MUSICC
Multi User Scenario Catalogue for Connected Autonomous Vehicles

MUSICC's Metadata: Enabling Scenario Searches by Story or ODD

Dr Zeyn Saigol
Principal Technologist | 2nd December 2019

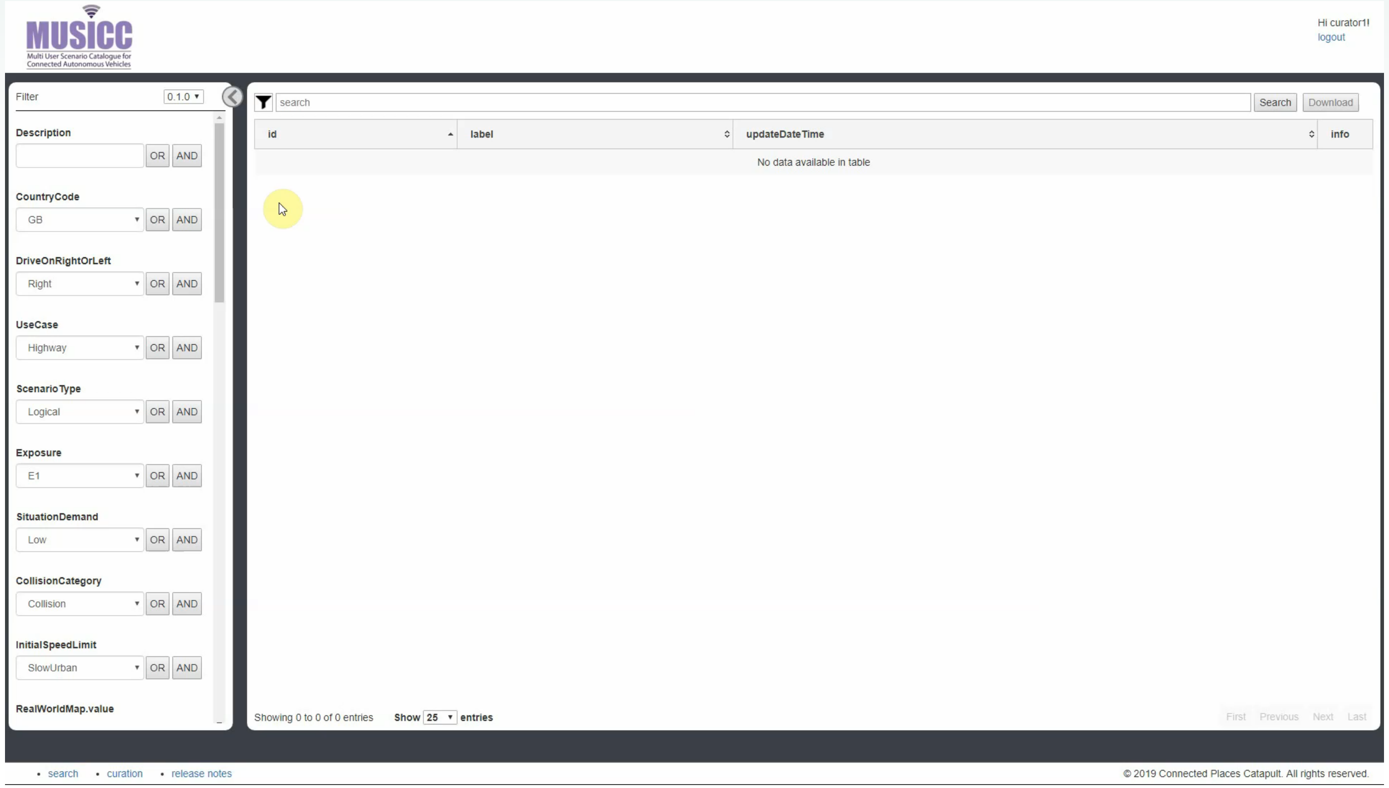
CATAPULT
Connected Places

MUSCC relevance

MUSICC is a live scenario database, aimed at regulator use. We've addressed:

- Storing OpenSCENARIO and OpenDRIVE files in a DB
- Metadata for searching scenarios
- An API for tool integrations
- Randomising parameters within scenarios

We fully support standardisation in this area.



