HADRIAN

Holistic Approach for Driver Role Integration and Automation Allocation for European Mobility Needs

Quantifying the Safety Impact of Innovations to Improve Take-Over Performance from Automated to Manual Driving

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virtual vehicle

www.hadrianproject.eu/

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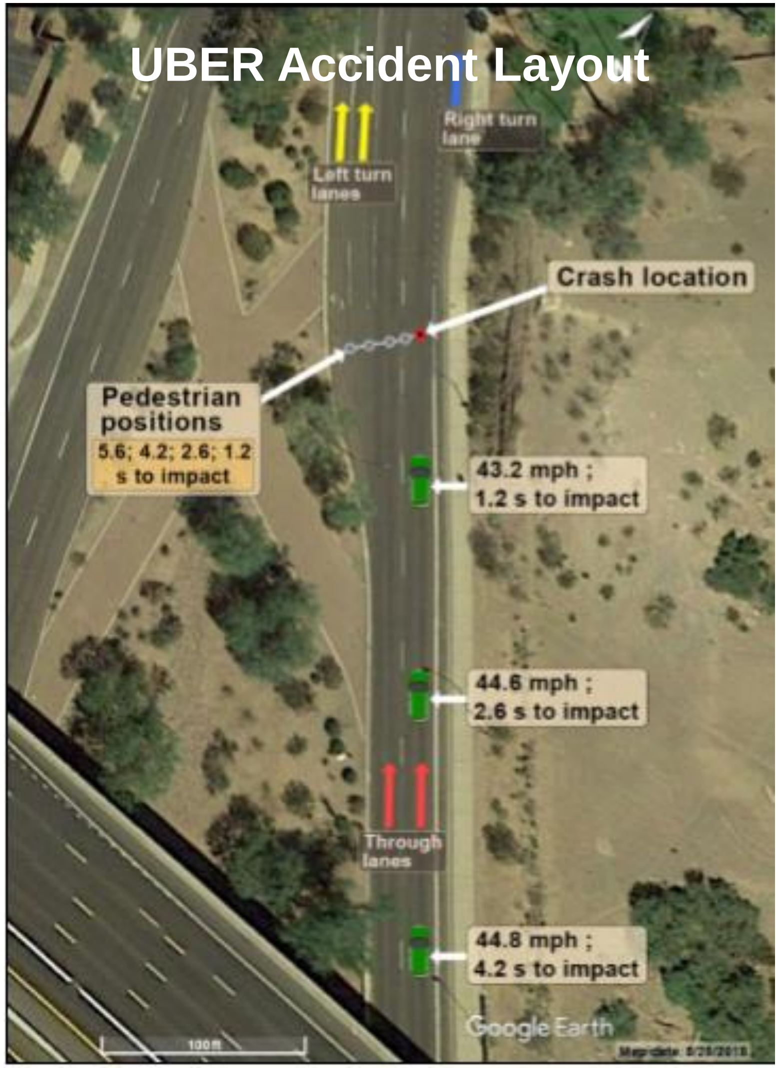
PROJECT

- **Response to call** H2020-DT-ART-2018-2019-2020
  - Human centred design for the new driver role in highly automated vehicles
  - **Coordinator**: VIF
  - **Duration**: 42 Months
  - **Start**: Dec 2019
  - **Funding**: 8 Mio EUR

MOTIVATION AND APPROACH

- An example for the severity of this problem comes from an accident with a automated driving vehicle on March 18, 2018
  - Safety driver appeared unable remain vigilant and monitor the situation
    - https://www.youtube.com/watch?v=RASBcc4yOOo



ADL 3 CHALLENGES FOR HUMAN DRIVERS

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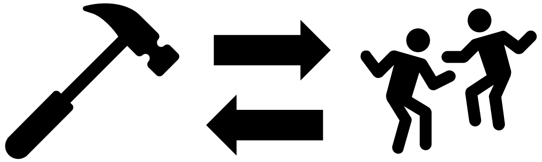
"Solutions need to be developed **to ensure both a safe transfer between use cases with different automation levels and that drivers always have a very clear understanding** about the degree of automation enabled in each situation." (DT-ART-03 call text)

Watching versus doing

- Safely taking back driving responsibilities after periods of AD
  - Difficulty of building sufficient situation awareness
  - Difficulty of human drivers to continuously monitor automation
  - Humans are good controllers but bad monitors

