Roadside Worker Detection and Alert System

by

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CERTIFICATION OF APPROVAL

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Approved by,

____
(Dr. Izzatdin Bin Abdul Aziz)

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own. The original work contained herein have not been undertaken or done by unspecified sources or persons.

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SITI NUR IZZATY BINTI NORIZAN

ABSTRACT

The project proposes a prototype system to alert drivers of the existence of roadside workers in order to reduce road accidents rate involving roadside workers. High fatality rate involving roadside workers can be reduce by pre-alerting the drivers during safe distance. A distance alert system is proposed to meet the need of alerting the drivers earlier to prevent accidents.

Radio Frequency Identification (RFID) technology is used as a simulator to indicate the existence of roadside workers and alert the drivers. In order for the prototype system to work effectively, RFID reader has to detect RFID tag and transfer the signal to a buzzer. The buzzer informs to the driver of the existence of nearby roadside workers for them to stay alert, and slow down, or change path if necessary.

The objectives of this project are to study the implementation of Radio Frequency Identification (RFID) as a simulator in detecting workers at the roadside of a highway and to develop a prototype system that can notify the driver on the presence of the worker at the highway. The significance this project; is to save lives by providing sufficient reaction time for drivers to safely avoid roadside workers.

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CHAPTER 1
INTRODUCTION

1 BACKGROUND OF STUDY

As reported by MIROS, number of road traffic deaths in Malaysia in the year of 2014 was 6,674 [1]. Every year, this fatality rate is on the rise as stated by Social Security Organisation (Socso) [2].

According to the World Health Organisation (WHO) in their latest 2013 Global Status Report on Road Safety, it is shown that the total number of road traffic death is as high as 1.24 million per year. This report covers statistics from 182 countries all over the world. They also highlighted five key risk factors that have been the main contributor to the road traffic accidents, which are drinking and driving, speeding, not wearing motorcycle helmets, does not fasten seat-belts and child restraint that disturb the focus of the driver [3].

In addition, there was a demand from the president of The National Institute for Occupational Safety and Health (NIOSH), Tan Sri Lee Lam Thye, when he voiced out his concern towards the safety of the contractor or roadside worker at the highway. Improvement is needed to avoid accidents from happening. He came out with this statement a day after an accident occurred involving an express bus, trailer and lorry which took place on 3.35 evening on December 8, 2014. The driver of the trailer had lost control and went to the opposite side of the highway and hit the express bus where at the opposite side, there was construction work undergoing [4].

Besides, we had also being informed by Encik Mohd Fauzi Mat Wazir and Puan Tuty Hamdan, staff from Traffic Safety Department of PLUS Highway; that there were two cases happened in 2012 and 2013. Case in 2012 was about a Propel staff that had been hit because the car was exceeding the speed limit. Meanwhile in 2013, an accident had occurred where a bus hit the Traffic Management Plan (TMP) and the bus was capsized [5]. Latest on July 13, 2015 it was reported that two roadside workers were dead while they were doing their job at the middle of the highway. Same thing happen when they were both being hit by a car and the driver was having some injury at the head part [6]. Those incidents happened are the strong reason why we need to add more safety precaution as a mechanism to protect the life of the roadside worker.

Therefore based on the cases and statistic presented, there is a dire need for a mechanism to prevent traffic accident from happening. This have motivates us to propose a prototype system that can alert drivers of the presence of roadside workers. The proposed prototype system uses Radio Frequency Identification (RFID) technology. This prototype system is only for simulation purpose to give better understanding on how the idea of this system will work in the future. To validate our approach, we have carry out lab scale experiments of roadside worker detection and alert system as a method of precaution with what is currently happened at the highway. Drivers can respond by slowing down their speed and change their path.

1.1 Problem Statement

We usually see workers at the highway. Some of them are cleaners and some are the contractors repairing the road. Their existence are sometimes not being realized by the driver at the highway which putting themselves in danger. Many factors can be the contributor to this problem, such as the attitude of the driver as well as their alertness. Lembaga Lebuhraya Malaysia (LLM), had released a statistics in 2013 regarding to accident factors. The statistics states that 86% of accidents are caused by human errors and the other two factors are from vehicle and surroundings environment, in which each contributes to 7% respectively [7]. This statistic shows to us that the drivers are the one that should be given extra attention to make them alert while driving.

Based on our previous interview with domain expert in accident and safety from PLUS Highway, Encik Mohd Fauzi Mat Wazir and Puan Tuty Hamdan; two main precautionary steps were always taken to make the drivers alert of the existence of the roadside worker. The precautionary steps can be divided into two which are to be used by the worker themselves and also for initial warning to the driver. Roadside workers have to wear their bright luminous personal protection equipment and safety vest; and the initial warning for the drivers are the Traffic Management Plan (TMP) where all the warning signboards being placed at the highway. Both can be considered as visual safety aspect which requires the driver to look at those to notify them that there are construction works in progress at the roadside [5].

There are other existing systems which relate to collision avoidance like what had been implemented by Volvo. As reported by Highway Loss Data Institute, Volvo cars had been equipped with five features and one of it is forward collision warning [8]. The difference that we are trying to implement with our proposed system is that we would like the car to specifically detect the existence of the roadside worker in front of them because our major concern is the safety of the road side worker. Therefore, we proposed to use RFID technology for the prototype system implementation based on the comparative study that we have done. RFID is the only technology that has specific detection item RFID tag [9][10][11][12]. Thus, detection will be made more specific and precise.

1.2 Objectives

1. To perform a comparative study and analysis of wireless technologies, microcontrollers and sensors that is feasible to detect roadside workers.
2. To develop a prototype system that can alert the driver on the presence of the roadside workers at the highway.

1.3 Scope of Study

In this Final Year Project (FYP) we are planning to make a simulation of the distance warning system. Therefore the data and all its measurement will be scaled to a lab scale environment. Since road traffic accident could happen anywhere, so we are narrowing the scope for the use of Malaysia highway and as proof of concept only for straight highway. The main device that will be used to be implemented in this prototype system is ID-12LA Innovation [12] Radio Frequency Identification (RFID). Meanwhile, for the microcontroller, Arduino UNO will be used in this project to be link with the buzzer.

CHAPTER 2
LITERATURE REVIEW

2 OVERVIEW

This chapter has been divided into four sections which are 2.1 on Reflection Time, 2.2 is the Existing System, 2.3 will be on Road Safety and lastly 2.4 will show the comparative study between technologies available and type of frequency for RFID.

2.1 Reflection Time

Many research and study have been done to come out with a system that can help reducing the number of collision or accidents with the cars or obstacles ahead. According to Yuan, Shun, and Chong, one salient factor that needs to be put into consideration is the safety reflection time or safety distance of a driver [13]. The safety distance consist of reflection time, change brake pedal time and braking action time.

Reflection time is the moment for an individual to be alerted with their external condition [13]. Vision, hearing and their own experience will drive them to be alert with the surrounding situation. Their vision will help them see what is actually happening, hearing might alert them with unconditional situation and experience, which is what they fell or preserve at that current moment. Yuan, Shun, and Chong stated that reflection time for a common person is estimated between 0.36 up till 0.66 seconds. This is the time taken for a normal person to be aware of the situation [13]. However, the reflection time can differ based on the changes of an individual emotion and also physical stamina. They also mentioned that unfavorable road condition will need more reflection time for the driver to vigilant to their surroundings.

Once a person started to alert with the surrounding condition, the next thing to be considered is to press the brake pedal. In Yuan, Shun, and Chong paper itself, they highlighted that there are relationship between reflection time and the brake pedal time. A person in the state of calmness does not need much time to change their foot from the accelerator pedal to the braking pedal as compared to person that is anxious. Time taken for a common person to change pedals is likely to in between 0.15 to 0.21 seconds [13].

Next, based on Yuan, Shun, and Chong, the third element that needs to be considered is the braking action times, which is time taken for a driver to step on the brake pedal and start to brake. This action takes for about 0.17 to 0.24 second [13]. Thus, it shows that there is a need for some improvement with the current vehicles. By knowing the common reflection time of normal drivers, we can now proceed to investigate and determine the safe distance for the drivers to be alerted. However, the safe distance for each driver is different depending on the speed of their vehicle at a particular time. With that, they can prepare themselves to change the path taken to avoid from hitting the roadside worker.

Table 1. Total Stopping Distance

Total Stopping Distance [14] [15]			
Speed of The Car	Thinking Distance	Braking Distance	Stopping Distance
20 mph (32 km/h)	6 m	6 m	12 m
30 mph (48 km/h)	9 m	14 m	23 m
40 mph (64 km/h)	12 m	24 m	36 m
50 mph (80 km/h)	15 m	38 m	53 m
60 mph (96 km/h)	18 m	55 m	73 m
70 mph (112 km/h)	21 m	75 m	96 m

Table 1 shows the total stopping distance based on the speed of the car. To be in a safe condition where the driver can stop easily, it is a need for each driver to leave adequate distance between their car and the other vehicle in front. In Table 1, the safe distance is the combination of thinking distance and braking distance [14]. Thinking distance is the distance before the driver strarts to react. It is a distance covered as the car keep on moving with the initial speed before brake. Meanwhile, braking distance is the distance covered while the car is braking [14]. The other important reason for keeping our car in safe distance is that, whenever there are obstacles or the car in front of us stop unexpectedly, we manage to control our car from hitting those in front. Plus, keeping our car at the safe distance will make us more calm to handle the car. For example, when a driver drive his car at the speed of 112 km/h the safe distance for them is 96 metres. 21 metres is the distance travel before the driver starts to break and the other is the distance while braking [14] [15]. In this project, we will insert the speed of the car as if it is the real travelling speed of the car. With the speed being keyed in, we will then determine when should the prototype system give alert to the vehicle depending on the safe distance.

2.2 Existing System

One of the famous motor vehicles brand, Volvo had implement additional features to avoid collision between cars and cars and also cars with other obstacles. Reported from the Highway Loss Data Institute in 2012, there are four features by Volvo which are Active Bending Lights, Forward Collision Warning, Forward Collision Warning with Auto Brake and Blind Spot Information System. The one that we would like to stress on is the Forward Collision Warning [8].

Basically the idea of Forward Collision Warning mentioned by the Highway Loss Data Institute is just like the problem statement of this project. Technology that has been used for this feature is radar sensor that has been mounted at the front part which is the bumper. The use of this sensor is to detect the risk of collision. Warning alert that will be produced will cover both auditory and visual as there will be red indicator lights located at the heads-up windshield display. In addition, this warning will only be applicable if the car is at the speed of 20 and 120mph. It will automatically cancel, once the driver hit the brake pedal [8].

2.3 Road Safety

Number of road traffic accident globally had led to United Nation General Assembly in 2010 which had made a declaration that 2011-2020 as 'A Decade of Action for Road Safety'. The goal of this declaration is to stabilize and reduce the forecasted level of traffic fatalities around the world. In Malaysia, Jabatan Kerja Raya (JKR) is the organization that having the responsibility to conduct this declaration in Malaysia [16].

