FISITA WORLD AUTOMOTIVE CONGRESS BUSAN 2016

Cyclist target and test setup for the evaluation of Cyclist-AEB systems

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TNO innovation for life

Overview

- Introduction
- Method for development of test matrix
- Test matrix development
- Testing system specification and realisation
- Verification
- Conclusion

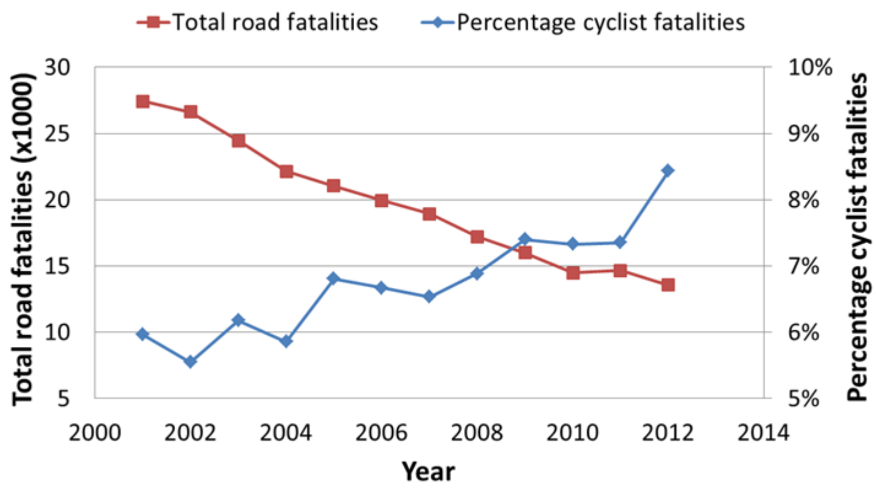
Cycling is increasingly popular

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

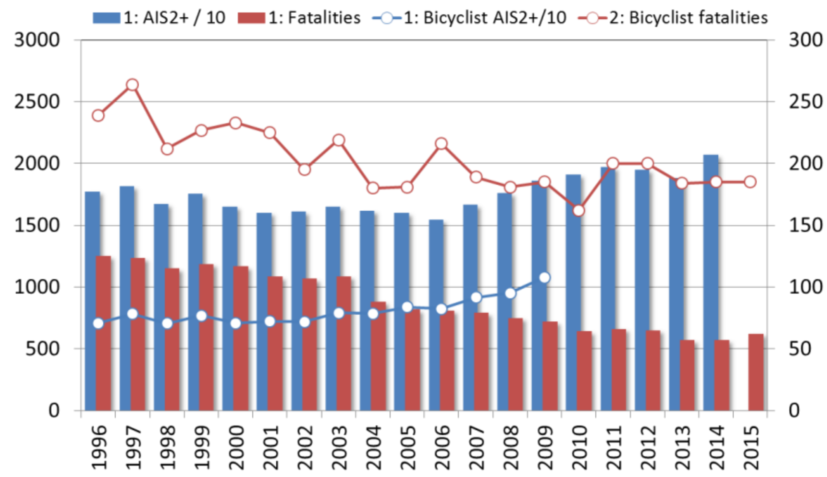
- Electric power-assisted bicycle:
  annual sales (in units) increased with factor of 10 in last 8 years in EU

- 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

Accident trends for cyclists (Europe, Netherlands)



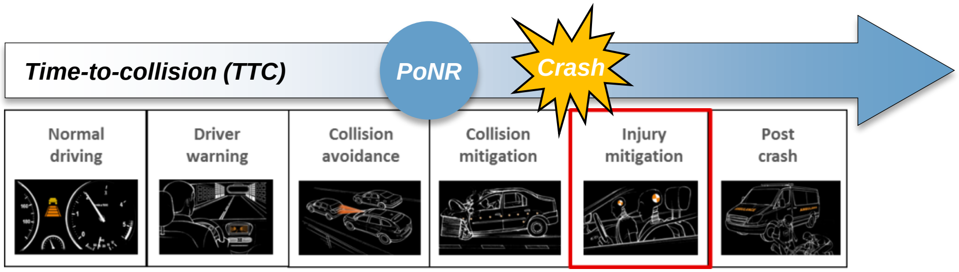
Trends of total road fatalities and cyclist fatalities for France, Germany, Italy, the Netherlands, Sweden plus the UK over the period of 2001 to 2012 according to CARE community road accident database as collected by the EU Member States.



