Introduction to VECTO

4th China-EU Workshop on Emissions Standards and Regulations
第四届中欧排放标准与法规研讨会

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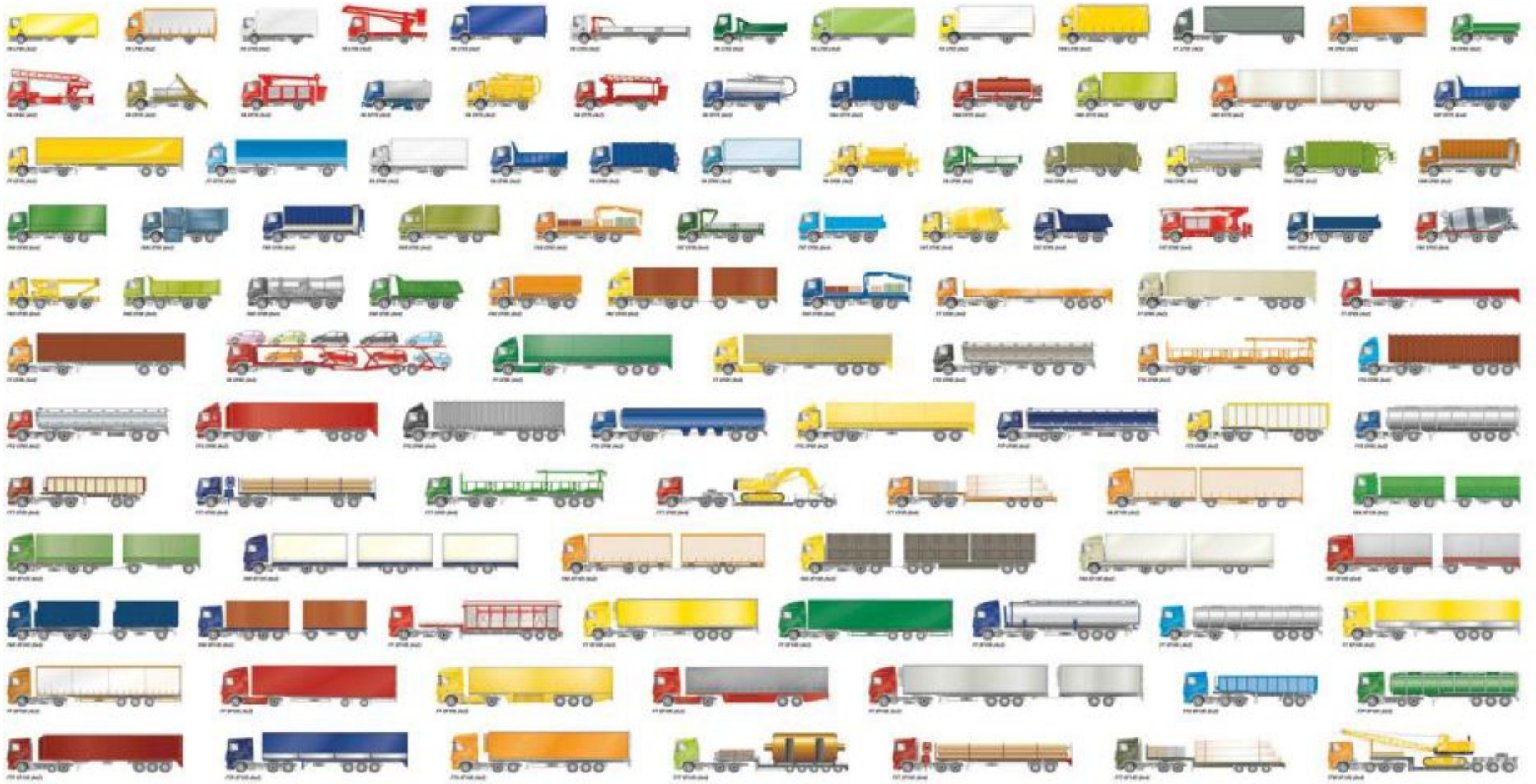
5 March 2021
2021年3月5日

Outline
概览

- Principle | 原则
- Component testing | 组件测试
- Mission profiles | 任务档案
- Operating modes | 运行模式
- Validation | 验证
- Air drag tool | 验证
- Engine tool | 发动机工具
- Hashing | 哈希算法
- Verification Testing Procedure | 验证测试程序
- More information | 更多信息

Heavy-duty ≠ light-duty vehicles
重型车辆 ≠ 轻型车辆



Source: ACEA

European Commission

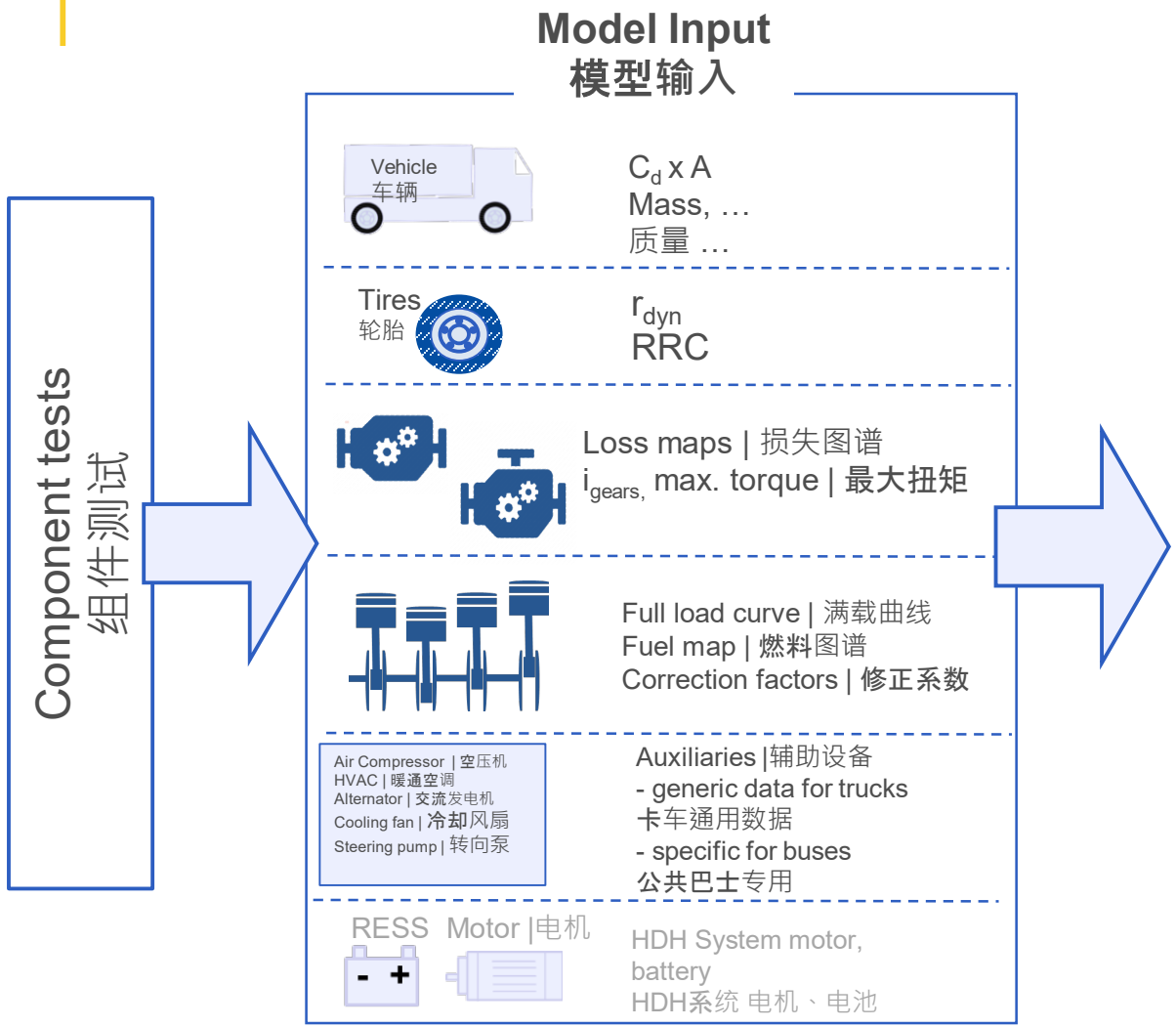
Simulation tool to calculate the energy demand, fuel consumption and CO_2 emissions
重型车辆 ≠ 轻型车辆

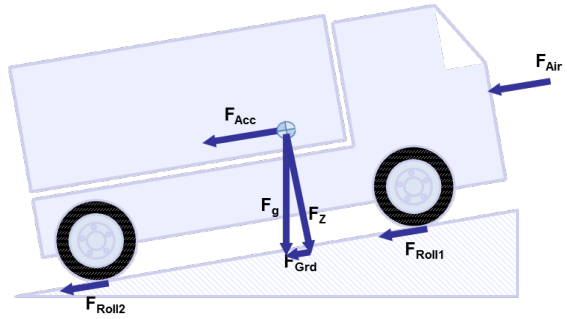
Entire vehicle
整车
Cost effective
成本效益
Reproducible
可复制
Flexible
灵活性

Regular updates
定期更新

European Commission

VECTO method
VECTO方法





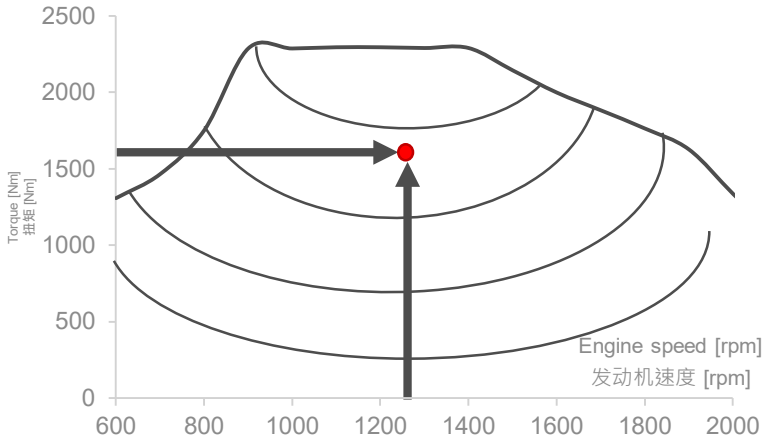
Engine power | 发动机马力：

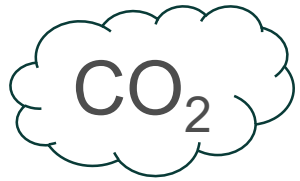
$$P_{Eng} = P_{Air} + P_{Roll} + P_{Grd} + P_{Acc} + P_{Losses} + P_{Aux}$$

Engine speed | 发动机速度：

$$n_{Eng} = v \cdot i_{Axle} \cdot i_{Gear} \cdot \frac{60}{\pi \cdot D_{Wheel}}$$

Fuel consumption | 燃料消耗量：





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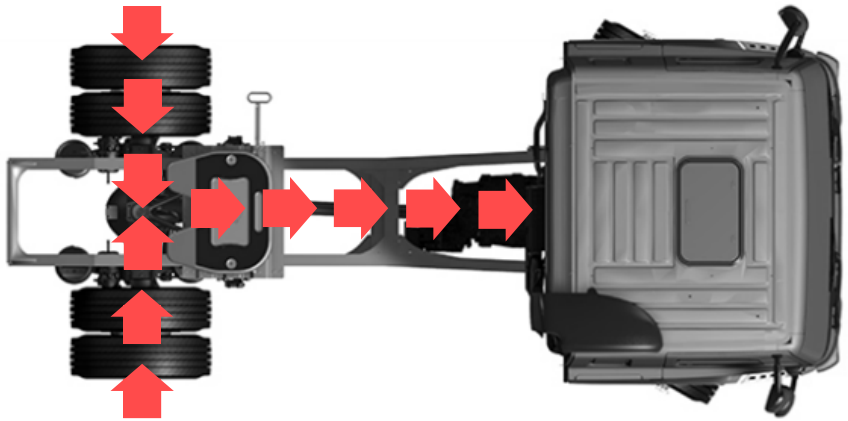
Backwards calculation
反向计算

Mission profile 任务档案 → Driver 司机 → Vehicle 车辆 → Wheels 车轮 → Brakes 刹车系统 → Axle 车轴 →

→ Angle drive 角传动 → Retarder 减速机 → Gearbox 变速箱 → Retarder 减速机 → Clutch 离合器 → Engine 发动机

Auxiliaries 辅助设备 → Engine 发动机



Process
工艺流程

Input
输入

Component data
组件数据

Hashing for integrity
完整性哈希算法

Results
結果

Each vehicle
每辆车辆

g/km, g/m^3.km,

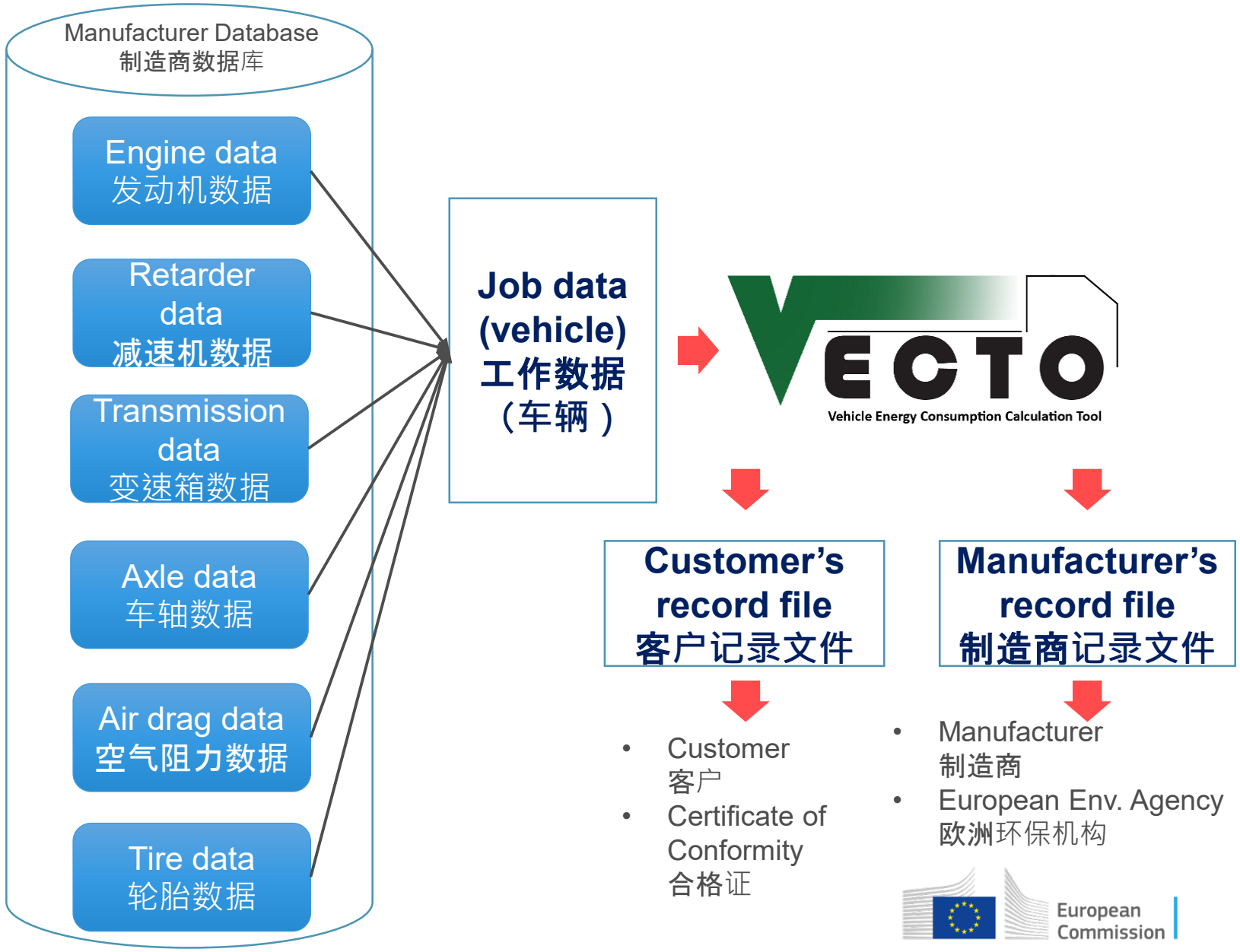
g/ton.km or g/pass.km

Use
使用

Certification
认证

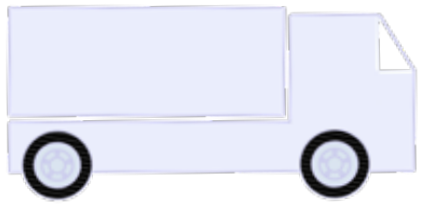
Monitoring
监测

CO_2 Standards
CO_2标准



Component testing
组件测试

Air drag
空气阻力



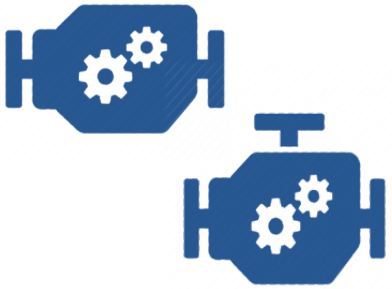
- Constant speed test
  恒速测试 ➔ C_dxA
- Standard body/trailer
  标准车身/拖车

