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Emergency Vehicle Response Time and Priorities System in Malaysia: A Review

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***Abstract*— Emergency Response Time (ERT) is a crucial indicator of an emergency provider's success. ERT of Emergency Vehicles (EVs) is significantly impacted by traffic congestion, especially at junctions with traffic signaling systems. ERTs for emergency providers in Malaysia are still lagging behind international standards and practices adopted by advanced countries. This paper firstly aims to review the achievement of ERT in Malaysia. Secondly, the factors that affect EV response time are discussed. Thirdly, this paper also explains that the conventional EV priorities system in Malaysia cannot solve the traffic congestion problems affecting EVs and further reviews current research to address the problem. The issues with current research are highlighted in this paper, and the prospect for future research is identified with the proposal to enhance the EV priorities system in Malaysia to improve ERT.**

***Index Terms*— Emergency Response Time, Emergency Vehicle Priorities System, Traffic Congestion, Traffic Signal Pre-emption**

I. Introduction

An incident is an event that happens suddenly and unexpectedly, such as building fires, vehicle accidents, or natural disasters, e.g., landslides and floods [1]. The time it takes for EVs to arrive at the scene of an incident is known as the Emergency Response Time (ERT) [1]. According to [1], [2], ERT considers the time to receive emergency calls, obtain information, such as location, incident type, prepare emergency tolls, travel time from station to incident site, as well as time to begin rescuing victims. ERT has become crucial for Malaysia's emergency providers, such as Emergency Medical Services (EMS) under hospitals and fire rescue services [1]–[7]. If the rescuer delays rescuing victims, the loss of life and property will occur.

In Malaysia, ERTs can be categorised into Ambulance Response Time (ART) for EMS [8] and Fire Response Time (FRT) for fire rescue services [9]. ART and FRT in Malaysia are still lagging behind in terms of international standards and practices adopted by advanced countries [1], [2], [6], [7], [10]. According to [1], [2], the factors contributing to ineffective ERTs are highly congested conditions, bad weather such as heavy rain, and vehicle accidents. Among these factors, traffic congestion, especially at junctions with traffic signal control, has a significant influence on the response times of EVs [1], [2]. Traffic congestion at signalised junctions causes delays for EVs and can cause a collision with other vehicles when the EV attempts to cross the junction [11], [12].

Traffic congestion is a direct relation to vehicular density. As a developing country, Malaysia is no exception in facing traffic congestion because of vehicular density. The Malaysian Average Daily Transport (ADT) in 2019 was approximately 2,952-138,507 [13]. The ADT reports for 2020 and 2021 were not taken into account due to the Malaysia Government's Movement Control Order (MCO) to curb the spread of Covid19 [14]. Apart from vehicular density, vehicle accidents cause EV delays. Records from the Ministry of Transport (MOT) indicated 548,598 accidents occurred in 2019 [13]. Other than that, passing traffic congestion at signalised junctions makes it difficult for EVs to meet ERT [15]–[17].

This article aims to discover a solution to traffic congestion, particularly at junctions with traffic control systems as well as evaluate methods of advanced EV priorities systems introduced by several researchers. The objectives of this article are 1) to review the achievement of ERT in Malaysia; 2) to explain the factors affecting ERT; 3) to briefly review current advanced EV priorities systems.

This article is organised as follows. Section II deals with a literature review of ERT in Malaysia, where different researchers' statistics on ERT are presented. Section III addresses Objective 2 by presenting the factors affecting ERT. Section IV addresses Objective 3 by providing an overview of emergency prioritise systems and the ability to cope with traffic congestion. Finally, Section V highlights and discusses advanced EV priority systems issues based on current research. Section VI concludes this article with a proposal for future research.

II. Emergency Response Time in Malaysia

The process of selecting information began by obtaining information on ERT in Malaysia, the involvement of the emergency provider, and reports on ERT achievements. After the information on ERT, the selection of information leads to the factor of non-achievements of ART international standards and FRT practices by advanced countries. The following information is used to figure out the priorities of Malaysia's traditional emergency prioritise systems, which makes it hard for EV to get through traffic jams. The final information process involves the current research on advanced emergency priority systems.

