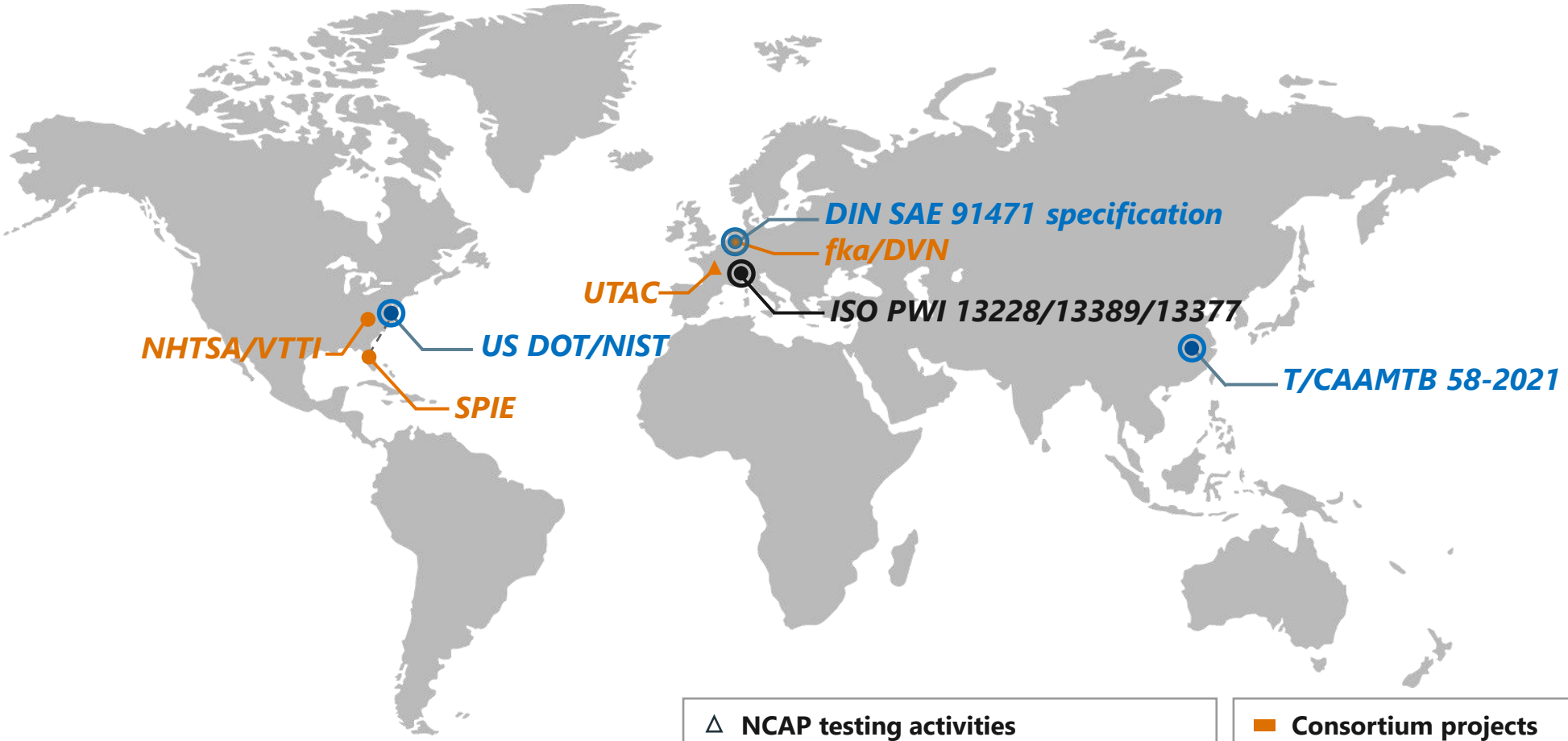
ON THE PATH TO STANDARDIZED TESTING FOR LIDARS

DVN LIDAR CONFERENCE 29.-30.11.23

Amogh Sakpal (fka)

Overview of LiDAR Performance Testing Activities



△ NCAP testing activities	Consortium projects
○ LiDAR test definition activities	National standards/specifications
◎ LiDAR standardisation work	International standards/specifications

Overview of LiDAR Performance Testing Activities

Evaluation

KPIs (Point Cloud)

- Probability of Detection (PD)
- Maximum Detection Distance
- Accuracy/Precision
- …

KPIs (Object)

