GRBIG-ASEP-01-008
GRB informal group ASEP R51
November 2005
Issued by the Netherlands

Position paper on part 2 of ISO 362

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Status of discussion: March 2004

(Changes of the last update are marked in red)

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1 INTRODUCTION

Road traffic ranks among the most important sources of environmental noise annoyance and therefore understanding the mechanisms of sound production is important both for necessary technological developments and procedures for controlling its level.

Road traffic noise has its origin in the sound production of the road vehicle while taking part of the traffic in cities, secondary roads and highways and it is a well known fact that the produced sound is dominated by the process of powering a vehicle and by the process of rolling over the road surfacing. Sources of minor importance are the aero dynamic noise, produced by the air flow over the car body and sound produced by rattling cargo, cooling devices etceteras.

Since the majority of annoyance is perceived in urban situations, studying sound production of road vehicles under urban driving conditions is essential for understanding the nature of urban noise annoyance and possibilities for improving the urban acoustic environment.

Standardisation of evaluation procedures has always been an important part of knowledge development and therefore ISO TC 43 and TC 22 have initiated the process of development of methodology to assess the sound production of road vehicles under urban driving conditions. ISO TC43/SC1/WG42 has been given the task to develop and update such standards.

The vehicle noise standard ISO 362 has been updated most recently in 1998. WG42 has been working since then on a next update. In a first stage the emphasis was given to situations which dominate the equivalent urban noise levels. This has resulted in a draft proposal for revision of ISO362, which has been presented at the ISO TC43/SC1 meeting in May 2002 in Paris.

After discussion on this proposal at the ISO TC43/SC1 meeting, it was proposed that the ISO 362 standard will be extended with a second part to cover low speed transient behaviour of road vehicles, typically found in residential areas, crossings and intersections.

The Netherlands have responded positively on this call and initiated a national project to formulate a proposal for this second part.

This paper is part of the output of this project and gives

-some background information for the scope of the part2 method

-a first outline for the principles of the part 2 measurement method

-a planning of the work to be done

This position paper reflects a summary of the relevant insights available up to the meeting of ISO WG42 in March 2004. It intents to be neither excessive nor finalised and it is set up as an evolving document. Additional data and insights might become available during the upcoming discussions in ISO WG42. All members of WG42 and other experts are encouraged to bring in these data in order to improve the basis for this part 2.

2 SCOPE

Part 2 of ISO 362 is intended to be complementary to the part 1, yet under development in stage 1 [1]. The scope of part 2 is the noise production of road vehicles under conditions of urban speed driving, and medium to high acceleration (typically 35 to 60 km/h and 1,5 to 2,5 m/s^2). Part 2 is applicable for M1 and N1 vehicles only.

Note: Part 1 focuses for M1 and N1 vehicles on 50 km/h and medium acceleration (0,8-1,3 m/s^2 typically).

The need for an additional part 2 besides a part 1 has its origin in the following:

Type approval:

1. ISO 362:1998 is closely related to the method which is currently in use in the EU and UN/ECE for type approval of vehicles (70/157/EC, respectively R51 and R59). The operation conditions of ISO 362 part 1 intends to better reproduce the noise emission of the total vehicle as it is found during normal driving in urban traffic. This leads to a shift in operation conditions: The part 1 proposal leads to relatively lower engine speeds compared to ISO 362:1998.
2. ISO 362:1998 is also used for the type approval of replacement exhaust systems (70/157/EC, respectively R59). The operation conditions of ISO 362 should therefore incorporate a condition which is suitable for determining the acoustical quality of the exhaust system. It is shown [12] that the ISO 362:1998 is better suitable for this task than the part 1 proposal.
3. The ad hoc group of UN/ECE GRB has discussed ISO 362 part 1 as a candidate for amending the current measurement method. They have agreed on the shift in operation condition under the condition of additional testing at a higher engine speed compared to the current part 1 condition. The current test method (R51.02 or ISO 362:1998) is used as placeholder for this type of testing.
4. In this light ISO 362:1998 can not be deleted as ISO standard, but should at least be kept as placeholder for a future ISO 362 part 2.

