



Draft Regulation on Driver Assist Systems to Avoid Blind Spot Accidents

Development of Test Procedure and First Verification Tests

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Structure

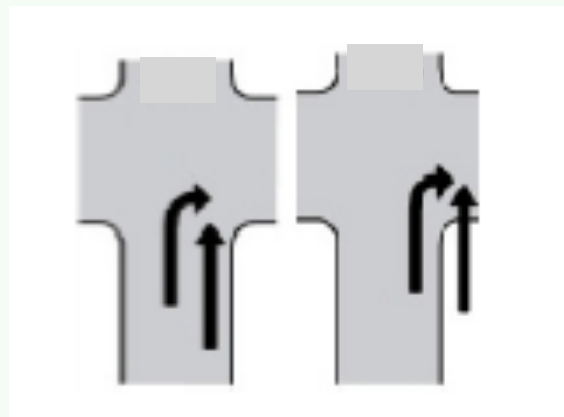
- Accidentology
- Definition of Relevant Parameters and Test Cases
- Definition of Assessment Criteria
- Verification Tests
- Test Results
- Conclusions

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



In depth accident analysis

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

Records include sketches, photos, aerial images, reconstruction

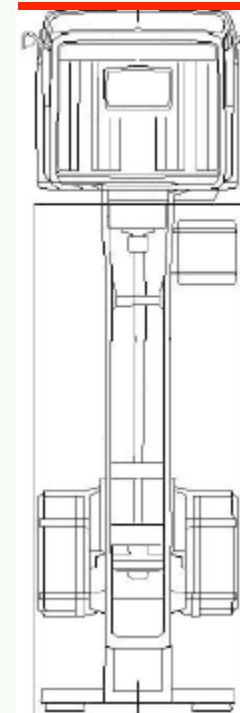
Purpose: gain information about

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



In depth accident analysis - results

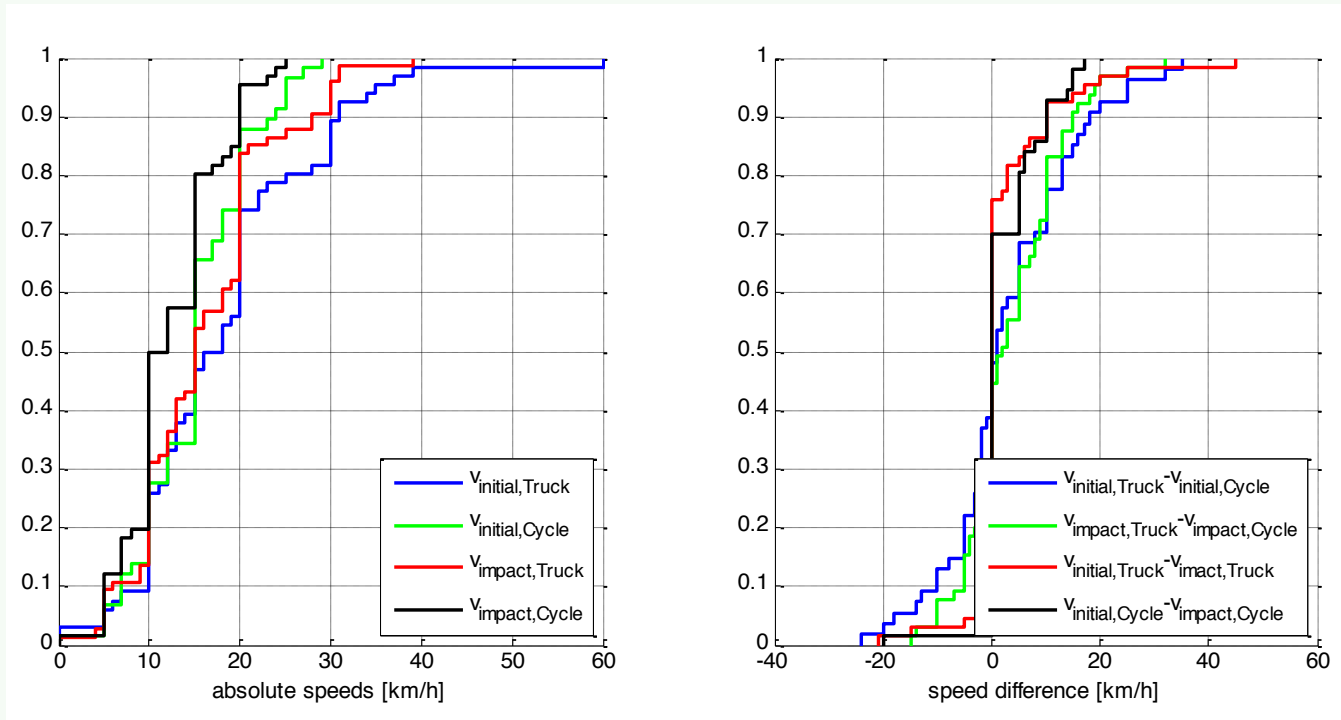
- Daytime about 90 %
- 90 % dry weather
- Truck drivers sight O.K.; obstruction in only 9 %
- Only 22 % of the cases after previous halt of the truck
- In 90 % of the cases truck did not brake
- In 90 % of the cases bicycle moved
- Impact point at frontal part of the truck (up to 6 m towards the rear,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



60-80%
(UDB /
DEKRA)

