State of the Art – Parameters

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Performance Requirements based on State of the Art

- Challenge: No automated vehicles exist!
- But: Active Safety Systems on the market
- Possible parameters:
  - Delay time for threat identification, brake activation
  - Brake system speed
  - Brake system deceleration
  - Steering intervention speed → No technology known, no data available to BASt
- **Goal of this presentation: Identify state of the art for accident avoidance**

Important: Performance vs. Behavior

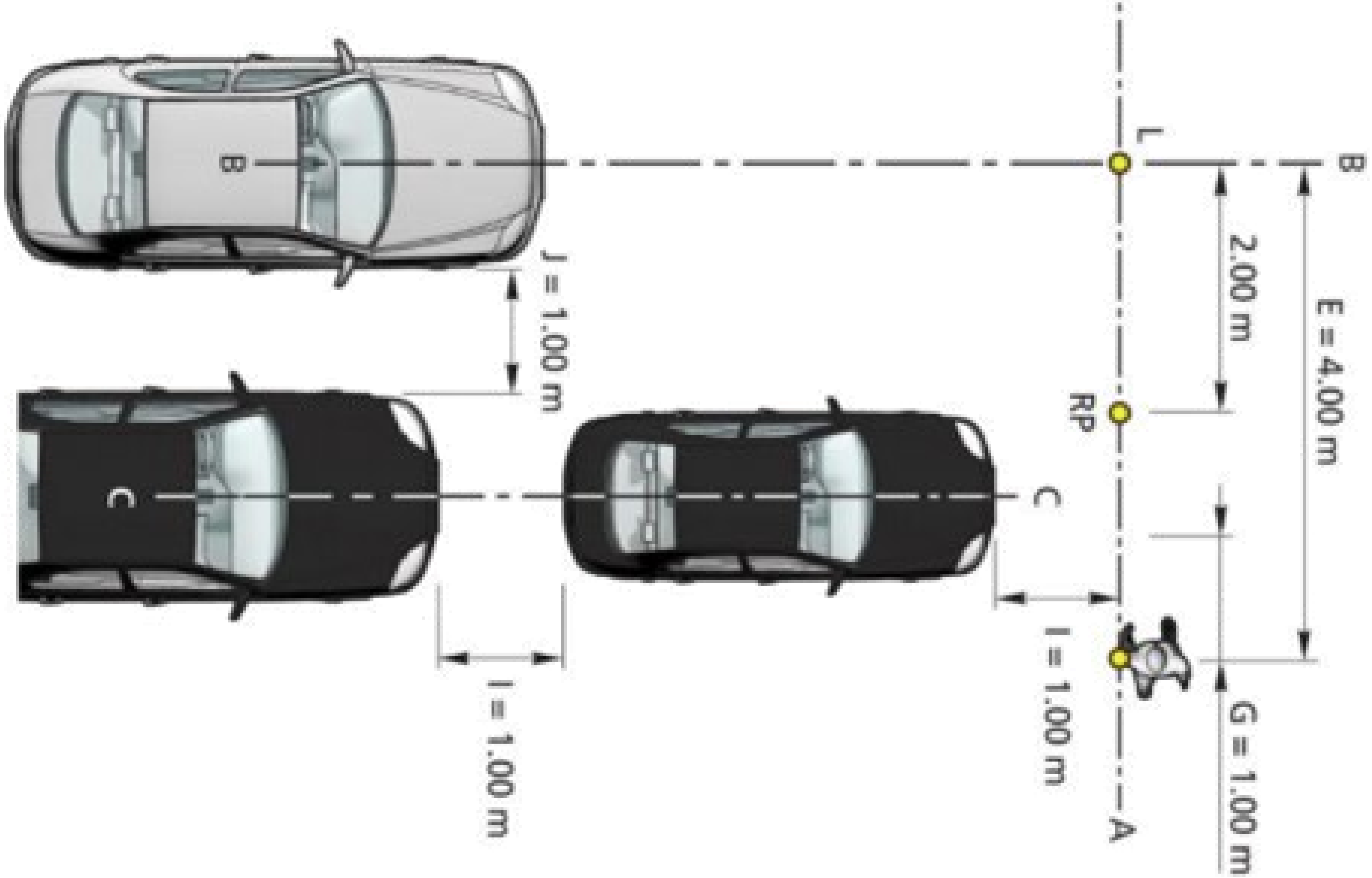
- Regulation should NOT specify an exact vehicle behavior
- Regulation SHOULD specify until what situations accidents should be avioded