Novel Tasks



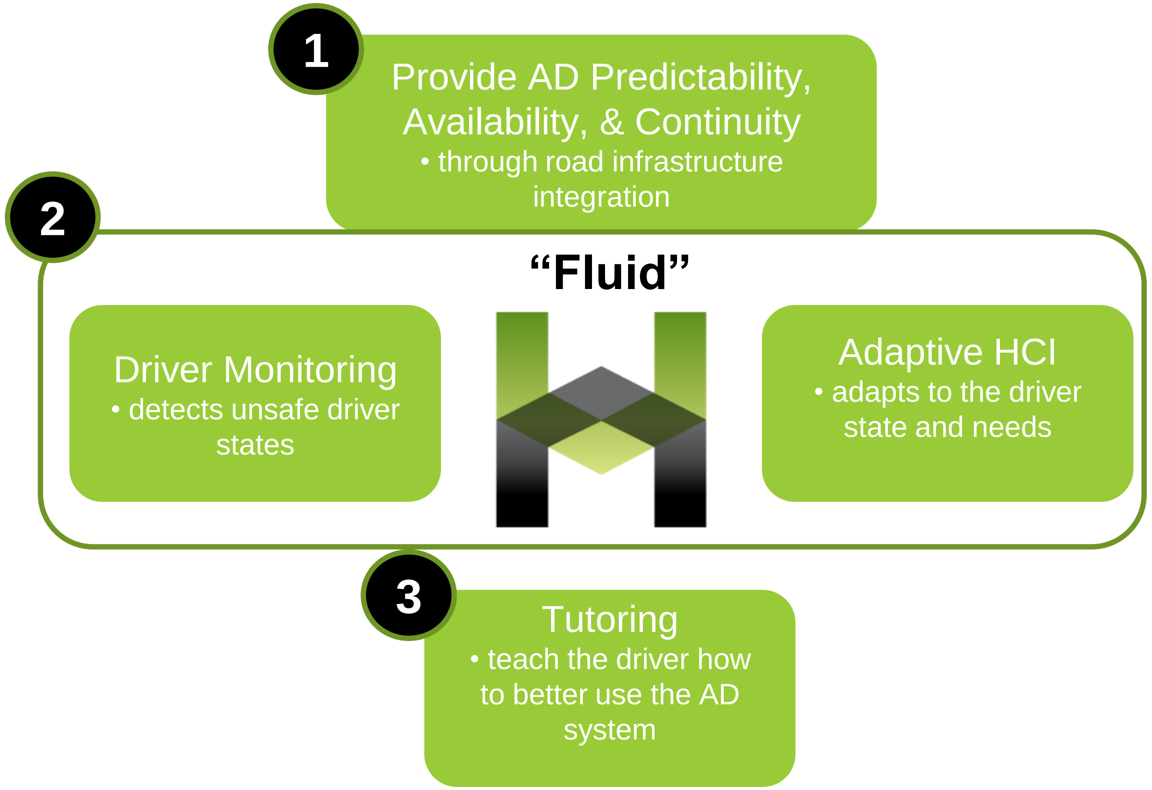
- Collaboration between humans and automation
  - Simple in manual driving
  - Complex in ADL 3 driving (e.g. implicit traffic rules, intent,..)
- Mode awareness, exacerbated by multiple available ADLs

