Gearshift installation and execution documentation

Contents:

Abbreviations:

Matlab tool Dot.NET tool ACCESS tool	Tools that implement the Sub-Annex 1 and Sub-Annex 2 of the COMMISSION REGULATION (EU) 2017/1151 of 1 June 2017 - Annex XXI
WLTC	Worldwide light-duty test cycles
WLTP	Worldwide harmonized Light vehicles Test Procedures

Introduction:

The gearshift tool is based in COMMISSION REGULATION (EU) 2017/1151 of 1 June 2017 - Annex XXI sub-Annex 1 and 2, using Python as programming language, in the same way that Heinz Steven tool, dot.net and access tool.

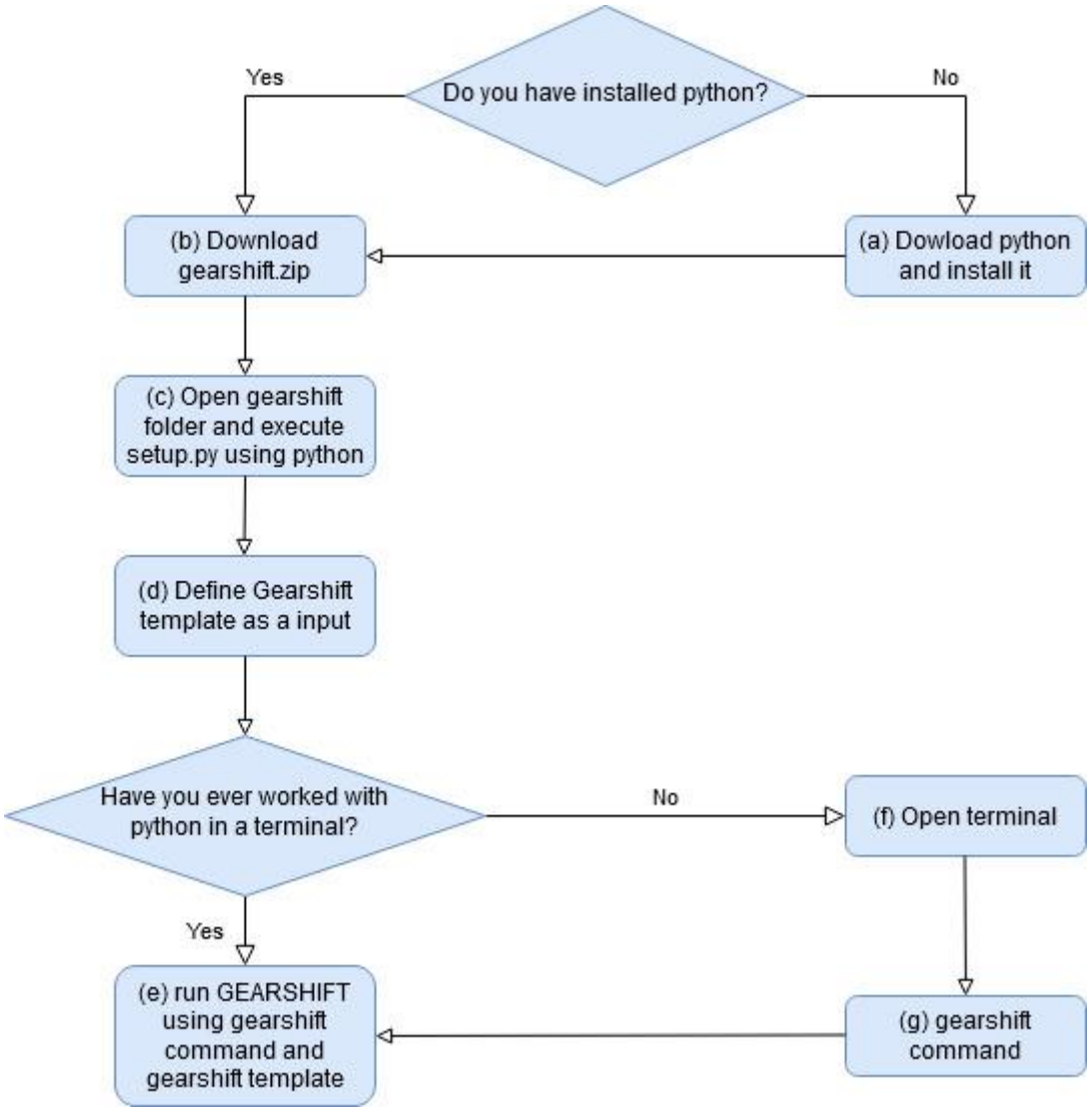
The aim of the Gearshift tool is obtain the Required Engine Speeds, the Available Powers, the Required Vehicle Speeds and the Gears for the whole WLTC based on the vehicle characteristics. The model should allow accurate calculation of final trace and the operating conditions of the engine.

