International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249 – 8958, Volume-9 Issue-3, February, 2020

Development of Smart Vehicle Blind Spot Detection System Based on 24 GHz Radar Sensors

M. Nor, Mz Hassan, N. Ab Wahab, S. M. Najib, Khairil Anwar Abu Kassim

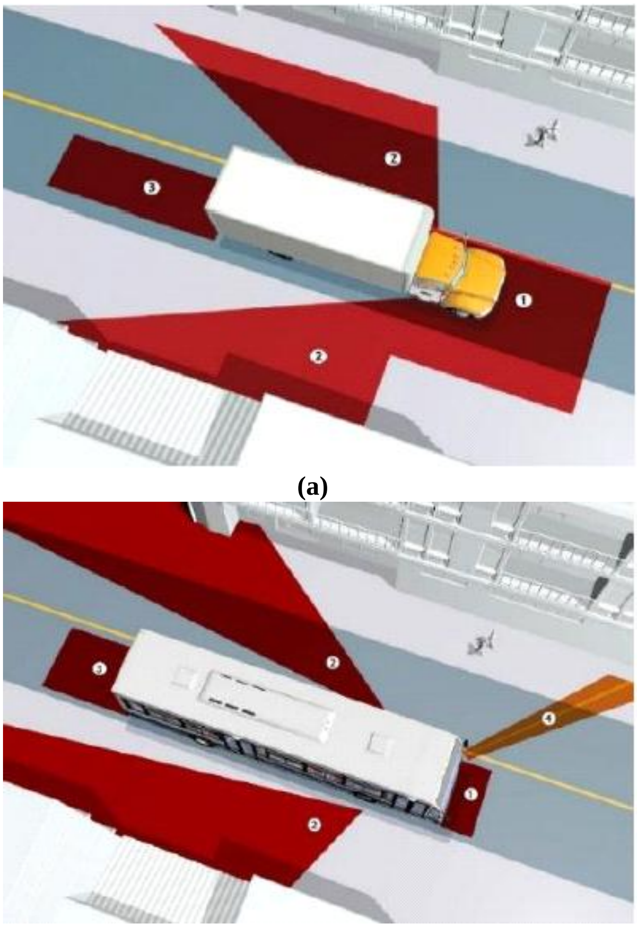
Abstract: Road safety has become more concern due to the number of accidents that keeps increasing every year. The safety system includes from simple installation such as seat belt, air bag and rear camera to more complicated and intelligent system such as braking assist, lane change assist and blind spot monitoring. This paper proposed a Smart Vehicle Blind Spot Detection System (VBDS) to observe the blind spot region based on ISO 17387: 2008(E). This system is mounted with two programmable 24 GHz radar sensors on the left and right rear side of the car. In addition, this system provides an audible and visual alert to the driver if the system senses any vehicles in the blind spot region using buzzer and LED, respectively. To analyze the performance of the system, test had been conducted at different demography condition. The accuracy of the system is analyzed by comparing number of vehicles detected within blind spot region and ground truth data. This system will alert the driver automatically to ensure the driver safety and reduce road accident. As conclusion, the system had been proofed applicable to use at different demography condition.

Keywords: Blind spot; ISO 17387:2008(E)

I. INTRODUCTION

Throughout the driving course, it is crucial for the driver to get information regarding the behavior of the other vehicles on the road to avoid road accidents and traffic jam (Padmanabhan and Chellamuthu, 2013). However, there is a certain area that cannot be seen directly by the driver or even through the side mirrors, which can be described as the rear quarter area on both sides of the vehicle. This is called blind spot phenomenon (Hassan and Zainal Ariffin, 2013).

The blind spot is crucial because when the other vehicle enters the blind spot while driving, the driver cannot see the presence of the vehicle and make the wrong decision to change lanes while the other vehicle is in the blind spot area. This is the main cause of the accident, especially for the motorcyclist (Md Isa, 2016). However, there are some factors that vary the blind spot occurrences such as the height of drivers and the size of the vehicle. Large vehicles tend to have a wider blind spot around the vehicle as shown in Figure 1(a) truck and Figure 1(b) for the bus.



(a)

(b)

Figure 1: Blind spot area on (a) Truck and (b) Bus (SAAQ, 2018)

More than 457000 accidents occur every year in the United States while an estimated 975 lives and 2100 injuries in Europe as a result of failing to detect any vehicle on the hazard zone or blind spot area, proving it as the main cause of vehicle and pedestrian impact occurred (Md Isa, 2016).

