

Tokyo, 21.03.2012

Working Paper No. **HDH-09-13**
(9th HDH meeting, 21 to 23 March 2012)

GRPE-HDH Research Project Status, TU Vienna



Institut für Fahrzeugantriebe
& Automobiltechnik



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Outline

GRPE-HDH TU Vienna

- Introduction
- Minutes to last meeting, Brussels 15.02.2012
- Topics for Tokyo meeting, Tokyo 21-23.03.2012
 - Review of Assessments, TU-Vienna
 - Suggestions for Validation Test Program

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Minutes to last meeting, Brussels 15.02.2012

- **IFA/TU Vienna presented assessment to Japanese HILS method**
 - Discussion about assessment
 - Discussion about extended HILS → possible alternative
 - Members agreed to assessment and suggestions
 - Final report (35-50 pages) till 21. March 2012
(7-10 comprehensive pages for combined institutes report till May 2012)

- **TU Graz presented their actual working status**
 - Suggestion of power cycle instead of speed cycle is a good opinion
 - still work to fulfil working tasks till April 2012

- **Chalmers University presented their actual working status**
 - Working status: modelling of non electric hybrid components (flywheel, pump/motor, ...)
 - still work to fulfil working tasks till April 2012

Next steps for upcoming meeting, Tokyo 21-23.03.2012

TODO for Tokyo-Meeting

- Make an draft offer on agreed working package including detailed steps.
 - One offer with costs of all institutes, separate offer for executed working tasks
- Finalise report
- Presentation of planned working tasks

