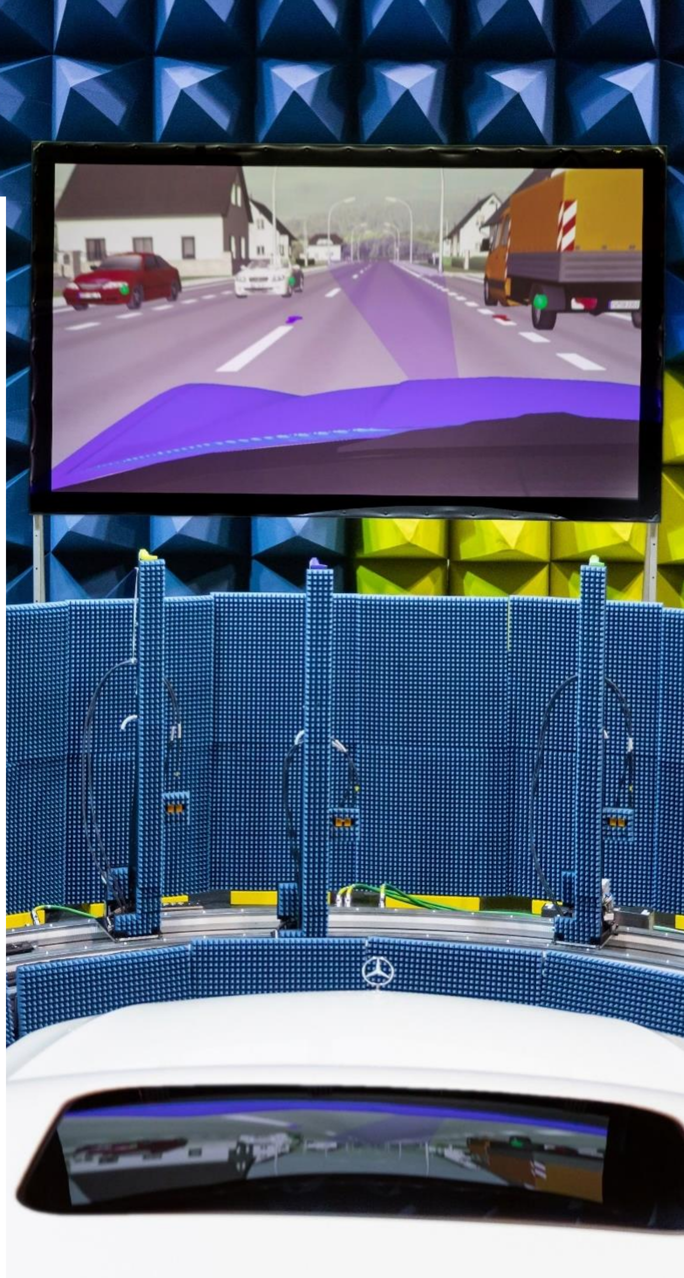
safeCAD-DJ



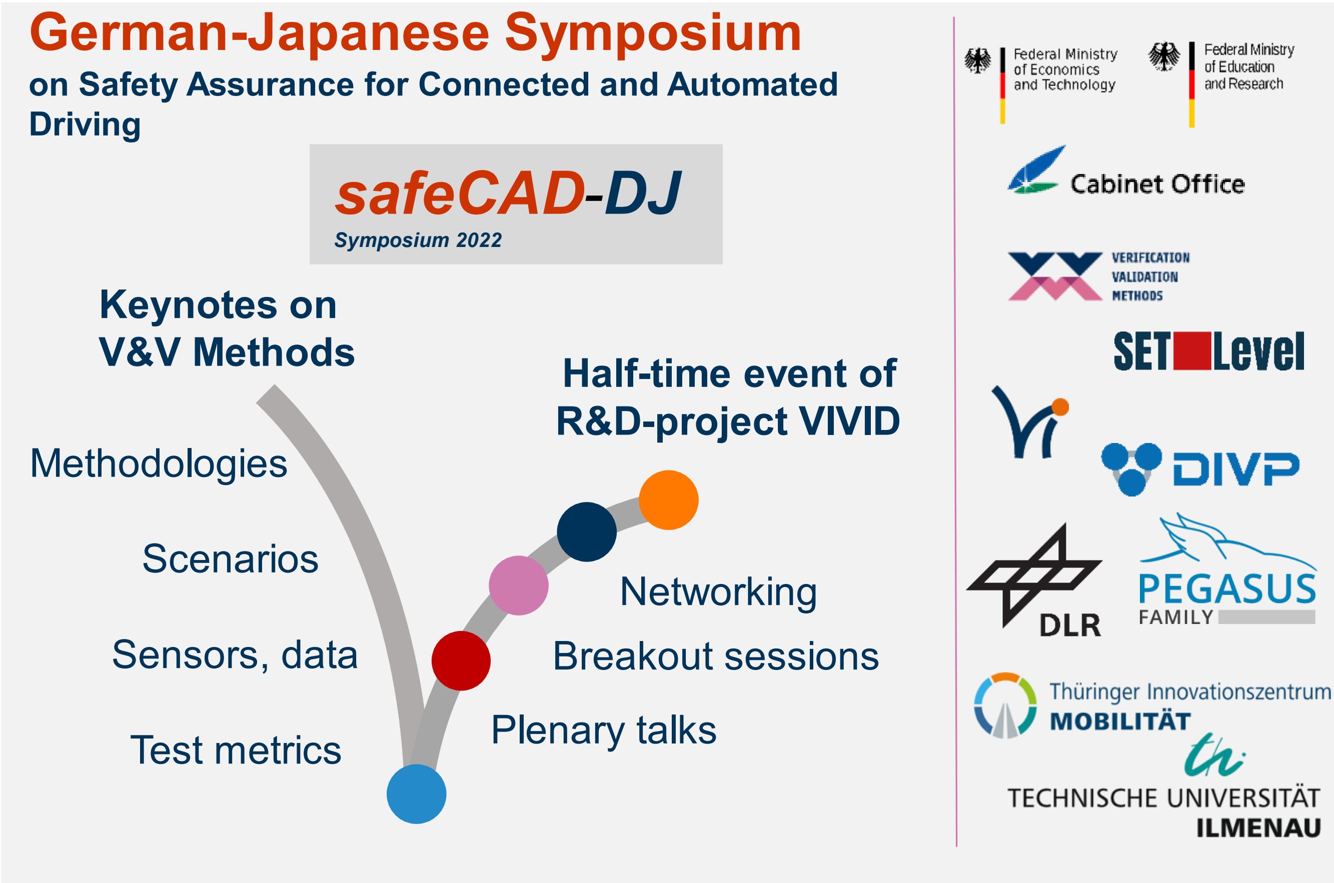
GERMAN-JAPANESE SYMPOSIUM ON SAFETY ASSURANCE FOR CONNECTED AND AUTOMATED DRIVING

June 1st – 3rd 2022

Organizers:

Thuringian Centre of Innovation for Mobility at Technische Universität Ilmenau,
German Aerospace Centre (DLR)

Event flyer



How to find our research projects

[VIVID](#) [DIVP](#) [PEGASUS Family](#) [SET Level](#) [VV Methods](#)

We gratefully acknowledge funding in the framework of the joint industrial-academic projects VIVID (BMBF) and VV-Methods (BMWK) and additional sponsoring from ADC Automotive Distance Control Systems, DLR, and TU Ilmenau.

