AV Driving Behaviour Measurement
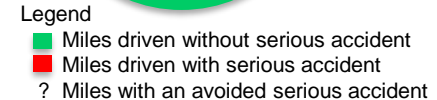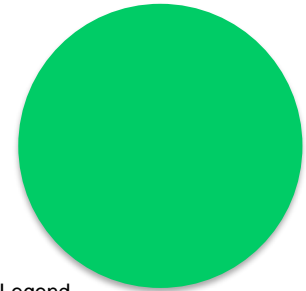
AutoVeh SG2

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Background and Needs

- The task of driving a vehicle on public roads requires
    - Understanding the environment and the actors within it – **Perception**
    - Planning a safe and appropriate manoeuvre – **Planning**
    - Commanding the vehicle to drive the planned manoeuvre – **Command**

- Perception is the most difficult
    - Hard to identify every object
    - Human behaviour is not precise or regionally consistent

- Human behaviour is too complex to model as a mechanical system
    - AI creates statistical models without formal proof
    - Behaviour evolves
    - For comfort and efficiency society accepts a level of risk, how should this be accounted for?

- Opensource software or winner takes all
    - How do these regulations protect against an unbranded engineering team badly integrating an opensource stack on to a vehicle platform?

- Testing should be outcome based
    - The 'how' is the OEMs task
    - The level of demonstrable safety is AutoVeh's challenge

Legend
- ■ Miles driven without serious accident
- ■ Miles driven with serious accident
- ? Miles with an avoided serious accident

2

A Measurement System is Required

- Testing should be based on electronic measurements and checked against criteria
    - Can be much finer granularity than any human judgement
    - Greater objectivity
    - Reproducible and reviewable
    - Greater scalability, the number of tests could get very large

- Measurements should be the conclusion of Perception and Plan
    - What relevant objects can be seen
    - Location and state of objects
    - Where in the view of the AV might these objects go in the near future
    - What is the driving plan of the ego AV
    - The raw video, LIDAR, GPS.. data should not be required, these are the OEMs 'how'.

- Standard protocol
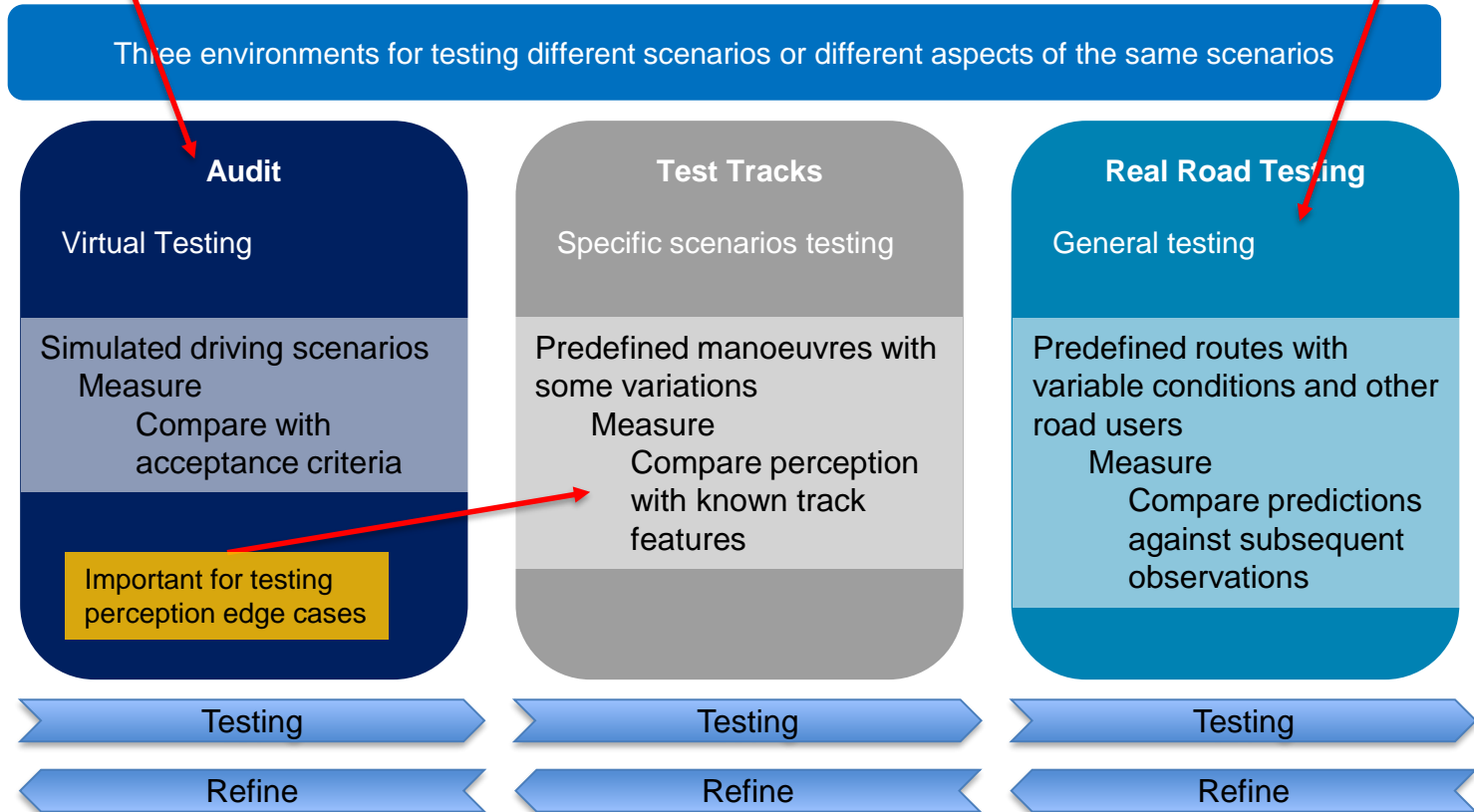   - Same language for all AV implementations

