Proposal for WLTC methodology and guidelines for in-use data collection

proposed by UK and Japan
DHC group
under GRPE/WLTP informal group

version 1 : 24 August 2009
revision 1 : 30 October 2009

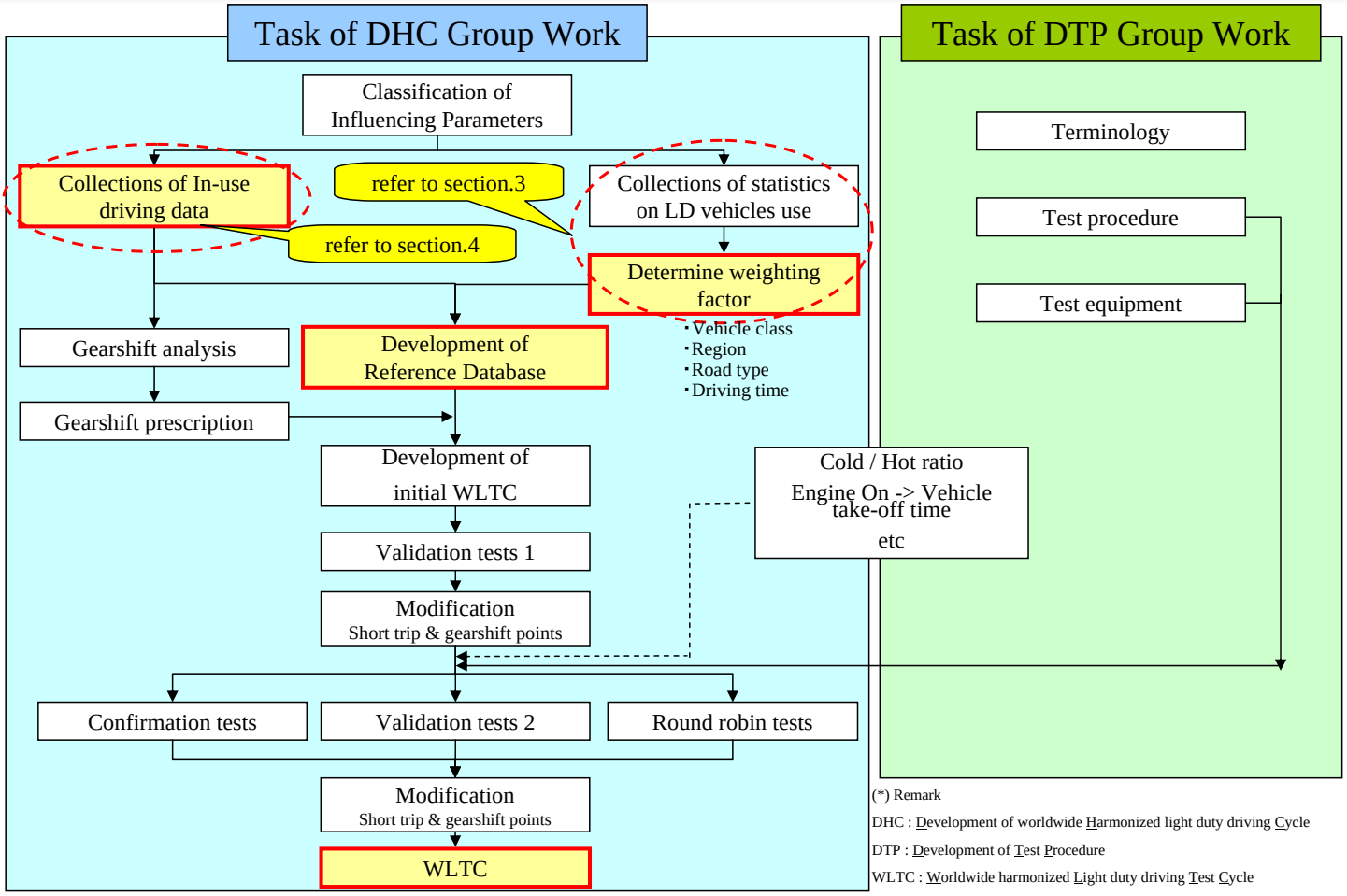
(*) WLTC : Worldwide harmonized Light duty driving Test Cycle

Contents

1. Purpose

- Develop the world wide harmonized light duty test cycle, which will represent typical driving conditions around the world
  - ✓ Define the methodology to develop the common test cycle and gear shift prescription based on the in-use driving data
  - ✓ Provide guideline for in-use data collection

2.1. Overall Process



2.2.1. Test Cycle Development - Step1 -

- Common test cycle is developed based on collected in-use data and weighting factor.

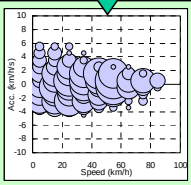
Weighting factor matrix and In-use driving data collection	Weighting factor (Section 3.) / In-use driving behaviors (Section 4.)
Develop unified speed-acceleration distribution	combine the short trips
Compare the short trip combination and the unified distribution	➢chi-squared based analysis ➢Other parameter comparison (refer to Appendix 1)
Common test cycle	

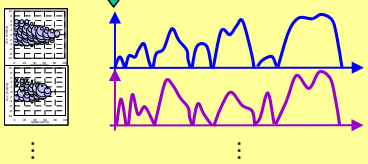
Weighting factor (Section 3.)

Vehicle Category	Region A	Region B	Region C
I	WF_{A1}	WF_{B1}	WF_{C1}
II	WF_{A2}	WF_{B2}	WF_{C2}
III	WF_{A3}	WF_{B3}	WF_{C3}

In-use driving behaviors (Section 4.)

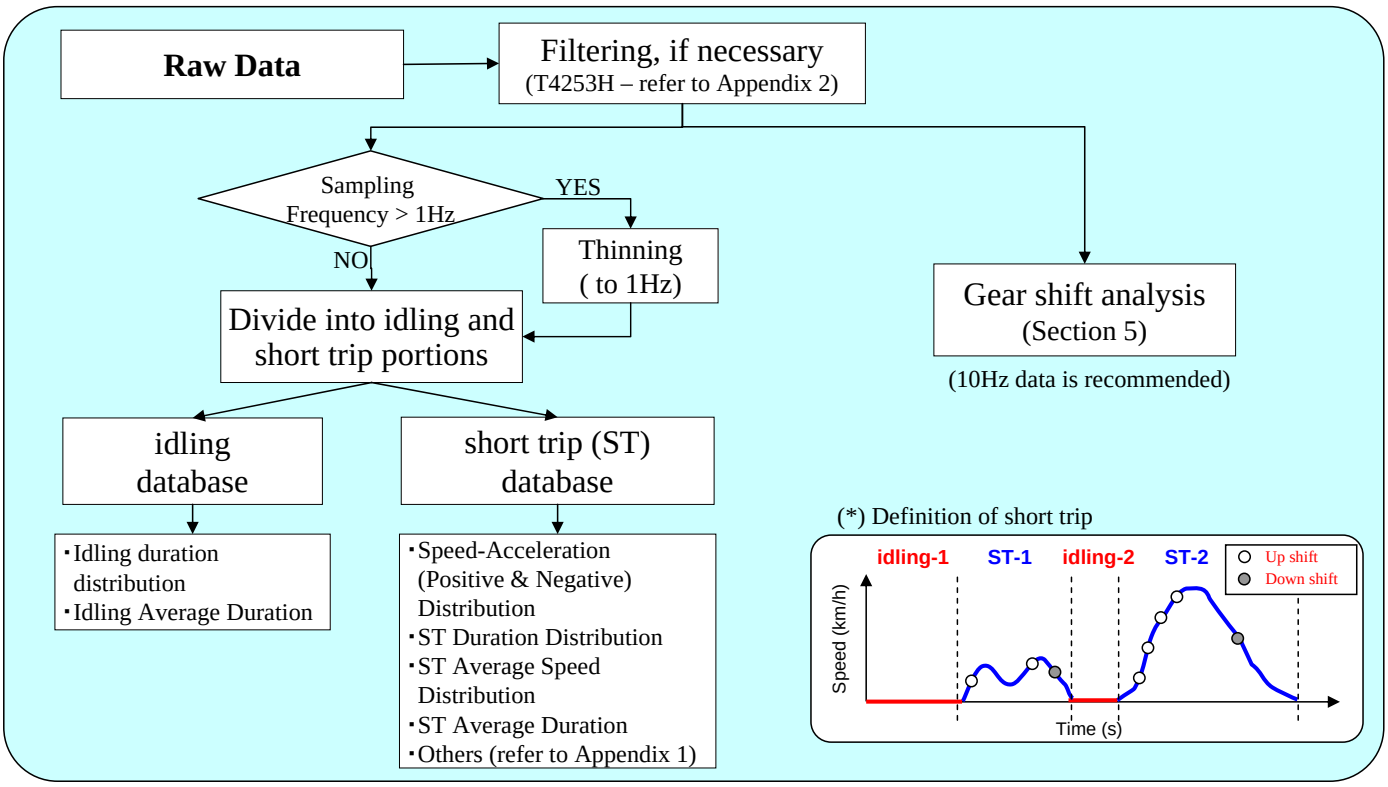
Vehicle Category	Region A	Region B	Region C
I			
II			
III			





2.2.2. Test Cycle Development - Step2 -

- In-use Driving Data Processing



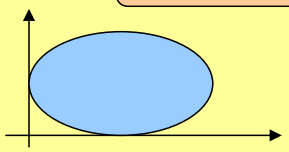
✓In-use data in each road type and in each region is processed separately.