Usable HCIs

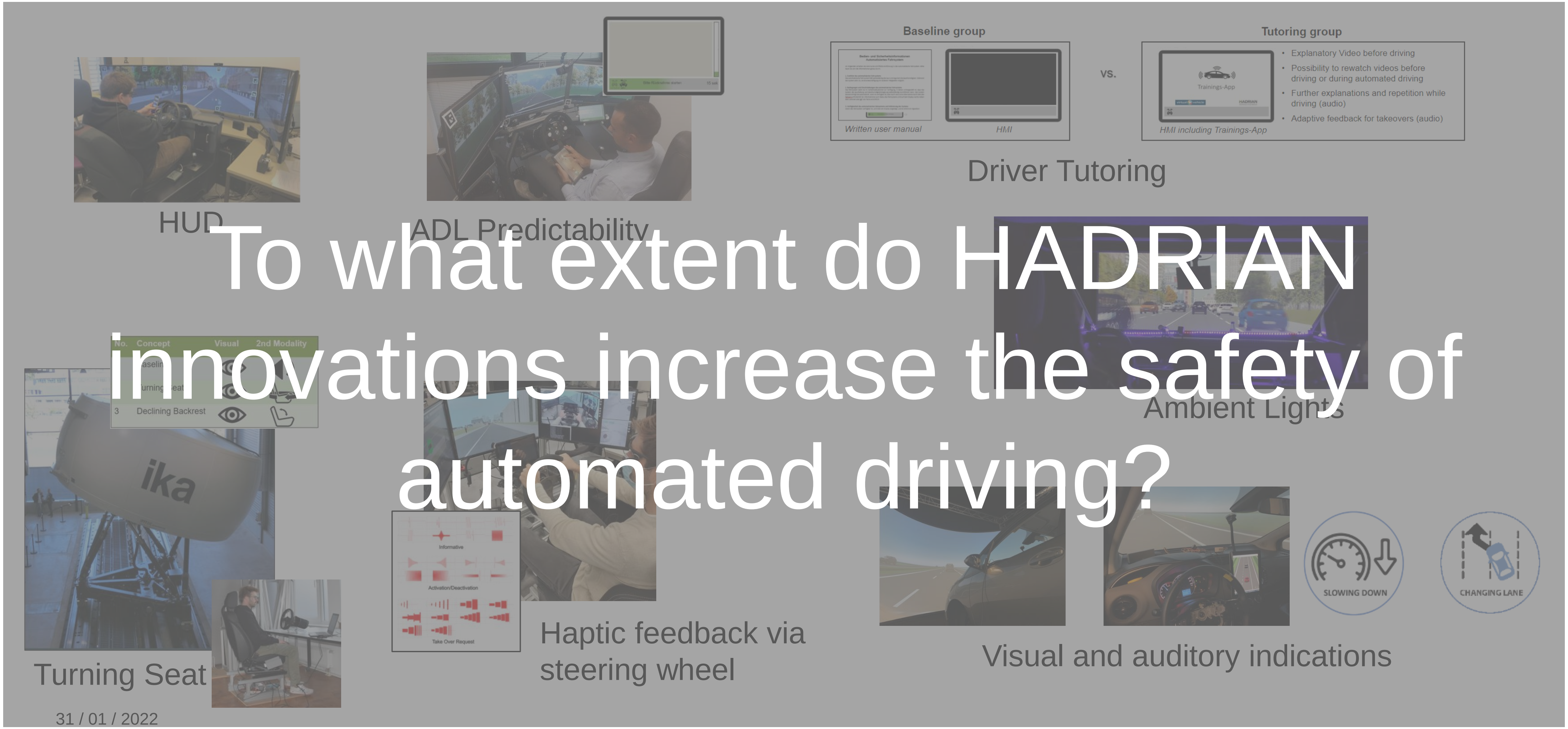
- Usable Human Computer Interaction and diverse implementations
  - Non-professional drivers
  - Complex functions in simple, good-looking interfaces
  - Diversity of implementations and of automation levels

HADRIAN HOLISTIC APPROACH

- HADRIAN uses a three-pronged approach to achieve acceptable & safe driver roles
  1. The **predictability** of automated driving states & transitions can be improved through **integration** of onboard vehicle sensors with **road infrastructure** sensors and communication
     - "Innovate" automated driving levels: 2, 3, and 3+
     - Guarantee ADL transition durations
     - Guarantee ADL durations
  2. Advanced driver monitoring capabilities facilitate in-cabin **fluid interactions** that offer the "just needed" information and interventions based on information from detailed **driver monitoring** systems
     - During automated driving
     - Before and during the transition to manual driving
     - During manual driving
  3. **Active tutoring** can improve the skills and knowledge of drivers to safely and comfortably use the automated vehicle
     - Before the drive
     - During the drive
     - After the drive



HADRIAN HMI INNOVATIONS TO INCREASE SAFETY OF AUTOMATED DRIVING



To what extent do HADRIAN innovations increase the safety of automated driving?

