

VeriCAV – Simulation Framework for Evaluating ADS Performance





Context – Automated Driving System Verification



Millions of driven miles required

Multi-pillar approach – Virtual simulation a key pillar

Simulation – offers efficiency, repeatability, controllability

Scenario based testing



Collaborative R&D



- Industry Lead
- End user interface
- Automated scenario generation and analysis
- Interfacing with ADS



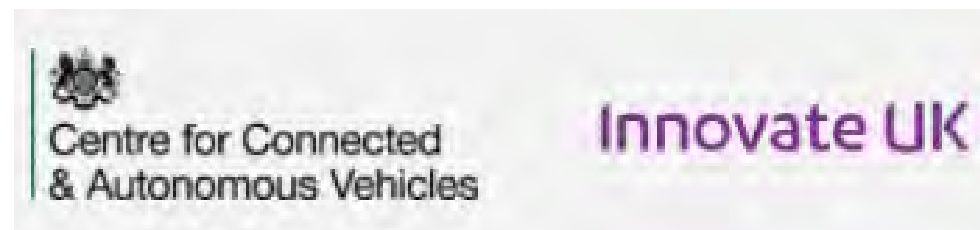
- Project Management
- Systems Engineering
- Dissemination



- A variety of intelligent actors to populate scenarios



- Expertise in wider simulation eco-system



Concludes March 2021



Challenges addressed in VeriCAV

Challenges in Scenario-based Testing:

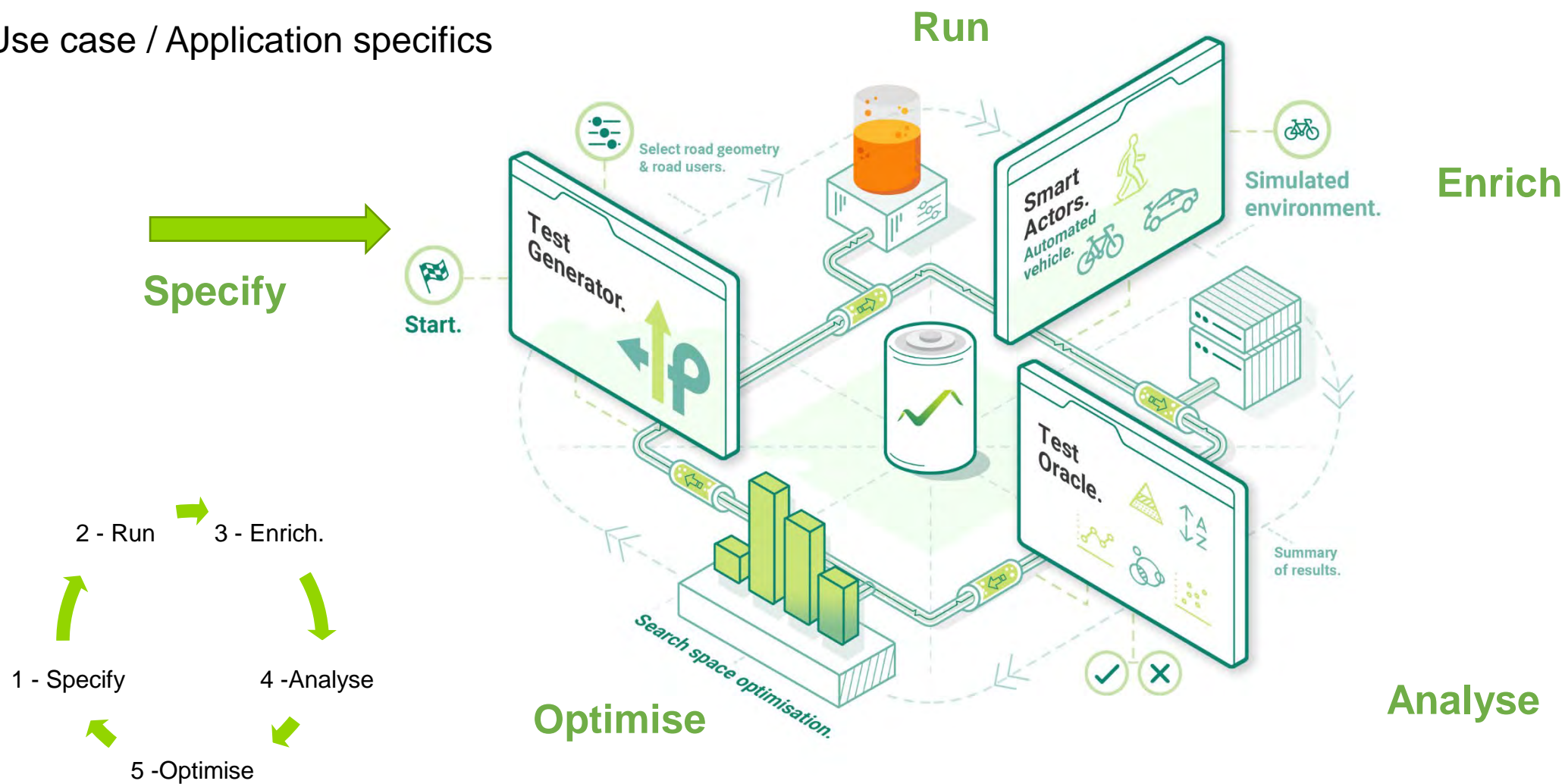
1. How can scenarios be described in a way that:
 1. captures the complexity of diverse scenario sets,
 2. allows automated scenario creation,
 3. and can be unambiguously interpreted by simulation tools?
2. How can the onerous activity of manual scenario generation be automated and made more efficient?
3. Ensuring results from Simulation are valid
4. Ensuring the use of the framework with different ADSs
5. How can virtual simulation coverage be ensured in an efficient manner?
6. How can test success be assessed in virtual simulations?





