United Nations

ECE/TRANS/WP.29/GRPE/2013/...

Economic and Social Council

Distr.: General
7 November 2013

Original: English

Economic Commission for Europe

Inland Transport Committee

World Forum for Harmonization of Vehicle Regulations

Working Party on Pollution and Energy

Sixty-seventh session
Geneva, 14 November 2013
Item 2 of the provisional agenda
Worldwide harmonized Light vehicles Test Procedures (WLTP)

Report on the development of a new UN Global Technical Regulation on Worldwide harmonized Light vehicles Test Procedures (WLTP)

Submitted by the Chairs of the subgroup on the development of the worldwide harmonized test cycle (DHC) and the subgroup on the development of the test procedure (DTP), under the informal working group Worldwide harmonized Light vehicles Test Procedure (WLTP)

The text reproduced below was prepared by the secretariat, in agreement with the ~~Chair~~ Technical Secretary of the informal working group on the Worldwide harmonized Light vehicles Test Procedure (WLTP) and the Chairs of its subgroups. It builds on detailed information contained in the technical reports on the development of a world-wide worldwide harmonized light duty driving test procedure (GRPE-~~66~~67-01) and test cycle (GRPE-~~66~~67-03).

Report on the development of a new UN Global Technical Regulation on Worldwide harmonized Light vehicles Test Procedures (WLTP)

A. Introduction

1. The development of the WLTP 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 (GRPE). The aim of this project was to develop, by 2014, a world-wide harmonized light duty driving test procedure (WLTP). A first roadmap for the development of a UN Global Technical Regulation (UN GTR) was first presented in August 2009 (see document ECE/TRANS/WP.29/2009/131).

2. This initiative responded to the interest of vehicle manufactures in the global harmonization of vehicle emission test procedures and performance requirements, since the compliance with different emission standards in each region creates high burdens from an administrative and vehicle design point of view. For regulatory authorities, this initiative aimed to offers opportunities for a more efficient development and adaptation to technical progress, it encourages collaboration on market surveillance and it facilitates the exchange of information.

3. The test procedure was also expected to be capable to represent typical driving characteristics around the world. This aimed to respond to the increasing evidence demonstrating that, mainly because of the exploitation the flexibilities available in current test procedures and the introduction of fuel consumption reduction technologies which show greater benefits during the cycle than on the road, the gap between the reported fuel consumption from certification tests and the fuel consumption during real-world driving conditions has increased over the years.

4. Since the beginning of the WLTP process, the European Union had a strong political objective set by its own legislation (Regulations (EC) 443/2009 and 510/2011) to develop a new and more realistic test cycle by 2014. This very aspect has been a major political driving factor for setting the time frame of the phase 1 of the WLTP development.

5. The development of the WLTP took place taking into account that two main elements form the backbone of a procedure for vehicle emission legislation:

(a) the driving cycle used for the emissions test; and

(b) the test procedure which sets the conditions, requirements, tolerances, and other parameters concerning the emissions test.

6. This document is the technical report that describes the development of these two elements, explaining what is new or improved with respect to test procedures that are already in place. It builds on detailed information contained in the technical reports on the development of a world-wide worldwide harmonized light duty driving test procedure (GRPE-66-01) and test cycle (GRPE-66-03).

B. Objective

7. This work aimed to develop a worldwide harmonized test procedure based on a world-wide harmonized light duty driving test cycle:

(a) the test procedure was intended to contain a method to determine the levels of gaseous and particulate emissions, fuel and electric energy consumption, CO_2 emissions and electric range in a repeatable and reproducible manner;

(b) the text cycle was meant to be representative of real-world vehicle operation.

8. The measurement resulting from the test procedure and the test cycle should form the basis for the regulation of light vehicles within regional type approval and certification procedures, as well as an objective and comparable source of information to consumers on the expected fuel/energy consumption (and electric range, if applicable).

C. Organization, structure of the project and contributions of the different subgroups to the UN GTR

1. WLTP Informal Group

9. The development of the test procedure and the test cycle were assigned to the WLTP informal working group (WLTP-IG), established under the GRPE.

10. The first meeting of the WLTP group took place in Geneva, on 4 June 2008.

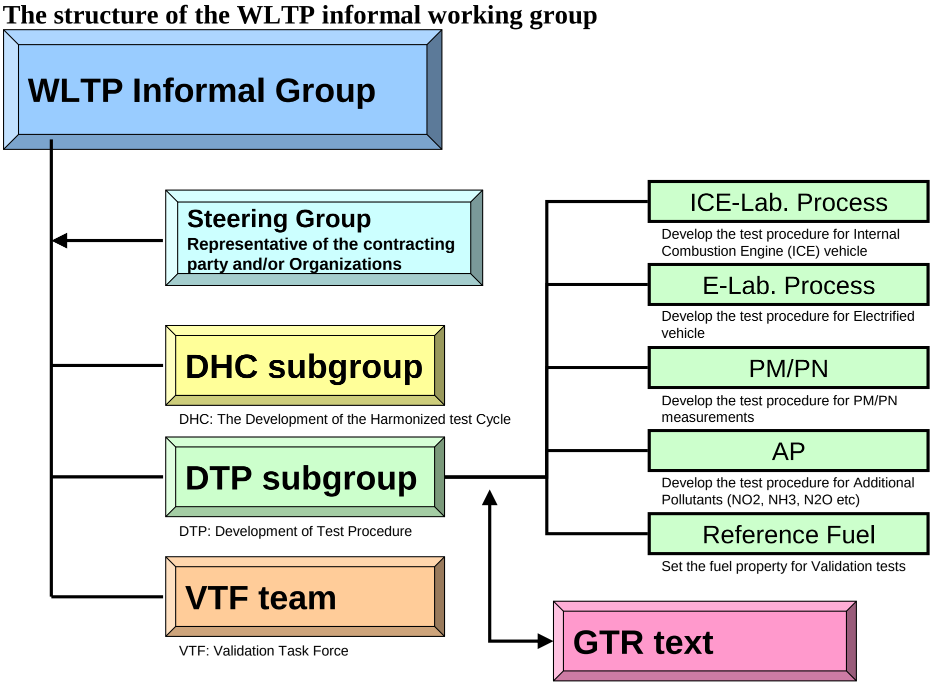
11. Three technical groups were established under this WLTP informal group, each with a specific development task:

