DEVELOPMENT OF A CYCLIST-AEB TESTING SYSTEM
CATS - Sjef van Montfort, TNO
OUTLINE

› Introduction
› CATS project:
   › Objectives & timing
   › Process
   › Accident analysis
   › Test scenario definition
   › Dummy & Propulsion system development
   › Verification & testing
   › CATS test matrix
› Euro NCAP: AEB-Cyclist 2018 proposal
› Conclusion & Outlook
› Acknowledgment
INTRODUCTION

- Cycling is increasingly popular
  - In the Netherlands, 26% of all journeys occur by bicycle (CROW, ECF)

- Electric power-assisted bicycle:
  - Annual sales (in units) increased with factor of 10 in last 8 years in EU

- Social benefits of cycling
  - Scope for development (working, learning, recreating) in case no car / driving license
  - Elderly keep mobile avoiding social isolation
  - Environmental benefit (true zero emission)
  - Flow problem for car traffic
  - Parking problem in town centres and at workplace
  - Health of cycling
  - Traffic safety: more cyclists, less risks
INTRODUCTION

Total number of road fatalities and cyclist fatalities over the period of 2001 to 2012 for: France, Germany, Italy, the Netherlands, Sweden and the UK
INTRODUCTION
EURO NCAP ROADMAP FOR AEB – FCW

AEB City
2014
2016
2018

AEB Inter Urban
2014
2016
2017

AEB VRU Pedestrian
2015
2017
2019

AEB VRU Cyclist
2016
2018
2020

AEB City update

AEB in crossing, junction and head-on scenarios

2015
2017
2019
CATS: OBJECTIVES & TIMING

CATS (Cyclist-AEB Testing System) project:

- Prepare the introduction of a protocol for consumer tests of Cyclist-AEB systems on board passenger cars
- Propose a test setup (incl. hardware) and test protocol for Cyclist-AEB systems based on technical/scientific considerations
- Base the tests on analysis of most relevant cyclist accident scenarios in EU countries

Timing: 2014 Q1 – 2016 Q2

Public information and reports to be found on: TNO.NL/CATS
CATS: PROCESS

1 Accident Analysis

2 Test scenario definition

3 Dummy development

4 Propulsion system development

5 Verification & Testing
CATS: PROCESS

Accidentology

Observation study

Simulation

NCAP pedestrian protocol (typical # tests, target)

First draft test matrix (July 2015)

Simulation studies

Initial tests with Volvo XC90 (2015)

Robustness tests TNO lab car

Updated draft test matrix (January 2016)

Verification tests (partners)

Final CATS test matrix (June 2016)

Euro NCAP AEB Working Group

: studies as input for CATS matrix
: CATS matrix with relevant scenarios and parameter ranges
: simulations and tests
: input for AEB working groups
Study databases for 6 European countries;
Select severe car-to-cyclists accidents → fatalities and seriously injured;
Provide overview of distinguished accident scenarios;
Determine the distribution of scenarios in the different countries;
Prioritize scenarios & indicate how many fatalities and seriously injured are covered.
CATS: TEST SCENARIO DEFINITION

› Most relevant accident scenarios

![Accident conditions and partners](image)

› Relevant accident parameters for those scenarios

<table>
<thead>
<tr>
<th>Accident conditions</th>
<th>Accident partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>Cyclist speed</td>
</tr>
<tr>
<td>Lighting conditions</td>
<td>Vehicle Speed</td>
</tr>
<tr>
<td>Location</td>
<td>Impact point</td>
</tr>
<tr>
<td>Road layout, obstruction</td>
<td>Cyclist gender</td>
</tr>
<tr>
<td>Speed limit</td>
<td>Cyclist age</td>
</tr>
<tr>
<td>Season</td>
<td>Helmet use</td>
</tr>
</tbody>
</table>
CATS: TEST SCENARIO DEFINITION

Examples of parameter evaluation

Accidentology

Observation study

Simulation
CATS: DUMMY & PROPULSION DEVELOPMENT

Various development workshops where together with partners different stages of dummy and propulsion system have been evaluated.

Dummy:
- Dimensions
- Features
- Camera
- LIDAR
- Radar
- Impactability/Durability

Test set-up:
- Accuracy
- Repeatability
- Reproducibility

<table>
<thead>
<tr>
<th></th>
<th>CATS partner 1</th>
<th>CATS partner 2</th>
<th>CATS partner 3</th>
<th>CATS partner 4</th>
<th>CATS partner 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static RCS</td>
<td>270.0</td>
<td>270.0</td>
<td>270.0</td>
<td>270.0</td>
<td>270.0</td>
</tr>
<tr>
<td>Dynamic RCS</td>
<td>90.0</td>
<td>90.0</td>
<td>90.0</td>
<td>90.0</td>
<td>90.0</td>
</tr>
<tr>
<td>Micro-Doppler</td>
<td>112.5</td>
<td>112.5</td>
<td>112.5</td>
<td>112.5</td>
<td>112.5</td>
</tr>
<tr>
<td>Dynamic Optical Representation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Target Bike and Byciclist target vs. Real Bike and Bicyclist

