# Use case webinar: Truck platooning

Álvaro Arrúe – Applus IDIADA

Sjef van Montfort – TNO & Jacco van de Sluis – TNO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824309.

# Agenda

- ✓ Álvaro Arrúe – Applus IDIADA

- ✓ Sjef van Montfort – TNO

- ✓ Jacco van de Sluis – TNO

# Agenda

- ✓ Introduction webinar
- ✓ Introduction HEADSTART project
- ✓ HEADSTART methodology in a nutshell
- ✓ Introduction use case: Truck platooning
- ✓ HEADSTART method application to use case: Truck platooning
  - Scenario selection and allocation
  - Testing of scenarios
  - Evaluation of test results
- ✓ Wrap-up

# Introduction webinar

Webinar rules and process

- ✓ Webinar is being recorded
- ✓ Slides, voting results and recording will be shared and published on HEADSTART website

- ✓ Participants feedback anonymously gathered via www.slido.com with event code: *HEADSTART*
- ✓ Questions can be raised via www.slido.com with event code: *HEADSTART*

  The questions are gathered and where possible raised by the webinar moderator at fixed time slots during the webinar to the presenters.

# Introduction webinar

- ✓ Goal of this meeting:

  **Get external expert feedback on HEADSTART method applied to use case:**

  **Truck platooning**

- ✓ Feedback will be integrated in HEADSTART deliverable:

  D2.3 Assessment method for each of the use cases defined

- ✓ Special attention to HEADSTART Key Enabling Technologies (KETs):

  **Communication V2X** and **Positioning (GNSS)**

- ✓ HEADSTART KET – **Cybersecurity** will be discussed in separate webinar on Friday May 15th 10:00-11:30 CET. Link to registration on HEADSTART website.

# HEADSTART

## HARMONISED EUROPEAN SOLUTIONS FOR TESTING AUTOMATED ROAD TRANSPORT

Álvaro Arrúe – Applus IDIADA

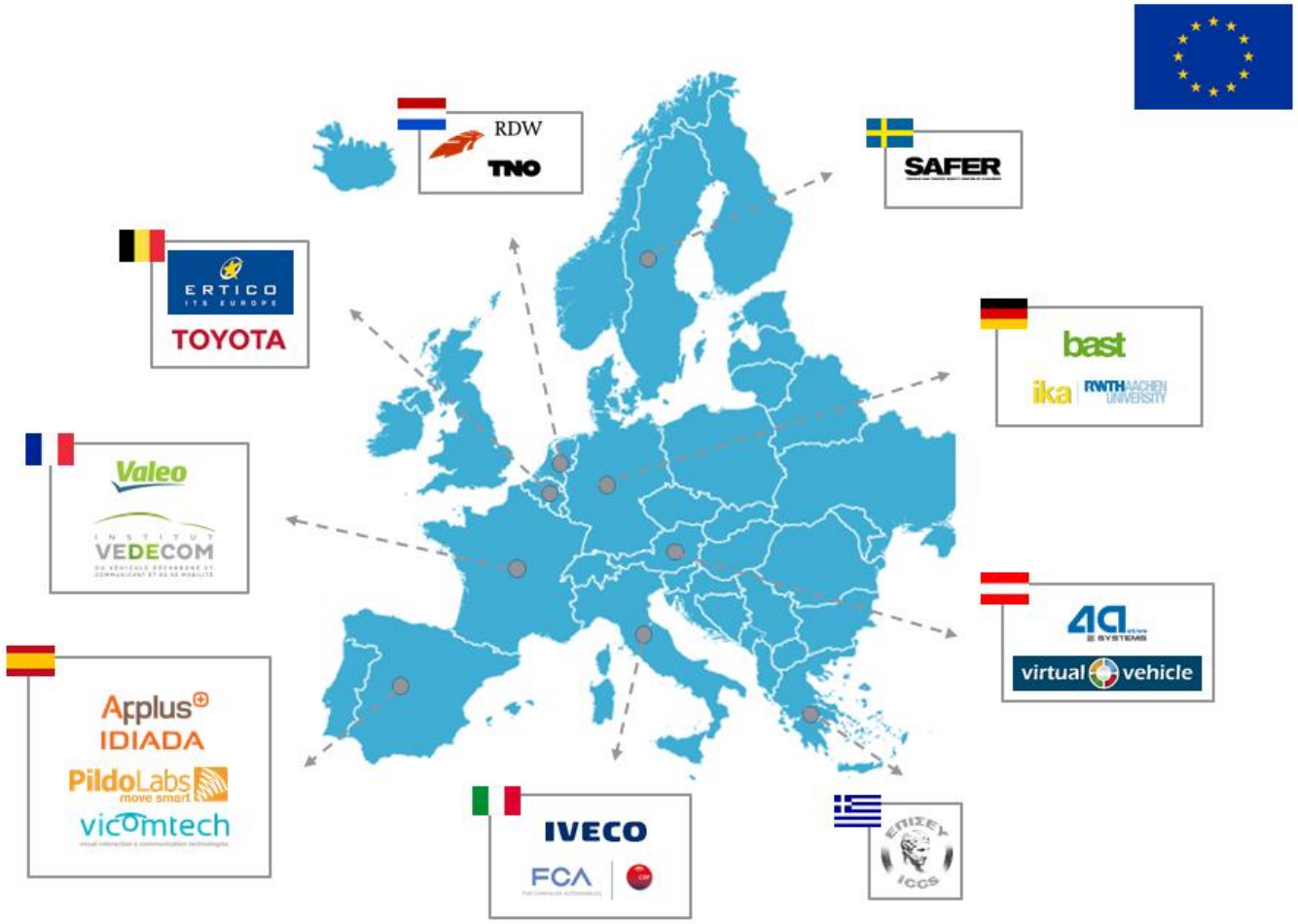
Project coordinator

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824309.

# HEADSTART project facts

- ✓ **Call identifier:** ART-01-2018
- ✓ **Type:** RIA
- ✓ **Duration:** 01.2019 – 12.2021 (36 months)
- ✓ **Budget:** 6M€
- ✓ **Consortium:** 17 partners
- ✓ **Coordinator:** Applus IDIADA, Mr. Álvaro Arrue, Project Manager
- ✓ **Dissemination Manager:** ICCS, Dr. Angelos Amditis, Research Director
- ✓ **Website:** https://www.headstart-project.eu
- ✓ **Social media:** / HEADSTART_EU
  / HEADSTART-PROJECT
  / HEADSTART project
  / @HeadstartEUproject

