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Development of a World-wide Worldwide harmonized Light duty driving Test Cycle (WLTC)

~ Technical Report ~

UN/ECE/WP.29/GRPE/WLTP-IG
DHC subgroup

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Author:
Monica Tutuianu[1], Alessandro Marotta[1], Heinz Steven[2], Eva Ericsson[3],
Takahiro Haniu[4], Noriyuki Ichikawa[5], Hajime Ishii[6]

1 European Commission - Joint Research Centre (Italy)
2 Data analysis and Consultancy (Germany)
3 WSP Analysis & Strategy (Sweden)
4 Japan Automobile Research Institute (Japan)
5 Japan Automobile Standards Internationalization Center (Japan, DHC Technical Secretary)
6 National Traffic Safety and Environment Laboratory (Japan, DHC Chair)

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1. Introduction

The development of the WLTC was carried out under a program launched by the World Forum for the Harmonization of Vehicle Regulations (WP.29) of the United Nations Economic Commission for Europe (UN-ECE) through the working party on pollution and energy transport program (GRPE). The aim of this project was to develop a World-wide harmonized Light duty driving Test Cycle (WLTC), to represent typical driving characteristics around the world, to have the basis of a legislative worldwide harmonized type certification test from 2014 onwards.

Driving cycles are produced by different countries and organizations and used to assess the performance of vehicles, such as pollutant emissions, fuel consumption and traffic impact. There are two main categories of test cycles: legislative cycles employed in type-approval tests for vehicles emissions certification and non-legislative cycles mainly used in research. Several international harmonized engine dynamometer cycles have been developed for engine emission certification of heavy-duty and non-road engines (WHSC, WHTC, NRTC). A worldwide harmonized test cycle has been developed also for motorcycles emissions (WMTC).

For Light-Duty (LD) vehicles, various vehicle dynamometer test cycles are employed in type-approval tests for emission certification. Such test cycles are: the NEDC[1] used in Europe, JC08[2] applied in Japan, the UDDS (FTP-75)[3] used in the United States. The NEDC cycle includes four urban driving cycle (ECE) segments characterized by low vehicle speed, low engine load, and low exhaust gas temperature, followed by one extra-urban segment to account for more aggressive and higher speed driving. JC08, represents driving in congested city traffic, including idling periods and frequently alternating acceleration and deceleration. In the U.S, currently the Federal Test Procedure (FTP-75) is used for emission certification of cars and light duty trucks. The US FTP -75 is a transient cycle produced from real measurements in Los Angeles and it represents only a specific region in the US.

Each of these driving cycles has advantages and drawbacks/disadvantages. For example, NEDC, which consists of several steady-steady test modes, is quite simple to drive and thus repeatable. However, it is well known that NEDC does not represent real driving behavior of a vehicle in actual traffic thus, does not necessarily reflect pollutant emissions and fuel consumption. JC08 represents real driving behavior but only in congested city traffic situations and does not cover other driving conditions and road types. FTP-75 covers a wider range of driving conditions than JC08, however it is still not complete enough to cover all possible driving situations (in fact, in the USA, vehicles have to be additionally tested on a Highway cycle and two Supplemental Federal Test Procedures (SFTP) designed to address shortcomings with the FTP-75 in the representation of (1) aggressive, high speed driving (US06), and (2) the use of air conditioning (SC03)).

Therefore, when the WLTC project was started it was agreed to design a new legislative driving cycle to predict

1 UNECE. Vehicle Regulations, Regulation No. 83, http://www.unece.org/trans/main/wp29/wp29regs81-100.html

2 TRIAS 31-J042-01 TEST PROCEDURE FOR EXHAUST EMISSION MEASUREMENT OF LIGHT- AND MEDIUM-DUTY MOTOR VEHICLES (PROCEDURE FOR JC08H+JC08C-MODE)

3 CODE OF FEDERAL REGULATIONS, Title 40, Part 86, Appendix I

more accurately the exhaust emissions and fuel consumption under real-world driving conditions.

The world-wide harmonized light duty test cycle (WLTC) presented in this paper, was derived from "real world" driving data from five different regions: EU + Switzerland, USA, India, Korea and Japan covering a wide range of vehicle categories (M1, N1 and M2 vehicles, various engine capacities, power-to-mass ratios, manufacturers etc), over different road types (urban, rural, motorway) and driving conditions (peak, off-peak, weekend).

2. Objective

The objectives of the Development of the worldwide Harmonized test Cycle (DHC) group under the WLTP informal group are to develop a world-wide harmonized light duty driving test cycle (WLTC) which represents typical driving characteristics around the world and to develop a gearshift procedure which simulates representative gearshift operation for light duty vehicle.

3. Structure of the project

The development of the cycle and the gearshift procedure belong to the tasks of the WLTP Informal Group (WLTP-IG). The 3 groups were established under the WLTP informal group in order to allocate important elements to each. Figure 3-1 shows the structure of WLTP-IG.

- The Development of the worldwide Harmonized test Cycle (DHC) group aims to develop the WLTC
- The Development of Test Procedure (DTP) group aims to develop the test procedure
- The Validation Task Force team aims to manage the validation test phase 2

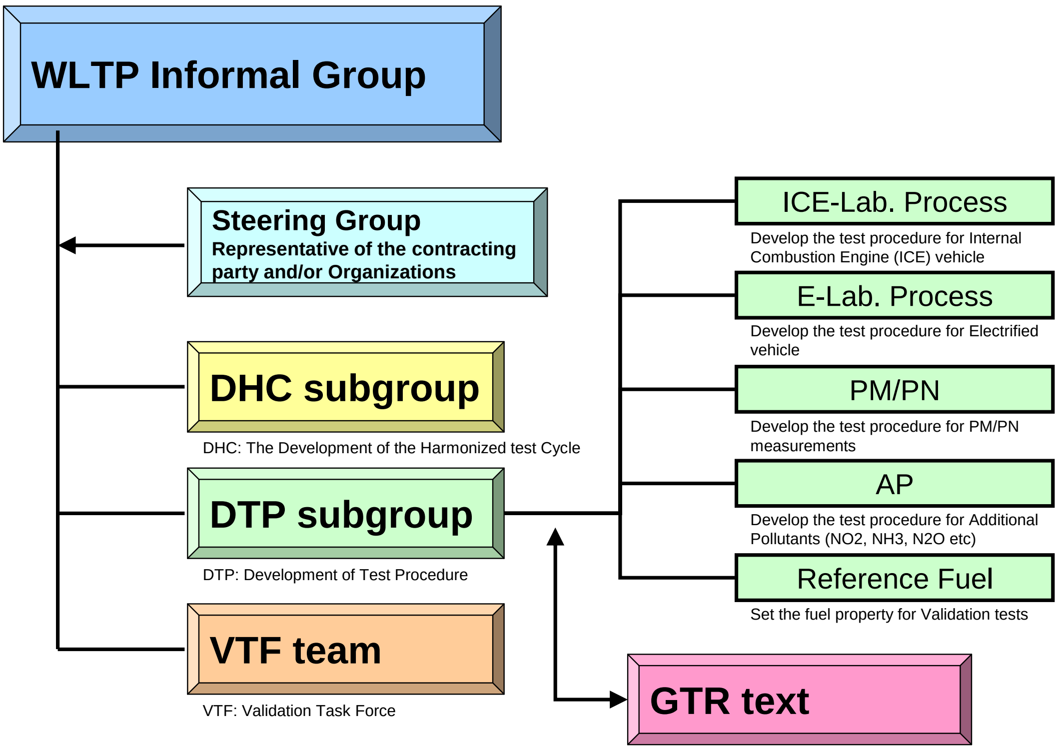


Figure 3-1 The structure of WLTP-IG

Figure 3-2 shows the overview of the WLTC development.

In the work schedule of the WLTP-IG, the two validation steps were conducted after the development of the initial test cycle and gearshift procedure. As the first step, the drivability and traceability was evaluated in the validation test phase 1. As the second step, the emission measurement results based on the proposed test procedure input from DTP group were evaluated.

Figure 3-3 shows the time schedule for Cycle development. The development of WLTC has started since September 2009.

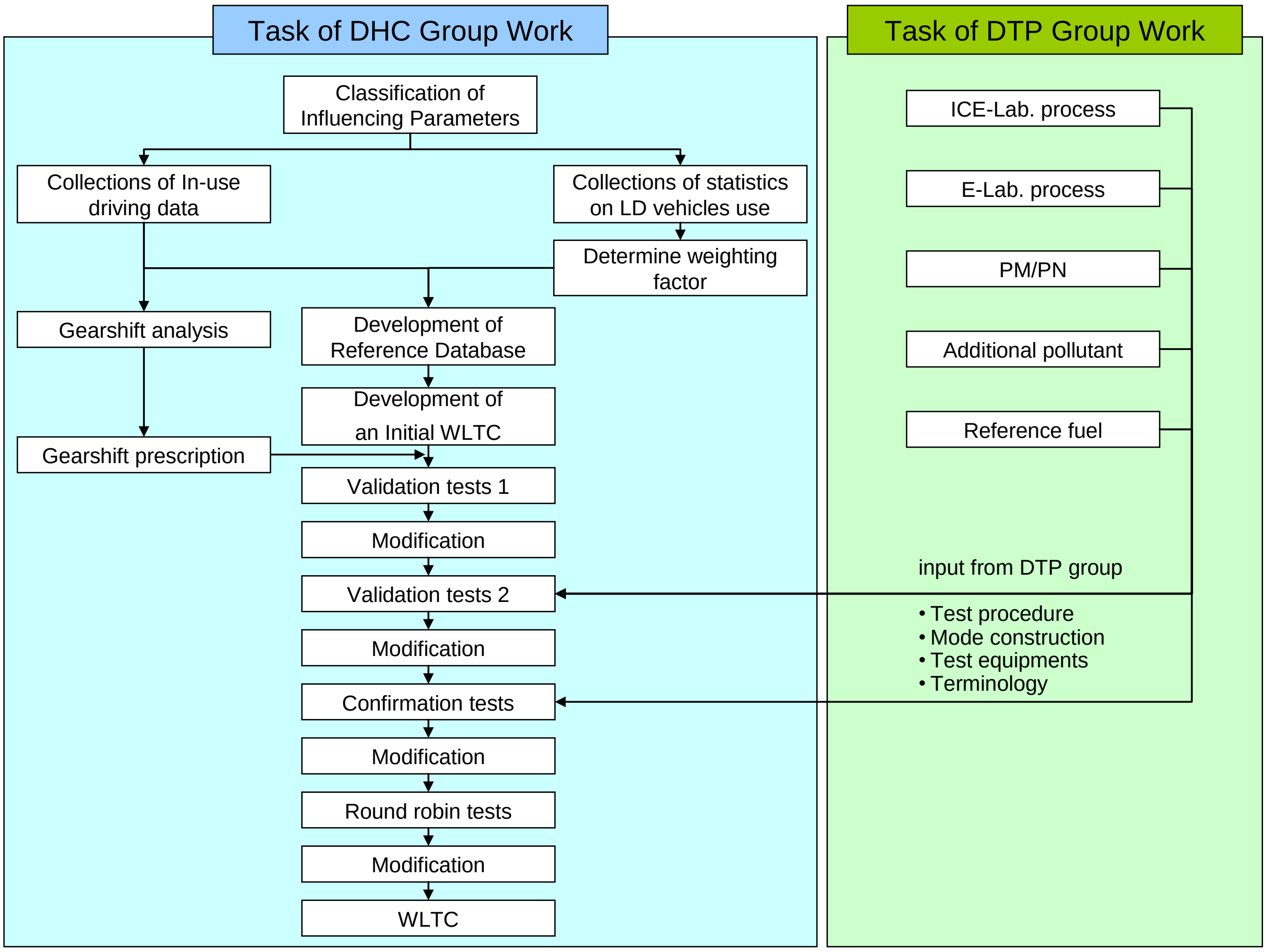


Figure 3-2 Overview of the WLTC development

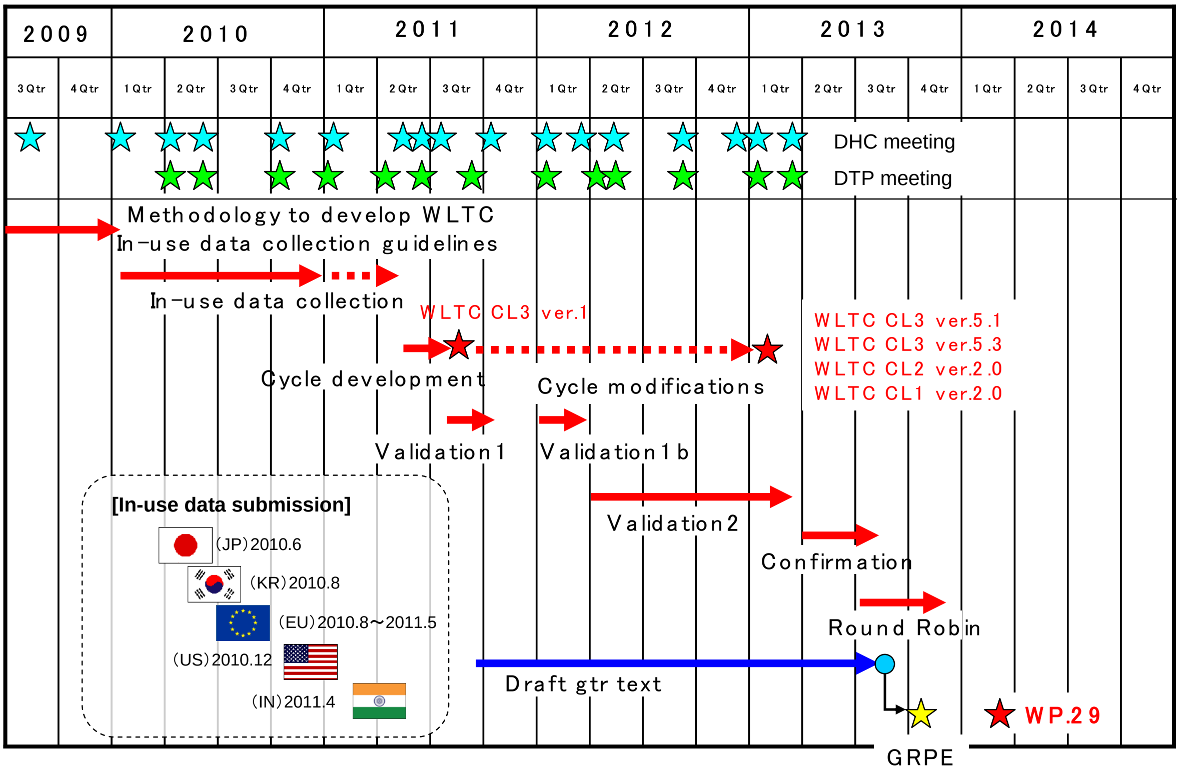


Figure 3-3 The time schedule for Cycle development

4. Cycle development

4.1. Approach

Driving behavior data and weighting factor matrix based on statistical information about light duty vehicle use in the different regions of the world were collected and analyzed as fundamentals to develop the cycle. The in-use driving behavior data were combined with the statistical information on vehicle use in order to develop a reference database that represents worldwide light duty vehicle driving behavior. Figure 4-1 shows the overview of the cycle development process Real world in-use data was collected from a range of Contracting Parties in the following regions:

- ·EU and Switzerland,
- ·India,
- ·Japan,
- ·Korea,
- ·USA,

Then, a reference database was developed. In-use data were weighted and aggregated to produce unified speed-acceleration distributions. Analysis was undertaken to determine the average short trip durations and idling times which were used to determine the number of short trips that should be included in each drive cycle phase. Short trips were combined to develop the final drive cycle.

The short trip combination and the reference database were compared on the basis of the chi-squared method for the speed –acceleration distribution. The combination of short trips with the least chi-squared value was selected as the ideal combination. After the short trip selection, the comparison of the other parameters such as average speed, Relative Positive Acceleration (RPA) etc. was conducted to check the representativity.

Finally a first draft of the WLTC was produced. The first draft had been expected to need modifying based on some evaluations of validation tests.

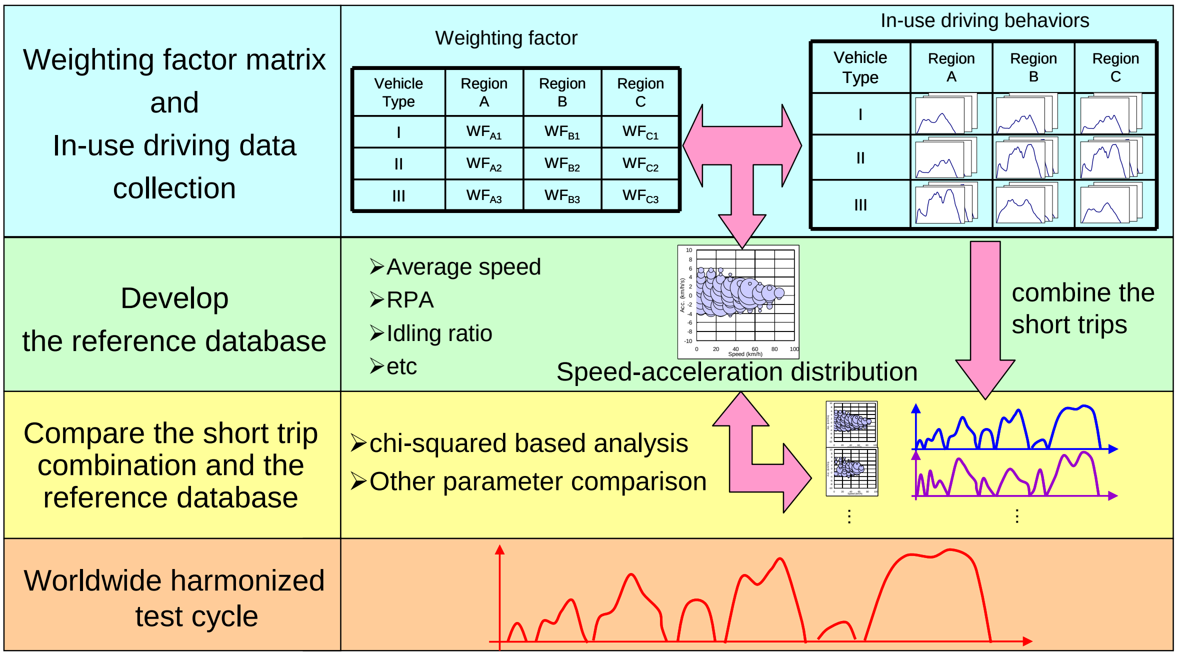


Figure 4-1 Overview of the cycle development process

4.2. In-use driving behavior data

The in-use data collection guidelines[4] were developed and agreed following a full discussion at the 1st DHC meeting held in September 2009. The each contracting party has started to gather the in-use data from January 2010.

The in-use driving data (second by second recording of time, vehicle speed, engine speed, GPS - Global Positioning System - information, in some cases also: altitude, engine load, accelerometer) used for the development of the WLTC was collected from five different regions: European Union (EU) + Switzerland (CH), USA (US), Japan (JP), Korea (KR), and India (IN). Within EU, collection campaigns have been organized in Germany (DE), Spain (ES), Italy (IT), Poland (PL), Slovenia (SI), United Kingdom (UK), Belgium (BE), France (FR) and Sweden (SE). Over 765, 000 km of data was collected covering a range of vehicle categories (M1, N1 and M2 vehicles, various engine capacities, power-to-mass ratios, manufacturers etc), over different road types (urban, rural, motorway) and driving conditions (peak, off-peak, weekend).

[4] WLTP-DHC-02-06 Draft in-use data collection guidelines

Table 4-1 summarizes the vehicle type, number of vehicles, total mileage for each region and the methodology used to collect the available in-use driving behavior data. Japan and Korea used “instructed drivers” (Drivers were instructed to follow the traffic flow), EU + CH collected data from “customer data” (drivers without any particular instruction to drive their cars). India submitted both “customer data” and “instructed drivers data”. Finally, USA submitted both “customer data” and instructed drivers using the “chase car” method. The chase cars were equipped with laser rangefinders mounted behind the front grill to measure the vehicle speed of randomly selected vehicles.

Table 4-1 Total amount of data collection (Available data)

Region/Country		Vehicle type	No. of vehicles	Method used for collection	Total amount of data collection (km)	
EU+CH	Belgium (BE)	PC	12	Customer data	106,952	106,952
		LDCV	0		0	
	Germany (DE)	PC	8		23,414	23,414
		LDCV	0		0	
	Spain (ES)	PC	6		2,619	9,666
		LDCV	4		7,047	
	France (FR)	PC	42		108,916	108,916
		LDCV	0		0	
	Italy (IT)	PC	8		57,646	57,646
		LDCV	0		0	
	Poland (PL)	PC	9		14,648	14,648
		LDCV	0		0	
	Slovenia (SI)	PC	18		48,934	48,934
		LDCV	0		0	
	Switzerland (CH)	PC	26		22,670	23,619
		LDCV	4		949	
	United Kingdom (UK)	PC	10		17,491	31,781
		LDCV	12		14,290	
	Sweden (SE)	PC	5		18,525	36,951
		LDCV	2		18,426	
India (IN)		PC	16	Instructed drivers and Customer data	41,804	55,778
		LDCV	4		13,974	
Japan (JP)		PC	11	Instructed drivers	25,670	52,955
		LDCV	13		27,285	
Korea (KR)		PC	6	Instructed drivers	26,033	34,403
		LDCV	2		8,370	
USA (US)		PC	156	Instructed drivers and Customer data	130,188	159,726
		LDCV	20			
		unclear	-	Chased car	29,538	

4.3. Data Analysis Processing

The processing of the raw data involved initially filtering and thinning the in-use driving behavior data. Filtering was performed using a standard smoothing algorithm (T4253H) as described in the SPSS software[5] Reducing data frequency from 10Hz to 1Hz was necessary only for a limited amount of data as most of the data was 1Hz data. The resulting smoothed data was converted into idling and short trips portions to create short trips and idles databases for each region/country and for each part of the cycle (e.g: urban, rural, motorway phases). A series of elimination criteria have been applied to the short trip and idle databases for determining the short trips and idle periods to be excluded from the subsequent analysis (e.g. idling periods with duration higher than ten minutes, short trips with duration smaller than ten seconds, short trips with the maximum speed less than 3.6 km/h, short trips with accelerations higher than $4 m/s^2$ and smaller than $-4.5 m/s^2$ etc). The short trip and idle databases so obtained were used to determine: short trip duration cumulative frequency distributions, short trip average speed distribution, idling duration distribution which were furthermore used for developing the unified distributions.

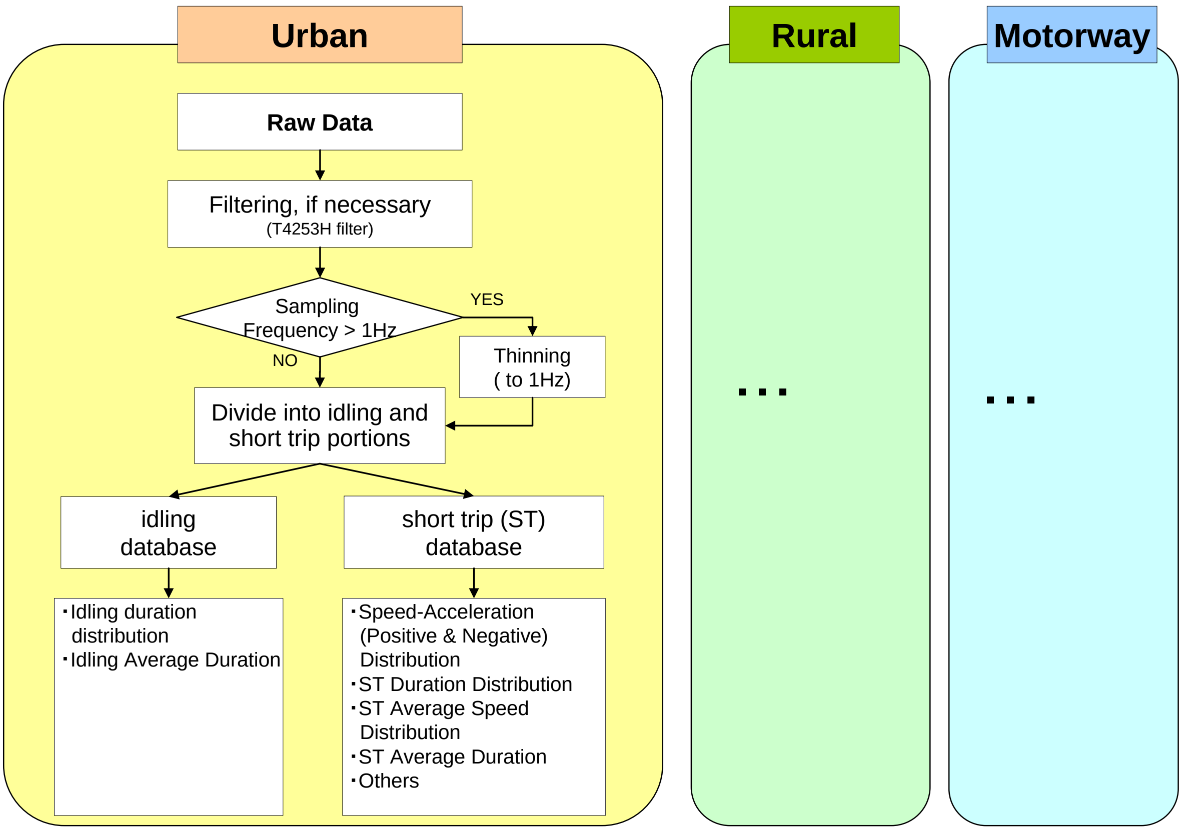


Figure 4-2 Data Analysis Processing

[5] IBM. Statistical Package for the Social Sciences (SPSS). Available from: http://www-01.ibm.com/software/analytics/spss/

4.4. The development of the world-wide harmonized light duty test cycle (WLTC)

The methodology to develop the WLTC[6] was reviewed and agreed following a full discussion at the 2nd DHC meeting held in January 2010. Then the revised methodology[7] proposed by Japan was agreed at the 6th DHC meeting.

4.4.1. Re-categorization of In-use driving data

During data analysis, it became soon evident that the road category (urban, rural, motorway) could not be used due to differences in definitions and speed limits of these road categories from different regions. (Table 4-2)

Table 4-2 Definition of Road Type in each region

	Urban	Rural	Motorway
India	Paved roads in urban areas with a **speed limit ≤40 km/hour** (exclude mountain areas)	Paved non-motorways outside and inside urban areas with a speed limit **between 40 and 60 km/hour**	Paved motorways (multi-lane roads specifically constructed and controlled for fast traffic) with a speed **60 to 80 km/hour**
Korea	Arterial, collector and local road inside and/or near central business district (CBD). **Speed limit is from 40 to 80 km/h**, depends on road type	Arterial, collector and local road inside non-urban area. **Speed limit is from 50 to 80 km/h**, depends on road type	Motorway which is designed, constructed and controlled for faster traffic in urban and rural area. **Speed limit is from 100 to 120 km/h**, depends on area
Japan	Densely Inhabited District (DID) ・**Speed limit ≤ 60km/h** ・exclude mountain areas	・Non-Densely Inhabited District ・Non motorways ・**Speed limit ≤ 60km/h** ・exclude mountain areas	Motorways (within City and between Cities) ・**Speed limit ≤ 100km/h** ・exclude mountain areas
EU	The definition depends on EU countries	The definition depends on EU countries	The definition depends on EU countries

Figure 4-3 shows the vehicle speed cumulative frequency distribution of various countries on urban, rural and motorway road types.

6 WLTP-DHC-02-05 Draft methodology to develop WLTP drive cycle
7 WLTP-DHC-06-03 WLTC methodology

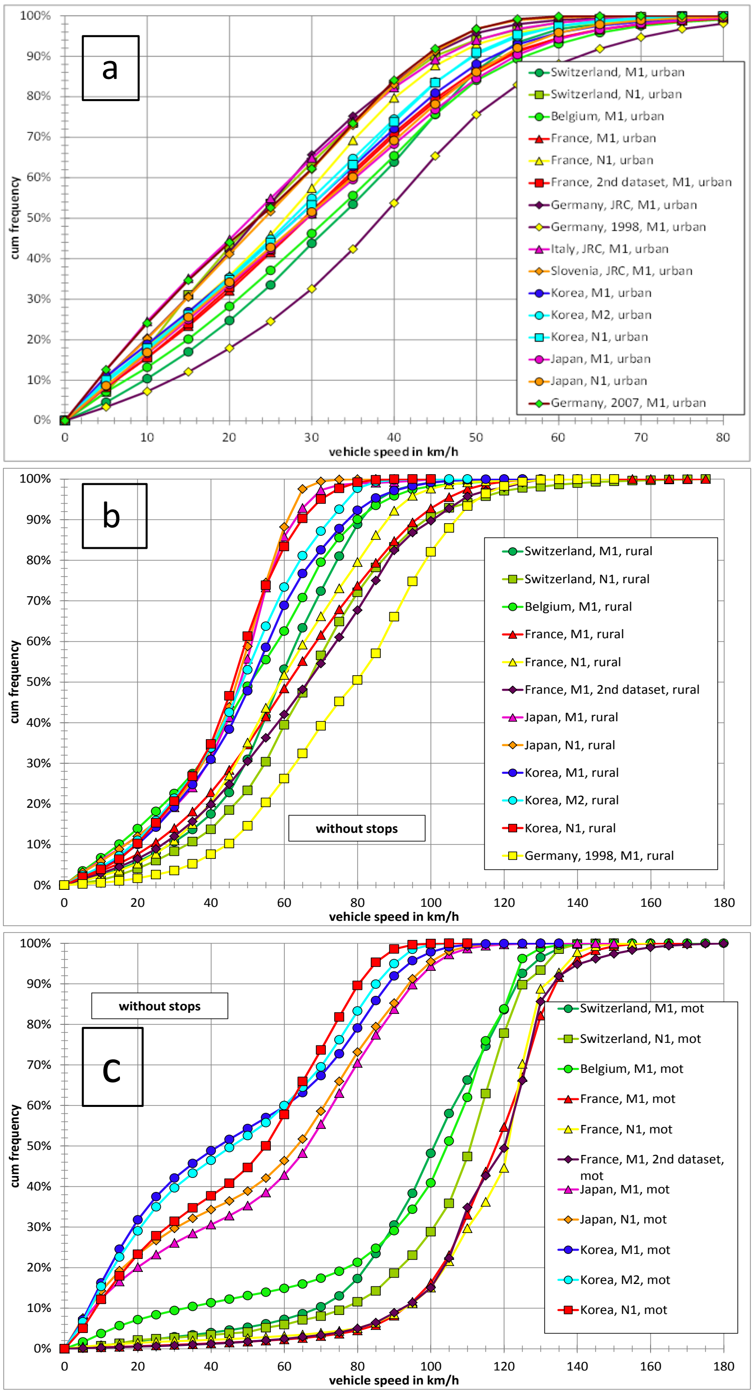


Figure 4-3 Vehicle speed cumulative frequency distribution of various countries on urban, rural and motorway roads

While for the urban road type there was encouraging evidence that all in-use driving behavior data can concur, for the rural and motorway road categories there was a clear difference between Europe on the one hand and Japan + Korea on the other hand. Figure 2 shows the speed cumulative frequency distribution for Japan and Korea almost 100% at vehicle speed of 80 km/h while for all European countries the 100% speed cumulative frequency distribution is reached at vehicle speed > 100 km/h. On motorways roads (figure 3) this difference is even higher. Korea and Japan have motorway top speed of 100km/h while in Europe the top speed is between 120-140 km/h. This was further confirmed when the Indian and USA in-use driving behavior data were added to the world-wide database. Therefore, it became necessary to develop the WLTC cycle on speed classes (low, medium and high speed) rather than on road categories (urban, rural, motorway). Furthermore the high speed phase was split in two segments: one high speed phase with a top speed value representative of Asian driving and one extra-high speed phase with a top speed more characteristic to the European and USA driving. Eventually, the world-wide harmonized test cycle (WLTC) consists of four speed phases (low, medium, high and ex-high). Having decided to develop the WLTC in four phases, a crucial aspect was to establish the speed limit between the four phases. The threshold vehicle speed between the Low/Medium/High and Extra High phases, was chosen after a comparative study for different candidate criteria (low speed < 50 km/h / medium speed < 70 km/h / high speed < 110 km/h / ex-high > 110 km/h]; [50/80/110]; [50/80/120]; [50/90/110]; [50/90/120]; [60/80/110]; [60/80/120]; [60/90/110]; [60/90/120]; [70/90/110]; [70/90/120]; [70/100/120]) was performed. Figure 4-4 and Figure 4-5 present the speed-acceleration distributions for each region for some of the above mentioned combinations. As can be seen, the best compromise in terms of similarity of speed-acceleration distribution of each region and the unified values of the parameters (average speed, short trip duration distribution, idle duration distribution) could be obtained with threshold speed values of 60/80/110 between the phases.

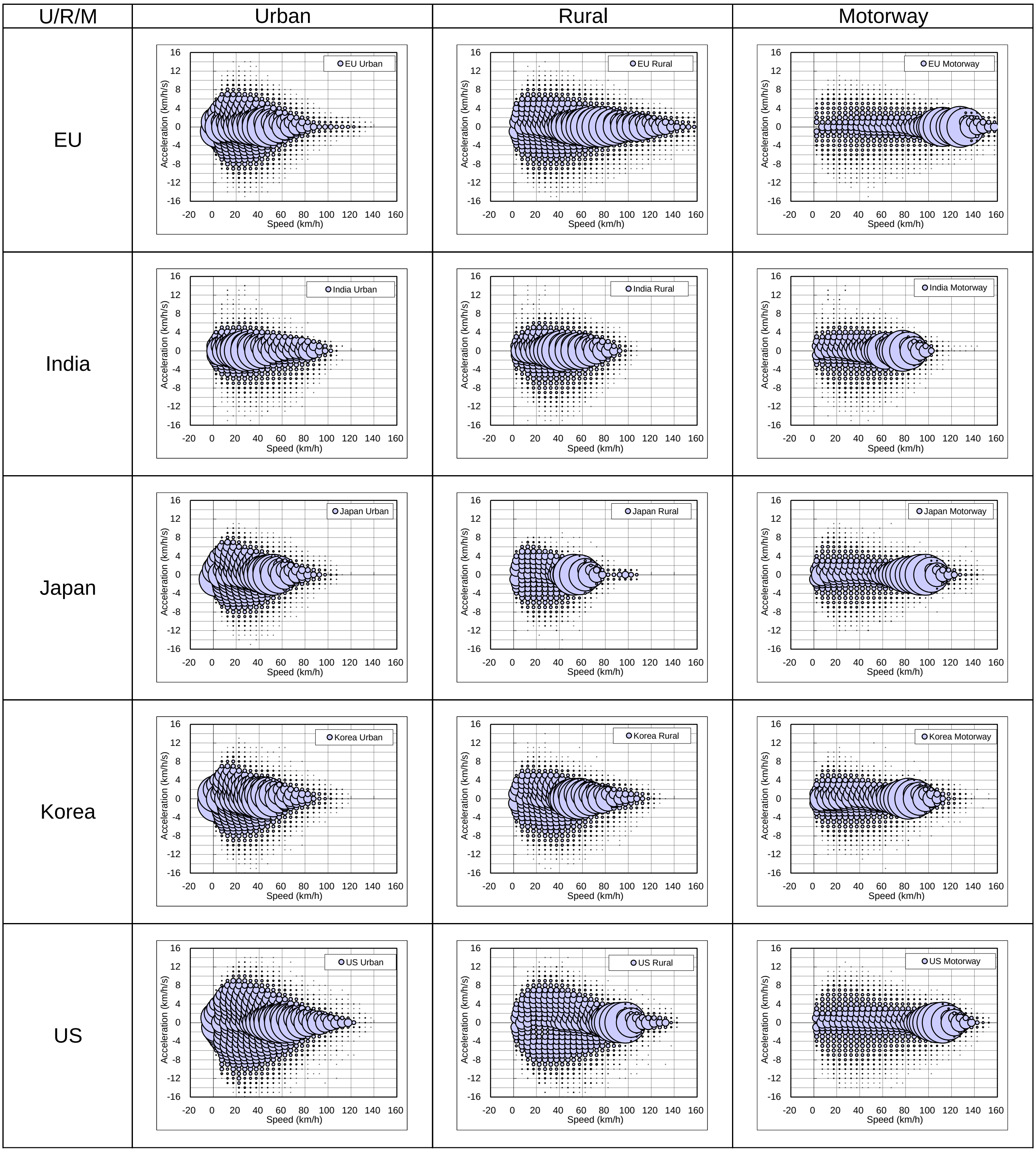


Figure 4-4 Speed–acceleration distribution in U/R/M category

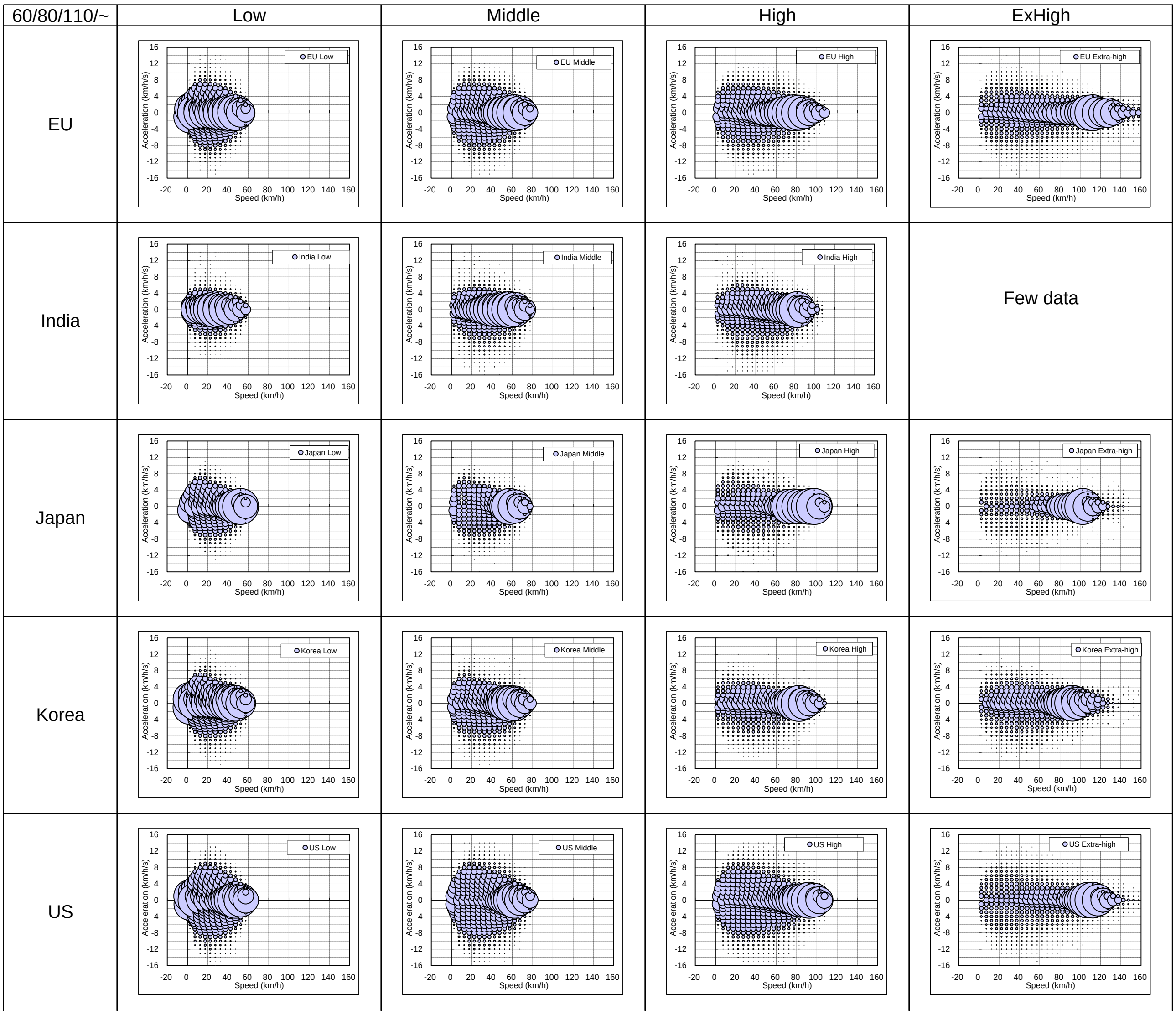


Figure 4-5 Speed–acceleration distribution in L/M/H/ExH category [60/80/110]

4.4.2. Statistics and Regional weighting factor

The driving cycle was developed from recorded in-use data ("real world" data) from different regions of the world (EU, India, Japan, Korea, USA) combined with suitable weighting factors. Regional weighting for L/M/H/Ex-H phases was necessary to represent each region driving characteristics when developing the unified distributions and harmonized cycle. The weighing factors were based on traffic volumes (current and foreseen) of each party. To derive such weighing factors the starting point was the national traffic statistics [8](as shown in Table 4-3).

