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Draft Regulation on Driver Assist Systems to Avoid Blind Spot Accidents

Development of Test Procedure and First Verification Tests

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Agenda

July 18 (Tuesday)

11:00 Introduction to the German Proposal

12:30 Lunch

13:30 ~~Accidentology~~ **Demonstration**

15:30 ~~Demonstration~~ **Accidentology**

18:00 Closure of first day

July 19 (Wednesday)

9:00 Test

12:00 Lunch

13:00 Preparation of informal document to change the German proposal

16:00 Closure of meeting

Lunch

Tuesday	Wednesday
Hot Curry/Mango noodles with cashew	Leberkäse (kind of meat loaf) with sauce and fries
Chickenbreast in parmesan-egg-crust with spaghetti	Turkey schnitzel with curry sauce and rice
Savoy cabbage	Green beans

Background / History

- Concepts and Prototypes for ADAS systems go back until at least 2000…
- … and yet we had no systems in place

- Various different aftermarket solutions available
  - Most of them have their shortcomings

- Mirrors nowadays cover the complete field of view…
- …and yet there are severe accidents, still.

- BASt was asked to priorizite research in Spring 2014 in the course of several accidents with a high severity in Germany

Previous Work

- Test protocol & requirements development second half of 2014 → Report *„Driver Assistance System for Right-Turning Trucks - Foundations of a Test Procedure"*
- First verification tests spring 2015
- First GRSG document (showing accidentology and background) in Autumn 2015

- Full verification tests Spring & Autumn 2016
  - Single Tractor, Spring 2016
  - Single Tractor, Tractor-Semitrailer Autumn 2016
  - City Bus, Autumn 2016
  - Single Truck, Winter 2017

- Most recent GRSG documents: Test procedure (*working document* to GRSG 2017_01)

State Of The Art

	System (Year)	Technical Maturity	Sensor concept	IWI concept
Vehicle Mfctrs.	MAN MoTiV (2000)	Demonstrator, discontinued	LASER scanner, region unknown	Unknown
Vehicle Mfctrs.	Mercedes Benz Blind-Spot Assist (2016)	In production (since 09/2016)	RADAR, viewing region from rear of articulated truck up to 2 m in front	Information, Warning, not coupled to turn signal activation
Vehicle Mfctrs.	Volvo Intersafe-2 (2011)	Demonstrator	Sensor fusion of 5 LASER scanner, several ultrasonic sensors, mono camera, covering the side of the truck up to 15 m in front	Information, Warning, (coupling to turn signal unknown)
AFTERMARKET	Fuel Defend Side-Warn (2014)	Aftermarket	4 ultrasonic sensors covering side of vehicle only	Warning, coupled to turn signal activation, up to 26 km/h
AFTERMARKET	FusionProc CycleEye	Aftermarket	RADAR and Camera	Warning/Information (unknown)
AFTERMARKET	Safety Shield Systems CycleSafetyShield	Aftermarket	Multiple Cameras covering side and front	Warning/Information (unknown)
AFTERMARKET	Sentinel BikeHotspot	Aftermarket	Ultrasonic sensors	Warning (internal and external) up to 16 km/h

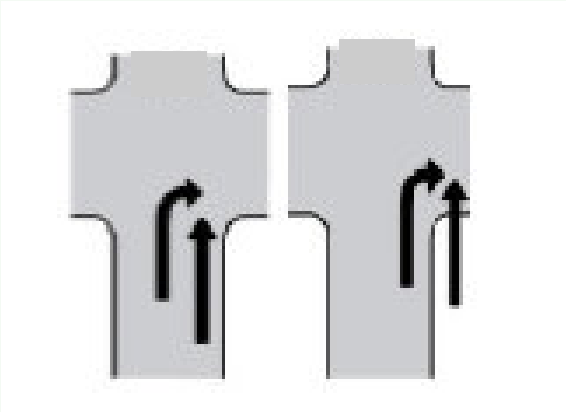
ACCIDENT SITUATION

Accident analysis – statistics (police reported)

Right turning trucks and straight driving cyclists (extrapolation for Germany):

	Cyclists	Pedestrians
injury accidents	640	55
seriously injured	118	16
fatalities	23	4

Main accident types



Bicyclists: Accident Partners and Accident Types

2012 Dtld.; innerorts	U(P)	Verunglückte (Radfahrer)		
		GT	SV	LV
Alleinunfall	10.640	65	3.328	7.294
genau 2 Bet.	55.417	167	7.880	46.673
3+ Bet.	2.081	16	292	1.974
Insgesamt	68.138	248	11.500	55.941

Two Accident Participants

2012 Dtld.; innerorts	U(P)	Verunglückte (Radfahrer)		
		GT	SV	LV
Pkw	41.475	86	5.659	35.762
Gkz und Sattelschlepper	3.402	50	598	2.752
Busse	[illegible]	[illegible]	[illegible]	320
Landw. Zug Sonderfahrzeuge	66	1	17	48
Fahrräder	4.372	8	945	4.695
Fußgänger	3.570	3	259	1.600
weitere Gegner	2.060	13	334	1.496
Insgesamt	55.417	167	7.880	46.673

Goods Vehicle + Tractor

2012 Dtld.; innerorts	Fahrrad und Gkz nach zGG mit...								
	<=7,5 t und o.A.			> 7,5 t und Sattelschlepper			Insgesamt		
	U(P)	Verunglückte (Radfahrer)		U(P)	Verunglückte (Radfahrer)		U(P)	Verunglückte (Radfahrer)	
		GT	SV		GT	SV		GT	SV
Fa[illegible]	58	0	13	18	1	3	76	1	16
Abbiegen	732	2	94	283	24	82	1.015	26	176
Einbiegen-Kreuzen	1.112	2	186	192	12	62	1.304	14	248
[illegible]	0	0	0	0	0	0	0	0	0
[illegible]	286	1	41	53	1	10	339	2	51
Längsverkehr	280	1	42	82	3	16	362	4	58
Sonstiger Unfall	255	3	38	51	0	11	306	3	49
Insgesamt	2.723	9	414	679	41	184	3.402	50	598

Turning

Crossing / Turning Into

All Turning Accidents
(incl. e.g. Turning Left, Cyclist from wrong direction)

Urban Accidents With Bcl. And Right-Turning Truck

→ Extrapolation for blind spot for 2012

	< 7.5 t GVW			**> 7.5 t GVW & Tractors**			**Total**		
2012 **Hochrechnung (Potenzialabschätzung)** Dtld.; innerorts	Fahrrad und Gkz nach zGG mit...								
	<=7,5 t und o.A.			> 7,5 t und Sattelschlepper			Insgesamt		
	U(P)	Verunglückte (Radfahrer)		U(P)	Verunglückte (Radfahrer)		U(P)	Verunglückte (Radfahrer)	
		GT	SV		GT	SV		GT	SV
Unfälle zwischen rechtsabbiegenden Gkz und...									
Bicyclists n	408	1	48	232	22	70	640	23	118
Pedestrians	nicht diff.						55	4	16

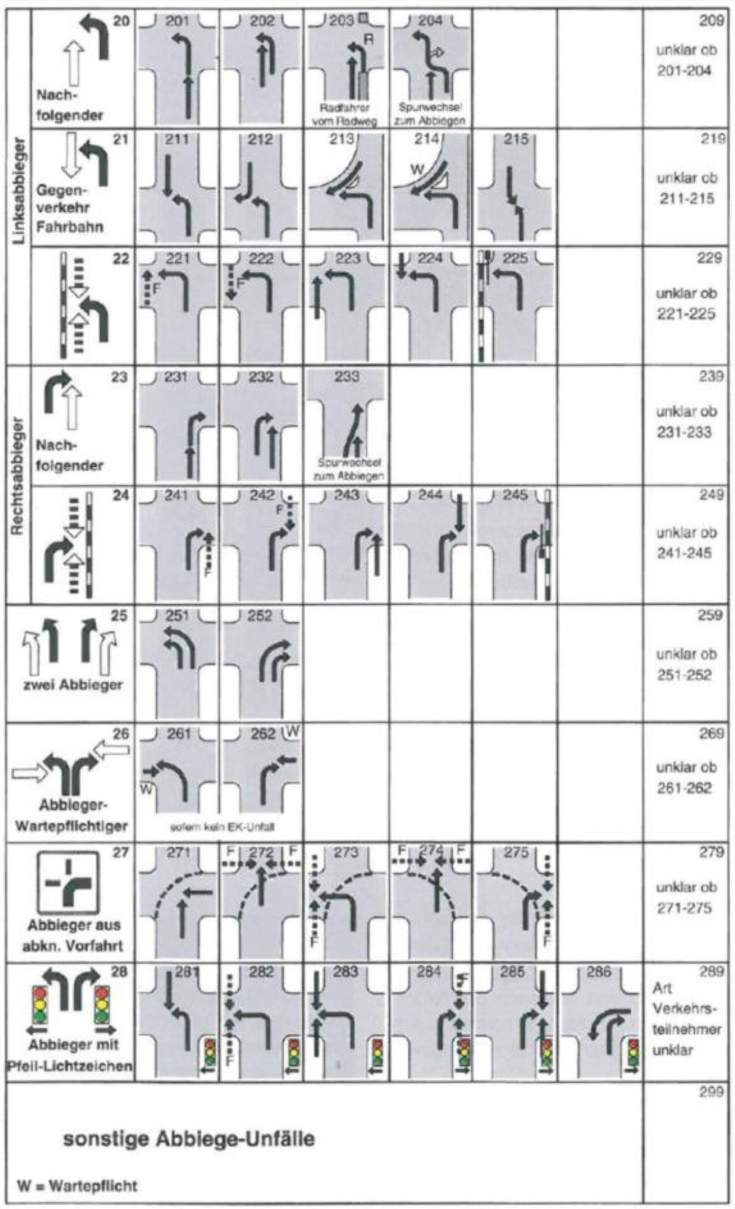
3-Digit Accident Type

- 37 Different Turning Situations
- 4 German States:
  - Niedersachsen (NI),
  - Nordrhein-Westfalen (NW) ,
  - Rheinland Pfalz (RP) und
  - Saarland (SL)