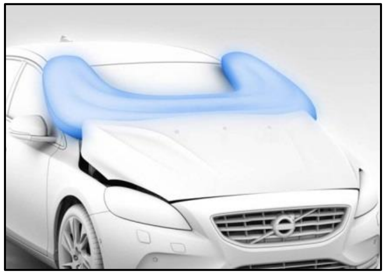
Trends for fatalities and seriously injured (total and bicyclists) for the Netherlands (NL) from 1996 to 2015.
30% of fatalities are bicyclists - 10% are pedestrians (2015)

Solutions to protect cyclists*

- **Injury mitigation:**
  - Pop-up bonnet



  - Windshield airbag

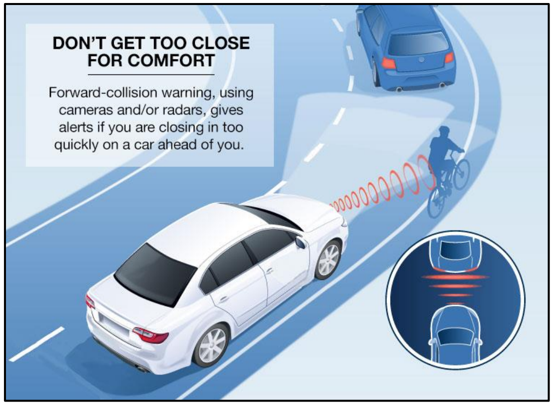


  - Personal protection equipment

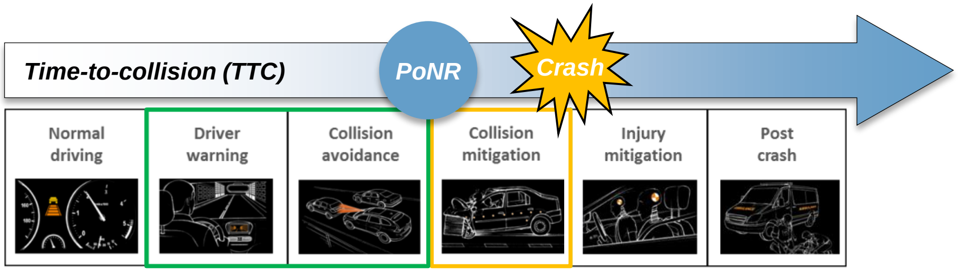
* In car-to-cyclist accidents

Solutions to protect cyclists*

- **Collision avoidance / mitigation:**
  - Forward collision warning



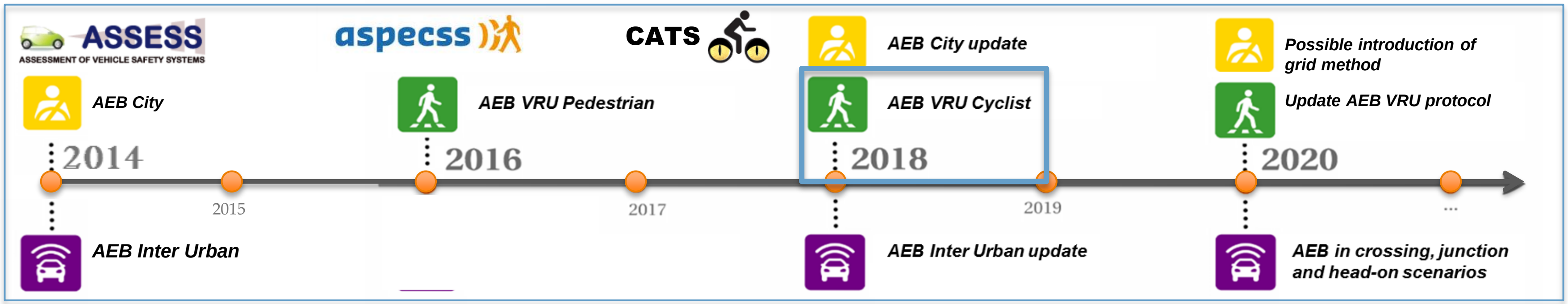
www.consumerreports.org



  - Autonomous Emergency Braking

* In car-to-cyclist accidents

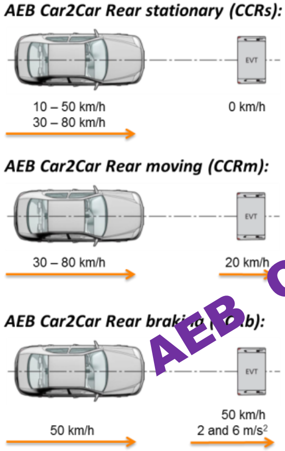
Euro NCAP roadmap



AEB Car2Car Rear stationary (CCRs):

AEB Car2Car Rear moving (CCRm):

