A GEOGRAPHICAL INFORMATION SYSTEM APPLICATION FOR AMBULANCE ROUTING SERVICES: A PROTOTYPE

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

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ABSTRACT

A GEOGRAPHICAL INFORMATION SYSTEM APPLICATION FOR AMBULANCE ROUTING SERVICES: A PROTOTYPE

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In public safety, geography plays a significant role. One of the most important front-line elements of public safety is an efficient emergency transport and care system. The capacity to access and process information rapidly and organize resources where needed can be critically important in an emergency situation. Information about the locality of an event or a disaster is often vital in knowing how to respond. A significant operation in handling emergency situations is the routing of ambulances to incident sites and then to the closest appropriate hospitals. One of the important steps to survival in an emergency is quick response time.

The aim of this thesis study is to build an immediate, rapid and efficient emergency medical transport system prototype, called Ambulance Routing Service Application Prototype (ARSAP), to be used in Middle East Technical University (METU) Emergency Service, Ankara, Turkey. In the study, geographical information systems (GIS) technology is used in assisting the development and implementation of an emergency medical service (EMS) response system.

In this prototype, while choosing a proper facility, the available quantity of beds, respiratory equipments and doctors in a hospital's intensive care room and the best traffic routes to the hospital in hand are also considered. The ARSAP is expected to shorten the commuting time and hence to reduce the damage to the patient to the lowest level and allow the ambulance staff to perform their task better. The results generated using the ARSAP are validated and analyzed by comparing with currently practiced emergency call paths data collected with the help of METU Emergency Service ambulance drivers.

Key Words:

Health Informatics, Emergency Medical Service, Geographical Information Systems, ArcView

ÖZ

AMBULANS SERVİSİ ULAŞIMINI KOLAYLASTIRAN COĞRAFİ BİLGİ SİSTEMİ UYGULAMASI

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Kamu güvenliği açısından coğrafya büyük bir önem taşır. Kamu güvenliğinin en önemli unsurlarından biri, acil hasta taşıma ve müdahale sisteminin etkili bir şekilde yürümesidir. Acil bir durumda, bilgiye süratle erişme ve bu bilgileri işleme koyma ve kaynakları ihtiyaç duyulan yerlerde organize etme kapasitesi çok büyük bir önem taşır. Bir olayın veya felaketin yerinin bilinmesi, genellikle nasıl müdahale edileceği açısından hayati önem taşır. Acil durum olaylarına yapılan müdahalelere ilişkin önemli bir faaliyet de, ambulansların önce olay yerine ve sonra da en yakındaki uygun hastanelere giderken kullanacakları güzergahların belirlenmesidir. Acil bir durumda, hayatta kalmayı sağlayan en önemli unsurlardan biri müdahale süresinin kısalığıdır.

Bu tez çalışmasının amacı, Türkiye'nin Ankara şehrinde bulunan Orta Doğu Teknik Üniversitesi (ODTÜ) Acil Durum Servisi tarafından kullanılacak, Ambulans Güzergah Servisi Uygulaması Prototipi (AGSUP) adında, anında yanıt verebilen, süratli ve etkili bir acil hasta taşıma sistemi prototipi oluşturmaktır. Bu çalışmada, acil durum servisi müdahale sisteminin geliştirilmesi ve uygulanmasında, coğrafi bilgi sistemleri (CBS) teknolojisi kullanılmıştır.

Bu prototipte, uygun bir tesis seçerken, bir hastanenin yoğun bakım odasındaki hazır yatak, solunum cihazı ve doktor sayısı ve hastaneye giden en iyi trafik güzergahları da değerlendirilmiştir. AGSUP'den beklenen hastayı ulaştırma süresini kısaltması, hastanın uğradığı zararı en aza indirmesi ve ambulans personelinin görevlerini daha iyi yapmasını sağlamasıdır. AGSUP'den elde edilen sonuçlar, ODTÜ Acil Servis sürücüleinin yardımıyla toplanan, şu anda kullanılan acil çağrı yol verileri ile karşılaştırma yoluyla geçerliliği testedilmiş ve analiz edilmiştir.

Anahtar Sözcükler:

Sağlık Bilişimi, Acil Tıp Servisi, Coğrafi Bilgi Sistemleri, ArcView

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LIST OF ABBREVIATIONS AND ACRONYMS

ALS	:	Advanced Life Support
ARSAP	:	Ambulance Routing Service Application Prototype
AVNA	:	ArcView Network Analyst
BLS	:	Basic Life Support
EMS	:	Emergency Medical Service
EMT	:	Emergency Medical Technicians
EPT	:	Emergency Patient Transportation
ESRI	:	Environmental Systems Research Institute
GIS	:	Geographical Information System
GUI	:	Graphical User Interface
IS	:	Information System
METU	:	Middle East Technical University
MICU	:	Mobile Intensive Care Units
PC	:	Personal Computer
USGS	:	United States Geological Survey
UTM	:	Universal Transverse Mercator
VTab	:	Virtual Table
NetDef	:	Network Definition

CHAPTER 1

1. INTRODUCTION

Geography plays an important role in public safety. Response capabilities often rely on a variety of data from multiple agencies. The capability to access and process information quickly and deploy resources where needed can be mission critical. Information about the location of an incident or disaster is often crucial in knowing how to respond [1]. One of the most important front-line elements of public safety is efficient emergency care system.

Nowadays, reducing damage in emergency situation to the lowest level becomes a very important matter [2]. Accepted emergency medical standards call for the provision of basic life support to the scene in four to six minutes, advanced life support to the scene within six to eight minutes and transport capability on the scene within eight to ten minutes [35].Therefore, it is a great urgency to build an immediate, rapid and efficient emergency medical care system. Geographical information systems (GIS) can assist in the development and implementation of an emergency medical service (EMS) response system. An emergency management computer-aided dispatch system saves time by identifying the suitable medical response unit closest to the location of the incoming call, displaying possible travel route to the call, and displaying travel routes from the call to the hospital, or other medical care facility [28].

ArcView is a technologically advanced geographical information system program that processes all the spatial and non-spatial data received from multiple sources and assigns it geographical attributes. ArcView allows an authority to merge information from multiple sources and plot that data on a map—a technique called spatial representation—which makes it easier to view and analyze data [3].

Network analysis, which is a function of geographical information system, can be taken by the ambulance personnel to realize whole situation and then decide on the most suitable hospital for the patient. The parameters generally considered include the quantity of beds in hospital's intensive care room, respiratory equipment needed and the best traffic routes to hospital in hand. With this valuable information, the first-aid personnel in ambulance can perform their task better. Therefore, Emergency medical care system cooperating with GIS shortens delivery time and reduces the damage to the lowest level [4].

Emergency patient transportation (EPT), at first glance, seems quite simple: an emergency call comes into emergency medical services headquarters or into emergency communications center and then it is directed to the suitable EMS, an ambulance is dispatched, medics arrive on the scene, and the patient is transported to an appropriate medical facility [15]. In reality, this chain of events is the result of a complex system. This system ideally blends technology, strategic planning and clinical expertise to ensure an immediate, effective response to each and every call for help [5].

Traditionally, ambulance services have constructed stations at different locations within their service areas, with each station staffed 24 hours a day to handle calls. Staffing levels remain constant, with the same amount of ambulances and staff available at the same locations at the same times [6]. In Turkey, this traditional system is in use.

Care begins the moment a call comes into the dispatch center. Using a set of advanced protocols, dispatchers ideally talk callers through a phone-based triage system to determine the scope and severity of the emergency situation. These calls can be monitored, working with the dispatchers to ensure that they follow all protocols while providing the highest level of clinical skills and customer service possible [7].

The first step to survival in an emergency is quick response time. The second, perhaps most important step, is receiving expert emergency medical care. Every ambulance should ideally be staffed and equipped to Advanced Life Support (ALS) levels—with at least one member of the medical team certified in advanced life support [1].

The METU Emergency Service has the responsibility area of mainly METU campus area and rarely nearby region (e.g. 100.Yıl quarter or Bilkent road). METU emergency department serves for 24 hours a day. There is always at least one emergency technician available for emergency patient transportation.

1.1. Scope and Objective of the Study

This study deals with the generating suitable travel paths in an emergency situation. The study consists of three main parts. First, data collection and improvement was carried out. Next, the ARSAP was implemented. For this part of the study, ArcView 3.3 was customized and avenue scripts were developed. Finally, the ARSAP generated paths and originally practiced paths used by METU emergency service ambulance drivers were compared to examine the results.

1.2. Outline

This study consists of six chapters.

Chapter 1 provides a brief introduction to the subject, and gives the scope and the objective of this study.

Chapter 2 introduces brief overview of geographic information systems for emergency medical services.

Chapter 3 presents data collection, improvement and the development of the ARSAP that were carried out during the thesis study.

Chapter 4 covers the analysis of originally practiced and the ARSAP generated ambulance paths.

Chapter 5 presents the discussions and conclusions of this study and commands for future work.

CHAPTER 2

2. GEOGRAPHIC INFORMATION SYSTEM FOR EMERGENCY MEDICAL SERVICES

2.1. Geographic Information System (GIS)

2.1.1. What is GIS?

GIS stands for *geographic information system*. An information system manages data. A GIS, then, is a type of information system that deals specifically with *geographic* or spatial information. Like other information systems, a GIS requires lots of data that it can access, manipulate, and use [8].

Simply put, a GIS combines layers of information about a place to give you a better understanding of that place. What layers of information you combine depends on your purpose—finding the best location for a new store, analyzing environmental damage, finding best route for an emergency call or a hospital [9], and so on. GIS as a rapidly growing technological field incorporates graphical features with tabular data in order to assess real-world problems [29]. GIS can be regarded as the high technology equivalent of the map. An individual map contains a lot of information which is used in different ways by different individuals and organizations. It represents the means of locating ourselves in relation to the world around us [10].

2.1.2. How does a GIS work?

In order for a GIS to work, it is necessary to link spatial data to the geographic information of a particular feature on the map. In short, a GIS doesn't hold maps or pictures - it holds a database. The database concept is central to a GIS and is the main difference between a GIS and drafting or computer mapping systems, which can only produce a good graphic output. Therefore a GIS gives you the ability to associate information with a feature on a map and to create new relationships that can determine the suitability of various sites for development, evaluate environmental impact, and find the best path to the place one need to go and so on [11].

Although many computer programs, such as statistics packages or spreadsheets packages can handle simple geographic or spatial data, this does not necessarily make them a GIS. All contemporary geographic information systems incorporate a database management system [12].

Relating information from different sources

The power of a GIS comes from the ability to relate different information in a spatial context and to reach a conclusion about this relationship. Most of the information about our world contains a location reference, placing that information at some point on the globe. A GIS can reveal important new information that leads to better decision-making [13].

Different kinds of data in map form can be entered into a GIS. A GIS can also convert existing digital information, which may not yet be in map form, into forms it can recognize and use. Census or hydrologic tabular data can be converted to a map like form and serve as layers of thematic information in a GIS [13].

GIS provides the facility to extract the different sets of information from a map (roads, settlements, vegetation, etc.) and use these as required. This provides great flexibility, allowing a paper map to be quickly produced which exactly meets the needs of the user. However, GIS goes even further: because, analysis and modeling become possible using the data stored on a computer [30].

Why is the layering so important?

GIS mapping software link information about the attribute and location of objects. Unlike a paper map, where "what you see is what you get," a GIS map can combine many layers of information [9].

As on the paper map, a digital map created by GIS will have dots, or points, that represent features on the map such as cities; lines that represent features such as roads; and small areas that represent features such as lakes. The difference is that this information comes from a database and is shown only if the user chooses to show it. The database stores where the point is located, how long the road is, and even how many square miles a lake occupy [9].

Each piece of information in the map sits on a layer, and the users turn on or off the layers according to their needs. One layer could be made up of all the roads in an area. Another could represent all the lakes in the same area. Yet another could represent all the cities [10].

The power of a GIS over paper maps is your ability to select the information you need to see according to what goal you are trying to achieve. A business person trying to map customers in a particular city will want to see very different information than a water engineer who wants to see the water pipelines for the same city. Both may start with a common map—a street and neighborhood map of the city—but the information they add to that map will differ [10].

2.1.3. What's Special About a GIS?

The way maps and other data have been stored or filed as layers of information in a GIS makes it possible to perform complex analyses [9].

Information retrieval

With a GIS you can "point" at a location, object, or area on the screen and retrieve recorded information about it from off-screen files. Using scanned aerial photographs as a visual guide, you can ask a GIS about the geology or hydrology of the area or about the type, name of a building, a street and so on. This type of analysis allows you to draw conclusions [12].

Topological modeling

A GIS can recognize and analyze the spatial relationships among mapped phenomena. Conditions of adjacency (what is next to what), containment (what is enclosed by what), and proximity (how close something is to something else) can be determined with a GIS [12].

Networks

When an ambulance from emergency call is running off into street(s), it is important to know in which direction the street(s) traffic flow and which street(s) have turn into other street(s). This is done by using a linear network. It allows the computer to determine how an ambulance (with emergency patient) transports through streets to reach a suitable hospital as soon as possible. Additional information on street length and speed throughout the spatial network can help the GIS determine how long it will take an ambulance to travel [10].

2.1.4. Why is GIS important?

GIS integrates spatial and other kinds of information within a single system, it offers a consistent framework for analyzing geographical data. By putting maps and other kinds of spatial information into digital form, GIS allows us to manipulate and display geographical knowledge in new and exciting ways [31].

GIS makes connections between activities based on geographic proximity. Looking at data geographically can often suggest new insights, explanations. These connections are often unrecognized without GIS, but can be vital to understanding and managing activities and resources. GIS gives a "high tech" feel to geographic information. GIS also is an important tool in understanding and managing the environment [31].

2.2. What is Emergency Medical Services?

An EMS system is an organized and also synchronized arrangement of resources, including personnel, vehicles, equipment, and facilities, which are coordinated to respond to medical emergencies, irrespective of cause [14]. Improvements in the provision of emergency medical care are closely related to the EMS system quality and effectiveness.

Emergency Medical Services (EMS) development began in 1966 when the Committees on Trauma and Shock of the National Academy of Sciences, National Research Council, USA published the report "Accidental Death and Disability: The Neglected Disease of Modern Society." This report made the public greatly aware of the need to provide proper care to the sick and injured and to develop and greatly improve pre-hospital care. By the early 1970's local EMS systems emerged under the guidance of many levels of USA government. The consistency of training and care which individuals received are also needed to increase. By the 1990's the value of the emergency medical technician(s) has increased with increased responsibilities [32].

EMS is a vital public service, as important to our community as the police or fire department. EMS can be seen as a two-tiered system. Focus is to provide care for victims of sudden and serious illness or injury [33].

The first tier of the system is *Basic Life Support (BLS)*, which is usually provided by first aid squad or rescue squad. Emergency Medical Technicians (EMT) staff these units. They provide first aid treatment and transportation to the hospital, but do *not* provide advanced life support [33].

The second tier of the system is *Advance Life Support (ALS)*. These are hospital-based units, Mobile Intensive Care Units (MICU), which are staffed by two paramedics to bring emergency department care to the scene of an emergency [25].

Paramedics are specially trained health care providers who act as the eyes and the ears of the emergency room physician. Once the paramedics have completed a patient exam, contact is made with the emergency room physician from hospital. This ensures the most appropriate care is rendered during transport to the hospital. The paramedics carry the most commonly used medications and equipment used in the emergency department to treat the critically ill [33].

Emergency preparedness is measured in terms of its ability to organize emergency response units in a timely and effective manner. Response time is a primary consideration in deploying emergency response units [34].

To make EMS work there are many elements which all work together. The functions of each group may differ greatly depending on the geographic area. Regardless of the area, there are 14 essential elements [32]:

- An advisory council on emergency medical service
- Physician-directed medical control, including quality control review
- EMT training programs, including continuing education programs
- Instructor training programs
- A communications system, including system access
- Dispatch centers
- Ambulance services
- EMT and emergency department personnel rapport and trust
- Reports and records
- Ongoing system evaluation with quality assurance, risk management, and outcome study programs

- Disaster plans
- Public information and education programs
- Categorized hospital emergency capabilities
- Funding

2.3. GIS for Emergency Medical Services

A powerful, easy-to-use tool that brings geographic information to the desktop is ArcView [3]. ArcView allows an authority to merge information from multiple sources and plot that data on a map—a technique called spatial representation—which makes it easier to view and analyze data [16]. It is a technologically advanced geographical information systems program that processes all the spatial and non-spatial data received and assigns it geographical attributes. ArcView GIS is sophisticated desktop geographic information system software that gives the power to present, visualize, explore, query, summarize, and analyze the data geographically. For the further information on ArcView, see Appendix B.

Network analyses are one of the basic operations for GIS spatial analysis. Network analyses are the techniques for routing resources along a set of linked linear objects [24]. Optimal path routing predicts the best route between two or more points based on distance, time, effort, or another measure. Optimal path routing is often used for routing emergency response vehicles [13]. For more information on network analyses, again see Appendix B.

Quick response time to the emergency call can be achieved by trying to minimize the travel times from the ambulance location to the emergency call and from the call to the suitable medical care facility. The correct choice of suitable free hospital can also save time by not allowing carrying the patient to a full capacity medical care facility.

CHAPTER 3

3. APPLICATION DEVELOPMENT

While developing the ARSAP, Middle East Technical University (METU) Emergency Service Ambulances are taken as customers that can use the customized application.

METU and therefore, METU Emergency Service are located in Çankaya district in Ankara, the capital of Turkey. The district is mainly composed of 30% residential and 27%forest areas. The other usages in the district are administrative usages with 8,5%, military usages with 6,5%, commercial usages with 3,16%, parks and green areas with 2,6, dam with 1,24, health with 0,11 and etc [17]. METU Emergency Service has the responsibility zone of METU Campus area. This region contains most of the forest areas of Çankaya districts.

Although the responsibility area of METU Emergency Service is only METU Campus, ambulances also try to serve when an emergency call come from the nearby region.

3.1. Process Model

The process below shows the steps of the study:

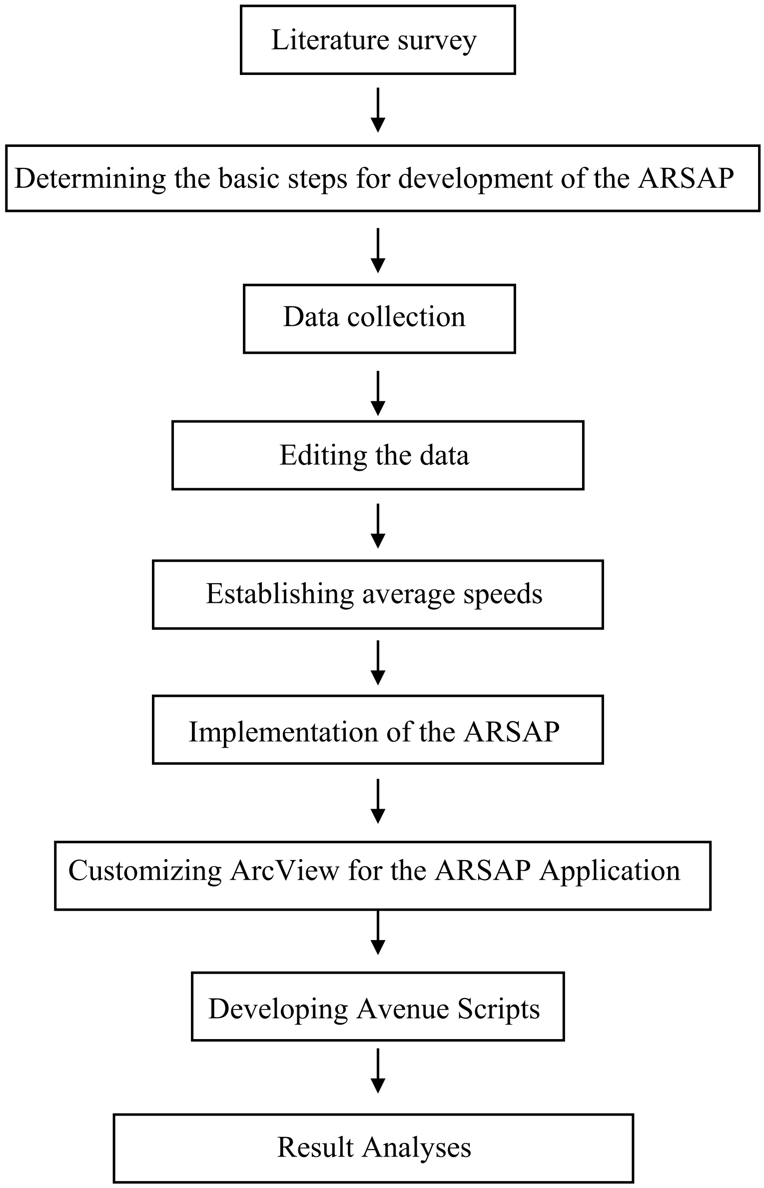


Figure 3.1 Process model

3.2. Data Collection for Spatial and Non-Spatial Contents

In this section, the general spatial and non-spatial data contents used in the study are described. The data used in this thesis are obtained from Kıvanç Ertuğay [17]. The data and the modifications on this data are explained below.

3.2.1. Raw Data

The raw data used in the study are listed below in Table 3.1 that Kıvanç Ertuğay obtained from the "Ankara Metropolitan Municipality Office of Information Systems", and "Ankara Metropolitan Municipality Office of Water and Infrastructure" [17]. All data on map-info file format were converted to ArcView shape file format (.shp) by Kıvanç Ertuğay.

Table 3.1 Raw data used in the study

Name	Scale	Year	Format/Type	Content	Source
Road Network Data-1	1/25000	2000	Digital MapInfo (Polyline)	Name, Type (All roads)	Ankara Metropolitan Municipality Office of Water and Infrastructure
Road Network Data -2	1/25000	2000	Digital MapInfo (Polyline)	Average Speed, Name (Main roads)	Ankara Metropolitan Municipality Office of Information Systems
Health Services	1/25000	2002	Digital MapInfo (Point)	Name, Quarter (Hospitals)	Ankara Metropolitan Municipality Office of Water and Infrastructure
Education Services	1/25000	2002	Digital MapInfo (Point)	Name, Quarter (Schools, Universities)	Ankara Metropolitan Municipality Office of Water and Infrastructure
Buildings	1/1000	2002	Digital MapInfo (Polyline)	Usage (Public Buildings, Residences)	Ankara Metropolitan Municipality Office of Water and Infrastructure
Border of Districts, Quarters	1/25000	2002	Digital MapInfo (Polyline)	District Name, Quarter Name	Ankara Metropolitan Municipality Office of Information Systems

These raw data needed to be updated and corrected in order to be used in his study. In this respect, the following process was carried out by Kıvanç Ertuğay [17]:

- Two Ankara transportation maps in paper format showing the road connections and classifications were scanned and saved in jpeg raster file format.
- Before using the scanned Ankara transportation maps as background raster object in ArcView environment, registration process was made and scanner coordinates of the raster images were transformed to their real UTM coordinates by using "imagewarp extension" of ArcView software which is a useful tool for registration of raster objects by using vector objects.
- For each raster transportation map, eight intersection points of roads are defined by the help of the vector transportation network data and used as registration reference points. Three pairs of the reference points were selected from the external corners of the raster maps and the remaining points were selected from the internal parts of the raster maps in order to obtain homogeneous distribution of reference points.
- After the registration process, ArcMap 8.1 software of ESRI is used in digitization process. At the end of the digitization, polyline topology was rebuilt by Arc toolbox software in order to obtain "record number", "from_junction", "to_junction" information of transportation data which were necessary data in the study.

