Euro NCAP
For Safer Cars

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On-Road Evaluation Sensing System & Guidance

Safe Driving

Technical Bulletin SD 303

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PREFACE

DISCLAIMER: Euro NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organisation. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, Euro NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

CONTENTS

1 INTRODUCTION

This document serves as a technical bulletin outlining the specifications for proper sensor data recording and formatting, ensuring compatibility with analysis processes required for Euro NCAP tests. It defines the setup and configuration of cameras, a GNSS receiver, and a LiDAR sensor in the vehicle, along with instructions on how to organize and deliver the collected data.

2 POSITIONING AND SENSOR REQUIREMENTS

The required setup includes the following components:

- 4 cameras: Front view, dashboard display, and road areas beside each front wheel
- GNSS receiver: Dual-antenna configuration with IMU and RTK corrections. RTK correction can be added in post-processing, if the corrections are applied before submitting the data to analysis (see 3.4)
- LiDAR sensor: 128-beam sensor, recording at 10 rotations per second
- Recording unit: A computer or equivalent capable of timestamping and capturing all sensor data
- Auxiliary equipment: Power supplies, internet router, and other necessary intermediaries

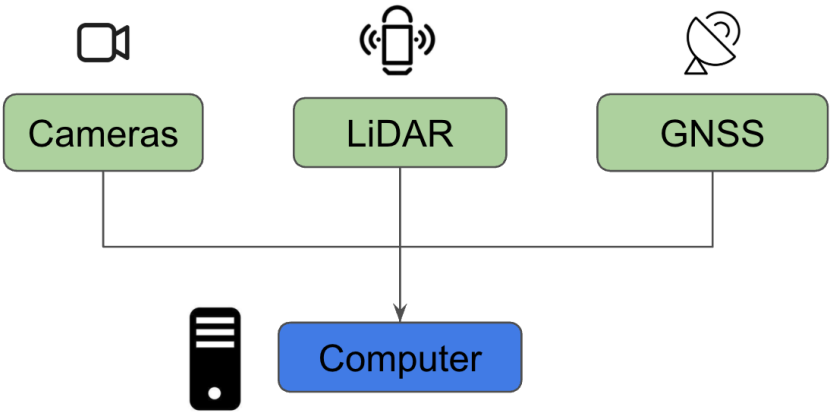

Figure 1. Hardware architecture example

2.1 Camera

There are four cameras in the setup:

- A front-facing camera
- A camera capturing the dashboard's information
- 2 cameras facing the road area beside each front wheel of the car

The cameras must record at a frequency between 20 fps and 30 fps. Whenever possible, the resolution of the recording must be 720p. The only other acceptable resolution is 1080p, in cases where the camera does not allow for a recording in 720p.

To avoid considerable distortion in the elements that must be detected in the images, the cameras and lenses used must have a resulting Horizontal Field of View (HFOV) of no more than 120º.

Fig. 2 shows typical fixation areas for the front camera and dashboard camera mounts on the windshield, and Fig. 3 shows suggested areas for the fixation of side cameras on the vehicle. In either case, the following sub-sections specify characteristics the recorded images must have, so adapt as necessary, also considering local laws.