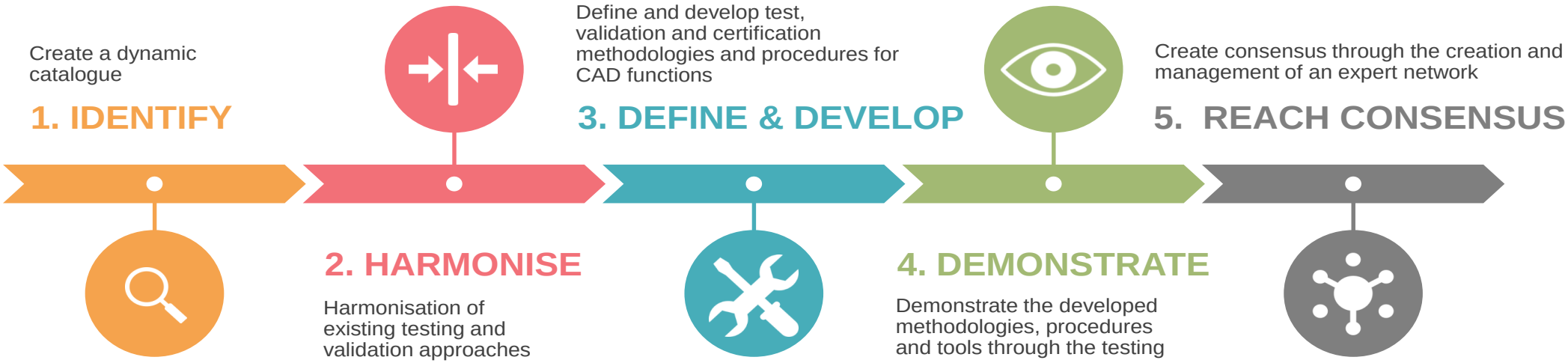
# HEADSTART Consortium



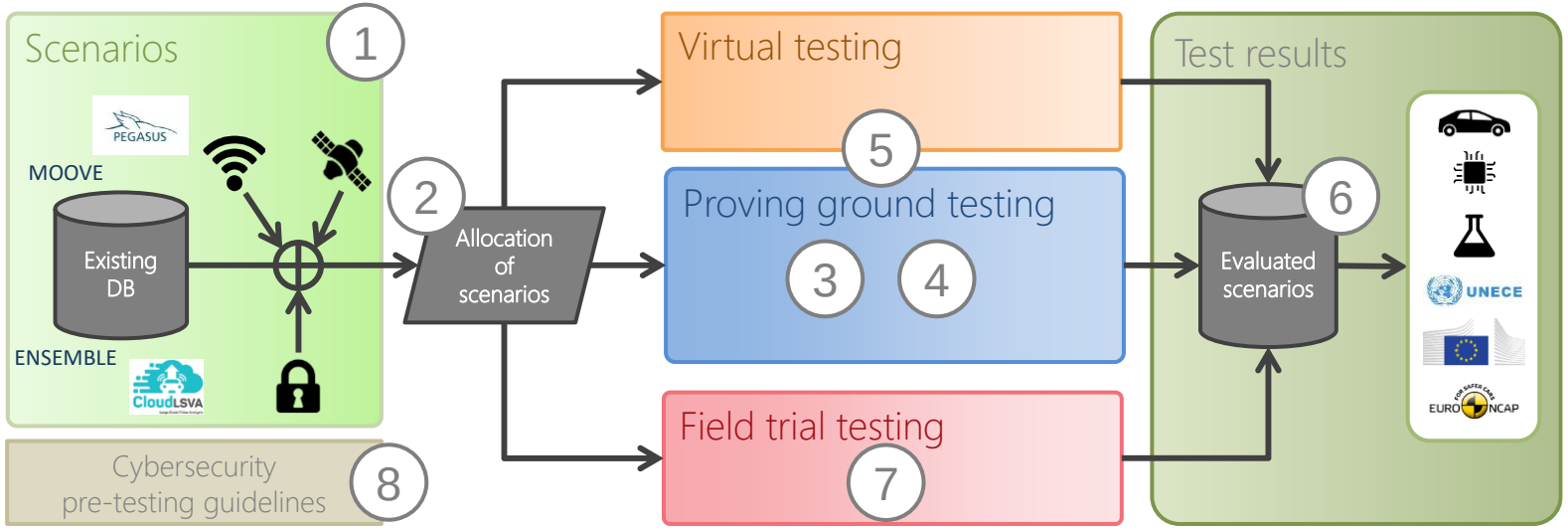
# Project's Objectives

HEADSTART will define testing and validation procedures of CAD functions including:

- its key enabling technologies (i.e. communication, cyber-security, positioning)
- by cross-linking of all test instances such as simulation, proving ground and real world field tests
- to validate safety and security performance according to the needs of key user groups (technology developers, consumer testing and type approval)



# Project's Concept




1. Integration of positioning, communications and cyber-security in CAD test scenarios
2. Comprehensive procedure for the allocation of test cases per testing platform
3. Selection criteria and specification for proving ground test scenarios taking into account criticality
4. Proving ground testing and evaluation
5. Correlation between simulation and proving ground results
6. Harmonised, open result compilation and sharing
7. Field trial test methodology description
8. Cyber-security principles and integration in the testing methodology

# Cooperate with HEADSTART project

## EXPERT GROUP PARTICIPATION

- Join as associated partner and our expert group
- Join the discussion group of your interest:
  - Cyber-security
  - Communications (V2X)
  - Positioning
  - Scenario selection
  - Consumer testing (NCAP)
  - Type approval
- Provide needs and requirements and evaluate project (intermediate) results

## JOINT TESTING ACTION

- ✓ Joint cooperation between both projects for testing validation and certification purposes
- ✓ Align your project with the harmonized methodology and tools developed within HEADSTART
- ✓ Become one of our use cases!

Please let us know about your interest and join our distribution list.
Website: www.headstart-project.eu
Contact: info@headstart-project.eu

# HEADSTART status update

- ✓ Available to be downloaded in www.headstart-project.eu
  - D1.1: State of innovation of existing initiatives and gap analysis
  - D1.2: Stakeholders and user group needs
  - D1.3: Technical and functional requirements for KETs
  - D1.4: Functional requirements of selected use cases
  - D2.1: Common methodology for test, validation and certification
  - D2.2: Criteria to choose optimal scenarios and tests for each KET
- ✓ HEADSTART Week
  - WC20: 11/05 – 15/05: A dedicated webinar + discussion every day from 10-11:30 CET
  - WB1: Methodology; WB2: Truck platooning; WB3: Traffic Jam assist; WB4: Cybersecurity
- ✓ International cooperation
  - Engage with US and Japan projects in a Project-2-project basis
  - Already discussing interaction with European initiatives

# The HEADSTART week!

✓ 4 Webinars: Different days for your convenience!