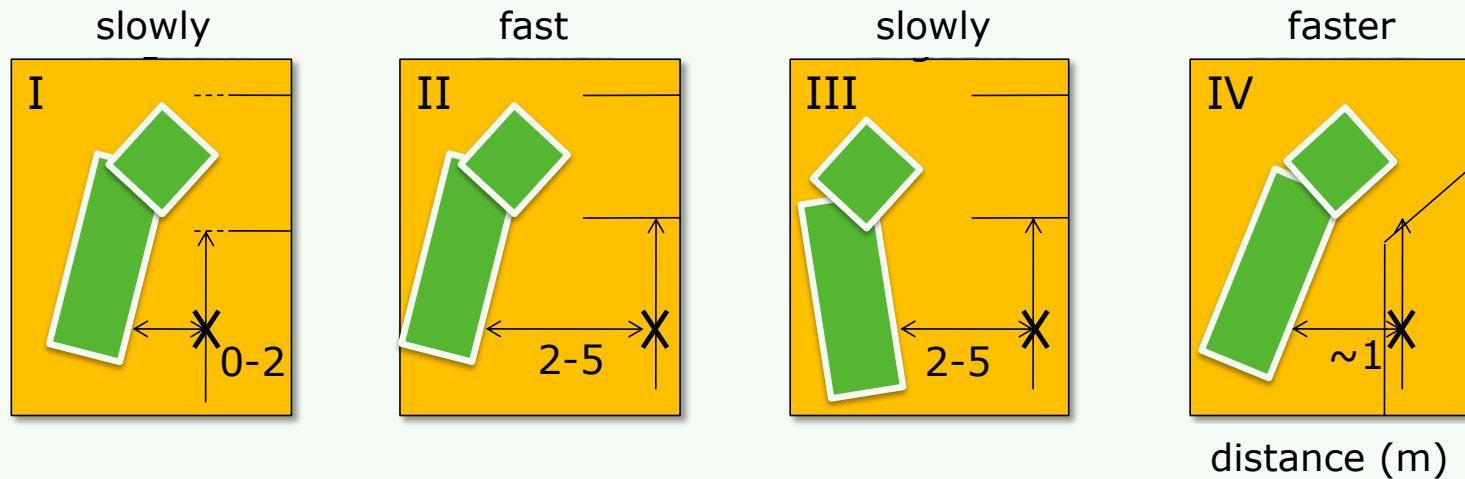
In depth accident analysis - results

Speeds:



- 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



Preconsiderations for Requirements

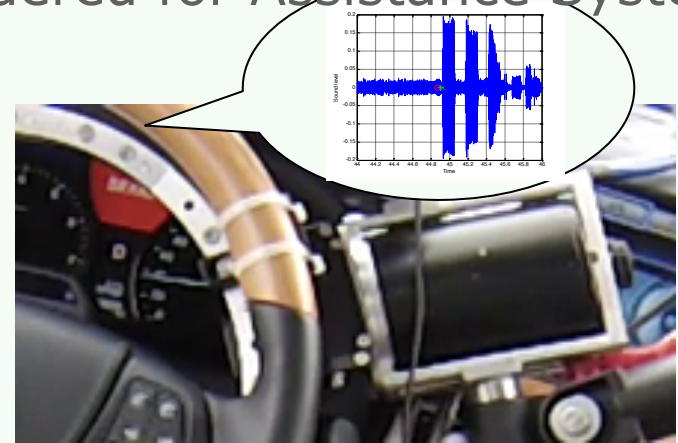
- Due to missing experience no emergency braking
- Warning (high intensity) only if accident is imminent in order to avoid annoyance (alert will be disabled)
- Since driver reaction time has to be taken into account warning will be too late in most of the cases and thus useless
- Informational assistance (early but not annoying)

