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# AEB Car-Car and Pedestrian: Last Point To Steer For Various Cars and Speeds

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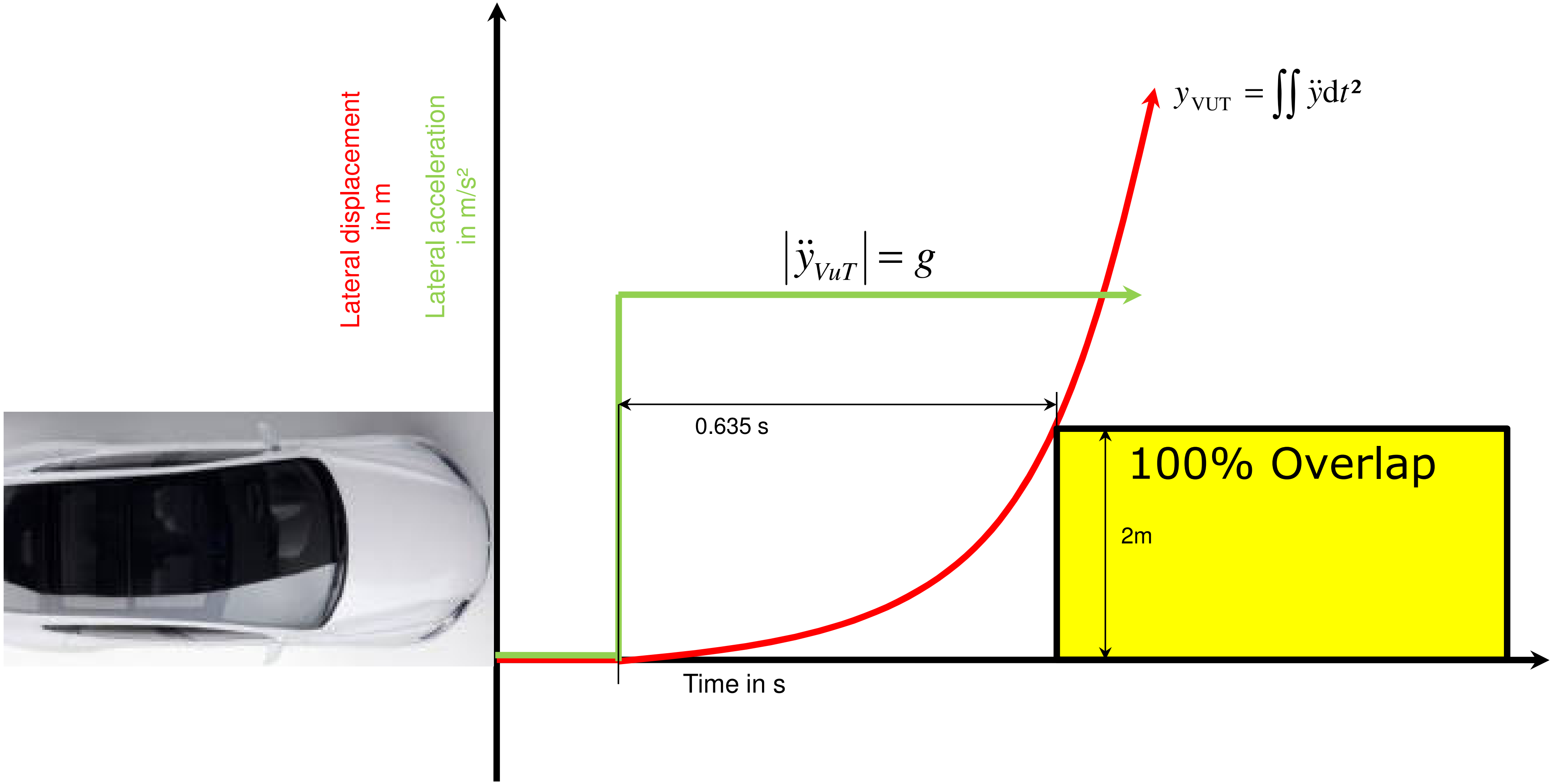
# Recap: Last Point to Steer (Theory)



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# Goals and Methodology

- Car-Car AEB: Automatic braking is justified at the latest when avoidance by steering is not possible
  - Last Point To Steer (highly dependend on speed)
  - Last Time To Steer (in theory independent from speed)
- Goal: Identify last time to steer
  - As function of driving speed (is it really independent?)
  - As function of vehicle
- Subjective Tests
  - Cars instrumented with DGPS only
  - VW Passat 2011 (20, 30, 40, 50 km/h)
  - Mercedes GLC 2017 (50 km/h)
  - Alfa Romeo Mito 2010 (50 km/h)
  - All tests performed by drivers with ATP License B
- Additional Objective Tests
  - Fully instrumented driving robot in Mercedes GLC 2017
  - Programmed lane change
  - Measurement of steering and tire response time