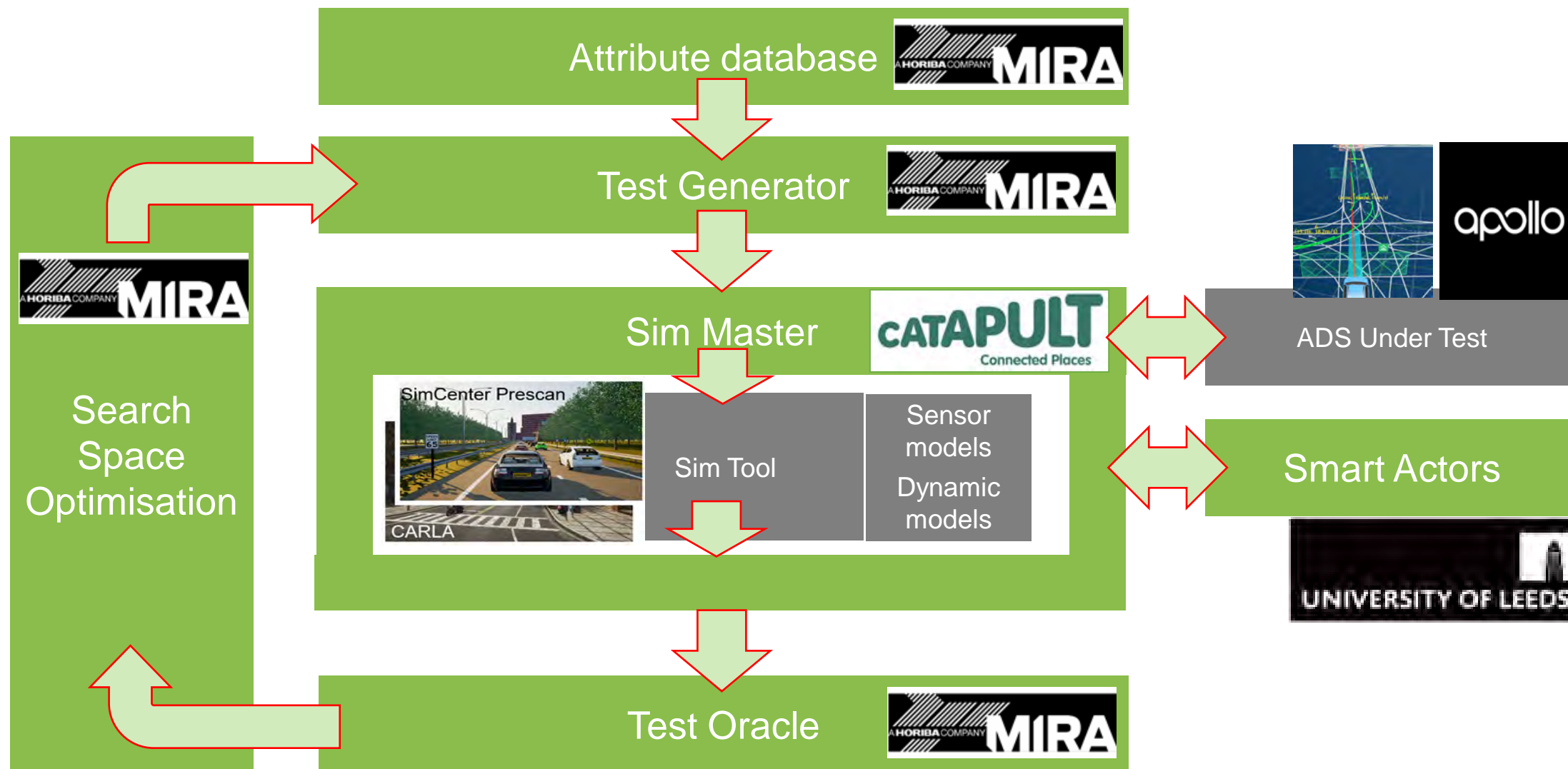
Introduction to the Framework

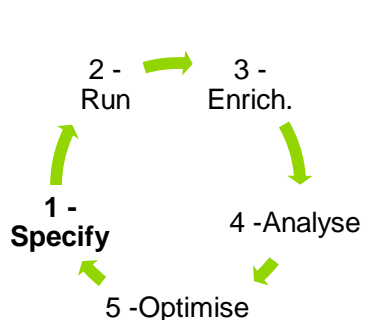
