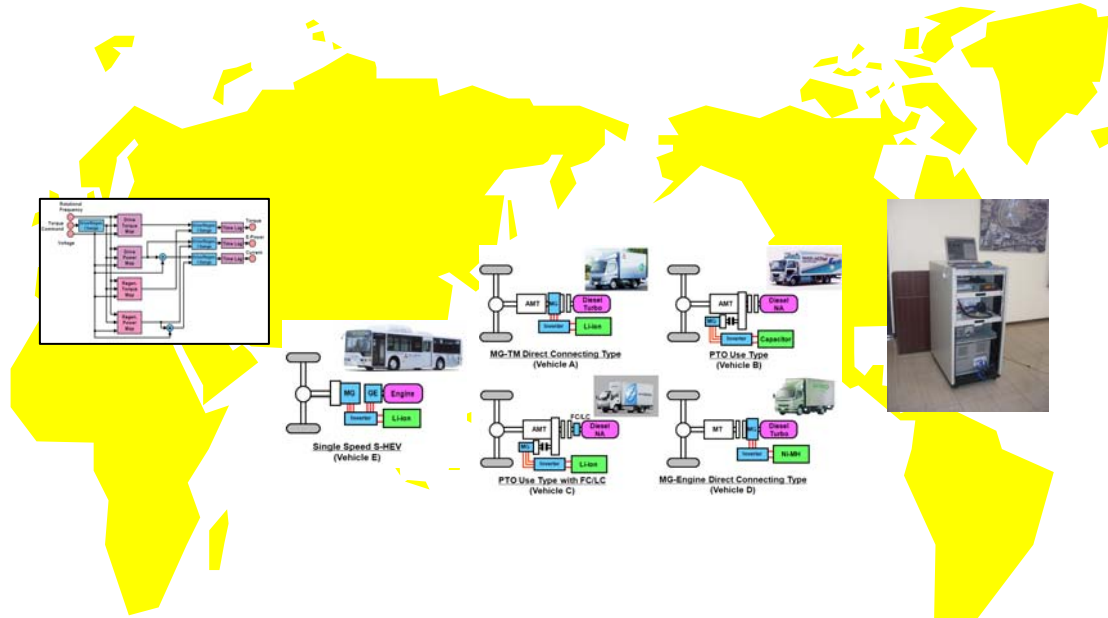




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Working Paper No. **HDH-10-07**  
(10th HDH meeting, 05 June 2012)



# GRPE Informal Group on Heavy Duty Hybrids

10th HDH, Geneva, 05 June 2012



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# Status of HDH Work Program

## ➤ Research program

- Work program at TU Vienna has been finished
- Work program at TU Graz has been largely finished
  - WHVC weighting factors will be submitted upon completion of EU CO2 test cycles
- Work program at Chalmers University has been finished

## ➤ Future steps

- Discussion on chassis dyno and powerpack testing will continue on the basis of input from ongoing programs at the Contracting Parties
- Validation step 1 based on SILS (Software-in-the-loop simulation) will start in June 2012
- Validation step 2 with real HDV will start around March 2013



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# Summary of 9th HDH Meeting

- **The results of the 9th meeting in Tokyo from 21 to 23 March 2012 are summarized, as follows:**
  - **The revised roadmap and project planning were agreed**
  - **TU Vienna will prepare a quote for the first validation study using software based simulation**
  - **The first validation study will cover both the original HILS approach (based on WHVC) and the power demand approach proposed by TU Graz (based on WHTC) for electric and non-electric hybrids**
  - **It is general understanding that a vehicle independent approach would be the most favorable solution provided the results largely match real world operation**
  - **The extended HILS approach will no longer be considered**
  - **OICA offered to submit part of the budget for validation phase 1**



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# Research Program - Task 1

- **Task 1: Investigation and modification, if applicable, of the Japanese HILS model and interface including a proposal for a verification method w/o vehicle testing**
  
- **Major findings**
  - **The Japanese HILS procedure and the HILS open source model were evaluated and possible improvements (e.g. more topologies, component library, temperature signals to include cold start tests) are proposed**
  - **In general, the simulation model provides a good basis for a global regulation, but needs to be refined for establishing a global regulation**
  - **The Japanese HILS model verification process is a promising method but needs some modification**
  - **The review of vehicle related data resulted in three different options for creating the HILS engine test cycle**
    - **WHVC with adapted gradients and vehicle data sets (original HILS approach)**
    - **power demand cycle (World Heavy Duty Hybrid Cycle = WHDHC) at the wheel hub**
    - **power demand cycle (WHDHC) at the power pack shaft, which is similar to the WHTC for conventional engines**