Example for appearing pedestrian

- Don‵ts: Behavior definition: brake at TTC=X with a deceleration of Y
- Do‵s: Performance definition: should not lead to a collision, (because collision would be avoided if braking starts at TTC=X with a deceleration of Y)
- Other options for ADS: braker later/harder, brake earlier/softer, drive slower, drive with more lateral distance to objects.

Euro NCAP Obscured Child Test

Schematics – Euro NCAP Obscured Child test

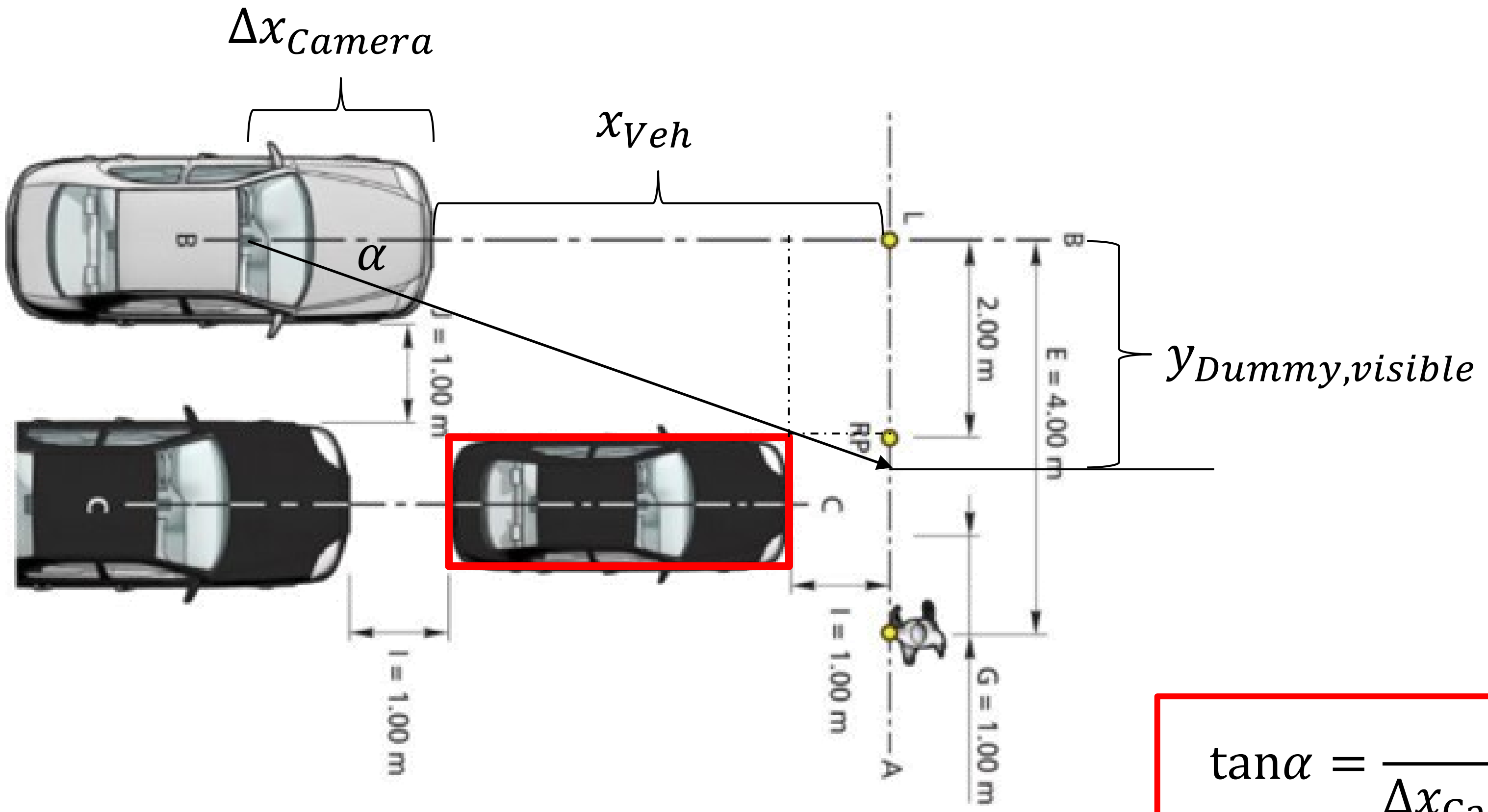


Assumptions and argumentation

- In obscured child scenarios, the dummy is critical as soon as it is visible → start of braking as soon as technically possible
- Only for vehicles with Camera systems
  (RADAR might be able to see the pedestrian dummy earlier)
- Delay between appearing dummy and braking comprises
  - Detection, classification, tracking and decision making
  - Transmitting of brake command to brake system
- This is the worst case - situations with tracked objects (such as ALKS lane change) are assumed to be much faster