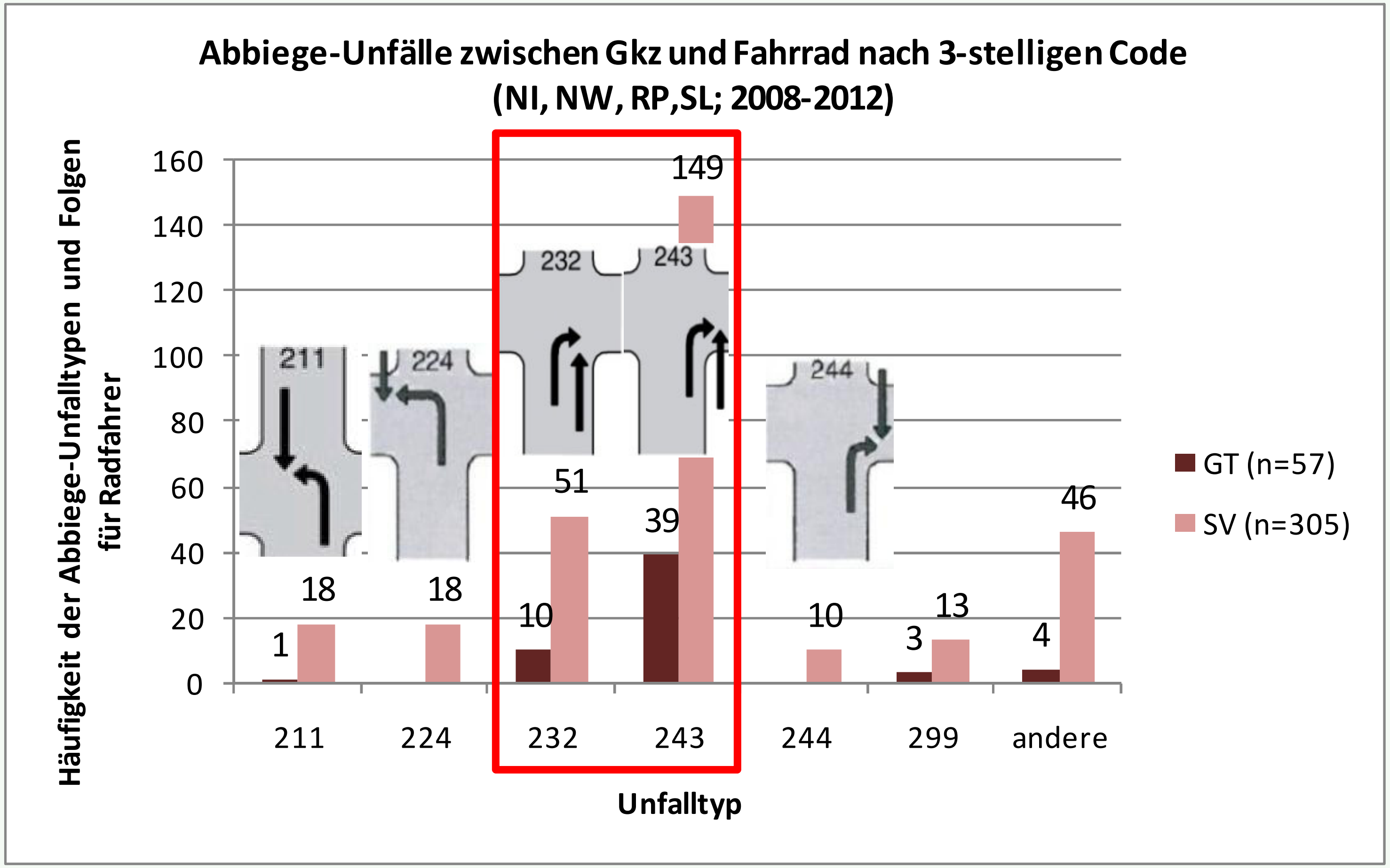
  → near 100 % knowledge

  → Approx. 1/3 of German Population
- For 2008 to 2012

  → sufficient data available

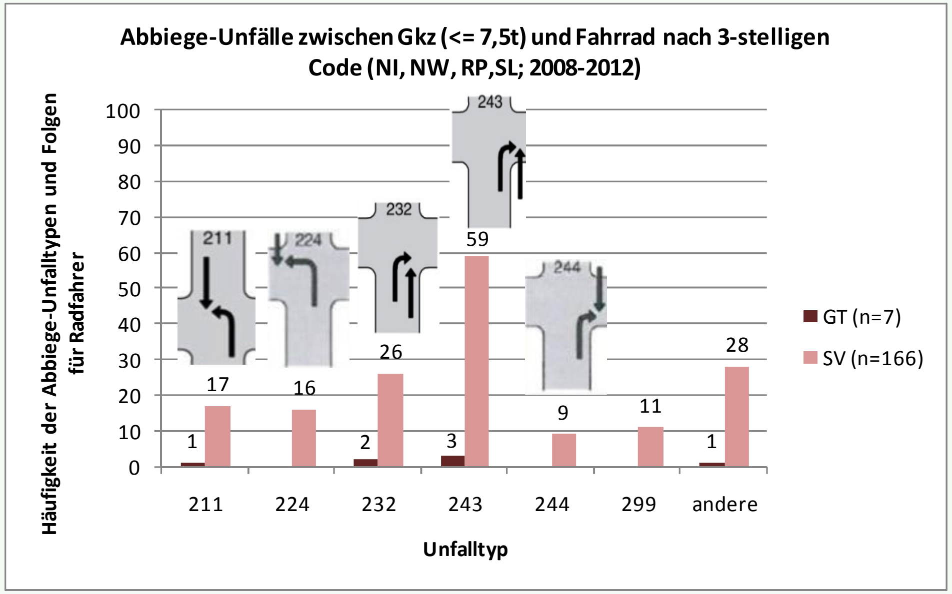


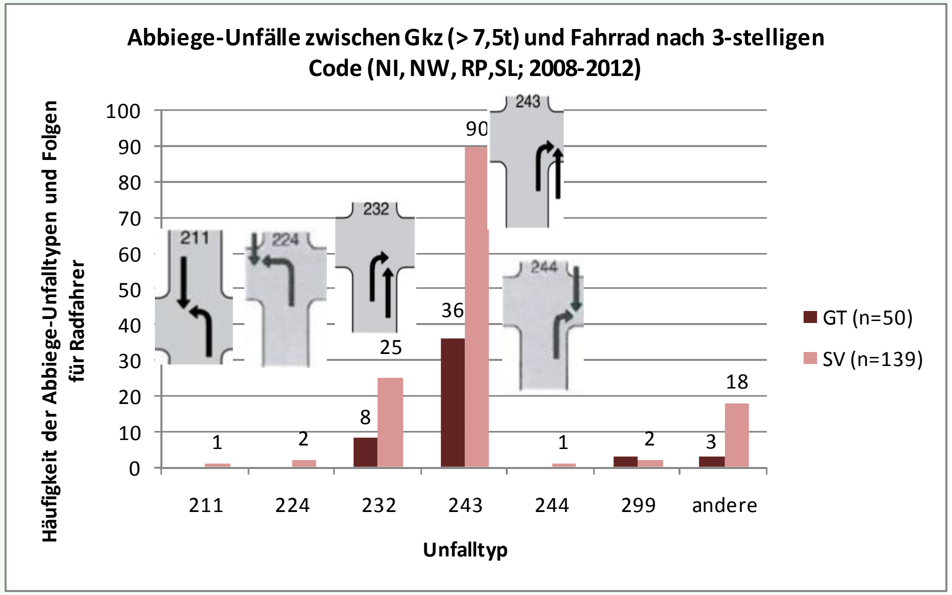
Accident Types



- Turning Right: 86% GT / 67 % SV
- Turning Right, Bicycle from rear: **86% GT / 64% SV**
- Turning Left: 2% GT / 11% SV

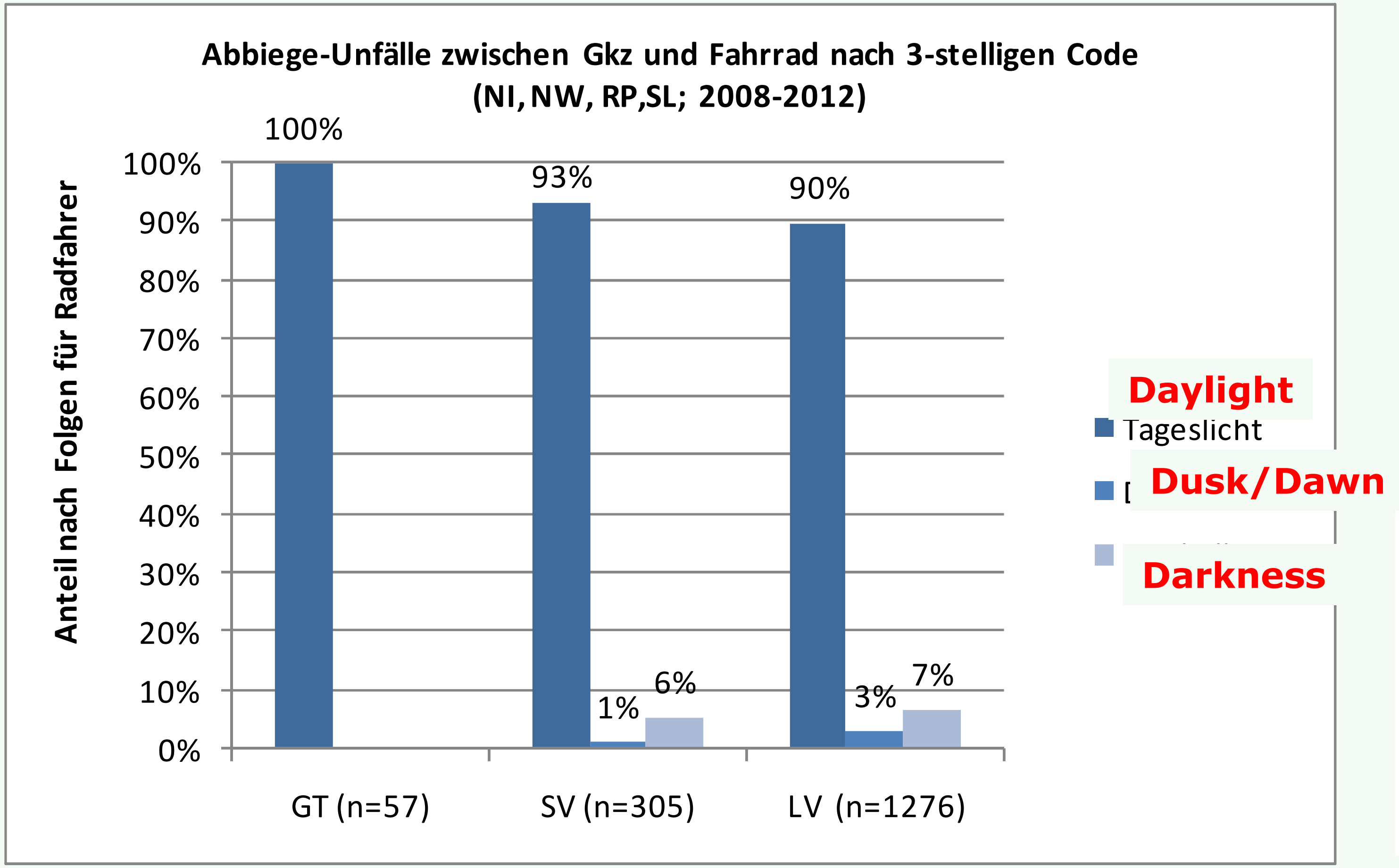
Differences <7.5t / >7.5t

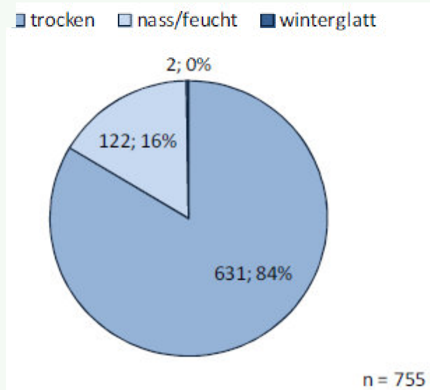




- Fatally injured: 12% / 87%
- Severely injured: 54% / 46%
- Turning right: 38% / 62%
- Turning right, Bcy from rear:
  - **>7.5t: 88% GT, 82% SV**
  - <=7.5t: 71% GT, 51% SV

Conditions


Abbiege-Unfälle zwischen Gkz und Fahrrad nach 3-stelligen Code
(NI, NW, RP,SL; 2008-2012)
Anteil nach Folgen für Radfahrer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
100%
93%
90%
1%
6%
3%
7%
GT (n=57)
SV (n=305)
LV (n=1276)
Daylight
Tageslicht
Dusk/Dawn
Darkness


trocken
nass/feucht
winterglatt
2; 0%
122; 16%
631; 84%
n = 755

Summary – Initial Accident Analysis

- Daylight → very few night accidents
- Fatally injured: heavy trucks
- Severely injured: both heavy and light trucks
- Dominant accident situation:
  <u>Turning right, Bicycle from rear</u>

In depth accident analysis

- German In-Depth Accident Study
- Database of accident research of German insurers (UDV)

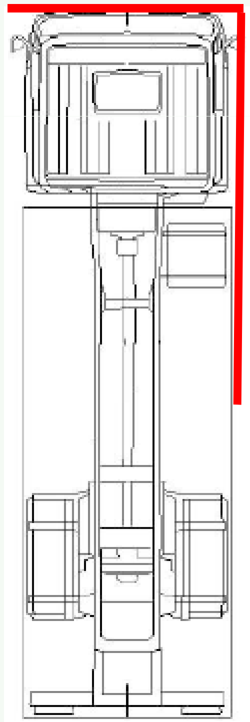
Records include sketches, photos, aerial images, reconstruction