Outline

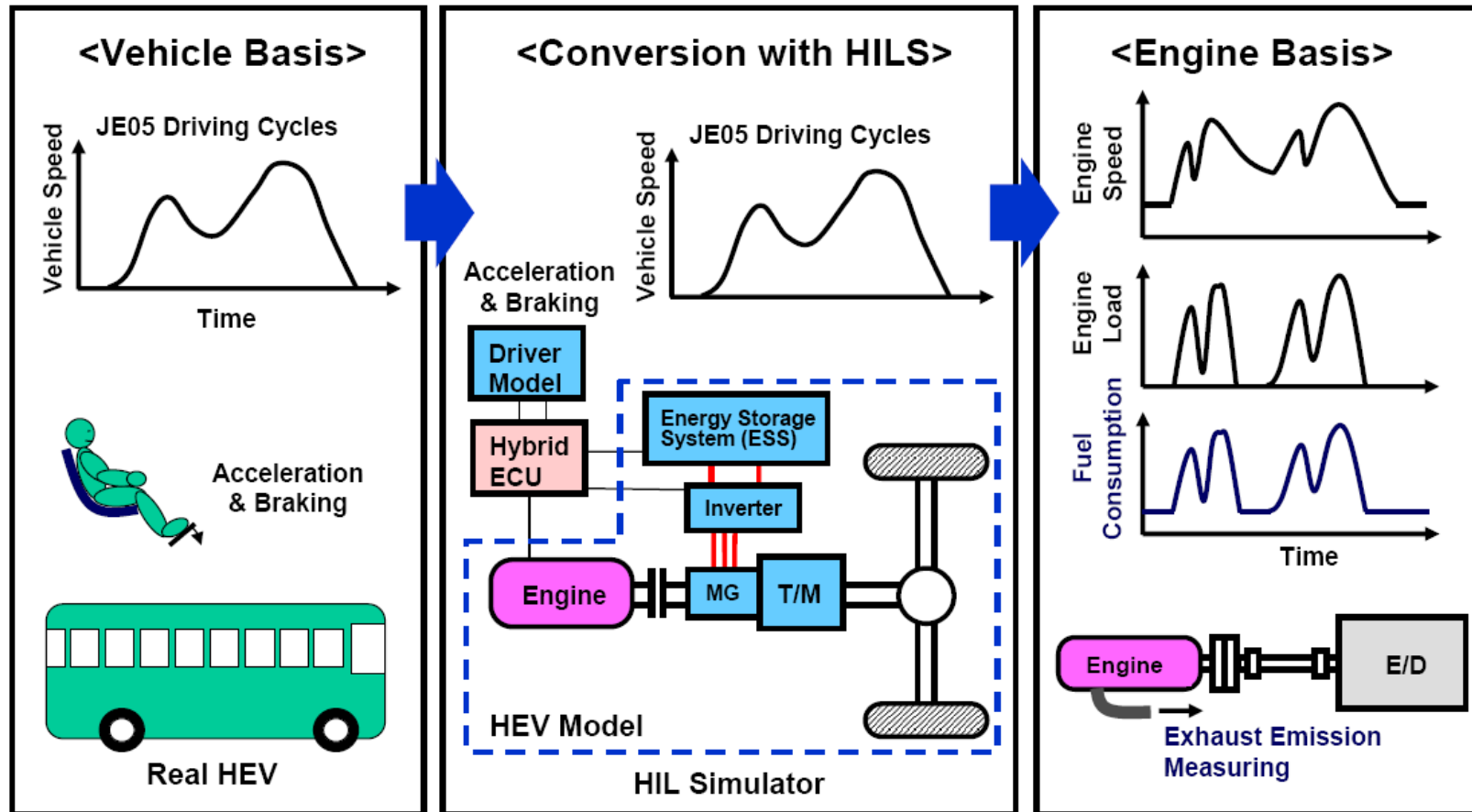
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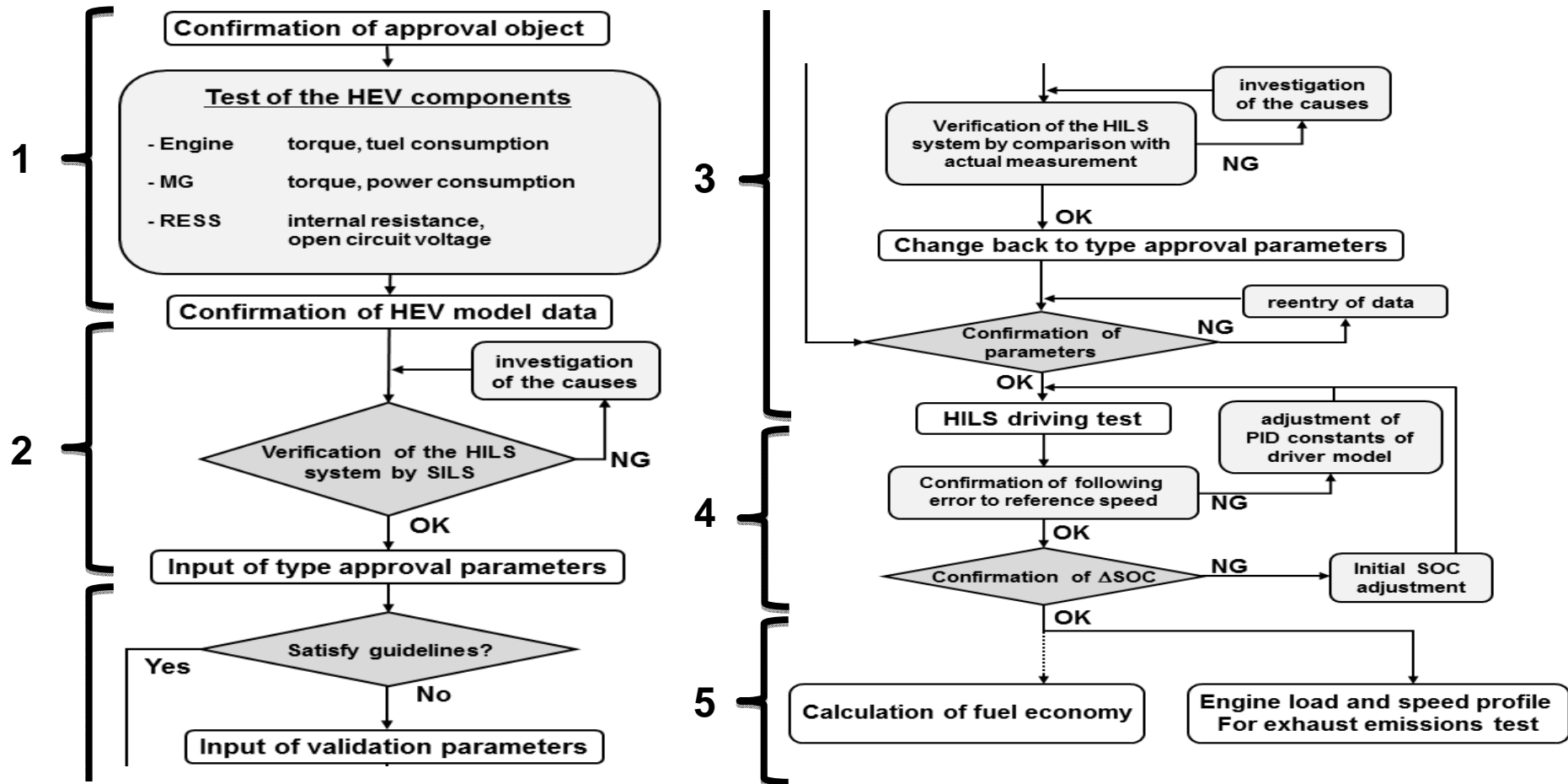
Development of an exhaust emissions and CO₂ measurement test procedure for heavy duty hybrids (HDH)