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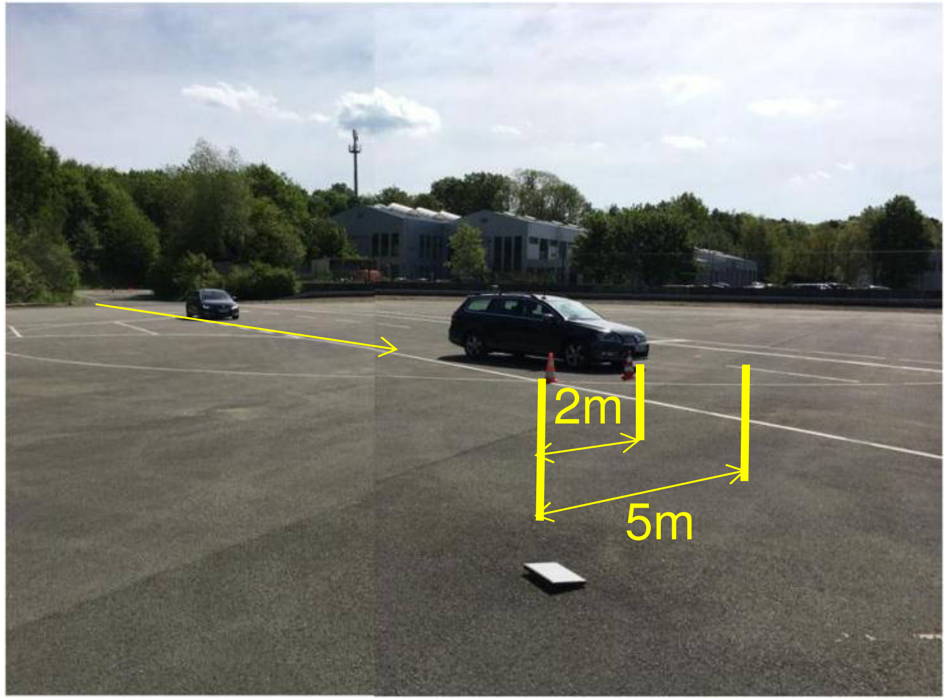
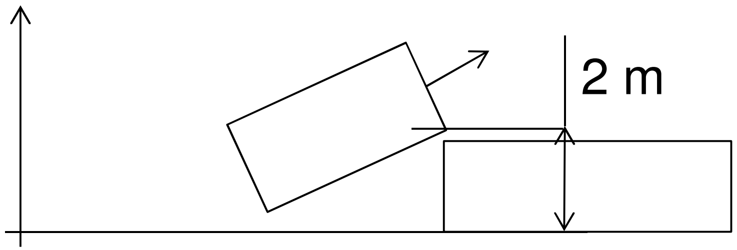
# Subjective Tests - Concept

- Task: full lane change as quick as possible
- Lane change width 2 m
- preferably with overshoot less than 3 m (of reference)
- Manual speed control (CC if possible)
- Reference point: front right corner of car

- Result: Time needed to reach a lateral shift of 2m for the front right corner (NOT for whole car!)



