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CATS Deliverable 3.2:
CATS report target specifications

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1 Introduction

The overall number of fatalities in road traffic accidents in Europe is decreasing, however unfortunately the number of fatalities among cyclists does not follow this trend with the same rate. In order to address this from 2018, AEB systems dedicated to avoid or mitigate car-to-cyclist collisions will be considered in the safety assessment by Euro NCAP. To develop protocols and appropriate equipment to test such systems, TNO has initiated the CATS “Cyclist-AEB Testing System” consortium, in which around 20 partners, mostly OEM’s and TIER1s, have joined forces. Accidentology was used to determine the three most common car-to-cyclist accident scenarios in the EU. Accident data and data from observation studies were used to determine the parameter ranges in the test matrix that has been proposed for the selected test scenarios. A bicyclist target has been specified to represent a real bicyclist on a bike, taking into account all different types of sensors used in AEB systems. 4activeSystem GmbH (Austria) has developed and manufactured a bicyclist target and propulsion system that meets the set of requirements to represent the defined scenarios. Together with car manufacturers and suppliers, the proposed test matrix has been verified.

This report describes the justification of the bicyclist and bike target specification. Besides this report a separate document is available with the detailed bicyclist and bike target specification [1].

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2 Definitions

Throughout this protocol the following terms are used:

Autonomous Emergency Braking (AEB) – braking that is applied automatically by the vehicle in response to the detection of a likely collision to reduce the vehicle speed and potentially avoid the collision.

Vehicle under test (VUT) – means the vehicle tested according to this protocol with a pre-crash collision mitigation or avoidance system on board

CATS Bicyclist and bike Target (BT) – means the bicyclist and bike target.

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3 Dummy specifications

The bicyclist and bike target (BT) described in this report represent an average human bicyclist on an average standard European utility bike (for example Figure 1) in relation to the vulnerable road users (VRU) detection sensors used in vehicles. The requirements relate, insofar not specified otherwise, to the BT including a platform, which is needed to keep the bike and bicyclist upright during testing. The BT is designed to work with the following types of automotive sensors technologies: RADAR (24 and 77 GHz), Video, Laser and Near-IR-based system similar to the Euro NCAP AEB VRU protocol [2].

Figure 1 Example of human bicyclist on a standard European utility bike

The bicyclist and bike target (BT) has been developed in an iterative process, where the initial BT was based on information of bicyclist and bike properties from the European FP7 project AsPeCSS (www.aspecss-project.eu/). Various development and verification workshops have been performed, in which OEM's and suppliers could evaluate the different version of BT. During those workshops both real and target bicyclist and bike were available for comparison. Based on the feedback from those workshops the BT has been adjusted in different development stages to better match the visual and RCS responses of a real bike and bicyclist. During those workshops both static and moving real and target bicyclist and bike have been used to also take into account the micro-Doppler signatures. The final bicyclist and bike target as described in this report and the detailed bicyclist and bike target specification [1] has been approved by the CATS partners.
Small fluctuations in position and angle of the target should not have a significant result on the visual and radar properties.

3.1 General properties and features

The fitment of various features of the bicyclist and bike have been evaluated as well as possible clothing of the bicyclist to check relevance for inclusion in the bicyclist and bike target (BT). Wearing reflective clothing or a helmet are both not mandatory under all conditions for bicyclists in any of the EU28 countries. For that reason neither reflective clothing nor a helmet will be part of the BT specification. Both however could be retrofitted on the BT as optional feature.

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Front, rear, pedal and wheel reflectors are mandatory in many of the EU28 countries and are therefore included in the specifications of the BT. The specifications for the reflectors are not uniform over the EU28 countries, but the most common ones have been selected for the BT specifications. The front, rear and all four pedal reflectors (left – right and front - rear) should be marked BS6102/2 (or equivalent) and coloured respectively white (front), red (rear) and amber (pedals). The front and rear reflector should be located on the bike target between 350mm and 900mm from the ground level, with the white front reflector positioned between most forward point of bike target and the top of the front frame facing forward. The red rear reflector is positioned between most rearward point of the bike target and the top of the rear frame facing rearward. The amber coloured pedal reflectors should be on the front and rear side of both left and right pedal. The wheel reflectors will be white reflective strips on both sides of the rims or tyres.

As mudguards, gear cases and luggage racks are fitted on most bikes in the EU, therefore they are included in the BT specifications.

Both the fact that the CATS test protocol [3] only includes daytime tests and the fact that front and rear light are not mandatory in most EU countries during daylight, front and rear lights are not included in the bike target requirements. However the defined front and rear reflectors have been selected in such a way that they can be easily replaced with front and rear lights that include reflectors. In that way the front and rear light can be offered as optional to the bike target.

For a realistic representation with respect to the micro-Doppler effect the bike target (BT) is fitted with rotating wheels. Both wheels should be in permanent contact with the ground to make sure that the wheel rotational speed is in agreement with the actual bike speed. More information on the radar properties of the target is provided in paragraph 3.4, which is dedicated to radar properties. The room between the spokes should be transparent and not give reflections for radar or visual systems independent of the viewing angle.

Within the CATS project the inclusion of rotating pedals and moving legs has been considered, however forward motion on a bicycle does not necessarily require moving neither pedals nor legs. An observation study on bicyclist behaviour showed that a significant part of the bicyclists stop pedalling when approaching a crossing [4]. Therefor nor rotating pedals nor moving legs are included in the specifications of bike and bicyclist target. Rotating pedals and/or moving legs could be implemented in a later phase or as an option to the target.

