US EPA's Mobile Source Technical Review Subcommittee (MSTRS)
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European development of a certification method to quantify the FC and CO_2 emissions of complete heavy-duty vehicles

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VOLVO

Summary EU Activities

- **EU Commission to present a strategy targeting fuel consumption and CO_2 emissions from heavy duty vehicles - Q1 2013**
  - **Will include a certification method to quantify FC and CO_2 emissions of complete HDV**
  - **The method will most likely be based on a simulation tool with verification of model parameters via measurement**

Usage of CO_2 test results not decided. Options are:

- **Pilot phase or mandatory testing from 2013 on?**
- **Collect experiences → eventually adaptations of test procedure**
- **Collect and analyse test results**

→ Labeling and information for customers to decide which model fits best to his demands. Further options are target values and limits (e.g. g CO_2/ton-km)

Three Commission projects

Lot 1: Assess the amount and reduction potential of GHG emissions from Heavy Duty Vehicles. Final report ready

Lot 2: Propose a method to quantify such emissions for whole vehicles as well as for vehicle components. Planned to be ready end of 2011

Lot 3: New extension of Lot 2

Draft Legislation

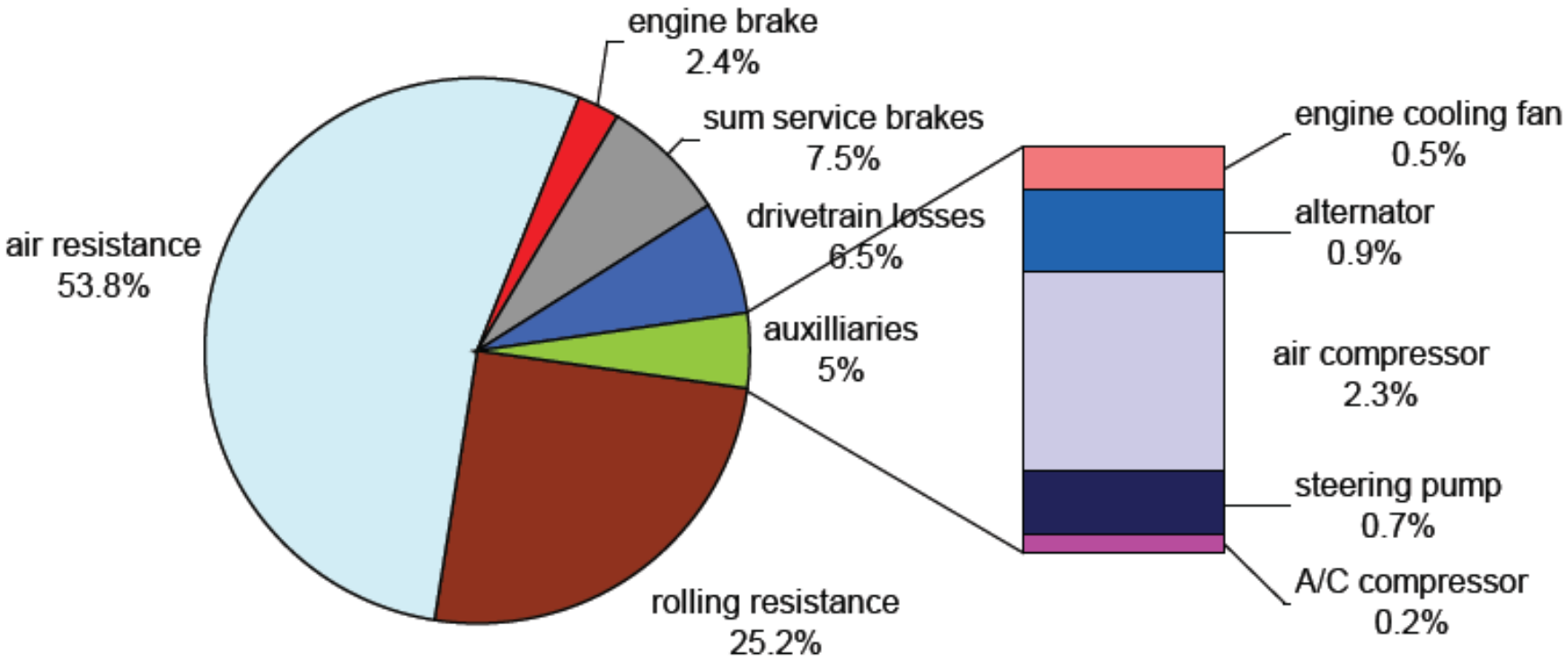
Lot 3 is expected to be completed during 2012