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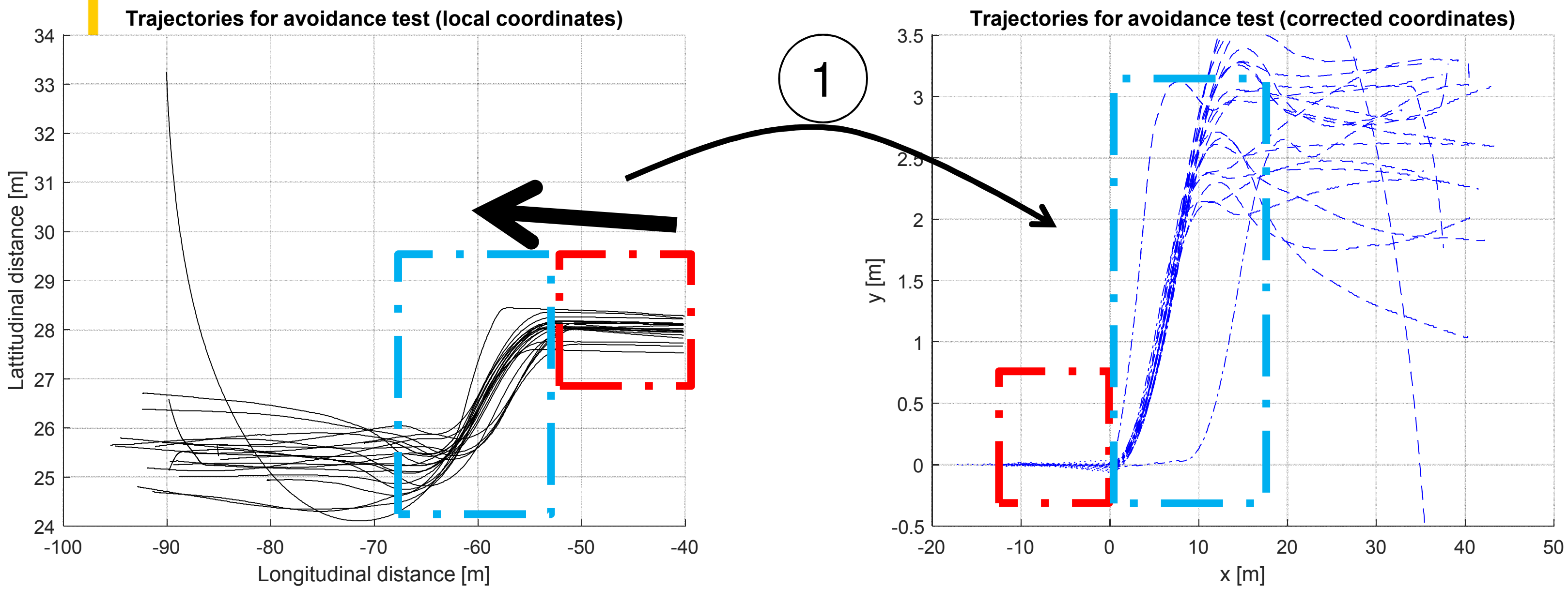
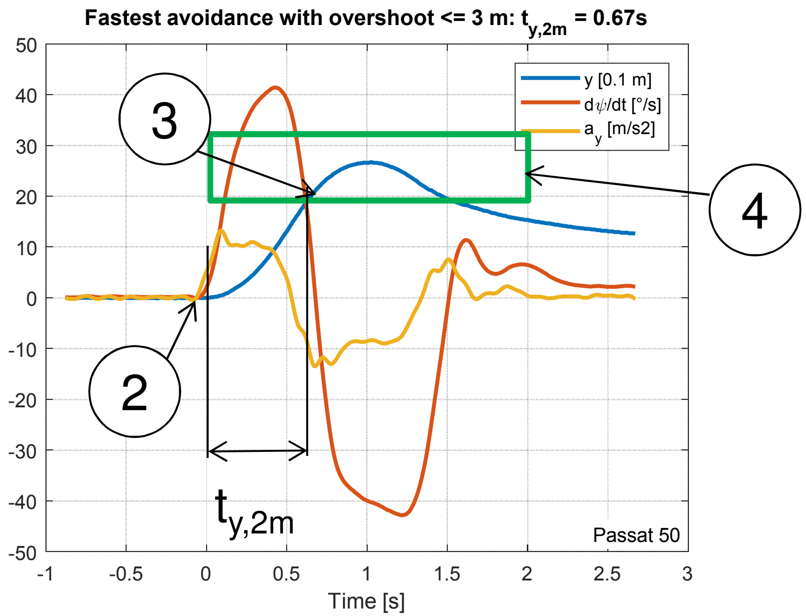
# Subjective Tests – Evaluation




