Downscaling Proposal

India Short validation results
India Proposal

India Presentation

5th June, 18th DHC Meeting,

Geneva.

Background

During the discussions in WLTP DHC Telecon on 16th May, 2013:

1. India confirmed Acceptability of Downscaling Principal with the consideration for:
   a) taking care of vehicles which are not able to trace the cycle, and
   b) taking care of vehicles which show very high P_WOT operation

2. Based on above, a short validation was proposed by WLTP-DHC.

Action plan formulated:

- Validation of Downscaling Proposal and
- Possible solutions to alleviate the concerns raised by India

DownScaling Proposal- Validation Summary

Sno	Class	Vehicle	Fuel type	Steven Proposal	Test Results Remarks				
				Downscaling %	Traceability	Traceability Error Duration	% Time where Reqd power > 95% avail Power (EXH Phase)	Vmax, kmph	Rated RPM
								Cycle V Max	Cycle Max RPM
1	Class I	A	Diesel	5.6%	O	5 sec	4.2%		
								56	3096
2		B	Diesel	10.5%	O				
3		C	Diesel	12.3%	O	0 sec		70	3200
								64	3118
4	Class II	D	Diesel	3.1%	O		3%		
								121.17	3158
5		E	Gasoline	23%	O	0 sec	40.0%	110	5000
								107.7	5346
6	Class III	F	Gasoline	0%	X	14 sec	11.8%	135	6000
								131.3	6790
7		G	CNG	7.9%	X	45 sec	23.8%	135	6000
								125.6	6954
8		H	Gasoline	0%	O	4 sec	2%	160	5000
								131.3	4963

Traceability	
X	Not Ok
O	OK

Class I : Vehicle Validation Results

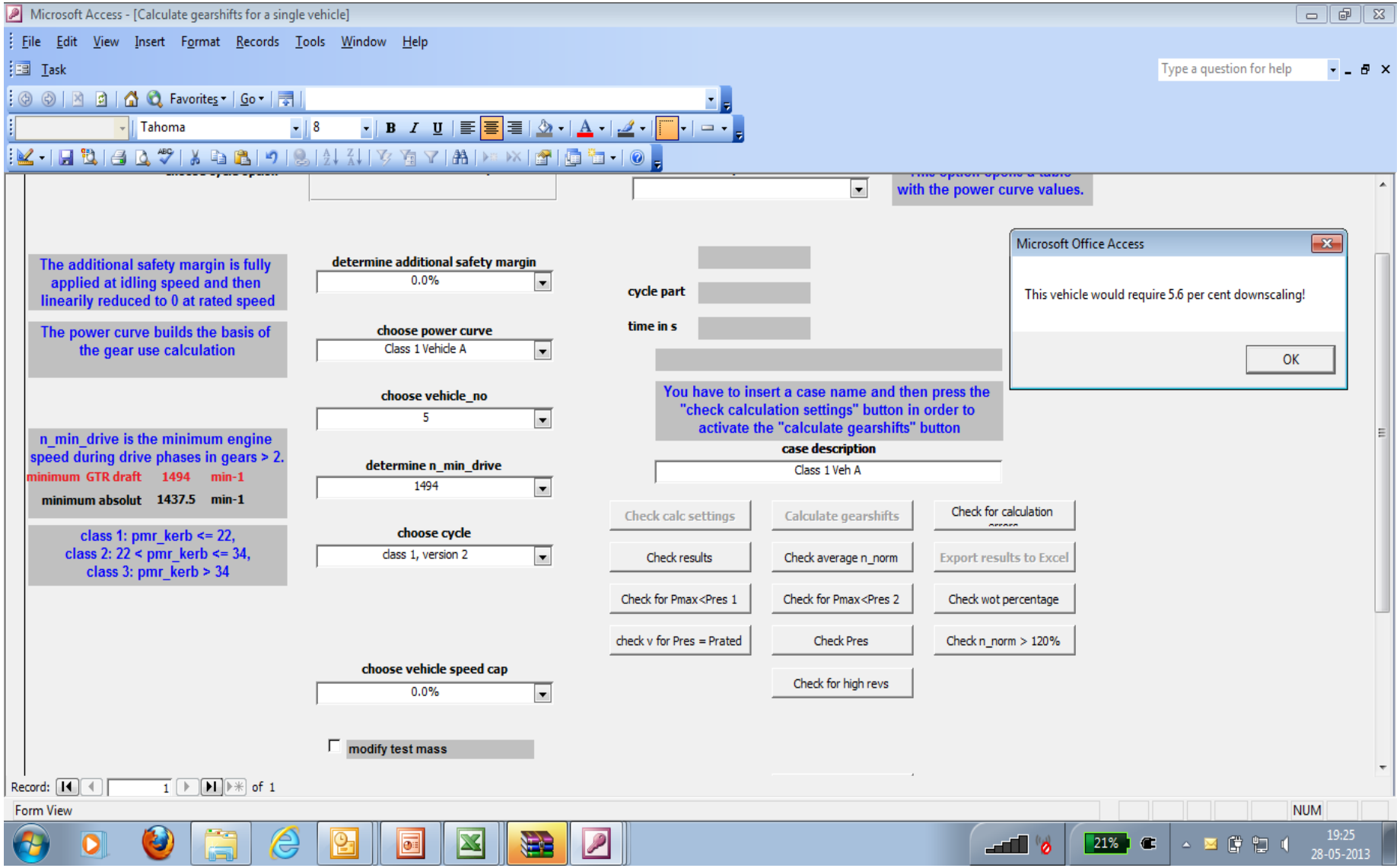
Observations on the WLTC Cycle Down scaling software tool

1. **Class I :**
   a) Once Class I cycle is selected, %Downscaling drop box selection becomes inactive in software tool provided.
   b) Some times the tool doesn't work if you would like to work for the same data file.
   c) Class-1 cycle generated with the coast down values show the truncation in the cycle rather than shifting the cycle with the down scaling factor as it happens correctly for class-3.
   d) For the same vehicle when the down scaling is applied with the road coast down coefficients a & b, but , if we modify the polynomial interms of $F = a + bV + cV2$ the tool doesn't give the down scaling at all. Theoretically, it shall provide the same down scaling.

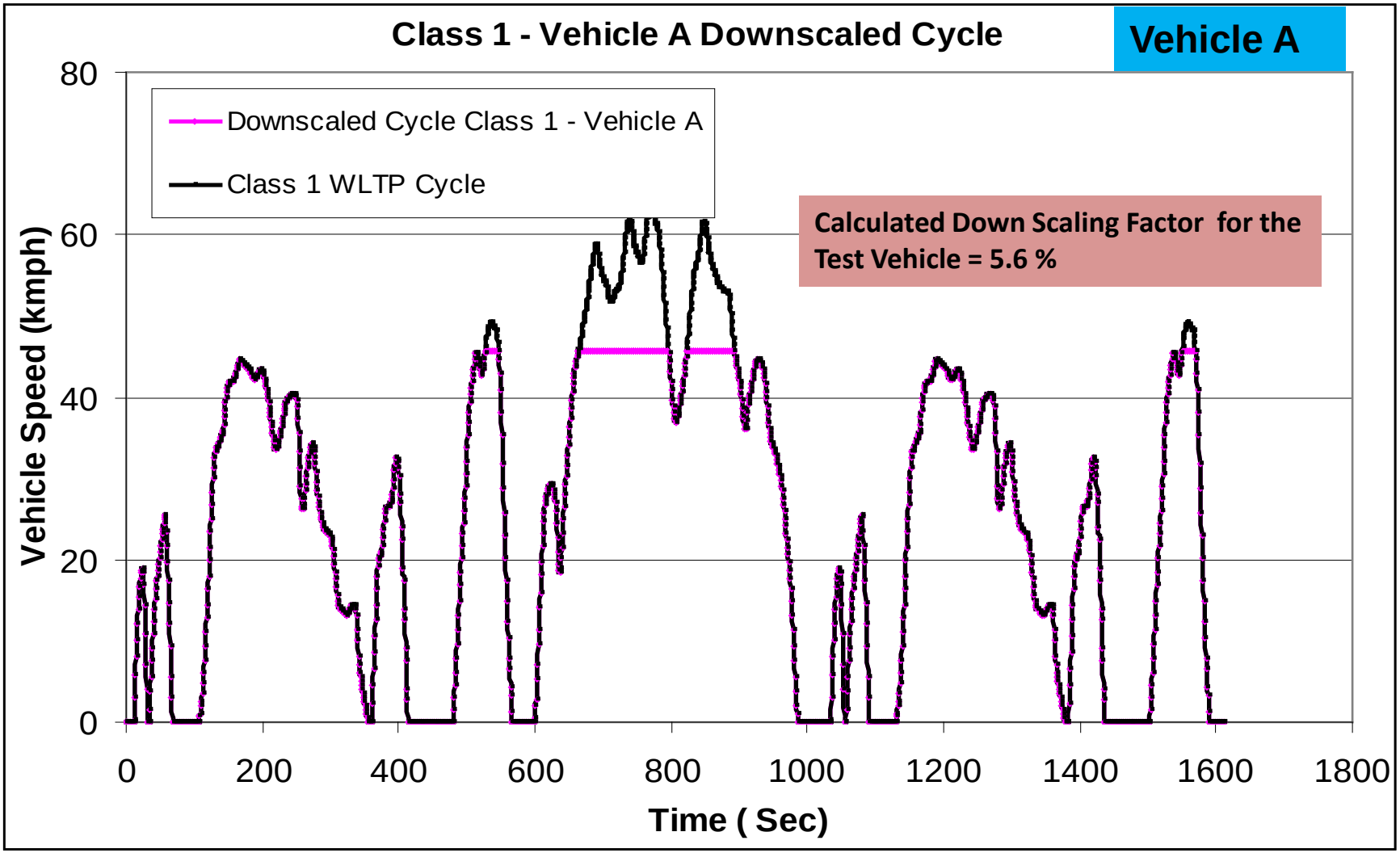
Example: Vehicle A:

Vehicle Road load coeff by coast down on road	Polynomial	Down scaling factor calculated
f0= 121.74, f2 = 0.11	$F = f0 + f2*V^2$	12.3 %
f0= 138.6, f1 = 2.28, f2= 0.027	$F = f0 + f1*V + f2*V^2$	0%

Example: Down scaling Factor Calculated for Class-1 Vehicle A

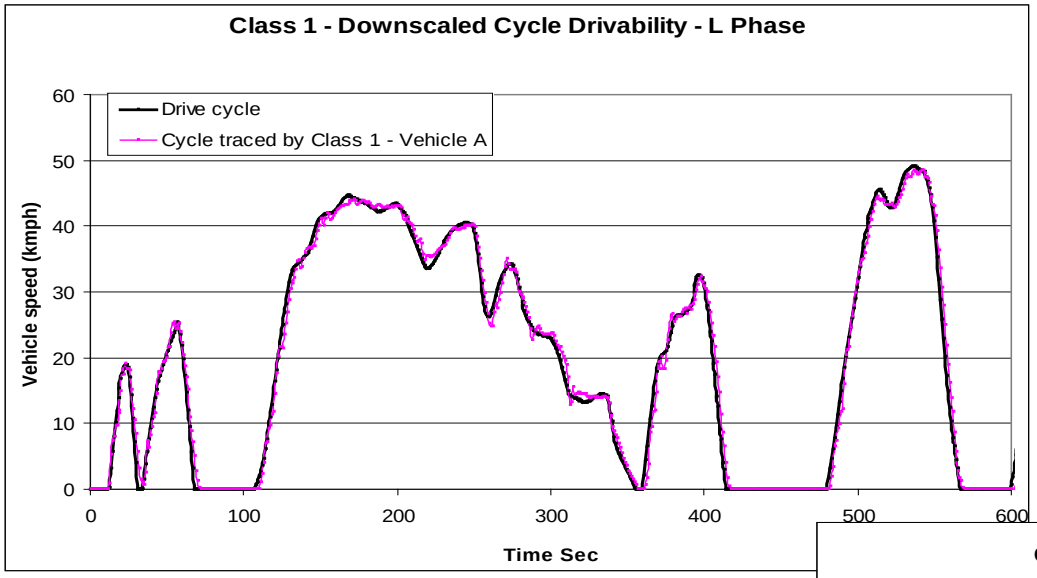


Downscaling – Class I

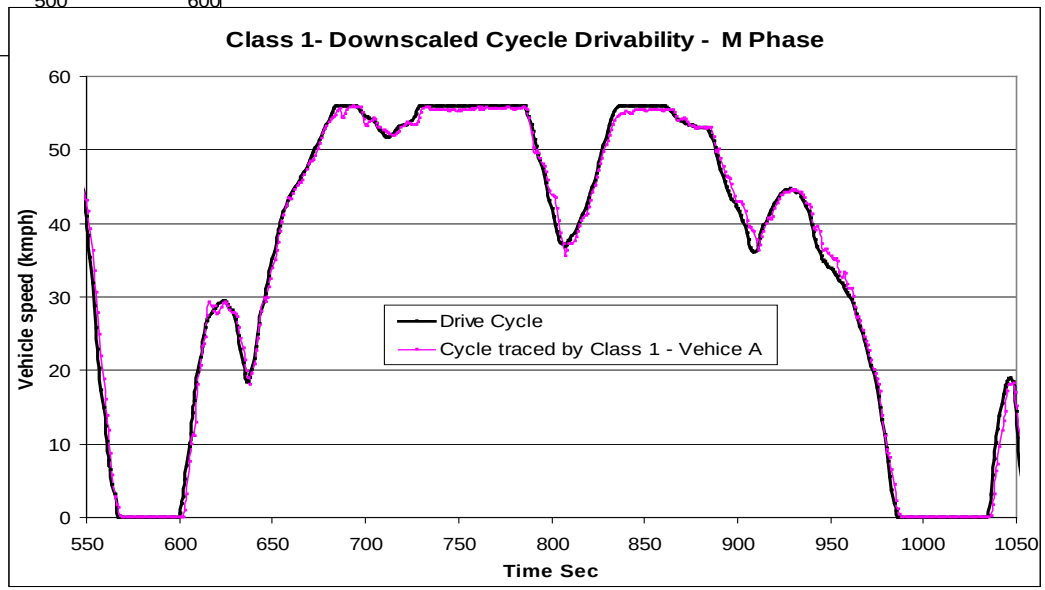


Downscaling leads to truncation of cycle similar to Capping. This needs correction similar to Class III Vehicle downscaling concept

