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AEB Car-Car and Pedestrian: Achievable Speed Reductions for Legislation 2020+

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Proposed Requirements for AEBS IWG

Proposal : Revision of UNR131(Advanced Emergency Braking System) to establish new requirements of AEBS for M1/N1

Scope
To extend to M1, N1

*Based on test procedures of JNCAP/Euro NCAP

02 series Moving obstacle/Stationary obstacle for M1/N1
Timeline: 2020 for new types of vehicles
2022 for new vehicles
Test procedure*:

Obstacle	Start speed	Requirement
Moving	60 km/h	Avoid impacting a moving target (20km/h)
Stationary	50 km/h	Avoid impacting a stationary target

03 series Pedestrian detection for M1/N1
Timeline: 2024 for new types of vehicles
2026 for new vehicles
Test procedure*:

Obstacle	Start speed	Requirement
Moving	50 km/h	Avoid impacting a cross-moving target (5km/h)

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Basics – Achievable Speed Reductions

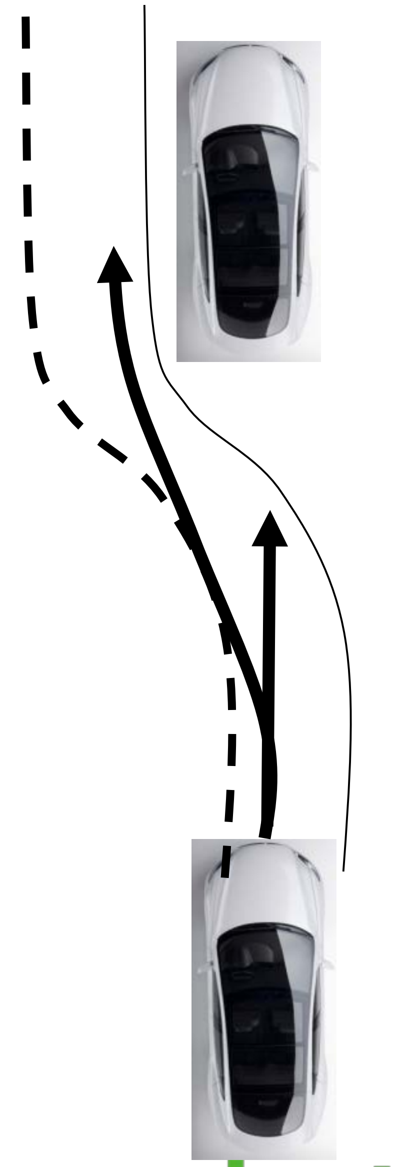
AEB should act only if accident is imminent

- „Last Point to Steer“

- „Last Point to Brake“

AEB Systems cannot select which one is relevant

- Driver intention unknown
- Road geometry unknown



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Last Point to Brake: Brake Timing for Avoidance

