

Understanding Safe Behaviour for Automated Driving Systems: Defining Rules of the Road

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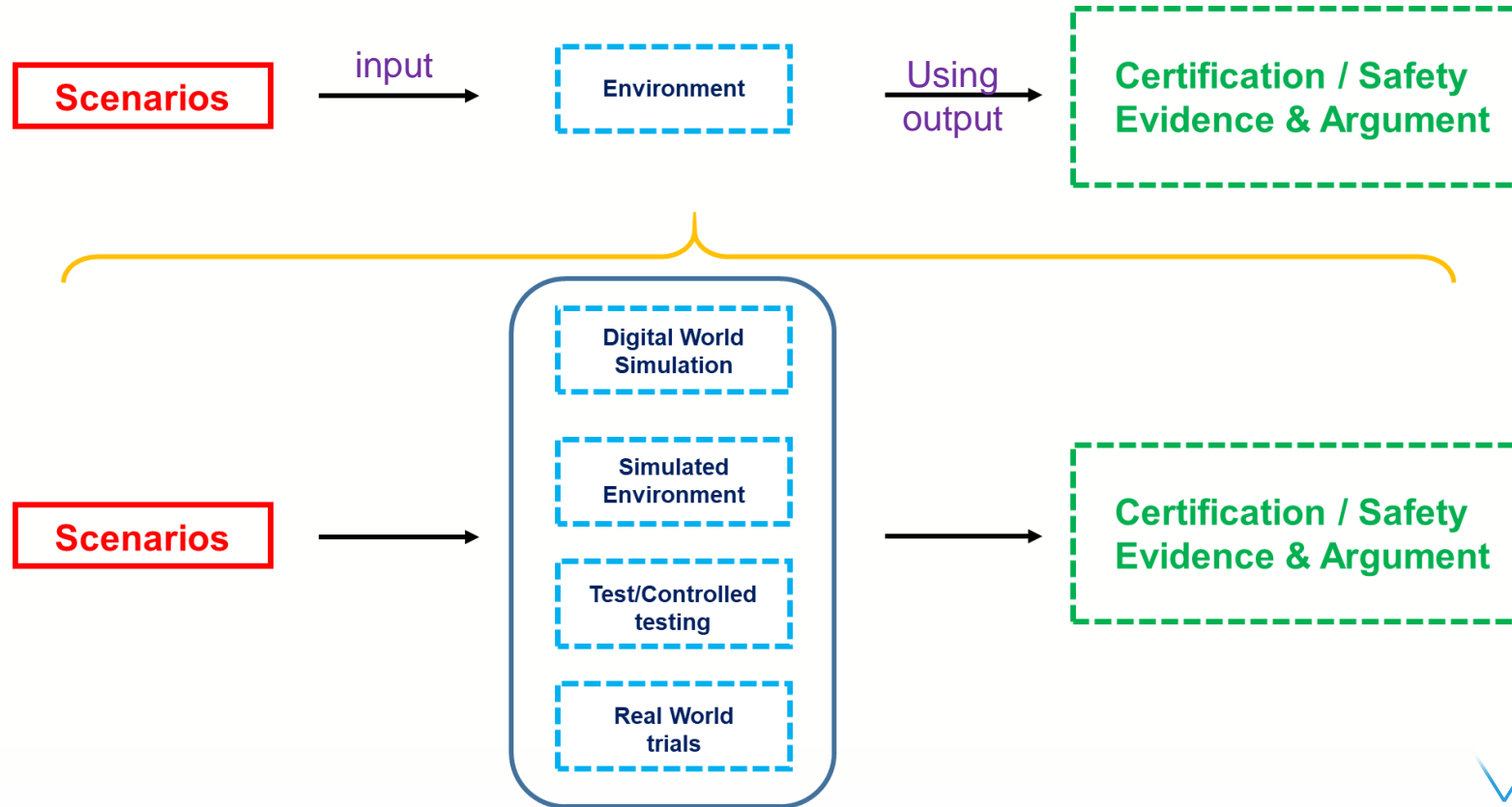


ITU Focus Group: In service monitoring and reporting for automated driving safety
16 May 2022

