ODD based Safety Assurance for Automated Driving Systems:
Standards and tools

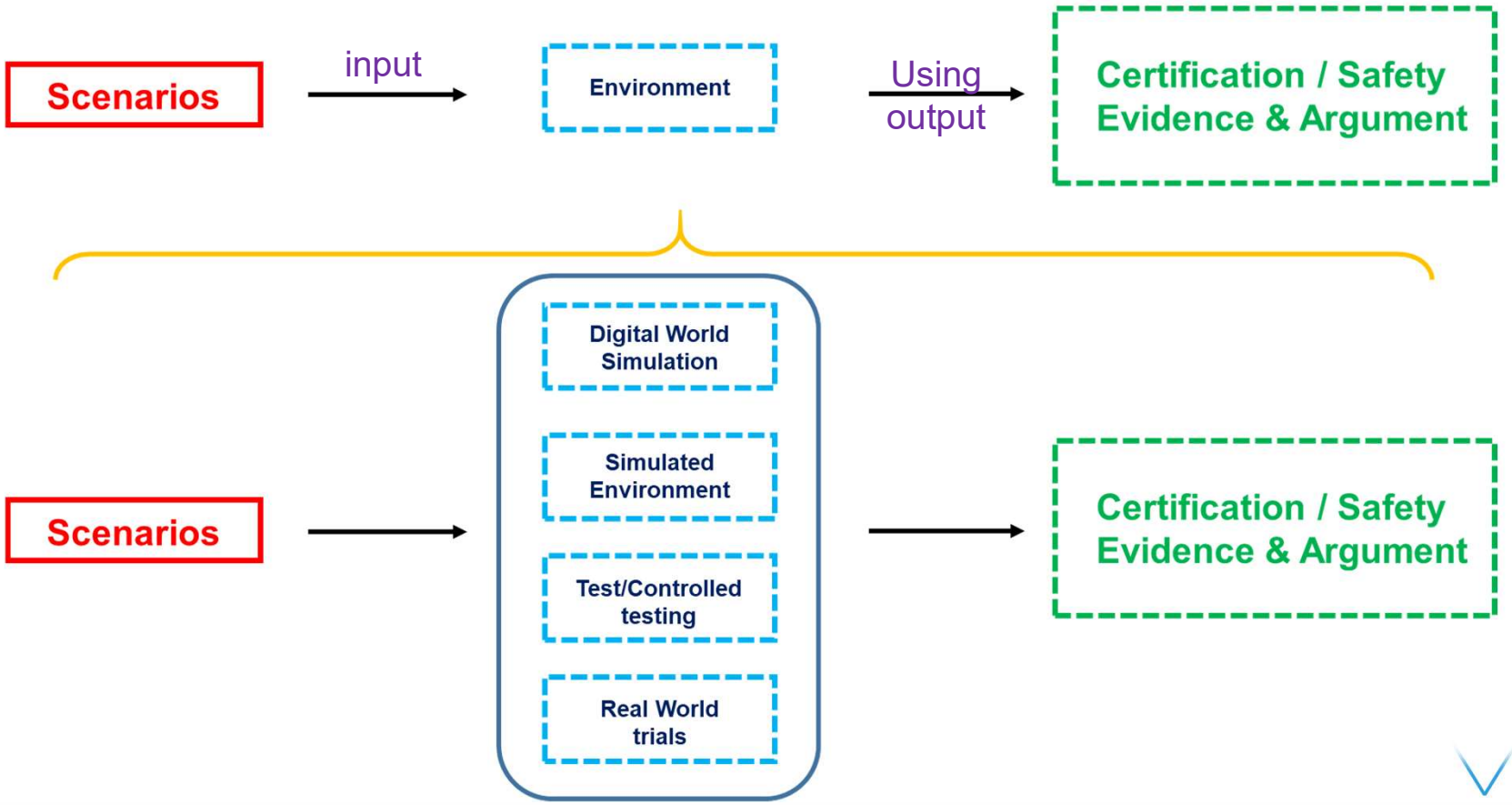
Dr Siddartha Khastgir CEng MIMechE
Head of Verification & Validation, Intelligent Vehicles
WMG, University of Warwick, UK

WMG
THE UNIVERSITY OF WARWICK

VVM Mid-Term Event
16 March 2022

Evaluation Continuum

Evaluation Continuum

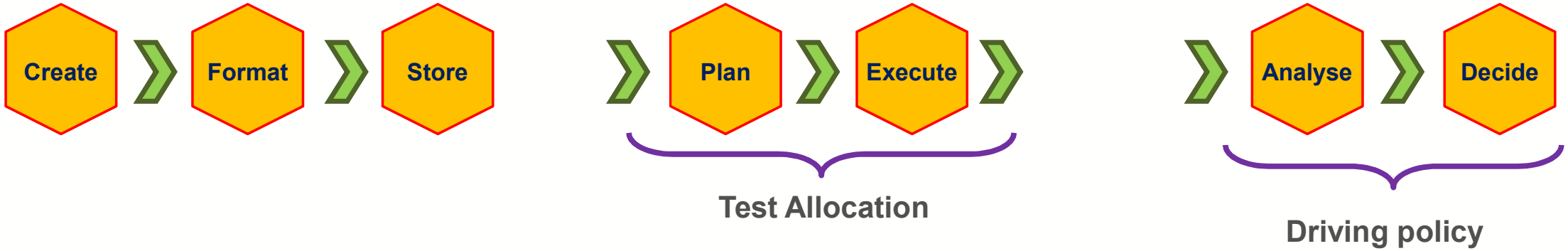


Evaluation Continuum

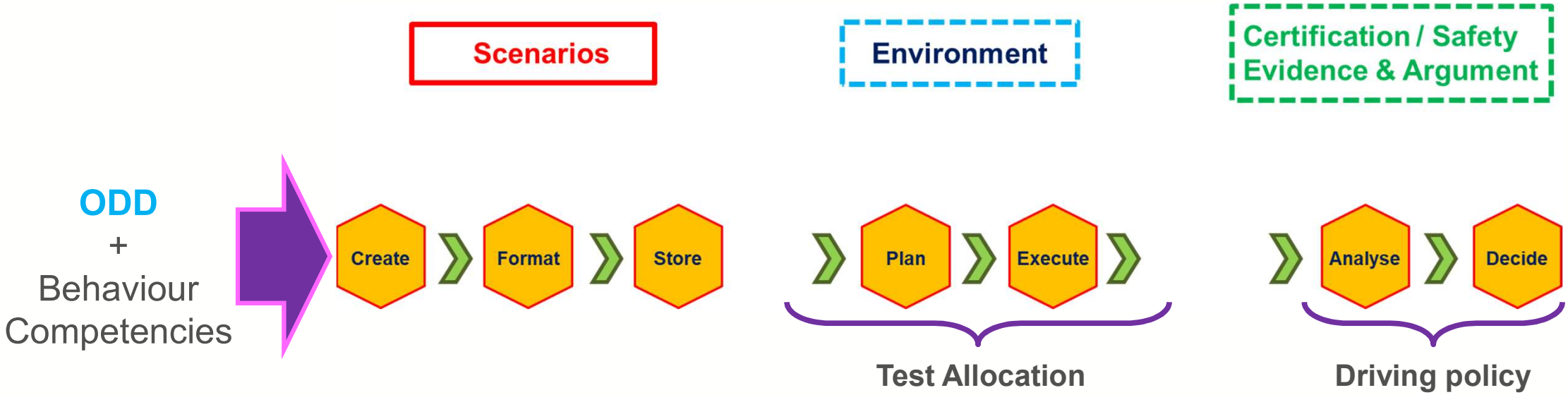
Scenarios

Environment

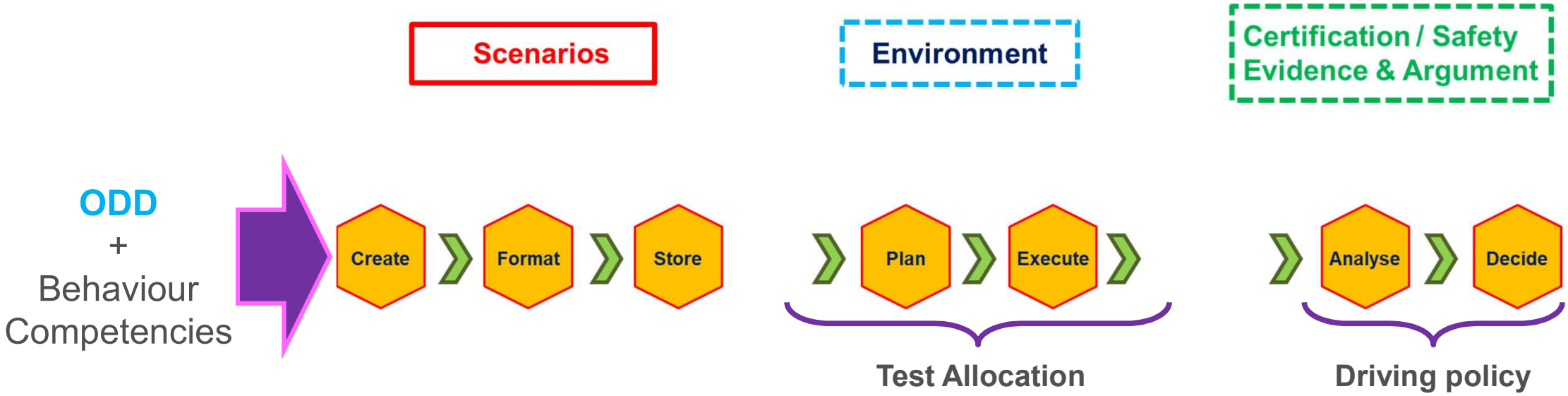
Certification / Safety Evidence & Argument



