

Influencing the trajectory of motorcyclists through strategic curve markings

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Abstract

The number of traffic accidents resulting in injuries on public roads in Germany has exhibited a gradual decline, with the exception of the impact of the Corona pandemic. Nevertheless, motorcyclists remain particularly vulnerable on rural roads and winding roads, where accidents frequently result in severe injuries. This study investigates a novel measure to enhance the safety of motorcyclists on the L218 between Vossenack and Schmidt, where there have been a considerable number of motorcycle accidents in recent years. The implementation of a novel road marking system, comprising ellipses situated in close proximity to the center line, was designed with the objective of influencing the lane selection of motorcyclists and subsequently reducing the incidence of accidents. This article presents the methodology, results, and impact of the measure, which employed the use of thermal cameras to analyze trajectories, roughness tests, and an online survey to collect feedback from motorcyclists. The preliminary findings suggest a notable enhancement in the safety of motorcyclists, with a reduction in the incidence of accidents and a shift in driving behavior following the implementation of the marking. The results indicate that approximately 86% of motorcyclists were redirected to safer lanes after the measure was introduced. These outcomes imply that the innovative approach could also be beneficial in other high-risk locations. To maintain and further enhance safety, it is recommended to conduct ongoing monitoring of accident rates and to obtain feedback from motorcyclists.

Keywords: Motorcyclist safety, Road marking innovation, Traffic accident prevention, innovative traffic analysis, Driving behavior modification

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1. Introduction

Notwithstanding a further augmentation in the number of motor vehicles on the road, the number of motorcyclists who have perished in road traffic accidents has exhibited a slight decline in comparison to that of car occupants. For those insured to operate a motorcycle, the number has even increased slightly. Motorcyclists are inherently more vulnerable than other road users due to the lack of physical protection afforded to them in comparison to car occupants. In Germany, motorcyclists account for a disproportionate number of serious injuries and fatalities on the road, especially on rural and winding roads where the risk of accidents increases due to sharp curves, inconsistent visibility, and variable road conditions. Despite an overall decrease in traffic fatalities, motorcycle accidents remain a significant concern. [1], [2]

In this context, the L218 road, situated between Vossenack and Schmidt in the Eifel region, has become identified as a high-risk area for motorcyclists. This particular stretch of road is notorious for its sharp curves and has witnessed a notable increase in motorcycle-related accidents in recent years. According to data provided by the Kreispolizei Düren, a considerable number of these accidents involve motorcyclists losing control on bends, frequently crossing into oncoming traffic or skidding off the road. Despite the implementation of safety measures through conventional means, such as the installation of signage, speed cameras, and increased police presence, the number of accidents has not exhibited a significant decline.

In response to this problem, a different approach has been introduced: the application of special road markings designed to alter the trajectory of motorcycle riders and encourage safer driving behavior. Initial pilot tests with similar markings have already been carried out in Austria [3] and Luxembourg [4]. This article presents the results of a study that examined the effects of these new markings, which were applied in the form of ellipses near the center line of the road. The objective of these markings was to guide motorcyclists away from the most dangerous sections of the road and reduce their speed, with the ultimate goal of decreasing the likelihood of accidents.

The principal objective of this study is to assess the efficacy of the recently implemented road markings in enhancing motorcycle safety along the L218. The study's specific objectives are as follows:

The study will analyze changes in motorcyclist trajectories following the application of the markings. It will also measure the impact on motorcyclist speeds and overall driving behavior. Furthermore, it will assess the skid resistance of the new markings and their long-term safety implications. Finally, it will collect and analyze motorcyclist feedback to gauge acceptance and perceived safety improvements. The goal of this research is to provide evidence-based recommendations for the broader implementation of similar markings on other high-risk roads in Germany and potentially beyond.

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2. Methodology

2.1 Study Area and Marking Design

The L218 road between Vossenack and Schmidt is a two-lane rural road that is renowned for its sharp curves and scenic vistas, which collectively render it a highly sought-after route for motorcyclists. However, the road's challenging layout has also resulted in a high incidence of accidents. The intervention was concentrated on two consecutive curves that had been identified as high-risk areas based on data from the Kreispolizei Düren concerning accidents that had occurred there. These curves are distinguished by restricted visibility and a proclivity for motorcyclists to veer into oncoming traffic or lose control due to excessive speed. In both bends, only one side was marked to prepare the drivers before they pass the markings on their own route.

The new road markings were implemented in the form of ellipses in close proximity to the centerline of the roadway. The markings were applied in a staggered pattern, with the size and spacing of the ellipses increasing as the motorcyclist approached the apex of the curve and then decreasing as they exited the curve. This design was intended to create a visual guide that would encourage motorcyclists to take a wider, safer line through the curve. Figure 1 shows the applied markings from a drone perspective.



Figure 1. Drone image of the applied markings

2.2 Data Collection

The study comprised four main components: accident data analysis, trajectory monitoring, skid resistance testing, and a user feedback survey.

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Accident Data

The data set comprised accident data collected from the Kreispolizei Düren and considered for the years 2019-2023. The data included the number of accidents, the severity of injuries, and the circumstances surrounding each accident. The focus was on motorcycle accidents that occurred in the study area before and after the markings were applied. The data was used to assess whether the new markings had a measurable impact on the number and severity of accidents.

