ESTIMATION OF TRAFFIC IMPACT AT SIGNALIZED INTERSECTIONS AROUND THE PROPOSED HEALTH CAMPUS IN ETLIK, ANKARA

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ABSTRACT

ESTIMATION OF TRAFFIC IMPACT AT SIGNALIZED INTERSECTIONS AROUND THE PROPOSED HEALTH CAMPUS IN ETLIK, ANKARA

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A proposed integrated health campus with a total bed capacity of 3566 will be built in Etlik, Ankara, in an area surrounded by two urban corridors and served by six 3-legged and two 4-legged signalized intersections. For such a large medical facility with emergency services, it is important to assess its accessibility at these intersections by determining current and future levels of service (LOS), which is the objective of this study. According to Highway Capacity Manual, the estimation of LOS for a signalized intersection requires the determination of control delay which includes i) uniform, ii) incremental and iii) initial queue delays. The first two components require signalization and flow parameters, such as effective green, cycle length, etc., which are estimated based on traffic surveys via video recordings in the study. The initial queue delay, however, could be estimated by simulating the observed corridor flows and obtaining the queue lengths, which are performed in Synchro v.9 and PTV Vistro.

The results showed that two main arterials serving the health campus area have different flow characteristics especially during the weekday peak periods: the intersections on the south corridor have lower LOS levels, mainly due to the heavy traffic between the Kecioren and the city center in the peak hours. LOS values range from B to D, and future values are expected between LOS C to E. The north corridor currently carries less traffic, and has LOS ranging from B to E, and is expected to have LOS C to E after project during the peak hour. This shows that proposed project must definitely be supported by new intersection design and control solutions to better manage the expected congestion after the opening of the health campus.

Keywords: Level of Service (LOS), signalized intersection, Synchro, Vistro, Simulation

ÖZ

ANKARA ETLİK SAĞLIK KAMPUSU PROJESİ ETRAFINDAKİ SİNYALİZE KAVŞAKLARDA TRAFİK ETKİSİ TAHMİN

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Ankara Etlik'te, iki şehir içi koridoru ve 3 kollu sinyalize kavşaklar tarafından çevrelenen bir bölgede 3566 yatak kapasiteli bir entegre sağlık kampüsü yapılması planlanmaktadır. Acil servis hizmeti de verecek böyle bir tıbbi merkeze erişimin incelenmesi önemli olup bu kavşaklardaki şimdiki ve gelecekte beklenen hizmet seviyelerinin (HS) tespit edilmesi bu çalışmanın ana hedefidir. HCM (Highway Capacity Manual)'ye göre sinyalize bir kavşağın HS tahmini için kontrol gecikmesinin belirlenmesi gerekmekte olup bu i) genel, ii) artımlı ve iii) başlangıç kuyruğundan kaynaklanan gecikmeden oluşmaktadır. İlk iki gecikme bileşeni hesabında sinyalizasyona ve video kayıtlarından yapılan trafik etüdü ile tahmin edilebilecek etkin yeşil, döngü süresi gibi akım parametrelerine gereksinim duymaktadır. Başlangıç kuyruğundan kaynaklanan gecikmede ise, gözlenen koridor akımının simüle edilmesi ve kuyruk uzunluklarının çıkarılması ile tahmin edilebilir. Bu aşamada çalışma kapsamında Synchro v.9 ve PTV Vistro yazılımları kullanılmıştır.

Yapılan çalışmada, kampüs alanını çevreleyen iki koridorun özellikle hafta içi zirve saatlerinde farklı akım karakteristiklerine sahip olduğu sonucuna varılmıştır. Güney koridorundaki kavşaklar, zirve saatlerde şehir merkezinden gelen ve şehir merkezine giden ağır taşıt trafiğine bağlı olarak daha düşük HS’ye sahiptir (C-F aralığında). Kuzey koridorunun trafiği daha az olup, zirve saatte HS’ler C-E aralığındadır. Bölgenin en önemli sorunu, projenin hayata geçirilmesi öncesinde bile ana yolların yüksek trafik hacmine sahip olmasıdır. Bu da göstermektedir ki sağlık merkezi açıldıktan sonra beklenen yoğunluklara karşı çözüm önerisi olarak tasarım ve kontrol çözümleriyle desteklenmesi önemlidir.

Anahtar Kelimeler: Simülasyon, Sinyalize Kavşaklarda Hizmet Seviyesi, Gecikme

To

- My parents: *Ali Akbar & Sholeh*

  This thesis is dedicated to my fathers, who taught me that the best kind of knowledge to have is that which is learned for its own sake and advise me to be expert in my field. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time

  Thank you for your unconditional support with my studies I am honored to have you as my parents. Thank you for giving me a chance to prove and improve myself through all my walks of life. Please do not ever change. *I love you.*

- My sister: *Hanieh*

  You are not only my sister; you are also my guiding light, my defender, and my help in time of need. Thank you for being there when I need you the most. *I love you always*

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CHAPTER 1

INTRODUCTION

As an interesting example of public-private partnership (PPP) in health sector, a series of "integrated health campus projects", which would be financed internationally, has been started in Turkey. One of these projects is the proposed integrated health campus in Etlik, Ankara, which will have a total bed capacity of 3566 and be built on area of 1,071,885 m2 (107 ha). It will include three hospitals with more than 100 surgery rooms, a local health authority building, hotels, shopping halls and commercial areas, and two heliports. Etlik is an already urbanized region in the middle of Ankara. The block is served by main arterials and it has 9 signalized intersections and one full clover-leaf interchange at the southeast corner (see Figure 1.1). The campus will be mainly served by the six 3-legged and two 4-legged signalized intersections (A1 to A8) and there will be a metro station in the south corridor which is under construction at the moment.

The increased utilization of health facilities during the last two decades has caused an intense growth in hospital traffic problems. The expanded rate of patient admissions and outpatients per unit of population and the increasing proportion of employees to patients confirm the expanding activity of hospitals. Besides the growth of population and automobile usage, these factors have had a multiplicative impact over the required access and terminal facilities at hospitals (Derby, 1980). Similarly, accessibility of this health campus has utmost importance, not only for emergency vehicle operations but for very large

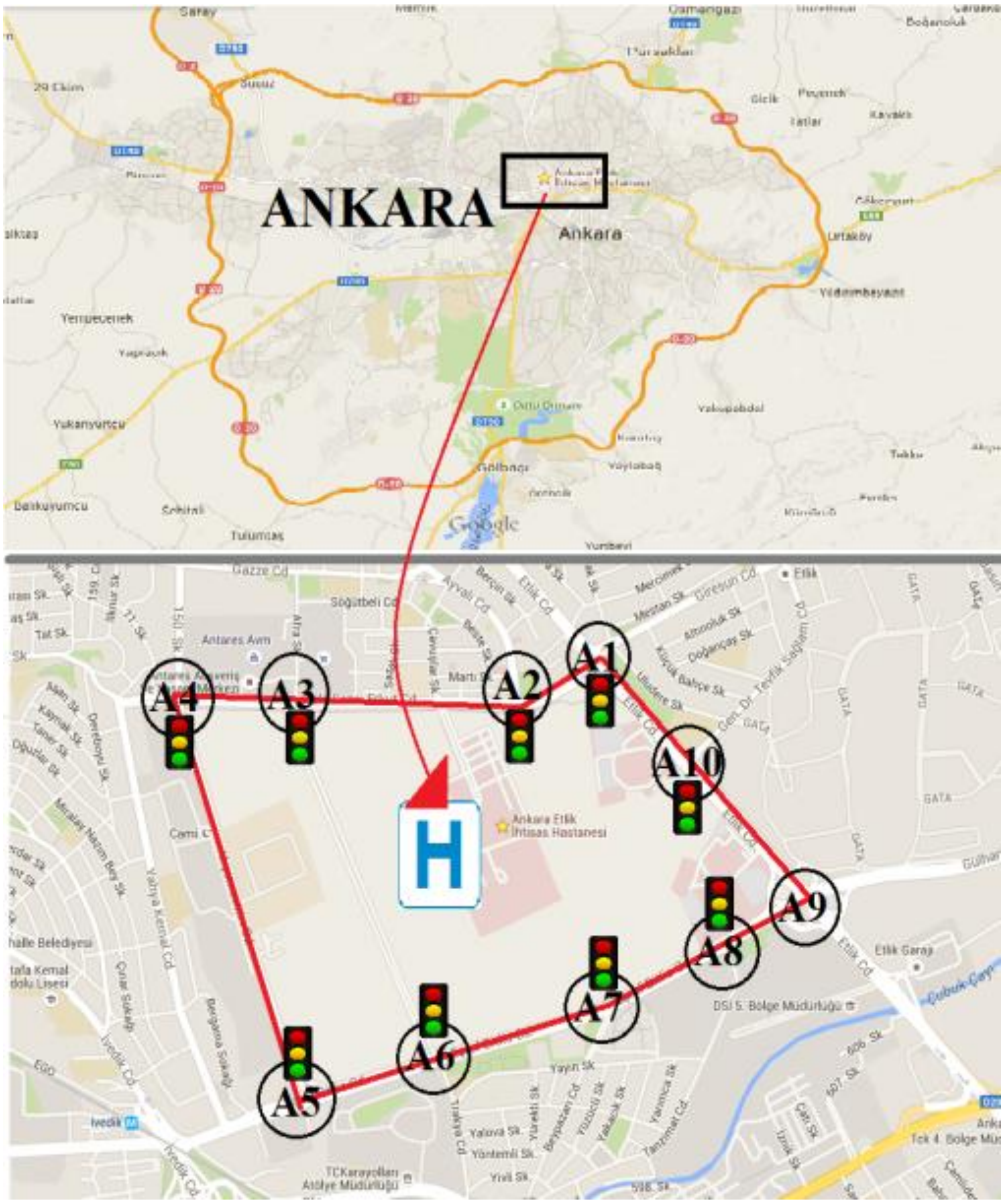

Figure 1.1 location of project site and surrounded intersections in the Ankara and Turkey (Google Map/Earth, 2014)

number of patients and employees it will attract. According to the project contractor, up to 50,000 people could make practical use of this site on a daily basis (ASTALDI, 2013). Any project of this size has to be evaluated to see the traffic impact it would create in the region and the project, itself, and potential solutions need to mitigate the results.

A Traffic Impact Analysis (TIA) for a proposed construction regularly depends upon the historically studied trip rates. TIA is conducted for the following purposes: i) to analyze the current conditions, ii) to determine the new growth in traffic demand due to the project, ii) to estimate the degree of influence over the surrounding transportation facilities, and iv) finally to propose mitigation procedures and improve the measures to guarantee the reduction of negative effect of the project by the surrounding transport facilities that are to maintain a certain level of service (Regidor & Teodord, 2005).

A part of the traffic impact is the determination of the delays a project would cause at a location. Traffic engineers perform capacity analysis at signalized intersections to measure vehicle delay and LOS. Highway Capacity Manual (HCM) characterizes one of the common strategies of the capacity analysis of signalized intersection. An operational system for determining the LOS at signalized intersections regarding the average control delay experienced by all vehicles movements through an intersection is defined by HCM (HCM, 2010). The trip generation manual published by the Institute of Transportation Engineers (ITE) is a commonly used reference which has different options for different land use purposes (ITE, 2008). Figures 1.2 and Figure 1.3 are demonstrated a simplified layout and model of the project complex.

Figure 1.2 Simplified general layout of heath campus (ASTALDI, 2013)

Figure 1.3 General view of the core and the towers (ASTALDI, 2013)

1.1 Scope of the Study

Determining the current and projected LOS and vehicle flow rate, more specifically at eight intersection around integrated heath campus, is the main motivation behind this research. This, first, requires counting number of cars from video recording, then calculation of LOS from HCM 2010 method. Then, trip generation rate and software, TripGen v.9, were used in order to calculate future traffic flow based on version 8 of Institute of Transportation Engineers (ITE). LOS calculations require the estimation of total delay of each intersection, which will be obtained by a traffic analysis and simulation tools, PTV Vistro v.2 and Traffic Ware Synchro v.9 software.

The layout of this thesis is as follows: In Chapter 2, the literature on LOS, delay and traffic impact analysis is summarized. An Etlik area characteristic is given in Chapter 3. Methodology for this study is given in Chapter 4. Current and future LOS of proposed heath campus is presented in Chapter 5 and followed by the conclusion and further recommendations are presented in Chapter 6.

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CHAPTER 2

LITERATURE REVIEW

As the project is a large health campus, it is important to access emergency service and project accessibility at rounded intersections under existing LOS. Furthermore, estimating LOS on existing condition and predict future LOS is important. So that, the literature on delay and LOS is needed, to have more accurate and efficient analysis. As the project will be generating many trips, traffic impact analysis should be checked in literature, in order to have better prediction of the future trip generation of the project.

2.1 Traffic Impact Analysis and Evaluation

Understanding the demands placed on the community's transportation network by development is an important dimension of assessing the overall impacts of development. All development generates traffic, and it may generate traffic to create congestion and to compel the community to invest more capital into the transportation network, whether it is in the form of new roads or traffic signals or turn lanes. Traffic congestion results in a number of problems, including economic costs due to delayed travel times, air pollution and accidents. (Jeihani & Camilo, 2009)

New development projects carried out in parts of a city generate additional traffic volume and in turn degrade the service of the traffic facilities around the project sites or even the entire road network. Traffic Impact Assessment (TIA) or Traffic Impact Analysis is carried out, prior to the institution of the development projects, to assess or analyze the severity and extent of the impact the new projects will have on the performance of traffic service and to seek ways to prevent service degradation; or to amend development projects so as to reduce impact on the traffic. (Wang & Lu, 2003)

The idea of TIA was initiated in the US. After some time, the US administrations and governments of other western nations understood that while gaining huge benefits, the developers additionally transfer the new traffic load that the developed projects have generated to the public sector. Beginning in the 1980s and as a consequence of this conception, most US federal, state and county authorities began to request developers perform TIA; this was for the purpose to define the responsibilities for the need to improve traffic after development projects have been finished. (ITE, 1991; ITE, 2008; Sharmeen, et al., 2012)

The planners and engineers own the powerful tool of TIA to determine the probable impact of a project on the traffic flow and transportation system (Regidor & Teodord, 2005). A TIA can be defined as an assessment of the potential impacts that a specific development's traffic will perform upon the transportation network in its impact area (Sharmeen, et al., 2012). Since the potential negative effects are particular for the development, it is usually only applied to the direct impact area and countermeasures (Regidor & Teodord, 2005). To consider the transportation planning and land-use planning together is the main intention. Furthermore, it has been taken into account as a productive means to make a harmony between the relationship of land exploitation and transportation development (Wang & Lu, 2003).

The Institute of Transportation Engineers suggest a list of requirements for TIA (ITE, 1991). Probably a scaled down report should be created since the recommended contents of a TIA are truly comprehensive and can possibly be impractical in certain situations, including the limited budget of a developer. A compact TIA may concentrate on seven items which are considered as basic or definitely essential in the conduct of traffic impact analysis. These items can be named as follows:

1. Definition of the impact area;
2. Characterization of baseline traffic;
3. Estimation of traffic generation attributed to the project;
4. Formulation of traffic management plan;
5. Access points and routing analysis;
6. Parking requirement analysis;
7. Formulation of implementation mechanisms for recommended countermeasures.

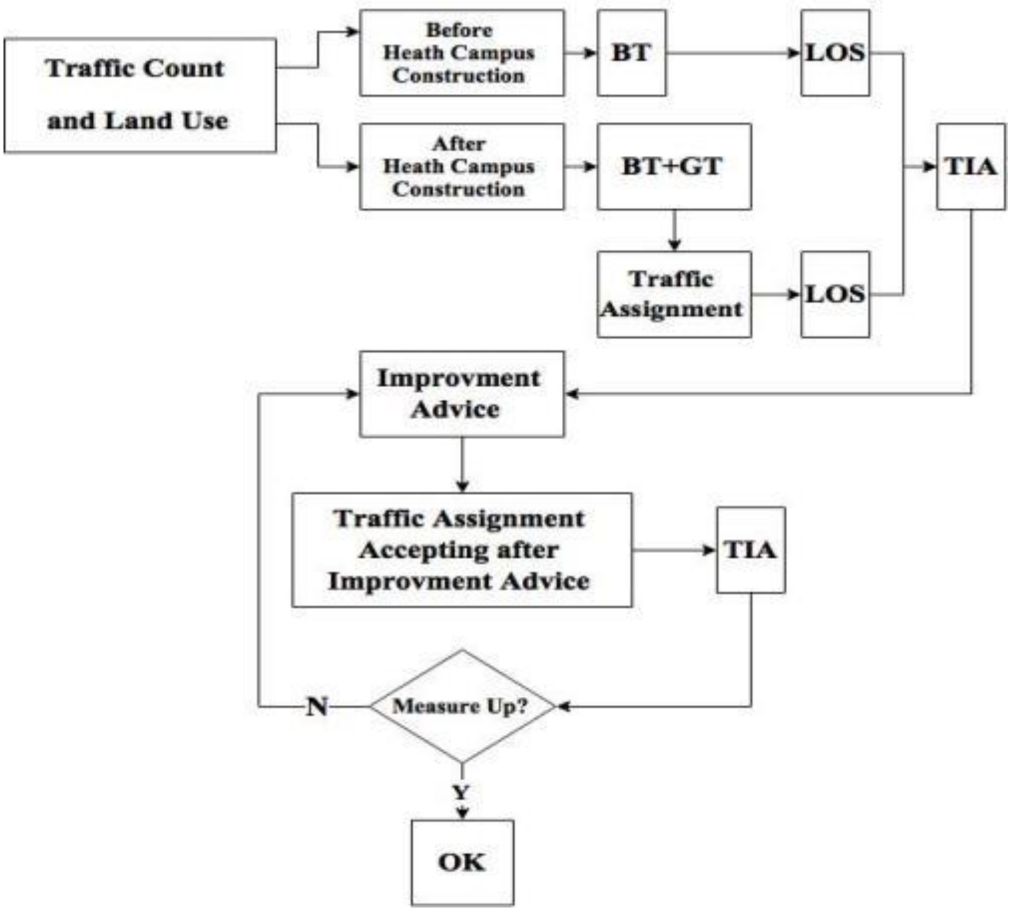


Figure 2.1 Procedure of TIA suggested **(NCHRP, 2013)**

TIA techniques are changed due to difference in network type or project perspective. In spite of that, the general strategies and steps are identical. The procedures of TIA in general can be summed in the steps as represented in Figure 2.1.(Where: BT means Background Traffic, GT means Generated Traffic, LOS means Level of Service, TIA means Traffic Impact Analysis)

2.1.1. Urban Transportation Modeling System

The most used method to estimate the future performance of the current or developed transportation system, is usually the transportation modeling. The rudiments of transportation modeling principles were created during the 1950s in the U.S., and from that point on, it turned into a essential component of transportation planning, investment and policy development everywhere throughout the world. (Martens, 2006; ITE, 1976)

The traditional transportation planning models are established upon the Urban Transportation Modeling System (UTMS) or upon the generally known four-step model. Trip generation, which is the primary step, forecasts the number of trips originating in each transport activity zone, depend on socio-economic and land use data. The second step, trip distribution, separates the whole number of trips produced by each transport activity zone among destination zones, depend on forecast of zonal attraction and travel impedance. The distribution of trips among the available modes is estimated by the mode choice which is the third step. Finally, allocating the trips between a specific origin and destination to the existing roads or public transport links is carried by the fourth step, called traffic assignment. The four-step model eventually brings about an estimation of future travel demand per transport link. These information are then used to evaluate the future performance of the available transport system, to identify transport links in the area that needs adequate capacity, and to estimate the impact of possible transport investments on the performance of the transportation system. (ITE, 2008; FEHR & PEERS, 2008)

2.1.2. ITE Trip Generation Manual

Trip generation is the first and the most critical step in the four step modeling for estimating the travel demand (Black, 1981). Mean trip rates are estimated by performing trip generation analysis. Estimating the number of trips that begins or ends in each zones within a study area is the objective of a trip generation model (Papacostas & Prevedouros, 2008).

There are a small number of national sources of trip generation data particular to specific sorts of land employments. ITE's Trip Generation manual is the most widely utilized and acknowledged source, which involves the biggest database and is occasionally updated. The database mostly contains the contributions from ITE's national membership. ITE gives guidance on the gathering of trip generation data and gives forms to the contributors. Hypothetically, this situation ensures the consistency in data collection (ITE, 2008; ITE, 1976). The methodologies in forecasting the trip generation in the ITE trip generation manual are mostly grounded upon the direct estimation or rate adjustment for rates in view of the empirical data or regression analysis (NCHRP, 2013) .

The ITE trip generation manual supplies for trip generation rates and equations for the average weekday, Saturday, and Sunday; the weekday morning and evening peak hours of the generator; the weekday morning and evening peak hours of the generator that corresponds with the conventional commuting peak hours for adjacent street traffic (i.e. 7:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m.); and the Saturday and Sunday peak hours of the generator. (NCHRP, 2013; Byrne, 2010; ITE, 1976)

2.1.3. Healthcare Projects and Their Traffic Impacts

An enthusiasm for determining the level of the traffic impact of a hospital on its neighborhood is shared by the traffic planner, the hospital planner, the zoning official, and the public (NCHRP, 2013). The importance problem in two aspects of the issue: one is the contribution of hospitals to the urban vehicle kilometers of travel and their demand for transportation facilities in their adjacent; and the other is the unexpected traffic patterns generated in the streets neighboring the clusters of hospitals (Kanaan, 1973).

Each year, the number of hospital patients has been expanded along with expansions in hospital services. A remarkable increase in hospital use has been the result of advances in medicine and surgery, the coming up of medical insurance and governmental health projects, and the more prominent proportion of elderly in the population (LSC, 2010). Moreover, the continuously growing older institutions being located in highly populated regions have been the additional factor of the traffic problems found at hospitals (Naser, et al., 2015).

Since the trip generation rates grounded in single activity indicators are easily and simply applicable and are most of the time accrute and precise for the current issue, they are measured and used in traffic planning purposes. Single indicators being used in hospitals contain: the number of employees, the number of beds, site acreage, or floor area. (ITE, 2008; NCHRP, 2013)

Site acreage and floor area have been exhibited poor associates to trip generations. The number of beds, the quantity of hospital employees, and total population (patient census plus hospital personnel) corresponded to the automobile trip generation developed in hospital (FEHR & PEERS, 2008).

By applying to the size of the development of the applicable trip generation rates published in the eighth edition of ITE, the magnitude of traffic produced by the proposed project was assessed. The hospital trip generation rates based on the number of beds (ITE category 610) were used for the proposed heath project. Trip generation rates and equations were produced for an average weekday, Saturday, Sunday and for weekday morning and evening peak hours regarding the land uses (ITE, 1976). The trip generation equation for one particular land use is the function of one or more independent variables related to the land use If the variables for every particular land use are recognized, so it is possible to evaluate the trip rates from the manual. (ITE, 2008)

Hospitals are served by a variety of transportation modes other than the automobile. Numerous workers, for instance, rely upon mass transit where its LOS is high. Pedestrian trips represent a considerable proportion of student and lower-income employee travel (Kanaan, 1973). High priority should be given to emergency vehicle access to hospitals. The ambulance routing ought to be most possibly direct, with the minimum possible number of traffic conflict and delay points. (Derby, 1980)

Urgent vehicles are typically destined to the emergency ward of a hospital. In spite of that, the increased role that these wards are playing in in satisfying the community's health needs will definitely cause an increase in traffic (Akdag, 2010). The delivery of health care during emergency circumstances is turning out to be increasingly complex for health care suppliers (Spieler, et al., 2008). Emergency healthcare service is a necessarily vital public health matter and it is essential to reach the accident location, to perform the first intervention and to guarantee transportation to a hospital as quickly as possible when it comes to emergency situations (Akdag, 2010).

2.2 LOS Studies in the Literature

In the 1965 version of the highway capacity manual (HCM), the level of service (LOS) concept for highways was presented for the first time. A large number of studies on measuring LOS were revealed after its presentation, which defined it as a way to determine the quality of road service as perceived by those who use it. This version of the manual described LOS within a range of classification from 'A' to 'F'. These classes represent a range of operating conditions; the definition of these conditions is based on the combination of travel time and the ratio of traffic flow rate to the capacity of road categories (HCM, 1965).

In the 1985 version of the HCM, this concept was shown again in relation to many different traffic situations. The measures of LOS for each type of road, adopted in 1985 version of HCM, are as follows: travel speed, traffic flow rate, and traffic density (HCM, 1985). The 2000 version of HCM put forth a more complete definition of LOS: "a qualitative measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience". This definition, provided by the 2000 version of HCM, interprets LOS as a quantitative stratification of performance measures. In other words LOS is defined as measures that represent quality of service (QOS) (HCM, 2000).

QOS specified six LOS for each kind of facility, from ‘A’ to ‘F’; while LOS ‘A’ represents the best operating conditions, LOS ‘F’ represents the worst operating conditions. Nevertheless the latest expressing version of HCM belongs to the year 2010. According to this latest version, many alternative methods exist in order to measure the performance of a transportation facility or service. There are also many points of view that can be considered while making decisions about the kind of the measurement that is going to be employed (HCM, 2010).

The criteria that determines the specific and different perspectives on how a roadway or service should perform and what can be called a ‘good’ performance differs according to the agency operating a roadway, the automobile drivers, the pedestrians, the bus passengers, the bicyclists, decision-makers, and finally the community at large. Therefore, no one way can be detected as the only right way to measure and interpret the performance. Although no alterations have been made, since the introduction of the versions of HCM, in the classes of LOS (A_F), from 1965 to 2010, different factors have been considered to describe LOS. (HCM, 1965; HCM, 1985; HCM, 2000; HCM, 2010)

The major effective factors in LOS, which were defined by the oldest version of HCM in 1965, are the travel time and traffic flow (v) to capacity (c) ratio. The subsequent version of HCM (1985) emphatically presented traffic flow and two more fundamental parameters such as travel speed and traffic density in the definition of LOS categories. The 2000 version of HCM laid stress upon the two already considered parameters of travel time and travel speed. However these are not the only two influential factors and the travelers' freedom to maneuver, convenience, comfort and interruption from traffic should also be taken under consideration. Therefore, the 2010 version of HCM, unlike the earlier versions, does not emphasize a particular Measure of Effectiveness (MOE) and gives freedom to the users in deciding their own assessment through qualitative measures. (HCM, 1965; HCM, 1985; HCM, 2000; HCM, 2010)

In some definitions offered by the service measures for LOS, the traveler's perspective on transportation system operation is reflected and many different alternatives have been introduced for improving the scaling of LOS. Here are some examples which illuminate the limitations of the (HCM, 1985) LOS measures.

The studies of Baumgaertner in 1996 named some factors that have had considerable roles in the increase of the traffic volumes, such as the continuous growth of urban populations, vehicle ownership, average trip length, and number of trips. So today’s motorists, especially commuters consider the same unbearable and undesirable travelling conditions of 1960s as being normal. Cameron (1996) pointed out the fact that waiting three minutes at a congested urban intersection with average delays of often two minutes is something usual.

These studies (Baumgaertner, 1996; Cameron, 1996; Brilon, 2000) declared their own new approaches to 1985 HCM. What they had in common in their purpose of giving a better explanation of the traffic conditions was to expand the six LOS designations to nine or more.

The studies (Kittelson & Roess, 2001) declared that the HCM (2000) methodologies are not established upon user perception surveys. Several factors such as elements related to traffic operations (e.g. signal timing), roadway geometry (e.g. lane width), esthetic aspects (e.g. presence of trees) and sign visibility, which influence the perception of QOS, are being considered by the users.

The HCM (2000) methodologies are the outcome of a combination of consulting studies, research, discussions and debates on the Highway Capacity and QOS (HCQS) committee (Pecheux, et al., 2000). A formal proposal was made in July 2001, which was the mid-year meeting of the HCQS committee. The motion stated: "The Committee recognizes that there are significant issues with the current LOS structure and encourages investigations to address these issues" (Pecheux, et al., 2004). The studies (Flannery, et al., 2005) compared the quantitative to qualitative service measuring methods for urban streets and they realized that LOS calculated by HCM (2000) methodology, predicted 35% of the variance in mean driver rating. Brilon and Estel in 2010 have figured out the standardized methods. These methods make possible a differentiated evaluation of saturated flow (LOS 'F') conditions beyond a static consideration of traffic conditions in German HCM (Brilon & Estel, 2010).

Defining LOS criteria should basically be acknowledged as a classification problem and an appropriate technique that can be applied on it as a solution is 'cluster analysis'. Since LOS of urban street is a function of travel speed and street segments, a large amount of free flow speed (FFS) and average travel speed (ATS) data are necessary for this cluster analysis. Travel speed data are traditionally accumulated by employing the floating car method. But this method of floating car was not accepted by (Turner, et al., 1998) who believed this method to be susceptible to human mistake. Then the distance measuring instrument (DMI) was proposed as a solution for the floating car method as a result of the improvement in computers.

Nevertheless,Benz and Ogden (1996) found out that there is a limitation in this method relating to installation of the DMI unit and data storage problems. Limited studies have been carried out for heterogeneous traffic flow in Indian context, in spite of the fact that speech ranges are not defined completely and sufficiently for the LOS categories. The 1990 version of the Indian Road Congress (IRC, 1990) put forth that on urban roads, the LOS are strongly influenced by factors such as heterogeneity of traffic, speed regulations, frequency of intersections, presence of bus stops, on-street parking, roadside commercial activities, and pedestrian volumes. (Benz & Ogden, 1996)

In another study carried on by Marwah and Singh in 2000, LOS categories were classified based on the simulation results of benchmark roads and traffic composition. They tried to classify LOS into four groups from I to IV. As a consequence of the progression in technologies, the global positioning system (GPS) has been successfully practiced on data collection and geographic information system (GIS) have been used for data compilation to a great extent. (Marwah & Singh, 2000)

Within these studies, ATS on street segments was used as the MOE, which has been accomplished by the second-wise speed data and collected by using GPS receiver. Many different cluster validation measures have been employed by the authors for the classification of urban streets into number of classes at its context. The authors have realized that FFS ranges of urban street classes and speed ranges of LOS categories valid in Indian context are different from those values specified in HCM (2000).

2.3 LOS for Signalized Intersections

In HCM version 2010, LOS is defined as “a quantitative stratification of a performance measure or measures that represent quality of service” (P. 5-3). The performance measure that used to evaluate LOS for signalized intersection is average control delay per vehicle. LOS worsens, when control delay increases. The criterion of LOS for signalized intersections is shown at Table 2.1.

Table 2.1. LOS criteria for signilized intersection (HCM, 2010)

LOS	Average Control Delay (sec/veh)	General Description (Signalized Intersections)
A	≤10	Free Flow
B	>10 - 20	Stable Flow (slight delays)
C	>20 - 35	Stable flow (acceptable delays)
D	>35 - 55	Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding)
E	>55 - 80	Unstable flow (intolerable delay)
F	>80 or V/C >1	Forced flow (jammed)

The most prominent parts of the transportation system are signalized intersections. It is a difficult work to explain some measure of effectiveness to evaluate a signalized intersection or to describe the quality of operations. Within the capacity analysis and simulation, a number of measures have been employed. All of them have the quality of measuring some aspect of experience of a driver crossing a signalized intersection (Akcelik & Rouphail, 1993). The most widespread measures can be listed as the average queue length, average delay per vehicle, and number of stops. Delay can be defined as a measure that most directly relates driver's experience and it is the measure of supplementary time spent in passing over the intersection. Length of queue at any time is an applicable and helpful measure. It is also very essential in order to ascertain when a given intersection will start to hinder the discharge from an adjacent upstream intersection (Akcelik, 1988; HCM, 2010).

One of the main measures of performance that can be employed to figure out and establish the LOS at signalized intersections is delay (Akcelik, 1988). Several methods have been made use of to evaluate vehicular delay. Very exact and precise estimate of the delays of individual vehicles at signalized intersections is absolutely required for road design and traffic signal control (Su, et al., 2009). One significant application of delay variability modeling is to equip the estimates of the confidence limits about the average delays to optimize signal timing. However, delays in vehicle queues rely on many different highly stochastic and time-variant factors, for example the occupancy. Therefore, no method can be introduced that can have the ability to provide satisfactory conclusions for every driving situation. (HCM, 2000; Teply, et al., 1995)

In the process of planning, designing and analyzing the signal controls, the critical part contains the exact and right quantifying of vehicle delays at signalized intersections (Yu & Sulijoadikusumo, 2012). The random fluctuations in traffic flow and interruptions caused by traffic controls produce the effect of delays that individual vehicles experience at a signalized approach. These delays are usually under the control of highly stochastic and time-dependent variation (Su, et al., 2009; HCM, 2010).

2.4 Delay Studies in the Literature

A precise and simple technique is introduced in this study (Reilly & Gardner, 1977) for measuring vehicular delay on an approach to a signalized intersection. Accurate definitions were set up for four measures of performance, which can be named as follows: stopped delay, time-in-queue delay, approach delay and percentage of vehicles stopping and interrelationships among the four measure of performance.

Then Hurdle provided the traffic engineers with a paper in order to serve as preliminary; though, familiar with capacity estimation techniques, these engineers have not proficiently used delay equations (Hurdle, 1984). What is noteworthy about the presented methods in that time was their disregard of how the delay changes with the time or their attempt to adapt to the changes in ways that are more mathematical application of common sense than mathematical models of traffic signal system. He realized that none of the models examined can be relied upon to give truly steady and exact results. To acquire such results, one would not require simply better models but rather better data about traffic patterns.

At that point, based on field data, and discussed required modifications, (Lin, 1989) assessed the reliability of the HCM 1984 procedure. Stopped delay was measured at seven intersections and compared with the HCM evaluation of delay. It was discovered that the system has a tendency to overestimate stopped delay at reasonably well-timed signal operations. Even in the case which correct cycle length and green durations were utilized as inputs, the inconsistency between the HCM assessments and the observed delays was large.

This study (Teply, 1989) inspected two methodologies for measuring delay, a time- space diagram and queuing diagram. It was deduced after describing many different issues connected to each that a precise and exact measuring of delay is almost impossible. Dowling examined how replacing most of the required field input data with the default values recommended by HCM influence the accuracy (Dowling, 1994). The outcomes which after the average stopped delay was computed for six signalized intersections, demonstrated that users could gain reliable estimate of intersection LOS and delay utilizing only field-measured turning movements, lane geometry, and signal timing in addition to the HCM-recommended defaults for the remaining required input data.

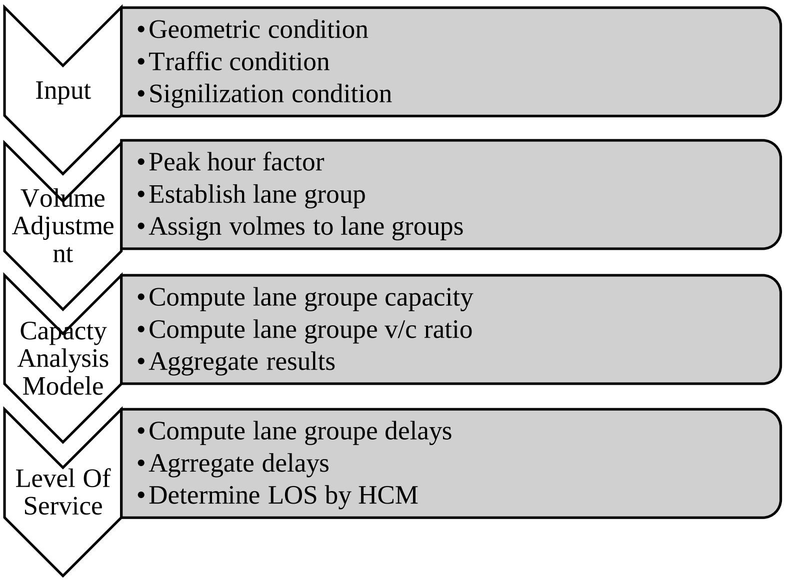
Afterward, the techniques for determining the average stopped delay at signalized intersection were inspected by Braun & Ivan. During afternoon peak hour, the average stopped delay which was experienced by vehicles at eight signalized intersections was measured. Then, by making use of the equations described in the 1994 version of the HCM, the average stopped delay is determined. Moreover, in order to identify the improvements recognized by applying these new techniques, the 1985 HCM equations were utilized to calculate the average stopped delay. The peak hour flow rates are determined as well as intersection geometry and signal phasing, amid the field estimation. At that point, the stopped delay was evaluated utilizing the 1985 HCM and the 1994 HCM equations. Error between field measurement and calculated values was analyzed and a few clarifications were presented for the major difference. A few proposals were additionally given concerning the use of delay equations. (Braun & Ivan, 1996)

As a further matter, Ko also inspected the gathering of signalized intersection delay data utilizing the vehicles outfitted with global positioning system (GPS) technology Their procedure included algorithms for assessing the acceleration profiles and speed profiles to automatically single out and indicate the critical control delay points, for example the deceleration onset points and accelerating ending points. This automated procedure gives way to analyzing of large data sets and presents steady results. In spite of that, while handling over-capacity conditions and closely spaced intersections, the methodology encountered some problematic points. (Ko, et al., 2007).

2.5 Delay Components in LOS by HCM

Delay, according to HCM, is one of the most basic measures of performance used for the purpose of evaluation the LOS at signalized intersections. The average control delay brought on the vehicles at signalized intersections is an essential criterion in the assessment of LOS. The procedure of LOS calculation is shown at Table 2.2

Table 2.2 The procedure of LOS calculation (HCM, 2010)



The HCM version 2010 proposed the method to determining control delay, which is based on the direct observation of the vehicle in queue counts at signalized intersection. The delay that was accomplished by all the vehicles that arrive during the examination period is demonstrated as an average control delay, which is presented in Equation 2.1.

$$d = d_1 + d_2 + d_3 \tag{2.1}$$

Where:

d = control delay (s/veh),

d_1 = uniform delay (s/veh),

d_2 = incremental delay (s/veh), and

d_3 = initial queue delay (s/veh)

2.5.1 Uniform Delay

The uniform delay is established upon the uniform arrivals trough the cycle with no individual cycle failures. Arrivals are indeed selected from the most often platooned and best random as a result of coordinated signal systems.
Equation 2.2 represents the formula to calcute uniform delay.

$$d_1 = \frac{0.5C(1-g/C)^2}{1-[\min(1,X)\,g/C]} \tag{2.2}$$

Where:

d_1 = delay due to uniform arrivals (s/veh)

C = cycle length (second)

g= effective green time for lane group (second)

X = Volume / Capacity ratio for lane group

2.5.2 Incremental Delay

Incremental delay is the combination of two delay components. The influence of random is the first segment which can be defined as the cycle by cycle variation in traffic flow that sometimes exceeds the capacity. This delay exhibits the overflow queue towards the end of green interval (i.e., cycle failure). The second component demonstrates delay due to the continuous oversaturation all through the examination period. This delay component takes place when the aggregate demand exceed aggregate capacity amid the analysis period. Incremental delay can be calculated by Equation 2.3.

$$d_2 = 900T[(X-1)+\sqrt{(X-1)^2+\frac{8KIX}{cT}}] \quad (2.3)$$

Where:

d_2 = delay due to random arrivals (s/veh),

T = duration of analysis period (hour),

K = delay adjustment factor that is dependent on signal controller mode,

I = upstream filtering/metering adjustment factor,

c = lane group capacity (veh/hr),

X = v/c ratio for lane group.

2.5.3 Initial Queue Delay

The initial queue delay is the extra delay that happens due to the initial queue. This queue happened due to un-met demand in the previous phase or series of phases The initial queue does not involve any vehicles that possibly remain in queue because of random; cycle by cycle fluctuations in demand after that rarely exceeding capacity. If no lane group has this delay, the initial queue can be considered as 0.0 s/veh. This delay can be calculated by Equation 2.4.

$$d_3 = \frac{3600}{\upsilon T}(t_A \frac{Q_b + Q_e - Q_{eo}}{2} + \frac{Q_e^2 + Q_{eo}^2}{2c_A} - \frac{Q_b^2}{2c_A}) \quad (2.4)$$

With:

If $\upsilon \geq c_A$ then: $\begin{bmatrix} Q_e = Q_b + t_A(\upsilon - c_A) \\ Q_{eo} = T(\upsilon - c_A) \\ t_A = T \end{bmatrix}$

If $\upsilon < c_A$ then : $\begin{bmatrix} Q_{eo} = 0.0 \cdot veh \\ t_A = Q_b/(c_A - \upsilon) \leq T \end{bmatrix}$

Where:

d_3 = delay due to initial queue delay (s/veh)

T = duration of analysis period (hour),

υ = demand flow rate (veh/h),

t_A = adjustment duration of un-met demand in the analysis period (hour),

c_A = average lane group capacity (veh/h),

Q_b = initial queue at the start of the analysis period (veh),

Q_e = initial queue at the end of the analysis period (veh),

Q_{eo} = initial queue at the end of the analysis period when $\upsilon > c_A$ and Q_b=0.0 (veh).

2.6 Software Usage in LOS Evaluation

In order to have a better assistance in planning, designing and operating the transportation system, the traffic simulation is used as the mathematical modeling through the application of computer. Simulation of transportation system began over 40 years ago. Many different studies have been carried out with the end of simulating the traffic for the analysis of LOS of urban transportation system. These researchers (Lin & Su, 1994) have added to a method to determine LOS for main-line toll plaza. That method depends intensely upon a computer simulation model referred to as toll-plaza simulation model (TPSIM). Such dependence on computer simulation reflects the recognition of the restrictions of analytical model, popularity and computing power of personal computer. A good macroscopic technique for assessing and measuring the LOS at a toll plaza was dictated by (Klodzinsk & Al-Deek, 2002). Based upon the field research and data analyses, the 85th percentile of the cumulative individual vehicular delay was discovered to be the most comprehensively complete measure for assessing the LOS at a toll plaza.

TPSIM was utilized to create various and alternative percentages of electronic toll collection usage and plaza configurations. An LOS hierarchy was set up based on the concluded results of this analysis and referred to the HCM (2000). At that point, through Synchro simulation (Kazemi Afshar & Tuydes-Yaman, 2014) studied the effect of a constriction large health campus on LOS of surrounded eight intersections. It evaluates current LOS around health campus and then predicts traffic flow after project and evaluates future LOS of sounded intersections.

Preceding the improvement of micro-simulation models, analytical methods were typically used in studies to design and improve the roadway facilities. These strategies can predict the capacity, LOS, delay and other different parameters for an arrangement of the roadway conditions (Akcelik & Rouphail, 1993)

2.6.1. Synchro

Synchro Studio is a software package with all the necessary and appropriate parts for modeling, managing, optimizing and simulating traffic systems.

Synchro Studio v.9 is a software suite involving the following elements:

- Synchro, a macroscopic analysis and optimization program;
- SimTraffic, a powerful, easy-to-use traffic micro-simulation software application;
- 3D Viewer, a three-dimensional view of SimTraffic simulations;

Synchro , as indicated by Synchro v.9 user manual, is a deterministic tool which is given progression by the Trafficware, and is fundamentally used for modeling traffic flow, traffic signal progression, and optimization of traffic signal timing. Furthermore, Synchro may possibly be used to assess the signalized intersections, and the unsignalized intersections. Synchro should only be utilized in analyzing intersections, arterials, and corridors and there is no possibility of its being used for analyzing freeways, interchange systems, or ramps. (Synchro, 2014)

Synchro can use two different techniques for analyzing intersections. The first methodology, which is called Intersection Capacity Utilization (ICU), calculates the capacity of an intersection, and was intended to handle planning level studies, for example future roadway design, traffic impact studies, and congestion management programs. While ICU does not estimate delay, it can be employed to predict how frequently an intersection could experience congestion. The ICU method cannot be considered as an acceptable approach to be employed as a part of this study.

HCM, as the second technique, is used to analyze the intersection operations depend on total control delay. Practically, the HCM method is the favored procedure for all types of signilized and unsignilized intersection operational analyses. The significant distinction between the two procedures is the Measures of Effectiveness used. While, the ICU methodology takes into acount the volume-to-capacity (v/c) ratios, the HCM methodology is in view of the control delay. This thesis use HCM method in order to calculate LOS of intersection. Figure 2.2 demonstrates the progression of modeling and LOS calculation of Synchro.