ODD based Scalable Safety Assurance Framework



ODD based Scalable Safety Assurance Framework



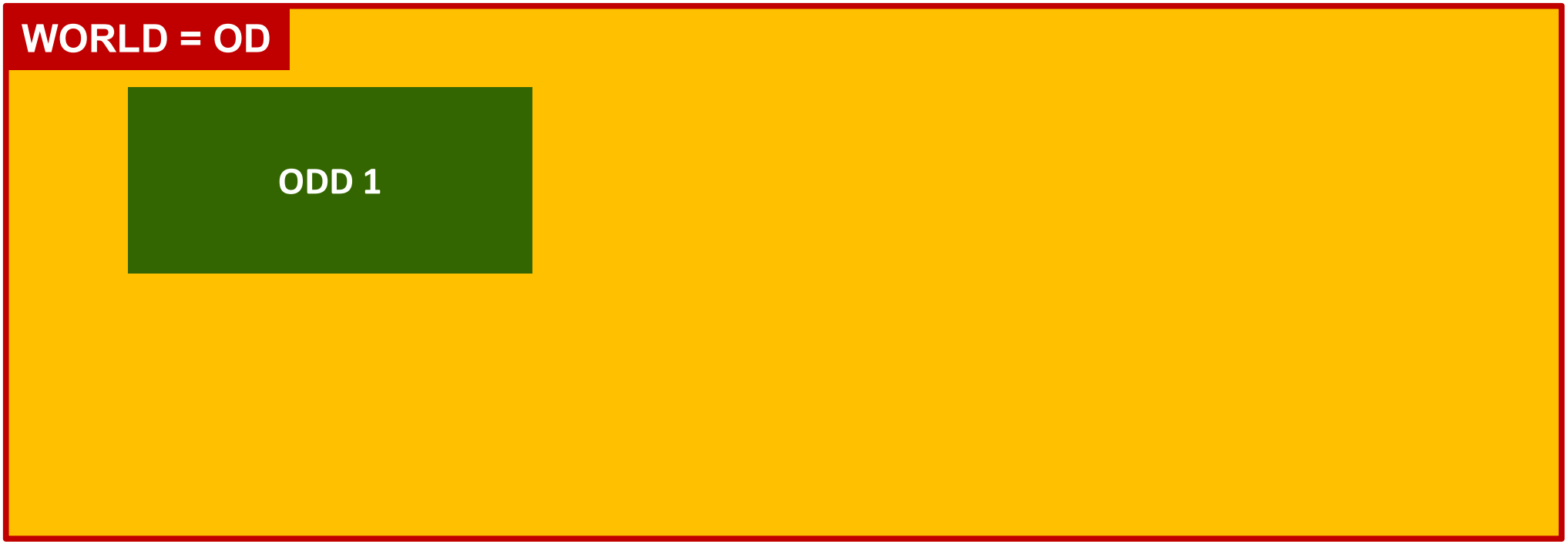
Standards and Tools!

WMG
THE UNIVERSITY OF WARWICK

ODD and Operational Domain (OD)

ODD and Operational Domain (OD)

ODD and Operational Domain (OD)



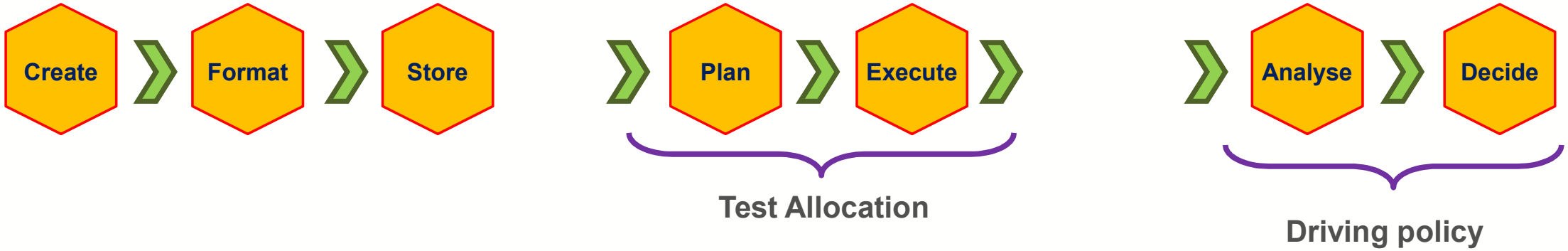
ODD and Operational Domain (OD)

