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ABSTRAK

Pada masa kini, pemantauan trafik menggunakan Sistem Kawalan Penyeliaan Dan Pengambilalihan Data (SCADA) adalah lebih cekap dan tepat. Objektif projek ini adalah untuk menjadi pengguna manual untuk para jurutera dan pengguna. Terdapat banyak jurutera yang masih menggunakan pengiraan manual dan juga kurang mengetahui cara menggunakan sistem SCADA sebagai alat pengawasan lalu lintas dalam kehidupan nyata. Dalam projek ini akan menunjukkan langkah demi langkah pengumpulan data trafik menggunakan Sistem Trafik Pintar Malaysia (MITS), ia adalah salah satu sistem SCADA. Terdapat begitu banyak jenis data yang berbeza, seperti jumlah lalulintas, klasifikasi kenderaan, kesilapan pelaporan, masa penetapan, beratur lalu lintas, masa hijau, persimpangan waktu persimpangan dan juga paparan langsung persimpangan. MITS boleh menjadi sistem SCADA yang hebat untuk pemantauan lalu lintas di Malaysia dan juga membantu para jurutera untuk mengumpulkan maklumat dan data pada masa akan datang

ABSTRACT

Nowadays, traffic monitoring using Supervisory Control And Data Acquisition (SCADA) system is more efficient and accurate. The objective of this project is to come up as a user manual for the engineers and also the users. There are so many engineers that are still using manual counting and also lack of know how to use SCADA system as a traffic monitoring tools in real life. In this project will show the step by step of collecting the traffic data using the Malaysian Intelligent Traffic System (MITS), it is one of the SCADA system. There are so many different types of data, such as traffic volume, vehicle classification, reporting errors, setting time, traffic queueing, green time, junction time setting and also live view of the junction. MITS could be a great SCADA system for traffic monitoring in Malaysia and also helps the engineers for collecting information and data in the future.

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LIST OF SYMBOLS

m	meter
Hz	hertz
+	plus
-	minus
/	divide
%	percent
hr	hour
min	minute
Spd	Speed
Veh	Vehicle
Vol	Volume

LIST OF ABBREVIATIONS

AADT	Annual Average Daily Traffic
AASTO	American Association of State Highway and Transportation Officials
ASTM	America Society for Testing and Materials
IED	Intelligent Electronic Devices
LTPP	Long-Term Pavement Performance
MITS	Malaysian Intelligent Traffic System
PCU	Passenger Car Unit
PHF	Peak Hour Factor
PLC	Programmable Logic Devices
RTU	Remote Terminal Units
SCADA	Supervisory Control And Data Acquisition
UHF	Ultra-High Frequencies
VMI	Vehicle Magnetic Imaging
WIM	Weigh In Motion

CHAPTER 1

INTRODUCTION

1.1 Background of Study

As the population in a town increases, the volume of traffic also increases proportionately. The amount of traffic volume is alerting: In 2030, 61 percent of the global population which is approximately five billion populations will be living in towns and cities. The influence of the upward trend towards urbanization has detrimental effect on urban traffic density (Hauke J & Thilo J, 2011). Kapileswar N & Gerhard P (2016) also suggested that, road traffic conditions have become complicated and chaotic particularly at intersection (Hashim et al., 2013) and (First A & Promila S, 2012). However, there is recently a solution to control intersection flow such as Supervisory Control and Data Acquisition SCADA system.

The implementation of such an Intelligent Traffic Control System is very useful to monitoring the traffic at busy intersections. However, the system is quite costly. For example, more than $423 million was spent on Intelligent Transport System (ITS) on Hong Kong's road network representing one of the busiest road system globally (Kapileswar N & Gerhard P, 2016). All studies are competing to develop new approaches and innovative system to come up with more efficient solution.

This study intend to produce a performance monitoring database of Kuantan-Gambang (FR 2) and Gambang Toll Plaza (FR 222)-Muadzam (FR 12) cross junction using Malaysian Intelligent Traffic System (MITS) as shown in Figure 1-1 below:

Figure 1-1: Kuantan-Gambang (FR 2) and Gambang Toll Plaza (FR 222)-Muadzam (FR 12) cross junction taken from MITS.

A SCADA system will be applied in this study is Malaysian Intelligent Traffic System (MITS) to monitor the performance of the traffic at this junction. MITS gives the power and flexibility to manage, monitor and allow the system to advise the user on the best optimized setting applicable for ever intersection (PPK Technology, 2018).

1.2 Problem Statement

Engineers and planners are so used with manual traffic counting. Therefore, they have little appreciation will regard to automated traffic counting devices such as MITS since they lack of know on how to use of advanced traffic counting system such as MITS.

1.3 Objective

The main objective for conducting this project is to come up with a user manual of MITS.

1.4 Scope of Study

The scope of this study is focus on how to use the MITS software while monitoring the traffic at the Kuantan-Gambang (FR 2) and Gambang Toll Plaza (FR 222)-Muadzam (FR 12) cross junction. Calculate the traffic volume, the speed of the vehicles, amount of vehicles passby and it's classification.

1.5 Significant of Study

The study is conducted as to provide the best performance monitoring of cross junction through the MITS. Besides, throughout this study, a clearer way to control the MITS software efficiently and productive. In the same time, a precise average waiting time of the traffic lights can be produced by collecting the traffic data and analyzing.

1.6 Expected Outcome

By the end of this project, the user friendly manual of MITS that can provide the best and suitable traffic waiting interval time for the intersection of Kuantan-Gambang (FR 2) and Gambang Toll Plaza (FR 222)-Muadzam (FR 12). Nevertheless, the efficiency of the traffic will improved and reduces the traffic problem and accident at the intersection.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In literature review includes a group of studies has been discussed the related topics which related to this project. The studies contain definition of traffic monitoring, basic concept of SCADA system and types of SCADA, user manual of SCADA system that has been discussed, traffic light control system and traffic volume.

2.2 Traffic Signal System

Traffic lights are signaling devices located at intersection to control traffic flow at all times (Ashish B, 2015). Normally, traffic light contains a set of three lights such as red, yellow and green lights. When the signal is green, traffic that facing the light shall move until the signal turns to yellow indicating the signal ready to stop. When the signal is red all traffic must stop before The green light is to go ahead in the direction denoted. The traffic light orders may different from each other and it may be special duties or set of lights for traffic turing in the particular direction. There are three order signs for turn left, forward and turn right in this system. The timing for red, yellow and green arrowed light at each crossing of road design are rely on the total traffic light on all nearby roads. By the circulation, the design of the green arrowed signal permits traffic to carry on in the direction denoted, yellow arrowed signal is to ready to stop before the intersection and the red arrowed signal stops any traffic from proceeding (Nang H & Chaw M, 2014).

Models rely on mathematical equations are used to calculate the car waiting time at a junction, the number of cars in the waiting queue, the extension of waiting cars along the lane, the optimal timing slots for green, yellow and red lights that best fit the real and veritable situation and the efficient combination of routing (Bilal G et al., 2017).

2.3 Traffic Monitoring

Most of all of traffic monitoring is usually depend on data from conventional stationary ground measurement systems. There are inductive loops, radar sensors or terrestrial cameras. The ground measurement systems installed in road infrastructure bring proper traffic data on time with high temporal resolution, however, the spatial distribution is narrow to preferred motorways and main road. Those low spatial resolution causes area-wide traffic monitoring harder (Dominik et al., 2009).

Traffic monitoring is applied in conformation management for duties like evaluate the requirement between different point in network, therefore the network capacity can be assigned to these requirements. For performance management, traffic monitoring applied to control whether the measured traffic levels over the assigned network capacity, plus effecting congestion or delays. Whenever there is a error in the network, traffic monitoring is applied in fault management to aid locate the source of the fault, depend on changes in traffic levels by the local network elements. Traffic monitoring can be applied in security management to define unsual traffic flows, that will effected by a denial-of-service attrack or other misuse (Abdun et al., 2010).

2.4 Supervisory Control and Data Acquisition (SCADA) system

SCADA system is familiar for monitoring and controlling industrial system such as power plants, water and sewage systems, traffic control, manufacturing industries, energy services and telecommunications (Ayodeji et al., 2015). The security of SCADA networks is depend on the vital role that SCADA system run in our national lives in giving necessary utility services. Penetrating internet enter at industrial workplaces expand the fragility of SCADA system since this cause it able for remote attacker to increase control of or cause disruption to the critical function of the network (Abdun et al., 2010).

The SCADA system in mostly designed for traffic management. The traffic light subsystem enable live monitoring of the operation and condition of all traffic lights in related area, analysis of coordinated signals and traffic intensity and become remote access to traffic controllers (see figure 2-1). It also provide a chance of remotely blocking some junctions with all red lights if needed. The environment data monitoring subsystem entitle live monitoring of the condition of environment parameters like air temperature, dew point, wind chill, air pressure, wind speed and direction, air humidity or rainfall in the pass hours or days. Parameter history diagrams can be produced anytime. The video monitoring subsystem entitles monitoring of the status in street or a road and nearby area. The system may be applied for public security services (Sylwester et al., 2010).

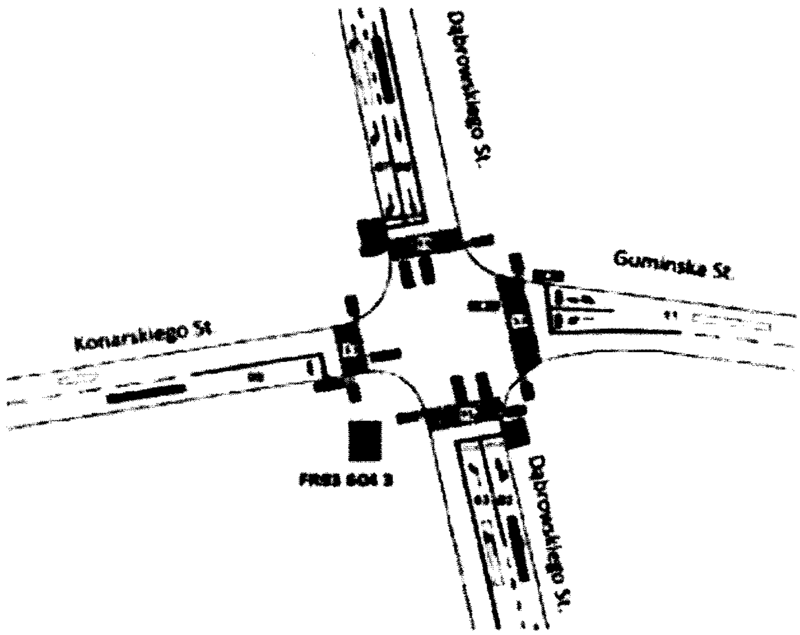

Figure 2-1: Scheme of a road crossing with traffic control and monitoring (Sylwester et al., 2010)

SCADA systems were created to manage communication through a large geographical distance and multiple sites. Before that it was invented to operate in an isolated environment using proprietary protocols that assured level of security by obscurity. However, in current years, these systems have evolved from stand-alone networks and now interconnected with both enterprise networks and the Internet using Transmission Control Protocols (TCP)/ Internet Control Protocol (IP) moving to wider networks. These lead to easy management and improvements in functionality and productivity, connecting SCADA networks to the Internet and corporate networks discloses the systems to attack with possible ruinous effects (Ayodeji et al., 2015).

Traffic control is essential in proper functioning in our daily life, so its security and protection are significant as our national concern. The primary function of a SCADA system is to connect and transfer information from large range of sources effectively, on the other way, it also reserving the data integrity and security. SCADA systems have invented since 1960s, when the direct human involvement in monitoring and handle of utility plants was gradually take over by remote operation of valves and switches by the use of modern telecommunication devices like phone lines and dedicated circuits. The appearance of personal computers and servers and the need to connect to the Internet have added a new dimension to the operation of SCADA systems. For instance, the operator able to remote login to the SCADA systems without present at the remote control sites. However, this also gives a chance for the intruders and attackers to hack the system by taking control of the operator's computer (Ayodeji et al., 2015).

Figure 2-2 indicates how a current SCADA system is linked. The types devices included are Remote Terminal Units (RTU), Programmable Logic Devices (PLC) and Intelligent Electronic Devices (IED). A couple of RTUs in remote locations obtain data from devices and send log data and alarms to a SCADA terminal by multiple communication links involving traditional telephone and computer network, wireless network and fibre optic cables. Data acquisition starts with the RTU or PLC level and contains meter readings and equipment status reports that are linked to SCADA as needed. Several industrial systems use PLCs to manage end devices such as sensors and actuators. The data from the RTUs and PLCs is gathered and formatted by the control room operator using Human Machine Interface (HMI) can do supervisory decisions to change or override normal RTU (or PLC) controls. This data may be obtained and saved in Historian, a kind of Database Management System, to enable auditing and the analysis of trends and anomalies (Kirti, 2014).

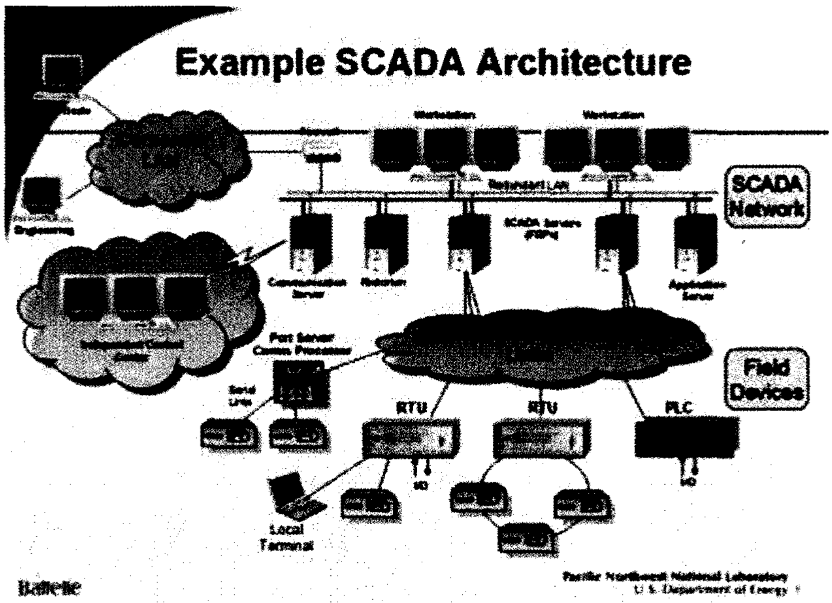

Figure 2-2: SCADA system (Kirti, 2014)

2.5 Cloud based Malaysian Intelligent Traffic System (MITS)

Cloud based MITS is deployed on a cloud based server which act as hub that communicates with the individual traffic controller on site. Communication to traffic controller is via GPRS/EDGE, 3G/4G, WI-FI, leased line or fiber optic mediums.

2.5.1 Introduction to MITS (Web-Based)

The web based MITS is deployed on a cloud based server which act as a hub which communicated with the individual traffic controllers on site. It is designed to provide information such as junctions' locations, traffic situations, controller's specifications and settings related to a junction and junction's live view. It is useful for :

- Remote maintenance and alarm monitoring.
- Real-time monitoring.
- Data collection and analysis.
- Flexible integration capabilities (e.g. CCTV and traffic portals)

2.5.2 Features of Cloud Based Intelligent Traffic System

1. **Fault Alert:**

- Cloud based MITS provide the fault alerts on Telegram.
- It provides a complete fault history/recent fault history of a junction.
- Upon rectification, it also provide the notification of traffic controller.
- It provide alert on faults like Amber Flash, Double lamp, Green Conflict etc.

2. **Monitoring and CCTV:**

- Web based MITS can be integrated with CCTV system so it could show live CCTV footage of a junction.
- Traffic management Officer is able to monitor the junction remotely from anywhere around the world.
- Web based MITS provide current running phase of a traffic junction along with the green time.

3. **Traffic Information:**

- Web based MITS provide the traffic capacity or traffic information of a junction.
- Location for a particular traffic junction can also be view on maps.

4. **Configuration:**

- TMO is able to configure Traffic Controller setting remotely.
- Able to Configure Junction Setting Like Vechicle actuated Time Setting, Multiplan Time Setting, Clock Synchronization.
- Reduce cost of fuel and save time.

5. **Data logs:**

- User can view the data logs/graphs for green time, vehicle count and vehicle waiting time.

(PPK Technology, 2018)

2.6 Traffic Data Collection

Traffic data are the foundation of monitoring traffic operations in urban networks. Accurate and relevant arterial traffic data collection becomes significant for traffic engineers with the increasing of implementation of both traffic management and traveler information systems (Jennifer N & Mark E, 2001). Nevertheless, collecting traffic data, reporting real-time travel conditions and predicting traffic flow can aid travelers to plan relevant travel plans and save travel costs. In fact, the importance of traffic data collection has long been recognized (Jon-Paul, 2005), majority of the data collection and traffic monitoring research has been concerted on freeway networks, where a few systems have been developed and are being applied for freeway performance monitoring like in Chicago, the Twin Cities, Detroit, Seattle and San Antonio (Henry X et al., 2008).

The traveler information system begins with data collection process. The processes involves collecting of real-time status information about the transportation network. Data collection can be carried out by the public agencies through acquiring data from other public or private agencies. A couple of data are gathered for traveler information systems and some are bi-products of other data collection systems. There are some technologies that used for collect the data, the main technologies are mentioned below (Iqbal, 2017).

2.6.1 Point Detector

Point detection technology is the frequently applied technology for traffic monitoring. The function of point detection technology is become international. This technology has been applied for different applications, such as transportation planning, traffic management, emergency management, evacuation monitoring, and traveller information systems. There are two kinds of detectors (Klein et al., 2006): pavement intrusive detectors and non-pavement intrusive detectors. Pavement intrusive detectors are located underneath the pavement. For instances, this type of detectors are the inductive loop, magnetometer, and magnetic detectors. Non-pavement intrusive detectors include microwave radar, active infrared, ultrasonic, acoustic, and video image processor technology. Generally, point detectors give volume counts, point speeds, occupancy, and in some cases, vehicle classification. Travel time is estimated for segments based on point detector measurements using methods with different levels of sophistication. (Iqbal, 2017).

2.6.2 Types of Traffic Counts

It is necessary to understand the magnitude of traffic data required or to be collected, which will then decide its quality and type of vehicle classification to be acquired. Traffic counting has two main categories, there are manual counts and automatic counts. There is unclear difference between the two methods. Meanwhile, the economic apply or choice of a proper method of traffic counting is a purpose of the level of traffic flow and the required data quality. This difference can be gathered from the discussions of the respective methods below, and in the subsequent chapters.

2.6.2.1 Manual Counts

The most familiar method of collecting traffic flow data is the manual method, which contains allocating a person to record traffic as it passes. This method of data collection can be expressed in terms of manpower, but it may be unnecessary in most cases where vehicles are to be classified with a number of movements recorded separately, such as at intersections.

While at intersection sites, the traffic on each arm should be calculated and recorded separately for each movement. It is significant that traffic on roads with more than one lane are counted and classified by direction of traffic flow.

Permanent traffic-counting teams are frequently set up to make the counting at the various locations throughout the road network at set interval. The duration of the count is set prior to commencement of traffic counting and it is controlled by the end use of data. The teams are directed and supervised by the technical staff to make sure that the efficiency and actual collection of data.

2.6.2.2 Automatic Counts

The observation of vehicular presence and road residencies has historically been executed firstly on or near the surface of the road. The utilization of new electromagnetic spectra and wireless communication media in modern year, has permitted traffic detection to happen in a non-intrusive fashion, at locations above or to the side of the roadway. Pavement-based traffic detection nowadays is with low cost, it will be quite competitive in the coming years from detectors that are released from the road surface.

The regular used detector types are:

i) Pneumatic tubes.

These are tubes located on the top of road surfaces at locations for traffic counting. When the vehicles pass over the tube, it will sends a burst of air to an air switch, which can be installed in any type of traffic counting devices. Air switches can supply accurate axle counts even when compressions occur more than 30 m from the traffic counter. Even though the life of the pneumatic tubes is traffic dependant as they directly drive over it, it is used globally for speed measurement and vehicle classification for all level of traffic. Taking concern should be trained in placing and operating the system, to make sure its efficient operation and reduce any potential error in the data.

ii) Inductive loops.

Inductive loop detector consists of embedded turned wire. It contains an oscillator, and a cable, which gives signals to pass from the loop to the traffic counting device. The counting device is triggered by the change of the magnetic field when a vehicle passes over the loop. Inductive loops are low-cost, almost free from maintenance and are recently the most frequent used equipment for vehicle counting and detection. Single loops are incapable of measuring vehicular speed and the length of a vehicle. This involves the use of a pair of loops to evaluate speed by surveying the time it takes a vehicle to pass through the loops installed in series. An inductive loop is able to detect the chassis heights and estimate the number of axles.

