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Research Article

Enhancing Road Infrastructure for Autonomous Vehicles in the Eastern Economic Corridor of Thailand

Jakkawat Laphet[1], Tapsatit Gooncokkord[2]*, Dultadej Sanvises[1], Waraphon Klinsreesuk[2] ,Sumate Auswasilawasukul[3]

[1] College of Tourism and Hospitality, Sripatum University, Khon Kaen 40000, Thailand.
[2] Faculty of Logistics, Burapha University, Chonburi 20130, Thailand.
[3] Thai German Institute, Chon Buri 20000, Thailand.
Correspondence Author: Tapsatit.go@go.buu.ac.th*

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ABSTRACT

Introduction: This paper addresses road safety issues in Thailand, particularly in the Eastern Economic Corridor (EEC), where high accident rates lead to financial and healthcare burdens. It explores effective road design techniques to improve safety and adapt infrastructure for the integration of autonomous vehicles (AVs). By examining successful practices from developed regions, the study aims to offer insights that enhance current road safety and prepare for the future use of AVs, fostering a safer and more efficient transportation system in the EEC

Objectives: Inspired by good practices in Singapore, one might find and apply efficient road design solutions that increase safety and lower accidents in the EEC.

Methods: Highway 344 in Chonburi/Rayong Province underwent systematic measures and observational data application including improved lane designs, energy-efficient street lights, and smart cameras. Based on accident data, field investigations were carried out to pinpoint places that needed work, with an eye toward ideal traffic lane markings and high-risk zones. Road user insights helped to spot possible safety risks.

Results: Field research focused on basic but effective remedies such improved traffic lane markings and particular changes in high-risk areas. The report also included suggestions for enhancing infrastructure, strengthening traffic law enforcement, and increasing public knowledge of laws.

Conclusions: The study emphasizes the need of giving low-cost, small-scale road safety top priority and provides practical advice for nations with limited means. This pragmatic approach shows that evidence-based interventions can result in significant safety improvements without major infrastructure changes, so offering a sustainable way to improve road safety in the EEC and support worldwide initiatives to lower traffic-related injuries and deaths.

Keywords: Enhancing, Autonomous Vehicles, Road Infrastructure, Road Safety, Eastern Economic Corridor

INTRODUCTION

This study addresses road safety research in Thailand, a topic with limited coverage in the context of developing countries, particularly those with constrained budgets and resources. [1] Currently, there are 152 developing countries worldwide, with a combined population of approximately 6.90 billion people, representing 85.59% of the global population. This research adopts a pragmatic approach by focusing on existing road infrastructure and prioritizing cost-effective and impactful interventions. The research team conducted field studies to identify and address high-risk areas characterized by significant accident rates. Simple yet effective measures, such as optimizing traffic lane markings and addressing hazardous locations, [2] were emphasized. Moreover, insights were gathered from road users to better understand their perceptions and to identify potential safety hazards. The findings of this study provide actionable, low-cost recommendations that can be implemented immediately, offering value to developing countries with limited resources. By targeting specific areas for improvement, this approach aims to

enhance road safety and reduce accidents and injuries, particularly in the Eastern Economic Corridor (EEC) and similar regions.

