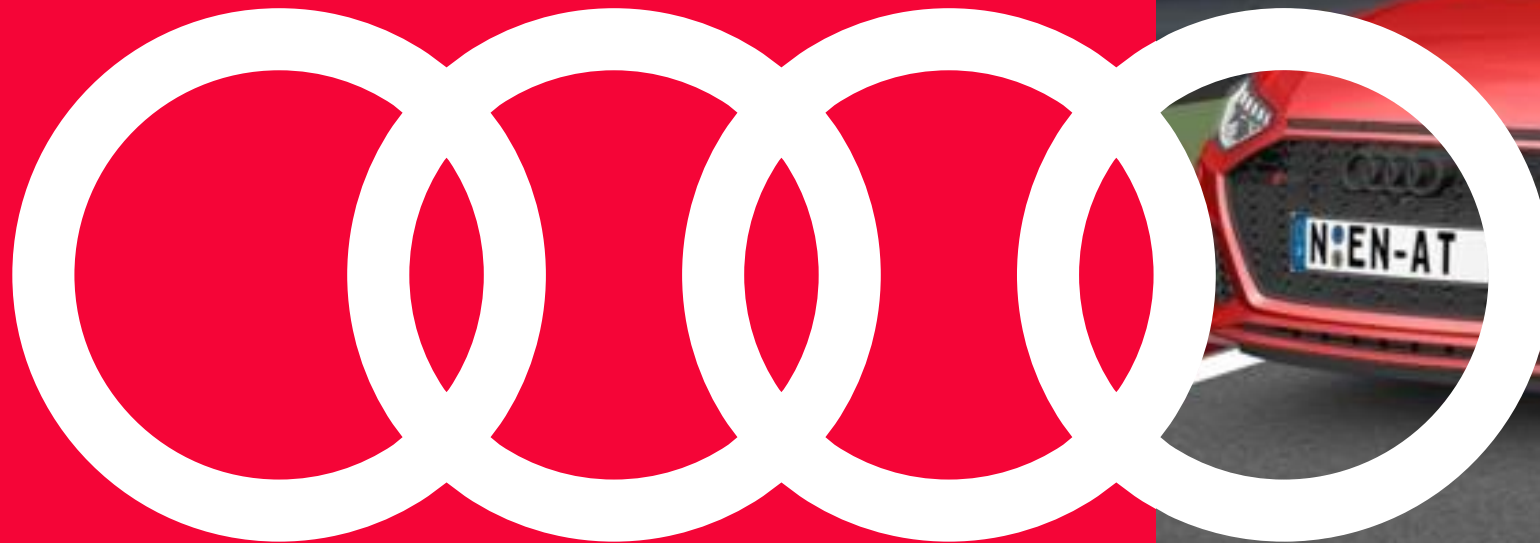


Complete vehicle testing on an engine test bench

Apply & Innovate 2024 | 11.09.2024

Alexander Gürtler, Jürgen Leidig, Jochen Petters, Laura Uson
Dominguez, Linus Rühmann, Jörg Vogg



Agenda

01 **Motivation and overview**
Engine-in-the-Loop, simulation environment

02 **Demonstrator Usecase**
V6 engine @ Family Day Neckarsulm

03 **Usecase 01**
Fuel mix and temperature on track

04 **Usecase 02**
Hybrid powertrain on endurance testing

05 **Summary and outlook**

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Motivation and overview

- running vehicle tests on engine testbed -

Pushing factors:

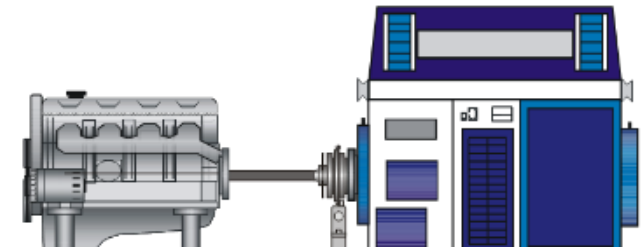
- need for vehicle prototypes
- cost of conventional testing
- influence of real-driving scenarios



vehicle



Testing shift



testbench

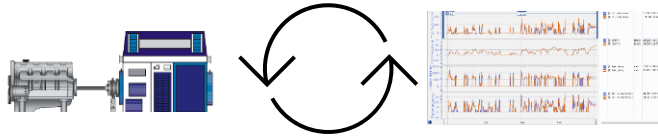
Technical benefits of testing on testbench:

- Repeatability
- Accurate measurement systems
- Possibility for extreme scenarios
- Automation level: 24/7

Motivation and overview

- evaluation of efficient testing method -

Replay of vehicle run



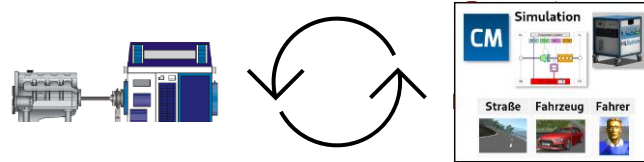
+ Advantages:

- > Simple implementation
- Measurement with (speed, torque, states)
- > Exact replay of engine behavior
- > Short time to testbench

⊗ Risks:

- > Open loop
- > Vehicle test run needed
- > Changes in application → new measurement needed
- > No application of powertrain strategies (e.g. behavior of shifting)

Engine testbench with vehicle sim.



+ Advantages:

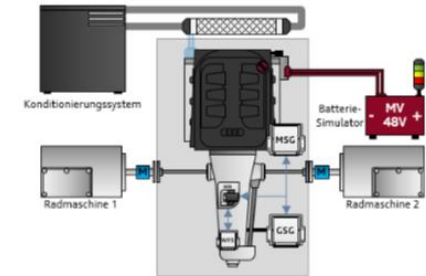
- > No measurement needed
- > Early testing of powertrain strategies
- > Real vehicle controller
- > Closed loop application

⊗ Risks:

- > Additional hardware and software per testbench needed
- > Modeling knowhow at testbench needed
- > Model validation required
- > Model-based simplifications

Focus of method development

Powertrain testbench



+ Advantages:

- > Vehicle-like hardware
- > Shifting strategies
- > High-level measurement systems
- > Closed-loop

⊗ Risks:

- > High costs
- > Limited capability
- > Limited scenarios
- > Complex unit-under-test

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Demonstrator Usecase

- V6 engine @ Family Day Neckarsulm -

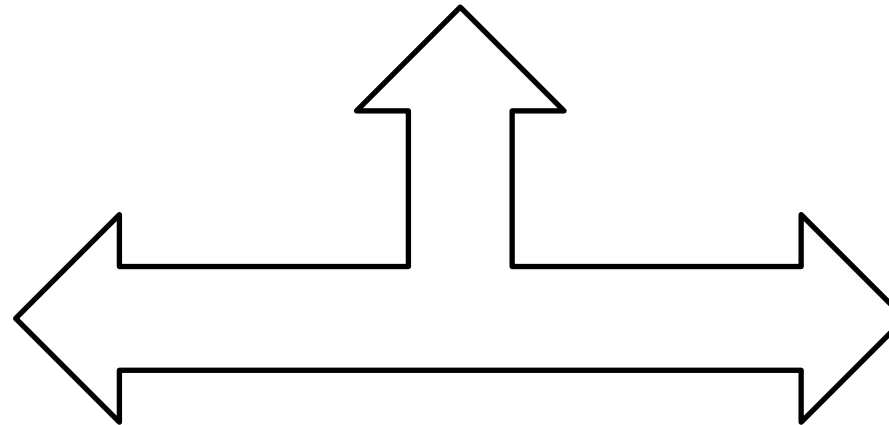
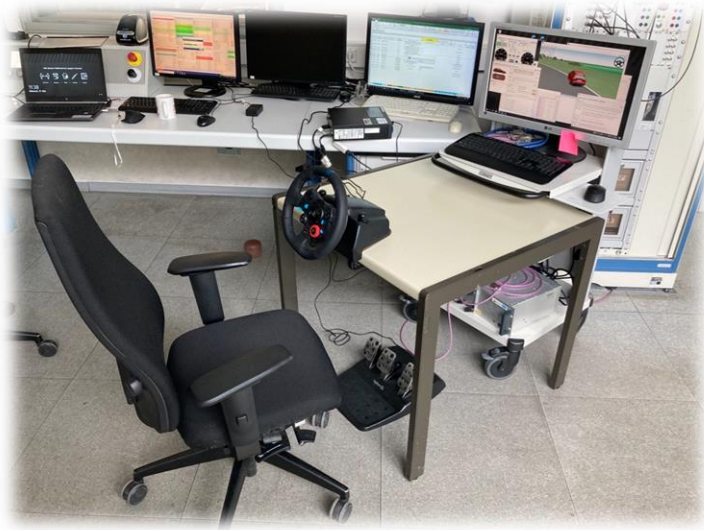
- › Cooperation of development teams:
 - › Testfield
 - › Workshop
 - › Applikation
 - › Simulation
- › Engine testbench up to 500 kW