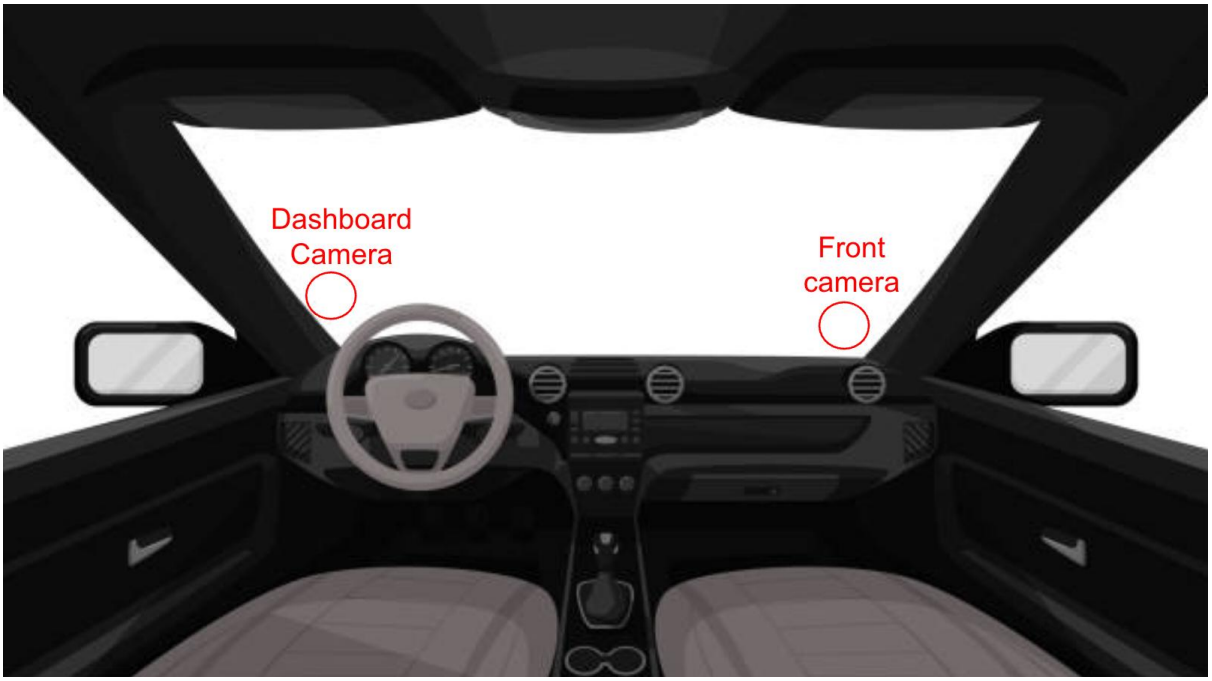

Figure 2. Typical fixation areas for the front and dashboard camera

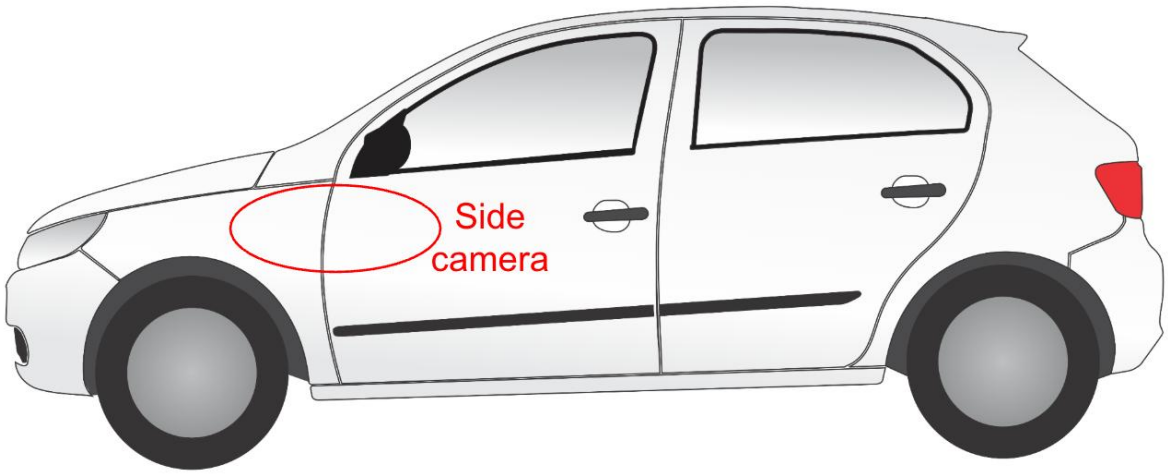

Figure 3. Suggested area for the fixation of side cameras

2.1.1 Front facing camera

This camera must be positioned inside the vehicle, considering local laws about obstruction of the driver's view.

The camera must be mounted on the inside of the vehicle, and positioned as close to the windshield as possible, to minimize reflections. Try to have as little of the frame of the windshield showing at the sides of the image as possible, to take advantage of the camera's entire horizontal field of view.

The image quality and field of view must be such that a traffic sign showing the current speed limit of the road will be readable, both during the day and at night, under the following conditions:

- At all speeds in which the vehicle will be driven during the test
- The traffic sign is between 5 m and 20 m ahead of the vehicle's frontmost point

Similarly, sub signs below the speed limit traffic sign must also be readable, both during the day and at night, under the following conditions:

- At all speeds in which the vehicle will be driven during the test
- The supplementary traffic sign is between 5 m and 15 m ahead of the vehicle's frontmost point.

There is no maximum speed limit for the test, provided that the specified image quality conditions are consistently maintained.

The camera must also be capable of showing the values of dynamic traffic signs under the above conditions. Alternatively, cameras with LED Flicker Mitigation (LFM) capabilities can be used if necessary.

The camera must be positioned in a way so that the ground is parallel to the long sides of the images (that is, the recording must be made in landscape orientation). A rotation of the camera with relation to the ground of up to 30º is still acceptable, though. If the camera needs to be mounted upside down, it can be done if the rotation with relation to the ground is still below 30º.