Based on our previous interview with Encik Mohd Fauzi Mat Wazir and Puan Tuty Hamdan, Staff from Traffic Safety Department of PLUS Highway (2015), they mentioned that two types of safety aspect currently being implemented for the safety of roadside worker at the highway which is the Traffic Management Plan (TMP) and Personal Protection Equipment (PPE). The first thing to be done before contractors get permission to start their construction work is to apply for working permit. Once they get the working permit, they have to propose TMP for that particular construction side, which the construction will take place. This is simply because TMP proposed is depending on the structure or condition of the place where the construction take place. TMP consist of five zones and this plan is used to arrange warning signboard at the construction side. It starts with Advanced Warning Area and continue with Transition Area, Buffer Area, Work Area and will end with the Termination Area [5]. Table 2 will describe in detail the five zone of the Traffic Management Plan (TMP) [16].

Table 2. Traffic Management Plan

ZONE	FUNCTION
Zone A: Advanced Warning Area	• It acts as the initial warning to the driver that there is construction work being done ahead.
Zone B: Transition Area	• Changes will be occurred from a normal traffic towards a construction area.
Zone C: Buffer Area	• This area will make free from any construction equipment, vehicles and roadside worker for safety purpose.
Zone D: Work Area	• Area where the construction work is being conduct.
Zone E: Termination Area	• Area to return back the traffic to normal traffic.

It is very important for the construction worker at the roadside of the highway to follow the guideline that has been prepared. Table 2 listed the five zone of TMP which need to be followed. In each zone, different warning signboard will be arranged. For example in Zone A, it will start with the main signboard informing that there are construction works ahead [16][17]. Figure 1 will show the basic arrangement of the warning signboards for all the five zones [16].

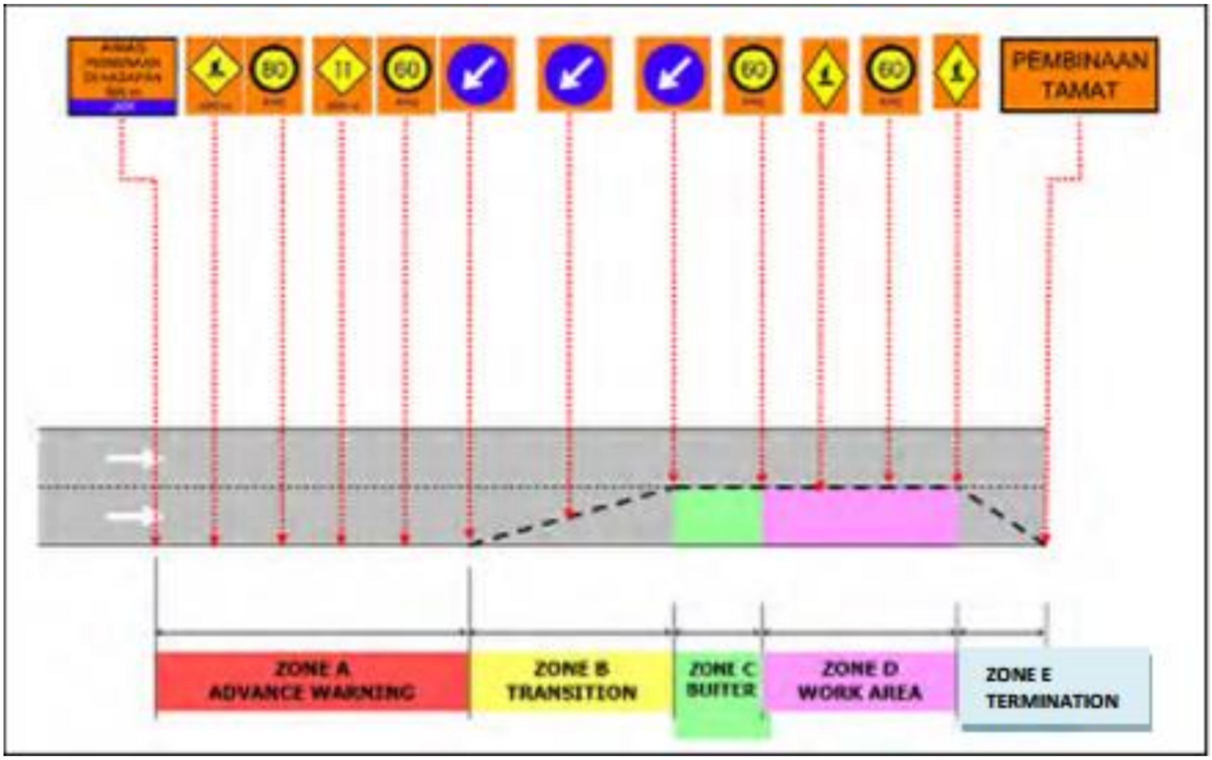

Figure 1. Warning Signboard at Traffic Management Plan

2.4 Driver Condition Contribute to Accident

Focus while driving is very important in order to avoid accident from happening. As stated by LLM, human is the main contributing factor of accidents by 86% [7]. Besides having this statistic, a news report by Berita Harian had published in 2012 that sleeping while driving is the other reason why accident occurred. Dr Norlen Mohamed, Head of Crash Injury Sciences and Preventions Unit (CRIS-P) claimed that 789 drivers admitted that they almost involved in accident because they felt asleep while driving [18]. 789 drivers is not a small number, thus advance improvement with our current safety aspect at the roadside need to be increased. Safety aspects that are currently being used are more to visual warning like having TMP [5][16][17] and the roadside workers are wearing PPE while they are working at the roadside of the highway [5]. Therefore, for this project, we are suggesting to implement auditory alert by using buzzer. We are actually considering the concept of waking up people by using alarm clock which is also be considered as auditory alert. Thus we hope that by adding on the safety aspect will decrease the number of accident and make the roadside workers feel safer to work at the roadside of the highway.

2.5 Comparative Study

2.5.1 Comparison between Technologies

In order to determine the existence of the worker at the roadside, we need to use technology that has the functionality to detect them. Here, in this section, we will make some comparison between three wireless technologies, which have the same basic functionality which are detection. Thus, three identified technologies that share the same functionalities are RFID, Ultrasonic Sensor and Proximity Sensor.

Table 3. Comparison between Technologies

Features	**UHF RFID** [9]	**Ultrasonic sensor** [19][20][21]	**Infrared Proximity sensor** [22][23]
Communication range (tracking or detection)	Long range: 1 to 6m for the card (RFID tag) reading distance	Medium range: Up to 2.5m (sensing range)	Small range: 10 to 80cm
Frequency range	High (920MHz – 925MHz)	Nominal frequency (40kHz)	High
Surroundings /Environment	Being affected with the presence of dielectrics (water or metal) as it can weaken communication between reader and tags. Working temperature: Between -20 degree and 80 degree C. Storage temperature: Between -40 and 125 degree C. Working humidity: Between 20% to 95% (No condensation)	Can be used in difficult surface properties. Normally used for liquid level detection.	
Accuracy	Very accurate	Very accurate	Very accurate
Detection Item	Roadside worker with the RFID tag	Ideally used to detect variety of applications (clear glass, plastic, metal, wood and many more)	Depends on proximity sensor type (metal, plastic)
Lifespan	Lifespan of an active tag can be long depends on two factors which are the battery used and how often it is asked to transmit signal. (Tag in a dry environment with moderate temperatures and not being banged around can continue perform normally for indefinite		Lifespan of the proximity sensor is long since it has lack of physical contact with the sensed object

	period of time) mostly vendors will put it as 10 years		
Application	1. Logistics and warehouse management 2. Intelligent parking management (Parking management and charge automation)	1. Security system 2. Robotics	1. Toys 2. Robotics 3. Parking sensors

Based on Table 3 here are all together seven features that has been listed out to be compared by these four technologies. All the technologies compared in Table 3 are used for detection purpose. The following paragraph provides thorough analysis of the comparative study.

Communication Range

Communication range can be referred as the distance from where the tracking item will be detected. The proposed system is to detect worker at the highway and sending alert to the driver to notify them with the presence of the worker. Thus, a large communication range is needed because the alert is sent to the driver from their safe distance depending on the car speed.

As for this prototype, the one with the longest communication range are UHF RFID. It covers up to 6 meters and the communication range of RFID is depending on the frequency type selected to be used [9]. Generally there are three types of RFID frequency which are low frequency, high frequency and ultra-high frequency [11]. The other two sensors which are ultrasonic [19][20][21] and infrared proximity [22][23], their communication range covered is not that wide, making them not very suitable for this project. This is simply because, to give alert to the driver, we need some distance between the driver's vehicle and the roadside worker which is called as safe distance. It has been explained earlier that safe distance is important since every driver will require thinking time before they start to slow down their car. The actual distance will be scaled for this prototyping purposes

Frequency Range

Comparisons that have been made shows that RFID [9][11] and Infrared Proximity Sensor [22][23], offered with high frequency. Frequency is the number of events or the rate at which something occurs over a period of time. Frequency range of the RFID will not influence the operation of the components. However, the speed, range as well as accuracy do affected from the frequency range being used in the system [10].

Surroundings, Environment and Accuracy

In terms of accuracy, all devices compared in Table 3 are very accurate [9][11][19][20][21][22][23]. However, RFID has slight limitation on dielectrics when it comes to far-field read range. Dielectric is a condition where there is water or metals nearby. As a result RFID could not operate well with the presence of those two main elements. Again, the accuracy of RFID is depending on the frequency that is being selected. The best condition for RFID to operate is at the temperature between -20 to 80 degree Celsius. That is mean; it is suitable to be used at room temperature. Storage temperature is also being considered, at what degree we should keep the RFID so that it will not affect their performance [11].

The positive side of ultrasonic sensor is that it can be used at many difficult surfaces [19][20][21]. This makes the detection easier.

Detection Item

Among all, RFID is the only one that has specific detection item since one of the basic items of RFID is RFID tag [9][10][11]. The tag is the one attached to the tagged item, as for this project, RFID tag will be with the worker at the roadside for them to wear. RFID Tag can also be embedded in cloth [11]. Thus, it makes RFID having a specific thing to be detected as compared to the other two technologies. Ultrasonic sensor and Infrared Proximity sensor will detect any obstacle in front of them. In addition, each RFID tag has unique codes embedded in it. Thus, makes the RFID tag more precise and specific compared to others [11].

On the other hand, ultrasonic sensor covers almost all items that can be detected like glass, plastic, metal and wood [19][20][21]. Infrared proximity sensor [22][23] is depending on the type of sensor that is being used whether it is used for metal or plastic. It has its own specific task according to specific proximity sensor type used. Overall all have the same function which is for detection. However, the difference between RFID and the other sensor is that RFID is able to detect targeted item via the RFID tag.

2.5.2 Feasibility Study and Analysis of RFID Frequency

While doing feasibility study, we have identified the reasons of choosing the best device for this project. The analysis result determines the technologies to be implemented in this project.

RFID Frequency

Previously we had mentioned that frequency is the most influencing characteristics of RFID to be considered. The effect of the frequency will influence the three major performance of the RFID which are the speed, range and accuracy of the system. In Table 4 some features of RFID frequency has been list out for us to select the most suitable frequency range to be implemented in this project.