Purpose: gain information about

- Road infrastructure
- Obstructions
- Velocities
- Trajectories
- Impact points

In depth accident analysis - results

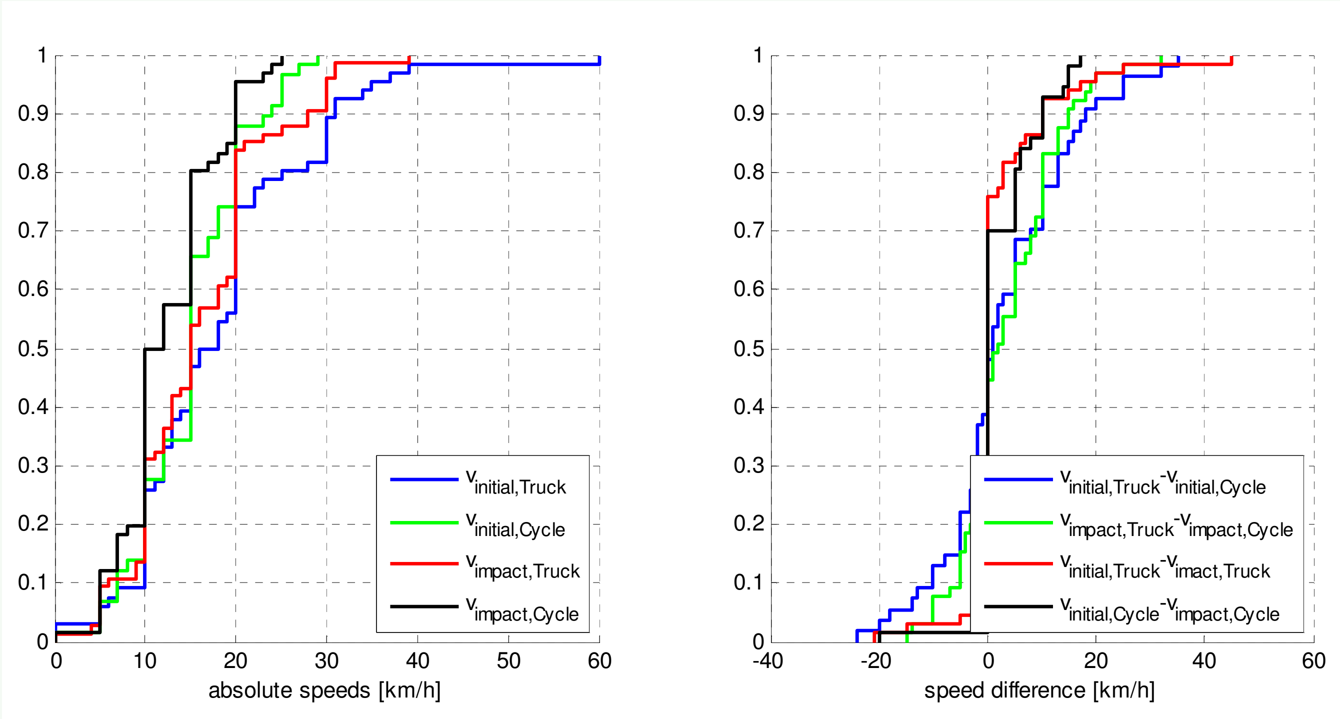
- Daytime about 90 %
- 90 % dry weather
- Truck drivers sight O.K.; obstruction in only 9 %
- Only 22 % of the cases after previous halt of the truck
- In 90 % of the cases truck did not brake
- In 90 % of the cases bicycle moved
- Impact point at frontal part of the truck (up to 6 m towards the rear, see Figure)
- 90 % of fatalities with trucks above 7.5 t
- Traffic lights do not play any role



60-80%
(UDB / DEKRA)

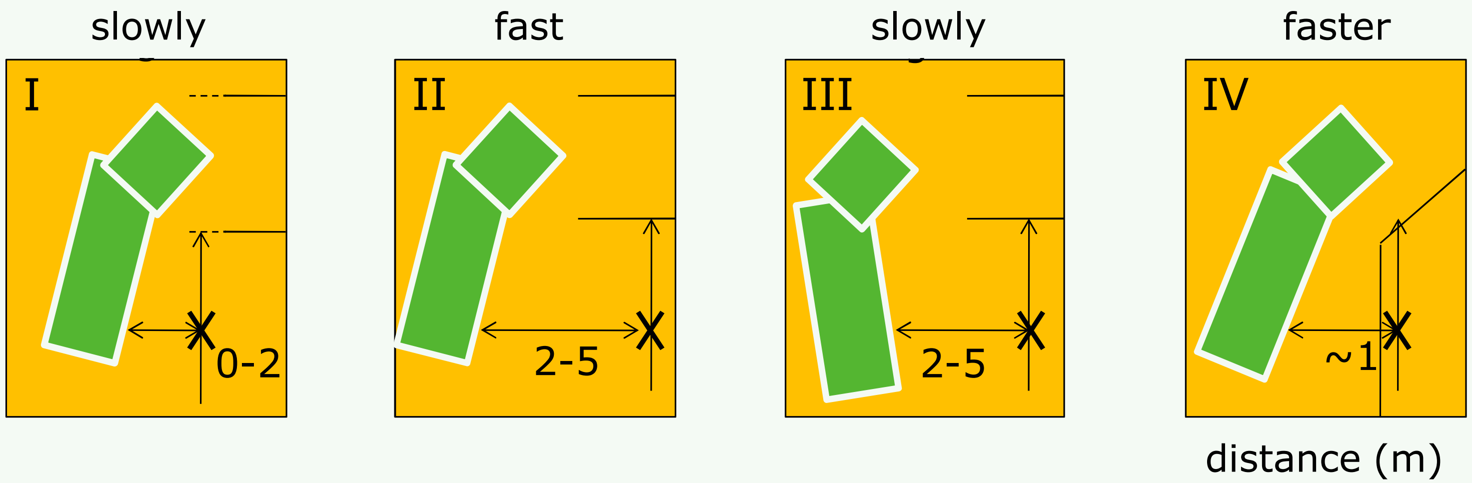
In depth accident analysis - results

<u>Speeds:</u>



- Bicycle and truck did not change their speeds during the accident in about two thirds of all cases
- Truck speeds are below 30 km/h in more than 90% of all cases
- Bicycle speeds are below 20 km/h in more than 80% of all cases

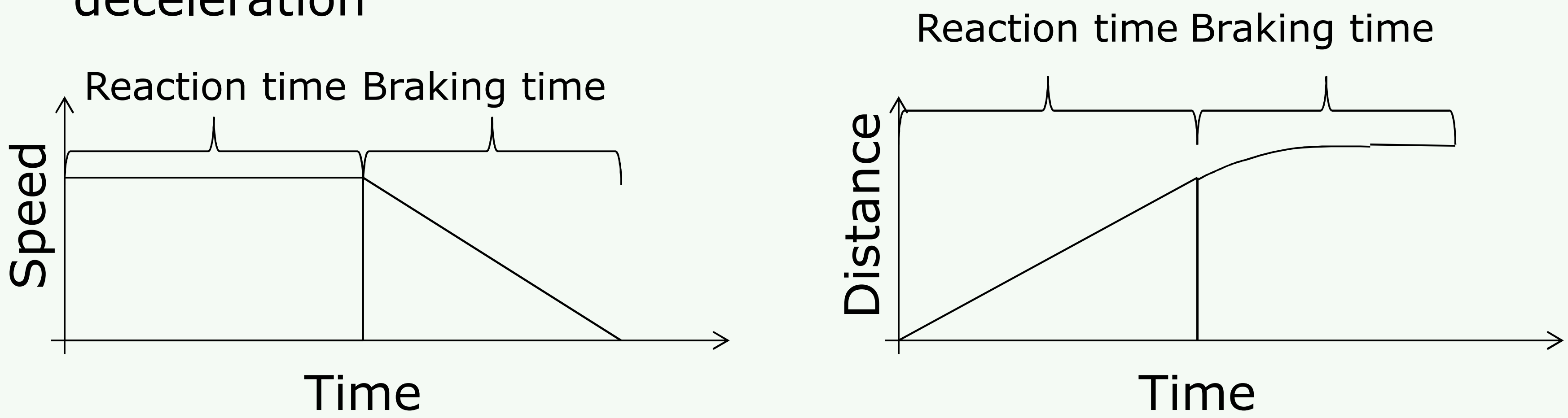
Rough Classification of Scenarios



SYSTEM REQUIREMENTS AND TEST CONCEPT

Last Point of Information LPI

- Stopping distance depends on driver reaction time and deceleration



- Information should be given at a point when the vehicle driver can still comfortably come to a full stop BEFORE crossing the bicycle line of movement
- This point is the „Last Point of Information“ (LPI)

Difference between Warning and Information

- Warning

  Not Considered for Assistance System

  - High intensity
  - If issued right, good effects in steering driver‘s attention
  - High annoyance if issued too often → risk of deactivation

- Information

  Considered for Assistance System

  - Low intensity
  - Low annoyance if issued too often → low risk of deactivation
  - Lesser effect in steering driver‘s attention

Difference between Warning and Information

- Warning

  Not Considered for Assistance System

  - High intensity
  - If issued right, good effects in steering driver`s attention
  - High annoyance if issued too often → risk of deactivation

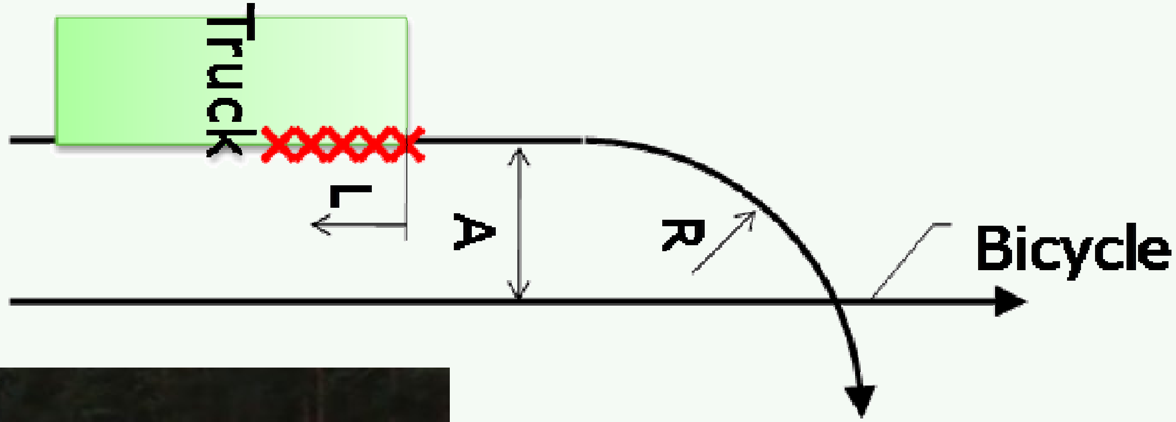
Additional „warning" shall be allowed as long as initial „information" signal is available (= as it is in today`s M_1 blind spot assist)

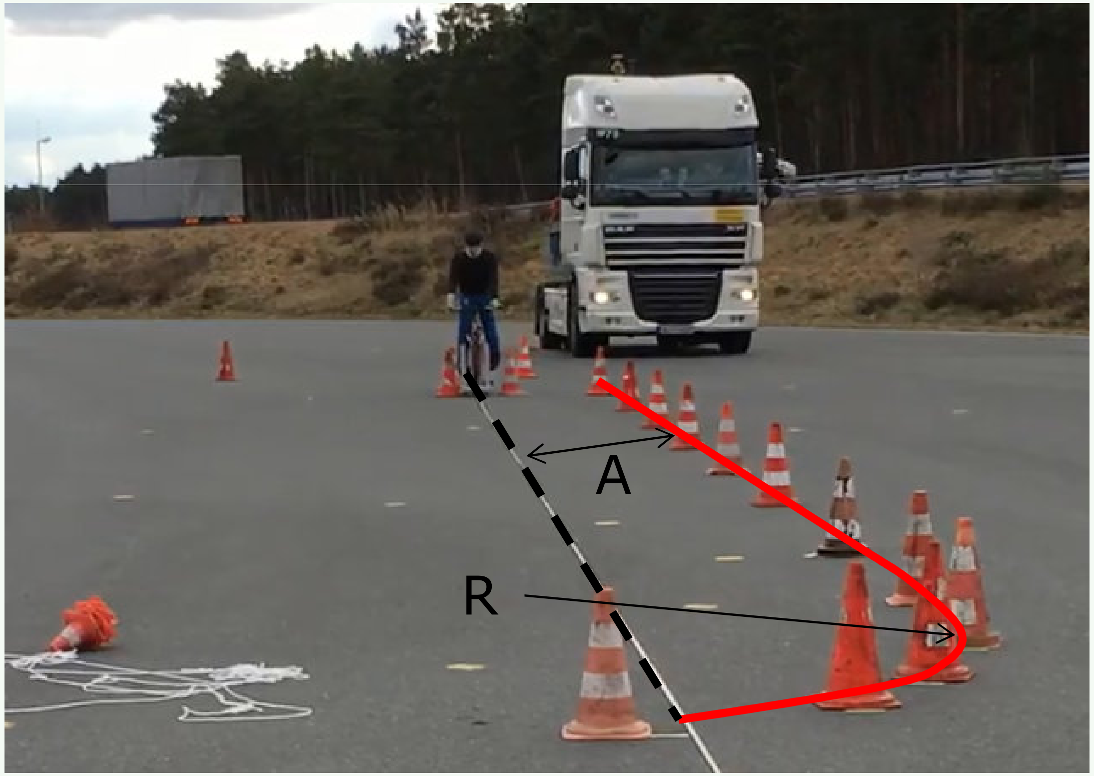
- Information

  ...sidered for Assistance System

  - Low ...
  - Low ... issued too o... → low risk of deactivation
  - Lesser effect in steering driver`s attention