3.2.2. Classification of Roads

Transportation road network data is classified according to types of roads. The field “type” in Roadcankayatd table stands for classified types of roads. (Figure 3.2)

Attributes of Roadcankayatd.shp

Shape	Length	Buffer	Tr_adi	Type	Oneway
PolyLine	275.36700439453	22	Cemal Gürsel Caddesi	3	
PolyLine	69.84649658203	30	Atatürk Bulvarý	3	
PolyLine	210.07000732422	30	Celal Bayar Bulvarý	3	
PolyLine	186.51800537109	30	Gazi Mustafa Kemal Bulvarý	3	
PolyLine	100.32199859619	30	Talat Paþa Bulvarý	3	
PolyLine	181.66900634766	22	Mamak Caddesi	3	
PolyLine	64.07579803467	30	Gazi Mustafa Kemal Bulvarý	3	
PolyLine	51.50740051270	30	Atatürk Bulvarý	3	
PolyLine	114.73000335693	22	Mareþal Fevzi Çakmak Caddes	3	
PolyLine	153.76800537109	30	Mithatpaþa Caddesi	3	ft
PolyLine	70.36509704590	22	Mareþal Fevzi Çakmak Caddes	3	
PolyLine	157.31399536133	30	Atatürk Bulvarý	3	
PolyLine	171.56500244141	30	Talat Paþa Bulvarý	3	
PolyLine	12.36050033569	30	Gazi Mustafa Kemal Bulvarý	3	
PolyLine	280.91400146484	0	Anadolu Bulvarý	2	
PolyLine	89.69999694824	0	Eskiþehir Yolu	2	
PolyLine	293.40600585938	33	Konya Yolu	2	
PolyLine	61.39680099487	0		2	
PolyLine	101.67500305176	0	Sivrihisar Yolu	2	
PolyLine	170.46800231934	33	Konya Yolu	2	
PolyLine	121.68499755859	30	Anadolu Bulvarý	2	
PolyLine	54.38750076294	22	Samsun Yolu	2	
PolyLine	345.88500976563	33	Konya Yolu	2	
PolyLine	142.94700622559	0	Samsun Yolu	2	
PolyLine	27.38220024109	22	Samsun Yolu	2	
PolyLine	464.93600463867	0	Sivrihisar Yolu	2	

Figure 3.2 The type field and its records in Roadcankayatd table

The database codes of “0”, “1”, “2”, “3”, “4” and “5” represent “Crossroads”, “Highways”, “State roads”, “Boulevards”, “Avenues” and “Streets”, respectively (Table 3.2).

Table 3.2 Data codes for the transportation road network data in database

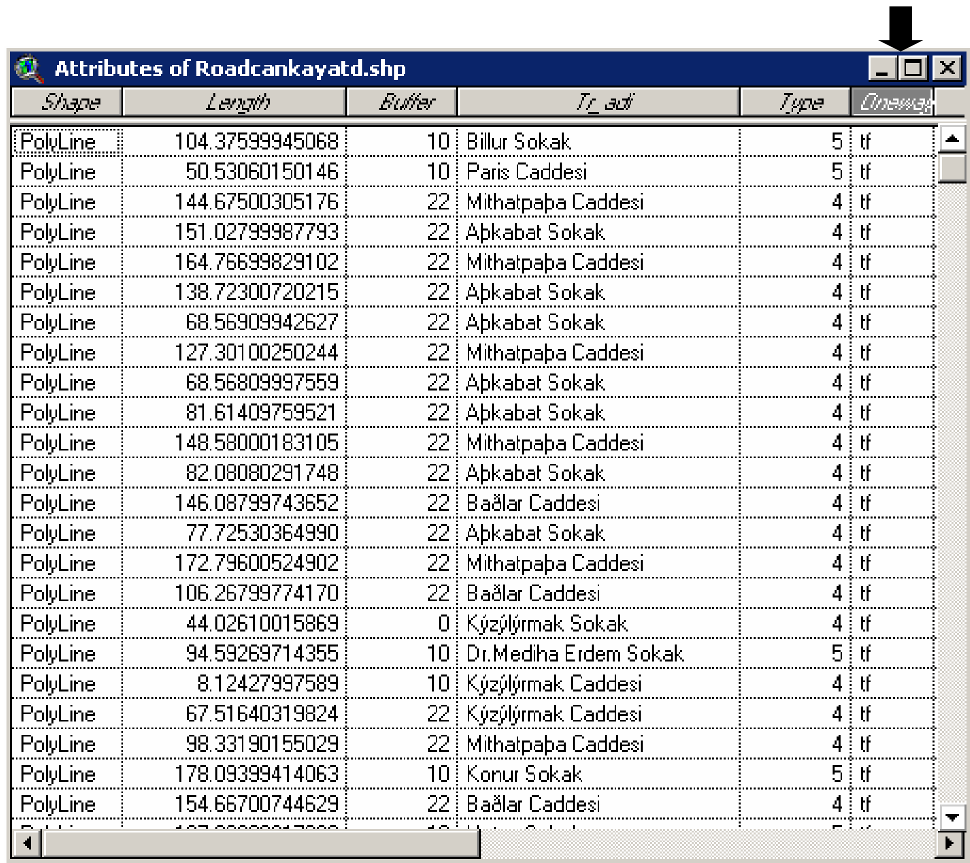
Road type	Database Code
Highways	1
State roads	2
Boulevards	3
Avenues	4
Streets	5
Crossroads	0

3.2.3. One-way Restrictions

Transportation road network attribute table has a string field “one-way”. One-way restrictions (Table 3.3) are represented by the string values of “FT”, “TF”, “N” and “ ” in order to restrict travel to certain directions. The string values of “FT” or “ft” represent that travel is permitted from the start to the end of the line only, which is the same as the digitized direction. The values of “TF” or “tf” represent that travel is permitted from the end of the line to the start of the line only, which is opposite the digitized direction. The values of “N” or “n” represent that travel is permitted in neither direction; the line is closed to travel. Finally, the string values of “ ” or any other value represent that travel is permitted in both directions (Figure 3.3).

Table 3.3 One-way restrictions on main streets [17]

One-way Restrictions On Main Streets
Esat Street One-way To Çankaya Direction
Reşit Galip Street One-way To Ulus Direction
Nenehatun Street One-way To Çankaya Direction
Tunali Hilmi Street One-way To Esat Intersection On Both Side
Bülbülderesi One-way To Çankaya Direction
Kenedy Street One-way To Kizilay Direction
Bağlar Caddesi One-way From Esat Intersection To Ulus Direction And One-way From Esat Intersection To Çankaya Direction
Başçavuş Street One-way To Ulus Direction
Tahran Street One-way From Nenehatun To Kavaklidere Direction
Billur Street (Abanvay Street) One-way From Kuğulupark To Esat Direction
Büklüm Street One-way From Tahran To Tunali And One-way From Akay To Tunali Direction
Ballibaba Street One-way To Çankaya Direction
Portakal Çiçeği Street One-way From Hoşdere To Ulus Direction
Paris Street One-way To Ulus Direction
Kuveyt Street One-way From Ayranci To Ulus Direction
Ahmet Mithat Efendi Street One-way From Çankaya To Vali Konaği Direction(Not Found In Street Database)
Ahmet Rasim Street One-way From Çankaya To Dikmen Direction
Güleryüz Street One-way From Ulus To Çankaya Direction
Meşrutiyet Street One-way From Kizilay To Esat Direction
Mithatpaşa Street One-way From Kocatepe To Ulus Direction
Bankalar Street One-way From Esat To Ulus Direction
Kizilirmak Street One-way From Kocatepe To Dedeman Direction
Karanfil Street One-way From Meşrutiyet To Dedeman Direction
Konur Street One-way From Çankaya To Meşrutiyet Direction
Hatay Street One-way From Meşrutiyet To Ulus Direction
Selanik1 Street One-way To Çankaya Direction
Doktor Mediha Erdem Street One-way To Çankaya Direction
Haci Road One-way From Bülbüldere To Bağlar Direction
Bağlayan Street One-way From Bülbülderesi To Bağlar Direction
Dalkiran Sokak One-way To Meşrutiyet(Not Found In Street Database)
Aşkabat Street One-way From 7^{th} Street To Beşevler Direction



Shape	Length	Buffer	Tr_adi	Type	Oneway
PolyLine	104.37599945068	10	Billur Sokak	5	tf
PolyLine	50.53060150146	10	Paris Caddesi	5	tf
PolyLine	144.67500305176	22	Mithatpaþa Caddesi	4	tf
PolyLine	151.02799987793	22	Aþkabat Sokak	4	tf
PolyLine	164.76699829102	22	Mithatpaþa Caddesi	4	tf
PolyLine	138.72300720215	22	Aþkabat Sokak	4	tf
PolyLine	68.56909942627	22	Aþkabat Sokak	4	tf
PolyLine	127.30100250244	22	Mithatpaþa Caddesi	4	tf
PolyLine	68.56809997559	22	Aþkabat Sokak	4	tf
PolyLine	81.61409759521	22	Aþkabat Sokak	4	tf
PolyLine	148.58000183105	22	Mithatpaþa Caddesi	4	tf
PolyLine	82.08080291748	22	Aþkabat Sokak	4	tf
PolyLine	146.08799743652	22	Baðlar Caddesi	4	tf
PolyLine	77.72530364990	22	Aþkabat Sokak	4	tf
PolyLine	172.79600524902	22	Mithatpaþa Caddesi	4	tf
PolyLine	106.26799774170	22	Baðlar Caddesi	4	tf
PolyLine	44.02610015869	0	Kýzýlýrmak Sokak	4	tf
PolyLine	94.59269714355	10	Dr.Mediha Erdem Sokak	5	tf
PolyLine	8.12427997589	10	Kýzýlýrmak Caddesi	4	tf
PolyLine	67.51640319824	22	Kýzýlýrmak Caddesi	4	tf
PolyLine	98.33190155029	22	Mithatpaþa Caddesi	4	tf
PolyLine	178.09399414063	10	Konur Sokak	5	tf
PolyLine	154.66700744629	22	Baðlar Caddesi	4	tf

Figure 3.3 The one way field and its records in Roadcankayatd table

3.3. Data Editing

In the next few pages, turn restrictions on junctions, average speed establishment, the cost parameter calculation, traffic condition in different time intervals and the suitable hospital selection are briefly described. The data obtained from Kıvanç Ertuğay already included this information. However, some corrections were needed to be made for data completeness.

3.3.1. Turn Restrictions on Junctions

The prohibited turns and the time it takes to complete valid turns are stored in a special table known as a turntable. Turntables contain one record for each turn that is possible. For example, rights turn from Akdeniz Street onto 68. Street is represented in one record. A lefts turn from Akdeniz Street onto 68. Street is represented in another record. Turntables need not contain entries for every turn in the network. If a turn is not represented in a turntable, it will simply have no travel cost associated with it. If the line theme is a shapefile, a turntable must be declared in order to use it [18].

Required fields

Turntables must contain the following fields [19]:

- *Node field:* Contains the identification number of the node in the line theme where the turn is located. For coverage, this field is related to the "from-node" and "to-node" fields in the line theme's feature table. The "from-node" and "to-node" fields store the identification numbers of the start and end node of each line. For shapefiles, this field is related to the FJUNCTION and TJUNCTION fields in NODES.DBF located in the network index directory. FJUNCTION and TJUNCTION store the identification numbers of the start and end node of each line. There are three acceptable field names.
    - NODE_, NODE#, JUNCTION
- *From and to line fields:* Contain the record numbers of the lines in the line theme that the turn is made between. A turn is made from the line in the first field to the line in the second field. There are four acceptable ways of naming these fields.

- F_EDGE and T_EDGE
- F-EDGE and T-EDGE
- ARC1_ and ARC2_
- ARC1# and ARC2#

- *Cost field:* Non-negative values or 0 (zero) in this field represent the cost of making the turn. Any negative value means the turn is prohibited.

Creating a turntable for use with shapefiles

If the line theme is a shapefile and user need a turntable for it, user can create one manually. The basic steps involved in creating a turntable are [19]:

- *Creating node numbers:* The first step in creating a turntable is to create node numbers for the network data set on which users are performing analysis. When user first solves a network analysis problem on a particular data set, node numbers are automatically generated by the Network Analyst and written to a file called NODES.DBF in the network index directory.
- *Copying over node numbers to the line theme feature table:* User can use the "Copying over Node Numbers" script to copy node numbers from NODES.DBF to the line theme feature table. This script also adds record numbers to the line theme feature table. This information will enable one to identify the number of the node where the turn is made and the record numbers of the lines the turn is made between.

- *Creating an empty turntable and adding records to it:* One should create a new table and add the required turntable fields to it. User enters manually this information into the turntable.

Declaring a turntable for use with shapefiles

If the line theme is a shapefile, one must declare a turntable with the "NetDef.SetTurnVtab" request before user can use it in any analysis. The "Declaring a Turntable script" can be used to do this [4].

A database table named "turntable.dbf" was created by K. Ertuğay [17]. This table is used in the study in order to set turn restrictions on separated state roads (Table 3.4).

Table 3.4 Turn restrictions on separated state roads [17]

Roads	Turn restrictions on separated state roads
Eskişehir State Road	Turn to all directions is possible on 5 intersection points on Eskişehir State Road within borders of Çankaya district which are Konya, Söğütözü, METU, Bilkent, Hacettepe intersections. Only right turn is possible according to traffic direction because of traffic separation.
Konya State Road	Turn to all directions is possible on 9 intersection points on Konya State Road within borders of Çankaya district which are Akköprü, Celal Bayar, Incitaşı, Bahçelievler, Hipodrom, Eskişehir, Çetin Emeç, Karakusunlar, Turan Güneş intersections. Only right turn is possible according to traffic direction because of traffic separation.
Ankara Transit Highway	Turn to all directions is possible on 4 intersection points on Ankara Transit Highway within borders of Çankaya district.

3.3.2. Establishing Average Speeds

There were two different data sets about the average network speeds.

First one was the transportation network data of Ankara Metropolitan Municipality Office of Information Systems (Figure 3.4) which included the average speeds for the main roads. The "Road Network Data-2" data (Table 3.1) which contained the average speeds was not for the main road network data. Therefore, it was connected with the "Road Network Data-1" by Kıvanç Ertuğay [17]. Table 3.5 shows the average speeds obtained.

The second data set was the average speed data obtained for this thesis based on ambulance driver experiences of METU Emergency Service and Demetevler Emergency Service (Table 3.6).

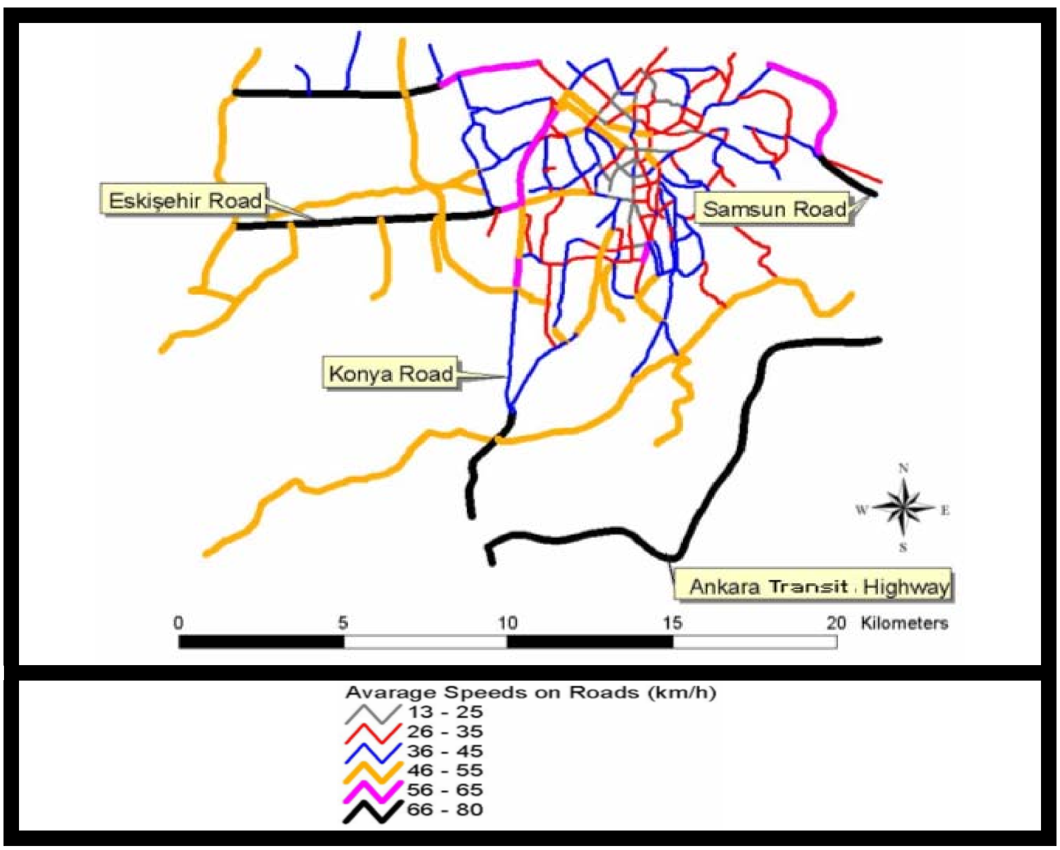


Figure 3.4 "Road Network Data-2" data (Table 3.1) of Ankara Metropolitan Municipality Office of IS [17]

Table 3.5 Average speeds on normal traffic conditions based on the study of Ankara Metropolitan Municipality Office of Information Systems [17]

Road Types	Average Speeds In Normal Traffic Conditions
Highways	80 km/h
State roads	55 km/h
Boulevards	38 km/h
Avenues	31 km/h
Streets	21 km/h

The speed ranges data in Table 3.6 is obtained from interviews with ambulance drivers Özcan Turan, Şaban Özçiçek, KadirIşıktaş, Yaşar Atasever and Sedat Ersun from METU Emergency Service on December 2003 and two anonymous drivers from Demetevler Emergency Service in November2003.

Table 3.6 The speed ranges based on interviews with ambulance drivers

Road Types	Speed Ranges In Heavy Traffic Conditions	Speed Ranges In Normal Traffic Conditions	Speed Ranges In Light Traffic Conditions
Highways	65-75 km/h	75-85 km/h	80-100 km/h
State roads	50-60 km/h	55-75 km/h	70-80 km/h
Boulevards	40-50 km/h	45-65 km/h	55-75 km/h
Avenues	35-45 km/h	45-55 km/h	55-65 km/h
Streets	20-40 km/h	30-50 km/h	40-60 km/h

The average speeds used in the study were than calculated as follows:

1. The speed ranges in Table 3.6 were averaged for each road type in each column (different traffic conditions) (Table 3.7).

Table 3.7 The average speeds based on interviews with ambulance drivers

Road Types	Average Speed In Heavy Traffic Conditions	Average Speed In Normal Traffic Conditions	Average Speed In Light Traffic Conditions
Highways	70 km/h	80 km/h	90 km/h
State roads	55 km/h	65 km/h	75 km/h
Boulevards	45 km/h	55 km/h	65 km/h
Avenues	40 km/h	50 km/h	60 km/h
Streets	30 km/h	40 km/h	50 km/h

2. Since ambulances are special vehicles, the weighted average of the values in Table 3.5 (by a factor of 0.25) and those in Table 3.7 (by a factor of 0.75) is calculated to find final accepted average speeds for normal traffic conditions (Table 3.8).

Table 3.8 The average speeds in normal traffic conditions

Road Types	Speed Ranges In Normal Traffic Conditions
Highways	80 km/h
State roads	63 km/h
Boulevards	51 km/h
Avenues	45 km/h
Streets	35 km/h

3. If the values in Table 3.5 and the middle column in Table 3.7 (normal traffic conditions) were equal to each other, the final average speeds in heavy and light traffic conditions were assumed as

equal to the values in Table 3.7 for respective road type. If this is not the case, the differences between the average speeds in Table 3.7 in normal traffic conditions and the values in Table 3.5 are reflected to the final average speeds for heavy and light traffic conditions (Table 3.9).

Table 3.9 Final accepted average speeds based on ambulance driver experiences and the study of Ankara Metropolitan Municipality Office of Information Systems

Road Types	Average Speed In Heavy Traffic Conditions	Average Speed In Normal Traffic Conditions	Average Speed In Light Traffic Conditions
Highways	70 km/h	80 km/h	90 km/h
State roads	53 km/h	63 km/h	73 km/h
Boulevards	41 km/h	51 km/h	61 km/h
Avenues	35 km/h	45 km/h	55 km/h
Streets	25 km/h	35 km/h	45 km/h

Afterwards, three attribute fields were added to the database of the road network data:

- "Speed_ht" : Average speed in heavy traffic conditions
- "Speed_nt" : Average speed in normal traffic conditions
- "Speed_lt" : Average speed in light traffic conditions

These attribute fields were filled with the values in Table 3.9 by considering the road type and traffic condition as shown in Figure 3.5.

Attributes of Roadcankayatd.shp

Shape	Length	Buffer	Tr_adi	Type	Oneway	Recon	Fjunctio	Tjunction	Speed_ht	Speed_nt	Speed_l
PolyLine	78.66709899902	22	Baålar Caddesi	4	ft	6391	17944	17875	35	45	55
PolyLine	168.27000427246	22	Bülbülderesi Caddesi	4	ft	6377	16874	17062	35	45	55
PolyLine	65.75759887695	10	Hacýyolu Sokak	5	ft	5955	16180	16328	25	35	45
PolyLine	69.00000000000	10	Hacýyolu Sokak	5	ft	5944	16450	16575	25	35	45
PolyLine	44.56679916382	10	Dr.Mediha Erdem Sokak	5	ft	5197	16393	16361	25	35	45
PolyLine	89.50160217285	10	Hacýyolu Sokak	5	ft	5185	17417	17511	25	35	45
PolyLine	24.81060028076	22	6.Cadde	4	ft	2449	10583	10631	35	45	55
PolyLine	47.17890167236	22	6.Cadde	4	ft	2443	10631	10723	35	45	55
PolyLine	39.23979949951	22	6.Cadde	4	ft	2456	10503	10583	35	45	55
PolyLine	222.16200256348	22	John F.Kenedi Caddesi	4	ft	0289	17254	17278	35	45	55
PolyLine	219.62699890137	22	Nenehatun Caddesi	4	ft	0267	17410	17423	35	45	55
PolyLine	170.49299621582	22	John F.Kenedi Caddesi	4	ft	9398	17245	17214	35	45	55

Figure 3.5 The speed fields of "Speed_ht", "Speed_nt" and "Speed_lt" in Roadcankayatd table

3.3.3. The Calculation of the Cost Parameter

The cost factor used in the study is time rather than distance for obvious reasons. The time is a function of distance and speed of the ambulance. Therefore, distance and speed (from previous section) of each line feature are used for calculations.

The transportation network cost values for light, normal and heavy traffic conditions were calculated by using the field calculator of the ArcView 3.3 software in seconds, for traveling from one point to another (Figure 3.6).