Evaluation Continuum



Evaluation Continuum

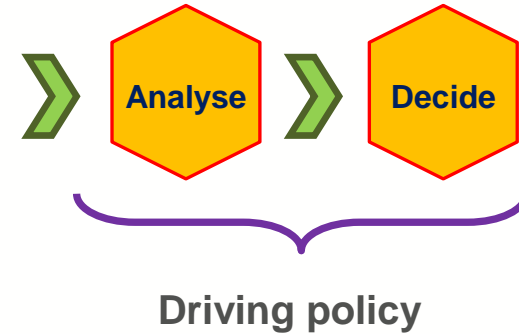
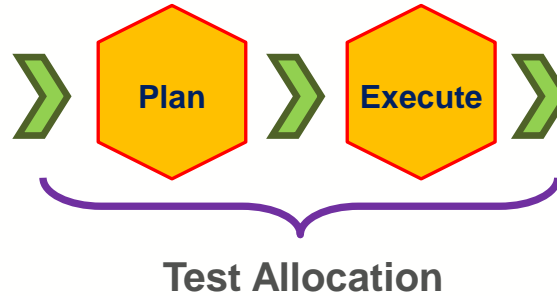


Evaluation Continuum

Scenarios

Environment

Certification / Safety
Evidence & Argument

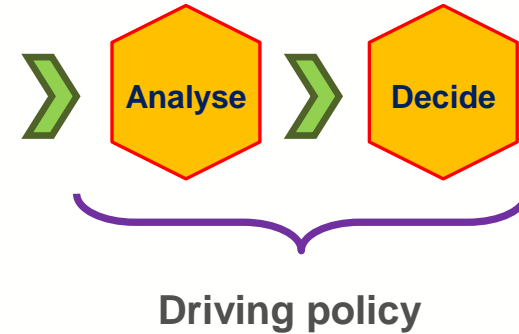
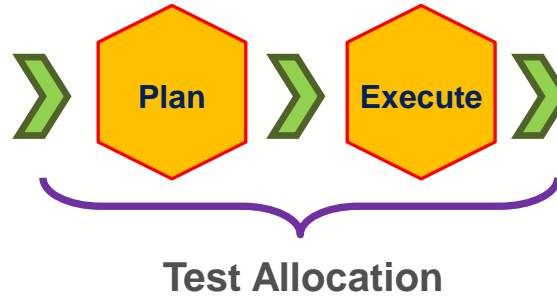


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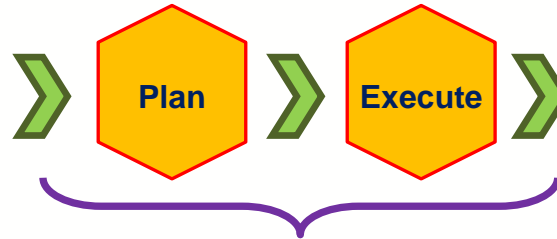


Evaluation Continuum

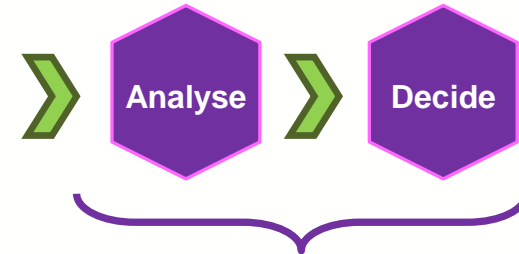
Scenarios

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Test Allocation



Driving policy

Motivation

FIRST PART: ADS Safety Topics

FRAV DDT Workstream

The ADS should drive safely

1. The ADS should be capable of performing the entire Dynamic Driving Task (DDT)
2. The ADS should recognize the ODD conditions and boundaries of the ODD of its feature(s)
3. The ADS should detect and respond to objects and events relevant for the DDT
4. The ADS should comply with traffic rules
5. The ADS should interact safely with other road users

Motivation

FIRST PART: ADS Safety Topics

FRAV DDT Workstream

The ADS should drive safely

1. The ADS should be capable of performing the entire Dynamic Driving Task (DDT)
2. The ADS should recognize the
3. The ADS should detect and respond
4. The ADS should comply with
5. The ADS should interact safely