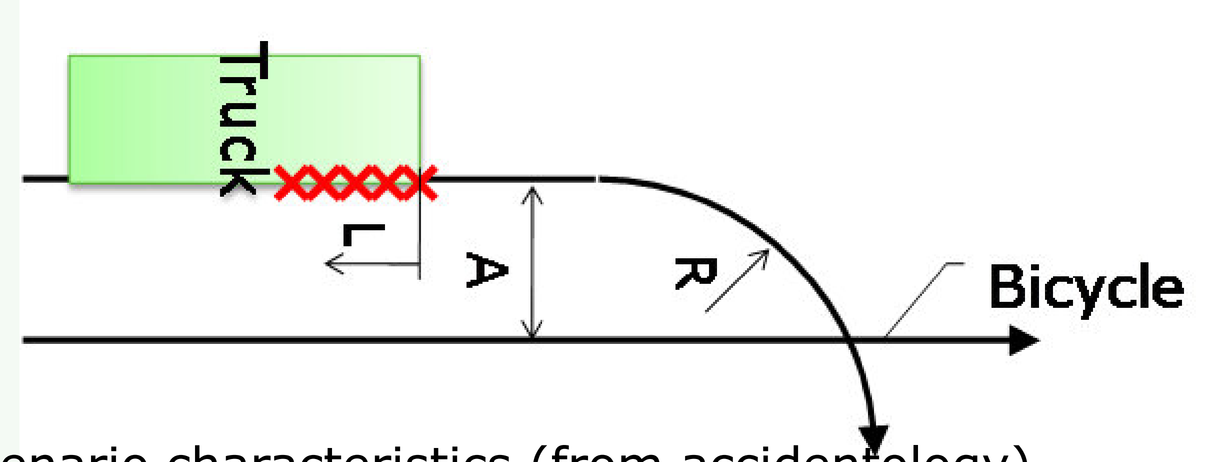
Test Setup





- L – Impact location from front of truck
- A – Initial lateral separation of HGV and Bicycle
- R – Turning Radius of HGV

Sketch of relevant parameters



Scenario characteristics (from accidentology)

- v_{Truck}: 10 to 20 km/h
- v_{Cycle}: 10 to 20 km/h
- Lateral separation: A = 1.5 to 4.5 m
- Truck turning radius: R = 5, 10, 25 m
- Maximum lateral acceleration: $a_y < 3$ m/s²
- Impact location: L = 0 to 6 m

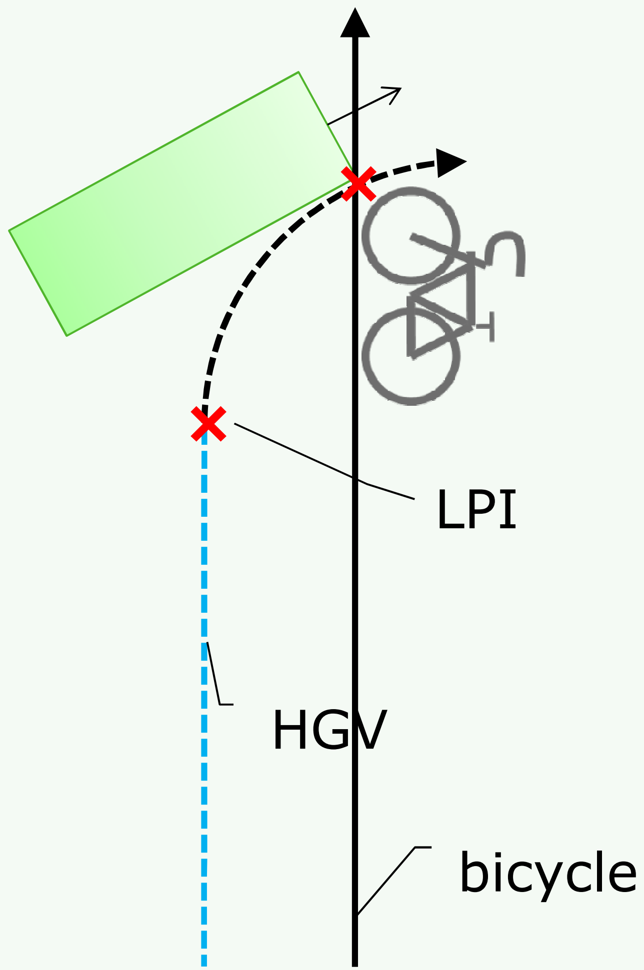
Assumed driver performance (conservative)

- reaction time after driver information: 1,4 s
- Braking performance of driver: 6 m/s²

Pass/Fail Criteria (1) – Impact on HGV Front

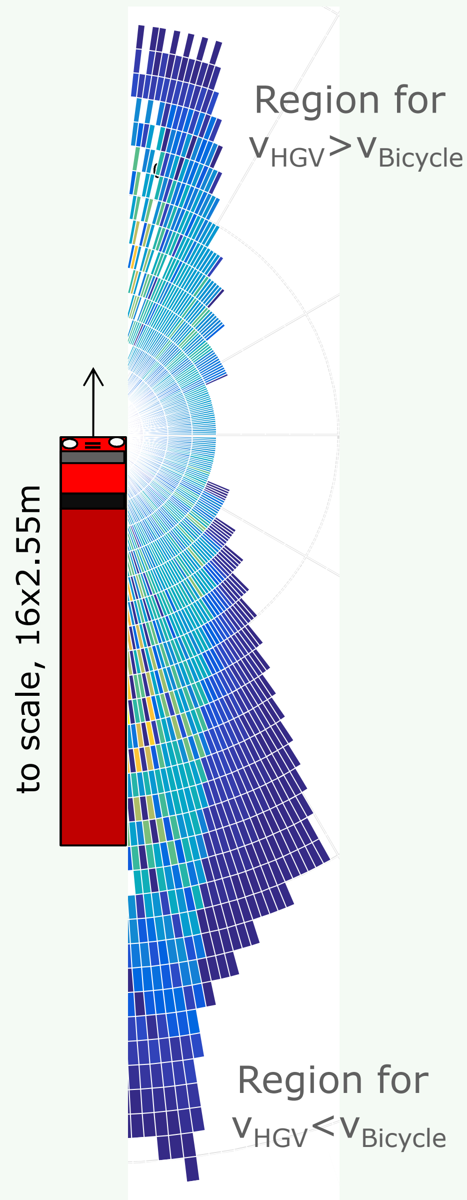
- Prevent HGV from crossing bicycle path
- Assistance System Information shall be early enough for driver to react
- Last Point of Information (LPI) reflects stopping distance
- Stopping distance results from assumed reaction time and brake deceleration (see slide 9)

$$TTC_{\text{LPI}} = t_{\text{Reaction}} + t_{\text{Brake}}$$
$$= 1.4\text{s} + \frac{v_{\text{HGV}}}{2 \cdot 6 \frac{\text{m}}{\text{s}^2}}$$



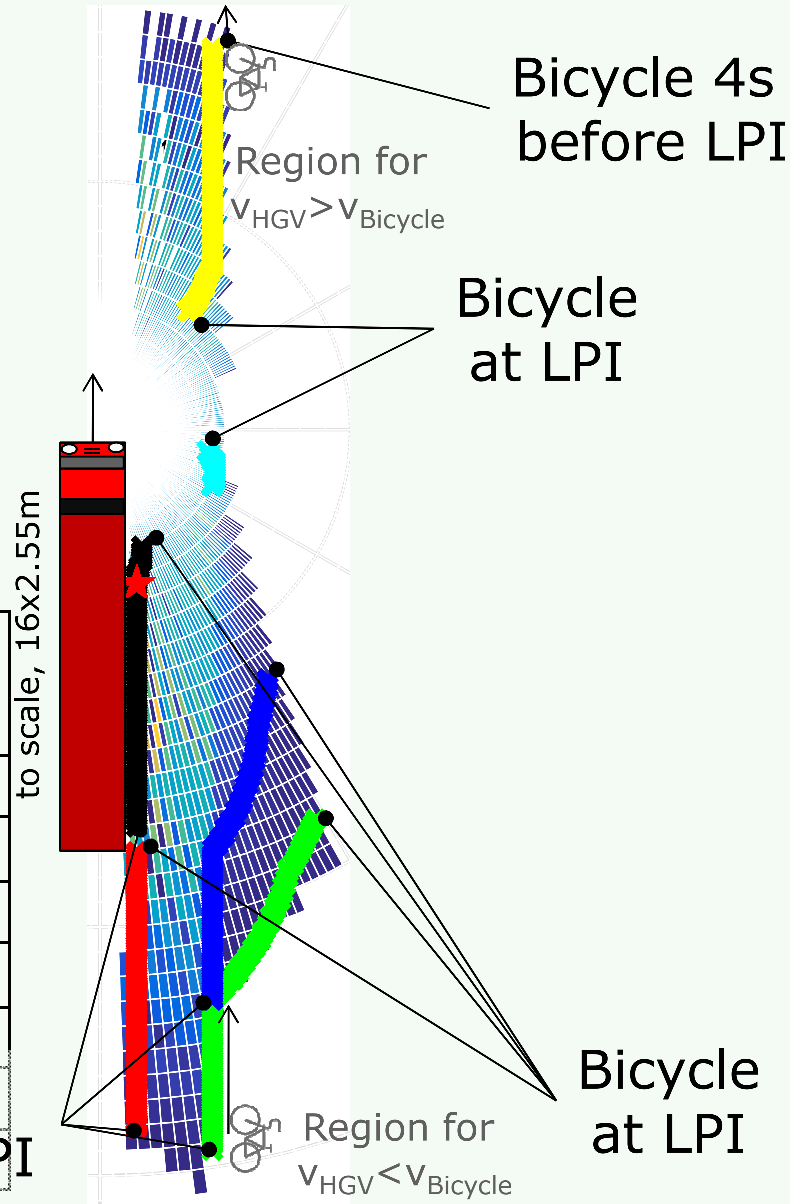
Definition of Test Cases

- Necessary Sensor Field-of-View (SFOV)
  - Scenario characteristics define possible locations of bicycle relative to HGV
  - Assumed driver performance defines **last point of information (LPI)**
  - Heatmap (resolution 1mx1°) shows all possible bicycle locations from 4 s before LPI until impact
  - This does NOT mean the complete heatmap needs to be covered
- Define Test Cases
  - Derive test cases to fill SFOV space (=heatmap) most efficient



- Information MUST be given at or before Last Point of Information (LPI)
- Exact timing defined by manufacturer
- Tests will simulate at least 8s before LPI

ID	v_{Truck} [km/h]	v_{Cycle} km/h]	R [m]	Initial lateral separation [m]	Impact location with respect to front of truck [m]
1	10	20	5	1,5	6
2	10	20	10	4,5	6
3	10	20	10	4,5	3
4	10	20	10	1,5	0
5	10	10	5	4,5	0
6	20	10	25	4,5	0
7 ★	20	20	25	1,5	6



TEST METHOD AND TOOLS

Possible Test Equipment

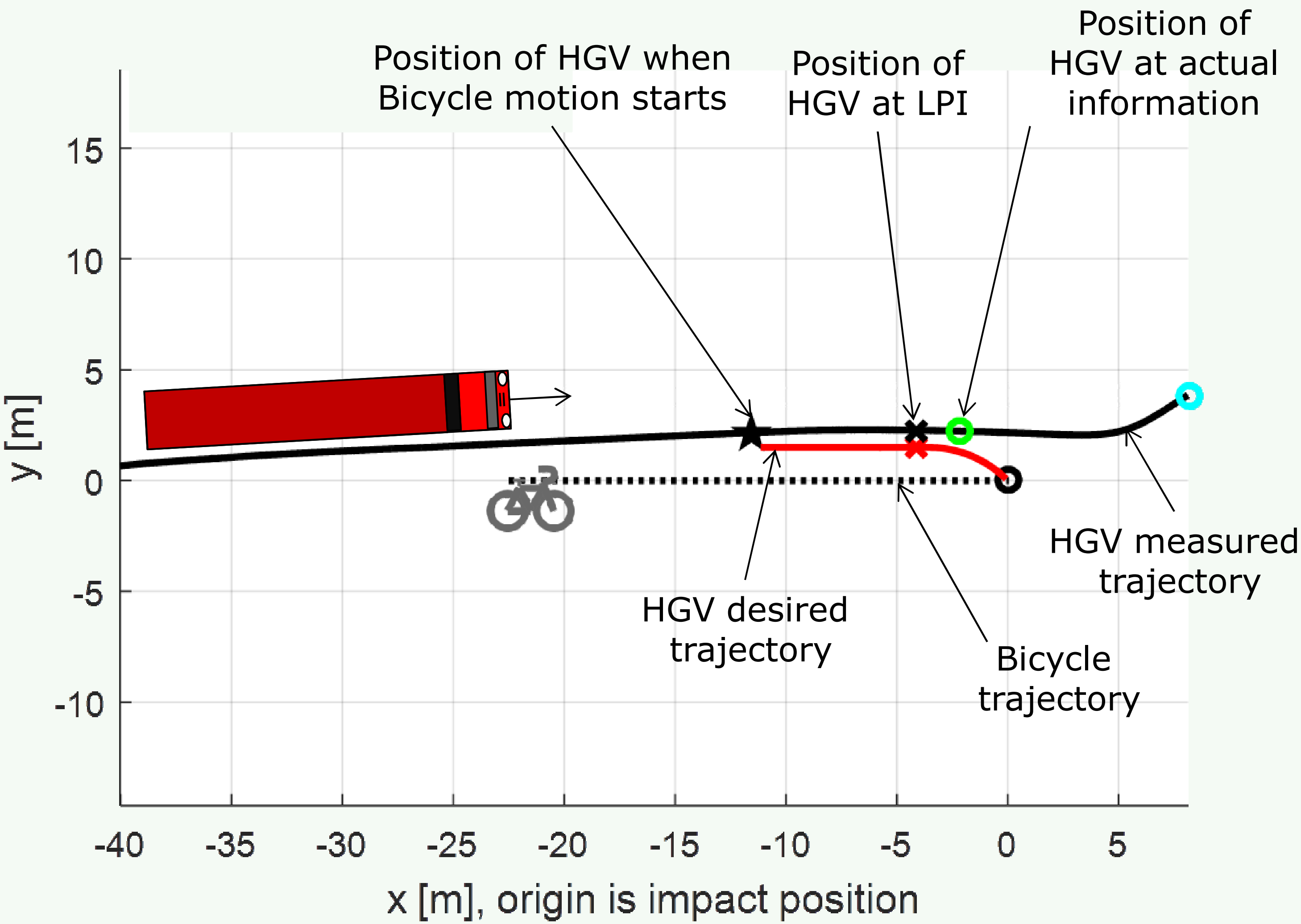
- <u>Vehicle</u>
  - Truck, manually driven, without trailer
  - Position estimation: GeneSys DGPS
  - Position transmitted to dummy propulsion system