Urban driving

5. Extensive studies were made (and are still being made) on urban driving behaviour of road vehicles and it was found that this type of behaviour, however not belonging to the "normal" driving pattern, is found especially in areas with high housing densities where crossings, roundabouts and other traffic controlling devices are situated.
6. The transient behaviour of road vehicles is found to exhibit a stronger dose-effect relation, meaning that the noise exposure due to transient (single-event) traffic behaviour leads to higher annoyance and physiological response than that of free flowing traffic with the same noise exposure level.
7. The noise emission of vehicles under the part 2 type of driving is not well correlated to the noise emission under the part 1 type of driving. This may lead to a different ranking of vehicles and a different contribution of sub sources under the two test circumstances.

The part 2 proposal should close the gap between ISO 362:1998 and the part 1 proposal. Part 2 should

- use the systematic of target acceleration conditions as proposed in part 1

- lead to similar vehicle operation conditions as ISO 362:1998

3 BACKGROUND INFORMATION

3.1 Driving states in urban traffic

The part 1 measurement method focuses on 50 km/h moderate acceleration (typically 0,8 – 1,3 m/s2). This driving condition is representative for main street operation with a normal driving behaviour, as it was analysed from data originally made available by ACEA [2]. This choice for main streets and normal driving behaviour clearly reflects the scope of reproducing the noise of the principle noise sources during normal driving in urban traffic.

In the underlying figures and tables, data is presented, which demonstrate the relevance of a complementary driving condition at a significant higher acceleration. This driving condition is thought to be connected to a different attitude of the driver. Various researchers have investigated this driving behaviour and called it “hectical”, “sporty” or “faster than most of the others” etc.

- Fig 1 shows data from FIGE on the acceleration in different driving styles. The acceleration in the normal driving style complies with the acceleration of the part 1 proposal. The acceleration in the hectical driving style is about 60% higher.
- Fig 2 shows data from an M+P investigation in the Netherlands with radar measurements of vehicles pulling away from a round about. The “average” acceleration is comparable with the acceleration as found by FIGE for the “normal” driving behaviour. The 90-percentile of the measured group of vehicles complies with the “hectical” driving style of FIGE.
- Table 1 shows data from a French survey in to driving styles as mentioned by TNO [6]. 23% of the drivers can be stipulated as “above average” (sporty or aggressive).