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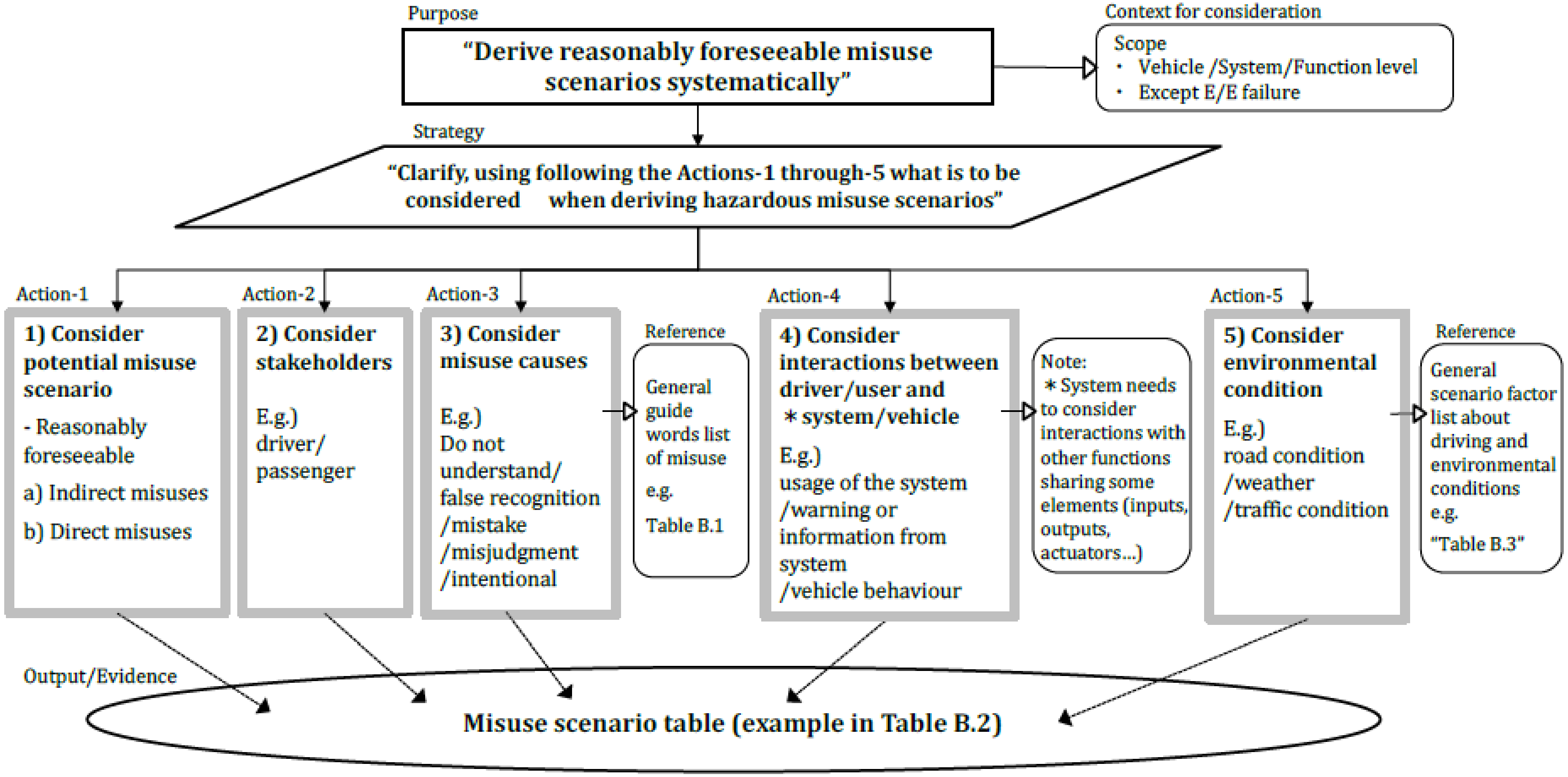

Figure B.1 — Systematic derivation of SOTIF-related misuse scenarios (example)

Source: ISO / DIS 21448 Road vehicles — Safety of the intended functionality

"MISUSE" → HUMAN ERRORS

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3) Misuse causes

When considering the SOTIF-related misuse causes, general "Guide words" derived from the typical human misuse process (Recognition, Judgment and Action) can be useful.

Examples of possible guide words are described in Table B.1.

