DCAS testing campaign
Proving ground tests

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European Commission Joint Research Centre

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Topics

- Challenges / Question
- Current testing activity
  - Proving ground – Critical scenarios
  - Public road
  - Driver monitoring systems
- Discussion
  - What is a SIM?
  - How to take into human factors

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Challenge

DCAS Safety?

- Reduction of work load
- Driver support
- Less aggressive driving
- Avoid critical situation
- Stress?

- Reduction of attentiveness
- System failure(s), sudden disengagement
- Mode confusion
- Overtrust
- Who drives?
- Stress?

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Safety gap/issues

"L2 systems cannot become L3 systems by just further extending the ODD and performance" – Schuster (BMW), 2022 SafetyWeek

"The driver needs to be aware of the allocation of driving task **all times!**" – Raisch (BMW), 2022 SafetyWeek

"Unexpected system behavior takes time for a driver to react to" - IIHS

System should be robust "enough" that it does not bring the vehicle to safety critical situation

"Added functionality can exacerbate driver misunderstanding about system limitations" - IIHS

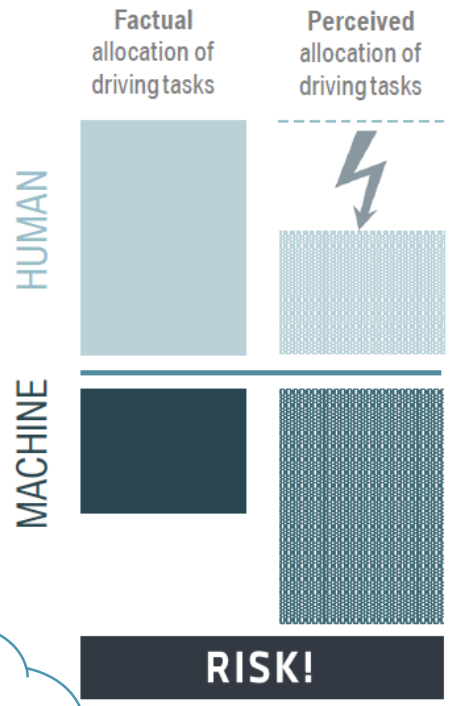
"Risky situations can develop if the vehicle starts to move or performs a complex maneuver before the driver is ready" - IIHS

Are they the right questions?

If not is there enough time for the driver to put the hands back on the steering wheel and to act?

How long will it take to put back the hands on the steering wheel when sudden, unexpected events happen like

How will the driver cope with a power steering failure during H-free operation? When taking back manual control the driver is expecting power steering support and absence can lead to dangerous situations;



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Tested vehicles

Deep analysis:

- Tesla Model 3 (v.11) with FSD
- Ford March-e with lane centering and lane change during eyes-on warning (hands-off) only
- Cupra – R79 (previous testing campaign)

Screening analysis

- Tesla Model 3 (new FSD, v12)
- GM with SuperCruise

- No vehicle was developed for DCAS!

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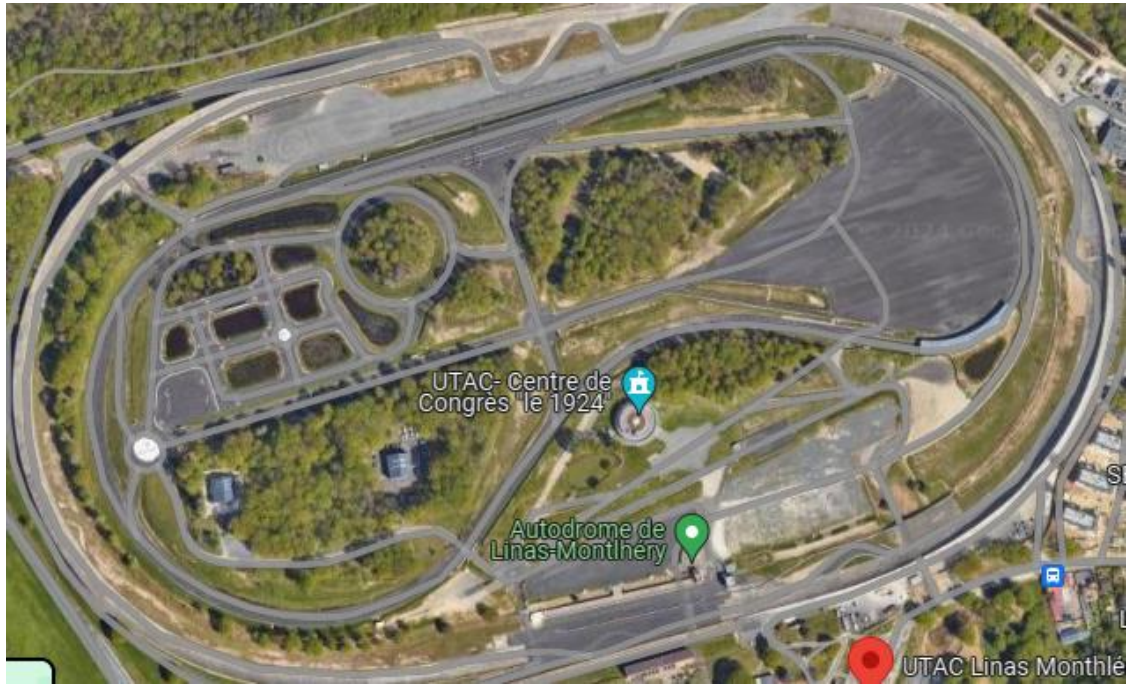
Behavior of an R79 vehicle

- Test site: UTAC, France
- Cupra R79 type approved vehicle
- Real motorbike and car target
- GVT for critical scenarios (AEB)
- Tests:
  - AEB – with different speed and overlap
  - B1 in curves and S-band
  - ACSF-C
  - Urban (e.g. round about



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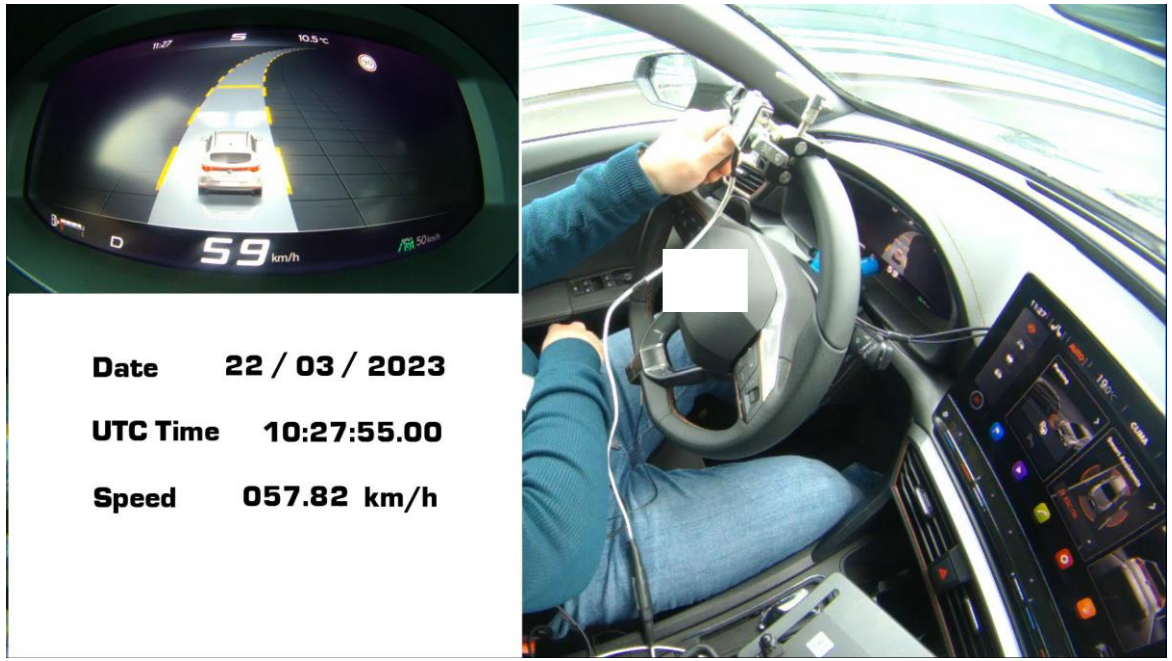
Reaction time at system disengagement



Critical for hands-off
Warning is too late
Strong steering intervention – lateral acceleration

Control of longitudinal speed already in DCAS

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Who needs to react?

Need to take into account the general behavior of the AEB
Robustness - “System should not change strategy” - already in DCAS