✓Raw data shall be shared within the DHC group.

2.2.3. Test Cycle Development - Step3 -

➢ Develop the Unified Speed-Acceleration Distribution

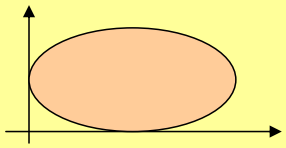
ex.: speed-acceleration distribution in urban area



Urban speed-acceleration distribution in region A

× $RW_{U,A}$

Urban WF in region A

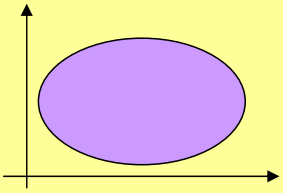


Urban speed-acceleration distribution in region B

× $RW_{U,B}$

Urban WF in region B

⋮ ⋮



Unified speed-acceleration distribution in urban area

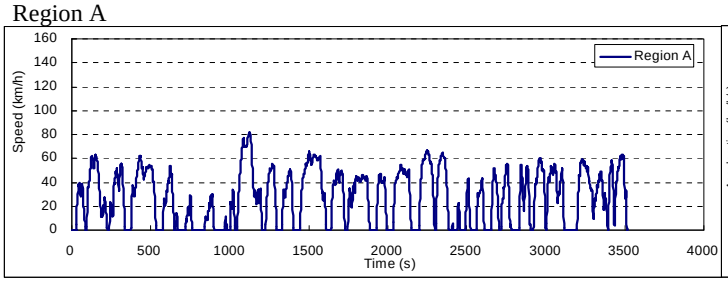
RW = Regional Weight

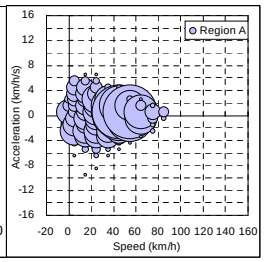
✓ Unified distributions for the following parameters will be generated.
Short trip speed - acceleration distribution, Short trip length distribution
Short trip average speed distribution, Idling length distribution, others

2.2.3. Test Cycle Development - Step3 - sample of data analysis

➢ Develop the Unified Speed-Acceleration Distribution

Region A

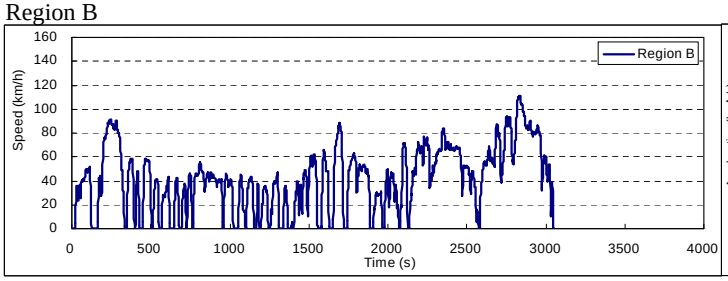


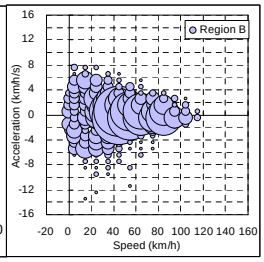


(exclude idling part)

× RW_A =0.45

Region B

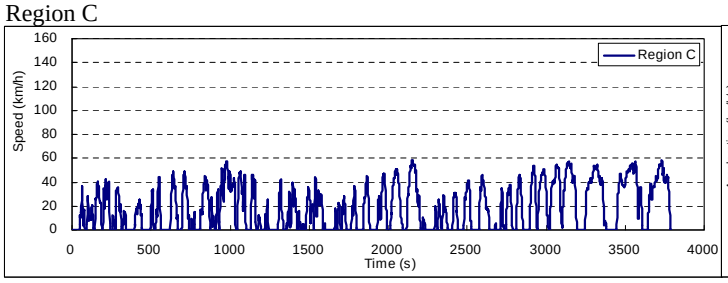


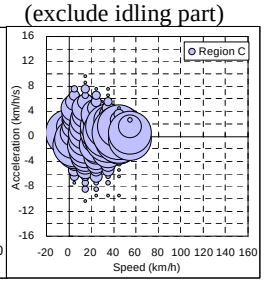


(exclude idling part)

× RW_B =0.30

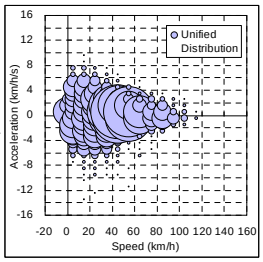
Region C





(exclude idling part)

× RW_C =0.25

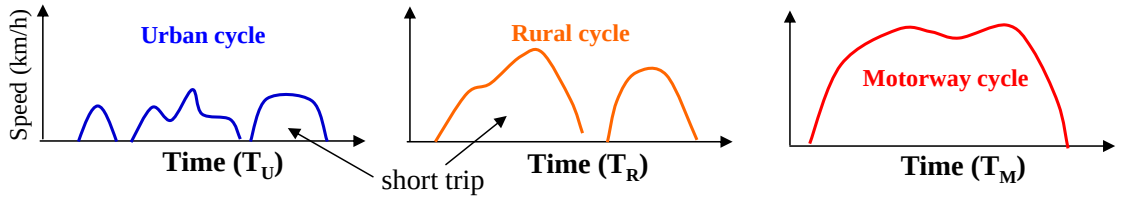


Unified Speed Acceleration Distribution

2.2.4. Test Cycle Development - Step4 -

- Determine the test cycle duration

  < ex. WMTC : 600 x 3phases, WHDC : 1800, LA#4 :1371, NEDC : 1180, JC08 : 1204 (sec) >



- Determine the number of idle and short trip in each phase
  - ✓ Calculate the number in each phase (Urban, Rural, Motorway)
    - ➢ number of short trip ($N_{ST,\,i}$)

$$= \frac{\text{drive cycle duration in each phase } (T_i) - \text{average idling duration}}{\text{average short trip duration} + \text{average idling duration}}$$

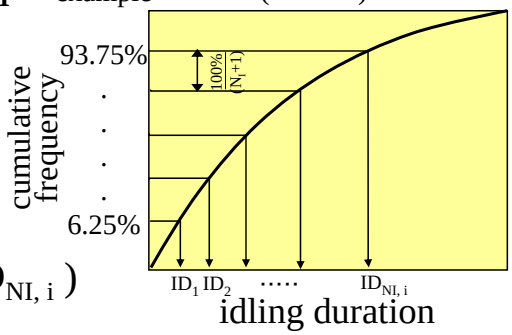
    - ➢ number of idle ($N_{I,\,i}$) = number of short trip ($N_{ST,\,i}$) + 1

<example> T_U = 600 sec, average urban short trip duration = 25 sec,
average urban idling duration = 15 sec,
number of short trip ($N_{ST,U}$) = (600 – 15) / (25 + 15) = 14.6⇒14
number of idling ($N_{I,U}$) = 14 + 1 = 15

2.2.5. Test Cycle Development - Step5 -

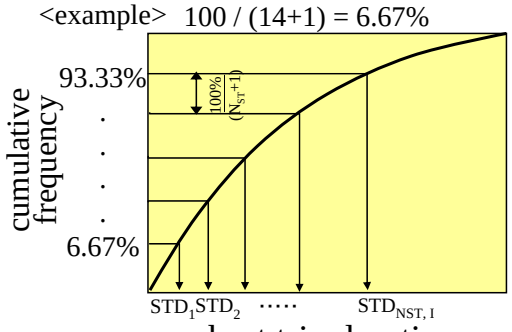
- Determine the $N_{I,\,i}$ units of idling duration in each phase
  - ✓ Generate the cumulative frequency graph based on idling data base
  - ✓ Divide into ($N_{I,\,i}$+1) equally in Y axis
  - ✓ $N_{I,\,i}$ units of idling duration (ID_1, ID_2, ..., $ID_{NI,\,i}$) in each phase are decided

