PRIORITIZING WEIGHTING CRITERIA IN ASEAN NCAP RATING ASSESSMENT BY USING THE ANALYTIC HIERARCHY PROCESS (AHP): INDUSTRY AND POLICY MAKER PERCEPTION

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DECLARATION

I declare that this report entitled Prioritizing Weighting Criteria in ASEAN NCAP Rating Assessment by Using The Analytic Hierarchy Process (AHP): Industry and Policy Maker Perception is the result of my own research except as cited in the references. Prioritizing Weighting Criteria in ASEAN NCAP Rating Assessment by Using The Analytic Hierarchy Process (AHP): Industry and Policy Maker Perception has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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APPROVAL

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DEDICATION

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Shea Hu Ping and Liew Suck Cheang whose words of encouragement and push for tenacity ring in my ears. I also dedicate this dissertation to my many friends who have supported me throughout the process. I will always appreciate all they have done

ABSTRACT

Automotive Technology is improving every moment nowadays, but road accidents are still happening. Road accidents and fatalities in Malaysia are still high today. ASEAN NCAP is introduced to elevate vehicle safety standards, raise consumer awareness and encourage a market for safer vehicles in the ASEAN market. There are many testing protocols and tests created by ASEAN NCAP to achieve their objectives. However, the weightage of each item and each pillar in the ASEAN NCAP rating assessment is incompatible with the data on road accidents shown. According to the Ministry of Transport of Malaysia, Motorcyclist has the highest fatalities rate in road accidents. Besides, according to World Health Organisation (WHO), children are more vulnerable to road accidents. There is a lack of study on the priority weighting criteria for safety technology in assessment protocol for ASEAN NCAP rating. Hence, there is a need to design and develop a research instrument for weighting criteria for each pillar and item in the ASEAN NCAP rating assessment. The weighting for each pillar in the ASEAN NCAP rating needed to be determined by using Analytic Hierarchy Process (AHP). There is also a need to determine the effectiveness of the current rating assessment protocol. At the beginning of this study, a survey will be distributed to policymakers makers and automotive industry workers to collect their preferences on each item in the ASEAN NCAP rating assessment for 2021 to 2025. Analytic Hierarchy Process (AHP) will analyse data collected from the questionnaire. The results obtained in this process can help in determining the weightage of each item and each pillar in the ASEAN NCAP. Simultaneously, the effectiveness of the current ASEAN NCAP rating assessment can be determined. Based on the preferences of the respondents, Child Occupant Protection (COP) was the most important criterion in the ASEAN NCAP rating assessment. The top 2 priority items from the standpoint of automotive industry worker were side (child) and vehicle-based assessment, while seatbelt reminder (front) and blind spot detection were perceived for that by the policymaker. Out of these items, two of them are under the pillar of Child Occupant Protection (COP) and Motorcyclist Safety (MS). The ASEAN NCAP should be prioritising the weightage of items in the pillar of COP and MS. By manipulating the weighting of the criteria in the ASEAN NCAP rating assessment based on the happening traffic data, it will encourage the vehicle manufacturer to introduce more safety technologies to their vehicles. At the same time, road accidents and fatalities can be reduced.

ABSTRAK

Teknologi Automotif bertambah baik setiap saat pada masa kini, tetapi kemalangan jalan raya masih berlaku. Kemalangan jalan raya dan kematian di Malaysia masih tinggi sehingga kini. ASEAN NCAP diperkenalkan untuk meningkatkan standard keselamatan kenderaan, meningkatkan kesedaran pengguna dan menggalakkan pasaran untuk menghasilkan kenderaan yang lebih selamat di pasaran ASEAN. Terdapat banyak protokol dan ujian-ujian yang dicipta oleh ASEAN NCAP untuk mencapai objektifnya. Walau bagaimanapun, wajaran setiap item dan setiap tunggak dalam penilaian penarafan ASEAN NCAP tidak serasi dengan data mengenai kemalangan jalan raya yang ditunjukkan. Menurut Kementerian Pengangkutan Malaysia, penunggang motosikal mempunyai kadar kematian tertinggi dalam kemalangan jalan raya. Selain itu, menurut Pertubuhan Kesihatan Sedunia (WHO), kanak-kanak lebih terdedah kepada kemalangan jalan raya. Terdapat kekurangan kajian mengenai kriteria pemberat keutamaan untuk teknologi keselamatan dalam protokol penilaian untuk penarafan ASEAN NCAP. Oleh itu, terdapat keperluan untuk mereka bentuk dan membangunkan instrumen penyelidikan untuk kriteria pemberat bagi setiap tunggak dan item dalam penilaian penarafan ASEAN NCAP. Wajaran bagi setiap tunggak dalam penarafan ASEAN NCAP perlu ditentukan dengan menggunakan Proses Hierarki Analitik (AHP). Terdapat juga keperluan untuk menentukan keberkesanan protokol penilaian penilaian semasa. Pada permulaan kajian ini, satu tinjauan akan diedarkan kepada pembuat dasar dan pekerja industri automotif untuk mengumpul keutamaan mereka pada setiap item dalam penilaian penarafan NCAP ASEAN untuk 2021 hingga 2025. Proses Hierarki Analitik (AHP) akan menganalisis data yang dikumpul daripada soal selidik . Keputusan yang diperolehi dalam proses ini boleh membantu dalam menentukan wajaran setiap item dan setiap tunggak dalam ASEAN NCAP. Pada masa yang sama, keberkesanan penilaian penarafan ASEAN NCAP semasa boleh ditentukan. Berdasarkan keutamaan responden, Perlindungan Penumpang Kanak-Kanak (COP) merupakan kriteria terpenting dalam penilaian penarafan ASEAN NCAP. 2 item keutamaan teratas dari sudut pandangan pekerja industri automotif ialah penilaian hentaman sisi (kanak-kanak) dan berasaskan kenderaan, manakala peringatan tali pinggang keledar (depan) dan pengesanan titik buta dilihat oleh pembuat dasar. Daripada barangan tersebut, dua daripadanya berada di bawah tonggak Perlindungan Penumpang Kanak-Kanak (COP) dan satu daripadanya di bawah tonggak Keselamatan Penunggang Motosikal (MS). ASEAN NCAP sepatutnya mengutamakan wajaran item dalam tonggak COP dan MS. Dengan memanipulasi wajaran kriteria dalam penilaian penarafan ASEAN NCAP berdasarkan data trafik yang berlaku, ia akan menggalakkan pengeluar kenderaan memperkenalkan lebih banyak teknologi keselamatan kepada kenderaan mereka. Pada masa yang sama, kemalangan jalan raya dan kematian dapat dikurangkan.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADAS	-	Advanced Driver Assistance Systems
PCAM	-	Pedestrian Crash Avoidance and Mitigation System
LDW	-	Lane Departure Warning
AEB	-	Autonomous Emergency Braking
BSM	-	Blindspot Monitoring System
ASEAN	-	Association of Southeast Asia Nation
NCAP	-	New Car Assessment Program
MIROS	-	Malaysian Institute of Road Safety Research
MOT	-	Ministry of Transport
AOP	-	Adult Occupant Protection
WHO	-	World Health Organization
COP	-	Child Occupant Protection
AHP	-	Analytic Hierarchy Process
HPT	-	Head Protection Technology
FRS	-	Fitment Rating System
CRS	-	Child Restraint System
OEM	-	Original Equipment Manufacturer
ISOFIX	-	International Standard for child car seat fittings
SA	-	Safety Assist
ESC	-	Electronic Stability Control
SBR	-	Seatbelt Reminder
ABS	-	Anti-lock Braking System
SATs	-	Safety Assist Technologies
FCW	-	Front Collision Warning
LKA	-	Lane Keep Assist
MS	-	Motorcyclist Safety
BST	-	Blindspot Technology
ARV	-	Advance Rear Visualization
AHB	-	Auto High Beam

IIT	-	Industrial Information Technology
GPS	-	Global Positioning System
GSM	-	Global System for Mobile Communications
LCD	-	Liquid-crystal Displays
SMS	-	Short Message Service
CV	-	Connected vehicle technology
DA	-	Driving Assistance Technology
FCW	-	Front Collision Warning
BSW	-	Blind Sport Warning
LCW	-	Lane Change Warning
CMBS	-	Collision Mitigation Brake System
SAM	-	Statistical Analysis Methodology
FOT	-	Field Operation Test
SIM	-	Safety Impact Methodology
TTC	-	Time-to-Collision
V2V	-	Vehicle-to-vehicle
IOAS	-	Intelligent Overtaking Advice System
EGV	-	Ego vehicle
LVF	-	Lead vehicle – Front
LVO	-	Lead Vehicle – Opposite
VNet	-	Velocity Net
TTC-Net	-	Time-to-Collision Net
MST	-	Motorcyclist Safety Technology
λmax	-	Maximum Eigen value
CI	-	Consistency Index
n	-	Number of elements

CR	-	Consistency Ratio
RI	-	Index Random Consistency
WS	-	Weight of synthesis
BSD	-	Blindspot Detection

CHAPTER 1

INTRODUCTION

1.1 Background

Automotive technology is advancing every second nowadays. In the old days, the automobile is invented to enable people to travel and relocate more efficiently, reduce human workload, etc. It is a common transport for a family as it provides comfort and protection from sun and rain. According to CEIC data, there were 17,728,482 vehicles registered in December 2021 in Malaysia.(CEIC Data, 2021) As time goes by, automobile manufacturers prioritize the performance and efficiency of an automobile. As a result, the automobile's speed increases, and the duration of travelling from one spot to another is reduced. Due to the growing number of vehicles and increment in automobile speed, safety concerns are created.

Five hundred sixty-seven thousand five hundred sixteen road accidents were reported in 2019 in Malaysia. (Ministry of Transport Malaysia, 2020) This figure rose from four hundred fourteen thousand four hundred and twenty-one cases in 2010. In this period of time, fifty-nine per cent of road fatalities are coming from motorcyclists, whereas passenger cars are responsible for twenty-one per cent of fatalities among all other road users. (Ministry of Transport Malaysia, 2020) Few studies indicate that human error is the main factor in road accidents. Examples of drivers' behaviour are carelessness, reckless driving, and over speeding. (Musa MF et al., 2020) Distracted driving such as using a phone while driving, interacting with passengers, eating, drinking, and smoking can also lead to road accidents. More than fourty-three per cent of Malaysian drivers use their mobile phones while driving. These dangerous driving behaviours will put the driver and others in danger.

Automobile manufacturers have introduced some strategies to overcome this problem. This includes increasing chassis rigidity and introducing Advanced Driver Assistance Systems (ADAS) to reduce road accidents. The ADAS can reduce the severe impact of those that cannot be avoided during a road accident. The essential safety critical ADAS applications include Pedestrian Crash Avoidance and Mitigation System (PCAM), Lane Departure Warning (LDW), Autonomous Emergency Braking (AEB), and Blindspot Monitoring System (BSM). These technologies can be used to keep a vehicle in its lane or control its motion in various situations. To standardize and improve the vehicle safety systems, the systems should be tested and evaluated by a regulation or consumer-based approach intervention. It should refer to professional opinions from automotive researchers and perspectives from people in different regions.

In December 2011, New Car Assessment Program for Southeast Asia countries (ASEAN NCAP) is established by the effort of the Malaysian Institute of Road Safety (MIROS) and Global NCAP. The main objective of ASEAN NCAP is to elevate vehicle safety standards, raise consumer awareness and encourage a market for safer vehicles in the ASEAN market. There is a variety of testing protocols and tests created by ASEAN NCAP to check the safety of a vehicle. Up till now, ASEAN NCAP has successfully reduced the number of road accidents by elevating vehicle safety standards. In addition, it also provides a vehicle safety reference for consumers when making car purchase decisions.

However, the weightage of each item and each pillar in the ASEAN NCAP rating assessment is incompatible with the data on road accidents shown. According to MOT, the motorcyclist has the highest percentage of road fatalities, fifty-nine per cent.(Ministry of Transport Malaysia, 2020) In ASEAN NCAP rating assessment protocol for 2021 to 2025, Motorcyclist Safety only contributes twenty per cent of the overall rating. (*Assessment Protocol-Motorcyclist Safety*, 2020) It is twenty percent lower than the weighting of Adult Occupant

Protection (AOP). Besides, according to World Health Organization (WHO), young children are more vulnerable to road accident compared to adults. (World Health Organization (WHO), 2015) Children are limited by their physical, cognitive, and social development. Additionally, due to their softer heads, children are more likely to sustain catastrophic head injuries in car accidents. Nevertheless, Child Occupant Protection (COP) only contributes twenty percent of the overall rating. (*Assessment Protocol-Child Occupant Protection*, 2019) This shows there is a contradictory relationship between the weightage of the ASEAN NCAP rating assessment and the reality.

In conclusion, there is a need to ascertain the effectiveness of the current ASEAN NCAP rating assessment. This can be done by collecting the opinion of individual who has knowledge in the aspect of road and vehicle safety: automotive industry workers and policymakers. Then, the weighting for each pillar in the ASEAN NCAP rating assessment can be determined by using Analytic Hierarchy Process (AHP). AHP is a method of "measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales.". Thomas L. Saaty created it in the 1970s.(Russo & Camanho, 2015) As a tool for multiple criteria decision-making, it has been one of the most popular. It is widely used by researchers and decision-makers due to its simplicity and ability. Hence, AHP will be the most suitable technique to be used in this paper to determine the weighting for each pillar in the ASEAN NCAP rating assessment.

1.2 Problem Statement

Automobile brings advantages and eases human in daily life. In the meantime, it may bring injury, in a worst-case scenario, resulting in fatalities when the driver and passenger are involved in a road accident. ASEAN NCAP is established in December 2011. To date, it has a history of 11 years. However, there is lack of study on the prioritiy weighting criteria for safety technology in assessment protocol for ASEAN NCAP rating. The weighting of each pillar for current ASEAN NCAP rating assessment is irreconcilable with the road accident index. Thus, There is a need to determine and evaluate the weighting for each item and each pillar in ASEAN NCAP. The effectiveness of the current assessment protocol for item in each pillar should be tested too.

1.3 Research Objective

The main objective of this research is to propose accurate, achievable, methodical, and effective methods of prioritzing the weighting criteria in an assessment protocol. Specifically, the objectives are as follows:

a) To design and develop a research instrument for weighting criteria for each pillar and item in the ASEAN NCAP rating assessment.

b) To determine the weighting for each pillar in the ASEAN NCAP rating by using Analytic Hierarchy Process (AHP).

c) To determine the effectiveness of the current assessment protocol for item in each pillar.

1.4 Scope of Research

The scopes of the research are as follows:

a) Respondent must be citizen of ASEAN countries.

b) Respondent must have considerable knowledge about road and vehicle safety.

c) Determination of weighting for each pillar is based on ASEAN NCAP rating scheme for 2021 to 2025.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is an academic writing that discusses the information from published articles in a particular subject area. It also demonstrates the knowledge and understanding of the published articles on a specific topic in a context. A literature review normally comes before a research proposal and the results of a project. Conducting a literature review can help in summarising and analysing previous research and studies. Information and knowledge that is useful for this project have been collected as a guide in completing this project.

For this project, statistics of road accidents, information about the pillars of ASEAN NCAP, innovative accident-avoidance technologies and analytic hierarchy process (AHP) is being collected need to be studied for quality project results. Thus, academic literature related to these topics will be collected and reviewed. All these efforts are to ensure the project can proceed smoothly.

2.2 Accident Statistic

2.2.1 Malaysia Road Accident 2010 to 2019

In October 2018, there is around 16,000,000 vehicles registered in Malaysia based on CEIC Data.(CEIC Data, 2021) When the number of vehicles increases, the number of road accidents will increase accordingly. According to the Department of Statistics Malaysia, transport accidents were ranked as the fourth principal cause of death in 2018.(*Department of Statistics Malaysia Official Portal*, 2020) Transport accidents can lead to economic losses and restrict a country's social development process.

