Testing framework for Automated Driving

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SUMMER SCHOOL 2020

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Motivation and Introduction

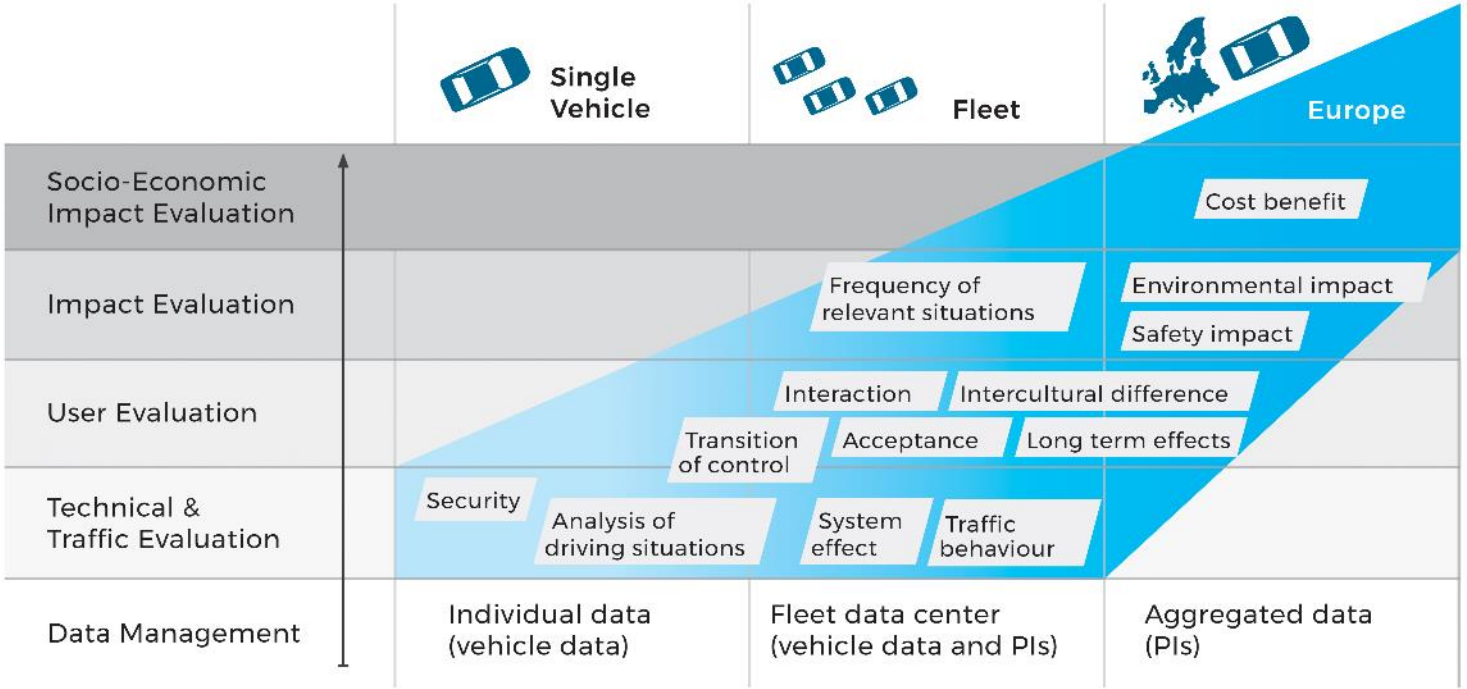
- AD requires new testing framework and new test methodology
- Scenario based testing is key
- Collection of scenarios in database for evaluation
- Focus in L3Pilot
  - Technical & Traffic evaluation
  - User evaluation
  - Impact Assessment and Socio-economic Impact Assessment
- Focus in PEGASUS family
  - Safety assurance

Test Cases

- **Functional based test cases** are derived from functions at the beginning of the development process
  - Strong focus on use cases (Quadrant I)
  - Known safe conditions (Quadrant III) can be analysed
  - Safe unknown conditions are not a big problem (Quadrant IV)
  - Impossible to identify unsafe unknown conditions (Quadrant III)
- Currently **scenario based** approaches are in focus
  - Independent of function
  - Can be defined by third party
- Need of methodology for **unknown unsafe conditions**
  - → **Data based scenarios → Database!**

	Condition Present	Condition Absent
Positive Results → safe / passed	**I** Known safe conditions	**II** Unknown safe conditions
Negative Results → Unsafe / failed	**III** Known unsafe conditions	**IV** Unknown unsafe condition