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



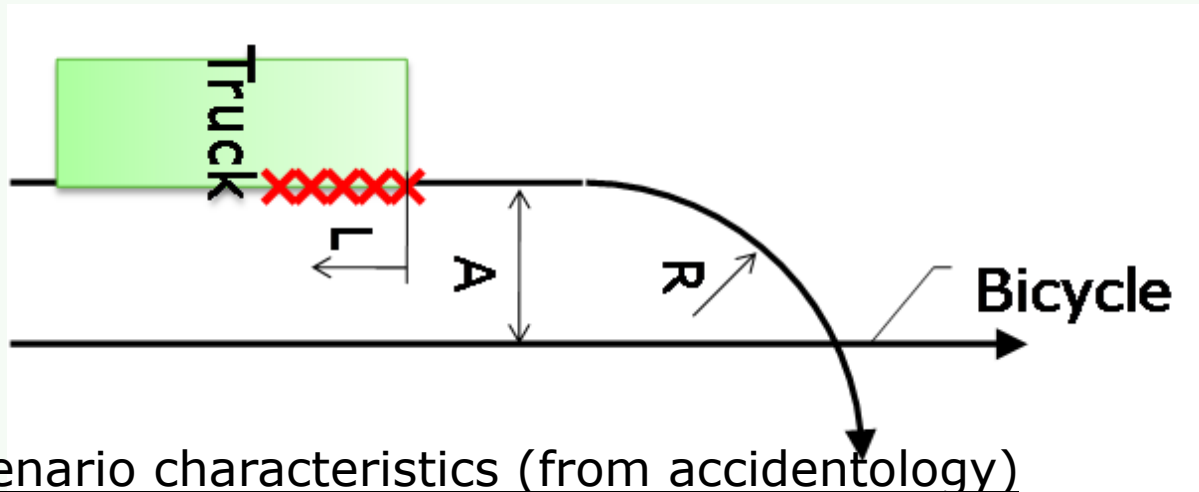
- Information

Considered for Assistance System

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



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

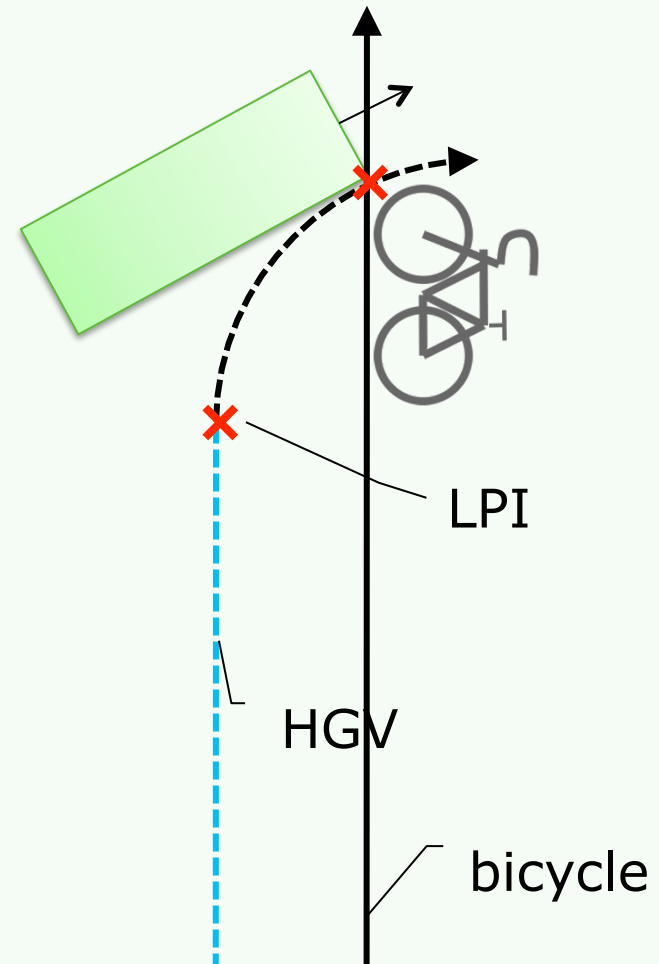
Assumed driver performance (conservative)

- 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)

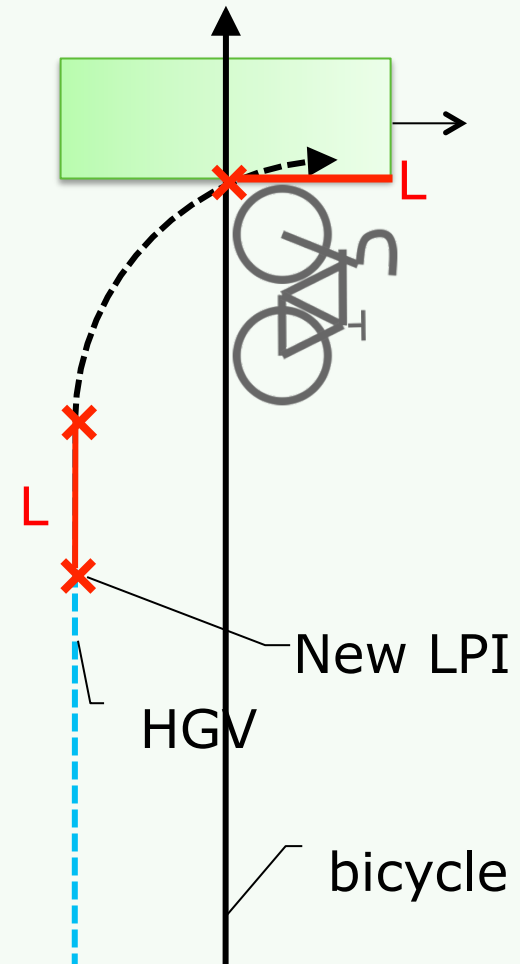
$$\begin{aligned}
 TTC_{LPI} &= t_{\text{Reaction}} + t_{\text{Brake}} \\
 &= 1.4\text{s} + \frac{v_{\text{HGV}}}{2 \cdot 6 \frac{\text{m}}{\text{s}^2}}
 \end{aligned}$$



Pass/Fail Criteria (2) – Impact to Side of HGV

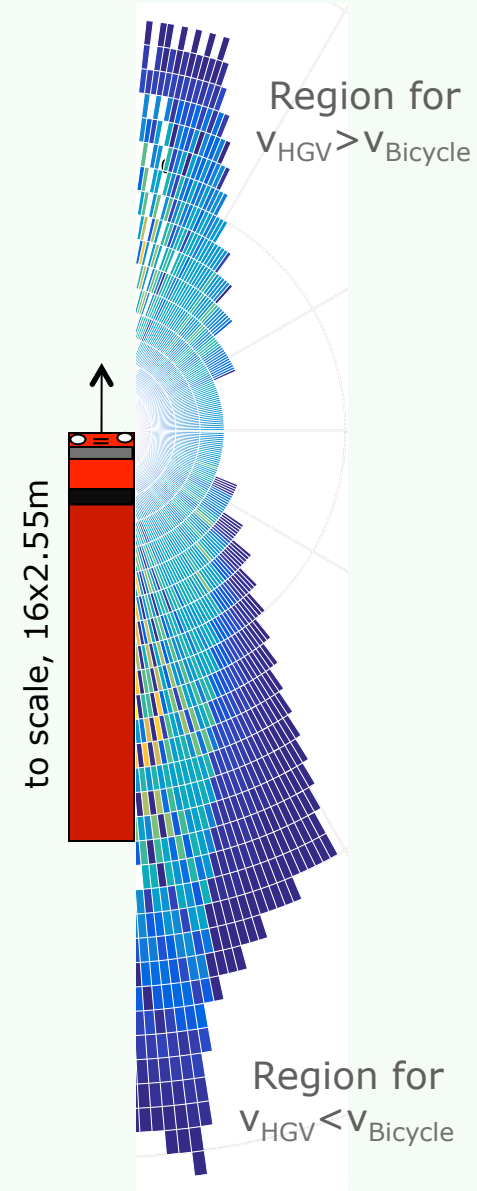
- Still prevent HGV from crossing pedestrian path
- Crossing bicycle trajectory happens earlier
- Warning needs to be issued earlier – LPI shifts
- In most cases, HGV has not started to turn at that point

$$\begin{aligned}
 TTC_{LPI} &= t_{\text{Reaction}} + t_{\text{Brake}} + t_{\text{to impact point}} \\
 &= 1.4\text{s} + \frac{v_{\text{HGV}}}{2 \cdot 6 \frac{\text{m}}{\text{s}^2}} + \frac{L}{v_{\text{HGV}}}
 \end{aligned}$$