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According to [1], [18], the Ministry of Health (MOH), the Fire-Rescue Department of Malaysia (FRDM), and the Royal Malaysia Police (PDRM) are the three primary emergency providers in Malaysia.The ambulance service is intended for the care and transportation of incident victims from the incident site to the hospital to save their lives [19]. The fire rescue services are responsible for protecting people and properties from fires and rescuing people from road traffic collisions. The police services, however, critical for ensuring the security of people and properties and covering all categories of emergencies [1], [20], [21].The Malaysia Civil Defence Force (MCDF) is a support agency to the primary emergency providers [1], [20], [21]. Another service provider important in managing emergencies is Malaysian Emergency Response Service 999 (MERS 999) as a unified system for answering emergency calls and dispatching emergency personnel [21], [22].

The main aim of government emergency providers is to respond as quickly as possible to reduce the loss of life and property [1], [4]. For example, the chance of surviving potentially fatal vehicle accidents is determined by the time it takes for EVs to arrive and begin rescuing victims who have been injured in an accident [1], [4]. Therefore, it is clear that EVs' response time is critical in saving lives and has become an important performance indicator [1]–[5], [23].

A. Ambulance Response Time

Ambulance services are essential services in the global healthcare arena [1]. Malaysia's ambulance services are under EMS known as Pre-Hospital Care and Ambulance Services (PHCAS) [19], [24]. The objective of PHCAS is to provide medical care services to patients or victims on the incident site, during transfer, by trained and credentialed practitioners under the direction of a medical advisor [19]. PHCAS covers a wide range of medical conditions, from minor illnesses and injuries to life-threatening conditions [19]. Accident injury is a major medical issue in Malaysia, contributing to a high proportion of fatalities and admissions to public hospitals for unintentional injuries [2]. PHCAS has been investigated by various studies in Malaysian to improve the performance of ART [2], [3], [25]. Studies have looked into PHCAS's role [2], issues, and challenges [4], as well as quality performance metrics [1].

According to [2], [26], ART had its own standards. The international health standard recommended ART is 8 minutes, which should be met in 90% of total calls [2], [26]. ART is defined as the period between receiving an emergency call and an ambulance arriving at the incident site [2], [26]. According to [2], in 2016, the average number of ambulance calls received by Hospital University Sains Malaysia (HUSM), Kelantan, was around 600 to 700 per year. The higher demand for ambulance services needs higher commitment from medical staff and effective management of EVs to achieve ART performance indicators [2].

Table I compares Malaysia's ART achievement to the international ART standard. Two achievement categories are presented: time and percentage achievements. A cross-sectional study was conducted by [2], between January 2016 and January 2017 at the HUSM, Kota Bharu Kelantan, with 300 sampling calls. The mean ART time was 14.10 minutes, with only 14.3% of 300 calls meeting the international ART standard of 8 minutes. Another cross-sectional study by [27] at HUSM, for six months, from September 1, 2017, to February 28, 2018, the average ART time was 12.42 minutes, and 25.5% of the 505 calls fulfilled the international ART standard of 8 minutes.

K. Hussin et al. [28] claims that ART in Malaysia's hospitals falls short of the international ART standard. Three hospitals, namely Hospital Kuala Lumpur (HKL), Hospital Tengku Ampuan Rahimah (HTAR), and Hospital Raja Perempuan Zainab II (HRPZII), participated in a study of Malaysia's public hospitals for ART achievement from June to July 2012. This is proven by reviewing [28] study's findings in Table I. Table I also shows that three public hospitals from various states were selected, with corresponding median ART times of 0.19, 0.19, and 0.20 minutes. Therefore, based on the results in Table 1, ART in Malaysia is still lagging behind the international ART standard [2], [27], [28].

B. Fire Response Time

FRDM is a crucial player in Malaysia's emergency response community, actively involving rescue operations [7], [10]. In 2020, FRDM responded to 124,596 emergency calls, with an average of 341 calls each day [7]. About 57.40% of the 124,596 calls were for rescue, 31.20% for fire, and 11.20% for other tasks [7]. According to annual reports, FRDM saved RM13 billion in property from the total incident in 2020 [7]. However, 118 people died, and an estimated RM2.25 billion in property was lost or destroyed [7].

FRDM is responsible for rescues in all kinds of significant

TABLE I
COMPARISON OF MALAYSIA'S ART ACHIEVEMENT TO INTERNATIONAL ART STANDARD [2], [27], [28].

