PEGASUS

First Steps for Safe Introduction of Automated Driving

PEGASUS

Prof. Dr. Hermann Winner | July 11, 2017

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

Current State of Development of Highly Automated Driving

Prototypes

- multitude of prototypes built by OEM with HAD-functionality
- evidence, that HAD is technologically possible
- partially tested in real traffic situations
- test drives involve backup safety driver

Lab / Test Ground

- individual ana
  optimize p
- current
  ground
  enough
  for all
  currentl
- there is n
  for adequa
  (particularly
  performance)
  systems

Advancement through PEGASUS

current status

Products

no release or
troduction of variety of
D-features without
cient assurance

OEM = Original Equipment Manufacturer HAD = Highly Automated Driving

PEGASUS Key Figures

project for the **e**stablishment of **g**enerally **a**ccepted quality criteria, tools and methods as well as **s**cenarios and **s**ituations for the release of highly-automated driving functions

42 months term	January 2016 – June 2019
17 partners	▪ OEM: Audi, BMW, Daimler, Opel, Volkswagen ▪ Tier 1: ADC Automotive Distance Control, Bosch, Continental Teves ▪ Test Lab: TÜV SÜD ▪ SMB: fka, iMAR, IPG, QTronic, TraceTronic, VIRES ▪ scientific institutes: DLR, TU Darmstadt
Affiliated partners & Subcontracts	▪ i.a. BASt, IFR, ika, OFFIS
Project volume	▪ approx. 34,5 Mio. EUR ▪ subsidies: 16,3 Mio. EUR
Personnel deployment	▪ approx. 1.791 man-month or 149 man-years

Project coordination, Project office

Central Issues of the PEGASUS Project

What level of performance is expected of an automated vehicle?
How can we verify that it achieves the desired performance consistently?

Scenario Analysis & Quality Measures

What human capacity does the application require?

What about technical capacity?

Is it sufficiently accepted?

Which criteria and measures can be deducted from it?

Implementation Process

Which tools, methods and processes are necessary?

Testing

How can complete-ness of relevant test runs be ensured?

What do the criteria and measures for these test runs look like?

What can be tested in labs or in simulation? What must be tested on test grounds, what must be tested on the road?

Reflection of Results & Embedding

Is the concept sustainable?

How does the process of embedding work?

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Scenario Analysis and Quality Measures

Deduction of requirements
based on the
accepted measure of quality

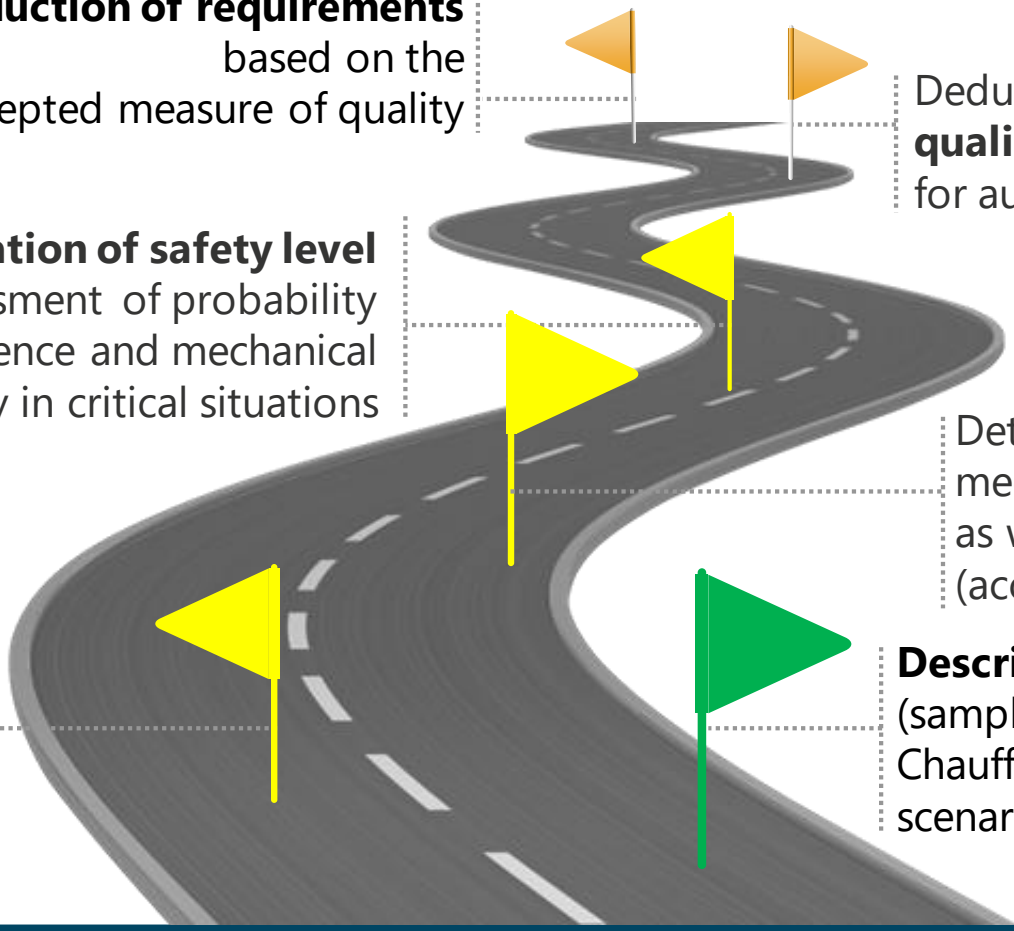
Deduction of an **accepted quality measure**
for automated driving features