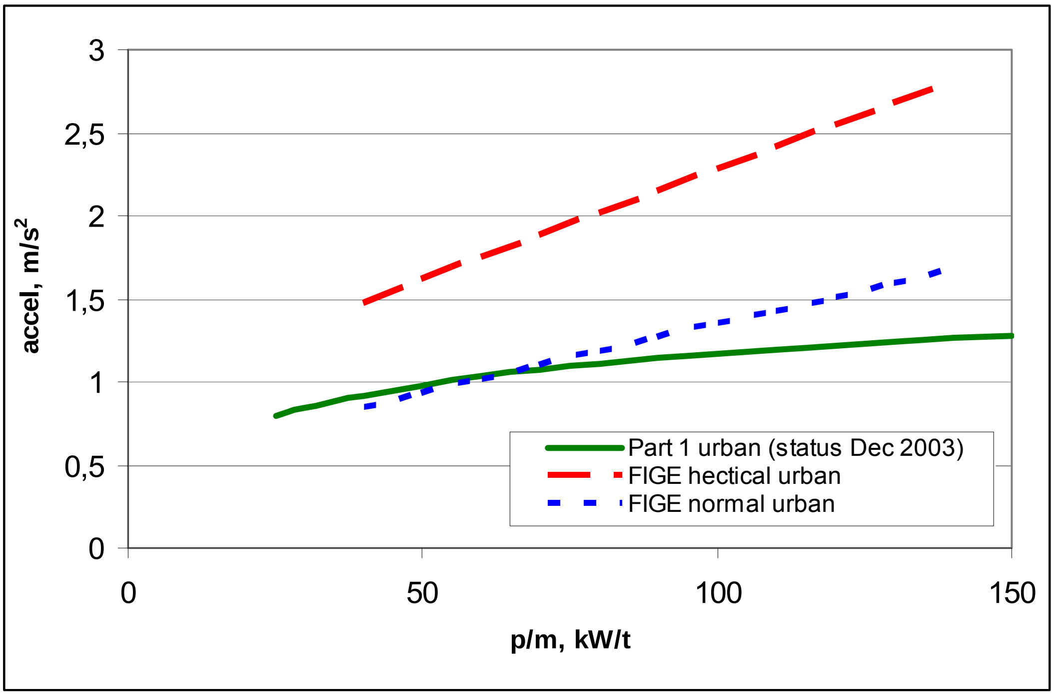

Fig 1 Acceleration as a function of power to mass ratio in different driving styles (FIGE data, [8]) compared to the acceleration in the current ISO 362 and the part 1 proposal.

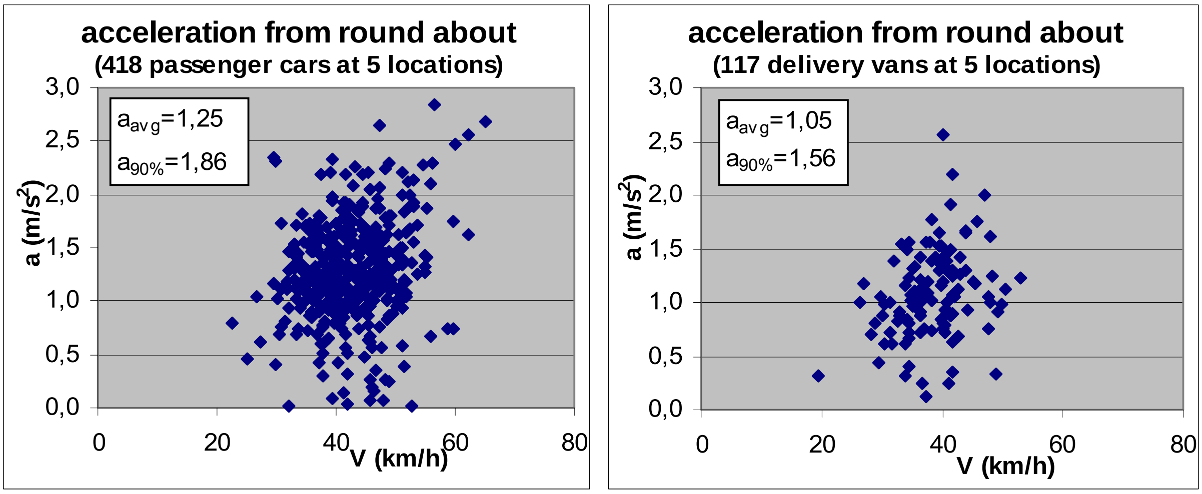

Fig 2 Speed-acceleration distribution of radar measurements at various roundabouts. Distance after round about: 20-50 m (M+P data).

Table 1. Typology of car drivers in France [6]

Quiet, disciplined and fuel saving drivers	26%
Rather quiet and slightly fuel saving drivers	23%
Fast and anticipating drivers	23%
Sportive and no fuel saving drivers	15%
Aggressive and obtrusive drivers	8%
Others	5%

3.2 dose effect relation

Literature on traffic noise annoyance

There is a great variety of literature on this theme. Most researchers end with the conclusion that the equivalent noise immission correlates best with the annoyance. Often it is recognised that signals with some serious peaks or signals with tonal components are more annoying than steady noise signals. Yet as soon as the number of peaks increases, as most of the time with traffic noise, the equivalent level appears to be the best descriptor.

Traffic noise calculations are also based on the Leq. This means that a great number of silent vehicles might dominate in the Leq over a small number of loud vehicles. This is why the traffic noise is mostly dominated by passenger cars, although the noise emission of a single passenger car is much lower than the emission of a truck.

Most literature is based on questionnaires and population surveys, where passive annoyance, reminded disturbance, health effects and other long term effects are investigated. Most likely long-term effects are more correlated to the long term Leq.

