QUADRÆ

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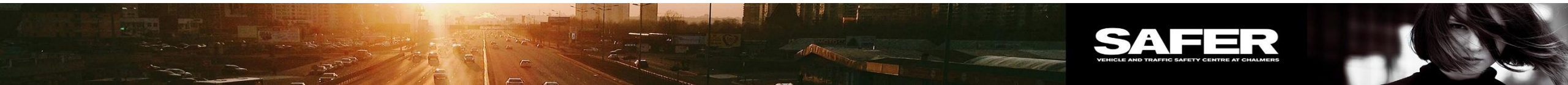
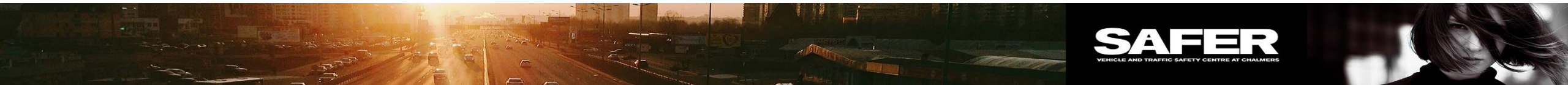


QUADRÆ = Quantitative Driver Behaviour Modelling for Active Safety Assessment – Expansion

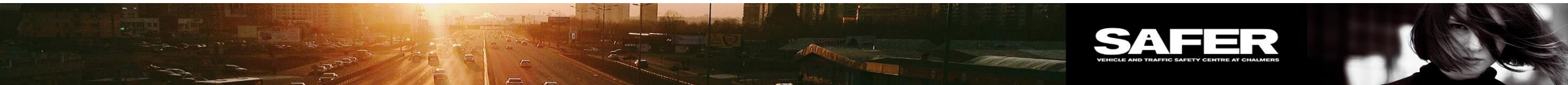
Funded by VINNOVA FFI

Consortium: Volvo Cars (coordinator), AB Volvo, Autoliv, VTI, and Chalmers

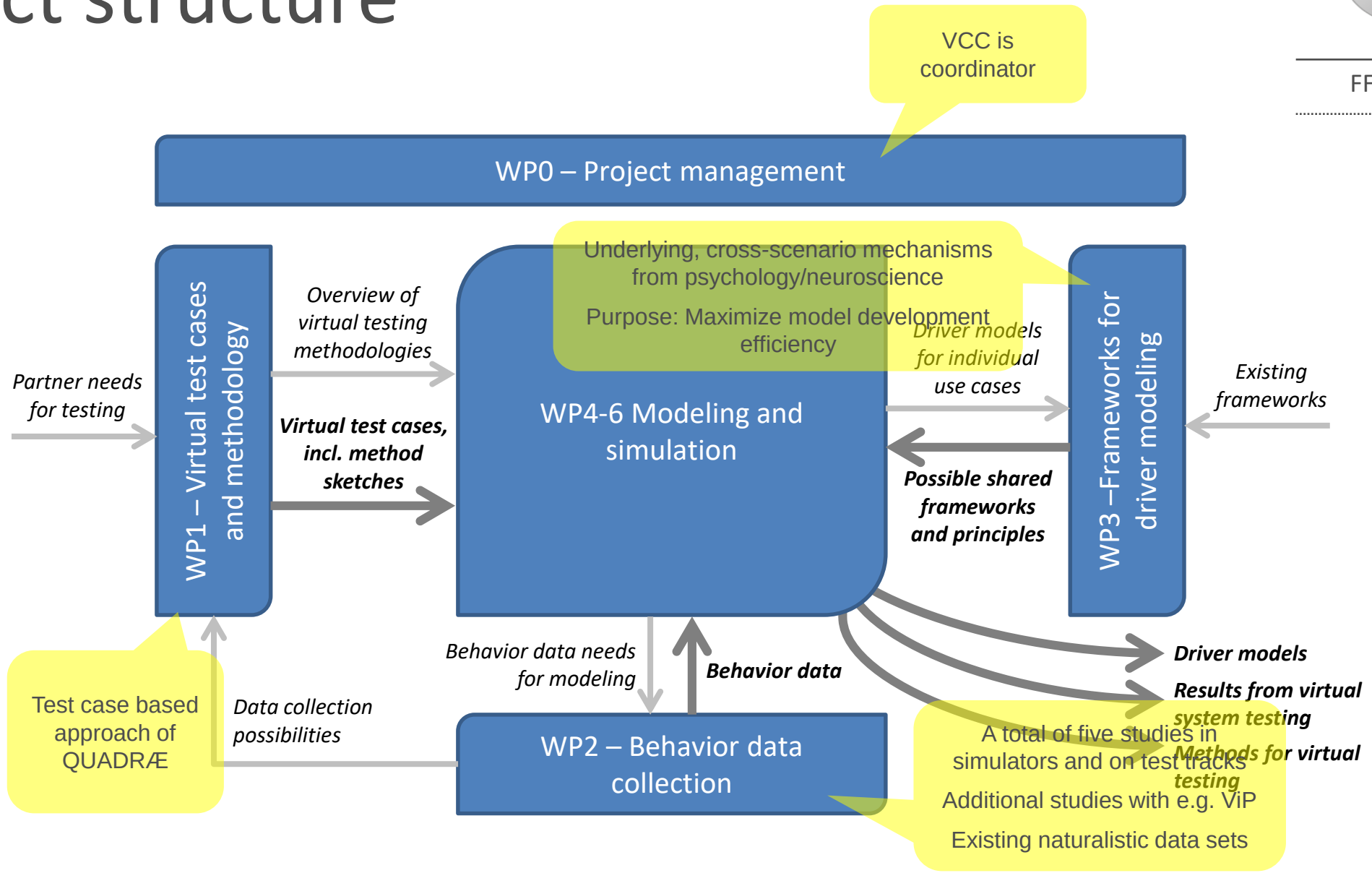


MAIN OBJECTIVES

- To develop and validate models of driver behaviour that are needed in current and future simulation tools for virtual testing of active safety and automation.
- To investigate a number of prioritised scenarios with virtual tests, to estimate the safety benefit of a system, to tune system parameters, and/or to explore potential outcomes in scenarios where the system is active.
- To increase the methodological knowledge on how to best do virtual testing.



Project structure



WP4-6, preliminary virtual test cases

WP4: Safety-critical events in semi-automated driving

”What is the outcome when a pilot assist function is suddenly disabled or encounters a critical situation?”

Simulations to assess impact of scenario factors (speed, road geometry...) and driver control resumption factors

Time to control resumption; transiently ill-tuned control...

WP5: Pre-crash scenarios with mainly lateral support

”What is the expected benefit of Emergency Manoeuvre Assist and Emergency Lane Keeping Assist?”

Simulations to assess impact of functions on synthetical and/or actual crashes (rear-end, run-off-road...)

Choice of manoeuvre; steering column vs wheel brake torque; run-off-road what-if...

WP6: Pre-crash scenarios with mainly longitudinal support

”What is the expected benefit of Collision Warning and Emergency Brake, and how should it be tuned?”

Simulations to assess function impact on actual crashes (rear-end, intersections...), integrated with existing industrial methods/tools

Angled and/or laterally moving vehicles (e.g. intersections); combining what-if with nuisance warning minimization...