Delay time for threat identification

- Worst case test in current NCAPs: obscured child AEB test

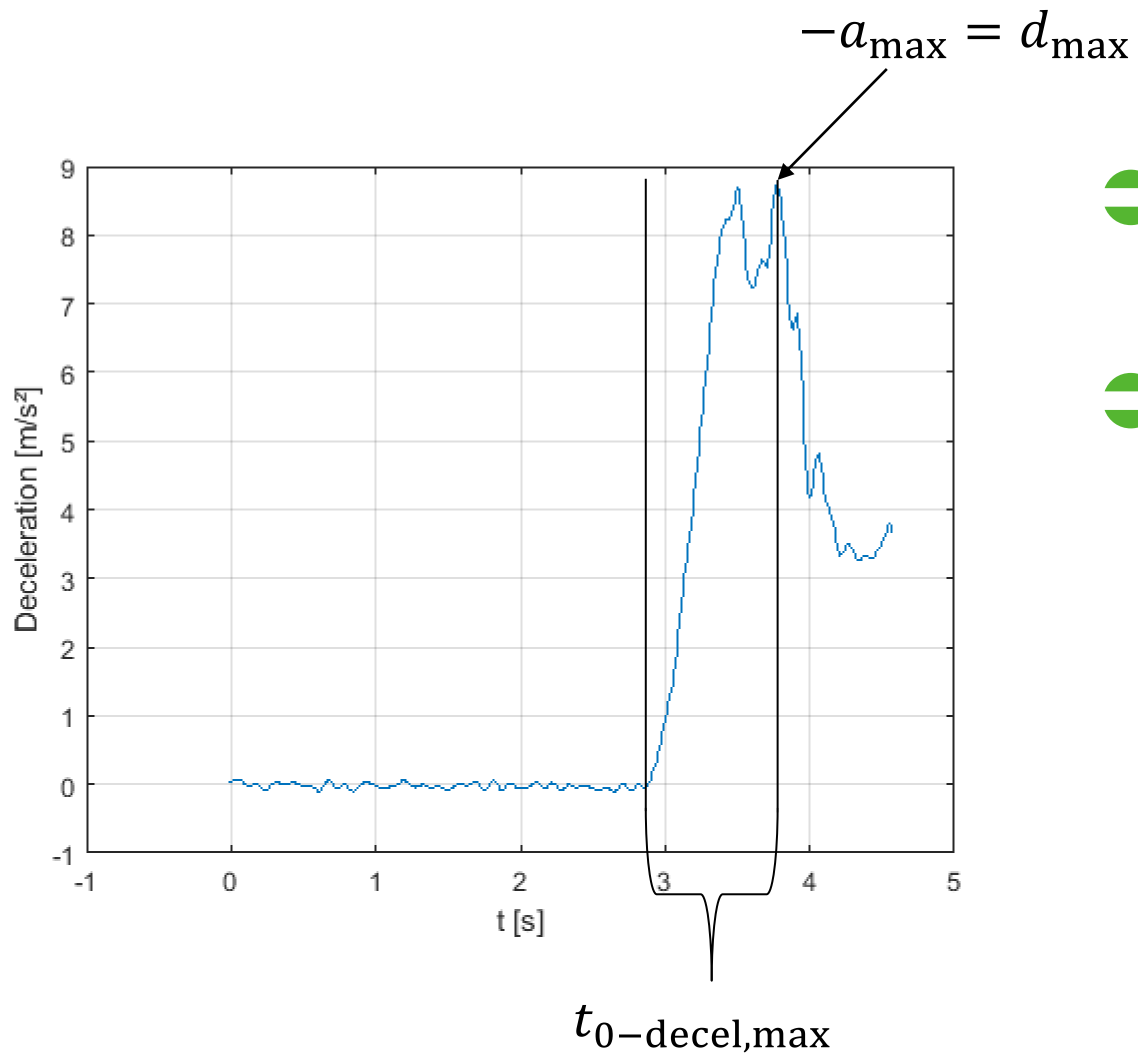


$$\tan\alpha = \frac{2\text{m}}{\Delta x_{\text{Camera}} + x_{\text{Veh}} - 1\text{m}} = \frac{y_{\text{Dummy,visible}}}{\Delta x_{\text{Camera}} + x_{\text{Veh}}}$$

$$y_{\text{Dummy,visible}}(x) = \frac{2\text{m} \cdot (\Delta x_{\text{Camera}} + x_{\text{Veh}})}{\Delta x_{\text{Camera}} + x_{\text{Veh}} - 1\text{m}}$$