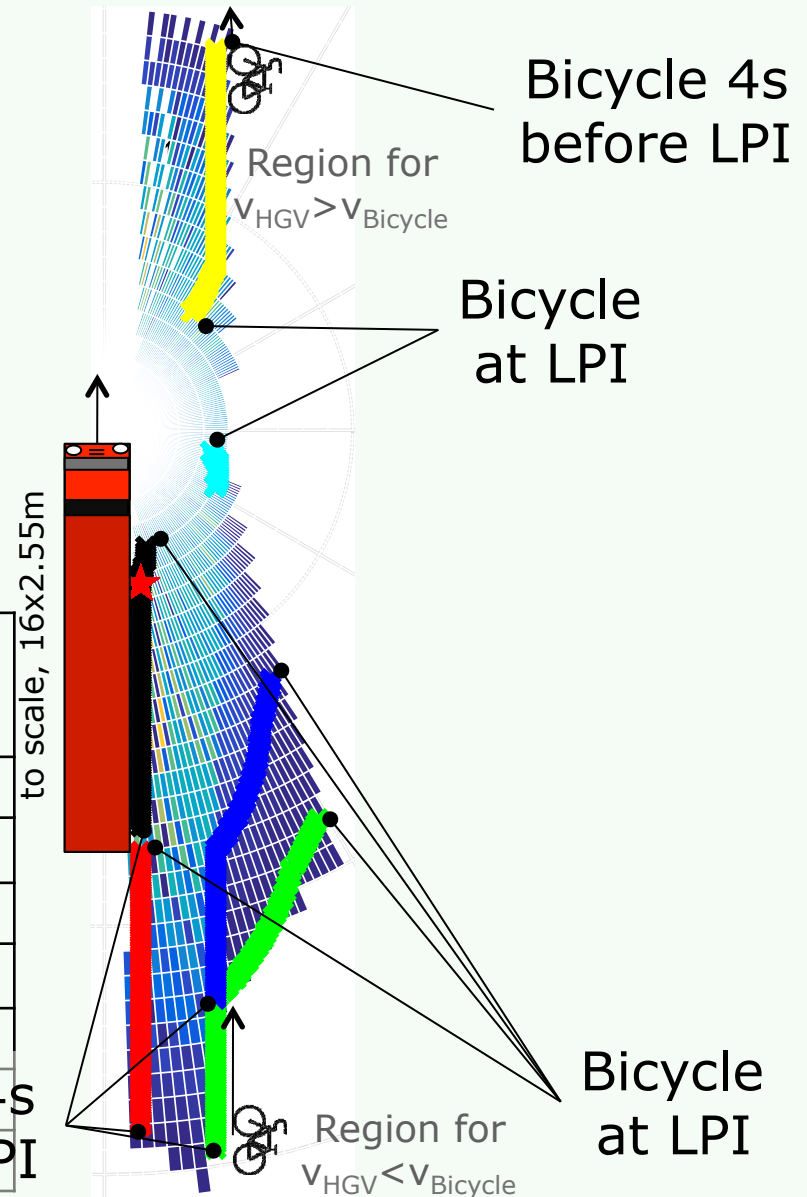
Definition of Test Cases

- 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 $1\text{m} \times 1^\circ$) 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 LPI
- Exact timing defined by manufacturer
- Tests will simulate at least 4s 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





- Vehicle
 - Truck, manually driven, without trailer
 - Position estimation: GeneSys DGPS
 - Position transmitted to dummy propulsion system
- Dummy
 - Standard commercial static pedestrian dummy (4active systems „EuroNCAP Pedestrian“)
 - Regular bicycle with custom carrier mechanism
- Dummy Propulsion
 - 4a „Surfboard“ commercial Dummy Propulsion with prototype software
 - Synchronisation of triggering time
 - Custom belt tensioning reel

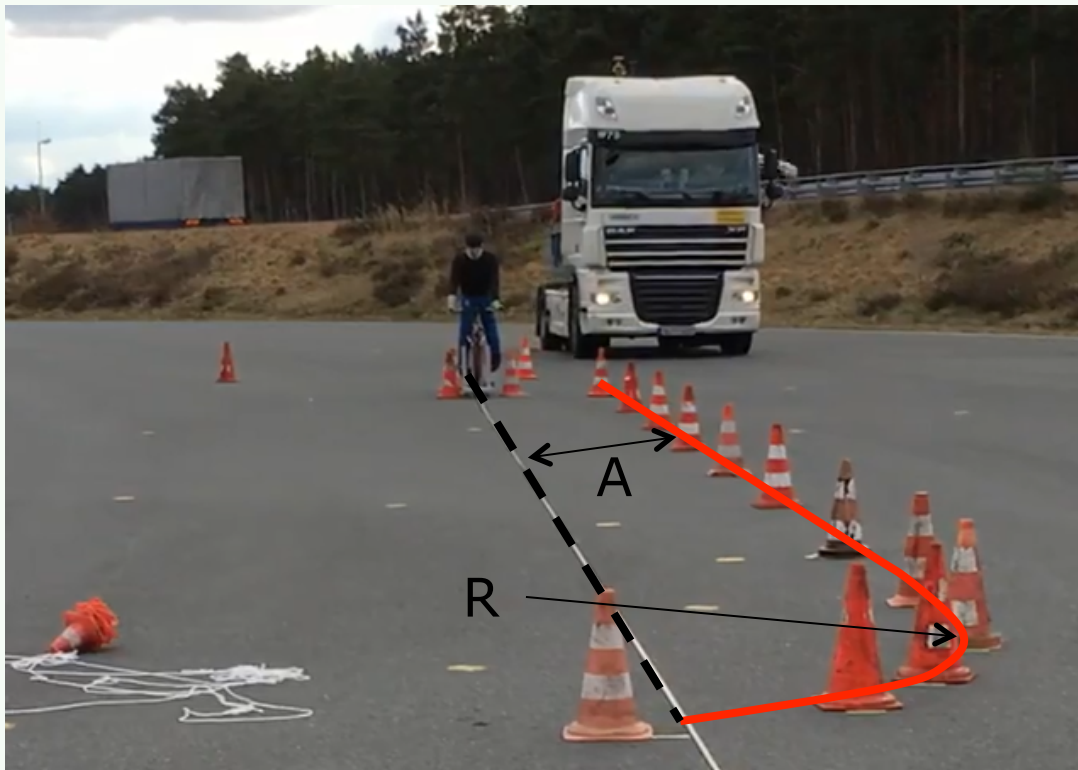
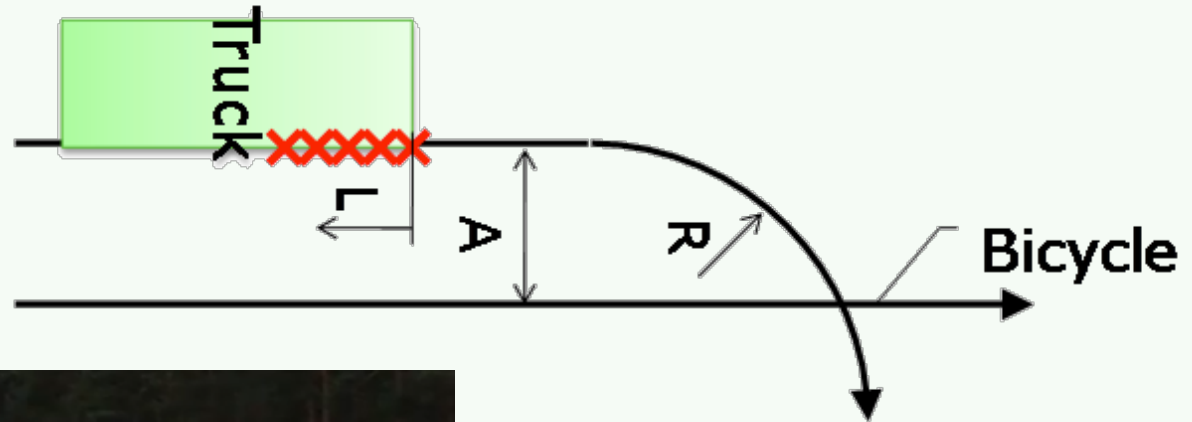


