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CREATING IDEAS &
DRIVING INNOVATIONS

DVN
Driving Vision News

LIDAR PERFORMANCE IN SEVERE CONDITIONS

LIDAR TEST FRAMEWORK EXTENSION

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AGENDA

- Motivation
- History – Existing Test Methods and DIN SAE SPEC 91471
- Project Idea

Motivation

▪ LiDAR market emerging	Deployment of L2+ & L3 systems will speed up from 2025-26 (CES) No agreed standardization of testing yet, many different technologies
▪ Need of a generic study	Measurement data is necessary, no existing studies in literature; potential interference btw Automotive Lidars (road safety), potential interference with other services (TSS, police? …) => can be used as input to an ISO standard
▪ Interference study similar to radar	Several projects realized with radar suppliers to characterize interference issues Standard use case scenarios defined incl. traffic jams with multiple sensors on cars Each supplier can evaluate its own mitigation SW
▪ Democratization of ADAS	Bringing ADAS into mass market (LiDAR will support this)

History

Project Conception

- Need for test methods
- Call for partners

Q2 2021 – Q4 2021

Concept & Validation

- Development of tools and scenarios
- Validation of analysis methodology

Q4 2021 – Q4 2022

Implementation & Benchmarking

- Application of developed methods
- Benchmarking of LiDAR sensors

Q1 2023 onwards






2000 - 2020

fka Sensor Testing

- LiDAR and RADAR sensors
- ACC related scenarios
- EU Consortia

Q4 2021

Project Launch

- Consortium Kick-Off
- Workshops on scenario brainstorming
- Workshops on LiDAR specification

Q3 2022 – Q1 2023

Standardization

- DIN SAE SPEC 91471

Q3 2023 onwards

Further Testmethods

- Bad weather tests
- Interference tests

Consortium Partners

CREATING IDEAS & DRIVING INNOVATIONS

DIN SAE SPEC 91471

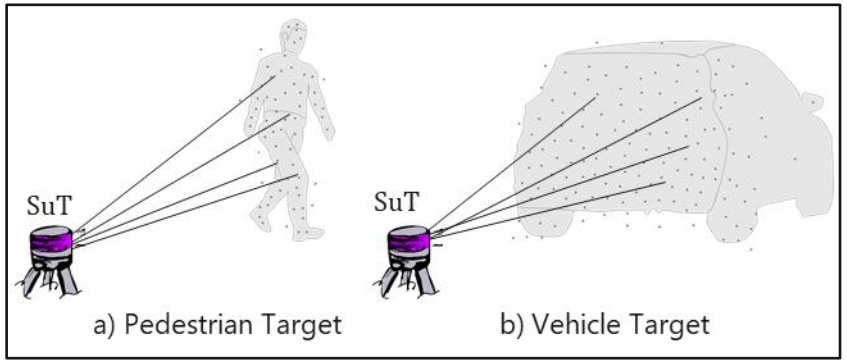
» Assessment methodology for automotive LiDAR sensors

- Establishment of an assessment methodology for LiDAR sensors independent of the design of the sensor, the specification and the technological approach.
- Application to car manufacturers and sensor suppliers to allow a defined assessment of the sensor performance on point cloud level, e.g. the detection distance, accuracy, precision and robustness of the measurements.
- Helping unify specification and testing.
- Support of R&D personnel, hardware and software sensor developers, test track operators, testing organizations and manufacturers of automated vehicles and ADAS/AD functions.
- Focus on tests under dry weather conditions
- Finalized in 2022; **published in Q1 2023**