Brake distance depends on relative speed

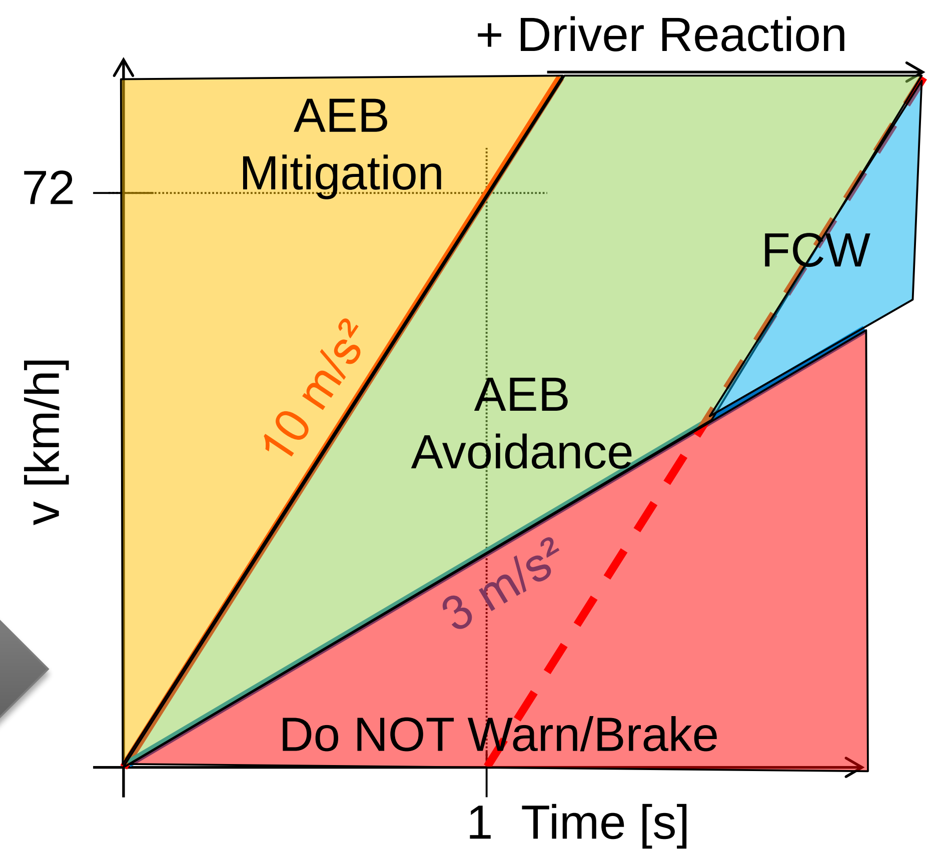
$$s_{rel} = \frac{v_{rel}^{2}}{2a}$$

Time-To-Collision

$$t_{TC} = \frac{s_{rel}}{v_{rel}}$$

TTC when braking needs to start for avoidance

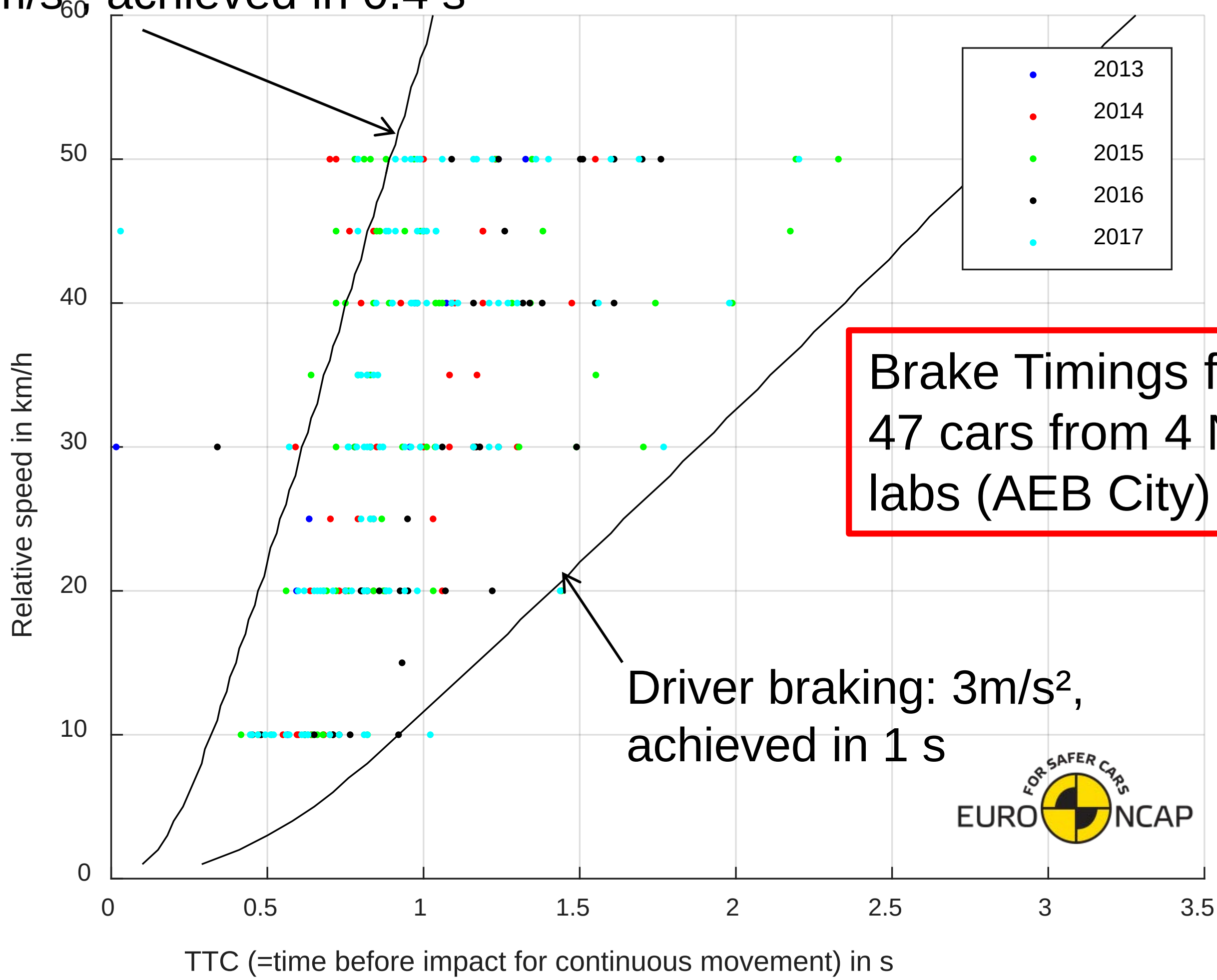
$$t_{TC} = \frac{v_{rel}}{2a}$$



Relative Speed is relevant:
50 km/h for stationary == 70 km/h for 20 km/h moving target

Last Point to Brake: Avoidance by Braking

Autobrake: 10 m/s², achieved in 0.4 s



Brake Timings for 47 cars from 4 NCAP labs (AEB City)

