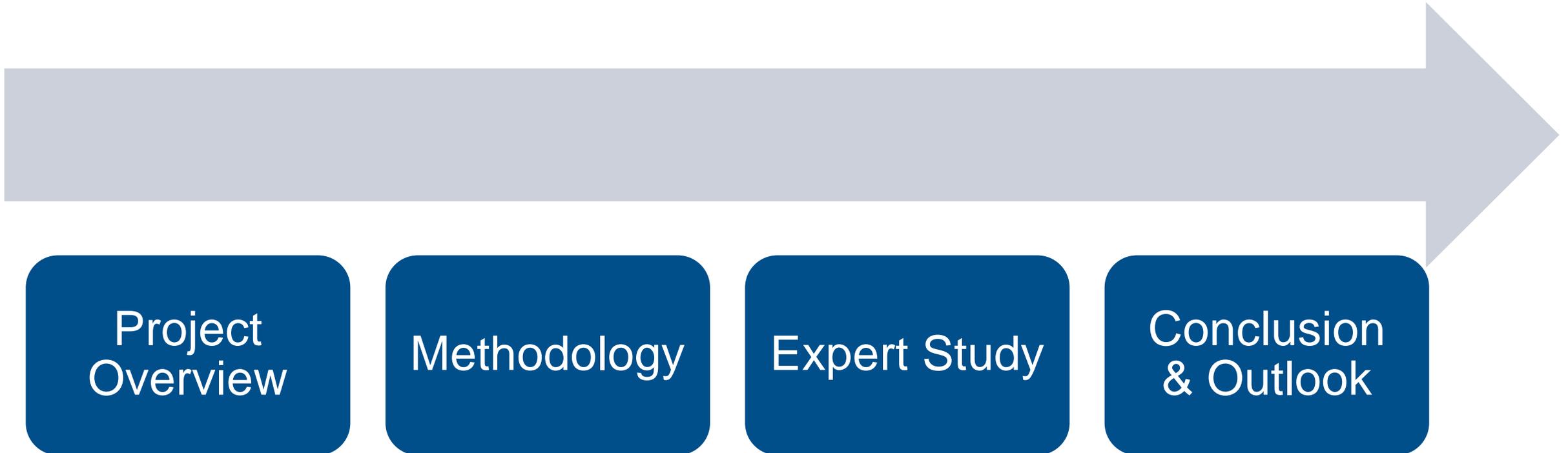


12th International Motorcycle Conference 2018, Cologne

Limits of Autonomous Emergency Brake Systems for Powered Two-Wheelers – an Expert Study

Agenda



Project Overview

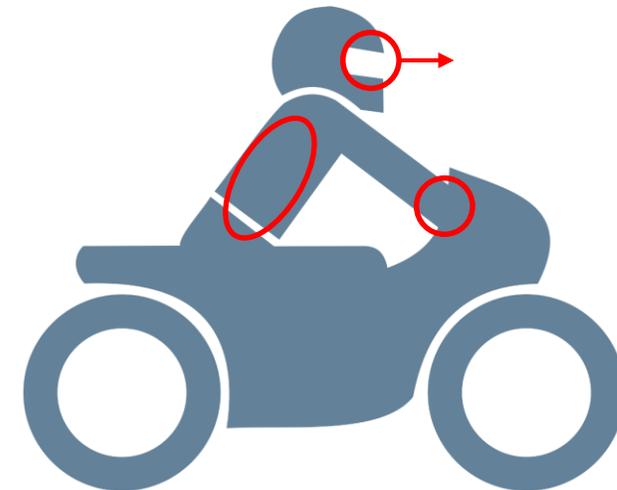
Motivation

- Safety potential of autonomous emergency braking for motorcycles
- Physical limits and limits due to riding dynamics are known
 - Which limits does the rider set to the applicability?
- Maximize the reduction of kinetic energy prior to a collision
 - What is the maximum deceleration that is feasible?