DIN SAE SPEC 91471

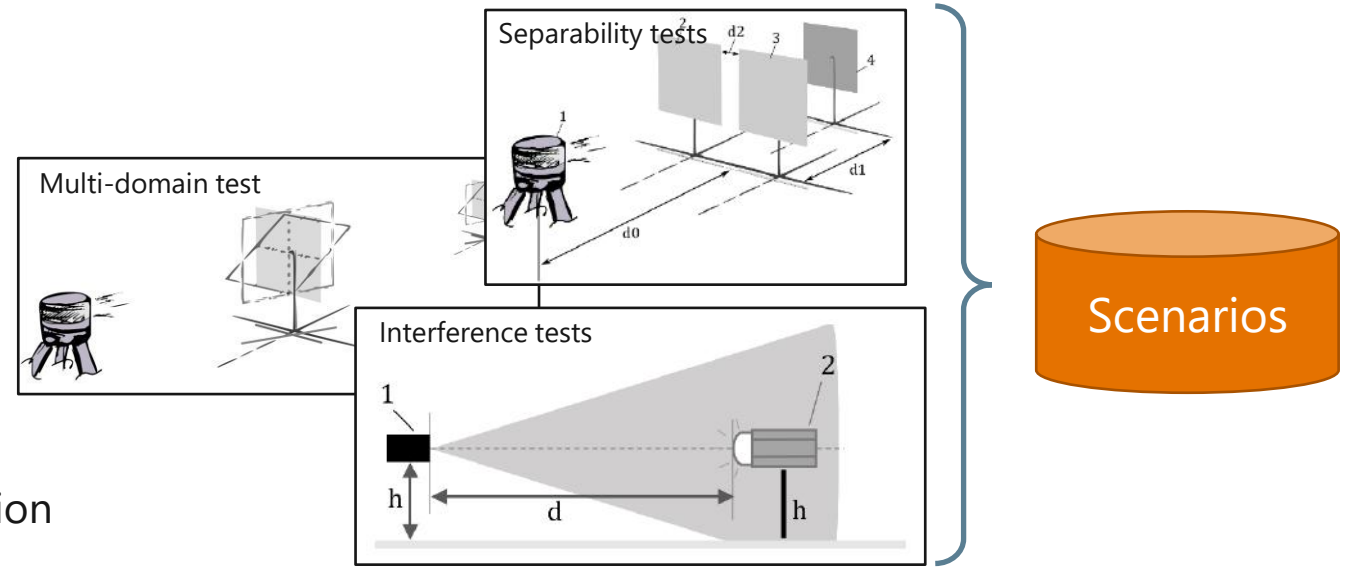
Scenarios

- Focus on sensor performance and not on object detection
- Scenarios designed for evaluation on point cloud level
- Use of simplified targets instead of real targets with complex geometries →



- Key Performance Indicators (KPIs) adapted to point cloud domain

- Scenarios are driven by a combination of:
  - Point cloud level testing
  - Adapted KPIs
  - Simplified targets

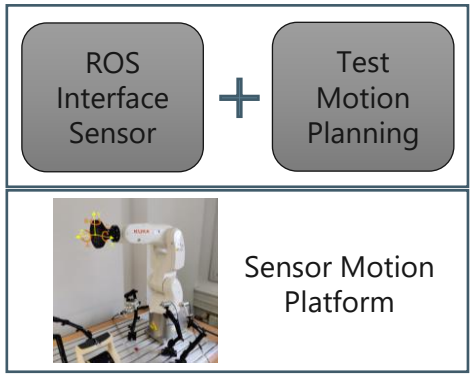


- Short-range LiDARs are not considered for evaluation

DIN SAE SPEC 91471

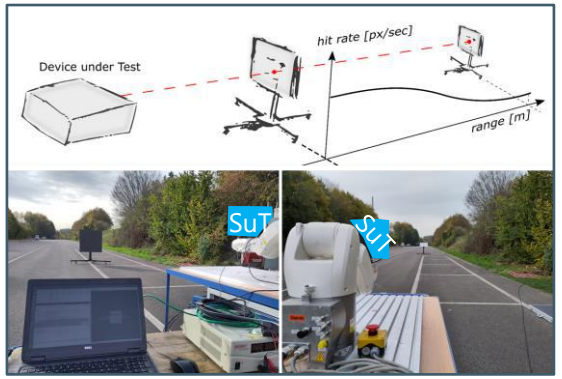
Validation process

Test Preparation



- Sensor oriented software development:
  - Update ROS drivers for new sensor
  - Integrate sensor in data recording tool chain
  - Adapt sensor motion platform to new sensor
- Sensor oriented hardware development
  - Sensor motion platform
  - Sensor power supply