Monday


Tuesday


Thursday


Friday

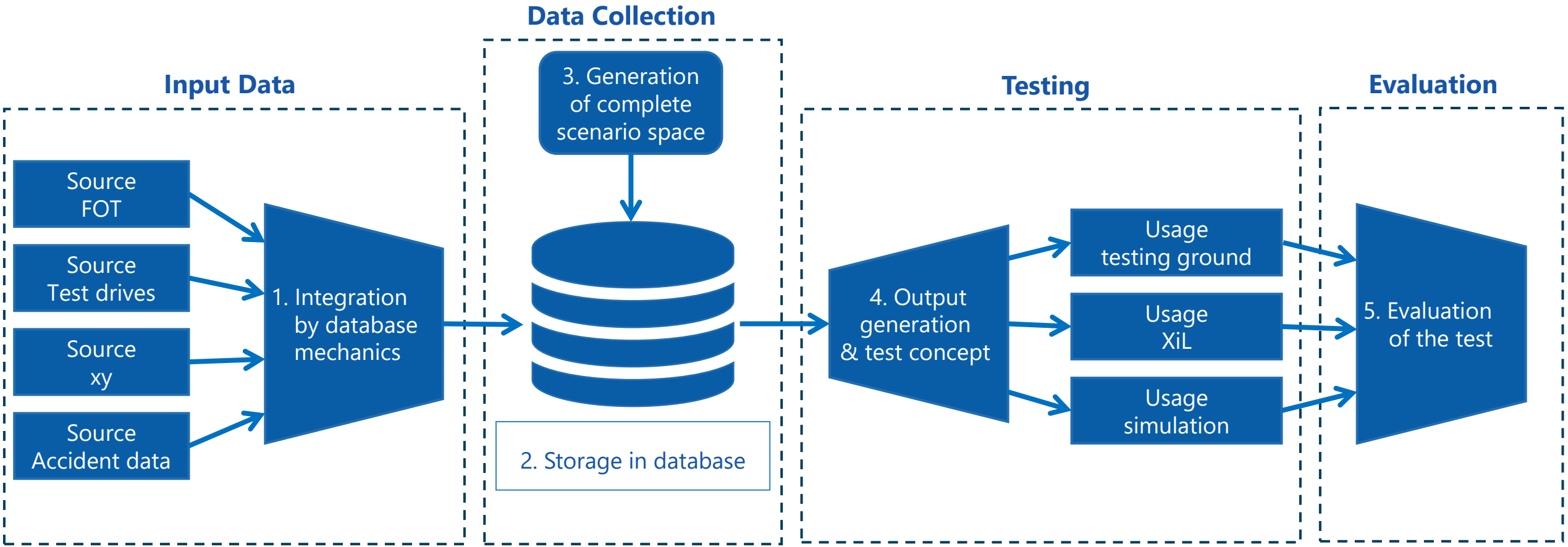

www.headstart-project.eu/headstart-wee

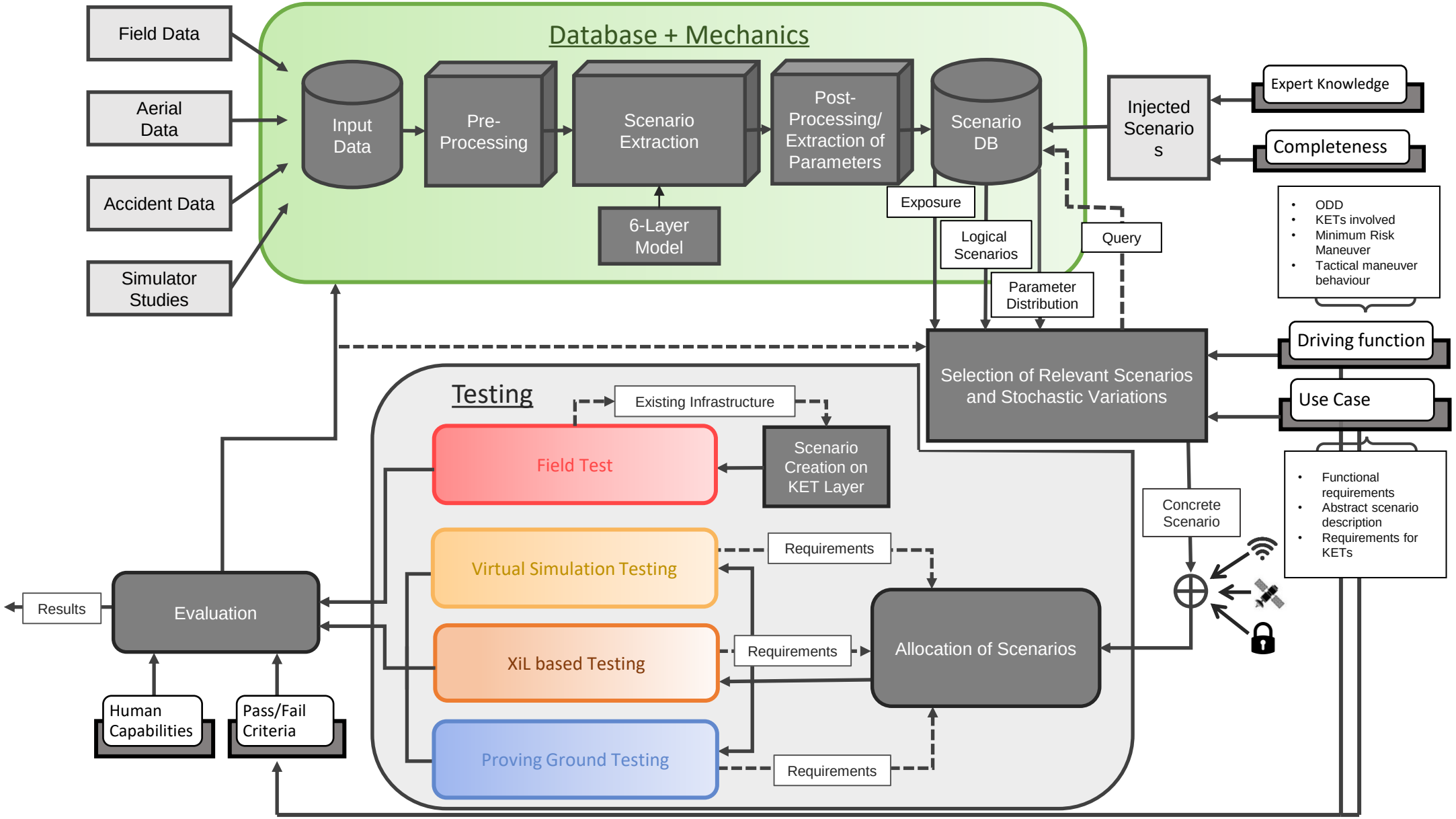
# HEADSTART methodology

Sjef van Montfort – TNO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824309.

# Overall Methodology




Field Data
Aerial Data
Accident Data
Simulator Studies
Database + Mechanics
Input Data
Pre-Processing
Scenario Extraction
6-Layer Model
Post-Processing/ Extraction of Parameters
Scenario DB
Exposure
Logical Scenarios
Parameter Distribution
Query
Injected Scenarios
Expert Knowledge
Completeness
ODD
KETs involved
Minimum Risk Maneuver
Tactical maneuver behaviour
Driving function
Use Case
Selection of Relevant Scenarios and Stochastic Variations
Functional requirements
Abstract scenario description
Requirements for KETs
Concrete Scenario
Testing
Existing Infrastructure
Field Test
Scenario Creation on KET Layer
Virtual Simulation Testing
Requirements
XiL based Testing
Requirements
Proving Ground Testing
Requirements
Allocation of Scenarios
Results
Evaluation
Human Capabilities
Pass/Fail Criteria

# Use case: Truck platooning

Sjef van Montfort – TNO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824309.

# HEADSTART: WP1 use case overview

| | | Truck Platooning | Highway Pilot | Traffic Jam Chauffeur | Valet Parking | Urban Automated Shuttle |
|---|---|---|---|---|---|---|
| Requirements for testing KETs | How suitable is the use case to meet the requirements on testability of positioning in HEADSTART | 3,8 | 3,6 | 2,6 | 4,3 | 4,5 |
| | How suitable is the use case to meet the requirements on testability of communication in HEADSTART | 4,8 | 3,4 | 1,9 | 3,5 | 3,5 |
| | How suitable is the use case to meet the requirements of testability of cyber-security in HEADSTART | 4,5 | 3,1 | 2,4 | 3,7 | 3,7 |
| Requirements for testing | How suitable is the use case to meet the requirements regarding physical testing in HEADSTART | 4,3 | 4,3 | 3,5 | 4,3 | 2,9 |
| | How suitable is the use case to meet the requirements regarding proving-ground testing in HEADSTART | 4,1 | 3,6 | 3,1 | 3,8 | 2,6 |
| | How suitable is the use case to meet the requirements regarding field operational tests in HEADSTART | 4,0 | 4,1 | 3,4 | 3,8 | 3,1 |
| | How suitable is the use case to meet the requirements regarding model-based testing in HEADSTART | 3,9 | 3,6 | 3,6 | 3,9 | 3,6 |
| Availability of Scenarios ➔ | How suitable is the use case to meet the requirements regarding definition and availability of scenarios in HEADSTART | 3,3 | 3,8 | 3,5 | 3,0 | 2,6 |
| Collaboration partners for this use case ➔ | How suitable is the use case to meet the requirements regarding requirements on collaboration partners in HEADSTART | 4,0 | 3,7 | 2,9 | 3,3 | 2,6 |
| Relevance to key user groups | How suitable is the use case to meet the requirements regarding relevance to OEMs andTier1s in HEADSTART. | 3,0 | 4,8 | 4,5 | 3,5 | 3,3 |
| | How suitable is the use case to meet the requirements regarding relevance to type-approval authorities in HEADSTART | 3,3 | 4,1 | 3,9 | 2,8 | 2,9 |
| | How suitable is the use case to meet the requirements regarding relevance to consumer testing in HEADSTART | 1,7 | 3,9 | 3,6 | 2,4 | 1,7 |
| | Total Average Score | 3,7 | 3,8 | 3,2 | 3,5 | 3,1 |