Article	Place	Median (Minutes)		Mean Time (Minutes)		Percentage (%)	
		Malaysia	International Standard	Malaysia	International Standard	Malaysia	International Standard
S. Di Teo et al. [2]	HUSM, Kota Bharu	-	-	14.10	8.00	14.3	90
Z. Asri et al. [27]	HUSM, Kota Bharu	-	-	12.42	8.00	25.5	90
K. Hussin et al. [28]	HKL, Kuala Lumpur	0.19	0.08	-	-	-	-
	HTAR Klang	0.19	0.08	-	-	-	-
	HRPZII, Kota Bharu	0.20	0.08	-	-	-	-

incidents, for example, in building fires, vehicle accidents, landslides, and hazardous material accidents, e.g., oil and gas spills [10], [29]. Therefore, various types of vehicles, such as Fire Rescue Tender (FRT), Rapid Intervention Motorcycle (RIM), water tanker, helicopter, Rapid Fire Rescue Tender (RFRT), Turn Table Ladder (TTL) and, Hazmat vehicle are needed to carry outdifferent kinds of rescue transportation [5], [7], [29], [30]. Each vehicle comprises a carriage and an upper structure with a water tank, pumps, and specialised firefighting gear [29].

FRT differs from ART because FRT depends on the country [14], [31]. Referring to the report from the Fire and EMS (FEMS) Department, Washington DC [32], it is clear that FRT does not have a specific international standard but is more dependent on best practice achievement. For instance, FEMS Department inWashington DC mentioned that in 2021, the FRT achievement is less than five (5) minutes and 20 seconds, with a total achievement rate for all fire stations at 96.6% [32]. However, in Malaysia, the targeted FRT is 10 minutes and is applicable to all of Malaysia's fire stations [7]. According to [7], the calculation of FRT is the initial movement of the fire engine or other rescue vehicle operating under the FRDM from the fire station to the incident site.

According to FRT achievement in [7], two graph properties are illustrated in Fig. 1: First, the average time it takes for the FRDM vehicles to get from their fire station to the incident site in 2019 and 2020. Secondly, the graph shows the percentage of FRDM vehicles that arrive at an incident site in less than ten minutes in 2019 and 2020. The FRT graph shows that the average time taken by FRDM vehicles from stations to incident sites in 2020 was lower than in 2019. The achievement percentage in 2020 was significantly higher than in 2019, except for Kedah and Pulau Pinang, where the percentage shows no significant difference.

According to the FRDM report, the average FRT for all states in 2020 was 11.59 minutes, which was the closest to the FRDM target, and the percentage achievement was 59.09%. This

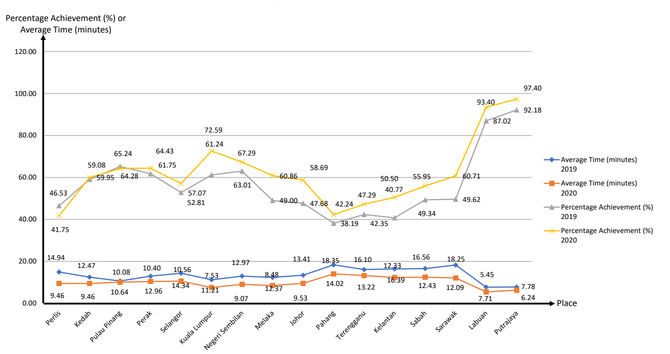

Fig. 1: Comparison of Malaysia's Fire Response Time (FRT) achievement[7].

achievement may be attributed to the traffic at that time, with no traffic congestion because very minimum vehicles were allowed to use the traffic network due to the MCO by the Malaysian government [14]. However, Malaysia's FRT in 2020 was still lagging behind other advanced countries, such as the FEMS, Washington DC [32], where the FRT standard is less than five (5) minutes and 20 second.

III. Factors Influencing The Ineffectiveness of Emergency Response Time

The previous section described how ERT in Malaysia is still lagging behind international standards and practices in advanced countries. Studies have been conducted to identify the exact factors affecting successful achievement of ideal ERTs.

According to [25]–[27], the factors affecting unsuccessful ERTs are heavy traffic conditions, bad weather such as heavy rain, and vehicle accident. Asri et al. [27] divided the factors into internal and external factors. Internal factors include caller type, call receiver, and call duration, all of which are relevant to emergency calls received by the dispatch call centre from MERS999 [1], [2], [26], [27]. External factors are weather and road conditions, and the duration of the rescue team's travel to the incident site [25]–[27]. In addition, the significant impact influencing the ineffectiveness of ERT is a lack of communication between emergency providers and traffic congestions [1], [2], [26], [27]. This review identified the related factors and discussed on two major factors which are inefficiency of the emergency response system and traffic congestion.

