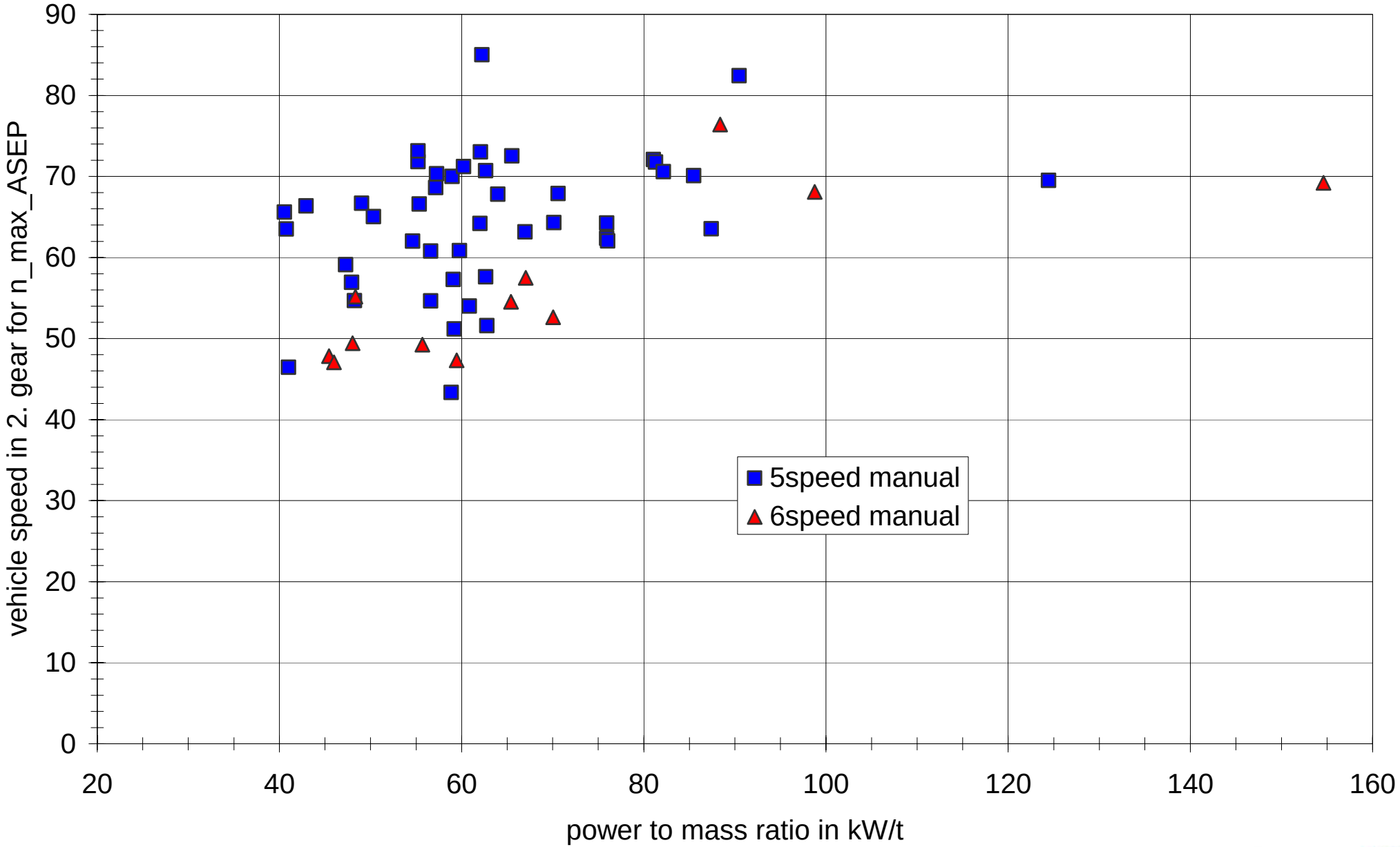


Figure 12

Conclusions and further remarks

- **The Dutch proposal does not need propulsion noise calculations but it can be doubted that the difference in overall noise between different gears is constant and it is questionable why the difference should be limited to 0 for lower gears than gear i, because it allows higher propulsion noise levels for those gears.**
- **A method that is based on total noise versus engine speed cannot work properly because of the tyre/road noise influence.**
- **At this stage of the investigations/discussions it seems to be too early to come up with a well-founded proposal for GRB.**