ZABIA AL OTHMAN

EVALUATION OF TRAFFIC LIGHTS OPERATING SYSTEM
IN NICOSIA USING SIDRA INTERSECTION 8 SOFTWARE

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2018

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
ZABIA AL OTHMAN

In Partial Fulfilment of the Requirements for the Degree of Master of Science in Civil Engineering

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Approval of Director of Graduate School of
Applied Sciences

Prof. Dr. Nadire ÇAVUŞ
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We certify that this thesis is satisfactory for the award of the degree of Master of Science in Civil Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Date:

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First and foremost, I would like to thank Allah for giving me the strength to finish this work. Then, I would like to thank my thesis advisor Dr. Shaban Ismael ALBRKA. He consistently allowed this thesis to be my work, but steered me in the right direction whenever he thought I needed it. The door to Dr. Hüseyin GÖKÇEKUŞ office was always open whenever we ran into a trouble spot or had a question about our research or writing.

My mother, I must express my very profound gratitude to my mother for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without her. Thank you.

To my mother…

ABSTRACT

Traffic congestion is manifested by delay and the importance of delay is evident due to impact on the loss of time, frustration and discomfort of drivers, in addition to the direct impact on fuel consumption and on-road networks during idleness and inactivity. This study is based on the evaluation of traffic congestion and formulates low-cost congestion solutions based on the coordination of traffic signals for five intersections in the city of Nicosia. The data of the study were collected using a video camera during the morning and evening peak hours for five intersections. The results show that the delay was reduced to 51 % in the morning and 52 % in the evening. Moreover, there was a significant improvement in low carbon dioxide emissions (CO_2) by 88% in the morning and 64% in the evening responding to the reduction of fuel consumption. Thus, through the re-coordination of traffic signals (cycle time), the level of service the intersections was improved which reflected positively on travel speed and reducing the fuel consumption.

Keywords: SIDRA Intersection; Traffic lights; Congestion; Delay; Travel Speed; Carbon Dioxide Emissions.

ÖZET

Trafik tıkanıklığı gecikmeyle kendini gösterir ve gecikme, sürücülerin boşta kalma ve hareketsizlik sırasındaki yakıt tüketimi ve yol ağları üzerindeki doğrudan etkisinin yanı sıra, zaman kaybı, hayal kırıklığı ve rahatsızlık üzerindeki etkisi nedeniyle de belirgindir. Bu çalışma, trafik sıkışıklığının değerlendirilmesine dayanmaktadır ve Lefkoşa kentinde beş kavşak için trafik sinyallerinin koordinasyonuna dayanan düşük maliyetli sıkışıklık çözümlerini formüle etmektedir. Çalışmanın verileri, sabah ve akşam en yoğun saatlerde beş kavşak için bir video kamera kullanılarak toplanmıştır. Sonuçlar, gecikmenin sabahları% 51'e, akşamları ise% 52'ye düştüğünü göstermektedir. Ayrıca, düşük karbon dioksit emisyonlarında (CO2) sabahları% 88, akşamları ise% 64 oranında yakıt tüketiminin azalmasına yanıt olarak önemli bir iyileşme oldu. Böylece, trafik sinyallerinin yeniden koordinasyonu yoluyla (çevrim süresi), seyahat hızına pozitif yansıyan ve yakıt tüketimini azaltan hizmet seviyesi kavşaklarda iyileştirildi.

Anahtar Kelimeler: SIDRA Kavşağı; Trafik ışıkları; Tıkanıklık; Gecikme; Seyahat hızı; Karbondioksit Emisyonları.

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LIST OF ABBREVIATIONS

FUC: Fuel Consumption,

OPC: Operation Cost,

LOS: Level of Service,

C_0: The optimal cycle length,

L: The Total Lost Time,

Y: The Sum of The Critical Flow Ratio of All Phases,

G_i**:** Actual Green Time,

g_i**:** Effective Green Time,

Y_i**:** Yellow and All-Red Time,

Tl: Lost Time Per Phase,

HCM: Highway Capacity Manual,

C: Signal Cycle,

g: Effective Green Signal Time,

q: Traffic Arrival Flow Rate,

S: Departure Flow Rate from Queue During Green,

Q: Expected Overflow Queue from Previous Cycles,

PCU: Passenger Car Unit,

PCE: Passenger Car Equivalent,

LCV: Light commercial vehicle,

T: Straight,

R: Right,

L: Left.

CHAPTER 1
INTRODUCTION

1.1 Background

The world is witnessing rapid growth, and rapid economic development which is the cause of considerable traffic congestion. Traffic engineers forced to find solutions to improve network operations solutions. In cities experiencing rapid growth, such as Nicosia / Turkish Republic of Northern Cyprus, where 48% of the area of Northern Cyprus is residential, it has been noted that traffic congestion on road networks was happening during peak hours in the morning and evening. This is due to the increase in the number of private cars that occupy different parts of the street, start at different speeds and move at different speeds. Poor coordination of traffic signals causes delays and congestion for citizens and the emissions associated with traffic cause environmental and health problems.

Nicosia has clear evidence of these problems at intersections and in traffic. It is worth mentioning that the capital of Cyprus, Nicosia, contains many prestigious universities. Therefore, it receives students from many countries. Traffic networks can be complicated, serving a variety of modes of public and private vehicles, so setting up timing plans for traffic signals is a difficult task for the traffic analyst.

Many traffic studies have focused on estimating delays and queues caused by the adoption of the signal control strategy at individual and sequences of intersections. There are many factors involved in determining the level of service intersections, and the important one is traffic delays, and queues that have an impact on the estimation of fuel consumption and emissions. Therefore, achieving the minimum delay is the first goal for traffic engineers. Traffic lights systems are complex system with random and dynamic events which makes it difficult to control, analyze and optimize. The normal function of traffic lights is more than a simple control, thus coordination is required to ensure that traffic and pedestrians move as smoothly and safely as possible.

However, by using the data from each intersection of the five that were collected in Nicosia city, the numbers of vehicles have been collected for 15 minutes, during rush hour in the morning and evening. Finally, the delay data was well analyzed and adjusted by SIDRA INTERSECTION 8 software is used to find the appropriate green time for traffic signals, to get some idea of how to solve the delay and congestion problem.

1.2 Problem Statement

In recent years, traffic lights systems have needed to address many of the problems, which extend across a wide range of technical, political and social boundaries. With progress in urbanization and increased traffic congestion comes the high demand for the operation of road systems with maximum efficiency. As a result, poor coordination of traffic signal time with the increase of traffic volume (number of vehicles) at intersections in urban areas, will result in delay, long queues and longer travel time, especially in the morning and evening during rush hours. These are times when the population of the city and its visitors during working hours are more than the number of residents during the rest of the day (non-working hours). This leads to increase delay, operation cost (OPC) of vehicles, fuel consumption (FUC), and CO_2 emissions. Two other possible problems are the decrease in the travel speed and Level of service (LOS).

1.3 The Aim and the Scope of Research

The main aim of this study is to evaluate the traffic light operating systems of five intersections in the city of Nicosia using SIDRA INTERSECTION 8 software and the following objectives were designed and implemented to achieve the main aim:

1-To evaluate the current situation of Traffic flow at the study area using SIDRA INTERSECTOIN 8 software,

2- To find out the effective green time for each direction,

3- To investigate the performance of a road network of the selected study area, after the calculation of appropriate green time using SIDRA INTERSECTION 8 software,

4-To formulate economic solutions to the existing traffic control system, by re-coordinating the traffic signals time according to the traffic volume at selected intersections.

1.4 The Motivation and The Importance of the Thesis

The importance of the thesis is in solving the problem of traffic congestion at intersections using a SIDRA INTERSECTION 8 software in Nicosia city, that provides simulation and analysis of the timing of the traffic signals in solving the problem of traffic congestion, instead of opening new streets or reorganizing old streets that would need more time and money. This study also investigates the methods for designing and evaluating signals. Specifically, we will depend on the results of SIDRA 8 software and evaluate it to select the best solution for our study.

1.5 Limitations of Study

This study is limited to traffic junctions in Nicosia city. Data collected in 2018 during April in the morning and evening during rush hours. Traffic forecast analysis is limited to population growth factors. The solutions are limited of choosing the proper green time for traffic signals, Therefore, these may need to increase or decrease according to traffic capacity.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Many cities around the world have faced different degrees of traffic congestion and that has led to different solutions. This will be discussed in this chapter, as well as discussing the history of traffic signals and the advantages and disadvantages of traffic signal coordination. The software used in the analysis of intersections was the SIDRA INTERSECTION 8. More information about input data and its features will be included. Analyzing the performance of an intersection is one of the most important things in traffic design. Accordingly, the delays in the intersection are directed to estimate the total delay or stopped delay.

2.2 SIDRA 8 INTERSECTION Software

SIDRA (Signalized Intersection Design and Research Aid) is a software package developed by the Australian Road Research Board as a means of assisting the capacity, timing, and analysis of the performance of signal intersections. It also provides a flexible structure that allows for multilevel analysis, from very simple intersection conditions to very complex ones (Transportation Research Board, 2000).

SIDRA's program is characterized by its strong analysis of signalized intersections and roundabouts. It also works to improve cycle lengths of traffic signals, phase sequences and splits. SIDRA has a wide range of graphic displays of intersection geometry, including the number of lanes and their design (Transportation Research Board, 2000).

SIDRA can be used to analyze the intersections lane-by-lane, and to identify lane flow calculations, common lanes and lane blockage, capacities of lanes, identify performance measures, and variable cycle lengths of traffic signals. Based on the profiles of the length of the cycle and the changing parameters defined by the user to allow the improvement of the signal by setting the best cycle length and sequence developed. This includes reducing delays, vehicle emissions, fuel consumption, operating costs, and improved traffic flow.

This includes reducing delays, vehicle emissions, fuel consumption, operating costs, and improved traffic flow (Transportation Research Board, 2000).

SIDRA INTERSECTION 8 software provides significant improvements to the user interface, including improved visual representation and accurate output reports as well as more graphical displays of Layout, Volumes, Phase Sequence and Movement, compared to the first version of SIDRA, which had limited options, we find intersections in SIDRA 8 more realistic.

The SIDRA INTERSECTION 8 software is for use as an aid in the design and evaluation of individual intersections and networks of intersections. It can be used to analyze signalized intersections, unsignalized and signalized roundabouts, two-way stop sign and give-way / yield sign control. Signal timing calculations for single intersections and network timings including signal offsets for signal coordination are carried out. It uses a unique method to determine the timing of the signal for some intersections operating under a single signal controller (common control groups) (Transportation Research Board, 2000).

SIDRA INTERSECTION 8 is an analytical assessment of the movement used for lane-by-lane and vehicle path (drive-cycle) models associated with an approximate way to provide estimates of capacity and performance statistics (delay, queue length, stop rate, etc.). All data and models of input and output are based on Origin-Destination movements. This improves handling of movements at intersections with diagonal legs and U-turns (Transportation Research Board, 2000).

Considerable improvements have been made to the network model and include optimum cycle time for networks and new options for phase time and improved processing for uncoordinated and unconnected Sites for signal timing calculations, as well as improvements to the iterative method used for the capacity of the site and the results of the analysis of time (Transportation Research Board, 2000).

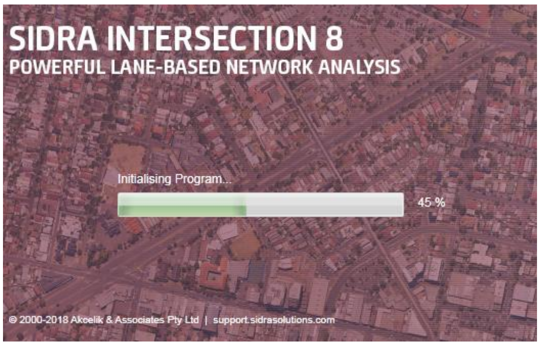

Figure 2.1: SIDRA INTERSECTION 8 Software

2.3 Brief History of Traffic Signals

Traffic lights are a form of traffic control signal by using colored lights displayed to the traffic stream, which has the right of way. The installation of the first traffic lights was on Bridge Street, London in December 1868. It consisted of a semaphore arm on top of a 6.7 meters post with green and red gas lamps. When the arm of the signal was extended, that meant stopping. When lowered, this intended caution. While at night, the red gas lamp was used in the stop position and the green gas lamp in the caution position.

But there were disadvantages to the signal; firstly, it frightened the horses and secondly caused the death of two police officers, due to the explosion of a gas lamp when they were trying to light it.

Police officers manually operated the next important step in 1918, when three-color light signals were installed at many intersections in New York City. The signals were quickly operated by an electro-mechanically fixed-time control device, to determine the green period for each traffic movement (Roads and Traffic Authority of NSW, 2010).

2.3.1 Principles of traffic signal control

Traffic streams in an intersection are separated by traffic signal control through allocating different time intervals for conflicting traffic movements. For each movement, the signals are given cyclically in the following order (Luttinen & Nevala, 2002).

1. Red
2. Red + yellow
3. Green
4. Yellow

Green signal represents “go,” and red indicates “stop.” A green interval is followed by a yellow change interval indicating that a vehicle must stop if it can be done safely. The length of the yellow change interval depends on the speed limit according to Table 2.1. A red+yellow signal indicates that the green signal will be given shortly. The length of the red+yellow interval is 1.0–1.5 seconds (Luttinen & Nevala, 2002).

Table 2.1: The length of the yellow change interval (Luttinen & Nevala, 2002)

Speed limit (km/h)	**Yellow (s)**
70	5
60	4
40-50	3

A signal head has typically three lenses (red, yellow and green). It is, however, possible to use four or five-lens arrangements according to Figure 2.2.

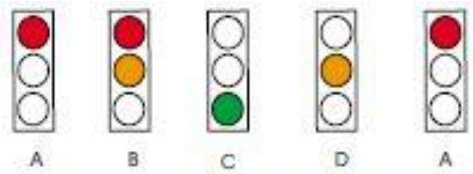

Figure 2.2: Allowed lens arrangements (Kehittämiskeskus, 1996)

2.3.2 Advantages and Disadvantages of Traffic Signal Coordination

Signal coordination has a beneficial improvement for the community. In many cases the quality of life and mobility in the region have been improved by using signal coordination techniques successfully (Nesheli et al., 2009).

A. Some of the Advantages of Traffic Signal Coordination

Traffic signal coordination has some advantages as following:

1. Reduces stops.
2. It reduces vehicle accidents in the region.
3. It reduces power and fuel consumption.
4. Improves mobility and access across the region.

5. Can control the travel speeds.

6. It provides environmental benefits due to lower vehicle emissions, such as CO_2.

B. Some of the Disadvantages of Traffic Signal Coordination

There are some disadvantages, apart from the features specific to one system or another. The disadvantages of the coordination system are as follows:

1. Traffic speeds will increase and may lead to accidents.
2. The additional movement may be attracted through the corridor. This will lead to an increase in maintenance and equipment costs based on the type of hardware and software used.
3. Needs qualified staff for maintenance and monitoring of daily operations.

2.4 Movements and Phases:

Every possible path of traffic flow is called a movement. The permissible movements at a typical four ways intersection can accommodate three movements, as shown in Figure 2.3:

1. vehicles turn to the left,
2. vehicles travel straight through,
3. vehicles turn to the right.

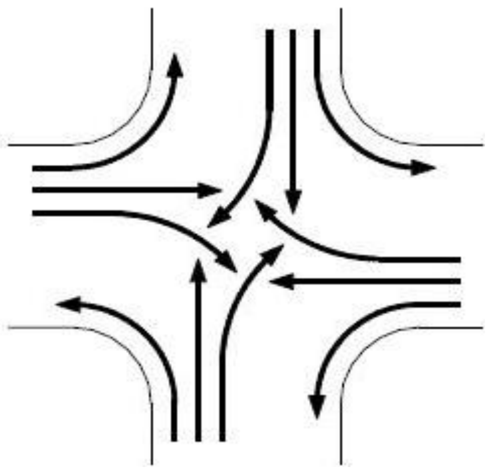

Figure 2.3: Vehicle movement at an intersection (Roads and Traffic Authority of NSW, 2010)

A phase consists of a set of conflicting or some non-conflicting movements. The choice of phasing design of the specified intersection depends on the flow of vehicular and pedestrian traffic. General guidelines are as follows (Roads and Traffic Authority of NSW, 2010):

1. The number of phases should be as few as possible to increase utilization of time.
2. Must allow as large a compatible movement as possible at each phase.
3. It is best that the phase consists of non-conflicting movements.
4. It should allow for each movement to operate as many phases as possible.

2.5 Cycle time

The amount of time from when a movement is first given the right of way, until that movement receives the signal again, is called the cycle length. It is calculated using the equation below. During the past decades, several studies have been conducted that address traffic signal cycle length. The most well-known and typical traffic signal cycle length models are the Transport Research and Road Laboratory TRRL model and the Australian Road Research Board ARRB model (Wu et al., 2015).

The TRRL model (Webster et al., 1966) has been widely used. In developing the TRRL formula for the optimal minimum delay cycle length, it was assumed that the effective green times of the phases were in the range of their respective flow ratio values. The TRRL formula given by Equation 2.1

$$C_0 = \frac{1.5L + 5}{1 - Y} \qquad (2.1)$$

Where:

C_0: The optimal cycle length (in seconds),
L: The total lost time (in seconds),
Y: The sum of the critical flow ratio of all phases.

2.5.1 Effective Green Time

When the driver approaches the intersection, and the signal is red, speed is gradually reduced until stopping at either the stop line at the end of a queue. When the signal turns green, speed is increased until reaching the required or maximum possible speed.

The Red+Yellow signal indicates that the green phase is about to begin. The drivers of the first vehicles become alert and prepare to start moving. As the green begins the first vehicle starts to accelerate. The Red+Yellow signal helps the first driver to anticipate the starting green interval (Luttinen & Nevala, 2002).

The discharge process of the vehicles in the queue is controlled by the reaction times and desired acceleration rates of drivers as well as the acceleration rates of the vehicles ahead. At the beginning of the green interval, the discharge rate at the stopped lane starts to increase. As the queuing vehicles have reached a constant speed at the stop line, the discharge rate has reached its maximum, called the saturation flow rate. On average, the discharge headways reach a constant level of slightly below two seconds after the fourth vehicle. The saturation flow rate may vary from cycle to cycle, but an average value can be used for given conditions (Luttinen & Nevala, 2002).

It is usually assumed (Clayton 1941, Webster 1958) that when time is lost after startup, the saturation flow rate remains constant until the beginning of the yellow change interval. The effective green time at Equation 2.2

$$g_i = G_i + Y_i - tl \qquad (2.2)$$

Where:

G_i: Actual green time (sec)

g_i: Effective green time (sec)

Y_i: Yellow and all-red time (sec)

Tl: Lost time per phase (sec)

2.6 Level of Service

LOS is regarded as the regular delay of the public vehicle and total movements through the intersection. Vehicle delay is the process of measuring many intangible aspects such as loss of travel time, frustration and driver inconvenience (Albrka et al., 2014).

The term often associated with capacity and confusion is the volume of service. When power gives a quantitative measure of traffic, the level of service or LOS tries to provide a qualitative measure. Service size is the maximum number of vehicles, passengers or similar, which can be accommodated by a road network or system under certain conditions at a certain level of service (Capacity and Level of Service, 2017).

