

Chip Simulation for Virtual ECUs



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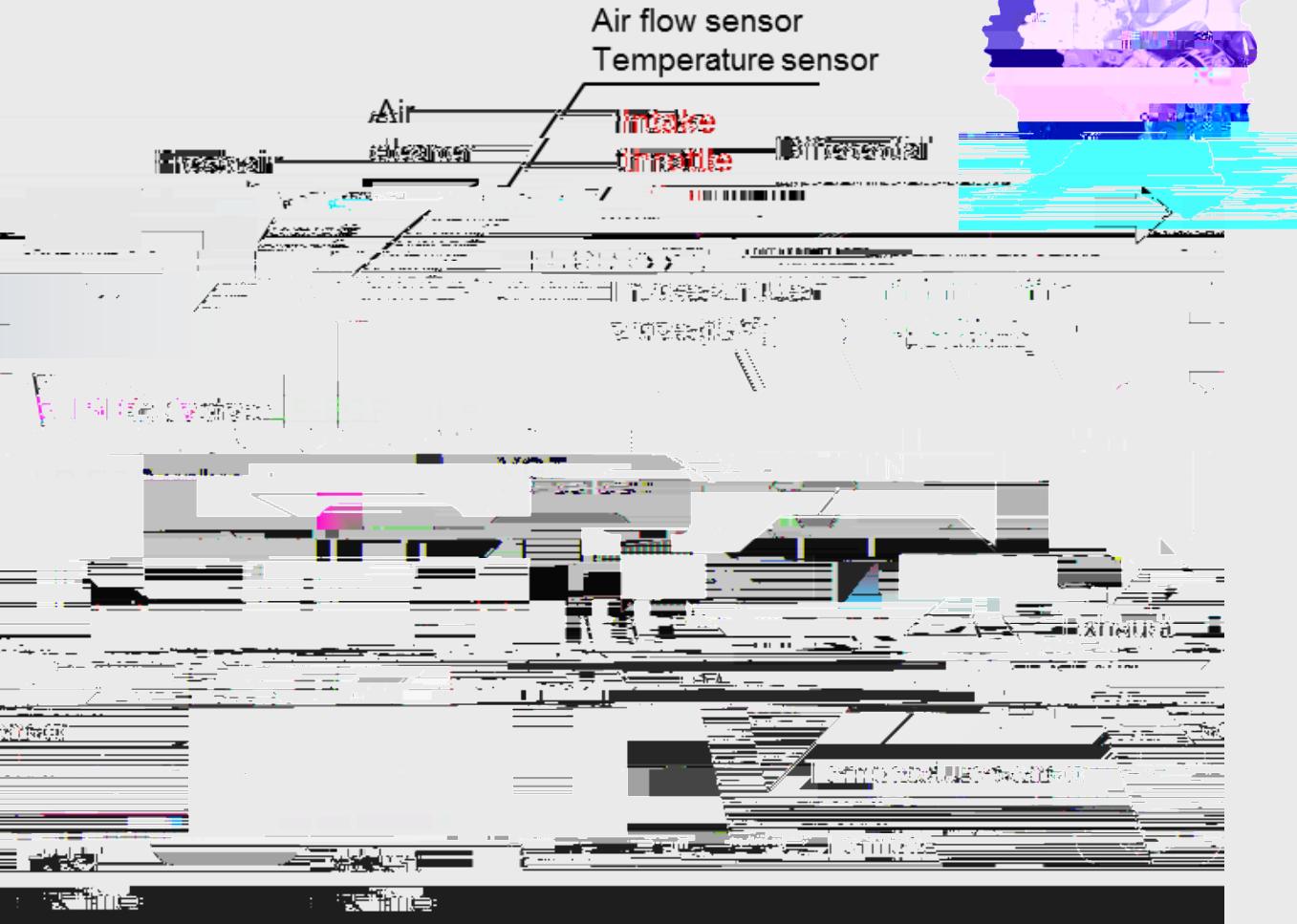
**Honda R&D Co., Ltd.
Automotive R&D Center**

● Background

Fuel economy (CO_2) Modified NEDC

91 g/km (6MT, Sedan)
93 g/km (6MT, Hatchback)
109 g/km (9AT)

1.6L diesel engine



Exhaust emissions

Euro6d-TEMP P



Civic

Method for calibration and validation



Tests on road	Chassis dynamometer (vehicle) + vehicle simulation	Engine test bed (engine) + vehicle simulation	
Vehicle s			