Focus

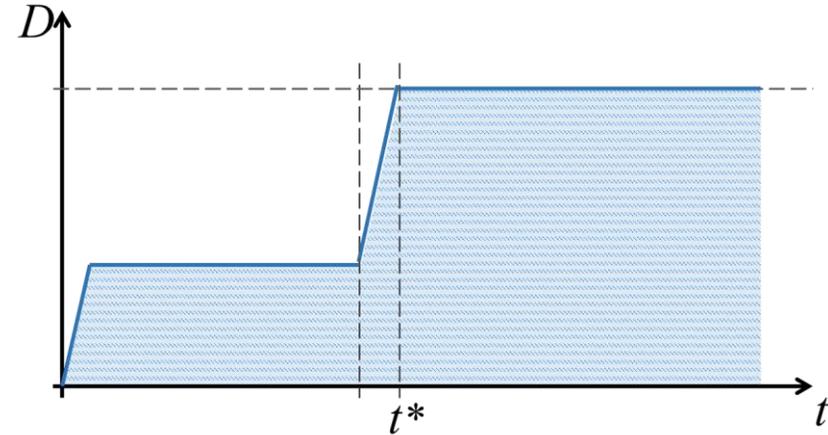
- Rider needs to be in a ready-for-braking state
 - How can we motivate the rider to get ready for braking?
 - How fast can he get there?
 - Is it possible to reduce velocity during this transition?



Methodology

Transition to ready-for-braking

- Bring the rider to the ready-for-braking state with preparatory partial braking interventions
 - Find deceleration profiles that are feasible for an unprepared rider



Challenges

- Critical test szenarios
 - Riders need to be unprepared to test reactions to surprising braking interventions
 - No determination of limits with unprepared riders!
- Determination of limits for preparatory partial braking maneuvers with experts

Methodology

Riding studies

Expert study with riding instructors/trainers

→ *Which decelerations/deceleration profiles are feasible for average riders?*



Participant study with average motorcycle riders

→ *How long does it take to bring the rider to the ready-for-braking state? Do they accept the intervention?*



Simulator study with average motorcycle riders

→ *How do riders behave during an autonomous braking maneuver when they are distracted?*



