

Mid-Term Presentation 15 / 16 March 2022

How to specify behavior of automated vehicles in accordance with traffic rules and regulations?

A contribution to the overall approach of the VMM project

Hans Nikolaus Beck, Robert Bosch GmbH

Frank Junker, Robert Bosch GmbH

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Problem description automated vehicle

Rules for participation in road traffic (*Germany*)

The **behavioral requirements** from **codified sources** for automated vehicles require freedom from collisions, understandable behavior and compliance with applicable traffic regulations in the allowed area of operation.

selection

UN-Regulation ECE-R157 for ALKS¹ 25.06.2020 *extraction*

5.1.1 ... The activated system **must not** cause any **collisions**, ...

5.1.2 ... The activated system **must comply with the traffic regulations** for the DDT² in the **country of use**.

ISO TR 4804: 2020.03 (SaFAD) *extraction*

4.4.3.7 Behavior in traffic: Behavior **be easy to understand**, ... also **predictable** and **manageable**.

4.4.3.7 Conforming to rules: ... **complies** with all applicable **traffic rules** must be ... observed. ...

5.2.5.2 FS_4: Create a **collision-free** and **lawful driving** plan (*explicit as well implicit traffic rules*)

UNECE GRAV-FRAV: 2021.11 *extraction*

1. ADS³ should **drive safely**: The ADS should **comply with traffic regulations**.

In Germany, **these behavioral requirements** are represented by requirements from the **Road Traffic Act (StVG⁴)** and the **Road Traffic Regulations StVO⁵**.

1) ALKS=Automated Lane Keep System
 2) DDT = Dynamic Driving Task

3) ADS = Automated Driving System

4) Straßenverkehrsgesetz
 5) Straßenverkehrsordnung

Forms for description of traffic behavior that conforms to the rules

Significance of descriptions of traffic behavior

The **basic prerequisite** for the **homologation capability** of an automated vehicle is the specification of the **traffic behavior descriptions** with the concretion of the quality and tolerance criteria. These quantified behavioral criteria relate to their technical significance, their implementation and their verification / validation.

It must be clearly **specified** and **verifiable** ...

... which traffic behavior “is **compliant**” and which “is non-compliant”.

Sources for quality and tolerance criteria for specifying such traffic behavioral descriptions are ...

(for example)

... in following to rules-compliant traffic behavior

... in avoiding illegal traffic behavior

... in learning from **documented accidents**

... in elaboration, argumentation, proof and legal coordination of **development results**.

How can rules-compliant traffic behavior be specified?

Methodical approach

In the following, a scenario based methodical procedure for determining and specifying compliant traffic behavior for automated vehicles is presented.

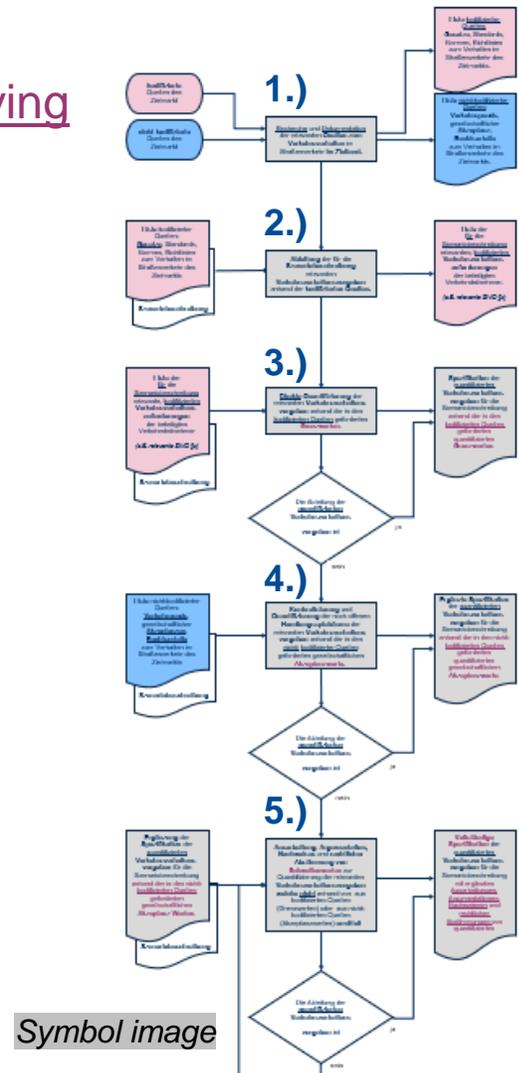
The scenario-based procedure is carried out in 5 steps:

- 1.) Determination of the sources for the traffic behavior in the **target country**.
- 2.) Derivation of the relevant, legal traffic behavior specifications.
- 3.) Direct quantification based on the **legal texts**.
- 4.) Quantification of scope of action based on **traffic laws**.
- 5.) Completion of quantification by means of **development services**.