Necessity of model utilization for efficient development

Background

Concept of model based simulation environment

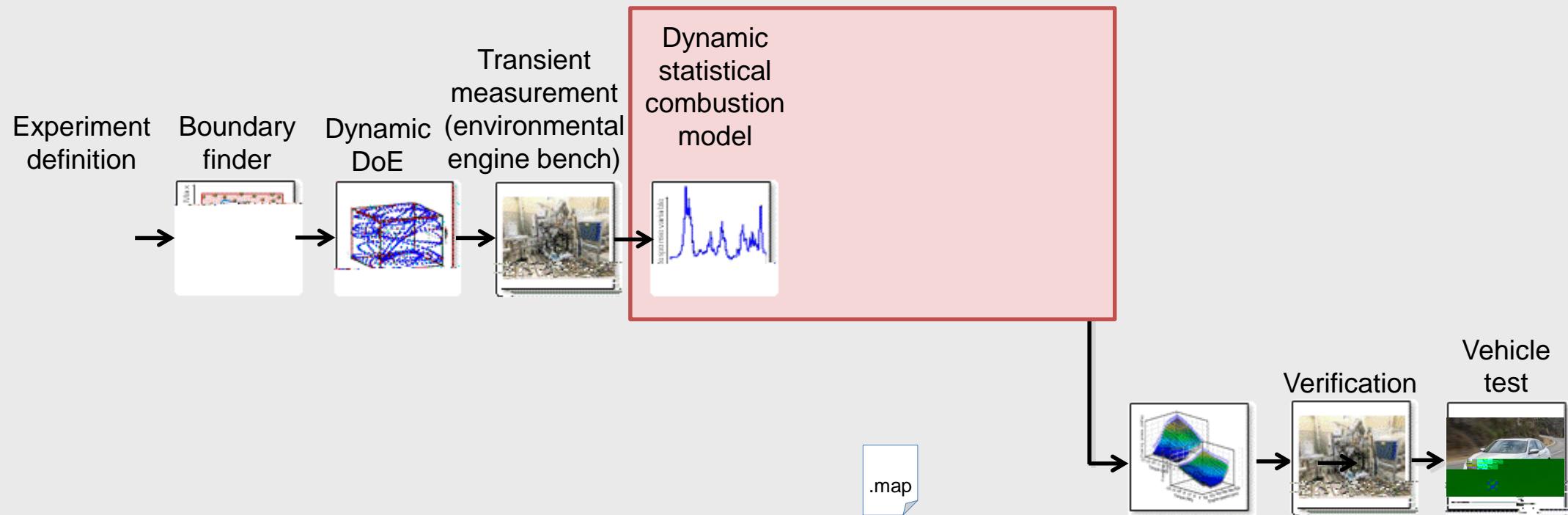
Engine simulation model

- ECU model
- Combustion model
- Catalyst model

RDE simulation combined with vehicle simulation model

Summary

Flowchart of model utilization



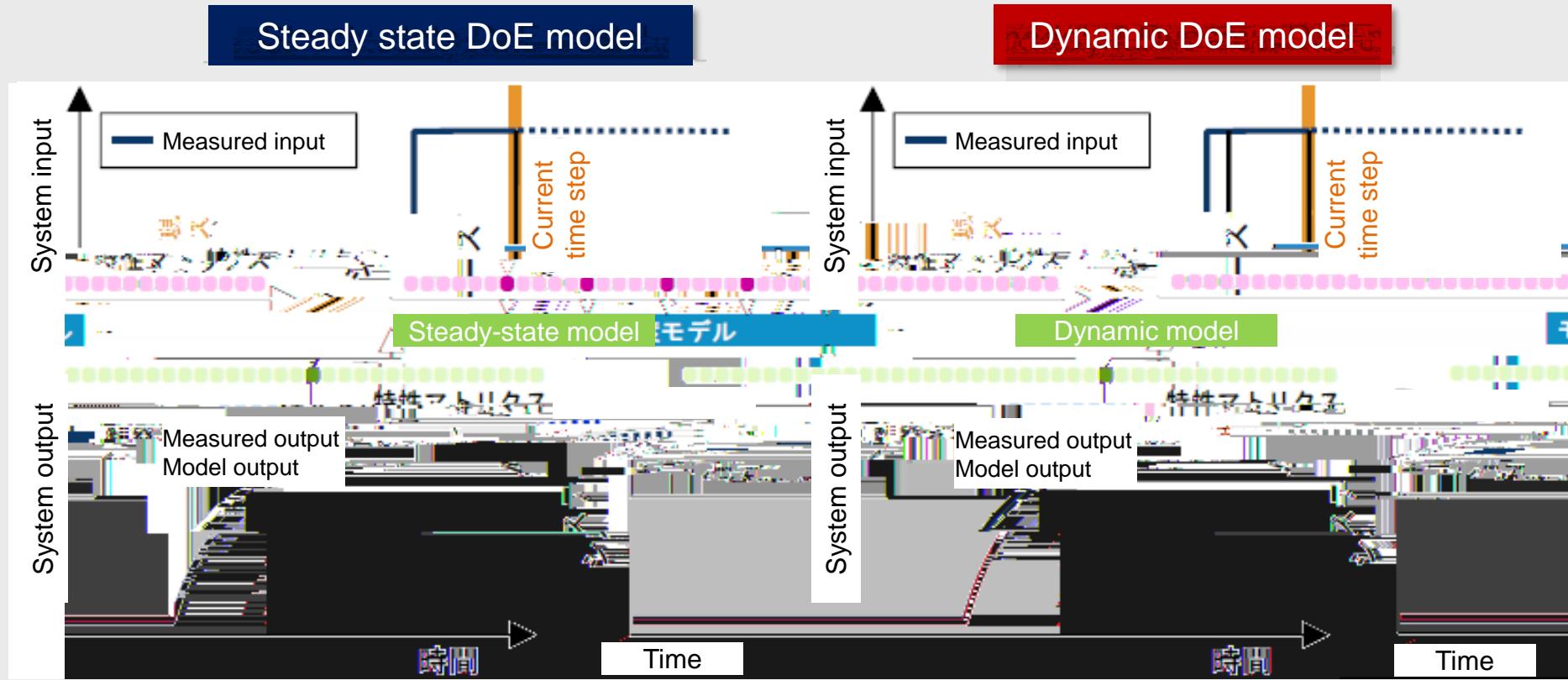
Coupling of vehicle simulation and engine simulation

Contents

Combustion modeling approach

Physical model (0D-3D)	Statistical model (Empirical model, DoE model)
	
Use case: concept study, advanced research	Use case: calibration, validation
Necessity of parameters tuning based on measurement data	Necessity of engine hardware and training data
Higher number of adjustment parameters	Lower number of fitting parameters
High predictive accuracy even at model extrapolation region	High predictive accuracy at model interpolation region
High dimension -> low calculation speed	High calculation speed
Suitable for engine hardware development and phenomenological analysis	Suitable for model based engine calibration (optimization)