[8] EU: TREMOVE http://www.tremove.org/, INDIA: WORLD ROAD STSTISTICS 2009 DATA 2002-2007 (http://www.irfnet.org/statistics.php), JAPAN: Road Traffic Census Data 2005 (MLIT), USA: EPA

Table 4-3 Traffic volume (vehicle hours)

Region		Traffic volume (vehicle hours)				Traffic volume ratio (%)			
		Urban	Rural	Motorway	Total	Urban	Rural	Motorway	Total
World-wide	EU	3.30E+10	3.02E+10	4.73E+09	6.79E+10	48.5	44.5	7.0	100.0
	US	4.95E+10	2.01E+10	1.97E+10	8.93E+10	55.4	22.5	22.1	100.0
	JP	1.10E+10	6.46E+09	1.30E+09	1.88E+10	58.7	34.4	6.9	100.0
	KR	4.26E+09	1.51E+09	2.64E+09	8.42E+09	50.6	18.0	31.4	100.0
	IN	2.10E+10	7.22E+09	1.53E+09	2.98E+10	70.6	24.2	5.1	100.0
	Total	1.19E+11	6.55E+10	2.99E+10	2.14E+11	55.4	30.6	14.0	100.0
EU+CH	BE	5.46E+08	1.02E+09	2.39E+08	1.80E+09	30.3	56.4	13.3	100.0
	DE	5.83E+09	4.24E+09	1.12E+09	1.12E+10	52.1	37.9	10.0	100.0
	ES	4.51E+09	3.71E+09	2.83E+08	8.51E+09	53.1	43.6	3.3	100.0
	FR	5.35E+09	5.37E+09	8.59E+08	1.16E+10	46.2	46.4	7.4	100.0
	IT	2.19E+09	3.23E+09	6.13E+08	6.03E+09	36.3	53.5	10.2	100.0
	PL	8.41E+08	1.45E+09	3.23E+07	2.33E+09	36.1	62.5	1.4	100.0
	SI	1.23E+08	7.55E+07	1.89E+07	2.18E+08	56.7	34.7	8.7	100.0
	UK	7.07E+09	3.83E+09	5.31E+08	1.14E+10	61.8	33.5	4.6	100.0
	CH	7.23E+08	1.05E+09	1.97E+08	1.97E+09	36.7	53.3	10.0	100.0
	SE	-	-	-	1.31E+09	-	-	-	100.0

After subdividing the database of each party into these four speed phases, the time percentage of each of them was multiplied by the total vehicle hour of the party, obtaining the vehicle hour for each speed class and each party (see Table 4-4). For India an exception was applied (total traffic volume increased by 50% in the light of the predicted increase over next years). From this, the weighing factors as shown in Figure 4-6 were defined.

Table 4-4 Traffic volume ratio between the L/M/H/ExH phase [million vehicle hours]

Region	Traffic volume (vehicle hours)					Traffic volume ratio (%)				
	Low	Middle	High	Ex-H	Total	Low	Middle	High	Ex-H	Total
EU+CH	2.33E+10	1.24E+10	1.57E+10	1.64E+10	6.79E+10	34.4	18.3	23.2	24.1	100.0
US	1.59E+10	2.26E+10	2.95E+10	2.13E+10	8.93E+10	17.8	25.3	33.1	23.8	100.0
JP	1.11E+10	6.16E+09	1.16E+09	3.28E+08	1.88E+10	59.3	32.8	6.2	1.7	100.0
KR	4.05E+09	1.84E+09	2.09E+09	4.43E+08	8.42E+09	48.1	21.8	24.8	5.3	100.0
IN	1.56E+10	8.47E+09	5.64E+09	6.42E+07	2.98E+10	52.4	28.4	18.9	0.2	100.0
World-wide	7.00E+10	5.15E+10	5.42E+10	3.85E+10	2.14E+11	32.7	24.0	25.3	18.0	100.0

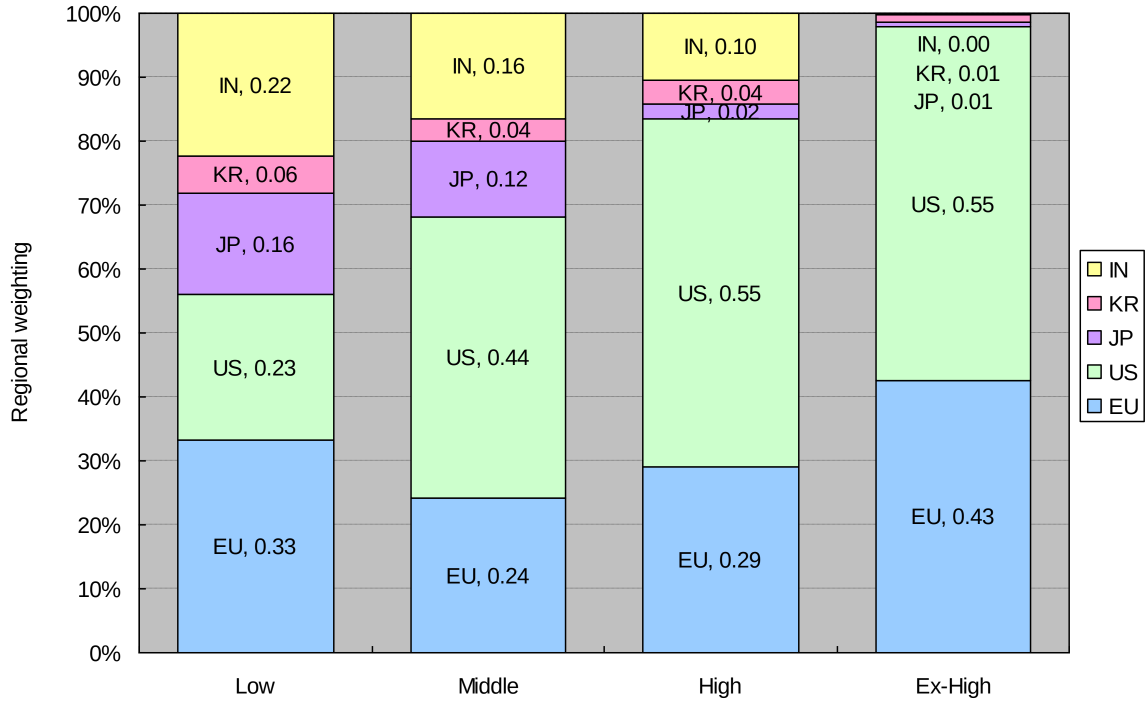


Figure 4-6 Regional weighting factors

To build the European database (which included the contribution of 9 EU member states + Switzerland) it was decided to use a slightly different approach. Starting from the observation/assumption that the driving behavior did not differ very much among EU countries, it was considered reasonable to give some weight also to the robustness of the single database. Thus, instead of considering only the traffic volume of the country (somewhat representative of the population) a 50% weight was assigned also to the mileage of each country's database. The result of this approach is shown in Figure 4-7.

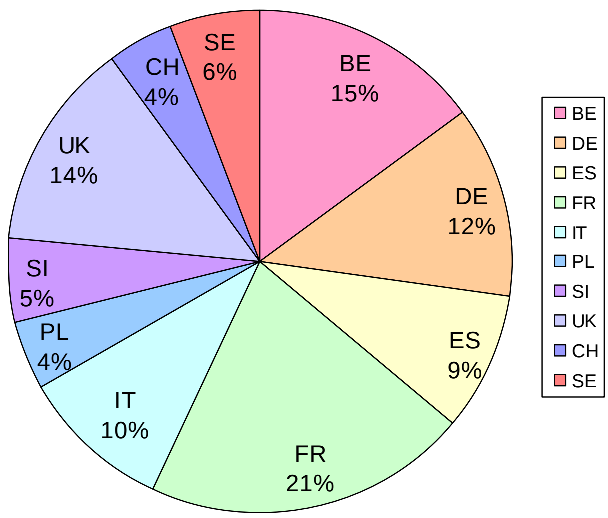


Figure 4-7 Internal weighting factors for Europe

4.4.3. Determination of test cycle duration

The length of the world-wide harmonized test cycle was set to 1800 seconds similar to WHDC (World Harmonized Heavy Duty Cycle) and WMTC. This cycle duration represents an accepted compromise between statistical representativeness on the one hand and test feasibility in the laboratory on the other hand. The length of each speed phase (Low, Medium, High and Extra-high) was determined based on traffic volume ratio between the L/M/H/Ex-H phases (Low: 589 s, Mid.: 433 s, High: 455 s, Ex-High: 323 s) as shown in Table 4-5.

Table 4-5 The length of each speed phase

(Unite: vehicle hours)

	Low	Mid.	High	Ex-H	Total
EU	2.33E+10	1.24E+10	1.57E+10	1.64E+10	6.79E+10
US	1.59E+10	2.26E+10	2.95E+10	2.13E+10	8.93E+10
JP	1.11E+10	6.16E+09	1.16E+09	3.28E+08	1.88E+10
KR	4.05E+09	1.84E+09	2.09E+09	4.43E+08	8.42E+09
IN	1.56E+10	8.47E+09	5.64E+09	6.42E+07	2.98E+10
World-wide	7.00E+10	5.15E+10	5.42E+10	3.85E+10	2.14E+11
propotion	0.327	0.240	0.253	0.180	1.000
Cycle duration	589	433	455	323	1800

4.4.4. Driving characteristics

Figure 4-8 - Figure 4-11 show the driving characteristics (average speed, RPA – Relative Positive Acceleration, average short trips duration and average idle duration) for each region (Japan, Europe, United States, Korea, India) and for the world-wide (unified) database.

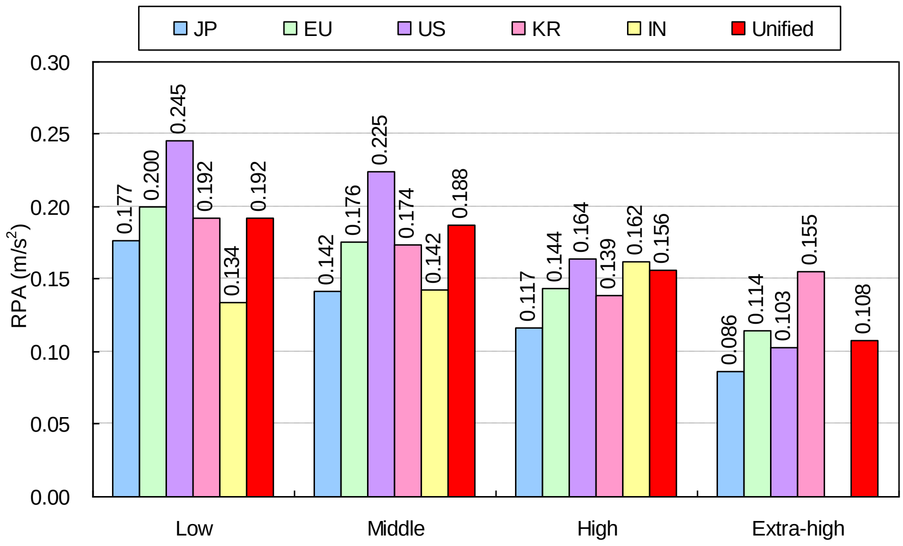


Figure 4-8 RPA - driving characteristics

The Relative Positive Acceleration (RPA) is an important parameter to characterize vehicle trips and compare the load of the test cycle. It is a speed-related average of acceleration of the vehicle (power of a vehicle) calculated with the following equation:[9]

$$\mathrm{RPA} = \frac{\int_0^T \left(v_i \times a_i^{+}\right) \cdot \mathrm{d}t}{x} \qquad (\mathrm{eq.}1)$$

With being the acceleration at time step i, (only $a_i > 0$ (m/s2), v_i being the vehicle speed at time step i (m/s) and being the total trip distance (m).

The vehicle acceleration was calculated from consecutive vehicle speed samples according to the following equation.

$$\mathrm{a_i} = \left[\frac{v_{i+1} - v_{i-1}}{2}\right] \div 3.6 \qquad (\mathrm{eq.}2)$$

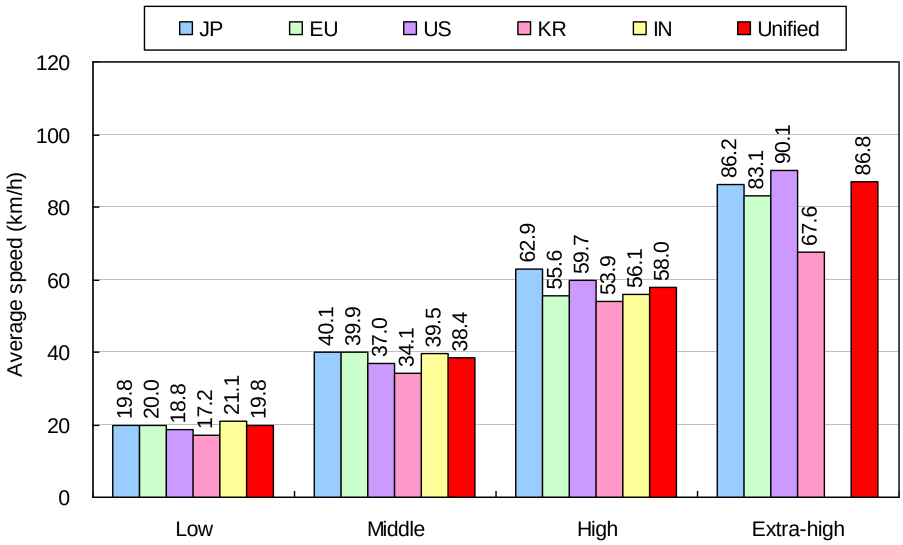


Figure 4-9 Average speed - driving characteristics

9 Van de Weijer, C., Heavy Duty Emission Factors: Development of Representative Driving Cycles and Prediction of Emissions in Real Life. 1997.

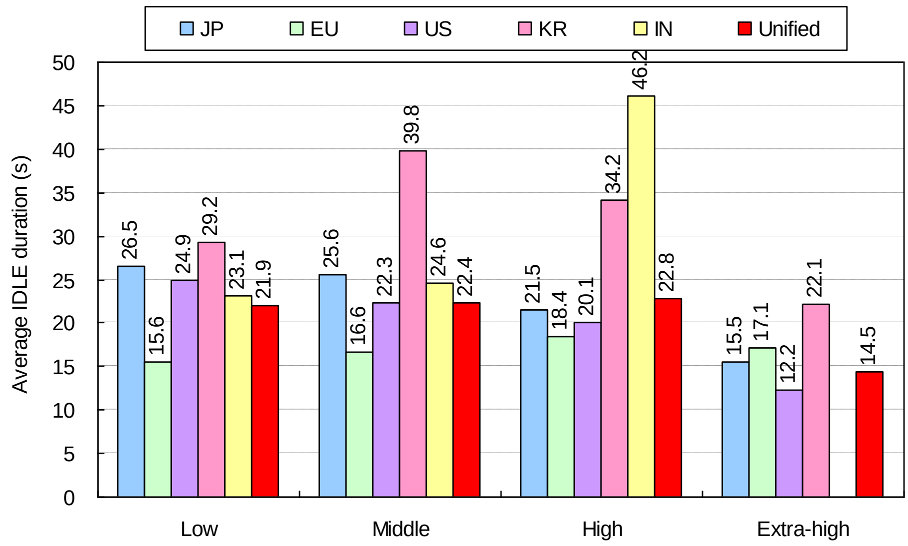


Figure 4-10 Average idle duration – driving characteristics

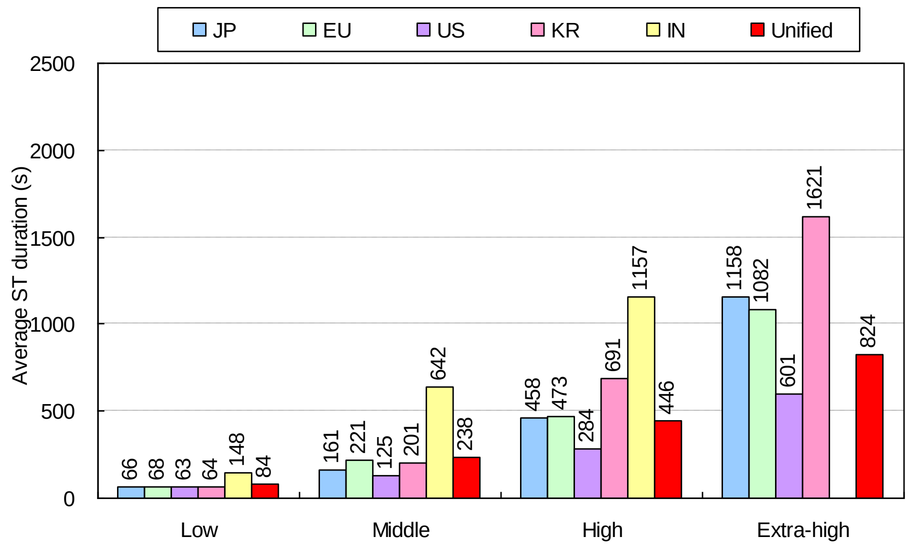


Figure 4-11 Average short trip duration – driving characteristics

4.4.5. Determination of short trips and idles number

Having determined the length of each speed phase, the number of short trips and idle periods in each of them (L/M/H/Ex-H) was calculated according to equations 3-4. The resulting number was rounded to an integer number:

$$N_{ST,i} = \frac{\text{phase duration} - \text{average idling duration}}{\text{average short trip duration} + \text{average idling duration}} \qquad (\text{eq. } 3)$$

$$N_{I,i} = \text{number of short trips}\left(N_{ST,i}\right) + 1 \qquad (\text{eq. } 4)$$

Table 4-6 shows, for each speed phase (L/M/H/Ex-H), the total duration, the average short trip duration and average idle duration (as determined from data analysis and shown in Figure 4-10 and Figure 4-11), number of short trips and number of idles (as calculated according to Eqs.3-4).

Table 4-6 Determination of No. of ST and Idle for the L/M/H/ExH phases.

	Target cycle duration	Average ST duration	Average IDLE duration	No. of ST	No. of IDLE
	s	s	s	#	#
Low	589	84	22	**5**	**6**
Middle	433	238	22	**1**	**2**
High	455	446	23	**1**	**2**
Extra-high	323	824	14	**1**	**2**

Applying equation 3, for the low and medium speed phase the number of short trips is higher than 1, while for the high and extra-high speed phases equation 3 gives a number of short trips smaller than 1 (rounded to 1). This is due to the average short trip duration (as obtained from the unified database) being longer than the duration of the high and extra-high speed phase in the WLTC. To determine the duration of the short trips in one phase a cumulative frequency graph of the short trip duration had to be generated. Figure 4-12 shows the short trip length cumulative frequency distributions for determining the short trips duration in the low speed phase. The Y axis was divided into the five equally parts (five short trips calculated in the low speed phase) and by selecting the average duration in each part, the duration of the short trips (ST1, ST2, ST3, ST4, ST5) was decided. Similar procedure was applied for determining the idle periods duration.

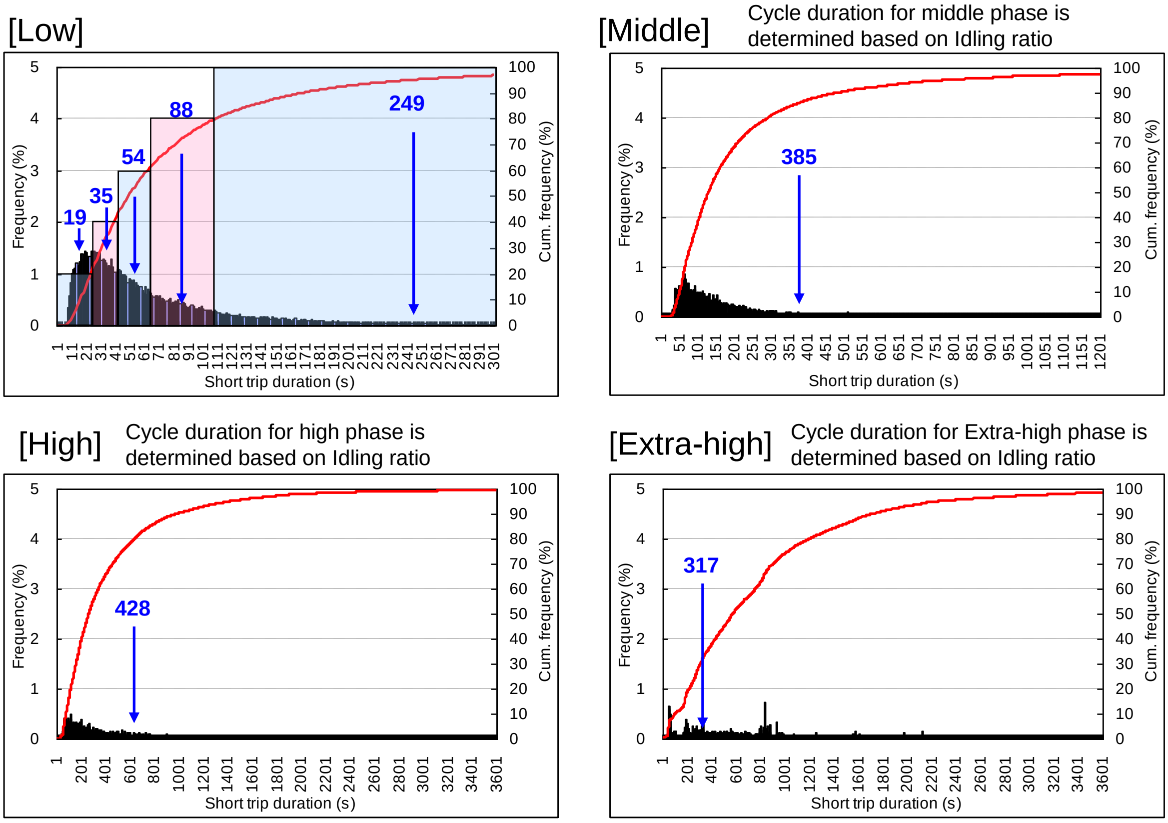


Figure 4-12 Cumulative frequency distributions of short trip duration.

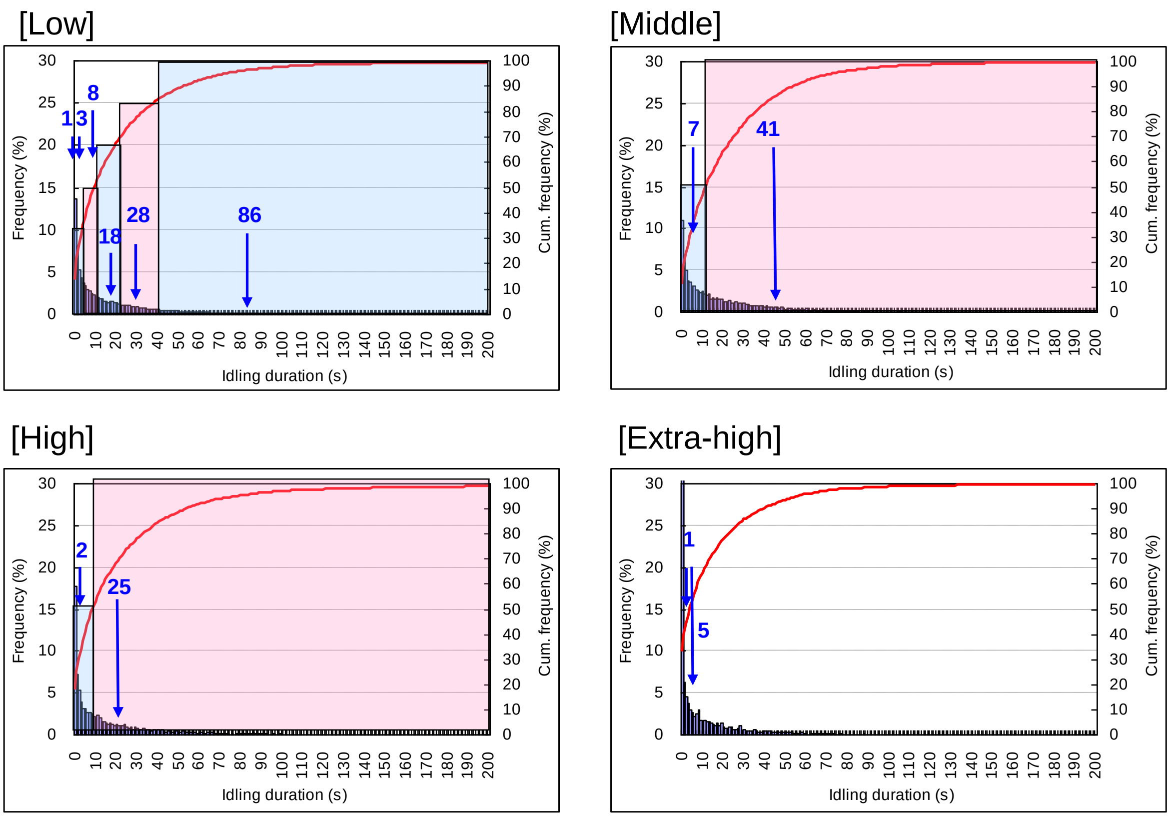


Figure 4-13 Number of ST and Idles and their duration for each phase of the WLTC

The short trips for WLTC had to be selected from the unified database. The selection criteria were based on the concept that the selected short trips must provide similar distributions of speed, acceleration, etc. to those of the unified database. Given the large number of different/possible short trips combinations, several selection criteria (average vehicle speed, acceleration duration ratio, deceleration duration ratio) were applied. This selection was necessary in order to reduce the number of possible combinations and to keep computation time for performing the chi-squared analysis to a reasonable limit. The combination of the short trips with the smallest chi-squared value was selected in the WLTC driving cycle.

4.4.6. The characteristics of first ST and Idling of the day

A separate statistical analysis has been performed in order to select the first short trip and the first idling of the driving cycle. Table 4-7 summarizes the characteristics of this analysis (the average idle duration, average short trip duration, average speed, maximum speed). Based on these characteristics, from the five short trips part of the low speed phase, ST5's characteristics was the best fit with the first initial short trip of the day and therefore is the first short trip of the test cycle. The first idling of the test cycle with a duration of 28 seconds (from the six idles as shown in Figure 4-13) was considered to fit the most the characteristics of the first idle of the day.

- Average Idling duration of first Idling of a day is 28 s. => Select 28 s
- The final Idling duration would be more than 5 s because of stable sampling. => Select 8 s
- Average speed of first short trip of a day is approx. 30 km/h. => ST of 245 s

Table 4-7 The characteristics of first ST and Idling of the day

region	sample number	stop duration in s	average short trip duration in s	average speed in km/h	maximum speed in km/h
Europe	3271	24.0	208.4	29.3	48.8
USA	1492	32.0	144.7	29.8	55.5
Average	-	28.0	176.5	29.6	52.2

4.4.7. The Extra-High Speed Phase

The selection of the Extra-high speed phase from the unified database was more challenging as/because the/its duration of 323 seconds (as determined by applying the methodology described earlier) was too small compared to the real world's extra-high short trips from the unified database. Therefore/for this reason, the extra-high speed phase was developed with a modified methodology based on a combination of different segments defined as: take-off, cruise and slow-down, extracted from real short trips from the unified database as shown in Figure

4-14Figure 4-14Figure 4-14Figure 4-14. The combination of the segments forming one extra-high short trip which fitted the most the characteristics (maximum speed, average speed, RPA, average positive acceleration, average speed x positive acceleration) of a real extra-high short trip and with the smallest chi-squared value was selected to represent the extra-high speed phase in the WLTC driving cycle.

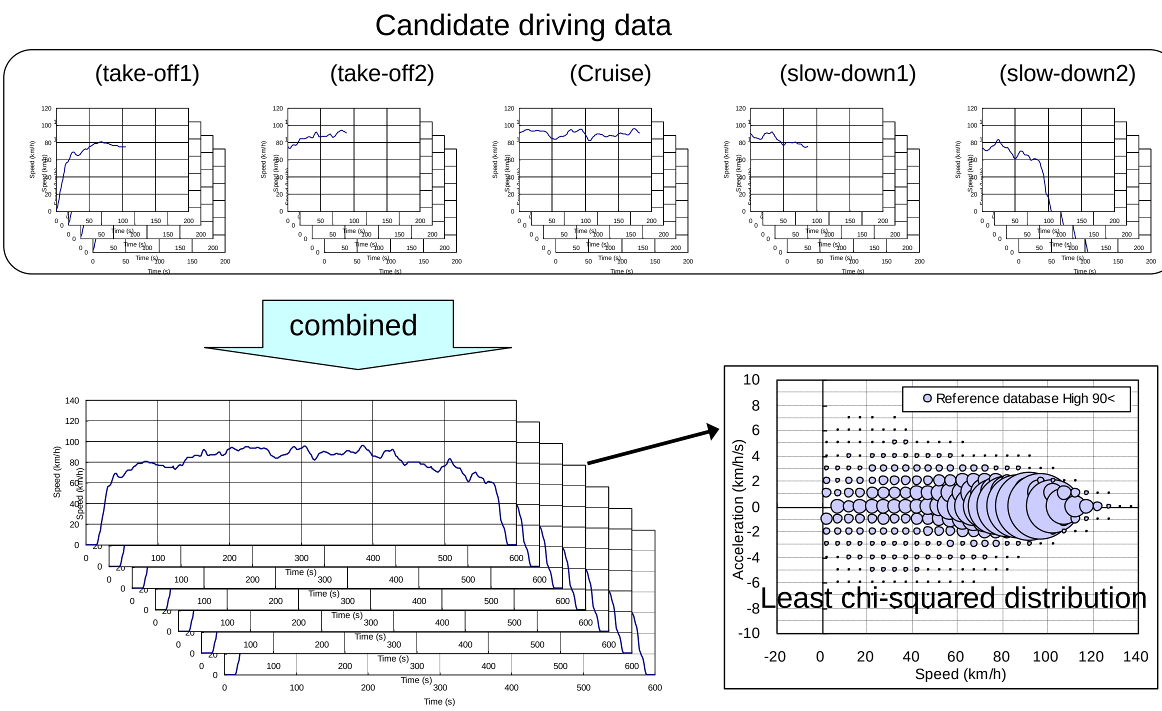


Figure 4-14 Image of the extra-high speed phase development methodology.

4.5. The initial world-wide harmonized light duty test cycle (WLTC version 1)

An initial WLTC was introduced by Japan in the 9th DHC meeting. Figure 4-15 shows the speed profile of the WLTC driving cycle. The first short trip in the driving cycle is the first short trip of the day as determined in Table 4-7 (average speed of first short trip of a day is approx. 30 km/h). The order of the other short trips in the low speed phase was set randomly. Also, the short trips with lowest speed were connected with the Idles with longest duration in order to reflect traffic jam. The speed acceleration distributions of WLTC ver. 1 were shown in Figure 4-16. The characteristics of the WLTC driving cycle are shown in Table 4-8.

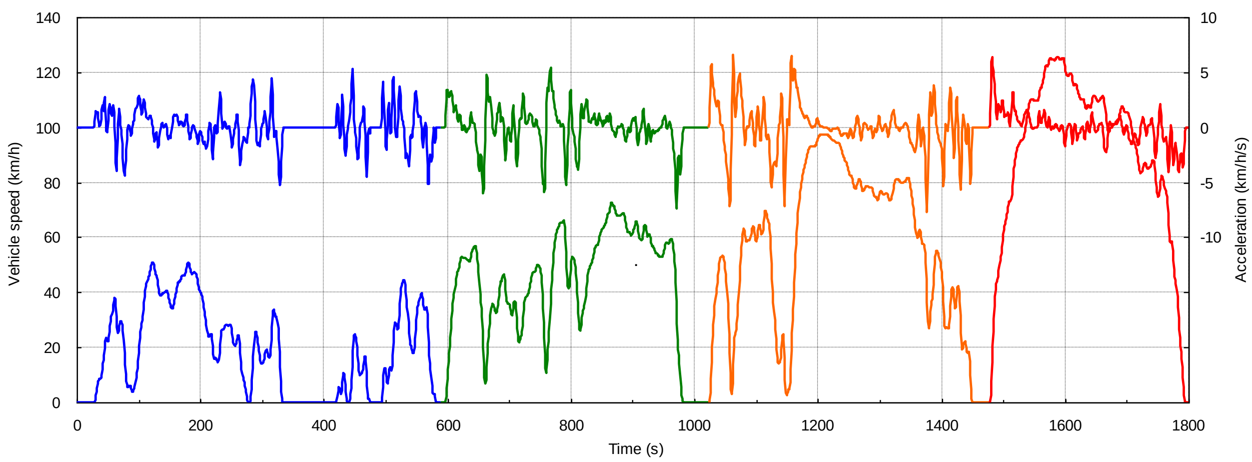


Figure 4-15 The speed profile of the WLTC driving cycle version 1.

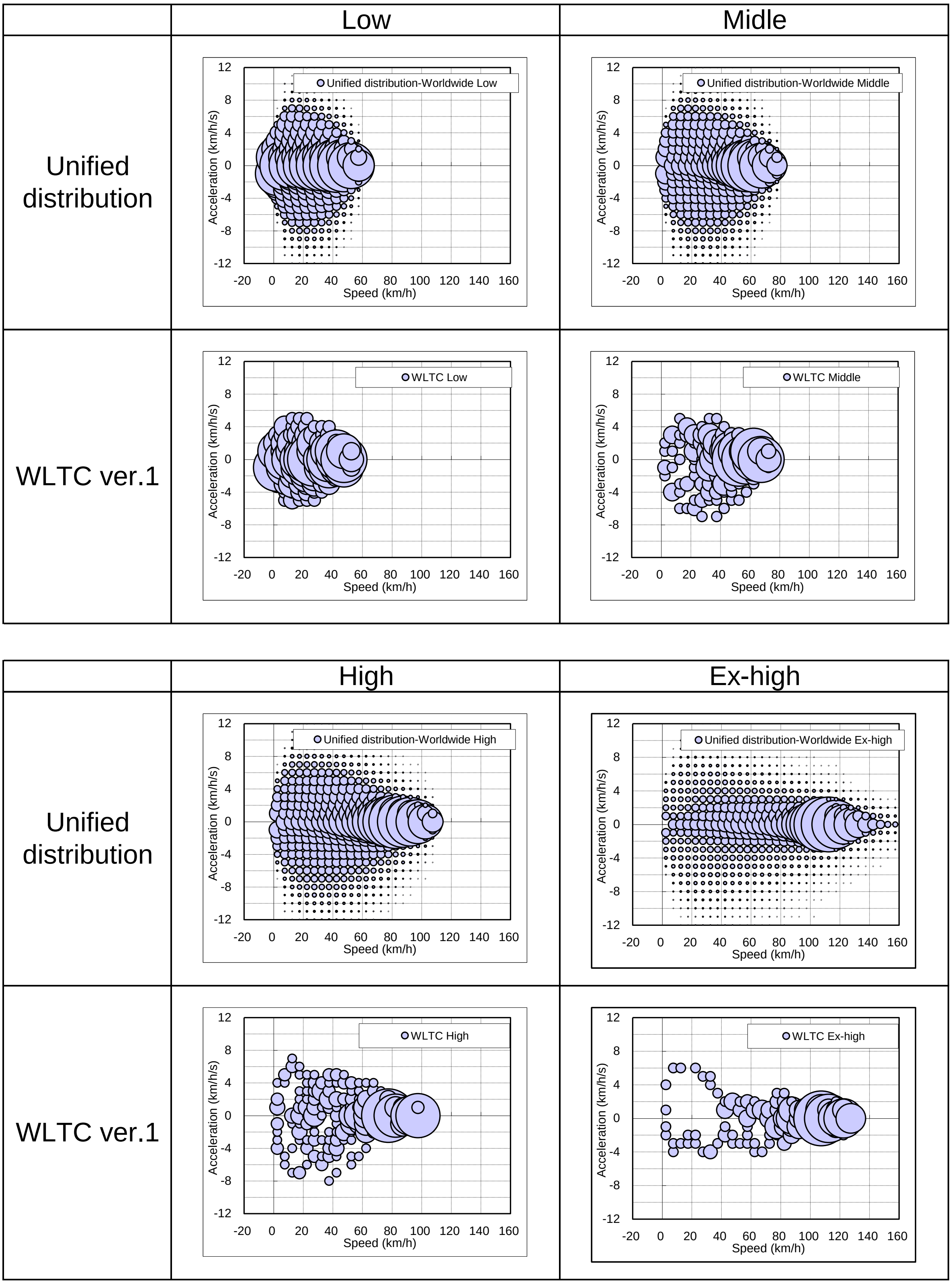


Figure 4-16 The speed acceleration distribution of WLTC ver.1

Table 4-8 The characteristics of the World-wide Light duty Test Cycle version 1 (WLTC ver.1)

Parameter		Cycle duration	Driving distance	Average speed	Max. speed	Max. acceleration	Max. Deceleration	driving mode(*)			
								Acceleration ratio	Deceleration ratio	Cruise ratio	Idling ratio
		s	km	km/h	km/h	km/h/s	km/h/s	%	%	%	%
World-wide	Low	-	-	19.8	60	-	-	27.5	25.4	22.7	24.5
	Middle	-	-	38.4	80	-	-	31.4	27.5	28.8	12.2
	High	-	-	58	110	-	-	31.3	27.2	35.5	6.0
	Extra-high	-	-	86.8	194.7	-	-	25.7	23.4	48.9	2.0
	Unified	-	-	45.9	194.7	-	-	29.1	26.0	32.1	12.8
WLTC 1st	Low	589	2.98	18.2	50.9	5.3	-5.3	26.1	27.8	19.7	26.3
	Middle	433	5.01	41.6	72.5	5.4	-7.4	37.0	24.2	27.2	11.1
	High	455	7.01	55.5	97.4	6.5	-7.7	29.0	28.8	35.2	7.0
	Extra-high	323	8.06	89.8	125.5	6.4	-4.1	28.5	27.2	42.1	2.2
	Total	1800	23.06	46.1	125.5	6.5	-7.7	29.9	27.1	29.6	13.4

The development of a World-wide harmonized Light duty Test Cycle (WLTC) which will represent typical driving conditions around the world was presented. The driving cycle was obtained from recorded in-use data ("real world" data) from different regions of the world (EU, India, Japan, Korea, USA) combined with suitable weighting factors. Over 654,000 km of data was collected covering a wide range of vehicle categories (M1, N1 and M2 vehicles, various engine capacities, power-to-mass ratios, manufacturers etc), over different road types (urban, rural, motorway) and driving conditions (peak, off-peak, weekend). The WLTC contains four individual sections (Low, Medium, High and Extra-high speed phase), each one composed by a sequence of idles and short trips, and has a total duration of 1800 seconds. The length of each speed phase L/M/H/ExH phases is: 589 [s], 433 [s], 455 [s] and 323 [s] respectively. The overall distance of the harmonized light duty test cycle is 23.06 km. The maximum speed is 125.5 km/h. An idle duration is 13.4% of the cycle time.

