CHARACTERISTICS OF CLOVERLEAF INTERCHANGE IN TURKEY

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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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ABSTRACT

CHARACTERISTICS OF CLOVERLEAF INTERCHANGE IN TURKEY

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Level of Service (LOS) is a qualitative key attribute for monitoring traffic performance of road infrastructure. As interchanges are major but rather limited designs in road networks, providing uninterrupted flow with high capacities, there is a no LOS concept developed for them. However, data collection capability via Bluetooth (BT) readers located at interchange approaches make it possible to collect continuous speed and travel time data for all possible movements, which can lead to a measure for LOS for interchanges, which is the main focus of this thesis. As a trial case BT readers were located to monitor traffic flows through a cloverleaf interchange in urban road network in Ankara during peak hours. Another cloverleaf interchange in Konya was accessorized with BT readers for a full-day observation. The results showed that while it was possible to monitor LOS for some of the movements in the interchange via BT reader data, some movements did not have enough readings in all time interval. Average speed reduction during peak periods was detected in the BT matching data, providing a promising outcome for future LOS development for cloverleaf interchanges

Keywords: Cloverleaf Interchange in Turkey, Interchange Characterization.

ÖZ

TÜRKİYE'DE YONCA KAVŞAK KARAKTERIZASYONU

Yalçın, Esra Gözde
Yüksek Lisans, İnşaat Mühendisliği
Tez Danışmanı: Doç. Dr. Hediye Tüydeş Yaman

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Hizmet Seviyesi, karayolu altyapısının trafik performansını izlemek için niteliksel bir anahtardır. Kavşaklar yüksek kapasitelerde kesintisiz akış sağlayan büyük fakat oldukça sınırlı tasarımlar olduğundan onlar için geliştirilmiş bir hizmet seviyesi konsepti yoktur. Bununla birlikte, kavşak alanlarına yerleştirilmiş Bluetooth (BT) okuyucularla veri toplama kapasitesi sürekli hız ve seyahat zamanı verisisi bu tezin ana odağı olan kavşaklarda hizmet seviyesi tespitinde ölçümlendirmede tüm olası hareketler için sürekli hız ve seyahat süresi verilerinin toplanmasını mümkün kılmaktadır. Bir deneme olarak, BT okuyucuları yoğun saatlerde Ankara'da şehir içi karayolu ağındaki bir yonca kavşaktan geçen trafik akışını izlemek için yerleştirilmiştir. Daha sonra, Konya'da bir başka yonca kavşak, tam gün gözlem için BT okuyucularıyla donatılmıştır. Sonuçlar, BT okuyucusu verileriyle kavşaktaki hareketlerin bazıları için hizmet seviyesinin izlenmesinin mümkün olmasına rağmen, bazı hareketlerin her zaman aralığında yeterli okumaya sahip olmadığını göstermiştir. BT eşleştirme verilerinde pik dönemlerde ortalama hızda azalma tespit edilmiş, bu da yonca kavşaklar için gelecekteki hizmet seviyesi gelişimi için umut verici bir sonuç sağlamıştır.

Anahtar Kelimeler: Türkiye'de Yonca Kavşak, Kavşak Karakterizasyonu

To my family…

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CHAPTER 1

INTRODUCTION

In this Chapter a brief introduction given about interchanges in Highway Capacity Manual, percentage of distribution of interchanges in the world and level of service definitions.

1.1. Types of Interchanges

Level of service (LOS) in interchanges is detailed in Highway Capacity Manual (HCM) according to types of interchanges and also some formula and coefficients are given for specific interchange types. Level of Service in cloverleaf interchanges is the main investigation field in the thesis.

Interchange Ramp Terminals are detailed in Chapter 22 in HCM. Interchange analysis on freeways and surface streets is presented. According to the methodology used in this chapter interchanges are addressed. Since the chapter is focused on service interchanges; full cloverleaf interchanges (freeway to freeway / system interchanges) are excluded. And also because of limitations of HCM procedure below topics are excluded also:

- Oversaturated conditions
- The impact of spillback on freeway operations
- Ramp metering and its resulting spillback of vehicles into the interchange
- Lane utilizations for interchanges with additional approaches that are not part of the prescribed interchange configuration (HCM, 2010).

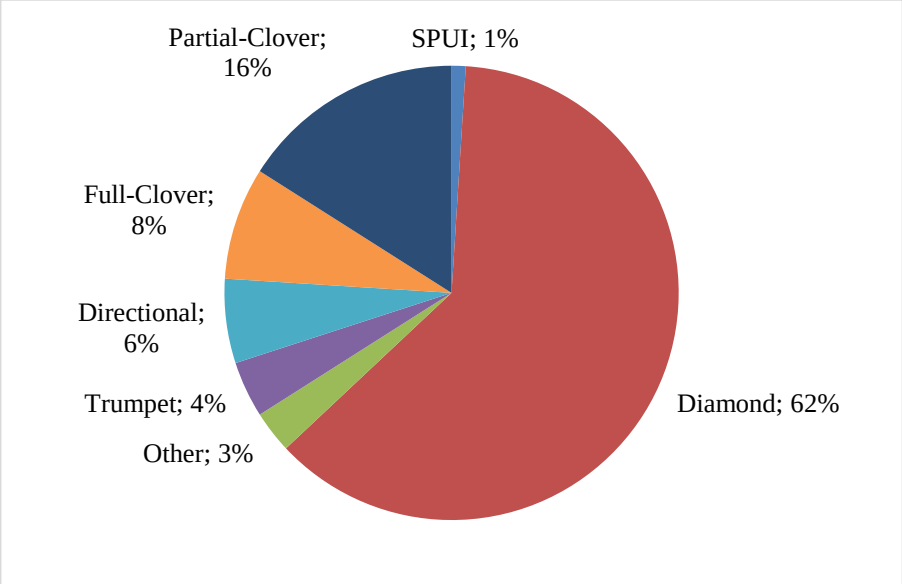

Figure 1.1. *Nationwide Interchange Type Percentages from Survey (Garber, 1999)*

And also; according to the Figure 1.1 the ratio of full cloverleaf type interchange is less than other types of interchanges and in HCM common types are detailed. According to the Figure 1.1 the percentages of interchanges in USA are as follows:

- Diamond in center of intersection (62%)
- SPUI (Single Point Urban Interchange) in cross road (1%)
- Partial cloverleaf in crossroad (16 %)
- Full cloverleaf in weaving area (8 %)
- Directional (6%)
- Trumpet (4%)

The aim of the thesis is to designate the level of service in the full cloverleaf in the intersection of Konya and Eskisehir Road. Level of Service is defined as "a performance indicator of a traveler's satisfaction with the trip (HCM, 2010)". Level of service is also based on speed, travel time, delay probability, comfort and safety and also transportation system capacity is defined as the maximum number of vehicles per unit time (Banks, 2017). Also in some sources it is defined as a parameter defining

the quality of the road which has values with labels from A to F in which A defines the best servicing and F denoted the worst servicing levels with some parameters as traffic flows density, speed and travel time, maneuverability, traffic volume and stop time of vehicles and comfort of the road (Ozbay, 2017).

CHAPTER 2

LITERATURE REVIEW

In this Chapter the type of the interchanges and level of service concept in the literature will be detailed. It will gain importance on next chapters of the thesis for understanding the usage of cloverleaf interchanges.

2.1. Types of Interchanges

To have knowledge in cloverleaf interchanges first of all; we should understand the types of interchanges.

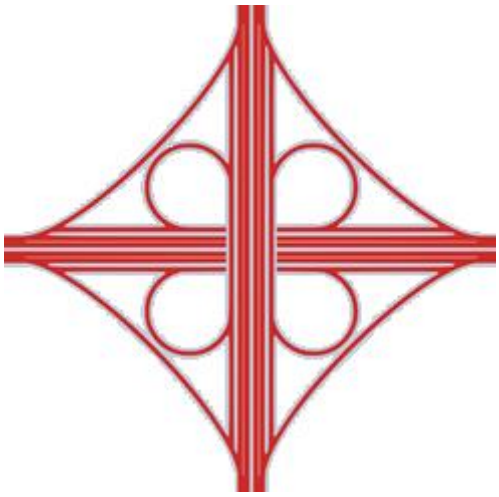

Figure 2.1. *Cloverleaf Interchange (Wikipedia, 2018)*

Cloverleaf interchange: Cloverleaf interchanges remind of the leaves of a four leaf clover from overhead. The design of cloverleaf interchange is made for denser interchanges which diamond interchanges remain incapable. The main advantage of cloverleaf interchange is they were free flowing so traffic signals are not a required. So when the traffic signals are insufficient with solving congestion problems

cloverleaf interchanges are viable options not only for interchange between freeways but also for busy arterials (Wikiwand, 2017).

The full cloverleaf useful in where both highways had equal traffic flow and turning traffic was slightly low (Robinson, 2017). In full cloverleaf interchange if a driver can make a left turn by driving a block beyond where the wanted turn, and continue with driving three right turns (Marshall, 2017).

The predominant collision locations according to types of interchanges are shown differences as in diamond interchange it is 54.8%, in partial cloverleaf 57.1% and it is really minimized in full cloverleaf: weaving area as 38.9% (Virginia Department of Transportation Report, 2017).

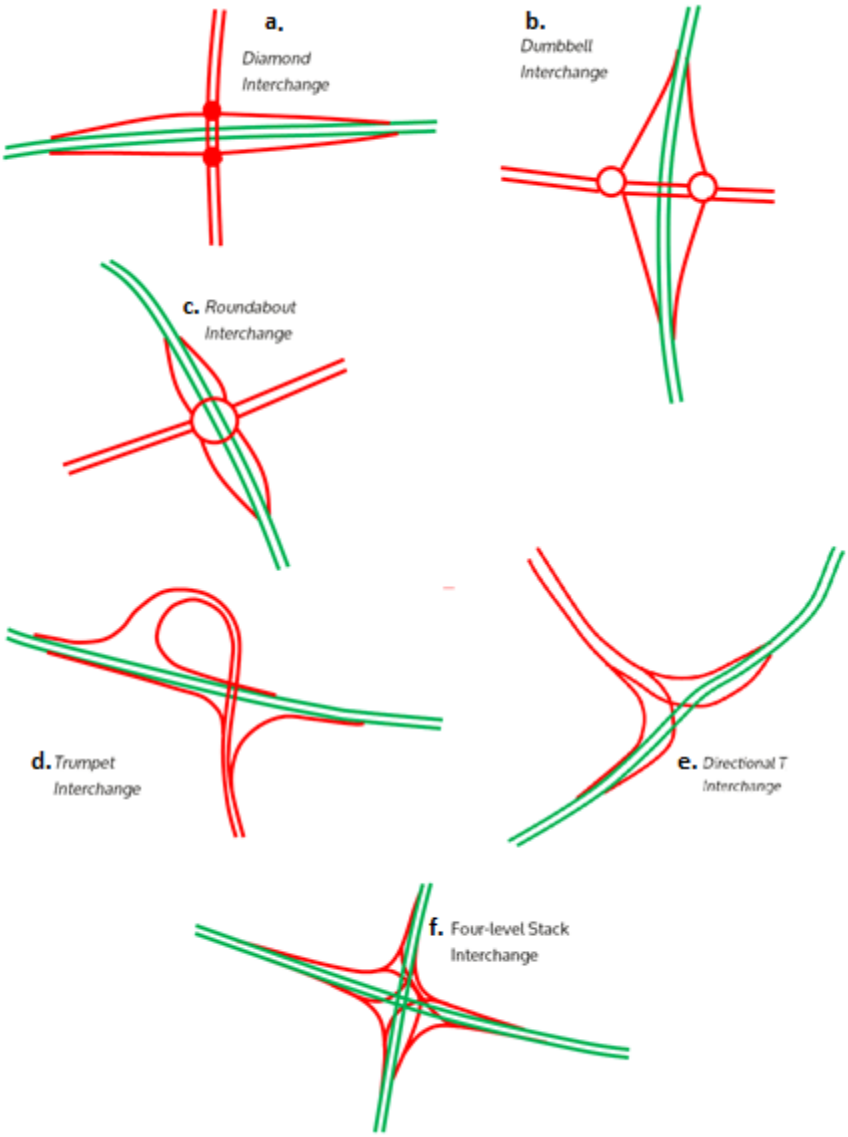

Figure 2.2. *Interchange Types (Roads Australia, 2017)*

Complete Interchange: A complete interchange has ramps for increasing accessibility in the junction from roads and directions to other roads and directions. Because of a freeway and another type of road needs minimum four ramps in a complete interchange so if it is in between two ways of interchanges needs at least eight ramps. As the ramp number decreases capacity could reduce and also it can cause an increasing in weaving. With using U Turns the ramps number could be

decrease to six at least. So, number of ramps depends on the type of interchange and requested accessibility and connectivity.

Incomplete Interchange: Difference between complete interchange of an incomplete interchange is it has at least one missing ramps. With this design avoided the accessibility to at least one direction of another road in the junction from any other road (Wikiwand, 2017).

Pretzel Interchange: The pretzel interchange was developed to decrease the bridge number and based on the traffic circle as it seen in the picture above and also in these interchange one could drive around the interchange without leaving it. This design has left hand ramps (contrary to right hand exists and entrances of new designs), sections of weaving, lack of lane balance and space between ramps similar to the old interchange designs. In that type of interchange; off ramps are very close to the other ramps and left hand ramps also, major flows weaving across which are disadvantages of pretzel interchange (Robinson, 2017).

Diamond Interchange: A diamond interchange which name is come from its shape is a common type of road junction and it is used places that a freeway crosses a minor road (Wikiwand, 2017). Diamond interchange is preferred because of its low cost where traffic is low places. In this type of interchange one way ramp is consisted in each entrance and exit to ramp and crossroad intersections. The capacity of the peer terminals of the ramps at the crossroad is the limitation of the capacity of a diamond interchange (Robinson, 2017).

If signalization is done in interchanges diamond interchange could be used in high traffic volumes (Jalan, 2011). The aim of the diamond interchange is to replace overloaded traffic signal intersections and providing accessibility between minor roads and interstate highways (Robinson, 2017).

In Figure 2.a. left one shows the diamond interchange in United Kingdom in where the traffic is left side and the right one is for right side traffic. Bigger arrows represent the turnings and smaller arrows represent the flow of traffic (Wikiwand, 2017).

Some of variations of Diamond Interchanges are:

Dumbbell: The dumbbell is very similar to the diamond and the roundabout interchanges as seen in Figure 2.b. In dumbbell two roundabouts are linked by a single bridge. The capacity of a roundabout interchange is the advantage of dumbbell because of providing maximum capacity of a roundabout interchange hence; it has disadvantages as; the smaller footprint and the single bridge of a diamond junction (Marshall, 2017).

Dogbone: Dogbone interchange is similar to the dumbbell interchange. And sometimes it is named as double roundabout interchange if roundabouts do not form a circle and have a shape of "raindrop" or "teardrop". And also if two raindrop roundabout coherent then it reduced the conflicts of vehicles entering from the ramps, delays and queuing reduces either. The disadvantage of dogbone interchange is that the Direct U-turns are not possible.

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Tight diamond: A tight diamond interchange (TDI) designed for inadequate right of way for a diamond interchange. It is called as compressed diamond interchange or a tight urban diamond interchange (TUDI). In TDI intersection pairs are spaced closely where the ramps meet the minor road. But because of spacing minor roads are wider than diamond interchange because of closely spacing.

Roundabout Interchange: A roundabout interchange (Figure 2.c) is settled between a controlled access highway (motorway, freeway e.g.) and a minor road and known as the simplest way of grade-separating a junction. It is grade-separated from the motorway lanes with bridges (Wikiwand, 2017).

Trumpet Interchange: Trumpet interchanges used in one highway ended at another one and include minimum one loop ramp connecting traffic any entering or exit the ended expressway with the away lanes of the continuous highway (Wikiwand, 2017).

At each end; every entrance and exit comprises of acceleration/ deceleration lanes. As seen in the Figure 2.d interchange is connected a road to highway. Trumpet feeds the access road and highway goes for other highway intersection (Robinson, 2017).

Triangle interchange: Triangle interchanges are supplying a free flowing junction to end one motorway on other without putting account any loops. Variations depend on the number of passing slip roads cross over and spacing in the design of junction. With the increasing construction site two-level could be used instead of three level (Marshall, 2017).

Variations of T interchanges are:

Directional T Interchange: Directional T interchange is known as also a full Y-interchange whose illustration is given in Figure 2.e. They used in semi parallel or perpendicular directions of two/three highways if a three way interchange is necessary. They also used in right angle cases either. Travel direction and angle effects the left or right side of the highway spurring with connecting ramps.

Semi-directional T Interchange: Semi directional T interchange is similar to directional T interchange but it uses flyover or underpass ramps in all directions at a three-way interchange and it safe and efficient however, it needs more terrain and more expensive than trumpet interchange. Also with splits and merges which are switching to avoiding ramps to eliminate the disadvantage of Directional T interchange.

It could have two or three level stacks. In two level stacks it could has one longer bridge or two shorter bridges on the same roadway. In three level stack overpass and underpass is used in a single point (Wikiwand, 2017).

Stack interchange: Stack interchanges known as butterfly junction also. It is a grade separated and free flowing junction. It has two pairs of right turning ramps in driver on the left countries (identical but reversed in driver on right countries) which can cause stacked situations in some arrangements as above or below two interchanging highways. In countries drivers on the left like Turkey, right turns are conducted with under ramps or semi directional over bridges. Firstly vehicles exits the carriageway to the left afterwards complete the turn through a ramp which passes highways, actually combining with the left turning traffic from opposite side of the stack interchange. In countries drivers on the right is the same but traffic flows are reversed.

Four-level stack: If semi directional left turn and a directional right turn are both could be applicable then four level stack interchange is useful in that manners which exemplified in Figure 2.f. Four level stacks are useful in motorway to motorway junctions with eliminating problems of other junctions with four levels of roads crossing each other. It is really unusual type of interchange and İn England the number of four level stack is only three and in Dallas there are seven but in wider urban areas number is increasing (Marshall, 2017).

