Book of abstracts

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Paving the way to safer active urban mobility: Challenges and opportunities

Changes in traffic behavior and perception related to the Covid-19 pandemic

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Introduction: With the beginning of the Covid-19 pandemic, the volume of traffic and thus the number of accidents decreased in spring 2020 in Germany. Possible resulting long-term changes in traffic behavior and perceptions of safety were investigated in this study.

Methods: A total of 1,320 people were interviewed via an online survey after the first lockdown between July and August 2020. Respondents had already participated in a representative traffic climate survey between September and October 2019.They were asked about their mode of transport choice, their safety perception and their perception of road traffic. Furthermore, the respondents were asked about their own traffic violations and the perceived traffic violations of other road users. All constructs were surveyed using Likert scales.

Results: Respondents' overall safety perception is high and is significantly higher in 2020 (M=3.52, SD=0.964) than in 2019 (M=3.62, SD=0.899) (t=-22.559, p<.001). The demands on road users are rated significantly lower (t=16.131, p<.001), traffic is experienced significantly more emotionally negative (t=16.768, p<.001) and the functionality of traffic is rated significantly more positive (t=-70.634, p<.001). However, the differences are small. In contrast, 30 % of the respondents stated that they observed traffic violations from others more often than before the pandemic, such as speeding or aggressiveness. Only 6% reported that they themselves behaved more often in this way. 22% stated that they were less likely to behave aggressively or violate rules than before the pandemic.

Discussion: The safety perception and the perception of traffic have developed slightly positive in Germany since the beginning of the pandemic. However, no long-term positive consequences for traffic safety can be assumed, since traffic violations or aggressive behavior in traffic is perceived more frequently. Apparently, the decrease in traffic volume also enabled new opportunities for traffic violations.

Speed perception and crossing behavior in children

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Introduction: Children mostly start their independent traffic participation on foot. By analogy, they frequently have accidents when crossing a street on foot and do not pay attention to approaching vehicles. This can be explained by the fact that their abilities to perceive vehicles and estimate their speeds are still developing. The present study therefore investigated speed perception in children in different age groups.

Method: Speed perception was operationalised through the decision to cross the street in a field and a laboratory study. The speeds (30, 50, 60 km/h, acceleration from 20 to 50 km/h) and the approach direction of the vehicles (right, left) on a two-lane road were varied. In addition, eye movements and reaction times were recorded. The children's hazard perception and attention performance were also examined. A total of 183 children between the ages of five and 14 took part, 45 of them in all studies.

Results: Street crossing decisions improve with age, but even children aged between 13 and 14 years still have considerable problems. Especially with vehicles coming from the right, where both lanes have to be considered, risky decisions are made significantly more often (right: 53.6%, left: 27.5%; $p<.05$). At lower speeds of 30 km/h, children make decisions to cross more often than against crossing (62%). Compared to the higher speed conditions, these decisions are significantly more often correct, but also significantly more often risky or would have led to collisions. Hazard perception and attention improve as children get older, but are not necessarily associated with safer decisions.

Discussion/Summary: Although children's speed perception improves with age, the development is not yet complete at the age of 14. In particular, the inclusion of both lanes seems to be more cognitively demanding for the children. Only at low speeds they feel confident in crossing the street. However, since these decisions are not safer, older children also benefit from pedestrian crossing aids and lower speeds.

CATAPULT (PoliCies for inclusive, demand-oriented and target group-specific automated mobility solutions for cities)

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Even though demand-oriented mobility solutions are becoming more and more user-oriented, the inclusivity of these offers and services is often not considered. Especially the requirements and needs of vulnerable road users, such as children, elderly people and people with impairments are neglected. Without mobility solutions that are suited for vulnerable road users, they will experience mobility restrictions which in turn lead to labour market disadvantages and hinders participation in social life and society. However, to make automated mobility solutions inclusive, it will be essential, to not only focus on the vehicle but include the whole mobility system including door-to-door access, ticketing, travel planning and others.

Aim: In the European research project CATAPULT these groups are in the focus of the research work. The aim of the project is to develop policy recommendations on how to make future automated mobility services more inclusive and sustainable. The project follows a co-creative approach. Together with children, elderly people, and people with sensory and /or physical impairments, the research team will develop automated mobility services that meet the needs of these target groups and identify potential benefits and conditions, that influence the willingness of different user groups to use automated mobility services. Thus, the CATAPULT project corresponds to responsible innovation and research.

Methods: Following an exploratory mixed method approach we first conduct qualitative interviews and workshops with the target groups and stakeholders (policy makers and mobility service providers) to gather basic data about the wishes, barriers, requirements, and pushing factors related to inclusive, demand-oriented and target-group-specific automated mobility solutions. In a second step, a quantitative survey will be conducted to quantify the interview data.

A serious game will be developed as a board game with a map of the planned future infrastructure of the European Corridor (Noordrand) in Brussels, automated vehicle routes, bottlenecks and other specifics. Rules and challenges will be designed to produce desirable interactions among the participants. Multiple sessions will be conducted bringing together policy makers, private companies (e.g. public transport providers), researchers and private stakeholders. Evaluation will be done by analysing the decisions made, the strategies followed, and the negotiations made during the game.

In addition, existing automated bus shuttles in Austria and Sweden will be tested by the target groups in terms of their inclusivity as part of field studies. Here, the focus will also be on the integration into the existing mobility system and the pedestrian-friendliness of the automated services. User group specific and adequate questionnaires as well as user group specific methods for discussing the potential and challenges of automated mobility systems will be applied. A SWOT Analysis will be conducted to learn from the different field studies.

Expected Results: The results will compromise amongst others a structured overview on the requirements of the user groups, including a statistically analysed catalogue of needs and requirements of vulnerable road users as well as the outcomes of the field tests and the serious game. Based on these findings, target group-specific policy recommendations for the implementation of inclusive, connected, and sustainable mobility services will be derived and step-by-step instructions for the actual implementation of these policies will be developed. Furthermore, the project will produce a handbook for using a serious game as part of policy support for inclusive, demand-oriented and target group-specific automated mobility solutions for cities.

The possibility to design a mixed methods and serious game approach suitable for the co-creative development of policy recommendations in local and regional testing environments makes the results not only useful for the project regions but provides useful innovative collaboration tools for the whole of Europe.

Conclusions: The research project CATAPULT will provide policy recommendations to set the foundations for creating inclusive automated mobility solutions in cities.

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Driving behavior in different road intersections: relationship between driving speed and driver electrodermal activity

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Background: Physiological signals are a useful metric for providing feedback about a driver's state because they can be collected continuously without interfering with the driver's task performance or the drivers' perception of the road. When humans are subjected to stressors, such as those resulting from driving activity, they tend to show a variety of physiological responses. Electrodermal activity is a reliable indicator of stress.

Electrodermal activity (EDA) refers to the variation of the electrical properties of the skin in response to sweat secretion. The Skin Conductance Response (SCR) could be a useful indicator of activities of the autonomic nervous system.

It is well known that intersections are among the most complex road environments: their geometric configuration, the signs and markings, the qualitative and quantitative characteristics of traffic, the vehicular conflicts are all elements which weigh the driver workload, conditioning the driving behaviour and, consequently, affecting the risk of accident.

Aim: While previous studies investigated the benefits of converting junctions into roundabouts in terms of crash rates and traffic conditions, few studies analysed how drivers' responses change between standard intersections and roundabouts in terms of physiological responses. Seeking to overcome this gap, this study presents a method for measuring and quantifying drivers' physiological responses when approaching T-junctions and roundabouts using physiological signals and speed variations.

Method: An experimental investigation which aimed to explore and capture the user's natural behaviours in the real-world was developed. The 20 participants involved within the trial were evenly divided between males and females. Participants were aged 28 to 50 years of age. They were required to have held a driving license which would be for a minimum of 3 years.

The ego vehicle driven by the participant was a Nissan Leaf. The vehicle was instrumented with 4 colour cameras (one forward facing, one driver facing, one steering wheel facing, one feet facing) and an vehicle localization system.

An Empatica E4 wrist band sensor was worn by participants to collect physiological data. The wristband embeds four sensors: Electrodermal activity (EDA), photo-plethysmograph, thermometer, and accelerometer. Participants wore the wristband on their right wrist. The instrument was used to record EDA continuously and unobtrusively during the experiment.

The driving study took place on the MUEAVI (Multi-User Environment for Autonomous Vehicle Innovation) test environment based at Cranfield University and surrounding roads. Participants drove the route multiple times continuously and therefore they made different manoeuvres through the different intersections situated on the driving route. The route included a roundabout and two T-junctions.

The Association Rule with Apriori algorithm was used in order to find associations between drivers' electrodermal activity (EDA) and speed variations when approaching the intersections studied. The variable related to electrodermal activity is SCR Peaks (SP), which takes into account the number and the amplitude rate of SCR peaks when approaching the intersection, i.e. between 100 m before the intersection and the centre of the intersection. The variables related to speed are: Speed Variation (SV), which takes into account the speed variation, i.e. the speed variation between 100 m before the intersection centre and the intersection centre; Sign of speed variation (SSV), which takes into account the sign of the speed variation (positive or negative).

Results: The main results of this study are the following: 1) the rules obtained for the manoeuvres on T-junctions highlight how T-junctions induce low variations in electrodermal activity and are often associated with a significant speed increase; 2) the rules obtained for the manoeuvres on the roundabout define a very strong association with the condition of maximum electrodermal activity (i.e. lot of peaks with high amplitude) and speed reduction. It is therefore evident that the roundabout strongly affects drivers' behaviour, inducing significant electrodermal activity and speed reductions (mainly between 20% and 40%).

The proposed model has shown that the stress level induced by roundabouts is significantly higher than that one induced by T-junctions.

Conclusion: The results of this study show how the verification of the safety level of a road infrastructure might be done by applying a double channel of investigation, i.e. the analysis of the driving behaviour (variation of speed, execution of trajectories, etc.) and the analysis of the physiological response resulting from the perception of the infrastructure scenario.

Exploring the safety level of a signalized roundabout with crossing BRT: an observational pilot, in Israel

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Background: Current policies for sustainable urban mobility focus on promoting public transport, walking and cycling. Bus rapid transit (BRT) systems are a common solution to promote public transport in big cities, while their implementation requires substantial changes in urban infrastructure, to enable bus running priorities on the traffic routes. Beside the evident improvement of public transport services, the impacts of BRT infrastructure changes on traffic safety can be mixed, with a possible increase in traffic injury of other road users. The infrastructure settings with an exclusive or priority run of BRT are typically more complex than traditional urban settings, thus imposing additional demands on road user behaviours. However, available evidence on the safety impacts of BRT infrastructure solutions is rather limited, indicating a need for more empirical research.

In Israel, the development of bus priority systems is one of the main policies promoted today by the Ministry of Transport. In particular, in the last decade, a new BRT system called "Matronit" was introduced in the Haifa metropolitan area. Further extension of the BRT network planned to include a new setting that was not familiar to Israeli drivers - a two-lane roundabout with a bi-directional BRT running through its center and traffic lights installed at the points where the circular traffic crosses the BRT route. Hence, concerns were raised by the authorities regarding the compliance with the traffic lights and other impacts of the new setting on driver behaviours, while entering or passing through the signalized roundabout. Previous literature on the subject is scarce, yet, examples of signalized roundabouts with crossing bus (or tram) routes can be found in many cities. Thus, it was decided to conduct a pilot on the initial operation of the setting which was accompanied by an observational study.

Aim: The study aimed to explore the safety level of the signalized roundabout with crossing BRT based on observations of driver behaviours. For that purpose, the study focused on safety-related behaviours, e.g. red-light violations by road users; dangerous interactions in the roundabout entrance areas; giving-right-of way to pedestrians by vehicles.

Methodological issues: In this study, a "before-after" comparison of driver behaviours was not possible as the roundabout was a new setting built for the BRT route. The study intended to characterize the safety level of the setting by estimating the extent of risky behaviours observed under the new arrangement and comparing them with similar indicators reported in the literature for multi-lane roundabouts and/or signalized intersections. In the study, video-recordings were conducted by cameras of the traffic control center, in four areas of the roundabout, two near the traffic lights and two entrance areas where the drivers could watch the traffic lights. In each area, three working days were recorded, between hours 8-18. Using video-records, vehicle samples were extracted and analysed to characterize driver behaviours under various traffic and traffic lights' conditions, in the roundabout.

Results: Red-light violations were committed by 14% of the vehicles in one traffic light area of the roundabout, with no cases in another one. Accounting for the BRT frequency, 1-2 red-light running can be expected per hour; this figure is not low but comparable with driver behaviours at signalized intersections. A detailed consideration revealed that 86% of the cases occurred during the first two seconds of the red-light, and no "near-collision" events were observed. In both entrance areas, when traffic was present inside the roundabout, 10%-20% of entering vehicles did not slow down, and this behaviour was more frequent under the red-lights. However, in most cases, the distance between the vehicles was sufficient, while conflicts (with braking) were rare, in 1% of cases. Pedestrian appearance on the crosswalks

was rare, but many of them (38%) were ignored by entering vehicles, while such behaviour is common for multi-lane roundabouts.

Conclusions: The pilot showed that the safety level of the roundabout was comparable to other settings, but risky driver behaviours were present both near the traffic lights and in the entrance areas. The findings seem to be site-specific and further research is needed to better fit infrastructure design solutions to various levels of traffic volumes at roundabouts with crossing BRT.