Simulations environment

- › Car, simulated
 - › Audi RS4
- › Track:
 - › Nardo Handling
- › Engine: V6 TFSI

Early bird



Demonstrator AddOn

Demonstrator Usecase

- V6 engine @ Family Day Neckarsulm -

Video



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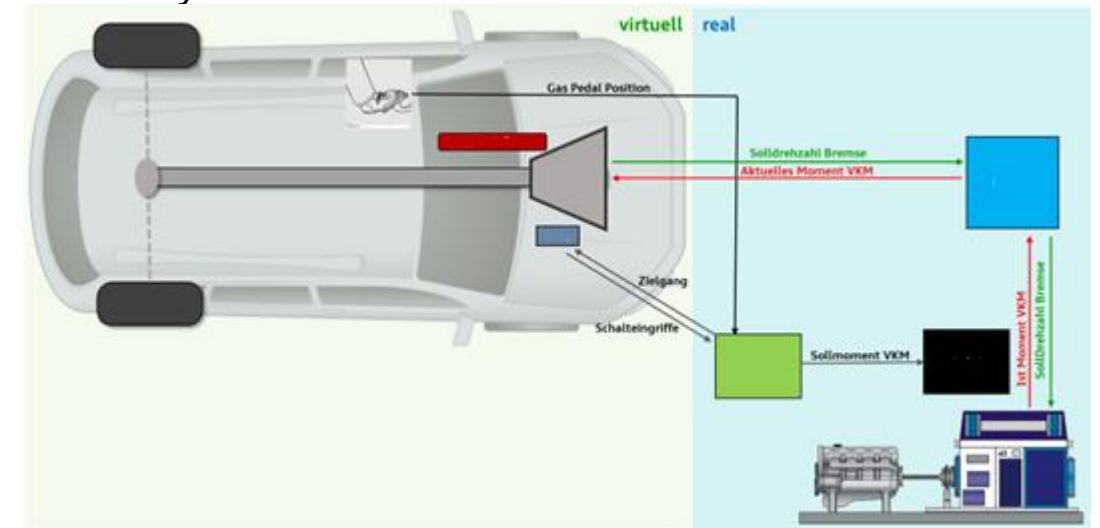
Usecase 01

- Fuel mix and temperature on track -

- Validation of stationary optimized application in dynamic environment
- Testing matrix
 - Fuel mix
 - Intake manifold temperature
- Aim:
 - Validation of method and qualifying testbench
 - Validation of dynamic state (TipIn, Shifting, etc.)
 - Optimized application

| Intake manifold temperature | ROZ98 E5 | ROZ95 E10 | ROZ95 R33 |
|-----------------------------|----------|-----------|-----------|
| Basis | X | X | X |
| 50 °C | X | X | X |
| 60 °C | X | X | X |
| 70 °C | X | X | X |
| 80 °C | X | X | X |
| 90 °C | X | | |

Control system:



Usecase 01

- Fuel mix and temperature on track -

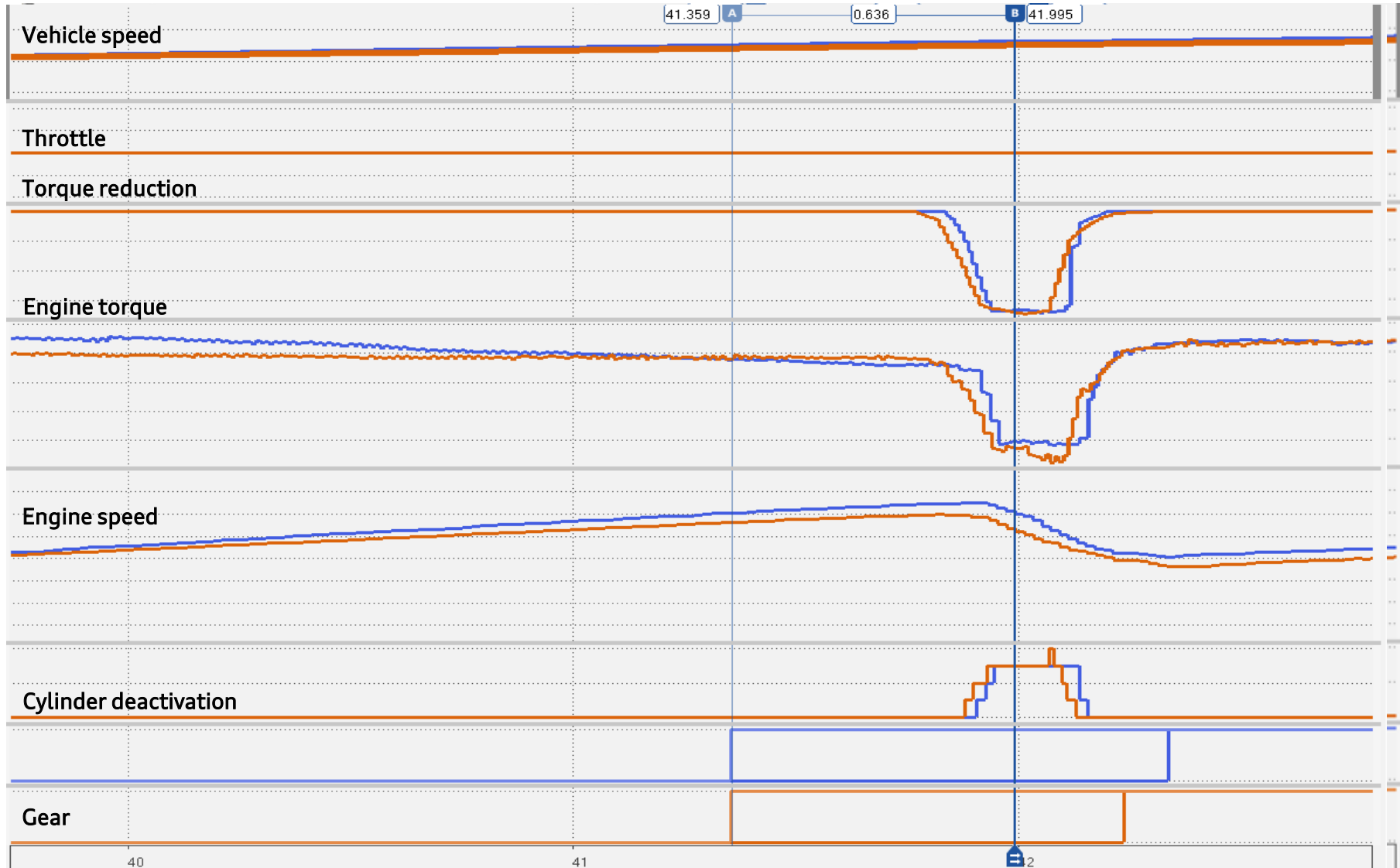
Video



Usecase 01

- Fuel mix and temperature on track -

Vehicle
EiL-Testbench



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Usecase 02

- Hybrid powertrain on endurance testing -

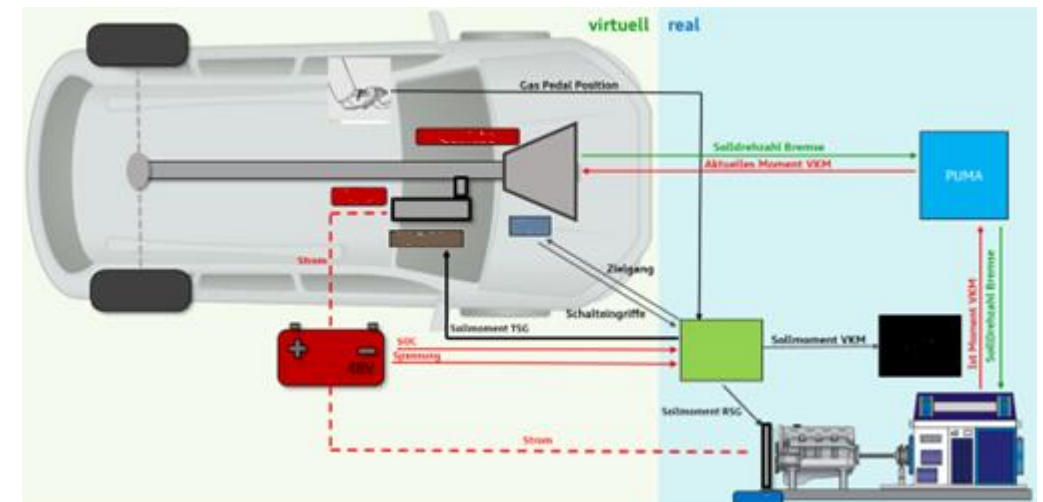