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## Research Program - Task 2

- **Task 2: Investigation and modification, if applicable, of the HILS component testing**
  
- **Major findings**
  - **The component test procedures laid down in the Japanese regulation are common test procedures that can be adapted for a global regulation and are considered to provide correct input data to the simulation models.**
  - **The procedures for component/system testing and for model validation appear to be applicable to the components of both electric and non-electric hybrids**
  - **A component library is proposed to be part of the global regulation**
  - **Thermal effects of component testing need further investigation**



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## Research Program - Task 3

- **Task 3: Extension of HILS to non-electrical hybrids, which are currently not covered by the Japanese test procedure**
  
- **Major findings**
  - **Non-electric hybrid powertrain topologies fit well into the same categories as for electric hybrid powertrains**
  - **In general, non-electric hybrids can be divided into serial, parallel and split powertrain topologies**
  - **The models to include non-electric hybrids have been developed based on models presented in the literature**
  - **No major modifications to the HILS model are needed, since non-electric components/subsystems have the same purpose as the electric components/subsystems**
  - **Model structures and mathematical models can be largely used “plug ‘n play” with the models of hybrid electric powertrains**



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## Research Program - Task 4

- **Task 4: Inclusion of PTO operation, which normally takes place outside the test cycle**
- **Major findings**
  - **Inclusion of PTO operation is not recommended for criteria pollutants due to the minor influence of PTO load on brake specific emissions and since it would not be in line with the test procedure for conventional engines**
  - **PTO operation could be included in a test procedure for CO<sub>2</sub> emissions of the entire vehicle in a way similar to dealing with auxiliaries**
  - **Options for taking PTO load into account are the use of a benefit factor according to US EPA regulations or including PTOs in the simulation tool or a combination of both**





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# Research Program - Task 5

- **Task 5: Development of WHVC weighting/scaling factors to represent real world vehicle operation**
  
- **Major findings**
  - A methodology to calculate WHVC weighting factors to represent real world vehicle operation was developed that is applicable to all combinations of test cycles and vehicles
  - The result for city bus operation was presented
  - For other vehicle categories, results will be provided w/o further cost upon final adoption of the test cycles of the EU CO<sub>2</sub> test program (end 2012)
  - Options to coordinate the HDH test procedure with the EU CO<sub>2</sub> test procedure for Heavy Duty Vehicles have been elaborated



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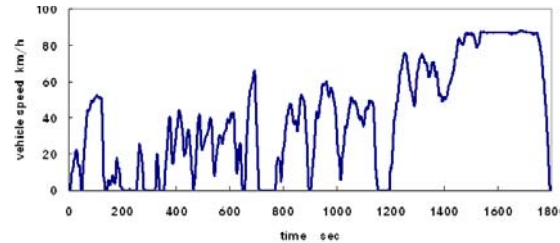
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# JASIC Alternative Proposal

Vehicle speed pattern (WHVC)

Harmonized vehicle specification

+

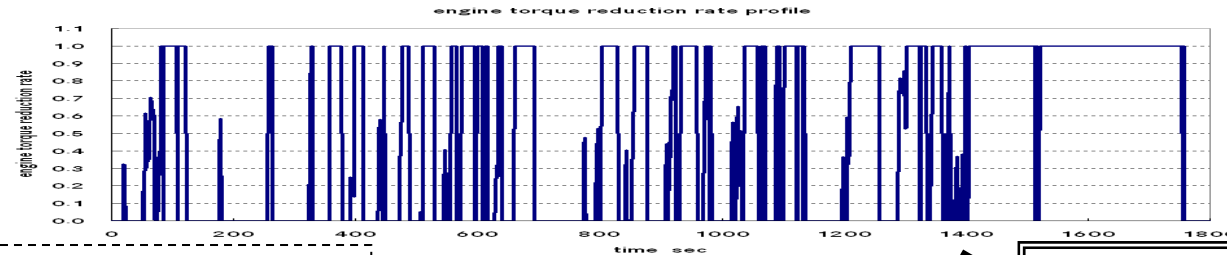


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Engine speed/torque and e-motor speed/torque by HILS

⇓

Engine torque reduction ratio profile = engine power / (engine power + e-motor power)



