Volume 4, No. 11 November 2025
p-ISSN 2980-4868 | e-ISSN 2980-4841
https://ajesh.ph/index.php/gp

Improving the Safety of Motorcycle Users in Crashes at Jakarta, Indonesia

Kyle Nicholas Hendrasono
SMA National High Jakarta School, Indonesia
Email : kylenhendras@gmail.com

Abstract
Indonesia has one of the largest motorcycle populations globally, with approximately 130 million registered units. This high density is coupled with a significant number of injuries and fatalities from motorcycle crashes, highlighting an urgent need for effective protective measures. This study aims to evaluate the effectiveness of existing and proposed protective technologies in enhancing the safety of motorcycle users in Jakarta, Indonesia, both in preventing accidents and mitigating injury severity during collisions. The research analyzes various Intelligent Transport Systems (ITS) implemented worldwide and assesses several prototypes developed by Indonesian researchers. The efficacy of these technologies, including an IoT-based smart system, Adaptive Cruise Control, and a Motorcycle Child Safety Seat, is examined through data from simulations and test runs. The findings demonstrate that the evaluated technologies are effective in reducing the risk of accidents and minimizing injuries. The IoT-based smart system showed high accuracy in helmet detection (100%), drowsiness detection (87%), and accident detection (90%). The Adaptive Cruise Control prototype exhibited a low percentage error (1.53%) in maintaining safe distances, while the Child Safety Seat design framework provided a structured approach to enhancing child passenger safety. The integration of advanced safety technologies, such as the prototypes developed locally, holds significant potential to improve motorcycle safety in Jakarta. Widespread adoption of these systems can substantially reduce accident rates and injury severity, thereby saving lives and reducing the public health burden associated with motorcycle crashes.

Keywords:Motorcycle safety, Accident prevention, Protective technology Indonesia, Motorcycle cras, Injury, reduction, Safety prototypes, Simulation and testing

INTRODUCTION

The use of motorcycles is very common in Indonesia's culture. According to a 2019 study, approximately 64.2% of vehicles are used to commute around Jakarta (BPS-Statistics Indonesia, 2019); about 73.92% of the composition of all vehicles in Jakarta are motorcycles, with over 15 million registered around the Greater Jakarta area. There are several reasons why there is a large proportion of motorcycles in the province: affordability, flexibility, and versatility (UK PACT, 2021). Firstly, there was a large production of motorcycles— as many as 7.3 million units—following a large demand from an increasing GDP per capita of 259.53% from 2004 to 2019. Due to the high production and demand, motorcycles became highly accessible for lower-income classes and were not as expensive as buying a car. Secondly, motorcycles have smaller bodies that can drive comfortably on relatively narrow roads and take up a small proportion of space on the roads (Barros, 2025; Das *et al.*, 2025). A study by UK PACT suggests that increasing the ratio of motorcycles to cars by 10% could decrease traffic congestion by 63%. Lastly, motorcycles serve a wide range of purposes, including ride-hailing services and delivery. Additionally, they create more job opportunities for informal workers as driving only requires foundational skills. Therefore, motorcycles have shown

explicit benefits from both economic and functional perspectives (Maphosa, 2025; Salem, 2025).

On the other hand, out of all 10 Association of Southeast Asian Nations (ASEAN) countries listed, Indonesia ranks highest in fatality rates, with 27,530 deaths from driving accidents, mostly involving motorcycles (Bolla, 2023). Factors influencing motorcycle accidents mainly involve poor decisions by motorcyclists, commonly speeding and lack of helmet-wearing enforcement (Gebru *et al.*, 2025; Vesali-Monfared *et al.*, 2025). Forty percent (40%) of motorcycle users exceed the speed limit, resulting in 25% of crashes. Other factors include unsafe road infrastructure (Ayuningtyas, 2024). Although motorcycle helmets can help reduce the risk of head injuries or trauma by 72% and death by 39%, they are still not effectively used by most motorcycle users. Research by Basuki Rachmat, a member of the Central Research of Public Health and Nutrition, shows that only 40.6% of drivers and riders wear standardized helmets. One reason for this is the lack of national-level promotion of the benefits of helmet use (Rachmat, 2023).