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- Opening of safeCAD-DJ
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- Networking dinner

Day 3

- Future research and funding perspectives

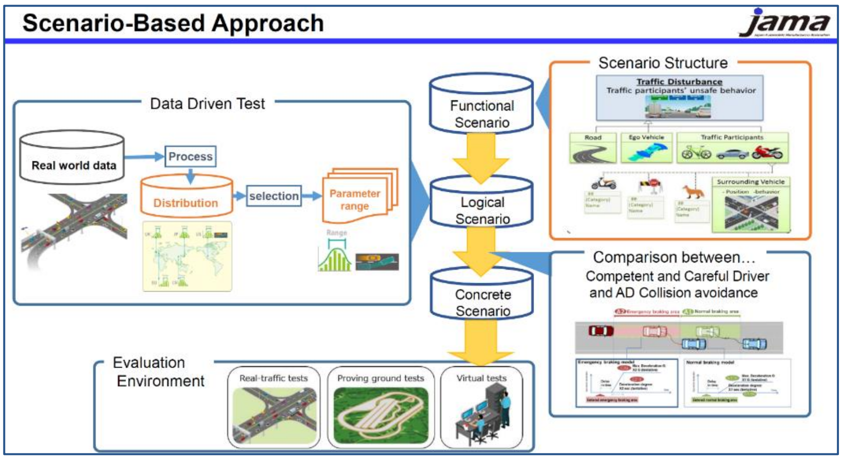
Keynote 1:
Virtual validation platform towards AD-safety assurance – Japanese research activities at JAMA, SAKURA & DIVP

Speaker:
Prof. Hideo Inoue, Kanagawa Institute of Technology, Japan

Conclusions

Safety Evaluation of Automated Driving Systems, JAMA

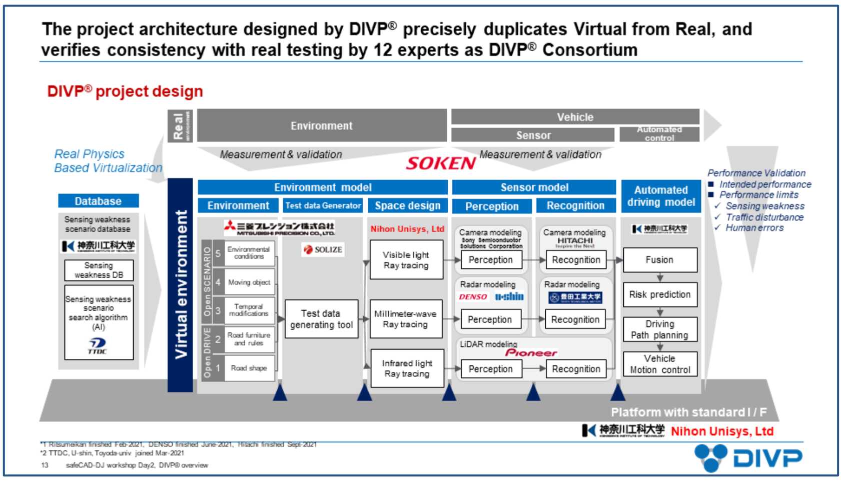
The safety of automated and connected driving cannot be ensured only by endurance tests with long-distance driving but also a definition the scope of validation and the demonstration between virtual and real test environments.



The scenario-based approach describes a method for safety evaluation. The three scenario steps, functional → logical → concrete, form a comprehensive structure for safety coming from the physical principles of automated driving systems targeting highways. In Japan, industry, government, and academia are collaborating on strategic activities to realize safety evaluation for automated driving.

Driving Intelligence Validation Platform for Automated Driving Safety Assurance, DIVP

Highly consistent sensor modelling is a key enabler for virtual validation of AD/ADAS safety assurance. DIVP started as a collaborative consortium between sensor manufacturers, software companies, universities and other parties, by connecting and taking advantage of the expertise of the twelve institutions. The project defines the interface specifications for a safety assurance platform that combines an automated driving control model with a set of models that include the driving environment, spatial propagation, and sensors.

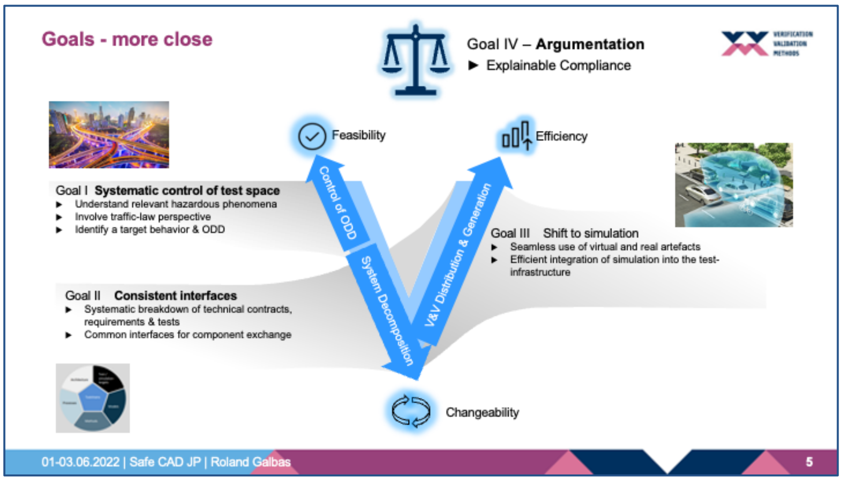


Keynote 2:
VV Methods – From assurance framework to data flow – Results from the German safety assurance project VV Methods

Speaker:
Roland Galbas, Robert Bosch GmbH, Germany

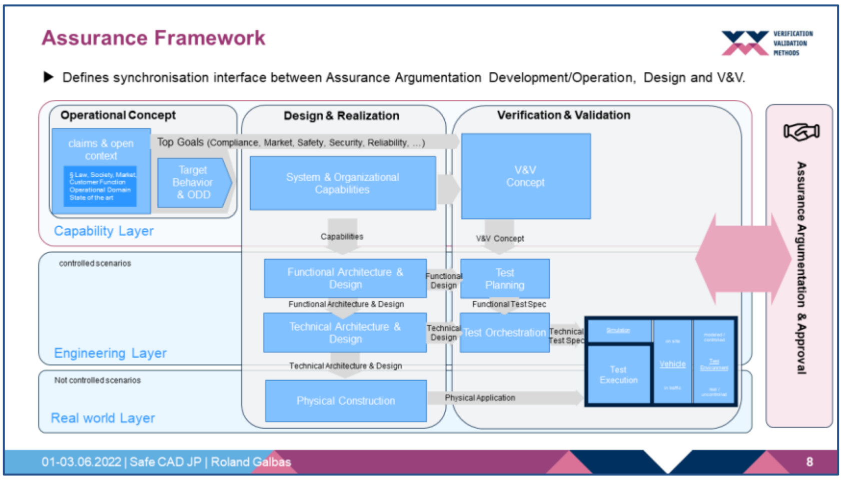
Conclusions

The PEGASUS project family, consisting of the *PEGASUS*, *VV Methods* (VVM), and *SET Level* research projects, focuses on development and testing of methods and tools for AD systems on highways and in urban environments.



The main goals of VVM are: systematic control of test space, industrial interfaces, shift to simulation, and argumentation. For this, VVM has chosen an approach which follows a systematic argumentation of coverage.
The assurance framework of VVM which defines synchronisation interface between the development/operation of assurance argumentation, design, and V&V.

This assurance framework also corresponds to the data-driven engineering (DDE) process of the AI industry.

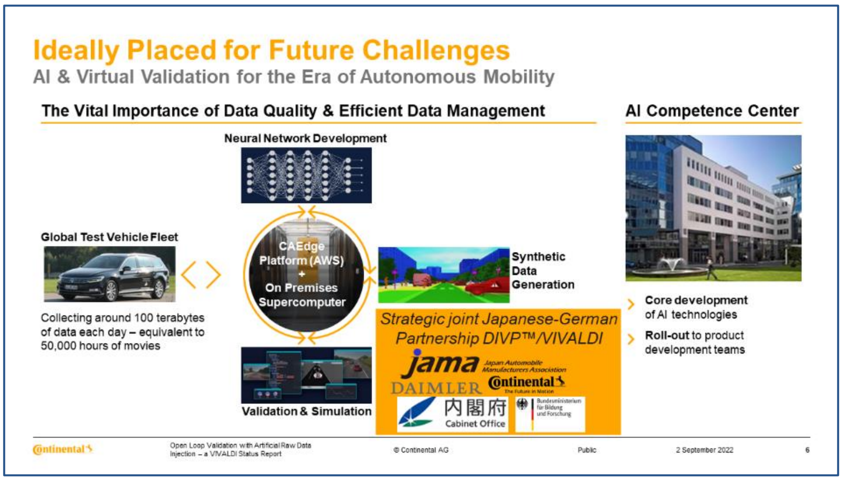


Keynote 3:
Open Loop Validation with Artificial Raw Data Injection – a VIVALDI Status Report

Speaker:
Hasan Iqbal, ADC Automotive Distance Control Systems, Germany

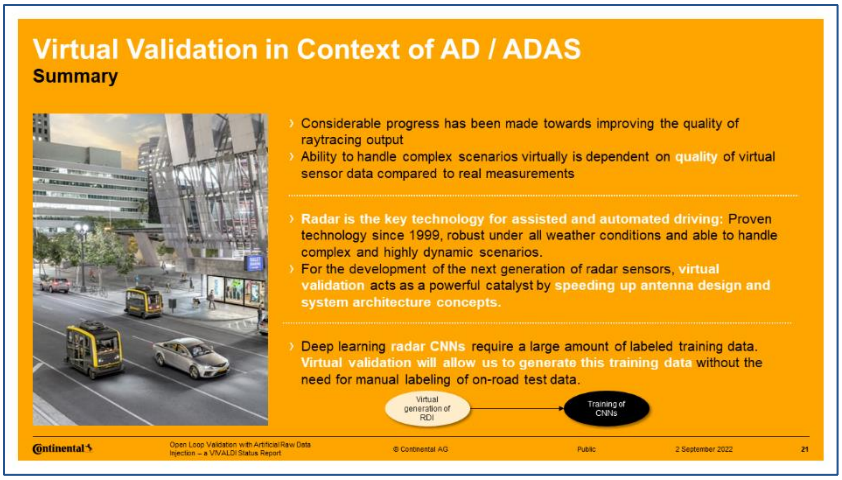
Conclusions

The current ecosystem of the Continental engineering development focuses more and more on virtual validation of AD/ADAS sensor components. Simulation becomes a tool for EuNCAP 2025 assessment, i.e., virtual testing >75%, vehicle test <25%.