Similar to the ACEA pedestrian target specification [5] the bicyclist target should be coated with a closed textile outer cover.

3.2 Dimensions and posture

The bike target is based on a standard European utility bike, as shown in Figure 1, and has a double triangle frame shape.
The dimensions of the bike target are based on an average Dutch utility bike for average male according to data from TU Delft ([6] and [7]) with additional dimensions taken from a standard Dutch utility bike (Gazelle Paris Pure male size

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57) to complete the dimension specifications. Also alternative European bikes have been taken into account.
The dimensions of the bicyclist target are based on an adult pedestrian target described in ACEA pedestrian target specification [5] representing average (50th %-ile) male. The shape of the adult bicyclist target has to comply in its contours with the 50% RAMSIS Bodybuilder based on the RAMSIS version 3.8.30 to a permitted tolerance of ± 20mm.
The posture of bicyclist target represents a natural driving position, facing forward, both hands on the steering wheel. The observation study performed showed that the majority of bicyclists have one foot down and the other foot up when approaching a crossing [4]. The same dummy posture is used for all driving directions, with right foot down and left foot up. The posture definition includes angle and/or position of torso, hips, knees, feet, shoulders, elbows and hands.

The actual dimensions and posture specification of the bike and bicyclist can be found in the bicyclist and bike target specification document [1].

3.3 Visual and infrared

The bicyclist target will have the same visual and infrared requirements as defined in ACEA pedestrian target specification [5]. The bicyclist target shall look like clothed with a long-sleeved shirt and shoes in the colour black and long trousers in blue. For practicality during testing the clothing should be made from tear-proof and water-resistant material. The “skin” surface parts (face and hands) have to be finished with a non-reflective flesh-coloured texture or paintwork and the head hairs should also be black.
The bike target will have a frame, mudguards, luggage rack and tires in black. The gear case and rims are grey.
The colour of support platform, stiffening ropes or other supports must be light grey or transparent and be of low optical reflectivity.

The detailed colour and infrared (IR) reflectivity specification of the bicyclist and bike can be found in the bicyclist and bike target specification document [1].

3.4 Radar

The radar reflective characteristics for ADAS relevant radar frequencies (77 GHz) of the bicyclist and bike target (BT) should be comparable to a real human bicyclist and bike of the same size. The requirement boundaries are also based on measurement spread of real human bicyclist and bikes.

The AsPeCSS 360° RCS measurements have been used as basis for the RCS properties of the bicyclist and bike target (BT). Within the FP7 AsPeCSS project 360° RCS measurements have been performed in an RF anechoic chamber on a bike with bicyclist for radar frequencies 24 GHz and 77 GHz. In those tests pedestrian and bicyclists have been place on a rotating pedestal and RCS signatures have been determined from a fixed distance [8]. For the bicyclist evaluation a standard European utility bike with an average bicyclist has been used. It is noted that for the 360° RCS measurements, the wheels of the bike are not rotating.

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After this a series of development and verification workshops, in which OEM's and suppliers could evaluate the BT, have been performed. During those workshops both real and target bicyclist and bike were available for comparison and both static and moving real and target bicyclist and bike have been used to also take into account the micro-Doppler signatures.

For the final target definition multiple configurations will be used to evaluate the RCS and micro-Doppler signature of the target, to ensure that RCS and micro-Doppler characteristics of the BT match a real human bicyclist and bike from different distances and angles.

RCS measurement configuration 1 is intended as baseline RCS measurement in well-controlled environment. RCS measurement configurations 2 and 3 can also be used as verification tests during testing, to ensure the target RCS properties are still within the set corridors.

Different radar property tests:

1. 2D Radar Cross Section Distribution (RCS)
   In this test the target is scanned in 2D over width and height. This is done for the 4 main angles (left, right, back and front).
2. Radar Cross Section (RCS)
   Measurements with automotive radar sensors moving towards the stationary BT, to take into account the RCS properties at different distances.
3. Micro-Doppler Effect of Articulation
   Measurements with automotive radar sensors at fixed location and moving BT, crossing and longitudinal, to measure response at different BT angles and distances and micro-Doppler effect of rotating wheels.

The radar profile of support platform, stiffening ropes or other supports must be low and not affect the overall radar profile of the BT.

The detailed radar specification of the bicyclist and bike can be found in the bicyclist and bike target specification document [1].

3.5 Stability

The bicyclist and bike target (BT) should have limited deviation relative to moving direction of BT during testing. A sideward motion up to +/- 5° is acceptable, similar to ACEA pedestrian target specification [5].

3.6 Crashworthiness

For test practicality the bicyclist and bike target (BT) should have limited weight (max. 11kg) and lack any hard impact points to prevent damage of the Vehicle Under Test (VUT). It should be possible to repair damage to both VUT and BT related to impact speeds (up to 60km/h for crossing scenarios and 45km/h for longitudinal scenarios) with limited time and costs. Any repair to the BT should not affect the properties related to representation of real bicyclist & bike, nor the stability.

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3.7 Environmental conditions

The bicyclist and bike target (BT) shall fulfil all requirements in a temperature range of -5ºC to +40ºC. The BT shall not deteriorate under storage temperatures in the range of -20ºC to +80ºC when properly stored.
Wind speeds up to 10m/s should not have a significant influence on the characteristics of the BT, similar to ACEA pedestrian target specification [5].

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4 Signature

Helmond, September 2nd 2016

TNO

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6 Acknowledgements

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