Remark:

This methodical approach **focuses** on the aspects of compliant traffic behavior.

Questions about the **completeness** of the scenarios and questions about **interrelation** of the requirements of society, law and ethics will be taken up in other lectures at this event.



Symbol image

Specification of traffic behavior in compliance with the rules

Determination of the sources for the traffic behavior in the target country

1.) The **relevant sources** on road traffic behavior in the target country have been researched and documented.

The **target market** intended for the product application is defined.

The relevant **sources** on road traffic behavior in the destination country have been researched and documented.

Result: List of relevant **codified sources**: A.o. laws, standards, norms, guidelines, ...

for example:

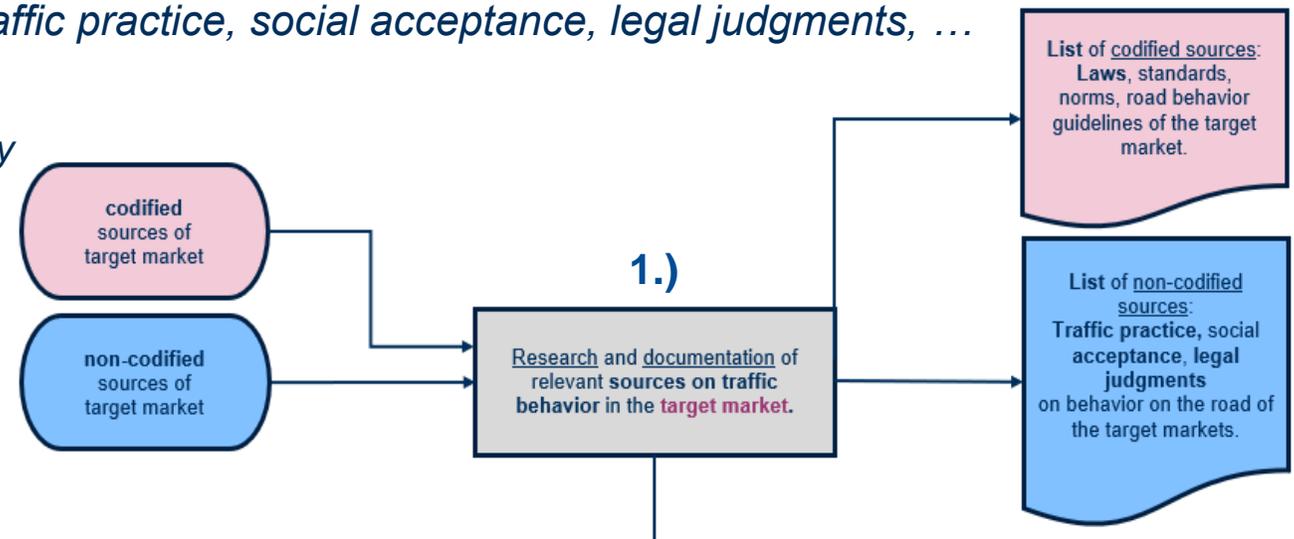
e.g. road traffic regulations (e.g. StVO), traffic offences (e.g. catalog of fines), ...

Result: List of relevant **non-codified sources**: A.o. traffic practice, social acceptance, legal judgments, ...

for example:

e.g. landmark legal judgements of the target country

e.g. accident database (e.g. of insurers, NHTSA)



Specification of traffic behavior in compliance with the rules

Derivation of the relevant, legal traffic behavior specifications

2.) The relevant traffic behavior specifications for the scenario description are **derived** from the codified sources.

The **codified sources** are analyzed with respect to the relevant **traffic behavior** specifications for the **scenario**.

Result: **List** of the relevant, codified **traffic behavior requirements** of the road users involved for the scenario.

