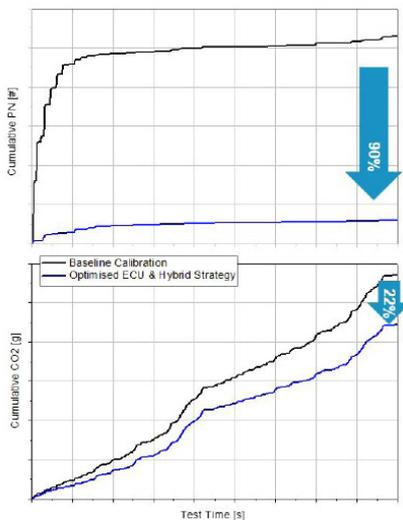




## Optimisation for Future Legislation



Baseline vs. Optimised Solution over aggressive RDE cycle



### The Challenge

Future powertrains are becoming increasingly complex and optimising powertrains efficiently and effectively is challenging. When coupled to the expected challenge of future emissions legislation such as EU7, SULEV20 and China7, the need for efficient solutions is paramount.

### The Solution

MAHLE Powertrain have developed an efficient approach where accurate emissions models are created using real test data. These models are fed into a virtual environment representing the powertrain and vehicle, allowing for off-line optimisation and assessment of the hardware and software.

Through inputting these accurate emissions models to the virtual powertrain and vehicle it is possible to derive an optimum -

ECU calibration and optimised hybrid strategy which achieved the following benefits for a major EU OEM:

- 90% reduction in PN
- 22% reduction in CO<sub>2</sub>

### MPT RDEC

The MPT Real Driving Emissions centre (RDEC) validates the engine test cell results on vehicle. The MPT RDEC 4WD facility meets all current legislative RDE conditions (temperature, altitude and emissions) and is ready for the expected EU7 legislation. We also offer cold box system enables full RDE temperature range to be assessed on an engine testbed. This high end engine test cell capability at MPT ensures that engines can be efficiently optimised and validated against all current and future emissions legislation requirements before prototype vehicles are available



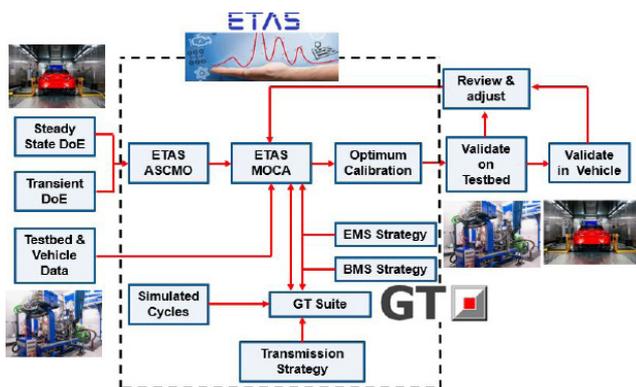
Future regulations & time/ cost savings  
Hybrid optimisation & model analysis

## EU7 Optimisation Approach

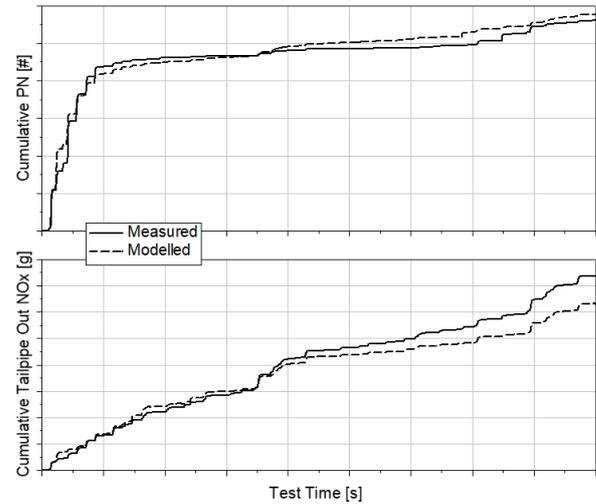
- Each system / subsystem represented by a model
  - › Different models for each hardware variant
  - › DoE data used to build models
  - › Software strategies represented by Simulink
  - › Vehicle & aftertreatment in GT-SUITE
- Virtual powertrain & vehicle created
  - › GT-SUITE allows drive cycles & aftertreatment to be assessed
- Co-Simulation enables optimisation of whole system
  - › Virtual optimisation and validation performed on testbed / vehicle
- Method used to assess gap to EU7 and determine hardware / software changes required to bridge gap

## MPT Testbeds

- High specification motoring testbeds to accurately reproduce real world and legislative cycles with automated running to efficiently gather dynamic modeling data.
- Full range of emission measurement hardware to meet the requirements of current and future emissions legislation:
  - › PN down to 10nm
  - › Full suite of gaseous emissions analysers
  - › Full suite of Combustion fast emissions analysers



Co-Simulation process diagram



Modelled vs. measured emissions data over aggressive RDE cycle

## Summary

MAHLE Powertrain provides optimisation for future legislation through model analysis and hybrid optimisation whilst implementing time and cost saving efficiencies. This highly developed modeling and simulation approach, coupled with precise emissions measurement, represents a real breakthrough in the optimisation of whole powertrains for future emissions compliance.