Table 4. Table of RFID Frequency

Features	**Low Frequency (LF)** [11]	**High Frequency (HF)** [11]	**Ultra-High Frequency (UHF)** [11]
Band	30KHz – 300 KHz (Commonly use 125KHz and 134KHz)	3MHz – 30MHz (Commonly use 13.56MHz)	300MHz – 3 GHz
Read Range	Very short (up to 10cm)	Long (10 cm – 100cm)	Passive UHF (12m)
Read Rate	Slow	Faster than LF	Faster than LF and HF
Sensitivity	Not very sensitive to radio wave interference	Moderate sensitivity to interference	Most sensitive to interference
Usage	Close contact system (Access control and livestock tracking)	Far contact system (Ticketing, payment and data transfer applications)	Retail inventory management, pharmaceutical anti-counterfeiting, to wireless device configuration and technology for item tagging

From Table 4, it seems like all the positive characteristics goes to Ultra-High Frequency (UHF) RFID. Firstly let us look at the band of those frequencies; high frequency gives a large value between 300MHz to 3GHz. This band will affect the other characteristics of the system like the accuracy of the system, the speed as well as the range of the RFID [11]. Our proposed system requires far contact system between the tag and the reader which mean it has a long read range. Thus, we agree to use ultra-high frequency RFID for this system.

Overall, we had compared between types of RFID item that should be used. Based on the comparison that has been made, the most suitable RFID item to be chosen is the one with high frequency which is UHF RFID.

Lastly, based on the comparison that have been done between the three technologies, we decided to use RFID in this proposed project as it is the only detection technologies that comes with specific item to be detected. Thus, it will be easier for us to develop the prototype.

CHAPTER 3
RESEARCH METHODOLOGY

3 Research Method

In this chapter, described what had been done throughout this project starting from the beginning. This chapter is divided into five sections.

3.1 Problem Identification

The problem identification took place by searching for several issues or cases which relate to safety of the roadside worker since they are our target audience. We had found several newspaper report related to this issues [2][4][6]. Later, we describe the objective of conducting the project and at the same time narrowing the scope of area covered. Scope has the role to set the boundary of the project. By narrowing down the scope of the project, the audience can limit their expectation and focus more on what will the project covers.

3.2 Data Gathering

The main method used in this project is through readings. Several resources have been revised and go through to capture the basic idea on what will be the possible solution for the project proposed. Book [10], newspapers [2][4][6][18], papers [13][14][16] and presentations [1][7][17] have been the main source of input. Besides, we also read on the existing system or device that was implemented to solve problem which have some similarities with the project objectives [8][24][25]. Output of this reading is to come out with comparative analysis between technologies and proposed prototype system architecture for this project. Both will further being discussed in the next point.

In addition, we also conducted an interview with representatives from Traffic Safety Department of PLUS Highway to get some overview and opinion from their perspective as the one who control the flow of the highway as well as the one that manage the contractor at the road side [5]. Several questions had been asked and before the interview session end, we did make a short demonstration with the prototype. Overall, we got a good response from them regarding the proposed idea and they are also willing to invest for this system if it is available in the future.

3.3 Comparative Study

This topic is about detecting the presence of the roadside worker at the highway. Thus, technologies that are being compared must fulfill the main role of the suggested solution which is for detection. Since this project will only implement a prototype system, therefore we are looking for technologies that are suitable in developing this prototype. Based on our reading that have been mentioned in section 3.1 and 3.2, several technologies were found to hold the same role such as RFID [9][10][11][12], ultrasonic sensor [19][20][21] and infrared proximity sensor [22][23]. Those technologies were being compared to help us in identifying the most suitable technologies to be used at the implementation phase of this project. One of the main features that help in deciding the most appropriate technologies to be used is the specific item used to be detected.

3.4 System Architecture and Implementation

In this section, we start to design the proposed system architecture for this project. The system's architecture provide a general overview on how all devices and components are integrated and linked. Plus, this also help us in constructing the flow of the prototype system starting from the worker is first being detected until the driver receive alert from the buzzer. Since we are proposing to develop a prototype system, therefore the speed of the car is being keyed in. Later, we will simulate the existence of the roadside worker by using the RFID Tag. Once the worker has been detected, they will proceed to send the input data to the reader and later the reader will send the data to Arduino UNO. Arduino UNO will then trigger the buzzer. The implementation part is where the prototype is build, coding take place and all hardware and software is being attached, linking and connecting with each other.

3.5 Project Testing

Our testing is based on the prototype that has been developed because we have limitation to conduct this testing with real car. Therefore, we have scaled the real distance and to get the speed of the car, we key in the value from the Serial Monitor of Arduino UNO.

Three project testing had been conducted. First testing is for Reading RFID Tag. The purpose of this testing is to study alertness of the prototype system when the distance between RFID Tag and the RFID reader is being manipulated. Second testing is about consistency of the prototype system and the last testing is to validate the RFID Tag that is being scanned.

CHAPTER 4
SYSTEM MODEL

4 SYSTEM ARCHITECTURE

Figure 2 is the proposed architecture for this project. It is the overview on how those device and tools be linked together.

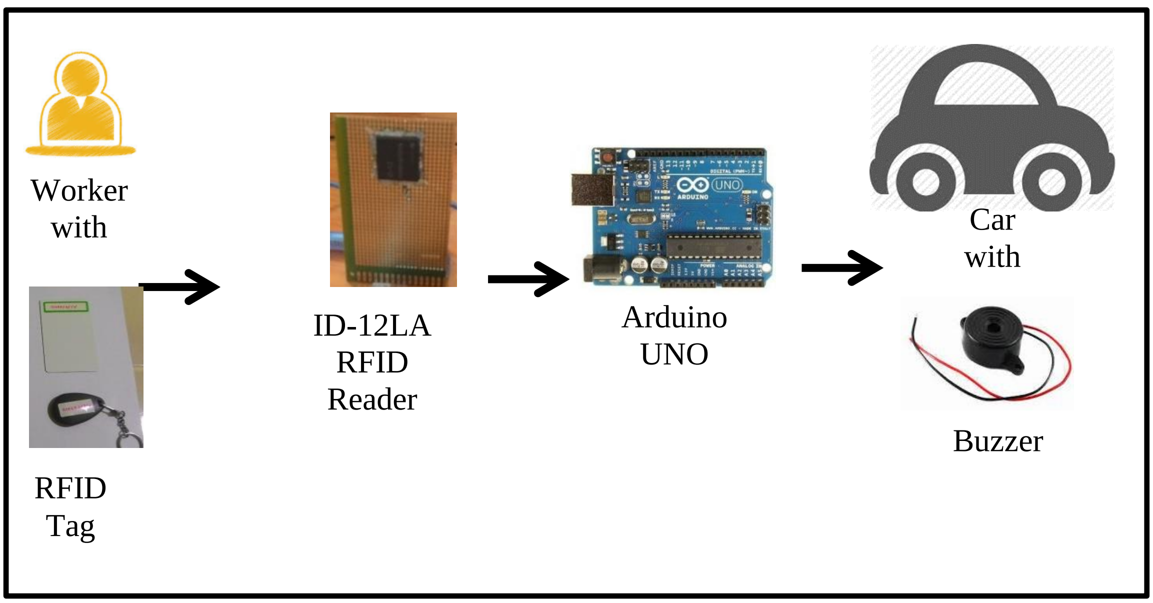

Figure 2. Proposed Architecture for Distance Warning Alert

There are four main devices that will be used for this project which are the RFID tag, ID-12LA RFID Reader, Arduino UNO and the buzzer. All items to be tracked need RFID tag to be attached to them. In this project the one that will be tracked is the roadside worker. Thus, the RFID tag should be with them. The tag is made up of tiny tag-chip or also being called as integrated circuit (IC). Each tag has their own specific unique tracking identifier. Also known as eletronic product code (EPC). Unique tracking code is the one that is vital for this system to identify whether there is any worker at the roadside. Description on RFID tag is detailed in section 4.4.

Signal or data from the RFID tag is being transmitted to ID-12LA RFID reader through Radio Frequency energy. Reader must being placed far from metal based item as it can absorbed the Radio Frequency which will make the read range shorter.

Next, data from RFID reader, also known as interrogator will be passed to Arduino UNO to be processed. Before that, the speed of the car was set in Arduino in order to determine the time when should the buzzer give alert to the driver. RFID reader is holding a role as a middle man between the tag and arduino.

As the input data from the reader reached arduino, the data will be process before it gives an instruction or command to ring the buzzer. The buzzer will ring as a sign to notify the driver that they need to slow down the speed of their car or to change the path taken at the highway as the roadside worker is in front of them. We are hoping with the implementation of this system in the future the number of death and accident at the highway can be reduced.

4.1 System Flow

In this section, we designed the system flow by using data flow diagram as shown in Figure 3. The flow in Figure 3 represents the flow of processes of the proposed system, starting from the vehicle speed input until the process end with detection of road side workers.

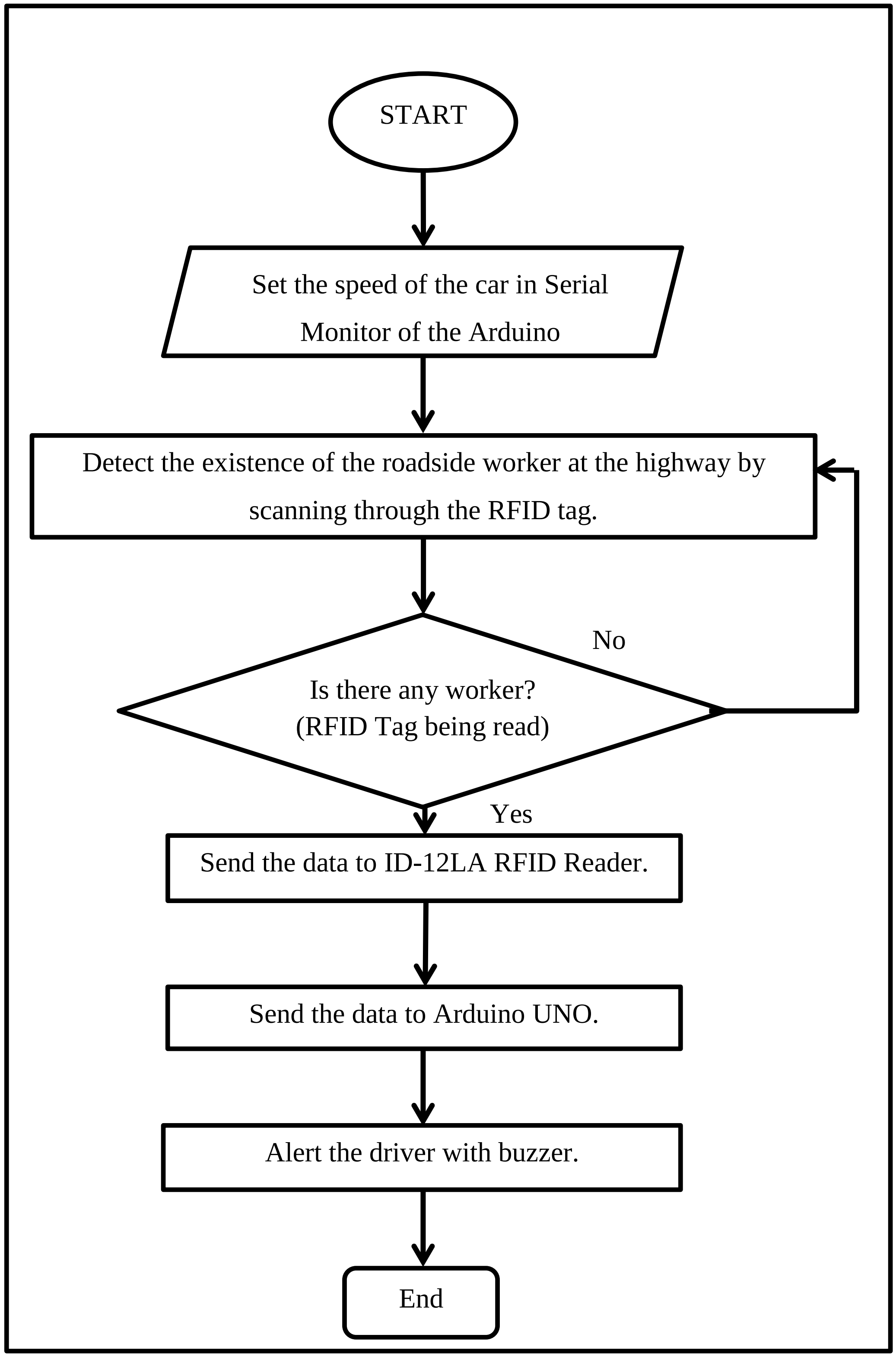

Figure 3. Proposed Data Flow Diagram of Distance Warning Alert

Referring to data flow diagram in Figure 3, the process of the system start by first set the speed of the car in Serial Monitor of the Arduino. The speed of the car will determine the safety distance for the driver to start pressing the brake pedal. This action is called Total Stopping Distance [13][14] which is the summation of Thinking Distance and Braking Distance. Next, determining the presence of the roadside worker at the highway by simulating it with detecting the existence of the RFID tag. This RFID tag is the one that will act as a tracker for this distance alert system. Once the condition of whether there is the presence of the roadside worker is fulfill, then the system can proceed to send the input data to the RFID Reader. However, if there is no roadside worker at the site of the highway, then the system will continue searching for the roadside worker.