Revised Manuscript Received on February 19, 2020.

***** Correspondence Author

Mohammad Nor Mustaza, Faculty of Electrical and Electronic Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
E-mail: moharon94@gmail.com

PM. Dr. Muhammad Zahir Hassan, Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan, Universiti Teknikal Malaysia Melaka, Malaysia.
E-mail: zahir@utem.edu.my

Ts. Dr. Norfariza Ab Wahab*, Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan, Universiti Teknikal Malaysia Melaka, Malaysia.
E-mail: norfariza@utem.edu.my

Dr. Suhaila Mohd Najib, Faculty of Electrical and Electronic Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
E-mail: suhaila.najib@utem.edu.my

Ir. Dr. Khairil Anwar Abu Kassim, Malaysian Institute of Road Safety Research, 43000 Kajang Selangor, Malaysia.
E-mail: khairilanwar@miros.gov.my

This shows that the demand for a safety equipment such as a blind spot detector on a vehicle is at a crucial state. A device such as Vehicle Blind Spot System (VBSS) is an example of which assist the driver in detecting the presence of another vehicle on the designated blind spot area (Hassan and Zainal Ariffin, 2013). Nowadays, car manufacturing companies have developed this technology with various ways on their cars, in relevant of the safety factors, such as Blind Spot Information System (BSIS) for Volvo, Audi Side Assist for Audi, Blind Spot Monitoring used by Mitsubishi and Toyota as well Blind Spot Warning system use in Mazda vehicle. Unfortunately, in Malaysia, it is estimated that only 3% of the vehicle sales are equipped with this technology (Md Isa, 2016). This shows the necessity for Malaysian vehicle manufacturer to include this technology in our local products.

The aim of this research is to provide the best way of solving the blind spot crash that involves road users. The developed system must assist the driver's awareness of the behavior of other vehicles around the car effectively in various situations. The three main objectives of this research are first to design and second to develop smart and low-cost blind spot detection system to overcome the vehicle's blind spot phenomenon. Lastly, is to conduct an experimental study of the developed product to investigate the system's performance in various conditions.

II. METHODOLOGY

Currently, there are numerous ways of eliminating the blind spot that has been already used and effective in assisting the driving situation. However, each developed system has its own advantages and disadvantages which require the engineer to further look for an improvement. This project circulates on the blind spot issue and discovers the best technology for blind spot detection system. A systematic methodology has been conducted to form a new system known as Vehicle Blind Spot Detection System (VBDS) based on 24 GHz radar sensors. A deep research within the area of blind spot technology has been carried out to detect the blind spot for the present work is presented in Figure 2.

As background study, some comparison had been done to compare type technology that are applicable which can achieve the objective of this study. Those technologies are ultrasonic technology, vision technology, radar technology and wireless technology. After some discussion with Malaysian Institute of Road Safety Research (MIROS) vision technology and radar technology

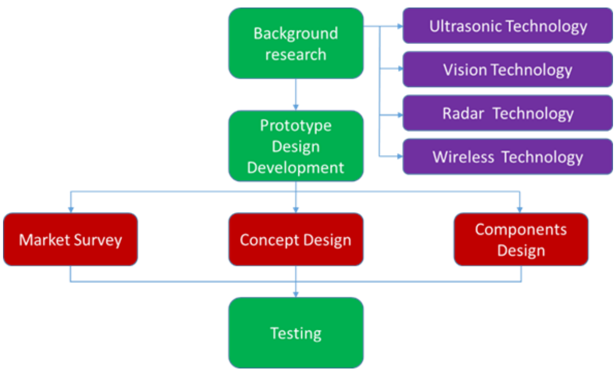


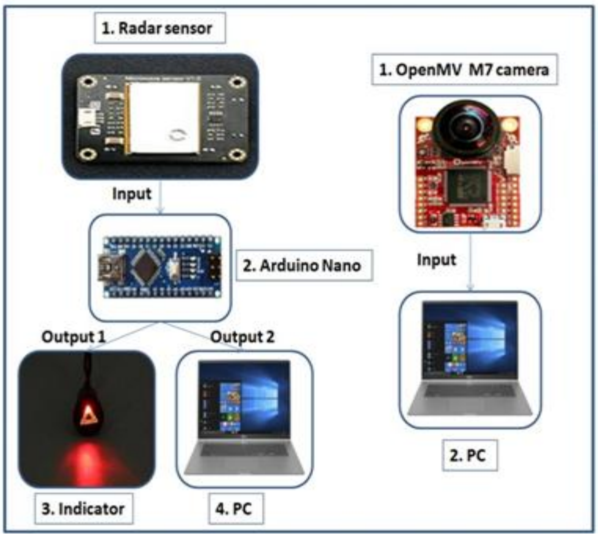
Figure 2: Flow chart of the VBDS development

