Submitted by the expert from OICA

Informal document **GRPE-77-08**
77th GRPE, 6-8 June 2018
Agenda item 13,

HD FE Harmonization

OICA
HD-FE TF
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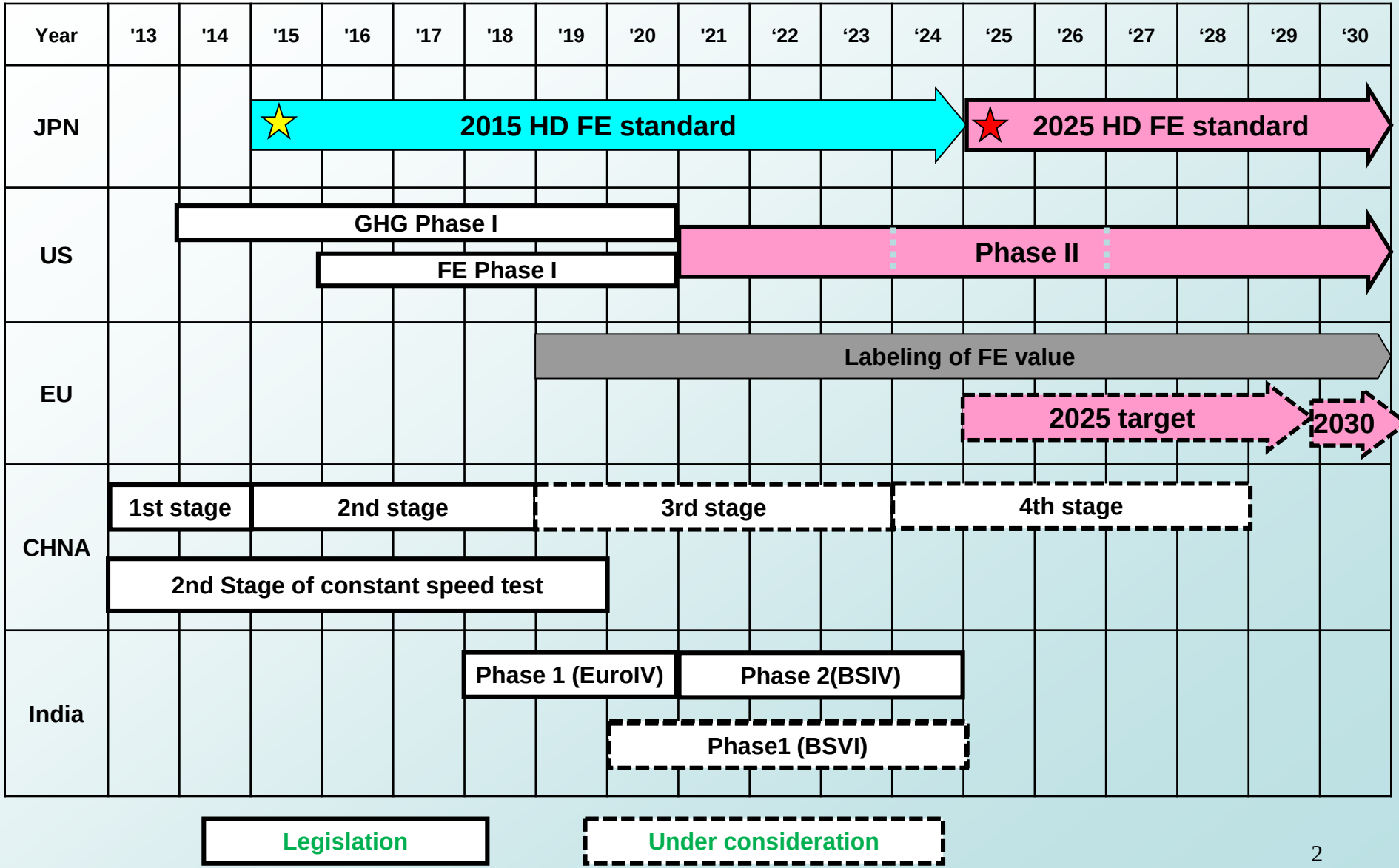
HD FE regulatory schedule in each area



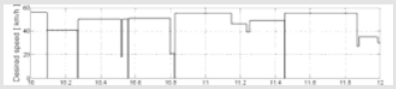
Example of FE Measurement

There are 3 major pillars of a simulation based CO2 declaration method: Simulation tool, certified input data and representative boundary conditions.