Summary of Lot 1
- Results

- A number of instruments have potential to reduce CO_2 emissions from HDVs
  - Performance requirements, best practices, speed reduction, dimensions, driver training, fuel taxes, road user charges, labeling, incentives etc.
  - No prioritization has been done by Lot 1
- Most meaningful metric of FC/GHG performance will be in relation to the work performed
- Any possible standards would also best take into account specific duty cycles for different applications or classes of HDV

Shares in energy consumption

Example: EURO V semitrailer with total 28 t, highway driving



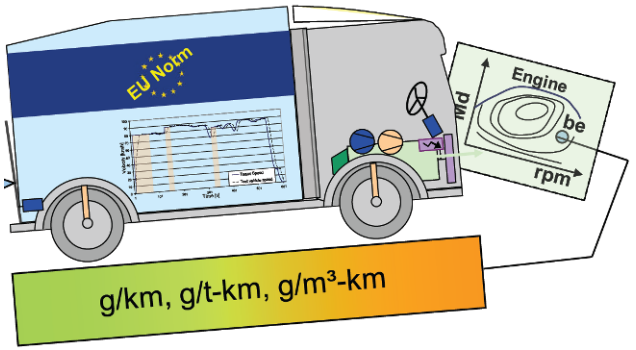
→ Must be included:
***** Air resistance**
***** Rolling resistance**
***** Engine efficiency**
→ +transmission ratios

Shall be included:
**** Transmission losses**

May be included:
*** Auxiliaries**
*** Power consumers**
(Auxiliaries are more important for buses!)

Summary of Lot 2
- Preliminary results

- Simulation based test method which should fulfill the following demands:
  - Incentive to apply efficient technologies
  - Repeatable and reproducible
  - High sensitivity to fuel saving measures
  - Realistic results
    - Categorize HDVs into different vehicle classes and mission profiles
  - Reasonable costs and efforts to run and examine the procedure
  - Applicable to (almost) all HDV categories and technologies
  - Simple and robust



Summary of Lot 2

- Preliminary results

- The simulation tool calculates engine power demand and speed based on a defined vehicle driving cycle
  - Fuel consumption will be interpolated from a steady state engine map
- Input data
  - Engine map for fuel consumption, measured during engine type approval
  - Basic vehicle data such as mass, number of axles, rolling resistance, air resistance, transmission
  - Driving cycles for different vehicle categories and mission profiles

Basic approach for planned CO_2 certification

MODEL

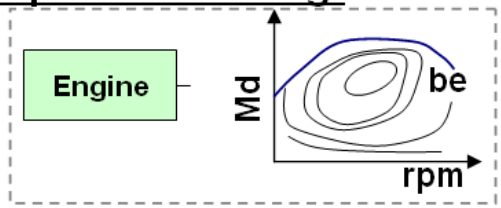
$Pe = P_{roll.} + P_{air} + P_{acc} + P_{grad} + P_{tr.} + P_{aux} + P_{cons.}$

$n = (v \times 60 \times I_{axis} \times I_{gear}) / (d \times \pi)$

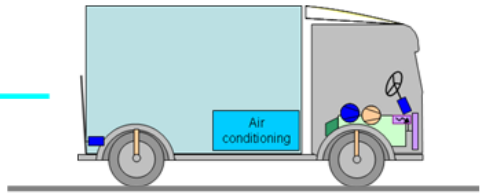
Gear shift model

Fuel cons., CO_2

Component testing:



Fuel consumption map:
a) steady state + WHTC correction factors
b) transient engine maps



Driving resistances, options:
a) constant speed (Pe from FC or Ecu-Pe)
b) coast down General: method for body builders

Influence from different tire models
Δ of resistance values from EC No 1222/2009

Gear box, axis:
transmission, η=F(...)

