World Light Duty Test Procedure

Validation-2 Summary & Way Forward

Presentation from India

03rd - 04th Dec, 15th DHC Meeting

Brussels, Belgium.

Validation-2 Results on Class-I / II Vehicles

Validation-2 Overview (for Class 1 / Class2 Vehicles)

Vehicle	M1/ N1	Fuel Type	Kerb Weight kg	Test Mass kg *	Engine CC	Max. Power kW	PMR kW/t	Max. vehicle speed in km/h	Phases Followed based on vehicle classification
TMD	M1	Diesel	685	833	611	8.0	11.67	55	L1+L1+L1
MMD	N1	Diesel	950	1313	909	18.0	18.95	70	L1+M1+L1
MBD	M1	Diesel	1670	1854	2523	46.3	27.70	100	L2+M2+H2
TMC	N1	CNG	1100	1275	701	15.5	14.09	77	L1+M1+L1
MOP	M1	Petrol	800	875	796	25.6	32.0	110	L2+M2+H2

***Note:**

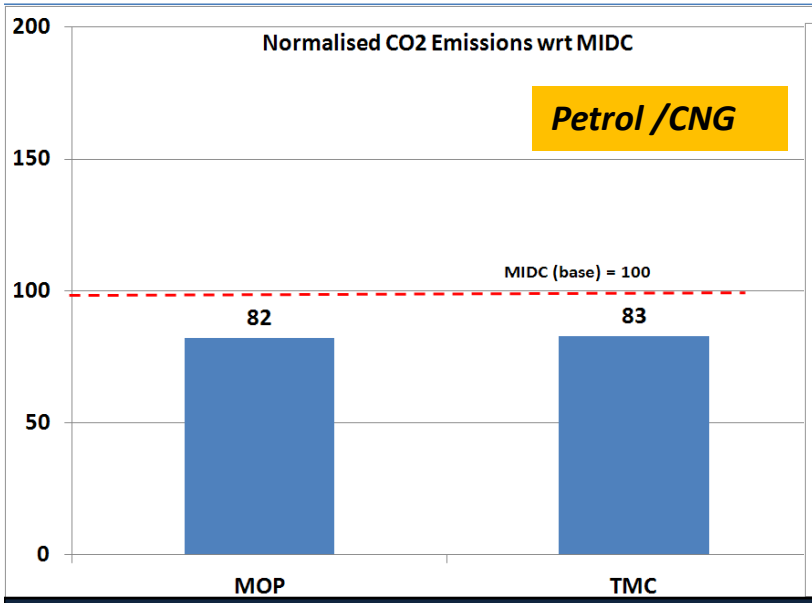
Test mass = Kerb mass + 100 + Optional mass.

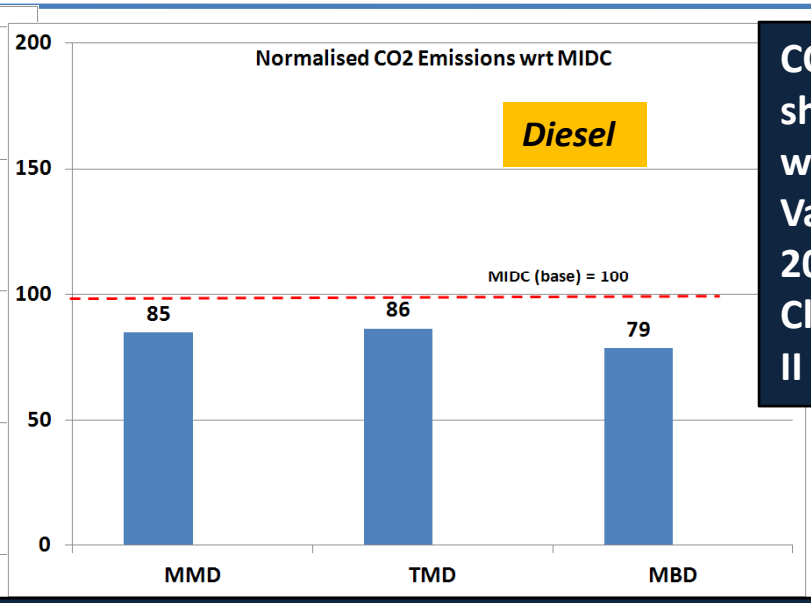
Optional mass = 15% of the (GVW - Kerb mass – 100) for Passenger vehicles

35% of the (GVW - Kerb mass – 100) for Commercial vehicles

The Class1 and Class2 Test Cycles have been found ok wrt to drivability and trace ability of test cycles. No issues observed in following the cycle and gear shifting.

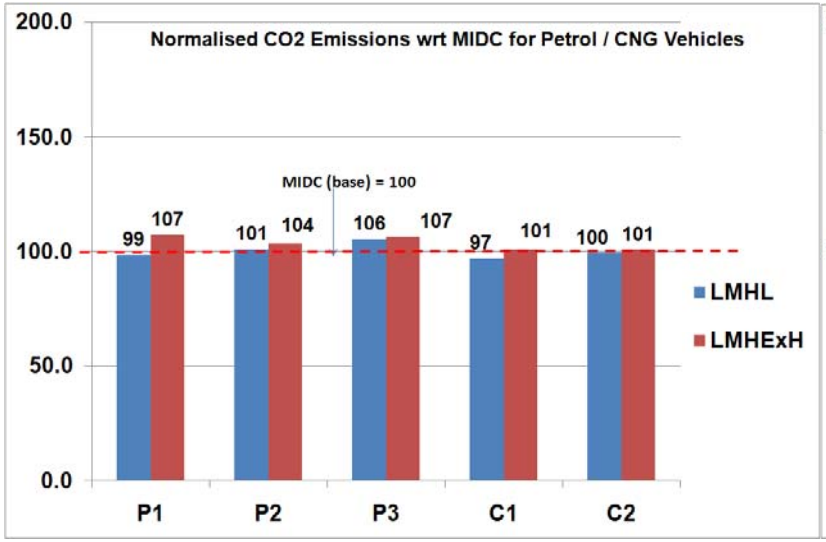
Validation-2 Overview –CO2

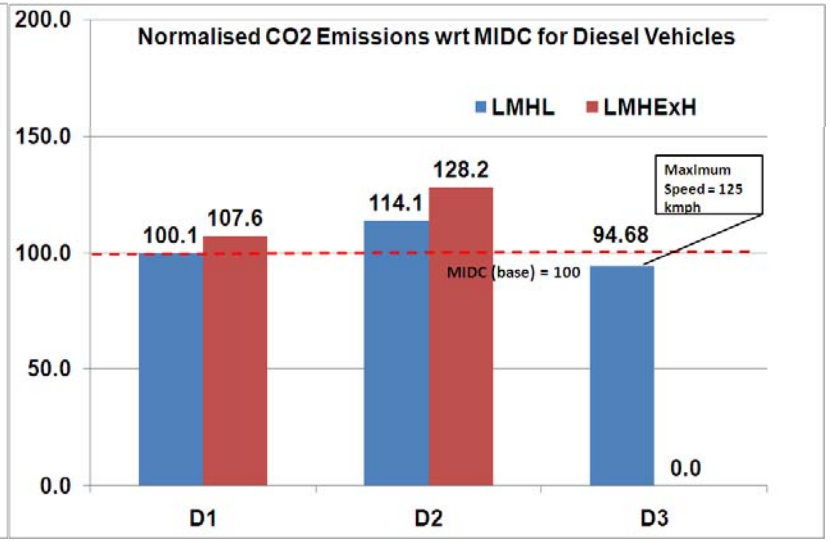




CO2 emissions show a decrease wrt to MIDC Values by 15 - 20 % for all Class-I and Class II Vehicles

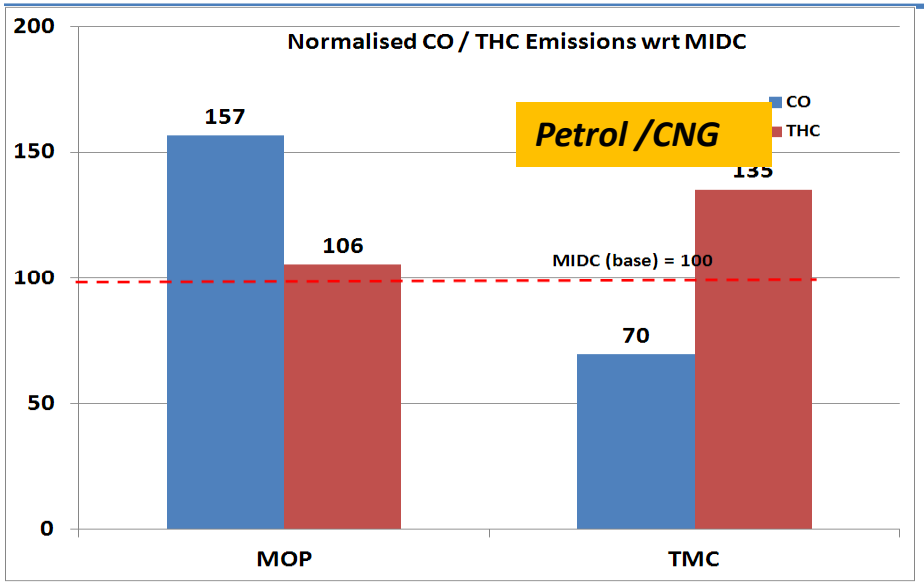
Since Class 3 Vehicles show comparable values of CO2 wrt MIDC, it is necessary to consider a correction factor for CO2 equivalence between Class I / II vehicles and Class III vehicles