Without the use of standardized helmets, bodily harm can still be sustained, leading to broken ribs and other fatal injuries. Table 1 shows the distribution of motorcycle accident injuries recorded in 2008; 50% of related injuries affect the limbs—vital organs for movement that serve multiple essential functions and are the most commonly affected. Expensive motorcycle parts may also be damaged, which can be a financial burden for owners (Enslin, Rohlwink and Figaji, 2020; Sasra, (MHI) and 2025, 2025). Additionally, there could be multiple cases of potential battery fires or engine issues that could cause harm and might be irreparable, posing risks to both the rider and others. Thus, solutions are needed to mitigate the effects of motorcycle accidents and ensure that both the user and the motorcycle experience reduced risk of injury and damage.

Table 1. The distribution of the motorcycle accidents injuries

Injury Type	Number	Percentage (%)
Limbs	106	50.0
Skull	103	48.6
Maxillofacial	38	17.9
Spine	10	4.7
Chest	15	7.1
Abdomen	6	2.8
Pelvis	1	0.5

Source: ACTA ORTHOPAEDICA et TRAUMATOLOGICA TURCICA

Due to the large number of motorcycle accidents happening in Indonesia and around the world, there have been multiple implementations of ideas that have been deemed effective by riders. These inventions have helped drivers to avoid accidents through Intelligent Transport Systems (ITS) to provide warnings towards themselves. ITS are technologies that have been created to protect vehicles, especially motorcycles, from experiencing crashes and reduce the impact from them. Although most ITS systems are designed for cars,
researchers suggest that it can also be applicable towards motorcycles. These systems are discussed below (Iswahyudi, 2025; Siddiq and Salam, 2025).

Intelligent Speed Adaptation is an advisory system for the driver to be within legal speed limit. As the motorcycle is driving on a certain road at a certain speed, the GPS takes note of its location to search for the certain speed limit of that particular road. If the user drives the motorcycle above its speed limit, it will send a signal to the driver. With this certain technology, riders will not just be able to slow down their vehicle safely but also be knowledgeable of speed limits in certain areas to decrease the likelihood of an accident in any part of the travel experience (Jia, Li and Wang, 2025; Tang *et al.*, 2025).

The study by researchers of the National Technical University of Athens on the ISA and speed limits sampled over 23 participants in a research implementing the Transport Research Laboratory full scale driving simulator (Budd, Ison and Attard, 2025; Zhang *et al.*, 2025). It simulated 3 different areas with certain speed limits such as its national speed limit (60 mph), village area (30 mph) and residential area (20 mph). Table 2 shows the average speed driven.

Table 2. Average Driving Speed

ISA system	Base	Informative	Warning	Intervening
Speed limit – 60 mph				
Mean	62.66	62.71	59.73	59.17*
SD	5.24	4.69	6.09	1.65
Speed limit – 30 mph				
Mean	30.53	31.07	29.48	30.12
SD	3.63	2.61	2.46	1.44
Speed limit – 20 mph				
Mean	24.33	23.39	21.25*	20.95*
SD	4.09	3.00	3.22	0.75

** Secara statistik berbeda signifikan dari kondisi base (α = 0.05).*

Source: National Technical University of Athens

In the experiment, it showed that human behavior is a critical factor as there were those who had admittedly sped with the intention to. The Intelligent Speed Adaptation still helps in providing information to drivers who, unintentionally, speed without knowing the speed limits of the area (Spyropoulou, 2014).Used in the motorcycles of multiple brands such as Volvo, Audi and BMW, this technology uses forward facing cameras to detect if the vehicle is driving along the lane markings. The system also causes vibrations to alert the driver to remain focused, while some systems use brakes to keep the vehicle in position. This fosters order between the motorcycle and other vehicles as well as avoids the risk of crashing when shifting lanes (Turner, 2016). A study conducted in Sweden with the aim to identify the effect of 'Loss of Control' towards Lane Departure crashes (loss of Control refers to the oversteering or understeering of a vehicle), found out that 87% of crashes happened on the center of the line markings and approximately half took place on roads with higher speed limits (Sternlund, 2017). A prototype on Lane Departure Identification was tested by researchers Vijay Gaikwad and Shashikant Lokhande; its performance showed that its detection rate is approximately 98% on straight roads (Gaikwad, 2015).