Definition: Real bike is the reference e.g. in this case the dummy RCS is bit to low compared to the Holland bike.
CATS: DUMMY & PROPULSION DEVELOPMENT

4activeBS v5

- Changeable handle bar for Dutch and European bike
- White reflector in the front mounted on the frame
- Polymer frame with metal layer for radar properties
- Plastic mud guard
- Real rubber tire with reflecting ring
- Rim with reflecting material
- Materials and properties of bicyclist same as Euro NCAP Pedestrian Target
- Adjustable torso-angle
- Rotational joint of hip connected to bike frame
- Rear red reflector mounted on the luggage rack
- Rotational joint at the knee point
- Rotating wheels due to contact to the ground

Dummy specification document available on TNO.NL/CATS

4activeSB Platform II

Longitudinal set-up
CATS: VERIFICATION & TESTING

Scenario:
- Realism
- Feasibility

Test set-up:
- Accuracy
- Repeatability
- Reproducibility
CATS: VERIFICATION & TESTING

Crossing Cyclist

source FCA
# CATS: TEST MATRIX

<table>
<thead>
<tr>
<th>Vehicle speed</th>
<th>CVNB</th>
<th>CVNBO</th>
<th>CVFB</th>
<th>CVLB</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 – 60 km/h</td>
<td>10 – 40 km/h</td>
<td>20 – 60 km/h</td>
<td>30 – 60 km/h</td>
<td>65 – 80 km/h</td>
</tr>
<tr>
<td>Cyclist speed</td>
<td>15 km/h</td>
<td>10 km/h</td>
<td>20 km/h</td>
<td>15 km/h</td>
</tr>
<tr>
<td>Obstruction</td>
<td>Without</td>
<td>With D1=3.55m, D2=4.80m</td>
<td>Without</td>
<td>Without</td>
</tr>
<tr>
<td>Collision point</td>
<td>50 %</td>
<td>50 %</td>
<td>25 %</td>
<td>50%</td>
</tr>
<tr>
<td>AEB / FCW</td>
<td>AEB</td>
<td>AEB</td>
<td>AEB</td>
<td>AEB</td>
</tr>
<tr>
<td># tests [36]</td>
<td>9</td>
<td>7</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

### Layout sketch

![Layout sketch](image)

### Expected feasibility 2018

<table>
<thead>
<tr>
<th>CVNB</th>
<th>CVNBO</th>
<th>CVFB</th>
<th>CVLB</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

### Important notes:

- Main challenge in CVNB is system robustness (AEB response after collision is unavoidable, cyclist cannot break or steer away to avoid collision).
- Main challenge in CVNBO is the limited time for system response.
- CVFB is not expected to be feasible for production vehicles in 2018, especially due to challenges in Field-of-View requirements, response time and real-world robustness.
- Recommended to verify that the vehicle shows AEB performance at a 25% collision point with one VUT speed in the 30-40 km/h speed range to ensure AEB performance at 25% collision point below 50%.
- Field-of-View is a general issue for the 3 crossing scenarios at low vehicle speeds.
- System robustness is a general issue for the 3 crossing scenarios at high vehicle speeds.
- Evaluation of FCW considers collision avoidance by steering and not braking.
# EURO NCAP: AEB-CYCLIST 2018 PROPOSAL

<table>
<thead>
<tr>
<th></th>
<th>CBAN</th>
<th>CBANO</th>
<th>CBAF</th>
<th>CBAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VUT speed</strong></td>
<td>20-60 km/h</td>
<td>20-60 km/h</td>
<td>20-60 km/h</td>
<td>25-60 km/h</td>
</tr>
<tr>
<td><strong>Cyclist speed</strong></td>
<td>15 km/h</td>
<td>10 km/h</td>
<td>20 km/h</td>
<td>15 km/h</td>
</tr>
<tr>
<td><strong>Obstruction</strong></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Impact point</strong></td>
<td>50%</td>
<td>50%</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>AEB/FCW</strong></td>
<td>AEB</td>
<td>AEB</td>
<td>AEB</td>
<td>AEB</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FCW</td>
</tr>
</tbody>
</table>

- **Year of test**: 2018, 2020, 2018

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17 | Development of a Cyclist-AEB Testing System
29 November 2016
CONCLUSION & OUTLOOK

› Conclusion
  › Successful process to develop the Cyclist-AEB Testing System
  › CATS protocol including test matrix proposed to Euro NCAP AEB VRU working group
  › Euro NCAP proposal for 2018 and 2020 in line with CATS findings, both test matrix and test target

› Outlook
  › Active global communication and dissemination of CATS results
  › Support further development & evaluation of Cyclist-AEB for Euro NCAP and others
  › Considerations towards 2020:
    › Specification of view-blocking barrier
    › Dealing with parameter ranges in protocol
  › Development of cyclist intent prediction models to support Cyclist-AEB control law
  › Market introduction of Cyclist-AEB systems on more production vehicles
ACKNOWLEDGEMENT
THANK YOU FOR YOUR ATTENTION

Take a look:
TNO.NL/CATS & TIME.TNO.NL

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