4.6. Modifications of the draft test cycle

The first draft needed modifying on the basis of an evaluation concerning drivability. In addition to that, EU concerned the representative of cycle dynamics. The following modifications were made during the validation phase.

4.6.1. WLTC version 2

In July 2011, modification of WLTC version1 was discussed over the DHC telephone conference between EU and Japan.

(1) Idling Duration

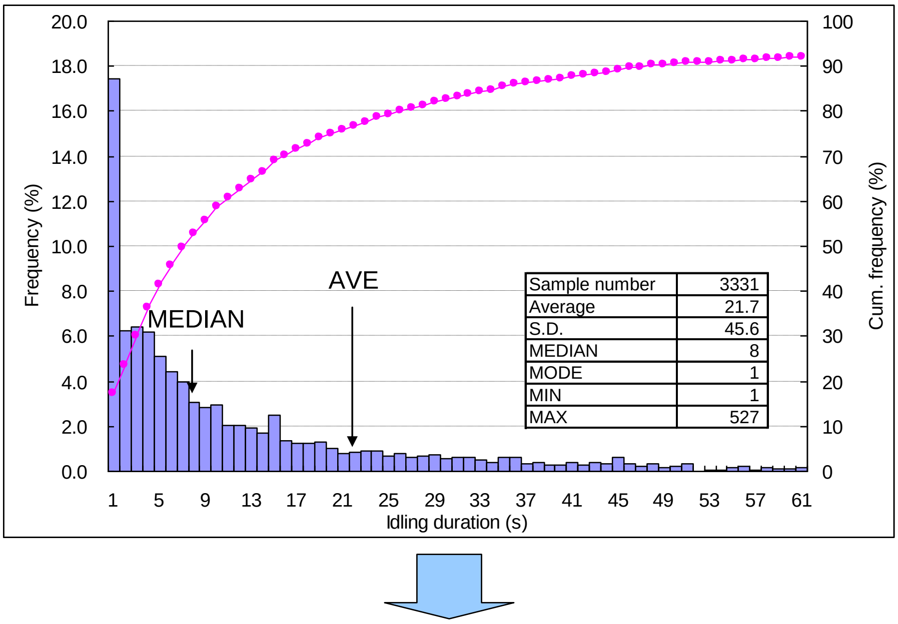
The concern which the relatively long initial idle period might impact on the effectiveness of the cycle at encouraging rapid catalyst light off was raised in the 9th DHC meeting. The determination of idling duration was reviewed and revised. **Error! Reference source not found.** shows the revised idling duration.

Table 4-9 Revised idling duration

Phase	Cycle version	T_{ID1}	T_{ID2}	T_{ID3}	T_{ID4}	T_{ID5}	T_{ID6}	Total
Low	Ver.1	1	3	8	18	28	86	144
	Ver.2	2	5	11	22	38	66	144
Middle	Ver.1	7	41	-	-	-	-	48
	Ver.2	11	37	-	-	-	-	48
High	Ver.1	2	25	-	-	-	-	27
	Ver.2	4	23	-	-	-	-	27
Extra high	Ver.1	1	5	-	-	-	-	6
	Ver.2	1	5	-	-	-	-	6

(2) Initial idling duration

The characteristics of first ST and Idling of the day were analyzed again. The first idling of the test cycle with a duration of 11 seconds was considered to fit the median value of the first idle of the day.



The idling duration of the closest to MEDIAN is 11 s.

	T_{ID1}	T_{ID2}	T_{ID3}	T_{ID4}	T_{ID5}	T_{ID6}	Total
Revised	2	5	11	22	38	66	144

Figure 4-17 Re-analysis of Initial idling duration

(3) Initial Short trip

A separate statistical analysis has been performed in order to select the first short trip and the first idling of the driving cycle. Table 4-10 summarizes the characteristics of this analysis (the average idle duration, average short trip duration, average speed, maximum speed, distance, RPA, maximum acceleration, average acceleration, average velocity*acceleration). Based on these characteristics, from the five short trips part of the low speed phase, ST4's characteristic was the best fit with the first initial short trip of the day and therefore is the first short trip of the test cycle.

Table 4-10 Further Analysis of Initial short trip

Item			ST duration	Average speed	Maximum speed	Distance	Maximum acceleration	Average acceleration (+)	Average V*A (+)	RPA
			s	km/h	km/h	m	m/s^2	m/s^2	m^2/s^3	m/s^2
First short trip of a day	Europe	AVE	216	29.6	49.3	3270	1.42	0.56	3.89	0.207
		S.D.	424	18.3	28.1	9979	0.48	0.19	2.23	0.088
	USA	AVE	207	30.5	55.6	3437	1.70	0.59	4.77	0.247
		S.D.	403	20.4	29.6	11166	0.74	0.20	2.87	0.108
	Average	AVE	212	30.0	52.4	3353	1.56	0.58	4.33	0.227
WLTC	Candidate short trip of Low phase	ST1	19	4.6	10.8	25	0.81	0.48	0.68	0.189
		ST2	35	11.6	24.6	116	1.47	0.57	1.98	0.255
		ST3	54	18.0	33.5	275	1.25	0.65	3.19	0.232
		ST4	88	23.6	44.5	582	1.26	0.57	3.68	0.227
		ST5	249	28.5	50.9	1981	0.88	0.37	2.68	0.120

(4) Extra-High phase

Extra High phase was modified according to EU request. High acceleration portion in take off part was applied in order to represent the "ramp" acceleration. In addition to that, in order to detect OBD error, the three kinds of cruise portion of 130, 90 and 65 km/h were applied. The WLTC version 2 was agreed to validate on drivability, traceability under the validation test phase 1.

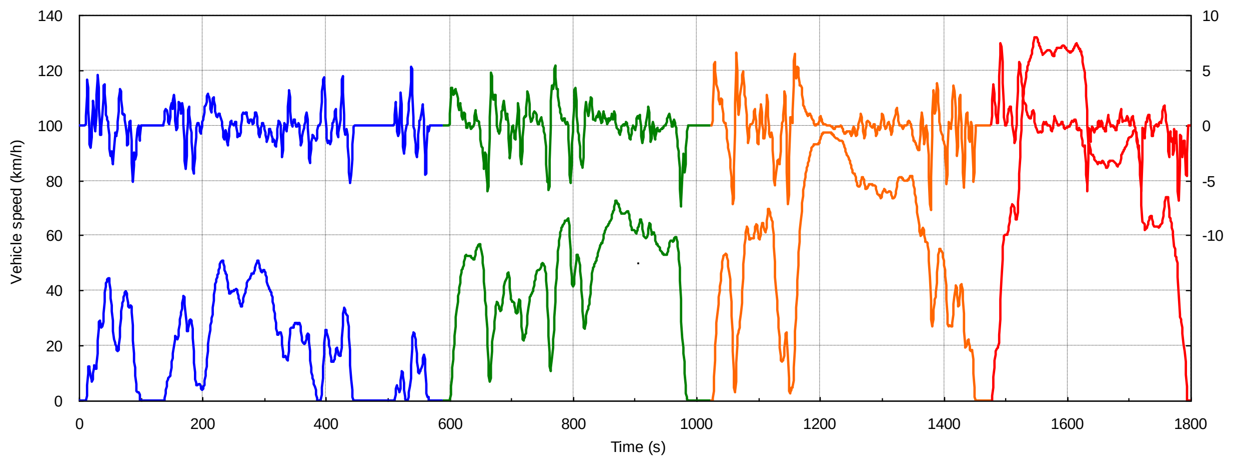


Figure 4-18 The speed profile of the WLTC driving cycle version 2

4.6.2. WLTC version 2-rev

The test cycle was modified based on Validation test phase 1 test results at the 10th DHC meeting in October 2011. The main modifications are as follows;

(1) Acceleration portions

Acceleration portions were reviewed based on comments from the participant laboratories. Then maximum acceleration parts were set 95 percentiles of cumulative frequency in each speed range. In Extra-High phase high acceleration part (65 - 130km/h) were replaced by alternative acceleration part from in-use database which matches the 95 percentiles of cumulative frequency.

(2) Deceleration portions

To avoid tire lock and/or shortage of brake power, maximum deceleration to appropriate value of - 5.31 km/h/s was set, same as maximum deceleration of UDDS.

(3) Drivability / reproducibility

Because Low speed portion (e.g. creep drive) has an adverse influence on drivability and reproducibility, minimum speed should be set to 7.5 km/h as an average speed at the idling engine speed on the 1st gear.

The more details were described in WLTP-DHC-10-10[10].

10 http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/wltp_dhc10.html

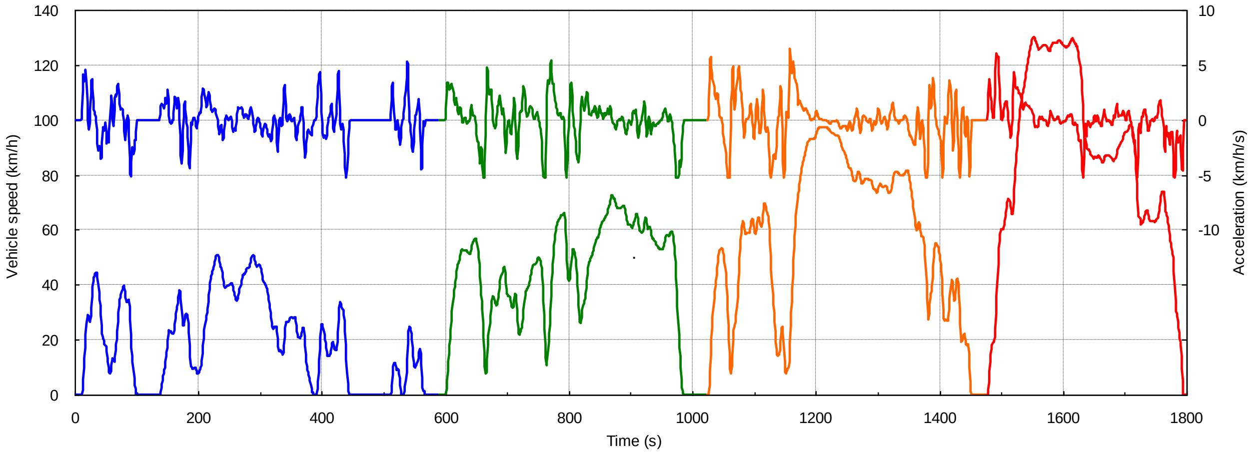


Figure 4-19 The speed profile of the WLTC driving cycle version 2 revised

4.6.3. WLTC version 3

As for the test cycle of low and middle speed phase, the acceleration was enhanced, as EU indicated dynamics shortage on the world-wide harmonized base.

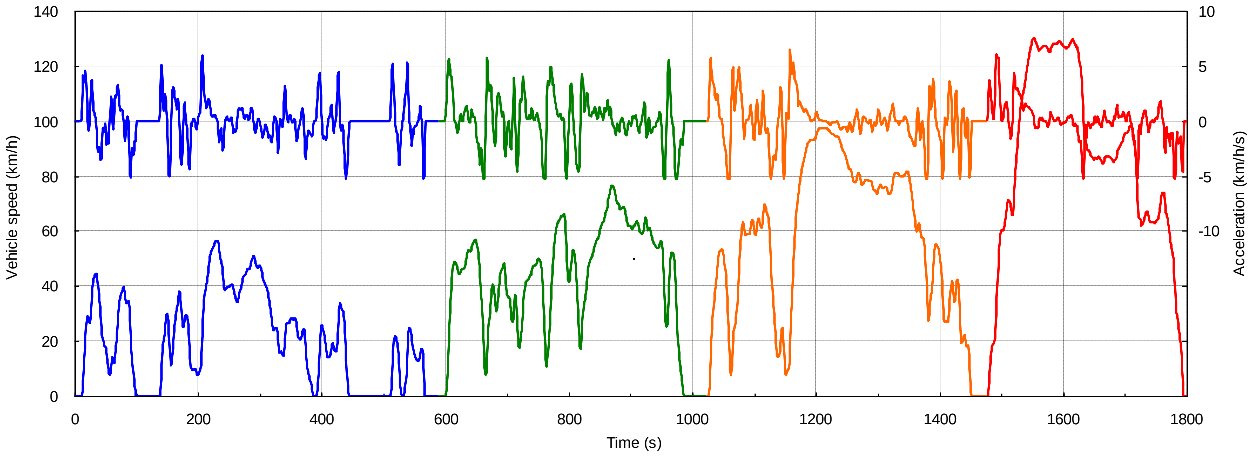


Figure 4-20 The speed profile of the WLTC driving cycle version 3

4.6.4. WLTC version 4

In order to adjust the test cycle dynamics to the reference database, both acceleration and deceleration in low and middle speed phase were increased. In addition to that, the lowest speed during the short trip (except for start and stop) was increased to 10km/h. As EU reconsidered extra-high speed phase, the test cycle was similar to the reference database. The 11th DHC meeting agreed to verify WLTC with validation test phase 1b.

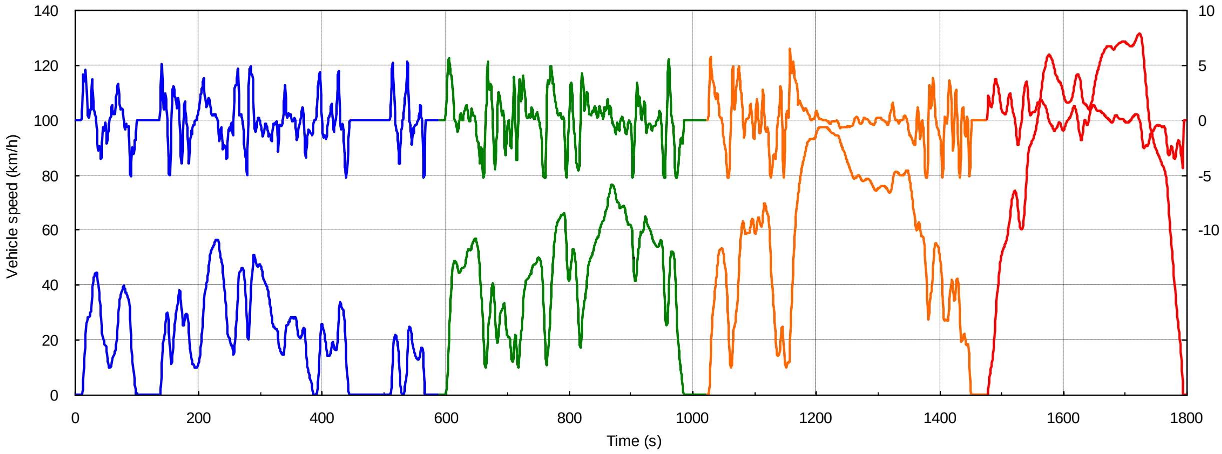


Figure 4-21 The speed profile of the WLTC driving cycle version 4

4.6.5. WLTC version 5

WLTC version5 was adopted for the validation test phase2, according to Japan's suggestion. 15 subjects out of 31 had raised from the results of validation test phase1b from each laboratory were reviewed and revised for version5. The main improvement s are changing the lowest speed to 12km/h and smoothing micro transient.
The more detail was described in WLTP-DHC-12-04[11].

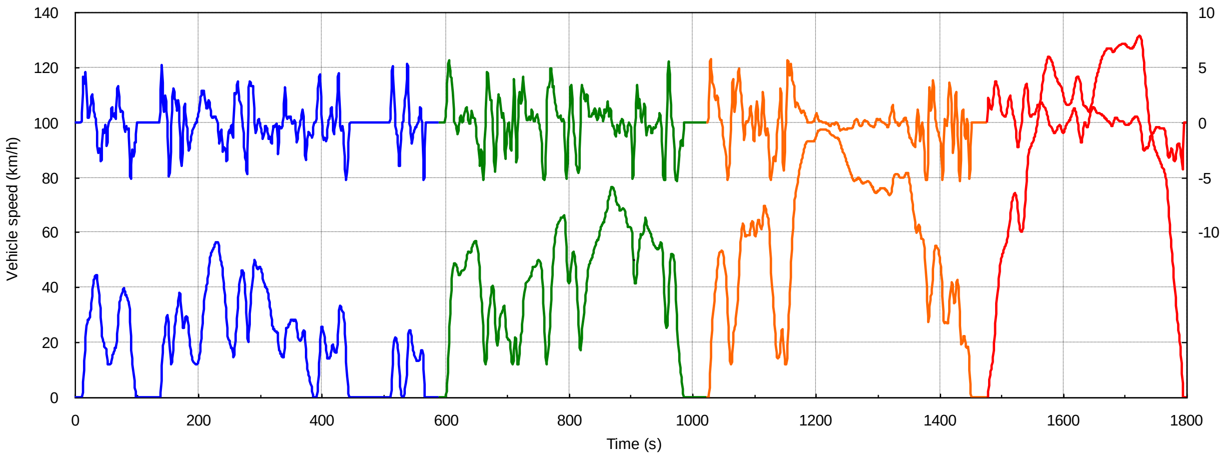


Figure 4-22 The speed profile of the WLTC driving cycle version 5

4.6.6. WLTC version 5.1

The validation test results indicate traceability of prescribed cycle and drivability issues on compact cars produced many in emerging nations. Thus, Japan and India requested a revision to traceability of prescribed cycle in the middle and high speed phase at the 14th DHC meeting, which was then agreed at the 15th meeting. This cycle was decided to apply to the vehicles with 120km/h or lower speed as the highest velocity.

[11] http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/wltp_dhc12.html

Specific time table of each cycle profile is uploaded as in WLTP-DHC-16-06[12]

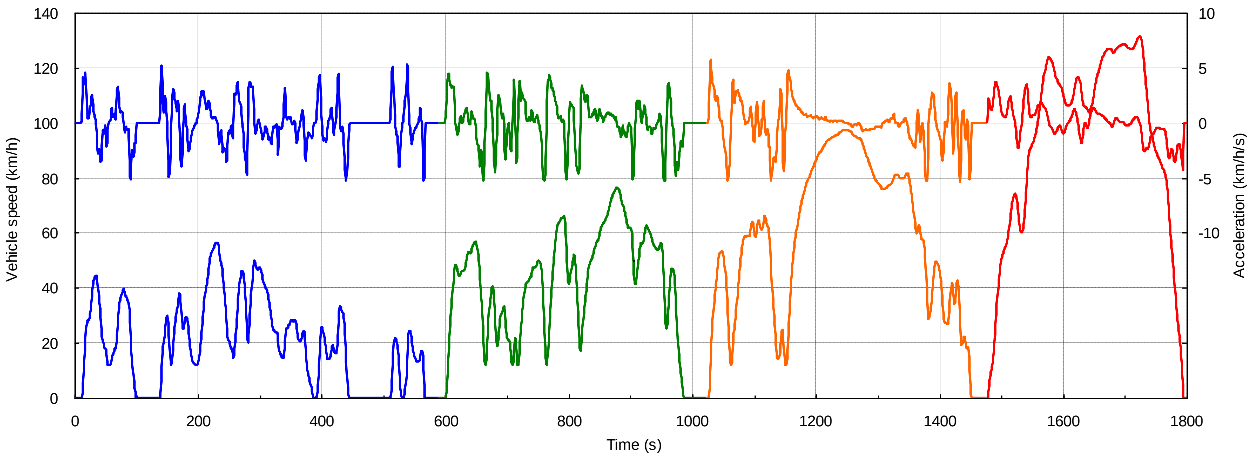


Figure 4-23 The speed profile of the WLTC driving cycle version 5.1

4.6.7. WLTC version 5.3

Modification of the cycle profile was agreed as Version 5.3 at the 15th DHC meeting, according to India's proposal. Specific time table of each cycle profile is uploaded as in WLTP-DHC-16-06[13].

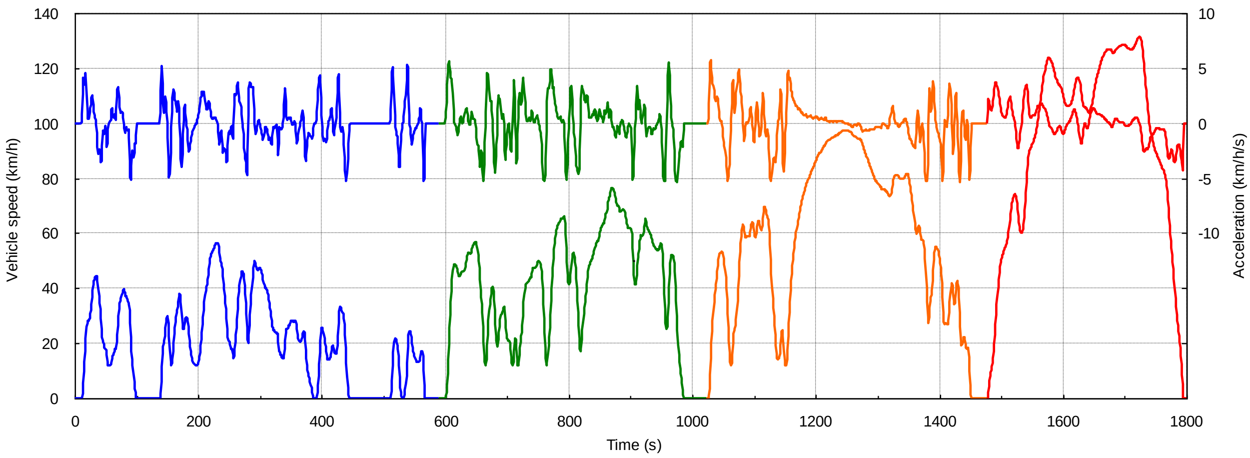


Figure 4-24 The speed profile of the WLTC driving cycle version 5.3

4.6.8. Characteristics of WLTC

Figure 4-25 to Figure 4-30 and Table 4-11 shows The change of characteristics of WLTC.

12 https://www2.unece.org/wiki/download/attachments/5801079/WLTP-DHC-16-06e_rev.xlsx
13 https://www2.unece.org/wiki/download/attachments/5801079/WLTP-DHC-16-06e_rev.xlsx

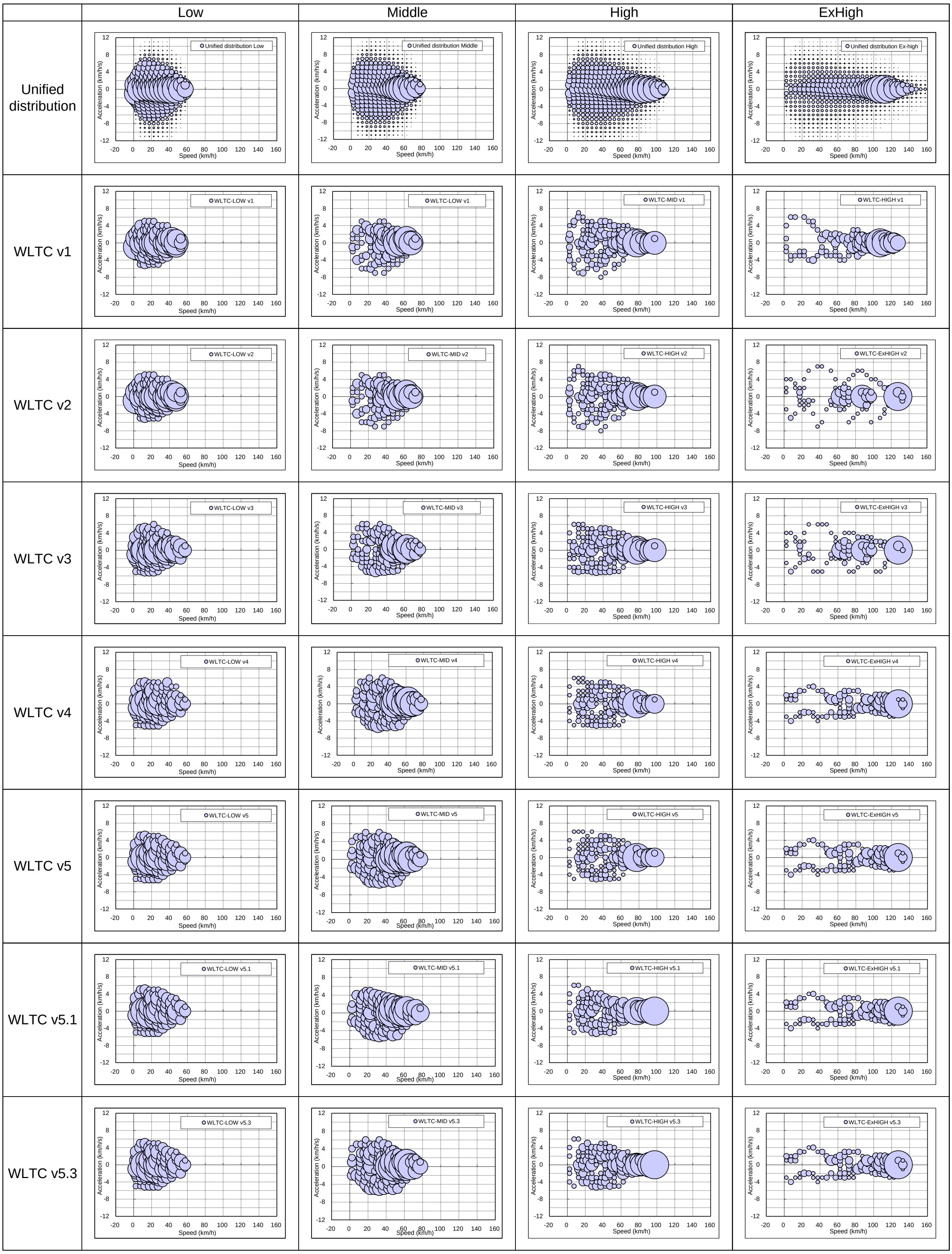


Figure 4-25 Transition of Speed-Acceleration distribution

Table 4-11 Characteristics of WLTC

Parameter		Cycle duration	Driving distance	Average speed	Max. speed	Max. acceleration	Max. Deceleration	RPA	Acceleration ratio	Deceleration ratio	Cruise ratio	Idling ratio	X^2 value
		s (h)	km	km/h	km/h	km/h/s	km/h/s	m/s^2	%	%	%	%	-
LOW	WWW database	-	-	19.8	60.0	-	-	0.192	27.5	25.4	22.7	24.5	-
	WLTC v1	589	2.98	18.2	50.9	5.3	-5.3	0.165	26.1	27.8	19.7	26.3	0.244
	WLTC v2	589	2.98	18.2	50.9	5.3	-5.3	0.165	26.3	27.8	19.5	26.3	0.244
	WLTC v3	589	3.19	19.5	56.5	5.9	-5.3	0.176	25.1	29.2	20.9	24.8	0.289
	WLTC v4	589	3.08	18.8	56.5	5.3	-5.3	0.209	27.0	31.1	17.1	24.8	0.608
	WLTC v5	589	3.09	18.9	56.5	5.3	-5.3	0.205	28.4	31.1	15.8	24.8	0.586
	WLTC v5.1	589	3.09	18.9	56.5	5.3	-5.3	0.205	28.4	31.1	15.8	24.8	0.586
	WLTC v5.3	589	3.09	18.9	56.5	5.3	-5.3	0.205	28.4	31.1	15.8	24.8	0.586
MID	WWW database	-	-	38.4	80.0	-	-	0.188	31.4	27.5	28.8	12.2	-
	WLTC v1	433	5.01	41.6	72.5	5.4	-7.4	0.155	37.0	24.2	27.7	11.1	0.629
	WLTC v2	433	5.01	41.6	72.5	5.4	-7.4	0.155	37.0	24.2	27.7	11.1	0.629
	WLTC v3	433	4.95	41.1	76.6	5.7	-5.3	0.184	33.7	29.6	26.1	10.6	0.613
	WLTC v4	433	4.74	39.4	76.6	5.6	-5.3	0.198	36.0	30.3	23.1	10.6	0.649
	WLTC v5	433	4.76	39.5	76.6	5.7	-5.4	0.196	36.0	30.3	23.1	10.6	0.650
	WLTC v5.1	433	4.72	39.3	76.6	4.6	-5.3	0.189	37.9	29.1	22.4	10.6	0.751
	WLTC v5.3	433	4.76	39.5	76.6	5.7	-5.4	0.196	36.0	30.3	23.1	10.6	0.650
HIGH	WWW database	-	-	58.0	110.0	-	-	0.156	31.3	27.2	35.5	6.0	-
	WLTC v1	455	7.01	55.5	97.4	6.5	-7.7	0.144	29.0	28.8	35.2	7.0	0.962
	WLTC v2	455	7.01	55.5	97.4	6.5	-7.7	0.144	29.0	28.8	35.2	7.0	0.962
	WLTC v3	455	7.05	55.8	97.4	6.5	-5.3	0.143	28.8	28.8	36.0	6.4	0.869
	WLTC v4	455	7.06	55.9	97.4	6.5	-5.3	0.137	27.0	27.3	39.3	6.4	1.065
	WLTC v5	455	7.16	56.6	97.4	5.7	-5.4	0.135	26.8	27.9	38.9	6.4	1.113
	WLTC v5.1	455	7.12	56.4	97.4	5.7	-5.4	0.122	28.1	27.0	38.5	6.4	1.137
	WLTC v5.3	455	7.16	56.7	97.4	5.7	-5.4	0.132	29.0	27.7	36.9	6.4	1.008
Ex-HIGH	WWW database	-	-	86.8	194.7	-	-	0.108	25.7	23.4	48.9	2.0	-
	WLTC v1	323	8.06	89.8	125.5	6.4	-4.1	0.108	28.5	27.2	42.1	2.2	1.026
	WLTC v2	323	7.72	86.0	132.0	7.4	-6.8	0.127	25.4	25.4	47.7	1.5	5.312
	WLTC v3	323	7.67	85.4	130.4	6.1	-5.3	0.126	26.9	25.7	45.8	1.5	4.413
	WLTC v4	323	8.25	92.0	131.3	3.7	-4.4	0.125	36.2	31.6	30.7	1.5	2.779
	WLTC v5	323	8.25	92.0	131.3	3.7	-4.4	0.125	37.2	32.2	29.1	1.5	2.678
	WLTC v5.1	323	8.25	92.0	131.3	3.7	-4.4	0.125	37.2	32.2	29.1	1.5	2.678
	WLTC v5.3	323	8.25	92.0	131.3	3.7	-4.4	0.125	37.2	32.2	29.1	1.5	2.678
ALL (L-ExH)	WWW database	-	-	45.9	194.7	-	-	0.167	29.1	26.0	32.1	12.8	-
	WLTC v1	1800	23.06	46.1	125.5	6.5	-7.7	0.137	29.9	27.1	29.6	13.4	0.204
	WLTC v2	1800	22.72	45.4	132.0	7.4	-7.7	0.144	29.4	26.8	30.5	13.3	0.738
	WLTC v3	1800	22.86	45.7	130.4	6.5	-5.3	0.151	28.4	28.6	30.4	12.6	0.652
	WLTC v4	1800	23.14	46.3	131.3	6.5	-5.3	0.155	30.8	30.0	26.6	12.6	0.657
	WLTC v5	1800	23.26	46.5	131.3	5.7	-5.4	0.153	31.4	30.3	25.8	12.6	0.641
	WLTC v5.1	1800	23.19	46.4	131.3	5.7	-5.4	0.148	32.2	29.8	25.5	12.6	0.681
	WLTC v5.3	1800	23.27	46.5	131.3	5.7	-5.4	0.152	31.9	30.2	25.3	12.6	0.609

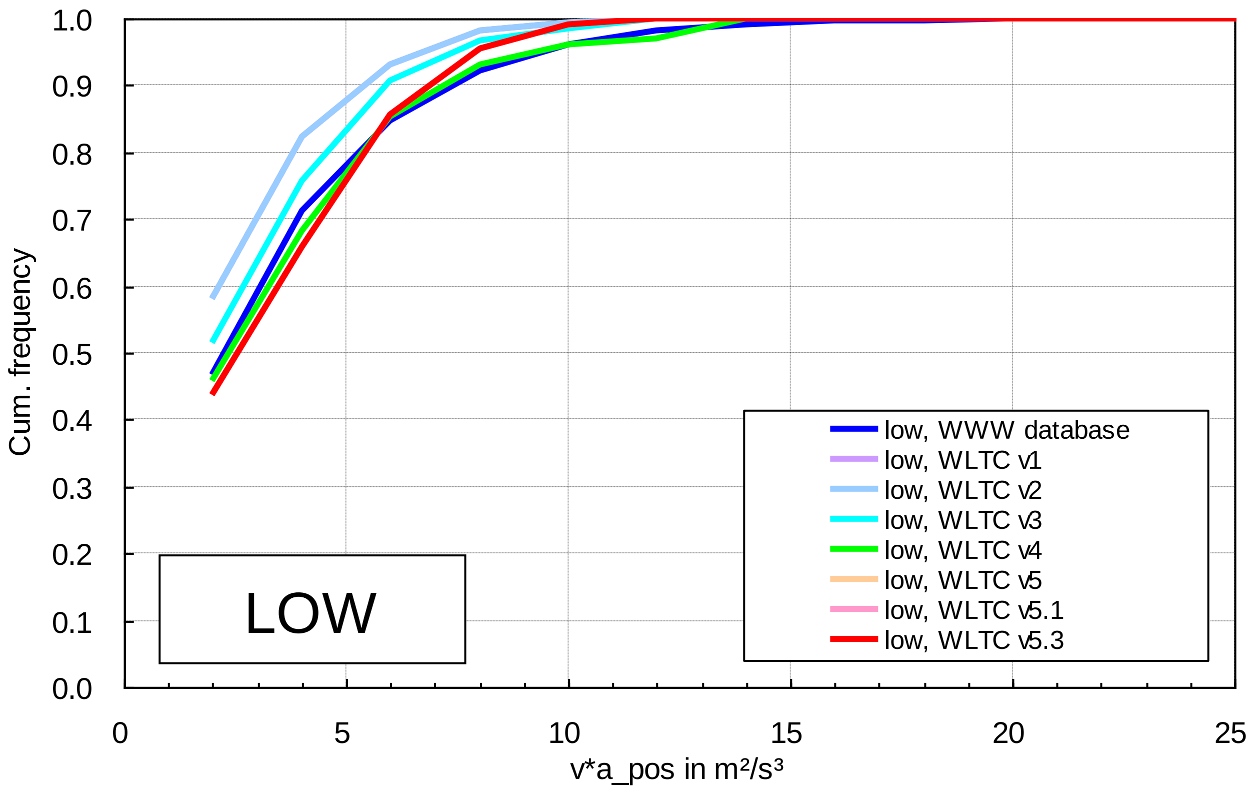


Figure 4-26 Cumulative frequency of multiplication of speed and acceleration (v*a) in Low phase

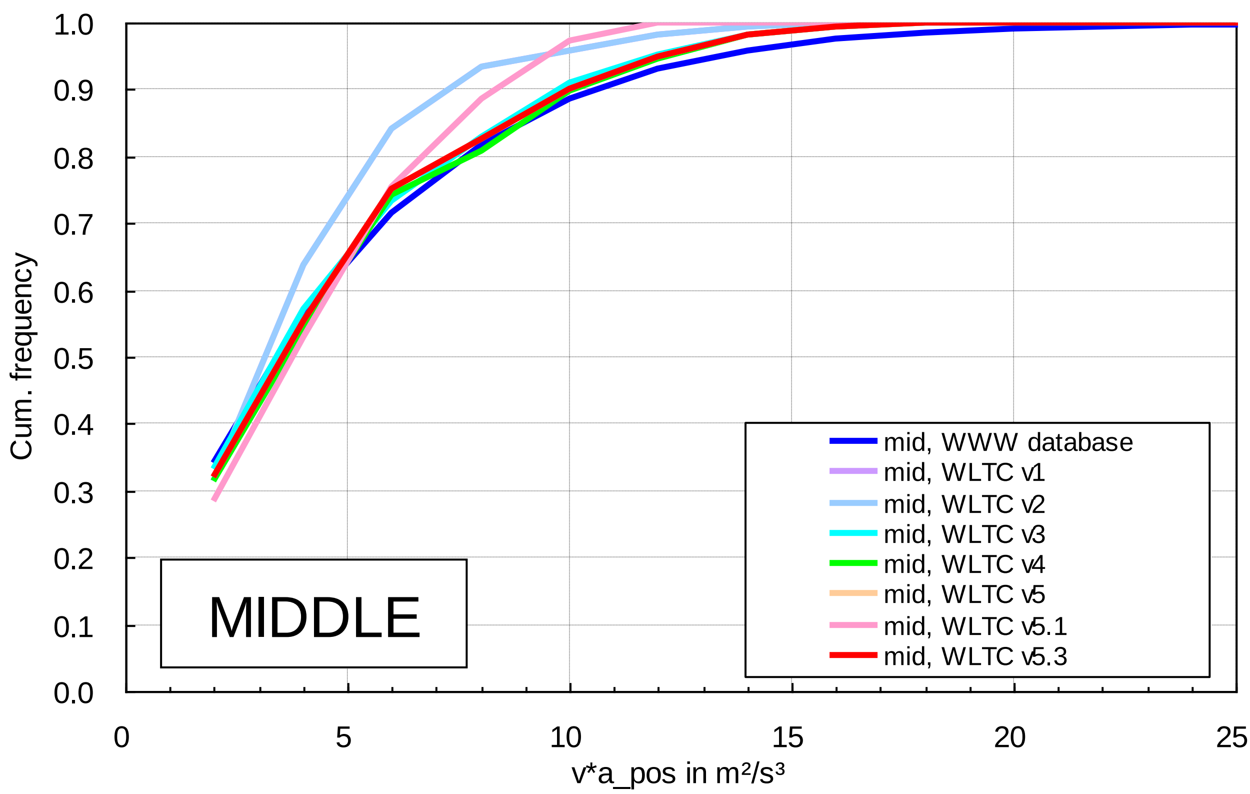


Figure 4-27 Cumulative frequency of multiplication of speed and acceleration (v*a) in Middle phase

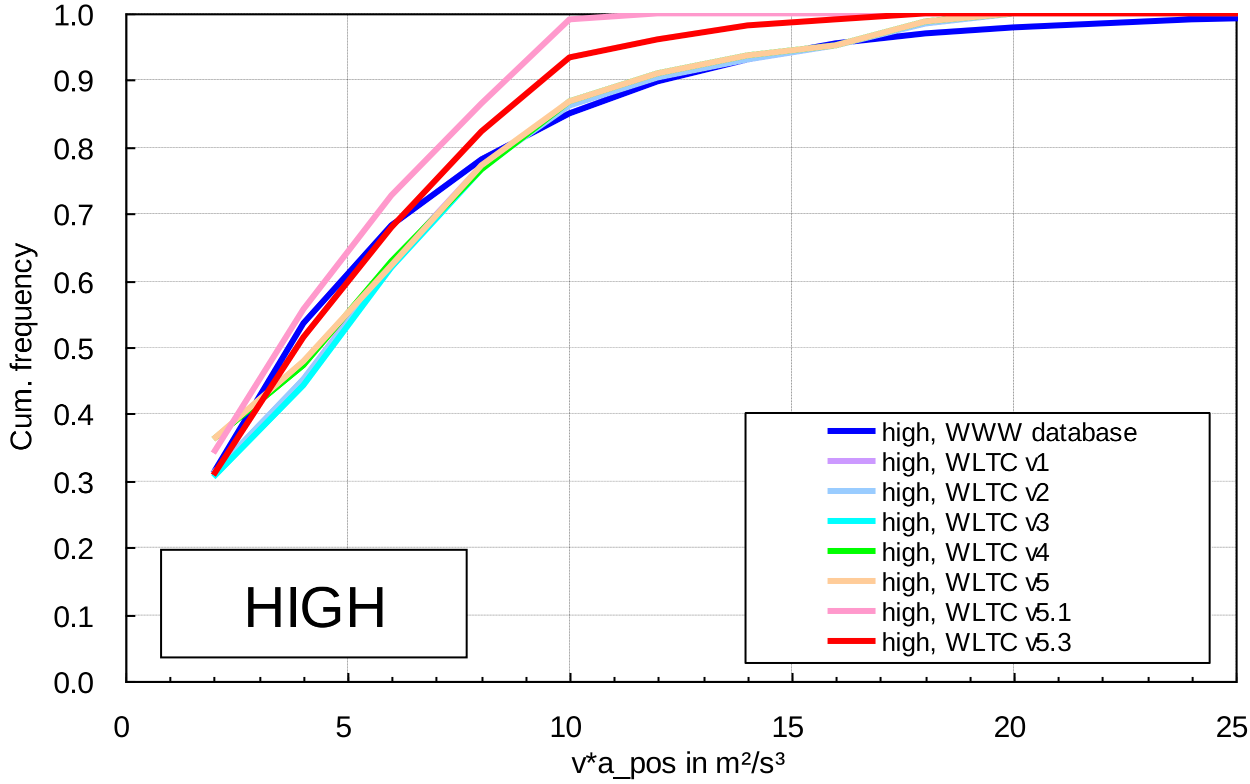


Figure 4-28 Cumulative frequency of multiplication of speed and acceleration (v*a) in High phase