Combining Vehicle Braking Behavior with an External Human-Machine Interface towards a Holistic Communication Strategy for Automated Buses

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Background: Future automated vehicles (AVs) of different sizes will share the same space with other traffic participants (TPs), e.g., manually-driven vehicles, cyclists or pedestrians. For a safe interaction, communication needs to be ensured, in particular, with vulnerable road users, e.g., pedestrians. This study focuses on two important research aspects of the future interaction between vehicle and pedestrians: firstly, the design of different communication strategies for the interaction between pedestrian and automated vehicle and, secondly, the concrete novel application to an automated bus. Current research shows that in today's interaction, pedestrians use mostly implicit communication signals, i.e., vehicle dynamics, for their road-crossing decision. Moreover, they use explicit communication in low distance and low speed to negotiate or to clarify ambiguous traffic situations. Both communication means (implicit and explicit) are highly relevant for a safe interaction between pedestrians and vehicles and need to be considered in the design of future AVs. An external Human-Machine Interface (eHMIs) presents a possible communication tool to transmit explicit communication signals to other TPs. So far, research showed that the use of an eHMI increases pedestrians' perceived safety and is seen as helpful for pedestrians' road-crossing decisions. Nevertheless, implicit communication signals are described as primary indicator for the road-crossing decision. As communication tool, dynamic Human-Machine Interfaces (dHMIs) are able to transmit implicit communication signals, e.g., vehicle dynamics. Nevertheless, it is not sufficiently studied how the exact interplay between both communication means, i.e., dHMi and eHMI, should take place. Therefore, the interplay of explicit and implicit communication signals stands in focus of this study. Besides the question of how to communicate, it also needs to be addressed who communicates. This study focuses on the interaction between pedestrian and a public bus as an example for a larger vehicle type. Research has shown that pedestrians' crossing behavior can be influenced by the interacting vehicle type. For smaller vehicles, pedestrians described a higher perceived chance to get out of the way and, therefore, felt safer with smaller vehicles compared to larger. This is also supported by research showing that larger vehicles are perceived to arrive earlier than smaller. In light of the aforementioned relevance of vehicle appearance, it is surprising that little research has focused on the design of a holistic communication strategy for different sized automated vehicles so far.

Aim: This experimental online study aims to shed light on the interplay between implicit and explicit communication for an automated vehicle. Concurrently, this study focuses on the practical novel implementation to an automated bus.

Method: In short video sequences, participants interacted with a highly automated bus equipped with a 360° LED light-band eHMI which was attached on the outer vehicle body. Three eHMI communication strategies were shown reflecting different information richness levels. The condition "no eHMI" was used as baseline and did not show any information. In the condition "status eHMI", a continuously enlighted eHMI was shown which displayed the vehicle's automation status. The condition "status + intention eHMI" included the status eHMI and further explicit information about the vehicle's intention which was shown by the pulsation of the eHMI. Furthermore, the vehicle braking behavior was varied (no braking vs. braking) and combined with the different eHMI communication strategies. After the video sequences had stopped at a predefined point, participants were asked to state their willingness to cross. We hypothesize that pedestrians are more willing to cross the road when the bus presents a status + intention eHMI.

Results: As this study is work-in-progress, the data collection is still on-going. Preliminary results indicated that the proposed eHMI communication strategies can contribute to a safe interaction between public bus and pedestrians.

Conclusion: This study addresses how automated buses can safely and efficiently interact with pedestrians in future traffic using explicit and implicit communication. Further implications towards a holistic communication strategy for automated buses will be discussed.

3-Step Performance Assessment of a Pedestrian Crossing Time Prediction Model

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Background: Pedestrian behaviour and safety are emerging issues in current transportation. Transport policies and public administrations are pushing for more sustainable modes of transport, with the aim of switching the rates of motorized and non-motorized users. The current situation related to the pandemic has also affected the transport sector by triggering a negative trend in the acceptance of public or shared transport modes and promoting single modes such as private vehicles, bicycles and pedestrians. While the former do not have a positive impact on sustainable mobility, the latter can encourage people to adopt more sustainable and healthier transport habits. To achieve this outcome, a safe transport system should be ensured for vulnerable road users such as pedestrians, and this could be done by improving knowledge about their behaviour.

One way to safely study pedestrian dynamics, especially at potential conflict points such as crosswalks, is through microsimulation. This tool provides the opportunity to repeatedly study pedestrian behavior and safety under different scenarios of interest. However, to obtain reliable results, microsimulation models need to be calibrated and their parameters fine-tuned. One way to methodically calibrate these models is to identify the outcomes of interest, develop a predictive model for those specific outcomes, and use it as a tool to fine-tune the input parameters of the microsimulation model. To be reliable, the results of the predictive model should be comparable to those of the microsimulation model, and these should be validated.

Aim: The aim of this research is to present a predictive model of pedestrian behaviour and to evaluate this model and a conventional microsimulation model developed using Vissim/Viswalk, given that the chosen common output is pedestrian crossing time.

Method: To achieve this goal, a multi-step procedure is followed, which is part of a more general methodological framework for calibrating the Vissim/Viswalk microsimulation model. Vissim/Viswalk simulations were run to obtain a set of simulated crossing times that could be compared to predicted ones, and to generate a dataset of combinations of input parameters associated with crossing time values. This dataset is used for the training step of the predictive model. The evaluation of the prediction model results was developed through a three-step validation procedure, i.e. visual, conceptual and operational validation. Operational (statistical) validation was performed by comparing the variances of the results to understand whether the predicted sample is representative of the simulated sample.

Obtained results: A correlation of 97% have been found between the predicted and microsimulated crossing time values, with mean values of 6.41s and 6.32s for the simulated and predicted crossing times, respectively. Furthermore, both the predicted and simulated crossing time values fall within the ranges found in the literature for field measurements of this variable, indicating good agreement with real observed pedestrian behaviour.

Conclusions: The results presented in this paper are perspective, as they demonstrate the ability of the formulated model to reproduce the simulated results in terms of crossing time. This will allow the prediction function defining the model to be implemented in the process of calibration for the Vissim/Viswalk microsimulation model, contributing to the automation of the procedure and its application in cases where the parameters are not measurable.

Macro-level traffic safety analysis in Rome based on integrated design consistency with low traffic volumes due to COVID-19

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Background: In March 2020, the World Health Organization declared COVID-19 a world-wide pandemic. The impact of the COVID-19 pandemic has been devastating in terms of human lives, and has led to temporary changes on various fronts, including those related to road mobility and road safety. Countries introduced public health measures to contain and reduce its spread. The most popular countermeasure to the spread of COVID-19 imposed by most countries was a "lockdown" restricting everyday life activities to the bare essentials and prohibiting people from leaving their homes. These measures have led to an economic downturn of unprecedented proportions. With the majority of the world's population in a "lockdown" status, road traffic volumes and mobility activities have declined massively. Generally speaking, as economic activity declines, travel decreases and drivers are at lower risk of collisions. Thus, the reduction of traffic due to COVID-19 restrictions, reduces exposure to another important health problem, i.e. road traffic accidents. COVID-19 pandemic restrictions offer the opportunity to examine road safety from a different perspective. Aim: This study aims to understand the impact on road safety of the COVID-19 restrictions applied during the year 2020 in Rome, Italy. The ultimate goal is the development of a macro-level safety model relating accident frequencies to different characteristics, including road network, traffic, socio-economic characteristics and land use features. Special focus is placed on the level of attractiveness related to various traffic attracting poles. The influence of the various features is assessed at the zone level, into which researchers have aggregated accidents into spatial units, i.e. the Traffic Analysis Zones (TAZs). The development of macro-level safety models at the TAZ level required reliable traffic and accident data, quantitatively defined roadway networks, and TAZs with properly delineated boundaries. Method: Five municipalities of the urban area of Rome were chosen to be studied. Each municipality was subdivided into TAZs. Land use types within each TAZ were checked to ensure that they were homogeneous. A macro-level safety model for the different traffic analysis zones (TAZs) within the urban area of Rome was developed to examine the relationship between traffic accident frequency and the independent variables considered. In order to account for the spatial correlations among TAZs, a forecast model was developed, linking accident frequencies in each TAZ to several independent variables. The independent variables considered were: TAZ area, length of major arterials, length of minor arterials, road density, land use intensity, density of traffic attracting poles, traffic. Police-reported accidents occurring in the years 2017, 2018, 2019 within the Rome study area were used to build the macro-level safety model. Police-reported accidents occurring in the years 2020 during the COVID-19 restrictions on vehicular mobility were then used to validate the model. Results: The results will allow to analyse the relationships between accident occurrence and the four types of variables considered, i.e. roadway, traffic, socio-economic factors, and land use. Moreover, the results will allow to quantify the reduction of road traffic accidents due to COVID-19 restrictions. Conclusions: This study's findings can be used to provide suggestions and references for transportation planners and managers. Based on the associations between different factors and traffic accidents found with this study, integrated approaches to design future low accident networks can be adopted. For example, the macro-level accident prediction model from this study can be used to identify TAZs with higher-than-expected accident levels, and area-based engineering, enforcement, and educational strategies and programs could set priorities for improving these TAZs. Results can also be used to predict TAZ-level changes in traffic accidents associated with socioeconomic and land use development. This model will thus be applicable in similar contexts, in order to predict the

number of accidents both for ordinary scenarios and for non-ordinary, occasional or planned scenarios, in which significant variations of the traffic flow should occur.

Acceptance of automated vehicles in a developing region: The case of Rio Grande do Sul, Brazil

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BACKGROUND: In opposition to rail, water, and air transport, in which highly trained professionals are responsible for the entire operation, road transport accommodates a wide variety of users interacting on the road environment. Thus, the launch of automated vehicles (AVs) on public roads will only be successful if a user-centric perspective is adopted. Together with a continuous and intensive technological development, this requires research on human factors, namely to understand the expectations and mental representations among different population groups, as well as to develop actions to raise public awareness on new risks introduced by AVs and train for the appropriate use of automation. A human system integration approach is crucial to the safety, convenience and acceptability of AVs. In many developed countries, several studies have been conducted about the public acceptance towards AVs, however few research has been made for developing countries, where the main priorities remain the deficit of infrastructure and the poor safety figures.

AIM: This work analyses the public acceptance of AVs in a developing region, using the state of Rio Grande do Sul (RS), Brazil, as a case study. RS is the southernmost state of Brazil, and shares its border with Argentina and Uruguay. It has 11.5 million inhabitants (similar to Belgium) for an area of almost 300,000 km2 (similar to Italy). The understanding of the users' intentions towards AVs in different and unstudied regions further supports the development of collaborative automated systems tailored to the needs of different markets.

METHOD: An online survey was conducted in RS between March and April 2021. The survey included 45 questions related to the participants' sociodemographic characteristics, travel and driving habits, design requirements for AVs, perceived benefits and risks, and intentions of use. It was possible to obtain 304 complete answers. The intentions of own use and use by family were considered as proxies for acceptance, being assessed through a five point Likert scale. Then, separate ordered logit models were developed considering own use and use by family as dependent variables. Given the large number of independent variables, a forward stepwise approach was used considering different groups of variables – sociodemographic characteristics, travel/driving habits, perceptions, and requirements – which were regressed against the intentions of use. Then, only the statistically significant variables found in the regressions by blocks were incorporated into the final models.

RESULTS: Preliminary results from the "own use" and "use by family" models show that, generically, the main drivers for AV acceptance do not change significantly between both models. Students and self-employed persons are more prone to adopt AVs, as well as the respondents who already had some previous information about this technology. Frequent car users, long-distance travellers, and people who enjoy driving are traditionally more sceptic about changing AVs, but public transport users are more enthusiastic. Regarding the benefits of the technology, participants who consider it as a way to reduce accidents and to have more time to work, rest, or engage in some leisure activity are more willing to adopt AVs. On the other hand, the public acceptance decreases as the concerns with safety and emissions increase.

CONCLUSIONS: The evaluation of public expectations and requirements for AVs in developing countries is crucial to avoid widening the gap between these countries and the developed countries in terms of safe and equitable mobility. The results from this pilot study in the Brazilian state of Rio Grande do Sul reflect a strong car culture, in which the car is a symbol of status and recreation. Given that public transport users seem to be more

enthusiastic about AVs, this technology may contribute to remove users from mass transit, especially those who use these systems for convenience rather that for economic reasons. This may lead to more traffic and emissions in cities and to an increased social segregation in public transport. Therefore, the development and deployment of AVs on public roads must be evaluated according to the use cases (e.g., private versus shared vehicles), and accompanied by a strong policy framework to prevent such issues. This research will be expanded to the analysis of the intention to own an AV in relation to a traditional, non automated vehicle, which can provide additional insights about the behaviour of current private and public transport users.

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Early detection of dangerous areas in road traffic using smart data and its implications for predictive policing

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Background and aim: In 2019, 2.7 million road traffic crashes were recorded by the German police. This is more than at any other time since 1991. The trend of increasing road traffic crashes and fatalities is found especially in cities and rural areas. In Germany, it is due to increased traffic volume, distraction, and aggressive driving behaviour such as speeding and tailgating. As a result, dangerous situations are often not properly assessed or not recognized in time. The German police forces so far analyse crash data in a retrospective way. Early detection of danger spots, their mitigation and adapted behaviour in road traffic would be extremely important to reduce the number of accidents. In the USA, local authorities use predictive analytics, such as data-driven approaches to road traffic safety (e.g., DDACTS) to forecast danger spots and identify the most effective methods to deploy their resources. In line with this, the project Early Detection of Dangerous Areas in road traffic using smart data (EDDA+ or FeGiS+ as the acronym for the German-speaking area) aims to identify danger spots in the road network at an early stage so that they can be further processed, communicated and remedied.