For a given road or facility, the capacity can be fixed. But the actual flow rate will be variable for different days and different times on the same day. The objective of LOS is to link the quality of the traffic service to a specific traffic rate.

The Highway Capacity Manual (HCM), developed by the Transportation Research Council of America, provides guidance for traffic design worldwide. In the HCM, LOS has been divided into six levels from A to F (Capacity and Level of Service, 2017) as shown in Table 2.2 and Figure 2.4-2.5 Where the level of service is acceptable to the level C but after that the levels of service D, E, and F are not acceptable, therefore it needs to work to improve the levels of service.

Table 2.2: LOS criteria for signalized intersection (Highway Capacity Manual, 2000)

LOS	Average delay (sec/veh)	General description (Signalized intersection)
A	0 - 10	Free flow
B	10 - 20	Slight delays
C	20 - 35	Acceptable delays
D	35 - 55	Tolerable delays
E	55 - 80	Intolerable delays
F	80 +	Jammed

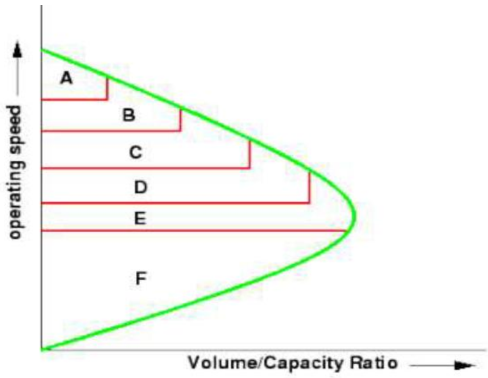

Figure 2.4: LOS, speed and flow/capacity (Capacity and Level of Service, 2017)

Level A in LOS

Level B in LOS

Level C in LOS

Level D in LOS

Level E in LOS

Level F in LOS

Figure 2.5: Level Of service LOS (Kandiboina, 2010)

The factors affecting the level of service (LOS) can be listed as follows Figure 2.6:

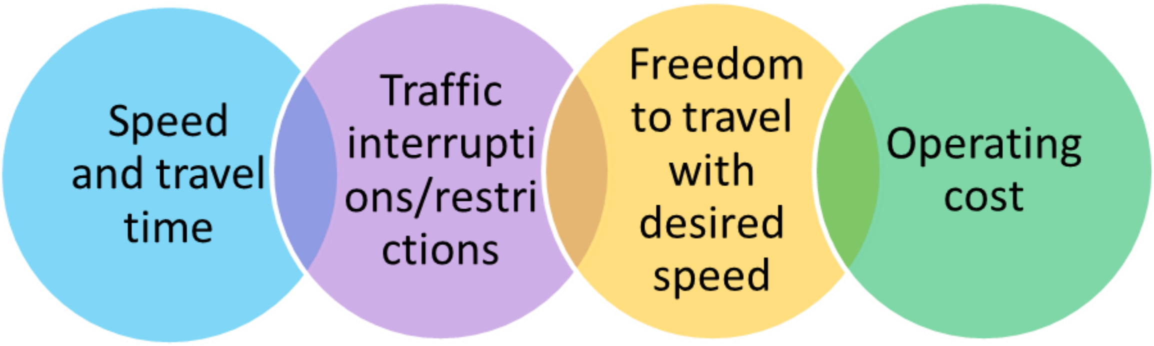

Figure 2.6: The factors affecting the level of service (LOS)

2.6.1 Speed and Travel Time

The delay experienced by the driver of the vehicle consists of factors related to traffic, control, congestion, and geometrics. Total delay is the difference between the actual travel time and travel time of reference which may result during the basic conditions, in the absence of congestion or control or traffic engineering or delay (Nesheli et al., 2009).

The most critical factors in determining LOS are speed and travel time, where speed is the amount of time spent in travel, total travel time is very important for motorists and the length of the trip can cause fatigue and consequently, accidents on the road.

Vehicle speed values on the road network are necessary to estimate traffic delays. As the speed of traffic and non-recurring flight stations provide more comfort for drivers, which are reflected positively on their behavior on the roads.

2.6.2 Delay

Delay is the additional travel time experienced by a driver, pedestrian or passenger. Delay of vehicles is one of the most important parameters used by transportation professionals in evaluating the performance of a signalized intersection. This is due directly to the loss of time that a vehicle experiences while crossing an intersection.

Delay at a signalized intersection is computed as the difference in the departure time and the arrival time of a vehicle. The total delay time can be classified into deceleration delay, acceleration delay and stopped delay. The deceleration delay is the loss of time that the vehicle takes in slowing down to reach to a stoppage. The stopped delay is the delay that the vehicle spends at the intersection while it is standing in a queue waiting for the traffic signal to turn green. (Gupta, 2009).

While most of the delays at intersections are caused directly by the operation of the traffic signal and randomness in vehicle arrivals, a part of the total delay due to the time required by the drivers of individual cars to interact with changes in the presentation of the signal at the beginning of the green interval, to mechanical constraints, and to individual driver behavior. The amount of traffic delay at the most common intersection is divided into the following forms (McShane et al., 1998):

• The stopped delay is the time when the vehicle is stopped while waiting to pass an intersection.

• The delayed approach includes the lost time and stop delay at a time when a vehicle decelerates from the normal speed to stop and accelerates from the stop to the normal speed.

• Travel delays time is the difference between the time for the vehicle to pass the intersection at the speed required by the driver and the actual time for the vehicle to pass the traffic intersection.

• Delays in the queue are the total time for a vehicle to join an intersection queue to discharge the intersection across the curb line or stop line.

The expected delay at fixed-time signals was first developed by (Beckman et al., 1956) with the assumption of the binomial arrival process and deterministic service regarding Equation 2.3

$$d == \frac{c-g}{c(1-q/s)}\left[\frac{Q_0}{q} + \frac{c-g+1}{2}\right] \qquad (2.3)$$

Where,

c: signal cycle,

g: effective green signal time,

q: traffic arrival flow rate,

S: departure flow rate from the queue during green,

Q: expected overflow queue from previous cycles.

2.6.3 Capacity

The capacity represents the maximum hourly rate at which vehicles or people are reasonably expected to pass a single point or section of a corridor or road over a given period under traffic conditions, the traffic itself, and prevailing conditions of observation. The capacity reaches its maximum during peak hours.

Unit: Vehicles per hour (VP/h)

Passenger cars per hour (pc / h)

Level of service and capacity are the two parameters that explain the current movement of any part of the highway, where the general characteristics of highways are (Kandiboina, 2010):

1. Some lanes: four or six.
2. Published speed limits 60 km / h to 90 km / h.
3. Traffic volume up to 100,000 units / day (usually between 15,000 - 40,000 in / day).

Capacity depends on:

1. Engineering design of the road, such as the number and width of lanes.
2. Traffic conditions: the ratio of switching moments, installation, etc.
3. Control conditions: signals, intersections etc.
4. Environmental conditions.

And often capacity determined by field observations or estimated under control conditions and as per Highway Capacity Manual 2010, the capacities of multilane highway to Free flow speeds are as shown in Table 2.3

Table 2.3: Free flow speed and capacity for Multilane highway (HCM, 2010)

Types of facility	Free flow Speed (kmph)	Capacity (pcphpl)
Multilane	100	2200
Multilane	90	2100
Multilane	80	2000
Multilane	70	1900

2.7 Fuel Consumption

Both traffic speed and the stopping or starting of vehicles will directly affect fuel consumption. Increased congestion will lead to more interruptions and slower speed and thus increase the operation of vehicle engines and fuel consumption.

2.8 Operating Cost

Operating cost refers to the vehicle's direct vehicle operating cost which varies with vehicle usage, including fuel, tires, and maintenance. Factors affecting the OPC of vehicles are: travel time, the speed of traffic and delays at intersections (Albrka et al., 2014).

2.9 Established Previous Studies

Many cities in the world face traffic congestion, but with different degrees of intensity. Tokyo, for example, faces congestion in the form of a public transport system; London and Kuala Lumpur in the form of high use of private vehicles. The share of private vehicle model in Kuala Lumpur between 1985 and 2003 increased from 66 percent to 84 percent (Hossain, 2006). Also, Cyprus in the form of high private vehicle use, where the private car is the dominant mode in Nicosia constituting about 90% of the daily trips (Ministry of Communications and Works, North Cyprus, 2010).

Two studies conducted in different countries will discussed, Malaysia and Cyprus. The both have been facing congestion in form of high private vehicle use.

In Malaysia, especially in the city of in Shah Alam used 7F software (TRANSYT-7F) to evaluate the performance of road junction networks found that the reasons behalf traffic congestion is that the timing setting (cycle time) of the intersection is normally developed without proper calculations, but it is generally assigned based on experience. But the method used was not economical as the provide cost in added lanes the most of to intersections (Albrka at al., 2014).

And the other one in the city of Kuala Lumpur, Malaysia used SIDRA 4.0 Software to evaluate the Performance of Traffic Flow at Intersections and Roundabouts. The concluded with that Improvement of traffic signal coordination and timing is one of the most important strategies for increasing travel speed and reducing delays and fuel consumption in urban areas. But the cycle time that they used depended on assumption (Irtema at el., 2015).

While the study conducted in Northern Cyprus, especially in the city of Nicosia used SIDRA 5.0 Software to evaluate the Performance of Traffic Flow at Intersections in Nicosia, North Cyprus. They concluded with “The cycle time at the intersections is normally established with unappropriated calculations of traffic volume or it was not updated with the increase in the number of vehicles. But the cycle time that they used depended on assumption and the adding lanes are not economically (Ali at el., 2018).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the proposed improvements to the analysis and study of the signalized intersections using SIDRA INTERSECTION 8 software and the overall research approach that will be used to accomplish these improvements. Figure 3.1 shows the flowchart for an overview of the study. The objective of this research is to improve the level of transport planning techniques to evaluate the coordination of the traffic signal system on congestion. Specifically, this study aimed to analyze the flow of traffic at the site of the study area to find the proper green time of the signal. The scope of the study includes the movement of the survey implementation such as flow volume calculation and saturated flow rate which has been classified at rush hour.

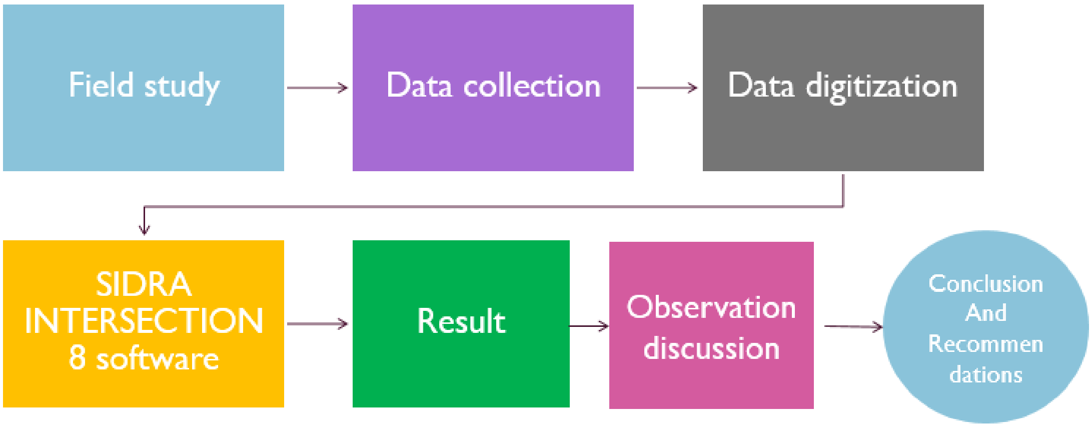

Figure 3.1: The flowchart of the study

3.2 Study Area

A northern and southern part as shown in Figure 3.2. Northen Cyprus is divided into five regions, namely: Nicosia (Lefkosa), Famagusta (Gazimagusa), Kyrenia (Girne), Iskele and Guzelyurt as shown in Figure 3.3.

Nicosia is the capital city of Cyprus. It is the only divided capital city in the world. It has northern and southern part. This study conducted in the northern part of Nicosia also known as Lefkosa.

Figure 3.2: Northern and southern part of Cyprus (Hasmens, 2014)

Figure 3.3: Northern Cyprus (Hasmens, 2014)

The population in North Cyprus was 292,129 in 2012 and increased to 335.455 in 2016; the increment was nearly 15%. Then the number of international students was 46134 in (2012-2013) then increased to 80.874 in (2016-2017) with increment around 75 %.

North Nicosia (Lefkosa) has a total population of 94824, where around one-third of the population live in the northern part according to the latest census which was performed in 2017 (Statistics and Research Department Nicosia, 2017).

In Northern Cyprus, the number of vehicles registered in Nicosia was up 4.5 % in 2015 compared to 2013 over 175.982 vehicles**,** then in 2017 the number of registered vehicles increase nearly 66% compared with 2015, including registered vehicles around 182.709

and non-registered vehicles approximately 109.665 according to the state planning organization (Statistics and Research Department Nicosia, 2017).

3.3 Data Collection

This chapter contains data collection steps as shown in Figure 3.4, in this chapter we collect all the needed data for the INPUT stage in SIDRA INTERSECTION 8.

The research selected Nicosia city as the study area. After choosing the area we divided it into five important intersections.

Figure 3.4: Data collection steps

3.3.1 Area Selection

This study is based on solving the problem of congestion. Therefore, the next step after selecting Nicosia as the study area in the search, is to identify the intersections to be processed at five important intersections as shown in Figure 3.5.

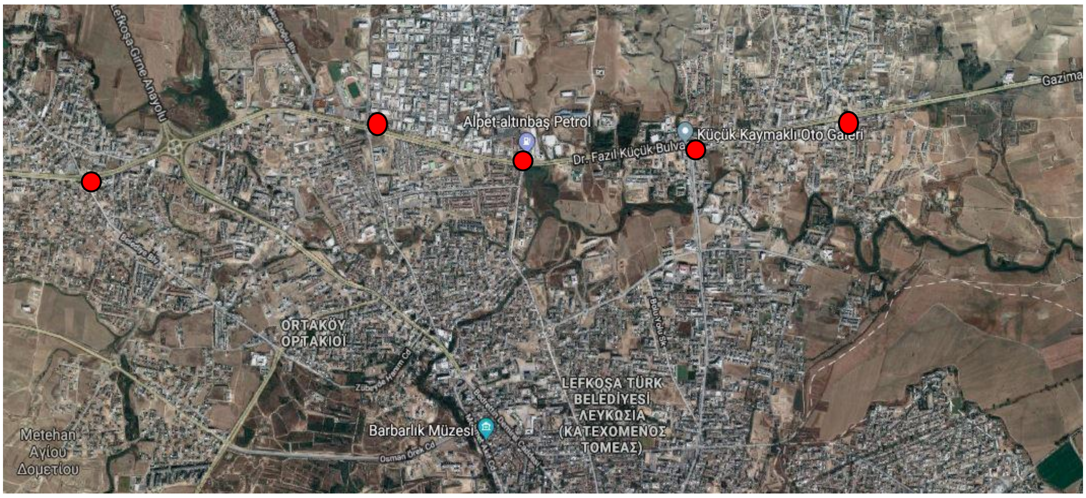

Figure 3.5: The locations of the 5 interactions (Google earth, 2018)

3.3.2 Time Determination

Two times were selected in this study the morning and evening peak hours, where the population of the city and its visitors during the working hours are more than the numbers of residents during the rest of the day (non-working hours).

In the morning from 08:00 to 09:00 am, as in Figure 3.6:

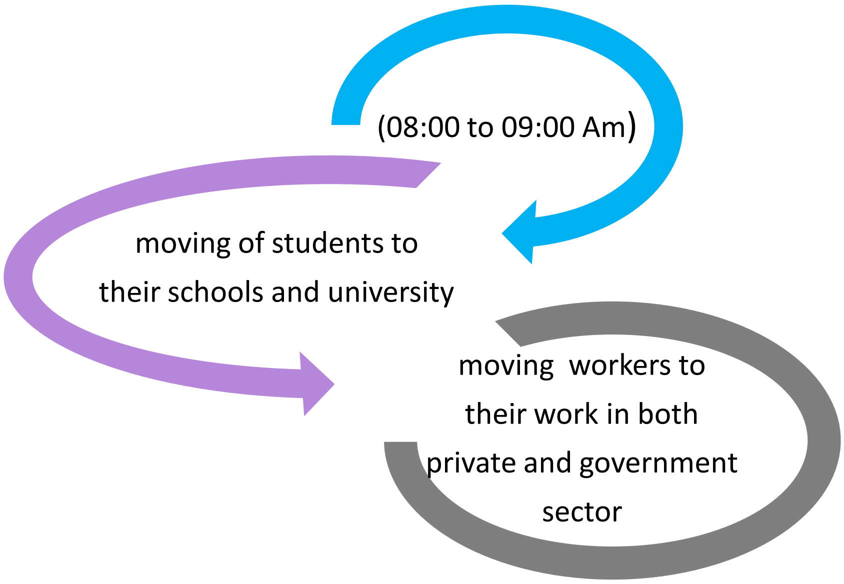

Figure 3.6: The reasons behind the choice of morning hours

And the evening is from 04:30 to 5:30 pm as in Figure 3.7:

Figure 3.7: The reasons behind the choice of evening hours

In Nicosia the weekend is on Saturday and Sunday, so we ignored these days and chose the working days in order to have the maximum volume of vehicles at all intersections.

3.3.3 Selection of Intersections

Five intersections were selected in Nicosia after visiting the city. The first step will be to give every intersection a name and use it as a mark to the intersection everywhere in the project, such as intersection number one, two, etc. as shown in Figure 3.8 while the intersections in the study area are shown in Figures 3.9 up to 3.13.

Figure 3.8: The numbers of the interactions (Google Earth, 2018)

Figure 3.9: Yenikent intersection (Google Earth, 2018)

Figure 3.10: Göçmenköy intersection (Google Earth, 2018)

Figure 3.11: Dr. Fazıl Küçük Bulvarı with Kemal Aksay Caddesi (Google Earth, 2018)

Figure 3.12: Honda intersection (Google Earth, 2018)

Figure 3.13: Hamitköy intersection (Google Earth, 2018)

3.3.4 Data Extraction from Video

Later the data was collected using a video camera for each morning and evening during rush hour. Therefore, the data was extracted by counting the number of vehicles manually.

3.4 Data Digitization

3.4.1 Data Adjustment and calibration

There are some spreadsheet options available for smoothing traffic volumes or balancing them, so the link outputs from one link equal the inputs at the downstream links. The spreadsheets can also be used to apply classification factors to convert vehicle numbers to PCU's (Morgan and Veysey, 2013). Traffic is composed of various types of vehicles, where different vehicle kinds occupy different spaces on the street and move at different speeds, the range and relative composition of which can vary from location to location.

SIDRA Traffic modeling software utilizes a common unit to represent public traffic, known as the Passenger Car Unit (PCU). Therefore, the collection will be adjusted according to the Passenger car unit (PCU). Passenger Car Equivalent (PCE) or Passenger Car Unit (PCU) is a metric used in Transportation Engineering, to assess traffic-flow rate on a highway. Where the numbers of vehicles according to the kind will be multiplied with the equivalent (Highway Capacity Manual, 2000), as shown in Table 3.1. A Passenger Car Equivalent is essentially the impact that a mode of transport has on traffic variables such as (headway, speed, density) compared to a single car. Moreover, Excel program was used to arrange the data taken from the videos from the videos as listed in Tables 3.2- 3.6, while the Figures 3.14-3.19 show the direction of traffic flow at intersections.

