Description of the VIDETEC dataset

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1. Introduction

1.1. Purpose of this document

The purpose of this document is to:

- Provide an overview of the VIDETEC measurement campaign; namely the equipment set up and the list of scenarios measured.
- Describe the data format of the measurement files from the different pieces of equipment used during the measurement campaign.

1.2. Measurement campaign description

The joint test measurements took place on the DLR site in Oberpfaffenhofen (Germany). The measurement campaign was carried out over two consecutive days in April 2021. Fig. 1 shows the intersection on the DLR site. The approximate coordinates for the intersection are: 48.0840457 N, 11.2766078 E. There are buildings, car parks, pavements, zebra crossings and vegetation in the intersection environment so that realistic scenarios with pedestrians, cyclists and cars could be carried out.

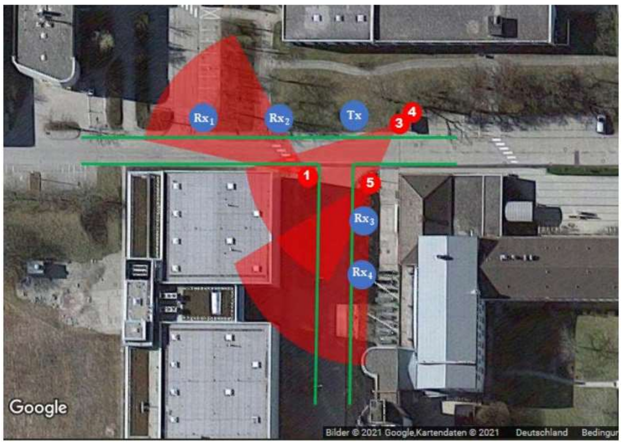

Figure 1 Crossing area on the DLR site, radar in red, CLS in blue.

Measurement system

The Communication-Localization-Surveillance (CLS) system is realized by using a channel sounding system at a frequency of 5.2 GHz. The antennas were placed around the intersection, using an omnidirectional transmit (Tx) and four omnidirectional receive antennas (Rx1-Rx4). The location of the antennas is plotted in blue in Fig. 1. The transmitter generates an OFDM-like signal with a rectangular spectral shape and a bandwidth of 120MHz. This signal was transmitted with 4W output power at a periodicity of 2.048ms. Thus, the system allows resolving a maximum Doppler of 244 Hz without aliasing. At Rx-side, a multi-switch was used to switch between the four RX antennas. The RF-cables, amplifiers and connectors were calibrated out prior to the measurements. In post-processing a super-resolution algorithm is applied to the stored channel impulse responses to estimate the complex amplitude and the delay of the line-of-sight (LoS) and multipath components (MPCs) in the received signal.

Reference Systems

Two independent reference systems were used during the measurement campaign to record a ground truth for the position of the moving objects involved in the scenarios. The pedestrian and the cyclist carried a Global Navigation Satellite System (GNSS) receiver connected to an antenna fixed on a helmet that was carried by the test subject. The ublox F9R GNSS receiver obtained real-time differential GNSS corrections from a NTRIP server from a German provider of GNSS correction data. The receiver computed a GNSS real-time kinematic solution which was recorded to be used in postprocessing. The test vehicles were equipped with the same GNSS receiver that was additionally making use of its internal inertial sensors to stabilize the RTK solution. A preliminary calibration run was performed to internally estimate the inertial sensor's biases.

In addition, two Velodyne VLP-16 laser scanners were installed at opposite ends of the intersection. The VLP performs 360° scans on 16 elevation planes between ±15° at 300 revolutions per minute, resulting in an horizontal angular accuracy of 0.1°. The VLPs scan points were synchronized with GNSS-based time using the pulse per second and date output of a GNSS receiver. The mounting positions were precisely surveyed in advance using a Leica Tachymeter. The measured point cloud from the VLP-16 laser scanners was recorded on a PC and stored for post-processing.

2. List of Scenarios

Table 1: Scenarios and maneuvers

Day	Scenario		Time UTC		Maneuver			Folder Name
14.04.2021	Scenario ID		Start	Stop	Car	Pedestrian	Bicycle	
	1	Car Turns right and intersects bicycle	07:54:50	07:55:00	Approaches intersection from SW, overtakes bicycle and tries to turns right into road to SE	N.A.	Drives straight over intersection from	/root/scenario1
	2	Pedestrian walks on road behind building and intersects car	08:25:30	08:26:30	Approaches intersection from SW and drives straight through to NE	Pedestrian walks next to high building towards intersection from SE. Stops when stepping on road at pedestrian crossing.	N.A.	/root/scenario2
	3	Car overtakes bicycle near intersection	08:39:30	08:30:40	Approaches intersection from SE and overtakes bicycle.	Drives towards intersection from SE	N.A.	/root/scenario3

3. Data Organization

The measurement data in the root-folder is organized in folders and subfolders. There is a folder for each scenario and subfolders for each measurement technology (CLS/Channel-Sounder, GNSS-RTK and laser scanners). An additional text file inside the root folder contains the position of the Radars, the CLS antennas and the laser scanners. Next, the file tree is presented.