(a) the development of the worldwide harmonized test cycle (DHC) group, to develop the Worldwide-harmonised Light-duty vehicle Test Cycle (WLTC), including validation test phase 1 to analyse the test cycle and propose amendments;

(b) the development of the test procedure (DTP) group, to develop the test procedure, and to transpose this into a UN GTR;

(c) the validation task force (VTF) group, to manage the validation test phase 2, to analyse the test results and to propose amendments to the test procedure.

Figure 1
The structure of the WLTP informal working group



12. Figure 1 shows the structure of WLTP-IG. The flow diagram of the WLTP development in phase 1 and the interaction between the technical subgroups/working groups is shown in Figure 2. Figure 3 shows the road map for the development of WLTP, which started in September 2009.

Figure 2

Overview of the WLTP development

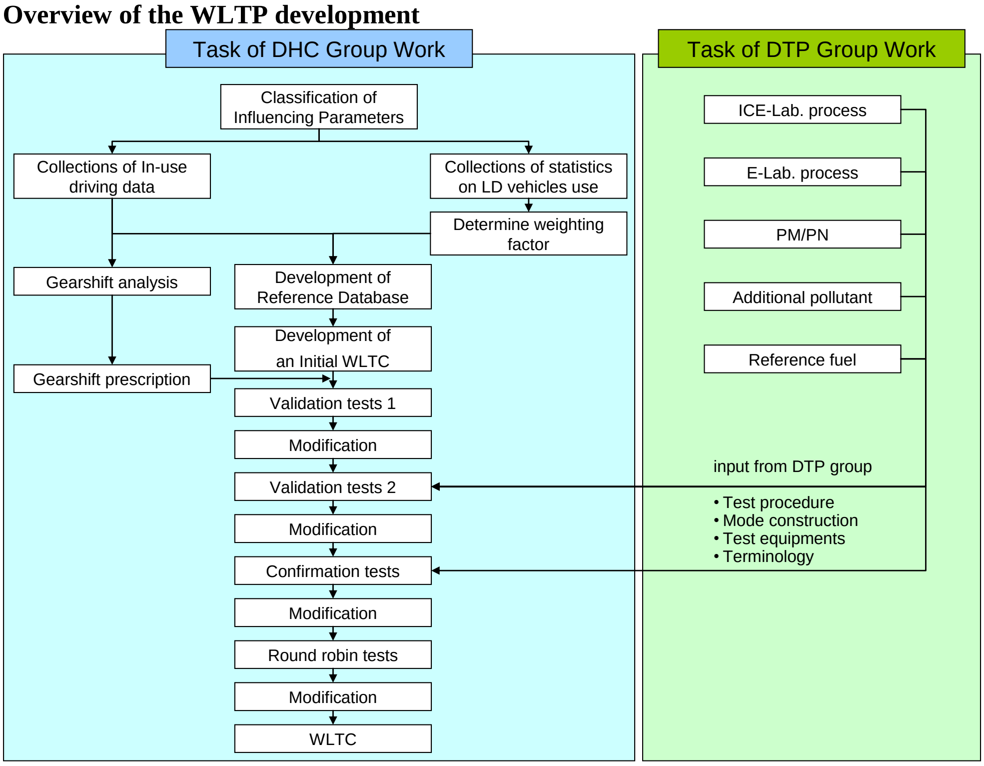
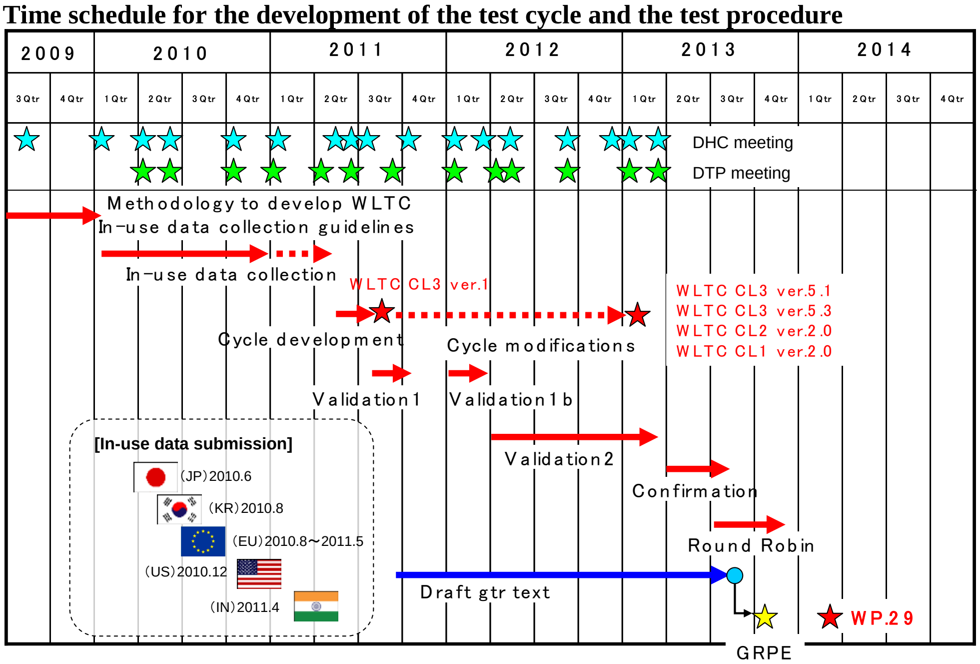


