The Challenges of V&V for Connected and Autonomous Vehicles

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Established in 1980 by Professor Lord Bhattacharyya as Warwick Manufacturing Group to facilitate technology transfer and knowledge creation for Industry

700+ people (900+ university and industry) working in 7 buildings

Training over 1,500 individuals in the UK and abroad (from school to post experience)

Co-located with Jaguar Land Rover & Tata Motors European Technical Centre

**Coming Soon:** National Automotive Innovation Centre
- £150m investment, led by private sector
- National focus of automotive research capability
- An environment to foster collaboration, cohesion and cross-fertilisation of knowledge
  - Academic, industry (including supply chain) teams
  - 33,000m$^2$ building:

**Greener, lighter, smarter vehicles**
Connected and/or Automated Driving: A Good Idea?
Some Challenges for CAVs

We need to ensure that new products and services are:

- **Dependable and affordable**
  - In a complex real world operating environment
  - With new high value components integrated on-board (and off!)  

- **Commercially viable**
  - With new entrants to the value chain
  - And new services and business models

- **Desirable**
  - Gaining public acceptance and trust
  - Achieving societal benefits

*How?* Learn from a continuum of simulation; testing; trials; and early deployment
Real World Trials

Strengths
- Validity - in the real world
- Important for understanding user behaviour, and for public engagement

Weaknesses
- Risk has to be minimised
- There is no repeatability, and limited control of the test conditions
- Cost is high (infrastructure and vehicle) & flexibility low
- (How many miles are required ?)
Track/Controlled Testing

Strengths
• Controlled conditions
• Real technology
• Lower risk

Weaknesses
• Not representative human behaviour
• No standard methods
• Limited number of use cases, scenarios and test cases
• Cost is high
Our Vision: To test or evaluate any new technology (infrastructure, communications and on-vehicle) in representative real world conditions with a “driver” in the loop.
A complementary alternative?

Strengths
• Real vehicle/technology/users
• Complete control of operating environment
• Repeatable and safe

Weaknesses
• Technical challenge
• Questions on validity
Digital World – Modelling and Simulation

**Strengths**
- Complete control of operating environment
- Could evaluate any vehicle/technology/users
- Repeatable, safe and efficient

**Weaknesses**
- Very few! ....but only if it is comprehensive, representative and accurate
- Can’t engage end-users
Evaluation continuum

Digital World - Simulation

Simulated Environment

Track/Controlled Testing

Real World Trials

Full control of operating environment

Increasing Realism

User-in-the-loop

Increasing ability to choose scenarios

Increasing flexibility to test different technology

More dependence upon real system availability

Faster than real-time possible

Increased efficiency

Real-time only

Aim: to confidently test earlier in product development
Evaluation continuum

- Digital World - Simulation
- Simulated Environment
- Track/Controlled Testing
- Real World Trials

Another Aim?
How can simulation also play a role in validation and certification?

Aim: to confidently test earlier in product development
Modelling and Simulation - 1

- Model creation should be driven by end usage and user
  - Who? When? Why?
- Performance optimisation; accelerated product development; validation and certification
- Examples:
  - Improving sensor performance
  - Verification of an autonomous control system
  - Validating safe vehicle behaviour
  - Evaluating impact on congestion of new fleets or connected infrastructure
  - Cost effectiveness of new services
Importance of: Use Cases; Scenarios; Test Cases ("smart miles" vs number of miles)

...and sequencing of test cases

Dependent upon application, improved models needed for:
- Sensor performance in real-time
- Effect of environment/infrastructure on sensor inputs
- Other road user behaviour
- Connectivity
- Threats

Can we model for ethics, human behaviour and perception?

How can models be used for AI/ML training and/or testing?

Need for standard APIs

Access to suitable input data and validation data for models
Coming soon: “UK Central CAV Testbed”

- Real-world testing of CAVs and related technologies & services
- Part of Meridian Mobility (“Testbed UK”)
- Initial investment of £25m
- 8 partners
- Part of broader CAV ecosystem

- Comprehensive mix of road environments (in Coventry & Birmingham)
  - Linked to existing infrastructure e.g. UK CITE
- Wireless infrastructure (4G and 5G ready network) open to all operators
  - Contiguous connectivity with high capacity and low latency across all testbed routes
- Smart vehicle monitoring
- Back office for data collection and analysis (collating multiple data feeds)
- Vehicle/user support infrastructure readily available
- Strong engagement with local public
- Access to a participant database for design evaluation
- Engagement with a broader and supportive CAV eco-system
- Regular upgrades over Testbed lifetime

National Automotive Innovation Centre
WMG’s Broader CAV Activity

• Ensuring CAV dependability
• Enabling new opportunities from connectivity
• Engaging the public to enhance designs and understand social implications
• Understanding and developing new supply and value chains
• Delivering new Education and Training (e.g. FT MSc in SCAV to launch 2018)

Major projects include: INTACT, UK CITE, CARMA, SWARM, SAVVy, RACeD, L3PILOT, ESCIPODS
Summary

New vehicles and technology are coming sooner than we might think, bringing benefits for all of us.

But we need to ensure they are secure, safe and robust in complex real world environments.

To do this, we will need new test infrastructure, and new modelling and simulation approaches too....

Vehicles and technology must also be desirable and commercially viable

Success will be dependent upon suitable collaboration and data sharing
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