Figure 4. Example frame containing a traffic sign

Figure 5. Example frame containing a dynamic traffic sign

Make sure to perform some tests to guarantee the capabilities of the equipment for recording at night. Besides the lower light conditions, some camera configurations might result in blurry images when recording at night, so adjust the maximum driving speed accordingly, if necessary, to maintain the necessary image quality.

Figure 6. Example frame of a recording at night

2.1.2 Dashboard camera

The camera must capture all the relevant areas of the dashboard of the vehicle, that is, it must capture at least the following information:

- Vehicle's current speed
- Speed limit information
- Any other signals or alerts the vehicle might inform the driver about

Having the camera pointing down at the screen (that is, positioned above the screen instead of below) usually helps avoid reflections. Also, keep in mind the screen brightness might need to be changed when recording at night, depending on the camera's configuration and behaviour in that situation.

The camera must be positioned close enough to the dashboard so that the speed limit information appears in the image at least with the size as it has in Fig. 7 below. That means that it must be at least 32 pixels in width and 32 pixels in height, on a 720p image.

Similarly to the front-facing camera, the dashboard camera must be positioned in landscape mode. A rotation of the camera with relation to the ground of up to 30º is still acceptable, though. If the camera needs to be mounted upside down, it can be done, if the rotation with relation to the ground is still below 30º.

Figure 7. The speed limit sign icon needs to be at least 30x30px on a 720p image.

Figure 8. Desired quality of a dashboard image. Note that the SLIF icon and speedometer info are quite clear, with limited reflections.

2.1.3 Side cameras

The cameras must be positioned to have the front wheel at the edge of the image besides a considerable area of the road. As a reference, lane markers must not disappear from the image before they are at least 70 cm away from the wheel.

A suggested location for the placement of these cameras is the area below the side mirrors, either attached to the mirrors themselves or to the doors, as seen previously in Fig. 3.

Below are example images of the recordings of side cameras:

Figure 9. Example frame of recording of left camera

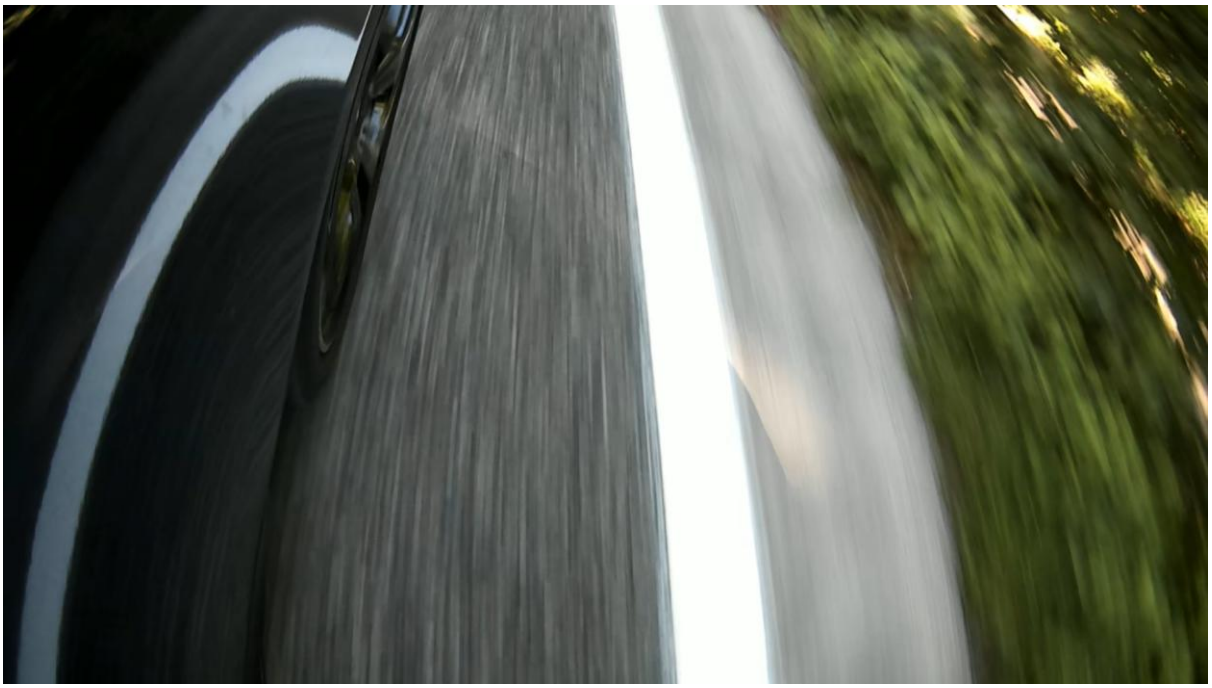

Figure 10. Example frame of recording of right camera

2.2 GNSS

The GNSS antennas must be positioned on the vehicle’s roof.

