General

ID[1]			
Use case name	Unmanned Protective Vehicle for Road Works on Motorways		
Context	Transportation		
Application domain	Self-driving vehicles		
Status	Prototype		
Contributor	Name	Affiliation	Contact
	Zielke	HSD, Germany	
Scope[2]	Unmanned operation of a protective vehicle in order to reduce the risk for road workers in short-time and mobile road works carried out in moving traffic		
Objective(s)	A vehicle that is able to follow mobile road works automatically on the hard shoulder of a German motorway.		
Narrative	Short description (not more than 150 words)	Mobile road works on the hard shoulder of German highways bear an increased accident risk for the crew of the protective vehicle safeguarding road works against moving traffic. The "Automated Unmanned Protective Vehicle for Highway Hard Shoulder Road Works" aims at the unmanned operation of the protective vehicle in order to reduce this risk. The vehicle has first been tested in a real operation on the German autobahn A3 in June 2018 [4]. It is actually the very first unmanned operation of a vehicle on German roads in public traffic. The scientific challenges of the project are strongly related to the general challenges in the field of automated driving.	
	Complete description	A typical operational scenario for the automated unmanned protective vehicle looks as follows: In the beginning of the operation, an employee of the road maintenance service manually drives the protective vehicle from the depot to the location of the road works. There the employee stops the protective vehicle and switches to the road maintenance vehicle in front. The employee can activate the automated operation of the protective vehicle via a user interface. The vehicle guidance system then takes over the longitudinal and lateral control of the protective vehicle and follows the road maintenance vehicle in a defined distance at low speeds of about 10 km/h. In unmanned operation the vehicle guidance system operates in one of the three automated modes: Follow Mode, Coupled Mode, and Safe Halt. In Follow Mode, the vehicle guidance system performs the longitudinal and lateral control based on environmental information. The environment perception extracts the lane boundaries, e.g. lane markings, of the highway hard shoulder, the road maintenance vehicle and other obstacles in front of the protective vehicle. If an obstacle is detected, for example an emergency halting car, the system automatically transitions into Safe Halt. The system also performs this transition in case it detects that it is not capable of maintaining unmanned operation. In Coupled Mode, the protective vehicle is controlled by the vehicle guidance system, too. The longitudinal and lateral control is purely based on control commands and state information of the road maintenance vehicle. While lane boundaries are ignored in this mode of operation, obstacles in front of the protective vehicle are still detected. As in	

		Follow Mode, the protective vehicle is able to detect functional system boundaries and to transfer itself to Safe Halt.		
Key performance indicators (KPIs)	ID	Name	Description	Reference to mentioned use case objectives
		probability of malfunctions	in potential hazardous events malfunctions should not occur	Safety
AI features	Taks(s)	obstacle detection, lane following, scene perception and representation, self perception		
	Method(s)[3]	computer vision , logical decision making, pattern recognition, multimodal event detection		
	Hardware[4]	truck vehicle equipped with cameras, radar system, motion and acceleration sensors, rain sensor		
	Terms and concepts used[5]	autonomous vehicle guidance, environment perception, self perception		
Challenges and issues	Safe operations in public traffic, compliance with ISO 26262			
Societal concerns				

Data (optional)

Data characteristics	
Description	
Source[6]	
Type[7]	
Volume (size)	
Velocity (e.g. real time)[8]	
Variety (multiple datasets)[9]	
Variability (rate of change)[10]	
Quality[11]	

Process scenario (optional)

Scenario conditions					
No.	Scenario name	Scenario description	Triggering event	Pre-condition[12]	Post-condition[13]

Training (optional)

Scenario name	Training				
Step No.	Event[14]	Name of process/Activity[15]	Primary actor	Description of process/activity	Requirement
Specification of training data[16]					

Evaluation (optional)

Scenario name	Evaluation				
Step No.	Event[17]	Name of process/Activity[18]	Primary actor	Description of process/activity	Requirement
Input of evaluation[19]					
Output of evaluation[20]					

Execution (optional)

Scenario name	Execution				
Step No.	Event[21]	Name of process/Activity[22]	Primary actor	Description of process/activity	Requirement
Input of Execution[23]					
Output of Execution[24]					

Retraining (optional)

Scenario name	Retraining				
Step No.	Event[25]	Name of process/Activity[26]	Primary actor	Description of process/activity	Requirement
Specification of retraining data[27]					

References

References						
No.	Type	Reference	Status	Impact on use case	Originator/organization	Link
					MAN Truck & Bus AG	www.mantruckandbus.com
					ZF Friedrichshafen AG	www.zf.com
					WABCO Development GmbH	www.wabco-auto.com
					Hochschule Karlsruhe	www.hs-karlsruhe.de
					Technische Universität Braunschweig	www.tu-braunschweig.de
					Hessen Mobil - Road and Traffic Management	mobil.hessen.de
					BASt - Federal Highway Research Institute	www.bast.de

[1]
G. Bagschik, M. Nolte, S. Ernst, and M. Maurer, “A System’s Perspective Towards an Architecture Framework for Safe Automated Vehicles,” Apr. 2018 [Online]. Available: http://arxiv.org/pdf/1804.07020v3

[2]
T. Stolte, A. Reschka, G. Bagschik, and M. Maurer, “Towards Automated Driving: Unmanned Protective Vehicle for Highway Hard Shoulder Road Works,” in *2015 IEEE 18th International Conference on Intelligent Transportation Systems*, 2015.

[3]
G. Bagschik, A. Reschka, T. Stolte, and M. Maurer, “Identification of Potential Hazardous Events for an Unmanned Protective Vehicle,” Apr. 2018 [Online]. Available: https://arxiv.org/pdf/1804.08728.pdf

[4]
P. Thomas, “Autonome Lastwagen: Folgen Sie mir unauffällig!” 2018 [Online]. Available: http://www.faz.net/aktuell/technik-motor/motor/selbstfahrende-lastwagen-sollen-wanderbaustellen-sichern-15669484.html

Footnote

[1] Leave this cell blank.

[2] The scope defines the limits of the use case.

[3] AI method(s)/framework(s) used.

[4] Hardware system used.

[5] Terms and concepts listed here can be used to extend the work of WG 1 (AWI 22989 and AWI 23053) as necessary.

[6] Origin of data, which could be from instruments, IoT, web, surveys, commercial activity, or from simulations.

[7] Structured/unstructured Images, voices, text, gene sequences, and numerical. Composite: time-series, graph-structured

[8] The rate of flow at which the data is created, stored, analysed, or visualized.

[9] Data from a number of domains and a number of data types. The wider range of data formats, logical models, timescales, and semantics complicates the integration of the variety of data.

[10] Changes in data rate, format/structure, semantics, and/or quality.

[11] Completeness and accuracy of the data with respect to semantic content as well as syntactical of the data (such as presence of missing fields or incorrect values)

[12] Describe which condition(s) should have been met before this scenario happens.

[13] Describe which condition(s) should prevail after this scenario happens. The post-condition may also define "success" or "failure" conditions.

[14] The event that triggers the step. This might be completion of the previous event.

[15] Action verbs should be used when naming activity.

[16] Training data can be further specified.

[17] The event that triggers the step. This might be completion of the previous event.

[18] Action verbs should be used when naming activity.

[19] Specify input of evaluation.

[20] Specify output of evaluation.

[21] The event that triggers the step. This might be completion of the previous event.

[22] Action verbs should be used when naming activity.

[23] Specify input of evaluation.

[24] Specify output of evaluation.

[25] The event that triggers the step. This might be completion of the previous event.

26 Action verbs should be used when naming activity.

27 Retraining data can be further specified.