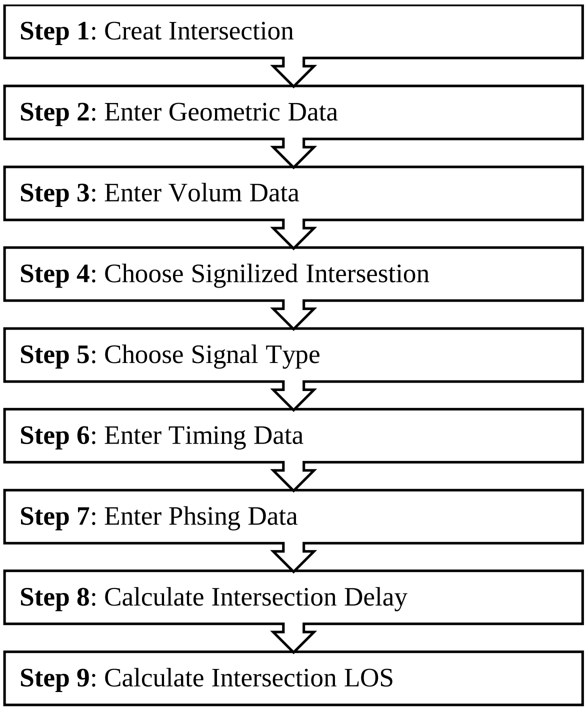


Figure 2.2 The step of LOS calculation according to Synchro v.9

2.6.2 TripGen

Trafficware has lately acquired Microtrans, which are recognized widely for their TripGen planning software. TripGen 2014 is a tool that computes trip generation in view of the Version 8 and 9 of ITE's Trip Generation Manual. The analyst can choose the independent variable that he needs and afterwards can determine the generated volumes by making use of the rates or equations found in the Trip Generation Manual. The following section shows the available trip generation data:

- Average Weekday 2-Way Trips (Daily)
- AM Peak Hour of Adjacent Street Traffic
- PM Peak Hour of Adjacent Street Traffic
- AM Peak Hour of Generator
- PM Peak Hour of Generator
- Saturday Average 2-Way Trips (Daily)

- Saturday Peak Hour
- Sunday Average 2-Way Trips (Daily)
- Sunday Peak Hour

As far as the user has not chosen the use equation, the average trip rate will be employed for the whole calculations. Based on the local or regional studies, the software permits users to enter in custom trip rates. This product was utilized to calculate future trip generation of heath campus. The calculated trip generation volumes were used as a part of Synchro and Vistro. (TripGen, 2014)

2.6.3 PTV Vistro

PTV Vistro v.2 is a complete traffic analysis solution; it provides you with the complete and important tools to fulfill the traffic engineering and transportation planning studies and assessments. According to Vistro v.2 User Manual, PTV Vistro can make comprehensive assessments of the impacts, optimization and re-timing of the traffic signals, evaluation of the intersection LOS, and production of the report-ready tables and figures. This makes it a helpful instrument for a wide range of sorts of traffic and transportation studies, and spares the time for you through its all-encompassing functionality.

Vistro is where the signalized intersection strategies from the HCM 2010 are implemented in. The intersection geometry is deconstructed into lane groups, which are the fundamental unit of investigation in the HCM method. A lane group is a lane or set of lanes designated for separate analysis. Each intersection proceed can possibly contain one or more lane groups. Subsequent to calculating the volumes and capacities for each lane group, different performance measures are calculated, which involve the average control delay per vehicle, the v/c ratios, the level of service and queues. (Vistro, 2014)

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CHAPTER 3

ETLIK INTEGRATED HEALTH CAMPUS PROJECT

3.1 Study Area Details

The Project site cuts across two districts: Keçiören and Yenimahalle. Districts are further sub-divided into "Mahalle". The project site falls inside Varlık Mahalle, which extends towards the south of the project site. Also, the health campus area is surrounded by five additional Mahalles:

- Aşağı Eğlence Mahallesi (Keçiören) to the east and north-east;
- Ayvalı Mahalle (Keçiören) to the north;
- Yunusemre Mahalle (Yenimahalle) to the north-west;
- Yeni Çağ Mahalle (Yenimahalle) to the west; and
- Işınlar Mahalle (Yenimahalle) to the west.

These are represented in Figure 3.1. The residential houses which exist inside of the Mahalles do not directly face the project block except in a few locations. Most residential housing is buffered from the proposed health campus by the public buildings and facilities that are neighboring the project block. The municipality predicts that approximately 35,000-40,000 occupants living inside of the Mahalles are inside of 500m of the project site (AEHC, 2014). Table 3.1 shows the population of district around project block.

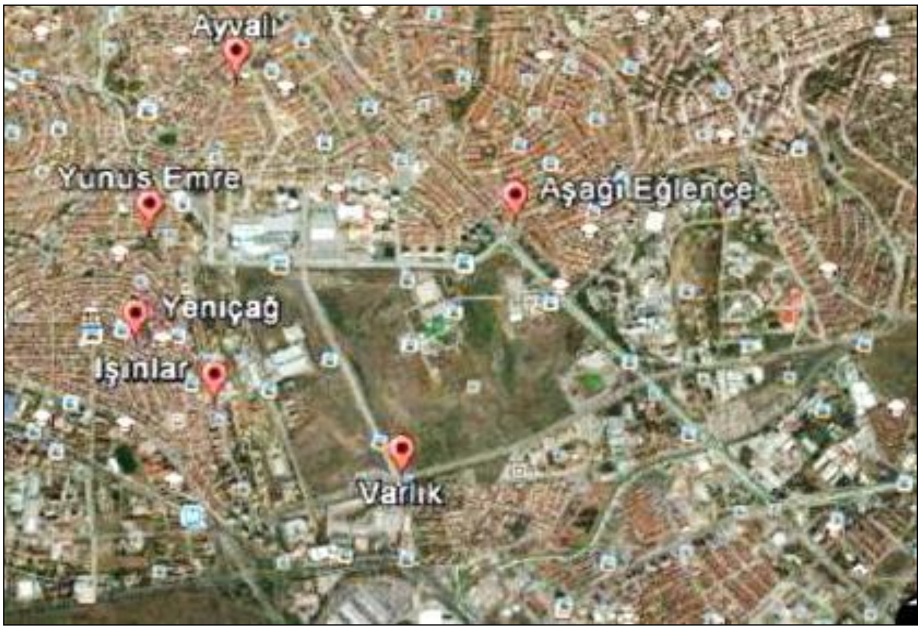

Figure 3.1 Neighborhoods around the project area (Google Map/Earth, 2014)

Table 3.1 Population of district around project site (Ankara Master plan, 2014)

Mahalle	District	Population
Ayvalı Mahalle	Keçiören	42,841
Aşağıeğlence Mahalle		28,656
Varlık Mahalle	Yenimahalle	11,250
Yeni Çağ Mahalle		4,689
Işınlar Mahalle		9,714
Yunusemre Mahalle		10,171
Total		**107,321**

The project site is surrounded by major arterials, which involve: Akşemseddin Street towards the west; Halil Sezai Erkut Street toward the north; Etlik Street toward the east; and Eşref Bitlis Street toward the south. As it is illustrated in Figure 3.2, the project site is surrounded by a sort of public buildings as well as popular public amenities,. These are likewise recorded in Table 3.2. There are many commuters, shoppers and users of these public facilities that are considered as part of the project.

Figure 3.2 Built environment around and within the project block (Google Map/Earth, 2014)

Table 3.2 Facilities near the project site (Ankara Master plan, 2014)

Name of the Surrounding Infrastructure, Building etc.	Location	Remarks
Antares AVM and Residence	North	Shopping mall and private housings
Metro Grossmarket	North	Market for shopping
Yildirim Beyazit University	North	Campus area with a population of c.750
Turgut Ozal University	North	Campus area with a population of c.1000
Park, Cafe and Sport Facility	North	A small leisure center with an area of 2 ha
Diskapi Yildirim Beyazit Policlinics	Northeast	Policlinic
GATA	East	Military Medical Academy and Hospital
DSI (GD of State Hydraulic Works) Social Facilities	Southeast	Social facilities for the staff of DSI
Ankara Province Special Administration	South	Founded in line with Special Provincial Administration.
KGM (State Road Authority) Facilities	South	Workshops of KGM for parking and maintenance of their heavy machineries
Ankara Metropolitan Municipality (MM) Heliport	Southwest	Heliport
MM’s Workshops (Parks, Gardening, Heavy Machinery Park)	West	Workshop of Ankara MM for machineries used in cleaning services in the city, plantation nursery for gardens and parks

There are ten intersection surround the Etlik health campus. Categorizing intersection according to importance of intersections such as direct connection to project area and distance to exit gate of project (See Figure 3.3). Then, last two set of intersections were eliminated from study, A9 and A10. The remained intersection divided to two groups. First group contains the intersection that impact directly from project trip generation (e.g. A2, A3, A6 and A7). Second group contain the intersections that impact indirectly (e.g. A1, A4, A5 and A8). Table 3.3 shows the link length between intersections.

Table 3.3 Link length between intersections (Km)

Northern Corridor					Southern Corridor				
ID	A1	A2	A3	A4	ID	A5	A6	A7	A8
A1	0	0.30	1.03	1.42	A5	0	0.46	1.07	1.48
A2	0.30	0	0.73	1.12	A6	0.46	0	0.60	1.04
A3	1.03	0.73	0	0.39	A7	1.07	0.60	0	0.42
A4	1.42	1.12	0.39	0	A8	1.48	1.04	0.42	0

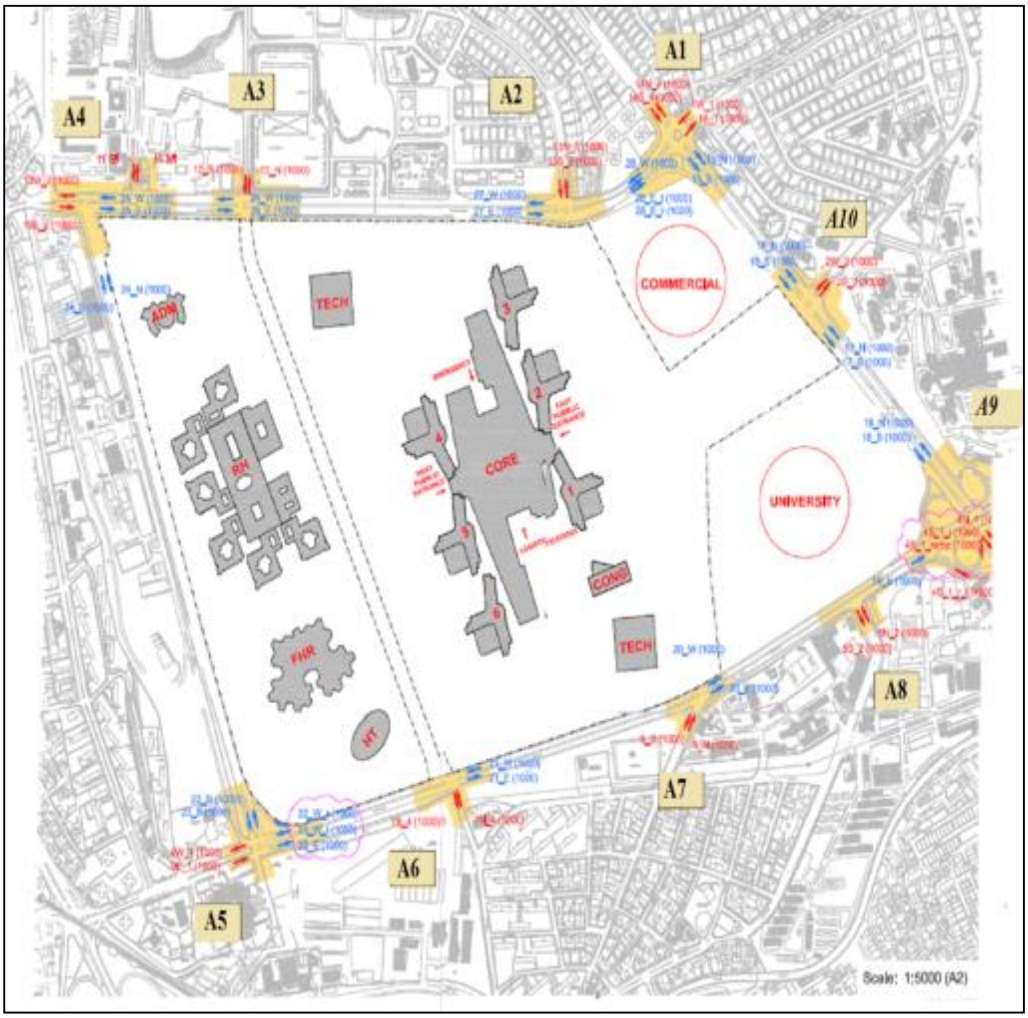

Figure 3.3 Intersections A1-A8 around the Health Campus

Ankara Metropolitan Municipality has prepared the "2023 Master Plan of Ankara the Capital", according to which the two health complexes are intended to be constructed in northern and south western Ankara. Within the master plan, it is explained that the area with blue hatching (see Figure 3.4) is the health campus area, i.e. the project site.

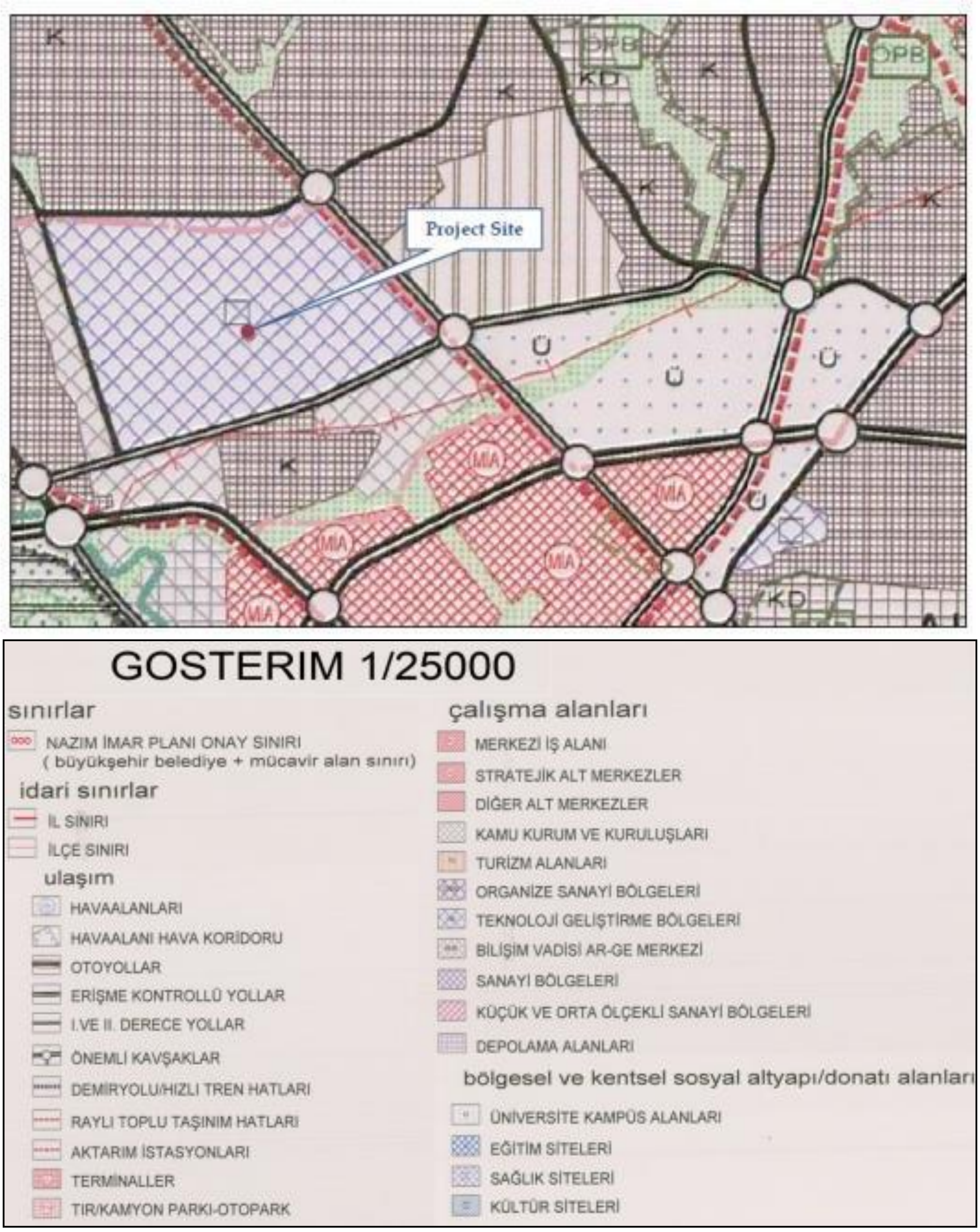

Figure 3.4 Project site in the "2023 Master Plan of Ankara the Capital" (Ankara Master plan, 2014; KGM map, 2014)

The project site is arranged in the city; that is surrounded by the houses, shopping center and other public buildings, e.g. the hospital and school. The site is likewise surrounded by the main arterials at each side. The proposed heath campus is covering the Etlik Maternity Hospital, Polyclinic of the Dışkapı Training & Research Hospital, Etlik Specialist Hospital with a capacity of 400 beds, 3 buildings for living quarters, and archive and storage buildings for the Social Security Agency, two cafes, garage and social recreation facilities. A metro line, which is passing from the south of the project block, is presently under construction. A camp site for subway construction is found neighboring the project site. Moreover, there is a kiosk which is located adjacent to the project at northwest.

3.2 Project Characteristics

Two Health Regions exist in Ankara, namely Etlik and Bilkent regions. The hospitals in Ankara Etlik Region serve 3,615,188 people in Ankara, covering the areas of Çubuk, Elmadağ, Kalecik, Akyurt, Pursaklar, Altındağ, Yenimahalle and Keçiören. A couple of regions neighboring Ankara are also within the Etlik region, namely Çorum (population of 535,405), Kırıkkale (population of 276,647), Kırşehir (population of 221,876) and Yozgat (population of 476,096). The Etlik district at present has 32 hospitals with a total bed capacity of 10,855 (AEHC, 2014). Table 3.4 below presents the current bed capacities of the hospitals in the Etlik Region.

Table 3.4 Current capacity of Etlik region hospitals by ownership (AEHC, 2014)

Source of Hospital	Number of Hospital	Capacity of Bed	Proportion (%)
State	22	8,171	75.27
Private	6	397	3.66
University	4	2,287	21.07
Total	32	10,855	100

Once the project is operational, twelve existing state hospitals will be closed and the employees of these hospitals will be assigned to Etlik and Bilkent health campuses. It should be noted that Table 3.4demonstrates the total number of beds including Ankara and nearby provinces within the Etlik region whereas Table 3.5 represents the bed capacity only within the Etlik region.

Table 3.5 Current Capacity of Etlik Region (AEHC, 2014)

Hospital Name to be transferred to Etlik	Bed Capacity
Dr. Zekai Tahir Burak Maternity H.	540
Ankara Training And Research H.	550
Atatürk Chest Diseases T&R H.	519
Turkey Yüksek İhtisas H.	500
Dr. Sami Ulus Maternity And Child H.	418
Ankara Ch,Ld Hematooncology H.	322
Keçiören Training And Reseacrh H.	308
Ankara Physical Therapy and Rehabilitation H.	270
Yenimahalle State H.	200
Gazi Mustafa Kemal State H.	160
Occupational Diseases H.	104
Ulucanlar Eye H.	101
Ulus State H.	100
Total	**4,092**

The project block has experienced significant in-migration over the last 50 years. The Ayvalı Mahalle population has significantly raised up because of the establishment of new institutions, for example the hospitals, universities and the Antares shopping mall. The Muhtar of Ayvalı Mahalle predicts that 80% of the occupants in Ayvalı are immigrants from different Districts of Ankara and also from the cities of Çankırı, Çorum and Sivas. Yunusemre Mahalle has almost the same immigrant population characteristics as Ayvalı Mahalle. In Yeni Çağ, Işınlar and Aşağıeğlence Mahalle, the Mukhtars predict that 65%-70% of the residents are immigrants from Yozgat (220km from Ankara), Çorum (244km), Çankırı (135km), Sivas (444km) and Kırıkkale (82km) cities. (AEHC, 2014; Akdag, 2010)

3.3 Project Area Traffic Characteristics

An integrated health campus with a total bed capacity of 3566 will be built in Etlik region, which is an already urbanized region in Ankara, Turkey. With an expected usage by 50,000 people, the health campus is expected to have a big impact on not only the neighborhood but also its traffic. The location of the campus surrounded with 10 major intersection and 4 major arterials. The campus area is area surrounded by two urban corridors (Halil Sezai Erkut Cad. in the north and Eşref Bitlis Cad. in the south) and served by six 3-legged and two 4-legged signalized intersections. As the project is a large health campus including emergency services, it is important to assess its accessibility at these intersections under existing LOS. But, it is even more important to estimate the expected LOS with after the opening of the health campus.

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CHAPTER 4

METHODOLGY

4.1 LOS Evaluation Approach

LOS for signalized intersections in HCM 2010 was explained in terms of average control delay. The data that is needed for the estimation of average control delay is classified into three main sections: geometric, traffic and signalization. Data must be collected at different times a day and weekday versus weekend because this is a health complex with 7/24 accessibility need. The data that depict the geometry of intersection is referred to as geometric conditions for example the number of lanes, lane width, grade and so on. Signalization is a component depicting the signalization conditions of intersections for example the green time and cycle length (Kazemi Afshar & Tuydes-Yaman, 2014; HCM, 2010).

Each leg of signalized intersection has the possible movement patterns of the right turning, the through and the left turning traffic (HCM, 2010). This study uses a microscopic simulation study to identify LOS and initial queue delay on six 3-legged and two 4-legged signalized intersections at Etlik, Ankara. Three peak periods were modeled; morning, noon, and evening. Microscopic simulation modeling is done in PTV Vistro and Synchro simulation environment. The procedure for obtain the current and future LOS along the selected intersections are shown in Figure 4.1.

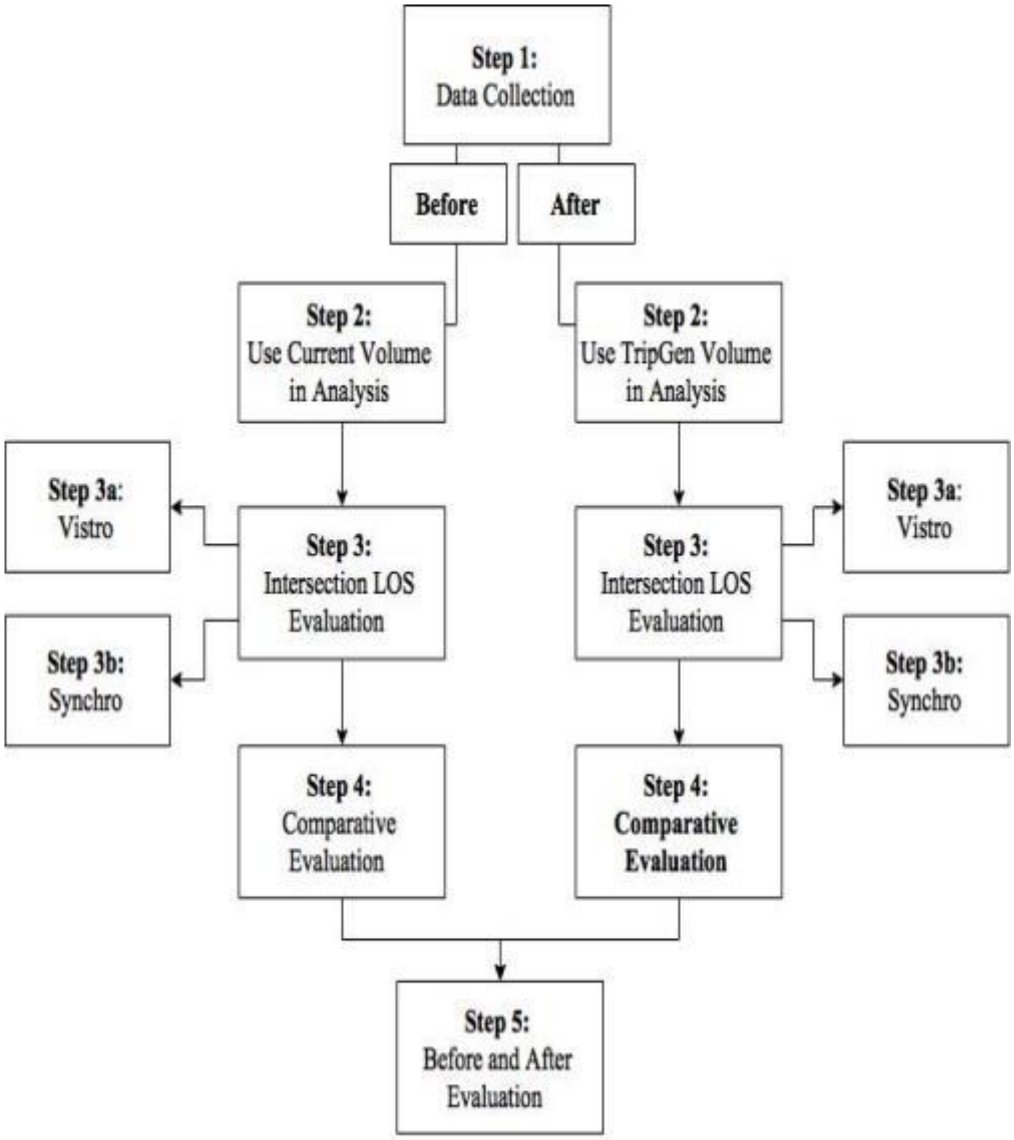


Figure 4.1 Procedure for obtain the LOS before and after project

4.1.1 Geometric Configuration and Design Features

Information on the geometric configuration and design features for each of the signalized intersections in the sample was organized in a large and detailed dataset. Most of the information on these features had been obtained back in 2012. Google Earth (2014) was accessed to refine and to determine additional parameters. Google Earth is one of the most practical and efficient aerial imagery tools available; this software application permitted an easy access to each signalized intersection's actual location, information that could be retrieved by the respective "ID" assigned to the intersection (e.g. A1, A2, etc.). Figure 4.2 displays the demonstration in Google Earth of the "A2 " 3-legged signalized intersections in the project area; the components, for example the number of lanes, orientation of both major and minor roads, and additionally the existence of signs, medians, markings and such, can be retrieved through the display. For all intersections sees Appendix A.

Figure 4.2 Satellite image of signalized intersection "A2" (Ayvalı Cad. with Halil Sezai Erkut Cad.) (Google Map/Earth, 2014)

Due to the large amount of features within the aforementioned dataset, an educated selection of the variables that would be most relevant to the study was made. Table 4.1 shows the geometry configuration of intersection around study area. Then comes the details on the content of the final dataset:

- *Intersection ID*: A unique name given to each signalized intersection (e.g. A1, A2, etc.); this ID was created for the purposes of this study only.
- *KM distance*: Number showing the distance between signalized intersection along a road from the project area (e.g. 4.73, 6.24, etc.); this value provided by the Google Earth ruler tool.
- *Direction:* Indicates the orientation/direction of the signalized intersection's major road (e.g. West-East, North-South, etc.)
- *Location:* Indicate the location of the intersection toward project location.(e.g. Southern corridor , Northern corridor)
- *Major and Minor Roads:* Indicates the names of the major and minor roads making the signalized intersection (e.g. Tanzimat Cad., Afra Sok., etc.); in this study, "Cad." indicates major road and "Sok." shows minor roads.
- *Number of Through Lanes*: Indicates the observed total number of through lanes along the major and minor roads creating the signalized intersection.
- *Number of Right-Turn Lanes*: Indicates the observed total number of right-turn lanes along the major and minor roads creating the signalized intersection
- *Speed Limit*: Indicates the observed speed limit (in Km per hour) along the major and minor roads creating the signalized intersection.

Table 4.1 Geometry configuration of intersections around study area

ID	Position	Major/ Minor	Direction	Speed (Km/h)	Control Type	Location	Intersection Type
A1	Etlik Cad. *with* Halil Sezai Erkut Cad.	Two major	West-East North-South	50	Signalized intersection	Northern corridor	4- legged
A2	Ayvalı Cad. *with* Halil Sezai Erkut Cad.)	Two major	West-East	50	Signalized intersection	Northern corridor	3- legged
A3	Afra Sok. *with* Halil Sezai Erkut Cad.	One major One minor	West-East	50	Signalized intersection	Northern corridor	3- legged
A4	150 Sok. *with* Halil Sezai Erkut Cad. *with* Akşemsettin Cad	Two major One minor	West-East North-South	50	Signalized intersection	Northern corridor	4- legged
A5	Eşref Bitlis Cad *with* Akşemsettin Cad	Two major	West-East	50	Signalized intersection	Southern corridor	3- legged
A6	Eşref Bitlis Cad *with* Trakya Cad	Two major	West-East	50	Signalized intersection	Southern corridor	3- legged
A7	Eşref Bitlis Cad *with* Beypazarı Cad	Two major	West-East	50	Signalized intersection	Southern corridor	3- legged
A8	Eşref Bitlis Cad *with* Tanzimat Cad.	Two major	West-East	50	Signalized intersection	Southern corridor	3- legged

4.1.2 Signal control details

Through the video recording and survey, the data which is related to the signal timing of each intersection was obtained. The cycle length and green time of each intersection are different along weekdays and weekend. Table 4.2 shows the brief summary of signal and phasing of intersections at “28.03.2012”. Next is a connection of the most relevant data provided by these arrangements:

- *Phase (Ø)*: Represents the number of main phases for a given cycle; there is a phase per approach (Eastbound, Westbound, Northbound and Southbound) and per left-turning movement (Eastbound Left, Westbound Left, Northbound Left and Southbound Left). The phasing sequence of each turning movement varies per signalized intersection.

- *Split*: Represents the duration (in seconds) of an single phase; there is a split per approach (Eastbound, Westbound, Northbound and Southbound) and per left turning movement (Eastbound Left, Westbound Left, Northbound Left and Southbound Left).
- *Direction:* Represents the basic movements (8 in total) that are allowed at the intersection; there is a direction per approach (Eastbound, Westbound, Northbound and Southbound) and per left-turning movement (Eastbound Left, Westbound Left, Northbound Left and Southbound Left).
- *Clearance*: Represents the length of yellow times (in seconds) for the signalized intersection; there is a clearance time per approach (Eastbound, Westbound, Northbound and Southbound) and per left-turning movement (Eastbound Left, Westbound Left, Northbound Left and Southbound Left).
- *Red:* Represents the length of all-red times (in seconds) for the signalized intersection; there is a red time per approach (Eastbound, Westbound, Northbound and Southbound) and per left-turning movement (Eastbound Left, Westbound Left, Northbound Left and Southbound Left).
- *Cycle Length*: Represents the minimum and maximum length (in seconds) allowed for a specific cycle and/or coordination pattern, resulting from the summation of the respective phases' time splits.
- *Time:* Represents the time at which a specific time split starts at the signalized intersection (e.g. 9:00, 15:00, 23:00, etc.)
- *Day*: Represents the day(s) on which a specific cycle and/or coordination pattern takes place at the signalized intersection.

Table 4.2 Signal control designs of study intersections (as of 28.03.2012)

28.03.2012				
ID	**Position**	**Time**	**Cycle enght(s)**	**Phase(Ø)**
A1	Etlik Cad. with Halil Sezai Erkut Cad.	Am	105	4
		Noon	95	
		Pm	120	
A2	Ayvalı Cad. with Halil Sezai Erkut Cad.	Am	105	2
		Noon	95	
		Pm	120	
A3	Afra Sok. with Halil Sezai Erkut Cad.	Am	105	3
		Noon	95	
		Pm	120	
A4	150 Sok. with Halil Sezai Erkut Cad. with Akşemsettin Cad.	Am	105	4
		Noon	95	
		Pm	120	
A5	Eşref Bitlis Cad with Akşemsettin Cad.	Am	105	3
		Noon	95	
		Pm	120	
A6	Eşref Bitlis Cad with Trakya Cad.	Am	105	3
		Noon	95	
		Pm	120	
A7	Eşref Bitlis Cad with Beypazarı Cad.	Am	105	3
		Noon	95	
		Pm	120	
A8	Eşref Bitlis Cad with Tanzimat Cad.	Am	105	3
		Noon	95	
		Pm	120	

4.1.3 Turning Movement Counts and Approach Volume

Through the video camera that was set on the intersection to record an unobstructed viewpoint of all approaches and turning movements, the traffic volume data have been gathered. At that point the vehicles in the videos were counted and required data was extricated. These volumes were recorded for 15-minute intervals and covered the times of the day to be examined in this study . This sort of information supplements the two other intersection information sorts (i.e. geometric arrangement/design components and signal timing) along with the purpose of performing the respective LOS calculations for different periods of the day. Figure 4.3 and Table 4.4 represent a part of the results at A2 intersection. For all days and intersections sees Appendix B. Following is a connection of the data contained in the traffic count documents:

- *Approach:* Shows the signalized intersection's approach for which particular traffic counts have been collected (e.g. Eastbound, Westbound, Northbound and Southbound).
- *Traffic counts:* Shows the total traffic counts collected for the signalized intersection; there is traffic count data collected per approach (Eastbound, Westbound, Northbound and Southbound) and per turning movement (Left, Through and Right).
- *Time:* Shows the time at which a particular 15-minute traffic count started (e.g. 7:00, 7:15, 7:30, 7:45, and 8:00, etc.)

There is a considerable high share of minibuses and minivans (mostly working as school, corporate workers' shuttle services) in the area. The vehicles in this category are labeled as "M" for vehicle category, whenever shown together. If minibus and minivans were reported separately, "M" used to denote specifically the par transit vehicles working on predefined routes in the area, while the latter was denoted by a "V" to represent either private or personal use of a minibus. See Table 4.3 for vehicle class notations.

Table 4.3 Vehicle class notations

Vehicle Type	Notation
Car	**C**
Minibus (a special par transit service)	**M**
Minivan	**V**
Bus	**O**
Light Duty Trucks	**K**
Heavy vehicles	**X**

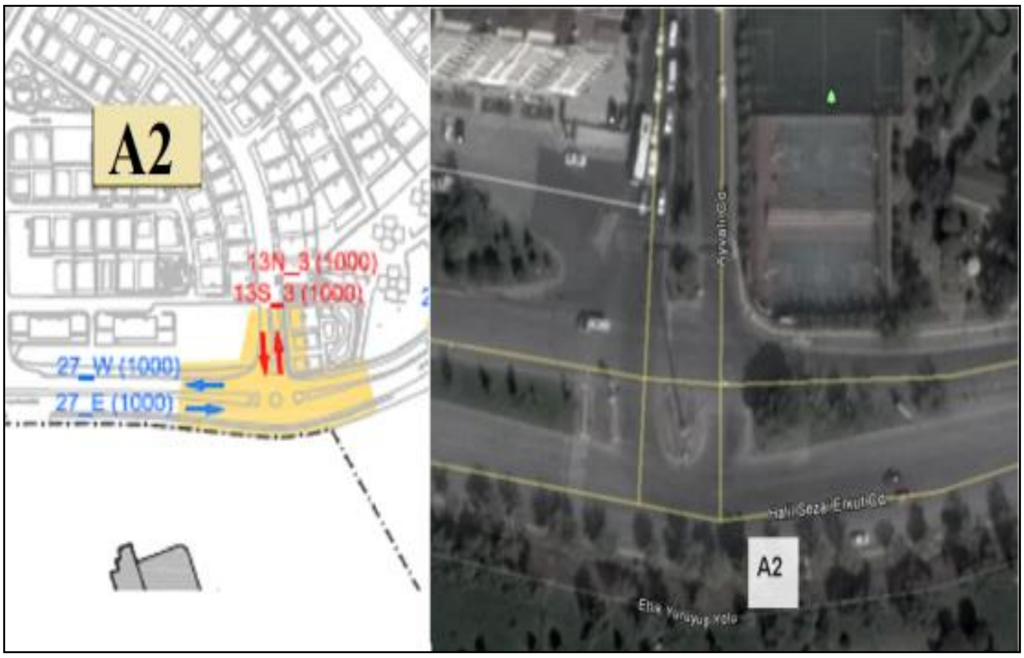


Figure 4.3 Name and direction of approach at A2 intersection

Table 4.4 Part of the traffic counting results at A2 intersection

A2													
28.03.2012								28.03.2012					
PM	**0-15**							**PM**	**0-15**	**15-30**	**30-45**	**45-60**	
Point	**C**	**M**	**V**	**O**	**K**	**X**	**∑**	**Point**	**∑**	**∑**	**∑**	**∑**	**Total**
27_E	203	16	0	4	3	0	**226**	**27_E**	226	271	308	305	**1110**
27_W	186	26	0	0	0	0	**212**	**27_W**	212	273	363	311	**1159**
13N_3	55	5	0	2	1	0	**63**	**13N_3**	63	66	67	78	**274**
13S_3	71	13	0	4	0	0	**88**	**13S_3**	88	91	110	100	**389**

4.2. Data Collection

The agreed methodology included traffic counts/video recordings performed in two phases as follows:

- **Phase I:** First week observations on a weekday

  This stage included a single weekday survey for three periods: morning peak, midday and evening peak. As the peak periods were not known clearly, the count duration for these periods were kept as 1.5hour, 1.5 hours and 3 hours, respectively.

- **Phase II:** Second week observations on a weekday and a weekend day
  This stage included a single weekday survey and a single weekend day survey for morning peak, midday and evening peaks of 1 hour duration. The start time of the morning and evening peak periods are determined by the analysis of the traffic counts in Phase I.

Upon the availability of traffic count permission and traffic count teams, the traffic count surveys were performed on the schedule shown in Table 4.5.

Six 3-legged and two 4-legged intersections serving the proposed Etlik Health Campus area have pre-timed signal control operating in 3 phases with permitted and protected condition for right turns. The data were collected in two working days and one weekend at three times (morning, noon and evening). The analysis of the first week count revealed the peak hours which were used in the second week data collection to determine the existing signal phasing, cycle length from the video. Also, six different vehicle (carrier) types were observed at the intersection; passenger cars, minibuses, minivan (12-18 passengers capacity), buses, van and trucks. Finally, the total traffic volume counts (including all 6 types of vehicles) for the eight study intersections for morning, noon and evening period.

Table 4.5 Traffic survey plans

Weekday 1 : Wednesday, March 28th , 2012			
Period	**Duration**	**Time Interval**	**Method**
AM Peak	1.5 hours	7:30-9:00	Video recording
Noon	1.5 hours	12:00-13:30	Video recording
PM Peak	3 hours	16:30-18:00 18:00-19:30	Manual Count Video recording
Weekday 2 : Wednesday, April 4th, 2012			
AM Peak	1 hour	7:75-8:45	Video recording
Noon	1 hour	12:30-13:30	Video recording
PM Peak	1 hour	17:15-18:15	Video recording
Weekend day: Saturday, April 7th, 2012			
AM Peak	1 hour	9:00-10:00	Video recording
Noon	1 hour	12:30-13:30	Video recording
PM Peak	1 hour	17:00-18:00	Video recording

The number and locations of the cameras are shown in Figure 4.4 for the traffic counts. The most accessorized intersections were A1 (with 3 cameras) and A5 (with two cameras, whenever possible). These intersections required more cameras because either a) they had wide design areas and/or b) separate movements such as right turns in the clovers.

Some of the cameras used were borrowed from an intelligent transportation systems company on METU Campus, the Integrated System and Systems Design (ISSD), and these cameras (shown with darker markers) have industrial size zooms and lenses which enabled capturing of larger areas with fewer cameras without losing selected movements. As a result, the A1 intersection was covered with 3 cameras. (A note: deciphering of these cameras took longer than the personal use cameras, as there were more movements in a frame). Figure 4.4 shows the location and number of the camera for traffic count.

Figure 4.4 Layout of the video camera recording in the Campus Area (Google Map/Earth, 2014)

The main comments about the traffic count days could be summarized as follows:

- Students recording videos were provided with manual count sheets and were asked to continue manually whenever they had a recording problem (such as battery problems, camera malfunctions, etc.)
- At some locations, manual counts were performed to capture movements that were not included in cameras (due to the geometry of the intersection, parked cars etc.)
- Most of the cameras run out of battery in the 3-hr evening peak of the Phase II. Students were switched to manual counts.
- Due to a short heavy rain and hail in the evening peak, traffic stopped for about 15-20 minutes at around 18:00-18:15 pm. Students were asked to seek shelter during the hail and wait. Majority of the recordings continued after 18:15 pm.
- Industrial size cameras were very sensitive to motions and had problems when used on shoulders, instead of fixed features; these caused some temporary problems in the videos but, they were not big enough to ruin recordings or deciphering. Some of these cameras had malfunctions and did not provide data but the missing movements mostly were captured from the nearby camera, if available.

4.3 Intersection LOS Analysis

In this study, two set of intersection must be monitored for LOS. First set of intersections includes the intersection that directly connected to study area. According to plan of health campus, A2, A3, A6 and A7 are exit gate of health campuses. Thus, this intersection affected directly. The second set includes A1, A4, A5 and A8, should be studied to see potential backup in corridor. Two software (Vistro and Synchro) were used to evaluate LOS of the project. In order to determine future trip generation, data of Tripgen software was used.

Data needs for various traffic analysis tools are summarized below:

- Traffic volume
- Speed (free flow speed, running speed, average speed, turning speed)
- Posted speed limit
- Parking characteristics (on-street parking presence and type, bus stops)
- Signal phasing and timing plans
- Detectors types and their location
- Intersection control type
- Arrival type
- Right turn and left turn treatments
- Lane restriction for vehicles or time of day

4.3.1 Intersection LOS by PTV Vistro

PTV Vistro was produced particularly for traffic investigation and helps transportation planners and traffic engineers with their projects and tasks. It provides quick and easy network setup, efficient data entry, and automated report generation. Vistro is a complete transportation planning software program that examines the transportation network macroscopically. The transportation system is characterized as traffic nodes, links, and zones; and different assignment are involved to perform traffic flow analysis. Moreover, different sorts of transportation modes can be defined within a single assignment. (See Figure 4.5)

For the micro traffic simulation, PTV Vistro is supported by Vissum, which analyzes private and public transport operations under the certain constraints such as, traffic composition, traffic signals, and lane configurations. By using volume data all vehicle and signals in microscopic model are simulated. Figure 4. 6 “a” part shows the model of “A2” intersection in Vistro. The “b” part of Figure 4. 6 shows the simulation of “A2” intersection in Vissim that exported from Vistro. Furthermore, PTV Company provides PTV Vissig to simulate and optimize the green time. (Vistro, 2014)

Figure 4.5 Screenshot of main window of Vistro v.2

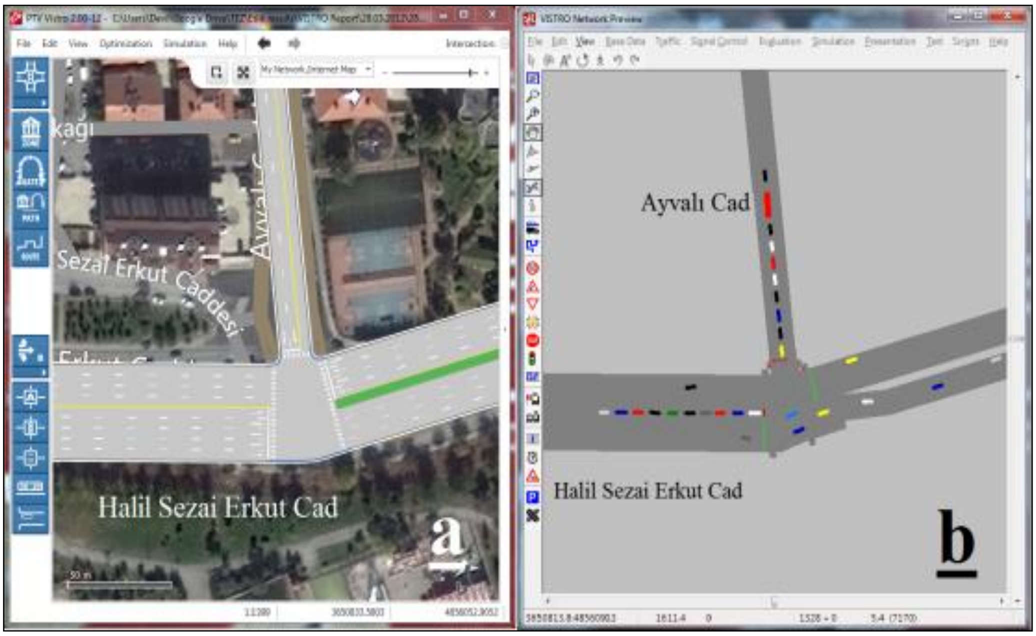


Figure 4.6 Screen shot of simulation of "A2" a) in Vistro b) in PTV Vissim

The LOS and delay of signalized intersections were assigned to the traffic simulation environment by utilizing Vistro. Initially, the street system was drawn in Vistro as far as the links, nodes and zones. The daily traffic volume was separated into three sub-branches, which are morning, evening and noon off-peak, and after that assigned to the traffic system to get the LOS and the delay of intersections. Toward the end of the analysis the total delays of the each intersections at the morning, evening, and the noon off-peak periods were calculated, which were later use to predict the future and current LOS of the study area. Figure 4. 7 demonstrate the 3D recreation of "A2" intersection.