Figure 3

Time schedule for the development of the test cycle and the test procedure



2. DHC group

13. The first meeting of the DHC subgroup took place in Brussels (Belgium) from 7 to 9 September 2009.

Table 1
DHC Chairs and secretaries

Chair	*Secretary*
Dr Hajime Ishii, National Traffic Safety and Environment Laboratory (NTSEL) (Japan)	Noriyuki Ichikawa (Toyota)

14. The scope of activity for this subgroup was described (see WLTP-DHC-01-02 and WLTP-DHC-02-02) as follows:

(a) devise a methodology for the development of a worldwide harmonized light-duty driving test cycle;

(b) develop guidelines for in-use data collection;

(c) develop and validate a world harmonized light-duty driving test cycle (activities to include validation, confirmation and round-robin tests).

15. The driving cycle was developed from recorded in-use data ('real world' data) from different regions of the world (European Union and Switzerland, India, Japan, Korea, the United States of America) combined with suitable weighting factors. Over 765,000 km of data was collected covering a wide range of vehicle categories (M_1, N_1 and M_2 vehicles), various engine capacities, power-to-mass ratios, and manufacturers. Different road types (urban, rural, motorway) and driving conditions (peak, off-peak, weekend) were taken into account.

16. 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.

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

18. More information on the test cycle development is available in section D (test cycle development).

3. DTP group and subgroups

19. The first meeting of the DTP subgroup took place at Ann Arbor (United States of America) from 13 to 15 April 2010.

Table 2
DTP Chairs and secretaries

Chair	*Secretary*
Giovanni D’Urbano, Federal Office for the Environment (Switzerland)	Jakob Seiler, German Association of the Automotive Industry (VDA)

20. The DTP group was first chaired by Michael Olechiw (Environmental Protection Agency, United States of America). The Chair was later Giovanni D’Urbano (Federal Office for the Environment, Switzerland). Initially the secretary was Norbert Krause

(International Organization of Motor Vehicle Manufacturers (OICA)), later followed-up by Jakob Seiler (German Association of the Automotive Industry (VDA)).

21. As indicated in Figures 1 and 2, there were five working groups established within the DTP group to promote an efficient development process by dealing with specific subjects of the test procedure:

(a) laboratory procedures for internal combustion engine vehicles (LabProcICE) to work on the road-load determination and test procedures in the testing laboratory for conventional vehicles;

(b) laboratory procedures for electrified vehicles (LabProcEV) to work on all test procedures that specifically address electrified vehicles;

(c) particulate mass/particle number (PM/PN) to work on test procedures for the determination of particulate mass and particulate numbers in the exhaust gas;

(d) alternative pollutants (AP) to work on test procedures for gaseous emission compounds other than CO2, NO_X, CO and HC;

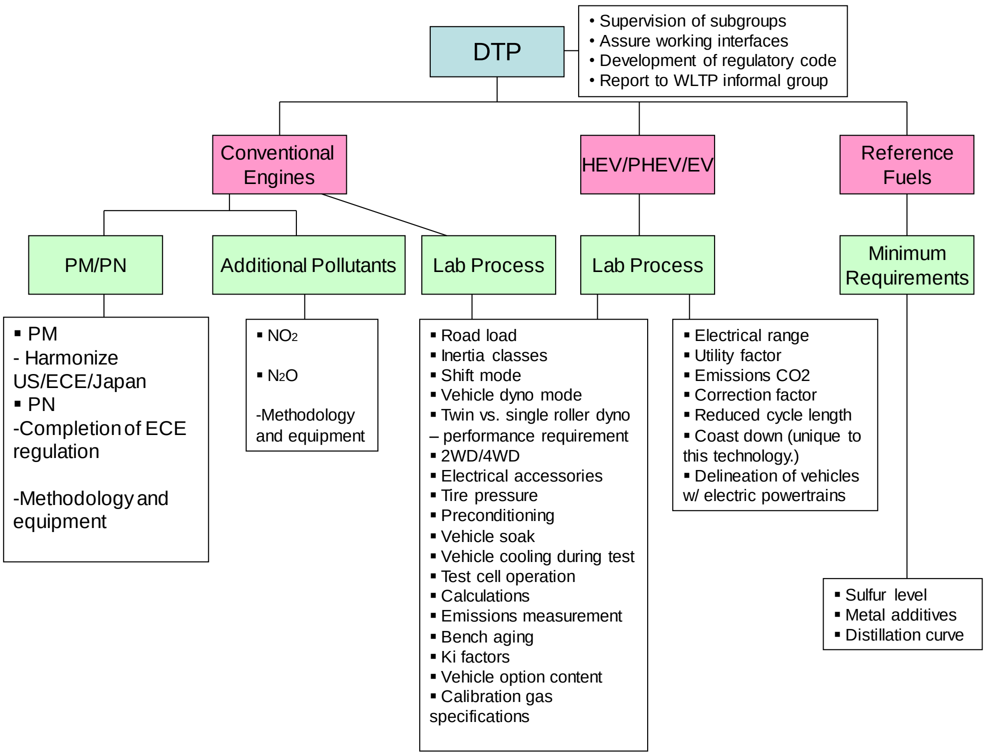
(d) reference fuel (RF) to work on specifications for reference fuels used in emission testing.