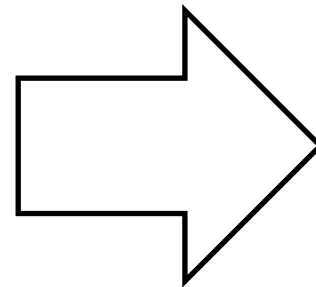
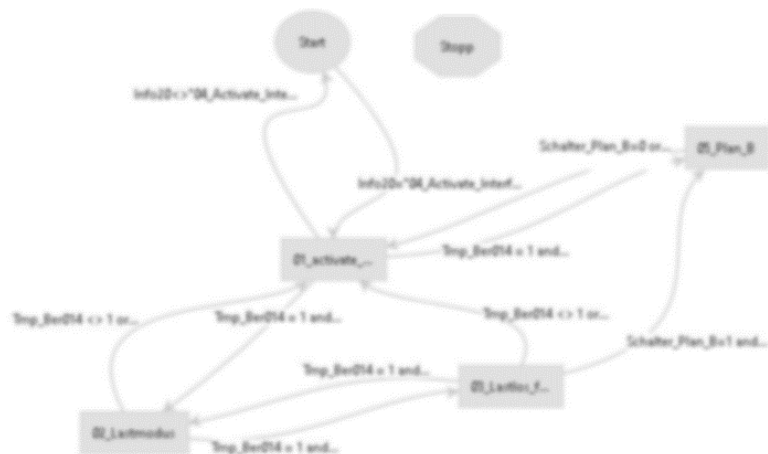
> Task

- > Implementation of new communication matrix
- > Low capability of vehicle prototypes

> Aim

- > Validation of neutral emission and consumption behavior
- > Implementation of new testbench clutch-control
- > Successful run of back-to-back test old vs. new communication