# HEADSTART: selected use cases


Truck Platooning

Highway pilot


Traffic-jam chauffeur

- Objective of the "HEADSTART week" webinars

# Introduction use case: Truck platooning

✓ Truck platooning refers to

**two or more cooperative trucks driving together in a line,**

**maintaining a close distance enabled by vehicle-to-vehicle (V2V) communication**

✓ Relevance of HEADSTART KETs:

- Communication V2X
- Positioning (GNSS)

✓ Main safety and security assessment stakeholders:

- OEMs & TIERs
- Type approval authorities
- ~~Consumer organisations (like Euro NCAP)~~

# Introduction use case: Truck platooning

✓ To limit scope:

Automation level closest to real-life deployment as basis for discussion:

- the first truck in the platoon is driven manually by a human driver

  possibly supported by advanced driver assistance systems (ADAS), like Adaptive Cruise Control (ACC) or Autonomous Emergency Braking (AEB).
- the following truck(s) have fully automated longitudinal control

  whereas a (safety) driver in each of these trucks is responsible to keep the following truck in its lane.

This automation level is similar to ENSEMBLE level A.

Used as basis for discussion, but with outlook to higher levels of automation.

# Introduction use case: Truck platooning

- ✓ Functional requirements:
  - Operational Design Domain (ODD)
  - Object and Event Detection and Response (OEDR)
  - tactical manoeuvre behaviour

# Introduction use case: Truck platooning

✓ Typical truck platooning (*as example*):

| Infrastructure | |
|---|---|
| Road type | Highway , Multilane |
| Road surface | Asphalt, concrete |
| Road marking | White lane marker |
| Road geometry | Straight, curves, exit/entrance lanes, tunnels, bridges, inclines/declines<br>Intersections not included |
| **Operational constraints** | |
| Driving direction | One-directional traffic<br>Traffic from other direction is separated by a barrier |
| Minimum speed limit | 0 kph |
| Maximum speed limit | 90 kph |
| Maneuvers | Longitudinal control automated (accelerate, decelerate, braking)<br>Lateral maneuvers not included (lane change, exit/enter highway) |
| Communication protocol? | |
| **Environmental constraints** | |
| Weather | Included: Sunny, cloudy, light rain, …<br>Excluded: heavy rain, storm, snow, … |
| Weather induced road conditions | Included: Dry/Damp surface, …<br>Excluded: Slate, Icy surface, Snow, … |
| Lighting conditions | Daylight, Dark, Dusk/Dawn |

| Environmental conditions | |
|---|---|
| Visibility | Low (fog, night time driving, sun's glare) to good visibility conditions.<br>Minimum visibility of X |
| Road friction | Slippery (ice, slate, rain) to normal roads<br>Minimum grip level of X |
| Heavy traffic (slower speeds) | Maximum traffic density of X |
| Emergency vehicle approaching | |
| Humans or big animals on the road | |
| Approaching a | |
| **Infrastructure** | |
| Highway or comparable road | (min/max nr of lanes? Intersections on highway? Separation of direction?) |
| Driving uphill | Maximum gradient of X |
| Driving downhill | Maximum gradient of X |
| Driving in tunnels | (maximum length?) |
| Driving near highway entry/exit ramps | |
| Obstacle on the lane | Minimum obstacle size of X |
| Curve radius of the road | Minimum road curvature of X |
| Unexpected object/vehicle on the road shoulder | |
| Special zone policy | e.g. toll gates, construction zones, bridges, city-limits |
| Maximum velocity per country in the EU | |

# Introduction use case: Truck platooning

- ✓ International context:
  Truck platooning being researched and implemented in different regions in the world:
  - Europe
  - United States
  - Japan
  - …



# Introduction use case: Truck platooning

- ✓ Question 1:

  Do you agree with statement below for truck platooning:

  A. Single-brand systems for both US and EU
  B. Multi-brand systems essential for both US and EU
  C. Multi-brand systems essential for EU and single-brand systems for US
  D. None of the statements above, because …

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# Introduction use case: Truck platooning

- ✓ Scoping

  V2X/cooperative essential for truck platooning:

  1) sharing operational and tactical data between multiple vehicles
  2) real-time, safety-related data
  3) received messages and transmitted messages are often not independent:

     Example: A received "Join request" will trigger a "Join response": Not accepted/Accepted (with additional configuration settings)

- ✓ Possible approaches:

  Single vehicle and/or platoon of vehicles approach

# Introduction use case: Truck platooning

✓ Question 2:

EU type approval for truck platooning to be done on:

A. Single vehicle level
B. Full platoon level
C. Both single vehicle level and full platoon level
D. Other: …

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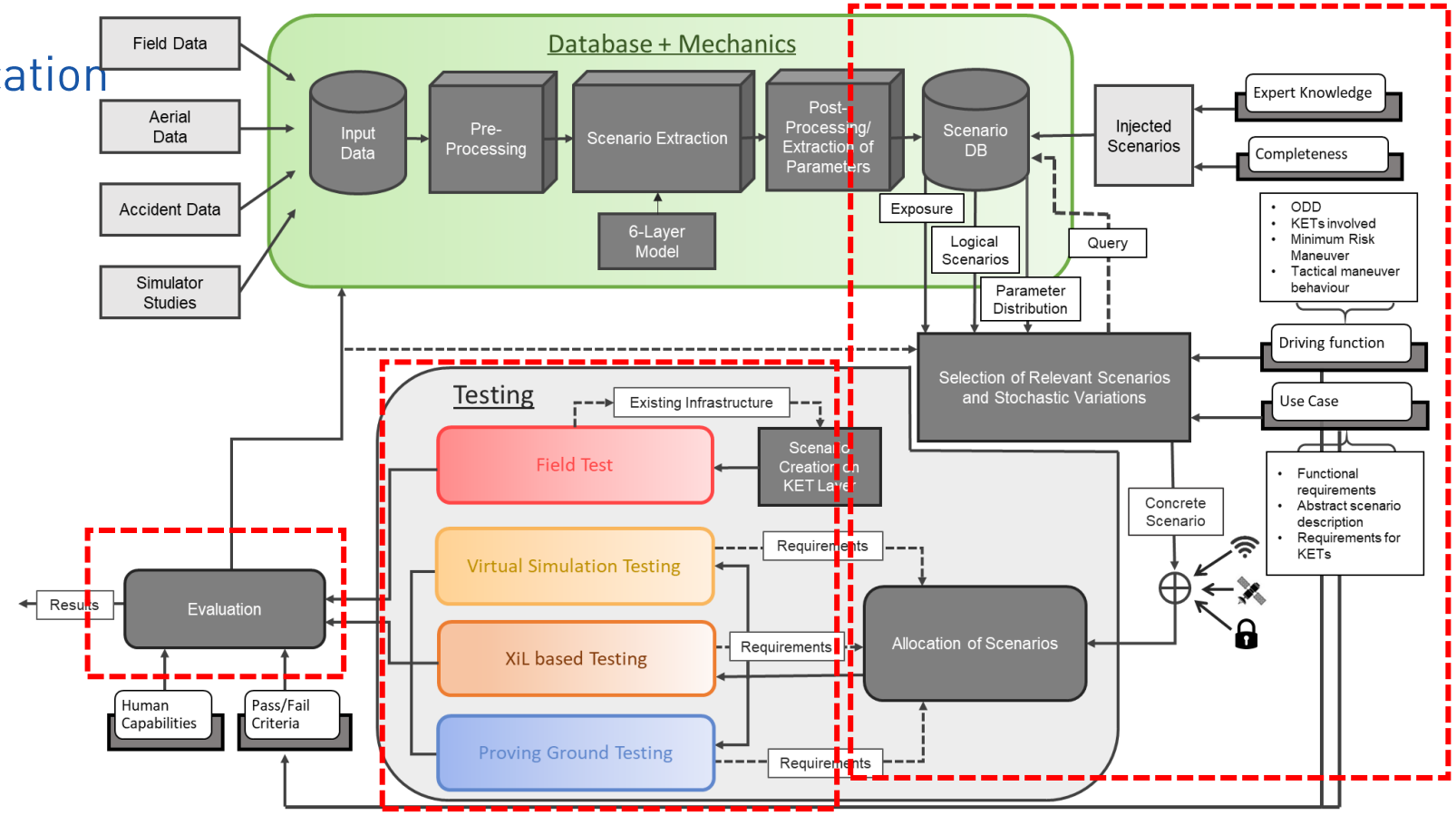
# Introduction use case: Truck platooning