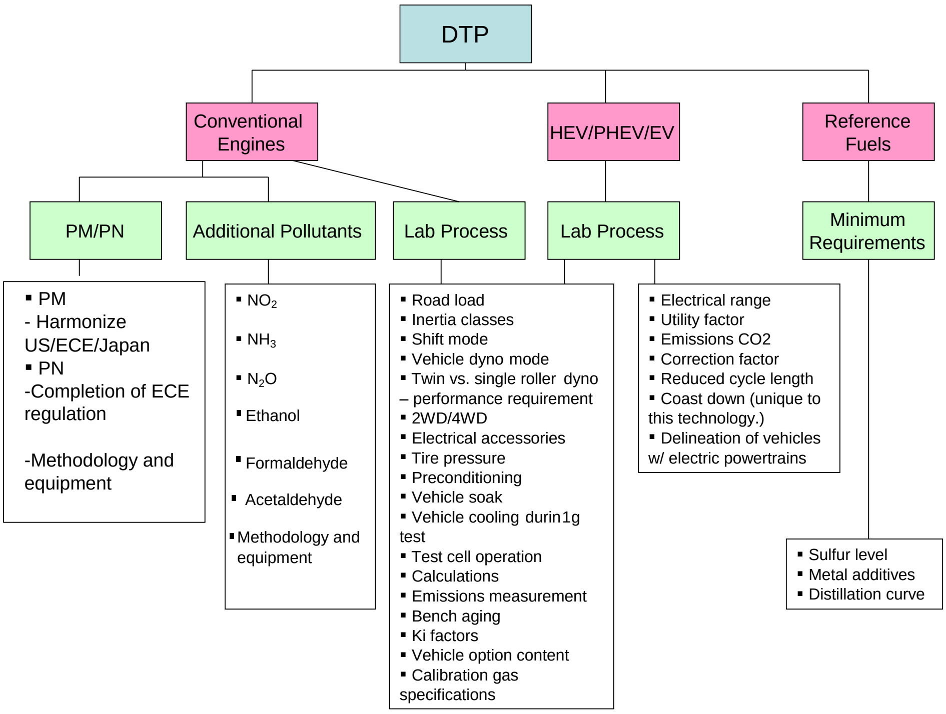
22. The subgroup leaders were appointed at the second DTP meeting which was held in Geneva in June 2010 (see WLTP-DTP-02-03). After this meeting, the subgroups started their work and the following DTP meetings (14 in total until mid of 2013) were dedicated to discussions about the reports from the subgroups.

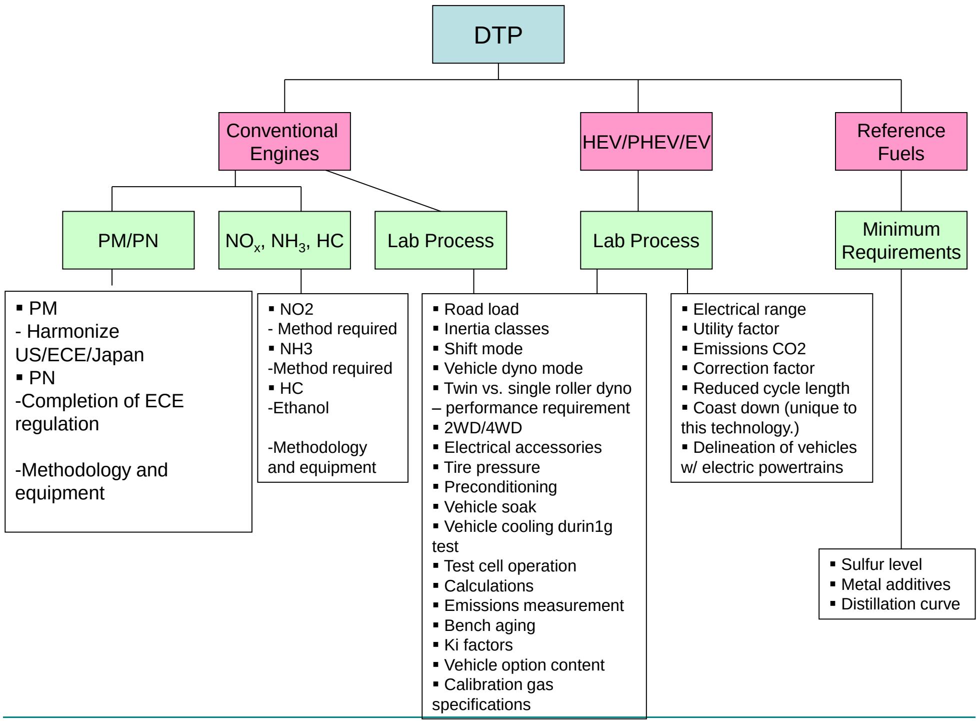
23. The structure of the work distribution and the allocation of tasks are illustrated in Figure 4.