Three-Level Stacked Roundabout Interchange: Three level stacked roundabout interchanges are suitable for motorway crossings over a road but generally they connect two motorways together and they have not enough capacity for that kind of usage. So, this type of interchange unremarkably causing congestion and it is expensive to upgrade the existing state of the interchange. Actually it is very similar to standard roundabout interchange hence it has a flyover for avoiding roundabout in two directions. So we can say it only managing traffic turning from one route to other route.

2.2. General Properties of Research Area's Cloverleaf Interchange

Researching field cloverleaf radius in Ankara is changing between 31-45 meters which affects the operating speed, super elevation and length of circular arc also according to table below.

Table 2.1. *Level of Service Classification*

Minimum Radii and Super Elevation for Turning Speeds				Minimum Radii and Super Elevation for Turning Speeds			
Operating Speed (km/h)	Radius (m)	Super Elevation (m/m)	Length Of Circular Arc, Desirable (m)	Operating Speed (km/h)	Radius (m)	Super Elevation (m/m)	Length Of Circular Arc, Desirable (m)
15	50	0.00	60	24.14	15.24	0.00	18.29
20	90	0.02	60	32.19	27.43	0.02	18.29
25	150	0.04	70	40.23	45.72	0.04	21.34
30	230	0.06	110	48.28	70.10	0.06	33.53
35	310	0.08	140	56.33	94.49	0.08	42.67
40	430	0.08	190	64.37	131.06	0.08	57.91
45	540	0.08	200	72.42	164.59	0.08	60.96

This radius curve is compounded with a shorter 12ort h curve 12ort he central portion of the loop (Engineering Policy Guide, 2017).

According to the table above our area of investigation's operating speed should be changing between 32 – 40 km/h, super elevation changing between 0.02-0.04 and length of circular arc between 18.29 – 21.34 meters. With the outputs of the study, we could investigate the average speeds of vehicles and compare its compatibility with the table above.

2.3. Concept of Level of Service

In Highway Capacity Manual (HCM, 2010); there is no chapter for full cloverleaf type interchange level of service because of rarely used type of interchange according to statistics of interchange types in USA.

LOS in the HCM is for Urban Streets (Chapter 15) is depend on auto speed, for Transit (Chapter 27) equals to frequency, for bicycles (Chapter 18) equals to bike speed and for pedestrians (Chapter 19) equals to pedestrian speed (HCM, 2010).

Assumptions for urban freeways:

- Total ramp density =3.00 ramps/mi (i.e.,Wmi average spacing between ramps);
- 5% trucks, no recreational vehicles (RVs), and no buses;
- PHF (peak hour factor) = 0.95; and fp = 1.00

There is no limit to the number of time periods that can be analyzed. The length of the freeway should be less than the distance a vehicle traveling at the average speed can achieve in15 min. This specification generally results in a maximum facility length between 9 and 12 min.

The methodology analyzes a set of connected segments over a set of sequential 15-minutal periods. In deciding which segments and time periods to analyze, two principles should be observed:

1. The first and last segments of the defined facility should not operate at LOS F.

2. The first and last time periods of the analysis should not include any segments that operate at LOS F.

The methodology does not account 13ort he delays caused by vehicles using alternative routes or vehicles leaving before or after the analysis period (HCM, 2010).

The analysis time interval, typically 15 minutes, is subdivided into time steps of 15 seconds to 60 seconds, depending on the length of the shortest segment.

Level of service on arterials depends on the average travel speed. And it is listed as below as:

Table 2.2. Level of Service Classification

Level of Service Classification	**Interpretation**	**V/C Ratio**	**Average Travel Speed (mph)**
A: free flow	Uncongested operations; all queues clear in a single signal cycle.	<0.60	>30
B: Stable Flow	Very light congestion, an occasional approach phase is fully utilized.	0.6 to 0.69	30>…>25
C: Stable Flow	Light congestion, occasional backups on critical approaches	0.70 to 0.79	25>…>20
D: Approaching Unstable Flow	Significant congestion on critical approaches, functional intersection	0.80 to 0.89	20>…>15
E: Unstable Flow (congestion)	Severe congestion with long queues on critical approaches	0.90 to 0.99	≈15
F: Forced Flow (jammed)	Total breakdown, stop-go	1.00 and greater	<15

Source: (Congestion Management Program for 2005, 2017) (Environmental Impact Statement, 1979).

According to Table 2.2 speed limit in research area is providing LOS A category. LOS E travel speed as 15 mile/h (24.14 km/h) could be taken as congestion travel time and free flow travel time is calculated.

2.4. Use of Bluetooth Data in Transportation Studies

In Bluetooth media access control (MAC) identification detection (ID) method; Bluetooth device is placed in four observation point for monitoring the real time traffic. The most important information provided by Bluetooth detection devices are; time of detection and detected Bluetooth sensor number (unique). Bluetooth data lack spatial location information.

2.5. Normal and log-normal distributions

Range definition is important for understanding the distribution concept. The distance between the smallest and largest score defines the range (Wallnau, 2008).

So formula below used as:

Range= UL-LL

In which UL defines the upper real limit for largest score and LL used as lower real limit for smallest score. So range does not include all values in the distribution.

The normal distribution, also known as the Gaussian or standard normal distribution, is the probability distribution that plots all of its values in a symmetrical fashion, and most of the results are situated around the probability's mean. Values are equally likely to plot either above or below the mean. Grouping takes place at values close to the mean and then tails off symmetrically away from the mean (Investopedia, 2017).

This has got several applications in Civil engineering. One of the illustrative applications in traffic engineering is with the distribution of the speed data. This distribution and its properties are very useful in dealing with the samples. It can also be used for approximating the other types of the probability distributions. Normal distribution is defined as;

$$f = (x; \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

where, μ = mean deviation, σ=standard deviation

Lognormal distribution is a type of a continuous distribution. It is a probability distribution in which logarithm of the random variable is distributed normally.

We may define a random variable x to be lognormally distributed where;

y=logx

or if above equation satisfies, then random variable x will be lognormally distributed. Also, if variable y is normally distributed, then $x = e^y$ will follow lognormal distribution.

Lognormal function defined as (Jiang, 2005);

$$f(x) = \frac{1}{x\sigma'\sqrt{2\pi}} e^{((lnx-\mu')^2/2\sigma'^2}$$

where;

$$\mu' = \ln(\frac{\mu^2}{\sqrt{\sigma^2+\mu^2}}) \text{ and } \sigma' = \sqrt{\ln(1+(\frac{\sigma}{\mu})^2)}$$

So with that formula mean and standard deviation formula given for lognormal function to find the lognormal function.

2.6. Extreme Value Detection

Extreme value theory is a branch of statistics dealing with the extreme deviations from the median of probability distributions. It seeks to assess, from a given ordered sample of a given random variable, the probability of events that are more extreme than any previously observed. Extreme value analysis is widely used in many disciplines, such as structural engineering, finance, earth sciences, traffic prediction, and geological engineering (Gravetter, Wallnau, 2008).

Interquartile range (IQR) is one of the method to eliminate excessive scores. IQR first took the lowest 25% of the distribution. Which is named as first quartile and shown with Q1 and it is also median of the lower half of data. After that highest 25% of the distribution taken as the third quartile (Q3) which is the top 25% of the data median. And finally IQR found with:

IQR= Q3-Q1

After that we could determine the outliers of data set. Lower outlier which is known also Lower Limit is denoted by LL and formulated as:

LL= Q1 -1.5(IQR)

Upper limit is denoted by UL and formulated as:

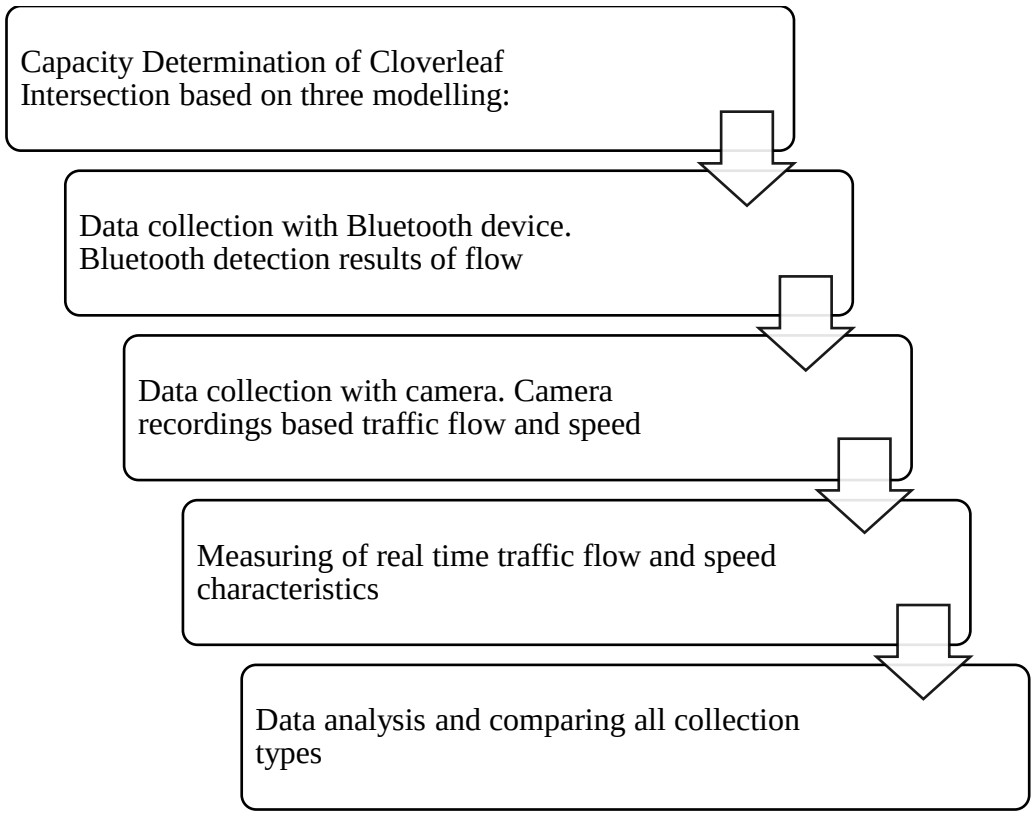
UL= Q3+1.5(IQR)

Three methods explained in that part which used in thesis to eliminate raw Bluetooth reader data information. If the outliers of the data set of travel time come from IQR is smaller than 0 than it is meaningless because of travel time value could not be smaller than 0 and we prefer to eliminate meaningless data with log-normal distribution. After that last elimination method is coming from measured distance of locations and free flow and congestion flows travel time criteria.

CHAPTER 3

METHODOLOGY

In this chapter the methodology of the study will be summarized as a chart below:



On camera based data collection type of measurement the data is collected on lane based and classification is done according to car, minibus, bus and heavy vehicles. Hence according to measurements minibus, bus and heavy vehicles number is ignorable with respect to car number.

3.1. Interchange Movement Travel Time Evaluation from Bluetooth Data

Bluetooth readings are saved and transferred to MATLAB code which consulate 4 readers separate CSV (comma separated values) file documents in one excel file with the information in Table 3.1.

Table 3.1. *MATLAB file statements*

MACID	MAC ID information of intercepted mac identification code of the car.
Date	Date
Hour	MAC ID passing hour in hour, minute and second information
Reader Number	Specified the reader number is according to the location of the reader
Loc Change	If the same mac id is changed in same reader then it is codded as 1, if mac id is same then location change is " " and if mac id is same in tout de suite hours in same reader then location change is 0 entered.
Stay Time	If location change is zero in other words if mac id is same in same readers in consecutive hours that means mac id is waiting in same station and this row calculate the staying time in seconds of same id in same station.
Travel Time	If there is a location change occurs with same MAC ID then travel time is calculated in seconds
Origin	Starting Station (origin) of the Travel
Destination	End Station (destination) of the Travel
Path	Path is designated the origin destination together.

With the origin destination path of the mac ids are consolidated. Code is reuniting the all readers' data according to same MAC ID catching time. With Bluetooth data measurements a MATLAB code is written to find the path of the mac numbers to catch the same mac numbers in different Bluetooth readers. It is done to find the paths of the MAC ID's of the vehicles. Code automatically detects the MAC IDs of the vehicle and readers logging names after evaluation it sort the data as an excel document with path information and also passing time from generated paths. To increase the accuracy of the data we made measurements with real time camera recordings in same hours of the data taken from Bluetooth readers. Camera data is also taken to find the usage of the Bluetooth data estimation accuracy in real time traffic recordings.

And in Konya region we used histogram method to identify speed ranges clearly. It was easy for Konya to use that method because of the number of data was so higher than collected data with BT than Ankara region.

3.2. Verification by Video Camera Data

So with the traffic area of investigation level of service criteria is determined by two methods:

1) Bluetooth Readings from traffic flow in morning and evening peak hours.
2) Traffic flow camera data saved in morning and evening peak hours.

Bluetooth measurements in four legs of interchanges are afterwards; inspection on these legs is done by visual inspection from video camera data in same hours as Bluetooth data.

Speed is the one of the important parameter during the analyzing of the video camera recording data. Time mean speed and space mean speed is used to represent the speed in this part which is important to understand the characteristic of flow. And also maximum and minimum speed for one minute incremental is calculated also to see the distribution clearly (Kadiyali, 1987). Minimum and maximum speed of the flow is calculated in sampling time for every one minute increments. And also space speed calculated for averaging the spot speed.

CHAPTER 4

CASE STUDY

In Chapter 4, study locations defined clearly in Ankara and Konya. Cloverleaf interchange in Ankara studied with two different data collection method which related to camera and Bluetooth recordings taken on the same day. For Konya location Bluetooth data used.

4.1. Study Location Ankara

Specified four study locations are located in the intersection of two urban arterials which are both old divided highways. Locations of investigations are selected due to understanding of the full cloverleaf traffic characteristics. Intersection points of the two urban arterials are eliminated with cloverleaf interchange on this conflict traffic area of the city. Studied road is one of them most populated areas. One route is connected Kızılay which is the center of Ankara and Eskisehir Road which is nowadays consisted major governmental buildings, universities, hospitals and commercial places which are one of the populated places either. So this interchange is connected governmental buildings and commercial locations to the center of the city. And the other route also connected residential areas near to Konya Road to AŞTİ which is the intercity bus terminal of Ankara. This interchange located on the most congested areas of capital city of Turkey to decrease the traffic density and increase the mobility.

Figure 4.1. *Camera and Bluetooth Devices Locations in Ankara*

Location directions are given due to clockwise direction selection. As seen in the picture above Location 1 (Loc 1) is located on the north direction of Ankara and will be shown by PN. Location 2 (Loc 2) will be donated with PE as point east, Location 3 (Loc 3) as PS as point south and finally Location 4 (Loc 4) as PW as point west according to the Figure 4.1.

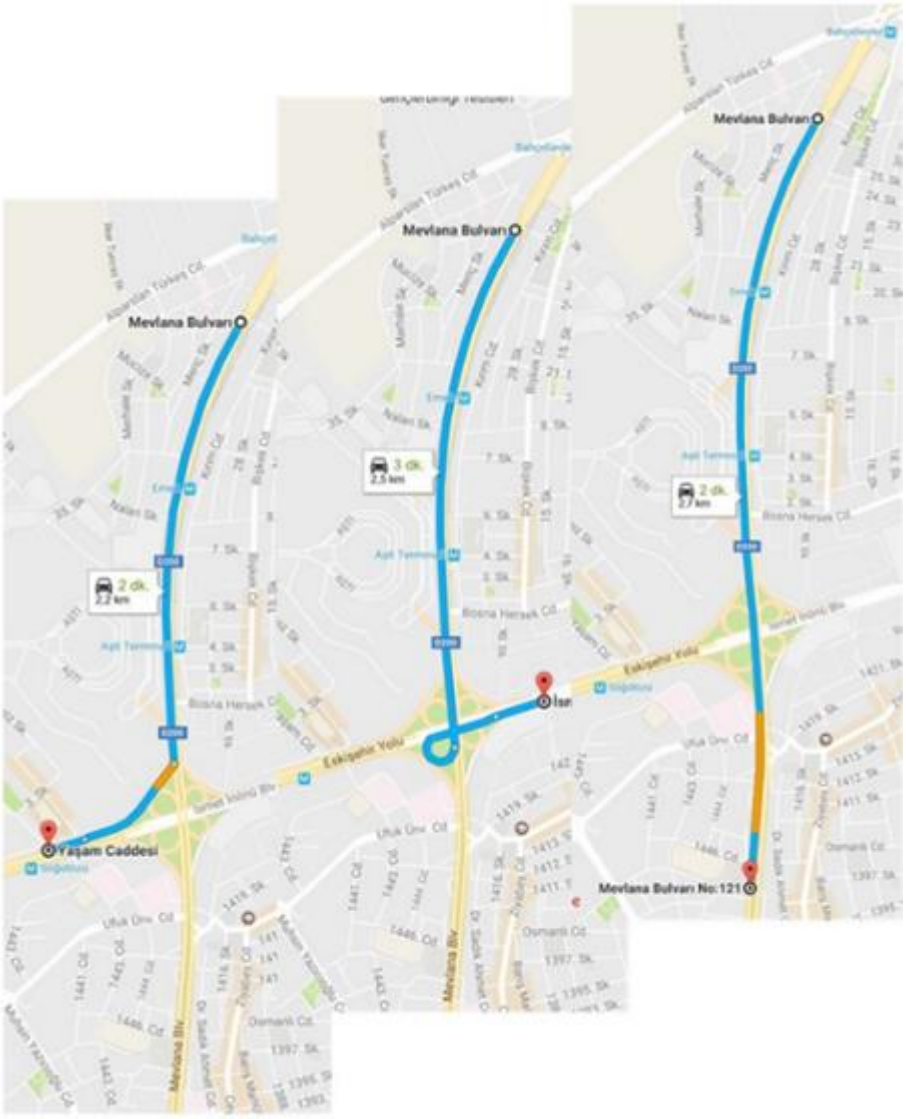


Figure 4.2. *Movements from the point in north (P_N) to direction of a) west (P_{NW}), b) east (P_{NE}), and c) south (P_{NS})*