- Measurement Precision (σ_{meas})
- Measurement Accuracy
- TPR-FPR
- Artefacts (Blooming, Ghosting,..)
- …

KPIs (Feature)

- Feature activation (TP/FP)
- Feature impact
- …

Environment

Ideal Conditions

- Ambient diffuse lighting
- Dry weather – no precipitation
- Dry test bed, sensor & targets
- …

Adverse Weather

- Rain
- Fog
- Snow
- Hail
- …

Contamination

- Spray
- Dust
- Dirt on sensor surface
- …

Performance

Base Performance

- No external disturbances

Interference Performance

- Direct LiDAR – LiDAR
- Co-directional
- …

Endurance Performance

- Consistency
- Thermal
- …

Safety Performance

- Radiation safety
- …

Static/Dynamic

Static Tests

- Single target
- Multi-target
- …

Dynamic Tests

- VRU scenarios
- Intersection scenarios
- HA scenarios
- …

DIN SAE Specification 91471

Evaluation

KPIs (Point Cloud)

- Probability of Detection (PD)
- Maximum Detection Distance
- Accuracy/Precision
- …

KPIs (Object)

- Measurement Precision (σ_{meas})
- Measurement Accuracy
- TPR-FPR
- Artefacts (Blooming, Ghosting,..)
- …

KPIs (Feature)

- Feature activation (TP/FP)
- Feature impact
- …

Environment

Ideal Conditions

- Ambient diffuse lighting
- Dry weather – no precipitation
- Dry test bed, sensor & targets
- …

Adverse Weather

- Rain
- Fog
- Snow
- Hail
- …

Contamination

- Spray
- Dust
- Dirt on sensor surface
- …

Performance

Base Performance

- No external disturbances

Interference Performance

- Direct LiDAR – LiDAR
- Co-directional
- …

Static/Dynamic

Static Tests

- Single target
- Multi-target
- …

Dynamic Tests

- VRU scenarios
- Intersection scenarios
- HA scenarios
- …

- ***Conducted by:*** *fka GmbH, DIN/SAE*
- ***Location:*** *Aachen, Germany*
- ***Status:*** *Closed (Released)*
- ***End Date:*** *May 2023*

Chinese Standard: T/CAAMTB 58-2021

Evaluation

KPIs (Point Cloud)

- Probability of Detection (PD)
- Maximum Detection Distance
- Accuracy/Precision
- …

KPIs (Object)

- Measurement Precision (σ_{meas})
- Measurement Accuracy
- TPR-FPR
- Artefacts (Blooming, Ghosting,..)
- …

KPIs (Feature)

- Feature activation (TP/FP)
- Feature impact
- …

Environment

Ideal Conditions

- Ambient diffuse lighting
- Dry weather – no precipitation
- Dry test bed, sensor & targets
- …

Adverse Weather

- Rain
- Fog
- Snow
- Hail
- …

Contamination

- Spray
- Dust
- Dirt on sensor surface
- …

Performance

Base Performance

- No external disturbances

Interference Performance

- Direct LiDAR – LiDAR
- Co-directional
- …

Static/Dynamic

Static Tests

- Single target
- Multi-target
- …

Dynamic Tests

- VRU scenarios
- Intersection scenarios
- HA scenarios
- …

- ***Conducted by:*** *Unknown*
- ***Location:*** *China*
- ***Status:*** *Closed (Released)*
- ***End Date:*** *2021*

NHTSA/VTTI Interference Study

Evaluation

KPIs (Point Cloud)

- Probability of Detection (PD)
- Maximum Detection Distance
- Accuracy/Precision
- …

KPIs (Object)

- Measurement Precision (σ_{meas})
- Measurement Accuracy
- TPR-FPR
- Artefacts (Blooming, Ghosting,..)
- …

KPIs (Feature)

- Feature activation (TP/FP)
- Feature impact
- …

Environment

Ideal Conditions

- Ambient diffuse lighting
- Dry weather – no precipitation
- Dry test bed, sensor & targets
- …

Adverse Weather

- Rain
- Fog
- Snow
- Hail
- …

Contamination

- Spray
- Dust
- Dirt on sensor surface
- …

Performance

Base Performance

- No external disturbances

Interference Performance

- Direct LiDAR – LiDAR
- Co-directional
- …

Static/Dynamic

Static Tests

- Single target
- Multi-target
- …

Dynamic Tests

- VRU scenarios
- Intersection scenarios
- HA scenarios
- …

- ***Conducted by:*** *Virginia Tech Transportation Institute (VTTI)*
- ***Location:*** *Virginia, USA*
- ***Status:*** *Started*
- ***Scheduled End:*** *2025*