WHTC for combustion engine

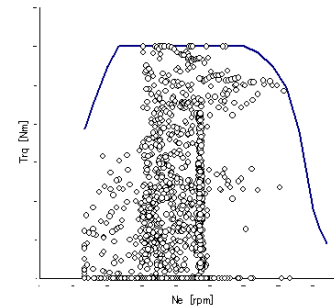
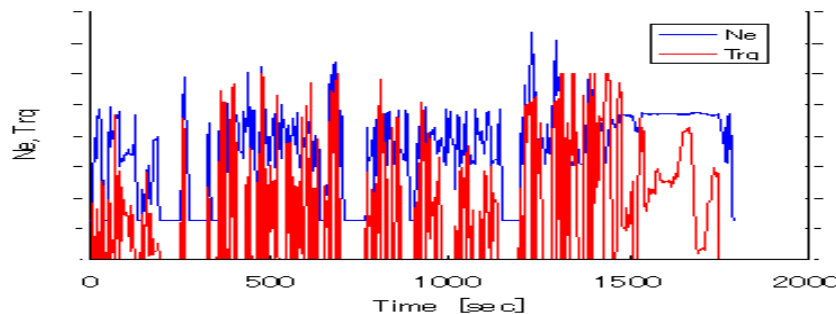
Normalized speed and torque

+

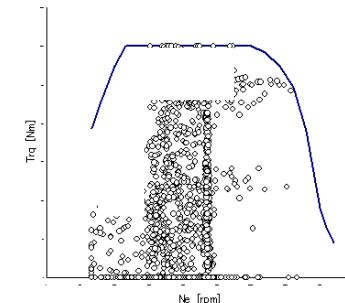
Full load torque curve of engine

⇒

HDH engine reduced torque/speed (same as WHTC)



⇒





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# Items for 10th Meeting

- **The following items need to be decided:**
  - **Adoption of validation step 1, as suggested by the research institutes**
    - ➔ will need to be finished before 2nd validation starts
    - ➔ will consequently delay roadmap
  - **Acceptance of considering the power demand cycles as an alternative to the vehicle cycle in validation step 1**
    - ➔ requires a method to define and to normalize the full load curve for hybrid power packs
  - **Financial contributions to validation step 1**
    - ➔ ACEA will cover task 1 (serial hybrid) of 181.570 €
    - ➔ remainder for tasks 2 and 3 is 134.130 €
  - **Consideration of JASIC proposal (torque reduction factor to WHTC)**
  - **Discussion of overall validation scheme**
  - **Laboratories/institutes interested in HDH validation studies**
    - for example, powerpack testing and vehicle testing
  - **Adoption of revised roadmap and project planning**



# Updated Roadmap & Project Planning

Activity	2 0 1 1				2 0 1 2				2 0 1 3				2 0 1 4																	
	06	07	08	09	10	11	12	01	02	03	04	05	06	07	08	09	10	11	12	01	02	03	04	05	06	07	08	09	10	11
HILS model verification	█				█																									
Component testing verification	█				█																									
Extension to non-electric hybrids	█				█																									
PTO operation	█				█																									
WHVC weighting & scaling factors	█				█																									
Assessment of chassis dyno procedure	█				█																									
Assessment of powerpack testing	█				█																									
7th meeting	X																													
8th meeting					X																									
9th meeting					X																									
Interim report					█																									
Validation test program 1					█																									
10th meeting					X																									
11th meeting									X																					
Validation test program 2					█																									
Drafting text for gtr n°4					█																									
12th meeting									X																					
Evaluation & conclusions									█																					
13th meeting									X																					
Final report									█																					
14th meeting									X																					
15th meeting													X																	
GRPE adoption													X																	
WP.29 adoption																	X													

- ➔ Timing for GRPE adoption delayed until 01/2014
- ➔ Timing for WP.29 adoption likely to be delayed by 8 months (11/2014)
- Updated roadmap finally agreed by HDH informal group at 10th meeting



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## Next Meetings

➤ **The next meetings are scheduled as follows:**

- **The 11th meeting will be from 10 to 12 October 2012 in Ottawa**
- **The 12th meeting will be on 15 January 2013 in Geneva (to be confirmed)**
- **The 13th meeting will be in March 2013 (Europe, date and place to be confirmed)**
- **The 14th meeting will be in June 2013 in Geneva (to be confirmed)**
- **The 15th meeting will be in October 2013 (San Francisco, date to be confirmed)**