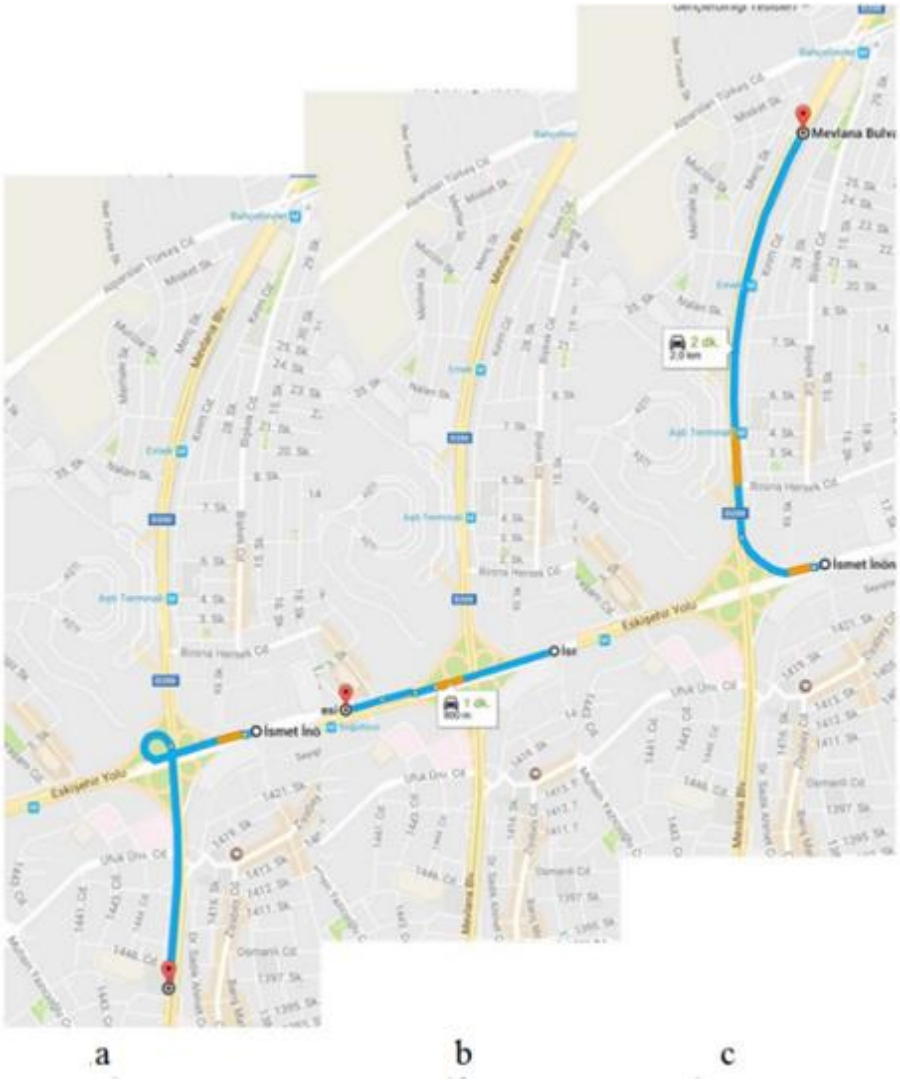


Figure 4.3. *Movements from the point east (P_E) to direction of a) south (P_{ES}), b) west (P_{EW}), c) north (P_{EN})*

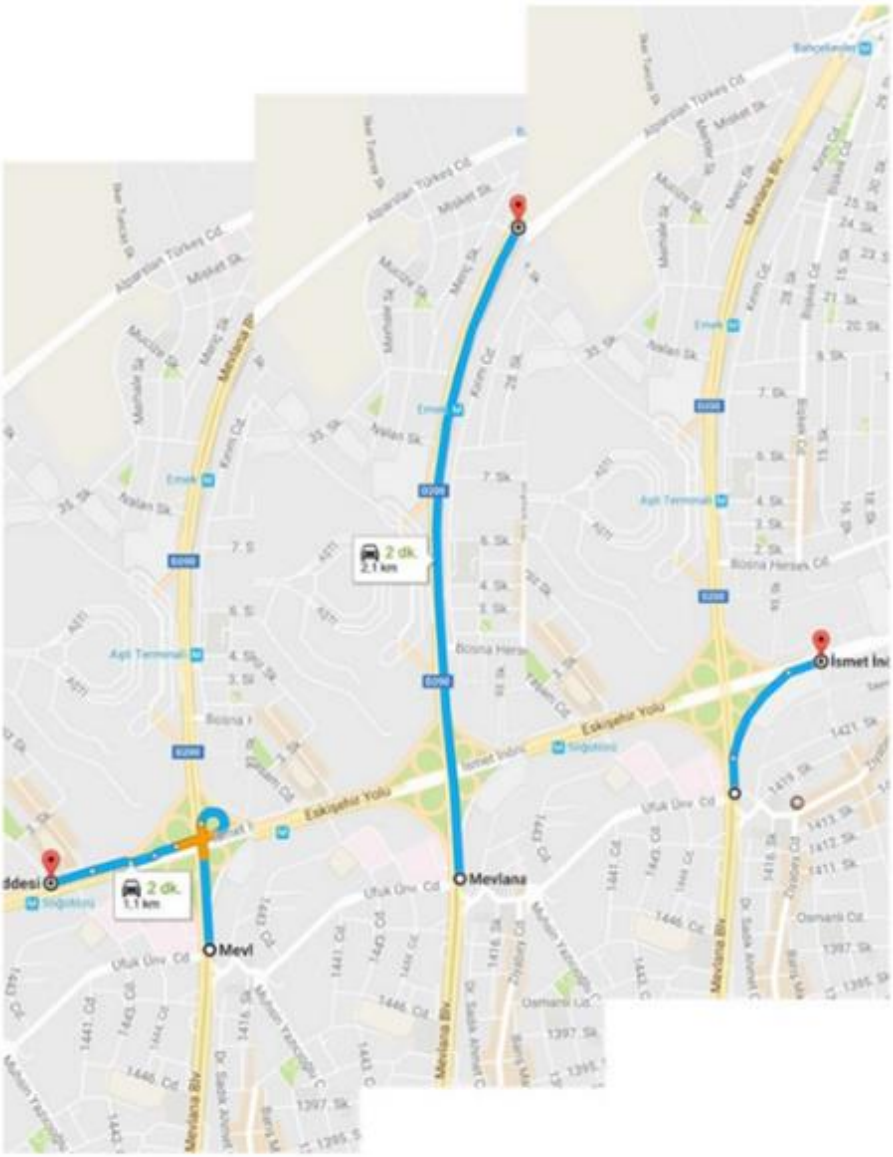


Figure 4.4. *Movement from the point in south (P_S) to direction of a) west (P_{SW}), b) north (P_{SN}), c) east (P_{SE})*

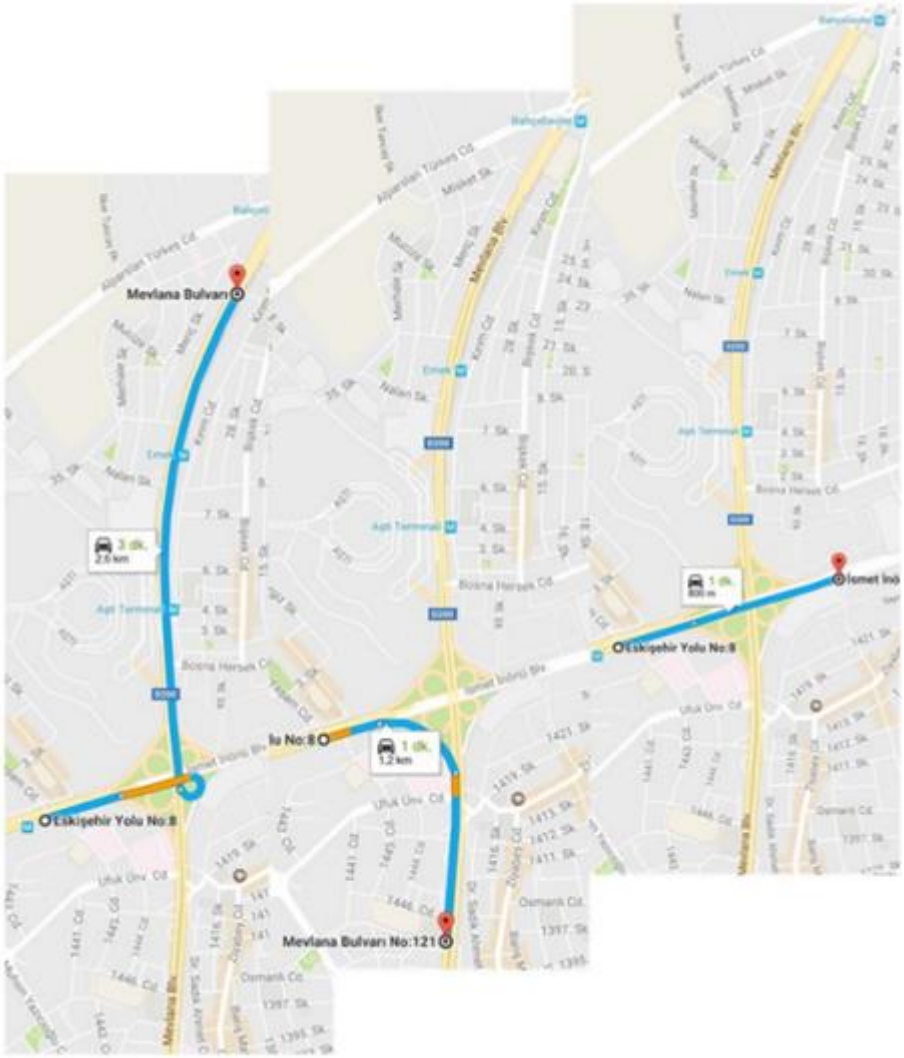


Figure 4.5. *Movements from the point in the west (P_W) to direction of a) north (P_{WN}), b) east (P_{WE}) and c) south (P_{WS})*

In the figures 4.2,4.3,4.4 and 4.5 movements are shown. Travels are separated according to starting locations. Point north is the location near to Bahçelievler Metro Station which located on Konya Road. Point east measurements are taken above an overpass near to Ministry of Foreign Affairs on the Eskişehir Road. Point south is located near to Ufuk University Hospital on the Konya Road. And point west is defined the location Söğütözü Metro Station on the Eskisehir Road.

Other concern in the location is the turning radiuses of arc of the cloverleaf. To make an assumption of the radiuses of leafs we make measurements in the google earth application. In the Figure 4.6 R1 shows the circle between P_S to P_W, R2 shows the circle between P_W to P_N, R3 shows the circle between P_N to P_E and R4 shows the circular arc through P_E to P_S.

Figure 4.6. *Radius curves of cloverleaf in Ankara*

Our researching field cloverleaf radius is changing between 33-46 meters which affects the operating speed, super elevation and length of circular arc also. Actually all leafs shape is not definitely circular but we take the measurements with manually locating a circle in the sharpest place of Google Earth in the inner diameter of leafs nearly as shown in the Figure 4.6.

This radius curve is compounded with a shorter radius curve for the central portion of the loop. (Engineering Policy Guide, 2017)

According to the table above our area of investigation's operating speed should be changing between 32 – 40 km/h, minimum super elevation changing between 0.02-

0.04 and minimum length of circular arc between 18.29 – 21.34 meters. With the study we could investigate the average speeds of vehicles and compare its compatibility with the Table 2.2.

Distance in the table below is taken from Google Maps travel by car mod results to measure the length of roads between locations traveled by vehicles. Speed limit in the area is specified as 82 km/h in the warning signs. And it is taken as 90 km/h with the 10% tolerances. Congestion speed is taken from "Minimum Radii and Super Elevation for Turning Speeds Table". The results are tabulated as shown in Table 4.1 which will be used for simplifying and cleaning raw data taken from Bluetooth readings.

Table 4.1. *Movement- Travel Time (sec) for a.m. and p.m. Table in Ankara*

Movement	**Distance (km)**	**Free Flow Speed limits (km/h)**	**Congestion Speed (km/h)**	**Travel Times (sec)**	
				Free flow	**Congestion**
				(LOS A)	**(LOS E)**
P_{NE}	2.5	90	24.14	100	372.8
P_{NS}	2.7			108	402.6
P_{NW}	2.2			88	328.1
P_{EN}	2.0			80	298.3
P_{ES}	1.5			60	223.7
P_{EW}	0.8			32	119.3
P_{SN}	2.1			84	313.3
P_{SE}	0.6			22	82.0
P_{SW}	1.1			44	164.0
P_{WN}	2.6			104	387.7
P_{WE}	0.8			32	119.3
P_{WS}	1.1			44	164.0

4.2. Raw Bluetooth Data in Ankara

Morning Bluetooth readings are taken from 4 locations hours between 07:27-10:25 on 04.07.2013. 7678 reading is done totally in four locations. 3894 MAC ID is recorded in the location near to P_W, 1752 of them is recorded in P_N, 1207 of them recorded in

P_E and 828 of them recorded near to P_S. 3260 of them has id changes and the others are seen in same stations in long hours. Bluetooth device used in study is Class 1 type Bluetooth reader device with antenna whose range is 300 meters.

Table 4.2 is tabulated from Bluetooth readings. According to location changes data is ranged with IQR method with results. Evening Bluetooth reading is taken from 4 locations between 16:06-18:47. 7684 reading is done totally in four locations. 49 of them are recorded in P_N, 2214 of them recorded in P_E, 1321 of them recorded in P_W and 4103 of them are recorded in P_W. According to path follower ones are sorted out in all clusters. And it's filtered with respect to the quartiles to eliminate possible errors.

Table 4.2. *Descriptive Statistics of Travel Times (seconds) of different movements – Raw Bluetooth Data (a.m.) from Ankara Study*

Movement	**Frequency**	Q0	Q1	Q2	Q3	Q4	IQR
P_{NE}	76	12*	131	153	173	3917*	42
P_{NS}	181	273	3382*	3437*	3744*	9302*	362
P_{NW}	19	153	197	720	1292	3694*	1095
P_{EN}	86	111	134	154	211	3431*	77
P_{ES}	112	117	3516*	3727*	3792*	8105*	277
P_{EW}	28	61	79	96	342	1757	264
P_{SN}	4	79*	140	294	729	1636	590
P_{SE}	2	462	513	563	614	664	101
P_{SW}	8	356	634	1107	1515	1818	881
P_{WN}	19	88	117	128	160	1889	43
P_{WE}	10	135	149	162	170	1739	22
P_{WS}	448	22*	3490*	3543*	3649*	8966*	160
*shows unexpectedly lower/ upper travel times							

Table 4.3. *Descriptive Statistics of Travel Times (seconds) of different movements – Raw Bluetooth Data (p.m.) from Ankara Study*

Movement	**Frequency**	Q0	Q1	Q2	Q3	Q4	IQR
P_{NE}	142	588	3495*	3521*	3788*	6816*	293
P_{NS}	26	20	74	86	134,75	1627*	60

P_{NW}	5	120	129	154	163	800	34
P_{EN}	3	10	82,5	155	1481	2807*	1398*
P_{ES}	1	277	277	277	277	277	0*
P_{SN}	44	122	168	212	239	3081*	70
P_{SE}	541	172	3528*	3647*	3670*	7866*	142
P_{WN}	2	154	419	684	949	1214	530
P_{WE}	5	3338*	3397*	3736*	3831*	4393*	434
*shows unexpectedly lower/ upper travel times							

Data needed to be cleaned up to eliminate raw data as seen with * labeled values are meaningless if we specify according to reading hours and distances between locations of travel. Two step elimination done; first one is according to lower an upper fence values and the second one is made for distance and average velocity criteria.

4.3. Bluetooth Data Clean-up with Normalization Method

To clean the Bluetooth normal distribution method, log normal distribution method and also traffic flow seconds which is calculated from travel distances and minimum and maximum velocity values are used and tabulated as Table 4.4.

Table 4.4. *Travel Times (seconds) according to distributions for a.m. in Ankara*

Movement	**Frequency**	**Normal Distribution**		**Log-normal Distribution**	
		LL	**UP**	**LL**	**UP**
P_{NE}	112	3100*	4207*	3138*	3939*
P_{NS}	28	-316*	737	9*	714
P_{NW}	86	42	286	76	235
P_{EN}	2	361	765	391	671
P_{ES}	8	-687*	2836*	171	2342*
P_{EW}	4	-744*	1613	12*	1666*
P_{SN}	10	116	202	122	182
P_{WN}	76	68	234	87	198
P_{WE}	181	2839*	4287*	2904*	3939*
P_{WS}	19	-1445*	2934*	12*	3309*
P_{SN}	19	53	223	74	186

P_{SE}	448	3250*	3888*	3263*	3731 *
*shows unexpectedly lower/ upper travel times					

After listing all the methods we should select the range from best match. Values with star are higher or lower seconds with respected to traffic flow data. And also values below zero are labeled with * mark. Some stationary Bluetooth devices could be the occasion of the meaningless values.

Cleaned up table is tabulated according to log normal and normal distribution data for a.m and p.m hours. According to the Table 4.5 maximum velocity is measured from P_{NS} which is the longest path in the same time, and minimum one is from P_{SE} which is the smallest path. Meaningful data are taken locations from P_{NS}, P_{NW}, P_{SW} and P_{WN} with frequencies bigger than 10.