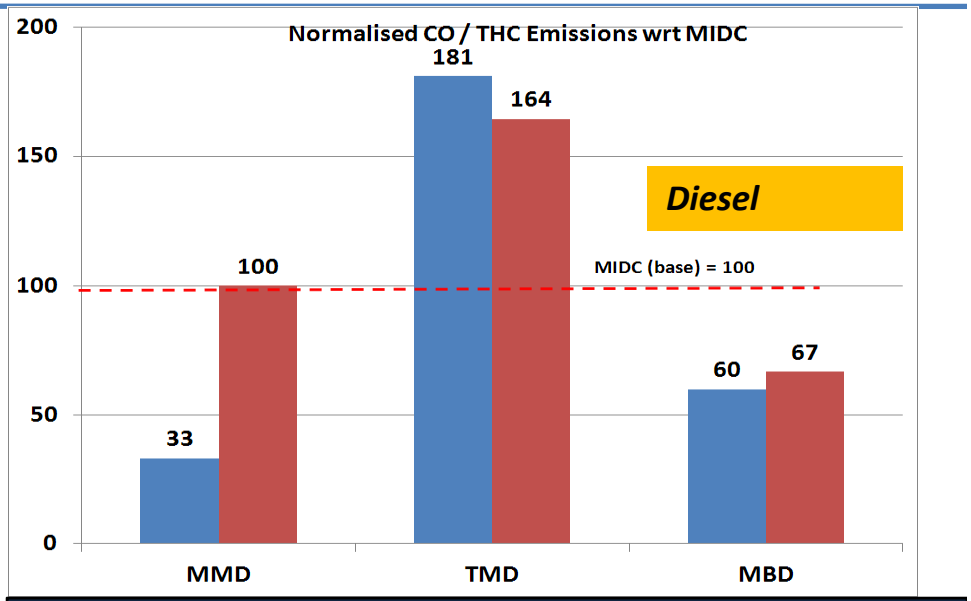




Class III Vehicles

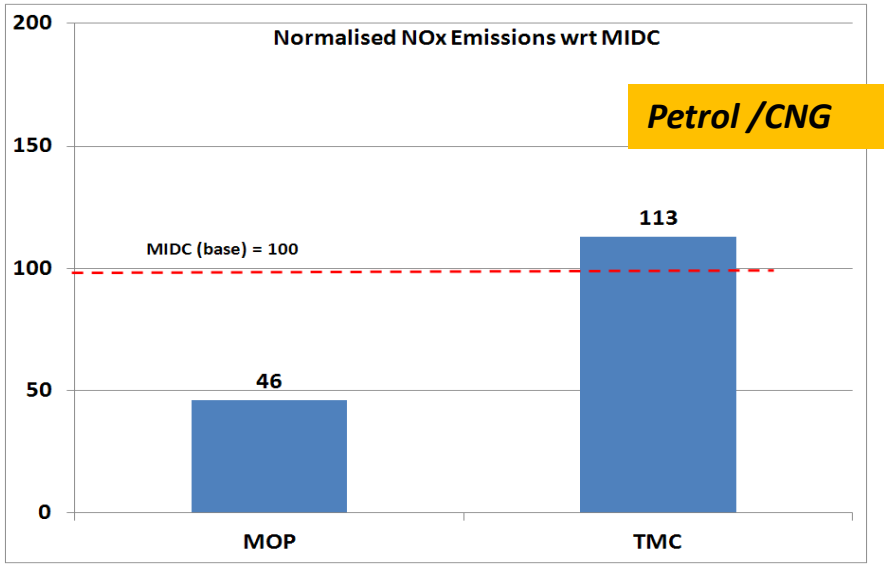
Validation-2 Overview –Other Emissions

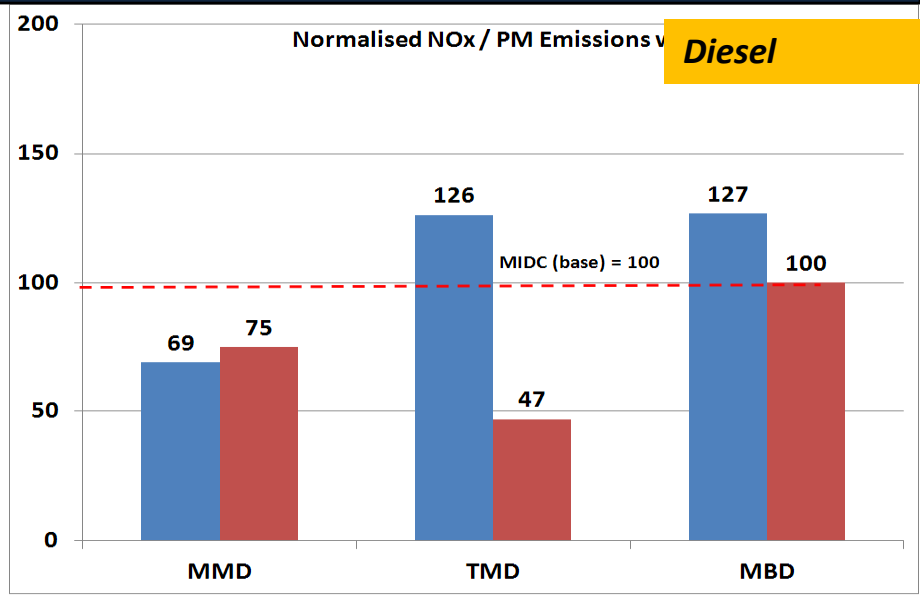




CO / THC / NOx emissions have not shown any particular trend for both Petrol /CNG .

For Diesel, except for one case, Nox emissions have shown an increase, while PM has decreased.





Summary

- With respect to Drivability / Traceability the current LPVC 2.0 Cycles are ok and hence can be finalized as a proposal for GTR text.

- Reduction in CO2 Values wrt to Baseline tests requires an appropriate correction factor for equivalence with Class III vehicles

Validation-2 Results for Class III Vehicles

Validation-2 Overview (On WLTC 5.0)

M1 / N1	Vehicle	Engine CC	PMR kW/Ton	TMR Nm /Ton	V Max km/h	L	M	H	Ex	Class as per Steven
M1	P1	796	49.0	93.2	135	O / O	O / O	O / EP	X / EP	Class3
M1	P2	998	55.6	101.8	145	O / O	O / O	O / EP	O / EP	Class3
M1	P3	796	32.6	74.8	110	O / O	O / O	O / O	NA	Class2
M1	P4	1405	47.3	99.5	150	O / O	O / O	O / O	O / EP	Class3
M1	C1	796	36.4	82.6	135	O / O	O / O	O / EP	X / EP	Class3
M1	C2	1586	60.4	113.9	160	O / O	O / O	O / EP	O/ EP	Class3
M1	D1	2179	46.0	146.2	140	O / O	O / O	O / O	O / O	Class3
M1	D2	2179	44.7	142.1	140	O / O	O / O	O / O	O / O	Class3
N1	D3	1405	44.0	112.0	125	O / O	O / O	O	NA	Class3

Legend :

Vehicle: P = Petrol, C = CNG, D = Diesel

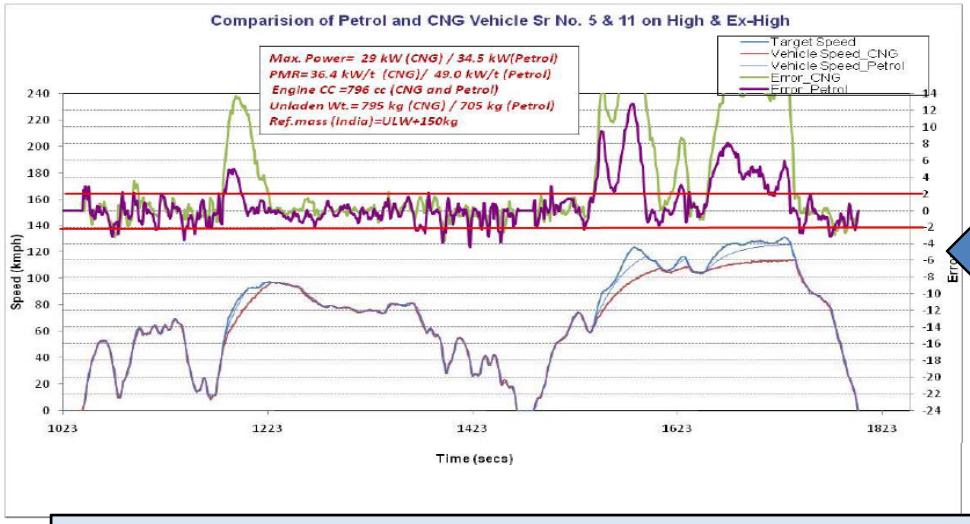
O / O : OK for Drive Cycle Traceability and WOT (Engine Protection Mode) not activated

O / EP: OK for Drive Cycle Traceability and WOT (Engine Protection Mode) activated

X / EP: Not OK for Drive Cycle Traceability and WOT (Engine Protection Mode) Activated

Entry into Engine Protection, WOT Operation and Traceability of the Cycle in Ex-H are still major concerns for Petrol / CNG Vehicles.

Main Concerns related to H & Ex-H Phases



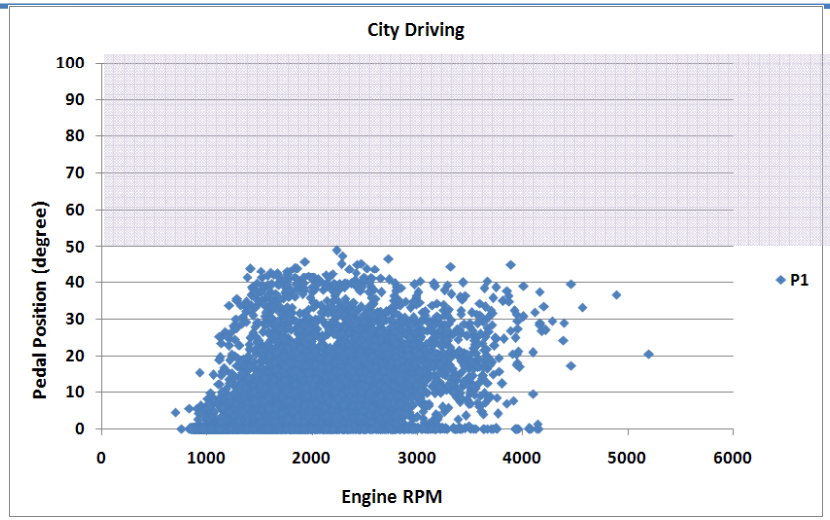
During 12th DHC India had presented Validation data. Most of Indian Compact Cars cannot follow the target speed with large deviations in driving High and Ex-High Phases as shown. (WLTP-DHC-12-02).

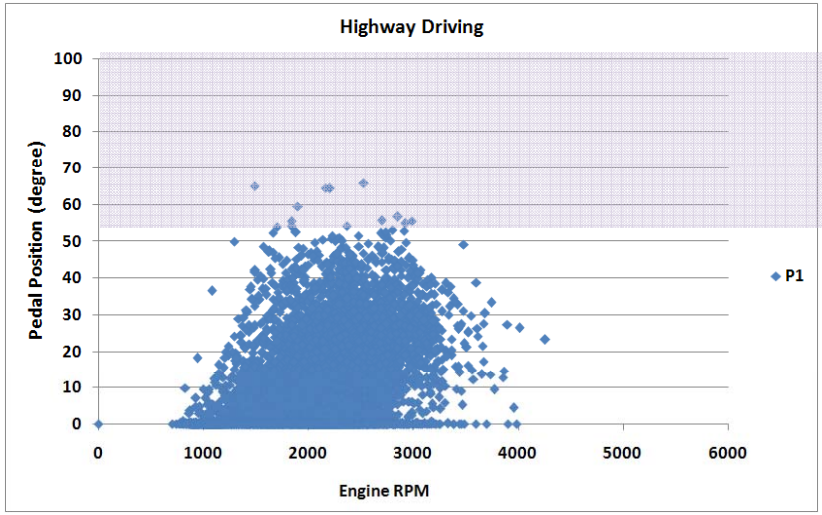
WLTC V5.0 finalized at ISPRA meeting has not addressed concerns of Steep Accelerations of High and Ex-High Phase.(WLTP-DHC-12-08) and these points are still open.

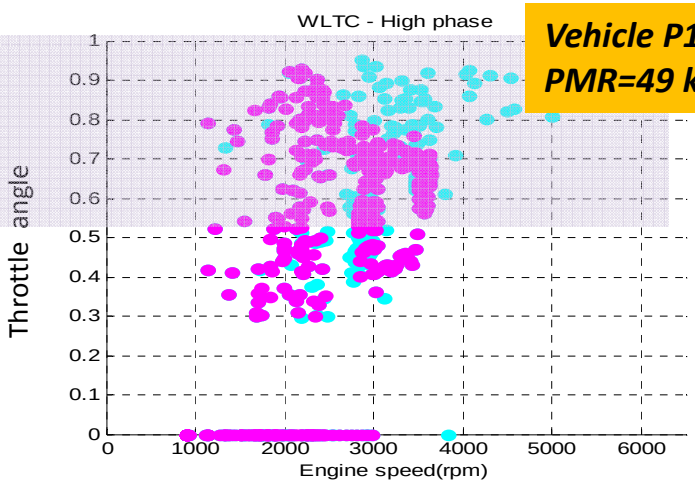
No.	Time	Comments	by	Action
1	24 - 28	Need to be smoothness	Japan	Smoothing
2	48 – 67	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
3	140 – 160	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
4	185 - 210	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
5	250 - 270	Need to be smoothness	India/Japan	Smoothing
6	275 - 295	Need to be smoothness	India/Japan	Smoothing
7	545 – 560	Need to be smoothness	Japan	Smoothing
8	600 - 615	Require close to W.O.T. operation	Japan	Evaluated during validation2
9	660 - 670	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h & Smoothing
10	709	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
11	715 – 718	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
12	720 – 730	Require close to W.O.T. operation	Japan	Evaluated during validation2
13	760 - 770	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
14	770 – 785	Require close to W.O.T. operation	Japan	Evaluated during validation2
15	780 -804	Difficult to drive (PMR concern)	India	Evaluated during validation2
16	800 – 810	Require close to W.O.T. operation	Japan	Evaluated during validation2