Road accidents are a major issue in Thailand, causing significant economic losses to victims and their families, and representing a significant burden on the country's healthcare system. [4,5] Various technologies have been proposed to analyze accident occurrences in the Eastern Economic Corridor. [6,7] Understanding road accident hotspots is crucial for reducing areas with high accident density. [8] Accidents involving large vehicles and multiple vehicles may overload an accident and emergency department when several severely injured individuals present simultaneously or in close succession. This situation worsens as the department must prepare to accommodate these patients within a short timeframe. Without initiating or improving mitigation policies, it is estimated that road accidents will result in 500 million injuries and 13 million deaths in the next decade. [9] Furthermore, the expansion of cities requires effective planning measures and infrastructure upgrades to maintain a good balance between growth and sustainability, to reduce future accidents. Integrated development has become a crucial component in various planning efforts, such as smart growth. [10] For instance, the integration of smart traffic management systems, real-time monitoring, and data-driven decision-making can significantly enhance road safety and reduce accident rates. These systems can provide early warnings about hazardous conditions, optimize traffic flow, and improve emergency response times. A study conducted in Bangkok, Thailand, identified rain as a risk factor for road accidents. [11] Another study in Malaysia reported that rain increases the risk of single-vehicle accidents on mountain roads. [12] In addition to weather conditions, road design and maintenance play a critical role in accident prevention. Poorly designed roads, inadequate drainage systems, and the lack of proper signage can exacerbate risks, especially during adverse weather. Therefore, incorporating weather-resilient infrastructure such as improved drainage systems, anti-skid road surfaces, and enhanced visibility measures is essential for mitigating weather-related accidents. In Singapore, researchers have studied risk factors for road accidents in the context of road types and traffic signs. [13] Furthermore, having safe roads and clear traffic signals can accommodate the growing demands of increasing traffic volumes. This research is particularly relevant for autonomous vehicles (AVs), where precise detection is crucial for road safety. Retroreflectivity, which influences visibility and legibility, is a key component in ensuring safe road conditions. By addressing these factors, we can enhance road safety and reduce accident risks in the future as well. [14,15] and other vehicle and collision characteristics. [16]

Researchers who study effective roads in Singapore have consistently received awards for their efficiency. High-quality roads significantly reduce travel time, enhance accessibility, and contribute to lowering time and energy costs for the public. [17] Singapore’s success in road design and management can serve as a model for other regions. The use of advanced materials, intelligent transportation systems, and rigorous safety standards has set a benchmark for road infrastructure development. These practices can be adapted to the Eastern Economic Corridor of Thailand to improve road safety and efficiency. The development of road networks impacts regional tourism growth, facilitating transportation and supporting urban tourism business development. [18,19] For example, well-connected and safe road networks can attract tourists, boost local economies, and promote sustainable tourism practices. In the context of the Eastern Economic Corridor, which is a hub for industrial and tourism activities, the design of Highway 344 in Chonburi/Rayong Province should prioritize connectivity, safety, and sustainability. This includes integrating multi-modal transportation options, such as bike lanes and pedestrian pathways, to encourage eco-friendly travel and reduce traffic congestion. Moreover, investments in road infrastructure have far-reaching implications for sustainability and regional development. [20,21] Sustainable road design should incorporate green technologies, such as solar-powered lighting, energy-efficient materials, and carbon-neutral construction practices. These measures not only reduce the environmental impact of road infrastructure but also contribute to long-term cost savings and resilience against climate change. However, previous research has focused on risk assessment and weather-related studies. This study is exploratory, utilizing road models in Singapore to design roads to achieve a road model in the context of roads in the Eastern Economic Corridor of Thailand. How should Highway 344 in Chonburi/Rayong Province be designed?

CASE STUDY

The construction project to expand Highway 344, section Ban Bueng District, to connect Highway 331 (Nong Prue), including the Nong Chak Intersection Overpass, has been completed. It spans approximately 102.181 kilometers with a budget of THB 1,196,859,600 in Chonburi Province. Due to increased traffic, the expansion from four lanes to six lanes aims to enhance travel and transportation convenience. This aligns with the study by Hutasavi-

Tungsapdoungto (2022), which highlights the use of Geographic Information Systems (GIS) and spatial analysis to effectively improve transportation connectivity in the Eastern Economic Corridor (EEC). [22] This highway expansion supports the EEC's objectives to develop infrastructure and drive economic growth. Projects such as Highway 344 play a vital role in regional logistics systems [23] and help reduce accidents and traffic issues. Research by UN ESCAP (2022) emphasizes the importance of highway connectivity and road safety enhancements, noting that widening lanes and installing traffic signals, such as on Highway 344, significantly mitigate accidents and traffic problems. The expansion of Highway 344 further supports the EEC, encompassing Chonburi, Rayong, and Chachoengsao provinces. [24,25] In recent years, Singapore has been recognized as having the best transportation system in Southeast Asia, excelling in various aspects of management and road safety systems. The New International Land–Sea Trade Corridor employs multimodal transportation to connect major ASEAN countries, including Singapore in the south, [26] thereby enhancing regional connectivity in Southeast Asia. Moreover, the role of land and sea networks in Asia has been exemplified by Singapore, which serves as a model of success in road management and connectivity, establishing itself as one of the best in Asia.