Evaluation Continuum

Scenarios

Environment

Certification / Safety Evidence & Argument



Evaluation Continuum

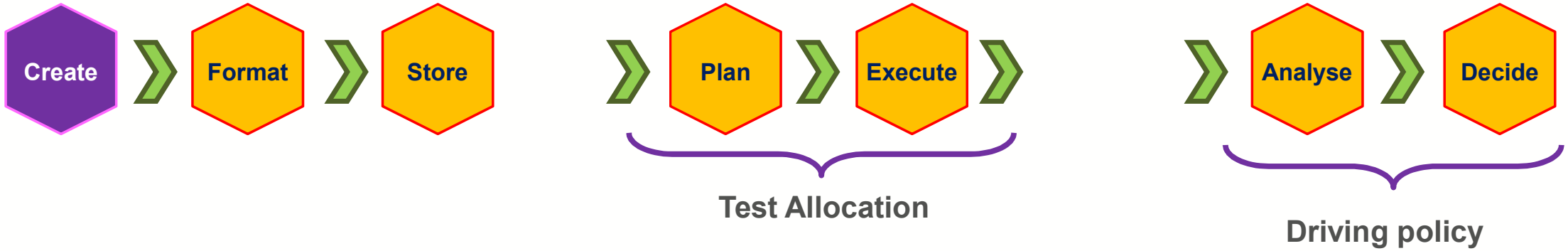
METHODS AND TOOLS

Evaluation Continuum

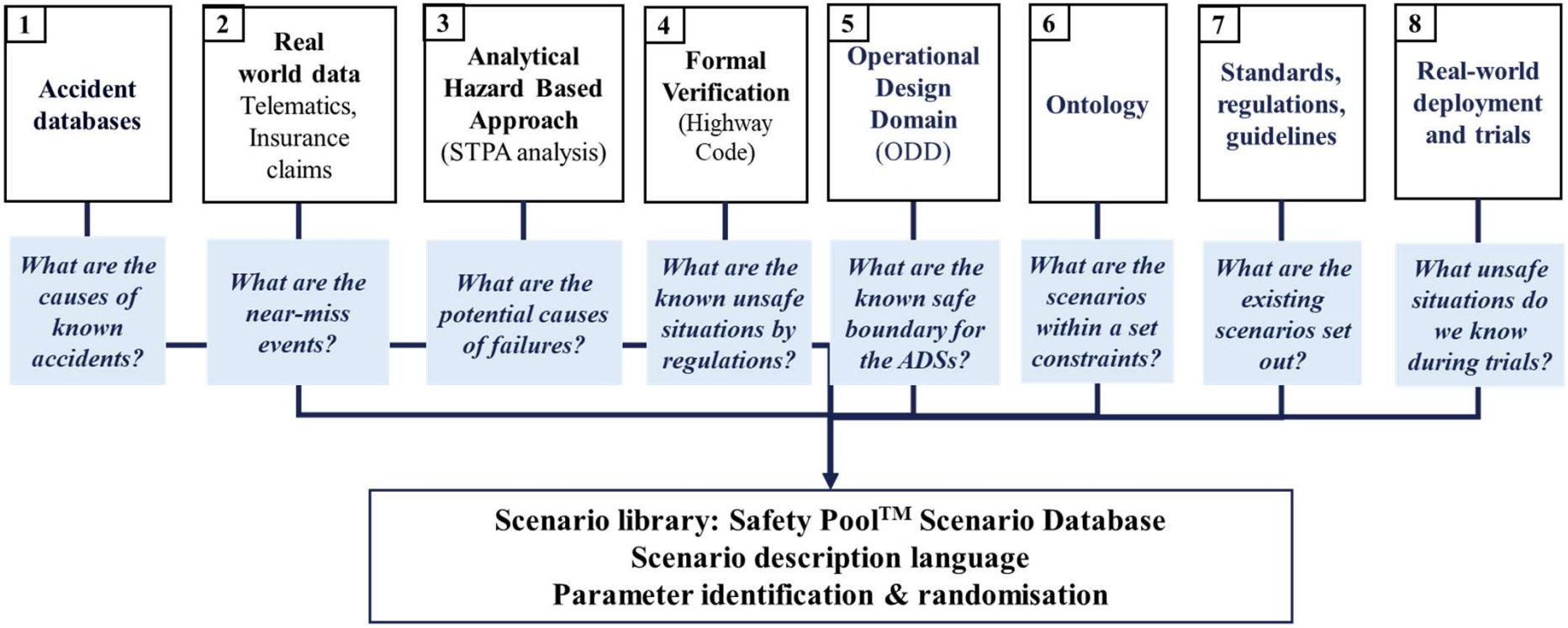
Scenarios

Environment

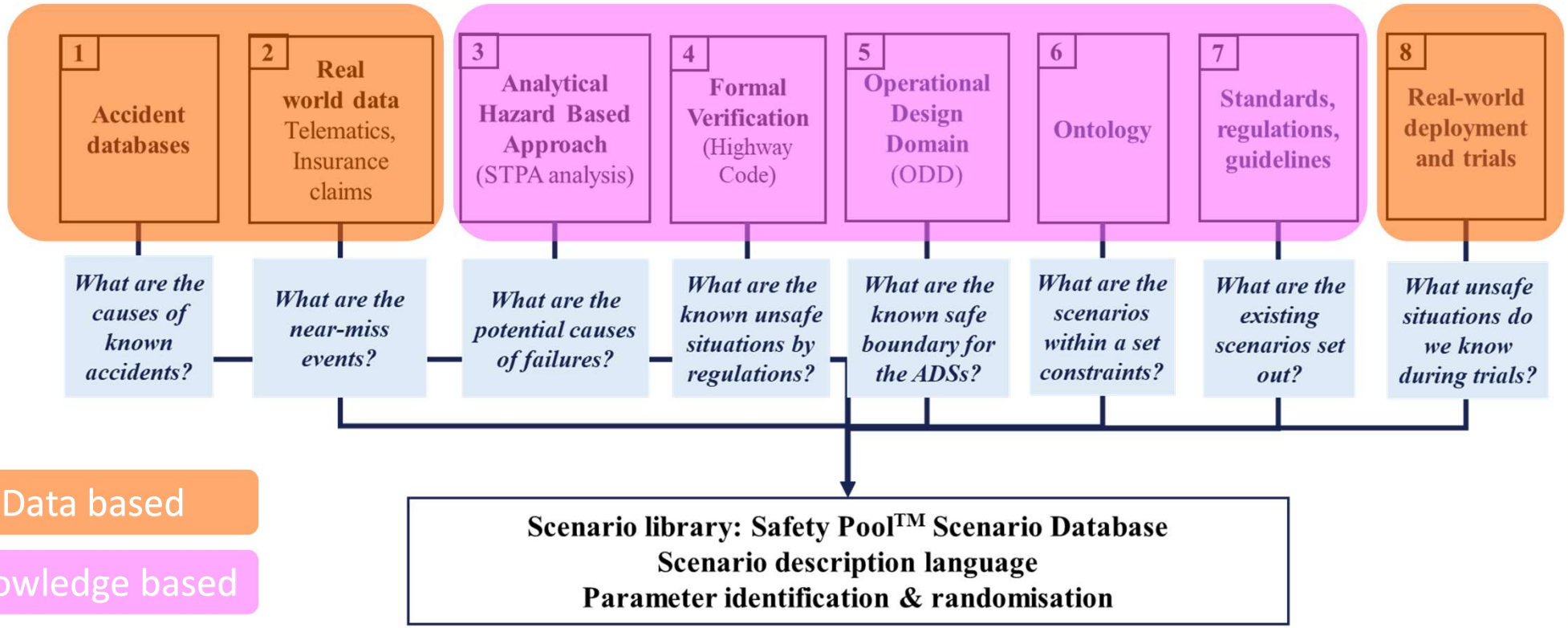
Certification / Safety Evidence & Argument