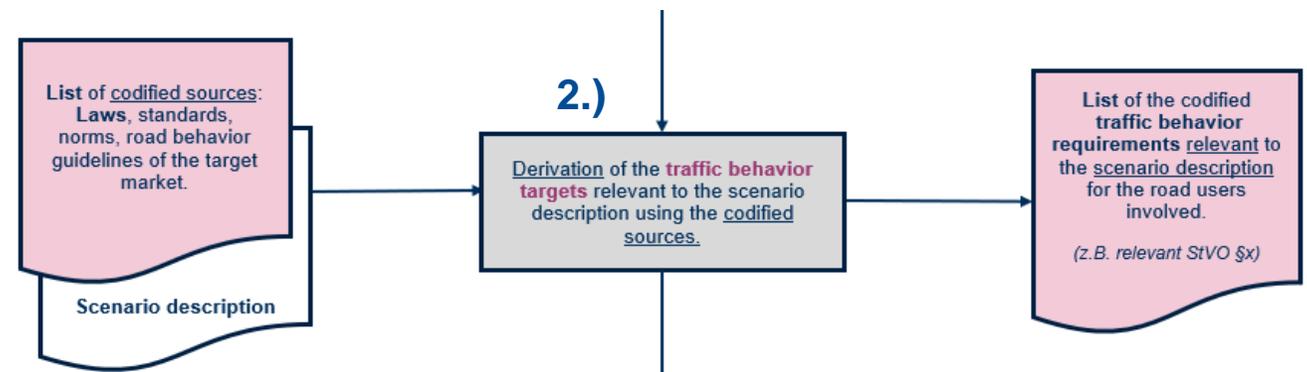
for example:

e.g. german road traffic regulations: StVO §2 Absatz (3a) - while driving ... distance ... at least half of the speedometer in km/h ...

e.g. german catalog of fines (Bußgeldkatalog): e.g. distance violation at less than 80 km/h with danger is, ...

e.g. UN ECE-R157 ALKS - e.g. Traffic critical scenarios: "Cut in", ...

e.g. ISO TR 4804: 2020.03: 4.3.2.10 Behavior on the street: The behavior must ... easy to understand, ... predictable and clear.



Specification of traffic behavior in compliance with the rules

Direct quantification based on the quantified wording of codified sources

3.) A **direct quantification** of the relevant **traffic behavior specifications** is carried out, as far as possible, based on the **permissible limit values** required primary by the codified sources.

The required **traffic behavior**, e.g. from **wording of law**, is **analyzed** with regard to a **directly usable quantifications** for the scenario description.

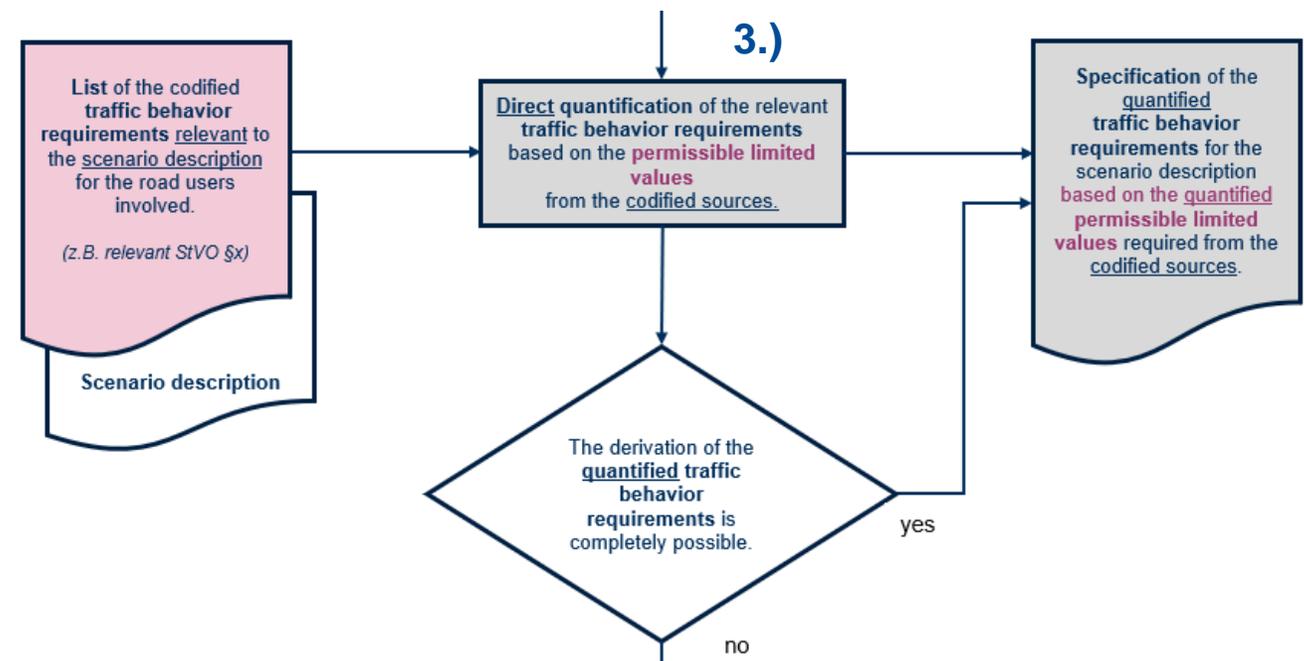
Results:

for example:

- e.g. quantitative limit values
- e.g. quantitative quality criteria
- e.g. quantitative tolerances

for e.g.:

- a.o. distance, velocity, deceleration, ...
- a.o. perception, reaction time, ...
- a.o. behavior, cooperation, right of way, ...



Specification of traffic behavior in compliance with the rules

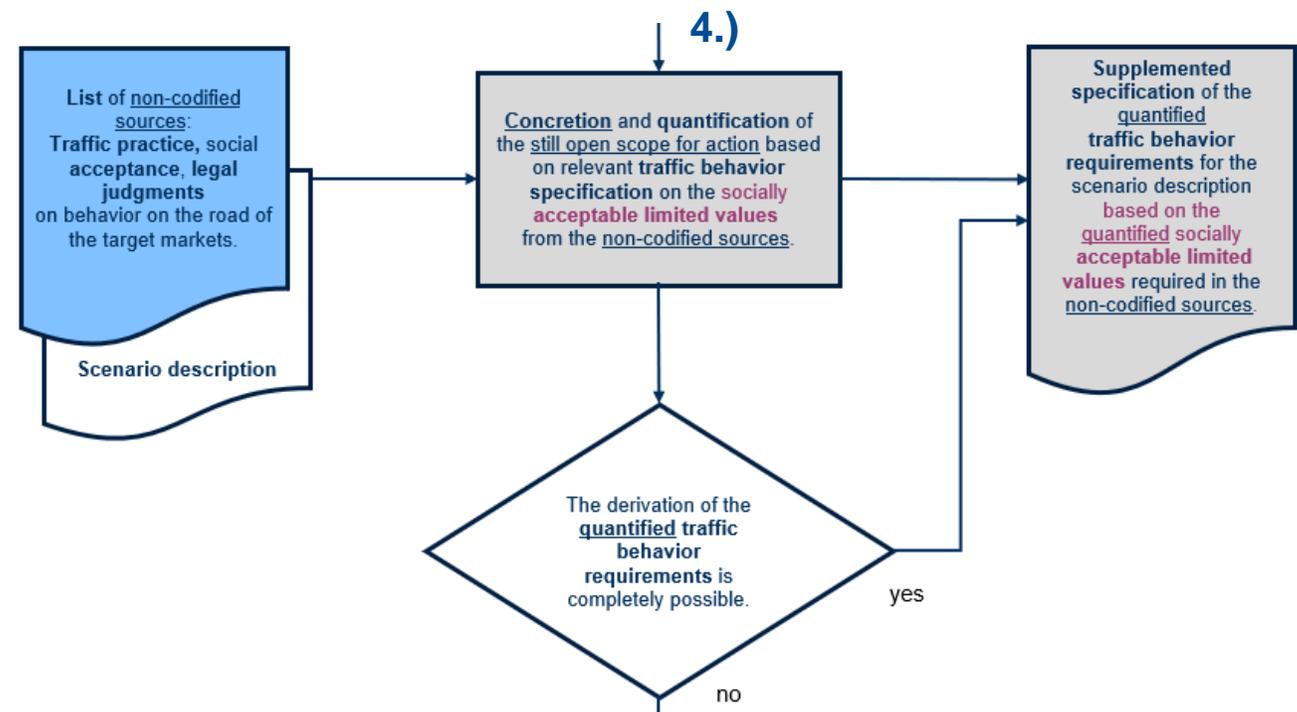
Quantification of open scope of action based on traffic laws

4.) A **concretion** and **quantification** of the open scope for action of the relevant traffic behavior specifications is carried out, as far as possible, based on the socially acceptable limited values required in the non-codified sources.