Evaluation Use Cases in L3Pilot



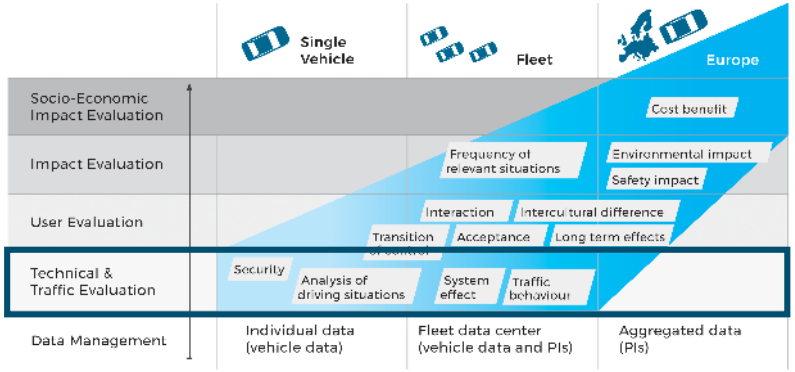
Technical & Traffic Evaluation

Technical:

- How does the AV behave in certain driving situations?
  - How smooth are lane changes?
  - How well does the AV keep a distance?
  - How often do take over requests occur?

Traffic:

- What situations does the AV encounter?
  - How frequent are *e.g. Cut-In* situations?



Key to success:

<u>The right level of aggregation</u>

- Do not look the entire trip in detail
- Define *Performance Indicators* for *Driving Scenarios*

Technical and Traffic Evaluation Workflow Analysis

- Automated toolchain for data evaluation
- Developed collaboratively by all analysis partners using a shared code repository

From **signals**

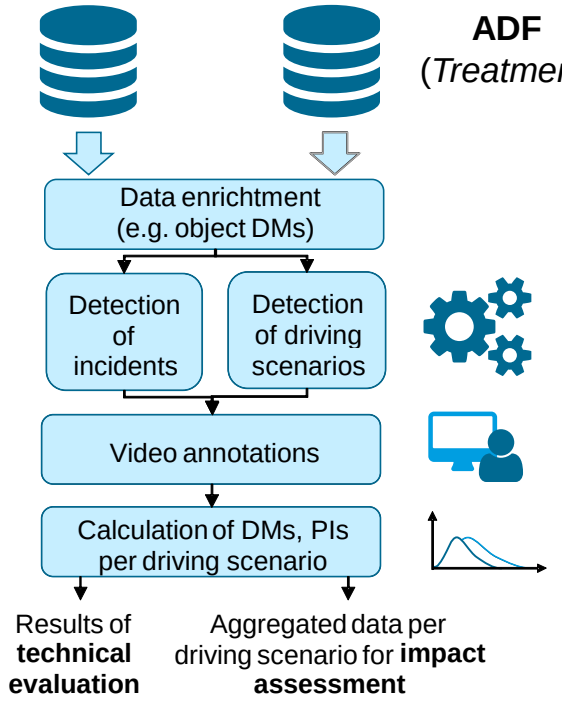
- As defined in L3Pilot Common data Format

To **derived measures** (DMs)

- Used for in depth evaluation of data

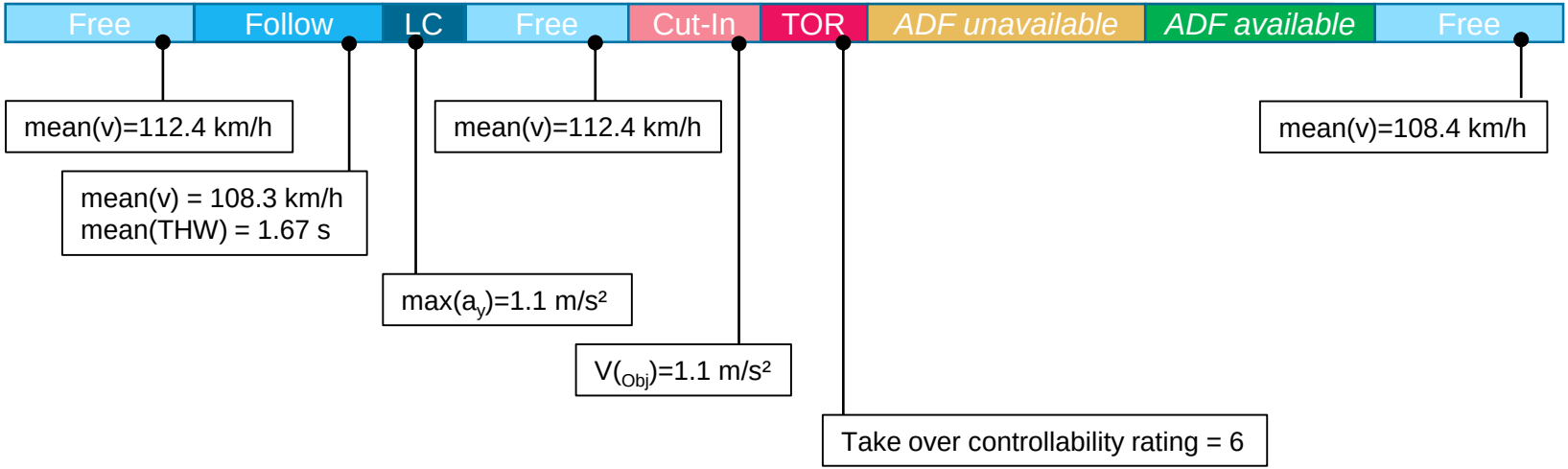
To **performance indicators** (PIs)