Figure 4.7 3D simulation of “A2” intersection

4.3.2 Intersection LOS by Synchro

Synchro is a macroscopic analysis tool which is utilized to plan and design, model and analyzes the signalized and unsignalized intersections. The product optimizes the traffic signal timings for isolated intersection, roads or a network.

It utilizes three techniques to analyze the signalized intersections: Intersection Capacity Utilization (ICU), HCM Signalized Method and Synchro Percentile Delay. This study utilized the HCM signalized method. Figure 4.8 demonstrates the primary window of Synchro v.9.

SimTraffic is a micro simulation device which models singular vehicles interactions and supply the animation of the model in a network. In order to perform the microscopic traffic simulation, SimTraffic uses direct data from Synchro. SimTraffic is able to model the signalized and unsignalized intersections and highway segment. At the point when a 3D Viewer application is utilized, the expert could change over a two-dimensional (2D) model from SimTraffic to a three-dimensional (3D) animation. Figure 4. 9 presents the main window of SimTraffic. (Synchro, 2014)

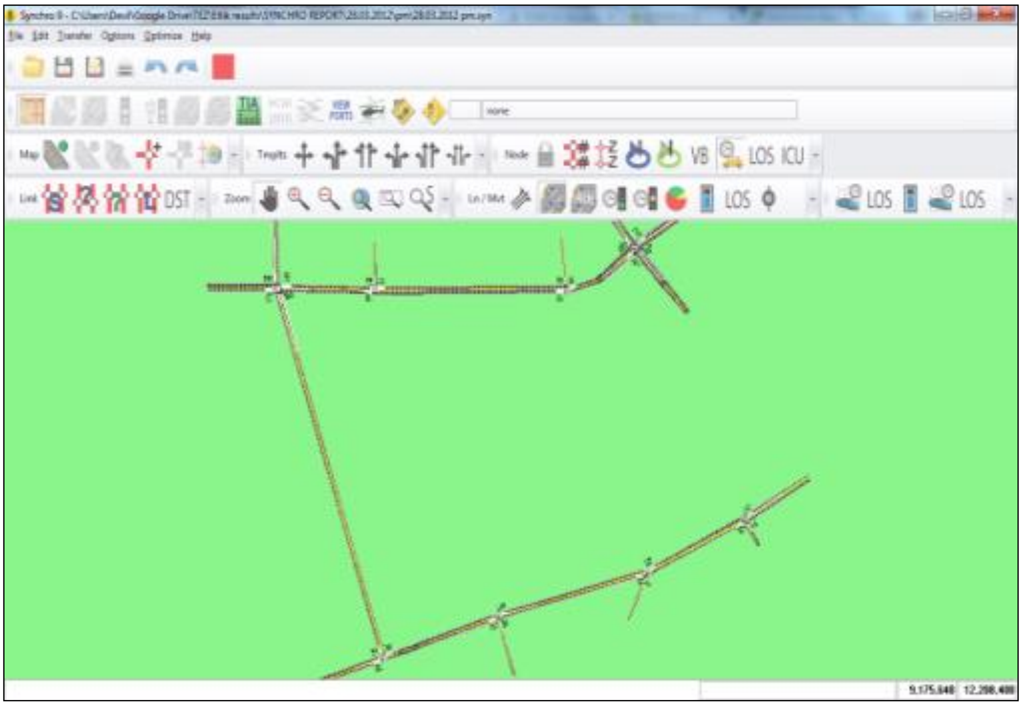


Figure 4.8 Main Window of Synchro v.9

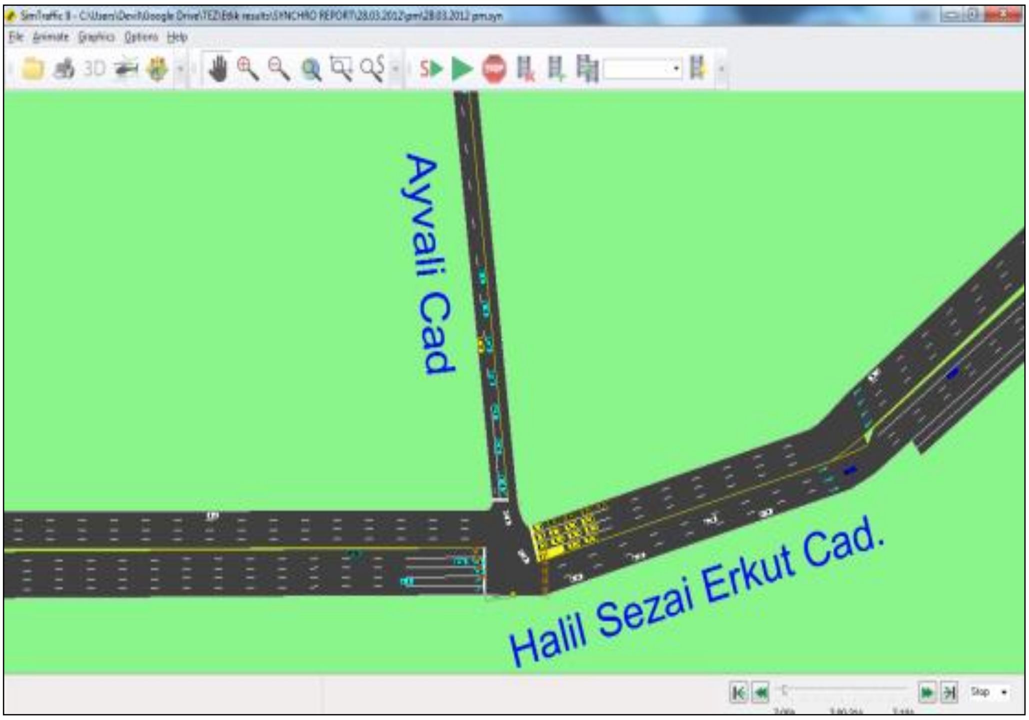
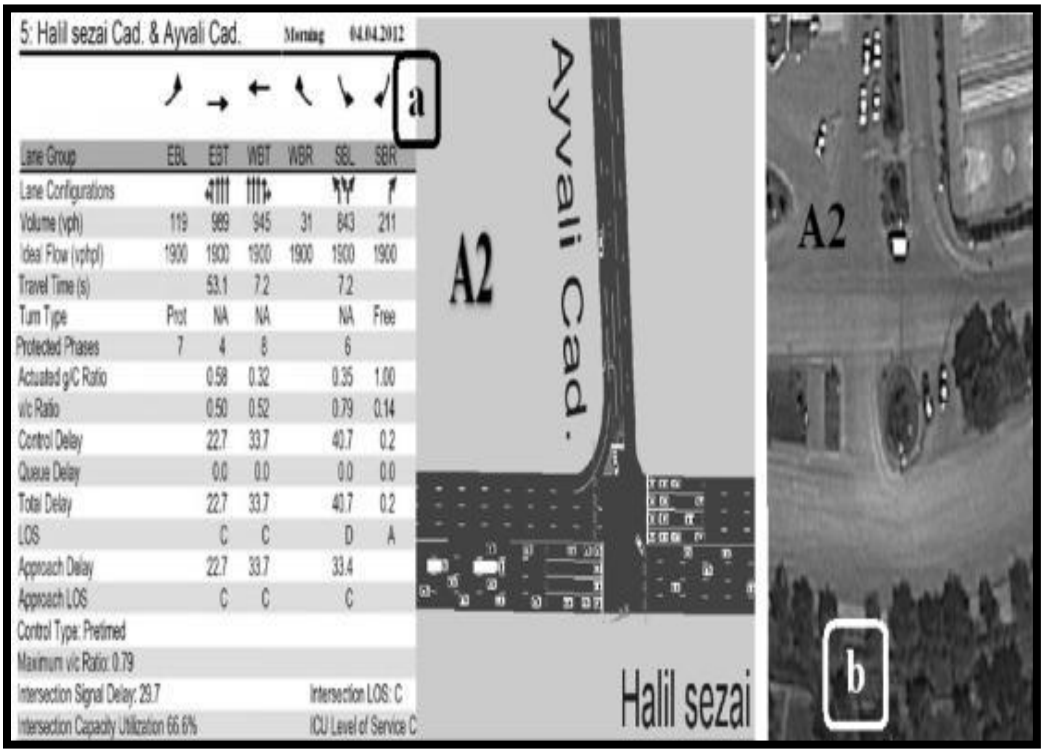


Figure 4.9 Screen shot of SimTraffic main window at "A2"

On the urban streets where contiguous signalized intersections have impact each other and there is a possibility of the need for the signal optimization or simulation, Synchro is used to analyze traffic system. Synchro is additionally utilized for operational analysis projects which include signal re-timing, corridor operational assessments, and capacity analysis of the individual intersections (signalized, unsignalized, or indirect).

The data that derived from video recordings did not show the queue and length of the queue, so traffic is simulated in software, to determine average control delay. Figure 4.10, “a” part, shows one of the results and reports that Synchro calculated for A2 interstation at morning peak. The studied intersections had a more local design which is basically a signalized roundabout (see Figure.4.11 “b” part). To study this peculiar design in the simulation environment, we assumed a basic signalized intersection in Synchro, with an imaginary left-turn lane to represent the vehicle storage at the roundabout (see Figures 4.10).


5: Halil sezai Cad. & Ayvali Cad. Morning 04.04.2012

Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (vph)	119	989	945	31	843	211
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Travel Time (s)		53.1	7.2		7.2	
Turn Type	Prot	NA	NA		NA	Free
Protected Phases	7	4	8		6	
Actuated g/C Ratio		0.58	0.32		0.35	1.00
v/c Ratio		0.50	0.52		0.79	0.14
Control Delay		22.7	33.7		40.7	0.2
Queue Delay		0.0	0.0		0.0	0.0
Total Delay		22.7	33.7		40.7	0.2
LOS		C	C		D	A
Approach Delay		22.7	33.7		33.4	
Approach LOS		C	C		C	

Control Type: Pretimed
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 29.7 Intersection LOS: C
Intersection Capacity Utilization 66.6% ICU Level of Service C

Figure 4.10 a) Screenshot from Synchro analysis result b) Photo of "A2" intersection

CHAPTER 5

CASE STUDY: PROPOSED HEALTH CAMPUS IN ETLIK, ANKARA

5.1 Data Collection

A traffic survey study was performed in the scope of the proposed project in order to determine the peak hour periods for the mornings and evenings, to determine current traffic volume on the surrounding roads of the project site.

5.1.1 Turning Movement Counts and Approach Volumes

A comprehensive and detailed study has been completed in order to identify the current condition of traffic during the rush hours in the surrounding nodes and arteries. In the setting of the study, 15-minute traffic counts were made utilizing cameras. This study focused on 8 intersections named A1 through A8. The location and direction of A2 intersection are shown at Figure 5.1. Table 5.1 shows traffic volume per hour of each approach at different day. For more detailed data about each intersection and traffic volume of each direction check Appendix B.

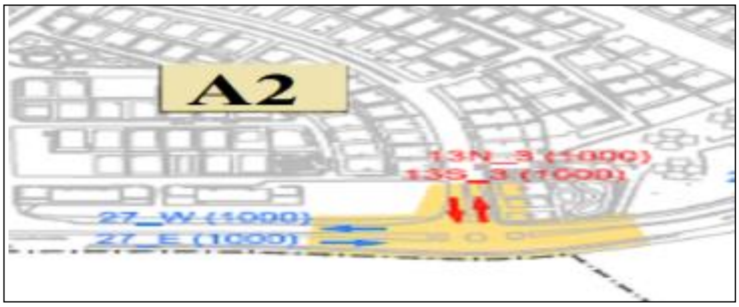


Figure 5.1 Location and direction of "A2" intersection (Ayvalı Cad. with Halil Sezai Erkut Cad.)

Table 5.1 One hour traffic volume of "A2" intersection (vehicle per hour)

A2	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
27_E	2105	989	635	984	882	1031	1167	1087	1343
27_W	1672	945	866	1132	922	1051	947	1010	1193
13N_3	151	150	172	226	148	226	228	153	344
13S_3	158	1054	655	528	476	531	398	458	598

A traffic survey study was performed in the scope of the proposed project in order to determine the peak hour periods for the mornings and evenings, to determine current traffic volume on the surrounding roads of the project site.
The health campus will operate in two shifts. During the daytime shift there will be 5,274 employees including doctors and nurses while total number of employees in both day and night shifts within a 24-hour period will be 10,339. On weekdays, there are e0stimated to be 3,500 patients assuming 98% occupancy and an estimated 20,000 outpatients, 800 emergency patients and 13,067 visitors. (AEHC, 2014; Akdag, 2010; Ankara Master plan, 2014)

5.1.2 Signal control details

Signal control details were obtained from video recording. According to videos, cycle length of intersections changed toward day time and weekdays. The phase setting and signal timing of the intersection is shown in Table 5.2 to 5.5 (G= Split/Green time, Y= Clearance/Yellow time, R=Red time, C=Cycle length). In Direction Colum, symbols were shorted as these methods: S=South, W=West, N=North, E=East, T=Through, L=Left, R=Right, B=Bound and "/" means "+", Ø = Phase)

Table 5.2 Signal control details of Northern intersections at Weekdays (Sec.)

Weekdays(Northern Corridor)														
ID	Time		AM				Noon				PM			
	Ø	Direction	G	Y	R	C	G	Y	R	C	G	Y	R	C
A1	Ø1	SWT/R+NET/L	21	3	1	105	21	3	1	95	31	3	1	120
	Ø2	SWL	6	3	1		6	3	1		6	3	1	
	Ø3	NWT/R+SWT	51	3	1		46	3	1		56	3	1	
	Ø4	NWL+SWL	11	3	1		6	3	1		11	3	1	
A2	Ø1	SWR+EBL	66	3	1	105	56	3	1	95	81	3	1	120
	Ø2	EBL2+SBL/R	31	3	1		31	3	1		31	3	1	
A3	Ø1	EBT+WBT	51	3	1	105	51	3	1	95	51	3	1	120
	Ø2	EBT/L	21	3	1		11	3	1		21	3	1	
	Ø3	SBL/R	21	3	1		21	3	1		36	3	1	
A4	Ø1	WBT+EBT/R/L	31	3	1	105	26	3	1	95	36	3	1	120
	Ø2	WBT/L	26	3	1		21	3	1		26	3	1	
	Ø3	SBL/T/R	16	3	1		16	3	1		21	3	1	
	Ø4	NBL/T/R	16	3	1		16	3	1		21	3	1	

Table 5.3 Signal control details of Southern intersections at Weekdays (Sec.)

Weekdays(Southern Corridor)														
ID	Time		AM				Noon				PM			
	Ø	Direction	G	Y	R	C	G	Y	R	C	G	Y	R	C
A5	Ø1	EBT+WBT/R	51	3	1	105	46	3	1	95	61	3	1	120
	Ø2	EBT/L	21	3	1		21	3	1		21	3	1	
	Ø3	SBL/R	21	3	1		16	3	1		26	3	1	
A6	Ø1	WBT+EBT/R	46	3	1	105	41	3	1	95	61	3	1	120
	Ø2	WBT+NBL	26	3	1		21	3	1		21	3	1	
	Ø3	WBL	21	3	1		21	3	1		26	3	1	
A7	Ø1	SWR+EBL/R	51	3	1	105	46	3	1	95	66	3	1	120
	Ø2	SWR/T	21	3	1		16	3	1		21	3	1	
	Ø3	NET/L	21	3	1		21	3	1		21	3	1	
A8	Ø1	SWT+NET	51	3	1	105	46	3	1	95	61	3	1	120
	Ø2	SWT/L+NWR	31	3	1		26	3	1		11	3	1	
	Ø3	NWL	11	3	1		11	3	1		36	3	1	

Table 5.4 Signal control details of Northern intersections at Weekend (Sec.)

Weekend (Northern Corridor)														
ID	Time		AM				Noon				PM			
	Ø	Direction	G	Y	R	C	G	Y	R	C	G	Y	R	C
A1	Ø1	SWT/R+NET/L	21	3	1	105	21	3	1	95	31	3	1	120
	Ø2	SWL	6	3	1		6	3	1		6	3	1	
	Ø3	NWT/R+SWT	51	3	1		46	3	1		56	3	1	
	Ø4	NWL+SWL	11	3	1		6	3	1		11	3	1	
A2	Ø1	SWR+EBL	66	3	1	105	56	3	1	95	81	3	1	120
	Ø2	EBL2+SBL/R	31	3	1		31	3	1		31	3	1	
A3	Ø1	EBT+WBT	51	3	1	105	51	3	1	95	51	3	1	120
	Ø2	EBT/L	21	3	1		11	3	1		21	3	1	
	Ø3	SBL/R	21	3	1		21	3	1		36	3	1	
A4	Ø1	WBT+EBT/R/L	31	3	1	105	26	3	1	95	36	3	1	120
	Ø2	WBT/L	26	3	1		21	3	1		26	3	1	
	Ø3	SBL/T/R	16	3	1		16	3	1		21	3	1	
	Ø4	NBL/T/R	16	3	1		16	3	1		21	3	1	

Table 5.5 Signal control details of Southern intersections at Weekends (Sec.)

Weekend(Southern Corridor)														
ID	Time		AM				Noon				PM			
	Ø	Direction	G	Y	R	C	G	Y	R	C	G	Y	R	C
A5	Ø1	EBT+WBT/R	41	3	1	85	41	3	1	85	51	3	1	105
	Ø2	EBT/L	21	3	1		21	3	1		21	3	1	
	Ø3	SBL/R	11	3	1		11	3	1		21	3	1	
A6	Ø1	WBT+EBT/R	41	3	1	85	41	3	1	85	46	3	1	105
	Ø2	WBT+NBL	16	3	1		16	3	1		26	3	1	
	Ø3	WBL	16	3	1		16	3	1		21	3	1	
A7	Ø1	SWR+EBL/R	36	3	1	85	36	3	1	85	51	3	1	105
	Ø2	SWR/T	16	3	1		16	3	1		21	3	1	
	Ø3	NET/L	21	3	1		21	3	1		21	3	1	
A8	Ø1	SWT+NET	36	3	1	85	36	3	1	85	51	3	1	105
	Ø2	SWT/L+NWR	16	3	1		16	3	1		311	3	1	
	Ø3	NWL	21	3	1		21	3	1		11	3	1	

5.2 Intersection LOS Determination

At the final step, all the previously stated data have been utilized in Synchro and Visto in order to predict delay and LOS of each approach and intersections. This section of the study demonstrates the current LOS around proposed health campus that gained from the simulation software. The following part gives a detailed description of a typical LOS calculation, as it was carried out for the study. It is to be noted that such a calculation was made for each period of the day, and for each intersection, considered in the study.

5.1.1 Synchro Modeling

The principal step while utilizing the Synchro was to create a new file, per period of the day to be calculated, demonstrating the type of operational analysis to be performed; particularly, the study discussed about here needed to select the signalized intersections analysis option. Second, draw network and located intersections on the arterials. The option "Modify Phase and Timing" was chosen as the analysis method; this option modifies the signal timing and cycle length and intersection’s protection type. Figure 5.2 shows the satellite image on “A2” intersection and its model in Synchro.

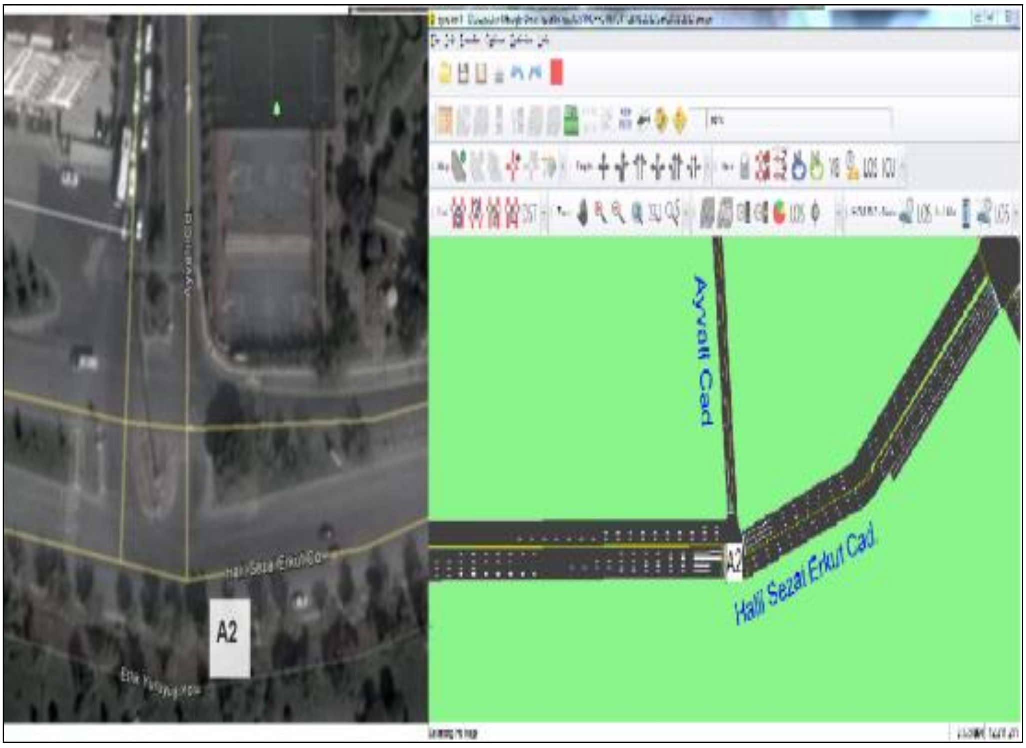


Figure 5.2 The satellite image of “A2” intersection and its model in Synchro

Geometry and Volume

The type of data to be entered for this first stage was the number of outflowing and receiving lanes –all expected to have a width of 3.5 m–, showing whether these are exclusive and/or shared, with respect to the obtainable queue storage lengths for each arterial and segment, these were based on the length of their individual left turn lane(s). Other input data were the respective traffic volumes. All aforementioned data were applied for each approaches of the intersection (i.e. Eastward, Westbound, Northbound and Southbound). Figure 5.3 shows geometry and volume input for "A2" intersection in Synchro. The second and last section of this stage was in view of the saturation flow rate adjustments, an essential part for calculating the final LOS. For instance, this comprised of indicating the saturation flow rate, parameter that was kept at its default value of 1,900 pcphgpl at all instances; likewise, the percent for heavy vehicles was set at 2%. Aside from that, this study did not consider parking maneuvers, bus stops, bicycles and pedestrian. All these assumptions were similarly applied for each approaches of the intersection.

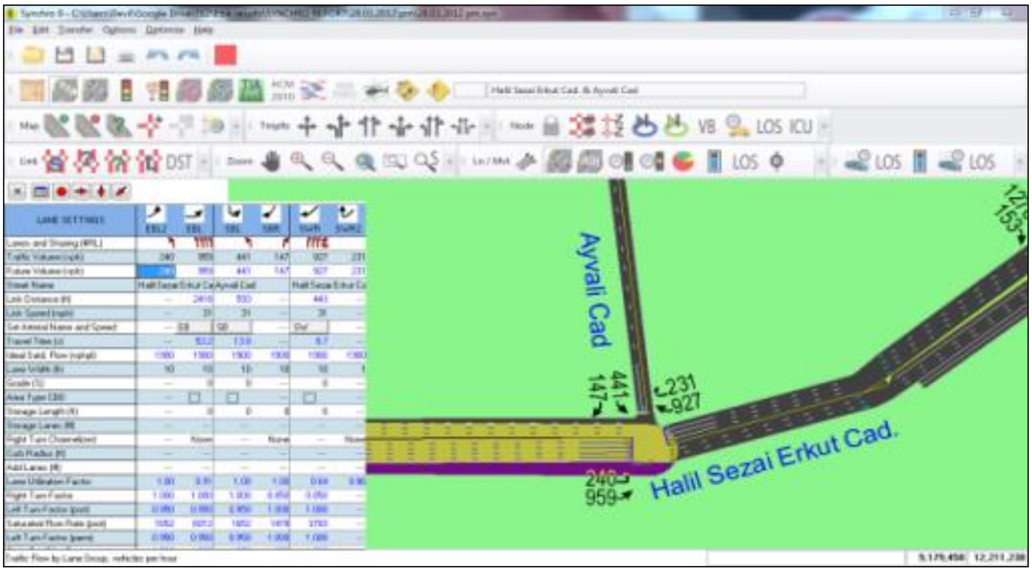


Figure 5.3 Screenshot of gemoetry and volume input for "A2" intersection in Synchro

Phasing Design

The first section of this stage comprised in presetting the respective phasing. Green times, and also clearance and red times were the first input data values. At the same time the total number of phases for each signalized intersections was set within the Synchro software. For this procedure, the respective phase diagram was utilized as it simplified the input of turning movement types acceptable per approach, their sequence (e.g. lead and/or lag, and so on.), type of protection (e.g. protected, permissive and combined). Additionally, since Synchro utilizes some option to optimize cycle length, by locking time for each intersection, this option disabled. Figure 5.4 indicate signal and phase time input for "A2" intersection.

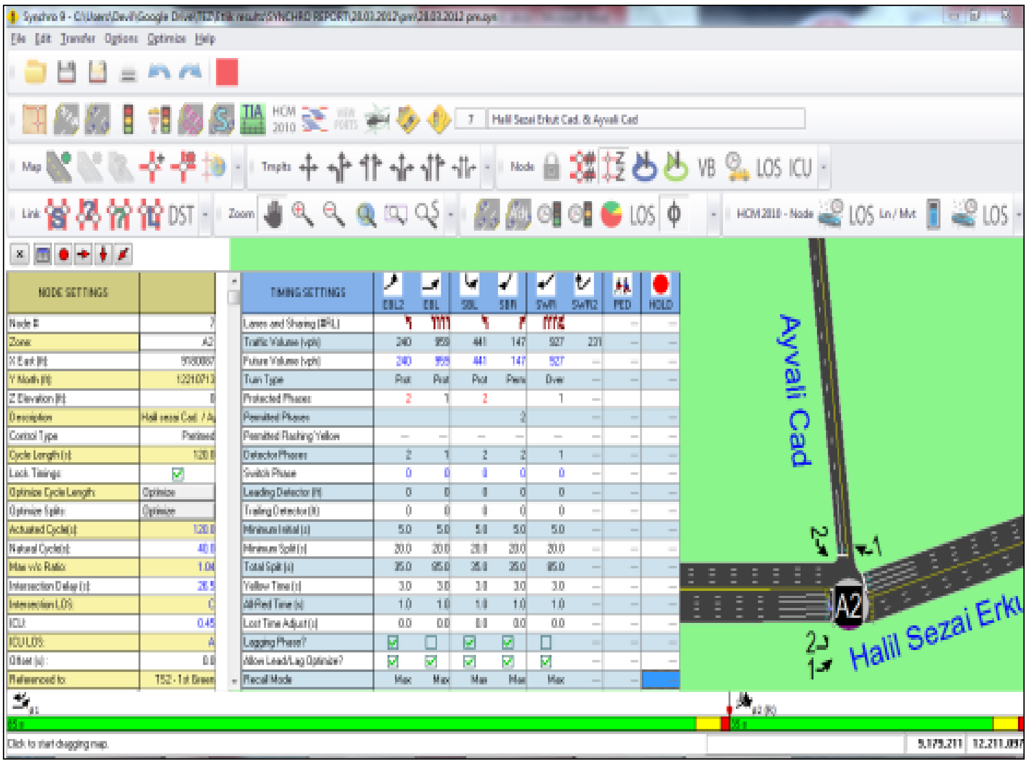
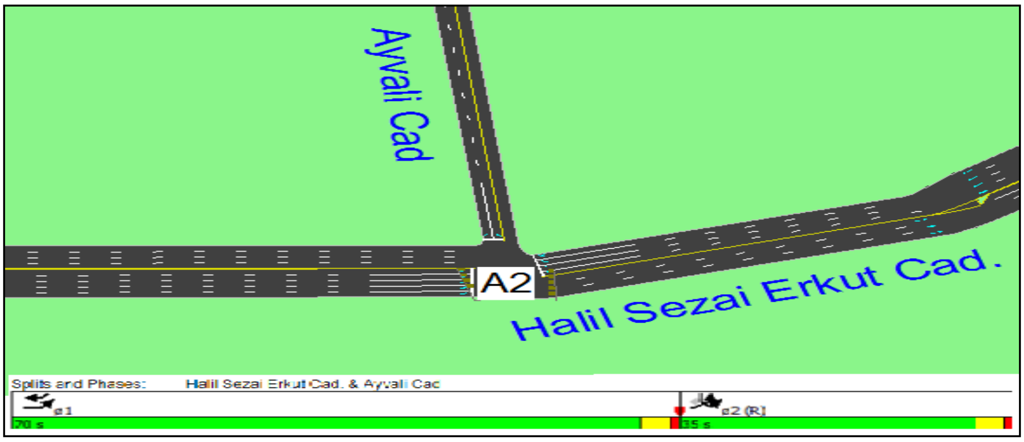


Figure 5.4 Screenshot of signal and phase time input for "A2" intersection in Synchro

Results

Finally, all operational measures which were related to the signalized intersection were provided by Synchro v.9. Specifically this resulted in a more complete source of LOS related information which now contained information on lane group capacity, flow rate, volume to capacity ratio (v/c), delay and LOS. Figure 5.5 demonstrates the phase, signal timing, volume, v/c ratio, delay, LOS of each intersection. The current LOS results of Synchro for all intersection are in Appendix C.



Lanes, Volumes, Timings
Halil Sezai Erkut Cad. & Ayvali Cad

Lane Group	EBL2	EBL	SBL	SBR	SWR	SWR2
Lane Configurations						
Traffic Volume (vph)	58	2105	101	57	1672	151
Future Volume (vph)	58	2105	101	57	1672	151
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
v/c Ratio	0.12	0.56	0.20	0.12	0.76	
Control Delay	25.4	9.5	29.1	16.3	22.4	
Queue Delay	0.0	0.0	0.0	0.0	0.0	
Total Delay	25.4	9.5	29.1	16.3	22.4	
LOS	C	A	C	B	C	
Approach Delay		10.0	24.5		22.4	
Approach LOS		A	C		C	
Protected Phases	2	1	2		1	
Permitted Phases				2		
Detector Phase	2	1	2	2	1	

Intersection Signal Delay: 16.0 Intersection LOS: B
Intersection Capacity Utilization 42.7% ICU Level of Service A
Analysis Period (min) 15

Figure 5.5 Results of Synchro for "A2" intersection at 28.03.2012(AM)

Synchro results display the delay and LOS for each direction and for intersection. According to direction coding that cited in Appendix B, Table 5.6 and 5.7 shows the delay and LOS for each direction at 28.03.2012. Table 5. 8 to 5.13 indicate the current total delay and LOS of all intersection around proposed health campus in Etlik for three studied day by Synchro. Figure 5.6 to 5.8 compare delays of each time period separately.

Table 5.6 Delay and LOS for each direction by Synchro at Nothern Corridor 28.03.2012

ID	Weekdays(Northern Corridor)												
		AM				Noon				PM			
	Direction	v/c	Delay	A. LOS	LOS	v/c	Dela y	A. LOS	LOS	v/c	Del ay	A. LOS	LO S
A 1	14ST	0.76	24	C	C (32)	0.31	14	B	B (19)	0.65	26	C	C (29)
	14SL	**0.92**	**80**	**F**		**0.53**	**53**	**D**		**0.52**	**58**	**E**	
	1WT	**0.46**	**38**	**D**	D (44)	0.41	33	C	C (29)	**0.53**	**39**	**D**	E (76)
	1WL	**0.80**	**79**	**E**		0.33	8	A		**0.99**	**80**	**F**	
	1WR	0.10	1	A		**0.18**	**44**	**D**		0.13	4	A	
	15NT	0.69	23	C	D (36)	0.42	17	B	C (29)	0.57	25	C	D (48)
	15NL	**1.06**	**111**	**F**		**0.97**	**101**	**F**		**1.16**	**81**	**F**	
	15NR	0.19	3	A		0.09	1	A		0.12	4	A	
	28ET	**0.42**	**49**	**D**	E (63)	0.39	30	C	D (36)	0.46	34	C	F (80)
	28EL	**1.07**	**140**	**F**		**0.75**	**64**	**E**		**1.01**	**80**	**F**	
A 2	27ET	0.56	10	A	A (10)	0.22	5	A	B (11)	0.24	4	A	B (12)
	27EL	0.12	25	C		**0.37**	**35**	**D**		**0.56**	**50**	**D**	
	13SL	**0.81**	**43**	**D**	D (35)	0.20	29	C	B (24)	0.30	7	A	E (70)
	13SR	0.20	5	A		0.12	16	B		**0.82**	**81**	**F**	
	27WT	0.76	22	C	C	0.45	16	B	B	0.45	24	C	C
A 3	26ET	0.15	4	A	C (27)	0.26	2	A	A (8)	0.25	6	A	B (18)
	26EL	**0.99**	**82**	**F**		**0.61**	**38**	**D**		**0.82**	**66**	**E**	
	12SL	**0.58**	**46**	**D**	D (46)	**0.83**	**55**	**E**	D (51)	**0.51**	**40**	**D**	D (41)
	12SR	**0.55**	**47**	**D**		0.22	32	C		**0.53**	**41**	**D**	
	26WT	0.48	7	A	A	0.26	4	A	A	0.38	16	B	B
A 4	24NT	**0.77**	**54**	**D**	F (90)	**0.69**	**38**	**D**	E (60)	**0.73**	**61**	**E**	F (91)
	24NL	**1.14**	**130**	**F**		**1.03**	**85**	**F**		**0.99**	**82**	**F**	
	24NR	0.18	10	B		0.16	7	A		0.53	13	B	
	10ET	**0.84**	**44**	**D**	D (38)	0.30	28	C	C (24)	**0.49**	**36**	**D**	C (33)
	10EL	**0.66**	**73**	**E**		0.11	28	C		**0.43**	**45**	**D**	
	10ER	0.35	6	A		0.11	2	A		0.18	7	A	
	25WT	0.36	8	A	B (12)	0.20	7	A	A (9)	0.27	11	B	B (13)
	25WL	0.63	32	C		0.33	20	C		0.34	34	C	
	11ST	**0.80**	**56**	**E**	D (46)	**0.72**	**45**	**D**	D (38)	**0.71**	**54**	**D**	D (45)
	11SL	**0.43**	**46**	**D**		**0.39**	**40**	**D**		**0.43**	**49**	**D**	
	11SR	0.35	14	B		0.32	9	A		0.32	11	B	

Table 5.7 Delay and LOS for each direction by Synchro at 28.03.2012

ID	Weekdays(Southern Corridor)												
		AM				Noon				PM			
	Direction	v/c	Delay	A.LOS	LOS	v/c	Delay	A.LOS	LOS	v/c	Delay	A.LOS	LOS
A5	22WT	0.40	20	B	B	035	11	B	A	0.38	5	A	A
	22WR	0.39	5	A	(16)	0.29	2	A	(4)	0.38	1	A	(9)
	9ET	0.24	5	A	D	0.31	4	A	C	0.27	6	A	C
	9EL	**1.08**	**114**	**F**	(38)	**1.02**	**90**	**F**	(23)	**0.91**	**82**	**F**	(25)
	23SL	**0.65**	**41**	**D**	D	0.13	19	B	B	0.61	51	D	D
	23SR	0.27	15	B	(36)	0.13	14	B	(17)	0.25	23	C	(49)
A6	7NL	**0.82**	**54**	**D**	D	**0.80**	**47**	**D**	D	**0.97**	**64**	**E**	E
	21ET	0.42	13	B	B	0.38	19	B	B	0.51	14	B	B
	21ER	0.28	1	A	(16)	0.26	4	A	(11)	0.34	2	A	(12)
	21WT	0.42	2	A	C	0.42	3	A	B	0.32	14	B	C
	21WL	**1.13**	**108**	**F**	(28)	**0.53**	**40**	**D**	(10)	**0.92**	**81**	**F**	(32)
A7	20ET	0.39	10	A	A	0.33	5	A	A	0.61	15	B	B
	20ER	0.36	3	A	(8)	0.23	1	A	(4)	0.39	3	A	(12)
	20WT	0.90	20	C	D	**038**	**41**	**D**	B	**0.95**	**83**	**F**	C
	20WL	1.13	117	F	(44)	0.39	7	A	(14)	0.45	7	A	(21)
	6NL	**0.38**	**47**	**D**	D	0.11	31	C	C	**0.41**	**52**	**D**	D
	6NR	**0.14**	**36**	**D**	(41)	0.08	39	C	(30)	**0.24**	**45**	**D**	(48)
A8	5NL	**0.75**	**72**	**E**	E	**0.45**	**47**	**D**	D	**0.48**	**38**	**D**	F
	5NR	**0.80**	**50**	**D**	(55)	**0.85**	**53**	**D**	(52)	**0.84**	**81**	**F**	(82)
	19ET	0.64	26	C	C	0.54	18	B	B	**0.81**	**41**	**D**	D
	19WT	0.24	2	A	C	0.29	3	A	A	0.92	26	C	D
	19WL	**1.00**	**66**	**E**	(34)	0.27	28	C	(8)	**0.99**	**82**	**F**	(36)

Table 5.8 Current Total Delay and LOS of Northern Corridor at Morning Peak Hour (using Synchro)

	Northern Corridor		A1	A2	A3	A4
Morning Peak	Day1 (Wed)	Delay(sec/veh)	38.7	16.0	11.6	37.1
		LOS	D	B	B	D
	Day2 (Wed)	Delay(sec/veh)	81.0	21.5	19.5	50.5
		LOS	F	C	B	D
	Day3 (Sat)	Delay(sec/veh)	38.1	18.6	18.0	35.2
		LOS	D	B	B	D

Table 5.9 Current Total Delay and LOS of the Northern Corridor at Noon Off-peak period (using Synchro)

	Northern Corridor		A1	A2	A3	A4
Noon Off-Peak	Day1 (Wed)	Delay(sec/veh)	27.7	21.5	22.5	32.0
		LOS	C	C	C	C
	Day2 (Wed)	Delay(sec/veh)	30.2	19.3	20.0	58.5
		LOS	C	B	B	E
	Day3 (Sat)	Delay(sec/veh)	40.8	23.5	17.2	60.6
		LOS	D	C	B	E

Table 5.10 Current Total Delay and LOS of Northern Corridor at Evening Peak Hour (using Synchro)

	Northern Corridor		A1	A2	A3	A4
Evening Peak	Day1 (Wed)	Delay(sec/veh)	53.0	26.5	21.5	57.7
		LOS	D	C	C	E
	Day2 (Wed)	Delay(sec/veh)	31.4	17.7	19.9	44.9
		LOS	C	B	B	D
	Day3 (Sat)	Delay(sec/veh)	30.0	24.0	25.1	46.5
		LOS	C	C	C	D

Table 5.11 Current Total Delay and LOS of Southern Corridor at Morning Peak Hour (using Synchro)

Morning Peak	Southern Corridor		A5	A6	A7	A8
	Day1 (Wed)	Delay(sec/veh)	28.4	24.5	33.9	33.7
		LOS	C	C	C	C
	Day2 (Wed)	Delay(sec/veh)	30.1	15.3	15.2	25.5
		LOS	C	B	B	C
	Day3 (Sat)	Delay(sec/veh)	16.4	13.7	13.1	31.3
		LOS	B	B	B	C

Table 5.12 Current Total Delay and LOS of Southern Corridor at Noon Off-peak period (using Synchro)

Noon Off-Peak	Southern Corridor		A5	A6	A7	A8
	Day1 (Wed)	Delay(sec/veh)	19.0	17.9	10.2	18.4
		LOS	B	B	B	B
	Day2 (Wed)	Delay(sec/veh)	13.7	17.7	10.8	17.4
		LOS	B	B	B	B
	Day3 (Sat)	Delay(sec/veh)	14.6	11.4	13.0	33.3
		LOS	B	B	B	C

Table 5.13 Current Total Delay and LOS of Southern Corridor at Evening peak Hour (using Synchro)

	Southern Corridor		A5	A6	A7	A8
Evening Peak	Day1 (Wed)	Delay(sec/veh)	19.0	30.6	18.0	55.2
		LOS	B	C	B	E
	Day2 (Wed)	Delay(sec/veh)	20.9	31.8	15.6	46.1
		LOS	C	C	B	D
	Day3 (Sat)	Delay(sec/veh)	25.7	32.6	14.3	36.4
		LOS	C	C	B	D

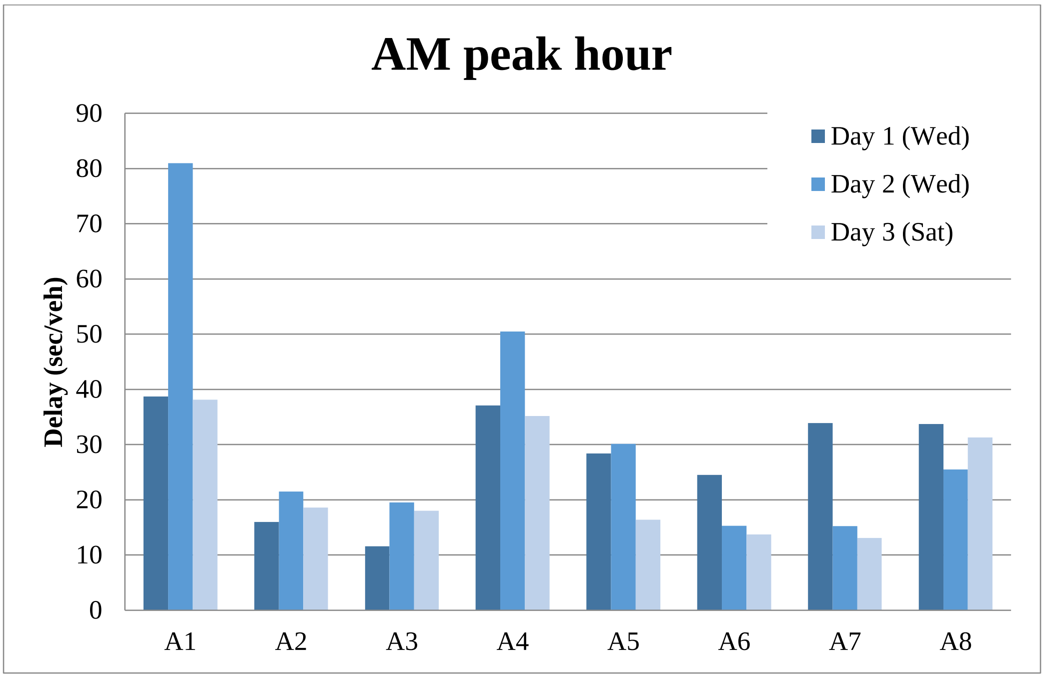


Figure 5.6 Delays in AM peak hour of all intersections in three days by Synchro

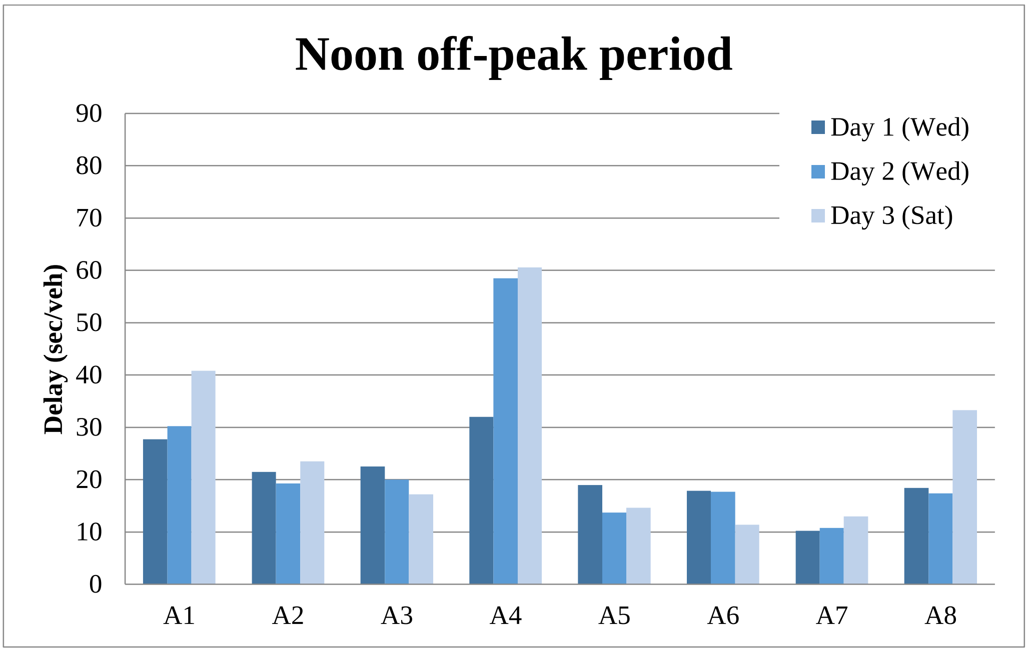


Figure 5.7 Delays in Noon off-peak period of all intersections in three days by Synchro

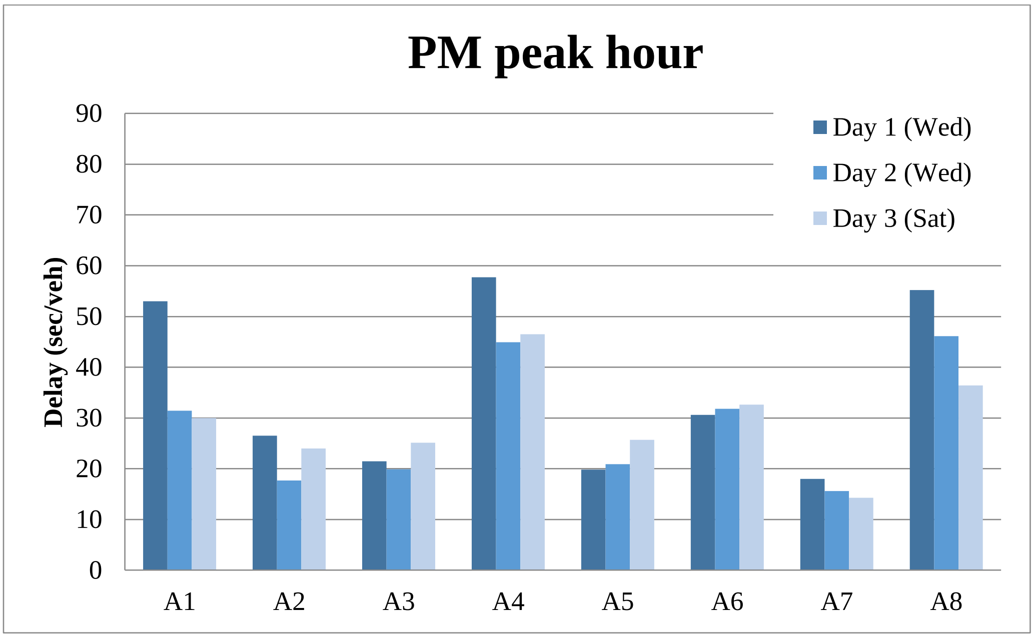


Figure 5.8 Delays in PM peak hour of all intersections in three days by Synchro

5.1.2 Vistro Modeling

Vitsro mostly requires the similar traffic flow and geometric data as Synchro. The system can be utilized to assess the existing traffic signal timing or to optimize the settings for intersections, arteries, or a network. The software performance measures contain blocking analysis average approach delay, intersection delay, v/c ratio, intersection LOS, signal timing settings. total stops, travel time, emissions, and fuel consumption.