Some researchers have investigated the question in more detail. Van Dongen [6] concluded that accelerating traffic is more annoying than free flow traffic at the same Lden. From the people who are annoyed by traffic noise 37% are especially annoyed by accelerating vehicles. He suggests a different dose-effect relation for accelerating vehicles and free flow traffic. In another study focused on special vehicles (taxi's, busses etc) he found that the noise of accelerating vehicles is the most annoying source. Low frequency noise of busses and driveline noise of busses are some of the most annoying specifically mentioned sub sources.

Pilot Investigation subjective annoyance versus noise level

In order to answer the questions somewhat more specific than in literature, a small pilot study was set up. On various urban locations in front of the adjacent dwellings, the following parameters where registered during 10 minutes in 10 second periods:

- Leq during 10 second periods
- Subjective annoyance in this period (judged by 2 "trained" observers in situ)
- Traffic situation causing this annoyance (stream/ single vehicle, acceleration/fixed speed etc)

Based on this limited study, the following observations were made:

- Per location there is a reasonable correlation (R^2 = 65%) between the 10 sec Leq and the 10 sec subjective annoyance. This 10 sec Leq correlates better to annoyance than the 10 sec L_{MAX} (R^2 = 51%).
- There is weak correlation (R^2 = 23%) between the 10 minute Leq and the 10 minute average annoyance per location.
- A noise immission signal with many fluctuations and clearly identifiable sources is more annoying than a signal with the same Leq but a steady level and without clearly distinguishable sources.

From these observations it was concluded that the noise of single events is more annoying than the noise of a steady traffic stream at the same Leq. The long term averaged noise level as caused by traffic streams is more or less accepted as a status quo, and therefore less correlated to the short term annoyance. These findings correlate well with the conclusions of Van Dongen mentioned above.

New insights

A new source of interesting information is being brought forward from the EU 5th framework SVEN project where vehicle driving behaviour and the character of its noise sources is brought into relation with the subjective and physiological response of listeners. Although the project is not finished yet, interesting results are already available and were discussed between the project leader and M+P.

They found similar findings as mentioned above. The noise of single events and/or interrupted flows is more annoying than the noise of a steady traffic stream at the same Leq. Furthermore they stressed that the equivalent sound level and the A frequency weighting are not adequate to describe subjective responses to vehicle noise and they recommend more advanced frequency and time weighting functions.

3.3 Vehicle target conditions in regulatory discussions of UN/ECE GRB

The ad hoc group of UN/ECE GRB has discussed the ISO 362/CD part 1 as a candidate for amending the current measurement method. During the discussions, the test conditions where drafted in a graph which is reproduced in figure 3. Three areas of potential test conditions where identified:

- The part 1 test conditions where identified as “green area” where most of the driving occurs. This test was thought to be most relevant in connection to equivalent urban noise levels.
- The present test conditions where identified as “red area”. The ad hoc group has identified that there is still a need to test in this red area, because it is thought to be relevant for worst case situations [11].
- The area at higher engine speeds than the current test was thought to be not relevant for a noise test, because this kind of driving is hardly found in urban traffic, other than emergency or abuse.