Filter: 0.1.0

Description:

CountryCode: GB

DriveOnRightOrLeft: Right

UseCase: Highway

ScenarioType: Logical

Exposure: E1

SituationDemand: Low

CollisionCategory: Collision

InitialSpeedLimit: SlowUrban

RealWorldMap.value

search

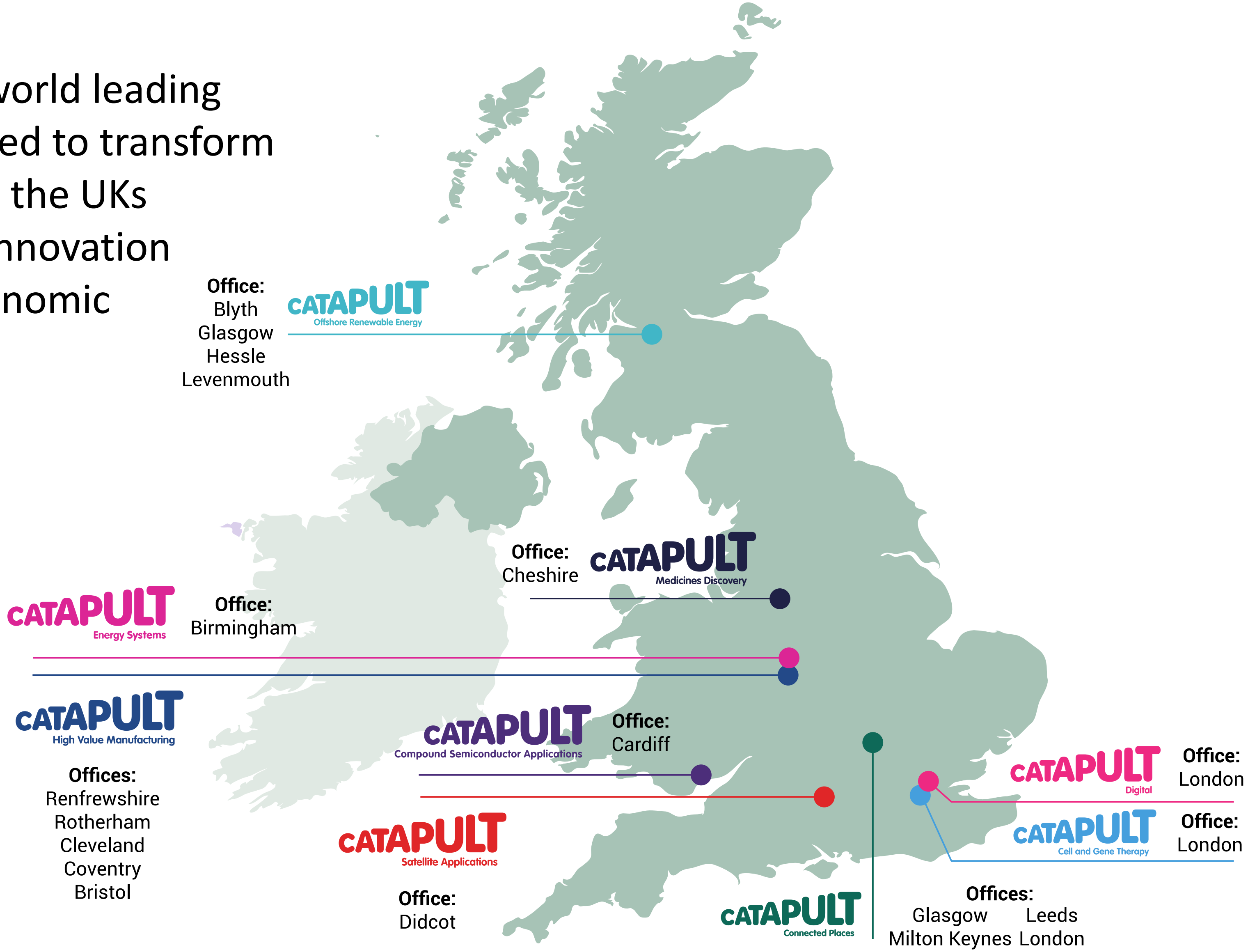
id	label	updateDateTime	info
No data available in table			

Showing 0 to 0 of 0 entries   Show 25 entries

© 2019 Connected Places Catapult. All rights reserved.

Catapults – a force for innovation and growth

A network of world leading centres designed to transform and accelerate the UKs capability for innovation and future economic growth.