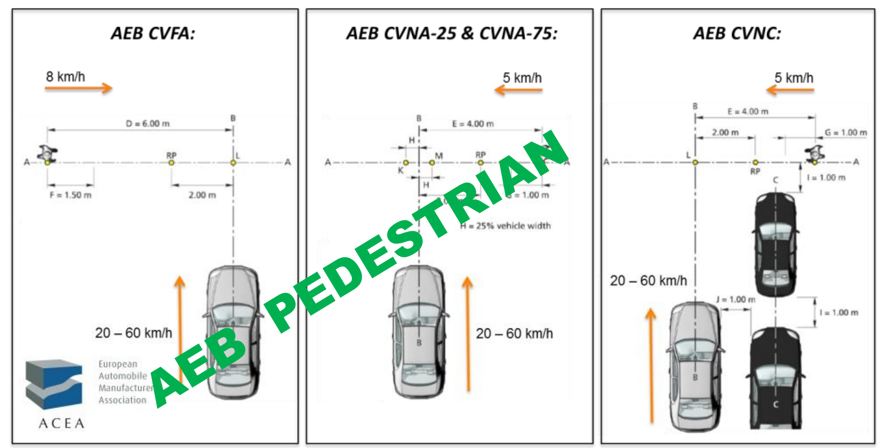
AEB Car2Car Rear braking (CCRb):



CCRs				
	AEB+FCW combined		AEB only	FCW only
	AEB	FCW		
AEB City	10-50 km/h	-	10-50 km/h	-
AEB Inter-Urban	-	30-80 km/h	30-80 km/h	30-80 km/h

CCRm				
	AEB+FCW combined		AEB only	FCW only
	AEB	FCW		
AEB Inter-Urban	30-70 km/h	50-80 km/h	30-80 km/h	50-80 km/h

CCRb			
		AEB+FCW combined, AEB only, FCW only	
		2 m/s²	6 m/s²
AEB Inter-Urban	12m	50 km/h	50 km/h
	40m	50 km/h	50 km/h



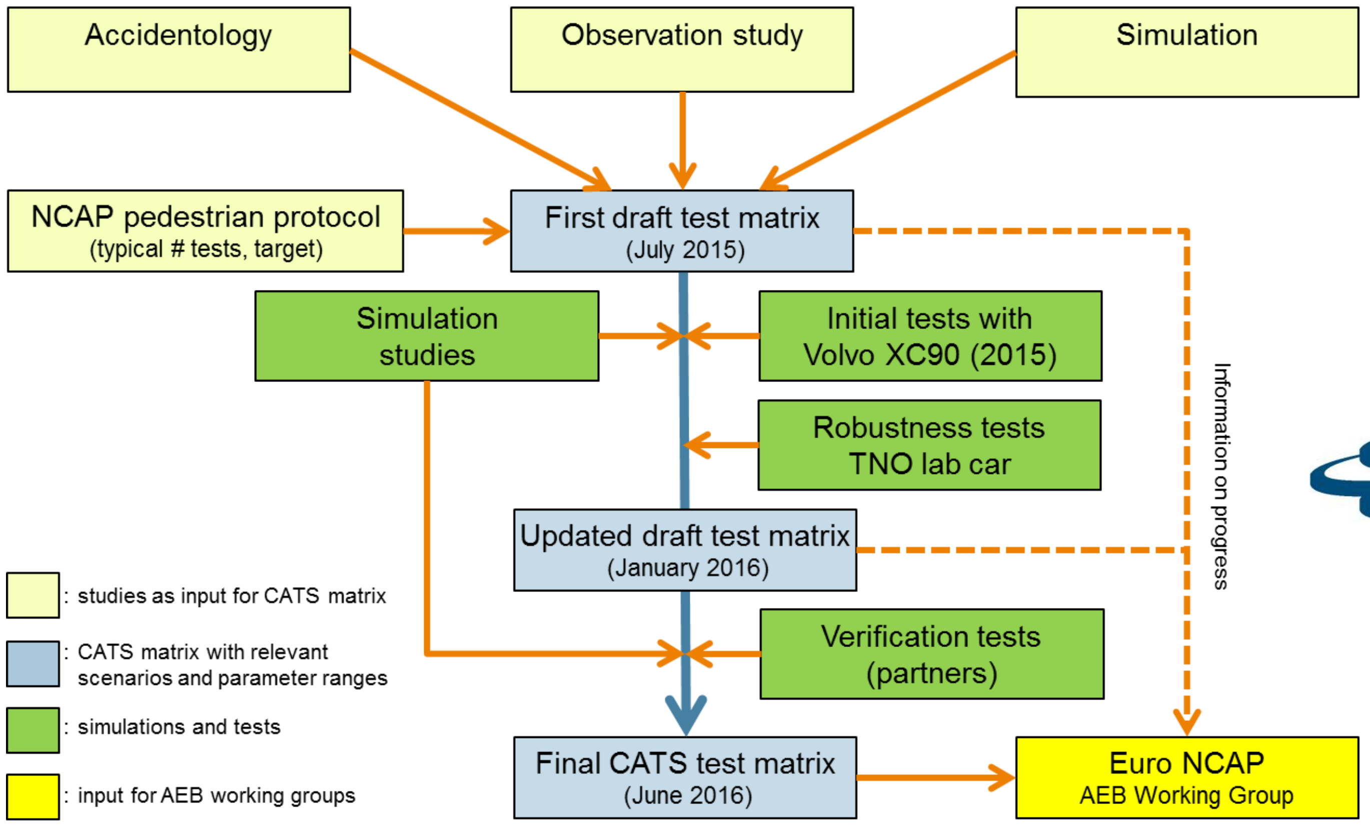
Development of a Cyclist-AEB testing system (CATS)