- /root
  - coordinates.txt
  - /channelSounder-calibration
    - VIDETEC_CH1_Cal_data.mat
    - VIDETEC_CH2_Cal_data.mat
    - VIDETEC_CH3_Cal_data.mat
    - VIDETEC_CH4_Cal_data.mat
  - /scenario1
    - /channelSounder
      - VIDETEC_S1_CH1_Dat_data.mat
      - VIDETEC_S1_CH2_Dat_data.mat
      - VIDETEC_S1_CH3_Dat_data.mat
      - VIDETEC_S1_CH4_Dat_data.mat
      - VIDETEC_S1_Dat_nmea.mat
      - VIDETEC_S1_Dat_head.mat
    - /gnss-rtk
      - /Bike_210414_074452.ubx
      - /Car_210414_075218.ubx
    - /laser-scanner
      - 2021-04-14-09-46-47_Velodyne-VLP-16-Data.pcap
      - 2021-04-14-09-46-53_Velodyne-VLP-16-Data.pcap
  - /scenario2
    - /channelSounder
      - VIDETEC_S2_CH1_Dat_data.mat
      - VIDETEC_S2_CH2_Dat_data.mat
      - VIDETEC_S2_CH3_Dat_data.mat
      - VIDETEC_S2_CH4_Dat_data.mat
      - VIDETEC_S2_Dat_nmea.mat
      - VIDETEC_S2_Dat_head.mat
    - /gnss-rtk
      - /Pedestrian_210414_082428.ubx

        - /Car_210414_082531.ubx
    - /laser-scanner
        - 2021-04-14-10-23-05_Velodyne-VLP-16-Data.pcap
        - 2021-04-14-10-23-10_Velodyne-VLP-16-Data.pcap
- /scenario3
    - /channelSounder
        - VIDETEC_S3_CH1_Dat_data.mat
        - VIDETEC_S3_CH2_Dat_data.mat
        - VIDETEC_S3_CH3_Dat_data.mat
        - VIDETEC_S3_CH4_Dat_data.mat
        - VIDETEC_S3_Dat_nmea.mat
        - VIDETEC_S3_Dat_head.mat

    /gnss-rtk
        - /Bike _210414_083847.ubx
        - /Car_210414_083938.ubx
    - /laser-scanner
        - 2021-04-14-10-38-20_Velodyne-VLP-16-Data.pcap
        - 2021-04-14-10-38-29_Velodyne-VLP-16-Data.pcap

4. File Formats

4.1. CLS – Channel Sounder

In general, one channel sounder measurement consists of three files:

- the Dat_data file with the channel transfer function H(t,f),
- the Dat_head file with information about the setting,
- the Dat_nmea file with NMEA strings corresponding to each H(t,f) for time reference.

For calibration measurements the files Dat_nmna and Dat_head are not recorded:

- the Cal_data file with the channel transfer function H(t,f),

The calibration measurements are measurements containing only the channel sounder equipment without antennas and wireless link. A fixed attenuator is placed between the transmitter (Tx) antenna cable and the receiver (Rx) antenna cable. For the channel sounder measurements Dat_dat the calibration is already considered. The measurements were performed with four spatially distributed Huber&Suhner Omni-SR 1399.17.0111 antennas, each measuring an individual communication channel. All four channels indicated as CH<ChannelID> are recorded within ts=2.048 ms.

Measurement files:
VIDETEC_S<scenarioID>_CH<ChannelID>_Dat_data.mat
VIDETEC_S<scenarioID>_Dat_head.mat
VIDETEC_S<scenarioID>_Dat_nmna.mat

Calibration files:
VIDETEC_CH<ChannelID>_Cal_data.mat

4.2. GNSS-RTK

The GNSS-RTK data on all moving road participants, i.e. car, pedestrian and cyclist, was acquired using a ublox F9R receiver that got GNSS corrections over an NTRIP server from the internet. The receiver was controlled, monitored and the GNSS data was logged used the proprietary GNSS receiver software uCenter. Information on the uCenter can be found on the ublox website (u-center | u-blox). The log files are in the uBlox proprietary format .ubx. More information on this file format can be found on the ublox website as well.

4.3. Velodyne laser scanner files

The format of the pcap files is specified in the Puck Manual of the VLP-16, which can be found at Velodyne Manuals.

