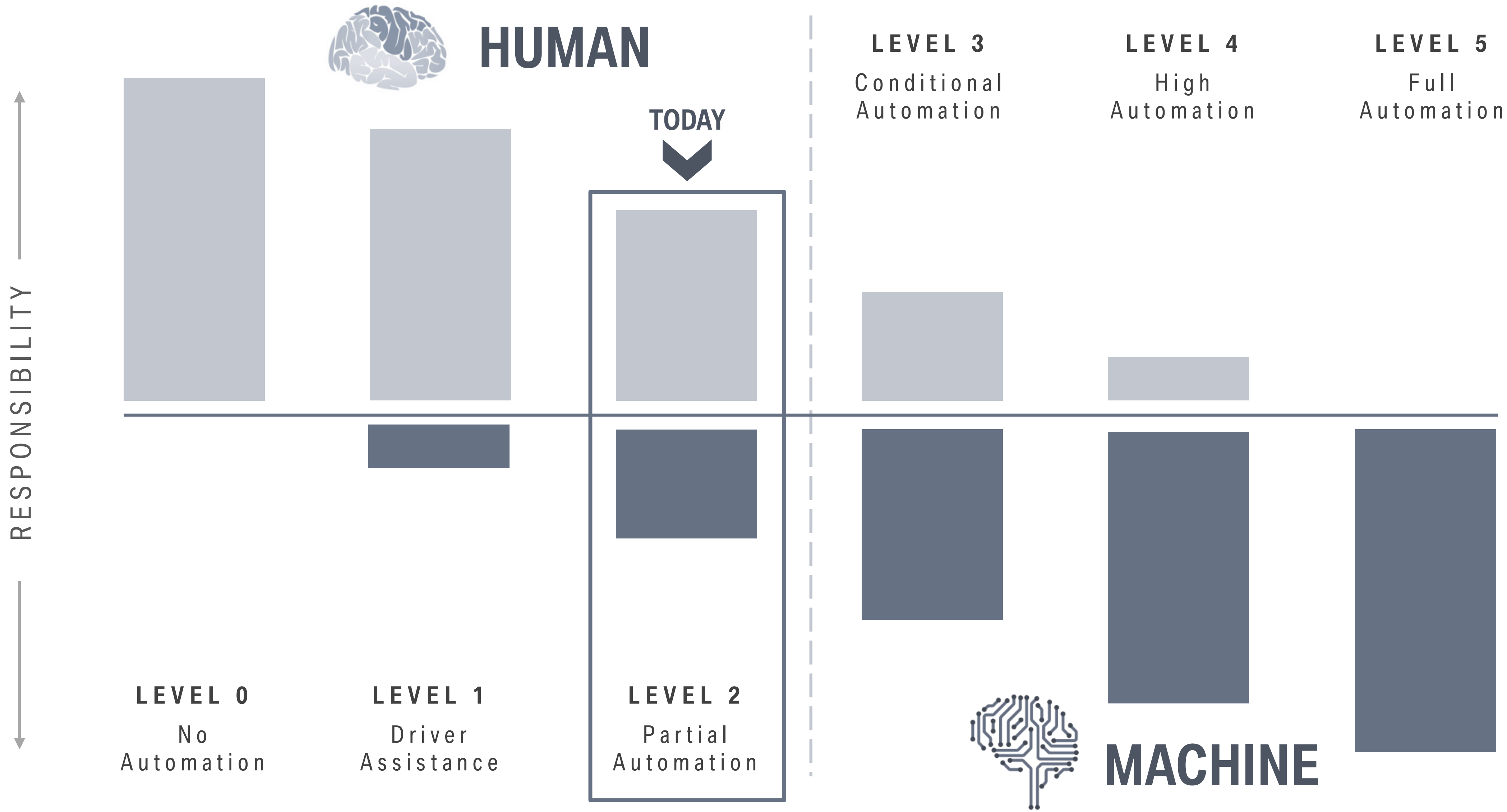
AKTIVE SICHERHEIT 4.0

Prof. K. Kompass, Dr. S. Nitsche April 2017

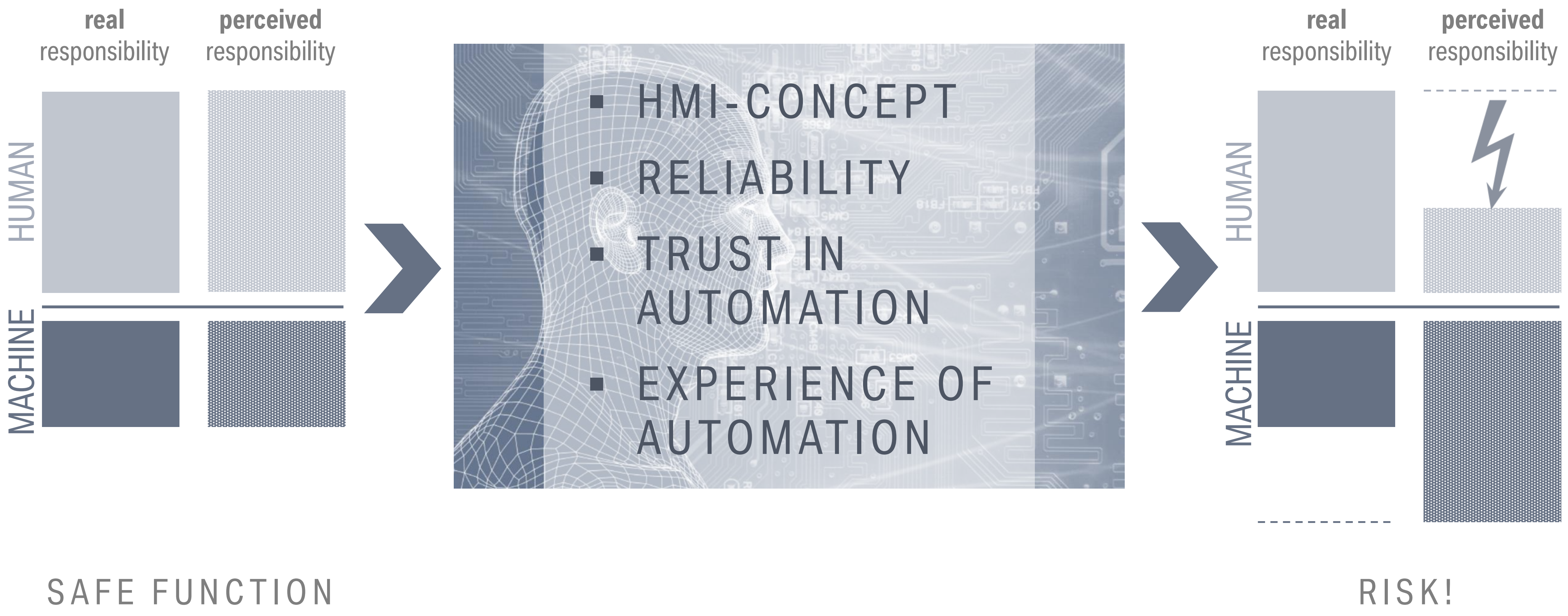
BMW GROUP THE NEXT 100 YEARS

YERKES–DODSON KURVE –
AUTOMATED DRIVING AND ACTIVE SAFETY.

LEVELS OF AUTOMATION – WHO IS RESPONSIBLE?



THE DISTRIBUTION OF RESPONSIBILITIES BETWEEN DRIVER AND CAR MUST BE CLEAR TO THE DRIVER AT ANY TIME.



DEFINITION OF "SAFETY IN USE" AND "FUNCTIONAL SAFETY".