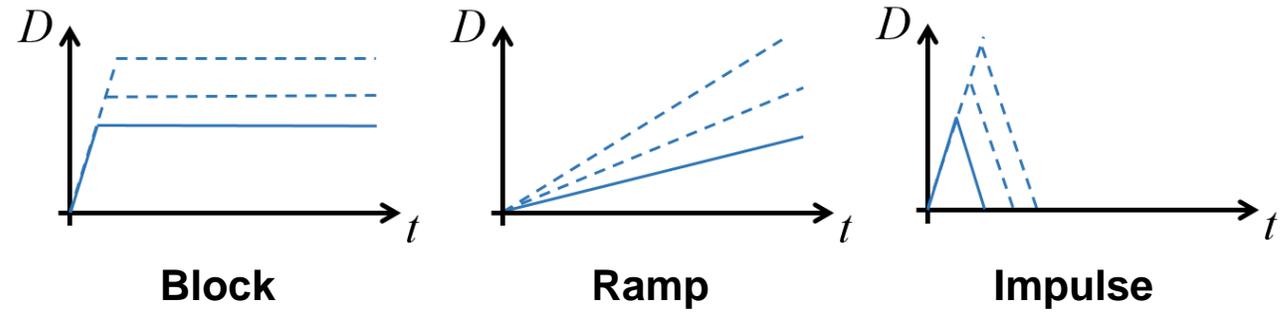
wivw

Würzburger Institut für
Verkehrswissenschaften/
Institute for Traffic Sciences

Expert Study

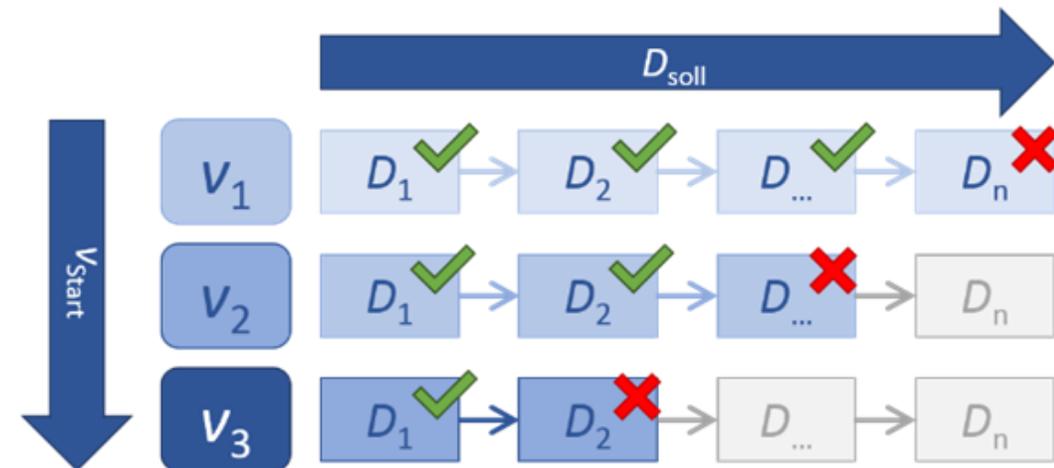
Test vehicle

- Three different braking profiles
- Braking via remote control, up to 7 m/s^2
- Automatic actuation of the clutch



Test process

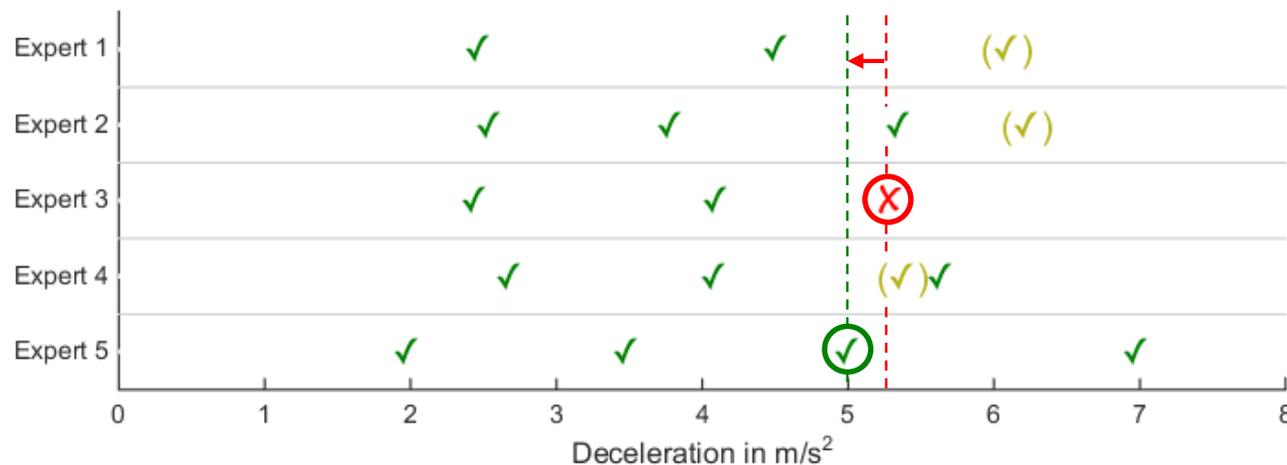
- Riding trainers estimate the controllability
 - Different test speeds
 - Increasing intensity of decelerations
- Determination of the parameters for the participant study