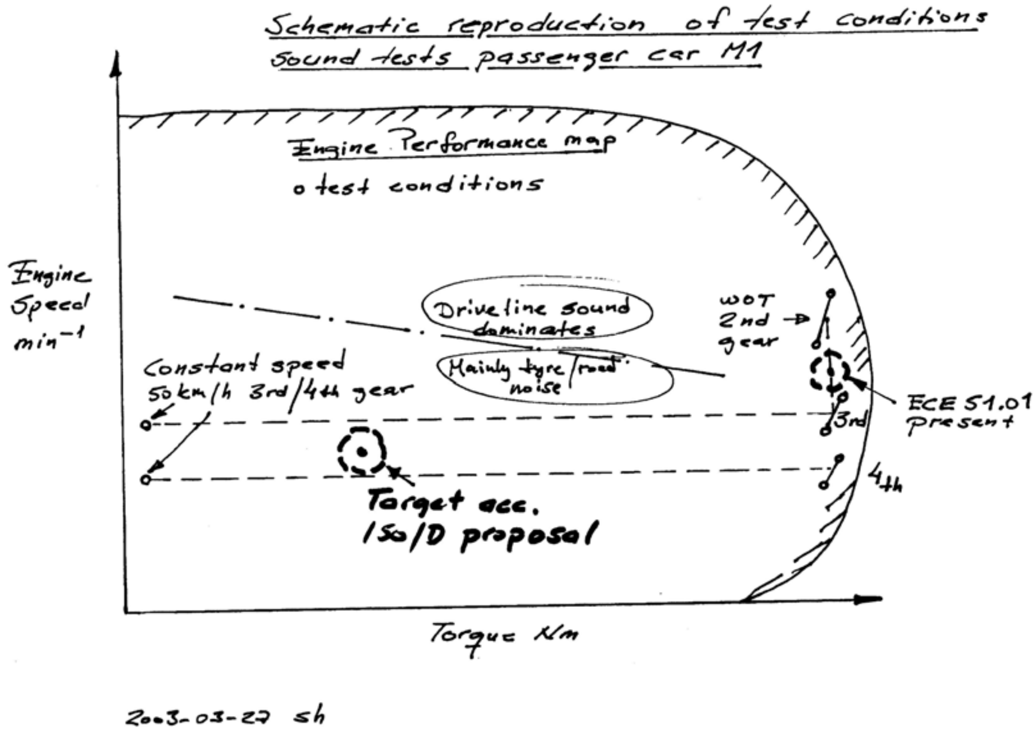

Fig. 3 Schematic reproduction of test conditions [9]
- “ECE 51.01 present” is equivalent to “current ISO 362”
- “ISO/D proposal” is equivalent to “ISO 362/CD” (part 1)

Recently UN/ECE GRB has discussed the amendment of the regulation for replacement exhaust silencers (R59). In its February 2004 meeting GRB has postponed further discussion of R59 until more clarity about the measurement method of R51 has been given.

4 OUTLINE OF A PART 2 MEASUREMENT METHOD

Apart from the driving condition, the test protocol (lay out of test track, vehicle categories, loading etc) should be as close as possible to that of part 1.

With respect to the operation condition, we propose to use a strategy similar to that used in defining the part 1 measurement method:

1. Choice of a realistic operation condition that is frequently encountered in urban traffic and fits within the scope.
2. Simulation of this operation condition on base of repeatable and reproducible measurement procedure

4.1 Target urban operation condition

The following background information and boundary conditions have been used for the construction of the target condition:

1. The operation conditions (especially engine speed and load) should be close to those of ISO 362:1998
2. The target acceleration should be close to the urban acceleration as found in single events as well as in hectical driving behaviour;
3. The engine speed at the end of the track should be close to the maximum engine speed of the WOT control zone of the German OCEP proposal in GRB;
4. First gear operation should be avoided, in order to keep away from too high transient behaviour and engine speeds above rated engine speed.

4.2 Simulation of this operation condition on the test track

Based on the above mentioned requirements a best fitting operation condition is calculated and defined by:

1. accelerator position: WOT
2. vehicle speed: $v_{target,PP'}$ = 50 km/h
3. acceleration: $a_{,WOT,target}$ = 0,6318 + 0,0231*PMR for PMR < 50

   $a_{,WOT,target}$ = 2.7*Log(PMR) – 2.8 for PMR ≥ 50

This operation condition should be reconstructed on the test track by driving in two consecutive gears: gear i with an acceleration higher than the target acceleration and gear i+1 with an acceleration lower than the target acceleration. Linear interpolation will determine the weight of the two measurements in the final result.

A pre acceleration phase between line DD' and line AA' should guarantee that the full acceleration potential of the vehicle is reached between AA' and BB'. The correct distance between DD' and AA' may vary per vehicle type and/or gear box type.

Calculation of the final noise values is similar to the procedure of part 1.