Scenarios



Scenarios



Data based

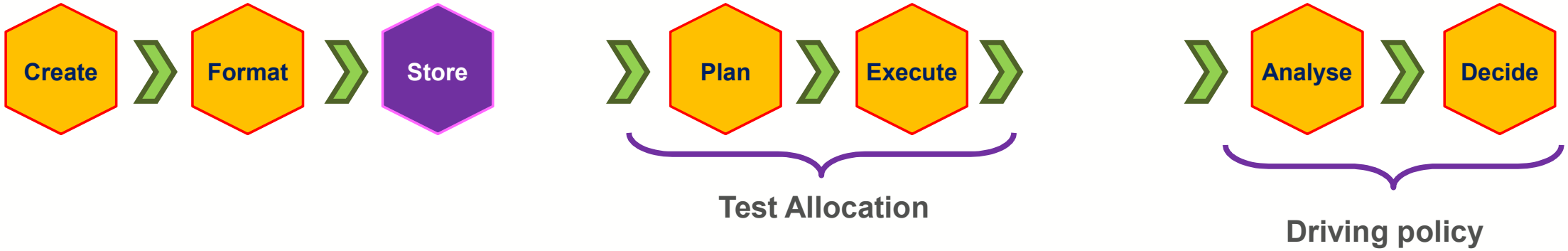
Knowledge based

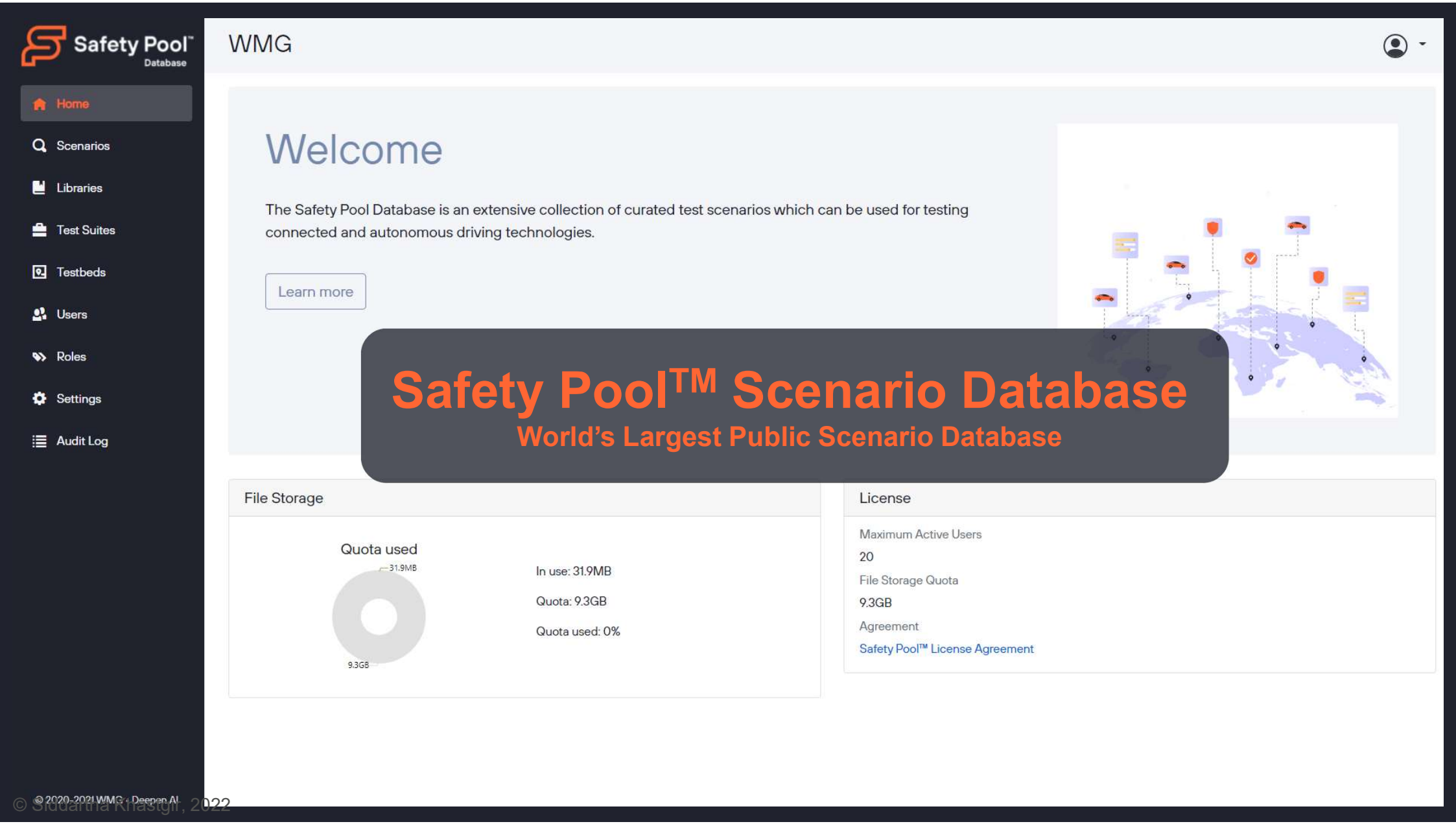
Evaluation Continuum

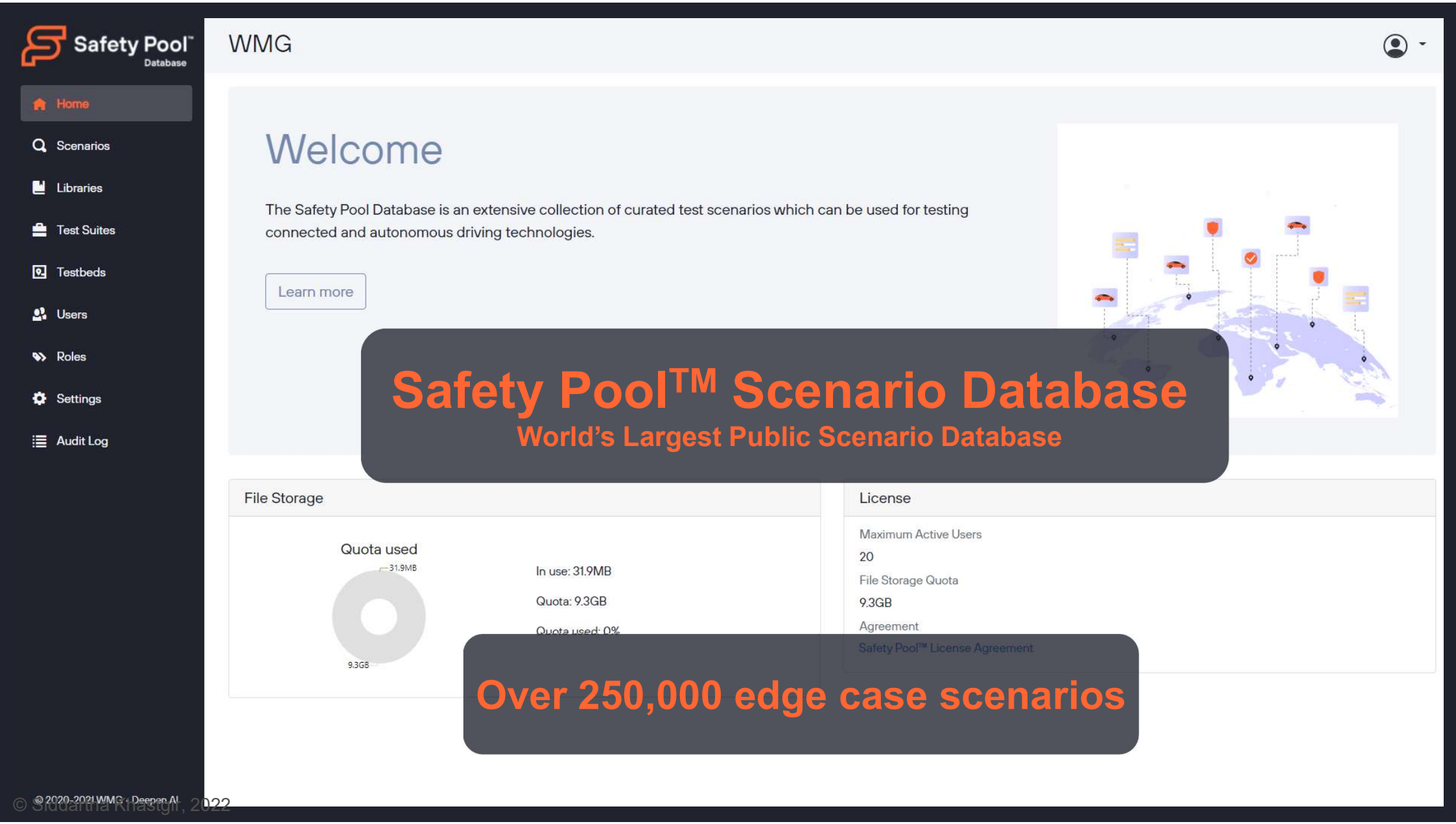
Scenarios

Environment

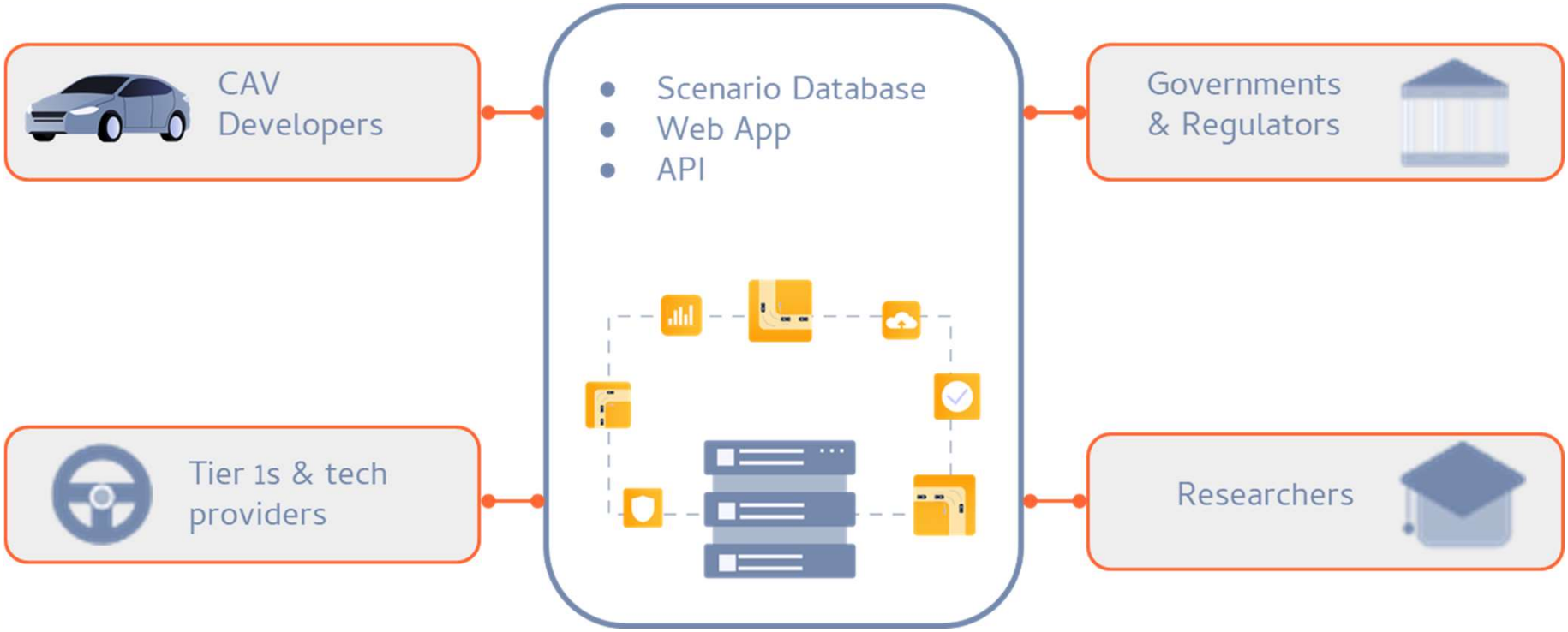
Certification / Safety Evidence & Argument







What is the Safety Pool™ Scenario Database?



Safety Pool™ Database

WMG

- Home
- Scenarios
- Libraries
- Test Suites
- Testbeds
- Users
- Roles
- Settings
- Audit Log

← Scenario

Download | Add to Test Suite

stat19_1_82482

Tags | Definition | Files | Route Locations | Versions

Scenery

- Broken line
- Contaminated
- Drive on left
- Lane dimensions [Width (m): 3.4 to 3.7]
- Level plane
- Normal roundabout
- Number of lanes [Lanes: 2]
- Radial road
- Shoulder (grass)
- Straights
- Traffic lane
- Undivided road
- Uniform surface

Environmental Conditions

- Cloudiness [Cloud cover (okta): 0 to 1]
- Day
- Sun elevation [Angle (degree): 10 to 30]
- Sun to the right
- Wind [Speed (m/s): 10.8 to 13.8]

Agents

- Cut-in
- Lane change left
- Vehicle

Meta Data

- Fatal collision

General

URN

d025e967-a9eb-452e-bd13-af66ec99a318

Library

STATS-19

License

Safety Pool™ Test Script License

Version

1.0

Safety Pool™ Database

- Home
- Scenarios
- Libraries
- Test Suites
- Testbeds
- Users
- Roles
- Settings
- Audit Log

WMG

← Scenario

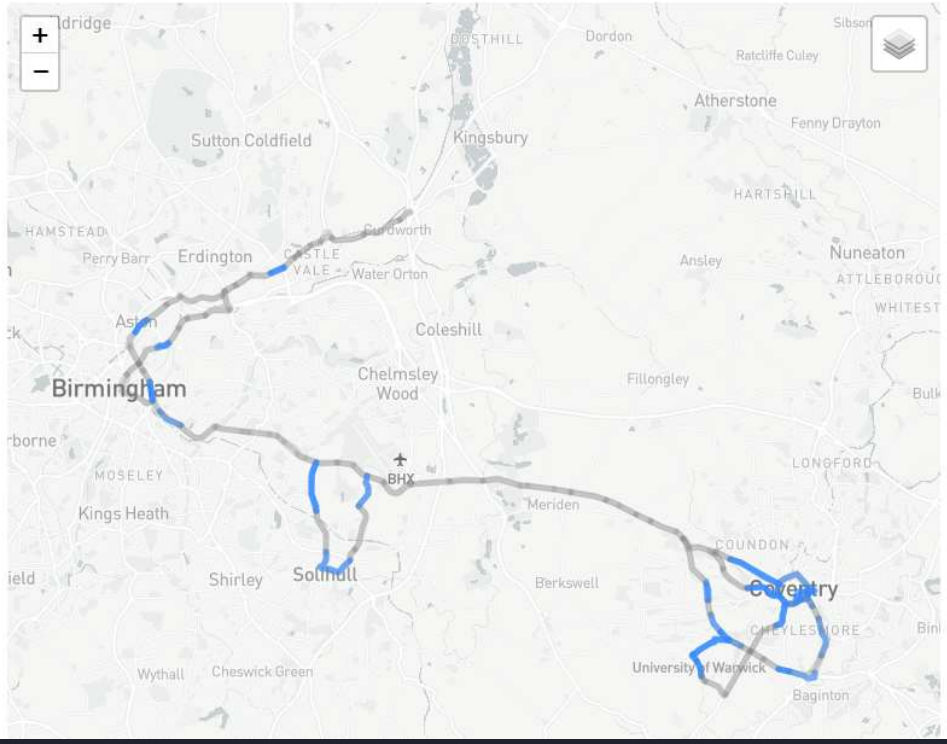
stat19_1_82482

Download | Add to Test Suite

Tags | Definition | Files | Route Locations | Versions

Midlands Future Mobility | Search | 38 possible testing locations found

This testbed does not support all of the tags for this scenario



General

URN

d025e967-a9eb-452e-bd13-af66ec99a318

Library

STATS-19

License

Safety Pool™ Test Script License

Version

1.0

Safety Pool™ Database

- Home
- Scenarios
- Libraries
- Test Suites
- Testbeds
- Users
- Roles
- Settings
- Audit Log

