Informal document GRVA-09-10
9th GRVA, 1-5 February 2021
Provisional agenda item 4(a)

✅ Certification of Automated Vehicles
What to expect from Automated Vehicles?

- **Safety and security**
  Ensure functional/operational safety and cyber security during the development, production and post-production/in-use phase.

- **Compliance with all applicable traffic laws**
  Comply to the latest versions of road traffic legislation/rules of the road in the countries of operation.

- **Improved performance**
  Learn from field incidents, e.g. take into account new relevant scenarios and update cyber security.
How can a vehicle manufacturer ensure that?

By adequate management of the safety* and security related to ADS including the supply chain...

*especially operational and functional

...using processes

Risk Management
V&V Management
Field Management
Which processes need to be considered?

Processes covering the development, production and post-production/in-use phase and the entire supply chain to manage the safety, especially operational and functional safety, and security related to ADS

• Processes to identify risks related to ADS, incl. their assessment, categorization and treatment
• Processes to verify that the risks identified are appropriately managed and to ensure that the risk assessment is kept current

• Processes to validate the safety, especially operational and functional safety related to ADS/ADS-Features
• Processes to validate & verify the performance of ADS-Features and their integration/interactions in the ADS

• Processes to monitor the ADS in the field in order to detect and respond to safety issues
• Processes to monitor rules of the road/road traffic legislation of countries/regions where an ADS is operated or intended to operate, to detect and respond to changes in order to maintain compliance with such legal aspects
How to organize these processes efficiently?

**Processes**
- Validation & Verification
- Risk assessment & treatment
- Field monitoring & response

**Automated Driving Management System (ADMS)**
How can these processes be used to certify an ADS?
Concept: 2 Core Components/Toolboxes

Automated Driving Management System
Safety management system anticipating the declared implementation of core processes to demonstrate the capability of a vehicle manufacturer to develop, validate, verify and maintain safe ADS in the field.

Automated Driving System Validation
Scenario based ADS validation approach with flexible testing configurations using virtual, physical and real-world test methods as well as safety assessments to cover the safety aspects of complex electronic ADS.
ADSV
Automated Driving System Validation
Assumptions

Each ADS-Feature is described by

**Internal Conditions**
- Driver Interactions: ...
- Feature Limitations: ...*anything restricting the ADS from being capable of reaching L5 automation

**External Conditions (ODD)**
- Weather Conditions: ...
- Road Types: ...
- Geographical Area: ...

primarily influencing applicable **requirements**

primarily influencing applicable **scenarios**
The ADSV² scope covers the Dynamic Driving Task (DDT) and a possible transfer of control between the ADS and other entities (if applicable).
ADSV
Sub-Components
Sub-Components

Technology neutral, non-design restrictive functional requirements...

...are filtered by a functional filter based on the internal and external conditions...

...resulting in ADS-Feature specific functional requirements.

Example

L4 Driverless Shuttle

<table>
<thead>
<tr>
<th>Functional Requirements</th>
<th>Functional Feature Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition Demand</td>
<td>not applicable</td>
</tr>
<tr>
<td>ODD Recognition</td>
<td>ODD Recognition</td>
</tr>
<tr>
<td>Minimal Risk Manoeuvre</td>
<td>Minimal Risk Manoeuvre</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

This exemplary level 4 driverless shuttle and features thereof will not issue a transition demand by design. Therefore requirements related to the transition of the dynamic driving task are not applicable.
Contains at a minimum the scenario description (e.g. based on the PEGASUS\(^1\) layers) and ADS-Feature specific **pass/fail criteria**, which can be derived from the (applicable) functional feature requirements, based on physical principles and/or human driving performance.

