



Development of Prototype Smart Helmet and Blind Spot Detection for Motorcyclist Safety Features

Umi Nuratiqah Mohd Hussin¹, Hong Yin Lam^{2, a}, Sim Sy Yi², Farahiyah Mustafa², Maizul Ishak²

¹Department of Electrical Engineering Technology,
Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia

²Department of Electrical Engineering Technology,
Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia

*Corresponding Author

Email: hylam@uthm.edu.my

Received 25 September 2020;
Accepted 28 October 2020;
Available online 28 October
2020

Abstract: Motorcycle safety concerns many aspects of vehicle and equipment design as well as operator skill and training that are unique to motorcycle riding. This project focus on the development of prototype smart helmet and blind spot detection features for motorcyclist safety system. The main objective of this work is to reduce the blind spot area for motorcyclists. The developed system are capable of measure appropriate distances (~ 10 cm to 50 cm) of insecurity among motorcyclists and vehicle behind by means of ultrasonic sensors and vibrator motor. The ultrasonic sensor play a role to detect any vehicle from behind the motorcyclist and system will alert the rider through the vibrator motor, LEDs and buzzer that install at the helmet as a warning to the rider about the range of insecurity. The system employed Arduino UNO as the main processing unit to control all the connectivity components. OLED display are also connected to the Arduino UNO mounted in front of the rider for displaying the distance detected by the ultrasonic sensor. Wireless transceiver module is use to serve as a data transmitter and receiver in which transmitted data collected by ultrasonic sensor will wirelessly transmit to the helmet node which is the receiver unit. In conclusion, this developed prototype project work are able to provide better solution for motorcyclist safety features in order to reduce the probability of accidental rate.

Keywords: *blind spot detection, motorcycle safety, wireless transceiver, smart helmet*

1. Introduction

Road accidents are defined as accidents involving vehicles accidentally or drivers losing control of the vehicles resulting in either minor or serious injuries including deaths. Among the Association of Southeast Asian Nations (ASEAN) countries, Malaysia has the highest road calamity risk and more than 50% per 100,000 population of the road accident fatalities involve motorcyclists [1]. According to the police statistics in 2016, 62.7% of people who died in the road were motorcyclists [2].

According to the fatality distribution by mode of transport in Malaysia, motorcycle has the highest percentage of accident rate compared to other vehicle. This shows that the motorcyclist have to focus more while riding than ordinary drivers. They must alert and have a lot to keep track of while on the road,

such speed, directions, and unobservant drivers sharing the lane and make any possible effort to avoid potential collisions.

The main causes of accidents faced by motorcyclists are failure to yield the right of way, lack of awareness of the potential dangers lingering outside of their natural field of view and lack of control of the motorcycle. Motorcyclists have an issue that they cannot see or view what is happening behind them or their vehicle. They should not to rotate their entire body and head away from their line of travel to know if there are vehicles to the side, back or even their blind spots. With this lack of ability, will lead to cause accident and motorcycle fatality.

Motorcyclists have issue to estimate the distance between themselves and any vehicle behind them or at the area of the

blind spots. Motorcycle or other equipment of motorcycle at least have to provide with this safety features so that they will be more alert and aware of the surroundings.

Accidents involving motorcyclists are getting worse day by day. The main factor of fatality involving motorcyclist is caused by the negligence of the motorcyclist itself. The motorcyclist does not alert of the blind spot during riding the motorcycle. As the result, unsafe distance will occur between other vehicles and likely to occur accidents that may cause injury or death. Besides, could cause damage to the motorcycle and the other vehicles involved. This situation needed to be stop or at least can be reduced. In addition, the sided mirror of motorcycle does not focus on the surroundings and cannot estimate the distance of the vehicle from behind the motorcyclist. The impact of this situation shows that the rear of the motorcycle cannot be ascertained with small side mirror. Furthermore, as the motorcyclists need to focus on the road, they cannot see or use smartphone to navigate direction, alert the speed limits and alert any obstacle ahead of the road. This shows that the information on the road are very limited due to the motorcyclist need to focus riding. The specific objectives of this project are as follows:

- i. To develop a prototype blind spot detection at motorcycle using ultrasonic sensor and Arduino UNO.
- ii. To develop a wireless prototype smart helmet alert system using nRF24L01 transceiver module, vibrator motor, buzzer and LED.
- iii. To integrate the blind spot detection features with wireless smart helmet and validate the functionality of the develop system.