The frequency in which the GNSS data must be captured is at least 10Hz, and the GNSS device used must have RTK correction.

2.3 LiDAR

The LiDAR sensor should be mounted near the centre of the vehicle's roof, at least 40 cm above any other rooftop structures to ensure an unobstructed 360-degree view. Its vertical field of view must be sufficient to fully capture a pedestrian, or vehicle located 3 meters directly in front of the test car, from the ground up to the top.

The sensor must have 128 vertical beams, equally spaced vertically, and its capturing frequency must be 10 HZ (10-point clouds per second). The sensor used must have a range at 10% reflectivity of no less than 50 m.

2.4 Safety considerations

Some things to pay attention to when mounting the sensors, to guarantee the safety of people both inside and outside the vehicle:

- Every sensor mounted outside the vehicle, on the roof or fixed on the sides, must have extra security measures, so as not to rely on a single means of fixation. Examples of additional fixation methods include safety straps or, for lightweight components, adhesive tape
- No components inside the vehicle must be mounted in areas subjected to the action of the vehicle's airbags. This means the dashboard camera must never be between the steering wheel and the driver, and other cameras inside the vehicle must avoid areas where there are airbags, unless those airbags can be safely disabled for the duration of the test

3 DATA FOTMAT

3.1 Folder structure

Each uninterrupted recording (that is, recording periods in which all sensor data was continually recorded, without pauses) must be contained in a folder named in the following format: YYYY-MM-DD-hh-mm-ss

That is, year, month, and day, followed by hour, minute, and second in which the recording started, in UTC and 24h format for the hours. All mentions of timestamps along this section refer to timestamp in UTC time.

Below is an example of such a folder structure, showing also the subfolders and example file names that must be used, which will be described in detail below:

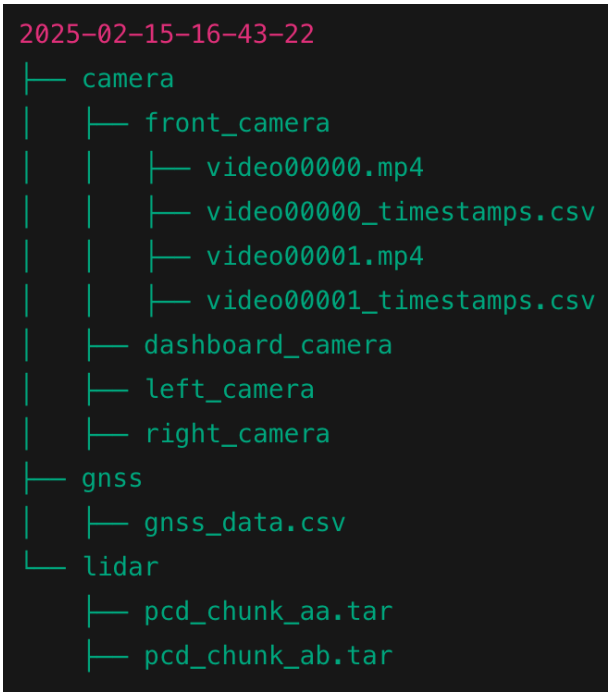

Figure 11. Folder structure and file name examples

3.2 Sensor data

Below are described the acceptable formats in which the data of each sensor can be delivered for analysis.

3.3 Camera data format

Inside the recording folder, there must be a “camera” subfolder, and inside that, the following subfolder names must be used for the respective cameras that exist in the setup:

- front_camera
- dashboard_camera
- left_camera
- right_camera

Camera data must consist of videos, either in MP4 or MKV formats. Each subfolder can contain either a single video or multiple videos; in case the recording is split into multiple video files.

Each video must be accompanied by a csv file of only one column, containing the integer part of the timestamp of each of the video's frames' capture time in milliseconds.

The naming convention must be as follows:

- Videos inside each folder must be named as video00000.mp4, or video00000.mkv, with the index of the videos increasing by one for each new video in the folder: video00001.mp4, video00002.mp4, etc.
- The files with the timestamps must be named like the equivalent video, followed by "_timestamps.csv", that is: video00000_timestamps.csv, video00001_timestamps.csv, etc.

The number of frames in each video must always be equal to the number of timestamps in the respective CSV file.