- Answering research questions



Technical and Traffic Evaluation
Scenario-based Assessment

- Automated scenario detection deriving performance indicator per encountered scenario



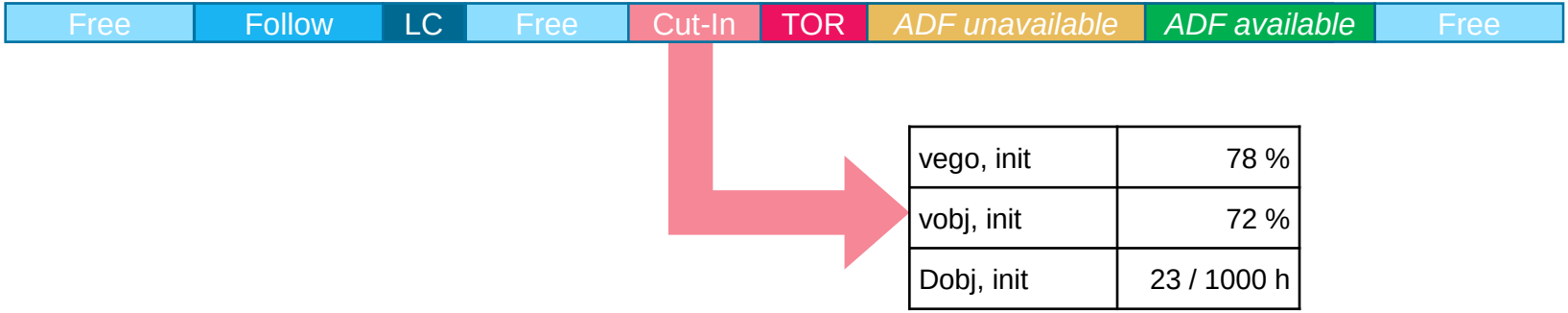
Technical and Traffic Evaluation
Scenario-based Assessment

- Automated scenario detection deriving performance indicator per encountered scenario
- Further performance indicators are evaluated on trip level

% ADF available	78 %
% ADF active	72 %
Frequency of take over requests	23 / 1000 h

Technical and Traffic Evaluation
Scenario-based Assessment

- Automated scenario detection deriving performance indicator per encountered scenario
- Further performance indicators are evaluated on trip level
- Analysis and re-simulation of relevant situation for safety impact assessment