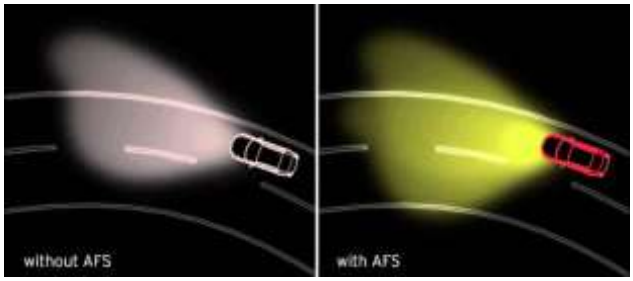

Figure 1 - Impact of Adaptive Front Lighting from Mazda Canada

Adaptive Front Lighting is a system that optimises light distribution and helps motorcyclists have a better viewpoint at night. As an emerging technology for motorcycles, adaptive front lighting allows motorcycles to see clearly in the direction they turn. It uses the steering wheel to project light at certain angles when steered (Turner, 2016). A survey by Tomasz Neumann, Faculty of Navigation at Gdynia Maritime University, aimed to analyze the safety and comfort of driving with this technology. The survey showed that 30% and 50% of motorcyclists always and often use adaptive driving assistance technology like Adaptive Front Lighting. In a study pool of 80 men and women, the technology was reported to have significantly increased comfort (55%) and reduced correction errors (60%), indicating its effectiveness (Neumann, 2024).

The Automated Crash Notification System is a safety feature in vehicles that alerts users when there is a car crash (Caradas, 2024). To assist users injured in a crash who need immediate attention, sensors triggered by airbags notify emergency personnel to arrive and assist victims more efficiently. Some advanced systems also collect crash data to assess the level of vehicle damage. Therefore, these systems aim to save lives promptly and to analyze the severity of crashes (Turner, 2016). Studies in Australia tested the ITS's effect on reducing road fatalities. In both urban and rural areas, ITS reduced fatalities by about 10.5% to 12%, saving approximately 103.7 Australian lives. It is also highly cost-effective for widespread and mandatory adoption. Typically, vehicle assistance systems cost between 199 and 695 USD, but the Automated Crash Notification (ACN) costs only 120 to 140 USD, representing a significant price reduction (Association for the Advancement of Automotive Medicine, 2008).

Based on this background, this study aims to examine and analyze the effectiveness of various safety technology systems, especially Intelligent Transport Systems (ITS) and prototypes developed in Indonesia, in *improving the safety of motorcycle users in crashes at Jakarta, Indonesia* . This study seeks to evaluate the performance of prototypes such as intelligent systems based on the Internet of Things (IoT), Adaptive Cruise Control, and Motorcycle Child Safety Seat in preventing accidents and reducing injury severity, to provide evidence-based recommendations for stakeholders.

The results of this research are expected to provide dual benefits, both practical and academic. Practically, the findings can guide policymakers and motor vehicle manufacturers to adopt and implement safety technologies proven effective into motorcycles circulating in the Indonesian market, ultimately reducing accidents and fatalities. For the public, this research aims to raise awareness of the importance of safety technology and encourage changes in driving behavior. Academically, it contributes to the literature on driving safety, especially in developing countries with high motorcycle density, and serves as a basis for further research into more innovative and contextual vehicle safety systems.