Introduction

- Japanese HILS method for Heavy Duty Hybrid Vehicle Certification:



State-Flow of Japanese HILS-Certification



1...Component Test
2...Model Pre-Check

3...short-time Model Verification
4...long-time Model Verification

5...Test-Bench

Summary and Suggestions

□ Japanese Method:

- Certification is done by using HILS method
- Only ECU is used as real hardware, remaining components are simulated
- Authorities cooperate closely with manufacturers
- Verification is done by comparing real measured vehicle data with simulation results in two steps: long term and short term verification within Japanese Test Cycle
- Specific test procedures are used to obtain component characteristic data for simulation model (e.g. combustion engine, motor/generator, battery,...)
- Model depth depends on regulations tolerances (e.g. Power, Torque $\leq 0,88$ for Motor/Generator)
- If model passes verification test, resulting engine speed and load profile are used for certification on test bench



Technical Evaluation of Japanese HILS Method

Global Overview (I)

Characteristics of Japanese HILS certification	Review of actual Japanese situation	Potential solution	Comment
Auxiliaries	Not recognized yet	Not important for emission certification	Alignment to WHDC
Recognized vehicle powertrain concepts	5 topologies	more types of powertrains have to be added including non electric hybrid concepts.	Component library
Component modeling	numerical solving of differential equations and usage of maps	Future components are actually not implemented	Component library
Usage of multi ECU or distributed functionality	Not recognized yet	Has to be provided	
Thermal modeling of electrical and mechanical components	Not recognized yet	Have to be recognized within HILS model	Additional model data and signals required

Technical Evaluation of Japanese HILS Method

Global Overview (II)

Characteristics of Japanese HILS certification	Review of actual Japanese situation	Potential solution	Comment
Hot and cold start	Certification only at hot condition	Cold start has to be recognized	As done in European certification
Durability recognition within component	Not recognized yet	Usage of aging models	

Provided Japanese open source model from JARI:

ECU	A simplification is used within open source model	Implement real software modeled ECU	Cooperation to OEM's
		Use own modeled ECU, predefining simple operating strategy	No acquisition to real ECU
Component data	Dummy data is used	Replace dummy by real data	Cooperation to OEM's

Technical Evaluation of Japanese HILS Method

Manufacturer required signals within HILS model

Model	Signal specification	Designation
RESS	Temperature	Temperature data of power electronics
Engine/Generator	Temperature	Temperature data of power electronics
Combustion Engine	Temperature	Exhaust temperature (at multiple locations) Coolant temperature Oil temperature Intake temperature
Environment	Temperature	Air temperature