FRAV ORU Workstream

3	<p>The ADS should respond in line with traffic laws to markings and signals used to identify the functions and authorizations of ORUs.</p>	<ul style="list-style-type: none"> ● The ADS should respond in accordance with traffic rules upon the operational status or dedicated signals displayed by emergency/enforcement vehicles. 	<p>Scenario/Virtual test/Track test:</p> <ul style="list-style-type: none"> ● Object: Emergency/Special vehicle with visual signal (flash/painting), ego vehicle; ● Case: 2-lane road, an emergency vehicle moves at low speed (in operational state) ahead while test vehicle drives in the same lane. 	
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Motivation

FIRST PART: ADS Safety Topics

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FRAV DDT Workstream

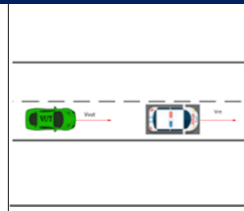
FRAV ORU Workstream

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Scenario/Virtual test/Track test:

- Object: Emergency/Special vehicle with visual signal (flash/painting), ego vehicle;
- Case: 2-lane road, an emergency vehicle moves at low speed (in



5.1.2. The activated system shall comply with traffic rules relating to the DDT in the country of operation.

4.1.1. Verification of the function of "The System"

The Type approval authority shall verify "The System" under non-failure conditions by testing on a track a number of selected functions from those described by the manufacturer in paragraph 3.2. above, and by checking the overall behaviour of the system in real driving conditions including the compliance with traffic rules.

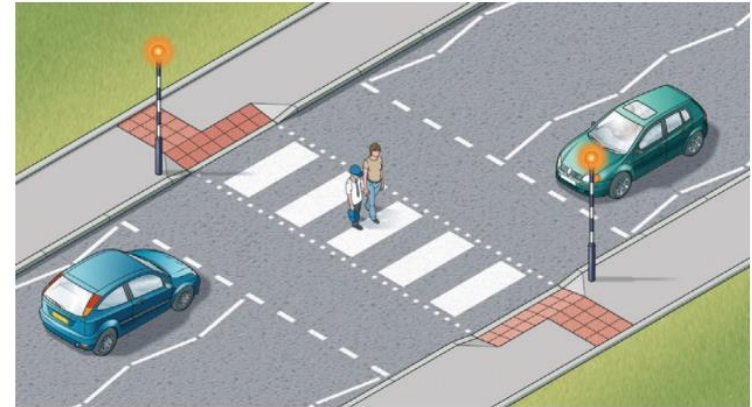
UNECE Reg 157

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

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

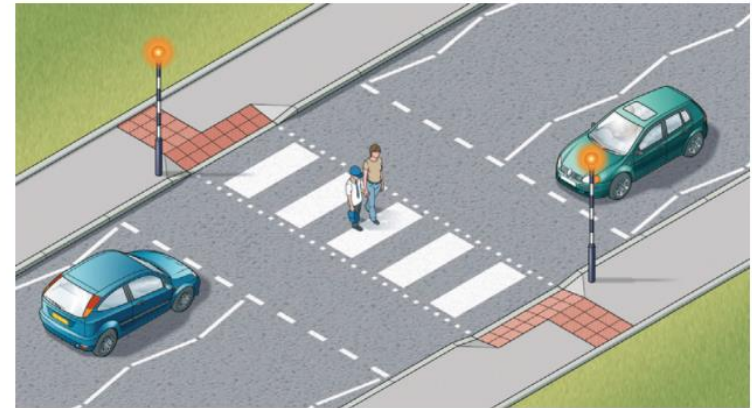
ODD

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
- Somewhere: ODD instantiation
- **ASSUMPTIONS: by the driver or from the driver**

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?

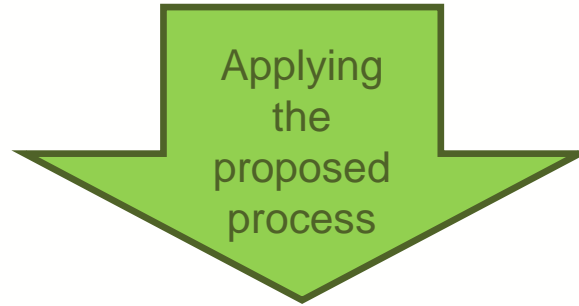
Behaviour

ODD

Assumptions

ODD based Codified Rules of the Road **PROCESS**

*Current Rules of Road
(for human drivers)* = $f(\text{Operating condition, Behaviour competency, Assumptions})$



*Codified
Rule of the Road* = $f(\text{Operating condition, behaviour competency, driving characteristics})$