Table 3.1: A Passenger Car Equivalents (Highway Capacity Manual, 2000)

Vehicle	Passenger car unit (PCU)
Motorcycle	0.5
Bicycle	0.2
Light commercial vehicle (LCV)	2.2
Bus, Truck	3.5 - 4
Car	1.0

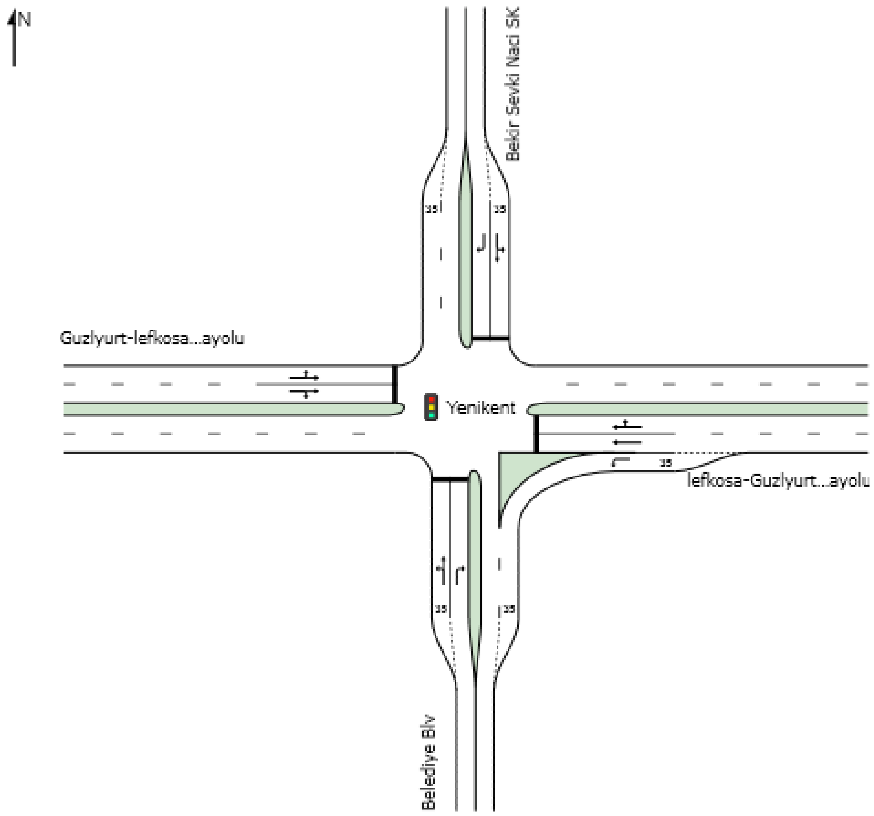

Figure 3.14: The layout of Yenikent intersection

Table 3.2: Data for Yenikent intersection

Time		Morning					Evening				
Roads	**Phase**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**
Q1 33 Sec	T	4	3	0	0	11	0	0	0	0	0
	L	95	16	1	15	192	82	9	1	24	199
	R	87	10	1	15	170	56	3	2	6	88
Q2 10 Sec	T	9	0	0	0	13	30	2	0	0	35
	L	36	7	1	2	61	66	6	4	1	86
	R	35	3	1	1	47	49	3	3	3	70
Q3 25 Sec	T	7	0	0	2	15	5	0	0	2	13
	L	70	14	0	32	230	101	11	1	15	187
	R	29	3	0	2	44	66	7	1	0	83
Q4 15 Sec	T	7	0	0	0	7	8	1	0	0	11
	L	62	1	6	0	68	51	6	2	3	78
	R	8	0	1	4	25	22	1	1	1	29

T: Straight,
R: Right,
L: Left.

The value 11 in the column of total represents the total of vehicles on street Q1 which come from straight after multiplied the number of vehicles according to the kind with the equivalent.

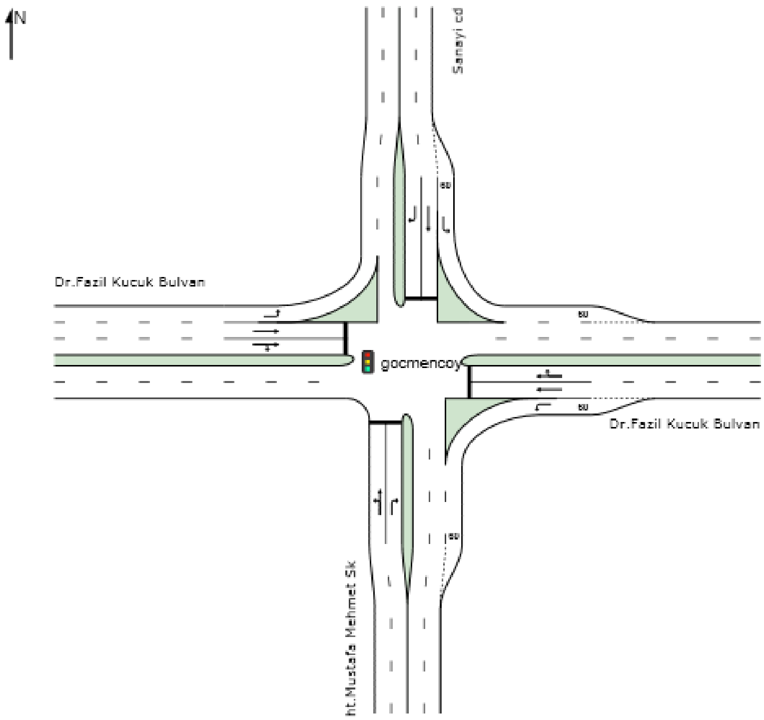

Figure 3.15: The layout of Göçmenköy intersection

Table 3.3: Data for Göçmenköy intersection

Time		Morning					Evening				
Roads	**Phase**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**
Q1 33 Sec	T	123	16	2	2	168	18	7	1	0	35
	L	146	18	0	9	223	96	11	23	4	215
	R	105	7	1	5	142	107	4	9	0	152
Q2 10 Sec	T	15	1	1	0	18	25	1	0	0	28
	L	73	4	2	2	91	30	1	1	1	39
	R	48	6	0	4	78	57	2	3	3	77
Q3 33 Sec	T	46	6	2	0	61	39	4	0	2	56
	L	81	11	1	7	135	212	11	3	12	286
	R	129	12	0	11	200	17	2	0	3	34
Q4 15 Sec	T	40	11	0	6	89	49	6	3	6	88
	L	48	14	2	4	97	72	12	1	1	103
	R	36	10	0	5	79	51	8	0	3	81

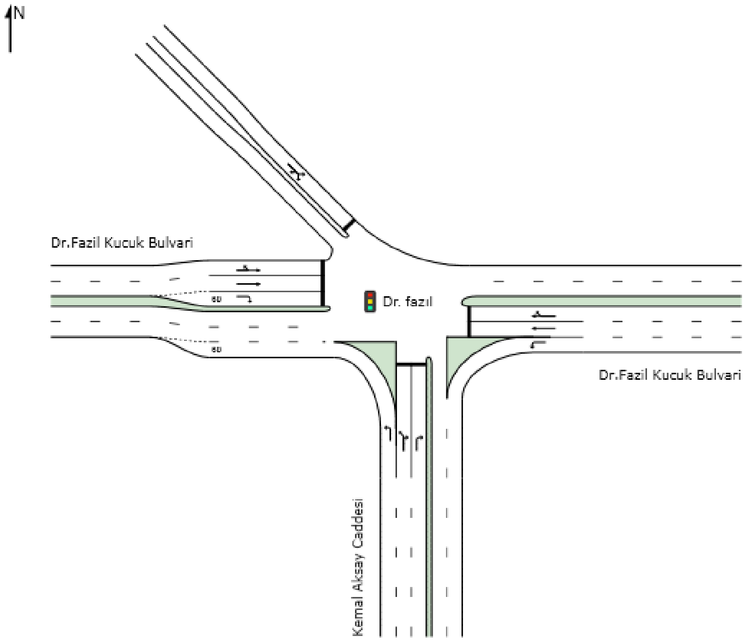

Figure 3.16: The layout of intersection Fazıl Küçük Bulvarı with Kemal Aksay Caddesi

Table 3.4: Data for Fazıl Küçük Bulvarı with Kemal Aksay Caddesi intersection

Time		**Morning**					**Evening**				
Roads	**Phase**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**
Q1 30 Sec	T	1	0	0	0	1	4	2	0	0	9
	L	231	23	4	17	352	188	29	2	24	349
	R	93	9	3	3	127	46	5	0	0	54
Q2 25 Sec	T	59	13	5	0	91	57	12	4	1	90
	L	0	0	0	0	0	0	0	0	0	0
	R	73	5	2	1	89	65	11	1	4	106
Q3 40 Sec	T	0	0	0	0	0	0	0	0	0	0
	L	154	19	3	7	226	237	23	4	14	346
	R	77	11	1	0	102	23	5	0	4	50
Q4 15 Sec	T	11	2	0	2	24	29	7	0	2	53
	L	3	1	0	0	6	0	0	0	0	0
	R	4	2	0	0	9	22	12	1	2	57

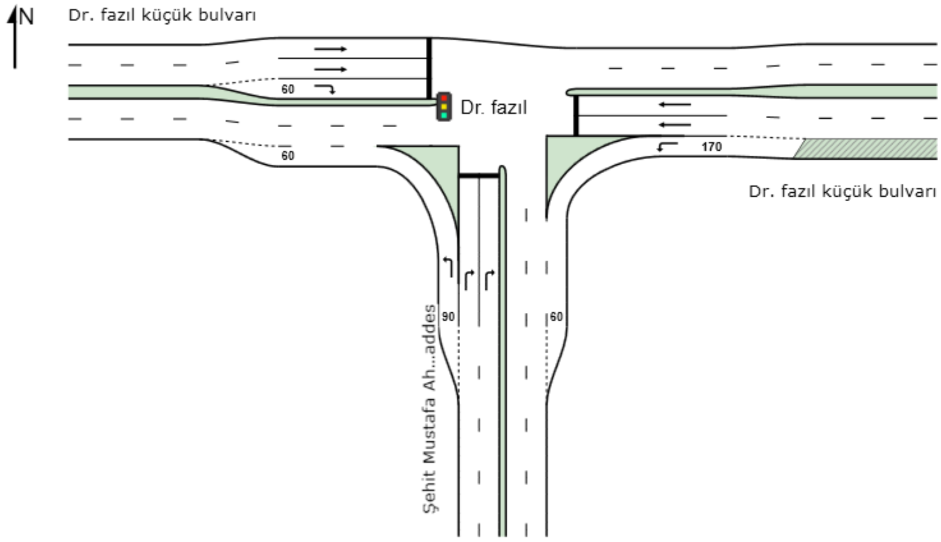

Figure 3.17: The layout of Honda intersection

Table 3.5: Data for Honda intersection

Time		Morning					Evening				
Roads	**Phase**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**
Q1 30 Sec	T	0	0	0	0	0	0	0	0	0	0
	L	47	6	0	4	77	60	12	4	1	93
	R	80	13	3	17	179	128	3	3	7	165
Q2 30 Sec	T	0	0	0	0	0	0	0	0	0	0
	L	171	17	1	28	321	170	6	1	8	216
	R	64	16	0	9	136	109	0	1	1	114
Q3 50 Sec	T	195	19	3	15	299	153	8	4	6	197
	L	80	10	2	3	121	28	12	1	2	61
	R	0	0	0	0	0	0	0	0	0	0

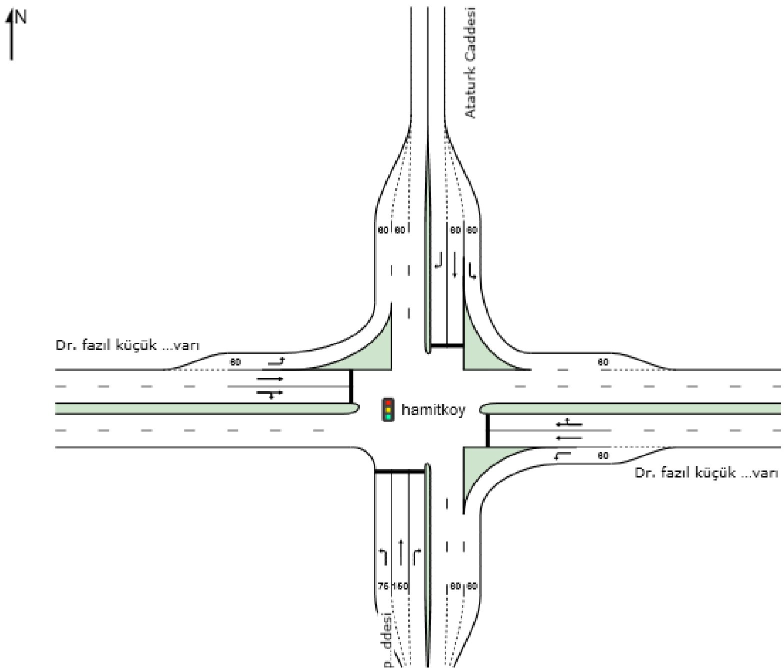

Figure 3.18: The layout of Hamitköy intersection

Table 3.6: Data for the Hamitköy intersection

Time		**Morning**					**Evening**				
Roads	**Phase**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**	**Car**	**Van**	**Motor**	**Bus & Truck**	**Total**
Q1 30 Sec	T	138	3	3	3	159	198	3	6	7	236
	L	25	0	2	0	26	21	0	3	1	27
	R	89	3	1	3	109	101	5	1	3	127
Q2 30 Sec	T	59	0	2	3	72	40	1	0	1	47
	L	26	0	2	0	29	68	1	0	1	75
	R	80	2	6	2	96	64	1	0	1	71
Q3 45 Sec	T	259	0	2	3	272	232	0	2	3	245
	L	40	1	6	3	58	89	3	1	3	109
	R	29	0	2	0	30	59	0	2	0	60
Q4 20 Sec	T	31	0	3	2	41	45	1	6	3	63
	L	32	0	3	2	42	36	1	6	3	54
	R	55	0	2	0	56	78	2	6	2	94

3.5 SIDRA INTERSECTION 8 Data Input

3.5.1 Intersection Definition

The first step in data input is intersection information; at this step, the type of the intersection will be defined. The geometric design of intersection such as four legs or three legs, the name of junctions of the intersection as shown in Figure 3.19.

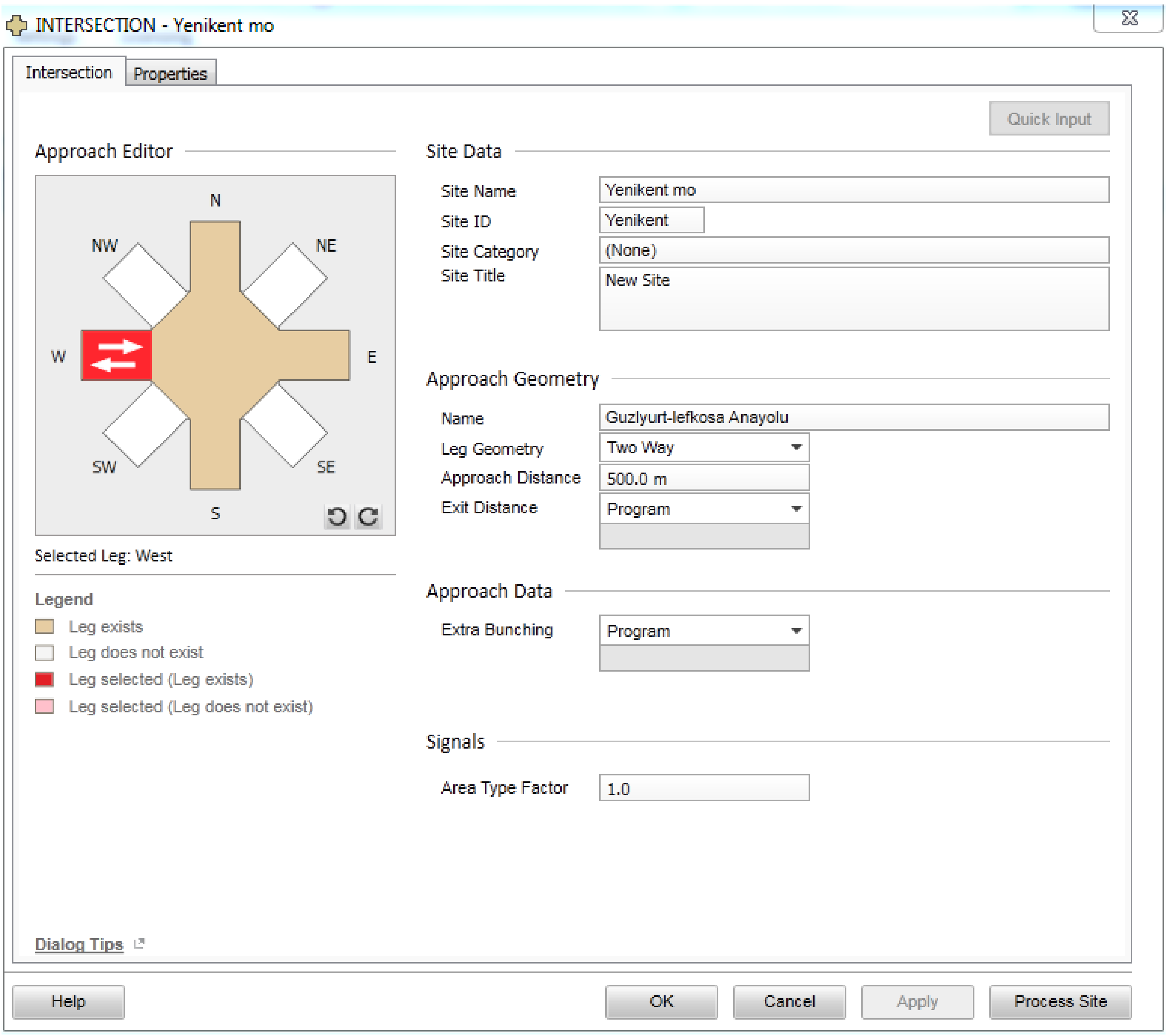

Figure 3.19: Intersection Definition

3.5.2 Lane Geometry

The second step in data input is lane geometry, the lane geometry dialog divided into Lane Configuration and Disciplines as shown in Figures 3.20, in this step the configuration data will be defined such as short lane or full-length lane. Also, the type of lane, if normal, slip (high angel or low angel) as well as the width and length of the lane. And Figure 3.21 outlines the permitted movements on the road.