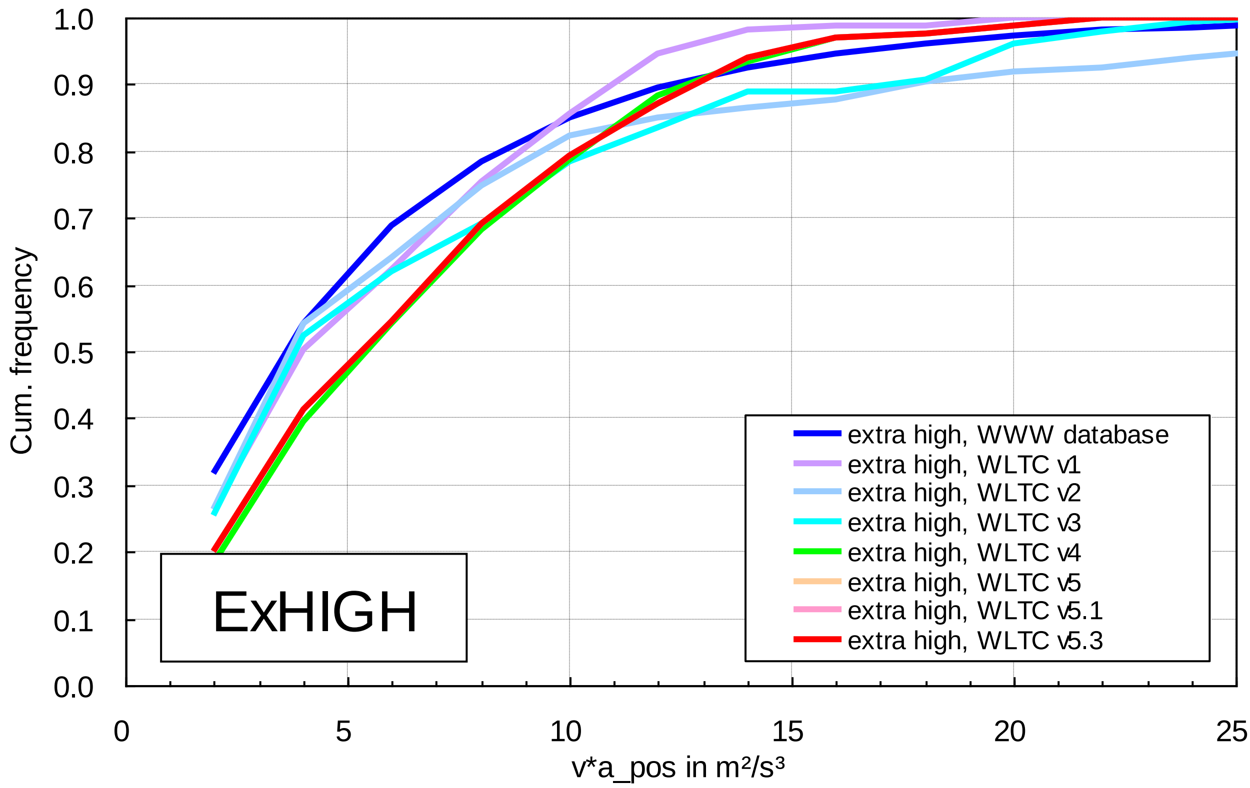


Figure 4-29 Cumulative frequency of multiplication of speed and acceleration (v*a) in Extra high phase

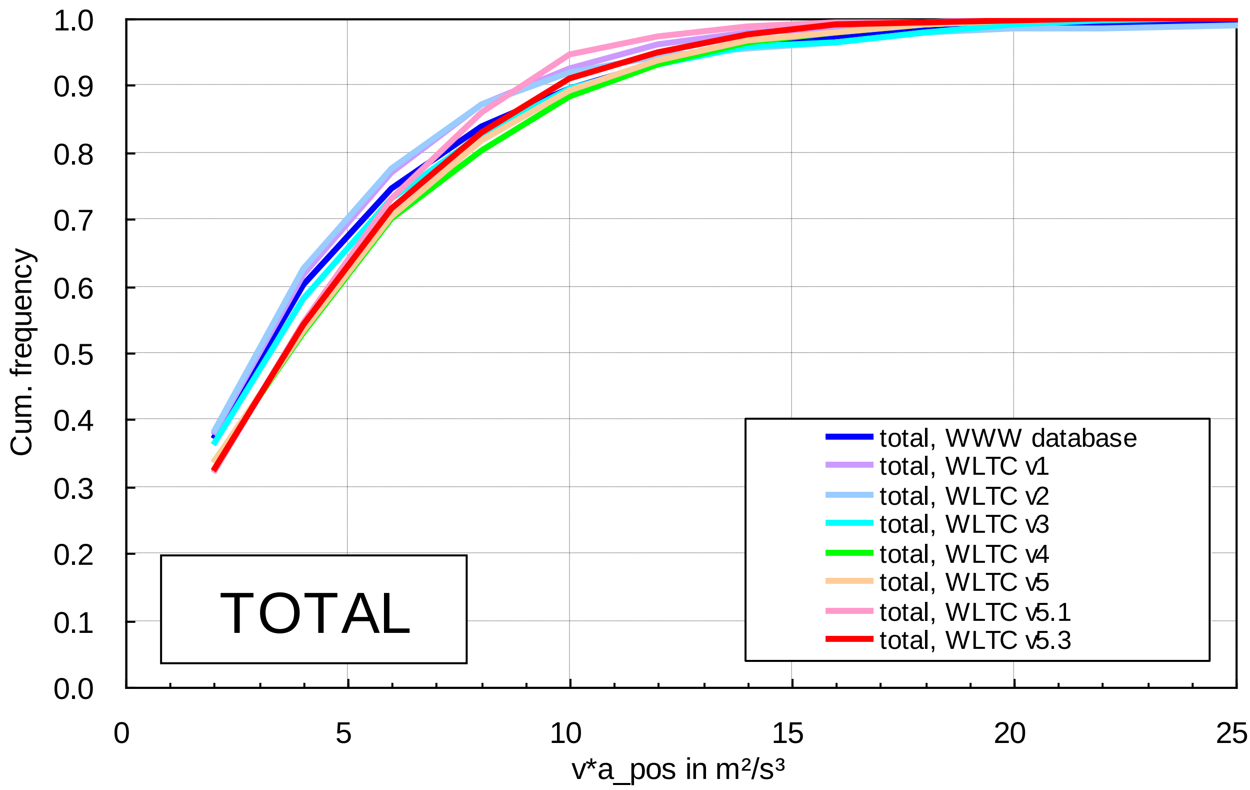


Figure 4-30 Cumulative frequency of multiplication of speed and acceleration (v*a) in WLTC

4.7. WLTC for Low Powered vehicle

India expressed substantial concerns with respect to the drivability of the test cycle for their low powered vehicles. These vehicles would have to drive a special cycle consisting of a modified low, medium and high speed part in the 10th DHC meeting. The cycle development for low powered vehicles was agreed at the 11th DHC meeting with the discussion on the definition of "low powered vehicles".

India submitted additional in-use driving data specialized in low powered vehicles. The cycle for the low powered vehicles were drawn up based on driving data of the vehicles with power to mass ratio 35tW/t or lower from the additional and existing data. Traceability of prescribed cycle and drivability were evaluated with validation 1b and 2. Then the revised version2.0 was agreed.

The speed profiles of the WLTC for low powered vehicle are shown in Figure 4-31 and Figure 4-32[14].

[14] https://www2.unece.org/wiki/download/attachments/5801079/WLTP-DHC-16-06e_rev.xlsx

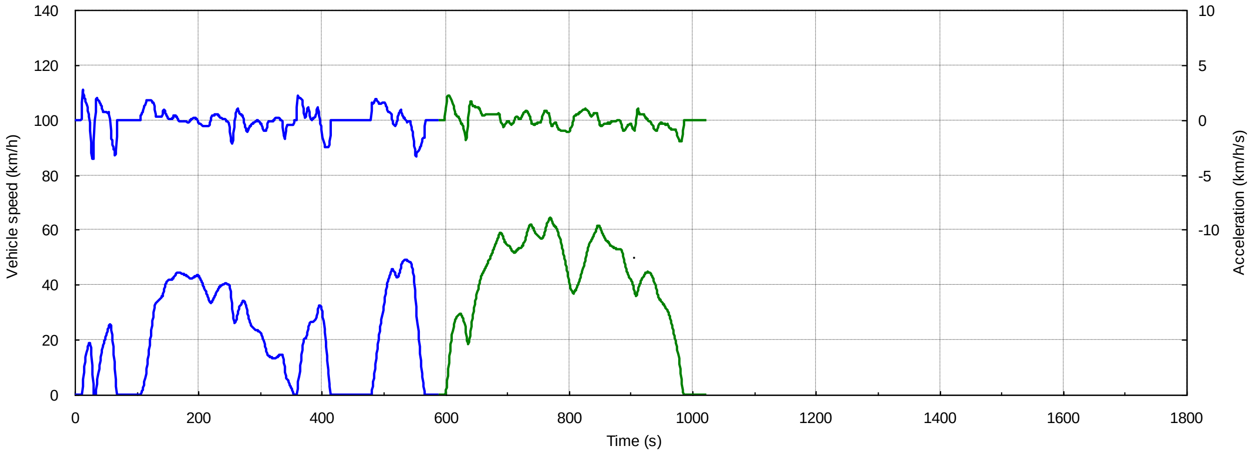


Figure 4-31 The speed profile of the WLTC Class 1 version 2.0

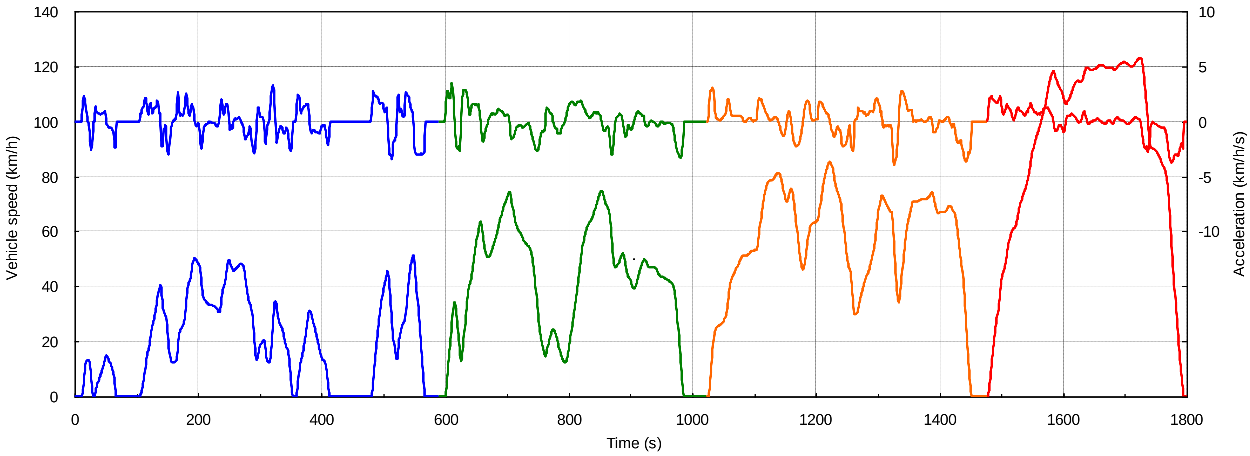


Figure 4-32 The speed profile of the WLTC Class 2 version 2.0

4.8. Vehicle classification and applicable test cycle

The vehicle classification is one of the important issues of the WLTP development process. From practical reasons, the cycle allocation was agreed during 15th DHC meeting on December 2012 as shown in Figure 4-33. (WLTP-DHC-15-04)

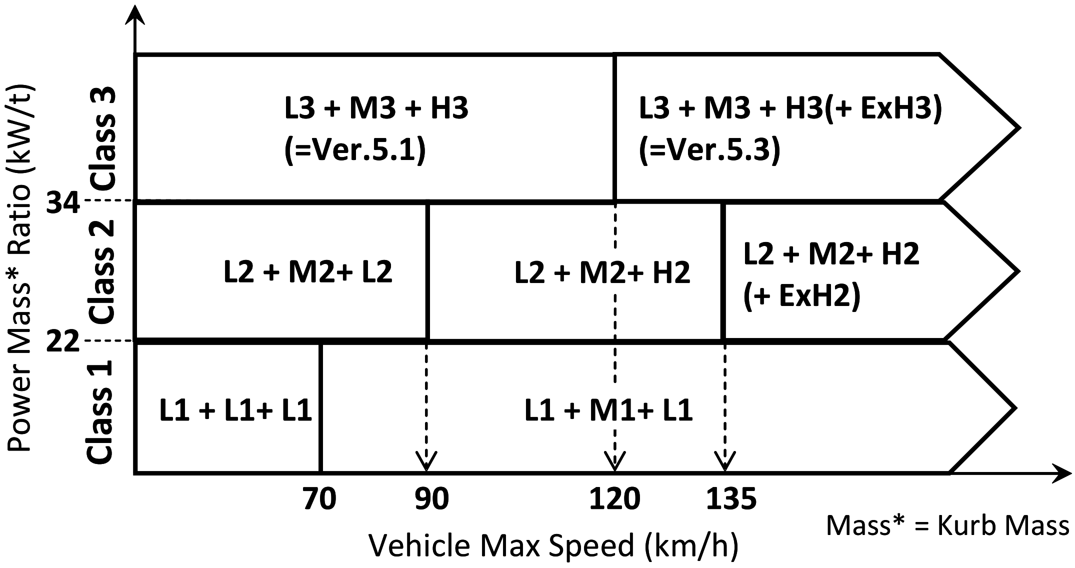


Figure 4-33 Vehicle classifications of WLTC

4.9. Down scale procedure

4.9.1. Preliminary note

The WLTP vehicle classification is based on the ratio between rated power and kerb mass (pmr). Based on an analysis of the dynamics of the in-use data the following classification was agreed:

1. Class 1: pmr <= 22 W/kg,
2. Class 2: 22 W/kg < pmr <= 34 W/kg,
3. Class 3: pmr > 34 W/kg.

Consequently, three different WLTC versions were developed according to the dynamic potentials of the different classes. The maximum speeds of the different cycle versions and phases are shown in Table 4-12.

Table 4-12 Maximum speeds of the cycle phases

Vehicle class	Cycle version	v_max for cycle phase in km/h			
		low	medium	high	extra high
1	2	49.1	64.4		
2	2	51.4	74.7	85.2	123.1
3	5.1/5.3	56.5	76.6	97.4	131.3

During the validation 2 phase some vehicles with pmr values close to the borderlines had problems to follow the cycle speed trace within the tolerances (+/- 2 km/h, +/- 1 s). The following figures show one example per vehicle class.

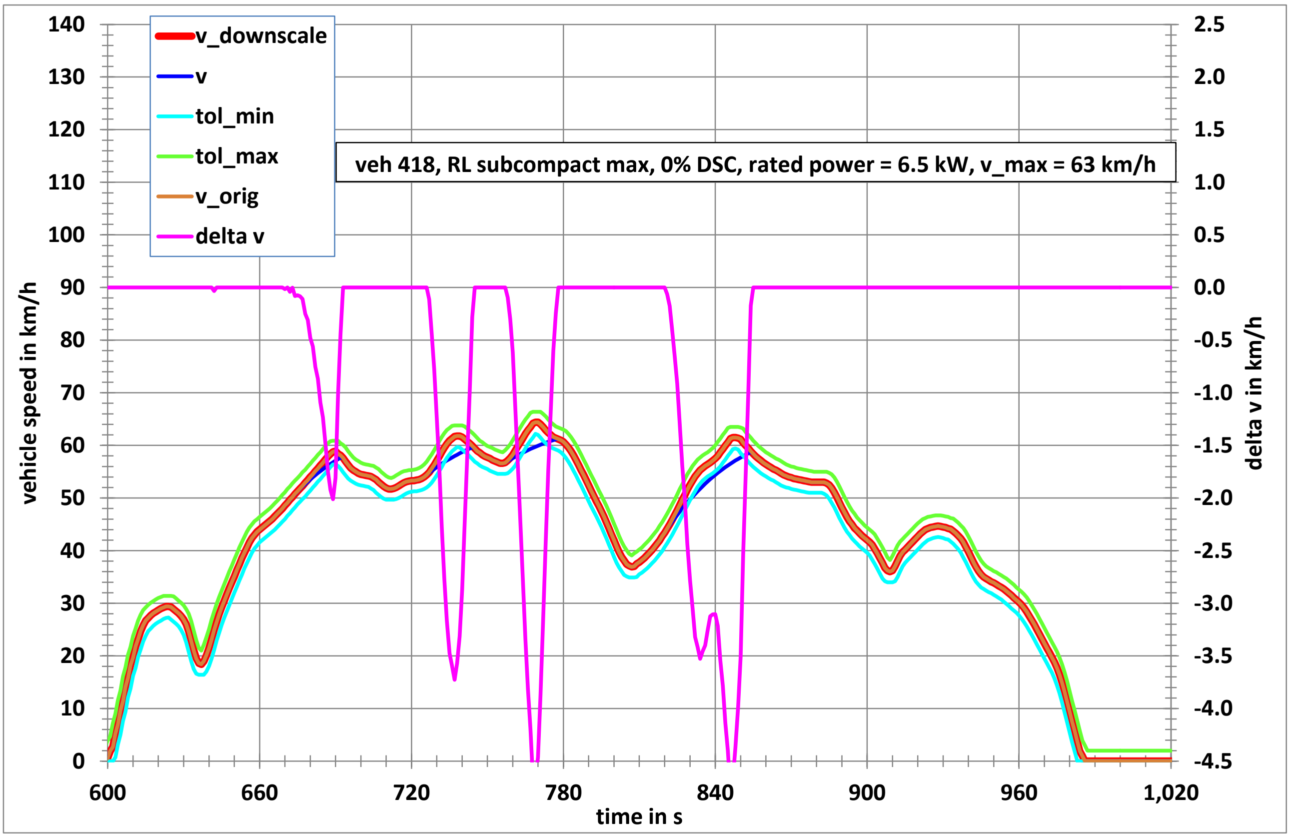


Figure 4-34 Speed trace of a class 1 vehicle with drivability problems

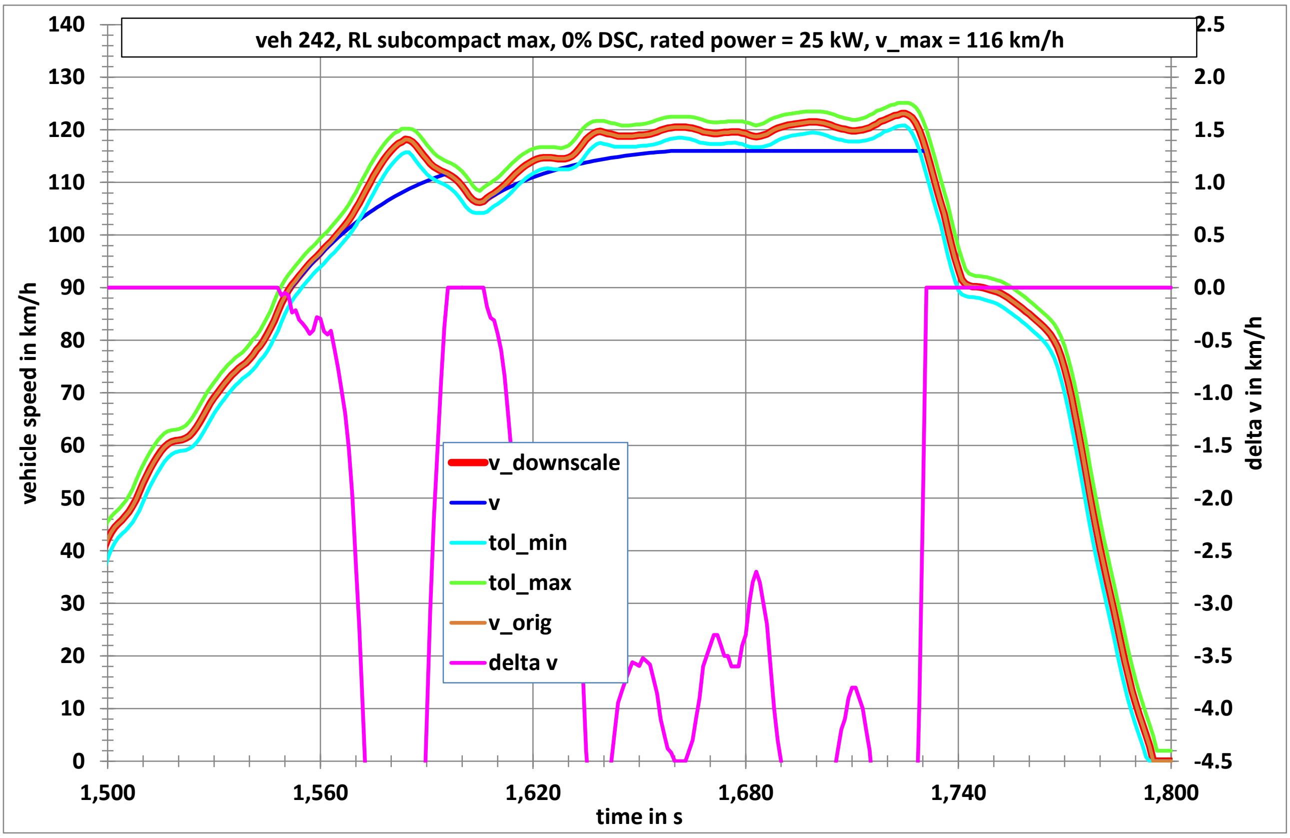


Figure 4-35 Speed trace of a class 2 vehicle with drivability problems

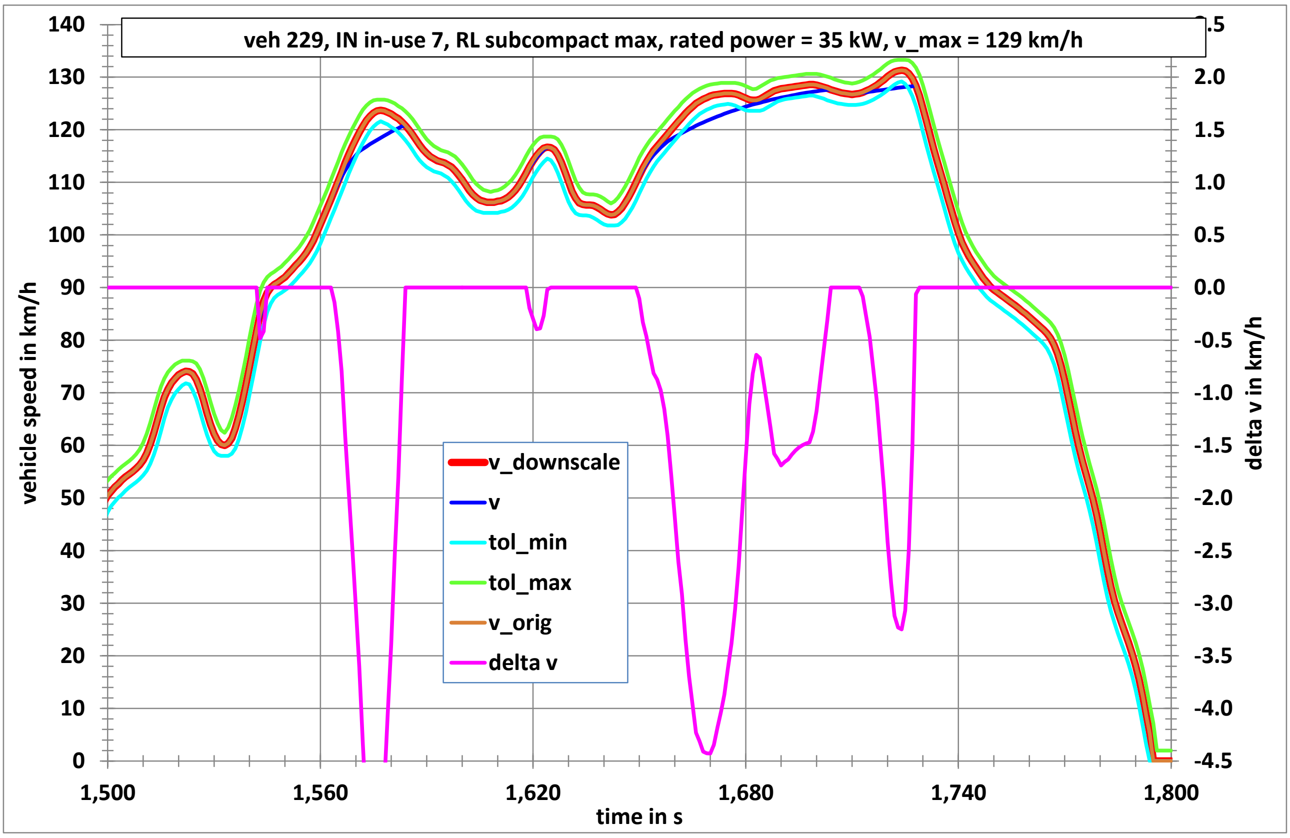


Figure 4-36 Speed trace of a class 3 vehicle with drivability problems

The question to be answered was, how to proceed with such vehicles. Three possibilities were discussed:

1. Follow the trace as good as possible,
2. Apply a cap on the maximum speed of the vehicle,
3. Downscale the cycle for those sections where the driveability problems occur.

The first possibility can lead to excessively high percentages of full load (wot) operation and would create a burden for those vehicles compared to vehicles without driveability problems. The second possibility was found to be not very effective. It works for some vehicle configurations but does not work for others. The third possibility was found to be more effective and the technical justification is given in the following paragraphs.

The calculation equations and calculation coefficients are based on correlation analyses and were modified in a second step in order to optimise the efficiency of the method.

The calculation of the downscaling factor is based on the ratio between the maximum required power of the cycle phases where the downscaling has to be applied and the rated power of the vehicle. The maximum required power within the cycle occurs at that time with the combination of high vehicle speed and high acceleration values. That means that the road load coefficients as well as the test mass are considered.

4.9.2. Cycle downscaling, class 1 vehicles

Since the driveability problems are exclusively related to the medium speed phase of the class 1 cycle, the downscaling is related to those sections of the medium speed phase, where the driveability problems occur (see Figure 4-37).

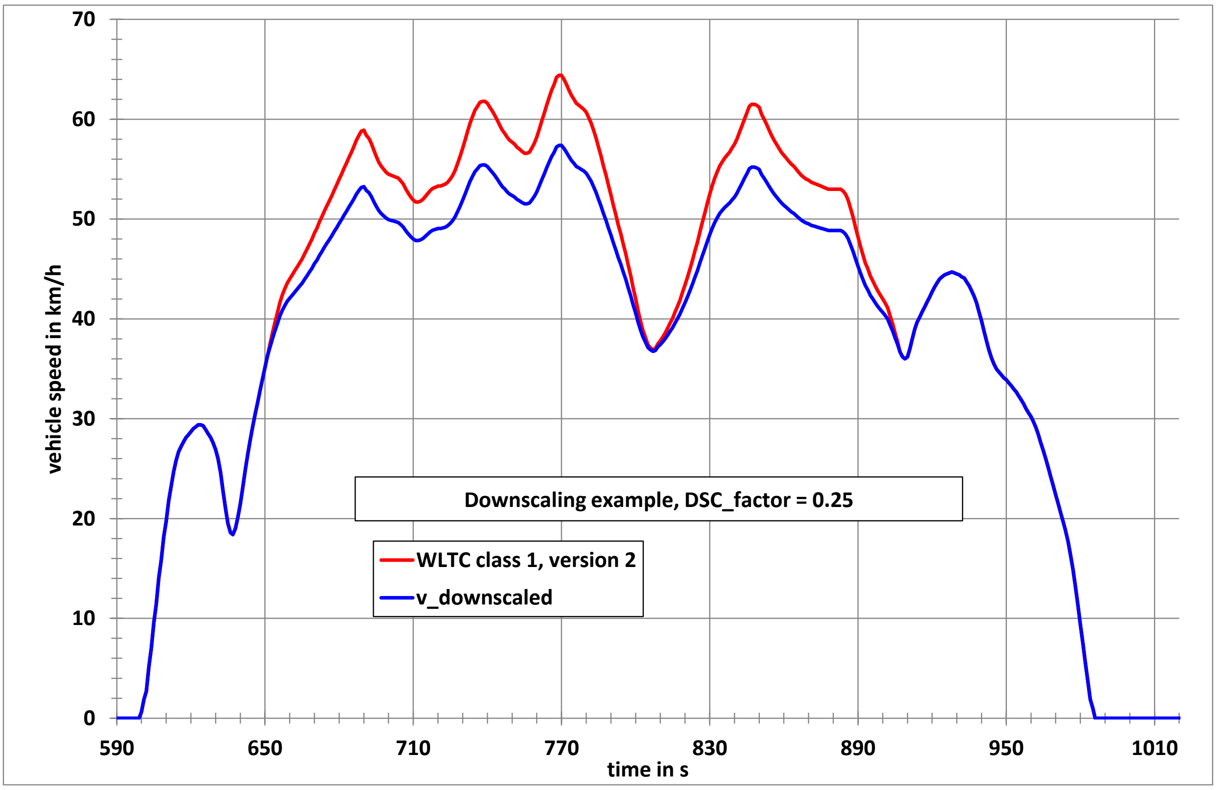


Figure 4-37 Downscaled medium speed phase of the class 1 WLTC

For the class 1 cycle the downscaling period is the time period between second 651 and second 906. Within this time period the acceleration for the original cycle is calculated using the following equation:

$$a\_orig\_i = (v\_i+1 - v\_i)/3.6 \qquad \textbf{Equation 1}$$

v_i is the vehicle speed in km/h, i is the time between 651 and 906 s.

The downscaling is first applied in the time period between second 651 and 848. Second 848 is the time where the maximum speed of the extra high speed phase is reached. The downscaled speed trace is then calculated using the following equation:

$$v\_dsc\_i+1 = v\_dsc\_i + a\_orig\_i * (1 - dsc\_factor) * 3.6 \qquad \textbf{Equation 2}$$

with i = 651 to 848. v_dsc_i = v_orig_i for i = 651.

In order to meet the original vehicle speed at second 907 a correction factor for the deceleration is calculated using the following equation:

$$f\_corr\_dec = (v\_dsc\_848 - 36,7) / (v\_orig\_848 - 36,7) \qquad \textbf{Equation 3}$$

36,7 km/h is the original vehicle speed at second 907.

The downscaled vehicle speed between 849 and 906 s is then calculated using the following equation:

$$v\_dsc\_i = v\_dsc\_i-1 + a\_orig\_i-1 * f\_corr\_dec * 3.6 \qquad \textbf{Equation 4}$$

with i = 849 to 906.

4.9.3. Downscaling procedure for class 2 vehicles

Since the driveability problems are exclusively related to the extra high speed phases of the class 2 and class 3 cycles, the downscaling is related to those sections of the extra high speed phases, where the driveability problems occur (see Figure 4-38).

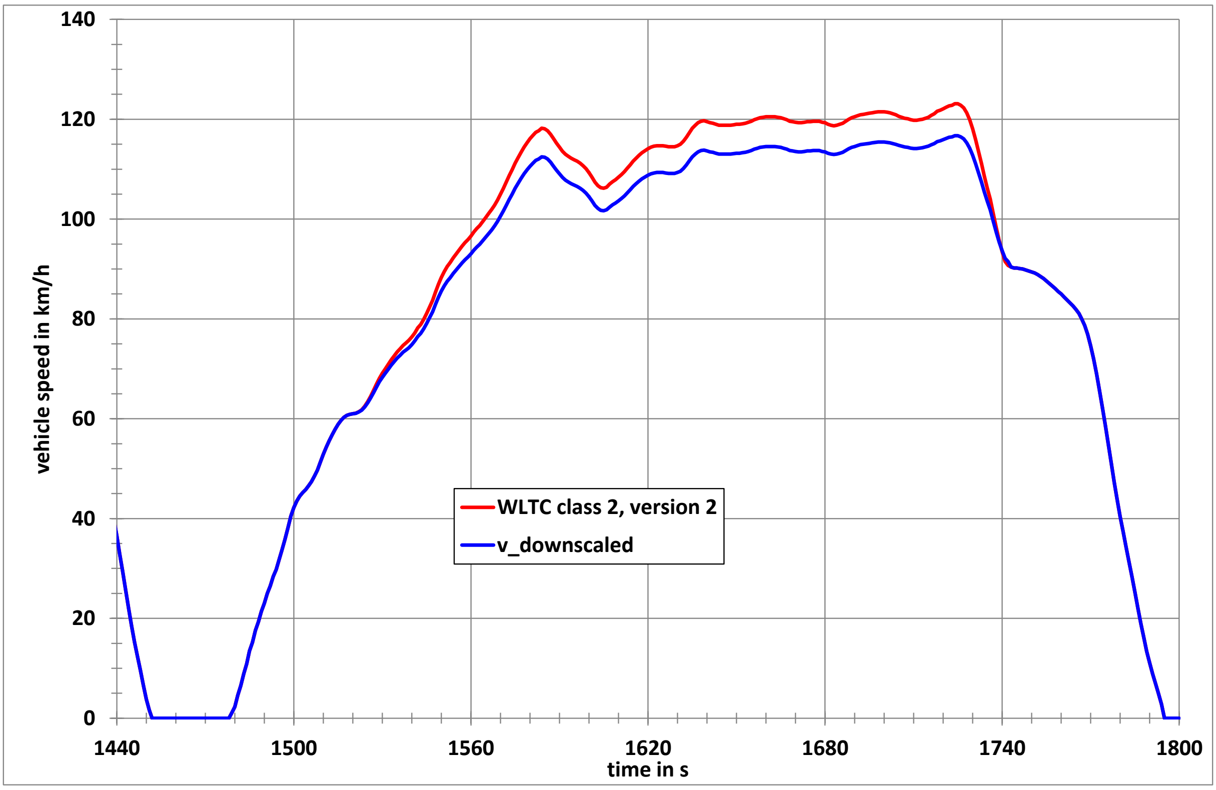


Figure 4-38 Downscaled extra high speed phase of the class 2 WLTC

For the class 2 cycle the downscaling period is the time period between second 1520 and second 1742. Within this time period the acceleration for the original cycle is calculated using the following equation:

$$a\_orig\_i = (v\_i+1 - v\_i)/3.6 \qquad \textbf{Equation 5}$$

v_i is the vehicle speed in km/h, i is the time between 1520 and 1742 s.

The downscaling is first applied in the time period between second 1520 and 1724. Second 1724 is the time where the maximum speed of the extra high speed phase is reached. The downscaled speed trace is then calculated using the following equation:

$$v\_dsc\_i+1 = v\_dsc\_i + a\_orig\_i * (1 - dsc\_factor) * 3.6 \qquad \textbf{Equation 6}$$

with i = 1520 to 1724. v_dsc_i = v_orig_i for i = 1520.

In order to meet the original vehicle speed at second 1743 a correction factor for the deceleration is calculated using the following equation:

$$f\_corr\_dec = (v\_dsc\_1725 - 90{,}4) / (v\_orig\_1725 - 90{,}4) \qquad \textbf{Equation 7}$$

90,4 km/h is the original vehicle speed at second 1743.

The downscaled vehicle speed between 1726 and 1742 s is then calculated using the following equation:

$$v\_dsc\_i = v\_dsc\_i-1 + a\_orig\_i-1 * f\_corr\_dec * 3.6 \qquad \textbf{Equation 8}$$

with i = 1726 to 1742.

4.9.4. Downscaling procedure for class 3 vehicles

Figure 4-39 shows an example for a downscaled extra high speed phase of the class 3 WLTC.

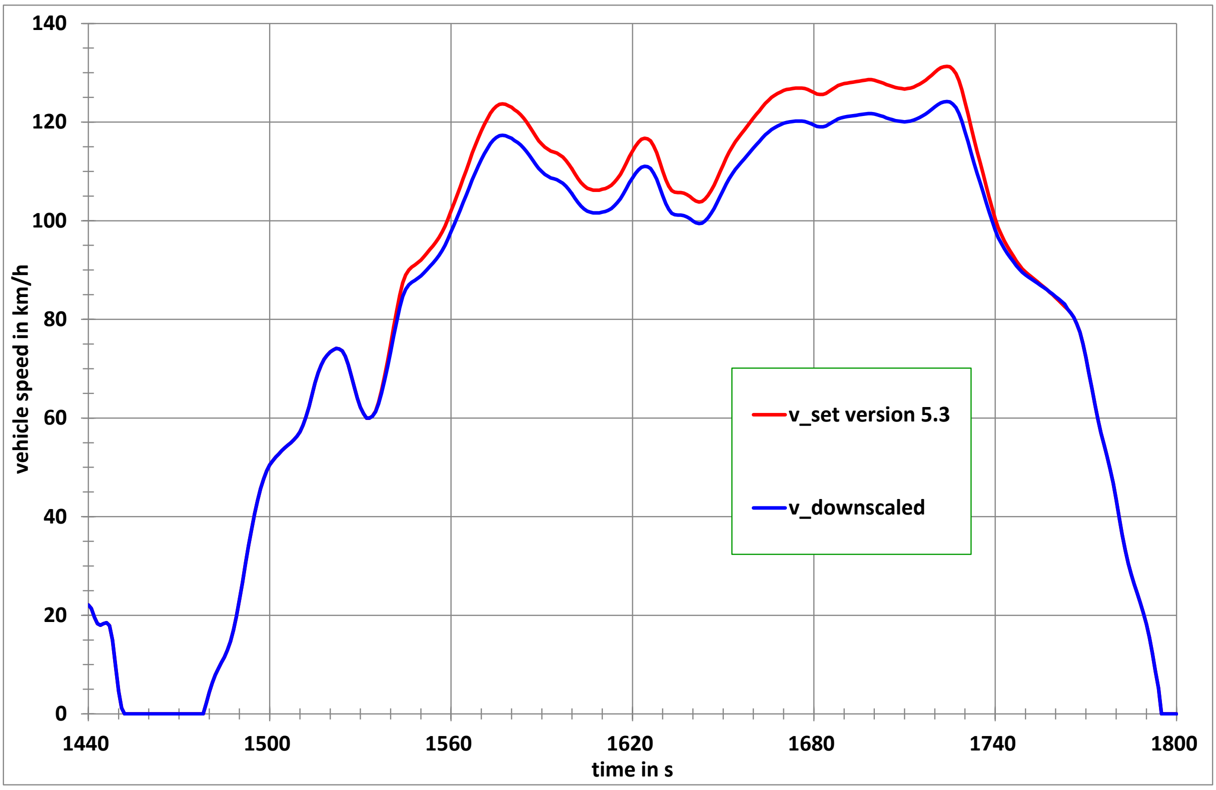


Figure 4-39 Downscaled extra high speed phase of the class 3 WLTC

For the class 3 cycle this is the period between second 1533 and second 1763. Within this time period the acceleration for the original cycle is calculated using the following equation:

$$a\_orig\_i = (v\_i{+}1 - v\_i)/3.6 \qquad \textbf{Equation 9}$$

v_i is the vehicle speed in km/h, i is the time between 1533 and 1762 s.