By utilizing the inductive loops, the length of the vehicle is therefore derived from the time taken by the vehicle to drive from the first to the second loop (driving time) and the time during which the vehicle was over the first and the second loop (cover time). The resulting length is called the electrical length, and is in general less than the actual length of the passing vehicle. This is affected by the built in detector threshold, the road surface material, the feeder length, the distance between the bottom of the vehicle and the loop, nevertheless, to a large extent, the synthetic materials used in modern cars. The system could be applied for all level of traffic.

iii) Weigh-in-Motion Sensor types.

A diversity of traffic sensors and loops are applied world-wide to calculate, weigh and classify vehicles while in motion, and these are collectively known as Weigh In Motion (WIM) sensor systems. On the other hand sensor pads can be applied on their own traffic speed and axle weighing equipment, they are activated by “leading” inductive loops located before them on the roadbed. This scenario is embraced where axles, speed and statistical data are needed. Some remarkable traffic sensors are:

• Bending Plates which includes strain gauges that weigh the axles of passing vehicles. Continuous electric signals are sent to the strain gauges, and these signals are changed as the plates are deflected by dynamic vehicular weight and measure the axle of the passing vehicles.

• Capacitive Strip is a thin and long extruded metal applied to detect passing axles. The force of vertical pressure used to this strip by a wheel alters its capacitance, which can be changed to a wheel-weight measure when interconnected to the speed of the vehicle. Capacitive strips can be applied for both statistical data and axle configuration.

• Capacitive Mat functions in a same way as the capacitive strip but it is invented to be mobile and applied on a temporary basis only.

• Piezo-electric Cable is a sensing strip of a metallic cable that reacts to vertical loading from vehicle wheels passing over it by making a corresponding voltage. The cable is excellent for speed measurement and axle-space registration, and is relatively affortable and free from maintenance like a inductive loop if located precisely.

iv) Micro-millimetre wave Radar detectors.

Radar detectors releases radioactive signals at frequencies ranging from the ultra-high frequencies (UHF) of 100 MHz, to 100 GHz, and can record vehicular presence and speed depending upon signals returned upon reflection from the vehicle. It also applied to determine vehicular volumes and classifications in both traffic directions.

Radar detectors are liable to be influenced due to adverse weather conditions, and can function day and night. Besides, they need relatively high levels of computing power to study the quality of signals.

v) Video Camera.

Video image processing system use machine vision technology to recognize vehicles and capture details about individual vehicles when needed. A video processing system normally controls multiple lanes at the same time, and consequently it needs high level of computing power. Generally, the operator can collaboratively set the desired traffic detection points anywhere near the system's view area.

Algorithms are applied to extract data needed for the detection of the raw data feeds. Based on the complexity of the images, it is not suggested that they should be processed outdoors as this can give deficient results. The system is functional for traffic counting and give a +/- 3% tolerance, and is not suitable for vehicular speed and their classification (Andrew N, 2004)

2.7 Volume Studies and Characteristics

2.7.1 Purpose

Traffic volume is the most basic and widely used parameter in traffic engineering. However, different agencies have employed varying definitions and methods in the collection, analysis, and description of traffic volume data. As a result, AASTO and ASTM, driven by the requirements of long-term pavement performance monitoring systems, have standardized traffic volume terminology and procedures to ensure that the traffic engineering community utilized common traffic monitoring practices to provide high-quality data for decision making (American Society for Testing and Materials, 1994).

Specific volume studies are undertaken to obtain factual information on the moment of vehicles and persons at selected points on the highway system. The resulting volume data are expressed in relation to time, with the base determined by the application in which the information will be used (Officials.ASSHTO, 1992).

2.7.1.1 Annual Traffic

In vehicles or vehicle kilometres (veh km) per year is used for

a) Determining travel and volume trends in a geographic area.
b) Estimating expected highway user revenue.
c) Computing accident rates.
d) Monitoring long-term pavement performance (LTPP).

2.7.1.2 Annual Average Daily Traffic (AADT)

a) Measuring or evaluating the present demand for service by the street or highway.
b) Developing the major or arterial street system.
c) Locating areas where new facilities or improvements to existing facilities are needed.
d) Programming capital improvements.

2.7.1.3 Hourly Traffic

In vehicles per hour is used for:

a) Determining length and magnitude of peak periods.
b) Evaluating capacity deficiencies
c) Assessing the need for traffic control device installation.
d) Geometric design or redesign of streets and intersection.

2.7.1.4 Short Term Counts

Total at 5 to 15 minutes intervals are usually expanded into hourly flow rates. Such counts are primarily used to analyse:

a) Maximum flow rate.
b) Flow variation within peak hours.
c) Capacity limitation on traffic flow.
d) Characteristics of peak volumes.

2.7.1.5 Density of Traffic

In vehicles per kilometre is obtained by dividing the hourly volume by the average speed. Density may be a better measure of street service than volume since it continue to increase as congestion increases. Volume, on the other hand, reaches a maximum under moderate congestion and then decreases with greater congestion. When a complete blockage occurs, density is at its maximum, and volume is zero (Robertson & J.E. Hummer, 1994).

2.7.2 Volume Studies

The type of data collected in a specific volume study depends upon the application in which the information will be used (French & D. Solomon, 1986).

2.7.2.1 Street Counts

Total volume without regard to direction are used in developing daily volumes, preparing traffic flow maps and determining trends.

2.7.2.2 Directional Counts

Directional counts are used for capacity analysis, determining signal timing, justifying traffic controls, monitoring loads on pavement, and obtaining accumulations of vehicles within a cordon.

2.7.2.3 Turning Movement or Intersection Counts

Tally movements at an intersection and are used for timing traffic signals, designing channelization, planning turn prohibitions, computing capacity, analysing high accident intersections and evaluation congestion.

2.7.2.4 Classification Count

Obtain volumes by class of vehicles, including bicycles, in the traffic stream are used in establishing structural and geometric design criteria, computing expected highway user revenue, computing capacity and determining correction factors for machine counts.

2.7.2.5 Occupancy Counts

Occupant counts are made to determine the distribution of passengers per vehicle accumulation of persons within an area and proportion of persons utilizing different travel modes.

2.7.2.6 Pedestrian Counts

Pedestrian counts are used in evaluating sidewalk and crosswalk needs, justifying pedestrian an signals and timing traffic signals

2.7.2.7 Cordon Counts

Cordon counts are made at the perimeter of an enclosed area, shopping centre. Vehicles and persons entering and leaving the area during a specified time period are counted. These data provide information relative to the accumulation of vehicles or person within the cordon.

2.7.2.8 Screen Line Counts

Screen line counts are classified counts taken at all streets crossing an imaginary line bisecting an area. These counts are used to determine trends, expand urban travel data and verify traffic assignment.

2.7.3 Counting Techniques

The collection of traffic volume data requires the detection of the vehicles (or vehicle types, pedestrians, or vehicle occupants) and the recording of this information (Kell, J.H. et al, 1990)

2.7.3.1 Traffic Detection may be accomplished in the following ways

a) Observers are stationed in the field to count the passing traffic. This is the most efficient method for short-duration (e.g., peak period) counts where the time and effort to place mechanical detection cannot be justified. Human observers are the only practical method for monitoring vehicle occupancy and the most realistic method for monitoring bicycle and pedestrian traffic. Prior to recent improvements in detection technology, observers were the only dependable method for conducting intersection turning movement and vehicle classification studies; they remain the best choice for brief studies of these types.

b) Hollow pneumatic road tubes, stretched across the roadway, have been the traditional form a vehicle detection for portable counters. An air pulse, generated when a tire rolls over the rubber tube, is transmitted to a diaphragm switch in a counter and converted into an electric impulse. Since the road tube detects axles rather than vehicle, counters are designed to interpret two impulses as a single vehicle. A correction factor must be applied at locations with significant numbers of vehicles with 3 or more axles. Pneumatic tubes are troublesome to place on high volume facilities, are unsuitable for high speed roadways, and are subject to wear and vandalism.

c) Tapeswitches (a pair of thin metal strips separated by a high-resistance material) and piezo-electric cables have also been used to detect passing vehicles. When deployed with portable counters, they have advantages and disadvantages similar to pneumatic tubes. New type of piezoelectric cables can be placed in the pavement at permanent count locations.

d) Loops (one or more turns of wire in a saw-cut slot) imbedded in the pavement are the most common detector at permanent count locations. These devices detect an inductance change due to a passing vehicle and send this information to an electronic amplifier. This device counts vehicles rather than axles. A loop can be placed in each lane. Loops may break, especially when placed in asphaltic concrete. Some agencies have successfully employed temporary loops taped to the roadway surface.

e) Microwave sensors (typically mounted at the side of the road about 6 m above the surface) distribute a low-power radar signal of varying frequency in a fan-shaped beam; reflections from passing vehicles are returned to the sensor, and if they are within a predefined detection zone, are counted. Sonic sensors, typically mounted over a traffic lane, 'hear' sounds from passing vehicles and with the use of software, distinguish passenger vehicles from trucks. Both devices provide alternatives to inductance loops at permanent count locations.

f) Vehicle magnetic imaging (VMI) employs a very low-powered device to detect distortions in the earth's magnetic field caused by a vehicle passing over the sensor. This technology, that can also be used to collect vehicle classification data, provides a viable alternative to pneumatic tubes for short-term counts. A current design utilizing this technique incorporates a detector and a recorder in a single unit.

g) Video cameras, when combined with video image processing technology, offer an alternative method of vehicle detection. Video systems permit the creation of virtual loops, that can be used to detect turning vehicles at intersections. These systems are most appropriate for permanent count locations.

2.7.3.2 Volume Data Recording may be accomplished using a variety of equipment types

a) Manual tally counters mounted on boards are still sometimes used to collect intersection turning counts; the observer is required to transfer data from the counters to a recording sheet at a specified time interval (e.g., every 15 minutes). The modern-day equivalent of this device is a 16-button electronic count board: one button tallies each left-turn, through, right-turn, and 'other' for every approach to the intersection. The count board sends data to an internal computer memory, thus avoiding transcription errors in the field. Data from these devices can be played lack in the office or downloaded directly onto a personal computer.

b) An older type of portable mechanical traffic volume counter accepted input from a pneumatic road tube and incremented an internal counter that was periodically read by the observer. More advanced models included a clock and printing devices that recorded count data on paper or magnetic tape at a specified time intervals. Because of their large power requirements, the units were bulky and heavy. Today, manufacturers offer a wide variety of traffic volume recording devices, virtually all of which save the count information in computer memory. Some recorders can be programmed to start and stop data collection at specific times, to record information at specified time intervals, and to simultaneously collect other information such as vehicle classification, speed, and headway. Most portable recorders are mounted securely at the roadside, although one unit (the size of a credit card and about 5mm thick) utilizing VMI detection is actually placed in the road. Virtually all of the counters weigh less than 5kg, and because of their low power requirements, battery life is measured in months or even years.

c) In addition to computerized data, systems utilizing video camera detection can retain video files of the data. This permits the subsequent analysis of other traffic parameters such as pedestrian volumes or traffic conflicts.

d) Recording counters employed at permanent count locations have benefitted from the technological changes that have improved portable counters. In addition, recording devices at these locations are checked daily with polling software that downloads volume data to a central location, verifies clock accuracy, and checks for possible equipment problems (e.g., multiple successive hours with identical volumes). Polling is generally accomplished using hard-wired or cellular phone lines.

2.7.4 Counting Periods

The time and duration of traffic counting at a particular location depends on the data desired the anticipated application of this information, and the expected variation in traffic volumes from one period to the next (U.S. Federal Highway Administration, 1987).

a) To help ensure that traffic monitoring procedures yield adequate traffic data and summary statistics, ASTM recommends the following minimum durations for short-term traffic volume and vehicle classification counts using mechanical equipment:

   i. 48 consecutive hours for non-Interstate rural roads and 24 consecutive hours for non-Interstate urban roads.

   ii. 48 consecutive hours on urban and rural Interstate roads and interchange ramps.

Counts taken on Monday through Thursday are referred to as weekday counts, while those taken on Saturday and Sunday are weekend counts. Depending on the conditions at the particular site, Friday traffic volumes could be representative of the typical weekday or the weekend (Kyte,M & S.Teply, 2000).

b) Other commonly used counting periods include the following:

   i. 16 hours counts, typically between the hours of 6 am and 10 pm. While conditions vary among sites, this period normally accounts for 90-95% of the daily traffic volume.

   ii. 12 hours counts, usually between the hours of 7 am and 7 pm. This limited period will miss the early morning business (especially freight delivery) and commuter traffic, as well as evening traffic, much of it shopping and leisure trips.

   iii. Peak period counts, traditionally conducted between 7-9 am and 4-6 pm. However, the occurrence of actual peak periods varies throughout a metropolitan area in response to the proximity of major traffic generators. Because of the growth of congestion on major transportation facilities and the use of staggered or flexible work hours, peak periods in larger urban areas can extend far beyond two hours in the morning and afternoon.

c) Special conditions should be avoided unless the purpose of the count is to obtain data concerning these unusual conditions, such as:

i. Special events (e.g., holidays, sports, exhibitions, the Friday after Thanksgiving).

ii. Temporary street closure affecting the volume pattern.

iii. Transit or trucking strikes.

iv. Time period preceding and following a disaster.

d) Adjustment factors must be applied to the data to remove seasonal or other variations, to provide a realistic estimate of the average volume condition, and or to expand a count to a volume estimate of a longer period. These factors may be obtained by means of permanent count stations or through an established counting program. Short term counts for special studies are used without modification.

2.7.5 Counting Programs

Regularly scheduled volume counts are essential for obtaining and maintaining accurate, current traffic volume data for street and highway system. These day are of critical importance in highway planning and design (U.S. Federal Highway Administration, 1985).

2.7.5.1 Rural Counting Programs

Rural counting programs vary considerably from one agency to another, depending on the nature of the roadways and the area covered. Generally, highways are grouped according to their traffic characteristics into categories such as farm routes, general purpose routes, recreational routes, and winter resort routes. Control stations are established on each type of highway to provide data on seasonal variation. Counts are taken at these locations monthly or bimonthly. FHWA's Highway Performance Monitoring System describes procedures for conducting short-term coverage counts for use in estimating traffic on the rural road system.

2.7.5.2 Urban Counting Programs

Urban counting programs differ from those in rural areas due to the different traffic patterns that exist in urban areas. Because the numerous needs for urban traffic volume counts must be balanced against financial constraints, urban traffic agencies must develop a comprehensive but realistic plan for the collection of traffic volume. One plan is outlined below:

a) Designation of street system is the first step in developing the count program.
   i. Major streets include freeways, expressway, arterials, and collector streets.
   ii. Minor or local streets are designated as residential, commercial, or industial.

b) Control counts provide the controls necessary to record volume counts on a common basis.
   i. Major control stations are selected to sample the traffic movement on the major street system. One station should be located on each major

street. The minimum recommended duration and frequency of counting is a 24-hour directional machine count every second year.

ii. Minor control stations should be located so as to sample typical streets of each classification in the minor street system. A minimum of three stations of each class described above should be established in a small city. A 24-hour non-directional machine count should be performed biennially.

iii. Key count stations are selected control stations used to obtain daily and seasonal variations in volumes. At least one key station should be selected from each class of street in both the major and minor system. These stations are counted as follows:
   - A nondirectional, seven-day count performed annually.
   - A nondirectional, 24-hour, weekday count monthly or quarterly.

c) Coverage counts are used to estimate ADT volumes throughout the street system.

   i. On the major street systems, one nondirectional, 24-hour weekday count should be taken within each control section. Since only the 24-hour total is needed, nonrecording counters are satisfactory. The counts should be repeated every four years.

   ii. On the minor streets, one 24-hour, nondirectional, nonrecording count should be made for every mile of minor street. Counts are repeated when local circumstances indicate a need.

d) CBD cordon counts are used to measure the transportation activity generated by the Central Business District.

e) Screen line counts are intended to detect long-range changes in volume and direction of traffic due to significant changes in land use and travel patterns.

2.7.6 Volume Characteristics

Traffic volume exhibit general characteristics depending on conditions at the site (Traffic Operation Division, n.d).

2.7.6.1 Variables

Variables that affect volume characteristics include:

a) Type or classification of street or highway.
   i. Rural – Interstate, state or country.
   ii. Urban – Freeway, arterial, collector, or local.

b) Usage – intercity or interstate, farm service, recreational, commercial, land service, commuter, or general purpose.

c) Composition of traffic – proportions of autos, trucks, or buses.

d) Temporal variation.

2.7.6.2 Rural Characteristics

a) A recreational route with high summer traffic and a high Sunday peak.

b) A general purpose interstate route having no Sunday peak. However, high summer volumes exist, due to the heavier long-distance leisure travel.

c) A farm service route with little variation between days of the week or months of the year.

d) A general purpose, winter resort route with high Sunday peak and higher winter and spring volume.

2.7.6.3 Urban Volume Characteristics

Urban volume characteristics differ from those in rural areas, since volumes are higher and more concentrated during certain hours of the day.

a) Peak-hour volumes are usually quite pronounced and directional in nature on radial streets used by commuters. Circumferential streets, on the other hand, do not have such sharp peaking characteristics.

b) Durations of peak flows vary and are important in planning controls that affect traffic flow (such as signal timing). A sustained peak volume is more critical than a sharp peak of short duration.

c) Within an hourly volume, arrival rates can be vary considerably. The peak hour factor (PHF), the ratio of the hourly volume to the peak flow rate, can be used to describe this variation.

   i. The highest 15-minute period may reach 40 percent of the hourly volume, corresponding to a PHF of 0.625.
   ii. The highest 5-minute period may be 20 percent of the hourly volume (PHF = 0.42).
   iii. Short-term arrival rates are important when studying frequencies of gaps in traffic of sufficient length to permit pedestrians and vehicles to enter and cross the stream.

2.7.6.4 Design Hourly Volumes (DHV)

DHV are used for the geometric design of new facilities. A common policy is to design for the 30th highest hourly volume (out of the 8760 hours in a year) expected to occur in some future year. To obtain this figure, knowledge of the current 30th highest hourly volume at similar facilities in similar locations is useful. If permanent counters are available for comparable situations, the 30th highest hours can be taken off the records and the DHV calculated by appropriate estimates of future traffic growth. When permanent counts are not available, the figure must be obtained by estimating the relationship of the 30th highest hourly traffic volume of the year to the AADT. In rural areas the 30th highest hour is from 12 to 16 percent of AADT while in urban areas the range is 9 to 13 percent. This process should be used cautiously on rural recreational routes where there may be substantial volume variations among the highest hours of the year (Wolfgang S. Homburger et al, n.d).

2.8 Characteristics of the Driver and Vehicle.

The four main components of the highway mode of transportation are the driver, the pedestrian, the vehicle, and the road. The bicycle is also becoming an important component in the design of urban highways and streets. To provide efficient and safe highway transportation, a knowledge of the characteristics and limitations of each of these components is essential. It is also important to be aware of the interrelationships among these components in order to determine the effects, if any that they have on each other. Their characteristics are also of primary importance when traffic engineering measures, such as traffic-control devices, are to be used in the highway mode. Knowing average limitations may not always be adequate; it may be necessary to obtain information on the full range of limitations. Consider, for example, the wide range of drivers' age in the United States, which usually begins at 16 and can exceed 85.

Highway statistics provided by the Federal Highway Administration indicate that the number of drivers age 70 years and older with a valid license increased from 8.8 million in 1980 to 21.9 million in 2009, representing an increase of about 149 percent of drivers in this age group since 1980. Sight and hearing vary considerably across age groups, with the ability to hear and see usually decreasing after age 65. In addition, these can vary even among individuals of the same age group.

Similarly, a wide range of vehicles, from compact cars to articulated trucks, is being designed, The maximum acceleration, turning radii, and ability to climb grades vary considerably among different vehicles. The road therefore must be designed to accommodate a wide range of physical and psychological characteristics (Nicholas J. G. & Lester A. H., 2015).

2.8.1 Driver Characteristics

One problem that faces traffic and transportation engineers when they consider driver characteristics in the course of design is the varying skills and perceptual abilities of drivers on the highway, as demonstrated by a wide range of abilities to hear, see, evaluate, and react to information. Studies have shown that these abilities may also vary in an individual under different conditions, such as the influence of alcohol, fatigue, and the time of day. Therefore, it is important that criteria used for design purposes be compatible with the capabilities and limitations of most drivers on the highway. A principal concern is that the engineer must balance the trade offs between accommodating the abilities of as many drivers as possible with the potential cost implications of designing for drivers with abilities far below normal. However, the use of an average value, such as mean reaction time, may not be adequate for a large number of drivers. Both the 85^{th} percentile and the 95^{th} percentile have been used to select design criteria; in general, the higher the chosen percentile, the wider the range covered (Nicholas J. G. & Lester A. H., 2015).