Step 1: Align approach phase (red), turn coordinates

Step 2: Check when yaw rate crosses 1°/s for the first time

Step 3: Check when y crosses 2 m for the first time

Step 4: Check if lateral position within 2 s is > 3 m

Final: $t_{y,2m}$

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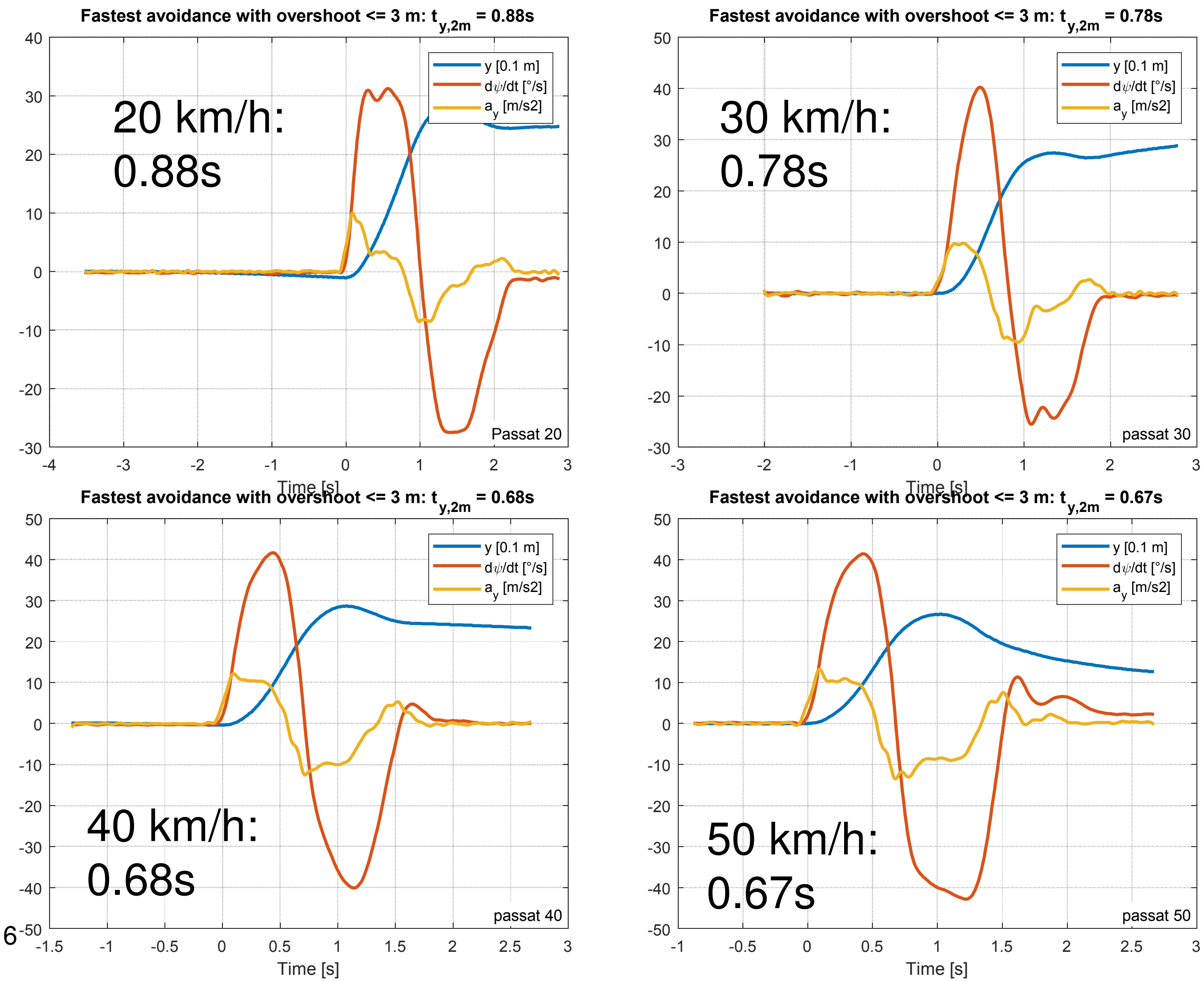
# Results – VW Passat 2011



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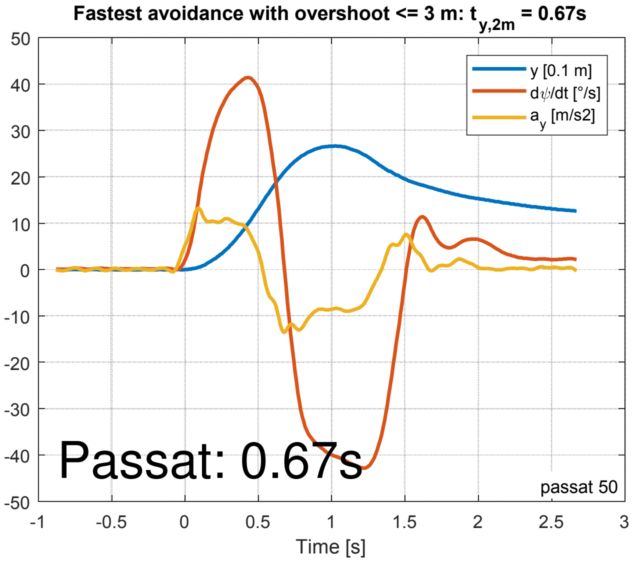
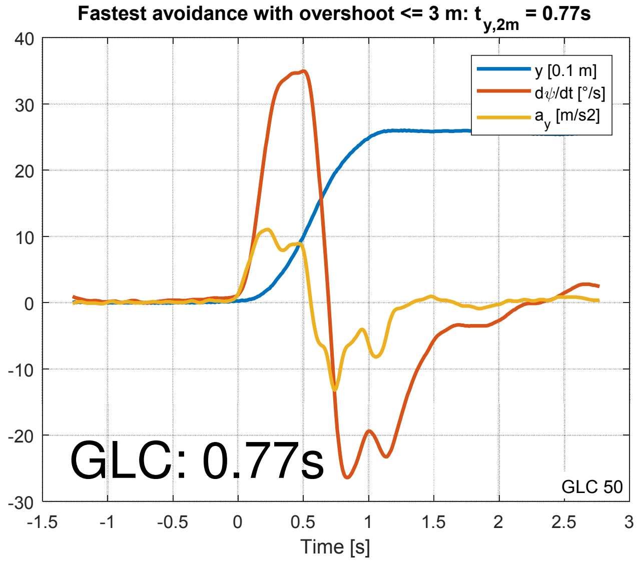
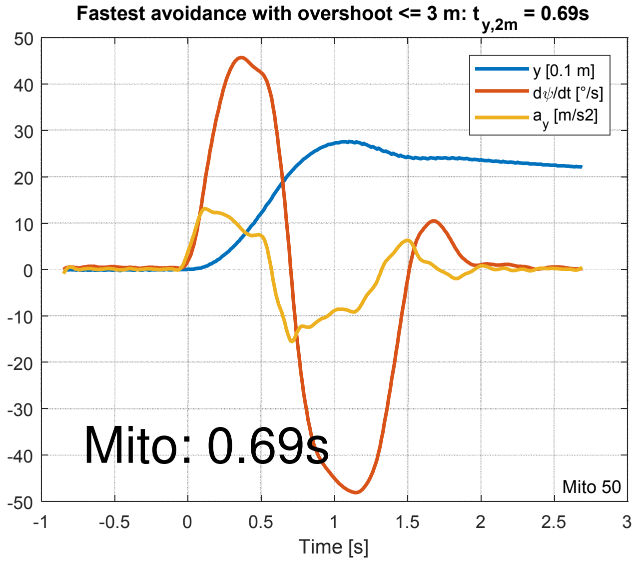
# Results – Different Cars at 50 km/h