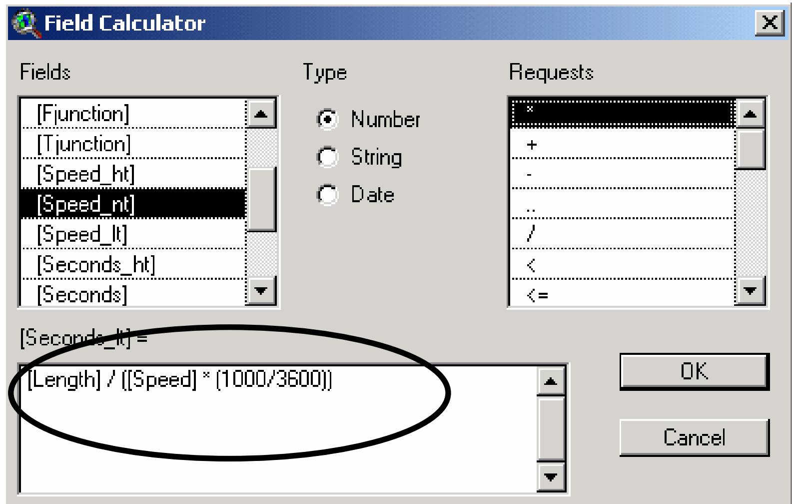


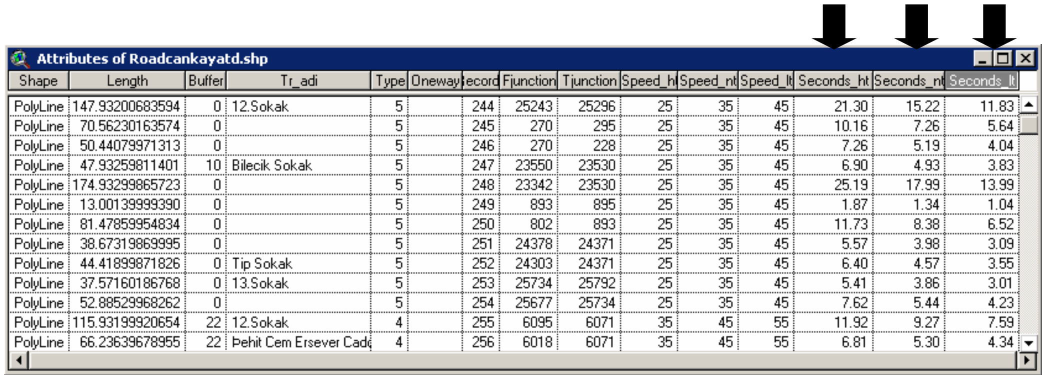
Figure 3.6 The cost values calculation in seconds in ArcView field calculator

The formula "[Length] / ((Speed Value) * 1000/3600)" was used to calculate the cost fields, where [Length] is the length of each network segment in km, "Speed Value" is the average traveling speed in km/h for each network segment and 1000/3600 is used to convert speed values in kilometer per hour (km/h) into meter per seconds (m/s).

Then, three cost fields were added to the database of the road network data to be used in the study:

- "Seconds_ht" : Cost of traveling in heavy traffic
- "Seconds_nt" : Cost of traveling in normal traffic
- "Seconds_lt" : Cost of traveling in light traffic

These cost fields were filled with the above calculated values by considering the road type and traffic condition as shown in Figure 3.7.



Attributes of Roadcankayatd.shp

Shape	Length	Buffer	Tr_adi	Type	Oneway	ecord	Fjunction	Tjunction	Speed_ht	Speed_nt	Speed_lt	Seconds_ht	Seconds_nt	Seconds_lt
PolyLine	147.93200683594	0	12.Sokak	5		244	25243	25296	25	35	45	21.30	15.22	11.83
PolyLine	70.56230163574	0		5		245	270	295	25	35	45	10.16	7.26	5.64
PolyLine	50.44079971313	0		5		246	270	228	25	35	45	7.26	5.19	4.04
PolyLine	47.93259811401	10	Bilecik Sokak	5		247	23550	23530	25	35	45	6.90	4.93	3.83
PolyLine	174.93299865723	0		5		248	23342	23530	25	35	45	25.19	17.99	13.99
PolyLine	13.00139999390	0		5		249	893	895	25	35	45	1.87	1.34	1.04
PolyLine	81.47859954834	0		5		250	802	893	25	35	45	11.73	8.38	6.52
PolyLine	38.67319869995	0		5		251	24378	24371	25	35	45	5.57	3.98	3.09
PolyLine	44.41899871826	0	Tip Sokak	5		252	24303	24371	25	35	45	6.40	4.57	3.55
PolyLine	37.57160186768	0	13.Sokak	5		253	25734	25792	25	35	45	5.41	3.86	3.01
PolyLine	52.88529968262	0		5		254	25677	25734	25	35	45	7.62	5.44	4.23
PolyLine	115.93199920654	22	12.Sokak	4		255	6095	6071	35	45	55	11.92	9.27	7.59
PolyLine	66.23639678955	22	Þehit Cem Ersever Cadd	4		256	6018	6071	35	45	55	6.81	5.30	4.34

Figure 3.7 The second fields of "Seconds_ht", "Seconds_nt" and "Seconds_lt" in Roadcankayatd table

3.3.4. Traffic Condition in Different Time Intervals

The traffic conditions in different time intervals data in Table 3.10 is obtained from interviews with ambulance drivers Özcan Turan, Şaban Özçiçek, KadirIşıktaş, Yaşar Atasever and Sedat Ersun from METU Emergency Service on December 2003 and two anonymous drivers from Demetevler Emergency Service in November2003.

Table 3.10 shows the traffic conditions in different time intervals obtained by interviews with METU Emergency Service ambulance drivers and two anonymous drivers from Demetevler Emergency Service.

Table 3.10 The traffic conditions in different time intervals based on interviews with ambulance drivers

Time Intervals	Traffic Conditions
7:00 - 9:00	Heavy Traffic
9:00 - 12:00	Normal Traffic
12:00 - 14:00	Heavy Traffic
14:00 - 17:00	Normal Traffic
17:00 - 19:00	Heavy Traffic
19:00 - 24:00	Normal Traffic
24:00 - 7:00	Light Traffic

3.3.5. Selection of a Suitable Hospital

A suitable hospital can be selected by the user or the ARSAP directing the emergency patient to the one requiring minimum travel time. The bed, doctor and oxygen tube capacities of some nearby hospitals are stored in the ARSAP database (Table 3.11). When one emergency patient is to be transported to a hospital, the above resources of that hospital are updated and stored as available bed, doctor and oxygen tubes. The available city wide hospital resources that the ARSAP needs have to be kept up-to-date in order for this feature to be useful. At present, this feature is not available; therefore the usage of it in the ARSAP is not functional.

The some nearby hospitals data in Table 3.11 is obtained from interviews with the intern Murat Turfan from Gazi University Hospital, Nursel Çalık from Hacettepe University Hospital, Mustafa Topal from Numune Hospital, Özgür Kemal from İbni Sina Hospital in December 2003 and one anonymous intern from Dr. M. Ülker Emergency Hospital in November2003.

Table 3.11 The bed, doctor and oxygen tube capacities of some nearby hospitals

Hospitals	Number of Beds	Number of Doctors (Day)	Number of Doctors (Night)	Number of Oxygen Tubes
Dr. M. Ülker Emergency Hospital	45	10	6	49
Gazi University Hospital	40	6	6	45
SSK Hospital	35	4	2	38
Hacettepe University Hospital	45	10	4	47
Numune Hospital	12	5	5	13
İbni Sina Hospital	15	4	1	16

3.4. Implementation of the ARSAP

ArcView GIS 3.3, a technologically advanced GIS program, and ArcView Network Analyst extension were used in implementation of the ARSAP. ArcView GIS 3.3 allowed merging information from multiple sources and made it easier to display, organize and analyze plotted data in a map with a technique called spatial representation (Figure 3.8).

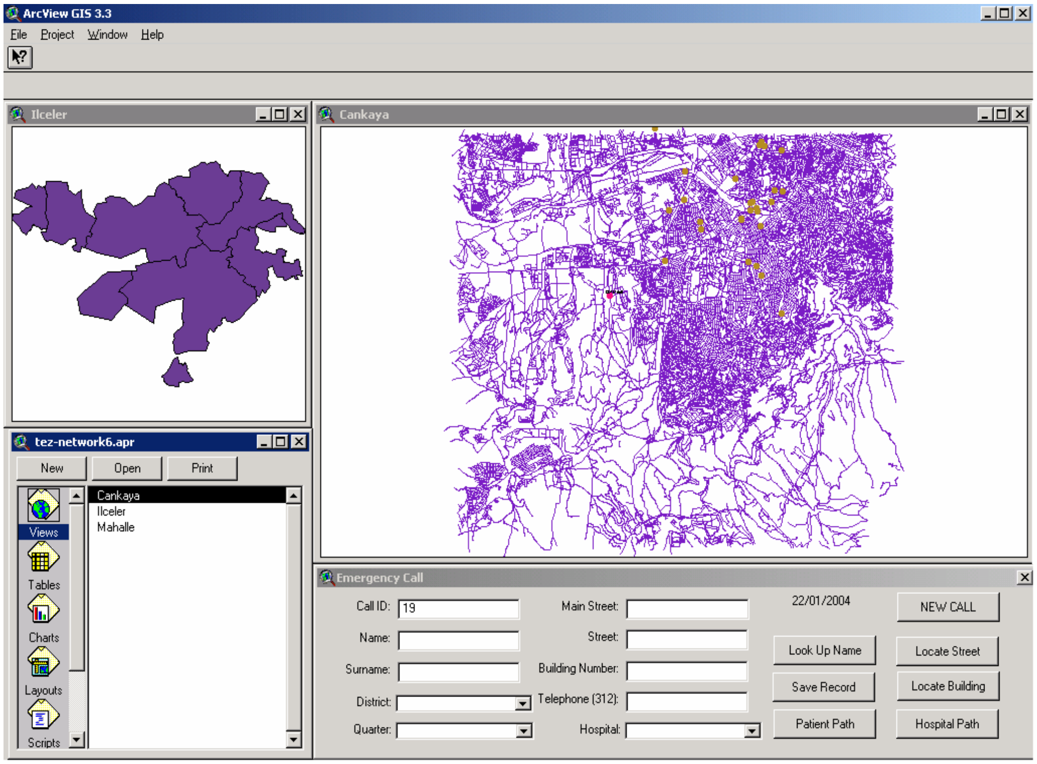


Figure 3.8 A screen shot from the customized ArcView application, the ARSAP

The ArcView Network Analyst extension added additional functionality to ArcView and Avenue (ArcView's robust object oriented scripting environment). It enabled to solve a variety of problems based on geographic networks (e.g., streets, highways, etc.). The complete customized solution including the user interface was built using the power of Avenue and the ArcView Network Analyst.

The ArcView Network Analyst can use any cost field for its calculations: drive time, street length, or any other criteria. This allowed many routing criteria to be defined. Time was used as transportation cost criteria in this thesis, as described in Section 3.3.3.

Network analysis, which is a function of ArcView GIS 3.3, was used to realize the whole situation, and then to find the most suitable hospital for patient.

Ambulance location was assumed as the starting point and emergency call address and suitable hospital were taken as destinations.

In the ARSAP, information about incoming emergency call is stored. Whenever the emergency call information is required to be saved for later uses, one click on “Save Record” button in emergency call dialog box will be enough (Figure 3.9).

Whenever emergency medical technician finishes the work with the last emergency call, “NEW CALL” button in emergency call dialog box can be used. This button allows the emergency medical technicians to renew the application window and a new emergency call is started automatically by a written script (Figure 3.9).

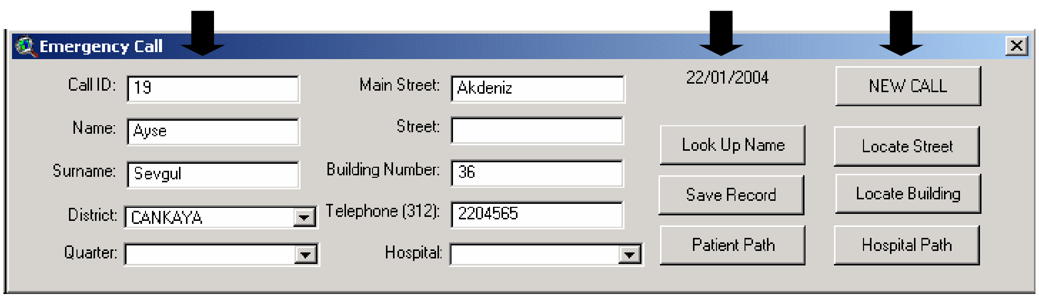


Figure 3.9 Information dialog box about the incoming emergency call

The system allows the emergency medical technician(s) to find address of emergency call by only entering name and surname if previous call information exists in the system. If the automatically retrieved address information is different from the new one, emergency medical technician(s) can correct it using the related line(s). The date and call number of emergency call are generated by the system automatically.

The confirmation is expected for every button click in the dialog box before starting the avenue script to minimize wrong click(s) due to vibration since the ARSAP is intended to be mostly used in emergency medical ambulances while they are on move (Figures 3.10 and 3.11).

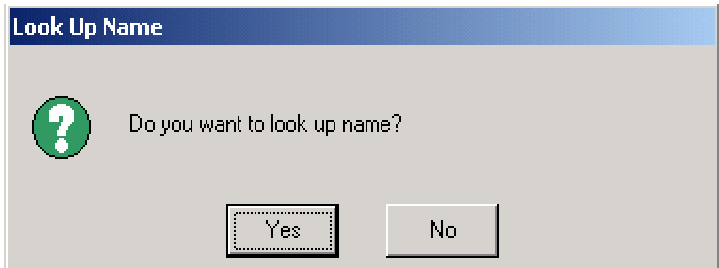


Figure 3.10 Confirmation box to look up emergency patient information from the ARSAP

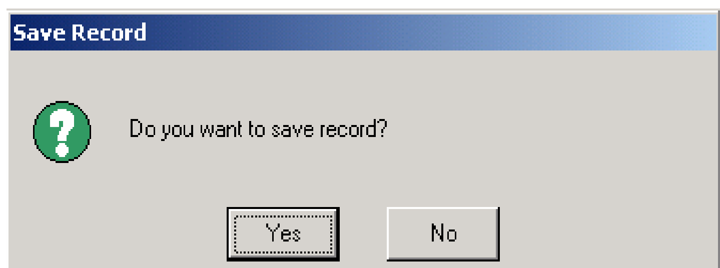


Figure 3.11 Confirmation box to save emergency call information into the ARSAP

The district information of an emergency call is highlighted in a separate view called "districts of Ankara". This property is added to the ARSAP with the aim of allowing the system to be used for city wide applications (Figure 3.12).

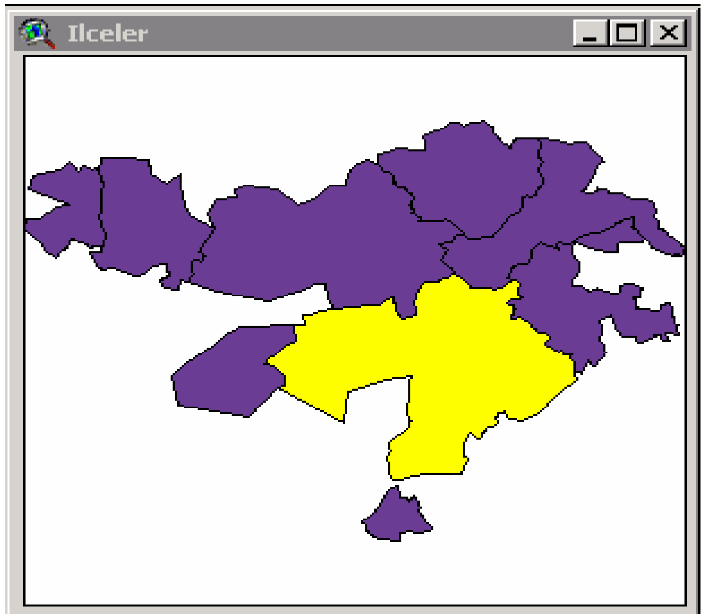


Figure 3.12 The district view of Ankara

Emergency medical technician(s) can locate the street/main street of an emergency call with respect to the position of METU Emergency Service by using the “Locate Street” option of the dialog box in the ARSAP (Figure 3.13).

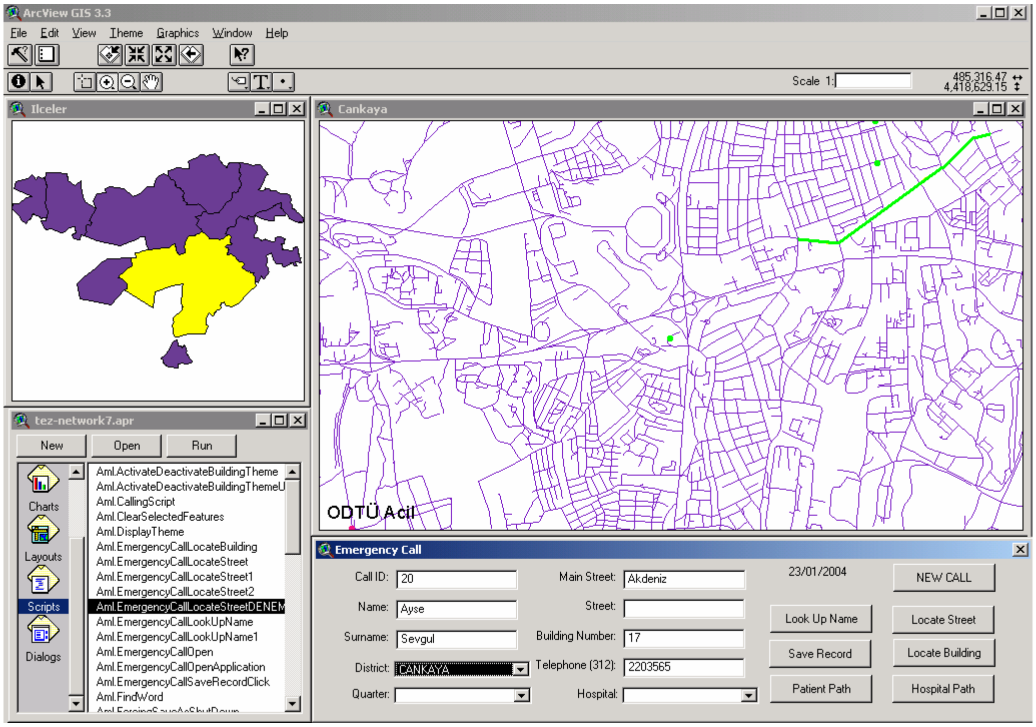


Figure 3.13 The location of the main street of an emergency call with respect to the position of METU Emergency Service

The building of an emergency call is highlighted using the “Locate Building” dialog box button. This feature intends to assist emergency medical technician(s) to locate the incident spot along the street/main street in zoomed view (Figure 3.14).

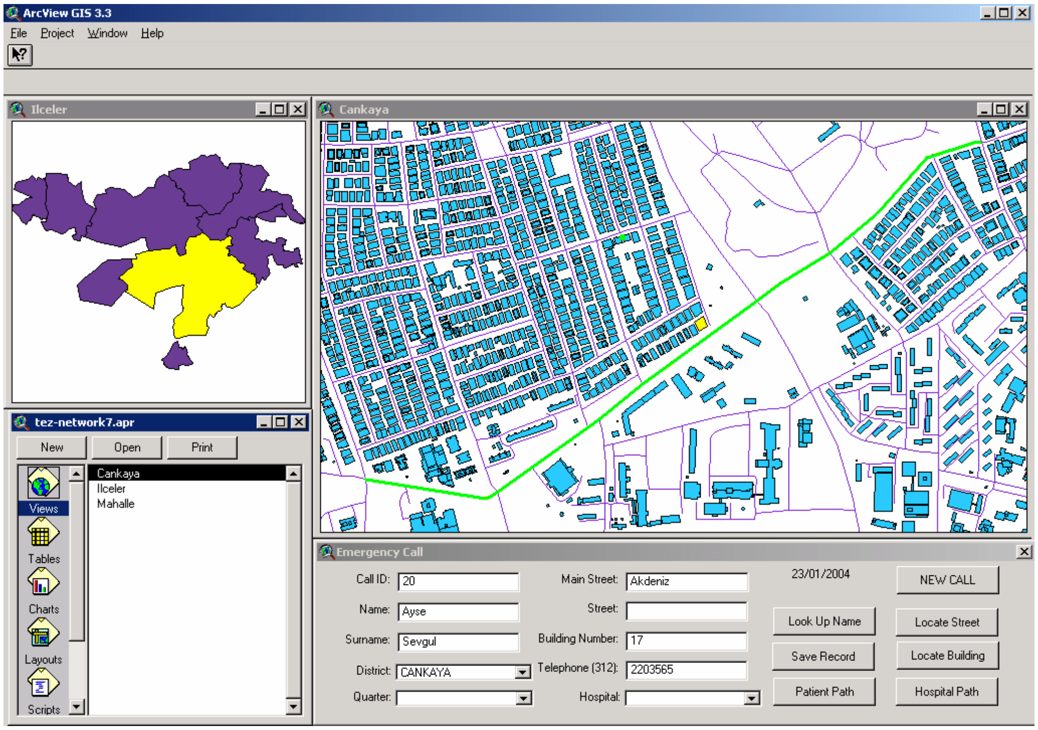


Figure 3.14 The highlighted location of the building of an emergency call

The minimum time cost of the calculated transportation path from the ambulance location to the emergency call location and from the call location to the suitable medical care facility is estimated by the system. Figure 3.15 shows the estimated minimum time cost of the transportation path from the emergency call location to the suitable hospital.

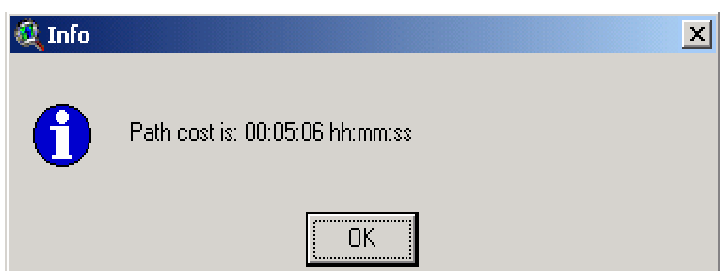


Figure 3.15 The information box for time cost of the path from the emergency call location to the suitable hospital

The ARSAP can also display the route requiring minimum travel time from the ambulance location to the emergency call location and from the call location to either the minimum travel time hospital or to another one chosen by the user (Figures 3.16 and 3.17).