The downscaling is first applied in the time period between second 1533 and 1724. Second 1724 is the time where the maximum speed of the extra high speed phase is reached. The downscaled speed trace is then calculated using the following equation:

$$v\_dsc\_i{+}1 = v\_dsc\_i + a\_orig\_i * (1 - dsc\_factor) * 3.6 \qquad \textbf{Equation 10}$$

with i = 1533 to 1723. v_dsc_i = v_orig_i for i = 1533.

In order to meet the original vehicle speed at second 1763 a correction factor for the deceleration is calculated using the following equation:

$$f\_corr\_dec = (v\_dsc\_1724 - 82.6) / (v\_orig\_1724 - 82.6) \qquad \textbf{Equation 11}$$

82.6 km/h is the original vehicle speed at second 1763.

The downscaled vehicle speed between 1725 and 1762 s is then calculated using the following equation:

$$v\_dsc\_i = v\_dsc\_i{-}1 + a\_orig\_i{-}1 * f\_corr\_dec * 3.6 \qquad \textbf{Equation 12}$$

with i = 1725 to 1762.

4.9.5. Results of model calculations

The development of the proposal for downscaling factors is based on calculations performed with a modified version of the WLTP gearshift calculation tool, which provides also estimates of the CO_2 emissions.

The following calculations were performed:

- Class 3 vehicles: 133 configurations with vmax between 90 km/h and 146 km/h, 96 of them needed downscaling, 37 did not.
- Class 2 vehicles: 164 configurations with vmax between 90 km/h and 141 km/h, 124 of them needed downscaling, 40 did not.
- Class 1 vehicles: 78 configurations with vmax between 58 km/h and 129 km/h, 23 of them needed downscaling, 55 did not .

The maximum speeds were calculated from the transmission data and the driving resistance coefficients used for the different vehicle configurations. For one part of the configurations the default values of the driving resistance coefficients, provided by the model, were used. Since these coefficients are based on existing European legislation and thus do not reflect the modifications currently discussed within the GTR development process, calculations were performed for additional configurations with varied driving resistance coefficients. These driving resistance coefficients were chosen from a data pool provided by vehicle manufacturers, TUG and TNO.

For the calculations min, ave and max values for f_0, f_1 and f_2 were used for the following vehicle categories:

- Subcompact cars,
- Compact cars,
- Medium cars,
- Large cars,
- Small N1,
- Medium N1,
- Large N1.

According to the aim of the analysis the focus was set on subcompact, compact cars and N1 vehicles.

The necessary downscaling factors were determined by a stepwise increase of the downscaling factor f_{dsc} by 1%, starting at 1% for vehicles with speed trace tolerance violations until no violations occurred.

The ratio between the maximum power demand (including acceleration power) within the extra high speed phase (medium speed phase for class 1 vehicles) and the rated power correlates reasonably with the necessary downscaling factors. This ratio is called r_{max}.

The cycle time i where the maximum power (including acceleration power) is required is

- 764 s for class 1, v = 61.4 km/h, a = 0.22 m/s²,
- 1574 s for class 2, v = 109.9 km/h, a = 0.36 m/s² and
- 1566 s for class 3, v = 111.9 km/h, a = 0.5 m/s².

The power demand can easily be calculated from the driving resistance coefficients, the mass of the vehicle and the cycle parameter vehicle speed and acceleration.

$$P_{req,max} = (f0*v + f1*v^2 + f2*v^3)/3600 + kr*m_{test}*a*v/3600$$

with v – vehicle speed in km/h, a – acceleration in m/s²,

mtest – test mass in kg and P in kW.

kr represents the rotational inertia and was set to 1,1.

The driving resistance coefficients f0, f1 and f2 have to be determined by coast down measurements or an equivalent method. The available power depends on the full load power curve (wot curve) and the transmission design. Average wot curves for Petrol and Diesel vehicles as provided by Stefan Hausberger were used for the calculations.

The transmission designs were taken from manual transmission vehicles either from the WLTP in-use database or the validation 2 database. In some cases the transmission design was modified in order to assess the influence on driveability. For the available power a safety margin of 10% was applied to the wot curves.

In order to illustrate the power demand and the available power both values were calculated for each second of the WLTC and plotted against the vehicle speed. The driveability was checked by a comparison of the actual speed, the set speed (original or downscaled) and the tolerance band.

4.9.6. Results for class 3 vehicles

Figure 4-40 shows the necessary downscaling factors versus the ratios between the maximum required power and rated power for class 3 vehicles. Since the maximum power demand is related to v = 111.9 km/h, vehicles with vmax above and below this threshold are separated. For vehicles with vmax below 112 km/h r_max is only a theoretical parameter.

In addition to that vehicles with 4speed transmissions and transmissions with more than 4 gears are separated.

Before the results are discussed it should be clarified if the maximum power demand at a specific second is a suitable parameter. Figure 4-41 shows a comparison of this parameter with average values over several seconds. The correlation is so strong, that the maximum values can be used.

But Figure 4-40 shows significant differences between the already mentioned subgroups. Vehicles with 4speed transmissions require on average higher downscaling factors (fdsc) than vehicles with transmissions with more than 4 gears and vehicles with vmax values below the threshold require downscaling only at high rmax values (above 130%).

On the other hand, the variation range of fdsc at given rmax values is significantly higher for vehicles with 4speed transmissions compared to vehicles with transmissions with more than 4 gears. Some of the vehicles with 4speed transmissions fit well to the group with transmissions with more than 4 gears.

The most extreme examples are two vehicles with rmax = 134%. One requires a fdsc of 35%, the other only 21%.

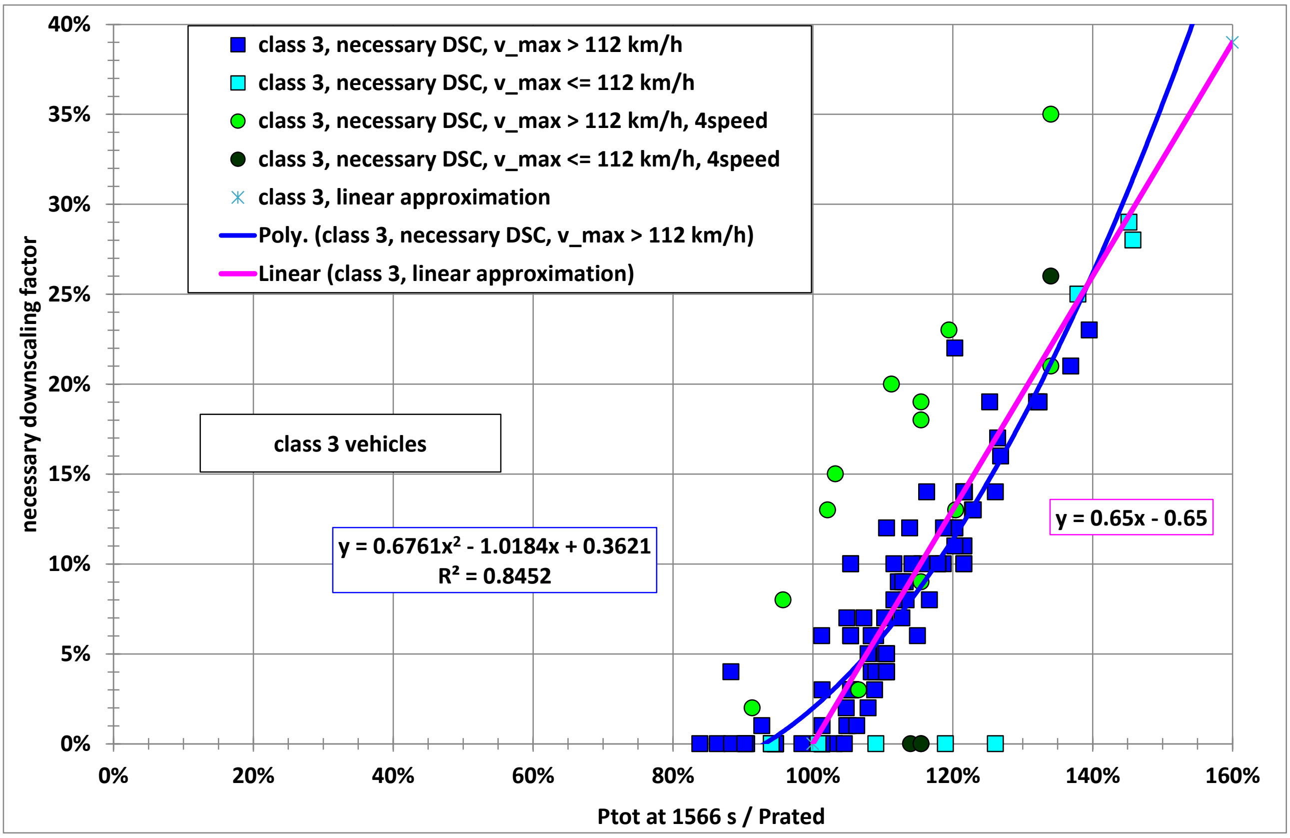


Figure 4-40 Necessary downscaling factor versus r_max for class 3 vehicles

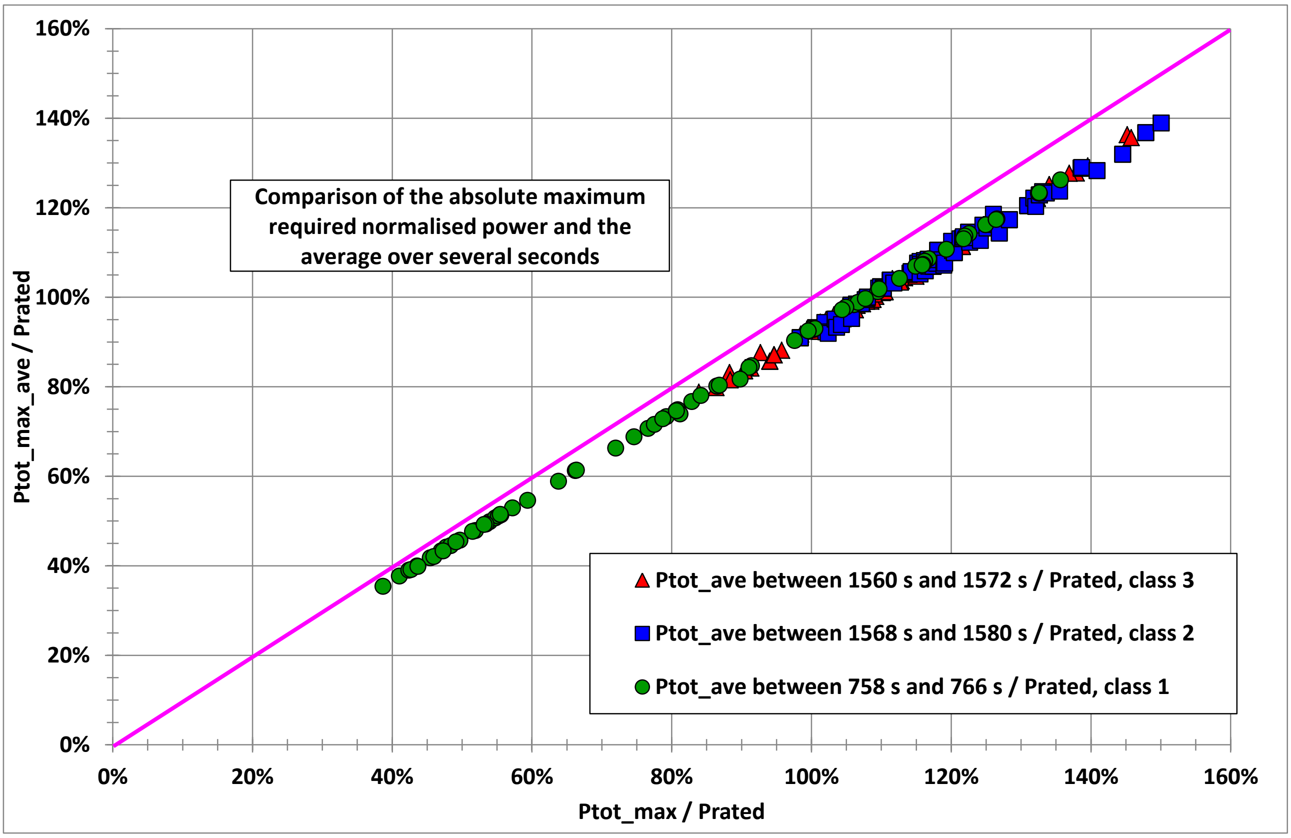


Figure 4-41 Comparison of Ptot_max and Ptot_ave

The differences between both vehicles are only related to the transmission design. Rated power and test mass are exactly the same. The speed traces of both vehicles for the extra high speed phase are shown in Figure 4-42 and Figure 4-43. The corresponding power values are shown in Figure 4-44 and Figure 4-45.

Vehicle 361 has higher driveability problems than vehicle 362, although vmax of vehicle 361 is slightly higher than for vehicle 362. The reason is the disadvantageous transmission design of vehicle 361 compared to vehicle 362. For vehicle 361 the highest power demand corresponds to a valley of the available power between gear 3 and gear 4 (see Figure 4-44), while for vehicle 362 the highest demand coincides with the highest available power in 4. Gear (see Figure 4-45).

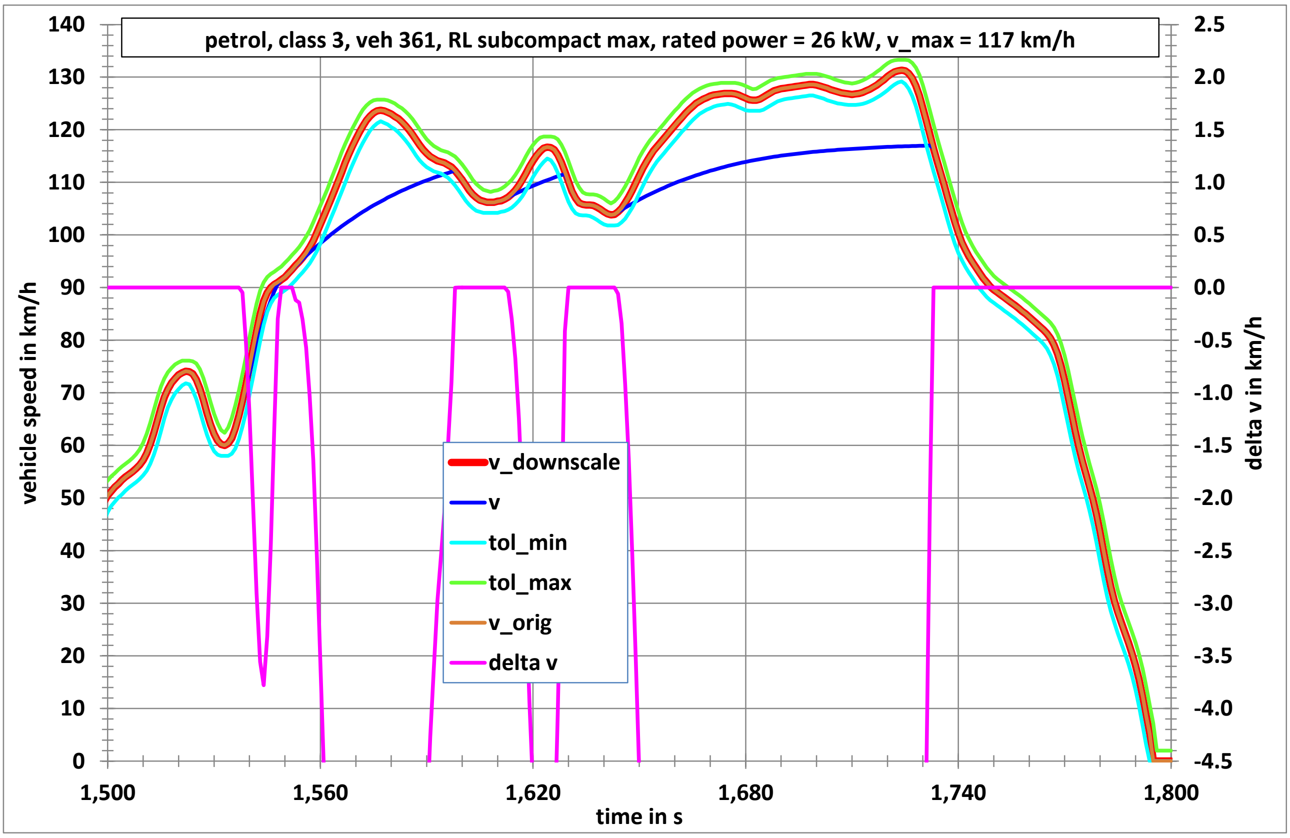


Figure 4-42 Speed trace of the extra high speed phase for vehicle 361

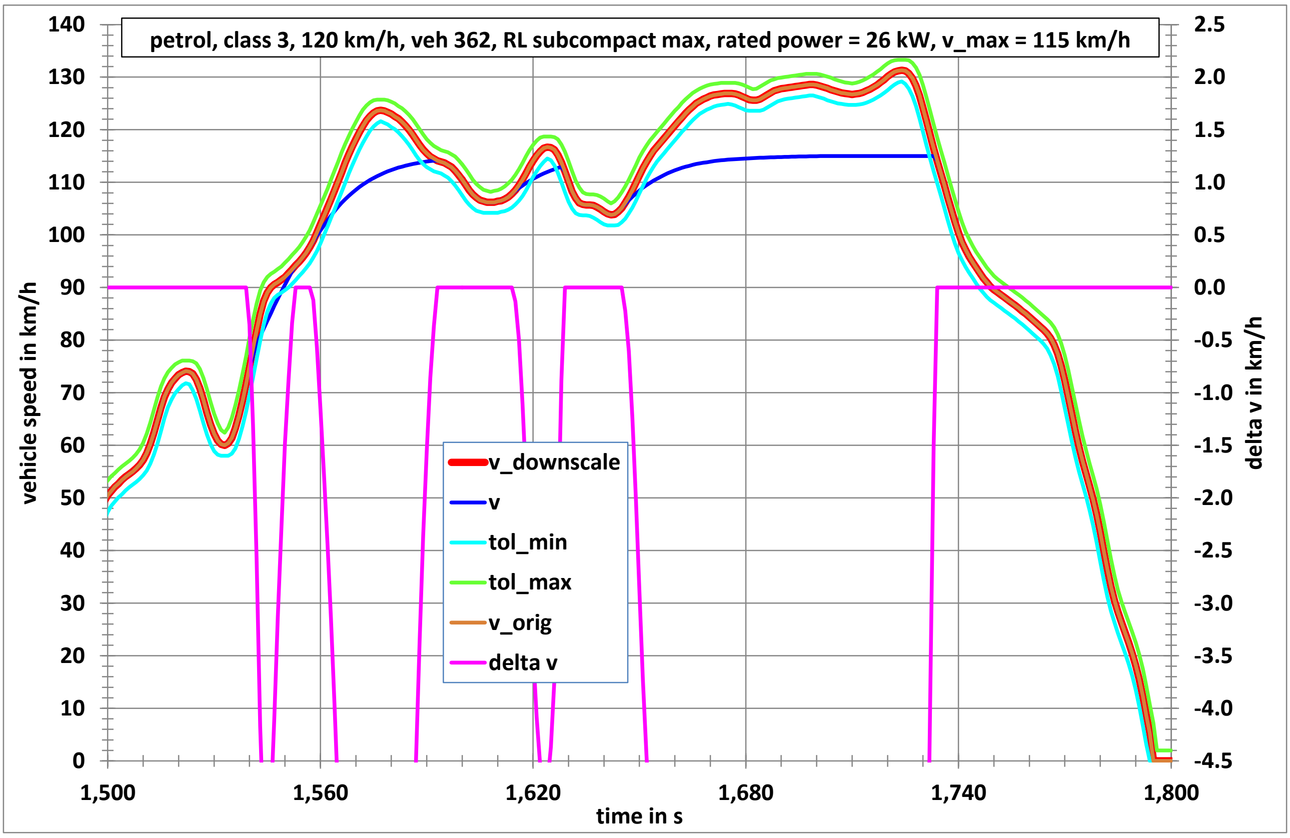


Figure 4-43 Speed trace of the extra high speed phase for vehicle 362

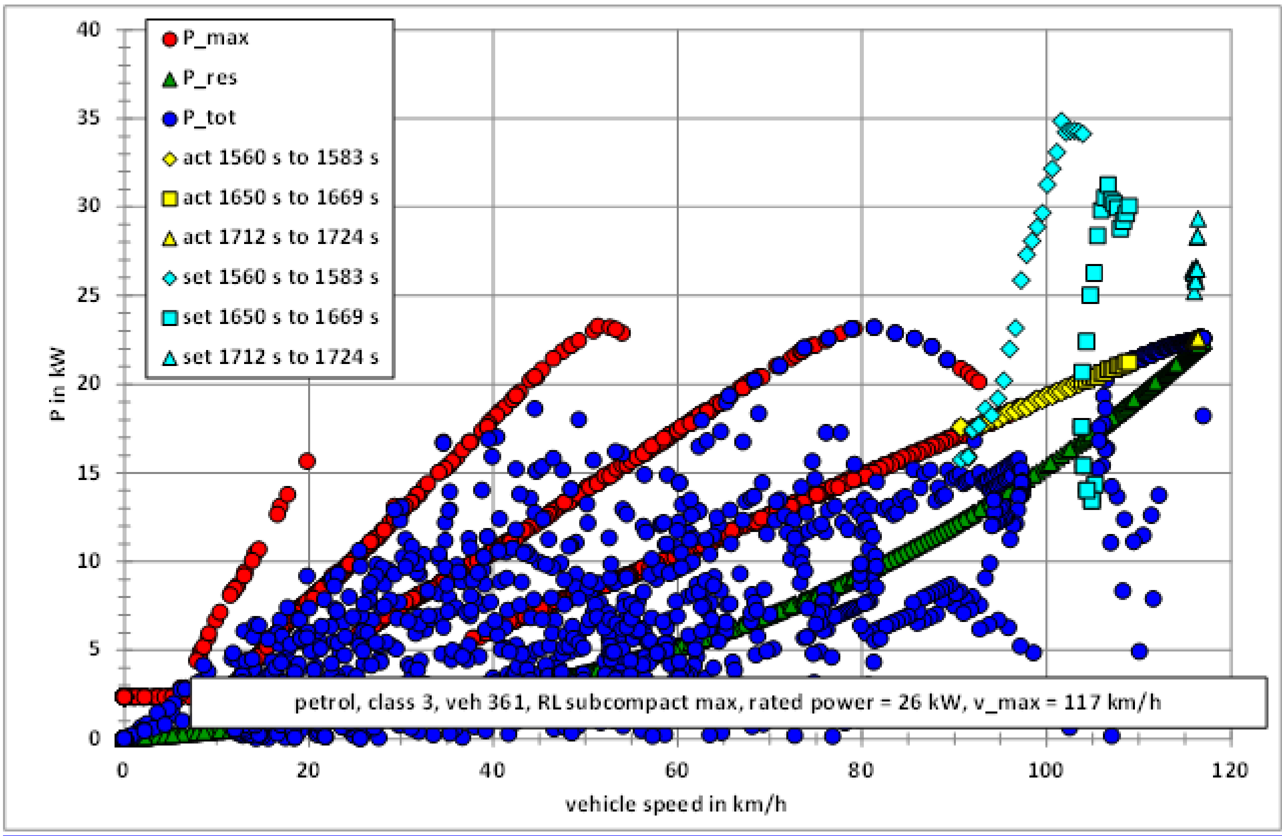


Figure 4-44 Corresponding power values for vehicle 361

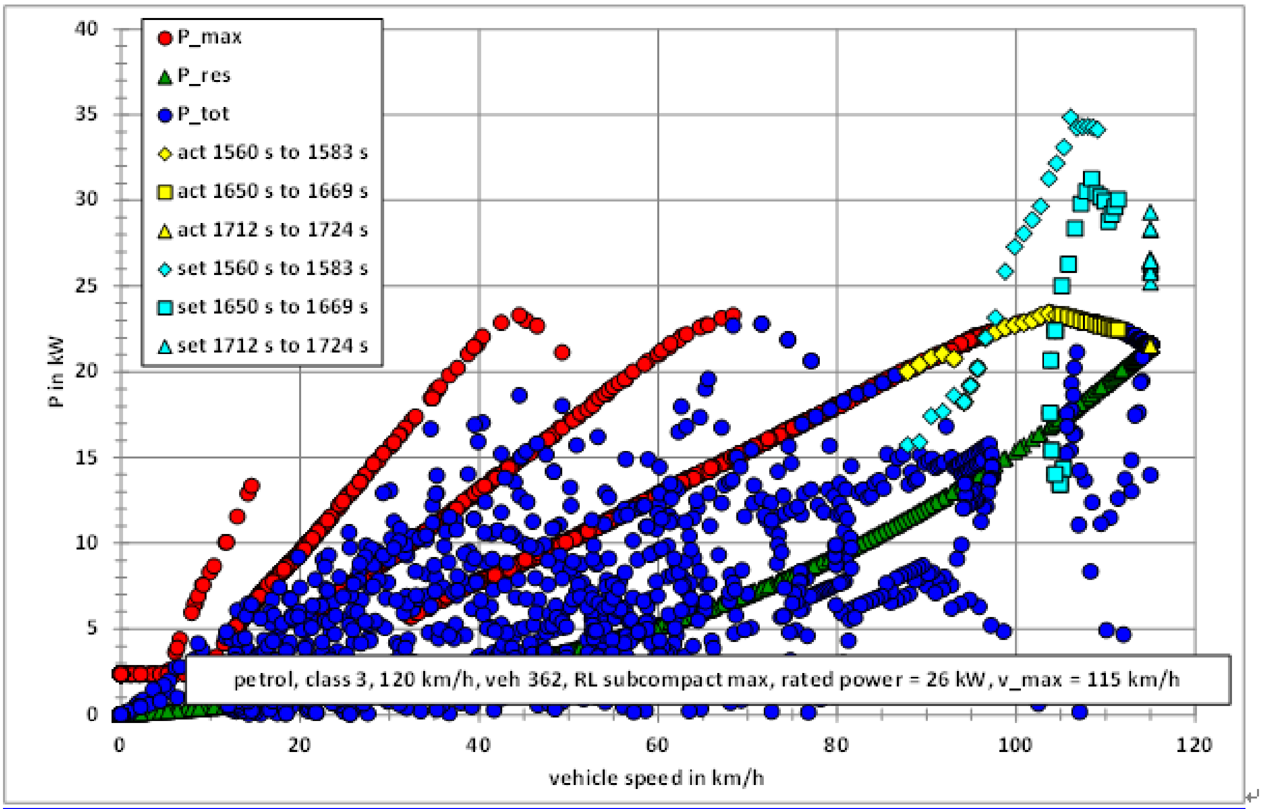


Figure 4-45 Corresponding power values for vehicle 362

Since vehicle 361 has a higher full load (wot) percentage and a higher fuel consumption (2% in total and almost 5% in the extra high speed phase) than vehicle 362.

Similar results were found for other 4speed examples and there are also a few examples of disadvantageous transmission design for vehicles with more than 4 gears. Such disadvantageous examples should not determine the forecast function for fdsc and the transmission design should not be included into the calculation, so that vehicles with automatic transmission can still be included. The results for vehicles with more than 4 gears and vmax > 112 km/h can be approximated by a 2nd degree polynomial regression curve (see Figure 4-40).

For simplification reasons this function was approximated by a linear curve starting at rmax = 100% with fdsc = 0% and reaching fdsc = 32.5% at rmax = 150%. For vehicles with vmax <= 112 km/h, the approximation function for fdsc is the same as above, but the downscaling is only applied for vehicles with rmax > 130%.

4.9.7. Results for class 2 vehicles

Figure 4-46 shows similar results as Figure 4-40, but for class 2 vehicles. The reference speed for the determination of the max. power demand is 110 km/h, but the analysis of the calculation results showed that 105 km/h is a better separator between the subgroups. Below this threshold no downscaling needs to be applied. Above this threshold a similar correlation of the fdsc values with the rmax values was found but with a less steep slope than for class 3 vehicles. And the differences between vehicles with 4 gears and more than 4 gears are less pronounced.

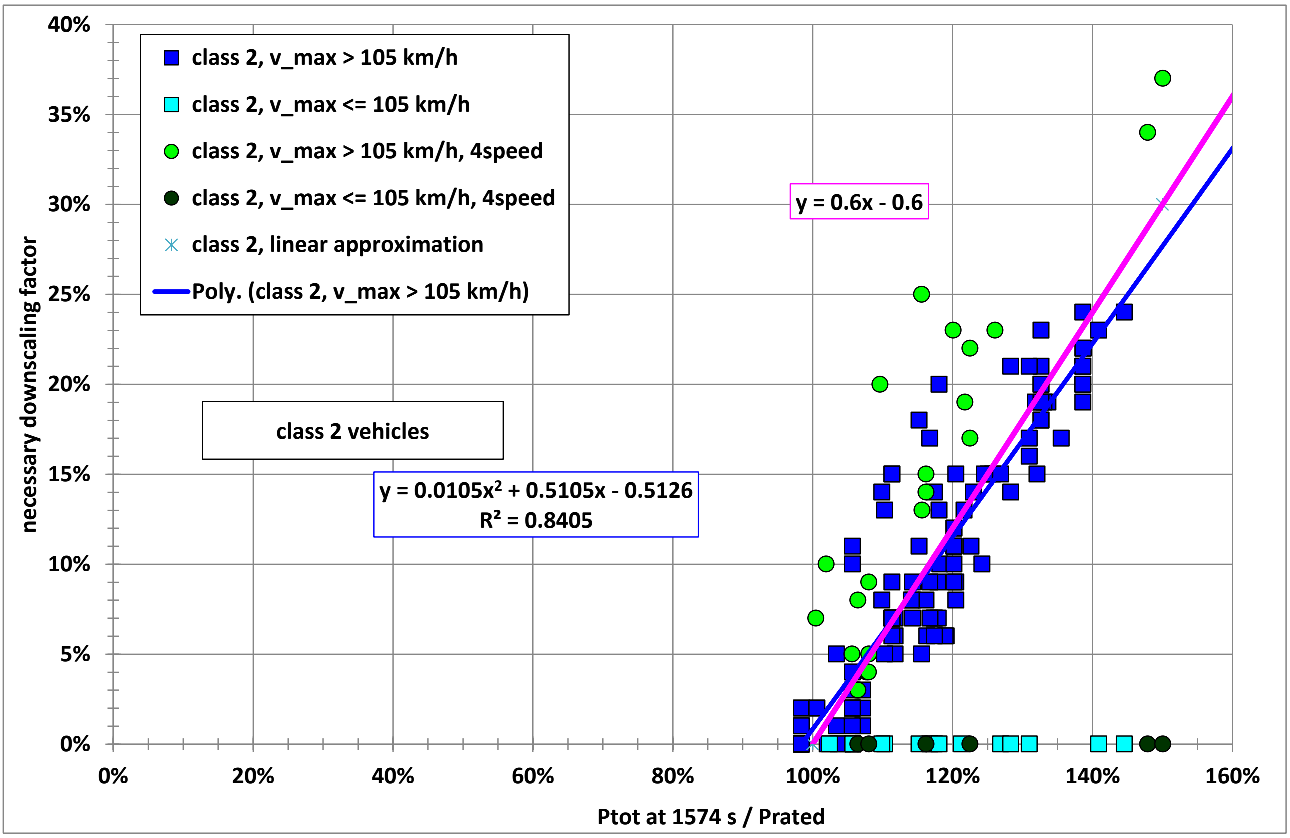


Figure 4-46 Necessary downscaling factor versus r_max for class 2 vehicles

The linear approximation curve starts also at rmax = 100% and fdsc = 0% and goes to fdsc = 30% at rmax = 150%. The differences in fdsc for a given rmax between different vehicles (up to 10% for fdsc for both subgroups) are also caused by differences in the transmission design.

4.9.8. Results for class 1 vehicles

The results for class 1 vehicles are shown in Figure 4-47. The reference speed for the maximum power demand is 61.4 km/h. Therefore 61 km/h was chosen as threshold. First of all must be mentioned that all vehicles with more than 4 gears had vmax values above the threshold and rmax values between 43% and 105%. None of them needed downscaling.

Furthermore, the results for vehicles with 4speed transmissions above and below the threshold do not show significant differences. Therefore it is proposed to use the linear approximation curve as shown in Figure 4-47 for all class 1 vehicles. This curve starts at rmax = 100% with fdsc = 0% and goes up to fdsc = 26% at rmax = 150%.

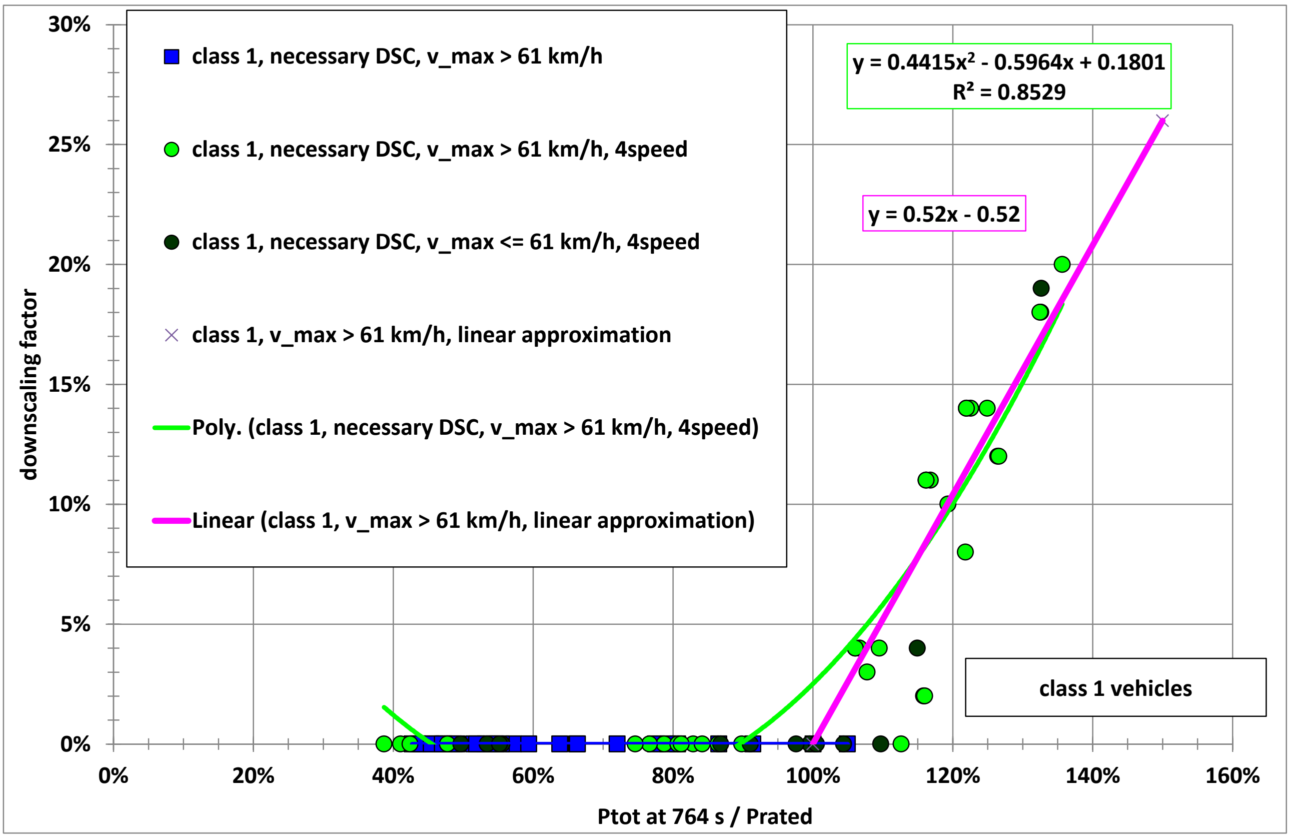


Figure 4-47 Necessary downscaling factor versus r_max for class 1 vehicles

4.9.9. Comparison between necessary downscaling factors and factors obtained from the linear regression curves

In order to check the results obtained by the linear approximation curves, calculations with the downscaling factors forecasted by these curves were performed in a second step.

Figure 4-46 shows the forecasted f_dsc values versus the necessary values for class 3 vehicles. The percentage of vehicles with speed trace violations drops from 72% to 27%, the total number of violations drops down to 17.5%. The wot percentage for the extra high speed phase is significantly reduced (by up to 30%) compared to the situation without downscaling. The reduction in fuel consumption compared to the situation without downscaling is 1.6% on average and 4.2% at maximum.

Figure 4-49 shows the forecasted f_dsc values versus the necessary values for class 2 vehicles. The percentage of vehicles with speed trace violations drops from 75% to 27%, the total number of violations drops down to 13%. The wot percentage for the extra high speed phase is significantly reduced (by up to 40%) compared to the situation without downscaling. The reduction in fuel consumption compared to the situation without downscaling is 1.3% on average and 5.5% at maximum.

Figure 4-50 shows the forecasted f_dsc values versus the necessary values for class 1 vehicles. The percentage of vehicles with speed trace violations drops from 30% to 13%, the total number of violations drops down to 4%.

The wot percentage for the medium speed phase is significantly reduced (by up to 13%) compared to the situation without downscaling. The maximum value with downscaling is 20.5% for the medium speed part. The reduction in fuel consumption compared to the situation without downscaling is 1% on average and 2.9% at maximum.

