



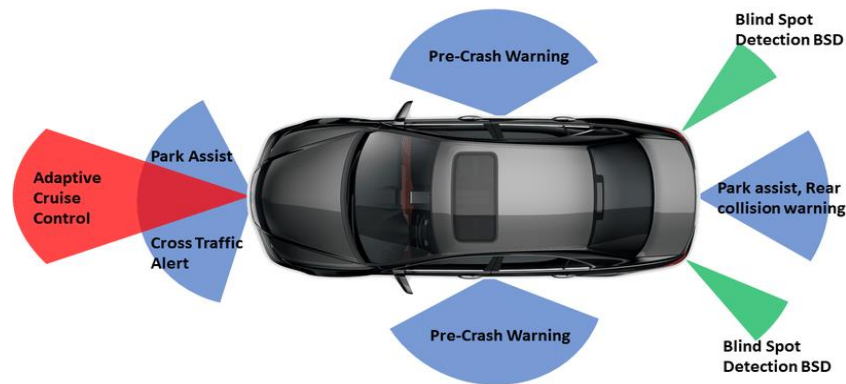
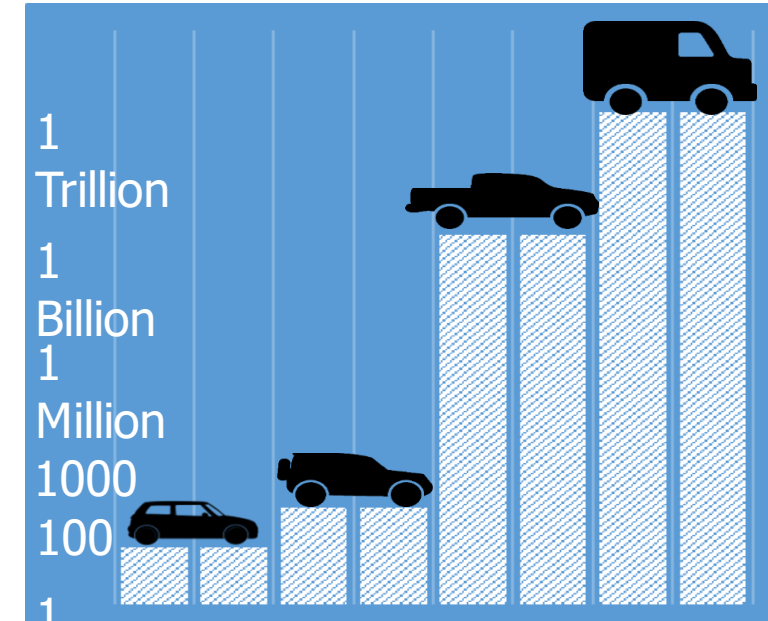
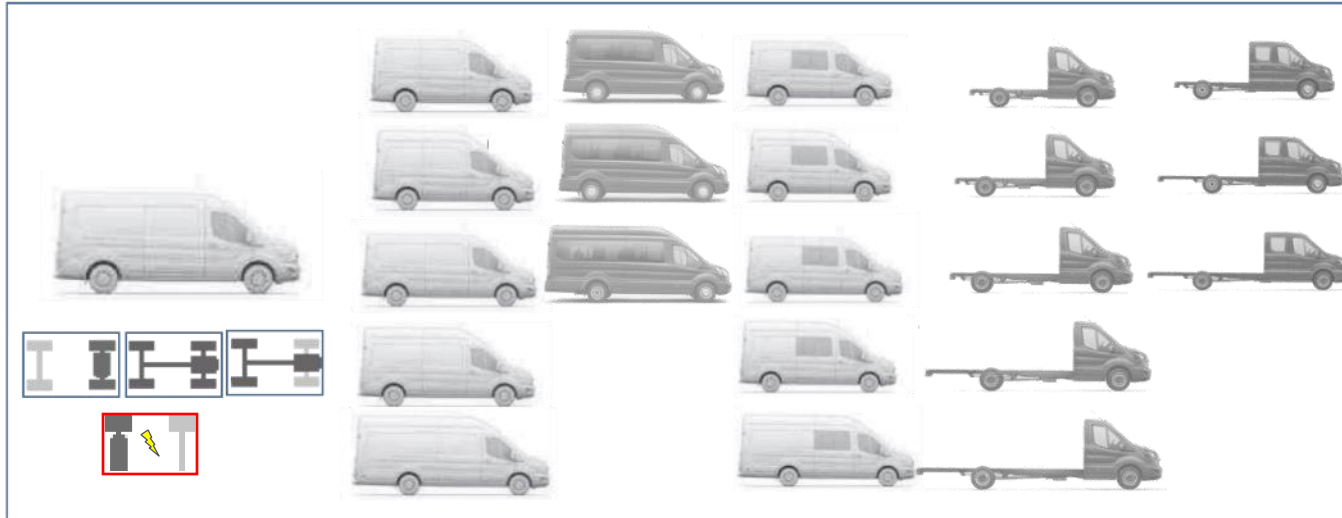
ViVID (Virtual Vehicle Integration & Development)