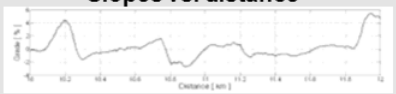
Pillar 3 – Representative boundary conditions

Cycles for each vehicle class

Target speed vs. distance



Slopes vs. distance



Trailer/body specification

Specification of one standard trailer and/or body for each vehicle class

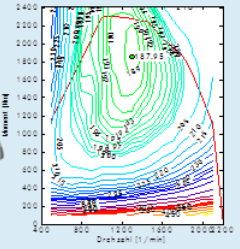
Metrics

g/t-km
g/passenger-km

Weight definition

Vehicle class specific weight definition for simulation and input data test

Pillar 2 – Certified input data



Engine fuel map & torque curve
Air drag
Transmission drag
Driven axle drag
Rolling resistance

Vehicle configuration
Weight
Transmission ratios
Axles ratios
Tire type & size
Auxiliary specifications
Technology specifications

Pillar 1 – Simulation tool

Tool

Physical models
Driver model
Control models
Technology models
& generic values

Simulation results

⇨ CO2 values
⇨ FC values
⇨ Average speed

+

Benefits by ECO-features

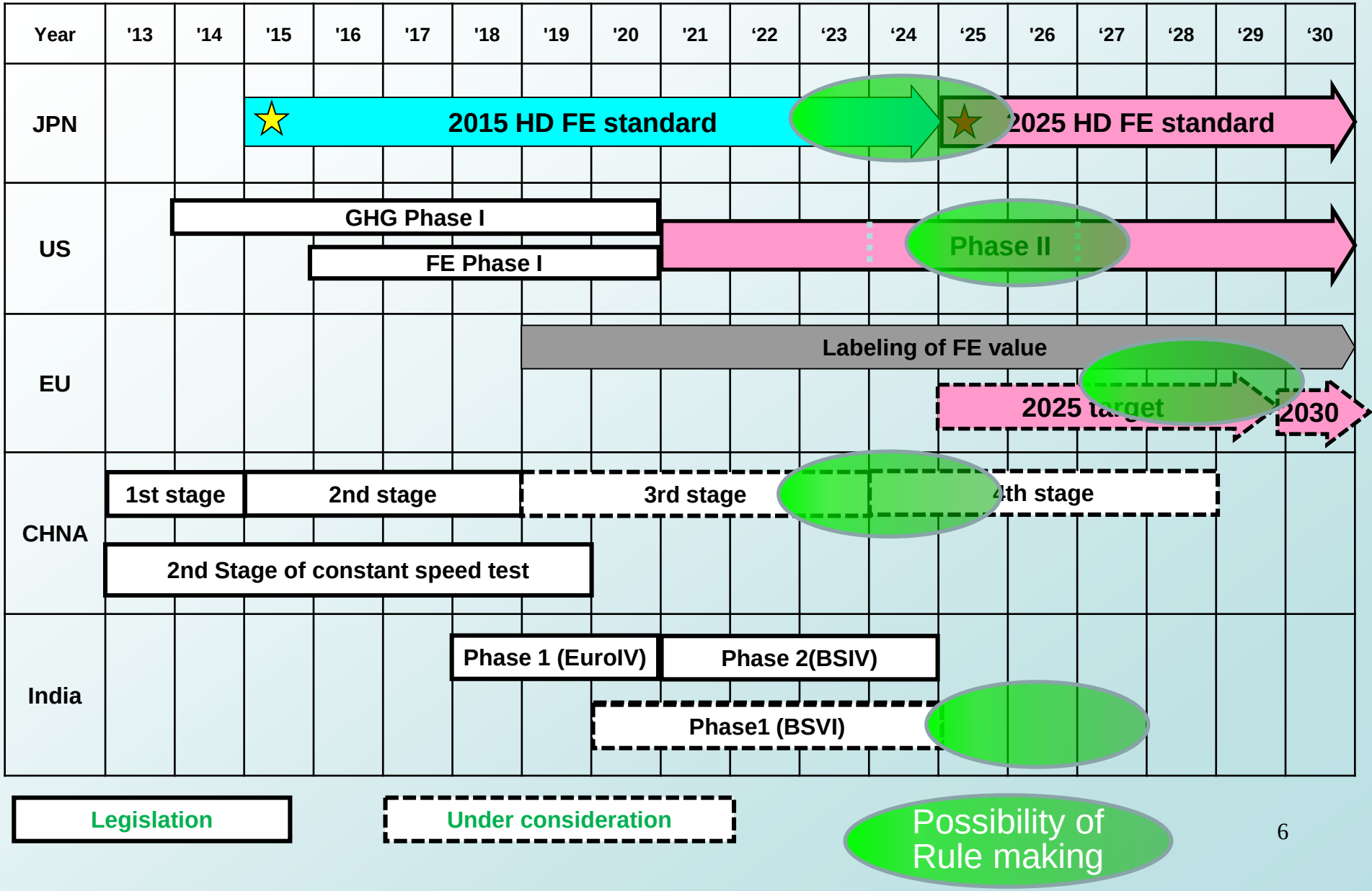
Elements FE regulation including measurement method