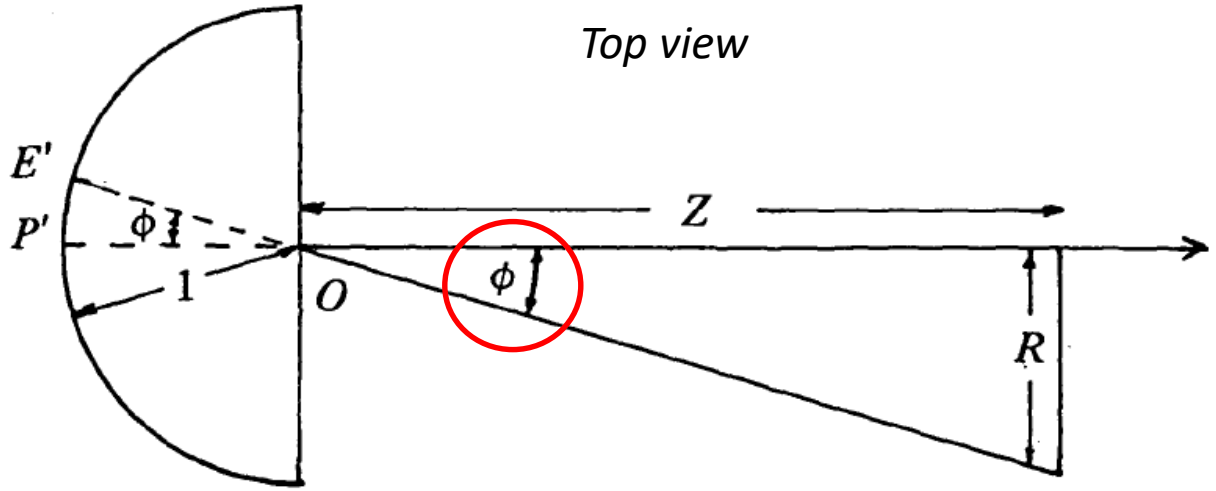
Method for driver model development

1. Define the specific behavioural phenomena that need to be captured in the virtual test case at hand (e.g. ”steering during skidding”, ”deceleration in a rear-end scenario”...)
2. Collect human behaviour data
3. Collect model candidates
   a) Existing models from literature
   b) Own ideas, based on:
      i. Exploratory analysis of human behaviour data
      ii. Potentially relevant psychological/neurobiological mechanisms (e.g. ”evidence accumulation”...)
4. Determine which model(s) best reproduce the human data, while controlling for parameter count / overfitting

See further (Markkula, 2015; Benderius, 2014)

EXAMPLE: BRAKING IN REAR-END SITUATIONS

VISUAL LOOMING



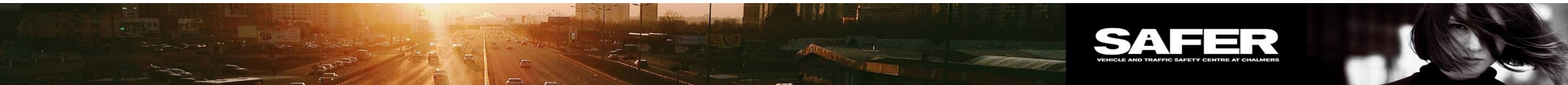
For small ϕ

$$\frac{Z(t)}{R} = \frac{1}{\Phi} \qquad (1)$$

Deriving $\frac{V(t)}{R} = \frac{v_\Phi(t)1}{\Phi^2}$ (2)

From (1) and (2) $\frac{Z(t)}{V(t)} = \frac{\Phi}{v_\Phi(t)}$

Figure from Lee, D. N. (1976). A theory of visual control of braking based on information about time-to-collision. *Perception*, *5*(4), 437-459.