Method: Methodically, the identification of danger spots is done by intersecting kinematic data, user reports and crash data. All three data sources are geocoded and collected Germany-wide. Kinematic data includes safety-critical movement data from cars and smartphones such as hard braking or swerving. Road user reports are collected via the specially developed platform and app gefahrenstellen.de. The reports contain a more detailed description of the danger spots as well as the road users endangered by them. The accumulation of unsafe driving manoeuvres on a particular road section, and user reports can reveal potential new hazardous areas, e.g., by capturing near-crashes and minor crashes. This information enriches the crash data, and is used for predictive analytics.

Results: In a data-driven approach, the various data are compiled in a database, analysed and aggregated into a hazard score. To improve the predictive value, contextual data such as weather data or traffic volumes are included in the algorithm. The calculated hazard scores are visualized in a Germany-wide road hazard map. A first map version is expected to be available in summer/fall 2021. A comprehensive filter and analysis tool integrated into this will enable an individual representation of the danger spots. Potential user groups, such as the police forces can use the hazard score provided by EDDA+ to forecast hot spots, effectively allocate resources and preventive measures. Furthermore, the police forces can use the analysis tools to define areas where the road user's hazard awareness should be heightened through increased police presence. After implementing the road safety measures, the effectiveness of the changes can be evaluated using user feedback and kinematic data.

Conclusions: For the prevention of crashes by means of police road traffic safety work, geocoded safety-relevant data is needed that allows crash forecasts. Based on crash data, kinematic data, user reports as well as contextual data, a dynamic Germany-wide hazard map for the road network is created within the EDDA+ project. Local police authorities can use the data provided by EDDA+ to implement road safety measures even before identified danger spots develop into collision blackspots. These measures can also be quickly verified for effectiveness using user reports and kinematic data.

Safety-Relevant Scenarios for Teleoperated Driving of Highly Automated Vehicles (SAE Level 4) in the Context of Public Transport

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Until fully automated driving (SAE level 5) will be achieved, there is still a long way to go. However, interim technologies may speed up the market introduction of highly automated vehicles (AVs). Teleoperation has the potential to enable a safe transition towards fully automated vehicle operation, especially for complex scenarios the automation cannot cope with yet (SAE level 4). Since maintaining safe and efficient operations is essential for the success of automated driving, the objective of this presentation is the creation of a comprehensive list of potentially safety-relevant scenarios that may require a human intervention. Once established, this list can be used to derive needs and requirements for teleoperation.

Relevant actors in the field of teleoperation such as public research facilities, public transportation companies, industrial R&D departments, as well as decision makers will be identified. Outcomes from national and international projects will be investigated. In addition, existing legal sources, such as the German Bus Drivers Service Act, and upcoming regulations on remote-operation in the context of automated driving, for example, the SAE Level 4 Act in Germany that specifies the legal framework for teleoperation by a "Technical Supervisor" will be analyzed. Taking these sources into account, a catalogue of scenarios that have to be considered from a human factors perspective to teleoperate AVs safely in public transport will be created.

This catalogue will be validated through a questionnaire-based interview in which a group of experts from public transportation facilities and associations as well as potential end users will mainly rate two properties of any given scenario: (1) the probability for a scenario' s occurrence, i.e., how frequently the scenario will occur in the future, and (2) the criticality for safe teleoperation, i.e., how relevant the scenario is for providing security to the AV's passengers as well as to other traffic participants. Finally, based on expert and user ratings, both a frequency and a criticality score will be calculated. From that, an overall priority level will be derived for any scenario. This priority classification will help to understand the pivotal challenges of teleoperation regarding security and will assure to address them effectively.

Identifying and addressing the most pressing challenges of teleoperated driving pave the way to using automated driving technologies in the near future already. Describing and classifying scenarios relevant to this will facilitate future users' acceptance of the technology and provide needs and requirements for a safe, effective, and intuitive human-machine interface (HMI) design for teleoperated driving in the context of public transport. This catalogue of scenarios will be created for this study but can be used for subsequent research in the context of teleoperation as it will cover a typical set of scenarios that address the core challenges and requirements of this interim technology. It could also be converted into a checklist for assessing the quality of a workstation of teleoperation from a human factors perspective: Only if the HMI is capable of coping with all scenarios mentioned, it will provide a viable solution to smooth interaction between man and machine. Further research will refine the catalogue presented here and consider methods for evaluation and validation of the scenarios it is comprised of.

Investigating the body posture as a predictor for the starting progress of cyclists

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With the upcoming development of automated vehicles (AVs), especially for urban areas, research regarding an adequate interaction between AVs and vulnerable road users (e.g. pedestrians and cyclists, VRUs) becomes more and more important. For a safe and cooperative interaction, AVs should be able to detect the intentions of VRUs. In particular, observable characteristics, such as the VRUs' body posture, are used for this purpose.

An important scenario in urban areas, especially in shared spaces and parking lots, is the starting of a cyclist. Here, we understand starting as a process between getting on the bike and finally rolling off. We assume that both the recognition of the final intention to rolling off, but also the recognition of the progress within the starting process (with preparations for rolling off) can be crucial. In addition to an adequate interaction with the cyclist, this may be important for an AV to decide whether it still takes priority (in early stages of the starting process) or rather yields priority (in later stages). Furthermore, it may be particularly important to detect the probability of the final rolling off, i.e., the last stage of the starting process, in order to avoid safety-critical situations.

The aim of the present work is to investigate how accurately the progress in the starting process as well as the probability of the final rolling off can be detected based on the body posture of cyclists. Furthermore, we would like to investigate the importance of different body parts in this rating. The results should support the development of efficient algorithms for intention recognition and, based on human abilities, make conclusions about how good the intention recognition should be at least.

We conducted an online study with N = 62 participants. During the study, we presented various images of cyclists in the starting process. These cyclists were previously recorded at a parking lot from the perspective of a car driver. The period of interest was the time between getting on the bike and the final rolling off. The recordings were split into four images per second to allow a better visibility of the body posture. For each image, participants were asked to provide ratings about the progress in the starting process, the probability of the final rolling off and parts of the cyclist's body that were relevant to these ratings. We presented the images of three different cyclists both in chronological (baseline condition) and random order (experimental condition). In the chronological order, participants were able to build up prior knowledge about the progress based on the images before. In the conditions with random order, prior knowledge was not available and the ratings were possible based on body posture only.

First results revealed similar ratings for the baseline and experimental conditions of the three cyclists. Furthermore, a lower variance can be observed in the ratings at the beginning and at the end of the starting process. In addition, ratings often increased from image to image in the conditions with random order. Thus, the randomly presented images of a cyclist could be surprisingly well rearranged into chronological order.

Regarding the relevant body characteristics, the legs were mainly indicated as the decisive part at the beginning. As the starting process continued, the importance of the legs decreased, while the importance of the upper body, head and feet increased. At the end of the starting process, the importance for all body parts often increased slightly. Upper body and legs often showed the highest ratings.

The results show that the progress in the starting process and the probability of the final rolling off can be recognized accurately based on the body posture. Furthermore, the beginning and the end of the starting process seem to be associated with characteristic body

postures, which is reflected in the lower variances in the ratings. Thus, it seems possible that the final rolling off can be detected early in favor of a safe interaction.

Further research should confirm these results for a higher number of cyclists and investigate possible differences depending on the type of bicycle. Furthermore, the extent of the prediction quality should be analyzed in case of an occlusion of certain body parts.

Evaluation of an AR-interface for efficient and safe navigation to DRT pick-up locations

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Background: Demand responsive transportation (DRT) services, like on demand ride pooling (ODPR) promise a more convenient transportation solution compared to conventional fixed route public transportation. The deployment of shared automated vehicles (SAV) may add additional benefits in terms of traffic efficiency. Once a fare is booked with a smartphone, the DRT service determines a pick-up location as a meeting point for the user and SAV. Users then walk to the pick-up location. The main challenge at this stage of the user journey is to navigate and identify the pick-up location in a short amount of time. Here, searching for the pick-up location at the roadside by focusing on their smartphone users may pose a safety risk in the traffic environment.

Aim: To achieve high user acceptance of automated ODRP services it is essential to provide customers with an intuitive and easy to use information system that provides high user experience (UX) along the user journey. When it comes to the challenges of navigating to the flexible pickup location and identifying the SAV stopping area in the street environment with no real-world cues, information representation on the smartphone interface has to be clear and efficient. Further-more, safety issues need to be taken into account as well. Focused on their smartphones, users try to find their pick-up location in the street space and may put themselves and other road users in danger. Hence, to master these challenges efficiently becomes essential. The concept of a virtual ride access point (VRAP) addresses this issue with means of augmented reality (AR) by providing users of automated ODRP with meaningful information items in reference to the street environment.

Method: A between subject design will be applied to compare the usability of two different types of information representations (A/B-testing) in real life exposure scenarios. Both interfaces will display the same amount of information and solely differ in type of information representation. The scenario will be staged as follows: participants are going to be asked to book a DRT service with SAV on a smartphone. After booking the main task of the user study will begin. Participants are going to navigate with the help of the smartphone to their pick-up location either through 1) a state-of-the-art “google maps”- inspired interface or 2) a novel AR-navigation interface. Navigation route to pick-up location will be approximately 300m. Participants have to accomplish the task of correct navigation within a given time frame. After arriving at the pick-up location, participants will answer a set of standardized questionnaires to evaluate the provided interface regarding UX. Furthermore, objective measures for mastering the task will be recorded.

Results expected: The results will show the difference in UX and efficiency between both infor-mation representation methods. We assume, that the AR-navigation interface will lead to a more efficient solving of the given task due to less cognitive workload as well as reducing uncertainty by clear information of the pick-up location embedded in the real world. Egocentric AR information items will potentially lead to more efficient information processing for the user. Hence, users will navigate more seamlessly and more safely to the pick-up location at the roadside. We expect users to be more aware of the surrounding environment when moving in the street space due to lower abstraction of the information items in contrast to conventional maps information representation. The explained study will yield a high validity for our test results, as the goal of our setup is to properly emulate realistic usage of such application.

Conclusion: With the use of AR-interfaces users of automated DRT services will likely have a safe and joyful experience before boarding the vehicle. AR-aided navigation might reduce workload when navigating and identifying the pick-up location. Hence, understanding and

interpreting of map information becomes obsolete and users will be able to move safely in the street environment. Results of this study will be used to derive and improve design guidelines for AR interfaces in the context of DRT. Furthermore, AR-navigation experiences will be optimized in future design iterations.

Assessment of the use of active road studs at spiral-marked roundabouts using the Swedish traffic conflict technique

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Background: Roundabouts have been adopted across the world as a useful and flexible form of high-capacity junction where multiple roads meet. Changes in design criteria over several decades have resulted in safety improvements at roundabouts; notably, the adoption of the offside priority rule at entries and a better understanding of the influence of geometric characteristics has reduced collision rates. However, collisions on the circulating carriageway and at exits remain common. The development of turbo roundabouts can be beneficial in such circumstances through physical segregation of traffic streams, but their use is less suited to large and complex multiple lane intersections. Other solutions such as spiral markings are more flexible, but the collision risk through unexpected lane changing by drivers remains inherent. Interventions that reduce this risk are therefore of potential interest to highway designers.

Active road studs are a recent development of the traditional reflective road stud. The technology features powered LED illumination, which can increase the visibility of the stud by a factor of ten. The basic form is powered by a solar charged battery and switches on only during hours of darkness; whereas a more advanced version features a permanent, powered cable connection and can be switched on and off on demand in conjunction with, for example, traffic signal control.

The potential offered by the technology in improving lane discipline resulted in the creation of the world's first spiral marked roundabout featuring active road studs near Edinburgh, Scotland, one of two roundabouts investigated as part of this work.

Aim: The aim of this research is to assess the effects of active road studs on driver behaviour at spiral-marked roundabouts, with a specific emphasis on road safety.

The objectives of the work are to:

- determine the rate of traffic conflicts at typical non-treated spiral-marked roundabouts;
- determine any changes to the rate of traffic conflicts experienced after the installation of active road studs;
- compare the rate of traffic conflicts with recorded collision statistics over a representative period; and
- observe other associated changes to traffic patterns such as variations to saturation flow.

Method: As a novel approach to collision reduction and prevention at roundabouts, extensive collision data is not currently available. On this basis, a conflict study approach was chosen to assess their potential as a road safety intervention, with traffic conflicts serving as a surrogate measure of safety.

Before and after video studies were undertaken at two major traffic signal-controlled spiral-marked roundabouts on the City of Edinburgh bypass. Comprehensive video surveys were undertaken on three occasions for each roundabout: before installation; one year after and three years after installation, respectively. Recordings were made over a week in each case, capturing a variety of weather, lighting, and traffic conditions.

At both locations, the Swedish traffic conflict technique has been used to analyse the video data collected to characterise conflicts and then assess any changes in the rate of conflicts following installation of the studs. In the case of the first roundabout to be installed, five years of recorded collision statistics is now available and comparisons of conflict rates with actual collision rates will be made.

Results obtained and expected: Preliminary naturalistic observation work showed an improvement in lane discipline immediately following installation of the studs. This early work looked only at lane adherence and not conflicts, but it is hypothesised that the reduction in lane transgressions found may translate to a corresponding reduction in traffic conflicts.

Statistical association between traffic conflicts and actual collisions at spiral-marked roundabouts is currently unclear. The results of the conflict analysis will also be compared with actual statistical data over a five-year period to determine whether such an association exists.

Finally, it is also possible the smoother traffic flow may result in greater capacity. This will be assessed using a comparison of saturation flows before and after installation.