The model of Gearshift tool is based in the Heinz Steven tool, having as input parameters those defined in this tool, for more information about these, please read:
https://docs.google.com/document/d/1yMSqYfS_vFp5LvakdrFFyD2otADGNnCZTIwkz7AMyX8/edit#heading=h.9c9hhgsc6v2u

Installation:

In this section we will provide a step-by-step guide on how to install GEARSHIT tool and its dependencies.

The following flow provides a visual guide of the process:



a) Python Installation:
To download python you must go to:
https://www.python.org/downloads/release/python-379/
and download the suitable python version for your operating system.

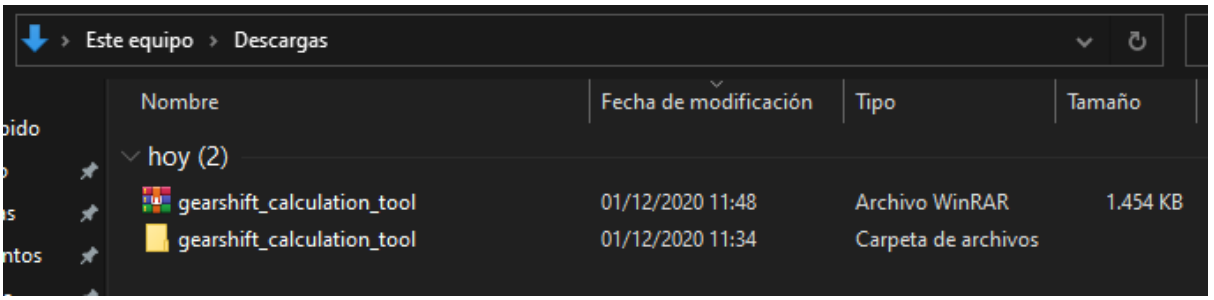
If your operating system is Windows the faster installation is using the executable installer. If you are not familiar with the process , please follow the instructions on the following link:
https://tutorial.djangogirls.org/en/python_installation/
Observation: When you install python, make sure that you are installing python 3 and that the option to "Add Python 3.X to PATH" is checked.

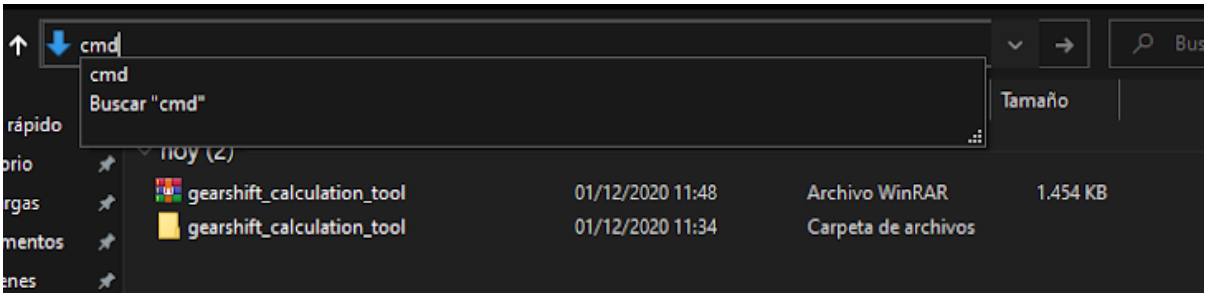
b) GEARSHIFT Installation:

To download gearshift.zip file you must go to:
https://jrcbox.jrc.ec.europa.eu/index.php/s/94n1yDSh9136Rw6
The requested password is: **GEARSHIFT.2020**

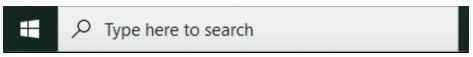
c) Execution of setup.py:

To execute *setup.py* script it is necessary to open the windows terminal in the gearshift_calculation_tool folder. To do this you only need to write cmd in the top bar that contains the folder path and press enter.





Alternatively, you can write cmd directly in the search bar from Windows 7 and open the Command Prompt app.