Objective

- 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

Process to final test matrix



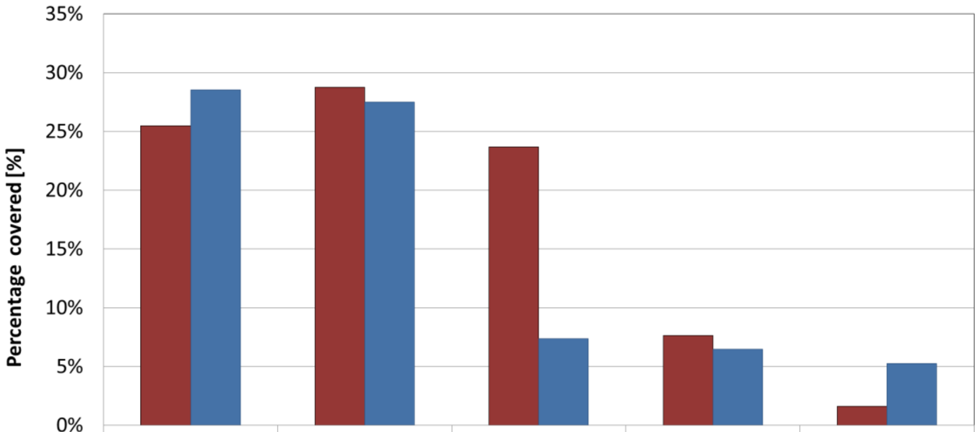
Approach

- Study databases for 6 European countries;
- Select severe car-to-cyclists accidents --> fatalities, seriously injured;
- Provide overview of distinguished accident scenarios;
- Determine the distribution of scenarios in the different countries;
- Prioritize scenarios & indicate coverage of fatalities and seriously injured.

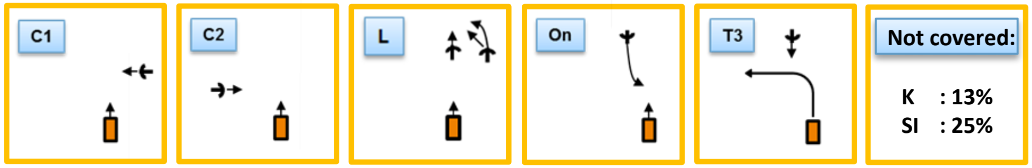
#	Country	Source	Killed (K) definition	n	Seriously Injured (SI) definition	n	Period
1	France	LAB	Fatal	72	severely injured	620	2011
2	Germany	GIDAS based PCM	Fatal	11	AIS2+	360	1999-2012
3	Germany	GIDAS	Fatal	12	AIS2+	514	2006-2013
4	Germany	National accident statistics	Fatal	345	AIS2+	11964	2008-2012
5	Italy	FIAT internal database	Fatal	23	AIS2+	17	2003-2014
6	Netherlands	BRON	Fatal	902	seriously injured	10854	2000-2013
7	Sweden	STA/STRADA	Fatal	104	AIS2+	435	2005-2014 K 2010-2014 SI
8	UK	STATS19	Fatal	116	seriously injured	2699	2008-2010

Most common car-to-cyclist accident scenarios

- Weighted for 5* European countries upon # cyclist fatalities / million inhabitants



	C1	C2	L	On	T3
mean K	25%	29%	24%	8%	2%
mean SI	29%	28%	7%	6%	5%

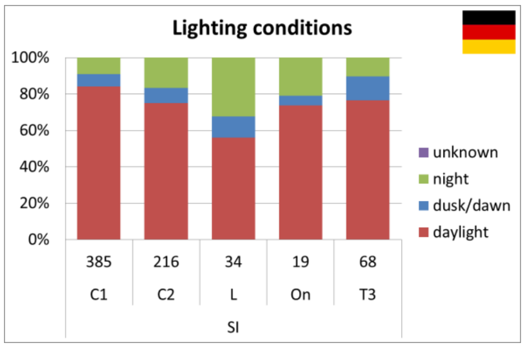


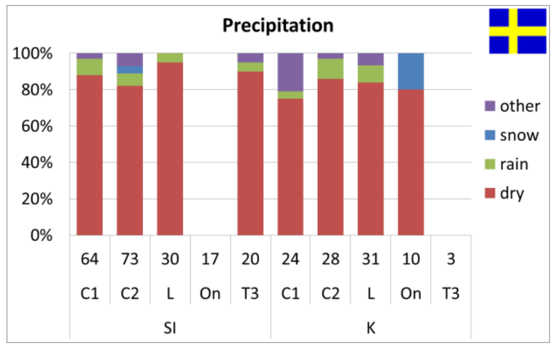
Country	# road fatalities per million	# cyclist fatalities per million	Weighting [%]
France	62	2,8	11%
Germany	45	6,0	26%
Italy	68	5,4	-
Netherlands	32	9,2	38%
Sweden	28	3,6	15%
UK	30	2,3	10%