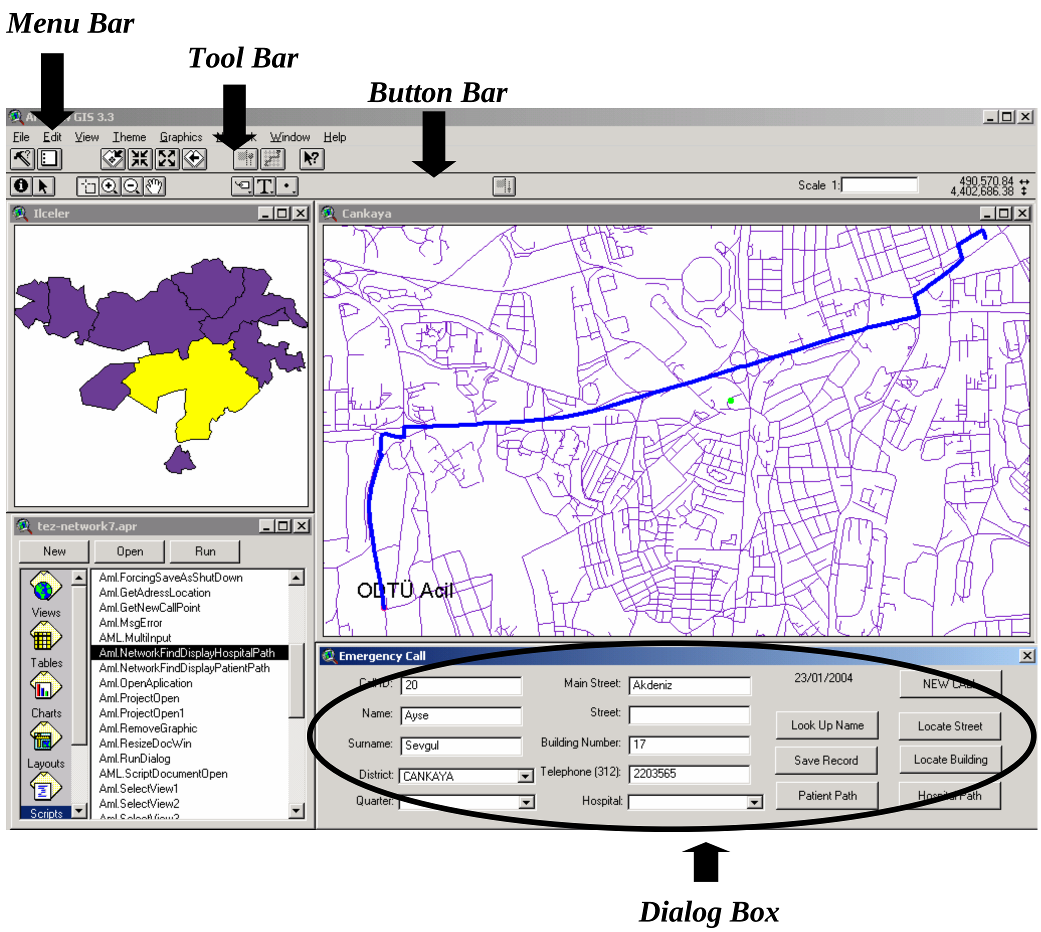


Figure 3.16 The path which has minimum travel time from the ambulance location to the emergency call position

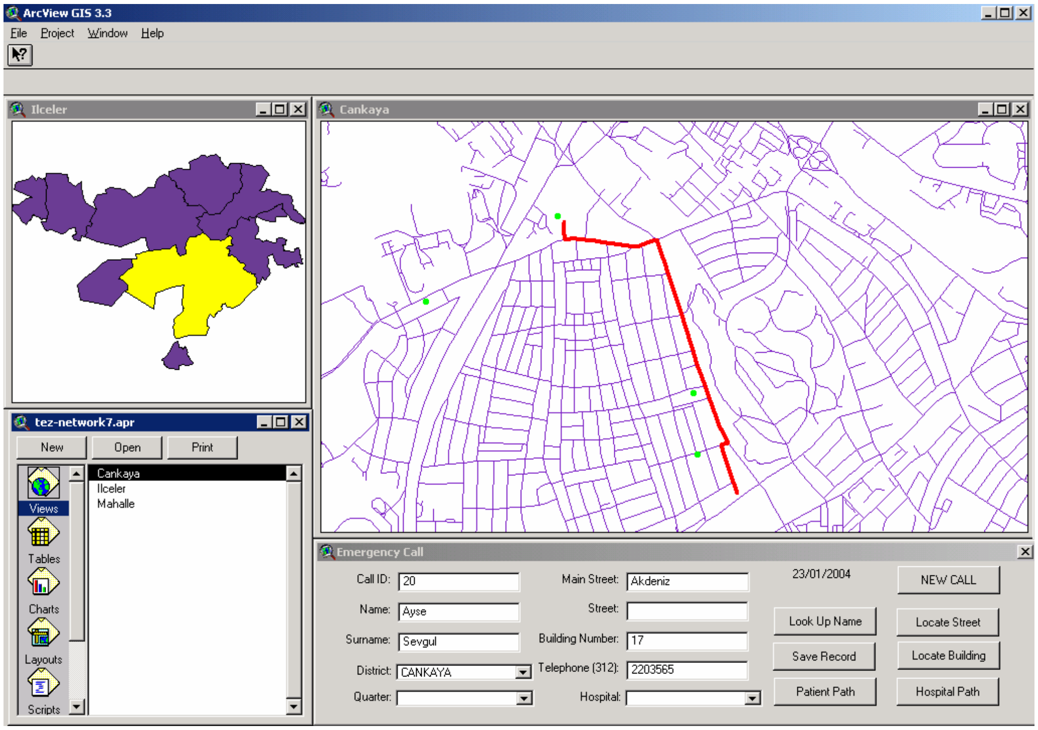


Figure 3.17 The path which has minimum travel time from the emergency call position to a hospital emergency service

3.5. Customizing ArcView for the ARSAP Application

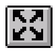
The ARSAP, graphical user interface (GUI) consists of windows that present information in different way: pull down menus (the menu bar), buttons (the button bar), and tools (the toolbar) and dialog box (Figure 3.16). They allow viewing data and performing analytical data operations in the database [36]. Each document type has its own set of menus, buttons, and tools. When user switches between document types, the ARSAP GUI accordingly changes [3].

The ARSAP has been customized in order to have only related functions in buttons and tools of GUI. Others that exist in ArcView GIS 3.3 are available in the main menu if desired. The ARSAP GUI tools and buttons used are the followings:

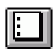
 *Query Builder:* Searches the table associated with the active theme

 *Zoom to selected feature:* Zooms to the extent of the selected feature

 *Zoom in:* Zooms in with respect to the center of the view

 *Zoom out:* Zooms out with respect to the center of the view

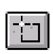
 *Zoom previous:* Zooms to the previous view

 *Clear selected features:* Deselects any features that are selected in an active theme

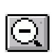
 *Help:* Provides information about a button or feature that it is clicked on

 *Info:* Displays the attribute features from an active theme for an area that is clicked on

 *Pointer:* Used to select, move and resize features

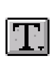
 *Select by feature:* Drag the mouse to create a box in which all features in the active theme are selected

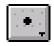
 *Zoom in:* Zooms in centered on cursor (can also be used to drag a box to zoom in)

 *Zoom out:* Zooms out centered on cursor (can also be used to drag a box to zoom out)

 *Drag and drop view:* Grabs the view and shifts it around

 *Tag:* Adds a label to a feature that is clicked on

 *Text:* Add text to a view of the active theme

 *Draw and Edit tools:* Add points, lines and polygon features

3.5.1. Developing Avenue Scripts

The program for this application and customization of the package has been written in Avenue programming language. Avenue is a robust object-oriented and scripting language for ArcView GIS [19]. The source code has been divided into a number of scripts, where each script is used to automate complex or repetitive tasks, to add new capabilities to ArcView and to create entire application. The flow chart of the application can be seen in the following figure (Figure 3.18). See Appendix C for details.

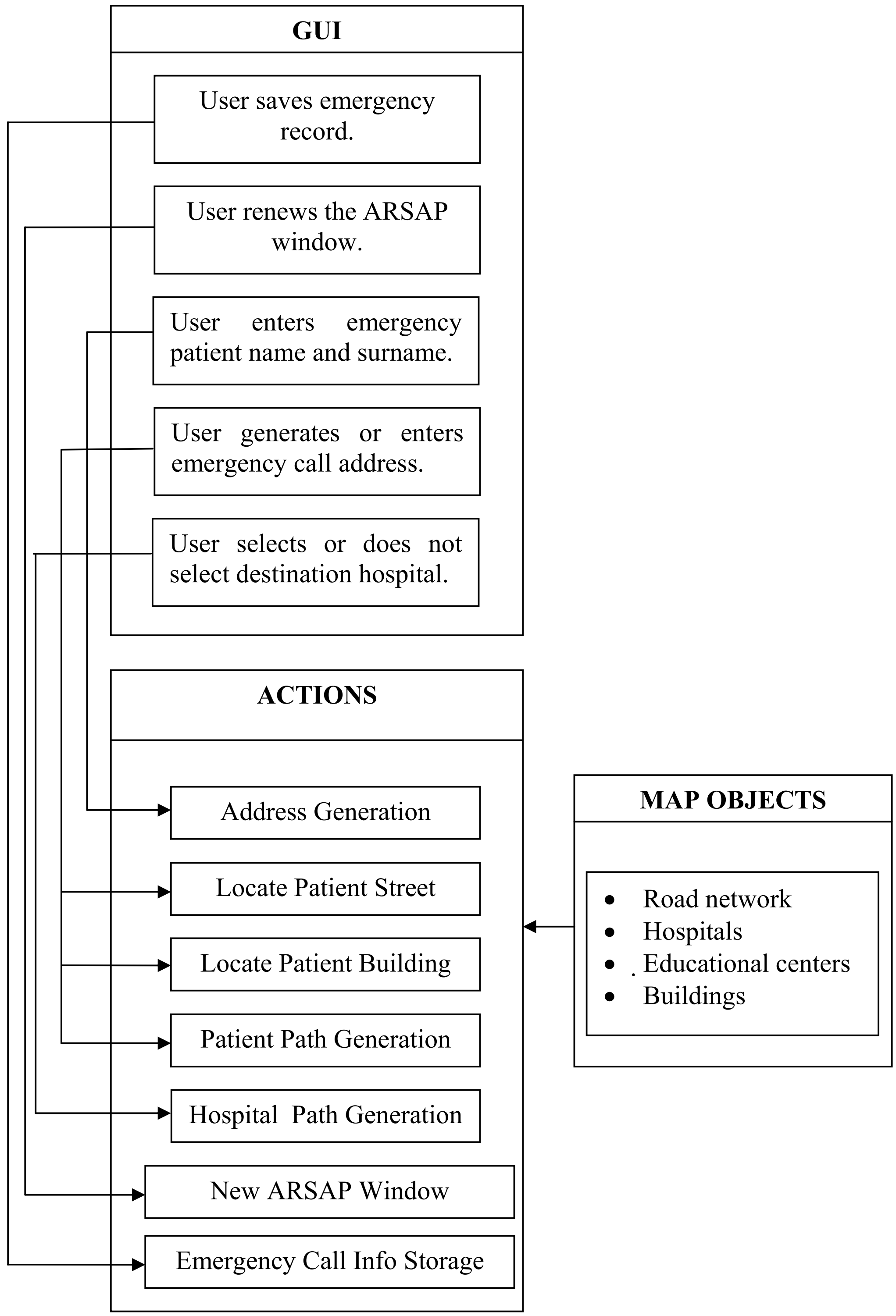


Figure 3.18 Flow chart of the application mechanism

CHAPTER 4

4. PATH ANALYSIS

In this chapter, the results generated using the ARSAP are validated and analyzed by comparing with currently practiced emergency call paths data collected with the help of METU Emergency Service ambulance drivers.

4.1. General Information about the Currently Practiced Emergency Call Paths

Since the METU Emergency Service is near the student dormitories and academic personnel residents, in most cases, emergency patient transports are mainly from METU Emergency Service to a hospital emergency department. In very few situations, the ambulance goes to emergency call positions elsewhere (e.g. Department of Educational Sciences or Bilkent road), and takes the emergency patient to a suitable hospital.

The nearest hospital to the METU campus area is the Dr. M. Ülker Emergency Hospital (Traffic Hospital). Therefore, most of emergency patients are transported to this hospital. In some cases, patients prefer to go to another hospital due to their social security type or other reasons.

4.2. Generation of Emergency Call Paths by Using the ARSAP

The ARSAP emergency call routes are generated by using routing techniques, time cost parameter and other spatial constraints [3]. The ARSAP uses Network Analyst Extension that covers finding shortest paths dependent on traffic flow [37].

4.3. Examination of Currently Practiced and ARSAP Generated Paths

Each emergency call path is generated using time cost parameter. Examination of currently practiced and the ARSAP generated emergency paths from the METU Emergency Service to some hospitals nearby are described below starting with Dr. M. Ülker Emergency Hospital.

Dr. M. Ülker Emergency Hospital

The currently practiced emergency path from the METU Emergency service to the Dr. M. Ülker Emergency Hospital is shown in the next figure. In this path, METU road, Eskişehir State road and Konya State road are traveled (Figure 4.1).

The usage of the state roads is good for the following reason: The ambulance speeds up to 70 km/hr or more in some sections of the state roads, hence there is a certain time saving in using the Eskişehir State road and Konya State road.

Average speed of the ambulance changes between 50 and 70 km/hr on state roads. Approximately 5 km are traveled in 5 minutes in normal traffic condition to reach the Dr. M. Ülker Emergency Hospital.

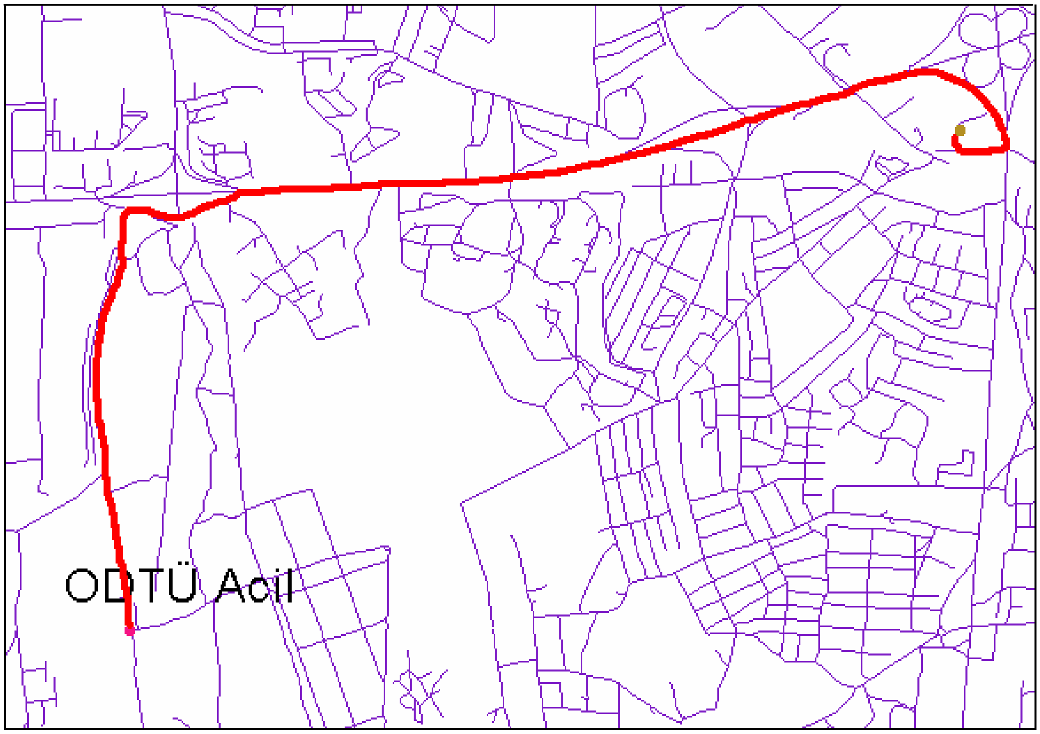


Figure 4.1 The currently practiced emergency path from the METU Emergency service to the Dr. M. Ülker Emergency Hospital

The ARSAP generated path is almost the same as the currently practiced route as shown in Figure 4.2. The time values for each case are also similar (Tables 4.1 and 4.2); since they are based on the same route and average speed of ambulances on each road segment are similar to our average speed data of each road segment.

Table 4.1 The distance and time values from METU Emergency Service to the destinations based on reports of the ambulance drivers

Destinations	Distance from METU Emergency Service to the destination (km)	Time from METU Emergency Service to the destination (min)	Traffic Condition
Dr. M. Ülker Emergency Hospital	5	5	Normal
Gazi University Hospital	7	6	Light
Gazi University Hospital	7	7	Normal
Gazi University Hospital	7	9	Heavy
SSK Hospital	12	13	Normal
Hacettepe University Hospital	12	13	Normal
Hacettepe University Hospital	12	15	Heavy
Numune Hospital	12	12	Normal
İbni Sina Hospital	11	12	Normal
Bişkek Avenue /36	6	6	Normal
Akdeniz Avenue /58	8	8	Normal

Table 4.2 The distance and time from METU Emergency Service to the destinations based on the ARSAP

Destinations	Distance from METU Emergency Service to the destination (km)	Time from METU Emergency Service to the destination (min)	Traffic Condition
Dr. M. Ülker Emergency Hospital	5,21	5,11	Normal
Gazi University Hospital	7,25	6,18	Light
Gazi University Hospital	7,25	7,14	Normal
Gazi University Hospital	7,25	9,09	Heavy
SSK Hospital	11,42	12,06	Normal
Hacettepe University Hospital	10,21	11,10	Normal
Hacettepe University Hospital	10,21	14,07	Heavy
Numune Hospital	11,12	11,14	Normal
İbni Sina Hospital	10,19	10,90	Normal
Bişkek Avenue /36	6,21	6,12	Normal
Akdeniz Avenue /58	7,6	7,50	Normal

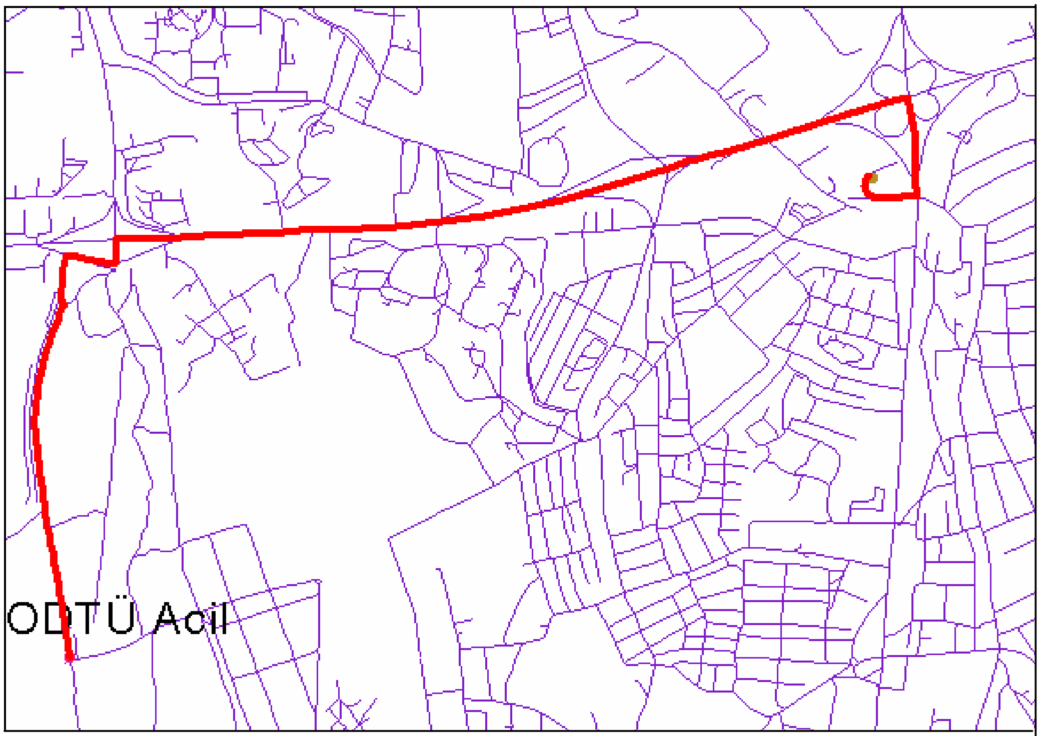


Figure 4.2 The emergency path generated by the ARSAP, from METU Emergency Service to the Dr. M. Ülker Emergency Hospital

By using the ARSAP application, 5.21 km are traveled in 5.11 minutes in normal traffic condition to reach the Dr. M. Ülker Emergency Hospital.

Gazi University Hospital

The currently practiced emergency path from the METU Emergency service to the Gazi University Hospital is shown in the next figure. In this path, METU road, Eskişehir State road and Samsun State road are traveled (Figure 4.3).

There is a certain time saving in using the Eskişehir State road and Samsun State road. Approximately 7 km are traveled in 6, 7 and 9 minutes in light, normal and heavy traffic conditions to reach Gazi University Hospital, respectively (Table 4.1).

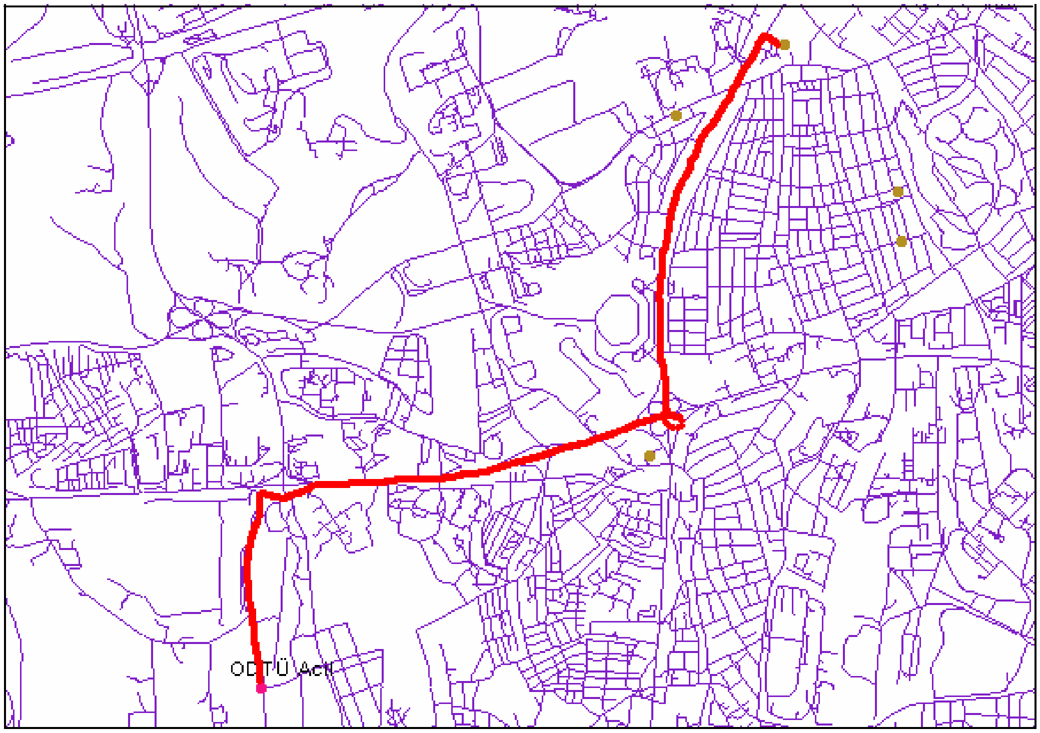


Figure 4.3 The currently practiced emergency path from METU Emergency service to the Gazi University Hospital

The ARSAP generated path is very similar to the currently practiced route. In the ARSAP generated path, METU road, Eskişehir State road, Samsun State road and B. Üçok Avenue are passed through. The ARSAP selects to enter to the hospital from the back entrance (Figure 4.4). The travel time values of the ARSAP generated route and currently practiced route are similar (Tables 4.1 and 4.2).