Table 4.5. *Travel Times (seconds) according to distributions for a.m. in Ankara*

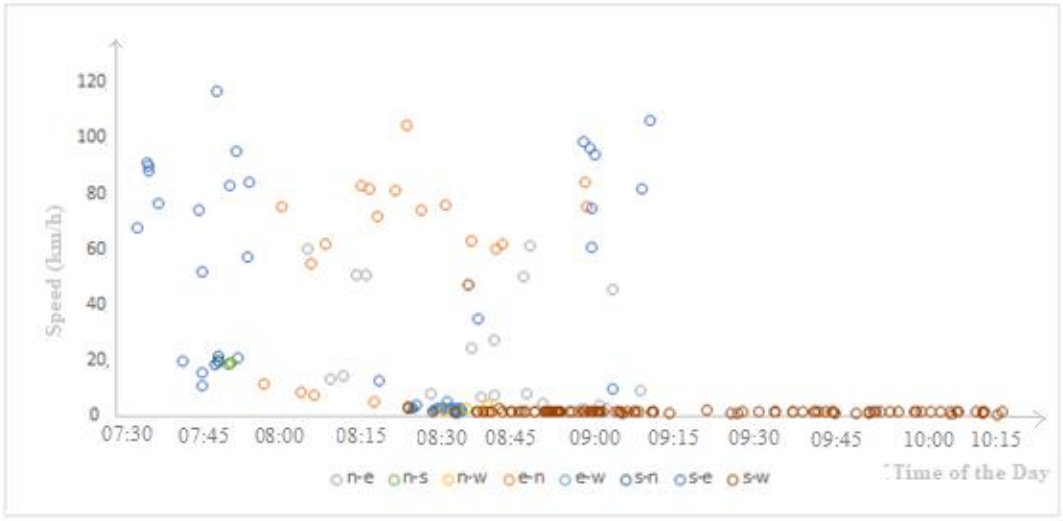
Movement	**Frequency**	**Average Travel Time (seconds)**	**Average Velocity (km/h)**	**Truncated Travel Times (seconds) (a.m.)**	
				LL	**UP**
P_{NE}	1	117.0	76.9	65.85	223.7
P_{NS}	14	104.9	92.7	35.12	119.3
P_{NW}	69	147.2	53.8	76.33	298.3
P_{EW}	2	119.5	24.1	92.20	313.2
P_{SN}	9	160.2	47.2	35.12	182.0
P_{WN}	1	199.0	9.9	48.29	164.0
P_{WE}	15	127.5	31.1	73.50	387.7
P_{WS}	65	160.5	58.3	68.75	372.8
P_{SN}	1	273.0	10.5	118.50	402.6
P_{SE}	6	179.0	22.1	96.60	328.1

Table 4.6. *Travel Times (seconds) according to distributions for p.m. in Ankara*

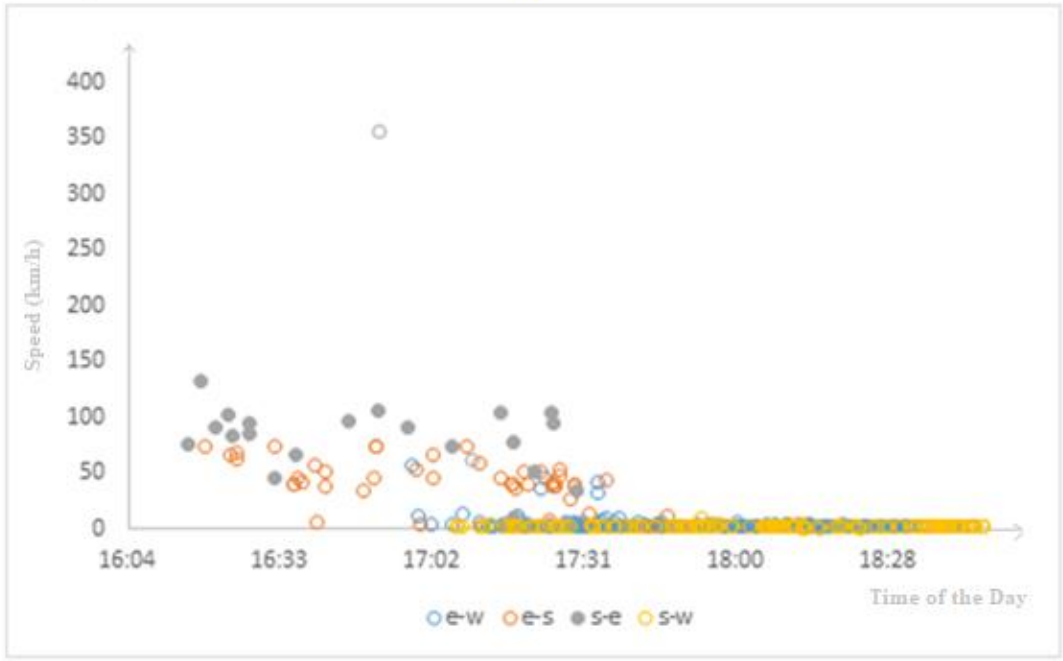
Movement	Frequency	Normal Distribution		Log-normal Distribution	
		LL	UP	LL	UP
P_{NS}	1	277	277	277	277
P_{NW}	3	-2015*	3579*	2*	11945*
P_{EN}	5	2746*	4482*	2930*	4764*
P_{EW}	2	-376*	1744	289	1617
P_{SN}	541	3315*	3883*	1151	11552*
P_{SW}	44	63	345	4*	11745*
P_{WN}	142	3056*	4227*	1307*	9483*
P_{WE}	5	2746*	4482*	2930*	4764*
P_{WS}	26	-16*	225	1*	7077
*shows unexpectedly lower/ upper travel times					

Table 4.6 shows the distributions of p.m hours. Marks with * shows the meaningless values. Which are so high or so lower for given distances (with respect to speed calculations neglectable) and some of them are negative with respect to distributions so we could not use them in tabulations. After distributions carried out cleaned up tables are tabulated in Figure 4.7. , it is seen that the majority of the data is accumulated between 0-5 km/h. This accumulation continued starts at 8:24 and continued up to 10:19. In this case, the speed range will be taken as 2-120 km/h to limit the data.

The evening data distribution that shown in Figure 4.8 that vehicles velocity is higher in P_{EN}. And the lowest value is in P_{EW}. The average passing duration is at 206.77 seconds and 144.46 seconds in P_{ES} direction. Data is a cleaned up data after all normalization part carried out.



(a)



(b)

Figure 4.7. *Travel Time (seconds) of different movements by time-of-the day (a) morning (b) evening (cleaned up data)*

The cleaned data for morning hours in the east-west direction between 8:24-8:35 the speed has fallen to about 2 km/h. Until 07:55 speeds are higher than 10 km/h. The number of data in the north-west direction is very low. However, when the data is

analyzed in detail, it is seen that the speed decreased to 1 km in some time intervals. Therefore, depending on the speed and the direction of the half-hour intervals to determine the average speed will lead to more accurate results. For evening hours the number of data decreases and the data measurement range is reduced in the restriction according to vehicle speed. Measurements are seen between 16:00-18:00 hours. The highest speed values were measured in the south east direction. However, this limitation according to the speed should be made depending on the direction. Therefore, depending on directions, the speeds will be collected again under a table for evening hours. Because trends shows that traffic flow decreases at evening hours and also flow comes to a halt.

The lowest average speed was in the west direction for the vehicles going from the north to the other directions and the most flow was seen in that direction. This shows that the data are meaningful although the average velocity in this direction is very low. The average speed of the traffic flowing in the east and south direction is the same.

Table 4.7. *North to Other Directions Average Speed (km/h) vs Hour a.m. for Ankara*

Daily Time	**P_{NE}**		**P_{NS}**		**P_{NW}**	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
07:30-08:00	-	-	25,6	38	-	-
08:00-08:30	32,9	6	21,6	27	-	-
08:30-09:00	19,7	9	25,3	4	2,1	42
09:00-09:30	19,2	3	-	-	1,3	62
09:30-10:00	-	-	-	-	1,2	67
10:00-10:30	-	-	-	-	0,9	10
Average Speed (km/h)	24,0		24,0		1,4	
Total MAC ID	18		69		181	

Table 4.8. *East to Other Directions Average Speed (km/h) vs Hour a.m. for Ankara*

Daily Time	P_{EN}		P_{EW}	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
07:30-08:00	43,5	2	-	-
08:00-08:30	59,4	12	4,8	13
08:30-09:00	68,9	4	5,4	190
09:00-09:30	-	-	3,8	94
09:30-10:00	-	-	2,8	110
10:00-10:30	-	-	2,6	34
Average Speed (km/h)	20,1		4,1	
Total MAC ID	18		441	

Measurements could not be taken for the south direction in vehicles going from east to other directions. The average speed data in the vehicles going to the west direction is very low, similar to the direction of north-west, and the number of vehicles is still the highest. While the average speed between east and north direction is between 07:30-09:00, it is seen that the number of data is very low.

Table 4.9. *South to Other Directions Average Speed (km/h) vs Hour a.m. for Ankara*

Hour	P_{SN}		P_{SE}		P_{SW}	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
07:30-08:00	20,2	21	65,3	16	-	-
08:00-08:30	22,8	19	53,5	9	2,7	3
08:30-09:00	21,6	29	94,2	2	1,6	55
09:00-09:30	-	-	-	-	1,4	17
09:30-10:00	-	-	-	-	1,4	22
10:00-10:30	-	-	-	-	1,3	15
Average Speed (km/h)	15,2		45,6		1,5	
Total MAC ID	69		27		112	

The speed data from the south to north and east were taken between 7:30 and 9:00 hours in Table 4.9. Similar to other measurements, the maximum number of vehicles going west is maximum, while the speed is minimum.

Table 4.10. *East to Other Directions Average Speed (km/h) vs Hour p.m. for Ankara*

Hour	**P_{EW}**		**P_{ES}**	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
16:00-16:30	-	-	67,7	4
16:30-17:00	-	-	47,7	14
17:00-17:30	3,8	107	40,4	23
17:30-18:00	3,3	178	17,8	4
18:00-18:30	2,7	209	-	-
18:30-19:00	2,4	38	-	-
Average Speed (km/h)	3,1		43,1	
Total MAC ID	532		45	

Although the average speed of the vehicles from the east to the west is low, the 532 measurements taken show that the vehicles here are at a standstill between 16:30-19:00 hours in Table 4.10. On vehicles with a destination point south, after 18.00 no measurement was taken. The average speed values are higher than the vehicles going west.

Table 4.11. *South to Other Directions Average Speed (km/h) vs Hour p.m. for Ankara*

Hour	P_{SE}		P_{SW}	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
16:00-16:30	94,7	7	-	-
16:30-17:00	80,9	5	-	-
17:00-17:30	67,7	9	1,8	26
17:30-18:00	-	-	1,9	42
18:00-18:30	-	-	1,6	40
18:30-19:00	-	-	1,5	29
Average Speed (km/h)	79,8		1,7	
Total MAC ID	21		137	

According to Table 4.11, the number of measurements is high for vehicles driving from south to west. In this direction, the average velocity values are close to each other and very low. The speed of the vehicles going in this direction between 17:00 and 19:00 is considered to be close to the stopping point. In the south-east direction, the speed values are quite high and the traffic is fluid. But in this direction, the measurement was made between 16:00-17:30 hours. For half-hour intervals, the number of measurements was not sufficient to reach a general opinion.

4.4. Video Camera Based Flow Data for Ankara

In those stations video recordings are done for peak hours at 08:00-10:00 and 17:00-18:30 on crowded nodes as specified above.

Recordings are evaluated according to two MATLAB codes which are include calculating data for speed and flow values. In the MATLAB code written for speed calculations; video watching scale, video start time and observation lane is entered by the user. After that the lane number is entered because it is important when we calculate the overall speed which is changing in every lane because of the bus stops and sudden changes in traffic and also useful for increasing number of sampling. Sampling distance is also entered by user. It changes according to the camera view

and sampling area. Minimum, maximum, space and average speeds are calculated in code for one minute intervals. So the outputs of the codes are time data in minute base, and sorts of speeds as mentioned before.

Some misreading's could be done in counting. The reasons are listed below:

- Camera views are blocked by buses or stopped vehicles.
- Camera angles are not directly above the vehicles and some lanes could not be seen clearly.
- Cameras are hanged by hand so some alignment changes occurs during recordings.
- Counting speed depends on the performance of the hand eye coordination.
- Drivers' lane changes and losing the track of lane.

The results are tabulated as:

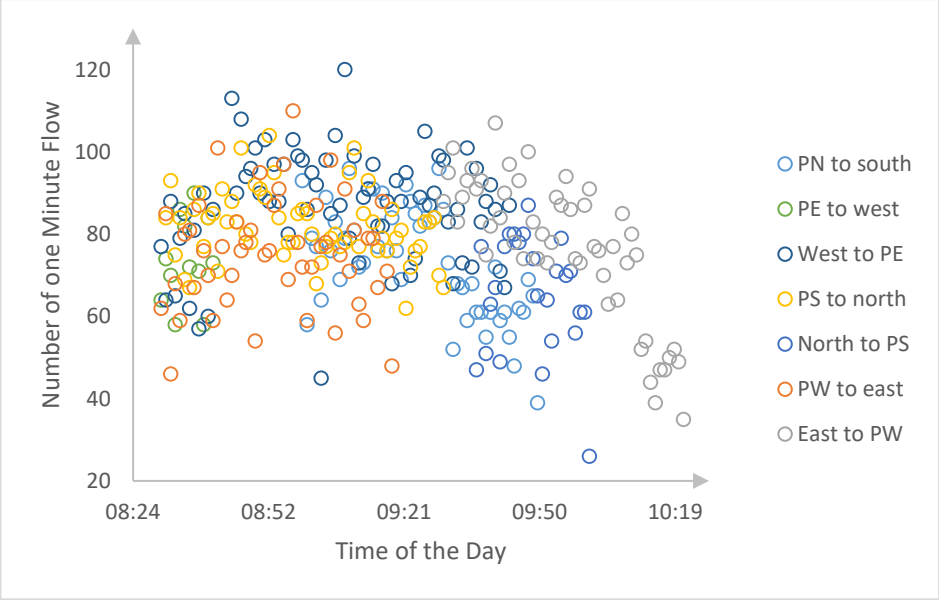


Figure 4.8. *Number of One Minute Flow vs Time of the Day (a.m.)*

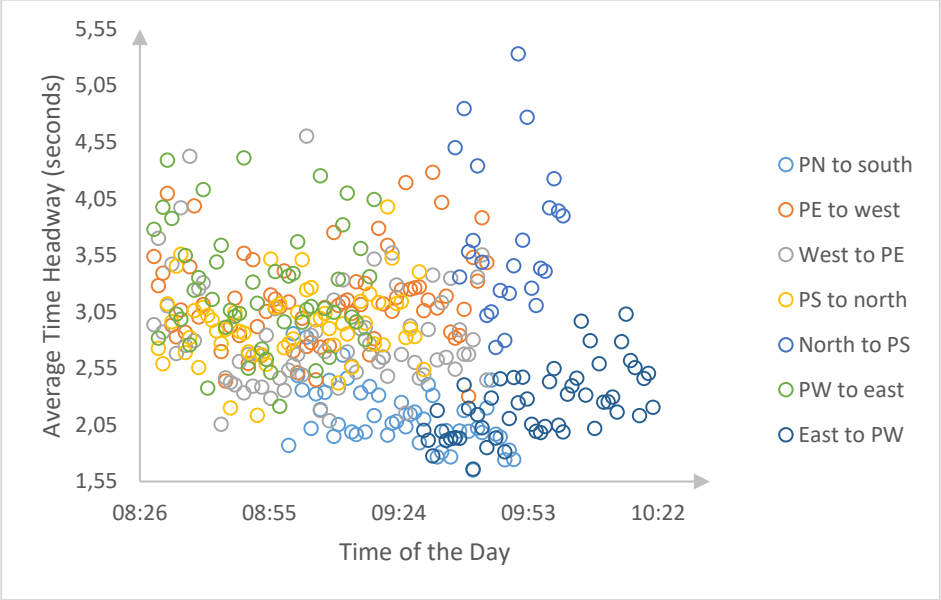


Figure 4.9. *Average Time Headway (seconds) vs Time of the Day (a.m.)*

PN to south is located on the road Overpass near to Bahcelievler Metro Station to Konya Road (there and back). In the first lane camera taking a bus stop and nearly in every 3 minutes a bus slow down the traffic to drop off passengers. And also cars are using that lane for parking in spite of being forbidden parking area. Camera recordings are taken in two separate hours and first one is between 08:30-08:42 and second one is between 08:45-09:47. Average number of vehicles between 08:30-08:42 is 73 and between 08:45-09:47 are 78. Average time headway between 08:30-08:42 is 3.30 seconds and between 08:45-09:47 is 3.12 seconds. Number of vehicles graph in each time section is nearly the same trend and it is generally steady up to the finishing times of data recordings. It could be caused because of data are collected for every minutes and it could be ended before the one minute session is not completed and also the average time headway is effected in the same way too between 08:30 and 08:42.

South to PN is located on the Konya Road to Overpass near to Bahcelievler Metro Station. There is no bus stop seen in that case but some cars are using the first lane as parking area which affect the traffic also. Average number of vehicles between 08:30-08:42 is 69 and between 08:45-09:45 are 89. Average time headway between 08:30-08:42 is 3.27 seconds and between 08:45-09:45 is 2.74 seconds. As seen in the graphs

above average time headway is decreasing but the trends are similar. Number of vehicles graph in each time section is nearly the same trend and it is generally steady up to the finishing times of data recordings. It could be caused because of data are collected for every minutes and it could be ended before the one minute session is not completed and also the average time headway is effected in the same way too between 08:30 and 08:42.