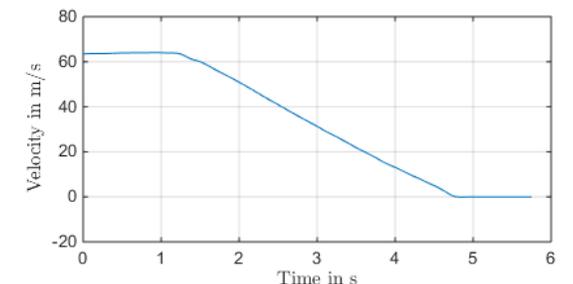
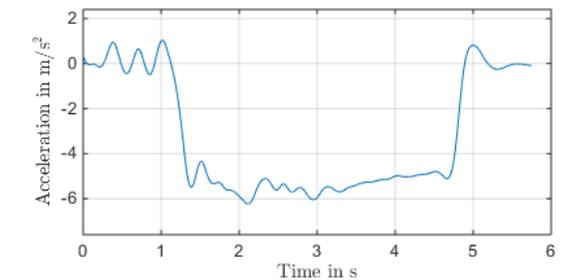
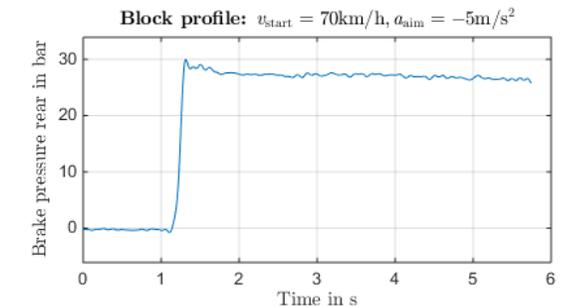
Expert Study

Results

Block profile, 70 km/h



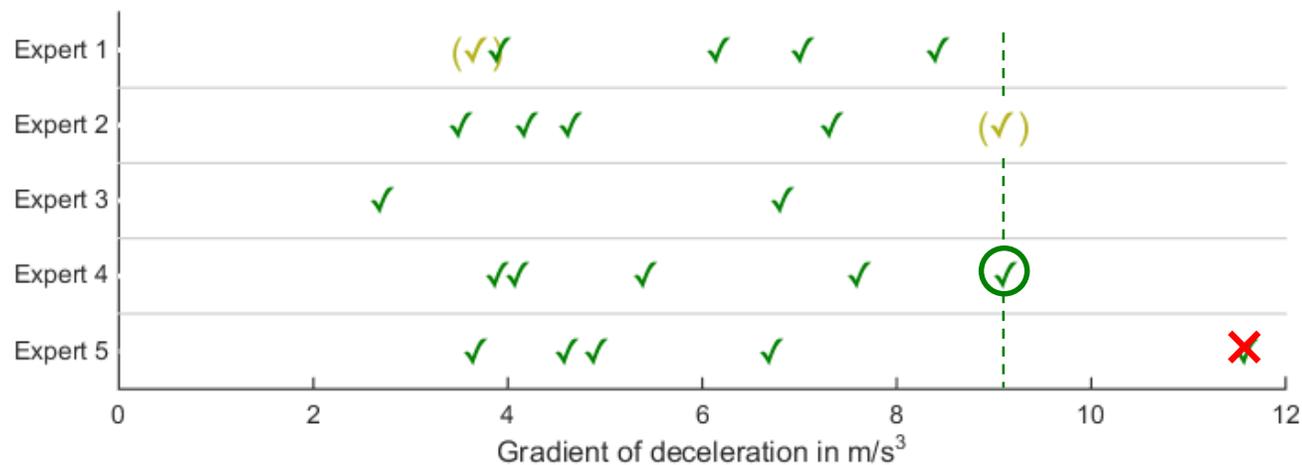
- Opening of clutch and soaring of engine speed causes attention
- Beginning deceleration causes reflexing finger movement to clutch and brake levers
- Higher decelerations more comfortable → clear message to rider