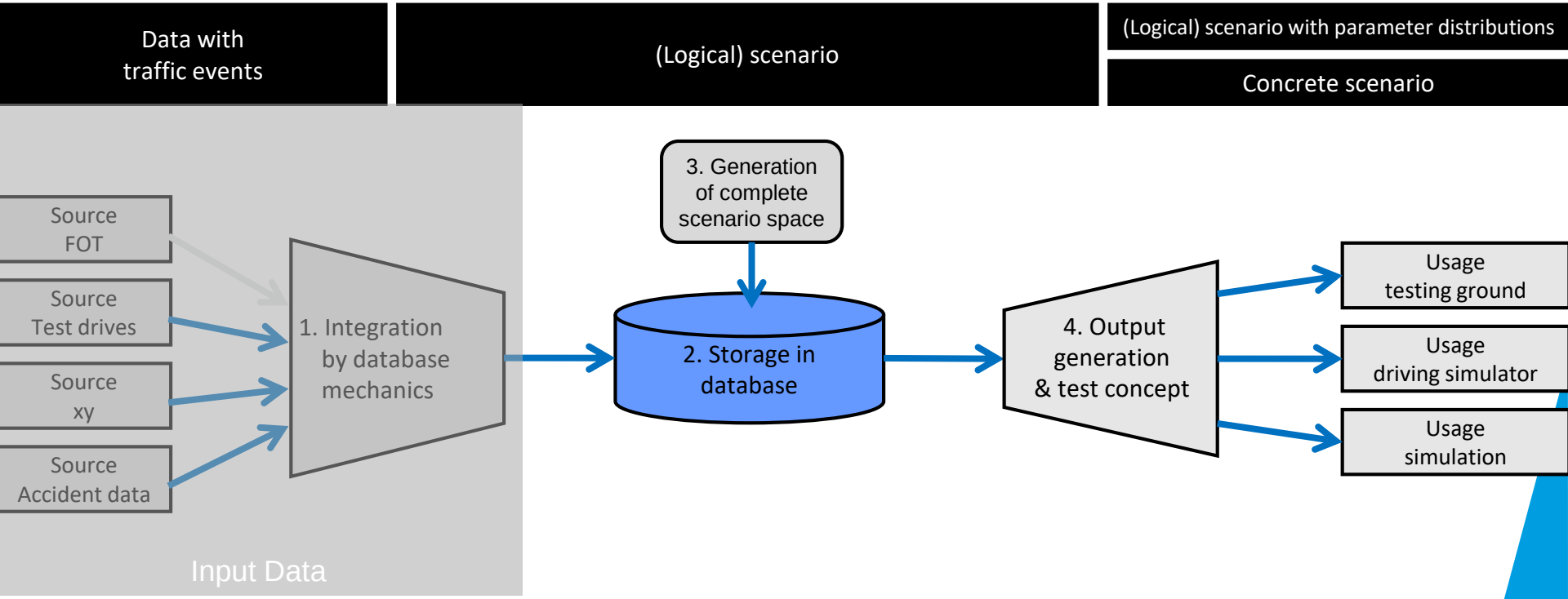


Technical and Traffic Evaluation
Scenario-based Assessment

- Automated scenario detection deriving performance indicator per encountered scenario
- Further performance indicators are evaluated on trip level
- Analysis and re-simulation of relevant situation for safety impact assessment
- Evaluation of all performance indicators using consolidated database
  - Answering research question on EU-level using data from all pilot sites
  - Entries are pseudoneumized

  → No vehicle owner can be identified

Database for Scenario based Testing



Upload Process for Data into the Database

- Signals according to JSON definitions
- Minimum requirements on dataset
- Format: Mat or HDF5

highD

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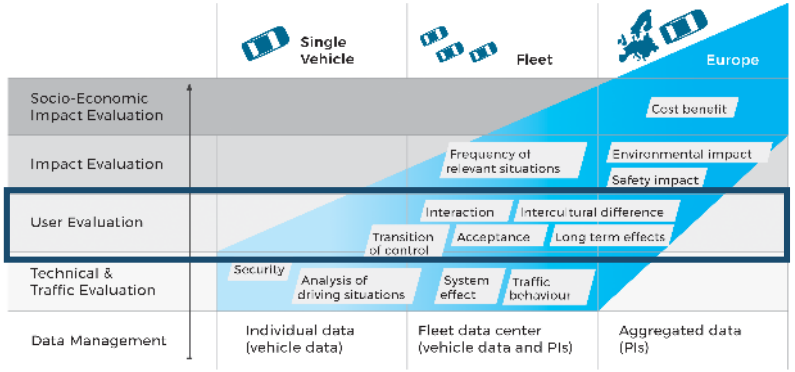
Testing of a Concrete Scenario in Simulation

- The selected concrete scenario can be reproduced in the simulation. A HAD-function integrated in the simulation can be tested.
- Here: “Slower turn into path challenger” (see screen 1)

Testing of a Concrete Scenario on the Test Track

- The selected concrete scenario can be reproduced on the test track. A HAD-function integrated in VUT can be tested.
- Here: “Slower turn into path challenger” (see screen 1)

User Evaluation
Data evaluation – Use Cases



User Acceptance:

- What is the user's experience with the system?
- What is the user's attitude towards AD?

→ *Questionnaires*

Interaction and transition of control:

- How fast does the driver retake control?
- How attentive is the driver in AD mode?