2.8.1.1 The Human Response Process

Actions taken by drivers on a road result from their evaluation of and reaction to information they obtain from certain stimuli that they see or hear. However, evaluation and reaction must be carried out within a very short time, as the information being received along the highway is continually changing. Most of the information received by a driver is visual, implying that the ability to see is of fundamental importance in the driving task. It is therefore important that highway and traffic engineers have some fundamental knowledge of visual perception as well as of hearing perception.

2.8.1.2 Visual Reception

The principal characteristics of the eye are visual acuity, peripheral vision, colour vision, glare vision and recovery, and depth perception. Visual acuity is the ability to see fine details of an object. It reflects the quality of an individual's sight along his/her direct line of vision.

Peripheral vision is the ability of people to see objects beyond the cone of clearest vision. For example, a driver sees a vehicle approaching from his/her side because of peripheral vision. Although objects can be seen within this zone, details and colour are not clear. The cone for peripheral vision could be subtending up to 160 degrees; this value is affected by the speed of the vehicle. Age also influences peripheral vision. For instance, at about age 60, significant reductions can occur in a person's peripheral vision.

Colour vision is the ability to differentiate one colour from another, but deficiency in this ability, usually referred to as colour blindness, is not of great significance in highway driving because other ways of recognizing traffic information devices (e.g., shape) can compensate for it. Combinations of black and white and black and yellow have been shown to be those to which the eye is most sensitive and are therefore commonly used in warning and regulatory traffic signs.

Glare vision and recovery. There are two types of glare vision: direct and specular. Rowland and others have indicated that direct glare occurs when relatively bright light appears in the individual's field of vision, like headlights shining in a driver's eyes, and specular glare occurs when the image reflected by the relatively bright light appears in the field of vision, like the image of the sun reflected off a windshield. Both types of glare result in a decrease of visibility and cause discomfort to the eyes. It is also known that age has a significant effect on the sensitivity to glare; about age 40, a significant increase occurs in a person's sensitivity to glare (Nicholas J. G. & Lester A. H., 2015).

The time required by a person to recover from the effects of glare after passing the light source is known as glare recovery. Studies have shown that this time is about 3 seconds when moving from dark to light and can be 6 seconds or more when moving from light to dark. Glare vision is of great importance during night driving for older people, who see much more poorly at night. This phenomenon should be taken into account in the design and location of street lighting so that glare effects are reduced to a minimum.

Glare effects can be minimized by reducing luminaire brightness and by increasing the background brightness in a driver's field of view. Specific actions taken to achieve this in lighting design include using higher mounting heights, positioning lighting supports farther away from the highway, and restricting the light from the luminaire to obtain minimum interference with the visibility of the driver. Likewise, glare shields or vegetated medians can reduce glare effects due to headlights.

Depth perception is the ability to see objects in three dimensions and estimate speed and distance. It is particularly important on two-lane highways during passing maneuvers or turning maneuvers, when crashes may result from a lack of proper judgement of speed and distance. The ability of human eye to differentiate between objects is fundamental to this phenomenon. It should be noted, however, that the human eye is not very good at estimating absolute values of speed, distance, size and acceleration. This is why traffic control devices are standard in size, shape, and colour. Standardization not only aids in distance estimation but also helps the colour-blind driver to identify signs (Nicholas J. G. & Lester A. H., 2015).

2.8.2 Perception-Reaction Process

The process through which a driver, cyclist, or pedestrian evaluates and reacts to a stimulus can be divided into four sub processes:

i. Perception: The driver sees a control device, warning sign, vehicle, or object on the road.

ii. Identification: The driver identifies the object or control device and thus understands the stimulus.

iii. Emotion: The driver decides what action to take in response to the stimulus; for example, to step on the brake pedal, to pass, to swerve, or to change lanes.

iv. Reaction or volition: The driver actually executes the action decided on during the emotion sub processes.

Time elapses during each of these sub processes. The time that elapses from the start of perception to the end of reaction is the total time required for perception, identification, emotion, and volition, sometimes referred to as PIEV time or as perception-reaction time.

Perception-reaction time is an important factor in the determination of braking distances, which in turn dictates the minimum sight distance required on a highway and the length of the yellow phase at a signalized intersection. Perception-reaction time varies among individuals and may, in fact, vary for same person as the occasion changes. These changes in perception-reaction time depend on how complicated the situation is, driver training, the existing environmental conditions, age, gender, whether the person is tired or under the influence of drugs and or alcohol, and whether the stimulus is expected or unexpected (Nicholas J. G. & Lester A. H., 2015).

2.8.3 Vehicle Characteristics

Criteria for the geometric design of highways are partly based on the static, kinematic, and dynamic characteristics of vehicles. Static characteristics include the weight and size of the vehicle, kinematic characteristics involve the motion of the vehicle without considering the forces that cause the motion. Dynamic characteristics involve the forces that cause the motion of the vehicle. Since nearly all highway carry both passenger-automobile and truck traffic, it is essential that design criteria take into account the characteristics of different types of vehicles. A thorough knowledge of these characteristics will aid the highway and or traffic engineer in designing highways and traffic-control systems that allow the safe and smooth operation of a moving vehicle, particularly during the basic maneuvers of passing, stopping, and turning. Therefore, designing a highway involves the selection of a design vehicle, whose characteristics will encompass those of nearly all vehicles expected to use the highway. The characteristics of the design vehicle are then used to determine criteria for geometric design, intersection design, and sight-distance requirements (Nicholas J. G. & Lester A. H., 2015).

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the methodological aspect of project will be explained from pre-project until the post-project. In this study, the user manual of MITS will be produced. Besides, traffic data will be collected and analysed.

First of all, the primary step of this methodology is to understand how to conduct the MITS software. A study on how to use the MITS is important in order to collect the traffic data from the intersection of Kuantan-Gambang (FR 2) and Gambang Toll Plaza (FR 222)-Muadzam (FR12).

Secondly, traffic volume of this intersection will be studied and the data will be collected. An average traffic volume will be produced and also the types of vehicles that pass over the intersection will be classified. Besides, performance monitoring of this cross junction will be carried out.

Furthermore, a clear and user friendly user manual will be produced and suitable average traffic waiting time will be produced after analyse the traffic data.

3.2 Outline Methodology

Figure 3.1, Shows outline methodology of the study.

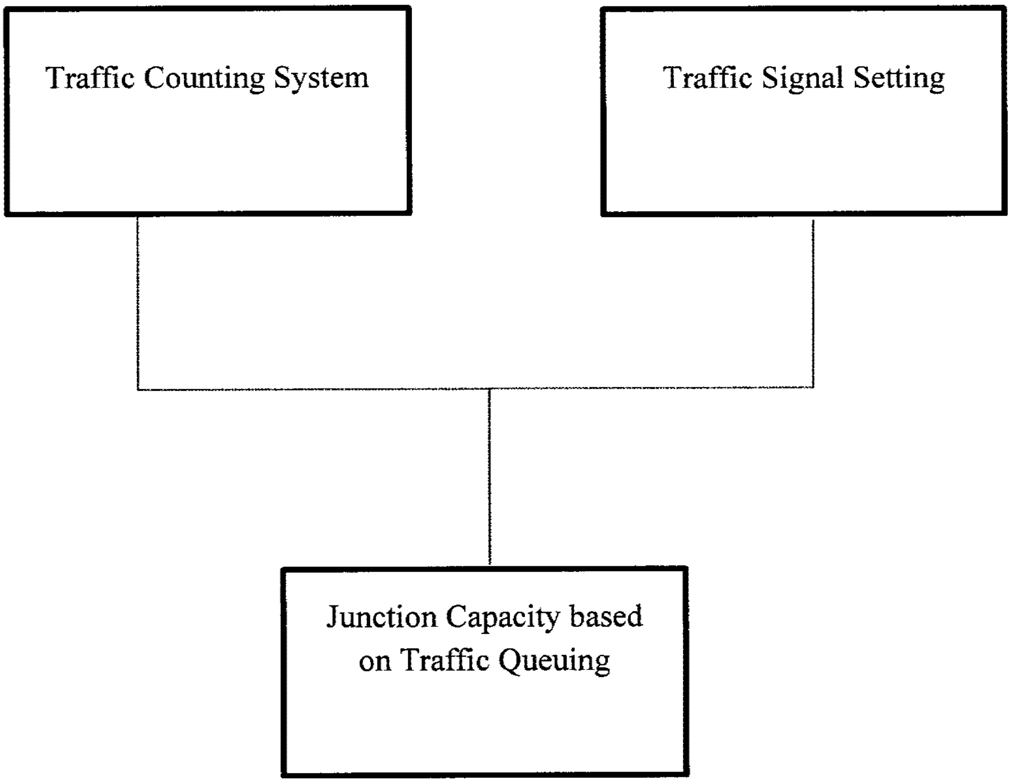

Figure 3-1: Outline Methodology

3.3 Detailed Methodology

The detailed methodology of this project will describe the implementation of using the MITS.

3.3.1 Receiving Data From Site

The Figure 3-2, 3-3, 3-4, 3-5, 3-6 and 3-7 shows the process of this MITS system works.

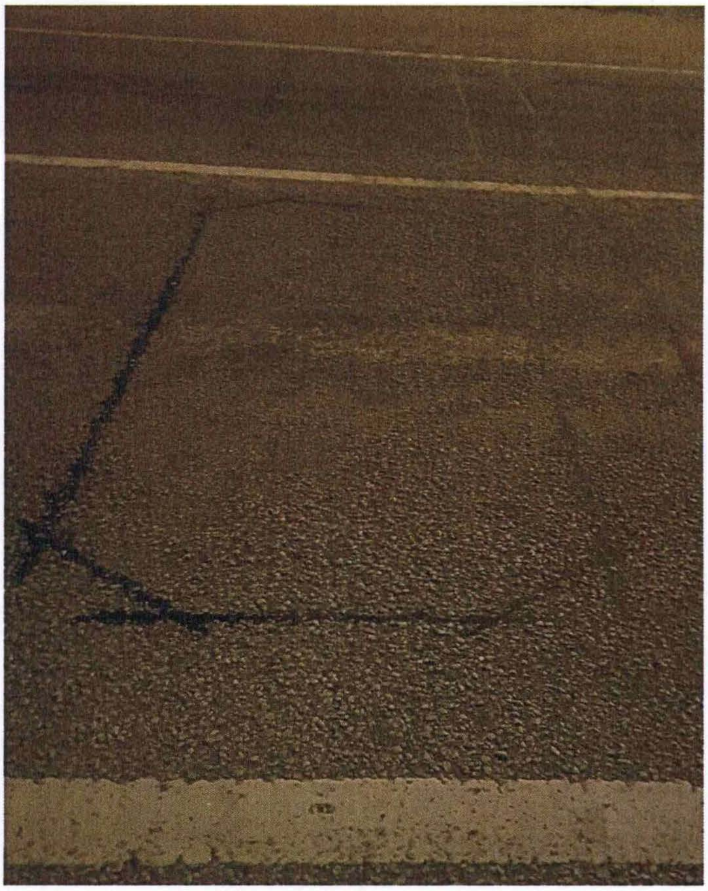

Figure 3-2: Loops under the road

The loops are installed under the road as shown at figure above, the loops are located under the box excavated from the road. The function of the loops is to detect the number of vehicles pass by. The physic concept of electro magnetic field is used to detect the number of vehicles goes through.

Figure 3-3: Vehicle Detector Card

The data received from the loops will send to Vehicle Detector Card.

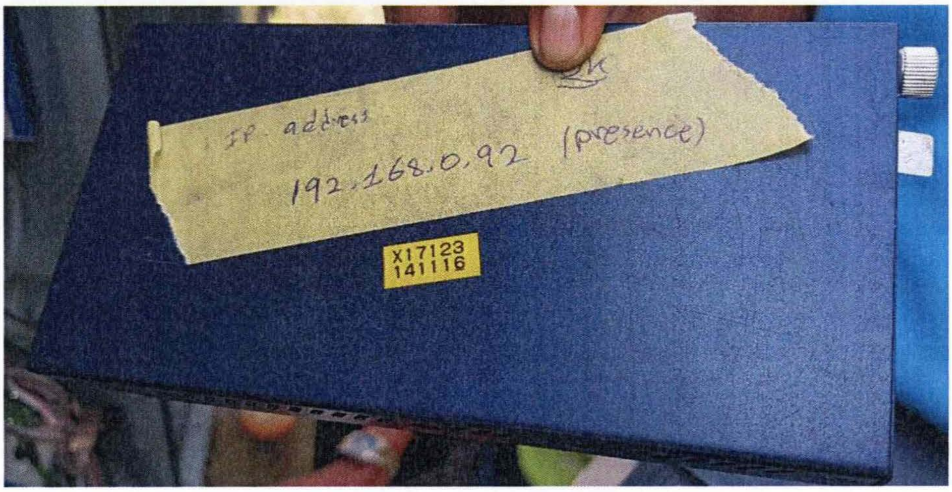

Figure 3-4: Module

Vehicle Detector Card will send the data to the module, the function of the module is act like a storage on site for saving the data.

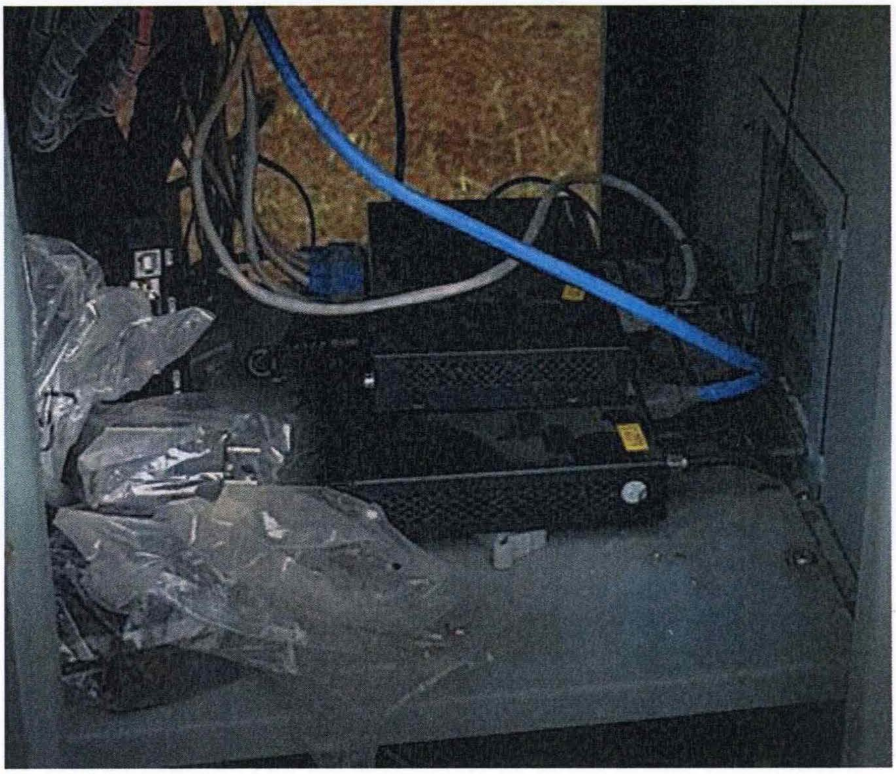

Figure 3-5: 3G Modem

The data from the Module will then send the data to the 3G Modem. The data will be transferred to the MITS server base. The figure below is the data base.

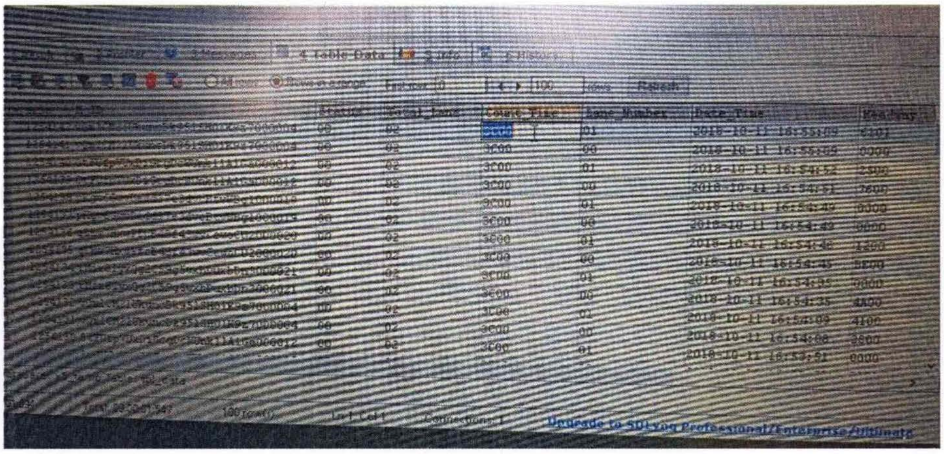

Figure 3-6: Data base

The data base of PPK Technology. If the clients that want to access the MITS software for getting data, the IP address is needed to connect this data base.

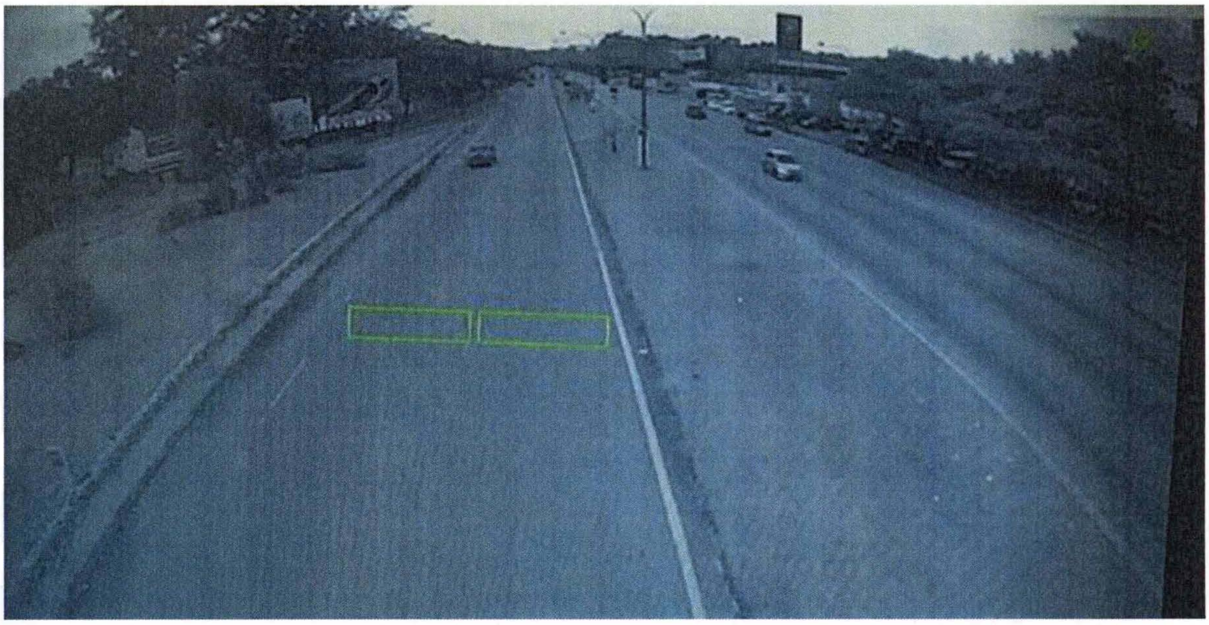

Figure 3-7: Video Camera

The wireless vehicles detector is the camera. It can differentiate the type of classes of vehicles and also the speed. The are two boxes as in the figure because it has two lanes on that road. Therefore, data from lane 1 will be different from lane 2. The video from this camera will then send to data base through Graphic User ID.

3.3.2 Connect to the server of MITS

The figure 3-8 below shows the MITS Server.

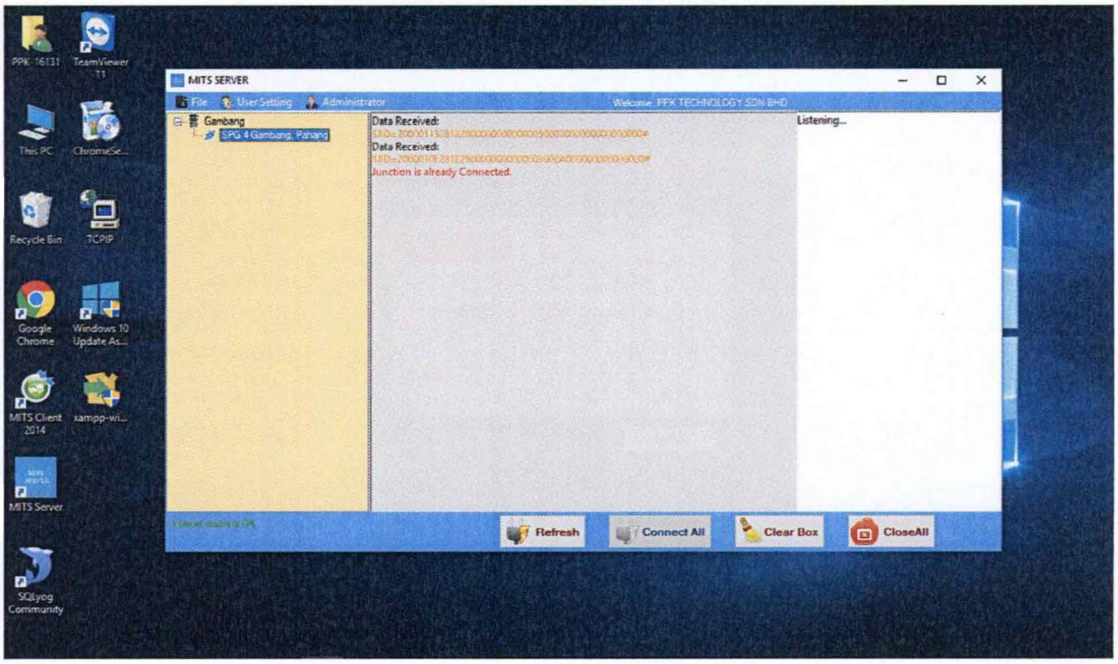

Figure 3-8: Connect to the server of MITS

Click the MITS Server icon on the desktop, until the program is running, click connect all in order to connect to the MITS Server to get the data from the MITS software.