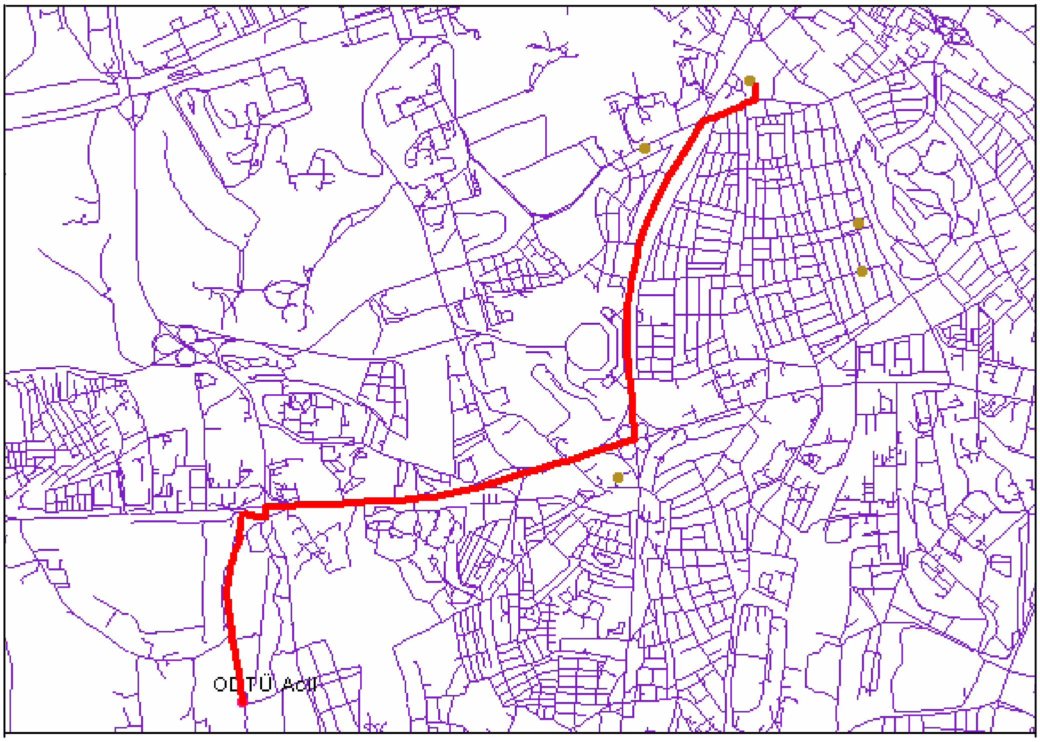


Figure 4.4 The emergency path generated by the ARSAP, from METU Emergency Service to the Gazi University Hospital

The generated path like the currently practiced path selects the usage of the state roads. By using the ARSAP application, 7.25 km are traveled in 6.18, 7.14 and 9.09 minutes in light, normal and heavy traffic condition to reach Gazi University Hospital, respectively (Table 4.2).

SSK Hospital

The currently practiced emergency path from the METU Emergency service to the SSK Hospital is shown in the next figure. In this path, METU road, Eskişehir State road, Samsun State road, T.Özal Boulevard, Etlik Avenue and İ.Başbuğ Avenue are passed through (Figure 4.5). Approximately 12 km are traveled in 13 minutes in normal traffic condition to reach the SSK Hospital (Table 4.1).

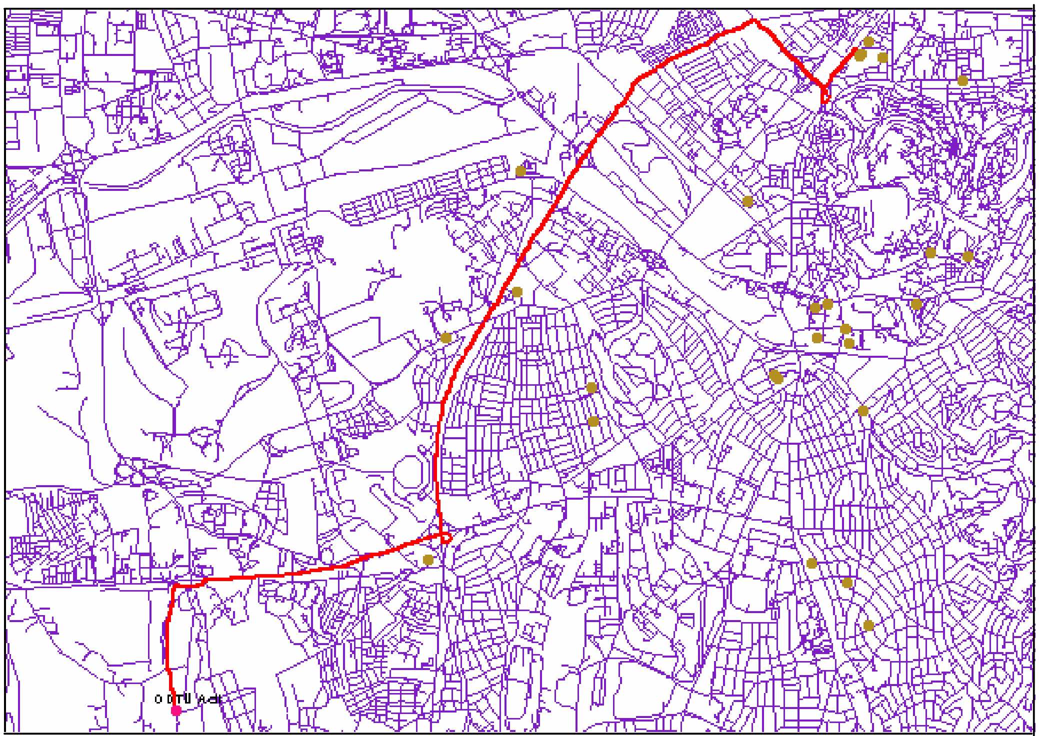


Figure 4.5 The currently practiced emergency path from METU Emergency service to the SSK Hospital

The ARSAP goes to the hospital by using the path that is alternative to the currently practiced path. In the ARSAP generated path, METU road, Eskişehir State road, Samsun State road, B. Üçok Avenue, B. Evler Avenue, Kazım Karabekir Avenue, Etlik Avenue and İ.Başbuğ Avenue are traveled to reach the SSK Hospital (Figure 4.6).

The travel time value of the ARSAP generated route is almost 1 minute less than the value of currently practiced route (Tables 4.1 and 4.2), which is a more direct route.

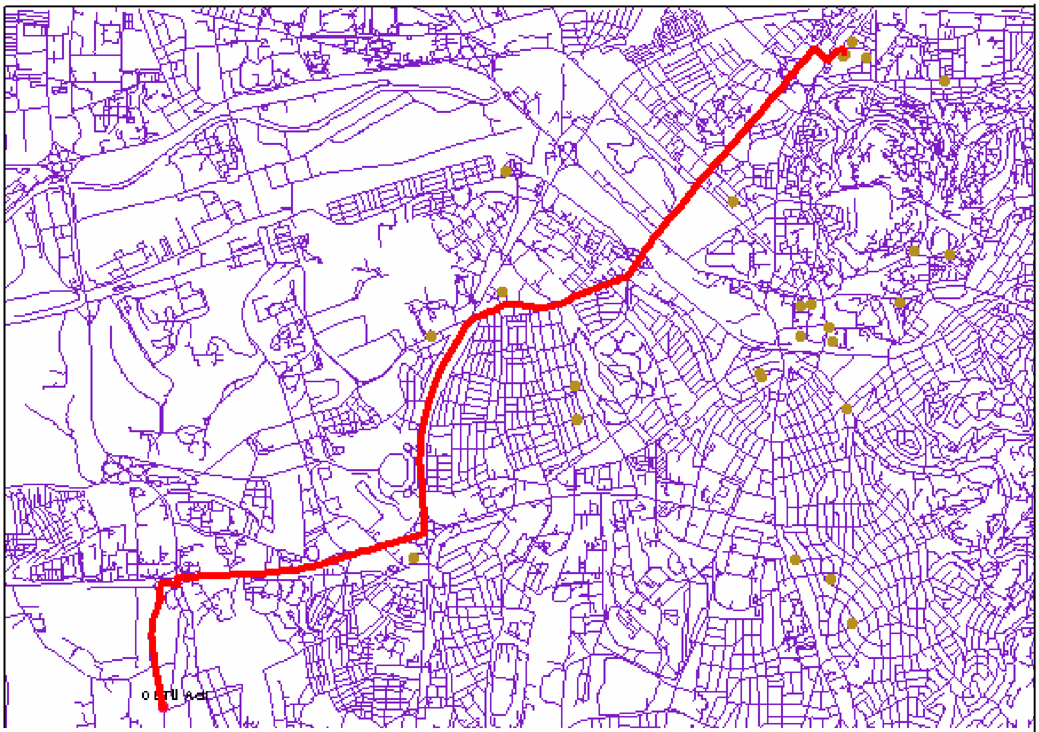


Figure 4.6 The emergency path generated by the ARSAP, from METU Emergency Service to the SSK Hospital

The generated path selects the avenues after the middle of the path. There is a certain time saving in using the Eskişehir State road and Samsun State road. The ambulances can speed up to 55 km/hr or more in some sections of the avenues. Average speed of the ambulance changes between 35 and 55 km/hr on avenues. By using the ARSAP application 11.42 km are traveled in 12.06 minutes in normal traffic condition to reach SSK Hospital (Table 4.2).

The ARSAP states that the alternative route is the best path. It is true except that B. Üçok Avenue, B. Evler Avenue and Kazım Karabekir Avenue have high parking intensity, most of the time. The parking is not allowed along those avenues, but due to the stores and shops on the roads, the trucks and other vehicles are parking along. The number of red lights is also more than the ones on the state roads. Those factors obviously affect the travel time as the ambulance has to continue with a low speed. These observations made above reveals the fact that speed data in our hand is not sufficiently accurate for high parking intensity and high traffic light intensity roads. A more detailed speed data and its representation in the database are necessary.

Hacettepe University Hospital

The currently practiced emergency path from METU Emergency Service to the Hacettepe University Hospital is shown in the next figure. In this path, METU road, Eskişehir State road, Samsun State road, T.Özal Boulevard, Celal Bayar Boulevard and A.A. Saygun Avenue are passed through (Figure 4.7). Approximately 12 km are traveled in 13 and 15 minutes in normal and heavy traffic conditions, respectively (Table 4.1).

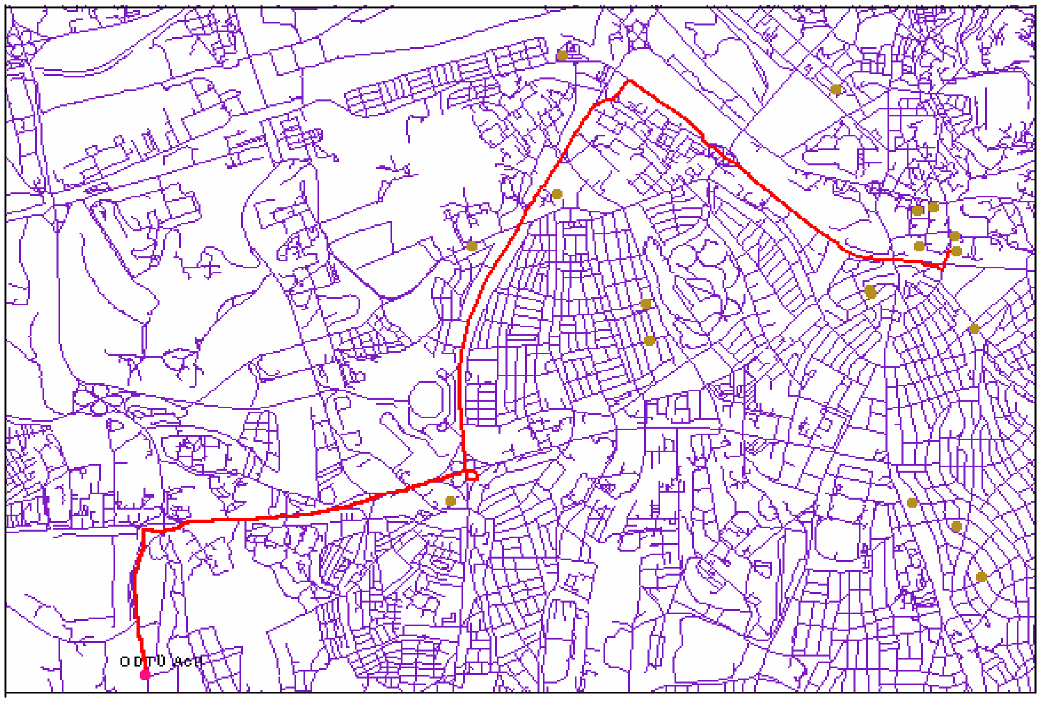


Figure 4.7 The currently practiced emergency path from METU Emergency service to the Hacettepe University Hospital

The generated path is different from the currently practiced route. In the ARSAP generated path, METU road, Eskişehir State road, İsmet İnönü Boulevard, Akdeniz Avenue, Gençlik Avenue, 2. Avenue, Strazburg Avenue, Celal Bayar Boulevard and A.A. Saygun Avenue are traveled (Figure 4.8).

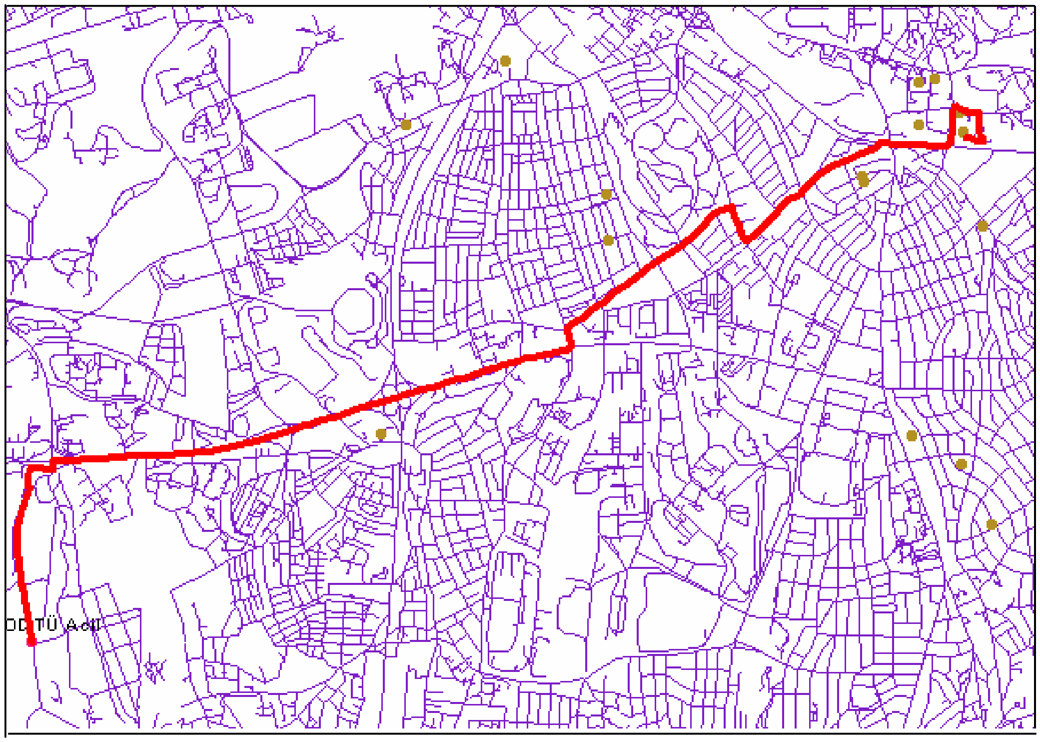


Figure 4.8 The emergency path generated by the ARSAP, from METU Emergency Service to the Hacettepe University Hospital

The ARSAP generated route passes through more avenues than the currently practiced route. The travel time value of the ARSAP generated route is almost 2 minute less then the value of currently practiced route (Tables 4.1 and 4.2), which is a more direct path to reach the hospital.

The generated path selects the avenues and boulevards after the middle of the path. There is a certain time saving in using the Eskişehir State road. Average speed of the ambulance changes between 41 and 61 km/hr on boulevards. By using the ARSAP application 10.21 km are traveled in 11.10 and 14.07 minutes in normal and heavy traffic conditions to reach Hacettepe University Hospital, respectively (Table 4.2).

Numune Hospital

The currently practiced emergency path from the METU Emergency Service to the Numune Hospital is shown in the next figure. In this path, METU road, Eskişehir State road, Samsun State road, T.Özal Boulevard, Hipodrom Avenue are passed through (Figure 4.9). Approximately 12 km are traveled in 12 minutes in normal traffic condition to reach Numune Hospital (Table 4.1).

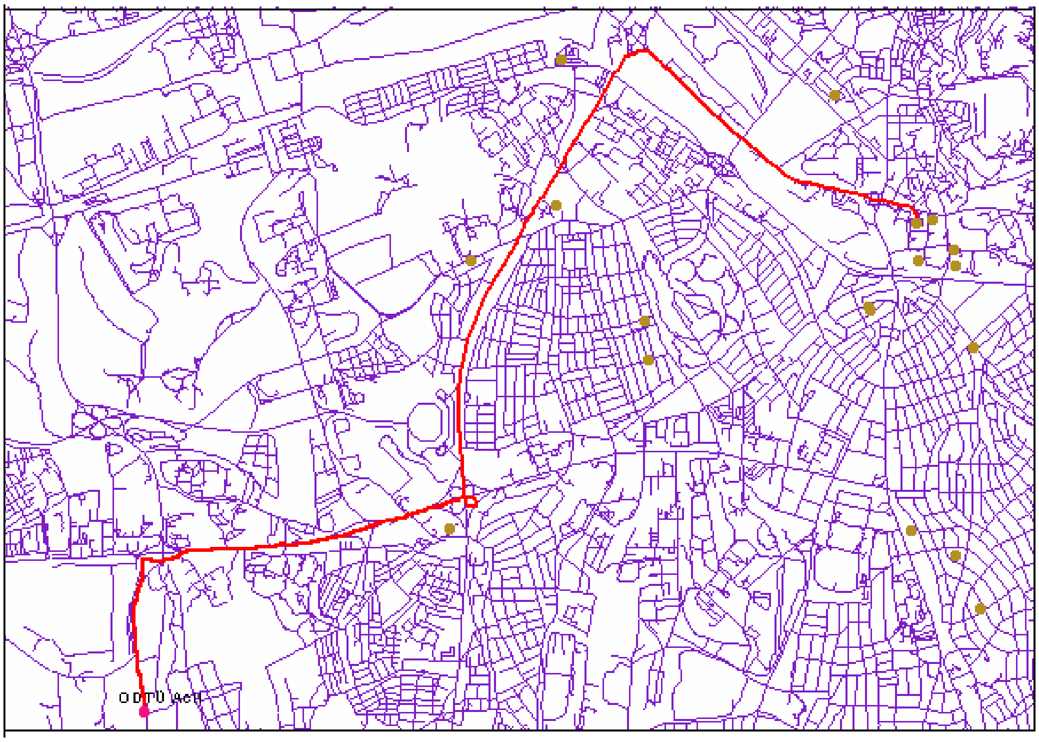


Figure 4.9 The currently practiced emergency path from METU Emergency service to the Numune Hospital

The ARSAP generated path is alternative to the currently practiced route. In the ARSAP generated path, METU road, Eskişehir State road, Samsun State road, B. Üçok Avenue, B. Evler Avenue and Hipodrom Avenue are traveled to reach the Numune Hospital (Figure 4.10).

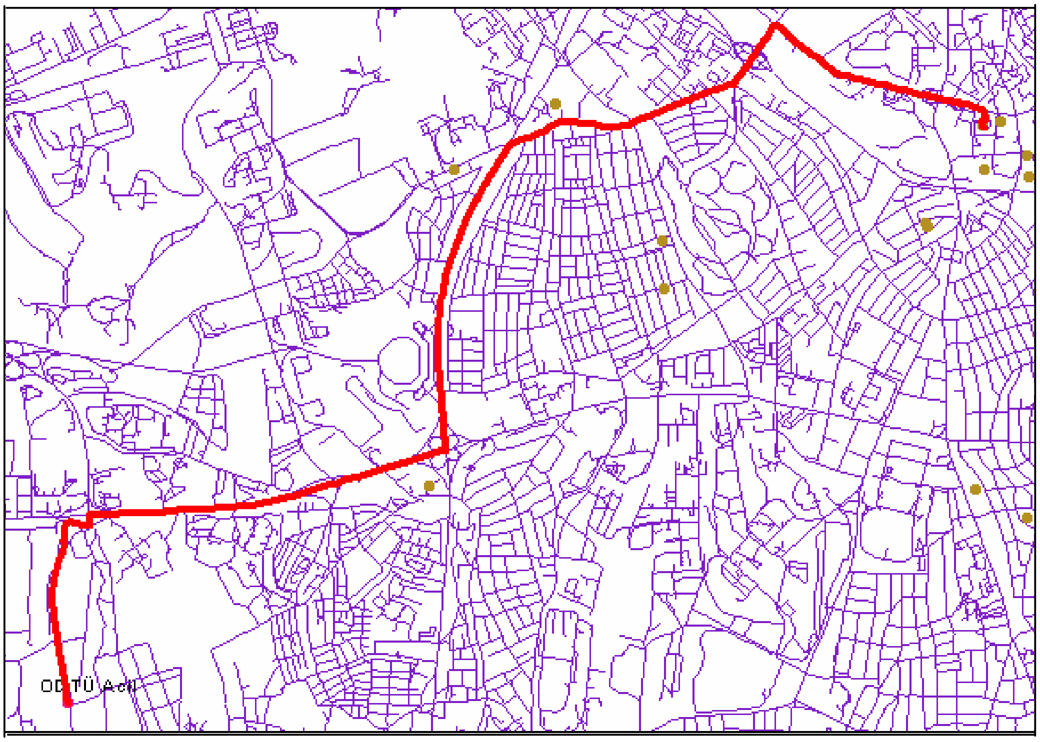


Figure 4.10 The emergency path generated by the ARSAP, from METU Emergency Service to the Numune Hospital

The ARSAP uses the path that is alternative to the original path. The travel time value of the ARSAP generated route is almost 1 minute less than the value of currently practiced route (Tables 4.1 and 4.2), and the first route follows a more direct route.

The ARSAP states that the alternative route to the hospital is the best path. The generated path selects the avenues for small part of the path. The rest of the path is the same as the originally practiced one. There is a certain time saving in using the Eskişehir State road and Samsun State road. By using the ARSAP application, 11.12 km are traveled in 11.14 minutes in normal traffic condition to reach Numune Hospital (Table 4.2).

İbni Sina Hospital

The currently practiced emergency path from the METU Emergency Service to the İbni Sina Hospital is shown in the next figure. In this path, METU road, Eskişehir State road, Samsun State road, T.Özal Boulevard and Hipodrom Avenue are passed through (Figure 4.11). Approximately 12 km are traveled in 12 minutes in normal traffic condition to reach the hospital (Table 4.1).