Legal requirements allow **scope of action** for the correct interpretation in relation to the specific driving situation. The limits of this **interpretation** result from **traffic law**.

Result: The **scope of action**, which is still open, for the scenario description from required traffic behavior specifications can **concretise** and, if necessary, **quantified** with the help of **landmark legal judgements** from traffic law.

It should be noted that the legal rulings from traffic law often only refer to **selected traffic scenarios** and can therefore only **generalized** to a limited extent.



Specification of traffic behavior in compliance with the rules

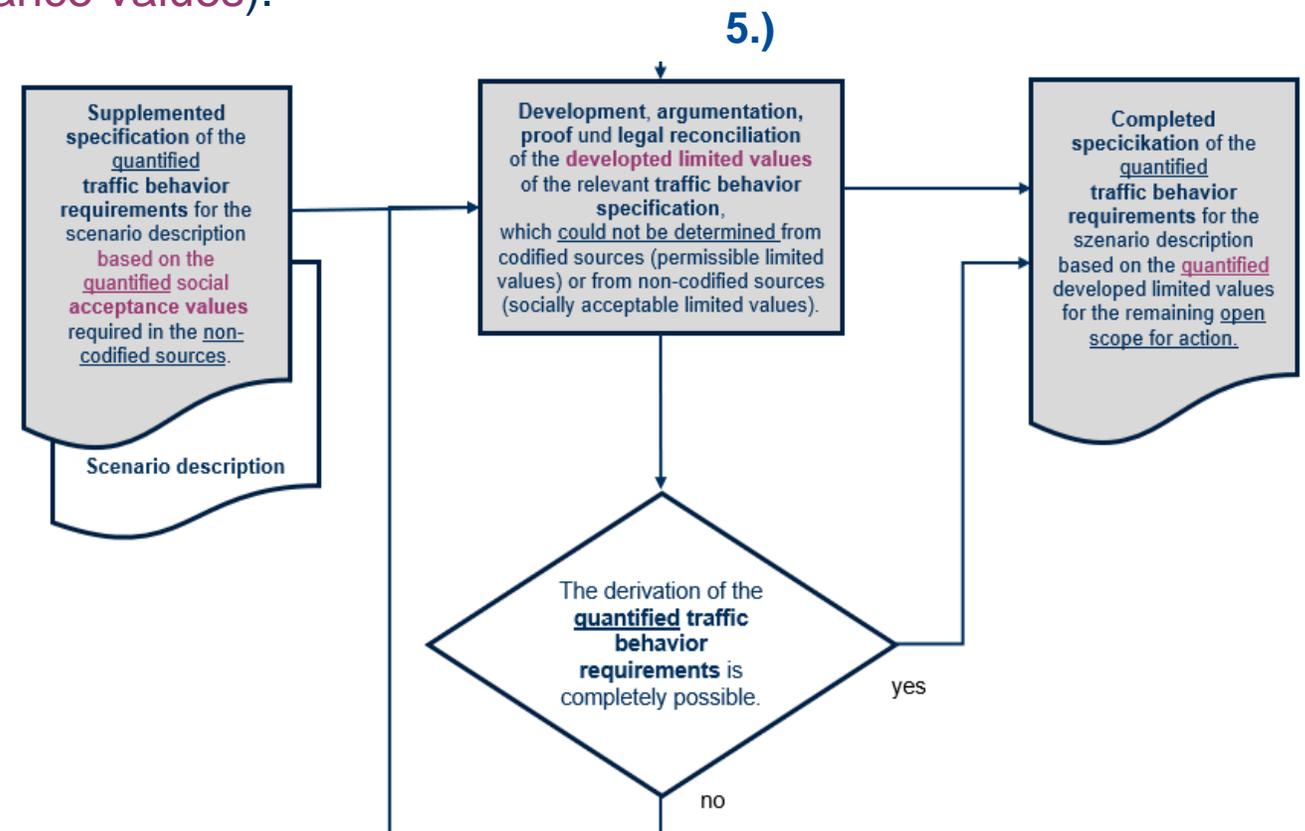
Completion of quantification by means of development services

5.) The **elaboration, argumentation, proof** and **legal reconciliation** of threshold values for the quantification of the relevant traffic behavior specifications which could not be determined using **either** codified sources (limit values) or non-codified sources (acceptance values).