Subsequently, after sending the input data to the reader, the reader will then pass the data to Arduino UNO microcontroller. The reader acts as a middleman between RFID tag and the Arduino. It is the one with the responsibility to inform the system software on the existence of the roadside worker. This input data is important for the system to move to the next stage.

The last stage will ring the buzzer to notified the driver on the existence of the roadside worker at the highway. This prototype system chose to alert driver with the use of buzzer instead of Short Message Service (SMS) because we are worried if the driver receive message while they are driving will even distract their focus.

4.2 Logical Design

In this project, the data flow is relate to starting from the RFID tag up till the buzzer being triggered. Figure 4 will shows the proposed design of the distance alert system's logical design.

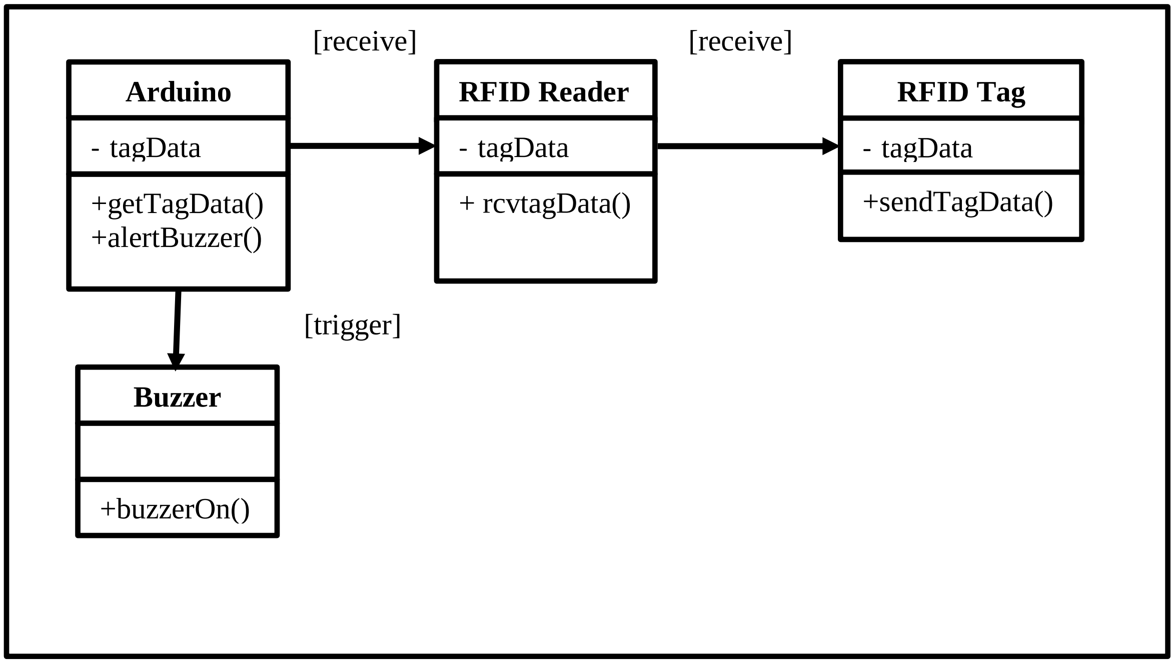

Figure 4. Proposed Logical Design of Distance Alert System

Figure 4 represents the proposed logical design for the proposed system. The one that will be the input data collector and analyzer is the Arduino whereas the one that will produce the output of this system is the buzzer. Arduino will receive the input data from RFID reader which had been mentioned earlier holding a role to let communication between Arduino and RFID tag. Before that, the RFID reader will first get the input data from the RFID tag which indicate the presence of the roadside worker at the roadsie of the highway. Once they have detected that there are roadside workers at the highway, Arduino will straight away send the signal to trigger the buzzer that produces sound to notify the driver.

4.3 Devices and Tools

4.3.1 Hardware

Figure 5. ID-12LA RFID Tag

Figure 5 shows the RFID Tag that will be weared by as the item to indicate the presence of the roadside worker. This tag will be detected by the ID-12LA RFID Reader [12] to determine the existence of the road side worker.

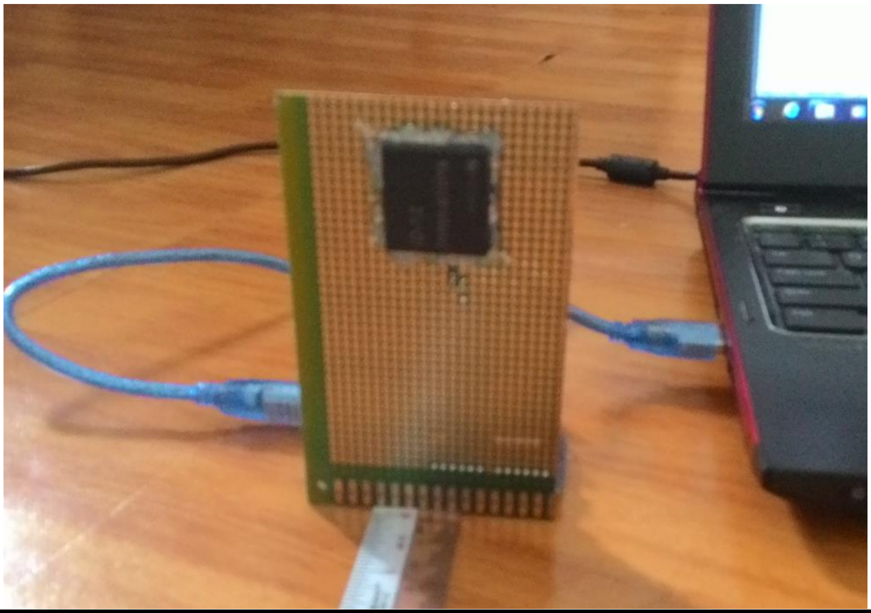

Figure 6. ID-12LA RFID Reader

Figure 6 shows the RFID Reader that will be used in this project. We did not use UHF RFID because Arduino UNO are not able to work or integrate with UHF-RFID. However, we still able to proceed with the lab scale experimentation.This RFID Reader is being choosed as it has a built in antenna. Built in antenna makes the detection easier as the RFID Reader can stand vertically. Antenna provide the vital link between reader and tag, serving as the conduit that moves data back and forth. Thus, for simulation purposes, this model will serve the best performance. ID-12LA RFID Reader [12] not only gather input data from RFID Tag, but it acts as a middleware to deliver the input data to the microcontroller, as shown in Figure 7.

Figure 7. Arduino UNO

Figure 8. Buzzer

Arduino UNO in Figure 7 is the microcontroller that will receive input data from the reader to determine whether is there any roadside worker exist at the highway. Next, it will then processed the input to trigger buzzer as shown in Figure 8 to alert the driver. The buzzer will notify the driver based on their speed and safety distance for that particular car. As for simulation purposes, the speed of the car will be keyed in from the Serial Monitor of the Arduino. This is essential, since different speed have different stopping distance that need to be considered.

CHAPTER 5
RESULT AND DISCUSSION

5 OVERVIEW

In this chapter, we will describe how we come out with the result of the testing. Starting from preparing the code of this prototype system, setup the hardware until we conduct the testing and record the result.

5.1 Control Panel Coding

5.1.1 Speed Key In

The prototype system starts by inserting the speed of the car value. Since we have some limitation to conduct a test by driving a car with the real speed, therefore, to test the prototype system, we will just key in the speed of the car in the Serial Monitor of the Arduino. Figure 9 shows the code to get the speed of the car.

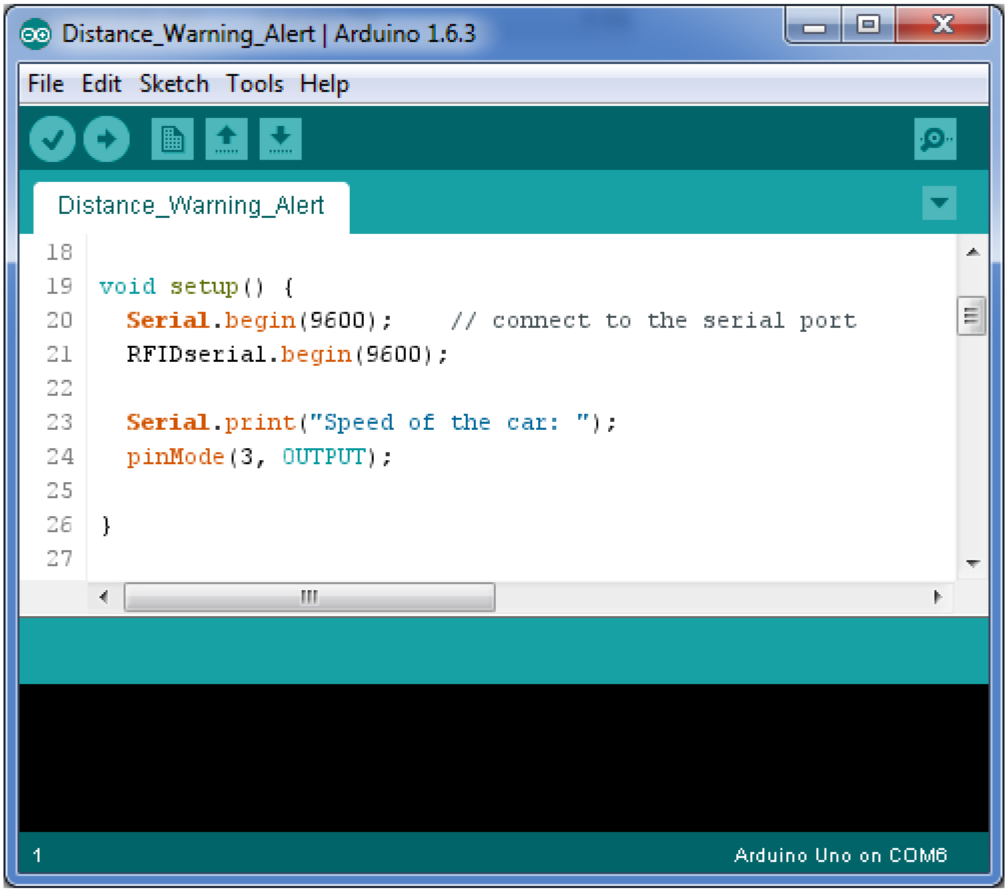

Figure 9. Code for Speed Key In

Once we upload and run the code, the Serial Monitor of Arduino will display "Speed of the car: ", as shown in Figure 10. Then we manually to key in the speed of the car in the text box of the Serial Monitor and click the Send button.