Downscaling – Class I – Vehicle A Results

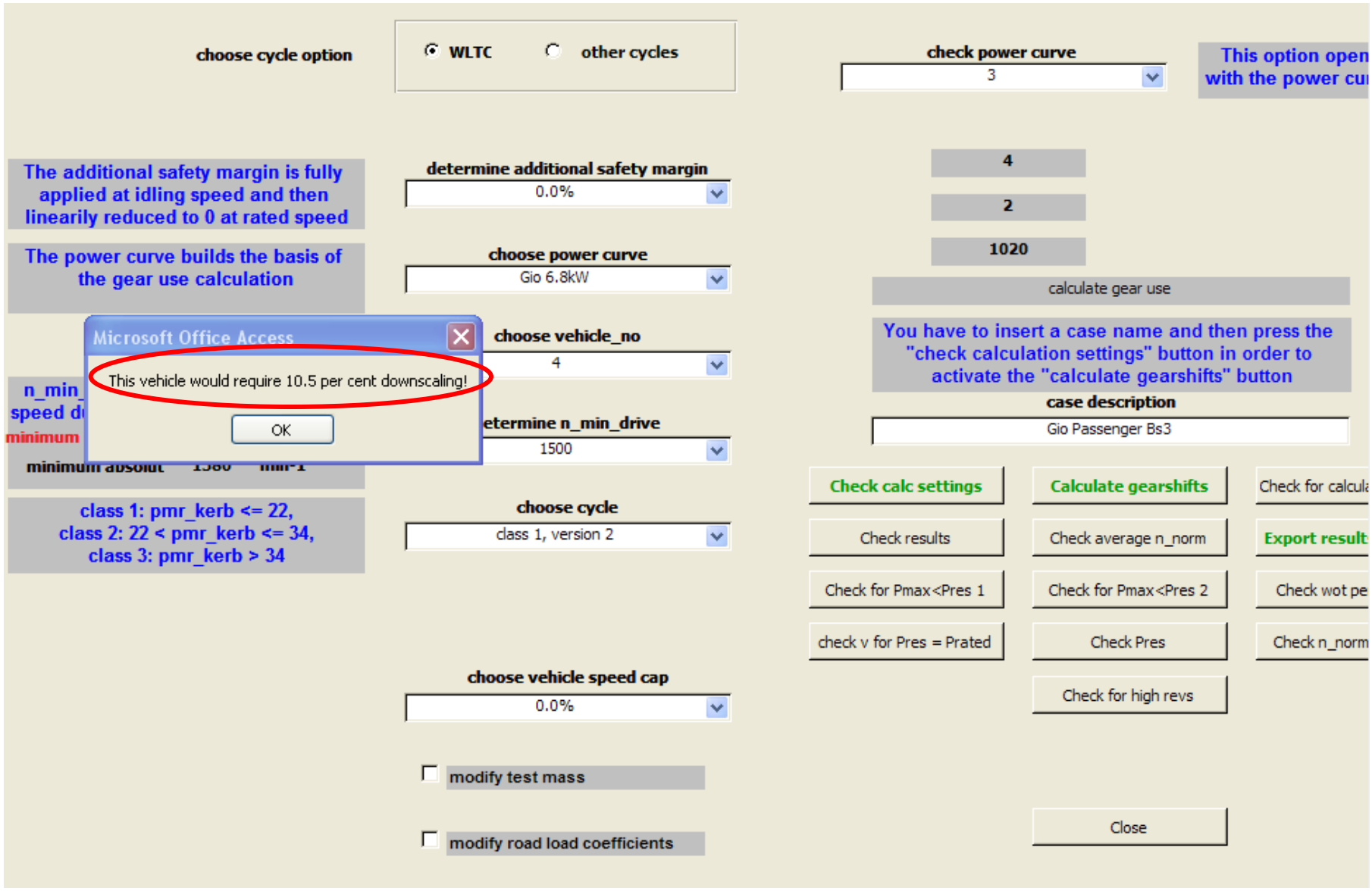


Calculated Down Scaling Factor for the Test Vehicle = 5.6 %

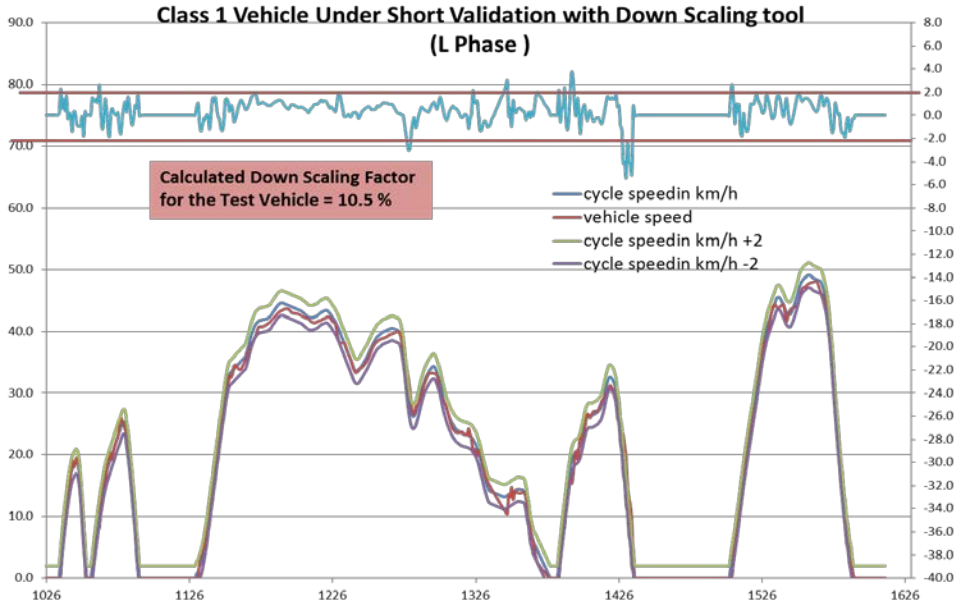


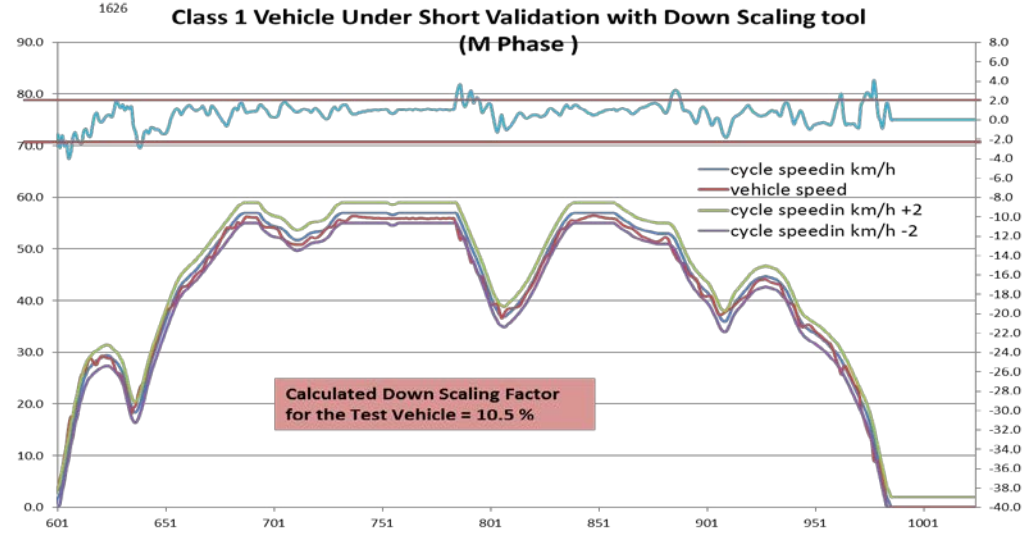
No drivability issues in L and M phases observed.

Example: Down scaling Factor Calculated for Class-1 Vehicle B



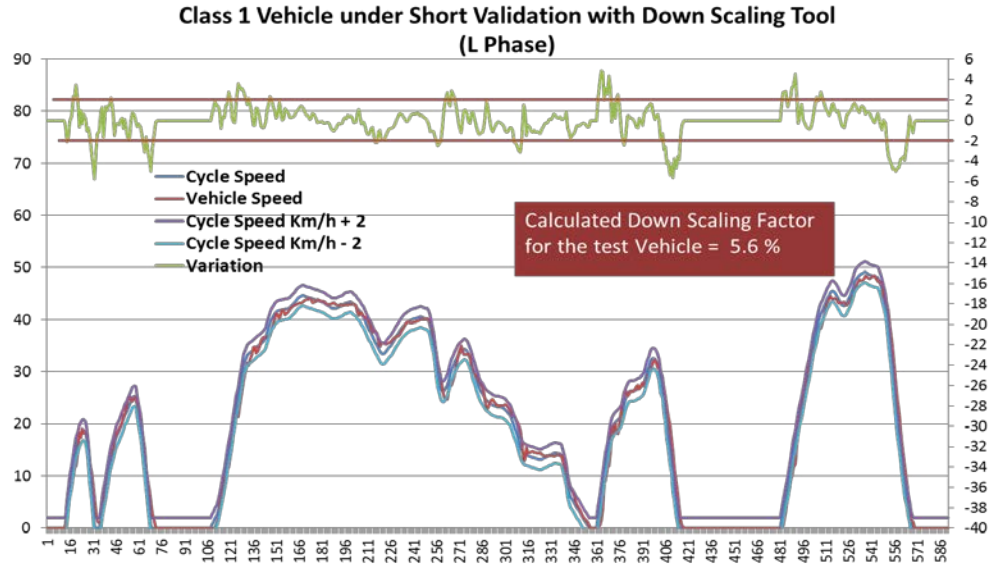
Downscaling – Class I – Vehicle B Results

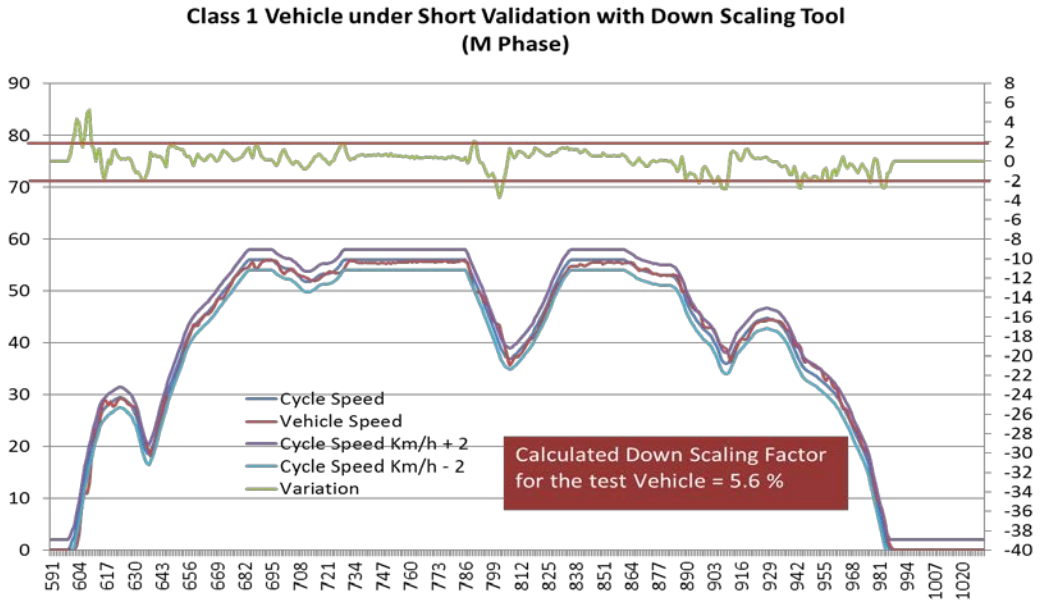




No drivability issues in L and M phases observed.