VISUAL LOOMING

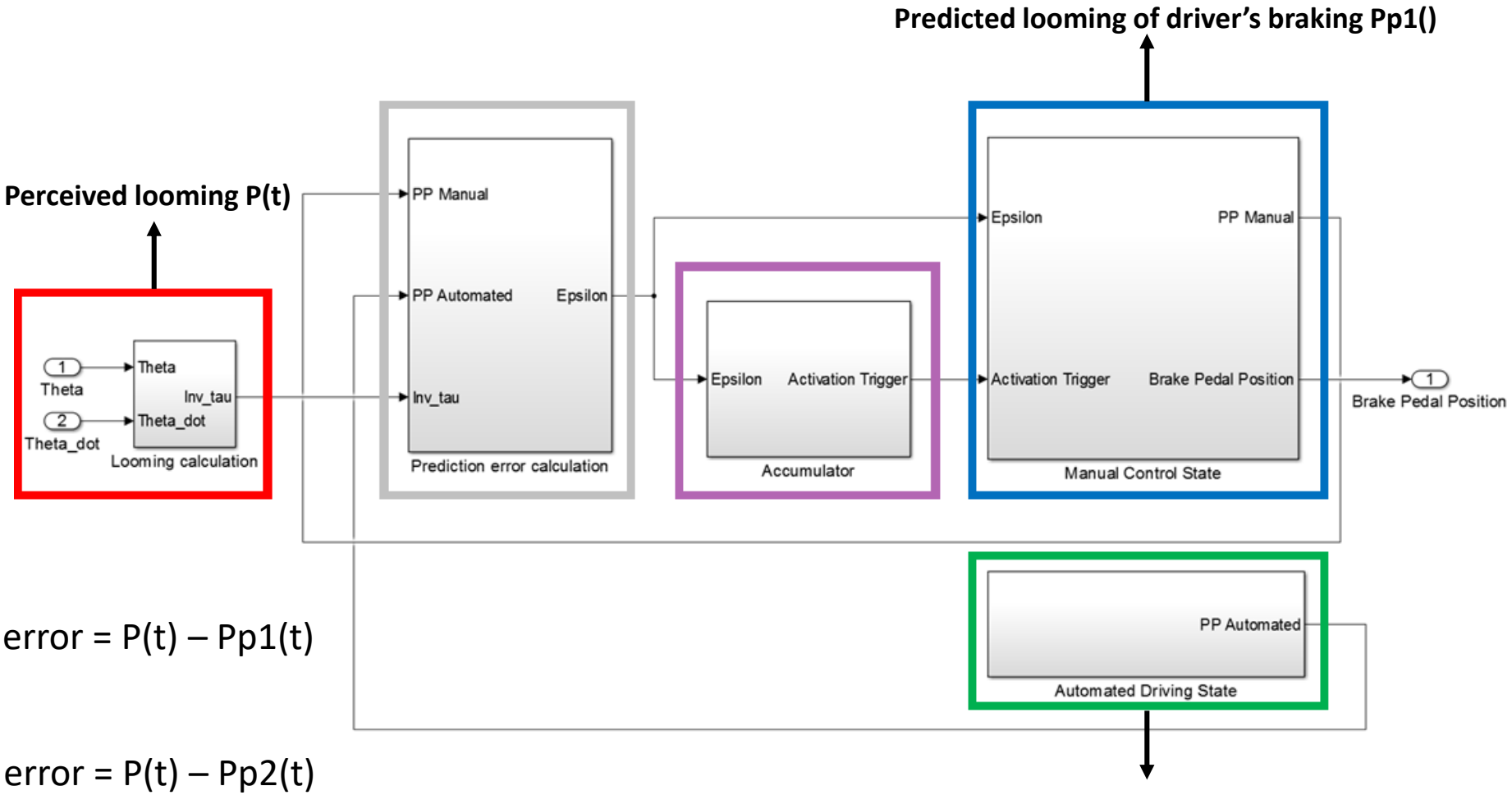
$$\frac{Z(t)}{V(t)} = \frac{\Phi}{v_\Phi(t)} = \tau$$

$$TTC = \frac{\Phi}{v_\Phi(t)} = \tau$$

Time To Collision

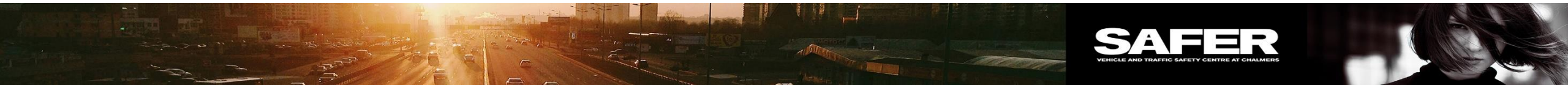
Looming = inv(TTC) = inv(τ)