The preparation of input data includes speed, percentage of heavy vehicles, different vehicle types, and different existing link types on the road network. These input data would provide as the base information for the signalized intersection simulation. The input data set needed for Vistro network is shown in Table 5.14.

Table 5.14 Input data set for Vistro

Input Data	Description
General Data	Simulation Time
Network Data	Digital images of plan showing the entire study area
	Detailed plans for each junction showing lane markings, signal heads and detectors
Traffic Flow Data	Turn movements for each junction
	Input flow in vehicles per hour
	Traffic Composition
	Vehicle speed at free flow (Speed limit of the road)
	Saturation Flows
Signal Control Data	Cycle Length
	Green, Amber and Red times for each signal group

Creating new file for each period of studied day is first step of using Vistro software. Then arterial images from Bing map selected for project area. After that, the road and intersection were drawn on map. In this step, control type for intersections, was choose as a signalized intersection. The signal timing and cycle length and protects type of intersection modified at last step. Figure 5.9 shows the satellite image on “A2” intersection and its model in Vistro.

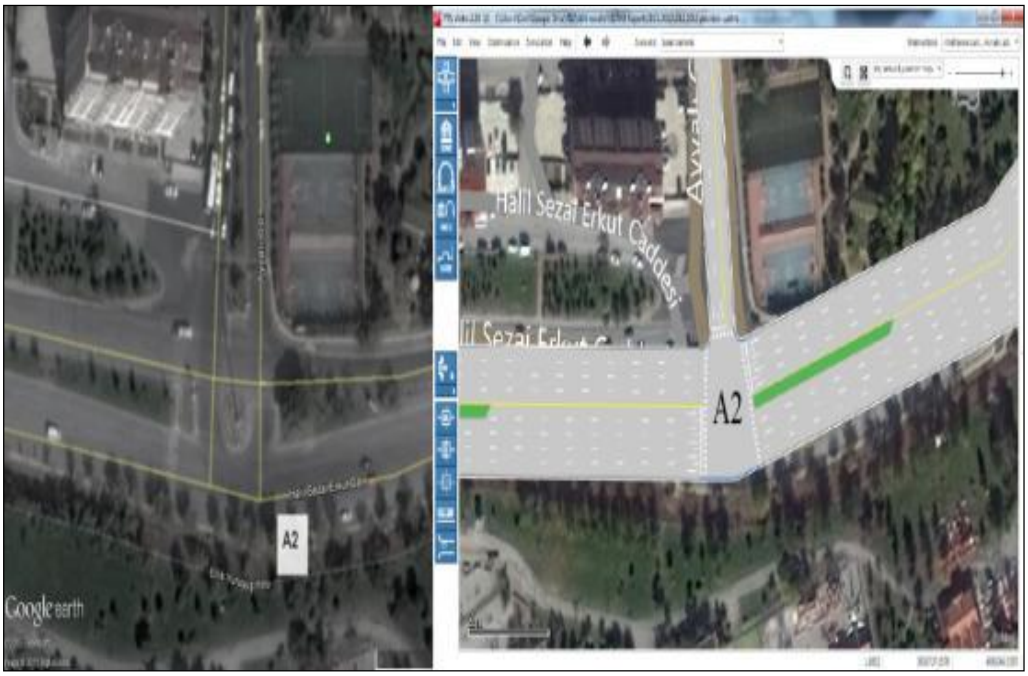


Figure 5.9 the satellite image on “A2” intersection and its model in Vistro

<u>Geometry and Volume</u>

For this stage, the number and width of the each approach were entered in network design. The width of the lanes are 3.5 for the entire project, also the speed limit is 50 Km/h for all major and minor roads in designed network. Then the traffic volume data of each outflowing and receiving lanes, which was obtained from video recording, were entered to designed network. All these considerations were applied for each of the intersection’s approaches (i.e. Eastbound, Westbound, Northbound and Southbound). Figure 5.10 shows gemoetry and volume input for "A2" intersection in Vistro. The last part of this stage, the saturation flow rate was kept at its default value of 1,900 and the percent for heavy vehicles was set at 2%. Apart from that, the analysis did not consider parking maneuvers, bus stops, neither bikes nor pedestrian flows. All these assumptions were equally applied for each of the intersection's approaches.

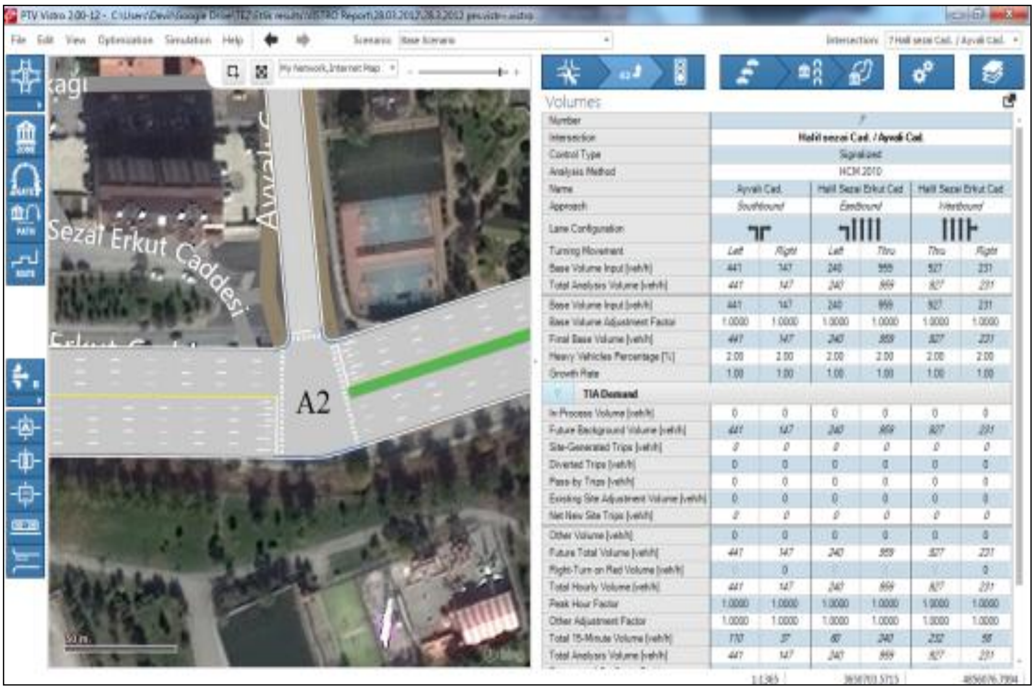


Figure 5.10 Screenshot of geometry and volume input for "A2" intersection in Vistro.

__Phasing Design__

The first part of this stage is about input data for phasing and cycle length of each signalized intersection. First of all, the cycle length and green time and amber time for each approach were obtained from video recording. Then, the priority of the each phase, the sequence of each direction (e.g. lead and/or lag, etc.) and the type of protection (e.g. protected, permissive and combined) had been entered into designed network.. Figure 5.11 shows signal and phase time input for "A2" intersection.

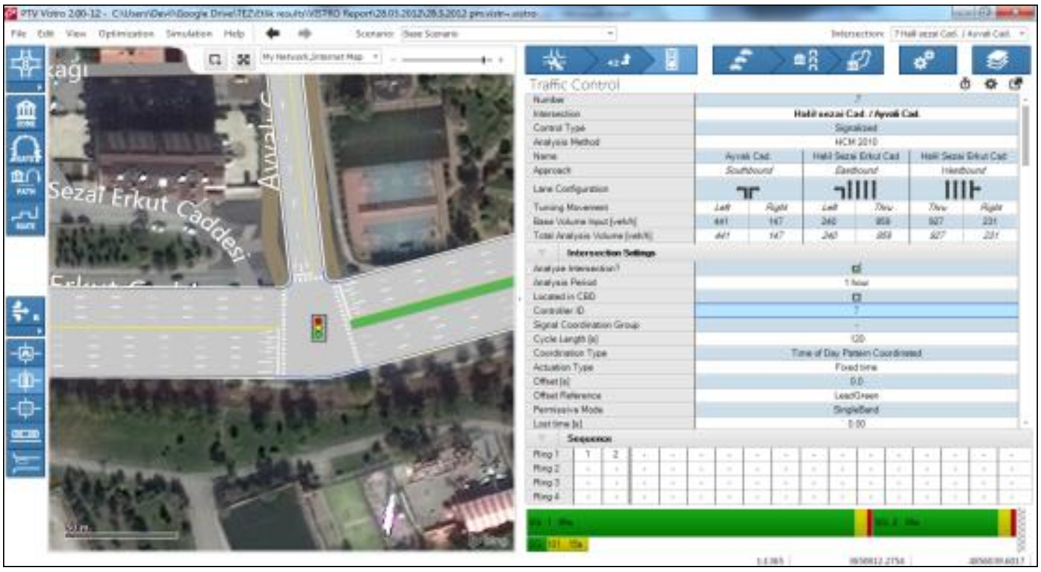


Figure 5.11 Screenshot of signal and phase time input for “A2” intersection in Vistro

<u>Results</u>

As a final point, all aforementioned data had been entered to Vistro v.2 and particular results of each0 serialized intersection were gained. These results contain flow rate, volume to capacity ratio (v/c), effective, delay and LOS. Figure 5.13 shows phase, signal timing, volume, v/c ratio, delay, LOS of A2 intersection. The current LOS results of Vistro for all intersection are in Appendix D. Figure 5.12 shows the layout of study intersections in Vistro.

Figure 5.12 Layout of study intersection in Vistro

Number	2					
Intersection	Halil sezai Cad. / Ayvali Cad.					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Ayvali Cad		Halil Sezai Erkut Cad.		Halil Sezai Erkut Cad.	
Approach	Southbound		Eastbound		Westbound	
Lane Configuration						
Turning Movement	Left	Right	Left	Thru	Thru	Right
Base Volume Input [veh/h]	441	147	240	959	927	231
Total Analysis Volume [veh/h]	441	147	240	959	927	231
Intersection Settings						
Analyze Intersection?	☐					
Analysis Period	1 hour					
Movement, Approach, & Intersection Results						
X, volume / capacity	0.47	0.47	0.60	0.21	0.25	0.26
d, Delay for Lane Group [s/veh]	37.55	37.69	48.19	7.49	7.82	8.28
Lane Group LOS	D	D	D	A	A	A
d_A, Approach Delay [s/veh]	37.62		15.64		7.94	
Approach LOS	D		B		A	
d_I, Intersection Delay [s/veh]	51.41					
Intersection LOS	D					
Intersection V/C	0.490					

Sequence

Ring 1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 5.13 Results of Vistro for "A2" intersection at 28.03.2012(PM)

Vistro results display the delay and LOS for each direction and for intersection. According to direction coding that cited in Appendix B, Table 5.15 and Table 5.16 shows the delay and LOS for each direction. Table 5.17 to 5.22 indicates the current total delay and LOS of all intersection around proposed health campus in Etlik for three studied day. Figure 5.14 to 5.16compare delays of each time period separately.

Table 5.15 Delay and LOS for each direction byVistro at Nothern Corridor 28.03.2012

ID	Weekdays(Northern Corridor)												
		AM				Noon				PM			
	Direction	v/c	Delay	A.LOS	LOS	v/c	Delay	LOS	LOS	v/c	Delay	LOS	LOS
A 1	14ST	0.67	24	C	C (32)	0.28	15	B	B (19)	0.58	24	C	C (28)
	14SL	**0.86**	**74**	**E**		**0.49**	**50**	**D**		**0.48**	**56**	**E**	
	1WT	**0.40**	**37**	**D**	D (44)	0.37	32	C	D (37)	**0.46**	**38**	**D**	E (77)
	1WL	**0.74**	**73**	**E**		**0.67**	**60**	**E**		**0.98**	**83**	**F**	
	1WR	**0.12**	**35**	**D**		0.11	30	C		0.14	34	C	
	15NT	0.65	22	C	D (42)	0.40	16	B	C (29)	0.54	23	C	E (68)
	15NL	**1.00**	**144**	**F**		**0.90**	**99**	**F**		**1.08**	**85**	**F**	
	15NR	**0.19**	**15**	**B**		0.09	13	B		0.12	18	B	
	28ET	**0.45**	**44**	**D**	D (43)	0.36	33	C	D (35)	**0.48**	**42**	**D**	E (46)
	28EL	**0.51**	**57**	**E**		**0.43**	**46**	**D**		**0.69**	**77**	**E**	
A 2	27ET	0.49	11	B	B (11)	0.20	9	A	B (13)	0.21	8	A	B (15)
	27EL	0.13	29	C		0.39	28	C		**0.60**	**49**	**D**	
	13SL	**0.86**	**56**	**D**	D (42)	0.22	30	C	C (29)	**0.36**	**38**	**D**	F (81)
	13SR	0.21	24	C		0.12	27	C		**0.95**	**88**	**F**	
	27WT	0.43	11	B	B	0.28	10	A	A	0.25	8	A	A
A 3	26ET	0.23	5	A	B (11)	0.14	5	A	C (29)	0.22	9	A	C (20)
	26EL	**0.57**	**44**	**D**		**0.92**	**89**	**F**		**0.77**	**65**	**E**	
	12SL	**0.52**	**43**	**D**	D (43)	**0.52**	**37**	**D**	D (38)	**0.47**	**37**	**D**	D (37)
	12SR	**0.52**	**44**	**D**		**0.52**	**38**	**D**		**0.48**	**38**	**D**	
	26WT	0.44	18	B	B	0.22	11	B	B	0.32	23	C	C
A 4	24NT	**0.71**	**57**	**E**	D (49)	**0.64**	**47**	**D**	D (41)	**0.66**	**52**	**D**	E (65)
	24NL	**0.58**	**45**	**D**		**0.52**	**39**	**D**		**0.85**	**77**	**E**	
	24NR	**0.23**	**41**	**D**		**0.21**	**35**	**D**		**0.87**	**71**	**E**	
	10ET	**0.79**	**40**	**D**	D (39)	0.28	27	C	C (27)	**0.45**	**35**	**D**	C (35)
	10EL	**0.35**	**45**	**D**		0.08	31	C		**0.30**	**44**	**D**	
	10ER	0.44	33	C		0.12	26	C		0.19	32	C	
	25WT	0.31	11	B	B (17)	0.17	11	B	B (14)	0.23	14	B	B (17)
	25WL	**0.59**	**40**	**D**		0.31	32	C		**0.31**	**41**	**D**	
	11ST	**0.74**	**52**	**D**	D (49)	**0.67**	**43**	**D**	D (41)	**0.66**	**51**	**D**	D (50)
	11SL	**0.41**	**44**	**D**		**0.37**	**38**	**D**		**0.40**	**47**	**D**	
	11SR	**0.45**	**46**	**D**		**0.41**	**40**	**D**		**0.40**	**48**	**D**	

Table 5.16 Delay and LOS for each direction by Vistro at 28.03.2012

ID	Weekdays(Southern Corridor)												
		AM				Noon				PM			
	Direction	v/c	Delay	A.LOS	LOS	v/c	Delay	LOS	LOS	v/c	Delay	LOS	LOS
A5	22WT	0.37	17	B	B	0.32	15	B	B	0.36	18	B	B
	22WR	0.45	20	B	(18)	0.33	16	B	(15)	0.43	20	C	(18)
	9ET	0.23	5	A	E	0.29	4	A	C	0.26	6	A	C
	9EL	**1.03**	**120**	**F**	(55)	**0.95**	**90**	**F**	(25)	**0.86**	**79**	**E**	(22)
	23SL	**0.58**	**44**	**D**	D	0.12	34	C	C	**0.54**	**47**	**D**	D
	23SR	**0.33**	**38**	**D**	(43)	0.14	34	C	(34)	**0.30**	**41**	**D**	(45)
A6	7NL	**0.85**	**69**	**E**	E	0.84	58	E	E	0.99	83	F	F
	21ET	0.39	20	C	C	0.36	18	B	B	0.48	19	B	B
	21ER	0.31	20	C	(20)	0.29	17	B	(18)	0.35	17	B	(19)
	21WT	0.60	6	A	D	0.22	5	A	B	0.30	6	A	C
	21WL	**1.05**	**101**	**F**	(48)	**0.49**	**36**	**D**	(11)	**0.88**	**84**	**F**	(21)
A7	20ET	0.37	17	B	B	0.31	15	B	B	0.56	18	B	B
	20ER	0.41	20	B	(18)	0.25	15	B	(15)	0.45	17	B	(18)
	20WT	0.60	8	A	E	0.26	5	A	B	0.30	5	A	C
	20WL	**1.08**	**102**	**F**	(60)	**0.37**	**36**	**D**	(11)	**0.93**	**106**	**F**	(24)
	6NL	**0.14**	**35**	**D**	D	0.06	29	C	C	**0.24**	**44**	**D**	D
	6NR	**0.13**	**35**	**D**	(35)	0.07	29	C	(29)	**0.23**	**45**	**D**	(44)
A8	5NL	0.69	66	E	D	**0.42**	**45**	**D**	D	**0.45**	**36**	**D**	F
	5NR	0.75	44	D	(50)	**0.79**	**47**	**D**	(46)	**0.99**	**91**	**F**	(89)
	19ET	0.57	20	C	C	0.47	17	B	B	0.86	21	C	C
	19WT	0.23	3	A	C	0.27	3	A	A	0.72	25	C	C
	19WL	**0.90**	**60**	**E**	(31)	0.25	27	C	(7)	0.75	29	C	(26)

Table 5.17 Current Total Delay and LOS of Northern Corridor at Morning Peak hour (usingVistro)

	Northern Corridor		A1	A2	A3	A4
Morning Peak	Day1 (Wed)	Delay(sec/veh)	38.5	11.7	17.9	33.5
		LOS	D	B	B	C
	Day2 (Wed)	Delay(sec/veh)	81.0	23.5	20.7	76.0
		LOS	F	C	C	E
	Day3 (Sat)	Delay(sec/veh)	32.0	16.2	18.1	38.5
		LOS	C	B	B	D

Table 5.18 Current Total Delay and LOS of Northern Corridor at Noon Off-Peak Period (usingVistro)

	Northern Corridor		A1	A2	A3	A4
Noon Off-Peak	Day1 (Wed)	Delay(sec/veh)	29.6	18.9	23.9	30.7
		LOS	C	B	C	C
	Day2 (Wed)	Delay(sec/veh)	32.1	18.0	20.2	36.8
		LOS	C	B	C	D
	Day3 (Sat)	Delay(sec/veh)	31.1	18.2	19.7	63.0
		LOS	C	B	B	E

Table 5.19 Current Total Delay and LOS of Northern Corridor at Evening Peak hour (usingVistro)

	Northern Corridor		A1	A2	A3	A4
Evening Peak	Day1 (Wed)	Delay(sec/veh)	68.7	51.4	24.7	43.3
		LOS	E	D	C	D
	Day2 (Wed)	Delay(sec/veh)	33.8	22.8	24.5	61.3
		LOS	C	C	C	E
	Day3 (Sat)	Delay(sec/veh)	32.2	43.7	27.5	65.1
		LOS	C	D	C	E

Table 5.20 Current Total Delay and LOS of Southern Corridor at Morning Peak hour (usingVistro)

	Southern Corridor		A5	A6	A7	A8
Morning Peak	Day1 (Wed)	Delay(sec/veh)	37.6	41.1	47.8	29.9
		LOS	D	D	D	C
	Day2 (Wed)	Delay(sec/veh)	34.7	20.8	15.3	22.9
		LOS	C	C	B	C
	Day3 (Sat)	Delay(sec/veh)	15.8	18.8	14.9	31.5
		LOS	B	B	B	C

Table 5.21 Current Total Delay and LOS of Southern Corridor at Noon Off-Peak Period (usingVistro)

	Southern Corridor		A5	A6	A7	A8
Noon Off-Peak	Day1 (Wed)	Delay(sec/veh)	21.9	20.9	13.6	17.1
		LOS	C	C	B	B
	Day2 (Wed)	Delay(sec/veh)	17.1	21.0	13.9	16.5
		LOS	B	C	B	B
	Day3 (Sat)	Delay(sec/veh)	16.0	15.7	14.4	50.1
		LOS	B	B	B	D

Table 5.22 Current Total Delay and LOS of Southern Corridor at Evening Peak hour (usingVistro)

	Southern Corridor		A5	A6	A7	A8
Evening Peak	Day1 (Wed)	Delay(sec/veh)	24.8	52.9	21.7	74.3
		LOS	C	D	C	E
	Day2 (Wed)	Delay(sec/veh)	23.7	36.2	17.2	54.7
		LOS	C	D	B	D
	Day3 (Sat)	Delay(sec/veh)	48.4	69.8	17.7	29.8
		LOS	D	E	B	C

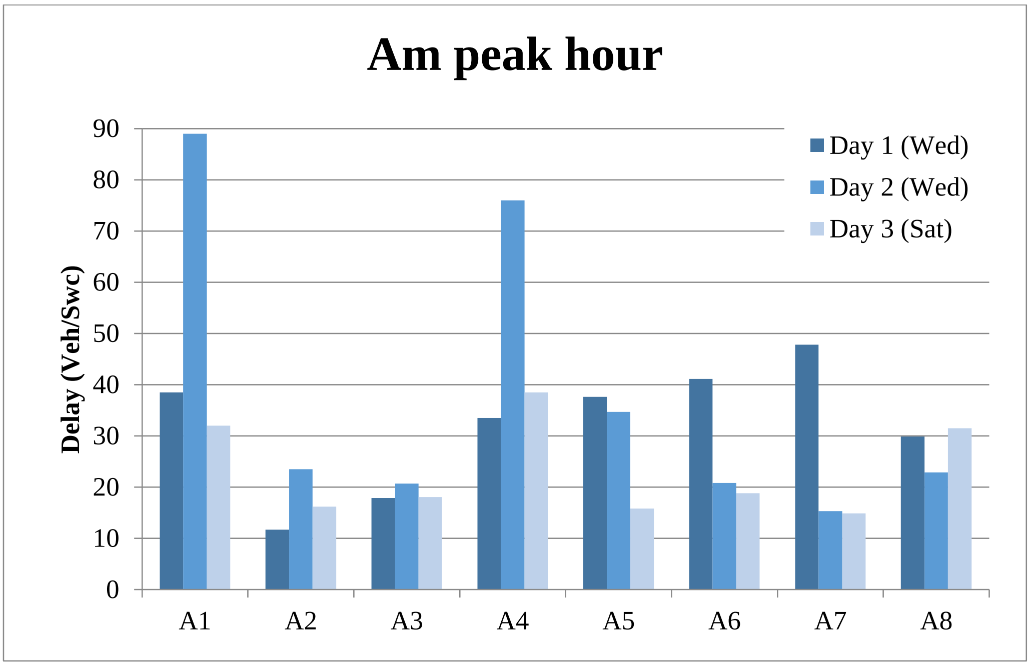


Figure 5.14 Delays in AM peak hour of all intersections in three days by Vistro

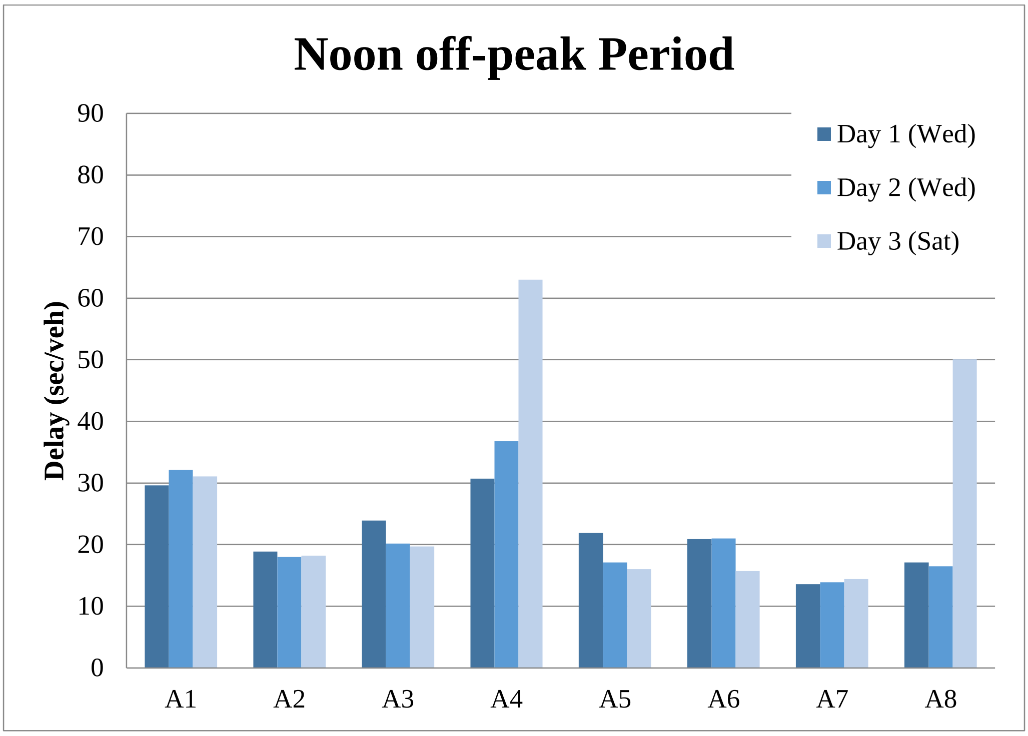


Figure 5.15 Total average delays in Noon off-peak period of all intersections in three days by Vistro

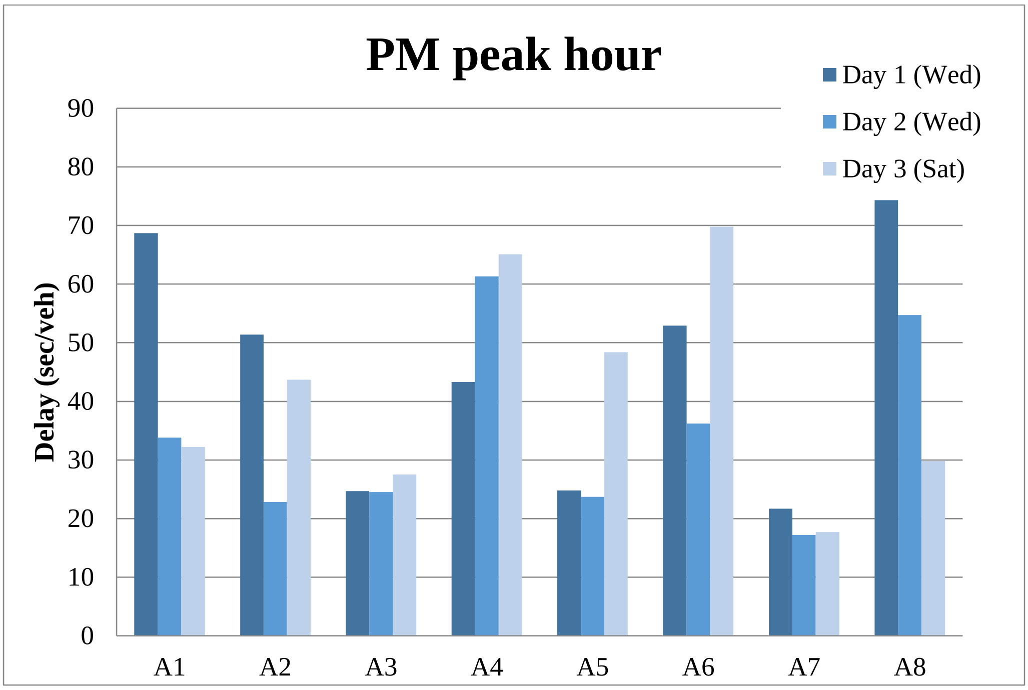
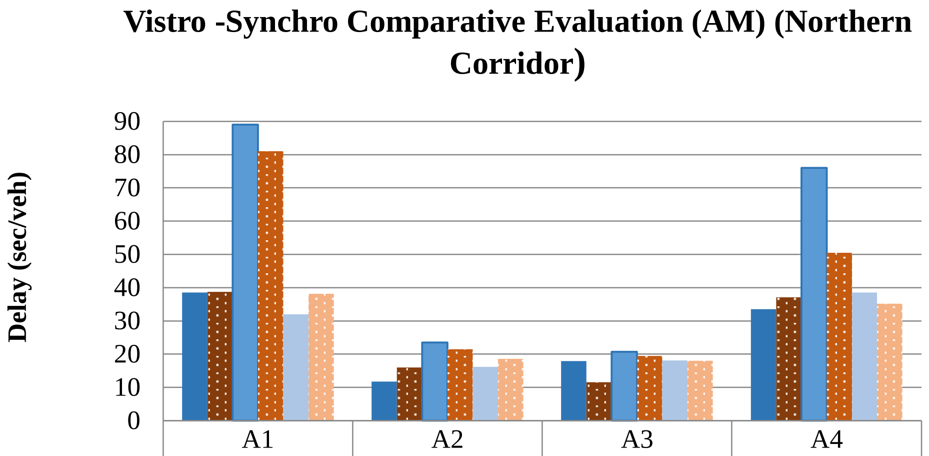


Figure 5.16 Delays in PM peak hour of all intersections in three days by Vistro

5.3 Comparative Evaluation

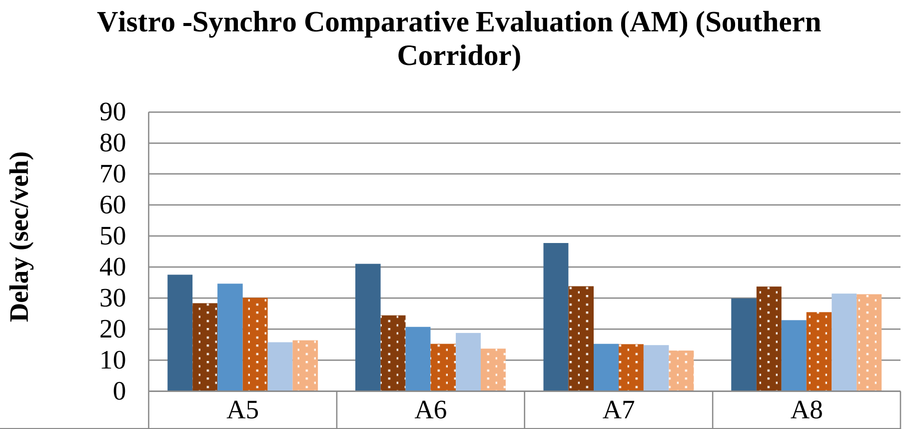
Last step before project is comparing delay and LOS for each day and intersection that obtained from Synchro and Vistro software. Figure 5.23 to 5.28 shows comparative evaluation of Vistro and Synchro results in different daytime.

Table 5.23 Vistro - Synchro comparative evaluation at Northern Corridor (AM Peak hour)



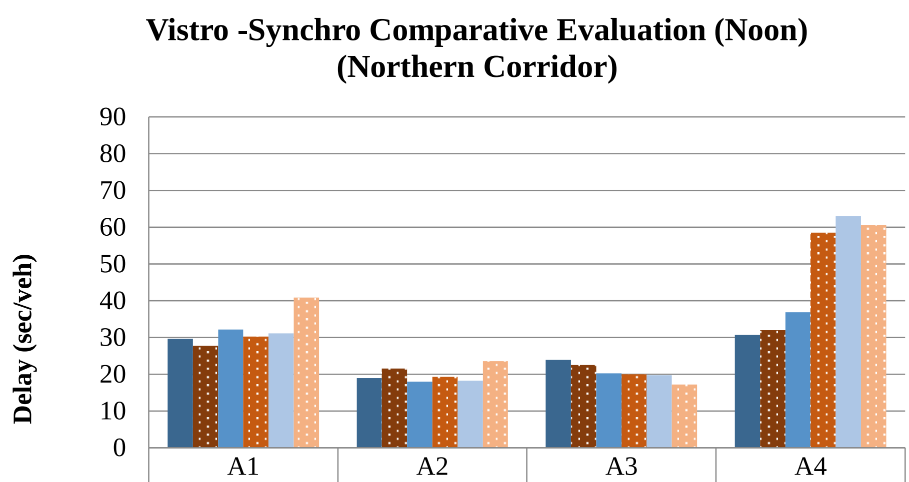
	A1	A2	A3	A4
V Day1 (Wed)	38.5	11.7	17.9	33.5
S Day1 (Wed)	38.7	16	11.6	37.1
V Day2 (Wed)	89	23.5	20.7	76
S Day 2 (Wed)	81	21.5	19.5	50.5
V Day3 (Sat)	32	16.2	18.1	38.5
S Day3 (Sat)	38.1	18.6	18	35.2

Table 5.24 Vistro - Synchro comparative evaluatio Southern Corridor (AM Peak hour)



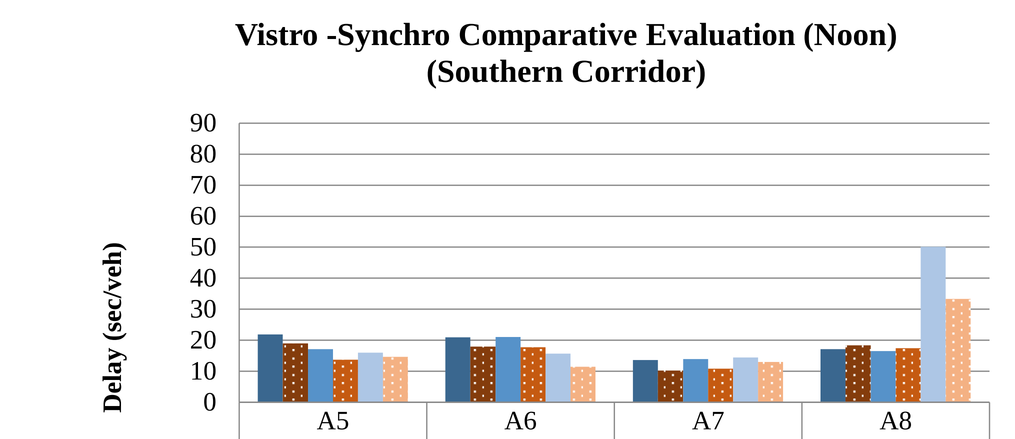
	A5	A6	A7	A8
V Day1 (Wed)	37.6	41.1	47.8	29.9
S Day1 (Wed)	28.4	24.5	33.9	33.7
V Day2 (Wed)	34.7	20.8	15.3	22.9
S Day 2 (Wed)	30.1	15.3	15.2	25.5
V Day3 (Sat)	15.8	18.8	14.9	31.5
S Day3 (Sat)	16.4	13.7	13.1	31.3

Table 5.25 Vistro - Synchro comparative evaluation at Northern Corridor (Noon Off –Peak Period)



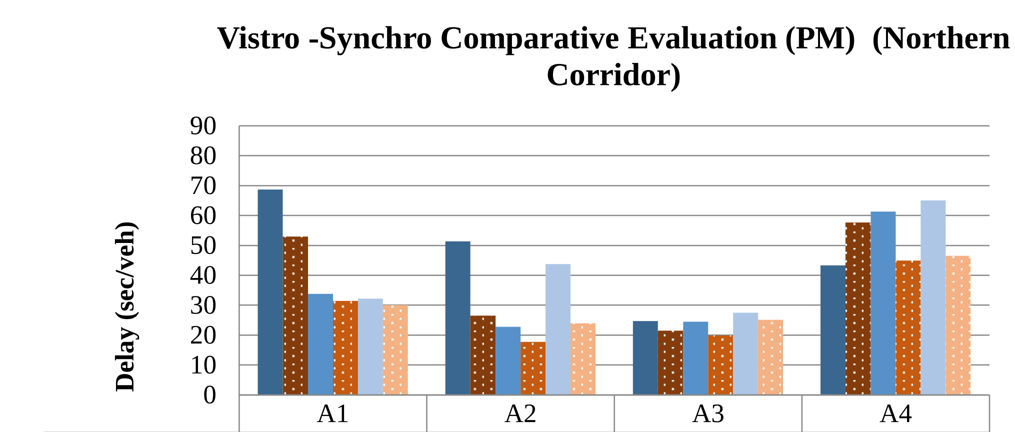
	A1	A2	A3	A4
V Day1 (Wed)	29.6	18.9	23.9	30.7
S Day1 (Wed)	27.7	21.5	22.5	32
V Day2 (Wed)	32.1	18	20.2	36.8
S Day 2 (Wed)	30.2	19.3	20	58.5
V Day3 (Sat)	31.1	18.2	19.7	63
S Day3 (Sat)	40.8	23.5	17.2	60.6

Table 5.26 Vistro - Synchro comparative evaluation at Southern Corridor (Noon Off-peak period)



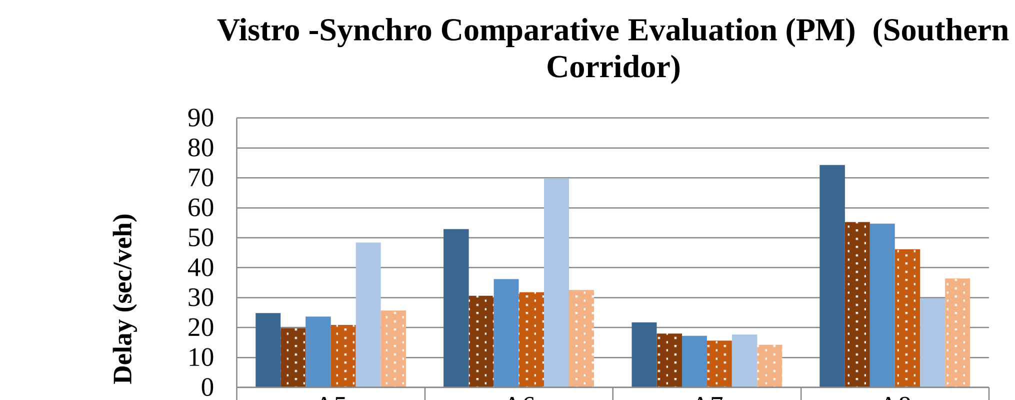
	A5	A6	A7	A8
V Day1 (Wed)	21.9	20.9	13.6	17.1
S Day1 (Wed)	19	17.9	10.2	18.4
V Day2 (Wed)	17.1	21	13.9	16.5
S Day 2 (Wed)	13.7	17.7	10.8	17.4
V Day3 (Sat)	16	15.7	14.4	50.1
S Day3 (Sat)	14.6	11.4	13	33.3

Table 5.27 Vistro - Synchro comparative evaluation at Northern Corridor (PM Peak hour)



	A1	A2	A3	A4
V Day1 (Wed)	68.7	51.4	24.7	43.3
S Day1 (Wed)	53	26.5	21.5	57.7
V Day2 (Wed)	33.8	22.8	24.5	61.3
S Day 2 (Wed)	31.4	17.7	19.9	44.9
V Day3 (Sat)	32.2	43.7	27.5	65.1
S Day3 (Sat)	30	24	25.1	46.5

Table 5.28 Vistro - Synchro comparative evaluation at Southern Corridor (PM Peak hour)



	A5	A6	A7	A8
V Day1 (Wed)	24.8	52.9	21.7	74.3
S Day1 (Wed)	19.8	30.6	18	55.2
V Day2 (Wed)	23.7	36.2	17.2	54.7
S Day 2 (Wed)	20.9	31.8	15.6	46.1
V Day3 (Sat)	48.4	69.8	17.7	29.8
S Day3 (Sat)	25.7	32.6	14.3	36.4

The analysis of the traffic surveys in the campus area provided the following findings:

- The traffic is heavily congested during the weekday morning and evening peak hours at A1 and A4 intersections; the Saturday observations on the given time periods did not show congestion level as critical as the weekday ones.
- In the campus area, north boundary, Halil Sezai Caddesi, is one of the main arterials connecting Keçiören region to the city center, and has major flow on it. The A1 intersection is located in the corner of this boundary that is intersecting with Etlik Cad and Halil Sezaie Cad.
- The morning peak started earlier on the north-east edge of the campus area, Etlik and Halil sezai Caddsi, (A1, A8), with really major flows.
- A8 was the first intersections to be congested. While there are not any

apparent traffic attraction points on the southern part of A8, driving through the study area during the weekday morning selected periods showed the south exit of the A8 intersection is used as a by-pass road to reach Konya Yolu (Mevlana Bulvarı) and İstanbul Yolu (Fatih Sultan Mehmet Bulvarı) avoiding a portion of the commute traffic congestion on these roads.

- The evening peak started generally around 17:15 and lasted until the end of the analysis period (almost 2 hours).
- While the amount of large trucks is not very high, there is a significant share of light duty trucks in the area.
- Traffic caught up slowly in the northern edge (A1, A2, A3 and A4). The PM peak again was observed more heavily and earlier on the same locations but lasted for about 2 hours
- As there is no strict lane policy and there is not a proper lane design along the road segments in the campus area, traffic counts were reported and analyzed as total number of vehicles passing through a cross-section before or after an intersection leg.

5.4 Future LOS

As previously mentioned, the proposed health campus surrounded by 8 major intersections, that two of them are 4-legged and six of 3-legged intersection. But after health campus construction done, the surrounded intersection will change to six 4-legged and two 3-legged intersections. According to project plan, it will have 4 main gates (A2, A3, A6, A7) for exit and entrance. So, these intersections geometry will changed from 3-legget to 4-legged and also the importance of them will changed from minor to major intersections. The analyzed intersection for future LOS divided to two groups. Firs group contains the intersection that impact and connect directly to project block (e.g. A2, A3, A6 and A7). Second group contain the intersections that impact and connect indirectly to the project block (e.g. A1, A4, A5 and A8).