Proposed Test Dummy - Regulation

- Crashable Cyclist Dummy is in the process of being finalized
- Specifications will be included in Draft Regulation as soon as available



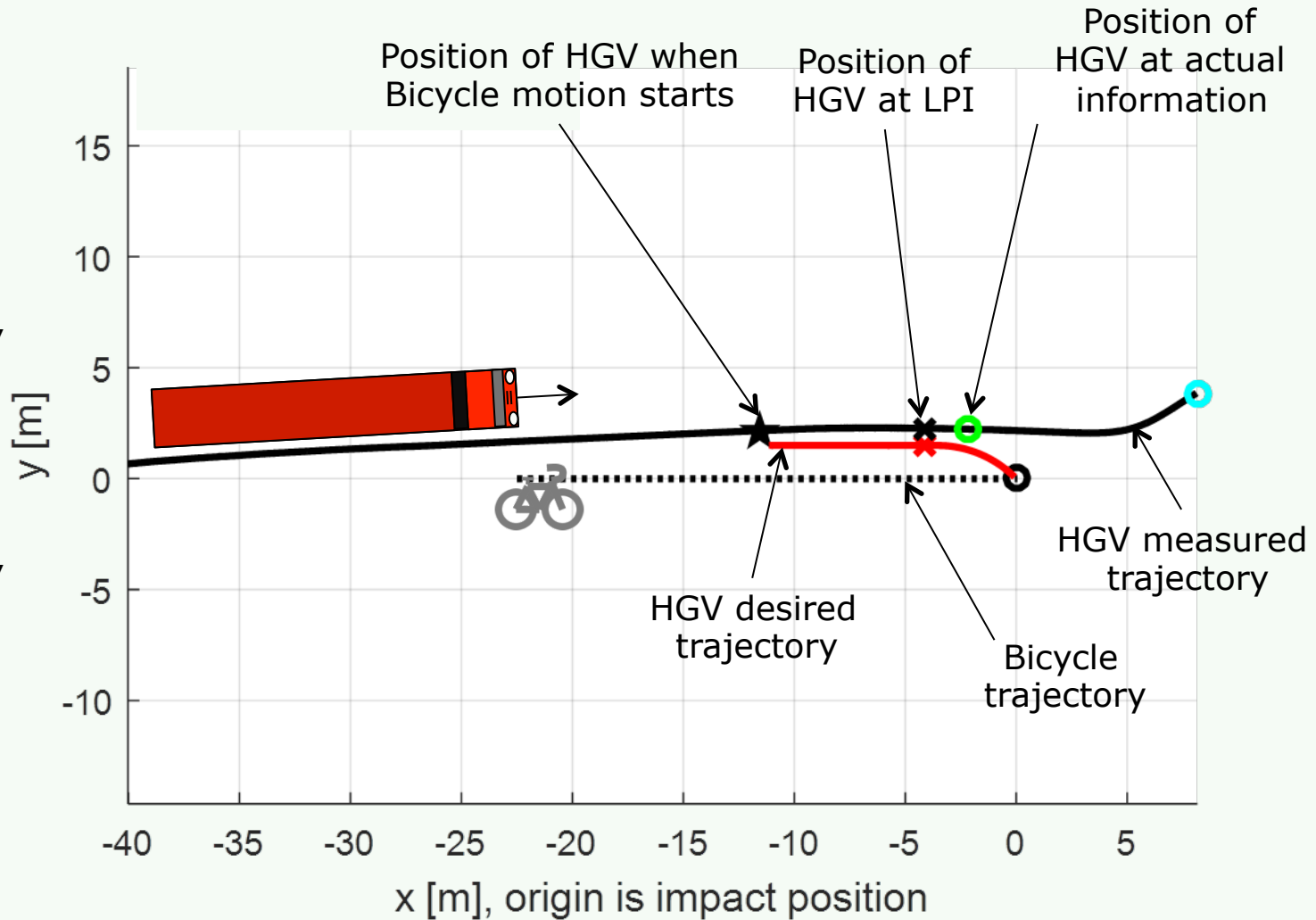
Test Setup



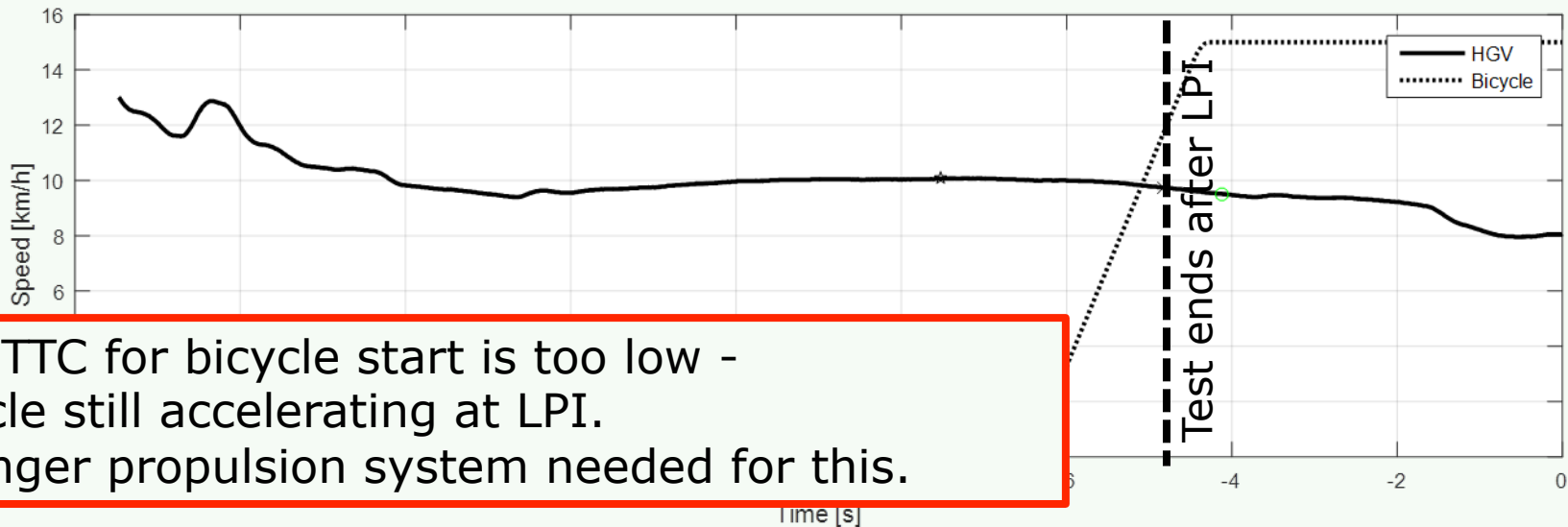
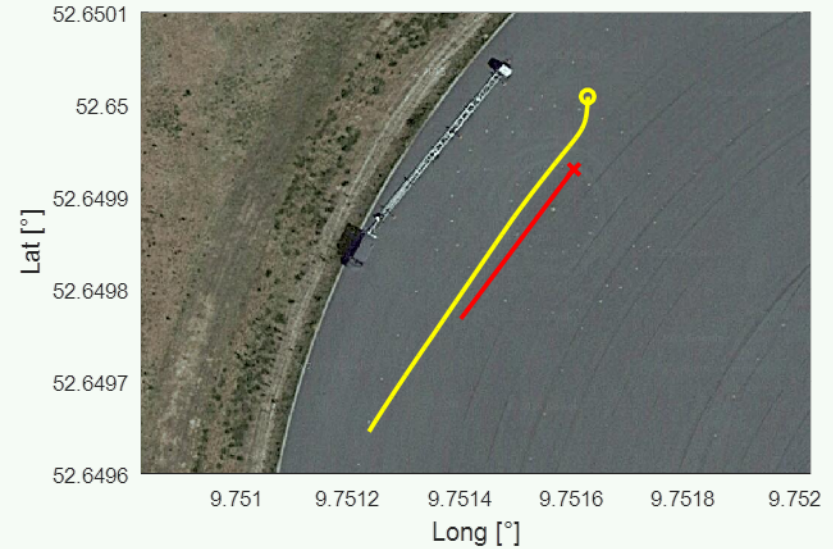