CATAPULT Offshore Renewable Energy
Office:
Blyth
Glasgow
Hessle
Levenmouth

CATAPULT Medicines Discovery
Office:
Cheshire

CATAPULT Energy Systems
Office:
Birmingham

CATAPULT High Value Manufacturing
Offices:
Renfrewshire
Rotherham
Cleveland
Coventry
Bristol

CATAPULT Compound Semiconductor Applications
Office:
Cardiff

CATAPULT Satellite Applications
Office:
Didcot

CATAPULT Connected Places
Offices:
Glasgow
Leeds
Milton Keynes
London

CATAPULT Digital
Office:
London

CATAPULT Cell and Gene Therapy
Office:
London

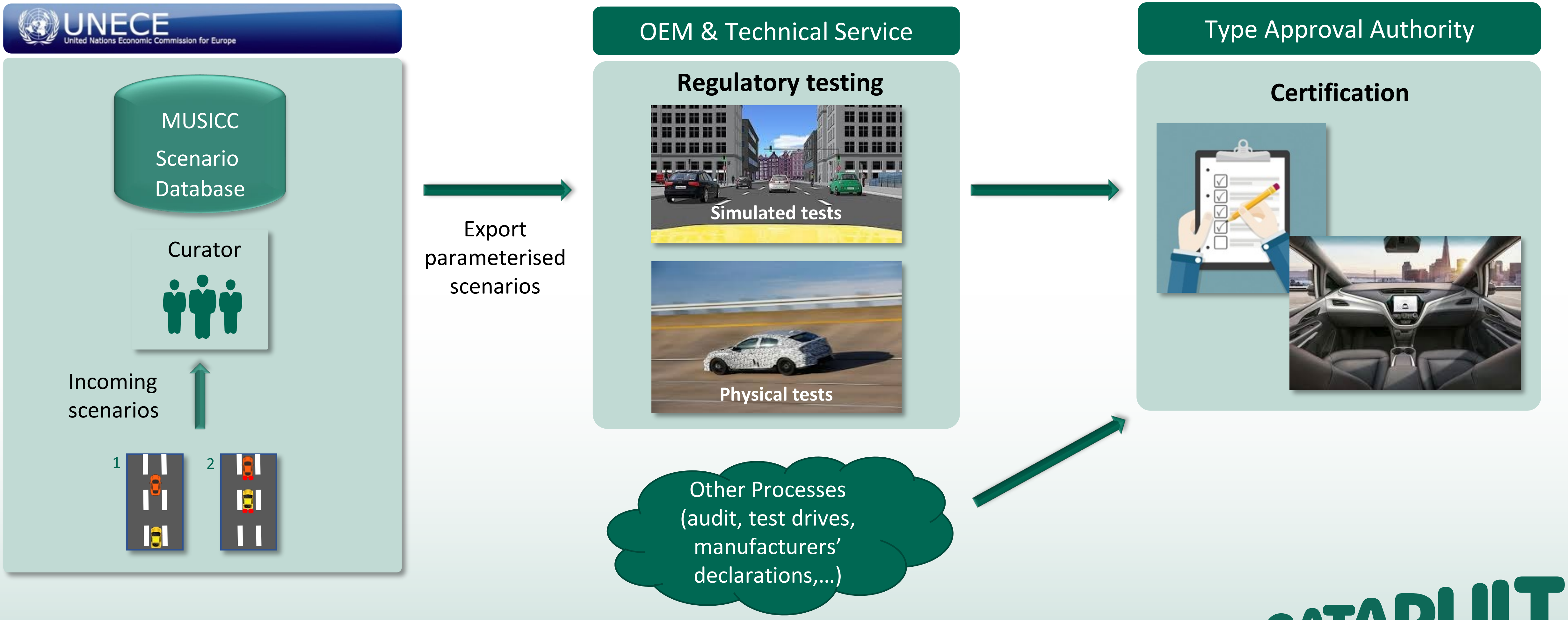
CATAPULT
Connected Places

9

Innovation Centres across the UK

Vision: The scenario-based certification process

MUSICC
Multi User Scenario Catalogue for Connected Autonomous Vehicles



UNECE
United Nations Economic Commission for Europe

MUSICC Scenario Database

Curator

Incoming scenarios

Export parameterised scenarios

OEM & Technical Service

Regulatory testing

Simulated tests

Physical tests

Other Processes (audit, test drives, manufacturers' declarations,…)