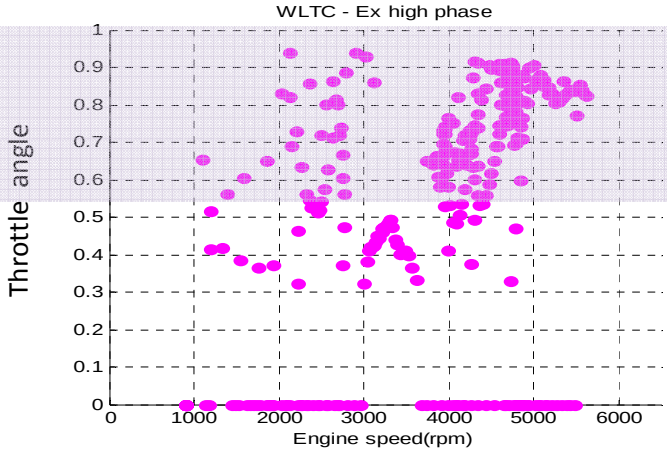
No.	Time	Comments	by	Action
17	815 – 830	Need to be smoothness	India/Japan	Smoothing
18	860 – 870	Require close to W.O.T. operation	Japan	Evaluated during validation2
19	910 – 925	Require close to W.O.T. operation	Japan	Evaluated during validation2
20	950 – 980	Require close to W.O.T. operation	Japan	Evaluated during validation2
21	1060 – 1065	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
22	1070 – 1125	Difficult to follow the target speed Require close to W.O.T. operation	India/Japan	Evaluated during validation2
23	1140 - 1155	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
24	1155 - 1250	Difficult to follow the target speed Require close to W.O.T. operation	India/Japan	Evaluated during validation2
25	1310 – 1325	Require close to W.O.T. operation	Japan	Evaluated during validation2
26	1375 - 1385	Difficult to follow the target speed Require close to W.O.T. operation	India/Japan	Evaluated during validation2
27	1420 - 1450	Difficult to follow the target speed	India	Evaluated during validation2
28	1530 - 1585	Difficult to follow the target speed	India/Japan	Evaluated during validation2
29	1640 - 1675	Difficult to follow the target speed	India/Japan	Evaluated during validation2
30	1530 - 1740	Difficult to drive (PMR concern)	India	Evaluated during validation2
31	All	to be one decimal point (to XX.X km/h)	Japan	one decimal point

Load Scatter: Real World Driving comparison with WLTC







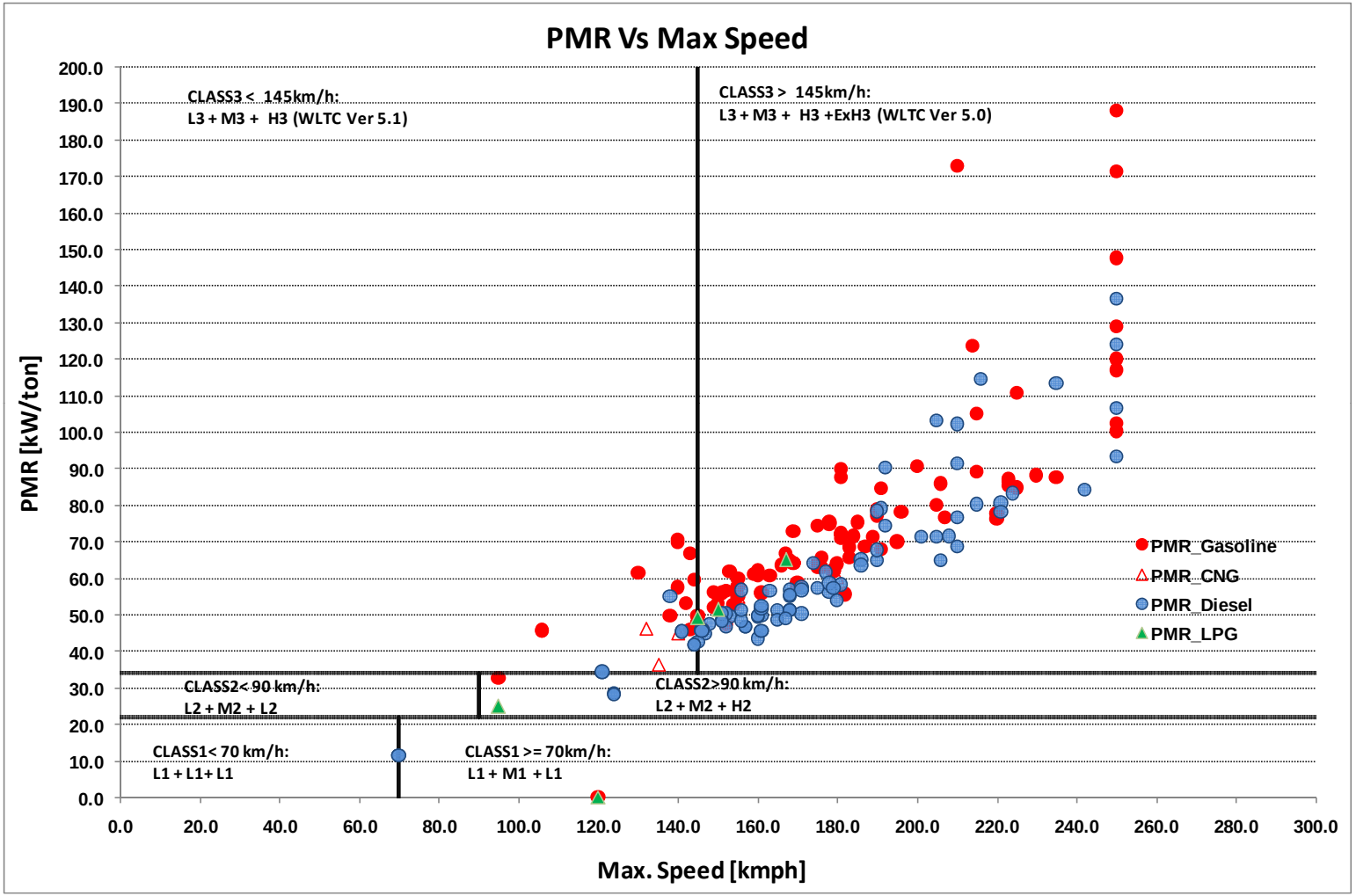


Vehicle P1
PMR=49 kW/ton

❑ *The above shows a comparison of load scatter of WLTC H and EXH phase and its comparison with City driving and Highway driving profile of P1 Vehicle.*

❑ *WLTC is very aggressive as compared with on road data. (Same data that is available in world wide data)*

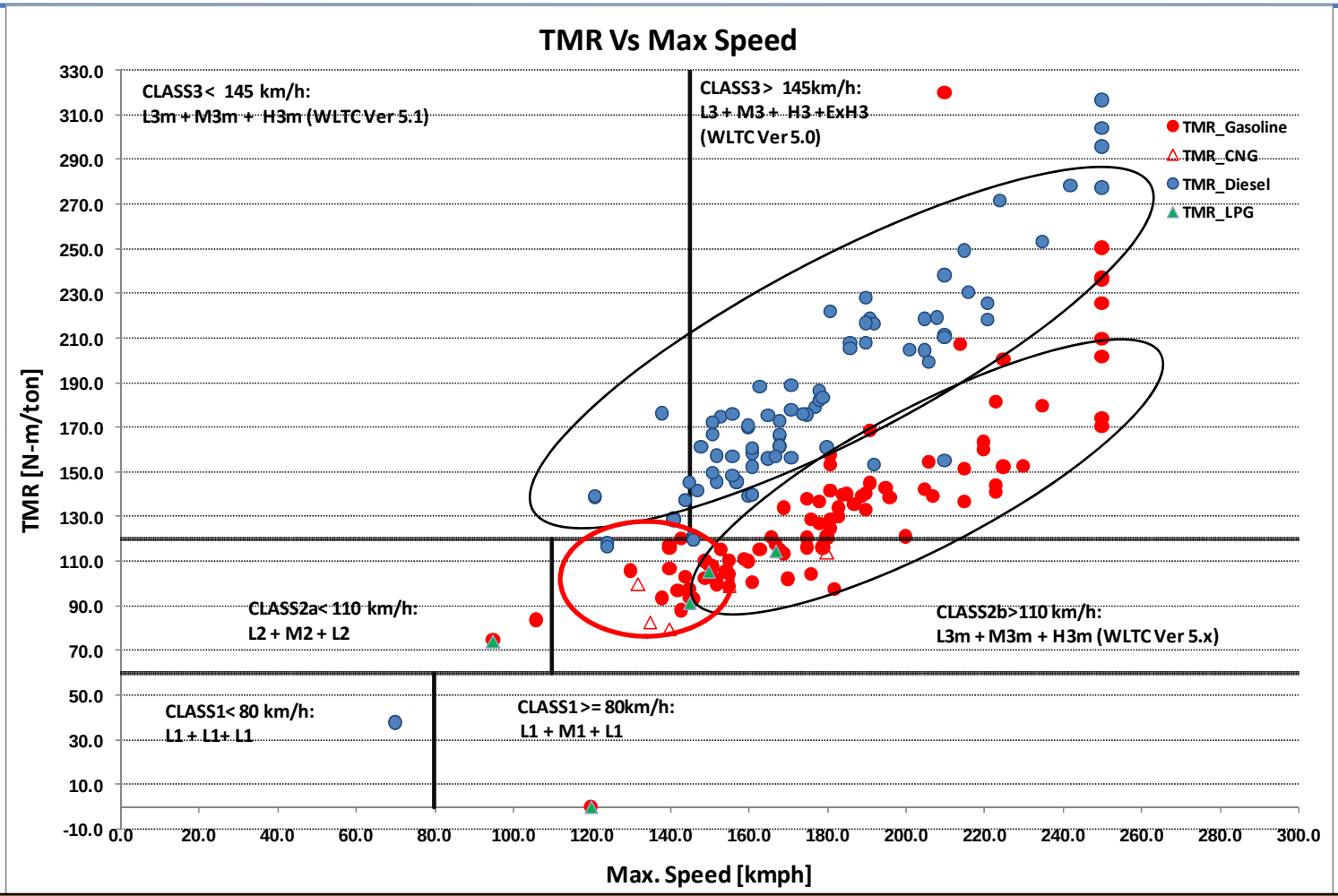
PMR of Vehicles in the Indian Market



The chart shows the distribution of Indian Vehicles based on current definition of Cycle Separation.