A. *Inefficient Emergency Response System (ERT)*

According to [26], the standard operating procedure (SOP) used by Malaysia's emergency providers is that emergency calls should be made to the MERS 999. MERS 999 is a one-stopcenter service for emergencies with only one specific number, 999 [26], [33]. MERS 999 consolidates the services of Malaysia's emergency providers on one platform. The 911 National Emergency Number Association (NENA) and the European Emergency Number Association (EENA) are the foundations of the MERS999 concept [22]. Malaysian government appointed Telekom Malaysia (TM) as the sole provider of the MERS999 system [22].

According to [22], [26], [34], MERS999 handles emergency calls and generates emergency priority codes called "call cards". Fig. 2 shows the MERS999 process, which starts when call centres receive an emergency call from accident victims or representatives [22].

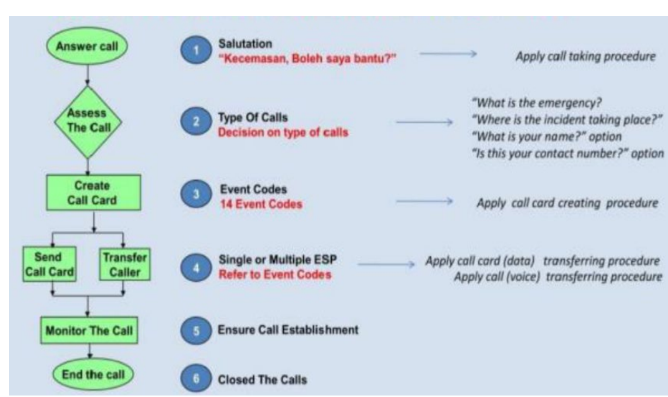

Fig. 2: Call Card Process at MERS999 Response Centre [22]

The MERS999 call centres are also responsible for verifying, filtering, and analysing calls to build call cards using the fourteen event codes shown in Fig. 3 [22]. Fig. 3 shows the MERS999 event codes and emergency priority codes depending on the incident's events. A call card will be sent to the emergency dispatch centre, which will take the call and gather more information about the emergency or incident, analyse the situation, and dispatch a team to the incident site [22].

EVENT CODES FOR MERS 999

	INCIDENT	CALL CARD + CALLER VOICE	COPY CALL CARD	NOTE
1	Perubatan (Medical)	HOSPITAL	-	-
2	Jenayah (Crime)	POLIS	-	-
3	Kebakaran (Fire)	BOMBA	POLIS	-
4	Kemalangan (Accident)	POLIS	-	Kuala Lumpur: Polis Trafik KL
5	Kemalangan + Mangsa (Accident + Victim)	HOSPITAL	POLIS	-
6	Kemalangan + HAZMAT (Accident + Hazmat)	BOMBA	POLIS	-
7	Bantuan Kemanusiaan (Humanitarian Service)	JPAM	-	-
8	Mencari & Menyelamat (Search & Rescue)	BOMBA	POLIS	-
9	Panggilan Senyap (Silent Call)	RC	-	'Suspicious silent' hantar ke POLIS
10	Panggilan Terputus (Drop Call)	RC	-	'Suspicious drop' hantar ke POLIS
11	Bantuan Khas (Special Service)	BOMBA	-	-
12	Perkhidmatan Persendirian (Private Service)	Ambulan / Hospital Swasta	-	-
13	Penguatkuasaan di Laut	APMM	PDRM	-
14	Kecemasan di Laut	APMM	PDRM, JBPM, KKM, JPAM	-

Fig. 3: Fourteen Emergency Event Codes [22]

According to [35], although MERS999 claims to be a platform that integrates all of Malaysia's emergency providers, it merely receives emergency calls, and forwards call cards to the relevant emergency provider. The emergency dispatch centre of the emergency provider will handle the report following their usual operational standards and communication systems without engaging MERS999 or other agencies involved in the same incident [35]. Each emergency provider has developed and deployed its communication and information resources [35]. In other words, MERS999 is not automated and not integrated among emergency providers [35].