4.3 Expected operation on the test track

The consequences for the individual vehicles are expected to be:

1. Part 2 results in an acceleration, which is about 65% higher than the WOT target acceleration of part 1;
2. Part 2 results in an engine speed which is about 50% higher compared to part 1.
3. Part 2 results in the use of 2nd and 3rd gear, where part 1 mainly results in 3rd and 4th gear.
4. The amount of test work in part2 is typically 50% compared to the amount in part 1 (only WOT testing, no cruise-by testing). When part 1 and part 2 are measured consecutive, some measurements (typically the 3rd gear WOT measurements) can be used for both parts. In individual cases part 2 may even use all measurements from part 1 and require recalculation of results only.
5. In some individual cases the engine speed in gear i during the test might be close to, or even exceeding rated engine speed. Especially in those cases where rated engine speed is relatively low compared to governed speed. This is a point of concern and should be investigated further.

However, the above mentioned target conditions and expected consequences are based on the limited amount of data available at M+P. Vehicle industry and several institutes have additional sources of data. They are called upon to analyse the consequences of these target conditions for the vehicles in their dBase and report any deviations from the target and other peculiarities.

5 WORK TO BE DONE

We propose the following work and planning:

1. Collection of comments and additional data: March 2004
2. Discussion in GRB ad hoc Annex 10: March 2004

Depending on the status of discussion in GRB ad hoc group on Annex 10

3. First Working Draft: May 2004
4. Testing with vehicles: spring/summer 2004
5. New Work Item Proposal December 2004

6 REFERENCES

[1] ISO WG42; ISO 362 – part 1- working paper rev 18 Sept 2002
[2] ACEA; Statistical background for the ACEA-proposal; GRB Feb. 2000; informal doc. 4
[3] R. le Salver; ACEA proposal for a new method to measure the noise emitted by a car in urban driving conditions; internoise 2001
[4] JAMA; Study on pass-by noise testing methods incorporating urban driving conditions; ISO/TC43/SC1/WG42/D134B also presented in GRB Sep 2000 inf.doc. 2
[5] U. Sandberg & H. Steven; An improved procedure for measurement of vehicle noise emission – background and outline; ISO/TC43/SC1/WG42/D172, also presented in GRB Feb 2002
[6] J.E.F. van Dongen; Prevalence of acceleration at low speed and driving at constant low speed and the influence on community annoyance; TNO-PG; GRB Feb 2001 informal document 8
[7] D.F. de Graaff; A speed and acceleration limit in the noise type approval of vehicles will enable silent cars to reveal their silence; internoise 2001
[8] H. Steven, Investigations on Improving the method of noise measurement for powered vehicles, FIGE report 10506068, December 1998
[9] Hedberg, Schematic reproduction of test conditions; CRP 008; GRB ad hoc group; March 2003
[10] H. Steven, Off cycle emission provisions; CRP 006; GRB ad hoc group; March 2003
[11] Minutes of the GRB Informal Group, 4th meeting, agenda item 6; Informal doc 2; TRANS-WP29-GRB-38;July 2003
[12] D.F. de Graaff, Measurement Results Demo Le Var; CRP-005; GRB ad hoc group March 2003

7 BACKGROUND DATA

The consequences of the above mentioned target conditions have been calculated by M+P for a dBase of 36 vehicles. The data for this calculation have been kindly supplied by ACEA members in ISO WG42.

The curves for part 1 are based on the status of discussion in September 2003. In October 2003 the target acceleration curve was updated on the basis of an extended dBase of 200 vehicles. ACEA has been asked to update the figures below on the base of this new proposal and extended dBase.