The classification shows Vehicles of all fuel types : Petrol / LPG /CNG / Diesel

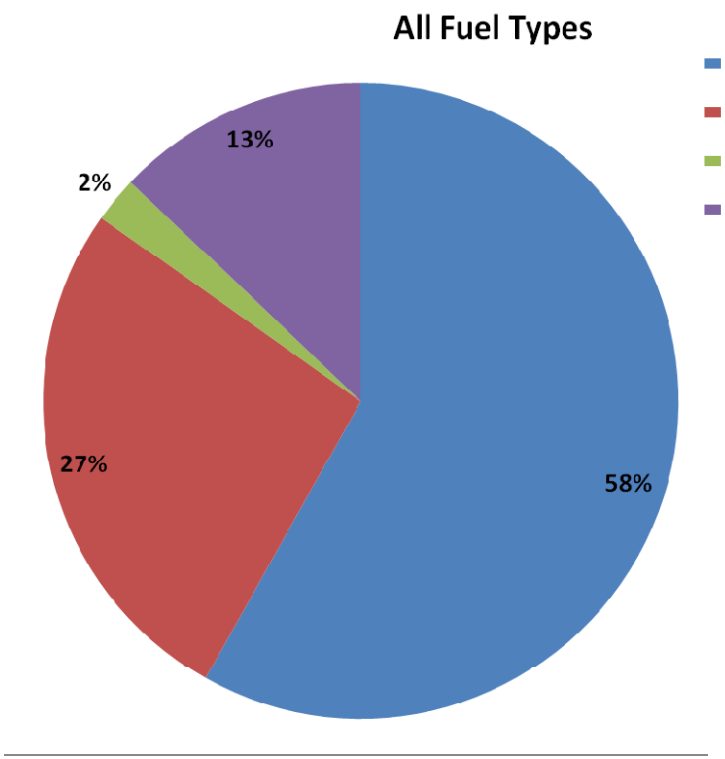
Another View in Terms of TMR

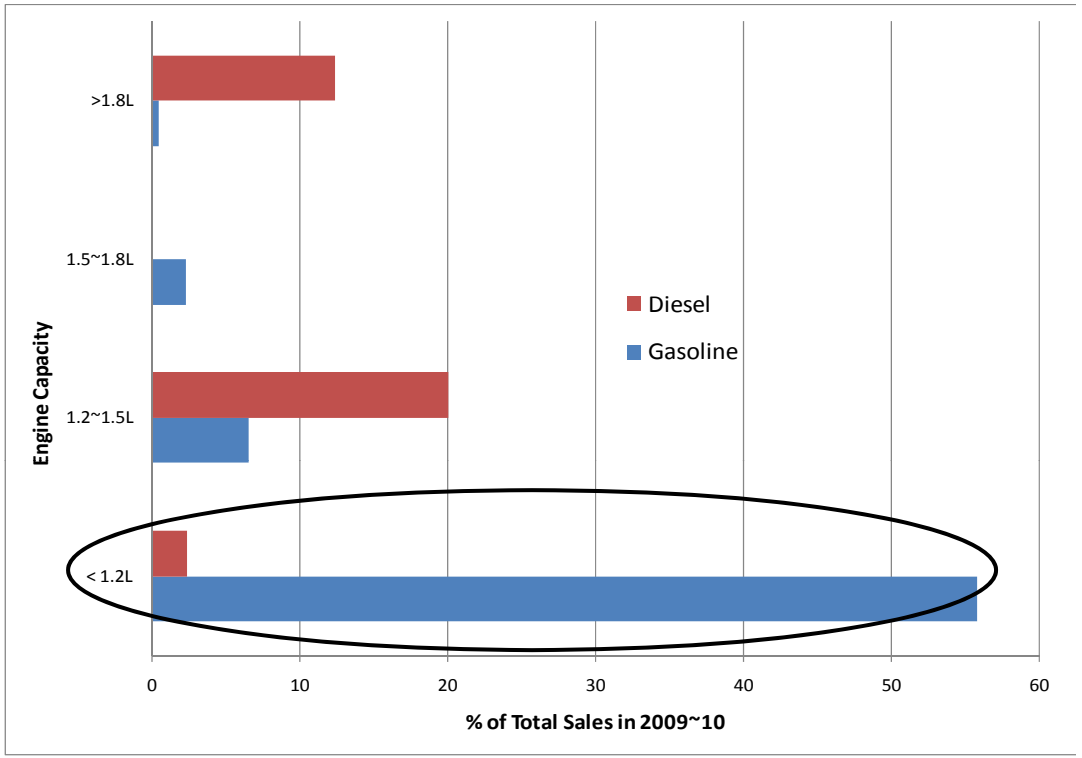


Assuming the that current Class I and Class II vehicles remain, in their respective classes, the same distribution plotted in terms of TMR.

The trend clearly demarcates vehicles in Class III for Gasoline / CNG / LPG / Diesel Vehicles which have concerns shown in the red circle with LOW TMR which are similar to certain Class II Vehicles

The Typical Compact Car in India





Compact Cars contribute to 60 % of Sales in in the Indian Market.

Most of these Cars Comprise of Conventional Gasoline Engines (Naturally Aspirated, Spark Ignition) (<1.2 L) and in some cases these cars have an CNG option in the same Car. (Bi-Fuel Vehicles).

Coast Down & Regulatory procedural Requirements

As per ECE R83, Annex 4a, Appendix 7, Clause 5.1.1.2

5.1.1.2. Test procedure

5.1.1.2.1. Accelerate the vehicle to a speed 10 km/h greater than the chosen test speed V

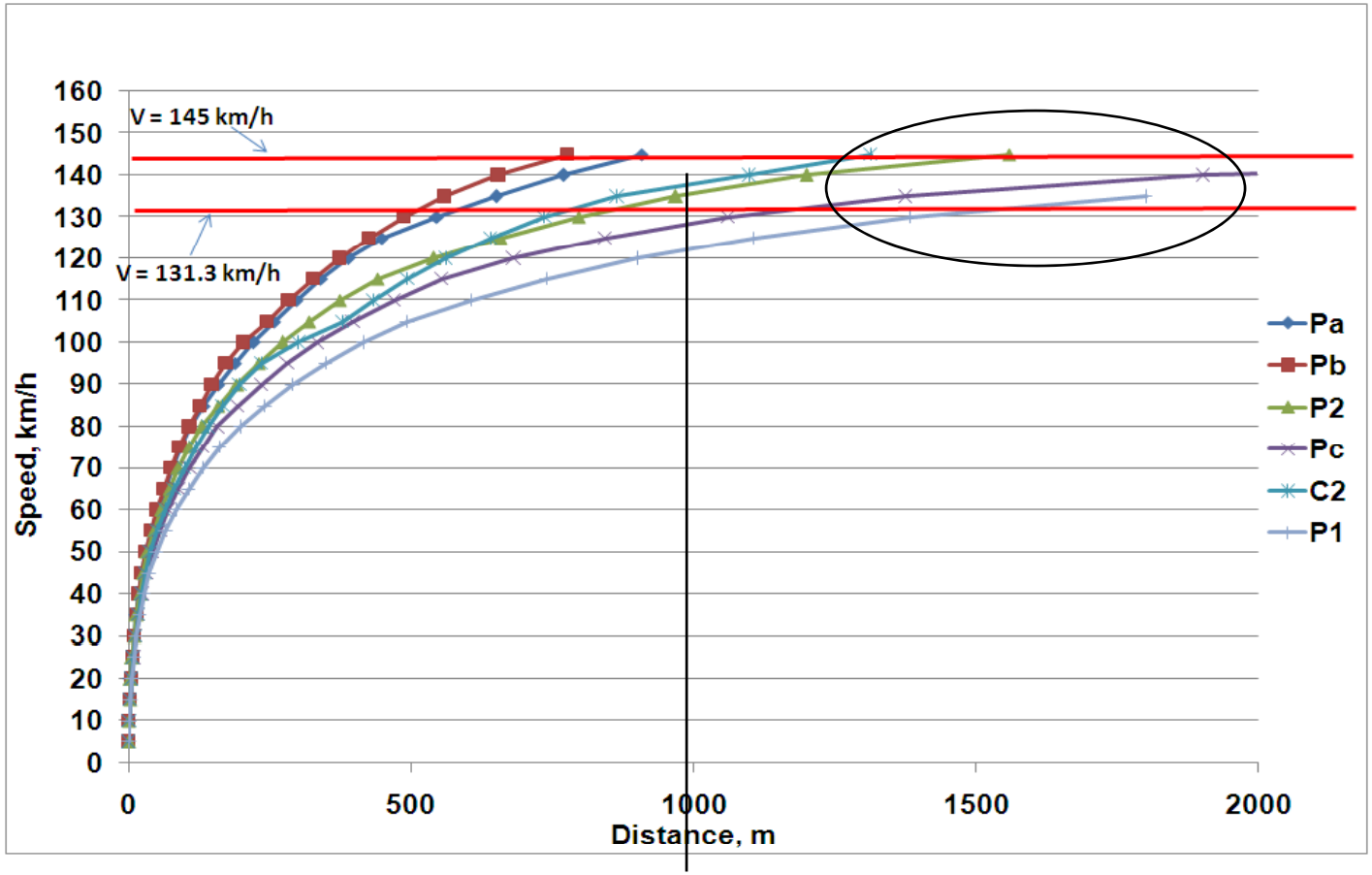
5.1.1.2.2. Place the gearbox in "neutral" position.

5.1.1.2.3. Measure the time taken (t_1) for the vehicle to decelerate from speed $V_2 = V + \Delta V$ km/h to $V_1 = V - \Delta V$ km/h

	MIDC	NEDC	WLTC
Max Speed on Test Cycle , km/h	90	120	131.2
Chosen Test Speed in Coast Down Test, V (km/h)	90	120	135
Time Measurement Interval for Coast Down Test , (km/h)	95 - 85	125 - 115	140 - 130
Test Start Speed as per Procedure, (V + 10) km/h	**100**	**130**	**145**

Due to requirements of Coast Down and Road Load Simulation, threshold speed for Cycle Separation needs to be revised from 135 km/h to 145 km/h for Class 3 Vehicles.

Need for Margin for Compact Vehicles



Launch Acceleration Test (0-145km/h) for typical Indian Cars

Speed (km/h) Vs Distance (m)

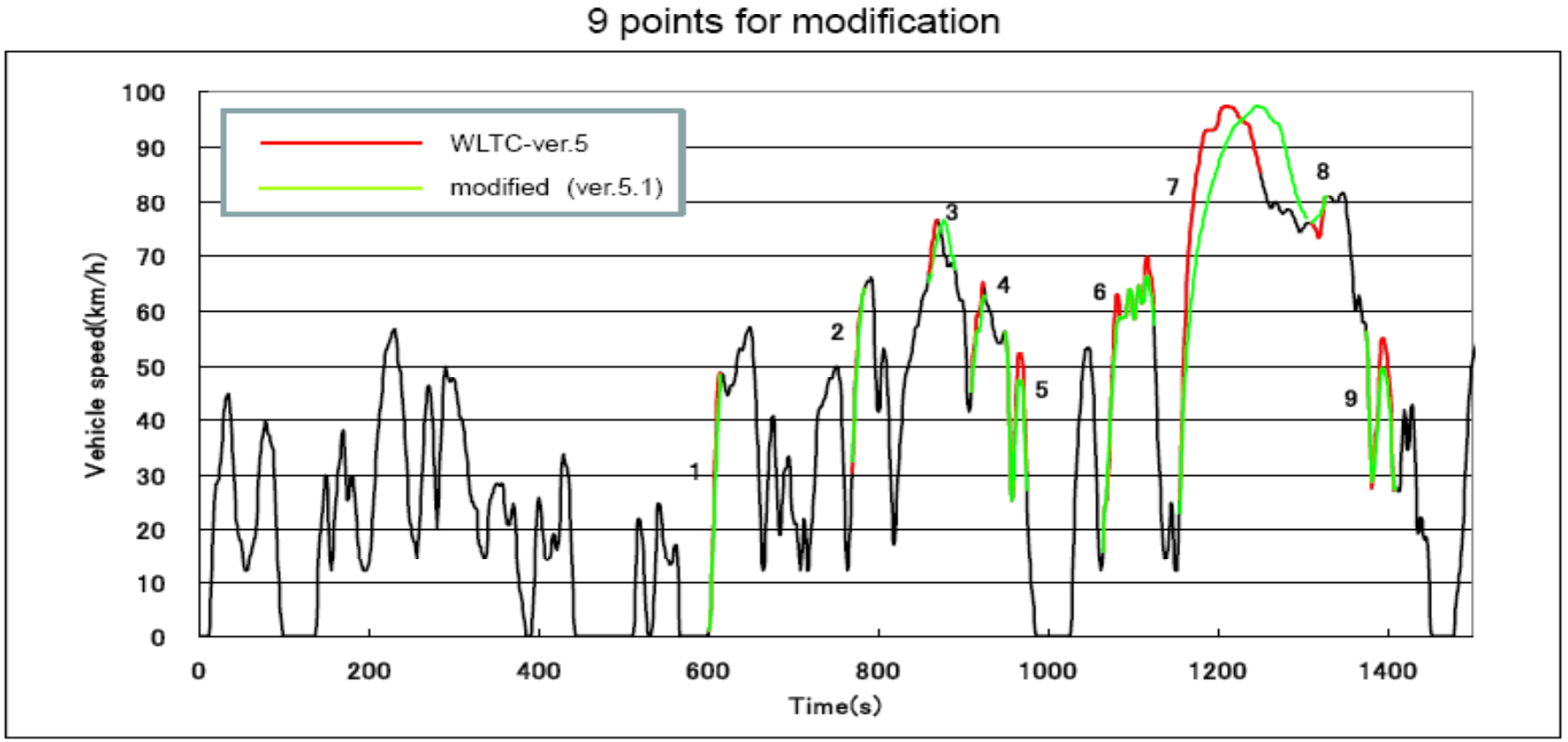
Vehicle shows in circle achieve the max speed after running for longer distances (approx 2kms)

PMR of these Vehicles > 34kw/ ton

- *Vehicles which have Max Speed of (~ 145km/h), have lower reserve power for acceleration in this speed range. These vehicles will have to cover longer distances for achieving max speed.*
- *For Such Vehicles, it will be extremely difficult to do Coast Down Test, due to track length limitations, and no. of readings to be taken for Statistical Accuracy.*