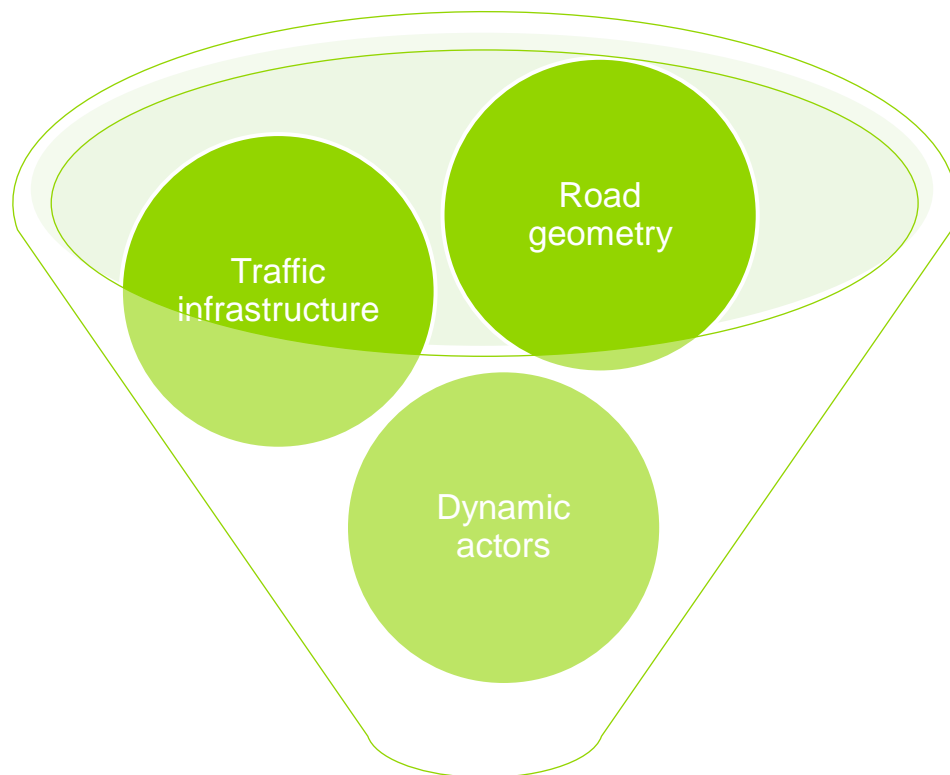
Use case / Application specifics