Determination of safety level
through assessment of probability of occurrence and mechanical manageability in critical situations

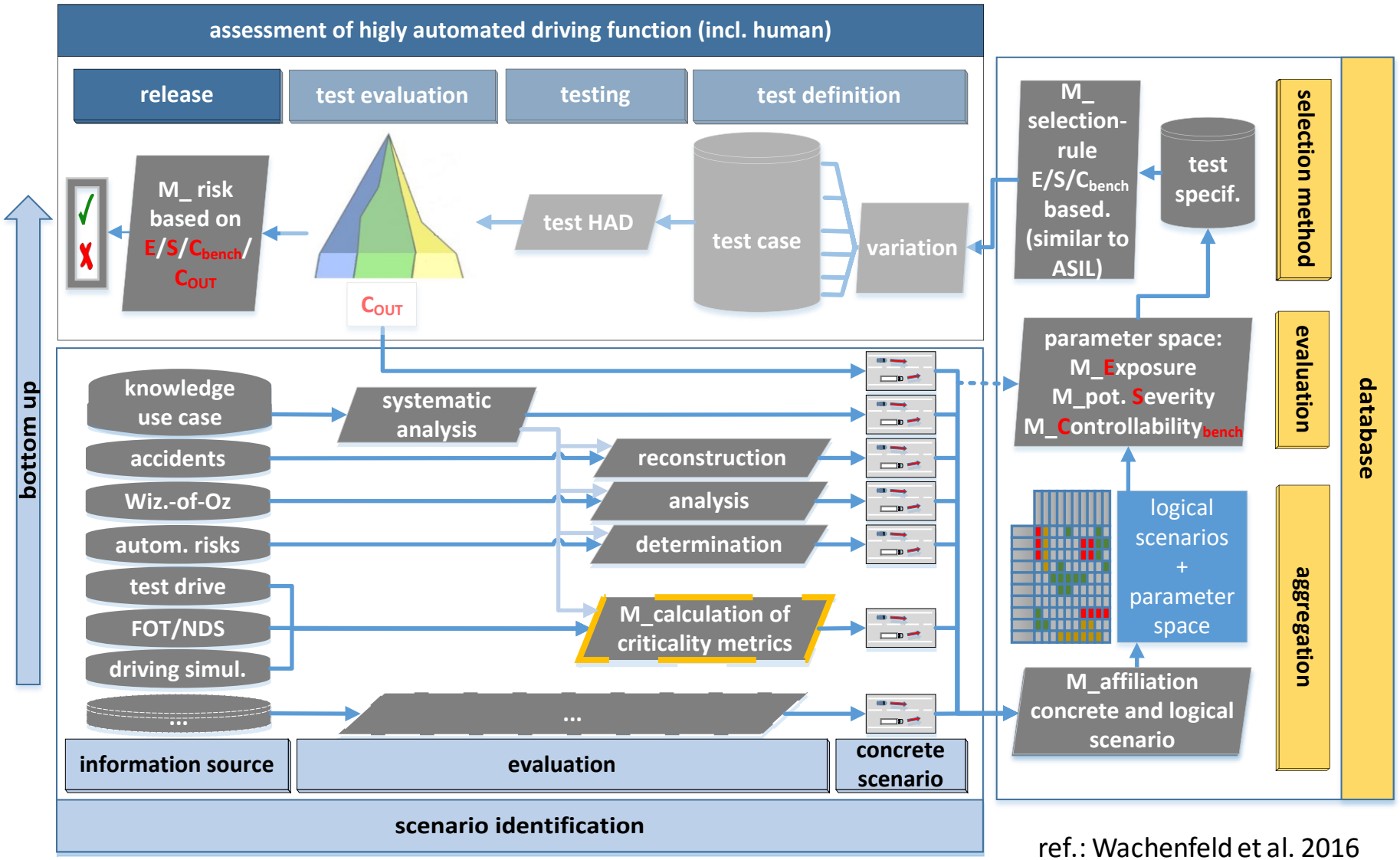
Determination of human and mechanical **performance** as well as **effectiveness** (accident avoidance potential)