In addition, in Singapore, the Land Transport Authority has launched a comprehensive and user-friendly road maintenance program that includes the repair of road surfaces, various components on roads, and pedestrian walkways. This maintenance program covers numerous facilities, such as road surfaces, sidewalks, signage, pedestrian overpasses, and energy-efficient street lighting. The implementation of modern street lighting technology can reduce energy consumption by up to 70%. [27] Any deteriorated infrastructure will be appropriately repaired, and potholes in the road surface must be fixed within 24 hours after a report is received. [28] Furthermore, the Land Transport Authority has implemented a "Black Spot Program" to measure, track, and monitor areas with high accident rates. The government mandates regular inspections and maintenance of roads and facilities, with a scheduled maintenance plan for different types of roads as follows: expressways: daily; main roads: every two weeks; secondary roads: every two months. [29] In Thailand, numerous locations, particularly in major urban areas, exhibit a high frequency of road traffic accidents. [30] This phenomenon underscores the critical need for comprehensive research to address accident prevention, risk modeling, and the development of effective safety strategies. The following studies focus on identifying high-risk areas, implementing community-based safety initiatives, and utilizing advanced data analysis techniques to enhance road safety and mitigate traffic-related risks across the nation. [31] In 2024, Thailand was frequently highlighted as one of the countries with a high prevalence of road traffic accidents, particularly during festive seasons when the numbers often surge. Despite occasional declines, road fatalities generally remain high year after year. Campaign to raise awareness of the importance of respecting discipline and traffic regulations, as well as the culture of road safety [32] According to the 2024 "Road Deaths" report, Thailand ranked 17th out of 181 countries globally and held the highest position within ASEAN. The country recorded 32.2 road fatalities per 100,000 population, equating to a total of 22,428 deaths. In stark contrast, Singapore ranked 171st globally, with a significantly lower figure of 2.1 fatalities per 100,000 population, equating to a total of 121 deaths. This highlights Singapore’s exceptional road management and safety systems. Countries ranked first to fifth are also noted for having particularly high road traffic fatality rates, as shown in Table 1

Table 1. Road traffic deaths per 100,000 population statistics 2024

No.	Country	Road Traffic Deaths (Per 100K)
1	Dominican Republic	64.4
2	Zimbabwe	41.2
3	Venezuela	39
4	Liberia	38.9
5	Eritrea	37.9
17	Thailand	32.2
176	Singapore	2.1

Source: World Population Review 2024.

METHODS

The improvement of road safety and infrastructure for autonomous vehicles (AVs) in the Eastern Economic Corridor (EEC) in Thailand by means of effective policies applied in Singapore is examined in this paper. Using advanced modeling approaches, the researcher underlines in the design process the incorporation of road safety measures including regular monitoring of road standards and quality assurance. Responding to found flaws in existing infrastructure including weak road marks, confusing street lights, and insufficient surveillance in high-risk regions,

the recommendations stress on building safe road components including T-junctions, crossroads, and straight roadways. These results show how urgently improvements in a safer driving environment and adjustments allowing AV integration are needed.

Key elements aiming at compatibility with (AVs) such as sufficient shoulder widths, lane widths, and energy-efficient street lighting—are part of the design process. While crash cushions and "SLOW" signage help to reduce collision effects, smart camera installation improves monitoring capability at key transition locations. Reflective lines and lane mark adjustments have shown to be quite successful in greatly lowering traffic accidents and injuries. Furthermore especially in cities, zigzag patterns in median regions seem to improve traffic safety even more. The study presents a clear road design plan with necessary safety precautions including smart technologies to increase safety in high risk areas and good indicators. Better traffic control is expected from these measures, especially in darkness when eyesight could be limited.The report also suggests building roundabouts out of somewhat crowded intersections to help to further ease traffic congestion and flow. Important elements worsening road accidents are underlined: type of collision, traffic regulation compliance, visibility circumstances, road alignment. Particularly with reference to bigger vehicles, stressed as essential to improve general road safety in the EEC is the need of customized traffic management systems to meet different road conditions.

