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Model based development calibartion of hybrid propulsion using a SiL environment

- PHEV Application as Use Case -

Gerald Teuschl[1)] **Peter Ebner[1)]** **Mario Ninaus[1)]**

Schiller Stefan[1)] **Martin Christian[1)]** **Goetschl Peter[1)]** **Knapp Patrick[1)]**

1) AVL List GmbH, Hans List Platz 1, 8020 Graz

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The use of the described simulation models enables hybrid operating strategies to be adapted to a new application with a given exhaust system. The optimizer with enhanced KPIs, as shown in Figure 1, provides an initial optimized calibration set for the operational strategy. In particular, start/stop, load point shift, load point variation with the electric motor, electric driving and shift map can be optimized with regard to the KPIs on the right-hand side. The resulting benefit is a significantly reduced initial calibration effort by providing a solid baseline calibration that requires only minor fine-tuning by calibration engineers.

Using the basic SiL setup shown in Figure 1, only limited OBD requirements can be accommodated by the engine control unit.

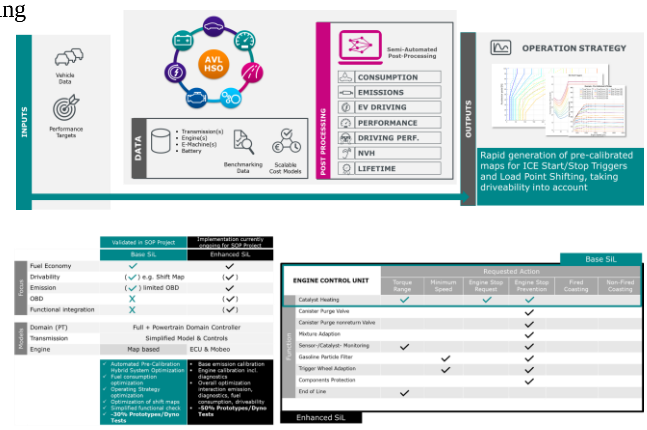

Fig. 1 AVL methodology and simulation environment for optimizing hybrid KPIs

In current projects, this map-based approach can result in a CO_2 deficit of up to 4 g within the WLTP approval cycle. Using the KPI-guided calibration and environment shown in Figure 5, the deviation can be reduced to 1 gram of CO_2. To support the calibration engineer, consistent data management is established from simulation to vehicle calibration, and additional effort using different development environments is eliminated. Another advantage besides the automated pre-calibration is the possibility to evaluate the target achievement, consistency and quality of the calibration before expensive bench tests are carried out. As an example, from an SOP project, around 60 homologation cycles can be run over the weekend. The current computing power of such a SiL base model, which is described in Figure 4, can be simulated at twice the speed and scaled to more than 100 parallel model instances. Significant efficiency gains can be achieved through an automated pre-assessment to identify calibration issues during calibration at the level of the entire propulsion system. In current SOP derivative projects, the validation effort and the number of prototypes have been reduced by 30%. An upgraded SiL environment is required for use cases and driving manoeuvres where higher pollutant emissions are expected. The thus transient emission feedback enables the optimization of the emission strategy and OBD requirements by the engine management.

Examples of such applications can be a transient downshift with a simultaneous cold start and warm-up phase of the exhaust aftertreatment system. The hybrid operating strategy is then supplemented by special strategies geared towards pollutant emissions. Possible effects such as consumed energy, which has to be recovered in a later phase of the driving operation, must be taken into account. Besides this obvious impact, additional relevant input for the overall robustness of propulsion energy management strategies, battery, system OBD and on-board network requirements is determined.