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# Results – Subjective Tests

- Last time to steer decreases slightly with speed
- Last time to steer seems to increase with vehicle mass
- Subjective Tests only give results from yaw rate = 1°/s
- Response from 1° steering angle to 1°/s yaw from objective tests
- Theoretical level (10 m/s², 2m) is never reached

| | Last time to steer | | | | Last distance to steer | | | |
|---|---|---|---|---|---|---|---|---|
| | **Passat** | **GLC** | **Mito** | **Theory** | **Passat** | **GLC** | **Mito** | **Theory** |
| 20 km/h | 0.88 s | - | - | 0.63 s | 4.89 m | - | - | 3.5 m |
| 30 km/h | 0.78 s | - | - | 0.63 s | 6.5 m | - | - | 5.25 m |
| 40 km/h | 0.68 s | - | - | 0.63 s | 7.56 m | - | - | 7 m |
| 50 km/h | 0.67 s | 0.77 s | 0.69 s | 0.63 s | 9.31 m | 10.69m | 9.58 m | 8.75 m |

**Table does not include response time!**

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# Objective Tests

Task: Robot programmed for lane change maneuver 0.9/1.0/1.1 s
Lane change width: 2m
Robot peak torque: 15 Nm
*(ABD SR15+CBAR Robot System)*

Evaluation:
<u>Steering Rate > 10°/s → y > 2m (new)</u>



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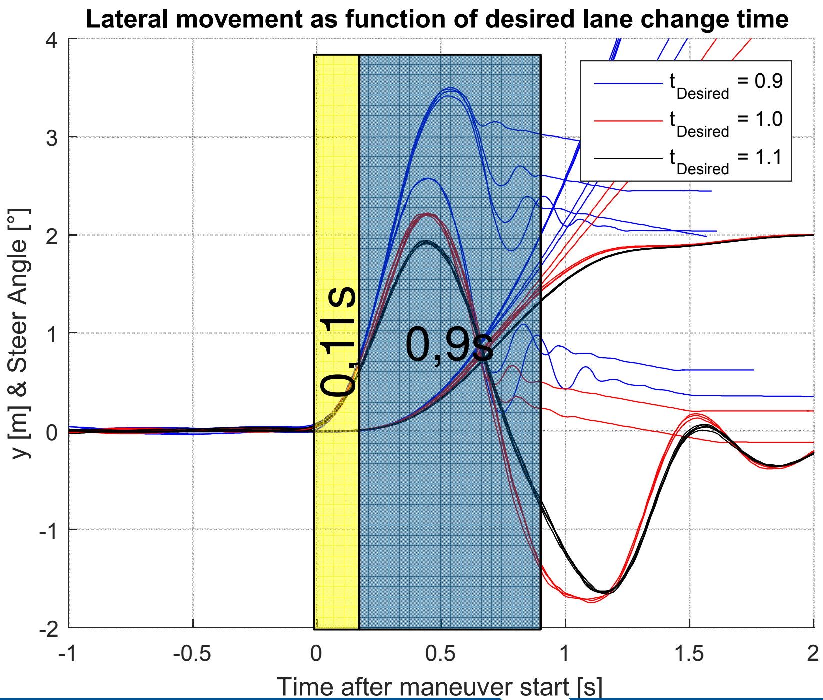
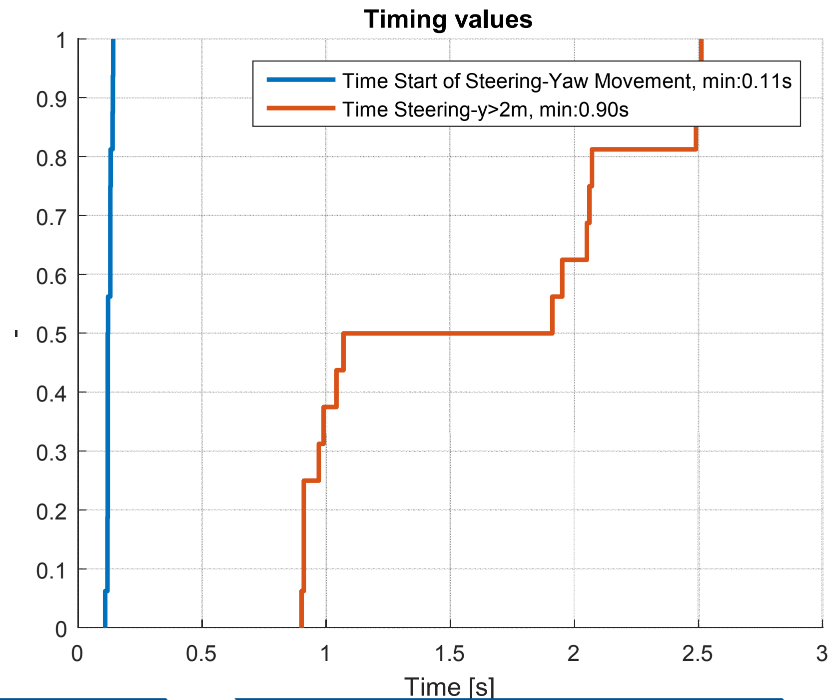
# Results – Objective Tests