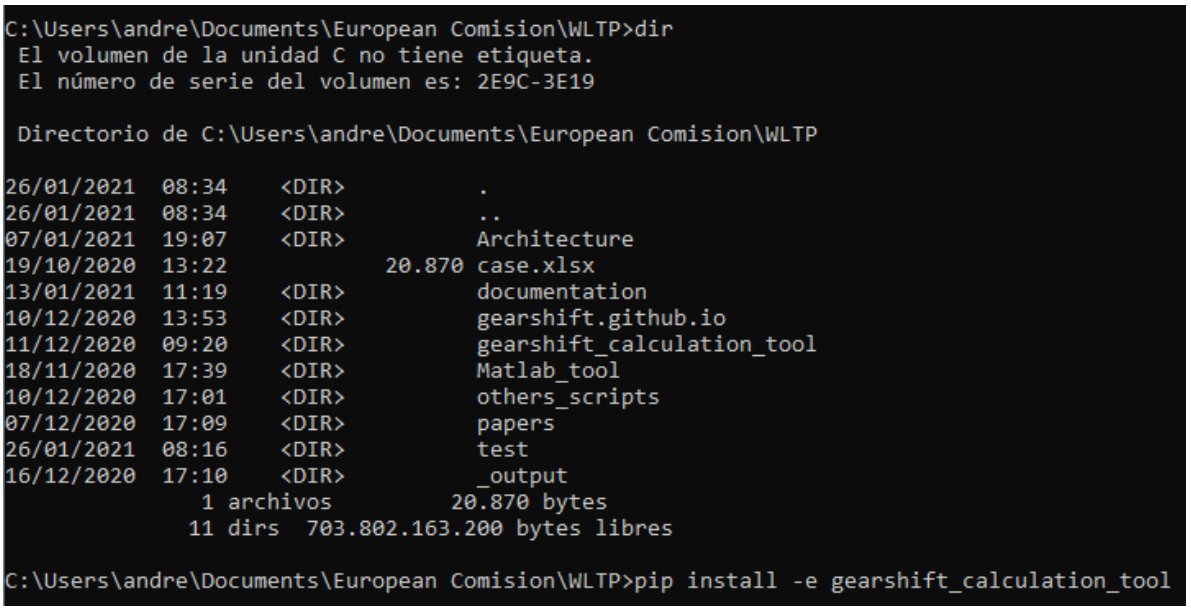


Once the terminal is open, navigate to the gearshift_calculation_tool folder and execute the setup.py script using the following pip sentence (pip is the standard package manager for Python):

pip install -e ./path_to_the_repository_downloaded/gearshift_calculation_tool

In our case (the rar is in the download folder and the cmd also):
pip install -e gearshift_calculation_tool

You can see how execute this command in the cmd in the following image:



In this case the folder *gearshift_calculation_tool* is in the WLTP folder (you can see this using the command dir in windows or ls in mac or linux).

Execution:

d) Get GEARSHIFT template:

To run GEARSHIFT you should use an excel file. To obtain the excel input file you have two options:

1. Using gearshift command:
   In the cmd terminal you can write:
   gearshift demo
   This command creates a folder that contains the excel input template. You can also write:
   gearshift demo "path_to_save_templates"
   This command saves the excel input template in *path_to_save_templates*.
2. copying the template:
   You can go to:
   gearshift_calculation_tool\gearshift\demos
   And copy the excel template in the folder that you want to edit it.

All parameters are described in the excel file.

e) and g) Run GEARSHIFT:
First, you need to define the GEARSHIFT input template. Please see the following section for that.

To run GEARSHIT tool in the terminal you need to execute the following command (**in the same terminal as the one that you have used in the GEARSHIFT too Installation section**):

gearshift run "path_input_file" -O "path_to_save_output_file"

- **path_to_file:** Path of excel file
- **path_to_save_output_file:** Path in which you want to save to output files

For example:
run "..\..\gs_input_demo_test.xlsx" -O "..\..\output_folder"

f) Open terminal:
To open a terminal you can follow the instructions of the section c).