RESEARCH METHOD

This research aimed to find out the efficacy of some Intelligent Transport Systems on the safety of motorcycle users, especially in Jakarta, a city with one of the highest recorded motorcycle accidents in ASEAN and the world. By finding out how much these technologies have helped motorcycle users reduce the risk of accidents or reduce the severity of injuries, manufacturers can implement this further into more of its vehicles and improve other ITS that can help drivers effectively. With the previous studies mentioned above, the following are the prototypes made in Jakarta, inspired from the previous works and to help improve the safety of motorcycle users:

Figure 2 - Electrical device embedded in helmet (Source: IConVET 2020)

Prototype of a Smart System using IoT

The smart system uses multiple parts of the motorcycle riding experience to enhance safety: motorcycle, helmet and an Android application. This proposed solution aims to encourage users to wear helmets when riding, signal riders when showing drowsiness, and detect accidents to share among other people through an app. The prototype has multiple electrical components such as a NodeMCU microcontroller, buzzer, GPS and more to function properly.

Starting off with the motorcycle, if the system does not detect the user wearing the helmet and using the switch belt properly, the motorcycle engine will not start. Next, the helmet can also detect the drowsiness of the rider. If the rate of change of drowsiness is relatively close to 0%, it will signal the rider with a buzzer to give a warning. Lastly, if the vehicle was to experience a shock or crash, the GPS will turn on and send location to the Firebase of an app to share with other people in order to get help in a shorter period of time through notifications (P Prasetyawan et al, 2021).

Adaptive Cruise Control

There have been high rates of motorcycle accidents due to the poor driver's attention while going at a constant speed, resulting in a motorcycle crash. Adaptive Cruise Control maintains safe speed and distance from surrounding vehicles with ultrasonic sensors. The technology is highly versatile in adjusting to traffic flow, as it can even brake the motorcycle in dire situations. Overall, it helps with conserving fuel use as well as promoting safe driving (D A Purba et al, 2021).

In creating the adaptive cruise control system, it uses an ultrasonic sensor to measure distance. After creating the system with multiple electrical components and code, it undergoes testing with data recorded measuring distances, changes in current and voltage, as well as

multiple stages of testing other factors and is validated with comparisons of computer simulations and prototype testing (D A Purba et al, 2021).

Motorcycle Child Safety Seat

Children at ages 15-19 are the highest age group affected by approximately 15.03% of all motorcycle crashes(Unmiyatun, 2021). With Indonesia's accident rate predicted to increase, protecting children is the utmost priority, especially when they are underage to obtain a physical drivers' license. These children are not just at risk of crashes due to uncontrolled driving or loss of attention span, but also due to the lack of balance to rest their feet on the foot pedal of the vehicle as well as the high risk of serious burns from the hot exhaust pipe.

Having the implementation of child backrest seats will allow children to have their body protected. To allow not just Jakarta, but ASEAN markets to have access, a framework must be developed for everyone to have identical standards in creating a safe setting for children to ride with an accompanied adult/guardian. Therefore, the New Product Introduction (NPI) was adopted for the design and development of this invention.

RESULTS AND DISCUSSION

Discussion of IoT Smart System Prototype

A functional electrical circuit attached inside the helmet allows the user to drive the vehicle. A flex sensor and copper wires ensure that the helmet is used and acts as a switch respectively. In Table 3, it shows the results of the helmet detection. When the sensor value reaches 330 above its average flex value, it is concluded that the helmet is worn. It shows that the results are satisfactory with the condition of the helmet that shows it works.

Helmet Detection Results

Table 3 - Comparison between flex value and status motorcycle components to show system performance

Condition of Helmet	Average Flex Value	Switch Belt	Expected Detection	System Detection
Being worn	336	on	True	True (10 from 10 testing)
Being brought	294	on	False	False (10 from 10 testing)
Being hanged	309	on	False	False (10 from 10 testing)
Being worn	335	off	False	False (10 from 10 testing)
Being brought	292	off	False	False (10 from 10 testing)
Being hanged	307	off	False	False (10 from 10 testing)

Source: The 6th International Conference Industrial, Mechanical, Electrical and Chemical Engineering (ICIMECE), 2020

According to trials and statistics published under the 3rd International Conference of Vocational Education and Technology 2020, there was a 100% helmet detection when using a helmet and buckling the switch belt to start the motorcycle. Additionally the drowsiness

detection worked at 87% and accident detection at 90%. Overall, it gave a positive output towards fostering safety for the motorcyclist.