The procedure to evaluate and predict future LOS at intersections around health campus contains two main steps. First, the calculation of the future demand and trip generation by hospital should be calculated. For this step, 9^{th} version of trip generation manual had been used. Trip generation rates at the general hospitals studied were computed on the basis of average weekday traffic volume related to: (1) number of hospital beds, (2) number of hospital employees, and (3) total hospital population. Second step is upgrading the intersection with new input data and geometry features. Then calculate new average control delay and v/c of intersections and future LOS of each intersection. Figure 5.17 shows the upgraded form on network in Synchro and Vistro.

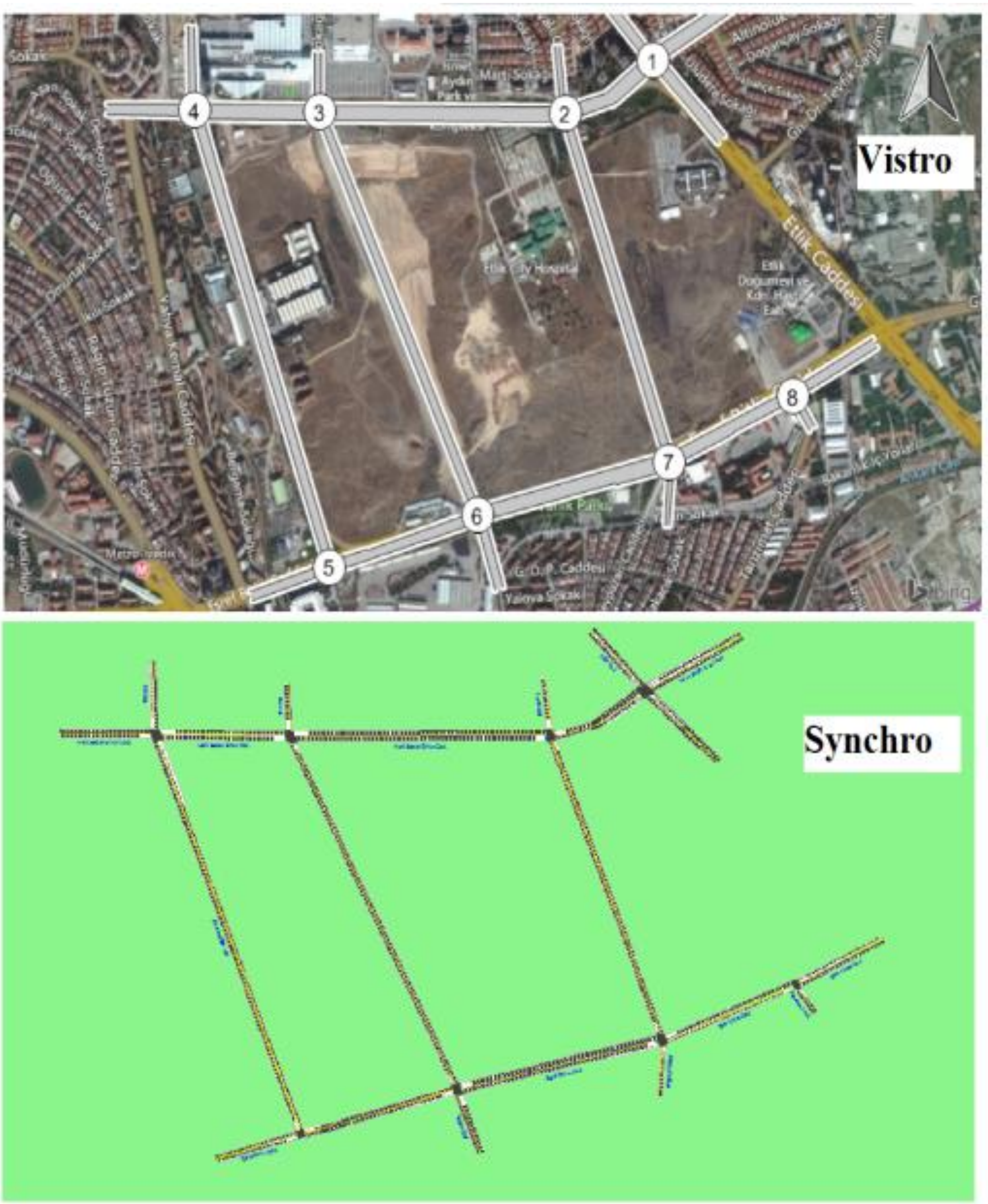


Figure 5.17 Upgraded form of current network in Synchro and Vistro

5.4.1 Data Requirements

In order to predict the future LOS at intersections around proposed health campus, future trip generation of project should be calculated by ITE 2008 rates and equations. Trip generation rates at the general hospitals studied were computed on the basis of average weekday and weekend traffic volume related to: (1) number of hospital beds, (2) number of hospital employees, and (3) total hospital population. Furthermore, in this study TripGen used to calcite this rates and equations. The analyst can choose the independent variable that he needs and afterwards can determine the generated volumes by making use of the rates or equations found in the Trip Generation Manual. Figure 5.18 indicate the main screen of TripGen software.

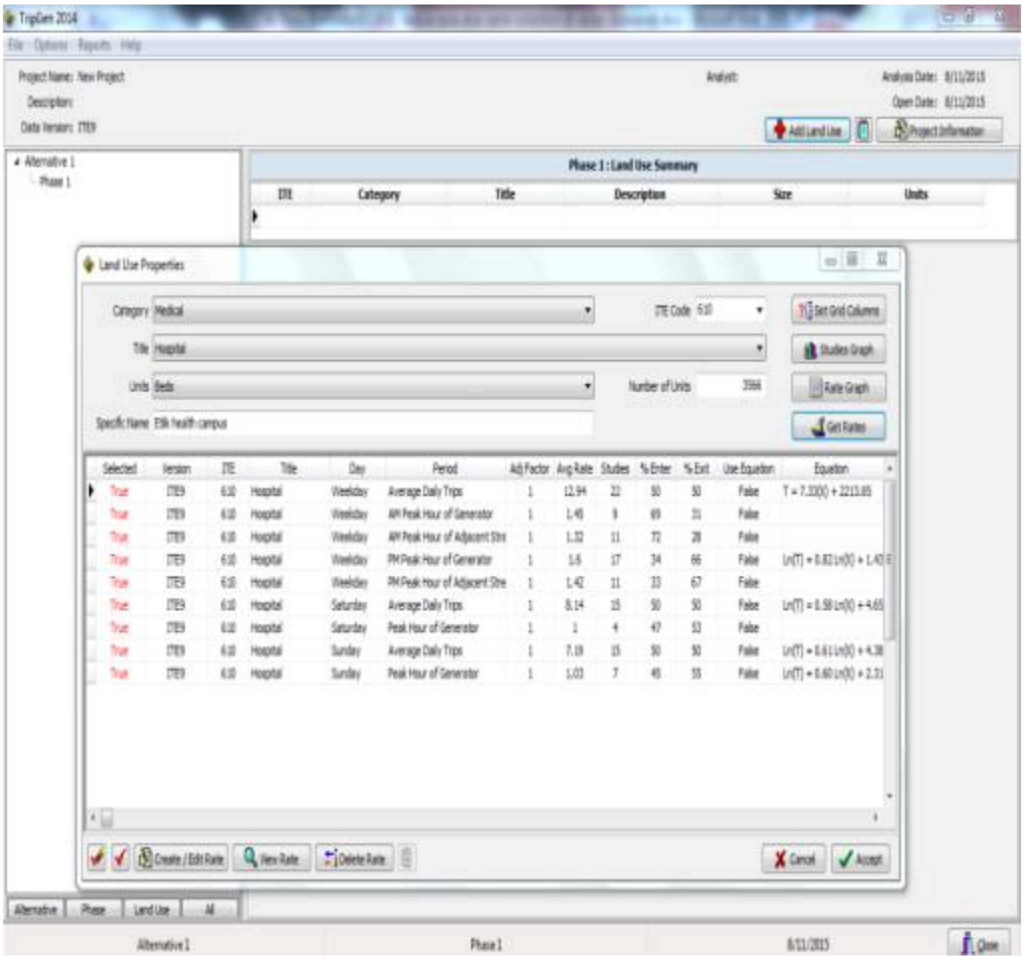


Figure 5.18 main screen of TripGen software

5.4.1.1 ITE Equation and Rates in TripGen

During the creation of the TripGen file, the user must select trip rates from either the 8th or 9th Edition of the ITE Trip Generation Manual. Once the user enters the appropriate land use information, the available trip generation rate data will be displayed. The average trip rate will be used for all calculations unless the user selects use equation. Once the Accept button has been selected, the Land Use information will be saved and be displayed in the Main Screen (See Figure 5.19).

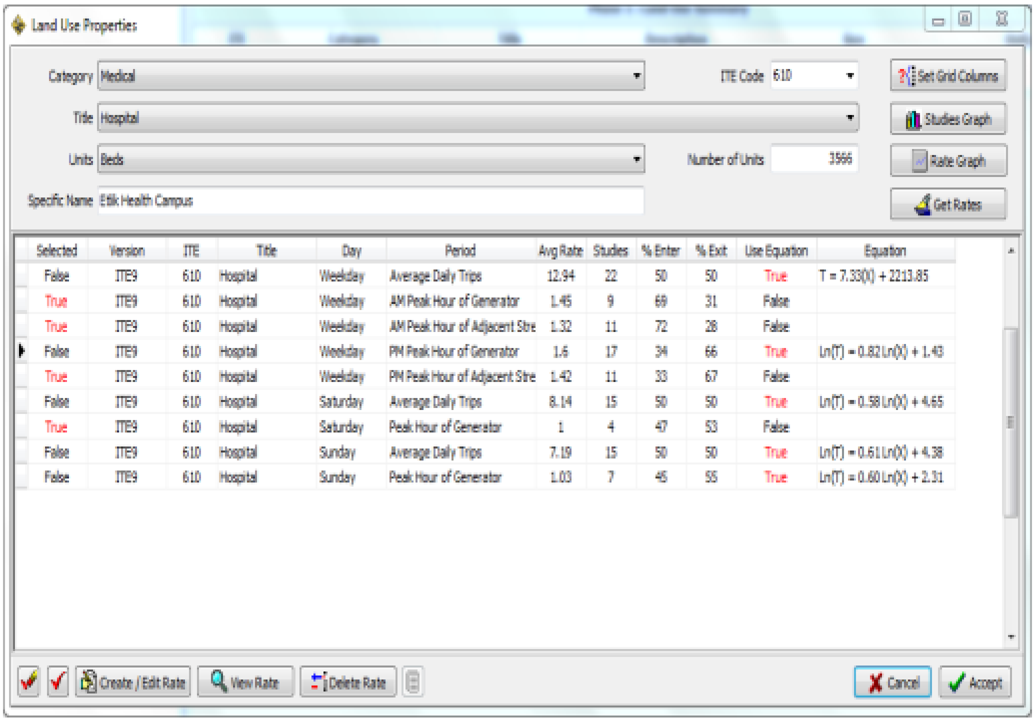


Figure 5.19 Scrrenshot of rate/equastion selection in TripGen

Click False within the Use Equation column to use ITE's Trip Generation Manual, 8th or 9th Edition equation to calculate the expected number of trips. Each equation is based on either of the two mathematical relationships;

• Linear relationship → T = aX +b

• Logarithmic relationship → T = a Ln(X) + b

Where T = expected number of trips

X = the independent variable

a & b = constants derived from the raw data

Once the Accept button has been selected, the Land Use information' will be saved and be displayed in the Main Screen. Table 5.29 shows the equation that selected for hospital trip generation. Also, Table 5.30 shows the trip generated by health campus according to ITE rates and equations.

Table 5.29 ITE Trip Generation Rate and Equation for Hospital

ITE Trip Generation Rate and Equation for Hospital					
Day	Period	Avgrage Rate	Enter%	Exit%	Equation
Weekday	Average Daily Trips	12.94	50	50	T = 7.33(X) + 2213.85
	AM Peak Hour of Generator	1.45	69	31	--
	PM Peak Hour of Generator	1.60	34	66	Ln(T) = 0.82 Ln(X) + 1.43
Saturday	Average Daily Trips	8.14	50	50	Ln(T) = 0.58 Ln(X) + 4.65
	Peak Hour of Generator	1.00	47	53	--
Sunday	Average Daily Trips	7.19	50	50	Ln(T) = 0.61 Ln(X) + 4.38
	Peak Hour of Generator	1.03	45	55	Ln(T) = 0.60 Ln(X) + 2.31

Table 5.30 trip generation for health campus with 3566 bed capacity

Trip Generation for health campuse(3566 beds)				
Day	Period	Total Trip	Enter%	Exit%
Weekday	Average Daily Trips	28353	14176	14176
	AM Peak Hour of Generator	5171	3568	1603
	PM Peak Hour of Generator	3418	1162	2256
Saturday	Average Daily Trips	12015	6007	6008
	Peak Hour of Generator	3566	1676	1890
Sunday	Average Daily Trips	11723	5861	5862
	Peak Hour of Generator	1363	614	749

More over the Tripgen uses trip generating rates and equation. The difference between equation and rates is accuracy. It means the rates are almost constant value for different type of trip generation. But the equation is a formula that derived from interpolated previous study. This study uses the equation of hospital trip generation to have more accurate data for future traffic volume. Figure 5.20 shows the difference between equation and rates in ITE at Sunday.

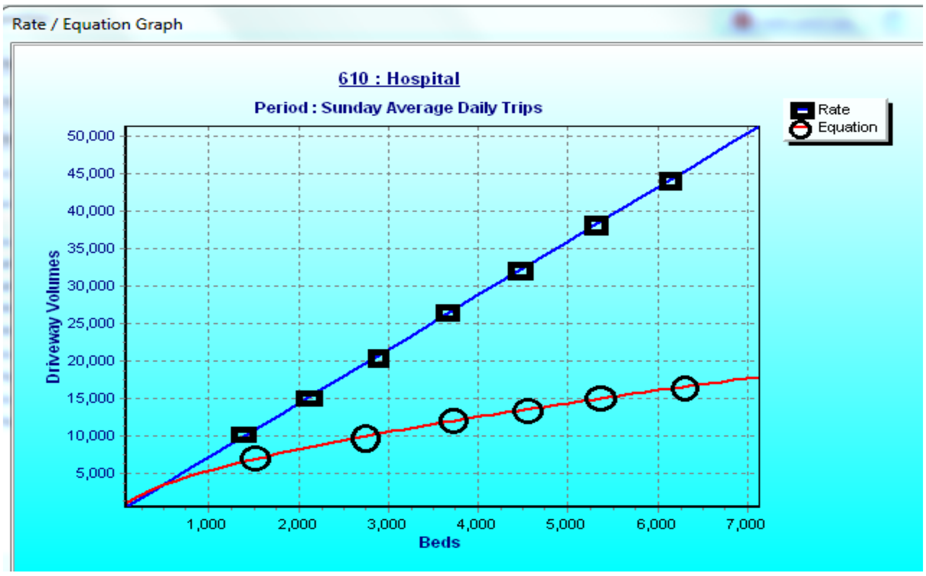


Figure 5.20 Difference between equation and rates in ITE 2008

5.4.1.2 Geometry

The Steps of this study divided to two main topics. First part contains current LOS and delay of surrounded intersections and second part is calculating future LOS and delay around project block. The current LOS was prenominated, so this step defines the future LOS calculation. The geometry of intersections that will use as entrance/exit will change from 3-legged to 4-legged signalized intersection. So the new intersections were designed for A2, A3, A6 and A7 intersections. Figure 5.21 shows the new designed intersections for A2 in Synchro and Vistro software.

Figure 5.21shows the new designed intersections for A2 in Synchro and Vistro software.

5.4.1.3 Phasing Design

Next step of LOS prediction at intersections around proposed health campus is phase design. The problem of this step is about how to organize new cycle length and green time of each approach. For solve this problem, both software, Vistro and Synchro, have some option to optimize cycle length or intersection. Using delay optimization in intersection shows the un acceptable cycle length for some intersection. The reason of this unacceptable data is, when these software try to optimize by delay or cycle length, they do for each individual approach. For example, in cycle length optimization, one approach gets low green time because of low traffic flow and another one gets higher green time because of heavy traffic flow, but at approach with low traffic flow, delay is higher than others, because software only optimizes cycle length not delay. For this reason, for estimating future LOS, cycle lengths of similar intersections with 4-legged (A1 and A4) have been used. Table 5.31 shows the brief summary of signal and phasing of intersections for future condition. Table 5.32 and Table 5.33 shows the detailed data of signal and phase for each direction.

Table 5.31brief summary of signal and phasing of intersections for future condition.

Future Cycle length and Phases				
ID	**Position**	**Time**	**Cycle length(s)**	**Phase(Ø)**
A1	Etlik Cad. with Halil Sezai Erkut Cad.	Am	105	4
		Noon	95	
		Pm	120	
A2	Ayvalı Cad. with Halil Sezai Erkut Cad. with New Road	Am	105	4
		Noon	95	
		Pm	120	
A3	Afra Sok. with Halil Sezai Erkut Cad. with New Road	Am	105	4
		Noon	95	
		Pm	120	
A4	150 Sok. with Halil Sezai Erkut Cad. with Akşemsettin Cad.	Am	105	4
		Noon	95	
		Pm	120	
A5	Eşref Bitlis Cad with Akşemsettin Cad.	Am	105	3
		Noon	95	
		Pm	120	
A6	Eşref Bitlis Cad with Trakya Cad. with New Road	Am	105	4
		Noon	95	
		Pm	120	
A7	Eşref Bitlis Cad with Beypazarı Cad. with New Road	Am	105	4
		Noon	95	
		Pm	120	
A8	Eşref Bitlis Cad with Tanzimat Cad.	Am	105	3
		Noon	95	
		Pm	120	

Table 5.32 Signal control details of Northern intersections for future (Sec.)

Future (Northern Corridor)														
ID	Time		AM				Noon				PM			
	Ø	Direction	G	Y	R	C	G	Y	R	C	G	Y	R	C
A1	Ø1	SWT/R+NET/L	21	3	1	105	21	3	1	95	31	3	1	120
	Ø2	SWL	6	3	1		6	3	1		6	3	1	
	Ø3	NWT/R+SWT	51	3	1		46	3	1		56	3	1	
	Ø4	NWL+SWL	11	3	1		6	3	1		11	3	1	
A2	Ø1	WBT+EBT/R/L	31	3	1	105	26	3	1	95	36	3	1	120
	Ø2	WBT/L	26	3	1		21	3	1		26	3	1	
	Ø3	SBL/T/R	16	3	1		16	3	1		21	3	1	
	Ø4	NBL/T/R	16	3	1		16	3	1		21	3	1	
A3	Ø1	WBT+EBT/R/L	31	3	1	105	26	3	1	95	36	3	1	120
	Ø2	WBT/L	26	3	1		21	3	1		26	3	1	
	Ø3	SBL/T/R	16	3	1		16	3	1		21	3	1	
	Ø4	NBL/T/R	16	3	1		16	3	1		21	3	1	
A4	Ø1	WBT+EBT/R/L	31	3	1	105	26	3	1	95	36	3	1	120
	Ø2	WBT/L	26	3	1		21	3	1		26	3	1	
	Ø3	SBL/T/R	16	3	1		16	3	1		21	3	1	
	Ø4	NBL/T/R	16	3	1		16	3	1		21	3	1	

Table 5.33 Signal control details of Southern intersections for future (Sec.)

Future (Southern Corridor)														
ID	Time		AM				Noon				PM			
	Ø	Direction	G	Y	R	C	G	Y	R	C	G	Y	R	C
A5	Ø1	EBT+WBT/R	51	3	1	105	46	3	1	95	61	3	1	120
	Ø2	EBT/L	21	3	1		21	3	1		21	3	1	
	Ø3	SBL/R	21	3	1		16	3	1		26	3	1	
A6	Ø1	WBT+EBT/L	31	3	1	105	26	3	1	95	36	3	1	120
	Ø2	WBT/L	26	3	1		21	3	1		26	3	1	
	Ø3	SBL/T/R	16	3	1		16	3	1		21	3	1	
	Ø4	NBL/T/R	16	3	1		16	3	1		21	3	1	
A7	Ø1	WBT+EBT/L	31	3	1	105	26	3	1	95	36	3	1	120
	Ø2	WBT/L	26	3	1		21	3	1		26	3	1	
	Ø3	SBL/T/R	16	3	1		16	3	1		21	3	1	
	Ø4	NBL/T/R	16	3	1		16	3	1		21	3	1	
A8	Ø1	SWT+NET	51	3	1	105	46	3	1	95	61	3	1	12 0
	Ø2	SWT/L+NWR	31	3	1		26	3	1		11	3	1	
	Ø3	NWL	11	3	1		11	3	1		36	3	1	

5.4.1.4 Volume

The last step of determine future LOS is predicting traffic volume and its distribution. As previously mentioned, TripGen 2014 and ITE have been used to calculate traffic volume that will generate from health campus. According to TripGen results that mentioned in Table 5.31, health campus will generate different traffic volume in weekdays and weekend. The distribution of generated volume is proportion of previous traffic volume. To calculate this proportion, first, the portion of traffic volume of each approach to intersection's total traffic volume was calculated. Then, for future traffic volume this proportion has been used for enters and exit flow calculation. The result shows the portion of each major road is almost 40% and 20% for minor road. Moreover, the other intersections indirectly connect to these gates, but in simulation and analysis part, software estimate the effect of this generated volume to LOS of nearby intersection. Table 5.34 indicate the future traffic volume of each intersections.(L= Left, TH= Through, R=Right).

Table 5.34 Future traffic volume of each intersections

ID		Day	Weekday			Saturday		
		Time	L	TH	R	L	TH	R
A2, A3, A6, A7	Enter	Am	356	178	357	167	84	166
		Noon	60	30	60	165	82	169
		PM	116	60	116	168	85	164
	Exit	Am	160	80	160	189	94	188
		Noon	60	30	60	187	96	190
		PM	226	112	226	185	95	187

5.4.2 LOS Determination

At final step, all aforementioned data have been used in PTV Visto v.2 and Synchro v.9 to estimate delay and LOS of each approach and intersections. This part of study shows the current LOS around proposed health campus that gained from software. The following section provides a thorough description of a typical LOS calculation process, as it was performed for the study. It is to be noted that such a calculation was made for each period of the day, and for each intersection, considered in the study. Figure 5.22, shows one of the results and reports that Vistro calculated for A2 interstation by Vistro. Figure 5.23, shows one of the results and reports that Synchro calculated for A2 interstation by Synchro. For all intersections see Appendix E.

Number	2											
Intersection	**Halil sezai Cad. / Ayvali Cad.**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	NEW			Ayvali Cad			Halil Sezai Erkut			Halil Sezai Erkut		
Approach	*Northbound*			*Southbound*			*Eastbound*			*Westbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	226	112	226	441	60	147	240	959	116	116	927	231
Total Analysis Volume [veh/h]	*226*	*112*	*226*	*441*	*60*	*147*	*240*	*959*	*116*	*116*	*927*	*231*
Movement, Approach, & Intersection Results												
d_M, Delay for Movement [s/veh]	*61.8*	*46.3*	*74.2*	*77.2*	*43.4*	*52.3*	*193.*	*35.0*	*32.9*	*41.4*	*15.1*	*14.9*
Movement LOS	*E*	*D*	*E*	*E*	*D*	*D*	*F*	*D*	*C*	*D*	*B*	*B*
Critical Movement	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐
d_A, Approach Delay [s/veh]	*63.74*			*68.47*			*63.77*			*17.54*		
Approach LOS	*E*			*E*			*E*			*B*		
d_I, Intersection Delay [s/veh]	*49.07*											
Intersection LOS	*D*											
Intersection V/C	*0.529*											

Sequence

Ring 1	2	3	4	5	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

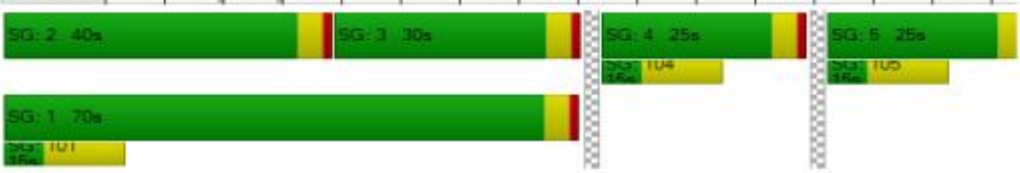
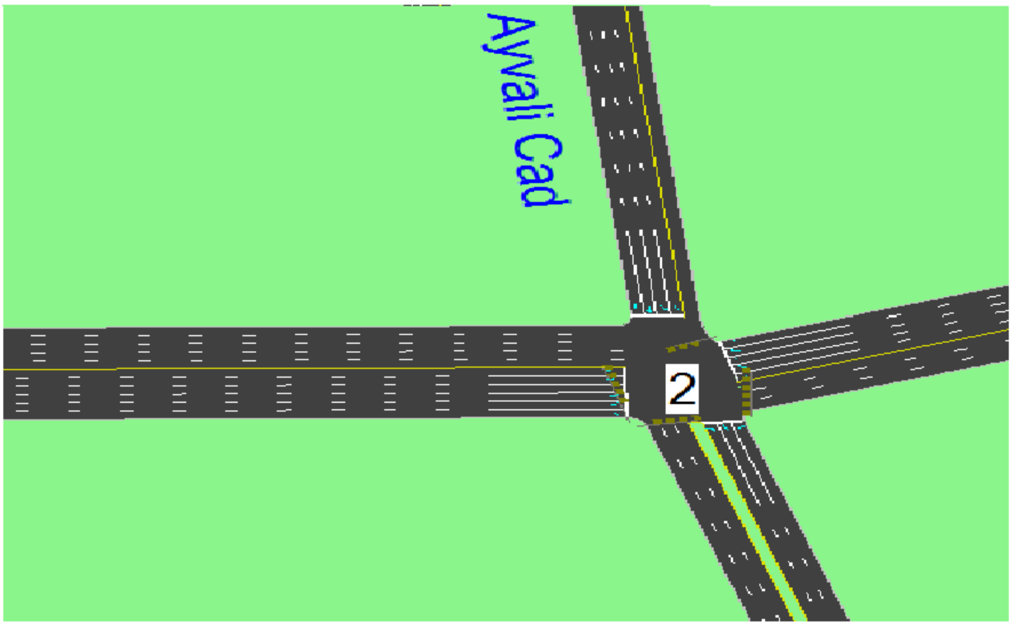


Figure 5.22 FutureLOS for A2 intersections by Vistro



Lanes, Volumes, Timings

2: Halil Sezai Erkut Cad. & Ayvali Cad

Lane Group	EBL2	EBL	EBR	NBL	NBT	NBR	SBL	SBT	SBR	SWL	SWR	SWR2
Lane Configurations												
Traffic Volume (vph)	147	927	226	116	60	116	231	112	240	226	959	441
Future Volume (vph)	147	927	226	116	60	116	231	112	240	226	959	441
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
v/c Ratio	0.51	0.51	0.38	0.40	0.20	0.33	0.41	0.37	0.57	0.63	0.52	0.44
Control Delay	44.4	42.7	15.5	75.0	70.3	48.4	46.6	47.7	15.9	51.7	18.2	2.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	44.4	42.7	15.5	75.0	70.3	48.4	46.6	47.7	15.9	51.7	18.2	2.7
LOS	D	D	B	E	E	D	D	D	B	D	B	A
Approach Delay		38.1			63.5			34.2		18.7		
Approach LOS		D			E			C		B		
Turn Type	Prot	Prot	Perm	Split	NA	Perm	Split	NA	Perm	Prot	Prot	Perm
Protected Phases	4!	2		5	5		4!	4!		3	1	
Permitted Phases			2			5			4			1
Minimum Split (s)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	9.0	20.0	20.0
Total Split (s)	25.0	40.0	40.0	25.0	25.0	25.0	25.0	25.0	25.0	30.0	70.0	70.0

Maximum v/c Ratio: 0.63

Intersection Signal Delay: 31.1 Intersection LOS: C

Splits and Phases: 2: Halil Sezai Erkut Cad. & Ayvali Cad

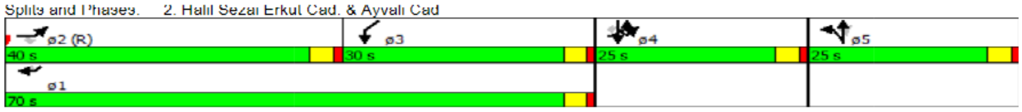


Figure 5.23 FutureLOS for A2 intersections by Vistro

The studied intersections had a more local design which is basically a signalized roundabout. To study this peculiar design in the simulation environment, we assumed a basic signalized intersection in simulation, with an imaginary left-turn lane to represent the vehicle storage at the roundabout . The analysis for the future demand case was modeled using a 4-legged intersection, assuming that the health campus road would be connected at these intersections, as planned by the contractor .The future total delays and LOS values for all study corridors are summarized in Table 5.37 for Synchro and Table 5.38for Vistro. Based on the traffic survey data (taken for two Wednesdays and a Saturday), the north corridor intersections, A2, A3, A6 and A7, currently has LOS values around B or C during the morning peak and noon off-peak periods, which are acceptable. But, at the intersection A2, there are severe congestions degrading the conditions to LOS D, even in the current situation. This is generally the spill of the congestion observed on the main arterial on the east side of the block running in the north-south direction (the city center is located in the southwest of the campus area and commute traffic is flowing on this arterial in the north direction heading back to the residential neighborhoods). Arterial serving the south of the campus has four intersections, A5, A6, A7 and A8, which are already cramped with the current traffic demand with mostly LOS D levels during the morning and evening peaks, and even sometimes on Saturdays. Main reason is that this arterial is one of the main arterials connecting residential neighborhoods in the northeast of the city to the city center. Due to the cloverleaf interchange, it is one of the main transfer points in the neighborhood.

The future LOS values are definitely worse, even for the north corridor during the peak values ranging from LOS D to E, with expected delays to increase 60%-150% for different intersections and time periods. LOS D level for even weekend days suggests the heavy congestion levels should be expected due to the integrated health campus

The future LOS and delay for each approach of intersections are shown in Table5.35 for Synchro and Table 5.36 for Vistro. The total future delay and LOS of each intersection that obtained from simulation shown in Table 5.37 to Table 5.48.

Table 5.35 Future LOS calculated by Synchro

ID	Future LOS of Each Approach Synchro												
		AM				**Noon**				**PM**			
	Direction	v/c	Delay	A.LOS	LOS	v/c	Delay	LOS	LOS	v/c	Delay	LOS	LOS
A 2	27ET	**0.97**	**81**	**F**	F (81)	**0.48**	**36**	**D**	D (35)	**0.51**	**43**	**D**	C (38)
	27EL	**0.23**	**42**	**D**		0.15	33	C		**0.50**	**45**	**D**	
	*ER	0.50	6	A		0.71	34	C		0.38	15	B	
	*ST	**0.86**	**56**	**E**	D (45)	0.10	35	C	D (42)	**0.37**	**48**	**D**	C (34)
	13SL	**0.41**	**46**	**D**		**0.32**	**51**	**D**		**0.41**	**47**	**D**	
	13SR	0.20	5	A		0.81	10	A		0.57	16	B	
	27WT	0.19	37	C	C (35)	0.50	14	B	B (13)	0.52	18	B	B (19)
	*WL	**0.88**	**61**	**E**		0.16	32	C		**0.63**	**51**	**D**	
	27WR	0.82	21	C		0.25	3	A		0.44	4	A	
	*NT	**0.31**	**43**	**D**	D (35)	**0.10**	**38**	**D**	C (29)	**0.20**	**70**	**E**	E (63)
	*NL	**0.64**	**55**	**E**		**0.22**	**40**	**D**		**0.40**	**75**	**E**	
	*NR	0.45	10	B		0.18	14	B		**0.33**	**45**	**D**	
A 3	26ET	**0.40**	**39**	**D**	D (39)	0.26	11	B	C (16)	0.24	11	B	C (24)
	26EL	0.47	22	C		**0.68**	**53**	**D**		**0.76**	**55**	**E**	
	*ER	**0.61**	**38**	**D**		0.13	7	A		0.26	6	A	
	*ST	0.59	34	C	C (31)	0.11	35	C	B (14)	0.23	33	C	C (21)
	12SL	**0.16**	**40**	**D**		**0.27**	**37**	**D**		**0.37**	**35**	**D**	
	12SR	0.53	24	C		0.44	6	A		0.25	8	A	
	26WT	0.41	12	B	C (22	0.26	27	C	C (29)	0.32	12	A	E (56)
	*WL	**0.87**	**60**	**E**		**0.16**	**53**	**D**		**0.89**	**75**	**F**	
	*NT	**0.36**	**44**	**D**	D (37	0.12	25	C	C (20)	**0.34**	**43**	**D**	E (63)
	*NL	**0.64**	**52**	**D**		0.22	26	C		**0.73**	**61**	**E**	
	*NR	0.44	18	B		0.18	12	B		**0.82**	**71**	**E**	
A 6	*NT	**0.82**	**54**	**D**	D (40)	0.10	35	C	C (28)	**0.18**	**43**	**D**	E (63)
	7NL	**0.57**	**51**	**D**		**0.57**	**45**	**D**		**0.87**	**73**	**E**	
	*NR	0.41	10	B		0.41	10	A		**0.66**	**53**	**D**	
	21ET	0.31	8	A	B (16)	**0.60**	**42**	**D**	D (37)	0.44	16	B	B (18)
	*EL	**0.81**	**48**	**D**		0.20	33	C		**0.30**	**41**	**D**	
	21ER	0.23	11	A		0.36	17	B		0.35	16	B	
	21WT	**0.89**	**73**	**E**	D (53)	0.31	20	C	C (25)	**0.72**	**40**	**D**	D (43)
	21WL	0.62	13	B		**0.53**	**46**	**D**		**0.68**	**59**	**E**	
	*WR	0.50	23	C		0.07	19	B		0.24	32	C	
	*ST	**0.33**	**49**	**D**	D (37)	**0.11**	**40**	**D**	C (30)	**0.34**	**46**	**D**	E (61)
	*SL	**0.60**	**53**	**D**		**0.20**	**42**	**D**		**0.71**	**60**	**E**	
	*SR	0.43	14	B		0.17	15	B		0.80	71	E	
A 7	20ET	**0.60**	**42**	**D**	D (37)	0.34	11	B	B (17)	**0.64**	**69**	**E**	E (61)
	*EL	0.20	33	C		**0.81**	**47**	**D**		0.74	33	C	
	20ER	0.36	17	B		0.32	3	A		0.15	36	C	
	20WT	**0.99**	**85**	**F**	E (77)	0.50	14	B	B (16)	0.84	28	C	C (28)
	20WL	0.62	27	C		0.30	29	C		**0.21**	**40**	**D**	
	*WR	**0.74**	**44**	**D**		0.09	11	B		0.16	19	B	
	*NT	**0.63**	**52**	**D**	D (42)	0.11	34	C	C (22)	**0.35**	**47**	**D**	E (62)
	6NL	**0.20**	**41**	**D**		0.10	34	C		**0.92**	**82**	**F**	
	6NR	0.16	4	A		0.09	3	A		0.58	10	B	
	*ST	**0.28**	**42**	**D**	C (32)	**0.11**	**38**	**D**	C (27)	**0.19**	**59**	**E**	D (49)
	*SL	**0.60**	**51**	**D**		**0.21**	**41**	**D**		**0.37**	**63**	**E**	
	*SR	0.43	10	B		0.16	11	B		0.35	32	C	

Table 5.36 Future LOS calculated by Vistro

ID	Future LOS of Each Approach Vistro												
		AM				Noon				PM			
	Direction	v/c	Delay	A.LOS	LOS	v/c	Delay	LOS	LOS	v/c	Delay	LOS	LOS
A 2	27ET	0.99	66	E	E (63)	0.43	29	C	D (35)	0.47	35	D	E (63)
	27EL	0.48	63	E		0.76	62	E		0.99	81	F	
	*ER	0.72	40	D		0.14	26	C		0.24	32	C	
	*ST	0.63	52	D	D (48)	0.10	33	C	E (64)	0.18	43	D	E (68)
	13SL	0.39	47	D		0.91	72	E		0.89	77	E	
	13SR	0.24	41	D		0.41	38	D		0.53	52	D	
	27WT	0.46	13	B	B (19)	0.33	12	B	B (13)	0.33	15	B	B (17)
	*WL	0.81	54	D		0.15	30	C		0.30	41	D	
	27WR	0.46	14	B		0.27	11	B		0.27	14	B	
	*NT	0.28	41	D	D (51)	0.10	30	C	D (35)	0.34	46	D	E (63)
	*NL	0.59	50	D		0.20	35	D		0.73	61	E	
	*NR	0.66	56	E		0.23	36	D		0.82	74	E	
A 3	26ET	0.74	36	D	E (64)	0.35	28	C	C (34)	0.47	35	C	E (62)
	26EL	0.95	81	F		0.73	55	E		0.92	83	F	
	*ER	0.76	45	D		0.14	26	C		0.24	32	C	
	*ST	0.61	51	D	D (53)	0.10	33	C	D (41)	0.18	43	D	E (55)
	12SL	0.17	41	D		0.26	38	D		0.30	48	D	
	12SR	0.63	53	D		0.64	43	D		0.76	58	E	
	26WT	0.36	12	B	C (21)	0.22	13	B	B (13)	0.27	14	B	B (17)
	*WL	0.81	53	D		0.15	30	C		0.30	41	D	
	*NT	0.28	41	D	D (37	0.10	32	C	D (35)	0.34	43	D	E (63)
	*NL	0.62	55	E		0.20	35	D		0.73	61	E	
	*NR	0.66	56	E		0.23	36	D		0.82	71	E	
A 6	*NT	0.61	51	D	D (52)	0.09	33	C	D (44)	0.18	43	D	E (63)
	7NL	0.56	52	D		0.56	46	D		0.87	73	E	
	*NR	0.59	51	D		0.57	45	D		0.66	53	D	
	21ET	0.29	12	B	C (25)	0.57	31	C	C (31)	0.44	16	B	C (22)
	*EL	0.80	50	D		0.23	39	D		0.30	41	D	
	21ER	0.24	11	B		0.45	32	C		0.35	16	B	
	21WT	0.96	60	E	D (52)	0.30	12	B	B (16)	0.72	40	D	D (43)
	21WL	0.74	26	C		0.49	36	D		0.68	59	E	
	*WR	0.44	44	D		0.07	10	B		0.24	32	C	
	*ST	0.28	41	D	D (37)	0.09	32	C	D (35)	0.34	46	D	E (61)
	*SL	0.64	55	E		0.20	36	D		0.71	60	E	
	*SR	0.65	55	E		0.22	35	D		0.80	71	E	
A 7	20ET	0.79	12	B	C (21)	0.54	30	C	C (31)	0.77	41	D	E (61)
	*EL	0.79	51	D		0.23	39	D		0.48	56	E	
	20ER	0.23	11	B		0.43	31	C		0.82	55	E	
	20WT	0.96	60	E	D (50)	0.3	12	B	B (16)	0.41	16	B	C (27)
	20WL	0.74	26	C		0.28	31	C		0.75	57	E	
	*WR	0.76	43	D		0.07	10	B		0.13	13	B	
	*NT	0.61	50	D	D (52)	0.09	33	C	C (34)	0.18	43	D	D (45)
	6NL	0.58	52	D		0.09	35	D		0.26	47	D	
	6NR	0.55	51	D		0.11	34	C		0.27	45	D	
	*ST	0.28	41	D	D (52)	0.09	33	C	D (35)	0.34	46	E	D (61)
	*SL	0.61	55	E		0.20	35	D		0.71	60	E	
	*SR	0.65	56	E		0.22	35	D		0.80	71	E	

Table 5.37 Future Total Delay and LOS of Northern Corridor at Morning Peak hour (using Synchro)

Morning Peak	Northern Corridor		A1	A2	A3	A4
	Day1 (Weekday)	Delay(sec/veh)	42.2	55.5	34.5	40.1
		LOS	D	E	C	D
	Day2 (Weekday)	Delay(sec/veh)	57.4	38.5	28.6	54.7
		LOS	E	D	C	D
	Day3 (Weekend)	Delay(sec/veh)	34.7	41.2	32.5	49.9
		LOS	C	D	C	D

Table 5.38 Future Total Delay and LOS of Southern Corridor at Morning Peak hour (using Synchro)

Morning Peak	Southern Corridor		A5	A6	A7	A8
	Day1 (Weekday)	Delay(sec/veh)	30.7	39.2	52.6	35.8
		LOS	C	D	E	D
	Day2 (Weekday)	Delay(sec/veh)	33.9	39.1	54.2	29.9
		LOS	C	D	D	C
	Day3 (Weekend)	Delay(sec/veh)	24.7	23.2	22.6	34.7
		LOS	C	C	C	C

Table 5.39 Future Total Delay and LOS of Northern Corridor at Noon Off-Peak Period(using Synchro)

	Northern Corridor		A1	A2	A3	A4
Noon Off-Peak	Day1 (Weekday)	Delay(sec/veh)	31.6	27.4	29.9	34.7
		LOS	C	C	C	C
	Day2 (Weekday)	Delay(sec/veh)	34.8	26.7	28.7	62.3
		LOS	C	C	C	E
	Day3 (Weekend)	Delay(sec/veh)	44.6	28.7	31.1	65.4
		LOS	D	C	C	E

Table 5.40 Future Total Delay and LOS of Southern Corridor at Noon Off-Peak Period(using Synchro)

	Southern Corridor		A5	A6	A7	A8
Noon Off-Peak	Day1 (Weekday)	Delay(sec/veh)	23.1	30.7	27.6	21.2
		LOS	C	C	C	C
	Day2 (Weekday)	Delay(sec/veh)	17.8	26.6	30.3	19.6
		LOS	B	C	C	B
	Day3 (Weekend)	Delay(sec/veh)	19.7	23.3	65.6	37.4
		LOS	B	C	E	D

Table 5.41 Future Total Delay and LOS of Northern Corridor at Evening Peak hour (using Synchro)

	Northern Corridor		A1	A2	A3	A4
Evening Peak	Day1 (Weekday)	Delay(sec/veh)	57.1	31.1	29.8	62.3
		LOS	E	C	C	E
	Day2 (Weekday)	Delay(sec/veh)	34.7	37.7	30.2	48.9
		LOS	C	D	C	D
	Day3 (Weekend)	Delay(sec/veh)	35.7	35.9	29.5	49.0
		LOS	D	D	C	D

Table 5.42 Future Total Delay and LOS of Southern Corridor at Evening Peak hour (using Synchro)

	Southern Corridor		A5	A6	A7	A8
Evening Peak	Day1 (Weekday)	Delay(sec/veh)	22.7	34.0	49.1	62.2
		LOS	C	C	D	E
	Day2 (Weekday)	Delay(sec/veh)	25.2	39.8	35.1	43.2
		LOS	C	D	D	D
	Day3 (Weekend)	Delay(sec/veh)	29.2	38.1	39.7	41.9
		LOS	C	D	D	D

Table 5.43 Future Total Delay and LOS of Northern Corridor at Morning Peak hour (using Vistro)

	Northern Corridor		A1	A2	A3	A4
Morning Peak	Day1 (Weekday)	Delay(sec/veh)	40.5	43.9	43.8	36.5
		LOS	D	D	D	D
	Day2 (Weekday)	Delay(sec/veh)	89.2	39.4	52.8	79.1
		LOS	F	D	D	E
	Day3 (Weekend)	Delay(sec/veh)	37.2	34.8	38.1	41.5
		LOS	D	C	D	D

Table 5.44 Future Total Delay and LOS of Southern Corridor at Morning Peak hour (using Vistro)

	Southern Corridor		A5	A6	A7	A8
Morning Peak	Day1 (Weekday)	Delay(sec/veh)	39.9	47.8	66.6	34.9
		LOS	D	D	E	C
	Day2 (Weekday)	Delay(sec/veh)	37.7	39.6	40.1	28.6
		LOS	D	D	D	C
	Day3 (Weekend)	Delay(sec/veh)	22.8	27.4	35.5	34.5
		LOS	C	C	D	C

Table 5.45 Future Total Delay and LOS of Northern Corridor at Noon Off-Peak Period (using Vistro)

Noon Off-Peak	**Northern Corridor**		A1	A2	A3	A4
	Day1 (Weekday)	Delay(sec/veh)	34.6	32.2	29.9	34.1
		LOS	C	C	C	C
	Day2 (Weekday)	Delay(sec/veh)	34.1	31.7	27.8	39.8
		LOS	C	C	C	D
	Day3 (Weekend)	Delay(sec/veh)	34.8	37.5	33.2	69.4
		LOS	C	D	C	E

Table 5.46 Future Total Delay and LOS of Southern Corridor at Noon Off-Peak Period (using Vistro)

Noon Off-Peak	**Southern Corridor**		A5	A6	A7	A8
	Day1 (Weekday)	Delay(sec/veh)	26.1	27.6	24.3	21.4
		LOS	C	C	C	C
	Day2 (Weekday)	Delay(sec/veh)	22.1	28.8	24.6	21.5
		LOS	C	C	C	C
	Day3 (Weekend)	Delay(sec/veh)	21.1	29.6	30.7	54.9
		LOS	C	C	C	D

Table 5.47 Future Total Delay and LOS of Northern Corridor at Evening Peak hour (using Vistro)

	Northern Corridor		A1	A2	A3	A4
Evening Peak	Day1 (Weekday)	Delay(sec/veh)	71.6	56.7	47.3	48.2
		LOS	E	D	D	D
	Day2 (Weekday)	Delay(sec/veh)	36.1	42.0	40.9	65.9
		LOS	D	D	D	E
	Day3 (Weekend)	Delay(sec/veh)	38.3	48.9	41.5	70.1
		LOS	D	D	D	E

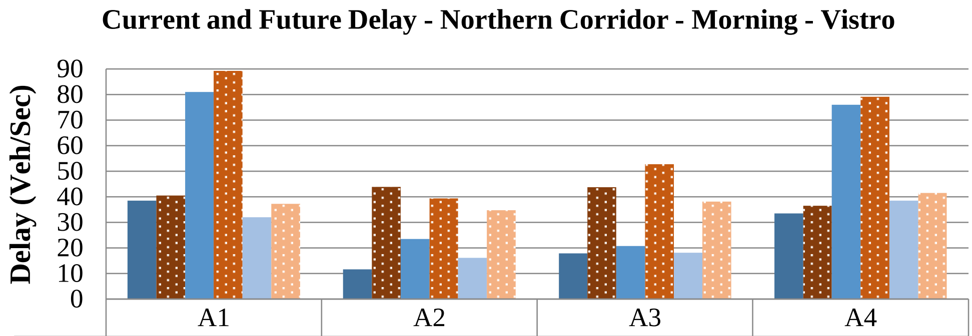
Table 5.48 Future Total Delay and LOS of Southern Corridor at Evening Peak hour (using Vistro)

	Southern Corridor		A5	A6	A7	A8
Evening Peak	Day1 (Weekday)	Delay(sec/veh)	29.5	56.1	39.9	77.4
		LOS	C	E	D	E
	Day2 (Weekday)	Delay(sec/veh)	27.2	41.5	38.1	58.8
		LOS	C	D	D	D
	Day3 (Weekend)	Delay(sec/veh)	52.4	75.9	37.2	34.1
		LOS	D	E	D	C

5.5 Comparative Evaluation

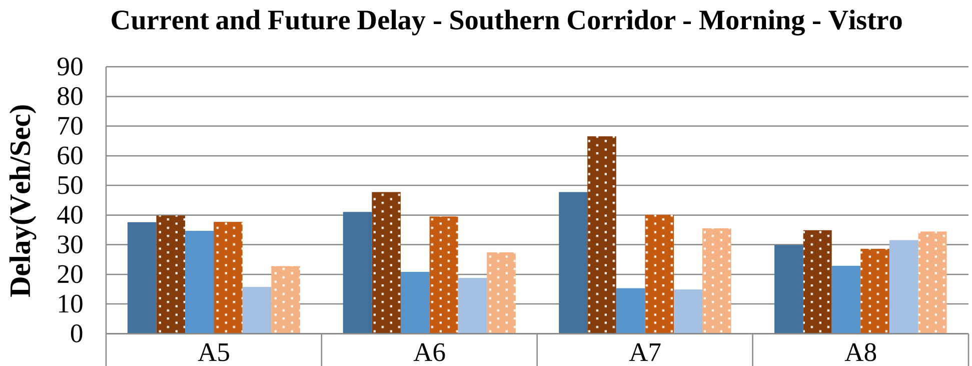
This part of study compares the results of LOS before and after proposed health campus (by both of Visto and Synchro software). The results showed the intersections will be more congested after health campus constructed. Table 5.49 to 5.54 indicate the current and future Delay and LOS in northern and southern corridor that calculated by Vistro. Table 5.55 to 5.60 indicate the current and future Delay and LOS in northern and southern corridor that calculated by Synchro.