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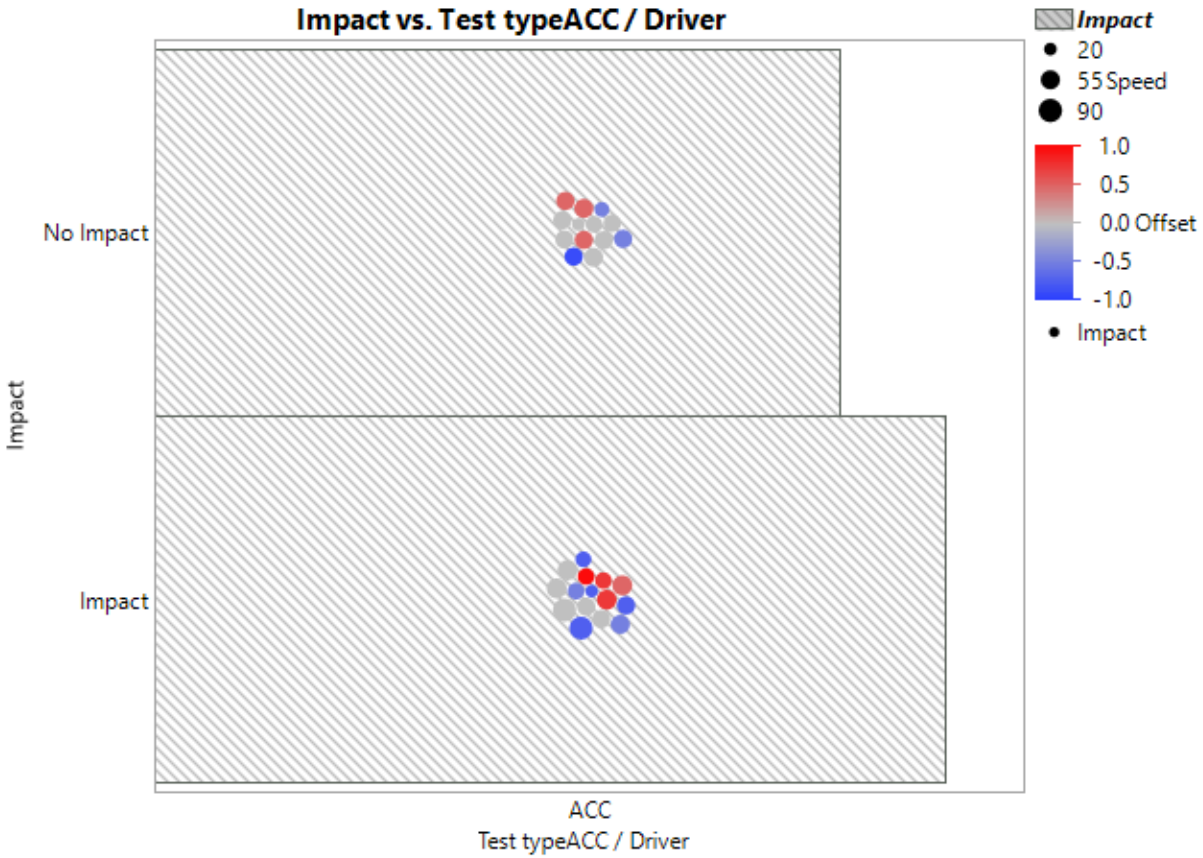
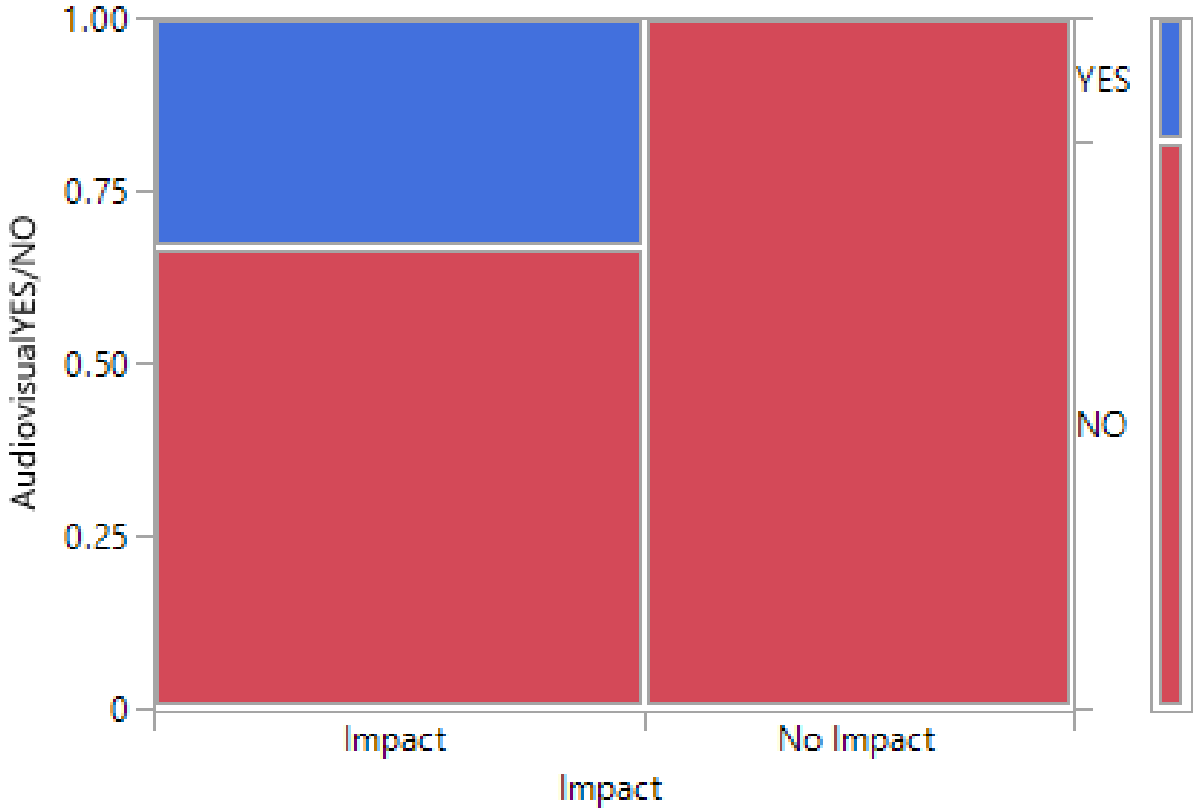
ACC (with AEB) in straight and curved roads





- No reaction above 70 km/h!

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What happens during a maneuver

Traffic situation changes

System reaches its boundary

Suspension? – Go on? – Go back?

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Proving ground test preliminary results

- Tesla Model 3 (v.11) with FSD
- Ford March-e with lane centering and lane change during eyes-on warning (hands-off) only

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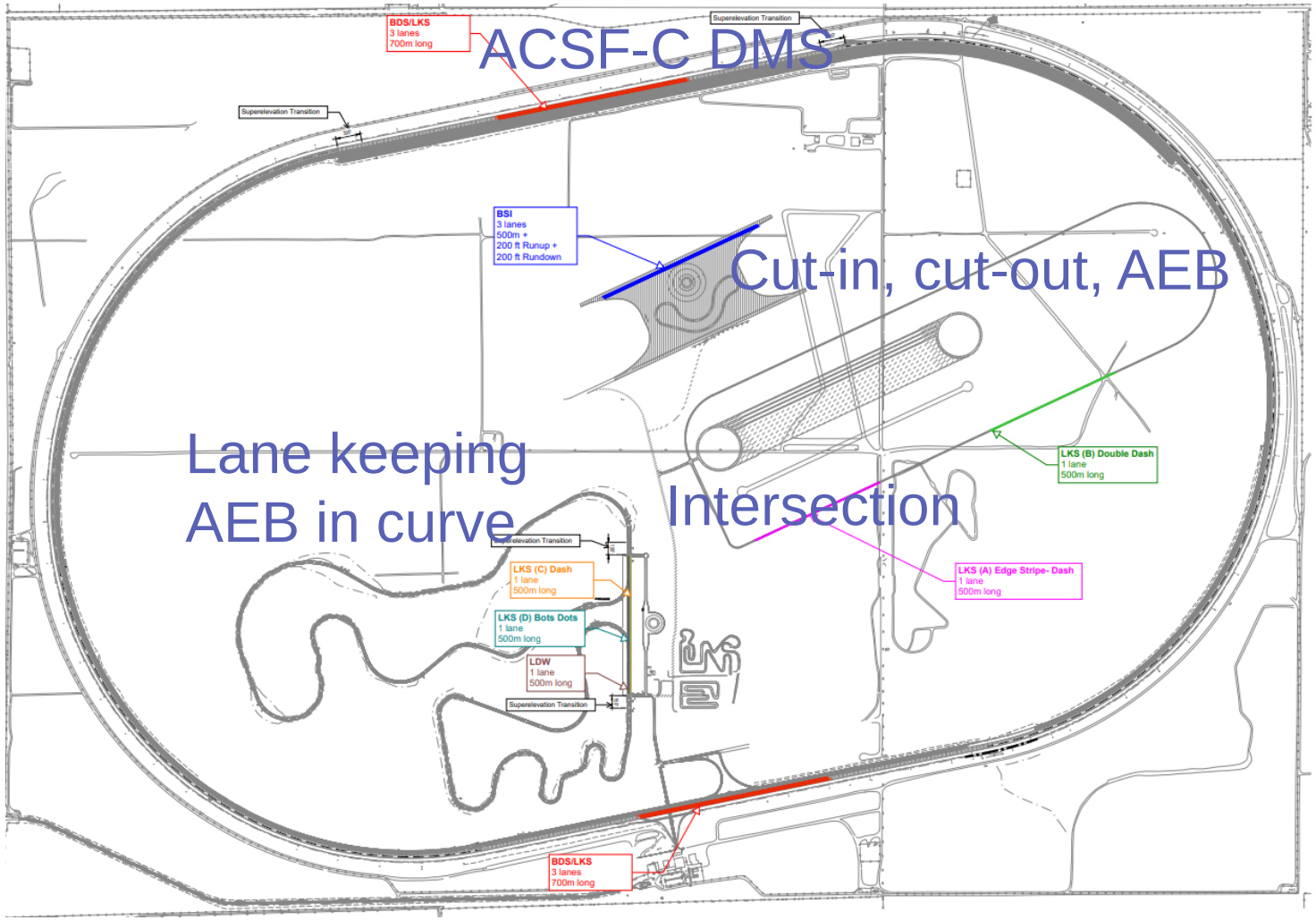
Testing critical scenarios

Test	DCAS paragraph in ANNEX 4	Conditions	Comments
Positioning in the lane of travel	4.2.5.1.1.	vary the speed, lane curvature (S-band), lane marking, road edge also	Hands-off could not be initiated
Driver-initiated lane changes	4.2.5.1.2.	Vary the ego speed, approaching vehicle and their position in the lane	Cannot be initiated for some vehicles
System-initiated lane changes	4.2.5.1.4.	Vary the ego speed, approaching vehicle and their position in the lane, curves included	Cannot be initiated for some vehicles
Stationary vehicle ahead on a straight section of road	**4.2.5.2.1.**	**vary the speed, the target and the overlap, daylight and night**	**Both in manual and ADAS driving**
Stationary vehicle ahead on a curved section of road	**4.2.5.2.2.**	**vary the speed, the target and the overlap**	**Both in manual and ADAS driving**
Cut-out of lead vehicle	**4.2.5.2.5.**	**vary the speeds and the headway distance**	**M1 target, different speeds and headway distance**
Cut-in of vehicle from adjacent lane	**4.2.5.2.6.**	**Vary cut-in vehicle type**	**M1 and motor targets**
~~Stationary pedestrian ahead in lane~~	~~4.2.5.2.8.~~		
~~Stationary bicycle target ahead in lane~~	~~4.2.5.2.9.~~	~~With different overlap~~	
Pedestrian target crossing into the path of the VUT	4.2.5.2.10.	With different overlap, daylight and night	Both in manual and ADAS driving
~~Bicycle crossing into the path of the VUT~~	~~4.2.5.2.11.~~	~~With different overlap~~	
Pedestrian target crossing into the path of the VUT in an intersection	4.2.5.2.12.	With different overlap,	
Bicycle target crossing into the path of the VUT in an intersection	4.2.5.2.13.	With different overlap	
~~VUT turns across a path of an oncoming vehicle~~	~~4.2.5.2.14.~~	~~With different overlap~~	
VUT crosses the straight path of the vehicle target in an intersection	4.2.5.2.15.	With different overlap	Stop signs may alter the test outcome
Complex traffic situation		**Oncoming, blocked road, braking, platooning and string stability**	**Different targets, configurations, overlap**