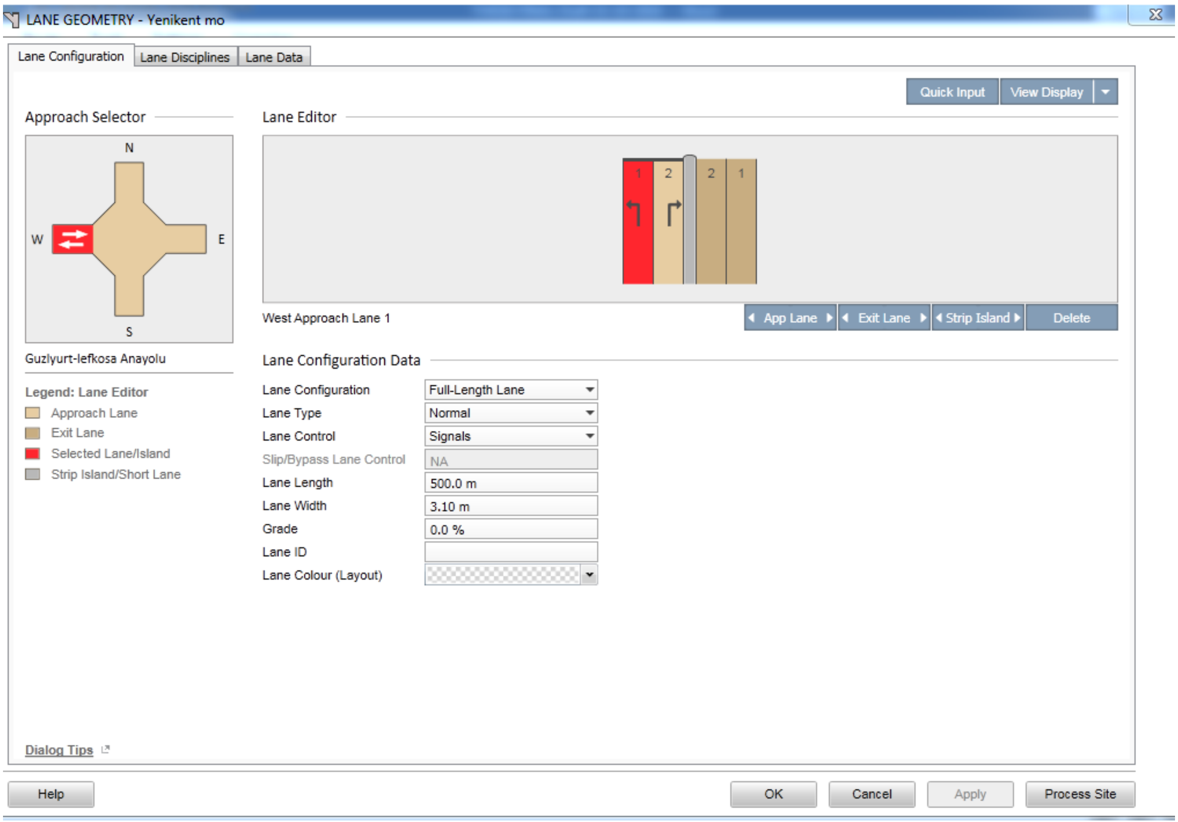

Figure 3.20: Lane Configuration

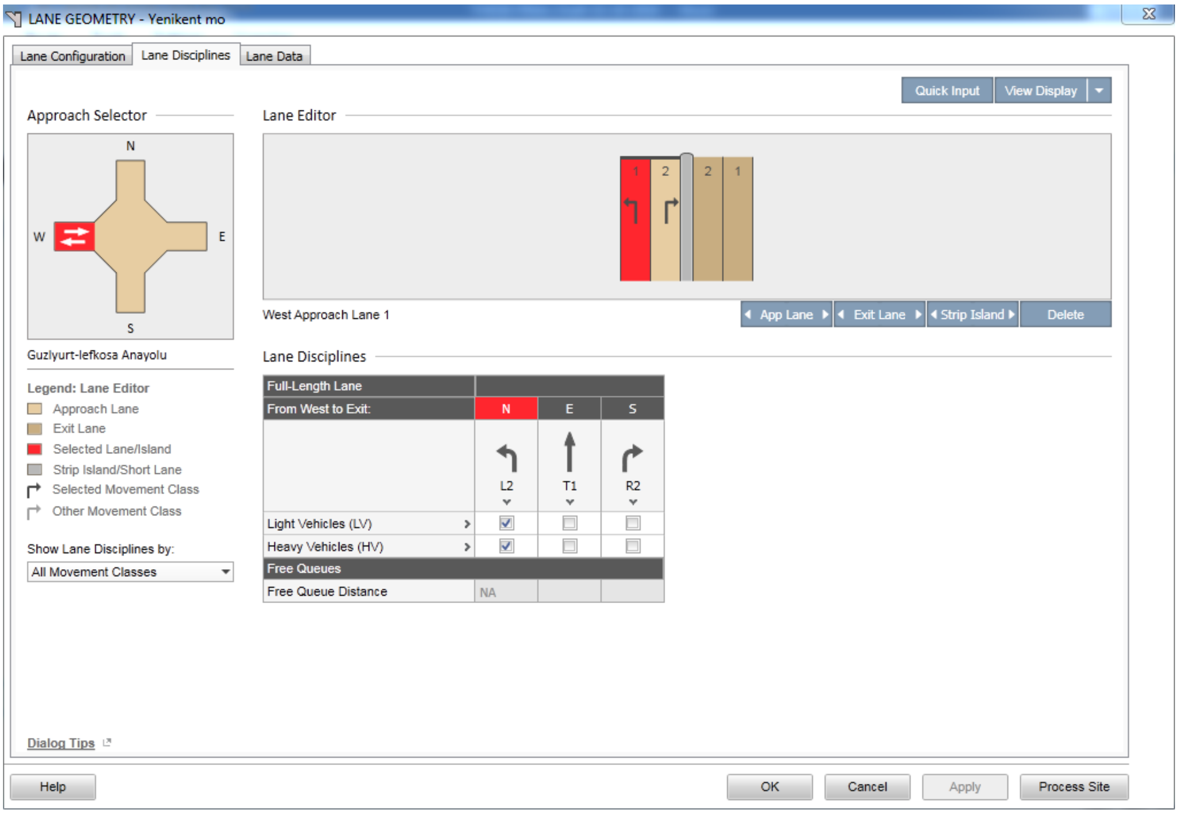

Figure 3.21: Lane Disciplines

3.5.3 Volumes

The data of the number of vehicles being converted into passenger car unit (PCU) shall be entered for each direction of lanes within a fixed time. 60 minutes was selected as the peak flow period for definition of the volume of vehicles, as shown in Figure 3.22.

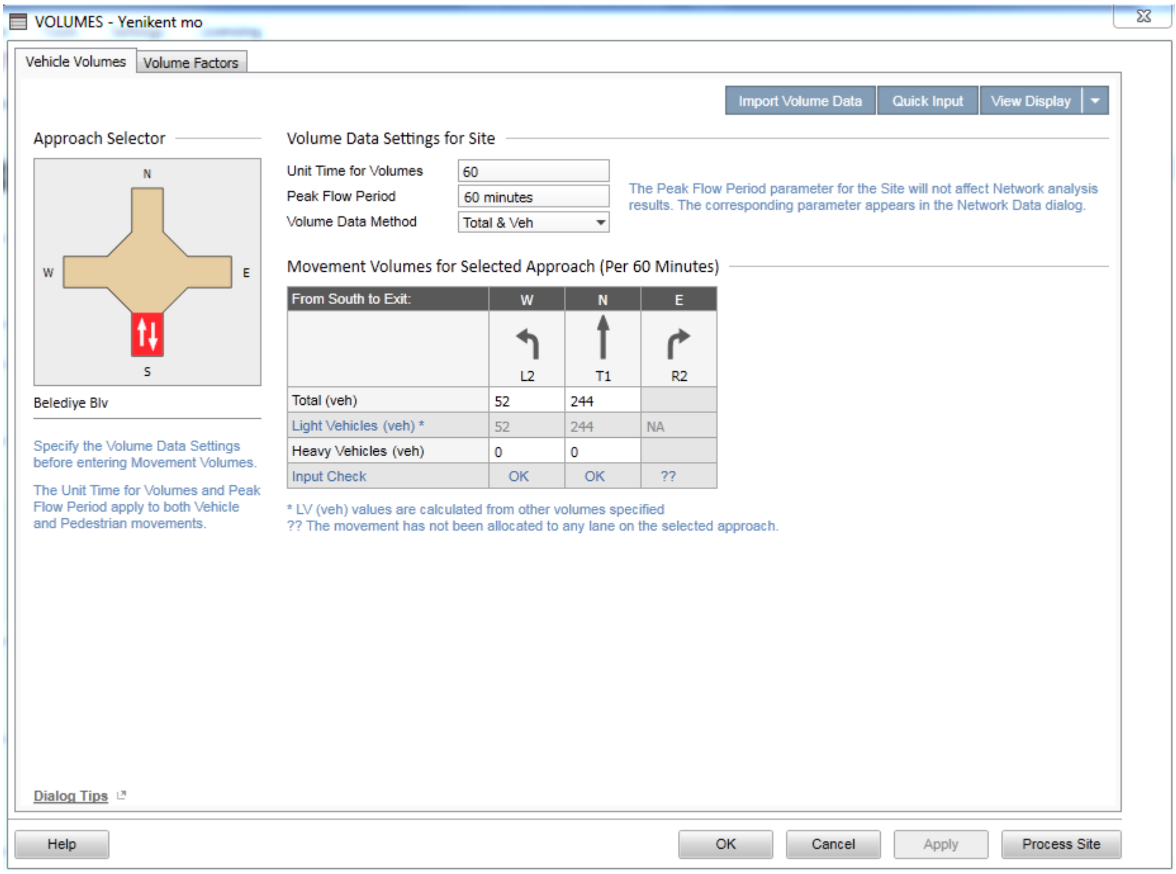

Figure 3.22: Definition of Volumes

3.5.4 Phasing and Timing

The motion at the intersection was divided into phases in the form of A, B, C and D which helped to determine the optimal time for each direction after classification as shown in Figure 3.23, phase and sequence data included the cycle time, which were represented by the total time of the green light for all phases A,B,C and D as well as containing yellow and all red times, given in time units of seconds, as in Figure 3.24.

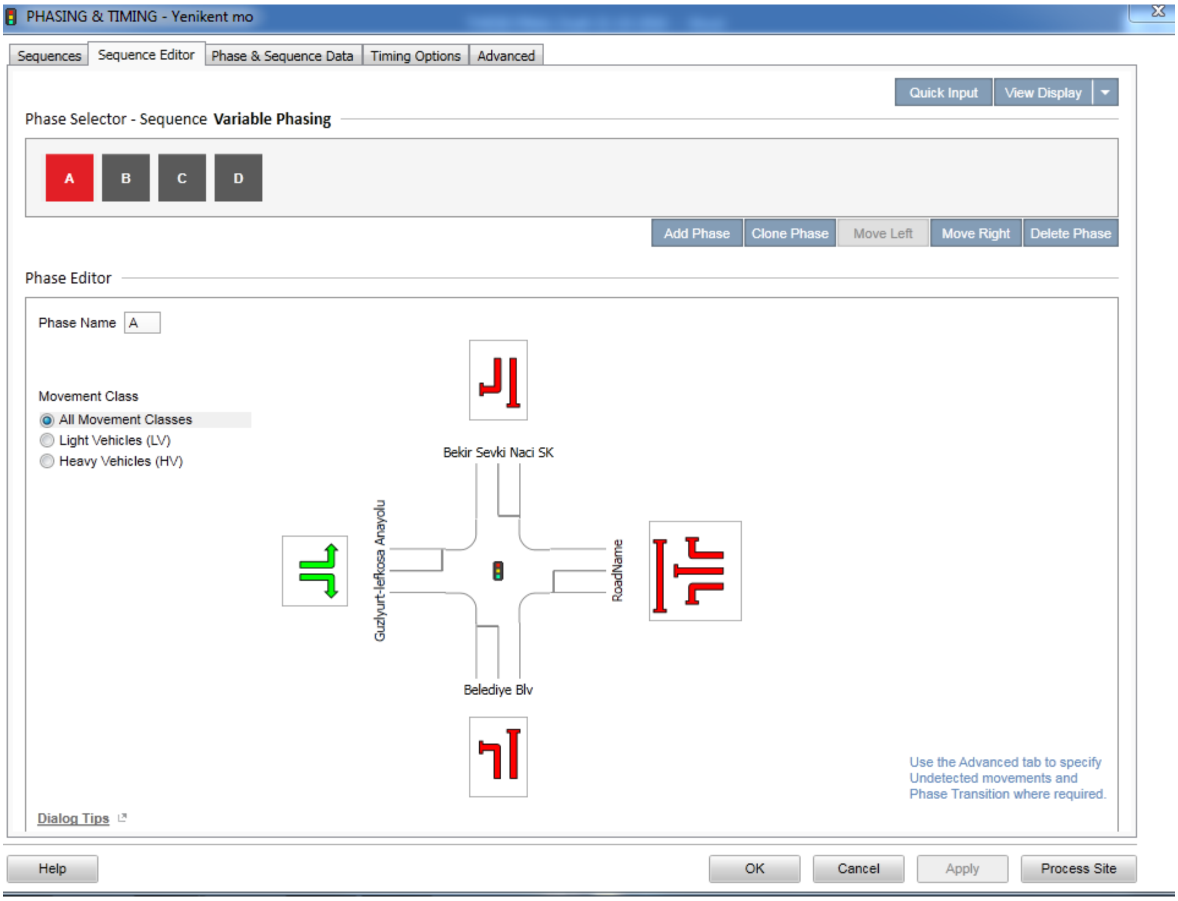

Figure 3.23: Sequence Editor

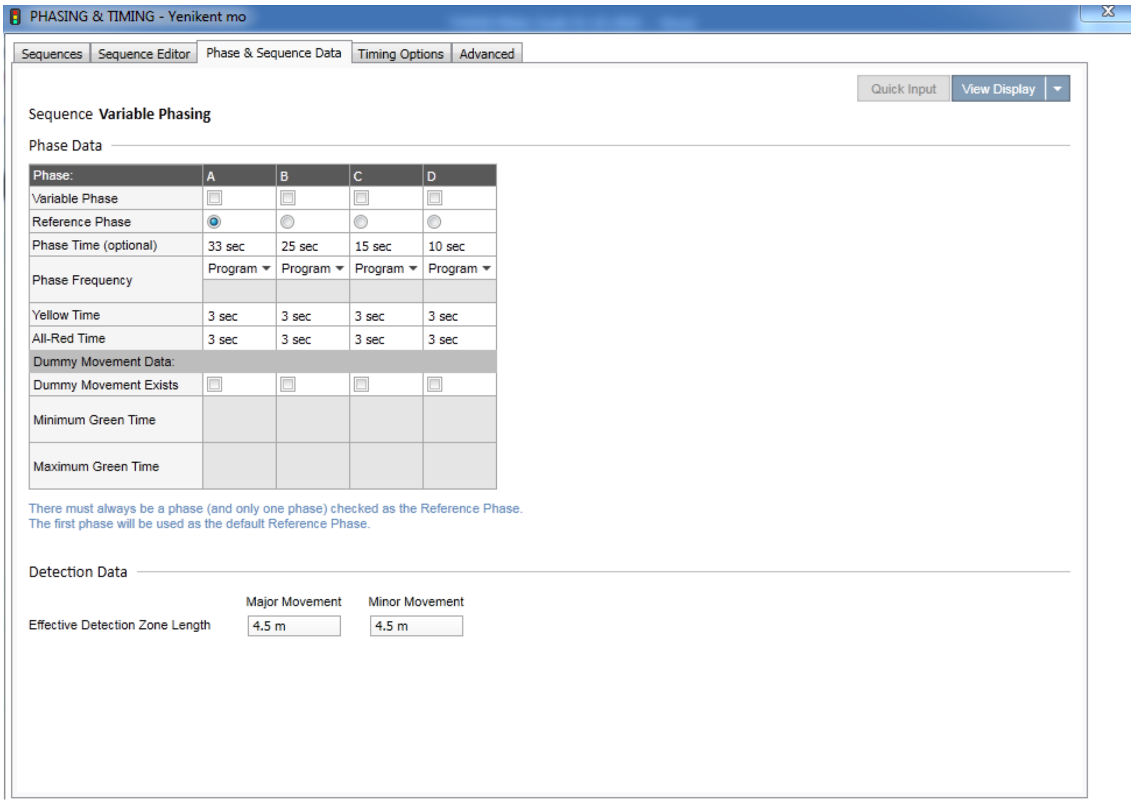

Figure 3.24: Phase and Sequence Data

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter explains and discusses the results obtained using the software SIDRA INTERSECTION 8. Analysis of the total data representing the number of vehicles and the timing of traffic signals for each peak period in the morning and evening, aims to understand the traffic flow at peak periods.

Traffic signals can be seen in cities all over the world. They have many advantages in solving problems of traffic congestion, saving human lives and avoiding vehicle accidents. The main aim of installing traffic lights is to prevent accidents and coordinate the movement of vehicles and humans. Governments should install traffic signals and detectors in large quantities to avoid accidents and optimize the safe movement of automobiles and humans. The mean aim of optimal traffic control is to improve the movement system and reduce delays. Stops and delays are not only annoying and costly to drivers and passengers, but they also increased air contamination such as increasing CO_2 emissions and energy use.

4.2 Evaluation of The Current Situation of Traffic Flow at Intersections

After the data input and running process, the summary of results regarding the delay, travel time, CO_2 emission for all intersections during rush hour of all nodes are listed in Tables 4.1 and 4.2. while the complete outputs of SIDRA INTERSECTION 8 are listed in Appendix 2. In the morning period it is noted that the delays at intersections 1 and 2 were more than delays at intersections 3, 4 and 5; while in the evening the delay value is close for some nodes and mostly greater at intersections 1, 2, 3 and 5, but at intersection 4 there is the lowest value among the intersections.

Table 4.1: Summary of "SIDRA intersection 8" results of all nodes (before optimization) in the morning

Intersection no.	Delay (sec)	Travel time (km / h)	CO_2 (kg/h)	LOS
1	957.3	3.6	3593.7	F
2	12920.1	2.7	6993.2	F
3	670.9	5	3835.7	F
4	170.9	15.7	1502.8	F
5	693.7	4.8	3077.7	F

Table 4.2: Summary of "SIDRA intersection 8" results of all nodes (before optimization) in the evening

Intersection no.	Delay (sec)	Travel time (km / h)	CO_2 (kg/h)	LOS
1	1597.1	2.2	5221.6	F
2	1145.4	3	5554.5	F
3	1158.7	3	6782	F
4	119	20.3	969.7	F
5	804.4	4.2	4254.4	F

4.3 Suggestions for Optimization the of Study Area

Roadway improvements focus on safety and congestion "Hotspots" at Intersections and improving the safety and efficiency of the region's critical intersections. This is achieved by making simple geometric improvements and improving traffic signals. These intersection projects are a higher priority than the expansion of road sections and other capacity expansion projects as they do not cost the government and thus are an economical solution.

Typical eligible Intersection proposals are:

1. Addition Cycle Time of signal.
2. Increase Lane Width.
3. Determining the path of heavy vehicles.

4.3.1 Addition Cycle Time of Signal

A. Optimum Cycle Time

The amount of time from when a movement first is given the right of way until that movement receives the signal again, is called cycle length. It is calculated using the equation 4.1 below. During the past decades, several studies have been conducted that address traffic signal cycle length. The most well-known and typical traffic signal cycle length models are the Transport Research and Road Laboratory (TRRL) model and the Australian Road Research Board (ARRB) model (Wu et al., 2015). The TRRL model (Webster et al., 1966) has been widely used. In developing the TRRL formula for the optimal minimum delay cycle length, it was assumed that the effective green times of the phases were in the range of their respective flow ratio values. The TRRL formula given by Equation 4.1

$$\boldsymbol{C}_0 = \frac{1.5L+5}{1-Y} \qquad (4.1)$$

Where:

C_0: The optimal cycle length (sec),
L: The total lost time (sec),
Y: The sum of the critical flow ratio of all phases.