→ *Coded videos*

<u>Anonymous</u> data required:

- Handling must comply with GDPR!
- Regional differences need to be eliminated

Impact Evaluation
Data evaluation – Use Cases

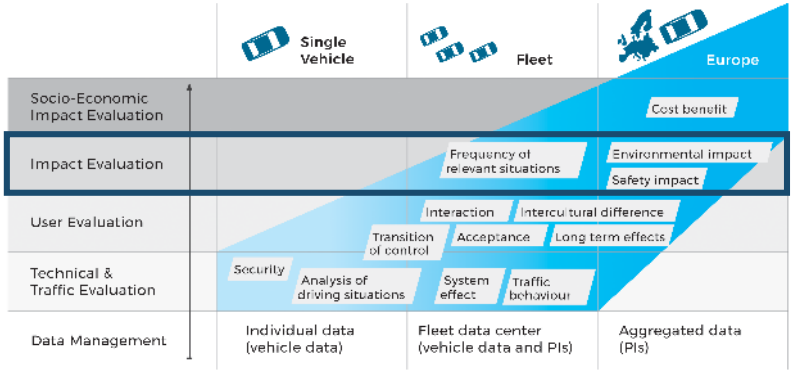
What is the impact of AD on ...

Safety?

- Resimulate situations encountered during piloting
- Vary parameters to increase the amount of available data

Efficiency?

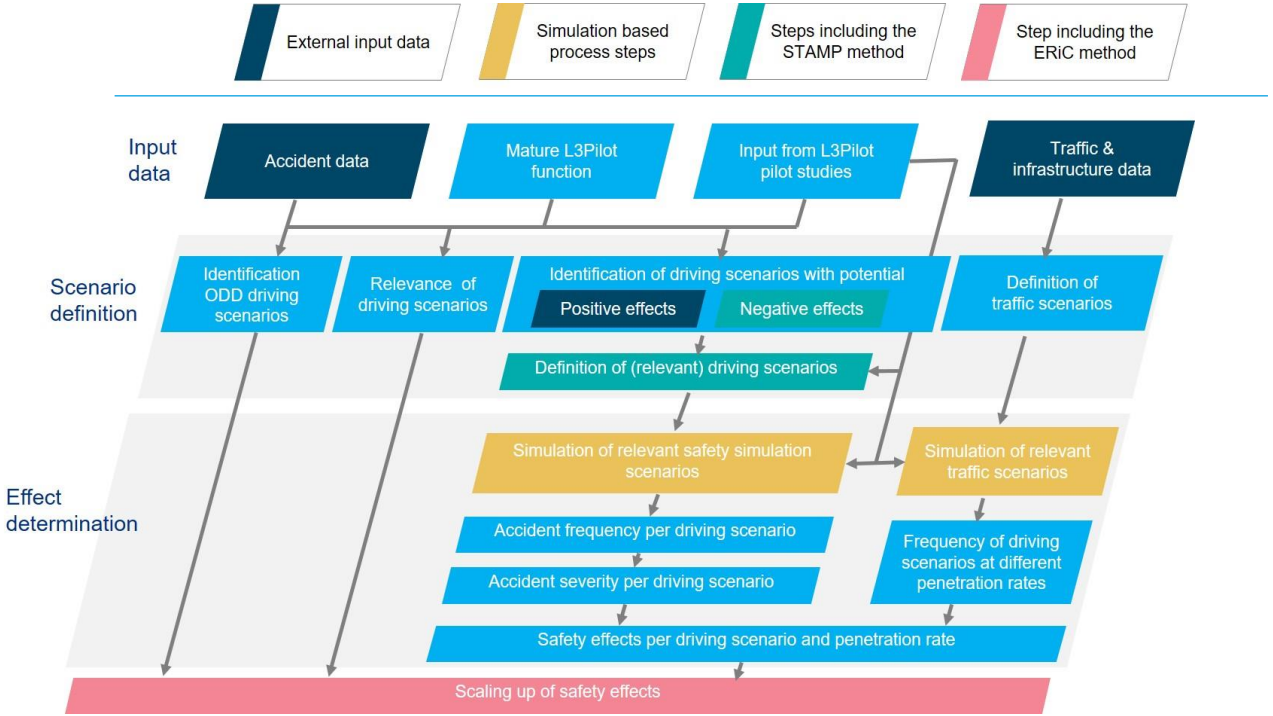
- Simulate traffic with the AV behaviour you observed in traffic
- Consider different penetration rates of AVs



Using piloting data for simulations:

- Simulations need to be in line with pilot results
- But consider that functions are not series-ready yet
- Form requirements together with simulation experts.

Impact Evaluation
Methodology for Safety Impact Assessment



Thank you for your kind attention.

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