<example> 100 / (14+1+1) = 6.25%



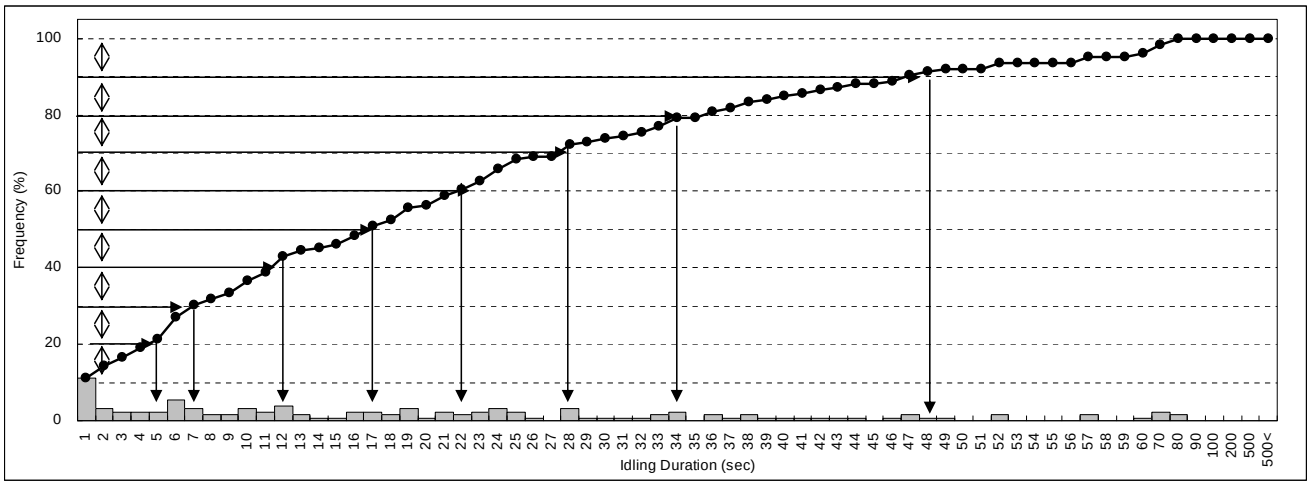
- Determine the $N_{ST,\,i}$ units of short trip duration in each phase
  - ✓ Generate the cumulative frequency graph based on short trip data base
  - ✓ Divide into ($N_{ST,\,i}$+1) equally in Y axis
  - ✓ $N_{ST,\,i}$ units of short trip duration (STD_1, STD_2,..... , $STD_{NST,\,i}$) in each phase are decided
  - ✓ Pick the candidate short trips which duration are STD_1, STD_2, ..., $STD_{NST,\,i}$

<example> 100 / (14+1) = 6.67%



2.2.5. Test Cycle Development - Step5 - sample of data analysis

If number of idling is 9, Y axis will be divided into (9+1) equally



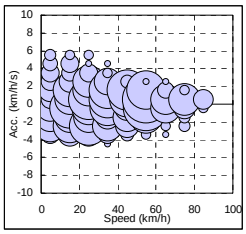
Idling No.	Duration (s)
1	1
2	5
3	7
4	12
5	17

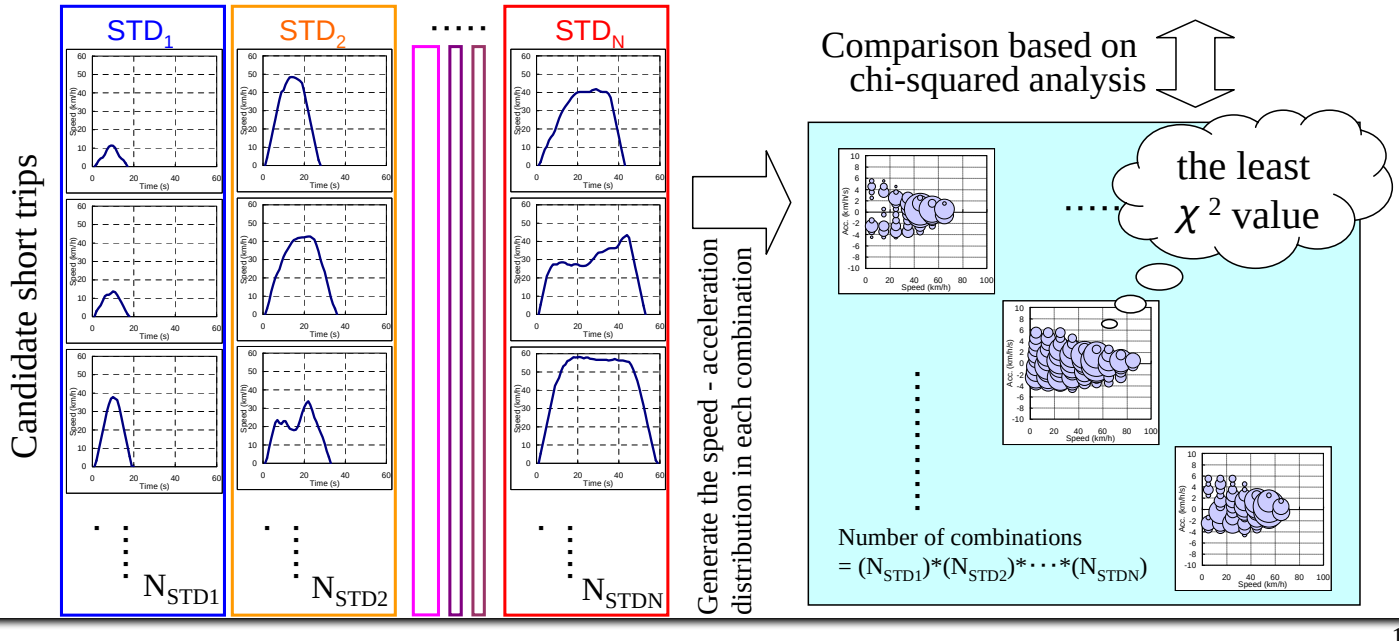
Idling No.	Duration (s)
6	22
7	28
8	34
9	48

2.2.6. Test Cycle Development - Step6 -

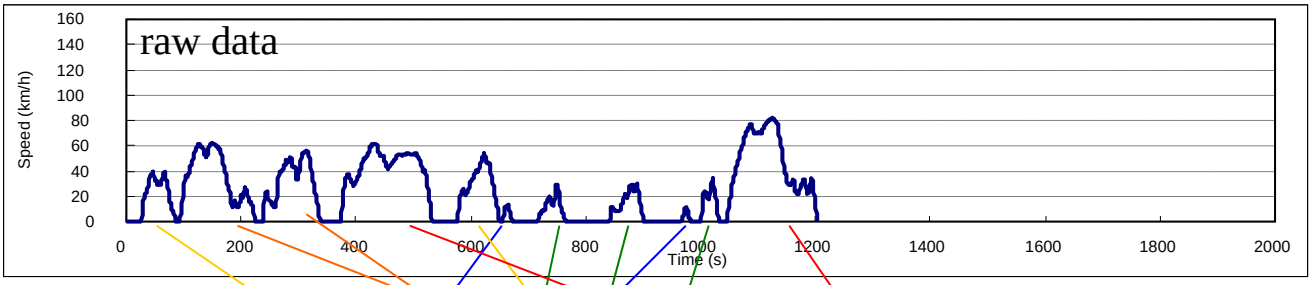
- Determine the short trip combination in each phase
  - ✓Generate the speed-acceleration distribution in each combination from candidate short trips
  - ✓Compare with the unified distribution
  - ✓Select the short trip combination with the least χ^2 value
  - ✓Check other distributions and parameters (refer to Appendix 1)

Unified speed - acceleration distribution





2.2.6. Test Cycle Development - Step6 - sample of data analysis



Duration (s) / No. of STD	~20 s	21~40 s	41~60 s	61~80 s	80~100 s	100 s ~
1						
2						
.						
.						
.						
N						

2.2.6. Test Cycle Development - Step6 - sample of data analysis

Duration (s) / No. of STD	STD1 10sec	STD2 15sec	STD3 18sec	STD4 24sec	STD5 38sec	STD6 60sec
1						
2						
.						
N						

Combinations	Selected Short Trips	V-A distribution
1-1-1-1-1-1		
1-1-1-1-1-2		
…	…	…
N-N-N-N-N-N		

This analysis is done for each phase, however, it is appropriate to break down some drive cycle phases into sub phases e.g. urban congested and urban non-congested

Contents

3.1. Weighting Factor Matrix- Previous Studies

	Weighting factor (Collection of Statistics on vehicle use)					
	Country	Road Type	Vehicle category (Specification)	Power to mass ratio	Matrix	Basic data for weighting factor
WHDC	EU USA JPN	Urban Rural Motorway	rigid trucks trailer trucks buses	3 classes 3 classes 1 class	63	driving duration
WMTC	EU USA JPN China		Engine Displacement 1 : ~ 150 2 : 150 ~ 450 3 : 450 ~		27	driving distance
JC08	JPN	Urban +Rural Motorway				average vehicle speed driving duration