For a growing country like Malaysia, transport infrastructure is important since it connects all the states in Malaysia and consequently brings up the economic sectors. Hence, the need for automobiles is growing every year. Road accident is the biggest risk in transport. As we can see, from Figure 2.1, the digit is rising constantly since 2010. There is an increment of 153095 road accidents from 2010 to 2019. For Malaysia Road Fatalities, the integer shown in Figure 2.2 is rising from 2010 to 2012 by 45. Then, it starts to drop from 2012 to 2014 by 213. The figure continues to increase from 2014 until 2016. It is worth noting that there is a sharp increment in 2016 which is 446 higher than that in 2015. After that Malaysia's road fatalities begin to drop until 2019. It is a good sign that the Malaysia road fatalities are reducing.

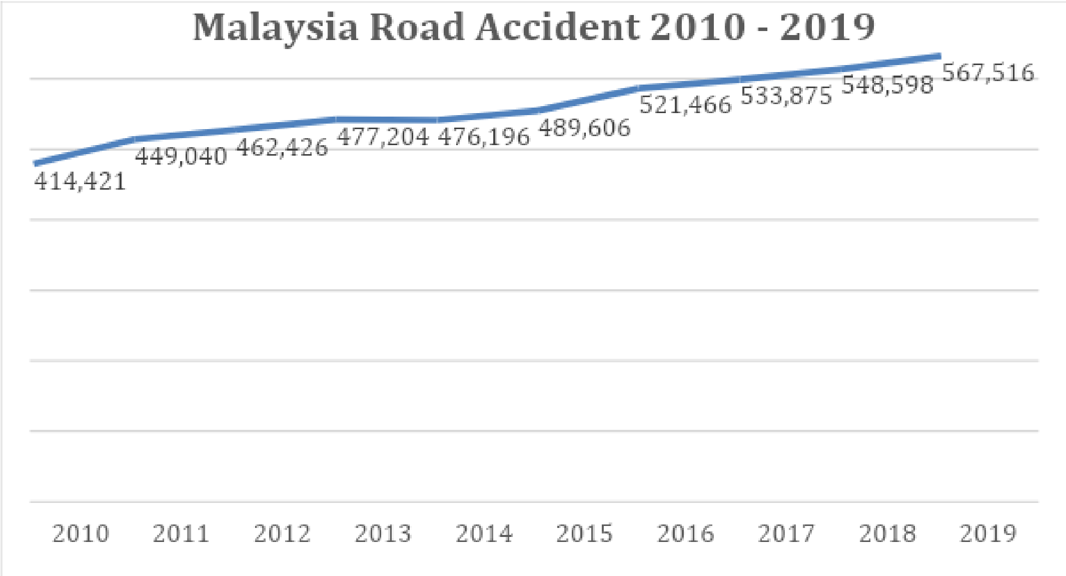


Figure 2.1: Malaysia Road Accident 2010 to 2019 (Ministry of Transport Malaysia, 2020)

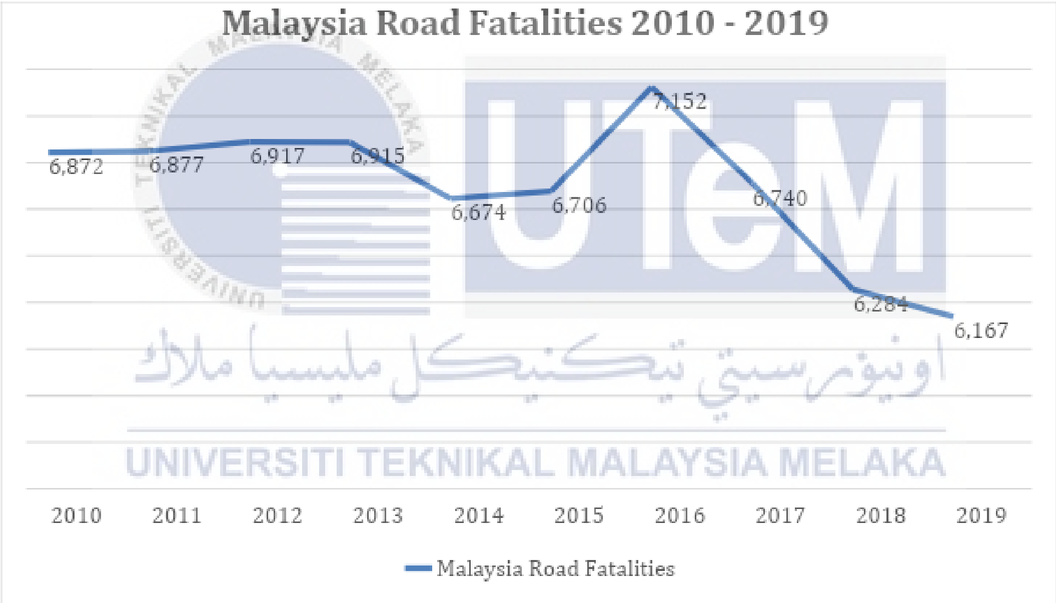


Figure 2.2: Malaysia Road Fatalities 2010 to 2019 (Ministry of Transport Malaysia, 2020)

2.2.2 Death and injuries in different states in Malaysia

Selangor has the highest number of deaths in road accidents compared to other states according to Figure 2.3. The number is followed by Johor (977 cases), Perak (693 cases), and Kedah (509 cases). On the other hand, Kelantan is the leading of injuries in road accidents with 1626 cases, followed by Perak with 1006 cases, Kedah with 797 cases, and Negeri Sembilan with 796 cases. There is a total of 8341 cases of injuries and 6284 cases of deaths in road accidents in Malaysia, in 2018. The Selangor has the highest, while Perlis has the lowest accident rate.

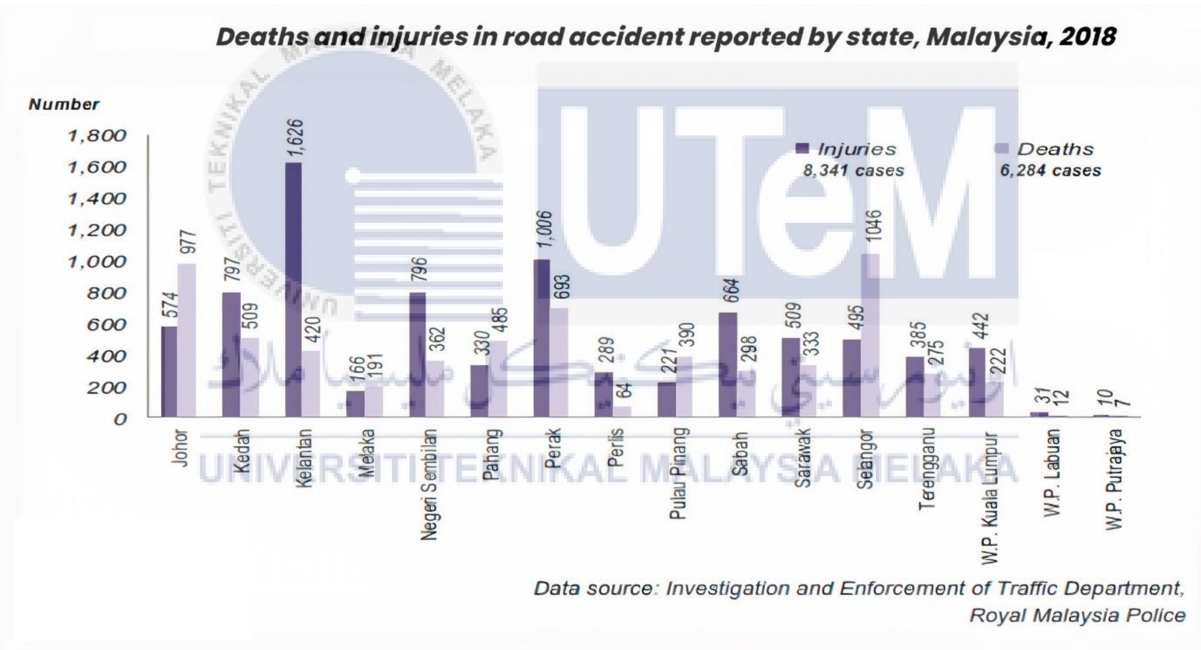


Figure 2.3: Deaths and injuries in road accident reported by state, Malaysia, 2018. (*The Official Portal of Royal Malaysia Police*, 2022)

2.2.3 Road Fatalities by Mode (2010 to 2019)

From 2010 to 2019, the highest percentage of road fatalities is come from the motorcyclist, which is fifty-nine percent. It is followed by the passenger car and pedestrian, twenty-one percent, and nine percent accordingly. Bicycle and Goods both contribute three percent in the road fatalities for 2010 to 2019. Then, the 4x4 provide two percent in the road fatalities for 2010 to 2019. As shown in Figure 2.4, bus, goods, and others contribute one percent of the overall road fatalities by mode.

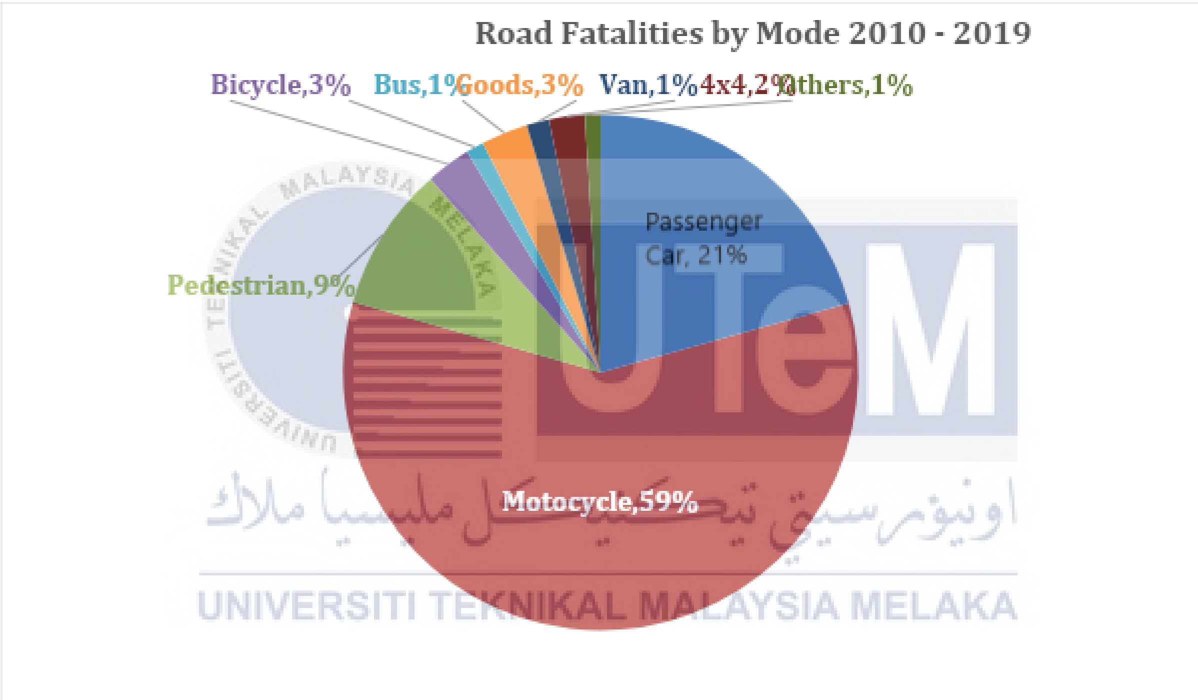


Figure 2.4: Road Fatalities by Mode (2010 to 2019) (Ministry of Transport Malaysia, 2020)

2.3 Pillars of ASEAN NCAP

2.3.1 Adult Occupant Protection (AOP)

For the ASEAN NCAP rating assessment of 2017 to 2020, instead of a separate rating for Adult Occupant Protection (AOP) and Child Occupant Protection (COP), a single rating system is introduced in which AOP hold fifty per cent of the overall rating system with a maximum of 36 points as shown in Figure 2.5. Head protection technology (HPT) is the additional item was introduced in the rating assessment for 2017 to 2020. The score is based on Fitment Rating System (FRS). HPT can be other than an airbag, as long as the head of the occupant is protected. In the rating assessment of 2020 to 2025, AOP maintains two main crash assessment which is the frontal and side-impact tests. ASEAN NCAP has amended the score for the side impact by reducing fifty per cent of the score whereas the additional point will be awarded for HPT. This is to increase car safety standards in the ASEAN region by implementing more curtain airbags. As we can see from Figure 2.6, the overall weighting of AOP is reduced to a maximum of 32 points which is only forty per cent of the overall rating system. The distribution of the points is as follows: Frontal Impact test (16 points), Side Impact Test (8 points), and HPT (8 points). (*Assessment Protocol-Adult Occupant Protection*, 2019)

2.3.2 Child Occupant Protection (COP)

Instead of a separate rating for AOP and COP, the requirement in the rating assessment for 2017 to 2020 for COP will provide 25% of the total score according to Figure 2.5. Frontal and side impact tests are the main assessment in COP by using Q series dummies instead of P series dummies in the assessment protocol for 2017 to 2020. Q series dummy provides better biofidelic response compared to the P series dummy. The Child Restraint System (CRS) based assessment section has been replaced by the CRS installation assessment in the rating assessment for 2017 to 2020. The CRS installation assessment includes a reference list assessment and an Original Equipment Manufacturer (OEM) assessment. Vehicle based assessment is also one of the items in the pillar of COP. It includes the provision of three-point seat belts, Gabarit installation on all passenger seats, two simultaneous use seating positions, ISOFIX usability, two or more largest ISOFIX positions, and passenger airbag warning marking. In the rating assessment for 2020 to 2025, the weighting of COP is reduced to twenty per cent of the overall rating score which is 51 points. From Figure 2.6, there are 5 items in the COP pillar of the rating scheme for 2021 to 2025, which are frontal impact test (16 points), side impact test (8 points), CRS installation (12 points), vehicle-based assessment (13 points), and child presence detection (2 points). (*Assessment Protocol-Child Occupant Protection*, 2019)

2.3.3 Safety Assist (SA)

Safety Assist is a main pillar introduced in the rating scheme for 2017 to 2020. In the assessment protocol of 2012 to 2016, electronic stability control (ESC) and frontal seatbelt reminder (SBR) are considered in the pillar. From Figure 2.6, in the rating scheme for 2021 to 2025, the SA pillar remains the test of effective braking and avoidance (EBA) which is anti-lock braking system (ABS) and ESC, autonomous emergency braking (AEB) in city and inter-urban, front and rear SBR and Advanced Safety Assists Technologies (SATs) including Lane Departure Warning (LDW), Forward Collision Warning (FCW), Lane Keep Assist (LKA), and other advanced SATs. The point distribution for pillar SA is as follows: EBA (6 points), SBR(Front) (3 points), SBR(Rear) (1.5 points), SBR (Rear, Advanced) (1.5 points), AEB (City) (2.5 points), AEB (3.5 points), and Advanced SATs (3 points). Total of maximum 21 points (20%) are contributed by SA pillars to the overall rating for 2021-2025. (*Assessment Protocol-Safety Assist,* 2019)

2.3.4 Motorcyclist Safety (MS)

Following the successful promotion of SATs in the rating scheme for 2017 to 2020, this new ranking will place more emphasis on a new pillar caller Motorcyclist Safety (MS), which accounts for twenty per cent of the final score. Due to the large number of motorcycle-related fatalities each year, ASEAN NCAP is encouraging the manufacturers to include extensive standards for Blind Spot Technology (BST) (8 points) and Advanced Rear Visualization (ARV) (4 points) in their new rating system. Pedestrian protection and the Auto High Beam (AHB) system will also add 2 points each to the final score of 16 points. Other Advanced Motorcyclist safety technologies will contribute extra 2 marks to the pillar. One of ASEAN NCAP's key initiatives to lessen the incidence of motorcycle accidents and injuries in the area is this endeavour. Figure 2.5 and 2.6 shows the complete scoring of the ASEAN NCAP rating assessment for 2017 to 2020 and 2021 to 2025 accordingly.(*Assessment Protocol-Motorcyclist Safety*, 2020)

2017–2020 ASEAN NCAP RATING	AOP		COP		Safety Assist*		
	ODB	16	Dynamic Assessment Frontal	16	Effective Braking & Avoidance	8	
	SIDE	16	Dynamic Assessment Side	8	Seatbelt Reminders	6	
	HPT Evaluation*	4	Installation of CRS	12	Blind Spot Technology	2	
			Vehicle Based Assessment	13	Advanced SATs	2	
Max.Score (1)		36		49		18	
Normalized Score (2)	actual score / (1)		actual score / (1)		actual score / (1)		
Weighing (3)	50%		25%		25%		Overall Score
Weighted Score	(2) x (3)		(2) x (3)		(2) x (3)		Total

Rating	***minimum: normalised (2) / actual score by box for the respective star rating***						Min. Overall Score
5-Star	75%	27.0	75%	36.75	60%	10.80	75%
4-Star	65%	23.4	60%	29.40	40%	9.00	65%
3-Star	45%	16.2	30%	14.70	30%	7.20	50%
2-Star	30%	10.8	25%	12.25	20%	3.60	40%
1-Star	20%	7.20	15%	7.35	10%	1.80	30%

** Apply FRS*

Figure 2.5: Scoring ASEAN NCAP Rating assessment for 2017 to 2020.