Continental hat put a lot of effort into the development of a radar ray tracer. In an iterative process, smart sampling aspects and realistic beam patterns were investigated and optimized. The validation using an Euro-NCAP scenario showed promising results and could also be quantified with suitable KPIs.

By initial benchmark tests of the ray tracing tool, synthetic aperture radar (SAR) applications were generated virtually to examine the performance of the precise phase information of targets.

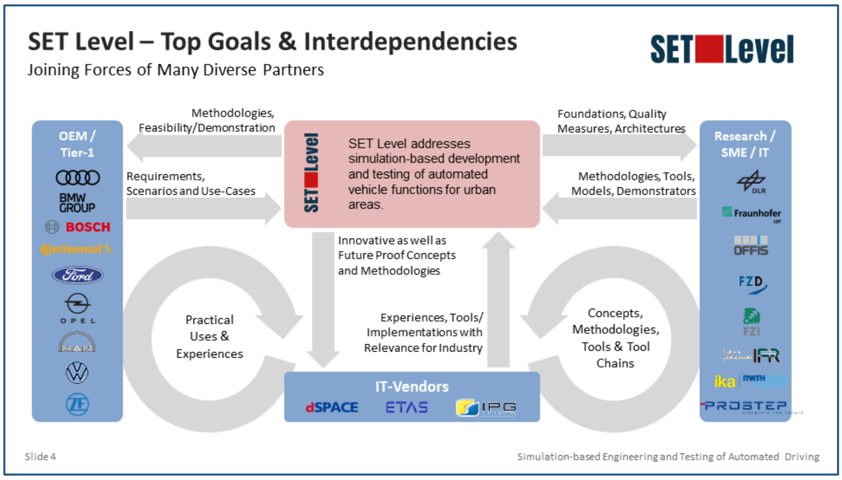


Keynote 4:
The SET Level simulation toolchain and open framework – Results from the German safety assurance project SET Level

Speaker:
Arun Das, BMW, Germany

Conclusions

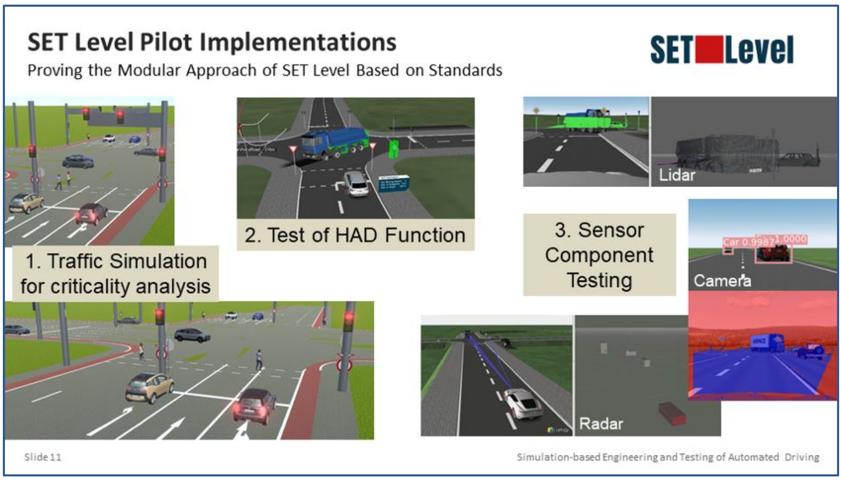
As a part of the PEGASUS project family, the SETLevel project (Simulation-based Engineering and Testing of Automated Driving) focuses on the development, testing methods and tools for AD systems on highways and in urban environments. The project consortium includes OEM / Tier-1 companies, IT vendors and as well as research institutions.



SETLevel provides an environment for simulation-based systems exploration, understanding, as well as verification & validation as a service. It creates a platform with highly generic compontents, i.e., open, flexible, and extendable.

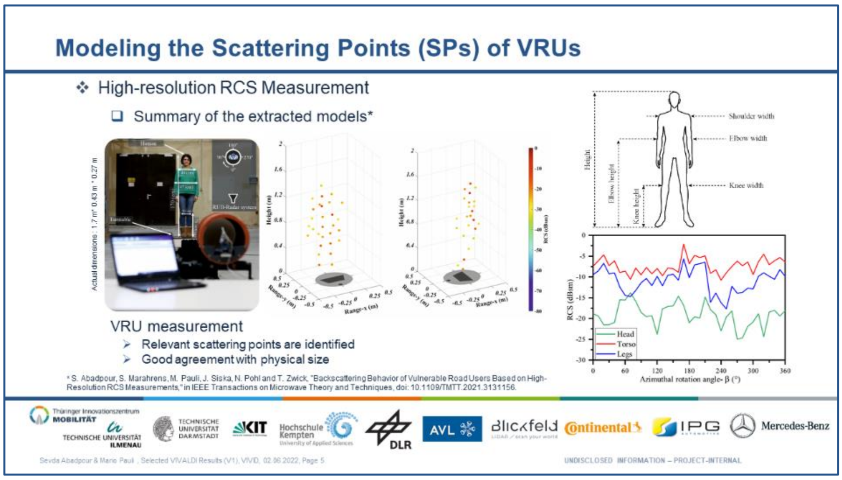
The project works on a “Credible Simulation Process” to develop and release new simulation methods. Following this structured process hierarchy, the proof and documentation of the quality for a decision based on a simulation result can be clearly evaluated.

As a generic open analysis and testing architecture, the SETLevel methodology defines a logical structure for simulation toolchains, builds a commong ground for tooling solutions, allows a wide range of engineering tasks, and, it enables a modular composition of tools.



Selected VIVID results: German R&D project

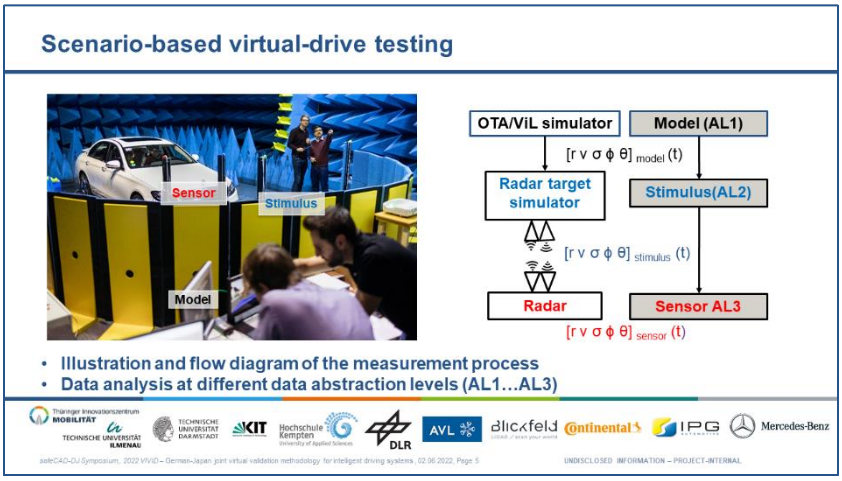
Modelling the scattering centres of traffic participants based on RCS measurements in a virtual validation tool chain