Tires
轮胎

- Drum test (EC1222/2009)
  转鼓试验（EC1222/2009） ➔ RRC
- Tire label
  轮胎标签

Component testing
组件测试

Drivetrain
动力传动系统

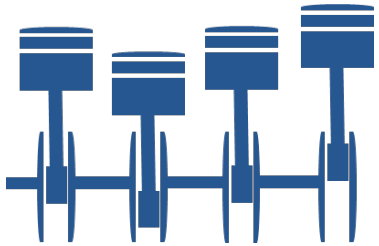


- Torque loss
  转矩损失

➔ torque loss map
转矩损失图谱

- Full map measurement
  全图谱测量
- Or idle measurement + calculation
  或怠速测量 + 计算

Engine
发动机



- Engine dyno
  发动机功率计

➔ fuel map
燃料图谱

- UN/ECE R49

➔ full load & motoring
满载 & 监测

- Steady-state & WHTC
  稳态 & WHTC

➔ WHTC correction
WHTC 修正

Component testing
组件测试

Auxiliaries
辅助设备

Air Compressor
空压机
HVAC
暖通空调
Alternator
交流发电机
Cooling fan
冷却风扇
Steering pump
转向泵

- Standard values
  标准数值
- Technology dependent
  科技依赖型
- Driving cycle depended
  驾驶循环依赖型

➔ power demand
功率需求

Reduced testing burden
减少测试负担

- Component families
  部件系列
- Standard values
  标准数值

Mission profiles
任务档案

Lorries
载重卡车

- Long haul
长途运输
- Regional delivery
区域配送
- Urban delivery
城区配送
- Municipal utility
市政公共设施
- Construction
建筑施工

Busses & coaches
公共巴士与长途巴士

- Coach
长途巴士
- Interurban bus
城际公共巴士
- City-bus suburban
郊区城市公共巴士
- City-bus urban
市区城市公共巴士
- City-bus heavy urban
市区城市公共巴士（重型）

Vehicle segmentation
车辆细分

Vehicle groups
车辆分组

- Axle configuration
车轴配置
- Chassis type
底盘类型
- TPMLM

- Mission profiles
任务档案
- Payload
有效载荷
- Body/trailer
车身/拖车
- Auxiliary power
辅助动力

Vehicle groups for vehicles of category N

Description of elements relevant to the classification in vehicle groups			Vehicle group	Allocation of mission profile and vehicle configuration						
Axle configuration	Chassis configuration	Technically permissible maximum laden mass (tons)		Long haul	Long haul (EMS)	Regional delivery	Regional delivery (EMS)	Urban delivery	Municipal utility	Construction
4 × 2	Rigid lorry	> 3,5 –7,5	(0)							
	Rigid lorry (or tractor) (**)	> 7,5 – 10	1			R		R		
	Rigid lorry (or tractor) (**)	> 10 – 12	2	R+T1		R		R		
	Rigid lorry (or tractor) (**)	> 12 – 16	3			R		R		
	Rigid lorry	> 16	4	R+T2		R		R	R	
	Tractor	> 16	5	T+ST	T+ST +T2	T+ST	T+ST +T2	T+ST		
	Rigid lorry	> 16	4v (***)						R	R
	Tractor	> 16	5v (***)							T+ST
4 × 4	Rigid lorry	> 7,5 – 16	(6)							
	Rigid lorry	> 16	(7)							
	Tractor	> 16	(8)							
6 × 2	Rigid lorry	all weights	9	R+T2	R+D +ST	R	R+D +ST		R	
	Tractor	all weights	10	T+ST	T+ST +T2	T+ST	T+ST +T2			
	Rigid lorry	all weights	9v (***)						R	R
	Tractor	all weights	10v (***)							T+ST
6 × 4	Rigid lorry	all weights	11	R+T2	R+D +ST	R	R+D +ST		R	R
	Tractor	all weights	12	T+ST	T+ST +T2	T+ST	T+ST +T2			T+ST
6 × 6	Rigid lorry	all weights	(13)							
	Tractor	all weights	(14)							
8 × 2	Rigid lorry	all weights	(15)							
8 × 4	Rigid lorry	all weights	16							R
8 × 6 8 × 8	Rigid lorry	all weights	(17)							

(*) EMS — European Modular System
(**) In these vehicle classes tractors are treated as rigid lorries but with specific curb weight of tractor
(***) Sub-group "v" of vehicle groups 4, 5, 9 and 10: these mission profiles are exclusively applicable to vocational vehicles
T = Tractor
R = Rigid lorry & standard body
T1, T2 = Standard trailers
ST = Standard semitrailer
D = Standard dolly'

Mission profiles
任务档案

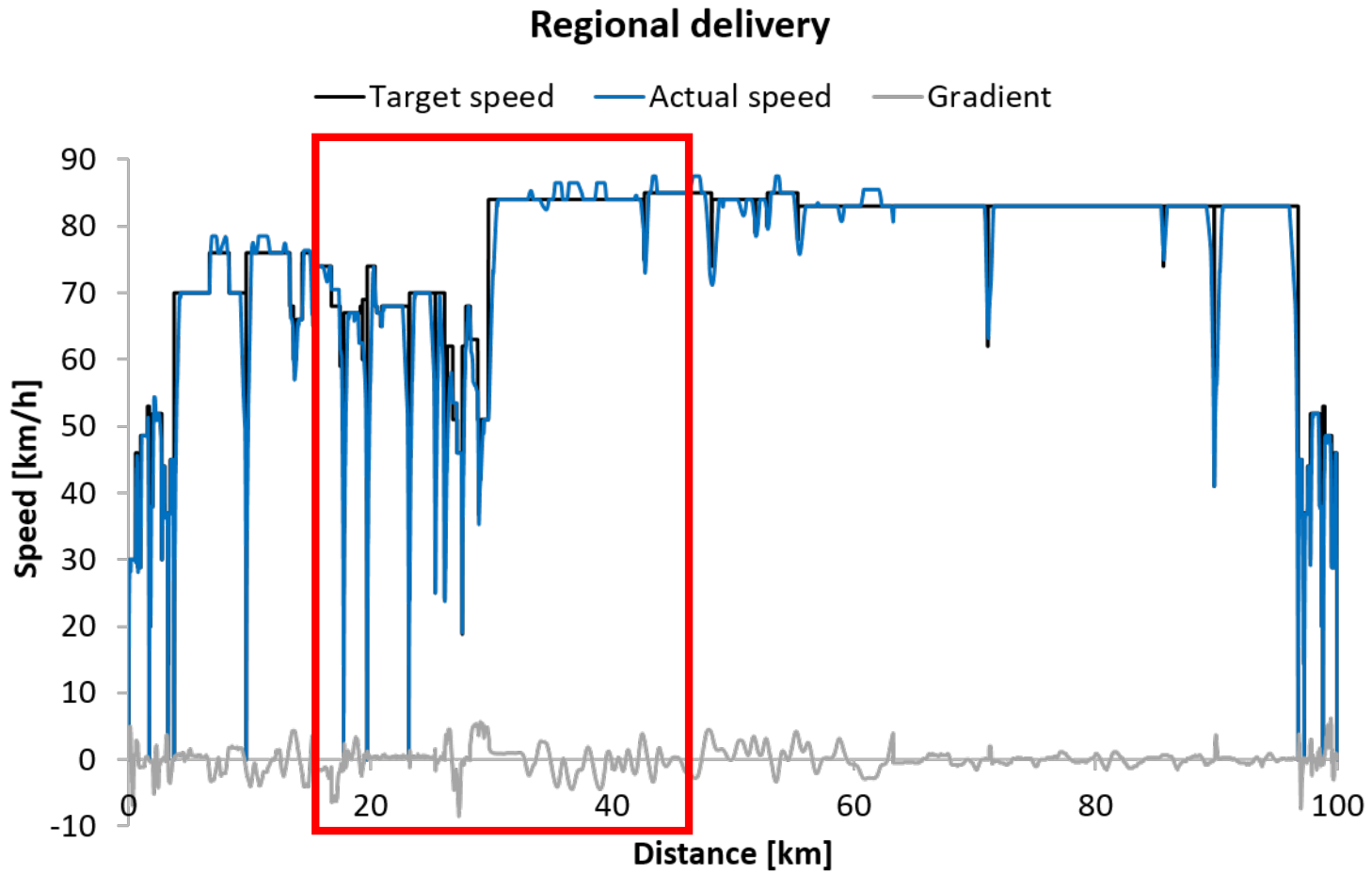
Target speed over distance
超距离目标速度

Road gradient
路面坡度

Stop time
停止时间

Driver model:
驱动模型

- Look ahead
  展望未来
- Overspeeding
  超速转动
- Gear shifting
  变速调档
- ADAS



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Mission profiles
任务档案

Target speed over distance
超距离目标速度

Road gradient
路面坡度

Stop time
停止时间

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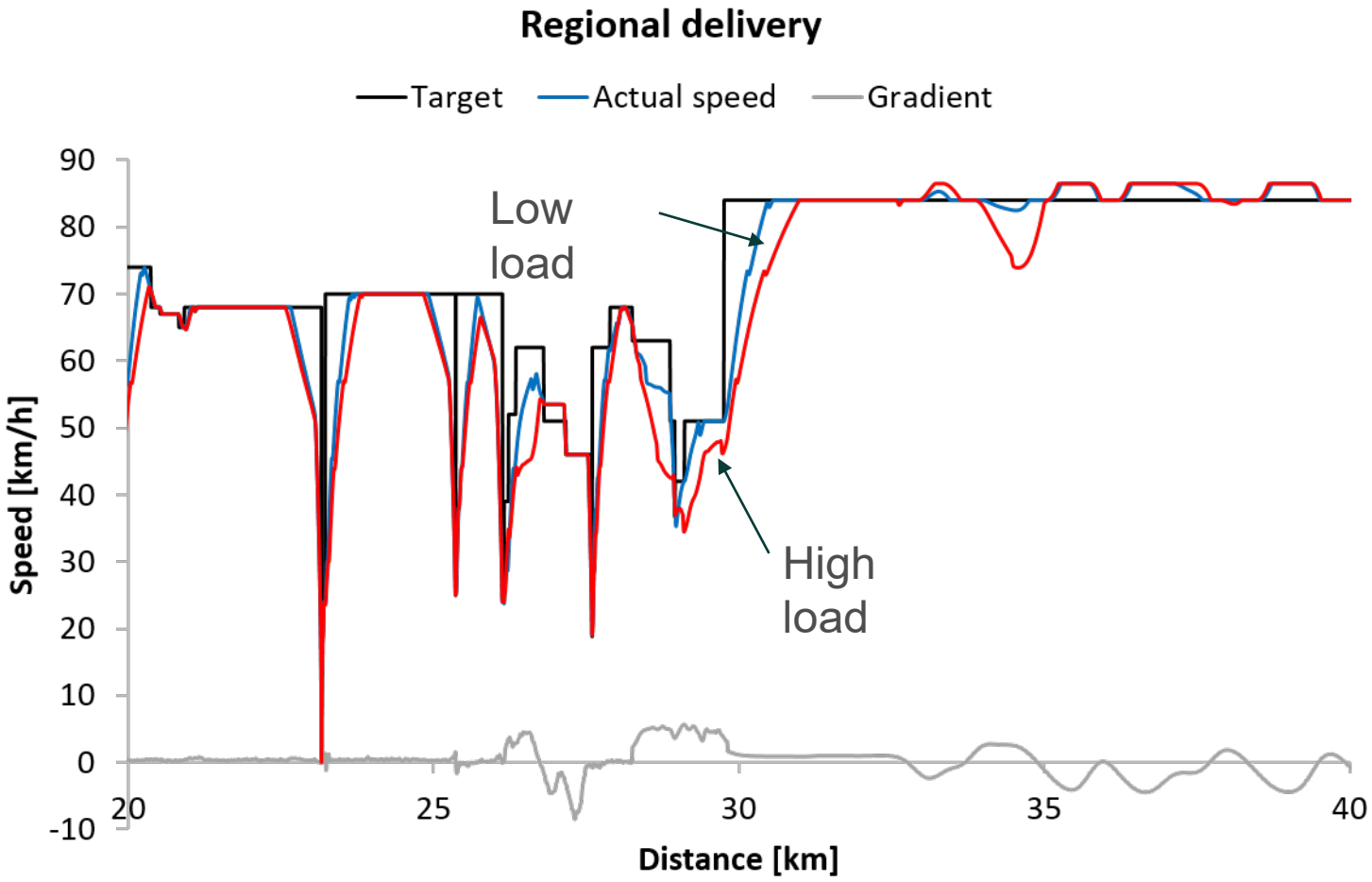


Operating modes
运行模式

Declaration mode
声明模式

- Parameters set according to regulation
参数按法规设置

- Predefined driving cycles
预定义的行驶工况

Engineering mode
工程模式

- Most parameters are tunable
大多数参数都可调

- Custom driving cycles
自定义的行驶工况

  ➔ Target speed
  目标速度

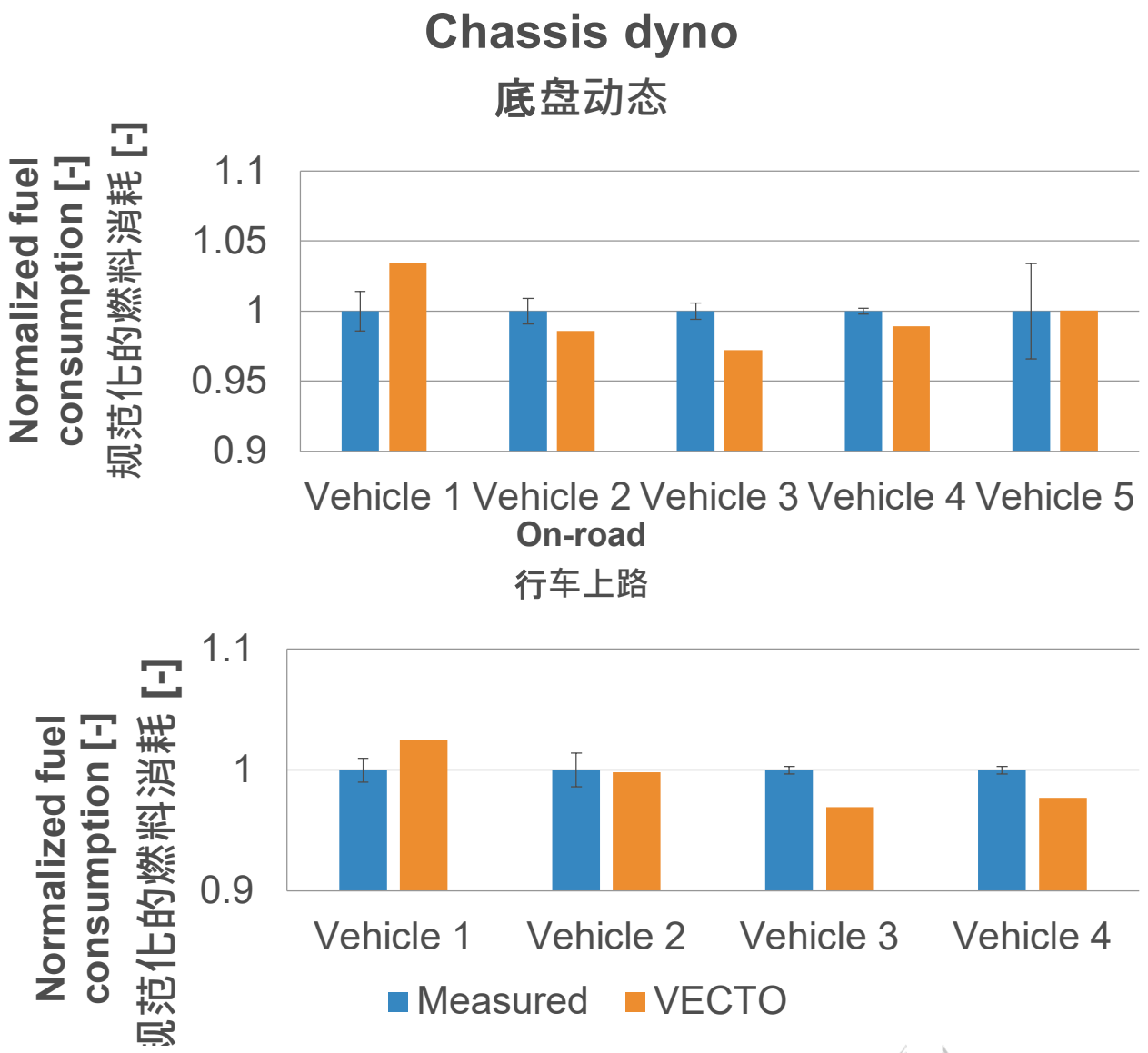
  ➔ Wheel-power mode
  轮上功率模式

Validation
验证

Test campaigns
测试活动

- JRC & industry measurements
JRC与行业测量
- Lorries, busses and coaches
载重卡车
- Chassis dyno and on-road
底盘动态和行车上路
- PEMS + wheel torque meas.
PEMS + 轮上扭矩测量