This study had been conducted in three phases. The proposed VBDS implementation can be categorized into 3 phases. The details for each phase are as follows.

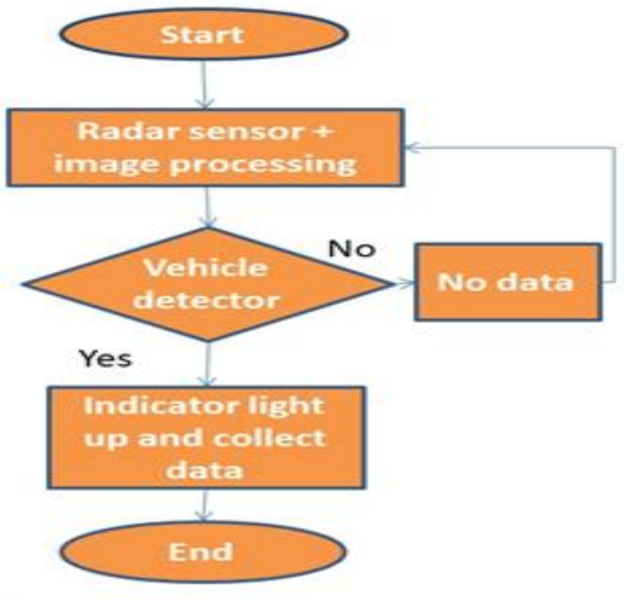
a) Phase 1: Development of VBDS based on 24 GHz radar
b) Phase 2: Data collection
c) Phase 3: Data analysis

A. Phase 1: Development of VBDS

Figure 3(a) shows the hardware requirements of VBDS. VBDS consists of radar sensor and OpenMV M7 camera as an input part, Arduino nano as a processor and indicator and personal computer as an output part. The complete process of VBDS can be illustrated in Figure 3(b). The visibility of the vehicle will be captured by the radar sensor and the camera. This process will be repeated continuously if no vehicle is detected within the blind spot region. Whereas, as a vehicle exists, the light will be light up and the buzzer will be ring. The driver will be notified and the data will be collected into the personal computer. The image of the assembled VBDS is shown in Figure 4. Two indicators which can light up and ring up had been setup at the front of vehicle in the left and right side. While, VBDS had been setup at the back of vehicle also for the left and right side. Thus, OpenMV M7 camera had been setup at the middle of back side of vehicle. The range of VBDS detection had been set to detect 3 to 6 meters from the back side of vehicle. Figure 5 shows how the VBDS had been setup within the range of blind spot.



(a)



(b)

Figure 3: Development of VBDS (a) Hardware requirements (b) VBDS process flowchart.