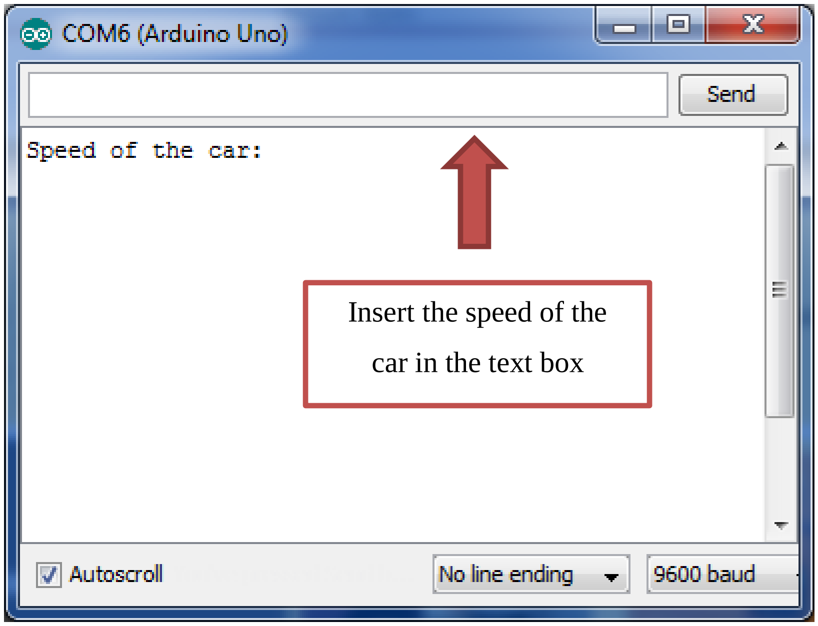

Figure 10. Serial Monitor to Insert Car Speed

Figure 11 shows the Serial Monitor, and the speed value that has been inserted is 110km/h. The speed inserted in the Serial Monitor is in `char` data type, thus we need to change this value into `integer` data type before we can proceed with the next code. To convert the value of the speed, we have created a function named as "`Speed()`". This function will be written outside of the main function and it will be call once at the beginning of the main function, "`void loop()`". The conversion take place by using "`Serial.parseInt()`" function, and assign it back to variable "`CarSpeedInsert`". After completing the conversion of the data type, we will display back the value of the speed at the serial monitor.

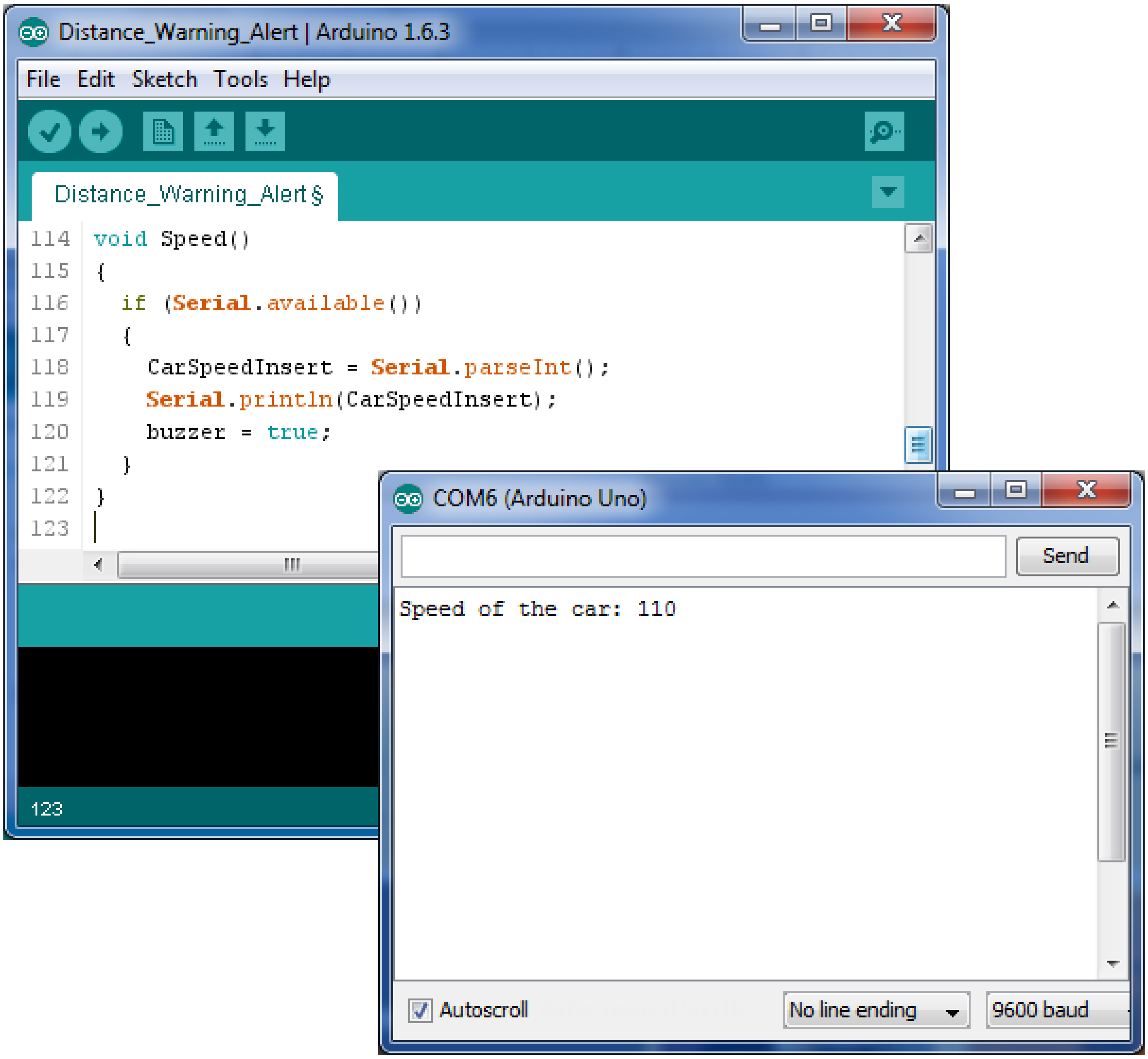

Figure 11. Speed of The Car Inserted

5.1.2 Reading the RFID Tag

In section 5.1.1, we already key in the speed of the car. The next step is to identify the existence of the RFID Tag which we perceive as the existence of the roadside worker. To complete this, RFID Tag will be scanned and the presence of the RFID Tag will be notified by the ID-12LA RFID Reader. First, we will get the number of bytes of the RFID Tag with `RFIDserial.available()` as shown in Figure 12 and this means that the RFID Tag had been identified. Next, we displayed the ID of the RFID Tag that had been detected and later verify the RFID Tag. `scanRFIDdatabase()` is the function that is being used to verify the RFID Tag detected. Figure 12 shows the code for reading RFID tag and Figure 13 shows RFID Tag ID displayed in the Serial Monitor.

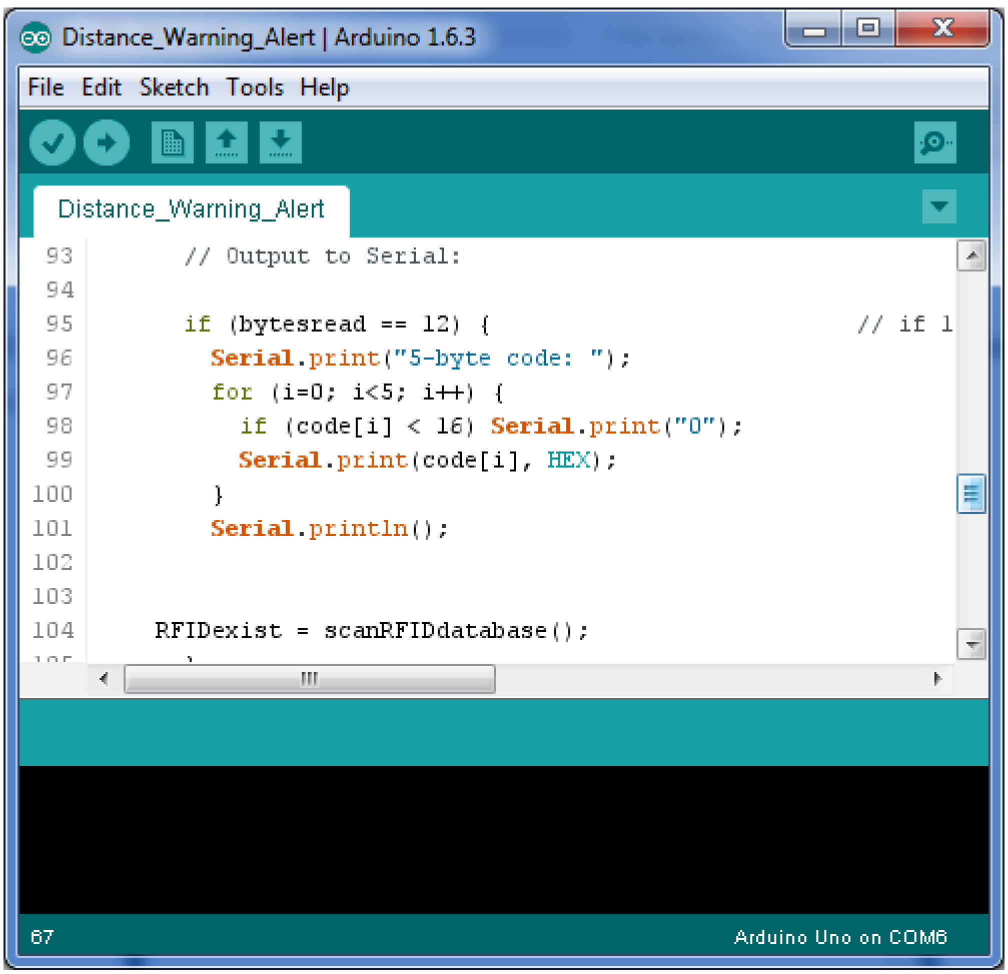

Figure 12. Code for Reading RFID Tag

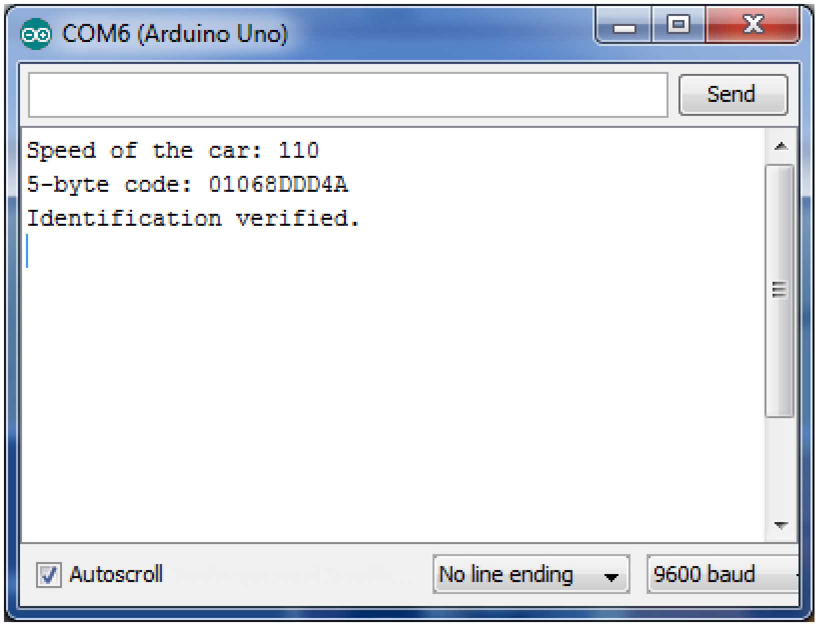

Figure 13. Serial Monitor Display RFID Tag ID

5.1.3 Prototype System Alert

In this prototype system, we use buzzer as the one that will give alert to the driver once we detect the presence of the roadside worker at the highway. This prototype system, will give alert to the driver based on the speed of the car that has been inserted earlier. We have set different delay time for different speed as shown in Table 5.