Downscaling – Class I – Vehicle C Results

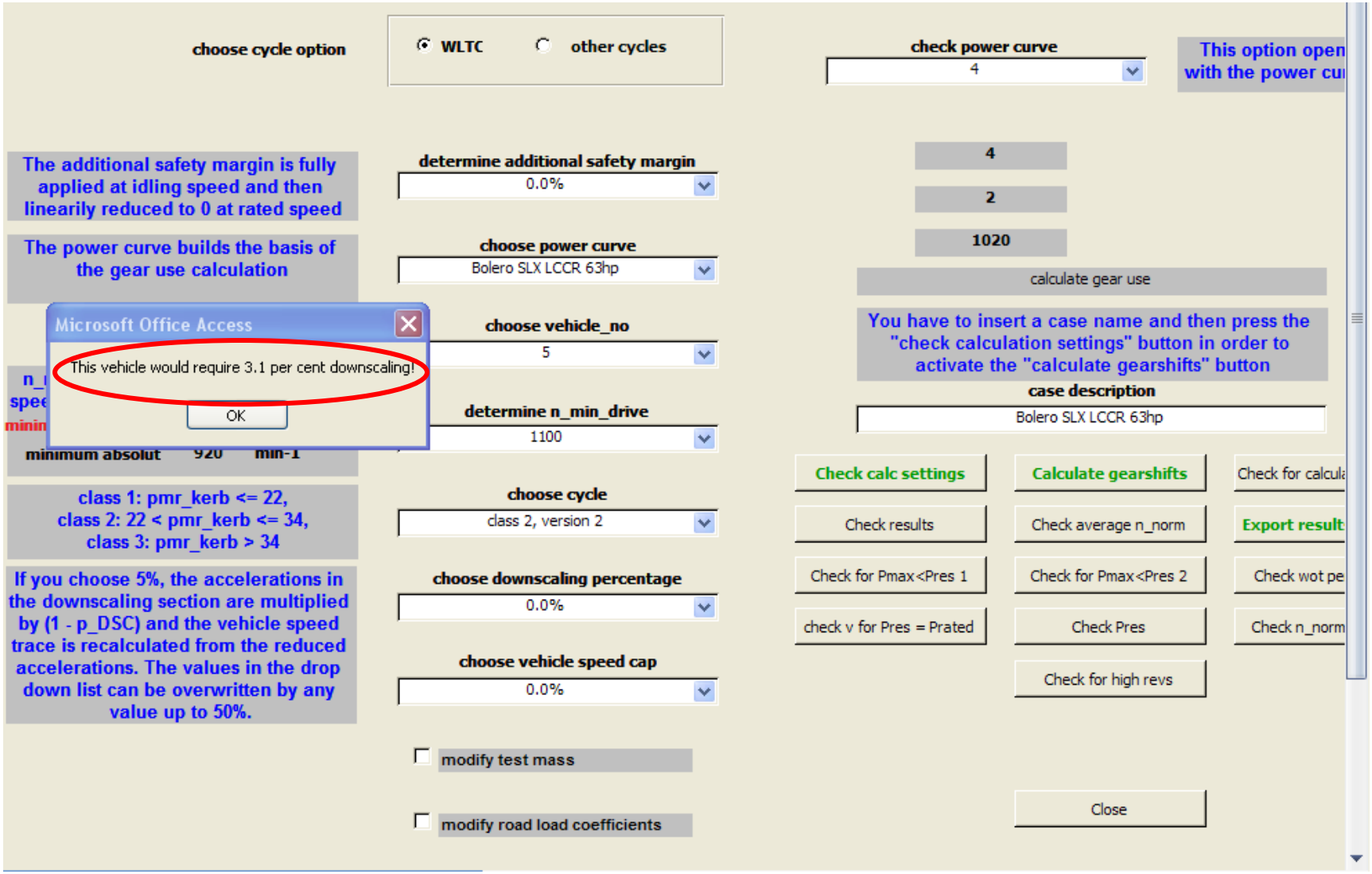




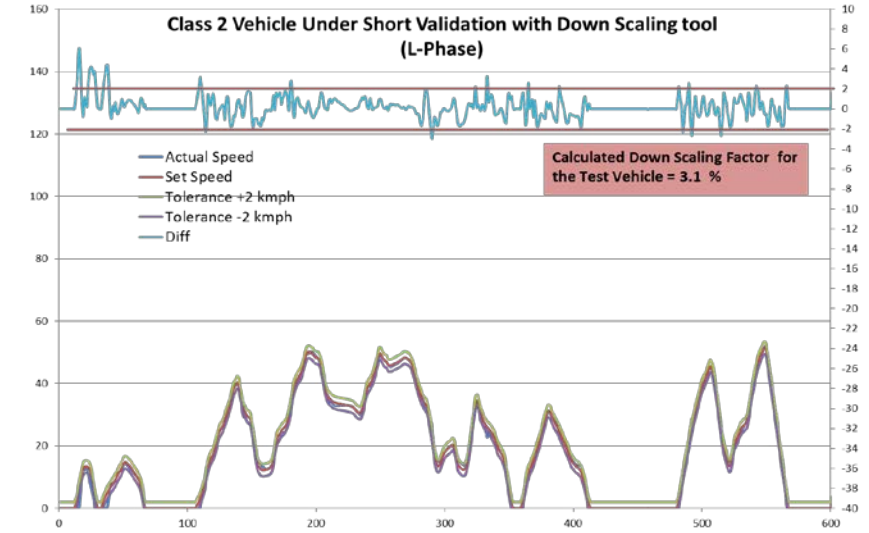
No drivability issues in L and M phases observed.

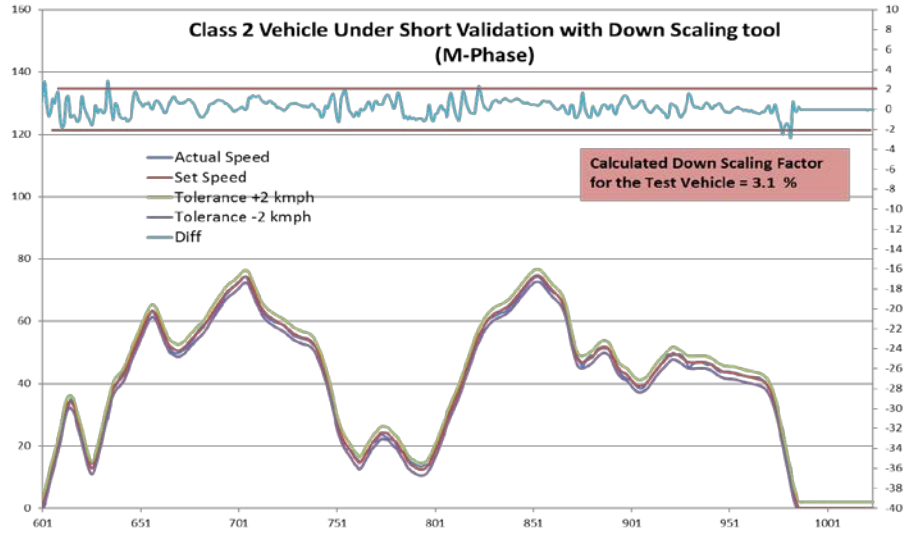
Class II : Vehicle Validation Results

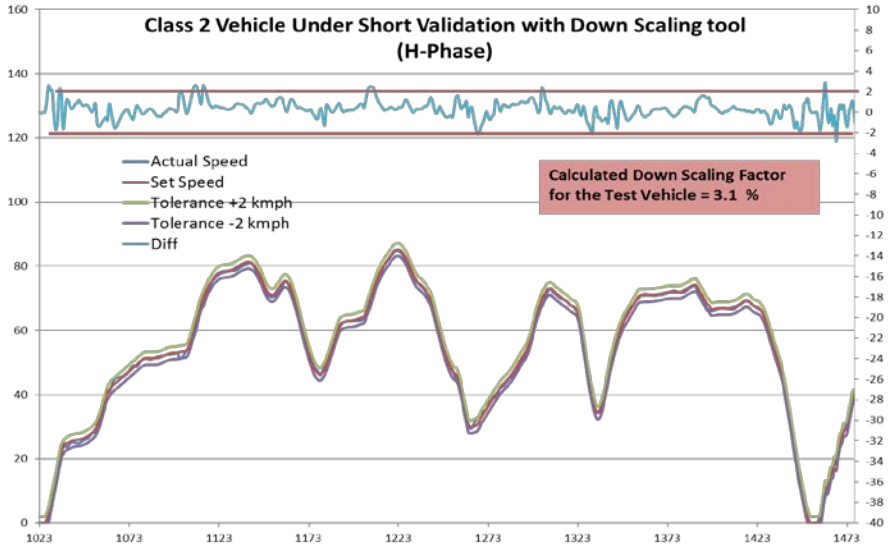
Example: Down scaling Factor Calculated for Class-2 Vehicle D

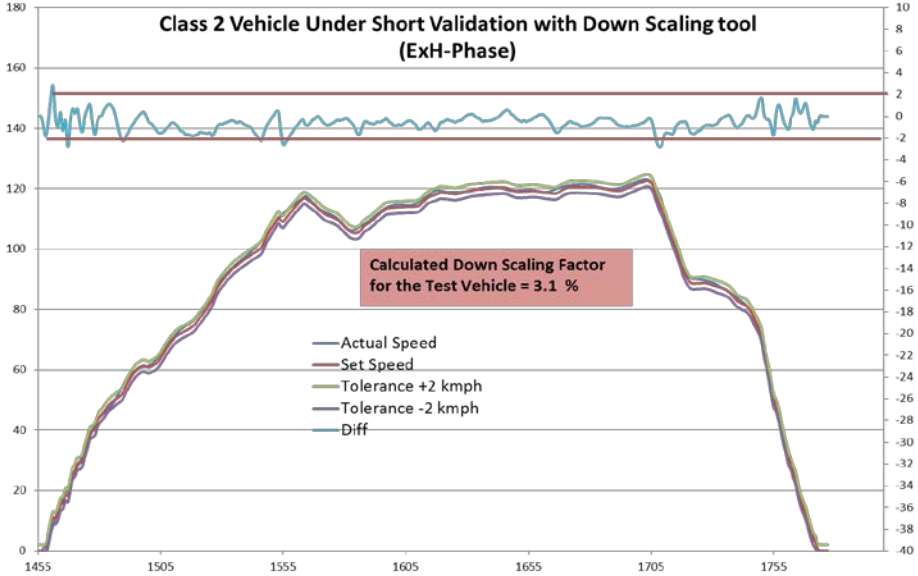


Downscaling – Class II – Vehicle D Results (Diesel Vehicle)