Framework Architecture





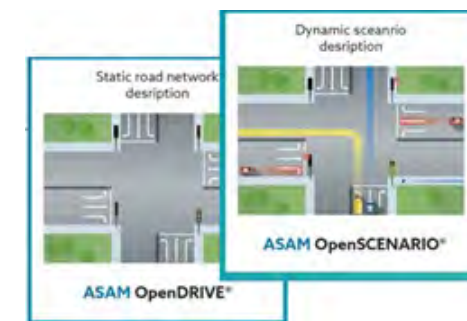
Automated test generation

Scenario attributes

- Attribute database
- Structured description (e.g. PEGASUS layers)
- Logical scenarios:
 - Parameter range, resolution, and probability distribution

Configurable constraints

- Operational Design Domain (ODD)
- Simulation capability
- System design and functionality
- Test objectives



i.e. different gaps in traffic



Creating Intelligent actors in the scenario

Challenge

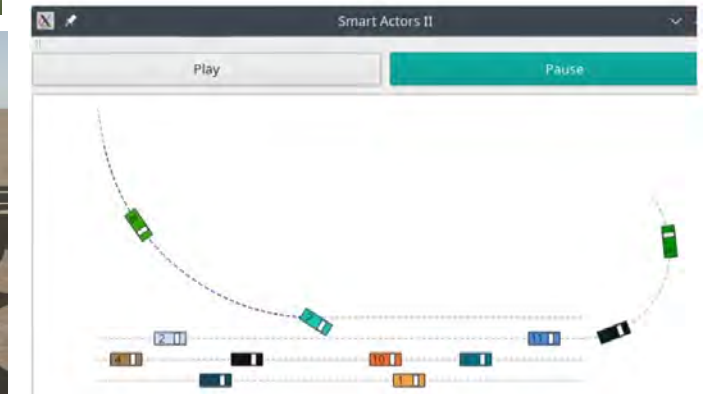
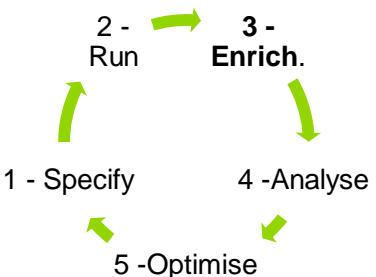
- Represent richness of human behaviour in simulation
- Dynamic interactions
- Varied responses to type / individual