David Brook
Ford Motor Company Limited
Tom Lee
HORIBA MIRA





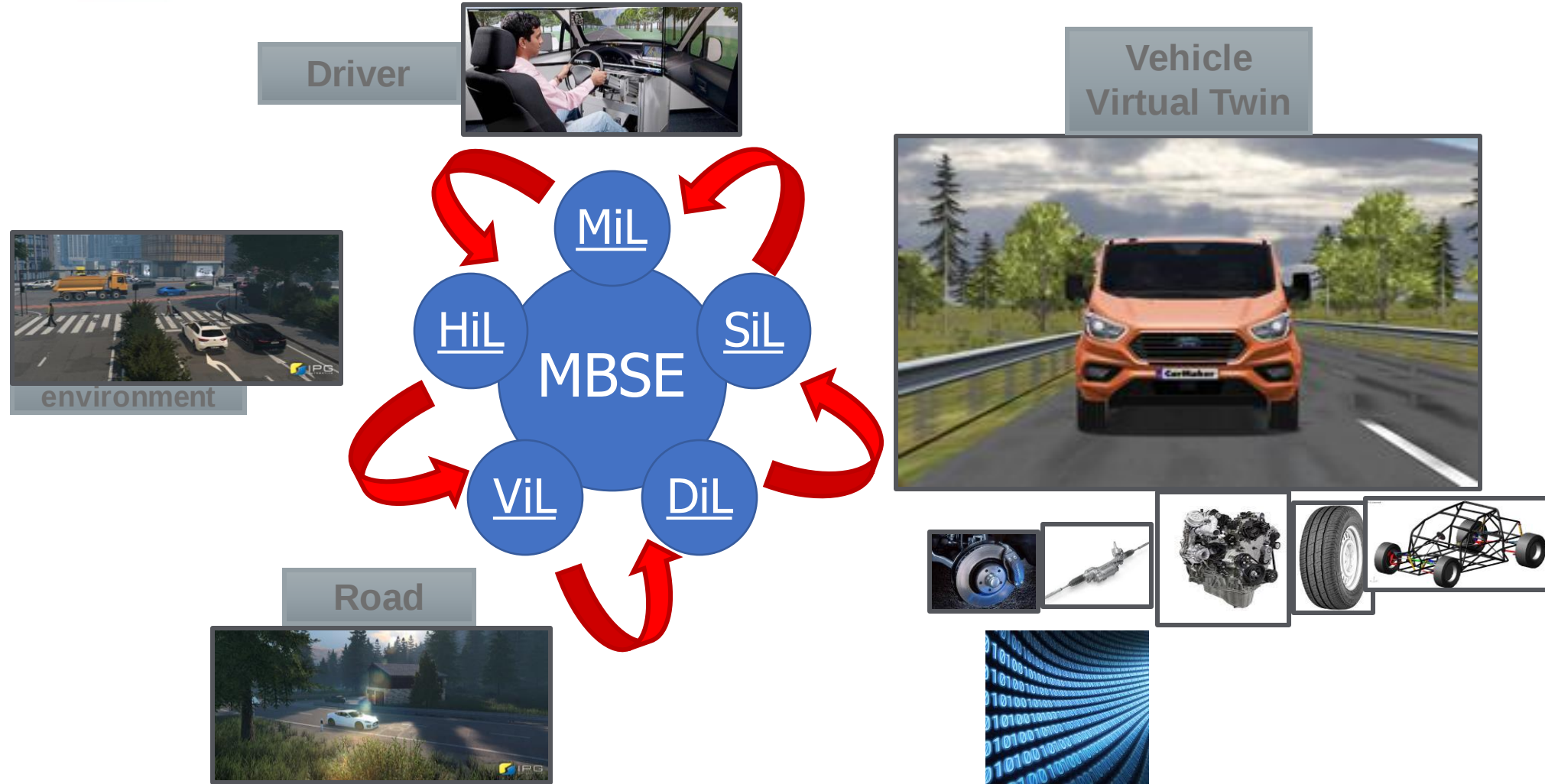
Transit Priorities & Complexity Only Containable With A New Approach



Virtual engineering critical for future success of automotive PD



What Is Virtual Engineering?