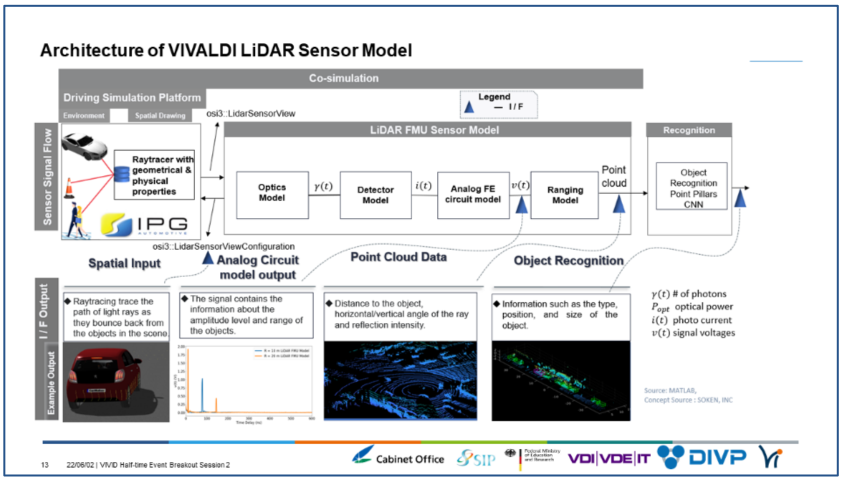
- Backscattering behaviour of vulnerable road users
- High-resolution monostatic RCS measurements
- Doppler measurements of human motion
- Implementing the extracted radar models in scenario simulation environment

Installed performance testing of automotive radar in virtual environment

- Over-the-air/ vehicle-in-the-loop implementation – virtual drive test in reality
- Scenario-based radar testing: Model → Stimulus → Sensor
- RCS maps to virtual environment
- Comparison between real and virtual test drives



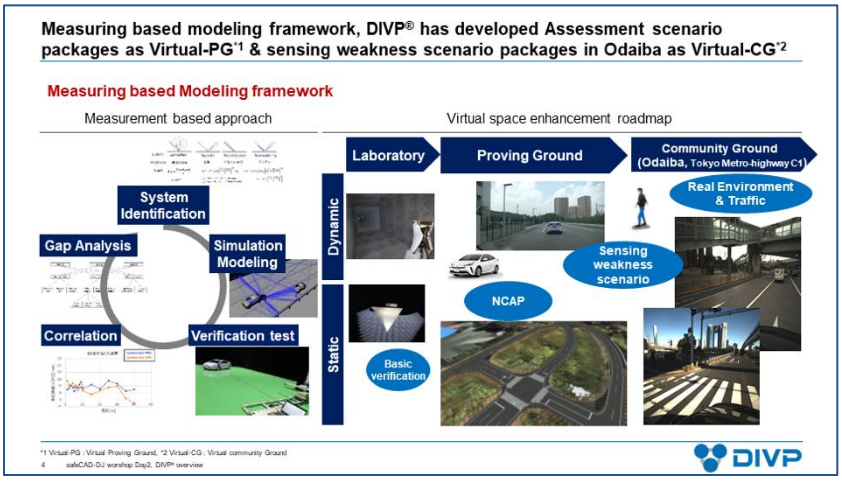
Virtual testing of automotive camera and lidar



- Lidar sensor validation in the CPLA scenario
- Tool chain for lidar FMU model validation using co-simulation approach
- Comparison between real and simulated lidar data
- Lidar sensor model performance highly depends on environmental modelling

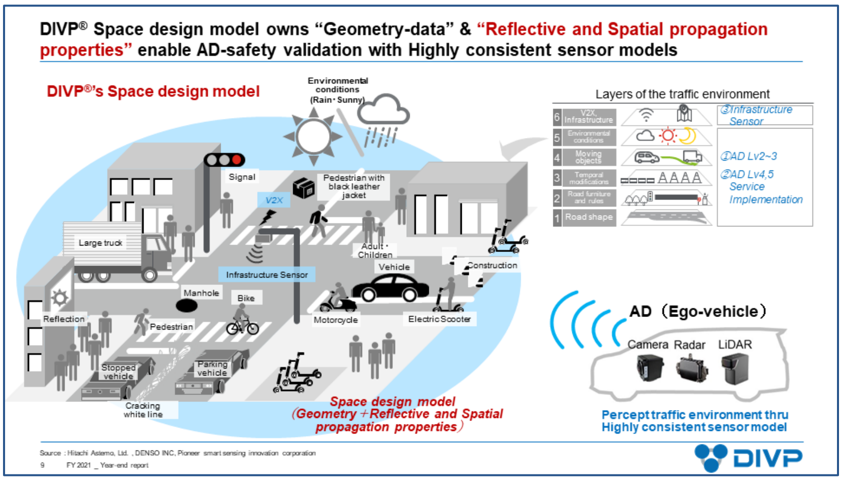
Selected VIVID results: Japanese R&D project

DIVP overview

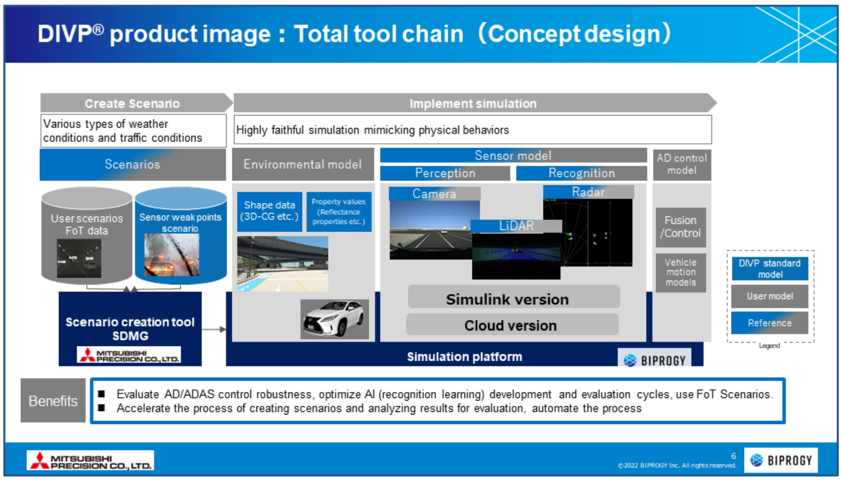


- DIVP scope:
  - Sensing weakness data
  - Platform implementation
  - Study reasonable semiconductor specification
- DIVP objectives:
  - Open standard interface
  - Reference platform with reasonable verification
  - Environmental and sensor model-based approach

- Modelling of the recognition environment outside the vehicle as an out-car model
- Conventional model-based development is characterized by models inside the vehicle as an in-car model
- Space design model generator creates and manages scenarios for DIVP simulators by placing vehicles and targets in virtual space environments



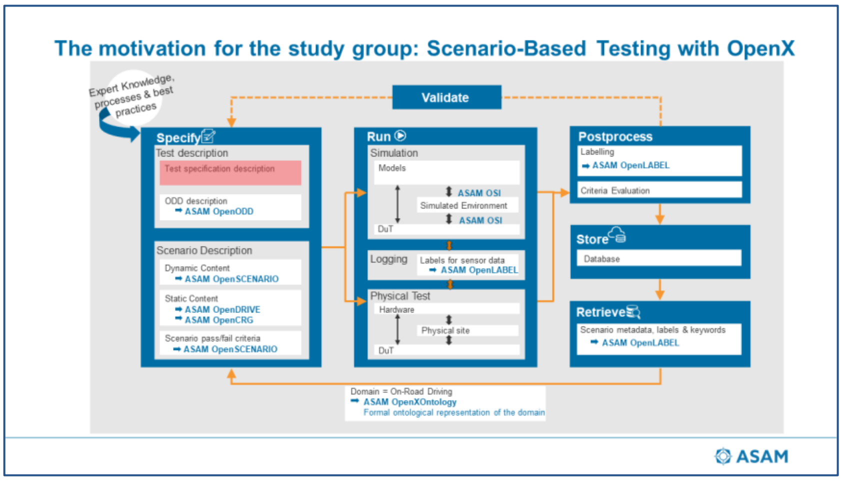
DIVP service



- V-Drive Technologies: Vehicle/(Autonomous) Drive, Virtual – Validation – Verification
- Roadmap:
  → Fundamental research
  → Commercialization
  → Standardization
- Business model: ecosystem based on automation tools, sensor and environmental models, measured data

Global standardization and harmonization

Standardized technical specifications of ASAM as endorser for deployment of automated driving systems