Table 5.49 Current and Future Delay at Morning Peak Hour by Vistro



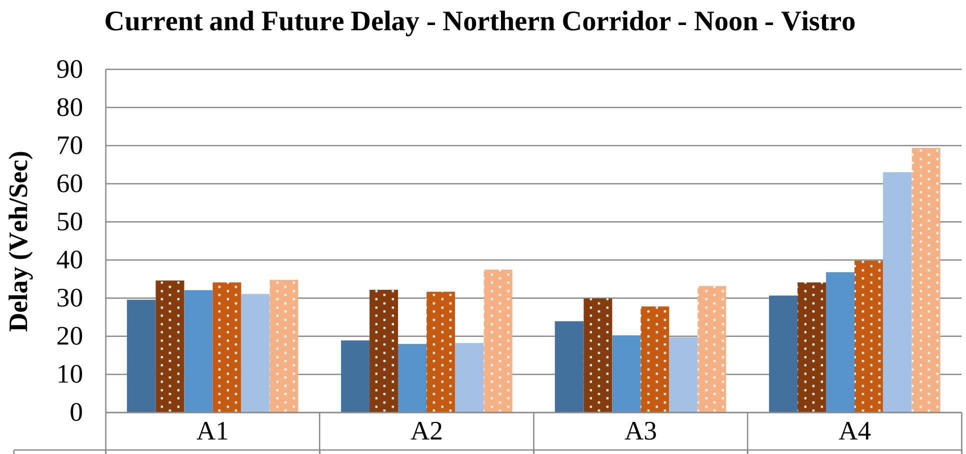
	A1	A2	A3	A4
C.D1	38.5	11.7	17.9	33.5
F.D1	40.5	43.9	43.8	36.5
C.D2	81	23.5	20.7	76
F.D2	89.2	39.4	52.8	79.1
C.D3	32	16.2	18.1	38.5
F.D3	37.2	34.8	38.1	41.5

Table 5.50 Current and Future Delay at Morning Peak Hour by Vistro



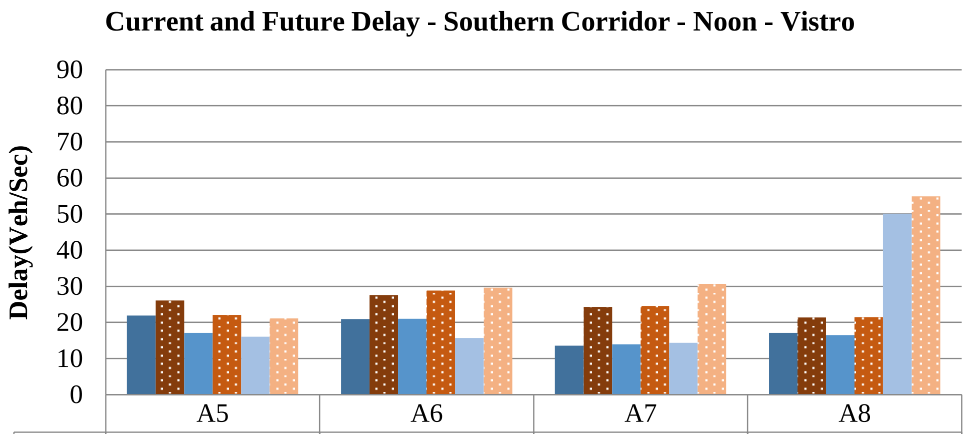
	A5	A6	A7	A8
C.D1	37.6	41.1	47.8	29.9
F.D1	39.9	47.8	66.6	34.9
C.D2	34.7	20.8	15.3	22.9
F.D2	37.7	39.6	40.1	28.6
C.D3	15.8	18.8	14.9	31.5
F.D3	22.8	27.4	35.5	34.5

Table 5.51 Current and Future Delay at Noon off- Peak Period by Vistro



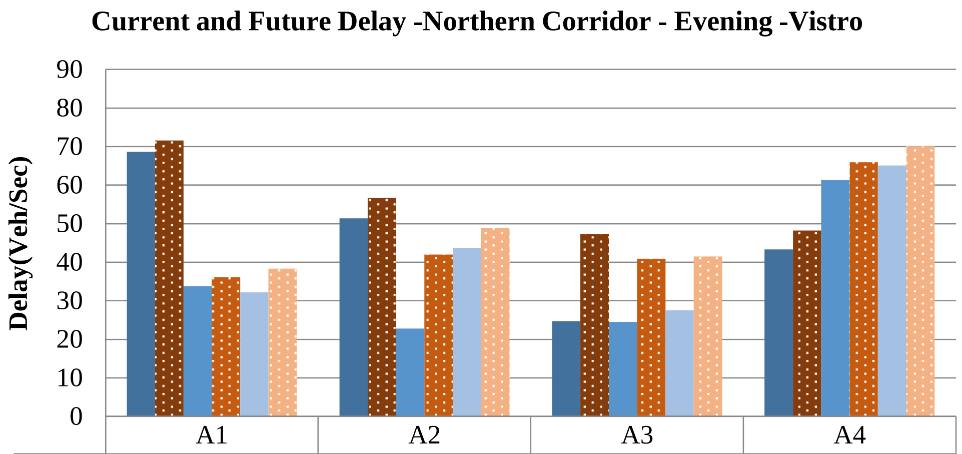
	A1	A2	A3	A4
C.D1	29.6	18.9	23.9	30.7
F.D1	34.6	32.2	29.9	34.1
C.D2	32.1	18	20.2	36.8
F.D2	34.1	31.7	27.8	39.8
C.D3	31.1	18.2	19.7	63
F.D3	34.8	37.5	33.2	69.4

Table 5.52 Current and Future Delay at Noon off- Peak Period by Vistro



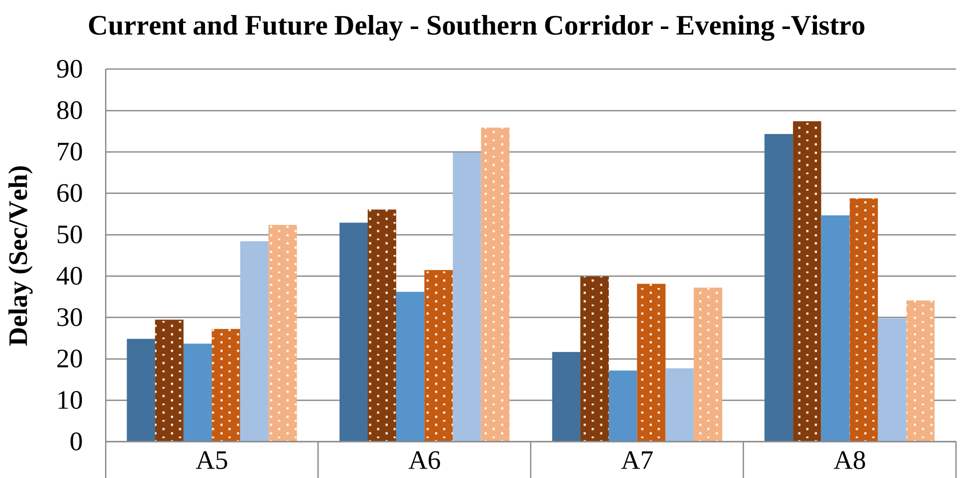
	A5	A6	A7	A8
C.D1	21.9	20.9	13.6	17.1
F.D1	26.1	27.6	24.3	21.4
C.D2	17.1	21	13.9	16.5
F.D2	22.1	28.8	24.6	21.5
C.D3	16	15.7	14.4	50.1
F.D3	21.1	29.6	30.7	54.9

Table 5.53 Current and Future Delay at Evening Peak Hour by Vistro



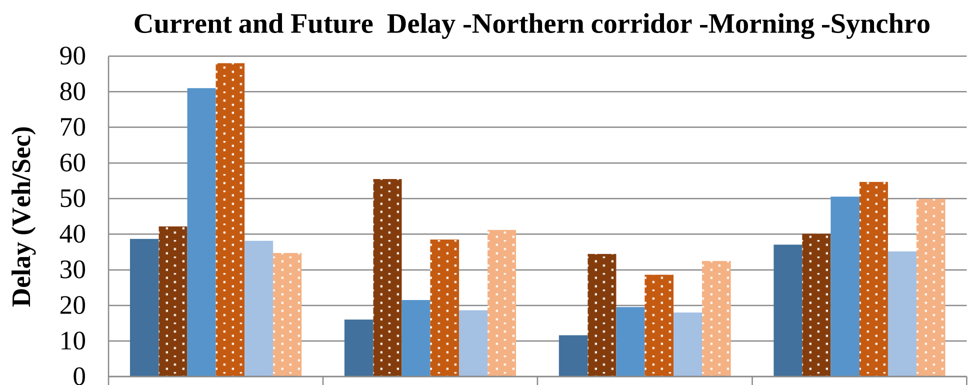
	A1	A2	A3	A4
C.D1	68.7	51.4	24.7	43.3
F.D1	71.6	56.7	47.3	48.2
C.D2	33.8	22.8	24.5	61.3
F.D2	36.1	42	40.9	65.9
C.D3	32.2	43.7	27.5	65.1
F.D3	38.3	48.9	41.5	70.1

Table 5.54 Current and Future Delay at Evening Peak Hour by Vistro



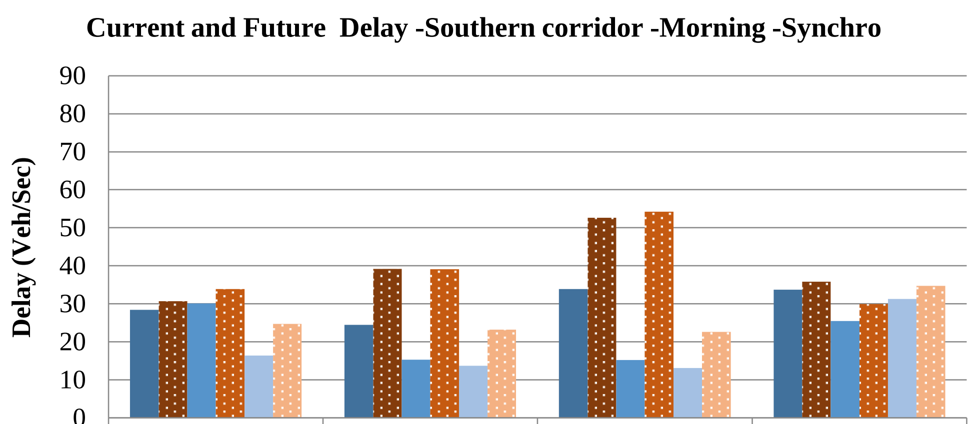
	A5	A6	A7	A8
C.D1	24.8	52.9	21.7	74.3
F.D1	29.5	56.1	39.9	77.4
C.D2	23.7	36.2	17.2	54.7
F.D2	27.2	41.5	38.1	58.8
C.D3	48.4	69.8	17.7	29.8
F.D3	52.4	75.9	37.2	34.1

Table 5.55 Current and Future Delay at Morning Peak Hour by Synchro



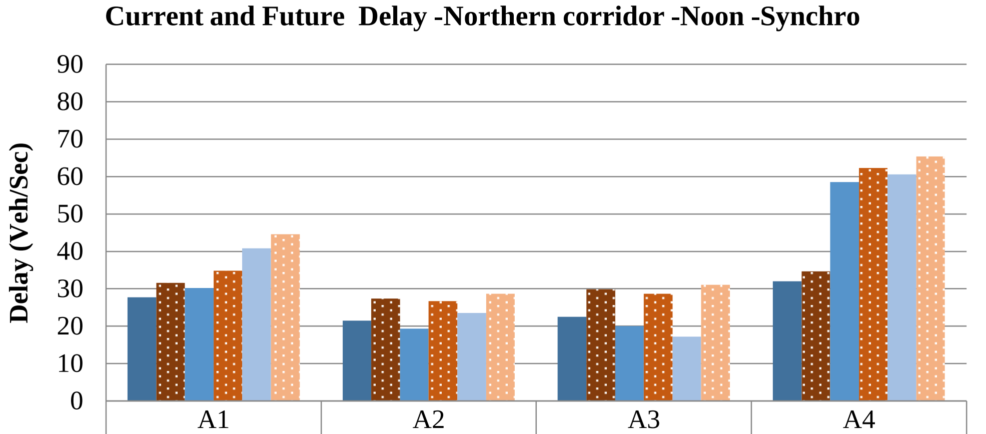
	A1	A2	A3	A4
C.D1	38.7	16	11.6	37.1
F.D1	42.2	55.5	34.5	40.1
C.D2	81	21.5	19.5	50.5
F.D2	88	38.5	28.6	54.7
C.D3	38.1	18.6	18	35.2
F.D3	34.7	41.2	32.5	49.9

Table 5.56 Current and Future Delay at Morning Peak Hour by Synchro



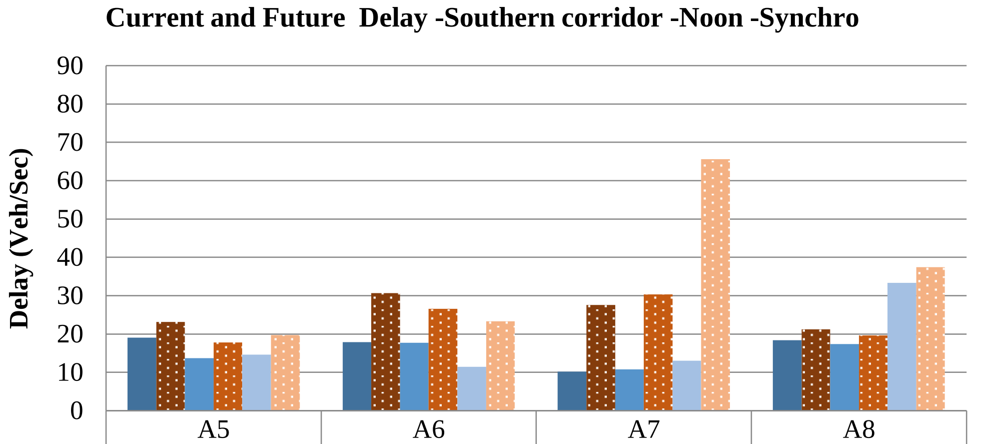
	A5	A6	A7	A8
C.D1	28.4	24.5	33.9	33.7
F.D1	30.7	39.2	52.6	35.8
C.D2	30.1	15.3	15.2	25.5
F.D2	33.9	39.1	54.2	29.9
C.D3	16.4	13.7	13.1	31.3
F.D3	24.7	23.2	22.6	34.7

Table 5.57 Current and Future Delay at Noon off- Peak Period by Synchro



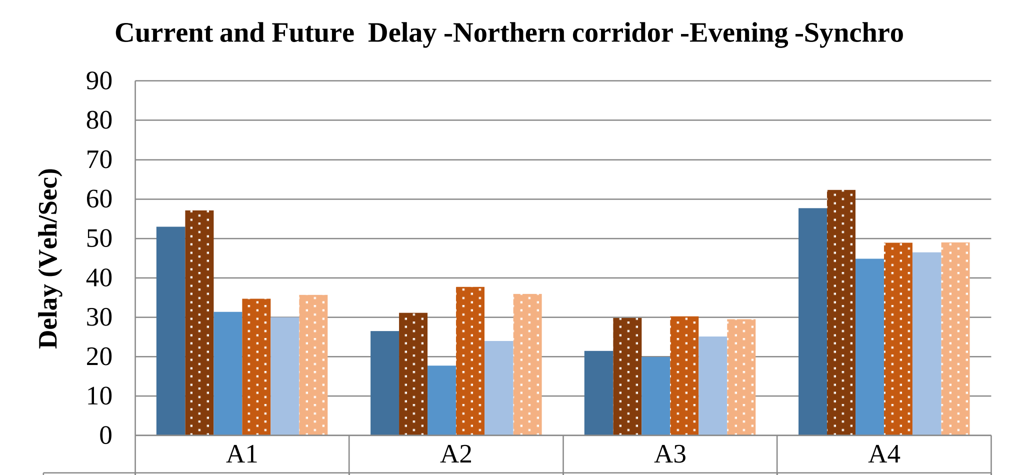
	A1	A2	A3	A4
C.D1	27.7	21.5	22.5	32
F.D1	31.6	27.4	29.9	34.7
C.D2	30.2	19.3	20	58.5
F.D2	34.8	26.7	28.7	62.3
C.D3	40.8	23.5	17.2	60.6
F.D3	44.6	28.7	31.1	65.4

Table 5.58 Current and Future Delay at Noon off-peak period by Synchro



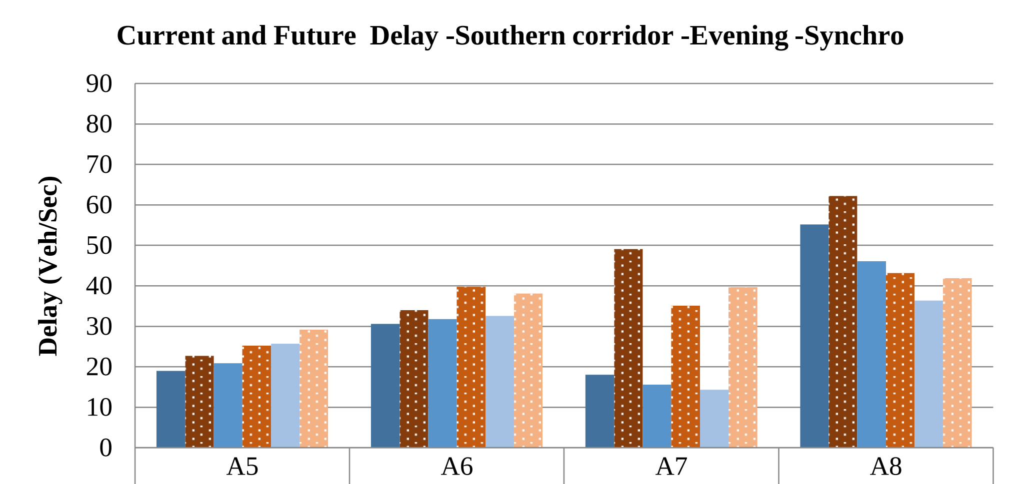
	A5	A6	A7	A8
C.D1	19	17.9	10.2	18.4
F.D1	23.1	30.7	27.6	21.2
C.D2	13.7	17.7	10.8	17.4
F.D2	17.8	26.6	30.3	19.6
C.D3	14.6	11.4	13	33.3
F.D3	19.7	23.3	65.6	37.4

Table 5.59 Current and Future Delay at Evening Peak Hour by Synchro



	A1	A2	A3	A4
C.D1	53	26.5	21.5	57.7
F.D1	57.1	31.1	29.8	62.3
C.D2	31.4	17.7	19.9	44.9
F.D2	34.7	37.7	30.2	48.9
C.D3	30	24	25.1	46.5
F.D3	35.7	35.9	29.5	49

Table 5.60 Current and Future Delay at Evening Peak Hour by Synchro



	A5	A6	A7	A8
C.D1	19	30.6	18	55.2
F.D1	22.7	34	49.1	62.2
C.D2	20.9	31.8	15.6	46.1
F.D2	25.2	39.8	35.1	43.2
C.D3	25.7	32.6	14.3	36.4
F.D3	29.2	38.1	39.7	41.9

In general, the results showed that the Delay and LOS of all intersections increase in all days. Also, the results by Vistro generally showed higher delay than Synchro, because of their embedded delay function. That is why, the Vistro results seem more reasonable than Synchro.

CHAPTER 6

CONCLUSIONS AND FUTURE RECOMMENDATIONS

6.1 Conclusions

Developing a mega project, such as the Etlik Integrated Health Campus, in an already urbanized region of in Ankara must be considered from the point of not only the services it would bring to the neighborhood and the city, but also its traffic cost, such as the delays it would generate. The analysis of the current traffic demand at intersections around the project location showed that they are at saturation and sometimes facing long but tolerable delays during the peak hours. Under the future demand expected after the opening of the health campus, even with the optimized phasing and cycle times, PTV Vistro and Synchro results estimated severe delays at all the intersections during the morning and peak hours, even during weekends at some locations. This potential problem may get even worse when the land use around the campus area changes due to increase in the number of business places related to healthcare (pharmacies, medical supply stores, etc.), which would increase not only the traffic demand but also the parking demand on the roads in the neighborhood (and cause loss of capacity at the intersections).

Although this simple analysis of traffic impact of the health campus shows the potential problems it may cause, despite the efforts of the contractors in foreseeing the potential problems the project may face due to adverse traffic conditions, there is no discussion of these problems by the municipality or the Ministry of Health, which contracted out the project in the first. Due to the lack of public participation or serious enforcement of TIA in such big urban projects in Turkey, the consequences will be faced after the opening of them and would be attempted to solved or mitigated within the capabilities of the time and infrastructure available.

According to results, A2 and A3 in northern corridor and A6 and A7 in southern corridor will be impact the most. So, the current and future results of these intersections mentioned below. This study only focused on trip generation rate based on bed capacity. The LOS of these intersections will be worsening if the trip generation rate based on employer number will add to it. In this part, our study only focused on Vistro results because the results are almost same. In the tables that mentioned below, symbols were shorted as these methods: S=South, W=West, N=North, E=East, T=Through, L=Left, R=Right, A=Approach,*N= New North,*S=New South, C=Current and F=Future)

A2 Intersection (Northern Corridor)

The A2 intersection at northern corridor is the one of minor intersection before project that currently carries the LOS B at east to west direction, LOS C to F at south to north direction and LOS A to B at west to east direction. According to the project design, this intersection will be one of the entrance/exit gates of the proposed health campus. It will be one of the major intersections after project that predict to carries the LOS D to E at east to west direction, LOS D to E at south to north direction , LOS B at west to east and LOS D to E at north to south direction. As results shows the A2 intersection will face long delay and lower LOS at east to west, north to south and south direction. To handle these traffic conditions, separate lanes for right and left turning movements (storage lane) can be design, also extending the number of the line at south and north direction can be improve future condition. The Figure 6.1 shows the current and future geometry condition of A2 intersection. The Table 6.1 indicates the current and future delay and LOS for each approach by Vistro.

Figure 6.1 Current and future geometry of "A2" intersection

Table 6.1 Current and future delay of each approch at "A2" intersection by Vistro

A2										
	Morning				**Noon**			**Evening**		
	Direction	Delay	ALOS	LOS	Delay	ALOS	LOS	Delay	ALOS	LOS
C	27ET	11	B	B (11)	9	A	B (13)	8	A	B (15)
	27EL	29	C		28	C		**49**	**D**	
F	27ET	**66**	**E**	E (63)	29	C	D (35)	**35**	**D**	E (63)
	27EL	**63**	**E**		**62**	**E**		**81**	**F**	
	*ER	**40**	**D**		26	C		**32**	**C**	
C	13SL	**56**	**D**	D (42)	30	C	C (29)	**38**	**D**	F (81)
	13SR	24	C		27	C		**88**	**F**	
F	*ST	**52**	**D**	D (48)	33	C	E (64)	**43**	**D**	E (68)
	13SL	**47**	**D**		**72**	**E**		**77**	**E**	
	13SR	**41**	**D**		**38**	**D**		**52**	**D**	
C	27WT	11	B	B	10	A	A	8	A	A
F	27WT	13	B	B (19)	12	B	B (13)	15	B	B (17)
	*WL	**54**	**D**		30	C		**41**	**D**	
	27WR	14	B		11	B		14	B	
F	*NT	**41**	**D**	D (51)	30	C	D (35)	**46**	**D**	E (63)
	*NL	**50**	**D**		**35**	**D**		**61**	**E**	

A3 Intersection (Northern Corridor)

The A3 intersection at northern corridor is currently minor intersection that shows the LOS B to C at east to west direction, LOS D at south to north direction and LOS B to C at west to east direction. This intersection will be one of the hospital gates after project. The future LOS analysis shows this intersection will serve the LOS C to E at east to west direction, LOS D to E at south to north direction, LOS B to C at west to east and LOS D to E at north to south direction. As a result shows the A3 intersection will have lower LOS at east to west, north to south and south direction. In order to have shorter delay at this intersection, storage lane for left at right turn can be added for all approach , also the ITS for northern corridor can be added to have green line corridor and emergency vehicle preemption after project, similarly extending the number of the line at south and north direction and preventing illegal parking can be improve future situation. The Figure 6.2 shows the current and future geometry condition of A3 intersection. The Table 6.2 indicates the current and future delay and LOS for each approach by Vistro.

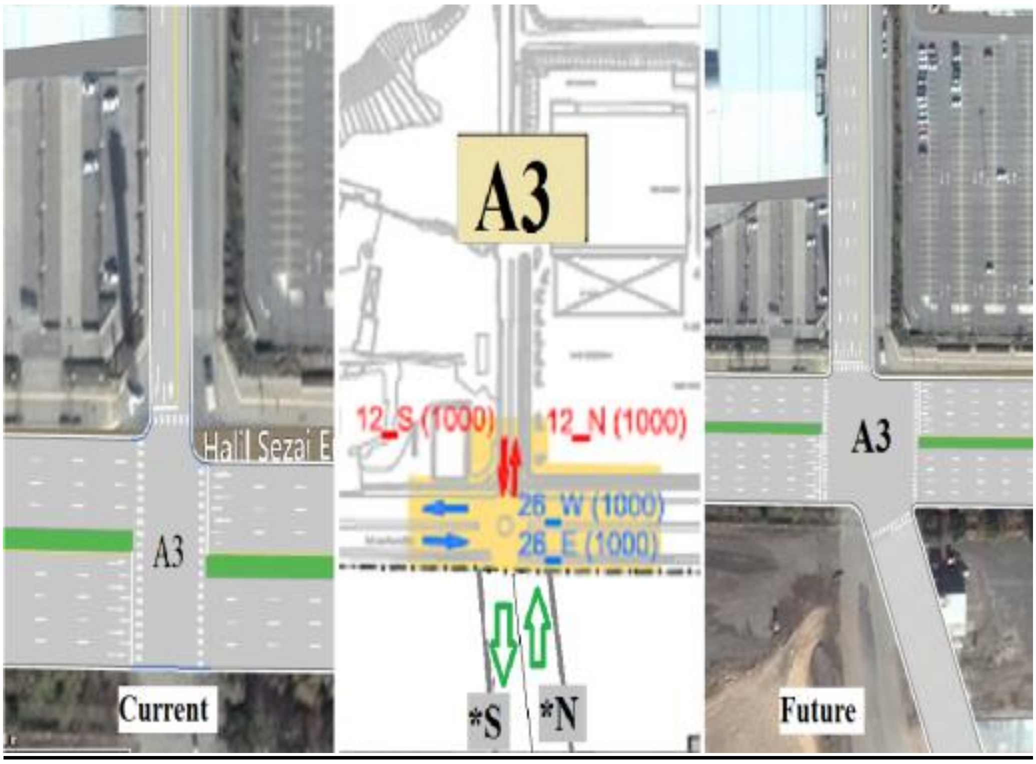


Figure 6.2 Current and future geometry of "A3" intersection

Table 6.2 Current and future delay of each approch at "A3" intersection by Vistro

A3										
		Morning			**Noon**			**Evening**		
	Direction	Delay	ALOS	LOS	Delay	ALOS	LOS	Delay	ALOS	LOS
C	26ET	5	A	B (11)	5	A	C (29)	9	A	C (20)
	26EL	**44**	**D**		**89**	**F**		**65**	**E**	
F	26ET	**36**	**D**	E (64)	28	C	C (34)	35	C	E (62)
	26EL	**81**	**F**		**55**	**E**		**83**	**F**	
	*ER	**45**	**D**		26	C		32	C	
C	12SL	**43**	**D**	D (43)	**37**	**D**	D (38)	**37**	**D**	D (37)
	12SR	**44**	**D**		**38**	**D**		**38**	**D**	
F	*ST	**51**	**D**	D (53)	33	C	D (41)	**43**	**D**	E (55)
	12SL	**41**	**D**		**38**	**D**		**48**	**D**	
	12SR	**53**	**D**		**43**	**D**		**58**	**E**	
C	26WT	18	B	B	11	B	B	23	C	C
F	26WT	12	B	C (21)	13	B	B (13)	14	B	B (17)
	*WL	**53**	**D**		30	C		**41**	**D**	
F	*NT	**41**	**D**	D (37	32	C	D (35)	**43**	**D**	E (63)
	*NL	**55**	**E**		**35**	**D**		**61**	**E**	
	*NR	**56**	**E**		**36**	**D**		**71**	**E**	

A6 Intersection (Southern Corridor)

According to project design the health campus will have two gates at southern corridor. The A6 intersection is one of the entrance/exit gates of hospital that carries the LOS B to C at east to west direction, LOS E to F at north to south direction and LOS C to D at west to east direction. It will be one of the major intersections after project that predict to carries the LOS C at east to west direction, LOS D to E at south to north direction , LOS B to D at west to east and LOS D to E at north to south direction. As results shows the A6 intersection will face long delay and lower LOS at west to east, north to south and south to north direction. So as to control future traffic condition, separate lanes for right and left turning movements (storage lane) can be design, also extending the number of the line at south and north direction can be improve future condition. The Figure 6.3 shows the current and future geometry condition of A6 intersection. The Table 6.3 indicates the current and future delay and LOS for each approach by Vistro.

Figure 6.3 Current and future geometry of "A6" intersection

Table 6.3 Current and future delay of each approch at "A6" intersection by Vistro

A6										
	Morning				**Noon**			**Evening**		
	Direction	Delay	ALOS	LOS	Delay	ALOS	LOS	Delay	ALOS	LOS
C	7NL	**69**	**E**	E	58	E	E	83	F	F
F	*NT	**51**	**D**	D (52)	33	C	D (44)	**43**	**D**	E (63)
	7NL	**52**	**D**		**46**	**D**		**73**	**E**	
	*NR	**51**	**D**		**45**	**D**		**53**	**D**	
C	21ET	20	C	C (20)	18	B	B (18)	19	B	B (19)
	21ER	20	C		17	B		17	B	
F	21ET	12	B	C (25)	31	C	C (31)	16	B	C (22)
	*EL	**50**	**D**		**39**	**D**		**41**	**D**	
	21ER	11	B		32	C		16	B	
C	21WT	6	A	D (48)	5	A	B (11)	6	A	C (21)
	21WL	**101**	**F**		**36**	**D**		**84**	**F**	
F	21WT	60	E	D (52)	12	B	B (16)	**40**	**D**	D (43)
	21WL	26	C		**36**	**D**		**59**	**E**	
	*WR	**44**	**D**		10	B		32	C	
F	*ST	**41**	**D**	D (37)	32	C	D (35)	**46**	**D**	E (61)
	*SL	**55**	**E**		**36**	**D**		**60**	**E**	
	*SR	**55**	**E**		**35**	**D**		**71**	**E**	

A7 Intersection (Southern Corridor)

The A7 intersection at northern corridor is currently minor intersection that shows the LOS B at east to west direction, LOS C to D at north to south direction and LOS B to E at west to east direction. This intersection will be one of the hospital gates after project. The future LOS and delay by simulation indicates that this intersection will serve the LOS C to E at east to west direction, LOS D at south to north direction, LOS B to D at west to east and LOS C to D at north to south direction. As a result shows the A7 intersection will be congested at west to east, north to south and south to north direction. In order to have higher LOS at this intersection, cycle length can be changed according to new condition and also storage lane for left at right turn can be added for all approach, moreover the ITS for northern corridor can be added to have green line corridor and emergency vehicle preemption after project, similarly extending the number of the line at south and north direction and preventing illegal parking can be improve future situation. The Figure 6.4 shows the current and future geometry condition of A7 intersection. The Table 6.4 indicates the current and future delay and LOS for each approach by Vistro.

Figure 6.4 Current and future geometry of "A7" intersection

Table 6.4 Current and future delay of each approch at "A7" intersection by Vistro

A7										
	Morning				**Noon**			**Evening**		
	Direction	Delay	ALOS	LOS	Delay	ALOS	LOS	Delay	ALOS	LOS
C	20ET	17	B	B (18)	15	B	B (15)	18	B	B (18)
	20ER	20	B		15	B		17	B	
F	20ET	12	B	C (21)	30	C	C (31)	**41**	**D**	E (61)
	*EL	**51**	**D**		**39**	**D**		**56**	**E**	
	20ER	11	B		31	C		**55**	**E**	
C	20WT	8	A	E (60)	5	A	B (11)	5	A	C (24)
	20WL	**102**	**F**		**36**	**D**		**106**	**F**	
F	20WT	**60**	**E**	D (50)	12	B	B (16)	16	B	C (27)
	20WL	26	C		31	C		**57**	**E**	
	***WR**	**43**	**D**		10	B		13	B	
C	6NL	**35**	**D**	D (35)	29	C	C (29)	**44**	**D**	D (44)
	6NR	**37**	**D**		28	C		**45**	**D**	
F	*NT	**50**	**D**	D (52)	33	C	C (34)	**43**	**D**	D (45)
	6NL	**52**	**D**		**35**	**D**		**47**	**D**	
	6NR	**51**	**D**		34	C		**45**	**D**	
F	*ST	**41**	**D**	D (52)	33	C	D (35)	**46**	**E**	D (61)
	*SL	**55**	**E**		**35**	**D**		**60**	**E**	
	*SR	**56**	**E**		**35**	**D**		**71**	**E**	

At a more technical level, the comparative study between PTV Vistro v.2 and Synchro v.9, suggested that Vistro depicted the delays more reasonably based on visual evaluation of the video recordings, but a more numerical evaluation is necessary before recommending one over the other scientifically. Also the results of Synchro and Vistro show that, the Vistro is more powerful in high traffic volume and saturated condition. However, the Synchro is more powerful in low traffic volume condition. The main difference in the results is because of different function that used for calculation delay. Vistro directly uses HCM delay formula to calculate LOS, but Synchro uses its own formula, and then compares it with HCM delay results and shows average of them. For this reason, generally the Vistro shows higher delay than Synchro. In conclusion, both software are powerful and useful, the advantage of Vistro is more accurate results, use HCM formula directly, simple and user friendly, good report creator and have less error in running. On the other hand, the advantage of Synchro is simulation part and more option to user to control cars during simulations and also it is more useful for TIA because of TripGen software and land use option on it.

6.2 Future Recommendations

In order to discrourage private car usage to access the health campus area, certain measures must be considered. Within the project area, it is crucial to have a very good in-campus road network design. It should not only support vehicle flow but also walkability to encourage use of public transit to access the campus area. Hospital personnel should be discouraged to use private cars by the means travel demand management strategies. Shuttle services should be arranged for the personnel. METRO usage can be encouraged, both for the personnel and patients/visitors. It will be very supportive, especially, if the municipality provides extended working hours and during the work shift change times for this line. In-campus walking network must be designed to connect the campus buildings to the METRO station. Shuttles should be provided to connect the METRO users to the campus buildings to further support the public transit usage. Bus and shuttle stops within the campus area have to be designed to support the flow of the traffic easily, and not to block it.

Design of the four intersections directly serving the campus is extremely crucial and should be handled by care. Separate lanes for right and left turning movements must be provided as much as possible. The island serving as miniature roundabouts must definitely be eliminated. Around the campus area, commute traffic should be diverted to other corridors, as much as possible. Furthermore, illegal parking on the northern and southern corridors roads must be definitely prevented by enforcement, if necessary. Any loss of capacity due to parking will drop the LOS values to failing levels. Also, intelligent transportation systems (ITS) for signal coordination and emergency vehicle preemption should be provided along these corridors for sure.

On the issue of traffic generation, ITE rates should be obtained based on Turkish demographics and travel characteristics. These new rates will be useful to city planner and transportation engineer to have more accrued and efficient ability to predict future trip generation from different zones. Moreover, the effect of public transport or subway after project also can be studied for further research. Also the Co2 Emissions from traffic around health campuses can be evaluated for environmental topic.