➔ Results ± 5%
结果 ± 5%



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Validation
验证

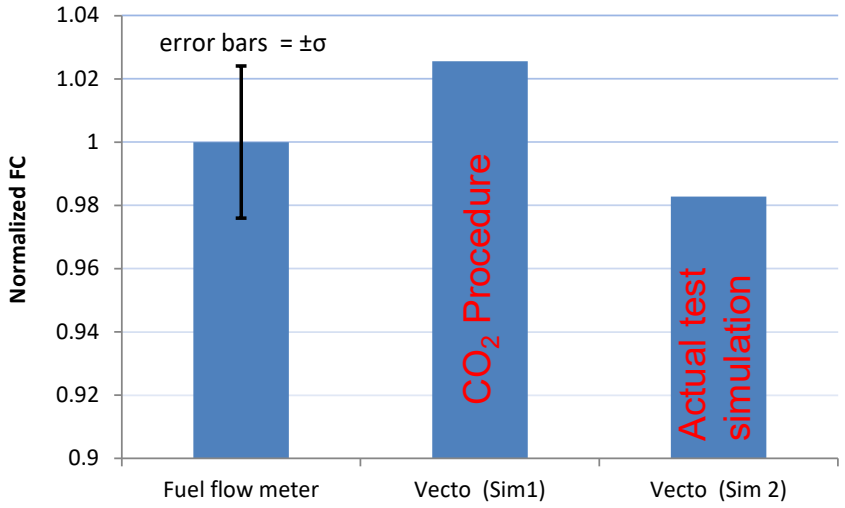
Proof of Concept
概念证明

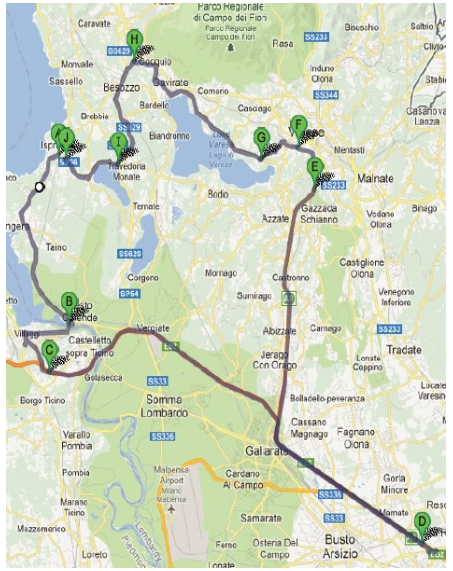
- 18t rigid & 40t tractor

18t 整体式车架载重卡车 & 40t 拖拉机

- Dyno, on-road & track

动态、行车上路和轨迹





Development of a CO2 certification and monitoring methodology for Heavy Duty Vehicles – Proof of Concept report, 2014
重型车辆CO_2认证和监测方法的制定——《概念证明报告》，2014

European Commission

Validation
验证

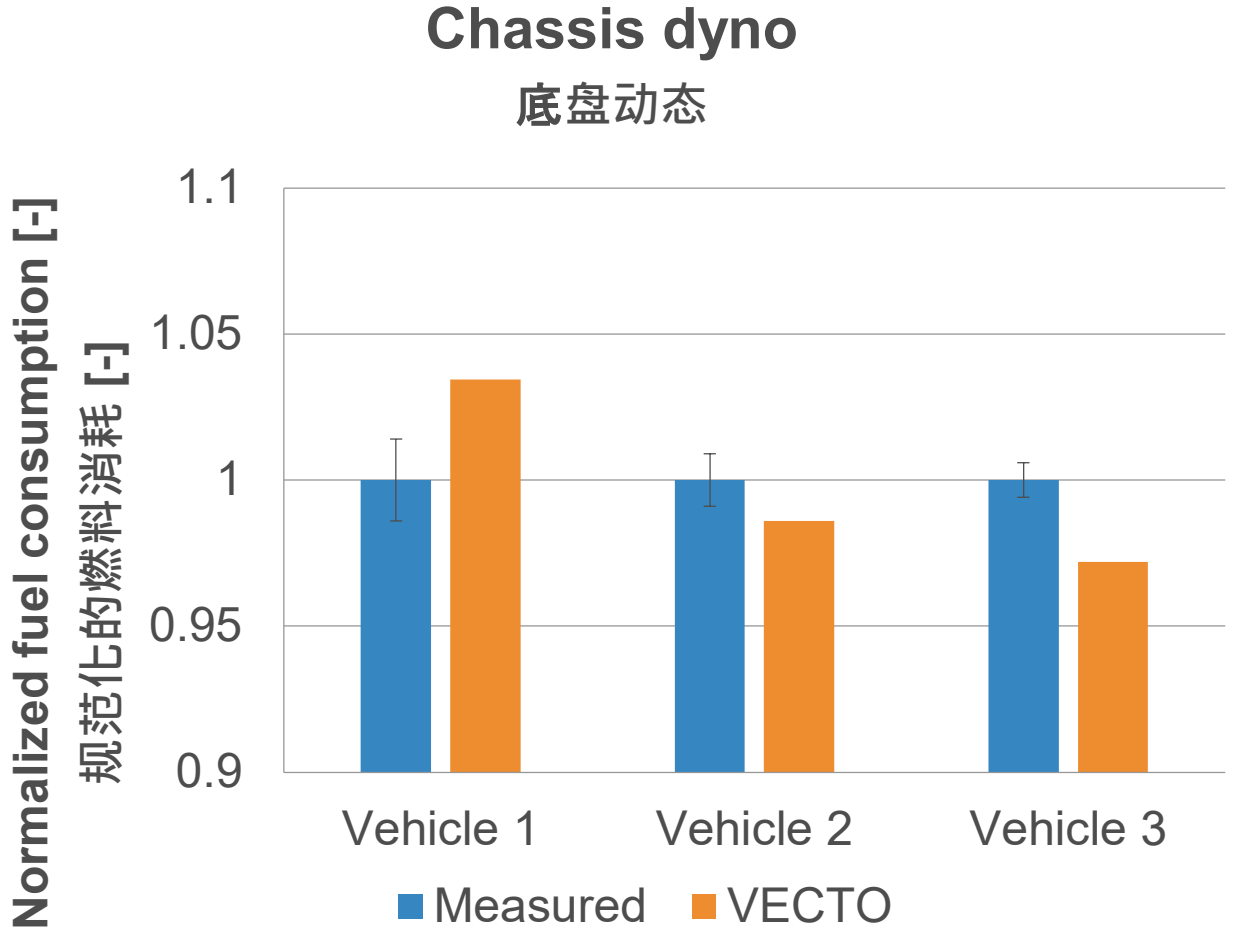
Lorries
载重卡车

- 4 lorries: 24 – 40t

4种载重卡车：24 – 40t

- Dyno: steady-state & cycles

动态：稳态与工况

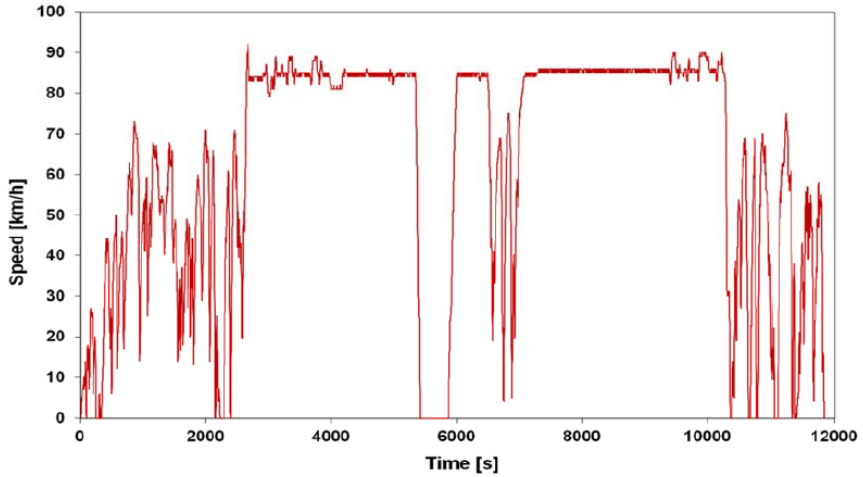


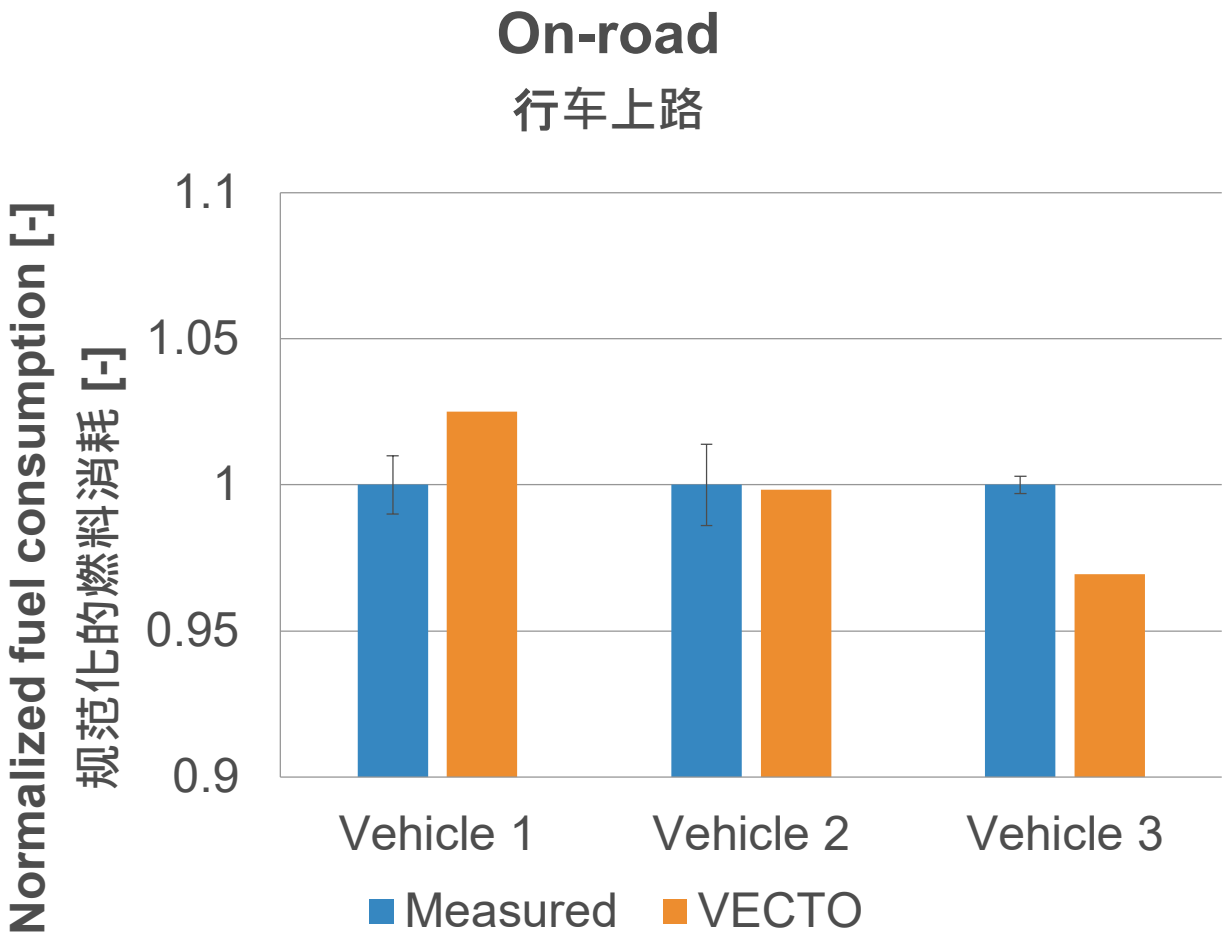
Assessment of the monitoring methodology for CO_2 emissions from heavy duty vehicles: Pilot phase test-campaign report and analysis of the ex-post verification options, 2017
重型车辆CO_2排放监测方法的评估：试点阶段的测试活动报告和验证后选项的分析，2017年

Validation
验证

Lorries
载重卡车

- 4 lorries: 24 – 40t
4种载重卡车：24 – 40t
- Dyno: steady-state & cycles
动态：稳态与工况
- On-road
行车上路





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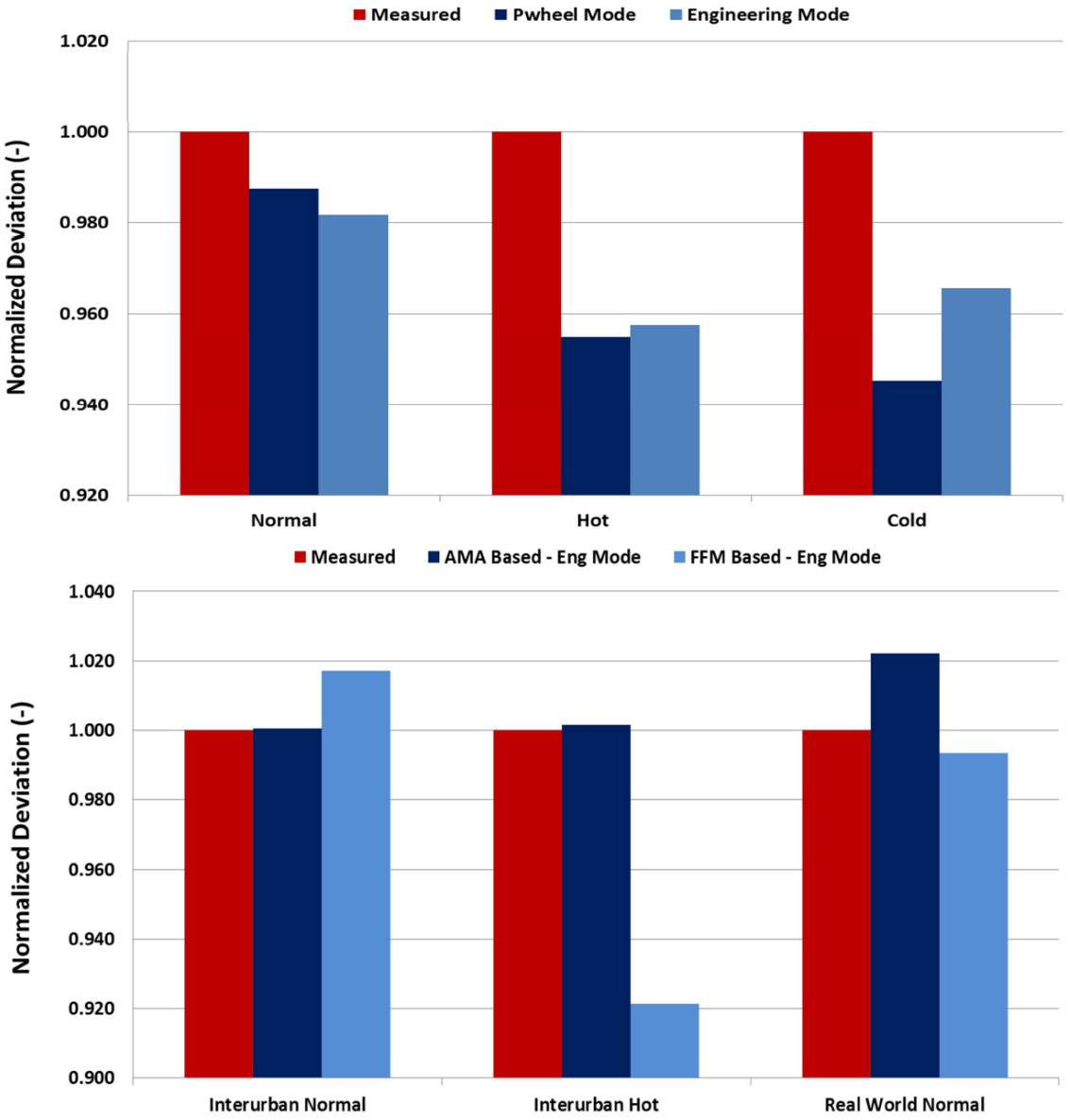
Validation
验证