Legal texts do not provide any possibility of **direct quantification**, and **traffic law** does not provide any possibility of **quantifying freedom of action**.

The **quantification** of the relevant traffic behavior specifications are carried out by the **development activities** elaborated, argued and supported by **evidence**. Finally, the quantifications developed are subjected to a **legal reconciliation**.

Result: The **quantified threshold values** for the traffic target behavior are specified.



Specification of traffic behavior in compliance with the rules

Where to expect a pedestrian crossing? (for example: Germany)

The **design** of the **traffic area** is described by the **VwV-StVO**¹ (administration regulation for the StVO).

This regulation characterizes the **design** of **traffic signs** and **traffic facilities**, including where and how pedestrian crossings are **installed** and **designed**. (for example)

Where are pedestrian crossings expected?

Def.: VwV-StVO § 26 pedestrian crossing

- within built-up area
- only on roads with a maximum speed of 50km/h
- if there is a walkway on both sides
- are in the direction in which pedestrians are walking
- not at intersections and junctions with a right of way that turns off

=> **A0 - Traffic area pedestrian crossing** (for example)

How pedestrian crossing be identified?

Def.: VwV-StVO § 42 direction signs / § 26 marking pedestrian crossing

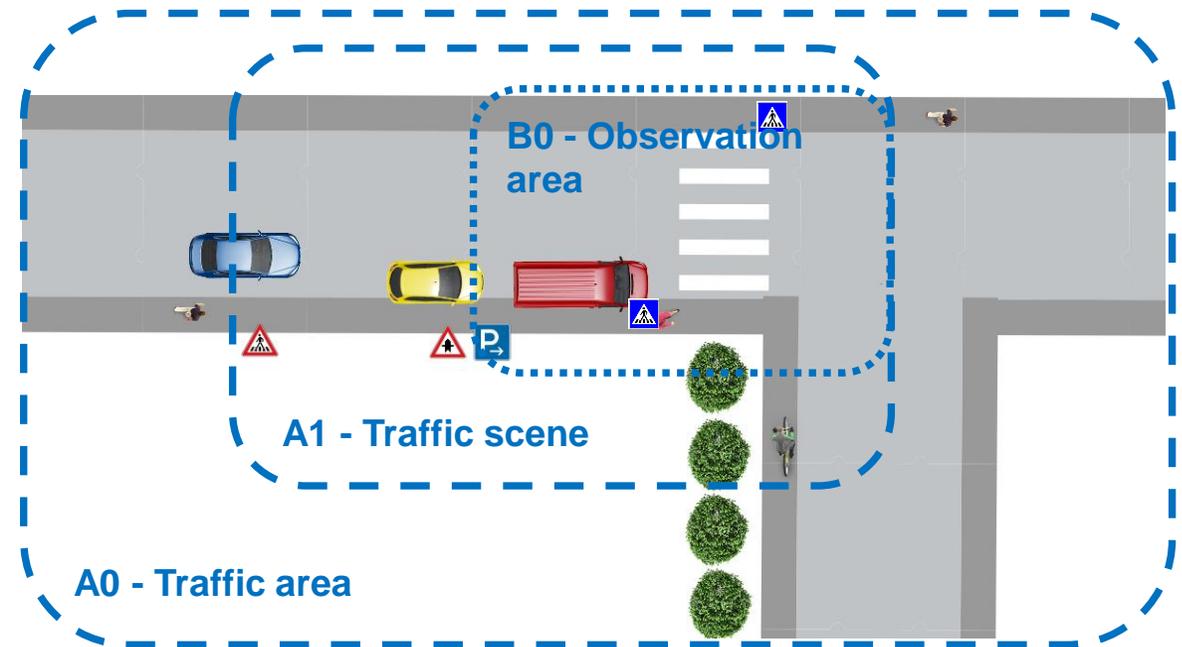
- at the indication of pedestrian crossings by sign 350
- at the marking of the pedestrian crossing by sign 293

What to observe at a pedestrian crossing?