FROM PSYCHOLOGY TO DRIVER MODELLING

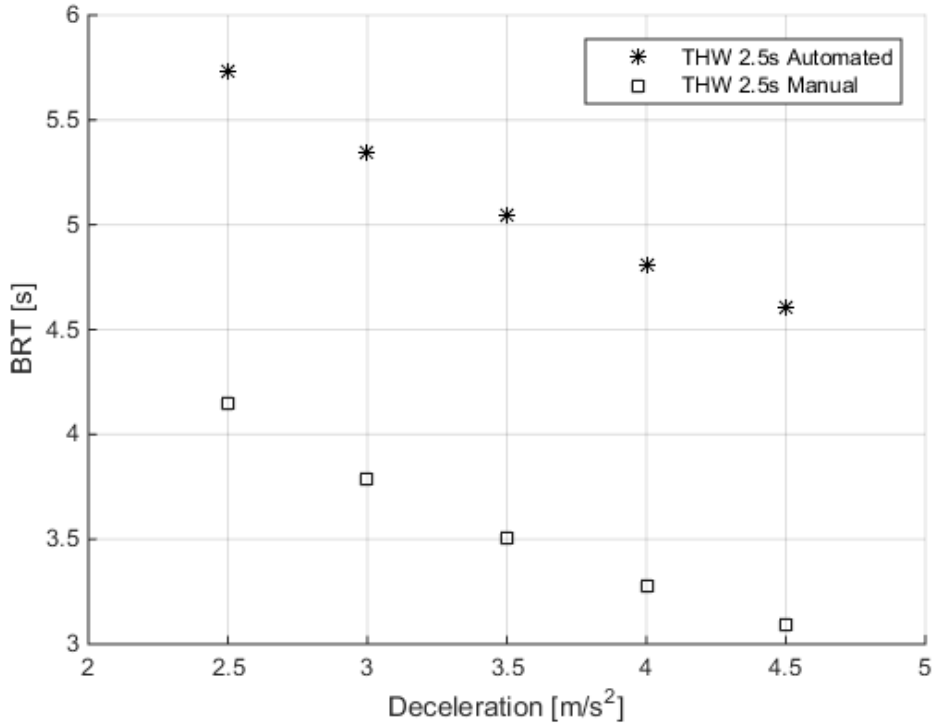


Manual driving:
Looming prediction error = P(t) – Pp1(t)

Automated driving:
Looming prediction error = P(t) – Pp2(t)

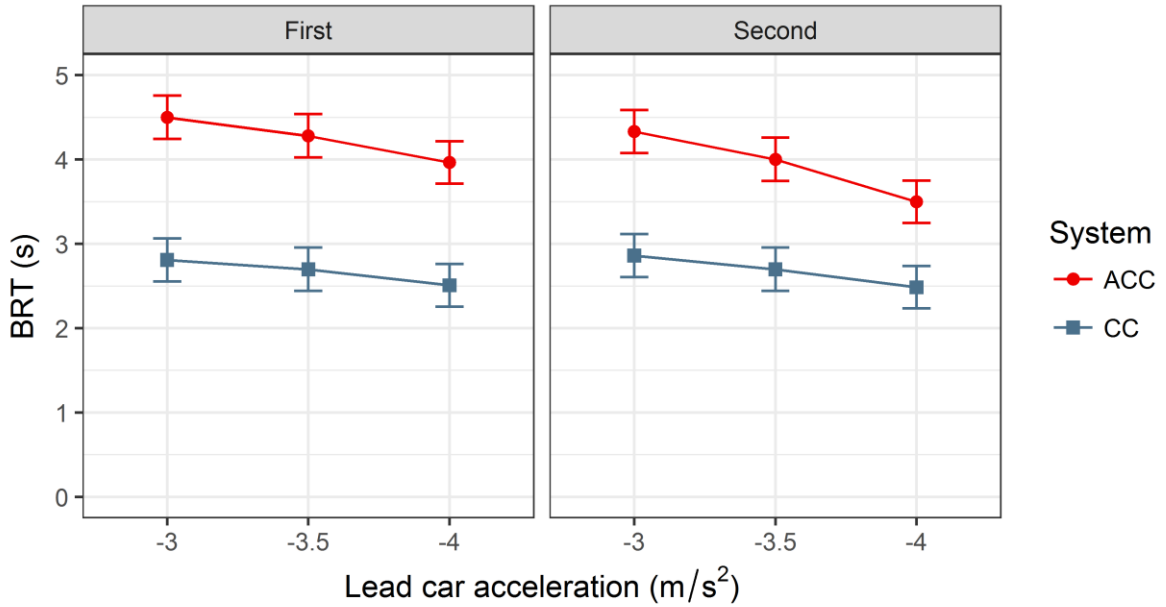


PREDICTIONS BASED ON SIMULATIONS



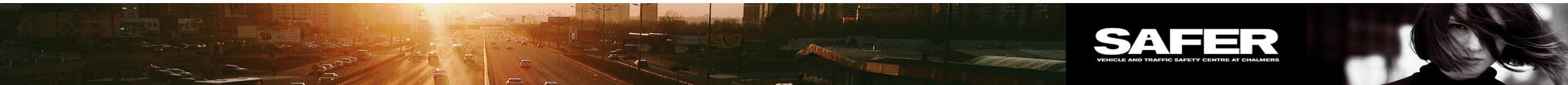
- Brake reaction times as a function o kinematic criticality and driving automation (manual vs. ACC)

VALIDATION OF THE MODELS



ON-GOING STUDIES

- Reactions in critical Straight Crossing Path situations
- Visual looming responses as a function of gaze eccentricity
- Drivers reactions to vehicles changing lanes to their lane
- Drivers reactions to stopped vehicles (e.g. revealed by a lead vehicle changing lanes)
- Steering with and without assistance in curves



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- https://www.chalmers.se/en/projects/Pages/Quantitative-Driver-Behaviour-Modelling-for-Active-Safety.aspx