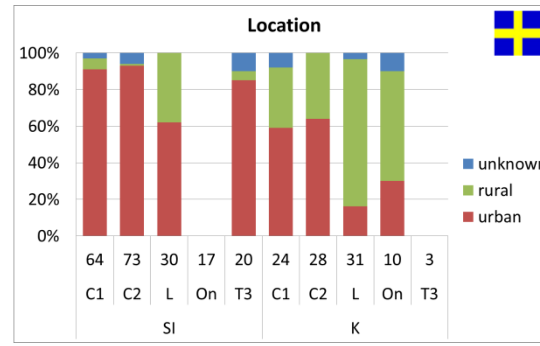
* Italy is dropped as the cases from the Italian database were too limited to be statistically relevant.

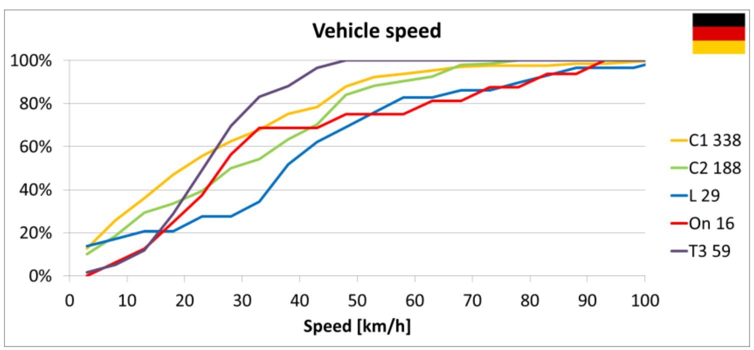
Typical parameter ranges for the scenarios