"SAFETY IN USE"

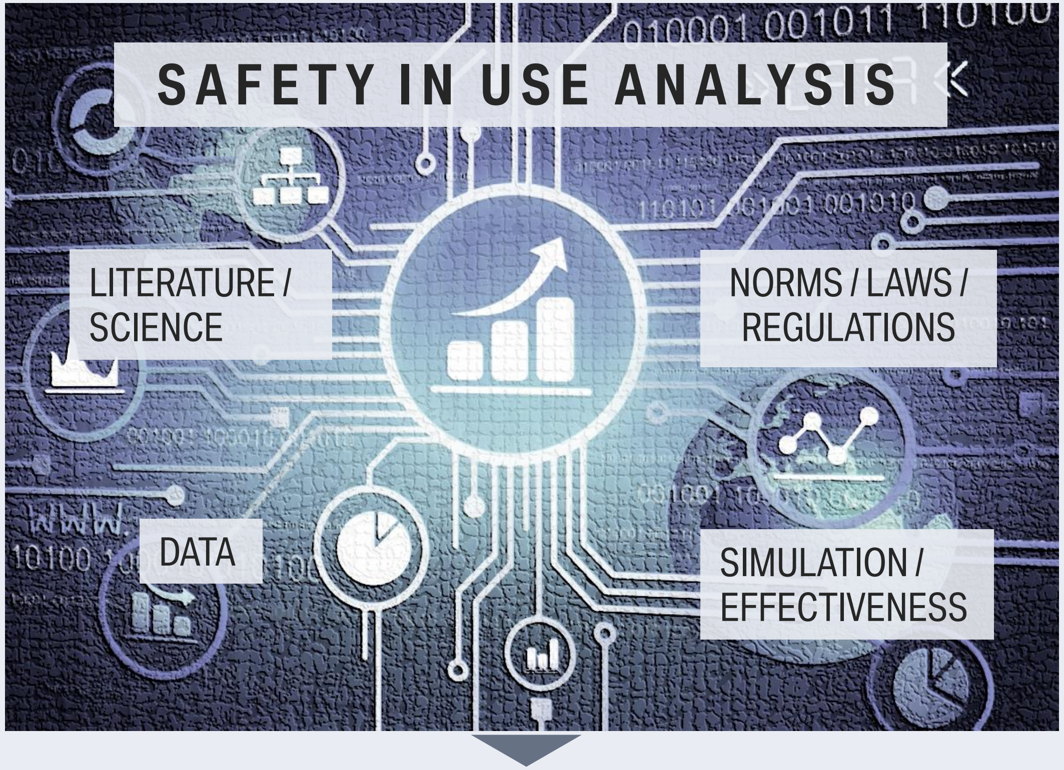
A function is safe if its proper use or its predictable misuse do not result in intolerable risk for people.

<u>Focus:</u>
System limits

"FUNCTIONAL SAFETY" (ISO 26262)

A function is safe if malfunctions do not result in intolerable risk for people during proper use or predictable misuse.

<u>Focus</u>
System failures



RISK EVALUATION =
SEVERITY x NON-CONTROLLABILITY x EXPOSURE

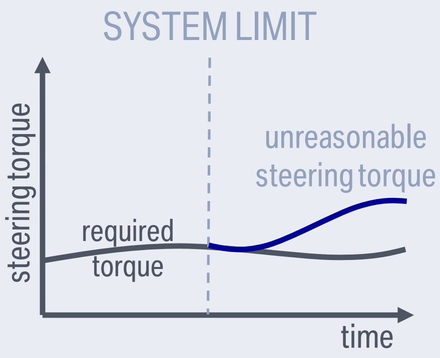
EXAMPLES OF SAFETY IN USE AND FUNCTIONAL SAFETY.

SAFETY IN USE

e.g. misinterpretation of structures as lane markings.
→ Unreasonable steering torque!

SYSTEM LIMIT (Safety in Use)

Possible measures: Plausibility check of markings and maneuvers, transparent limits & responsibilities…

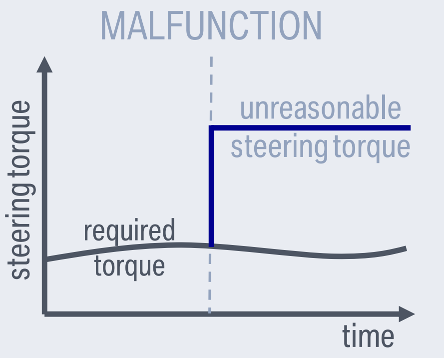


FUNCTIONAL SAFETY (ISO 26262)

e.g. hardware failure.
→ Unreasonable steering torque!