Understanding links between UNECE groups



Deriving Requirements from Rules of Road

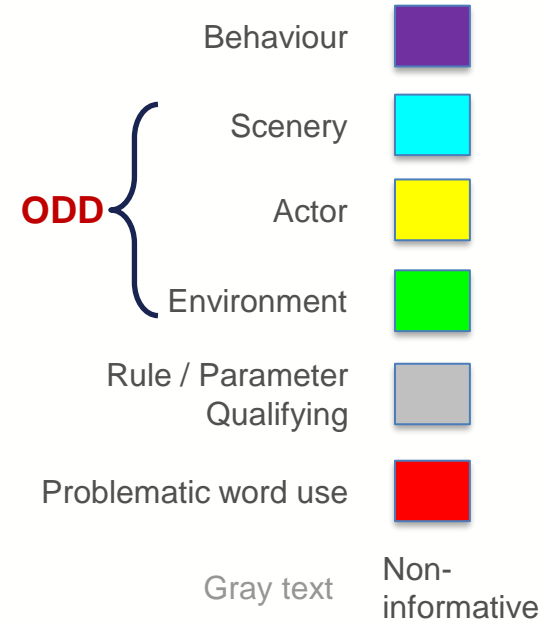
UK Highway Code Rule 125

- The speed limit is the absolute maximum and does not mean it is safe to drive at that speed irrespective of conditions. Driving at speeds too fast for the road and traffic conditions is dangerous. You should always reduce your speed when:
 - the road layout or condition presents hazards, such as bends
 - sharing the road with pedestrians, cyclists and horse riders, particularly children, and motorcyclists
 - weather conditions make it safer to do so
 - driving at night as it is more difficult to see other road users.

Deriving Requirements from Rules of Road

UK Highway Code Rule 125

- speed limit is absolute maximum and does not mean safe speed. reduce speed when:
 - road layout or condition hazards, bends
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Deriving Requirements from Rules of Road

UK Highway Code Rule 125

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 - driving at night

- ▶ $\text{isVehicle}(x) \rightarrow \text{speed}(x) < \text{limit}(\text{speed})$
- ▶ $\text{isVehicle}(x) \wedge (\text{isAtHazard}(x) \vee (\text{near}(x, a_1) \wedge \text{isPedestrian}(a_1)) \vee (\text{near}(x, a_2) \wedge \text{isCyclist}(a_2)) \vee (\text{near}(x, a_3) \wedge \text{isHorseRider}(a_3)) \vee (\text{near}(x, a_4) \wedge \text{isChildren}(a_4)) \vee (\text{near}(x, a_5) \wedge \text{isMotorcyclist}(a_5)) \vee \text{isUnsafeWeather}(\text{env}) \vee \text{isNight}(\text{tod})) \rightarrow \text{action}(\text{reduceSpeed})$

Define “near” ;
“hazard” ;
“UnsafeWeather”

$(\text{near}(x, a_1) \wedge \neg \text{isVehicle}(a_1))$

We define vehicle to be anything that is a four wheeler or larger

Need to define what reduceSpeed means
What would an acceptable “slow” speed mean?

Codification of Vienna Convention Rules of Road

Chapter II

RULES OF THE ROAD

PART I

CONVENTION ON ROAD TRAFFIC
DONE AT VIENNA ON 8 NOVEMBER 1968

(Consolidated version)*

* Including the amendments to the Convention which entered into force on 3 September 1993 (marked in the margin with a single line) and the amendments which entered into force on 28 March 2006 (marked in the margin with a double line).

Codification of Vienna Convention Rules of Road

ARTICLE 7

General rules

3. Drivers shall show **extra care** in relation to the most vulnerable road-users, such as pedestrians and cyclists and in particular children, elderly persons and the disabled.
4. Drivers shall take care that their vehicles **do not inconvenience road-**users or the occupants of properties bordering on the road, for example, by causing noise or raising dust or smoke where they can avoid doing so.

Codification of Vienna Convention Rules of Road

Chapter II - Rules of the Road – Article 11 (Overtaking)

ARTICLE 11

Overtaking and movement of traffic in lines

1. (a) Drivers overtaking shall do so on the side opposite to that appropriate to the direction of traffic.