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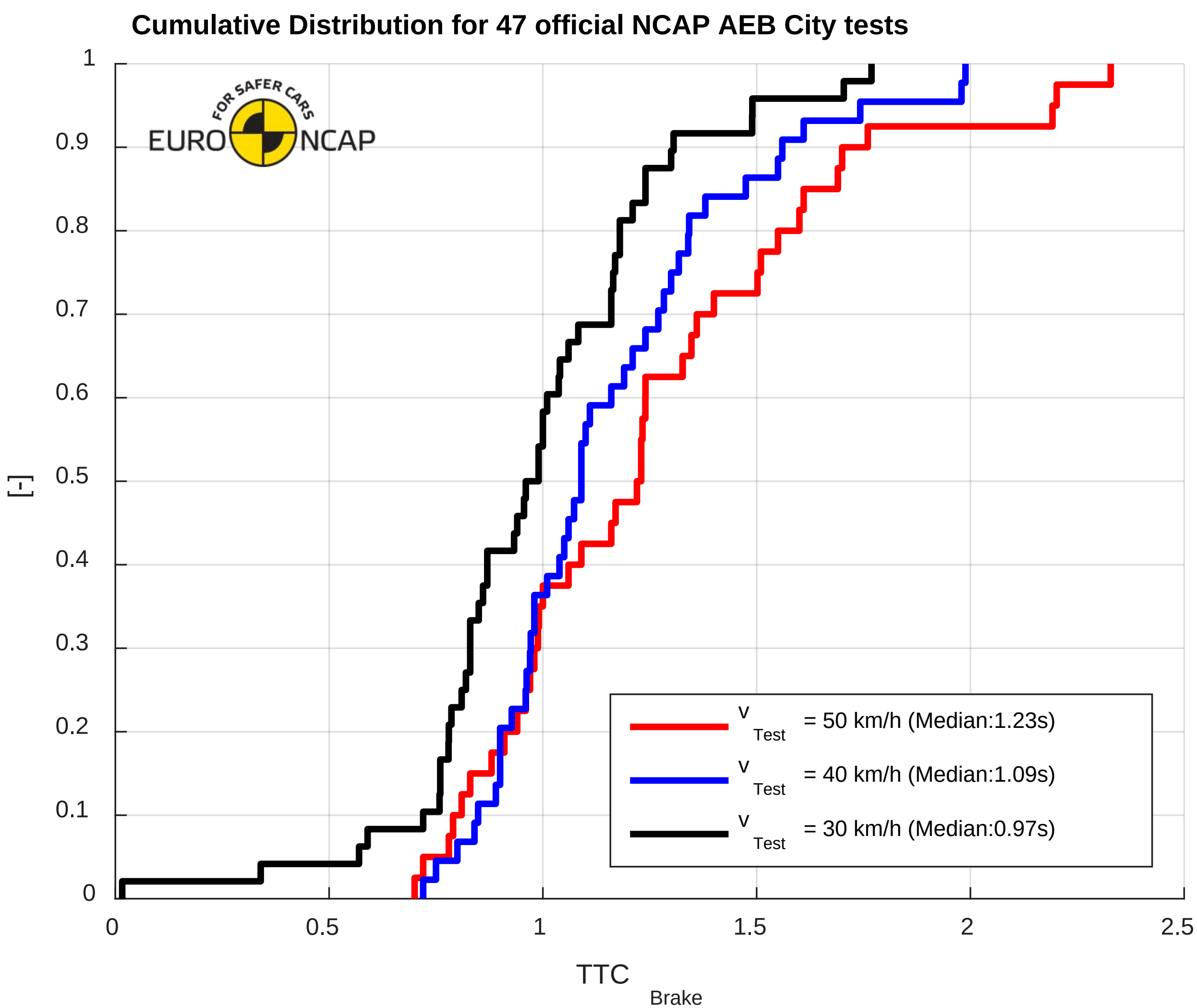
Brake Timings for 30, 40, 50 km/h



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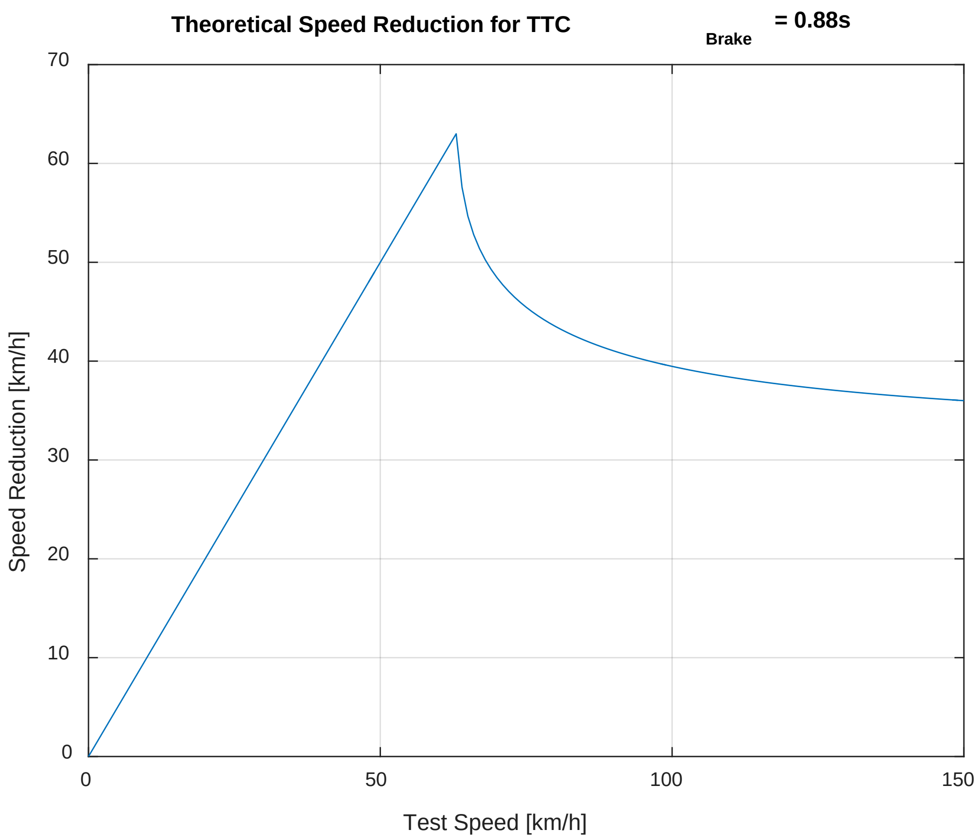
A Bit More Theory: Shark‘s Fin-Curves