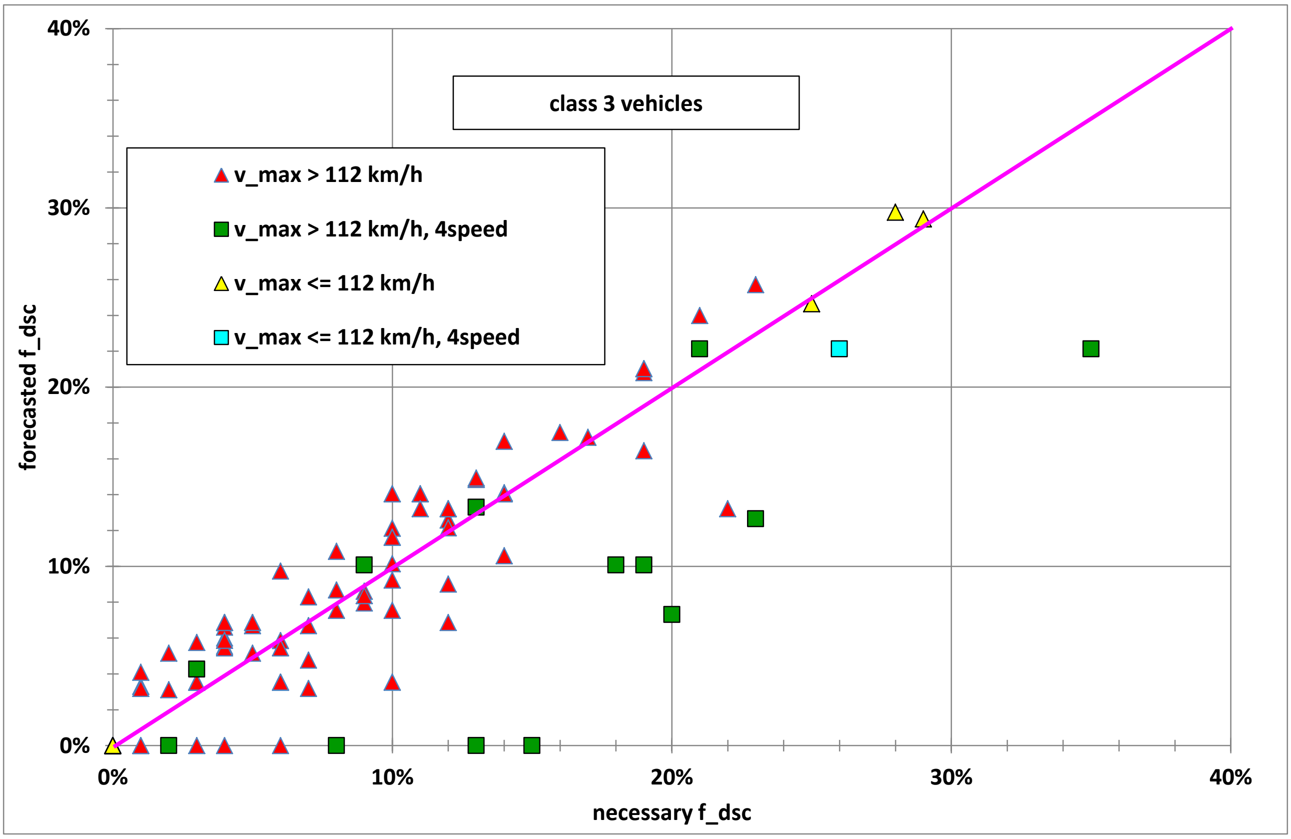


Figure 4-48: Comparison between necessary downscaling factors and factors obtained from the linear regression curves, class 3

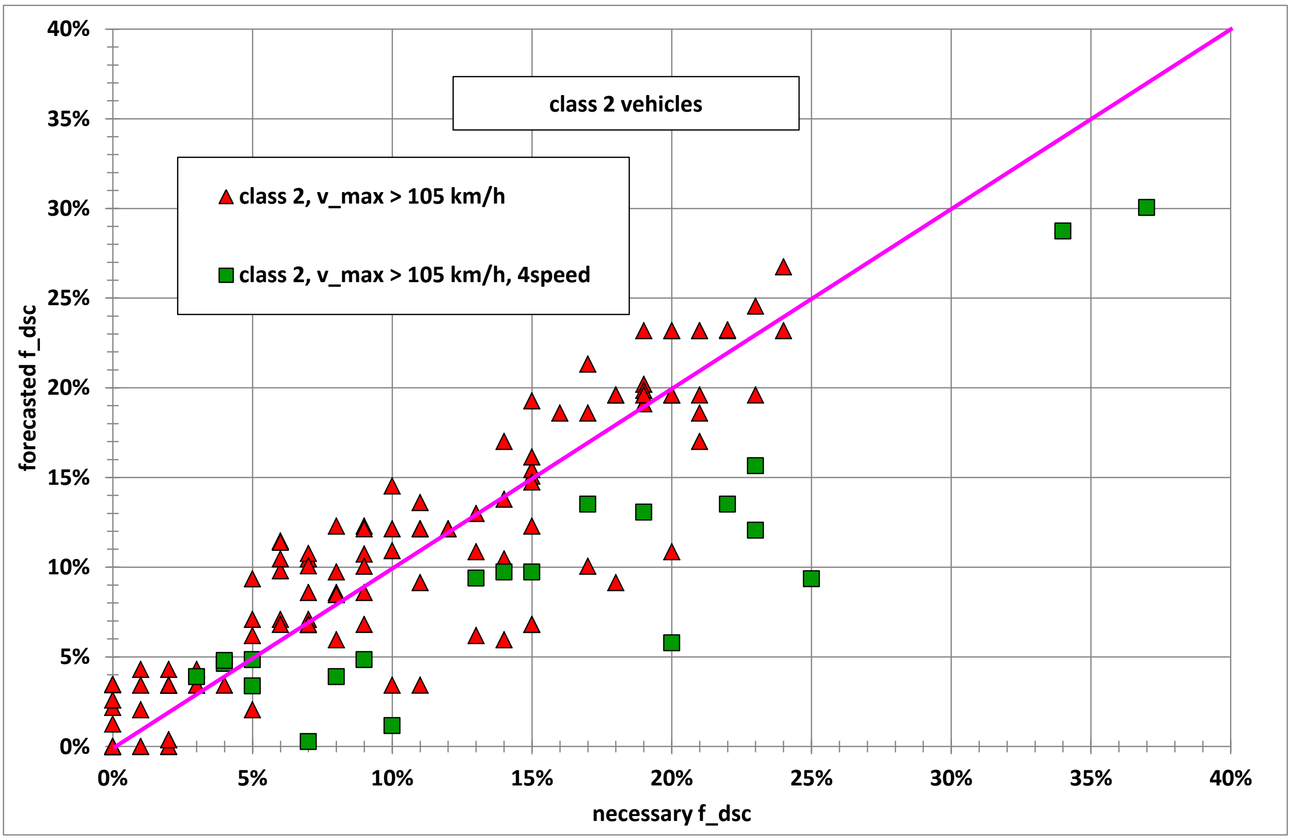


Figure 4-49: Comparison between necessary downscaling factors and factors obtained from the linear regression curves, class 2

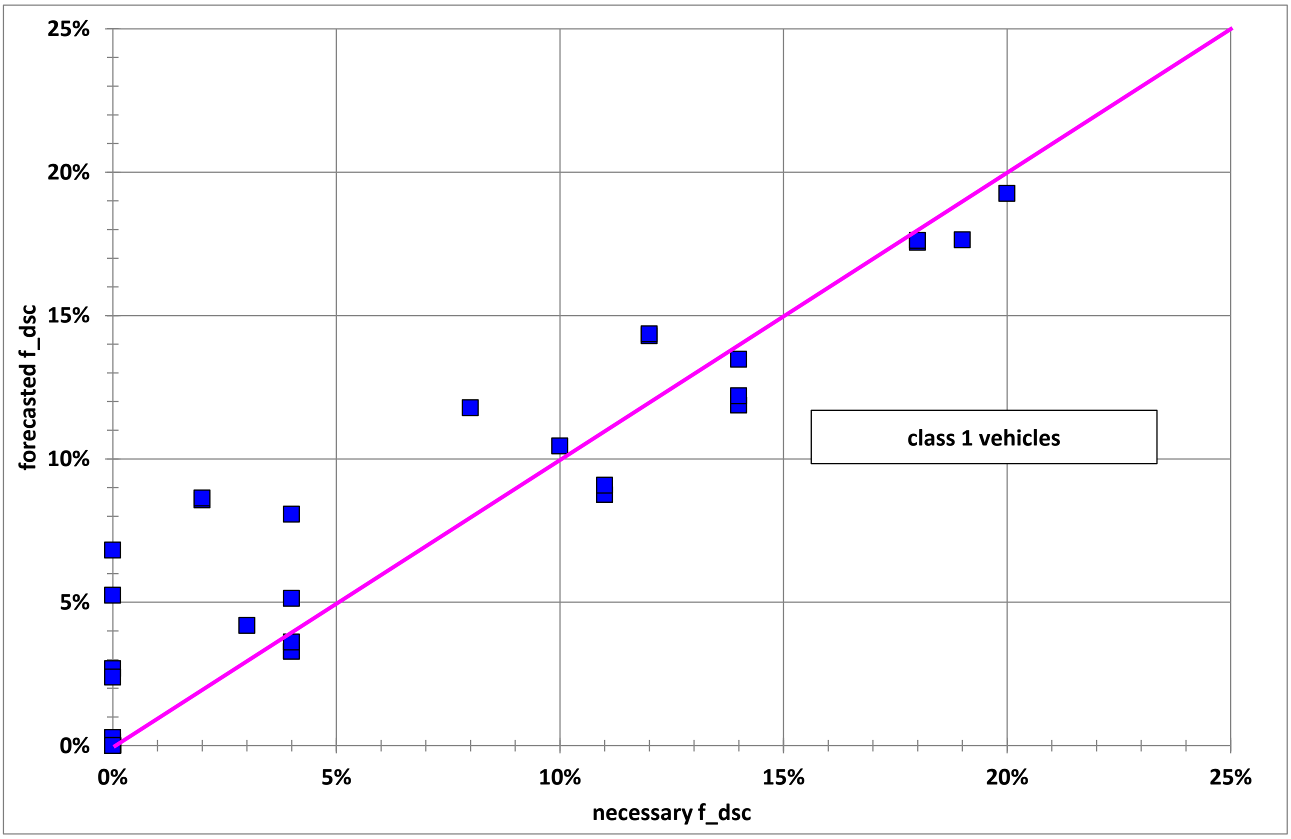


Figure 4-50: Comparison between necessary downscaling factors and factors obtained from the linear regression curves, class 1

4.9.10. Determination of the downscaling factor

The downscaling factor fdsc is a function of the ratio between the maximum required power of the cycle phases where the downscaling has to be applied and the rated power of the vehicle (Prated).

This ratio is named rmax, the maximum required power is named Preq, max. It is related to a specific time i in the cycle trace.

Preq, max, i in kW is calculated from the driving resistance coefficients f0, f1, f2 and the test mass mtest as follows:

Preq, max, i = (f0*vi + f1* vi 2 + f2* vi 3 + 1.1*mtest * vi*ai)/3600   Equation 13

with f0 in N, f1 in N/(km/h) and f2 in N/(km/h)2, mtest in kg

The cycle time i where the maximum power is required is

- 764 s for class 1,
- 1574 s for class 2 and
- 1566 s for class 3

The corresponding vehicle speed values vi and acceleration values ai are as follows:

- vi = 61.4 km/h, ai = 0.22 m/s² for class 1,
- vi = 109.9 km/h, ai = 0.36 m/s² for class 2,
- vi = 111.9 km/h, ai = 0.50 m/s² for class 3,

The driving resistance coefficients f0, f1 and f2 have to be determined by coast down measurements or an equivalent method.

rmax is calculated using the following equation:

rmax = Preq, max, i / Prated   Equation 14

The downscaling factor fdsc is calculated using the following equation:

fdsc = 0, if rmax < r0

a* rmax + b, if rmax >= r0   Equation 15

The calculation parameter/coefficients r0, a1 and b1 are as follows:.

- Class 1: r0 = 100%, a = 0.54, b = -0.54,
- Class 2:
  - vmax > 105 km/h: r0 = 100%, a = 0.41, b = -0.41,
  - vmax <= 105 km/h: no downscaling,
- Class 3:
  - vmax > 112 km/h: r0 = 100%, a = 0.65, b = -0.65,
  - vmax <= 112 km/h: r0 = 130%, a = 0.65, b = -0.65.

The vmax thresholds are related to the reference speeds for the determination of the maximum required power.

[Open point: should there be a lower limit for fdsc (e.g. 3%). In other words, shall fdsc < threshold be disregarded?]

4.9.11. Additional requirements

If a vehicle is tested under different configurations in terms of test mass and driving resistance coefficients, the worst case (highest Preq, max, i value) has to be used for the determination of the downscaling factor and the resulting downscaled cycle shall be used for all measurements.

If the maximum speed of the vehicle is lower than the maximum speed of the downscaled cycle, the vehicle shall be driven with its maximum speed in those cycle periods where the cycle speed is higher than the maximum speed of the vehicle.

If the unlikely situation occurs that the vehicle cannot follow the speed trace of the downscaled cycle within the tolerance for specific periods, it shall be driven with the accelerator pedal fully engaged during these periods.

5. Gearshift procedure development

5.1. Analysis of gear use in the WLTP in-use database, discussion of alternative approaches

The development of the gearshift prescriptions for vehicles with manual transmissions was based on an analysis of the gear use in the WLTP in-use database. This database contains 128 M1 and 29 N1 vehicles with manual transmissions and engine speed signals that allowed a sufficiently good gear determination. 3 vehicles have 4speed gearboxes, 115 vehicles have 5speed gearboxes and 39 vehicles have 6speed gearboxes.

The approach for gearshift detection was as follows:

In a first step the ratio between engine speed in min-1 and vehicle speed in km/h was calculated and added to the databases. The appropriate ratios for the different gears were then derived from the frequency distributions of the ratios. The gears were then assigned to the data by applying a window of +/- 10% to these ratios. Figure 5-1 shows a Diesel vehicle with a 6speed gearbox as an example.

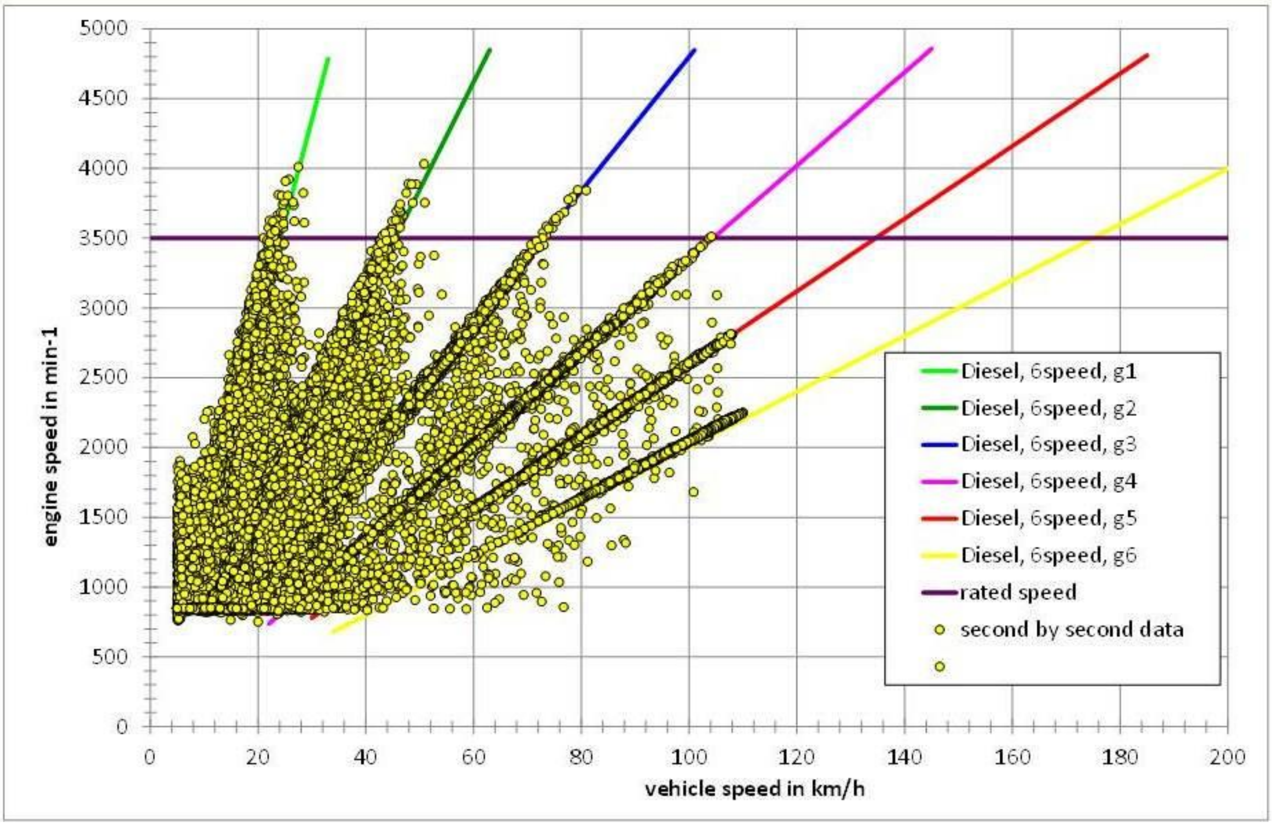


Figure 5-1: Example of engine speed versus vehicle speed plot for a 6speed Diesel vehicle from the WLTP in-use database

Based on this up- and downshifts were detected and collected in an additional database table for consecutive time periods, allowing 1 s for clutch operation in between. The analysis of the gear use was performed separately but with intensive information exchange by JARI, Eva Ericsson and Heinz Steven. The most important result was, that the gearshift behaviour is much more influenced by individual driving behaviour rather than by technical parameter of the vehicles or the transmissions. Since type approval is more related to the technical parameters of the vehicle rather than to individual driving behaviour and since the technical designs of the transmissions have changed significantly over the last decades and will keep changing also in future, there was no need to stick too much to the in-use database results, which reflects the situation 5 to 10 years ago.

As results of the data analysis and assessment the following two alternative approaches were proposed and discussed:

- Vehicle speed based gearshifts,
- Normalised engine speed based gearshifts

The vehicle speed based gearshift approach defines shiftpoints as function of vehicle speed and acceleration. For a given cycle this results in fixed vehicle speeds. But this approach requires a separation of M1 and N1 vehicles.
The engine speed based gearshift approach determines normalised engine upshift speeds as function of the power to mass ratio of the vehicle. The shift speeds are the same for each gear and independent of the number of gears.

The Advantage of the vehicle speed based prescriptions is the simplicity and easy implementation into drivers aids of test benches and that no vehicle specific input data is needed. The disadvantages are that different gearbox designs in terms of numbers of gears cause differences in average engine speeds against the trend in real traffic and that driveability problems could occur for low powered vehicles, especially for N1 vehicles.

The advantage of the engine speed based approach is the independency from the gearbox design, the disadvantage is the need of vehicle specific input data like power to mass ratio, rated speed, idling speed and transmission ratios. Driveability problems could also occur depending on the transmission design.

The validation 1 tests showed driveability problems for both approaches, which could only be solved or reduced by more specific requirements. In case of the vehicle speed based approach a further separation into vehicle subgroups would have been needed. In case of the engine speed based approach the consideration of the engine power demand and the available power would have been required.
Since the latter was seen to be more appropriate and effective with respect to future transmission developments, the vehicle speed based proposal was skipped and the engine speed based proposal was further improved.

With respect to future developments one of the vehicle manufacturers developed gearshift prescriptions that are purely based on the individual acceleration performance of a vehicle under test. This means that in addition to rated engine speed and power and idling speed also the test mass, the full load power curve, the driving resistance coefficients f_0, f_1 and f_2 and the gear ratios were needed as input data. This proposal was merged with the engine speed based approach used for validation 1 and built the basis for the further development.
In order to reflect practical use as well as fuel efficient driving behaviour as much as possible, the prescriptions are based on the balance between the power required for driving resistance and acceleration and the power provided by the engine in all possible gears at a specific cycle phase.
The developed gearshift prescriptions were used for the validation 2 tests and further amended based on the comments/recommendations from the validation 2 participants. This led to the following prescriptions.

5.2. Input data

The required input data is described below and summarized in Table 5-1.

The following data is required to calculate the gears to be used when driving the cycle on a test bench:

(a) P_{rated}, rated engine power. The maximum power of the engine as declared by the manufacturer.

(b) s, rated engine speed. The engine speed at which an engine develops its maximum power. If the maximum power is developed over an engine speed range, s is determined by the mean of this range.

(c) n_{idle}, idling speed as defined in Annex 1 of ECE R 83

(d) n_{min_drive}, minimum engine speed for short trips, and is used to define downshifts. The minimum value is determined by the following equation:

$$n_{min\_drive} = n_{idle} + (0.125) \times (s - n_{idle}) \quad (1)$$

Higher values can be used if requested by the manufacturer.

(e) i = 1 to ng_{max} determine the gear number

(f) ng_{max}, the number of gears

(g) ndv_i, a ratios determined by dividing n in min^{-1} by v in km/h for each gear i, i = 1 to ng_{max}.

(h) m_t, test mass of the vehicle in kg.

(i) f_0, f_1, f_2, driving resistance coefficients as defined in Annex 4.

(j) full load power curve, normalized to rated power and (rated speed – idling speed).

Table 5-1 Necessary input data for the gear use calculation

parameter	unit	definition/description
P_{rated}	kW	The maximum power of the engine as declared by the manufacturer.
s	min^{-1}	Rated engine speed, the engine speed at which an engine develops its maximum power. If the maximum power is developed over an engine speed range, s is determined by the mean of this range.
n_{idle}	min^{-1}	Idling speed, the engine speed when the gear lever is in neutral and the vehicle is not in motion.
n_{min_drive}	min^{-1}	minimum engine speed for gear numbers ≥ 3 when the vehicle is in motion. The minimum value is determined by $n_{idle} + 0{,}125\times(s - n_{idle})$. Higher values can be required by the manufacturer.
m_t	kg	test mass of the vehicle
ng_{max}		number of foreward gears
ndv_i	$min^{-1}/(km/h)$	ratio of engine speed and vehicle speed for gear i, i = 1 to ng_{max}
f_0	N	driving resistance coefficients as defined in Annex 4
f_1	N/(km/h)	
f_2	$N/(km/h)^2$	
$P_{wot}(n_{norm})/P_{rated}$		Normalised full load power curve as function of normalised engine speed $n_{norm} = (n - n_{idle})/(s - n_{idle})$

5.3. Calculation steps

The calculation steps are described in the following paragraphs and summarized in Table 5-2.

Calculation of required power

For every second j of the cycle trace the power required to overcome driving resistance and to accelerate is calculated using the following equation:

$$P_{required,j} = [f_0 \times v_j + f_1 \times (v_j)^2 + f_2 \times (v_j)^3]/3600 + [(kr \times a_j) \times v_j \times m_t)]/3600 \qquad (2)$$

where:

f_0 is the road load coefficient in N

f_1 is the road load parameter dependent on velocity in N/(km/h)

f_2 is the road load parameter based on the square of velocity in N/(km/h)²

$P_{required,j}$ is the power required in kW at second j

v_j is the vehicle speed at second j in km/h,

a_j is the vehicle acceleration at second j in m/s², $a_j = (v_{j+1} - v_j)/3.6$

m_t is the vehicle test mass in kg,

kr is a factor taking the inertial resistances of the drivetrain during acceleration into account and is set to 1.1.

Determination of engine speeds

For each $v_j \leq 1$ km/h, the engine speed is set to n_{idle} and the gear lever is placed in neutral with the clutch engaged.

For each $v_j \geq 1$ km/h of the cycle trace and each gear i, i = 1 to ng_{max}, the engine speed $n_{i,j}$ is calculated using the following equation:

$$n_{i,j} = ndv_i \times v_j \qquad (3)$$

All gears i for which $n_{min} \leq n_{i,j} \leq n_{max}$ are possible gears to be used for driving the cycle trace at v_j.

$n_{min} = n_{min\_drive}$, if $i \geq 3$,

$= 1.25 \times n_{idle}$, if i = 2,

$= n_{idle}$, if i = 1

$n_{max} = 0.9 \times (s - n_{idle}) + n_{idle}$.

In cases where v_j is ≥ 1 km/h and $n_{1,j}$ drops below n_{idle}, the only possible gear is ng = 1 and the clutch must be disengaged.

Calculation of available power

The available power for each possible gear i and each vehicle speed value of the cycle trace v_j is calculated using the following equation:

$$P_{available,i,j} = P_{norm\_wot}(n\_norm_{i,j}) \times P_n \times SM \qquad (4)$$

where:

$n_{norm\_i,j} = (ndv_i \times v_j - n_{idle})/(s - n_{idle})$,

P_n is the rated power in kW,

P_{norm_wot} is the percentage of rated power available at $n_{norm\_i,\ j}$ at full load condition from the normalized full load power curve,

SM is a safety margin accounting for the difference between stationary full load condition power curve and the power available during transient conditions. SM is set to 0.9.

n_{idle} is the idling speed in min^{-1}

s is the rated engine speed, the engine speed in min^{-1} at which an engine develops its maximum power. If the maximum power is developed over an engine speed range, s is determined by the mean of this range.

Determination of possible gears to be used

The possible gears to be used are determined by:

(1) $n_{min} \leq n_{i,j} \leq n_{max}$

as defined in paragraph 4.1.4 of this annex and

(2) $P_{available,i,j} \geq P_{required,j}$

$P_{available,i,j}$ as defined in equation 2, $P_{required,j}$ as defined equation 4 of this annex.

The initial gear to be used for each second j of the cycle trace is the maximum final possible gear i_max.

Table 5-2: Calculation steps

Step	Task	Description/Requirements	Remark
1	Calculation of required power	$P_{required,j} = [f_0 \times v_j + f_1 \times (v_j)^2 + f_2 \times (v_j)^3]/3600 + [(kr \times a_j) \times v_j \times m_t)]/3600$	for each second j of the cycle trace, a_j is the vehicle acceleration, kr is a factor taking the inertial resistances of the drivetrain during acceleration into account and is set to 1.1
2	Determination of engine speeds for each gear i	$n_{min} = n_{min\_drive}$, if i >= 3,	
		$= 1.25 \times n_{idle}$, if i = 2,	
		$= n_{idle}$, if i = 1	
		$n_{max} = 0.9 \times (s - n_{idle}) + n_{idle}$.	
		$n_{min} <= n_{i,j} = ndv_i \times v_j <= n_{max}$	
3	Calculation of available power	$P_{available,i,j} = P_{norm\_wot}(n_{norm,i,j}) \times P_{rated} \times SM$	SM is a safety margin accounting for the difference between stationary full load condition power curve and the power available during transient conditions. SM is set to 0.9.
4	Determination of possible gears to be used	The possible gears to be used are determined by	
		(1) $n_{min} \leq n_{i,j} \leq n_{max}$ as defined in paragraph 4.1.4 of this annex and	
		(2) $P_{available,i,j} \geq P_{required,j}$ $P_{available,i,j}$ as defined in paragraph 4.1.5 of this annex, $P_{required,j}$ as defined in paragraph 4.1.3 of this annex	
5	Final gear choice	i_{max} detemines the highest possible gear	
j is the index for the cycle time, i is the index for the gear number			

5.4. Additional requirements for corrections and/or modifications of gear use

The initial gear use shall be checked and modified in order to avoid too frequent gearshifts and to ensure drivability and conformity with practical use. The requirements are described below and summarized in Table 5-3.

Corrections/modifications are made depending on the following requirements:

(a) First gear shall be selected 1 second before the beginning of an acceleration phase from standstill. Vehicle speeds below 1 km/h imply that the vehicle is standing still.

(b) Skipping of gears during acceleration phases is not permitted. Gears used during accelerations and decelerations must be used for a period of at least 3 seconds.
E.g. a gear sequence 1, 1, 2, 2, 3, 3, 3, 3, 3 is replaced by 1, 1, 1, 2, 2, 2, 3, 3, 3

(c) Skipping of gears during deceleration phases is permitted. For the last phases of a deceleration down to a stop, the clutch may be either disengaged or the gear lever in neutral position and the clutch engaged.

(d) There shall be no gearshift during the transition from an acceleration phase to a deceleration phase. E.g., if $v_j < v_{j+1} > v_{j+2}$ and the gear for the time sequence j and j+1 is i, gear i is also kept for the time j+2, even if the initial gear for j+2 would be i+1.

(e) If a gear i is used for a time sequence of 1 to 5 s and the gear before this sequence is the same as the gear after this sequence, e.g. i-1, the gear use for this sequence is corrected to i-1.
That means:

(1) a gear sequence i-1, i, i-1 is replaced by i-1, i-1, i-1

(2) a gear sequence i-1, i, i, i-1 is replaced by i-1, i-1, i-1, i-1

(3) a gear sequence i-1, i, i, i, i-1 is replaced by i-1, i-1, i-1, i-1, i-1

(4) a gear sequence i-1, i, i, i, i, i-1 is replaced by i-1, i-1, i-1 ,i-1, i-1, i-1,

(5) a gear sequence i-1, i, i, i, i, i, i-1 is replaced by i-1, i-1, i-1, i-1, i-1, i-1, i-1.

for all cases (1) to (5), $g_{min} \leq i$ must be fulfilled.

(f) a gear sequence i, i-1, i, is replaced by i, i, i, if the following conditions are fulfilled:

(1) the engine speed does not drop below n_{min} and

(2) These corrections do not occur more often than 4 times each for the low, medium and high speed cycle parts and not more than 3 times for the extra high speed part.

The requirement (2) is necessary, because the available power will drop below the required power, when the gear i-1 is replaced by i. And this should not occur too frequently.

(g) If during an acceleration phase a lower gear is required at a higher vehicle speed, the higher gears before are corrected to the lower gear, if the lower gear is required for at least 2 s.
Example: vj < vj+1 < vj+2 < vj+3 < vj+4 < vj+5 < vj+6. The originally calculated gear use is 2, 3, 3, 3, 2, 2, 3. In this case the gear use will be corrected to 2, 2, 2, 2, 2, 2, 2, 3.

Since the above modifications may create new gear use sequences which are in conflict with these requirements, the gear sequences shall be checked twice.

Table 5-3: Additional requirements for corrections/modifications

Step no	Step	Explanation
1	**First gear shall be selected 1 second before the beginning of an acceleration phase from standstill.** Vehicle speeds below 1 km/h imply that the vehicle is standing still.	
2	**Skipping of gears during acceleration phases is not permitted.** Gears used during accelerations and decelerations must be used for a period of at least 3 seconds.	
3	**Skipping of gears during deceleration phases is permitted.** For the last phases of a deceleration down to stop, the clutch may be either disengaged or the gear lever in neutral position and the clutch engaged.	
4	**There shall be no gearshift during the transition from an acceleration phase to a deceleration phase.**	
5	If a gear i is used for a time sequence of 1 to 5 s and the gear before this sequence is the same as the gear after this sequence, e.g. i-1, the gear use for this sequence is corrected to i-1.	i-1, i, i, i, i, i, i-1 is replaced by i-1, i-1, i-1, i-1, i-1, i-1, i-1
6	a gear sequence i, i-1, i, is replaced by i, i, i, if the following conditions are fulfilled:	The requirement (2) is necessary, because the available power will drop below the required power, when the gear i-1 is replaced by i. And this should not occur too frequently.
	(1) the engine speed does not drop below nmin and	
	(2) These corrections do not occur more often than 4 times each for the low, medium and high speed cycle parts and not more than 3 times for the extra high speed part.	
7	If during an acceleration phase a lower gear is required at a higher vehicle speed, the higher gears before are corrected to the lower gear, if the lower gear is required for at least 2 s.	Example: The originally calculated gear use is 2, 3, 3, 3, 2, 2, 3. In this case the gear use will be corrected to 2, 2, 2, 2, 2, 2, 3.
These modifications may create new gear sequences which are in conflict with these requirements, so the gear sequences shall be checked twice.		

6. Summary and Conclusions

The development of a World-wide harmonized Light duty Test Cycle (WLTC) which will represent typical driving conditions around the world was presented. The driving cycle was obtained from recorded in-use data ("real world" data) from different regions of the world (EU, India, Japan, Korea, USA) combined with suitable weighting factors. Over 765, 000 km of data was collected covering a wide range of vehicle categories (M1, N1 and M2 vehicles, various engine capacities, power-to-mass ratios, manufacturers etc), over different road types (urban, rural, motorway) and driving conditions (peak, off-peak, weekend). The WLTC contains four individual sections (Low, Medium, High and Extra-high speed phase), each one composed by a sequence of idles and short trips, and has a total duration of 1800 seconds. The length of each speed phase L/M/H/ExH phases is: 589 [s], 433 [s], 455 [s] and 323 [s] respectively.

The developed test cycle and the gearshift procedure were tested in several laboratories all over the world. The dynamics of the WLTC reflect the average driving behavior of light duty vehicle in real world. In addition to that, a good balance between representatively of in-use driving data and drivability on chassis dynamometer was also obtained.

The final result of the cycle development is as follows;

- For Class 1 vehicles: WLTC CL1 version 2.0
- For Class 1 vehicles: WLTC CL2 version 2.0
- For Class 3 vehicles of which maximum speed is less than 120 km/h: WLTC CL3 version 5.1
- For Class 3 vehicles of which maximum speed is higher than 120 km/h: WLTC CL3 version 5.3

7. Annex A – Final cycle time table (Class 1 ver.2.0, Class 2 ver.2.0, Class 3 Ver.5.1/5.3)

Table A/1 WLTC, Class 1 vehicles, phase Low

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
0	0.0	47	18.8	94	0.0	141	35.7
1	0.0	48	19.5	95	0.0	142	35.9
2	0.0	49	20.2	96	0.0	143	36.6
3	0.0	50	20.9	97	0.0	144	37.5
4	0.0	51	21.7	98	0.0	145	38.4
5	0.0	52	22.4	99	0.0	146	39.3
6	0.0	53	23.1	100	0.0	147	40.0
7	0.0	54	23.7	101	0.0	148	40.6
8	0.0	55	24.4	102	0.0	149	41.1
9	0.0	56	25.1	103	0.0	150	41.4
10	0.0	57	25.4	104	0.0	151	41.6
11	0.0	58	25.2	105	0.0	152	41.8
12	0.2	59	23.4	106	0.0	153	41.8
13	3.1	60	21.8	107	0.0	154	41.9
14	5.7	61	19.7	108	0.7	155	41.9
15	8.0	62	17.3	109	1.1	156	42.0
16	10.1	63	14.7	110	1.9	157	42.0
17	12.0	64	12.0	111	2.5	158	42.2
18	13.8	65	9.4	112	3.5	159	42.3
19	15.4	66	5.6	113	4.7	160	42.6
20	16.7	67	3.1	114	6.1	161	43.0
21	17.7	68	0.0	115	7.5	162	43.3
22	18.3	69	0.0	116	9.4	163	43.7
23	18.8	70	0.0	117	11.0	164	44.0
24	18.9	71	0.0	118	12.9	165	44.3
25	18.4	72	0.0	119	14.5	166	44.5
26	16.9	73	0.0	120	16.4	167	44.6
27	14.3	74	0.0	121	18.0	168	44.6
28	10.8	75	0.0	122	20.0	169	44.5
29	7.1	76	0.0	123	21.5	170	44.4
30	4.0	77	0.0	124	23.5	171	44.3
31	0.0	78	0.0	125	25.0	172	44.2
32	0.0	79	0.0	126	26.8	173	44.1
33	0.0	80	0.0	127	28.2	174	44.0
34	0.0	81	0.0	128	30.0	175	43.9
35	1.5	82	0.0	129	31.4	176	43.8
36	3.8	83	0.0	130	32.5	177	43.7
37	5.6	84	0.0	131	33.2	178	43.6
38	7.5	85	0.0	132	33.4	179	43.5
39	9.2	86	0.0	133	33.7	180	43.4
40	10.8	87	0.0	134	33.9	181	43.3
41	12.4	88	0.0	135	34.2	182	43.1
42	13.8	89	0.0	136	34.4	183	42.9
43	15.2	90	0.0	137	34.7	184	42.7
44	16.3	91	0.0	138	34.9	185	42.5
45	17.3	92	0.0	139	35.2	186	42.3
46	18.0	93	0.0	140	35.4	187	42.2

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
188	42.2	237	39.7	286	25.3	335	14.3
189	42.2	238	39.9	287	24.9	336	14.3
190	42.3	239	40.0	288	24.5	337	14.0
191	42.4	240	40.1	289	24.2	338	13.0
192	42.5	241	40.2	290	24.0	339	11.4
193	42.7	242	40.3	291	23.8	340	10.2
194	42.9	243	40.4	292	23.6	341	8.0
195	43.1	244	40.5	293	23.5	342	7.0
196	43.2	245	40.5	294	23.4	343	6.0
197	43.3	246	40.4	295	23.3	344	5.5
198	43.4	247	40.3	296	23.3	345	5.0
199	43.4	248	40.2	297	23.2	346	4.5
200	43.2	249	40.1	298	23.1	347	4.0
201	42.9	250	39.7	299	23.0	348	3.5
202	42.6	251	38.8	300	22.8	349	3.0
203	42.2	252	37.4	301	22.5	350	2.5
204	41.9	253	35.6	302	22.1	351	2.0
205	41.5	254	33.4	303	21.7	352	1.5
206	41.0	255	31.2	304	21.1	353	1.0
207	40.5	256	29.1	305	20.4	354	0.5
208	39.9	257	27.6	306	19.5	355	0.0
209	39.3	258	26.6	307	18.5	356	0.0
210	38.7	259	26.2	308	17.6	357	0.0
211	38.1	260	26.3	309	16.6	358	0.0
212	37.5	261	26.7	310	15.7	359	0.0
213	36.9	262	27.5	311	14.9	360	0.0
214	36.3	263	28.4	312	14.3	361	2.2
215	35.7	264	29.4	313	14.1	362	4.5
216	35.1	265	30.4	314	14.0	363	6.6
217	34.5	266	31.2	315	13.9	364	8.6
218	33.9	267	31.9	316	13.8	365	10.6
219	33.6	268	32.5	317	13.7	366	12.5
220	33.5	269	33.0	318	13.6	367	14.4
221	33.6	270	33.4	319	13.5	368	16.3
222	33.9	271	33.8	320	13.4	369	17.9
223	34.3	272	34.1	321	13.3	370	19.1
224	34.7	273	34.3	322	13.2	371	19.9
225	35.1	274	34.3	323	13.2	372	20.3
226	35.5	275	33.9	324	13.2	373	20.5
227	35.9	276	33.3	325	13.4	374	20.7
228	36.4	277	32.6	326	13.5	375	21.0
229	36.9	278	31.8	327	13.7	376	21.6
230	37.4	279	30.7	328	13.8	377	22.6
231	37.9	280	29.6	329	14.0	378	23.7
232	38.3	281	28.6	330	14.1	379	24.8
233	38.7	282	27.8	331	14.3	380	25.7
234	39.1	283	27.0	332	14.4	381	26.2
235	39.3	284	26.4	333	14.4	382	26.4
236	39.5	285	25.8	334	14.4	383	26.4

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
384	26.4	433	0.0	482	3.1	531	48.2
385	26.5	434	0.0	483	4.6	532	48.5
386	26.6	435	0.0	484	6.1	533	48.7
387	26.8	436	0.0	485	7.8	534	48.9
388	26.9	437	0.0	486	9.5	535	49.1
389	27.2	438	0.0	487	11.3	536	49.1
390	27.5	439	0.0	488	13.2	537	49.0
391	28.0	440	0.0	489	15.0	538	48.8
392	28.8	441	0.0	490	16.8	539	48.6
393	29.9	442	0.0	491	18.4	540	48.5
394	31.0	443	0.0	492	20.1	541	48.4
395	31.9	444	0.0	493	21.6	542	48.3
396	32.5	445	0.0	494	23.1	543	48.2
397	32.6	446	0.0	495	24.6	544	48.1
398	32.4	447	0.0	496	26.0	545	47.5
399	32.0	448	0.0	497	27.5	546	46.7
400	31.3	449	0.0	498	29.0	547	45.7
401	30.3	450	0.0	499	30.6	548	44.6
402	28.0	451	0.0	500	32.1	549	42.9
403	27.0	452	0.0	501	33.7	550	40.8
404	24.0	453	0.0	502	35.3	551	38.2
405	22.5	454	0.0	503	36.8	552	35.3
406	19.0	455	0.0	504	38.1	553	31.8
407	17.5	456	0.0	505	39.3	554	28.7
408	14.0	457	0.0	506	40.4	555	25.8
409	12.5	458	0.0	507	41.2	556	22.9
410	9.0	459	0.0	508	41.9	557	20.2
411	7.5	460	0.0	509	42.6	558	17.3
412	4.0	461	0.0	510	43.3	559	15.0
413	2.9	462	0.0	511	44.0	560	12.3
414	0.0	463	0.0	512	44.6	561	10.3
415	0.0	464	0.0	513	45.3	562	7.8
416	0.0	465	0.0	514	45.5	563	6.5
417	0.0	466	0.0	515	45.5	564	4.4
418	0.0	467	0.0	516	45.2	565	3.2
419	0.0	468	0.0	517	44.7	566	1.2
420	0.0	469	0.0	518	44.2	567	0.0
421	0.0	470	0.0	519	43.6	568	0.0
422	0.0	471	0.0	520	43.1	569	0.0
423	0.0	472	0.0	521	42.8	570	0.0
424	0.0	473	0.0	522	42.7	571	0.0
425	0.0	474	0.0	523	42.8	572	0.0
426	0.0	475	0.0	524	43.3	573	0.0
427	0.0	476	0.0	525	43.9	574	0.0
428	0.0	477	0.0	526	44.6	575	0.0
429	0.0	478	0.0	527	45.4	576	0.0
430	0.0	479	0.0	528	46.3	577	0.0
431	0.0	480	0.0	529	47.2	578	0.0
432	0.0	481	1.6	530	47.8	579	0.0

