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GRPE/HDH-03-07



GRPE Informal Group on Heavy Duty Hybrids

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Principles of HD Emissions Certification

- From the beginning of heavy duty emissions regulation, the large diversity and complexity of heavy duty vehicles resulted in the establishment of an engine based emissions test procedure; currently, different engine test cycles are used in Europe, Japan and the USA
- GRPE/WHDC developed from individual duty cycles a world harmonized vehicle cycle (WHVC), which was transferred into engine cycles (WHTC, WHSC); they were adopted as gtr n° 4 in 2006 and amended in 2010
- The WHDC database best represents the average driving behavior of heavy duty vehicles worldwide
- The WHDC test procedure is not representative of an individual duty cycle, but is a reasonable approximation of engine operation in conventional powertrains



UNITED NATIONS Development of WHDC Engine cycles

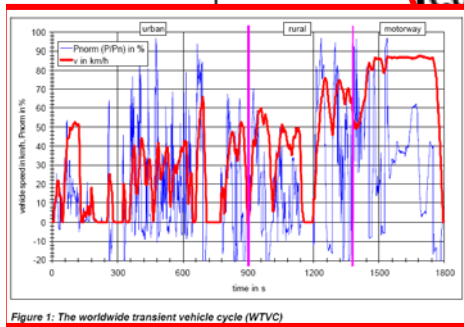
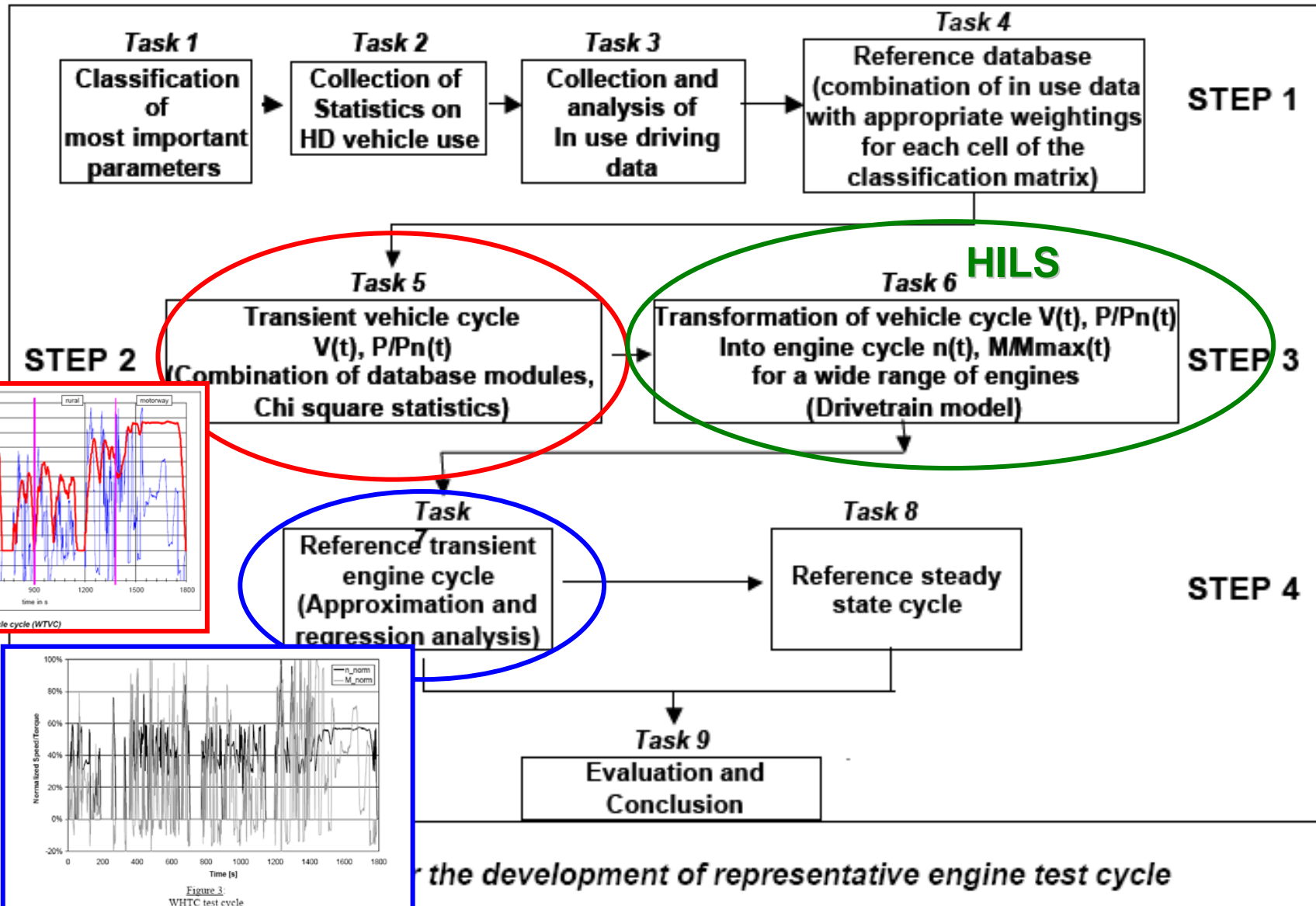