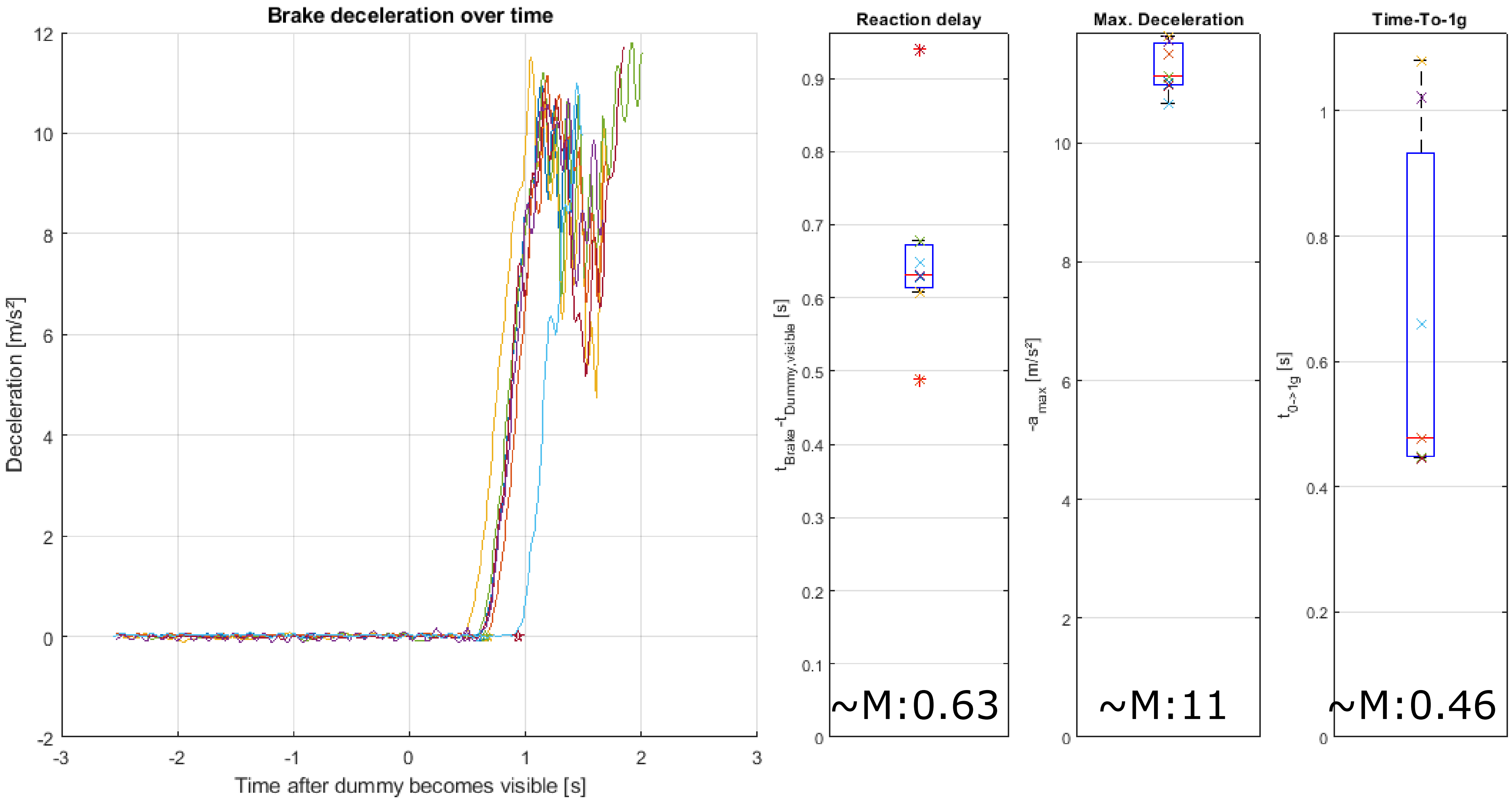
$$visible = \propto(x) \leq \alpha_{Camera} \vee y_{Dummy} \geq y_{Dummy,visible}$$