Table 5. Delay Time (s)

Speed of the car insert (km/h)	Delay time (s) before the system give alert
0 to 60	22
More than 60 up till 110	10
More than 110 up till 240	0

The delay time is derived based on the Total Stopping Distance that has been calculated. Conversion are made from kilometer per hour to meter per second. This conversion is being made simply because the Total Stopping Distance will be measured in meter. Thus, it will make the calculation easier since we have converted it at the very beginning. As stated in Chapter 2, Total Stopping Distance is the safe distance for a car to stop. It is the summation of the Thinking Distance and Braking Distance. Thinking Distance is the distance before the driver strarts to react. It is a distance covered as the car keep on moving with the initial speed before brake. Braking Distance is the distance covered while braking is applied. The Total Stopping Distance equation is shown in Figure 14.

Total Stopping Distance = Thinking Distance + Braking Distance

Figure 14. Total Stopping Distance Equation

After calculating the Total Stopping Distance, we will then proceed to calculate the delay time needed before this prototype system gives alert. For lab scale experiment purposes, we have chosen three different speed limits which are 60km/h, 110km/h and 240km/h. 60km/h is a speed limit which commonly usually being used at the Traffic Management Plan (TMP) depending on the condition of the highway where the construction is being done. 110km/h is the speed limit for normal car at the highway while 240km/h is assumed as the maximum speed of a normal car. Based on the speed inserted and Total Stopping Distance calculated, we have come out with a ratio of 1cm is equal to 54.7m.

Speed 60km/h:

1. Remaining distance to travel before reaching stopping distance. Given the total distance is 383m.

   Remaining distance (m) = Total distance (m) – Stopping distance (m)

   = 383m – 32m

   = 351m

2. Delay time (s) = Remaining distance (m) / Speed (m/s)

   = 351m / (16m/s)

   = 21.9s (Approximately 22s)

Speed 110km/h:

1. Remaining distance to travel before reaching stopping distance. Given the total distance is 383m.

   Remaining distance (m) = Total distance (m) – Stopping distance (m)

   = 383m – 92m

   = 291m

2. Delay time (s) = Remaining distance (m) / Speed (m/s)

   = 291m / (30m/s)

   = 9.7s (Approximately 10s)

Speed 240km/h:

1. Remaining distance to travel before reaching stopping distance. Given the total distance is 383m.

   Remaining distance (m) = Total distance (m) – Stopping distance (m)

   = 383m – 383m

   = 0m

2. Delay time (s) = Remaining distance (m) / Speed (m/s)

   = 0m / (66m/s)

   = 0s

All this can be summarized with Table 6. Based on calculated data in Table 6, we will start to code for delay time as in Figure 15.

Table 6. Table of Speed, Total Stopping Distance and Delay Time

Speed (km/h)	**Speed (m/s)**	**Thinking Distance (m)**	**Braking Distance (m)**	**Total Stopping Distance (m)**	**Delay Time (s)**
60	16	11	21	32	22
110	30	21	71	92	10
240	66	45	339	383	0

After we have done with all this calculation, now we can proceed to code the delay time needed before the prototype system gives alert.

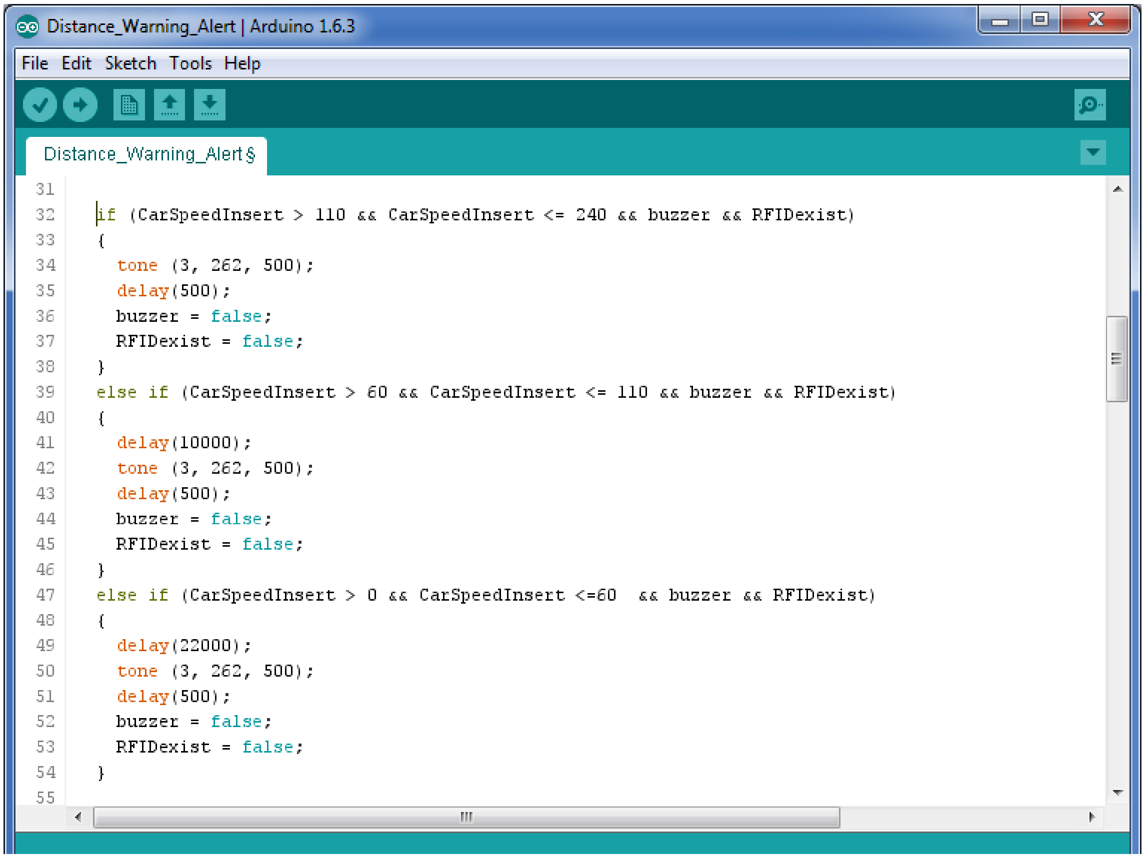

Figure 15. Code for Delay Time

5.2 Hardware Setup

This section presents the hardware setup for the purpose of testing.

1. Attach RFID Reader to Arduino UNO and connect the TX pin of RFID Reader to RX pin of Arduino UNO. Digital pin number 10 has been set as RX pin for Arduino UNO.
2. Connect the ground wire of the buzzer to the ground (GND) pin at Arduino UNO. Then connect output wire of the buzzer to the digital pin 3 set as output. Ground wire of the buzzer is the one in black whereas the output wire is the one in red.
3. Next, connect Arduino UNO USB wire to the laptop.
4. Open the code, verify it and then upload the code to Arduino UNO as shown in Figure 16.

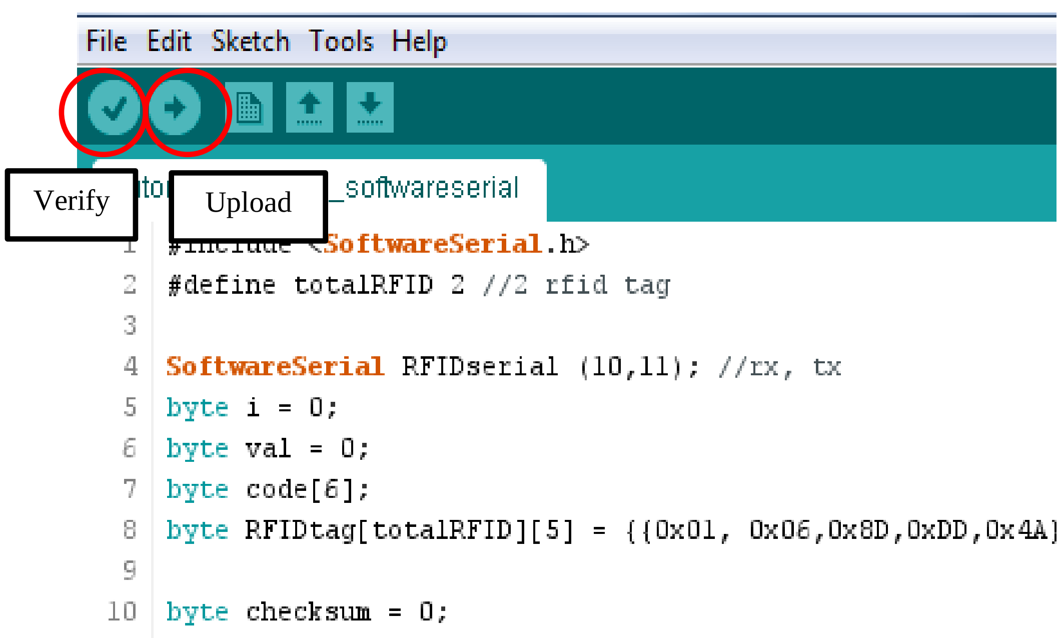

Figure 16. Verify and Upload Code

5. After the code had successfully uploaded to Arduino UNO, click on the Serial Monitor icon and a pop up window of the Serial Monitor of Arduino UNO will appear as shown in Figure 17. Now we can proceed with the testing.