Khamis et el. [34] appear to agree with [35], claiming that the MERS999 system is incapable of reducing the travel time for the relevant emergency provider arriving at the incident site. According to [34], the delay is caused by the MERS999 system's call receiving and forwarding procedures, which necessitate human intervention. Khamis et el. [34] proposed an automated call receiving and forwarding method to enable an integrated emergency management system to overcome the MERS999 limitation [34].

The system by [34] can identify the relevant emergency provider to rescue victims at an incident site to reduce human intervention in the MERS999 operation. The process begins when a mobile user starts an activity on the mobile phone app to report an incident. The mobile app then sends an alert (report) to a web-based system, which contains the mobile user's location and photographs. The system could determine the automatic emergency priority codes and significantly reduce the time between emergency providers' stations and the incident site.

B. Traffic Congestion

Apart from MERS999, Malaysian emergency providers also have their own emergency prioritise systems. EVs in Malaysia use flashing lights and sounding sirens and horns to warn other vehicles to pull over [36] and are given precedence over non-EVs [37]. However, the traditional emergency prioritise systems still delays EV travel time due to traffic congestion from stations to incident site [12], [36].

Traffic congestion has become a global issue with rapid growth in the world population and the escalation of vehicular density [38]. As a result, traffic congestion result is slower speeds, expand excursion time, expand vehicles' lining, and waste numerous person-hours [39]. As mentioned earlier, Malaysia is no exception with traffic congestion issues. Malaysia has one of the most developed infrastructures in Asia, with a 98,721km-long road network [40]. The number of roads has increased along with the rapid expansion of the road network and the growing number of vehicles on Malaysian roads [40].

Vehicles continue to increase in number and density on Malaysia's transportation infrastructure, particularly in urban areas like Wilayah Persekutuan Kuala Lumpur (WPKL), Selangor, and Johor [41]. For example, Malaysia Transportation Statistics reported that the number of vehicles registered in 2019 was 810,526 [13]. The number of EVs in 2020 increased by 21,897 to 832,423 [13]. The Average Daily Transport (ADT) can be used to determine the transport density of a specific road [13]. Overall, the ADT on roads in Malaysia in 2019 was around 2,952- 138,507, and roads in WPKL showed the highest ADT with 6,889 - 138,507 vehicles [13]. However, ADT for 2020 and 2021 cannot be considered as those years are outliers due to the Malaysian government's enforcement of lockdown or MCO. This data is supported by the fact that the number of vehicles registered each year is increasing and could cause congestion when the existing infrastructures could not meet up to the demand.

Apart from vehicular density, vehicle accidents also contributed to traffic congestion. Ministry of Transport (MOT) recorded 548,598 accidents in 2019 and 533,875 cases of the accident in 2020 [13]. According to [42], Malaysia was the 17th most dangerous place for drivers worldwide. Congestion builds up as the accident blocks vehicular flow whenever an accident happens in the traffic stream.

The increment in vehicular population and vehicle accidents in Malaysia may bring difficulty for EVs to achieve satisfactory ERT. Vehicle accidents happen among vehicles and involve EVs [11], [12]. According to the World Health Organization (WHO) Global Road Safety Report, road traffic fatalities worldwide reached 1.35 million in 2018 compared from 1.25 million in 2015 [12]. The Malaysia Institute for Health Systems reported that 129 ambulance accidents involved nine fatalities and 636 non-fatal injuries [12]. Most accidents, about 70.4%, of ambulance accidents occurred during the daytime on weekdays [12]. For example, an EV accident was caused by the driver having to drive the vehicle within the shortest time possible to ensure rescuers reach the incident site [36]. Therefore, many studies aim to provide traffic congestion solutions to ensure that EVs in Malaysia achieve the standard emergency response time and improve the safety of users of EVs [36].

According to [12], [13], [36], [38]–[41], [43], the leading factor for traffic congestion is vehicular density and vehicle accidents. An increase in vehicular density result in traffic congestion at signalised junctions. Several surveys found that EVs' difficulty reaching the response time was due to passing traffic congestion at junctions, especially signalised junctions [15]–[17]. In most circumstances, EVs have difficulty passing through these junctions, which are always congested with several vehicles, making it more difficult for EVs to arrive at their location on time, particularly during peak hours [11], [44], [45]. EVs would need to queue at the junction because of lack of space and for ambulance safety reasons, due to hearing impairment from other vehicles in adjacent lanes [37].

