EVALUATION OF VEHICLE LANE KEEPING ASSISTANCE (LKA) AND LANE DEPARTURE WARNING (LDW) SYSTEM FOR ADVANCED DRIVER ASSISTANCE SYSTEM (ADAS) TECHNOLOGY UNDER MALAYSIAN ENVIRONMENT CONDITIONS

MUHAMMAD AMIN BIN ARSHAD

UNIVERSITI TEKNIKAL MALAYSIA MELAKA (UTeM)

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MUHAMMAD AMIN BIN ARSHAD

This report is submitted

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DECLARATION

I declare that this project report entitled "Evaluation of Vehicle Lane Keeping Assistance (LKA) and Lane Departure Warning (LDW) system for Advanced Driver Assistance System (ADAS) Technology under Malaysian Environment Conditions" is result of my own work except as cited in the references.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of Degree of Bachelor of Mechanical Engineering.

Signature : .....

Name of Supervisor : .....

Date : .....

DEDICATION

It is a dream in doing something big in my life and this project is a big part of my life.

I dedicate this to my mama and abah for giving me a chance in pursuing degree and following my dream.

ABSTRACT

Lane Departure Warning (LDW) and Lane Keeping Assistance (LKA) systems are part for the Advanced Driver Safety Assist (ADAS) technologies which is equipped in latest passenger vehicle models sold in South-East Asia (SEA) countries. Both technologies are very beneficial to gain improved safety performance for vehicle occupants and surrounding road users (such as other vehicle occupants, pedestrians and cyclists), by alerting the driver and making automatic trajectory correction when the vehicle deviate away from the correct path while the vehicle moves. Nevertheless, there is yet any test protocol established by ASEAN New Car Assessment Programme (ASEAN NCAP) to evaluate the LDW and LKA performance tailored to SEA environmental conditions. Hence, in this project, preliminary investigation on the new test protocol developed for LDW and LKA based on SEA environment condition was conducted. The new protocol incorporated the effect of both dry and wet environment condition, which is unique to simulate the driving conditions in this region. The new test protocol is derived using EURO NCAP Lane Support System test procedure v.2.0.2 2018 as the benchmark. On-road test using actual passenger vehicle was conducted, using a dedicated rain simulator to simulate the rainy weather. The preliminary test was also performed on straight road condition. Results showed that the new test protocol was able to assess the effectiveness of the LDW and LKA system, at both dry and wet weather conditions.

ABSTRAK

Lane Departure Warning (LDW) dan Lane Keeping Assistance (LKA) adalah sebahagian daripada teknologi Advanced Driver Safety Assist (ADAS) yang dilengkapi dengan model kenderaan penumpang terkini yang dijual di negara-negara Asia Tenggara (SEA). Kedua-dua teknologi ini sangat bermanfaat untuk memperoleh peningkatan prestasi keselamatan bagi penghuni kenderaan dan pengguna jalan raya di sekitarnya (seperti penghuni kenderaan lain, pejalan kaki dan penunggang basikal), dengan memberi amaran kepada pemandu dan membuat pembetulan lintasan automatik ketika kenderaan menyimpang dari jalan yang betul semasa kenderaan bergerak. Walaupun begitu, masih ada protokol ujian yang ditetapkan oleh New Car Assessment Programme dalam kawasan negara ASEAN (ASEAN NCAP) untuk menilai prestasi LDW dan LKA yang disesuaikan dengan keadaan persekitaran SEA. Oleh itu, dalam projek ini, penyelidikan awal mengenai protokol ujian baru yang dikembangkan untuk LDW dan LKA berdasarkan keadaan persekitaran SEA telah dilakukan. Protokol baru menggabungkan kesan keadaan persekitaran kering dan basah, yang unik untuk mensimulasikan keadaan pemanduan di wilayah ini. Protokol ujian baru dihasilkan menggunakan prosedur ujian Sistem Sokongan Lorong EURO NCAP v.2.0.2 2018 sebagai penanda aras. Ujian di jalan menggunakan kenderaan penumpang sebenar telah dilakukan, menggunakan simulator hujan khusus untuk mensimulasikan cuaca hujan. Ujian awal juga dilakukan pada keadaan jalan lurus. Hasil kajian menunjukkan bahawa protokol ujian baru dapat menilai keberkesanan sistem LDW dan LKA, baik pada keadaan cuaca kering dan basah.