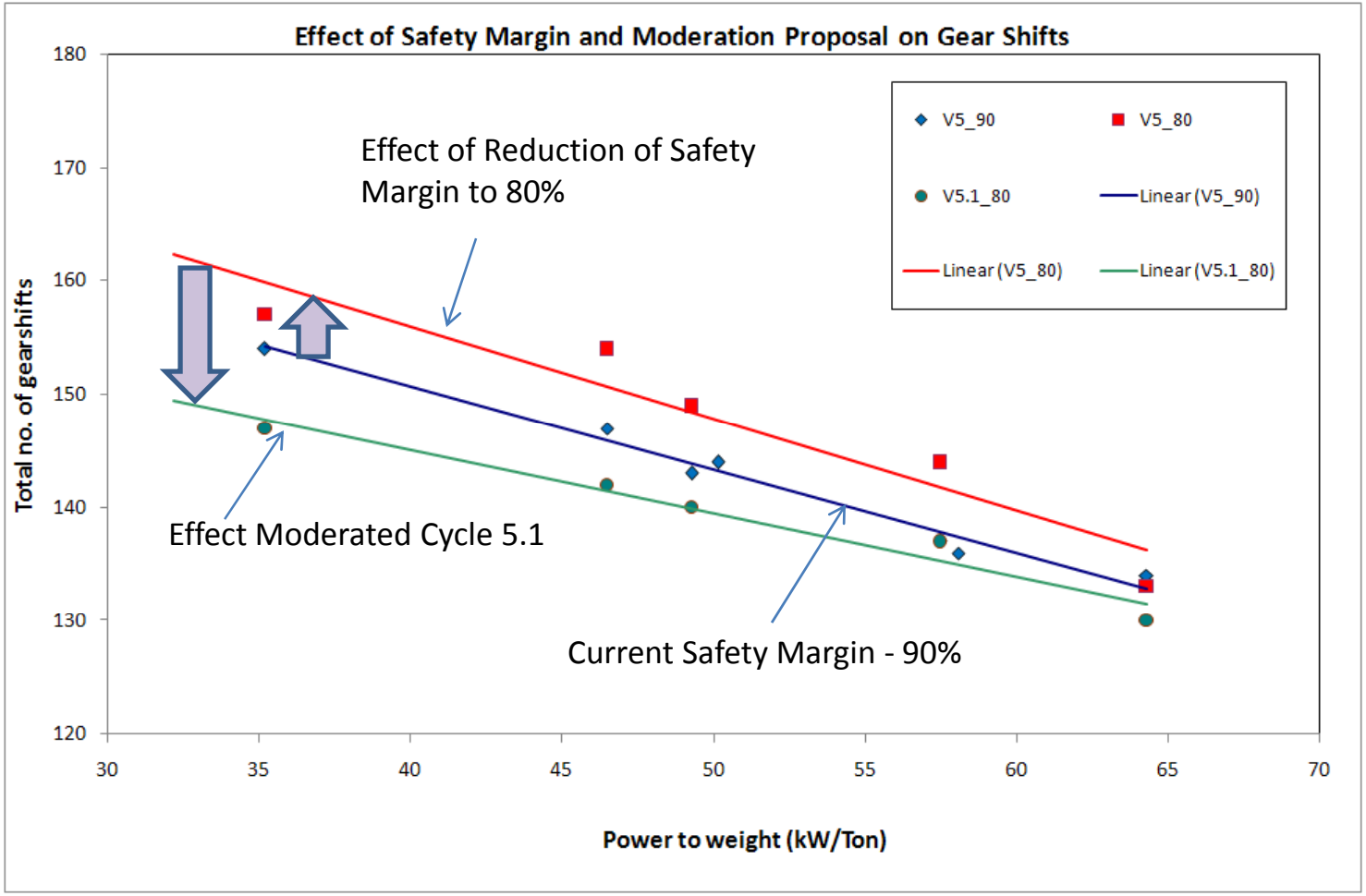
***Cycle Separation at 145km/h will address this concern**.*

India Proposal at DHC 14 for Cycle Moderation: WLTC V5.1



- *Japan had proposed WLTC V 5.1 in 64th GRPE Meeting*
- *The proposals consist of 9 point modifications in M and H phases in order to address typical Gasoline & bifuel PC / LDCV.*
- *India proposed V5.1 as a possible solution to address concerns on* ***typical small & compact cars which is major and growing sector***

No. of Gear Shifts (Stevens) vs PMR

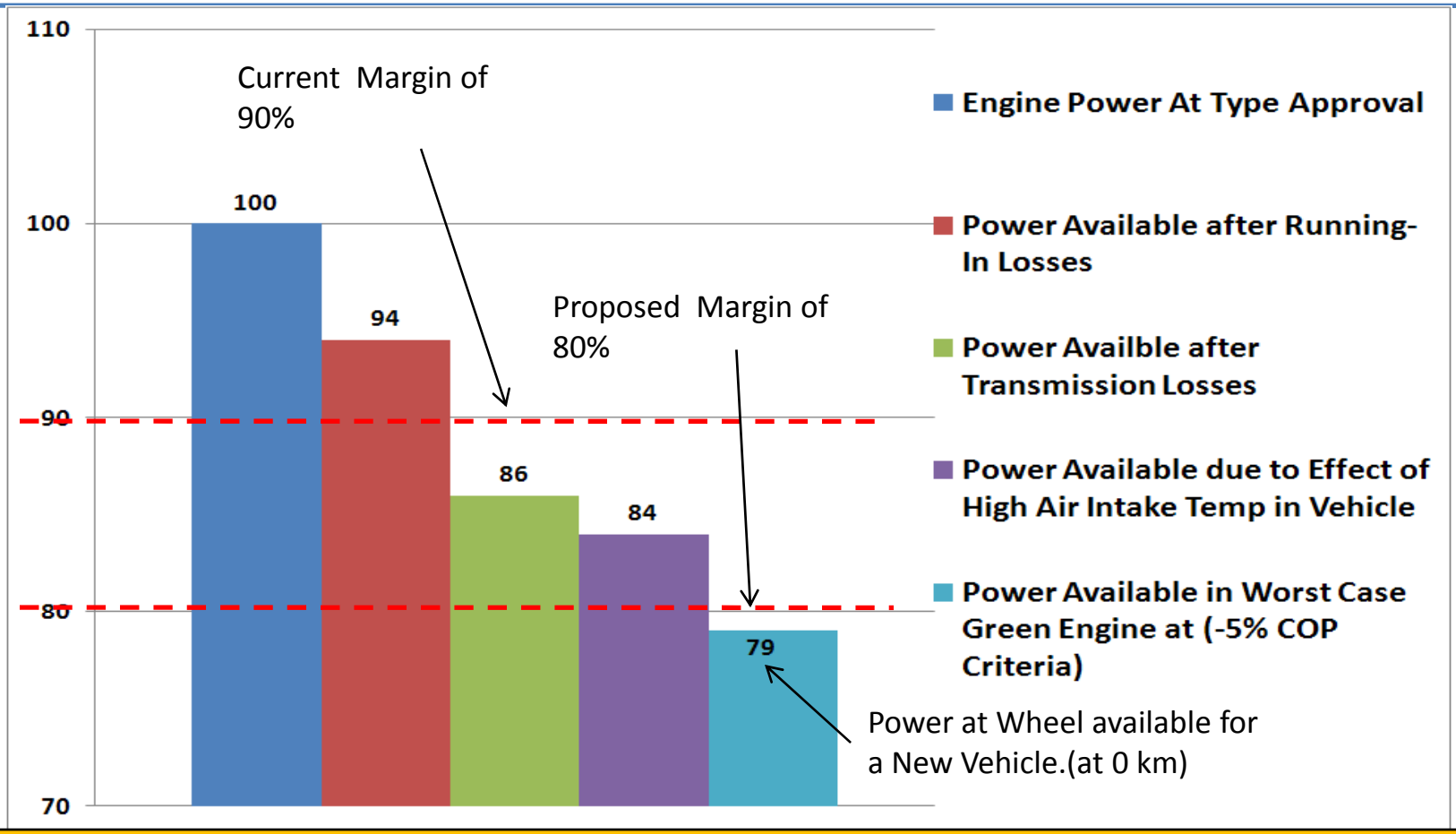


❑ ***Gear shifts are higher than proposed by Japan***

❑***With reduction of Safety Margin 80 % the cycle is expected to become stringent on the lower PMR Range***

❑ ***Use of Moderated Cycle 5.1 will compensate for this effect as shown in the above chart.***

Safety Margin on Full Load Power Curve

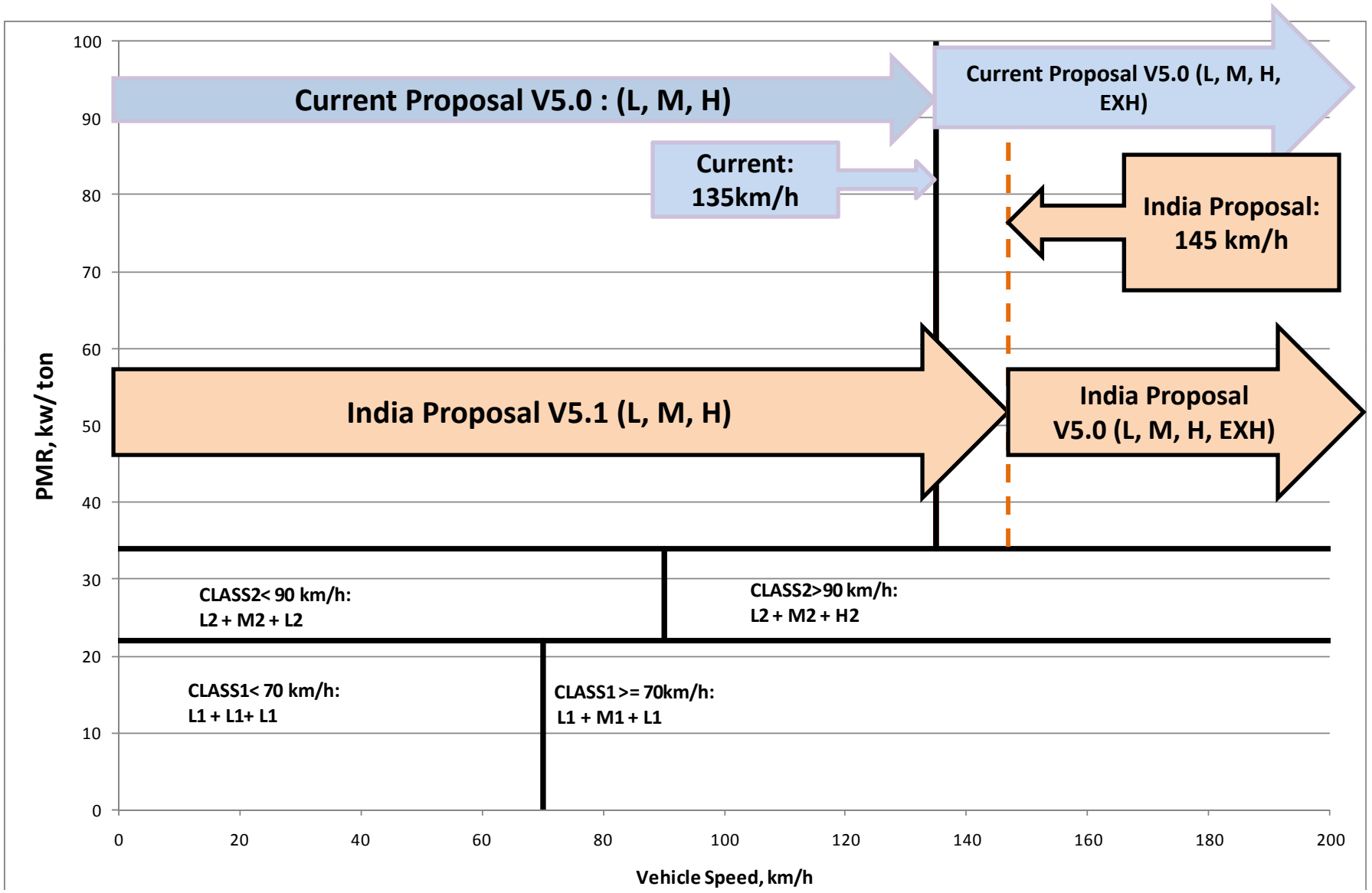


- *Steven's Gear Shift is based on the assumption of 90% Safety Margin of Power Available.*