ASEAN NCAP 2021-2025	AOP		COP		Safety Assist		Motorcyclist Safety	
	Item	**Max**	**Item**	**Max**	**Item**	**Max**	**Item**	**Max**
	Frontal	16	Frontal	16	*EBA*	6	*BSD / BSV*	8
	Side	8	Side	8	*SBR(Fr.)*	3	*Rear View Technology*	4
	HPT Evaluation	8	CRS Installation	12	*SBR(Rr.)*	1.5	*AHB*	2
			Vehicle Based Assessment	13	*SBR(Rr.) Advanced*	1.5	Pedestrian Protection	2
			Child Presence Detection	2	*AEB City*	2.5		
					AEB Inter Urban	3.5	*[Advanced MST]**	2*
					Advanced SAT	3	**BONUS POINT*	
Score		32		51		21		16
Weighting		40%		20%		20%		20%

Slanting = Fitment Rating System   ** To add 2 points MAX to total MS point*

	AOP (%)	COP (%)	Safety Assist (%)	Motorcyclist Safety (%)
5 ★	80	75	70	50
4 ★	70	60	50	40
3 ★	60	30	40	30
2 ★	50	25	30	20
1 ★	40	15	20	10

Figure 2.6: Scoring of ASEAN NCAP Rating Assessment for 2021 to 2025.

2.4Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a method of “measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales”.(Russo & Camanho, 2015) Thomas L. Saaty created it in the 1970s. It makes use of the human capacity to make wise decisions in the context of modest issues with a limited collection of relevant factors. AHP is a tool that combines qualitative and quantitative analysis. It develops a number of criteria and sub-criteria that can be used to contrast the various solutions to a problem. These criteria and sub-criteria are organised in a pair-wise correlation and hierarchical structure to make the criteria simpler to understand and evaluate at lower level. The comparisons can be made against an absolute scale or against one another. Saaty (1994) recommended a scale of 1 through 9, with 1 denoting equal relevance of each criterion to each other and 9 denoting extremely important. The matrix’s reciprocal values can be used to acquire the other half of the comparisons, leaving only half of the others to be made manually. It is relatively simple to perform these calculations using excel spreadsheets so long as certain conditions are met. As shown in Table 2.1, there are 33 articles where their objectives are evaluation of specific real cases. Out of 33 articles, there are 11 articles where the AHP method was adopted. Public Administration, education, telecommunication, Industrial Information Technology (IIT), defence, oil, textile, electronics, entertainment, and healthcare are the industries that implementing AHP method in selection and ranking problems. Evidently, AHP method present a wide variety of usage in the decision making scenario.

Like any other modelling techniques, AHP has its share of advantages and disadvantages. The use of the AHP technique has a number of benefits. One of the obvious advantages is its simplicity. The AHP's primary benefit is its ability to organize the rank possibilities according to the effectiveness in coping with contradictory objectives.(Binti & Adnan, 2016) AHP is acknowledged for its consistency and adaptability in the face of modifications to and additions to the hierarchy. Furthermore, the method is able to rank criteria according to the opinion of the respondent which leads to more specific scoring standard. Hence, ASEAN NCAP can refer the opinion of the automotive industry regarding the vehicle safety by using the criteria hierarchy and thus able to restructure the scoring standards of the rating assessment.

Despite the AHP's popularity, there are certain problems with its methods. While using AHP or any of its variations, there have been certain instances of ranking abnormalities. When a copy or nearly copy of the existing choice is added to the evaluated alternatives, rank reversal may take place.(Binti & Adnan, 2016) AHP also needs for information in light of experience, expertise, and some deliberation, some of which may be personal to each decision-maker.

Table 2.1: References selected in systematic review of literature. (Russo & Camanho, 2015)

Id	Journal	Year	Problem type	Industry, function or system	Criteria source	Scale	Group judgment	Technique used
[9]	1	2005	Selection	IIT Industry	Organizational team and experts	AHP (9)	AIP#	AHP
[10]	2	2006	Selection	Public Administration	Organizational team	AHP (9)	AIJ	AHP
[11]	1	2008	Selection	Manufacturing industry	Organizational team	Fuzzy (5)	AIP#	FAHP
[12]	1	2009	Selection	Defense Industry	External expert team	AHP (9)	AIP#	AHP - TOPSIS
[13]	1	2009	Selection	Shipping industry	Literature	Fuzzy (5)	AIJ	FAHP
[14]	1	2009	Selection	Textile Industry	Organizational team and literature	Fuzzy (5)	AIJ#	FAHP
[15]	1	2010	Selection	Oil Industry	Organizational team	AHP (9)	AIJ#	AHP - FTOPSIS
[16]	1	2011	Selection	Textile Industry	Literature	AHP (9)	AIJ#	AHP - GRA

Id	Journal	Year	Problem type	Industry, function or system	Criteria source	Scale	Group judgment	Technique used
[17]	1	2011	Selection	Washing Machine industry	Organizational team and literature	Fuzzy (5)	AIP	FAHP
[18]	1	2011	Selection	Public Administration	Organizational team	Fuzzy (9)	AIJ	FAHP - VIKOR
[19]	1	2012	Selection	Public Administration	Literature and experts	Fuzzy (5)	AIJ#	FAHP
[20]	1	2012	Selection	Electronics industry	Organizational team	Fuzzy (9)	QFD (HOQ)	QFD-FAHP
[21]	1	2012	Selection	Shipping industry	External Expert team	Fuzzy (5)	AIJ	FAHP
[22]	1	2014	Selection	Airline industry	Literature	Fuzzy (9)	AIP#	FAHP
[23]	5	2007	Ranking	Manufacturing industry	Organizational team	Fuzzy#	AIJ#	FAHP
[24]	1	2008	Ranking	Electronics industry	External expert team	Fuzzy (9)	AIP#	FAHP
[25]	1	2010	Ranking	Electronics industry	Organizational team and experts	Fuzzy (9)	AIJ#	FAHP - Max-Min
[26]	1	2010	Ranking	Electronics industry	External expert team	Fuzzy (9)	AIP	FAHP - FTOPSIS
[27]	1	2011	Ranking	Education	Literature and experts	AHP (9)	AIJ	AHP
[28]	1	2011	Ranking	Public Administration	Literature	Fuzzy (9)	AIJ#	FAHP - ELECTRE
[29]	1	2012	Ranking	Healthcare Industry	Literature	Fuzzy (5)	AIJ#	FAHP - FTOPSIS
[30]	3	2012	Ranking	Telecommunications	Organizational indicators	AHP (9)	AIJ#	AHP
[31]	4	2012	Ranking	Education	Literature and experts	Fuzzy (5)	AIJ#	FAHP - COPRAS
[32]	5	2008	Ranking indicators	Education	Organizational team	AHP (5)	AIJ e AIP	AHP
[33]	5	2008	Ranking indicators	Public Administration	Literature and experts	Fuzzy#	AIP	FAHP
[34]	1	2008	Ranking indicators	Manufacturing industry	Literature and experts	Fuzzy (9)	AIP	FAHP
[35]	1	2009	Ranking indicators	Electronics industry	Literature	AHP (9)	AIP#	ANP-AHP
[36]	1	2010	Ranking indicators	Oil Industry	Literature and experts	Fuzzy (9)	SAM	FAHP
[37]	1	2010	Ranking indicators	Entertainment Industry	Literature and experts	Fuzzy (5)	AM	FAHP
[38]	1	2011	Ranking indicators	Entertainment Industry	Literature and experts	AHP (5)	AIJ#	AHP
[39]	1	2011	Ranking indicators	Manufacturing industry	Literature	Fuzzy (9)	AIP#	AHP and FAHP and FTOPSIS
[40]	1	2013	Ranking indicators	ICT industry	Literature	Fuzzy (6)	AIJ#	FAHP
[41]	6	2015	Ranking indicators	Healthcare Industry	Literature	AHP (9)	AIJ#	AHP

2.5 Innovative Accident-Avoidance Technology

2.5.1 Development of GPS & GSM Based Advanced System for Tracking Vehicle Speed Violations and Accidents

Most of the time, fatality in road accidents is due to delays in getting medical assistance. A. Om Venkat Pavan Kumar, D. Nandini, M. Manobi Sairam, et al. designed a system to reduce fatalities in road accidents. This can be done by reminding the driver about the speed limit and providing quicker emergency first aid services if there is an accident occurred.

According to Figure 2.7, two modules are used in the system: the Global Positioning System (GPS) module and the Global System for Mobile Communications (GSM) module. GPS module is used to provide coordinates of latitude and longitude of the vehicle. GSM module is used to transmit mobile voice and data services. The speedometer in this system conveys the speed of the vehicle. Then, the microcontroller can compare the vehicle's speed with the limit set by the traffic protocols. When the microcontroller detects that the driver is exceeding the speed limit, it will send a signal to the GSM module to send a message to remind the driver that he is speeding. A vibration sensor is also used in the system to detect a simulated accident.

Three scenarios were used in the experiment. Firstly, when the driver is driving within the speed limits set by the traffic protocol, the system will only display “Speed: Low” on the Liquid-crystal Displays (LCD) and no Short Message Service (SMS) is generated. When the driver exceeds the speed limits, but no accident happens, the LCD will display “Speed: High Vib: Off”. An SMS with the latitude and longitude information and “High Speed” will be generated and sent to the phone number linked to the GSM module. Lastly, when the driver violates the speed limit and an accident happens, the LCD will display “Speed: High Vib: ON”. An SMS with positional information and “Accident Occurred” will be sent to the linked phone number. This system will help provide faster emergency first aid rescues. (Om Venkat Pavan Kumar et al., 2021)

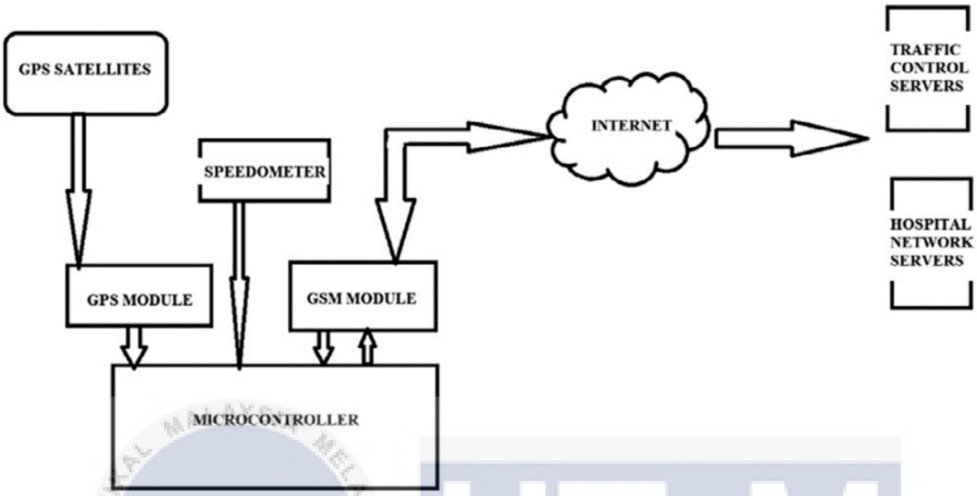


Figure 2.7: Block Diagram of the system. (Om Venkat Pavan Kumar et al., 2021)

2.5.2 Assessment of The Safety Benefits of Vehicles' Advanced Driver Assistance, Connectivity, and Low-level Automation System

Connected vehicle technology (CV) and driving assistance technology (DA) are believed to bring benefits to traffic safety. These technologies will inform a vehicle about the information around it, such as the position and speed of a nearby vehicle and the traffic condition of the road. By CV & DA technology, they can help to take over the vehicle when it is going to face an accident. Examples of CV & DA technology are Forward Collision Warning (FCW), Autonomous Emergency Braking (AEB), Autobrake, Blind Spot Warning (BSW), and Lane Departure Warning (LDW), Lane Change Warning (LCW), and Collision Mitigation Brake System (CMBS).

Three types of estimation are used in research. First, SAM is the statistical analysis methodology that uses the real cases for vehicles equipped with and without CV & DA technology. However, some under-tested technologies have not been put on the market. Therefore, researchers often use the other two estimation methods, FOT and SIM. FOT means field operation test. It is a crash-occurrence-based estimation method. The types of crashes include crash-event, near-crash event, or severe crash event that happens in the real world. These number of events will be used to calculate the effectiveness of CV & DA technology. Lastly, SIM stands for safety impact methodology. The difference between FOT and SIM is that SIM is a crash-probability-based estimation method. It is simulation and virtual. The estimation is done by using crash-defined kinematic equations, and some parameters with random number distribution. Figure 2.8 shows that the highest crash avoidance effectiveness of CV & DA technology is almost 70% and the lowest is 10%. (Yue et al., 2018) This has proven that CV & DA technology is effective in avoiding road accidents.