Busses and coaches
公共巴士与长途巴士
Dyno:
动态：

- Cycles & real world
  工况与真实条件
- Multiple ambient conditions
  多种环境条件



Assessment of the Measurement Methodology for CO2 Emissions from Heavy Duty Buses and Coaches, 2018
公共巴士与长途巴士CO_2**排放**监测方法的评估，2018

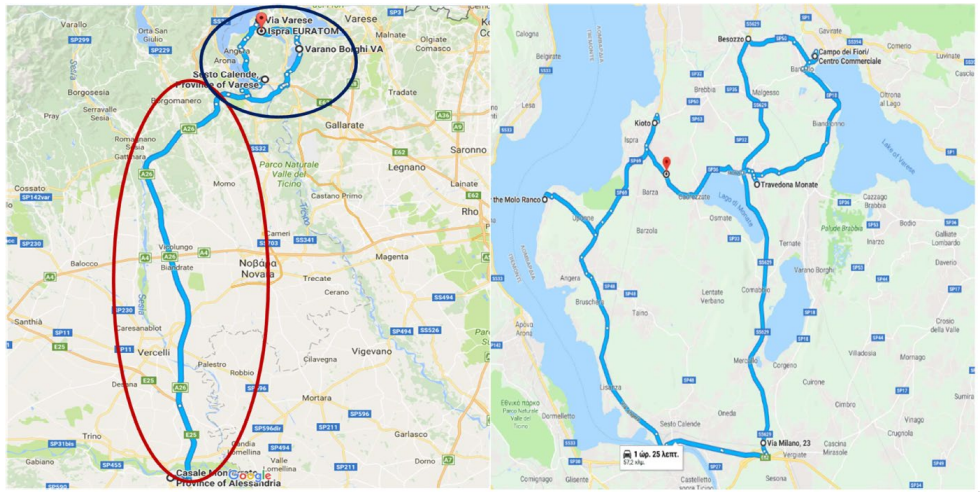
European Commission

Validation
验证

Busses and coaches
公共巴士与长途巴士

On-road
行车上路

- Coach
  长途巴士
- Interurban bus
  城际公共巴士



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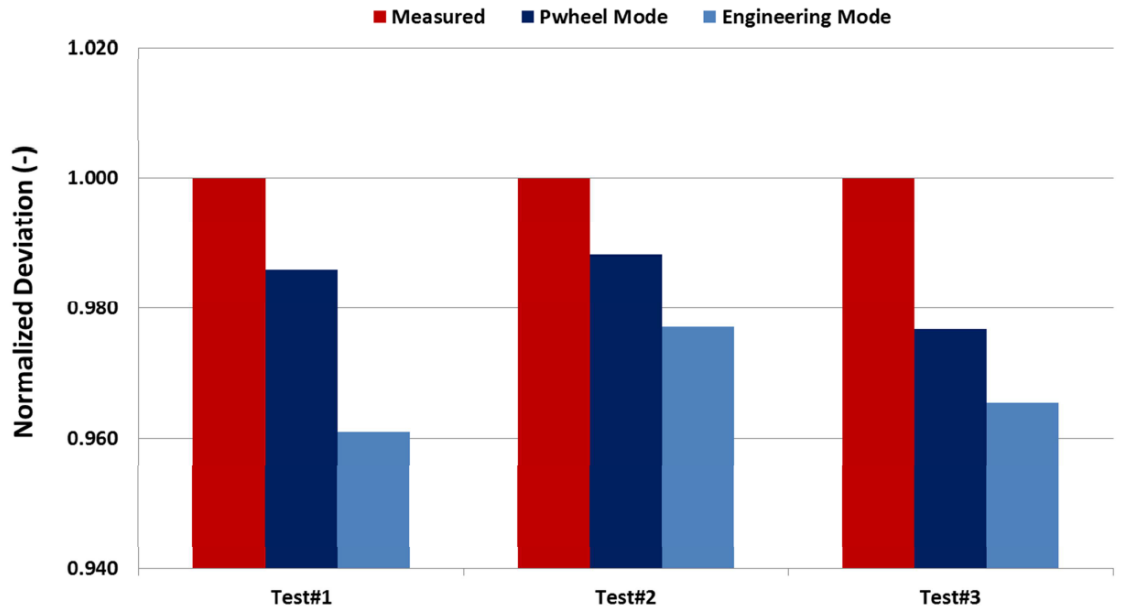
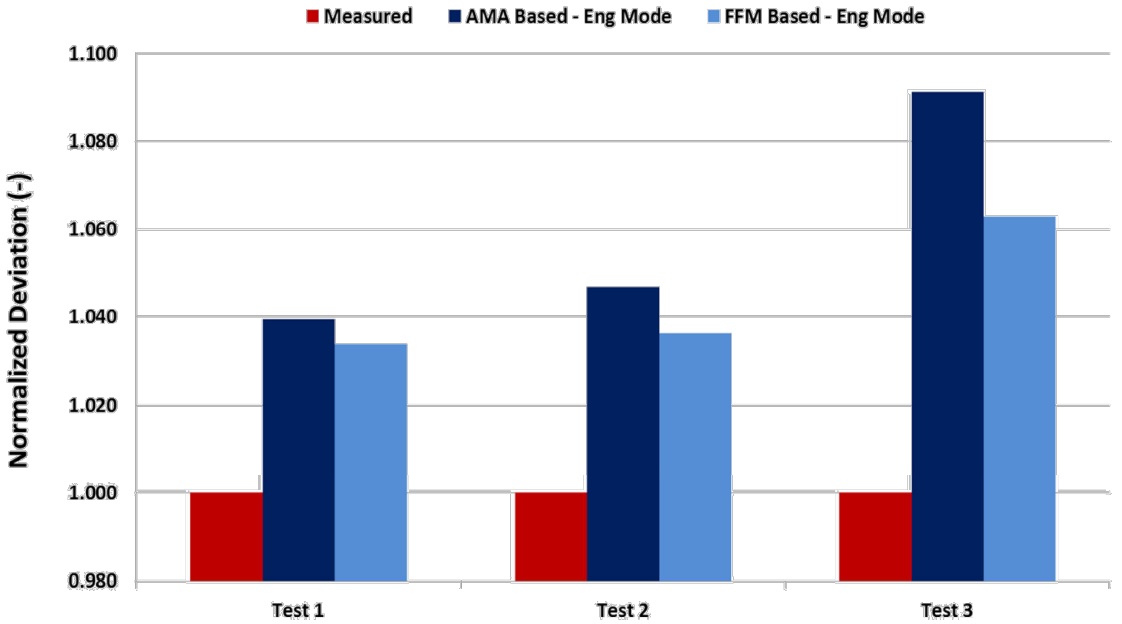


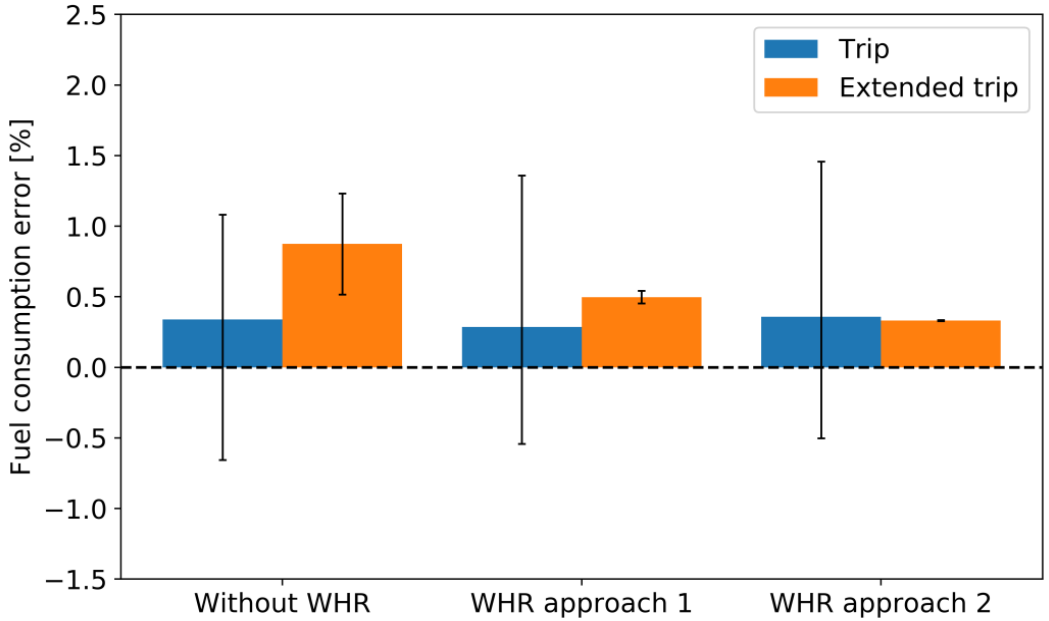


European Commission

Validation
验证

Waste Heat Recovery
废热回收

- Lorry + WHR
载重卡车 + WHR
- Chassis dyno:
底盘动态：
- On-road
行车上路



Experimental Evaluation and Modelling of Waste Heat Recovery in VECTO, SAE technical paper 2020-01-1287, 2020
VECTO余热回收的实验评价与建模，SAE技术论文2020-01-1287，2020

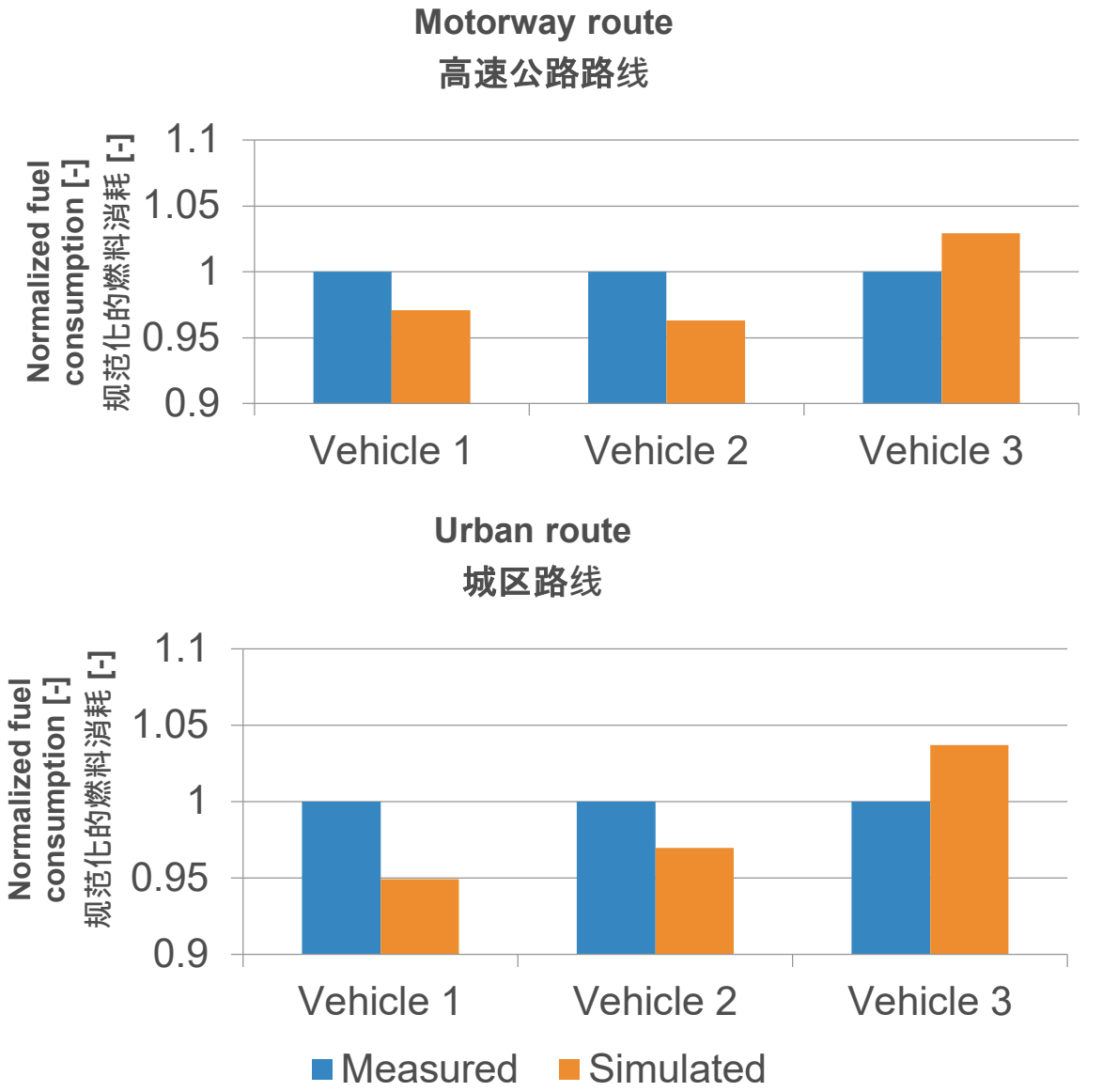
European Commission

Validation
验证

VTP

- Heavy buses and medium lorries
重型巴士与中型卡车

- On-road
行车上路



Development of Heavy Duty Vehicles CO2 certification for Heavy Buses and Medium Lorries, 2020
重型巴士和中型卡车的重型车辆CO2认证开发，2020

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VECTO
Engine

Engine
发动机

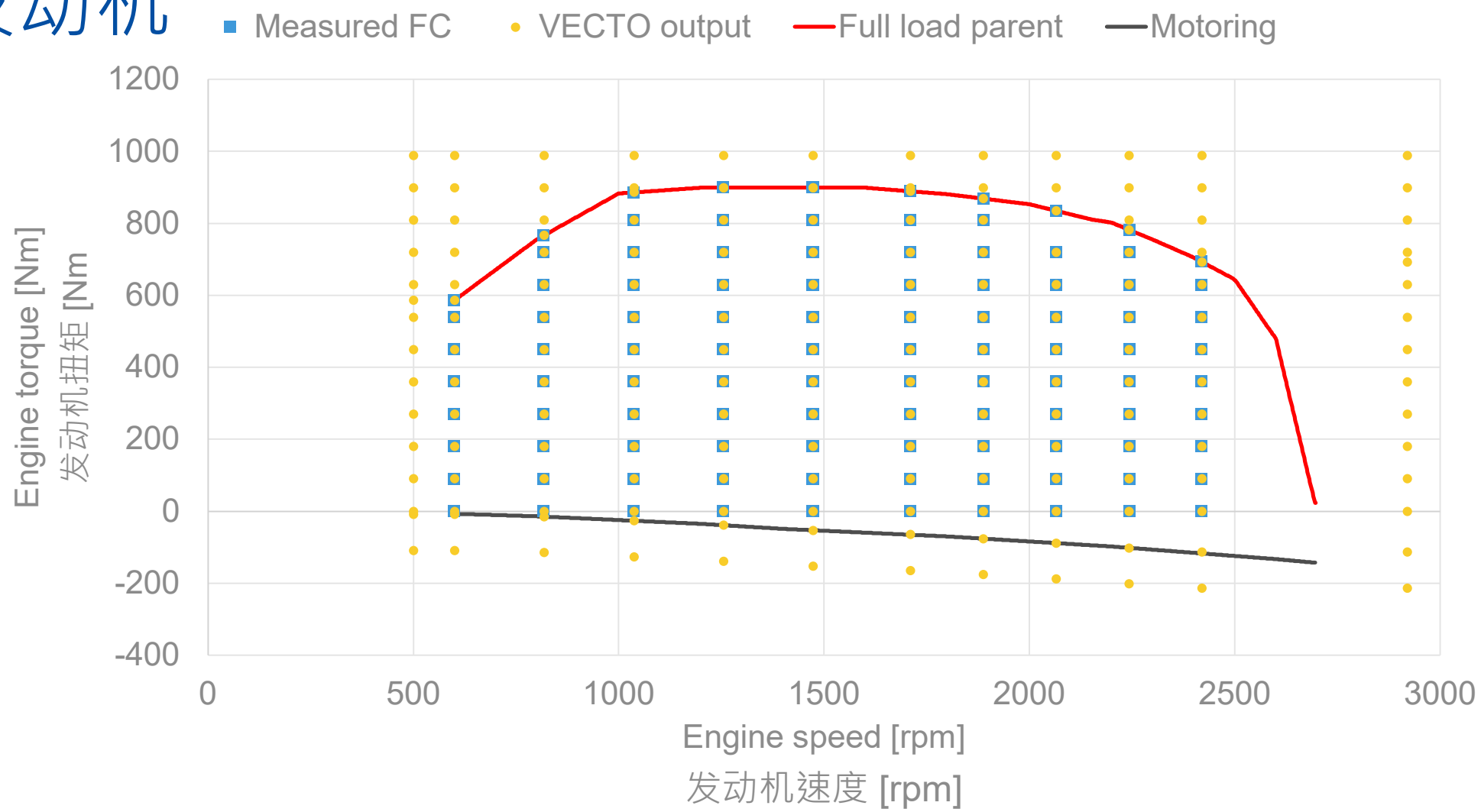
Engine test
发动机测试

Related to pollutant emissions test (EURO VI & UN/ECE R49)
与污染物排放测试相关（EURO VI & UN/ECE R49）