Lost time= 4sec in one cycle — Lost time for all L= $4 \times 4 = 16\text{sec}$
All red= 1 sec in one cycle — All red= $1 \times 4 = 4\text{sec}$
Amber= 3sec — Amber= $3 \times 4 = 12\text{sec}$

$$C_{QAM}\frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-o.46} = 53.7 = 55 \text{ sec}$$

$$C_{Q1Am} = \frac{\boldsymbol{Y_{Q1}}}{\boldsymbol{Y}} \times Co = \frac{0.20}{0.46} \times 55 = 23.9 = 25 \text{ sec}$$

After the calculation of the optimum cycle time, the number should increase to the nearest multiple of 5. Therefore, 53.7 will be changed to 55 sec as well as C_{Q1} to 25 sec as shown in Tables 4.1-4.7.

The optimum cycle time of Yenikent intersection in the morning:

$$C_{QAM}\frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-o.46} = 53.7 = 55 \text{ sec}$$

$$C_{Q1Am} = \frac{\boldsymbol{Y_{Q1}}}{\boldsymbol{Y}} \times Co = \frac{0.20}{0.46} \times 55 = 23.9 = 25 \text{ sec}$$

$$C_{Q2Am} = \frac{\boldsymbol{Y_{Q2}}}{\boldsymbol{Y}} \times Co = \frac{0.06}{0.46} \times 55 = 10 \text{ sec}$$

$C_{Q3Am} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.15}{0.46} \times 55$ = 20 sec

$C_{Q4Am} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.05}{0.46} \times 55$ = 10 sec

For the evening:

$C_{QPM} \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-o.46}$ = 55 sec

$C_{Q1\ Pm} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.15}{0.46} \times 55$ = 20 sec

$C_{Q2Pm} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.1}{0.46} \times 55$ = 15 sec

$C_{Q3Pm} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.15}{0.46} \times 55$ = 20 sec

$C_{Q4Pm} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.06}{0.46} \times 55$ = 10 sec

All calculations of the optimum cycle time of the other intersections can be found in appendix 1.

Table 4.3: Optimum cycle time determination: Yenikent intersection

Green Time Sec	phase	Saturated flow pcu/h	Actual flow Am	Y=a/v	C_o Am	Actual flow Pm	Y=a/v	C_o Pm
33	Q1	1850	373	0.20	25	287	0.15	20
10	Q2	1850	121	0.06	10	191	0.1	15
25	Q3	1850	289	0.15	20	283	0.15	20
15	Q4	1850	100	0.05	10	118	0.06	10
				0.46			0.46	

Table 4.4: optimum cycle time determination: Göçmenköy intersection

Green Time Sec	phase	Saturated flow pcu/h	Actual flow Am	Y=a/v	C_o Am	Actual flow Pm	Y=a/v	C_o Pm
33	Q1	1850	535	0.289	45	402	0.217	30
10	Q2	1850	187	0.101	20	144	0.077	15
33	Q3	1850	396	0.21	35	376	0.203	30
15	Q4	1850	265	0.143	25	272	0.147	20
				0.74			0.64	0.743

Table 4.5: optimum cycle time determination: intersection Fazıl Küçük Bulvarı with Kemal Aksay Caddesi

Green Time Sec	phase	Saturated flow pcu/h	Actual flow Am	Y=a/v	C_o Am	Actual flow Pm	Y=a/v	C_o Pm
30	Q1	1850	480	0.26	35	412	0.22	30
25	Q2	1850	180	0.09	15	196	0.11	15
40	Q3	1850	328	0.18	25	396	0.21	30
15	Q4	1850	39	0.02	10	110	0.06	10
				0.55			0.6	

Table 4.6: optimum cycle time determination: Honda intersection

Green Time Sec	phase	Saturated flow pcu/h	Actual flow Am	Y=a/v	C_o Am	Actual flow Pm	Y=a/v	C_o Pm
30	Q1	1850	256	0.14	15	258	0.14	15
30	Q2	1850	457	0.25	30	330	0.18	20
50	Q3	1850	420	0.23	25	258	0.14	15
				0.62			0.46	

Table 4.7: optimum cycle time determination: Hamitköy intersection

Green Time Sec	phase	Saturated flow pcu/h	Actual flow Am	Y=a/v	C_o Am	Actual flow Pm	Y=a/v	C_o Pm
30	Q1	1850	294	0.16	20	390	0.21	30
15	Q2	1850	197	0.11	20	193	0.1	20
45	Q3	1850	360	0.2	25	414	0.22	30
20	Q4	1850	139	0.07	10	211	0.11	15
				0.54			0.64	

B. Optimized Cycle Time

The addition of cycle time includes an increase or decrease in the duration of green light and reduction of the duration of all red times at intersections. The maximum time cycle of 150 seconds was used to great advantages. The level of service of some intersections has changed for the better after increasing the cycle length as well as great improvements in travel speed, low delay and CO_2 emissions for all intersections. This way is the best economic method to solve this problem. The time value for all intersections as shown in Tables 4.8-4.12

Table 4.8: Time value for Yenikent intersection

Phase	Field Cycle Time	Optimum Cycle Time Co Am	Optimized Cycle Time Co Am	Optimum Cycle Time Co Pm	Optimized Cycle Time Co Pm
Q1	33	25	57	20	45
Q2	10	10	24	15	31
Q3	25	20	44	20	45
Q4	15	10	25	10	29

Table 4.9: Time value for Göçmenköy intersection

Phase	Field Cycle Time	Optimum Cycle Time Co Am	Optimized Cycle Time Co Am	Optimum Cycle Time Co Pm	Optimized Cycle Time Co Pm
Q1	33	45	57	30	45
Q2	10	20	24	15	31
Q3	33	35	44	30	45
Q4	15	25	25	20	29

Table 4.10: Time value for intersection Fazıl Küçük Bulvarı with Kemal Aksay Caddesi

Phase	Field Cycle Time	Optimum Cycle Time Co Am	Optimized Cycle Time Co Am	Optimum Cycle Time Co Pm	Optimized Cycle Time Co Pm
Q1	30	35	57	30	41
Q2	25	15	24	15	27
Q3	40	25	44	30	60
Q4	15	10	25	10	22

Table 4.11: Time value for Honda intersection

Phase	Field Cycle Time	Optimum Cycle Time Co Am	Optimized Cycle Time Co Am	Optimum Cycle Time Co Pm	Optimized Cycle Time Co Pm
Q1	30	15	30	15	31
Q2	30	30	30	20	56
Q3	50	25	50	15	44

Table 4.12: Time value for Hamitköy intersection

Phase	**Field Cycle Time**	**Optimum Cycle Time Co Am**	**Optimized Cycle Time Co Am**	**Optimum Cycle Time Co Pm**	**Optimized Cycle Time Co Pm**
Q1	30	20	48	30	55
Q2	15	20	22	20	21
Q3	45	25	55	30	48
Q4	20	10	25	15	26

4.3.2 Increase Lane Width

Increased lane width to intersection numbers 1, 2, 3, 4 and 5 from all sides has changed the performance index for the better. The lane was 3.1m, widened to 4 m.

4.3.3 Determining the Path of Heavy Vehicles

The presence of a large number of heavy vehicles at Honda intersection in the morning, made the level of service bad. The solution was to change the path of heavy vehicles that come from the west and turning directly to the south and change this movement from the West and continue its way back from the east and turning to south. This movement improves the level of service so much, and the solution was needed in the morning only. As shown in Figure 4.1 the movement changed from A to B.

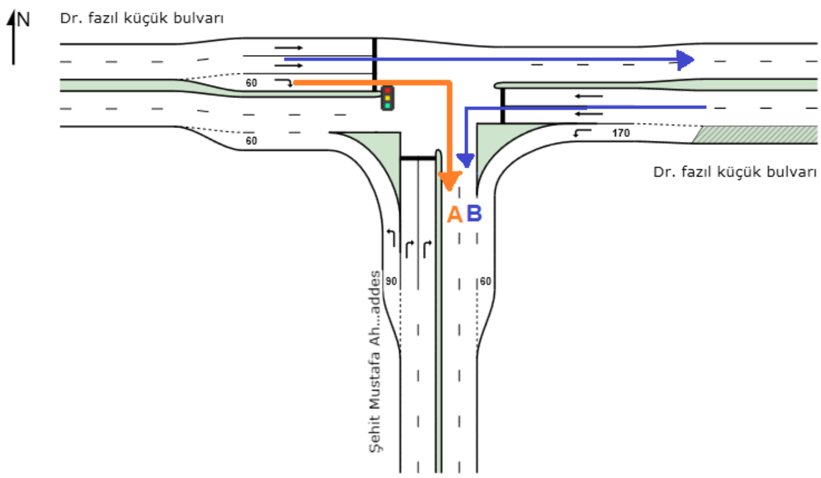

Figure 4.1: The movement of heavy vehicle

4.4 Table of Traffic Performance

A significant improvement in the level of service was observed regarding reduction in delays and improving travel speed as well as reducing Co_2 emission after adjusting and determining the optimal value of the green light in the traffic signal through using SIDRA intersection 8. Table 4.13 and 4.14 show us the results in the level of service and delay at the intersections before and after optimization; some intersections did not change LOS, but the value of delay change improved after optimization.

Table 4.13: comparison of the level of service in the morning before and after optimization

No. Intersection	Proposal	Level service before optimization	Delay (sec) Field Cycle time	Level service after optimization	Delay(sec) Optimum Cycle time	Delay(sec) Optimized Cycle time
1	Add cycle time Add lane width	F	957.3	F	894.4	473.2
2	Add cycle time Add lane width	F	1292.1	F	639.3	598.8
3	Add cycle time Add lane width	F	670.9	F	554.6	466.8
4	Determine heavy path Add lane width	F	170.9	F, C	164.2	23.5
5	Add cycle time Add lane width	F	693.7	F	514.3	340.9

Table 4.14: comparison of level of service in the evening before and after optimization

No. Intersection	Proposal	Level service before optimization	Delay (sec) Field Cycle time	Level service after optimization	Delay(sec) Optimum Cycle time	Delay(sec) Optimized Cycle time
1	Add cycle time Add lane width	F	1597.1	F	952.4	615.5
2	Add cycle time Add lane width	F	1145.4	F	699.5	589.8
3	Add cycle time Add lane width	F	1158.7	F	1218	800.6
4	Add cycle time Add lane width	F	119	D	39.5	38.7
5	Add cycle time Add lane width	F	804.4	F	632	438

4.5 SUMMARIES OF THE COMPARISON OF RESULTS

Comparison graphs show some effectiveness measurement value before and after optimization in the morning and evening during peak hours for all intersections.

4.5.1 Delay

Traffic congestion is manifested by three factors delay, travel speed and CO_2 emission, the most important of which is delay. The importance of delay comes from the fact that time is a commodity that is not bought and if it is lost, it will not return. And yet billions of seconds are uselessly wasted, and this time is wasted in congestion and traffic signals, so the main objective of this study is to reduce the delay as much as possible. Comparison of the delay value in the morning and evening after the optimal time and cycle optimal cycle time are shown in Figures 4.2 and 4.3

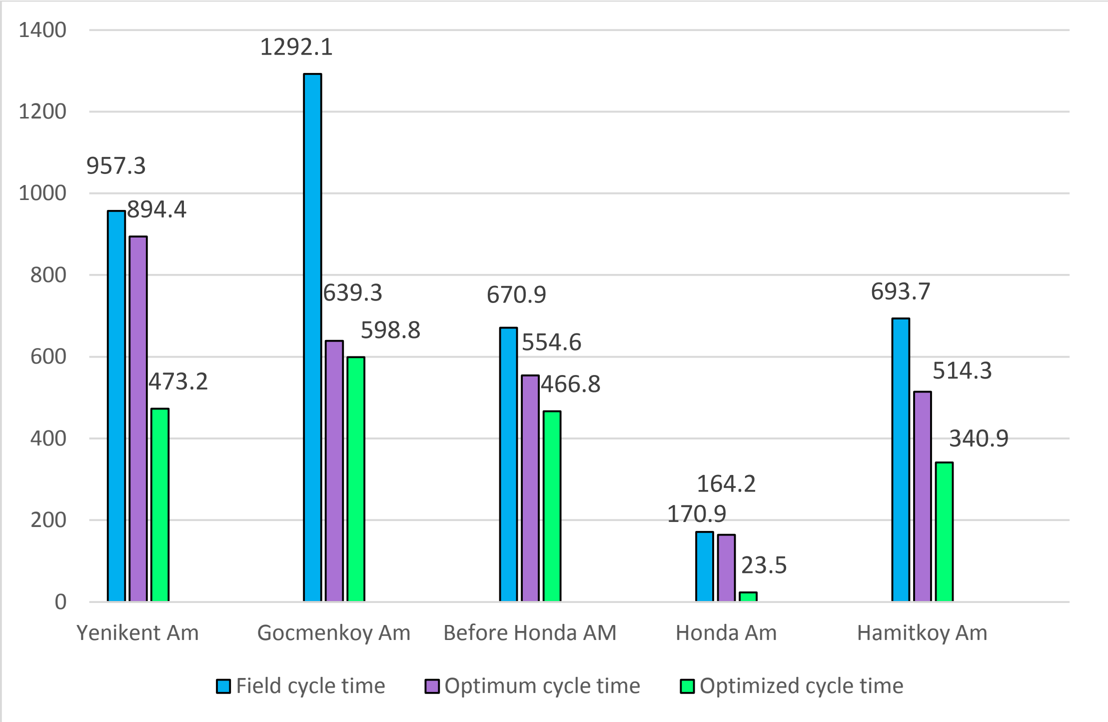

Figure 4.2: The delay before and after the optimization for morning peak hours

As shown in Figure 4.2, the results of the delay were the best after optimized cycle time so the results of optimized cycle will adapt in this study. After evaluating the performance of intersections and adjusting the optimal green time at all intersections in the morning and evening, it was noticed in the morning that the most significant value for the delay was at the second intersection in the Göcmenköy area and the evening was at the first intersection in the Yenikent area. This is due to a large number of vehicles as it's a busy area, and after optimization, it decreased to half, as the other intersections also decreased. It was observed that the average delay in the evening period is greater than the morning, and probably this is due to the vehicles going to work at different hours in the morning, but return home all at the same time at the rest of the day.

The reduction in delay after calculation of optimum green time was up to 50% for intersection 2 followed by intersection 5, while it was 17% for intersection 3. The lowest value of improvement was noted for intersection 4 with 4% followed by intersection 1 with 7%. These results indicate that the study area traffic signals were not appropriately coordinated according to the volume of traffic flow or the adjustment was made a long time ago, which means it is not able to work with the current volume of vehicles.

Moreover, the improvement after optimized the cycle time of the whole intersection was very high at 86% for intersection 4, 53% for intersection 2, 50% for intersection 1, 47% for intersection 5 and 30% for intersection 3. This indicates that the suggested cycle time, after calculating the optimum cycle time, has a great effect in reducing the delay at intersections. The results of the delay in the evening period as shown in Figure 4.3 was similar to the morning regarding improvement as the optimized cycle time was better than the current and the optimum cycle time.

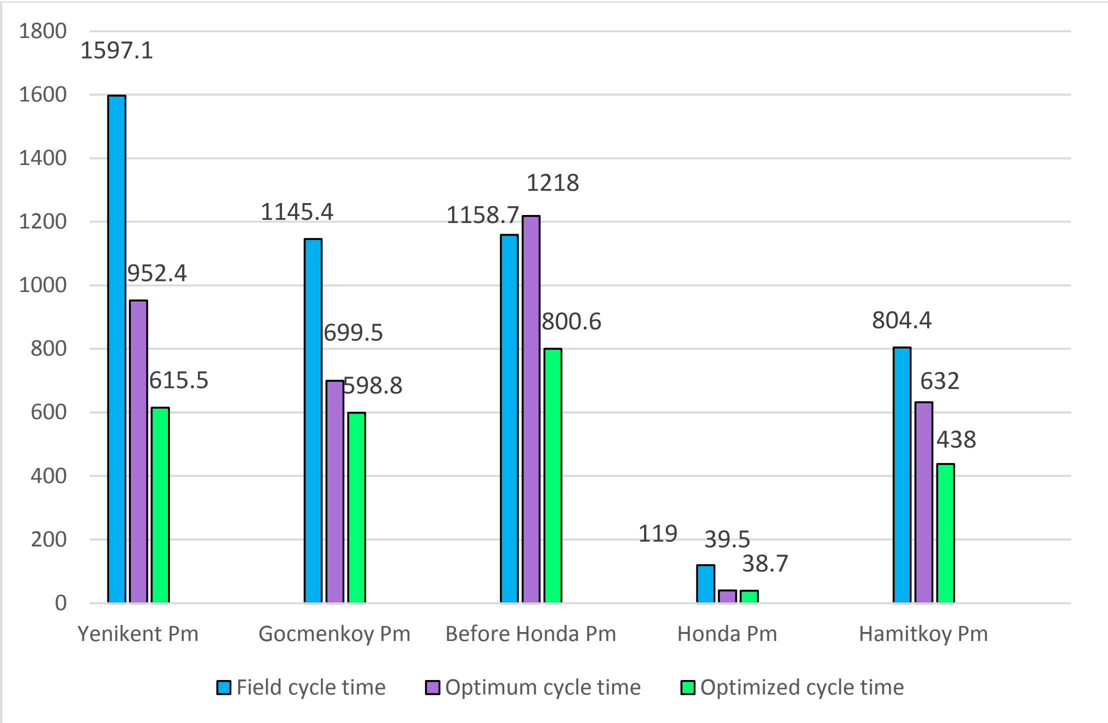

Figure 4.3: The delay before and after the optimization for the evening peak hours

In addition, these results were similar to the results obtained from a study conducted in Malaysia by Irtema et al., 2015. The study was conducted to evaluate the traffic flow at intersections in the morning and evening rush hours using the program SIDRA.

The percentage of reduction in the morning was about 44% in studies conducted in Malaysia while it was 51% in the current study in North Cyprus. For the evening peak hours, it was found to be nearly 40% in Malaysia and 52 % in North Cyprus. Based on the results it was found that the study in Cyprus is better, regarding overall improvements and economic solutions.

4.5.2 Travel Speed

During congestion there is a gradual slowing of the speed of travel, which can cause complete closure of the road directions and then gradually start all the vehicles by acceleration of speed and improve the flow of traffic, therefore, the speed on the roads is in direct correlation with traffic congestion. Comparison between the travel speed value before and after optimization in the morning and evening can be seen in Figures 4.4 and 4.5.