Conclusions: The results of this work will be of interest to engineering practitioners by providing an indication of the potential outcome of active road studs as a safety intervention at roundabouts and their possible role in capacity enhancement. In addition, from a research methodological perspective, it will contribute to the evidence base associating the results of conflict study with actual collision data for this junction type.

Pedestrians' Crossing Behaviors and Preferences: A Field Study

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The planning of the walkable environment is gaining more and more attention due to its various benefits related to public, sustainability, or social life. Therefore, there is an increasing need for knowledge about the concept of walking and the walking behaviors of pedestrians in the built environment. During the pandemic period, as the interest in public transportation decreased in many countries, interest in non-motorized travel options increased and influenced the countries' policies. In this respect, walking is one of the most preferred transportation modes as a sustainable urban transportation mode. However, pedestrians are one of the most vulnerable road user groups in traffic, and therefore pedestrians face many risky situations in traffic. Most accidents involving pedestrians occur when pedestrians cross the street because it is a possible situation for pedestrians-vehicle interaction or conflict. Statistics indicated that in Turkey, the reason for approximately 7% of pedestrian accidents is not to slow down at pedestrian and school crossings and not to give pedestrians the right of way (General Directorate of Security, 2020). In the light of all these, countermeasures that emphasize pedestrian safety should be considered in the planning of cities, and the effective use of pedestrian crossings should be encouraged by these design features. Understanding the crossing behavior of pedestrians is critical for deciding effective countermeasures to increase pedestrian safety. Pedestrian crossing behavior is influenced by various factors such as personal characteristics, traffic conditions, and environmental factors.

In this context, this study examines pedestrian behaviors and the factors affecting pedestrian behavior in Ankara-Tunalı Hilmi Street. Tunalı Hilmi Street has an approximate length of 1.5 km. Due to its location close to the city center, it is an area with high traffic and pedestrian density. A 250-meter-long section starting from Tunalı Hilmi Street to Tunus Street was selected as the study area. This study aims to understand the behaviors, perceptions, and preferences of pedestrians in the study area. In addition, it aims to identify situations that create safety concerns for pedestrians in the area and offer suggestions addressing these concerns. For this purpose, a survey study and an observational study are planned to be conducted. An online survey will be designed to reach more people. People who live and work around the study area will be contacted by delivering brochures advertising the study and from social media platforms. The survey will include questions about road user demographics (e.g., age, gender), opinions about the site, crossing behaviors, and preferences. The expected results of the survey are to determine the crossing preferences of pedestrians, understand their motivation when crossing the street, understand the main reason for the attitude regarding traffic rules, and understand the safety perceptions about the area. In addition, it is expected that the situations that negatively affect road safety in the area for pedestrians will be understood. The observation study was planned by dividing the study area into three parts according to its spatial characteristics. The observation study involves taking 30-minute recordings from different angles, capturing the pedestrian mobility in these three parts. The observation data aims to give information about crossing points (whether it is on a pedestrian crossing), crossing time, pedestrian crossing volumes, pedestrian crossing behavior (whether pedestrians are walking, running, or whether it is a group crossing). From the observation study, the preferred location for pedestrians to cross (e.g., crossing patterns) are expected to be determined. It is also expected that the observation data will provide information about the compatibility of pedestrian facilities with pedestrians. As a result of these studies, the suggestions aiming to increase pedestrian safety in this area are planned to be offered. In addition, it is thought that the results of this study will contribute to the determination of the factors affecting the crossing behaviors of pedestrians related to the external environment. As a result, it will help to arrange crossing facilities according to

pedestrian preference because the proper design of facilities contributes to pedestrian safety and encourages walking without sacrificing safety and comfort.

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A cyclist's dream of biking in every season – Encouragements and obstacles for urban winter cycling

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Background: The bicycle, as a mode of transport, has seen increased acceptance in recent years. Nevertheless, various studies have outlined that, compared to summer months, cycling frequencies are often significantly lower in winter when weather conditions are colder and surfaces are often wet and snowy. The winter road maintenance service in many cities is still mainly oriented towards car traffic and often does not address the requirements of cyclists to get around safely and comfortably in urban traffic during harsh weather conditions. The studies on winter road maintenance in car traffic can therefore only be applied partly to cycling and its specific needs. Described in literature the main influencing factors for winter cycling are: weather, surface conditions, trip purpose, distance, safety perception as well as peer group, moderated by personal factors.

Aim: In this study, we concentrate on the surface conditions and their link to cyclist's safety perception. The aim of the study is to find out if, and how, the safety perception of different surface conditions influences the willingness to cycle during winter for different types of cyclists. As personal aspects such as experience have an effect on safety perception, the moderation of such factors on safety perception is also quantified.

Method: We evaluated and grouped international practices for winter cycling to find out how cities can intervene to motivate more winter-cyclists. Based on this literature analyses we conducted a nationwide online survey (n = 3'521) in Germany in spring 2020. The sample consists of 31.4 % women (n = 1104), 66.8 % men (n = 2353) and 0.5 % (n = 19) participants of a different gender (45 have not stated). The mean age is 42.6 years (14 - 89 years). Participants of this survey were asked to indicate how likely they are to cycle in winter under surface conditions, like snowfall, wetness, foliage, new snow, packed snow, slush or ice. They also indicated under which reasons they feel unsafe when riding their bike in winter (e.g. weather, own cycling skills, lack of equipment/fitting of the bicycle, condition of the cycle tracks/roads and how safe they feel in general when cycling in winter).

Results obtained: We present results primarily on the assessment of, and satisfaction with, cycling infrastructure conditions in the winter months. Bicycle commuting, high subjective safety, a positive attitude towards cycling, a high subjective norm, as well as high perceived behavioural control could be identified as promoting factors of winter cycling. Equipment and winter road maintenance had no direct influence on winter cycling. However, snow on the road and ice were identified as hindering factors. The most frequent reasons given by winter cyclists for feeling unsafe when cycling in winter were "inconsideration of other road users", "small distance to other road users" and the "condition of cycle paths/roads". When cycling in winter, winter cyclists on average feel "neither unsafe nor safe", in snow and ice, on the other hand, they feel "rather unsafe" to "neither unsafe nor safe" and in other weather conditions (cold, wet, light rain and light wind) they feel "rather safe". The higher the subjective safety is assessed for cycling in winter and under different weather conditions, the more often people cycle in winter.

Conclusions: There are good reasons why more people should bike all year round: the bicycle is a cost-effective mode of transportation, which helps people to stay active, contributes to a more sustainable transportation system, and improves the quality of living. Results of this study show that subjective safety should be increased, winter road maintenance improved, and a positive image of cycling should be aimed for. Commuting by bicycle and cycling in winter then would be made easier. With these results we can understand what kind of encouragement as well as mandatory infrastructural conditions cyclists actually need to help them not to

abandon their bikes during the winter months. These measures can contribute to a higher winter cycling rate as they influence positive safety perception and therefore the willingness to cycle all year round. This then could help to increase the number of year round cyclists, e.g. when municipalities include this in their cycle traffic planning.

Conflicts between cyclists and pedestrians – the effect of infrastructure and perceived risk

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Separating cyclists from cars makes cycling more attractive for many cyclists, mainly inexperienced cyclists, but the practical solutions are neither appreciated by all cyclists nor by all pedestrians. In Germany, compulsory bike paths which cyclists and pedestrians have to share are common, mainly when there is not sufficient space to separate cyclists and pedestrians. Even if there are bike paths which are dedicated to cyclists only, pedestrians often walk on them, often because pedestrian infrastructure is insufficiently small. When there is much car traffic on the road, cyclists often are allowed to cycle on the footpath, and there are many situations where many cyclists use the footpath illegally. There are four types of situations which differ in their legal basis, and conflicts between cyclists and pedestrians are common in all of them.

Interviews showed that some cyclists see pedestrians as road users who move in an unpredictable manner and have the right to do so. These cyclists perceive cycling in the same space and on the same level as pedestrians as uncomfortable and risky. Other cyclists see themselves and pedestrians as suitable partners on footpaths and stress that both groups of road users are no risk for each other.

We intend to find out which perspective "pedestrians" and "cyclists" – persons who identify to a different amount with both road user roles – have towards sharing space with the other group, potential conflicts and behaviour.

For this purpose we programmed an online survey with road scenes of the four types of situations. The participants are asked how they would behave and how they judge the behaviour of other road users.

We expect that cyclists are better informed about the different legal situations than pedestrians. We expect that legal space allocation is important for cyclists: We expect that cyclists are willing to pass pedestrians faster and with a smaller distance when they cycle on a bike path which pedestrians are not allowed to use than in the other situations where they share space with pedestrians. We expect that cyclists who know that they are cycling on a footpath illegally are more willing to slow down and pass pedestrians with a larger distance than in the other situations. We expect that the legal situation affects pedestrians' less than cyclists' judgement.

We expect that subjective control is important for cyclists and pedestrians: pedestrians who feel more in control of the situation and who perceive less risk tolerate smaller passing distances, cyclists who feel more in control and perceive less risk report smaller passing distances. Perception is a prerequisite for control: We expect that pedestrians who often do not perceive that cyclists are approaching are generally less tolerant towards sharing space with cyclists and bike paths on the same level as footpaths.

We expect that pedestrians and cyclists who prefer to cycle on the road are more likely to judge passing distances between cyclists and pedestrians as insufficient than cyclists who prefer to cycle separated from car traffic. We expect that persons who have experienced a collision between a cyclist and a pedestrian feel less safe in situations where cyclists cycle on the same level as pedestrians.

Show me the street and I'll tell you where they'll cycle: The impact of sharrows and parked cars on cyclists‘ lane positioning and perceived safety on narrow roads

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The number of persons cycling in Germany has been increasing over the past few years. This trend has only intensified since the start of the COVID-19 pandemic. However, despite the increasing cycling numbers and the positive effects of cycling for individuals, society and the environment, the share of trips made by bicycle in Germany is still relatively low compared to other countries, with subjective safety being one of the most important barriers to cycling. Calls for safe cycling infrastructure and the increased cyclist numbers to be reflected in the allocation of road space are getting louder. In particular, the demand for separate cycling infrastructure is high, as it is being perceived as safer than cycling in mixed traffic. In cases where street cross-sections are too narrow to accommodate bicycle facilities, bicycle symbols on the road (so-called “sharrows”) are increasingly being used to convey to cyclists that they should cycle on the road, not on the more crash-prone sidewalk, to improve their perceived safety in mixed traffic and to alert motorists of possible cyclists in their vicinity. Furthermore, the symbols are intended to guide cyclists away from parked cars and closer towards the middle of the lane, out of the dooring zone. Sharrows are currently not regimented by German road traffic regulations, leading to a wide range of designs, e.g. regarding the presence or absence of arrows complementing the bicycle symbols as well as their size. The present study to date is the first to investigate differences in cyclists’ perceived safety and lateral positioning on the road with regards to different sharrow designs in a German traffic context. Furthermore, effects of parked cars and the position of a pictured cyclist ahead on respondents were investigated. 2,537 persons took part in an online survey and were presented with 20 pictures depicting a 6.65m wide main urban commercial road with or without curb-side parking and different kinds of sharrows (or no sharrows) on the road. Additionally, the position of the pictured cyclist ahead varied, with them riding in a distance of either 0.80 or 1.20m from the curb/parked cars. Respondents were asked to indicate where they would cycle in the depicted scenarios and how safe they would feel cycling in the position of the pictured cyclist ahead.

The present study shows that respondents indicated feeling safer in conditions with sharrows compared to conditions without sharrows. Even more importantly, they reported feeling safer in conditions without parked cars compared to conditions with curb-side parking. In conditions without parked cars, no anchor effects of the position of the cyclist ahead on respondents’ perceived safety could be found, while in conditions with parked cars, the respondents felt safer when the cyclist ahead cycled further towards the middle of the lane. Both for scenarios with and without parked cars, respondents stated using a position further away from the curb when the pictured cyclist ahead was cycling further away from the curb as well, indicating an anchor effect. In general, the respondents stated using a position further towards the middle of the lane in conditions with parked cars. No relevant differences with regards to perceived safety and lane positioning could be found for the different sharrow designs presented. This indicates that previously reported differences in the effects for sharrows on road users’ perceived safety and behavior stem from differences in the sites investigated rather than from differences in the design of the sharrows.

Our results show that the symbols could be effective in improving cyclists’ perceived safety and thus getting more individuals to cycle (on the road) in Germany, particularly on narrow streets with no separate cycling infrastructure. The respondents’ position on the road was mainly influenced by the presence of parked cars as well as the position of the depicted cyclist ahead (and not by the presence or absence of the sharrows), indicating the need for further research regarding the effectiveness of the symbols to lead cyclists out of the dooring zone.

Road safety knowledge in Dutch municipal civil servants

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In the Netherlands, most traffic fatalities occur on municipal roads. Therefore, local civil servants should have enough knowledge on how to create and carry out solid and effective local road safety policies. Our study aimed at measuring the knowledge level of municipal civil servants responsible for road safety. Firstly, a theoretical classification of types of knowledge was created, applicable for municipal civil servants. We distinguish five relevant types of knowledge: Situational knowledge, Conceptual knowledge, Procedural Knowledge, Strategic knowledge and Cultural knowledge. 135 municipalities (38% of all Dutch municipalities) filled out a questionnaire with factual questions and self-assessment questions and nine municipalities participated in in-depth interviews. The results show clear differences between the presence of the five knowledge types in municipal civil servants. Local civil servants have a good understanding of their local situation and the leading vision in the Dutch road safety field. Furthermore, they are convinced of their strategic skills to find budget for road safety policies. On the other hand, knowledge about effectiveness of road safety measures was (very) limited, as was knowledge on (the handling of) road safety data. Future research should find out the reasons for this limited knowledge about road safety measures and road safety data.