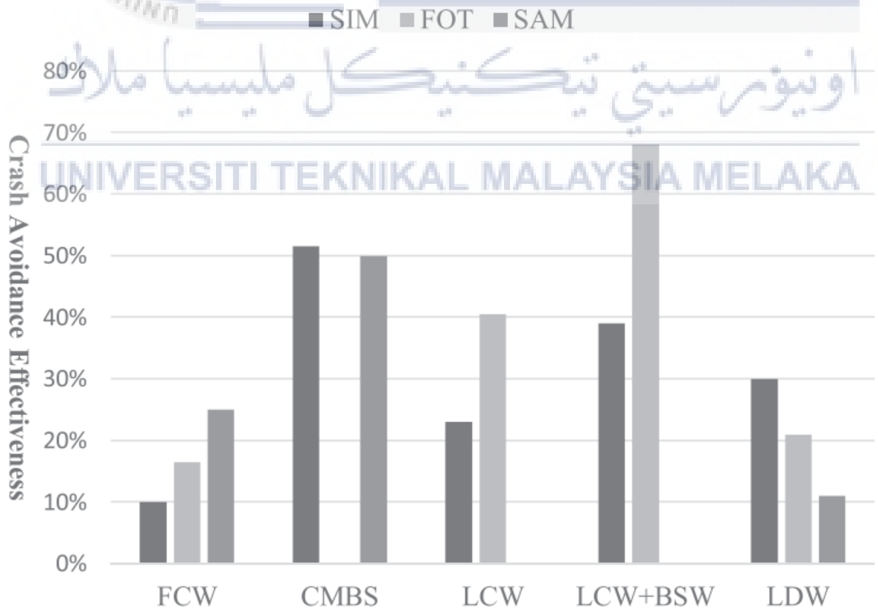


Figure 2.8: Crash Avoidance Effectiveness of CV & DA technology estimated by using different methodologies. (Yue et al., 2018)

2.5.3 Intelligent Advice System for Human Drivers to Prevent Overtaking Accidents on The Road

Miscalculation and misjudgement of Time-to-Collision (TTC) during overtaking manoeuvres can lead to road accidents. Many researchers are trying to solve this problem. One of the solutions is using a vehicle-to-vehicle (V2V) based collision avoidance system. (Shunmuga Perumal et al., 2022) Exchange of information such as velocity and location with other vehicles can help in calculating the TTC. However, this requires both vehicles equipped with the wireless networking infrastructure. There is half a portion of the vehicles in the market nowadays are not capable of this function. In addition, this system does not provide advice for drivers with accurate TTC calculations.(Shunmuga Perumal et al., 2022) Due to these restrictions, P. Shunmuga Perumal et al. have proposed Intelligent Overtaking Advice System (IOAS) as an alternate solution. (Shunmuga Perumal et al., 2022)

An overtaking scenario with Ego vehicle (EGV), Lead vehicle – Front (LVF), and Lead Vehicle – Opposite (LVO) is shown in Figure 2.9. When EGV is overtaking LVF, there is a potential risk that EGV will collide with LVF or LVO due to a miscalculation of TTC. IOAS is functioning by converting the distance information provided by the virtual LiDAR sensor into TTC and advice for overtaking. It consists of two important modules: Velocity Net (VNet) and Time-to-Collision Net (TTC-Net). In every second, the virtual LiDAR sensor sends the distance between EGV and LVF/LVO. From Figure 2.10, VNet enables the EGV to calculate the TTC between EGV and LVF/LVO by using the following equations:

Equation 1: $$V_{EGV} = \frac{x_i}{t_i}$$

Equation 2: $$x_i = V_i \times t_i$$

Equation 3: $$D_i = y_i + D_{i+1} + x_i, where\ i = 1,2,3, \ldots, TTC - 1$$

$$y_i = D_i - D_{i+1} - x_i$$

Equation 4: $$V_{LVO} = \frac{y_i}{t_i}$$

The velocity predicted by VNet and the initial distance between EGV and LVO is provided to TTC-Net to predict the TTC. When the velocity of EGV, LVF, and LVO is between 45 km/s to 60 km/h, Shunmuga Perumal et al. found out that 10 seconds of threshold TTC is safe for a human driver to complete an overtaking action. IOAS will show "OT" (Overtake) to the driver when the estimated TTC is larger than 10 seconds, and "NOT" (No Overtake) when it is not. The accuracy of the velocity of LVO and TTC values is 97% and 98% respectively. (Shunmuga Perumal et al., 2022)

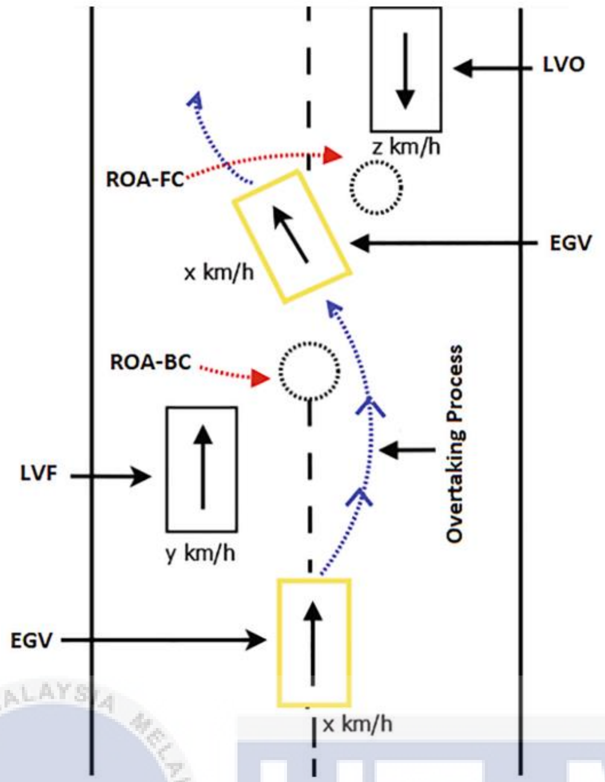


Figure 2.9: Overtaking scenario with EGV, LVF, and LVO.

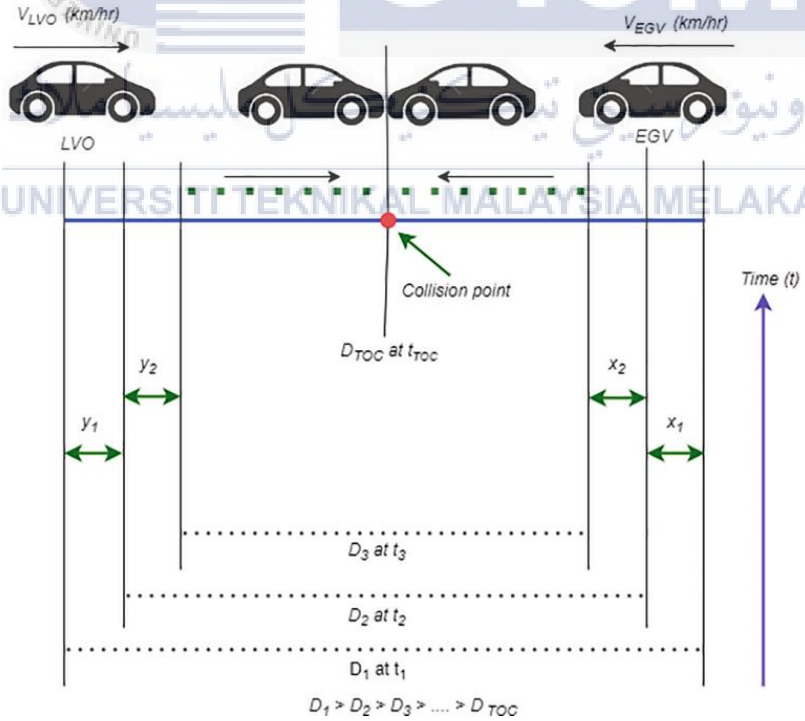


Figure 2.10: Displacement of LVO and EGV over time.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The methodology is a body of methods, rules, and presume used by a discipline. It includes the analysis of the principles or procedures explored in previous research. An ideology that combines the theories, ideas, concepts, techniques, and procedures used to identify and analyze the objective of the research is recorded in the methodology.

In this chapter, the research design and method are highlighted. Data collection from specific methods is required in this research. Certain techniques to identify and select information are used to understand and solve the problem of the research. This research study is divided into three phases. The first phase is the literature review used to identify the knowledge and information related to the research on current trends. Several key themes are examined, including road accident rate, type of vehicles involved in road accidents, road fatalities by mode, AHP, and innovative road accidents-avoidance technologies,

The second phase is the design process of the survey to be distributed to the respondent. The objective of this survey is to collect opinions about the weighting of the ASEAN NCAP rating assessment from the respondent. The respondent should have considerable knowledge about vehicle safety. The survey is distributed in the simplest way to ease the respondent to complete the survey.

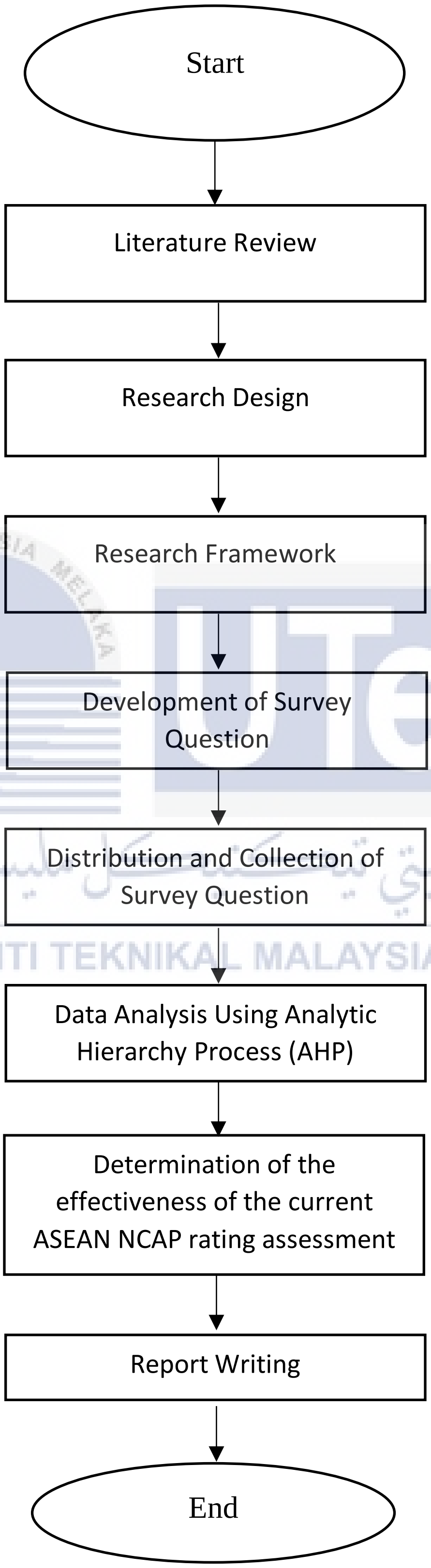
Lastly, after receiving the results from the respondent, the last phase includes the analysis of the data collected. The data collected will be analyzed using AHP. Weighting of the ASEAN NCAP can be determined after the analysis of data. Consequently, the effectiveness of the current ASEAN NCAP rating assessment can be determined.

3.2 Research Design

In this study, incompatible of current ASEAN NCAP rating assessment weighting with the road accident statistic is the main problem. There is a need to determine the effectiveness of the current ASEAN NCAP rating assessment. AHP is used in this study to determine the priority of each item in the pillars of ASEAN NCAP in terms of safety. This study implements quantitative approaches for the data collection which is the respondent's preference on each item in the pillars of ASEAN NCAP. The preference of the respondent is collected in a scale of one to nine. After that, these scales will be analysed. To ensure the reliability of the data, background of the respondent is collected too. Data were collected using an open-ended project selection survey form. Name, age, company name, gender, driving experience, designation, nationality, and preference on the item in the pillars of ASEAN NCAP were collected. The survey form will be distributed through internet for the ease of the respondent to complete it. After the data is collected, it will be analysed by AHP method. The result is then compared with the current weighting of ASEAN NCAP rating assessment for its effectiveness.

3.3 Research Framework

3.3.1 Methodology Schematic Diagram



3.3.2 Selection of criteria

ASEAN NCAP rating assessment for 2021 to 2025 was used in this study. They were Frontal (Adult), Side (Adult). Head Protection Technology (HPT) Evaluation, Frontal (Child), Side (Child), Child Restraint System (CRS) installation, Vehicle Based Assessment, Child Presence Detection, Effective Braking and Avoidance (EBA), Seatbelt Reminder (SBR) Front, Seatbelt Reminder (SBR) Rear, Seatbelt Reminder (SBR) Rear Advanced, Autonomous Emergency Braking (AEB) City, Autonomous Emergency Braking (AEB) Inter Urban, Advanced Safety Assists Technologies (SAT), Blind Spot Detection/ Blind Spot Visualization, Rear View Technology, Auto High Beam (AHB), Pedestrian Protection, and Advanced Motorcyclist Safety Technologies (MST). The hierarchical framework is constructed and shown in Figure 3.1.

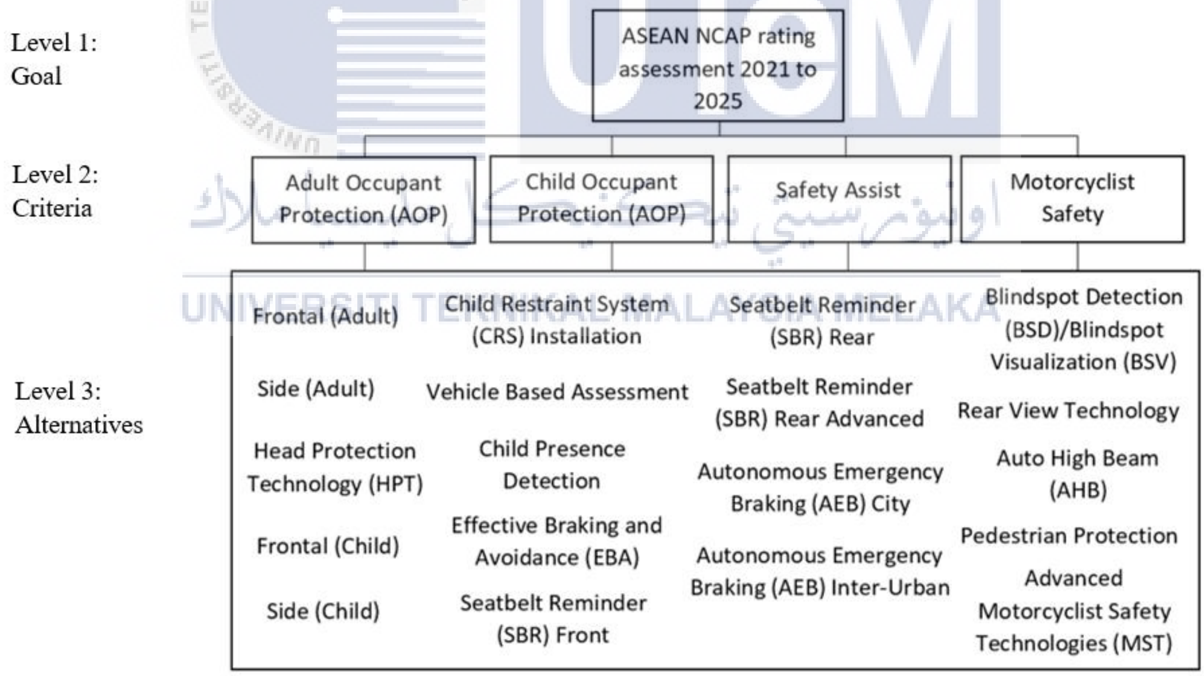


Figure 3.1: Hierarchical Framework.

3.3 Development of Survey

A set of survey form (Appendix A) was prepared to collect data. The respondents of the decision-maker were required to make a pair-wise comparison for indicating an appropriate degree of importance of each pair of the selection criteria. Then, the respondents were asked for indicating a preference for the alternatives set against the respective selection criteria. The respondents compared the selection criteria shown on the left with another indicated at the top. The importance scale for pairwise comparison analysis as the table shown in Table 3.1. The data collected were then used for AHP analysis (details in Chapter 4).

Table 3.1: Importance Scale for pairwise comparison analysis.

Preference	Numerical Rating
Extremely more important	9
Very strongly more important	7
Strongly more important	5
Moderately more important	3
Equally Important	1
Intermediate values between two adjacent judgements	2,4,6,8
Reciprocals for inverse comparison	Reciprocals

3.4 Distribution of Survey Question

The survey is conducted using *Google Forms*. 24 respondents are answering this survey. This survey is used to collect data and analyse the respondents' preferences. The *Google Form* is distributed through social media such as Email, *Facebook* and *WhatsApp*. The target respondents are individual that has considerable knowledge about road and vehicle safety. This is done by distributing the survey question to the automotive industry worker and policy maker.

3.5 Data Analysis Using Analytic Hierarchy Process (AHP)

The following step is to estimate the relative weight (priority) element of the results using data collected. These weights represented a decision maker for any judgment on the relative importance or preferences of the elements in the hierarchy (Saaty, 1994). This is a called pair-wise comparison. The eigenvector and the weighted a score of each alternative were computed with the help of Microsoft Office Excel programme before the ranking of the item in pillars of ASEAN NCAP rating assessment was made. The detail data analysis is described in Chapter 4. The following steps are carried out: The first step is to measure how much important a criterion that the other criterion, AHP used a scale with the values from 1 to 9. This action is done by the respondent by using the importance scale in Table 3.1. Next, produced a normalized matrix on the pairwise comparison by adding the value of each matched pair matrix column then dividing each value from the column with the sum of the corresponding columns to obtain the normalization of the matrix.