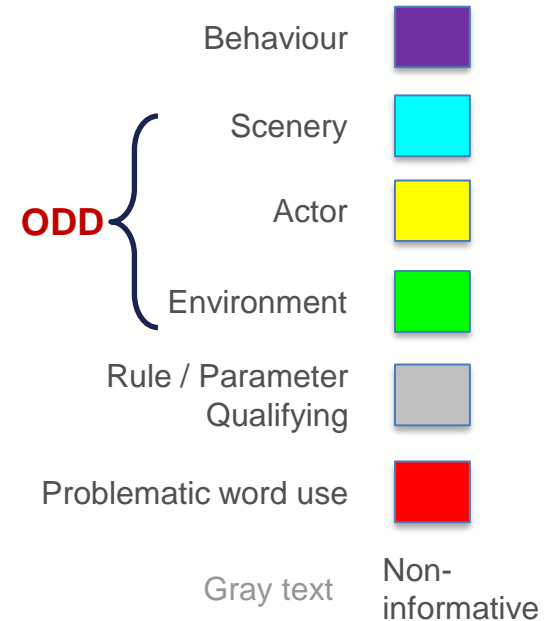
4. When overtaking, a driver shall give the road-user or road-users overtaken a sufficiently wide berth.

9. A vehicle shall not overtake another vehicle which is approaching a pedestrian crossing marked on the carriageway or signposted as such, or which is stopped immediately before the crossing, otherwise than at a speed low enough to enable it to stop immediately if a pedestrian is on the crossing. Nothing in this paragraph shall be construed as preventing Contracting Parties or subdivisions thereof from prohibiting overtaking within a prescribed distance from a pedestrian crossing, or from imposing stricter requirements on a driver of a vehicle proposing to overtake another vehicle stopped immediately before such a crossing.

Codification of Vienna Convention Rules of Road

Chapter II - Rules of the Road – Article 11 (Overtaking - 4)

When **overtaking**, a driver shall give the **road-user** or **road-users** **overtaken** a **sufficiently wide berth**.



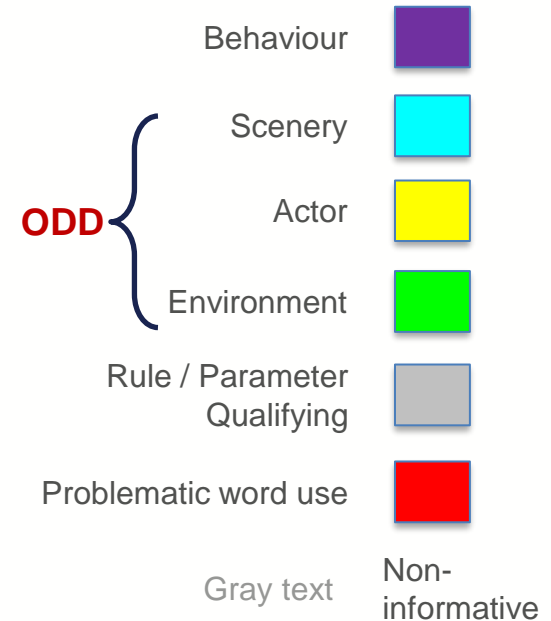
Codification of Vienna Convention Rules of Road

Chapter II - Rules of the Road – Article 11 (Overtaking - 4)

When **overtaking**, a driver shall give the **road-user** or **road-users** **overtaken** a **sufficiently wide berth**.

$\text{isVehicle}(x) \wedge \text{onRoad}(x,r) \wedge$
 $\text{roadUser}(y,r) \wedge$
 $\text{isOvertaking}(x,y) \wedge$
 $\text{lateralDistance}(x,y,z)$