Test location



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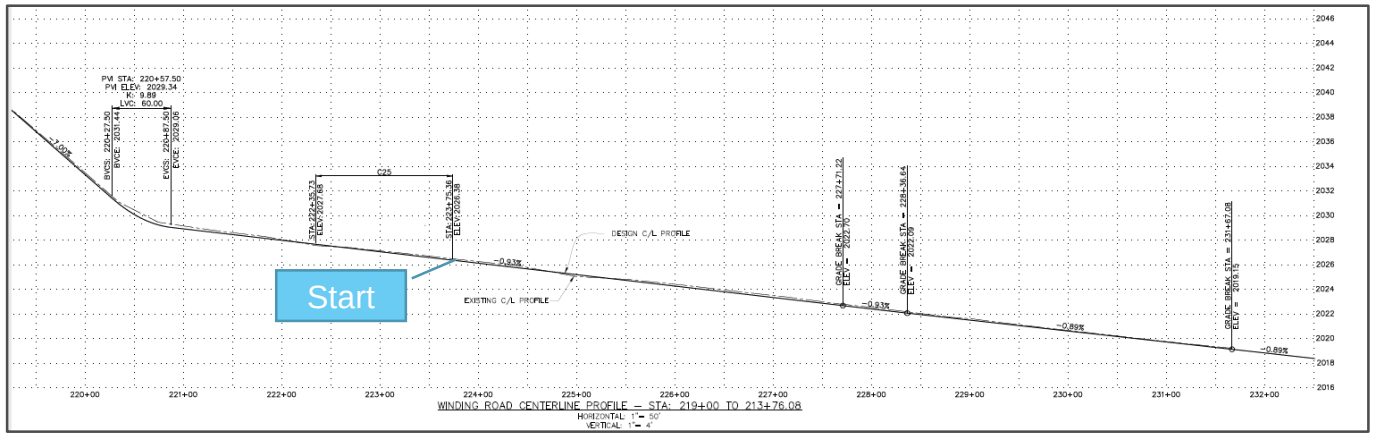

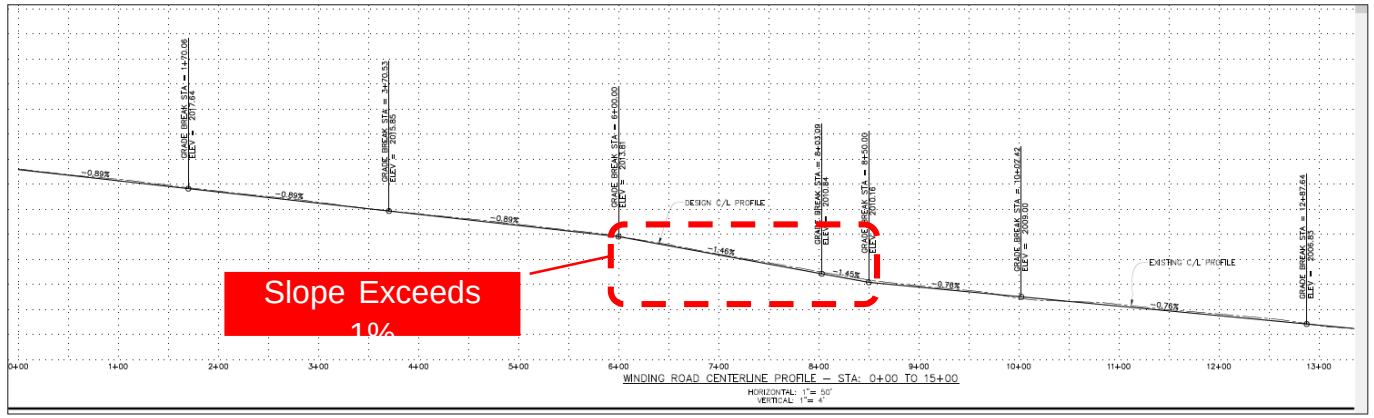

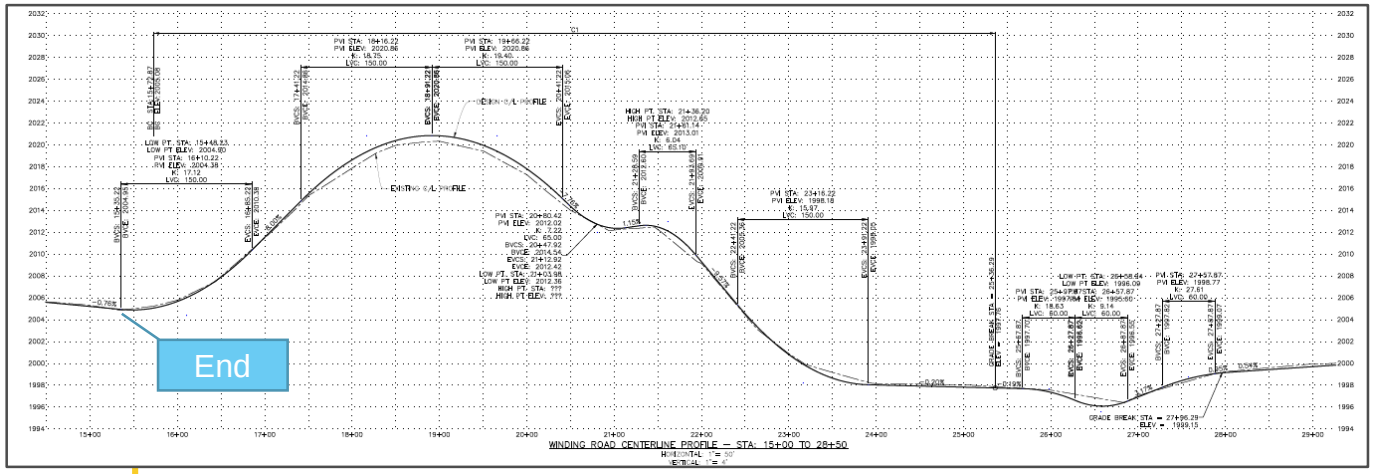

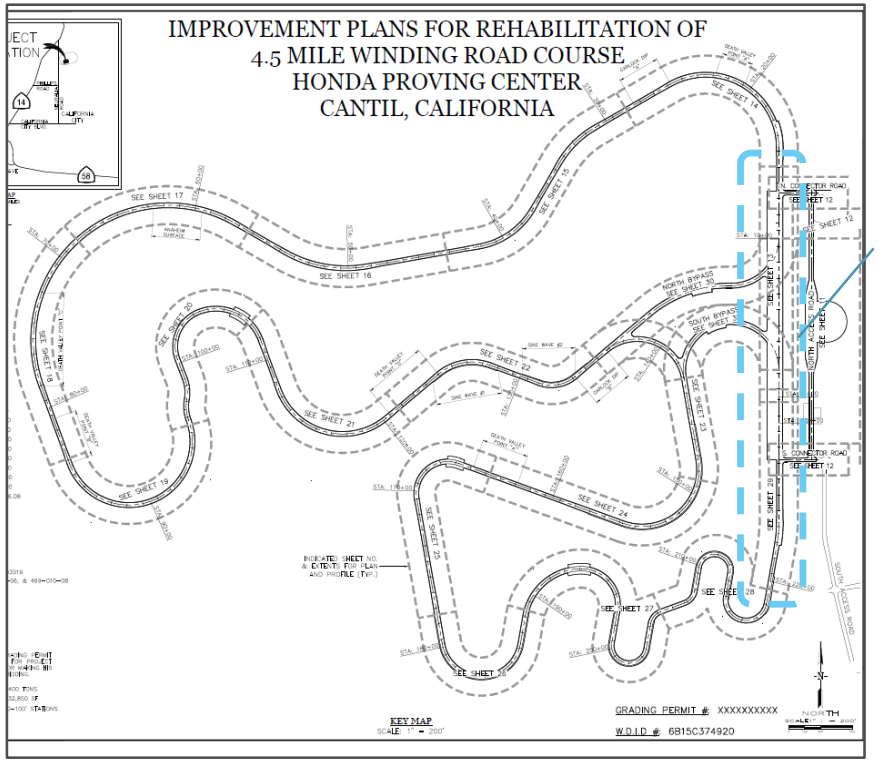

Winding Straight

Winding Straight Length = 2292 Ft / 698.60 M

Segment 1 – Sta 223+75 to 231+67 = 792 Ft / 241.4 M

Grade = -0.89%

Segment 2 – Sta 0+00 to 6+00 = 600 Ft / 182.88 M

Grade = -0.89%

Segment 3 – Sta 6+00 to 8+03 = 203 Ft / 61.87 M

Grade = -1.46%

Segment 4 – Sta 8+03 to 8+50 = 47 Ft / 14.33 M

Grade = -1.45%

Segment 5 – Sta 8+50 to 15+00 = 650 Ft / 198.12

Grade = -0.76%

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Preliminary results

- Stationary vehicle ahead on a straight section of road (4.2.5.2.1.)

Driving modes:

- Manual driving = Driver controls both lateral and longitudinal direction with active safety (e.g. AEB) activated
- ADAS: highest level of L2 system is activated
- ACC: Driver lateral and system (ACC) longitudinal control

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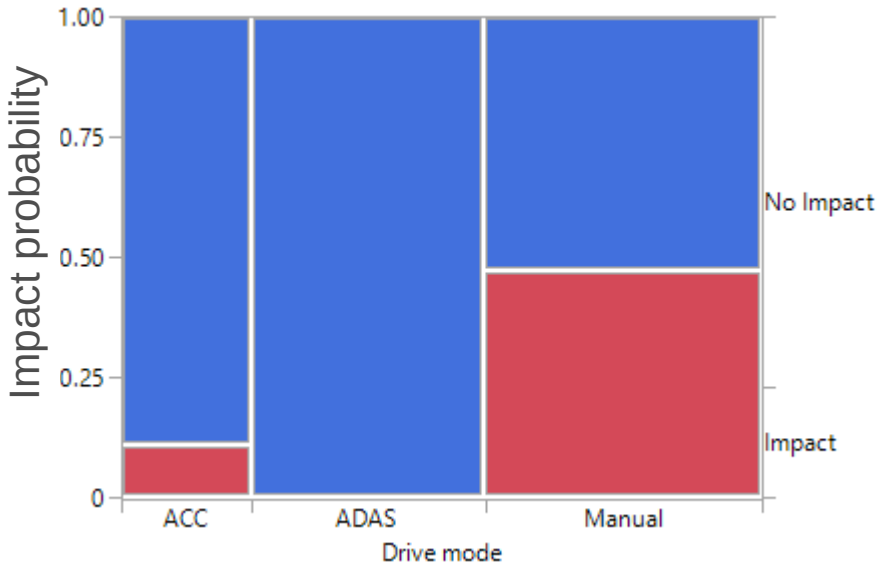
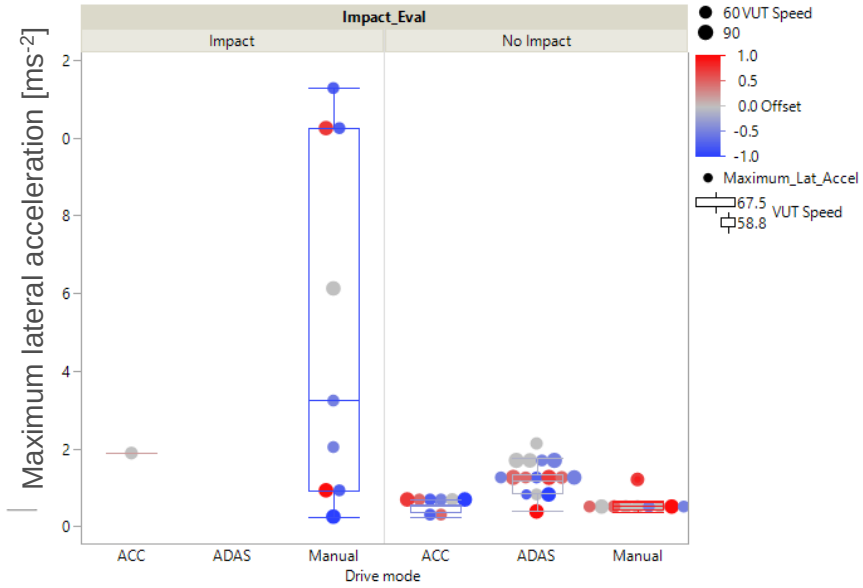
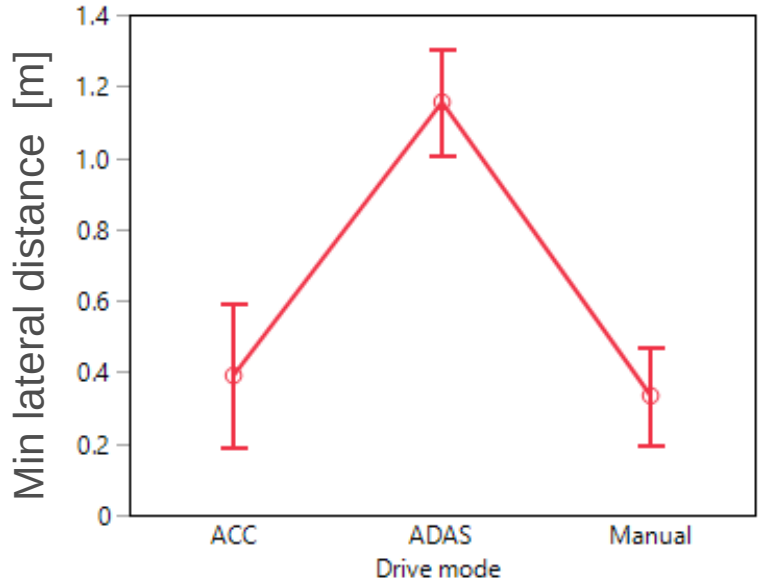
General test result – SILC (Vehicle 1)