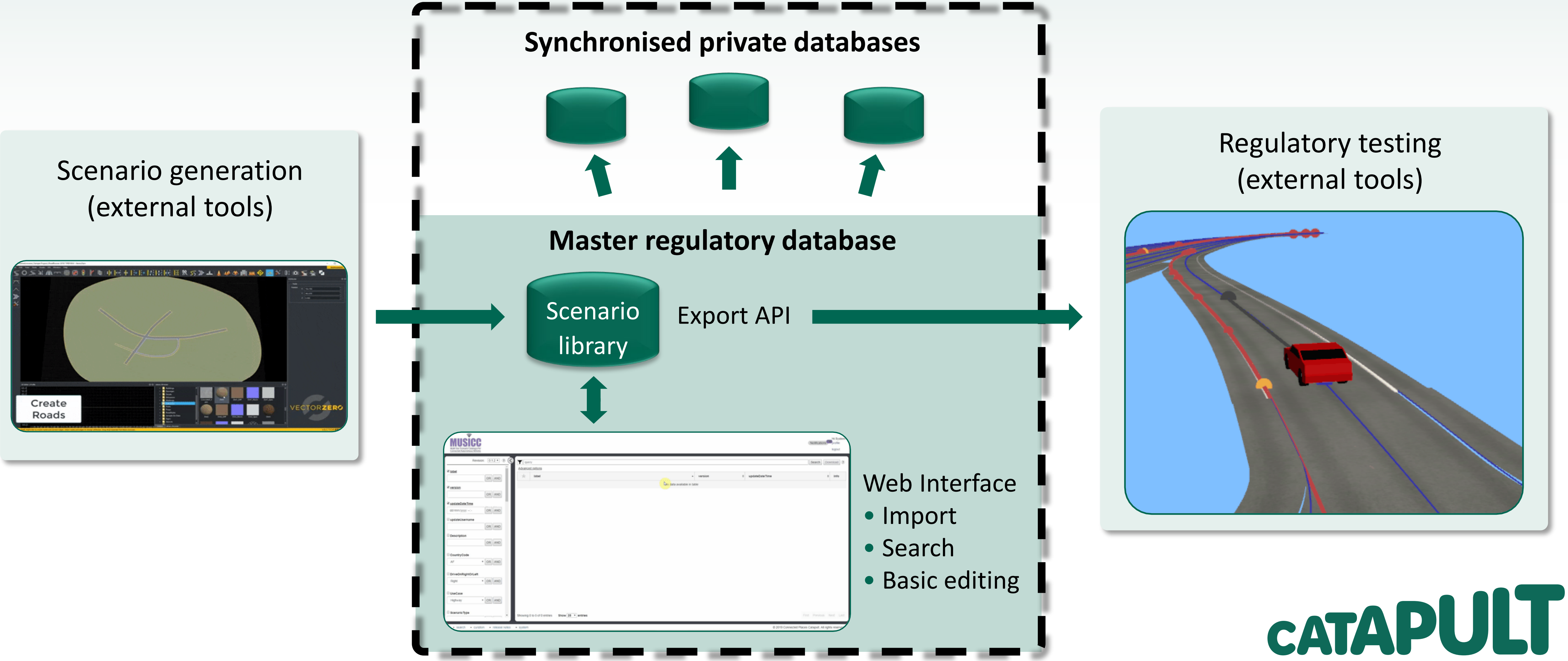
Type Approval Authority

Certification

CATAPULT
Connected Places

MUSICC scope and context

MUSICC
Multi User Scenario Catalogue for Connected Autonomous Vehicles



Scenario generation (external tools)

Synchronised private databases

Master regulatory database

Scenario library

Export API

Web Interface
- Import
- Search
- Basic editing

Regulatory testing (external tools)