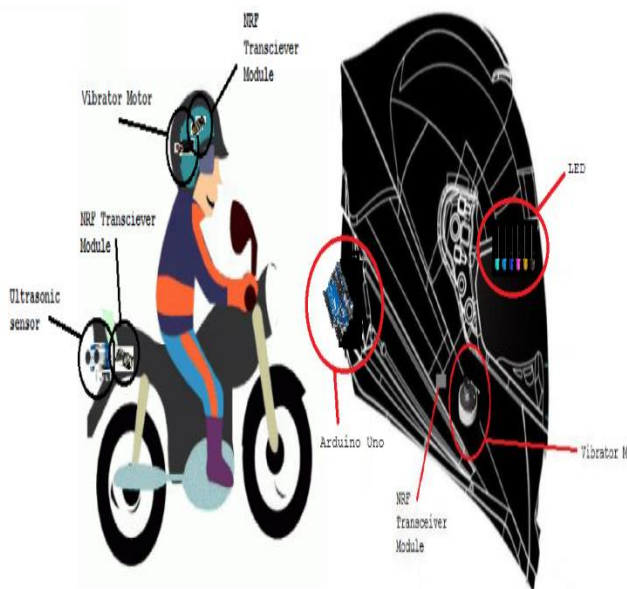


Figure 1: The specific system design for this project

2. Review of currently developed product and system

This section survey and review currently existing related project/product. The review mainly surveys related development of smart helmet, and comparison among them.

2

Then followed by review of blind spot detection and others subsystem such as communication, sensors and processing unit.

2.1 Smart Helmet

Smart Helmet in this world globalization becoming a very common product used by the motorcyclist. This IoT product helps to reduce the impact of accident faced by the motorcyclist [3] in a high-speed accident that can cause the fatality. Wearing a helmet can reduce shock from the impact and may save a life. There are many countries enforcing a regulation that requires the motorcyclist to wear a helmet during riding on their motorcycle.

Based on the study on the existing types of smart helmet with different safety features, it is shown that there are many types of smart helmet with different function and features depending on the user's requirement.

Table 1: Summary of existing smart helmet project.

No	Design Project	Sensor used	Safety Features	Communication Unit / Controller
1.	Rasli. M. K. et.al [4]	Force Sensing Resistor (FSR) and BLDC Fan	Detect rider's head, safety belt and speed limit	315MHz Radio Frequency Module and PIC16F84a microcontroller
2.	Muthiah et.al [5]	Accelerometer	Automatic autonomous headlight based on rider's facial movement	RF Transceiver Module and Arduino Atmel Atmega 328 chip
3.	Chitte P. P. et. al [6]	Alcohol sensor, FSR, MQ-3 sensor and accelerometer	Ignition control, accident identification and hands free device	RF Module, GSM, GPS module and Arduino Lilypad
4.	Kumar D. P. et.al [7]	Vibration sensor	Bluetooth hands free and cooling device module	GSM Modem, GPS Module, PIC Microcontroller and RF Transceiver
5.	Katkar S. et. al [8]	Flow sensor, alcohol sensor, tilt sensor, bumper switch and limit switch	Ignition control, detect whether rider wear helmet, bike theft and fuel theft alert	GSM, GPS and RF Transceiver

2.2 Blind Spots Detection

An accident involving motorized vehicle usually occur when the rider attempt to change lane from one to another lane either to the left or to the right. Due to the carelessness of the rider to make sure there is no other vehicle or oncoming vehicle

on the lane and the unsighted blind spot could lead to a fatality to the motorcyclist.

Vehicles blind spot detection and warning system [9] is a project proposed by a student from Universiti Teknikal Melaka to overcome the problem. The main purpose of the project was to develop and implement a device that will warn the rider about the incoming vehicles in the blind spot area. The system of the project was controlled by Arduino and the main sensor used is an ultrasonic sensor. The design of the project focused the area covered by the ultrasonic sensor to detect the incoming vehicle from the back of the motorcyclist. The sensor was put in two different positions on the motorcycle which are above the rear tire and under the side mirror with 45° slant. When a vehicle is detected by the ultrasonic sensor, it sends the data to Arduino and LED will be blinking to give an alert or warn to the motorcyclist.