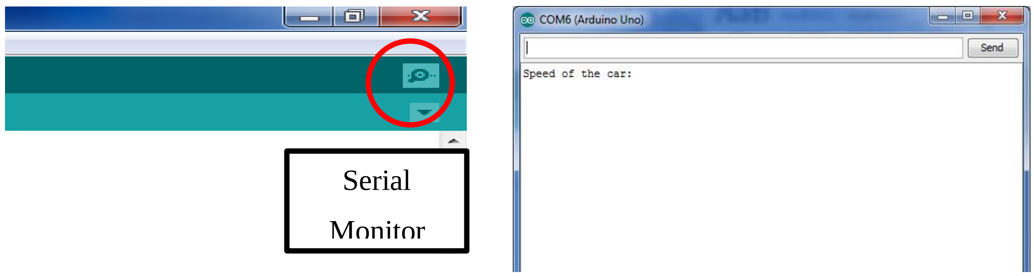

Figure 17. Serial Monitor

5.3 Prototype System Testing

5.3.1 Testing for Reading RFID Tag

The purpose of this testing is to study alertness of the prototype system when the distance of the RFID Tag from the reader is being manipulated. Three different scaled distances had been used in this testing (3cm, 5cm, 7cm). The ratio of the distance is 1cm equal to 57.4m. Speed of the car has been fixed to 110km/h. The result of this testing will show time taken for the prototype system to give alert and this is measure in second (s).

Steps:

1. Setup the hardware as explained in section 5.2.
2. Key in the fix speed of the car (110km/h) in the text box of the Arduino Serial Monitor.
3. Scan the RFID Tag in front of the RFID Reader at a distance of 3cm (164m). Start the stopwatch to record time taken for the system to give alert.
4. Repeat steps 2 and 3 with different distance.

Table 7. Result for Reading RFID Tag Testing

Distance (cm) / No of trial	3cm (164m)	5cm (274m)	7cm (383m)
1	9.65s	9.82	10.03
2	9.69 s	9.88	10.05
3	9.66 s	9.85	10.04
4	9.68 s	9.89	10.04
5	9.66 s	9.87	9.98
6	9.70 s	9.89	9.99
7	9.66 s	9.89	10.03
8	9.68 s	9.87	10.00
9	9.68 s	9.89	10.02
10	9.67	9.88	10.02
11	9.65	9.86	9.97
12	9.65	9.87	9.97
13	9.65	9.89	9.98
14	9.66	9.88	10.03
15	9.68	9.85	10.00
16	9.68	9.84	9.95
17	9.65	9.89	9.96
18	9.65	9.82	9.97
19	9.64	9.83	9.99
20	9.69	9.85	10.01
21	9.69	9.86	10.02
22	9.65	9.87	10.00
23	9.69	9.88	10.02
24	9.65	9.85	10.03
25	9.65	9.86	9.96
26	9.64	9.87	10.03
27	9.66	9.86	10.03
28	9.67	9.85	9.97
29	9.66	9.84	9.96
30	9.65	9.86	9.95

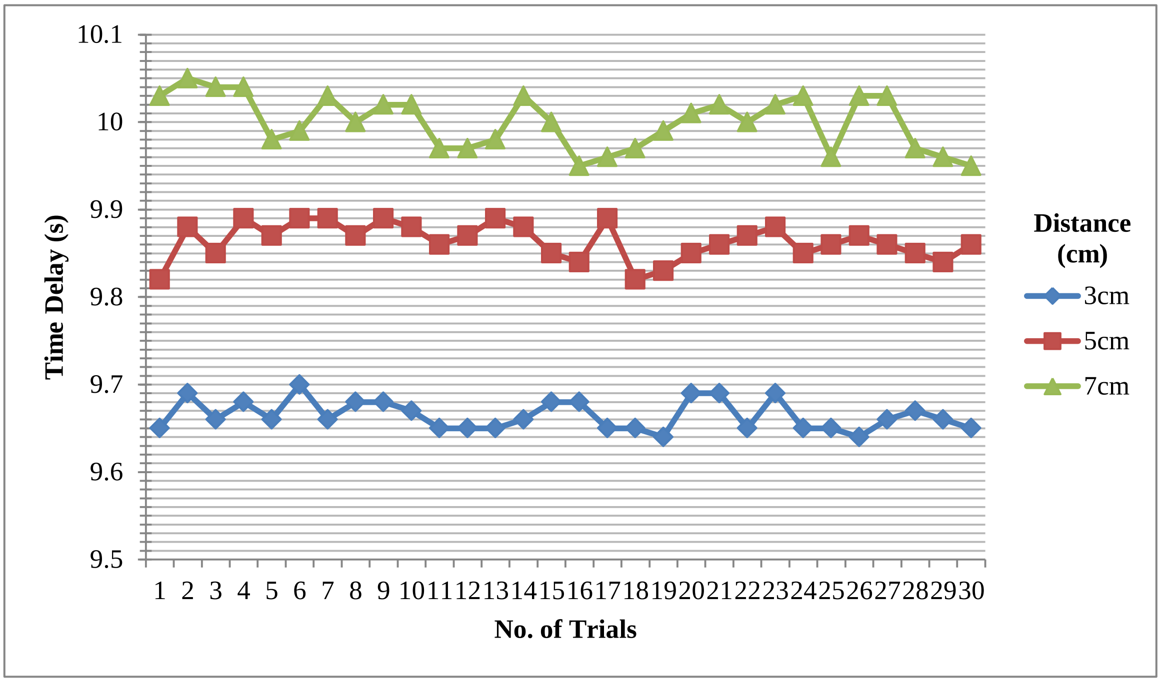

Figure 18. Graph for Reading RFID Tag Testing

Table 7 shows the time taken for the prototype system to give alert depending on the distance that has been manipulated. Based on this result, a graph have been plotted to show the overall performance. From this testing, we can conclude that the distance between RFID Tag from RFID reader that has been manipulated do affect the performance of the prototype system to give alert. Supposedly, delay time for a speed of 110km/h has been set to 10s. However based on the graph plotted in Figure 18, there were actually slightly different in the delay time for each different distance. Human error is also considered while taking the delay time. Therefore, the shorter the distance of the RFID Tag from the RFID Reader, the shorter the time delays for the prototype system to give alert.

5.3.2 Consistency Testing

The purpose of this testing is to study the consistency of the delay time before the prototype system starts to give alert depending on the value of speed being keyed in. For this testing, the speeds that will be used are 60km/h, subsequently 110km/h and 240km/h. Distance to scan the RFID Tag from the RFID Reader will be fixed at 7cm (383m). Once the RFID Tag has been scanned the delay time for the system to give alert is recorded.

Steps:

1. Setup the hardware as explained in section 5.2.
2. Key in the speed of the car in the text box of the Serial Monitor of the Arduino. Start with 60km/h.
3. Scan the RFID Tag in front of the RFID Reader at a fix distance, 7cm. Start the stopwatch to record time taken for the system to give alert.
4. Repeat step 2 to 3 with different speed.

Table 8. Result for Consistency Testing

Speed (km/h) / No of trial	60	110	240
1	21.82	10.00	0
2	21.59	9.80	0
3	21.62	9.76	0
4	21.91	9.72	0
5	21.90	9.81	0
6	21.89	9.95	0
7	22.00	9.67	0
8	21.83	9.58	0
9	21.76	9.75	0
10	21.83	9.84	0
11	21.82	9.89	0
12	21.54	9.66	0
13	21.85	9.75	0
14	21.60	9.78	0

15	21.81	9.86	0
16	21.60	9.89	0
17	21.63	9.89	0
18	21.70	9.99	0
19	21.49	10.04	0
20	21.54	9.66	0
21	21.70	9.99	0
22	21.79	9.95	0
23	21.57	10.02	0
24	21.84	10.10	0
25	21.87	9.94	0
26	21.68	9.14	0
27	21.82	9.81	0
28	22.00	9.62	0
29	21.89	9.80	0
30	21.87	10.00	0

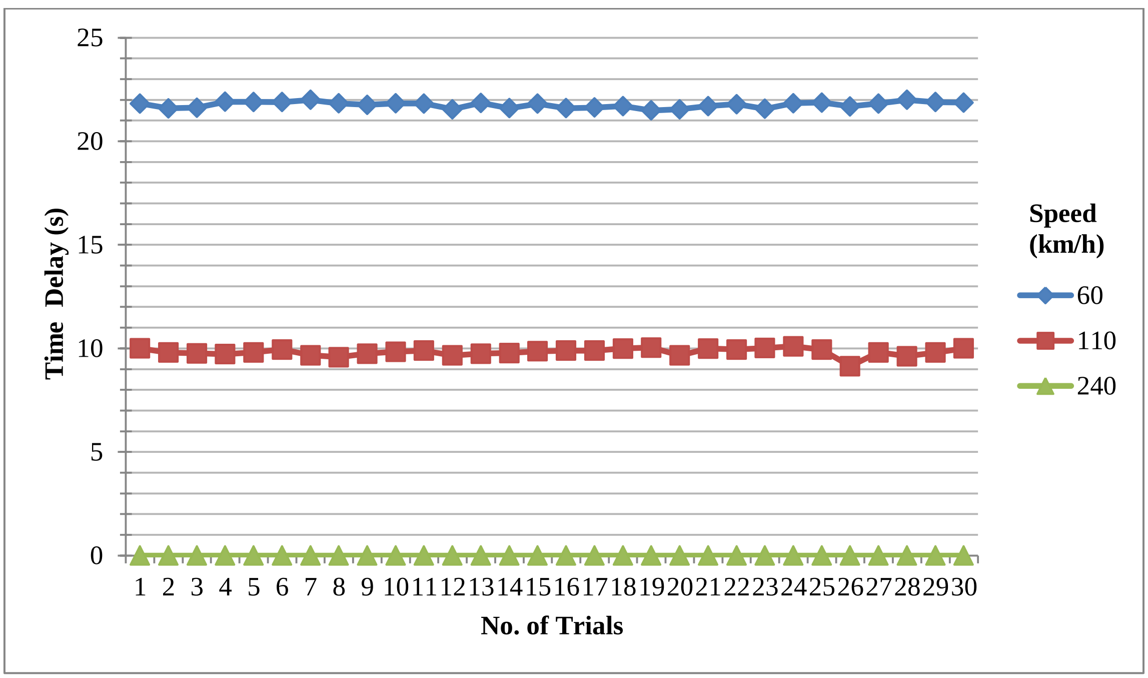

Figure 19. Graph of Consistency Testing

Table 8 shows the delay time recorded before the prototype system give alert depending on the speed inserted in the Serial Monitor. A graph has been plotted based on results in Table 8. Delay time for 60km/h supposedly to be 22s meanwhile for 110km/h, the delay time should be 10s and lastly delay time for 240km/h is 0s. Details of the delay time can be referred from Table 5. Based on the graph presented in Figure 19 and the recorded results in Table 8, the time delay for each speed shows consistency in reading. There is not much difference in value of the delay time from the 30 trials that have recorded as we also considered human error to get the stopwatch reading. Overall from this testing, we can conclude that this prototype system has achieved consistency based on 30 trials that have been done.

5.3.3 Authentication of RFID Tag

The purpose of this testing is to study the validity of the RFID Tag that will be scanned. Here we will test with different RFID Tag. The distance for RFID Tag to be scanned in front of the RFID Reader had been fixed to 7cm and the result of this experiment is the authentication message displays at the serial monitor.

Steps:

1. Setup the hardware as explained in section 5.2.
2. Scan the RFID Tag at a fixed distance of 7cm (Scaled down 1 cm is equal to 54.7m).
3. Record the authentication message display at the Serial Monitor.
4. Repeat step 2 and 3 by using different card and we can also try to randomly pick any RFID Tag to be scanned in the same trial.