WMG

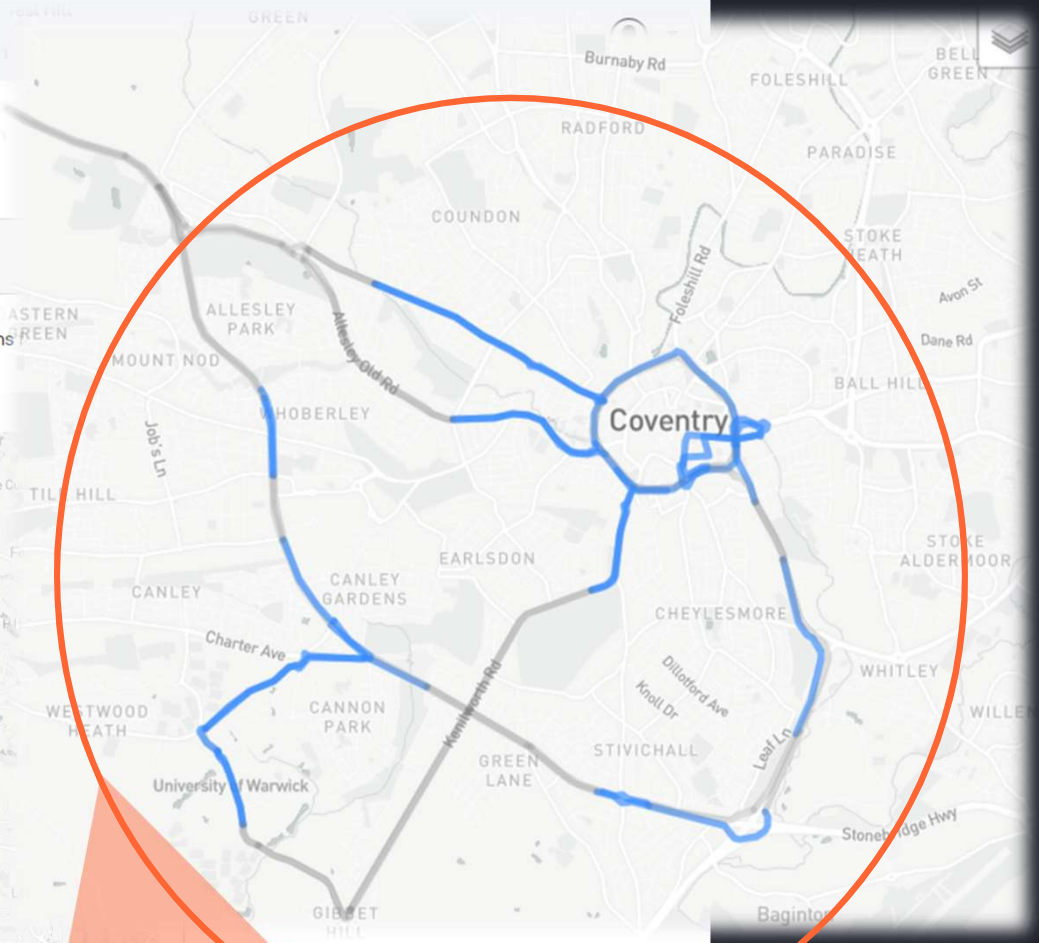
← Scenario

stat19_1_82482

Tags | Definition | Files | Route Locations | Versions

Midlands Future Mobility | Search | 38 possible testing locations

This testbed does not support all of the tags for this scenario



Safety Pool Database

- Home
- Scenarios
- Libraries
- Test Suites
- Testbeds
- Users
- Roles
- Settings
- Audit Log