2.3 Communication Unit

Radio frequency (RF) Transceiver Module is a single chip radio transmitter and receiver for worldwide 2.4 GHz – 2.5 GHz ISM band. The transceiver consists of a fully integrated frequency synthesizer, a power amplifier, a crystal oscillator, a demodulator, modulator and Enhanced ShockBurst™ protocol engine. Output power, frequency channels, and protocol setup are easily programmable through a SPI interface. Current consumption is very low, only 9.0mA at an output power of -6dBm and 12.3mA in RX mode. Built-in Power Down and Standby modes makes power saving easily realizable [10].

This project is use the nRF24L01 Single chip 2.4 GHz Transceiver because is cheapest and nearly the smallest module available. It is perfectly usable with the Arduino IDE for example and it is easy connecting to the Arduino UNO. It also has many tutorials can be refer to ensure the nRF24L01 can be function as well. Range of nRF24L01 is very dependent on the situation and is much more with clear line of sight outdoors than indoors with effects of walls and materials. The usual distance quoted by different suppliers for the low-power version module with the single chip is 200 Feet or 100 Meters.

2.4 Sensing Unit

Ultrasonic ranging module HC-SR04 [11] provides the range of measure distance from 2cm to 400cm for measurement function, the ranging accuracy can reach to 3mm. The modules include ultrasonic transmitters, receiver and control circuit. Its operation is not affected by sunlight or black material like Sharp rangefinders although acoustically soft materials like cloth can be difficult to detect.

The basic principle of work of the HC-SR04 are using IO trigger for at least 10us high level signal and the module automatically sends eight 40 kHz and detect whether there is a pulse signal back. Besides that, IF the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning. For the test distance is equal to high level time $\times$ velocity of sound (340M/S) / 2.

The features of HC-SR04 ultrasonic sensor are 5V DC power supply, quiescent current less than 2mA, working current is 15mA, the effectual angle is less than 30°. For the ranging distance is from 2cm to 400cm, the resolution is up to 0.3cm. The ultrasonic sensor HC-SR04 is not suggested to connect directly to electric, if connected electric, the GND

terminal should be connected first, otherwise, it will affect the normal work of the ultrasonic sensor.

2.5 Processing Unit

Processing unit is the main component for both sink node and sensor node. Behavior of the developed system is defined or determined by the program designed in the processing unit. The Arduino is a flexible platform with great ability to interface to most anything. It is a great platform to learn first and perfect for many smaller projects. The Raspberry Pi is good for projects that require a display or network connectivity. The Beagle Bone black is a great combination of some of the interfacing flexibility of the Arduino with the fast processor and full Linux environment of the Raspberry Pi. Arduino has been chosen and used as it has an easy to use development environment, an avid user base and is designed to be easy to interface all sorts of hardware to.

3 Operating Principles and Methodology of the System

This section outline the methodology used in this work. These include in details of working principle, the flow of the overall development and techniques for the entire project as well as details methodology of hardware, software including project cost.

Figure 2 and Figure 3 separately shows the block diagram of the overall project consists of transmitter and receiver unit.

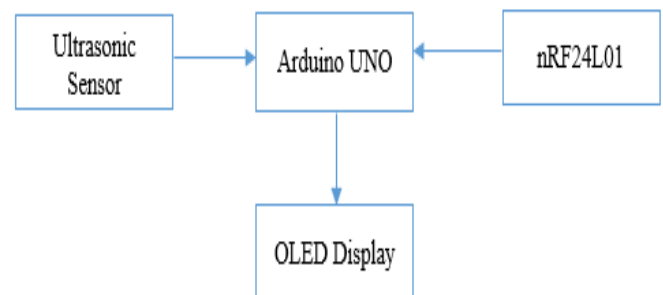


Figure 2: Block diagram of transmitter unit

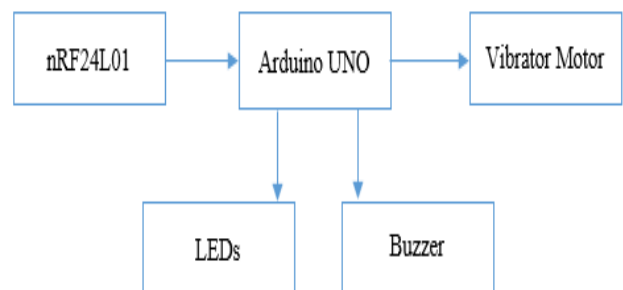


Figure 3: Block diagram of receiver unit

Transmitter unit consists of one Arduino UNO that act as the processing unit connected with ultrasonic sensor that function as the sensor to detect the blind spot and safety distance between motorcyclist and any vehicle or obstacle behind it. OLED display mounted at the front of the motorcycle will display the distance detected by the ultrasonic sensor. One transceiver module nRF2L01 connected with Arduino UNO will act as the transmitter that will transmits data collected by