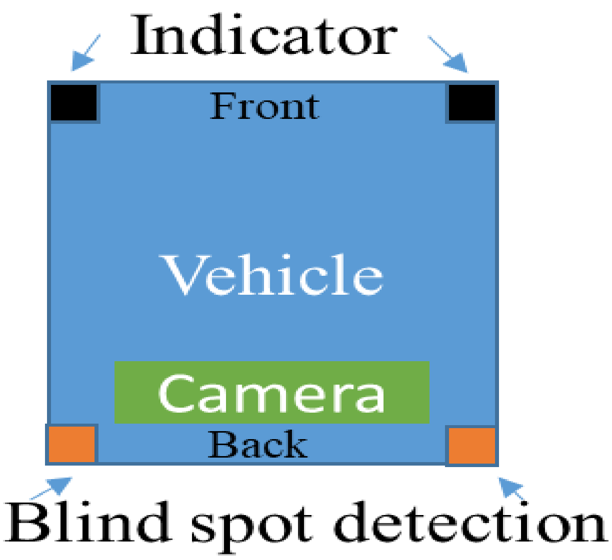


Figure 4: VBDS assembled in a car

Figure 5: VBDS range of blind spot setup for right side

B. Phase 2: Data Collection

At first, to test the functionality of VBDS. VBDS has been tested at Malacca with 3 different roads and 4 different time settings had been selected based on the traffic situation which included with peak hour and non-peak hour. Data collection during particular 30 minutes of driving on the selected locations in Malacca were recorded. Type of 4-wheel drive vehicle (HONDA CIVIS) had been choose to run the test. Figure 6 to Figure 8 illustrate the respective road that have been selected for testing. The test was conducted continually from road 1 to road 2 and to road 3 and repeated again for 4 times within the range hour of 8:00 to 10:00, 11:00 to 13:00, 16:00-18:00 and 19:00 to 21:00.

Malacca, Road 1

Road 1 was selected from Malacca International Trade Centre, 75450 Ayer Keroh, Malacca to Multimedia University, Jalan Ayer Keroh Lama, 75450 Bukit Beruang, Malacca. Location details for Road 1 with a total distance of 4.4 km as shown in Figure 6.

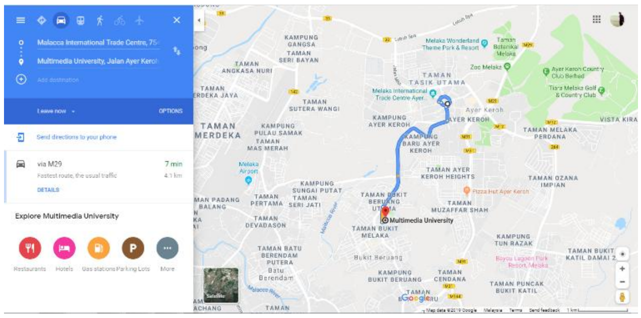


Figure 6: Road 1 for Malacca

Malacca, Road 2

Multimedia University, Jalan Ayer Keroh Lama, 75450 Bukit Beruang, Malacca to AEON Bandaraya Melaka, Aeon Bandaraya Melaka No, 2, Jalan Lagenda, Taman Lagenda, 75400, Melaka was selected for Road 2 with a total distance of 8.4 km (Figure 7).

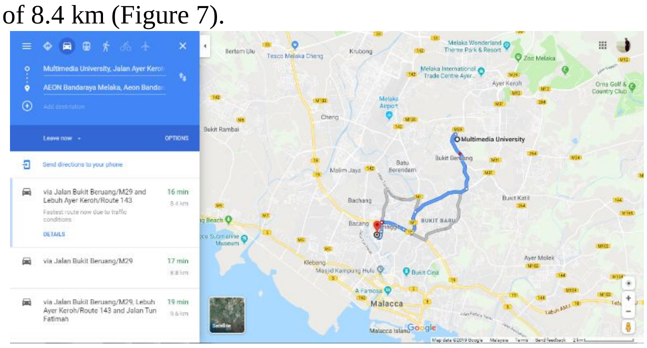


Figure 7: Road 2 for Malacca

Malacca, Road 3

Figure 7 shows route selection for Road 3 in Malacca which started from AEON Bandaraya Melaka, Aeon Bandaraya Melaka No, 2, Jalan Lagenda, Taman Lagenda, 75400, Melaka to airport to Melaka Airport, Jalan Lapangan Terbang Melaka, 75350 Batu Berendam. Location details for Road 3 has a total distance of 6.9 km.

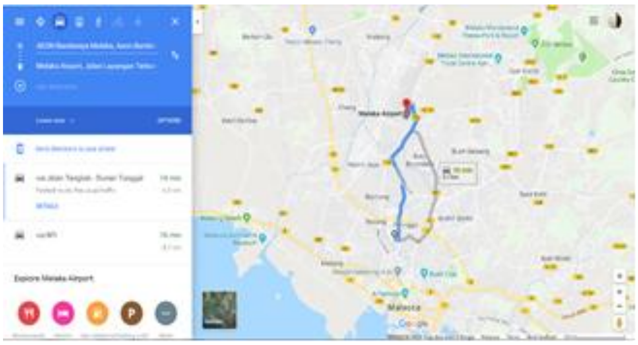


Figure 8: Road 3 for Malacca

C. Phase 3: Data Analysis

The VBDS data were analyzed using Microsoft Excel. The International Organization for Standardization (ISO) standards (ISO 17387) has been referred. It is a standard Intelligent transport system — Lane change decision aid systems (LCDAS) — Performance requirements and test procedures. LCDAS are fundamentally intended to warn the driver of the subject vehicle against potential collisions with vehicles to the side and/or the rear of the subject vehicle, and moving the in the same as direction as the subject vehicle during lane change maneuvers. For this study we applied Type 1 as shown in Table 1.