Table B.1 Guide words for human error

Process	Guide word	Example
Recognition	1. Does not understand	Cannot operate correctly due to complicated usage or insufficient information.
	2. False recognition	Cannot recognize correctly due to overloaded information.
Judgment	3. Judgment error/misjudgement	Misjudgement due to wrong impression or misunderstanding.
Action	4. Slip/Mistake	Mistake due to loss of concentration (distraction, snooze, automation complacency, etc.).
	5. Intentional	Violation of social rules, well-known human behaviour, correct operation usage (according to user manual)
	6. Unable	Hard to operate

Source: ISO / DIS 21448 Road vehicles — Safety of the intended functionality

- To address our task to quantify the safety impact of the HADRIAN innovations, we start with the definition and measurement of Human Errors

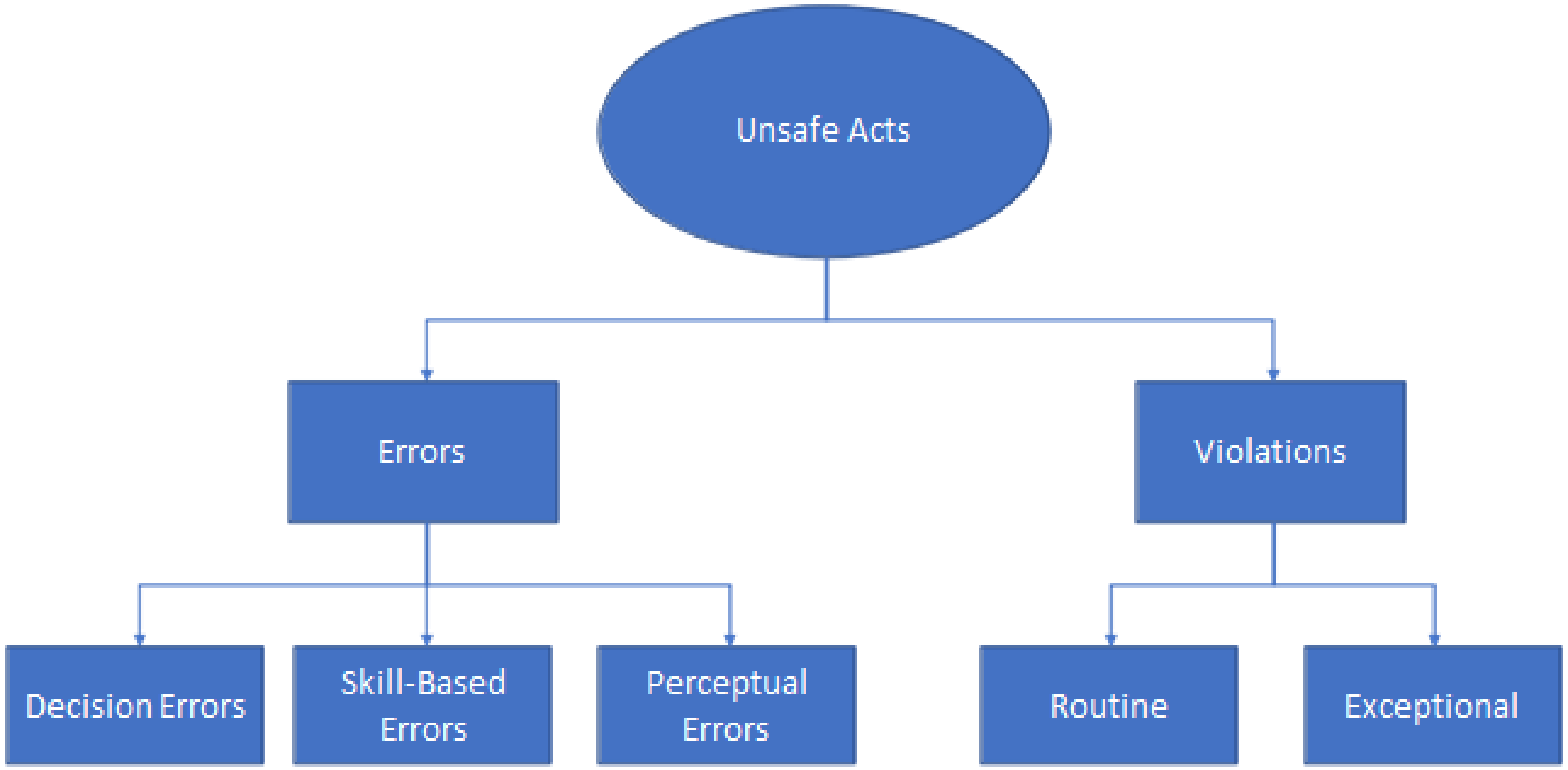
Human Error Definitions

Intentions	System Tolerance
"A generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome." (Reason, 1990)	"[Human] error is merely an out of tolerance action, where the limits of tolerable performance are defined by the system." (Swain and Guttmann, 1983)