Inputs:

The input file of the GEARSHIFT tool is an excel file, structured in different sheets. We will use the same structure to describe the input parameters:

- **Case**
  The case sheet contains a list of cases that the tool will run. In this sheet we can find the following parameters:

Name	Description	Regulation Reference
case	Execution Case	--
vehicle	Execution Vehicle	--
do_dsc	Apply Downscaling	Paragraph 8 of Sub-Annex 1
do_cap	Apply Speed Cap	Paragraph 9.1 of Sub-Annex 1
do_cmp	Apply Distance Compensation	Paragraph 9.2.1 of Sub-Annex 1
calc_dsc	Use Calculated Downscaling	Paragraph 8.2 of Sub-Annex 1

	Percentage	
f_dsc	Downscaling Percentage	Paragraph 8.2 of Sub-Annex 1
v_cap	Capped Speed	Paragraph 9.1 of Sub-Annex 1
class	Class (1, 2, 3a, 3b)	Paragraph 2 of Sub-Annex 1
n_min1	Minimum Drive Engine Speed 1st	Paragraph 2, point k of Sub-Annex 2
n_min12	Minimum Drive Engine Speed 1st To 2nd	Paragraph 2, point k, subpoint 2 (i) of Sub-Annex 2
n_min2d	Minimum Drive Engine Speed 2nd Deceleration	Paragraph 2, point k, subpoint 2 (ii) of Sub-Annex 2
n_min2	Minimum Drive Engine Speed 2nd	Paragraph 2, point k, subpoint 2 (iii) of Sub-Annex 2
n_min3	Minimum Drive Engine Speed Greater 2nd	Paragraph 2, point k, subpoint 3 of Sub-Annex 2
n_min3a	Minimum Drive Engine Speed Greater 2nd Acceleration	Paragraph 2, point k, subpoint 3 of Sub-Annex 2
n_min3d	Minimum Drive Engine Speed Greater 2nd Deceleration	Paragraph 2, point k, subpoint 3 of Sub-Annex 2
n_min3as	Minimum Drive Engine Speed Greater 2nd Acceleration Start Phase	Paragraph 2, point k, subpoint 3 of Sub-Annex 2
n_min3ds	Minimum Drive Engine Speed Greater 2nd Deceleration Start Phase	Paragraph 2, point k, subpoint 3 of Sub-Annex 2
t_start	Time End Of Start Phase	Paragraph 1.2.4 of Annexes to the test report
supp0	Suppress Gear 0 During Downshifts	Paragraph 4, point f of Sub-Annex 2
excl1	Exclude Crawler Gear	Paragraph 2, point j of Sub-Annex 2
autom	Automatic Clutch Operation	Paragraph 1.5 of Sub-Annex 2
n_lim	Engine Speed Limit VMax	Paragraph 2, point i of Sub-Annex

		2
asm_0	Additional Safety Margin	Paragraph 3.4 of Sub-Annex 2
n_asm_s	Start Engine Speed	Paragraph 3.4 of Sub-Annex 2
n_asm_e	End Engine Speed	Paragraph 3.4 of Sub-Annex 2

- **Vehicle**
  The vehicle sheet contains a list of vehicles along with their characteristics. In this sheet we can find the following parameters:

Name	Description	Regulation Reference
vehicle	Vehicle identification	--
p_rated	Rated Engine Power	Paragraph 2, point a of Sub-Annex 2
n_rated	Rated Engine Speed	Paragraph 2, point b of Sub-Annex 2
n_idle	Idling Engine Speed	Paragraph 2, point c of Sub-Annex 2
n_max1	Max95 Engine Speed	Paragraph 2, point g of Sub-Annex 2
#g	Number Of Gears	--
m_test	Vehicle Test Mass	Paragraph 2, point l of Sub-Annex 2
f0	The constant road load coefficient	Paragraph 2.4 of Sub-Annex 4
f1	The linear road load coefficient	Paragraph 2.4 of Sub-Annex 4
f2	The quadratic road load coefficient	Paragraph 2.4 of Sub-Annex 4
SM	Safety Margin	Paragraph 3.4 of Sub-Annex 2

- **Engine**
  The engine sheet contains the vehicle's full load curves. In this sheet we can find the following parameters:

Name	Description	Regulation Reference
vehicle	Vehicle identification	--
n	Full Power Curve	--
p		Paragraph 2, point h of Sub-Annex 2
ASM	Additional Safety Margin	Paragraph 3.4 of Sub-Annex 2

- **Gearbox Ratios**
  The gearbox ratios sheet contains the gearbox transmission ratios. In this sheet we can find the following parameters:

Name	Description	Regulation Reference
vehicle	Vehicle identification	--
gear	Gear	--
ndv	Gearbox Ratios	Paragraph 2, point e of Sub-Annex 2

Outputs:

After GEARSHIFT execution, you will find the output files in the path defined in the command line (see section '*Execution*').