Analysis of implicit communication of motorists and cyclists in intersection using video and trajectory data

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The interaction of automated vehicles with vulnerable road users is one of the greatest challenges in the development of automated driving functions. In order to improve efficiency and ensure the safety of mixed traffic, automated driving functions need to understand the intention of vulnerable road users, to adapt their driving behavior, and to show its intention. However, this communication may occur in an implicit way, meaning they may communicate with vulnerable road users by using dynamic information, such as speed, distance, etc. Therefore, investigating patterns of implicit communication of human drivers with vulnerable road users is relevant for developing automated driving functions. The aim of this study is to identify the patterns of implicit communication between human drivers and vulnerable road users. For this purpose, the interaction between right-turning motorists and crossing cyclists was investigated at a traffic light controlled urban intersection. In the scenario, motorists and cyclists had a green signal at the same time, but cyclist had right of way. Using the Application Platform for Intelligent Mobility (AIM) Research Intersection, trajectory and video data was recorded at an intersection in Braunschweig. Data had been recorded for four weeks: from 22nd August to 18th September 2016. Based on the criticality metric post encroachment time (PET) and quality of the recorded trajectory, 206 cases of interaction were selected for further analyses. According to the video annotation, four common interaction patterns between motorist and cyclist when approaching the intersection were identified. With regard to their relative position: 1. Motorists were in front of cyclists at all times; 2. Motorist were in front, then abreast then, and in the end behind cyclists; 3. Motorists stayed behind cyclists; 4. Motorists were behind, then abreast, and again behind cyclist. The analysis of the trajectory data revealed different patterns of changes in velocity and the interdependence of the spatial distance. The findings of this study might provide automated driving functions with a communication strategy, contributing to traffic efficiency as well as ensuring safety in the interaction with vulnerable road users. In a next step, suitable parameters need to be identified in order to quantify the performance of the communication.

Are 3D zebra crossings an effective measure to improve the safety of crossing pedestrians?

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Background: Crossing a road at an unprotected crossing is one of the most risky manoeuvres for pedestrians in traffic. Researchers and practitioners are looking for effective ways to improve safety of crossing pedestrians. Making visual changes to the crossing design to affect road users behaviour and ultimately safety has raised interest in recent years. Among others, some cities and road authorities have implemented, or are considering to implement, so-called "3D zebra crossings". 3D zebra crossings use an adjusted design of the classic zebra stripes to give approaching drivers the illusion that the stripes are physical objects hovering above the pavement. The idea is that it makes the crossing more conspicuous, raises attention of the drivers and leads to lower driving speeds, better yielding to pedestrians, and therefore ultimately improves safety. Several pilot projects with 3D zebra crossings existed or still exist in various countries such as Belgium, The Netherlands, UK, Iceland and India. However, most were short projects, and none of them seem to have undergone any formal evaluation. Therefore, it is unclear whether 3D zebra crossings are just a nice gimmick or a real measure that can have an enduring favourable effect on road safety.

Aim: This paper aims to assess the road safety effects of replacing a traditional zebra crossing with a 3D crossing using surrogate measures of safety.

Methodology: A field experiment of 3D zebra crossings at three test sites in Belgium was conducted and evaluated in a before-after design. The test sites are crossings at high-volume roads through urbanized areas. The effects are evaluated using speed measurements from radars and behavioural and traffic conflict observations using video footage obtained by using temporary cameras.

Video footage was collected during four days (6h00 till 22h00) before and after the implementation of a 3D crossing. At each crossing, the interactions and behaviour of crossing pedestrians were registered for one day using a predefined codebook. Serious conflicts were collected from four days of video footage at each crossing. A video analysis software was used to preselect crossing events and another software was used to measure the severity of potential conflicts using the surrogate safety indicators Post Encroachment Time (PET) and minimal Time-to-Collision (TTCmin). Three radars were installed for measuring individual road user speeds: at the actual crossing, 50m before the crossing and 300m before the crossing. The radar at 300m from the crossing was used as a control site.

Results and conclusions: The radar measurements showed no statistically significant effect of the 3D crossing on driving speed. The behavioural observations show a small but statistically significant improvement in yielding behaviour after the installation of the 3D crossing. There is an increase in the percentage of interactions in which the crossing pedestrian receives the right-of-way (defensive yielding), and a reduction of the percentage in which the pedestrians takes the right-of-way (assertive behaviour) as well as a reduction in the number of interactions in which the pedestrian does not get the right-of-way. No significant effect on the walking lines (i.e. crossing the road at or outside the marked crossing) was observed. A small reduction in the number of serious conflicts was observed. A noteworthy observation was the fact that the majority of the serious conflicts took place in the second lane - from his/her viewpoint -that the pedestrian is crossing. Given the relatively low numbers of serious conflicts, the results should be interpreted with caution.

In summary, no indications of negative effects were found and some indications of potential positive effects, but these were not consistent. Therefore, the study concludes that there is

insufficient basis to recommend further deployment of 3D zebra crossings. Further research is needed to confirm these findings.

Comparison of safety and kinematic patterns of automated vehicles turning left in interaction with oncoming manually driven vehicles

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Highly and fully automated driving has been under development for the past two decades in order to increase comfort, efficiency, and traffic safety. Particularly in the latter domain, experts agree on automated driving, especially in case of automated vehicles (AV) with SAE level 4 or higher, having the most promising effects. Automated driving is expected to decrease the number of seriously injured or even killed road users to zero (Vision Zero). However, automated driving is still in an early stage of development and many AV tend to drive very carefully to avoid crashes. So, the goal is to make driving more efficient while maintaining the highest level of safety. In the project “Digitaler Knoten 4.0” cooperative automated driving was assessed regarding efficiency and safety aspects. One of the use cases investigated was turning left with oncoming traffic at an urban intersection as this situation represents one of the most complex situations in urban areas yielding to crashes with—in many cases—serious consequences for the involved road users. At the Application Platform Intelligent Mobility (AIM) Research Intersection in Braunschweig, Germany, an SAE level 3 AV was turning left interacting with oncoming manually driven vehicles (MV). The performance of the AV was compared to MV executing the same manoeuvre. The recorded video-based trajectories of the respective AV as well as MV were analysed regarding the influence of situational factors (e.g. position of the vehicle in the queue and gap acceptance) and kinematic factors (e.g. speed and acceleration) on traffic safety. The similarities and differences between this specific AV and MV were identified yielding insight for further developing algorithms for more efficient driving while maintaining the same traffic safety level. For instance, it appears that the AV shows a very conservative left turning behaviour leading to very safe PET distributions in comparison to left turning MV.

Diagnose and severity evaluation of the coverage of Emergency Medical Services due to road accidents in Bogota, Colombia

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Background: Bogota, Colombia's capital, is not only the most extensive and wealthiest city in the country, but it's also the city that gathers the uppermost number of fatal victims in traffic crashes. Between 2012 and 2017 the number of fatal victims of traffic crashes summed up a total of 3,444 casualties, with an average of 574 deaths per year. Local authorities have been making significant efforts to drop the number of victims and prevent road traffic accidents. Emergency Medical Services (EMS) are key to preserve life when motor vehicle crashes with injuries occur. EMS provide medical attention, which can result in reduction of death rates and disabilities. Therefore, it is essential to analyze and identify weaknesses in the healthcare network that impact traffic safety. In 2017, 6,759 of the 8,599 crash victims were sent to the Kennedy's Hospital (HOK). Half the cases occurred at an average distance of 7 km. However, some of them occurred as far as 25 km from HOK, which can be considered a long distance to cover, especially in cases of severely injured victims crashes when response time is critical. The "Golden Hour" paradigm, attributed to Dr. Adams Cowley in 1975, states that "the first hour after injury will largely determine a critically injured person's chances for survival." Even though it's a matter of clinical controversy (with full supporters and critics), for the porpoise of our investigation, 60 minutes is the optimum attention standard for EMS services.

Aim: Our research aims to characterize traffic-crash-risk zones in Bogotá, accounting for response and travel times to EMS, considering that increasing travel times and delaying medical attention are related to higher mortality rates.

Method or methodological issues: We estimated only travel times to HOK, which is the last stage of the emergency response chain before a victim receives formal treatment. Using a transportation model of Bogota calibrated for 2019 in PTV Visum software, we developed a methodology to select the most effective coverage area to include in our model based on the number of befell cases. We considered flow conditions and restrictions of three critical scenarios: 1) the day of higher mortality, a typical Saturday of December, 2) the day of higher morbidity; a typical Thursday of September in the morning rush hour and 3) the day of higher morbidity; a typical Thursday of September in evening rush hour.

Results: We found that only 15% of the traffic crashes involving fatal or injured victims occurred at less than 15 minutes from the hospital, and 50% of the total accidents occurred at 30 minutes or less. We also found that city districts of Kennedy, Tunjuelito, and Puente Aranda were at a reasonable threshold of 20 minutes or less for EMS travel times to HOK. However, others like Chapinero, Santa Fe, Candelaria, Teusaquillo, Bosa, and Rafael Uribe Uribe are out of the threshold of optimal travel time for convenient medical attention, meaning that average travel time takes furthermore than 20 minutes.

Conclusions: Even though there is not enough information to prove that high travel times are correlated to higher death rates in Bogota, it is clear that most of the events had an assistance time cycle of more than 60 minutes. Travel time from the crash site to the hospital was only less than 20 minutes, in the 28% of the cases related with deceased individuals with average travel time for all deceased cases of 31.53 minutes and 16% in cases related only with injured individuals with an average travel time of 37.79 minutes for the morning rush hour and 43.06 minutes for the evening rush hour. The map created with the travel time information and the incidence of events is a helpful tool to plan EMS transfer policies. Estimates of travel time to the HOK may inform about where it is convenient to rush the victim to increase the patients' chances of survival.

Impact of outdoor lighting and quality of the road surface on cyclist safety

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Street lighting is an important factor affecting preferences towards cycling as a transportation mode, particularly in wintertime when the number of daylight hours is severely limited. Lighting also serves to improve cyclist safety. Several studies report the same funding that single-bicycle crashes are more likely to occur in the dark and twilight (Schepers et al. 2011; Boufous et al. 2013). Swedish data show that cyclists are dissatisfied with the current situation of street lightning, stating that it is insufficient (Niska 2007). Almost half of the single bicycle crashes that result in severe injury are due to road surface deficiencies such as slipperiness or potholes. These deficiencies are more difficult to detect in darkness and, in total, 20% of single bicycle crashes occur during dark hours (Niska et al. 2013). The existing research aims to study and explore how lighting conditions and the quality of the road pavement affects the travel behaviour and experiences of bicyclists. Thus, we develop a method that combines both self-report data on cyclists' experiences and microscopic cyclist/pedestrian trajectory data from video recording. This method can be further applied to improve the quality of travel and safety for cyclists in twilight and dark. Data were collected by self-reports during structured biking performed in the urban setting under study. Study participants individually cycled a certain route and were immediately afterward asked to assess perceived qualities of the routes including the perceived lighting quality as well as their experience of traveling in such environment. The participants were video filmed along the entire route using a drone. In addition to the filming of the participants, filming of the locations in an undisturbed condition was also performed. The trajectories were extracted using a semi-automated video analysis tool, T-Analyst, which allows the measuring of different objective indicators (T-Analyst 2015). The aggregation of trajectories in terms of average speed/lateral position profiles along the path allows for studying the changes in the entire group of experiment participants while the individual trajectories are used for the analysis of specific interactions, e.g. overtaking or meetings with an on-coming cyclist/pedestrian. The actual lightning and unevenness of the predefined route are measured with a specially designed equipment. The method was tested at two different locations in Sweden during fall and winter seasons. The locations consist of road stretches of about 200 meters with different designs. One location has a mix of both cyclists and pedestrians while the second location has a separation between cyclists and pedestrians. Following the completed data collection, the next step of the study is to analyse how the travel behaviour differs between day and night conditions at the studied locations and how differences in the designs might affect the behaviour of the cyclists. It would be especially interesting to know whether there are any synergy effects between weather, quality of the road, lighting conditions and safety. Using the data from the undisturbed conditions, an effort will also be made to investigate whether the behaviour of the participants is representative of normal road users.

Mobility patterns and mode choice preferences during the Covid 19 situation

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Background: Attitudes and preferences in the context of mode choice are, besides other factors, influenced by situational factors, such as personal safety, comfort or availability of traffic modes. Restrictions during the Covid 19 situation created a natural experimental situation when situational factors were drastically changed from day to day. This enabled us to research how concrete situational factors influence mode choice and what role do habits play in this process.

Aims: The study aims to understand how the Covid 19 situation influences/ed the preferences and attitudes concerning the different traffic modes and mode choice (during the restricted period and also in the follow-up period, after the end of the restrictions). We aim to provide an international perspective on this topic.

Methods: We designed a questionnaire with standardized and open-ended questions, which consists of 2 main parts: the first part, to collect during the C19 restrictions – exploring attitudes before and during this phase, and the second part, after the Covid 19 restrictions – attitudes a few months later. The questionnaire was applied on-line or in a dialogue with the respondents on the phone. A dialogue in person was difficult due to the circumstances and was therefore skipped. The following countries are included in the data collection: Austria, Czech Republic, Finland, Germany, Italy, Latvia, Portugal, Russia, Spain, Sweden, and the United Kingdom. For each country, we aim to receive answers from at least 50 respondents with balanced quotas (gender, age: 18 - 24, 25 – 64, 65+).