The primary role of the traffic control system is to manage traffic flow. Traffic control systems are crucial in preventing EVs from being delayed as a result of traffic congestion [16], [36], [43]–[45]. Moreover, traffic control systems are critical for managing road congestion, particularly during peak hours and seasons [36], [43]. Malaysia's conventional traffic control system comprises three simple colours: red indicates 'stop', yellow indicates 'ready to stop', and green means 'go' [36]. Prioritising EVs in emergencies is one of Malaysia's major traffic control system difficulties [36]. This is because conventional traffic control systems cannot prioritise and distinguish between EVs and regular vehicles [36]. As a result, EVs such as ambulances and fire vehicles occasionally encounter difficulties when they wait for other vehicles to yield at traffic control junctions causing delays in rescuing incident victims [36].

IV. Emergency Vehicle (EV) Priorities System

Several studies have developed EV priority systems in attempt to solve the issue of EVs becoming stranded in traffic congestion at junctions with traffic signaling systems. According to [16], [43]–[50], the traffic signal pre-emption approach is the common method applied to reduce EV travel time. Table 2 summarises some approaches and their disadvantages [16], [43]–[45], [49], [51].

TABLE II
Comparison of Emergency Vehicle Priorities Systems

Source	Proposed Method	Advantage	Disadvantage
Al-Ostath et al. [51]	Proposed an Emergency Traffic Light (ETL) control system that would allow emergency vehicles to safely cross traffic control signal.	-Reduce emergency vehicle travel time -Overcome the constraints of comparable devices, such as the strobe light and the Mobile Infar-Red Transmitter (MIRT) at junctions	-Does not provide pre-emption along emergency route from station to incident site -Does not integrate with emergency response system
Khan et al. [16]	Proposed system of Emergency Vehicle Priority and Self-organised Traffic Control (EVP-STC) for controlling emergency vehicles at junctions.	-Reduce emergency vehicle travel time -Provide traffic signal pre-emption algorithm to allow green signal to EV	-Does not provide pre-emption along emergency route from station to incident site -Does not integrate with emergency response system
Wani et al. [17]	Proposed live controlling system to prioritise ambulance along route from hospital to accident site.	-Provide pre-emption along emergency route from station to incident site	-Does not integrate with emergency response system -Unable to verify the analysis results due to hardware limitations.
Sumia&Ranga [11]	Proposed an Intelligent Traffic Management System (ITMS) for prioritising emergency vehicles based on the type of incident and traffic signal pre-emption.	-Provide pre-emption along emergency route from station to incident site -Integrate with emergency response system and provide emergency priority codes or call cards	-Does not go in depth on the algorithm for EVs or provide detailed analytical findings to show that system can reduce EV travel time.
Chowdhury et al. [45]	Proposed Intelligent Traffic System (ITS) for prioritising emergency vehicles based on the type of accidents, and a method for detecting and responding to the pre-emption of traffic signals.	-Provide pre-emption along emergency route from station to incident site -Integrate with emergency response system and provide emergency priority codes or call cards	-Does not go in depth on the algorithm for EVs or provide detailed analytical findings to show that system can reduce EV travel time.
Karmakar et al. [44]	Proposed an Emergency Vehicle Priority System (EVPS) that involves emergency vehicles based on the type and severity of accidents, by estimating multiple junctions, and minimising the impact of nearest junctions along the emergency vehicle's route.	-Reduce emergency vehicle travel time by calculating the cell clearance times of adjacent cell vehicles. -Provide pre-emption along emergency route from station to incident site -Integrate with emergency response system and provide emergency priority codes or call cards	-Does not guarantee a smoother cell clearance time due to event sites, accessible road infrastructure, and traffic circumstances,

The pre-emption method, according to [51], can allow EVs to use a green light signal while all other vehicles use a red light signal. The Emergency Traffic Light (ETL) control system [51] was presented as a way to construct a communication system between EVs and traffic control systems based on this concept. The ETL control system is comprised of two main components: an EV (sender) and a traffic control phase (receiver). The microcontroller is integrated with a Radio Frequency (RF) transceiver of the same type as the sender RF transceiver using an Arduino Uno. As a result, ETL can overcome the constraints of comparable devices, such as the strobe light and the Mobile Infar-Red Transmitter (MIRT) at crossings, allowing for safer EV access to traffic signals and faster response times [51]. On the other hand, ETL focuses on signal pre-emption for EVs at dedicated junctions and excludes the travel time of the EV from the station to the incident site. However, the work skips through the process of creating emergency priority codes and call cards.