Elements	Sub-Elements	Issues	Examples
FE Unit	-	Transport efficiency or easily understand able unit	- km/L - ton.km/L
Others	Criteria	Limit of FE value or average value	- Averaged by number of sales (CAFE)
Vehicle classification	-	Simpler category is desired, but needs to reflect to real world complexity	- Vehicle type (Tractor, bus….etc) - GVW, type of cabin
Items of FE effect	-	Accuracy vs. cost of measurement Contribution for FE	- Engine, T/M - Aero dynamic and rolling resistance
Driving Mode	-	Vehicle speed base or road data base less complexity vs real world reflection	- Combination of two cycles - Unique mode for each vehicle type
Measurement Method	Chassis dynamometer	Chassis dynamometer measurement requires real vehicle	
	Simulation	Driver model is required for simulation	- Common calculation logic - Difference of steady and transient
	Engine measurement	Number of measurement points Transient operation effect	- CO2 measurement by engine - Engine FE map and simulation
	Aero dynamic measurement	Measurement methods Selection of vehicle type, rear body	- Coast down, steady speed drive - CFD - Wind tunnel
	Tyre rolling resistance	Measurement method, labeling	- Common tyre measurement method - How to handle a number of axis
	Others	Measurement method	- Driveline drag, Auxiliary drag, etc

FE Elements in each Area

Item		Sub-item	Status of each region			
			EU	US (Phase Ⅱ)	China	Japan (Next FES)
Categorize			Axles, Configurations, Weight	Weight Cab type	Vehicle type Weight	Vehicle type Weight
FE Unit			CO_2 g/ton-km g/passenger-km	gal/1000ton-mile CO_2 g/ton-mile	L/100km	km/L
FE Criteria			Consider after labeling	Becomes strict every 3 years	Becoming strict in 2019	FES value around 2025 is decided this year
Mode			10type	ARB tangents 55,65 mph	C-WHVC	JE05, Inter city
Measurement method	Engine	Steady state Engine Map	100 points	70points for 55,65 mph	81 points	51 points
		Transient Engine Map	NA	Cycle average map	NA (Include chassis dyno)	NA
		Transient coefficient	WHTC correction factor tool	Include Cycle average map	NA (Include chassis dyno)	Table value 3%
	Powertrain	FE map with powertrain	For Hybrid, AT, AMT by simulation	For Hybrid, AT, AMT by powertrain test	NA	For Hybrid and AMT by simulation
	Gear	T/M efficiency	Table value or Measurement	Table value or Measurement	NA (Include chassis dyno)	Table value
		AT parts efficiency	Table value or Measurement	Include powertrain test method	NA (Include chassis dyno)	Table value or Measurement
		Axle efficiency	Table value or Measurement	Table value or Measurement	NA (Include chassis dyno)	Table value
	Aero Drag	Aero Drag measurement	Constant speed Simulation	Coast down Wind tunnel CFD	Table value (Opt. Wind tunnel or coast down)	Coast down or Constant speed
		Vehicle select method	Family Concept	?	?	Family Concept
	Tire	Resistance measurement	(EC) 1222/2009 = ISO28580	ISO28580	Table value	Ranking by ISO28580
		Resistance select Method	Direct input of tire RRC for each vehicle	Direct input of tire RRC for each vehicle	-	Averaging tire RRC to be used
	auxiliary parts		Generic or OEM-specific	?	NA	Only installed when measuring engine
Determine FE value	Simulation	Input data & Logic	Input data and driver model is different based on item above			
	Chassis dyno		NA	NA	Must family-representative vehicle	NA