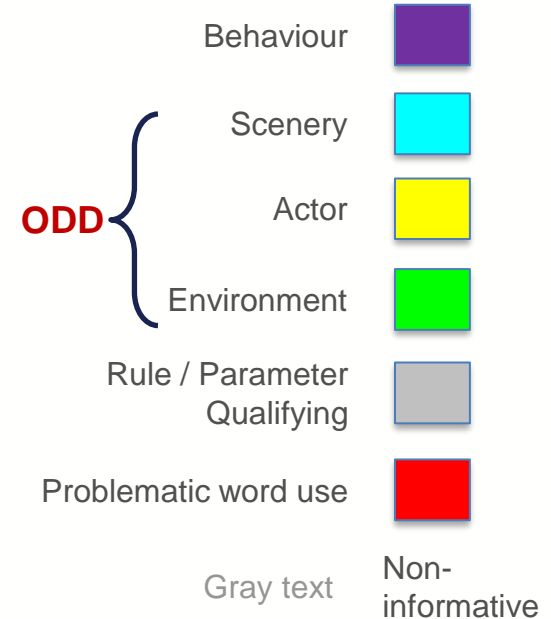
→ $\text{sufficientlyWideBerth}(z)$



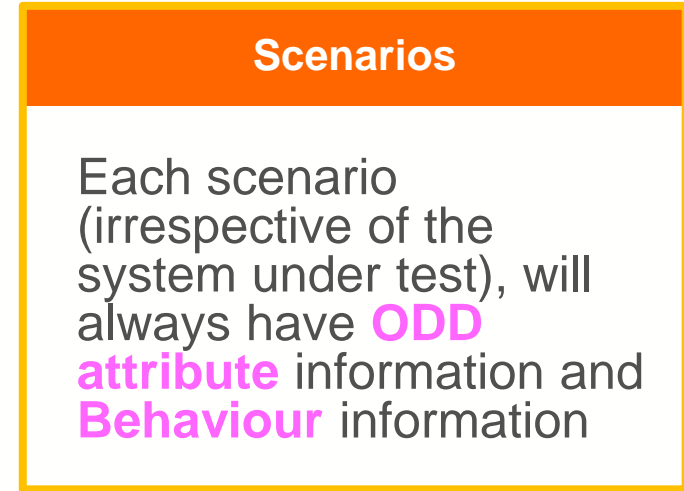
Codification of Vienna Convention Rules of Road

Chapter II - Rules of the Road – Article 11 (Overtaking - 11)

A vehicle shall not **overtake** **another vehicle** which is **approaching** a **pedestrian crossing** marked on the **carriageway** or **signposted** as such, or which is **stopped** immediately before the **crossing**, otherwise than at a **speed** low enough to enable it to **stop** immediately if a **pedestrian** is on the **crossing**.