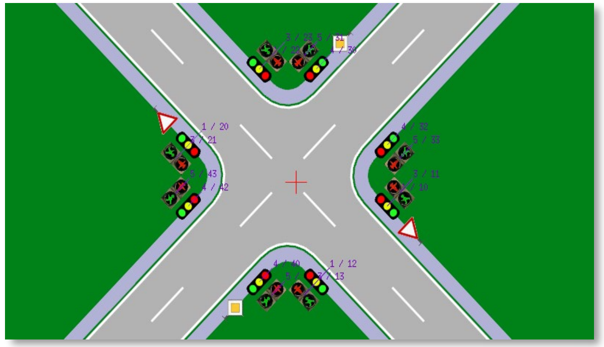
CATAPULT
Connected Places

MUSICC's scenario description language

MUSICC
Multi User Scenario Catalogue for Connected Autonomous Vehicles

1 Represent the road network

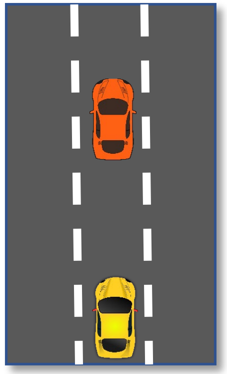
ASAM OpenDRIVE
managing the road ahead



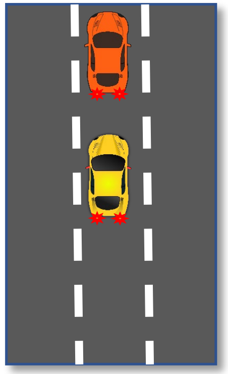
2

Represent the actions of other road users

1



2



ASAM OpenSCENARIO
bringing content to the road

3 Additions (the MUSICC record)

Metadata

– Search for scenarios corresponding to the ODD of the ADS under test

Parameter stochastics

– Variables in the scenario can take randomly generated values

The SDL is a key part of MUSICC's deliverables.

- Stakeholders will be more willing to engage given a standardised format
- CPC is an active member of ASAM OpenSCENARIO standardization groups

CATAPULT
Connected Places

Quick notes: API and parameter stochastics

API for tool integration

- Simple HTTP GET requests, with responses encoded in JSON if applicable
- Currently working on automating fetch and execution of scenarios from CARLA

Parameter stochastics

From regulatory perspective, important to prevent *design-to-test*; stochastically varying parameters within scenarios is one method.

- Using PEGASUS terminology, MUSICC stores *logical* scenarios (plus optionally concrete scenarios). This is enabled by parameters in the OpenSCENARIO file:

```
<ParameterDeclaration>
        <Parameter name="$lead_vehicle_speed" type="double" value="33.3"/>
```

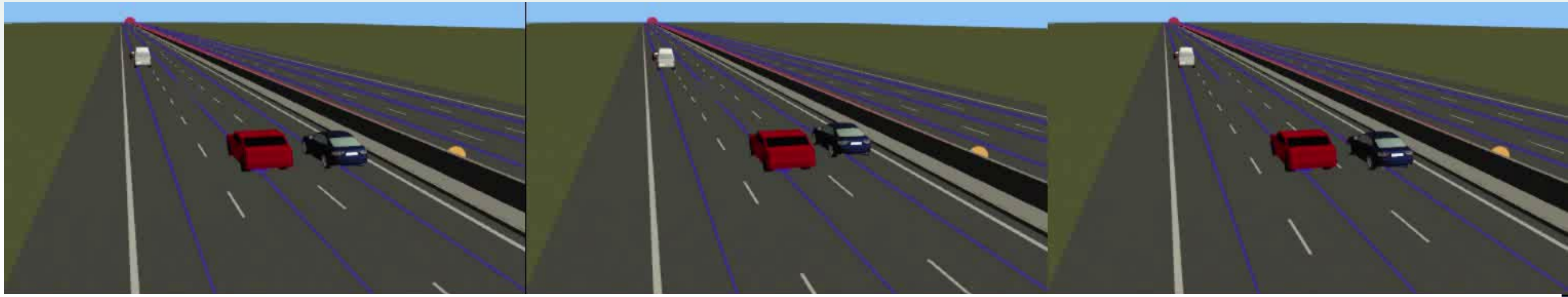
- Random selection of parameter values, according to ranges and distributions defined in the MUSICC record, has been implemented in our system

Randomisation

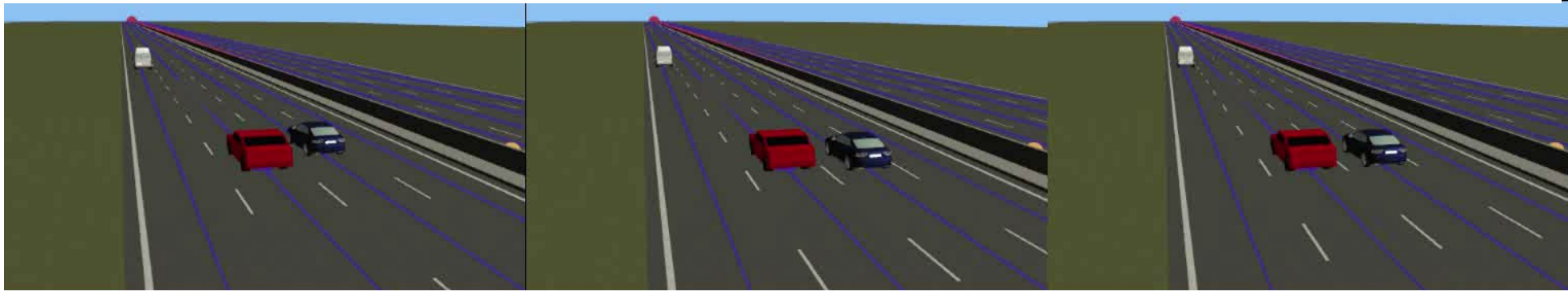
Generates multiple concrete scenarios from each logical