Transmission ratios, transmission losses:
a) default value (optional OEM specific map)

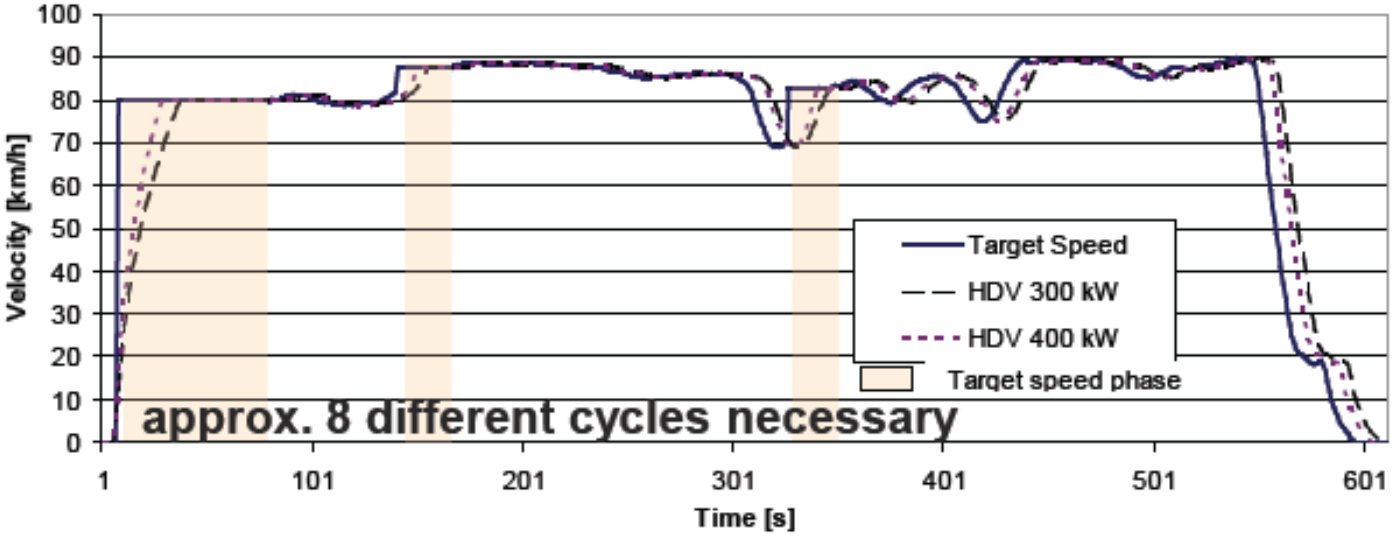
Auxiliaries
duty cycle, η=F(...)

Power demand from engine from
a) default P_e for different technologies
b) detailed simulation

Test cycles as input for simulation tool

Driving conditions very different between vehicle categories and mission profiles. Options:

a) One representative cycle per vehicle category (and mission profile) eventually including target speed phases and road gradients + one short standard cycle verifiable with PEMS or on chassis dyno



Length not limited

b) WHVC with different weighting factors for urban, road, motorway

Disadvantages: no target speed phases, no road gradients
→ may be unfair for several future technologies

Advantages: simpler, compatible with engine test approach

Summary of Lot 2
- Preliminary results

- Determination of driving resistance values
  - Constant velocity (preferred) and/or Coast down (variability concerns)
  - Both options will be further investigated in the project
- Determination of the Fuel Consumption Engine Map
  - The Euro VI test cycles, WHSC and WHTC, can not be used, don't fully cover all relevant engine operation conditions
  - Most promising proposal is to measure 50 to 80 steady state points in addition to the type approval
    - Interpolation of the fuel consumption for the WHTC engine load course from the steady state engine map
    - Measured fuel consumption in WHTC
    - Calculate a "WHTC correction factor"

Summary of Lot 2

- Preliminary results

- **Practicable approaches have been found for main elements of the certification procedure for FC and CO_2 emissions of heavy duty vehicles**
  - **Detailed description of the procedure and of the formulas for evaluation can be expected for many parts in 2011**
- **To include gear box and auxiliaries in the certification test would give incentives to further improve the energy efficiency of these components**
  - **Need to figure out which to include and which to replace by a simplified approach**
- **Fully representative test cycles should include road gradients and target speed phases**

Summary of Lot 3
- Planned deliverables

- Development of a simulation tool, definition of test cycles, type approval procedure etc.
- Draft Legislation with the indicated objective to cover 95% of EU HDVs
- Lot 3 is expected to be completed during 2012