3.3.3 Login to MITS

The figure 3-9 below shows the Login page of MITS.

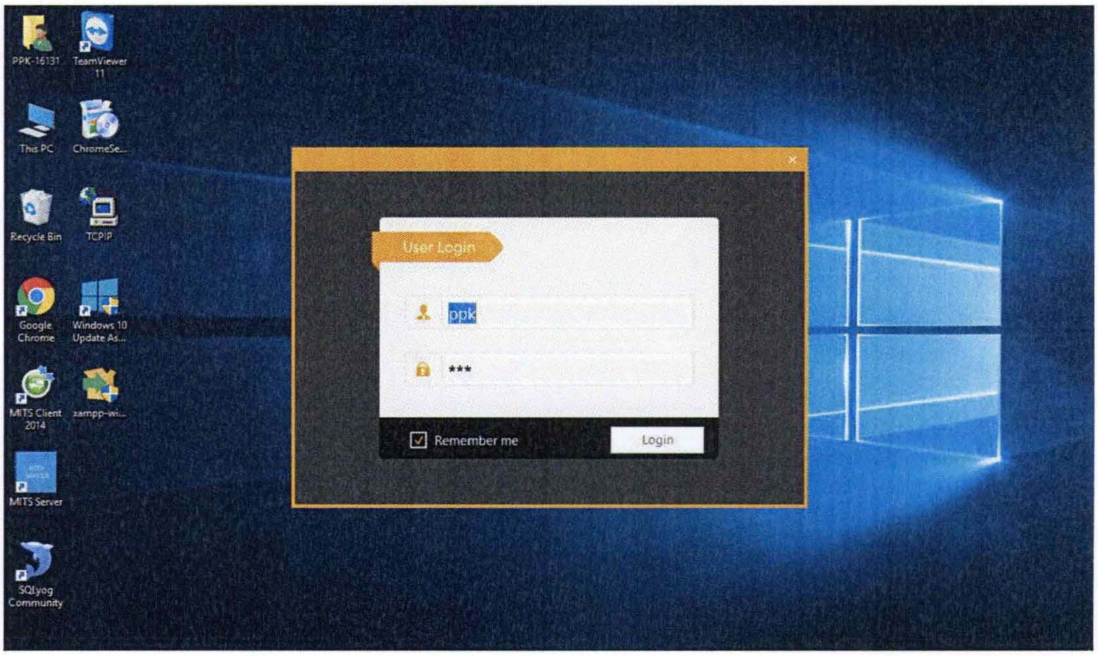

Figure 3-9: Login page of MITS

Click the MITS icon on the desktop, key-in the ID and password in order to login MITS. Tick "remember me" for convenient of login next time.

3.3.4 Detailed Page

The figure 3-10 and 3-11 shows the Dashboard of MITS.

Figure 3-10: Detailed page 1

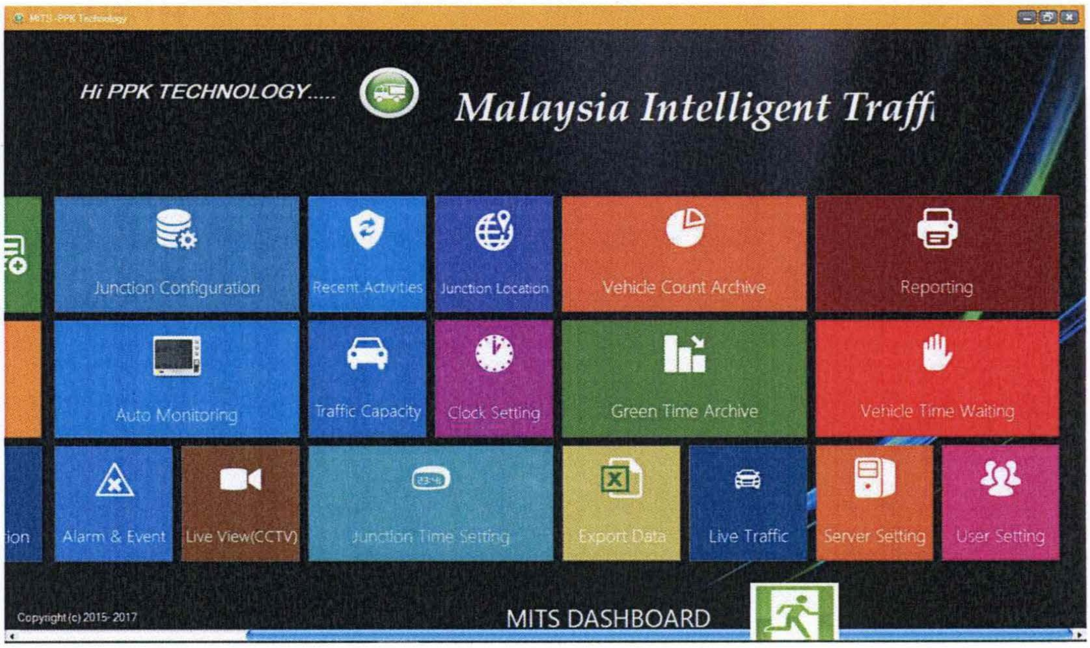

Figure 3-11: Detailed page 2

All the menu in MITS includes, List of the junction, Junction monitoring, Hand shaking, Classification, Junction configuration, Auto monitoring, Alarm and event, Live view(CCTV), Recent activities, Traffic capacity, Clock Setting, Junction location, Junction time setting, Vehicle count archive, Green time archive, Export data, Live traffic, Reporting, Vehicle time waiting, Server setting and User setting.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This Chapter reviewed about outcome, discussion and future works of MITS. After monitoring the performance at the junction of Gambang using MITS, data of traffic volume were collected and analysed using Excel. The data from the MITS can be exported as Excel file for future analysis.

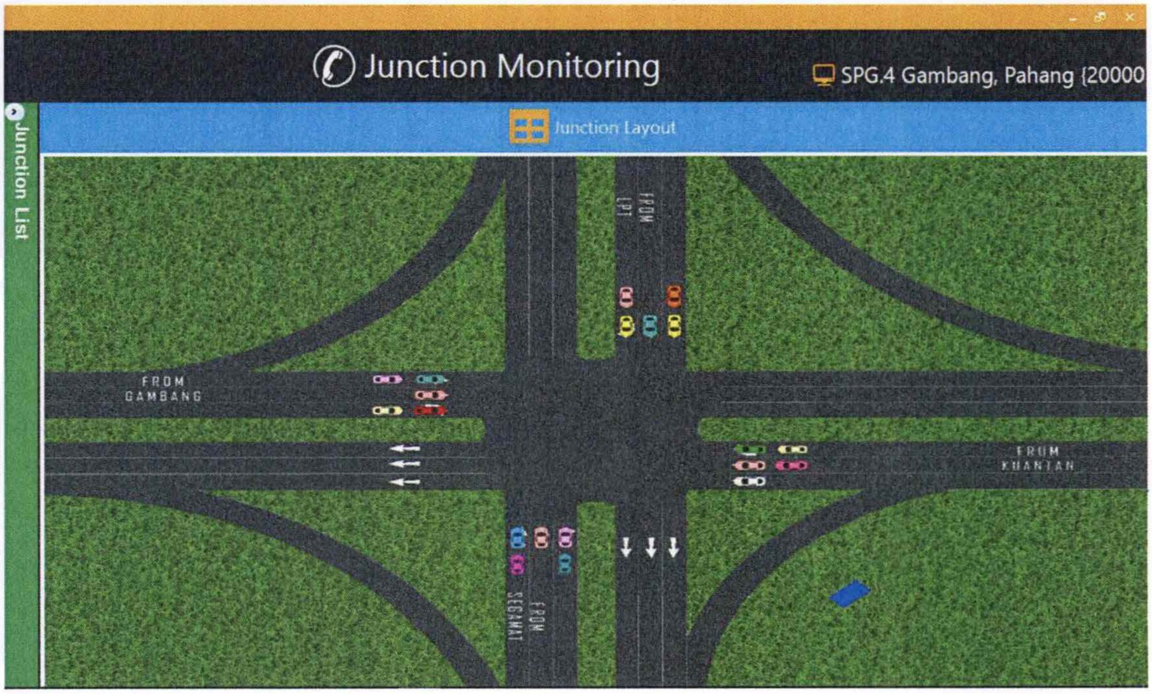

Figure 4-1: Live Junction Monitoring

4.2 Data Collection

All the data collection are collected form the software MITS.

4.2.1 Vehicle Classification for period of seven days

Vehicle classification data was collected with a period of seven days started from 1st April 2018 until 7th April 2018. The location was on Phase 1, camera 1.

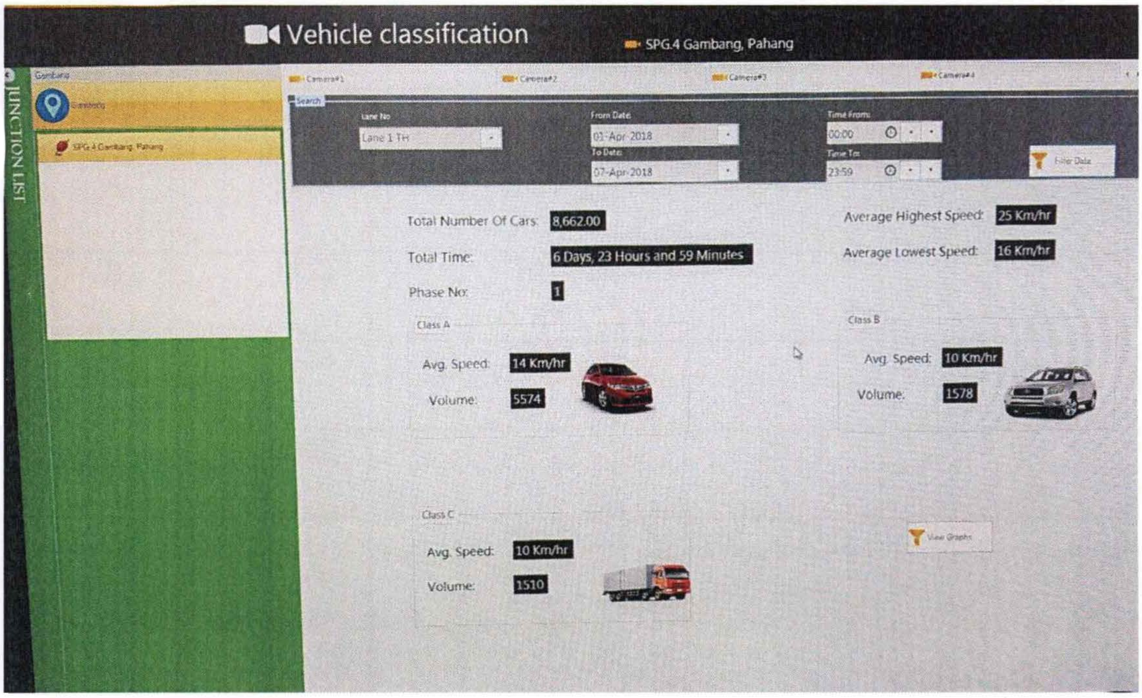

Figure 4-2: Vehicle classification from 1st April 2018 until 7th April 2018

Table 4-1: Volumes and speed of vehicles according to different classification

Class	Volume of vehicles	Average Speed (km/hr)	Average Highest Speed (km/hr)	Average Lowest Speed (km/hr)
A	5574	14	-	-
B	1578	10	-	-
C	1510	10	-	-
Total	8662	-	25	16

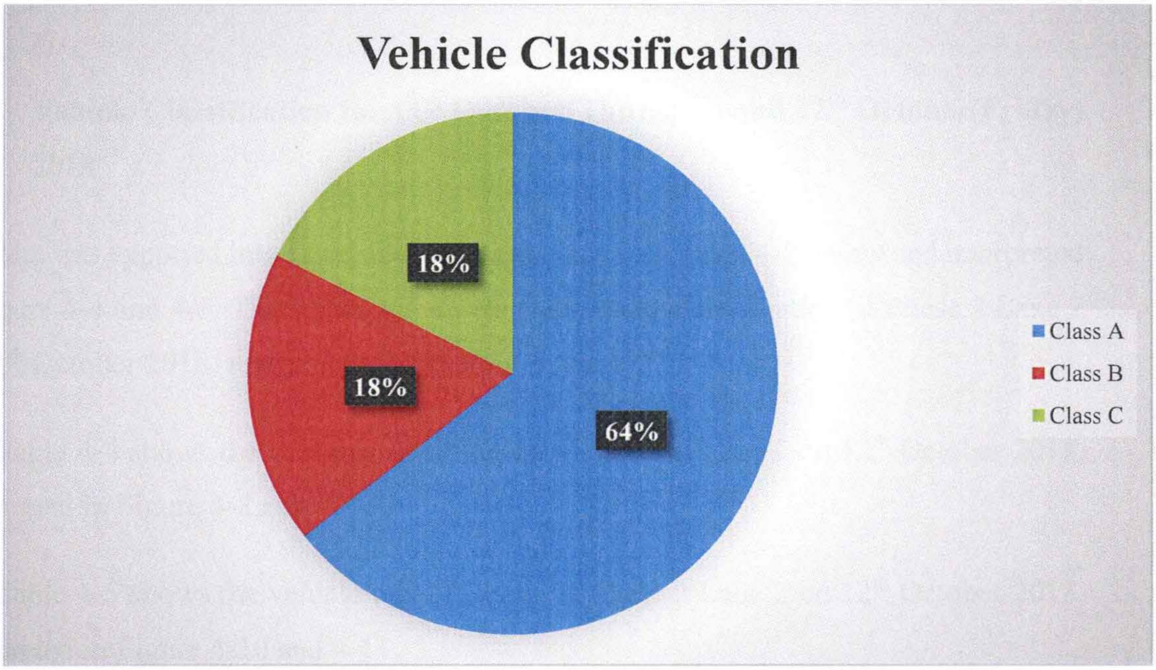

Figure 4-3: Pie Chart of vehicle classification from 1st April 2018 until 7th April 2018

Based on Figure 4-2, Table 4-1 and Figure 4-3 above, it can be concluded that highest volume of vehicles were from Class A vehicles, 5574 units with average speed of 14 kilometres per hour, whereas the lowest were Class C vehicles, 1510 units with average speed of 10 kilometres per hour. From the Figure above, it shown 64 percent of vehicles came from Class A, whereas the others two were 18 percent from Class B and Class C.

4.2.2 Vehicle Classification for 11th October(Thursday) and 12th October(Friday) 2018

The data was exported into Excel file and transferred into Table 4-2 below and interpreted in Figure 4-4 and 4-5. The Table 4-3 shows the vehicle classification of Phase 2 Lane 2 on 11th October 2018, interpreted in Figure 4-6 and 4-7.

The Table 4-4 shows the vehicle classification of Phase 2 Lane 1 on 12th October 2018, interpreted in Figure 4-8 and 4-9.

The Table 4-5 shows the vehicle classification of Phase 2 Lane 2 on 12th October 2018, interpreted in Figure 4-10 and 4-11.

Table 4-2: Vehicle Classification of Phase 2 lane 1 on 11th October 2018

Sr #	Lane No.	Time	Avg High Speed Vehicle, Km/hr	Avg Low Speed Vehicle, Km/hr	Type A Vehicle speed, Km/hr	Type A Vehicle Volume, Km/hr	Type B Vehicle speed, Km/hr	Type B Vehicle Volume	Type C Vehicle speed, Km/hr	Type C Vehicle Volume
1	1	02:00	24	15	6	90	2	21	18	537
2	1	17:00	24	11	15	46	5	4	10	4
3	1	18:00	23	12	16	507	4	12	7	32
4	1	19:00	22	13	16	354	6	19	9	58
5	1	20:00	32	14	15	98	4	8	21	236
6	1	21:00	28	14	10	48	3	10	20	207
7	1	22:00	25	15	6	28	2	5	19	162
8	1	23:00	21	15	2	7	1	4	18	100
9	1	00:00	22	15	3	7	1	2	17	70

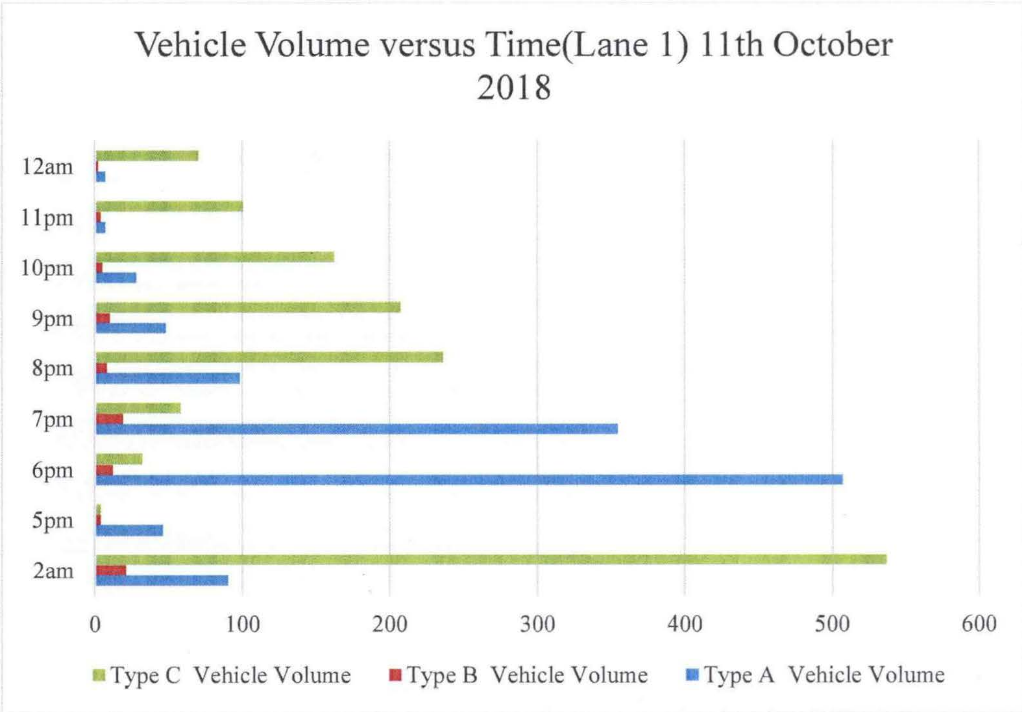

Figure 4-4: Vehicle Volume versus Time (Lane 1) 11th October 2018

From the Figure 4-4 above, it can be concluded that phase 2 lane 1 on 11th October 2018, the highest vehicle volume was from Class C vehicle with 537 units at 2:00 a.m., whereas the lowest vehicle volume was from Class B vehicle with 2 units at 12 a.m.