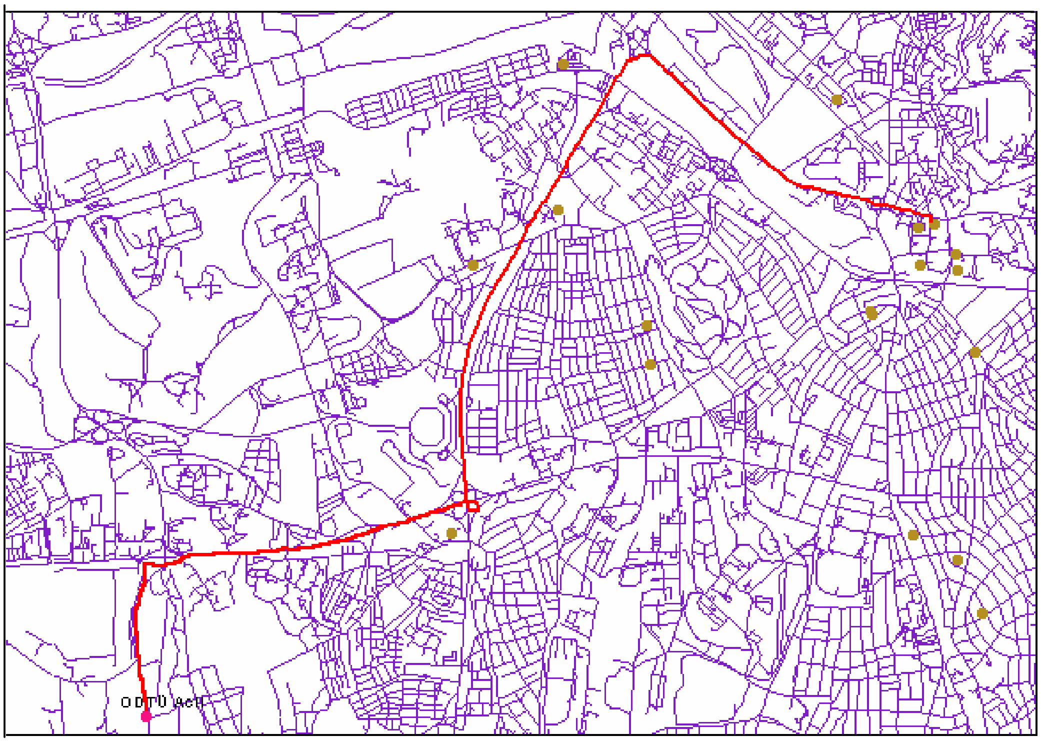


Figure 4.11 The currently practiced emergency path from METU Emergency service to the İbni Sina Hospital

The ARSAP generated path is different from the currently practiced route. In the ARSAP generated path, METU road, Eskişehir State road, İsmet İnönü Boulevard, Akdeniz Avenue, Gençlik Avenue, 2. Avenue, Strazburg Avenue and Atatürk Boulevard are traveled to reach the İbni Sina Hospital Emergency Service (Figure 4.12).

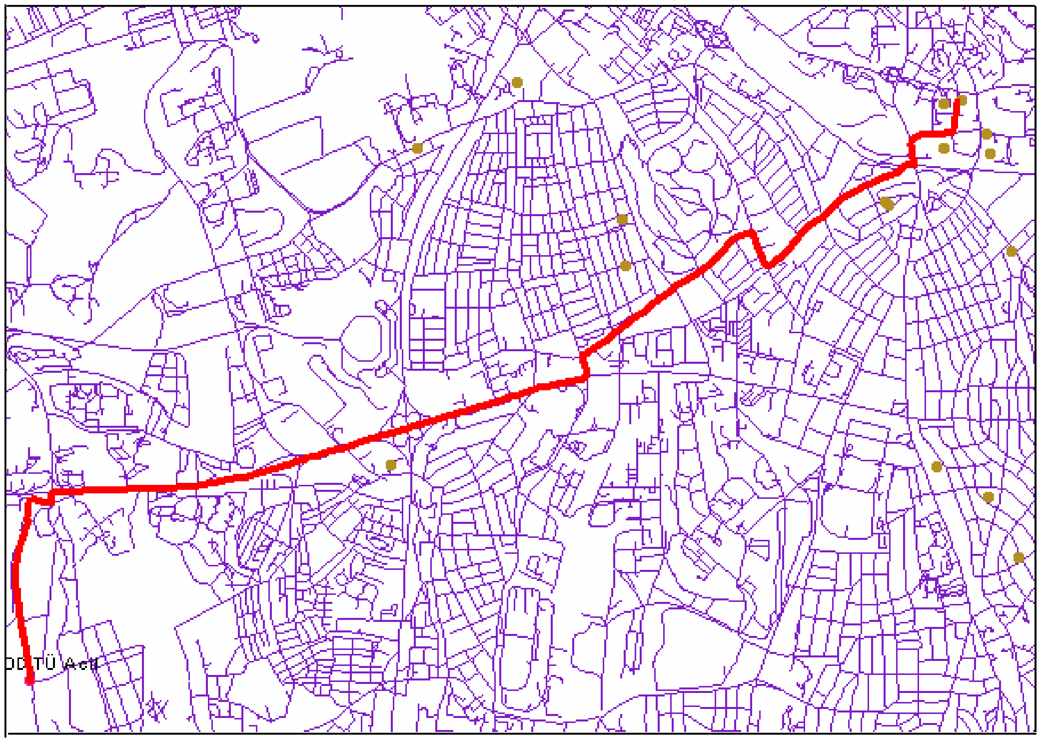


Figure 4.12 The emergency path generated by the ARSAP, from METU Emergency Service to the İbni Sina Hospital

The ARSAP generated path selects more avenues and boulevards than the currently practiced one. The travel time value of the ARSAP generated route is almost 1 minute less than the value of currently practiced route (Tables 4.1 and 4.2), and the first route uses more direct path to reach the hospital.

The generated path selects the avenues and boulevards after the middle of the path. There is a certain time saving in using the Eskişehir State road and boulevards. By using the ARSAP application, 10.19 km are passed in 10.9 minutes in normal traffic condition to reach İbni Sina Hospital (Table 4.2).

4.3.1. Examination of Two Emergency Call Cases

Examination of two currently practiced and the ARSAP generated emergency call paths from the METU Emergency Service to the emergency call addresses and then to the suitable hospitals are described below.

An Emergency Patient at Bişkek Avenue

The practiced path from the METU Emergency Service to the Bişkek Avenue No:36, which is the address of emergency call, is shown in the next figure. In this path, METU road, Eskişehir State road, Samsun State road, Bosna Hersek Avenue and Bişkek Avenue were traveled. Both the practiced route and the ARSAP generated route followed the same path. (Figure 4.13) The time values for each case were also similar (Tables 4.1 and 4.2).

There was a certain time saving in using the Eskişehir State road and Samsun State road. The practiced path was approximately 6 km (6 minutes) in normal traffic condition. The ARSAP generated path was 6.21 km (6.12 minutes) in normal traffic condition to reach the emergency patient (Tables 4.1 and Table 4.2).

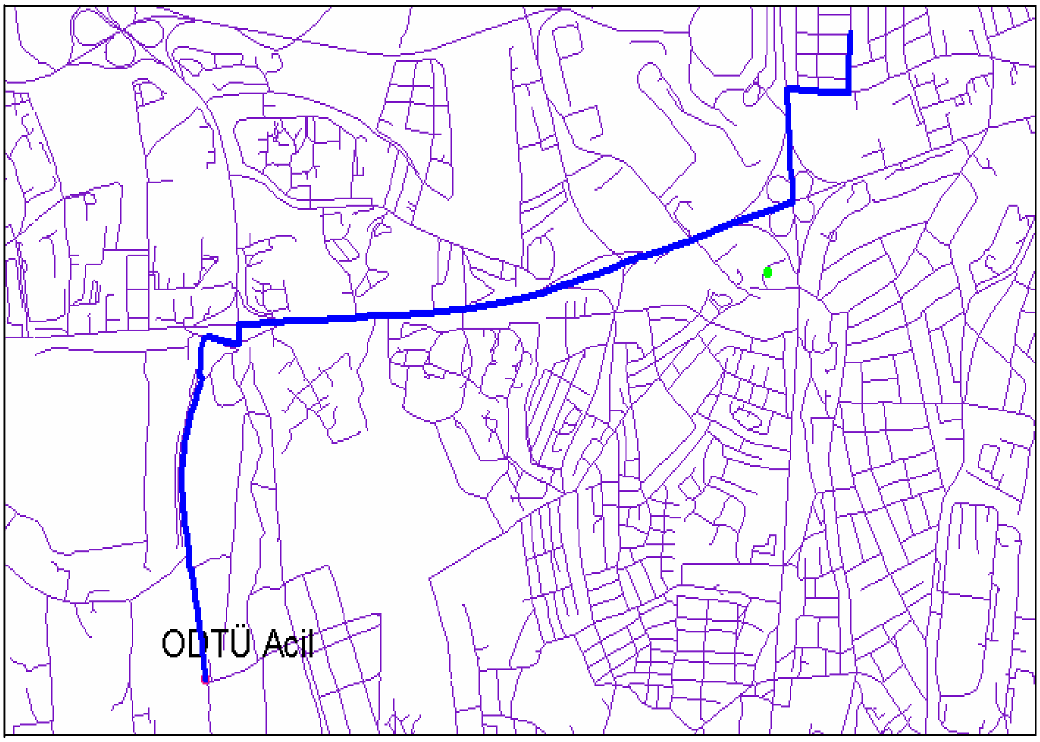


Figure 4.13 The emergency call path from the METU Emergency service to an emergency patient at Bişkek Avenue

The emergency patient was then transported to hospital specified by the ARSAP user, which was SSK Hospital, even though, the nearest hospital was Gazi University Hospital. The path was Bişkek Avenue, T.Özal Boulevard, Etlik Avenue, and İ.Başbuğ Avenue. The path after Bişkek Avenue can be seen at the Figure 4.5. The ARSAP gave a different path: Bişkek Avenue, B. Üçok Avenue, B. Evler Avenue, Kazım Karabekir Avenue, Etlik Avenue and İ.Başbuğ Avenue (Figure 4.14).

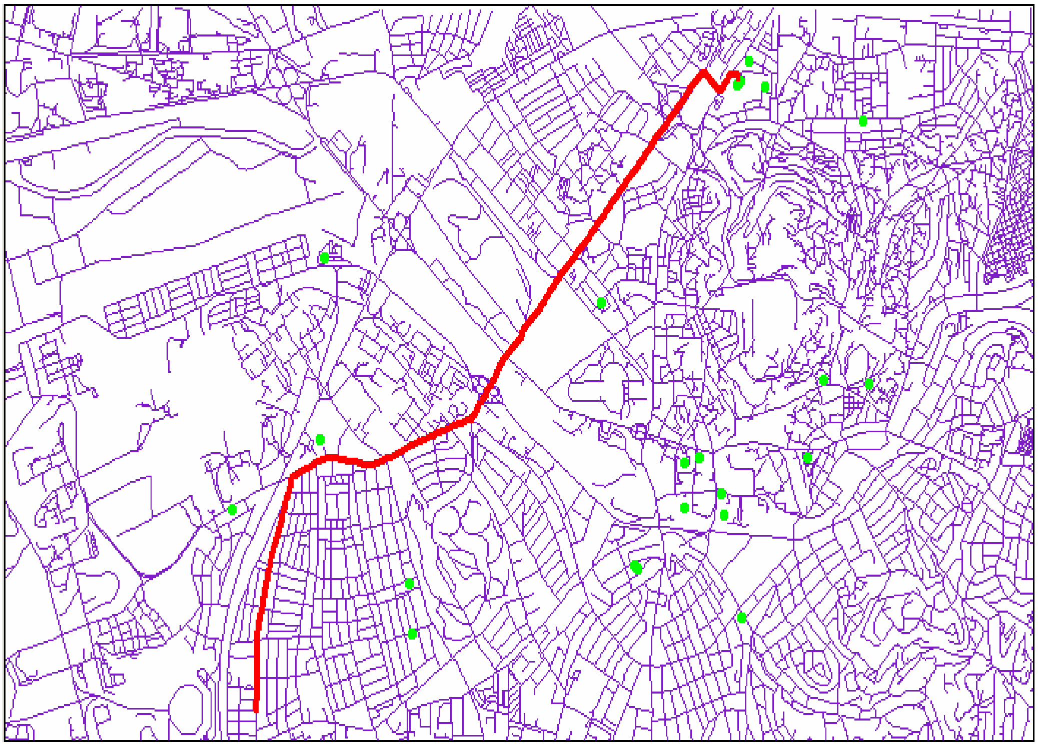


Figure 4.14 The emergency call path, from an emergency patient at Bişkek Avenue to SSK Hospital by the ARSAP

The ARSAP states that the direct route to the hospital is the best path for this case. It is true except that B. Üçok Avenue, B. Evler Avenue and Kazım Karabekir Avenue have high parking intensity, most of the time. The parking is not allowed along those avenues but due to the stores on the roads, the trucks and other vehicles are parking along. The number of red lights is also more than the state roads. Those factors obviously affect the time consumption while reaching to the hospital emergency service as the ambulance has to continue with a low speed. This observation again reveals the fact that speed data in our hand is not sufficiently accurate for high parking intensity and high traffic light intensity roads. A more detailed speed data and its representation in the database are necessary.

The practiced path traveled approximately 8 km in 8 minutes in normal traffic condition. The ARSAP generated path passed through 6.75 km in 7.45 minutes in normal traffic condition to reach the emergency department of SSK Hospital. The travel time of the ARSAP generated route was almost 1/2 minute less than the value of practiced route (Tables 4.1 and 4.2), and the first route followed a more direct route.

An Emergency Patient at Akdeniz Avenue

The practiced path from the METU Emergency Service to the Akdeniz Avenue No: 58, which is the address of emergency call, is shown in the next figure. In this path, METU road, Eskişehir State road, İsmet İnönü Boulevard and Akdeniz Avenue were traveled. Both the practiced route and the ARSAP generated route followed the same path (Figure 4.15). The time values for each case were also similar (Tables 4.1 and 4.2) and they were based on the same route.

There was a certain time saving in using the Eskişehir State road. The practiced path was approximately 8 km (8 minutes) in normal traffic condition. The ARSAP generated path was 7.6 km (7.5 minutes) in normal traffic condition to reach the emergency patient.

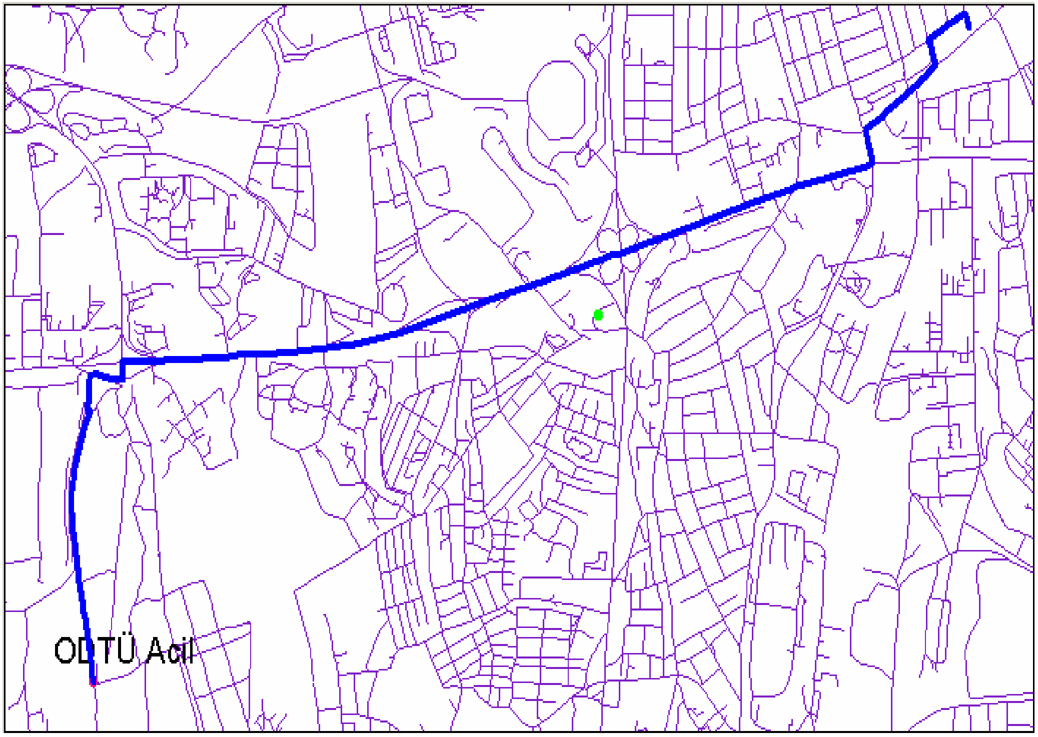


Figure 4.15 The emergency call path from METU Emergency service to an emergency patient at Akdeniz Avenue

For this case, the patient was transported to nearest hospital (i.e. Gazi University Hospital). Both the ARSAP and the drivers choose the same path: Mareşal Fevzi Çakmak Avenue, Degol Avenue and Bahriye Üçok Avenue (Figure 4.16). The time values for each case were also similar: 2 km in 2 minutes and 2.08 km in 2.35 minutes in normal traffic condition, respectively (Tables 4.1 and 4.2).

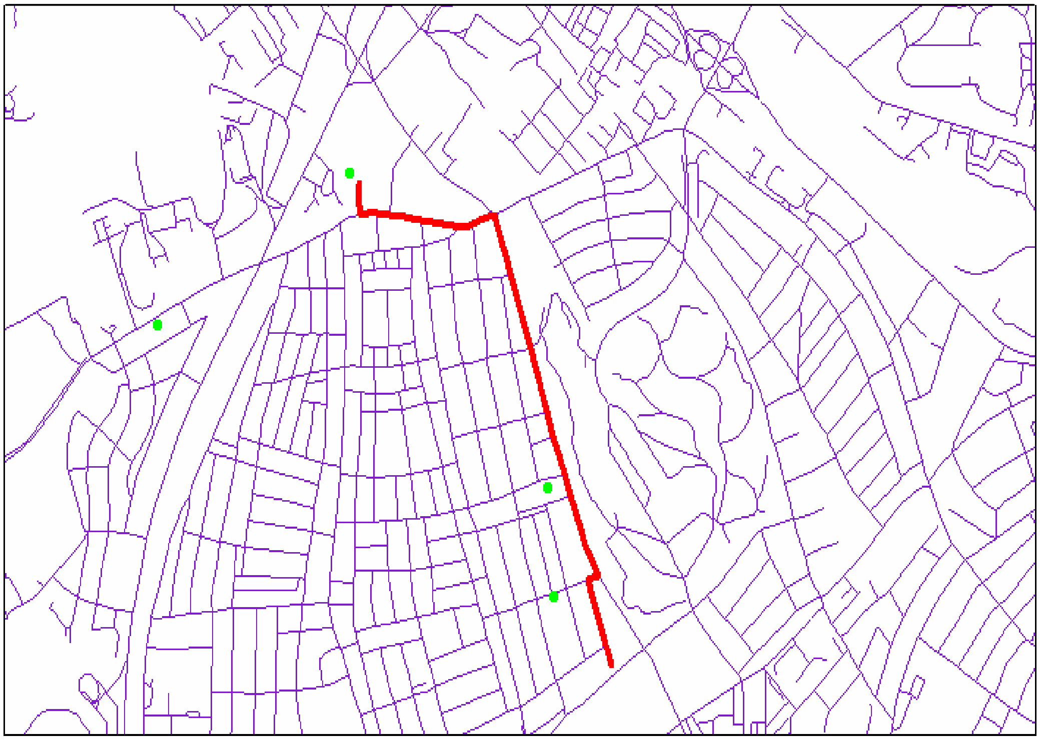


Figure 4.16 The emergency call path, from an emergency patient at Akdeniz Avenue to the Gazi University Hospital

4.4. The Analysis of Distance, Time and Speed of the Practiced and ARSAP Generated Emergency Paths of METU Emergency Service Ambulances

The distance and time information of the emergency paths from the METU Emergency Service to the destinations were obtained by interviewing with ambulance drivers Özcan Turan, Şaban Özçiçek, Kadir Işıktaş, Yaşar Atasever and Sedat Ersun in December 2003 (Table 4.1). The ambulance drivers reported the values when they went to the specified destinations. The destinations in Table 4.1 and Table 4.2 are the most commonly arrived ones from the METU Emergency Service.

The average speeds of ambulances from the METU Emergency Service to the destinations were calculated as shown in Figure 4.17.

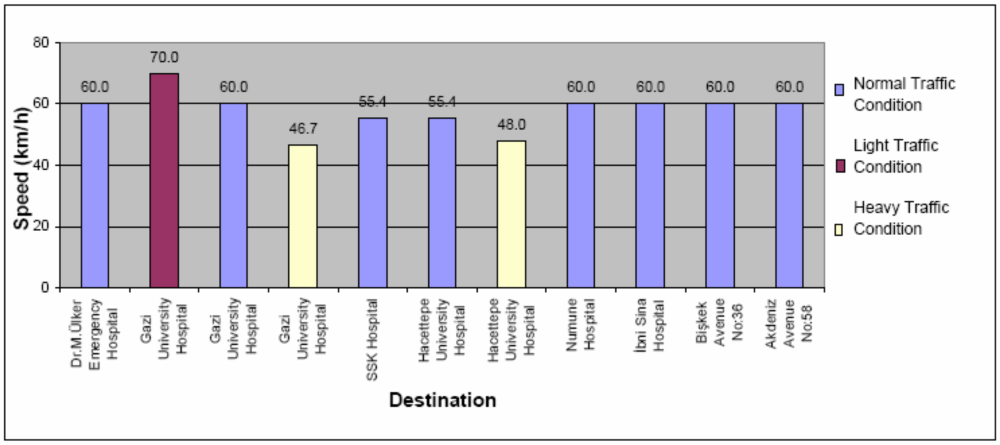


Figure 4.17 The average speeds from METU Emergency Service to the destinations based on reports of METU ambulance drivers

Using the data in Table 4.1 for only normal traffic condition case, a METU ambulance travels [11.81, 6.69] km in [12.29, 6.71] min with the average speed of [60.64, 57.06] km/h from the METU Emergency Service to the first destination, with a 95% confidence level (α=0,05) [26].

The average speeds of ambulances based on the ARSAP (Table 4.2) from the METU Emergency Service to the destinations were calculated (Figure 4.18).

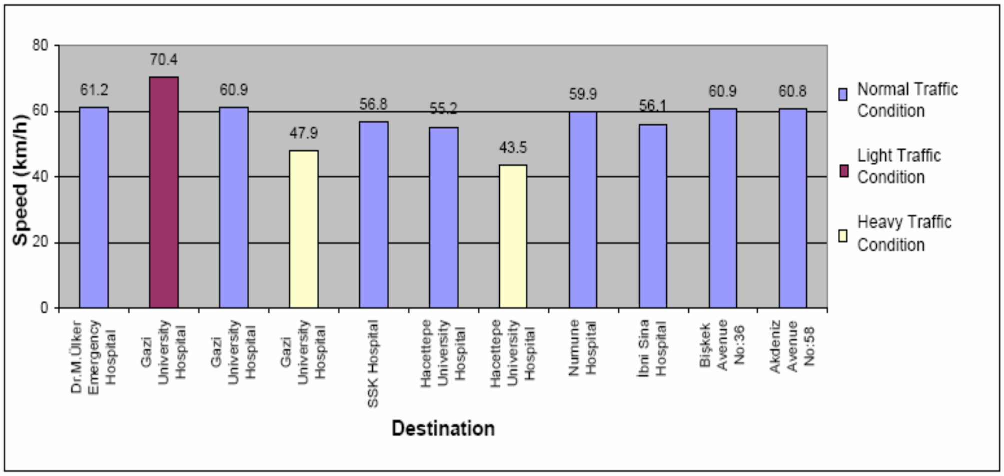


Figure 4.18 The average speeds from METU Emergency Service to the destinations based on the ARSAP

Using the data in Table 4.2 for only normal traffic condition case, a METU ambulance travels [10.63, 6.67] km in [11.14, 6.62] min with the average speed of [61.06, 56.88] km/h from the METU Emergency Service to the first destination, with a 95% confidence level (α=0,05) [26].