PE to west is located on overpass of Foreign Ministry of Turkey through Söğütözü Metro Station to Kızılay. Recordings are taken near to bus stop and when the busses used this lane other lanes view is blocked for some minutes. And number ıf vehicles are changing in a wide range in that measurement. Average vehicle passed during 08:30 and 09:30 is 82 vehicles and average time headway during these hours is 2.95 seconds. Number of vehicles changed between 62 and 104. If we add a linear trend line to the average time headway in one minute durations we could easily see that the average headways are increasing.

PE to west is located on overpass of Foreign Ministry of Turkey through Söğütözü Metro Station to Kızılay. Average vehicle passed during 09:37 and 10:01 is 65 vehicles and average time headway during these hours is 3.69 seconds. Number of vehicles changed between 26 and 87 and also average time headway is changing between 2.73 and 5.33 seconds. Total number of car is 1474, minibus is 96, bus is 18 and truck is 46. Number of trucks were remarkable.

North to PN is located on Ufuk University and going through Bahcelievler Metro Station to Ufuk University. Number of vehicles passed is decreasing according to the table above between 09:30-10:20. Number of trucks in all lanes are higher than other directions and it could be because of the recordings are done from in front of Ufuk University to Konya Highway. To emphasize more precisely the number of cars are 3536, number of minibuses are 266, number of buses are 28 and number of trucks are 155. Contrary to the vehicle number, average headway has an increasing trend and also average vehicle passed is 77 and average time headway is 2.23 seconds.

Maximum time headway in this time gap is 3.03 seconds between 10:15-10:16 and maximum vehicle number is 107 between 09:41-09:42.

PS is located across Ufuk University. Camera recordings in PS to north directions is from across the Ufuk University to Bahcelievler Metro Station. 3196 cars, 466 minibuses, 94 buses and 116 trucks are passed between 08:30 and 9:20 in all 4 lanes. Maximum time headway between 08:50-08:51 is 4.41 seconds, minimum time headway 2.22 second occurs between 8:58 and 8:59. Between 08:30-09:20; average vehicle passed is 76 and average headway is 3.25 seconds.

PW is located near to Söğütözü Metro Station and record the way Söğütözü Metro Station to Kızılay station recordings are tabulated below. The opposite site Kızılay to Eskisehir road recordings cannot seen clearly because of the camera view so that, one way recordings are take into account and it is not included in the graphs. In table above vehicle number changes according to hourly data are tabulated. Between 09:00-09:50 maximum vehicle is counted at 09:29 as 96. Average vehicle number is 73 and according to table above average time headway is 2.13 seconds. Maximum time headway is detected on 09:01 as 2.86 seconds.

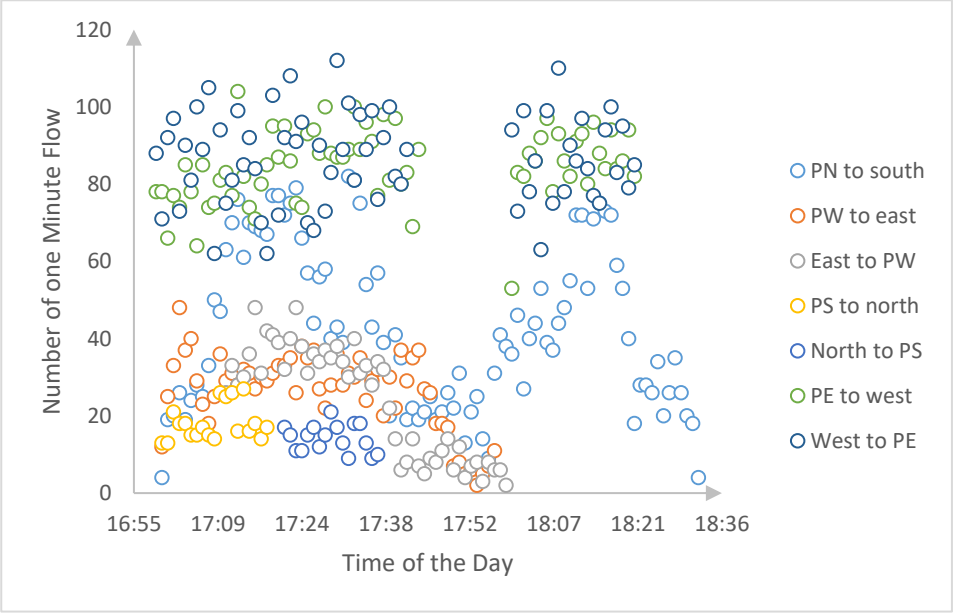


Figure 4.10. *Number of One Minute Flow vs Time of the Day (p.m.)*

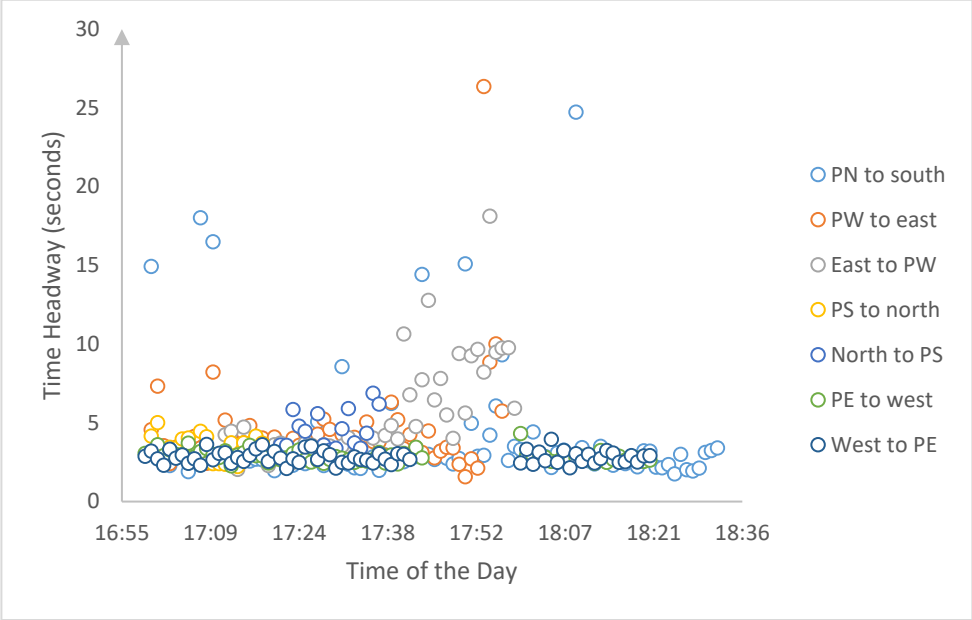


Figure 4.11. *Average Time Headway (seconds) vs Time of the Day (p.m.)*

PN video recordings are done on footbridge so the camera perspective is covering both comings and goings between Overpass near to Bahcelievler Metro Station and Konya Road.

PN to south is measured hours between 17:00 and 17:45. Average vehicle number is 87 and average time headway is 2.81 seconds.

Average flow number is 84 and average time headway is 2.90 seconds for south to PN.

PE to west is located on overpass of Foreign Ministry of Turkey, where vehicle comes from Kızılay. Average vehicle passed during 17:2 21 and 17:38 is average time headway during these hours is 4.49 seconds and average flow is 14. Bus lane is separated from main lane physically so it does not affect the main traffic flow.

West to PE is located on overpass of Foreign Ministry of Turkey through Söğütözü Metro Station to Kızılay. During 17:00 and 17:18, average time headway 3.49 seconds and average flow is 18.

North to PS 3 is located on Ufuk University and going through Bahcelievler Metro Station to Ufuk University. Number of vehicles passed is decreasing according to the table above between 18:00-18:48. Average time headway is 5.44 sec and also average flow is 24.

Camera recordings in PS to north directions is from across the Ufuk University to Bahcelievler Metro Station. Recordings are done between 17:00-17:57 whom average time headway is 4.21 seconds and average flow is 26.

PW to east is measured on 3 lanes for just one direction for pm recordings because of the camera location reading is impossible for the reverse flow direction. Measuring's are done hours between 17:00-18:30. Because of the recording is done near to the bus stop; busses waiting times headways show a wide range in that road. Average time headway is 3.91 seconds and average flow number recorded as 43 on that readings.

4.5. Video Camera Recordings Based on Speed Data

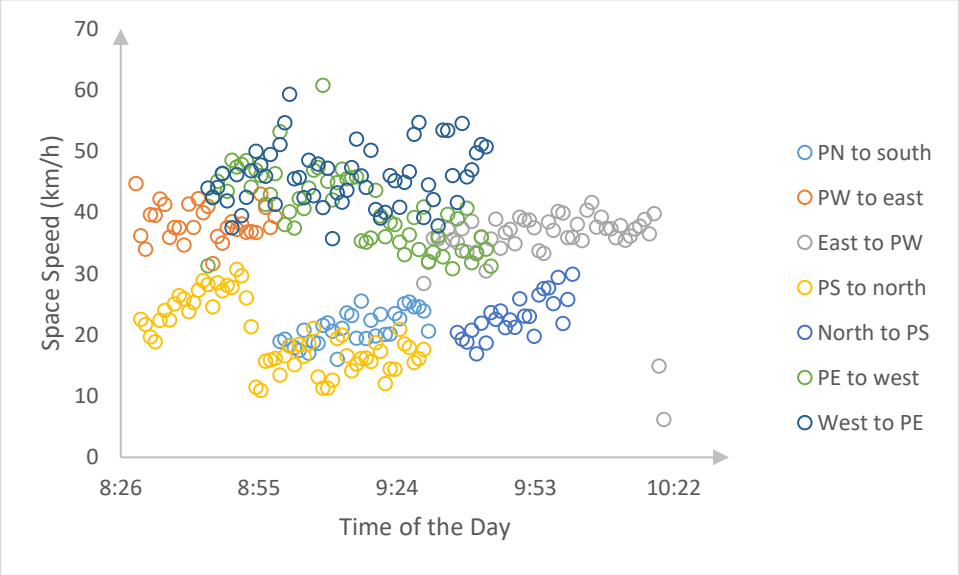


Figure 4.12. *Number of One Minute Space Speed (km/h) vs Time of the Day (a.m.)*

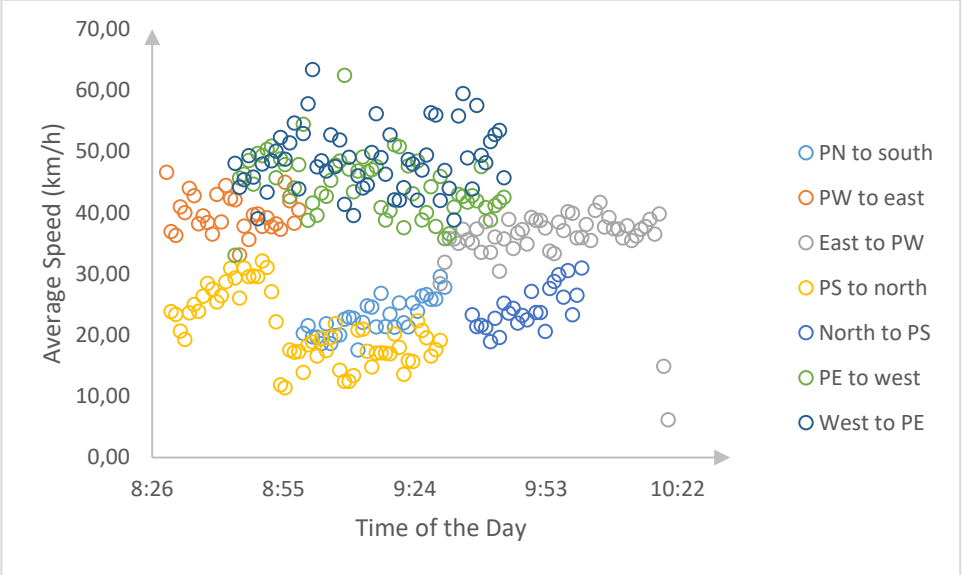


Figure 4.13. *Average Speed (km/h) vs Time of the Day (a.m.)*

Figure 4.14. *PN location and measurement area*

Location PN to south data is recorded between 8:45 and 9:45. The distance between two lighting pole is taken as the reference for speed calculations. Average space speed is 45.77 km/h and average mean speed is 48.58 km/h. As seen in the graph speed values are not changing strictly in that area. This measurement gives the higher speeds than others and because of the camera view counting the cars are easier.

South to PN direction data is recorded between 8:45 and 9:45. Average space speed is 40.68 km/h and average mean speed is 44.52 km/h. Traffic speed characteristics are similar to PN to PS, but number of minibus is higher and traffic is denser.

Figure 4.15. *PE location and measurement area*

PE is located on overpass of Foreign Ministry of Turkey. PE to west measurements are done between 09:37-10:00 average space speeds is 23.10 km/h and average mean speed is 24.35 km/h but flow is not stocked in that hours and it distributed equally.

West to PE is recorded during 08:30 and 09:30. Distance is referenced from measurement taken between 2 trees. In the graph above there is a sudden decrease in all speed sorts after 08:54 when the traffic peaks and until the end of recording there is not so much change in speed type's values. And again after 08:54 as the average speed decreasing number of vehicles are not showing a sudden change. Average space speed is 19.67 km/h and average mean speed is 20.94 km/h.

North to PS data speed calculations are taken from the 3 road lines and 2 spaces between them which is taken as 15 meters. (KGM, 2015) PS direction PN to PS data is recorded between 9:30 and 10:20. Average space speed is 36.25 km/h and average mean speed is 37.22 km/h.

PS to north data speed calculations are taken from the 2 road line and 2 spaces between them which is taken as 12 meters. (KGM, 2015) Between 8:30 and 9:00, data are taken. Average space speed is 38.36 km/h and average mean speed is 39.75 km/h.

Bluetooth located on PW to east speed date is taken for three lanes for one way. Data is taken between 09:00 – 09:30. Flow graph of the same data was taken between 09:00-09:50 hence because of the camera view is changing after 09:30 data is not taken after hour 09:30 for keep the data in safe side. Average space speed is 21.12 km/h and average speed is 22.87 km/h in that range. All the taken speed data is uptrend.

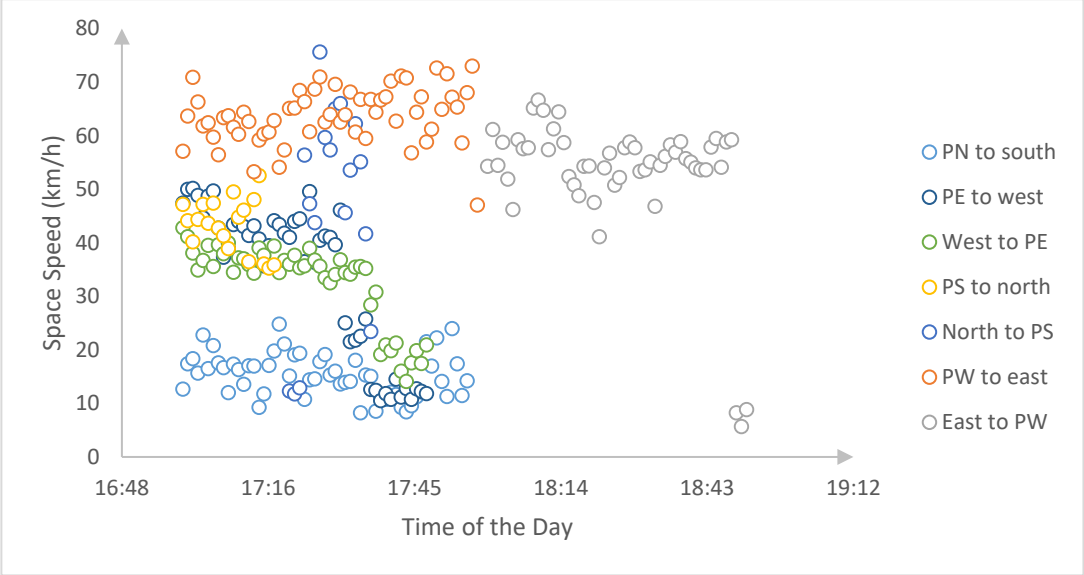


Figure 4.16. *Number of One Minute Space Speed (km/h) vs Time of the Day (p.m.)*

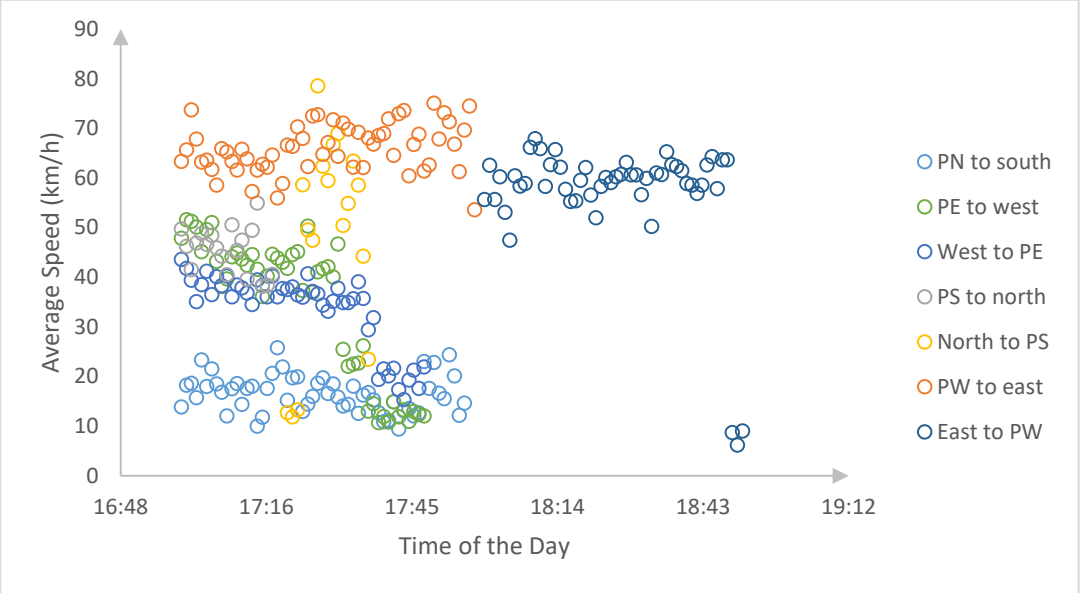


Figure 4.17. *Average Speed (km/h) vs Time of the Day (p.m.)*

Location PN data are taken on overpass which is near Bahçelievler Metro Station. For direction PN to south data is recorded between 17:00 and 17:48. Average space speed is 33.48 km/h and average mean speed is 34.15 km/h.