Speed reduction for a given braking time:

$$v_{\text{Impact}} = \sqrt{{v_0}^2 - 2 \cdot TTC \cdot v_0 \cdot d}$$



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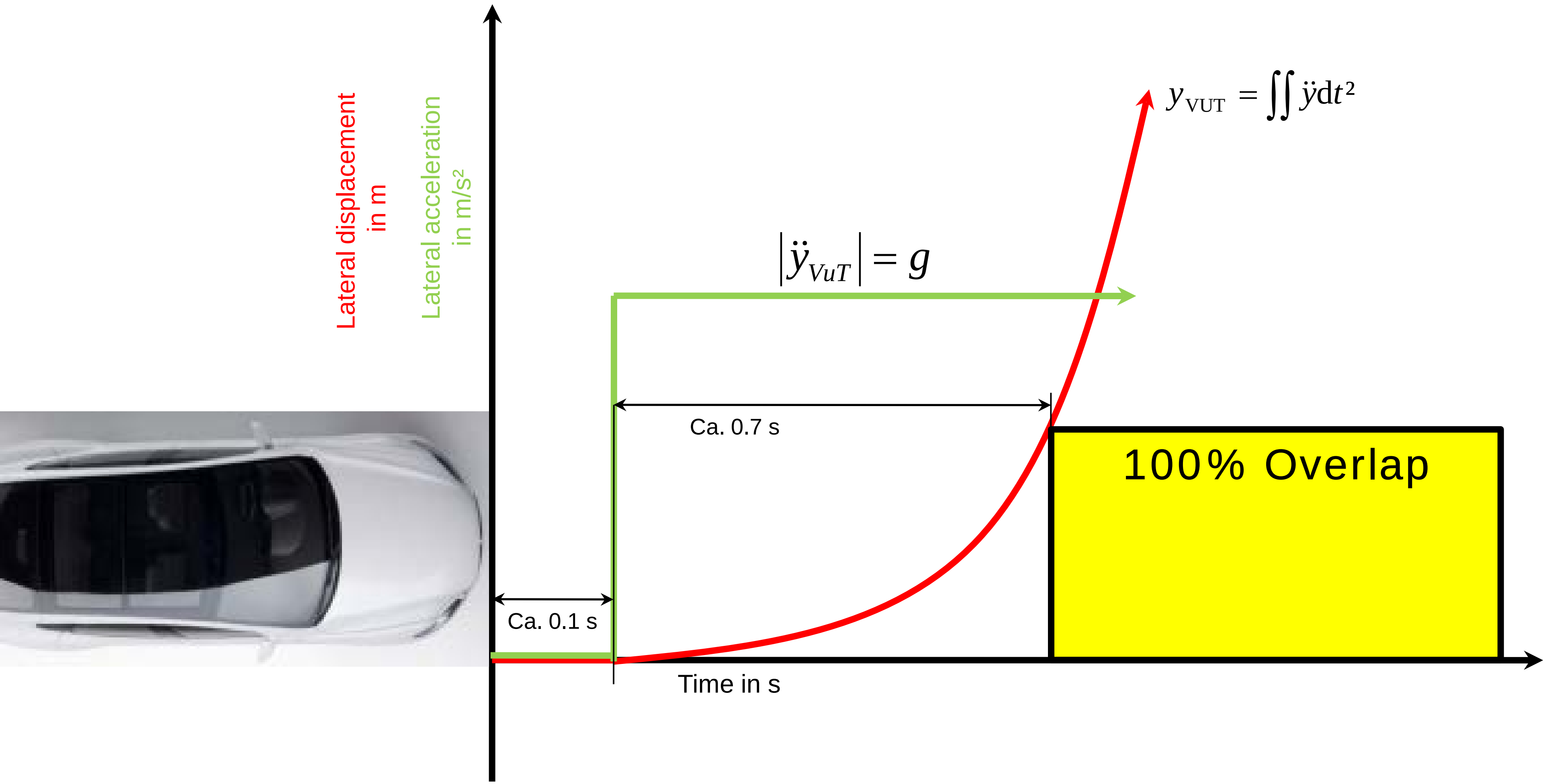
Last Point to Steer: Avoidance by steering (Theory, worst case)



