VERIFICATION
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PROJECT of the PEGASUS FAMILY

LEARNING-DRIVEN PRODUCT LIFE CYCLE & IN-SERVICE MONITORING AND REPORTING

Learning-Driven Product Lifecycle (LPL) as DevOps Process for highly Automated Vehicles

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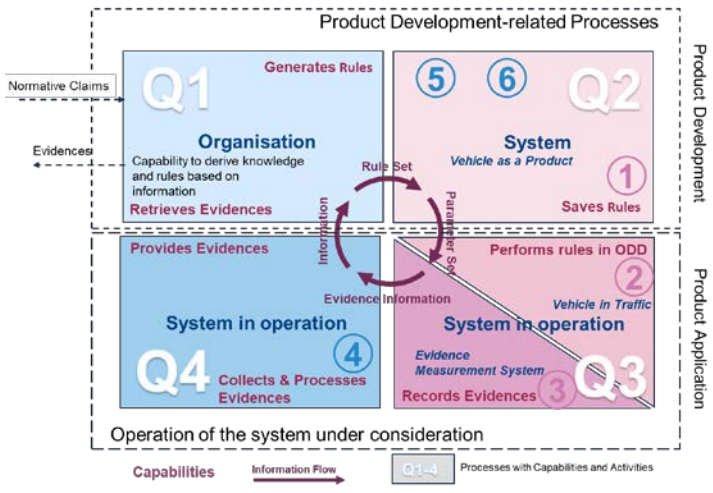
To ensure the safe behavior of automated road vehicles, the challenges of the open traffic context must be considered throughout the whole product life cycle. *The LPL* ensures, by continuously collecting and analyzing information on AD vehicle during operation that

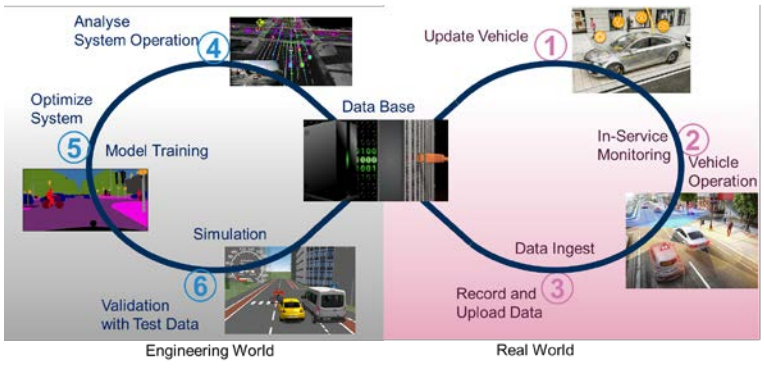
- potential residual safety risks are identified and eliminated at an early stage, thus ensuring the product quality promised to the customer
- and valuable information is gained for the development of future AD systems



The LPL consists of 4 quadrants which represents:

- a knowledge pool of an organization (Q1)
- the development and production of the AD system (Q2)
- the operation of the product (AD System in traffic) and the collection of data (Q3)
- analysis and evaluation of the data and provision for the knowledge pool of the organization (Q4)

A practical implementation of the LPL can be realized in a DevOps approach.
By monitoring a defined number of AD vehicles in real traffic (real world), information is collected about their behavior in the traffic context ② and stored in a central database ③
The information can then be made available to fleet operators and development organizations of AD (sub)systems (OEM, Supplier).



In the DevOps approach, the database is a core element and enables data to be used for virtual development.

④ Analyze System Operation
⑤ System Optimization (e. g. Model Training)
⑥ System Validation with Test Data by Simulation

If there is a safety need, improved and validated updates can be made available to the vehicle in traffic ①
The DevOps process thus confirms the safe behavior of an ADS in operation, as demonstrated by the safety argumentation.

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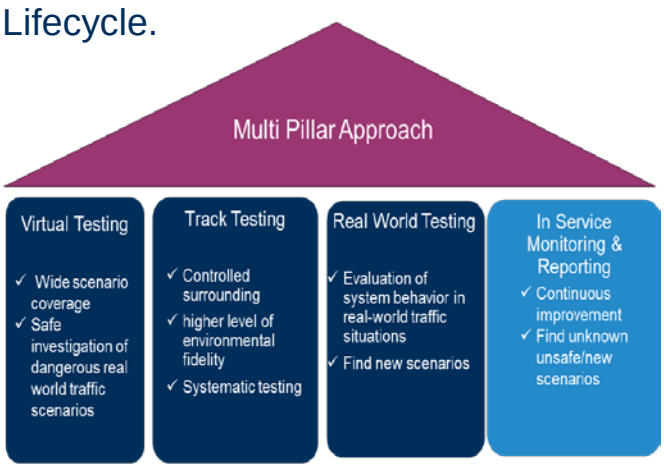
In-Service Monitoring and Reporting System (ISMR System)

The In-Service Monitoring and Reporting addresses the in-service safety of automated vehicles after market introduction and is an element of the Learning-Driven (safety and liability maintenance-driven) Product Lifecycle.