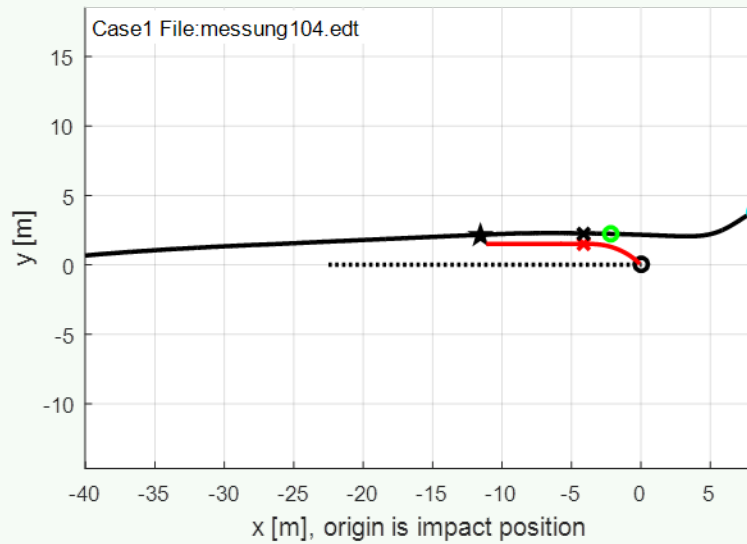
- \underline{L} – Impact location from front of truck
- \underline{A} – Initial lateral separation of HGV and Bicycle
- \underline{R} – Turning Radius of HGV

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
 $R=25m$, $L=6m$,
 $A=4.5m$,
 $v_{HGV}=20km/h$,
 $v_{Bicycle}=10km/h$