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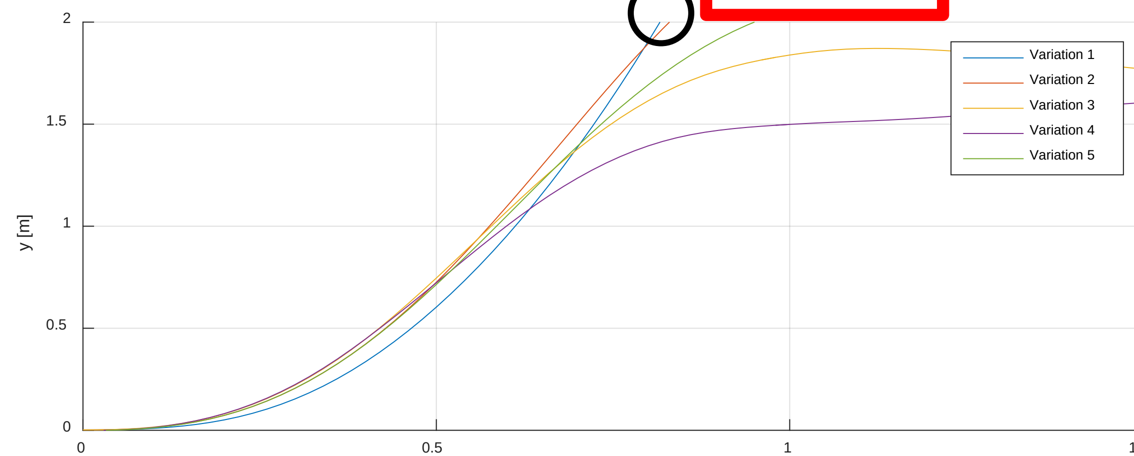
Last Point to Steer - Simulations

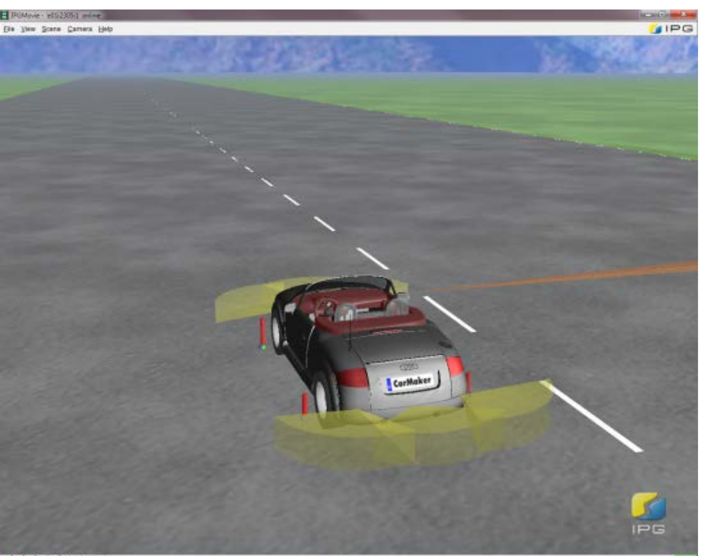
IPG CarMaker
Generic Audi TT
Direct SWA input
Variations:

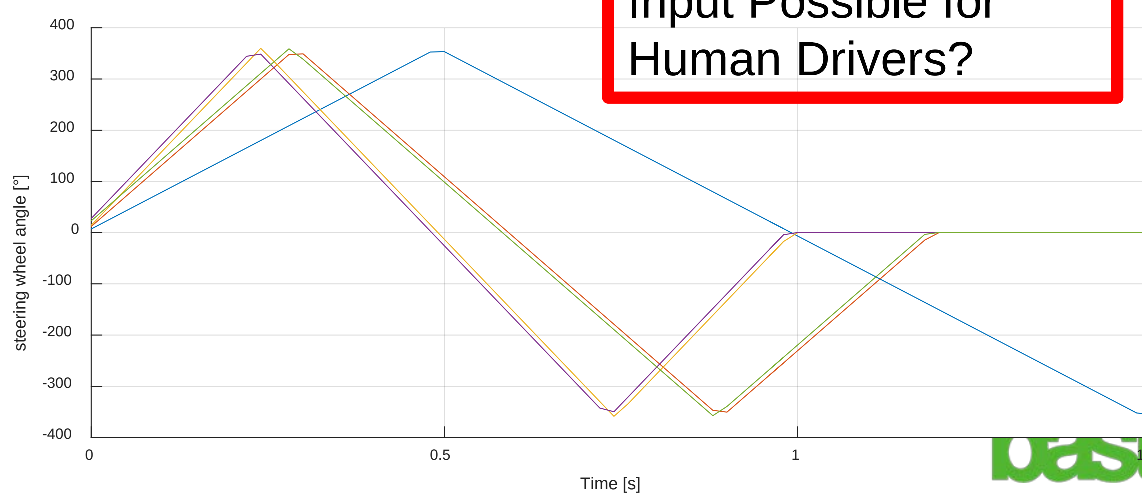
Par1	Par2	Par3	Par4	Par5
Amplitude	*Periode*	*Speed*	*Periode2*	*Amplitude2*
360	0.5	50	1	-720
360	0.3	50	0.6	-720
360	0.25	50	0.5	-720
360	0.25	40	0.5	-720
360	0.3	40	0.6	-720

t = 0,8s



Necessary Steering Input Possible for Human Drivers?