4.4.1. Statistical Analysis of Practiced and Forced ARSAP Paths

In order to specify whether there is correspondence between distance and time values according to the reports of METU emergency service ambulance drivers and the ARSAP, the paired *t*-test for two samples is used [27]. In order to use paired *t*-test for two samples, there has to be a one-to-one correspondence between the values in the two samples (same route but different method of computation in our case).

Both the ARSAP generated and practiced paths followed the same routes from METU Emergency Service to Dr. M. Ülker Emergency Hospital, Gazi University Hospital, Bişkek Avenue No:36 and Akdeniz Avenue No:58. The other destinations (SSK Hospital, Hacettepe University Hospital, Numune Hospital and İbni Sina Hospital), however, followed different routes. In order to be able to use the paired *t*-test, the ARSAP generated time and distance values were recalculated by forcing the paths to follow the same route as the practiced ones (Tables 4.3 and 4.4).

Table 4.3 shows the travel distances from METU Emergency Service to the destinations based on reports of emergency service ambulance drivers and the ARSAP (by forcing it to use the same path).

Table 4.3 The travel distances from METU Emergency Service to the destinations based on reports of emergency service ambulance drivers and the ARSAP (by forcing it to use the same path)

Destinations	**Distance from METU Emergency Service to the destination (Reports)**	**Distance from METU Emergency Service to the destination (ARSAP)**
Dr. M. Ülker Emergency Hospital	5	5,21
Gazi University Hospital	7	7,25
SSK Hospital	12	11,95
Hacettepe University Hospital	12	11,35
Numune Hospital	12	11,63
İbni Sina Hospital	11	10,98
Bişkek Avenue /36	6	6,21
Akdeniz Avenue /58	8	7,60

In analyzing the data, the two-tail P-value corresponding to probability is found as 0,42 [26]. The sample size is equal to eight, n=8. The *t* distribution with n-1=7 degrees of freedom is used. Since the two-tail P-value is bigger than the significance level, 0.05, the mean of "Reports" is *not significantly different* from the mean of "ARSAP" with reference to the paired *t*-test for two samples at a 95% degree of confidence.

The result of this analysis reveals that our distance data in our database is consistent with the distance measurements of ambulance drivers by reading ambulance tachometer.

Table 4.4 shows the travel time from METU Emergency Service to the destinations based on reports of emergency service ambulance drivers and the ARSAP (by forcing it to use the same path).

Table 4.4 The travel time from METU Emergency Service to the destinations based on reports of emergency service ambulance drivers and the ARSAP (by forcing it to use the same path).

Destinations	Time from METU Emergency Service to the destination (Reports)	Time from METU Emergency Service to the destination (ARSAP)	Traffic Condition
Dr. M. Ülker Emergency Hospital	5	5,11	Normal
Gazi University Hospital	6	6,18	Light
Gazi University Hospital	7	7,14	Normal
Gazi University Hospital	9	9,09	Heavy
SSK Hospital	13	12,55	Normal
Hacettepe University Hospital	13	12,21	Normal
Hacettepe University Hospital	15	14,07	Heavy
Numune Hospital	12	11,42	Normal
İbni Sina Hospital	12	11,65	Normal
Bişkek Avenue/36	6	6,12	Normal
Akdeniz Avenue/58	8	7,50	Normal

In analyzing the data, P-value corresponding to probability is found as 0,06 [26]. The sample size is equal to eight, n=11. The *t* distribution with n-1=10 degrees of freedom is used. Since the P-value is bigger than the significance level, 0.05, the mean of "Reports" is *not significantly different* from the mean of "ARSAP" with reference to the paired *t*-test for two samples at a 95% degree of confidence.

The result of this analysis reveals that our time information generated by the ARSAP is consistent with the time measurements of ambulance drivers.

The result of this analysis also reveals that the speed data that we have in the ARSAP database and calculations that we carried out is correct. But note that, state roads, boulevards and avenues are the principle road types in the data. Therefore, our conclusion that validated speed data/calculations is only valid for these road types. Since we do not have enough data related with highways and streets, we can not verify the speed data for these road types.

CHAPTER 5

5. DISCUSSION AND CONCLUSION

This study is based on the use of GIS in planning emergency patient transportation to shorten the commuting time. ArcView GIS 3.3 has been used to generate the suitable paths for emergency situations. The interfaces and the complete application were developed by using Avenue, ArcView software's scripting language.

A GIS function called network analysis is used to calculate the time to travel to the location of emergency patient and/or to the suitable hospital. The network analysis function considers three elements to find minimum path: (1) length, (2) speed on different road types and (3) time of day.

The result of the paired *t*-test for two samples showed that the distance data in the ARSAP database is consistent with the distance measurements of ambulance drivers. The time information generated by the ARSAP is found as consistent with the time measurements of ambulance drivers.

The results also reveal that the speed data in the ARSAP database and calculations that were carried out are correct. However, state roads, boulevards and avenues are the principle road types in the data available. Therefore, the conclusion that validated speed data/calculations is only valid for these road types. Since there are not enough data related with highways and streets, the speed data for these road types cannot be tested.

Although, the ARSAP generated paths can provide shorter time path solutions, the METU Emergency Service ambulance drivers state that in order not to risk the emergency patients' life, they usually prefer state roads to reach the hospitals. This reality reveals the fact that speed data in our hand is not sufficiently accurate for high parking intensity and high traffic light intensity roads. A more detailed speed data and its representation in the database are necessary.

During our meetings with ambulance drivers, they refused to use the application, because they perceived the application as a burden while they are performing their jobs. Motivating and/or obliging ambulance drivers to use the ARSAP or another similar tool seem to be a challenge.

5.1. Future Work

More comprehensive tests of the application require the tests in several different emergency services. Due to the time restriction of thesis study and difficulty in collecting data, such test was not carried out. However, in order to use the ARSAP in real life, these tests need to be performed.

Since all emergency medical response calls information are stored in our database, these data can be analyzed and displayed by type, time of call, location, and other criteria. Trends, volume of emergency patients, and areas of high impact can be visually displayed and quickly reviewed. Epidemics can be displayed and tracked. Future response activity can be anticipated and planned.

The traffic condition of roads is specified by time of day in the ARSAP. The rush hours are fixed in the scripts, which are determined by interviews made with the ambulance drivers. The ideal case for specifying the traffic condition (considering time, parking intensity and number of red lights) is to have a dedicated organization that reports the traffic conditions of roads either for all roads or for categorized road types (street, avenue, etc.) in a downloadable format. Then, the ARSAP can download this document and use this real time information for emergency situations. Holidays and other national days are not considered in current application. The holiday table can be prepared and downloaded by the ARSAP.

The ARSAP can be used in real life for city wide applications. For this purpose, whole city street network, hospitals and building data need to be integrated into the application. The road properties (one-way, type of the road, closed or open to traffic, etc) and turn restrictions on the network data should also be updated and uploaded into the ARSAP.

The available hospital resources and road network information in the ARSAP need to be updated frequently. At present, the local update in the application is not sufficient for real life usage of the ARSAP.

The inaccuracy in address information makes the use of the ARSAP difficult. For example, a street can have more than one name due to name change in various times. This is a problem that needed to be addressed by the application.

Another handicap of the current data set we have is that building numbers stored on database are not the actual building numbers on streets, but by a sequential numbering in Çankaya district (1, …, 423814). Therefore, when an emergency call comes, the system requires that specific number from the caller. In the future, the database has to be modified by the actual building numbers.

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APPENDICES

A. FURTHER INFORMATION ABOUT GIS

Other quotes to answer "What is GIS?"

The United States Geological Survey (USGS), sole science agency for the department of the interior, states: "In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. Practitioners also regard the total GIS as including operating personnel and the data that go into the system [40].

"A geographic information system is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps." ESRI [29]

"GIS is an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced." NASA [29]

Short History

Some 35,000 years ago, Cro-Magnon hunters drew pictures of the animals they hunted on the walls of caves near Lascaux, France. Associated with the animal drawings are track lines and tallies thought to depict migration routes. These early records followed the two-element structure of modern geographic information systems (GIS): a graphic file linked to an attribute database [41].

What is now the GIS field began around 1960, with the discovery that map could be programmed using simple code and then stored in a computer allowing for future modification when necessary. This was a welcome change from the era of hand cartography when maps had to be painstakingly created by hand; even small changes required the creation of a new map. The earliest version of a GIS was known as computer cartography and involved simple line work to represent land features [29].

The capabilities of GIS are a far cry from the simple beginnings of computer cartography. At the simplest level, GIS can be thought of as a high-tech equivalent of a map. However, not only can paper maps be produced far quicker and more efficiently, the storage of data in an easily accessible digital format enables complex analysis and modeling not previously possible. The reach of GIS expands into all disciplines and has been used for such widely ranged problems as prioritizing sensitive species habitat to determining optimal real estate locations for new businesses [29].

The key word to this technology is Geography - this usually means that the data (or at least some proportion of the data) is spatial, in other words, data in some way is referenced to locations on the earth. The attribute data is usually coupled with this data. Attribute data generally defined as additional information, which can then be tied to spatial data. An example of this would be hospitals. The actual location of the hospitals is the spatial data. Additional data such as the hospitals name, level of health service, hospitals capacity would make up the attribute data. It is the partnership of these two data types that enables GIS to be such an effective problem solving tool [29].

GIS operates on many levels. On the most basic level, GIS is used as computer cartography, i.e. mapping. The real power of GIS is through using spatial and statistical methods to analyze attribute and geographic information. The end result of the analysis can be derivative information, interpolated information or prioritized information. [29].

GIS has already affected most of us in some way without even realizing it. The new supermarket chain on the corner was probably located using GIS to determine the most effective place to meet customer demand [29].

Components of GIS

A full GIS, or geographic information system, requires:

- Hardware (computers and peripherals)
- Software
- Data
- People
- Training

for interpreting the results generated by the GIS [42].

Hardware

Hardware comprises the equipment needed to support the many activities of GIS ranging from data collection to data analysis. The central piece of equipment is the workstation, which runs the GIS software and is the attachment point for ancillary equipment. Data collection efforts can also require the use of a digitizer for conversion of hard copy data to digital data. The use of handheld field technology is also becoming an important data collection tool in GIS [29].

Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information [43]. Different software packages constitute a GIS. Central to this is the GIS application package. Such software is essential for creating, editing and analyzing spatial and attributes data; therefore these packages contain a myriad of GIS functions inherent to them. Extensions or add-ons are software that extends the capabilities of the GIS software package. For example, Xtools is an ArcView extension that improves editing capabilities of ArcView 3.x. Component GIS software is the opposite of application software. Component GIS seeks to build software applications that meet a specific purpose and thus are limited in their spatial analysis capabilities. Utilities are stand-alone programs that perform a specific function. For example, a file format utility that converts from one type of GIS file to another [29].

Data

Possibly the most important component of a GIS is the data. Data is the core of any GIS. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider. A GIS will integrate spatial data with other data resources. GIS information is organized in logical coverage layers, one for each type of information being accumulated and reported (i.e. street centerlines, waterlines, street lights, etc.) [43].

There are two primary types of data that are used in GIS. A geodatabase is a database that is in some way referenced to locations on the earth. Geodatabases are grouped into two different types: vector and raster. Coupled with this data is usually data known as attribute data. Attribute data generally defined as additional information, which can then be tied to spatial data. Documentation of GIS datasets is known as metadata [29].

People

GIS technology is of limited value without the people who manage the system and develop plans for applying it to real-world problems. GIS user ranges from technical specialists who design and maintain the system to those who use it to help them perform their everyday work [43].

Well-trained people knowledgeable in spatial analysis and skilled in using GIS software are essential to the GIS process. There are two factors to the people component: education, and networking. The right education is a key; taking the right combination of classes. Continuous networking with other GIS professionals is essential for the exchange of ideas as well as a support community [29].

The future of GIS

Environmental studies, geography, geology, planning, business marketing, and other disciplines have benefited from GIS tools and methods. Together with cartography, remote sensing, global positioning systems, photogrammetry, and geography, the GIS have evolved into a discipline with its own research base known as geographic information sciences [23]. An active GIS market has resulted in lower costs and continual improvements in GIS hardware, software, and data. These developments will lead to a much wider application of the technology throughout government, business, and industry [41].

GIS and related technology will help analyze large datasets, allowing a better understanding of terrestrial processes and human activities to improve economic vitality and environmental quality [41].

B. ARCVIEW AND NETWORK ANALYST

What is ArcView?

ArcView is a powerful, easy-to-use tool that brings geographic information to the desktop [20]. ArcView gives the power to visualize, explore, query and analyze data spatially. ArcView is made by Environmental Systems Research Institute, ESRI, a software company specializing in GIS [3]. ArcView was created to allow simple manipulations of data in a user-friendly interface [44].

ArcView was designed for those people who do not regularly use GIS, but need access to spatial information for decision making. The main advantage of using ArcView is the easy to learn user interface [45]. It is a desktop geographic information system, a data base that links information to location (i.e., what to where) [22].

ArcView is used throughout the world in many different professions. One of the typical ArcView usages is in emergency response. ArcView has a set of dialog boxes, and tools that provide easy-to-use access to advanced functionality. Map data can be read directly from shapefiles, ArcInfo and PC ARC/INFO coverage. Map data can be imported from MapInfo, Atlas GIS, and ASCII formats. ArcView makes GIS accessible to everyone in organization [46].

ArcView support the following data sources [3]:

- Vector data: Vector data is the data that stores the location, shape and attributes of each feature
  - Shapefiles: A shapefile is the native ArcView format that is used for vector data for storing location and attributes information for each feature. Each shapefile is a collection of following files:
    - Spatial data (shape geometry) .shp
    - Spatial data index .shx
    - Attribute data .dbf
  - ARC/INFO Coverage (in "coverage" format)
  - MapInfo Files
- ARC/INFO's raster data format (called a Grid)
- Image Data: ArcView themes (known as image themes) can be created from image data (e.g., satellite images, aerial photographs, scanned documents). Image Themes do not have attribute tables. They can be manipulated by using the Image Legend editor.

Themes in a view use symbols to represent real-world features by points, lines or polygons [19]. Real world objects, whether natural or man-made, are called features when they are represented on a map. Each map feature has a location, shape, and symbol that represent one or more of its characteristics. Features can be points, lines, or polygons [47]:

- Schools, traffic lights, crime locations, and park benches are examples of point features. Points represent objects that have discrete locations and are too small to be depicted as areas.
- Freeways, streets, pipelines, and waterways are examples of line features. Lines represent objects that have length but are too narrow to be depicted as areas.
- Parks, census tracts, postal codes, and trade areas are examples of polygon (or area) features. Polygons represent objects too large to be depicted as points or lines.

In ArcView, features are stored in a database along with information describing them. The descriptive information stored with a feature is called the feature's *attributes*. Attributes of a street might include its name, street type, length, street code. The attributes of a hospital may be its name, area, capacity, and department types. Because features and their attributes are linked, user can easily access the attributes for any feature or locate any feature from its attributes. Attributes are displayed in a spreadsheet-like ArcView document called a table [48].

ArcView GIS software facilitates loading spatial and tabular data so one can display the data as maps, tables. ArcView provides the tools needed to query and analyze the data and present results as presentation-quality maps. ArcView has a number of features that make it a good tool for using GIS [49]:

- Unlike most GIS software of the past, ArcView provides a graphical user interface. ArcView has apparent simplicity. Many operations are hidden below several layers of pull down menus and dialog boxes.

- Only recently have computers become cheap and powerful enough to supply the resources needed for a fully-functional GIS on a typical office or school desktop. At the same time, much effort has been undertaken by software manufacturers to increase the functionality and ease of use of their products. In the recent past, GIS software was able to be used only on high-end UNIX workstations. Today, PCs are powerful enough to handle GIS applications, and the software is easy enough to get started using. The software runs on Microsoft Windows and various UNIX platforms [46].
- ArcView ships with a robust programming language (Avenue). With Avenue, part or all of ArcView can be customized to meet the needs of end users [46].
- An extension is a plug-in to ArcView that one can load when need additional functionality [46]. These extensions increase the functionality of ArcView (such as Network Analyst).

Working spatially

ArcView can be used by anyone who wants to work spatially. One can display, query, summarize, and organize spatial and non-spatial data geographically [3].

All the components of ArcView session: views, tables, layouts, and scripts are conveniently stored in one file called a project. ArcView's Project window shows the contents of the project and makes it easy to manage all user work [3]. ArcView projects are used to organize and store a collection of associated documents that work together during an ArcView session. Project information is stored in a project file (.apr). The project window displays the names of all project documents [19].

A project file can be thought of as being a folder that stores ArcView documents. Actually, projects do not contain duplicates of spatial or tabular data, but merely stores "pointers" to the original data as well as storing the project GUI display format. Project has documents ([45]):

- **View:** With ArcView one work with geographic data in interactive maps called views. Every view makes it easy to understand and control what's displayed [3]. In ArcView, a view is a collection of themes (or data layers) that can be displayed together in the map view window. The view comprises all the themes of interest and can be represented on a single map. A theme is a single layer of spatial information. A theme is stored as a shape (.shp) file in ArcView. A theme contains the mapped feature and its associated characteristics or attributes stored in a table [19]. A GIS links sets of features (with their attributes), and manages them in units called themes. Themes are displayed as views from many data sources [19].
- **Tables:** A Table is a collection of attribute data, typically linked to spatial features in a Theme. Working with tabular data in ArcView's

tables puts user in control. Clicking on features on a view, and their records highlight in the table show user their attributes. Selecting records in the table and the features they represent highlight on the view [3].

- **Layouts:** A layout is a collection of other ArcView documents in map format. With layout documents one can arrange views, tables, charts and images as graphic elements [19]. ArcView's layouts let user create high quality, full color maps by first arranging the various graphic elements on-screen the way user wants them. Layouts are smart because they have a live link to the data they represent. When user works with a layout, any changes to the data are automatically included, so user knows everything on map will be up-to-date [3].
- **Scripts:** A script is a computer program that accomplishes these three objectives: add new capabilities to ArcView, automate tasks, and build customized applications. With Avenue you can customize almost every aspect of ArcView, from adding a new button to run a script you write, to creating an entire custom application that you can distribute [3]. Scripts are used to customize almost any aspect of the standard ArcView interface and written using the Avenue application development language. Avenue code is written in a script editor document. The script editor allows you to create, modify, compile, execute, and debug Avenue script [19].

The Application Window contains all of the ArcView Document windows and the Project window. The Application window has several components that allow user to interact with each type of document [45].

- **Menu bar:** The menu bar is a pull-down menu that allows user to manipulate each type of ArcView document.
- **Button bar:** The button bar duplicates many of the Menus Bar options in a quick and easy to use button. User need to click on the button to execute that particular operation.
- **Tool bar:** The tool bar is similar to the button bar, in that buttons are used to execute a function quickly and easily. However, the tool buttons carry out more utilitarian functions, such as selecting features in a View.
- **Status bar:** The status bar is located at the bottom of the applications window. The status bar informs the user about the function of a button, tool, or menu choice by moving the cursor over the button, tool, or menu choice. The status bar will also inform the user about the progress of an operation.

What is a Network?

A network is a system of linearly interconnected features. The most common examples are transportation networks, such as, streets or railroad tracks and communication networks, such as, phone lines. All networks have the following in common [50] :

- There is some kind of object or resource which moves through the network.
- In order for an object at a point A on the network to get to a point B on the network, there must be a connected path between the two points.

What is Network Analysis?

Network analysis is a technique that involves network data such as roads [20]. This type of analysis is used when the data has been coded according to flow direction (one-way streets) and impedance values (travel time) to find information about routing and other applications. This may involve calculating travel time for a particular route or finding the best route to a specified location. These applications have many uses in resource-related fields [31].

Network Analysis is a special type of analysis for vector datasets that are joined by topology. Topology refers to the connectedness of objects on a map. It may refer to roads that are linked together or polygons that are adjacent to each other. If a GIS layer preserves topology, it means that it can calculate how objects affect each other. For instance, in a road network, it is possible to calculate a route from one side of the city to the other just by entering a start point and a destination point. The GIS figures out if they are connected. Such applications make topology very useful [31].

Using these vector datasets, one can create a network connecting different points. This could be a stream or road network, for example. Network analysis, then, takes advantage of the connected network to solve certain problems [51].

One common use of network analysis is to find the most efficient transportation route to a series of destinations. Network analysis uses special tools to find a route that accounts for travel times, rush hour traffic, and one-way streets. Such analysis tools are now becoming available for a GIS that is installed directly in some luxury cars (and may eventually be commonplace like in ambulance use) [51].

ArcView Network Analyst

The ArcView Network Analyst (AVNA) extension module allows the user to solve three categories of network analysis problems; Find Best Route, Find Closest Facility and Find Service Area. If you need to conduct more complex analyses than these three default options available, you can do these using Avenue scripts [50].

Find Best Route problems involve finding the "least cost impedance" path on the network between two or more stops based on time, distance and other customized variables [38]. Find Closest Facility pertains to finding the distances from an event to the nearest facilities, or vice versa, finding the distance from a facility to one or more events. Find Service Area determines the area that a particular facility can serve within a given time or cost frame [50].

The ArcView Network Analyst is an extension product designed to help in using networks more efficiently. It can solve common network problems on any theme containing lines that connect. This theme can be a shapefile. Before solving a problem, user can model networks precisely, including setting up average travel times, one-way streets, and closed streets [4].

The ArcView Network Analyst finds the best way to get from one location to another. User can specify the locations by pointing to places on a line theme, by entering addresses, or by using a point theme [4].

Network Analyst in ArcView 3.3 supports the existence of realistic conditions such as one-way roads, turn costs in two directions and prohibited turns. Figure 7.1 shows an example solution between two arbitrary selected nodes (one in north of Cankaya district, one in south). The cost parameter used is the time to pass the line features representing the streets.

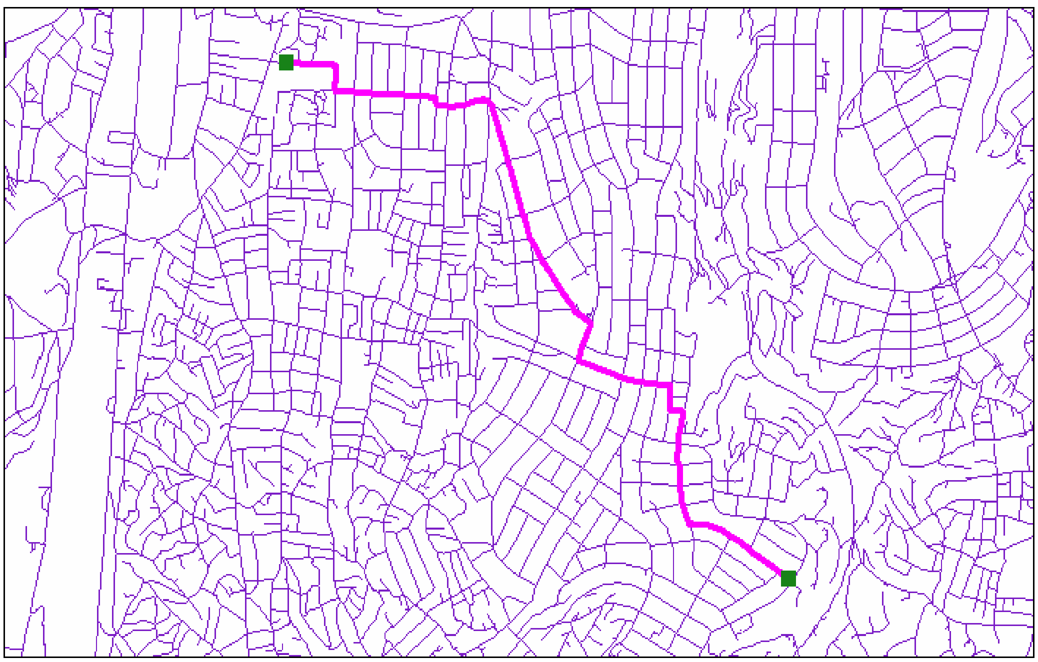

Figure B.1 Generated shortest path between two arbitrary nodes

The Routing Analysis Software and the Algorithm

Throughout the study, routing analyses were carried out using the Network Analyst Extension that is marketed by ESRI, the producer.