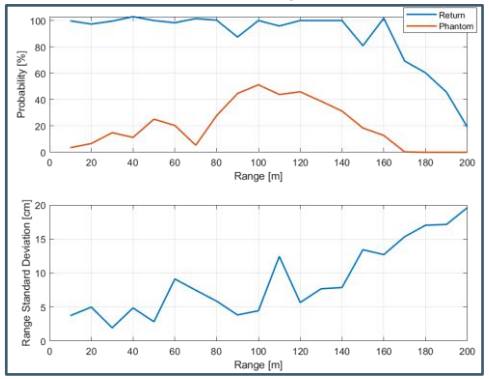
Test Execution



Scenarios

- False alarm rate
- Angular separability
- Radial separability
- ...

Test Analysis



KPIs

- Probability of detection
- Accuracy
- Precision
- ...

DIN SAE SPEC 91471

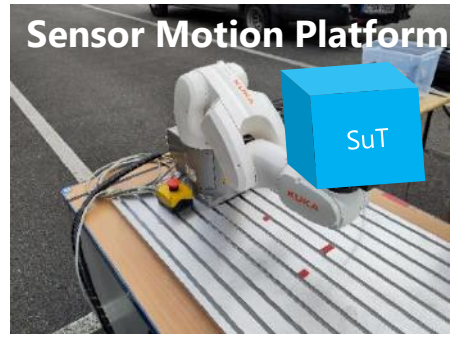
Evaluation tools

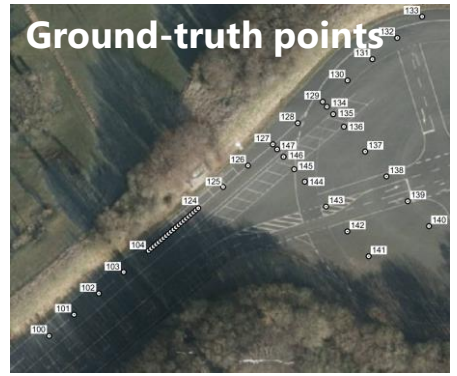
- Targets

Target	A	B	C	D	E	F
Reflection	10%*	50%*	80%*	Retro-reflector	10%*	50%*
Size	1m x 1m	1m x 1m	1m x 1m	1m x 1m	15cm x 50cm	15cm x 50cm

- Sensor motion Platform
  - KUKA KR 3 R540 - Position repeatability: +- 0.02 mm

- Ground-truth (positions measured by surveying office)
  - 147 measured points (133 on straight line over length 440 Meter) with accuracy of 1 mm
  - Two perpendicular axes with 7 points each – for accurate lateral positioning
  - Grid-sizes of 1 m and 10 m





** Lambertian reflectivity*

PROJECT IDEA

» LiDAR performance in severe conditions

- Extension of testing framework already established in DIN SAE SPEC 91471
- Build a trustful basis for RFQs and introduction of the right product
- Provide acknowledged testing procedures for adverse weather conditions and interference
- Provide insights into virtual simulation possibilities for LiDAR sensors
- Provide facts and data
- Support position on ISO standard

Project Idea

Approach

- Build upon work on the LiDAR Test Framework as developed in DIN SAE SPEC 91471 „Assessment methodology for automotive LiDAR sensors"
- **Create extended test methodology and scenarios with focus on the effect of external influences**
  - Adverse weather conditions, especially bright sunlight, rain/spray, fog → first step is to apply DIN SAE 91471 test methods
  - Interference of other LiDAR sensors or laser/light sources → need for additional test methods on top of DIN SAE 91471
  - Sensor surface conditions, especially dirt, drops/droplets, ice. → first step is to apply DIN SAE 91471 test methods
- Proof and verify methodology and feasibility in test campaign, creating real-world measurement data.
- Feed input to ISO standard.
- Advance virtual modelling of LiDAR sensors and work towards possible standardization
- Structure
  - WP1: Project Management
  - WP2: Methodology
  - WP3: Test Procedure Implementation
  - WP4: Testing Procedure Execution
  - WP5: Simulation