Steering Input

Yaw rate response **(>0,11s)**

Lateral shift (0,79s Robot) (0,68/**0,77s** Human)



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# Results and Discussion – Last Time To Steer

- The following values have been identified as limits for last point to steer for various speeds and cars

| | Last time to steer | | | | Last distance to steer | | | |
|---|---|---|---|---|---|---|---|---|
| | Passat | GLC | Mito | Theory | Passat | GLC | Mito | Theory |
| 20 km/h | 0.99 s | - | - | 0.74 s | 5.5 m | - | - | 4.11 m |
| 30 km/h | 0.89 s | - | - | 0.74 s | 7.42 m | - | - | 6.17 m |
| 40 km/h | 0.79 s | - | - | 0.74 s | 8.78 m | - | - | 8.22 m |
| 50 km/h | 0.78 s | 0.88 s | 0.8 s | 0.74 s | 10.83m | 12.22m | 11.11 m | 10.28m |

**Table does include 0.11s response time!**

- These limits have been measured as „best case“ for trained drivers
- Judge for yourselves whether these values are representative for “planned behavior” in regular traffic situations:

# Videos

passat_20_088.MP4

passat_30_078.MP4

passat_40_069.MP4

passat_50_067.MP4

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# German Position wrt Last Point To Steer

- „Last Point To Steer“ avoidance is considered as part of a planned maneuver.

- An AEBS incorporating the „Last Point To Steer“ concept should not require drivers to perform an ermergency avoidance maneuver in order to avoid an accident.

- „Last Point To Steer“ should be kept at a total of 0.9 seconds despite that trained drivers in optimal conditions are able to achieve a full collision avoidance by steering up to a total of 0.78s.

- The resulting requirement of at least avoidance up to 42 km/h (relative speed) should still be maintained.



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# AEBS Pedestrian – Performance Req‘s

- Method to derive performance requirements for AEB-Car: Braking as soon as last point to steer has been passed is acceptable under certain conditions (see previous slide).

- This method is not acceptable for Pedestrian AEBS, since it effectively means that drivers should be given the chance to approach a pedestrian with high speed and steer at the last possible moment, see next slide for a comparison.

- Germany presented the „pedestrian-enters-path“-criterion in AEBS-03-04, which is much more appropriate to describe pedestrian situations. A „first time/point to brake“ can be derived from this method as well.

- Germany proposes to derive necessary speed reductions, also for those speeds where a full avoidance is physically not possible (e.g. higher speeds than the peak avoidance speed).