MUSICC
Multi User Scenario Catalogue for
Connected Autonomous Vehicles

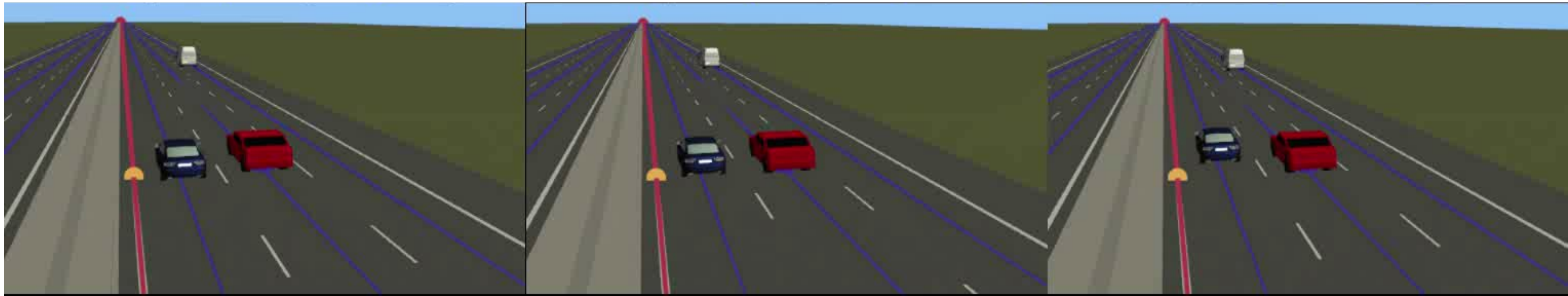
3 lane – GB



4 lane – GB



3 lane – FR



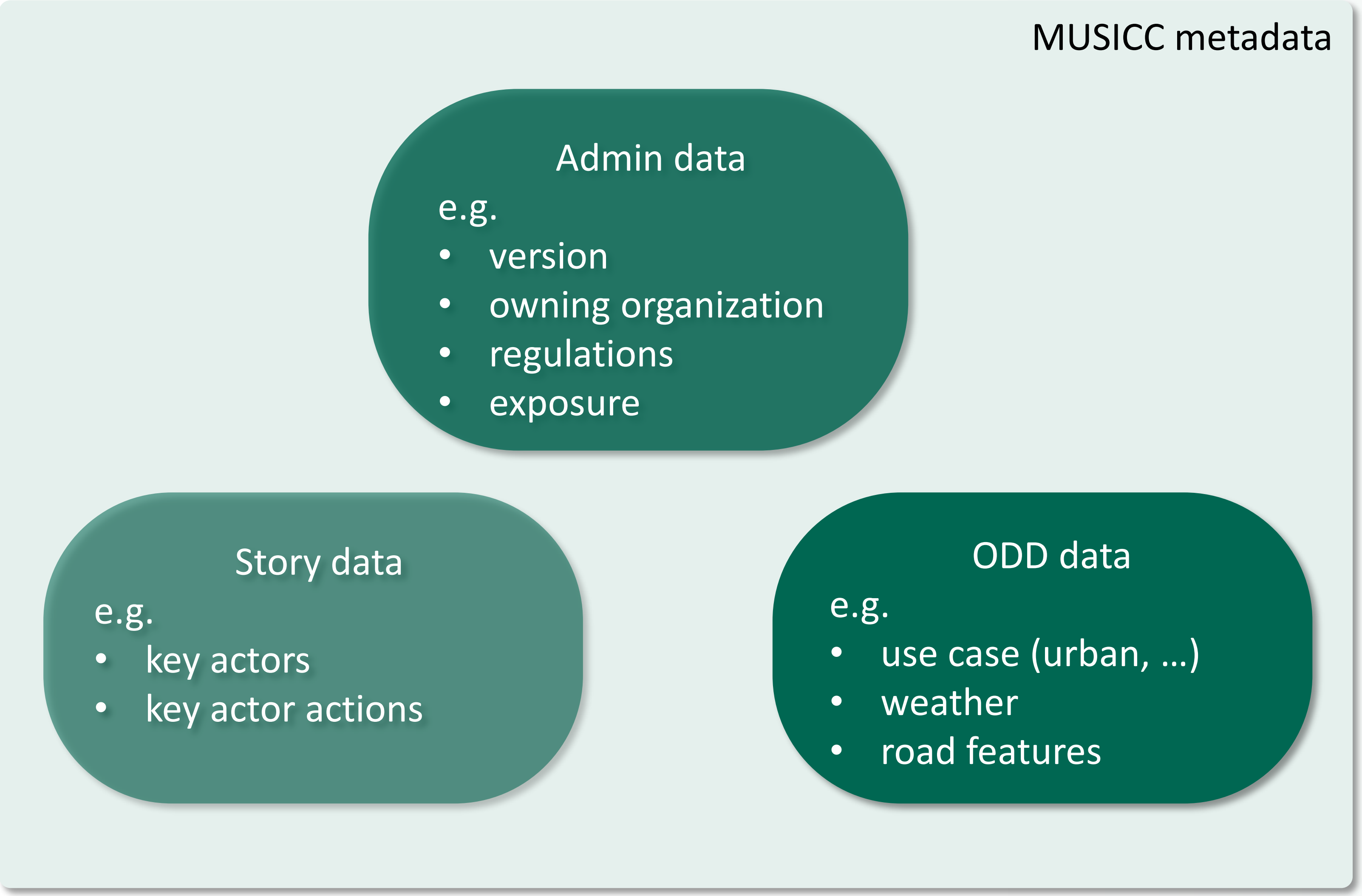
Quick notes: Storing OpenX files

MUSICC is a database targeted at certification use, with scenarios arriving from a variety of different sources. This leads to two key requirements:

1. **We cannot rely on filenames being unique**
2. **We need to track version history of stored scenarios**

- For the "parent" MUSICC record, we enforce a unique key of:
  - label + version + revision
- For OpenSCENARIO, catalog, OpenDRIVE, and other child files, we assign them a unique ID number in the DB
- On import a file/string comparison needs to be carried out to check if the file(s) are already present in the DB