Project Idea

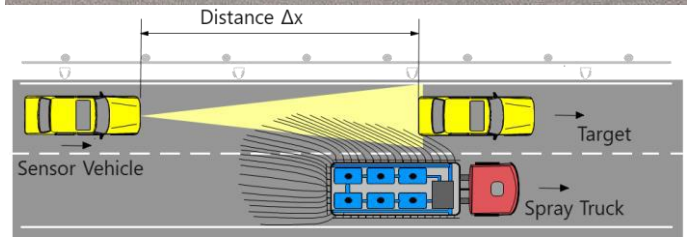
Content of Work Packages

- WP1: Project Management
  - Schedule, meetings and milestones
  - Dissemination
  - ISO standard communication
  - Documentation
- WP2: Methodology
  - Collect relevant scenarios and influences
  - Research and analyse appropriate test methods and tools, especially for glare, rain and sensor surface conditions
  - Define testing procedures and create catalogue
- WP3: Test Procedure Implementation
  - Procurement and build-up of facilities and equipment
  - Implementation of testing software toolchain
  - Try out of testing procedures to check feasibility and to improve effectiveness and efficiency
  - Verification of test results
- WP4: Testing Procedure Execution
  - Performance of testing procedures with defined set of sensors
  - Joint testing week with LiDARs from several OEMs to study interference
  - Analysis, interpretation and documentation of measurement results
- WP5: Simulation
  - Research on common LiDAR simulation principles and available simulation models
  - Collect and prioritize requirements for LiDAR simulator
  - Draft of simulation toolchain
  - Preparation of add-on project for implementation of simulation software

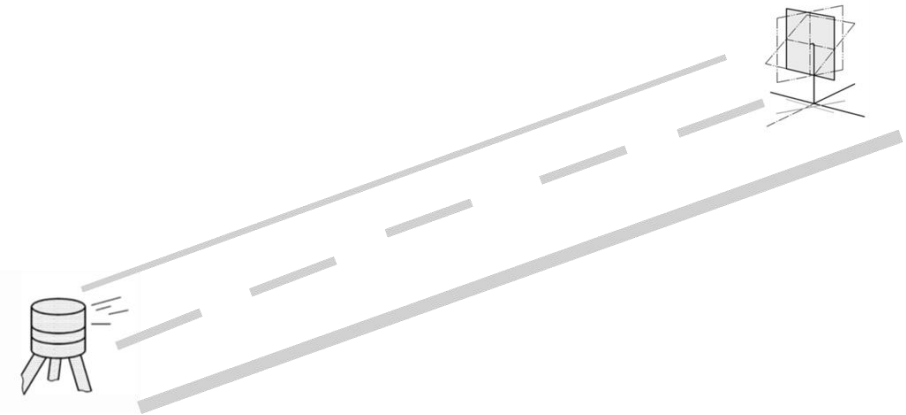
Project Idea

Example of weather tests

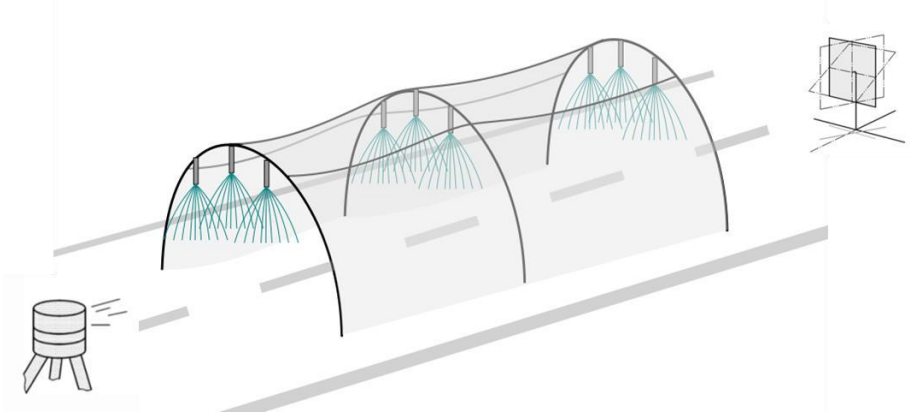
- Spray/rain simulation tools available for testing: spray truck
- Used for rain simulation on functional/object level
- Needs to be adapted for lidar testing on point cloud level