- <u>Dummy</u>
  - Standard impactable bicycle dummy
  - Draft dummy specs included in Regulation

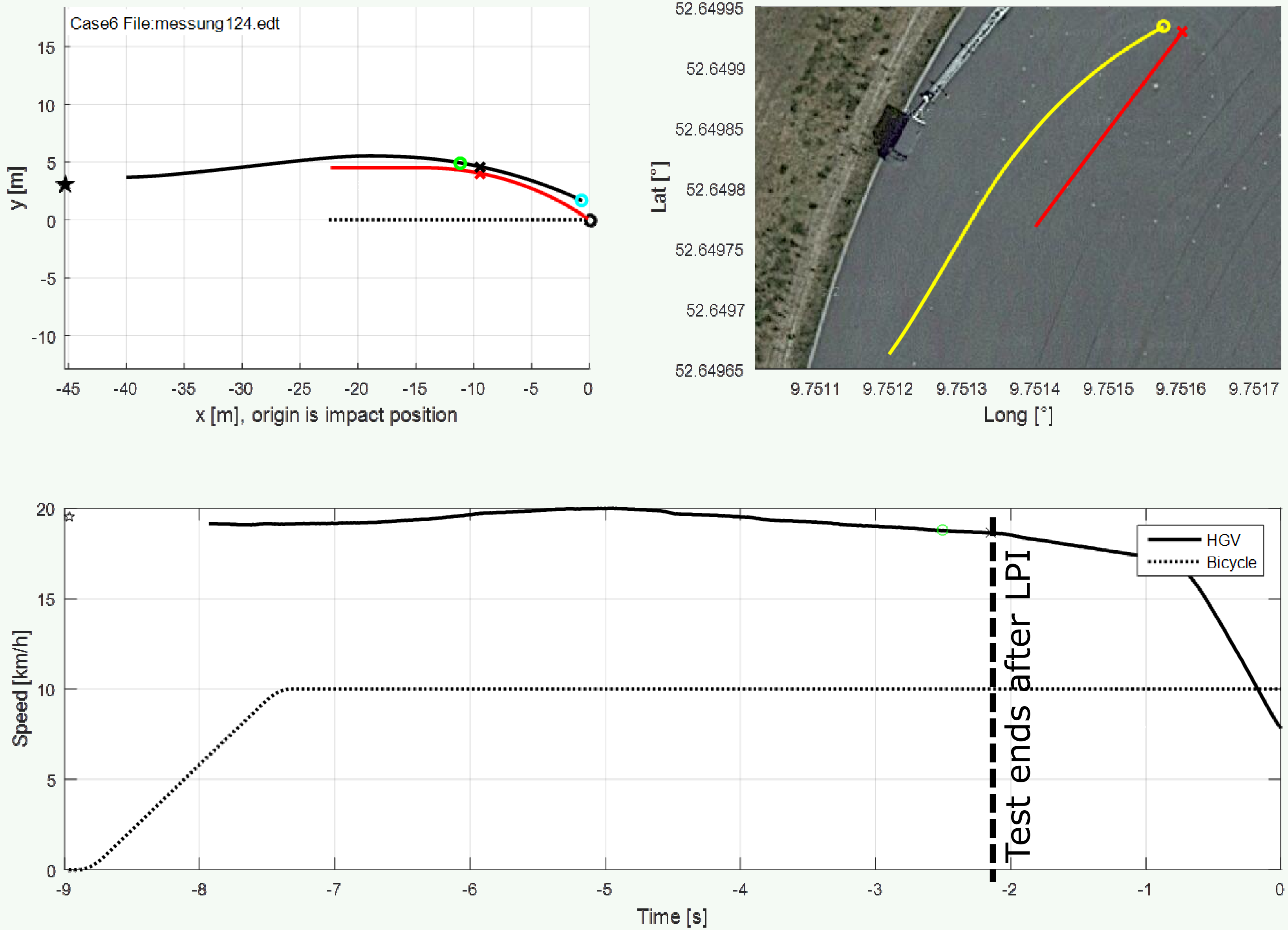
- <u>Dummy Propulsion</u>
  - 4a „Surfboard" commercial Dummy Propulsion
  - Synchronisation of triggering time

3 Test Cases: Presentation of Results

- Case 1
  R=5m, L=6m,
  A=1.5m,
  v_{HGV}=10km/h,
  $v_{Bicycle}$=20km/h
- Case 4
  R=10m, L=0m,
  A=1.5m,
  v_{HGV}=10km/h,
  $v_{Bicycle}$=20km/h
- Case 6
  R=25m, L=6m,
  A=4.5m,
  v_{HGV}=20km/h,
  $v_{Bicycle}$=10km/h

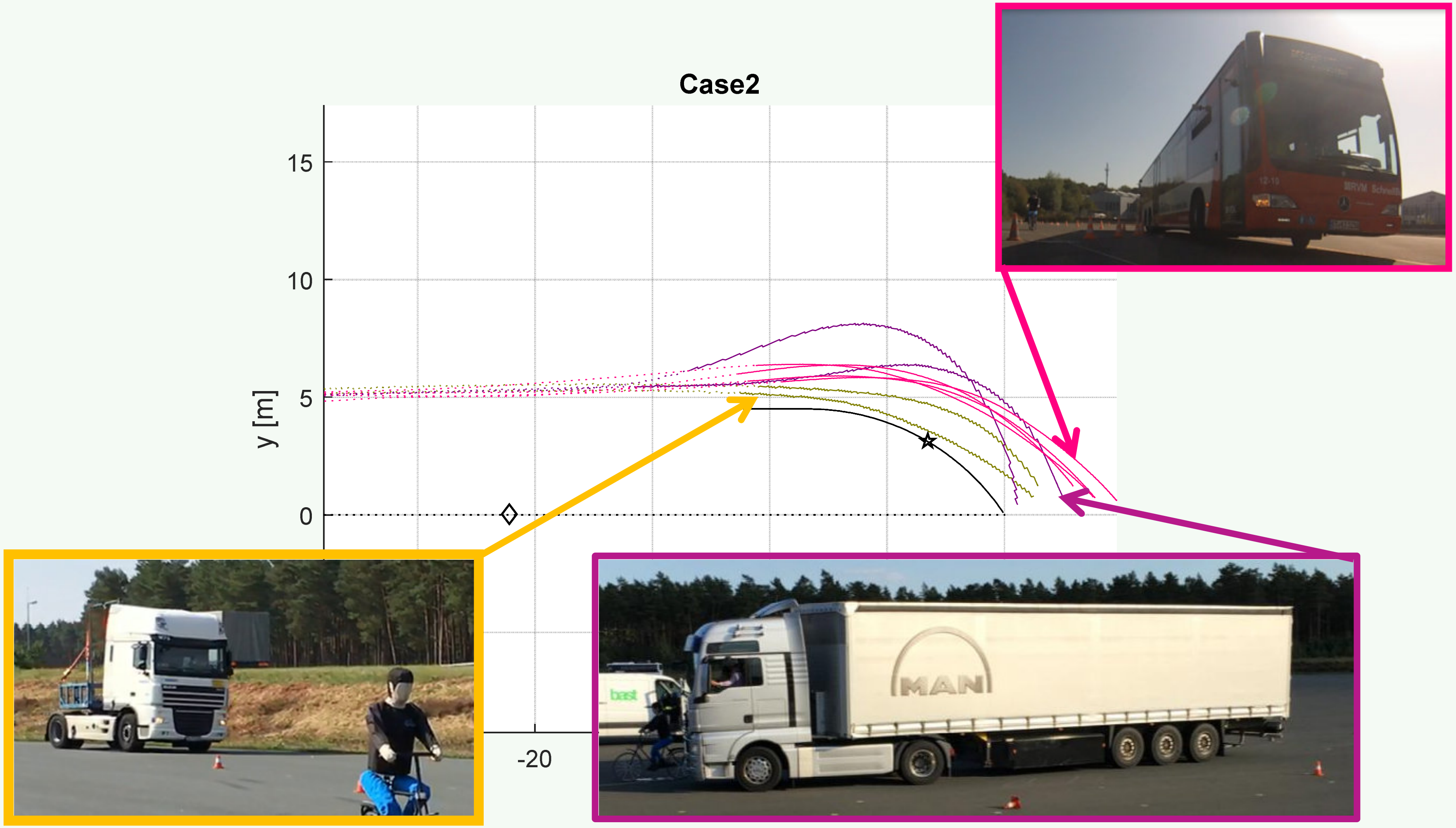


Test Case 6 (Example)



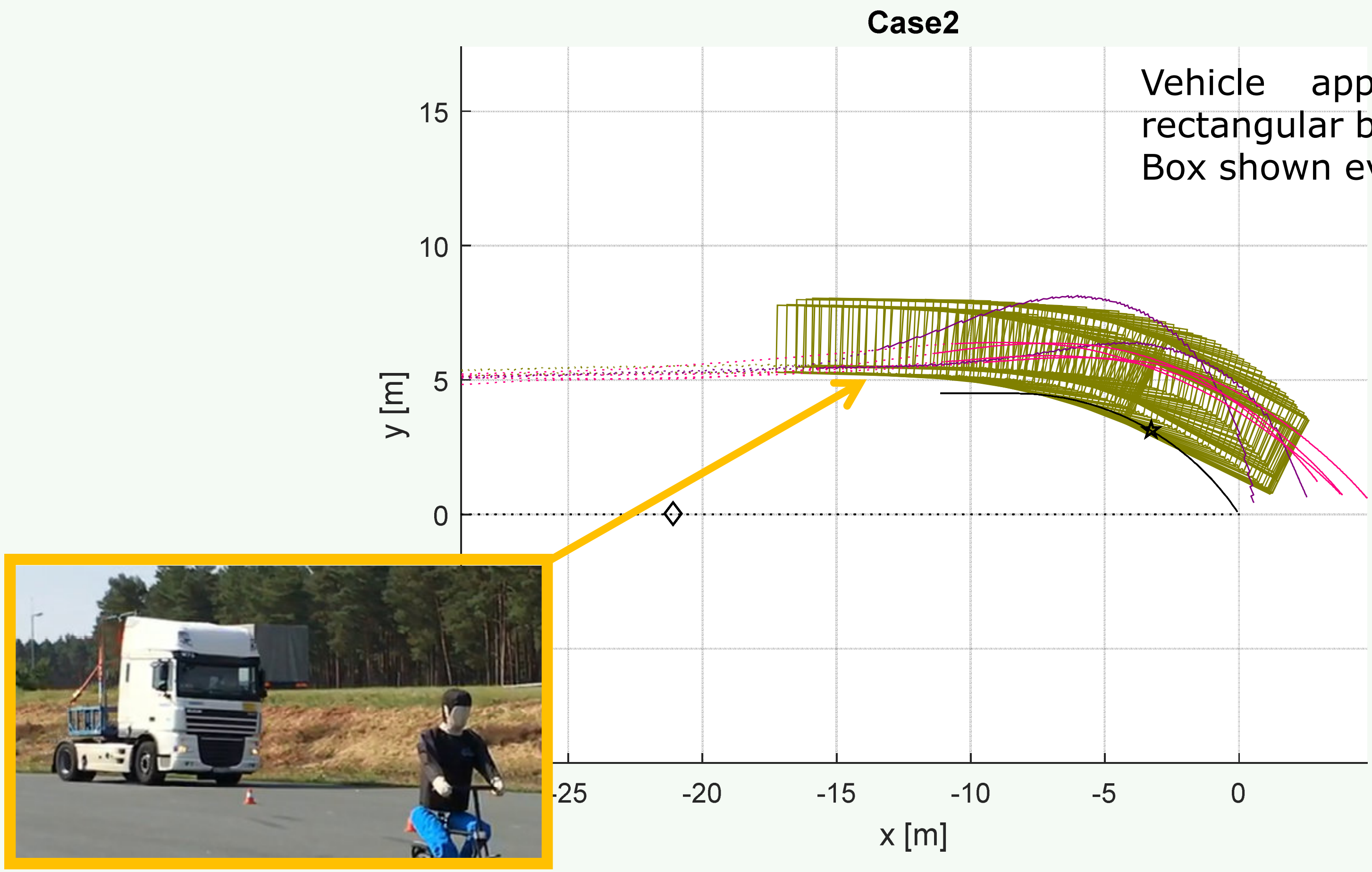
INFLUENCE OF VEHICLE GEOMETRY

Influence of Vehicle Geometry (Example Case2)