3.2. Basic Concept on Weighting Factor

◆Weighting Factor Matrix

- Statistical data : Traffic volume（driving duration, distance）, vehicle volume
- Countries, Region : Europe, U.S.A. , Asia, etc
- Type of roads : Urban, Rural, Motorway, etc
- Vehicle Categories : Passenger cars, Commercial vehicles Mini Buses, etc
- Days, Time : Weekday/Weekend, On/Off peak, etc
- Method of W.F. : Driving duration or Driving distance
- others

3.3.1. Items for Weighting Factors

- Statistical data
  - ✓ Total annual vehicle hours
    - same as WHDC methodology
- Countries, Region
  - ✓ China, EU, India, Japan, USA, South Korea, South America
- Vehicle Categories
  - ✓ Passenger Cars & LD Commercial Vehicles
    - sub categorized, if necessary
- Type of roads
  - ✓ Urban, Rural, Motorway
    - please refer to Slide 35 for definition
- Days, Hours
  - ✓ Weekday-on peak, Weekday-off peak, Weekend

3.3.2. Development of Weighting Factor - Comparison of 2 Units

	Weighting Factor using time (duration)	Weighting Factor using distance
Advantage	●Same dimension can be applied to all factors (road type, driving conditions, etc) and to in-use data processing (speed-acceleration distribution, short trip/idle, etc) ●Provides more flexibility to adjust the cycle duration when developing the drive cycle	●Simpler to develop the weighting matrix
Dis-advantage	●Requires more resources to generate weighting factor matrix ●Potential difficulties in obtaining the required statistical data from data collecting CPs	●Inconsistent process to analyze idling periods and short trips ●Difficulty when modifying the test cycle

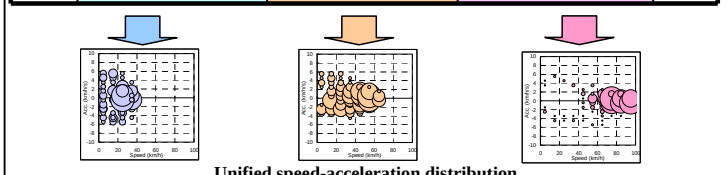
⇒ Following discussion at the 1st DHC meeting, it was agreed to use time as the basis for generating weighting factors

3.3.3. Classification of the Weighting Factor Matrix

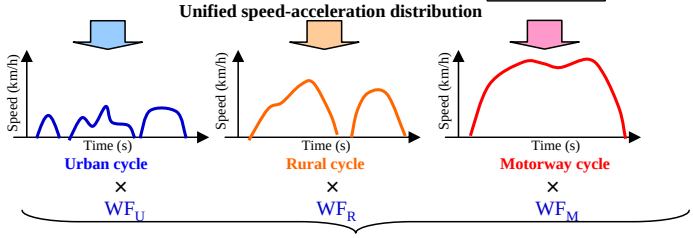
- WMTC method：Each country by road type accounts for 100%
- WHDC method：Total items account for 100%

○WMTC method（Consisting of 3 phases）

Veh. Cate.	Urban			·	·	Rural			·	·	Motorway			·	·	Total
	C	E	I	·	·	C	E	I	·	·	C	E	I	·	·	
a																
b																
c																
Sub	**(100%)**					**(100%)**					**(100%)**					
Total	** % → WF_U					** % → WF_R					** % → WF_M					100%



Unified speed-acceleration distribution



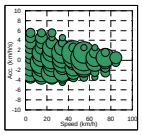
Emission M (g/km, km/L)

➢ Proposal ⇒ WMTC Method

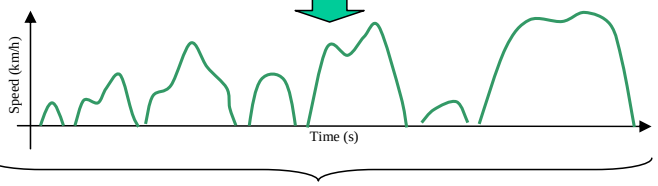
○WHDC method

	China			Europe			India			·	·	Total
	U	R	M	U	R	M	U	R	M	·	·	
a												
b												
c												
												100%

U : Urban, R : Rural, M : Motorway



Unified speed-acceleration distribution



Emission M (g/km, km/L)

[reason]
have more flexibility to adjust and/or modify phase duration, candidate short trips and so on.

3.3.4. Weighting Factor Matrix - Minimum Requirement

- The following matrix is minimum requirement for each in-use data collection CP, with consistency between weighting factors and collected data.
- Sub categorization is acceptable with consistency between weighting factors and collected data.

	Urban			Rural			Motorway		
	Weekday		Week-end	Weekday		Week-end	Weekday		Week-end
	On-peak	Off-peak		On-peak	Off-peak		On-peak	Off-peak	
Passenger Car (PC)									
LD Commercial Vehicle (LDCV)									

3.3.5. How to Generate the Weighting Factor

- Calculate total driving duration by using statistical information currently available in each Contracting Party.
- If these data are not available, the following methods are recommended.

most favorable

Method-1 : Full Traffic Census Data (Japan applies this method)

Method-2 : Partial Traffic Census Data
+ Total Network Distance per road type (statistical data)

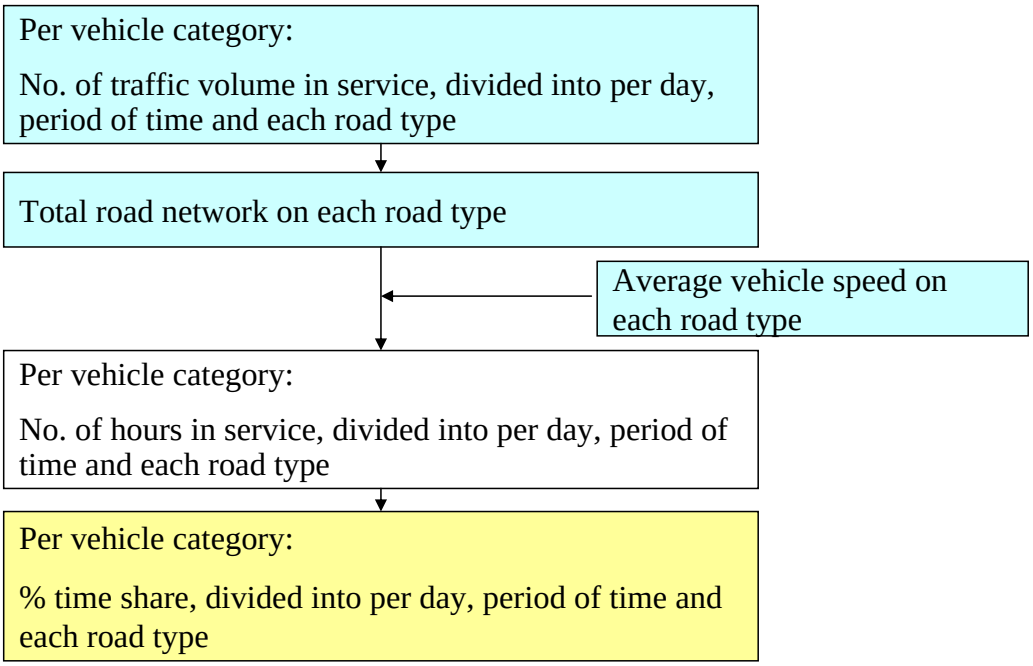
Method-3 : Partial Traffic Census Data
+ Driving Distance per road type (questionnaire survey)

least favorable

Method-4 : Questionnaire Survey only

3.3.6. How to Generate the Weighting Factor - Method 1 -

- Using traffic census….