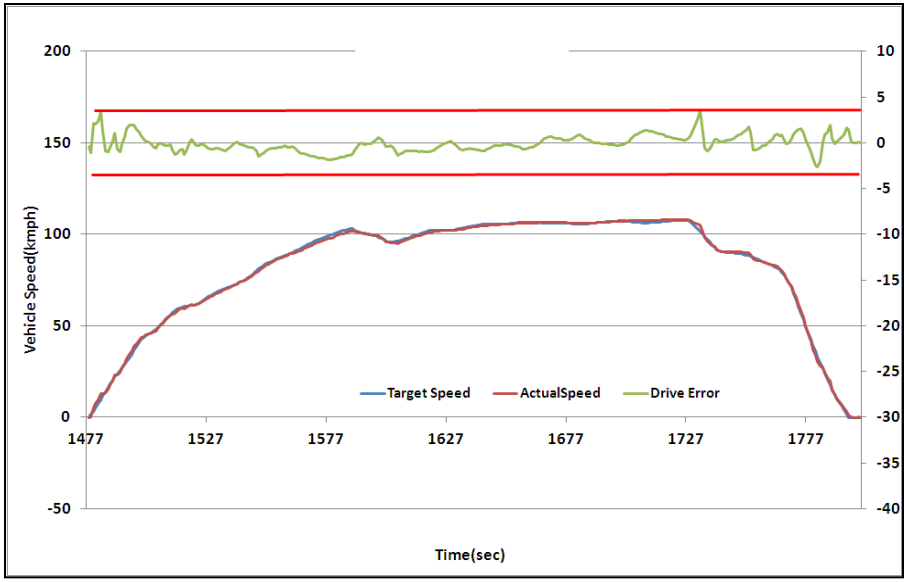


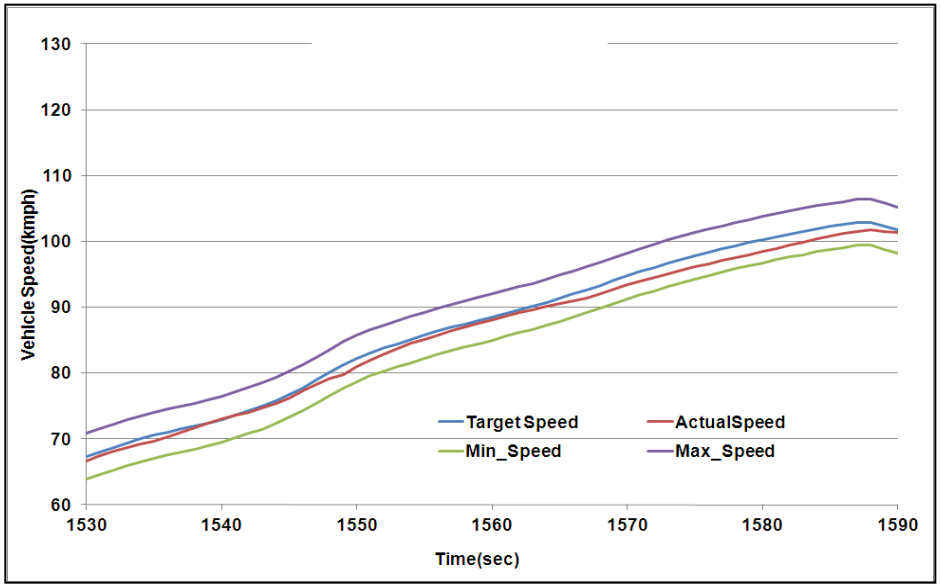


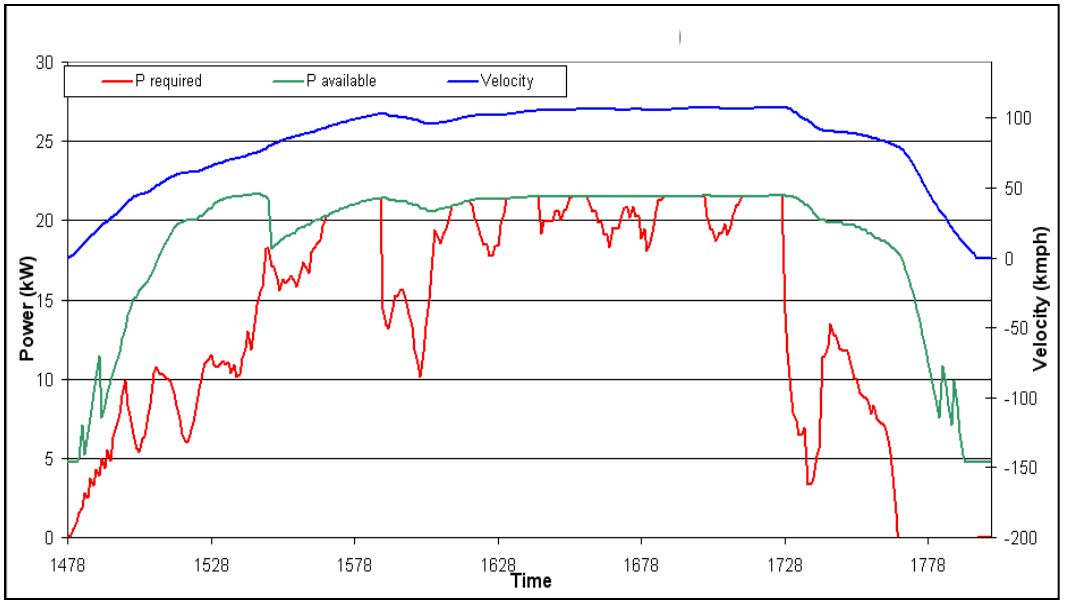
No drivability issues observed (Diesel Vehicle).

Test Results : Vehicle E - Class II (Gasoline Vehicle)

Vehicle E: Gasoline Class II – EXH Phase







Remarks

1. Cycle Traceability :

a. Steven Downscaling factor = 23 %

b. Vehicle able to follow the targeted trace

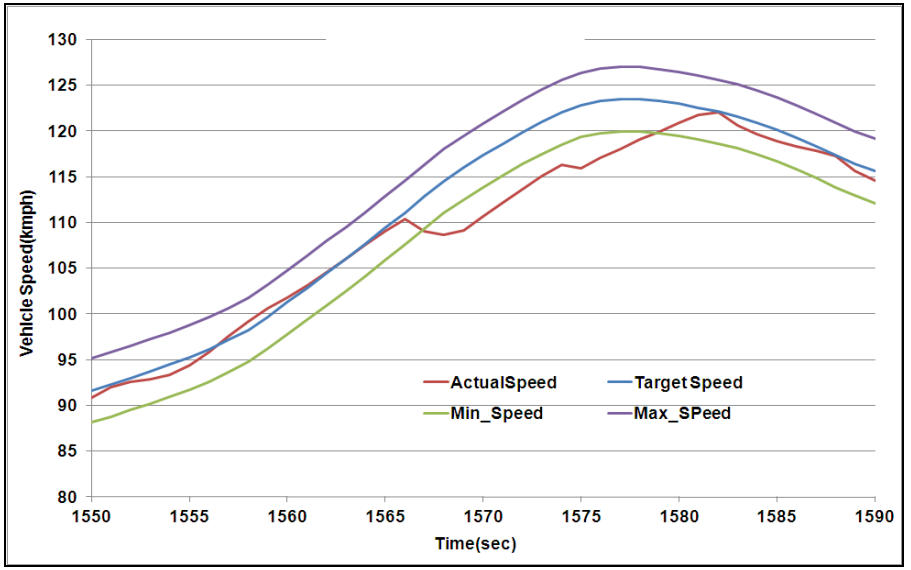
c. **40% of operation** is in near WOT area in EXH phase. Component protection area operation is very high

Class III : Vehicle Validation Results

Concerns with the New Tool

A) N_norm_max : Set Value 120% in new tool, which leads to very high Engine RPM's, Engine hitting the rev limiter, resulting in errors

Vehicle F Gasoline Class III – EXH Phase

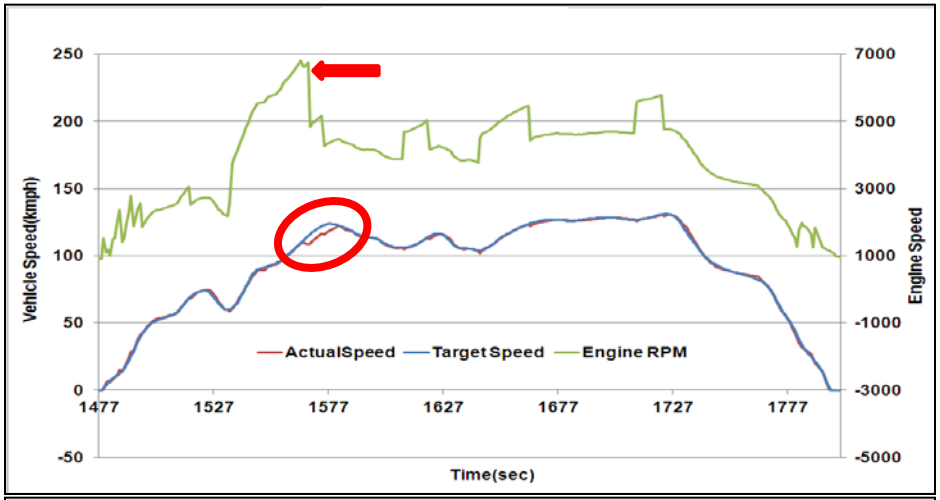


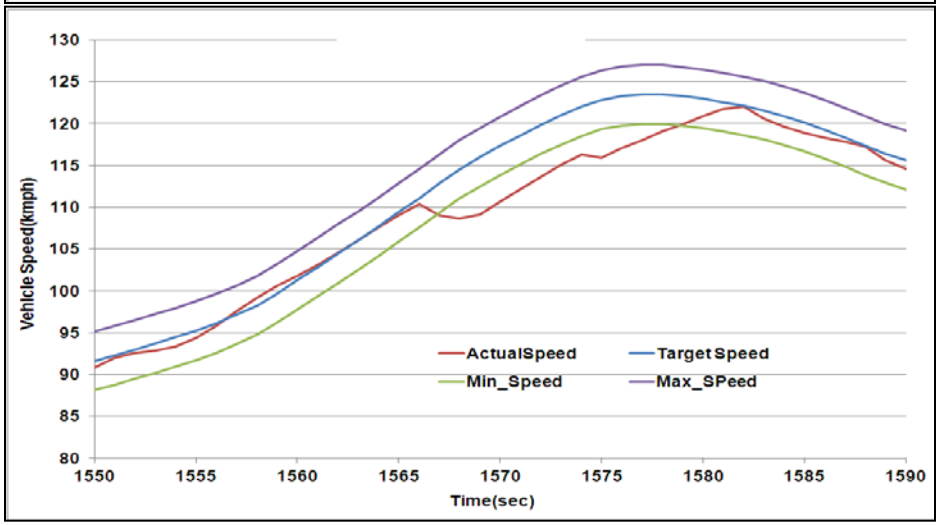
- This is not a natural driving behavior!
- This Results in driving error from target
- Creates artificial downscaling requirements