An observer cannot tell if a vulnerable road user has been seen by the AV or not if the AV takes no discernible action.

Drivers in a region have different norms for slowing down for a red light. To avoid unnecessary rear ending maybe the AV needs to be within x% of the norm.

3

Concept for a Structure of a Regulation Automation Level 3-5

Three environments for testing different scenarios or different aspects of the same scenarios
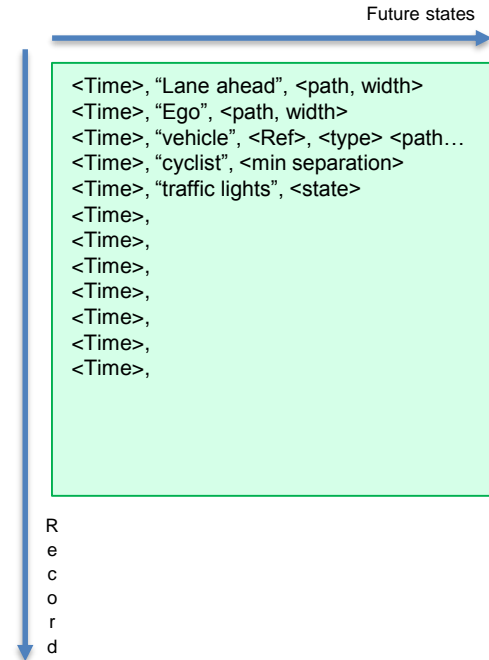
In practice the audit will be a super set of track & real world

Adds the random nature of the real world, but was everything seen and allowed for?

Audit

Virtual Testing

Simulated driving scenarios
Measure
Compare with acceptance criteria

Important for testing perception edge cases

Test Tracks

Specific scenarios testing

Predefined manoeuvres with some variations
Measure
Compare perception with known track features

Real Road Testing

General testing

Predefined routes with variable conditions and other road users
Measure
Compare predictions against subsequent observations

| Testing | Testing | Testing |
| Refine | Refine | Refine |

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What Could A Measurement Look Like

- Should mimic what a good driver perceives and anticipates
  - Vehicle, pedestrian, cyclists ... Location and likely trajectories
  - Road furniture and active state traffic lights etc.
  - Applicable traffic laws
  - Compromises taken for safety reasons

- Measurements should be human readable
  - Reviewable after the event
  - Software tools will make it easier to visualize

- Future prediction
  - Expected path and bounds of other vehicles that might effect the ego path

- Regular updates
  - Suggest 10Hz refresh rates

- Near miss capture
  - All the data to show the state change from driving to plan to exception
  - Incident capture for any in-use-compliance monitoring

Future states

```
<Time>, "Lane ahead", <path, width>
<Time>, "Ego", <path, width>
<Time>, "vehicle", <Ref>, <type> <path...
<Time>, "cyclist", <min separation>
<Time>, "traffic lights", <state>
<Time>,
<Time>,
<Time>,
<Time>,
<Time>,
<Time>,
<Time>,
```

Record

Real World Testing

What Truths do we have? Any measurement system is only useful if there is a truth to compare with

Human examiner

- + Good at spotting the unusual
- - Not so good at the comprehensive list of items to monitor
- - Likely to miss very minor risks
- - May quickly go from nervous to confident about the AV's ability

Prediction vs history

- • Testing has the benefit of hindsight an AV does not!
- • Perception at distance is harder than at short range
- • The unpredictable movement of other vehicles has to be allowed for
- • An AV does not have to predict the future precisely but its margins of error should never be violated.

In real world driving the trust in the measurement system is established so that the result of the audit can be relied upon.

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