WMG

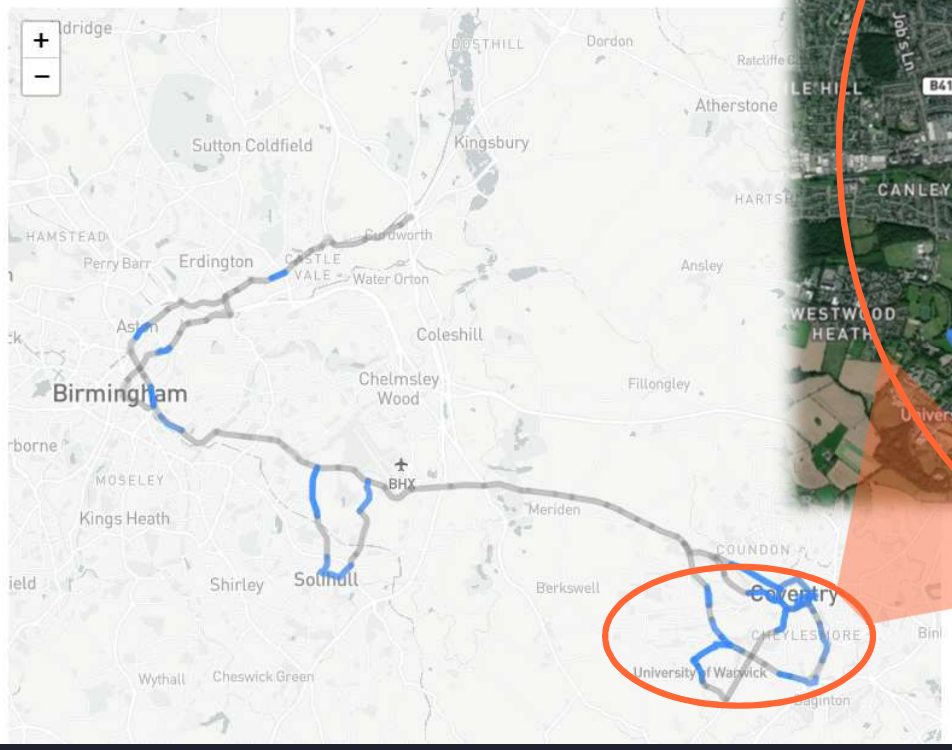
← Scenario

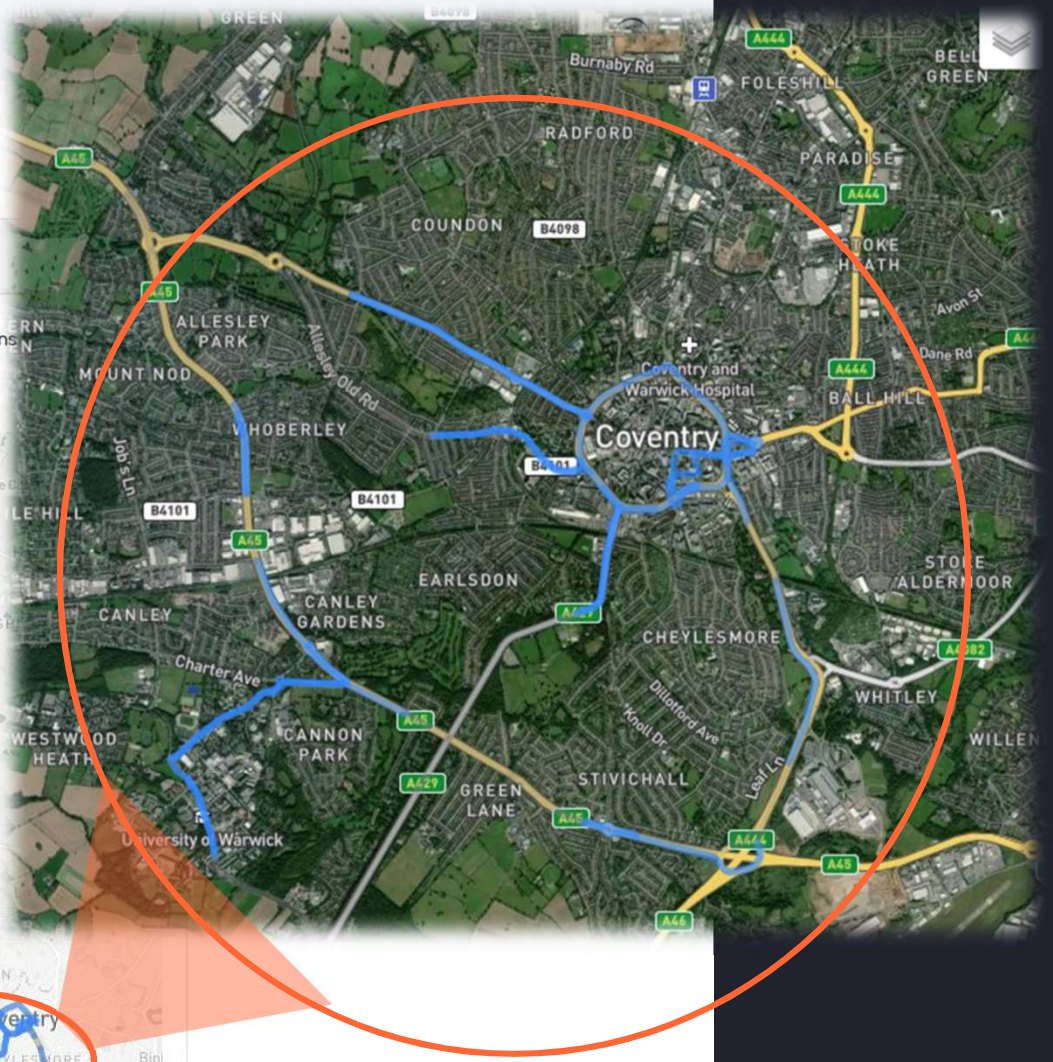
stat19_1_82482

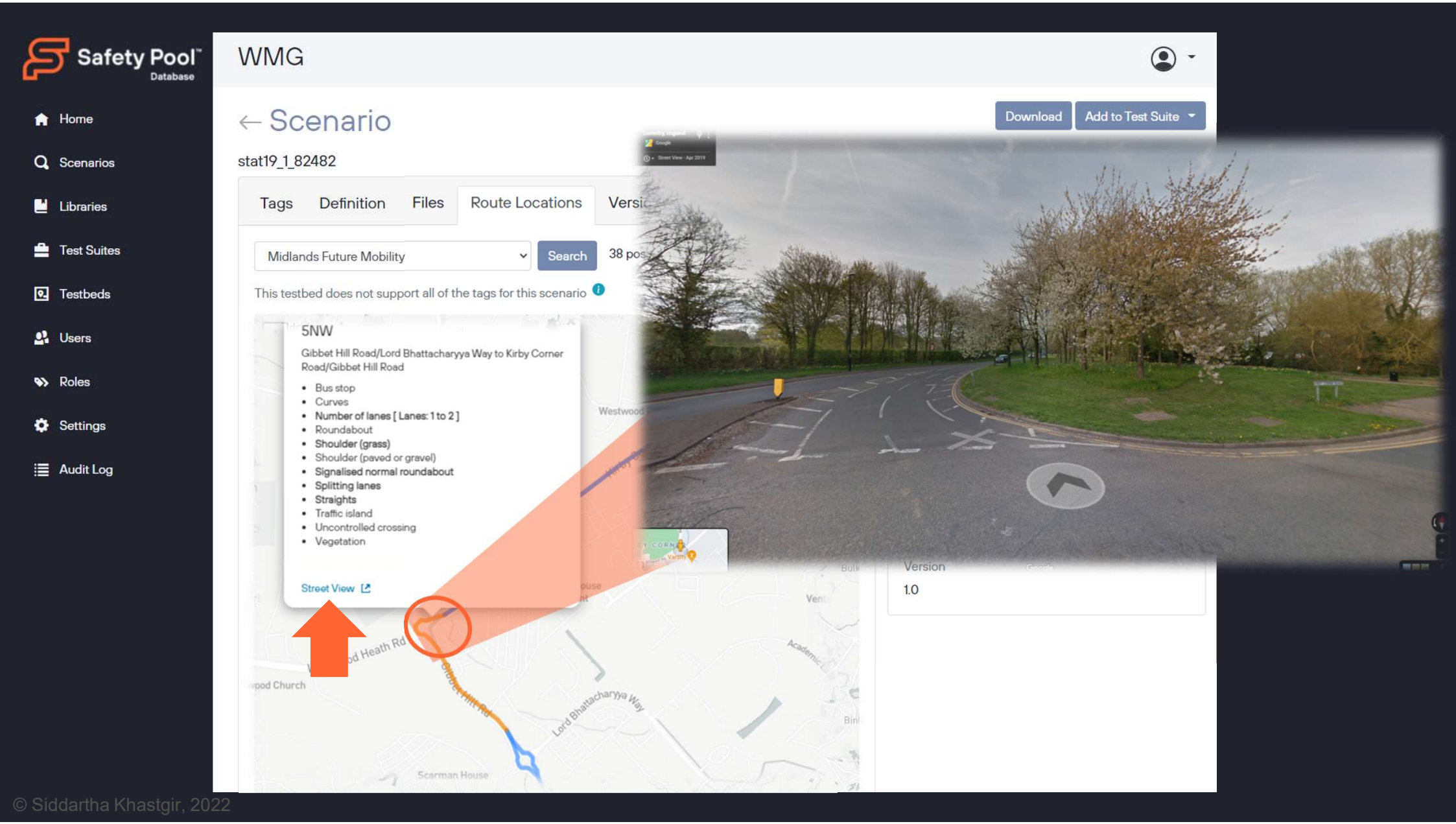
Tags | Definition | Files | Route Locations | Versions

Midlands Future Mobility | Search | 38 possible testing locations

This testbed does not support all of the tags for this scenario





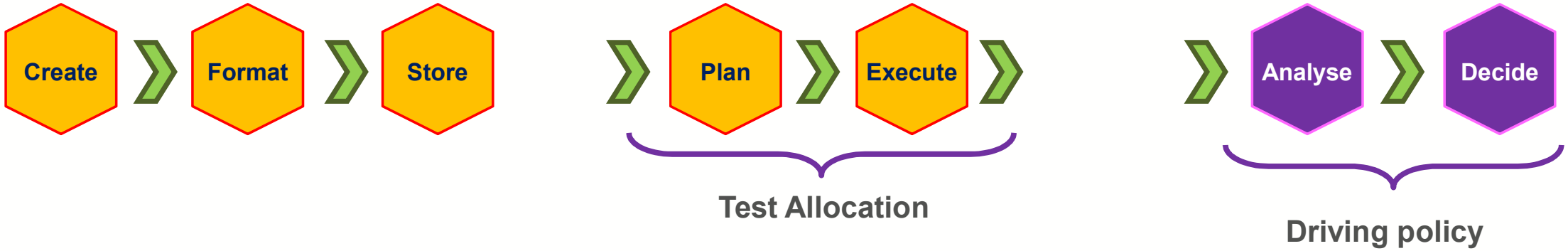


Evaluation Continuum

Scenarios

Environment

Certification / Safety Evidence & Argument



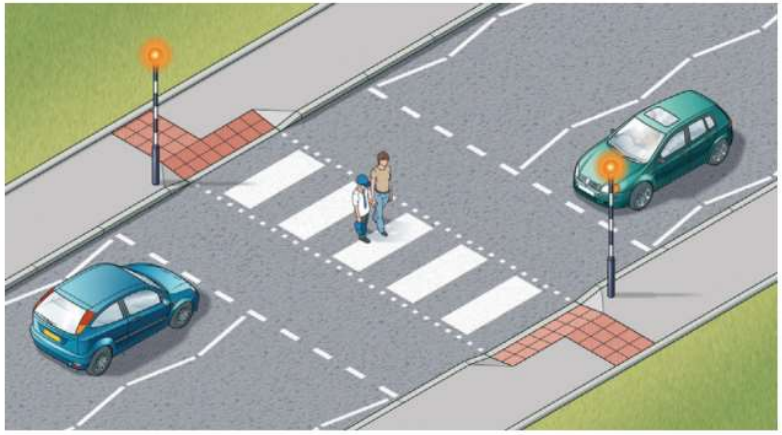
Rules of the Road (for human drivers)

- UK Highway code (for human drivers) rule defines:
  - Doing some behaviour somewhere
  - NOT doing some behaviour somewhere
- Doing/not doing: Behaviour competency library
- Somewhere: ODD instantiation

DRIVING POLICY

UK Highway Code: Rule 195

"As you approach a zebra crossing: look out for pedestrians waiting to cross and be ready to slow down or stop to let them cross; you MUST give way when a pedestrian has moved onto a crossing"



Rule 19: Zebra crossings have flashing beacons

Behaviour

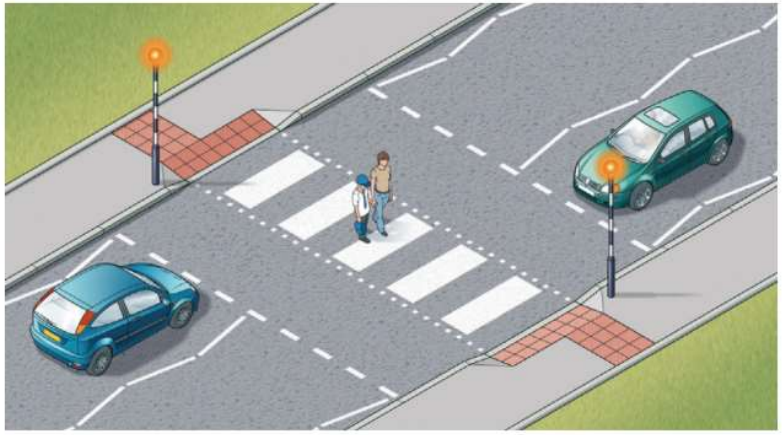
ODD

WMG
THE UNIVERSITY OF WARWICK

DRIVING POLICY

UK Highway Code: Rule 195

"As you approach a zebra crossing: look out for pedestrians waiting to cross and be ready to slow down or stop to let them cross; you MUST give way when a pedestrian has moved onto a crossing"



Rule 19: Zebra crossings have flashing beacons

How long to wait?