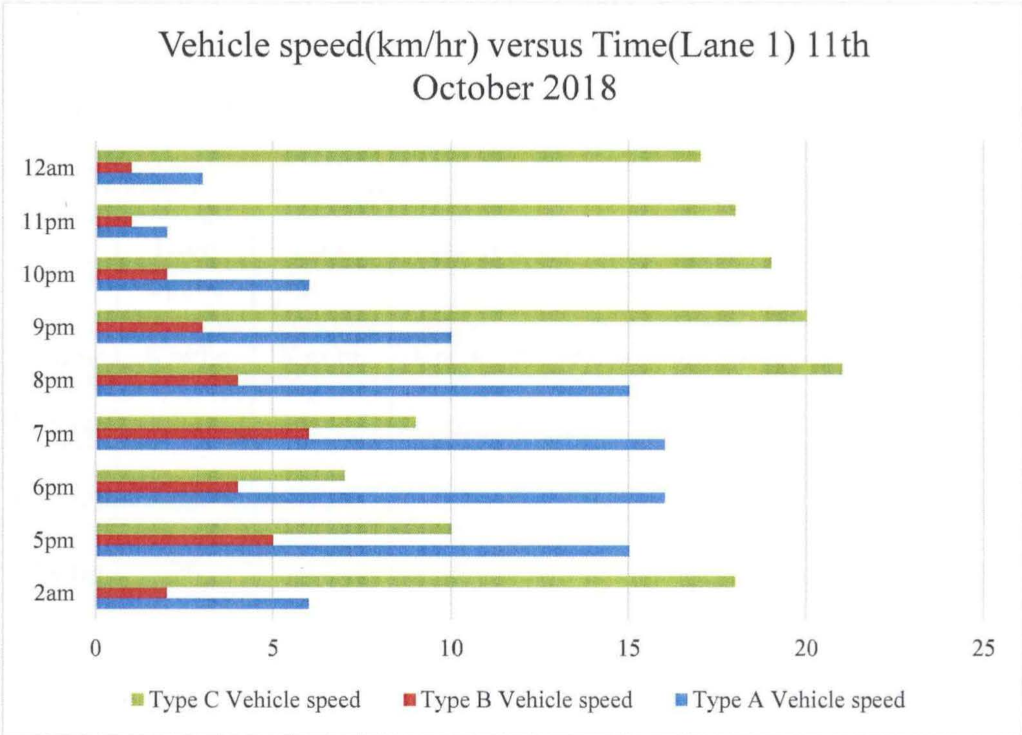

Figure 4-5: Vehicle speed(km/hr) versus Time (Lane 1) 11th October 2018

From the Figure 4-5 above, it can be concluded that phase 2 lane 1 on 11th October 2018, the highest vehicle speed was from Class C vehicle with 21 kilometers per hour at 8 p.m., whereas the lowest vehicle speed was from Class B with 1 kilometers per hour at 11 p.m. and 12 a.m.(12th October).

Table 4-3: Vehicle Classification of Phase 2 lane 2 on 11th October 2018

Sr #	Lane no.	Time	Avg High Speed Vehicle, Km/hr	Avg Low Speed Vehicle, Km/hr	Type A Vehicle speed, Km/hr	Type A Vehicle Volume	Type B Vehicle speed, Km/hr	Type B Vehicle Volume	Type C Vehicle speed, Km/hr	Type C Vehicle Vol.
1	2	02:00	24	13	9	183	1	14	16	512
2	2	17:00	18	12	12	18	8	5	5	5
3	2	18:00	26	14	18	306	3	10	10	91
4	2	19:00	22	13	17	267	3	8	10	68
5	2	20:00	29	13	13	97	3	6	17	177
6	2	21:00	25	14	11	61	1	2	17	175
7	2	22:00	29	13	15	70	2	6	18	157

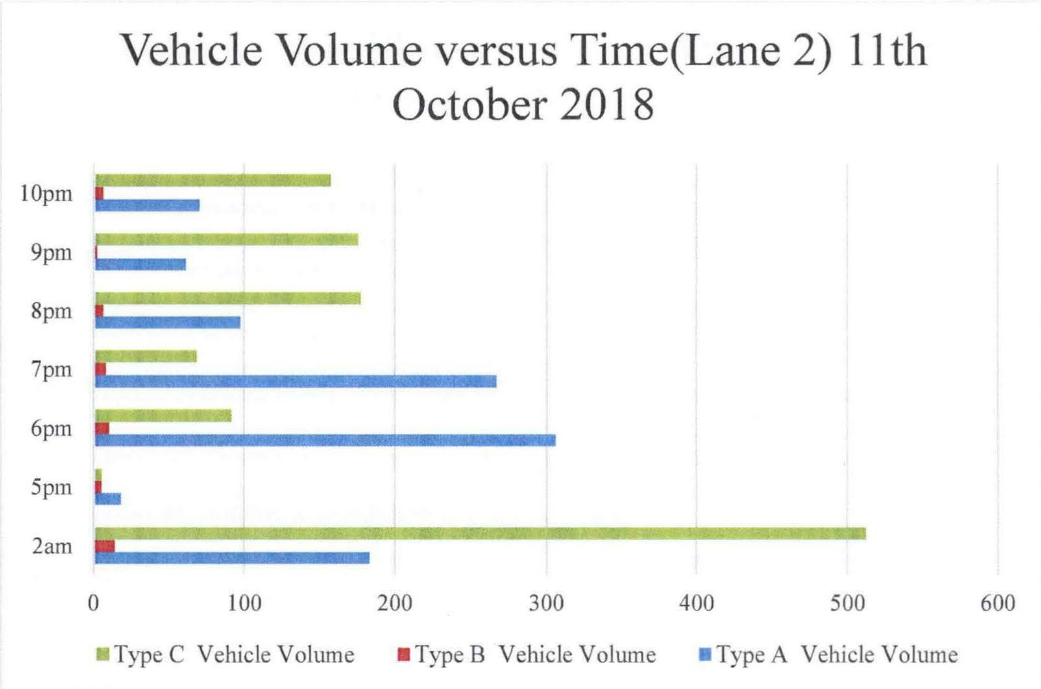

Figure 4-6: Vehicle Volume versus Time(Lane 2) 11th October 2018

From the Figure 4-6 above, it can be concluded that phase 2 lane 2 on 11th October 2018, the highest vehicle volume was from Class C vehicle with 512 units at 2:00 a.m., whereas the lowest vehicle volume was from Class B vehicle with 2 units at 9 p.m.

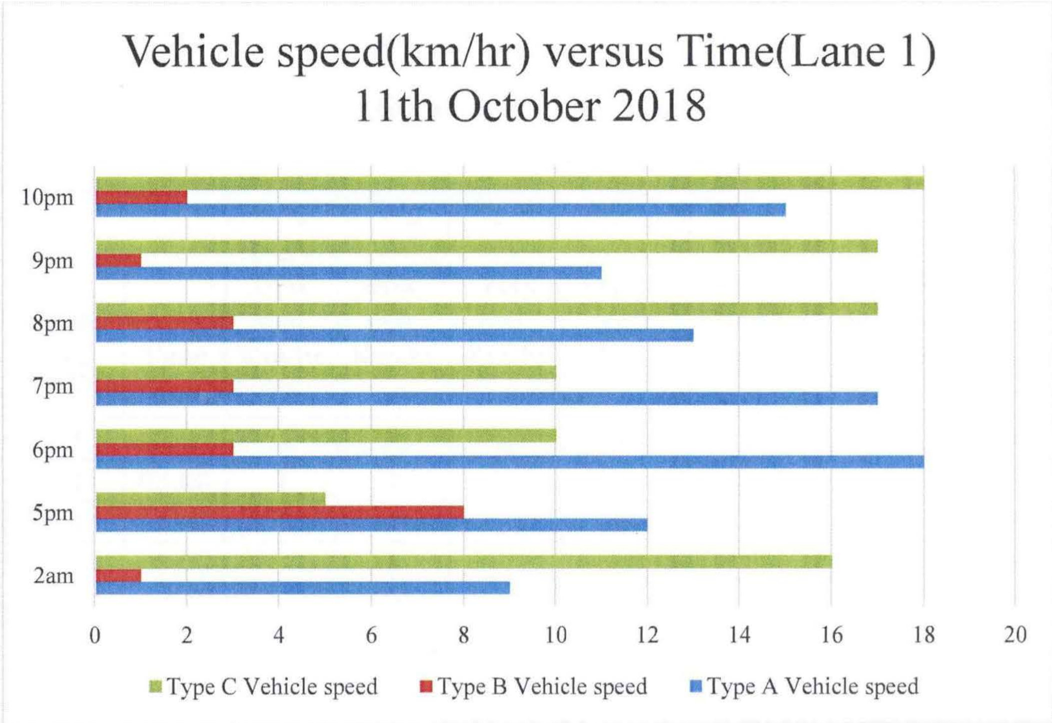

Figure 4-7: Vehicle speed(km/hr) versus Time(Lane 2) 11th October 2018

From the Figure 4-7 above, it can be concluded that phase 2 lane 2 on 11th October 2018, the highest vehicle speed was from Class C vehicle with 21 kilometers per hour at 8 p.m., whereas the lowest vehicle speed was from Class B with 1 kilometers per hour at 11 p.m. and 12 a.m. (12th October).

Table 4-4: Vehicle Classification of Phase 2 lane 1 on 12th October 2018

Sr #	Lane No.	Time	Avg High Spd Veh, Km/hr	Avg Low Spd. Veh., Km/hr	Type A Veh. spd, Km/hr	Type A Veh. Vol.	Type B Vehicle speed, Km/hr	Type B Vehicle Volume	Type C Vehicle speed, Km/hr	Type C Vehicle Volume
1	1	01:00	17	13	4	9	0	0	14	54
2	1	02:00	12	10	2	8	0	1	10	31
3	1	03:00	7	4	1	4	1	5	5	21
4	1	04:00	6	4	3	11	0	3	3	13
5	1	05:00	14	8	7	32	2	5	5	45
6	1	20:00	12	10	2	8	0	1	10	31

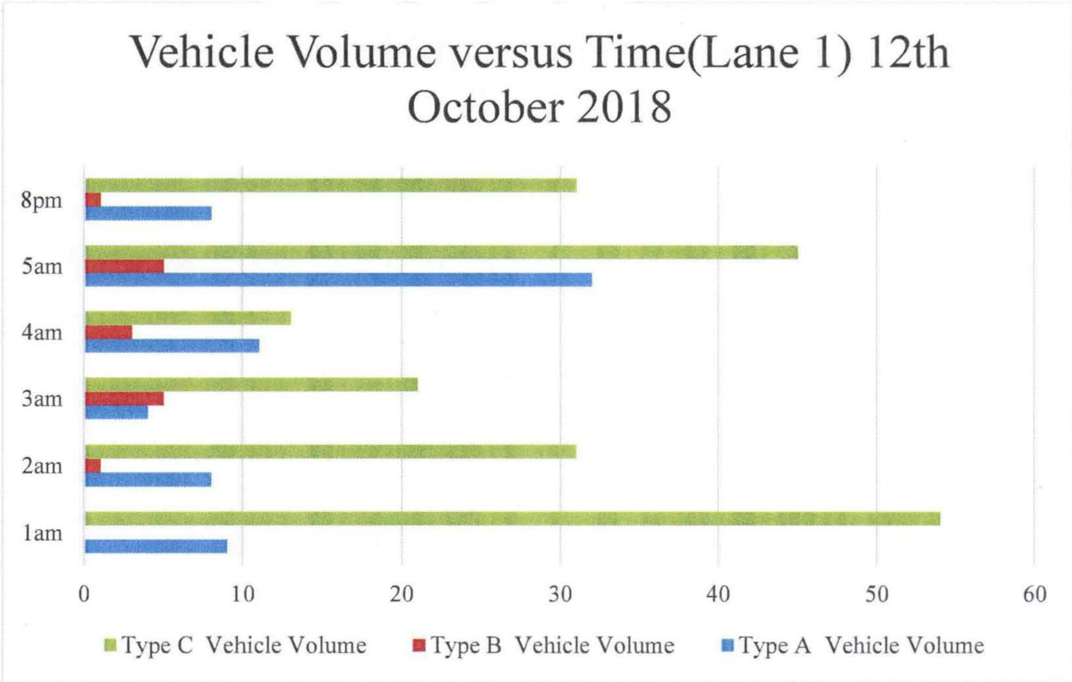

Figure 4-8: Vehicle Volume versus Time(Lane 1) 12th October 2018

From the Figure 4-8 above, it can be concluded that phase 2 lane 1 on 12th October 2018, the highest vehicle volume was from Class C vehicle with 54 units at 1:00 a.m., whereas the lowest vehicle volume was from Class B vehicle with 0 units at 1 a.m.

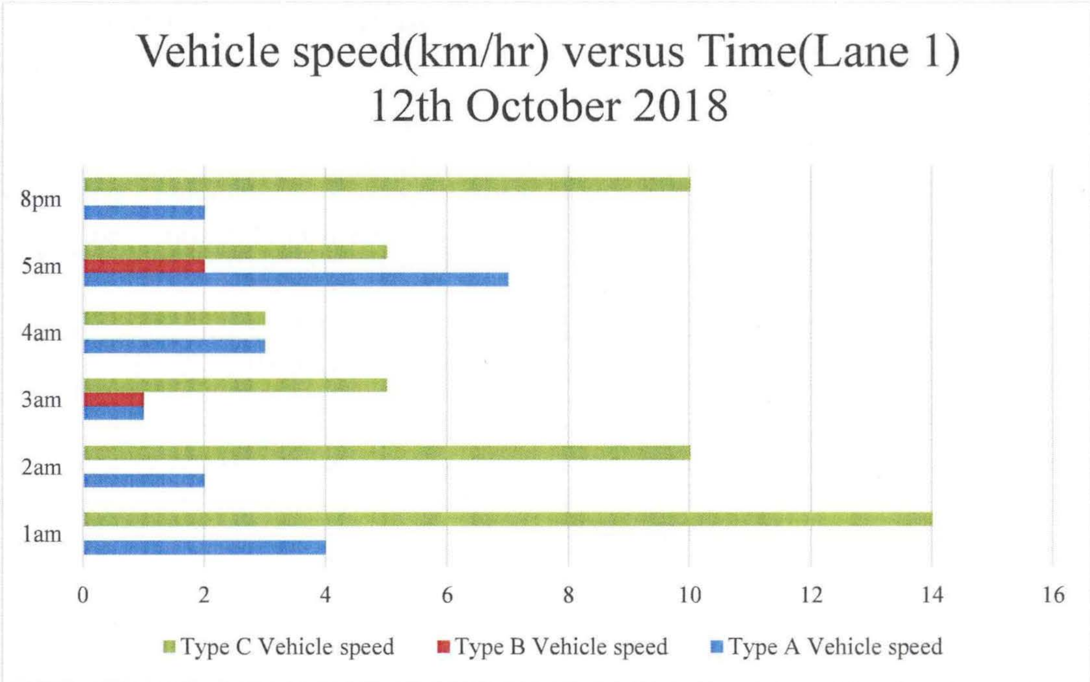

Figure 4-9: Vehicle speed(km/hr) versus Time(Lane 1) 12th October 2018

From the Figure 4-9 above, it can be concluded that phase 2 lane 1 on 12th October 2018, the highest vehicle speed was from Class C vehicle with 14 kilometers per hour at 1 a.m., whereas the lowest vehicle speed was from Class B and Class A with 1 kilometers per hour at 3 a.m.

Table 4-5: Vehicle Classification of Phase 2 lane 2 on 12th October 2018

Sr #	Total Lane	Lane no.	Time	Avg High Speed, Km/hr	Avg Low Speed, Km/hr	Type A speed, Km/hr	Type A Volume	Type B speed, Km/hr	Type B Vol.	Type C speed, Km/hr	Type C Vehicle Vol.
1	2	2	01:00	15	10	6	26	0	0	10	53
2	2	2	02:00	15	10	6	26	1	2	10	65
3	2	2	03:00	14	9	4	15	1	3	10	54
4	2	2	04:00	12	8	3	14	2	6	8	48
5	2	2	05:00	15	6	5	17	2	3	5	38
6	2	2	20:00	15	10	6	26	1	2	10	65

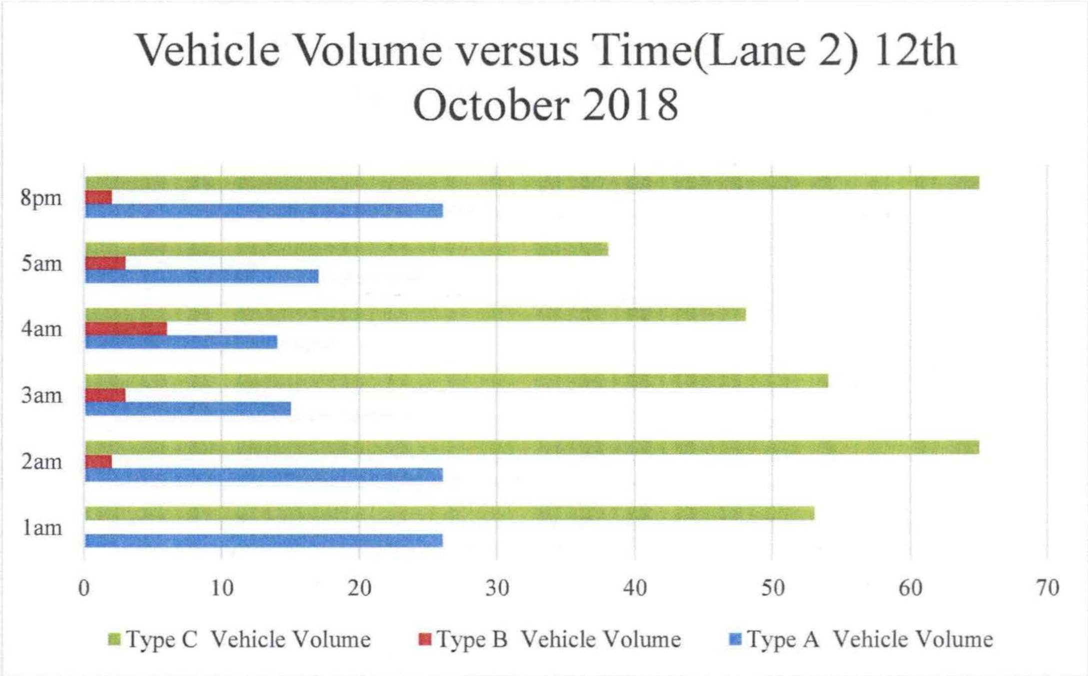

Figure 4-10: Vehicle Volume versus Time(Lane 2) 12th October 2018

From the Figure 4-10 above, it can be concluded that phase 2 lane 2 on 12^{th} October 2018, the highest vehicle volume was from Class C vehicle with 65 units at 2:00 a.m. and 8 p.m., whereas the lowest vehicle volume was from Class B vehicle with 0 units at 1 a.m.

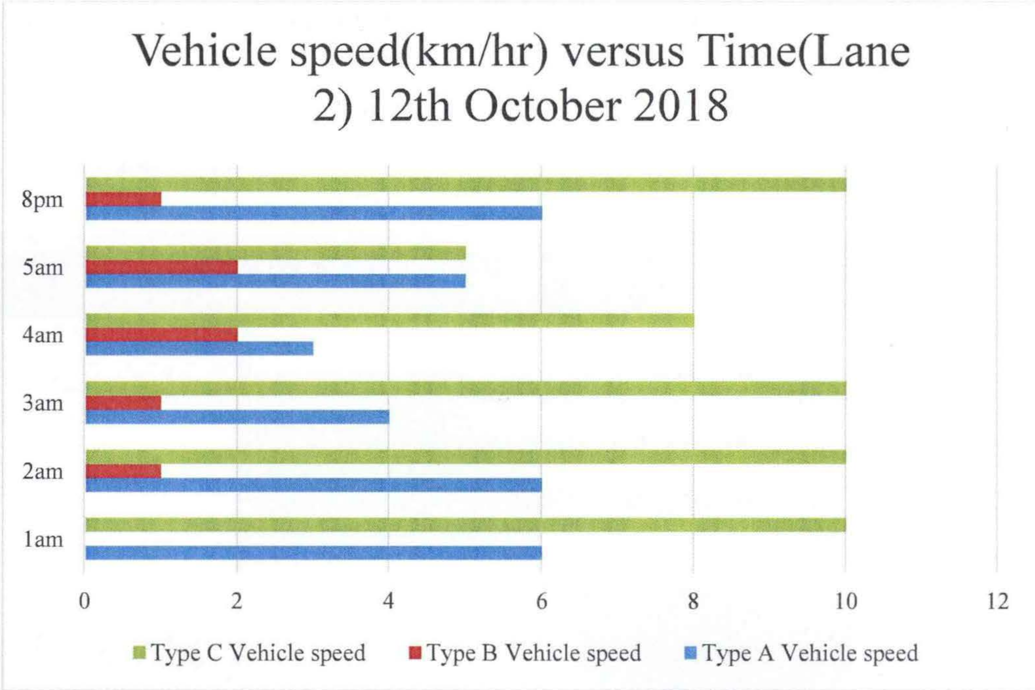

Figure 4-11: Vehicle speed(km/hr) versus Time(Lane 2) 12th October 2018

From the Figure 4-11 above, it can be concluded that phase 2 lane 2 on 12th October 2018, the highest vehicle speed was from Class C vehicle with 10 kilometers per hour at 1 a.m., 2 a.m., 3 a.m., 8p.m., whereas the lowest vehicle speed was from Class B with 1 kilometers per hour at 2 a.m., 3 a.m. and 8

4.2.3 Monthly Setting between 4th April, 4th May and 4th June

The Figure 4-12, 4-13, 4-14, 4-15 and Table 4-6 indicates the Monthly Setting between 4th April, 4th May and 4th June.