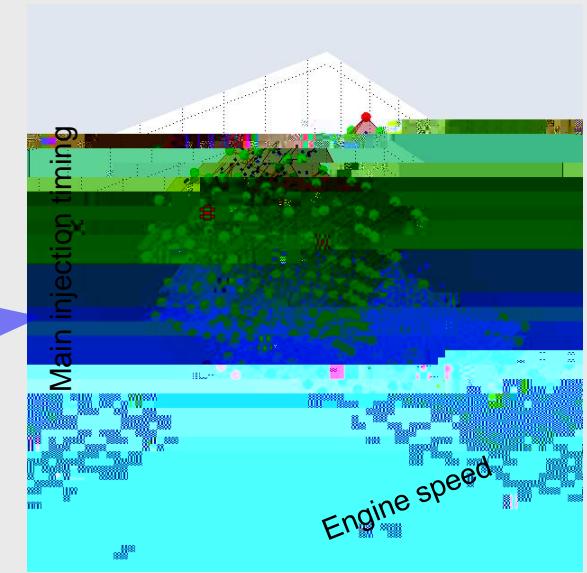
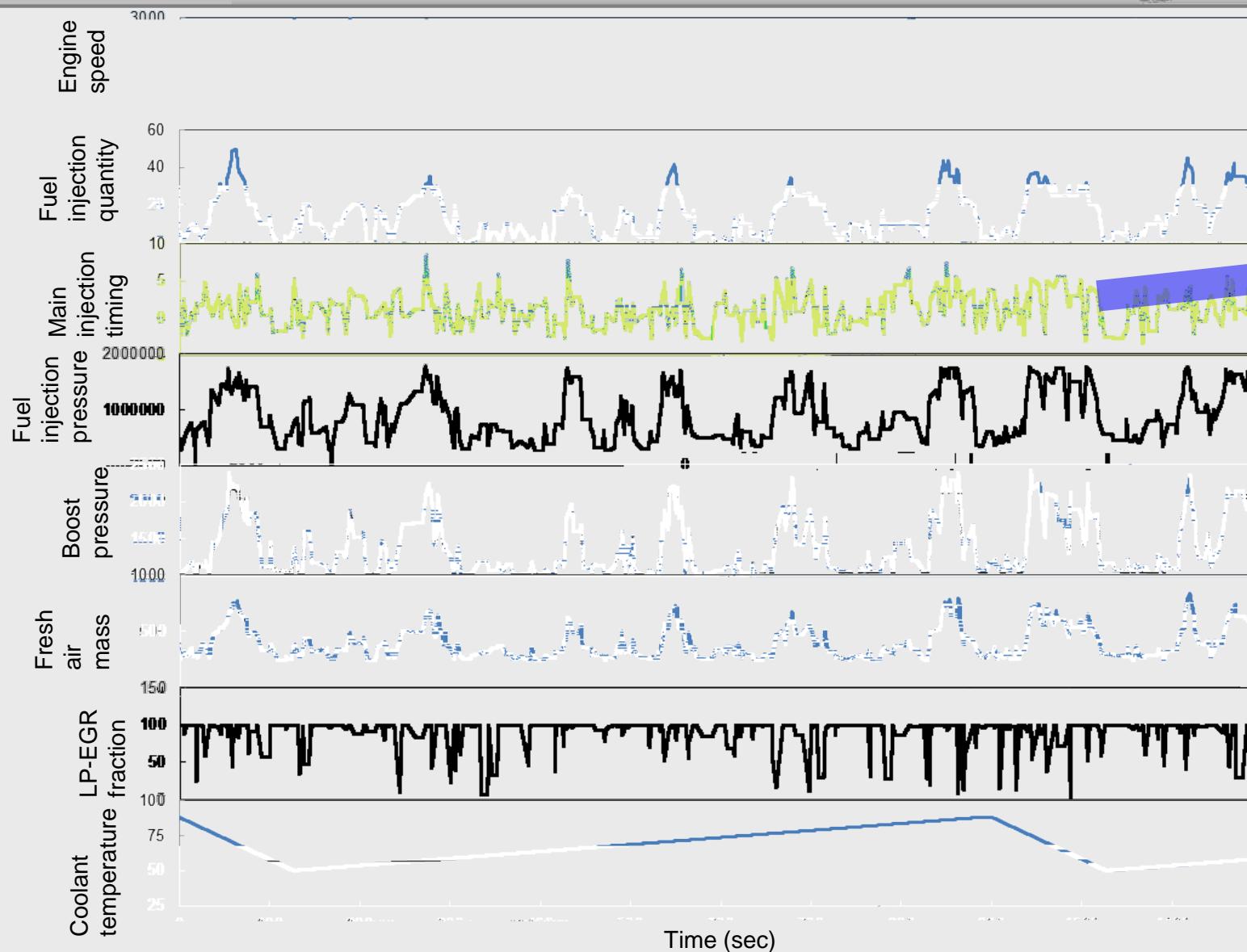
Advantage of dynamic DoE model