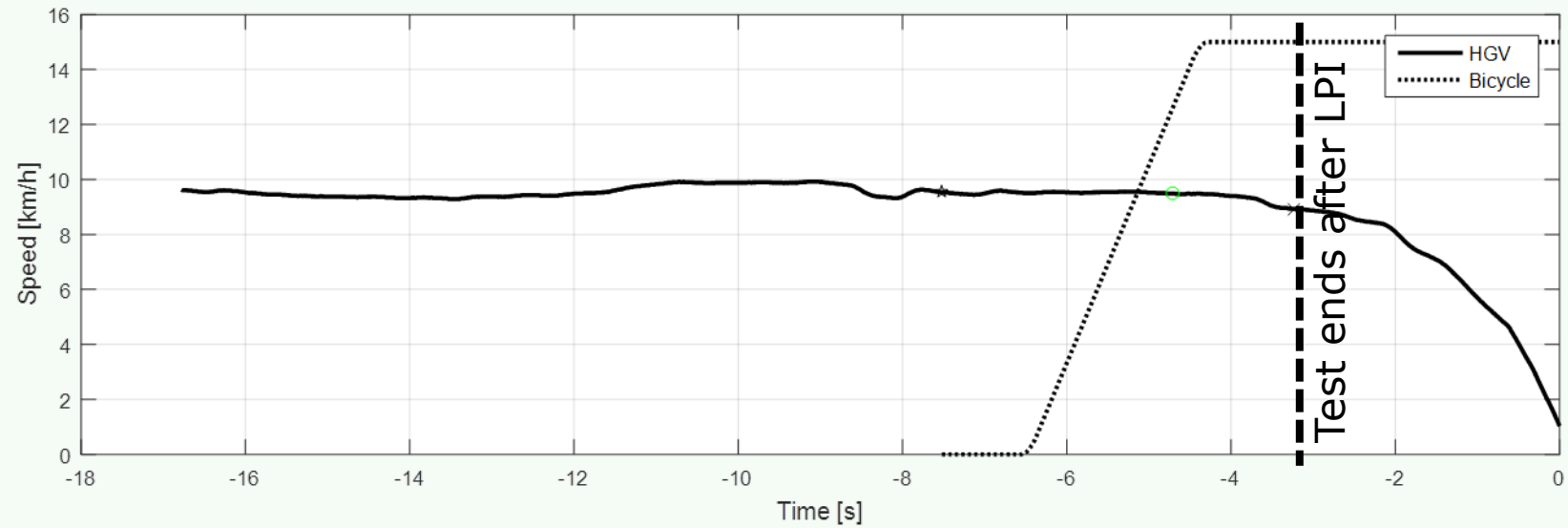
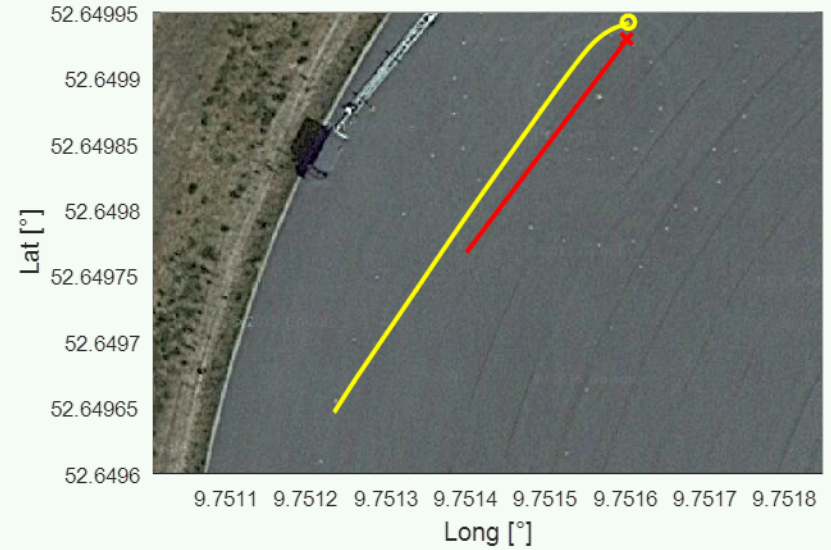
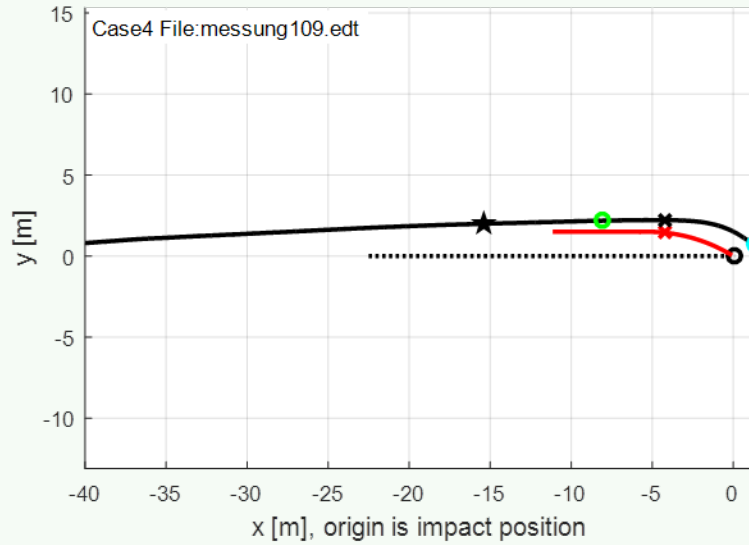


Test Case 1 (Example)