- Probability of impact was significantly lower with assisted driving
- SILC kept longer longitudinal distance and lower lateral acceleration

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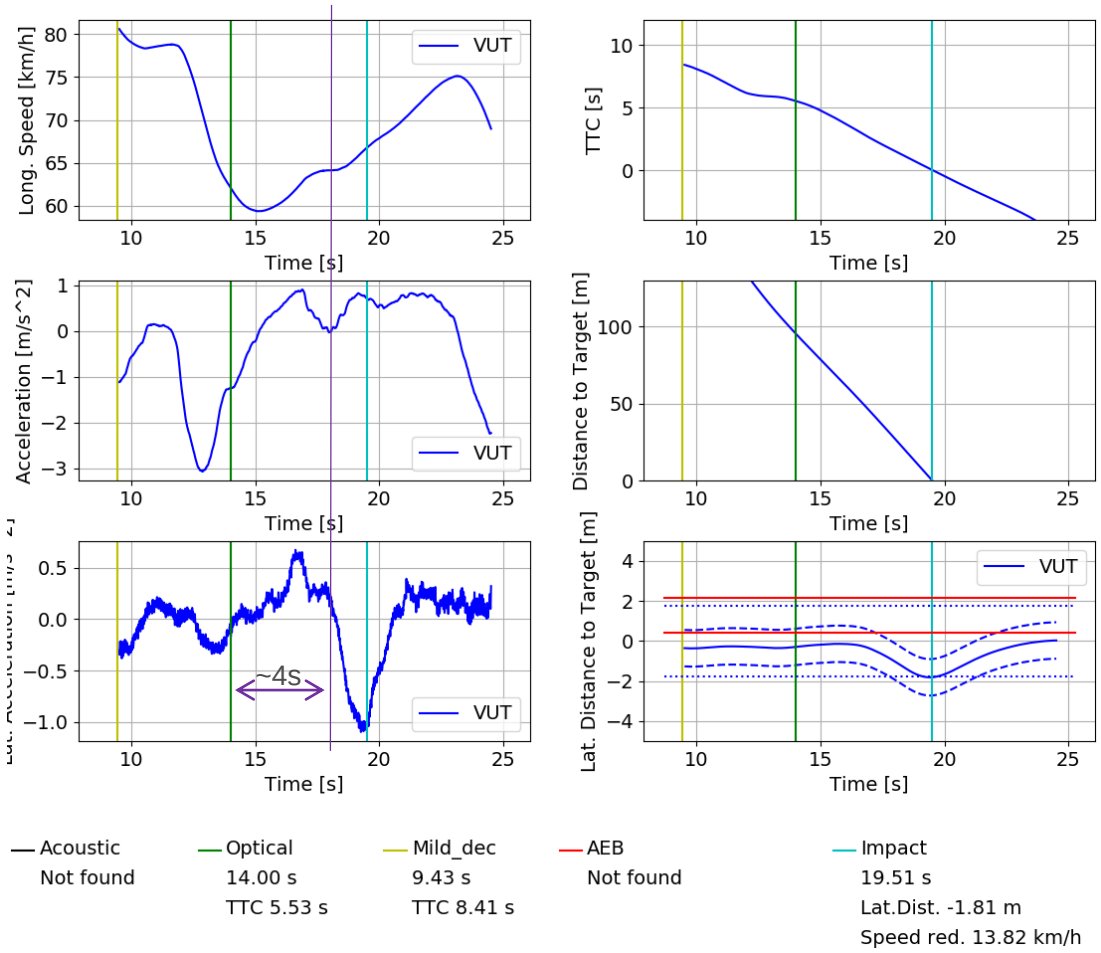
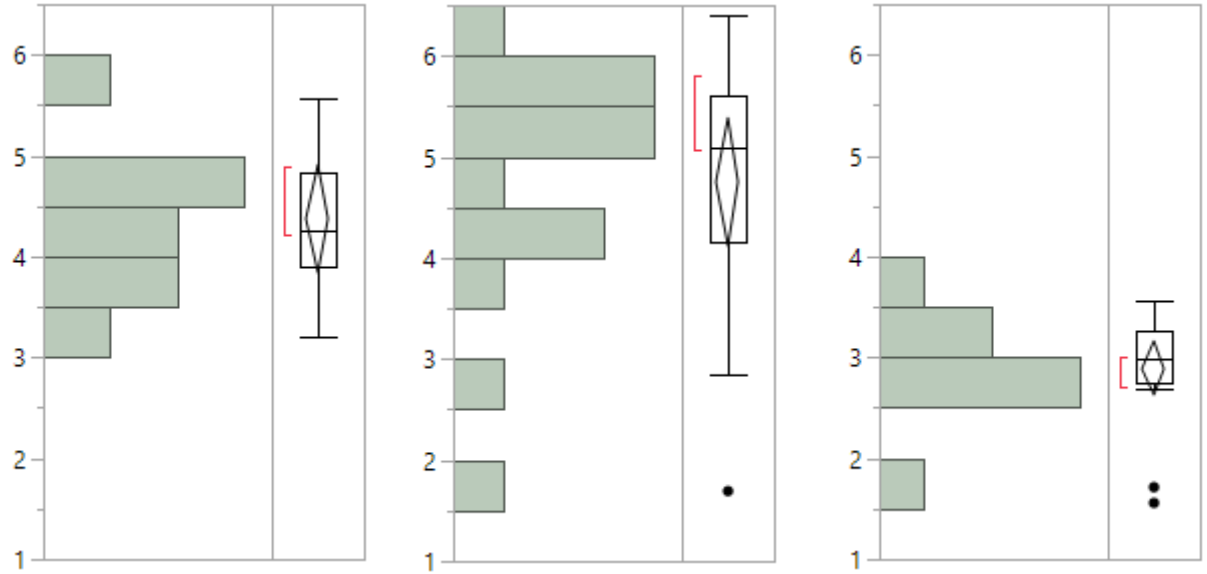
Assessment of warning times



Optical warning/indication time distribution



- Can the driver confirm the maneuvers? What to do if not or too late?
- What happens after the confirmation?