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APPENDIX A

GEOMETRIC CONFIGURATION

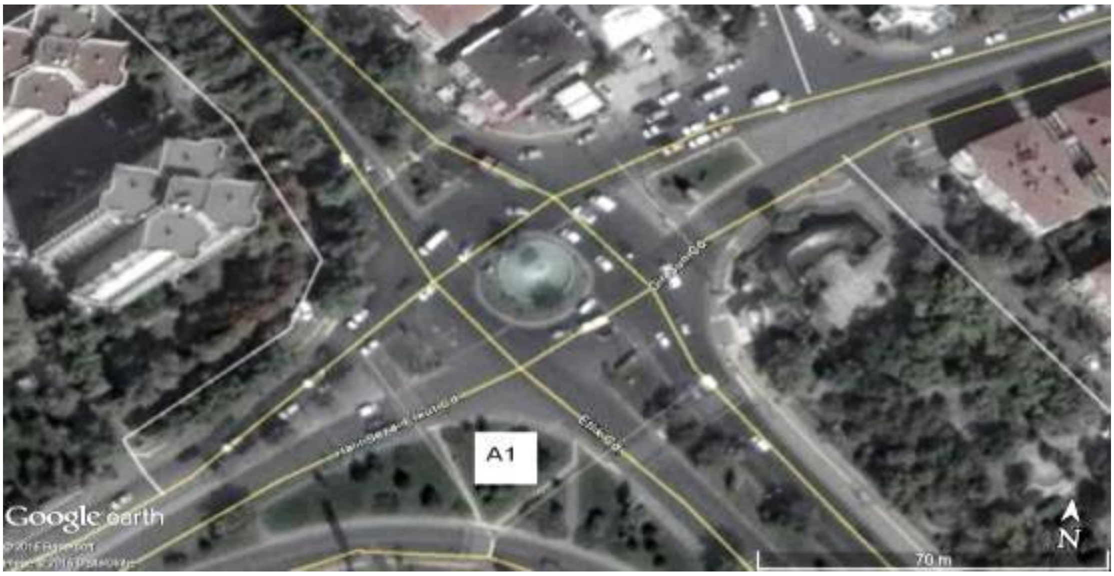


Figure A. 1 Google Earth View of Signalized Intersection “A1” (Etlik Cad. with Halil Sezai Erkut Cad.) (Google Map/Earth, 2014)

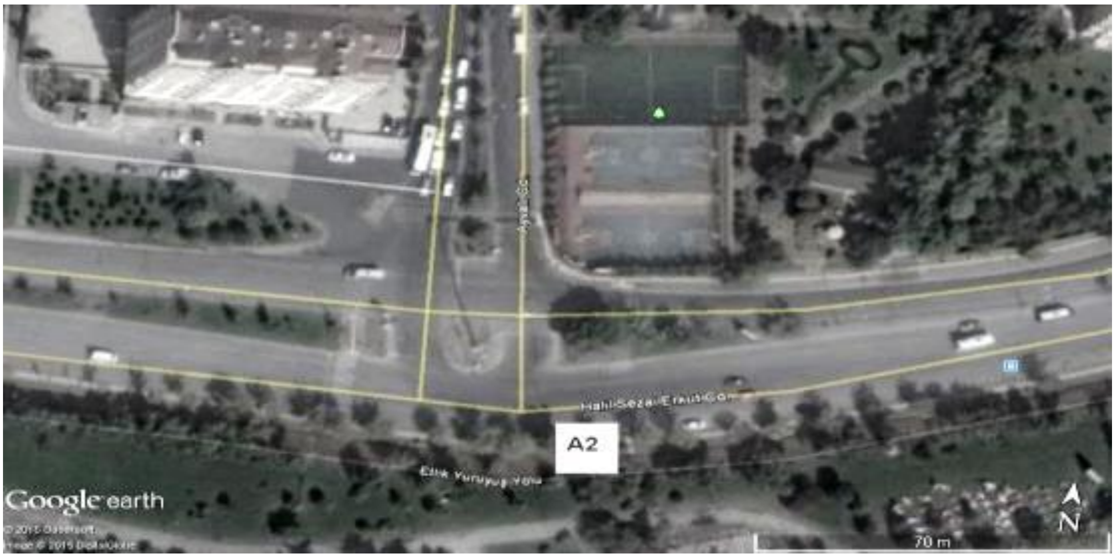


Figure A. 2 Google Earth View of Signalized Intersection “A2” (Ayvalı Cad. with Halil Sezai Erkut Cad.) (Google Map/Earth, 2014)

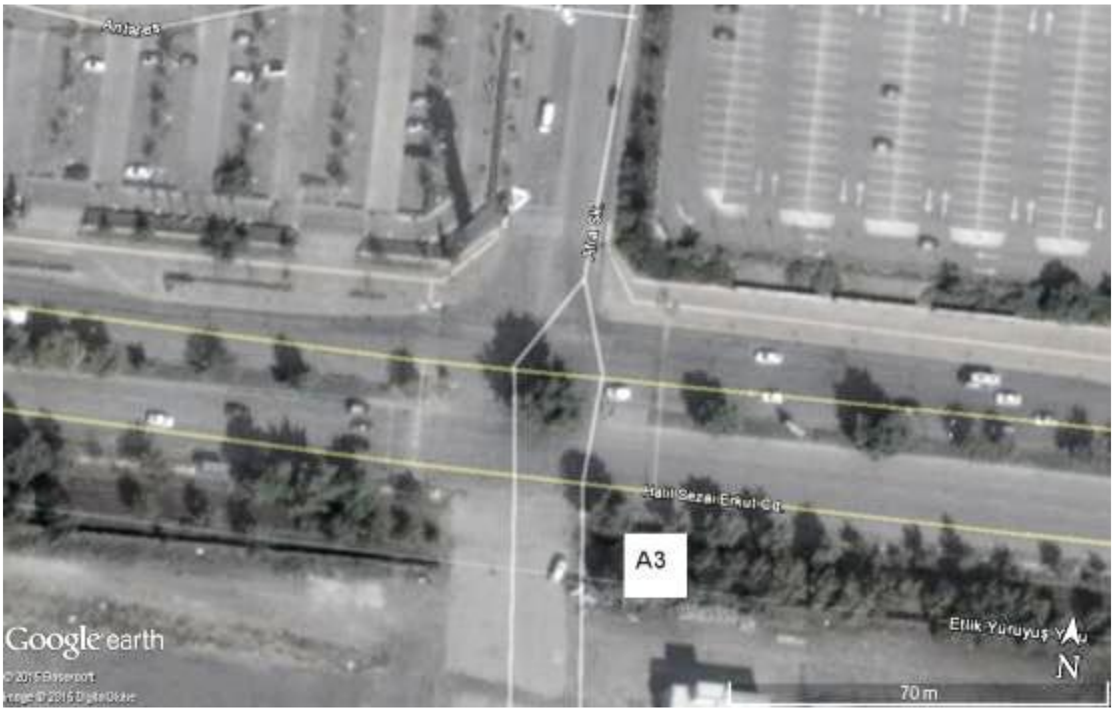


Figure A. 3 Google Earth View of Signalized Intersection “A3” (Afra Sok. with Halil Sezai Erkut Cad.) (Google Map/Earth, 2014)

Figure A. 4 Google Earth View of Signalized Intersection “A4” (150 Sok. with Halil Sezai Erkut Cad. with Akşemsettin Cad) (Google Map/Earth, 2014)

Figure A. 5 Google Earth View of Signalized Intersection “A5” (Eşref Bitlis Cad with Akşemsettin Cad) (Google Map/Earth, 2014)

Figure A. 6 Google Earth View of Signalized Intersection “A6” (Eşref Bitlis Cad with Trakya Cad) (Google Map/Earth, 2014)

Figure A. 7 Google Earth View of Signalized Intersection “A7” (Eşref Bitlis Cad with Beypazarı Cad) (Google Map/Earth, 2014)

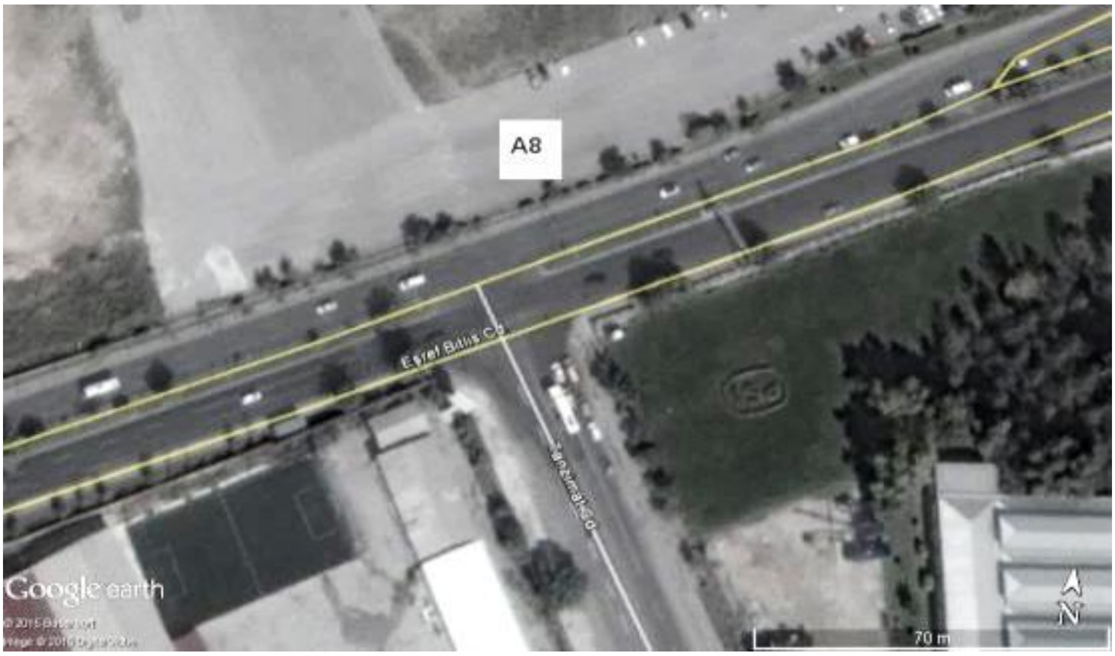


Figure A. 8 Google Earth View of Signalized Intersection “A8” (Eşref Bitlis Cad with Tanzimat Cad.) (Google Map/Earth, 2014)

APPENDIX B

DIRECTION AND ONE HOUR TRAFFIC VOLUME

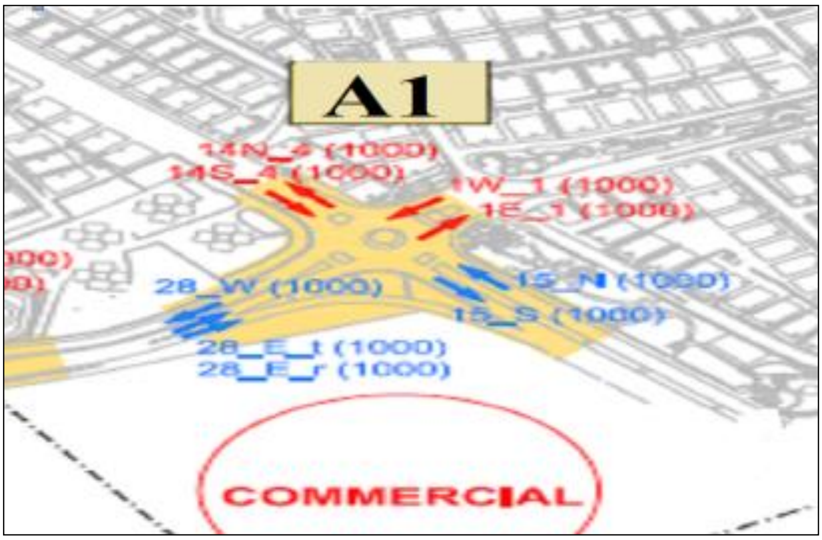


Figure B.1 Location and direction of "A1" intersection (Etlik Cad. with Halil Sezai Erkut Cad.)

Table B. 1 One hour traffic volume of "A1" intersection (vehicle per hour)

A1	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
14N_4	1310	2051	758	920	1323	1011	1235	1321	899
14S_4	1419	280	1321	160	560	851	1523	928	662
1E_1	148	1246	1194	160	459	618	151	610	349
1W_1	731	1366	1052	986	867	955	1083	506	709
15_N	1599	3334	328	1301	1389	1328	1696	1652	1181
15_S	3669	3672	2292	708	1521	1870	2691	1456	1231
28_W	1100	1366	1102	1121	1199	1106	1092	1116	1062
28_E_thr	498	501	394	516	524	614	637	695	604
28_E_right	1665	1643	814	708	770	936	809	832	1024

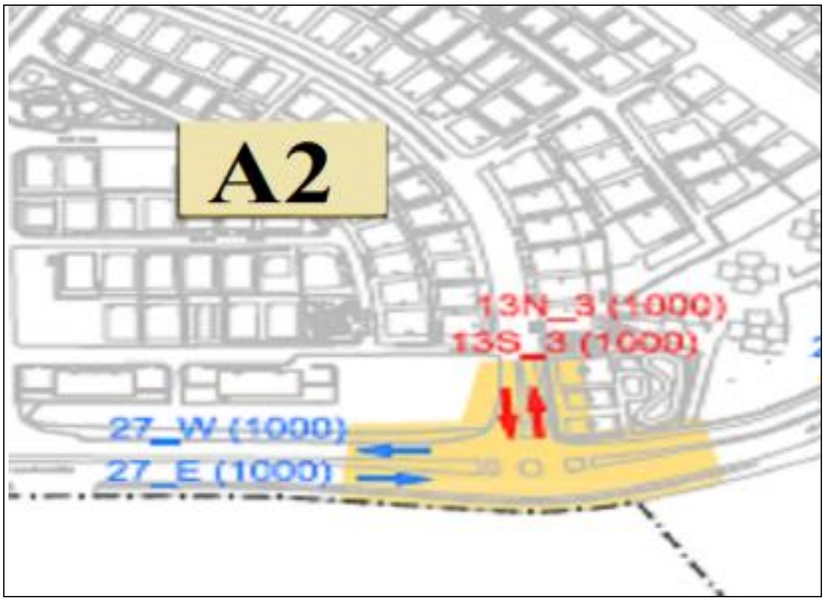


Figure B.2 Location and direction of "A2" intersection (Ayvalı Cad. with Halil Sezai Erkut Cad.)

Table B. 2 hour traffic volume of "A2" intersection (vehicle per hour)

A2	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
27_E	2105	989	635	984	882	1031	1167	1087	1343
27_W	1672	945	866	1132	922	1051	947	1010	1193
13N_3	151	150	172	226	148	226	228	153	344
13S_3	158	1054	655	528	476	531	398	458	598

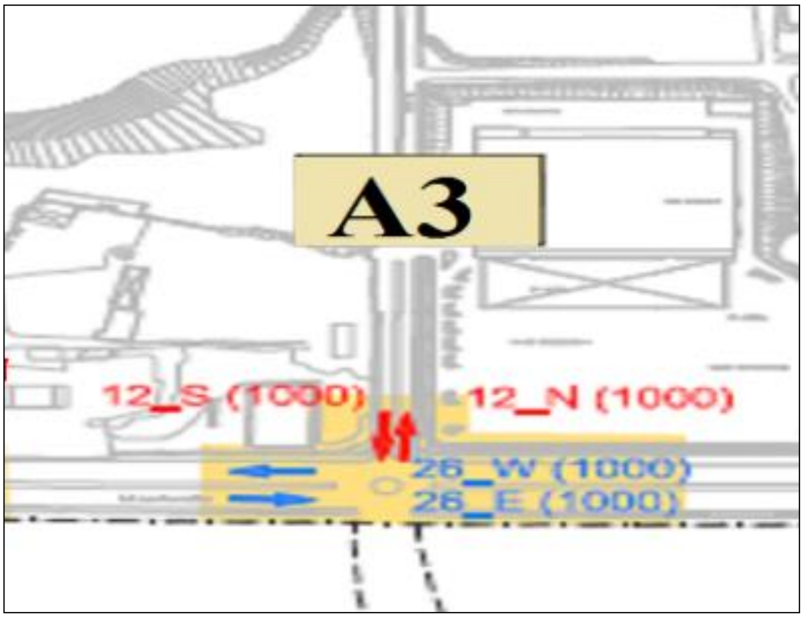


Figure B.3 Location and direction of "A3" intersection (Afra Sok. with Halil Sezai Erkut Cad.)

Table B. 3 One hour traffic volume of "A3" intersection (vehicle per hour)

A3	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
26_E	1107	873	695	842	844	893	1190	929	1001
26_W	1408	1310	702	757	778	821	786	878	933
12_N	229	159	150	349	488	137	522	346	127
12_S	335	411	227	374	397	442	326	501	681

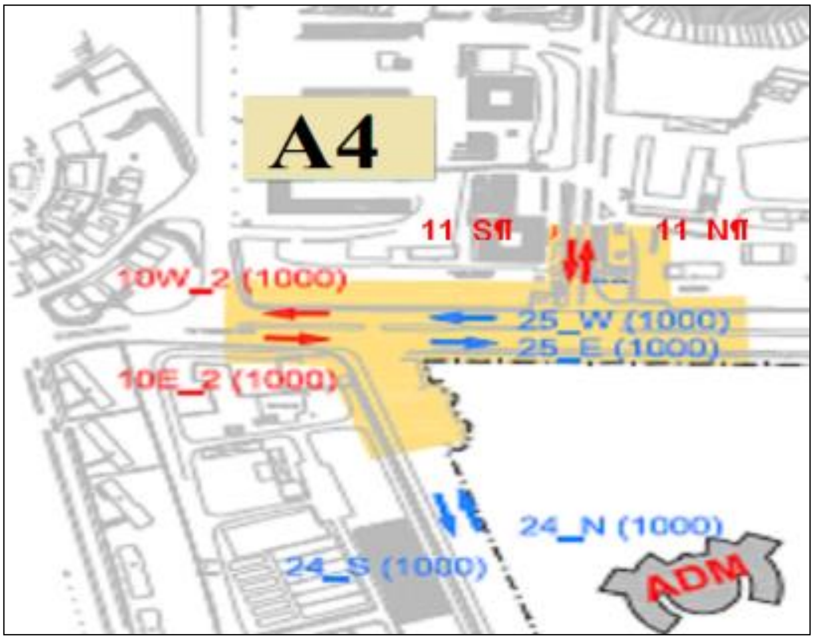


Figure B. 4 Location and direction of "A4" intersection (150 Sok. with Halil Sezai Erkut Cad. with Akşemsettin Cad.)

Table B. 4 One hour traffic volume of "A4" intersection (vehicle per hour)

A4	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
24_N	555	760	638	743	971	983	56	1260	1308
24_S	735	1036	278	186	290	393	278	291	419
10W_2	1131	1265	802	64	824	876	610	994	1093
10E_2	828	880	382	364	474	541	433	520	532
25_E	669	1028	742	450	960	1057	1022	1103	1141
25_w	1289	1348	820	1123	909	879	813	941	1114
11-N	560	231	193	430	497	333	442	594	646
11_S	621	572	175	665	217	256	56	261	345

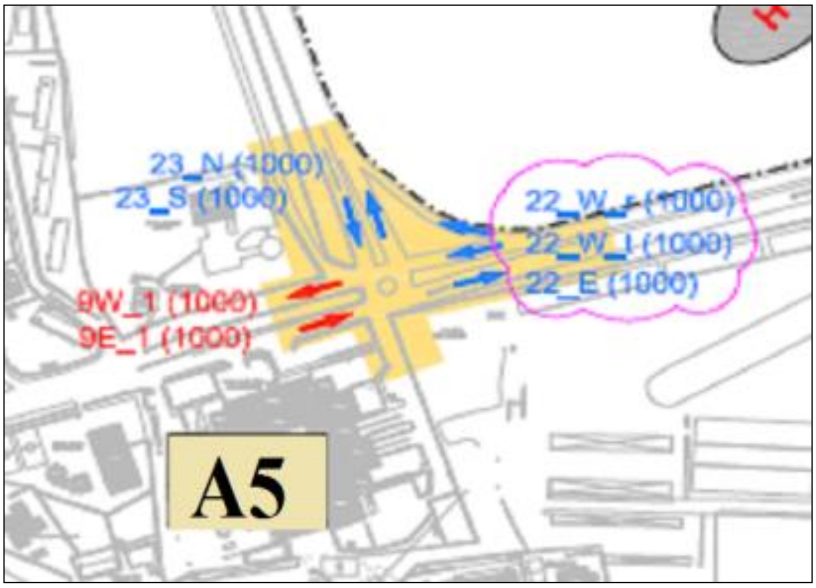


Figure B. 5 Location and direction of "A5" intersection (Eşref Bitlis Cad with Akşemsettin Cad.)

Table B. 5 One hour traffic volume of "A5" intersection (vehicle per hour)

A5	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
22_E	1175	1380	1104	951	1072	1175	851	1709	1543
22_W_thr	923	736	1124	768	831	994	968	1378	1337
22_W_right	345	382	327	243	390	433	243	577	601
9E_1	1044	1157	1055	1503	1507	1511	1403	2254	2037
9W_1	923	976	1078	768	1036	1220	878	1652	1504
23_N	738	757	623	827	920	882	854	1226	1206
23_S	516	838	304	80	300	339	321	378	278

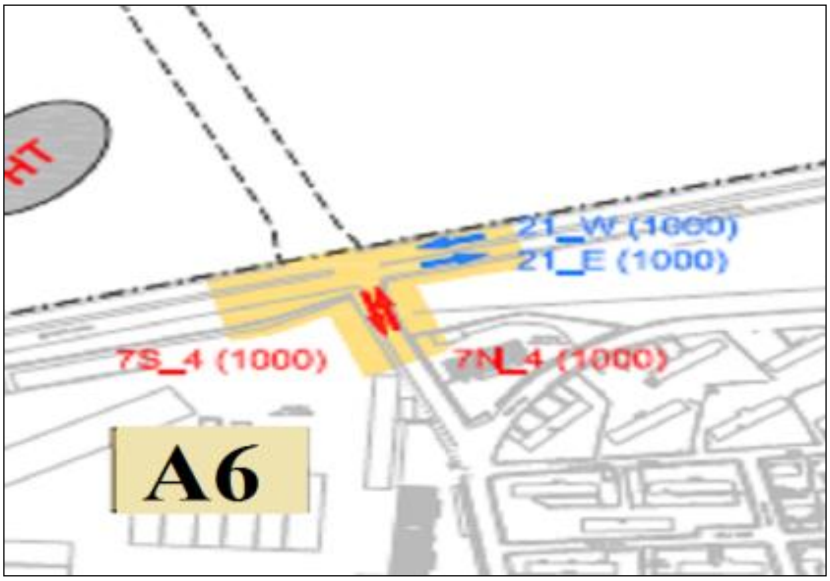


Figure B. 6 Location and direction of "A6" intersection (Eşref Bitlis Cad with Trakya Cad.)

Table B. 6 One hour traffic volume of "A6" intersection (vehicle per hour)

A6	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
7N_4	286	271	268	329	295	295	799	796	771
7S_4	1185	1142	226	141	143	143	139	176	161
21_E	1085	946	855	982	882	882	1423	1731	1551
21_W	1805	1667	1214	988	962	962	1366	1548	1341

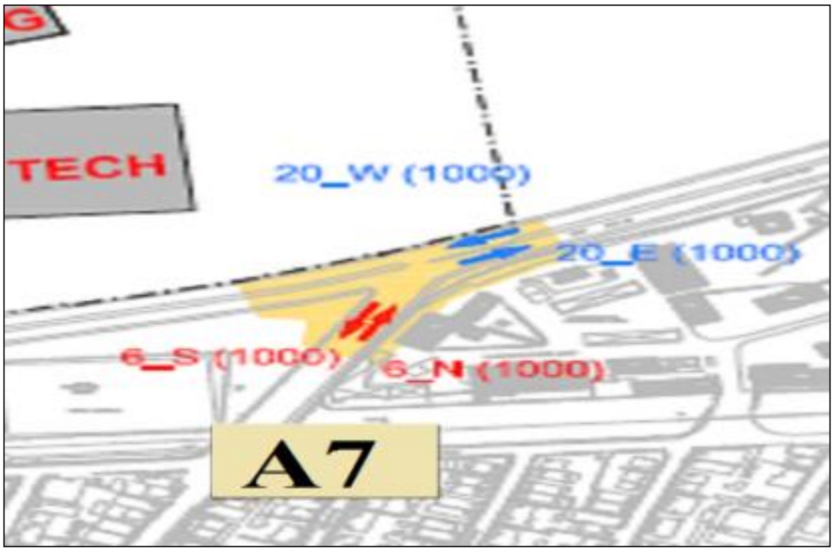


Figure B. 7 Location and direction of "A7" intersection (Eşref Bitlis Cad with Beypazarı Cad.)

Table B. 7 One hour traffic volume of "A7" intersection (vehicle per hour)

A7	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
20_E	908	978	1011	936	1047	946	1945	856	821
20_W	2205	2151	1490	1014	1042	1333	1313	1021	1310
6_N	97	90	164	54	59	139	144	149	186
6_S	1065	674	184	86	108	111	100	48	105

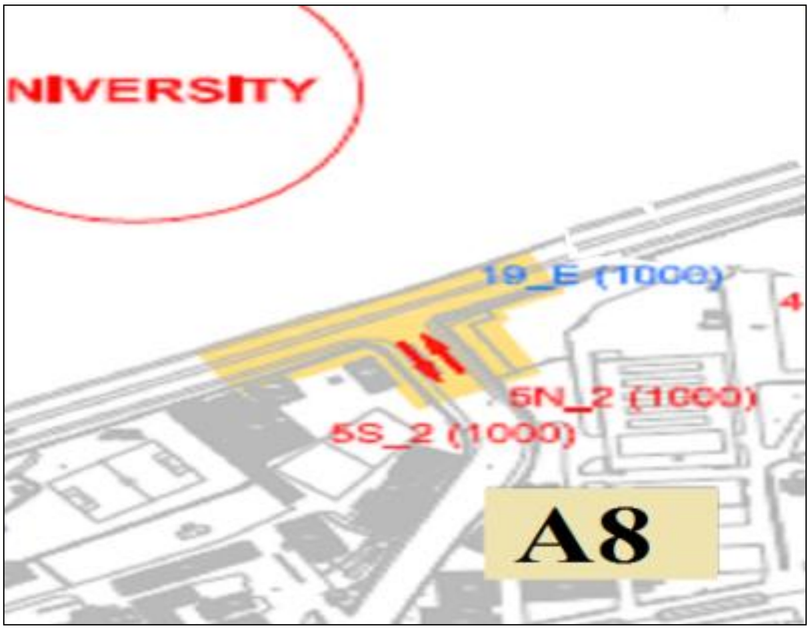


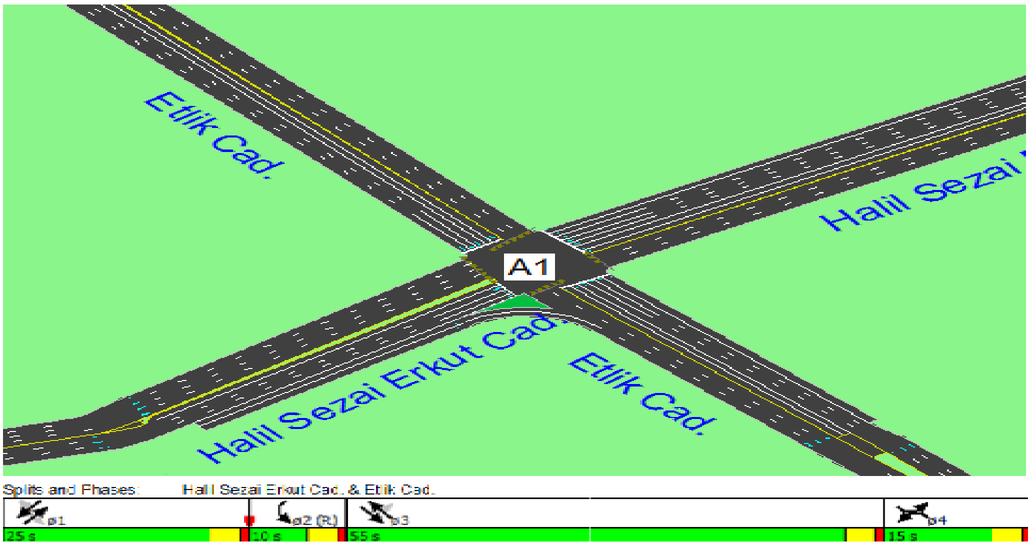
Figure B. 8 Location and direction of "A8" intersection (Eşref Bitlis Cad with Tanzimat Cad.)

Table B. 8 One hour traffic volume of "A8" intersection (vehicle per hour)

A8	AM			Noon			PM		
	Day1	Day2	Day3	Day1	Day2	Day3	Day1	Day2	Day3
5N_2	479	377	494	430	460	490	1194	1096	854
5S_2	1909	1651	534	310	288	419	165	256	372
19_E	1396	1456	1228	1220	1353	1730	3097	2683	2407
19-W	1916	1321	1221	822	906	1107	990	990	898

APPENDIX C

CURRENT SYNCHRO RESULTS

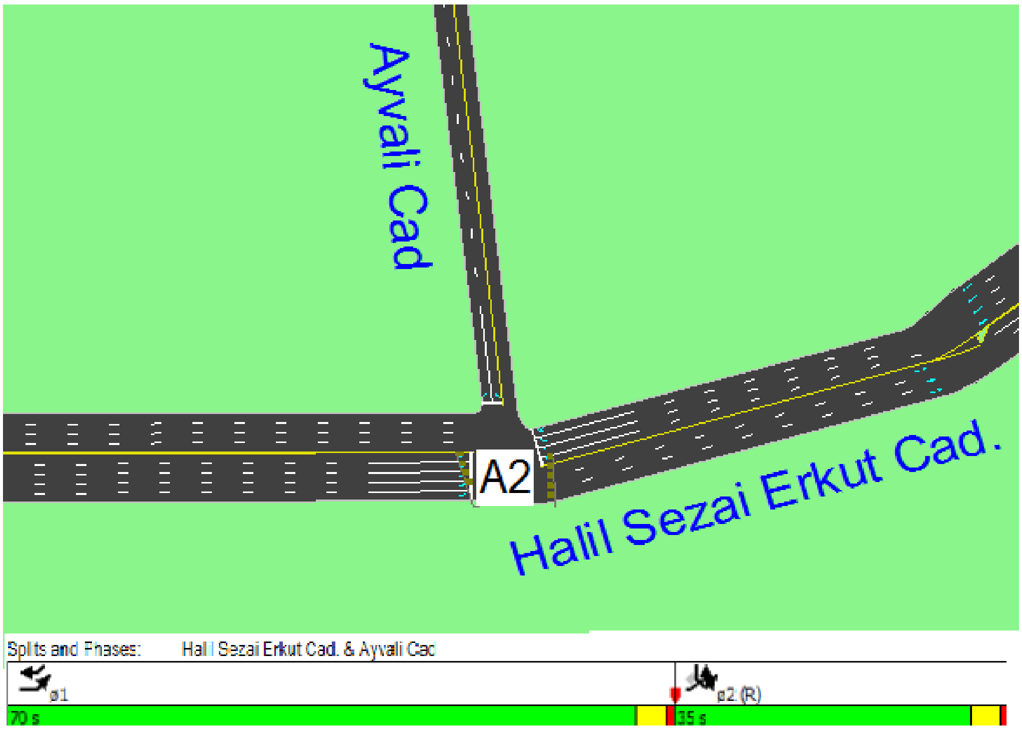


Lanes, Volumes, Timings
Halil Sezai Erkut Cad. & Etlik Cad.

Lane Group	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Traffic Volume (vph)	309	1419	305	362	1599	148	125	399	0	146	548	37
Future Volume (vph)	309	1419	305	362	1599	148	125	399	0	146	548	37
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
v/c Ratio	0.92	0.76		1.06	0.69	0.19	1.07	0.42		0.80	0.46	0.10
Control Delay	80.4	23.7		110.8	22.9	3.1	139.9	39.6		79.1	38.4	0.5
Queue Delay	0.0	0.0		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
Total Delay	80.4	23.7		110.8	22.9	3.1	139.9	39.6		79.1	38.4	0.5
LOS	F	C		F	C	A	F	D		E	D	A
Approach Delay		32.3			36.6			63.5			44.6	
Approach LOS		C			D			E			D	
Protected Phases	4	3		4	3			1		2	1	
Permitted Phases						3	1		1			1
Detector Phase	4	3		4	3	3	1	1	1	2	1	1

Intersection Signal Delay: 38.7 Intersection LOS: D
Intersection Capacity Utilization 72.7% ICU Level of Service C
Analysis Period (min) 15

Figure C. 1 Results of Synchro for "A1" intersection at 28.03.2012(AM)

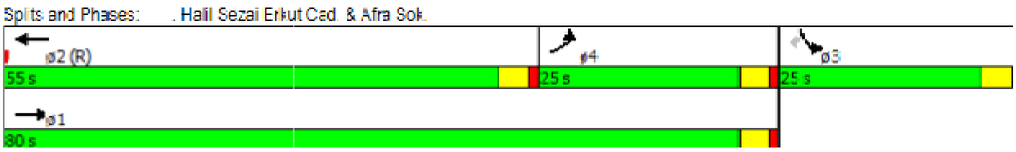


Lanes, Volumes, Timings
Halil Sezai Erkut Cad. & Ayvali Cad

Lane Group	EBL2	EBL	SBL	SBR	SWR	SWR2
Lane Configurations						
Traffic Volume (vph)	58	2105	101	57	1672	151
Future Volume (vph)	58	2105	101	57	1672	151
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
v/c Ratio	0.12	0.56	0.20	0.12	0.76	
Control Delay	25.4	9.5	29.1	16.3	22.4	
Queue Delay	0.0	0.0	0.0	0.0	0.0	
Total Delay	25.4	9.5	29.1	16.3	22.4	
LOS	C	A	C	B	C	
Approach Delay		10.0	24.5		22.4	
Approach LOS		A	C		C	
Protected Phases	2	1	2		1	
Permitted Phases				2		
Detector Phase	2	1	2	2	1	

Intersection Signal Delay: 16.0 Intersection LOS: B
Intersection Capacity Utilization 42.7% ICU Level of Service A
Analysis Period (min) 15

Figure C. 2 Results of Synchro for "A2" intersection at 28.03.2012(AM)

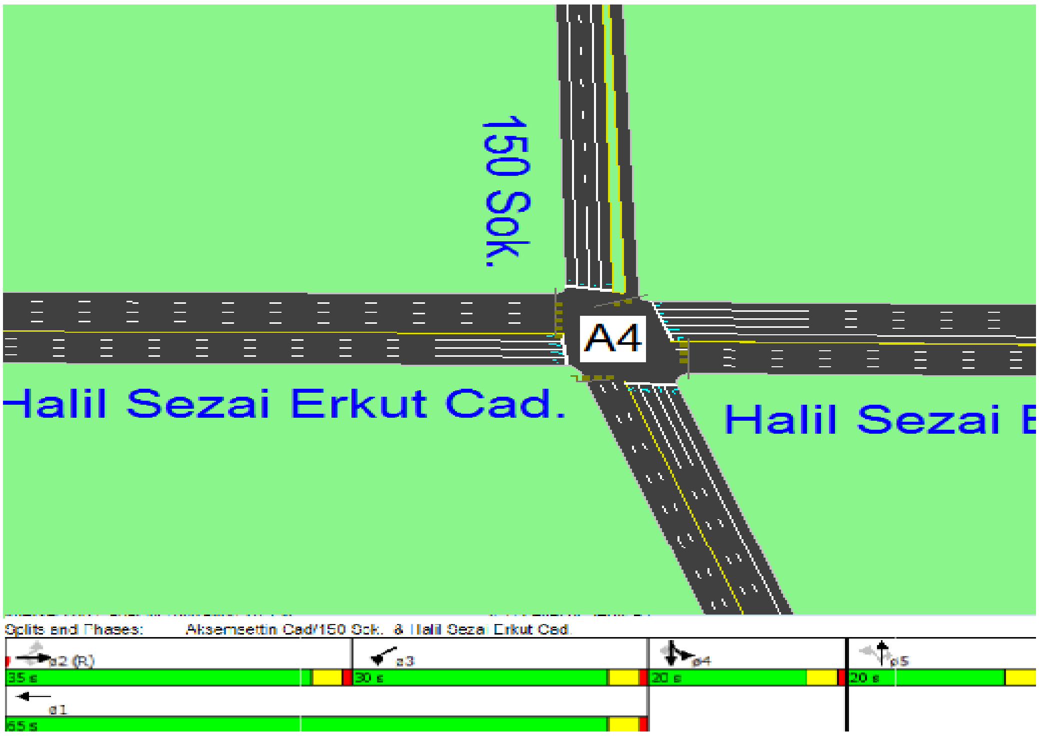


Lanes, Volumes, Timings
Halil Sezai Erkut Cad. & Afra Sok.

Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (vph)	201	1107	1408	24	40	295
Future Volume (vph)	201	1107	1408	24	40	295
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
v/c Ratio	0.61	0.26	0.48		0.55	0.58
Control Delay	37.6	2.3	7.1		45.5	47.1
Queue Delay	0.0	0.0	0.0		0.0	0.0
Total Delay	37.6	2.3	7.1		45.5	47.1
LOS	D	A	A		D	D
Approach Delay		7.7	7.1		46.3	
Approach LOS		A	A		D	
Protected Phases	4	1	2		3	
Permitted Phases						3
Detector Phase	4	1	2		3	3

Intersection Signal Delay: 11.6 Intersection LOS: B
Intersection Capacity Utilization 50.2% ICU Level of Service A
Analysis Period (min) 15
Description: Halil sezai Cad. / Afra sok.

Figure C. 3 Results of Synchro for "A3" intersection at 28.03.2012(AM)

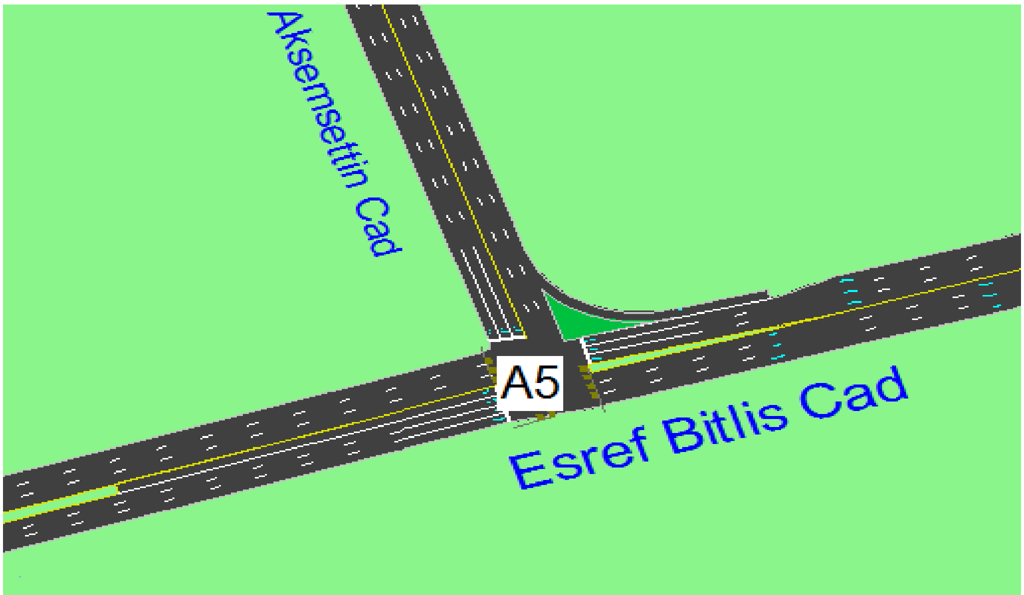


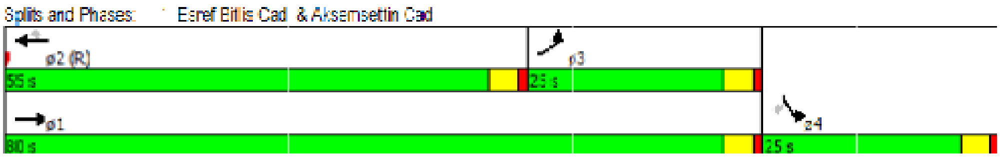
Lanes, Volumes, Timings
Aksemsettin Cad/150 Sok. & Halil Sezai Erkut Cad.

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	52	822	206	258	1031	201	302	202	55	110	402	109
Future Volume (vph)	52	822	206	258	1031	201	302	202	55	110	402	109
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
v/c Ratio	0.66	0.84	0.35	0.63	0.36		1.14	0.77	0.18	0.43	0.80	0.35
Control Delay	72.9	44.1	5.8	32.5	8.1		129.7	54.0	10.3	46.3	56.0	13.6
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	72.9	44.1	5.8	32.5	8.1		129.7	54.0	10.3	46.3	56.0	13.6
LOS	E	D	A	C	A		F	D	B	D	E	B
Approach Delay		38.2			12.3			90.6			46.9	
Approach LOS		D			B			F			D	
Protected Phases		2		3	1			5		4	4	
Permitted Phases	2		2				5		5			4
Detector Phase	2	2	2	3	1		5	5	5	4	4	4

Intersection Signal Delay: 37.1 — Intersection LOS: D
Intersection Capacity Utilization 70.1% — ICU Level of Service C
Analysis Period (min) 15

Figure C. 4 Results of Synchro for "A4" intersection at 28.03.2012(AM)





Lanes, Volumes, Timings

Esref Bitlis Cad & Aksemsettin Cad

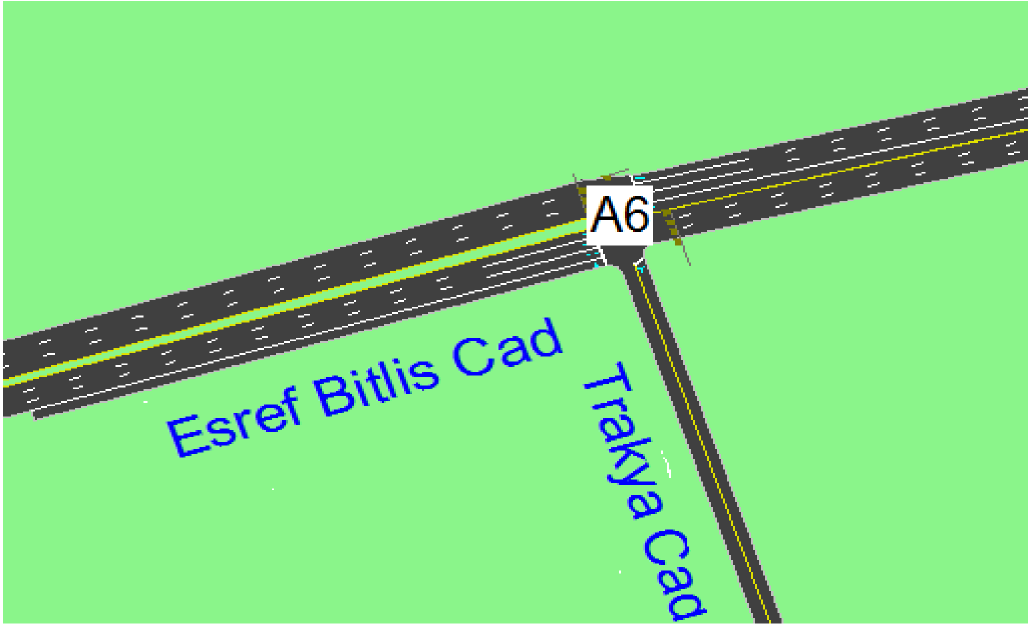
Lane Group	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Traffic Volume (vph)	365	835	923	345	412	103
Future Volume (vph)	365	835	923	345	412	103
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
v/c Ratio	1.08	0.24	0.40	0.39	0.65	0.27
Control Delay	113.9	5.1	20.0	5.3	40.9	15.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	113.9	5.1	20.0	5.3	40.9	15.4
LOS	F	A	B	A	D	B
Approach Delay		38.2	16.0		36.3	
Approach LOS		D	B		D	
Protected Phases	3	1	2		4	
Permitted Phases				2		4
Detector Phase	3	1	2	2	4	4

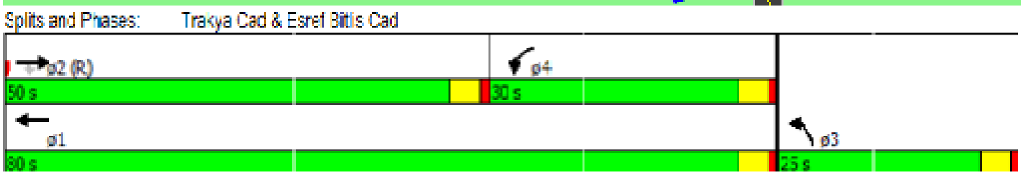
Intersection Signal Delay: 28.4 Intersection LOS: C

Intersection Capacity Utilization 60.9% ICU Level of Service B

Analysis Period (min) 15

Figure C. 5 Results of Synchro for "A5" intersection at 28.03.2012(AM)



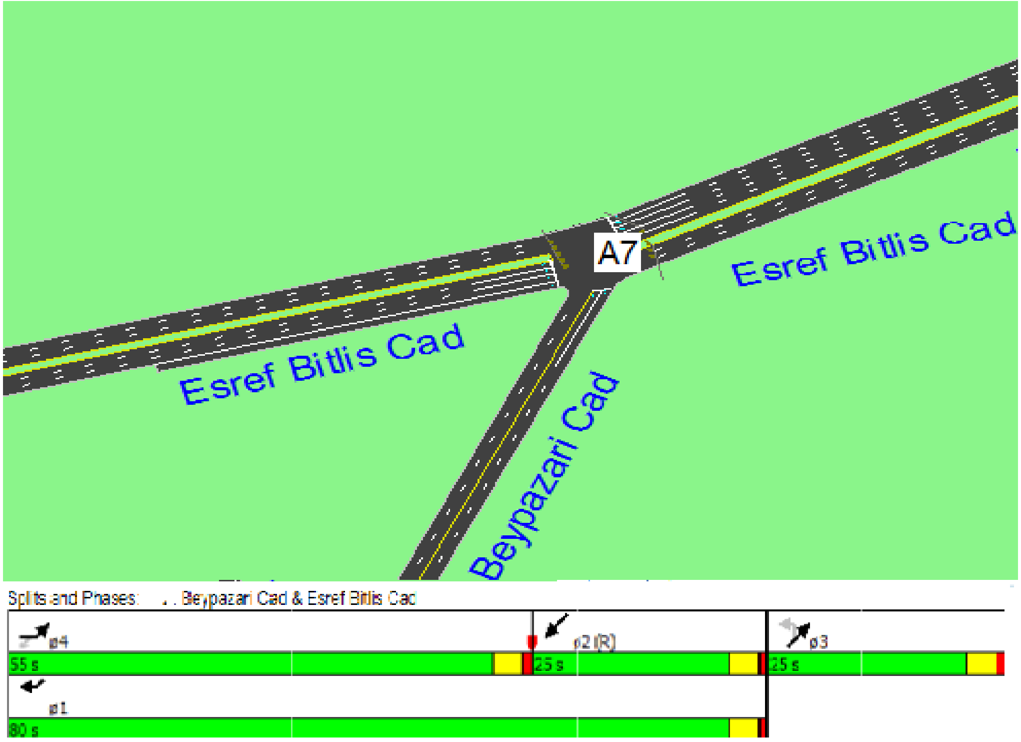


Lanes, Volumes, Timings
Trakya Cad & Esref Bitlis Cad

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	868	217	461	1444	143	143
Future Volume (vph)	868	217	461	1444	143	143
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
v/c Ratio	0.42	0.28	1.13	0.42	0.82	
Control Delay	13.3	0.9	108.1	2.3	53.8	
Queue Delay	0.0	0.0	0.0	0.0	0.0	
Total Delay	13.3	0.9	108.1	2.3	53.8	
LOS	B	A	F	A	D	
Approach Delay	10.8			27.9	53.8	
Approach LOS	B			C	D	
Protected Phases	2		4	1	3	
Permitted Phases		2				
Detector Phase	2	2	4	1	3	

Intersection Signal Delay: 24.5 Intersection LOS: C
Intersection Capacity Utilization 69.0% ICU Level of Service C
Analysis Period (min) 15

Figure C. 6 Results of Synchro for "A6" intersection at 28.03.2012(AM)

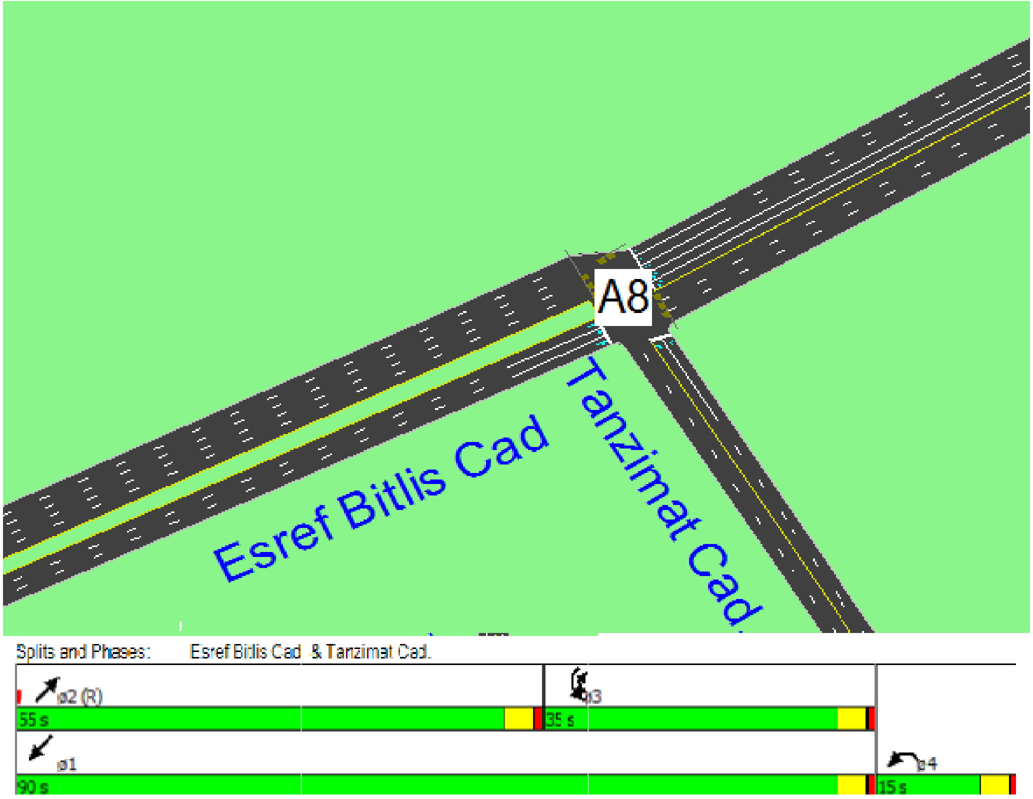


Lanes, Volumes, Timings
Beypazari Cad & Esref Bitlis Cad

Lane Group	EBL	EBR	NEL	NET	SWT	SWR
Lane Configurations						
Traffic Volume (vph)	908	319	49	48	745	2205
Future Volume (vph)	908	319	49	48	745	2205
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
v/c Ratio	0.39	0.36	0.38	0.14	1.13	0.90
Control Delay	9.9	2.8	46.5	35.8	116.6	20.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	9.9	2.8	46.5	35.8	116.6	20.1
LOS	A	A	D	D	F	C
Approach Delay	8.1			41.2	44.4	
Approach LOS	A			D	D	
Protected Phases	4			3	2	1
Permitted Phases		4	3			
Detector Phase	4	4	3	3	2	1

Intersection Signal Delay: 33.9 Intersection LOS: C
Intersection Capacity Utilization 62.3% ICU Level of Service B
Analysis Period (min) 15

Figure C. 7 Results of Synchro for "A7" intersection at 28.03.2012(AM)



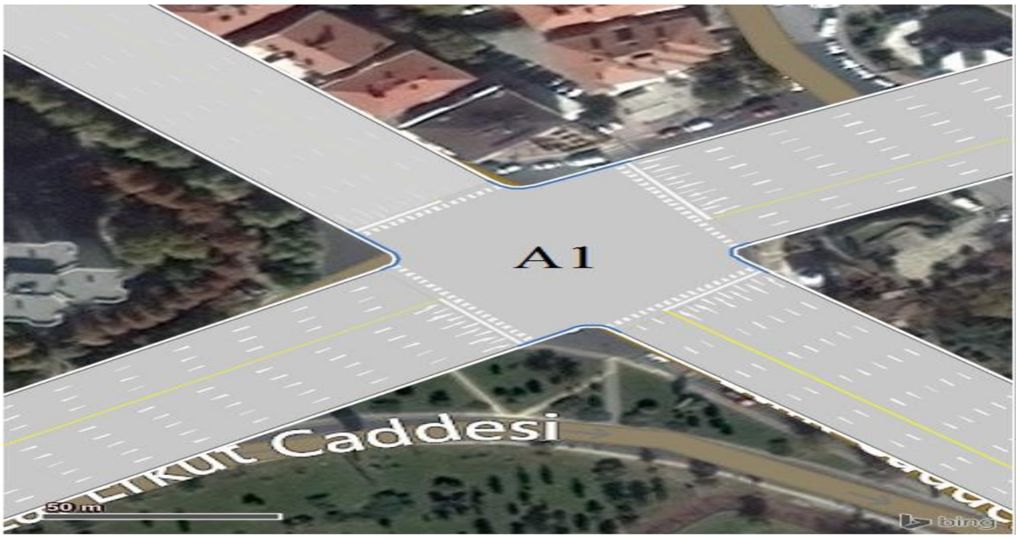
Lanes, Volumes, Timings
Esref Bitlis Cad & Tanzimat Cad.