More stringent measurement requirements
更严格的测量要求

Test 测试	Parent engine 母型发动机	Each engine 各个发动机
Full load curve 满载曲线	✓	✓
Motoring 监测	✓	×
WHTC	✓	✓
WHSC	✓	✓
Fuel mapping 燃料图谱	✓	×

Engine
发动机



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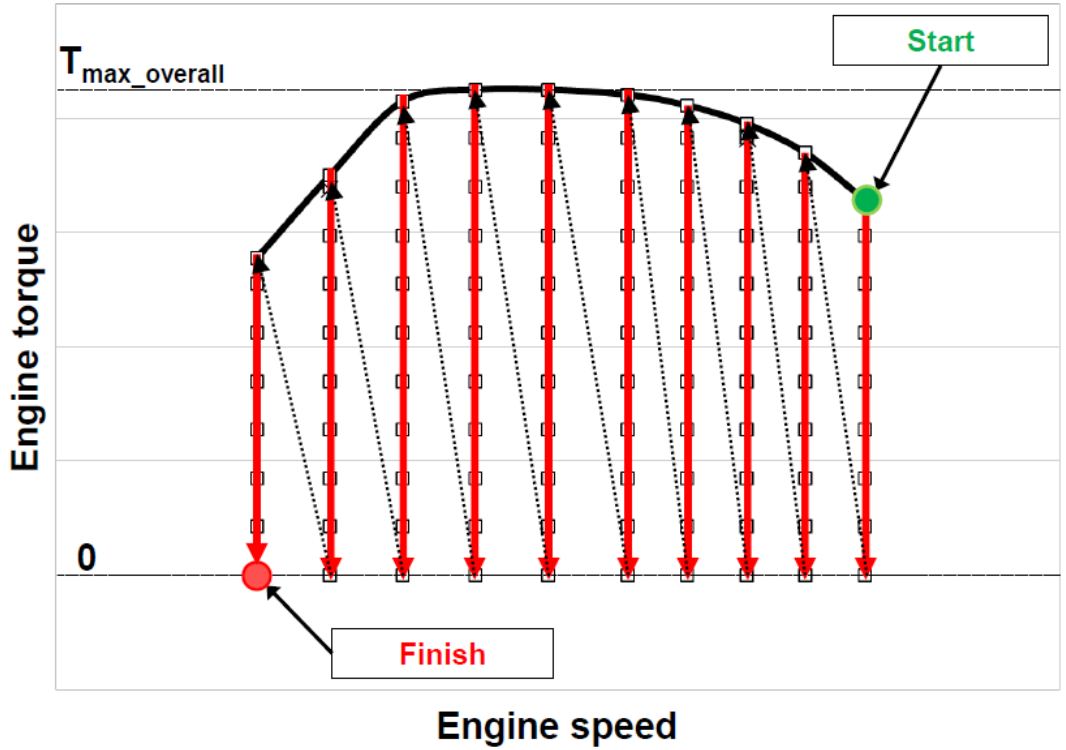
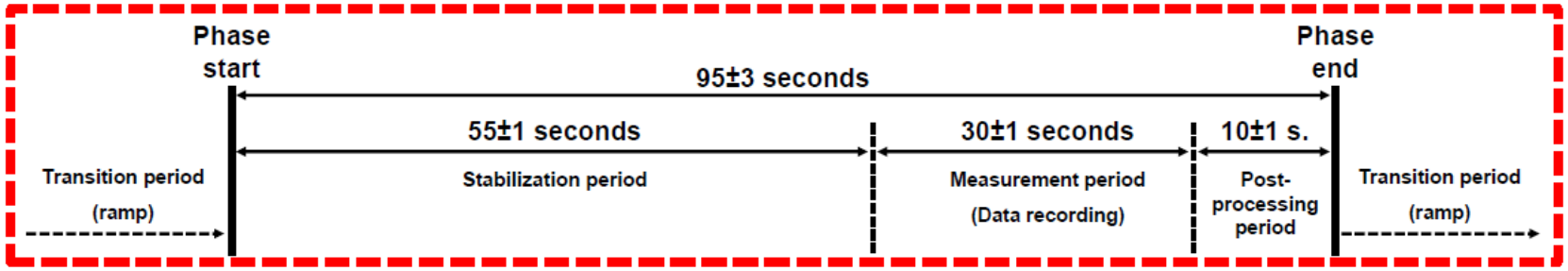
Engine
发动机



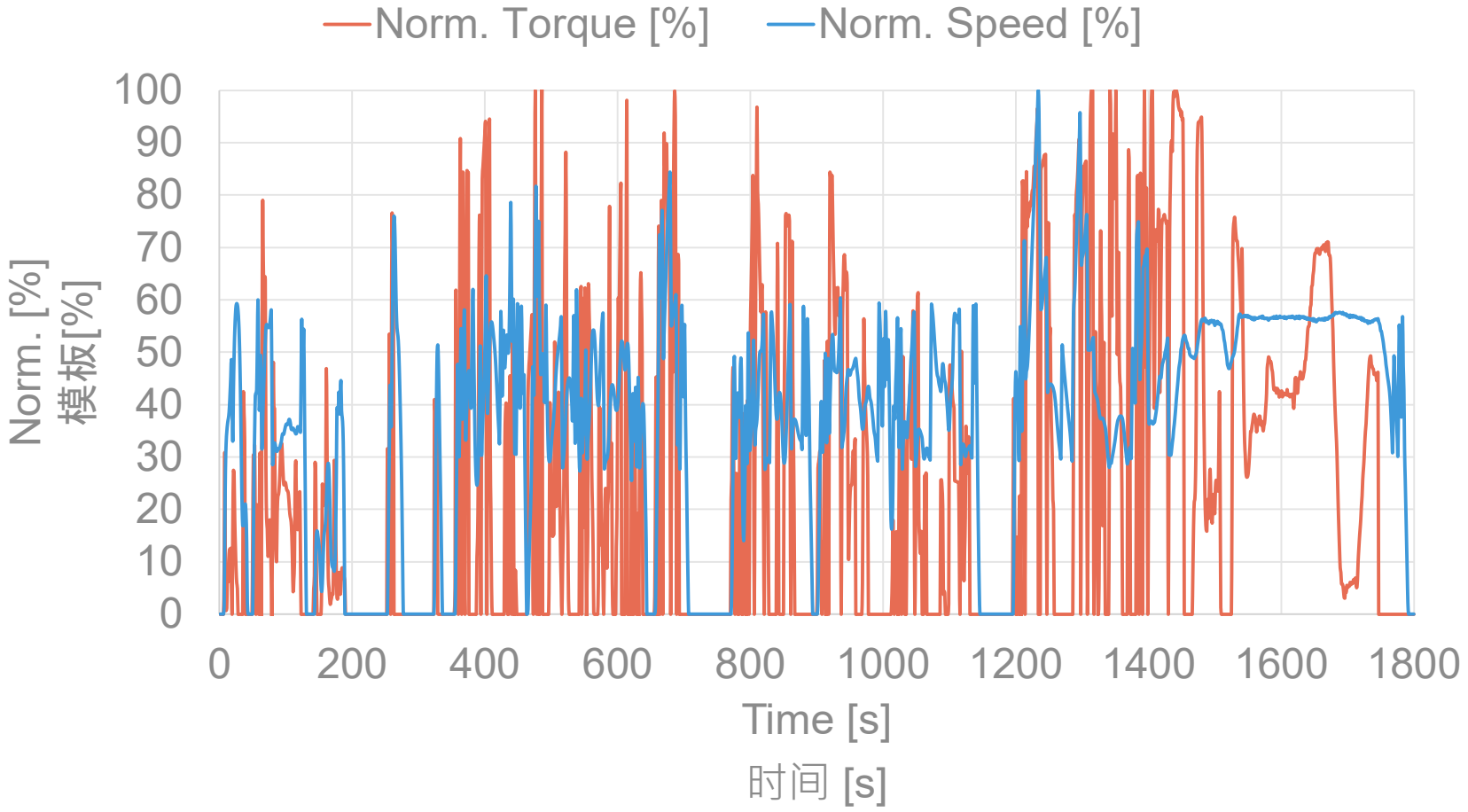
- preconditioning of 20 min at WHSC preconditioning mode 9
- ramp time of 20 sec for load change at constant speed
  (20-46 sec at speed and load changes)
- 55 sec stabilization time at each point
- 30 sec averaging (measuring) time at each point



Engine
发动机

WHTC

- UN/ECE R49
- Transient test
瞬态测试
- Engine dyno
发动机功率计



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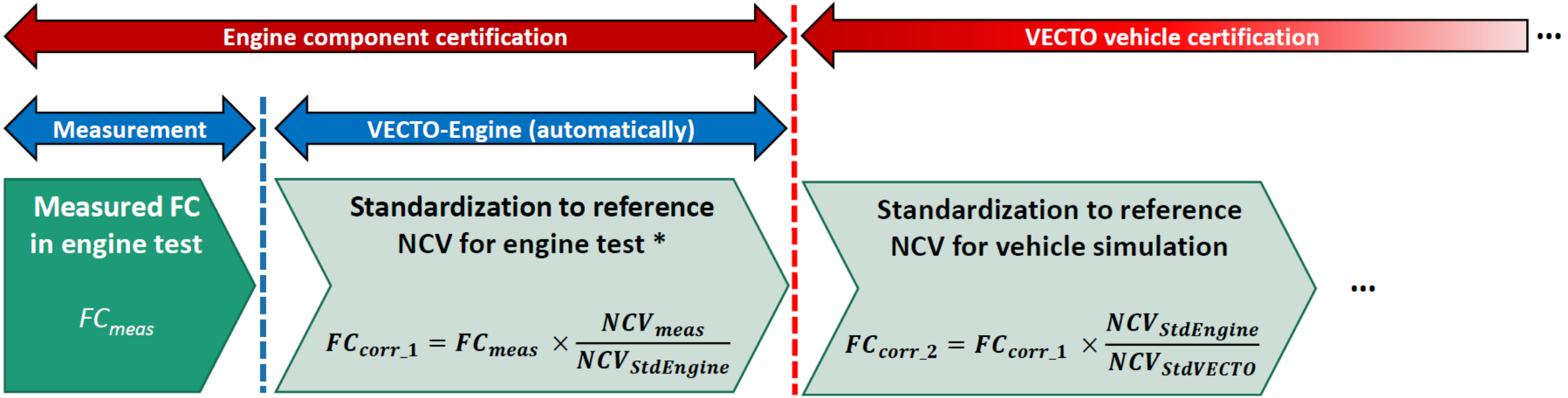
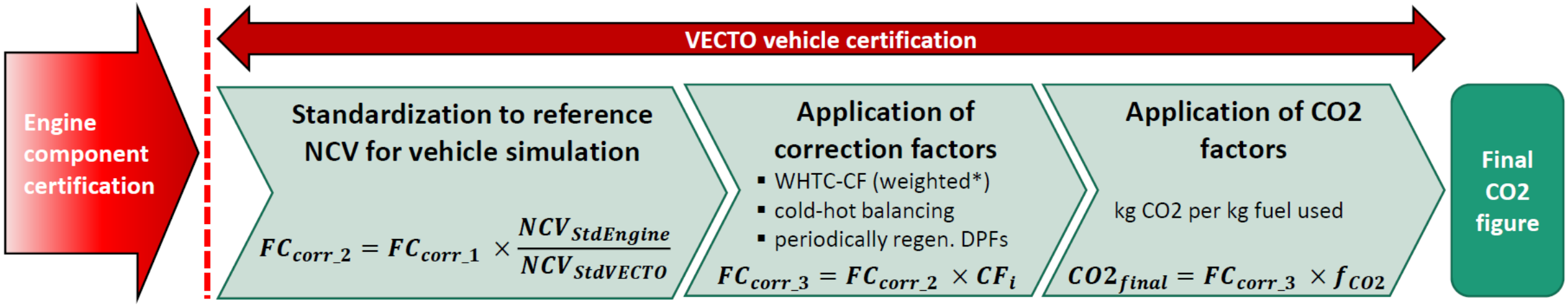
Engine
发动机

Correction factors
修正系数



Engine
发动机

Correction factors
修正系数



Engine
发动机

WHTC correction factor
WHTC修正系数

- Transient effects
瞬态效应
- Avoid optimization pollutant – fuel consumption
避免优化污染物 - 燃料消耗
- Correction factor for urban, rural and motorway
城市、农村和高速公路的修正系数

$$CF_{WHTC} = \frac{FC_{meas}\ [g/kWh]}{FC_{map}\ [g/kWh]}$$

Engine
发动机

Cold-hot balancing factor
冷热平衡系数

- Avoid optimization pollutant – fuel consumption

避免优化污染物 - 燃料消耗

- WHTC hot & cold

WHTC（热态&冷态）

$$BF_{cold-hot} = 1 + 0.1 \cdot \frac{FC_{meas,cold}\ [g/kWh] - FC_{meas,hot}\ [g/kWh]}{FC_{meas,hot}\ [g/kWh]}$$