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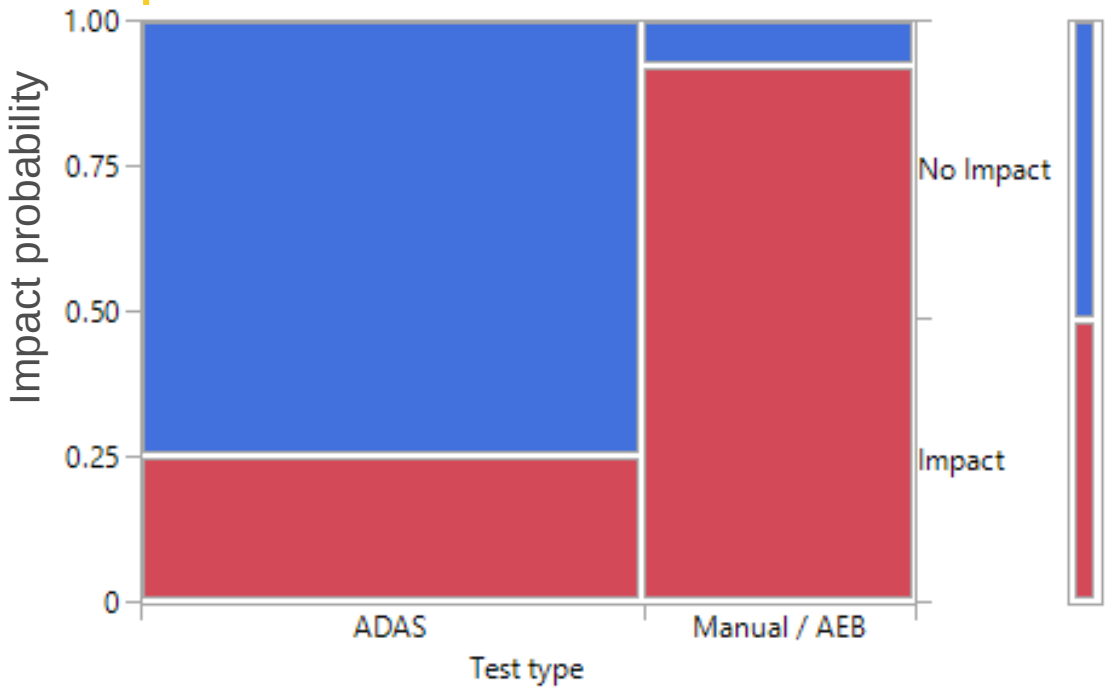
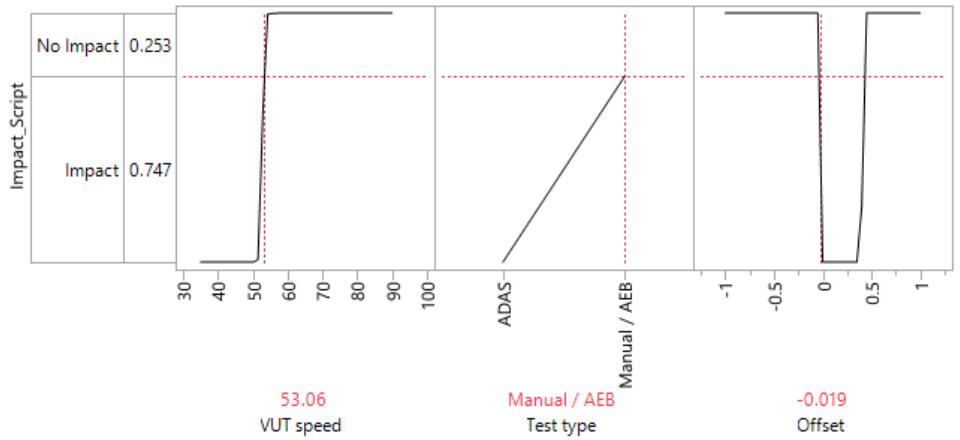
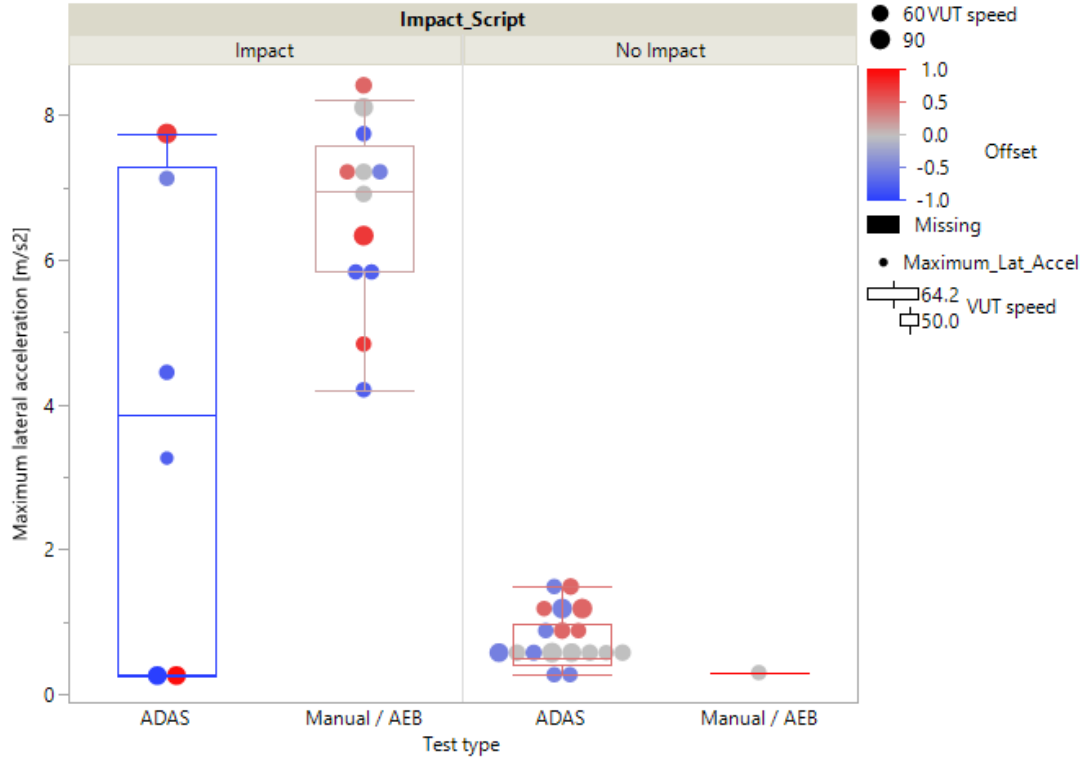
General test results - no SILC (Vehicle 2)







- Probability of impact is higher at smaller offset especially for manual driving
- During avoidance higher lateral acceleration is needed to avoid in the last minute

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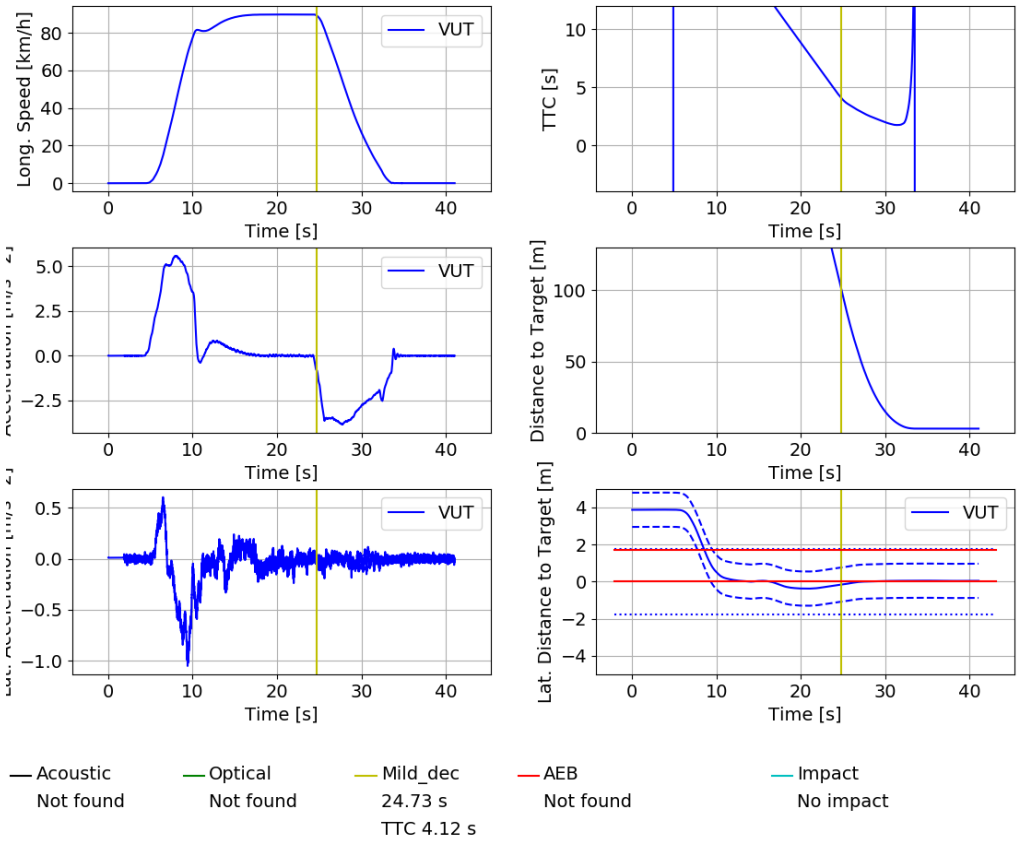
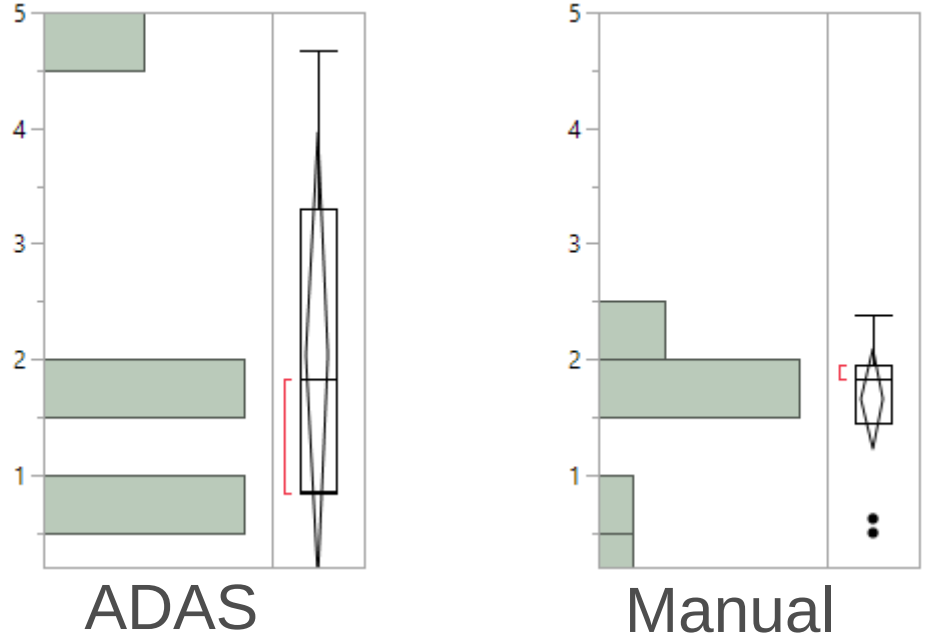
Assessment of warning times



Optical warning/indication time distribution



- The time of moving the hands back needs to be taken into account
- No warning or indication was shown when the system avoided the impact

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Preliminary results

- Stationary vehicle ahead on a **curved** section of road (4.2.5.2.2.)

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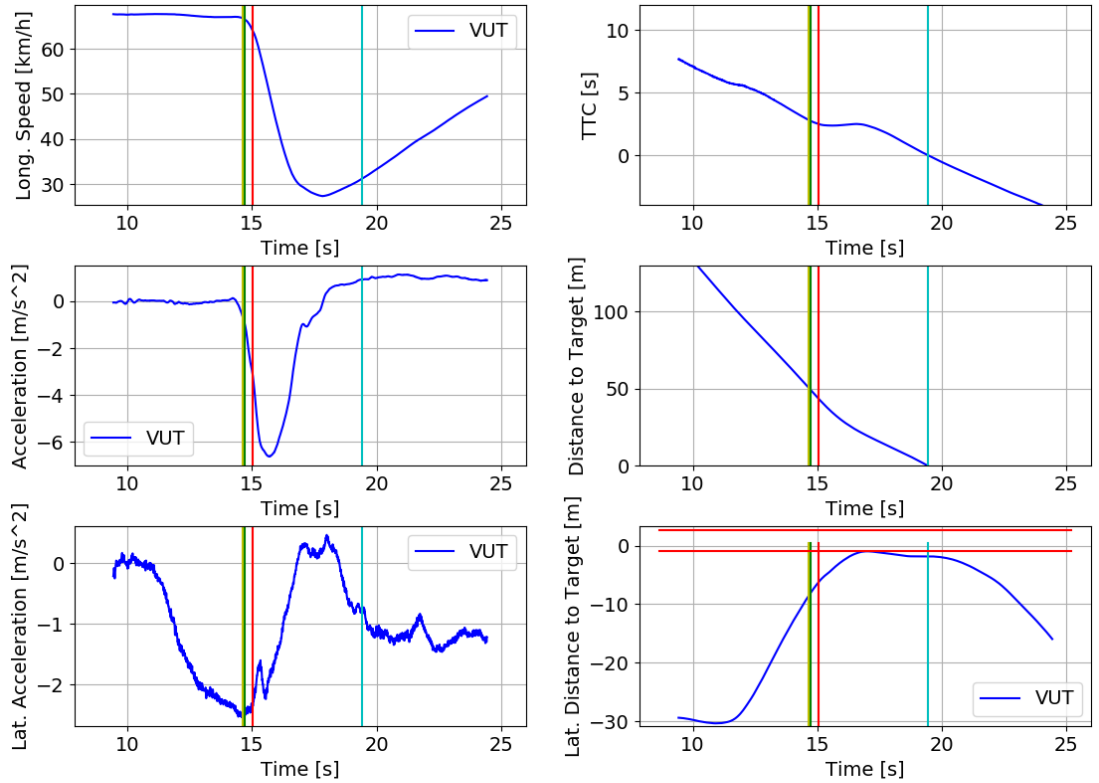
With SILC