the ultrasonic sensor to the other pair of nRF24L01 at the receiver unit that act as the receiver.

At the receiver unit, the processing unit use as same as the transmitter unit, which is the Arduino UNO. The Arduino UNO connected with nRF24L01 that act as the receiver will receive data from the transmitter and will trigger the alert unit at certain distance that have been programmed in the Arduino UNO. The alert unit consist of the buzzer, vibrator motor and LEDs.

3.1 System Design

The system design are generally divided into two main part. The first part is the hardware design and development while the second part focusing on the programming coding and software development. The hardware design involves integration of processing unit, communication unit, alerting system and sensor unit while software development focused on the programming implementation of the project. Figure 4 shows the flow diagram of designing and development of hardware and software.

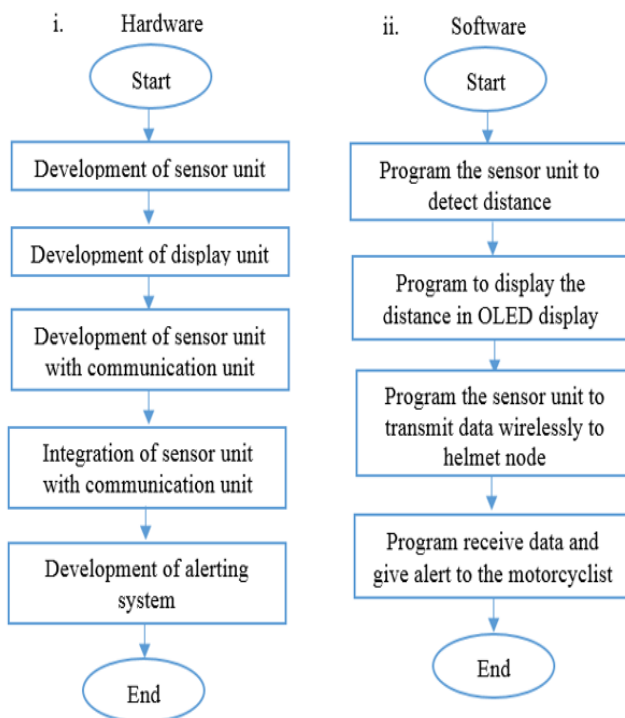


Figure 4: Flow diagram of designing hardware and software

3.2 Hardware Development

Hardware design and development mainly divided into two major part namely the transmitter section and the receiver section.

Development of transmitter unit employed Arduino UNO which connected with the ultrasonic sensor. The Arduino UNO act as the processing unit and the ultrasonic sensor function to detect the distance of insecurity between the motorcyclist and any vehicle from the back direction. On the other hand, OLED display are connected on the front part of the motorcycle (beside of the meter) which display the distance detected by the ultrasonic sensor in real time. Figure 5 shows the circuit diagram of transmitter unit.