Holistic Definition:

"[Human] error means that something has been done which was: not intended by the actor; not desired by a set of rules or an external observer; or that led the task or system outside its acceptable limits." (Sender and Moray, 1991)

Error Taxonomies: Unsafe Acts from HFACS; Shappell & Wiegmann (2000)

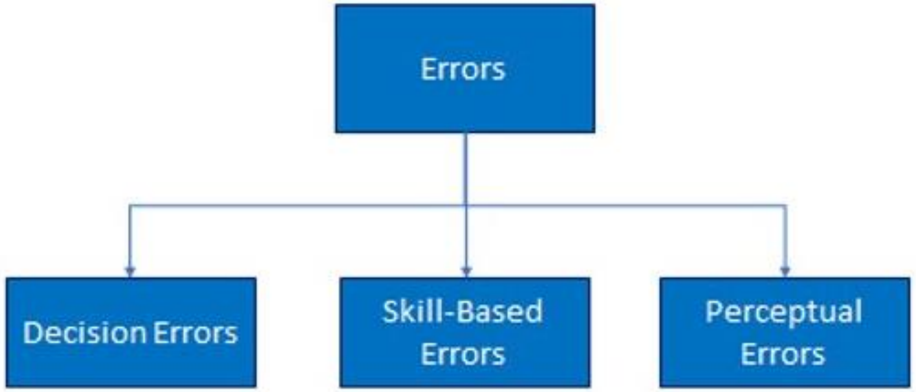


Errors

Skill-based Errors: error in skills, often basic skills that occur without conscious thought; vulnerable to failures of attention/memory; e.g., poor technique, omitted step in procedure (adding knowledge errors – combined with skill to „competence error“)

Decision Errors: intentional behavior that proceeds as intended, yet the plan proves inadequate or inap-propriate for the situation; e.g., misdiagnosed emergency, wrong response to emergency

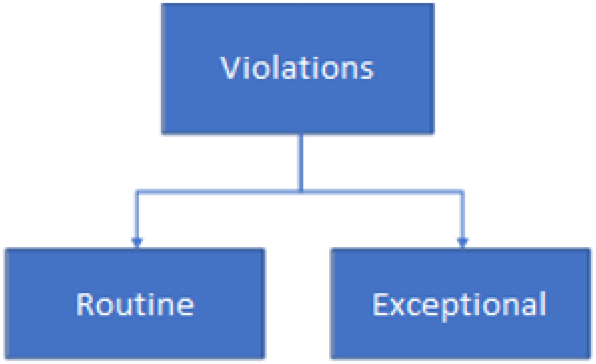
Perceptual Errors: when one’s perception of the world differs from reality, errors can, and often do, occur; e.g., due to misjudged distance, visual illusion (Shappell & Wiegmann, 2000)



Violations

represent a willful disregard for rules and regulations

→ violation can only arise when one knows the rules and regulations



Routine:

habitual by nature and often tolerated by governing authority

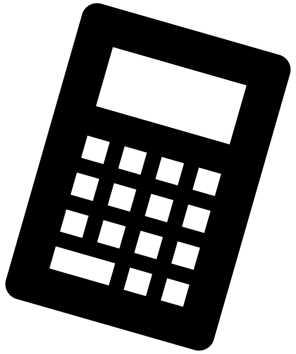
- e.g., driving 5 km/h faster than allowed (people do that routinely and will not get fined)

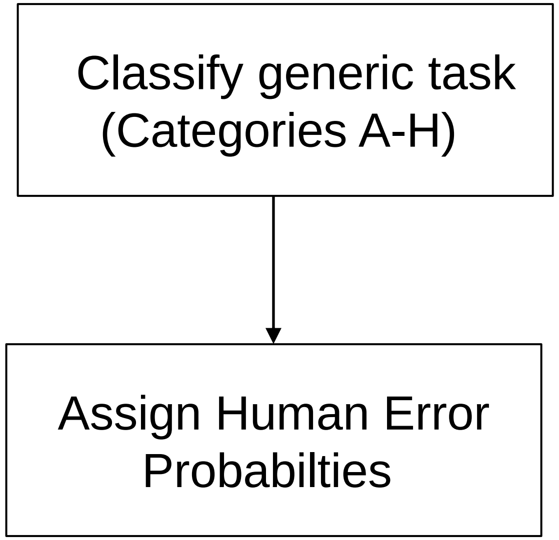
Exceptional:

- Isolated departures from authority, not necessarily indicative of typical behaviour pattern
- e.g., driving 100 km/h in Graz

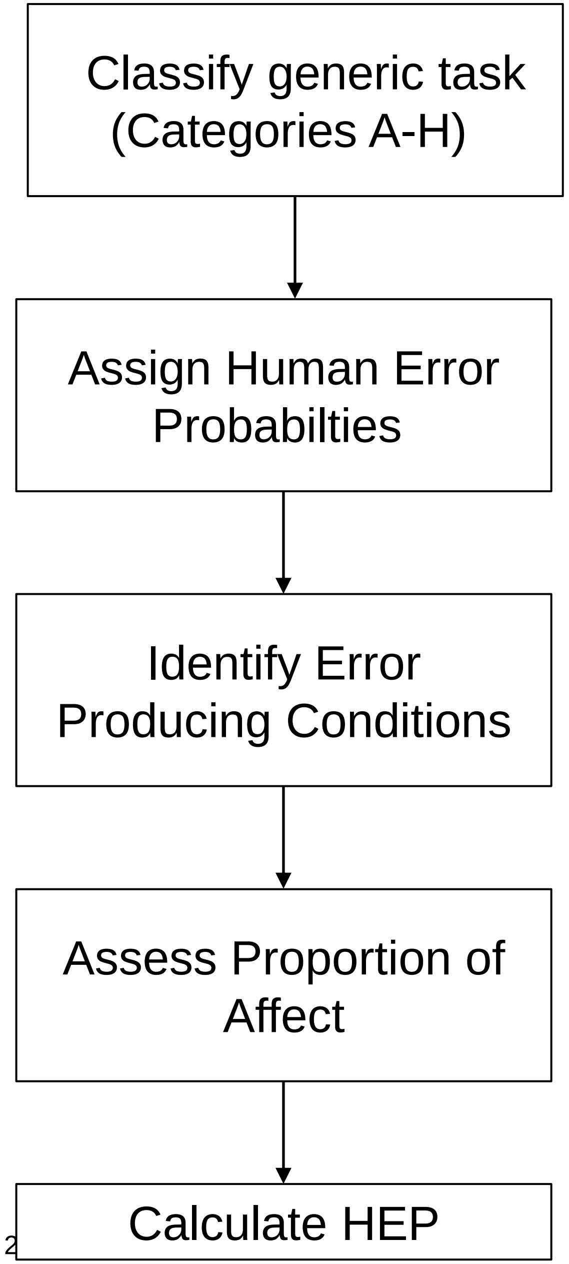
Quantifying Human Error Probabilities: HEART

- Performed a review of the state of the art and identified various methods
- Most promising: HEART (Human Error Assessment and Reduction Technique)
- Developed by Williams (1986)
- Validated by, e.g., Kirwan (1997); Bye et al. (2010)
- Used in areas such as healthcare, rail, aviation, nuclear industry





Category	Human Error Probability
A) Totally unfamiliar, performed at speed with no real idea of likely consequences	.55 (0.35-0.97)
B) Shift or restore system to a new or original state on a single attempt without supervision or procedures	.26 (0.14-0.42)
C) Complex task requiring high level of comprehension and skill	.16 (0.12-0.28)
D) Fairly simple task performed rapidly or given scant attention	.09 (0.06-0.13)
E) Routine, highly-practised, rapid task involving relatively low level of skill	.02 (0.007-0.045)
F) Restore or shift a system to original or new state following procedures, with some checking	0.007 (0.0008 - 0.0035)
G) Completely familiar, well-designed, highly practised, routine task occurring several times per hour, performed to highest possible standards by highly-motivated, highly-trained and experienced person, totally aware of implications of failure, with time to correct potential error, but without the benefit of significant job aids	0.0004 (0.00008 - 0.009)
H) Respond correctly to system command even when there is an augmented or automated supervisory system providing accurate interpretation of system state	0.00002 (0.000006 - 0.0009)