Proposal: N-Norm max set value of 90% as in previous tool should be used

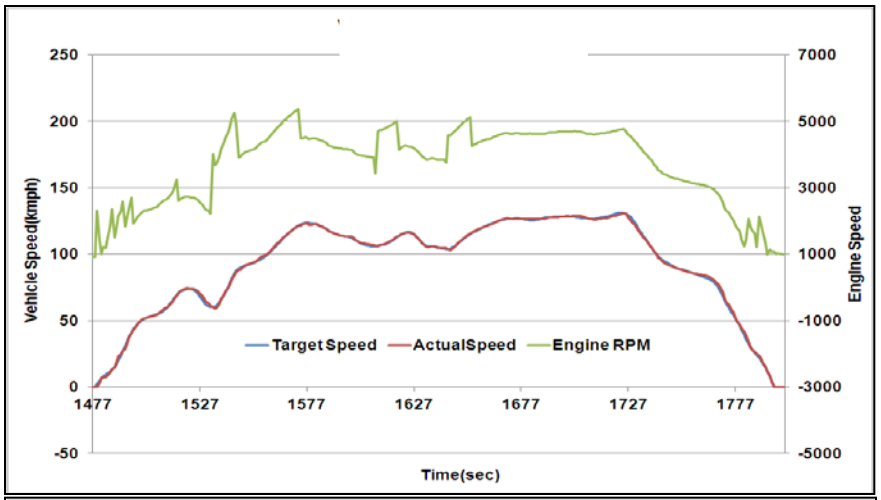
Comparison of N_norm_max =120% and 90% - Vehicle F Class III

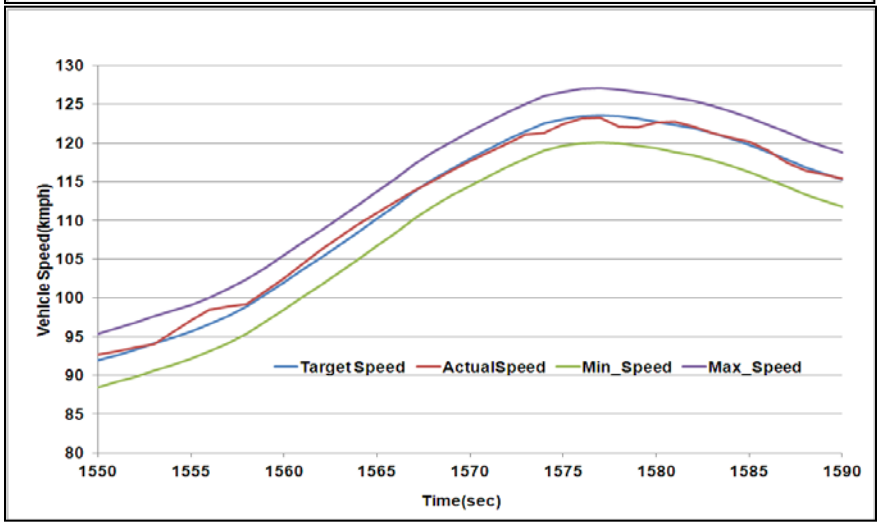
Vehicle F : N_norm_max =120%





Vehicle F : N_norm_max =90%

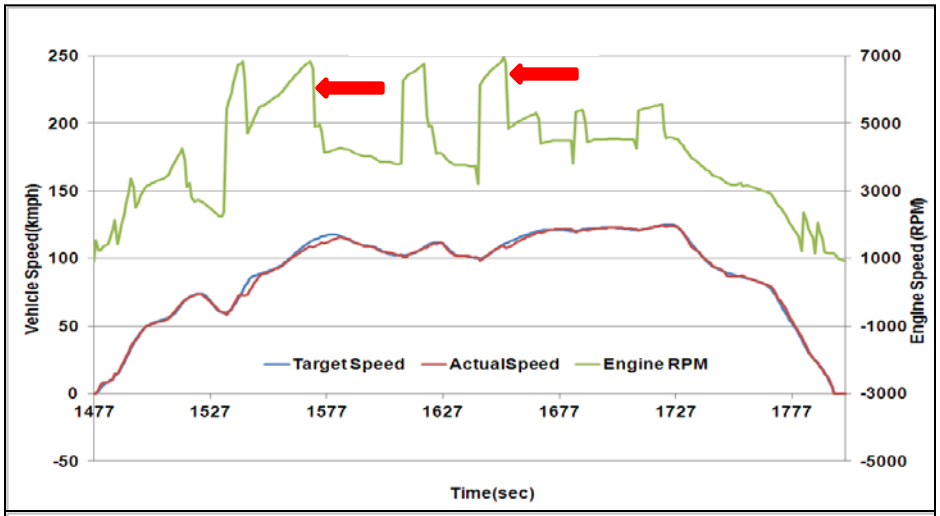


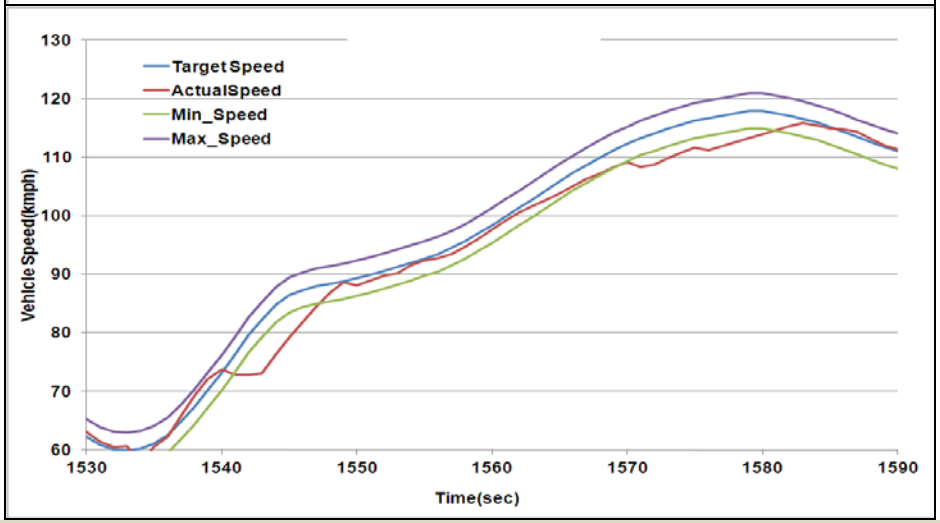


1. With N_norm_max=120% Engine RPM in cycle reaches maximum permissible limit.
2. Fuel Cut results in sudden power loss and deviation from targeted trace, whereas with 90 % n_norm_max vehicle follows the trace . With 120%, artificial downscaling requirements get created

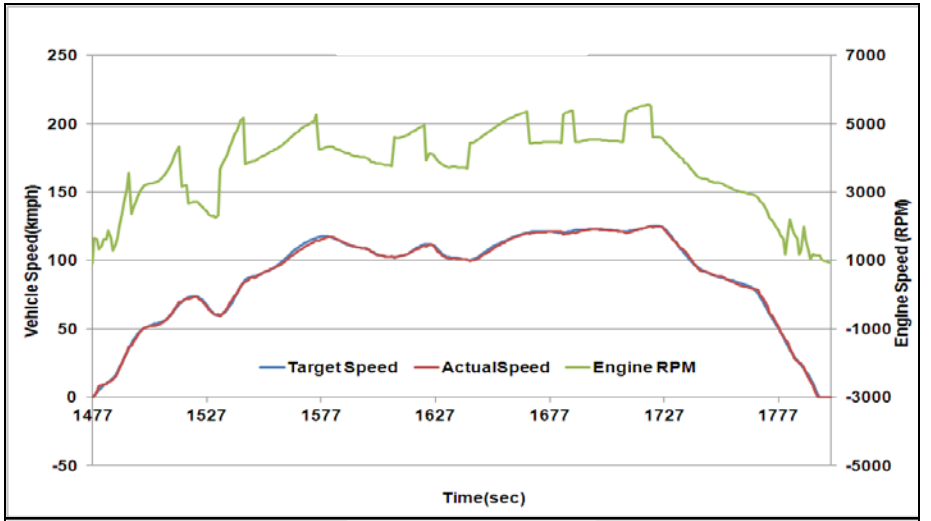
Comparison of N_norm_max =120% and 90% - Vehicle G Class III

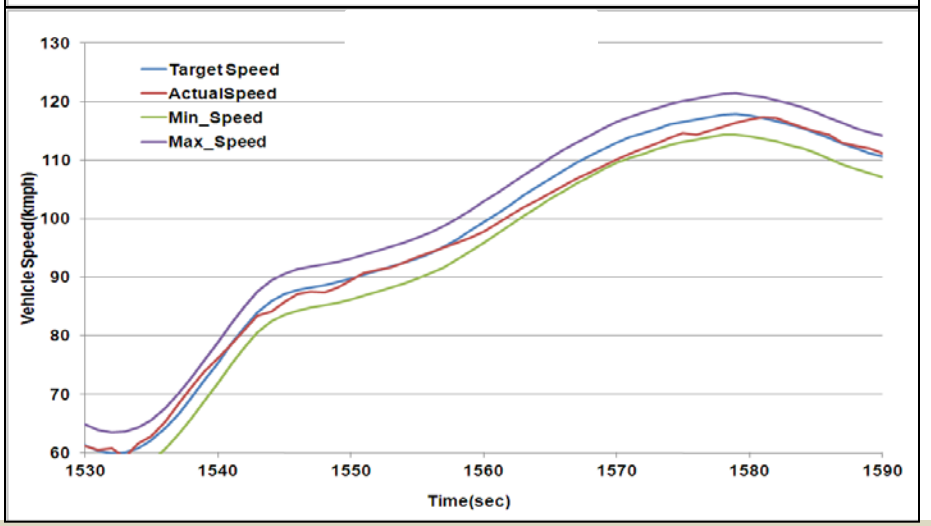
Vehicle G : N_norm_max =120%





Vehicle G : N_norm_max =90%





1. With N_norm_max=120% Engine RPM in cycle reaches maximum permissible limit
2. Fuel Cut results in sudden power loss and deviation from targeted trace, whereas with 90 % n_norm_max vehicle follows the trace.