UTAC Adverse Weather Conditions NCAP Study

Evaluation

KPIs (Point Cloud)

- Probability of Detection (PD)
- Maximum Detection Distance
- Accuracy/Precision
- …

KPIs (Object)

- Measurement Precision (σ_{meas})
- Measurement Accuracy
- TPR-FPR
- Artefacts (Blooming, Ghosting,..)
- …

KPIs (Feature)

- Feature activation (TP/FP)
- Feature impact
- …

Environment

Ideal Conditions

- Ambient diffuse lighting
- Dry weather – no precipitation
- Dry test bed, sensor & targets
- …

Adverse Weather

- Rain
- Fog
- Snow
- Hail
- …

Contamination

- Spray
- Dust
- Dirt on sensor surface
- …

Performance

Base Performance

- No external disturbances

Interference Performance

- Direct LiDAR – LiDAR
- Co-directional
- …

Static/Dynamic

Static Tests

- Single target
- Multi-target
- …

Dynamic Tests

- VRU scenarios
- Intersection scenarios
- HA scenarios
- …

- ***Conducted by:*** *UTAC*
- ***Location:*** *Paris, France*
- ***Status:*** *Started*
- ***Scheduled End:*** *End of 2025*

US DOT-NIST/SPIE LiDAR Data Standardisation Tests

Evaluation

KPIs (Point Cloud)

- Probability of Detection (PD)
- Maximum Detection Distance
- Accuracy/Precision
- …

KPIs (Object)

- Measurement Precision (σ_{meas})
- Measurement Accuracy
- TPR-FPR
- Artefacts (Blooming, Ghosting,..)
- …

KPIs (Feature)

- Feature activation (TP/FP)
- Feature impact
- …

Environment

Ideal Conditions

- Ambient diffuse lighting
- Dry weather – no precipitation
- Dry test bed, sensor & targets
- …

Adverse Weather

- Rain
- Fog
- Snow
- Hail
- …

Contamination

- Spray
- Dust
- Dirt on sensor surface
- …

Performance

Base Performance

- No external disturbances

Interference Performance

- Direct LiDAR – LiDAR
- Co-directional
- …

Static/Dynamic

Static Tests

- Single target
- Multi-target
- …

Dynamic Tests

- VRU scenarios
- Intersection scenarios
- HA scenarios
- …

- ***Conducted by:*** *SPIE*
- ***Location:*** *Florida/Washington DC, USA*
- ***Status:*** *Started (Planning for interference yet to start)*
- ***Scheduled End:*** *2024/2025*

fka/DVN LiDAR Performance in Adverse Conditions

Evaluation

KPIs (Point Cloud)

- Probability of Detection (PD)
- Maximum Detection Distance
- Accuracy/Precision
- …

KPIs (Object)

- Measurement Precision (σ_{meas})
- Measurement Accuracy
- TPR-FPR
- Artefacts (Blooming, Ghosting,..)
- …

KPIs (Feature)

- Feature activation (TP/FP)
- Feature impact
- …

Environment

Ideal Conditions

- Ambient diffuse lighting
- Dry weather – no precipitation
- Dry test bed, sensor & targets
- …