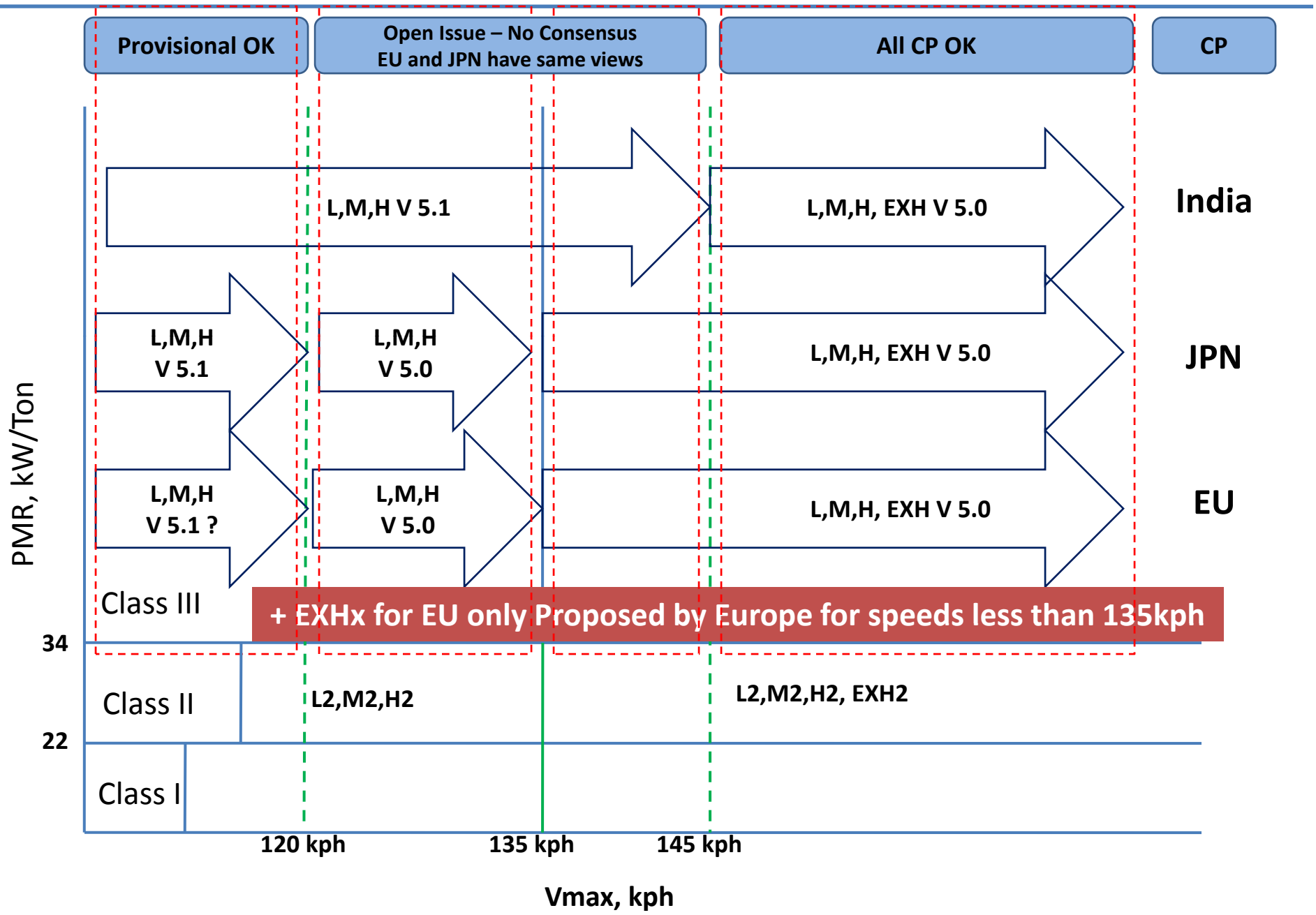
- *The above schematic shows the actual power available at Wheel is 80%. Hence for actual safety margin, the criteria should be modified to 80%. (20% margin)*

- *For new vehicles tested for COP will have lesser Power Availability due to Higher Engine Friction Losses. The proposed criteria of 80% barely meets requirements of new vehicles*

India Proposal at DHC 14



Summary of Viewpoints from 14th DHC meeting



Proposals and EU's Concerns

Area	Max Speed on Cycle, kph	Max Veh Speed, kph	Ratio	Remarks
Class III, V<120	97.4	120	1.232	In principle acceptance
Class III, 120<V<135	97.4	135	1.386	EC: Big difference of speeds. Vehicles with max speed around 135 will only have to run on 97kph, which is not even same as current NEDC demands. Need an Extra high phase for this group.
Class III, 120<V<145	97.4	145	1.489	The gap is even higher and may not be ok for EC

From EU Stand Point:

- ❑ **For Vehicles with Max Speed till 120 km/h, it is agreed to have Cycle Max Speed at 97.4 km/h (Margin is around 23%).**

- ❑ **For Vehicles with Max Speed > 120km/h, it is difficult to accept Cycle Max Speed at 97.4 km/h, as these vehicles will be driving a more relaxed cycle than current NEDC as far as Max cycle speed is concerned. Also the margin ratio is becoming skewed.**

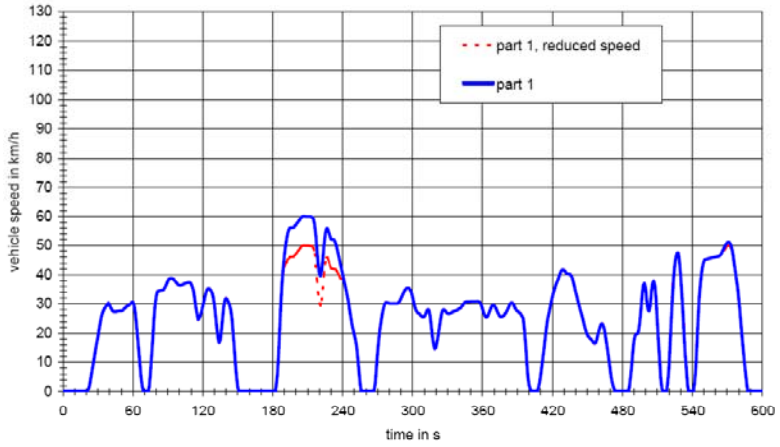
India's Concern on the proposal

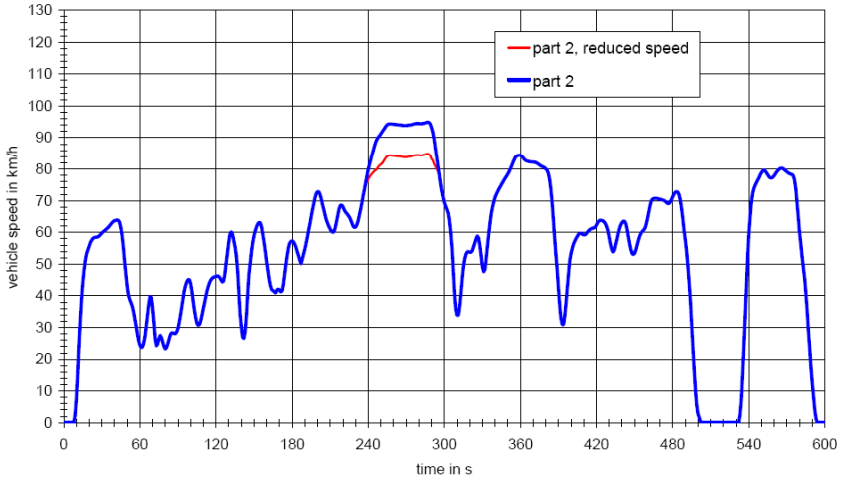
Area	Max Speed on Cycle, kph	Max Veh Speed, kph	Ratio (margin)	Remarks
Class III, V>135	131.3	136	1.036	Margin is too low.

Traceability Issues on cycle for vehicles close to max speed of 135~145kph due to no margins and highly dynamic cycle

Coast down not possible for vehicles which have max speeds lower than 145kph (as per regulation)

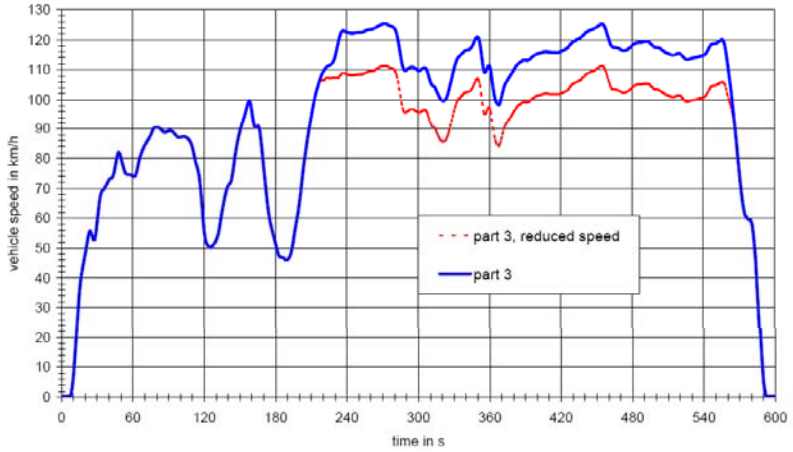
Learning's from WMTC Cycles





Speed Margin Availability (Min ~ Max)*

	Part 1	Part 2	Part 3
Class 1-1	1.20		
Class 1-2	1		
Class 1-3	1.67		
Class 2-1		1.17~1.35	
Class 2-2		1.1~1.37	
Class 3-1			1.15~1.27
Class 3-2			1.12



- **Provision of Reduced speeds on all cycles**
- **Availability of Margin between Max Cycle speed and minimum speed of vehicle required to follow the trace**

***Speed Margin = Max speed of Vehicle/Max speed on cycle. (Orange colour – Reduced speed cycle applicable)**

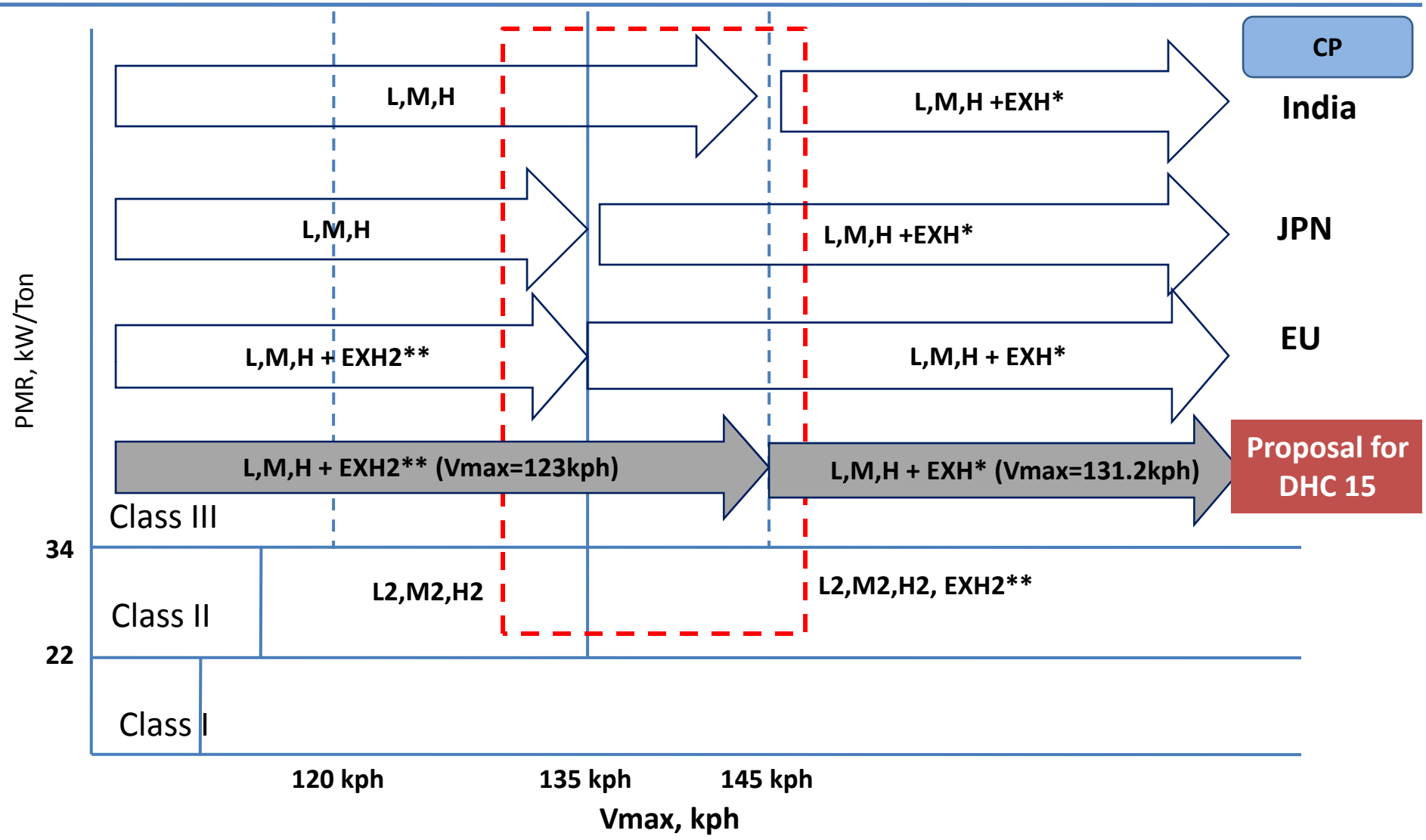
Possible solution to take care of margins – Regional Consideration for Europe