Diverse Approach

- Machine Learning
- Game theory
- Choice models
- Cognitive models

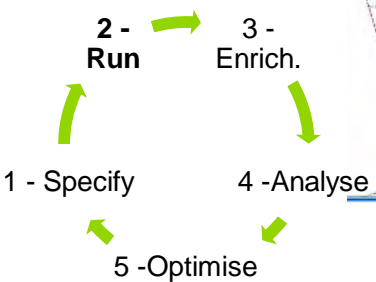
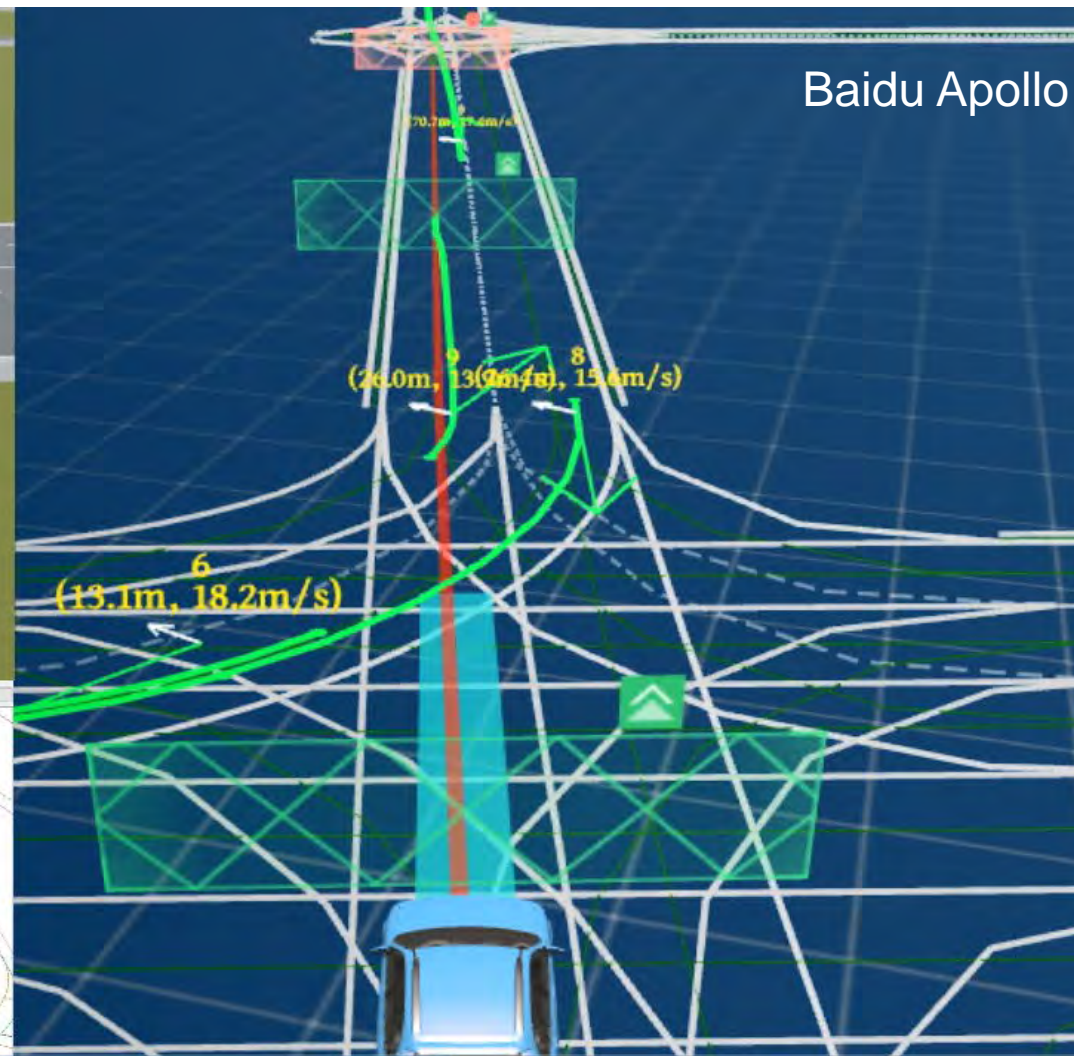
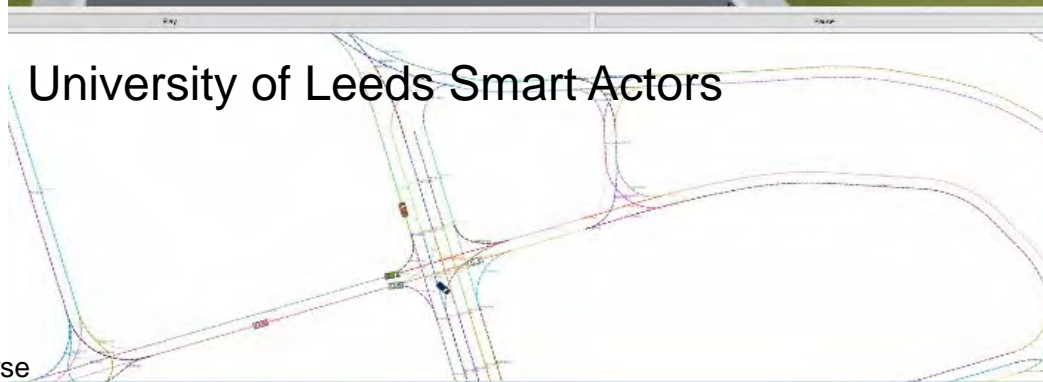
Scenarios