Concerns with the New Tool

B. R max : $r_{0\_} > 1$ for downscaling applicability.

This means that demand power should be higher than engine rated power

Downscaling proposal

- The downscaling factor f_{dsc} is calculated using the following equation:
- $f_{dsc} = 0$, if $r_{max} < r_0$
- $a_1 * r_{max} + b_1$, if $r_{max} >= r_0$
- The calculation parameter/coefficients r_0, a_1 and b_1 are as follows:.
- $r_0 = 1.053$, $a_1 = 0.54$, $b_1 = -0.5385$ for class 1
- $r_0 = 1.022$, $a_1 = 0.532$, $b_1 = -0.5133$ for class 2
- $r_0 = 1.024$, $a_1 = 0.63$, $b_1 = -0.615$ for class 3.
- The r_0 values are chosen so that the downscaling starts with $f_{dsc} = 3\%$.

Class	r_0
Class I	1.053
Class II	1.022
Class III	1.024

r_{max} is calculated using the following equation:

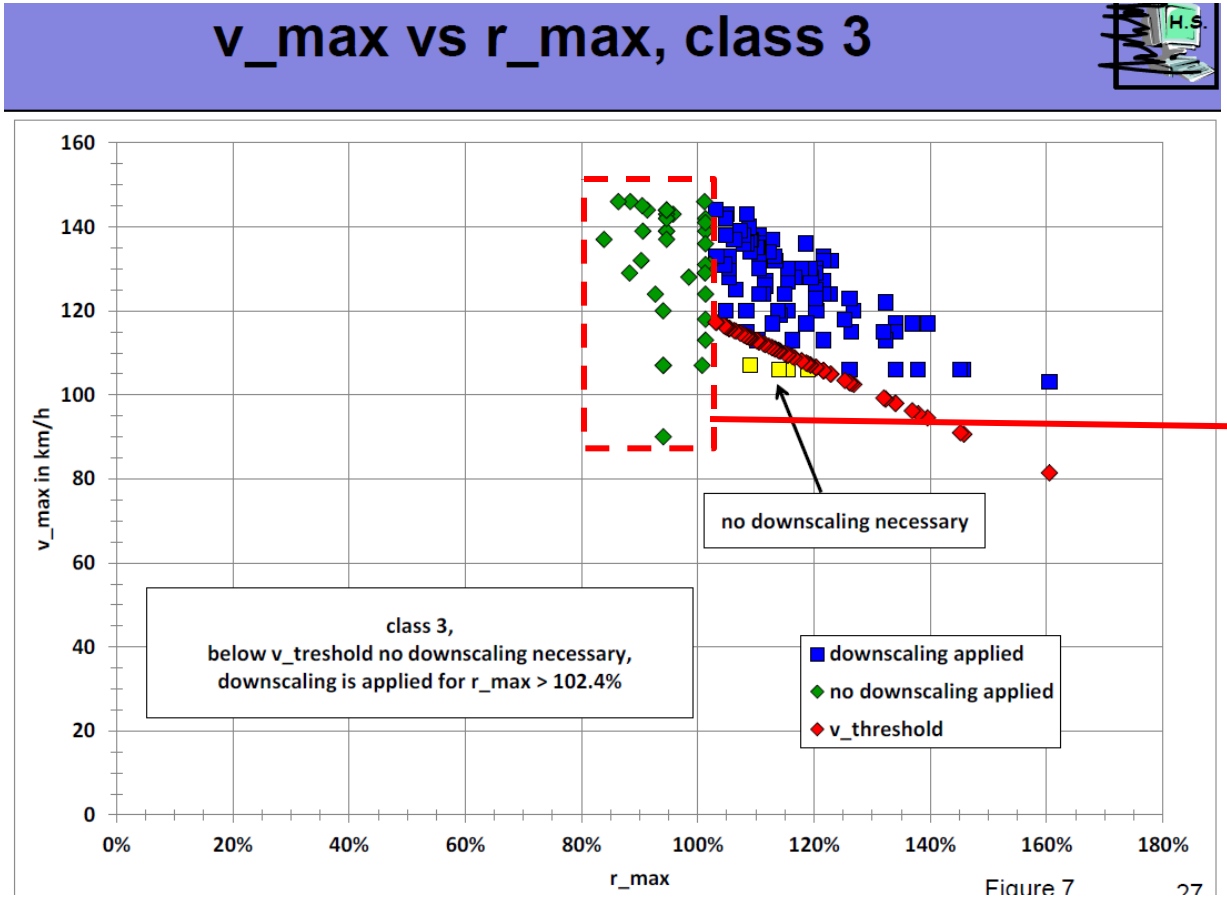
$$r_{max} = P_{req,\,max,i} / P_{rated}$$

Downscaling will be required if **$P_{req,max,i}$** is higher than **P_{rated}**, with a margin

Concerns with the New Tool

B. R max : $r_{0\_} > 1$ for downscaling applicability.

This means that demand power should be higher than engine rated power

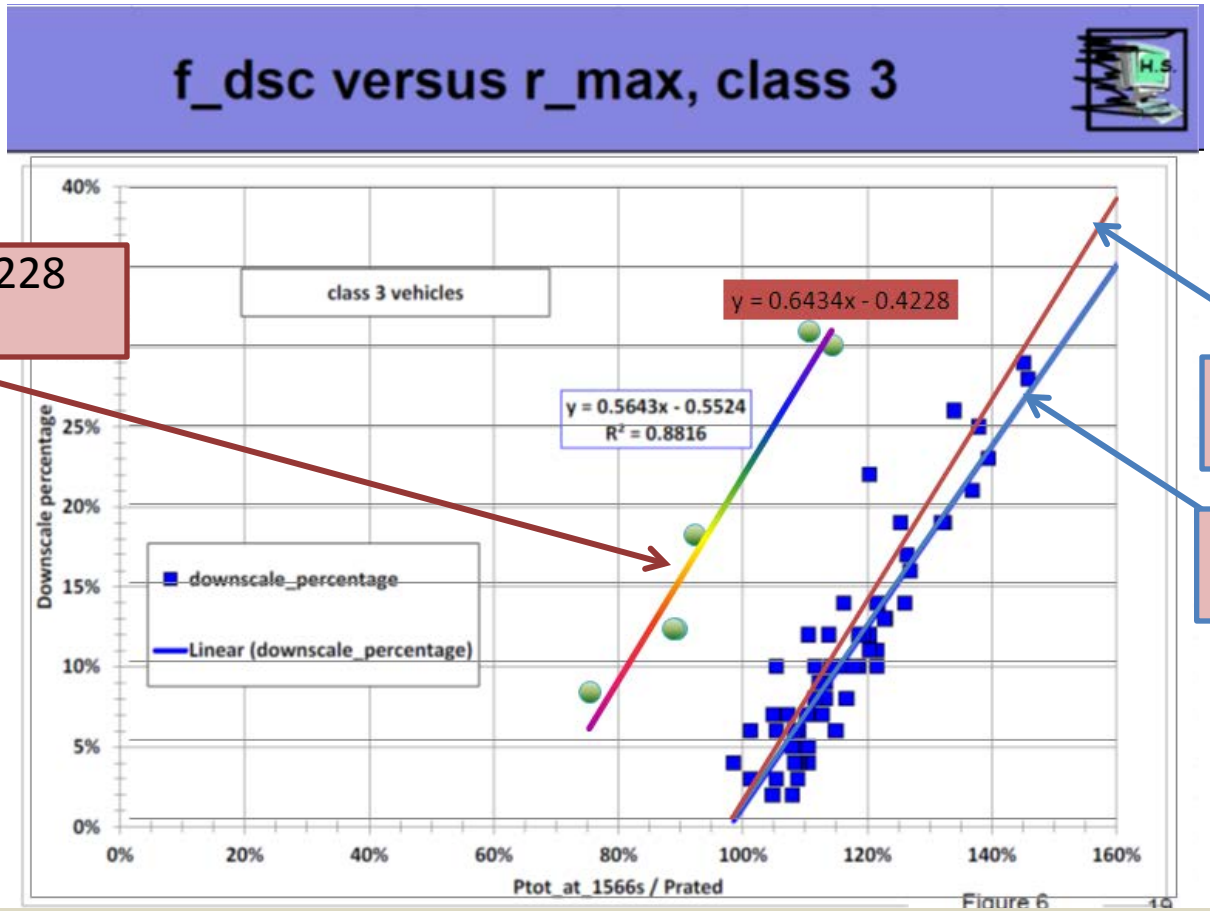


Vehicles may be able to trace the cycle but will have high P_WOT rates

Example: Vehicle with $P_{req,max,i} / P_{rated} = 89\%$.
Vehicle available power = 90%.
Difference is only 1% which will result in high P_WOT.