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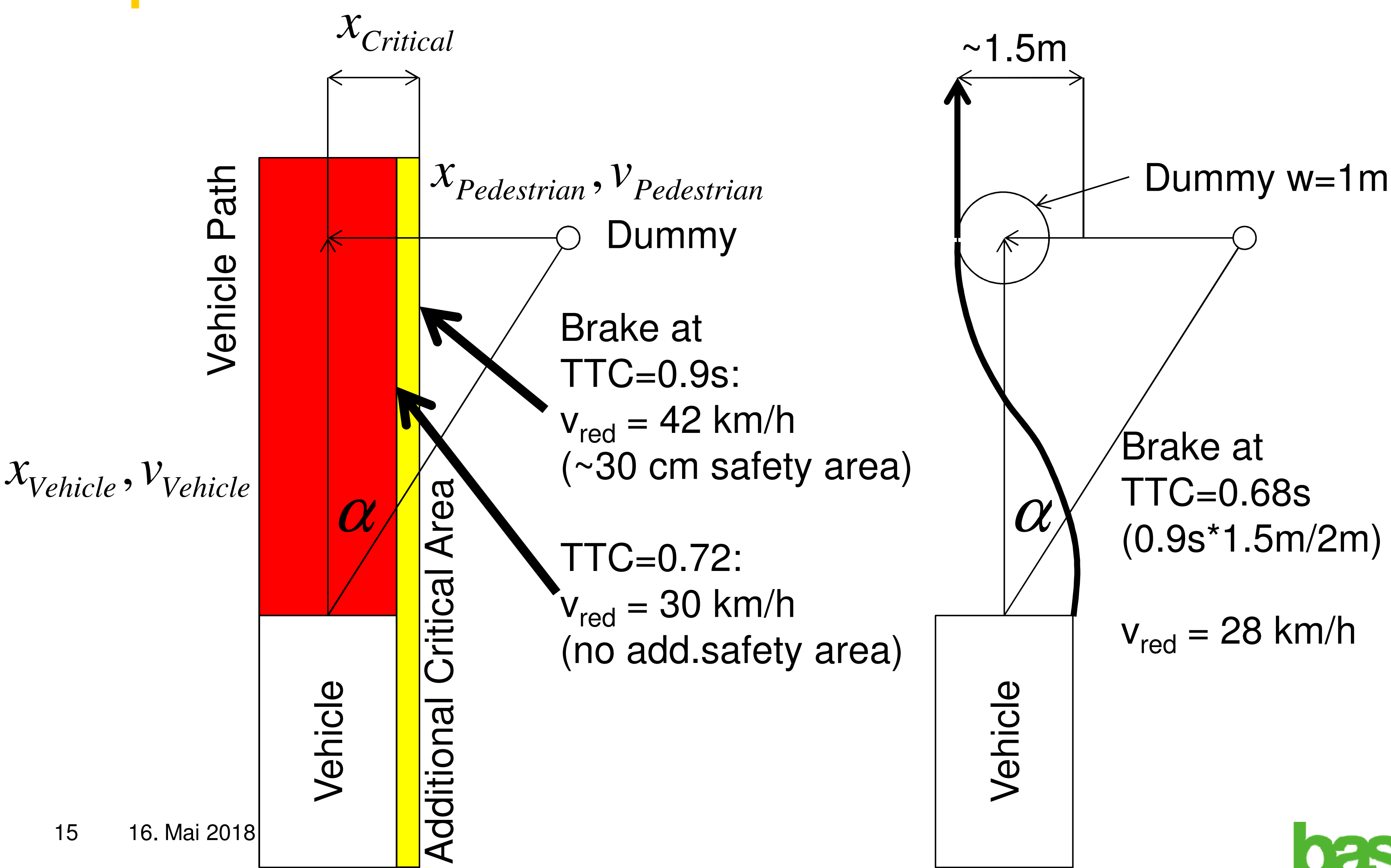
# Comparison: Critical-Area-Approach vs. LPS