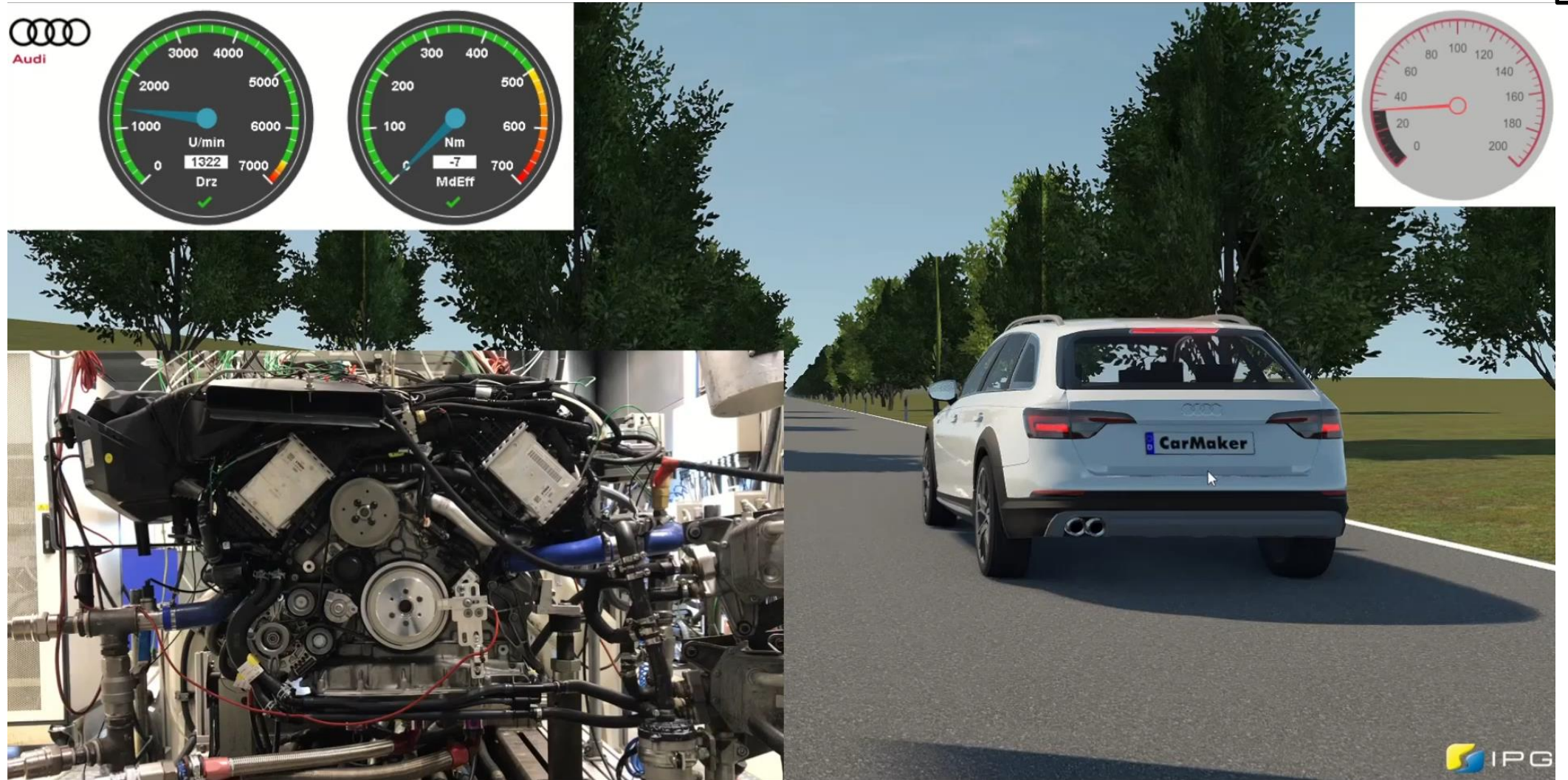
Advance testbed state machine:



Usecase 02

- Hybrid powertrain on endurance testing -

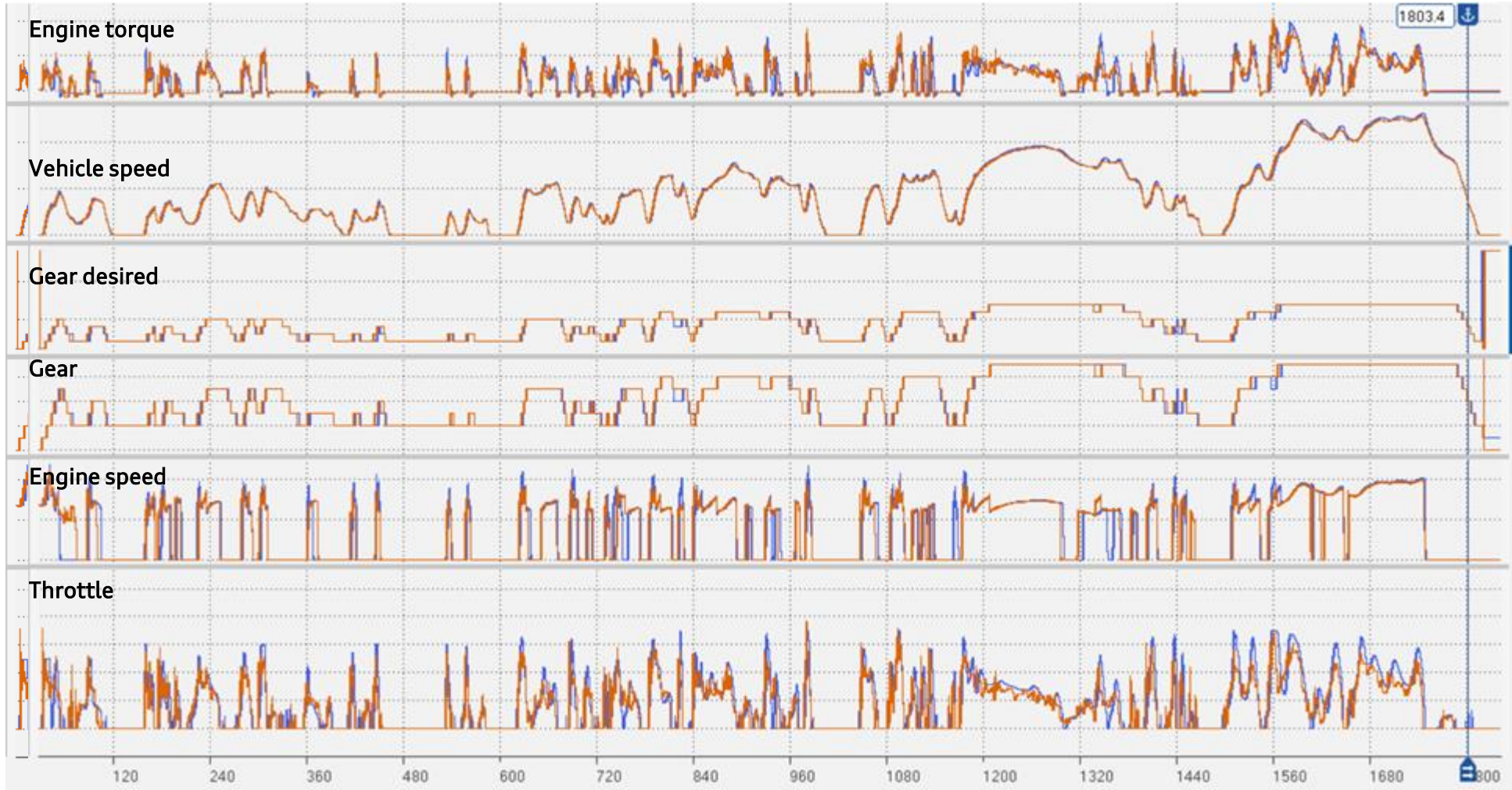
Video



Usecase 02

- Hybrid powertrain on endurance testing -

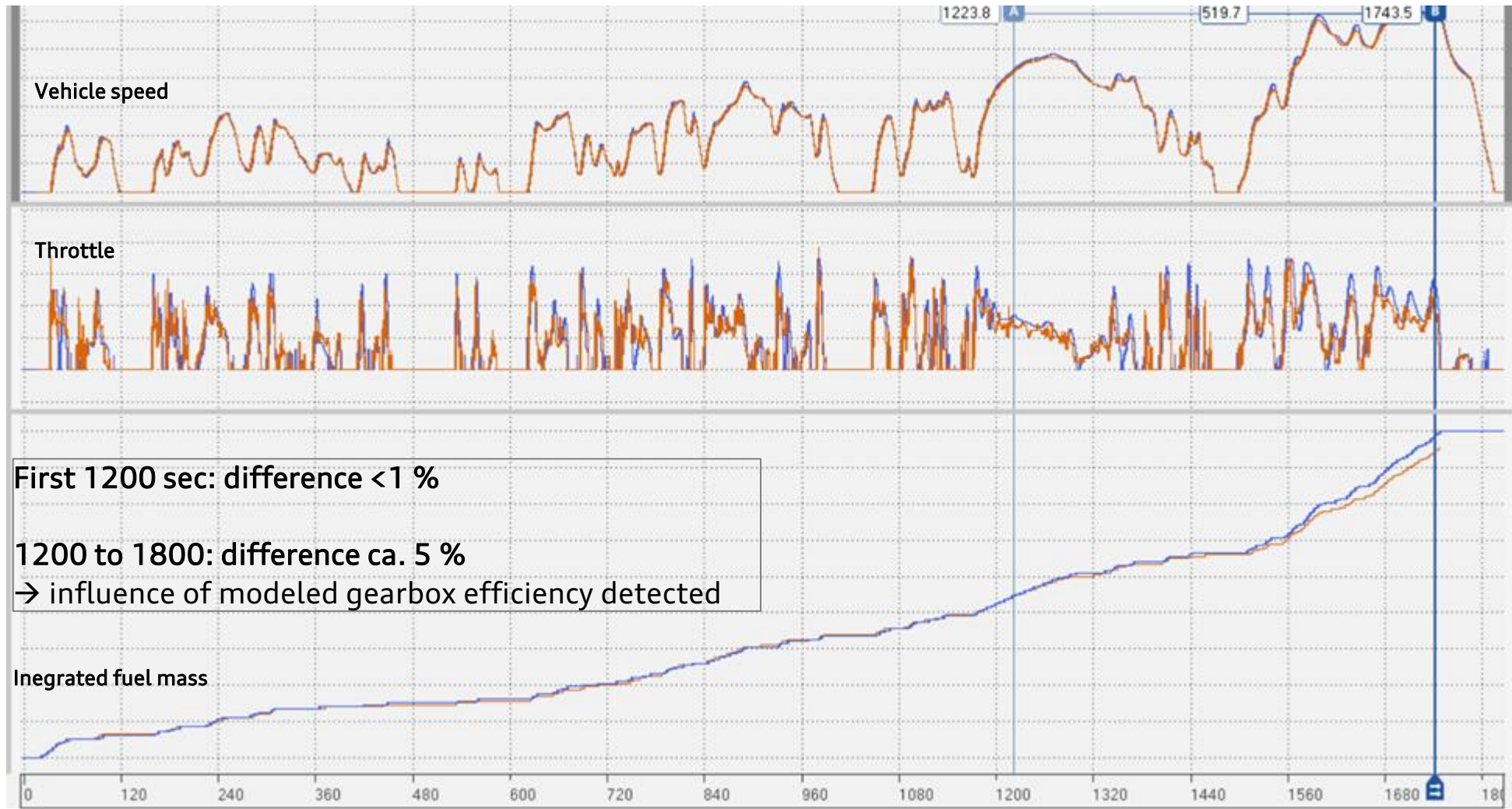
Vehicle
EiL-Testbench



Usecase 02

- Hybrid powertrain on endurance testing -

Vehicle
EiL-Testbench



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Summary and outlook

> Summary

- > Successfully validated method
- > Increased use cases of engine testbenches
- > Simplified handling and prepared automation
- > Increased demand for application engineers

> Outlook

- > Definition of the next test cases started
- > Increasing availability of testbench with vehicle simulation