Tools & capability critical to future program delivery



Transit Future

- Expand use cases horizontally & vertically
- Develop the capability (facilities & people)
- Drive facility interoperability
- Explore new customers & use cases (PD & non-PD)
- Explore new partnerships







Aim

- Creation of a digital engineering framework for the assessment of an electrified Transit platform using simulator technology
 - Vehicle Dynamics
 - Advanced driver assistance systems
 - Propulsion and Electromobility

Objective

- Drastically accelerate time-to-market leveraging the output from digital engineering, simulators and XiL

Real Driving Emissions (RDE+)

- Road to rig characterisation of PHEV powertrain
- Generation and optimisation of a digital twin

Advanced Driver Assistance Systems (ADAS)

- Determination of functional and logical test scenarios
- Scenario based development and SOTIF analysis

Vehicle Dynamics

- Subjective and objective vehicle assessment and correlation from track to simulator
- Simultaneous and interlinked development of multiple vehicle attributes



RDE+ Road to Rig Correlation

HORIBA OBS ONE (x2) and ONE XL measuring vehicle emissions

- Engine out and tailpipe: CO, CO₂, NO_x & PN
- Tailpipe: N₂O & NH₃

Monitoring of battery state of charge and fuel flow

Four 90km on road tests

- Urban
- Rural
- Motorway

HORIBA OBS ONE



HORIBA OBS ONE XL (IRLAM)



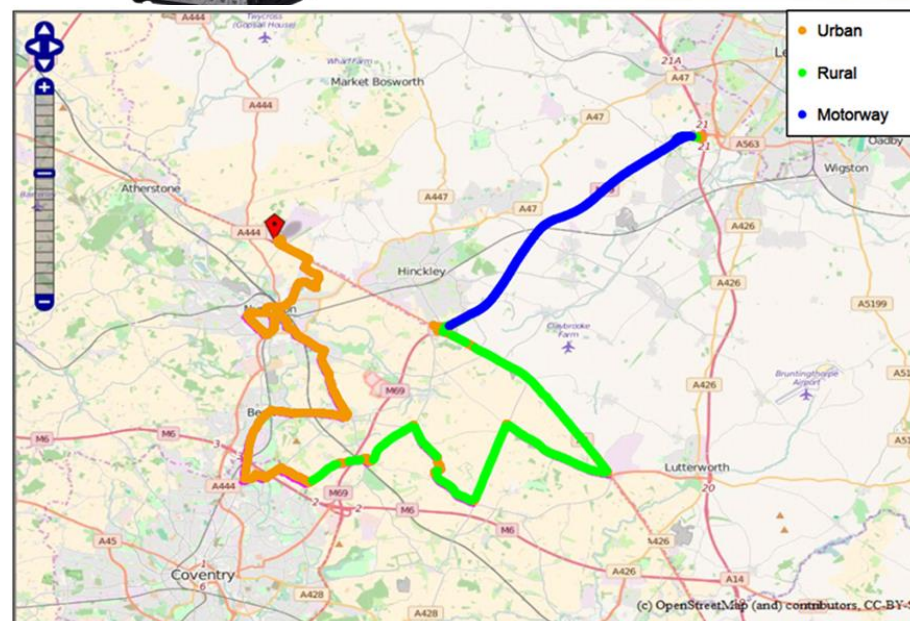
National Instruments



HORIBA RealFlow

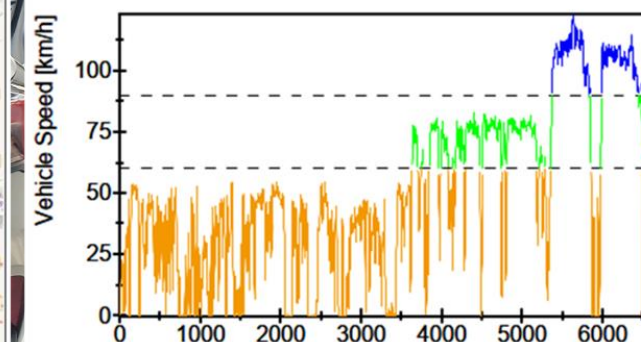


HORIBA OBS ONE



Trip Composition

	Unit	Urban	Rural	Motorway	Total Trip
Duration	min:s	73:04	22:23	15:34	111:01
Distance	km	34.5	28.0	27.6	90.1
Distance Share	%	38.3	31.1	30.6	---
Average Speed	km/h	28.3	75.1	106.3	48.7