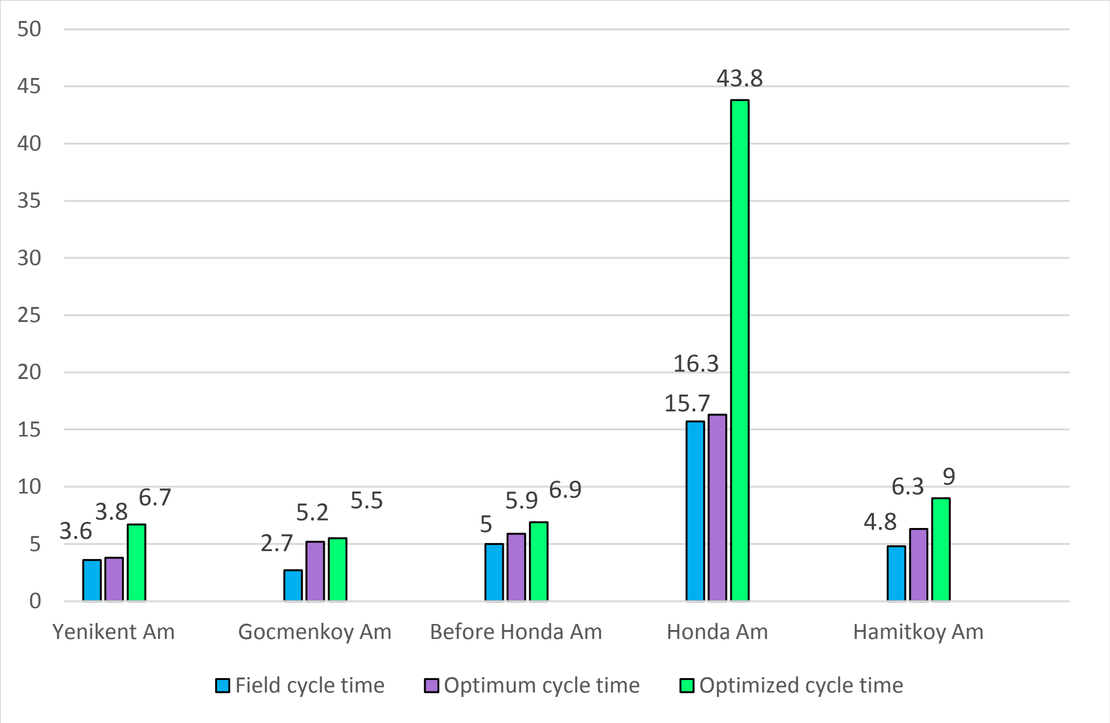

Figure 4.4: Travel speed value before and after the optimization for the morning peak hours

And here significant improvements can be seen in travel speed after Optimized cycle time Compared with Optimum cycle time. This study was coordinated through traffic signals, and also note from Figure 4.4 and 4.5 that the rate of speed is very slow, but with using SIDRA software optimization, a significant improvement in travel speed occurred from 31.8 km /h to 71.9 km/h in the morning at all intersections especially at the fourth intersection in the morning and evening.

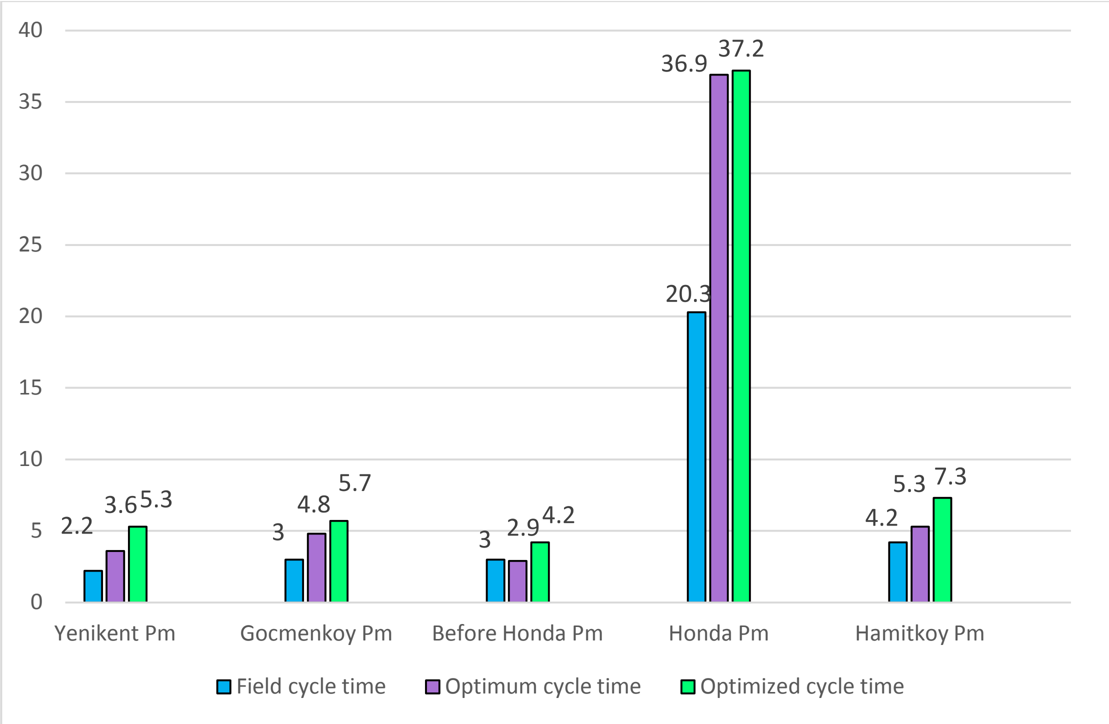

Figure 4.5: Travel speed value before and after the optimization for the evening peak hours

Also, the study conducted by Irtema et al., 2015, in the morning the total travel speed for all intersections in Malaysia improved from 72.5 km/h to 124.9 km/h while in Cyprus increased from 31.8 km/h to 71.9 km/h. On the other hand, the percentage of increase of travel speed in the evening was about 85% in Malaysia from 53 km /h to 98.2 km /h and 82% in Cyprus from 32.7 km/h to 59.7 km/h.

4.5.3 CO_2 Emission

Vehicles can cause environmental degradation. Before driving one meter on the road, whether it is operated by gasoline or diesel, the vehicle emits gases that increase the emission of CO_2. Comparison between CO_2 emission value in the morning and evening after the optimal time and cycle Optimal cycle time is in Figure 4.6 and 4.7.

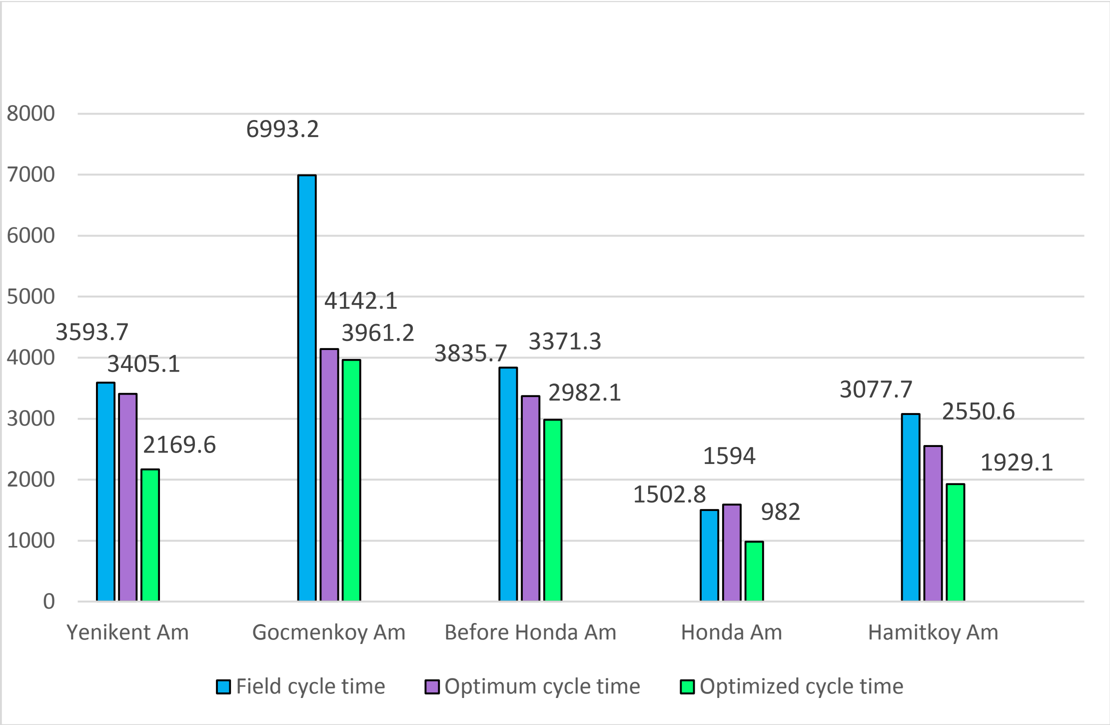

Figure 4.6: Comparison between CO_2 emission before and after the optimization for the morning peak hours

As shown in Figure 4.6 the higher CO_2 emission at number two Göçmenköy intersection was observed compared to the other intersections and after optimized cycle time was reduced by 43%, While at intersection number four, the Honda intersection, after optimum cycle time, CO_2 emissions increased rather than declined, therefore the results of delay were the best after optimized cycle time so the result of optmized cycle time will adapt.

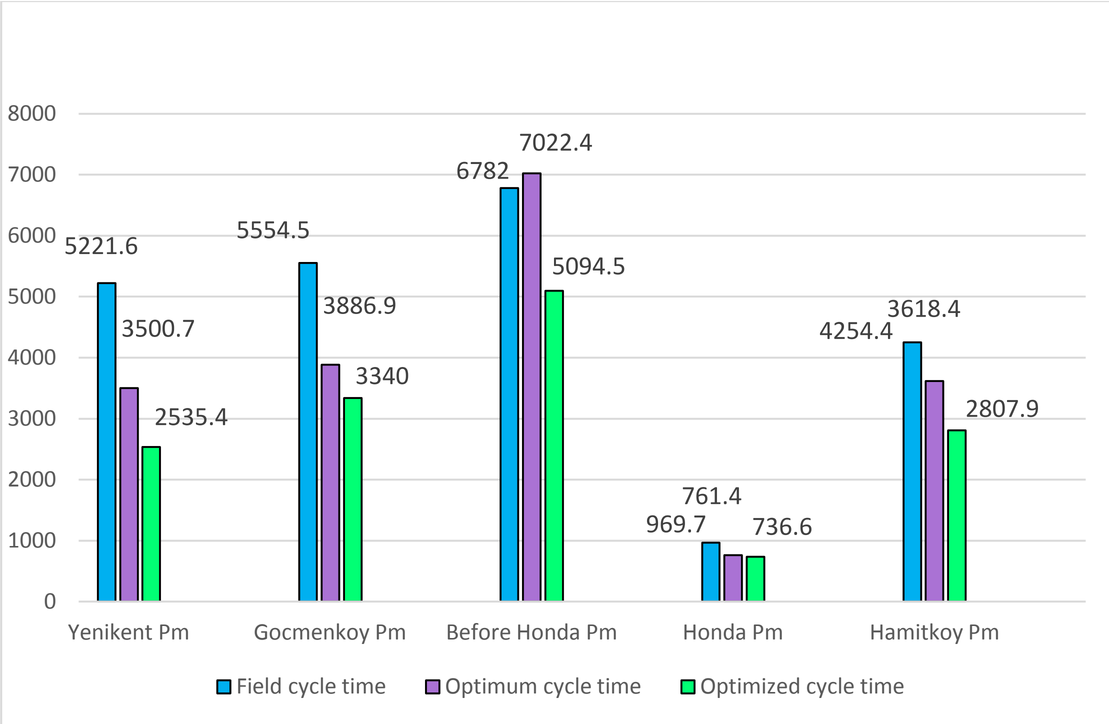

Figure 4.7: Comparison between CO_2 emission value before and after the optimization for the evening peak hours

As well as the result of CO_2 emission value after Optimized cycle time was better than Optimum cycle time, therefore it will be used. And here as shown in Figure 4.6 and 4.7 a significant improvement through decreasing CO_2 emission happens at all intersections. The total CO_2 emission for all intersections reduced about 88% from 16678.4 kg/h to 14514.4 kg/h in the morning and 64% from 22782.2 kg/h to 14514.4 kg/h in the evening.

CHAPTER 5

CONCLUSION

5.1 Conclusion

This study focuses on the study and analysis of SIDRA INTERSECTION 8 at intersections and to perform traffic performance before and after the application form flexibility model about the identification of goal improving functions, and any one of the numbers of different performance indicators that can be used with this method. The survey was observed in five signalized intersections that are located in Nicosia city. Also, SIDRA INTERSECTION 8 has the additional benefit of a software package, so it is widely used to improve the timing of the lanes so the results are more realistic and accurate with what can be implemented.

If the time of the signal is incorrect, small movements may face excessive delays. As a result, many drivers turn to alternative roads or residential roads to avoid additional delays. The results from studies before and after optimization of the SIDRA INTERSECTION 8 revealed that the total travel time, total delay, the degree of saturation, CO_2 emission were decreased significantly. There was also an increase in travel speed on the network road. The effectiveness measurement for the whole system was formulated in traffic performance tables which detailed information of plan or plan timing in every junction also indicated in Signal Timing Tables SIDRA.

5.2 Recommendations for Future Work

Through this study and its results, it could be concluded that the green time of intersections is not effective at this time, which affects the future capacity of the road in the intersection areas, because there are many associated problems, such as increase in the number of vehicles. As a result, the following recommendations might be useful:

1-It could be useful to use other software such as PARAMICS, VISSIM, HCS, and TRANSYT-7F for the same case study and compare the results with results of SIDRA.

2- It is recommended to expand the study area to include more intersections to observe other traffic coordination on the network in order to avoid congestion problems.

3- The number of vehicles is always increasing, so it is better to calculate annually the appropriate green time for traffic signals, since this method is the easiest and most economical.

4- It is recommended to change the course and movement of heavy vehicles from Göcmenköy to Kücük Kaymaklı or determine the times of heavy vehicles durıng the morning.

5- The final recommendation is to improve and develop public transport to cover larger areas of North Cyprus and to encourage the use of public instead of private transport.

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APPENDIX 1

Optimum Cycle Time:

After calculating the optimum cycle time, all numbers should increase to the nearest multiple of 5.

The optimum cycle time of Göçmenköy intersection in the morning:

$C_{QAM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.74}$ =115 sec

$C_{Q1Am} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.289}{0.74} \times 115$ =45 sec

$C_{Q2Am} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.101}{0.74} \times 115$ = 20 sec

$C_{Q3Am} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.21}{0.74} \times 115$ = 35 sec

$C_{Q4Am} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.143}{0.74} \times 115$ = 25 sec

For the evening:

$C_{QPM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-o.46}$ = 55 sec

$C_{Q1\ Pm} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.217}{0.46} \times 55$ = 30 sec

$C_{Q2Pm} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.077}{0.46} \times 55$ = 15 sec

$C_{Q3Pm} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.203}{0.46} \times 55$ = 20 sec

$C_{Q4Pm} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.147}{0.46} \times 55$ = 10 sec

The optimum cycle time of Fazıl Küçük Bulvarı with Kemal Aksay Caddesi intersection in the morning:

$C_{QAM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.55}$ = 65 sec

$C_{Q1Am} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.26}{0.55} \times 65$ = 35 sec

$C_{Q2Am} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.09}{0.55} \times 65$ = 15 sec

$C_{Q3Am} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.18}{0.55} \times 65$ = 25 sec

$C_{Q4Am} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.02}{0.55} \times 65 = 10$ sec

For the evening:

$C_{QPM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.6} = 75$ sec

$C_{Q1\ Pm} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.22}{0.6} \times 75 = 30$ sec

$C_{Q2Pm} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.11}{0.6} \times 75 = 15$ sec

$C_{Q3Pm} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.21}{0.6} \times 75 = 30$ sec

$C_{Q4Pm} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.06}{0.6} \times 75 = 10$ sec

The optimum cycle time of Honda intersection in the morning:

$C_{QAM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times12+5}{1-0.62} = 65$ sec

$C_{Q1Am} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.14}{0.62} \times 65 = 15$ sec

$C_{Q2Am} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.25}{0.62} \times 65 = 30$ sec

$C_{Q3Am} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.23}{0.62} \times 65 = 25$ sec

For the evening:

$C_{QPM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times12+5}{1-0.46} = 45$ sec

$C_{Q1\ Pm} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.14}{0.46} \times 45 = 15$ sec

$C_{Q2Pm} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.18}{0.46} \times 45 = 20$ sec

$C_{Q3Pm} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.14}{0.46} \times 45 = 15$ sec

The optimum cycle time of Hamitköy intersection in the morning:

$C_{QAM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.54} = 65$ sec

$C_{Q1Am} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.16}{0.54} \times 65 = 20$ sec

$C_{Q2Am} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.11}{0.54} \times 65 = 20$ sec

$C_{Q3Am} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.2}{0.54} \times 65 = 25$ sec

$C_{Q4Am} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.07}{0.54} \times 65 = 10$ sec

For the evening:

$C_{QPM} = \frac{1.5L+5}{1-Y} = \frac{1.5\times16+5}{1-0.64} = 85$ sec

$C_{Q1\ Pm} = \frac{Y_{Q1}}{Y} \times Co = \frac{0.21}{0.64} \times 85 = 30$ sec

$C_{Q2Pm} = \frac{Y_{Q2}}{Y} \times Co = \frac{0.1}{0.64} \times 85 = 20$ sec

$C_{Q3Pm} = \frac{Y_{Q3}}{Y} \times Co = \frac{0.22}{0.64} \times 85 = 30$ sec

$C_{Q4Pm} = \frac{Y_{Q4}}{Y} \times Co = \frac{0.11}{0.64} \times 85 = 15$ sec

ABBENDIX 2

The Result of Lefkoşa - Güzelyurt Anayolu with Belediye Blv and Bekir Şevki Hacı Sk, Gönyeli Interesction

Lane Use and Performance	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Belediye Blv													
Lane 1	296	0.0	193[1]	1.536	100	1029.2	LOS F	108.4	758.6	Short	35	0.0	NA
Lane 2	188	0.0	164[1]	1.144	100	354.3	LOS F	35.9	251.5	Full	500	0.0	43.2[8]
Approach	484	0.0		1.536		767.0	LOS F	108.4	758.6				
East: lefkosa-Guzlyurt Anayolu													
Lane 1	60	0.0	1826	0.033	100	5.6	LOS A	0.0	0.0	Short	35	0.0	NA
Lane 2	529	0.0	458[1]	1.155	100	360.2	LOS F	105.8	740.8	Full	500	0.0	41.0
Lane 3	567	0.0	491	1.155	100	360.9	LOS F	113.2	792.1	Full	500	0.0	47.2
Approach	1156	0.0		1.155		342.2	LOS F	113.2	792.1				
North: Bekir Sevki Naci SK													
Lane 1	372	0.0	243[1]	1.533	100	1022.9	LOS F	135.8	950.4	Short	35	0.0	NA
Lane 2	28	0.0	243	0.115	100	67.5	LOS E	1.8	12.7	Full	500	0.0	64.5[8]
Approach	400	0.0		1.533		956.1	LOS F	135.8	950.4				
West: Guzlyurt-lefkosa Anayolu													
Lane 1	762	0.0	663	1.150	100	347.1	LOS F	151.2	1058.2	Full	500	0.0	74.8
Lane 2	730	0.0	635	1.150	100	352.8	LOS F	145.2	1016.4	Full	500	0.0	70.9