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}} \qquad (1)$$

Calculates the weight of synthesis by adding up all the columns in a row from the matrix's comparison normalisation result.

$$\Sigma \text{ column} = k1 + k2 + k3 + \ldots + kn$$

(2)

Then, calculates the eigenvalues by multiplying each of the matched matrix columns in the same row, then being lifted by an existing criterion number.

$$\boldsymbol{\lambda_1 = (k1 \times k2 \times k3 \times \ldots \times kn)^{\frac{1}{n}}}$$

(3)

Next, calculates the priority weight of each criterion by means of the eigenvalues for each criterion divided by the total number of eigenvalues. Calculates the importance of each criterion by dividing the weight of synthesis by priority weight. Following by calculating the maximum eigen value (λmax) by dividing the total number of importance values by the number of criteria. Besides, Measures the consistency of use to ensure that judgment for decision making is of high consistency.

$$CI = \frac{(\lambda\, max - n)}{n}$$

(4)

where: **CI** = Consistency Index **λ *max*** = Maximum eigenvalue

n = Number of elements

Lastly, check for consistency in the hierarchy provided that if the consistency ratio (CI / IR) is less than or equal to 0.1 then the result of the calculation is declared true.

$$\boldsymbol{CR = \frac{CI}{RI}}$$

(5)

where: **CR** = Consistency Ratio **CI** = Consistency Index

RI = Index Random Consistency

The Index Random Consistency can be gotten from Table 3.2.

Table 3.2: Index Random Consistency (Levon R. Hayrapetyan, 2019)

Matrix Size	3	4	5	6	7	8	9	10
RI	0.52	0.89	1.13	1.25	1.35	1.43	1.47	1.50
Matrix Size	11	12	13	14	15	16	17	18
RI	1.53	1.54	1.56	1.57	1.59	1.60	1.61	1.61
Matrix Size	19	20	21	22	23	24	25	26
RI	1.62	1.63	1.63	1.64	1.65	1.65	1.66	1.66

3.6 Determination the effectiveness of the current ASEAN NCAP rating assessment

The priority weightage of current ASEAN NCAP rating assessment is calculated by dividing the max score of the item over the total score of the pillar and multiply it with the weighting of the pillar.

$$priority\ weightage = \left(\frac{max\ score\ of\ item}{total\ score\ of\ pillar}\right) \times weighting\ of\ pillar \qquad (6)$$

The priority weightage will be ranked accordingly in Table 3.3 and will be compared with the result of the AHP analysis to determine its effectiveness.

Table 3.3: Ranking of the current ASEAN NCAP rating assessment.

No	**Item**	Max score	Priority Weightage	Rank
1	Front (Adult)	16	0.200	1
2	Side (Adult)	8	0.100	2
3	Head Protection Technology (HPT)	8	0.100	2
4	Blindspot Detection/ Blindspot Visualization	8	0.100	2
5	Front (Child)	16	0.063	5
6	Effective Braking and Avoidance	6	0.057	6
7	Vehicle Based Assessment	13	0.051	7
8	Rear View Technology	4	0.050	8
9	Child Restraint System (CRS) Installation	12	0.047	9
10	Autonomous Emergency Braking (Inter-Urban)	3.5	0.033	10
11	Side (Child)	8	0.031	11
12	Seatbelt Reminder (Front)	3	0.029	12
13	Advanced Safety Assist Technologies	3	0.029	12
14	Auto High Beam	2	0.025	14
15	Pedestrian Protection	2	0.025	14
16	Advanced Motorcyclist Safety	2	0.025	14
17	Autonomous Emergency Braking (City)	2.5	0.024	17
18	Seatbelt Reminder (Rear)	1.5	0.014	18
19	Seatbelt Reminder (Rear) Advanced	1.5	0.014	18
20	Child Presence Detection	2	0.008	20

CHAPTER 4

RESULT AND DISCUSSION

4.1 The Respondents

To understand the opinion of the automotive industry, this study included people who were related to the automotive safety department and policymakers. The survey's results covered a wide range of factors, including age, gender, designation, and nationality. Table 4.1 shows the demographic profile of the survey respondents.

There were twenty-four respondents are involved in this research. The respondents were between 22 to 50 years old. Only thirty-three point three three per cent of the respondents fell in the age group of above 39. This result is expected as the elderly are more willing to answer the survey in the traditional way which is with a hardcopy. The elderly acknowledged that they lacked experience with more sophisticated smartphones, but when asked if they would be interested in using one if instructions were provided, they appeared hesitant and unsure of themselves. They asserted that they were too elderly to learn, and even if they did, mild dementia would cause them to forget how to use it over time. (H. M. Mohadisdudis & N. M. Ali, 2014)

The respondents were mostly male in the gender category (79.17%). According to a study by Lawrence A, the automotive industry is still male dominated. There is only 23.6 percent of female workers employed by automotive manufacturers. (Lawrence, n.d.) The designation of the respondents was equally distributed. Twelve of them are automotive industry workers and come from Perodua. Perodua is a car manufacturer that is established in 1993. Many cars that manufactured by Perodua have been awarded 5-star in ASEAN NCAP. It shows that Perodua is the expertise in vehicle safety. The other twelve respondents are policymakers and come from Malaysia Road Transport Department or known as Jabatan Pengangkutan Jalan (JPJ) Malaysia. JPJ is a government agency that handles all transportation matters in Malaysia

– providing services to ensure prudent drivers, safe vehicles, and the management of licenses nationwide. (Sangfor Technologies, n.d.) With the experiences and specialized field JPJ has, it is compatible to capture the preference of the items in ASEAN NCAP rating assessment and compare it with the current rating assessment. In order to capture the precise opinions and suggestions of the study, the nationality of all the respondents is Malaysian. Malaysia is one of the members of ASEAN. Therefore, when the respondents are answering the survey, the traffic conditions of the ASEAN countries were referred. The responses of this group of respondents were compatible and reliable in this study.

Table 4.1: Demographic profile of survey respondents.

Independent variables	**Level**		**Percentage (%)**
Age Group	1	22 - 39	66.67
	2	Above 39	33.33
Gender	1	Male	79.17
	2	Female	20.83
Designation	1	Automotive Industry Worker	50.00
	2	Policymakers	50.00
Nationality	1	Malaysian	100
	2	Non-Malaysian	0

4.2 AHP analysis

The 20 identified selection alternatives were given weights, primarily using the AHP approach. These criteria and sub-criteria are organised in a pair-wise correlation and hierarchical structure to make the criteria simpler to understand and evaluate at lower level. The analysis was done by using Microsoft Office Excel programme.

4.2.1 Pair-wise Comparison

An AHP method was used to perform pairwise comparison among the defined goal, the criteria, and the alternatives within the Hierarchical Framework built in Figure 3.1. The pair-wise comparisons were used to define the order of importance for each criterion. A pair-wise comparison matrix was created from the tabulated data to evaluate the criterion. The criteria and alternatives were presented in Table 4.2 and Table 4.3.

Table 4.2: List of Criteria.

Criteria	
Adult Occupant Protection	AOP
Child Occupant Protection	COP
Safety Assist	SA
Motorcyclist Safety	MS

Table 4.3: List of Alternatives.

Alternatives	
Front (Adult)	FA
Side (Adult)	SA
Head Protection Technology (HPT)	HPT
Front (Child)	FC
Side (Child)	SC
Child Restraint System (CRS) Installation	RSI
Vehicle Based Assessment	VBA
Child Presence Detection	CPD
Effective Braking and Avoidance	EBA
Seatbelt Reminder (Front)	SRD
Seatbelt Reminder (Rear)	SRR
Seatbelt Reminder (Rear) Advanced	SRA
Autonomous Emergency Braking (City)	AEB
Autonomous Emergency Braking (Inter-Urban)	AEI
Advanced Safety Assist Technologies	AST
Blindspot Detection/ Blindspot Visualization	BSD
Rear View Technology	RVT
Auto High Beam	AHB
Pedestrian Protection	PPR
Advanced Motorcyclist Safety Technologies	AMS

Many researchers recommended using geometric mean rather than arithmetic mean for aggregation between actors for group decisions. Compute the priority matrix for each survey response first then make a geometric average to aggregate the results.(Kardi, n.d.) After calculating the geometric mean for the responses of the respondent. The pair-wise comparison matrix of alternatives of Automotive Industry Worker and Policymakers were made and shown in Table 4.4 and 4.5. The pair-wise comparison matrix of criteria of both perceptions were shown in Table 4.6 In the pair-wise comparison matrix, the diagonal elements are normally equal to one, and the lower triangle elements of the matrix are the reciprocal of the elements of the upper triangle. (Zahedi, 1986) The sum of the columns was calculated at the last row of the tables.

Table 4.4: Pair-wise comparison – Automotive Industry Worker perceptions.

	FA	SA	HPT	FC	SC	RSI	VBA	CPD	EBA	SRD	SRR	SRA	AEB	AEI	AST	BSD	RVT	AHB	PPR	AMS
FA	1.00	3.76	3.76	1.94	3.58	1.85	5.06	2.17	2.35	2.20	2.08	2.80	1.67	1.71	2.16	2.45	2.55	1.82	2.07	4.07
SA	0.27	1.00	2.50	1.59	2.96	2.11	3.93	2.25	1.72	2.54	3.56	3.74	1.98	2.02	2.22	2.13	2.72	2.40	1.62	2.45
HPT	0.27	0.40	1.00	1.99	2.70	1.69	2.17	1.98	1.04	1.59	1.86	1.66	1.29	1.48	1.45	1.98	1.77	2.61	2.48	4.43
FC	0.52	0.63	0.50	1.00	1.98	1.82	3.00	2.41	2.40	2.66	2.22	1.87	2.33	2.37	1.68	3.07	2.70	3.20	1.88	3.05
SC	0.28	0.34	0.37	0.50	1.00	2.01	2.68	2.33	1.35	2.23	2.27	2.38	1.86	2.13	2.68	2.55	2.14	2.80	3.58	3.07
RSI	0.54	0.47	0.59	0.55	0.50	1.00	3.56	1.95	1.37	1.97	2.82	2.80	1.62	1.46	1.32	2.23	2.72	3.48	3.34	3.03
VBA	0.20	0.25	0.46	0.33	0.37	0.28	1.00	1.77	1.12	1.37	1.42	1.18	0.95	1.23	1.52	1.19	1.37	1.47	2.01	2.11
CPD	0.46	0.44	0.50	0.41	0.43	0.51	0.56	1.00	1.82	1.81	1.98	1.72	1.04	1.15	1.45	1.50	2.08	2.05	1.70	3.66
EBA	0.43	0.58	0.96	0.42	0.74	0.73	0.89	0.55	1.00	2.14	2.68	2.33	1.51	1.70	1.15	3.41	3.93	3.98	3.15	3.34
SRD	0.45	0.39	0.63	0.38	0.45	0.51	0.73	0.55	0.47	1.00	3.18	2.26	1.70	1.58	1.24	1.71	1.51	1.90	2.50	2.38
SRR	0.48	0.28	0.54	0.45	0.44	0.35	0.70	0.50	0.37	0.31	1.00	2.43	0.99	0.97	1.18	2.10	1.79	2.30	1.90	2.04
SRA	0.36	0.27	0.60	0.53	0.42	0.36	0.84	0.58	0.43	0.44	0.41	1.00	1.15	0.91	0.83	1.25	1.16	1.70	1.23	1.10
AEB	0.60	0.50	0.78	0.43	0.54	0.62	1.06	0.96	0.66	0.59	1.01	0.87	1.00	3.13	1.51	1.70	3.53	2.02	1.76	2.01
AEI	0.59	0.49	0.67	0.42	0.47	0.68	0.82	0.87	0.59	0.63	1.03	1.10	0.32	1.00	1.71	2.22	1.94	3.25	1.66	1.73
AST	0.46	0.45	0.69	0.59	0.37	0.75	0.66	0.69	0.87	0.81	0.85	1.20	0.66	0.59	1.00	3.11	2.20	2.80	2.48	3.84
BSD	0.41	0.47	0.50	0.33	0.39	0.45	0.84	0.66	0.29	0.59	0.48	0.80	0.59	0.45	0.32	1.00	3.27	2.28	2.19	2.78
RVT	0.39	0.37	0.56	0.37	0.47	0.37	0.73	0.48	0.25	0.66	0.56	0.86	0.28	0.52	0.45	0.31	1.00	2.14	1.54	2.43
AHB	0.55	0.42	0.38	0.31	0.36	0.29	0.68	0.49	0.25	0.53	0.44	0.59	0.49	0.31	0.36	0.44	0.47	1.00	1.69	1.57
PPR	0.48	0.62	0.40	0.53	0.28	0.30	0.50	0.59	0.32	0.40	0.53	0.81	0.57	0.60	0.40	0.46	0.65	0.59	1.00	3.22
AMS	0.25	0.41	0.23	0.33	0.33	0.33	0.47	0.27	0.30	0.42	0.49	0.91	0.50	0.58	0.26	0.36	0.41	0.64	0.31	1.00
Total	8.97	12.56	16.64	13.42	18.78	17.01	30.89	23.07	18.98	24.90	30.86	33.32	22.50	25.88	24.90	35.17	39.93	44.42	40.08	53.30

Table 4.5: Pair-wise comparison – Policymakers' perceptions.

	FA	SA	HPT	FC	SC	RSI	VBA	CPD	EBA	SRD	SRR	SRA	AEB	AEI	AST	BSD	RVT	AHB	PPR	AMS
FA	1.00	2.65	1.55	1.59	1.59	1.75	3.09	2.52	1.52	3.36	3.51	3.51	1.44	1.44	1.48	1.69	3.15	3.48	4.04	1.58
SA	0.38	1.00	1.54	1.18	1.12	1.09	1.97	1.65	1.27	3.44	3.27	3.34	0.98	1.07	1.27	1.73	1.82	4.52	2.02	1.58
HPT	0.65	0.65	1.00	0.59	0.71	1.35	2.10	1.58	1.07	4.30	3.58	3.58	1.15	1.26	1.18	1.38	2.19	4.69	1.97	1.73
FC	0.63	0.85	1.70	1.00	2.19	1.78	2.23	1.73	0.98	4.15	4.55	4.07	1.20	1.20	1.65	2.22	2.94	6.30	2.98	1.86
SC	0.63	0.89	1.41	0.46	1.00	2.57	2.23	1.66	1.12	5.10	5.58	5.58	1.59	1.59	1.52	2.03	2.32	4.55	2.28	2.25
RSI	0.57	0.92	0.74	0.56	0.39	1.00	1.34	2.00	1.15	3.31	3.31	4.33	1.28	1.32	1.70	1.94	2.61	5.28	2.23	1.85
VBA	0.32	0.51	0.48	0.45	0.45	0.74	1.00	1.55	0.91	1.82	1.82	1.82	1.04	1.07	0.98	1.42	2.33	4.19	1.86	1.18
CPD	0.40	0.61	0.63	0.58	0.60	0.50	0.65	1.00	0.74	1.97	1.97	1.88	0.70	0.68	0.73	0.74	1.19	2.08	0.94	0.71
EBA	0.66	0.79	0.93	1.02	0.89	0.87	1.10	1.34	1.00	5.24	5.24	5.24	1.91	1.75	2.04	2.70	3.46	6.16	3.71	2.94
SRD	0.30	0.29	0.23	0.24	0.20	0.30	0.55	0.51	0.19	1.00	2.35	2.35	0.91	0.91	1.18	1.12	1.51	2.98	1.76	1.26
SRR	0.29	0.31	0.28	0.22	0.18	0.30	0.55	0.51	0.19	0.43	1.00	1.55	0.62	0.62	0.61	0.73	0.80	1.37	1.28	0.71
SRA	0.29	0.30	0.28	0.25	0.18	0.23	0.55	0.53	0.19	0.43	0.65	1.00	0.55	0.55	0.52	0.53	0.61	1.00	0.74	0.52
AEB	0.69	1.02	0.87	0.83	0.63	0.78	0.96	1.43	0.52	1.10	1.61	1.81	1.00	2.70	1.15	1.15	2.57	3.63	2.61	3.09
AEI	0.69	0.93	0.79	0.83	0.63	0.76	0.93	1.47	0.57	1.10	1.61	1.81	0.37	1.00	1.41	1.32	1.86	3.63	2.08	1.58
AST	0.67	0.79	0.85	0.61	0.66	0.59	1.02	1.37	0.49	0.85	1.65	1.92	0.87	0.71	1.00	1.77	3.71	4.52	2.82	3.39
BSD	0.59	0.58	0.72	0.45	0.49	0.52	0.70	1.34	0.37	0.89	1.37	1.88	0.87	0.76	0.56	1.00	3.71	4.78	2.45	3.24
RVT	0.32	0.55	0.46	0.34	0.43	0.38	0.43	0.84	0.29	0.66	1.25	1.64	0.39	0.54	0.27	0.27	1.00	3.44	1.57	1.23
AHB	0.29	0.22	0.21	0.16	0.22	0.19	0.24	0.48	0.16	0.34	0.73	1.00	0.28	0.28	0.22	0.21	0.29	1.00	0.85	0.45
PPR	0.25	0.49	0.51	0.34	0.44	0.45	0.54	1.07	0.27	0.57	0.78	1.35	0.38	0.48	0.35	0.41	0.64	1.18	1.00	1.02
AMS	0.63	0.63	0.58	0.54	0.44	0.54	0.84	1.41	0.34	0.79	1.41	1.94	0.32	0.63	0.30	0.31	0.81	2.22	0.98	1.00
Total	10.24	14.97	15.75	12.22	13.44	16.70	23.02	26.00	13.36	40.83	47.25	51.60	17.87	20.57	20.11	24.67	39.52	71.00	40.18	33.18

Table 4.6: Pair-wise comparison – Both perceptions.