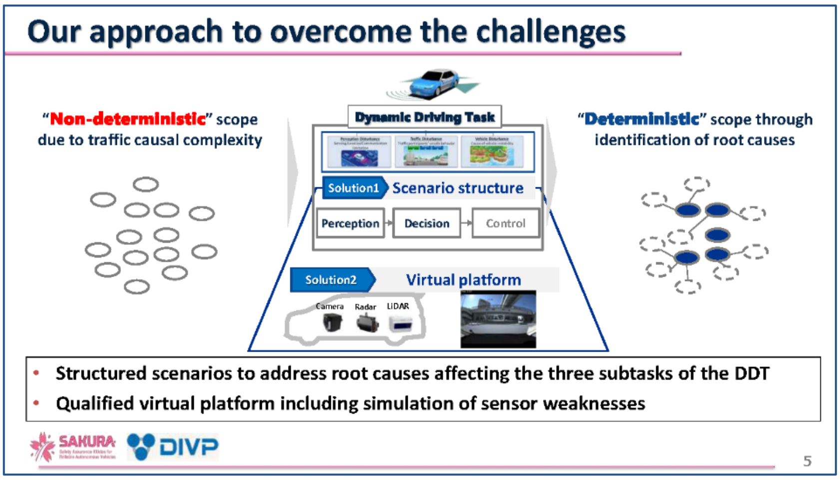


- ASAM OpenX test specification study groups about analysis and harmonization of automotive testing techniques and standards
- Main outputs:
  - Blueprint to meet challenges of testing
  - Holistic best practice
  - Possible basis for homologation of automated driving functions and software-defined vehicles

- Recommendations for a new standard at ASAM
  - Multiple test methods require a flexible approach to the interaction between scenarios and testing
  - Standardized interface between test cases, scenarios, and ODD definition
  - Test data management as basis for release and homologation
  - Proposals for global alignment

Advancing on the development of sustainable and standardized ecosystems for autonomous driving safety assurance in Japan

- AD safety cannot be ensured with long-distance endurance driving tests alone
  - Challenge 1: Safety validation scope
  - Challenge 2: Virtual platform consistent with reality
- Leading role of Germany and Japan on safety standardization
  - ISO 34502 truly collaborative leading effort → expected final release in Oct. 2022
  - Pro-active in other safety related activities (e.g., SOTIF)



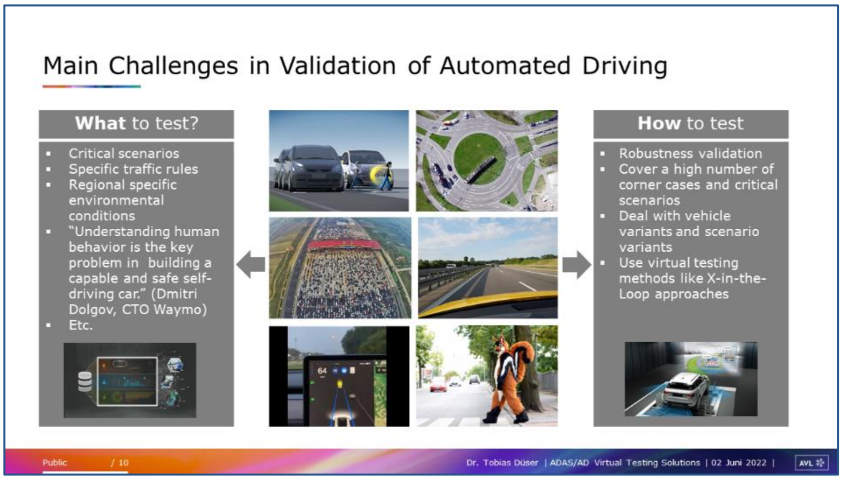
Keynote 5:
Virtual validation for ADAS and AD systems

Speaker:
Dr. Tobias Düser, AVL, Germany

Conclusions

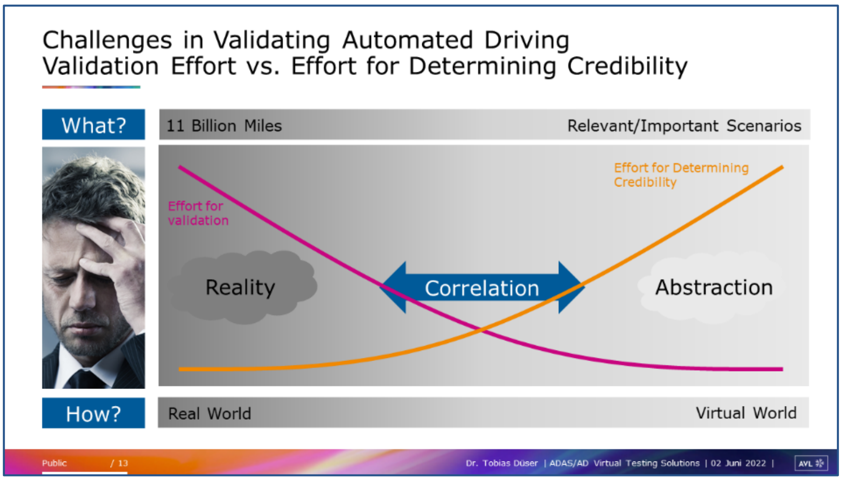
With the introduction of automated driving functions, the market is now facing new challenges in the further development: Validation of AD systems and later, credibility of validation methods.

The functionality of autonomous vehicles might need to be limited to fit the constraints of feasible validation techniques. Removing those constraints will require advances in areas such as characterizing the coverage of machine learning training data compared to the expected operational environment, gaining confidence in safety requirements regarding exceptional driving conditions, and being able to validate the independence of failures irredundant inductive-based systems.



The main challenges in validation of automated driving can be described by two comparison questions: "What to test?" ←→ "How to test?". The trade-off between the validation effort and the effort for determining credibility including their correlation has to be handled.

- ➲ The virtual testing in AD/ADAS means setting up a virtual vehicle with different components out of different domains in different tools.
- ➲ Defined model fidelity levels (also for Sensor and environmental models) will help to setup the virtual testing toolchain and to assess it.

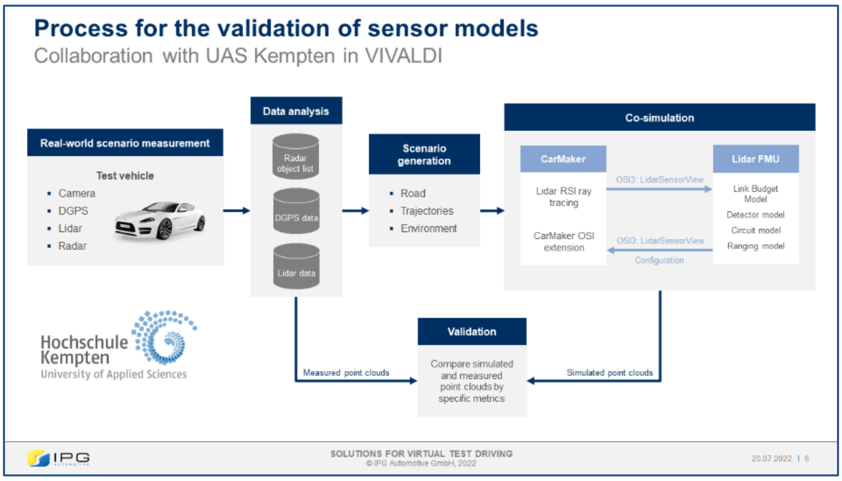


Keynote 6:
Environmental modelling – a foundation for sensor simulation

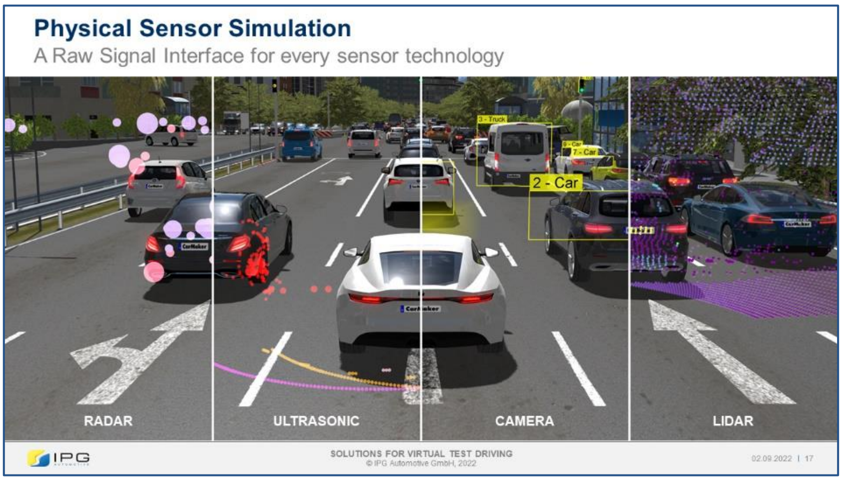
Speaker:
Yannik Cichy, IPG Automotive, Germany

Conclusions

In the VIVID project, IPG Automotive leads the work packages about the implementation of simple and complex scenarios used for the virtual validation of the sensor models. For the better feasibility, the scenarios are decomposed into different layers, which are based on the six-layer-model of the PEGASUS project family.