- ✓ Show survey results:
  - Q1
  - Q2

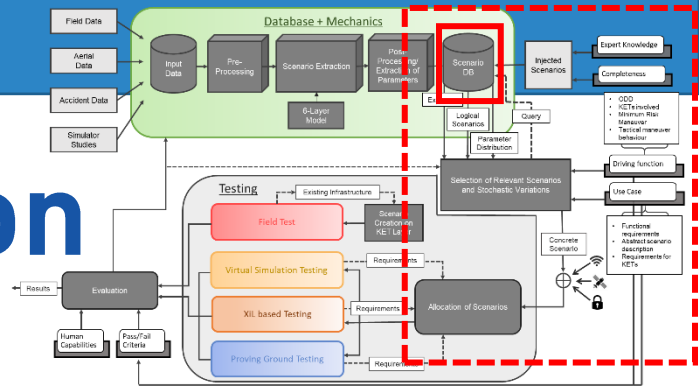
- ✓ Open questions

# HEADSTART method

- ✓Scenario selection and allocation
- ✓Testing of scenarios
- ✓Evaluation of test results



# Scenario selection and allocation




- ✓ Scenario database

  Current scenario databases (often) miss information on:

  - Communication V2X
  - Positioning (GNSS)
  - Cybersecurity

# Scenario selection and allocation

✓ Question 3:

Ultimately the (truck platooning) scenario database(s) should also include:

A. Communication V2X parameters
B. Positioning (GNSS) parameters
C. Cybersecurity parameters
D. Others missing parameters: …
E. None additional parameters needed.

Please provide as answer: the applicable numbers (multiple possible) and additional parameters.

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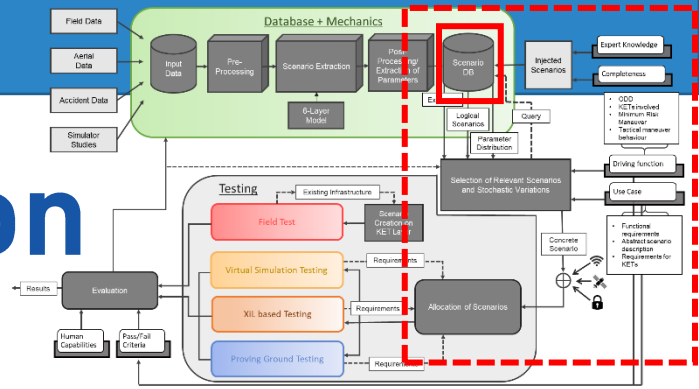
# Scenario selection and allocation




✓ Scenario database

Databases can be representative for / contain information of:

- Various vehicle types
  - Passenger cars
  - Trucks
  - …
- Various configurations / automation levels
  - SAE levels
  - Platooning
  - …
- Regions of the world
  - Europe
  - United States
  - Japan
  - …

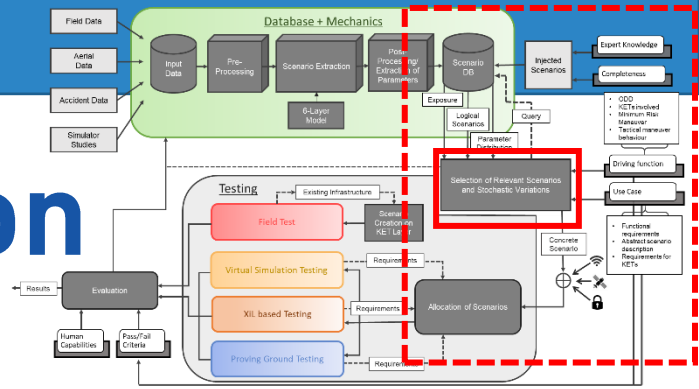
# Scenario selection and allocation

- ✓ Question 4:

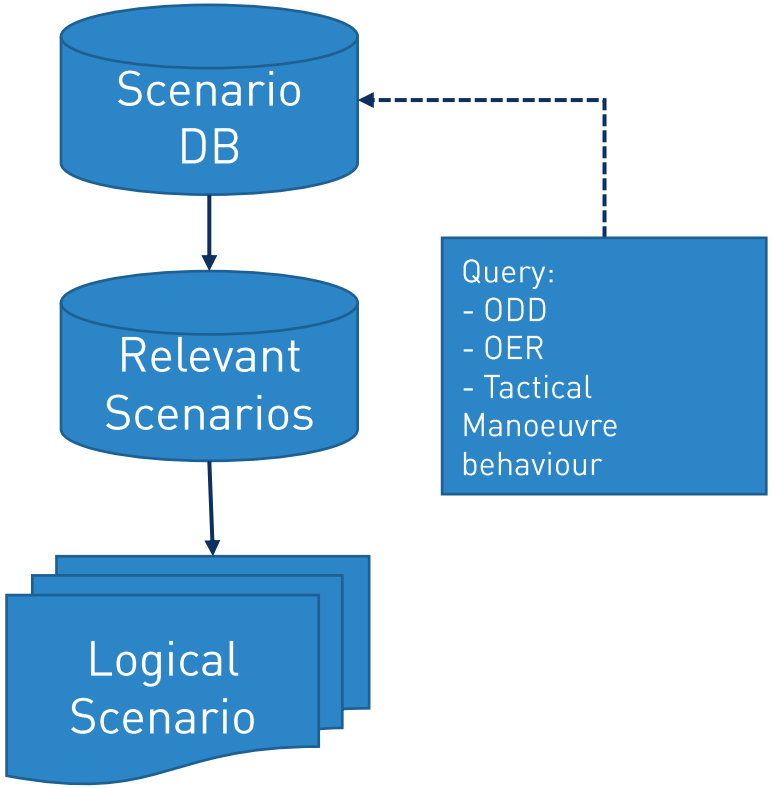
  Scenario database(s) needed:

  A. Single world database for all vehicle types and automation levels (incl. platooning)
  B. World database per vehicle type and automation level (incl. platooning)
  C. Regional database for all vehicle types and automation levels (incl. platooning)
  D. Regional database per vehicle types and automation level (incl. platooning)
  E. Other: …

# Scenario selection and allocation

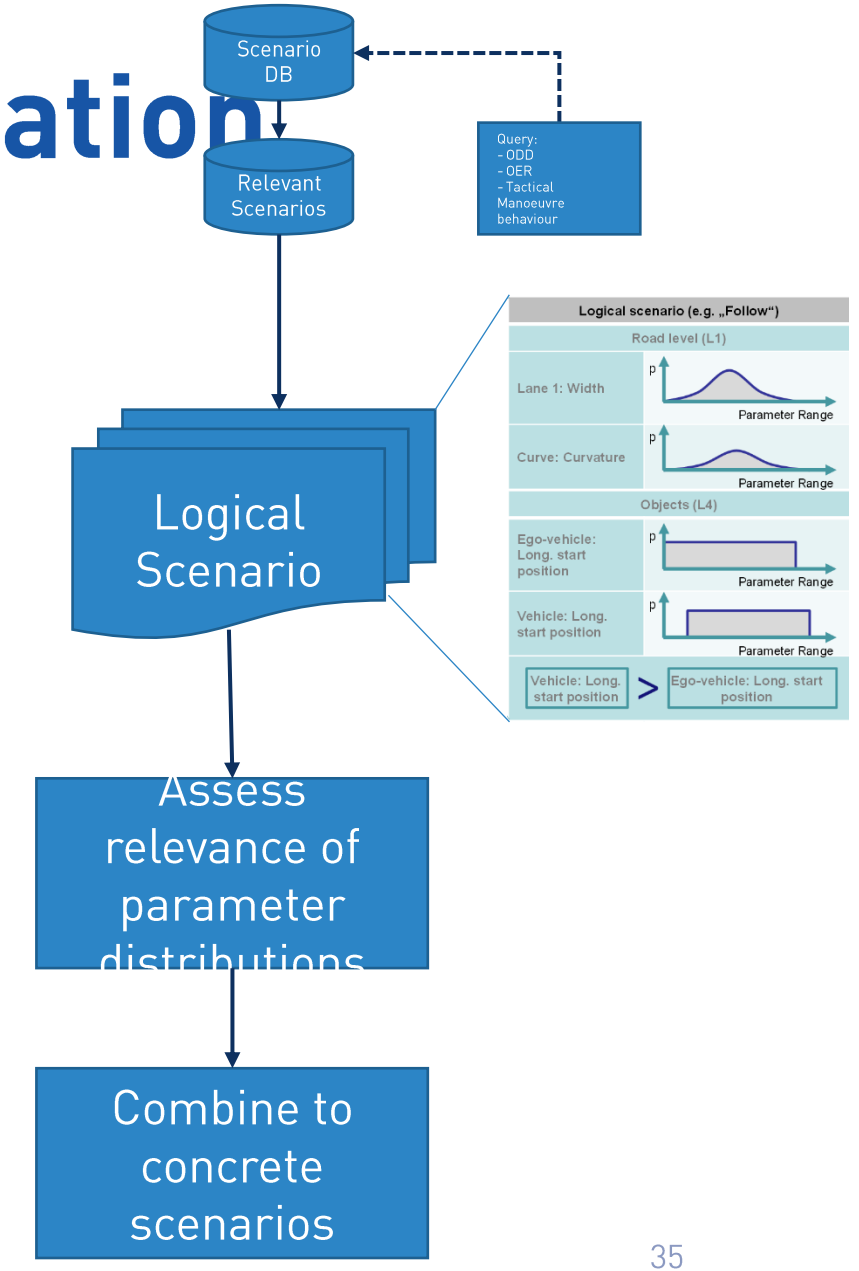



- ✓ Scenario selection – Filtering logical scenarios
  - Relevant logical scenarios filtered based on functional requirements
  - Functional requirements of a driving function should at least consist of the:
    - Operational Design Domain (ODD)
    - Object and Event Detection and Response (OEDR)
    - Tactical manoeuvre behaviour



# Scenario selection and allocation

- ✓ Scenario selection – Parameter distribution
  - Gather all relevant logical scenarios with parameter distributions
  - Assess relevance of the parameters
    - Based on probably distributions
    - Taking potential parameter constraints into account
    - Considering prohibited parameter combinations
  - Combine to concrete scenarios



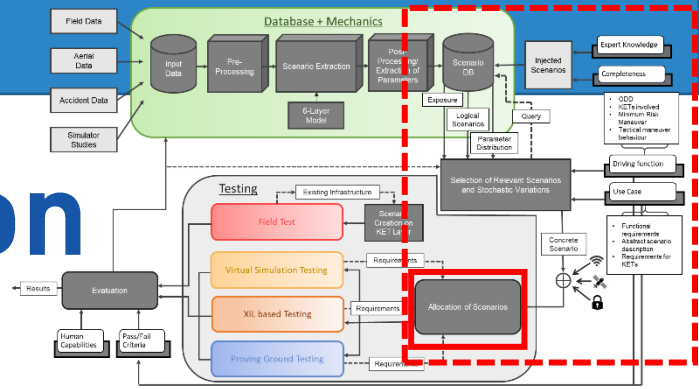
# Scenario selection and allocation

- ✓ Question 5:

  Wrt the format for concrete scenarios (for truck platooning):

  A. Essential to have worldwide format
  B. Multiple formats possible, but per region one
  C. Multiple formats possible within a region
  D. Other: …

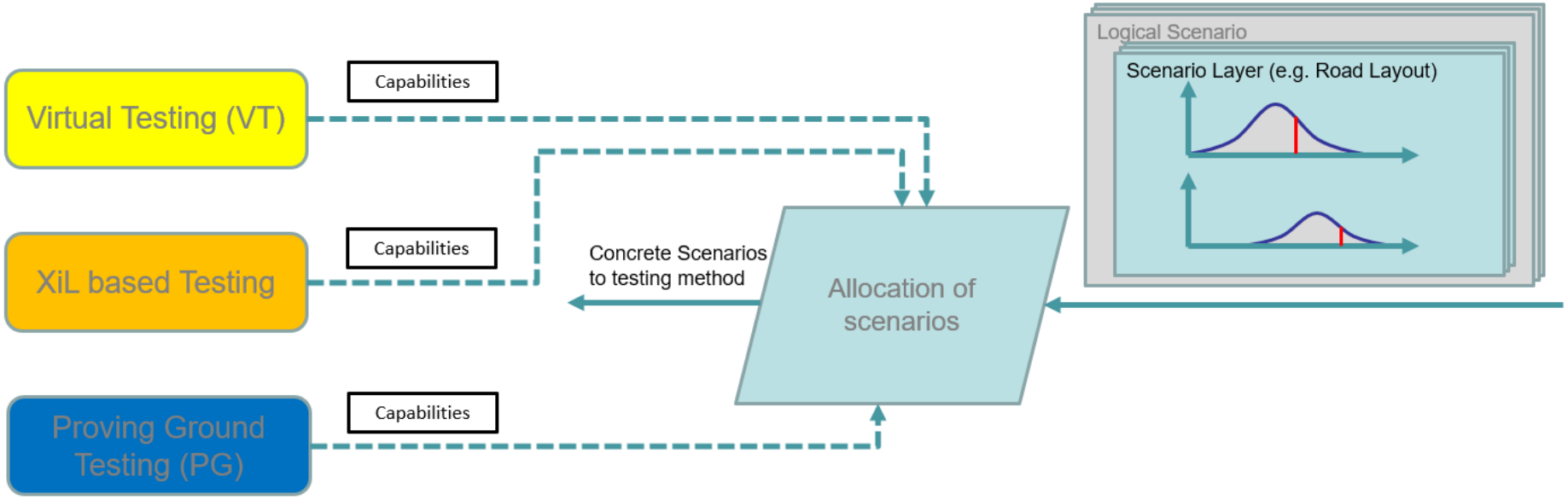
# Scenario selection and allocation




- ✓ Scenario allocation

  3 test methods:

  - Virtual Testing (VT)
  - X in the Loop (XiL) based Testing
  - Proving Ground Testing (PG)



# Scenario selection and allocation

- ✓ Show survey results:
  - Q3
  - Q4
  - Q5

- ✓ Open questions

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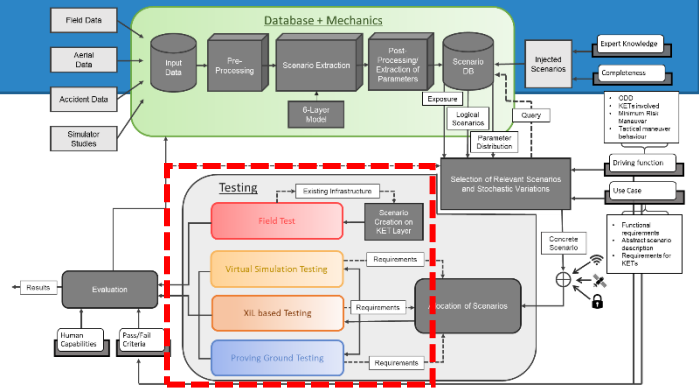
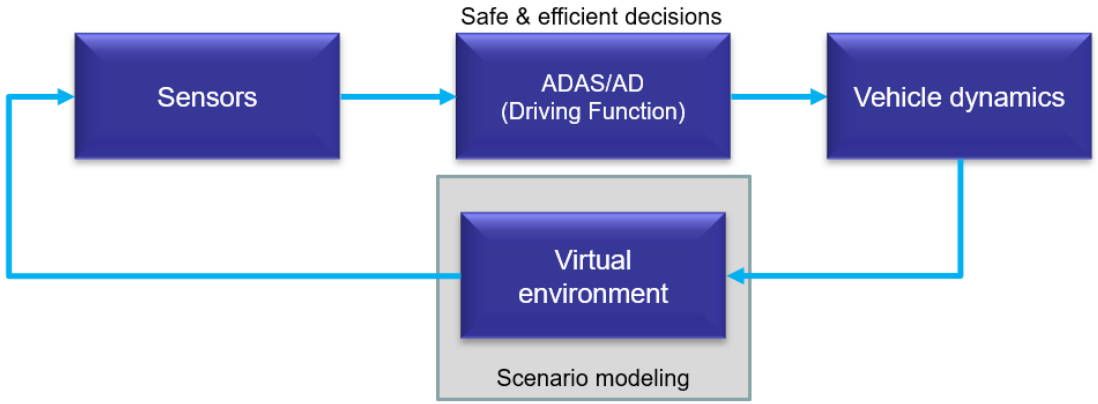
# Testing of scenarios

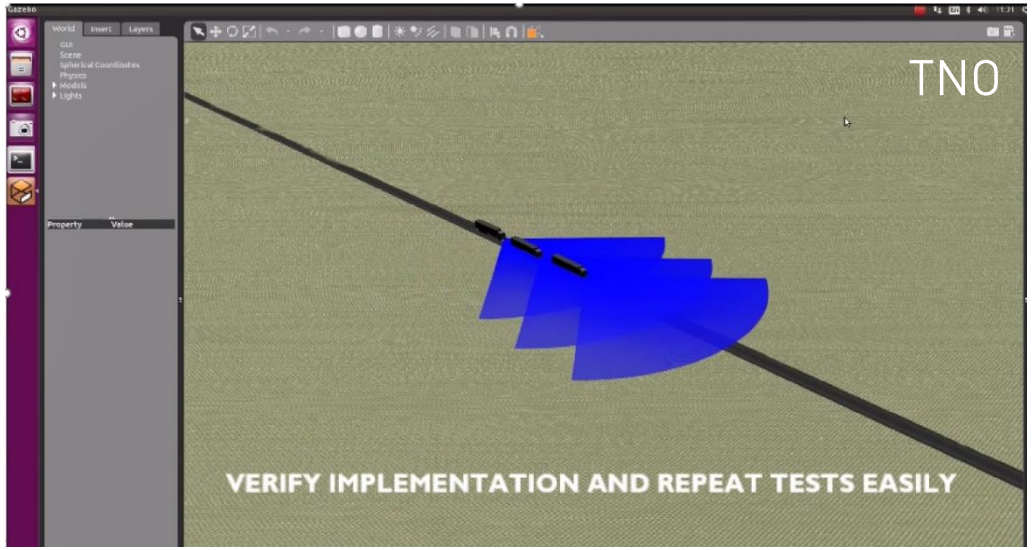



- ✓4 testing methods
  - Virtual Testing (VT)
  - XiL based Testing
  - Proving Ground Testing (PG)
  - Field test (public road)

# Testing of scenarios

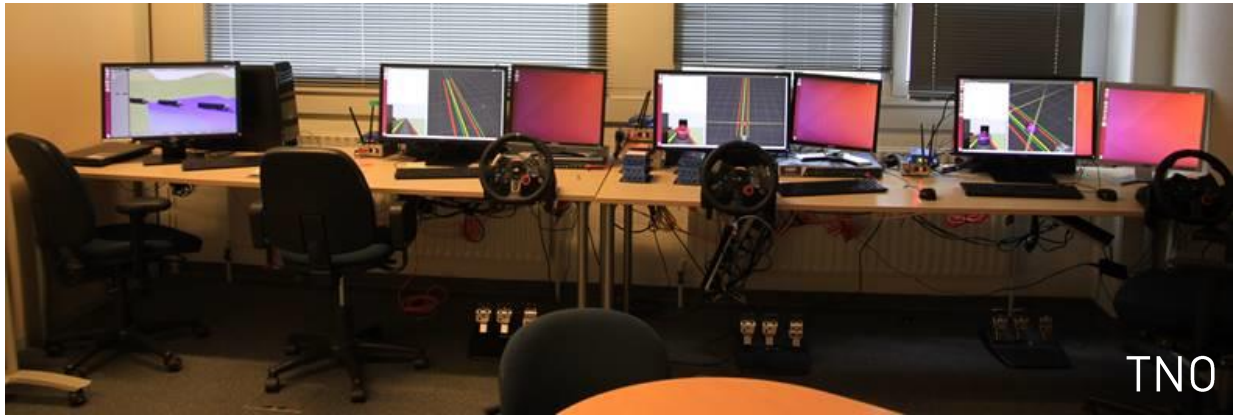
- ✓Virtual Testing (VT)
  - Pros
    - Easy to evaluate and compare different systems under identical conditions
    - Large set of scenarios with parameters can be evaluated
  - Cons
    - Model creation and validation expensive



# Testing of scenarios

- ✓XiL based testing
  - Pros
    - Evaluation of critical components possible, for example Communication V2X components
    - Controlled and repeatable environment
  - Cons
    - Model creation and validation expensive
    - Interaction model – real parts

# Testing of scenarios

- ✓ Question 6:

  Do you believe XiL testing is an essential part of CAD assessment and truck platooning in particular:

  A. Yes, also in the future
  B. Yes, at least for the coming years
  C. No
  D. Other: …

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# Testing of scenarios

- ✓ Proving Ground (PG)
  - Pros
    - Full system testing possible
    - Controlled and safe environment
  - Cons
    - Geofencing
    - Limits for Communication V2X and Positioning (GNSS) performance
    - Large space needed for truck testing, platooning in particular
    - Limited infrastructure features: bridges / tunnels / undulated roads
    - Limited V2I availability




# Testing of scenarios

- ✓ Field test (public road)
  - Pros
    - Multi-actor testing in real environment
    - Geofencing testing
    - Results feedback into other testing configurations
  - Cons
    - Limited control over scenarios / Scenarios as they are encountered
    - Public road allowance / exemption

# Testing of scenarios

✓ Question 7:

Do you believe alternative ways of testing are needed for assessment of CAD, in particular Truck platooning?