	AOP	COP	SA	MS
AOP	1.00	2.84	2.18	1.42
COP	0.35	1.00	2.10	1.33
SA	0.46	0.48	1.00	0.49
MS	0.70	0.75	2.03	1.00
Total	2.51	5.07	7.31	4.24

4.2.2 Weight of Synthesis and Eigenvector

The pair-wise comparison matrix for the selection criterion was then used to generate the normalised relative weight matrix. As a result, the weight of synthesis, WS was determined. The column totals were first calculated using the data gathered in Table 4.4, Table 4.5 and Table 4.6, in order to perform matrix normalisation. The weight of synthesis was shown in Table 4.7, Table 4.8 and Table 4.9.

Table 4.7: Normalised Relative Weight – Automotive Industry Worker.

	FA	SA	HPT	FC	SC	RSI	VBA	CPD	EBA	SRD	SRR	SRA	AEB	AEI	AST	BSD	RVT	AHB	PPR	AMS	WS
FA	0.111	0.300	0.226	0.145	0.191	0.109	0.164	0.094	0.124	0.089	0.067	0.084	0.074	0.066	0.087	0.070	0.064	0.041	0.052	0.076	2.232
SA	0.030	0.080	0.150	0.119	0.158	0.124	0.127	0.098	0.091	0.102	0.115	0.112	0.088	0.078	0.089	0.060	0.068	0.054	0.040	0.046	1.829
HPT	0.030	0.032	0.060	0.149	0.144	0.099	0.070	0.086	0.055	0.064	0.060	0.050	0.057	0.057	0.058	0.056	0.044	0.059	0.062	0.083	1.376
FC	0.057	0.050	0.030	0.075	0.105	0.107	0.097	0.105	0.126	0.107	0.072	0.056	0.104	0.091	0.068	0.087	0.068	0.072	0.047	0.057	1.582
SC	0.031	0.027	0.022	0.038	0.053	0.118	0.087	0.101	0.071	0.090	0.073	0.071	0.083	0.082	0.108	0.073	0.054	0.063	0.089	0.058	1.392
RSI	0.060	0.038	0.036	0.041	0.027	0.059	0.115	0.085	0.072	0.079	0.091	0.084	0.072	0.057	0.053	0.064	0.068	0.078	0.083	0.057	1.318
VBA	0.022	0.020	0.028	0.025	0.020	0.017	0.032	0.077	0.059	0.055	0.046	0.036	0.042	0.047	0.061	0.034	0.034	0.033	0.050	0.040	0.778
CPD	0.051	0.035	0.030	0.031	0.023	0.030	0.018	0.043	0.096	0.073	0.064	0.052	0.046	0.044	0.058	0.043	0.052	0.046	0.042	0.069	0.948
EBA	0.048	0.046	0.058	0.031	0.039	0.043	0.029	0.024	0.053	0.086	0.087	0.070	0.067	0.066	0.046	0.097	0.098	0.090	0.079	0.063	1.218
SRD	0.051	0.031	0.038	0.028	0.024	0.030	0.024	0.024	0.025	0.040	0.103	0.068	0.075	0.061	0.050	0.049	0.038	0.043	0.062	0.045	0.907
SRR	0.054	0.022	0.032	0.034	0.023	0.021	0.023	0.022	0.020	0.013	0.032	0.073	0.044	0.038	0.047	0.060	0.045	0.052	0.047	0.038	0.739
SRA	0.040	0.021	0.036	0.040	0.022	0.021	0.027	0.025	0.023	0.018	0.013	0.030	0.051	0.035	0.033	0.036	0.029	0.038	0.031	0.021	0.591
AEB	0.067	0.040	0.047	0.032	0.029	0.036	0.034	0.042	0.035	0.024	0.033	0.026	0.044	0.121	0.060	0.048	0.088	0.046	0.044	0.038	0.934
AEI	0.065	0.039	0.041	0.032	0.025	0.040	0.026	0.038	0.031	0.025	0.033	0.033	0.014	0.039	0.069	0.063	0.049	0.073	0.041	0.033	0.809
AST	0.052	0.036	0.041	0.044	0.020	0.044	0.021	0.030	0.046	0.033	0.028	0.036	0.030	0.023	0.040	0.089	0.055	0.063	0.062	0.072	0.864
BSD	0.046	0.037	0.030	0.024	0.021	0.026	0.027	0.029	0.015	0.024	0.015	0.024	0.026	0.017	0.013	0.028	0.082	0.051	0.055	0.052	0.644
RVT	0.044	0.029	0.034	0.028	0.025	0.022	0.024	0.021	0.013	0.027	0.018	0.026	0.013	0.020	0.018	0.009	0.025	0.048	0.038	0.046	0.526
AHB	0.061	0.033	0.023	0.023	0.019	0.017	0.022	0.021	0.013	0.021	0.014	0.018	0.022	0.012	0.014	0.012	0.012	0.023	0.042	0.029	0.452
PPR	0.054	0.049	0.024	0.040	0.015	0.018	0.016	0.026	0.017	0.016	0.017	0.024	0.025	0.023	0.016	0.013	0.016	0.013	0.025	0.060	0.508
AMS	0.027	0.033	0.014	0.024	0.017	0.019	0.015	0.012	0.016	0.017	0.016	0.027	0.022	0.022	0.010	0.010	0.010	0.014	0.008	0.019	0.354
Total	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20.000

Table 4.8: Normalised Relative Weight – Policymakers.

	FA	SA	HPT	FC	SC	RSI	VBA	CPD	EBA	SRD	SRR	SRA	AEB	AEI	AST	BSD	RVT	AHB	PPR	AMS	WS
FA	0.098	0.177	0.098	0.130	0.119	0.105	0.134	0.097	0.114	0.082	0.074	0.068	0.081	0.070	0.074	0.068	0.080	0.049	0.100	0.048	1.865
SA	0.037	0.067	0.098	0.096	0.083	0.065	0.085	0.063	0.095	0.084	0.069	0.065	0.055	0.052	0.063	0.070	0.046	0.064	0.050	0.048	1.357
HPT	0.063	0.043	0.063	0.048	0.053	0.081	0.091	0.061	0.080	0.105	0.076	0.069	0.064	0.061	0.058	0.056	0.055	0.066	0.049	0.052	1.298
FC	0.061	0.057	0.108	0.082	0.163	0.107	0.097	0.067	0.073	0.102	0.096	0.079	0.067	0.058	0.082	0.090	0.074	0.089	0.074	0.056	1.682
SC	0.061	0.060	0.090	0.037	0.074	0.154	0.097	0.064	0.084	0.125	0.118	0.108	0.089	0.077	0.075	0.082	0.059	0.064	0.057	0.068	1.644
RSI	0.056	0.061	0.047	0.046	0.029	0.060	0.058	0.077	0.086	0.081	0.070	0.084	0.072	0.064	0.084	0.079	0.066	0.074	0.056	0.056	1.306
VBA	0.032	0.034	0.030	0.037	0.033	0.045	0.043	0.060	0.068	0.045	0.039	0.035	0.058	0.052	0.049	0.058	0.059	0.059	0.046	0.036	0.917
CPD	0.039	0.040	0.040	0.047	0.045	0.030	0.028	0.038	0.056	0.048	0.042	0.037	0.039	0.033	0.036	0.030	0.030	0.029	0.023	0.021	0.733
EBA	0.064	0.053	0.059	0.084	0.066	0.052	0.048	0.052	0.075	0.128	0.111	0.101	0.107	0.085	0.101	0.109	0.087	0.087	0.092	0.089	1.651
SRD	0.029	0.019	0.015	0.020	0.015	0.018	0.024	0.020	0.014	0.024	0.050	0.045	0.051	0.044	0.058	0.045	0.038	0.042	0.044	0.038	0.654
SRR	0.028	0.020	0.018	0.018	0.013	0.018	0.024	0.020	0.014	0.010	0.021	0.030	0.035	0.030	0.030	0.030	0.020	0.019	0.032	0.021	0.452
SRA	0.028	0.020	0.018	0.020	0.013	0.014	0.024	0.020	0.014	0.010	0.014	0.019	0.031	0.027	0.026	0.022	0.015	0.014	0.018	0.016	0.384
AEB	0.068	0.068	0.055	0.068	0.047	0.047	0.042	0.055	0.039	0.027	0.034	0.035	0.056	0.131	0.057	0.047	0.065	0.051	0.065	0.093	1.150
AEI	0.068	0.062	0.050	0.068	0.047	0.045	0.040	0.057	0.043	0.027	0.034	0.035	0.021	0.049	0.070	0.053	0.047	0.051	0.052	0.048	0.967
AST	0.066	0.053	0.054	0.050	0.049	0.035	0.044	0.053	0.037	0.021	0.035	0.037	0.049	0.034	0.050	0.072	0.094	0.064	0.070	0.102	1.067
BSD	0.058	0.039	0.046	0.037	0.037	0.031	0.031	0.052	0.028	0.022	0.029	0.037	0.049	0.037	0.028	0.041	0.094	0.067	0.061	0.098	0.918
RVT	0.031	0.037	0.029	0.028	0.032	0.023	0.019	0.032	0.022	0.016	0.027	0.032	0.022	0.026	0.013	0.011	0.025	0.048	0.039	0.037	0.549
AHB	0.028	0.015	0.014	0.013	0.016	0.011	0.010	0.018	0.012	0.008	0.015	0.019	0.015	0.013	0.011	0.008	0.007	0.014	0.021	0.014	0.286
PPR	0.024	0.033	0.032	0.027	0.033	0.027	0.023	0.041	0.020	0.014	0.017	0.026	0.021	0.023	0.018	0.017	0.016	0.017	0.025	0.031	0.485
AMS	0.062	0.042	0.037	0.044	0.033	0.032	0.037	0.054	0.025	0.019	0.030	0.038	0.018	0.031	0.015	0.012	0.021	0.031	0.024	0.030	0.636
Total	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20.000

Table 4.9: Normalised Relative Weight – Both Perceptions.

	AOP	COP	SA	MS	WS
AOP	0.398	0.560	0.298	0.335	1.591
COP	0.140	0.197	0.287	0.313	0.937
SA	0.183	0.094	0.137	0.116	0.530
MS	0.280	0.148	0.278	0.236	0.942
Total	1	1	1	1	4

Then, the eigenvector was then generated by averaging the different rows of the number matrix, as illustrated in Table 4.10 and Table 4.11. For example, in the case of Frontal (Adult) alternatives for Automotive Industry Workers, the sum of the row was 2.232. The sum of the row was divided by 20 since there are 20 alternatives. An average value of 0.112 was produced. The average values were multiplied with each column total of the alternatives. Then, the priority vectors were produced. Priority vectors indicate the importance of the alternatives. The maximum eigenvalue, λmax was calculated by summing all the priority vectors.

Table 4.10: Priority vectors of the alternatives.

Automotive Industry Worker				**Policymaker**			
Alternatives	**Eigenvector**	**Total Column**	**Priority Vector**	**Alternative**	**Eigenvector**	**Total Column**	**Priority Vector**
FA	0.1116	8.9691	1.0011	**FA**	0.0933	10.2373	0.9548
SA	0.0914	12.5570	1.1483	**SA**	0.0678	14.9684	1.0153
HPT	0.0688	16.6413	1.1447	**FC**	0.0649	15.7526	1.0224
FC	0.0791	13.4184	1.0611	**SC**	0.0841	12.2210	1.0279
SC	0.0696	18.7783	1.3067	**HPT**	0.0822	13.4368	1.1045
RSI	0.0659	17.0052	1.1208	**RSI**	0.0653	16.6972	1.0903
VBA	0.0389	30.8891	1.2013	**EBA**	0.0458	23.0194	1.0553
CPD	0.0474	23.0674	1.0936	**CPD**	0.0366	25.9969	0.9523
EBA	0.0609	18.9758	1.1560	**AEB**	0.0825	13.3598	1.1026
SRD	0.0454	24.8982	1.1293	**SRD**	0.0327	40.8336	1.3357
SRR	0.0369	30.8613	1.1402	**AST**	0.0226	47.2464	1.0678
SRA	0.0295	33.3223	0.9840	**AEI**	0.0192	51.6007	0.9898
AEB	0.0467	22.5001	1.0503	**VBA**	0.0575	17.8678	1.0274
AEI	0.0404	25.8835	1.0466	**SRR**	0.0484	20.5679	0.9947
AST	0.0432	24.8983	1.0750	**BSD**	0.0534	20.1139	1.0736
BSD	0.0322	35.1654	1.1323	**SRA**	0.0459	24.6677	1.1327
RVT	0.0263	39.9262	1.0499	**RVT**	0.0274	39.5222	1.0841
AHB	0.0226	44.4242	1.0050	**PPR**	0.0143	70.9966	1.0137
PPR	0.0254	40.0845	1.0185	**AHB**	0.0242	40.1783	0.9739
AMS	0.0177	53.2980	0.9437	**AMS**	0.0318	33.1765	1.0545
		λmax	21.8084			**λmax**	21.07336

Table 4.11: Priority vectors of the criteria.

Automotive Industry Worker and Policymaker			
Criteria	**Eigenvector**	**Total Column**	**Priority Vector**
AOP	0.3979	2.5141	1.0003
COP	0.2343	5.0714	1.1881
SA	0.1324	7.3058	0.9672
MS	0.2355	4.2426	0.9990
		λmax	4.1546

4.2.3 Consistency Ratio

If a person is consistent, the consistency index of the response should be substantially lower than what would be generated by random entries. According to Saaty, a consistency ratio should be less than 0.1 to be regarded acceptable, while a ratio of less than 0.2 is also acceptable. (Wedley, 1993) The consistency index (CI) and consistency ratio (CR) of automotive industry worker and policymaker were calculated as shown in Table 4.12. Since there were alternatives in this study (n = 20), the random index consistency (RI) is 1.63 as shown in Table 3.3. For the criteria, RI = 0.89 was used as there were 4 criteria. The consistency ratio of automotive industry worker and policymaker were 0.05832 and 0.034658 accordingly. On the other hand, the consistency ratio of both perceptions on the criteria was 0.05792 as shown in Table 4.12. All the consistency ratios were less than 0.1, where the pair-wise judgement was acceptable.

Table 4.12: Consistency Ratios.