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Driving Tests (1) - Human

Task: perform a single lane change as quick as possible, if possible keep the overshoot small
Lane change width: 2m

Mercedes GLC 2017 with DGPS measurement system for speed, position and rotation
No measurement of steering angle

4 Individuals, 10 test runs each
Calculation of lane change time: increase of yaw rate → lateral shift >= 2 m
Evaluation: Yaw rate>1° → y > 2m (best case)

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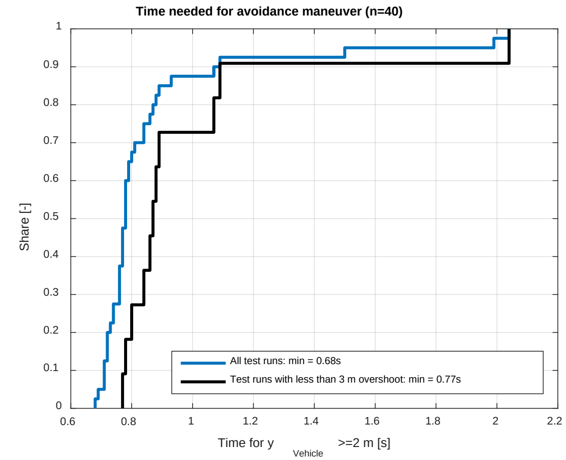
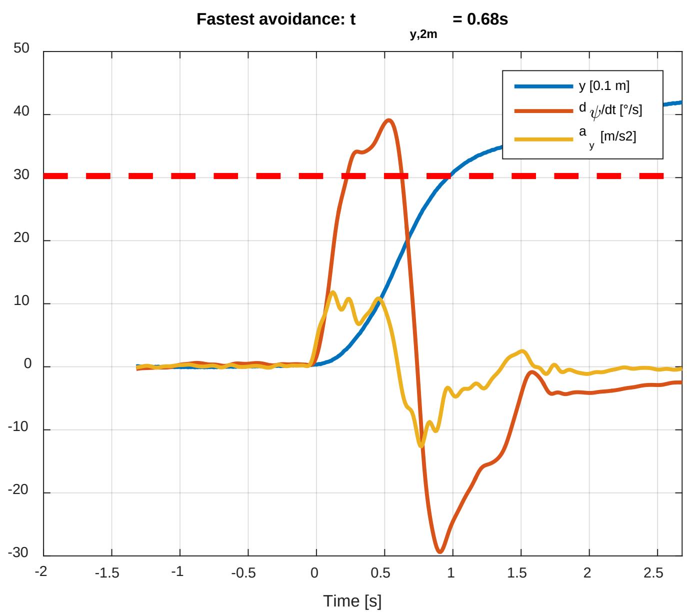
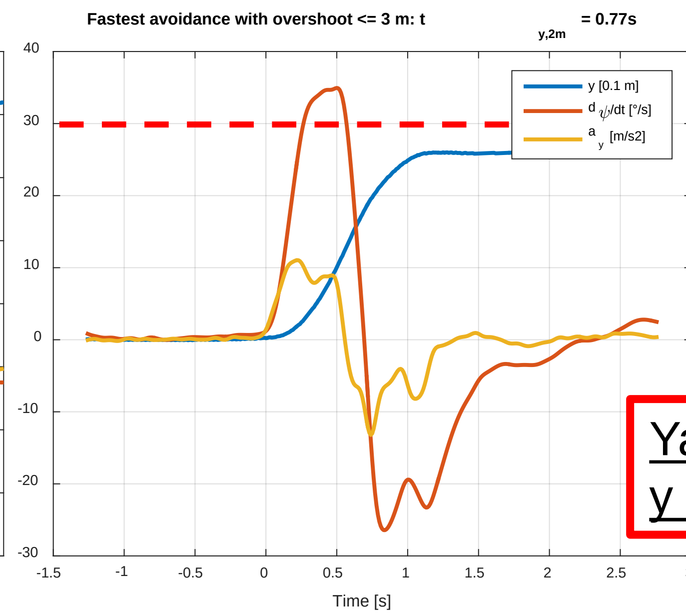
Results (1) - Human