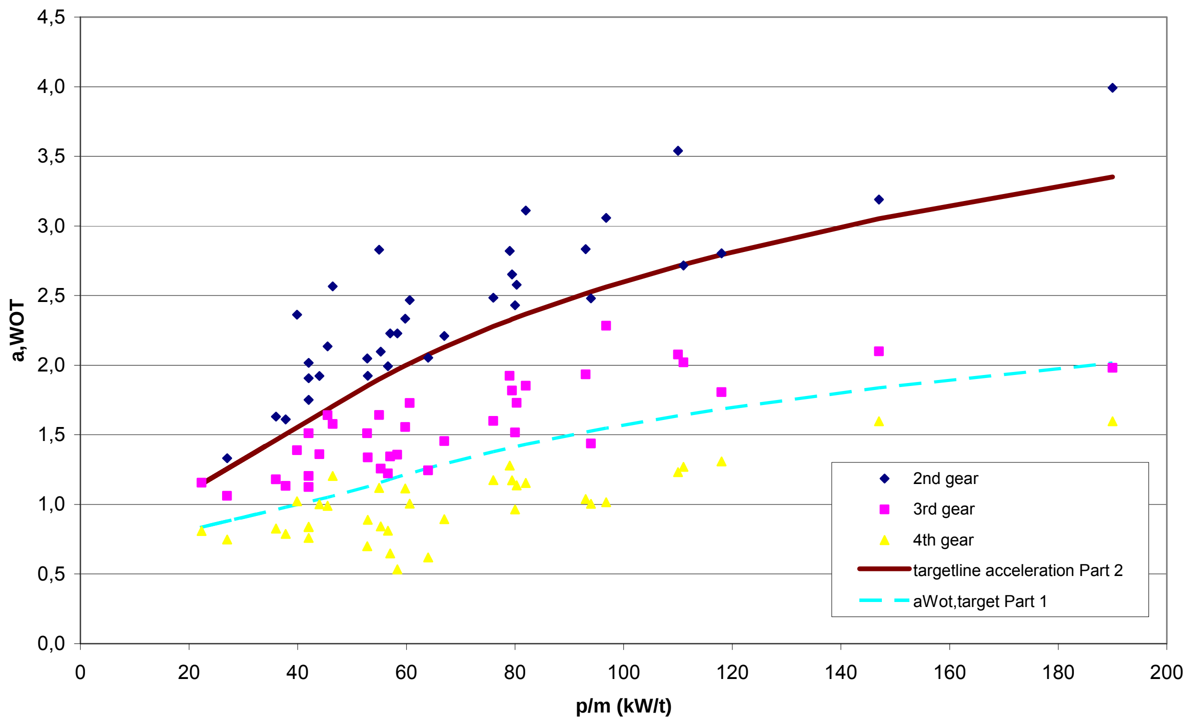

Fig. 5 The target acceleration of the proposed part 2 method compared to the measured acceleration in various gears for 36 vehicles. Also given is the WOT target acceleration of part 1 (status 2002).