  - This is a complex process, as we need to back-propagate any existing record IDs during the uniqueness check
  - Even then, there's no way to know if an uploaded OpenX file should be a **new version** or a **new OpenX record**

MUSICC metadata overview



MUSICC metadata

Admin data

e.g.

- version
- owning organization
- regulations
- exposure

Story data

e.g.

- key actors
- key actor actions

ODD data

e.g.

- use case (urban, …)
- weather
- road features

- ODD language should be complete and independent

Need for story metadata

In many cases, it’s important to find, or treat as a group, all the logical scenarios for a particular functional scenario. E.g.:

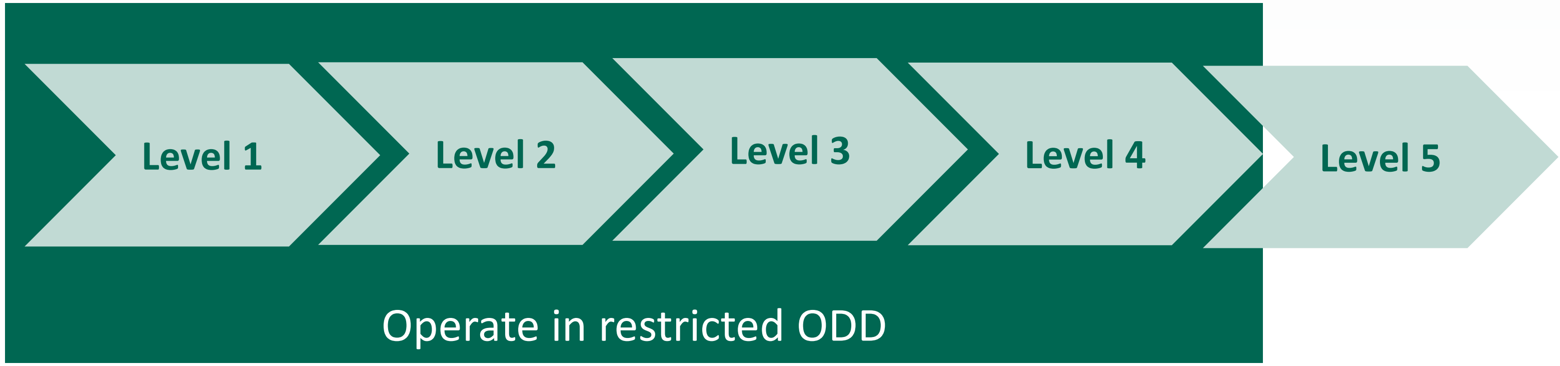
- Find all highway cut-in scenarios
- Find all scenarios that test AEB

Some relevant fields may be part of the ODD, e.g. weather, and the desired ego manoeuvre. But not all.

