Heavy-duty hybrids
working group

Bernardo MARTÍNEZ
Automotive Industry Unit
bernardo.martinez@ec.europa.eu
UNECE Regulatory framework

• **General purpose**
  - Setting harmonized standards for vehicle components and systems at worldwide level
  - Reduction of burden to international trade

• **1958 Agreement**
  - Harmonization of administrative and technical requirements for **type-approval** of components and systems
  - Regulations apply entirely
  - Legal instrument: UNECE Regulations (140)

• **1998 Agreement**
  - Harmonization of technical requirements, but not type-approval
  - Contracting Parties may apply a specific Global Technical Regulation (GTR) totally or partially
  - Legal instrument: Global Technical Regulations (13)
Informal group on heavy-duty hybrids

- UNECE 1998 Agreement
- Participants: Japan, European Union, USA-EPA, Environment Canada... and private stakeholders
- Target: to develop a procedure for the determination of pollutants in hybrid heavy-duty vehicles
- Legal format: Annex 8 to Global Technical Regulation No 4
- Foreseen date of adoption: November 2014
- European Commission has already contributed with 440,000 $
HILS Methodology (I)

- Methodology: hardware in-the-loop (HILS) simulation
- First used in Japanese legislation
HILS Methodology (II)
HILS Methodology (III)
Vehicle based/engine based

• Implement both vehicle based and engine based methodology
Driving cycle: WHDHC

- WHDHC departs from WHTC, but adds the negative power recovered by the powertrain
Road gradients

- Approach: Work WHVC = Work WHTC at the end of each cycle → Constant slope

- Problem: still very different works in small $\Delta t$ leads to different emission results

- Solution: splitting WHVC into 12 sections and calculating average road gradient for each section
Other inputs needed for HILS

- Driver model for WHDHC
- Engine model
- RESS model
- Interface model
- Library of electric and non-electric components
- Development of test procedures (RESS, electric motor...)
**CO₂ emissions. VECTO**

Fuel consumption map:
- a) steady state + WHTC correction factors measured on engine test bed (for engine families)

Driving resistances, options:
- a) constant speed with torque measurement
- b) coast down tests

Influence from different tire models: resistance values adapted to EC No 1222/2009 (apply absolute value or Δ)

Transmission ratios, transmission losses
OEM specific maps and default values

Power demand from engine from
- a) generic $P_e$ for different technologies
- b) detailed simulation

Component testing:
- Engine
- Gear box, axis: transmission, $\eta = F(\ldots)$
- Auxiliaries: duty cycle, $\eta = F(\ldots)$

**MODEL**

- $\text{Pe} = P_{\text{roll}} + P_{\text{air}} + P_{\text{acc}} + P_{\text{grad}} + P_{\text{tr}} + P_{\text{aux}} + P_{\text{cons}}$
- $n = \left( v \cdot 60 \cdot I_{\text{axis}} \cdot I_{\text{gear}} \right) / \left( d \cdot \pi \right)$

Fuel cons., CO₂
VECTO and HILS

- CO\(_2\) is not included in the GTR
- However, it is important that information coming from CO\(_2\) simulation tools can be used as input in HILS
- Interaction VECTO/HILS
  - VECTO provides powertrain power and rpm (instead of WHDHC)
  - HILS calculates
    - Conventional engine torque and rpm
    - Fuel consumption (interpolated from engine map)
Next steps

- Validation phase with real vehicles (Volvo, Iveco, MAN)
- Editorial work, to be finished in June 2014
- GTR to be adopted at the end of 2014
- Enactment in European legislation