Type 1 systems provide the blind spot function only. These systems are intended to warn the subject vehicle driver of target vehicles in the adjacent zones. These systems are not required to provide warnings of target vehicles that are approaching the subject vehicle from car. The subject vehicle drives shall be made aware of the limitations of this type of system, at least in the owner's manual. In particular, the owner's manual shall include following statement. “This system provides support only within a limited area beside the vehicle. The system may not provide adequate warning for vehicles approaching from the rear.”

Table 1 Coverage zone classification

Type	Left adjacent zone coverage	Right adjacent zone coverage	Left rear zone coverage	Right rear zone coverage	Function
I	X	X			Blind spot warning
II			X	X	Closing vehicle warning
III	X	X	X	X	Lane change warning

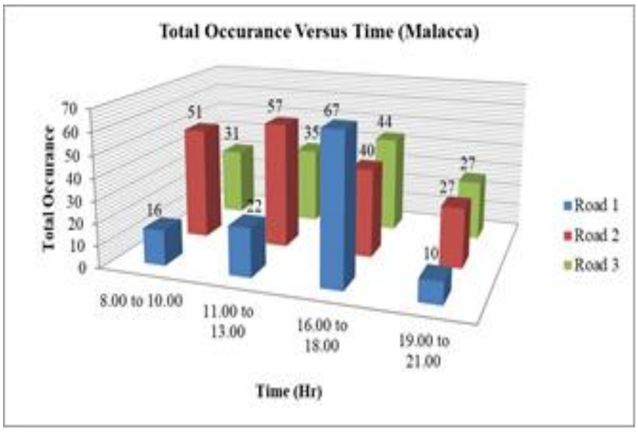


Figure 9: Total vehicle detection in Malacca

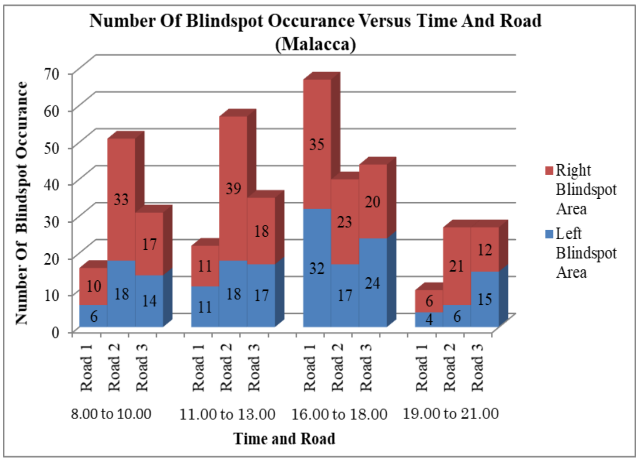


Figure 10: Vehicle detection based on different blind spot region in Malacca

III. RESULT AND DISCUSSION

Figure 9 show the total vehicle detection by VBDS at the 3 selected locations. The test was conducted on 13 September 2019 (Friday). While Figure 10 show the division of the vehicle detection based on left and right blind spot area for those selected locations. The results show that the system can recognize the vehicles exist within the blind spot area especially during peak hour which will provide a huge impact for the people in the urban city.

IV. CONCLUSIONS

The design and development of a Vehicle Blind Spot Detection System (VBDS) is demonstrated in this article by implementing a radar sensor and OpenMV M7 camera as a significant device to detect the vehicle visibility in the blind spot region. The system performs as planned in detecting the vehicles in 3 different locations situated in urban areas which known as the busiest route during peak hour. In the meantime, future work may be done to improve the accuracy in the recognition process as well as speed up the time taken to detect the multiple vehicles at the same time.

ACKNOWLEDGMENT

The authors would like to thank the support and guidance given by Faculty of Mechanical and Manufacturing Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM), Malaysian Institute of Road Safety Research (MIROS) and ASEAN NCAP secretariat through ASEAN NCAP Collaborative Holistic Research (ANCHOR II) programme. This work had been carried out through the grant of

Antarabangsa-ANCHOR/2019/FTKMP-AMC/A00019.