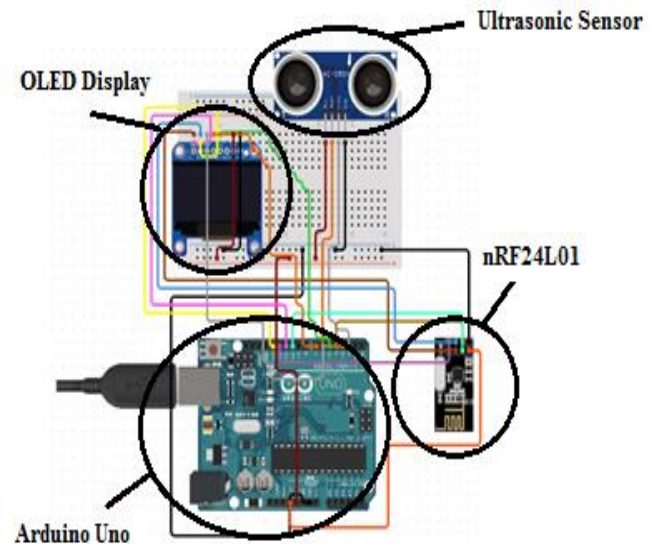


Figure 5: Circuit diagram of transmitter unit

The data collected will be transmitted wirelessly via transceiver module to the receiver unit consists of Arduino UNO as the processing unit, nRF24L01 as the wireless device to transmit and receive data and the alert unit consists of buzzer, LEDs and vibrator motor. If the distance between the motorcyclist and the vehicle from the back direction is less than 50 cm, the alert unit will triggered alert to the motorcyclist with buzzer, vibrator motor and LEDs to the helmet. Figure 6 shows the circuit diagram of receiver unit.

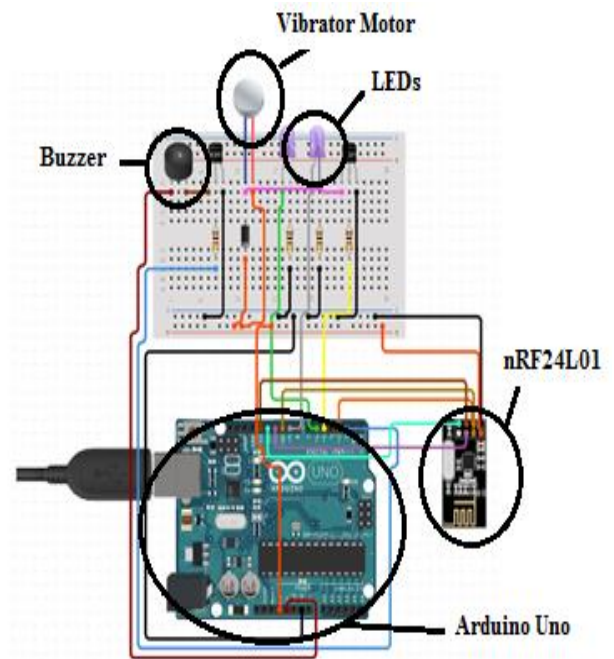


Figure 6: Circuit diagram of receiver unit

3.3 List of hardware

Below is the list of hardware and component cost of the project. Table 2 shows the hardware required for this project.

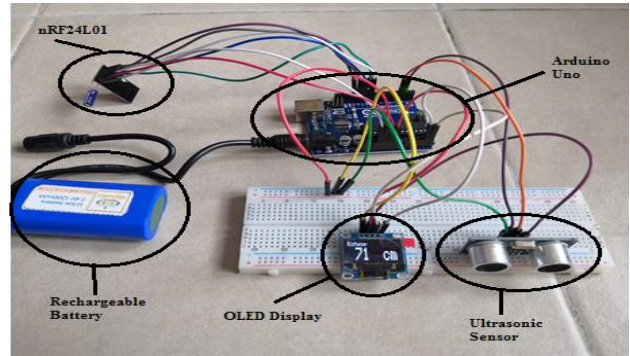
Table 2: List of Hardware

No.	Item	Quantity	Price/unit
1.	Arduino UNO	2	RM 32
2.	RF Module Transceiver	2	RM 10
3.	Ultrasonic Sensor	1	RM 5
4.	Jumper Wire	20	RM 5
5.	Vibrator Motor	1	RM 8
6.	Capacitor (10uF)	2	RM 0.50
7.	LED	4	RM 1.20
8.	Resistor	1	RM 0.20
9.	OLED display	1	RM 30
10.	Rechargeable Battery (7.4V)	2	RM 26.50
11.	Strip board	1	RM 0.80
12.	Acrylic board	1	RM 30

4 Results and Discussions

The developed prototype smart helmet and blind spot detection for motorcyclist are completed and their functionality has been fully tested which strive to achieve the main aims of the work.

Figure 7 shows the transmitter unit which comprise of several devices such as ultrasonic sensor, OLED display, wireless transmitter as well as Arduino UNO. The transmitter unit are installed at the motorcycle and ultrasonic sensor are placed at the back of the motorcycle. Implementation and installation of the transmitter unit are illustrates in Figure 8 below.