- Area of road-user conflict
- Pedestrian crossings & turning across traffic
- Advanced cases inc. complex roundabouts and highway merge





Simulation Integration





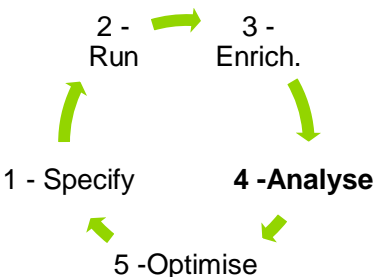
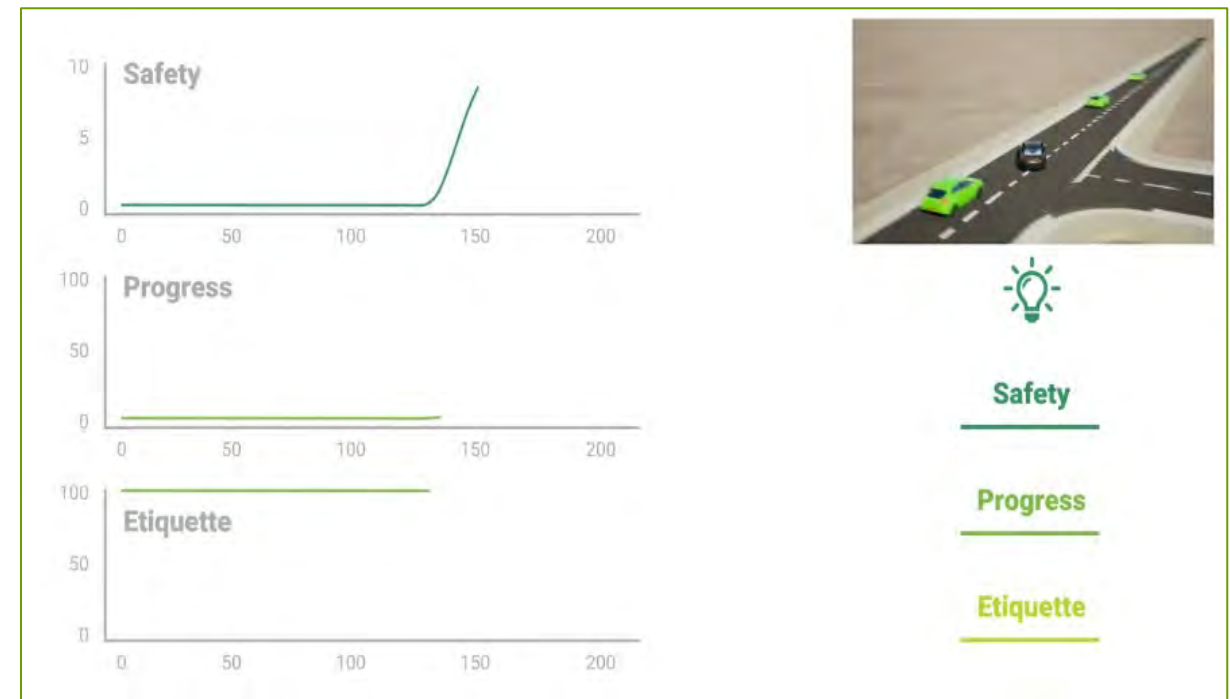
Automating the Test Analysis – Test Oracle

Automated acceptance criteria

- Generated scenarios require generated acceptance criteria
- Need to reduce human workload
- Account for scenario context - how complex was the driving task