RESS.....Rechargeable Energy Storage System

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Summary and Suggestions

- **Suggestions for global regulation:**
 - Cooperation between authorities and manufacturers is necessary.
 - e.g. responsibilities matrix for, interface model, powertrain model, component library,...
 - Japanese HILS certification method is a possible concept and provides a good basis in order to do certification of heavy duty hybrids
 - For a global regulation additional work has to be done
 - Interface and powertrain model have to be modified in case of additional necessary temperature signals
 -) by using temperature specific functions within Japanese HILS Model
 -) possible alternative: Extended HILS Method for complex combustion engine behaviour

Summary and Suggestions

- Generally common methods are used as component test procedure, but in cases of inaccurate simulation results, model depth has to be enhanced since verification is passed
- Additional components like non-electric hybrids have to be modelled for future certification process. Promising concept is the usage of a component library.
- In cases of using multiple ECUs, measurement hardware and the software model have to be able to handle ECUs signals
- In cases of too high effort for setting up an HILS-Model, consideration should also be given to alternative methods (e.g. extended HILS-Method, powerpack)

Final Report will be handed in at march 21 (GRPE HDH Meeting Tokyo)

Summary and Suggestions

□ **Manufacturers opinion:**

- For global regulation close cooperation between authorities and manufacturers is necessary
- Japanese HILS method is a possible concept but has to be modified in order to a global regulation because of:
 - Additional signals within simulation models are required
 - Additional components like non-electric hybrids have to be modelled for future certification process. Promising concept is the propose of a component library.
 - Component testing procedure could raise effort in a tremendous way if simulation results are not accurate enough for verification
- TU Vienna/IFA's suggestion of an "extended HILS-Method" would be a promising concept

Outlook

Suggestions for Validation Test Program (I):

According to the assessment of the Japanese HILS certification method, which has been made in previous working tasks by IFA and partner University Institutes, following tasks could be covered:

- **Task 1)** Adaptation of the Japanese HILS Simulator for serial hybrid
 - Task 1.1) Set up a serial HDH in the Simulator with the ECU as software in the loop as basis for further programming and software development
 - Task 1.2) Add a software tool (“driver model”) which allows running the simulator with test cycles consisting of power and rpm at the wheel hub and at the power pack shaft as basis for the “GTR-HILS” model
 - Task 1.3) Extend the Simulator with a library for non-electric components (as defined in part one of the project)
 - Task 1.4) Survey on relevant components to be included in a first version of a “GTR-HILS model” as basis for tasks 1.5 and 1.6

Outlook

Suggestions for Validation Test Program (II):

- Task 1.5) Extend the GTR-HILS Simulator with a library of new components (planetary gear box, power split, ...)
- Task 1.6) Extend the GTR-HILS Simulator with thermal models (exhaust gas aftertreatment components, coolant, lube oil, battery and electric motor where relevant according to task 1.4)
- Task 1.7) Simulation runs and validation of basic functions

□ **Task 2)** Adaptation of the GTR-HILS Simulator for parallel hybrid

- Task 2.1) Set up a data bus system in the model to allow various combinations of engines, gear boxes and storage systems
- Task 2.2) Adapt the Software to simulate a parallel HDH
- Task 2.3) Simulation runs and validation of basic functions, including the functions from task 1

Outlook

Suggestions for Validation Test Program (III):

- **Task 3)** Adaptations and improvements on the methods for component testing, test cycle definition and simulation method according to demands of industry and Commission

- **Task 4)** Define and provide the interface system for real ECU's

- **Task 5)** Reporting on test procedure and writing a user manual for software

- **Task 6)** Validation of the entire test procedure with real HDH vehicles and ECU's in the HILS.
 - Task 6.1: Support for OEMs
 - Task 6.2: Collecting feedback and make adaptations in the methods
 - Task 6.3: Assessment of expenses to apply the HILS Model

Thank you for your attention!



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