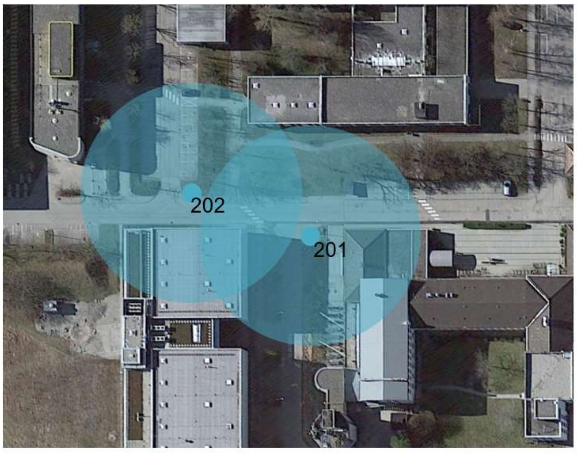

Figure 2 The approximate position of laser scanner 201 and 202 are shown on the Google Earth aerial view.

4.4. Coordinate Files

The coordinates of the radars, the CLS TX and RX antennas and the position of the Velodyne laser scanners has been precisely measured with a Leica Tachymeter. Before using the Tachymeter to measure the points of interest, the Tachymeter needs to be referenced. For this purpose, the station was configured with SET AZIMUTH and up to six known points were measured in. The coordinates of the known points in a local East-North-Up (ENU) coordinate frame centered at [48.0841633° 11.2780893° 627.914m] are shown in table

Point name	East [m]	North [m]	Up [m]
4.52	-112.6974	-8.4162	-1.3458
4.4	-106.8794	1.1539	-1.7718
4.71	-101.0142	-2.9148	-1.6722
6.1	-84.6325	-16.9703	-1.9581
6.2	-102.9451	-23.6191	-1.3832
6.3	-94.3935	-29.1336	-1.3617

Table 2 Coordinates of known points in ENU coordinate frame

The next figure shows the measured points inside coordinates.txt. The coordinates are in a local (tachymeter centered and gravity leveled) coordinate frame. With help of the known points from Table 2 the points of interest can be rotated and translated to the ENU frame.

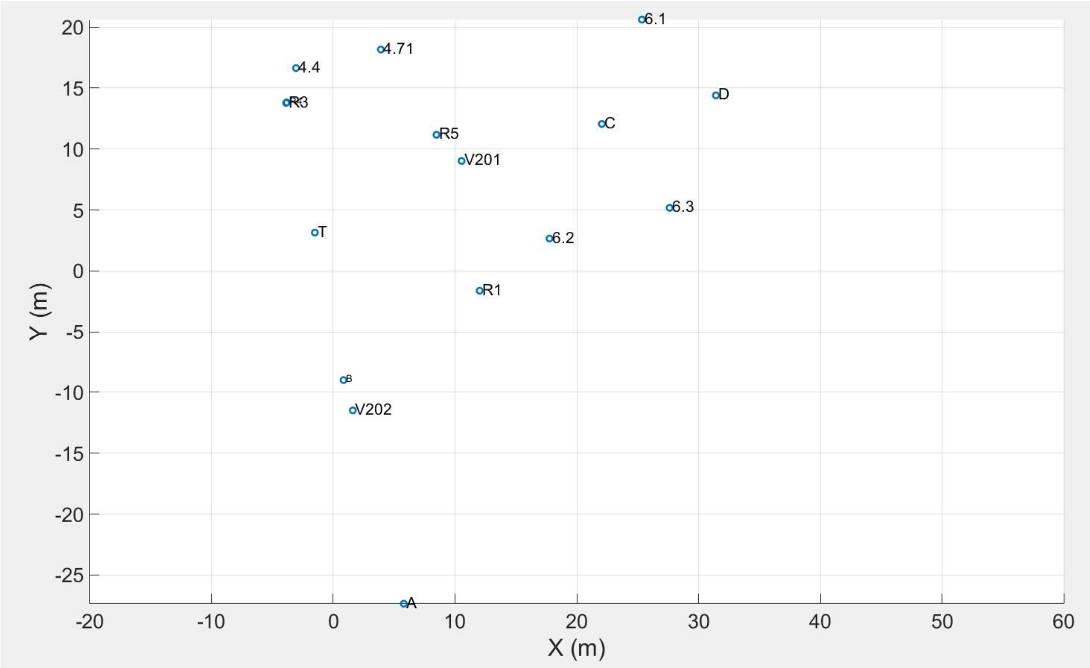

Figure 3 Measured points with Leica tachymeter.

The points of interest in the file coordinates.txt are specified in the next table:

Short name in coordinates.txt	**Description of point**
T	CLS Transmit antenna
A	CLS Receive antenna A
B	CLS Receive antenna B
C	CLS Receive antenna C
D	CLS Receive antenna D
V201	Position of Velodyne laser scanner 201
V202	Position of Velodyne laser scanner 202
R1	Position of Radar 1
R3	Position of Radar 3
R4	Position of Radar 4
R5	Position of Radar 5

5. Access and Contact

To obtain access to the VIDETEC dataset please send us an e-mail to videtec_data@dlr.de