MALFUNCTION (Functional Safety)

Possible measures: Limitation of maximum steering torque, ASIL classification for input signals, redundancy…

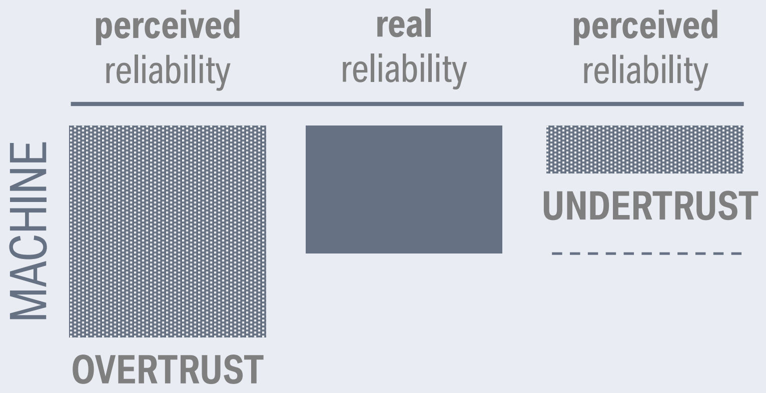


MODERATING TRUST IN AUTOMATION.

TRUST IN AUTOMATION

The design of a function (HMI, limits, use-cases, warnings, marketing,…) may lead to too much trust : “overtrust” - as well as too little: “undertrust”.

Inappropriate trust levels may lead to misuse, abuse or disuse, resulting in possible impairment of driving safety or reduction of potential safety benefits, gained by the introduction of automated driving functions.



MODERATING TRUST LEVELS

Moderating system trust by conceptual adaptions to adjust the **perceived reliability** to the **actual reliability** of the system.

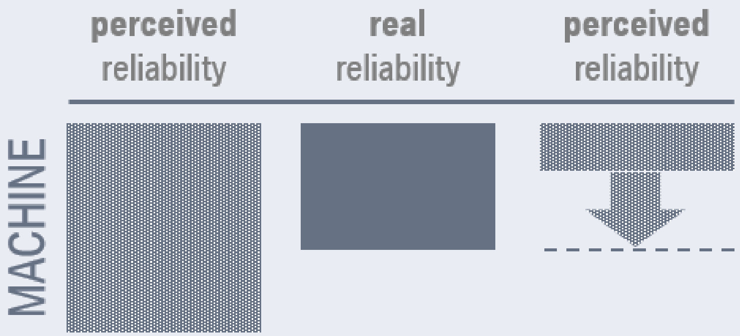
Examples:

“Steering and lane control assistant”