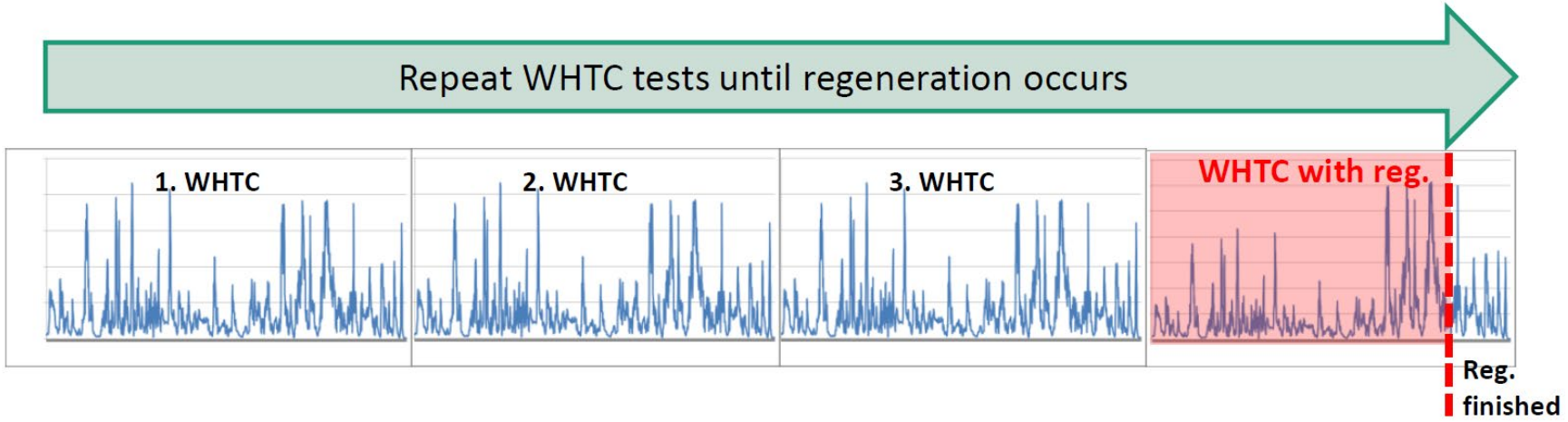
Engine
发动机

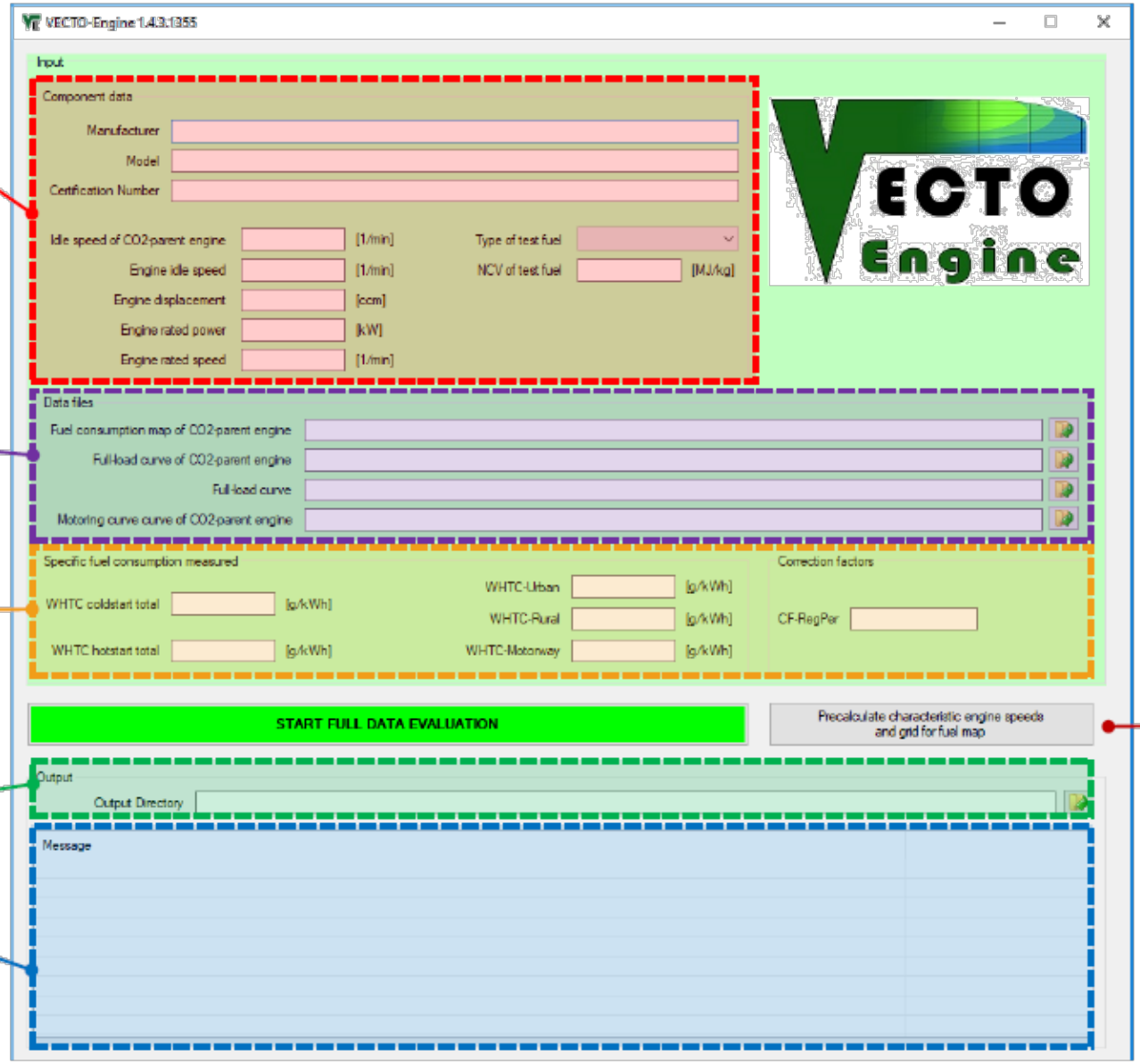
Periodic regeneration factor
周期性再生系数

- Effect periodically regenerated DPF

影响周期性再生的DPF

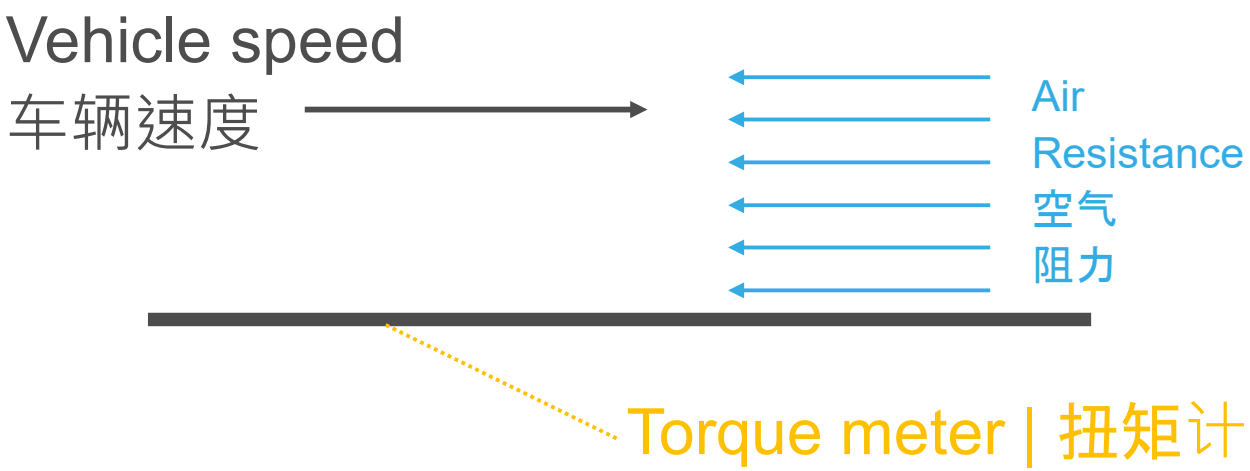
$$CF_{per\ reg} = \frac{n_{without} + n_{with} \cdot \frac{FC_{with}[g/kWh]}{FC_{without}\ [g/kWh]}}{n_{without} + n_{with}}$$

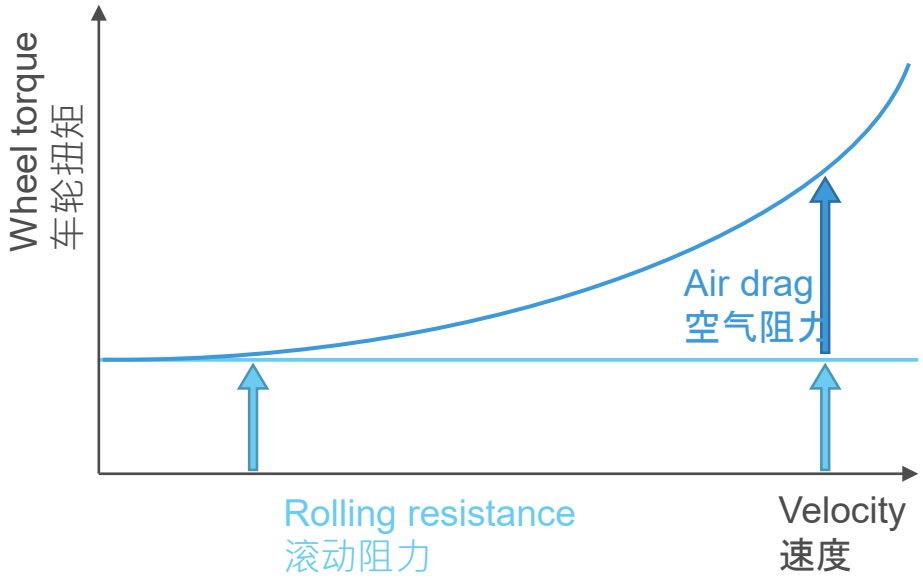




Air drag
空气阻力

Constant speed test | 恒速测试





High speed test ➔ aerodynamic losses
高速测试 ➔ 气动损失

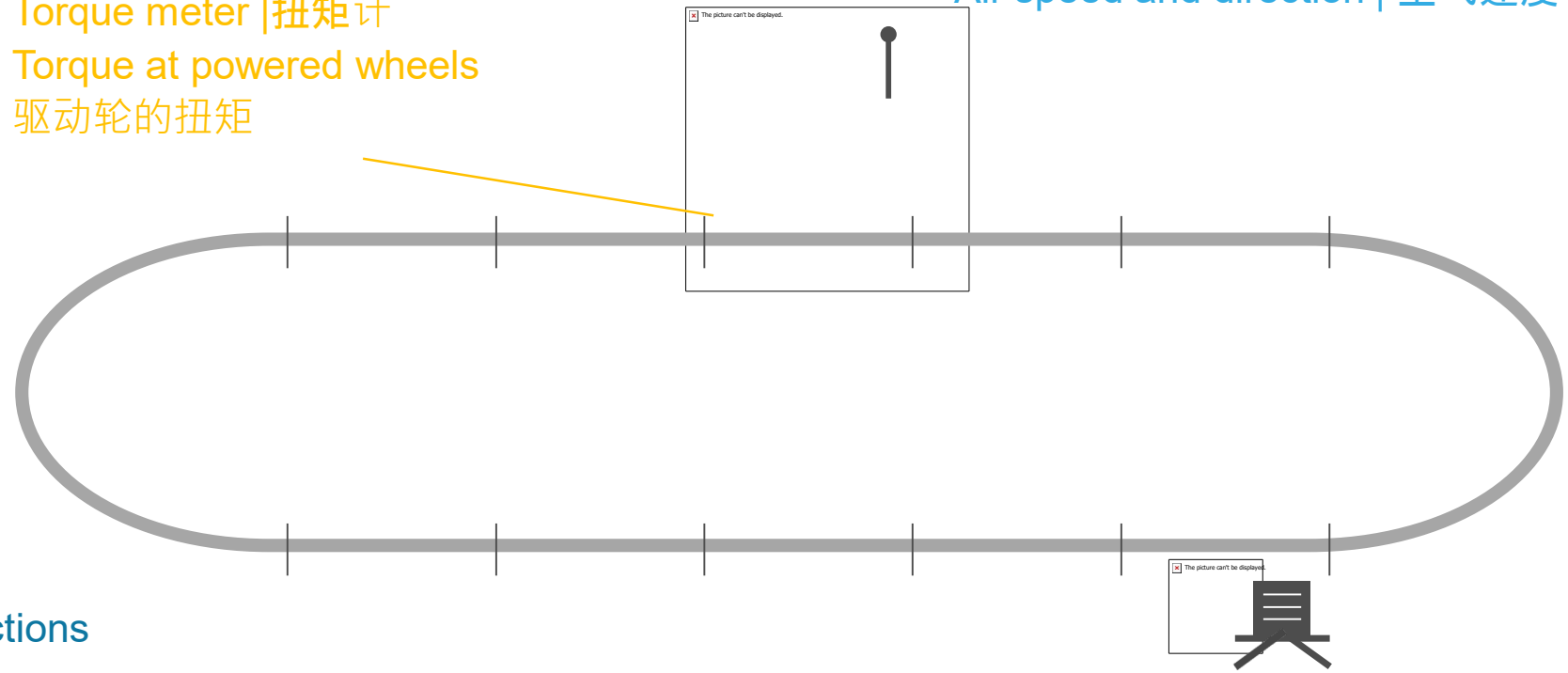
Low speed test ➔ rolling resistance losses
低速测试 ➔ 滚动阻力损失