➢ Per vehicle category, Per Road type, Per period of time :

$$\text{No. of hours in service} = \frac{\text{Total road network} \times \text{No. of traffic volume}}{\text{Average vehicle speed}}$$

3.3.7. How to Generate the Weighting Factor - Method 1 -

➢No. of hours in services will be calculated as follows,

$$T = \sum_{i=1}^{n} \left\{ \sum_{j=1}^{m} \frac{L_j \times N_j}{V_j} \right\}_i$$

T : No. of hours in services（vehicle * hours）

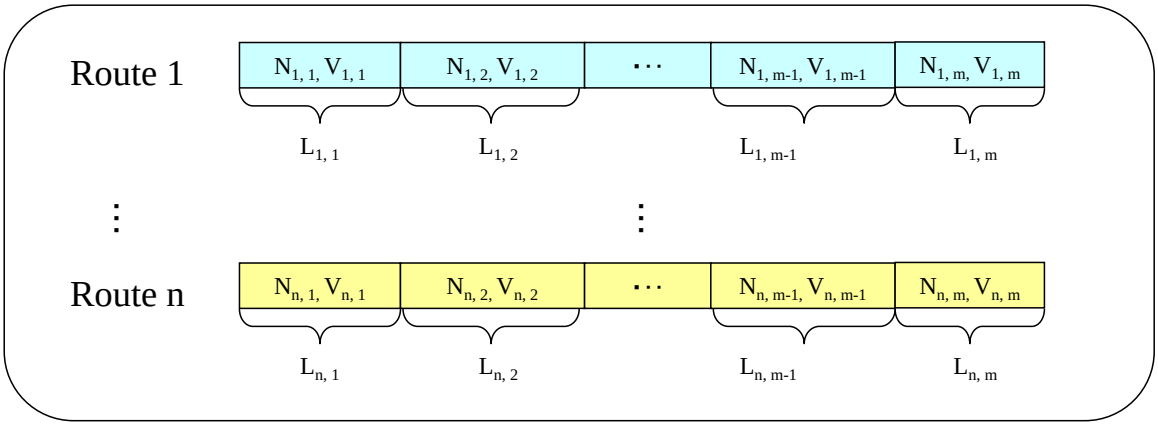
L : Distance（km）

N : traffic volume（No. of vehicle）

V : Average speed（km/h）

i : Route number

j : Section number

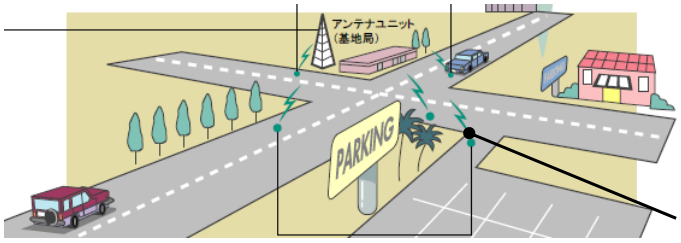


Fairly cover all over Japanese traffic (measured points are approx. 36,000)

3.3.8. How to Generate the Weighting Factor - Method 2 -

Road to be measured
- ➢Urban
- ➢Rural
- ➢Motorway

Measured points : fairly represent the region conditions



sensors or counted by other device

X

Time to be measured
- ➢ On-peak (7~9AM & 5~7PM in Japan)
- ➢ Off-peak (rest of above hours)
- ➢ Weekend (Saturday & Sunday)

X

Minimum measure duration : 2 weeks

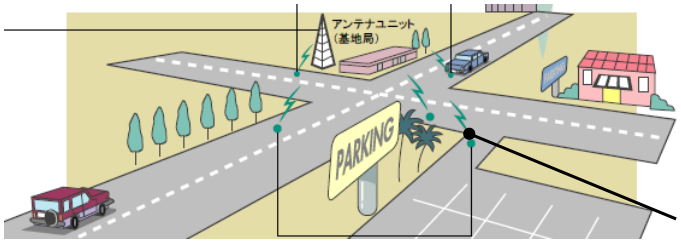
Items to be measured
- ➢ # of vehicles passed measured points per passenger cars & light commercial vehicles
- ➢ Average vehicle speed @ measured point <- not mandate, can be deviated from in-use collection data.

Statistical Data of Total Network Distance
- ➢Urban : xxxxx km
- ➢Rural : yyyyyykm
- ➢Motorway : zzzzzzz km

3.3.9. How to Generate the Weighting Factor - Method 3 -

Road to be measured
- ➢Urban
- ➢Rural
- ➢Motorway

Measured points : fairly represent the region conditions



sensors or counted by other device

X

Time to be measured
- ➢ On-peak (7~9AM & 5~7PM in Japan)
- ➢ Off-peak (rest of above hours)
- ➢ Weekend (Saturday & Sunday)

X

Minimum measure duration : 2 weeks

Items to be measured
- ➢ # of vehicles passed measured points per passenger cars & light commercial vehicles
- ➢ Average vehicle speed @ measured point <- not mandate, can be deviated from in-use collection data.

Questionnaire to vehicle users
- ➢Urban : xxxxx km
- ➢Rural : yyyyyykm
- ➢Motorway : zzzzzzz km

3.3.10. How to Generate the Weighting Factor - Method 2&3 -

	Urban			Rural			Motorway		
	Weekday		Weekend	Weekday		Weekend	Weekday		Weekend
	On-peak	Off-peak		On-peak	Off-peak		On-peak	Off-peak	
PC	# of vehicles per year based on partial traffic census								
LDCV									

X

PC	Driving distance (km) based on statistical data (Method-2) questionnaire (Method-3)
LDCV	

Divided by

PC	Average vehicle speed deviated by in-use collected data (km/h)
LDCV	

3.3.11. How to Generate the Weighting Factor - Method 4 -

< Sample format >

Please describe your driving pattern weekly basis

Your vehicle : PC / (LDCV)

Mon. 0 2 4 6 8 10 12 14 16 18 20 22 24

Tue. 0 2 4 6 8 10 12 14 16 18 20 22 24

Wed. 0 2 4 6 8 10 12 14 16 18 20 22 24

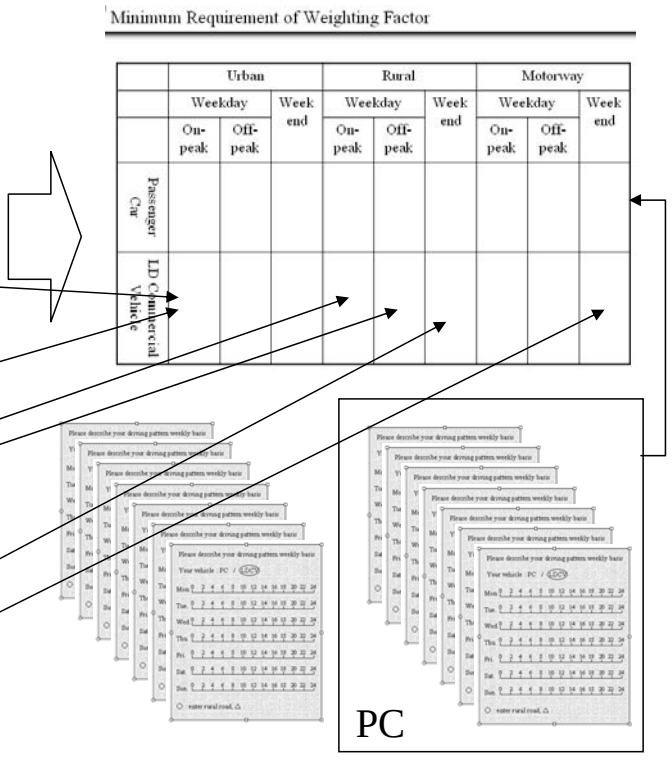
Thu. 0 2 4 6 8 10 12 14 16 18 20 22 24

Fri. 0 2 4 6 8 10 12 14 16 18 20 22 24

Sat. 0 2 4 6 8 10 12 14 16 18 20 22 24

Sun. 0 2 4 6 8 10 12 14 16 18 20 22 24

○ : enter rural road, △ :



Sample size : fairly represent the region condition

3.3.12. How to Generate the Weighting Factor - Method 4 -

	Urban			Rural			Motorway		
	Weekday		Weekend	Weekday		Weekend	Weekday		Weekend
	On-peak	Off-peak		On-peak	Off-peak		On-peak	Off-peak	
PC			Ratio of cumulative vehicle usage hours in each column						
LDCV									

3.4. Weighting Factor Matrix- Final Image

Vehicle Category		Urban										Rural	Motorway
		China			Europe			India	Japan	South America	U.S.A	…	…
A	B	Weekday On peak	Weekday Off peak	Weekend	Weekday On peak	Weekday Off peak	Weekend	…	…	…	…	…	…
Passenger cars	Class I							…	…	…	…	…	…
	Class II (if necessary)							…	…	…	…	…	…
Trucks	…	…	…	…	…	…	…	…	…	…	…	…	…

Total driving duration shall be divided into per vehicle type, road type and driving hours.