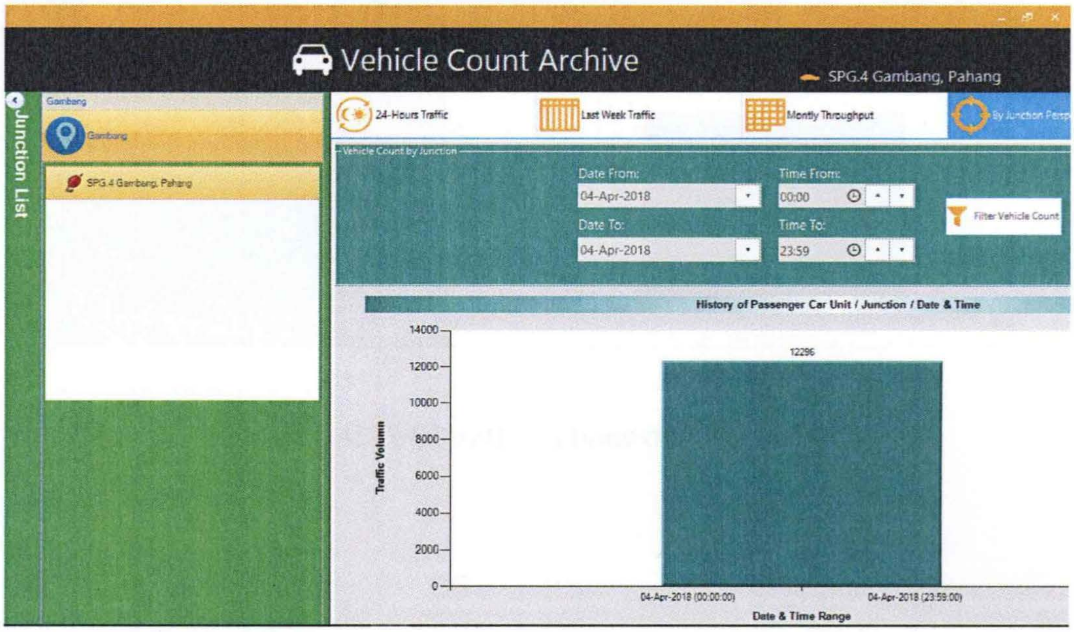

Figure 4-12: Total traffic volume on 4th April 2018

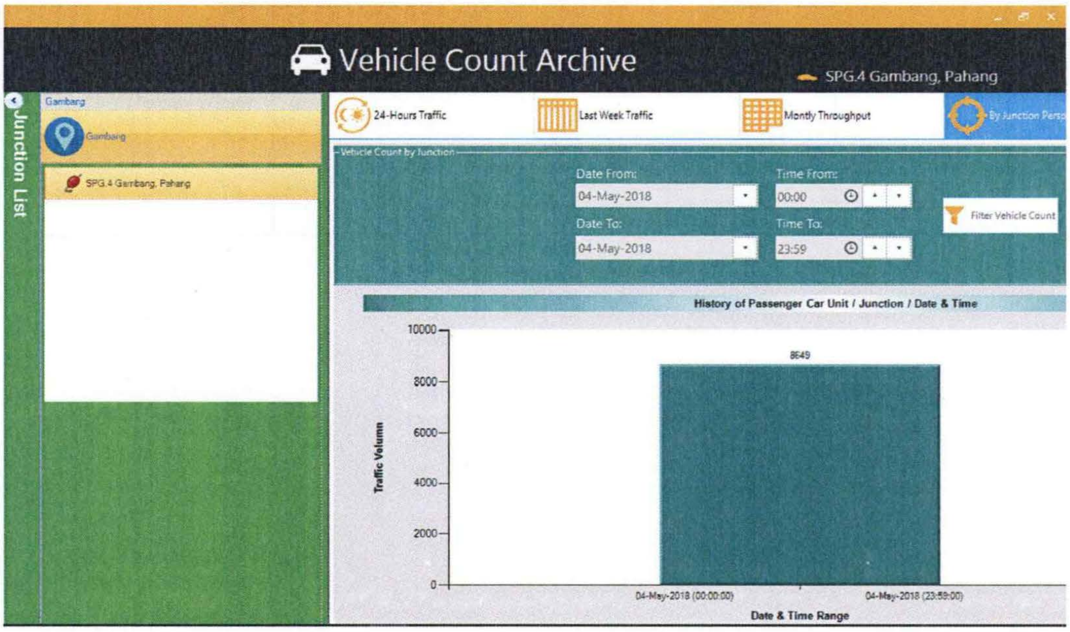

Figure 4-13: Total traffic volume on 4th May 2018

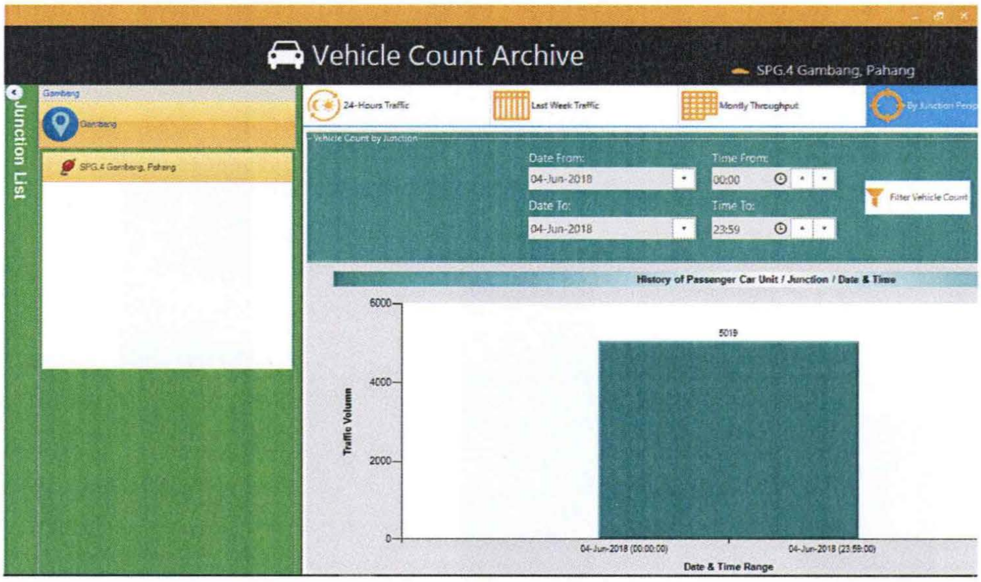

Figure 4-14: Total traffic volume on 4th June 2018

Table 4-6: Traffic volume on 4th April, 4th May, 4th June

DATE	4th April	4th May	4th June
TRAFFIC VOLUME(Passenger Car Unit)	12296	8649	5019

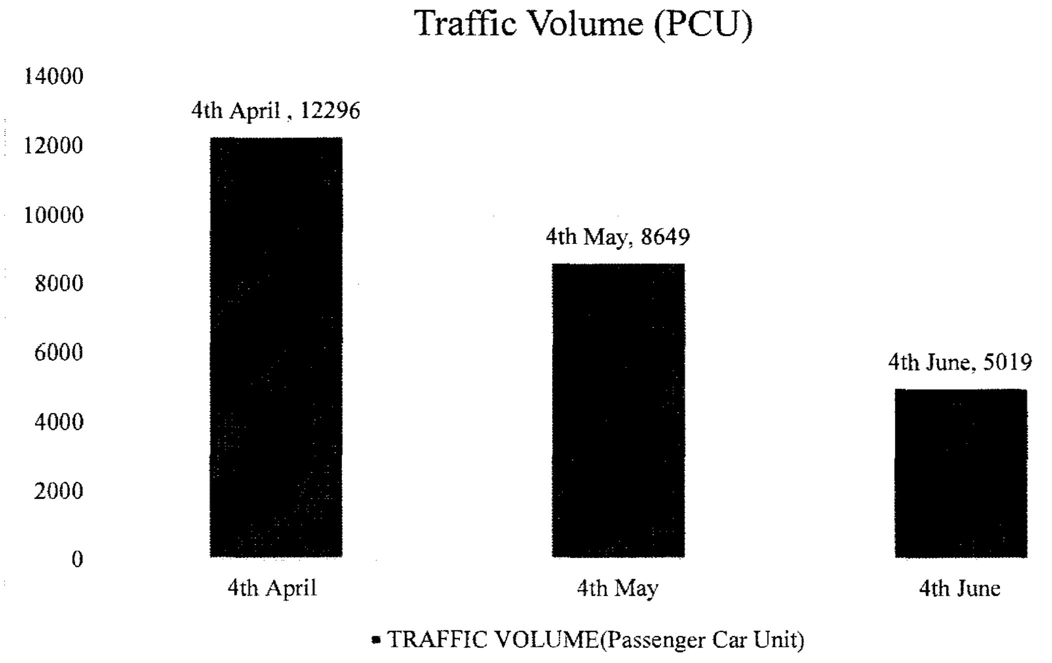

Figure 4-15: Traffic Volume from 4th April, 4th May and 4th June

From the Figure 4-15 above, it can be concluded that the highest traffic volume was on 4th April with 12296 units, whereas the lowest was 4th June with 5019 units.

4.2.4 Weekly Setting in May 2018

The figure 4-16, 4-17, 4-18, 4-19, 4-20, 4-21 and Table 4-7 shows the Weekly Setting in May 2018.

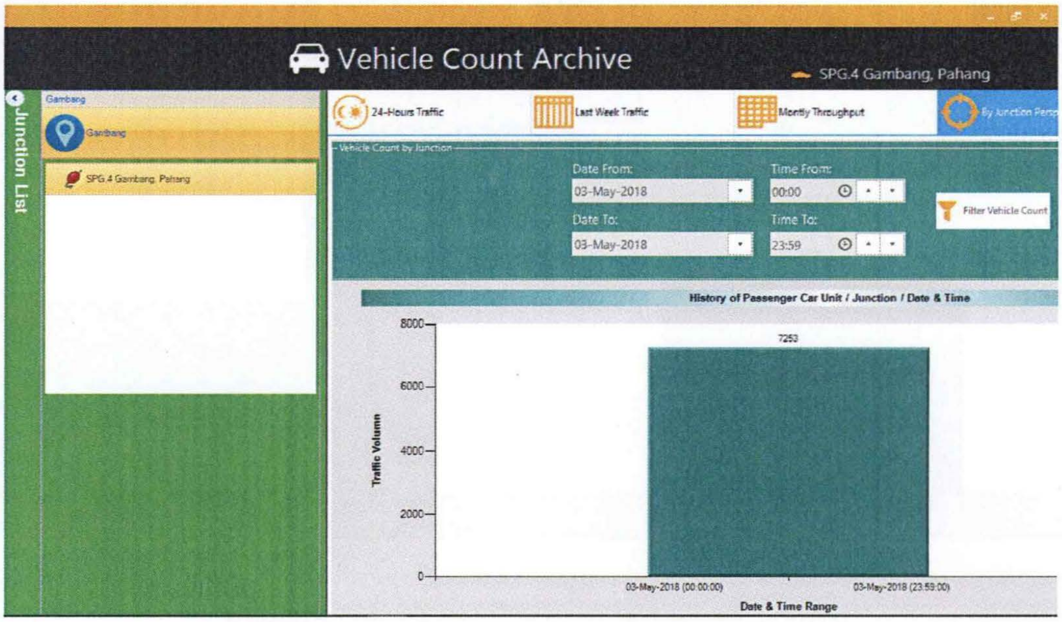

Figure 4-16: Traffic volume on 3rd May 2018

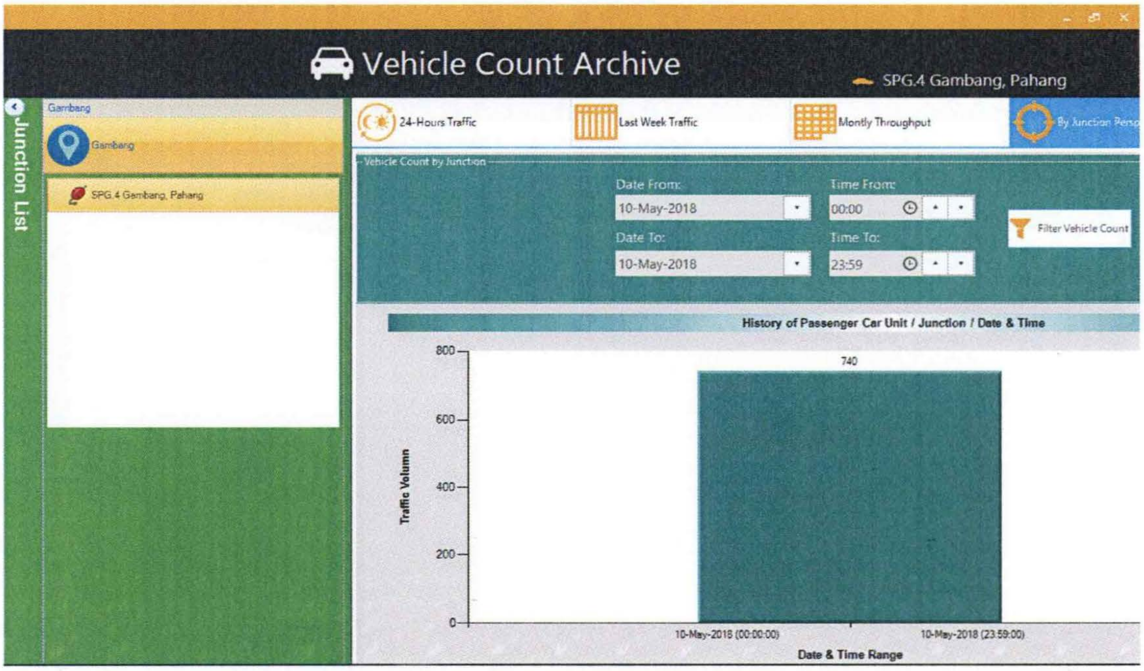

Figure 4-17: Traffic volume on 10th May 2018

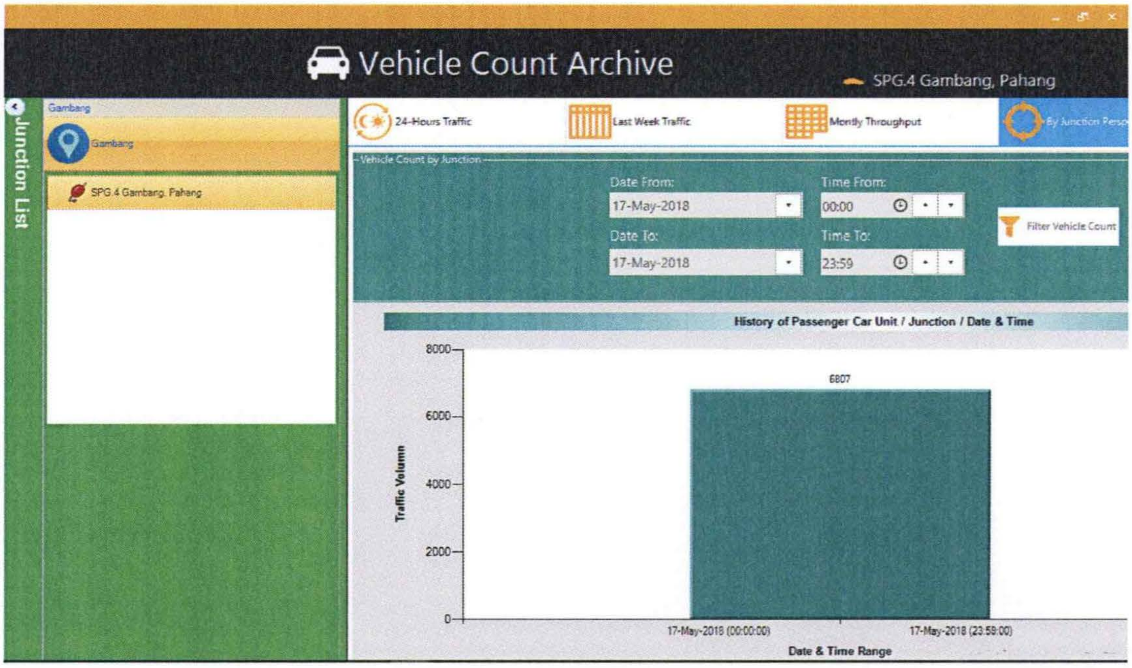

Figure 4-18: Traffic volume on 17th May 2018

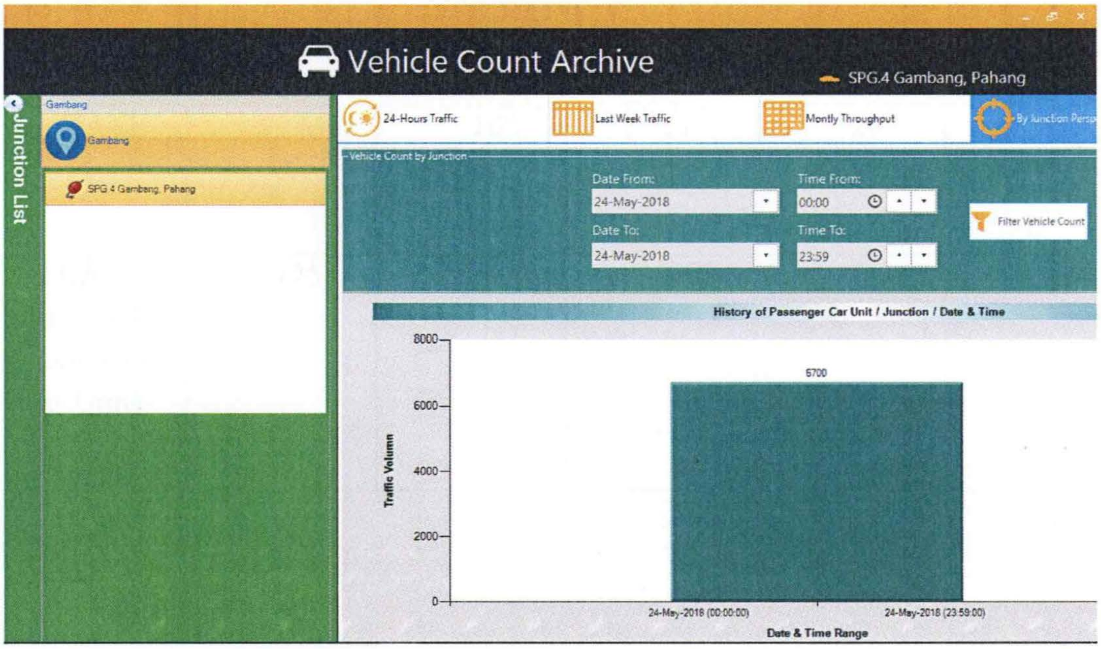

Figure 4-19: Traffic volume on 24th May 2018

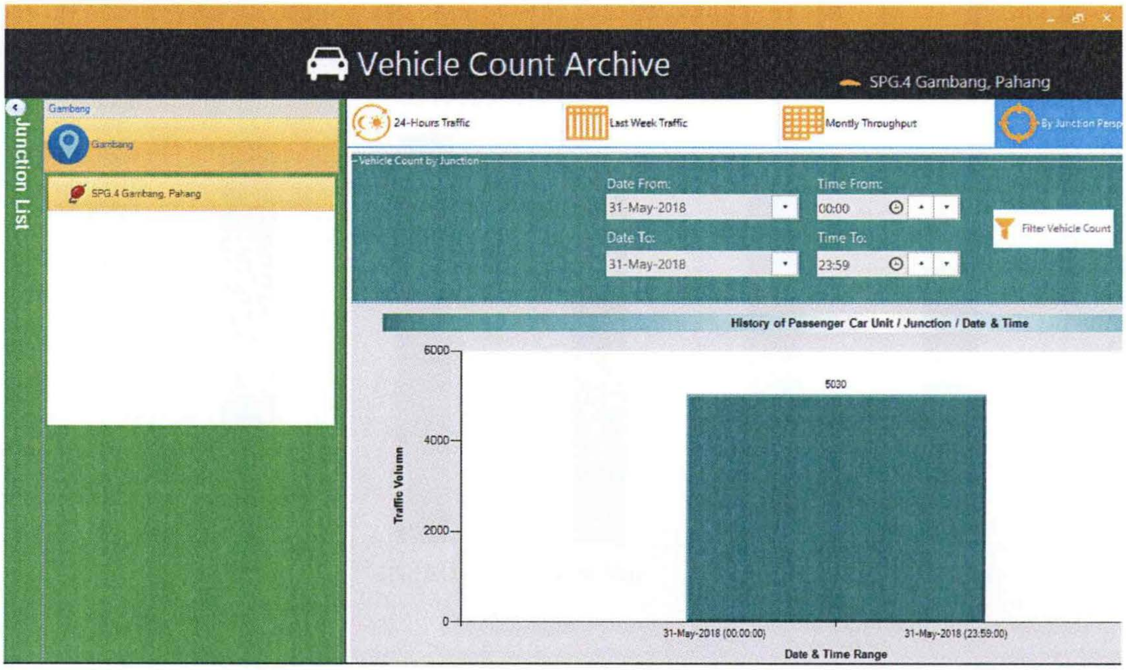

Figure 4-20: Traffic volume on 31st May 2018

Table 4-7: Traffic volume of Thursday in May of 5 weeks

DATE	3rd May	10th May	17th May	24th May	31st May
TRAFFIC VOLUME (Passenger Car Unit)	7253	7400	6807	6700	5030

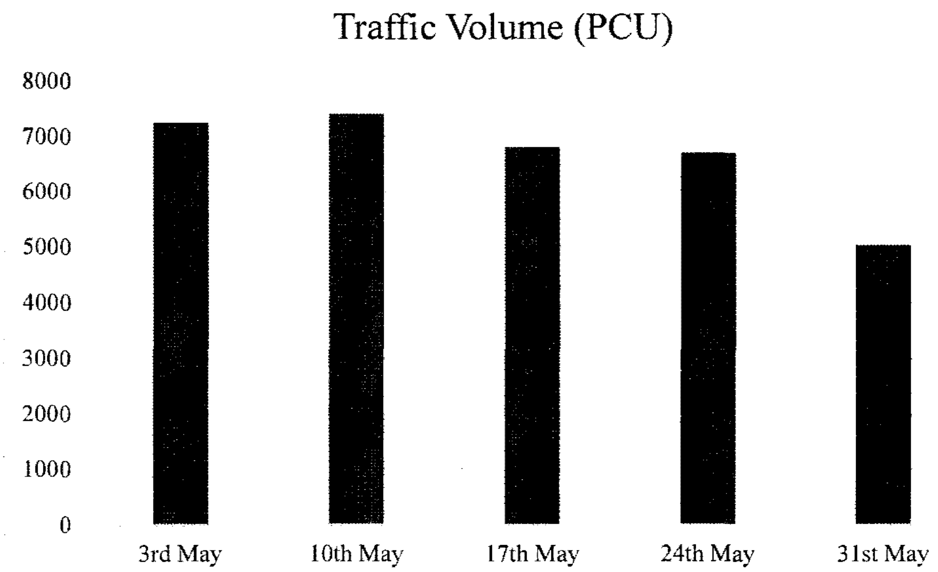

Figure 4-21: Traffic Volume of weekly setting

From the Figure 4-21 above, the lowest traffic volume of Thursday was 5030 units of the fifth week of May (31st May), whereas the highest was 7400 units from the second week of May(10th May). The average units of traffic volume from the weekly setting is 6638 units.