Discussion of Adaptive Cruise Control

In parts of the circuit, there is an LED light that flashes different colors to show distance: red, yellow, green and blue. Red shows that its distance from surrounding vehicles is less than 10cm, yellow is between 10-30cm, green is 30-50cm and blue is above 50cm, this is shown in table 4 below.

Adaptive Cruise Control Prototype Data

Table 4. LED light color display from distance between vehicles

Distance (x cm)	Detail Distance (cm)	Voltage (V)	Duty Cycle (%)	Motor Speed (RPM)	LED Condition
x > 50	65	7.901	86.75	1200	Blue
	60	7.873	86.65	1155	
	55	7.832	86.62	1125	
	49	7.757	84.68	1155	
30 < x < 50	40	7.625	74.19	1050	Green
	35	7.418	67.87	900	
10 < x < 30	25	5.882	39.29	840	Yellow
	20	5.872	39.25	810	
	15	5.862	39.25	810	
x < 10	9	0	0	0	Red
	8	0	0.09	0	
	5	0	0.09	0	

Source: IOP Conf. Series: Materials Science and Engineering

According to Table 4, the highest speed recorded was 1200RPM at a further distance than 50cm and the lowest was 0 since it was recorded to be extremely near the object. It uses an ultrasonic sensor to record the distance and a barrier to imitate a vehicle. Although there is a decrease in RPM between distances 49cm and 55cm, the speed range is still similar and within the instructions from the code created. Statistics by D A Purba et all show that a 1.53% percentage error has been found in an experiment, showing its high effectiveness in safety.

Discussion of Motorcycle Child Safety Seat

The NPI was used to help as a framework in the design and development of the motorcycle child safety seat

1. **New Product Introduction (NPI)**

   The New Product Introduction is a framework created by International Automotive Consultancy to create efficient systems that contribute to the technical and commercial functional groups that provide success of a new vehicle project. There will be 5 stages: Kick Off, Concept Initiation, Concept Direction, Concept Verification and Concept Approval (Sambasivam et al, 2016).

2. **Explanation of the Stages**

   Firstly, Kick Off is the stage where the severity of the need to create the product is suitable whether it is essential or necessary, which will then be sent for approval towards

a higher authority. Additionally, the resource needed to undertake the project will be then given by them as well. Secondly, the Concept Initiation is the first stage of creating suitable designs as well as the division of labor in planning its product development. Thirdly, Concept Direction is where planning should be finalized which contains budget plans, product specifications and timelines. Concept Verification is a long-term review of issues made in the process, leading towards Concept Approval with the design at its final stage and presented to higher management. Lastly, the Prototype is made through Computer Aided Design (CAD) and virtual prototyping to save costs (Sambasivam et al, 2016).

CONCLUSION

Indonesia, particularly Jakarta with over 15 million registered motorcycles, has a vast motorcycle population due to affordability, flexibility, and job opportunities. However, this contributes to the country having the highest vehicle accident fatality rate, mostly involving motorcycles, influenced by poor driving decisions, unsafe road infrastructure, and low helmet use. Injuries often affect limbs severely. Globally, Intelligent Transportation Systems (ITS) like Intelligent Speed Adaptation, Lane Keeping, Adaptive Front Lighting, and Automated Crash Notification have improved motorcycle safety. Indonesia and ASEAN have developed prototypes—such as IoT-based Smart Systems, Adaptive Cruise Control, and Motorcycle Child Safety Seats—that enforce helmet use, maintain safe speeds and distances, and protect child passengers. These systems have demonstrated strong effectiveness in Jakarta by reducing injuries, fatalities, and accident risks. Future research should explore the large-scale implementation challenges and user acceptance of these technologies across diverse Indonesian regions to optimize their impact on motorcycle safety nationwide.

REFERENCES

Ayuningtyas, K. N. S., Grzebieta, R., Olivier, J., & Caponecchia, C. (2024). Addressing Indonesia's biggest road safety challenge: Reducing motorcycle deaths. *IOP Conference Series: Earth and Environmental Science, 1294*(1), 012013. https://doi.org/10.1088/1755-1315/1294/1/012013

Barros, A. (2025). *Assessment and mitigation of road traffic noise: A perception-based approach* [Tesis, University of Antwerp].