REFERENCES

1. Audi Technology Portal (2016) Audi Q2 Side Assist. Available at: https://www.audi-technology-portal.de/en/electrics-electronics/driver-assistant-systems/audi-q2-side-assist_en (Accessed on 5 February 2018)
2. Grosch, T (1995) Radar Sensor for Automotive Collision Warning and Avoidance, Proceedings of The SPIE-The International Society of Optical Engineering, Vol. 2463, pp. 239-247.
3. Hanlon, M. (2004) Volvo Launch Blind Spot Information System (BLIS). Available at: https://newatlas.com/go/2937/ [Accessed on 23 February 2018].
4. Hassan, M.Z. and Zainal Ariffin, H.I. (2013) Development of Vehicle Blind Spot System for Passenger Car, Applied Mechanics and Material, Vol. 393, pp. 350-353.
5. Instructables (2014) How to Use Ov7670 Camera Module With Arduino? Available at: http://www.instructables.com/id/How-to-use-OV7670-Camera-Module-with-Arduino/ [Accessed on 14 April 2018]
6. Lidar and Radar Information (2017) Advantages and Disadvantages of Radar System. Available at: http://lidarradar.com/info/advantages-and-disadvantages-of-radar-systems (Accessed on 1 March 2018)
7. Md Isa, M.H. (2016) Blind Spot Technology Must Be Seen, The Sun(Malaysia).
8. Muller, F d P (2017) Survey on Ranging Sensors and Cooperative Techniques for Relative Positioning of Vehicles, Sensors, Vol. 17, Issue 2, pp. 1-7.
9. Padmanabhan, S. and Chellamuthu, C. (2013) A Study on Blind Spot Warning and Lane Change Warning in Vehicular Communication, Journal of Machine Learning Technologies, Vol. 3, Issue 1, pp. 72-75.
10. Park, M.W., Jang, K.H. and Jung, S.K. (2012) Panoramic Vision To Eliminate Driver's Blind Spot Using a Laser Sensor and Cameras, International Journal of Intelligent Transportation Systems Research, Issue 3.
11. Qureshi, K.N., Abdullah, H. and Ullah, G. (2014) Sensor Based Vehicle Environment Perception Information System, Ubiquitous Intelligence and Computing, 2014 IEEE 11th Intl Conf on and IEEE 11th Intl Conf on and Autonomic and Trusted Computing, and IEEE 14th Intl Conf on Scalable Computing and Communications and Its Associated Workshops (UTC-ATC-ScalCom).
12. Rasshofer, R. H. and Gresser, K. (2005) Automotive Radar and Lidar Systems for Next Generation Driver Assistance Functions, Advances in Radio Science, Vol. 3, pp. 205-209.
13. SAAQ (2018), Visibility Around Heavy Vehicles. Available at: https://saaq.gouv.qc.ca/en/road-safety/behaviours/blind-spots/visibility-around-heavy-vehicles/ (Accessed on 31 January 2018.

AUTHORS PROFILE

Mohammad Nor Bin Mustaza is an undergraduate student of Universiti Teknikal Malaysia Melaka. From Faculty of Electrical and Electronic Engineering Technology.

PM. Dr. Muhammad Zahir Hassan Qualification in Ph.D. Engineering from University of Leeds. Area of Interest in Innovative Automotive Technology.

Ts. Dr. Norfariza Ab Wahab Qualification in Ph.D. Engineering (Mechanical Engineering), Master Engineering (Mechanical Engineering), Bachelor of Degree Engineering (Mechanical Engineering), Diploma (Electronic Mechanical Engineering). Area of Interest in Manufacturing, Machining Process, CAD/CAM, Green Technology. Has Won Gold in UTeMEX19, Bronze in MIIX19, Gold in MIIX17 and Bronze in UTeMEX17 of Vacuum Clamping.

Dr. Suhaila Mohd Najib Qualification in Ph.D. Engineering from Universitit Teknologi Malaysia. Area of Interest in Process Tomography, Tomographic, Image Processing, Instrumentation System and Embedded System.

Ir. Dr. Khairil Anwar Abu Kassim, is a Director of Center of Vehicle Safety and Biomechanics at Malaysian Institute of Road Safety Research. Area of Interest in Vehicle Safety, Automotive and Consumerism.