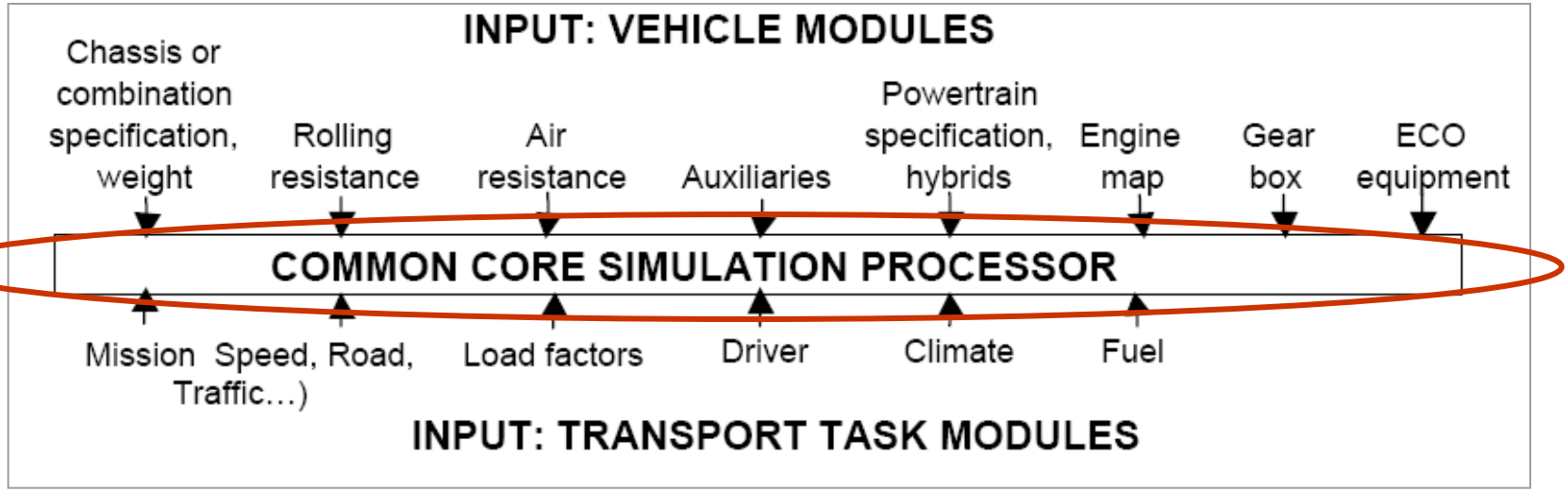
Industry input to the Commission

- Fuel efficiency for HDV is market driven

Industry supports

- Integrated approach to CO_2 emissions
  - Procedure for fuel efficiency calculation of complete vehicles
- Cost-effective policy measures
- Globally harmonized policies
- Study inclusion of transport into an international, non-sector specific, emission trading scheme