	Automotive Industry Worker	Policymaker	Both Perceptions
λmax	21.8084	21.0734	4.1546
CI	0.09518	0.05649	0.05155
RI	1.63	1.63	0.89
CR	0.05839	0.03466	0.05792

4.2.4 Priority of the alternatives in ASEAN NCAP rating assessment

This study evaluated three perception criteria: Automotive Industry Worker, Policymaker and ASEAN NCAP. The AHP findings presented in Table 4.13 showed that Side (Child), Vehicle Based Assessment and Effective Braking and Avoidance were the top three concerns from the standpoint of automotive industry workers. Regardless of impact force, side impact collisions are worse than frontal or rear impact collisions. (Steward C. Wang, 2011) Compared to head-on crashes, side impact accidents produce more serious injuries since cars provide relatively little protection for occupants. Not only would the vehicle's doors and side panels protrude into the interior with little effort, but the entire structure may also collapse violently. As a result of the warping of the car frame in these high-impact situations, which results in a banana-shaped vehicle and what crash reconstructionist refer to as "wheelbase reduction," the distance between the tyres gets smaller as the vehicle is bent. Moreover, due to a lack of side protection, the children were more exposed to danger compared to adults. their softer heads make them more susceptible to serious head injury than adults. (World Health Organization (WHO), 2015) The top three priorities from the viewpoint of policymakers were Seatbelt Reminder (Front), Blindspot Detection/Blindspot Visualisation and Side (Child). Seatbelt reminders are gadgets that check to see if seat belts are fastened in a variety of seating positions before sending out a series of alarm signals that are progressively more urgent until the belts are fastened. According to a study by Mohd Amirudin M, the risk of death is 3.37 times higher for unrestrained passengers than for restrained ones. (Mohd Amirudin et al., 2021) Blindspot detection is a system that alerts the driver to any cars or other objects in their blind area. Driver blind spots are a common driver vision impairment while driving and are typically found in the back and side areas. When a car or object enters the driver's blind spot, BSD activates, giving the driver both a visual and an audible warning as they try to change lanes. Due to the motorcycle's smaller size and the driver's increased blind spot, this technology assists the driver in preventing blind spot collisions. (M. S. Abdul Khalid et al., 2021) An apparent downtrend in accident claims was discovered for side crashes – and at this stage, it can be arguably said that side collisions have been reduced for BSD-equipped models, whereby the system is designed to prevent blind-spot-related collisions. (Aziz et al., 2020) For the Frontal (Adult) alternative, the automotive industry worker and policymaker ranked it as 18 and 19 respectively. On the other side, the current ASEAN NCAP rating assessment ranked it as the most important alternative. This showed a great contrast between ASEAN NCAP and the others. Frontal impact protection for adults was categorised as passive safety. Passive safety features were safety measures that aid passengers in the event of a crash to reduce the severity of the passengers. For active safety, it was designed to prevent accidents before they happen. Effective braking and avoidance system was an example of active safety. The automotive industry worker and policymaker ranked EBA as 3 and 4 respectively. This showed that active safety features were preferred by the respondent compared to the passive safety features.

Table 4.13: Ranking of the alternatives from three perceptions.

	Automotive Industry Worker		Policymaker		Current Rating Assessment	
Alternatives	**Priority Vector**	**Rank**	**Priority Vector**	**Rank**	**Priority Vector**	**Rank**
FA	1.0011	18	0.9548	19	0.2000	1
SA	1.1483	4	1.0153	14	0.1000	2
HPT	1.1447	5	1.0224	13	0.1000	2
FC	1.0611	12	1.0279	11	0.0630	5
SC	1.3067	1	1.1045	3	0.0310	11
RSI	1.1208	9	1.0903	5	0.0470	9
VBA	1.2013	2	1.0553	9	0.0510	7
CPD	1.0936	10	0.9523	20	0.0080	20
EBA	1.1560	3	1.1026	4	0.0570	6
SRD	1.1293	8	1.3357	1	0.0290	12
SRR	1.1402	6	1.0678	8	0.0140	18
SRA	0.9840	19	0.9898	17	0.0140	18
AEB	1.0503	13	1.0274	12	0.0240	17
AEI	1.0466	15	0.9947	16	0.0330	10
AST	1.0750	11	1.0736	7	0.0290	12
BSD	1.1323	7	1.1327	2	0.1000	2
RVT	1.0499	14	1.0841	6	0.0500	8
AHB	1.0050	17	1.0137	15	0.0250	14
PPR	1.0185	16	0.9739	18	0.0250	14
AMS	0.9437	20	1.0546	10	0.0250	14

4.2.5 Priority of the criteria in ASEAN NCAP rating assessment

The priorities of criteria in ASEAN NCAP rating assessment by the viewpoint of automotive industry worker and policymaker were shown in Table 4.14 and as followed: Child Occupant Protection, Adult Occupant Protection. Motorcyclist Safety and Safety Assist. The perspective of the automotive industry worker and policymaker was compatible with the road accident data. In Malaysia, traffic injuries were the top leading cause of hospital admission among children (0-19 years) from 2003 - 2005. (Wong, 2011) Because of the physical, cognitive, and social limitations of a child, younger children are more susceptible in road traffic than adults. Although Motorcyclist Safety was ranked as the third priority vector, it only had a slight difference from the priority vector of Adult Occupant Protection. The test protocol should be tougher on Motorcyclist Safety to ensure that consumers will be offered extra options for a safer vehicle in the market. It is anticipated that the rapidly developing safety assist technologies will contribute to a reduction in traffic accidents and the lifesaving of motorcyclists, who are responsible for more than 4000 road fatalities annually in Malaysia. (M. S. Abdul Khalid et al., 2021) Based on the preference of the automotive industry worker and policymaker, ASEAN NCAP should be prioritising the Child Occupant Protection instead of Adult Occupant Protection.

Table 4.14: Ranking of the criteria from three perceptions.

	Automotive Industry Worker and Policymaker		**ASEAN NCAP**	
Criteria	**Priority Vector**	**Rank**	**Priority Vector**	**Rank**
Adult Occupant Protection	1.0003	2	0.4	1
Child Occupant Protection	1.1881	1	0.2	2
Safety Assist	0.9672	4	0.2	2
Motorcyclist Safety	0.9990	3	0.2	2

CHAPTER 5

CONCLUSION

5.1 Summary

This study aims to ascertain automotive industry workers' and policymakers' viewpoints on determining the prioritiy weighting criteria for safety technology in assessment protocol for ASEAN NCAP rating by proposing a hierarchical framework. Due to the algorithm's simplicity, the traditional AHP is still often utilised even though cutting-edge decision-making tools are readily available. In general, the objectives set were achieved. A research instrument for weighting criteria for each pillar and item in the ASEAN NCAP rating assessment was designed and developed. The data collected from the research instrument was analysed using AHP. The CR of the study was below 0.1, hence considered to be acceptable. Child Occupant Protection was chosen as the most important criterion in the ASEAN NCAP rating assessment by automotive industry worker and policymaker. The top 2 priority items from the standpoint of automotive industry worker were side (child) and vehicle-based assessment, while seatbelt reminder (front) and blind spot detection were perceived for that by the policymaker. Out of four priority items, three of them are under the pillar of COP and MS. The results are in line with the road accident data. ASEAN NCAP should be prioritising the criterion of COP and MS. ASEAN NCAP plays a big role in bringing safety technologies to Malaysia. By manipulating the weighting of the criteria in the ASEAN NCAP rating assessment based on the happening traffic data, it will encourage the vehicle manufacturer to introduce more safety technologies to their vehicles. At the same time, road accidents and fatalities can be reduced.

5.2 Recommendations

For future improvements, accuracy of the weighting for each pillar in ASEAN NCAP rating could be enhanced by expanding the nationality of respondents. In this study, only respondents from Malaysia were taken into consideration. ASEAN is the Association of Southeast Asia Nation which include Thailand, Indonesia, Philippines, Myanmar, Singapore, Laos, Vietnam, Cambodia, Brunei, and Malaysia. This survey should be exposed to the respondent from these countries. By doing so, a more comprehensive data can be collected and analysed. Besides, type of designation of respondent e.g., academics, user, and public should be increased. Different points of view from other perspective can provide a more accurate result.

5.3 Research Potential

The study finding could be used by ASEAN NCAP for constructing the road map of ASEAN NCAP rating assessment for 2026 to 2030. This helps to elevate the vehicle safety standard and encourage the vehicle manufacturers to produce safer vehicles in ASEAN. Additionally, the rate of road accidents involving motorcyclist and children can be substantially reduced.

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APPENDICES

Appendix A

Name : ____________________________

Contact No. : ____________________________

Nationality : ____________________________

Age : ____________________________

Designation : ___________________________

Company/Institution:______________________

Do you consider NCAP star rating when purchasing a vehicle?
Yes / No

Prioritizing Weighting Criteria in ASEAN NCAP Rating Assessment

Greetings,
A New Car Assessment Program (NCAP) is a government car safety program tasked with evaluating new automobile designs for performance against various safety threats. This program was established to encourage manufacturers to build safer vehicles and consumers to buy them. However, there is a lack of study on the Priority Weighting criteria for safety technology in the Assessment Protocol for ASEAN NCAP Rating. Currently, we, students from Universiti Teknikal Malaysia Melaka (UTeM) are doing research to determine the weighting for each pillar in ASEAN NCAP by using Analytic Hierarchy Process (AHP).

From the above lists, we need to make a pairwise comparison between each of the criteria. **The preference level of pairwise comparison must be between scale 1 to 9 depending on which criteria prefer most for car safety that will be reflected in the ASEAN NCAP Rating**. The numerical value and preference level are shown below:

Numerical Value	Preference Level
1	Equally preferred
2	Equally to moderately preferred
3	Moderately preferred
4	Moderately to strongly preferred
5	Strongly preferred
6	Strongly to very strongly preferred
7	Very strongly preferred
8	Very strongly to extremely preferred
9	Extremely preferred

Example:

Head-on collision or frontal collision is the deadliest accident type. It considers both vehicles' speeds at the time of the crash, which means even an accident at lower speeds can be catastrophic. On the other hand, the side impact is only depending on the speed of the vehicle that hits from the side. Hence, you **very strongly preferred** the Frontal (Adult) rather than Side (Adult) in terms of safety. Then, you should mark the number 7 on the left.

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Frontal (Adult			/															Side (Adult)

Reference

Youtube Link: https://youtu.be/uLjp4Z2mbLo

<u>ASEAN NCAP ROADMAP 2021 TO 2025</u>

ASEAN NCAP 2021-2025	AOP		COP		Safety Assist		Motorcyclist Safety	
	Item	Max	Item	Max	Item	Max	Item	Max
	Frontal	16	Frontal	16	*EBA*	6	*BSD / BSV*	8
	Side	8	Side	8	*SBR(Fr.)*	3	*Rear View Technology*	4
	HPT Evaluation	8	CRS Installation	12	*SBR(Rc.)*	1.5	*AHB*	2
			Vehicle Based Assessment	13	*SBR(Rr.) Advanced*	1.5	Pedestrian Protection	2
			Child Presence Detection	2	*AEB City*	2.5		
					AEB Inter Urban	3.5	[Advanced MST]*	2*
					Advanced SAT	3	*BONUS POINT	
Score		32		51		21		16
Weighting		40%		20%		20%		20%

Slanting = Fitment Rating System

* To add 2 points MAX to total MS point

	AOP (%)	COP (%)	Safety Assist (%)	Motorcyclist Safety (%)
5 ★	80	75	70	50
4 ★	70	60	50	40
3 ★	60	30	40	30
2 ★	50	25	30	20
1 ★	40	15	20	10

Calculation Table of the ASEAN NCAP Roadmap 2021-2025

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Adult Occupant Protection																		Child Occupant Protection
Adult Occupant Protection																		Safety Assist
Adult Occupant Protection																		Motorcyclist Safety
Child Occupant Protection																		Safety Assist
Child Occupant Protection																		Motorcyclist Safety
Safety Assist																		Motorcyclist Safety

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Frontal (Adult)																		Side (Adult)
Frontal (Adult)																		Head Protection Technology (HPT) Evaluation
Frontal (Adult)																		Frontal (Child)
Frontal (Adult)																		Side (Child)
Frontal (Adult)																		Child Restraint System Installation
Frontal (Adult)																		Vehicle-Based Assessment
Frontal (Adult)																		Child Presence Detection
Frontal (Adult)																		Effective Braking and Avoidance (EBA)
Frontal (Adult)																		Seatbelt Reminder (Front)
Frontal (Adult)																		Seatbelt Reminder (Rear)
Frontal (Adult)																		Seatbelt Reminder (Rear) Advanced
Frontal (Adult)																		Autonomous Emergency Brake (City)
Frontal (Adult)																		Autonomous Emergency Brake (Inter-Urban)
Frontal (Adult)																		Advanced Safety Assist Technologies
Frontal (Adult)																		Blind Spot Detection/ Blind Spot Visualization
Frontal (Adult)																		Rear View Technology
Frontal (Adult)																		Auto High Beam
Frontal (Adult)																		Pedestrian Protection
Frontal (Adult)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Side (Adult)																		Head Protection Technology (HPT) Evaluation
Side (Adult)																		Frontal (Child)
Side (Adult)																		Side (Child)
Side (Adult)																		Child Restraint System Installation
Side (Adult)																		Vehicle-Based Assessment
Side (Adult)																		Child Presence Detection
Side (Adult)																		Effective Braking and Avoidance (EBA)
Side (Adult)																		Seatbelt Reminder (Front)
Side (Adult)																		Seatbelt Reminder (Rear)
Side (Adult)																		Seatbelt Reminder (Rear) Advanced
Side (Adult)																		Autonomous Emergency Brake (City)
Side (Adult)																		Autonomous Emergency Brake (Inter-Urban)
Side (Adult)																		Advanced Safety Assist Technologies
Side (Adult)																		Blind Spot Detection/ Blind Spot Visualization
Side (Adult)																		Rear View Technology
Side (Adult)																		Auto High Beam
Side (Adult)																		Pedestrian Protection
Side (Adult)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Head Protection Technology (HPT) Evaluation																		Frontal (Child)
Head Protection Technology (HPT) Evaluation																		Side (Child)
Head Protection Technology (HPT) Evaluation																		Child Restraint System Installation
Head Protection Technology (HPT) Evaluation																		Vehicle-Based Assessment
Head Protection Technology (HPT) Evaluation																		Child Presence Detection
Head Protection Technology (HPT) Evaluation																		Effective Braking and Avoidance (EBA)
Head Protection Technology (HPT) Evaluation																		Seatbelt Reminder (Front)
Head Protection Technology (HPT) Evaluation																		Seatbelt Reminder (Rear)
Head Protection Technology (HPT) Evaluation																		Seatbelt Reminder (Rear) Advanced
Head Protection Technology (HPT) Evaluation																		Autonomous Emergency Brake (City)
Head Protection Technology (HPT) Evaluation																		Autonomous Emergency Brake (Inter-Urban)
Head Protection Technology (HPT) Evaluation																		Advanced Safety Assist Technologies

Head Protection Technology (HPT) Evaluation																		Blind Spot Detection/ Blind Spot Visualization
Head Protection Technology (HPT) Evaluation																		Rear View Technology
Head Protection Technology (HPT) Evaluation																		Auto High Beam
Head Protection Technology (HPT) Evaluation																		Pedestrian Protection
Head Protection Technology (HPT) Evaluation																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Frontal (Child)																		Side (Child)
Frontal (Child)																		Child Restraint System Installation
Frontal (Child)																		Vehicle-Based Assessment
Frontal (Child)																		Child Presence Detection
Frontal (Child)																		Effective Braking and Avoidance (EBA)
Frontal (Child)																		Seatbelt Reminder (Front)
Frontal (Child)																		Seatbelt Reminder (Rear)