Traction force from wheel torque meter
车轮扭矩计的牵引力

Air drag
空气阻力

Torque meter |扭矩计
Torque at powered wheels
驱动轮的扭矩

On-board anemometer |车载风速计
Air speed and direction | 空气速度和方向



Measurement sections
测量部分

- Optoelectronic barriers
  光电障碍
  OR |或者
- Differential GPS
  差分GPS

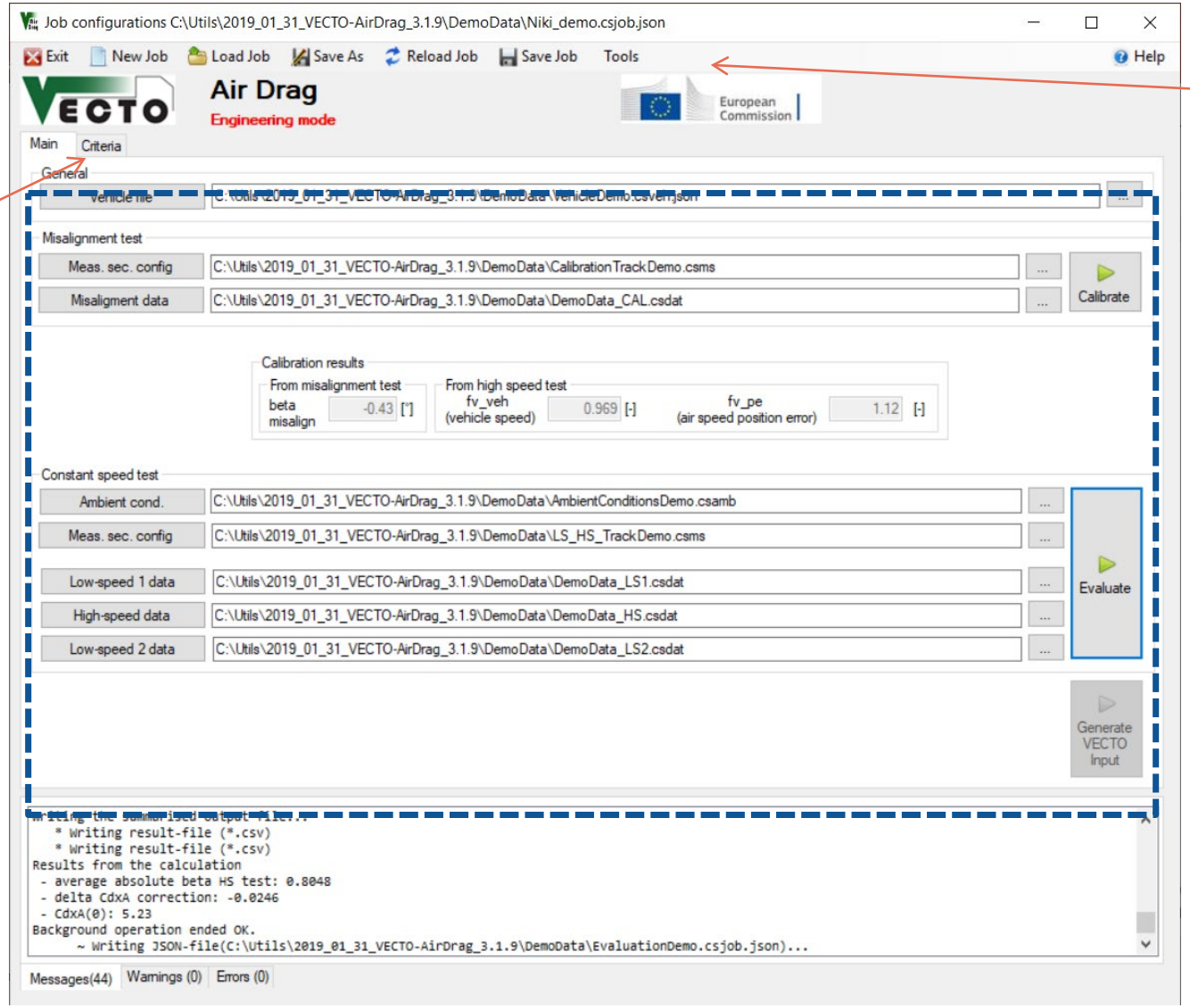
Weather station
气象站

- Ambient temperature
  环境温度
- Air pressure
  气压
- Humidity
  湿度

VECTO air drag
VECTO空气阻力

Main tab
主要选项卡

Validation criteria tab
验证标准选项卡



Toolbar
工具栏

File inputs
文件输入

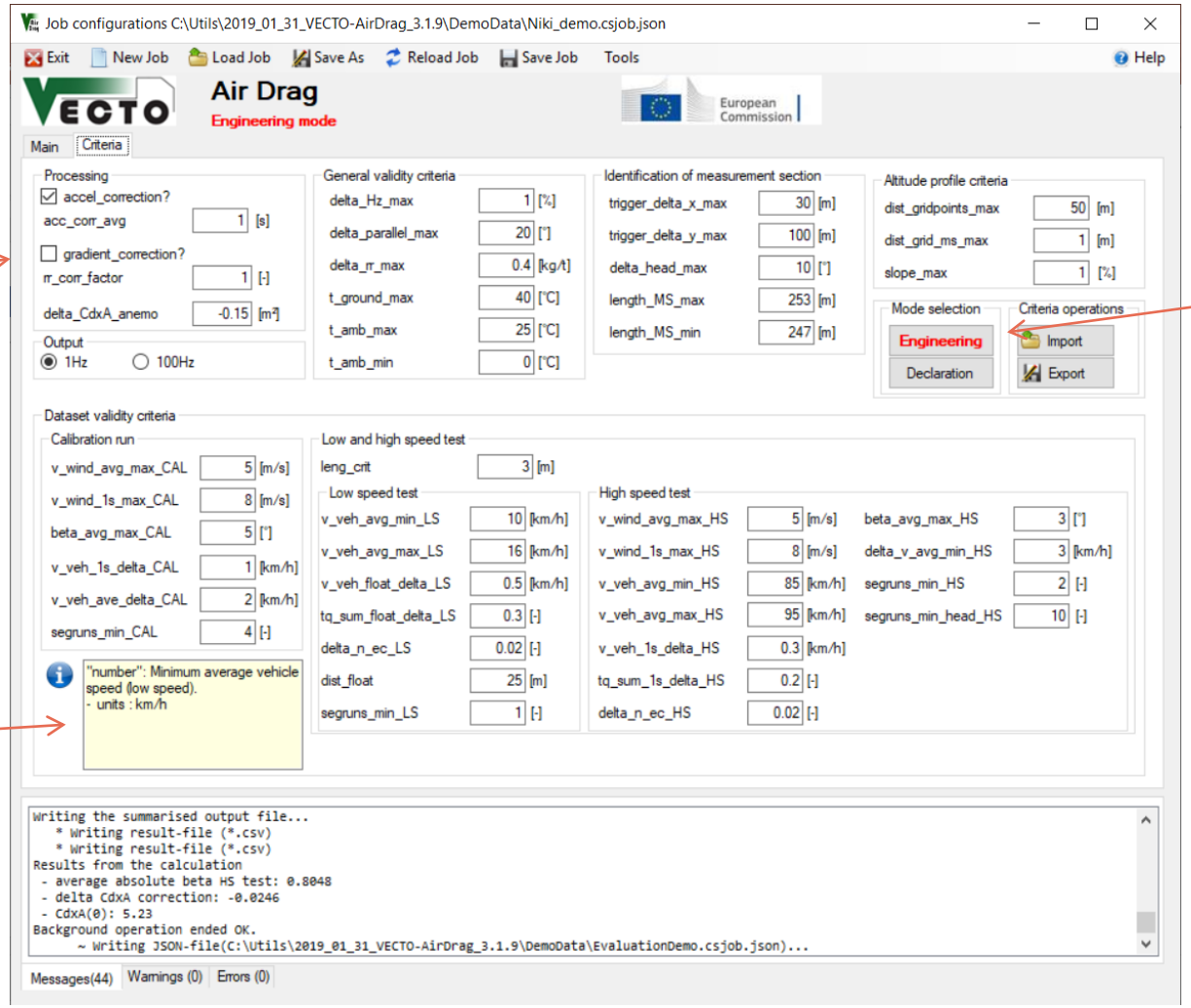
Message log
消息日志

European Commission

VECTO air drag
VECTO空气阻力

Validity criteria inputs
有效性标准输入

Input info section
输入信息部分

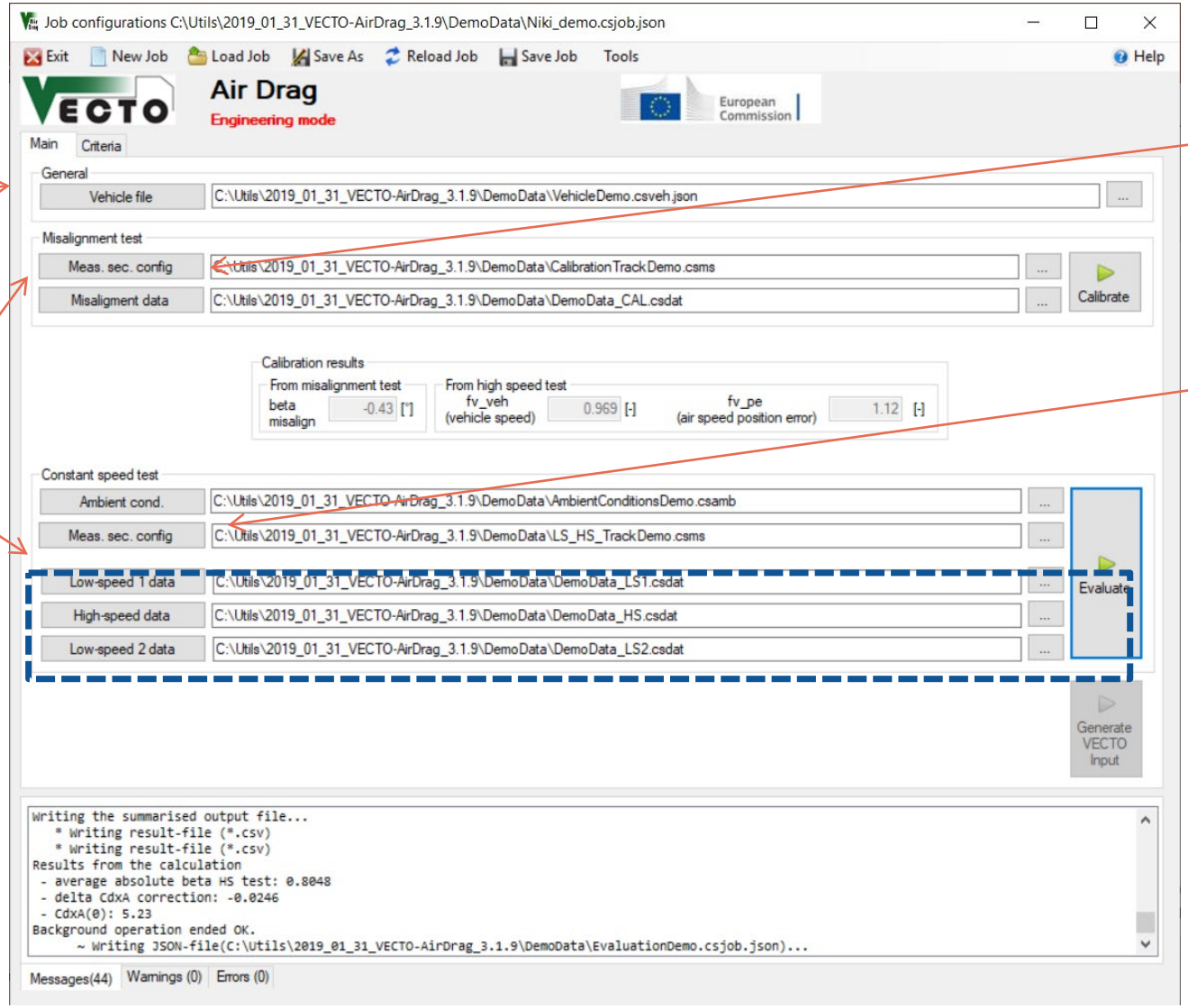


Mode selection
模式选择

VECTO air drag
VECTO空气阻力

Vehicle technical data file
车辆技术数据文件

Configuration of measurement section
测量部分的结构



Misalignment test
偏差测试

Ambient conditions
环境条件

High and low speed test measurements
高速和低速测试测量

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VECTO Hashing Tool
VECTO哈希算法工具

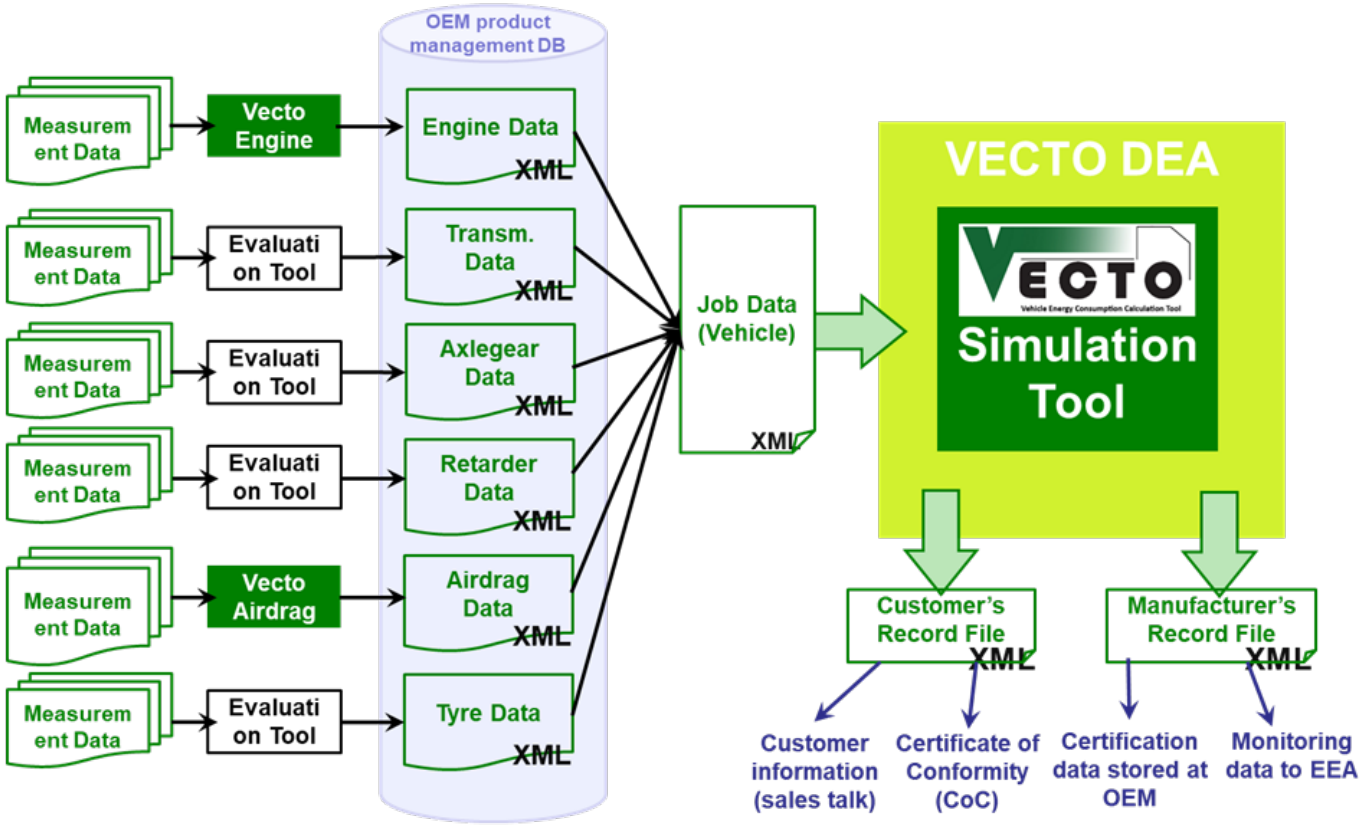
Hashing
哈希算法

Data integrity
数据完整性

- Traceability
可追溯性
- Detect modifications
检测修改
- Without actual data
没有实际数据

➔ Cryptographic hashing
密码哈希算法

➔ Digest value
摘要数值



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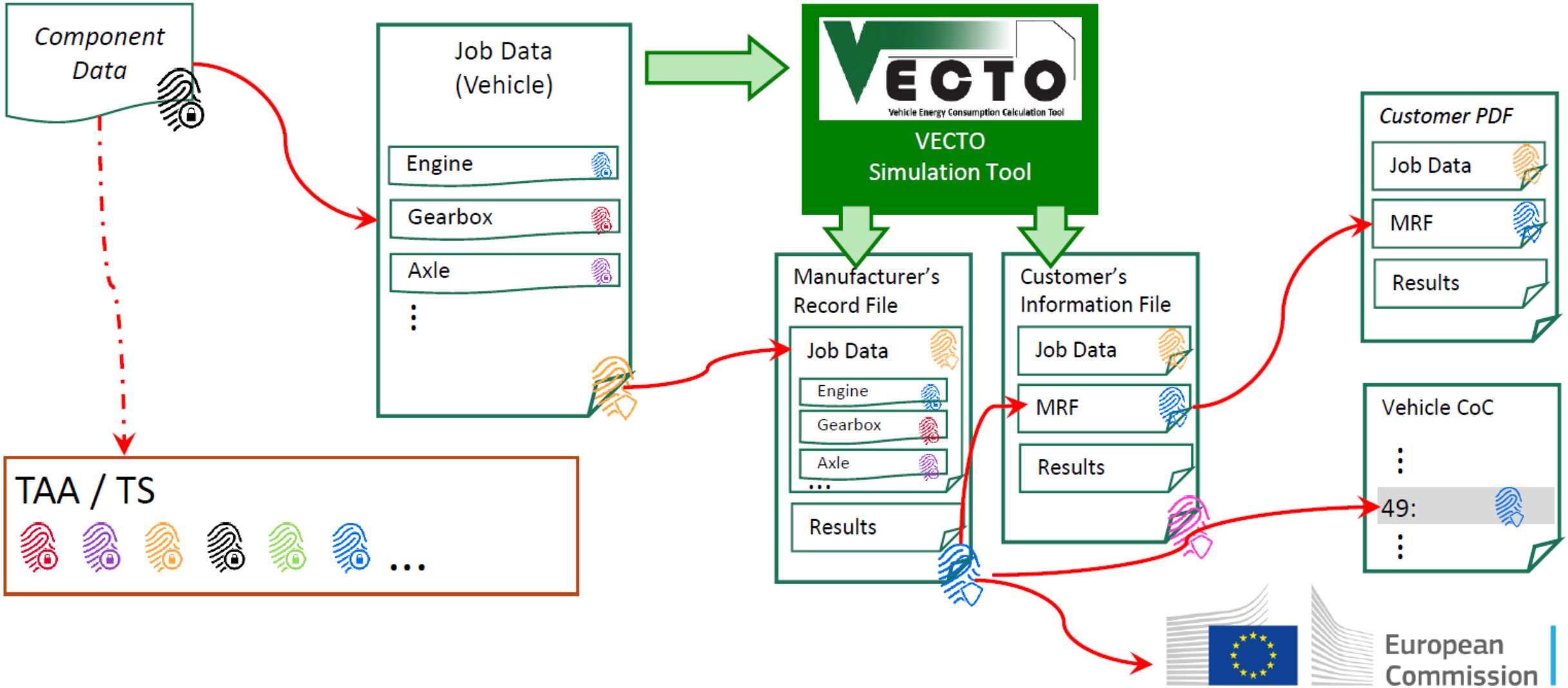
Hashing
哈希算法



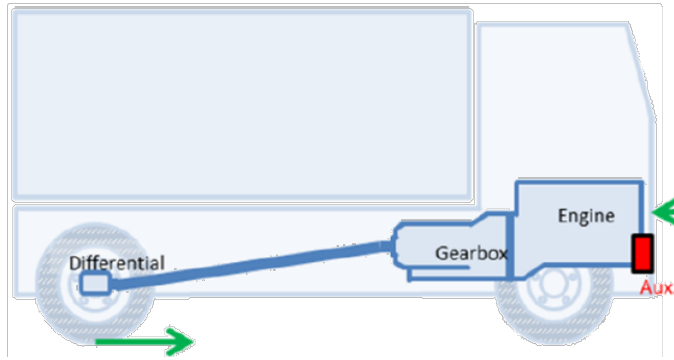
Verification Testing Procedure
验证测试程序

VTP

- On-road verification of declared fuel consumption
对所声明的燃料消耗量进行道路验证
- Test new vehicle
测试新车辆
- Measure:
测量：
  - Wheel torque & speed
车轮扭矩和速度
  - Engine speed
发动机速度
  - Gear
变速箱
  - Fuel consumption
燃料消耗量

VECTO
Fuel consumption
燃料消耗量

[g/kWh]



Wheel power
轮上功率

Fuel flow
燃料流量

European Commission

Heavy buses
重型巴士

Heavy buses - UNDER DEVELOPMENT
重型巴士 - 正在开发

- Dedicated auxiliary model
专门的辅助模型

- Dedicated mission profiles
专门的任务档案

- Factor method for multistage certification:
多级认证因式分解法：

$$CO_2\,[g/km] = CO_2{}_{\text{SpecPT, SpecEff, GenBody}} \cdot \frac{CO_2{}_{\text{SpecPT, GenEff, SpecBody}}}{CO_2{}_{\text{SpecPT, GenEff, GenBody}}}$$

VECTO primary

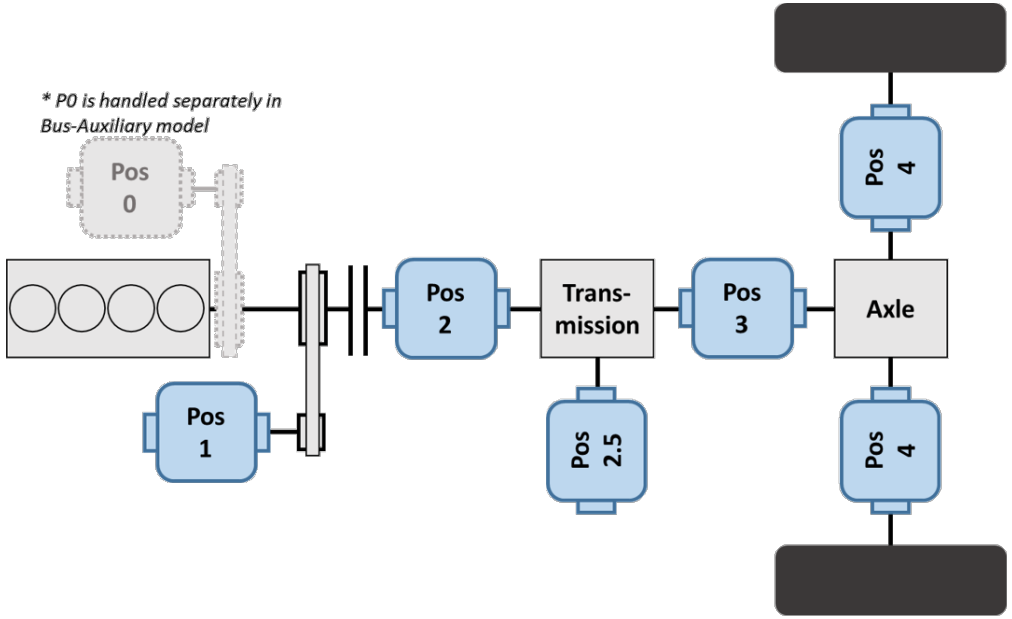
VECTO complete(d)