Yaw rate>1° → y > 2m: 0,77 s

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Driving Tests (2) - Robot

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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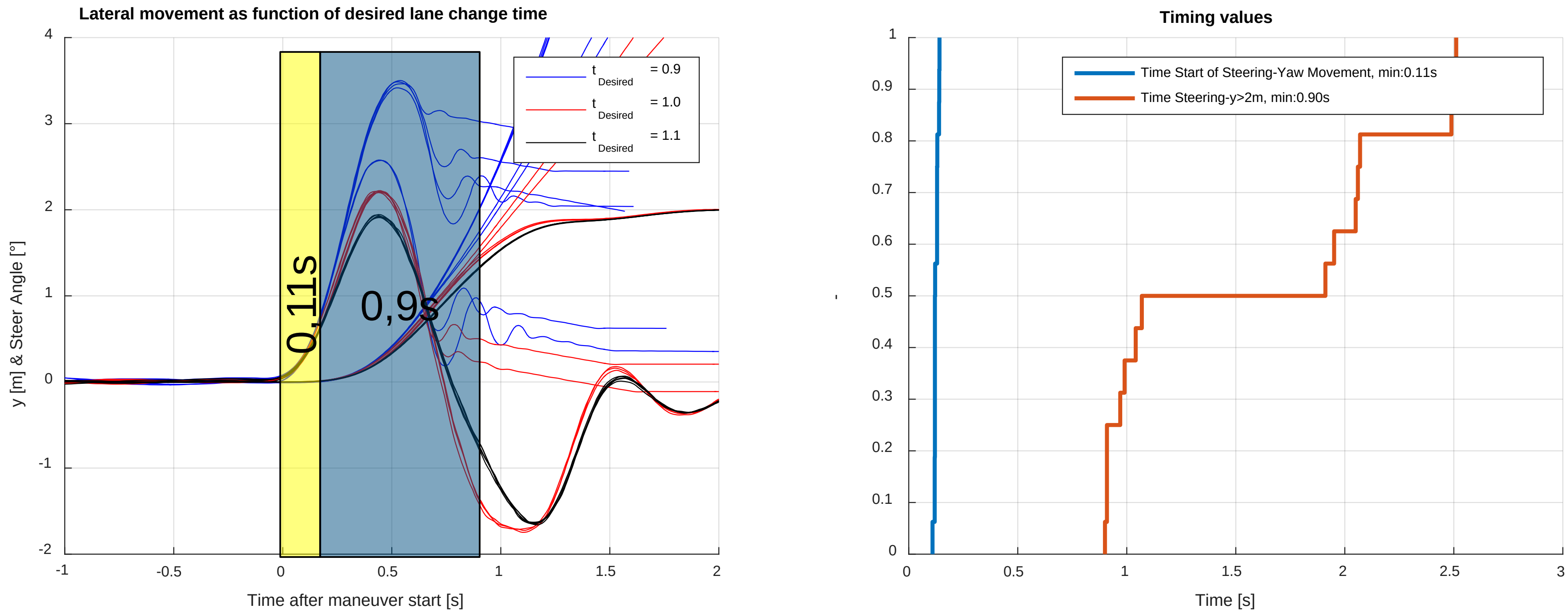
Results (2) - Robot



Steering Input

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

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

Total time for steering avoidance: >0,79s / **>0,88s**

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Discussion on Last Point to Steer

Subject Performance

- 4 drivers, all with Test Track License „ATP B“, 4x10 runs
- Values correspond to **best try!**
- Majority of drivers on the road likely performs worse

Vehicle Characteristics

- Mercedes GLC, total 1000 km
  (=new dampers/springs, new but appropriate tires)
- **BASt can perform tests with other, proposed cars as well, if desired**

Other data

- ADAC data → similar, yet higher values

Transferability

- **Measured values are considered transferable**

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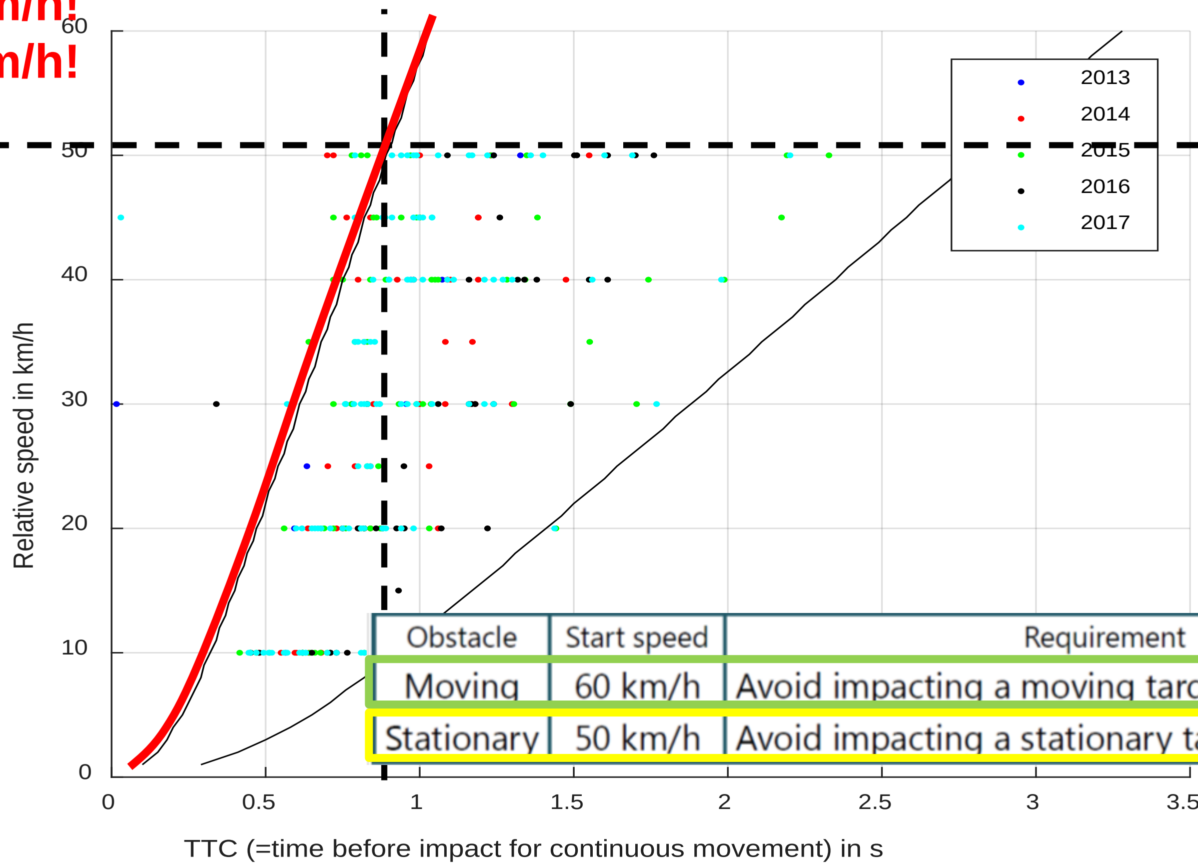
Achievable Avoidance Speed - Conclusion

0,88s: v_{red}=49 km/h!
0,89s: v_{red}=50 km/h!