Figure 4

Structure of the DTP and its subgroups ~~(see document WLTP-DTP-01-14)~~







24. A more detailed overview for the scope of activities of each subgroups is presented in the next paragraphs. Section E (test procedure development), below, contains details on the development of the test procedure.

a. Laboratory procedures for internal combustion engine vehicles

25. The first meeting of this subgroup took place from 3 to 6 August 2010 in Ingolstadt, Germany.

Table 1
Laboratory procedures for internal combustion engine vehicles (LabProcICE) Chairs and secretaries

Chair	*Secretary*
Stephan Redmann, Ministry of Transport (Germany)	Dr. Werner Kummer, OICA
Béatrice Lopez de Rodas, UTAC (France)	Dr. Konrad Kolesa, OICA

26. The LabProcICE subgroup had to develop a test procedure including vehicle preparation, vehicle configuration, vehicle operation, measurement equipment and formulae for the measurement of criteria pollutants, CO_2, and fuel consumption for internal combustion engine light duty vehicles. In addition, the LabProcICE subgroup was responsible for the development of the testing specifications that are in common with electrified vehicles.

27. The scope of activity for this subgroup (see WLTP-DTP-LabProcICE-002-ToR-V3) covered:

(a) the identification of the content of Contracting Party legislation relevant to laboratory procedures for conventionally fuelled light duty vehicles excluding PM/PN and additional pollutants measurement procedures;

(b). the comparison of the relevant content of Contracting Party legislation (United States of America, Japan, UN ECE);

(c) deciding upon which content to use for WLTP or, where appropriate, to specify alternative requirements for WLTP;

(d) if necessary, conducting improvements on the basis of the following principles:

(i) narrow tolerances/flexibilities to improve reproducibility;

(ii) cost effectiveness;

(iii) physically reasonable results;

(iv) adapted to new cycle;

(e) drafting laboratory procedures for internal combustion engine light duty vehicles and specification text.

28. In LabProcICE, the work was further structured into the following three subjects:

(a) road load determination;

(b) test procedure;

(c) emission measurement/measurement equipment.

29. The LabProcICE subgroup was responsible for the following annexes of the UN GTR:

(a) Annex 4 - Road load and dynamometer setting. This Annex describes the determination of the road load of a test vehicle and the transfer of that road load to a chassis dynamometer. Annex 4 has the following appendices:

(i) Appendix 1 - Calculation of road load for the dynamometer test;

(ii) Appendix 2 - Adjustment of chassis dynamometer load setting;

(b) Annex 5 - Test equipment and calibrations;

(c) Annex 6 - Type 1 test procedure and test conditions. These tests verify the emissions of gaseous compounds, particulate matter, particle number, CO2 emissions, and fuel consumption, in a representative driving cycle. Annex 6 has the following appendices:

(i) Appendix 1 - Emissions test procedure for all vehicles equipped with periodically regenerating systems,

(ii) Appendix 2 - Test procedure for electric power supply system monitoring.

(d) Annex 7 – Calculations. All the necessary steps are included to work out the mass emissions, particle numbers and cycle energy demand, based on the test results. CO2 and fuel consumption are calculated for each individual vehicle within the CO2 vehicle family.

30. Those parts of Annexes 5 and 6 that are dealing with particles and additional pollutants were developed by the corresponding (PM/PN and AP) subgroups.

c. Laboratory procedures for electrified vehicles

31. The first meeting of this subgroup took place on 21 September 2010.

Table 3
Laboratory procedures for electrified vehicles (LabProcEV) Chairs and secretaries

Chair	*Secretary*
Per Öhlund, Swedish Transport Agency (Sweden)	Yutaka Sawada, OICA
Kazuki Kobayashi, NTSEL (Japan)	

32. The LabProcEV subgroup was tasked with developing a test procedure which includes vehicle preparation, vehicle configuration, vehicle operation, measurement equipment and formulae for the measurement of criteria pollutants, CO_2, fuel consumption and electric energy consumption for electrified vehicles.

33. The scope of activity was described (see WLTP-DTP-E-LabProc-001-ToR._V2) as follows:

(a) identify content of Contracting Party legislation relevant to laboratory procedures for Electrified vehicles excluding PM/PN and additional pollutants measurement procedures;

(b) compare relevant content of Contracting Party legislation (US, UN ECE, Japanese);

(c) decide upon which content to use for WLTP or, where appropriate, to specify alternative requirements for WLTP;

(d) identify additional performance metrics associated with electrified vehicles that may not be covered by existing regulations. (i.e. battery charging times). Create harmonized test procedures for the new performance metrics;

(e) if necessary, conduct improvements on the basis of the following principles:

(i) narrow tolerances / flexibilities to improve reproducibility;

(ii) cost effectiveness;

(iii) physically reasonable results;

(iv) adapted to new cycle.

(f) draft laboratory procedures for electrified light duty vehicles and specification text.