For south to PN data is recorded between 17:00 and 17:48. Average space speed is 32.71 km/h and average mean speed is 33.61 km/h.

Two camera recording are done from PE to west is taken hours between 17:20-17:37 for PE to PW direction. Average space speed is 46.46 km/h and average speed is 48.51 km/h. There seen an increase in all sort of speeds between 17:14-17:15. There is not a remarkable relation between the average speed and flow rate.

West to PE direction and taken between 17:00-17:18. Average space speed is 43.26 km/h and average speed is 45.46 km/h. According to graph there is not seen a clear relation between flow rate and average speeds. So the third graph shows these data according to the time of the day.

Location PS data are taken on overpass which is near Ufuk University. For north to PS data is recorded between 17:00 and 17:58. Average space speed is 63.94 km/h and average mean speed is 66.22 km/h.

For direction PS to north data is recorded between 18:00 and 18:50. Average space speed is 55.76 km/h and average mean speed is 59.70 km/h.

Bluetooth located on PW speed date is taken for one way. Data is taken between 17:00-17:56. Flow graph of the same data was taken between 17:00-18:30 but the camera view is always changing so after 17:56 it is not included speed graphs. Average Space speed in the range is 16.28 km/h and average speed is 17.31 km/h. Area of measuring is taken as the interval between two lighting poles. Two graphs are taken for average speed and flow rate as vehicle per minute. In the average speed versus flow rate graph we can easily see that there is not a steady distribution between average speed and vehicle. Afterwards when we check the data according to the time of the day; when the vehicle number in one minute increases generally the average speed is increasing either. But after 17:45; average speed increasing on the contrary vehicle number per minute is decreasing.

With the data taken from Bluetooth reader we made a comparison between real values of traffic flows from camera recordings:

Table 4.12. *Without MACID Changes BT readings to camera recordings*

BT Readers	Reader Locations	BT MAC ID		Camera Recordings		MAC to Volume Ratio	
		AM	PM	AM	PM	AM	PM
P_N	Overpass near to Bahçelievler Metro Station	1752	49	11785	11475	14,87%	0,43%
P_S	Ufuk University	828	1321	7710	10153	10,74%	13,01%
P_W	Söğütözü Metro Station	3894	4103	4090	3957	95,21%	103,69%
P_E	Overpass of Foreign Ministry	1207	2214	6561	1427	18,40%	155,15%

In the Overpass of Foreign Ministry locations there seen a strict difference between mac id number and readings from camera because of camera readings are done just

for one lane because of the camera location and also Bluetooth Readings MAC ID numbers are repeated in some cases because of stopped vehicles and device faults. In the Söğütözü Metro Station results are really near to the MAC ID results.

With the id changes counted the table is changed as Table 4.13.

Table 4.13. *BT readings to camera recordings with MAC ID changes*

BT Readers	Reader Locations	BT MAC ID with ID Changes		Camera Recordings		MAC to Volume Ratio	
		AM	PM	AM	PM	AM	PM
P_N	Overpass near to Bahçelievler Metro Station	795	23	11785	11475	6,75%	0,20%
P_S	Ufuk University	560	888	7710	10153	7,26%	8,75%
P_W	Söğütözü Metro Station	1046	1047	4090	3957	25,57%	26,46%
P_E	Overpass of Foreign Ministry	859	1210	6561	1427	13,09%	84,79%

4.6. Study Location in Konya

Other study is held on in Konya with BT measurements hours between 06:30-23:30. Cloverleaf intersection is located in industrial area and also Konya airport is settled on the north of the intersection. And also intersection is connecting Adana Belt Highway and Ankara high street.

Figure 4.18. *Bluetooth Devices Locations*

Location directions are given due to clockwise direction selection. As seen in the Figure 4.23, Location 1 (Loc 1) is located on the north direction of Konya and will be shown by P_N. Location 2 (Loc 2) will be donated with P_E as point east, Location 3 (Loc 3) as P_S as point south and finally Location 4 (Loc 4) as P_W as point west according to the map.

Other concern in the location is the turning radiuses of arc of the cloverleaf. To make an assumption of the radiuses of leafs we make measurements in the google earth application. In the picture R1 shows the circular arc through P_S to P_W, R2 shows the circular arc through P_W to P_N, R3 shows the circular arc through P_N to P_E and R4 shows the circular arc through P_E to P_S.

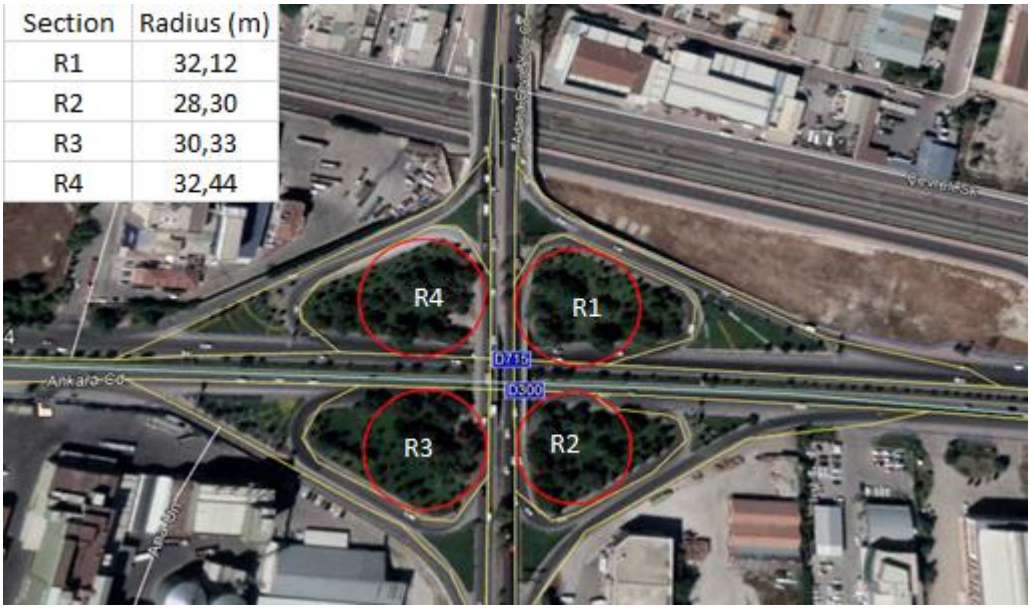


Figure 4.19. *Radius curves of cloverleaf in Konya*

Our researching field cloverleaf radius is changing between 28-33 meters which affects the operating speed, super elevation and length of circular arc also.

Speed limit in the area is specified as 82 km/h in the warning signs. And it is taken as 90 km/h with the 10% tolerances. The results are tabulated in Table 4.14.

Table 4.14. *Movement- Travel Time (sec) for a.m. and p.m. Table for Konya*

Movement	Distance (km)	Free Flow Speed limits (km/h)	Congestion Speed (km/h)	Travel Times (seconds)	
				Free flow	Congestion
				(LOS A)	(LOS E)
P_{NE}	1,01	90	24,14	40	151
P_{NS}	0,79			32	118
P_{NW}	0,73			29	109
P_{EN}	0,63			25	94
P_{ES}	1,18			47	175
P_{EW}	0,92			37	137
P_{SN}	0,79			32	118
P_{SE}	0,79			32	118
P_{SW}	1,27			51	189
P_{WN}	1,09			43	162
P_{WE}	0,93			37	138
P_{WS}	0,90			36	134

Free flow time is changing between 29-43 seconds and congestion flow time changes between 94-189 seconds which shows more variety than free flow times. In the analysis part we should look at the results with respect to free flow and congestion flow properties.

4.7. Raw Bluetooth Data for Konya

31740 BT data is read hours between 06:30-23:30. They are raw data without any restriction from displacement and direction. After that we applied a filter to just see with respect to direction change in same MAC identities. 4809 BT reading is

simplified after all. So the numbers became with respect to movements summarized in Table 4.15.

Table 4.15. *Movement vs Frequency Table for Konya*

Movement	P_{NE}	P_{NS}	P_{NW}	P_{EN}	P_{ES}	P_{EW}	P_{SN}	P_{SE}	P_{SW}	P_{WN}	P_{WE}	P_{WS}
Frequency	231	855	410	261	127	592	642	101	251	465	609	265

In that study again Class 1 type Bluetooth reader device is used with antenna whose range is 300 meters. Python is used as the software for classifying data.

We used 2 different approaches for extracting raw data. Methods are histogram plot with frequency with respect to time and scatter plot of speed with respect to time.

Let's start with first one which is frequency verses time (hour) histograms. In that method with respect to directions frequencies of MAC identities extracted related to time values. It could give us the peak hours of traffic flow. According to time data peak hours could be detected on 15:00 on north to other directions in Figure 4.25. Maximum frequency is seen in direction north to south and also from north to west direction after 16:00 we could not see any MAC identity.

From east to other directions again hours between 15:00-16:00 seen the denser hour range. East to west direction has the maximum number of mac identities for Figure 4.26. And east to west direction data could not be counted after 16:00 similar to north to west direction.

According to Figure 4.27, denser Mac identities are seen on south to north direction. Peak hour is not have a normal distribution in directions. Direction south to west data could not be counted after 16:00 similarly. Peak hours for directions are for south to west hours between 13:00-15:00, south to east hours between 11:00-12:00 and 16:00-17:00, south to north is hours between 15:00-16:00.

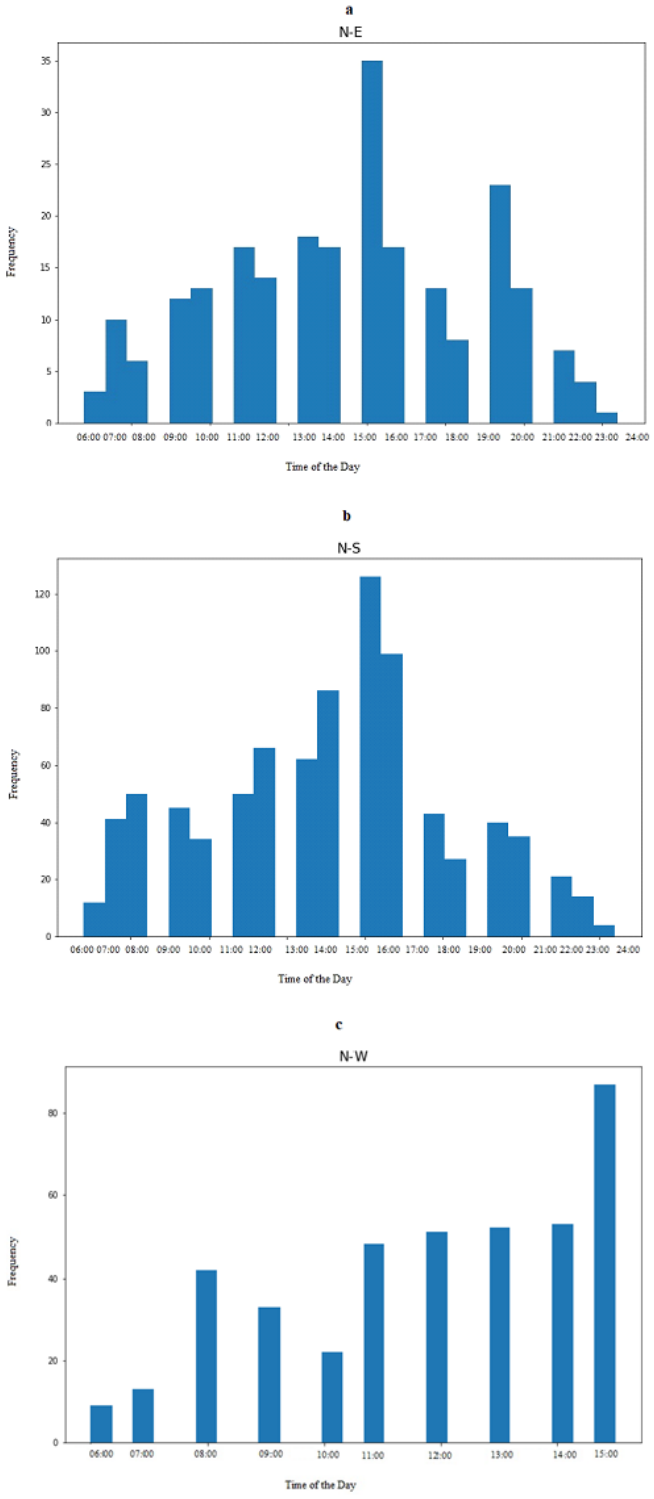


Figure 4.20. *Movements from the point in north (P_N) to direction of a) west (P_{NW}), b) east (P_{NE}), and c) south (P_{NS}) Histogram for Konya*

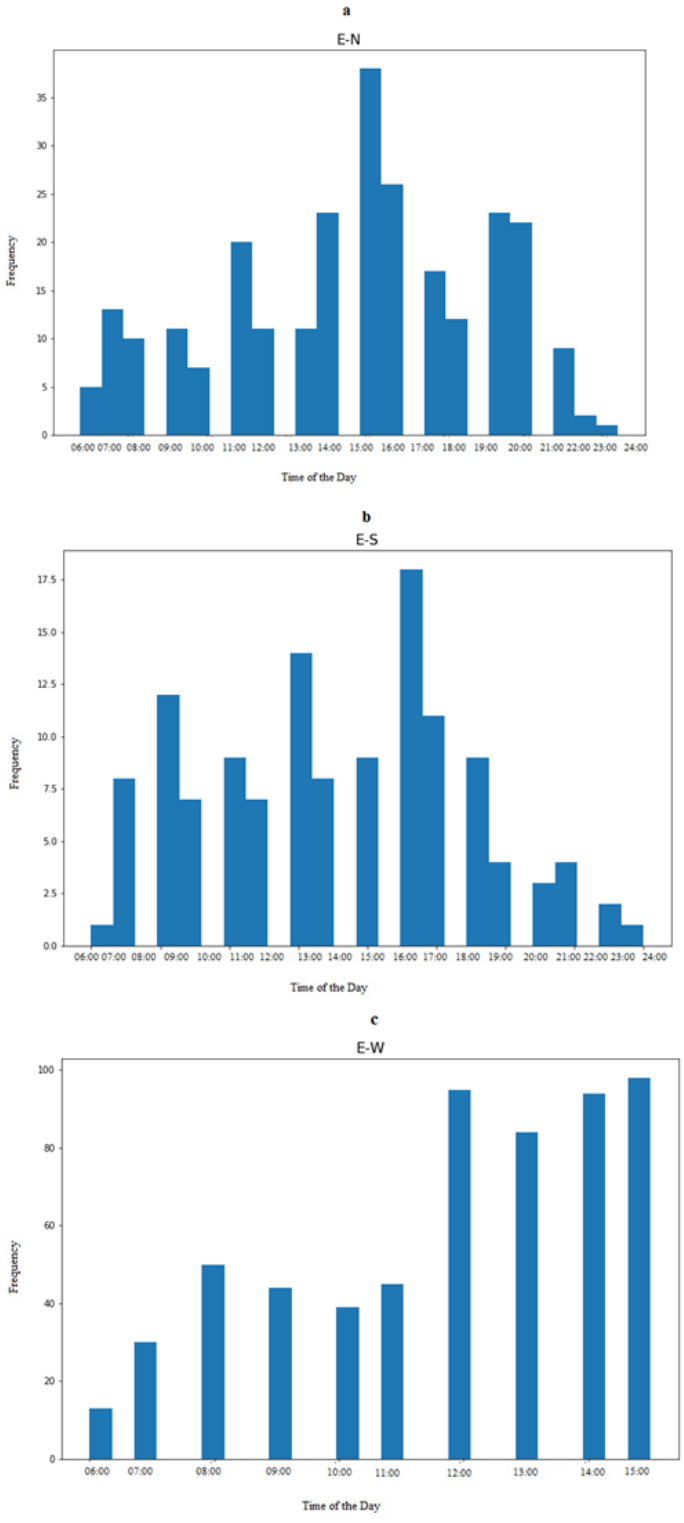


Figure 4.21. *Movements from the point east (P_E) to direction of a) south (P_{ES}), b) west (P_{EW}), c) north (P_{EN}) Frequency Time of the Day Histogram for Konya*