Frontal (Child)																		Seatbelt Reminder (Rear) Advanced
Frontal (Child)																		Autonomous Emergency Brake (City)
Frontal (Child)																		Autonomous Emergency Brake (Inter-Urban)
Frontal (Child)																		Advanced Safety Assist Technologies
Frontal (Child)																		Blind Spot Detection/ Blind Spot Visualization
Frontal (Child)																		Rear View Technology
Frontal (Child)																		Auto High Beam
Frontal (Child)																		Pedestrian Protection
Frontal (Child)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Side (Child)																		Child Restraint System Installation
Side (Child)																		Vehicle-Based Assessment
Side (Child)																		Child Presence Detection
Side (Child)																		Effective Braking and Avoidance (EBA)
Side (Child)																		Seatbelt Reminder (Front)
Side (Child)																		Seatbelt Reminder (Rear)
Side (Child)																		Seatbelt Reminder (Rear) Advanced

Side (Child)																		Autonomous Emergency Brake (City)
Side (Child)																		Autonomous Emergency Brake (Inter-Urban)
Side (Child)																		Advanced Safety Assist Technologies
Side (Child)																		Blind Spot Detection/ Blind Spot Visualization
Side (Child)																		Rear View Technology
Side (Child)																		Auto High Beam
Side (Child)																		Pedestrian Protection
Side (Child)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Child Restraint System Installation																		Vehicle-Based Assessment
Child Restraint System Installation																		Child Presence Detection
Child Restraint System Installation																		Effective Braking and Avoidance (EBA)
Child Restraint System Installation																		Seatbelt Reminder (Front)
Child Restraint System Installation																		Seatbelt Reminder (Rear)
Child Restraint System Installation																		Seatbelt Reminder (Rear) Advanced

Child Restraint System Installation																		Autonomous Emergency Brake (City)
Child Restraint System Installation																		Autonomous Emergency Brake (Inter-Urban)
Child Restraint System Installation																		Advanced Safety Assist Technologies
Child Restraint System Installation																		Blind Spot Detection/ Blind Spot Visualization
Child Restraint System Installation																		Rear View Technology
Child Restraint System Installation																		Auto High Beam
Child Restraint System Installation																		Pedestrian Protection
Child Restraint System Installation																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Vehicle-Based Assessment																		Child Presence Detection
Vehicle-Based Assessment																		Effective Braking and Avoidance (EBA)
Vehicle-Based Assessment																		Seatbelt Reminder (Front)
Vehicle-Based Assessment																		Seatbelt Reminder (Rear)
Vehicle-Based Assessment																		Seatbelt Reminder (Rear) Advanced
Vehicle-Based Assessment																		Autonomous Emergency Brake (City)
Vehicle-Based Assessment																		Autonomous Emergency Brake (Inter-Urban)

Vehicle-Based Assessment																		Advanced Safety Assist Technologies
Vehicle-Based Assessment																		Blind Spot Detection/ Blind Spot Visualization
Vehicle-Based Assessment																		Rear View Technology
Vehicle-Based Assessment																		Auto High Beam
Vehicle-Based Assessment																		Pedestrian Protection
Vehicle-Based Assessment																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Child Presence Detection																		Effective Braking and Avoidance (EBA)
Child Presence Detection																		Seatbelt Reminder (Front)
Child Presence Detection																		Seatbelt Reminder (Rear)
Child Presence Detection																		Seatbelt Reminder (Rear) Advanced
Child Presence Detection																		Autonomous Emergency Brake (City)
Child Presence Detection																		Autonomous Emergency Brake (Inter-Urban)

Child Presence Detection																		Advanced Safety Assist Technologies
Child Presence Detection																		Blind Spot Detection/ Blind Spot Visualization
Child Presence Detection																		Rear View Technology
Child Presence Detection																		Auto High Beam
Child Presence Detection																		Pedestrian Protection
Child Presence Detection																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Effective Braking and Avoidance (EBA)																		Seatbelt Reminder (Front)
Effective Braking and Avoidance (EBA)																		Seatbelt Reminder (Rear)
Effective Braking and Avoidance (EBA)																		Seatbelt Reminder (Rear) Advanced
Effective Braking and Avoidance (EBA)																		Autonomous Emergency Brake (City)
Effective Braking and Avoidance (EBA)																		Autonomous Emergency Brake (Inter-Urban)
Effective Braking and Avoidance (EBA)																		Advanced Safety Assist Technologies
Effective Braking and Avoidance (EBA)																		Blind Spot Detection/ Blind Spot Visualization

Effective Braking and Avoidance (EBA)																		Rear View Technology
Effective Braking and Avoidance (EBA)																		Auto High Beam
Effective Braking and Avoidance (EBA)																		Pedestrian Protection
Effective Braking and Avoidance (EBA)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Seatbelt Reminder (Front)																		Seatbelt Reminder (Rear)
Seatbelt Reminder (Front)																		Seatbelt Reminder (Rear) Advanced
Seatbelt Reminder (Front)																		Autonomous Emergency Brake (City)
Seatbelt Reminder (Front)																		Autonomous Emergency Brake (Inter-Urban)
Seatbelt Reminder (Front)																		Advanced Safety Assist Technologies
Seatbelt Reminder (Front)																		Blind Spot Detection/ Blind Spot Visualization
Seatbelt Reminder (Front)																		Rear View Technology

Seatbelt Reminder (Front)																		Auto High Beam
Seatbelt Reminder (Front)																		Pedestrian Protection
Seatbelt Reminder (Front)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Seatbelt Reminder (Rear)																		Seatbelt Reminder (Rear) Advanced
Seatbelt Reminder (Rear)																		Autonomous Emergency Brake (City)
Seatbelt Reminder (Rear)																		Autonomous Emergency Brake (Inter-Urban)
Seatbelt Reminder (Rear)																		Advanced Safety Assist Technologies
Seatbelt Reminder (Rear)																		Blind Spot Detection/ Blind Spot Visualization
Seatbelt Reminder (Rear)																		Rear View Technology
Seatbelt Reminder (Rear)																		Auto High Beam
Seatbelt Reminder (Rear)																		Pedestrian Protection
Seatbelt Reminder (Rear)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Seatbelt Reminder (Rear) Advanced																		Autonomous Emergency Brake (City)
Seatbelt Reminder (Rear) Advanced																		Autonomous Emergency Brake (Inter-Urban)
Seatbelt Reminder (Rear) Advanced																		Advanced Safety Assist Technologies
Seatbelt Reminder (Rear) Advanced																		Blind Spot Detection/ Blind Spot Visualization
Seatbelt Reminder (Rear) Advanced																		Rear View Technology

Seatbelt Reminder (Rear) Advanced																		Auto High Beam
Seatbelt Reminder (Rear) Advanced																		Pedestrian Protection
Seatbelt Reminder (Rear) Advanced																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Autonomous Emergency Brake (City)																		Autonomous Emergency Brake (Inter-Urban)
Autonomous Emergency Brake (City)																		Advanced Safety Assist Technologies
Autonomous Emergency Brake (City)																		Blind Spot Detection/ Blind Spot Visualization
Autonomous Emergency Brake (City)																		Rear View Technology
Autonomous Emergency Brake (City)																		Auto High Beam
Autonomous Emergency Brake (City)																		Pedestrian Protection
Autonomous Emergency Brake (City)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Autonomous Emergency Brake (Inter-Urban)																		Advanced Safety Assist Technologies
Autonomous Emergency Brake (Inter-Urban)																		Blind Spot Detection/ Blind Spot Visualization
Autonomous Emergency Brake (Inter-Urban)																		Rear View Technology
Autonomous Emergency Brake (Inter-Urban)																		Auto High Beam

Autonomous Emergency Brake (Inter-Urban)																		Pedestrian Protection
Autonomous Emergency Brake (Inter-Urban)																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Advanced Safety Assist Technologies																		Blind Spot Detection/ Blind Spot Visualization
Advanced Safety Assist Technologies																		Rear View Technology
Advanced Safety Assist Technologies																		Auto High Beam
Advanced Safety Assist Technologies																		Pedestrian Protection
Advanced Safety Assist Technologies																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Blind Spot Detection/ Blind Spot Visualization																		Rear View Technology
Blind Spot Detection/ Blind Spot Visualization																		Auto High Beam
Blind Spot Detection/ Blind Spot Visualization																		Pedestrian Protection
Blind Spot Detection/ Blind Spot Visualization																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Rear View Technology																		Auto High Beam
Rear View Technology																		Pedestrian Protection
Rear View Technology																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Auto High Beam																		Pedestrian Protection
Auto High Beam																		Advanced Motorcyclist Safety Technology

Criteria 1	Scoring																	Criteria 2
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pedestrian Protection																		Advanced Motorcyclist Safety Technology

We'd greatly appreciate your feedback so this research can be successfully completed. Do fill up the feedback box if you have any suggestions for us to improve in the future. Thank you for your precious time and your help!

Feedback: ____

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Frontal (Adult)

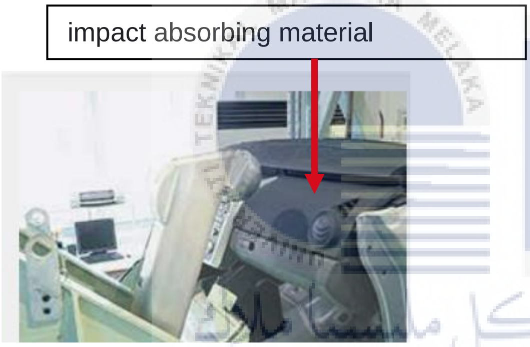
Performance of the Airbag and protections that are provided for adults in the critical body region (Head, neck, chest, and lower body) in the event of a frontal impact are tested.

Side (Adult)

Protections that are provided for adults in the body regions (head, chest, abdomen, and pelvis) such as side airbags. Door opening during the impact and door opening forces after the impact are tested.

Head Protection Technology (HPT)

Technology that protects the head, can be other than airbags such as energy absorbing areas at the front seat and rear seat.



Frontal (Child)

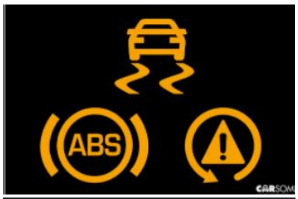
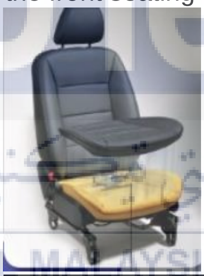
Protections that are provided for children in the critical body regions (Head, neck, chest, and lower body) when there is a frontal impact. The child is not ejected/ partially ejected during the impact.

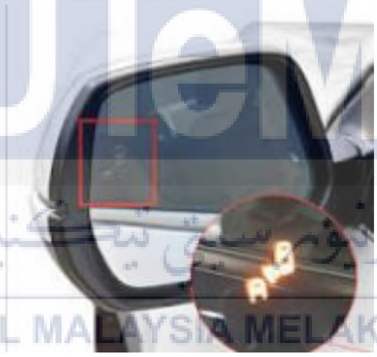
Side (Child)

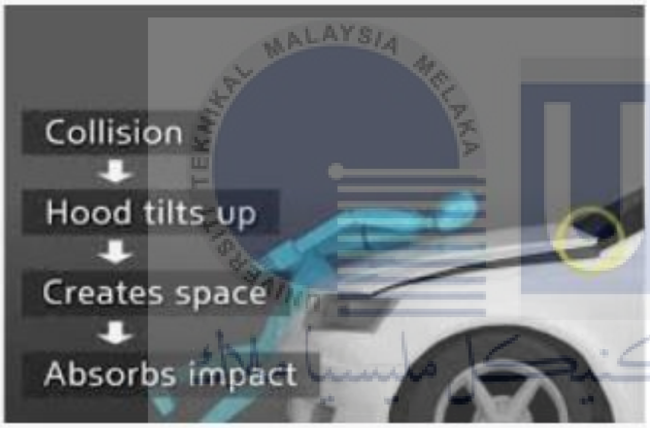
Protections that are provided for the children in the body regions (Head, chest, abdomen, and pelvis) when there is a side impact. The child is not ejected/ partially ejected during the impact.

Child Restraint System (CRS) Installation

A child Restraint System (CRS) is a safety device as a car seat or seat belt, designed to secure a child in a motor vehicle. Ease of installation in a car, ease of tightening belt, ease of operating the lock off clip, insert and locking ISOFIX probes, obstruction, and stability of CRS are tested.

Vehicle-Based Assessment Provision of a three-point seat belt, Gabarit installation on all passenger seats, two simultaneous use of seating positions, and passenger airbag warning markings are examples of vehicle-based assessment.  	**Child Presence Detection** A system that notifies the driver when a child is left inside vehicle 
Effective Braking and Avoidance (EBA) Anti-lock Braking systems (ABS) and Electronic Stability Control (ESC) are examples of effective braking and avoidance (EBA). Anti-lock Braking System (ABS) is an active safety technology that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up and avoiding uncontrolled skidding. The electronic Stability Control (ESC) system is designed to assist drivers in maintaining heading control of their vehicles in high speed or sudden maneuvers and on slippery roads. 	**Seatbelt (SBR) (Front)** A system that checks the usability of seatbelts at the front seating position of the vehicle. 
Seatbelt (SBR) (Rear) A system that checks the usability of seatbelts at the rear seating position of the vehicle. 	**Seatbelt (SBR) (Rear) Advanced*** Audible signal to remind the driver when the rear passengers are not using the seatbelts. 

Autonomous Emergency Brake (AEB) (City) Braking that is applied automatically by the vehicle in response to detection of a likely collision to reduce the vehicle speed and potentially avoid the collision.  	**Autonomous Emergency Brake (AEB) (Inter-Urban)** Braking that is applied automatically by the vehicle in response to detection of a likely collision to reduce the vehicle speed and potentially avoid the collision. (up to 60 km/h) 
Advanced Safety Assist Technology (SAT) Forward Collision Warning (FCW), Lane Departure Warning (LDW), and Lane Keep Assist (LKA) are examples of other advanced safety assist technologies. Forward Collision Warning (FCW) is a system that will provide an audio-visual warning automatically to the driver in response to the detection of a likely collision. Lane Departure Warning (LDW) is a system that is designed to warn the driver when the vehicle begins to move unintentionally out of its lane on highways and urban roads. Lane Keep Assist (LKA) is a system that is designed to support the driver when the vehicle begins to move unintentionally out of its lane. The system supports the driver with a haptic vehicle cue (e.g., steering nudge) which may help to keep the vehicle in lane.  	**Blind Spot Detection/Visualization (BSD/BSV)** A system that warns the driver of the subject vehicle against a potential collision with the vehicle to the side and/or rear of the subject vehicle and moving in the same direction as the subject vehicle during lane change maneuvers. The system shall be able to provide a live visual of the vehicle static in the same direction, and on the side and/or rear of the subject vehicle which can be manually activated or via a turn signal action. 

Rear View Technology Assist in determining the presence of motorcycles or small vehicles. A system designed to provide an enhanced live view that displays the view images created from the rearward camera. 	**Auto High Beam (AHB)** A system that detects oncoming vehicles and preceding vehicles and automatically switches between high and low beams during night driving, making it easier for the driver to recognize hazards such as impeding motorcycles. 
Pedestrian Protection Safety technology that allows vehicle components that may come into contact with a pedestrian in a collision to deform or break apart easily for better impact energy absorption. 	**Advanced Motorcyclist Safety Technology (MST)** Technology that could benefit to reduce the possibility of an accident between a car and motorcycle.

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Universiti Teknikal Malaysia Melaka

Tuan

PENGKELASAN TESIS SEBAGAI TERHAD BAGI TESIS PROJEK SARJANA MUDA

Dengan segala hormatnya merujuk kepada perkara di atas.

2. Dengan ini, dimaklumkan permohonan pengkelasan tesis yang dilampirkan sebagai TERHAD untuk tempoh **LIMA** tahun dari tarikh surat ini. Butiran lanjut laporan PSM tersebut adalah seperti berikut:

Nama pelajar: SHEA YU XIANG
Tajuk Tesis: Prioritizing Weighting Criteria In Asean Ncap Rating Assessment By Using The Analytic Hierarchy Process (Ahp): Industry And Policy Maker Perception

3. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

“BERKHIDMAT UNTUK NEGARA”
“KOMPETENSI TERAS KEGEMILANGAN”

Saya yang menjalankan amanah,

Dr. Nur Hazwani Binti Mokthar
Penyelia Utama/ Pensyarah Kanan
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