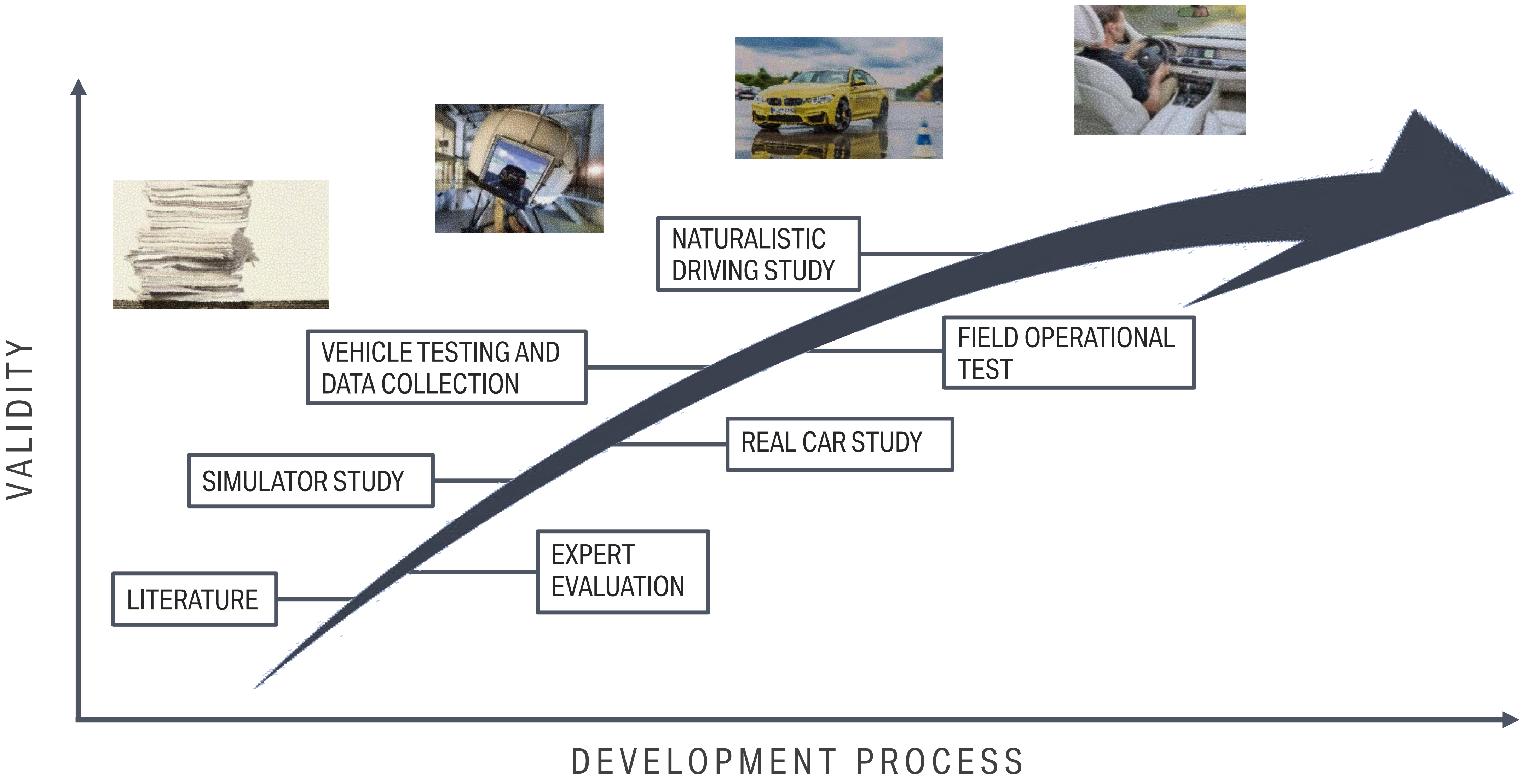
“Silent” system limits

Cooperative steering characteristic

Immediate Hands-On request



DATA COLLECTION.



EVALUATION OF A LEVEL 2 FUNCTION STEERING AND LANE CONTROL ASSISTANCE (SLA).

SAMPLE

- **N** = 18 CUSTOMERS (1 MONTH / CUSTOMER)
- **AGE** = 38-65 YEARS
- **GENDER** = 2 WOMEN, 16 MEN
- **EXPERIENCE** = ACC, NAVIGATION

- **DRIVING PERFORMANCE** = > 600 Mi / MONTH
- **STREET TYPE** = AT LEAST 3-4 DRIVES ON HIGHWAY / WEEK
- **ATTITUDE** = OPEN TO AUTOMATED DRIVING AND NEW TECHNOLOGIES

IMPLEMENTATION

RESEARCH QUESTIONS.
MAIN FOCUS.

ANALYSIS OF SAFETY IN USE BY COMBINING **OBJECTIVE** MEASUREMENTS WITH **EXPLORATIVE** INTERVIEWS.

SLA USAGE BEHAVIOR

HOW **OFTEN** AND IN WHICH **SITUATIONS** IS SLA USED?

→traffic or weather conditions, street type, etc.

DRIVER BEHAVIOR

HOW DO DRIVERS **BEHAVE** WHEN USING A LEVEL 2 DRIVING FUNCTION (SLA)?