The Internet of Things (IoT) was used in [16] to pre-empt when an EV would arrive at a junction. Khan et al. [16] proposed a system called EV Priority and Self-organised Traffic Control (EVP-STC) that has three components. The first component is the detector, which is installed at each road section to identify EVs and transmit detected data to the junction controller via ZigBee. The second component is the junction controller, which is deployed at traffic signals to collect data on EV locations and vehicle density on each road segment entering a junction. The junction controller is supposed to change the signal timing signals based on how much traffic is being seen at the time. The third component of the system is that EVs will be equipped with a module that will send Global Positioning System (GPS) coordinates to the junction controller. This will keep EVs from having to wait at a junction. Khan et al. [16] used Planning Transport Vehicle - Vehicle In Städten Simulations (PTV-VISSIM) model simulation to evaluate the system, and the results showed a comparison to conventional traffic signal systems. The evaluation result showed that the relevant EV could arrive at an incident site with the shortest delay compared to the conventional system. On the other hand, the EVP-STC was only used for prioritising EVs at one junction and did not include all junctions between the station and the incident site. EVP-STC also leaves out procedures for creating emergency priority codes and call cards.

Wani et al. [17] appeared to address the shortcomings of the systems proposed by [16], [51] by prioritising an ambulance from the hospital to the incident site and vice versa. Wani et al. [17] developed an ambulance traffic management programmer that utilises IoT to control all junctions along the ambulance route. Using the ambulance's inbuilt GPS, i.e., NEO 6M [9], the method allows the ambulance driver to choose the hospital route. The shortest route between the hospital and the emergency site is displayed using Google Maps. The traffic control room and the hospital control system receive a link to the live location. The traffic control room is a subcomponent that helps ambulances arrive on time by clearing the ambulance's route and adjusting traffic control as needed. The proposed solution was designed and evaluated using a prototype of the Arduino-based solution's connectors, and it was found to operate well for its main purposes. Since the driver must provide the ambulance's live location as a message, the proposed system is only semi-automatic. Wani et al.[17], however, were unable to verify the analysis results due to hardware limitations. Furthermore, the study alsofailed to show that traffic signal control could reduce EV delays. The study also does not mention any methods to manage emergency priority codes or call cards.

According to [11], [44], [45], the methods needed to prioritise EVs are: 1) an appropriate emergency priority code; 2) a method for detecting EVs and pre-empting traffic control signals. An emergency priority code is based on the type and severity of an incident [11], [44], [45]. Researchers in [11], [44], [45] proposed the emergency priority code as per Table 3. Table 3 explains the three scenarios of incidents that have been used to determine the emergency priority code. In Case 1, ambulances are prioritised when medical assistance is more critical, such as vehicle accidents or transporting critical patients. Ambulances can be accompanied by fire engines and police cars, as they play a support function. In Case 2, fire engines will take precedence in the event of a fire, as paramedics are incapable of rescuing people from flames. Ambulances will have a secondary priority for treating incident victims, followed by police cars. In Case 3, police cars will be prioritised in riots, violence, or crowd management.

TABLE III
EMERGENCY PRIORITY CODE [11], [44], [45]

Case No.	Emergency Medical Assistance?	Fire Threat?	Fire Control Need?	Crowd Criminal?	Priority
1	Yes	Yes	No	No	Ambulance > Fire Brigade > Police
2	Yes	Yes	Yes	No	Fire Brigade < Ambulance < Police
3	Yes	Yes	No	Yes	Police < Ambulance < Fire Brigade

According to [11], the proposed Intelligent Traffic Management System (ITMS) combines the concept of Vehicular Ad-hoc Network (VANET) with IoT. According to [7], ITMS is made up of a Traffic Management Server (TMS), Roadside Units (RSUs), EVs, and sensors stationed at strategic locations. ITMS prioritises EVs at junctions after determining the emergency priority code. First, the distance between the EV and the junction was measured by ITMS. After that, an EV was dispatched from that junction based on the type of event and EV type, with the premise that the traffic signals were either pre-emptive or not. For performance evaluation, [11] proposed using the Cup Carbon U-One simulator to compare ITMS performance to the Green Wave System and the Emergency Priority Code System (EPCS). The ITMS results, according to this study, showed that ITMS can reduce EV travel time when combined with the Green Wave System. However, [11] does not go into great depth on the algorithm for EVs or provide detailed analytical findings to show that ITMS can reduce EV travel time.