Adverse Weather

- Rain
- Fog
- Snow
- Hail
- …

Contamination

- Spray
- Dust
- Dirt on sensor surface
- …

Performance

Base Performance

- No external disturbances

Interference Performance

- Direct LiDAR – LiDAR
- Co-directional
- …

Static/Dynamic

Static Tests

- Single target
- Multi-target
- …

Dynamic Tests

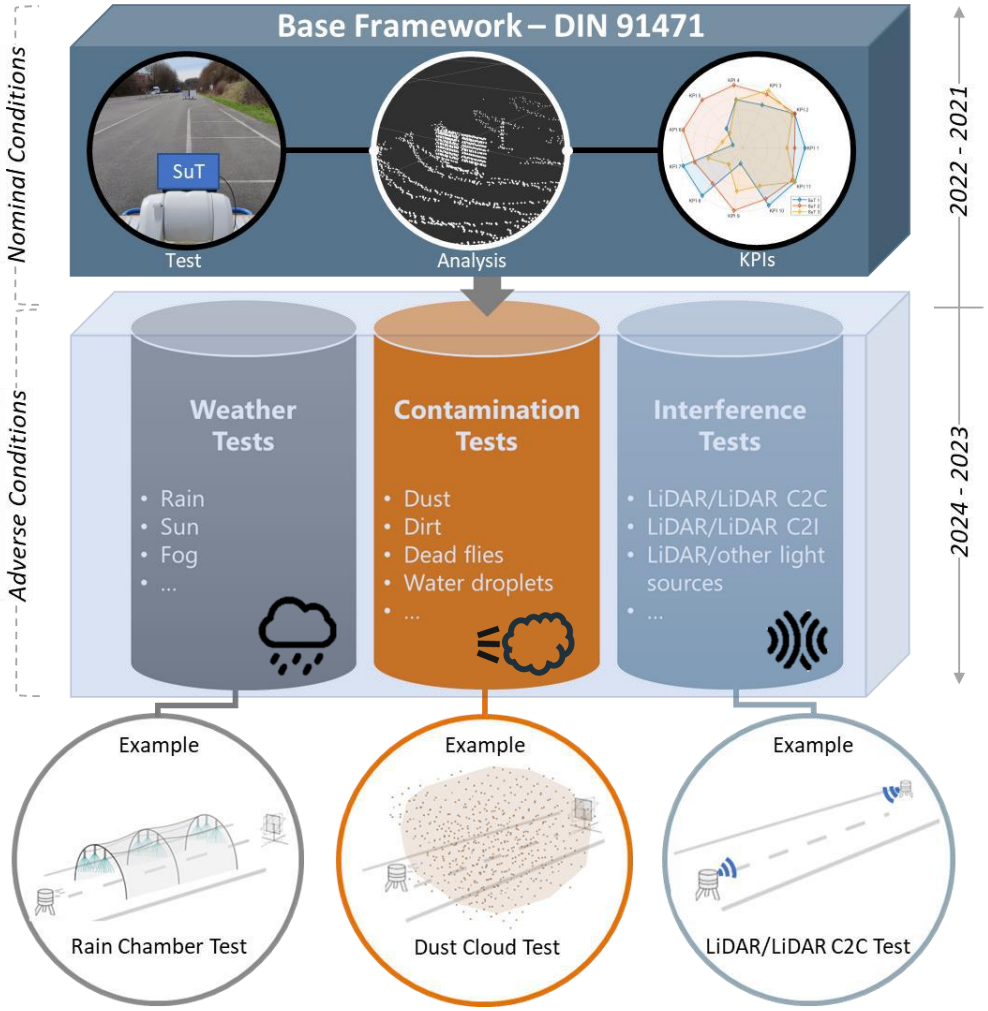
- VRU scenarios
- Intersection scenarios
- HA scenarios
- …

- ***Conducted by:*** *fka GmbH/DVN*
- ***Location:*** *Aachen, Germany*
- ***Status:*** *Started*
- ***Scheduled End:*** *End of 2024*

LiDAR Performance in Adverse Conditions

Motivation

- Provide useful basis for RFQs & future standards
- Definition of robust testing procedures for:
  - Adverse weather
  - Contamination
  - Interference
- Execution of certain selected tests
- Provision of an overview of simulation tools



LiDAR performance in adverse conditions

Project Outputs

Participation in Project Meetings & Workshops

Execution of Sensor Tests - Multiple LiDARs

Project Documentation & Reports

One Vote per Partner in Project Decisions

Anonymised Results of Sensor Tests

Support for Formation of Future Standards

LiDAR performance in adverse conditions

Project Key Points

- **Funding:**
  - Each partner contributes € 30.000 to fka to join the project

- **Timeline (tentative)**
  - Project Start: October 2023
  - Project End: December 2024
  - Final report & conclusions on 29 Nov. 2024 (DVN Conf)

  - Sensor tests planned for Q2/Q3 2024
  - Joint test week for interference tests
  - Sensor availability by May/June 2024

- **Contract Phase**
  - Set up of trilateral NDAs between fka, DVN and each individual partner joining the project
  - Set up of bilateral contracts between fka and each individual partner joining the project

Eric Amiot

DVN

Amogh Sakpal

Adrian Zlocki

fka

fka GmbH
Steinbachstraße 7
52074 Aachen
Germany

phone +49 241 8861 219
e-mail amogh.sakpal@fka.de
adrian.zlocki@fka.de
amiotejp@gmail.com

web www.fka.de

CREATING IDEAS & **DRIVING INNOVATIONS**

fka