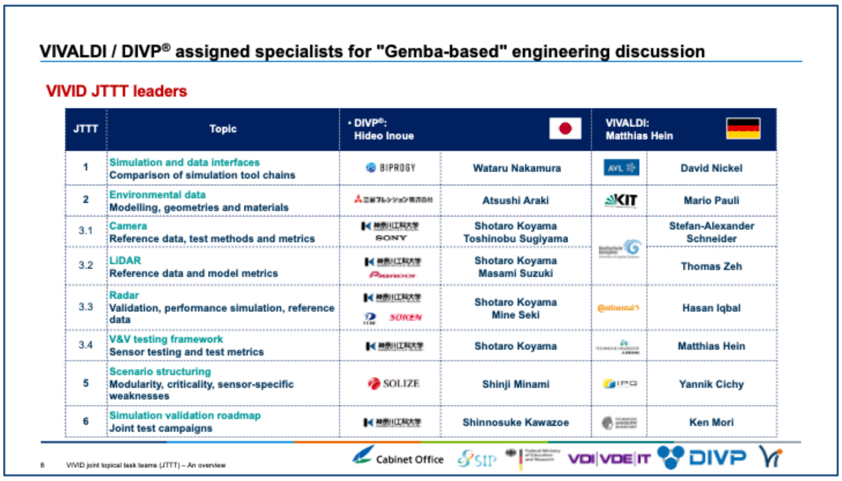


Based on measurements with a test vehicle equipped with several sensors, recorded DGPS trajectory data and object lists from the sensors are used for the scenario generation and data analysis. The co-simulation between the environmental model and the sensor model is based on open standards. The comparison of the measured sensor data with the simulated data by specific metrics completes the validation chain.



VIVID joint topical task teams

Overview



VIVALDI / DIVP® assigned specialists for "Gemba-based" engineering discussion

VIVID JTTT leaders

JTTT	Topic	DIVP®: Hideo Inoue		VIVALDI: Matthias Hein	
1	Simulation and data interfaces Comparison of simulation tool chains	BIPROGY	Wataru Nakamura	AVL	David Nickel
2	Environmental data Modelling, geometries and materials		Atsushi Araki	KIT	Mario Pauli
3.1	Camera Reference data, test methods and metrics	SONY	Shotaro Koyama Toshinobu Sugiyama		Stefan-Alexander Schneider
3.2	LiDAR Reference data and model metrics	Pioneer	Shotaro Koyama Masami Suzuki		Thomas Zeh
3.3	Radar Validation, performance simulation, reference data	SOKEN	Shotaro Koyama Mine Seki	Continental	Hasan Iqbal
3.4	V&V testing framework Sensor testing and test metrics		Shotaro Koyama		Matthias Hein
5	Scenario structuring Modularity, criticality, sensor-specific weaknesses	SOLIZE	Shinji Minami	IPG	Yannik Cichy
6	Simulation validation roadmap Joint test campaigns		Shinnosuke Kawazoe		Ken Mori

8 VIVID joint topical task teams (JTTT) – An overview

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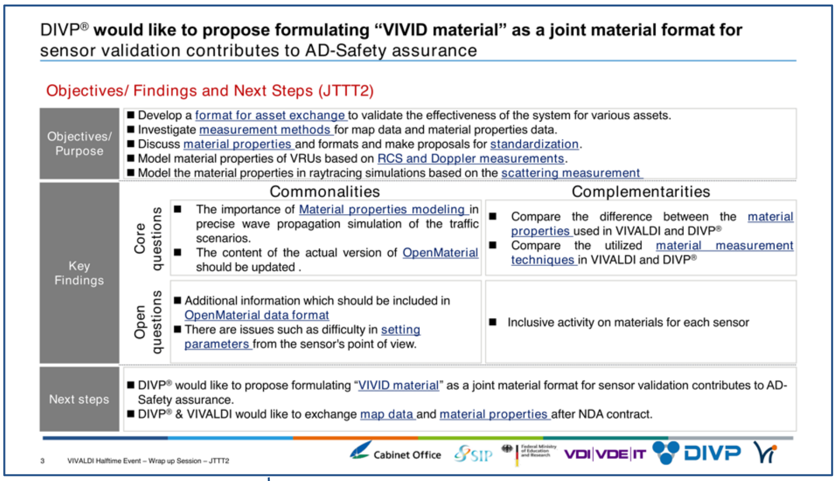
- Common goals:
  - Exchangeability
  - Interoperability
  - Data-driven safety assurance
- Commonalities
  - HD map and sensor raw data
  - Material and object data bases
  - Environmental and sensor modelling
- Complementarities
  - Sensor types and raw data
  - Test methods

During the mid-term event of VIVID, the JT structure was reconsolidated as below.

	Topics
JT1	Tool chain
JT2	Scenario structuring & environmental data
JT3.1	Propagation and sensor modelling - Camera
JT3.2	Propagation and sensor modelling - Lidar
JT3.3	Propagation and sensor modelling - Radar
JT4	V&V test and simulation framework

Breakout session 1 – Scenarios



DIVP® **would like to propose formulating "VIVID material" as a joint material format for** sensor validation contributes to AD-Safety assurance

Objectives/ Findings and Next Steps (JTTT2)

		Commonalities	Complementarities
Objectives/ Purpose	■ Develop a format for asset exchange to validate the effectiveness of the system for various assets. ■ Investigate measurement methods for map data and material properties data. ■ Discuss material properties and formats and make proposals for standardization. ■ Model material properties of VRUs based on RCS and Doppler measurements. ■ Model the material properties in raytracing simulations based on the scattering measurement		
Key Findings	Core questions	■ The importance of Material properties modeling in precise wave propagation simulation of the traffic scenarios. ■ The content of the actual version of OpenMaterial should be updated .	■ Compare the difference between the material properties used in VIVALDI and DIVP® ■ Compare the utilized material measurement techniques in VIVALDI and DIVP®
	Open questions	■ Additional information which should be included in OpenMaterial data format ■ There are issues such as difficulty in setting parameters from the sensor's point of view.	■ Inclusive activity on materials for each sensor
Next steps	■ DIVP® would like to propose formulating "VIVID material" as a joint material format for sensor validation contributes to AD-Safety assurance. ■ DIVP® & VIVALDI would like to exchange map data and material properties after NDA contract.		

3 VIVALDI Halftime Event – Wrap up Session – JTTT2

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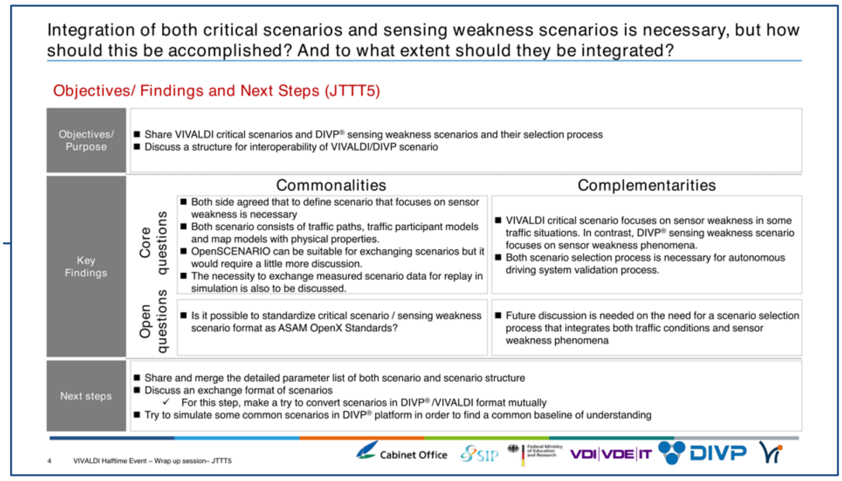

Integration of both critical scenarios and sensing weakness scenarios is necessary, but how should this be accomplished? And to what extent should they be integrated?