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LIST OF ABBREVIATIONS

ADAS	Advance Driving Assistance System
LKA	Lane Keeping Assistance
LDW	Lane Departure Warning
NCAP	New Car Assessment Program
MIROS	Malaysian Road Safety Research Institute
AOP	Adult Occupant Protection
COP	Child Occupant Protection
SATs	Safety Assist Technologies
ESC	Electronic Stability Control
SBR	Seatbelt Reminder
AEB	Autonomous Emergency Braking
DAQ	Data Acquisition
ACC	Adaptive Cruise Control
BSM	Blind Spot Monitoring
DLC	Distance to lane crossing
TLC	Time to lane crossing
SW	Southwest
NE	Northeast
NHTSA	National Highway Traffic Safety Administration
LSS	Lane Support System
VUT	Vehicle Under Test

GVT	Global Vehicle Target
DGPS	Differential Global Positioning System
PBC	Peak Braking Coefficient
UNESE	United Nations Economic Commission for Europe
LIDAR	Light Detection and Ranging
OEM	Original Equipment Manufacturer
SAE	Society of Automotive Engineers
ABS	Antilock braking system
3D CAD	Three-dimensional computer-aided design
PDS	Product Design Specifications
PVC	Polyvinyl Chloride

CHAPTER 1

INTRODUCTION

1.1 Background

Advance Driving Assistance System (ADAS) is a system designed to assist the driver when driving. It has become an essential technology for vehicles equipped to reduce road accidents and fatalities. Lane Keeping Assistance (LKA) and Lane Departure Warning (LDW) are some of the feature examples provided by ADAS. Those examples are also known as Lane Support System. Lane Support Systems can support and alert the driver if they leave the road lane suddenly or switch the lane without providing a signal. The negligence conduct of the driver is enough to stray the vehicle from its lane. The systems monitor the vehicle's position on the road and while LDW warns the driver if the vehicle inadvertently drives off the road, LKA helps them to correct the course of their vehicle. (www.euroncap.com, 2019).

1.1.1 Lane Departure Warning

LDW is a camera-based system that recognizes lane markings and is activated when a driver is about to leave a lane without using the turning signal being used. A driver can drift inadvertently towards the line identifying the edge of the lane on a long highway journey. Very often, the driver will not be aware that the car is in a potentially dangerous situation until such time as the situation becomes severe, for example, the car's tires may be on the grass or gravel on the side of the road or, in extreme cases, the car may find itself in the path of oncoming. This sudden, late realization may trigger a panic response that causes the driver to lose control over the vehicle, sometimes resulting in a crash.

Several manufacturers have developed technologies that warn the driver as the car approaches a lane marking. Various systems use different warnings: some give an audible signal while others use a vibrating steering wheel to simulate the car's feeling running over a 'rumble strip'. The intention is simply to inform the driver that there is a danger that the car will cross the line. Many systems only need a line on one side of the vehicle, while other systems depend on different lines on either side.

Manufacturers take great care to ensure that the signal does not irritate drivers unnecessarily irritate drivers and is always in control. Most systems operate at above 60 km/h and, if the direction indicator is used, it suppresses the warning signal

A camera is usually positioned at the top of the windscreen, behind the rear view mirror. A computer continually analyses the images of this camera to identify the lane markings and, in some cases, an unmarked edge of the road. At the same time, the steering input of the driver is monitored along with the vehicle's speed and trajectory. These parameters are combined to determine whether or not the car is about to depart the lane of travel.

LDW rely on distinct lane markings that will reduce their efficiency if lines cannot be clearly distinguished, such as in heavy rain or fog, or if the road markings are obscured by mud or snow. In such cases, the driver is given an indication that the system could not assist.

