

# The European Commission's science and knowledge service

## Joint Research Centre



# JRC proposal for Safety Assessment of Automated Vehicles

EC DG JRC C.4

*3<sup>rd</sup> VMAD Meeting - July 1<sup>st</sup>, 2019*

# Q1: What is a safe AV?



Q2: How to demonstrate it?

# WHAT IS A SAFE AV?

- **FUNDAMENTAL PRINCIPLES**

- I. EFFECTIVENESS**

- When the AV drives it shall replace the driver for all driving task under OD

- II. OPTIMIZATION**

- As safe as reasonably achievable

- III. DAMAGES LIMITATION**

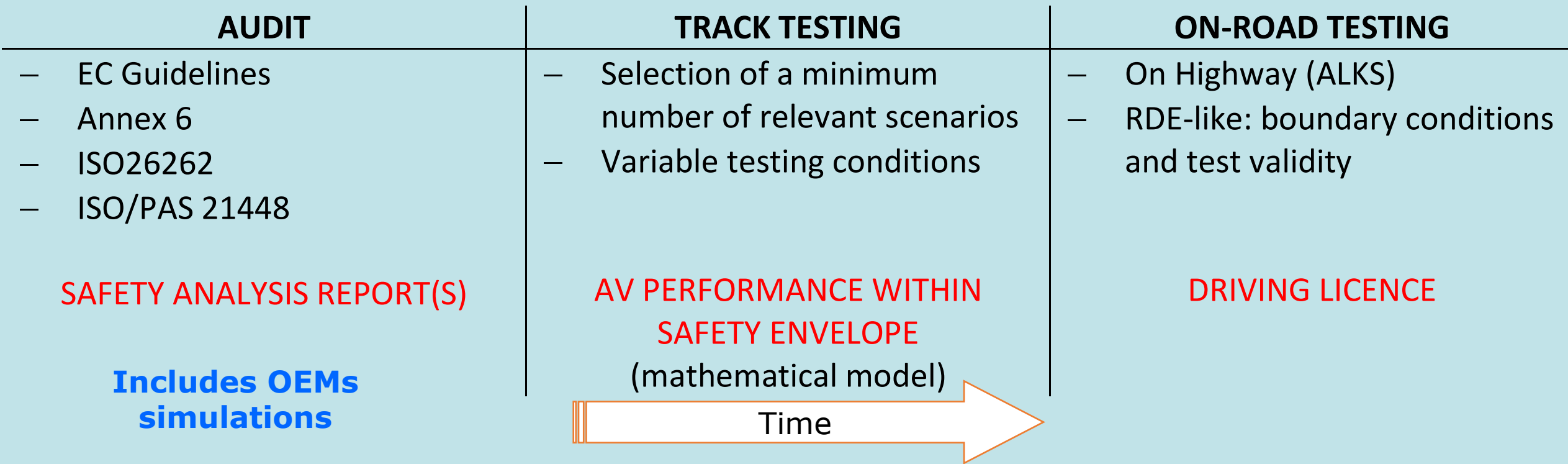
- Minimize damages to people and collectivity (not to cause accidents)

- **Definition of ACCEPTABLE RESIDUAL RISK**

- **SAFETY ENVELOPE**

# HOW TO DEMONSTRATE IT?

## MULTI-PILLAR APPROACH



**4<sup>th</sup> PILLAR: In-use data reporting?**

# Questions for open discussion

- What is ALKS L3/4 (in particular today in Geneva we speak about only systems working below 60 km/h)?
- How the mathematical model can apply to these systems?
- What shall be used for the audit? SOTIF approach+STPA?
- Have we collected the critical scenarios (in particular manufacturers)?
- Can we use simulation?
- What can we use from Pegasus?

# L3 ALKS - Part I AUDIT

# SAFETY ANALYSIS REPORT

OEMs shall be required to submit or make available to the TA authority all information that is specified or requested.

This information should be presented in the form of a safety analysis report (SAR).

The TA authority/EC shall issue guidance on the format and content of documents to be submitted by the operator in support of applications for authorization.



# MULTI-STEP APPROACH

## SARs issued in successive and complementary parts:

1. An initial (preliminary) SAR that, in the certification process, precedes an application for authorization to market distribution.
  - Limited scope, during development phase
  - Information exchange with TA
2. A finalized (final) SAR that incorporates the revisions to the intermediate report prior to the vehicle entering the market.
  - Incorporates revisions to the preliminary report
  - Clearly demonstrates that design intent is met
  - Systematic and periodical updating

# FORMAT AND CONTENTS OF SAR - highlights

## VIII. Operation

- operational aspects
- maintenance, surveillance, inspection and testing
- management of ageing
- control of modifications (updates)
- qualification and training of users
- in-service data recording and feedback of operational experience
- documents and records related to operation

# FORMAT AND CONTENTS OF SAR - highlights

## IX. Operational limits and conditions

- controls, limits, conditions, rules and required actions that are formally derived from the safe operation

## IX. Emergency management

- info/actions required in case of accident, if any

## X. End of life aspects

- environmental aspects
- ...