Steady state prediction
Model fitting based on averaged
measurement data

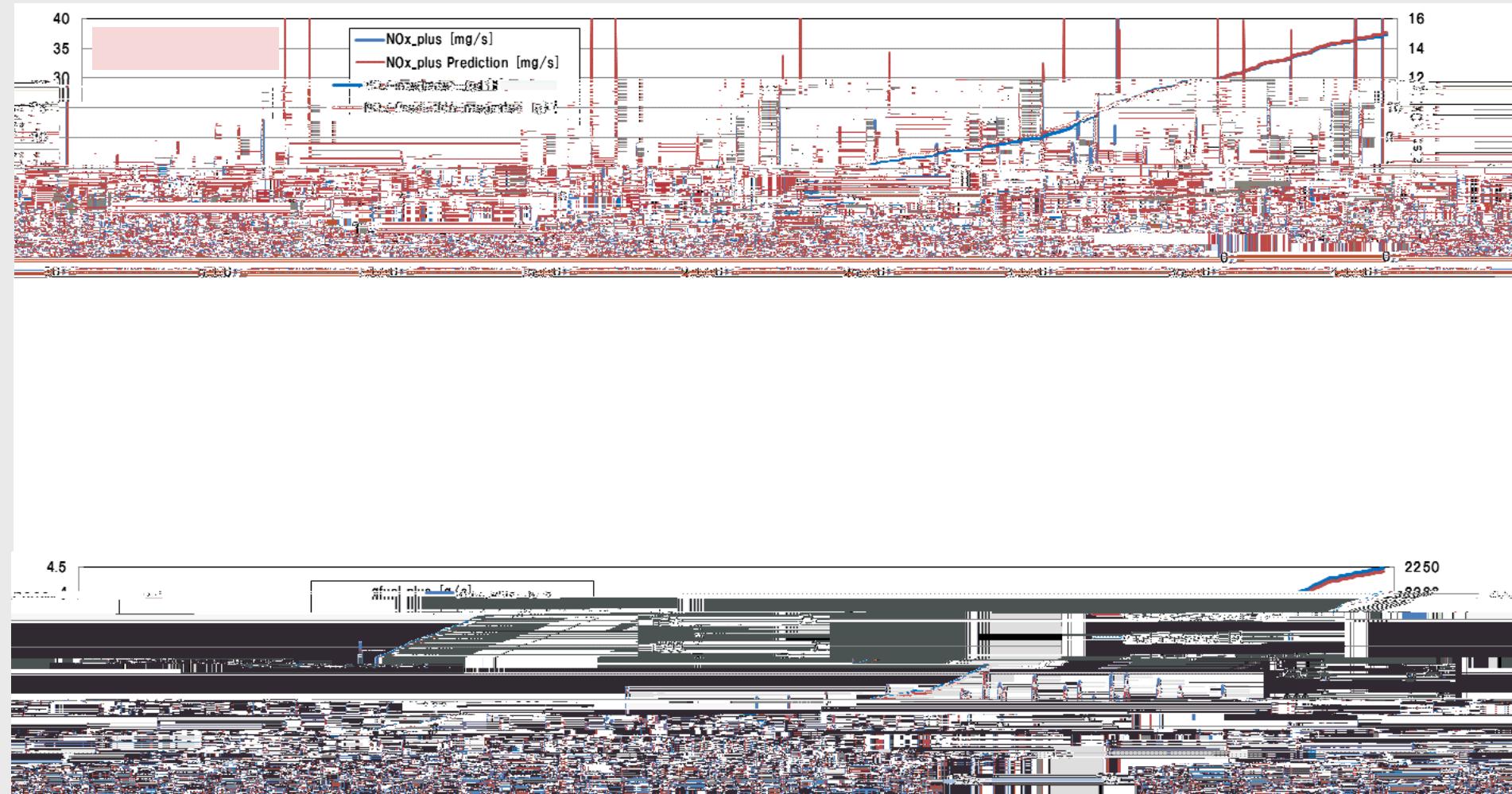
Transient prediction including time lag of
measurement apparatus
Model fitting based on recorder
measurement data