Objectives/ Findings and Next Steps (JTTT5)

		Commonalities	Complementarities
Objectives/ Purpose	■ Share VIVALDI critical scenarios and DIVP® sensing weakness scenarios and their selection process ■ Discuss a structure for interoperability of VIVALDI/DIVP scenario		
Key Findings	Core questions	■ Both side agreed that to define scenario that focuses on sensor weakness is necessary ■ Both scenario consists of traffic paths, traffic participant models and map models with physical properties. ■ OpenSCENARIO can be suitable for exchanging scenarios but it would require a little more discussion. ■ The necessity to exchange measured scenario data for replay in simulation is also to be discussed.	■ VIVALDI critical scenario focuses on sensor weakness in some traffic situations. In contrast, DIVP® sensing weakness scenario focuses on sensor weakness phenomena. ■ Both scenario selection process is necessary for autonomous driving system validation process.
	Open questions	■ Is it possible to standardize critical scenario / sensing weakness scenario format as ASAM OpenX Standards?	■ Future discussion is needed on the need for a scenario selection process that integrates both traffic conditions and sensor weakness phenomena
Next steps	■ Share and merge the detailed parameter list of both scenario and scenario structure ■ Discuss an exchange format of scenarios ✓ For this step, make a try to convert scenarios in DIVP® /VIVALDI format mutually ■ Try to simulate some common scenarios in DIVP® platform in order to find a common baseline of understanding		

4 VIVALDI Halftime Event – Wrap up session– JTTT5

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Breakout session 2 – Sensors

JT1 and JT3.1 will continue data exchange, JT3.2 will exchange scenarios and sensor model, JT3.3 will propose a new use-case to OSI

Objectives/ Findings and Next Steps (JTTT3.1/3.2/3.3/1)

		Commonalities	Complementarities
Objectives/ Purpose		■ Achieve mutual understanding of VIVALDI/ DIVP® simulation platform architecture ■ Discuss required interfaces and architecture of sensor models by data exchange	
Key Findings	Core questions	■ Reify data exchangeable interface through OSI trace files exchange (JT3.1) ■ Achieve mutual understanding of Ground Truth Sim and Physical Sensor Sim (JT3.1) ■ Confirm concept of sensor models are similar (JT3.2) ■ Exchange of scenario will be done by OpenSCENARIO and OpenDRIVE format (JT3.2) ■ Virtual RAW data and interfaces of perception model are important (JT1) ■ Achieve mutual understanding of Vehicle/Sensor Coordinate System (JT1)	■ Input data format of camera perception model: (DIVP®) spectral 35band format v. (VIVALDI) RGB format (JT3.1) ■ Modelling of sunlight noise and backscattering: (DIVP®) ray tracing model v. (VIVALDI) Lidar sensor model (JT3.2) ■ Calculation of radar ray reception azimuth: (DIVP®) ray tracing model v. (VIVALDI) Radar sensor model (JT3.3)
	Open questions	■ Further discussion is needed for virtual RAW data format and lens model (JT3.1) ■ Further discussion is needed for osi3::EnvironmentalConditions such as "street lights" (JT3.2) ■ Further discussion is needed for osi3::RadarSensorView such as "signal_strength" (JT3.3)	■ (DIVP®) Necessity of ray tracing interface that can communicate even if both the sensor model and the ray tracing model are black boxes (JT3.3) ■ (DIVP®) Confirm both sides of virtual RAW data and perception model interfaces and propose mutual standard interface (JT1)
Next steps		■ Exchange of environment model/sensor model output (JT3.1) ■ Exchange of scenarios/sensor model (JT3.2) ■ Propose a new use-case to OSI (JT3.3) ■ Convert DIVP® data to OSI format (JT1)	

6 VIVALDI Halftime Event – Wrap up Session – JTTT3.1/3.2/3.3/1

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Breakout session 3 – Test and validation metrics

JTTT3.4 will continue to focus on standardization and documentation of measurement methodology and validation process

Objectives/ Findings and Next Steps (JTTT3.4)

		Commonalities	Complementarities
Objectives/ Purpose		■ Aim for de-facto standardization of measurement methodology, consistency validation and sensor model validation	
Key Findings	Core questions	■ Measurement is key for modeling (OSI proposal) and standardization approach has been agreed (data exchange/format) ■ Both sides agreed on the general sensor pipeline, and its validation on multiple levels (including I/Fs)	■ Sensor specific characteristics (High-resolution RCS measurement, Odaiba sensor output measurement)
	Open questions	■ Both sides are grappling with material parameters prioritization, scenario/ metric selection, and measurement error	
Next steps		■ Documentation (white paper) of test/ measurement methodology for modeling, establish guideline ■ Select validation scenario, and discuss validation process of recognition limitation in the context of sensor consistency validation (metrics being the possible outcome)	

8 VIVALDI Halftime Event – Wrap up Session – JTTT3.4

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JTTT6 will focus on sensor models, comparing LiDAR point cloud metrics, and validation process, clarifying reliability of sensor measurement and metrics selection

Objectives/ Findings and Next Steps (JTTT6)

		Commonalities	Complementarities
Objectives/ Purpose		■ Aim for de-facto standardization of measurement methodology, consistency validation and sensor model validation (process)	
Key Findings	Core questions	■ Agreed on the general sensor pipeline, and its validation on multiple levels (including I/Fs) ■ Agreed to compare sensor output, and to further discuss the feasibility of comparative studies of sensor data or specific objects	■ (DIVP) Perception with object detection v. (VIVALDI) sensor data (system under test/ I/F validation) ■ (DIVP)Path planning v. (VIVALDI) Public PerCOLLECT (system requirement)
	Open questions	■ Both sides are grappling with material parameters prioritization, scenario/ metric selection, and measurement error ■ Both sides agreed that other parameters may need to be considered regarding the 2-stage validation concept	■ (DIVP)Sensor-specific validation process v. (VIVALDI)process-based validation approach
Next steps		■ Sensor models ✓ Comparison of LiDAR point cloud metrics for concrete sensor output, and discuss validation of intermediate output ✓ Focus on I/Fs, and pros and cons, and conduct feasibility study ■ Validation process ✓ Clarify reliability of sensor measurement and metric selection	

9 VIVALDI Halftime Event – Wrap up Session – JTTT6

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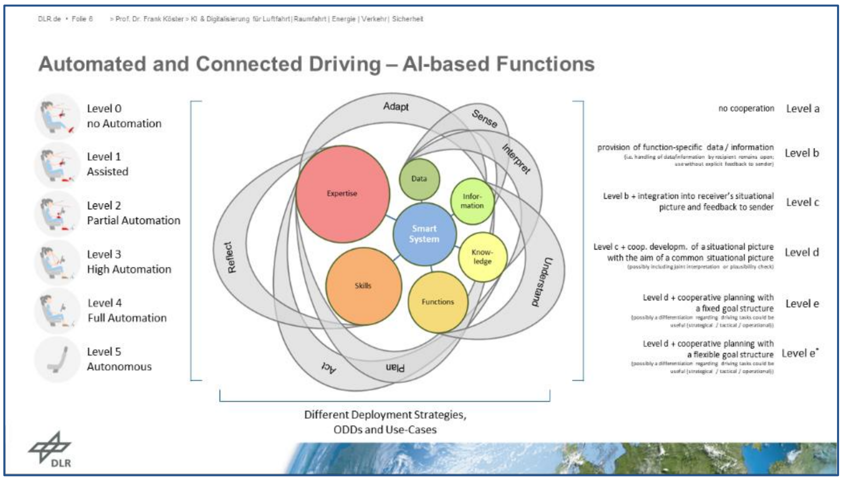
Keynote 7: The role of AI and data qualification in safety assurance

Speaker:
Prof. Frank Köster, German Aerospace Center (DLR), Germany

Conclusions

With the enormous complexity of advanced vehicles and automated systems in even more complex environments established methods reach their limits in generating safety evidences. Moreover, we can't expect that an automated vehicle will be designed, developed, tested, produced, quality assured, delivered, deployed, used, serviced and recycled in a straight-line process. Not just because of AI-based components there is a need to establish iterated Processes which are e.g. well known from the field of software engineering, like the DevOps approach (Dev = Development; Ops = Operations). Continuous improvement of products (e.g. AI-based products) is a concept that can be implemented on a DevOps environment. The typical DevOps-phases are data-centric and data-driven respectively. This is a perfect environment to apply AI-based tool for the automated data-processing and -analysis – e.g. with the aim to identify new test-cases, monitor AI-based functions in the field and retrain them on improved training data sets, derive models to support predictive maintenance functionalities etc.



The overall goal of an AI and data-driven engineering process methodology is the transfer of product development chains based on single fail/pass verification runs to continuous integration and assessment methodologies. The better we can automate this by AI-based engineering tools the more we can speak of a game changer in innovative product development.