B : sub categorized to more specific vehicle category and/or engine displacement and/or GVW, etc

Contents

4.1. In-use Data Collection - Previous Studies

	In-use data collection								
	Country	Cities	# of Vehicles	Vehicle Category (specification)	# of vehicles	driving duration	driving distance (km)	Type of roads	# of drivers
WHDC	EU USA JPN		65	Light trucks GVW < 7.5t Rigid trucks GVW > 7.5t, incl. special purpose truck and coaches Trailer trucks Public buses	9 21 18 11		2213 13428 56324 2473 Total 74400 Ave 1145	Urban Rural Motorway	
WMTC	EU USA JPN China (India)	Paris Pisa Amsterdam Frankfurt Mandeure Munich Biel Darmstadt Birmingham Tokyo Ji Nan	23 7 9 1	49cc - 1500 cc		518	27224	Urban Rural Motorway	
JC08	JPN	Tokyo Osaka	10	Passenger Cars Light truck 1 Light truck 2	4 1 5	245 64	4937 3450	Urban/Rural Motorway	
JC08 (Gear Shift Point)	JPN	Tokyo	11	Passenger Cars (5MT) Passenger Cars (6MT) Light truck 1 (5MT) Light truck 2 (5MT) Light truck 3 (5MT)	4 1 2 1 3			Urban/Rural Motorway	36

4.2. Basic Concept on In-use Data Collection

◆Data Collection

➢Regions

✓Countries, Regions : China, Europe, India, Japan,
South America, South Korea, U.S.A,

➢Vehicle Selection

✓Vehicle Categories : Passenger Cars, Light Duty Commercial Vehicles
"Category 1-1 vehicles" and "Category 2 vehicle (GVW<3.5)"
defined under the Special Resolution No.1
(data may be gathered and submitted for heavier vehicles)

✓Vehicle Specifications : Represent each CP market mix
(up to data collecting CP's decision)

➢Test Conditions

✓Driving Route : Urban, Rural, Motorway

✓Driving Period : On&OFF-peak Weekday, Weekend

✓others : up to data collecting CP's decision

4.3.1. Vehicle Selection Method - 1

➢ Vehicle Categories

✓ "Category 1-1 vehicles" and "Category 2 vehicle (GVW<3.5)" defined under the Special Resolution No.1

✓ Data may be gathered and considered for heavier vehicles

➢ Transmission

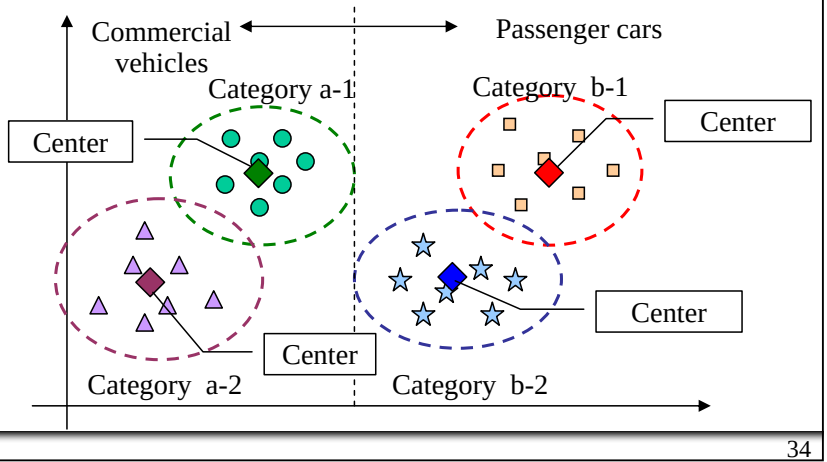
✓ AT(CVT): 1 or more

✓ MT : 1 or more per # of gear (use for gear shift analysis)

Under the above criteria, each Contracting Party is able to select the specific test vehicles with good engineering judgment.

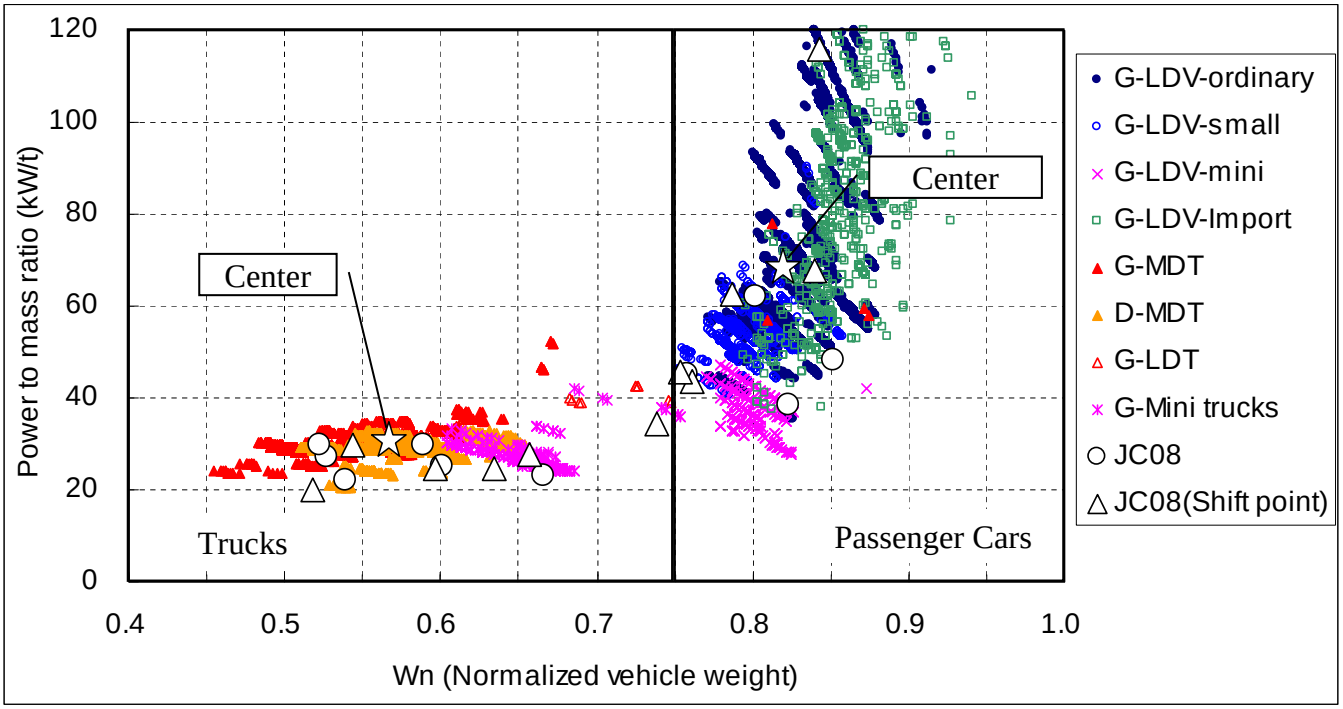
Select the appropriate factors to represent the each vehicle category

- "Power to mass ratio"
- "Engine Displacement"
- "Maximum Speed"
- "Normanized Weight"
  (Wn = Unloaded weight / GVW)
  etc



4.3.2. Vehicle Selection – JC08 Development

In case of JC08 development, test vehicles were randomly selected in each category.



reference : Vehicle Specification Book (2008) by JSAE

(*) Normalized vehicle weight = Unloaded weight / Gross vehicle weight

4.4.1. Test Conditions - Road Type

➢Definition of road type

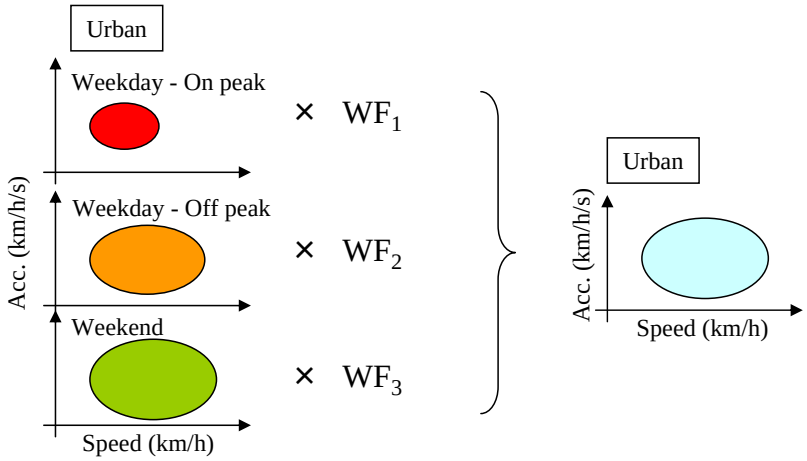
	Urban	Rural	Motorway
WHDC (define based on road type)	Roads in urban areas with a speed limit of 50 km/h or lower	Non motorways outside and inside urban areas, with a speed limit between 50 km/h and 80km/h	Roads specially constructed and controlled for fast motor traffic (in most cases with more than 2 lanes)
WMTC (define based on collected data)	Vehicle Speed : ~ 60km/h : 80% or more 90km/h ~ : 0% and Max. speed =< 80km/h and Each Trip distance >= 1m	Vehicle Speed : ~ 60km/h : 70% or less 60 ~ 90km/h : 30% or more 90km/h ~ : 50% or less and Max. speed =< 110km/h	Vehicle Speed : ~ 60km/h : 20% or less 90km/h ~ : 50% or more
Proposed WLTP	Each data collection Contracting Party will define their road types. Photographic/video evidence should be provided for future discussion.		