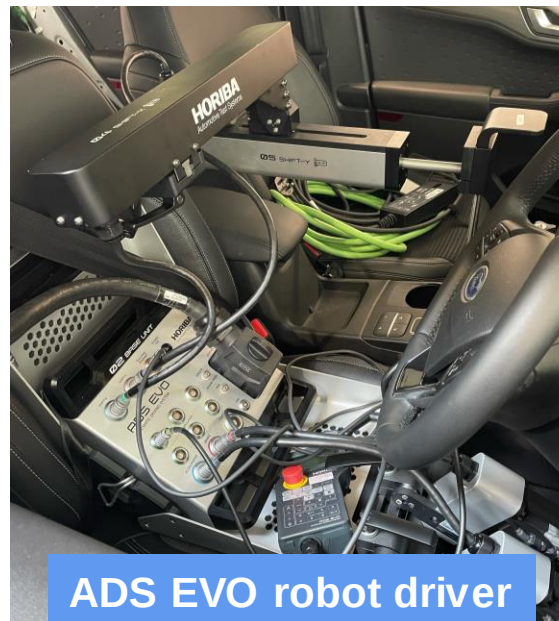


Vehicle installed into the Powertrain Test & Development Centre (PTDC)

- Engine and battery pack installed in test cell
- Remote vehicle

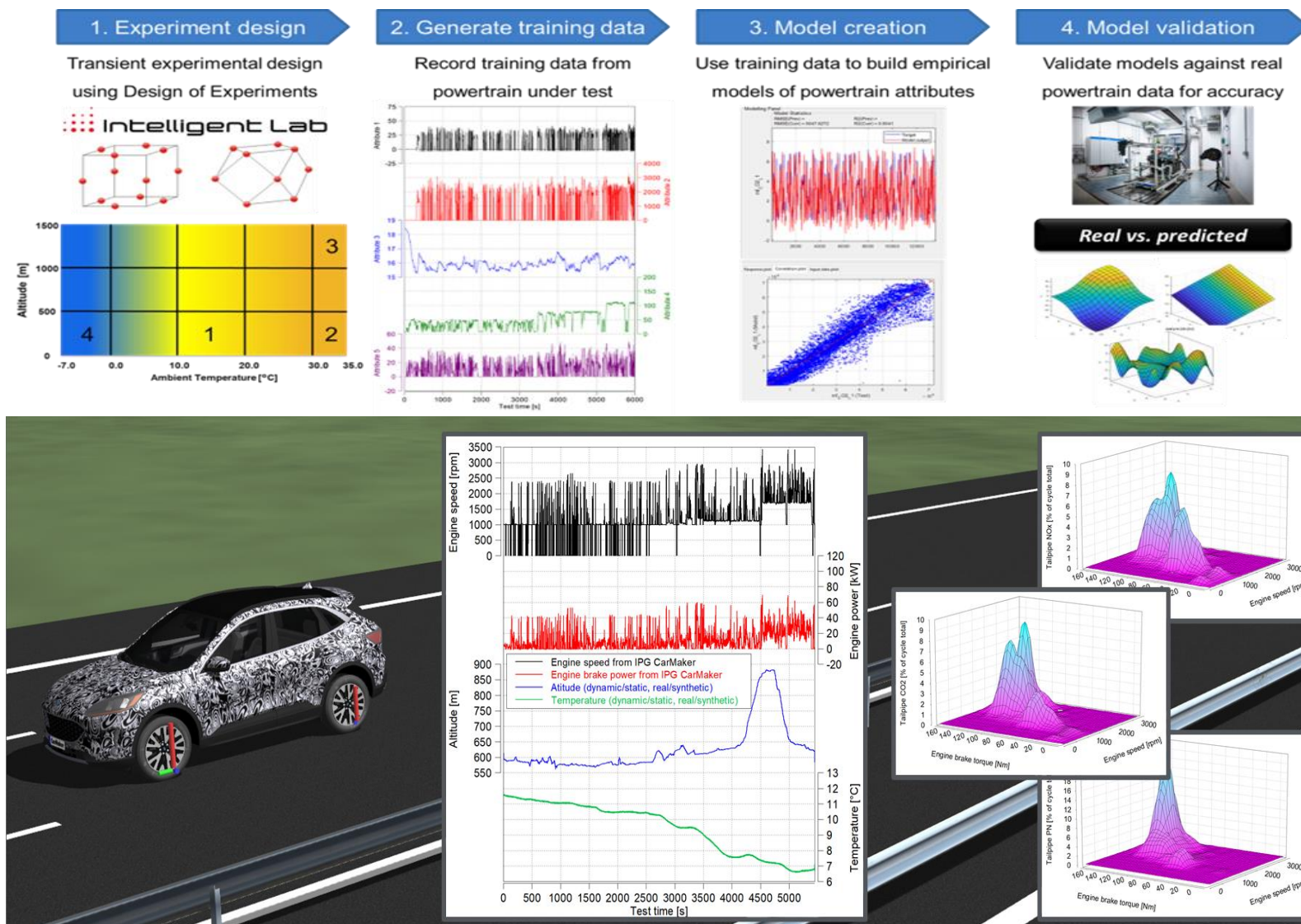
HORIBA ADS EVO robot driver used to replicate the power flow strategy recorded on the road