A. Yes, also in the future
B. Yes, at least for the coming years
C. No
D. Other: …

If Yes, please indicate which type of testing.

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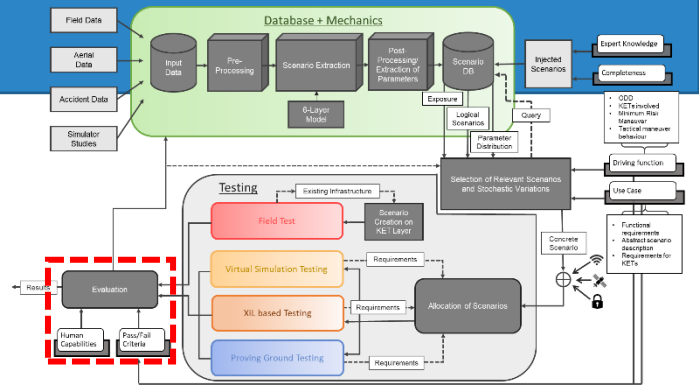
# Testing of scenarios

- ✓ Show survey results:
  - Q6
  - Q7

- ✓ Open questions

# Evaluation of test results




- ✓ Evaluation
  - Depends on
    - Driving function
    - Use Case
    - Stakeholder:
      - OEMs & TIERs
      - Type approval authorities
      - Consumer organisations (like Euro NCAP)

- ✓ Especially relevant for Truck platooning
  - Proper handling of Communication V2X issues
  - Correct Positioning GNSS

# Evaluation of test results

- ✓ Question 8:

  Do you see additional stakeholders (besides OEMs, TIERs and type approval authorities) for scenario based safety assessment of truck platooning?

  A. No
  B. Yes, ...

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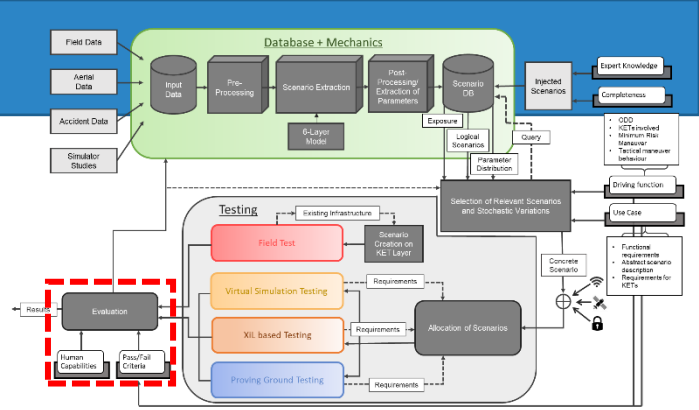
# Evaluation of test results




- ✓ Additional benefits
  - Link of logged/recorded data as input for “scenario database”
  - Feedback loop to scenario selection

# Evaluation of test results

- ✓ Question 9:

  Do you see additional areas of usage for results of scenario based CAD assessment as proposed by HEADSTART?

  A. No

  B. Yes, …

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# Evaluation of test results

- ✓ Show survey results:
  - Q8
  - Q9

- ✓ Open questions

# Wrap-up

- ✓ Question 10:

  The biggest challenge for use case Truck platooning to be implemented worldwide on large scale is:

  A. Type approval
  B. Liability
  C. Viable business case
  D. Consumer acceptance
  E. Other: …

# Wrap-up

✓ Summary – Recap

✓ Slides, voting results and recording will be shared and published on HEADSTART website

✓ Feedback will be integrated in HEADSTART deliverable:

D2.3 Assessment method for each of the use cases defined

# Wrap-up

- ✓ Show survey results:
  - Q10
- ✓ Final Q&A

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# Wrap-up

- ✓ Follow-up plans and next steps HEADSTART:
  - Definition of procedures and tools in HEADSTART WP3
  - Application and demonstration of method, procedures and tools in HEADSTART WP4
  - Wrt HEADSTART use case: Truck platooning
    - Cooperation with ENSEMBLE and individual OEMs

- ✓ Next HEADSTART sessions:
  - HEADSTART **Validation of use case: Traffic Jam Chauffeur** webinar on Thursday May 14th 10:00-11:30 CET.
  - HEADSTART **Cybersecurity validation in automated driving** webinar on Friday May 15th 10:00-11:30 CET.
  - HEADSTART **Wrap-up & lessons from HEADSTART Week webinar** on Friday May 15th 11:30-11:45 CET.
  - HEADSTART WP2 & WP3 dissemination webinar in September (dates to be confirmed)


HEADSTART WEEK
1 WEBINAR PER DAY
The free webinars will take place from Monday, 11/05 to Friday, 15/05.


Presentation of the HEADSTART week
WEBINAR
Monday, 11/05/2020
09:45 - 10:00 CET


Overall methodology and processes for testing and validati
automate
road vehicle
WEBINAR
Monday, 11/05/2020
10:00 - 11:30 CET


HEADSTART validation methodology applied for the tru
platooning
use case
WEBINAR
Tuesday, 12/05/2020
10:00 - 11:30 CET


Validation of use case: Traffic jam chauffeur
WEBINAR
Thursday, 14/05/2020
10:00 - 11:30 CET


Cybersecurity validation in automated driving
WEBINAR
Friday, 15/05/2020
10:00 - 11:30 CET


Wrap-up & lessons from HEADSTART Week Webinar
WEBINAR
Friday, 15/05/2020
11:30 - 11:45 CET

# Cooperate with HEADSTART project

## EXPERT GROUP PARTICIPATION

- Join as associated partner and our expert group
- Join the discussion group of your interest:
  - Cyber-security
  - Communications (V2X)
  - Positioning
  - Scenario selection
  - Consumer testing (NCAP)
  - Type approval
- Provide needs and requirements and evaluate project (intermediate) results

## JOINT TESTING ACTION

- ✓ Joint cooperation between both projects for testing validation and certification purposes
- ✓ Align your project with the harmonized methodology and tools developed within HEADSTART
- ✓ Become one of our use cases!

Please let us know about your interest and join our distribution list.
Website: www.headstart-project.eu
Contact: info@headstart-project.eu

# Stay connected with HEADSTART

- ✓Visit HEADSTART website

  www.headstart-project.eu

- ✓Follow our Social Media:

  @HEADSTART_EU

  HEADSTART-PROJECT

  HEADSTART project (Group)

  @HeadstartEUproject

- ✓Reach us via an e-mail:

  info@headstart-project.eu

- ✓Sign up to our newsletter:

  https://lists.iccs.gr/wws/subscribe/headstart-news

- ✓Get in touch with our partners

# Thank you!

*Any questions?*


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