4.4.2. Test Conditions - Driving Period

➢Execute the data collection during the following period of time

- ✓ Weekday - On peak（commuting hours）
- ✓ Weekday - Off peak
- ✓ Weekend（morning, afternoon and evening）

< sample for data handling >



4.4.3. Test Conditions - others

- ➢ Driving Behavior
  - ✓ Drivers should be instructed to follow the traffic flow.
- ➢ Vehicle Conditions
  - ✓ Vehicle weight：not prescribed, but ensure that load state is recorded
  - ✓ Warm up condition：collect data from engine on (i.e. cold start)
- ➢ Driver selection
  - ✓ ensure that as wide a range (gender / age) of drivers are used
- ➢ Season / weather conditions
  - ✓ due to tight timeline, data collection season doesn't matter
    (desirable to collect data during the same season)
  - ✓ collect data under safe conditions (avoid situations of low visibility)
    (if severe weather condition is common in certain Contracting Parties, these data are acceptable with detailed description)

4.4.4. Amount of Data to be Collected

< Criteria >

- Distance : Set upper & lower limit, Set only lower limit, no criteria
- Time Range : Set upper & lower limit, Set only lower limit, no criteria

< Previous Studies >

Mode	Region	# of Vehicles	Vehicle Categories	Road Type	Driving Duration			Driving Distance		
					Total Duration	Average Duration	Average Duration (hrs/vehicle, road type, region)	Total Distance (km)	Average Distance	Average Distance (km/vehicle, road type, region)
WHDC	3	65	4	3	-	-		74400	1145	2067
JC08	1	10	3	Urban/Rural	245	25	82	4937	494	1646
				Motorway	64	6	21	3450	345	1150
JC08 (Shift point)	1	11	4	Urban/Rural	-	Weekdays 20days/vehicle	-	-	approx. 2500	-
				Motorway	-		-	-		-
WMTC	4	40	3	3	518	13	14	27224	681	756

Proposal

➢ Minimum 1000km per each region&category&road type and per each transmission

4.4.5. Measurement Items and Methods

➢ Measurement Items and Methods

	Measurement Items	Necessity	Sampling Time	Measurement Methods
1	Time	MUST	1Hz or greater	-
2	Vehicle Speed (resolution : 0.1km/h)	MUST	↑	①ECU ②GPS Speed Meter ③Calculate from drive shaft speed ・Non-contact vehicle speed meter ・Additional wheel
3	Engine Speed	Recommend (MT:MUST)	↑	①ECU ②Photoelectric Pick Up ③Ignition Pulsation ④Accelerometer
4	Road Gradient (altitude)	Recommend	↑	①GPS＋Pressure sensor, Geographic information, etc
5	Clutch Signal	Recommend	↑	①ECU ②Assume from engine speed ③Clutch Depression Switch

✓ Data Format : CSV

✓ Take special care to minimize the noise level (apply LPF, etc)

✓ For gearshift analysis, high sampling rate (10Hz) is preferable

4.5.1. Data Collection Matrix

	Country Region	Road Type	Period of time	Driver (Age)	Vehicle Category		Power to mass ratio	TM type	# of test vehicle
					①	②			
# of cells	6	3	3	3	2	2	1	6	1
Total cells	3888 (=> 1944, practically)								
# of test vehicle in each region	-				24 (=> 12, practically)				
Choices	China, Europe, India, Japan, S.A, U.S.A	Urban, Rural, Motorway	Weekday-On peak, Weekday-Off peak, Weekend	20's 30-40's, 50-60's,	Passenger cars Trucks	GVW, Engine swept volume, etc	Class I Class II Class III ・ ・	AT or CVT (3MT) (4MT) 5MT 6MT (7MT)	1~

- 24 different kind of test vehicles per region are needed

  => can be reduced to 12 vehicles (Manual transmission 6 => 3)

- Total cell number: 3888 (=> 1944)
  - ✓the number of regions * the number of road types * the number of measurement time range * the number of drivers * the number of vehicles

4.5.2. Image of Data Collection Matrix

Vehicle Category		Transmission type	Power to mass ratio	Driver (Age)	Urban										Rural	Motorway
					China			Europe			India	Japan	South America	U.S.A	…	…
A	B				Weekday On peak	Weekday Off peak	Weekend	Weekday On peak	Weekday Off peak	Weekend	…	…	…	…	…	…
Passenger cars	Class I	AT·CVT	Class 1 (Average)	20's 30~40's 50~60's	A1						…	…	…	…	…	…
		5MT	Class 1 (Average)	20's 30~40's 50~60's	B1						…	…	…	…	…	…
		6MT	Class 1 (Average)	20's 30~40's 50~60's							…	…	…	…	…	…
		…	Class 1 (Average)	20's 30~40's 50~60's							…	…	…	…	…	…
	Class II	AT·CVT	Class 1 (Average)	20's 30~40's 50~60's	A2						…	…	…	…	…	…
		5MT	Class 1 (Average)	20's 30~40's 50~60's	B2						…	…	…	…	…	…
		6MT	Class 1 (Average)	20's 30~40's 50~60's							…	…	…	…	…	…
		…	Class 1 (Average)	20's 30~40's 50~60's							…	…	…	…	…	…
Trucks	2	3	3	3	…	…	…	…	…	…	…	…	…	…	…	…

A1 + A2 ≧ 1000km

B1 + B2 ≧ 1000km

B : sub categorized to more specific vehicle category and/or engine displacement and/or GVW, etc

4.5.3. Test Vehicle Parameters & Data Logging Proforma - sample

For more detail, please refer WLTP-DHC-02-06, 15

Test Vehicle Parameters

Parameter	Example
Vehicle category	Passenger car/Light duty commercial vehicle
	S.R. 1 category (1-1, 1-2, 2)
Engine type	Diesel/Gasoline/LPG
Engine displacement	2 L
Curb mass (kg)	1600 kg
Transmission type	Manual/Automatic
Number of gears	4/5/6
Power:Mass	0.05 kW/kg
Maximum rated power	80 kW
Maximum rated speed	130 km/hour
Number of passengers	5
Maximum load	500 kg
Year model first registered	2006
Make[1]	*Ford*
Model[1]	*Focus*
GSI[1]	*Yes/No*
Adaptive speed limit indicator[1]	*Yes/No*

[1] Optional — it is recommended that these parameters are recorded

In-use Data Logging Proforma

● **File name (Example)**

① Country	② Vehicle category	③ Vehicle number	④ Driver's age
J	P	01	Y
C : China E : EU I : India J : Japan K : South Korea S : South America U : US	C : LD Commercial vehicle P : Passenger car		Y: Young M : Middle O : Older

④ Driver's age	⑤ Road type	⑥ Time period	⑦ File number
Y	U	N	001
Y: Young M : Middle O : Older	U : Urban R :Rural M : Motorway	N : oN peak - weekday F : oFf peak - weekday E : week End	

Contents

5.1. Process of Gear Shift Point Development（ex. JC08 mode in Japan)

➢ Developed gear shift points based on in-use survey to represent the real driving behavior during JC08 study.

In-Use Survey (data acquisition)