Results and implementation: This is still work in progress, so we cannot present any results yet. However, we expect that we will have the preliminary results ready to present during fall. Understanding how restrictions influenced mode choice and whether people will get back to their previous habits is important for transport policy; e.g. will citizens use public transport as much as before Covid 19 situation? Will Covid 19 boost car use? The results are going to be relevant for potentially similar situations in the future.

Optimization Model for Highway Work Zones Considering Safety, Mobility, and Project Cost

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Highway Work Zones (HWZs) are associated with significant adverse impacts on safety, mobility, and project cost. The goal of this research is to mitigate these adverse impacts by developing an optimization model for HWZ designs that explicitly consider their safety costs jointly with mobility, and project costs implications under various constraints on the budget, acceptable crash rates and delays. The model results indicate that the additional costs associated with improving HWZs safety are well justified by the savings obtained from mitigating crashes. The model can be used by transportation agencies to find the minimal project cost under maximum traffic delay and maximum safety impacts thresholds placed by the police and local authorities that approves the work plans.

Project DROVA: Traffic safety analysis in temporary traffic regulations using drone videos

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Traditional traffic safety analysis relies on historical accident data. The contradiction of this type of analysis is the critical number of traffic accidents needed in order to draw traffic safety conclusions, and make either infrastructural or traffic management changes. When it comes to examining the safety of temporary traffic regulations in road construction sites, traditional traffic safety analysis tends to fail because of the temporary and temporally changing nature of these regulations. The goal of our project DROVA is therefore to analyse and compare the traffic safety of different temporary traffic regulations on highways using Surrogate Safety Measures (SSM). This method is based on traffic conflicts instead of accident data, and aims to detect unsafe situations between interacting vehicles. In our project, for the safety analysis we recorded the traffic in highway construction sites with a drone in five different locations in western Germany.

Temporary traffic regulations do not usually have a clear design with respect to road markings. Besides, there can be differences between design and as-built constructions. For these reasons, in project DROVA our very first step was to obtain information about the as-built constructions: we digitalized the road sections including markings using photogrammetrical methods. In addition to this information, the created UTM-referenced point clouds provided the needed data for the camera calibration and allowed us to obtain the vehicle positions in UTM coordinates. For the latter purpose we implemented our own software to detect, classify and track the vehicles through the videos.

In a previous project, we generated 3D point clouds of different vehicle classes using a laser scanner placed above the road. In project DROVA, we used 25 vehicle-models from these point clouds for the classification, which models were able to represent most of the vehicles in the videos. With our software, the detection and classification of the vehicles can be done manually, where the user chooses one of the vehicle classes (using the 25 models) and its initial position. The tracking of the vehicles through the length of the video is automated and sufficiently stable to produce adequate results. This combination of methods (semi-automated) allowed us to collect a large amount of microscopic traffic data and serves as a strong basis for developing the fully automatic method.

After the traffic data collection, we built continuous trajectories for the vehicles from the discrete tracked positions and derived the information needed for the safety analysis with Surrogate Safety Measures, such as Time-to-Collision (TTC), Deceleration Rate to Avoid Crash using Initial Acceleration (DCIA) and Stopping Distance (SD). Since we digitalized the road sections and now we have continuous trajectories from all the vehicles passing through the analysed sections, these information allow us not only to conduct temporal but also spatial analysis with the SSM. Thus, we expect to be able to identify dangerous locations in the construction site and identify the problems causing these locations. Moreover, we expect that the differences in the safety level of the different temporary traffic regulations can be shown and that we can determine which design is safer in comparison.

In summary, video based traffic data collection has many advantages, such as the greater quantity of data which can be obtained and analysed in a shorter period of time compared to manual data collection. Furthermore, it makes it possible to investigate the traffic phenomena comprehensively, not only the seemingly dangerous situations, which allows a deeper safety analysis. As the aim of traffic safety analysis with SSM is to detect unsafe interactions between road users based on traffic conflicts, this method is suitable for pre-emptive safety analysis of temporary traffic regulations, where it is difficult to collect sufficient number of

accident data to draw traffic safety conclusions. Furthermore, with the digitalization of the road sections it is possible to analyse the influence of road design on traffic safety, thus the safer designs can be preferred in future constructions.

Project FeGiS+: A proactive approach towards road safety evaluation enabled by smart data

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In today's digital age, more and more data is collected every day in the field of transportation. Still, authorities solely rely on historical traffic accident data to detect black spots. This leads to the shortcoming that accidents must happen before measures are taken. Additionally, in relation to a specific location on the traffic network, traffic accidents are rare events. Thus, for credibly evaluating the safety of a road element, several years of traffic accident data are needed. As a result, road users are put at an unnecessary risk if measurements are taken too late. There is therefore an urgent need to take new paths in the field of road safety analysis.

Our project aims to build a framework to detect potential dangers in road traffic at an early stage by combining existing safety-relevant data with new data sources. Our project's framework builds on three main data sources: traffic accident data, crowdsourced data about dangerous spots in road traffic shared by road users on an internet platform and vehicle kinematic data. For the second data source, road users can report information about dangerous spots systematically. The features that users can report are based on the features of the German accident report used by police authorities. This enables an accurate comparison to the official traffic accident data. The third data source, vehicle kinematic data, describe vehicle motion data from cars and smartphones that indicate safety critical driving manoeuvres, e. g. emergency braking or evasive manoeuvres. Similar to Surrogate Safety Measures, the frequency and severity of safety critical driving manoeuvres can indicate low level of traffic safety. Vehicle kinematic data is collected via smartphone apps and partner companies that already collect this data.

The data will be blended together into a composite safety index for each element of the road network. This method comprises of three steps. The first step is a segmentation of the road network into segments of different lengths depending on the location and road class, as well as into junctions. In order to take into account the relationships between accidents, user reports and critical driving manoeuvres at neighbouring segments, these point events are smoothed over several segments. A weighted smoothing function is applied that places most weight on the target segment and decreases to zero at the boundaries. In this way, events on nearby segments are given more weight than those on distant segments. In the second step, these values are converted into separate safety-indices for each of the data sources. Finally, by combining the sub-indices for each data source, an overall safety index is formed for each segment.

The resulting safety index thus combines a reactive and proactive perspective to further enhance current traffic safety work. While accident data are a reliable source for estimating the level of safety and is thus still needed, the two crowdsourced data sources can provide additional information as well as a faster evaluation. In the future, these novel data sources will be of particular importance for achieving Vision Zero when accident data becomes less informative.

An important aspect of the composite safety index is that the index will be calculated monthly for all road categories and all road users, i.e. for urban and rural street networks as well as for pedestrian, cyclists and motorised road users. This allows for broad use cases when made available to those involved in road safety work such as local authorities, police, science, engineering offices, navigation providers and car manufacturers. Examples of use cases for the composite safety index are timely warnings of danger zones and navigation solutions with the option to choose the safest route for pedestrian, cyclists and car drivers. Thus, the new

data sources and the composite safety index enables many applications for preventive road safety work and is contributing to a greater safety on our roads.

Quantifying the severity of pedestrians-vehicle encounters in shared spaces

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In 2019, approximately 2.7 million crashes occurred in Germany corresponding to an increase of 1.9% in comparison to 2018. Especially vulnerable road users (VRU) have a high risk of being seriously injured or killed in traffic. Within the safe system approach, changes to the traffic infrastructure have been implemented to increase VRU safety. The creation of so-called shared spaces, in which all road users are encouraged to negotiate priority, is part of these efforts. Even though the concept has been known and applied for more than 30 years, comparatively little is known about interactions between different road users and methods to quantify interactions in shared spaces. The aim of this study is to investigate consistencies and differences in quantifying the level of severity of encounters between pedestrians and motorized vehicles applying the pedestrian-vehicle conflicts analysis (PVCA) and the Swedish traffic conflicts technique (STCT). The PVCA integrates four factors: time to collision (TTC), severity of evasive action, complexity of evasive action, and distance to collision (DTC). In contrast to the PVCA, the STCT only integrates the factors conflicting speed and time to accident (TA, corresponding to TTC in PVCA) to arrive at a degree of criticality. Trajectory and video data of a shared space were recorded using the Application Platform for Intelligent Mobile Units (AIM) in Ulm, Germany. 1364 encounters were randomly selected. Due to different exclusion criteria, such as interaction partners not being a car or pedestrian, detection errors, and missing values, 69 encounters were available for analyses. Using the PVCA, nine encounters were classified as critical and 60 as non-critical interactions. In contrast, computing the values based on the STCT, only three of the 69 encounters were categorized as critical. The results of the Spearman rank correlation with ties did not show a significant correlation between the severity categories of the PVCA and the severity levels of the STCT ($r=0.03$, $p = 0.78$). An additional analysis of the encounters ranked as critical by the PVCA but as non-critical by the STCT showed that all six encounters had a large temporal distance (> 2 s) combined with very small spatial distance (< 5m for vehicles and < 2.5 m for pedestrians). While the PVCA and STCT yielded similar results with regards to the categorization of non-critical encounters between vehicles and pedestrians, this could not be confirmed for critical encounters. Results indicate that distance to collision may contribute to the severity of encounters between pedestrians and vehicles in a shared space. Further research with diverse shared-space environments and larger sample sizes needs to be conducted to investigate the interrelation between PVCA and STCT in more detail. In addition, linking severity ratings of encounters to crash and injury data appears a promising approach to investigate the validity of the PVCA and STCT for quantifying the severity of encounters in shared spaces.

Real-time trajectory data acquisition and evaluation for an adaptive, dynamic infrastructure measure for safer behaviour using the concept of Nudging

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One of the main reasons for road accidents is excessive speed due to wrong perception of the road or inattentiveness. An infrastructure-based road safety measure should therefore target only those drivers that drive unsafely and "nudge" them towards safer behaviour. The term Nudging originates from behavioral science and proposes ways of influencing drivers using indirect suggestions with the purpose of a more persistent effect of safety increase and higher acceptance than with traditional methods such as speed enforcement cameras. One crucial system component necessary for such a measure is a real-time trajectory acquisition which is able to evaluate the position and speed of individual drivers.

We present a system that detects vehicle positions and speeds using thermal cameras and computer vision algorithms. The image processing consists of a 3D-model based vehicle detection in combination with a full camera calibration. Tracking and pose estimation within single cameras is conducted by a Bayesian approach, namely a Sequential Monte-Carlo Simulation, while the data fusion between consecutive cameras is implemented by object matching based on temporal dynamics of the tracked vehicles. The system then nudges the vehicles exceeding a predefined speed threshold by a light pattern from LEDs along the road markings. The light pattern adapts to the current position and speed of the individual vehicles without distracting other drivers.

The system has been implemented on a motorway exit in Eindhoven, the Netherlands. On the motorway the curve radii are large, while the exit lane has a small curve radius with short sight distances, which might cause drivers to approach the curve too fast or to inadvertently decelerate too late. The acquisition is conducted over a sequence of three cameras covering a road stretch in the order of magnitude of several hundred meters. The field test ran from October 2019 until May 2020. First, a baseline measurement without active nudging was conducted for one week. Afterwards different nudging scenarios with varying light patterns were tested. Trajectory data of several hundred thousand vehicles using the motorway exit were recorded. About two third of them fulfilled the criteria for nudging (speed above threshold, headway large enough to show the light pattern).

After careful data preprocessing the trajectories were analysed to evaluate the effectiveness of the measure. The vehicles that have been nudged reduce their speed in the exit by approximately 3 km/h (5 %) more than vehicles with the same initial speed that have not been nudged. The higher the initial speed, the more can nudging reduce the speed. The percentage of vehicles faster than the 85 % quantile of speeds ("V85") in the baseline scenario (without nudging) is reduced by 39 % at the beginning of the curve.

Thus, the proposed system design enables a more effective and target driven reduction of vehicle speed and facilitates a validation of the increase in traffic safety by measuring indicators based on individual trajectories rather than traditional analysis of accident statistics. The system can be applied to other locations where the road design poses a risk of inadvertent speeding and where other speed reduction measures have failed.

Safety critical event detection - Applying and evaluating different Surrogate Safety Measures in a roundabout traffic scenario

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Even though surveys have proven roundabouts to be safer than classic intersections, they still are a source of critical traffic encounters especially when entering and leaving them. Traffic participants' lack of experience on how to drive in this environment and multiple interactions between different types of road users (RU), such as vulnerable road users (VRU) and motorized road users, (MRU) make near-crashes likely to arise. Therefore, VRU-MRU (zebra crossing when the motorist enters or exits) and MRU-MRU (yield situation for entering or leaving the roundabout) scenarios were investigated in a real-world traffic scenario. The collection of critical events from recorded real traffic data is of value for better understanding critical situations and for the development of further automated driving functions (ADF). One of the weak points of evaluating the performance of automated driving functions is that they mostly rely on synthetic simulated traffic scenarios. Feeding this simulated environment with real-traffic based near-crashes will allow testing of ADF under more reliable circumstances. Within the framework of the EU-funded project L3 Pilot, for 30 days, video and trajectory data had been collected in an urban roundabout in the city of Wolfsburg, Germany. The so called AIM Mobile Traffic Acquisition, camera-equipped systems able to detect, track and classify traffic participants were used for data collection. The output was a space-time virtual representation of these traffic agents that can be used for behavior analyses. Surrogate safety measures (SSM) are well known metrics sensitive to space-temporal closeness between different road agents. Depending on the applied combination of metrics, a risk prediction, the closeness of an already occurred event and/or its criticality can be determined. Different SSMs will be applied in a roundabout setting to identify safety-critical events between motorists as well as motorists and vulnerable road users. The aim is to draw conclusions on the performance of the applied metrics and on the quality of detection of safety-critical encounters. For this purpose, non-normative driving behaviors will be triggered by addressing a risk-related analysis. To do so, different combinations of surrogate safety measures will be applied and the suitability of the metrics investigated and evaluated. The application of SSM on the recorded trajectory data is the key to identifying safety-critical events. The risk analysis will cover the following aspects: (1) Development and testing of different metrics, such as time-to-collision (TTC), TTC2 (also taking the current acceleration of the respective vehicles into account), and-post encroachment-time (PET) among others. (2) An empirical performance analysis of these metrics. Since the SSM rely on several dynamic assumptions, a study is made on how sensitive these metrics are to the risk inherent in the different types of road user encounters. (3) A critical event analysis, where parameters such as frequency of incidence and magnitude of the triggered event will be assessed. Therefore, significant statistical distributions will be created helping to evaluate the critical areas in the roundabout and generating knowledge about the most extreme driving situations. These situations can afterwards be used within the development of ADF, which currently rely on modelled traffic simulation scenarios for their validation. This study will support the testing and development of tools for collection of real traffic based near-crash situations data, which later on could serve as a reference for scenario-modelling within the validation process of ADF.