HD FE regulatory schedule in each area



Steps for Harmonization

Elements	Sub-Elements	Issues	Examples
FE Unit	-	Transport efficiency or Easy to understand for everybody	- km/L - ton.km/L
Others	Criteria	Limit of FE value or average value	- Averaged by number of sales - CAFÉ
Vehicle classification		Simpler category is desired but needs to reflect to real world complexity	- Vehicle type (Tractor, bus….etc) - GVW, type of cabin
Items of FE effect	-	Accuracy vs. cost of measurement Contribution for FE	- Engine, T/M - Aero dynamic and rolling resistance
Driving Mode	-	Vehicle speed base or road data base less complexity vs real world reflection	- Combination of two cycles - Unique mode for each vehicle type
Measurement Method	Chassis dynamometer	Should Chassis dynamometer measurement be used	
	Simulation	Should simulation be used Driver model contents	- Common calculation logic - Difference of steady and transient
	Engine measurement	Number of measurement points Transient operation effect	- CO2 measurement by engine - Engine FE map and simulation
	Aero dynamic measurement	Measurement methods Selection of vehicle type, rear body	- Coast down, steady speed drive - CFD - Wind tunnel
	Tyre rolling resistance	Measurement method, labeling	- Common tyre measurement method - How to handle a number of axis
	Others	Measurement method	- Driveline drag, Auxiliary drag, etc

Second step

First step

Summary

- FE legislation is increased in these 10 years and will increase more in future. This is big burden for manufactures.
- Several rules are updated but not harmonized, rather sometimes unique rules are introduced based on each governmental policy.
- Simulation is adopted in each rule and exist 4 different software. It may increase in future.
- It seems each rule will be updated in near future. Several countries is planning to introduce FE legislation near future. Harmonize rule should be prepared as soon as possible not to miss the chance of harmonization.
- It is recommended to separate two steps for HD FE harmonization to be effective in short time. FE measurement GTR is recommended as 1st step.
- It is strongly recommended by OICA/GEPE that the WS to share the information on this matter and consider about suitable action in future will be organized in next GRPE.

Technical Information

Major Elements of FE Measurement

- Driving cycle
- Simulation
- Engine measurement
- Driving Resistnace

Key Elements of FE Measurement

Driving Cycle

Driving cycle defines the driving conditions to evaluate the fuel consumption.

Two types of driving cycle are adopted in.

A: Time and vehicle speed

B: Distance and target speed

Item	Status of each region				Remarks
	EU	US (Phase Ⅱ)	China	Japan (FES 2025)	
Type	**B** Distance and target speed	**A** Time and speed	**A** Time and speed	**A** Time and speed	B requires more realistic driver model
Number of cycle types	**10**	**4**	**3**	**2**	Although there are few types of cycles other than EU, weighting factor is changed for each vehicle category.
Details of cycle	• Trucks:5 • City Bus:3 • Bus:2	• ARB tangents • 55 mph • 65 mph • Idle Above four kinds of weighting factor depending on the category of the vehicle.	C-WHVC • Urban • Suburban • Highway Above three kinds of weighting factor depending on the category of the vehicle.	• JE05 • Inter city (80km/h) Above two kinds of weighting factor depending on the category of the vehicle.	

Key Elements of FE Measurement

➢ Simulation

Simulation is introduced to evaluate HDV with fuel efficiency.
Mathematical method of simulation seems similar for each software.
Input data differs because of the difference of concept or FE items.