Figure 1: Detail Delay for each line and the total at intersection 1 Am before solution

Lane Use and Performance	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Belediye Blv													
Lane 1	296	0.0	109	2.707	100	3099.3	LOS F	166.0	1162.1	Short	35	0.0	NA
Lane 2	188	0.0	105	1.790	100	1459.9	LOS F	76.5	535.5	Full	500	0.0	84.0[8]
Approach	484	0.0		2.707		2462.5	LOS F	166.0	1162.1				
East: lefkosa-Guzlyurt Anayolu													
Lane 1	60	0.0	1744	0.034	100	5.6	LOS A	0.0	0.0	Short	35	0.0	NA
Lane 2	538	0.0	398[1]	1.352	100	676.8	LOS F	140.9	986.6	Full	500	0.0	68.0
Lane 3	558	0.0	413	1.352	100	678.3	LOS F	146.1	1023.0	Full	500	0.0	71.5
Approach	1156	0.0		1.352		642.7	LOS F	146.1	1023.0				
North: Bekir Sevki Naci SK													
Lane 1	372	0.0	196	1.899	100	1652.0	LOS F	160.9	1126.2	Short	35	0.0	NA
Lane 2	28	0.0	189	0.148	100	43.3	LOS D	1.1	7.5	Full	500	0.0	80.9[8]
Approach	400	0.0		1.899		1539.3	LOS F	160.9	1126.2				
West: Guzlyurt-lefkosa Anayolu													
Lane 1	762	0.0	594	1.283	100	554.1	LOS F	176.6	1236.1	Full	500	0.0	90.1
Lane 2	730	0.0	569	1.283	100	559.4	LOS F	169.4	1185.6	Full	500	0.0	85.9

Figure 2: Detail Delay for each line and the total at intersection 1 Am after solution

Lane Use and Performance	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Belediye Blv													
Lane 1	484	0.0	250[1]	1.937	100	1744.4	LOS F	230.3	1611.8	Short	35	0.0	NA
Lane 2	280	0.0	194[1]	1.446	100	878.0	LOS F	93.9	657.2	Full	500	0.0	100.0[8]
Approach	764	0.0		1.937		1426.9	LOS F	230.3	1611.8				
East: lefkosa-Guzlyurt Anayolu													
Lane 1	52	0.0	1826	0.028	100	5.6	LOS A	0.0	0.0	Short	35	0.0	NA
Lane 2	528	0.0	475[1]	1.112	100	289.4	LOS F	92.8	649.9	Full	500	0.0	28.9
Lane 3	552	0.0	496	1.112	100	292.0	LOS F	97.0	678.7	Full	500	0.0	32.9
Approach	1132	0.0		1.112		277.6	LOS F	97.0	678.7				
North: Bekir Sevki Naci SK													
Lane 1	428	0.0	285[1]	1.501	100	967.3	LOS F	151.7	1061.9	Short	35	0.0	NA
Lane 2	44	0.0	292	0.151	100	64.1	LOS E	2.8	19.5	Full	500	0.0	75.1[8]
Approach	472	0.0		1.501		883.1	LOS F	151.7	1061.9				
West: Guzlyurt-lefkosa Anayolu													
Lane 1	569	0.0	511	1.113	100	289.5	LOS F	100.1	700.4	Full	500	0.0	35.8
Lane 2	553	0.0	497	1.113	100	293.3	LOS F	97.4	681.7	Full	500	0.0	33.3
Approach	1122	0.0		1.113		291.4	LOS F	100.1	700.4				
Intersection	3490	0.0		1.937		615.5	LOS F	230.3	1611.8				

Figure 3: Detail Delay for each line and the at intersection 1 Pm before solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Belediye Blv													
Lane 1	484	0.0	109	4.452	100	6236.9	LOS F	328.5	2299.8	Short	35	0.0	NA
Lane 2	280	0.0	105	2.666	100	3029.1	LOS F	155.8	1090.4	Full	500	0.0	100.0[8]
Approach	764	0.0		4.452		5061.3	LOS F	328.5	2299.8				
East: lefkosa-Guzlyurt Anayolu													
Lane 1	52	0.0	1744	0.030	100	5.6	LOS A	0.0	0.0	Short	35	0.0	NA
Lane 2	536	0.0	400[1]	1.338	100	651.8	LOS F	137.0	959.1	Full	500	0.0	65.3
Lane 3	544	0.0	407	1.338	100	655.1	LOS F	139.2	974.3	Full	500	0.0	66.8
Approach	1132	0.0		1.338		623.7	LOS F	139.2	974.3				
North: Bekir Sevki Naci SK													
Lane 1	428	0.0	196	2.185	100	2164.6	LOS F	209.1	1463.6	Short	35	0.0	NA
Lane 2	44	0.0	189	0.233	100	43.9	LOS D	1.7	12.0	Full	500	0.0	100.0[8]
Approach	472	0.0		2.185		1966.9	LOS F	209.1	1463.6				
West: Guzlyurt-lefkosa Anayolu													
Lane 1	569	0.0	595	0.956	100	63.0	LOS E	35.0	244.7	Full	500	0.0	0.0
Lane 2	553	0.0	579	0.956	100	66.9	LOS E	34.1	238.9	Full	500	0.0	0.0
Approach	1122	0.0		0.956		64.9	LOS E	35.0	244.7				
Intersection	3490	0.0		4.452		1597.1	LOS F	328.5	2299.8				

Figure 4: Detail Delay for each line and the total at intersection 1 Pm after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	32	57	72
Green Time (sec)	27	19	9	5
Phase Time (sec)	33	25	15	10
Phase Split	40 %	30 %	18 %	12 %

Figure 5: phase timing intersection 1 Am before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	57	101	126
Green Time (sec)	52	39	20	19
Phase Time (sec)	57	44	25	24
Phase Split	38 %	29 %	17 %	16 %

Figure 6: phase timing intersection 1 Am after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	32	57	72
Green Time (sec)	27	19	9	5
Phase Time (sec)	33	25	15	10
Phase Split	40 %	30 %	18 %	12 %

Figure 7: phase timing intersection 1 Pm before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	45	90	119
Green Time (sec)	40	40	24	26
Phase Time (sec)	45	45	29	31
Phase Split	30 %	30 %	19 %	21 %

Figure 8: phase timing intersection 1 Pm after solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Sht.Mustafa Mehmet Sk													
Lane 1	436	0.0	100	4.370	100	6089.9	LOS F	296.3	2074.1	Full	500	0.0	100.0
Lane 2	312	0.0	96	3.257	100	4092.3	LOS F	192.2	1345.4	Full	500	0.0	98.6
Approach	748	0.0		4.370		5256.7	LOS F	296.3	2074.1				
East: Dr.Fazil Kucuk Bulvan													
Lane 1	244	0.0	1744	0.140	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	645	0.0	485[1]	1.329	100	639.8	LOS F	166.0	1162.2	Full	500	0.0	84.0
Lane 3	695	0.0	523	1.329	100	643.5	LOS F	178.9	1252.0	Full	500	0.0	91.4
Approach	1584	0.0		1.329		543.8	LOS F	178.9	1252.0				
North: Sanayi cd													
Lane 1	356	0.0	1744	0.204	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	388	0.0	181	2.143	100	2089.3	LOS F	188.3	1317.9	Full	500	0.0	96.5
Lane 3	316	0.0	172	1.832	100	1539.5	LOS F	133.1	931.7	Full	500	0.0	62.6
Approach	1060	0.0		2.143		1225.6	LOS F	188.3	1317.9				
West: Dr.Fazil Kucuk Bulvan													
Lane 1	672	0.0	1744	0.385	100	5.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	744	0.0	543	1.370	100	711.0	LOS F	204.6	1432.2	Full	500	0.0	100.0
Lane 3	716	0.0	522	1.370	100	715.7	LOS F	196.9	1378.4	Full	500	0.0	100.0
Approach	2132	0.0		1.370		490.2	LOS F	204.6	1432.2				
Intersection	5524	0.0		4.370		1292.1	LOS F	296.3	2074.1				

Figure 9: Detail Delay for each line and the total at intersection 2 Am before solution

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Sht.Mustafa Mehmet Sk													
Lane 1	436	0.0	228	1.911	100	1693.3	LOS F	204.5	1431.5	Full	500	0.0	100.0
Lane 2	312	0.0	219	1.424	100	834.9	LOS F	101.3	709.4	Full	500	0.0	36.9
Approach	748	0.0		1.911		1335.2	LOS F	204.5	1431.5				
East: Dr.Fazil Kucuk Bulvan													
Lane 1	244	0.0	1826	0.134	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	613	0.0	457 [1]	1.341	100	682.5	LOS F	180.3	1262.0	Full	500	0.0	92.1
Lane 3	727	0.0	542	1.341	100	684.6	LOS F	213.4	1493.8	Full	500	0.0	100.0
Approach	1584	0.0		1.341		579.2	LOS F	213.4	1493.8				
North: Sanayi cd													
Lane 1	356	0.0	1826	0.195	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	388	0.0	251 [1]	1.548	100	1048.7	LOS F	143.7	1006.2	Full	500	0.0	69.9
Lane 3	316	0.0	280	1.129	100	324.5	LOS F	57.5	402.4	Full	500	0.0	0.0
Approach	1060	0.0		1.548		482.5	LOS F	143.7	1006.2				
West: Dr.Fazil Kucuk Bulvan													
Lane 1	672	0.0	1826	0.368	100	5.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	744	0.0	575	1.294	100	597.7	LOS F	202.5	1417.7	Full	500	0.0	100.0
Lane 3	716	0.0	553	1.294	100	602.7	LOS F	195.0	1365.1	Full	500	0.0	100.0
Approach	2132	0.0		1.294		412.8	LOS F	202.5	1417.7				

Figure 1 0: Detail Delay for each line and the total at intersection 2 Pm after solution

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Sht.Mustafa Mehmet Sk													
Lane 1	268	0.0	99	2.720	100	3124.7	LOS F	151.8	1062.8	Full	500	0.0	75.2
Lane 2	308	0.0	96	3.215	100	4017.3	LOS F	188.7	1321.1	Full	500	0.0	96.7
Approach	576	0.0		3.215		3602.0	LOS F	188.7	1321.1				
East: Dr.Fazil Kucuk Bulvan													
Lane 1	136	0.0	1744	0.078	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	666	0.0	507 [1]	1.313	100	610.8	LOS F	166.5	1165.2	Full	500	0.0	84.2
Lane 3	702	0.0	535	1.313	100	612.1	LOS F	175.4	1228.0	Full	500	0.0	89.4
Approach	1504	0.0		1.313		556.7	LOS F	175.4	1228.0				
North: Sanayi cd													
Lane 1	352	0.0	1744	0.202	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	412	0.0	181	2.275	100	2326.9	LOS F	209.0	1463.2	Full	500	0.0	100.0
Lane 3	324	0.0	172	1.879	100	1622.5	LOS F	140.0	980.1	Full	500	0.0	67.4
Approach	1088	0.0		2.275		1366.1	LOS F	209.0	1463.2				
West: Dr.Fazil Kucuk Bulvan													
Lane 1	140	0.0	1744	0.080	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	749	0.0	543	1.379	100	727.3	LOS F	208.9	1462.1	Full	500	0.0	100.0
Lane 3	719	0.0	521	1.379	100	732.3	LOS F	200.5	1403.8	Full	500	0.0	100.0
Approach	1608	0.0		1.379		666.7	LOS F	208.9	1462.1				
Intersection	4776	0.0		3.215		1145.4	LOS F	209.0	1463.2				

Figure 11: Detail Delay for each line and the total at intersection 2 Pm after solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Sht.Mustafa Mehmet Sk													
Lane 1	268	0.0	225	1.189	100	423.1	LOS F	57.6	403.1	Full	500	0.0	0.0
Lane 2	308	0.0	219	1.406	100	802.8	LOS F	97.8	684.5	Full	500	0.0	33.6
Approach	576	0.0		1.406		626.1	LOS F	97.8	684.5				
East: Dr.Fazil Kucuk Bulvan													
Lane 1	136	0.0	1826	0.074	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	648	0.0	498 [1]	1.301	100	611.4	LOS F	178.6	1250.1	Full	500	0.0	91.2
Lane 3	720	0.0	554	1.301	100	611.8	LOS F	198.3	1388.2	Full	500	0.0	100.0
Approach	1504	0.0		1.301		556.8	LOS F	198.3	1388.2				
North: Sanayi cd													
Lane 1	352	0.0	1826	0.193	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	412	0.0	252 [1]	1.633	100	1200.2	LOS F	163.8	1146.9	Full	500	0.0	82.7
Lane 3	324	0.0	280	1.157	100	372.1	LOS F	64.2	449.7	Full	500	0.0	0.0
Approach	1088	0.0		1.633		567.1	LOS F	163.8	1146.9				
West: Dr.Fazil Kucuk Bulvan													
Lane 1	140	0.0	1826	0.077	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	749	0.0	575	1.302	100	612.9	LOS F	206.9	1448.5	Full	500	0.0	100.0
Lane 3	719	0.0	552	1.302	100	618.2	LOS F	198.8	1391.3	Full	500	0.0	100.0
Approach	1608	0.0		1.302		562.4	LOS F	206.9	1448.5				
Intersection	4776	0.0		1.633		569.4	LOS F	206.9	1448.5				

Figure 12: Detail Delay for each line and the total at intersection 2 Pm after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	32	65	80
Green Time (sec)	27	27	9	5
Phase Time (sec)	33	33	15	10
Phase Split	36 %	36 %	16 %	11 %

Figure 13: phase timing intersection 2 Am before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	50	99	127
Green Time (sec)	45	44	23	18
Phase Time (sec)	50	49	28	23
Phase Split	33 %	33 %	19 %	15 %

Figure 14: phase timing intersection 2 Am after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	32	65	80
Green Time (sec)	27	27	9	5
Phase Time (sec)	33	33	15	10
Phase Split	36 %	36 %	16 %	11 %

Figure 15: phase timing intersection 2 Pm before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	50	99	127
Green Time (sec)	45	44	23	18
Phase Time (sec)	50	49	28	23
Phase Split	33 %	33 %	19 %	15 %

Figure 16: phase timing intersection 2 pm after solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Kemal Aksay Caddesi													
Lane 1	296	0.0	1744	0.170	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	365	0.0	326	1.119	100	288.5	LOS F	57.0	398.8	Full	500	0.0	0.0
Lane 3	355	0.0	317	1.119	100	290.3	LOS F	55.4	388.0	Full	500	0.0	0.0
Approach	1016	0.0		1.119		206.7	LOS F	57.0	398.8				
East: Dr.Fazil Kucuk Bulvari													
Lane 1	528	0.0	1744	0.303	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	660	0.0	583	1.133	100	305.5	LOS F	110.6	773.9	Full	500	0.0	45.0
Lane 3	652	0.0	575	1.133	100	308.4	LOS F	109.3	764.8	Full	500	0.0	43.9
Approach	1840	0.0		1.133		220.5	LOS F	110.6	773.9				
NorthWest:													
Lane 1	156	0.0	157	0.995	100	112.3	LOS F	12.9	90.6	Full	500	0.0	0.0
Approach	156	0.0		0.995		112.3	LOS F	12.9	90.6				
West: Dr.Fazil Kucuk Bulvari													
Lane 1	760	0.0	416	1.828	100	1534.0	LOS F	327.6	2293.3	Full	500	0.0	100.0
Lane 2	649	0.0	355 [1]	1.828	100	1535.0	LOS F	279.6	1957.4	Full	500	0.0	100.0
Lane 3	508	0.0	333 [1]	1.527	100	1003.6	LOS F	174.9	1224.5	Short	60	0.0	NA
Approach	1917	0.0		1.828		1393.8	LOS F	327.6	2293.3				
Intersection	4929	0.0		1.828		670.5	LOS F	327.6	2293.3				

Figure 17: Detail Delay for each line and the total at intersection 3 Am before solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Kemal Aksay Caddesi													
Lane 1	296	0.0	1826	0.162	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	365	0.0	209	1.749	100	1403.0	LOS F	154.2	1079.2	Full	500	0.0	76.7
Lane 3	355	0.0	203	1.749	100	1404.8	LOS F	149.8	1048.8	Full	500	0.0	73.9
Approach	1016	0.0		1.749		996.5	LOS F	154.2	1079.2				
East: Dr.Fazil Kucuk Bulvari													
Lane 1	528	0.0	1826	0.289	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	660	0.0	568	1.162	100	363.9	LOS F	129.6	907.4	Full	500	0.0	60.0
Lane 3	652	0.0	561	1.162	100	366.8	LOS F	128.1	896.7	Full	500	0.0	58.9
Approach	1840	0.0		1.162		262.1	LOS F	129.6	907.4				
NorthWest:													
Lane 1	156	0.0	134	1.166	100	379.7	LOS F	30.1	210.9	Full	500	0.0	0.0
Approach	156	0.0		1.166		379.7	LOS F	30.1	210.9				
West: Dr.Fazil Kucuk Bulvari													
Lane 1	843	0.0	710	1.188	100	405.3	LOS F	178.7	1250.8	Full	500	0.0	91.3
Lane 2	566	0.0	476[1]	1.188	100	412.2	LOS F	121.5	850.3	Full	500	0.0	53.9
Lane 3	508	0.0	446[1]	1.140	100	338.2	LOS F	96.1	672.5	Short	60	0.0	NA
Approach	1917	0.0		1.188		389.6	LOS F	178.7	1250.8				
Intersection	4929	0.0		1.749		466.8	LOS F	178.7	1250.8				

Figure 18: Detail Delay for each line and the total at intersection 3 Am after solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Kemal Aksay Caddesi													
Lane 1	580	0.0	1744	0.333	100	5.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	397	0.0	309	1.285	100	572.9	LOS F	97.1	679.5	Full	500	0.0	33.0
Lane 3	387	0.0	301	1.285	100	574.4	LOS F	94.6	662.2	Full	500	0.0	30.6
Approach	1364	0.0		1.285		332.1	LOS F	97.1	679.5				
East: Dr.Fazil Kucuk Bulvari													
Lane 1	484	0.0	1744	0.278	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	900	0.0	566	1.591	100	1110.4	LOS F	329.8	2308.3	Full	500	0.0	100.0
Lane 3	892	0.0	561	1.591	100	1112.5	LOS F	326.8	2287.6	Full	500	0.0	100.0
Approach	2276	0.0		1.591		876.3	LOS F	329.8	2308.3				
NorthWest:													
Lane 1	464	0.0	135	3.434	100	4417.0	LOS F	296.1	2072.7	Full	500	0.0	100.0
Approach	464	0.0		3.434		4417.0	LOS F	296.1	2072.7				
West: Dr.Fazil Kucuk Bulvari													
Lane 1	726	0.0	399	1.817	100	1515.0	LOS F	310.8	2175.3	Full	500	0.0	100.0
Lane 2	671	0.0	369[1]	1.817	100	1515.5	LOS F	287.5	2012.6	Full	500	0.0	100.0
Lane 3	216	0.0	380	0.568	100	47.6	LOS D	10.5	73.7	Short	60	0.0	NA
Approach	1613	0.0		1.817		1318.7	LOS F	310.8	2175.3				
Intersection	5717	0.0		3.434		1158.7	LOS F	329.8	2308.3				