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
580	0.0						
581	0.0						
582	0.0						
583	0.0						
584	0.0						
585	0.0						
586	0.0						
587	0.0						
588	0.0						
589	0.0						

Table A1/2

WLTC, Class 1 vehicles, phase Medium

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
590	0.0	637	18.4	684	56.2	731	57.9
591	0.0	638	19.0	685	56.7	732	58.8
592	0.0	639	20.1	686	57.3	733	59.6
593	0.0	640	21.5	687	57.9	734	60.3
594	0.0	641	23.1	688	58.4	735	60.9
595	0.0	642	24.9	689	58.8	736	61.3
596	0.0	643	26.4	690	58.9	737	61.7
597	0.0	644	27.9	691	58.4	738	61.8
598	0.0	645	29.2	692	58.1	739	61.8
599	0.0	646	30.4	693	57.6	740	61.6
600	0.6	647	31.6	694	56.9	741	61.2
601	1.9	648	32.8	695	56.3	742	60.8
602	2.7	649	34.0	696	55.7	743	60.4
603	5.2	650	35.1	697	55.3	744	59.9
604	7.0	651	36.3	698	55.0	745	59.4
605	9.6	652	37.4	699	54.7	746	58.9
606	11.4	653	38.6	700	54.5	747	58.6
607	14.1	654	39.6	701	54.4	748	58.2
608	15.8	655	40.6	702	54.3	749	57.9
609	18.2	656	41.6	703	54.2	750	57.7
610	19.7	657	42.4	704	54.1	751	57.5
611	21.8	658	43.0	705	53.8	752	57.2
612	23.2	659	43.6	706	53.5	753	57.0
613	24.7	660	44.0	707	53.0	754	56.8
614	25.8	661	44.4	708	52.6	755	56.6
615	26.7	662	44.8	709	52.2	756	56.6
616	27.2	663	45.2	710	51.9	757	56.7
617	27.7	664	45.6	711	51.7	758	57.1
618	28.1	665	46.0	712	51.7	759	57.6
619	28.4	666	46.5	713	51.8	760	58.2
620	28.7	667	47.0	714	52.0	761	59.0
621	29.0	668	47.5	715	52.3	762	59.8
622	29.2	669	48.0	716	52.6	763	60.6
623	29.4	670	48.6	717	52.9	764	61.4
624	29.4	671	49.1	718	53.1	765	62.2
625	29.3	672	49.7	719	53.2	766	62.9
626	28.9	673	50.2	720	53.3	767	63.5
627	28.5	674	50.8	721	53.3	768	64.2
628	28.1	675	51.3	722	53.4	769	64.4
629	27.6	676	51.8	723	53.5	770	64.4
630	26.9	677	52.3	724	53.7	771	64.0
631	26.0	678	52.9	725	54.0	772	63.5
632	24.6	679	53.4	726	54.4	773	62.9
633	22.8	680	54.0	727	54.9	774	62.4
634	21.0	681	54.5	728	55.6	775	62.0
635	19.5	682	55.1	729	56.3	776	61.6
636	18.6	683	55.6	730	57.1	777	61.4

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
778	61.2	827	49.7	876	53.2	925	44.4
779	61.0	828	50.6	877	53.1	926	44.5
780	60.7	829	51.6	878	53.0	927	44.6
781	60.2	830	52.5	879	53.0	928	44.7
782	59.6	831	53.3	880	53.0	929	44.6
783	58.9	832	54.1	881	53.0	930	44.5
784	58.1	833	54.7	882	53.0	931	44.4
785	57.2	834	55.3	883	53.0	932	44.2
786	56.3	835	55.7	884	52.8	933	44.1
787	55.3	836	56.1	885	52.5	934	43.7
788	54.4	837	56.4	886	51.9	935	43.3
789	53.4	838	56.7	887	51.1	936	42.8
790	52.4	839	57.1	888	50.2	937	42.3
791	51.4	840	57.5	889	49.2	938	41.6
792	50.4	841	58.0	890	48.2	939	40.7
793	49.4	842	58.7	891	47.3	940	39.8
794	48.5	843	59.3	892	46.4	941	38.8
795	47.5	844	60.0	893	45.6	942	37.8
796	46.5	845	60.6	894	45.0	943	36.9
797	45.4	846	61.3	895	44.3	944	36.1
798	44.3	847	61.5	896	43.8	945	35.5
799	43.1	848	61.5	897	43.3	946	35.0
800	42.0	849	61.4	898	42.8	947	34.7
801	40.8	850	61.2	899	42.4	948	34.4
802	39.7	851	60.5	900	42.0	949	34.1
803	38.8	852	60.0	901	41.6	950	33.9
804	38.1	853	59.5	902	41.1	951	33.6
805	37.4	854	58.9	903	40.3	952	33.3
806	37.1	855	58.4	904	39.5	953	33.0
807	36.9	856	57.9	905	38.6	954	32.7
808	37.0	857	57.5	906	37.7	955	32.3
809	37.5	858	57.1	907	36.7	956	31.9
810	37.8	859	56.7	908	36.2	957	31.5
811	38.2	860	56.4	909	36.0	958	31.0
812	38.6	861	56.1	910	36.2	959	30.6
813	39.1	862	55.8	911	37.0	960	30.2
814	39.6	863	55.5	912	38.0	961	29.7
815	40.1	864	55.3	913	39.0	962	29.1
816	40.7	865	55.0	914	39.7	963	28.4
817	41.3	866	54.7	915	40.2	964	27.6
818	41.9	867	54.4	916	40.7	965	26.8
819	42.7	868	54.2	917	41.2	966	26.0
820	43.4	869	54.0	918	41.7	967	25.1
821	44.2	870	53.9	919	42.2	968	24.2
822	45.0	871	53.7	920	42.7	969	23.3
823	45.9	872	53.6	921	43.2	970	22.4
824	46.8	873	53.5	922	43.6	971	21.5
825	47.7	874	53.4	923	44.0	972	20.6
826	48.7	875	53.3	924	44.2	973	19.7

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
974	18.8						
975	17.7						
976	16.4						
977	14.9						
978	13.2						
979	11.3						
980	9.4						
981	7.5						
982	5.6						
983	3.7						
984	1.9						
985	1.0						
986	0.0						
987	0.0						
988	0.0						
989	0.0						
990	0.0						
991	0.0						
992	0.0						
993	0.0						
994	0.0						
995	0.0						
996	0.0						
997	0.0						
998	0.0						
999	0.0						
1000	0.0						
1001	0.0						
1002	0.0						
1003	0.0						
1004	0.0						
1005	0.0						
1006	0.0						
1007	0.0						
1008	0.0						
1009	0.0						
1010	0.0						
1011	0.0						
1012	0.0						
1013	0.0						
1014	0.0						
1015	0.0						
1016	0.0						
1017	0.0						
1018	0.0						
1019	0.0						
1020	0.0						
1021	0.0						
1022	0.0						

Table A1/3 WLTC, Class 2 vehicles, phase Low

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
0	0.0	47	11.6	94	0.0	141	36.8
1	0.0	48	12.4	95	0.0	142	35.1
2	0.0	49	13.2	96	0.0	143	32.2
3	0.0	50	14.2	97	0.0	144	31.1
4	0.0	51	14.8	98	0.0	145	30.8
5	0.0	52	14.7	99	0.0	146	29.7
6	0.0	53	14.4	100	0.0	147	29.4
7	0.0	54	14.1	101	0.0	148	29.0
8	0.0	55	13.6	102	0.0	149	28.5
9	0.0	56	13.0	103	0.0	150	26.0
10	0.0	57	12.4	104	0.0	151	23.4
11	0.0	58	11.8	105	0.0	152	20.7
12	0.0	59	11.2	106	0.0	153	17.4
13	1.2	60	10.6	107	0.8	154	15.2
14	2.6	61	9.9	108	1.4	155	13.5
15	4.9	62	9.0	109	2.3	156	13.0
16	7.3	63	8.2	110	3.5	157	12.4
17	9.4	64	7.0	111	4.7	158	12.3
18	11.4	65	4.8	112	5.9	159	12.2
19	12.7	66	2.3	113	7.4	160	12.3
20	13.3	67	0.0	114	9.2	161	12.4
21	13.4	68	0.0	115	11.7	162	12.5
22	13.3	69	0.0	116	13.5	163	12.7
23	13.1	70	0.0	117	15.0	164	12.8
24	12.5	71	0.0	118	16.2	165	13.2
25	11.1	72	0.0	119	16.8	166	14.3
26	8.9	73	0.0	120	17.5	167	16.5
27	6.2	74	0.0	121	18.8	168	19.4
28	3.8	75	0.0	122	20.3	169	21.7
29	1.8	76	0.0	123	22.0	170	23.1
30	0.0	77	0.0	124	23.6	171	23.5
31	0.0	78	0.0	125	24.8	172	24.2
32	0.0	79	0.0	126	25.6	173	24.8
33	0.0	80	0.0	127	26.3	174	25.4
34	1.5	81	0.0	128	27.2	175	25.8
35	2.8	82	0.0	129	28.3	176	26.5
36	3.6	83	0.0	130	29.6	177	27.2
37	4.5	84	0.0	131	30.9	178	28.3
38	5.3	85	0.0	132	32.2	179	29.9
39	6.0	86	0.0	133	33.4	180	32.4
40	6.6	87	0.0	134	35.1	181	35.1
41	7.3	88	0.0	135	37.2	182	37.5
42	7.9	89	0.0	136	38.7	183	39.2
43	8.6	90	0.0	137	39.0	184	40.5
44	9.3	91	0.0	138	40.1	185	41.4
45	10	92	0.0	139	40.4	186	42.0
46	10.8	93	0.0	140	39.7	187	42.5

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
188	43.2	237	33.5	286	32.5	335	25.0
189	44.4	238	35.8	287	30.9	336	24.6
190	45.9	239	37.6	288	28.6	337	23.9
191	47.6	240	38.8	289	25.9	338	23.0
192	49.0	241	39.6	290	23.1	339	21.8
193	50.0	242	40.1	291	20.1	340	20.7
194	50.2	243	40.9	292	17.3	341	19.6
195	50.1	244	41.8	293	15.1	342	18.7
196	49.8	245	43.3	294	13.7	343	18.1
197	49.4	246	44.7	295	13.4	344	17.5
198	48.9	247	46.4	296	13.9	345	16.7
199	48.5	248	47.9	297	15.0	346	15.4
200	48.3	249	49.6	298	16.3	347	13.6
201	48.2	250	49.6	299	17.4	348	11.2
202	47.9	251	48.8	300	18.2	349	8.6
203	47.1	252	48.0	301	18.6	350	6.0
204	45.5	253	47.5	302	19.0	351	3.1
205	43.2	254	47.1	303	19.4	352	1.2
206	40.6	255	46.9	304	19.8	353	0.0
207	38.5	256	45.8	305	20.1	354	0.0
208	36.9	257	45.8	306	20.5	355	0.0
209	35.9	258	45.8	307	20.2	356	0.0
210	35.3	259	45.9	308	18.6	357	0.0
211	34.8	260	46.2	309	16.5	358	0.0
212	34.5	261	46.4	310	14.4	359	0.0
213	34.2	262	46.6	311	13.4	360	1.4
214	34.0	263	46.8	312	12.9	361	3.2
215	33.8	264	47.0	313	12.7	362	5.6
216	33.6	265	47.3	314	12.4	363	8.1
217	33.5	266	47.5	315	12.4	364	10.3
218	33.5	267	47.9	316	12.8	365	12.1
219	33.4	268	48.3	317	14.1	366	12.6
220	33.3	269	48.3	318	16.2	367	13.6
221	33.3	270	48.2	319	18.8	368	14.5
222	33.2	271	48.0	320	21.9	369	15.6
223	33.1	272	47.7	321	25.0	370	16.8
224	33.0	273	47.2	322	28.4	371	18.2
225	32.9	274	46.5	323	31.3	372	19.6
226	32.8	275	45.2	324	34.0	373	20.9
227	32.7	276	43.7	325	34.6	374	22.3
228	32.5	277	42.0	326	33.9	375	23.8
229	32.3	278	40.4	327	31.9	376	25.4
230	31.8	279	39.0	328	30.0	377	27.0
231	31.4	280	37.7	329	29.0	378	28.6
232	30.9	281	36.4	330	27.9	379	30.2
233	30.6	282	35.2	331	27.1	380	31.2
234	30.6	283	34.3	332	26.4	381	31.2
235	30.7	284	33.8	333	25.9	382	30.7
236	32.0	285	33.3	334	25.5	383	29.5

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
384	28.6	433	0.0	482	2.5	531	26.0
385	27.7	434	0.0	483	5.2	532	26.5
386	26.9	435	0.0	484	7.9	533	26.9
387	26.1	436	0.0	485	10.3	534	27.3
388	25.4	437	0.0	486	12.7	535	27.9
389	24.6	438	0.0	487	15.0	536	30.3
390	23.6	439	0.0	488	17.4	537	33.2
391	22.6	440	0.0	489	19.7	538	35.4
392	21.7	441	0.0	490	21.9	539	38.0
393	20.7	442	0.0	491	24.1	540	40.1
394	19.8	443	0.0	492	26.2	541	42.7
395	18.8	444	0.0	493	28.1	542	44.5
396	17.7	445	0.0	494	29.7	543	46.3
397	16.6	446	0.0	495	31.3	544	47.6
398	15.6	447	0.0	496	33.0	545	48.8
399	14.8	448	0.0	497	34.7	546	49.7
400	14.3	449	0.0	498	36.3	547	50.6
401	13.8	450	0.0	499	38.1	548	51.4
402	13.4	451	0.0	500	39.4	549	51.4
403	13.1	452	0.0	501	40.4	550	50.2
404	12.8	453	0.0	502	41.2	551	47.1
405	12.3	454	0.0	503	42.1	552	44.5
406	11.6	455	0.0	504	43.2	553	41.5
407	10.5	456	0.0	505	44.3	554	38.5
408	9.0	457	0.0	506	45.7	555	35.5
409	7.2	458	0.0	507	45.4	556	32.5
410	5.2	459	0.0	508	44.5	557	29.5
411	2.9	460	0.0	509	42.5	558	26.5
412	1.2	461	0.0	510	39.5	559	23.5
413	0.0	462	0.0	511	36.5	560	20.4
414	0.0	463	0.0	512	33.5	561	17.5
415	0.0	464	0.0	513	30.4	562	14.5
416	0.0	465	0.0	514	27.0	563	11.5
417	0.0	466	0.0	515	23.6	564	8.5
418	0.0	467	0.0	516	21.0	565	5.6
419	0.0	468	0.0	517	19.5	566	2.6
420	0.0	469	0.0	518	17.6	567	0.0
421	0.0	470	0.0	519	16.1	568	0.0
422	0.0	471	0.0	520	14.5	569	0.0
423	0.0	472	0.0	521	13.5	570	0.0
424	0.0	473	0.0	522	13.7	571	0.0
425	0.0	474	0.0	523	16.0	572	0.0
426	0.0	475	0.0	524	18.1	573	0.0
427	0.0	476	0.0	525	20.8	574	0.0
428	0.0	477	0.0	526	21.5	575	0.0
429	0.0	478	0.0	527	22.5	576	0.0
430	0.0	479	0.0	528	23.4	577	0.0
431	0.0	480	0.0	529	24.5	578	0.0
432	0.0	481	1.4	530	25.6	579	0.0

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
580	0.0						
581	0.0						
582	0.0						
583	0.0						
584	0.0						
585	0.0						
586	0.0						
587	0.0						
588	0.0						
589	0.0						

Table A1/4 WLTC, Class 2 vehicles, phase Medium

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
590	0.0	637	38.6	684	59.3	731	55.3
591	0.0	638	39.8	685	60.2	732	55.1
592	0.0	639	40.6	686	61.3	733	54.8
593	0.0	640	41.1	687	62.4	734	54.6
594	0.0	641	41.9	688	63.4	735	54.5
595	0.0	642	42.8	689	64.4	736	54.3
596	0.0	643	44.3	690	65.4	737	53.9
597	0.0	644	45.7	691	66.3	738	53.4
598	0.0	645	47.4	692	67.2	739	52.6
599	0.0	646	48.9	693	68.0	740	51.5
600	0.0	647	50.6	694	68.8	741	50.2
601	1.6	648	52.0	695	69.5	742	48.7
602	3.6	649	53.7	696	70.1	743	47.0
603	6.3	650	55.0	697	70.6	744	45.1
604	9.0	651	56.8	698	71.0	745	43.0
605	11.8	652	58.0	699	71.6	746	40.6
606	14.2	653	59.8	700	72.2	747	38.1
607	16.6	654	61.1	701	72.8	748	35.4
608	18.5	655	62.4	702	73.5	749	32.7
609	20.8	656	63.0	703	74.1	750	30.0
610	23.4	657	63.5	704	74.3	751	27.5
611	26.9	658	63.0	705	74.3	752	25.3
612	30.3	659	62.0	706	73.7	753	23.4
613	32.8	660	60.4	707	71.9	754	22.0
614	34.1	661	58.6	708	70.5	755	20.8
615	34.2	662	56.7	709	68.9	756	19.8
616	33.6	663	55.0	710	67.4	757	18.9
617	32.1	664	53.7	711	66.0	758	18.0
618	30.0	665	52.7	712	64.7	759	17.0
619	27.5	666	51.9	713	63.7	760	16.1
620	25.1	667	51.4	714	62.9	761	15.5
621	22.8	668	51.0	715	62.2	762	14.4
622	20.5	669	50.7	716	61.7	763	14.9
623	17.9	670	50.6	717	61.2	764	15.9
624	15.1	671	50.8	718	60.7	765	17.1
625	13.4	672	51.2	719	60.3	766	18.3
626	12.8	673	51.7	720	59.9	767	19.4
627	13.7	674	52.3	721	59.6	768	20.4
628	16.0	675	53.1	722	59.3	769	21.2
629	18.1	676	53.8	723	59.0	770	21.9
630	20.8	677	54.5	724	58.6	771	22.7
631	23.7	678	55.1	725	58.0	772	23.4
632	26.5	679	55.9	726	57.5	773	24.2
633	29.3	680	56.5	727	56.9	774	24.3
634	32.0	681	57.1	728	56.3	775	24.2
635	34.5	682	57.8	729	55.9	776	24.1
636	36.8	683	58.5	730	55.6	777	23.8

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
778	23.0	827	59.9	876	46.9	925	49.0
779	22.6	828	60.7	877	47.1	926	48.5
780	21.7	829	61.4	878	47.5	927	48.0
781	21.3	830	62.0	879	47.8	928	47.5
782	20.3	831	62.5	880	48.3	929	47.0
783	19.1	832	62.9	881	48.8	930	46.9
784	18.1	833	63.2	882	49.5	931	46.8
785	16.9	834	63.4	883	50.2	932	46.8
786	16.0	835	63.7	884	50.8	933	46.8
787	14.8	836	64.0	885	51.4	934	46.9
788	14.5	837	64.4	886	51.8	935	46.9
789	13.7	838	64.9	887	51.9	936	46.9
790	13.5	839	65.5	888	51.7	937	46.9
791	12.9	840	66.2	889	51.2	938	46.9
792	12.7	841	67.0	890	50.4	939	46.8
793	12.5	842	67.8	891	49.2	940	46.6
794	12.5	843	68.6	892	47.7	941	46.4
795	12.6	844	69.4	893	46.3	942	46.0
796	13.0	845	70.1	894	45.1	943	45.5
797	13.6	846	70.9	895	44.2	944	45.0
798	14.6	847	71.7	896	43.7	945	44.5
799	15.7	848	72.5	897	43.4	946	44.2
800	17.1	849	73.2	898	43.1	947	43.9
801	18.7	850	73.8	899	42.5	948	43.7
802	20.2	851	74.4	900	41.8	949	43.6
803	21.9	852	74.7	901	41.1	950	43.6
804	23.6	853	74.7	902	40.3	951	43.5
805	25.4	854	74.6	903	39.7	952	43.5
806	27.1	855	74.2	904	39.3	953	43.4
807	28.9	856	73.5	905	39.2	954	43.3
808	30.4	857	72.6	906	39.3	955	43.1
809	32.0	858	71.8	907	39.6	956	42.9
810	33.4	859	71.0	908	40.0	957	42.7
811	35.0	860	70.1	909	40.7	958	42.5
812	36.4	861	69.4	910	41.4	959	42.4
813	38.1	862	68.9	911	42.2	960	42.2
814	39.7	863	68.4	912	43.1	961	42.1
815	41.6	864	67.9	913	44.1	962	42.0
816	43.3	865	67.1	914	44.9	963	41.8
817	45.1	866	65.8	915	45.6	964	41.7
818	46.9	867	63.9	916	46.4	965	41.5
819	48.7	868	61.4	917	47.0	966	41.3
820	50.5	869	58.4	918	47.8	967	41.1
821	52.4	870	55.4	919	48.3	968	40.8
822	54.1	871	52.4	920	48.9	969	40.3
823	55.7	872	50.0	921	49.4	970	39.6
824	56.8	873	48.3	922	49.8	971	38.5
825	57.9	874	47.3	923	49.6	972	37.0
826	59.0	875	46.8	924	49.3	973	35.1

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
974	33.0						
975	30.6						
976	27.9						
977	25.1						
978	22.0						
979	18.8						
980	15.5						
981	12.3						
982	8.8						
983	6.0						
984	3.6						
985	1.6						
986	0.0						
987	0.0						
988	0.0						
989	0.0						
990	0.0						
991	0.0						
992	0.0						
993	0.0						
994	0.0						
995	0.0						
996	0.0						
997	0.0						
998	0.0						
999	0.0						
1000	0.0						
1001	0.0						
1002	0.0						
1003	0.0						
1004	0.0						
1005	0.0						
1006	0.0						
1007	0.0						
1008	0.0						
1009	0.0						
1010	0.0						
1011	0.0						
1012	0.0						
1013	0.0						
1014	0.0						
1015	0.0						
1016	0.0						
1017	0.0						
1018	0.0						
1019	0.0						
1020	0.0						
1021	0.0						
1022	0.0						

Table A1/5

WLTC, Class 2 vehicles, phase High

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1023	0.0	1070	46.0	1117	73.9	1164	71.7
1024	0.0	1071	46.4	1118	74.9	1165	69.9
1025	0.0	1072	47.0	1119	75.7	1166	67.9
1026	0.0	1073	47.4	1120	76.4	1167	65.7
1027	1.1	1074	48.0	1121	77.1	1168	63.5
1028	3.0	1075	48.4	1122	77.6	1169	61.2
1029	5.7	1076	49.0	1123	78.0	1170	59.0
1030	8.4	1077	49.4	1124	78.2	1171	56.8
1031	11.1	1078	50.0	1125	78.4	1172	54.7
1032	14.0	1079	50.4	1126	78.5	1173	52.7
1033	17.0	1080	50.8	1127	78.5	1174	50.9
1034	20.1	1081	51.1	1128	78.6	1175	49.4
1035	22.7	1082	51.3	1129	78.7	1176	48.1
1036	23.6	1083	51.3	1130	78.9	1177	47.1
1037	24.5	1084	51.3	1131	79.1	1178	46.5
1038	24.8	1085	51.3	1132	79.4	1179	46.3
1039	25.1	1086	51.3	1133	79.8	1180	46.5
1040	25.3	1087	51.3	1134	80.1	1181	47.2
1041	25.5	1088	51.3	1135	80.5	1182	48.3
1042	25.7	1089	51.4	1136	80.8	1183	49.7
1043	25.8	1090	51.6	1137	81.0	1184	51.3
1044	25.9	1091	51.8	1138	81.2	1185	53.0
1045	26.0	1092	52.1	1139	81.3	1186	54.9
1046	26.1	1093	52.3	1140	81.2	1187	56.7
1047	26.3	1094	52.6	1141	81.0	1188	58.6
1048	26.5	1095	52.8	1142	80.6	1189	60.2
1049	26.8	1096	52.9	1143	80.0	1190	61.6
1050	27.1	1097	53.0	1144	79.1	1191	62.2
1051	27.5	1098	53.0	1145	78.0	1192	62.5
1052	28.0	1099	53.0	1146	76.8	1193	62.8
1053	28.6	1100	53.1	1147	75.5	1194	62.9
1054	29.3	1101	53.2	1148	74.1	1195	63.0
1055	30.4	1102	53.3	1149	72.9	1196	63.0
1056	31.8	1103	53.4	1150	71.9	1197	63.1
1057	33.7	1104	53.5	1151	71.2	1198	63.2
1058	35.8	1105	53.7	1152	70.9	1199	63.3
1059	37.8	1106	55.0	1153	71.0	1200	63.5
1060	39.5	1107	56.8	1154	71.5	1201	63.7
1061	40.8	1108	58.8	1155	72.3	1202	63.9
1062	41.8	1109	60.9	1156	73.2	1203	64.1
1063	42.4	1110	63.0	1157	74.1	1204	64.3
1064	43.0	1111	65.0	1158	74.9	1205	66.1
1065	43.4	1112	66.9	1159	75.4	1206	67.9
1066	44.0	1113	68.6	1160	75.5	1207	69.7
1067	44.4	1114	70.1	1161	75.2	1208	71.4
1068	45.0	1115	71.5	1162	74.5	1209	73.1
1069	45.4	1116	72.8	1163	73.3	1210	74.7

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1211	76.2	1260	35.4	1309	72.3	1358	70.8
1212	77.5	1261	32.7	1310	71.9	1359	70.8
1213	78.6	1262	30.0	1311	71.3	1360	70.9
1214	79.7	1263	29.9	1312	70.9	1361	70.9
1215	80.6	1264	30.0	1313	70.5	1362	70.9
1216	81.5	1265	30.2	1314	70.0	1363	70.9
1217	82.2	1266	30.4	1315	69.6	1364	71.0
1218	83.0	1267	30.6	1316	69.2	1365	71.0
1219	83.7	1268	31.6	1317	68.8	1366	71.1
1220	84.4	1269	33.0	1318	68.4	1367	71.2
1221	84.9	1270	33.9	1319	67.9	1368	71.3
1222	85.1	1271	34.8	1320	67.5	1369	71.4
1223	85.2	1272	35.7	1321	67.2	1370	71.5
1224	84.9	1273	36.6	1322	66.8	1371	71.7
1225	84.4	1274	37.5	1323	65.6	1372	71.8
1226	83.6	1275	38.4	1324	63.3	1373	71.9
1227	82.7	1276	39.3	1325	60.2	1374	71.9
1228	81.5	1277	40.2	1326	56.2	1375	71.9
1229	80.1	1278	40.8	1327	52.2	1376	71.9
1230	78.7	1279	41.7	1328	48.4	1377	71.9
1231	77.4	1280	42.4	1329	45.0	1378	71.9
1232	76.2	1281	43.1	1330	41.6	1379	71.9
1233	75.4	1282	43.6	1331	38.6	1380	72.0
1234	74.8	1283	44.2	1332	36.4	1381	72.1
1235	74.3	1284	44.8	1333	34.8	1382	72.4
1236	73.8	1285	45.5	1334	34.2	1383	72.7
1237	73.2	1286	46.3	1335	34.7	1384	73.1
1238	72.4	1287	47.2	1336	36.3	1385	73.4
1239	71.6	1288	48.1	1337	38.5	1386	73.8
1240	70.8	1289	49.1	1338	41.0	1387	74.0
1241	69.9	1290	50.0	1339	43.7	1388	74.1
1242	67.9	1291	51.0	1340	46.5	1389	74.0
1243	65.7	1292	51.9	1341	49.1	1390	73.0
1244	63.5	1293	52.7	1342	51.6	1391	72.0
1245	61.2	1294	53.7	1343	53.9	1392	71.0
1246	59.0	1295	55.0	1344	56.0	1393	70.0
1247	56.8	1296	56.8	1345	57.9	1394	69.0
1248	54.7	1297	58.8	1346	59.7	1395	68.0
1249	52.7	1298	60.9	1347	61.2	1396	67.7
1250	50.9	1299	63.0	1348	62.5	1397	66.7
1251	49.4	1300	65.0	1349	63.5	1398	66.6
1252	48.1	1301	66.9	1350	64.3	1399	66.7
1253	47.1	1302	68.6	1351	65.3	1400	66.8
1254	46.5	1303	70.1	1352	66.3	1401	66.9
1255	46.3	1304	71.0	1353	67.3	1402	66.9
1256	45.1	1305	71.8	1354	68.3	1403	66.9
1257	43.0	1306	72.8	1355	69.3	1404	66.9
1258	40.6	1307	72.9	1356	70.3	1405	66.9
1259	38.1	1308	73.0	1357	70.8	1406	66.9

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1407	66.9	1456	0.0				
1408	67.0	1457	0.0				
1409	67.1	1458	0.0				
1410	67.3	1459	0.0				
1411	67.5	1460	0.0				
1412	67.8	1461	0.0				
1413	68.2	1462	0.0				
1414	68.6	1463	0.0				
1415	69.0	1464	0.0				
1416	69.3	1465	0.0				
1417	69.3	1466	0.0				
1418	69.2	1467	0.0				
1419	68.8	1468	0.0				
1420	68.2	1469	0.0				
1421	67.6	1470	0.0				
1422	67.4	1471	0.0				
1423	67.2	1472	0.0				
1424	66.9	1473	0.0				
1425	66.3	1474	0.0				
1426	65.4	1475	0.0				
1427	64.0	1476	0.0				
1428	62.4	1477	0.0				
1429	60.6						
1430	58.6						
1431	56.7						
1432	54.8						
1433	53.0						
1434	51.3						
1435	49.6						
1436	47.8						
1437	45.5						
1438	42.8						
1439	39.8						
1440	36.5						
1441	33.0						
1442	29.5						
1443	25.8						
1444	22.1						
1445	18.6						
1446	15.3						
1447	12.4						
1448	9.6						
1449	6.6						
1450	3.8						
1451	1.6						
1452	0.0						
1453	0.0						
1454	0.0						
1455	0.0						

Table A1/6 WLTC, Class 2 vehicles, phase Extra High

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1478	0.0	1525	63.4	1572	107.4	1619	113.7
1479	1.1	1526	64.5	1573	108.7	1620	114.1
1480	2.3	1527	65.7	1574	109.9	1621	114.4
1481	4.6	1528	66.9	1575	111.2	1622	114.6
1482	6.5	1529	68.1	1576	112.3	1623	114.7
1483	8.9	1530	69.1	1577	113.4	1624	114.7
1484	10.9	1531	70.0	1578	114.4	1625	114.7
1485	13.5	1532	70.9	1579	115.3	1626	114.6
1486	15.2	1533	71.8	1580	116.1	1627	114.5
1487	17.6	1534	72.6	1581	116.8	1628	114.5
1488	19.3	1535	73.4	1582	117.4	1629	114.5
1489	21.4	1536	74.0	1583	117.7	1630	114.7
1490	23.0	1537	74.7	1584	118.2	1631	115.0
1491	25.0	1538	75.2	1585	118.1	1632	115.6
1492	26.5	1539	75.7	1586	117.7	1633	116.4
1493	28.4	1540	76.4	1587	117.0	1634	117.3
1494	29.8	1541	77.2	1588	116.1	1635	118.2
1495	31.7	1542	78.2	1589	115.2	1636	118.8
1496	33.7	1543	78.9	1590	114.4	1637	119.3
1497	35.8	1544	79.9	1591	113.6	1638	119.6
1498	38.1	1545	81.1	1592	113.0	1639	119.7
1499	40.5	1546	82.4	1593	112.6	1640	119.5
1500	42.2	1547	83.7	1594	112.2	1641	119.3
1501	43.5	1548	85.4	1595	111.9	1642	119.2
1502	44.5	1549	87.0	1596	111.6	1643	119.0
1503	45.2	1550	88.3	1597	111.2	1644	118.8
1504	45.8	1551	89.5	1598	110.7	1645	118.8
1505	46.6	1552	90.5	1599	110.1	1646	118.8
1506	47.4	1553	91.3	1600	109.3	1647	118.8
1507	48.5	1554	92.2	1601	108.4	1648	118.8
1508	49.7	1555	93.0	1602	107.4	1649	118.9
1509	51.3	1556	93.8	1603	106.7	1650	119.0
1510	52.9	1557	94.6	1604	106.3	1651	119.0
1511	54.3	1558	95.3	1605	106.2	1652	119.1
1512	55.6	1559	95.9	1606	106.4	1653	119.2
1513	56.8	1560	96.6	1607	107.0	1654	119.4
1514	57.9	1561	97.4	1608	107.5	1655	119.6
1515	58.9	1562	98.1	1609	107.9	1656	119.9
1516	59.7	1563	98.7	1610	108.4	1657	120.1
1517	60.3	1564	99.5	1611	108.9	1658	120.3
1518	60.7	1565	100.3	1612	109.5	1659	120.4
1519	60.9	1566	101.1	1613	110.2	1660	120.5
1520	61.0	1567	101.9	1614	110.9	1661	120.5
1521	61.1	1568	102.8	1615	111.6	1662	120.5
1522	61.4	1569	103.8	1616	112.2	1663	120.5
1523	61.8	1570	105.0	1617	112.8	1664	120.4
1524	62.5	1571	106.1	1618	113.3	1665	120.3

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1666	120.1	1715	120.4	1764	82.6		
1667	119.9	1716	120.8	1765	81.9		
1668	119.6	1717	121.1	1766	81.1		
1669	119.5	1718	121.6	1767	80.0		
1670	119.4	1719	121.8	1768	78.7		
1671	119.3	1720	122.1	1769	76.9		
1672	119.3	1721	122.4	1770	74.6		
1673	119.4	1722	122.7	1771	72.0		
1674	119.5	1723	122.8	1772	69.0		
1675	119.5	1724	123.1	1773	65.6		
1676	119.6	1725	123.1	1774	62.1		
1677	119.6	1726	122.8	1775	58.5		
1678	119.6	1727	122.3	1776	54.7		
1679	119.4	1728	121.3	1777	50.9		
1680	119.3	1729	119.9	1778	47.3		
1681	119.0	1730	118.1	1779	43.8		
1682	118.8	1731	115.9	1780	40.4		
1683	118.7	1732	113.5	1781	37.4		
1684	118.8	1733	111.1	1782	34.3		
1685	119.0	1734	108.6	1783	31.3		
1686	119.2	1735	106.2	1784	28.3		
1687	119.6	1736	104.0	1785	25.2		
1688	120.0	1737	101.1	1786	22.0		
1689	120.3	1738	98.3	1787	18.9		
1690	120.5	1739	95.7	1788	16.1		
1691	120.7	1740	93.5	1789	13.4		
1692	120.9	1741	91.5	1790	11.1		
1693	121.0	1742	90.7	1791	8.9		
1694	121.1	1743	90.4	1792	6.9		
1695	121.2	1744	90.2	1793	4.9		
1696	121.3	1745	90.2	1794	2.8		
1697	121.4	1746	90.1	1795	0.0		
1698	121.5	1747	90.0	1796	0.0		
1699	121.5	1748	89.8	1797	0.0		
1700	121.5	1749	89.6	1798	0.0		
1701	121.4	1750	89.4	1799	0.0		
1702	121.3	1751	89.2	1800	0.0		
1703	121.1	1752	88.9				
1704	120.9	1753	88.5				
1705	120.6	1754	88.1				
1706	120.4	1755	87.6				
1707	120.2	1756	87.1				
1708	120.1	1757	86.6				
1709	119.9	1758	86.1				
1710	119.8	1759	85.5				
1711	119.8	1760	85.0				
1712	119.9	1761	84.4				
1713	120.0	1762	83.8				
1714	120.2	1763	83.2				

Table A1/7 WLTC, Class 3 vehicles, phase Low

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
0	0.0	47	19.5	94	12.0	141	11.7
1	0.0	48	18.4	95	9.1	142	16.4
2	0.0	49	17.8	96	5.8	143	18.9
3	0.0	50	17.8	97	3.6	144	19.9
4	0.0	51	17.4	98	2.2	145	20.8
5	0.0	52	15.7	99	0.0	146	22.8
6	0.0	53	13.1	100	0.0	147	25.4
7	0.0	54	12.1	101	0.0	148	27.7
8	0.0	55	12.0	102	0.0	149	29.2
9	0.0	56	12.0	103	0.0	150	29.8
10	0.0	57	12.0	104	0.0	151	29.4
11	0.0	58	12.3	105	0.0	152	27.2
12	0.2	59	12.6	106	0.0	153	22.6
13	1.7	60	14.7	107	0.0	154	17.3
14	5.4	61	15.3	108	0.0	155	13.3
15	9.9	62	15.9	109	0.0	156	12.0
16	13.1	63	16.2	110	0.0	157	12.6
17	16.9	64	17.1	111	0.0	158	14.1
18	21.7	65	17.8	112	0.0	159	17.2
19	26.0	66	18.1	113	0.0	160	20.1
20	27.5	67	18.4	114	0.0	161	23.4
21	28.1	68	20.3	115	0.0	162	25.5
22	28.3	69	23.2	116	0.0	163	27.6
23	28.8	70	26.5	117	0.0	164	29.5
24	29.1	71	29.8	118	0.0	165	31.1
25	30.8	72	32.6	119	0.0	166	32.1
26	31.9	73	34.4	120	0.0	167	33.2
27	34.1	74	35.5	121	0.0	168	35.2
28	36.6	75	36.4	122	0.0	169	37.2
29	39.1	76	37.4	123	0.0	170	38.0
30	41.3	77	38.5	124	0.0	171	37.4
31	42.5	78	39.3	125	0.0	172	35.1
32	43.3	79	39.5	126	0.0	173	31.0
33	43.9	80	39.0	127	0.0	174	27.1
34	44.4	81	38.5	128	0.0	175	25.3
35	44.5	82	37.3	129	0.0	176	25.1
36	44.2	83	37.0	130	0.0	177	25.9
37	42.7	84	36.7	131	0.0	178	27.8
38	39.9	85	35.9	132	0.0	179	29.2
39	37.0	86	35.3	133	0.0	180	29.6
40	34.6	87	34.6	134	0.0	181	29.5
41	32.3	88	34.2	135	0.0	182	29.2
42	29.0	89	31.9	136	0.0	183	28.3
43	25.1	90	27.3	137	0.0	184	26.1
44	22.2	91	22.0	138	0.2	185	23.6
45	20.9	92	17.0	139	1.9	186	21.0
46	20.4	93	14.2	140	6.1	187	18.9