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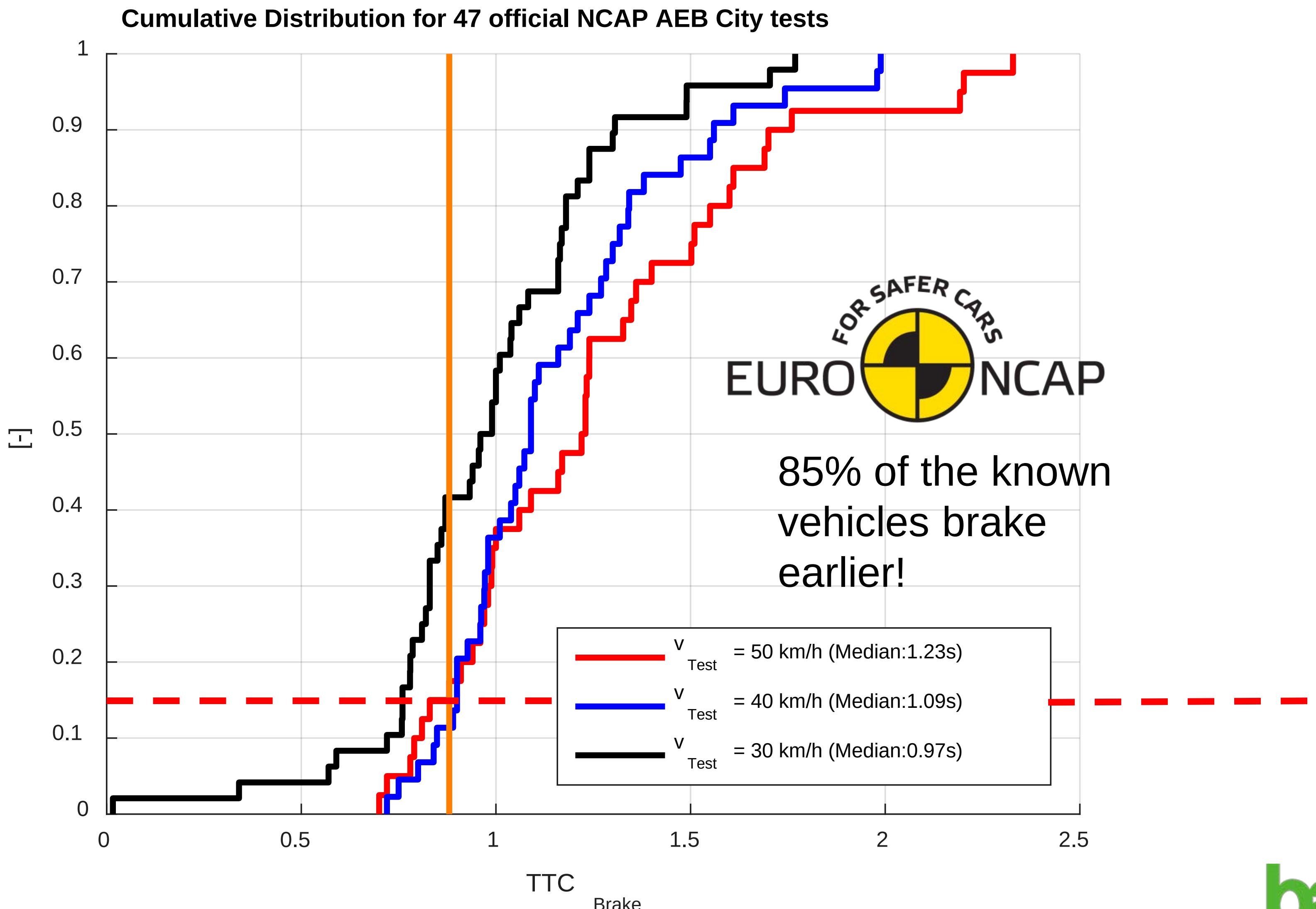
Conclusion – Brake Timing



85% of the known vehicles brake earlier!

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Summary

Avoidance by steering possible up to 0.88 s before the impact (driving tests)

Braking at 0.88 s results in avoidance up to 49 km/h (relative speed), 50 km/h would be achieved with 0.89s

A relative speed reduction of **50 km/h** is achievable

Higher speed reductions possible with earlier brake intervention

ALL tested vehicles start to brake much earlier than 0.8 s!

The Japanese proposal could even be adjusted to 50 km/h (relative)
for moving cases as well

- Currently: moving target **40 km/h** reduction,
  stationary target + pedestrian **50 km/h** reduction

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