Lane Group	NWL	NWR	NET	NER	SWL	SWT
Lane Configurations						
Traffic Volume (vph)	129	350	1117	350	960	955
Future Volume (vph)	129	350	1117	350	960	955
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
v/c Ratio	0.75	0.80	0.64		1.00	0.24
Control Delay	71.9	49.8	26.0		65.7	2.3
Queue Delay	0.0	0.0	0.0		0.0	0.0
Total Delay	71.9	49.8	26.0		65.7	2.3
LOS	E	D	C		E	A
Approach Delay	55.7		26.0			34.1
Approach LOS	E		C			C
Protected Phases	4	3	2		3	1
Permitted Phases						
Detector Phase	4	3	2		3	1
Intersection Signal Delay: 33.7				Intersection LOS: C		
Intersection Capacity Utilization 73.9%				ICU Level of Service D		
Analysis Period (min) 15						

Figure C. 8 Results of Synchro for "A8" intersection at 28.03.2012(AM)

APPENDIX D

CURRENT VISTRO RESULTS



Number	1											
Intersection	**Halil sezai Cad. / Etlik Cad.**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	Halil Sezai Erkut Cad.			Halil Sezai Erkut Cad.			Etlik Cad.			Etlik Cad.		
Approach	*Northeastbound*			*Southwestbound*			*Northwestbound*			*Southeastbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	140	560	869	216	812	56	340	1272	85	151	1278	153
Total Analysis Volume [veh/h]	*140*	*560*	*869*	*216*	*812*	*56*	*340*	*1272*	*85*	*151*	*1278*	*153*
Intersection Settings												
Analyze Intersection?	☑											
Analysis Period	1 hour											
Movement, Approach, & Intersection Results												
X, volume / capacity	*0.69*	*0.48*	*0.51*	*1.25*	*0.46*	*0.14*	*1.08*	*0.54*	*0.12*	*0.48*	*0.58*	*0.58*
d, Delay for Lane Group [s/veh]	*77.27*	*42.00*	*40.31*	*560.87*	*38.40*	*34.91*	*249.13*	*23.66*	*18.35*	*56.97*	*24.85*	*26.35*
Lane Group LOS	*E*	*D*	*D*	*F*	*D*	*C*	*F*	*C*	*B*	*E*	*C*	*C*
d_A, Approach Delay [s/veh]	*46.31*			*142.33*			*68.57*			*28.36*		
Approach LOS	*D*			*F*			*E*			*C*		
d_I, Intersection Delay [s/veh]	*68.72*											
Intersection LOS	*E*											
Intersection V/C	*0.589*											

Sequence																
Ring 1	1	2	3	4	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

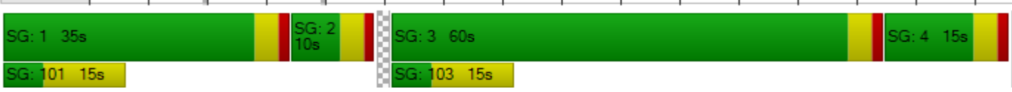


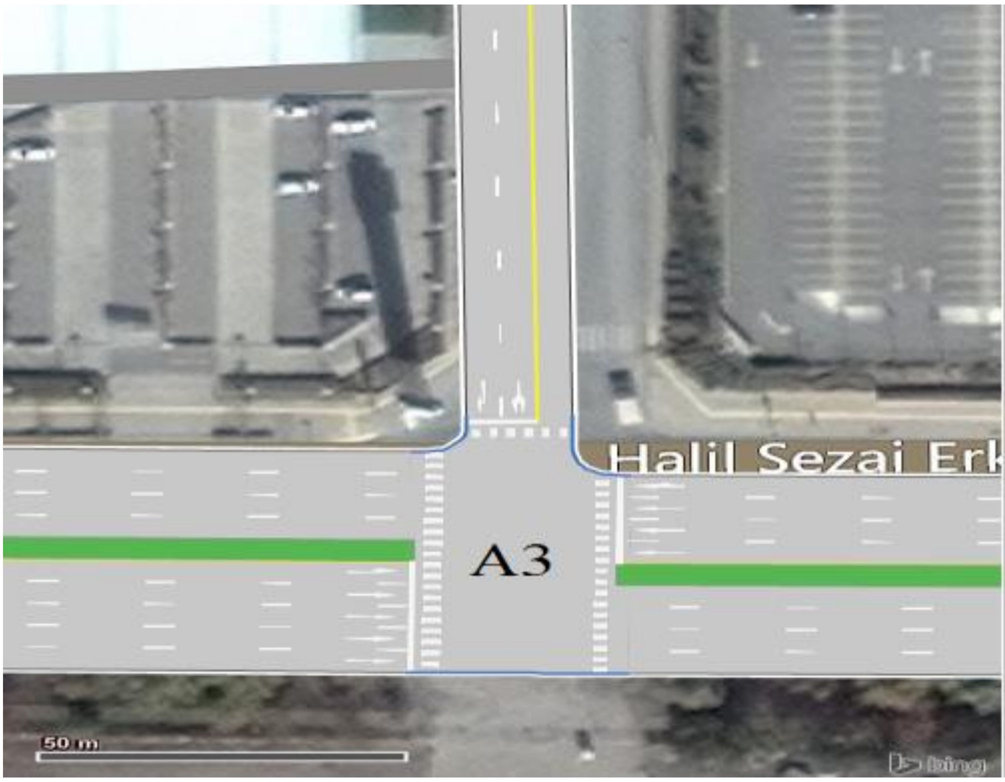
Figure D. 1 Results of Vistro for "A1" intersection at 28.03.2012(PM)

Number	2					
Intersection	Halil sezai Cad. / Ayvali Cad.					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Ayvali Cad		Halil Sezai Erkut Cad.		Halil Sezai Erkut Cad.	
Approach	*Southbound*		*Eastbound*		*Westbound*	
Lane Configuration						
Turning Movement	*Left*	*Right*	*Left*	*Thru*	*Thru*	*Right*
Base Volume Input [veh/h]	441	147	240	959	927	231
Total Analysis Volume [veh/h]	*441*	*147*	*240*	*959*	*927*	*231*
Intersection Settings						
Analyze Intersection?	☐					
Analysis Period	1 hour					
Movement, Approach, & Intersection Results						
X, volume / capacity	*1.10*	*0.36*	*0.60*	*0.21*	*0.25*	*0.26*
d, Delay for Lane Group [s/veh]	*266.99*	*38.85*	*48.19*	*7.49*	*7.82*	*8.28*
Lane Group LOS	*F*	*D*	*D*	*A*	*A*	*A*
d_A, Approach Delay [s/veh]	*209.95*		*15.64*		*7.94*	
Approach LOS	*F*		*B*		*A*	
d_I, Intersection Delay [s/veh]	*51.41*					
Intersection LOS	*D*					
Intersection V/C	*0.490*					

Sequence

Ring 1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure D. 2 Results of Vistro for "A2" intersection at 28.03.2012(PM)



Number	3					
Intersection	Halil sezai Cad. / Afra sok.					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Afra Sok.		Halil Sezai Erkut Cad.		Halil Sezai Erkut Cad.	
Approach	*Southbound*		*Eastbound*		*Westbound*	
Lane Configuration						
Turning Movement	*Left*	*Right*	*Left*	*Thru*	*Thru*	*Right*
Base Volume Input [veh/h]	86	374	238	952	740	185
Total Analysis Volume [veh/h]	*86*	*374*	*238*	*952*	*740*	*185*
Movement, Approach, & Intersection Results						
X, volume / capacity	*0.47*	*0.47*	*0.77*	*0.22*	*0.32*	*0.33*
d, Delay for Lane Group [s/veh]	*37.55*	*37.69*	*65.42*	*9.51*	*23.38*	*24.41*
Lane Group LOS	*D*	*D*	*E*	*A*	*C*	*C*
d_A, Approach Delay [s/veh]	*37.62*		*20.69*		*23.63*	
Approach LOS	*D*		*C*		*C*	
d_I, Intersection Delay [s/veh]	*24.77*					
Intersection LOS	*C*					
Intersection V/C	*0.418*					

Sequence

Ring 1	2	4	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

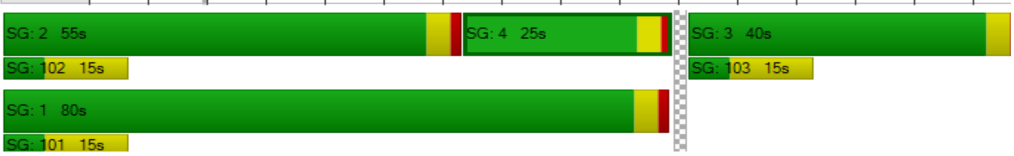


Figure D. 3 Results of Vistro for "A5" intersection at 28.03.2012(PM)

Number	4											
Intersection	Halil sezai Cad. / 150 sk./Aksemsettin Cad											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	Aksemsettin Cad			150 Sok.			Halil Sezai Erkut Cad.			Halil Sezai Erkut Cad.		
Approach	*Northbound*			*Southbound*			*Eastbound*			*Westbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	264	423	429	123	410	114	59	481	91	121	650	201
Total Analysis Volume [veh/h]	*264*	*423*	*429*	*123*	*410*	*114*	*59*	*481*	*91*	*121*	*650*	*201*
Movement, Approach, & Intersection Results												
X, volume / capacity	*0.85*	*0.68*	*0.87*	*0.40*	*0.66*	*0.41*	*0.30*	*0.45*	*0.19*	*0.31*	*0.23*	*0.24*
d, Delay for Lane Group [s/veh]	*77.65*	*52.51*	*71.45*	*47.67*	*51.77*	*48.53*	*44.46*	*35.41*	*32.09*	*41.66*	*14.10*	*14.63*
Lane Group LOS	*E*	*D*	*E*	*D*	*D*	*D*	*D*	*D*	*C*	*D*	*B*	*B*
d_A, Approach Delay [s/veh]	*65.74*			*50.42*			*35.78*			*17.65*		
Approach LOS	*E*			*D*			*D*			*B*		
d_I, Intersection Delay [s/veh]	*43.29*											
Intersection LOS	*D*											
Intersection V/C	*0.473*											

Sequence

Ring 1	2	3	4	5	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

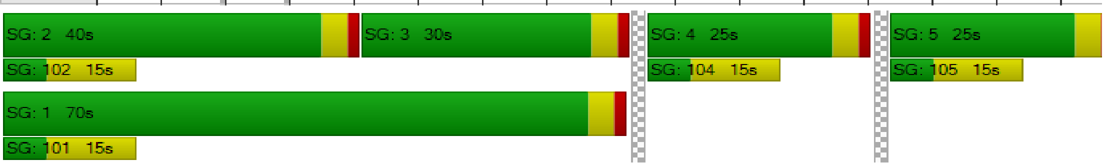


Figure D. 4 Results of Vistro for "A4" intersection at 28.03.2012(PM)

Number	5						
Intersection	**Esref bitilis cad. / Aksemestiin cad.**						
Control Type	Signalized						
Analysis Method	HCM 2010						
Name	Aksemsettin Cad			Esref Bitlis Cad		Esref Bitlis Cad	
Approach	*Southbound*			*Eastbound*		*Westbound*	
Lane Configuration	┐┬┌			┐↑↑↑		↑↑↑┌	
Turning Movement	*Left*		*Right*	*Left*	*Thru*	*Thru*	*Right*
Base Volume Input [veh/h]	412		103	266	935	923	345
Total Analysis Volume [veh/h]	*412*		*103*	*266*	*935*	*923*	*345*
Movement, Approach, & Intersection Results							
X, volume / capacity	*0.54*	*0.54*	*0.30*	*0.86*	*0.26*	*0.36*	*0.43*
d, Delay for Lane Group [s/veh]	*47.03*	*47.03*	*41.63*	*79.01*	*6.08*	*18.12*	*20.22*
Lane Group LOS	*D*	*D*	*D*	*E*	*A*	*B*	*C*
d_A, Approach Delay [s/veh]	*45.95*			*22.23*		*18.69*	
Approach LOS	*D*			*C*		*B*	
d_I, Intersection Delay [s/veh]	*24.82*						
Intersection LOS	*C*						
Intersection V/C	*0.484*						

Sequence

Ring 1	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

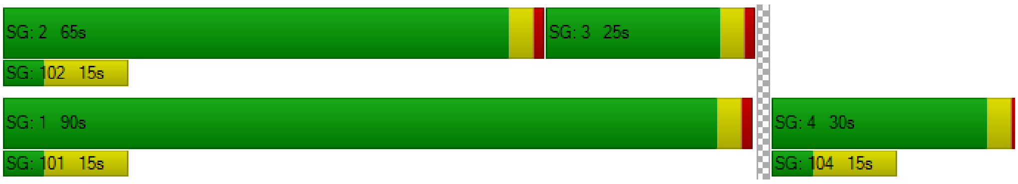


Figure D. 5 Results of Vistro for "A5" intersection at 28.03.2012(PM)

Number	6					
Intersection	**Esref bitilis Cad. / Trakiya Cad.**					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Trakya Cad		Esref Bitlis Cad		Esref Bitlis Cad	
Approach	*Northbound*		*Eastbound*		*Westbound*	
Lane Configuration						
Turning Movement	*Left*	*Right*	*Thru*	*Right*	*Left*	*Thru*
Base Volume Input [veh/h]	432	323	1231	307	273	1092
Total Analysis Volume [veh/h]	*432*	*323*	*1231*	*307*	*273*	*1092*
Movement, Approach, & Intersection Results						
X, volume / capacity	*1.02*	*1.05*	*0.48*	*0.38*	*0.88*	*0.30*
d, Delay for Lane Group [s/veh]	*157.04*	*197.61*	*19.79*	*19.37*	*84.48*	*6.35*
Lane Group LOS	*F*	*F*	*B*	*B*	*F*	*A*
d_A, Approach Delay [s/veh]	*176.59*		*19.70*		*21.98*	
Approach LOS	*F*		*B*		*C*	
d_I, Intersection Delay [s/veh]	*52.93*					
Intersection LOS	*D*					
Intersection V/C	*0.623*					

Sequence

Ring 1	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

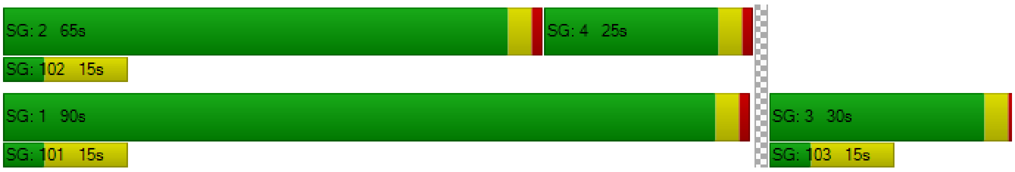


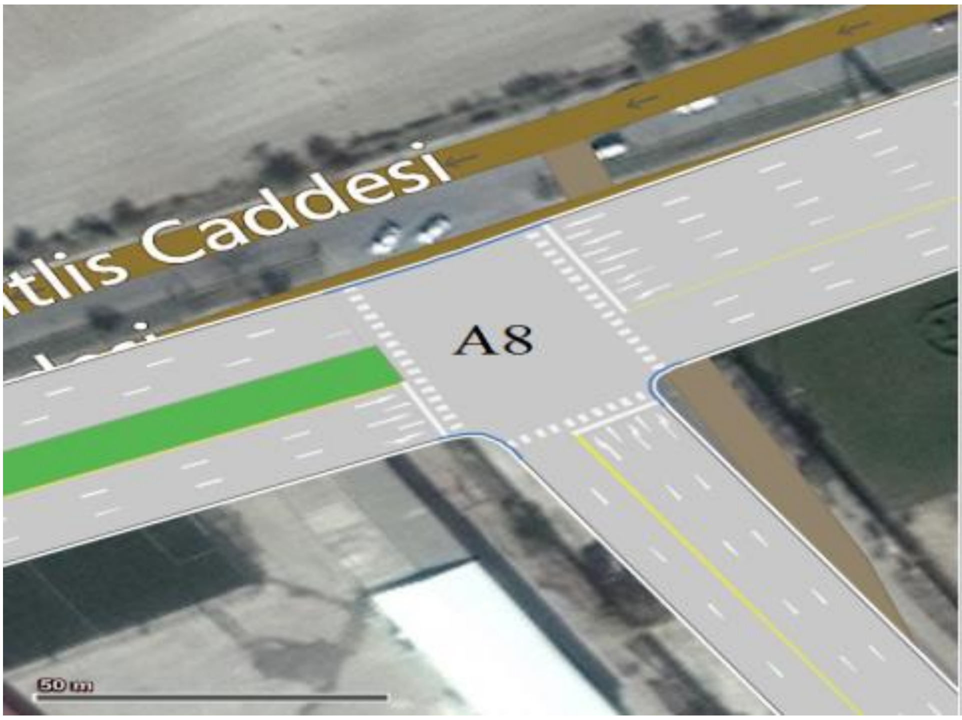
Figure D. 6 Results of Vistro for "A6" intersection at 28.03.2012(PM)

Number	7					
Intersection	Esref bitilis Cad. / Beypazar Cad.					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Esref Bitlis Cad		Beypazari Cad		Esref Bitlis Cad	
Approach	*Eastbound*		*Northeastbound*		*Southwestbound*	
Lane Configuration						
Turning Movement	*Thru*	*Right*	*Left*	*Thru*	*Left*	*Thru*
Base Volume Input [veh/h]	1556	389	73	74	288	1152
Total Analysis Volume [veh/h]	*1556*	*389*	*73*	*74*	*288*	*1152*
Movement, Approach, & Intersection Results						
X, volume / capacity	*0.56*	*0.45*	*0.24*	*0.23*	*0.93*	*0.30*
d, Delay for Lane Group [s/veh]	*18.34*	*17.77*	*44.37*	*44.15*	*101.63*	*4.73*
Lane Group LOS	*B*	*B*	*D*	*D*	*F*	*A*
d_A, Approach Delay [s/veh]	*18.22*		*44.26*		*24.11*	
Approach LOS	*B*		*D*		*C*	
d_I, Intersection Delay [s/veh]	*21.71*					
Intersection LOS	*C*					
Intersection V/C	*0.510*					

Sequence

Ring 1	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure D. 7 Results of Vistro for "A7" intersection at 28.03.2012(PM)



Number	8					
Intersection	Esref bitilis Cad. /Tanzimat Cad.					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Esref Bitlis Cad		Esref Bitlis Cad		Tanzimat Cad.	
Approach	*Northeastbound*		*Southwestbound*		*Northwestbound*	
Lane Configuration						
Turning Movement	*Thru*	*Right*	*Left*	*Thru*	*Left*	*Right*
Base Volume Input [veh/h]	1548	387	319	2777	238	955
Total Analysis Volume [veh/h]	*1548*	*387*	*319*	*2777*	*238*	*955*
Movement, Approach, & Intersection Results						
X, volume / capacity	*0.72*	*0.75*	*1.01*	*0.86*	*0.45*	*1.14*
d, Delay for Lane Group [s/veh]	*25.29*	*29.83*	*165.80*	*21.33*	*36.68*	*303.35*
Lane Group LOS	*C*	*C*	*F*	*C*	*D*	*F*
d_A, Approach Delay [s/veh]	*26.81*		*36.22*		*250.15*	
Approach LOS	*C*		*D*		*F*	
d_I, Intersection Delay [s/veh]	*74.30*					
Intersection LOS	*E*					
Intersection V/C	*0.888*					

Sequence																
Ring 1	2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

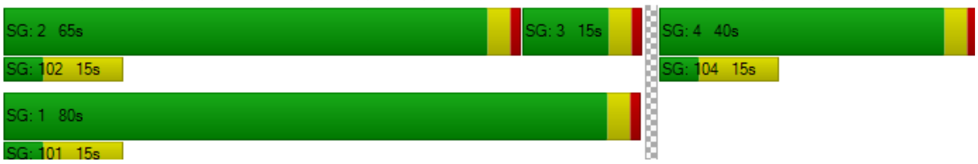
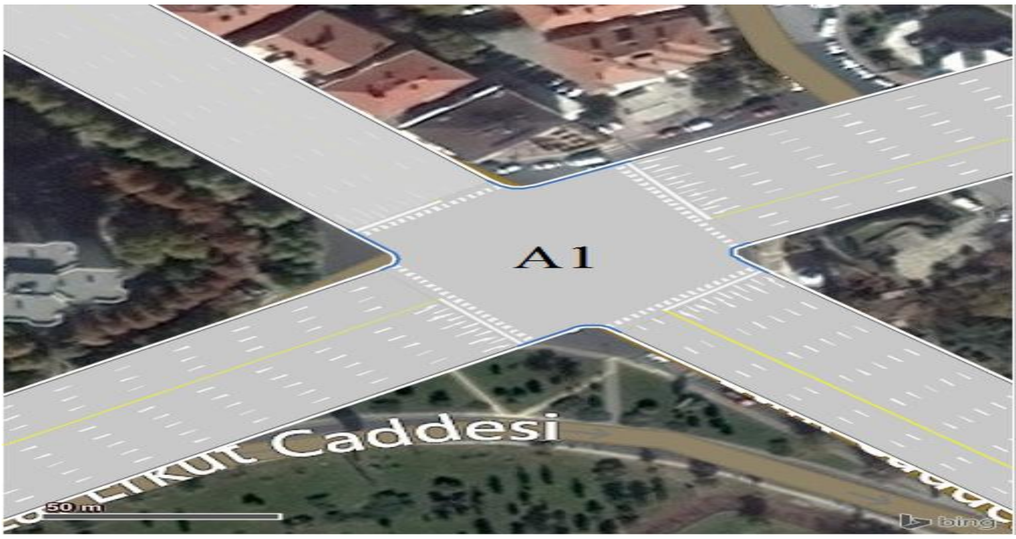


Figure D. 8 Results of Vistro for "A8" intersection at 28.03.2012(PM)

APPENDIX E

FUTURE VISTRO REULTS



Number	1											
Intersection	**Halil sezai Cad. / Etlik Cad.**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	Halil Sezai Erkut			Halil Sezai Erkut			Etlik Cad.			Etlik Cad.		
Approach	*Northeastbound*			*Southwestbound*			*Northwestbound*			*Southeastbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	140	560	869	216	812	56	340	1272	85	151	1278	153
Total Analysis Volume [veh/h]	*140*	*560*	*869*	*216*	*812*	*56*	*340*	*1272*	*85*	*151*	*1278*	*153*
Intersection Settings												
Analyze Intersection?	☑											
Analysis Period	1 hour											
Movement, Approach, & Intersection Results												
d_M, Delay for Movement [s/veh]	*77.2*	*40.7*	*0.00*	*560.*	*38.4*	*34.9*	*249.*	*23.6*	*18.3*	*56.9*	*25.2*	*26.3*
Movement LOS	*E*	*D*		*F*	*D*	*C*	*F*	*C*	*B*	*E*	*C*	*C*
Critical Movement	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐
d_A, Approach Delay [s/veh]	*46.31*			*142.33*			*68.57*			*28.36*		
Approach LOS	*D*			*F*			*E*			*C*		
d_I, Intersection Delay [s/veh]	*68.72*											
Intersection LOS	*E*											
Intersection V/C	*0.589*											

Sequence																
Ring 1	1	2	3	4	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure E. 1 Results of Vistro for "A1" intersection

Number	2											
Intersection	**Halil sezai Cad. / Ayvali Cad.**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	NEW			Ayvali Cad			Halil Sezai Erkut			Halil Sezai Erkut		
Approach	*Northbound*			*Southbound*			*Eastbound*			*Westbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	226	112	226	441	60	147	240	959	116	116	927	231
Total Analysis Volume [veh/h]	*226*	*112*	*226*	*441*	*60*	*147*	*240*	*959*	*116*	*116*	*927*	*231*
Movement, Approach, & Intersection Results												
d_M, Delay for Movement [s/veh]	*61.8*	*46.3*	*74.2*	*77.2*	*43.4*	*52.3*	*193.*	*35.0*	*32.9*	*41.4*	*15.1*	*14.9*
Movement LOS	*E*	*D*	*E*	*E*	*D*	*D*	*F*	*D*	*C*	*D*	*B*	*B*
Critical Movement	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐
d_A, Approach Delay [s/veh]	*63.74*			*68.47*			*63.77*			*17.54*		
Approach LOS	*E*			*E*			*E*			*B*		
d_I, Intersection Delay [s/veh]	*49.07*											
Intersection LOS	*D*											
Intersection V/C	*0.529*											

Sequence

Ring 1	2	3	4	5	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

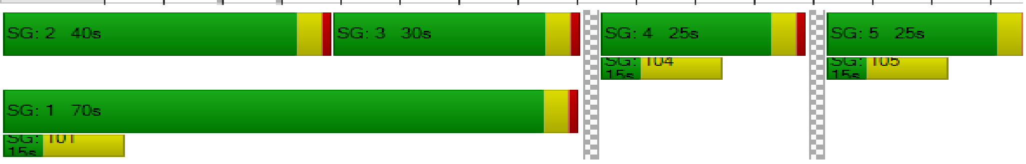


Figure E. 2 Results of Vistro for "A2" intersection

Number	3											
Intersection	**Halil sezai Cad. / Afra sok.**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	Afra Sok.			Halil Sezai Erkut			Halil Sezai Erkut			NEW		
Approach	*Southbound*			*Eastbound*			*Westbound*			*Northwestbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	86	60	374	238	952	116	116	740	185	226	112	226
Total Analysis Volume [veh/h]	*86*	*60*	*374*	*238*	*952*	*116*	*116*	*740*	*185*	*226*	*112*	*226*
Intersection Settings												
Analyze Intersection?	☐											
Analysis Period	1 hour											
Located in CBD	☐											
Movement, Approach, & Intersection Results												
d_M, Delay for Movement [s/veh]	*48.0*	*43.4*	*58.6*	*184.*	*35.0*	*32.9*	*41.4*	*14.4*	*14.3*	*61.8*	*46.3*	*74.2*
Movement LOS	*D*	*D*	*E*	*F*	*C*	*C*	*D*	*B*	*B*	*E*	*D*	*E*
Critical Movement	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐
d_A, Approach Delay [s/veh]	*55.11*			*62.03*			*17.44*			*63.74*		
Approach LOS	*E*			*E*			*B*			*E*		
d_I, Intersection Delay [s/veh]	*47.73*											
Intersection LOS	*D*											
Intersection V/C	*0.527*											

Sequence

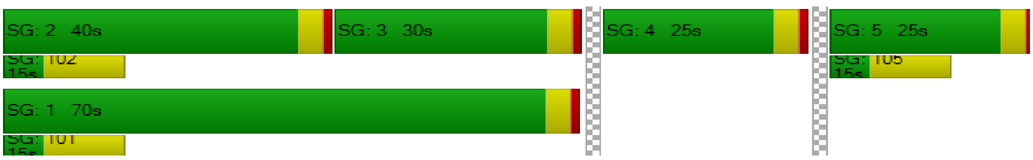


Figure E. 3 Results of Vistro for "A3" intersection

Number	4											
Intersection	**Halil sezai Cad. / 150 sk./Aksemsettin Cad**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	Aksemsettin Cad			150 Sok.			Halil Sezai Erkut			Halil Sezai Erkut		
Approach	*Northbound*			*Southbound*			*Eastbound*			*Westbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	264	423	429	123	410	114	59	481	91	121	650	201
Total Analysis Volume [veh/h]	*264*	*423*	*429*	*123*	*410*	*114*	*59*	*481*	*91*	*121*	*650*	*201*
Intersection Settings												
Analyze Intersection?	☑											
Analysis Period	1 hour											
Located in CBD	☐											
Movement, Approach, & Intersection Results												
d_M, Delay for Movement [s/veh]	*77.6*	*52.5*	*71.4*	*47.6*	*51.7*	*48.5*	*44.4*	*35.4*	*32.0*	*41.6*	*14.1*	*14.6*
Movement LOS	*E*	*D*	*E*	*D*	*D*	*D*	*D*	*D*	*C*	*D*	*B*	*B*
Critical Movement	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d_A, Approach Delay [s/veh]	*65.74*			*50.42*			*35.78*			*17.65*		
Approach LOS	*E*			*D*			*D*			*B*		
d_I, Intersection Delay [s/veh]	*43.29*											
Intersection LOS	*D*											
Intersection V/C	*0.473*											
Sequence												

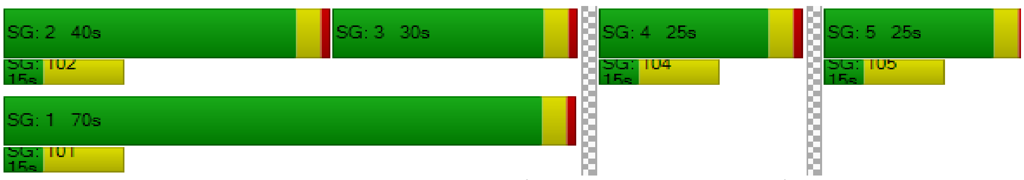


Figure E. 4 Results of Vistro for "A4" intersection

Number	5					
Intersection	**Esref bitilis cad. / Aksemestiin cad.**					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Aksemsettin Cad		Esref Bitlis Cad		Esref Bitlis Cad	
Approach	*Southbound*		*Eastbound*		*Westbound*	
Lane Configuration						
Turning Movement	*Left*	*Right*	*Left*	*Thru*	*Thru*	*Right*
Base Volume Input [veh/h]	412	103	266	935	923	345
Total Analysis Volume [veh/h]	*412*	*103*	*266*	*935*	*923*	*345*
Intersection Settings						
Analyze Intersection?	☑					
Analysis Period	1 hour					
Located in CBD	☐					
Movement, Approach, & Intersection Results						
d_M, Delay for Movement [s/veh]	*47.03*	*41.63*	*79.01*	*6.08*	*18.12*	*20.22*
Movement LOS	*D*	*D*	*E*	*A*	*B*	*C*
Critical Movement	☐	☐	☑	☐	☐	☐
d_A, Approach Delay [s/veh]	*45.95*		*22.23*		*18.69*	
Approach LOS	*D*		*C*		*B*	
d_I, Intersection Delay [s/veh]	*24.82*					
Intersection LOS	*C*					
Intersection V/C	*0.484*					

Sequence

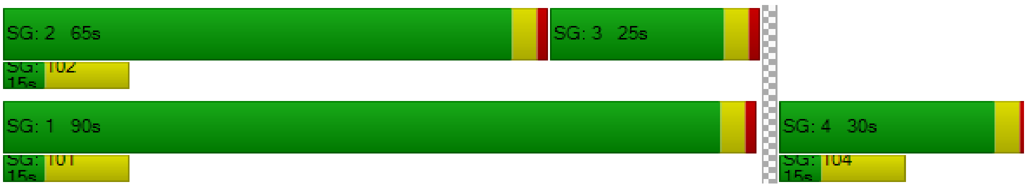


Figure E. 5 Results of Vistro for "A5" intersection

Number	6											
Intersection	**Esref bitilis Cad. / Trakiya Cad.**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	Trakya Cad			Esref Bitlis Cad			Esref Bitlis Cad			NEW		
Approach	*Northbound*			*Eastbound*			*Westbound*			*Southeastbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	432	60	323	116	1231	307	273	1092	116	226	112	226
Total Analysis Volume [veh/h]	*432*	*60*	*323*	*116*	*1231*	*307*	*273*	*1092*	*116*	*226*	*112*	*226*
Intersection Settings												
Analyze Intersection?	☑											
Analysis Period	1 hour											
Located in CBD	☐											
Movement, Approach, & Intersection Results												
d_M, Delay for Movement [s/veh]	*73.4*	*43.3*	*53.1*	*41.2*	*16.5*	*16.2*	*59.9*	*40.4*	*32.8*	*60.4*	*46.1*	*71.3*
Movement LOS	*E*	*D*	*D*	*D*	*B*	*B*	*E*	*D*	*C*	*E*	*D*	*E*
Critical Movement	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d_A, Approach Delay [s/veh]	*63.21*			*18.22*			*43.45*			*61.97*		
Approach LOS	*E*			*B*			*D*			*E*		
d_I, Intersection Delay [s/veh]	*40.09*											
Intersection LOS	*D*											
Intersection V/C	*0.577*											

Sequence

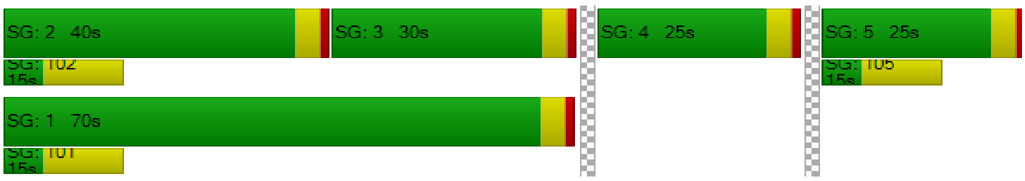


Figure E. 6 Results of Vistro for "A6" intersection

Number	7											
Intersection	**Esref bitilis Cad. / Beypazar Cad.**											
Control Type	Signalized											
Analysis Method	HCM 2010											
Name	Beypazari Cad			NEW			Esref Bitlis Cad			Esref Bitlis Cad		
Approach	*Northbound*			*Southbound*			*Eastbound*			*Southwestbound*		
Lane Configuration												
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh/h]	73	60	74	226	112	226	116	1556	389	288	1152	116
Total Analysis Volume [veh/h]	*73*	*60*	*74*	*226*	*112*	*226*	*116*	*1556*	*389*	*288*	*1152*	*116*
Intersection Settings												
Analyze Intersection?	☐											
Analysis Period	1 hour											
Located in CBD	☐											
Movement, Approach, & Intersection Results												
d_M, Delay for Movement [s/veh]	*47.0*	*43.3*	*45.2*	*60.4*	*46.1*	*71.3*	*56.5*	*41.0*	*55.3*	*57.5*	*16.1*	*13.3*
Movement LOS	*D*	*D*	*D*	*E*	*D*	*E*	*E*	*D*	*E*	*E*	*B*	*B*
Critical Movement	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐
d_A, Approach Delay [s/veh]	*45.31*			*61.97*			*44.63*			*23.62*		
Approach LOS	*D*			*E*			*D*			*C*		
d_I, Intersection Delay [s/veh]	*39.44*											
Intersection LOS	*D*											
Intersection V/C	*0.633*											

Sequence

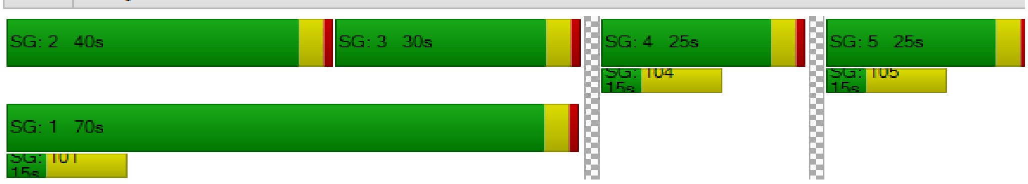
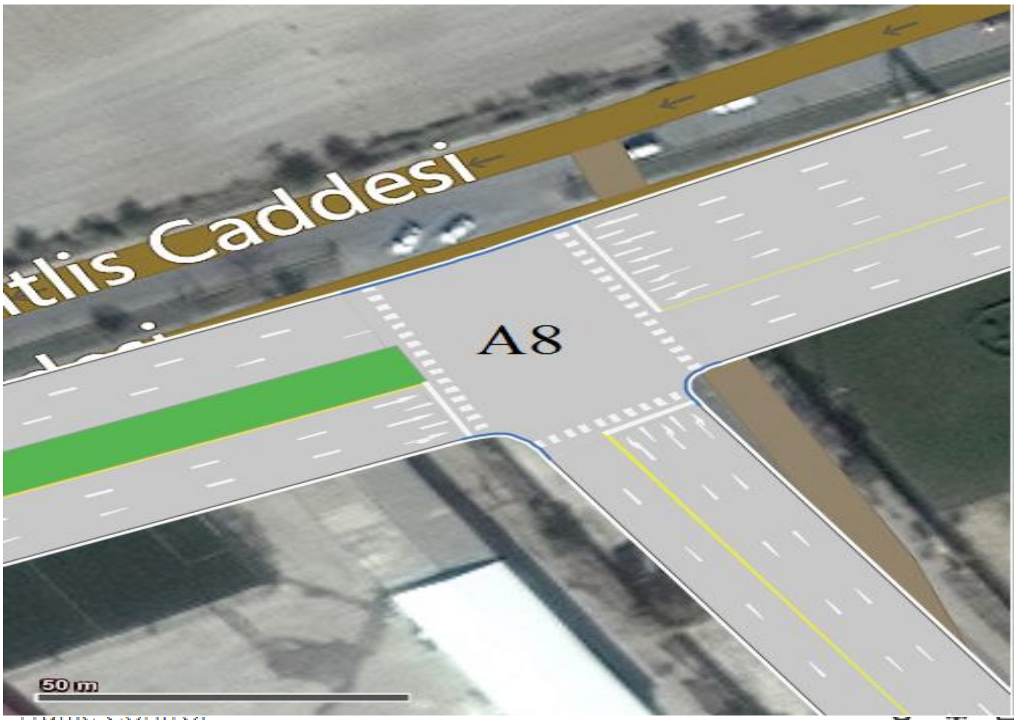


Figure E. 7 Results of Vistro for "A7" intersection



Number	8					
Intersection	**Esref bitilis Cad. /Tanzimat Cad.**					
Control Type	Signalized					
Analysis Method	HCM 2010					
Name	Esref Bitlis Cad		Esref Bitlis Cad		Tanzimat Cad.	
Approach	*Northeastbound*		*Southwestbound*		*Northwestbound*	
Lane Configuration						
Turning Movement	*Thru*	*Right*	*Left*	*Thru*	*Left*	*Right*
Base Volume Input [veh/h]	1548	387	319	2777	238	955
Total Analysis Volume [veh/h]	*1548*	*387*	*319*	*2777*	*238*	*955*
Intersection Settings						
Analyze Intersection?	☐					
Analysis Period	1 hour					
Located in CBD	☐					
Movement, Approach, & Intersection Results						
d_M, Delay for Movement [s/veh]	*26.05*	*29.83*	*26.05*	*21.33*	*36.68*	*60.4*
Movement LOS	*C*	*C*	*C*	*C*	*D*	*E*
Critical Movement	☐	☐	☐	☐	☐	☑
d_A, Approach Delay [s/veh]	*26.81*		*36.22*		*26.81*	
Approach LOS	*C*		*D*		*C*	
d_I, Intersection Delay [s/veh]	*74.30*					
Intersection LOS	*E*					
Intersection V/C	*0.888*					
Sequence						

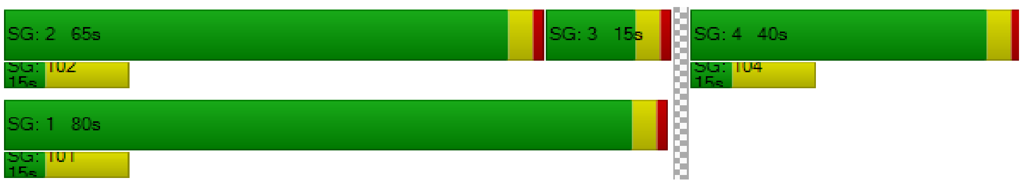


Figure E. 8 Results of Vistro for "A8" intersection