Where:
PT ..... Powertrain (ICE fullload curve, transmission type and ratios ...)
Eff ..... Component efficiency data (ICE map, ICE correction factors, Drivetrain efficiencies), CONFIDENTIAL DATA
Body .. Total vehicle mass, air drag, parts of auxiliaries (HVAC, Pneumatic System, Electric System)

Hybrid and Battery electric vehicles
混合动力和电池电动汽车

Hybrids - UNDER DEVELOPMENT
混合动力汽车 - 正在开发

- Battery electric and hybrid powertrains
电池电力和混合动力系统
  - Parallel, serial and powersplit
平联、串联和动力分配
  - Battery and supercapacitir
电池与超级电容
  - Electric motor
电动机
- Controller
控制器
  - Equivalent Consumption Minimization Strategy
等效消耗最小化策略



More information
更多信息

Confluence

➔ Latest Releases
最新发布

Bitbucket

➔ Version control
版本控制

JIRA

➔ Bug tracking
漏洞跟踪

Confluence

VECTO
version 3.3.9.2175,
released on December 15 2020.
版本3.3.9.2175，
发布日期：2020年12月15日。

VECTO AirDrag
version 3.1.9,
released on January 31 2019.
VECTO空气阻力
版本3.1.9，
发布日期：2019年1月31日。

VECTO Engine
version 1.4.4.1492,
released on February 1 2019.
VECTO发动机
版本1.4.4.1492，
发布日期：2019年2月1日。

Confluence Spaces People Calendars Create ··· Search

VECTO

- Pages
- Blog
- Canvas
- Calendars

SPACE SHORTCUTS

- Stakeholders
- JIRA
- Installation instructions
- Releases
- File lists

PAGE TREE

- Admin How-to
- Docs
- File lists
- Installation instructions
- IT Expert Group
- JIRA Overview
- Releases ①
  - Releases VECTO-Air Drag ②
  - VECTO Engine Releases ③
- Stakeholders ④

Pages Edit Save for later Watch Share ···

VECTO Home

Created by Unknown User (toolsconfluence), last modified by ANAGNOSTOPOULOS Kostis on Dec 03, 2015

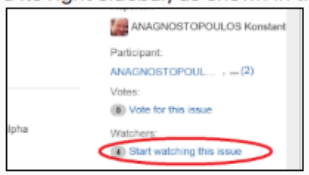
VECTO: *Vehicle Energy Consumption Calculation Tool*

VECTO is a vehicle simulation software created to support CO2 emissions monitoring from Heavy Duty Vehicles (HDV) in Europe and serve as the official CO2 calculation tool in a possible future certification scheme. It is written for .Net (VBasic & C#).

The purpose of this web site is to facilitate the communication between VECTO's development team with the users and streamline VECTO support related issues between the Commission and other organizations (OEMs, member states and type approval authorities) contributing to the development, review, and dissemination of VECTO.

Stay Up-to-date with VECTO
You can receive notifications on specific JIRA-issues or on the whole project.

- You can choose to *watch* an issue by clicking the *"Start watching this issue"* respective link a its right sidebar, as shown in the image:



- You can watch the project as a whole by clicking the "Watches" at the left navigation-bar and then clicking "Watch project", as shown in the image:

Navigate space

- Search
- **JIRA:** VECTO: Bug-tracking
- SVN: File-repository, accessed by developers
- Admin How-to
  - Docs
  - File lists
  - Installation instructions
  - IT Expert Group
  - JIRA Overview
  - Releases
  - Stakeholders

- Favourite Pages

There are currently no pages on your favourites list

Stakeholders Table

Includes a private page for every Stakeholder.

利益相关者表格

包括每个利益相关者的私人页面。

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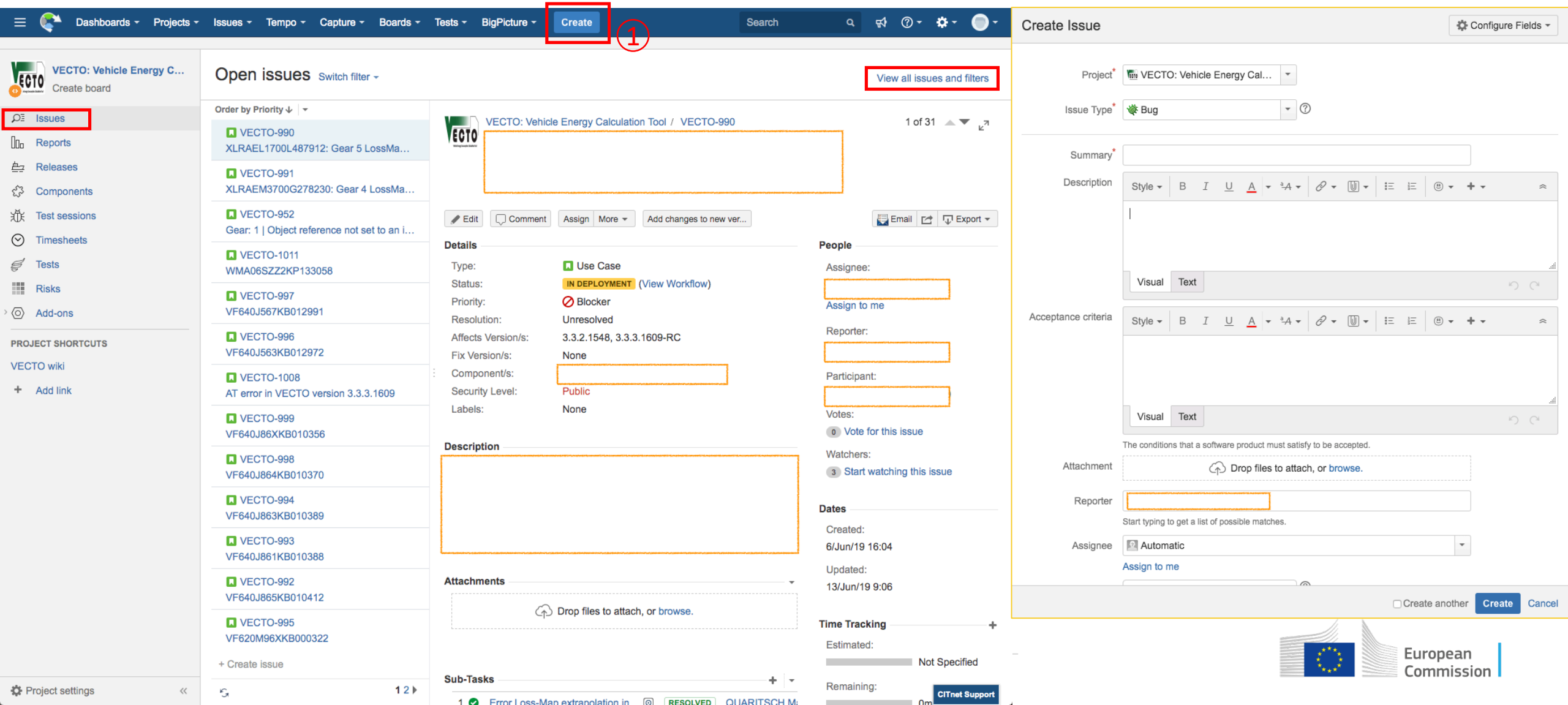
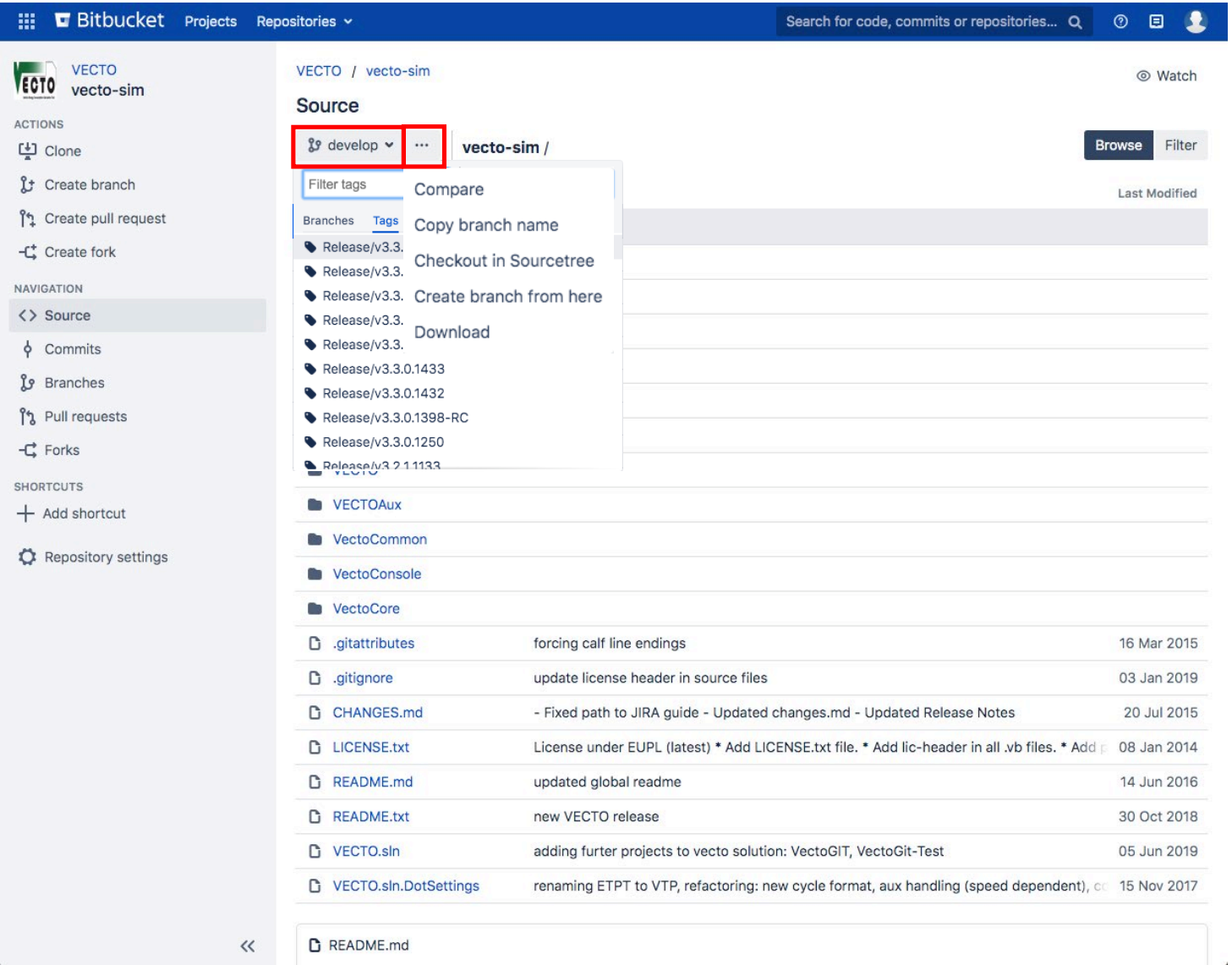
JIRA



European Commission

Bitbucket



What is there in Bitbucket?
Bitbucket有什么？

- **Version control** tool for code.
  代码的**版本控制**工具。
- **All** VECTO code is hosted here.
  All VECTO代码托管于此。
- Uses **Git** (in a *similar* way to Github).
  使用**Git**（与Github类似）。

Link to VECTO repositories in Bitbucket:
Bitbucket中VECTO资源库的链接：

://httpswebgate.ec.europa.eu/CITnet/stash/projects/VECTO

European Commission

Collaboration
协作

Software
软件

- Access to CITnet
CITnet使用权限
- Software support
软件支持
- Access to source code
源代码使用权限

Validation
验证

- Setting-up experimental campaigns
设置实验活动
- Setting-up VECTO
设置VECTO
- Analyzing simulation and experimental results
分析仿真模拟和实验结果

More information
更多信息

- Official VECTO website:
  官方VECTO网站：
  https://ec.europa.eu/clima/policies/transport/vehicles/vecto_en
- Video material
  视频材料
- Or contact:
  或联系方式：

jrc-vecto@ec.europa.eu

Keep in touch
联系我们

EU Science Hub | 欧盟科技中心: ec.europa.eu/jrc

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EU Science Hub – Joint Research Centre

欧盟科技中心 – 联合研究中心

EU Science, Research and Innovation

欧盟科技、研究和创新

EU Science Hub

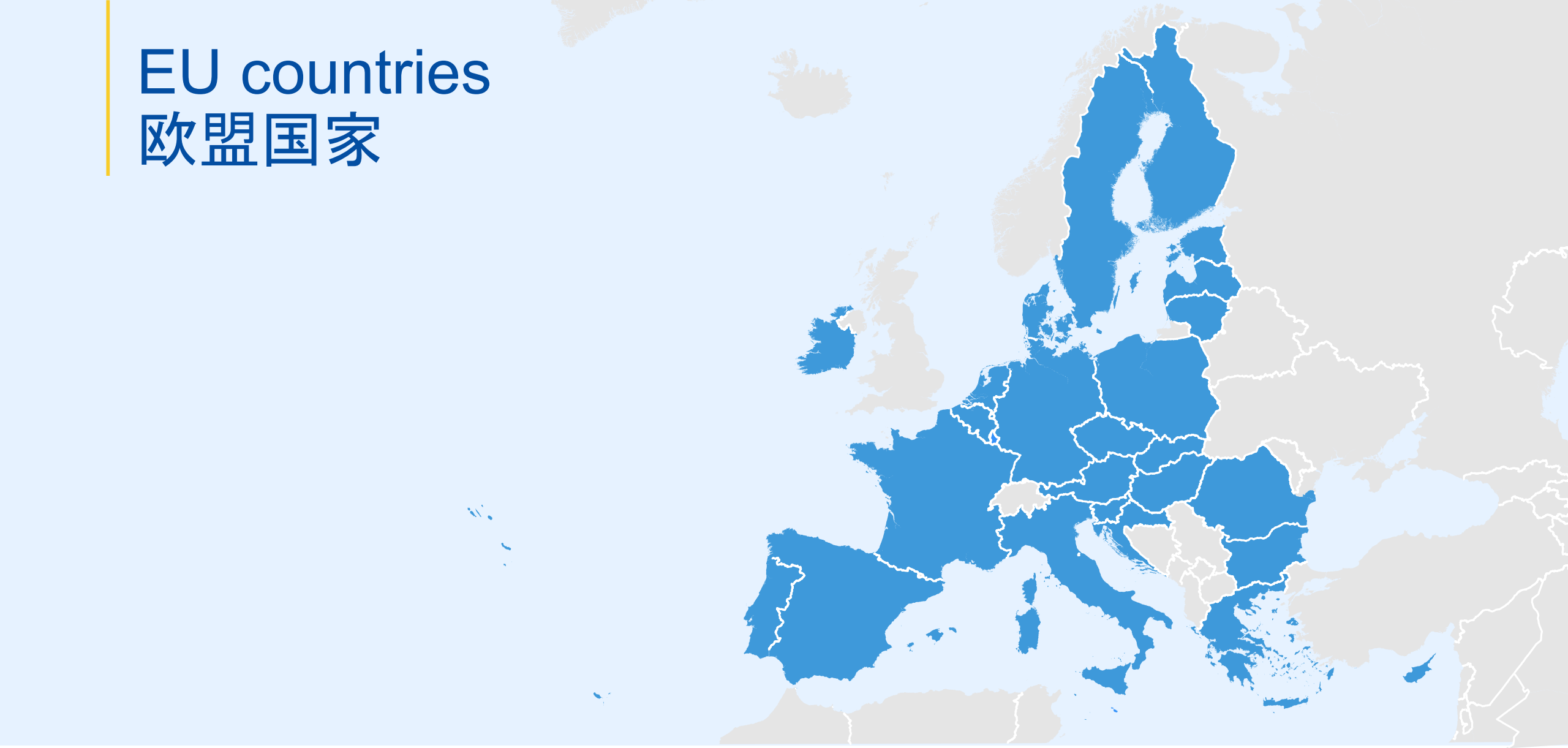
欧盟科技中心

European Commission

Thank you
谢谢！

European Commission

EU countries
欧盟国家



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European Commission