Table 9. Result of Authentication of RFID Tag Testing

RFID Tag / Number of trial	RFID (01068DDD4A)	RFID (0107758F5D)
1	Identification verified.	Identification not verified.
2	Identification verified.	Identification not verified.
3	Identification verified.	Identification not verified.
4	Identification verified.	Identification not verified.
5	Identification verified.	Identification not verified.
6	Identification verified.	Identification not verified.
7	Identification verified.	Identification not verified.
8	Identification verified.	Identification not verified.
9	Identification verified.	Identification not verified.
10	Identification verified.	Identification not verified.
11	Identification verified.	Identification not verified.
12	Identification verified.	Identification not verified.
13	Identification verified.	Identification not verified.
14	Identification verified.	Identification not verified.
15	Identification verified.	Identification not verified.
16	Identification verified.	Identification not verified.
17	Identification verified.	Identification not verified.
18	Identification verified.	Identification not verified.
19	Identification verified.	Identification not verified.
20	Identification verified.	Identification not verified.
21	Identification verified.	Identification not verified.
22	Identification verified.	Identification not verified.
23	Identification verified.	Identification not verified.
24	Identification verified.	Identification not verified.
25	Identification verified.	Identification not verified.
26	Identification verified.	Identification not verified.
27	Identification verified.	Identification not verified.
28	Identification verified.	Identification not verified.
29	Identification verified.	Identification not verified.
30	Identification verified.	Identification not verified.

Table 10. Result of Random RFID Tag Authentication Testing

RFID Tag / Number of trial	RFID (01068DDD4A)	RFID (0107758F5D)
1	-	Identification not verified.
2	Identification verified.	-
3	Identification verified.	-
4	Identification verified.	-
5	-	Identification not verified.
6	-	Identification not verified.
7	Identification verified.	-
8	-	Identification not verified.
9	-	Identification not verified.
10	Identification verified.	-
11	-	Identification not verified.
12	Identification verified.	-
13	-	Identification not verified.
14	-	Identification not verified.
15	-	Identification not verified.
16	Identification verified.	-
17	Identification verified.	-
18	-	Identification not verified.
19	-	Identification not verified.
20	-	Identification not verified.
21	Identification verified.	-
22	Identification verified.	-
23	-	Identification not verified.
24	-	Identification not verified.
25	Identification verified.	-
26	-	Identification not verified.
27	-	Identification not verified.
28	Identification verified.	-
29	-	Identification not verified.
30	Identification verified.	-

From this last testing, the aim is to determine the validity of the RFID Tag that will be scanned. We were using two different tags for this testing. Results recorded in Table 9 were taken by scanning one RFID Tag for 30 times before proceed with the other RFID Tag. For Table 10, the result is taken by randomly scanned the RFID Tag. From both different approached being used, we can see that this prototype system is managed to validate those RFID Tag. This authentication is important as we wanted to make the detection specifically to the roadside worker. Specific identification is the main reason why RFID technology is being used in this prototype system instead of other detection device available. Only RFID has specific item to be detected which is RFID Tag and it comes with unique ID.

From these three testing, this prototype system had proved to us three main things. Firstly, it shows to us that different in distance between RFID Tag and RFID reader, do affect the delay time before this prototype system can give alert. Second, this prototype system managed to get consistent reading after 30 trials in the consistency testing. Thirdly, it proved that only authentic RFID Tag will be validate by the prototype system. Lastly, these three testing that had successfully achieved the second objective of this project.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

6 OVERVIEW

This chapter consists of two main section; 6.1 for the conclusion from the overall performance of the prototype system and 6.2 will be the recommendation. In the recommendation section, suggestion of the future implementation will be included since in this project we just manage to come out with the prototype system.

6.1 Conclusion

Distance warning alert system is proposed to reduce the rate of road accident especially involving roadside workers. The system provides a pre-alert notification for drivers to stay alert with the roadside workers so that drivers have more reaction time avoiding them. The proposed solution of this prototype system has been shown in the software architecture to show how RFID could help in simulating the detection of the roadside worker as mentioned in the first objective.

Next, the implementation part is where the prototype is being developed and it has been tested based on the three testing conducted. This phase will need us to link all the four main devices which are RFID tag, ID-12LA RFID Reader, Arduino UNO and the buzzer. The input data gather must be send correctly to trigger the buzzer. Since we are just developing a prototype system, the distance is being scaled and the speed of the moving car is then been key in from the Serial Monitor of Arduino UNO.

Overall, we manage to accomplish both objectives of this project. First, we have done comparative study on technology that should be used in developing this prototype system. This had been covered in Chapter 2. Second, we developed the prototype system and had successfully done three testing on the prototype system. All the three testings are important to test the functionality of the prototype system.

6.2 Recommendation

The basic idea of this project is to enhance the safety aspect of the roadside worker. Based on the news reported [2][4][6][18], there is a serious need for us to improve the current safety aspect. Thus we came out with the idea of proposing this project. However, this project only manages to come out with a prototype system and still a lot more improvement need to be done. We had go through several technologies currently being used at the real implementation but still we did not find any technologies or sensor that can be used to specifically detect the roadside worker. Besides, those technologies that are currently available have their own limitation.

Based on the detection technologies that we found, radar had been the innovator choice of creating detection sensor with a long range. Some of the car companies like Honda and BMW had use Far Detection Sensor (FDS) in cars that they produced [25]. In Volvo, they are now using radar sensor [8] to avoid collision with the front vehicle. However, both sensors are still having some limitation. FDS is high accuracy of target range but the maximum range is not that far. It only covers up to 180m [25]. Meanwhile, for radar sensor used by Volvo, one of the limitations is that radar sensor cannot detect when it is raining. The detection will be blocked [26]. In addition, both technologies mentioned, are not having specific item to be detected.

In Korea, they already have a system which they name it as Smart Incident Detecting System. This detecting system is using radar for the detection. The detect range can cover up till 1km which is far enough if we compared with the Total Stopping Distance that we have calculated in Table 6. This might be a good choice to be improved in the future. Just that it need to be embed in the car and the detection is made specifically for the roadside worker.

Lastly, we hope that this idea can be further improve to be used in the next future.

REFERENCES

[1] Miros.gov.my, 'Official Website of Malaysian Institute of Road Safety Research (MIROS)', 2015. [Online]. Available: https://www.miros.gov.my/1/page.php?id=17. [Accessed: 18- Aug- 2015].

[2] News Straits Time, 'Need to ensure workers' safety on the road', 2014.

[3] Who.int, 'WHO | World Health Organization', 2015. [Online]. Available: http://www.who.int/en/. [Accessed: 24- Feb- 2015].

[4] Berita Harian, 'PLUS, kontraktor perlu tingkat aspek keselamatan - NIOSH', 2014.

[5] M. Mat Wazir and T. Hamdan, 'Roadside Worker Detection and Alert System', Menara Koprat, Persada PLUS, 2015.

[6] A. Salleh, 'Pekerja penyelenggaraan maut dirempuh', *Harian Metro*, 2015.

[7] 'Road Safety Challenges On Expressways in Malaysia', in *PSKLM International Expressway Conference and Exhibition (PIECE) 2015*, MATRADE Exhibition and Convention Centre, Kuala Lumpur, 2015.

[8] 'Volvo Collision Avoidance Features: Initial Results', *HLDI Bulletin*, vol. 29, no. 5, 2012.

[9] LinkSprite, 'Cottonwood: Long Range UHF RFID reader UART (ISO18000-6C EPC G2)', 2015. [Online]. Available: http://store.linksprite.com/cottonwood-long-range-uhf-rfid-reader-uart-iso18000-6c-epc-g2/. [Accessed: 28- Apr- 2015].

[10] E. Cooney, RFID+. Clifton Park, NY: Thomson Delmar Learning, 2006

[11] Impinj.com, 'The Different Types of RFID Systems | Impinj', 2015. [Online]. Available: http://www.impinj.com//resources/about-rfid/the-different-types-of-rfid-systems/. [Accessed: 24- Feb- 2015].

[12] Sparkfun.com, 'RFID Reader ID-12LA (125 kHz) - SEN-11827 - SparkFun Electronics', 2015. [Online]. Available: https://www.sparkfun.com/products/11827. [Accessed: 28- Jul- 2015].

[13] Y. Chen and W. Lee, 'Safety distance warning system with a novel algorithm for vehicle safety braking distance calculating', *International Journal of Vehicle Safety*, vol. 5, no. 3, p. 213, 2011.

[14] En.aodos.gr, 'Attiki Odos - CALCULATING SAFE DISTANCES - road safety , driving and road safety , calculating safe distances', 2015. [Online]. Available: http://en.aodos.gr/services.asp?catid=21733. [Accessed: 07- Mar- 2015].

[15] UK Government, 'Typical Stopping Distances'. [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/312249/the-highway-code-typical-stopping-distances.pdf. [Accessed: 18- Jun- 2015].

[16] 'CKJG Technical Updates', *Road Safety*, vol. 213000-0021-11, no. 9, 2011.

[17] 'Arahan Teknik (Jalan) 2C-85- Temporary Signs and Zone Control', 2015.

[18]S. Syed Ali, 'Masalah Tidur Punca Nahas Profil Tinggi. Sikap Manusia Faktor 80 Peratus Kemalangan: MIROS', *Berita Harian*, 2012.

[19] Machinedesign.com, 'Proximity sensors compared: Inductive, capacitive, photoelectric, and ultrasonic', 2013. [Online]. Available: http://machinedesign.com/sensors/proximity-sensors-compared-inductive-capacitive-photoelectric-and-ultrasonic. [Accessed: 28- Mar- 2015].

[20] Sensorcentral.com, 'Ultrasonic Sensor Measurement Principles and Effective Use - KEYENCE Corporation', 2015. [Online]. Available: http://www.sensorcentral.com/photoelectric/ultrasonic01.php. [Accessed: 28- Mar- 2015].

[21] Teachengineering.org, 'How Does an Ultrasonic Sensor Work? - Lesson - www.TeachEngineering.org', 2015. [Online]. Available: https://www.teachengineering.org/view_lesson.php?url=collection/umo_/lessons/umo_sensorswork/umo_sensorswork_lesson06.xml. [Accessed: 28- Mar- 2015].

[22] T. others, 'IR distance sensor includes cable (10cm-80cm) [GP2Y0A21YK0F] ID: 164 - $14.95 : Adafruit Industries, Unique & fun DIY electronics and kits', *Adafruit.com*, 2015. [Online]. Available: http://www.adafruit.com/products/164. [Accessed: 28- Mar- 2015].

[23] Sparkfun.com, 'Infrared Proximity Sensor - Sharp GP2Y0A21YK - SEN-00242 - SparkFun Electronics', 2015. [Online]. Available: https://www.sparkfun.com/products/242. [Accessed: 28- Mar- 2015].

[24] S. Lee, 'ITS Trends on Expressway', in *PSKLM International Expressway Conference and Exhibition (PIECE) 2015*, MATRADE Exhibition and Convention Centre, Kuala Lumpur, 2015.

[25] B. Guzman, 'Far Distance Sensors (FDS)', 2012.

[26] Support.volvocars.com, 'Radar sensor - limitations', 2015. [Online]. Available: http://support.volvocars.com/uk/cars/Pages/owners-manual.aspx?mc=Y555&my=2015&sw=14w20&article=90edfa41f3a1e14dc0a801e80081a5fa. [Accessed: 28- Jul- 2015].