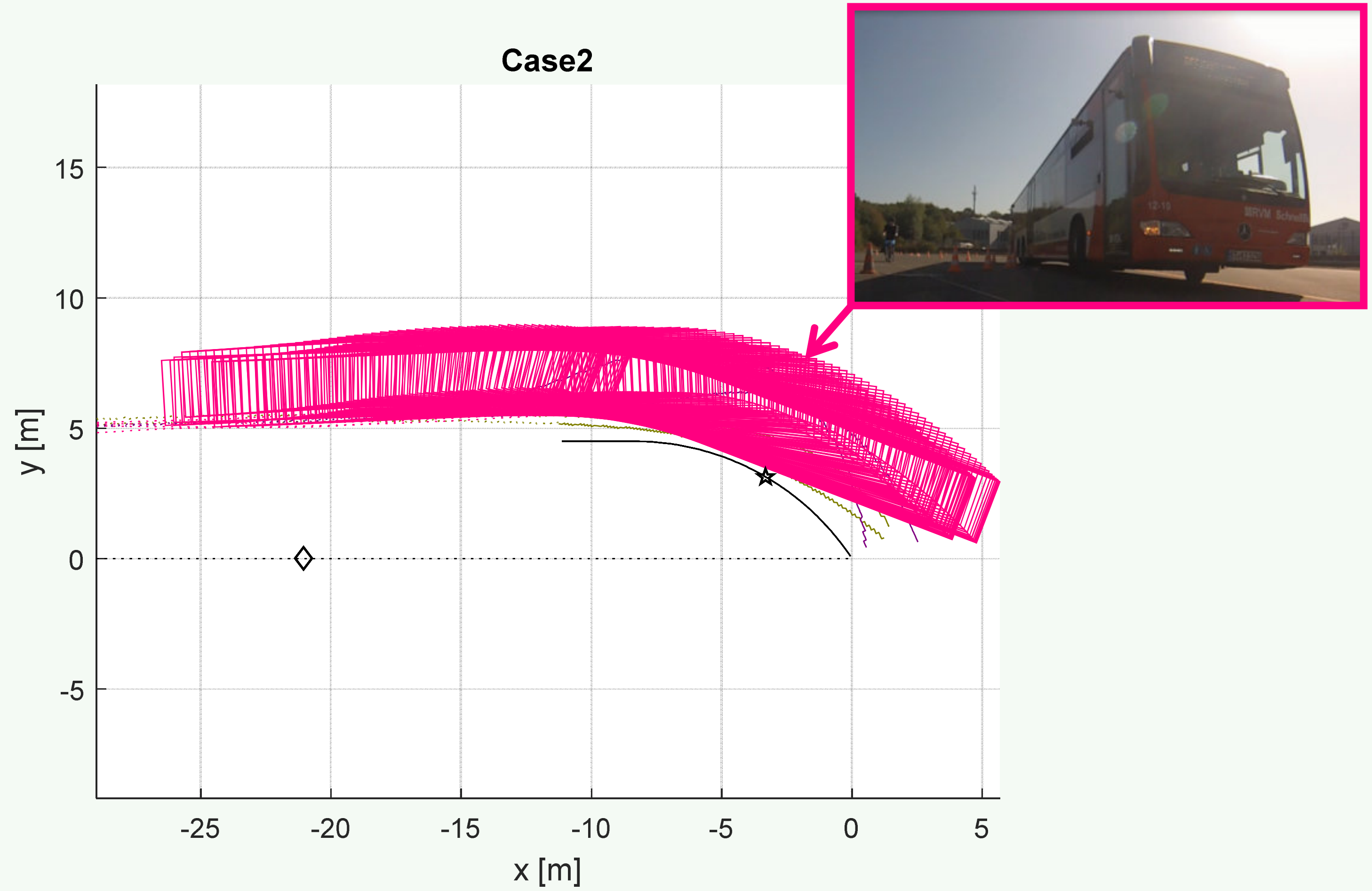
Case 2: All positions of single tractor

Vehicle approximated as rectangular box;
Box shown every 100 ms

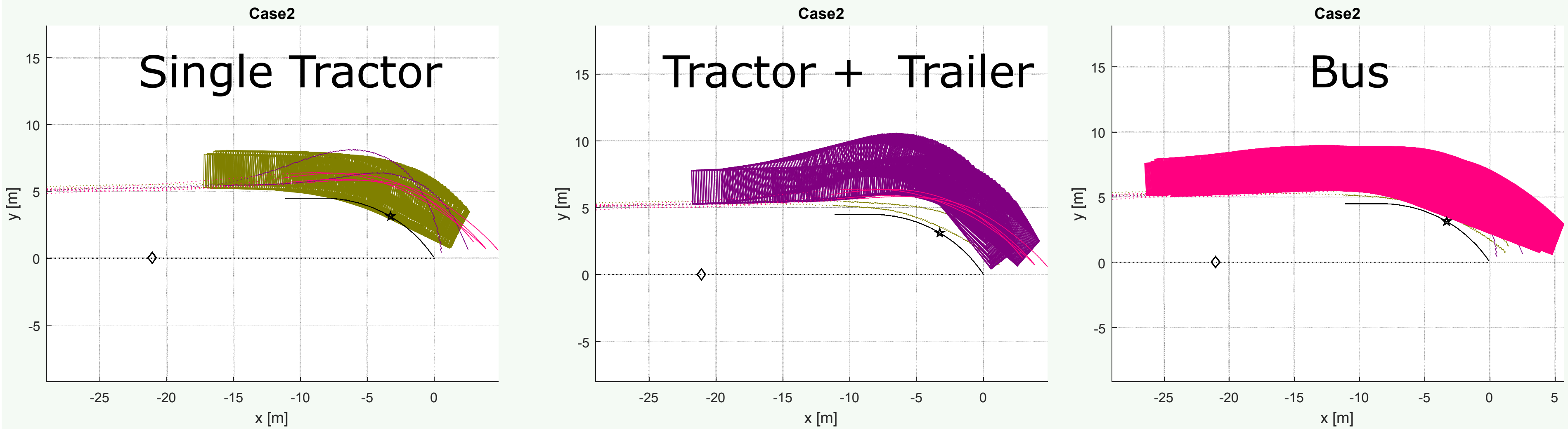


Case 2: All positions of tractor (driven with trailer)

Case 2: All positions of bus

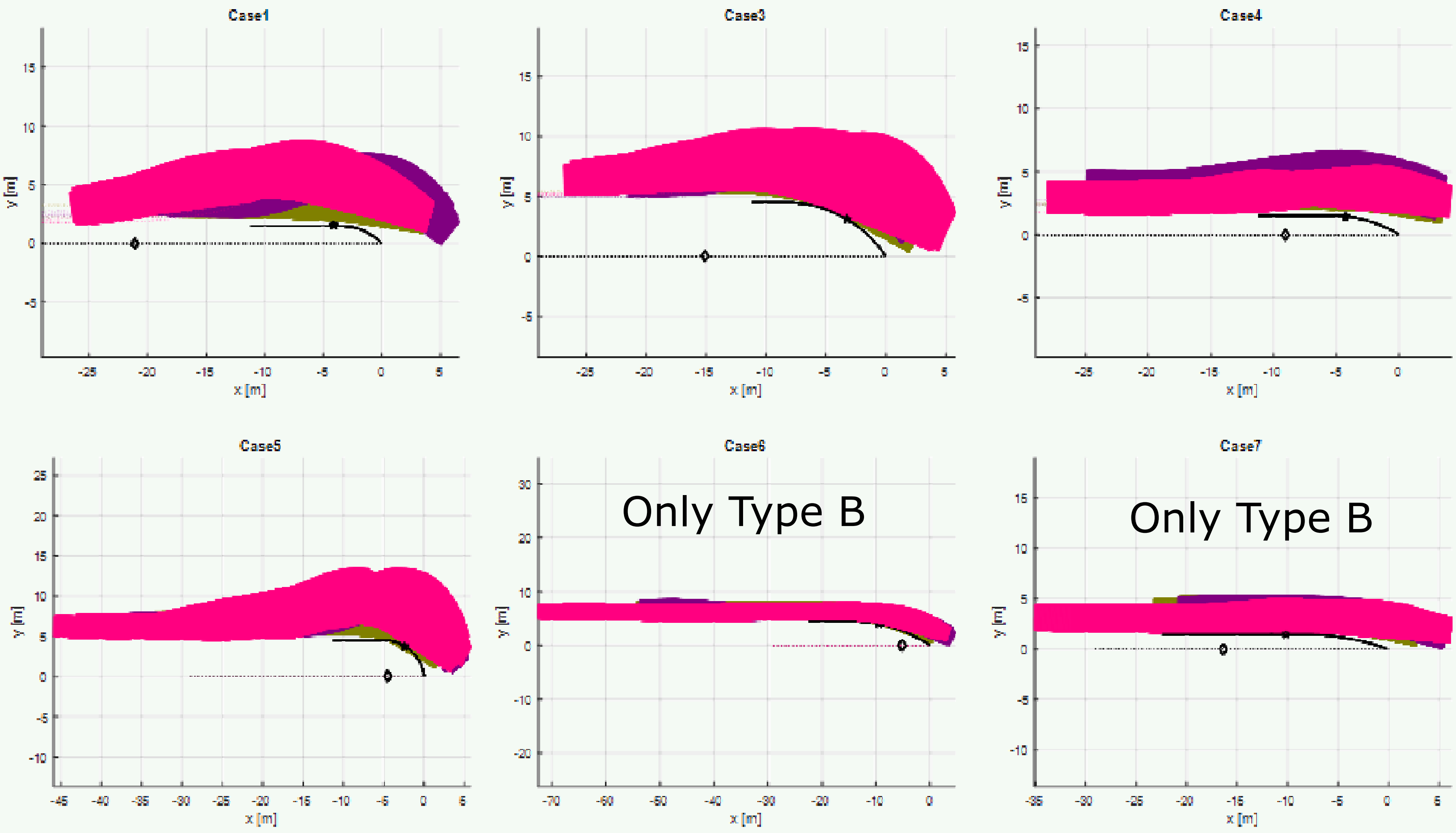


Case 2: Overview



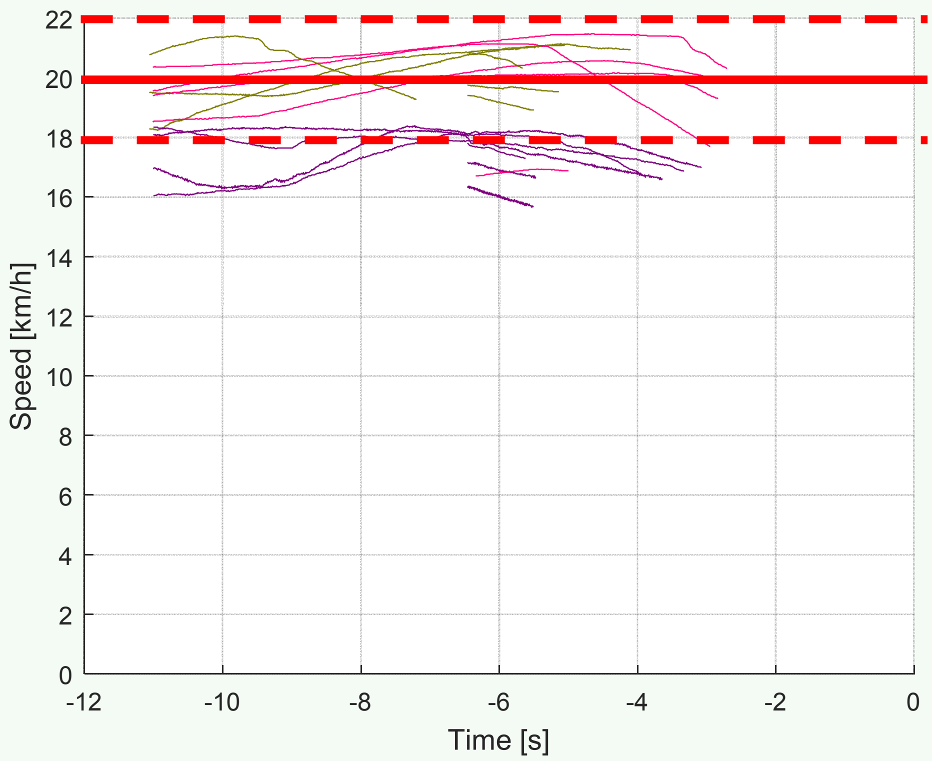
- Different vehicle types show different cornering styles
- Corridors for test conduction need to be adjusted to take this into account
- → Corridors Type A and Type B