Quantified performance metrics

- Not just pass/fail, looking for performance degradation
- Evaluation from multiple perspectives:
 - e.g. Mobileye Responsibility Sensitive Safety (RSS)
 - Legality
 - Etiquette to other road users
 - Comfort

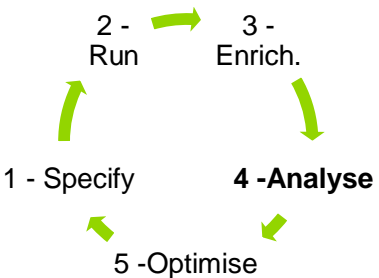
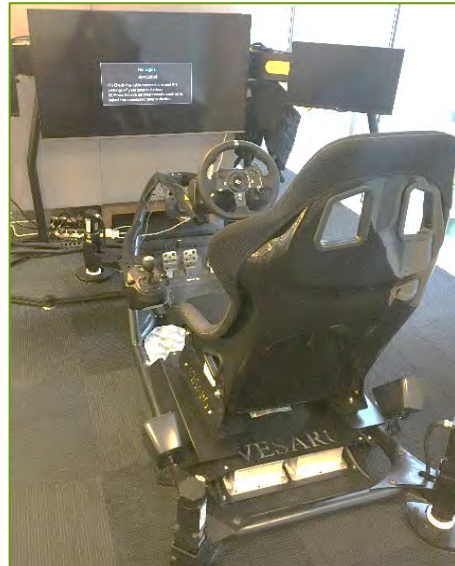




Occupant Comfort - Oracle Layer

Goal: Automatically assess the ADS in relation to the comfort of future occupants

Validate the oracle assessment with real participants in Virtual Reality experiment



Metrics:

Accelerative
comfort
factors

Lateral
distance
from
objects

Headway to
other actors

Entering
traffic flow



Test Oracle - Approach



Simulation data

- Ego telemetry data
- Actor telemetry data
- Road geometry

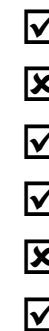


Coverage

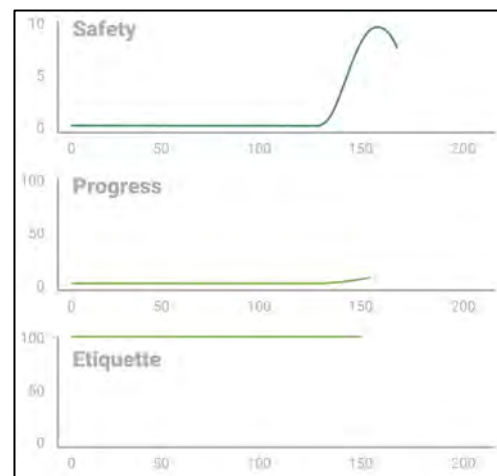
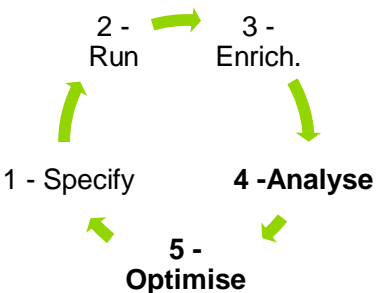
Context