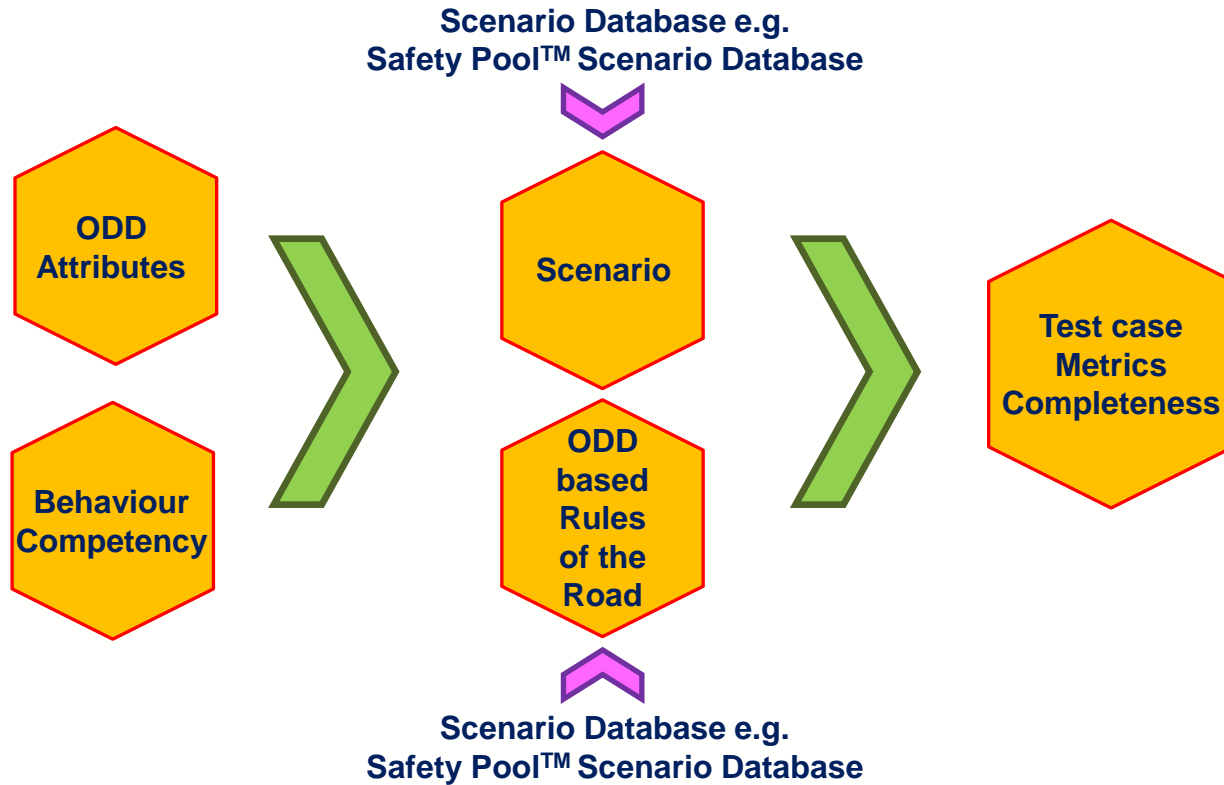


Using **ODD Based** Rules of Road in wider Safety Assurance



Mapping using labels / tags

Using **ODD Based** Rules of Road in wider Safety Assurance



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.

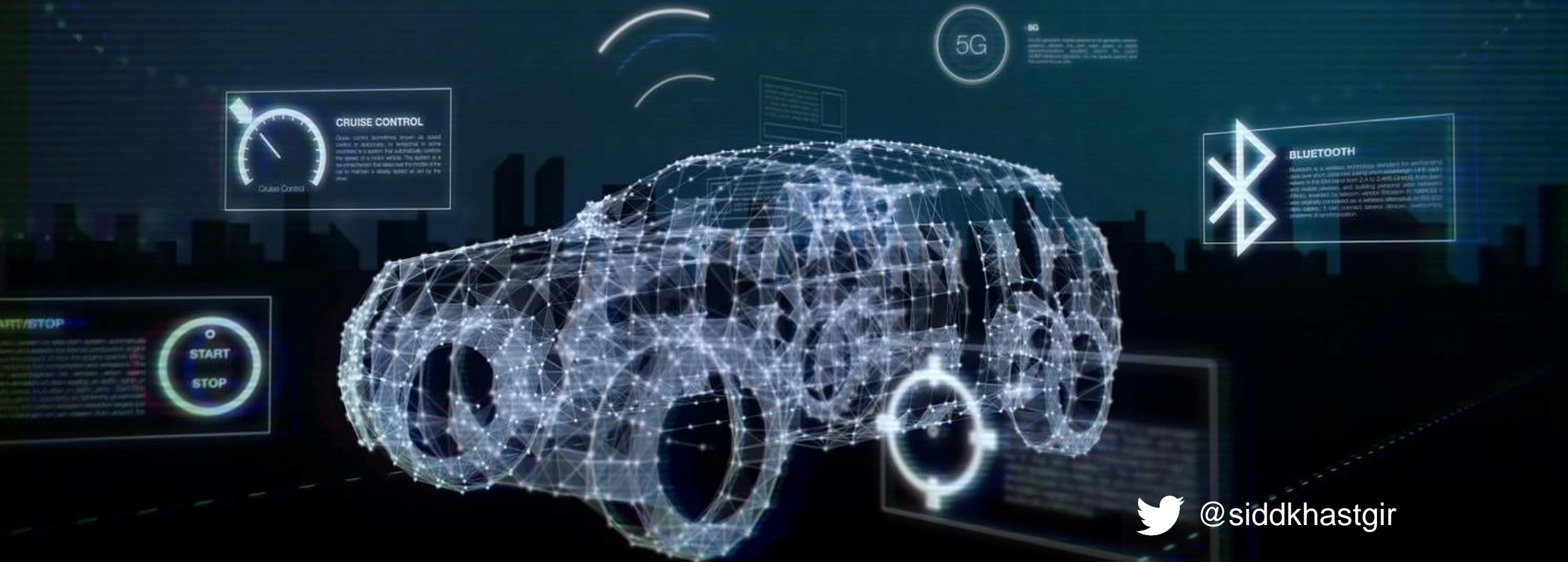
Safe Behaviour definition needs to be a function of ODD.

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

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



Thank you... Discussions...



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