Trajectory Analysis

To monitor the behavior of motorcyclists, thermal imaging cameras were installed at two locations in one of the critical curves for about 7 weeks. The cameras recorded approximately 2,500 motorcycle journeys prior to the application of the markings and 8,500 journeys subsequent to their implementation. The cameras employed 3D computer vision algorithms to track the trajectory of each motorcyclist in Universal Transverse Mercator (UTM) coordinates, thereby enabling the precise measurement of their position on the road as they negotiated the curve.

The road was divided into three zones for the purpose of the analysis. Exemplary, Figure 2 shows that division:

- Green Zone: The safest area, representing the outermost section of the lane.
- Yellow Zone: The area adjacent to the centerline where the new markings were applied.
- Red Zone: The oncoming traffic lane, which represents the most dangerous area for motorcyclists.

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Figure 2. Division of the road in three different zones according to their safety level

Motorcyclists who spent more than 15% of their journey in any one zone were categorized accordingly. If a motorcyclist spent time in multiple zones, they were assigned to the most critical zone (red before yellow before green).

Skid Resistance Testing

The skid resistance of the new markings was evaluated using a Skid Resistance Tester (SRT). Measurements were obtained immediately following the application of the markings and then again at two and six months post-application. The results were compared to those of the surrounding road surface to ascertain whether the markings presented any additional skid risk for motorcyclists.

User Feedback Survey

An online survey was conducted to gather feedback from motorcyclists who regularly used the L218. The survey was available for four weeks and included questions about the motorcyclists' experiences with the new markings. The topics addressed were visibility, haptic feedback (how the markings felt when ridden over), and perceived safety improvements. The survey received 467 responses, with a completion rate of 68%.

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3. Results

3.1 Accident Data

The initial data indicates a promising reduction in accidents following the implementation of the new markings. In the 2023 motorcycle season, which was the first to occur after the markings were applied, only three minor accidents (two after the application) were recorded. Notably, neither of these accidents resulted in personal injury. While it is acknowledged that accident data must be collected over a longer period to draw definitive conclusions, these early results suggest that the markings have had a positive impact on road safety. In comparison, the years preceding the intervention saw a higher number of accidents, with several resulting in serious injuries.

3.2 Trajectory and speed analysis

The trajectory analysis revealed a notable alteration in the behavior of motorcyclists. As shown in Figure 3, prior to the implementation of the markings, 43% of motorcyclists remained within the designated green zone, 54% occupied the yellow zone, and 3% traversed into the red zone. Following the introduction of the markings, the percentage of motorcyclists in the green zone increased to 86%, while the percentage in the yellow zone decreased to 12%, and the percentage in the red zone remained at 2%. This indicates that the implemented markings effectively directed motorcyclists onto safer routes through the curves.