Figure 1: The worldwide transient vehicle cycle (WTVC)

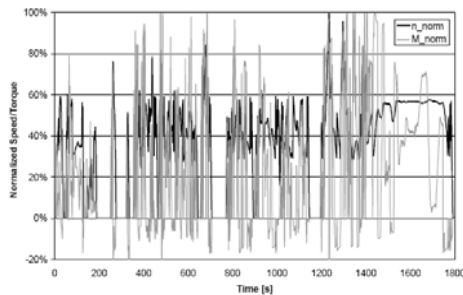


Figure 3: WHTC test cycle

for the development of representative engine test cycle



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Variety of HD Vehicles

Due to the diversity and complexity of heavy duty vehicles an engine based emissions test procedure has been considered superior over a chassis based emissions test procedure; this principle has been retained with HILS





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Hybrid Vehicle Operation

- **A hybrid system has the capability to capture braking energy and to modify engine operation**
- **In a hybrid vehicle, the combustion engine is used less and is operated differently than in conventional vehicles**
- **Engine operation in a hybrid results from interactions between the engine and the hybrid components**
- **These interactions will affect criteria component and CO₂ emissions**
- **The resulting hybrid engine duty cycle can be very different from the conventional engine duty cycle**
- **In such case, the results of the conventional engine duty cycle are not representative of real world operation**
- **Consequently, engine and hybrid components need to be certified as a set**



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HILS Principles

- **HILS starts from the (WHVC) vehicle cycle**
- **Powertrain and vehicle components are simulated**
- **For specific vehicle operation, subsets of the WHVC in combination with appropriate weighting or scaling factors will be investigated**
- **Result is an engine cycle typical for a specific hybrid vehicle**
- **Rationale**
 - **use of normal engine test cell environment**
 - **engine test cells are widely available within industry and type approval authorities**
 - **chassis dyno test cells with emissions measurement capability are very limited and not suitable for all types of heavy duty vehicles**
 - **a certified powerpack can be used in different vehicles, which reduces certification burden**



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Elements for Hybrid Certification

- **As a summary, hybrid certification should**
 - **cover a wide range of RESS (battery, capacitor, hydraulic accumulator, kinetic storage device, flywheel capacitor , fuel cell)**
 - **account for RESS and engine power**
 - **allow for technology development**
 - **include provisions for transmission, gearing and rear axle ratio**
 - **account for benefits of hybrid PTO operation**
 - **account for vehicle regenerative energy gained or lost during testing**
 - **minimize discrepancy between certification and real world CO2 and criteria emissions**