Def.: StVO § 26 pedestrian crossing

- observance of the StVO - § 26 pedestrian crossing
- observance of other, situational StVO - §

=> **B0 - „Observation area“ of the pedestrian crossing** (for example)



1) http://www.verwaltungsvorschriften-im-internet.de/bsvwwvbund_26012001_S3236420014.htm

Specification of traffic behavior in compliance with the rules

Interim results from Step 4 (for example)



B1 - Range of protection at pedestrian crossing (for example)

The **range of protection** for pedestrian extends **up to 4 meter** beyond the marking of the pedestrian crossing.

Sources geman raffic law (selection):

according to: Ha (VRS 54, 223 = StVE 9): *Fußgängerschutzbereich bis mind. 4 m seitlich*

according to: OLG Koblenz (VRS 49, 140): *gilt er 14 Schritte seitwärts nicht mehr;*

according to: Booß (Anm 1): *bis zu 4 m seitwärts und*

according to: Bay (VM 78, 76): *nicht mehr 6–8 m daneben*

according to: OLG Karlsruhe VRS 44, 370 = StVE 2): *...der Kraftfahrer damit rechnen, dass Fußgänger die Fahrbahn einige Meter neben dem Zebrastreifen überschreiten.*

With moderate speed when approaching (for example)

A **moderate speed** when approaching pedestrian crossing is **less than 30 km/h** under optimal conditions.

The person who can **stop without emergency braking** drives at a **moderate speed**.

Sources geman raffic law (selection):

according to: OLG Frankfurt (DAR 68, 247); OLG Schleswig (VM 76, 38): *IdR sind 25–30 km/h mäßig*

according to: OLG Düsseldorf DAR 74, 160): *40-50 km/h dagegen nicht mehr mäßig, weil dann kein rechtzeitiges Anhalten mehr möglich ist.*

according to: *Praxiswissen Verkehrsrecht von Robert Daubner*): *derjenige, der ohne Gefahrbremung anhalten kann, fährt mit mäßiger Geschwindigkeit.*

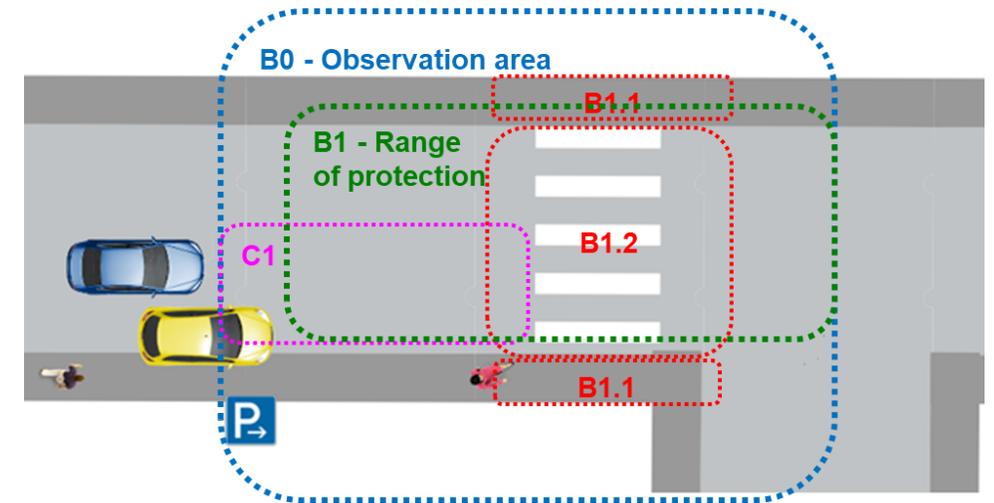
Also to consider: StVO § 3 Speed

according to the possibility of observation,

the width of the vehicle,

the behavior of pedestrians and

the line of travel (OLG Celle VM 75, 71).



Bereiche am Zebrastreifens (for example)

B0-Observation area

B1-Range of protection

B1.1 typical entry range

B1.2 typical passing zone

C1 typical deceleration / stop zone

Thank you!

Hans Nikolaus Beck, Robert Bosch GmbH

Frank Junker, Robert Bosch GmbH



**A project developed by the
VDA Leitinitiative
autonomous and connected driving**

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