ACEA pre-study on fuel efficiency simulation

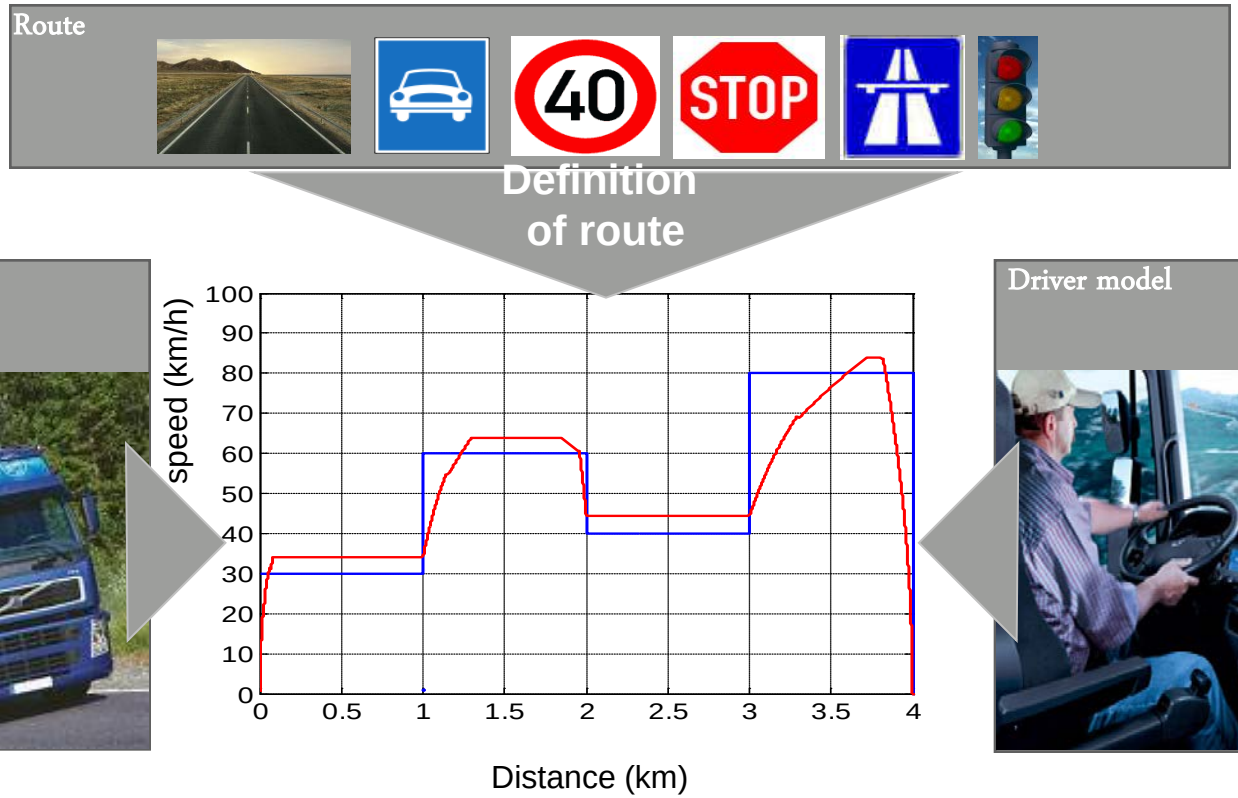


- **Vehicle classes and missions**
- **Efficiency metrics**
- **Demonstrate simulation methodology**
- **Validation**

Identified vehicle classes and transport mission profiles > 7.5 GVW

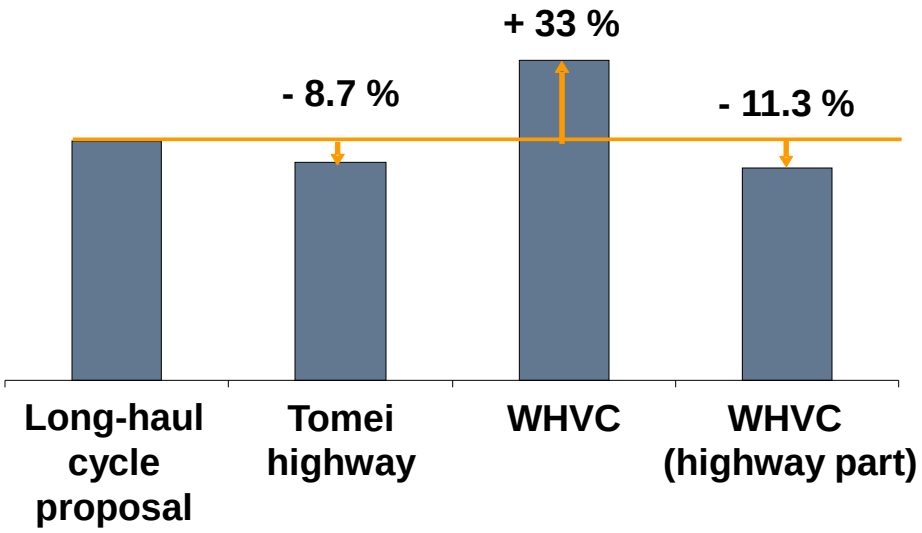
Vehicle classes and mission	
Long Haul	
One day trip	
Regional delivery/collection	
Urban delivery/collection	
Municipal utility	
Light off road	
Heavy off road	

One drive cycle for each vehicle class and mission



Choice of drive cycle is important

- Main target is realistic fuel consumption values
- Fuel consumption is heavily influenced by the cycle



Accuracy of simulation depends on accurate data input

- Aerodynamics
- Rolling resistance
- Engine
- Weight
- Transmission
- Torque converter
- Axles
- Auxiliaries
- Vehicle control strategies

ACEA input to EU Commission

- Any legal requirement shall result in the intended effects on road
- Compliance should be verifiable by standardized and accurate procedures