Combined Metrics

Assessment Summary



Optimise subsequent scenarios



Multiple Metric results



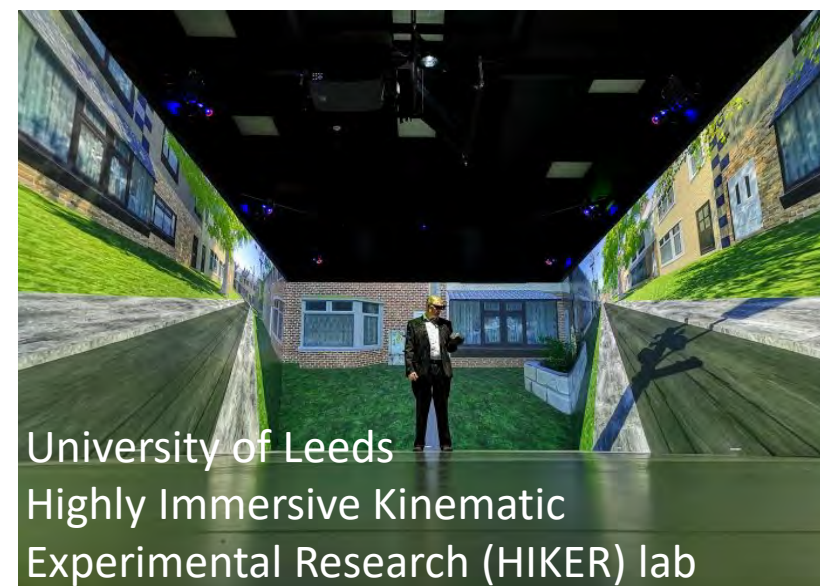
Challenges – Validating Simulation

Ensuring results from Simulation are representative

No simulation tool is currently sufficient for verification of a complete highly automated driving system.

Pragmatic solution:

- Interchangeable simulation tools – to utilise future developments
- Open Simulation Interface (OSI) standardisation to support this interchange
- Focus on decision-making – bypassing sensor modelling
- Physical test track and pedestrian simulation facility to validate the simulation results.



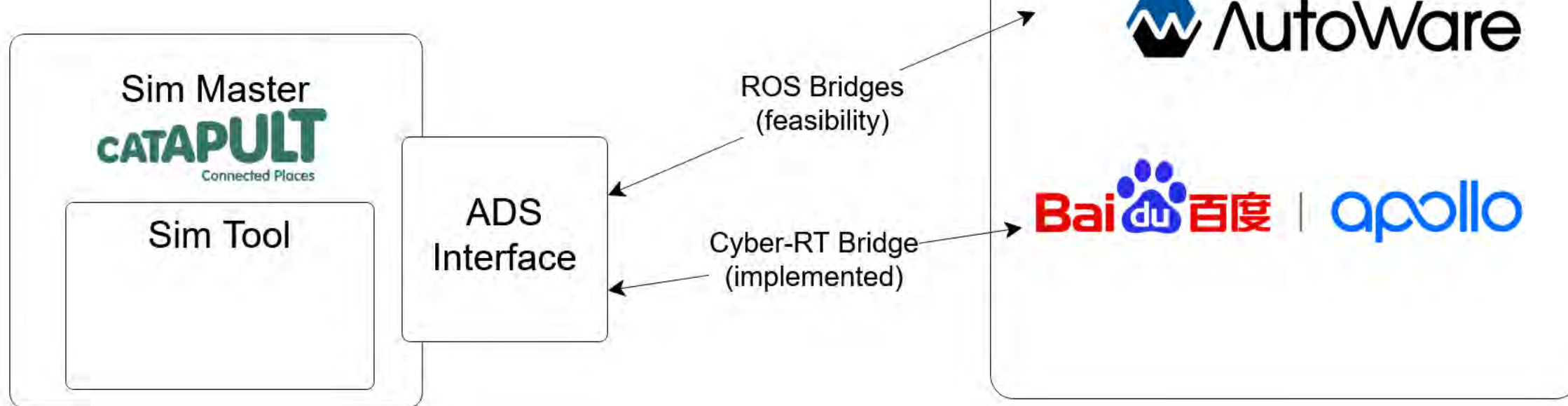


Challenges – Maximising reuse

Maximising the use of the framework with different ADSs

Pragmatic solution:

- Bridges maintain simulation tool interface while allowing new Automated Driving Systems to be connected.
- Implemented Apollo, conducting feasibility for other Automated Driving Systems





Key Innovations

- Reduction in human involvement
 - In setting up scenario – Test generator
 - In analysing scene – Test oracle
- Flexible framework - independent of simulation tool - Sim master
- Rich eco-system of actors to create challenging test scenarios – Smart actors





MIRA

CATAPULT
Connected Places



aimsun.



UNIVERSITY OF LEEDS



VERIFICATION OF CONNECTED AND AUTONOMOUS VEHICLES



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Including: [VeriCAV Introduction Paper](#)