**Figure 7:** The circuit of transmitter unit**Figure 8:** Implementation of transmitter unit at motorcycle

As the data transmitted to the receiver unit, another pair of nRF24L01 will received the data and at a certain distance it will trigger the alert unit which consist of buzzer, LEDs and vibrator motor. As the distance less than 50 cm, the alert unit will trigger. The receiver unit were embedded on the top of the helmet as shown in Figure 9. Functionality test of the developed prototype work has been carried out on real scenarios and the overall system work well. The video evidence of the test and system validation can be retrieve at [12].

**Figure 9:** The smart helmet embedded with circuit receiver unit

5 Conclusions

The prototype of smart helmet and blind spot detection for motorcyclist safety features has been successfully developed and validated. The prototype system are capable detect the range of insecurity between motorcycle and vehicle at the back at approximately 50 cm. The distance data are subsequently transmitted wirelessly to the receiver unit to trigger the alert unit embedded on the helmet consists of LEDs, buzzer and vibrator motor. The distance detected will also display at OLED display that have been mounted at the front of the motorcycle.

5.1 Recommendation

For the future extension of the prototype, there are several improvements that can be made to improve various features as follows:

- i. The project can be extended by adding sensor camera such embedded at the back of car.
- ii. The used of two ultrasonic sensor instead of one ultrasonic sensor at the back of the motorcycle to ensure the range coverage of the blind spot is bigger to reduce the probability of accident between the motorcyclist and the vehicle behind it. Such features are not implemented in this prototype due to budget constraint.
- iii. Several crucial safety features such as speed limit, navigation system and hands free device to attend call during riding the motorcycle could be considered as extension work.

Acknowledgement

This accomplishment would not have been possible without the cooperation and support of all the related individuals.

References

- [1] G. Jacobs, A. Aeron-Thomas & A. Astrop (2000). *Estimating global road fatalities*, TRL Report 445, Transport Research Laboratory, London, United Kingdom
- [2] Malay Mail. (2017, July 28). Police statistics: Motorcyclists form bulk of road accident fatalities | Malay Mail. Retrieved from <https://www.malaymail.com/news/malaysia/2017/07/28/police-statistics-motorcyclists-form-bulk-of-road-accident-fatalities/1430839>
- [3] Liu, B. C., Ivers, R., Norton, R., Boufous, S., Blows, S., & Lo, S. K. (2008). Helmets for preventing injury in motorcycle riders. *Cochrane Database of Systematic Reviews*. doi:10.1002/14651858.cd004333.pub3
- [4] Rasli, M. K., Madzhi, N. K., & Johari, J. (2013). Smart helmet with sensors for accident prevention. *2013 International Conference on Electrical, Electronics and System Engineering (ICEESE)*. doi:10.1109/iceese.2013.6895036
- [5] M, M., V, A. N., & K, S. R. (2015). Smart helmets for automatic control of headlamps. *2015 International Conference on Smart Sensors and Systems (IC-SSS)*. doi:10.1109/smartsens.2015.7873589
- [6] Chitte P. P., Salunke A. S., & Thorat A. N. (2016). Smart Helmet & Intelligent Bike System. *International research Journal of Engineering and Technology (IRJET)*
- [7] Kumar P. D., Ramaiah G. N. K., Subramanyam A., & Dharani M. (2015). A Powered Smart Helmet with Multifeatures. *International Journal of Engineering Invention (IJET)*
- [8] Katkar S., Matkar N., Parab S., & Shaikh S. (2017). Smart Helmet for Alcohol Detection and Accident Avoidance. *International Journal of Advance Engineering and Research Development*, 4 (03). doi:10.21090/ijaerd.47721
- [9] Redzuan. M. Q. A. (2015). Vehicles Blind Spot Detection and Warning System. *Universiti Teknikal Malaysia Melaka*
- [10] S. Nordic, (2007). "nRF24L01 Single Chip 2.4 GHz Transceiver," no. March, pp. 1 – 39.
- [11] Indoware, (2013). "Ultrasonic Ranging Module HC - SR04," *Datasheet*, pp. 1–4.
- [12] Video evidence of the test and system validation. (n.d.). Retrieved from <https://drive.google.com/open?id=1JjQbf0hth2sSCJtxpdfOGF9z0Un235s7>