EC is considering a EXH phase 2* for vehicles more than 120kph max speed. This can be used to maintain good and reasonable margin with Max Vehicle speed for reasonable classification as given in table below

Area	Max Speed on Cycle	Min Vehicle Speed	Max Veh Speed	Minimum Ratio	Max Ratio
Class III, V<120	97.4 (H)	-	120	-	1.23
Class III, 120<V<135	113 (EXH2)* Reduced speed	121	135	**1.07**	1.17
Class III, 135<V<145	123 (EXH2)*	136	145	**1.10**	1.18
Class III, V>145	131.2 (EXH)	146	-	**1.11**	-

Reduced speed cycle proposal to maintain minimum margin

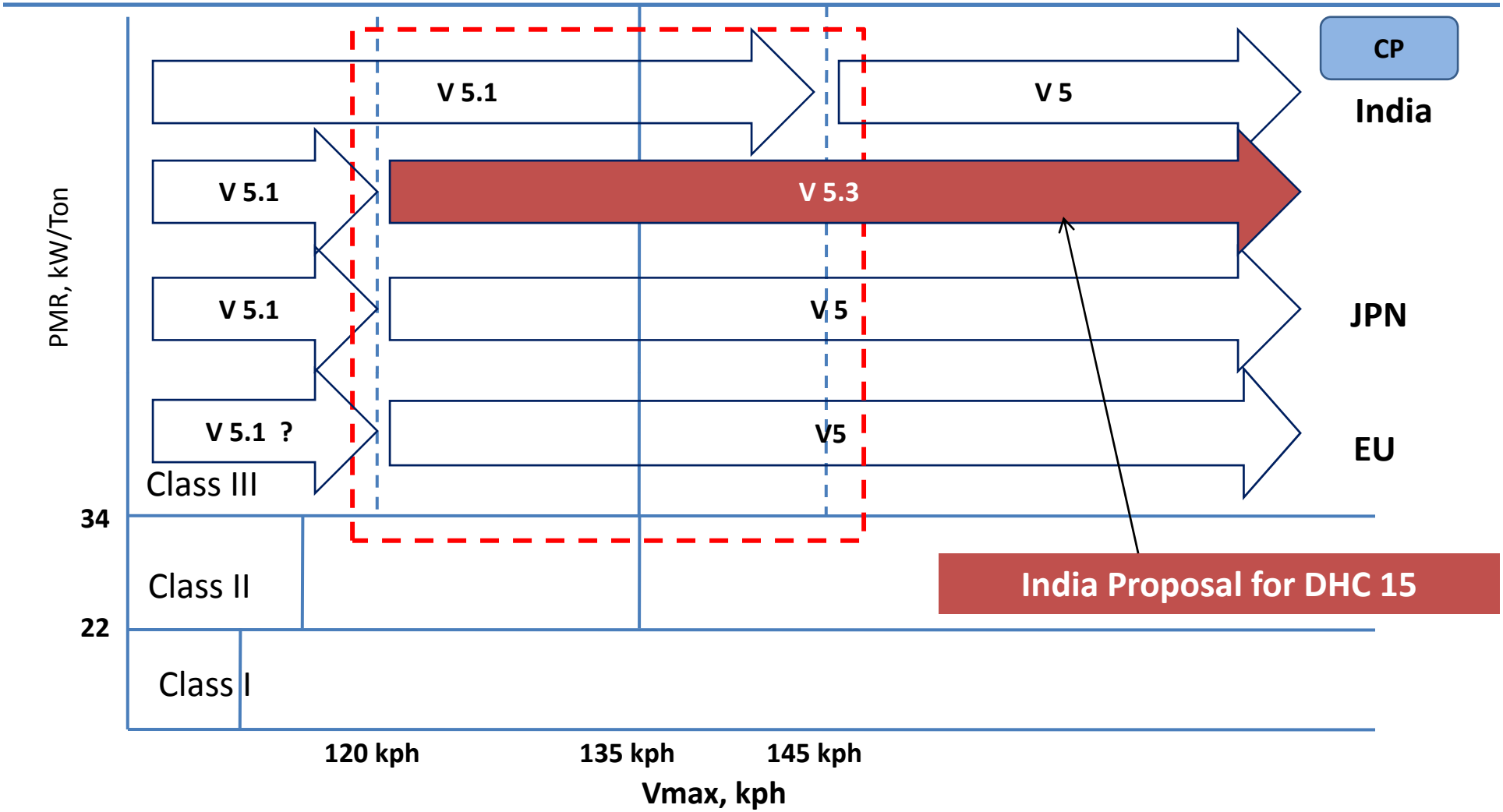
Cycle Phase Separation 1 – Phase Applicability



*EXH Phase as a Regional consideration has been accepted already

** EXH2 Phase is a EU Specific Regional consideration.

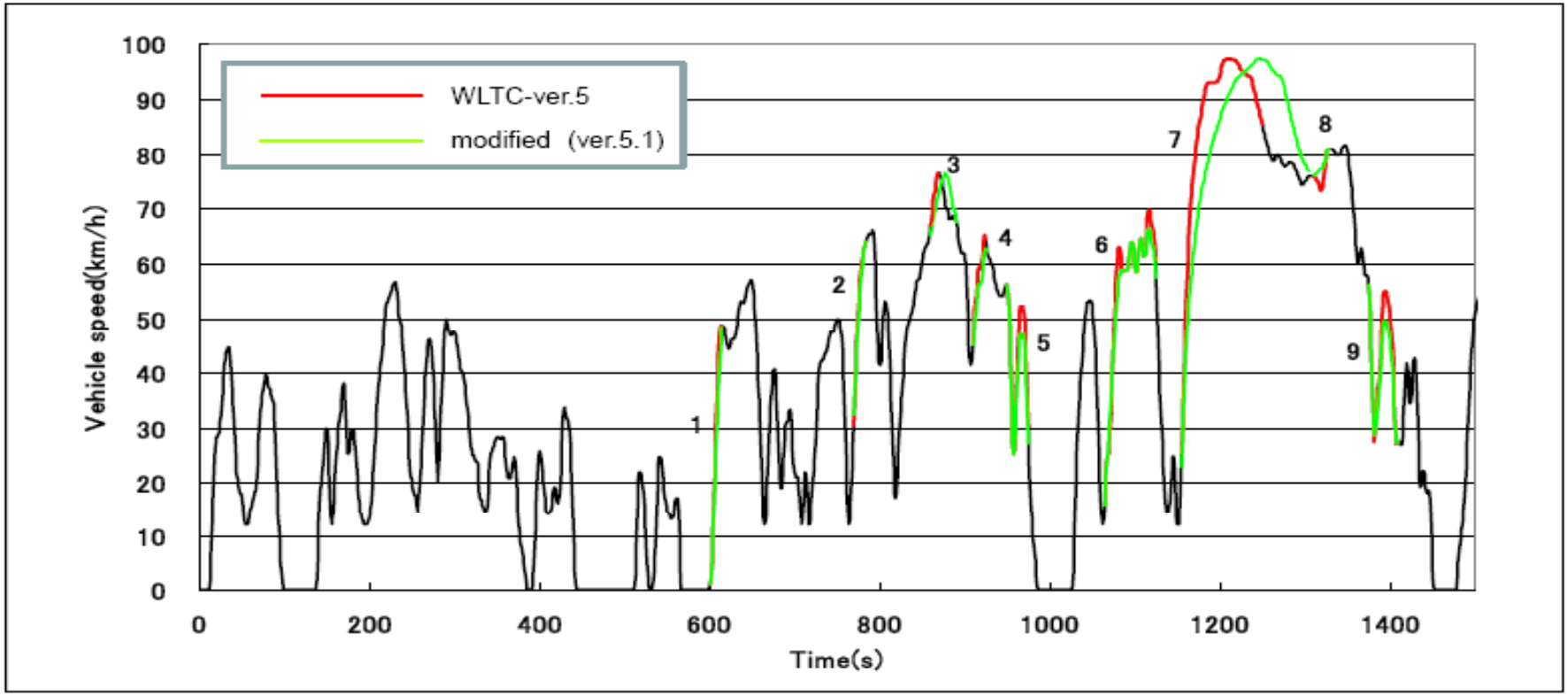
Cycle : Phase Applicability



Acceleration on H phase are main concern. India proposes only one change point instead of 9 points modification over V5 to arrive at a consensus.