Bolla, M. E., Djakfar, L., Wicaksono, A., & Yusainy, C. A. (n.d.). The development of motorcycle accident models based on riders' characters. *Civil Engineering Journal*. http://dx.doi.org/10.28991/CEJ-SP2023-09-018

Budd, L., Ison, S., & Attard, M. (2025). *The Routledge handbook of sustainable urban transport*. Taylor & Francis.

Das, S., et al. (2025). Understanding patterns of factor influences in motorcycle crashes with fixed objects. *Journal of Transportation Safety & Security, 17*(5), 483–509.

Enslin, J. M. N., Rohlwink, U. K., & Figaji, A. (2020). Management of spasticity after traumatic brain injury in children. *Frontiers in Neurology, 11*, 126.

Gaikwad, V., & Lokhande, S. (2015). Lane departure identification for advanced driver

assistance. *IEEE Transactions on Intelligent Transportation Systems, 16*, 910–918.

Gebru, S. W., et al. (2025). Analyzing predictive factors influencing helmet-wearing behavior among e-bike riders. *Transport Policy*. (Preprint).

Iswahyudi, E. (2025). Human rights and legal reforms in Indonesia: Challenges and progress. *The Journal of Academic Science, 2*(2), 734–743.

Jia, B., Li, J., & Wang, Q. (2025). Understanding electric bike accidents through safe system approach in Guangzhou, China: A mixed-methods study. *Systems, 13*(4), 261.

Maphosa, S. T. (2025). *Enhancing motorcycle maintenance: A study on centre lift design*.

Neumann, T. (2024). Analysis of advanced driver-assistance systems for safe and comfortable driving of motor vehicles. *Sensors, 24*(19), 6223. https://doi.org/10.3390/s24196223

Prasetyawan, P., Samsugi, S., Mulyanto, A., Iqbal, M., Prabowo, R., & Ardiansyah. (2021). A prototype of IoT-based smart system to support motorcyclists' safety. *Journal of Physics: Conference Series, 1810*(1), 012005. https://doi.org/10.1088/1742-6596/1810/1/012005

Purba, D. A., Nizam, M., Maghfiroh, H., Putra, M. R., & Inayati. (2021). Prototyping adaptive cruise control on electric motorcycle. *IOP Conference Series: Materials Science and Engineering, 1096*(1), 012076. https://doi.org/10.1088/1757-899x/1096/1/012076

Rachmat, B., Irianto, J., Handayani, K., Kristanto, A. Y., Sulistiyowati, N., Ashar, H., Senewe, F. P., Kristanto Mulyantoro, D., Suratri, M. A., Rustika, R., & Musadad, D. A. (2023). Prevalence and factors associated with the use of standard helmets among motorcyclists among workers in Indonesia. *E3S Web of Conferences, 448*, 02023. https://doi.org/10.1051/e3sconf/202344802023

Salem, K. (2025). *Shifting to electric: An exploration of motorcyclists' future perspectives*.

Sasra, A., B. B.-M. H. I., & MHI. (2025). Analisis konsep transaksi cryptocurrency dalam perspektif hukum ekonomi syariah. *Jurnal Ilmiah Riset Syariah, 1*(1), 23–28. https://doi.org/10.71094/jirs.v1i1.16

Siddiq, N., & Salam, R. (2025). Enhancing legal certainty through legal reform in Indonesia: Problems and efforts to strengthen legal institutions. *Strata Law Review, 3*(1), 1–14.

Tang, A. X., et al. (2025). At the breaking point: How bus operators cope with transit technology failures and what that can tell us about the integration of future innovations. In *Proceedings of the 2025 ACM Designing Interactive Systems Conference* (pp. 3621–3634).

Vesali-Monfared, E., et al. (2025). Exploring the barriers and facilitators of helmet use among motorcyclists: A qualitative study. *Traffic Injury Prevention, 26*(4), 457–465.

Zhang, A., et al. (2025). Driving innovation and sustainable development in cultural heritage education through digital transformation: The role of interactive technologies. *Sustainability, 17*(1), 314.