Requirements fulfilled for achieving road to rig correlation



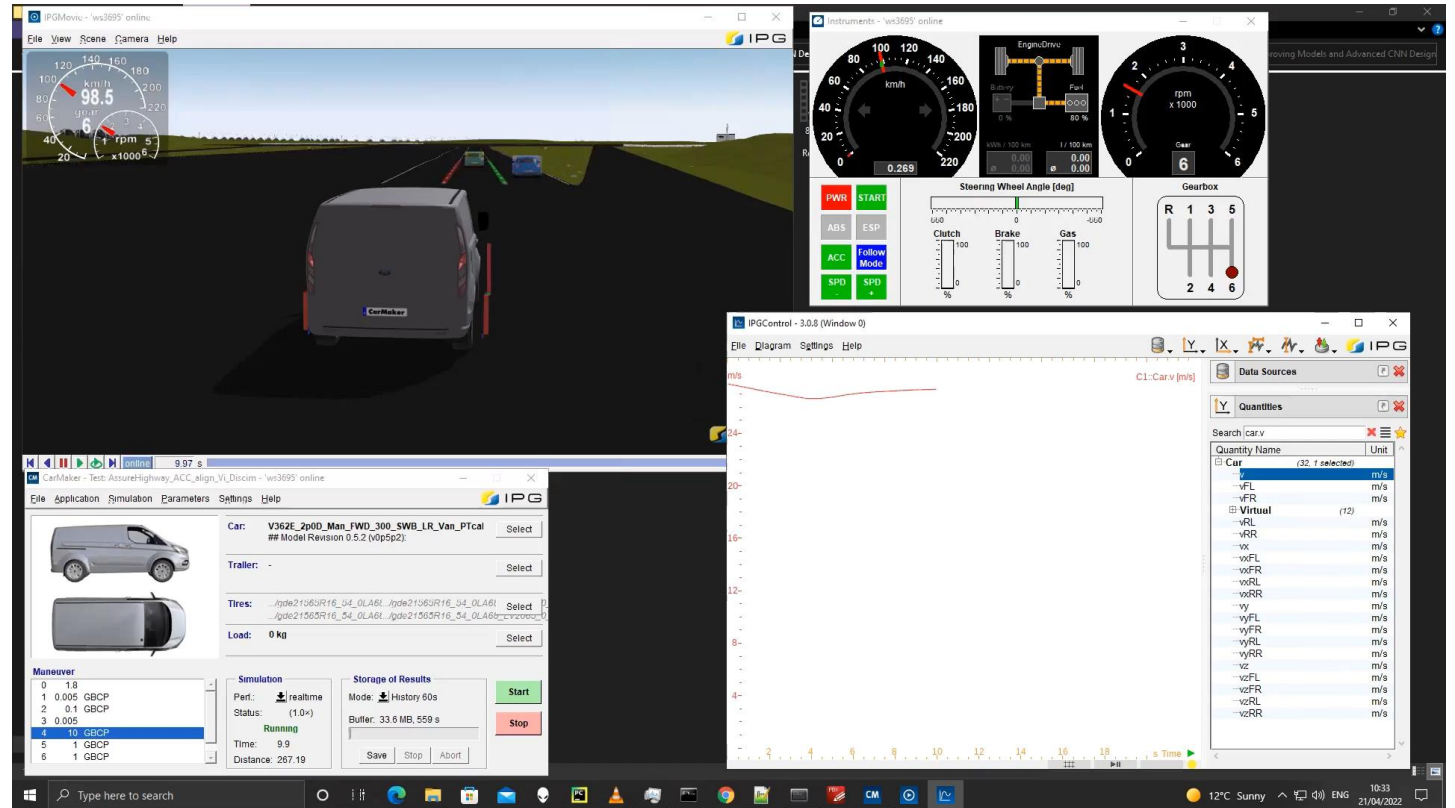
RDE+ Powertrain Digital Twin

- Design of Experiment exercise run on four EU6 conditions
- Digital twin model created and validated against road and rig tests
- Scenarios generated in IPG Carmaker and coupled with the digital twin
- Performance and emissions attributes predicted to allow powertrain development 30X faster than real time



ADAS Development of test cases

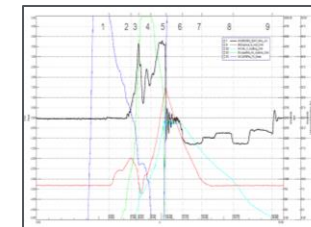
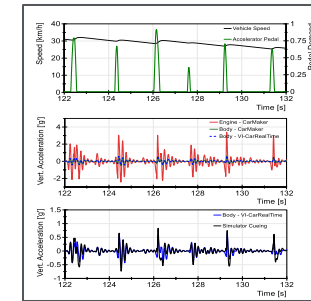
- Integrated the vehicle model, ADAS models and test environment models into IPG Carmaker
- Identified the possible scenario permutations (the 'scenario space') possible within the system's ODD
- Developed test programme to efficiently sample from the scenario space
- Test scenarios implemented within IPG Carmaker



- Proving ground tests conducted on HORIBA MIRA's ASSURED CAV Highway multi-lane platform
- Correlation exercise completed to validate virtual test results against physical ones
- Safety of the Intended Functionality (SOTIF) analysis conducted to identify hazardous scenarios
- Reported on test results, correlation and SOTIF



- Vehicles tested on the SPMM to characterise the Kinematics and Compliance of the chassis system
- Automated process to generate real time models in IPG Carmaker
- Detailed subjective and objective assessments of the vehicle dynamics and drivability attributes