Brake system speed & deceleration



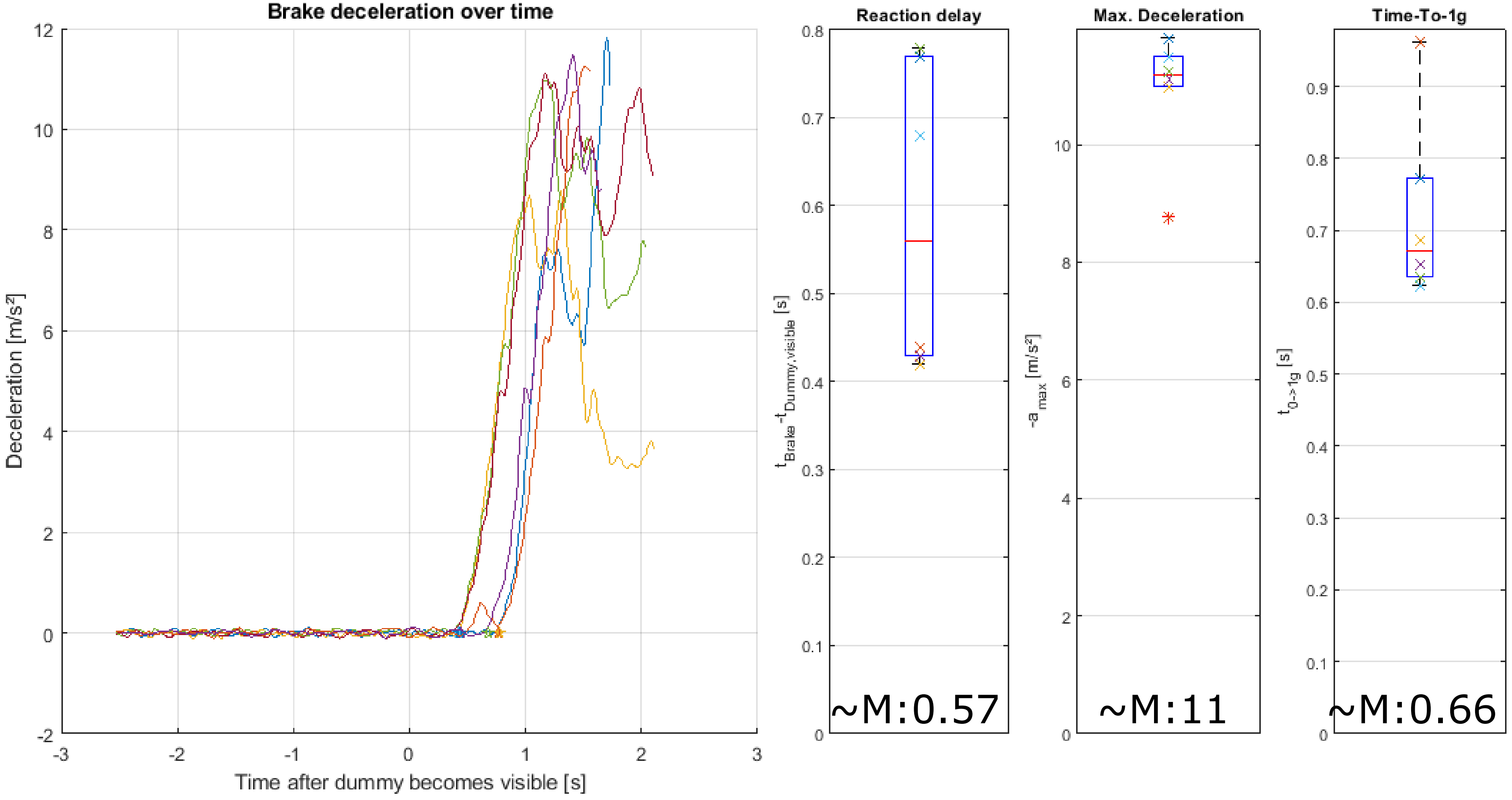
- **Brake system deceleration**
  - $d_{\max}$
- **Brake system speed**
  - $t_{0-1g} = t_{0-decel,max} \cdot \frac{9{,}81 m/s^2}{d_{max}}$