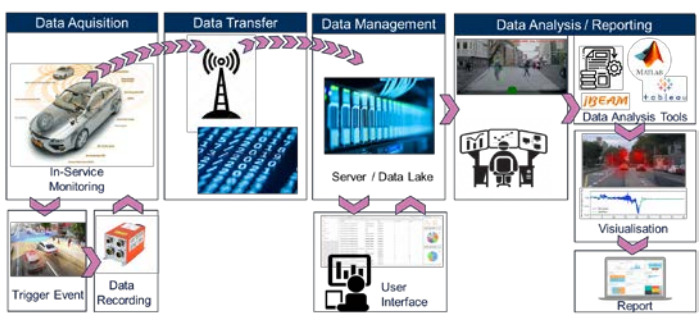
Multi Pillar Approach *

*proposed by UNECE IWG VMAD

In-Service Monitoring and Reporting System will collect evidence from the field operation to demonstrate that the ADS continues to be safe when operated on the road and thus supporting the safety argumentation. The ISM addresses:

- the dynamic nature of road transportation,
- the assumptions made during development
- the residual risk of unknown unsafe events

and thus, ensure that the guaranteed product safety and quality is maintained throughout the entire service life by collecting and processing data.



iSMR Workflow

ISMR System provides a framework that allows monitoring & assessment of the performance of a HAD vehicle functionality during operation.

The framework

- provides all the data required to evaluate the functionality
- event recording & storage of data
- allows the transfer of stored data to a cloud for analysis
- provides an interface that allows an operator to configure the system for a defined Campaign

To reduce the amount of data and the analysis effort is to collect data only in scenarios that shows unexpected or unknown traffic behavior.

The expected behavior can be defined in a campaign & implemented as a trigger.

Scenario	Urban intersection scenario
Test object	Pedestrian detection function
Trigger function	Evaluate expected pedestrian behavior (predicted trajectory within ROI)
Recording duration before/after trigger	Recording starts 10 sec before trigger activation and 15 sec after trigger deactivation
Data to Record	e. g., Sequence of images
Fleet Definition	e. g. Fleet size, User Group (Rental Cars), vehicle Location etc.
Data Analysis	e. g. Compute frequency of occurrence of event

Example Campaign Configuration

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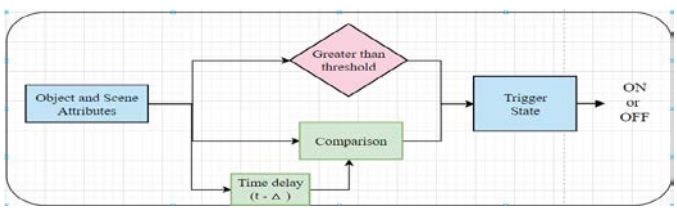
Development of AI Based Reference System Trigger Functions for In-Service Monitoring (ISM)

Concepts: Intelligent monitoring with AI functionalities during operation (ISM). Data monitoring methods includes:

- Rule based e.g., threshold exceedance
- Data driven e.g., self supervised, comparison to time-delayed features and perception attributes.
-



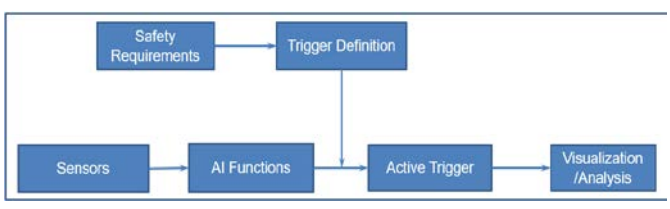
Active trigger with cyclist inside RoI with less then 10m distance

Active trigger with pedestrian prediction path inside RoI

Data and Execution mode:

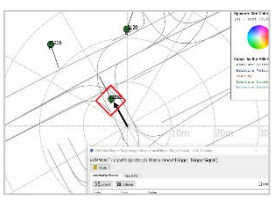
Data: Models are trained with annotated data and tested with both real and simulated data. Evaluation and analysis are mostly done with offline data.

Vehicle Integration: Results with active trigger are shown though integrated pipeline.



Workflow from sensor setups to data visualization and analysis

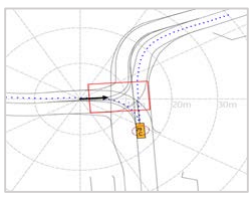
Captured image from front camera and Object detections



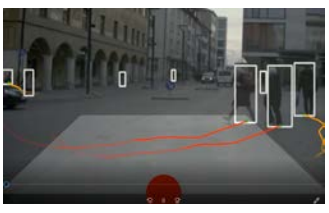
Active trigger according visualization in top view

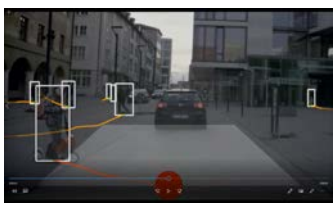
AI Functionality: Configurable Region of Interest (RoI) is developed for trigger generation with defined rules. Current trigger definitions are as follows.

- Trigger to check the presence of pedestrian in the defined RoI
- To check presence of pedestrian predicted trajectory within RoI



Active (red)/ inactive (green) trigger visualization in top view

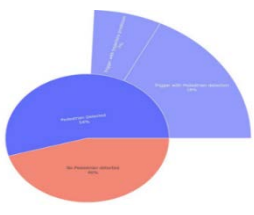


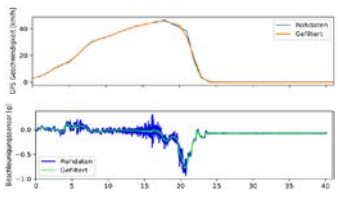


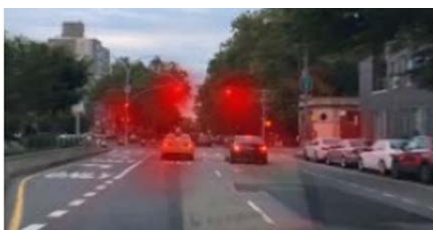
Active trigger with pedestrian predicted path inside RoI

Analysis and Visualization: Recent development and the follow-up tasks include:

- Quantitative and qualitative analysis
- Further trigger development with AI-based event prediction







Braking event prediction with heat map

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