Scenarios are partitioned into three different abstraction layers, as defined in the PEGASUS project: **Functional, Logical** and **Concrete**:

<table>
<thead>
<tr>
<th>Functional Scenario Description (Example)</th>
<th>Logical Scenario Description (Example)</th>
<th>Concrete Scenario Description (Example)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base road network:</strong></td>
<td><strong>Base road network:</strong></td>
<td><strong>Base road network:</strong></td>
</tr>
<tr>
<td>three-lane motorway in a curve;</td>
<td>Lane width [2.3..3.5] m</td>
<td>Lane width [3.2] m</td>
</tr>
<tr>
<td>100 km/h speed limit indicated by traffic signs</td>
<td>Curve radius [0.6..0.9] km</td>
<td>Curve radius [0.7] km</td>
</tr>
<tr>
<td><strong>Stationary objects:</strong></td>
<td><strong>Stationary objects:</strong></td>
<td><strong>Stationary objects:</strong></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Moveable objects:</strong></td>
<td><strong>Moveable objects:</strong></td>
<td><strong>Moveable objects:</strong></td>
</tr>
<tr>
<td>Ego vehicle, traffic jam;</td>
<td>End of traffic jam [10..200] m</td>
<td>End of traffic jam 40 m</td>
</tr>
<tr>
<td>Interaction: Ego in maneuver, approaching “on the middle lane, traffic jam moves slowly”</td>
<td>Traffic jam speed [0..30] km/h</td>
<td>Traffic jam speed 30 km/h</td>
</tr>
<tr>
<td><strong>Environment:</strong></td>
<td><strong>Environment:</strong></td>
<td><strong>Environment:</strong></td>
</tr>
<tr>
<td>Summer, rain</td>
<td>Temperature [10..40] °C</td>
<td>Temperature 20 °C</td>
</tr>
<tr>
<td></td>
<td>Droplet size [20..100] μm</td>
<td>Droplet size 30 μm</td>
</tr>
</tbody>
</table>
The Scenario Detailer narrows the Functional Scenario space to the Logical Scenario parameter space taking the ADS-Feature conditions into consideration. The external conditions will primarily influence the applicable range for the parameters. The internal conditions may additionally influence the detailing procedure.

Ego vehicle, traffic jam; Interaction: Ego in maneuver, approaching on the middle lane, traffic jam moves slowly

Detailing:
- End of traffic jam: [10..200] m
- Traffic jam speed: [0..30] km/h
- Ego distance: [50..300] m
- Ego speed: [80..130] km/h
The Scenario Selector selects logical and/or concrete scenarios out of the continuous logical scenario space and outputs them consecutively for further processing until a sufficient coverage of the logical scenario space is achieved.

The Scenario Selector is controlled by a selection algorithm which is influenced by the internal and external conditions of the ADS-Feature. These conditions have an impact on which and how many concrete/logical scenarios needs to be selected to reach a desired level of confidence.

Selection algorithm examples:
- 500 random scenarios
- 30 traffic accident scenarios
- 1 manually selected scenario ("human selector") for re-testing
- ...

1 virtual, physical and realworld test methods
ADSV

Validation Flows
Validation Flows

Feature
Performance

System
Integration
Feature Performance

1. Functional Requirements
   - Conditions
   - Functional Filter
   - Functional Feature Requirements

2. Functional Scenarios
   - Conditions
   - Scenario Detailer
   - Logical Scenarios

3. Scenario Selector
   - Logical/Concrete Scenario Test Methods
     - Virtual
     - Physical
     - Realworld

4. Additional Checks
   - HMI
   - ODB/ODD Recogn.

5. Documentation
   - Feature Description
   - Test Reports
   - ...
System Integration

The vehicle manufacturer shall declare adequate test coverage, the use of adequate virtual test models/tools, the sufficient coverage of safety aspects of complex electronic ADS and/or features thereof in assessments and the ensurance of the expected level of safety in the countries of operation.

1. Process ADS-Features individually
2. Finalize ADSV Documentation Package for the ADS
3. Declare configuration of Filter, Detailer and Selector
4. Finalize Declaration
Certification of Automated Vehicles