Small SUV

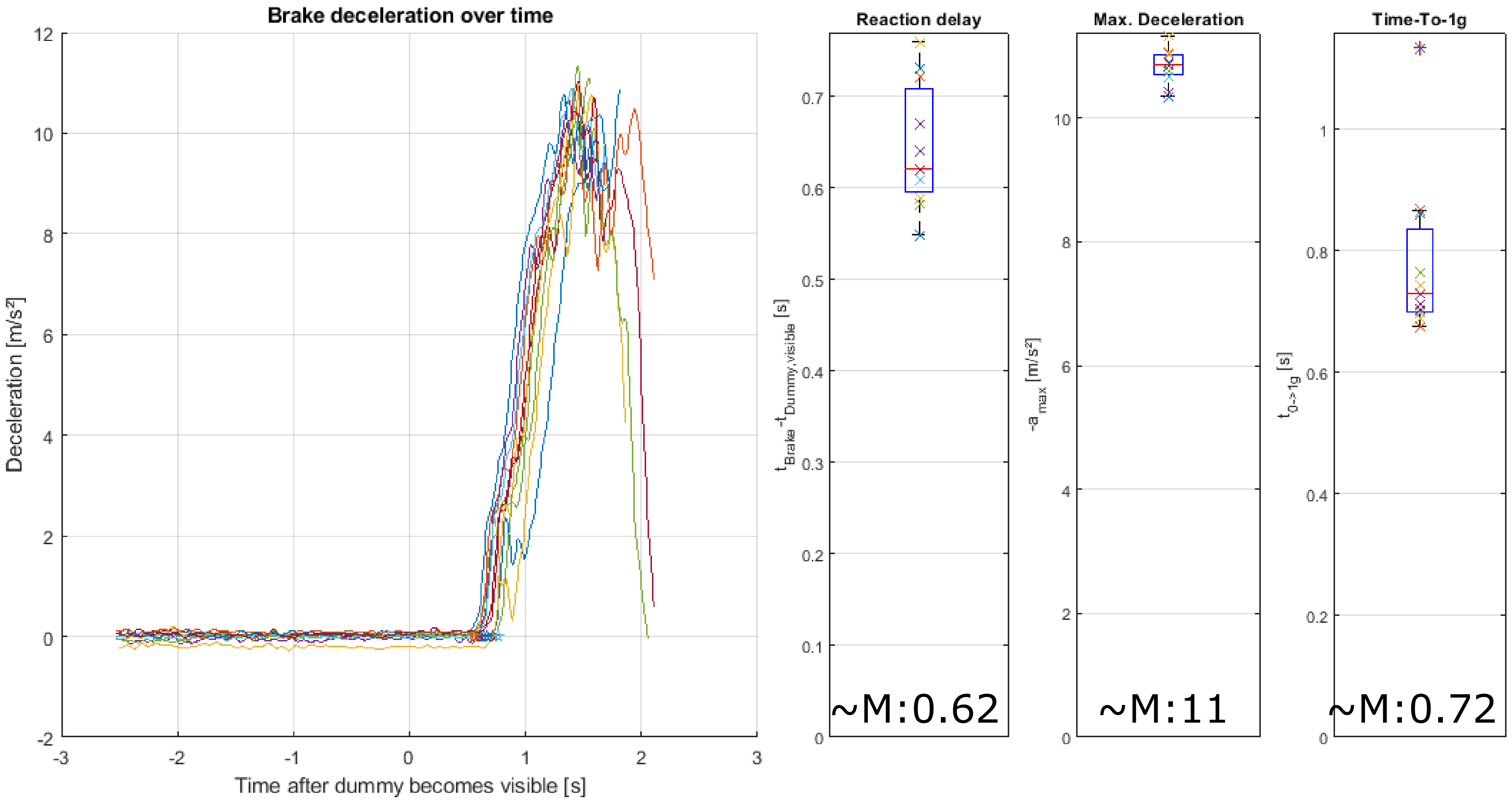


Brake deceleration over time
Deceleration [m/s²]
Time after dummy becomes visible [s]
Reaction delay
$t_{Brake}-t_{Dummy,visible}$ [s]
~M:0.63
Max. Deceleration
$-a_{max}$ [m/s²]
~M:11
Time-To-1g
$t_{0\to1g}$ [s]
~M:0.46

N1 Transporter



Large SUV



Brake deceleration over time
Deceleration [m/s²]
Time after dummy becomes visible [s]
Reaction delay
$t_{Brake}-t_{Dummy,visible}$ [s]
~M:0.62
Max. Deceleration
$-a_{max}$ [m/s²]
~M:11
Time-To-1g
$t_{0->1g}$ [s]
~M:0.72

State of the Art – Possible parameters

- These parameters show what is currently possible
- They should provide a reference for the expected performance in accident-prone situations (see slide 3)
- Reference: Performance, not behavior, should be required (slide 3)

- Reaction delay (object appearance → start of braking / swerving):
  Not more than 0.57 seconds
- Brake speed (time to reach 1 g):
  Not more than 0.5 to 0.66 s (depending on vehicle mass)
- *Maximum brake deceleration: not less than available μ!*
- *Steering performance – no systems available yet*