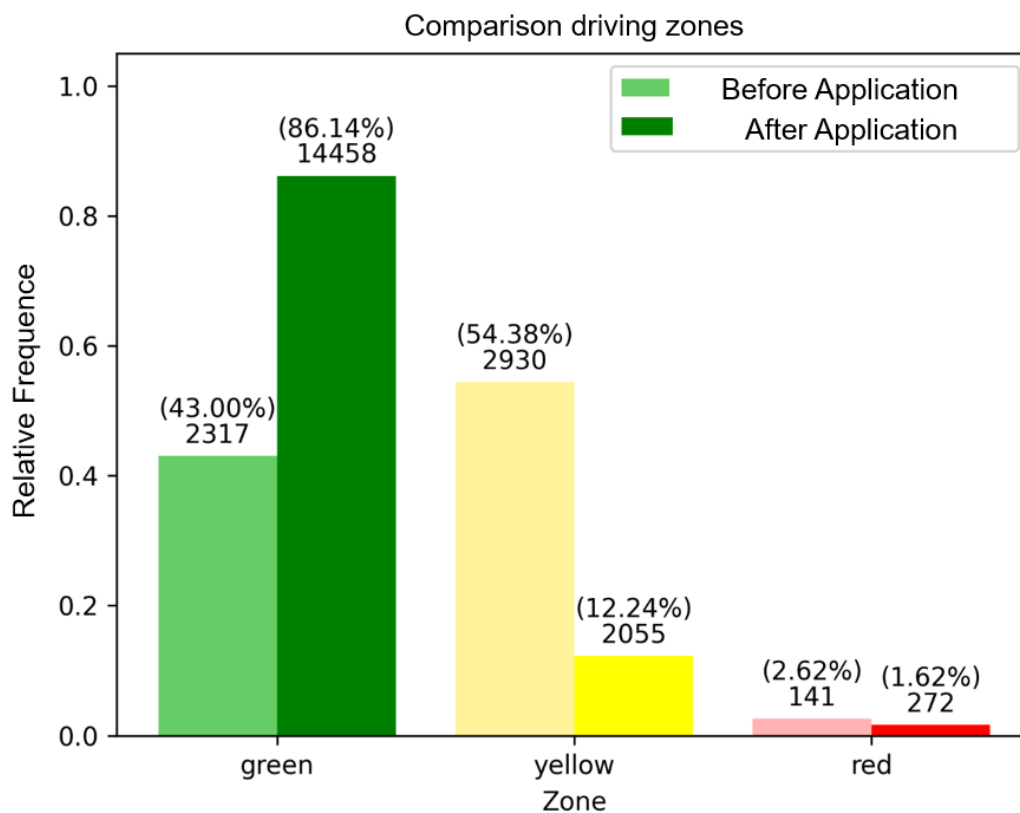


Figure 3. Comparison of the trajectories matched to the different zones

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Furthermore, the analysis demonstrated a decline in the mean velocity of motorcyclists subsequent to the implementation of the new markings. The mean traveling speed decreased by 14%, accompanied by a reduction in the frequency of excessive speeding. This reduction in speed is likely a contributing factor to the decrease in accidents, as lower speeds afford motorcyclists more time to respond to changes in road conditions or the presence of oncoming traffic.

3.3 Skid Resistance

The results of the skid resistance tests indicated that the new markings did not increase the risk of skidding. The initial measurements yielded an SRT value of 70, which subsequently decreased to 57 after two months and stabilized at 55 after six months. These values were consistently higher than those of the surrounding road surface, which exhibited an SRT value between 45 and 55. This indicates that, despite subsection to wear, the markings maintain sufficient grip to ensure the safety of motorcyclists, even in wet conditions.

3.4 User Feedback

The results of the online survey indicated that 63% of respondents had a positive or neutral view of the new markings. The respondents cited improved safety and familiarity with similar markings from other countries as the reasons for their positive view. However, 37% of respondents expressed concerns, particularly regarding the visibility of the markings in bright sunlight and the tactile feedback when riding over them. Some motorcyclists reported that the markings caused a slight vibration, which they found distracting. A small number of respondents also expressed concerns about dirt accumulating near the markings, which could affect their visibility and effectiveness.

4. Discussion

4.1 Effectiveness of the new road markings

The findings of this study indicate that the implementation of elliptical road markings has resulted in a discernible improvement in the behavior and road safety of motorcyclists on the L218. The notable rise in the number of motorcyclists opting for more secure trajectory, coupled with the decline in speeds, suggests that the markings are successfully directing motorcyclists through the curves in a safer manner. This finding is consistent with the results of previous studies conducted in Austria and Luxembourg, which also reported a reduction in dangerous driving behavior following the introduction of similar markings. [3],[4]

Although it is premature to draw definitive conclusions about the long-term impact of the markings, the initial reduction in accidents is encouraging. The absence of any serious accidents during the 2023 motorcycle season suggests that the markings may have a lasting effect on motorcyclist safety. However, ongoing monitoring will be necessary to determine whether these improvements are sustained over time, particularly as motorcyclists become more accustomed to the markings.

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4.2 Skid Resistance and Long-Term Durability

The skid resistance tests indicate that the new markings do not pose an increased risk of skidding, even after several months of wear. This is an important finding, as concerns about skid resistance are often raised when new road markings are introduced, particularly for motorcyclists. The fact that the SRT values remained above the threshold of 55 suggests that the markings will continue to provide adequate grip, even in adverse weather conditions.

However, the fact that the skid resistance values decreased over time highlights the need for regular maintenance and monitoring. If the markings are allowed to wear down too much, they could become slick and increase the risk of skidding, particularly in wet conditions. Therefore, it is recommended that the markings be inspected and re-applied as necessary to maintain their effectiveness.

4.3 Motorcyclist Feedback and Acceptance

The majority of motorcyclists responded favorably to the new markings. However, concerns about visibility and tactile feedback warrant further investigation. In particular, a certain amount of vibration during the crossing is likely unavoidable. However, the safest trajectory is chosen when the marking is not crossed. Thus, unpleasant vibrations can be easily avoided by every motorcyclist.

5. Conclusion and Recommendations

The implementation of elliptical road markings on the L218 has illustrated the considerable potential for enhancing the safety of motorcyclists on rural, meandering roads. The observed reduction in accidents, in conjunction with favorable alterations in trajectory and speed, substantiates the assertion that such markings could serve as a valuable instrument for road authorities. The findings of this study indicate that the markings are efficacious in directing motorcyclists through curves, thereby mitigating the risk of accidents resulting from crossing into opposing traffic or skidding off the road.

Nevertheless, there are multiple areas where enhancements could be implemented. A periodic assessment of skid resistance is essential to guarantee the continued safety of the markings over time. Furthermore, additional research is required to evaluate the long-term influence of the markings on accident rates, particularly as motorcyclists become more accustomed to them.

In light of the findings of this study, it is recommended that similar markings be applied to other high-risk roads in Germany and potentially beyond. The cost-effective nature of road markings renders them an attractive option for enhancing road safety, particularly in regions where more costly interventions such as physical barriers or road widening are not viable. With an appropriate design and regular maintenance, elliptical road markings could serve as a pivotal strategy for reducing motorcycle accidents on rural roads, ultimately saving lives and improving safety for all road users.

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