Dynamic DoE for combustion model

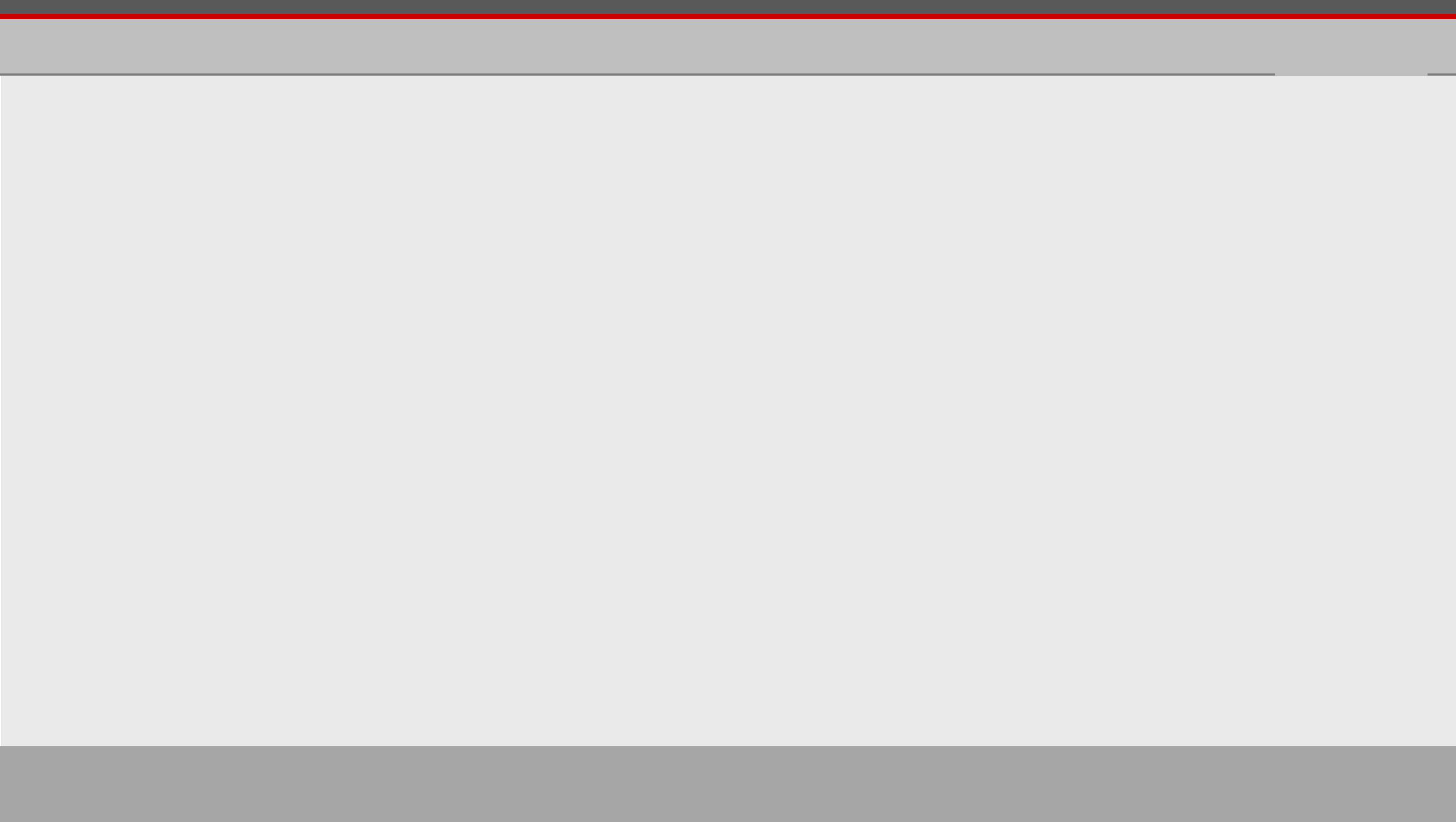


Space filling methodology for the Gaussian Process Modeling (GPM)