→ Attention rate

→ Hands-off time and frequency

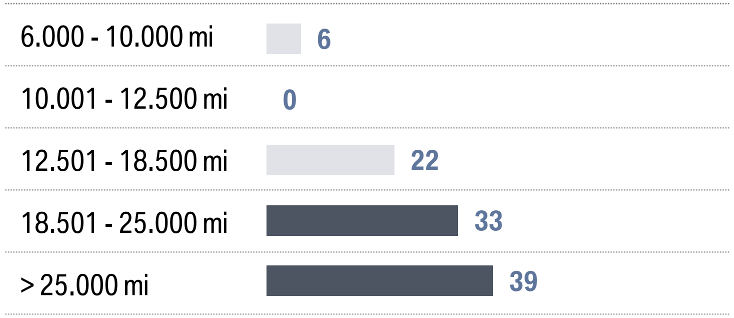
CRITICAL SITUATIONS

DO ANY **CRITICAL** DRIVING SITUATIONS OCCUR DUE TO THE USE OF SLA?

RESULTS.
VEHICLE USAGE.

EVERYDAY/ ANNUAL DRIVING PERFORMANCE, TYPICAL TRIP PROFILE, USAGE

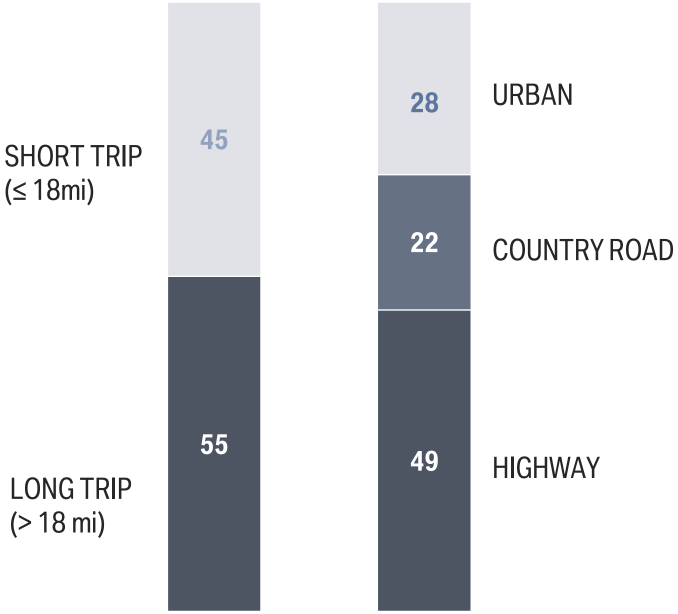
ANNUAL DRIVING PERFORMANCE [IN %]



EVERYDAY DRIVING PERFORMANCE [AVERAGE]

ca. 62 mi

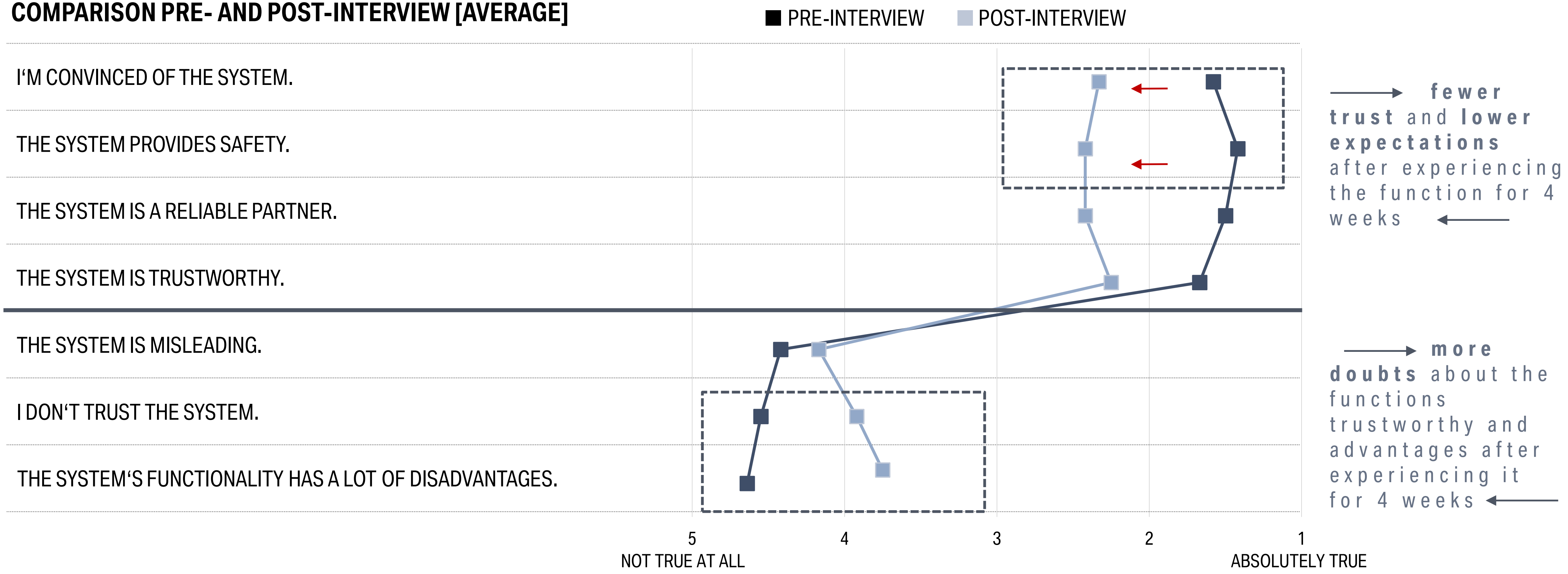
TRIPS [IN %]