Determination of critical **traffic situations**

Description of application scenario
(sample application: Highway Chauffeur + enhanced application scenario)



PEGASUS Metrics Perspective



ref.: Wachenfeld et al. 2016

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Implementation Process

Analysis

of modification needs of existing metrics and automobile series development processes

1

Transfer

of systematic scenario guidelines into process steps in consideration of system classifications and levels of vehicle utilization

2

Transfer

of target value parameters into process steps

3

Preparation

of requirements definition for simulation, lab tests, test ground and field coverage

4

Refinement

of the guidelines for required documentation of process steps

5

Guidelines and Protocols

for the documentation of technological state-of-the-art compliance during the development process

6

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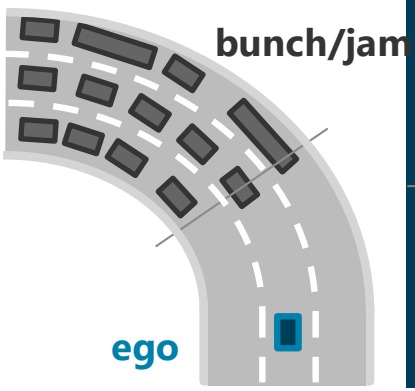
Reflection of Results & Embedding

Generation of scenarios: levels of abstraction



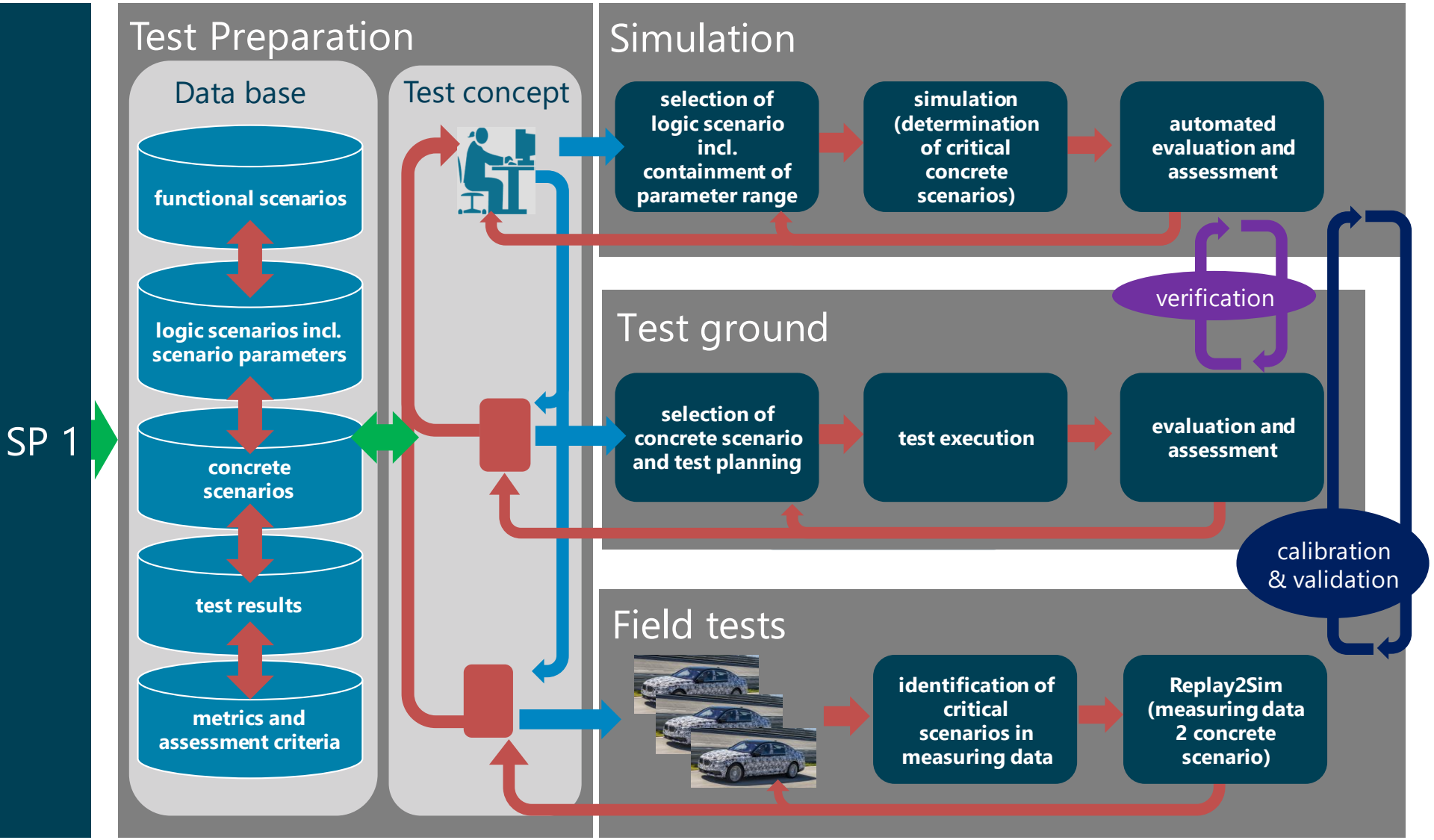
Functional scenarios	Logic scenarios	Concrete scenarios
Basis road:	Basis road:	Basis road:
highway in bend	number of lanes [2..4] curve radius [0,6..0,9] kph	number of lanes 3 curve radius 0,7 km