- This doesn’t cover the types, locations, and actions of the other participants
- **But:** that’s what OpenSCENARIO is supposed to represent
- In some ways, the requirement here is for an abstract variant of OpenSCENARIO
    - Will OpenSCENARIO 2.0 be usable for this purpose?

Metadata: Importance of ODD

All near-term AVs are likely to have a restricted Operational Design Domain



- For MUSICC, it’s critical that we test an ADS against all the scenarios matching its ODD (and not against scenarios outside its ODD)
- This implies we need a precise way of specifying ODDs

Current ODD metadata

Current MUSICC ODD variables include:

- Use Case (Highway, Urban, Inter-Urban, Parking)
- Country (GB, FR, DE, etc)
- Features of the road
  (e.g. roundabout / 2-lane / 3-lane / divided carriageway / roadworks)
- Environmental conditions
  (e.g. weather: rain / snow / fog; time-of-day: day / night / dawn / dusk)
- … and others not listed.

(Note most of these may have multiple values.)

Evaluation of current ODD metadata

Good points

- Simple and unambiguous

Key problem: level of detail

- Too much (e.g. want to allow any manoeuvre at a junction, but forced to list them all explicitly – `RightTurn, LeftTurn, GoStraightAtJunction, TurnOntoMinorRoad, TurnOntoMajorRoad`)
- Too little (e.g. can only specify `PedestrianCrossing`, but want to specify pelican crossing as OK, but not zebra crossings)
- Never likely to be exactly right…

Second problem: cannot specify combinations

- E.g. can perform a `TurnOntoMajorRoad`, but only in daylight

In short: developers are creating ADS with ODDs that we cannot currently represent in MUSICC metadata

Solution #1: Hierarchy

Allow different levels of detail to be used, depending on need and use case

- Query for scenarios matching an ODD
- Specify ODD elements present in a scenario

Thanks to several key stakeholders for input on this!

Category: Road type

- Arterial
  - Urban
    - Urban motorway
    - ……
    - High street (significant through traffic)
    - Urban arterial other
  - Rural
    - Rural motorway
    - ……
- Local (minimal through vehicle traffic)
  - Urban
    - Residential street
    - Town centre / high street
    - Commercial / industrial area

Category: Atmospheric weather

- Precipitation
  - Rain (categories as per METAR)
    - Light rain
    - Moderate rain
    - Heavy rain
    - Violent rain
    - Cloudburst
  - Snow
    - Light
    - Medium
    - ……
- Obscuration
  - Fog or mist
  - Haze

Solution #2: Language

Need a formal method for declaring which ontology elements are part of the ODD

- Need to be clear about semantics: e.g. does *exclude* "Town centre / high street" mean everything else under the "Local/Urban" category is included?
- What about combinations? E.g. "can use rural roads but not at night"

Requirements

- Easy to understand (for safety drivers, regulators, and the **end users**)
- Can specify simple ODDs concisely
- Powerful enough to express complex ODDs
- Cope with fact that ontology cannot (and should not) model everything

PAS 1883: Guidance for defining Operational Design Domain for an Automated Driving System

Challenges

- SAE J3016 introduces the concept of Operational Design Domain – what are the conditions in which the ADS is expected to perform the driving task?
- ISO/SAE standards (e.g. ISO AWI 22737) use concept but no agreed approach to defining ODD for an ADS.
- Stakeholders currently can under define ODD that may lead to confusion with end-users and unsafe introduction of ADS on roads.

Opportunity

- Provide guidance framework on ODD definitions for the CAV eco-system (OEMs, operators, end-users, regulators) to ensure safe deployment of L3+ ADS.
- Create consistency in how ODD attributes are described (and monitored potentially) but allowing flexibility for limited and controlled environments.
- Assist end-users (e.g. transport authorities) to reference minimum sets of attributes for the ODD.
- PAS will provide recommendations on a hierarchical taxonomy for defining and describing the ODD.

Thank you for your attention

MUSICC
Multi User Scenario Catalogue for Connected Autonomous Vehicles

is supported by

Department
for Transport

musicc-support@cp.catapult.org.uk

CATAPULT
Connected Places