↓

Factor Analysis Frequency Distribution

↓

Regression Analysis Shift Point Formula

↓

Validation

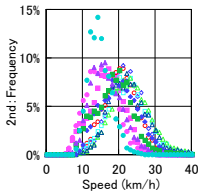
Test Vehicle : Passenger Cars, Trucks

Fuel : Petrol, Diesel

# of test vehicle : 11

# of drivers : 36

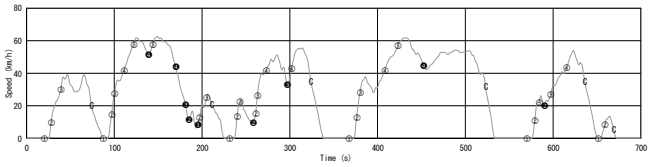
ex. 2nd Gear Analysis



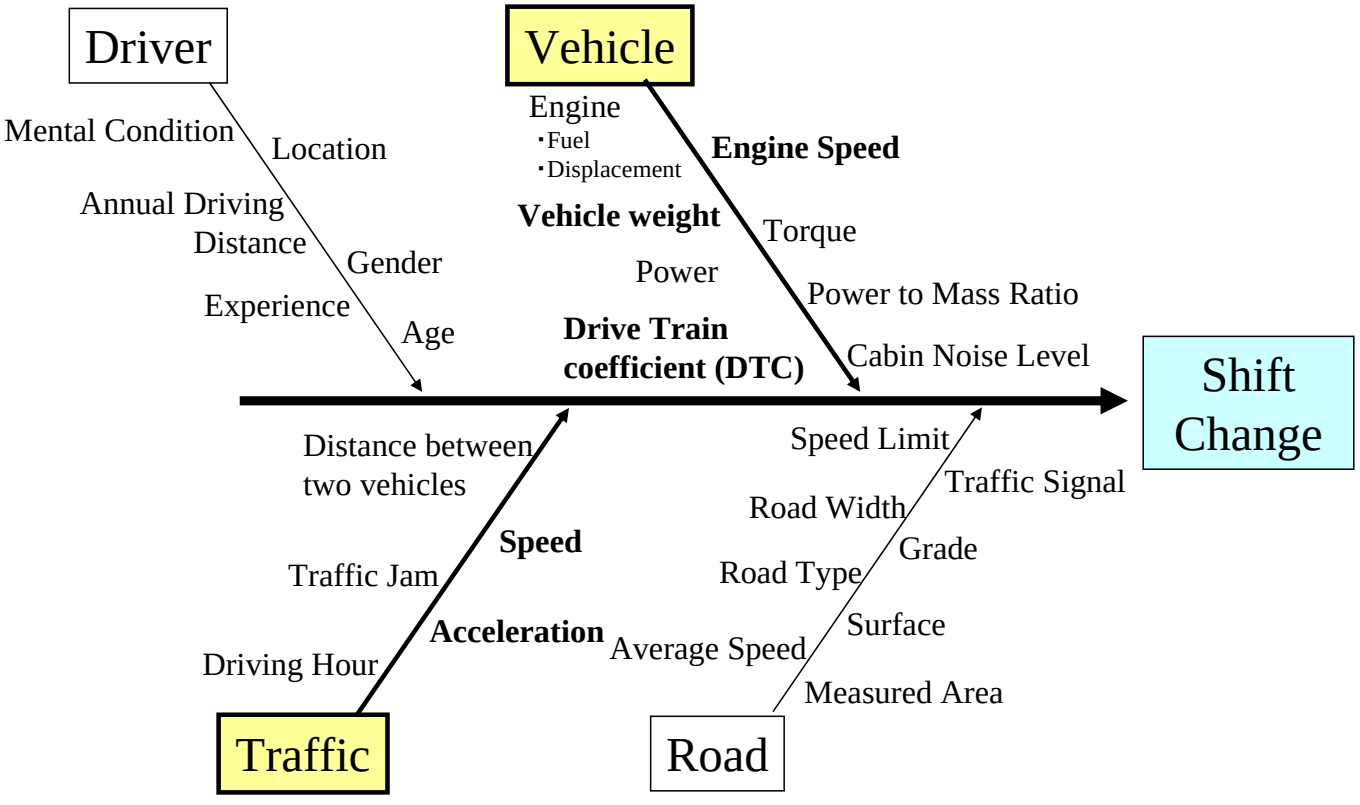
✓Gear shift is influenced mainly by traffic conditions and vehicle specification .

✓Vehicle speed factor, acceleration factor and engine speed factor are normal distribution in each gear shift.

$G(x)=a*V+b*A+\cdots\cdots$



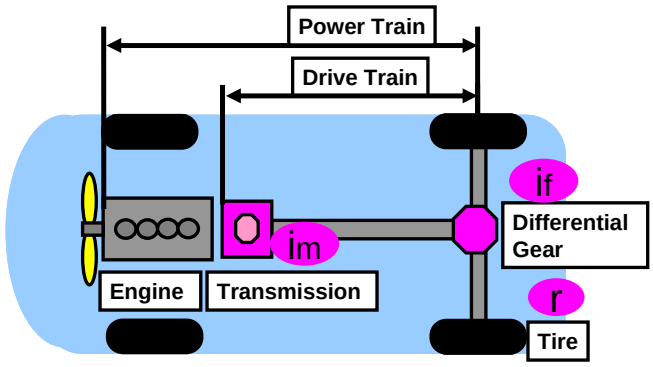
5.2. Factor Analysis (ex. JC08 mode in Japan)



・Shift change is influenced mainly by traffic conditions and vehicle specification.

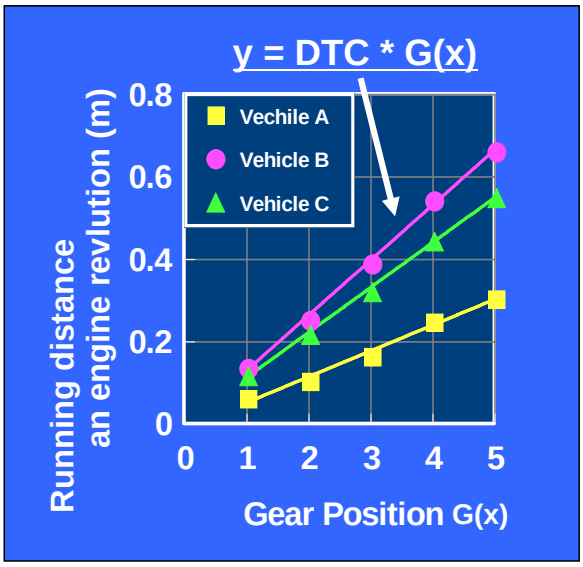
・Few influence by road type and driver is observed in urban area.

5.3. Drive Train Coefficient（DTC）



$$\frac{2\pi r}{im \times if} = \frac{V}{Ne} \times \frac{1000}{60}$$

2πr / (im * if)	:	running distance per engine speed	(m)
r	:	tire radius	(m)
im	:	gear ratio	
if	:	final reduction gear ratio	
V	:	vehicle speed	（km/h）
Ne	:	engine speed	（rpm）



DTC : Drive Train Coefficient

5.4. Result of regression analysis

The 4 most important explanatory variables were selected by the stepwise regression.

ex.) Up Shift

R^2	Explanatory variable						
	1	2	3	4	5	6	7
0.752	Speed						
0.815	Speed	Acceleration					
0.844	Speed	Acceleration	Normalized vehicle weight				
0.847	Speed	Acceleration	Normalized vehicle weight	DTC			
0.851	Speed	Acceleration	Normalized vehicle weight	DTC	Normalized vehicle weight of running order		
0.851	Speed	Acceleration	Normalized vehicle weight	DTC	Normalized vehicle weight of running order	Engine Speed @ Max. torque	
0.852	Speed	Acceleration	Normalized vehicle weight	DTC	Normalized vehicle weight of running order	Engine Speed @ Max. torque	Engine speed @ Max. power

5.5. Gear Shift Formula（ex. JC08 mode in Japan）

- Up shift

$$G(x)_{up} = 2.96 + 0.0576 \cdot V - 0.139 \cdot A - 1.81 \cdot W_n - 3.36 \cdot DTC$$

- Down shift

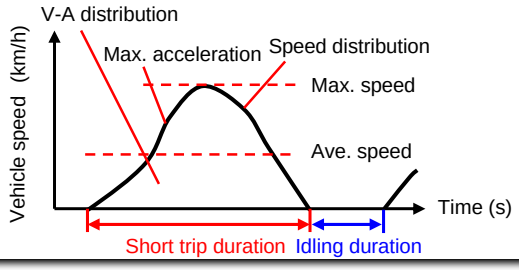
$$G(x)_{down} = 5.12 + 0.0924 \cdot V - 0.043 \cdot A - 0.00129 \cdot E - 25.9 \cdot DTC$$

$G(x)$	: Gear shift formula
V	: Vehicle speed km/h
A	: Vehicle Acceleration km/h/s
W_n	: Normalize Weight (=Unloaded Vehicle Weight/Gross Vehicle Weight)
E	: Engine speed rpm
DTC	: Drive Train Coefficient

Appendix 1. Parameter list

- To confirm the representativeness of the unified cycle, the following distributions and parameters are checked.
- Other statistical methods of comparing distributions may be considers when proposed.

Distribution
ST speed-acceleration distribution
ST duration distribution
ST average speed distribution
ST maximum speed distribution
ST length distribution
ST cruise speed distribution
ST speed * acceleration distribution
Idling duration distribution



Parameter
Average speed (km/h)
Maximum Speed (km/h)
Maximum Acceleration (km/h/s or m/s^2)
Maximum Deceleration (km/h/s or m/s^2)
Relative Positive Acceleration (km/h/s or m/s^2)
Average short trip duration (s)
Average idling duration (s)
Number of idling per kilometer (#/km)
Number of idling per second (#/s)
Time accelerating (%)
Time decelerating (%)
Time cruising (%)
Time stop (%)

Appendix 2. T4253H smoothing filter

- T4253H smoothing
  (description in the SPSS calculation software)

The smoother starts with a running median of 4, which is centered by a running median of 2. It then resmoothes these values by applying a running median of 5, a running median of 3, and hanning (running weighted averages). Residuals are computed by subtracting the smoothed series from the original series. This whole process is then repeated on the computed residuals. Finally, the smoothed residuals are computed by subtracting the smoothed values obtained the first time through the process. This is sometimes referred to as T4253H smoothing.

For more detail :

ftp://ftp.spss.com/pub/spss/statistics/spss/algorithms/create.pdf