SAMPLE SHOWS A HIGH EVERYDAY DRIVING PERFORMANCE WITH A HIGH PROPORTION OF TRIPS ON A HIGHWAY, WHICH GENERATED A **LARGE DATA** SET WITH SLA-USAGE.

RESULTS.
SYSTEM EVALUATION OF SLA.

COMPARISON PRE- AND POST-INTERVIEW [AVERAGE]



EXPERIENCING THE FUNCTION FOR 4 WEEKS, DRIVERS DEVELOPED MORE REALISTIC **TRUST** AND **EXPECTATIONS**.

RESULTS.
EYE GAZE BEHAVIOR.

VIDEO ANALYSIS RESULTS

PROPORTION OFF-ROAD GLANCE TIME [IN %]

WITH ACTIVE SLA	WITHOUT SLA
Ø 4%	Ø 3%

DURATION OFF-ROAD GLANCES [AVERAGE AND %]

Ø 3 Seconds

	< 5 sec	5-10 sec	>10 sec
WITH ACTIVE SLA	70	13	17
WITHOUT SLA	76%	10%	14%

STREET TYPE & OFF-ROAD GLANCES [IN %]

	WITH ACTIVE SLA	WITHOUT SLA
HIGHWAY	6	2
URBAN TRAFFIC	6	3
COUNTRY ROAD	6	4

SPEED RANGE % OFF-ROAD GLANCES [IN %]

	WITH ACTIVE SLA	WITHOUT SLA
<20 mi/h	10	3
20-40 mi/h	4	3
40-60 mi/h	6	4
60-90 mi/h	6	1
>90 mi/h	1	0

TRAFFIC SITUATION & OFF-ROAD GLANCES [IN %]

	WITH ACTIVE SLA	WITHOUT SLA
TRAFFIC JAM	18	9
STOP & GO	11	7
FREE DRIVE		2

WITH **ACTIVE SLA**, DRIVERS SHOW **OFF-ROAD GLANCES** SLIGHTLY MORE OFTEN, ABOVE ALL IN TRAFFIC JAMS, STOP & GO TRAFFIC OR AT LOW SPEEDS. THE **DURATION** OF OFF-ROAD GLANCES DIFFERS ONLY SLIGHTLY BETWEEN USING/NOT USING SLA.

RESULTS.
HANDS-OFF BEHAVIOR.