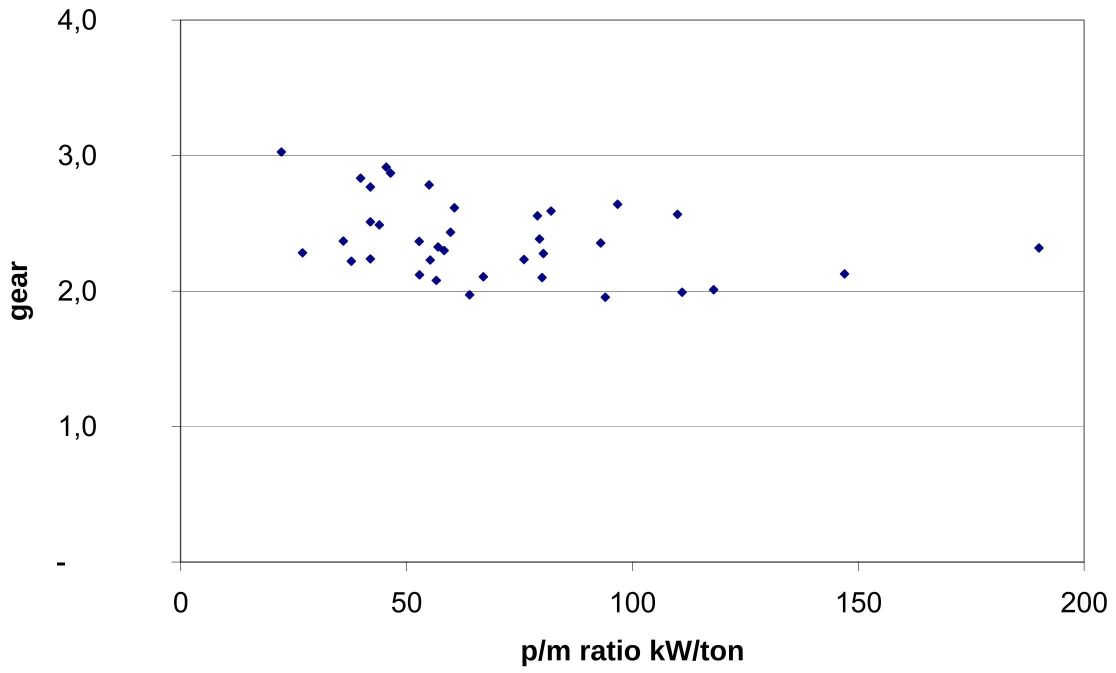

Fig. 6 The calculated gear for 36 vehicles following the proposed part 2 method (weighted average of two gears).

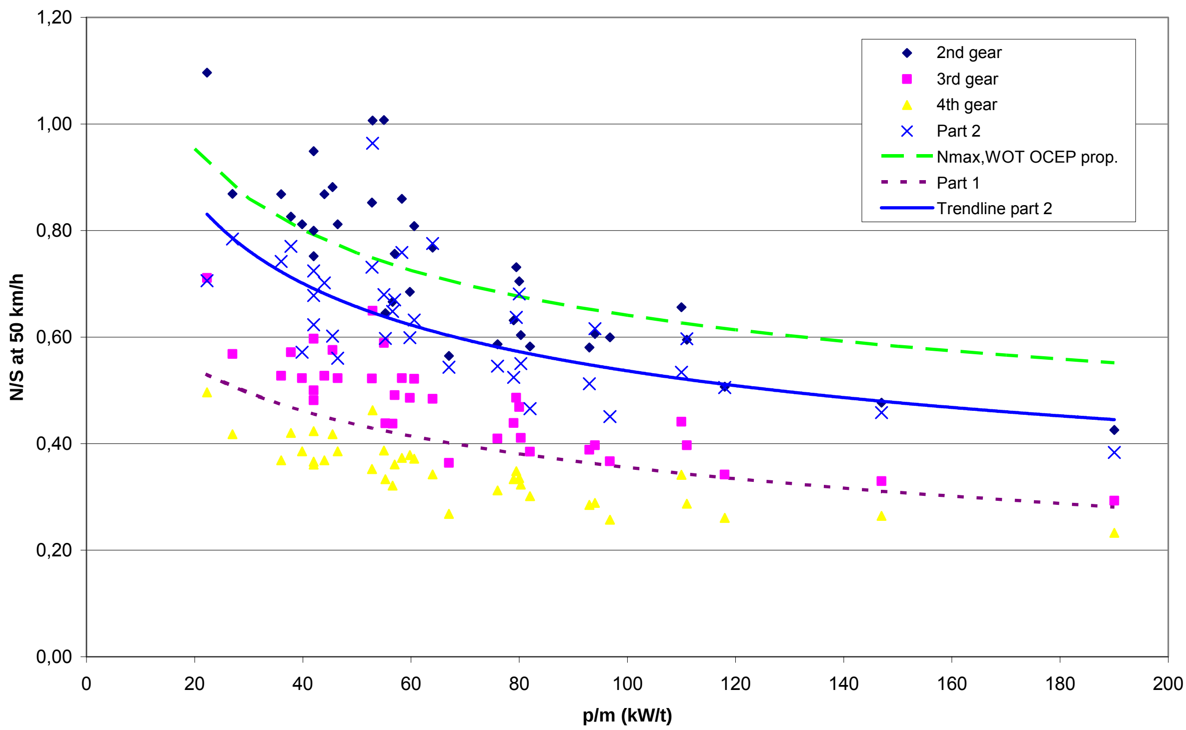

Fig. 7 The calculated engine speed for 36 vehicles following the proposed part 2 method (weighted average of two gears) compared to the engine speed at 50 km/h in several gears. Also given is the engine speed in part 1 (status 2002) as well as the maximum engine speed of the WOT control zone in the GRB OCEP proposal of Germany.

NOTE: The (green dashed) OCEP curve shows a maximum value. All other data show values in the middle of the test track (line P-P'). Due to transient behaviour, the part 2 values at line B-B' are expected to be in line with the OCEP proposal.