System requirements and data treatment for cycling safety assessment with probe data collection

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Background: Cyclists, while relatively small in proportion to motorized vehicles, have a high level of road crash sharing and severity, creating a significant need to better understand the safety characteristics specific to this user group. Moreover, less severe non-motorized vehicle accidents are often not reported to the police, and hence do not appear in official statistics. This underreporting can lead to bias in accident statistics and limitation in the safety assessment and identification of high-risk locations. Traffic conflict technique is widely applied to provide surrogate measure of safety to complement the lack of reliable crash data.

In this framework, bicyclist behavior can be recorded with different equipment and bicycle used as a probe vehicle to collect data. Anyway, bicycle dynamics and bicyclist traffic conflict have specific characteristics that must be carefully considered when data are collected and analyzed.

Aim: Observational studies usually do not suffer from such bias and the traffic conflict technique is a methodology of field observations widely applied to quantitatively describe the interactions between road users involved in a critical event for safety. With this technique, it is possible to record safety critical events (SCEs) as “situations that require a sudden, evasive maneuver to avoid a crash or to correct for unsafe acts performed by the driver himself/herself or by other road users”.

The research aim is to analyze data needs and capability to identify SCEs in cycling in urban context. Three distinct research questions are treated in the paper:

1. What equipment can provide suitable measures and data;
2. How to account for the noise induced in the sensor’s signals;
3. What ride analytics are informative to identify critical events.

Method: An instrumented bike was equipped with:

1. Video Vbox Lite that provided GPS data, speed and acceleration, synchronized with a video recording, with a frequency of 10 Hz;
2. Smartphone sensors to record GPS data with a frequency of 1 Hz and acceleration at 50 Hz.
3. Odometer measuring speed at 2 Hz frequency, used as reference system.

The calibration test was carried out in a closed track by two cyclist riding at different speeds with controlled braking and accelerating phases. Raw data was analyzed and compared to the reference values to identify the more suitable procedure to clean the signals from the noise given by the measurement system. The signal pre-processing is composed by signal denoising, outlier removal and signal filtering. Resampling and Dynamic Time Warp (DTW) procedures were applied to make comparable to the reference values, data acquired by different sensors at different frequency acquisition. Finally, different criteria to identify and classify hard breaking were compared.

Results: Researchers found that to draw the speed profile of the bicyclist, the more relevant information of the signals is contained at very low frequencies. It was possible to find the best pre-processing procedure and configuration of the filtering parameters for each sensor that minimize the Euclidean distance, evaluated with the DTW procedure, among the reference acceleration and those ones detected by different system. Speed and acceleration profiles were drawn from the different data. Maximum values of deceleration and Mahalanobis distances in the deceleration profile were computed for each signal. Results and the proposed methodology calibrated in the test track were validated in a real traffic scenario.

Conclusions: In this study, a signal processing procedure has proposed to correctly deal with velocity and acceleration signals and recognize hard breaking. Furthermore, the proposed methodology has been applied for validation in real scenario with actual traffic conflicts between cyclist and other road users. Obtained results confirm that a at least a sampling frequency of 1 Hz is needed to track the rider's behavior to detect events and so with a very cheap hardware setup, i.e. smartphone, is possible to monitor riders' speed and acceleration. Anyway, dataset available from GPS probe data providers (e.g. STRAVA, bike sharing) are typically collected with a 5-25% capture rate (i.e. less than 0.25 Hz) making such data not suitable for traffic conflict studies rather than more general roadway analytics like O/D and route mapping. The outlier detection technique based on Mahalanobis' distance outperform traditional approach based on threshold values to identify the critical events in terms of both event identification and severity.

The role of learning processes in road safety trends

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Road safety trend of a country is influenced by many factors related to the infrastructure, vehicles, health care etc. Nevertheless, road safety improvement is also a result of a learning process, which can come at an individual and a societal level, according to the current available literature. The former is due to the relationship between exposure (number of events an individual experiences) and risk of road accidents, and the latter is due to the learning process in the society.

As for the individual learning and looking at the relationship between exposure and risk of road accidents, several researchers found a negative relationship between the annual distance driven and accident rate. As for the societal learning the long-term decline in death rates is attributable to a learning process in the society. In other words, even if the motorization level increases resulting in more exposure the society as a whole is able to improve safety through learning over time.

The author argues that the long-term improvement in safety does not only happen through individual and societal (within society) learning, but also through a third dimension which is the learning process across nations (in between societies). In relation to that this paper attempts to answer two research questions using data for the EU Member States:

- What kind of differences are there in between countries regarding the speed of their improvement in safety in relation to their motorization level?
- What learning pattern can we identify across nations, if there is any?

To answer the first question countries' progress in safety improvement in relation to their motorization level is analyzed, namely what delay or advance in motorization and safety countries have within the EU in comparison with others. Several threshold values were chosen for both indicators (motorization and mortality rate) and the years when these values were reached for different countries were collected. The resulting years then were compared to the old Member States' average. In other words, the EU15 average was used as a reference point to compare each country's performance with. The results show that for many countries lagging behind both in motorization and safety it took less time to converge in terms of safety than in motorization level. Countries reaching a given motorization level later in time can show a better safety level, which we might call the advantage of latecomers.

Addressing the second question is more difficult since knowledge transfer between nations is intangible, such a variable does not exist and thus cannot be measured directly. As a proxy the Human Development Index (HDI) is used. Panel regression is applied to investigate whether HDI as a measure of knowledge is a better predictor of safety instead of exposure measures (like car ownership level). It was found that HDI is overall a better predictor in the panel models. While a few countries are already getting close to the saturation point in their motorization, an alternative knowledge-based predictor is needed for these countries to better describe trends in their mortality rates.

Toward a conceptual framework for understanding the interactions and relationships between road safety, accessibility, and built environment

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"Road safety" and "accessibility" are important aspects of both transportation and land-use policies; although improvements in these concepts are typically considered as separate goals in these policies. On the one hand, road safety denotes the understanding of traffic crashes to prevent them, and reduce the risk of fatalities and severe injuries for people while they are moving through the transport systems. Accessibility, on the other hand, indicates the extent that transport and land-use systems enable people to reach destinations by using transportation systems. Both safety and accessibility are extensively studied and several conceptual models were developed to identify the factors influencing road safety and accessibility. However, the relationships between these concepts are not fully understood yet, even though the literature reveals that there are factors affecting both road safety and accessibility levels.

Several factors related to the locations of activities, transport system characteristics, and individual characteristics are acknowledged to influence traffic safety; since these factors affect the overall travel patterns (i.e., traffic volumes, distributions, and modal share). In addition, temporal factors such as different time-spans during the year, week, and day have shown to be correlated with the occurrence and severity of crashes. Similarly, accessibility is known to interact with four elements: land-use (locations of activities and opportunities), transport system (representing transport infrastructure and resistance factors), temporal factors (indicating temporal constraints of activities), and individual factors (representing the individuals' needs opportunities, and abilities). Being inspired by these notions in addition to the results of the previous analytical studies, a conceptual framework is proposed in this study. Unlike previous conceptual models, this study aims to focus on identifying and utilizing the interactions between road safety and accessibility.

The proposed framework conceptualizes that 'land-use', 'transport system', 'temporal', and 'individual' factors, influence accessibility and road safety in two ways. As road safety can be influenced by these factors (i) directly, through their impacts on the distribution of traffic over time and space; and (ii) indirectly, through their impacts on accessibility. For instance, mixed land-use areas that provide high accessibility levels for the residents can have impacts on the safety of pedestrians and cyclists. Additionally, the proposed framework hypothesizes that the four above-mentioned factors not only directly interact with accessibility, but also they may indirectly affect accessibility via their impacts on road safety. For instance, the accessibility of the senior and minor road users might decrease due to low road safety levels. Thereby, it can be hypothesized that the interactions between road safety and accessibility may produce unforeseen outcomes resulted from implementing certain safety and land-use policies. However, currently, the impacts of such policies are assessed only by observing the changes imposed on traffic volume, modal shares, and road safety indicators.

Within the urban areas, the built environment (BE) characteristics, such as population and job densities, land-use diversity, road network design, and distance to transit, can be affected by land-use and transportation policies. The BE variables have leading impacts on the accessibility levels in the urban areas. Therefore, in this study, we investigate the relationships among the "BE characteristics", "accessibility indicators", and "rate of different types of traffic crashes" at "different time intervals" through statistical analyses. This study is conducted based on the BE characteristics and crash data of the urban parts of the most populated and urbanized area in the Western Netherlands, known as the Randstad area. Thereby, the effects of different types of BE features and accessibility levels on the probability of having crashes involving vehicles and/or bikes will be presented. For instance, it is expected that the vehicle-involved crashes are less prevalent in the mixed land-use areas

where cyclists and pedestrians can easily access to various destinations; since such areas can encourage people to use slower modes more frequently than high speed modes of transportation.

Being informed about the interactions between “road safety and accessibility”, as well as the factors influencing these concepts, triggers the necessity of integrating these two concepts in design and organization of various policy and planning practices which aim to improve the levels of road safety and/or accessibility. Therefore, this conceptual framework informs the planners and policymakers about the probable impacts of their decisions on both road safety and accessibility levels.

Traffic safety evaluation of two trials of switching off lighting on motorways

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Background: Most road authorities are facing increased focus on climate effects, efficient operation and at the same time improved traffic safety. This is also the case for the Danish Road Directorate, who operates the Danish motorway network. The lighting equipment for sign portals at motorway exit ramps and for general lighting along some parts of the motorway network is worn down, and the electricity consumption is significant. Hence, the Road Directorate has decided to study if switching off the lighting equipment can be done without negative effect on traffic safety. Both types of equipment have been temporarily switched off since October 2019 on specific sites and road sections to study the safety effect.

Aim: The aim of this study is to assess the safety and behavioural effects from switching off the lighting equipment in order to clarify, if the motorway lighting can be switched off permanently without substantial negative effects on traffic safety, in order to protect the environment and reduce costs for operation and maintenance.

Method or methodological issues: The study consists of two sub-studies: one studying the switch-off of lighting at exit ramp sign portals, and one studying the switch-off of lighting along selected road sections at the motorways around Copenhagen. In both studies, the safety and behavioural effects are studied based on a range of data sets, and both are conducted as before-after studies with the after period in late 2019/beginning of 2020. In the study of exit ramp sign portals, the lighting at 295 of 337 (87.5%) sign portals was switched off. To study the safety and behavioural effects of this initiative, we carried out crash analyses for the motorway segments near the exit ramps of selected exits. In addition, two exit ramps were filmed for several weeks before and after the lighting had been switched off. The video recordings, which consist of more than 2,000 hours in total, were analysed to assess the extent of inappropriate driving behaviour around the exits, concretely how often drivers cross the chevron marking.

In the study of switching off lighting along the motorway, the lighting at 30 km of the road sections around Copenhagen were switched off. The effect was studied by crash analyses and an assessment of driving behaviour based on data extracted from permanent loop detectors. In addition, a web-based attitude questionnaire was circulated among a representative cross section of the population living near the motorway in question.

Results obtained or expected: The first sub-study (lighting at exit ramps) found no change in the crash frequency as a result of the switched-off lighting, nor did it affect the driving behaviour, measured as the extent to which the road users entered the exit ramp late (i.e., across the chevron markings), remarkably. The second sub-study (lighting along road sections) did not find any statistically significant increase in the number of crashes despite the change in lighting conditions. In addition, the speed of the road users was not affected by the change, and there was little to no change in the traffic flow resulting in traffic breakdowns. More than 4,400 drivers answered the survey, and in general only few (2.9%) had noticed the change, but a larger share would like improved lighting (8.8%) or road markings (10.4%).

Conclusions: Switching off lighting at motorways can be a means to saving energy and reducing maintenance costs, particularly if it can be done without impairing the safety at motorways. Therefore, the Danish Road Directorate initiated a trial in the autumn 2019 to test if switching off lighting on sign portals and along parts of the motorway network can be done without significant negative effects on traffic safety and road user behaviour. Depending on the results of this trial, the lighting may be switched off permanently.

Turning left at urban intersections: turning patterns and gap acceptance

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Turning left through oncoming traffic is one of the most safety-critical traffic manoeuvres. This work aims to describe and understand the interaction behaviour between left-turning and oncoming traffic by analysing video and trajectory data collected at the Application Platform for Intelligent Mobility (AIM) research intersection in Braunschweig, Germany. At this intersection, motorists turning left from Rebenring into Brucknerstraße must give way to oncoming traffic as well as crossing cyclists and pedestrians. In the following analyses, video and trajectory data of thirteen days (recorded in the period of 20th of May to 2nd of June 2019) were included.