1.1.2 Lane Keeping Assistance

LKA systems tackle LDW related accident circumstances. Although alert systems, however, depend on the driver for corrective action, LKA also proactively steers the car back into the lane. The machine gently steers the car away from the line until it is safely inside the lane when the vehicle is close to the lane marking. The system can control the car either by applying gentle braking on one wheel or by applying a direct steering input in the case of electrical steering systems.

Drivers however should not rely on LKA to do their driving for them. Some systems deactivate if they sense that the driver is no longer steering the vehicle. In any case, the systems can take corrective action only if the lane marking is being approached very gradually which that more rapid departures cannot (and should not) be corrected by LKA systems.

1.2 Problem Statement

Models with innovative safety features were quickly adapted by manufacturers to remain competitive and comply with strict regulatory reform. Somehow, these features are quite new and their safety could not be fully guaranteed. To verify that the features are sufficiently safe, the car should be tested. The New Car Assessment Program is responsible for these tests. For this scope of project, the NCAP is Southeast Asia based, and it is known as ASEAN NCAP.

ASEAN NCAP is an automotive safety rating program established jointly by the Malaysian Road Safety Research Institute (MIROS) and the Global New Car Assessment Program (Global NCAP). It is also a new addition to the NCAP family and is aimed at evaluating vehicle safety standards, raising awareness among consumers and thus promoting the region's market for safer vehicles. The ASEAN NCAP rating plate consists ofimportant information of the crash tested vehicle; make and model, star ratings of Adult Occupant Protection (AOP) and Child Occupant Protection (COP), side impact test result, crash test date and fitment status of Safety Assist Technologies (SATs) (www.aseancap.org, 2019). Adult Occupant Protection is determined from frontal impact, side impact and whiplash tests, which are carried out to evaluate the protection of adult driver and passengers offered by the vehicle while the assessment of Child Occupant Protection covers three aspects which are the protection offered by the child restraint systems in the frontal and side impact tests, the vehicle's ability to accommodate child restraints of various sizes and designs and the availability of provisions for safe transport of children in the car.

For Safety Assist Technologies, Electronic Stability Control (ESC) and Seatbelt Reminder (SBR) system have been considered in the rating system as a prerequisite for tested vehicle to obtain a 5-Star rating. This requirement is valid until end of 2016. For the ASEAN NCAP new rating system for 2017–2020, Safety Assist requirement has changed and improved considerably. Apart from ESC and SBR, which dominantly affect the scoring, new technologies such as Blind Spot Indicator, Autonomous Emergency Braking (AEB) and other up to date devices have been considered in the rating system. (www.aseancap.org, 2019).

The Table 1.1 below shows the selected NCAP whether they have conducted the test protocol for Safety Assist System specifically for LDW and LKA. Based from the Table 1.1, many NCAP have obtained their test protocol for evaluating the LKA and LDW except for ASEAN NCAP. Hence, ASEAN NCAP needs to develop new comprehensive test protocol for evaluating ADAS safety assist system, specifically LDW and LKA systems. This initiative is for making the rating system under Safety Assist to become more accurate. The test protocol should be based on South-East Asia environment and road conditions, to reflect current situation of ASEAN road users.

Table 1.1: Existence of test protocol of LDW and LKA for selected NCAP

NCAP	LDW	LKA
ASEAN NCAP	X	X
Euro NCAP (www.euroncap.com, 2019)	✓	✓
JNCAP (Japan) (www.nasva.go.jp, 2019)	✓	✓
ANCAP (Australasia) (www.ancap.com.au, 2019)	✓	✓
National Highway Traffic Safety Administration (United States of America) (www.safercar.gov, 2019)	✓	✓

1.3 Objectives of Study

The main objectives of this research are:

i. To develop new test protocol for LDW and LKA systems based on selected environment and road conditions parameters.

ii. To test the car equipped with LDW and LKA Safety Assist Systems under simulated dry and rainy weather conditions