- Optimisation of vehicle model to correlate from proving ground to virtual



- Virtual vehicle model assessed in the compact simulator
- Full alignment of virtual and physical, objective and subjective vehicle performance generating a digital mirror of the engineering process
- Development process validated using the DiM-150 Simulator at VI-grade



Compact Simulator

Driving Simulator



Simulation Platform



UDP

Fire wall



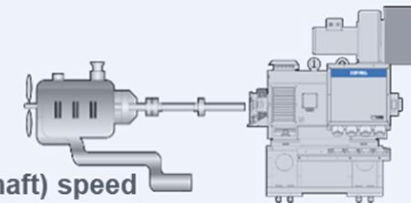
UDP

800m distance

Brake pedal position



Wheel (Drive shaft) speed



ACC pedal position



Test Automation

Control Room

Powertrain Test & Development Centre

PTDC to Simulator Connection



Integration into HORIBA MIRA's Driving Simulator Centre



- Driving Simulator Centre opening Summer 2023
 - VI-Grade DiM-250 Simulator
 - Compact Simulator
 - Customer Hospitality Suite
- Comprehensive engineering, consultancy and testing services available to support virtual engineering
- First of its kind in the UK!



- Simultaneous and interlinked development of multiple vehicle attributes
- Automated model generation from MIRA K&C data
- Simulated ADAS functionality
- SOTIF analysis of ADAS functionality



- Powertrain in the loop with the vehicle simulator to provide actual powertrain performance into the vehicle model
- Human-in-the-loop capability to operate powertrain dyno via a human operated simulator model

SAFER

CLEANER

SMARTER

Thank You!

May 30, 2023