Acoustic	Optical	Mild_dec	AEB	Impact
Not found	14.71 s	14.63 s	15.03 s	19.43 s
	TTC 2.75 s	TTC 2.83 s	TTC 2.50 s	Lat.Dist. -1.82 m
	AEB 0.32 s	AEB 0.40 s	Speed red. 2.72 km/h	Speed red. 35.41 km/h

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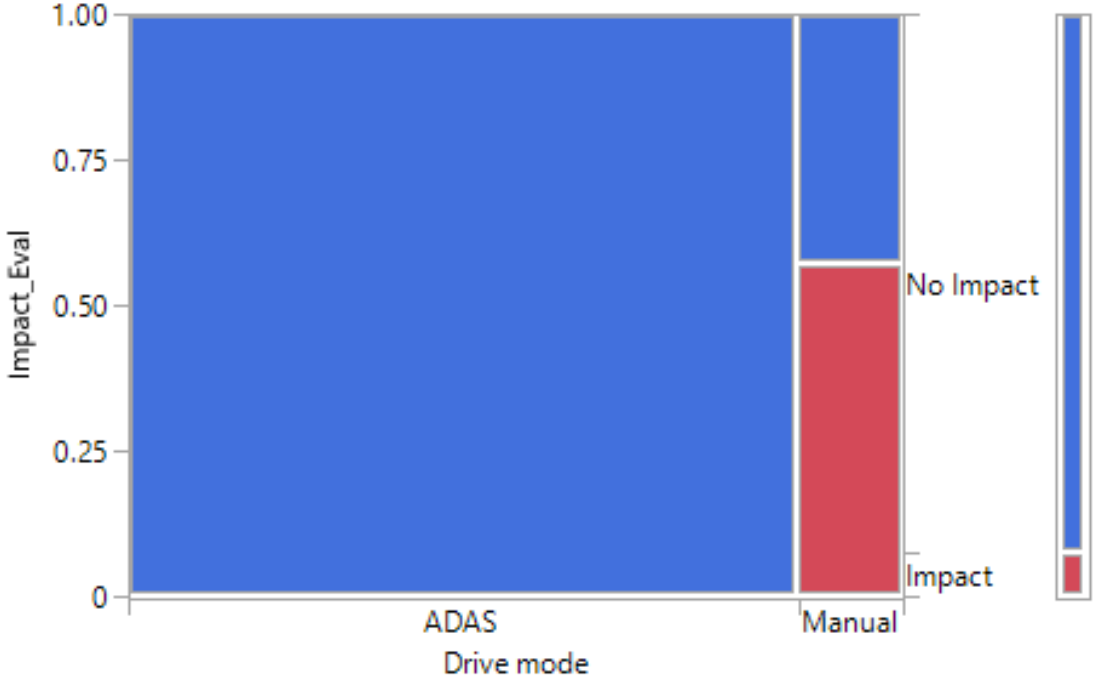
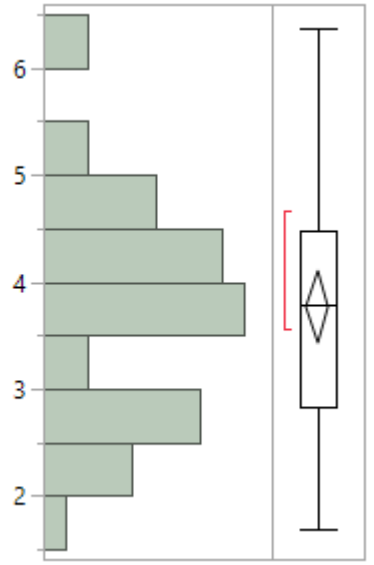
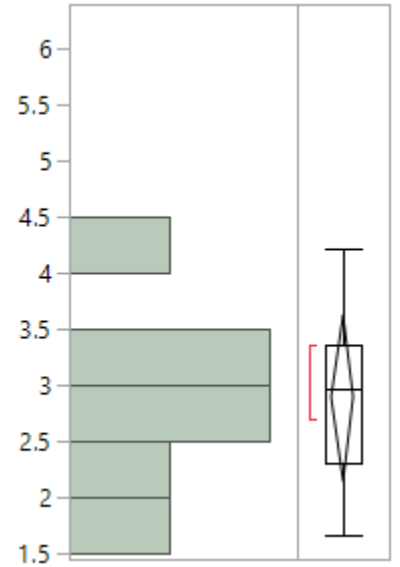
General description (Vehicle 1)

Optical warning/indication time distribution





ADAS



Manual

- Depending on the scenario the time gap for reaction can decrease

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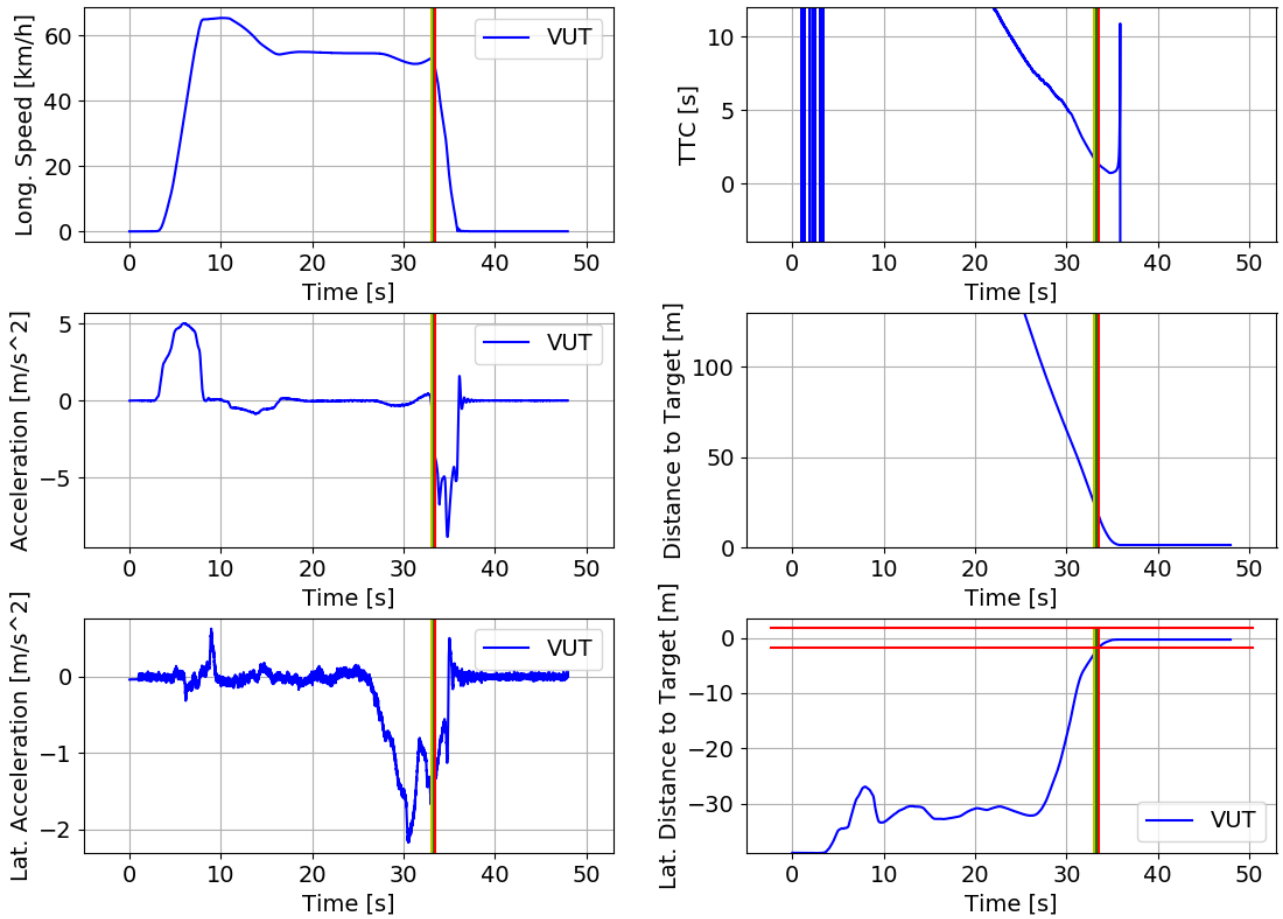
Without SILC



Acoustic	Optical	Mild_dec	AEB	Impact
33.28 s	33.29 s	33.08 s	33.49 s	No impact
TTC 1.47 s	TTC 1.46 s	TTC 1.65 s	TTC 1.32 s	
AEB 0.22 s	AEB 0.20 s	AEB 0.41 s	Speed red. 3.40 km/h	

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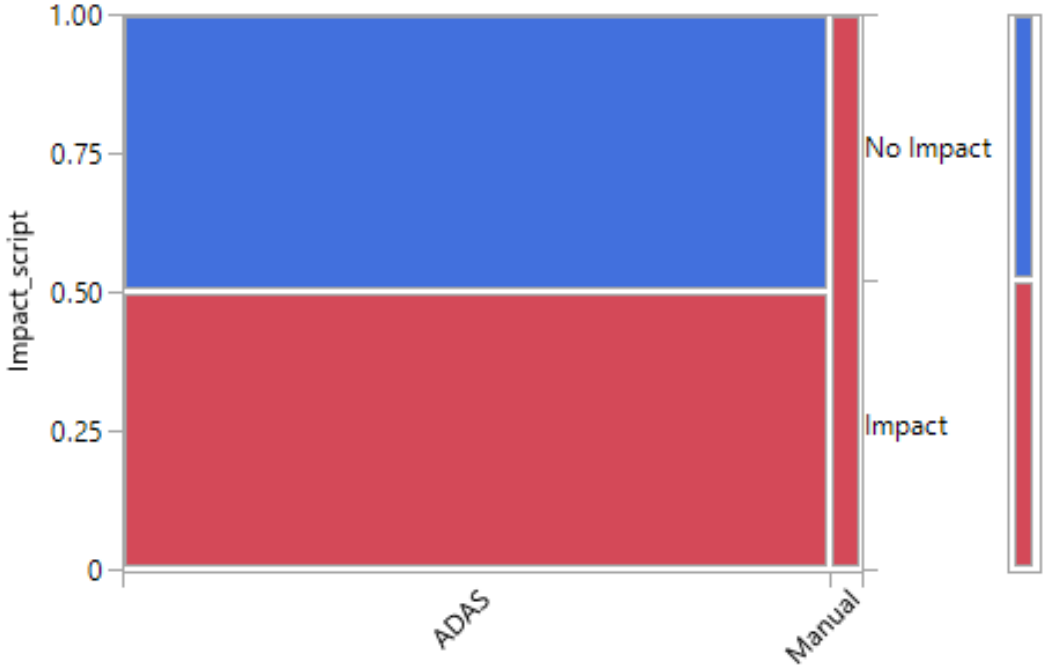
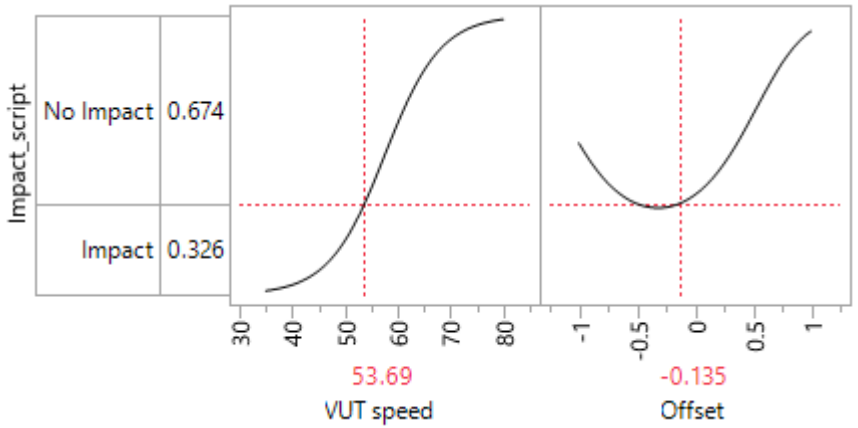
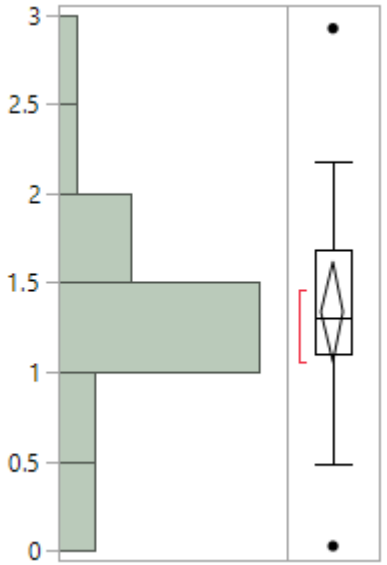
General results (Vehicle 2)