Similar to [11], [45] also proposed an Intelligent Traffic System (ITS) for the EV to infrastructure (EV2I) system, which prioritised EVs based on their type and severity. In order toreduce traffic congestion and improve the system's reliability, ITS also considered the priority of an EV based on the type of incident and traffic signal pre-emption. IoT was reportedly used in the ITS plan based on green wave technology, which allows a traffic signal system to turn green when an EV approaches, according to [10]. To avoid the impact of poor synchronisation, [10] advocated an RFID-based traffic control system and proved that the system could establish the EV's targeted travel time via Simulation of Urban Mobility (SUMO). However, [45] did not go into extensive detail on the traffic pre-emption approach.

In the case of an incident, [44] adopted the same method in [11], [45] to identify emergency priority codes and offer signal pre-emption to clear the way for the EV. The Smart EV Priority (SEVP) system developed by [44] is an integration of the emergency response system with traffic signal control to enhance the EV priority system in achieving emergency response time. When an EV arrives, the SEVP system detects and monitors it, transmitting a wave of green signals to the traffic signal control, which immediately turns on the green light. The SEVP system defined the priority code and offered a novel method for determining the number of green signal pre-emptions required to provide a faster travel route for an EV. SEVP also takes into account how pre-emptions will affect traffic on roads near the EV's route.

To prove the system's performance, [44] combined real-time traffic data from VicRoads with a simulation model using a realistic simulator called SUMO. Generally, this method succeeds in assigning an EV the appropriate priority in order to speed up its arrival at an incident site. Furthermore, depending on the type and severity of the incident, this system can send the correct priority code to an EV. In addition, SEVP calculates the number of signal pre-emptions required to reduce an EV's travel time by counting the cell clearance times of adjacent cell vehicles. SEVP, on the other hand, can't promise a faster cell clearance time because of the event sites, accessible roads, and traffic.

V. Discussion

This article reviews the achievements of Malaysia’s emergency response time, which is still lagging behind ART international standards [27] and best practices in advanced countries such as FEMS, Washington DC [32]. The factors most influencing the ineffectiveness of emergency response time have been found to be the lack of effective emergency response system and traffic congestion. Several studies mentioned that Malaysia's emergency response system, also called MERS999, is not integrated among emergency providers [22], [34], [35]. Most studies mentioned that EVs were stranded in traffic congestion at signalised junctions [16], [43]–[50].

As a result, studies have developed advanced EV priority systems based on traffic signal pre-emption to address the issue of EVs becoming stranded at signalised junctions [16], [43]–[50]. Sumia and Ranga [11], [44], [45] proposed not only the method of traffic signal pre-emption to allow EVs to pass through the signalised junction but also proposed emergency priority codes, similar to MERS999. Looking at the whole article that has been reviewed, it is found that the findings in [44] could help Malaysian emergency providers achieve better emergency response times. This is because, [44] proposed integrating the emergency response system with traffic signal control to enhance the EV priority system in achieving emergency response time.

To improve Malaysia's emergency response time, MERS999 must be enhanced and evolved into a single integrated system that creates automatic emergency priority codes and enhanced EV priority systems. The automatic emergency priority codes can aid in accomplishing better ERT by connecting all stand-alone dispatching EV systems from emergency providers and Malaysia's traffic control system. Automatic emergency priority codes, on the other hand, will be more accurate and consistent than emergency priority codes generated by humans.

Malaysia's traffic control system must be fitted with a signal pre-emption module that distinguishes between EVs and non-EVs in order to implement an emergency vehicle pre-emption strategy. The integration with automatic emergency priority codes can alert the traffic control system to an emergency situation. As a result, the traffic signal pre-emption module can allow EVs to proceed through junctions on green signals.

Malaysia's advanced EV priority system is critical in helping Malaysia's emergency response providers meet international standards and best practises.

VI. Conclusion

In conclusion, the objectives of this article have been successful by obtaining information on the following: the achievement of emergency response time in Malaysia, the major factors affecting emergency response time, and the current advanced EV priority systems developed by researchers. This article has also come out with the recommendation to improve the emergency response system by MERS999 and Malaysia traffic signal control to assist emergency providers in achieving an emergency response time that complies with international standards.

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