3rd Revolution of the Automotive Sector

1st Assembly Line Manufacture

2nd Low Carbon Technologies

3rd Connectivity & Autonomy
### Automated Driving Deployment – Passenger Cars Only

<table>
<thead>
<tr>
<th>Level</th>
<th>Established</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
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- Established: 2015
- 2020
- 2025
- 2030

- **Fully Automated Private Vehicle**

- **Similar trends for Commercial vehicles**
- **More aggressive for off-highway**

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September 16, 2016
Automated Driving Deployment
Disrupters

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Automated Car

Automated

- Improve road safety
- Limited perception range can constrain vehicle control performance
- Clear path for deployment through evolution

Cooperative Car

Cooperative

- Improve efficiency and enhance safety applications
- Gathers data from further ahead to optimise vehicle control strategy
- Deployment challenges include standardisation, and market penetration

Vehicle Control Systems & Driver Assistance

Intelligent Transportation Systems (ITS)

Technology Convergence
Overview of test and validation

- The goal is to validate “fit for purpose” functionality and demonstrate due diligence
- Regulations and standards have limited scope
  - Simple repeatable scenarios applicable to all implementations
  - Proving robust behavior in varied scenarios and environmental conditions falls to the OEM and Tier I
- ADAS test procedures will form part of future automated-vehicle testing.

Start of Production (SOP)

Legislative Tests

National/International Standards, Consumer Standards, Best Practices

Product Specific Performance Scenarios Tested

Product Specific Performance Scenarios Modelled

Test & development scope

Company/Internal Standards

Legal req.

Minimum product liability protection
Q: How do we control so many variables?
Q: How do we identify faults?
Q: How do we validate failure mode mitigation?
Controlled Environment
Purpose built facility for developing and evaluating ITS solutions in a highly reproducible and safe ‘living laboratory’ environment for VeHIL
City Circuit Features

Urban driving environment
- Junctions, intersections and roundabouts
- Multi-lane highway sections
- Varied road surfaces and markings
- Power and network access around the site
- Over-road gantries for test installations

- Traffic lights
  - Two signal controlled intersections
  - User defined control
  - UK and European driving modes
- Street lighting
- Road signs
Wireless Communications and Denial

- Private GSM/GPRS network
  - 12 BTS cells with independent power and channel allocations
- Extended Vodafone 3G network
  - 3 local femtocells
- Network of WiFi access points
  - 6 controlled IEEE 802.11a/b/g/n nodes
- ITS G5 / IEEE 802.11p (5.9GHz for V2X)
  - 6 controlled infrastructure nodes
  - ETSI CAM support
Precise Tracking and Monitoring

- RTK-GPS (Error correction service)
  - Two local reference stations
- NOW Wireless Mesh 4G
  - Robust always-on network communications
- Ground Truth (3D motion capture)
  - Constellation of cameras around the master junction
  - Millimetre level accuracy and high frame rates
Prototype: Network Guided Vehicle

- Network Guided Vehicle is a research and demonstrator vehicle for Cooperative Driving.
- Exercised on the City Circuit using complex road maps, and communication infrastructure.
Prototype and Simulation: Cooperative HIL

- Realistic, portable and scalable software architecture
- Allows seamless interactions between physical and virtual vehicles

Deployment
Field Trials
Prototype
Simulation
Component
Autonomous vehicles can be legally tested on public roads - DfT Code of Practice (Spring 2015)
Introducing driverless cars to UK roads

- Covering multiple aspects of automated driving in distinctly different urban layouts
  - Milton Keynes
  - Coventry
- Researching and building a deep understanding of the impact of driverless vehicles on road users and society
The project will be trialling:
- Interlink between the urban and Strategic Road Network (SRN)
- Multipath broadcasting using multiple communications methods
  - DSRC 802.11p, 3G, LTE and LTE-V, Wi-Fi services on the move
- Functionality, safety and convenience services
- Road network efficiency and modelling
- Test site access
  - Access for vehicle manufactures and technology companies when operational

Stakeholders:
- The Vehicle Manufacturers & Suppliers
- Local and National Highways Authorities
- Communications Companies and Infrastructure Providers
- The consumer/businesses and their journey experience
Virtual Environment
The $10^4$ – $10^6$ km Drive Cycle

- There are numerous reported figures for the drive cycle or mileage accumulation to test and validate ADAS and CAV systems:
  - $10^4$ to $10^6$ to $10^7$km

- What is clear, new methodologies for the test and validation of these systems will be required:
  - Limiting the dependency on the amount of physical testing and reducing cost, risk and time to market

Correlated New Methodologies

- Development of vDVP as well as more traditional techniques
  - Controlled environments
  - Public environments
  - Cyber-Physical environments
  - Virtual environments
    - Using verified vDVP techniques including analytical and virtual methods as part of the systems development lifecycle V-mode
Virtual Design Verification Processes (vDVP)

- Simulated environments with real world features for Model in the loop (MiL), Software in loop (SIL), Processor in loop (PIL), Hardware in loop (HIL) and Vehicle in the loop (VeHIL) validation.
Summary

- Physical testing will continue to be critical and requires ongoing development:
  - Controlled Environments
  - Public Environments

- To meet the requirement for ever increasing complexity of use case and scenarios

- Rapidly growing need to limit the dependency on the amount of physical testing:
  - Address the $10^4$ to $10^6$ drive cycles / mileage accumulation
  - Reducing cost, risk and time to market

- New methodologies using verified vDVP techniques as part of the systems development lifecycle
Thank you and questions