Behaviour | ODD | Assumptions

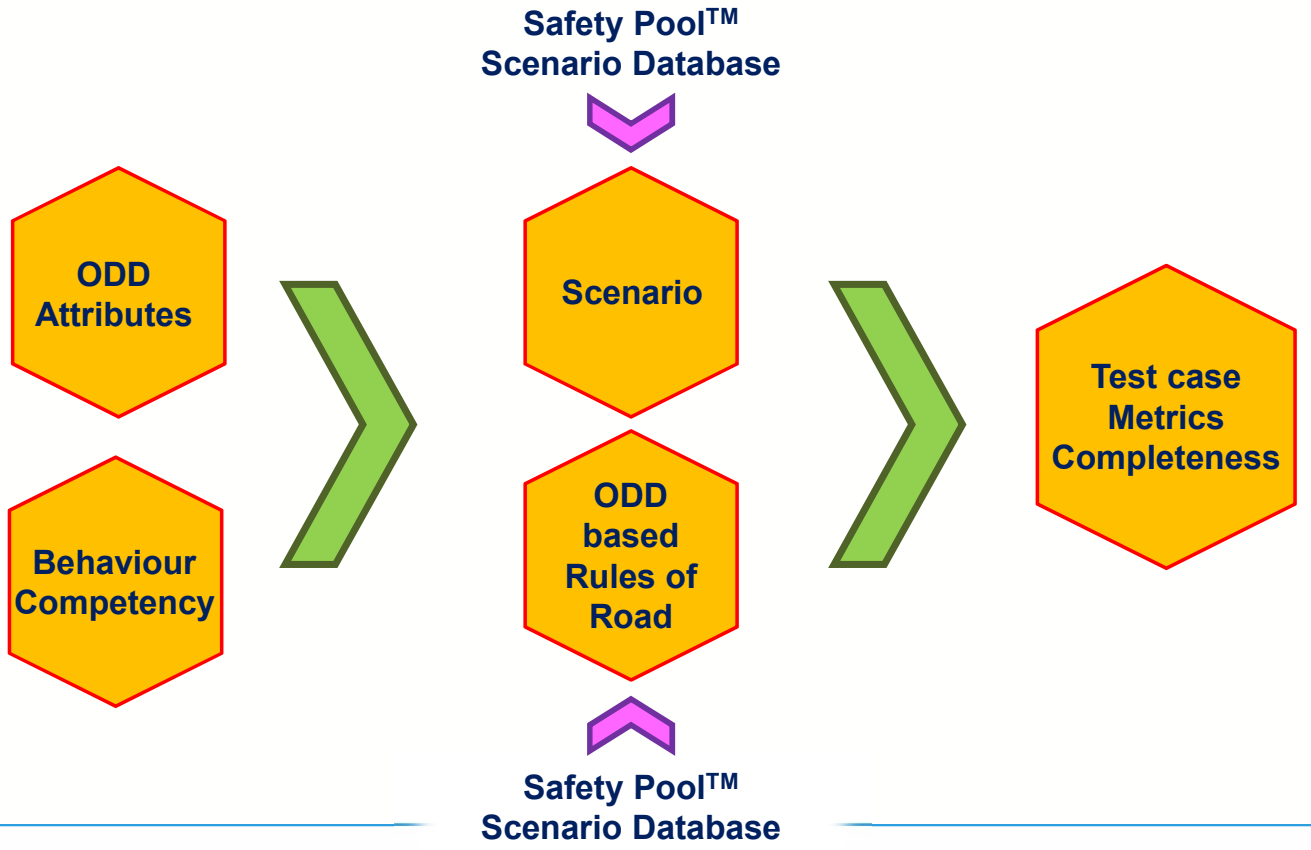
ODD based Codified Rules of the Road

Current Rules of Road (for human drivers) = *f(Operating condition, Behaviour competency, Assumptions)*

Codified Rule of the Road = *f(Operating condition, behaviour competency, driving characteristics)*

IMPLICATIONS

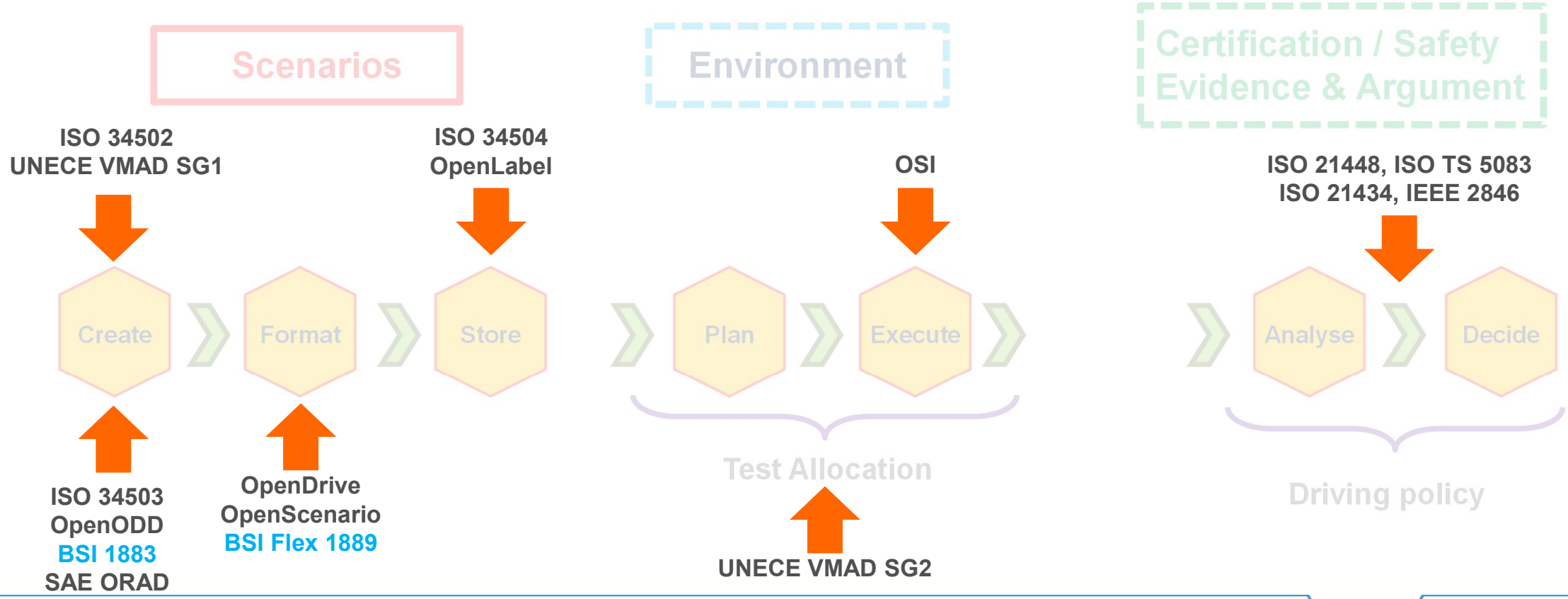
ODD based Scalable Safety Assurance Framework