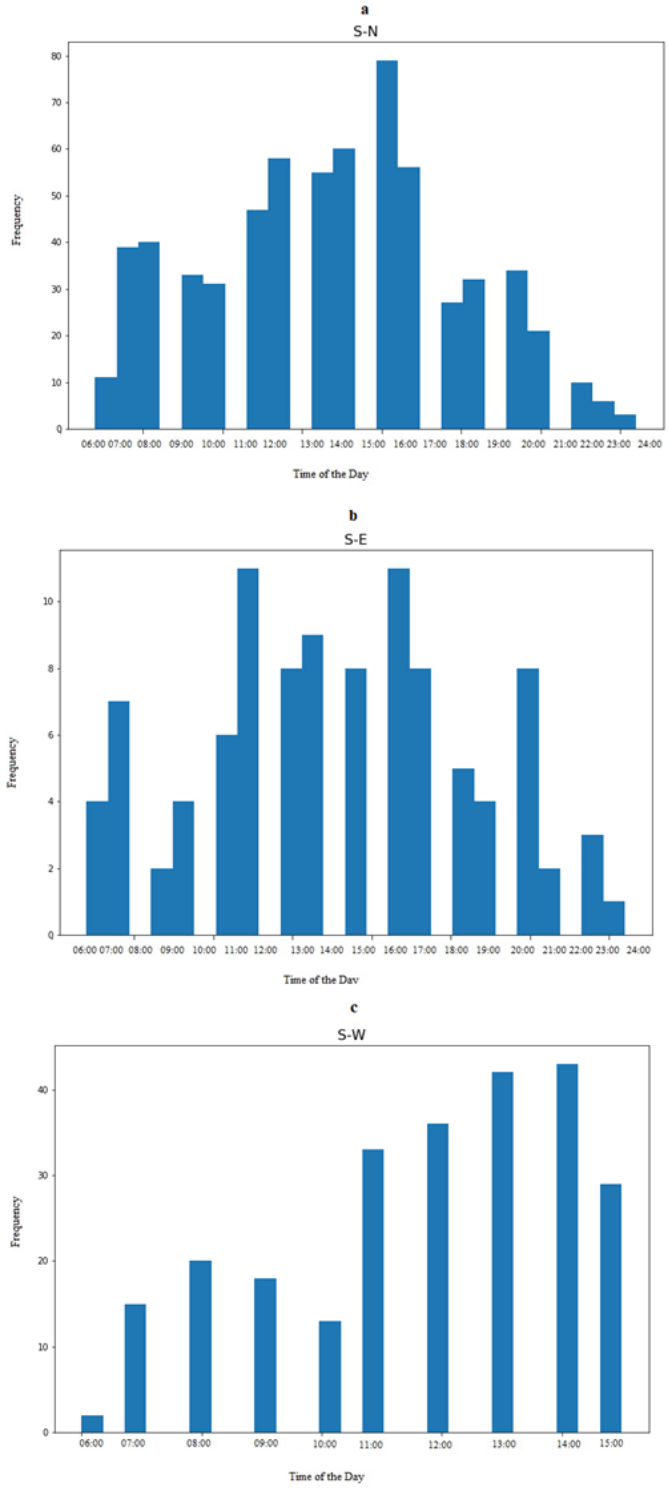


Figure 4.22. *Movement from the point in south (P_S) to direction of a) west (P_{SW}), b) north (P_{SN}), c) east (P_{SE}) Frequency Time of the Day Histogram for Konya*

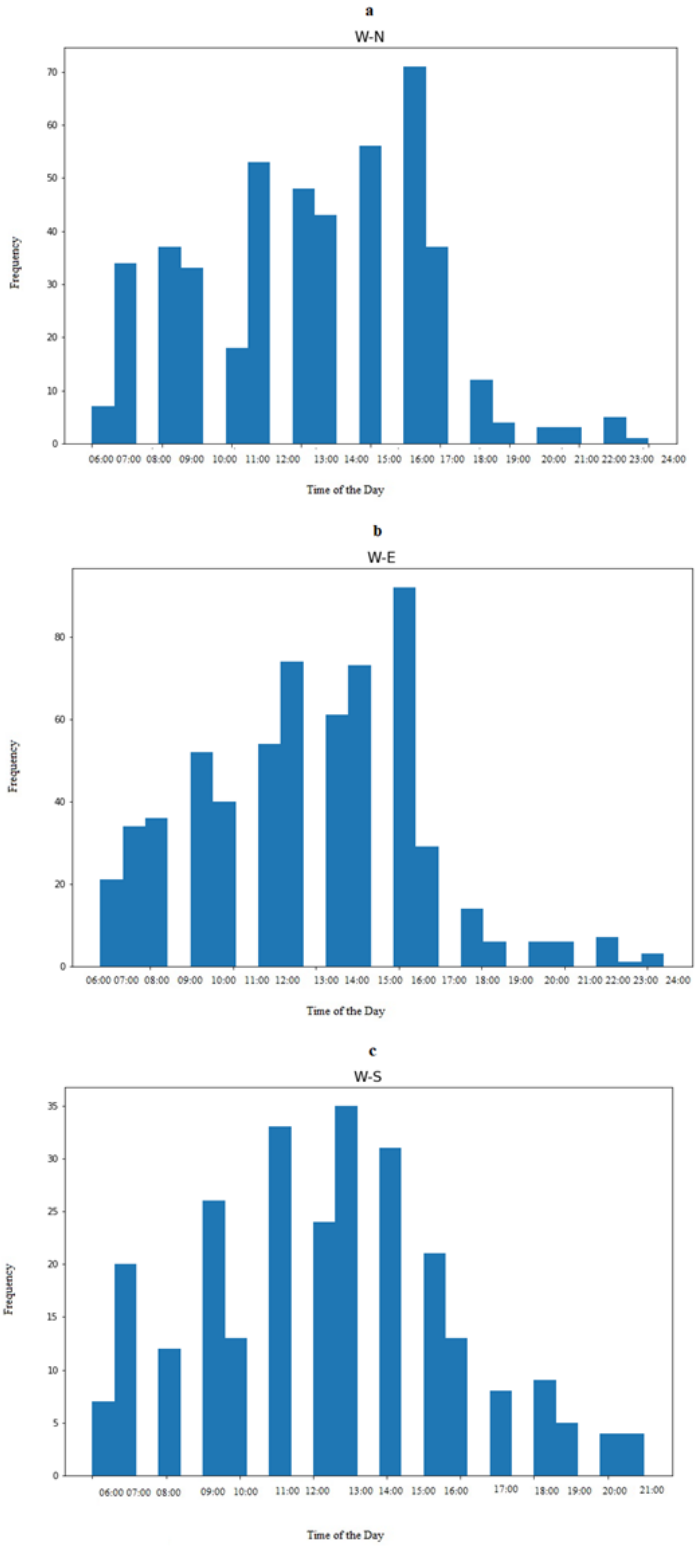


Figure 4.23. *Movements from the point in the west (P_W) to direction of a) north (P_{WN}), b) east (P_{WE}) and c) south (P_{WS}) Frequency Time of the Day Histogram for Konya*

From Figure 4.28, peak hours for directions west to north and west to east is between 15:00-16:00 and west to south is between 13:00-14:00. Frequency is counted denser in direction west to south.

According to hour we could not identify the same peak hours for each directions. And also, in some directions data number is very low so we could not separate 15:00-16:00 time period as peak hour.

IQR method will be used and their values with respect to directions evaluated in Table.

North to other directions' cluster point between 0-5 km/h. In north to south direction speed changes between 40-60 km/h, north to east direction it's between 25-50 km/h and north to west has two different areas one is near to 20 km/h and other hot up range is between 40-75 km/h. The slower speeds are seen in direction north to east which we could say from airport to industrial areas.

East to other directions speed tendency shows more alteration than north to other directions. Again we could see accumulation speed between 0-5 km/h. For east to north direction speed changes a lot variety between 35-60 km/h, east to west speed has two rallying area one of them is between 15-25 km/h and other is between 60-90 km/h and east to south direction speed average is between 45-55 km/h.

Table 4.16. *Descriptive Statistics of Travel Times (seconds)of different movements - Raw Bluetooth Data (a.m.) from Konya Study*

Movement	**Frequency**	**Raw BT Travel Times (seconds)**				
		Q0	**Q1**	**Q2**	**Q3**	**IQR**
PNE	123	25,3	32,3	37,2	43,2	10,8
PNS	606	46,1	56,4	62,8	66,3	9,9
PNW	237	21,6	21,6	50,8	54,2	32,6
PEN	133	24,1	34,1	41,5	44,9	10,9
PES	58	5,0	27,7	42,6	48,1	20,4
PEW	397	28,3	65,7	70,2	74,0	8,3
PSN	338	48,1	56,3	58,2	59,5	3,2
PSE	17	23,8	35,3	48,1	55,0	19,7
PSW	121	37,4	43,5	45,2	48,7	5,2
PWN	153	23,4	39,2	41,6	44,9	5,7

PWE	292	39,9	51,8	62,5	68,3	16,5
PWS	110	38,3	47,0	49,6	56,8	9,8

Flow from south to east direction can be neglected because of number of data is inadequate. We could measure total number of 14 MAC identities speeds differs between 65-35 km/h. Direction south to north speed changes between 50-90 km/h and south to west direction speed changes between 40-90 km/h. Maximum number of measurements counted in direction south to north which gives the direction industrial sites to airport.

One meaningless data could be seen in west to north direction easily. Mean speed range for direction west north changes between 30-60 km/h, west to east direction shows high width range with speeds between 35-100 km/h and west to south has least number of data with speed range 40-80 km/h.

According to scatter plots of the diagrams speed vs time period of the day we could not say that velocity change is remarkable on specified hours of the day. Generally speed characteristics of the directions are not changed a lot according to hour.

4.8. Cleaned Up Bluetooth Data for Konya

According to MAC identity number in identified speed limits we could see some changes in peak hours. From direction north to all directions it changes as 14:00-15:00.

Maximum identity number changes with respect to arrival directions in east to other directions. East to north and to west directions peak hours seen hours between 14:00-15:00, from east to south 09:00-10:00 and 15:00-16:00.

South to other directions identified identity numbers changed a lot. From south to north direction 12:00 13:00 could be identified as seen maximum MAC identity hours, south to east 06:30-08:00 and south to west 12:00-13:00. From south to north we could see denser flow.

West to other directions denser flow seen in west to east direction. Peak hours changed with arrival direction. West to north direction 10:30-11:30, west to east 11:30-12:00 and west to south 12:30-13:00 acquired as heavier MAC identity population.

And also with given speed constraint average speed and time graphs are given below with respect to departure and arrival directions.

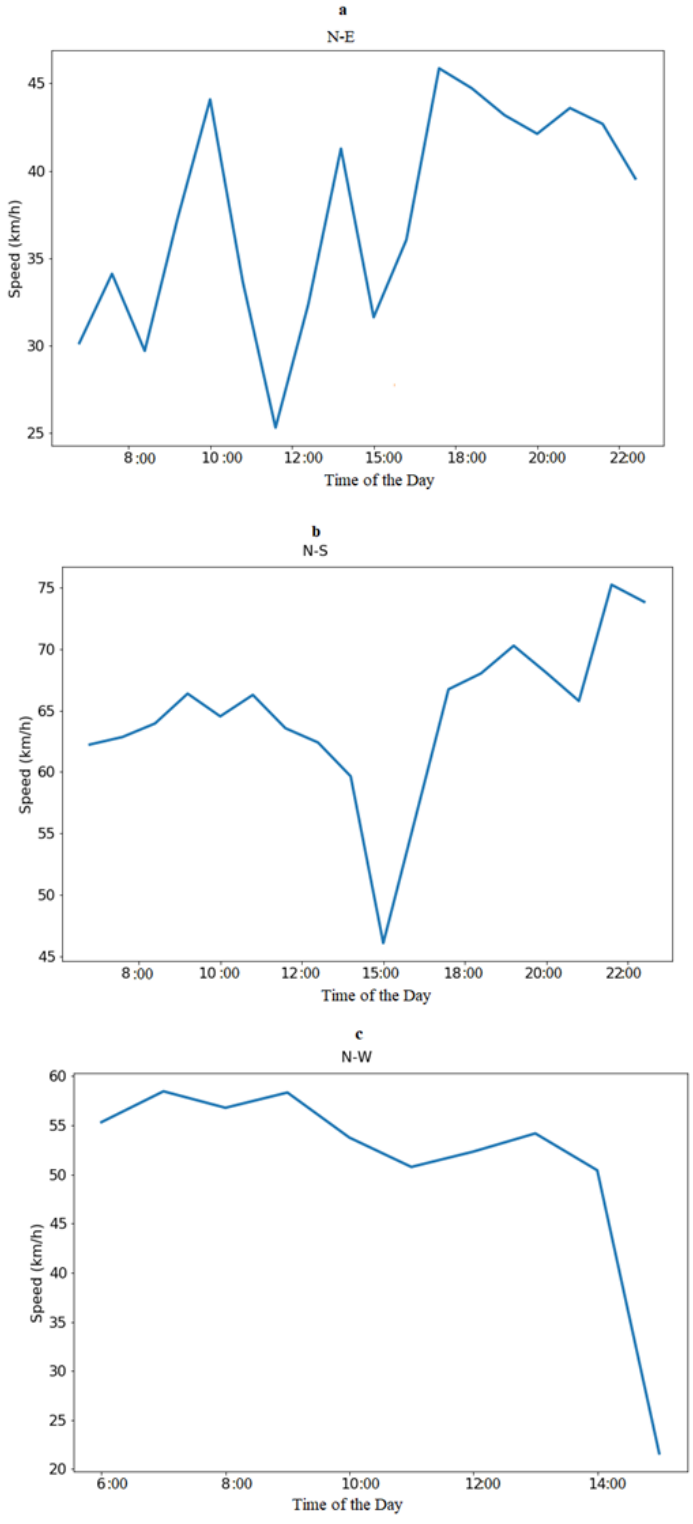


Figure 4.24. *Movements from the point in north (P_N) to direction of a) west (P_{NW}), b) east (P_{NE}), and c) south (P_{NS}) Average Speed (km/h) and Time of the Day*

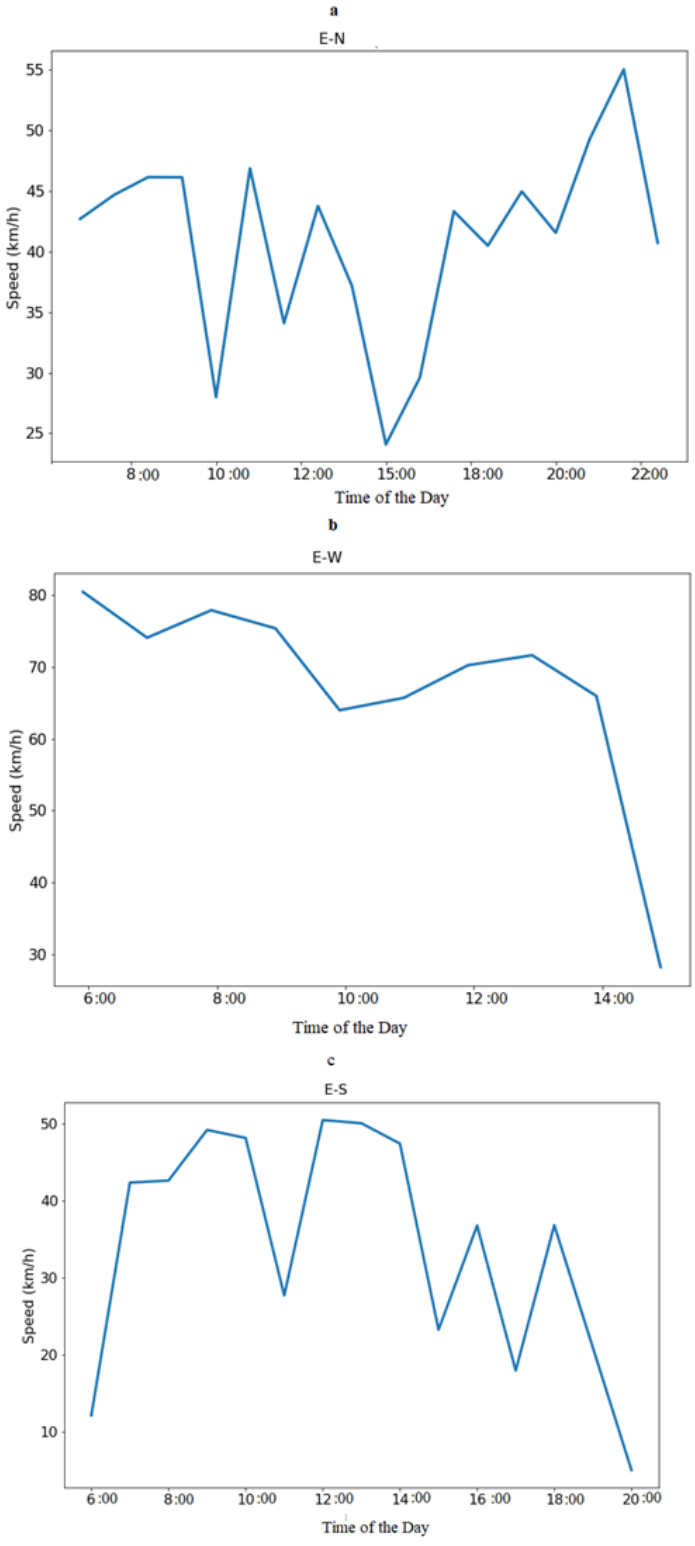


Figure 4.25. *Movements from the point east (P_E) to direction of a) south (P_{ES}), b) west (P_{EW}), c) north (P_{EN}) Average Speed (km/h) and Time of the Day*