Expert Study

Results

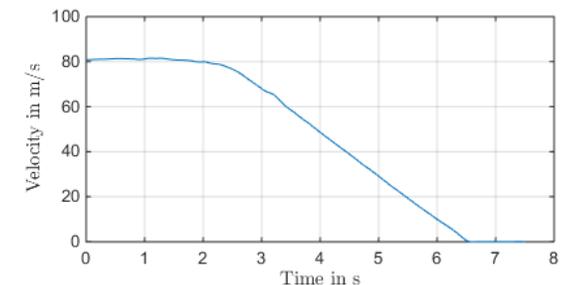
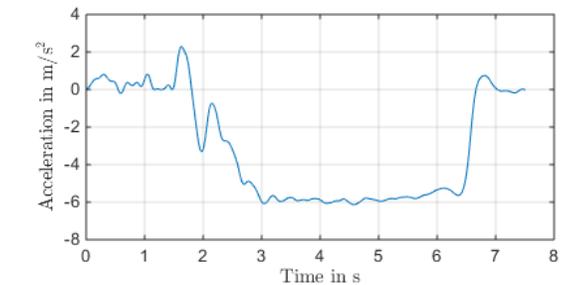
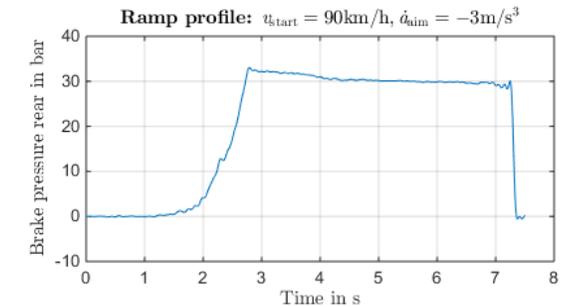
▪ Ramp profile, 70 km/h



▪ Progressive behaviour of pressure buildup

→ Adaption of upper body movement more challenging

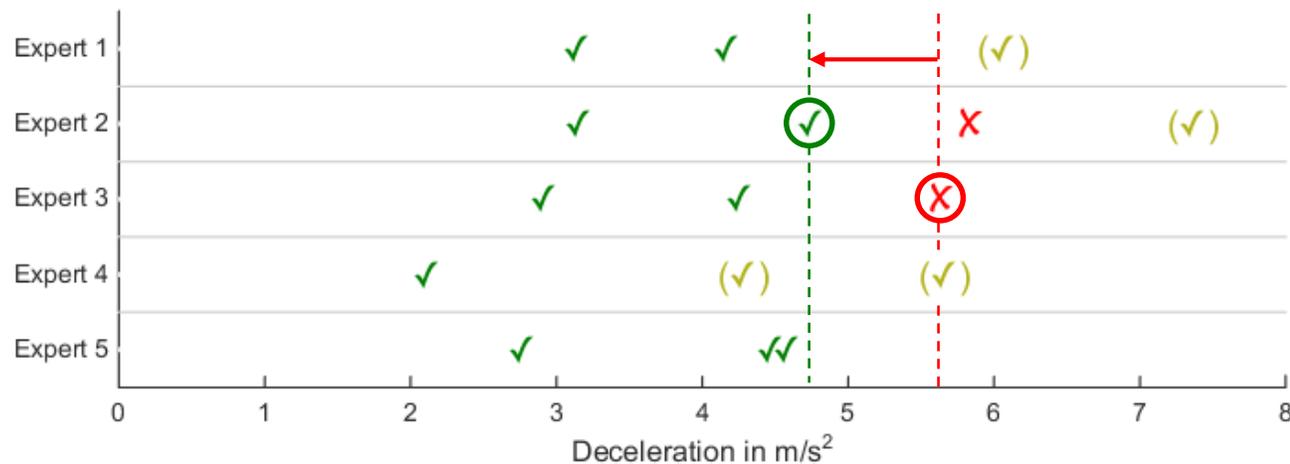
▪ Opposed assessments concerning comparison between ramp and block profile