4.2.5 Daily Setting

The data below taken from the MITS software.

Table 4-8: Traffic volume of a week

Date	Day	Traffic Volume (PCU)
13th May	Friday	11160
14th May	Saturday	12415
15th May	Sunday	14929
16th May	Monday	11080
17th May	Tuesday	10872
18th May	Wednesday	11167
19th May	Thursday	11203

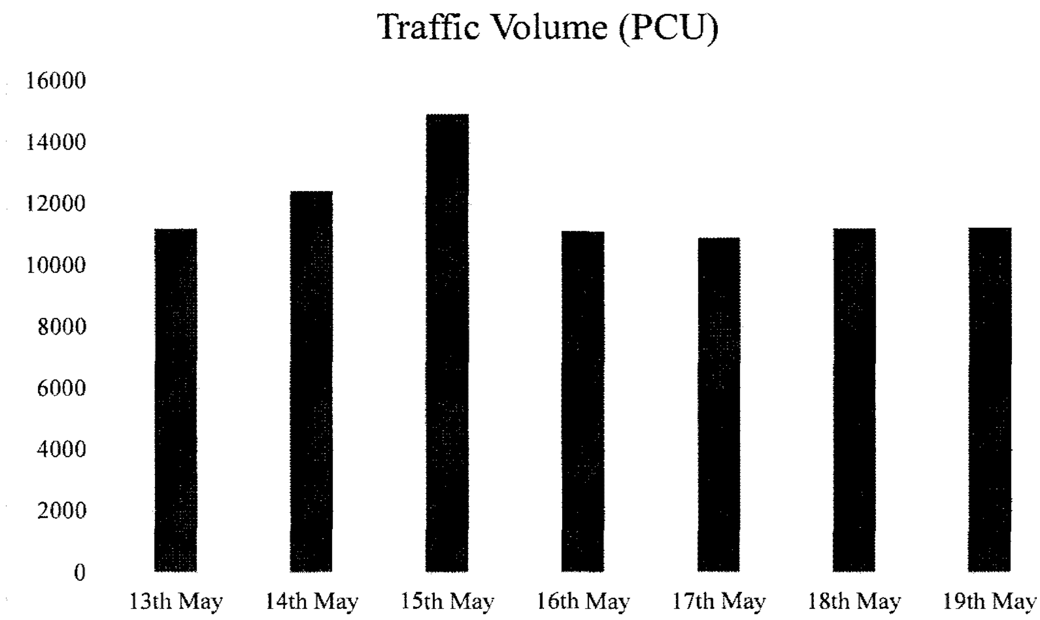

Figure 4-22: Traffic Volume of daily setting

From the Figure 4-22 above, it can be concluded that Sunday is the most traffic volume as compared to the other day, that was 14929 units, whereas the lowest traffic volume was on Tuesday, 10872 units. Traffic volume of Monday was 11080 units, Wednesday was 11167 units, Thursday was 11203 units, Friday was 11160 units and Saturday was 12415 units.

4.2.6 Hourly Setting

The data below taken from the MITS software.

Table 4-9: Traffic Volume of 21st April 2018 by hourly

Time (21st April 2018)	Traffic Volume (PCU)
00:00-01:00	120
01:00-02:00	282
02:00-03:00	177
03:00-04:00	53
04:00-05:00	216
05:00-06:00	228
06:00-07:00	389
07:00-08:00	623
08:00-09:00	655
09:00-10:00	810
10:00-11:00	774

11:00-12:00	704
12:00-13:00	707
13:00-14:00	765
14:00-15:00	745
15:00-16:00	762
16:00-17:00	815
17:00-18:00	778
18:00-19:00	782
19:00-20:00	673
20:00-21:00	637
21:00-22:00	704
22:00-23:00	524
23:00-00:00(22nd April)	406

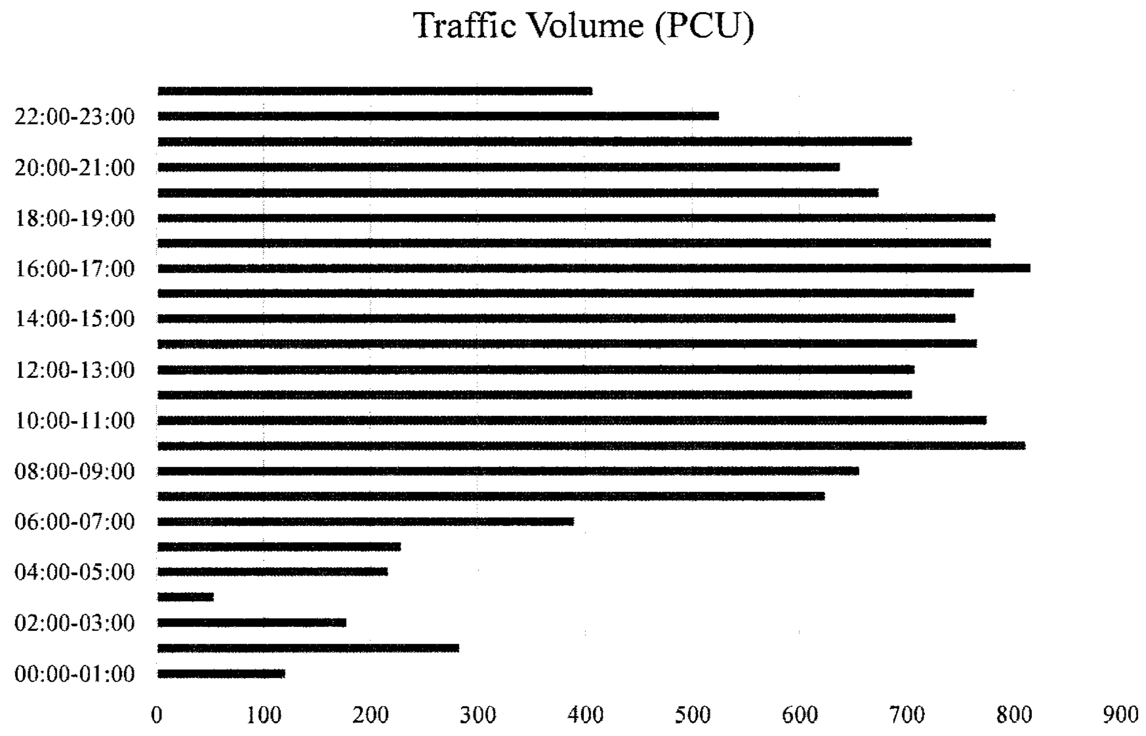

Figure 4-23: Traffic volume of hourly setting

From the Figure 4-23 above, the peak hours were 09:00-10:00 and 16:00-17:00, those are 810 units and 815 units. The hour with the lowest traffic volume was 03:00-04:00, 53 units.

4.2.7 Comparison of the peak hour factor of day 21^{st},22^{nd},23^{rd},24^{th} and 27^{th} of April 2018

Table 4-10: Peak hour factors of the day 21st,22nd,23rd,24th and 27th of April 2018

Date	Day	Peak Hour	Traffic Volume(PCU)
21^{st} April	Saturday	09:00-10:00	810
21^{st} April	Saturday	16:00-17:00	815
22^{nd} April	Sunday	09:00-10:00	774
22^{nd} April	Sunday	16:00-17:00	616
23^{rd} April	Monday	09:00-10:00	537
23^{rd} April	Monday	16:00-17:00	764
24^{th} April	Tuesday	09:00-10:00	672
24^{th} April	Tuesday	16:00-17:00	702
27^{th} April	Friday	09:00-10:00	736
27^{th} April	Friday	12:00-13:00	837
27^{th} April	Friday	13:00-14:00	878
27^{th} April	Friday	14:00-15:00	810
27^{th} April	Friday	16:00-17:00	864

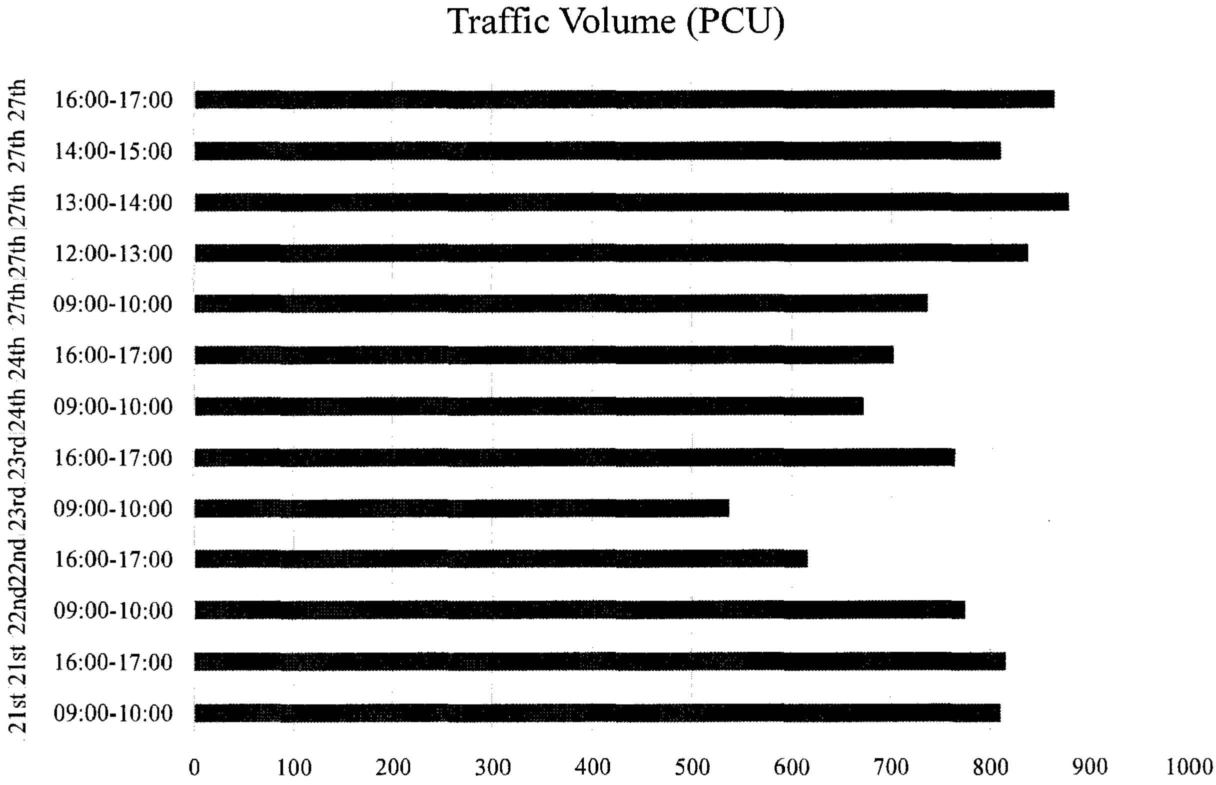

Figure 4-24: Comparison of peak hour factors of 21st, 22nd,23rd,24th and 27th of April 2018

From the Figure 4-24 above, it can be concluded that the peak hours of the day are 09:00-10:00 and 16:00-17:00. For the 09:00-10:00 and 16:00-17:00 of 21st April there are 810 units and 815 units, 22nd April there are 774 units and 616 units, 23rd April there are 537 units and 764 units, 24th April there are 672 units and 702 units. There was an exception that was on Friday, 27th April, the peak hours were 09:00-10:00, 12:00-13:00, 13:00-14:00, 14:00-15:00 and 16:00-17:00, there were 736 units, 837 units, 878 units, 810 units and 864 units.

As a result, it can be concluded that the peak hour factor of Friday were affected by the "Solat Jumaat" of every week for the Muslims in Malaysia. This is the reason why there are more peak hour factors on Friday.

4.2.8 Traffic Capacity based on Traffic Queueing Condition

The Figure 4-25 shows the Junction Status.

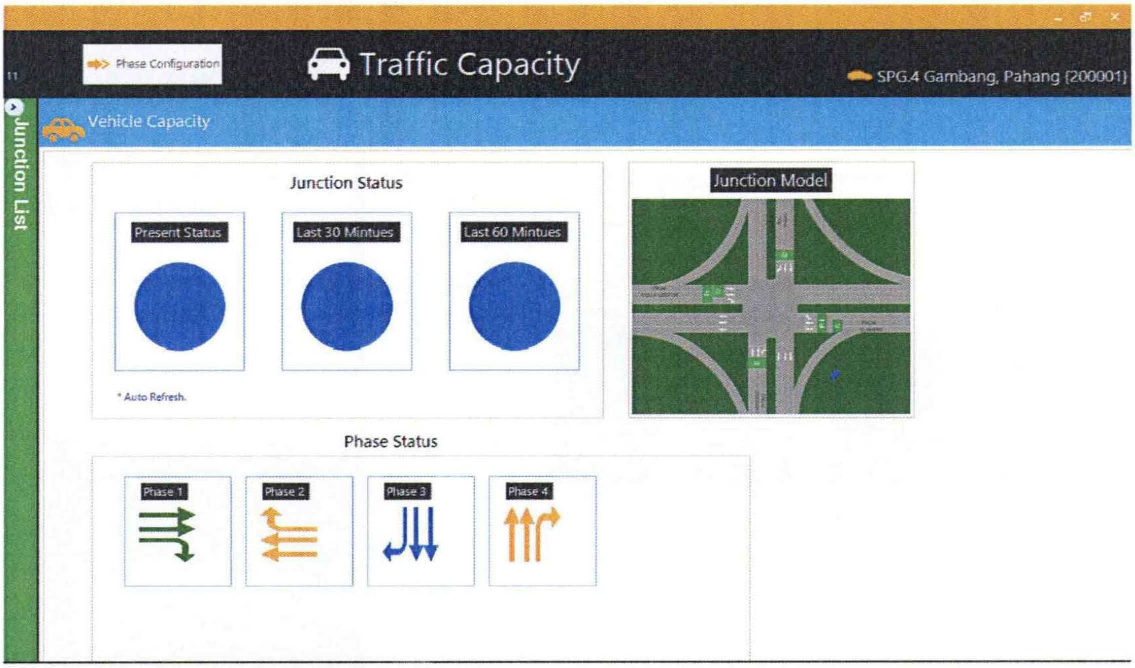

Figure 4-25: Junction Status

From the Figure 4-25 above, it indicated that Traffic Queuing from West is Phase 1, Traffic Queuing from East is Phase 2, Traffic Queuing from North is Phase 3 and Traffic Queuing from South is Phase 4.

4.2.9 Traffic Queueing from West, East, North and South

The Figure 4-26 shows the vehicle waiting time of SPG 4, Gambang, Pahang.

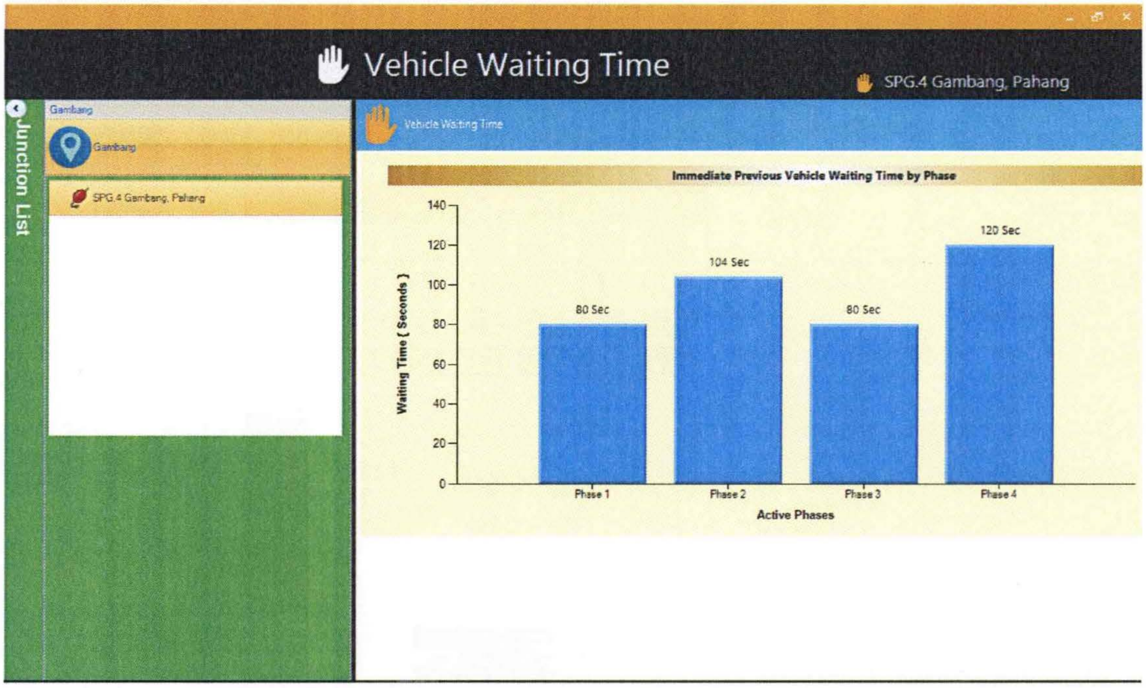

Figure 4-26: Vehicle Waiting Time of SPG4, Gambang, Pahang

From the Figure 4-26 above it indicated that Traffic Queueing from West is 80 seconds, Traffic Queueing from East is 104 seconds, Traffic Queueing from North is 80 seconds and Traffic Queueing from South is 120 seconds.

4.2.10 Junction Time Setting

The Figure 4-27 shows the Junction Time Setting.