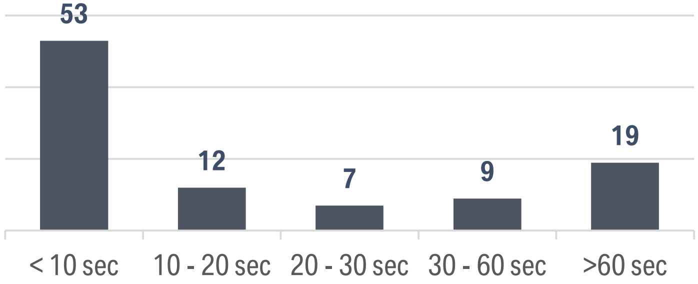
VIDEO ANALYSIS RESULTS

PROPORTION HANDS-OFF TIME [AVERAGE WHILE SLA-USAGE]

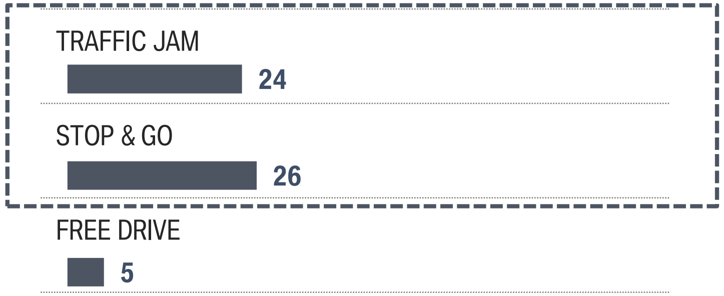
Ø 7%

DURATION HANDS-OFF [AVERAGE AND IN %]

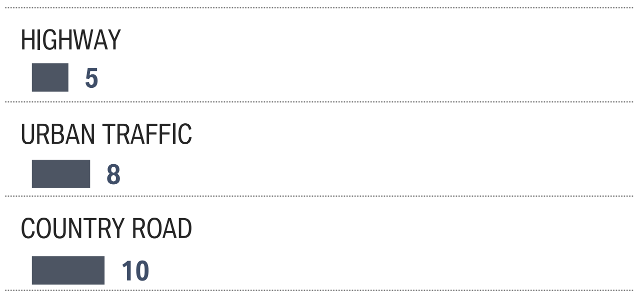
Ø 19 Seconds [Median]



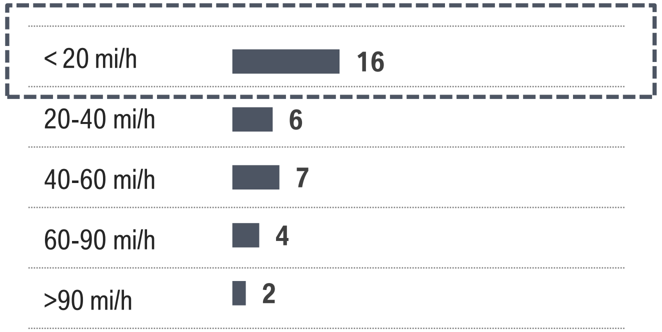
TRAFFIC SITUATION & HANDS-OFF [IN %]



STREET TYPES & HANDS-OFF [IN %]



SPEED RANGE & HANDS-OFF [IN %]



DAYLIGHT / NIGHT & HANDS-OFF [IN %]

WITH **ACTIVE SLA**, DRIVERS DO TAKE OFF HANDS OCCASSIONALY, ABOVE ALL IN TRAFFIC JAMS OR STOP & GO TRAFFIC AND AT LOW SPEED RANGES. THE **DURATION** IS MOSTLY LOWER THAN **10 SECONDS**.

CONCLUSIONS.

1. Increasing **automation** poses new **challenges** to human-machine-interaction.
In the course of this, considering **safety in use** becomes more and more relevant.

2. With a **safety in use analysis**, requirements for the technical and conceptional implementation of a function are defined.

3. As part of an **iterative** process, the function is **evaluated** periodically (e.g. with customer studies).
A function is only **released**, after its **safety in use** and **functional safety** are ensured.

4. A **real life observation** with video-tracking in form of a **field operational test** with clients, offers a valid data base to develop and evaluate the safety in use of **advanced driver assistance systems.**

5. For further evaluations on driver behavior in realistic traffic situations (level of trust, take over times, higher levels of automation, …) **enhanced simulator tools** need to be established.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