The output of GEARSHIFT execution is an excel file structured in different sheets. The following is a description of the different output values for each sheet:

- **Summary**
  The Summary sheet contains a different parameters that have been calculated to obtain the outputs i.e. this sheet contains the used parameters to obtain the gears that will be used during the WLTC. In the following table you can find a description of each of these parameters:

Name	Description	Type
case	Execution Case	integer
No Of Gears	Number Of Gears	integer
Required To Rated Power Ratio	Required To Rated Power Ratio	float
Downscaling Factor	Downscaling Factor	float
Calculated Downscaling Percentage	Calculated Downscaling Percentage	float
Total Checksum	Total Checksum	float
Max Vehicle Speed	MaxVehicleSpeed in km/h of the applicable trace	float
Total Distance	TotalDistance in m of the applicable trace	float
Average Gear Output	Sub-Annex 2 in section 5. In order to enable the assessment of the correctness of the calculation, the average gear for v >= 1 km/h, rounded to four places of decimal, shall be calculated and recorded.	float
Adjusted Max95 Engine Speed	Sub-Annex 2 in section 2g $n_{max1} = n_{95_{high}}$ adjusted. If $n_{95_{high}}$ cannot be determined because the engine speed is limited to a lower value n_lim for all gears and the corresponding full load power is higher than 95 percent of rated power, n_95_high shall be set to n_lim.	float
Max Engine Speed Cycle Output	Sub-Annex 2 in section 2g $[n_{max2}]$, $n_{max2} = \frac{n}{v} * ng_{vmax} * v_{max,cycle}$. The engine speed for the maximum vehicle speed of the trace using the gear in which the maximum vehicle speed can be reached.	float
Max Engine Speed Reachable	Sub-Annex 2 in section 2g $[n_{max3}]$, $n_{max3} = \frac{n}{v} * ng_{vmax} * v_{max,vehicle}$. The engine speed for the maximum vehicle speed reachable	float

Output	using the gear in which the maximum vehicle speed can be reached.	
Max Engine Speed Output	Sub-Annex 2 in sections 2g and 2h [n_{max}], $n_{max} = max(n_{max1}, n_{max2}, n_{max3})$. The power curve shall consist of a sufficient number of data sets. The last data set shall be at n_{max} or higher engine speed.	float
Max Vehicle Speed Cycle Output	Sub-Annex 2 in section 2g [$v_{max,cycle}$]. The maximum vehicle speed of the trace using the gear in which the maximum vehicle speed can be reached.	float
Max Vehicle Speed Reachable Output	Sub-Annex 2 in sections 2g and 2i [$v_{max,vehicle}$]. The maximum vehicle speed reachable using the gear in which the maximum vehicle speed can be reached.	float
Gear Max Vehicle Speed Reachable Output	Sub-Annex 2 in sectio 2i [ng_{vmax}].The gear in which the maximum vehicle speed is reached.	float
Min Drive Engine Speed 1st Output	Sub-Annex 2 in section 2k [$n_{min_{drive}} = n_{idle}\ for\ n_{gear}: 1$]. The minimum engine speed when the vehicle is in motion. This is the maximum of calculated value and input parameter value.	float
Min Drive Engine Speed 1st To2nd Output	Sub-Annex 2 in section 2ka [$n_{min_{drive}} = 1.15 * n_{idle}\ for\ n_{gear}: 1\ to\ 2$] The minimum engine speed for transitions from first to second gear. This is the maximum of calculated value and input parameter value.	float
Min Drive Engine Speed 2nd Decel Output	Sub-Annex 2 in section 2kb [$n_{min_{drive}} = n_{idle}\ for\ n_{gear}: 2$] The minimum engine speed for decelerations to standstill in second gear. This is the maximum of calculated value and input parameter value.	float
Min Drive Engine	Sub-Annex 2 in section 2kc [$n_{min_{drive}} = 0.9 * n_{idle}\ for\ n_{gear}: 2$]	float

Speed 2nd Output	The minimum engine speed for all other driving conditions in second gear. This is the maximum of calculated value and input parameter value.	
Min Drive Engine Speed Greater 2nd Output	Sub-Annex 2 in section 2k $[n_{min_{drive}} = n_{idle} + 0.125 * (n_{rated} - n_{idle}) \; for \; n$ This value shall be referred to as n_min_drive_set. The minimum engine speed for all driving conditions in gears greater than 2. This is the maximum of calculated value and input parameter value.	float
Checksum Vx Gear Output	Checksum of $v * gear \; for \; v >= 1 \; km/h$rounded to four places of decimal	float

- **Required Engine Speeds Output**

  The Required Engine Speeds Output sheet contains the Required Engine Speeds for each gear that will be used during the WLTC. This is defined in Sub-Annex 2 in the section 3.1 $[P_{required,j}]$ as the power required to overcome driving resistance and to accelerate for each second j of the cycle trace.