Figure 19: Detail Delay for each line and the total at intersection 3 Pm before solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Kemal Aksay Caddesi													
Lane 1	580	0.0	1826	0.318	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	397	0.0	275	1.444	100	869.4	LOS F	132.3	926.2	Full	500	0.0	62.0
Lane 3	387	0.0	268	1.444	100	871.1	LOS F	128.9	902.6	Full	500	0.0	59.5
Approach	1364	0.0		1.444		502.6	LOS F	132.3	926.2				
East: Dr.Fazil Kucuk Bulvari													
Lane 1	484	0.0	1826	0.265	100	5.6	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	900	0.0	703	1.280	100	571.9	LOS F	240.4	1682.5	Full	500	0.0	100.0
Lane 3	892	0.0	697	1.280	100	574.0	LOS F	238.2	1667.7	Full	500	0.0	100.0
Approach	2276	0.0		1.280		452.3	LOS F	240.4	1682.5				
NorthWest:													
Lane 1	464	0.0	196	2.367	100	2513.8	LOS F	255.8	1790.5	Full	500	0.0	100.0
Approach	464	0.0		2.367		2513.8	LOS F	255.8	1790.5				
West: Dr.Fazil Kucuk Bulvari													
Lane 1	753	0.0	460	1.636	100	1204.1	LOS F	301.0	2106.7	Full	500	0.0	100.0
Lane 2	644	0.0	394[1]	1.636	100	1205.4	LOS F	257.9	1805.2	Full	500	0.0	100.0
Lane 3	216	0.0	438	0.493	100	58.5	LOS E	13.6	95.3	Short	60	0.0	NA
Approach	1613	0.0		1.636		1051.2	LOS F	301.0	2106.7				
Intersection	5717	0.0		2.367		800.6	LOS F	301.0	2106.7				

Figure 20: Detail Delay for each line and the total at intersection 3 Pm after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	30	70	85
Green Time (sec)	25	35	10	20
Phase Time (sec)	30	40	15	25
Phase Split	27 %	36 %	14 %	23 %

Figure 21: phase timing intersection 3 Am before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	55	100	115
Green Time (sec)	50	40	10	15
Phase Time (sec)	55	45	15	20
Phase Split	41 %	33 %	11 %	15 %

Figure 22: phase timing intersection 3 Am after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	80	0	40	55
Green Time (sec)	24	34	9	19
Phase Time (sec)	30	40	15	25
Phase Split	27 %	36 %	14 %	23 %

Figure 23: phase timing intersection 3 Pm before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	109	0	60	82
Green Time (sec)	36	55	17	22
Phase Time (sec)	41	60	22	27
Phase Split	27 %	40 %	15 %	18 %

Figure 24: phase timing intersection 3 Pm after solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Şehit Mustafa Ahmet Ruso Caddes													
Lane 1	308	0.0	1744	0.177	100	6.2	LOS A	0.0	0.0	Short	90	0.0	NA
Lane 2	358	0.0	380	0.941	100	78.9	LOS E	25.5	178.2	Full	500	0.0	0.0
Lane 3	358	0.0	380	0.941	100	78.9	LOS E	25.5	178.2	Full	500	0.0	0.0
Approach	1024	0.0		0.941		57.0	LOS E	25.5	178.2				
East: Dr. fazıl küçük bulvar													
Lane 1	484	0.0	1744	0.278	100	5.6	LOS A	0.0	0.0	Short (P)	170	0.0	NA
Lane 2	598	0.0	732	0.817	100	35.1	LOS D	30.4	213.0	Full	500	0.0	0.0
Lane 3	598	0.0	732	0.817	100	35.1	LOS D	30.4	213.0	Full	500	0.0	0.0
Approach	1680	0.0		0.817		26.6	LOS C	30.4	213.0				
West: Dr. fazıl küçük bulvarı													
Lane 1	663	0.0	1232	0.538	100	9.8	LOS A	17.9	125.6	Full	500	0.0	0.0
Lane 2	621	0.0	1156	0.538	100	9.4	LOS A	16.2	113.7	Full	500	0.0	100.0 [8]
Lane 3	544	0.0	331 [1]	1.643	100	1211.2	LOS F	207.6	1452.9	Short	60	0.0	NA
Approach	1828	0.0		1.643		367.2	LOS F	207.6	1452.9				
Intersection	4532	0.0		1.643		170.9	LOS F	207.6	1452.9				

Figure 25: Detail Delay for each line and the total at intersection 4 Am after solution

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Şehit Mustafa Ahmet Ruso Caddes													
Lane 1	308	0.0	1826	0.169	100	6.2	LOS A	0.0	0.0	Short	90	0.0	NA
Lane 2	358	0.0	415	0.863	100	59.6	LOS E	21.2	148.2	Full	500	0.0	0.0
Lane 3	358	0.0	415	0.863	100	59.6	LOS E	21.2	148.2	Full	500	0.0	0.0
Approach	1024	0.0		0.863		43.5	LOS D	21.2	148.2				
East: Dr. fazıl küçük bulvar													
Lane 1	772	0.0	1826	0.423	100	5.7	LOS A	0.0	0.0	Short (P)	170	0.0	NA
Lane 2	598	0.0	784	0.762	100	30.2	LOS C	27.6	193.3	Full	500	0.0	0.0
Lane 3	598	0.0	784	0.762	100	30.2	LOS C	27.6	193.3	Full	500	0.0	0.0
Approach	1968	0.0		0.762		20.6	LOS C	27.6	193.3				
West: Dr. fazıl küçük bulvarı													
Lane 1	883	0.0	1307	0.676	100	10.9	LOS B	27.5	192.6	Full	500	0.0	0.0
Lane 2	689	0.0	1019 [1]	0.676	100	9.2	LOS A	18.0	126.2	Full	500	0.0	0.0
Lane 3	256	0.0	415	0.617	100	47.3	LOS D	12.5	87.7	Short	60	0.0	NA
Approach	1828	0.0		0.676		15.4	LOS B	27.5	192.6				
Intersection	4820	0.0		0.863		23.5	LOS C	27.6	193.3				

Figure 26: Detail Delay for each line and the total at intersection 4 Am after solution

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Şehit Mustafa Ahmet Ruso Caddesi.													
Lane 1	372	0.0	1744	0.213	100	6.2	LOS A	0.0	0.0	Short	90	0.0	NA
Lane 2	330	0.0	380	0.867	100	61.3	LOS E	19.8	138.6	Full	500	0.0	0.0
Lane 3	330	0.0	380	0.867	100	61.3	LOS E	19.8	138.6	Full	500	0.0	0.0
Approach	1032	0.0		0.867		41.4	LOS D	19.8	138.6				
East: Dr. fazıl küçük bulvarı													
Lane 1	244	0.0	1744	0.140	100	5.6	LOS A	0.0	0.0	Short (P)	170	0.0	NA
Lane 2	394	0.0	732	0.538	100	27.1	LOS C	16.1	112.8	Full	500	0.0	0.0
Lane 3	394	0.0	732	0.538	100	27.1	LOS C	16.1	112.8	Full	500	0.0	0.0
Approach	1032	0.0		0.538		22.0	LOS C	16.1	112.8				
West: Dr. fazıl küçük bulvarı													
Lane 1	432	0.0	1232	0.351	100	8.1	LOS A	9.7	68.2	Full	500	0.0	0.0
Lane 2	432	0.0	1232	0.351	100	8.1	LOS A	9.7	68.2	Full	500	0.0	59.9 [6]
Lane 3	456	0.0	333 [1]	1.369	100	724.2	LOS F	129.5	906.2	Short	60	0.0	NA
Approach	1320	0.0		1.369		255.5	LOS F	129.5	906.2				
Intersection	3384	0.0		1.369		119.0	LOS F	129.5	906.2				

Figure 27: Detail Delay for each line and the total at intersection 4 Pm before solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Şehit Mustafa Ahmet Ruso Caddesi.													
Lane 1	372	0.0	1826	0.204	100	6.2	LOS A	0.0	0.0	Short	90	0.0	NA
Lane 2	330	0.0	362	0.911	100	78.9	LOS E	24.8	173.8	Full	500	0.0	0.0
Lane 3	330	0.0	362	0.911	100	78.9	LOS E	24.8	173.8	Full	500	0.0	0.0
Approach	1032	0.0		0.911		52.7	LOS D	24.8	173.8				
East: Dr. fazıl küçük bulvarı													
Lane 1	244	0.0	1826	0.134	100	5.6	LOS A	0.0	0.0	Short (P)	170	0.0	NA
Lane 2	394	0.0	571	0.690	100	43.7	LOS D	22.2	155.6	Full	500	0.0	0.0
Lane 3	394	0.0	571	0.690	100	43.7	LOS D	22.2	155.6	Full	500	0.0	0.0
Approach	1032	0.0		0.690		34.7	LOS C	22.2	155.6				
West: Dr. fazıl küçük bulvarı													
Lane 1	432	0.0	1390	0.311	100	6.7	LOS A	9.5	66.8	Full	500	0.0	0.0
Lane 2	432	0.0	1390	0.311	100	6.7	LOS A	9.5	66.8	Full	500	0.0	0.0
Lane 3	456	0.0	485[1]	0.939	100	76.8	LOS E	34.8	243.3	Short	60	0.0	NA
Approach	1320	0.0		0.939		30.9	LOS C	34.8	243.3				
Intersection	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]				

Figure 28: Detail Delay for each line and the total at intersection 4 Pm after solution

PHASE TIMING SUMMARY

Phase	A	B	C
Phase Change Time (sec)	0	50	80
Green Time (sec)	44	24	24
Phase Time (sec)	50	30	30
Phase Split	45 %	27 %	27 %

Figure 29: phase timing intersection 4 Am before solution

PHASE TIMING SUMMARY

Phase	A	B	C
Phase Change Time (sec)	0	50	80
Green Time (sec)	44	24	24
Phase Time (sec)	50	30	30
Phase Split	45 %	27 %	27 %

Figure 30: phase timing intersection 4 Am after solution

PHASE TIMING SUMMARY

Phase	A	B	C
Phase Change Time (sec)	0	50	80
Green Time (sec)	44	24	24
Phase Time (sec)	50	30	30
Phase Split	45 %	27 %	27 %

Figure 31: phase timing intersection 4 Pm before solution

PHASE TIMING SUMMARY

Phase	A	B	C
Phase Change Time (sec)	0	44	100
Green Time (sec)	39	51	26
Phase Time (sec)	44	56	31
Phase Split	34 %	43 %	24 %

Figure 32: phase timing intersection 4 Pm after solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Mimar Mehmet Vahip Caddesi													
Lane 1	168	0.0	222	0.757	100	60.1	LOS E	9.4	65.9	Short	75	0.0	NA
Lane 2	164	0.0	233	0.704	100	52.7	LOS D	8.9	62.6	Short	150	0.0	NA
Lane 3	224	0.0	222	1.009	100	128.7	LOS F	20.5	143.5	Full	500	0.0	0.0
Approach	556	0.0		1.009		85.5	LOS F	20.5	143.5				
East: Dr. fazıl küçük bulvarı													
Lane 1	232	0.0	1744	0.133	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	549	0.0	536[1]	1.025	100	142.4	LOS F	59.5	416.2	Full	500	0.0	0.0
Lane 3	659	0.0	643	1.025	100	138.7	LOS F	70.1	490.4	Full	500	0.0	3.2
Approach	1440	0.0		1.025		118.7	LOS F	70.1	490.4				
North: Ataturk Caddesi													
Lane 1	116	0.0	1744	0.067	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	288	0.0	150	1.923	100	1700.6	LOS F	130.1	910.4	Short	60	0.0	NA
Lane 3	386	0.0	143	2.706	100	3109.2	LOS F	221.6	1551.4	Full	500	0.0	100.0
Approach	790	0.0		2.706		2140.0	LOS F	221.6	1551.4				
West: Dr. fazıl küçük bulvarı													
Lane 1	104	0.0	1744	0.060	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	533	0.0	379[1]	1.405	100	780.4	LOS F	158.9	1112.1	Full	500	0.0	79.6
Lane 3	539	0.0	384	1.405	100	784.8	LOS F	160.9	1126.3	Full	500	0.0	80.9
Approach	1176	0.0		1.405		713.9	LOS F	160.9	1126.3				
Intersection	3962	0.0		2.706		693.7	LOS F	221.6	1551.4				

Figure 33: Detail Delay for each line and the total at intersection 5 Am before solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Mimar Mehmet Vahip Caddesi													
Lane 1	168	0.0	243	0.690	100	74.5	LOS E	12.1	84.7	Short	75	0.0	NA
Lane 2	164	0.0	256	0.642	100	67.5	LOS E	11.6	81.1	Short	150	0.0	NA
Lane 3	224	0.0	243	0.920	100	94.3	LOS F	19.3	134.9	Full	500	0.0	0.0
Approach	556	0.0		0.920		80.4	LOS F	19.3	134.9				
East: Dr. fazıl küçük bulvarı													
Lane 1	232	0.0	1826	0.127	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	535	0.0	504[1]	1.062	100	212.3	LOS F	80.4	562.9	Full	500	0.0	15.7
Lane 3	673	0.0	633	1.062	100	207.3	LOS F	99.4	695.7	Full	500	0.0	35.1
Approach	1440	0.0		1.062		176.7	LOS F	99.4	695.7				
North: Ataturk Caddesi													
Lane 1	116	0.0	1826	0.064	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	288	0.0	211[1]	1.368	100	731.0	LOS F	86.8	607.8	Short	60	0.0	NA
Lane 3	386	0.0	206[1]	1.870	100	1625.3	LOS F	177.5	1242.6	Full	500	0.0	90.6
Approach	790	0.0		1.870		1061.5	LOS F	177.5	1242.6				
West: Dr. fazıl küçük bulvarı													
Lane 1	104	0.0	1826	0.057	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	515	0.0	489[1]	1.053	100	196.9	LOS F	73.3	513.1	Full	500	0.0	7.3
Lane 3	557	0.0	529	1.053	100	199.4	LOS F	78.8	551.6	Full	500	0.0	13.9
Approach	1176	0.0		1.053		181.2	LOS F	78.8	551.6				
Intersection	3962	0.0		1.870		340.9	LOS F	177.5	1242.6				

Figure 34: Detail Delay for each line and the total at intersection 5 Am after solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Mimar Mehmet Vahip Caddesi													
Lane 1	216	0.0	222	0.973	100	97.1	LOS F	16.7	116.8	Short	75	0.0	NA
Lane 2	252	0.0	233	1.082	100	222.5	LOS F	33.1	231.9	Short	150	0.0	NA
Lane 3	376	0.0	222	1.694	100	1300.1	LOS F	148.5	1039.7	Full	500	0.0	73.1
Approach	844	0.0		1.694		670.5	LOS F	148.5	1039.7				
East: Dr. fazıl küçük bulvarı													
Lane 1	436	0.0	1744	0.250	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	522	0.0	477[1]	1.094	100	246.5	LOS F	77.3	541.1	Full	500	0.0	12.1
Lane 3	698	0.0	638	1.094	100	242.7	LOS F	101.8	712.9	Full	500	0.0	37.4
Approach	1656	0.0		1.094		181.5	LOS F	101.8	712.9				
North: Ataturk Caddesi													
Lane 1	300	0.0	1744	0.172	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	188	0.0	150	1.255	100	516.8	LOS F	42.9	300.3	Short	60	0.0	NA
Lane 3	284	0.0	143	1.991	100	1828.1	LOS F	132.4	926.9	Full	500	0.0	62.1
Approach	772	0.0		1.991		800.6	LOS F	132.4	926.9				
West: Dr. fazıl küçük bulvarı													
Lane 1	108	0.0	1744	0.062	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	725	0.0	383[1]	1.892	100	1649.8	LOS F	323.5	2264.6	Full	500	0.0	100.0
Lane 3	731	0.0	386	1.892	100	1653.7	LOS F	325.8	2280.8	Full	500	0.0	100.0
Approach	1564	0.0		1.892		1538.1	LOS F	325.8	2280.8				
Intersection	4836	0.0		1.991		804.4	LOS F	325.8	2280.8				

Figure 35: Detail Delay for each line and the total at intersection 5 Pm beforer solution

Lane Use and Performance

	Demand Flows Total veh/h	Demand Flows HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	95% Back of Queue Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: Mimar Mehmet Vahip Caddesi													
Lane 1	216	0.0	256	0.845	100	81.6	LOS F	16.9	118.1	Short	75	0.0	NA
Lane 2	252	0.0	268	0.939	100	93.3	LOS F	22.5	157.2	Short	150	0.0	NA
Lane 3	376	0.0	256	1.471	100	917.5	LOS F	129.0	903.1	Full	500	0.0	59.6
Approach	844	0.0		1.471		457.5	LOS F	129.0	903.1				
East: Dr. fazıl küçük bulvarı													
Lane 1	436	0.0	1826	0.239	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	509	0.0	387[1]	1.316	100	640.6	LOS F	144.2	1009.5	Full	500	0.0	70.2
Lane 3	711	0.0	541	1.316	100	638.4	LOS F	200.6	1404.2	Full	500	0.0	100.0
Approach	1656	0.0		1.316		472.5	LOS F	200.6	1404.2				
North: Ataturk Caddesi													
Lane 1	300	0.0	1826	0.164	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	188	0.0	205	0.919	100	89.7	LOS F	16.0	112.2	Short	60	0.0	NA
Lane 3	284	0.0	195	1.458	100	895.1	LOS F	96.0	671.7	Full	500	0.0	31.9
Approach	772	0.0		1.458		353.3	LOS F	96.0	671.7				
West: Dr. fazıl küçük bulvarı													
Lane 1	108	0.0	1826	0.059	100	5.6	LOS A	0.0	0.0	Short	60	0.0	NA
Lane 2	704	0.0	579[1]	1.216	100	462.8	LOS F	165.4	1158.1	Full	500	0.0	83.6
Lane 3	752	0.0	618	1.216	100	465.6	LOS F	176.4	1234.9	Full	500	0.0	90.0
Approach	1564	0.0		1.216		432.6	LOS F	176.4	1234.9				
Intersection	4836	0.0		1.471		438.0	LOS F	200.6	1404.2				

Figure 36: Detail Delay for each line and the total at intersection 5 Pm after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	30	75	90
Green Time (sec)	24	39	9	14
Phase Time (sec)	30	45	15	20
Phase Split	27 %	41 %	14 %	18 %

Figure 37: phase timing intersection 5 Am before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	48	103	125
Green Time (sec)	43	50	17	20
Phase Time (sec)	48	55	22	25
Phase Split	32 %	37 %	15 %	17 %

Figure 38: phase timing intersection 5 Am after solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	30	75	90
Green Time (sec)	24	39	9	14
Phase Time (sec)	30	45	15	20
Phase Split	27 %	41 %	14 %	18 %

Figure 39: phase timing intersection 5 Pm before solution

PHASE TIMING SUMMARY

Phase	A	B	C	D
Phase Change Time (sec)	0	55	103	124
Green Time (sec)	50	43	16	21
Phase Time (sec)	55	48	21	26
Phase Split	37 %	32 %	14 %	17 %

Figure 40: phase timing intersection 5 Pm

after solution