Downscaling will be required if **$P_{req,max,i}$** is higher than **P_{rated}**, with a margin

Proposal 1– Considering operation times> 90% of available Power

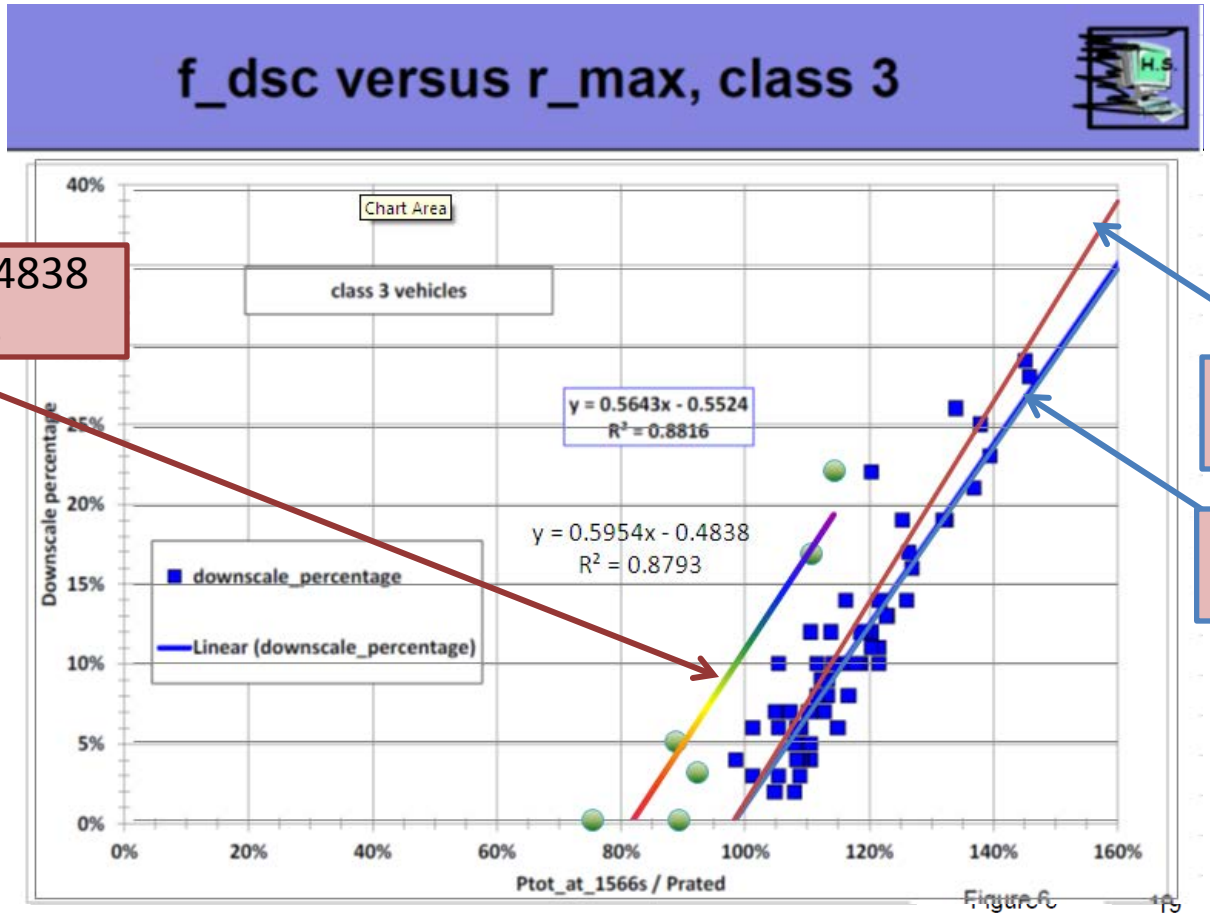


Normal running of vehicles as per road data collected shows near WOT operation < 2%

Considering vehicle running above 90% of available power for ~5% time in EXH phase

Proposal: May give some undue advantage to some vehicles (dropped). EXH operations with required power >90% of available power for 5% of times is equivalent to around 3~4**%** on overall cycle

Proposal 2– Considering operation times> 95% of available Power



Y = 0.5954x-0.4838
R^2=0.8793

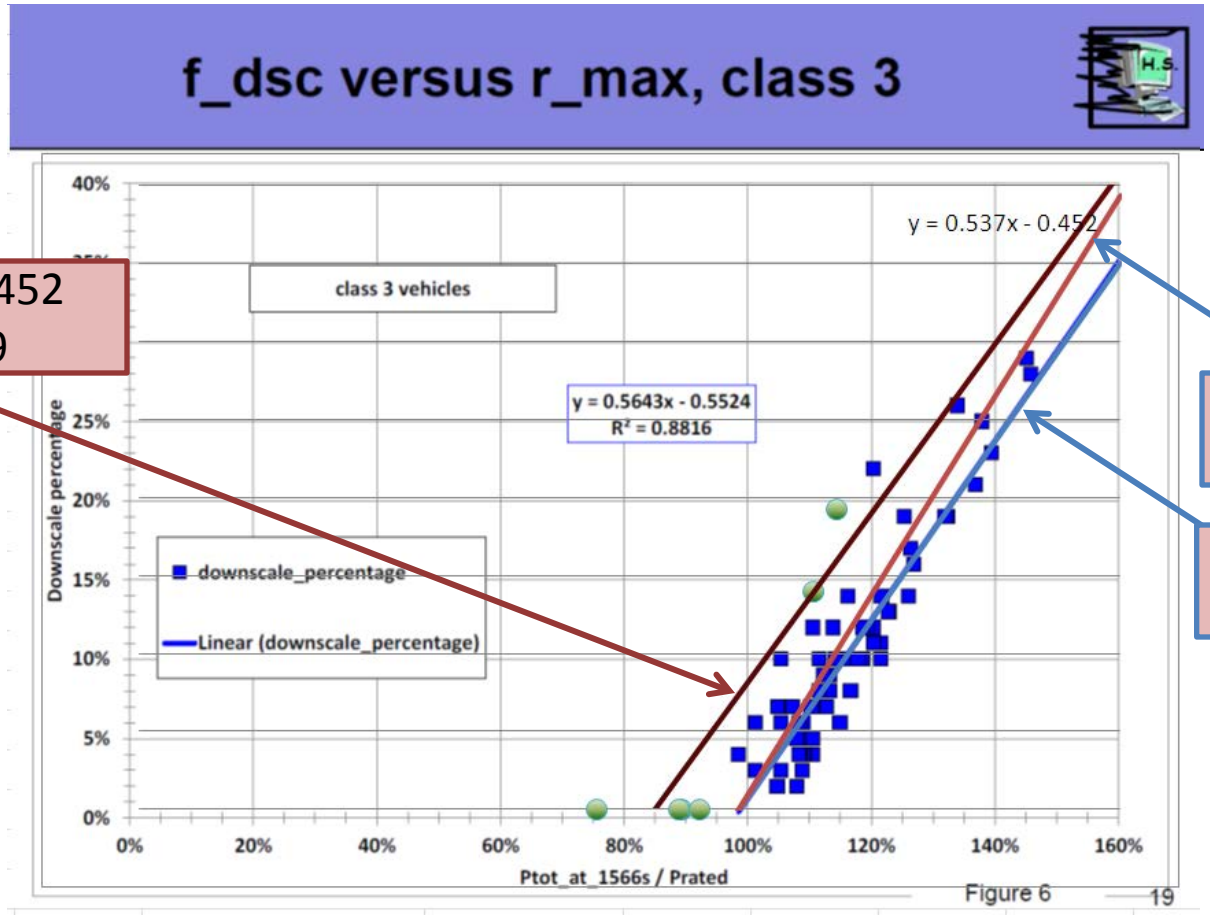
Target line Proposal by HS

Regression line by HS

In order to rationalize further, operation times only above 95% of available power were considered. Criteria was to limit these conditions to 5% of operation times in EXH phase

Proposal: Looks reasonable. EXH operations with required power >95% of available power for 5% of times is equivalent to around **2%** on overall cycle.

Proposal 3– Considering operation times> 95% of available Power



Y = 0.537x-0.452
R^2 =0.8349

Target line Proposal by HS

Regression line by HS

In order to rationalize even further, criteria was changed from 5% to 10% of operation times in EXH phase

Proposal: Will be a worst case criteria for real borderline vehicles. EXH operations with required power >95% of available power for 10% of times is equivalent to around 3% on overall cycle.

Steven Proposal vs Proposal 2 & 3

Parameter	Vehicle	Steven-Proposal	Proposal 2 (EXH P_WOT 5%)	Proposal 3 (EXH P_WOT 10%)
Down- Scaling factor	F	**0%**	4.37%	**2.38%**
	G	**7.90%**	17.17%	**13.92%**
	X1	**10.20%**	19.38%	**15.91%**
	X2	**0%**	0.00%	**0.00%**
WOT Operation EXH Phase	F	**5.60%**	6.8%	**7.1%**
	G	**15.50%**	3.1%	**7.7%**
	X1	**27.90%**	10.2%	**16.1%**
	X2	**4.00%**	4.00%	**4.00%**
WOT Operation Cycle	F	**1.60%**	1.8%	**1.9%**
	G	**4.60%**	2.1%	**3.1%**
	X1	**6.1%**	2.9%	**3.9%**
	X2	**0.70%**	0.70%	**0.70%**
Max Cycle Speed Kmph	F	**131.3**	128.1	**129.6**
	G	**125.6**	119.0	**121.3**
	X1	**122.4**	117.4	**119.8**
	X2	**131.3**	131.3	**131.3**

Based on short validation for downscaling tool, India recommends Proposal 3 for Class III Vehicles. This change does not affect vehicles ≥ 1.0L Engine capacities.

Summary of India‘s Proposal

1) N-Norm_max criteria need to be reverted from 120% back to 90% (original value) to avoid unnatural driving conditions and align with real life driving

2) Based on short validation for downscaling tool, India recommends Proposal 3 for Class III Vehicles (considering 10% WOT operation in EXH Phase and approximately 3% in overall cycle time).

3) Similar criteria to be applied for Class II Vehicles

4) Class I downscaling shows truncation of cycle speed instead of downscaling of cycle. Needs uniformity of concept similar to Class III

Thank You for Your Attention