- **Available Powers Output**

  The Available Powers Output sheet contains the Available Powers for each gear that will be used during the WLTC. This is defined in Sub-Annex 2 in the section 3.2 $[n_{i,j}]$ as the power available for each gear "i" from 1 to ng and for each second j of the cycle trace. Note that this power values are determined from uncorrected values $n_{i,j}$ i.e. without the engine speed increments required by Sub-Annex 2 (3.3).

- **Time Series**

  The Time Series sheet contains all values that change over time i.e. all values that have a different value each second during the WLTC. In the following table you can find the description of each value:

Name	Description	Type
Trace Times Output	Times for the vehicle speed required re-sampled in 1Hz	integer array
Required Vehicle	The vehicle speed required for the	float array

Speeds Output	whole cycle re-sampled in 1Hz	
Required Powers Output	Sub-Annex 1 in the section 8.3 v_i interpolated. The interpolated vehicle speeds (second by second).	float array
Gears Output	Array of gears copied from InitialGears, which are also merged into the parameter GearsOutput. Opposite to CalculatedGearsOutput the gear values are not condensed here.	integer array
Clutch Disengaged Output	Array of booleans copied from ClutchDisengaged, which are also merged into the parameter GearsOutput. Opposite to CalculatedGearsOutput the clutch values are not condensed here.	boolean array
Clutch Undefined Output	Array of booleans copied from ClutchUndefined, which discriminates clutch disengaged sub-states.	boolean array
Clutch H S T Output	Array of clutch state names as used by the Heinz Steven Tool (HST).	string array
Gear Corrections Output	Array of gear correction strings for debugging. This contains a historic transformation of each gear during all execution and the transformation applied.	string array

- **Original Trace**
  The Original Trace sheet contains the initial trace before applying the necessary corrections interpolated in 1Hz. It consists of time series and vehicle speeds.

- **Applicable Trace**
  The Applicable Trace sheet contains the trace after applying the necessary corrections interpolated in 1Hz. It consists of time series and vehicle speeds.

Annex I:

The inputs parameters are described in the excel file and the reference of the documentation is present in Inputs section, therefore in the table below we have created the name and type of each parameter:

Name	Description	Type
case	Execution Case	integer
vehicle	Execution Vehicle	integer
do_dsc	Apply Downscaling	boolean
do_cap	Apply Speed Cap	boolean
do_cmp	Apply Distance Compensation	boolean
calc_dsc	Use Calculated Downscaling Percentage	boolean
f_dsc	Downscaling Percentage	float
v_cap	Capped Speed	float
class	Class (1, 2, 3a, 3b)	string
n_min1	Minimum Drive Engine Speed 1st	float
n_min12	Minimum Drive Engine Speed 1st To 2nd	float
n_min2d	Minimum Drive Engine Speed 2nd Deceleration	float
n_min2	Minimum Drive Engine Speed 2nd	float
n_min3	Minimum Drive Engine Speed Greater 2nd	float
n_min3a	Minimum Drive Engine Speed Greater 2nd Acceleration	float
n_min3d	Minimum Drive Engine Speed Greater 2nd Deceleration	float
n_min3as	Minimum Drive Engine Speed Greater 2nd Acceleration Start Phase	float
n_min3ds	Minimum Drive Engine Speed Greater 2nd Deceleration Start Phase	float
t_start	Time End Of Start Phase	integer
supp0	Suppress Gear 0 During Downshifts	boolean

excl1	Exclude Crawler Gear	boolean
autom	Automatic Clutch Operation	boolean
n_lim	Engine Speed Limit VMax	float
asm_0	Additional Safety Margin	float
n_asm_s	Start Engine Speed	float
n_asm_e	End Engine Speed	float
vehicle	Vehicle identification	integer
p_rated	Rated Engine Power	float
n_rated	Rated Engine Speed	float
n_idle	Idling Engine Speed	float
n_max1	Max95 Engine Speed	float
#g	Number Of Gears	integer
m_test	Vehicle Test Mass	float
f0	The constant road load coefficient	float
f1	The linear road load coefficient	float
f2	The quadratic road load coefficient	float
SM	Safety Margin	float
vehicle	Vehicle identification	integer
n	Full Power Curve	float
p		float
ASM	Additional Safety Margin	float
vehicle	Vehicle identification	integer
gear	Gear	integer
ndv	Gearbox Ratios	float