The Network Analyst implements the Dijkstra's shortest path algorithm [39]. A node in the network uses Dijkstra's algorithm to construct a spanning tree of shortest paths from a node called the root. Assuming that each node in the network has a complete map of the network, to update the maps, each node sends to all the other nodes a message that indicates the lengths of the links attaching to it. Each node, then, can implement shortest path algorithm to find the shortest path to every possible destination. The algorithm picks the unmarked node with the smallest current label. The algorithm explores the neighbors, after which it marks the node. The algorithm compares the labor of each neighbor to the sum of the node's label plus the links length. If that sum is smaller, it becomes the new label and the link is added to the preferred links while previously preferred link leading to that node is removed from the list of preferred links [21].

Customize the Work

All of the problems one solves with the user interface can also be solved by writing and running Avenue scripts. When install the Network Analyst, user get several new Avenue classes and requests for solving network problems. These classes and requests can be used to automate tasks, add new capabilities, and build applications [4].

Network Modeling in ArcView

The basic network model is made up of links (arc segments) that have an associated attribute known as the impedance. The impedance represents the cost of traveling over the link or the measure of resistance to movement of goods through the link. Network centers or facilities represent locations, which either distribute resources, such as a pizza bakery, or attract resources, such as a hospital. Any place on the network in which resources get picked up or dropped off is referred to as a stop. However, facilities are associated with events, not stops [50].

Networks typically have rules about how objects move through them. For example, left turns may be prohibited at certain intersections and bridges may be closed for repairs. Networks are often a combination of one-way and two-way streets, with multiple lanes going in different directions, and some roads will have speed limits imposed. AVNA allows user to model this as close to reality as possible [50]. The following rules can be modeled in AVNA:

- *Travel cost:* The average cost of traversing a link, modeled as distance, time or any other cost unit.
- *One-way streets:* Streets that can be traveled in one direction only.
- *Turns:* Turns that are not allowed, i.e. left, right, straight or U-turn at an intersection, or turns that are more "expensive" in terms of travel cost, i.e. left turns at intersections.
- *Over- and underpasses:* A street that passes over or under another street, such that you cannot make a turn onto the road you are passing over or passing under.
- *Closed streets:* Streets currently closed to traffic or certain types of streets to avoid.

Performing Network Analysis

To perform a network analysis, a road theme must be present in user View window. The first time user performs a network analysis on a line theme; AVNA will build the topology, create a cost matrix and then run the analysis. In a large network, this may take some time. The next time user run an analysis on the same network, the topology is then already present, and the analysis runs much quicker. However, as soon as user edits the theme attribute table, AVNA will have to rebuild the topology again before running any analysis [50].

C. AVENUE SCRIPTS

Representative the ARSAP Avenue Scripts

In the next pages, a few representative scripts written for this thesis are briefly summarized (“Arsap.EmergencyCallOpenAplication”, “Arsap.RunDialog”, “Arsap.SelectView1”, “Arsap.SelectView2”, “Arsap.EmergencyCallOpenScript”, “Arsap.EmergencyCallLookUpName”, “Arsap.EmergencyCallSaveRecord”, “Arsap.EmergencyCallLocateStreet”, “Arsap.EmergencyCallLocateBuilding”, “Arsap.NetworkFindDisplayPatientPath”, “Arsap.NetworkFindDisplayHospitalPath”):

Arsap.EmergencyCallOpenAplication

The user can start the ARSAP application from the Desktop icon easily. While starting, “Arsap.EmergencyCallOpenAplication” script opens Çankaya road view, District view and the dialog box. This script calls other scripts to do these actions:

```
'Calls specified scripts to be run
av.Run("Arsap.RunDialog","")

'Calls specified scripts to be run
av.Run("Arsap.SelectView1","")
```

```
'Calls specified scripts to be run
av.Run("Arsap.SelectView2","")

'Removes the line graphic in the Cankaya view
av.Run("Arsap.RemoveGraphic","")
```

Arsap.RunDialog

This script runs the “Emergency Call” dialog:

```
av.FindDialog ("EmergencyCall").Open
```

Arsap.SelectView1

This script opens the Cankaya view document:

```
Project=av.GetProject
cankayaView=Project.FindDoc("Cankaya")
cankayaViewWin=cankayaView.GetWin
    if (cankayaViewWin.IsOpen.Not) then
      cankayaViewWin.Open
    else
      cankayaViewWin.Activate
    end
```

Then it gets the hospital theme object, displays the theme and clear any selected features:

```
hastaneTheme=cankayaView.FindTheme("Hastane.shp")
    if (hastaneTheme.IsVisible.Not) then
      hastaneTheme.SetVisible (true)
    end
hastaneTable=hastaneTheme.GetFTab
allSelected=hastaneTable.GetSelection
allSelected.ClearAll
hastaneTable.UpdateSelection
```

After that, it gets the building and road theme objects. The road theme object is displayed but the building theme object is not displayed. The building is displayed according to the action of the user:

```
binaTheme=cankayaView.FindTheme ("Bina.shp")
roadCankayaTheme=cankayaView.FindTheme("Roadcankayatd.shp
")
        if (binaTheme.IsVisible.Not) then
          binaTheme.SetVisible (false)
        end
        if (roadcankayaTheme.IsVisible.Not) then
          roadcankayaTheme.SetVisible (true)
        end
```

Then, it zooms to the extent of the road theme to allow seeing all the roads of Cankaya District at the beginning of the emergency call procedure:

```
cankayaView.GetDisplay.SetExtent
(roadcankayaTheme.ReturnExtent.Scale(1.0))
```

Arsap.SelectView2

This script opens the districts view document. Then, this script gets the district theme object, displays the theme and clear any selected features by using a similar code structure that is shown above. It also zooms to the extent of the district theme.

Arsap.EmergencyCallOpenScript

This script runs when the dialog is opened. The values for quarter, district and hospital combo boxes are called from the database. In the following code SELF refers to the dialog [19]:

```
vtbQuarter = av.GetProject.FindDoc("amlmahalle.dbf").GetVTab
fldQuarter = vtbQuarter.FindField("Mahalleadi")
cboQuarterName = SELF.FindByName("cboQuarter")
cboQuarterName.DefineUniqueFromVTab(vtbQuarter, fldQuarter,
false, false, false)
SELF.SetServer(vtbQuarter)
```

Next, for each emergency situation, Call ID text line is automatically updated if the previous emergency call record has been saved in the database:

```
vtbEmergencyCall=
av.GetProject.FindDoc("emergencycall.dbf").GetVTab
fldCallID = vtbEmergencyCall.FindField("Call ID")
fldCallIDCount = 0
        for each rec in vtbEmergencyCall
          fldCallIDValue=
          vtbEmergencyCall.ReturnValueString(fldCallID,rec)
          fldCallIDCount = fldCallIDCount + 1
        end
fldCallIDNext=fldCallIDCount+1
dlgAmlEmergencyCall=av.FindDialog("AmlEmergencyCall")
txlCallID = dlgAmlEmergencyCall.FindByName("txlCallID")
txlCallIDNext=txlCallID.SetText(fldCallIDNext.AsString)
```

Then, it customizes date format:

```
today=Date.Now
today.SetFormat("dd/MM/yyyy")
txtDate = dlgAmlEmergencyCall.FindByName("txtDate")
txtDateNext=txtDate.SetLabel(today.AsString)
```

Arsap.EmergencyCallLookUpName

This script looks up the address for the emergency call by using the name and surname information of the emergency patient. If a correct match is found in database, it takes all the stored values of the patient and sends them to the dialog box.

```
'This code runs when the "Look Up Name" button is clicked ...
'SELF refers to the button
'Reference all dialog controls ...
dlgAmlEmergencyCall = SELF.GetDialog
'
if(MsgBox.YesNo("Do you want to look up name?","Look Up
Name",true))then
  txlCallID = dlgAmlEmergencyCall.FindByName("txlCallID")
  txlName = dlgAmlEmergencyCall.FindByName("txlName")
  txlSurname = dlgAmlEmergencyCall.FindByName("txlSurname")
  cboQuarter = dlgAmlEmergencyCall.FindByName("cboQuarter")
  cboDistrict = dlgAmlEmergencyCall.FindByName("cboDistrict")
  txlMainStreet =
  dlgAmlEmergencyCall.FindByName("txlMainStreet")
  txlStreet = dlgAmlEmergencyCall.FindByName("txlStreet")
  txlBuildingNo =
```

```
dlgAmlEmergencyCall.FindByName("txlBuildingNo")
txlPhone = dlgAmlEmergencyCall.FindByName("txlPhone")
txtDate = dlgAmlEmergencyCall.FindByName("txtDate")
'
'-Reference the emergencycall.dbf VTab and all required fields ...
vtbEmergencyCall =
av.GetProject.FindDoc("emergencycall.dbf").GetVTab
dlgAmlEmergencyCall.SetServer(vtbEmergencyCall)
vtbEmergency=dlgAmlEmergencyCall.GetServer
'
fldCallID = vtbEmergency.FindField("Call ID")
fldName = vtbEmergency.FindField("Name")
fldSurname = vtbEmergency.FindField("Surname")
fldQuarter = vtbEmergency.FindField("Quarter")
fldDistrict = vtbEmergency.FindField("District")
fldMainStreet = vtbEmergency.FindField("MainStreet")
fldStreet = vtbEmergency.FindField("Street")
fldBuildingNo = vtbEmergency.FindField("BuildingNo")
fldPhone = vtbEmergency.FindField("Phone")
fldDate = vtbEmergency.FindField("Date")
'
'Look up specified name
txlNameCurrent=txlName.GetText
txlSurnameCurrent=txlSurname.GetText

for each rec in vtbEmergencyCall
  fldNameValue =
  vtbEmergencyCall.ReturnValueString(fldName,rec)
  fldSurnameValue =
  vtbEmergencyCall.ReturnValueString(fldSurname,rec)
  if(txlNameCurrent.AsString=fldNameValue.AsString)then
    if(txlSurnameCurrent.AsString=fldSurnameValue.AsString)then
      '
        fldNameValue =
        vtbEmergencyCall.ReturnValueString(fldName,rec)
        txlNamePast=txlName.SetText(fldNameValue.AsString)
        fldSurnameValue =
        vtbEmergencyCall.ReturnValueString(fldSurname,rec)
        txlSurnamePast=
        txlSurname.SetText(fldSurnameValue.AsString)
        fldQuarterValue =
        vtbEmergencyCall.ReturnValueString(fldQuarter,rec)
        cboQuarterPast=
        cboQuarter.SetCurrentValue(fldQuarterValue.AsString)
        fldDistrictValue =
        vtbEmergencyCall.ReturnValueString(fldDistrict,rec)
        cboDistrictPast=
```

```
                cboDistrict.SetCurrentValue(fldDistrictValue.AsString)
                fldMainStreetValue =
                vtbEmergencyCall.ReturnValueString(fldMainStreet,rec)
                txlMainStreetPast=
                txlMainStreet.SetText(fldMainStreetValue.AsString)
                fldStreetValue =
                vtbEmergencyCall.ReturnValueString(fldStreet,rec)
                txlStreetPast=txlStreet.SetText(fldStreetValue.AsString)
                fldBuildingNoValue=
                vtbEmergencyCall.ReturnValueString(fldBuildingNo,rec)
                txlBuildingNoPast=
                txlBuildingNo.SetText(fldBuildingNoValue.AsString)
                fldPhoneValue =
                vtbEmergencyCall.ReturnValueString(fldPhone,rec)
                txlPhonePast=txlPhone.SetText(fldPhoneValue.AsString)
      end
    end
  end
end
```

Arsap.EmergencyCallSaveRecord

This script allows the user to save the emergency call record if it is needed. For this purpose, it reference all dialog controls. It populates the field values in database and then, it adds the new record.

Arsap.EmergencyCallLocateStreet

This script locates the street of the emergency call address with respect to the ambulance location. First, it takes the street value from the dialog box:

```
        txlMainStreet=
dlgAmlEmergencyCall.FindByName("txlMainStreet")
        txlStreetCurrVal=txlStreet.GetText
        txlMainStreetCurrVal=txlMainStreet.GetText
```

If a matching record is found in the database, it highlights the related road with respect to the ambulance location. Finally, in order to make the location more visible, it zooms the view into a rectangle that includes the street and ambulance location together. It also highlights the district information of the emergency call in a separate view of districts of Ankara. (This property is added to the ARSAP with the aim of allowing the system to be used for city wide applications.)

Arsap.EmergencyCallLocateBuilding

This script shows the building of the emergency call address on the street if building code is known. First, it takes the building value from the dialog box related text line by using the similar code shown above for the street value. If the correct matching record is found in the database, it highlights the related building. Finally, in order to make the location more visible, the view is zoomed into a rectangle that includes the street and building location together.

```
'This code runs when the "Locate Building" button is clicked ...
'SELF refers to the button
dlgAmlEmergencyCall = SELF.GetDialog
'
if(MsgBox.YesNo("Do you want to locate building?","Locate Building",true))then
'Take the Main Street, Street and Building Number of the emergency call
  '
  txlMainStreet =
  dlgAmlEmergencyCall.FindByName("txlMainStreet")
  txlStreet = dlgAmlEmergencyCall.FindByName("txlStreet")
  txlBuildingNo =
  dlgAmlEmergencyCall.FindByName("txlBuildingNo")
  '
  txlMainStreetCurrVal=txlMainStreet.GetText
  txlStreetCurrVal=txlStreet.GetText
  txlBuildingNoCurrVal=txlBuildingNo.GetText.AsNumber
 '
  cankayaView=av.GetProject.FindDoc("Cankaya")
  '
  'Check if the view document does not exist.
  if(nil=cankayaView)then
    MsgBox.Error
    ("Cankaya view document does not exist.","Tez")
  end
```

```
'Open the view document.
  cankayaViewWin=cankayaView.GetWin
  if(cankayaViewWin.IsOpen.Not)then
    cankayaViewWin.Open
  end
  'Get the Road Cankaya theme object.

roadCankayaTheme=cankayaView.FindTheme("Roadcankayatd.shp
")
      '
      'Stop if the theme does not exist.
            if(nil=roadCankayaTheme)then
              MsgBox.Error
              ("Roadcankayatd theme does not exist.","Cankaya")
              exit
            end
      'display the theme.
            if(roadCankayaTheme.IsVisible.Not)then
              roadCankayaTheme.SetVisible(true)
            end
      'Clear any selected features.
      roadCankayaTableF=roadCankayaTheme.GetFTab
      allSelected=roadCankayaTableF.GetSelection
      allSelected.ClearAll
      roadCankayaTableF.UpdateSelection

  'Get the Bina theme object.
    binaTheme=cankayaView.FindTheme("Bina.shp")
  'Stop if the theme does not exist.
            if(nil=binaTheme)then
              MsgBox.Error
              ("Bina theme does not exist.","Cankaya")
              exit
            end
    'Display the theme.
            if(binaTheme.IsVisible.Not)then
              binaTheme.SetVisible(true)
            end
    '
    'Clear any selected features.
    binaTableF=binaTheme.GetFTab
    allSelected=binaTableF.GetSelection
    allSelected.ClearAll
    binaTableF.UpdateSelection
    '
```

```
 if(txlMainStreetCurrVal.AsString<>"".AsString)then
    'Find Tr_adi and Type fields and
     Tr_adiField = roadCankayaTableF.FindField("Tr_adi")
     shapeField = roadCankayaTableF.FindField("Shape")

   roadList=List.Make
   roadRecordNumber=roadCankayaTableF.GetNumRecords
   roadBitMap=BitMap.Make(roadRecordNumber)
   '
   for each roadRow in roadCankayaTableF
     '
     Tr_adiFieldValue=
roadCankayaTableF.ReturnValueString(Tr_adiField,roadRow)

if(Tr_adiFieldValue.AsString=txlMainStreetCurrVal.AsString)then
      'Get the selection bitmap
      roadLine =
      roadCankayaTableF.ReturnValue(shapeField,roadRow)
      roadList.Add(roadLine)
      roadBitMap.Set(roadRow)
     end
   end
   '
   'NumberOfRoads=roadList.Count
   'CountParts=roadList.Get(80).CountParts
   'NumberOfSetRoads=roadBitMap.Count

'MsgBox.ListAsString(roadList,NumberOfRoads.AsString++"Num
ber
of"++txlMainStreetCurrVal.AsString+NL+NumberOfSetRoads.AsS
tring,"")
   roadCankayaTableF.SetSelection(roadBitMap)
   '
   xBuyuk=0
   yBuyuk=0
   xKucuk=roadList.Get(0).AsLine.ReturnStart.GetX
   yKucuk=roadList.Get(0).AsLine.ReturnStart.GetY
   for each selectedRoad in roadList
     selectedRoadLine=selectedRoad.AsLine
     lineStartX=selectedRoadLine.ReturnStart.GetX
     lineStartY=selectedRoadLine.ReturnStart.GetY
     lineEndX=selectedRoadLine.ReturnEnd.GetX
     lineEndY=selectedRoadLine.ReturnEnd.GetY
     'Finds the biggest X
     if(lineStartX>xBuyuk)then
       xBuyuk=lineStartX
     end
```

```
   if(lineEndX>xBuyuk)then
     xBuyuk=lineEndX
   end
   'Finds the smallest X
   if(lineStartX<xKucuk)then
     xKucuk=lineStartX
   end
   if(lineEndX<xKucuk)then
     xKucuk=lineEndX
   end
   'Finds the biggest Y
   if(lineStartY>yBuyuk)then
     yBuyuk=lineStartY
   end
   if(lineEndY>yBuyuk)then
     yBuyuk=lineEndY
   end
   'Finds the smallest Y
   if(lineStartY<yKucuk)then
     yKucuk=lineStartY
   end
   if(lineEndY<yKucuk)then
     yKucuk=lineEndY
   end
  end
 '
 end
 if(txlBuildingNoCurrVal<>"")then
  binaList=List.Make
  binaRecordNumber=binaTableF.GetNumRecords
  binaBitMap=BitMap.Make(binaRecordNumber)
  '
  Bina_idField = binaTableF.FindField("Bina_id")
  for each binaRow in binaTableF
   '
   Bina_idFieldValue =
   binaTableF.ReturnValue(Bina_idField,binaRow)
   if(Bina_idFieldValue=txlBuildingNoCurrVal)then
    'Get the selection bitmap
    binaList.Add(Bina_idFieldValue)
    binaBitMap.Set(binaRow)
   end
  end
end
   cankayaDisplay=cankayaView.GetDisplay
   xKucuk=xKucuk-50
   yKucuk=yKucuk-100
```

```
        rectOrigin=Point.Make(xKucuk,yKucuk)
        SizeX=xBuyuk+50-xKucuk
        SizeY=yBuyuk+50-yKucuk
        rectSize=Point.Make(SizeX,SizeY)
        Rectengular=Rect.Make(rectOrigin,rectSize)
        cankayaDisplay.ZoomToRect(Rectengular)
    end
```

Arsap.NetworkFindDisplayPatientPath

This script allows the user to solve the problem of finding the "least cost impedance" path on the network between two stops by taking into account the followings: flow direction (one-way streets), traffic conditions. A view with a line theme and a point theme representing stop should be active before it is run.

It gets the view and the road line theme, and checks if a proper network theme is found. Then, it calls the virtual table (VTab) of the road table. A VTab manages a tabular view of tabular data source. The table document is a viewer for a VTab in the form of a grid [3]. After that, the script makes the NetDef and checkes for errors. The Network Definition (NetDef) discovers and manages the fields in the line theme feature table and in the turntable that define travel costs, one-way streets, prohibited turns. It also coordinates the building and maintenance of the network index directory [3].

Then, the script makes the “Network” object. The “Network” is the primary class used in solving network problems. It represents the network problem the user is trying to solve. Each of the problem solving requests operates on the Network class, requests for finding routes. Besides representing the network problem, the Network class can have several properties associated with it, such as cost fields [19].

The script also gets the point theme representing the ambulance location and checks if the point theme is found. It adds this point to a point list. Then, it locates the building of emergency patient and adds the center of the building to the point list. Afterwards, it sets the alias to cost fields in order to specify the traffic conditions (heavy, normal, light) with respect to current time of the application and sets a cost for solving a network problem.

Finally, it lets to find the minimum travel time path from the ambulance location to the emergency patient. It displays the cost of calculated path in a dialog box. It creates a shape for the path and shows in the view. It also zooms the view to the proper size.

Arsap.NetworkFindDisplayHospitalPath

This script allows finding the minimum travel time path from the emergency patient location to the suitable hospital by using a similar code structure that is described in the previous script. A view with a line theme and a point theme representing stop should be active before it is run. The suitable hospital can be identified by the user or the application that will direct the emergency patient to the closest one with respect to time. The ARSAP also informs user about the available beds, doctors and the respiratory equipments in hospital's intensive care room. The available hospital resources in the ARSAP need to be updated from time to time for real life usage of the ARSAP:

```
aHospitalPropertiesVTab = av.GetProject.FindDoc
("amlhospitalproperties.dbf" ).GetVTab
aHastane_IDV = aHospitalPropertiesVTab.FindField( "Hastane_ID"
)
aHastaneAdiV = aHospitalPropertiesVTab.FindField( "HastaneAdi"
)
```

```
aBed_NumberV = aHospitalPropertiesVTab.FindField
("Bed_Number" )
aBNAvailV = aHospitalPropertiesVTab.FindField( "BNAvail" )
aOksijenTV = aHospitalPropertiesVTab.FindField( "OksijenT" )
aOTAvailV = aHospitalPropertiesVTab.FindField( "OTAvail" )
aDotorGeceV = aHospitalPropertiesVTab.FindField( "DotorGece" )
aDGAvailV = aHospitalPropertiesVTab.FindField( "DGAvail" )
aDoktorGunV = aHospitalPropertiesVTab.FindField( "DoktorGun"
)
aDGunAvailV = aHospitalPropertiesVTab.FindField( "DGunAvail"
)
aMalzemeAvailV = aHospitalPropertiesVTab.FindField
("Malzemeava" )
```

Whenever the there is no available bed, doctor or oxygen tube, the script generates a message box that inform the user about this situation. Even though, the selected hospital is not suitable for an emergency patient, the ARSAP shows the cost of path creates a shape for the path and shows it in the view. The view is then zoomed to the proper size. The ARSAP user, then, decides to transport or not to transport the emergency patient to the hospital.