Classification	Item	Status of each region				Remarks
		EU /VECTO	US/GEM (PhaseⅡ)	China	Japan (FES2025)	
Vehicle Parameters	Vehicle Category	✓	✓	✓	✓	
	Curb Weight	✓	✓	✓	✓	
	Gross Vehicle Weight	✓	✓	✓	✓	
	Maximum Payload	✓	✓	✓	✓	
	Gross Combination Weight	✓	✓	✓	✓	
	Rated Passenger Capacity	✓	✓	✓	✓	
	Axle Configuration	✓	-	✓	-	
	Axle Number	✓	-	✓	-	
	Aero drag (Cd)	✓	✓	✓	✓	
	Auxiliary	(✓) *	-	-	-	* By spec. of technology
Engine Parameters	Engine Fuel Map	✓	✓	✓	✓	
	Full Load Engine Torque	✓	✓	✓	✓	
	Motored Engine Torque	✓	✓	✓	✓	
	Idling Speed	✓	✓	✓	✓	
	Rated Engine Speed	✓	✓	✓	✓	
	Maximum Engine Speed	✓	✓	✓	-	
	Transient Engine Map	-	✓	-	-	
Drive train	Transmission type	✓	✓	-	✓	MT,AT,AMT
	Number of gear	✓	✓	✓	✓	
	Transmission gear ratio	✓	✓	✓	✓	
	Transmission drag	✓	✓	-	✓	
	Final reduction gear ratio	✓	✓	✓	✓	
	Drive axle drag	✓	✓	-	✓	
Tire	Rolling radius	✓	✓	✓	✓	
	Rolling resistance	✓	✓	✓	✓	

Key Elements of FE Measurement

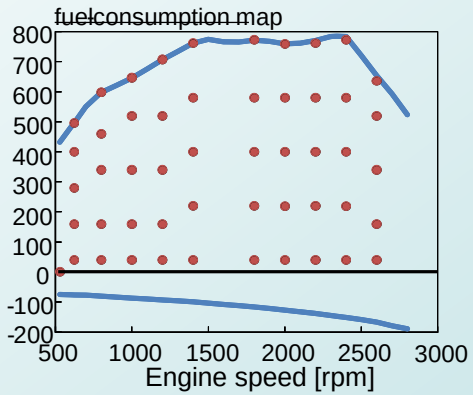
➢ Engine measurement

FE map measured by steady state operation is commonly used to take account engine performance.

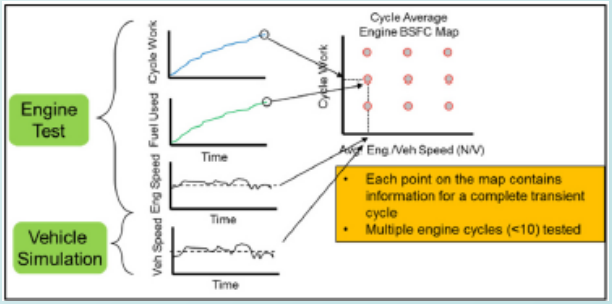
However, US Phase II introduced new method called "Cycle averaging map".

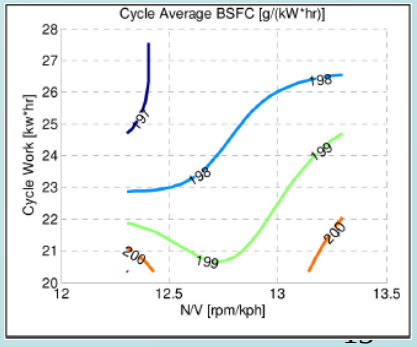
Item	Status of each region				Remarks
	EU	US (PhaseⅡ)	China	Japan (FES2025)	
Steady state Engine Map	100 points	70points for 55,65 mph	81 points	51 points	Difference in concept
Transient Engine Map	NA	Cycle averaging map	NA	NA	
Transient coefficient	WHTC correction factor tool	Include Cycle averaging map	NA	Table value 3%	

Steady state Engine measurement



Cycle averaging map





Key Elements of FE Measurement

Driving Resistance

There are two types of methods for measuring Aero Drag, “Coast down test” and “Constant speed test”. One of these or both is adopted in each area.

Tire RRC measurement uses ISO 28580 which is a tire bench test method common to each region.

Item	Sub-item	Status of each region				Remarks
		EU	US (Phase Ⅱ)	China	Japan (FES2025)	
Aero Drag	Aero Drag measurement	・Constant speed ・Simulation	・Coast down ・Wind tunnel ・CFD	・Table value (Opt. Wind tunnel or coast down)	・Coast down ・Constant speed	Similar method is used, but no common method
Tire RRC	Resistance measurement	(EC) 1222/2009 = ISO28580	ISO28580	Table value	ISO28580	Method of measuring tire RRC is common in individual areas in the unit test by ISO method.
	Resistance select Method	Direct input of tire RRC for each vehicle	Direct input of tire RRC for each vehicle	-	Averaging RRC to be used	