- Alternative: create an artificial rain chamber
- Apply rain chamber between sensor and target for DIN SAE 91471 tests



DIN SAE SPEC 91471: Multi-domain test



Multi-domain test under rain/fog

Project Idea

Possible Partners

OEMs & Trucks	Lidar Tier1s & Integrators	Eco-system
DAI	VALEO	TÜV
STELLANTIS	INNOVIZ	UTAC
HKM	MICROVISION/IBEO	Fraunhofer
FORD	LUMINAR	Hi-Drive EU Project
GEELY	AEYE/CONTI	Percival
VOLVO Cars	CEPTON	Rhode & Schwarz
VW-CARIAD	ROBOSENSE	PTB
AUDI, PORSCHE	HESAI	Metrologie Nationale
BMW	OUSTER/VELODYNE	DIGITRANS
RENAULT	OPSYS	
NISSAN	HUAWAI	
HONDA	KOITO	
GREATWALL	INNOVUSION	
GM-CRUISE	LS-Lidar	
JLR	LUMENTUM	
SAIC-VW	BOSCH	
RIVIAN	**SYSTEM Integ.**	
TRUCKS	MOBIS	
DAI-TRUCKS	ZF	
VOLVO-TRUCKS	MAGNA	
TRATON	NVIDIA	
MAN	QUALCOM	
ROBOTAXIS	MOBILEYE	
NURO		
HOLON		

Goal: 15 companies + fka/DVN + Agencies/Test Labs associated + Hi-Drive Project

Project Idea

Organization

- DVN/fka organizes three face-to-face meetings with all partners.
  - The dates will be agreed or will be defined by DVN/fka and announced at least two months prior to the meeting.
- Participation of each partner is mandatory.
- Each partner nominates one responsible person, who is entitled to fully represent the partner in the project.
- A joint “test week” will be organized in 2024 to test interference between all sensors offering all partners to collect data.

- Funding
  - Each partner (except DVN, FKA, ADAS_MC) pays a lumpsum of € 27.700,- to fka at the beginning of the project
  - Each partner will receive all documentation and results and is entitled to perform tests based on the resulting test catalogue.

Project Idea

Advantages and Results for Partners

- Each partner gets:
  - Preparation and documentation of meetings
  - One vote in all project related decisions
  - Consideration of partner's expert input for relevant tests and influence on the testing procedures
  - Detailed documentation of the project output and discussions
  - Full description of all testing -procedures, -scenarios, -targets, etc.
  - Test results of LiDAR tests are free of charge (sensor(s) to be agreed and provided by partners)
  - Semester status reports

Project Idea

Next Steps

1 ACQUISITION OF PARTNERS

- March:
  Start acquisition of interested partners
  - DVN Deep Dive 28.02.2023
  - F2F meeting of fka's current LiDAR Testing Consortium
  - SAE WCX Conference
  - fka, DVN and personal Networks and LinkedIn

2 CONTRACT PREPARATION

- Work out detailed project plan and tasks
- Draft requirements for testing equipment and facilities
- Setup contractual basis and discuss with individual partners

3 PROJECT START

- Possible project start:
  June 2023
- Duration: 1.5 years, end 2024
- Number of partners: 15
- F2F Kick-off meeting

Questions

- Was für einen Einfluss hat Regen auf Sensoren und deren Performance?
- *Which negative effects due to rain, fog were observed on sensors and their performance?*

- Wie kann man Schmutz reproduzierbar für Performance Tests darstellen?
- *How can dirt be reproduced for possible standardised tests for evaluating lidar perforamcnce?*

- Wie hoch ist der Bedarf an LiDAR Simulation? Und im welchen Form soll diese Erfolgen: virtuelle Sensor/Target oder echten Sensor mit virtuellen Target?
- How high is the need for simulation of LiDAR sensors? And is there a possibility to emulate targets using target emulators?

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