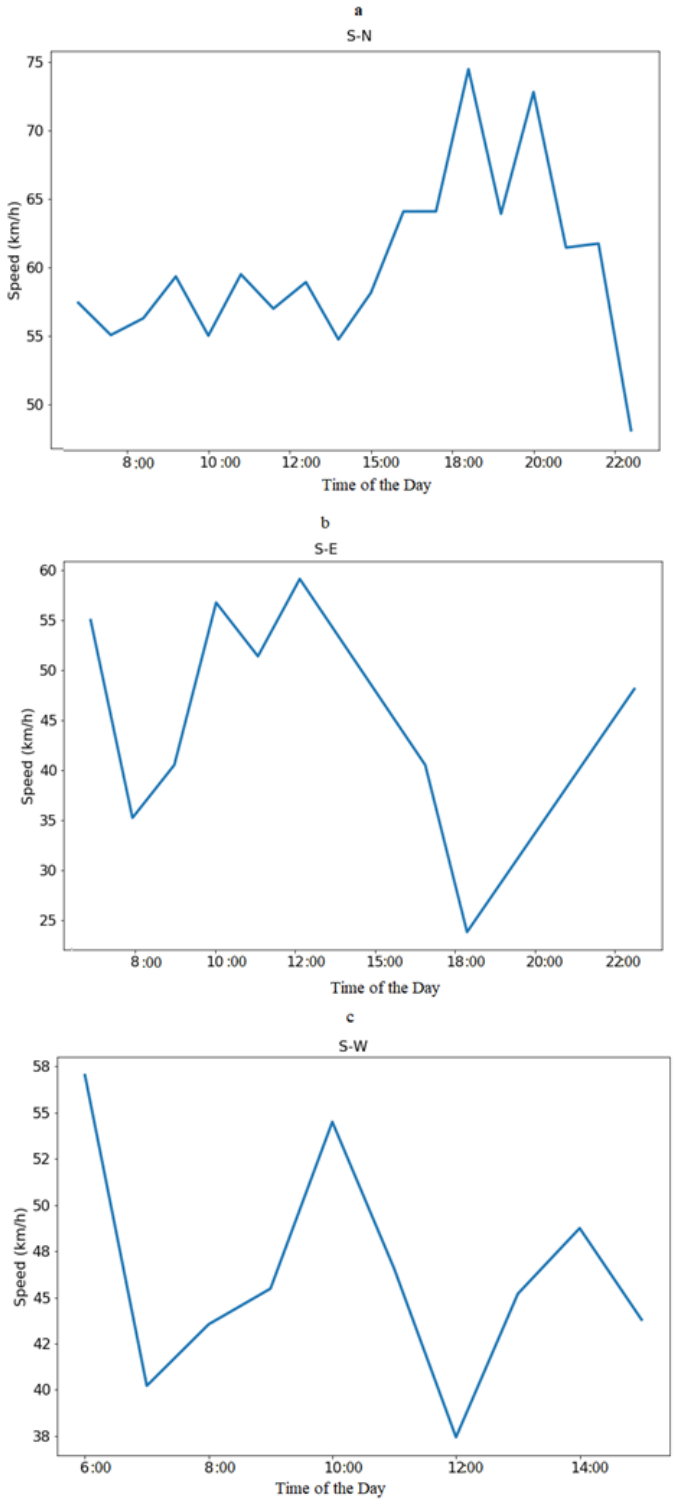


Figure 4.26. *Movement from the point in south (P_S) to direction of a) west (P_{SW}), b) north (P_{SN}), c) east (P_{SE}) Average Speed (km/h) and Time of the Day*

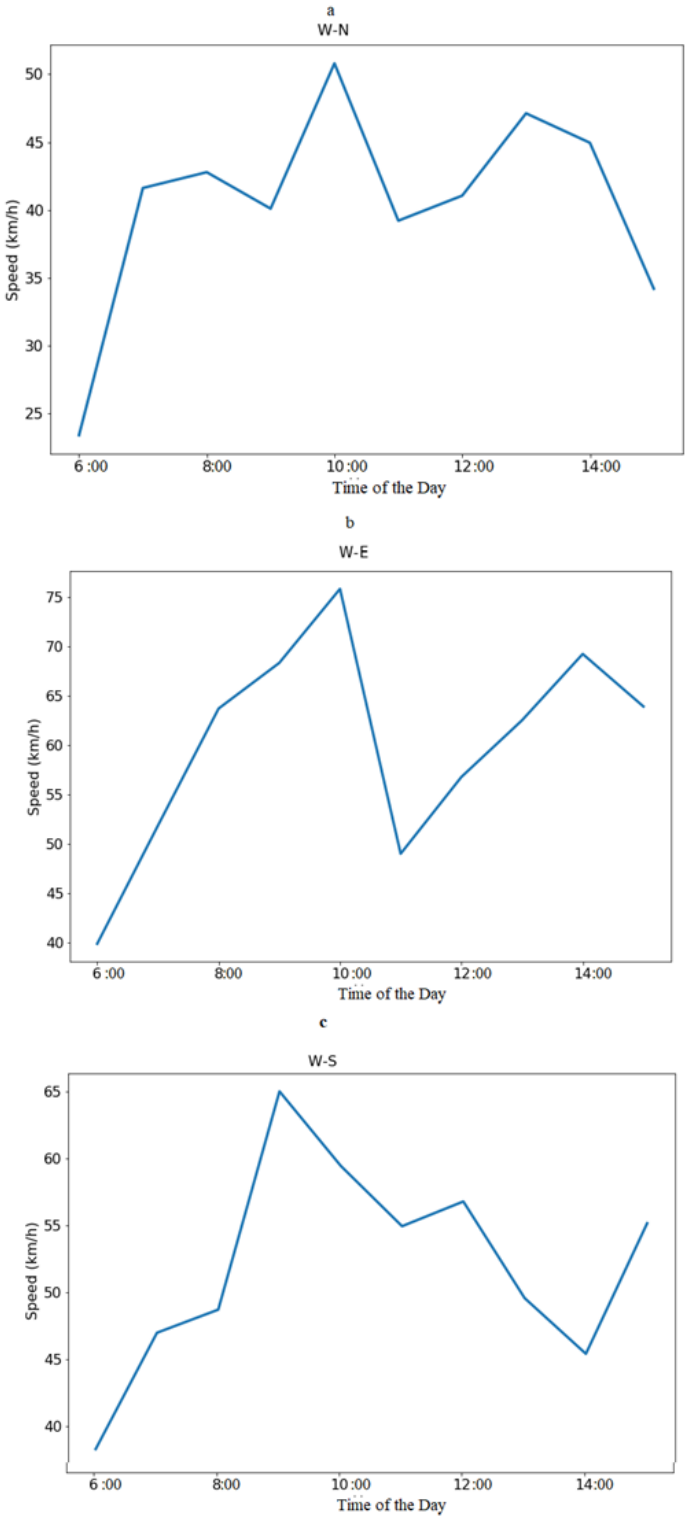


Figure 4.27. *Movements from the point in the west (P_W) to direction of a) north (P_{WN}), b) east (P_{WE}) and c) south (P_{WS}) Average Speed (km/h) and Time of the Day*

When we check the speed with respect to hours from north to other directions from Figure 4.37, we could easily realize the peak hours of the flow. From north to east direction minimum speeds seen at maximum flow hours and after 18:00 speed change is minimum and higher. Speed is changing between 25 – 45 km/h.

For east to north direction (Figure 4.38) after 16:00 speed measurements are not changed a lot but we see the peak speed between 21:00-22:00 and lowest value between 15:00:16:00. After 21:00 we could not take any measurements on east to south direction and speed is steady hours between 12:00-14:00. East to west direction has seems to highest speed values, but after 16:00 there could not read any values. Highest speeds on that direction measured on morning hours.

Speed is steady hours until 15:00 south to north direction and its value changes 55 to 60 km/h but after that hour it is increasing to 75 km/h value according to Figure 4.39. From south to east direction lowest speed value is smaller than 25 km/h and seen on hours between 16:00-17:00. Highest values on that direction seems hours between 10:00-13:00 and near to 60 km/h. Deep saw tooth shape could be identified on south to west direction. We could not take any measurements after 15:00. Speed values highest value seems on morning hours near to 58 km/h and lowest values seen between 12:00-13:00 with values near to 30 km/h.

According to Figure 4.40, the speed profiles of the vehicles going from other directions to the west are obvious. The highest peaks of speed in the west-north direction were seen between 10:00-11:00 hours, while the lowest speeds were between 09:00-10:00 and 11:00-12:00.

On the vehicles driving west-east, the average speed between 09:00-10:00 is 75 km/h and it is 45 km/h between 11:00-12:00. In the morning we see that the speed values are very low.

The average speed is 65 km / h between 09: 00-10: 00. Again in the morning, the speed drops below the average speed of 40 km / h.

As a result, according to the speed and the number of vehicles passing, new graphics were created for the selected area in Konya.

Average speed and the number of vehicles counted are given according to the direction of departure and departure. To sum up all the detailed cleaned up graphs shown as:

Table 4.17. *Movements from the point in north (P_N) to direction of west (P_{NE}), east (P_{NS}), and south (P_{NW}) Average Speeds (km/h) with MAC ID Counts*

Hour	P_{NE}		P_{NS}		P_{NW}	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
06:00-07:00	30,1	2	62,2	12	55,3	9
07:00-08:00	34,1	4	62,8	35	58,5	10
08:00-09:00	29,7	2	63,9	38	56,8	24
09:00-10:00	37,2	7	66,4	31	58,3	14
10:00-11:00	44,1	8	64,5	20	53,7	13
11:00-12:00	33,6	9	66,3	33	50,8	21
12:00-13:00	25,3	8	63,6	46	52,3	22
13:00-14:00	32,3	9	62,4	38	54,2	23
14:00-15:00	41,3	9	59,6	62	50,4	33
15:00-16:00	31,6	17	46,1	104	21,6	68
16:00-17:00	36,0	10	56,4	77	-	-
17:00-18:00	45,9	7	66,7	23	-	-
18:00-19:00	44,7	5	68,0	18	-	-
19:00-20:00	43,2	14	70,3	21	-	-
20:00-21:00	42,1	4	68,1	25	-	-
21:00-22:00	43,6	5	65,8	14	-	-
22:00-23:00	42,7	2	75,2	6	-	-
23:00-24:00	39,6	1	73,8	3	-	-
Average Speed (km/h)	37,4		60,3		44,5	
Total MAC ID	123		606		237	

The total average speed for vehicles going from north to east was 37,4 km/h. Hourly average speeds are also around this value. It was observed that there was not much speed change in the vehicles in this direction. The average speed of the vehicles from north to south was measured as 60,3 km/h. In the hourly values, the average speed

value of the vehicles passing after 23:00 hours is 73,8 km/h and the lowest speed value of 46,1 km/h is measured between the peak hours of 15:00-16:00 hours. Maximum vehicle number counted as 606 in north to south direction. Measurements could not be obtained after 16:00 o'clock in the north-west direction. While the average speed value was 44.5 km/h, the average speed value decreased to 21.6 km/h between 15:00-16:00 hours and the highest number of vehicles in this direction was observed at this time.

Table 4.18. *Movements from the point east (P_E) to direction of south (P_{ES}), west (P_{EW}), north (P_{EN}) Average Speeds (km/h) and MAC ID Counts*

Hour	P_{EN}		P_{ES}		P_{EW}	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
06:00-07:00	42,7	5	12,1	1	80,4	13
07:00-08:00	44,7	11	42,3	5	74,0	25
08:00-09:00	46,1	6	42,6	8	77,8	35
09:00-10:00	46,1	4	49,2	2	75,3	28
10:00-11:00	28,0	2	48,1	7	64,0	17
11:00-12:00	46,8	9	27,7	5	65,7	31
12:00-13:00	34,1	8	50,4	6	70,2	56
13:00-14:00	43,8	5	50,0	4	71,6	51
14:00-15:00	37,2	9	47,4	3	65,9	63
15:00-16:00	24,1	17	23,2	9	28,3	77
16:00-17:00	29,6	14	36,8	5	-	-
17:00-18:00	43,3	8	17,9	1	-	-
18:00-19:00	40,5	6	36,8	1	-	-
19:00-20:00	44,9	9	5,0	1	-	-
20:00-21:00	41,5	12	-	-	-	-
21:00-22:00	49,3	5	-	-	-	-
22:00-23:00	55,0	2	-	-	-	-
23:00-24:00	40,7	1	-	-	-	-
Average Speed (km/h)	39,0		38,5		62,5	
Total MAC ID	133		58		396	

The total number of vehicles going to other directions from the east is 587. While the highest vehicle speed average is seen in the east west direction, the highest number of

vehicles has been reached. In the north-east direction, the lowest speed was measured as 24,1 km/h between 15:00-16:00 hours and the number of vehicles in this time range was 17. The highest speed was measured as 55 km/h between 22:00-23:00 hours. No measurements were made in this direction after 20:00 o'clock.

Table 4.19. *Movement from the point in south (P_S) to direction of west (P_{SW}), north (P_{SN}), east (P_{SE}) Average Speeds (km/h) and MAC ID Counts*

Hour	P_{SN}		P_{SE}		P_{SW}	
	Average Speed (km/h)	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**	**Average Speed (km/h)**	**MAC ID Count**
06:00-07:00	57,4	10	55,0	3	57,0	2
07:00-08:00	55,1	30	35,3	3	40,2	11
08:00-09:00	56,3	25	40,5	1	43,5	11
09:00-10:00	59,3	21	56,7	1	45,5	9
10:00-11:00	55,0	19	51,4	3	54,5	7
11:00-12:00	59,5	27	59,1	1	46,6	16
12:00-13:00	57,0	30	40,5	1	37,4	13
13:00-14:00	58,9	32	23,8	2	45,2	19
14:00-15:00	54,8	31	48,1	2	48,7	22
15:00-16:00	58,2	34	-	-	43,8	11
16:00-17:00	64,1	20	-	-	-	-
17:00-18:00	64,1	14	-	-	-	-
18:00-19:00	74,5	14	-	-	-	-
19:00-20:00	63,9	13	-	-	-	-
20:00-21:00	72,8	10	-	-	-	-
21:00-22:00	61,5	5	-	-	-	-
22:00-23:00	61,7	1	-	-	-	-
23:00-24:00	48,1	1	-	-	-	-
Average Speed (km/h)	59,3		45,0		45,2	
Total MAC ID	337		17		121	

When we go to the other directions from the south direction, the highest number is seen in the north direction. In this direction, the reason for this high count can be up to 16:00 in the east direction and 15:00 o'clock in the west direction. The highest vehicle speed average was measured in the south north direction. As mentioned earlier, this may be due to airport traffic. The number of vehicles in the north direction

is reduced after 21:00, while the highest speed average is seen between 20:00-21:00 hours. The number of hourly vehicles in the south-east direction is small enough to be ignored, and the velocity averages are highly variable compared to the hours. In the south-west direction, vehicles have convergent values for the speed average of 45,2 km/h.

Table 4.20. *Movements from the point in the west (P_W) to direction of north (P_{WN}), east (P_{WE}) and south (P_{WS}) Average Speeds (km/h) and MAC ID Counts*

Hour	**P_{WN}**		**P_{WE}**		**P_{WS}**	
	Average Speed:	**MAC ID Count**	**Average Speed:**	**MAC ID Count**	**Average Speed:**	**MAC ID Count**
06:00-07:00	23,4	7	39,9	20	38,3	7
07:00-08:00	41,6	22	51,8	27	47,0	14
08:00-09:00	42,8	22	63,7	18	48,7	11
09:00-10:00	40,1	11	68,3	34	65,0	12
10:00-11:00	50,8	8	75,8	27	59,4	7
11:00-12:00	39,2	26	49,0	32	54,9	11
12:00-13:00	41,0	17	56,8	38	56,8	12
13:00-14:00	47,1	17	62,5	33	49,6	18
14:00-15:00	44,9	16	69,2	35	45,4	12
15:00-16:00	34,2	7	63,9	28	55,1	6
Average Speed (km/h)	41,5		60,7		51,9	
Total MAC ID	153		292		110	

On vehicles driving from the West to other directions, no measurements were made after 16:00 o'clock. However, the number of vehicles does not differ much from other measurements. The average velocity is the lowest in the west direction. The lowest speed in this direction was measured as 23,4 km/h between the morning 6:00-7:00 hours and the highest speed was measured as 50,8 km/h between 10:00-1:001 hours. The speed of the vehicle with the highest number of vehicles measured in 26 hours is 39.2 km. While the average speed value is higher in the west-east direction than in other directions, the number of vehicles is higher. The highest speed was measured in the range of 10:00-11:00 like the vehicles going north. The lowest speed was parallel to the north direction between the hours of 6:00-7:00 am. The highest speed average

of 65 km/h was 9:00-10:00 for the vehicles going to the west, while the lowest speed was again in the range of 6:00-7:00.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Cloverleaf interchanges are one of the most commonly used type of interchange in Turkey. In the world we could see the samples with same radiuses but in our working area radiuses of the ramps are different from each other. If we look at the average velocities of the roads coming through each ramps we could see they are different from each other. It could be caused because of the roads are coming from different population densities. And also the workplaces and universities are settled generally in Eskişehir road so the speed averages are lower in that areas as expected.

Other goal of this study was to compare the camera and BT data inputs with comparing the accuracy of the measurements. Hence, according to results their accuracy unfortunately not even close. So BT data could provide information about the general state of the density of the roads and state of the interchanges but just with BT readings it is not possible to see the detailed view. And also BT readings are not include the coming and going lane data. It could just read the MAC ID's independently from the direction vehicles comes from. So we cannot evaluate the travel behavior from BT readings. But we just have a general idea about traffic flow. When we evaluate the BT morning data obtained from Ankara for morning hours, it is observed that the speed values are at the stop level while the maximum measurement is the maximum in all traffic to the west. In this direction cannot remove the traffic flow clover junction. The flow is thought to be congested. In the evening hours, BT measurements could be obtained on vehicles driving from the east and from the south to the other directions. It is seen that the vehicles have come to a halt in the measurements going to the west from both directions. It is presumed to be congestion in the direction of east-west and south-west. The multiplicity of measurements received also supports this prediction.

Due to the fact that there are 16 lane road data in total, a data scan corresponding to 200 hours was carried out in camera readings within the scope of this thesis. Misreading's may have been caused by a human error because camera images are controlled by eyes.

In the study conducted in Ankara, it was seen that the camera images were relatively healthy and the measurements made with Bluetooth were not sufficient in the measured measurements. In the measurements made in Konya, it was observed that the measurements in the west direction could not be made after 16:00 hours. Nevertheless, it is seen that it is necessary to increase the measured time interval in case of using Bluetooth technology which is a faster data collection method in clover junction applications. Turning radii are similar in Konya and Ankara. However, the traffic flow characteristics differ from each other because of the province population and different close region properties.

In future work, if the camera recordings are analyzed by data analysis with respect to the shapes of the vehicles or license plate readings accuracy ratio of the work will be increased. Nevertheless, it is seen that it is necessary to increase the measured time interval in case of using Bluetooth technology which is a faster data collection method in determination of the traffic characterization applications

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