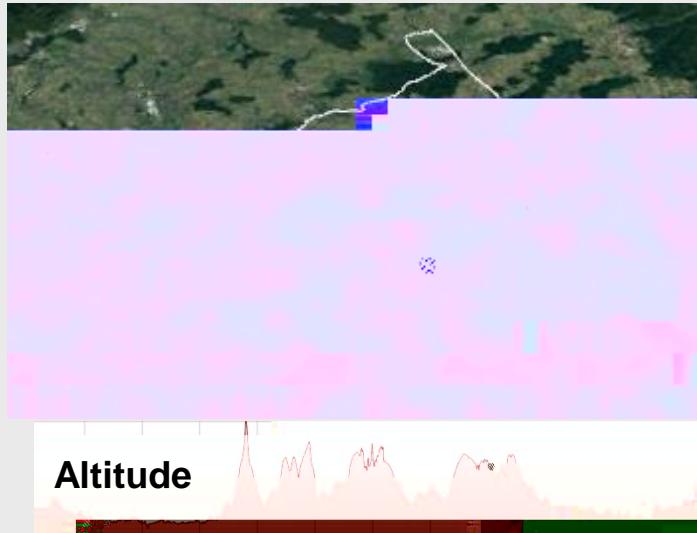
Predictive accuracy of engine model



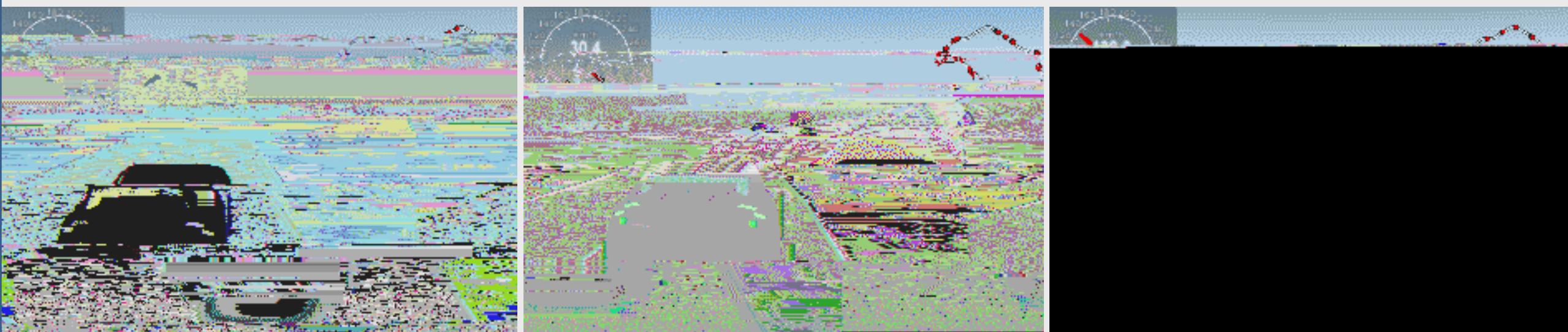
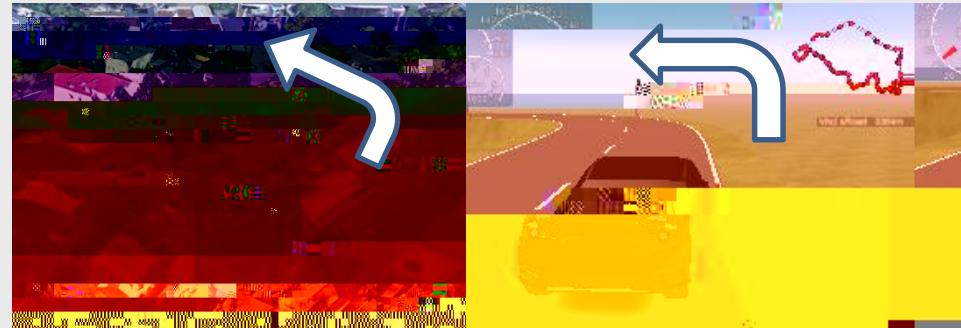
Achievement of quantitative emissions prediction at RDE