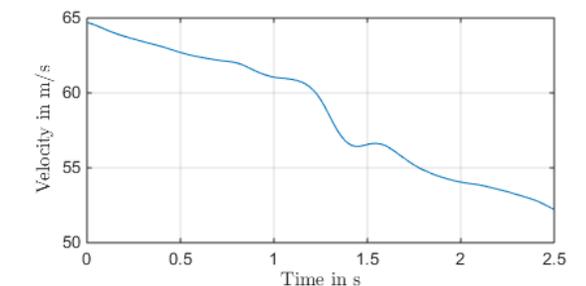
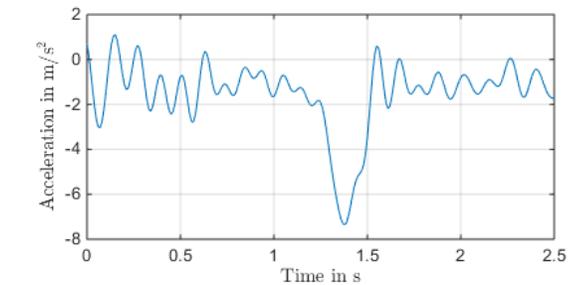
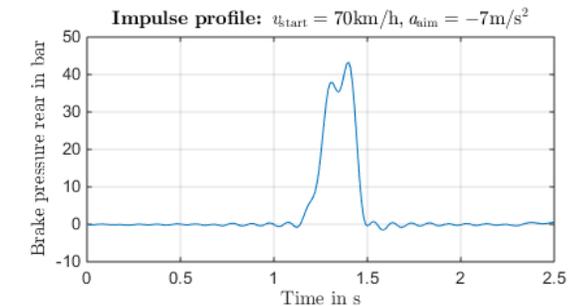
Expert Study

Results

Impulse profile, 70 km/h



- Low decelerations: can hardly be differentiated from pot hole
- High decelerations: good warning but most surprising → highest risk to cause undesired rider reaction