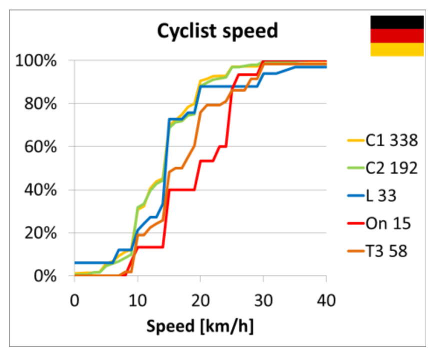
- Based on in-depth accident studies

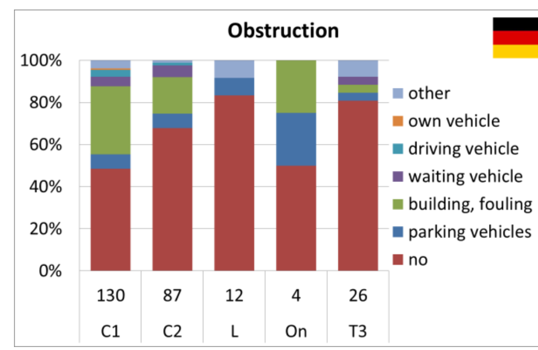






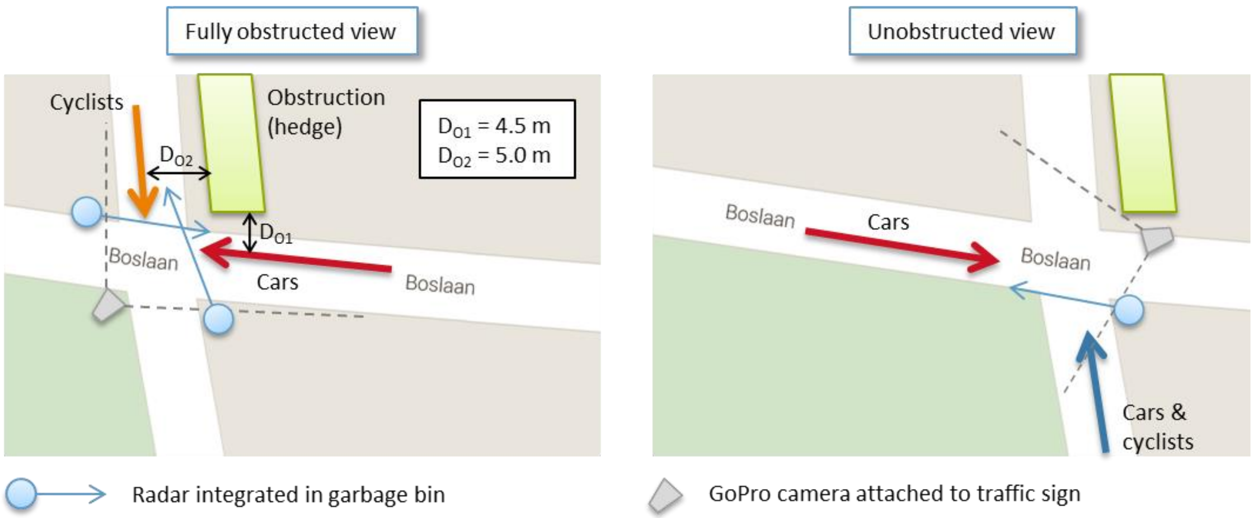


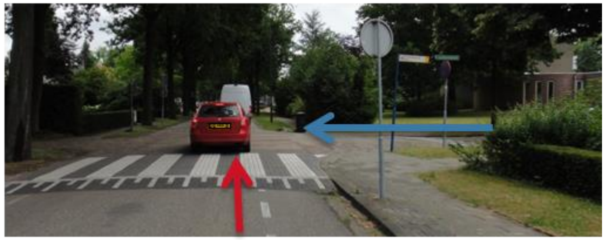


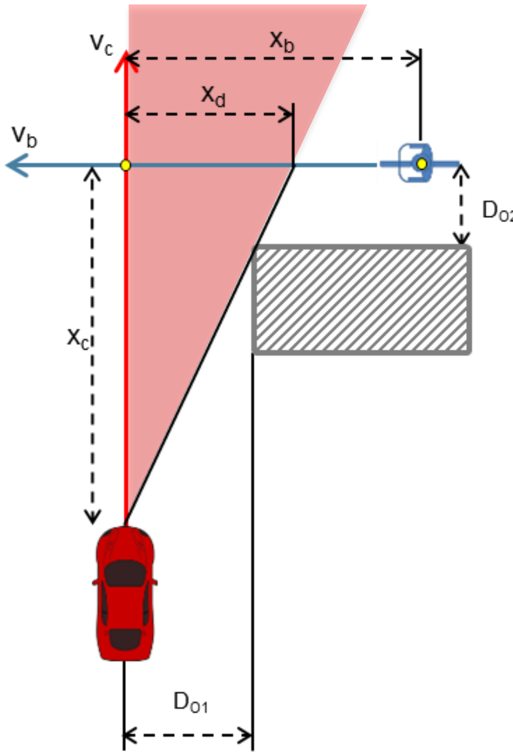


Observation study into view-blocking obstructions

- Influence on speed profile of bicycle and car upon approach
- Posture and behaviour of bicyclist (e.g. pedaling or not)

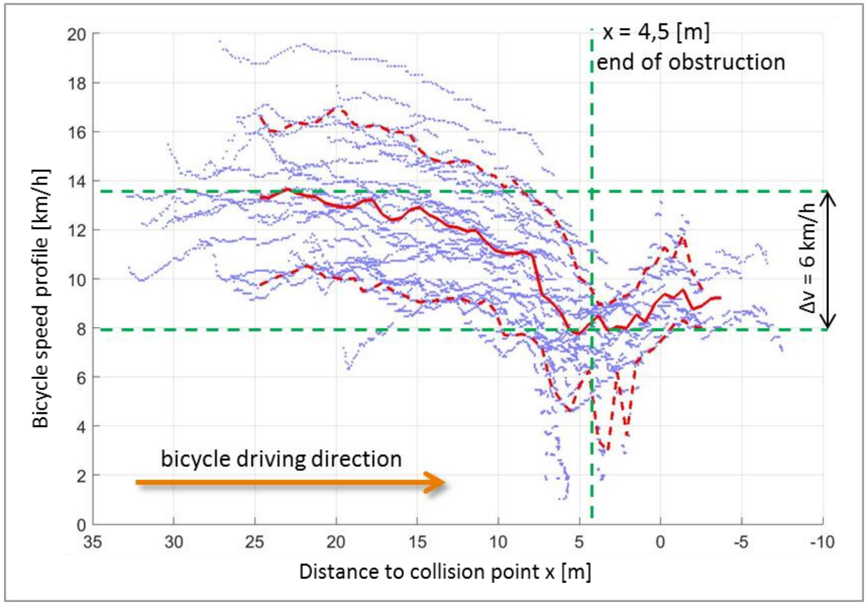






Observation study into view-blocking obstructions

- Bicycles reduce speed with 6 km/h in case of a view-blocking obstruction
- More than 80% of all cyclists stopped pedaling

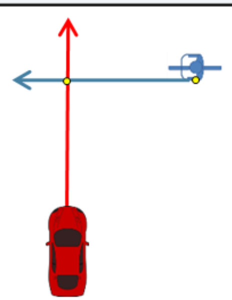
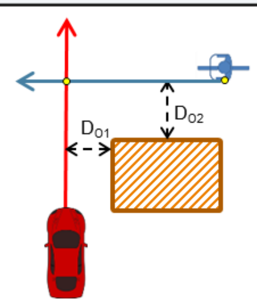
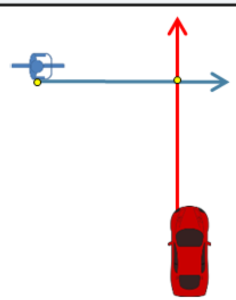
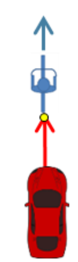