## XI. OEM declaration (?)

# REVIEW AND UPDATING OF THE SAR

- Preliminary and final SARs are important documents
- SAR may be only one of several sources of information and the final safety justification that TA accepts may consist of a far wider range of information (e.g. co-testing activities, informal exchange of information,...)
- Acceptability of alternative forms of reports, in accordance with national laws and regulations, where appropriate
- Routine revisions of the SAR: it should reflect the current state and the certification basis of the vehicle and should be kept up to date accordingly ('living' SAR).

# L3 ALKS - Part II

## TRACK TESTING

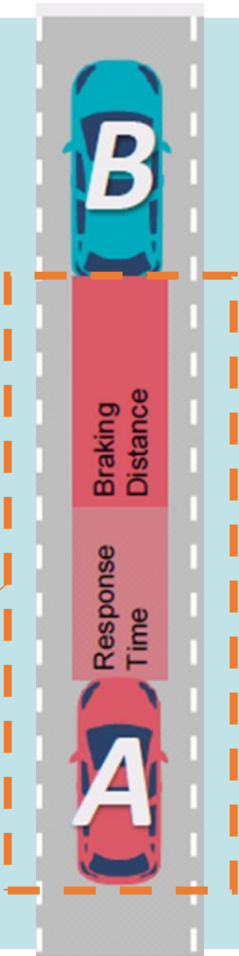
# SAFETY ENVELOPE - how to apply it?

Test scenarios to verify that

- the vehicle respects the safety envelope boundaries
- the vehicle takes appropriate actions to timely restore safety once in unsafe condition
- Appropriate emergency measures for unsafe conditions

➤ agree on model parameters to define acceptable residual risk level

Safety Envelope



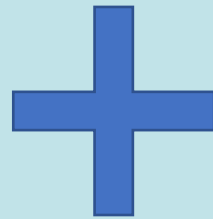
# SAFETY ASPECTS TO BE ADDRESSED

## 1. Tests on track/proving ground

- Nominal Safety: operation within safety envelope
- Functional safety: if the vehicle is still capable of driving, it shall operate within the safety envelope
- Environmental factor: if within ODD, the vehicle shall operate within the safety envelope (adaptable parameters)
- Interactions with other road users: considering EuroNCAP-like tests
- Interactions with human in the cabin
- Non-failures

## 2. Tests on-road (driving license)

# TRACK TESTING



## Testing conditions

- Vehicle parameters (speed, ...)
- Environmental conditions (weather, temperature, visibility, asphalt,...)
- Failures
- Non-failures
- Interaction with other road users
- Interaction with human inside the cabin

- Road geometry
- Other vehicles
- ...

**NORMAL & CRITICAL (EDGE CASES?)**



# TRACK TESTING

- **Test 1: Basic capabilities within ODD, normal operation (30 min)**

- red traffic light (lane use);

- a road stretch with no lane marks;

- a dangerous road bend (with the smallest radius admissible in Europe for the specific road category);

- the presence of men at work;

- work-zone marks;

- work-zone marks with closure of the adjacent left lane;

- the presence of unmarked material on the same lane (e.g. garbage)

- the presence of water/oil on the asphalt;

- Presence of police/emergency vehicles;

- Tunnel;

- HMI/driver availability;

# TRACK TESTING

- **Test 2: ODD Boundaries and transition demand (30 min)**

- Exceeding ODD speed

- Need for lane change

- Construction site

- Other - based on defined ODD

- Human unavailable to take back control

- Driving conditions outside ODD

Transition requests to be recorded and documented, including vehicle behavior post-transition

# TRACK TESTING

- **Test 3: Interaction with other road users (30 min)**

- Car following: lead vehicle follows WLTC low and medium speed up to 80km/h

- At least 3 breakings (max deceleration)

- Aggressive cut-in from left

- Aggressive cut-in from right

- Unexpected cut-out

- Unexpected cut-out with occluded obstacle in same lane

- Front vehicle moving backward?

- More than 2 vehicles?

- Different vehicle types?

# TRACK TESTING

- **Test 3:** selection of normal, critical testing conditions (results from BAST modelling activity)

Speed Part \	10	...	...	...	...	...	...	...	60
A	Green	Green	Green	Green	Green	Green	Green	Green	Green
B	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow
C	Green	Green	Green	Green	Yellow	Yellow	Yellow	Red	Red
D	Green	Green	Green	Yellow	Yellow	Yellow	Red	Red	Red
E	Green	Green	Green	Yellow	Yellow	Yellow	Red	Red	Red
F	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Red

# TRACK TESTING

- **Test 1 to 3: repeated considering more challenging**
    - Environmental conditions (whether, temperature, visibility, asphalt conditions)
    - Single failures (SW/HW), based on AUDIT
    - Miscommunication (blind camera,...) , based on AUDIT
    - More complex interaction with other road users (different vehicle types, pedestrian/man at work,...)
- Multiple failures?
- Random selection (Montecarlo approach)

# L3 ALKS - Part III

# ONROAD TESTING

# ONROAD TESTING

## 4. Test on road (Real Driving Safety)

- On Highway (low speed application?)
- RDE conditions: boundary conditions and test validity requirements to be defined
- Safety envelope shall apply

**NEEDED FOR ALKS AT LOW SPEED??**

# **L3 ALKS - Part IV**

## **IN-USE DATA REPORTING**



# DATA REPORTING

- Onboard event data recording (including near-miss events)
- Feedback of operating experience
- Coordination Centre for Accident and Incident Reporting  
System Safety
- Recommendations Information System



# Any questions?

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