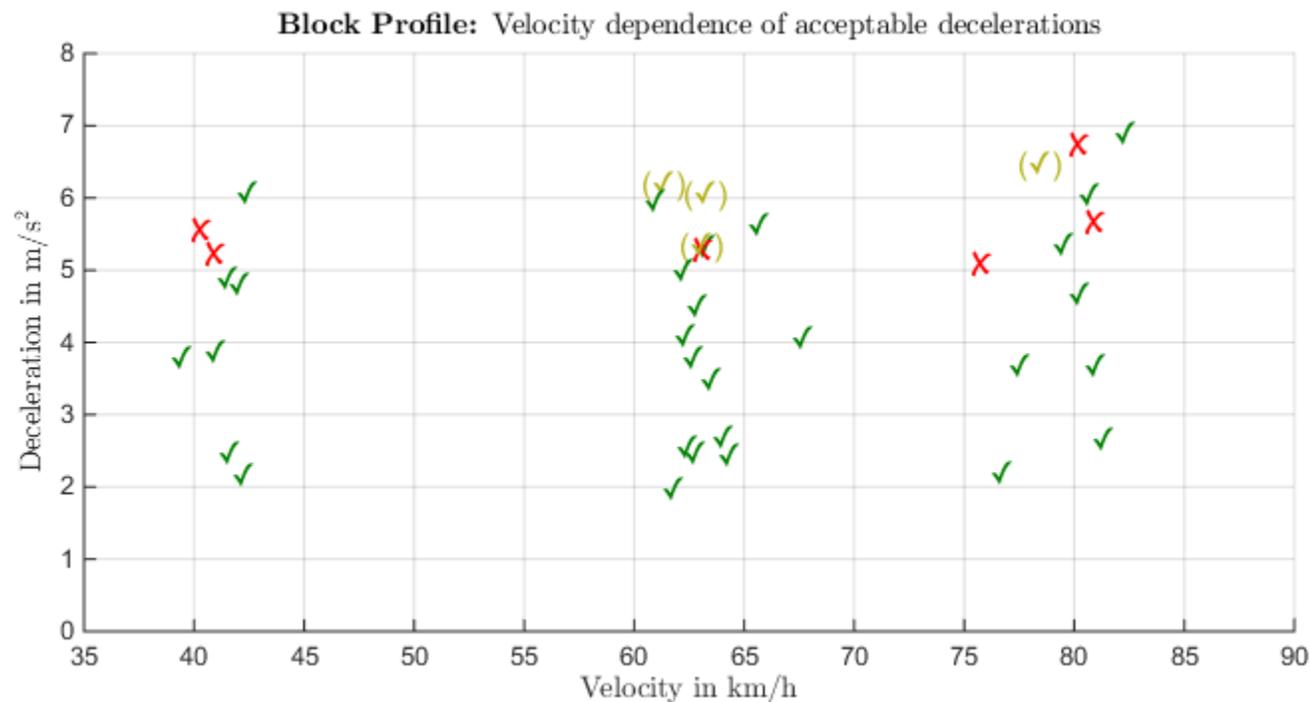


Expert Study

Velocity dependence

- Block profile

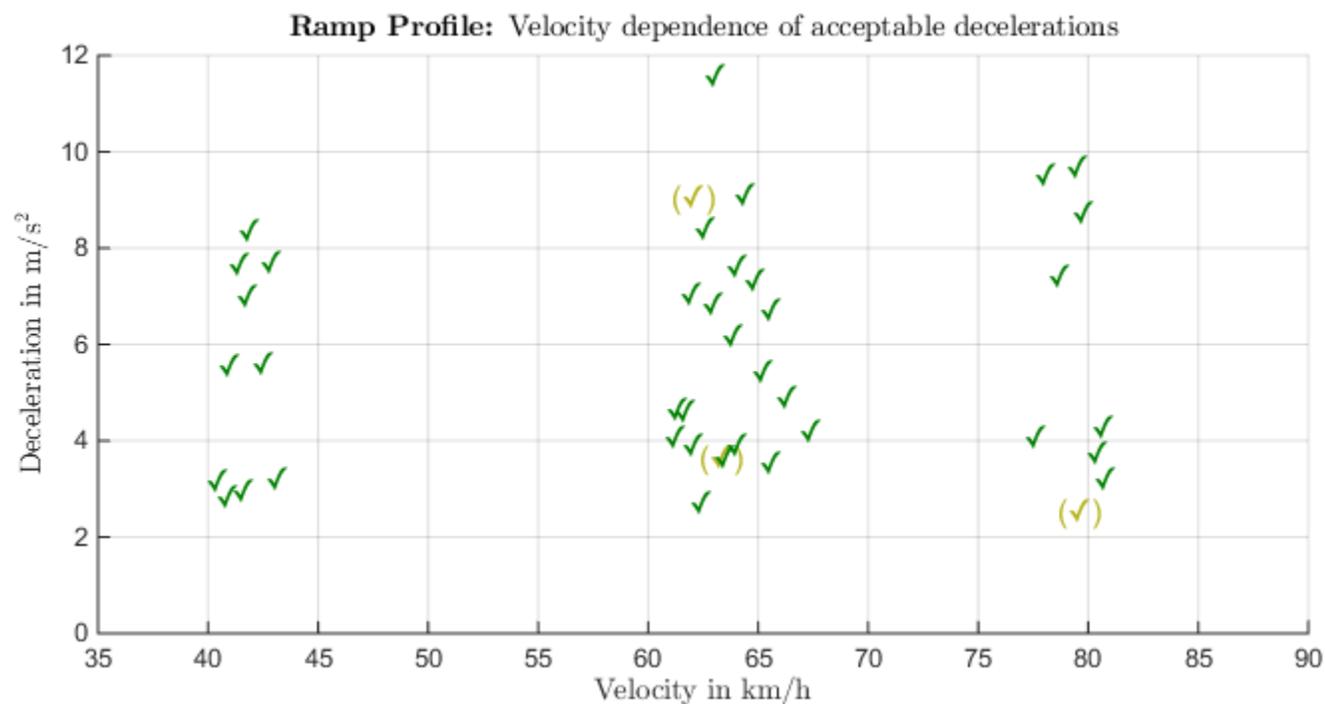
→ no indication for velocity dependence



Expert Study

Velocity dependence

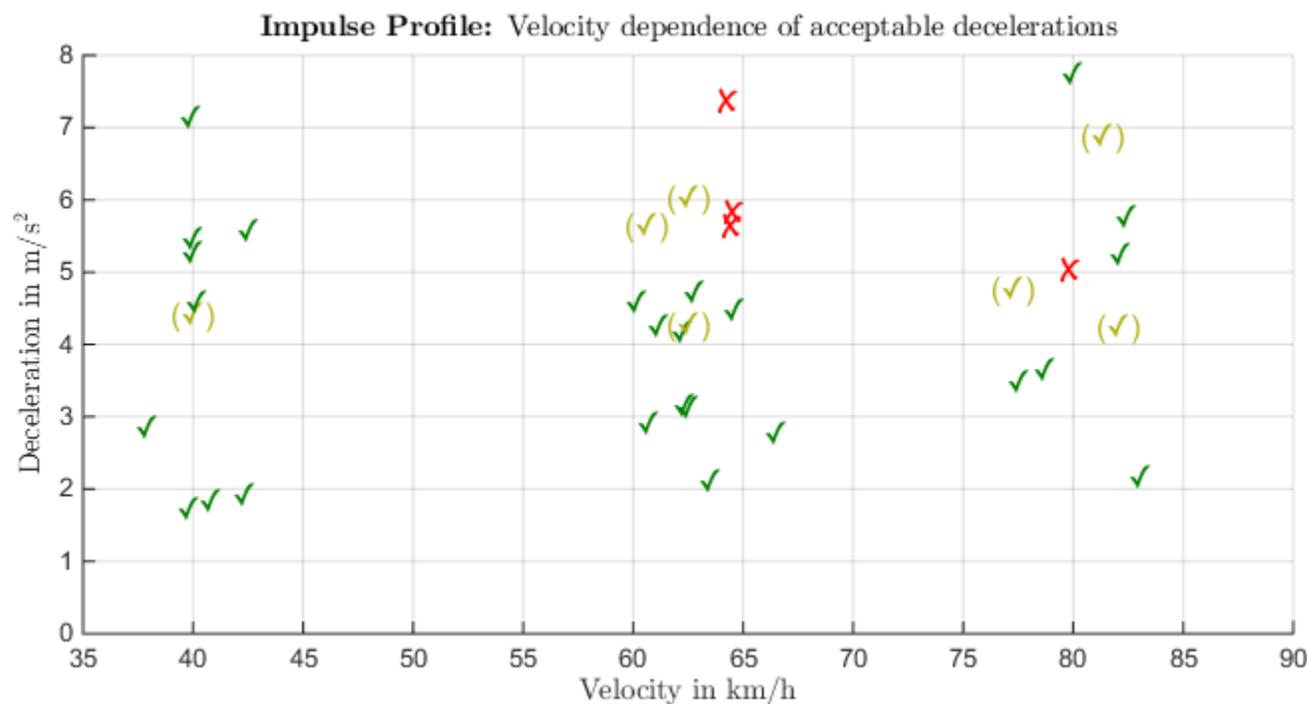
- Ramp profile
 - no indication for velocity dependence



Expert Study

Velocity dependence

- Impulse profile
 - lower decelerations at higher velocities

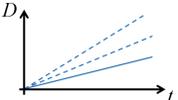
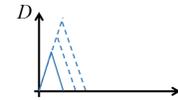


→ More data needed for more significant results!

Conclusion and Outlook

Parameters for participant study

- Parameters of feasible deceleration profiles for participant study
 - For unprepared average riders
 - Riding straight at 70 km/h

Profile		Varied Parameter	Determined Maximum
Block		Deceleration	5 m/s ²
Ramp		Gradient of Deceleration	9,1 m/s ³
Impulse		Deceleration	4,7 m/s ²

Variation of initial velocities

- First estimations of velocity dependence of feasible decelerations
 - Lower decelerations at higher velocities for some profiles
 - More data needed for reliable results

Conclusion and Outlook

Limitations

- **Assessment of feasibility for unprepared riders BUT experts know what will happen**
- **Results only applicable at 70 km/h**
- **Only applicable for specific vehicle type**
 - **Influence of different vehicle geometries expected**

Next steps

- **Participant study with realistic emergency braking scenario (dummy target EVITA)**
 - **Investigation on how unprepared riders react to braking interventions**
 - **Subjective assessment and acceptability (questionnaire)**



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Thank you for your Attention!

**TU Darmstadt
Institute of Automotive Engineering**

**Nora Leona Merkel, M.Sc.
Otto-Berndt-Str. 2
64287 Darmstadt**

+ 49 6151 16 – 24230

**merkel@fzd.tu-darmstadt.de
www.fahrzeugtechnik-darmstadt.de**



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