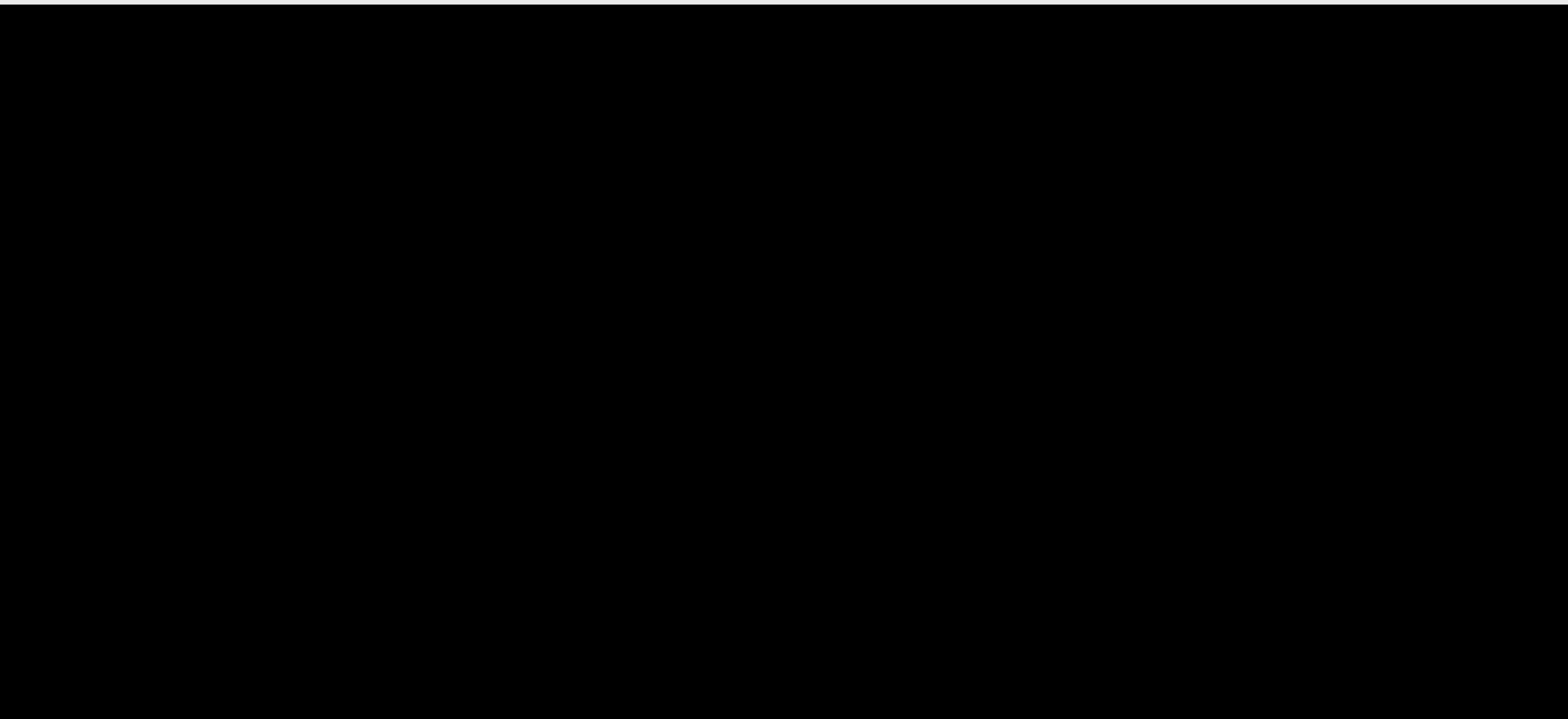
Vehicle simulation for RDE route



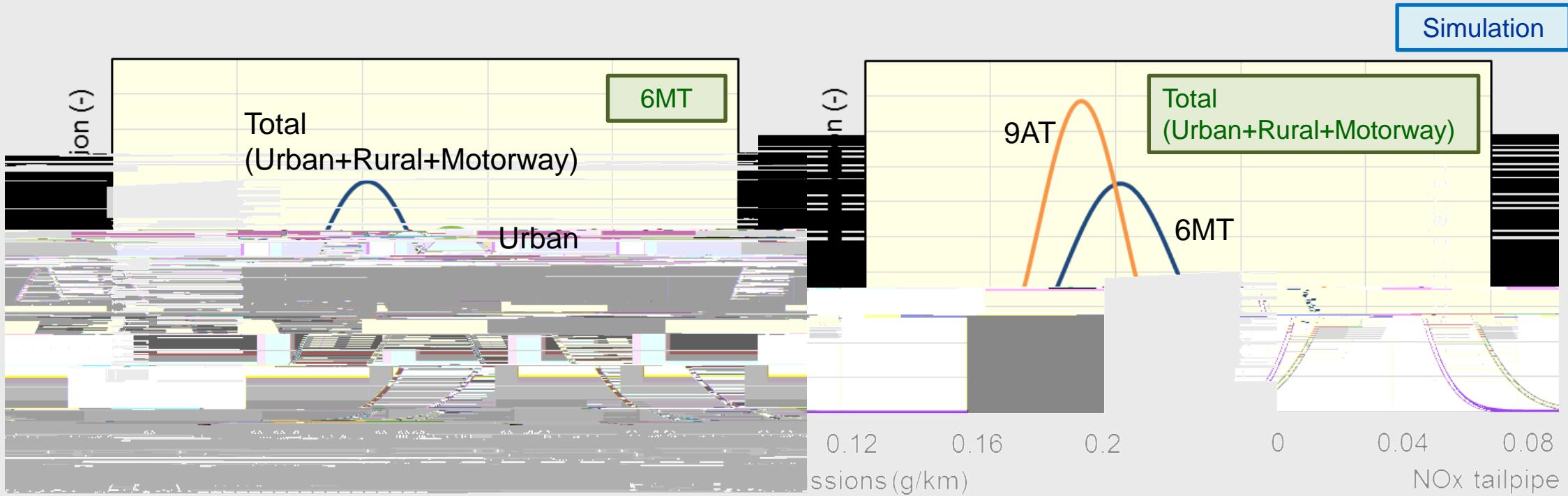
Digital map Simulation



Generation of vehicle speed by vehicle, driver, route, and traffic models



Evaluation of emission robustness



It is a challenge to sufficiently validate RDE performance under all conditions through road tests during vehicle development due to wide range of validating conditions.

A model based development technology was established to simulate, verify and calibrate the emissions performance of a vehicle.

RDE performance could be accurately predicted by coupling a vehicle driving simulation with an engine simulation that includes an ECU model, combustion model (dynamic data based statistical model), and exhaust aftertreatment(en-US)>> BDC q0.00001

Thank you very much for your kind attention.