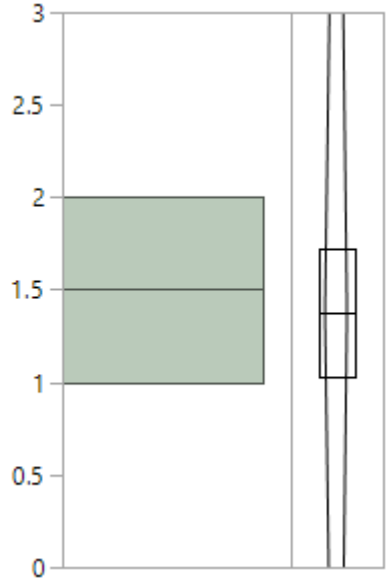




Optical warning/indication time distribution



ADAS



Manual

- Small overlap is a main cause of impacts

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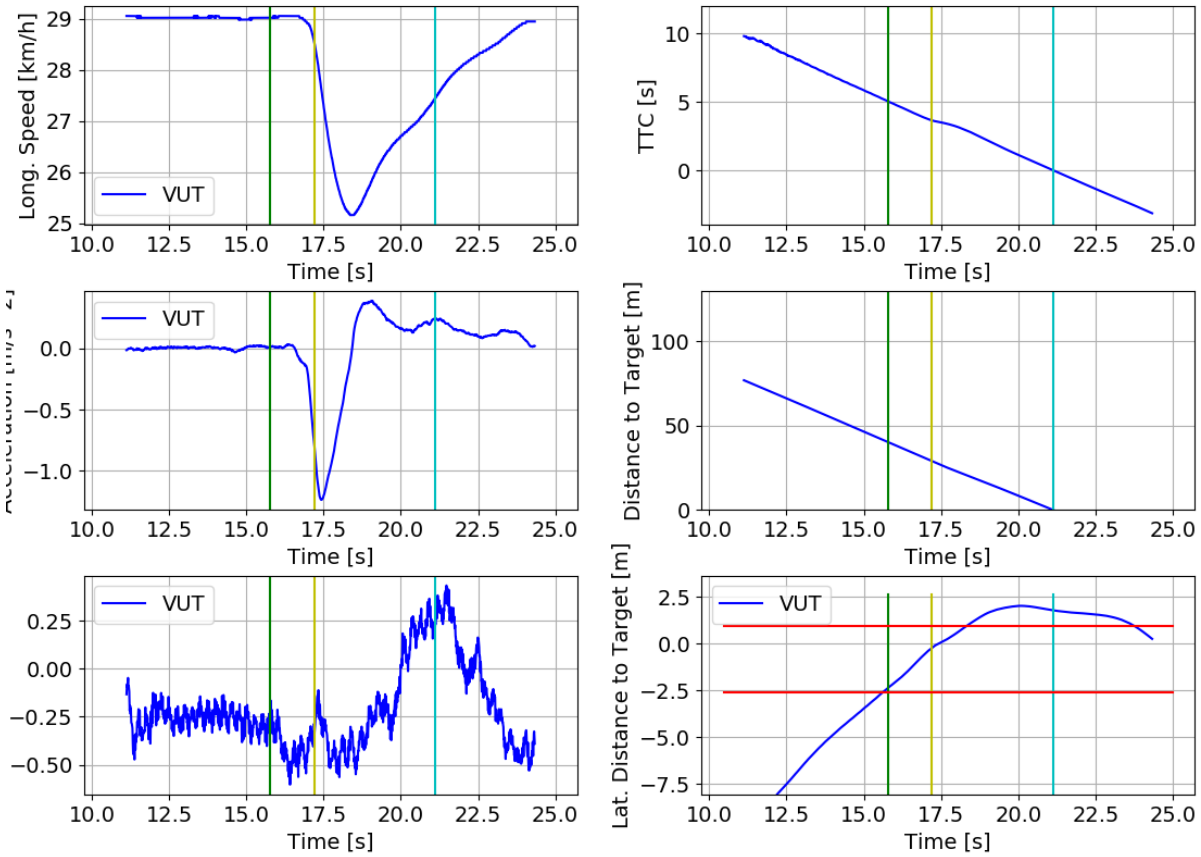
Oncoming traffic



Acoustic
Not found

Optical
15.78 s
TTC 5.05 s

Mild_dec
17.19 s
TTC 3.65 s

AEB
Not found

Impact
21.12 s
Lat.Dist. 1.78 m
Speed red. 1.55 km/h

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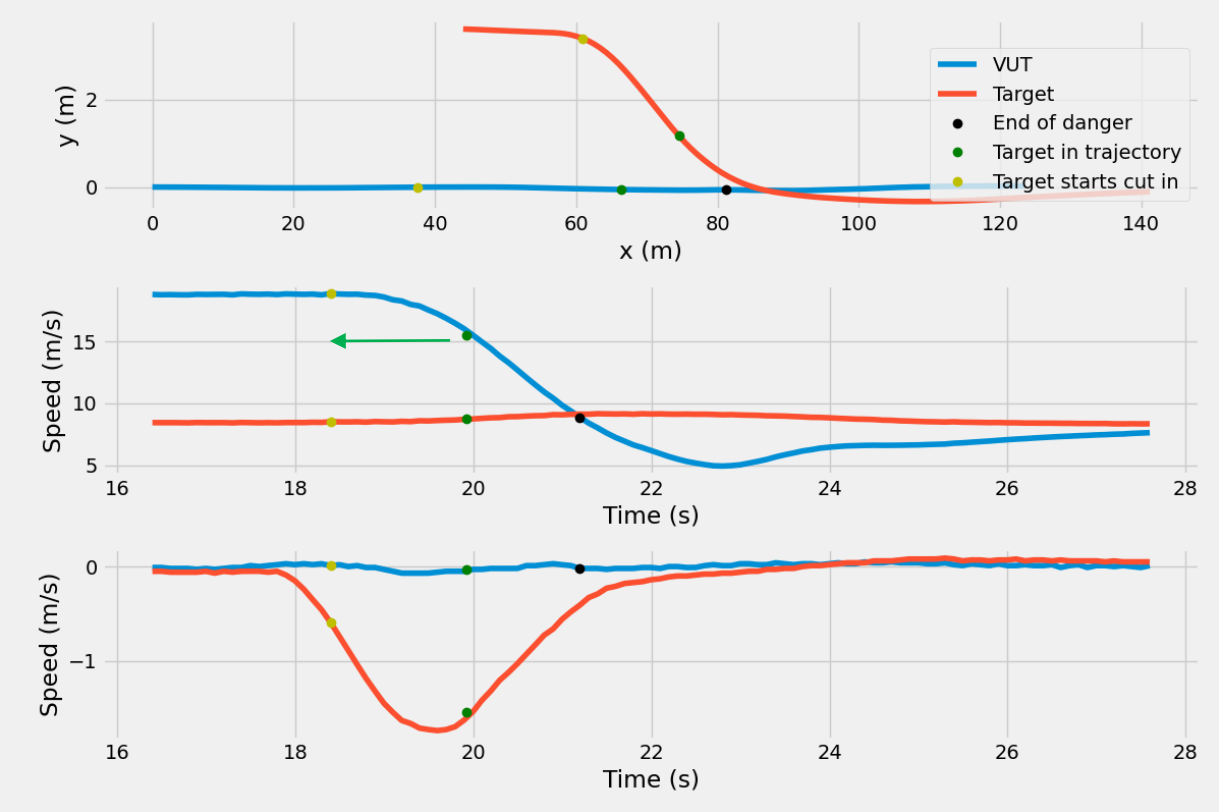
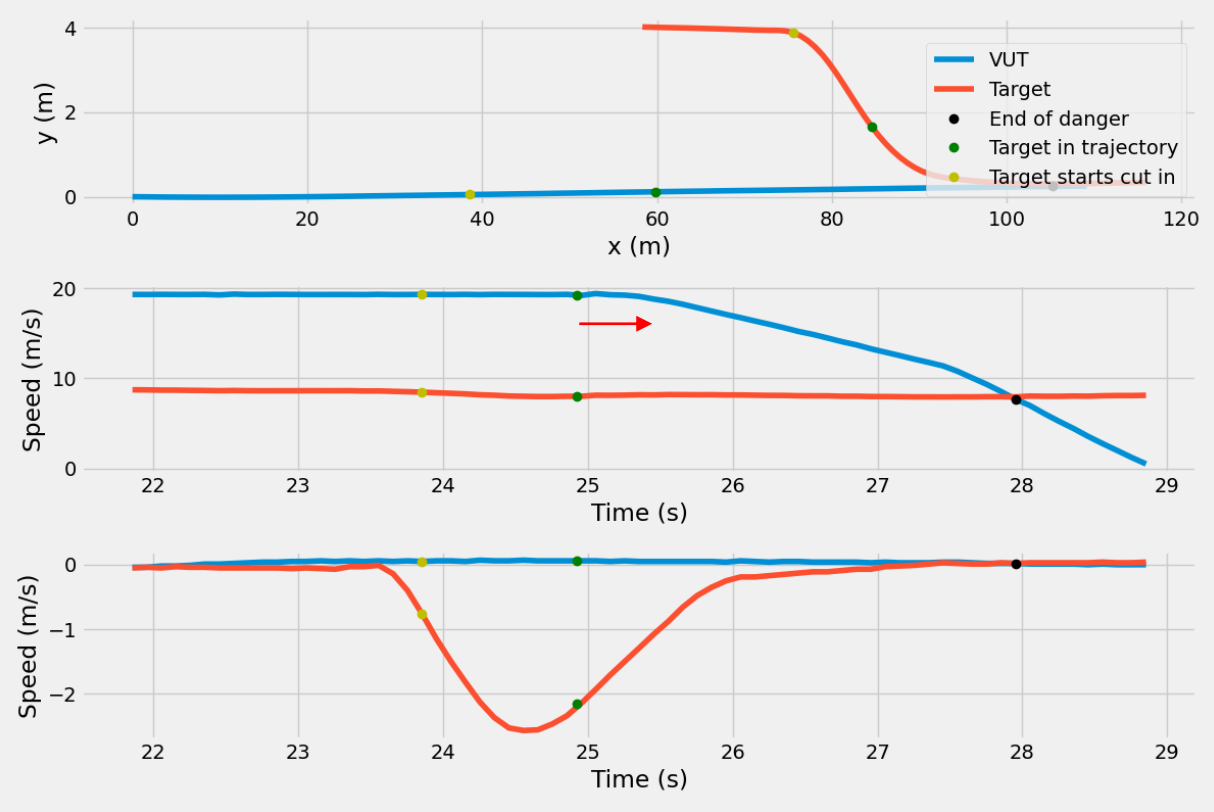
Preliminary results Cut-in (4.2.5.2.6)