Stationary objects:	Stationary objects:	Stationary objects:
-	-	-
Movable objects:	Movable objects:	Movable objects:
ego, jam; interaction: ego approaches end of jam	End of jam position [10..200] m jam speed [0..30] kph ego distance [50..300] m ego speed [80..130] kph	end of jam position 40 m jam speed 30 kph ego distance 200 m ego speed 100 kph
Environment:	Environment:	Environment:
summer, rain	temperature [10..40] °C droplet size [20..100] µm rain amount [0,1..10] mm/h	temperature 20 °C droplet size 30 µm rain amount 2 mm/h

number of scenarios

level of abstraction

Source: Lemmer VDA 2017

Testing


SP 1
Test Preparation
Data base
functional scenarios
logic scenarios incl. scenario parameters
concrete scenarios
test results
metrics and assessment criteria
Test concept
Simulation
selection of logic scenario incl. containment of parameter range
simulation (determination of critical concrete scenarios)
automated evaluation and assessment
verification
Test ground
selection of concrete scenario and test planning
test execution
evaluation and assessment
calibration & validation
Field tests
identification of critical scenarios in measuring data
Replay2Sim (measuring data 2 concrete scenario)

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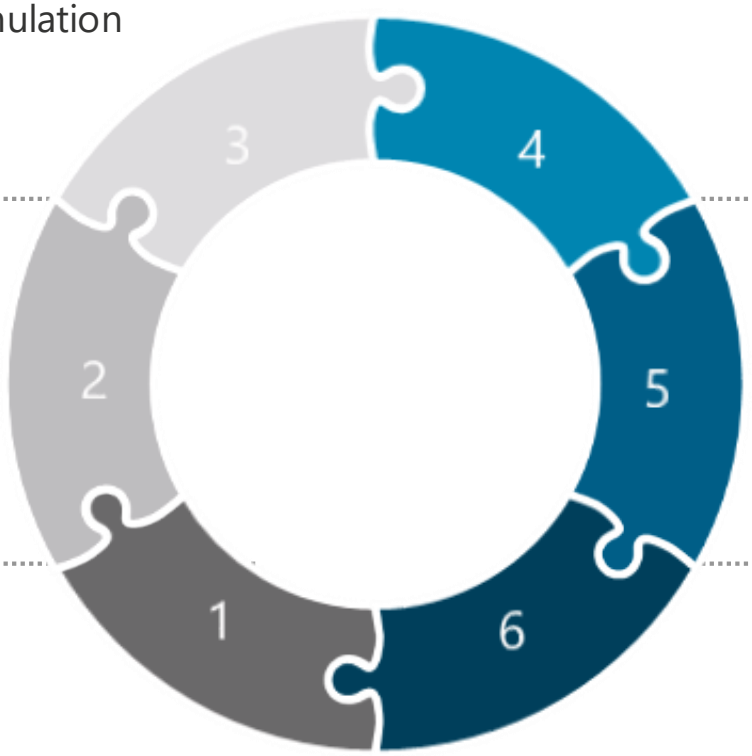
Reflection of Results & Embedding