3.4 GNSS output

Inside the recording folder, there must be a "gnss" subfolder. Captured GNSS data must be delivered in a CSV file, named gnss.csv, inside that subfolder. Listed below are the column names and data types that must be used, followed by a brief description and requirements of each field:

- Timestamp_ns, timestamp in nanoseconds, as FLOAT32
- Latitude, latitude in radians, as FLOAT64
- Longitude, longitude in radians, as FLOAT64
- Heading, values between 0 and 360 degrees, as FLOAT32, following the usual convention for GPS heading values:
    - 0 degrees when facing North
    - 90 degrees when facing East
    - 180 degrees when facing South
    - 270 degrees when facing West
- Speed, 2-D ground speed (horizontal speed excluding vertical/z-axis component), measured by the GNSS receiver, in meters per second (m/s), as FLOAT32

Note that any post-processing corrections necessary to the GNSS data must be already applied when generating the CSV file to be delivered, so that the output consists only of the above data description.

3.5 LiDAR output

Inside the recording folder, there must be a "lidar" subfolder, containing tarball files. LiDAR data must, at first, be recorded or converted into PCD files, stored in binary format. Each file's name must be the integer part of the timestamp of that point cloud's capture time in nanoseconds. The files must contain the following fields, all of them with FLOAT32 precision:

- x
- y
- z
- intensities

Fields x, y, and z represent the spatial coordinates of each point in the point cloud, in meters. Field intensities represent the perceived intensity of the reflected beam corresponding to each of the points and contain values in the range 0-255.

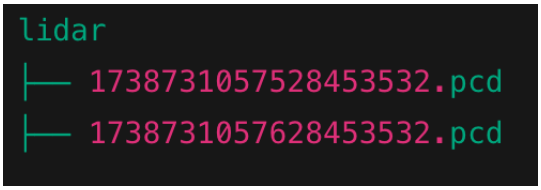

Figure 12. Example files in the lidar subfolder, before performing the tar command

After having all the PCD files in a folder (example in Fig. 12), they must be converted into tarball files, each of size 500 MB. The resulting files must be the ones delivered in the “lidar” subfolder, as seen in Fig. 11.

4 VALIDATION SETUP

Before taking the assembled system on a long recording session, the system should be tested by performing a short recording and making sure the generated data can match all the requirements in this document. For that to be possible, the trajectory for this test should include the items that must be used for the validation of the camera images:

- Traffic signs
- Dynamic traffic signs
- Visible lane markers

Additionally, one such test must occur at least twice to cover for day and nighttime driving.

The quality of the sensor data should then be checked by both visual checks (looking at camera images, plotted GPS trajectories, and point clouds), as well as automated checks, to check for the correctness of the output formats.

The tables below can be used to summarize the quality checks that must be made in the camera images, especially because those are affected by the differences between day and night driving.

4.1 Front camera quality check

The images must be readable on all the below conditions:

	Day driving	Night driving
Speed limit traffic sign (and supplementary sign) on the right-hand side must be readable	30, 50, 120 kph	30, 50, 120 kph
Speed limit traffic sign (and supplementary sign) on the left-hand side must be readable	30, 50, 120 kph	30, 50, 120 kph
Dynamic traffic sign above the road must be readable	30, 50, 120 kph	30, 50, 120 kph

4.2 Dashboard camera quality check

Two factors are important here: the light coming from the outside may cause reflections, and the screen brightness can change based on outside brightness and state of the headlights.

	Day driving (sun low in the sky)	Day driving (sun high in the sky)	Night driving
SLIF information is readable	Any speed	Any speed	Any speed

4.3 Side cameras quality check

	Day driving	Night driving
Lane markers are visible in the images	Any speed	Not applicable

5 RECORDING PROCEDURE

In the definitive recording campaign, it's assumed many hours of data will often be recorded in each day of driving. Some good practices must be adopted to ensure no data will be lost over time because of technical problems:

- Daily checks of representative samples of the recorded data
- Daily backing up and uploading of the recordings
- Development of a checklist to be used daily, at the beginning of recording days, including the physical checks that must be made, specific to the setup (cable connections, sensor mount robustness, etc.)

Besides that, always keep visible on both sides of the vehicle a panel with a QR Code, which links to a description of the tests that are being conducted. The exact design of this panel, as well as the link it should contain, are still to be defined.

6 UPLOAD PROCEDURE

To upload recorded data, a GUI application will be made available, to be installed or executed on a computer containing the data. Detailed instructions will be made available with the tool, but the procedure can be summarized as:

- Authentications
- Select the path to the data that will be uploaded
- Upload the data