RESULTS

This study investigates whether a safe road project on Highway 344 in Thailand's Eastern Economic Corridor (EEC) where field surveys were conducted to identify workable upgrading initiatives is viable. High accident rates and road safety issues that negatively affect the economy and tax national healthcare resources clearly reveal a direct relationship. Review of road performance highlights the need of methodical design applying sound engineering concepts to reduce the degree of incidents. The report offers several policy recommendations, including enhancing traffic law enforcement using automated monitoring tools such smart cameras, so tracking compliance in high-risk areas. Traffic violations should have penalties rising to inspire better driving behavior. Improving road infrastructure also means altering lane designs with obvious marks, crash cushions, energy-efficient lighting, and sophisticated surveillance systems. Future integration of autonomous vehicles (AVs) depends on clear lane markings and intelligent traffic management systems appropriate for this transformation ready. Public awareness initiatives aimed at traffic rules and safe driving practices should take top priority since they help to foster a culture of road safety by means of community involvement. Low-cost interventions allow one to apply safety measures faster. Future transportation needs depend on long-term planning, and infrastructure built to include multi-modal choices like bike lanes and pedestrian paths to improve connectivity and sustainable travel. Drawing lessons from successful international models, such Singapore's "Black Spot Program," which methodically identifies and reduces high-accident areas, will help. Following these all-encompassing policy recommendations will help the EEC address present problems and ensure a better surroundings for the predicted rise of autonomous cars, thereby addressing major road safety challenges.

DISCUSSION

Inspired by Singapore's road safety master plan, this study aims at improving Eastern Economic Corridor (EEC) Thai road infrastructure for autonomous vehicles (AVs). Emphasizing methodical techniques to increase road safety, it adds safety measures including ongoing road standards monitoring and quality assurance into EEC designs using tools like SketchUp Pro. Highway 344 boasts primary features of a two-meter-wide shoulder, 3.5-meter-wide lanes, energy-efficient street lights every eight meters, and intelligent cameras for lane changes [33]. Further suggested safety precautions are revised lane markers, "SLOW" signs, and wider use of crash cushions. Designed for urban settings, the design uses smart cameras for real-time surveillance and ample illumination to tackle issues including heavy traffic and pedestrian presence [34,35]. Emphasizing distinctive lane markers and strong illumination, critical junctions satisfy Singapore's safety requirements. Moreover, the study underscores the need of a framework for AV adoption since it shows that consumer acceptance is basically dependent on trust [36]. Although all of which help to modernize transportation systems and boost overall road safety—efficient signs, traffic law enforcement, constant maintenance, and infrastructure improvements—improved infrastructure will enable AV integration [37].

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CONFLICT OF INTEREST

The author declares no conflict of interest

AUTHOR CONTRIBUTIONS

Conceptualization, J.L.; methodology, J.L., W.K., and D.S.; software S.A. and; J.L.; formal analysis, T.G., J.L., W.K., and D.S.; investigation, T.G. and J.L.; resources, J.L.; writing—original draft preparation, T.G., J.L., W.K., D.S.; and S.A., writing—review and editing, J.L., W.K; and D.S.; supervision, T.G.; project administration, T.G.; funding acquisition, T.G. All authors have read and agreed to the published version of the manuscript. And E-mail; Jakkwat.la@spu.ac.th (J.L.) ; Tapsatit.go@go.buu.ac.th (T. G.) ;Waraphon.kl@go.buu.ac.th (W. K.) ; Dultadej.sa@spu.ac.th (D. S.); Sumate.a@tgi.mail.go.th (S. A.)

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