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
188	17.1	237	49.2	286	37.4	335	15.0
189	15.7	238	48.4	287	40.7	336	14.5
190	14.5	239	46.9	288	44.0	337	14.3
191	13.7	240	44.3	289	47.3	338	14.5
192	12.9	241	41.5	290	49.2	339	15.4
193	12.5	242	39.5	291	49.8	340	17.8
194	12.2	243	37.0	292	49.2	341	21.1
195	12.0	244	34.6	293	48.1	342	24.1
196	12.0	245	32.3	294	47.3	343	25.0
197	12.0	246	29.0	295	46.8	344	25.3
198	12.0	247	25.1	296	46.7	345	25.5
199	12.5	248	22.2	297	46.8	346	26.4
200	13.0	249	20.9	298	47.1	347	26.6
201	14.0	250	20.4	299	47.3	348	27.1
202	15.0	251	19.5	300	47.3	349	27.7
203	16.5	252	18.4	301	47.1	350	28.1
204	19.0	253	17.8	302	46.6	351	28.2
205	21.2	254	17.8	303	45.8	352	28.1
206	23.8	255	17.4	304	44.8	353	28.0
207	26.9	256	15.7	305	43.3	354	27.9
208	29.6	257	14.5	306	41.8	355	27.9
209	32.0	258	15.4	307	40.8	356	28.1
210	35.2	259	17.9	308	40.3	357	28.2
211	37.5	260	20.6	309	40.1	358	28.0
212	39.2	261	23.2	310	39.7	359	26.9
213	40.5	262	25.7	311	39.2	360	25.0
214	41.6	263	28.7	312	38.5	361	23.2
215	43.1	264	32.5	313	37.4	362	21.9
216	45.0	265	36.1	314	36.0	363	21.1
217	47.1	266	39.0	315	34.4	364	20.7
218	49.0	267	40.8	316	33.0	365	20.7
219	50.6	268	42.9	317	31.7	366	20.8
220	51.8	269	44.4	318	30.0	367	21.2
221	52.7	270	45.9	319	28.0	368	22.1
222	53.1	271	46.0	320	26.1	369	23.5
223	53.5	272	45.6	321	25.6	370	24.3
224	53.8	273	45.3	322	24.9	371	24.5
225	54.2	274	43.7	323	24.9	372	23.8
226	54.8	275	40.8	324	24.3	373	21.3
227	55.3	276	38.0	325	23.9	374	17.7
228	55.8	277	34.4	326	23.9	375	14.4
229	56.2	278	30.9	327	23.6	376	11.9
230	56.5	279	25.5	328	23.3	377	10.2
231	56.5	280	21.4	329	20.5	378	8.9
232	56.2	281	20.2	330	17.5	379	8.0
233	54.9	282	22.9	331	16.9	380	7.2
234	52.9	283	26.6	332	16.7	381	6.1
235	51.0	284	30.2	333	15.9	382	4.9
236	49.8	285	34.1	334	15.6	383	3.7

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
384	2.3	433	31.3	482	0.0	531	0.0
385	0.9	434	31.1	483	0.0	532	0.0
386	0.0	435	30.6	484	0.0	533	0.2
387	0.0	436	29.2	485	0.0	534	1.2
388	0.0	437	26.7	486	0.0	535	3.2
389	0.0	438	23.0	487	0.0	536	5.2
390	0.0	439	18.2	488	0.0	537	8.2
391	0.0	440	12.9	489	0.0	538	13
392	0.5	441	7.7	490	0.0	539	18.8
393	2.1	442	3.8	491	0.0	540	23.1
394	4.8	443	1.3	492	0.0	541	24.5
395	8.3	444	0.2	493	0.0	542	24.5
396	12.3	445	0.0	494	0.0	543	24.3
397	16.6	446	0.0	495	0.0	544	23.6
398	20.9	447	0.0	496	0.0	545	22.3
399	24.2	448	0.0	497	0.0	546	20.1
400	25.6	449	0.0	498	0.0	547	18.5
401	25.6	450	0.0	499	0.0	548	17.2
402	24.9	451	0.0	500	0.0	549	16.3
403	23.3	452	0.0	501	0.0	550	15.4
404	21.6	453	0.0	502	0.0	551	14.7
405	20.2	454	0.0	503	0.0	552	14.3
406	18.7	455	0.0	504	0.0	553	13.7
407	17.0	456	0.0	505	0.0	554	13.3
408	15.3	457	0.0	506	0.0	555	13.1
409	14.2	458	0.0	507	0.0	556	13.1
410	13.9	459	0.0	508	0.0	557	13.3
411	14.0	460	0.0	509	0.0	558	13.8
412	14.2	461	0.0	510	0.0	559	14.5
413	14.5	462	0.0	511	0.0	560	16.5
414	14.9	463	0.0	512	0.5	561	17.0
415	15.9	464	0.0	513	2.5	562	17.0
416	17.4	465	0.0	514	6.6	563	17.0
417	18.7	466	0.0	515	11.8	564	15.4
418	19.1	467	0.0	516	16.8	565	10.1
419	18.8	468	0.0	517	20.5	566	4.8
420	17.6	469	0.0	518	21.9	567	0.0
421	16.6	470	0.0	519	21.9	568	0.0
422	16.2	471	0.0	520	21.3	569	0.0
423	16.4	472	0.0	521	20.3	570	0.0
424	17.2	473	0.0	522	19.2	571	0.0
425	19.1	474	0.0	523	17.8	572	0.0
426	22.6	475	0.0	524	15.5	573	0.0
427	27.4	476	0.0	525	11.9	574	0.0
428	31.6	477	0.0	526	7.6	575	0.0
429	33.4	478	0.0	527	4.0	576	0.0
430	33.5	479	0.0	528	2.0	577	0.0
431	32.8	480	0.0	529	1.0	578	0.0
432	31.9	481	0.0	530	0.0	579	0.0

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
580	0.0						
581	0.0						
582	0.0						
583	0.0						
584	0.0						
585	0.0						
586	0.0						
587	0.0						
588	0.0						
589	0.0						

Table A1/8 WLTC, Class 3 vehicles of which maximum speed is less than 120 km/h, phase Medium

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
590	0.0	637	53.0	684	18.9	731	41.9
591	0.0	638	53.0	685	18.9	732	42.0
592	0.0	639	52.9	686	21.3	733	42.2
593	0.0	640	52.7	687	23.9	734	42.4
594	0.0	641	52.6	688	25.9	735	42.7
595	0.0	642	53.1	689	28.4	736	43.1
596	0.0	643	54.3	690	30.3	737	43.7
597	0.0	644	55.2	691	30.9	738	44.0
598	0.0	645	55.5	692	31.1	739	44.1
599	0.0	646	55.9	693	31.8	740	45.3
600	0.0	647	56.3	694	32.7	741	46.4
601	1.0	648	56.7	695	33.2	742	47.2
602	2.1	649	56.9	696	32.4	743	47.3
603	5.2	650	56.8	697	28.3	744	47.4
604	9.2	651	56.0	698	25.8	745	47.4
605	13.5	652	54.2	699	23.1	746	47.5
606	18.1	653	52.1	700	21.8	747	47.9
607	22.3	654	50.1	701	21.2	748	48.6
608	26.0	655	47.2	702	21.0	749	49.4
609	29.3	656	43.2	703	21.0	750	49.8
610	32.8	657	39.2	704	20.9	751	49.8
611	36.0	658	36.5	705	19.9	752	49.7
612	39.2	659	34.3	706	17.9	753	49.3
613	42.5	660	31.0	707	15.1	754	48.5
614	45.7	661	26.0	708	12.8	755	47.6
615	48.2	662	20.7	709	12.0	756	46.3
616	48.4	663	15.4	710	13.2	757	43.7
617	48.2	664	13.1	711	17.1	758	39.3
618	47.8	665	12.0	712	21.1	759	34.1
619	47.0	666	12.5	713	21.8	760	29.0
620	45.9	667	14.0	714	21.2	761	23.7
621	44.9	668	19.0	715	18.5	762	18.4
622	44.4	669	23.2	716	13.9	763	14.3
623	44.3	670	28.0	717	12.0	764	12.0
624	44.5	671	32.0	718	12.0	765	12.8
625	45.1	672	34.0	719	13.0	766	16.0
626	45.7	673	36.0	720	16.3	767	20.4
627	46.0	674	38.0	721	20.5	768	24.0
628	46.0	675	40.0	722	23.9	769	29.0
629	46.0	676	40.3	723	26.0	770	32.2
630	46.1	677	40.5	724	28.0	771	36.8
631	46.7	678	39.0	725	31.5	772	39.4
632	47.7	679	35.7	726	33.4	773	43.2
633	48.9	680	31.8	727	36.0	774	45.8
634	50.3	681	27.1	728	37.8	775	49.2
635	51.6	682	22.8	729	40.2	776	51.4
636	52.6	683	21.1	730	41.6	777	54.2

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
778	56.0	827	37.1	876	75.8	925	62.3
779	58.3	828	38.9	877	76.6	926	62.7
780	59.8	829	41.4	878	76.5	927	62.0
781	61.7	830	44.0	879	76.2	928	61.3
782	62.7	831	46.3	880	75.8	929	60.9
783	63.3	832	47.7	881	75.4	930	60.5
784	63.6	833	48.2	882	74.8	931	60.2
785	64.0	834	48.7	883	73.9	932	59.8
786	64.7	835	49.3	884	72.7	933	59.4
787	65.2	836	49.8	885	71.3	934	58.6
788	65.3	837	50.2	886	70.4	935	57.5
789	65.3	838	50.9	887	70.0	936	56.6
790	65.4	839	51.8	888	70.0	937	56.0
791	65.7	840	52.5	889	69.0	938	55.5
792	66.0	841	53.3	890	68.0	939	55.0
793	65.6	842	54.5	891	67.3	940	54.4
794	63.5	843	55.7	892	66.2	941	54.1
795	59.7	844	56.5	893	64.8	942	54.0
796	54.6	845	56.8	894	63.6	943	53.9
797	49.3	846	57.0	895	62.6	944	53.9
798	44.9	847	57.2	896	62.1	945	54.0
799	42.3	848	57.7	897	61.9	946	54.2
800	41.4	849	58.7	898	61.9	947	55.0
801	41.3	850	60.1	899	61.8	948	55.8
802	43.0	851	61.1	900	61.5	949	56.2
803	45.0	852	61.7	901	60.9	950	56.1
804	46.5	853	62.3	902	59.7	951	55.1
805	48.3	854	62.9	903	54.6	952	52.7
806	49.5	855	63.3	904	49.3	953	48.4
807	51.2	856	63.4	905	44.9	954	43.1
808	52.2	857	63.5	906	42.3	955	37.8
809	51.6	858	63.9	907	41.4	956	32.5
810	49.7	859	64.4	908	41.3	957	27.2
811	47.4	860	65.0	909	42.1	958	25.1
812	43.7	861	65.6	910	44.7	959	27.0
813	39.7	862	66.6	911	46.0	960	29.8
814	35.5	863	67.4	912	48.8	961	33.8
815	31.1	864	68.2	913	50.1	962	37.0
816	26.3	865	69.1	914	51.3	963	40.7
817	21.9	866	70.0	915	54.1	964	43.0
818	18.0	867	70.8	916	55.2	965	45.6
819	17.0	868	71.5	917	56.2	966	46.9
820	18.0	869	72.4	918	56.1	967	47.0
821	21.4	870	73.0	919	56.1	968	46.9
822	24.8	871	73.7	920	56.5	969	46.5
823	27.9	872	74.4	921	57.5	970	45.8
824	30.8	873	74.9	922	59.2	971	44.3
825	33.0	874	75.3	923	60.7	972	41.3
826	35.1	875	75.6	924	61.8	973	36.5

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
974	31.7						
975	27.0						
976	24.7						
977	19.3						
978	16.0						
979	13.2						
980	10.7						
981	8.8						
982	7.2						
983	5.5						
984	3.2						
985	1.1						
986	0.0						
987	0.0						
988	0.0						
989	0.0						
990	0.0						
991	0.0						
992	0.0						
993	0.0						
994	0.0						
995	0.0						
996	0.0						
997	0.0						
998	0.0						
999	0.0						
1000	0.0						
1001	0.0						
1002	0.0						
1003	0.0						
1004	0.0						
1005	0.0						
1006	0.0						
1007	0.0						
1008	0.0						
1009	0.0						
1010	0.0						
1011	0.0						
1012	0.0						
1013	0.0						
1014	0.0						
1015	0.0						
1016	0.0						
1017	0.0						
1018	0.0						
1019	0.0						
1020	0.0						
1021	0.0						
1022	0.0						

Table A1/9

WLTC, Class 3 vehicles of which maximum speed is higher than 120 km/h, phase Medium

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
590	0.0	637	53.0	684	18.9	731	41.9
591	0.0	638	53.0	685	18.9	732	42.0
592	0.0	639	52.9	686	21.3	733	42.2
593	0.0	640	52.7	687	23.9	734	42.4
594	0.0	641	52.6	688	25.9	735	42.7
595	0.0	642	53.1	689	28.4	736	43.1
596	0.0	643	54.3	690	30.3	737	43.7
597	0.0	644	55.2	691	30.9	738	44.0
598	0.0	645	55.5	692	31.1	739	44.1
599	0.0	646	55.9	693	31.8	740	45.3
600	0.0	647	56.3	694	32.7	741	46.4
601	1.0	648	56.7	695	33.2	742	47.2
602	2.1	649	56.9	696	32.4	743	47.3
603	4.8	650	56.8	697	28.3	744	47.4
604	9.1	651	56.0	698	25.8	745	47.4
605	14.2	652	54.2	699	23.1	746	47.5
606	19.8	653	52.1	700	21.8	747	47.9
607	25.5	654	50.1	701	21.2	748	48.6
608	30.5	655	47.2	702	21.0	749	49.4
609	34.8	656	43.2	703	21.0	750	49.8
610	38.8	657	39.2	704	20.9	751	49.8
611	42.9	658	36.5	705	19.9	752	49.7
612	46.4	659	34.3	706	17.9	753	49.3
613	48.3	660	31.0	707	15.1	754	48.5
614	48.7	661	26.0	708	12.8	755	47.6
615	48.5	662	20.7	709	12.0	756	46.3
616	48.4	663	15.4	710	13.2	757	43.7
617	48.2	664	13.1	711	17.1	758	39.3
618	47.8	665	12.0	712	21.1	759	34.1
619	47.0	666	12.5	713	21.8	760	29.0
620	45.9	667	14.0	714	21.2	761	23.7
621	44.9	668	19.0	715	18.5	762	18.4
622	44.4	669	23.2	716	13.9	763	14.3
623	44.3	670	28.0	717	12.0	764	12.0
624	44.5	671	32.0	718	12.0	765	12.8
625	45.1	672	34.0	719	13.0	766	16.0
626	45.7	673	36.0	720	16.0	767	19.1
627	46.0	674	38.0	721	18.5	768	22.4
628	46.0	675	40.0	722	20.6	769	25.6
629	46.0	676	40.3	723	22.5	770	30.1
630	46.1	677	40.5	724	24.0	771	35.3
631	46.7	678	39.0	725	26.6	772	39.9
632	47.7	679	35.7	726	29.9	773	44.5
633	48.9	680	31.8	727	34.8	774	47.5
634	50.3	681	27.1	728	37.8	775	50.9
635	51.6	682	22.8	729	40.2	776	54.1
636	52.6	683	21.1	730	41.6	777	56.3

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
778	58.1	827	37.1	876	72.7	925	64.1
779	59.8	828	38.9	877	71.3	926	62.7
780	61.1	829	41.4	878	70.4	927	62.0
781	62.1	830	44.0	879	70.0	928	61.3
782	62.8	831	46.3	880	70.0	929	60.9
783	63.3	832	47.7	881	69.0	930	60.5
784	63.6	833	48.2	882	68.0	931	60.2
785	64.0	834	48.7	883	68.0	932	59.8
786	64.7	835	49.3	884	68.0	933	59.4
787	65.2	836	49.8	885	68.1	934	58.6
788	65.3	837	50.2	886	68.4	935	57.5
789	65.3	838	50.9	887	68.6	936	56.6
790	65.4	839	51.8	888	68.7	937	56.0
791	65.7	840	52.5	889	68.5	938	55.5
792	66.0	841	53.3	890	68.1	939	55.0
793	65.6	842	54.5	891	67.3	940	54.4
794	63.5	843	55.7	892	66.2	941	54.1
795	59.7	844	56.5	893	64.8	942	54.0
796	54.6	845	56.8	894	63.6	943	53.9
797	49.3	846	57.0	895	62.6	944	53.9
798	44.9	847	57.2	896	62.1	945	54.0
799	42.3	848	57.7	897	61.9	946	54.2
800	41.4	849	58.7	898	61.9	947	55.0
801	41.3	850	60.1	899	61.8	948	55.8
802	42.1	851	61.1	900	61.5	949	56.2
803	44.7	852	61.7	901	60.9	950	56.1
804	48.4	853	62.3	902	59.7	951	55.1
805	51.4	854	62.9	903	54.6	952	52.7
806	52.7	855	63.3	904	49.3	953	48.4
807	53.0	856	63.4	905	44.9	954	43.1
808	52.5	857	63.5	906	42.3	955	37.8
809	51.3	858	64.5	907	41.4	956	32.5
810	49.7	859	65.8	908	41.3	957	27.2
811	47.4	860	66.8	909	42.1	958	25.1
812	43.7	861	67.4	910	44.7	959	26.0
813	39.7	862	68.8	911	48.4	960	29.3
814	35.5	863	71.1	912	51.4	961	34.6
815	31.1	864	72.3	913	52.7	962	40.4
816	26.3	865	72.8	914	54.0	963	45.3
817	21.9	866	73.4	915	57.0	964	49.0
818	18.0	867	74.6	916	58.1	965	51.1
819	17.0	868	76.0	917	59.2	966	52.1
820	18.0	869	76.6	918	59.0	967	52.2
821	21.4	870	76.5	919	59.1	968	52.1
822	24.8	871	76.2	920	59.5	969	51.7
823	27.9	872	75.8	921	60.5	970	50.9
824	30.8	873	75.4	922	62.3	971	49.2
825	33.0	874	74.8	923	63.9	972	45.9
826	35.1	875	73.9	924	65.1	973	40.6

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
974	35.3						
975	30.0						
976	24.7						
977	19.3						
978	16.0						
979	13.2						
980	10.7						
981	8.8						
982	7.2						
983	5.5						
984	3.2						
985	1.1						
986	0.0						
987	0.0						
988	0.0						
989	0.0						
990	0.0						
991	0.0						
992	0.0						
993	0.0						
994	0.0						
995	0.0						
996	0.0						
997	0.0						
998	0.0						
999	0.0						
1000	0.0						
1001	0.0						
1002	0.0						
1003	0.0						
1004	0.0						
1005	0.0						
1006	0.0						
1007	0.0						
1008	0.0						
1009	0.0						
1010	0.0						
1011	0.0						
1012	0.0						
1013	0.0						
1014	0.0						
1015	0.0						
1016	0.0						
1017	0.0						
1018	0.0						
1019	0.0						
1020	0.0						
1021	0.0						
1022	0.0						

Table A1/10 WLTC, Class 3 vehicles of which maximum speed is less than 120 km/h, phase High

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1023	0.0	1070	29.0	1117	66.2	1164	52.6
1024	0.0	1071	32.0	1118	65.8	1165	54.5
1025	0.0	1072	34.8	1119	64.7	1166	56.6
1026	0.0	1073	37.7	1120	63.6	1167	58.3
1027	0.8	1074	40.8	1121	62.9	1168	60.0
1028	3.6	1075	43.2	1122	62.4	1169	61.5
1029	8.6	1076	46.0	1123	61.7	1170	63.1
1030	14.6	1077	48.0	1124	60.1	1171	64.3
1031	20.0	1078	50.7	1125	57.3	1172	65.7
1032	24.4	1079	52.0	1126	55.8	1173	67.1
1033	28.2	1080	54.5	1127	50.5	1174	68.3
1034	31.7	1081	55.9	1128	45.2	1175	69.7
1035	35.0	1082	57.4	1129	40.1	1176	70.6
1036	37.6	1083	58.1	1130	36.2	1177	71.6
1037	39.7	1084	58.4	1131	32.9	1178	72.6
1038	41.5	1085	58.8	1132	29.8	1179	73.5
1039	43.6	1086	58.8	1133	26.6	1180	74.2
1040	46.0	1087	58.6	1134	23.0	1181	74.9
1041	48.4	1088	58.7	1135	19.4	1182	75.6
1042	50.5	1089	58.8	1136	16.3	1183	76.3
1043	51.9	1090	58.8	1137	14.6	1184	77.1
1044	52.6	1091	58.8	1138	14.2	1185	77.9
1045	52.8	1092	59.1	1139	14.3	1186	78.5
1046	52.9	1093	60.1	1140	14.6	1187	79.0
1047	53.1	1094	61.7	1141	15.1	1188	79.7
1048	53.3	1095	63.0	1142	16.4	1189	80.3
1049	53.1	1096	63.7	1143	19.1	1190	81.0
1050	52.3	1097	63.9	1144	22.5	1191	81.6
1051	50.7	1098	63.5	1145	24.4	1192	82.4
1052	48.8	1099	62.3	1146	24.8	1193	82.9
1053	46.5	1100	60.3	1147	22.7	1194	83.4
1054	43.8	1101	58.9	1148	17.4	1195	83.8
1055	40.3	1102	58.4	1149	13.8	1196	84.2
1056	36.0	1103	58.8	1150	12.0	1197	84.7
1057	30.7	1104	60.2	1151	12.0	1198	85.2
1058	25.4	1105	62.3	1152	12.0	1199	85.6
1059	21.0	1106	63.9	1153	13.9	1200	86.3
1060	16.7	1107	64.5	1154	17.7	1201	86.8
1061	13.4	1108	64.4	1155	22.8	1202	87.4
1062	12.0	1109	63.5	1156	27.3	1203	88.0
1063	12.1	1110	62.0	1157	31.2	1204	88.3
1064	12.8	1111	61.2	1158	35.2	1205	88.7
1065	15.6	1112	61.3	1159	39.4	1206	89.0
1066	19.9	1113	61.7	1160	42.5	1207	89.3
1067	23.4	1114	62.0	1161	45.4	1208	89.8
1068	24.6	1115	64.6	1162	48.2	1209	90.2
1069	27.0	1116	66.0	1163	50.3	1210	90.6

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1211	91.0	1260	95.7	1309	75.9	1358	68.2
1212	91.3	1261	95.5	1310	76.0	1359	66.1
1213	91.6	1262	95.3	1311	76.0	1360	63.8
1214	91.9	1263	95.2	1312	76.1	1361	61.6
1215	92.2	1264	95.0	1313	76.3	1362	60.2
1216	92.8	1265	94.9	1314	76.5	1363	59.8
1217	93.1	1266	94.7	1315	76.6	1364	60.4
1218	93.3	1267	94.5	1316	76.8	1365	61.8
1219	93.5	1268	94.4	1317	77.1	1366	62.6
1220	93.7	1269	94.4	1318	77.1	1367	62.7
1221	93.9	1270	94.3	1319	77.2	1368	61.9
1222	94.0	1271	94.3	1320	77.2	1369	60.0
1223	94.1	1272	94.1	1321	77.6	1370	58.4
1224	94.3	1273	93.9	1322	78.0	1371	57.8
1225	94.4	1274	93.4	1323	78.4	1372	57.8
1226	94.6	1275	92.8	1324	78.8	1373	57.8
1227	94.7	1276	92.0	1325	79.2	1374	57.3
1228	94.8	1277	91.3	1326	80.3	1375	56.2
1229	95.0	1278	90.6	1327	80.8	1376	54.3
1230	95.1	1279	90.0	1328	81.0	1377	50.8
1231	95.3	1280	89.3	1329	81.0	1378	45.5
1232	95.4	1281	88.7	1330	81.0	1379	40.2
1233	95.6	1282	88.1	1331	81.0	1380	34.9
1234	95.7	1283	87.4	1332	81.0	1381	29.6
1235	95.8	1284	86.7	1333	80.9	1382	28.7
1236	96.0	1285	86.0	1334	80.6	1383	29.3
1237	96.1	1286	85.3	1335	80.3	1384	30.5
1238	96.3	1287	84.7	1336	80.0	1385	31.7
1239	96.4	1288	84.1	1337	79.9	1386	32.9
1240	96.6	1289	83.5	1338	79.8	1387	35.0
1241	96.8	1290	82.9	1339	79.8	1388	38.0
1242	97.0	1291	82.3	1340	79.8	1389	40.5
1243	97.2	1292	81.7	1341	79.9	1390	42.7
1244	97.3	1293	81.1	1342	80.0	1391	45.8
1245	97.4	1294	80.5	1343	80.4	1392	47.5
1246	97.4	1295	79.9	1344	80.8	1393	48.9
1247	97.4	1296	79.4	1345	81.2	1394	49.4
1248	97.4	1297	79.1	1346	81.5	1395	49.4
1249	97.3	1298	78.8	1347	81.6	1396	49.2
1250	97.3	1299	78.5	1348	81.6	1397	48.7
1251	97.3	1300	78.2	1349	81.4	1398	47.9
1252	97.3	1301	77.9	1350	80.7	1399	46.9
1253	97.2	1302	77.6	1351	79.6	1400	45.6
1254	97.1	1303	77.3	1352	78.2	1401	44.2
1255	97.0	1304	77.0	1353	76.8	1402	42.7
1256	96.9	1305	76.7	1354	75.3	1403	40.7
1257	96.7	1306	76.0	1355	73.8	1404	37.1
1258	96.4	1307	76.0	1356	72.1	1405	33.9
1259	96.1	1308	76.0	1357	70.2	1406	30.6

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1407	28.6	1456	0.0				
1408	27.3	1457	0.0				
1409	27.2	1458	0.0				
1410	27.5	1459	0.0				
1411	27.4	1460	0.0				
1412	27.1	1461	0.0				
1413	26.7	1462	0.0				
1414	26.8	1463	0.0				
1415	28.2	1464	0.0				
1416	31.1	1465	0.0				
1417	34.8	1466	0.0				
1418	38.4	1467	0.0				
1419	40.9	1468	0.0				
1420	41.7	1469	0.0				
1421	40.9	1470	0.0				
1422	38.3	1471	0.0				
1423	35.3	1472	0.0				
1424	34.3	1473	0.0				
1425	34.6	1474	0.0				
1426	36.3	1475	0.0				
1427	39.5	1476	0.0				
1428	41.8	1477	0.0				
1429	42.5						
1430	41.9						
1431	40.1						
1432	36.6						
1433	31.3						
1434	26.0						
1435	20.6						
1436	19.1						
1437	19.7						
1438	21.1						
1439	22.0						
1440	22.1						
1441	21.4						
1442	19.6						
1443	18.3						
1444	18.0						
1445	18.3						
1446	18.5						
1447	17.9						
1448	15.0						
1449	9.9						
1450	4.6						
1451	1.2						
1452	0.0						
1453	0.0						
1454	0.0						
1455	0.0						

Table A1/11 WLTC, Class 3 vehicles of which maximum speed is higher than 120 km/h, phase High

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1023	0.0	1070	26.4	1117	69.7	1164	52.6
1024	0.0	1071	28.8	1118	69.3	1165	54.5
1025	0.0	1072	31.8	1119	68.1	1166	56.6
1026	0.0	1073	35.3	1120	66.9	1167	58.3
1027	0.8	1074	39.5	1121	66.2	1168	60.0
1028	3.6	1075	44.5	1122	65.7	1169	61.5
1029	8.6	1076	49.3	1123	64.9	1170	63.1
1030	14.6	1077	53.3	1124	63.2	1171	64.3
1031	20.0	1078	56.4	1125	60.3	1172	65.7
1032	24.4	1079	58.9	1126	55.8	1173	67.1
1033	28.2	1080	61.2	1127	50.5	1174	68.3
1034	31.7	1081	62.6	1128	45.2	1175	69.7
1035	35.0	1082	63.0	1129	40.1	1176	70.6
1036	37.6	1083	62.5	1130	36.2	1177	71.6
1037	39.7	1084	60.9	1131	32.9	1178	72.6
1038	41.5	1085	59.3	1132	29.8	1179	73.5
1039	43.6	1086	58.6	1133	26.6	1180	74.2
1040	46.0	1087	58.6	1134	23.0	1181	74.9
1041	48.4	1088	58.7	1135	19.4	1182	75.6
1042	50.5	1089	58.8	1136	16.3	1183	76.3
1043	51.9	1090	58.8	1137	14.6	1184	77.1
1044	52.6	1091	58.8	1138	14.2	1185	77.9
1045	52.8	1092	59.1	1139	14.3	1186	78.5
1046	52.9	1093	60.1	1140	14.6	1187	79.0
1047	53.1	1094	61.7	1141	15.1	1188	79.7
1048	53.3	1095	63.0	1142	16.4	1189	80.3
1049	53.1	1096	63.7	1143	19.1	1190	81.0
1050	52.3	1097	63.9	1144	22.5	1191	81.6
1051	50.7	1098	63.5	1145	24.4	1192	82.4
1052	48.8	1099	62.3	1146	24.8	1193	82.9
1053	46.5	1100	60.3	1147	22.7	1194	83.4
1054	43.8	1101	58.9	1148	17.4	1195	83.8
1055	40.3	1102	58.4	1149	13.8	1196	84.2
1056	36.0	1103	58.8	1150	12.0	1197	84.7
1057	30.7	1104	60.2	1151	12.0	1198	85.2
1058	25.4	1105	62.3	1152	12.0	1199	85.6
1059	21.0	1106	63.9	1153	13.9	1200	86.3
1060	16.7	1107	64.5	1154	17.7	1201	86.8
1061	13.4	1108	64.4	1155	22.8	1202	87.4
1062	12.0	1109	63.5	1156	27.3	1203	88.0
1063	12.1	1110	62.0	1157	31.2	1204	88.3
1064	12.8	1111	61.2	1158	35.2	1205	88.7
1065	15.6	1112	61.3	1159	39.4	1206	89.0
1066	19.9	1113	62.6	1160	42.5	1207	89.3
1067	23.4	1114	65.3	1161	45.4	1208	89.8
1068	24.6	1115	68.0	1162	48.2	1209	90.2
1069	25.2	1116	69.4	1163	50.3	1210	90.6

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1211	91.0	1260	95.7	1309	75.9	1358	68.2
1212	91.3	1261	95.5	1310	75.9	1359	66.1
1213	91.6	1262	95.3	1311	75.8	1360	63.8
1214	91.9	1263	95.2	1312	75.7	1361	61.6
1215	92.2	1264	95.0	1313	75.5	1362	60.2
1216	92.8	1265	94.9	1314	75.2	1363	59.8
1217	93.1	1266	94.7	1315	75.0	1364	60.4
1218	93.3	1267	94.5	1316	74.7	1365	61.8
1219	93.5	1268	94.4	1317	74.1	1366	62.6
1220	93.7	1269	94.4	1318	73.7	1367	62.7
1221	93.9	1270	94.3	1319	73.3	1368	61.9
1222	94.0	1271	94.3	1320	73.5	1369	60.0
1223	94.1	1272	94.1	1321	74.0	1370	58.4
1224	94.3	1273	93.9	1322	74.9	1371	57.8
1225	94.4	1274	93.4	1323	76.1	1372	57.8
1226	94.6	1275	92.8	1324	77.7	1373	57.8
1227	94.7	1276	92.0	1325	79.2	1374	57.3
1228	94.8	1277	91.3	1326	80.3	1375	56.2
1229	95.0	1278	90.6	1327	80.8	1376	54.3
1230	95.1	1279	90.0	1328	81.0	1377	50.8
1231	95.3	1280	89.3	1329	81.0	1378	45.5
1232	95.4	1281	88.7	1330	81.0	1379	40.2
1233	95.6	1282	88.1	1331	81.0	1380	34.9
1234	95.7	1283	87.4	1332	81.0	1381	29.6
1235	95.8	1284	86.7	1333	80.9	1382	27.3
1236	96.0	1285	86.0	1334	80.6	1383	29.3
1237	96.1	1286	85.3	1335	80.3	1384	32.9
1238	96.3	1287	84.7	1336	80.0	1385	35.6
1239	96.4	1288	84.1	1337	79.9	1386	36.7
1240	96.6	1289	83.5	1338	79.8	1387	37.6
1241	96.8	1290	82.9	1339	79.8	1388	39.4
1242	97.0	1291	82.3	1340	79.8	1389	42.5
1243	97.2	1292	81.7	1341	79.9	1390	46.5
1244	97.3	1293	81.1	1342	80.0	1391	50.2
1245	97.4	1294	80.5	1343	80.4	1392	52.8
1246	97.4	1295	79.9	1344	80.8	1393	54.3
1247	97.4	1296	79.4	1345	81.2	1394	54.9
1248	97.4	1297	79.1	1346	81.5	1395	54.9
1249	97.3	1298	78.8	1347	81.6	1396	54.7
1250	97.3	1299	78.5	1348	81.6	1397	54.1
1251	97.3	1300	78.2	1349	81.4	1398	53.2
1252	97.3	1301	77.9	1350	80.7	1399	52.1
1253	97.2	1302	77.6	1351	79.6	1400	50.7
1254	97.1	1303	77.3	1352	78.2	1401	49.1
1255	97.0	1304	77.0	1353	76.8	1402	47.4
1256	96.9	1305	76.7	1354	75.3	1403	45.2
1257	96.7	1306	76.0	1355	73.8	1404	41.8
1258	96.4	1307	76.0	1356	72.1	1405	36.5
1259	96.1	1308	76.0	1357	70.2	1406	31.2

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1407	27.6	1456	0.0				
1408	26.9	1457	0.0				
1409	27.3	1458	0.0				
1410	27.5	1459	0.0				
1411	27.4	1460	0.0				
1412	27.1	1461	0.0				
1413	26.7	1462	0.0				
1414	26.8	1463	0.0				
1415	28.2	1464	0.0				
1416	31.1	1465	0.0				
1417	34.8	1466	0.0				
1418	38.4	1467	0.0				
1419	40.9	1468	0.0				
1420	41.7	1469	0.0				
1421	40.9	1470	0.0				
1422	38.3	1471	0.0				
1423	35.3	1472	0.0				
1424	34.3	1473	0.0				
1425	34.6	1474	0.0				
1426	36.3	1475	0.0				
1427	39.5	1476	0.0				
1428	41.8	1477	0.0				
1429	42.5						
1430	41.9						
1431	40.1						
1432	36.6						
1433	31.3						
1434	26.0						
1435	20.6						
1436	19.1						
1437	19.7						
1438	21.1						
1439	22.0						
1440	22.1						
1441	21.4						
1442	19.6						
1443	18.3						
1444	18.0						
1445	18.3						
1446	18.5						
1447	17.9						
1448	15.0						
1449	9.9						
1450	4.6						
1451	1.2						
1452	0.0						
1453	0.0						
1454	0.0						
1455	0.0						

Table A1/12 WLTC, Class 3 vehicles, phase Extra High

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1478	0.0	1525	72.5	1572	120.7	1619	113.0
1479	2.2	1526	70.8	1573	121.8	1620	114.1
1480	4.4	1527	68.6	1574	122.6	1621	115.1
1481	6.3	1528	66.2	1575	123.2	1622	115.9
1482	7.9	1529	64.0	1576	123.6	1623	116.5
1483	9.2	1530	62.2	1577	123.7	1624	116.7
1484	10.4	1531	60.9	1578	123.6	1625	116.6
1485	11.5	1532	60.2	1579	123.3	1626	116.2
1486	12.9	1533	60.0	1580	123.0	1627	115.2
1487	14.7	1534	60.4	1581	122.5	1628	113.8
1488	17.0	1535	61.4	1582	122.1	1629	112.0
1489	19.8	1536	63.2	1583	121.5	1630	110.1
1490	23.1	1537	65.6	1584	120.8	1631	108.3
1491	26.7	1538	68.4	1585	120.0	1632	107.0
1492	30.5	1539	71.6	1586	119.1	1633	106.1
1493	34.1	1540	74.9	1587	118.1	1634	105.8
1494	37.5	1541	78.4	1588	117.1	1635	105.7
1495	40.6	1542	81.8	1589	116.2	1636	105.7
1496	43.3	1543	84.9	1590	115.5	1637	105.6
1497	45.7	1544	87.4	1591	114.9	1638	105.3
1498	47.7	1545	89.0	1592	114.5	1639	104.9
1499	49.3	1546	90.0	1593	114.1	1640	104.4
1500	50.5	1547	90.6	1594	113.9	1641	104.0
1501	51.3	1548	91.0	1595	113.7	1642	103.8
1502	52.1	1549	91.5	1596	113.3	1643	103.9
1503	52.7	1550	92.0	1597	112.9	1644	104.4
1504	53.4	1551	92.7	1598	112.2	1645	105.1
1505	54.0	1552	93.4	1599	111.4	1646	106.1
1506	54.5	1553	94.2	1600	110.5	1647	107.2
1507	55.0	1554	94.9	1601	109.5	1648	108.5
1508	55.6	1555	95.7	1602	108.5	1649	109.9
1509	56.3	1556	96.6	1603	107.7	1650	111.3
1510	57.2	1557	97.7	1604	107.1	1651	112.7
1511	58.5	1558	98.9	1605	106.6	1652	113.9
1512	60.2	1559	100.4	1606	106.4	1653	115.0
1513	62.3	1560	102.0	1607	106.2	1654	116.0
1514	64.7	1561	103.6	1608	106.2	1655	116.8
1515	67.1	1562	105.2	1609	106.2	1656	117.6
1516	69.2	1563	106.8	1610	106.4	1657	118.4
1517	70.7	1564	108.5	1611	106.5	1658	119.2
1518	71.9	1565	110.2	1612	106.8	1659	120.0
1519	72.7	1566	111.9	1613	107.2	1660	120.8
1520	73.4	1567	113.7	1614	107.8	1661	121.6
1521	73.8	1568	115.3	1615	108.5	1662	122.3
1522	74.1	1569	116.8	1616	109.4	1663	123.1
1523	74.0	1570	118.2	1617	110.5	1664	123.8
1524	73.6	1571	119.5	1618	111.7	1665	124.4

Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h	Time in s	speed in km/h
1666	125.0	1715	127.7	1764	82.0		
1667	125.4	1716	128.1	1765	81.3		
1668	125.8	1717	128.5	1766	80.4		
1669	126.1	1718	129.0	1767	79.1		
1670	126.4	1719	129.5	1768	77.4		
1671	126.6	1720	130.1	1769	75.1		
1672	126.7	1721	130.6	1770	72.3		
1673	126.8	1722	131.0	1771	69.1		
1674	126.9	1723	131.2	1772	65.9		
1675	126.9	1724	131.3	1773	62.7		
1676	126.9	1725	131.2	1774	59.7		
1677	126.8	1726	130.7	1775	57.0		
1678	126.6	1727	129.8	1776	54.6		
1679	126.3	1728	128.4	1777	52.2		
1680	126.0	1729	126.5	1778	49.7		
1681	125.7	1730	124.1	1779	46.8		
1682	125.6	1731	121.6	1780	43.5		
1683	125.6	1732	119.0	1781	39.9		
1684	125.8	1733	116.5	1782	36.4		
1685	126.2	1734	114.1	1783	33.2		
1686	126.6	1735	111.8	1784	30.5		
1687	127.0	1736	109.5	1785	28.3		
1688	127.4	1737	107.1	1786	26.3		
1689	127.6	1738	104.8	1787	24.4		
1690	127.8	1739	102.5	1788	22.5		
1691	127.9	1740	100.4	1789	20.5		
1692	128.0	1741	98.6	1790	18.2		
1693	128.1	1742	97.2	1791	15.5		
1694	128.2	1743	95.9	1792	12.3		
1695	128.3	1744	94.8	1793	8.7		
1696	128.4	1745	93.8	1794	5.2		
1697	128.5	1746	92.8	1795	0.0		
1698	128.6	1747	91.8	1796	0.0		
1699	128.6	1748	91.0	1797	0.0		
1700	128.5	1749	90.2	1798	0.0		
1701	128.3	1750	89.6	1799	0.0		
1702	128.1	1751	89.1	1800	0.0		
1703	127.9	1752	88.6				
1704	127.6	1753	88.1				
1705	127.4	1754	87.6				
1706	127.2	1755	87.1				
1707	127.0	1756	86.6				
1708	126.9	1757	86.1				
1709	126.8	1758	85.5				
1710	126.7	1759	85.0				
1711	126.8	1760	84.4				
1712	126.9	1761	83.8				
1713	127.1	1762	83.2				
1714	127.4	1763	82.6				