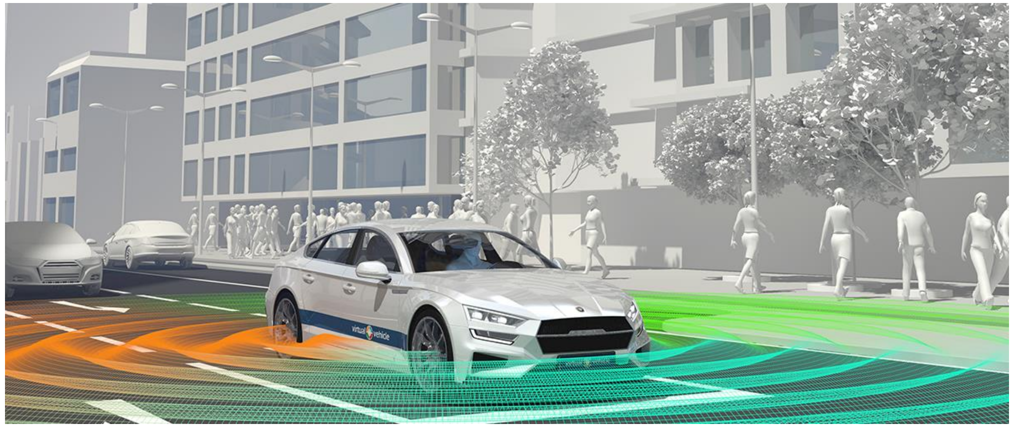


Error Producing Condition	Maximum Proportion of Affect
Unfamiliarity with a situation which is potentially important but which only occurs infrequently or which is novel (*17)	*17
A shortage of time available for error detection and correction (*11)	*11
A low signal-noise ratio (*10)	*10
No means of conveying spatial and functional information to operators in a form which they can readily assimilate (*8)	*8
A mismatch between an operator's model of the world and that imagined by a designer (*8)	*8

Example

A safety engineer wishes to assess the likelihood of a driver failing to safely take-over from automated driving at SAE Level 3, following strict procedures. The driver is fairly inexperienced and has previously used another vehicle with opposite AD disengagement procedures. He is only dimly aware of the hazards involved in taking-over from ADL3.

It is assumed that the driver has been driving for seven hours, has family problems and he is under pressure to arrive on time. His boss is very strict and has previously fired several drivers who did not keep to the schedule.



HEART Analysis

Type of task			Nominal human unreliability
F			0.003

Error-producing conditions	Total HEART effect	Engineer's assessed proportion of effect (from 0 to 1)	Assessed effect
Inexperience	× 3	0.4	((3 − 1) × 0.4) + 1 = 1.8
Opposite technique	× 6	1.0	((6 − 1) × 1.0) + 1 = 6.0
Risk misperception	× 4	0.8	((4 − 1) × 0.8) + 1 = 3.4
Conflict of objectives	× 2.5	0.8	((2.5 − 1) × 0.8) + 1 = 2.2
Low morale	× 1.2	0.6	((1.2 − 1) × 0.6) + 1 = 1.12

Assessed, nominal likelihood of failure:

$$0.003 \times 1.8 \times 6.0 \times 3.4 \times 2.2 \times 1.12 = 0.27$$

Scenarios we will examine

Baseline Condition	HADRIAN Condition
The vehicle drives in ADL2 on the motorway. A construction site is ahead that involves a lane change which requires to transition back to manual driving. The driver detects the construction site and terminates ADL2, the driver performs the necessary checks, and takes back driving control.	The vehicle drives in ADL2 on the motorway. Construction site is ahead that involves a lane change which requires to transition to manual driving. The HMI informs the driver that the driver should get ready for manual driving. After that transition message, the driver performs the necessary checks, and takes back driving control.
The vehicle drives in ADL3 mode. Coming closer to the construction area, the driver sees the signage and markings on the roadside that inform him/her about the construction site. The vehicle initiates the maneuver to avoid the construction area.	The vehicle drives in ADL3 mode. Coming closer to the construction area, the vehicle receives a message from the road infrastructure about the lane closure. As it approaches the detection area, the vehicle receives information about the closed lane ahead, informs the driver, and performs the lane change automatically.

Conclusions

- Have presented a method to assess human error probabilities that can be used for
  - Identifying and quantifying safety problems of existing socio-technical systems
  - Measure the impact of safety improvement
- Currently are applying this method to several safety innovations that were developed in the HADRIAN project
  - Once we have completed the analysis,
    - We would like to share lessons and results
    - Possible recommendations as input to SOTIF ISO
    - We look for opportunities to work with you to apply this technique to other applications

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