Other cases – overview

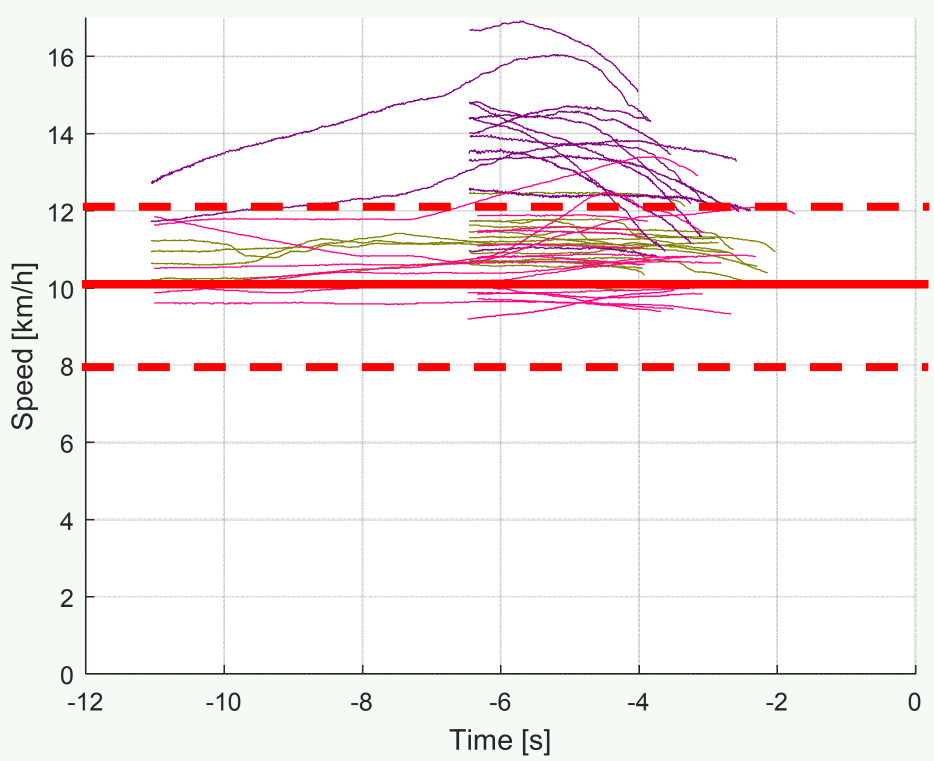


Speed Accuracy (manual driving)

20 km/h desired speed

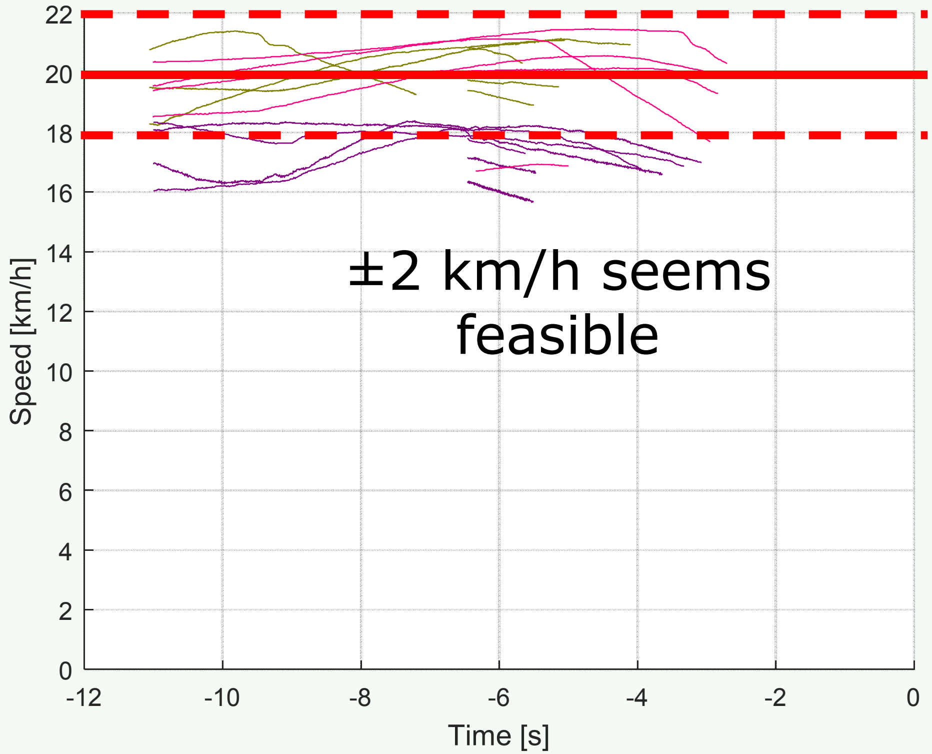


10 km/h desired speed

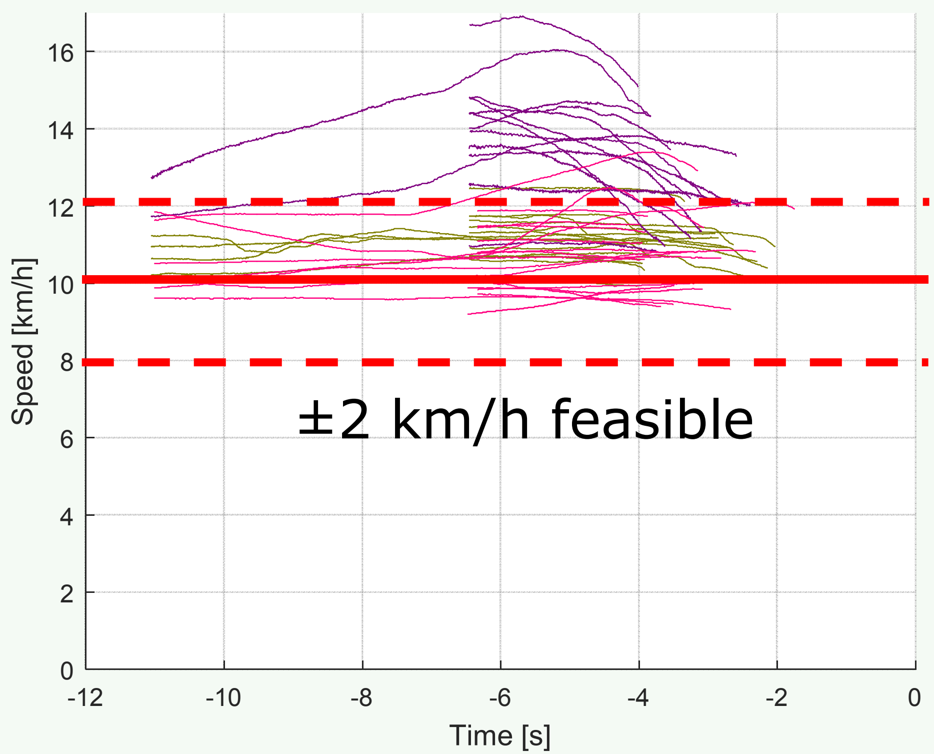


Speed Accuracy (manual driving)

20 km/h desired speed



10 km/h desired speed



OTHER CONSIDERATIONS

False Positive Tests

- System must not react to trees, cones and other road clutter
- Tests will always be carried out using cones
  - Information should only be given when approaching the bicycle
- Generic local road sign should be placed
  - No information should be given when entering the corridor
  - Additionally road sign positioned at entry of corridor

Remaining issues

- Start of bicycle at 4s before „Last Point of Information" (LPI) not sufficient
- Better: bicycle at speed at least 8 seconds before LPI [included in regulation proposal]
  - This means 33 m bicycle at full speed and 9 m acceleration length = 41 m belt length before impact point
  - Requires updates to current propulsion system control software

REGULATION PROPOSAL

Performance Requirements

5.3.1. Whenever the system is active, as specified in paragraph 5.3.1.4. below, the BSIS shall inform the driver about bicycles, travelling initially in parallel to the vehicle on the near side of the vehicle, that would be in conflict if the vehicle would start a turn towards the bicycle line of movement.

5.3.1.1. The information signal shall be given at a time when the vehicle driver would still be able to avoid a collision, taking into account an appropriate reaction time and an achievable brake deceleration.

5.3.1.2. The information signal shall meet the requirements as defined in paragraph 5.4. below.

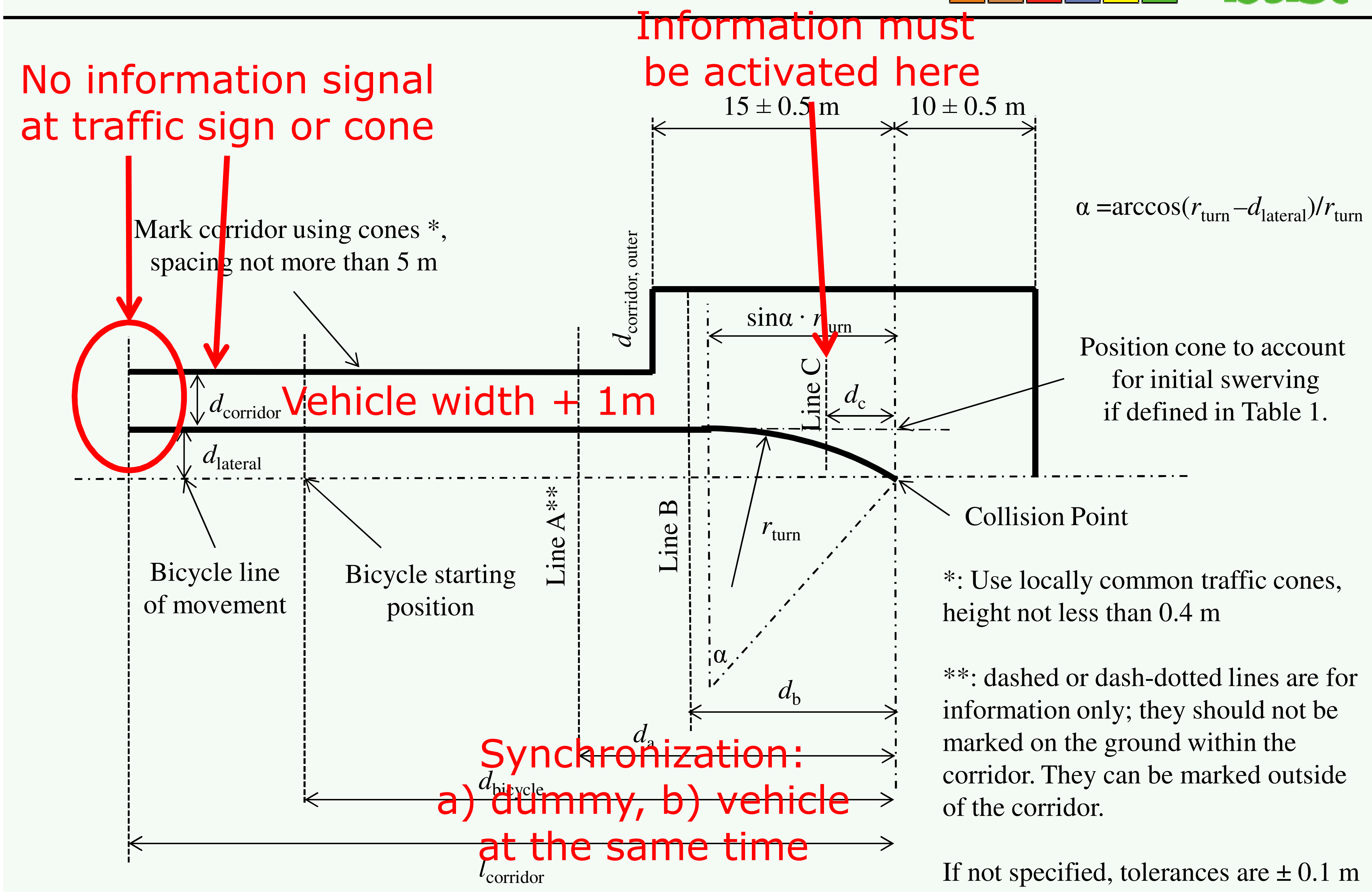
5.3.1.3. The information signal shall be given independently from the activation of turn signals.