Evaluation Continuum

Evaluation Continuum

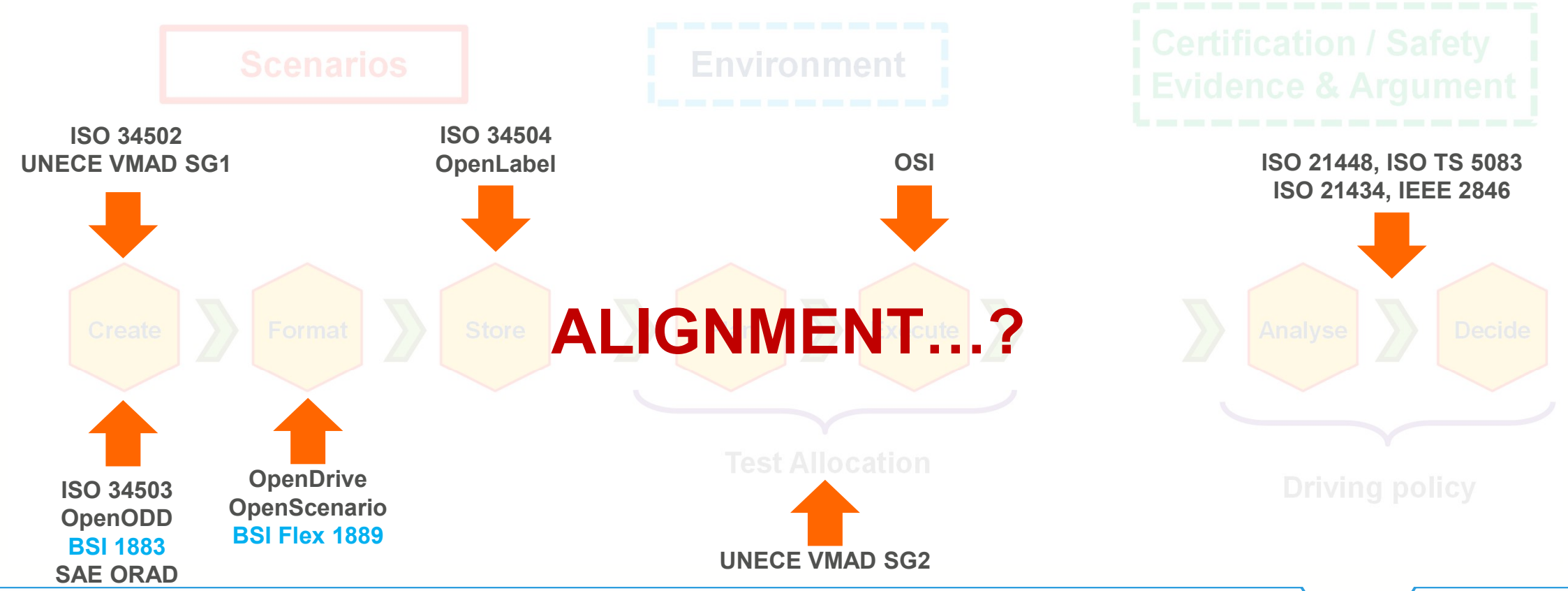
STANDARDS REGULATIONS



WMG
THE UNIVERSITY OF WARWICK

Evaluation Continuum

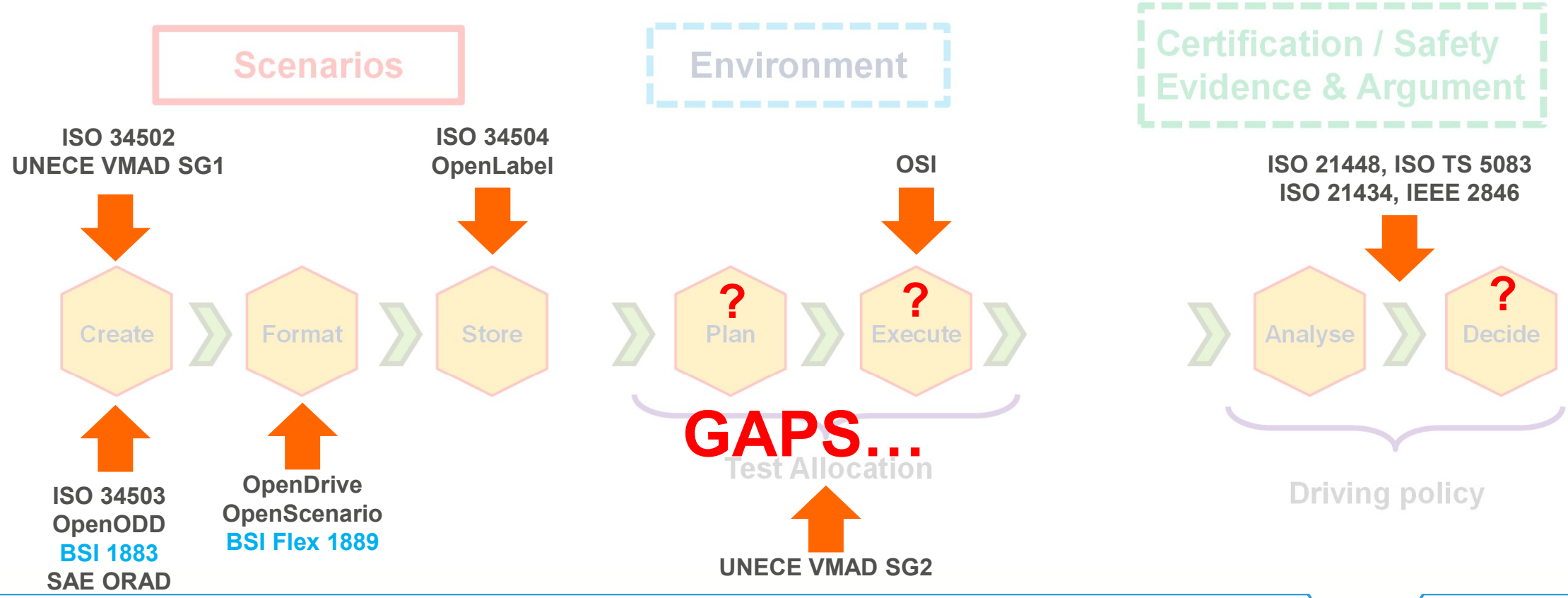
STANDARDS REGULATIONS



WMG
THE UNIVERSITY OF WARWICK

Evaluation Continuum

STANDARDS REGULATIONS



WMG
THE UNIVERSITY OF WARWICK

Summary

Each aspect of safety assurance *of Automated Driving Systems needs to consider its* ***relationship with ODD****.*

Scenarios need to be a function of their ODD. Safety metrics need to be a function of ODD.

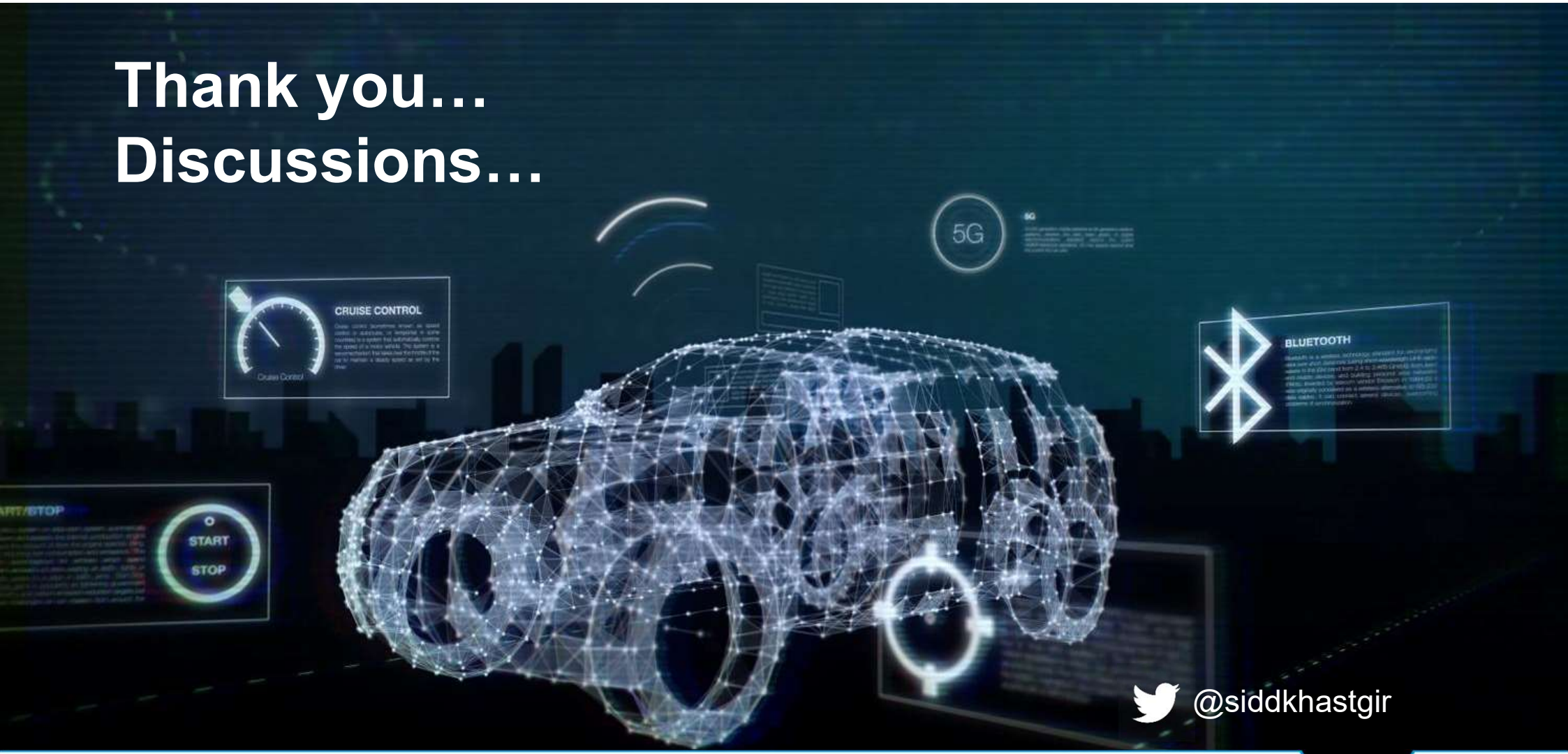
Need for **concrete tools and methods** to convert philosophical concepts into implementation.

Focus on **addressing gaps in standards** and consolidation of existing standards.

Success will be dependent upon suitable collaboration and data sharing, nationally and internationally.

WMG
THE UNIVERSITY OF WARWICK

Thank you…
Discussions…



@siddkhastgir

Dr Siddartha Khastgir CEng MIMechE
S.Khastgir.1@warwick.ac.uk

WMG
THE UNIVERSITY OF WARWICK