34. The LabProcEV subgroup was responsible for Annex 8 (pure and hybrid electric vehicles) of the UN GTR. This is where measurement procedures and equipment dedicated to electric vehicles (and deviating from Annexes 5 and 6) are defined.

d. Particulate mass/particle number

35. The PM/PN subgroup started its work by a web/phone conference on 7 July2010.

Table 4
Particulate mass/particle number (PM/PN) Chairs and secretaries

Chair	*Secretary*
Chris Parkin, Department for Transport (United Kingdom)	Caroline Hosier,. OICA

36. The scope of activity (see WLTP-DTP-PMPN-01-02-Rev.2) included the following tasks:

(a) identify content of Contracting Party legislation relevant to PM and PN measurement procedures;

(b) compare relevant content of Contracting Party legislation (US, UN ECE, Japanese);

(c). decide upon which content to use for WLTP or, where appropriate, to specify alternative requirements for WLTP;

(d) draft PM and PN measurement procedure and specification text;

37. The approach taken by the PM/PN group was to start from a detailed comparison of the regulations from European Union, Japan and the United States of America. PM/PN established a number of small expert teams to review and make recommendations back to the wider team on measurement equipment specifications, particulate mass sampling, weighing and all aspects of particle number measurement.

38. PM measurement is made by collecting the particulate on a filter membrane which is weighted pre and post-test in highly controlled conditions. It was decided to update the requirements as far as possible for technical progress and harmonisation but without leading to the need to completely replace the majority of existing particle mass measurement systems. A major aspect of this decision is that particle number is also measured.

39. Regarding PN, only the UN Regulation No. 83 contains particle number measurement requirements. Particle number measurement is an on-line measurement process to count solid particles in the legislated size range in real time, where the total number of particles per kilometre is reported for the test.

40. The experts on particle number measurement reviewed the procedure in detail to identify opportunities for tightening the tolerances to improve repeatability / reproducibility

as well as improvements to the process and calibration material specifications to adapt this method to recent technical progress.

41. The work of the PM/PN subgroup was incorporated in relevant parts of Annex 5, 6 and 7 of the UN GTR.

e. Additional pollutants

42. The first web/phone meeting of the AP subgroup took place on 20 July 2010.

Table 4
Additional pollutants (AP) Chairs and secretaries

Chair	*Secretary*
Oliver Mörsch, Daimler AG	Covadonga Astorga, Joint Research Centre (European Commission)

43. The scope of activity for the AP subgroup (see WLTP-DTP-AP-01-01) included the following tasks, building on procedures in existing legislation and expert knowledge within the group:

(a) agree on additional pollutants to be addressed;

(b) identify appropriate measurement methods for each of the pollutants;

(c) describe measurement and calibration procedures and calculations based on existing legislation and on output from lab procedure subgroup;

(d) draft legislation text.

44. The following guidelines have been applied for the development of measurement methods for the additional pollutants:

(a) use or modify existing methods where ever reliable, cost effective and easy to apply technologies are available;

(b) reflect state of the art;

(c) stipulate development of new measurement technologies;

(d) replace cumbersome offline methods by online methods.

45. The work of the AP subgroup was incorporated in relevant parts of Annex 5, 6 and 7 of the UN GTR.

e. Reference fuels

Table 5
Reference fuels (RF) Chairs and secretaries

Chair	*Secretary*
William (Bill) Coleman, Volkswagen AG	-

46. The scope of activity for the RF subgroup was described as follows:

(a) defining a set of validation fuels to support the development stages of the WLTP project (stage 1), and;

(b) defining a framework for reference fuels to be used by Contracting Parties when applying the WLTP UN GTR (stage 2).

47. The scope of activity is related to stage 1. The subgroup had to undertake the following tasks on the basis of a comparison of reference fuels in existing legislation and expert knowledge within the group:

(a) agree a limited number of fuel types and/or blends for which reference fuels are expected to be required in the time frame of implementation of the WLTP project;

(b) identify a list of fuel properties that will be significant to the validation of a future drive cycle and/or test procedure for emissions and/or fuel consumption;

(c) propose limits for the variation of these critical properties in order to specify a limited number of candidate validation fuels to assess potential impact of the future drive cycle on emissions and/or fuel consumption;

(d) obtain approval from the WLTP project for the technical scope of the validation fuels described in (c);

(e) upon approval of the above mentioned parameter list, develop specifications for candidate validation fuels to be used in the validation of the proposed drive cycles and test procedures. These fuels should be limited in number, available at reasonable cost and are not intended to restrict the decisions regarding reference fuels for the final implementation of WLTP (Stage 2);

(f) provide a forum of reference fuel experts who can at relatively short notice provide coordinated advice and support on fuel related project issues to members of other sub-groups of the WLTP Project;

48. These tasks required a fruitful cooperation with experts from the fuel production industry. Since this cooperation could not be established, points (a) to (d) and (f) could not be fulfilled. Already defined regional reference fuels were used for the validation tests of the proposed drive cycles and test procedures.

49. As a consequence, Annex 3 of the UN GTR dedicated to reference fuels consists only of the two paragraphs, requiring the recognition of regionally different reference fuels, proposing examples of reference fuels for the calculation of hydrocarbon emissions and fuel consumption, and recommending that Contracting Parties select their reference fuels from the Annex. The text recommends to bring regionally agreed amendments or alternatives into the UN GTR by amendments, without limiting the right of Contracting Parties to define individual reference fuels to reflect local market fuel specifications.