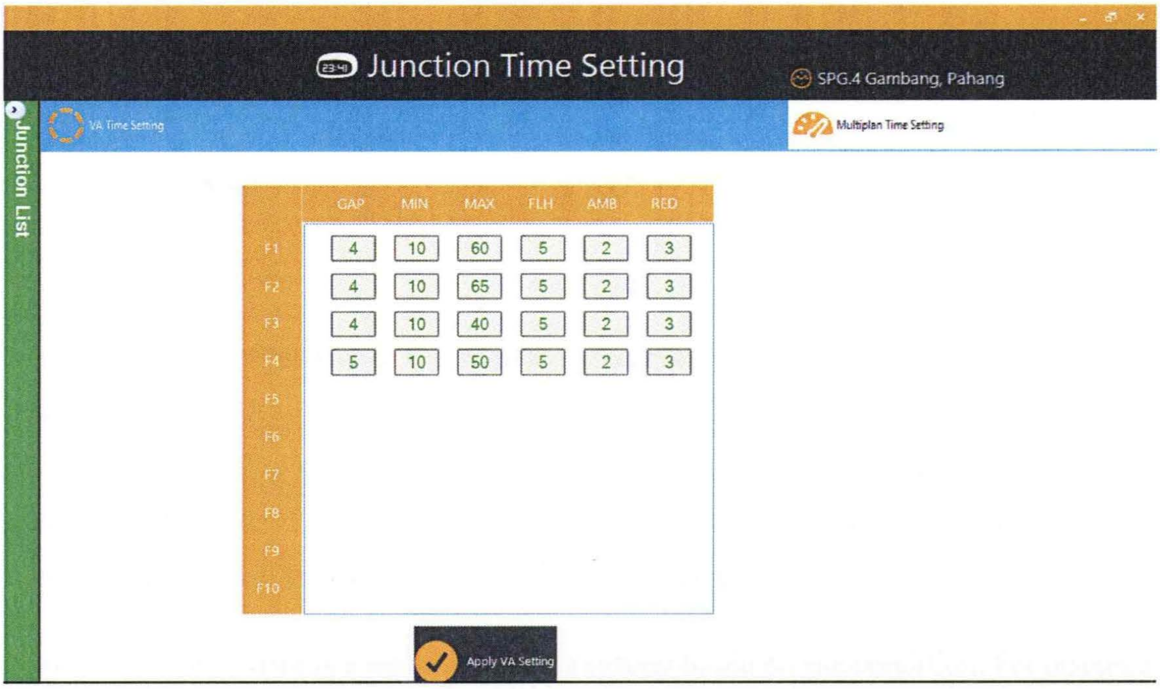

Figure 4-27: Junction Time Setting

The junction time setting applied at this gambang junction is Vehicle Activated(VA) Time Setting. It represent that when more vehicle pass through it will automatically increase the green time, if the phase has no cars to pass through the junction, then it will shorten the green time for that particular phase. F1, F2, F3, F4 represent the phases. GAP is the time amount(4 seconds) will be added when cars pass through the loops after the minimum green time that is 10 seconds, the maximum green time will be different based on different phases. FLH represent the flash time(5 seconds) when green time going to end. After FLH that will be AMB, that is yellow light that will flash for 2 seconds before it turning red. After the particular phase turns red light, then all the phase will remain red time for 3 seconds, then only the next phase start green time. The reason why that MITS design all phase need to stop for 3 seconds is to avoid accident occur when cars went through red light.

CHAPTER 5

CONCLUSION

5.1 Conclusion

In conclusion, the objective of this project is achieved, that is a user manual of Malaysian Intelligent Traffic System (MITS) is produced. Based on the knowledge from literature review is sufficient to know the way and technique to calculate the data. In methodology, there is a full guide of using MITS to collect information and data. Lastly, in chapter 4, there are the data collections and the method to interpret it.

Last but not least, there is a weakness of this system based on site condition. For instance, at this Kuantan-Gambang (FR 2) and Gambang Toll Plaza (FR 222)-Muadzam (FR 12) cross junction, there are eight cameras, after an accident happens on 12th September 2018, the other 6 cameras are not functioning. This required a frequent maintenance work from the company of MITS. Recommendation for this project is to create more maintenance work on this MITS system in every MITS system installed in Malaysia, so that the traffic data is always available.

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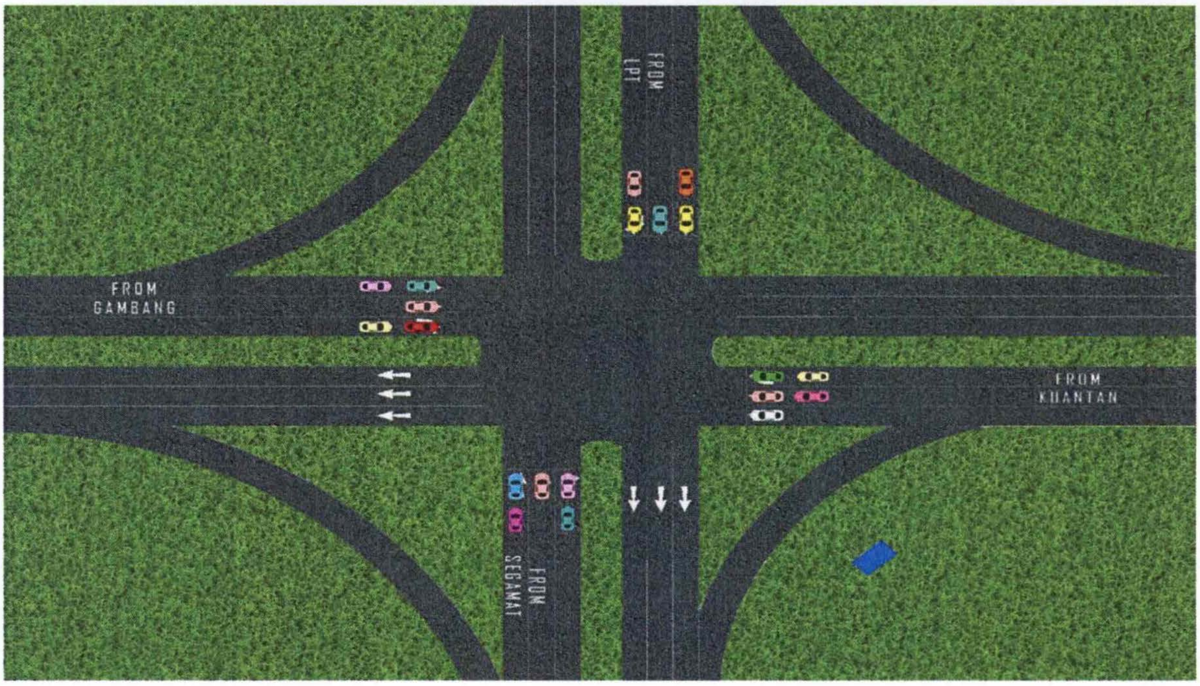
APPENDIX A
SAMPLE REPORT OF MITS

PPK Technology Sdn Bhd

MITS Report: SPG.4 Gambang, Pahang

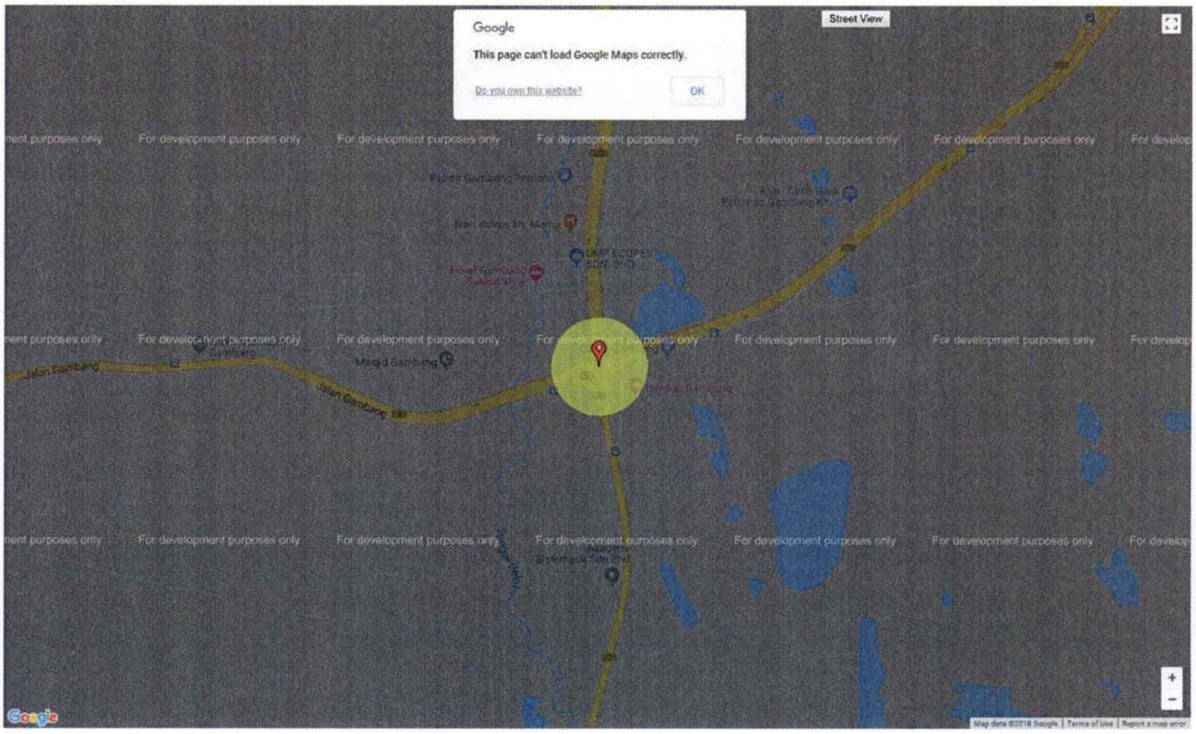
Junction Model

Below is the Model of the Junction. It showing the Phases Locations and representing the Model of Junction



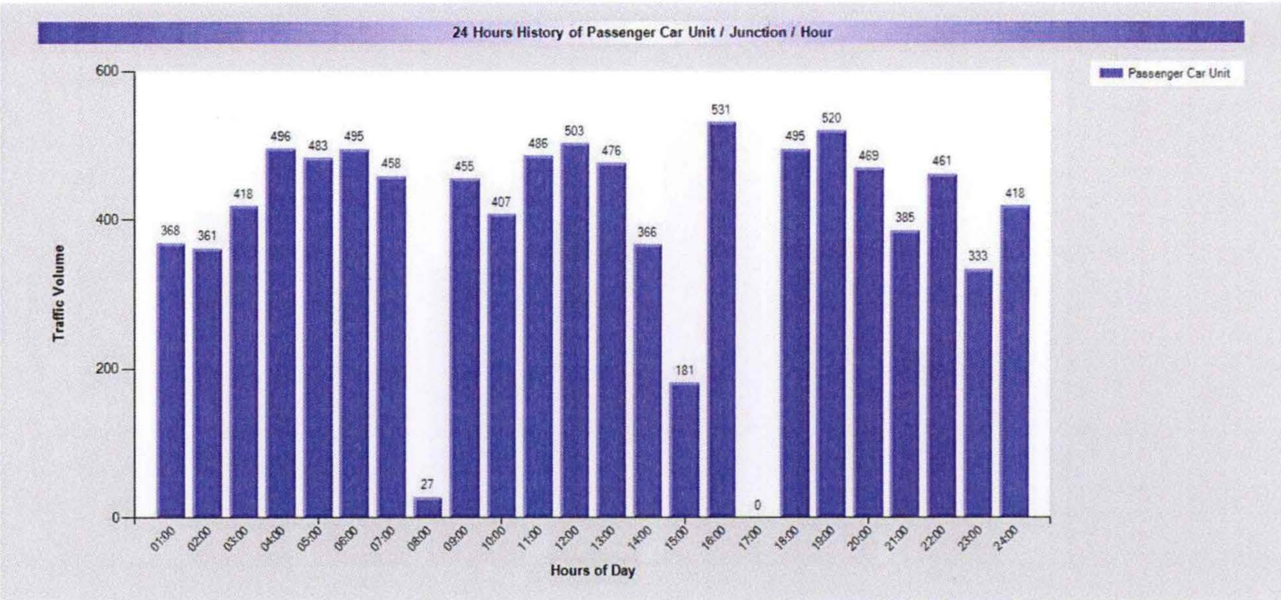
Junction Location on Map

Representing the Actual Location of Junction base on Google Map



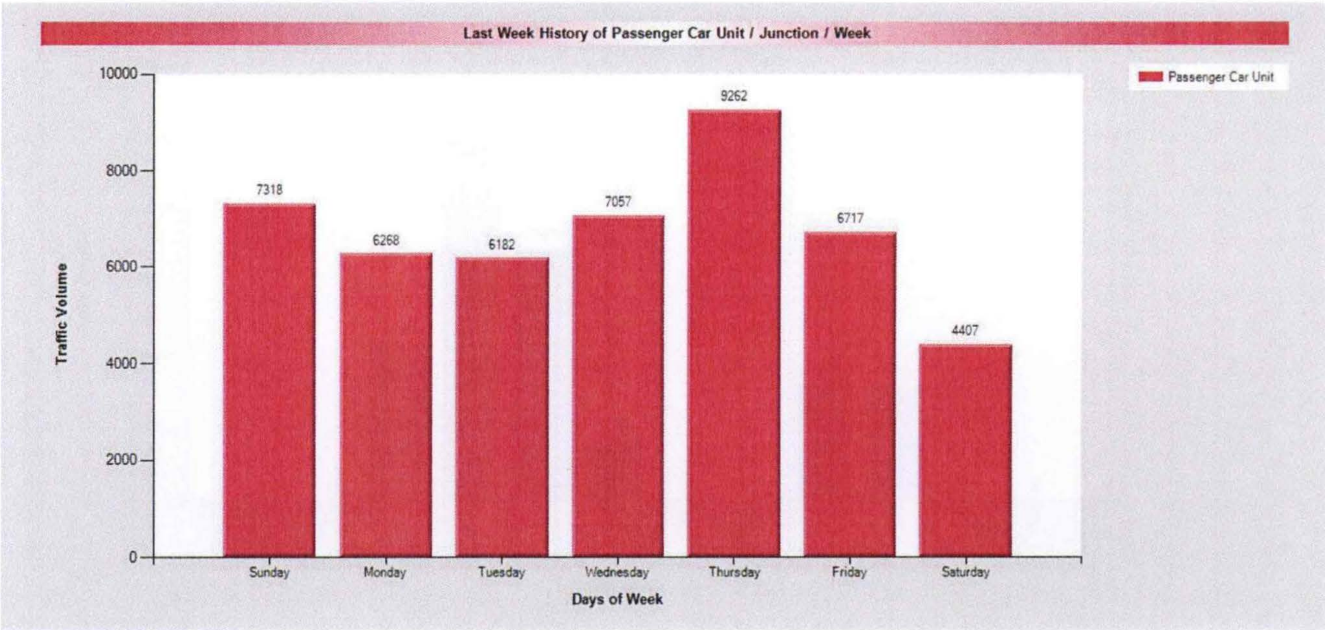
24 Hours Vehicle Count Report

Representing the Actual Junction's statistics of 24 hour Vehicle Count



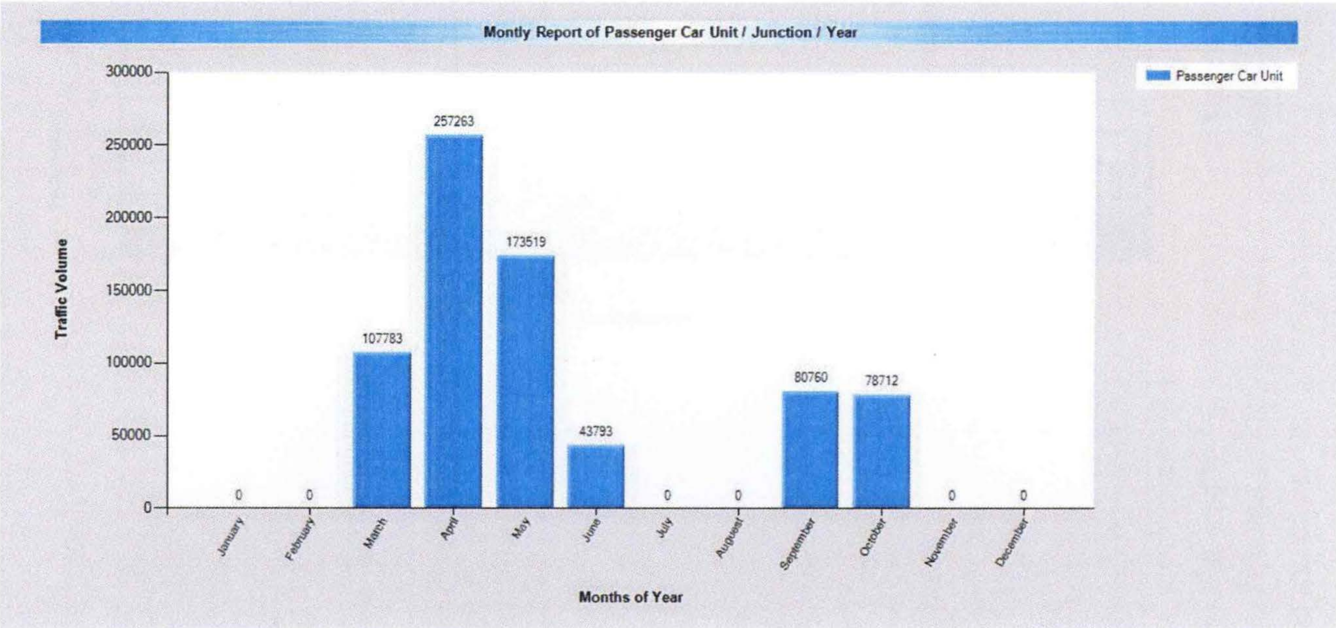
Weekly Vehicle Count Report

The figures shown represent Vehicle Count occurring on traffic Junction in a last 1 week



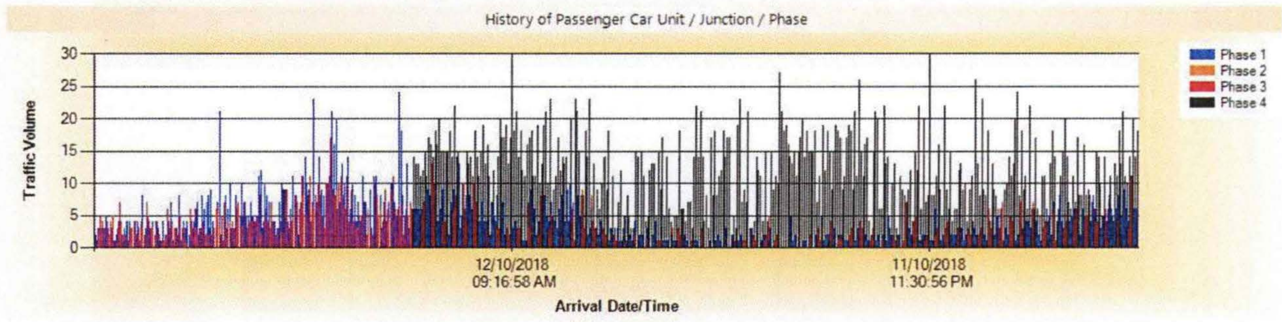
Monthly Vehicle Count Report

The figures shown represents the Vehicle Count occurring on traffic Junction filtered as Per Month



By Phase Vehicle Count Report

The figures shown represents the Vehicle Count occurring on traffic Junction filtered as Per Phase



VA Time Setting Report

The figures shown represents the VA Timings running on traffic Junction

	GAP	MIN	MAX	FLH	AMB	RED
F1	4	10	60	5	2	3
F2	4	10	65	5	2	3
F3	4	10	40	5	2	3
F4	5	10	50	5	2	3
F5						
F6						
F7						
F8						
F9						
F10						

Multiplan Time Setting Report

The figures shown represents the MP Timings running on traffic Junction.

	0	1	2	3	4	5	6	7	8	9
F1	40	25	30	35	40	20	20	10	20	30
F2	55	45	40	50	55	35	35	10	20	30
F3	25	20	25	20	25	20	20	10	20	30
F4	40	25	40	30	40	35	35	10	20	30
F5										
F6										
F7										
F8										
F9										
F10										

Alarm & Events Report

Date	Time	Fault Type	Detail	Status
12/10/2018	09:51:00 PM	Loop Fail	1 Failed	Fault Detected
12/10/2018	09:50:59 PM	Loop Fail	Loop 1 is OK	Fault OK
12/10/2018	09:49:40 PM	Loop Fail	1 Failed	Fault Detected
12/10/2018	09:49:39 PM	Loop Fail	Loop 1 is OK	Fault OK
12/10/2018	09:41:12 PM	Loop Fail	1 Failed	Fault Detected
12/10/2018	01:31:53 PM	Loop Fail	1 Failed	Fault Detected
12/10/2018	01:28:50 PM	Loop Fail	Loop 1 is OK	Fault OK
12/10/2018	01:28:38 PM	Loop Fail	1 Failed	Fault Detected
11/10/2018	03:37:45 PM	Loop Fail	Loop 1 is OK	Fault OK
11/10/2018	03:37:26 PM	Loop Fail	1 Failed	Fault Detected
11/10/2018	03:27:10 PM	Loop Fail	Loop 1 is OK	Fault OK
11/10/2018	03:27:01 PM	Loop Fail	1 Failed	Fault Detected
11/10/2018	03:08:28 PM	Loop Fail	Loop 1 is OK	Fault OK
11/10/2018	03:07:50 PM	Loop Fail	1 Failed	Fault Detected
11/10/2018	01:32:07 PM	Loop Fail	1 Failed	Fault Detected