In a first step, potential interactions between left-turning and oncoming traffic were extracted based on post encroachment time (PET), which indicates by how many seconds two intersecting road users miss each other. In order to investigate both critical and less critical interactions between left-turning and oncoming traffic, left-turns with a PET $\leq$ 2 seconds between the left-turning vehicle and oncoming traffic were randomly selected for further analysis (80 left-turns per day). In two cases a left turn was detected by mistake, reducing the number of cases to n = 1038. The video data of these left-turns were then analysed to determine the turning pattern.

Four turning patterns were identified: The left-turning motorist turned a) before all oncoming traffic, b) after all oncoming traffic, c) between oncoming traffic (i.e. both before and after oncoming traffic passed the intersection within a traffic light phase), and d) while the traffic light for oncoming traffic turned red (i.e. while oncoming traffic slowed down or stopped in front of the traffic light). Due to the selection by means of PET, left-turns without oncoming traffic were not included. The analysis revealed that left-turning motorists turned between oncoming traffic (pattern c) in about 50 % of cases, and were the first to turn left within one traffic light phase in 85 % of cases.

In a second step, the gap acceptance was determined for a subset of cases (n = 191; all motorists who turned left first within one traffic light phase with pattern c that passed between 6 and 20 o'clock within seven days) by first calculating the gap size of all accepted and rejected gaps. The gap size was defined as the time between the point in time when the rear of the first vehicle crossed the future path of the left-turning vehicle and the point in time when the front of the second vehicle crossed this path. Including 191 accepted and 830 rejected gaps, gap acceptance was then estimated by means of logistic regression. The analysis showed that all gaps larger than 8.03 seconds were accepted and all gaps smaller than 2.74 seconds were rejected. Gap acceptance was 50 % for a gap size of 4.70 seconds.

In a next step, cases with gap sizes around 4.70 seconds will be examined in more detail to determine factors influencing the decision to turn (besides gap size). Of special interest is the behaviour of oncoming traffic (e.g. speed and acceleration patterns of oncoming motorists). If, for example, specific driving patterns affect left-turn decisions, these patterns could be implemented in automated vehicles to facilitate safe turning behaviour. In general, these findings might support the selection of suitable infrastructure measures and the development of assistance systems and autonomous driving functions to promote safety.

Validity of self-reports of traffic crashes registered in the emergency room

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Background: Self-reporting is a common tool in traffic safety. Due to police underreporting of especially single crashes and lighter injuries. The validity of self-reports has however been questioned. The evidence on the pros and cons of self-reporting, and how to ask the injured about their crash, is scarce.

Aim: To assess the validity of self-reports obtained in the emergency room. To investigate whether self-reports could be a fixed element in the emergency room in Denmark for provision of crash coordinates and crash circumstances for the preventive work of the road authorities.

Method: All injured in traffic crashes registered in a hospital or emergency room in The North Denmark Region were potential respondents in a survey asking for crash coordinates and circumstances. Before we could send out a questionnaire, the emergency room staff had to ask for consent according to Danish Law of patient protection. For those who gave consent, we distributed the survey through digital mail. All Danish citizen hold a unique social security number facilitating linkage of the survey with the hospital and police registries at the individual level with a separate permission of the respondent. Subsequently, we interviewed eight respondents.

Results: In total, the emergency rooms in The North Denmark Region registered 3,809 patients injured in traffic crashes during the project period of 13 months. Of those, 930 were asked by the staff and consented to participate in our survey (24 %), 439 responded (47 %), thus resulting in an overall response rate of 12 %. However, when restricting the analysis to the main city emergency room, where the focus on the project was larger, the staff asked 1,132 of 2,817 for consent (40 %). Of those asked, relatively few rejected thus rendering an effective response rate of 38 %. Regarding self-reports of the crash circumstances, we found a very good correspondence on the crash date of the cases when compared with the police. We also noticed very good correspondence between the self-reported road user type and type of counterpart and the emergency room data and the police data. Good correspondence between police registered lighting and surface conditions, weather conditions and crash situation. The results showed (on a limited sample) that the correspondence between the respondents' description of where the accident occurred and the crash coordinates (obtained through point-and-click on a map in the questionnaire) was good. Only 5 % of the respondents were not able to locate the crash coordinates by the point-and-click solution. A relatively high proportion of respondents reported contact with the police (25%) but only in 11 % of the cases we found a matching police report documenting some disagreement. 47 % of the self-reported sample were single crashes whereas only 18 % in the police data were single crashes. We had 87 reports of single pedestrian crashes (20 %). Interviews with respondents gave valuable information on the use of the survey method and the motivation behind participation.

Conclusions: We conclude that self-reports of traffic crashes is a useful instrument, which is also cost effective when using digital mail. It renders valid and informative answers including information on crash coordinates and circumstances of the crashes, which are missing in the hospital registry but necessary in the preventive work of the road authorities. The project also showed that it takes a great deal of effort to change registration routines in the emergency rooms; and it will require a far greater change in the work routines in the emergency room, than was possible in this project, if all injured in road crashes should be asked by the staff to self-report.

The Impact of Covid-19 on Traffic Safety, Mobility and Infrastructure with Focus on Cycling in Stockholm City

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Background: Cycling is a sustainable transport mode, especially in urban areas for short distances. Electric bikes and electric scooters are increasingly emerging into traffic network in cities in Sweden as well as in other countries due to advantages related to accessibility, longer-distance of travel, environment, convenience, etc. However, they bring questions in terms of traffic risk and accidents. Since the start of Covid-19, countries around the world are still struggling to control the spread of this virus and its impacts on health and society. There are increasingly number of observations and studies made worldwide to investigate the impacts of Covid-19 on the traffic system and infrastructure. Covid-19 shifted travel from public transport to walking, cycling and e-cycling in order to eliminate or minimise the chances of transmission of the virus in daily crowded traffic in public transport.

Aim: The study will assess cyclists and e-cyclists safety and mobility in Stockholm city in Sweden according to exposure, risk and consequences before and during the pandemic period

Methods: Accident and traffic data was collected, using databases STRADA (the Swedish Traffic Accident Data Acquisition), Apple Mobility Data, Google Mobility Data and Environmental Barometer Data - bicycle mobility in Stockholm. Data regarding mobility and traffic accidents in Stockholm was analysed and visualised in excel and PTV Visum Safety.

Results: There is a clear reduction of road accidents during Covid-19 period in Stockholm due to partly nationwide lockdown. It can be observed that in 2020, the number of fatalities was 190 in Sweden, which was lower than the target. However, the number of young fatalities was higher under 2020. The number of cyclists accidents and fatalities in Stockholm was also higher due to the shift of traffic from public transport to walking and cycling. In Stockholm, 57 % of the kilometres travelled are by public transport (2019 before the pandemic). The reduced travel during Covid-19 lead to less accidents, less exposure to traffic risk, higher average speed, and higher speed variance.

Conclusions: The drop of accidents has been less strong than the drop in traffic during Covid-19 period. As the number of young fatalities was higher, under 2020, than previous years, years of life lost (YLL) was also higher. The study will bring recommendations on how the road infrastructure must be adapted to accommodate the increasing share of cycling and ecycling in respect of social distancing and safety during Covid-19 situation and after.

Past the braking point? – Configuration of automated driving behavior at an urban junction from a vulnerable road user's perspective

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Background: Highly automated vehicles (L4; SAE, 2018) will be introduced to urban areas soon. Thus, vulnerable road users (pedestrians, cyclists) will successively interact with this new type of vehicle, especially when crossing the road at junctions. In this traffic situation, vulnerable road users will have to interact with the automated vehicle itself instead of the passenger inside who may pursue secondary activities while the vehicle is in charge of the driving task. While the vulnerable road user crosses the road, the automated vehicle will be on direct collision course. This raises the question of how automated driving behavior should be designed in such interactions to ensure the safety of vulnerable road users. Regarding the configuration and implementation of automated driving behavior, however, current research mostly addresses the passengers' perspective neglecting how vulnerable road users may perceive automated driving behavior from their outside perspective.

Aim: The present study explored how automated driving behavior should be designed so that vulnerable road users feel safe in the interaction. Specifically, we examined a situation in which an automated vehicle approaches a junction where the vehicle has to give way to crossing pedestrians and cyclists. For this situation, we aimed to answer the question of when the automated vehicle should initiate braking so that crossing pedestrians and cyclists feel safe.

Method: Originally, the study was planned as a cycling simulator study. Due to the pandemic, however, the study was conducted as an online study using pre-recorded videos from the cycling simulator. In each video, an automated vehicle approached the same junction where it had to give way to crossing pedestrians and cyclists. The videos were recorded from the vulnerable road user's perspective who approached the junction while observing the automated vehicle. Three variables were varied in this traffic scenario: firstly, the automated vehicle's speed approaching the junction (30 km/h, 50 km/h) and secondly, the direction from which the vulnerable road users approach the junction (left, right). Thirdly, participants experienced the scenario from either a pedestrian's or a cyclist's perspective. So, there was a total of eight variations of the traffic scenario. To limit study completion time to 15 to 20 minutes per participant, each participant completed a subset of two variations plus a training session in advance. In the examined driving scenario, the participants' task was to trigger the vehicle's braking maneuver when approaching the junction at two points in time by stopping the video. In the first trial, participants' task was to trigger the braking maneuver at a point they consider ideal, i.e. completely safe for them to cross. In the second trial, participants' task was to trigger the braking maneuver at the last acceptable point in time they consider safe enough to cross in front of the vehicle. Following each trial, participants were presented with a second video showing their self-selected braking maneuver in replay. Participants could then either correct the timing of the self-selected braking maneuver once or confirm their choice to complete the trial. For each trial, the ideal and last acceptable braking onset timings were recorded. Finally, participants rated perceived risk during the interaction on a single item scale after each complete trial. In addition, the distance and time headway to the stop line at braking onset were recorded for each trial. Data from N = 50 cyclists and N = 51 pedestrians were collected from June to August 2020. Linear mixed models were fitted for each outcome variable due to the nested structure of the data.

Results: The results showed that pedestrians and cyclists aim to avoid experiencing any risk in interactions with an automated vehicle, with interactions being rated as unpleasant at maximum, but not as dangerous. In line with this finding, vulnerable road users prefer an early braking onset of the vehicle. So, vulnerable road users want an early kinematic reaction

from the vehicle as signal that the vehicle has “detected” them. The results obtained from this study are currently being validated in a driving simulator. We also aim at conducting a field test.

Conclusions: Taken together, the findings support the zero risk theory and provide recommendations for the design of automated driving behavior for the examined crossing situation taking a vulnerable road user’s perspective into account.

A multivariate negative binomial model characterizing crash frequency and severity of arterial road crashes in Colombia: An empirical assessment

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Road crashes are among the leading causes of death and incapacitating injuries on poorly design and maintained roads in developing countries. Academic institutions intensively provide constituent efforts towards understanding and forecasting the nature of this problem in order to meet global traffic safety goals. Furthermore, extensive literature over the past 20 years has discussed a myriad of methods utilized in predicting the frequency of motor vehicle crashes on transportation facilities. Considering a wide range of commonly used statistical models, their different assumptions, and the diverse characteristics of transportation facilities in cities, a comprehensive comparison provides fruitful insight for researchers targeting this problem. Additionally, to be effective, policy on traffic safety in developing countries must be based on local evidence and research.

The primary objective of the following paper aims to perform a comparative analysis of multiple models discussed in the literature for modeling crash counts and severities. Models characterizing three levels of severity including property damage only (PDO), incapacitating/non-incapacitating Injuries (ABC), and Fatal (K) are estimated for the 713 kilometers of arterial roads from Bogotá, Colombia. A comparison between univariate and multivariate approaches of negative binomial regression are conducted to show the benefits of providing a correlated structure among the different crash severities. Fitting of the models is assessed via goodness of fit measures including the Akaike's information criterion (AIC) and the residual deviance. The study included more than 30 covariates influencing crash counts and severity related. They relate to geometric design, infrastructure, transit, and traffic among others. Key findings from this study pinpoint that exposure variables of volume, the proportion of heavy vehicles, and the presence of transit routes are statistically significant and positively correlated with the number of crashes for all the severities. On the other hand, the frequency of non-signalized intersections and the proportion of motorcycles are significant for higher severities including incapacity/non-incapacitating injuries (ABC) as well as fatal crashes (K). Lower severity crashes (PDO) were influenced by the standard deviation of the speed measurements.

The multivariate negative binomial model showed a significant correlation among severities. The same significant parameter estimates were found in this structure. The difference in the predicted mean squared error when comparing the three different modeling approaches showed a slightly lower value for the individual negative binomial models with random effects. However, the results were not significantly different compared to the model without random effects or the multivariate approach specified in the report. In general, the increase in complexity of the model did not provide a reduction in prediction power neither major difference in the parameter estimates of the significant variables.

Summing up, the results from the three modeling techniques provided a good characterization of the factors influencing crash frequency and severity in Bogota, Colombia. The predictive power of the approaches is comparable without major differences with more complex models. It indicates adopting simpler model representations as a more desirable approach to develop safety performance functions for in a systemic evaluation of arterial roads in Bogota. These functions can also be applied by practitioners in regression to the mean corrective measures and identification of factors increasing the risk of a crashes in arterial roads. The adoption of traditional regression models are encouraging considering the significant risk faced by drivers in roads located on developing countries from Latin America.