Statement

about the distribution ratio between the applied test methods (from simulation to test ground to field test)

Proof of Concept

trough verification (1), assessment (2) and statement (3)



Assessment,

whether the test goal can be achieved with the utilized processes and methods in PEGASUS

Assistance

with embedding of acquired results with our project partners

Verification

of methods to identify relevant situations, quality and criticality measures for the assurance of HAD features

Lessons learned

regarding the implementation of the results in existing corporate structures

PEGASUS Goals beyond Research

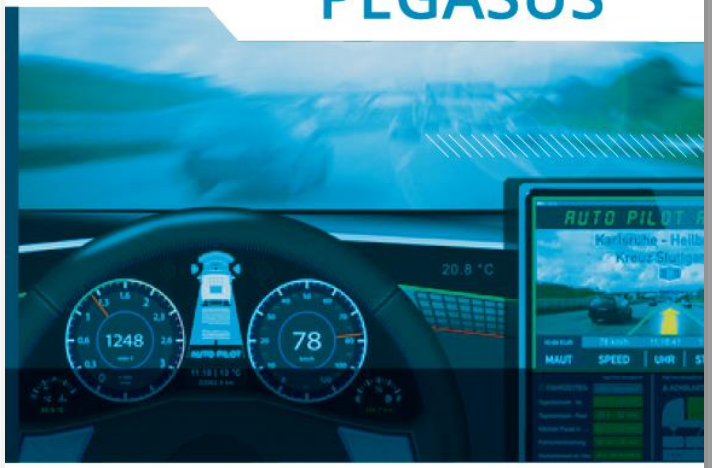
- PEGASUS is a national project implementation for fast progress in automated driving.
- Embedding of findings in the industry.
- Distribution and pioneering of a standardization.

➔ All essential project results are freely accessible.

- Collaboration with other consortia is highly appreciated.
- We need a worldwide common understanding about how safety of automated driving has to be assured.
- Exchange with safety assurance experts worldwide at PEGASUS Symposium with interim presentation (9th of November 2017)

PEGASUS Symposium Nov. 9, 2017, Aachen

PEGASUS



PEGASUS Symposium -
HOW SAFE IS SAFE ENOUGH?

09. November 2017

Institute for Automotive Engineerng (ika)
Aachen

ABOUT THE EVENT

HOW SAFE IS SAFE ENOUGH?
HOW TO PROOVE THAT THE AUTOMATION IS GOOD ENOUGH?
17 scientific and industry partners are working in the joint research project PEGASUS to answer these questions, define a new state of the art for the test and release of highly automated driving functions and demonstrate the procedure hands-on using a sample application - autonomous Autobahn-driving.

With the **PEGASUS Symposium**, an international platform will be created, which allows an **open exchange for effective and uniform testing** as well as for securing highly-automated vehicles.

The PEGASUS Symposium will be accompanied by an **exhibition** which provides insights of the work in PEGASUS and presents the major results of the first half of the project.

AGENDA

Thursday, 09. November 2017

08:30	Registration
09:00	**Welcome**
09:15	**Keynotes**
11:15	**General introduction to PEGASUS opening of the parallel exhibition**
13:00	**Automated driving initiatives and projects**
15:30	**PEGASUS key activities**
16:30	**Panel Discussion**
17:30	**Dinner speech**
	Evening reception

register online at: www.pegasusprojekt.de

References:

Wachenfeld et al. 2016: Wachenfeld, W.; Junietz, P.; Winner H.; Themann, P.; Pütz, A.: Safety Assurance Based on an Objective Identification of Scenarios – One Approach of the PEGASUS – Project; Presentation TRB-AUVSI-Automated Vehicle Symposium, San Francisco, 2016-07-20

Lemmer, K., VDA, 2017: PEGASUS: Automatisiertes Fahren effektiv absichern (PEGASUS: effectively ensuring automated driving), Presentation slides, VDA Technial Congress 2017

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PEGASUS

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