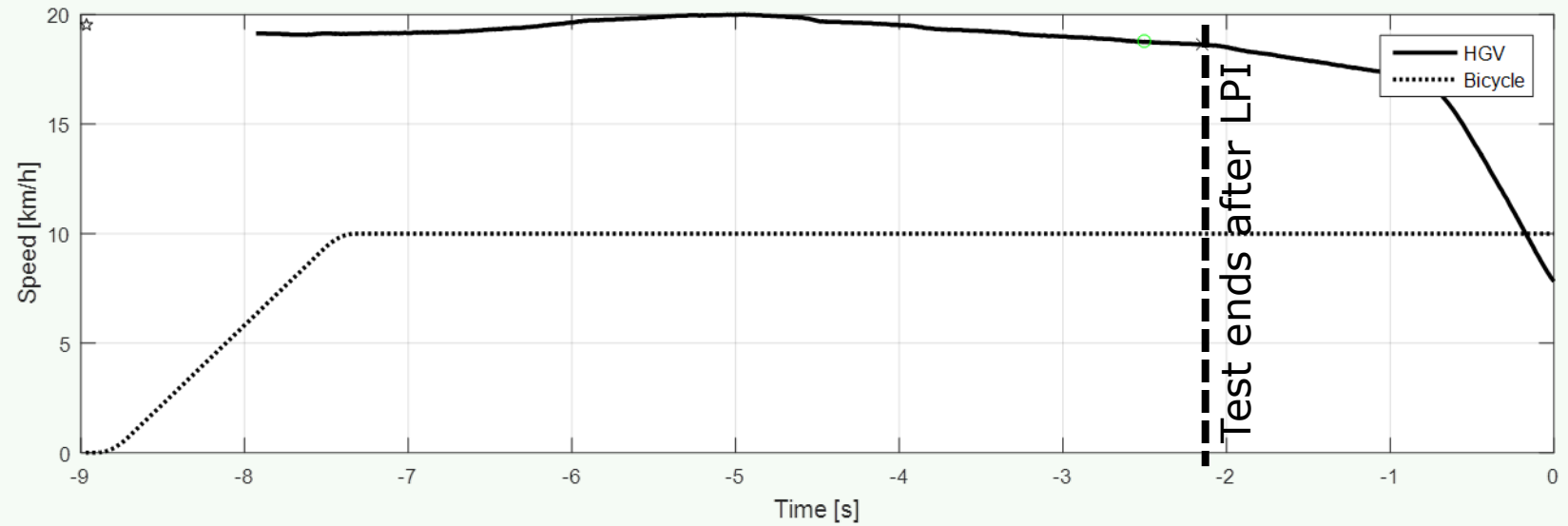
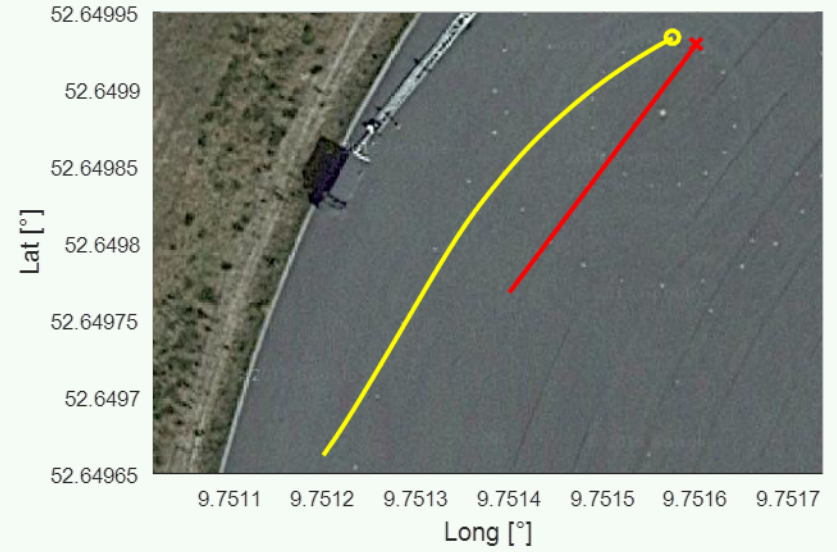
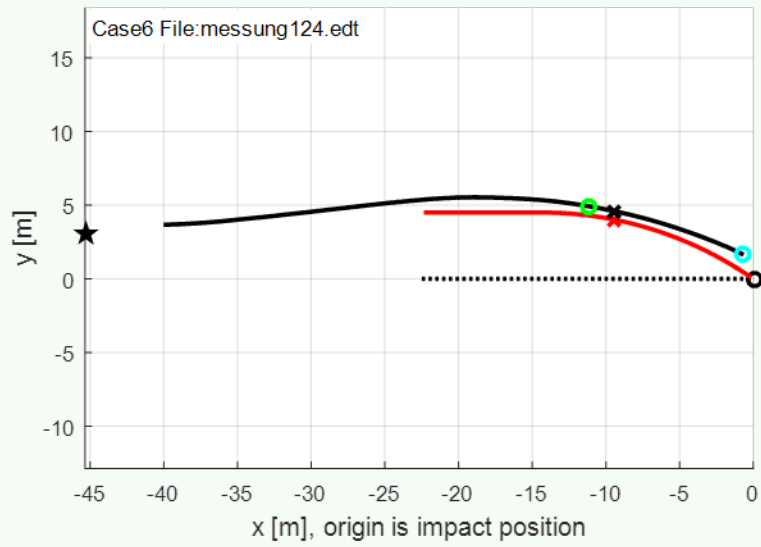


4s TTC for bicycle start is too low -
cycle still accelerating at LPI.
Longer propulsion system needed for this.

Test Case 4 (Example)



Test Case 6 (Example)



Test Results and Conclusions

- Prototype information system implemented in HGV
- Test Scenarios carried out:
 - Case 1, 0/4 tests passed, bicycle movement starts late
 - Case 4, 4/4 tests passed
 - Case 6, 3/4 tests passed
 - Other test scenarios were not possible because of bug in dummy control software (to be fixed soon)
- Manual driving using cones is possible (driving robots not required)
- Manual speed control is possible
- Corridors for trajectory and speed will be defined

Conclusions

- Accidentology shows that accidents between truck and bicycle occur:
 - With right-turning trucks
 - Constant and slowly moving trucks and bicycles
 - Pedestrians are not relevant in these accidents
- A Test Procedure has been defined based on accidentology
 - Requirements for an information-only system
 - Test setup and pass criteria
 - Tools
- Verification Tests for 3 out of 7 test cases have been successfully performed