50. In addition to that, tables with specifications for the following fuel types are included in the UN GTR:

(a) liquid fuels for positive ignition engines:

(i) gasoline/petrol (nominal 90 RON, E0);

(ii) gasoline/petrol (nominal 91 RON, E0);

(iii) gasoline/petrol (nominal 100 RON, E0);

(iv) gasoline/petrol (nominal 94 RON, E0);

(v) gasoline/petrol (nominal 95 RON, E5);

(vi) gasoline/petrol (nominal 95 RON, E10)

(vii) ethanol (nominal 95 RON, E85);

(b) gaseous fuels for positive ignition engines:

(i) LPG (A and B);

(ii) natural gas (NG)/biomethane:

a. "G20" "High Gas" (nominal 100 % methane);

b. "K-Gas" (nominal 88 % methane);

c. "G25" "Low Gas" (nominal 86 % methane);

d. "J-Gas" (nominal 85 % methane)

(c) liquid fuels for compression ignition engines:

(i) J-Diesel (nominal 53 Cetane, B0);

(ii) E-Diesel (nominal 52 Cetane, B5);

(iii) K-Diesel (nominal 52 Cetane, B5);

(iv) E-Diesel (nominal 52 Cetane, B7).

D. Test cycle development

51. This section provides details on the development of the test cycle. More detailed information about this task are available in technical report of the DHC subgroup.

1. Approach

52. Data on driving behaviours and a weighting factor matrix, based on statistical information about light duty vehicle use in the different regions of the world, were collected and analysed as fundamentals to develop the cycle.

53. The data on in-use driving behaviours data were combined with the statistical information on vehicle use in order to develop a reference database that represents worldwide light duty vehicle driving. Real world in-use data were collected from a range of Contracting Parties in the following regions: the European Union and Switzerland, India, Japan, the Republic of Korea, the United States of America.

54. The weighing factors were based on traffic volumes (current and foreseen) of each Contracting Party. National traffic statistics were the starting point to derive such weighing factors. The sources used for different global regions are the following: European Union: TREMOVE (http://www.tremove.org); India: World road statistics 2009, data 2002-2007 (http://www.irfnet.org/statistics.php), Japan: Road traffic census data 2005 (Ministry of Land, Infrastructure, Transport and Tourism), United States of America: Environmental Protection Agency.

55. 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 that 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.

56. 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 (a quantity commonly used to test whether any given data are well described by some hypothesized function) was selected as the ideal combination. After the short trip selection, the comparison of the other parameters such as average speed and relative positive acceleration (RPA) was conducted to check the representativeness.

57. The methodology to develop the WLTC (WLTP-DHC-02-05: draft methodology to develop WLTP drive cycle) was reviewed and agreed following a full discussion at the second DHC meeting held in January 2010. The revised methodology (WLTP-DHC-06-03: WLTC methodology), proposed by Japan, was agreed at the sixth DHC meeting.

2. Vehicle classification

58. The WLTP vehicle classification is based on the power to mass ratio (PMR), i.e. the ratio between rated power and kerb mass. The following classification was agreed on the basis of an analysis of the dynamics of the in-use data:

(a) Class 1: ~~pmr~~PMR <= 22 W/kg;

(b) Class 2: 22 W/kg < ~~pmr~~PMR <= 34 W/kg;

(c) Class 3: ~~pmr~~PMR > 34 W/kg.

59. Consequently, three different WLTC versions were developed according to the dynamic potentials of the different classes.

3. Test cycles

60. The length of the world-wide harmonized test cycle was set to 1800 s. This is similar to the World-wide Harmonized Heavy Duty Cycle (WHDC) and the World-wide harmonized Motorcycle Test Cycle (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 on the basis of traffic volume ratio between the speed phases (low: 589 s, mid.: 433 s, high: 455 s, ex-high: 323 s).

61. An initial WLTC was introduced by Japan in the ninth DHC meeting. This first draft needed modifying on the basis of an evaluation concerning drivability. In addition to that, EU concerned the representative of cycle dynamics. Four modifications were made during the validation phase until the final version (version 5, with version 5.1 for vehicles with maximum speed below 120 km/h and version 5.3 for vehicles with maximum speed ≥ 120 km/h) was agreed for vehicles with rated power to kerb mass values above 34 kW/t.

62. 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 tenth DHC meeting. The cycle development for low powered vehicles was agreed at the eleventh DHC meeting with the discussion on the definition of 'low powered vehicles'.

63. 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 35 kW/t or lower from the additional and existing data. Traceability of prescribed cycle and drivability were evaluated with validation phases 1b and 2. Then the revised versions 2.0 were agreed for two different power to mass ratio classes (up to 22 kW/t and > 22 kW/t up to 34 kW/t).

64. The final result of the cycle development is as follows:

(a) for class 1 vehicles: WLTC CL1 version 2.0;

(b) for class 1 vehicles: WLTC CL2 version 2.0;

(c) for class 3 vehicles of which maximum speed is less than 120 km/h: WLTC CL3 version 5.1;

(d) for class 3 vehicles of which maximum speed is higher than 120 km/h: WLTC CL3 version 5.3.

4. Downscaling procedure

65. 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). Three possibilities were discussed to proceed with such vehicles:

(a) follow the trace as good as possible;

(b) apply a cap on the maximum speed of the vehicle;

(c) downscale the cycle for those sections where the driveability problems occur.