Bicycle manouevre		*Stopped pedaling*		*Continued pedaling*
		Continued riding	*Full stop*	*Continued riding*
Straight	**total**	**68**	**38**	**15**
	no cars present	25	0	4
	car from left	17	14	5
	car from right	14	13	6
	cars from both sides	12	11	0
Turning left	**total**	**16**	**6**	**1**
	no cars present	5	0	0
	car from left	7	0	0
	car from right	3	3	1
	cars from both sides	1	3	0
Turning right	**total**	**9**	**2**	**20**
	no cars present	2	0	10
	car from left	4	0	3
	car from right	2	0	6
	cars from both sides	1	2	1
Total # bicycles		93	46	36

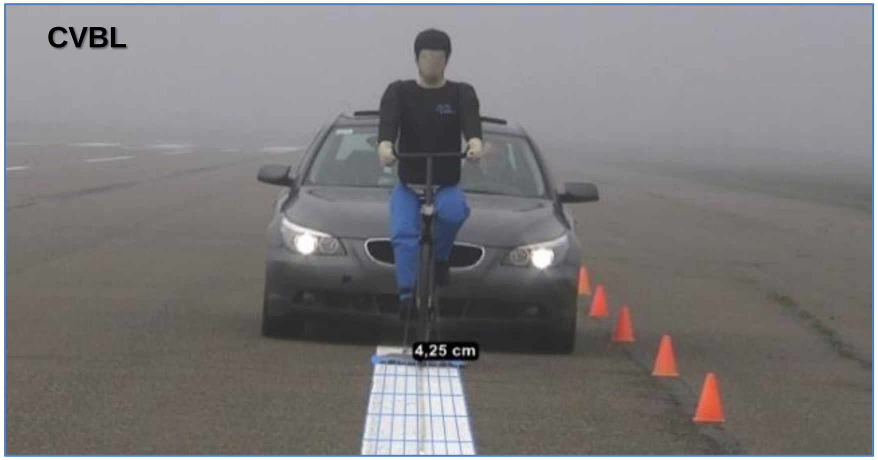
Cyclist target: soft bicyclist dummy on soft bike dummy

- Version 4activeBS v5

Final CATS matrix – version June 2016

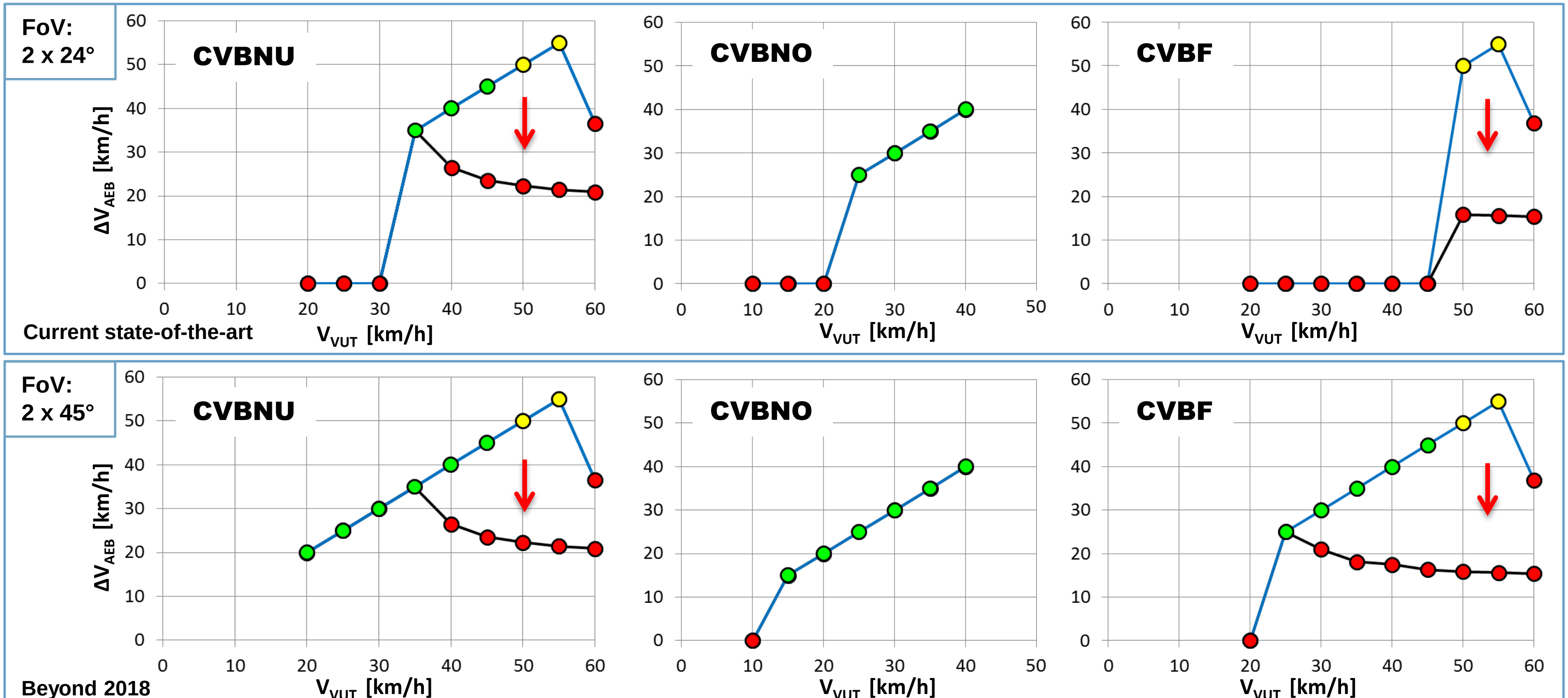
	CVNBU	CVNBO	CVFB	CVLB	
Vehicle speed	20 – 60 km/h	10 – 40 km/h	20 – 60 km/h	30 – 60 km/h	65 - 80 km/h
Cyclist speed	15 km/h	10 km/h	20 km/h	15 km/h	20 km/h
Obstruction	Without	With D1=3.55m, D2=4.80m	Without	Without	Without
Collision point	50 %	50 %	25 %	50%	25 %
AEB / FCW	AEB	AEB	AEB	AEB	FCW
# tests [36]	9	7	9	7	4
Layout sketch					
Expected feasibility 2018	YES	YES	NO	YES	
Important notes:	• Main challenge in CVNBU 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 with a 25% collision point with one VUT speed in the 30-60 km/h speed range to ensure AEB performance at a 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.	