- Virtual environments for V&V are essential – in particular in terms of Simulation as a service
- The integrated use of different test facilities/environments is essential to gain a sufficient overall evidence: virtual environments, HiL/ViL, proving grounds, field tests etc.
- Focusing the product is not sufficient → the entire process-landscape, set of methods, tool chains and their interaction are important – "go for DevOps!"
- Security must be guaranteed and trustworthiness is of high importance
- Trusted data spaces or data (and service) ecosystems has to be established for V&V – linked or meshed with other data spaces
- Humans are a better decision maker when the goal structures must be adapted/adjusted (no strong AI available) – adequate Human-in-the-Loop concepts need to be developed

Panel discussion: Change of paradigm – From product validation to data-driven and AI-enhanced process validation

Moderator: Prof. Frank Köster, German Aerospace Center, Germany
Panel list: Prof. Hideo Inoue, Kanagawa Institute of Technology, Japan
Roland Galbas, Robert Bosch GmbH, Germany
Hasan Iqbal, ADC Automotive Distance Control Systems, Germany
Arun Das, BMW, Germany
Dr. Tobias Düser, AVL, Germany
Yannik Cichy, IPG Automotive, Germany

Communication technologies (in particular 5G and 6G) for cooperative automated driving and their relation to AI-based vehicle functions

Robust communication is an important foundation for intelligent AI-based cooperation (and collaboration) of automated systems and intelligent traffic infrastructures. Particularly, this helps to raise a vehicle's range of perception and also the quality of the perception. By this an improvement of safety can be assumed in many traffic situations. Accordingly, advances in single communication technologies as well as the integrated use of complementary communication technologies should be provided by future research initiatives. Furthermore, it is also important to mention, that communication technologies are the basis for a large-scale data collection in the mobility system, which enable the monitoring of AI-based products as well as the continuous product improvement.

Impact of AI-based functions on test procedures

In the context of perception (beside other application areas) it is commonly accepted, that AI-based function will play a major role in automated systems. We can't life without AI-based components in the context of advanced vehicles and automated systems. Because of that, we have to compensate some drawbacks of highly relevant AI-methods like artificial neural networks or deep learning approaches. In this context, the following research streams are essential:

- Accompanying safety layers from a systems perspective
- Architectures to integrate conventional algorithms with (updateable) AI-based components
- Hybrid AI-based solutions that integrate sub-symbolic and symbolic AI-methods and -technologies respectively
- Improved test methodologies and tools for AI-based functions

Next steps towards safety assurance by virtual V&V

- Rational and integrated use of various tests and test equipment in the context of a substantial safety argumentation
- Certification of tool chains and test equipment
- Raise the proportion of virtual or simulation-based methods/tools and the level of evidence
- Establishment of digital twins across the overall automotive value chain
- Increase efficiency in testing.

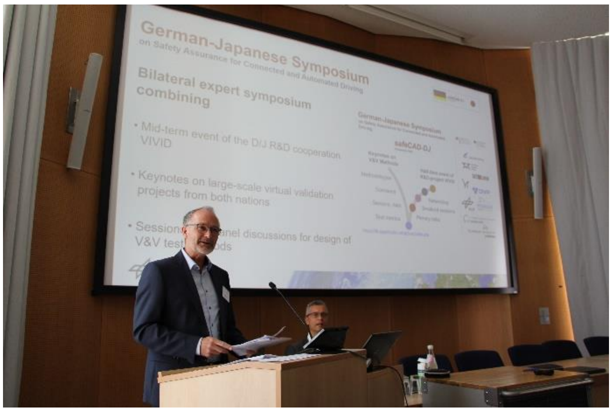
Aspects about metrics to quantify the degree of realism and evidence

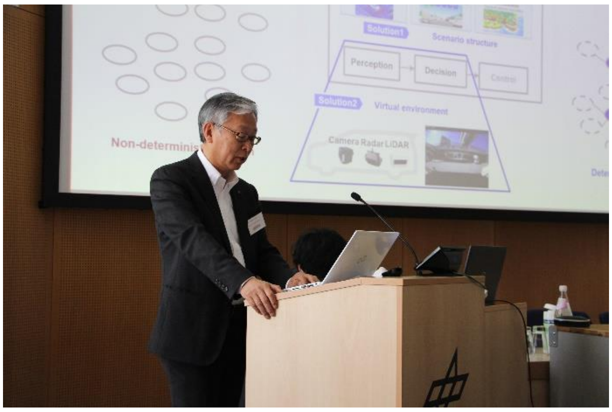
- Rational use of simulation tools and simulation approaches – we need research on methodologies and not just a tool centric research (How to do things best should be in the focus?)
- More accurate models don't always equal better for safety reasoning
- Mew scalable simulation approaches are urgently needed

Improvements for DevOps cycles for complex and AI-based systems

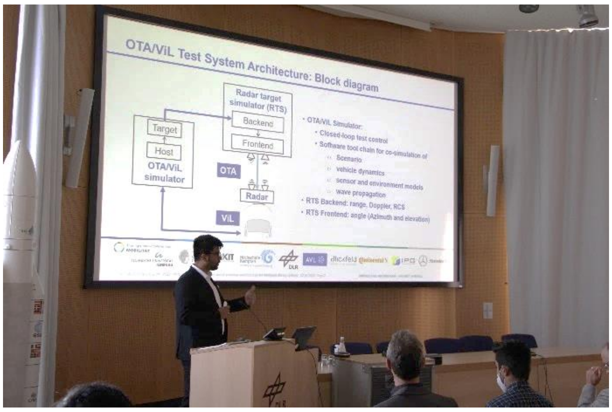
- Digital twins (as already mentioned above) will be of increasing relevance
- High degree of automation of processes (e.g. in virtual or simulation-based environments
- Scalability and maintenance of digital twins over the entire product lifetime is essential
- Standards (especially big pictures for the practical use of standards) are extremely important in order to be able to set up the urgently required tool chains
- Methods for the efficient execution of tests are also indispensable

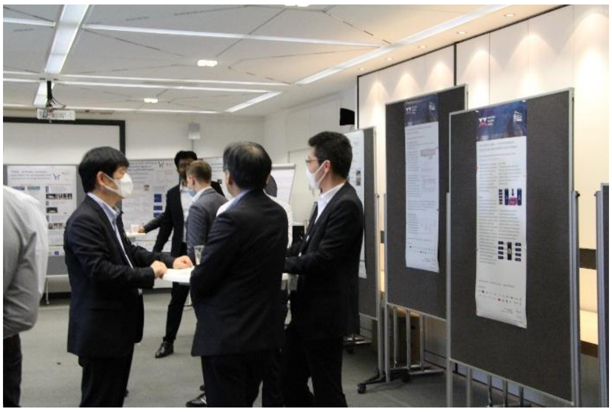
Impressions from *safeCAD-DJ* 2022



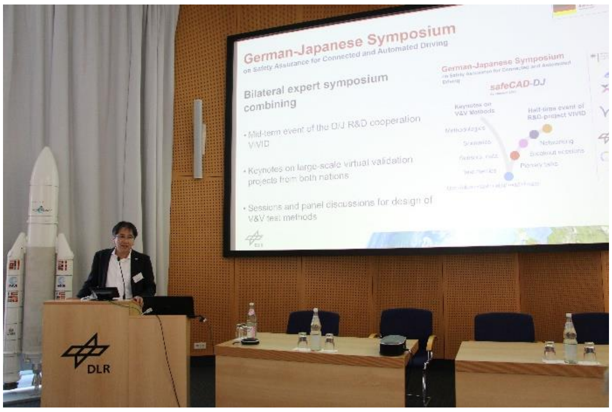



Overview


OTA/ViL Test System Architecture: Block diagram
Radar target simulator (RTS)
Backend
Frontend
Target
Host
OTA/ViL simulator
OTA
Radar
ViL
OTA/ViL Simulator:
Closed-loop test control
RTS Backend: range, Doppler, RCS
RTS Frontend: angle (Azimuth and elevation)




German-Japanese symposium on safety assurance for connected and automated driving
Data-driven approaches and funding strategies
Marco SCHULDT,
Division: "Digitalization, Industrie 4.0"
June 3, 2022
DLR


German-Japanese Symposium
on Safety Assurance for Connected and Automated Driving
Bilateral expert symposium combining
Mid-term event of the DJ R&D cooperation VIVID
Keynotes on large-scale virtual validation projects from both nations
Sessions and panel discussions for design of V&V test methods
safeCAD-DJ
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iacetto


Trachtenshop

PEGASUS
FAMILY
SET Level

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