5.3.1.4. The BSIS shall be operative for all forward vehicle speeds between 1 km/h and 30 km/h.

5.3.1.5. The BSIS shall be able to give an information signal for all bicycles moving with a speed between 5 km/h and 20 km/h.

5.3.1.6. The BSIS shall not give an information signal for stationary objects that are not pedestrians or cyclists.

5.3.1.7. The information signal shall be provided in such a timely manner that the accident is avoided, i.e. the vehicle is stopped before crossing the bicycle trajectory, if there was a driver brake application, resulting in 5 m/s^2 brake deceleration, and initiated with a reaction time of 1.4 seconds after the information signal. This shall be tested as specified in paragraph 6.5.


No information signal
at traffic sign or cone
Information must
be activated here
15 ± 0.5 m
10 ± 0.5 m
α =arccos(r_turn –d_lateral)/r_turn
Mark corridor using cones *,
spacing not more than 5 m
d_corridor, outer
sinα · r_turn
Line C
d_c
Position cone to account
for initial swerving
if defined in Table 1.
d_corridor
Vehicle width + 1m
d_lateral
Collision Point
Bicycle line
of movement
Bicycle starting
position
Line A**
Line B
r_turn
α
d_b
d_a
d_bicycle
l_corridor
Synchronization:
a) dummy, b) vehicle
at the same time
*: Use locally common traffic cones,
height not less than 0.4 m
**: dashed or dash-dotted lines are for
information only; they should not be
marked on the ground within the
corridor. They can be marked outside
of the corridor.
If not specified, tolerances are ± 0.1 m

Test Cases

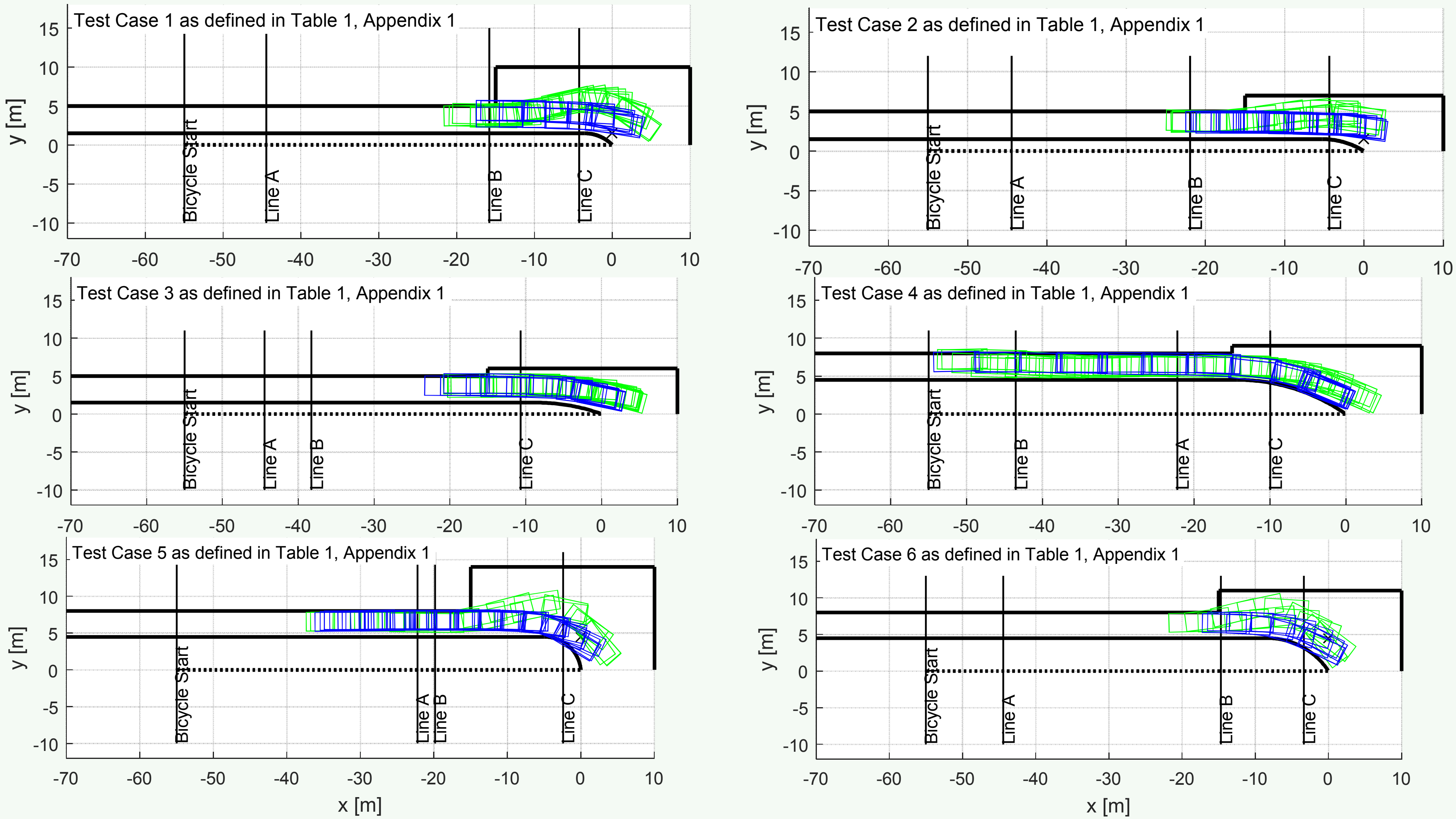
New Test Case	Orig. Test Case	r_{turn}	$v_{vehicle}$ [km/h]	$v_{Bicycle}$ [km/h]	$d_{lateral}$ [m]	d_a [m]	d_b [m]	d_c [m]	$d_{bicycle}$ [m]	$l_{corridor}$ [m]	$d_{corridor}$ [m]	$d_{corridor\ outer}$ [m]	Include cone to account for initial swerving?
1	1	5	10	20			15.8	4.3				5	Yes
2	4	10	10	20	1.5	44.4	22	4.4				2	Yes
3	7	25	20	20			38.3	10.7				1	No
4	6	25	20	10		22.2	43.5	10				1	No
5	5	5	10	10	4.5		19.8	2.4				6	Yes
6	2	10	10	20		44.4	14.7	3.4	< 55	> 70	vehicle width + 1m	3	Yes
7	3						17.7					2	Yes
8	1*	5	10	20	1.5	44.4	15.8	4.3					No
9	4*	10	10	20			22	4.4					No
10	5*	5	10	10		22.2	19.8	2.4				1	No
11	2*	10	10	20	4.5	44.4	14.7	3.4					No
12	3*	10	10	20			17.7						No

Test cases where vehicle initially swerves to the outside

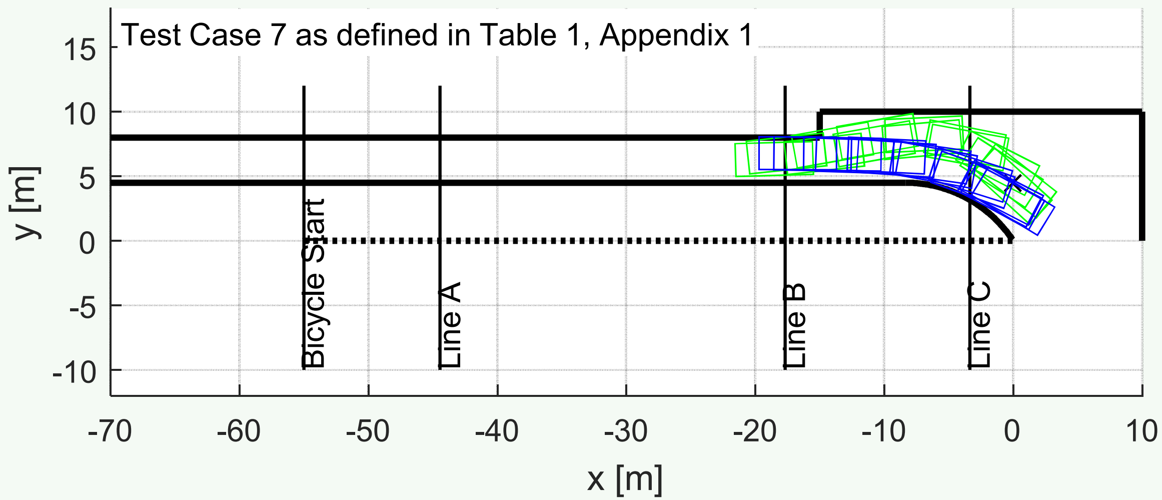
Test cases where vehicle does not swerve to the outside

Test Case No. corresponding to presentations from GRSGs 2016

Regulation Proposal + Trajectories (1)



Regulation Proposal + Trajectories (2)



Test Procedure

6.5.1. Using cones and the bicycle dummy, form a corridor according to Figure 1, Appendix 1 of this document and the additional dimensions as specified in Table 1, Appendix 1 of this Regulation.

6.5.2. Position the bicycle target (as detailed in Annex 3 of this Regulation) at the appropriate starting position as shown in Figure 1, Appendix 1 of this Regulation.

6.5.3. Position a local traffic sign corresponding to sign C14 as defined in the Vienna convention on road signs and signals (speed limit 50 km/h) or the local sign closest to this sign in meaning on a pole at the entry of the corridor as shown in Figure 1, Appendix 1 of this Regulation.

6.5.4. Drive the vehicle at a speed as shown in Table 1, Appendix 1 of this document with a tolerance of +/- 2 km/h through the corridor.

6.5.5. Do not operate the turn lights when initiating the turn towards the bicycle trajectory.

6.5.6. Move the bicycle dummy on a straight line as shown in Figure 1, Appendix 1 of this document in way that the dummy position crosses line A (Figure 1, Appendix 1) with a tolerance of +/- 0.5 m at the same time when the vehicle crosses line B (Figure 1, Appendix 1) with a tolerance of +/- 0.5 m (verify e.g. with video or picture).

Move the dummy in a way that the dummy moves in a steady state for at least 8 seconds, with the speed as shown in Table 1, Appendix 1 of this document with a tolerance of +/- 0.5 km/h, before reaching the collision point.

6.5.7. Verify that the Blind Spot Information signal has been activated before the vehicle crosses line C, Figure 1, Appendix 1 of this document.

6.5.8. Verify that the Blind Spot Information signal has not been activated when passing the traffic sign and any cones as long as the bicycle dummy is still stationary.

Feedback after GRSG Spring 2017 (1)

- 47. The expert from Germany presented GRSG-112-36 on the development of test procedures for a new draft UN Regulation on Blind Spot Information Systems (BSIS). He reported on the research results, the derivation of test cases and the new technical requirements on the conduction of test for such BSIS. He introduced a proposal for a new draft UN Regulation on BSIS (ECE/TRANS/WP.29/GRSG/2017/11). GRSG welcomed the detailed information and the proposal by Germany.
- 48. The expert from Israel recommended to extent the scope also to categories of vehicles other than N_2 and N_3. He added to even insert provisions on aftermarket BSIS for the purpose of retrofitting vehicles already in service. **A number of experts underlined their preference to adopt, in a first step, the new UN Regulation and then to extend the scope in a further stage.**

Feedback after GRSG Spring 2017 (2)

- 49. During a first reading of ECE/TRANS/WP.29/GRSG/2017/11, the document received a number of comments on the definitions and cross-references to other UN Regulations. Following the discussion, GRSG agreed that the IWG on VRU-Proxi (see para. 16 above) shall resume consideration of ECE/TRANS/WP.29/GRSG/2017/11 as a first priority at its forthcoming meetings.
- 50. GRSG agreed to, at its next session, have a further review of draft UN Regulation on BSIS and **to resume consideration of ECE/TRANS/WP.29/GRSG/2017/11 on the basis of the detailed feedback by the IWG on VRU-Proxi.**