Test track



Simulation

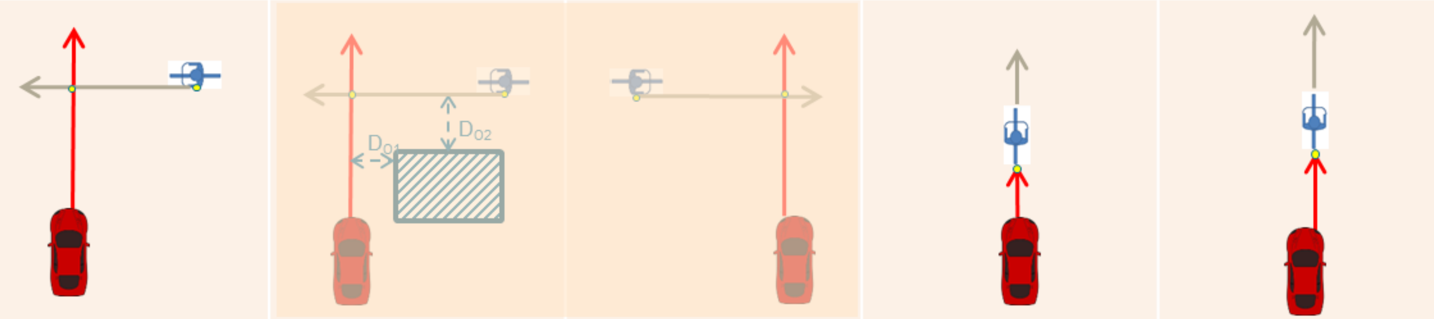
- Decrease in performance to avoid false positive responses



The figures show the speed reduction of the AEB system at the end of a test for the different initial VUT speeds, where the markers indicate the results for one test. The upper row shows the results for a sensor field of view of 2 x 24º for the 3 different scenarios, the lower row shows the results for an FoV of 2 x 45º. The line for collision avoidance is the 45º grey dashed line in each figure:

● : full collision avoidance, VUT comes to full stop ● : full collision avoidance by reduction of speed ● : collision, no speed reduction or speed reduction insufficient

AEB-Cyclist 2018 proposal

	CVNB	CVNBO	CVFB	CVLB	
VUT speed	20-60 km/h	20-60 km/h	20-60 km/h	20-60 km/h	50-80 km/h
Cyclist speed	15 km/h	10 km/h	20 km/h	15 km/h	20 km/h
Obstruction	No	Yes	No	No	No
Impact point	50%	50%	25%	50%	25%
AEB/FCW	AEB	AEB	AEB	AEB	FCW
					
Nr of points	3.0	**Euro NCAP proposes to postpone the intro-duction of CVNBO and CVFB until 2020.**		1.5	1.5

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Conclusion and 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

Outlook

- Active communication and dissemination of CATS results
- Technical briefing October 6th, 2016, Helmond (NL)
- Euro NCAP Round Robin test of Cyclist-AEB protocol (spring 2017)
- 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

KNCAP Korean New Car Assessment Program

Japan New Car Assessment Program JNCAP

C-NCAP

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