- Anticipation is a key to avoid impact!
- Very little time or no time may be available to move the hands back and react

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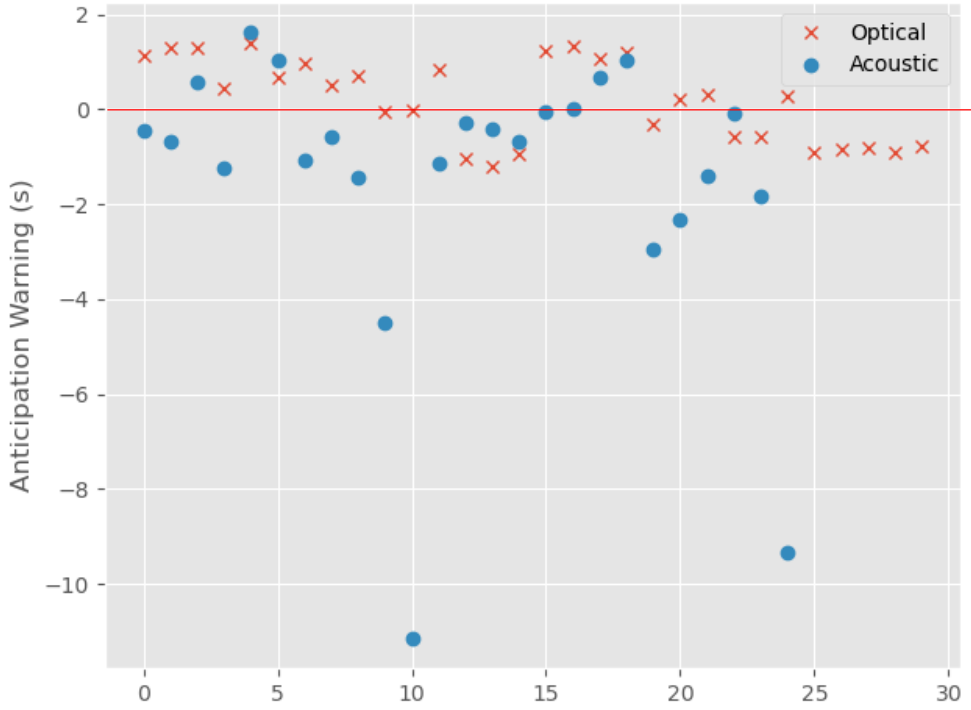
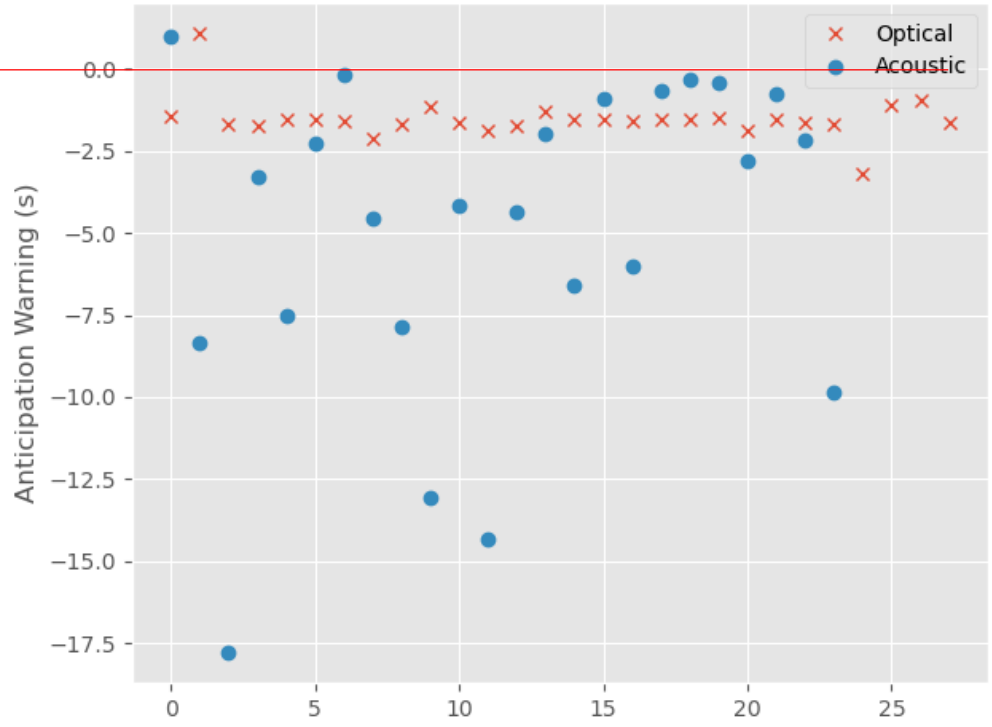
Warning times during cut in



Positive: anticipatory
Negative: late warning



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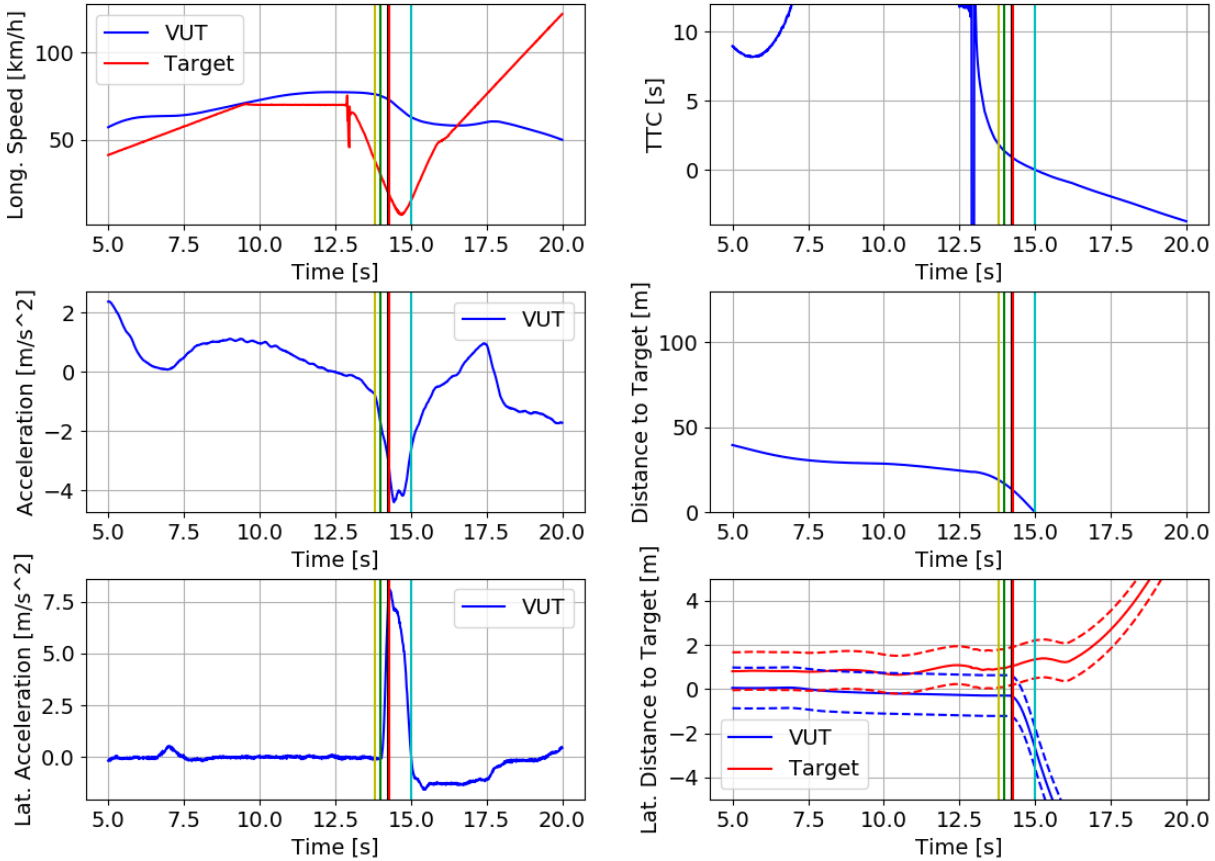
Lead vehicle brakes at 6m/s^2



Acoustic	Optical	Mild_dec	AEB	Impact
14.23 s	13.98 s	13.79 s	14.28 s	14.99 s
TTC 0.91 s	TTC 1.36 s	TTC 1.82 s	TTC 0.83 s	Lat.Dist. -2.66 m
AEB 0.05 s	AEB 0.30 s	AEB 0.49 s	Speed red. 3.29 km/h	Speed red. 13.03 km/h

- No chance for the driver to avoid the accident
- Further measures are needed regarding controllability
- Mandatory test for EOW in the while range of the operating speed (i.e. upto 130 km/h)

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Discussion

- Higher level assistance given to the driver resulted in lower level of risk of impact on proving ground tests
  - The tested L2 vehicles have better safety performance than an L1 vehicle (R79/L1)
  - More capable systems may avoid critical situation rather than to wait for the last moment of intervention – limitation of active safety systems?
  - **No evidence is found to limit the level of assistance to the driver**
- Does the driver have enough time to react?
  - Earlier indication of maneuvers was observed for SLIC but the available times depends on the traffic situation. Time is not always enough time for decision and confirmation
  - In some scenarios (cut-in, braking) there is no or very little time exists for the driver to react (especially in EOW driving) -> system needs to have the capability to mitigate or avoid impact.

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Thank you

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