66. The first possibility can lead to excessively high percentages of full load (wide open throttle, 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 not for others. The third possibility was found to be more effective. The equations and calculation coefficients in the UN GTR are based on correlation analyses and were modified in a second step in order to optimize the efficiency of the method.

67. 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 a time combining high vehicle speed and high acceleration values. This means that the road load coefficients as well as the test mass are considered. The downscaling factor 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.

5. Gearshift procedure development

68. 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. The following two alternative approaches were proposed and discussed:

(a) vehicle speed based gearshifts;

(b) normalised engine speed based gearshifts.

69. The validation 1 tests showed driveability problems for both approaches. This could only be solved or reduced by more specific requirements. In case of the approach based on the vehicle speed, a further separation into vehicle subgroups would have been needed. In case of the approach based on the engine speed, the consideration of the engine power demand and the available power would have been required.

70. Since the latter option 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.

71. In addition to rated engine speed and power and idling speed also the test mass, the full load power curve, the driving resistance coefficients and the gear ratios were needed as input data. In order to reflect both a conventional driving behaviour use as well as a fuel efficient driving behaviour, 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.

72. The developed gearshift prescriptions were used for the validation 2 tests and further amended based on the comments/recommendations from the validation 2 participants.

E. Test procedure development

73. This section provides details on the development of the test procedure. More detailed information about the test procedure development work can be found in the technical report of the DTP subgroup

1. Approach

74. For the development of the test procedures, the DTP sub-group took into account existing emissions and energy consumption legislation, in particular those of the UN ECE 1958 and 1998 Agreements, those of Japan and the US Environmental Protection Agency Standard Part 1066. These test procedures were critically reviewed to find the best starting point for the text of the UN GTR. The development process focused in particular on:

(a) updated specifications for measurement equipment towards the current state-of-art in measurement technology;

(b) increased representativeness of the test and vehicle conditions, in order to achieve the best guarantee for similar fuel efficiency on the road as under laboratory conditions;

(c) ensure the capacity to deal with current and expected technical progress in vehicle and engine technology in an appropriate and representative way. This is especially relevant for the section on electrified vehicles.

2. New elements

75. Important elements derived from the DTP activities and incorporated in the UN GTR text include, in particular:

(a) each individual vehicle within a family of vehicles is characterised by a specific CO_2 emission value, based on the installed vehicle options. This considers the CO_2 influence of mass, rolling resistance and aerodynamic performance characteristics. It also requires the test of at least two different vehicles within a family: a 'worst-case' vehicle and a 'best-case'. In the UN GTR, these test vehicles are referred to as vehicle H and vehicle L, respectively. Pollutant emission standards need to be met by all vehicles of the family;

(b) the test-mass of the vehicle was raised to a more representative level, also making this test mass dependent on the payload. In addition, instead of using discrete inertia steps, the test mass is set continuously;

(c) the test cycle development is monitored to make sure the WLTC is representative for average driving behaviour with respect to characteristics that have an impact on CO_2 emissions;

(d) the state-of-charge of the battery at the start of the test is set to a representative start value by a preconditioning cycle. The difference in the state-of-charge of the battery over the cycle is monitored and CO_2 emissions are corrected, if needed;

(e) the test temperature in the laboratory is amended from a range of 20 to 30 °C to 23 °C. In the European Union, a temperature correction for the average temperature is expected to be applied;

(f) the requirements and tolerances with respect to the road load determination procedure are improved and strengthened. This includes:

(i) demanding that the test vehicle and tyre specifications are similar to those of the vehicle that will be produced;

(ii) asking for a more stringent test tyre preconditioning (tread depth, tyre pressure, running-in, shape, no heat treatment allowed);

(iii) strengthening the correction method for wind during the coast-down method (both for stationary wind measurement as for on-board anemometry);

(iv) preventing 'special' brake preparation;

(v) setting more stringent test track characteristics (inclination);

(g) a methodology to create a proper revision of the 'table of running resistances' has been developed;

(h) the torque-meter method for road load determination has been improved to make the UN GTR text more robust;

(i) means to include in the soak procedure the positive effect of heat storage/insulation (safeguarding that the benefit for in-use vehicles is similar have been discussed and will be further developed, in conjunction with the temperature correction mentioned in point (e) above;

(j) NO_2 and ~~NH_3~~N_2O were added as additional emission measurement procedures.

76. The GTR includes also comprehensive paragraphs with definitions and abbreviations.

3. Validation phases

77. The development work was supported by two validation phases with intensive vehicle testing. The first validation phase aimed at the assessment of the driveability of the WLTP cycles. A second phase was dedicated to procedural issues. This phase was executed between April 2012 and December 2012.

78. In total, 34 different laboratories, institutions or manufacturers participated in the validation 2 phase; Test results for 109 vehicles were delivered to the JRC server and then collected in a database which built the basis for the further evaluation work.

79. The following evaluation issues were discussed in the DTP subgroups based on the validation 2 results: soak temperature tolerances, soak with forced cooling down, test cell temperatures, tolerances of humidity during test cycle, tolerances of emission measurement system, preconditioning cycle, preconditioning for dilution tunnel, speed trace tolerances, gearshift tolerances for manual transmission vehicles, monitoring of reverse current blocking (RCB) of all batteries, cycle mode construction, required time for bag analysis, dilution factor, dyno operation mode.