India Proposal for DHC 15: WLTC V5.3

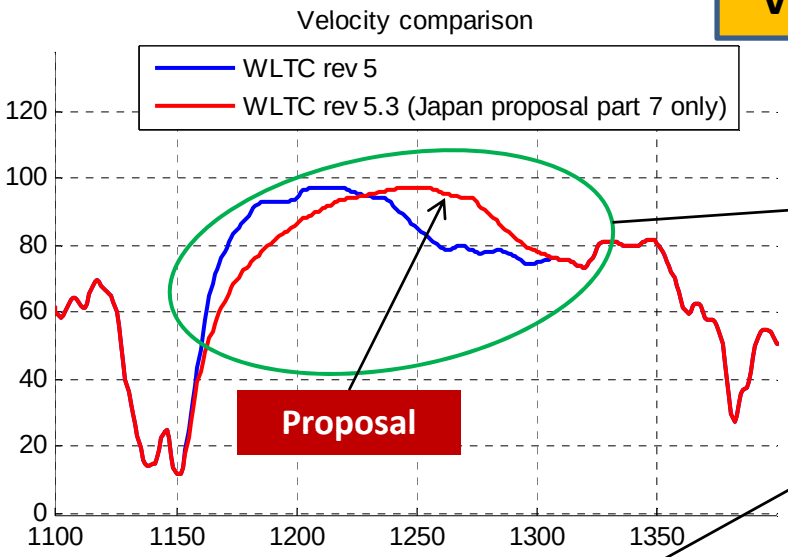
ONLY Pt no 7 modification is proposed

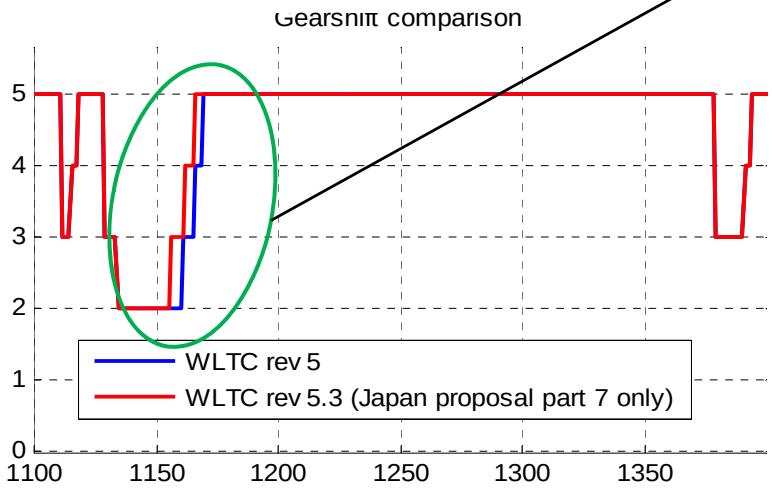


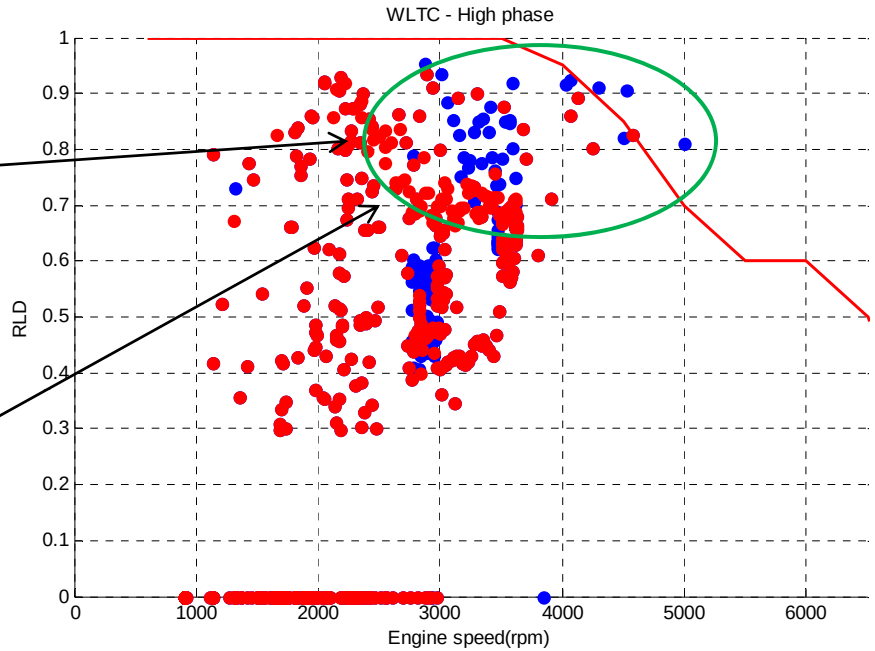
❑ ***India proposal for DHC 15, V5.3 as a possible consensus solution.***

WLTP v5 vs v5.3 (V5.1 7th point only)

Veh P1







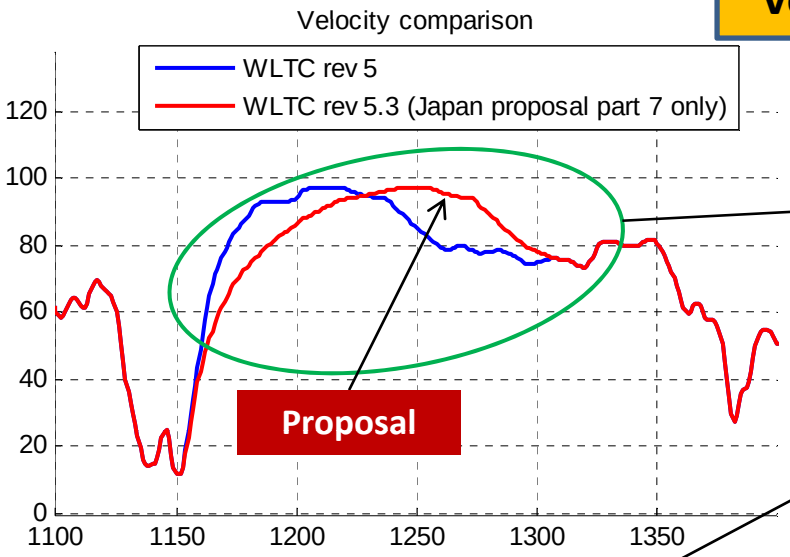
Fuel Economy Comparison

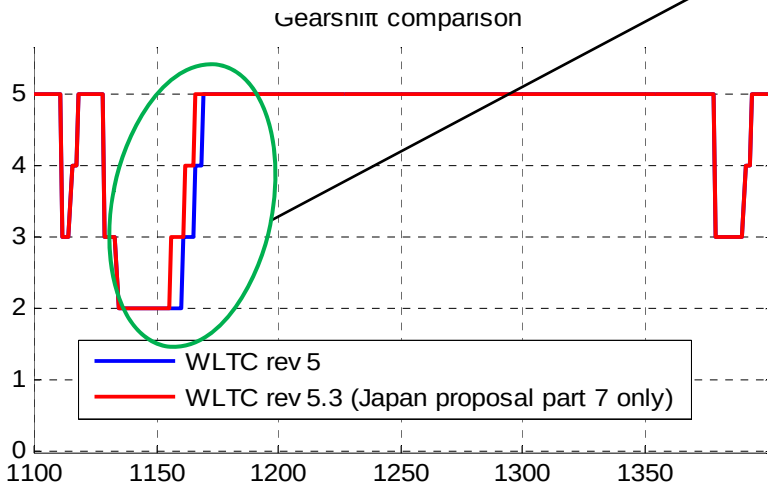
VEH – P2			
MODE	**WLTP v5**	**WLTP v5.3**	**% Diff**
L+M+H	20.45	20.49	0.20
L+M+H+ExH	18.41	18.43	0.11

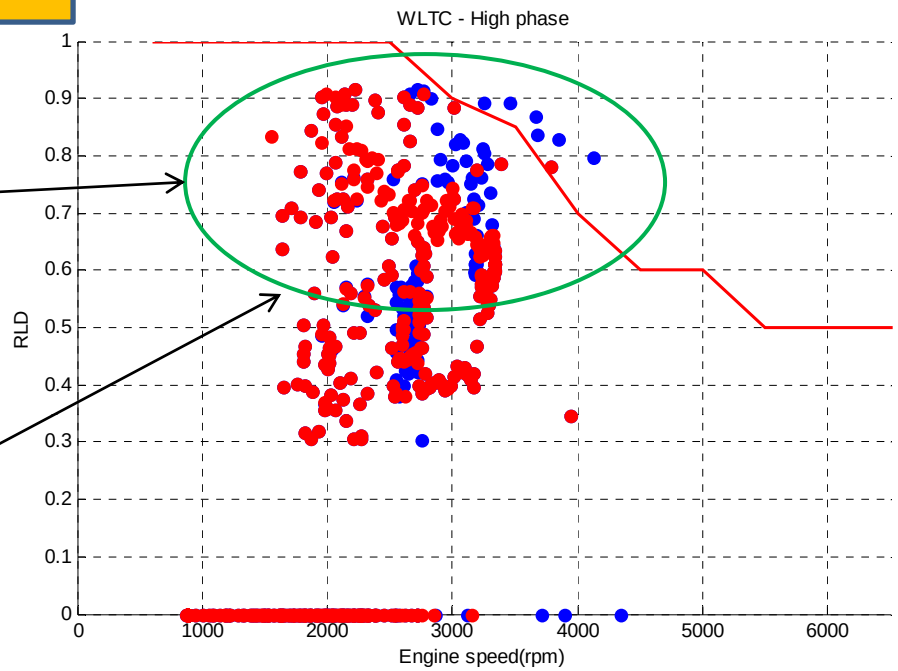
With change from V5 to V5.3, there is no appreciable change in CO2 from even borderline vehicles Situation should be better for other vehicles. Stringency is maintained

WLTP v5 vs v5.3 (V5.1 7th point only)

Veh P2





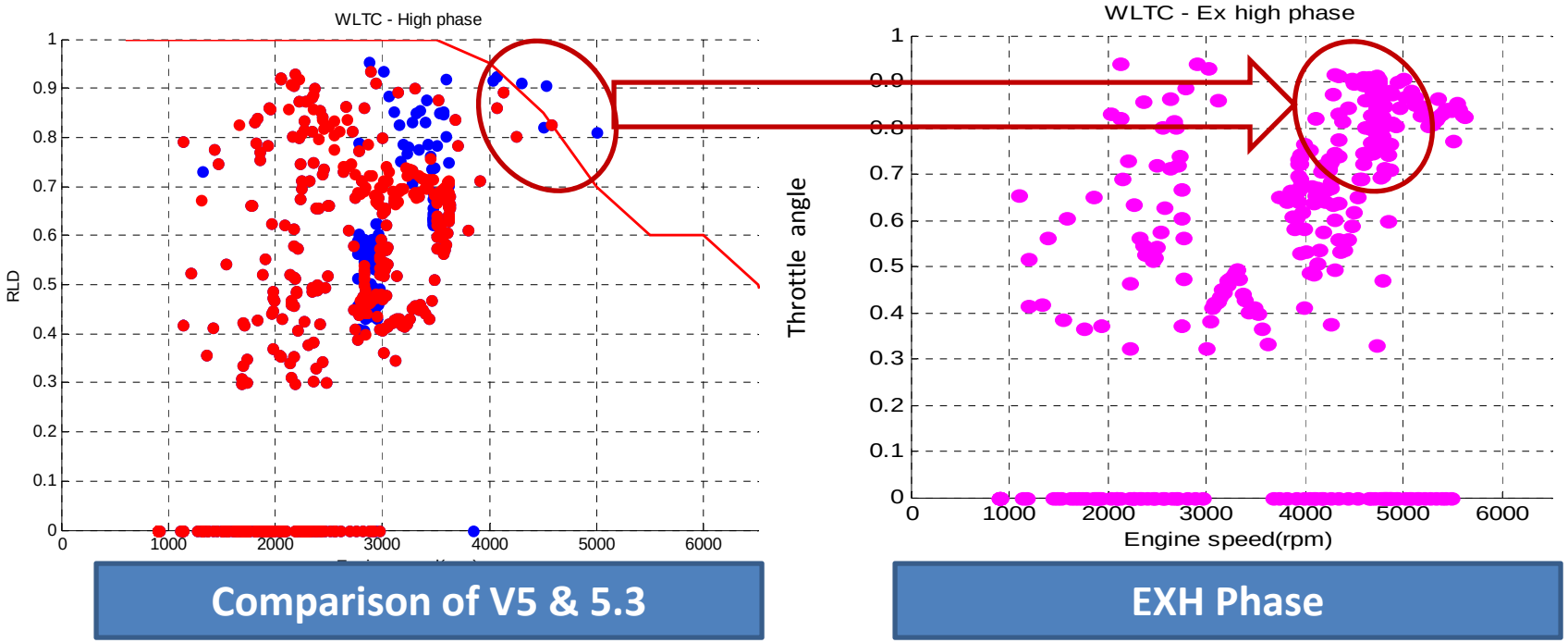


Fuel Economy Comparison

VEH – P2			
MODE	**WLTP v5**	**WLTP v5.3**	**% Diff**
L+M+H	18.90	18.94	0.21
L+M+H+ExH	16.55	16.57	0.12

With change from V5 to V5.3, there is no appreciable change in CO2 from even borderline vehicles. Stringency is still maintained

Comparison of Engine Operating points in P1 Vehicle



- Operating points which are not covered in V5.3 are covered in EXH phase
- Overall Stringency of WLTC is not compromised
- Fuel Consumption is almost identical on V5 and V5.3

Compromises by India

- Open points which have not been closed.
  - Of the 16 open points which were to be closed with Validation 2 results. India wants only Pt no 24 to be addressed (with V5.3)

- Speed Threshold
  - India already compromised from 160 to 145kph for EXH applicability

- Accelerations & Gear Shift Strategy
  - Even though the cycle is much more severe than Indian typical road driving pattern(Slide no 10). India has still accepted

Indian Proposals – Not affecting Cycle Stringency

- Change in profile on H Phase (V 5.3)
  - Overall no change in coverage of engine operating points on the cycle.
  - Stringency maintained for WLTC.
  - V5.3 doesn't show any significant change in CO_2 emissions

- Speed Threshold at 145kph
  - Required for proper Coast down on Vehicles as per regulation
  - A minimum margin of 10% is at least required for driving on the "aggressive test pattern"

Appeal to a review the position adopted so far in order to drive a solution at DHC 15

THANK YOU