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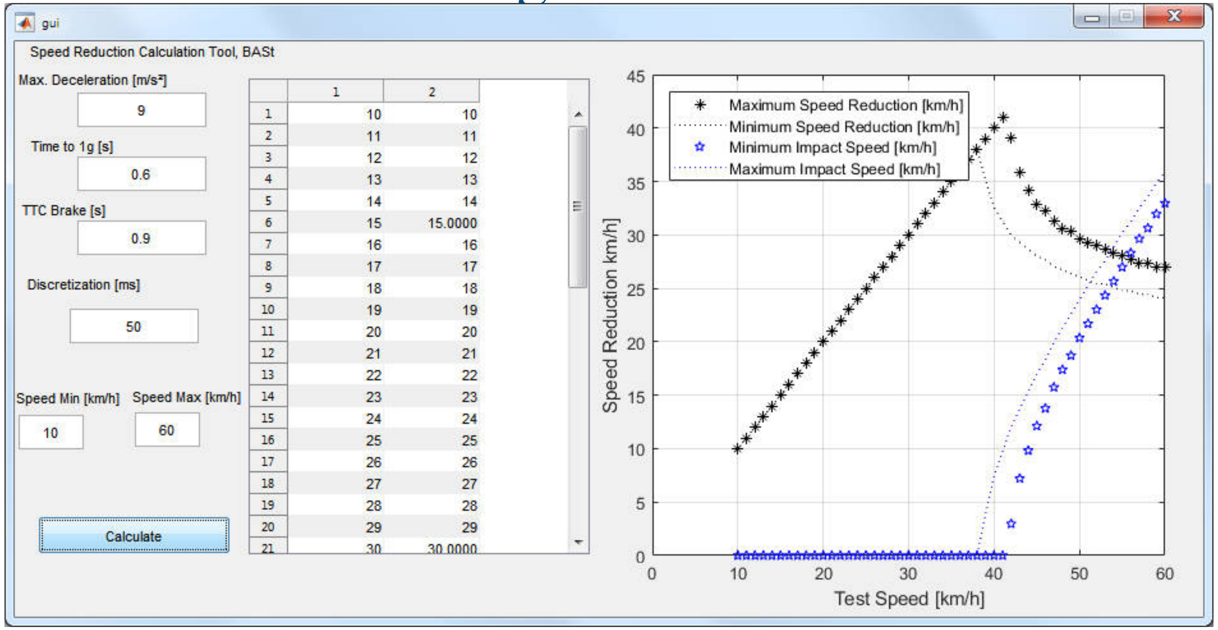
# Speed Reduction Requirements – 0.9 and 0.72s Brake Timing

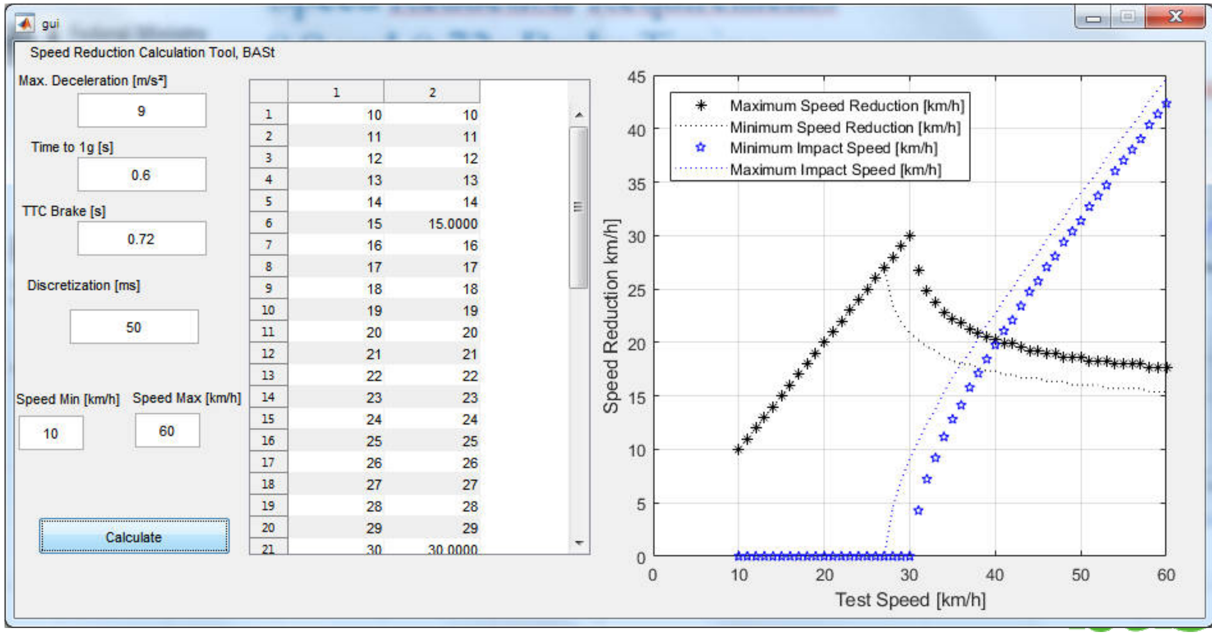
Brake when ped. is 30 cm from path

TTC 0.9s




Brake when ped. enters path

TTC 0.72s



# Deaction of AEBS-M1 – German Position

- Manual deactivation of AEBS function is not acceptable for Germany
- An automatic activation/deactivation in specific situations is acceptable (e.g. those named at AEBS-04)
- However, sensor misalignment should rather be targeted by AEBS self-tests which are – by the state of the art – required for any given safety-critical function at startup!
- AEBS dectivation in offroad use is possible by
  - E.g. evaluating vehicle gearbox and AWD status or
  - E.g. evaluating vehicle chassis status, e.g. largely different wheel displacement at or between axles or …
- Towing with rope and engine running can be detected as prolonged driving in neutral gear with unexplicable wheel speeds
- Dynamometer can be detected by wheel acceleration without body acceleration
- …
- There is no technological need for manual deactivation